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Item 9 of the provisional agenda*

AVAILABLE TOOLS AND TECHNOLOGIES ON ECOSYSTEM RESTORATION

Note by the Executive Secretary

INTRODUCTION

1. The Executive Secretary is circulating herewith, for the information of participants in the eleventh meeting of the Conference of the Parties (COP) to the Convention on Biological Diversity, an annotated compilation of publically available documents on ecosystem restoration tools and technologies.

2. The present note addresses paragraphs 2 (c) and (d) of recommendation XV/2, in which the SBSTTA requested the Executive Secretary, subject to availability of funding, in collaboration with relevant international organizations and other partners to initiate work to:

(c) Compile information on all relevant tools and technologies, including lessons learned (both positive and negative), and experiences used at different spatial scales and for specific ecosystems and make this information available to support:

(i) Informed decision-making on ecosystem-restoration policy, legislation, and regulation;

(ii) Use of best practices for ecosystem restoration among implementing agencies; and

(iii) The effective design, implementation, and monitoring of ecosystem restoration projects/programmes on the ground;

(d) Compile information on the application of new and emerging among others for ecosystem restoration.

3. The Executive Secretary, with the generous funding from the European Union, commissioned the Society for Ecological Restoration (SER), in collaboration with relevant partners and organizations, to collate and compile the required information. SER in collaboration with the IUCN World Commission on

* UNEP/CBD/COP/11/1.

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Protected Areas (WCPA), the IUCN Commission on Ecosystem Management (CEM), the Global Partnership on Forest Landscape Restoration (GPFLR), the Society of Wetland Scientists (SWS), the World Resources Institute (WRI), the Botanic Gardens Conservation International (BGCI) and other related organizations, including the United Nations Convention to Combat Desertification (UNCCD) and the Ramsar Convention on Wetlands, through reaching out to their members/networks, prepared this note.

4. The document is circulated in the form and language in which it was received by the Secretariat of the Convention on Biological Diversity.

Annotated Compilation of Publically Available Documents on Ecosystem Restoration Tools and Technologies

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1. Introduction

The Society for Ecological Restoration (SER) defines ecosystem or ecological restoration as "the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed" (SER 2004).This definition is sufficiently broad to encompass a wide variety of approaches to reversing ecosystem degradation across a wide spectrum of contexts. It refers not only to activities aimed at returning an ecosystem to its pre-disturbance conditions, insofar as possible, but also to rehabilitation and other activities focused on the recovery of biodiversity, ecosystem functioning, or other indicators of ecological health. It does not however include afforestation, reforestation for the sole purpose of timber production or carbon sequestration, garden and landscape design, or the creation of ecosystems, all of which often ignore historical continuity as a guideline for restoration planning and execution.

It is also important to understand that ecological restoration is a "process of assisting" that involves gradual changes in order to fulfill a long-term commitment and vision. It is not a one-time intervention, like planting trees on barren lands or removing dams from rivers and streams. Activities such reclamation, remediation, revegetation, ecological engineering, etc., are often important first steps or components of restoration projects and programs, but when implemented in isolation or seen as ends in of themselves, these activities do not constitute ecological restoration as defined here. To further distinguish ecological restoration from other related activities that address environmental degradation, it is essential to recognize that the object being restored or recovered is an ecosystem, not an individual species nor the habitat of any one species. In addition to recovering ecosystem functionality and the flow of ecosystem services, the science and practice of ecological restoration also fosters a healthy relationship between humans and the environment by reinforcing the link between nature and culture and highlighting the important benefits that ecosystems provide to humans.

At the 15th meeting of the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA), the Secretariat issued an Information Note on Agenda Item 3.2 suggesting a number of recommendations on the "Ways and Means to Support Ecosystem Restoration" (UNEP/CBD/SBSTTA/15/4). In response, the SBSTTA adopted the following recommendations and this Information Note fulfills the request made by the Parties in UNEP/CBD/SBSTTA/REC/XV/2 – Section 2, Para (c) and (d) which requests the Executive Secretary, subject to availability of funding, in collaboration with relevant international organizations and other partners to initiate work to:

> (c) Compile information on all relevant tools and technologies, including lessons learned (both positive and negative), and experiences used at different spatial scales and for specific ecosystems and make this information available to support:

(i) Informed decision-making on ecosystem-restoration policy, legislation, and regulation;

(ii) Use of best practices for ecosystem restoration among implementing agencies; and

(iii) The effective design, implementation, and monitoring of ecosystem restoration projects/programmes on the ground;

(d) Compile information on the application of new and emerging technologies [such as synthetic biology] among others for ecosystem restoration;

This Information Note was produced by the Society for Ecological Restoration (SER) in collaboration with the IUCN World Commission on Protected Areas (WCPA), the IUCN Commission on Ecosystem Management (CEM), the Global Partnership on Forest Landscape Restoration (GPFLR), the Society of Wetland Scientists (SWS), the World Resources Institute (WRI), the Botanic Gardens Conservation International (BGCI) and other relevant organizations, including the UN Convention to Combat Desertification and the Ramsar Convention on Wetlands.

For the purposes of this Information Note, 'tools' and 'technologies' are defined as the specific methods, materials, and means used to accomplish ecosystem restoration goals and objectives, or to solve practical problems related to ecosystem restoration. The vast majority of the tools and technologies for ecosystem restoration are found in case studies and reported experiences which inform decision-making, illustrate best practices, and present lessons learned from on-the-ground projects and programs. The tools and technologies presented here were selected using knowledge-based criteria, recognizing that the unifying principles of ecology and ecosystem management are most effective in guiding the best practice for restoring degraded ecosystems and landscapes, including the establishment of goals, the prioritization of restoration activities and their design and planning, biophysical interventions and manipulations, monitoring and adaptive management, and long-term ecosystem maintenance.

Each publically available document is presented in an annotated bibliography format which includes a short abstract or summary, language(s) in which the document is available, and an indication of primary targeted end-users as well as a citation or reference with weblink (URL). It is important to note that the abstract or summary does not include an assessment of the document's value or quality and unless otherwise indicated, the document is available only in the language presented.

Although this Information Note is not an exhaustive compilation, every effort has been made to present a representative range of tools and technologies that are publically available from a wide variety of organizations and individuals. Section 2 contains ecosystem-specific tools and technologies. Section 3 contains landscape-scale tools and technologies. Section 4 contains sector-specific guidance and guidelines. Section 5 contains national plans, strategies and experiences. Section 6 contains documents on future directions for ecosystem restoration. Annex 1 contains a short note on the application of new and emerging technologies related to ecosystem restoration.

As the field of ecological restoration has advanced rapidly in the last decade, the vast majority of the documents cited in this Information Note were published after the year 2000. However, a few older documents have also been included as they represent seminal works that still have relevance today. The hope is that this compilation will continue into the future and that a "living" database will be created to ensure the inclusion of new and valuable resources, and to provide the greatest ease of access for those interested in all aspects of ecosystem restoration.

This compilation is intended to focus, inform and direct decision-makers and stakeholders in the public, private and NGO sectors in their efforts to develop and manage ecosystem restoration projects and programs in a variety of geographic, socio-economic, and political contexts. It is important to bear in mind that documents on ecosystem restoration tools and technologies can often be quite diverse with regard to their level of specificity, technical depth, ecosystem and degradation context, and targeted end-user, and the resources cited herein should therefore not be taken as blueprints without adapting them to the appropriate, site-specific circumstances.

It is also important to note that although ecosystem restoration can clearly play an important role in enhancing biodiversity and recovering ecosystem services, it should not be considered to be a substitute for protecting, conserving and sustainably managing ecosystems, landscapes, and all forms of natural capital. The potential to restore an ecosystem that has been degraded does not in any way justify continued degradation, as experience shows that a "restored" ecosystem rarely provides the full range and magnitude of services delivered by an undisturbed or intact ecosystem. Even when such restoration is ecologically and economically feasible, it may take decades or even centuries. Therefore, given that all human societies and economies ultimately depend on natural capital, the priority must be to conserve and sustainably manage relatively intact ecosystems of all kinds, rather than to condone or ignore their continued degradation when feasible and sustainable alternatives are now available.

2. Ecosystem-Specific Tools and Technologies

Coastal/Marine

Coastal Wetlands: An Integrated Ecosystem Approach

This book provides an understanding of the functioning of coastal ecosystems and the ecological services that they provide, and suggestions for their management. Section VI presents six chapters on Coastal Wetland Restoration and Management.

Implementing agencies, practitioners

Perillo, G., E. Wolanski, D. Cahoon and M. Brinson (2009) Coastal Wetlands: An Integrated Ecosystem Approach. Elsevier Science.

http://store.elsevier.com/Coastal-Wetlands/isbn-9780444531032/

Coastal Restoration: Where Have We Been, Where Are We Now, and Where Should We Be Going?

Advances in coastal restoration in the last decade are documented in this collection of papers that were commissioned for a symposium held at Restore America's Estuary's inaugural national conference, Coastal and Estuarine Habitat Restoration, Saving Our Coastal Heritage. The symposium presented the current status of our ability to (1) achieve restoration goals, (2) restore fish and wildlife habitat, (3) increase the understanding of coastal habitats and the role of restoration in maintaining them, and (4) use adaptive management approaches. The papers illustrate some of the progress made to date in the restoration of coastal habitats. They also point to the need for continuing study of restoration and for extending the practice of restoration to include a human dimension. The work presented demonstrates the value of science to the management of the nation's resources and confirms the potential of restoration to repair damaged ecosystems.

Practitioners, implementing agencies

Thayer, G.W. and M.E. Kentula (2005) Coastal Restoration: Where Have We Been, Where Are We Now, and Where Should We Be Going? Special Issue of Journal of Coastal Research 40: 1-140.

http://www.jstor.org/stable/i25736609

Estuarine, Coastal and Marine Ecosystem Restoration: Confusing Management and Science - A Revision of Concepts

This review presents recent concepts, understanding and experience of the restoration, recovery and human-mediated modification of estuarine, coastal and marine ecosystems. It shows that these can be divided into four categories: natural recovery from a natural or anthropogenic change (whether adverse or otherwise); anthropogenic interventions in response to a degraded or anthropogenically changed environment; anthropogenic responses to a single stressor; and habitat enhancement or creation. A conceptual framework for restoration and recovery of marine marginal and semi-enclosed areas is presented after exploring and refining the plethora of terms used in restoration science and management.

Implementing agencies, policymakers

Elliott, M., D. Burdon, K.L. Hemingway and S.E. Apitz (2007) Estuarine, Coastal and Marine Ecosystem Restoration: Confusing Management and Science - A Revision of Concepts. Estuarine, Coastal and Shelf Science 74(3): 349-366.

http://www.sciencedirect.com/science/article/pii/S0272771407002181

Restoration Scaling in the Marine Environment

Restoration ecology and conservation biology share the broad goal of managing human impacts on natural resources and ecosystems. Although seminal books on the 2 disciplines appeared almost simultaneously, subsequent conceptual growth in conservation biology has exceeded that of restoration ecology. Consequently, technical restoration activity in both terrestrial and marine environments has progressed faster than the fundamental conceptual support for it. A major goal of this Theme Section is to expose to wide review the conceptual bases for various types of restoration projects so as to stimulate further growth of the ecological theory required to advance and improve restoration practices.

Practitioners

Peterson, C.H. and R.T. Kneib (2003) Restoration Scaling in the Marine Environment. Special Theme in Marine Ecology Progress Series 264: 173-307.

http://www.int-res.com/articles/theme/m264_TS.pdf

A New Imperative for Improving Management of Large Marine Ecosystems

This paper describes GEF supported processes being used to assist them in adopting a science-driven, ecosystem-based approach to the management of human activities affecting coastal and marine ecosystems and linked freshwater basins. At risk are renewable goods and services valued at $10.6 trillion per year. A total of10 LME projects involving 72 countries have been approved by the GEF Council, and another 7 LMEs involving 54 countries have GEF international waters projects under preparation. A five-module assessment and management methodology is being tested that moves the countries toward adopting practical joint governance institutions through place-based management. This LME approach engages stakeholders, fosters the participation of the science community, and leads to the development ofadaptive management institutions. Comprehensive initiatives in four LMEs are described.

Policymakers

Duda, A.M. and K. Sherman (2002) A New Imperative for Improving Management of Large Marine Ecosystems. Ocean & Coastal Management 45: 797-833.

http://www.lme.noaa.gov/lmeweb/publications/2002a_duda.pdf

Bridging the Marine–Terrestrial Disconnect to Improve Marine Coastal Zone Science and Management

Management efforts have been hampered by disconnects both between management and scientific research and across linked marine–terrestrial systems. Management jurisdictions often start or end at the shoreline, and multiple agencies at different levels of government often have overlapping or conflicting management goals or priorities, or suffer from a lack of knowledge or interest. Scientists also often fail to consider connections among linked marine–terrestrial systems, and communication among agencies, among scientists in different disciplines, and between scientists and managers is often inadequate. However, despite the institutional and scientific challenges inherent in improving coastal zone management, there are examples of increased coordination and cooperation among different organizations. We discuss a number of examples— including where the marine–terrestrial and science–management disconnects persist and where better integration has led to successes in coastal zone management—and provide recommendations to scientists and managers on how to better link their efforts in science and management across marine and terrestrial systems.

Implementing agencies, practitioners

Ruttenberg, B.I., and E.F. Granek (2011) Bridging the Marine–Terrestrial Disconnect to Improve Marine Coastal Zone Science and Management. Marine Ecology Progress Series 434: 203-212.

http://www.int-res.com/articles/theme/m434p203.pdf

Ecohydrology and Restoration

Estuaries and coastal ecosystems are transitional between terrestrial and ocean environments, and this is the reason why they are highly dynamic ecosystems. Being situated at the lower point of the river basins, estuaries and coastal ecosystems are highly dependent on all the factors, processes, and uses directly or indirectly related with water over the entire river basin. Finding sustainable solutions to reverse the degradation and restore estuarine and coastal ecosystems requires a profound knowledge about the processes occurring at different spatial and temporal levels, and understanding of the need for a transdisciplinary approach to water issues in estuarine and coastal environments.

Practitioners, implementing agencies

Wolanski, E., D. McLusky, L. Chícharo and M. Zalewski (2011) Ecohydrology and Restoration. Treatise on Estuarine and Coastal Science, 10, Academic Press, London.

http://eprints.jcu.edu.au/21560/

Incorporating Positive Interactions in Aquatic Restoration and Conservation

The role of positive interactions in structuring biological communities is recognized throughout the field of ecology, but has yet to be well integrated into the restoration and conservation of aquatic systems. Here, we use examples of success in terrestrial restoration to (1) describe how a broader perspective on the scale and nature of positive interactions is necessary if we are to take full advantage of their conservation potential and (2) explain why and when positive interactions should be considered in restoration and conservation of marine, estuarine, and freshwater habitats. Such goals can be accomplished without considering positive interactions, and situations certainly exist in which positive interactions should play a minor role in restoration plans. However, a more explicit recognition of these interactions will make restoration and conservation more successful. In some cases, restoration activities may fail if these interactions are not included.

Practitioners, implementing agencies

Halpern, B.S., B.R. Silliman, J.D. Olden, J.P. Bruno and M.D. Bertness (2007) Incorporating Positive Interactions in Aquatic Restoration and Conservation. Frontiers in Ecology and the Environment 5(3): 153-160.

http://www.fish.washington.edu/research/oldenlab/pdf/2007/FrontiersEcoEnv_2007.pdf

The Case for Restoration of Tropical Coastal Ecosystems

At no time have humans so altered their natural environment than the present. Marine ecosystems have not been spared, and the degradation of coastal habitats has reached severe proportions in many parts of the world. The mere setting aside of areas for protection may not be enough to ensure adequate production and provision of services for a growing global human population. Hence, the active restoration of habitats, in addition to protection and preservation, is probably the more desirable conservation strategy.

Policymakers

Yap, H.T. (2000) The Case for Restoration of Tropical Coastal Ecosystems. Ocean & Coastal Management 43(8-9): 841-851.

http://www.sciencedirect.com/science/article/pii/S0964569100000612

Coastal/Marine>China

An Assessment on Restoration of Typical Marine Ecosystems in China: Achievements and Lessons

In this paper, three cases in marine ecosystem restoration (i.e. mangrove restoration in Quanzhou bay, bay ecosystem restoration in Wuyuan Bay of Xiamen and eutrophic semi-enclosed bay restoration in Xiamen western waters) were evaluated. The results, together with the brief assessment of practices in other coastal areas, showed that the major barriers for success are: (i) more comprehensive insights into ecological, socio-economic, political factors are necessary for setting-up clear project objectives and targets; (ii) more attention should be paid to ecological functions in order to restore the ecosystem's values and benefits; (iii) more scientific processes need to be conducted to evaluate the causes for ecosystem degradation and predict the probability for natural recovery; and (iv) degradation causes diagnosis, restoration technologies and methods, monitoring strategies and techniques, assessment and evaluation, adaptive management and results dissemination should be all emphasized during the restoration efforts.

Policymakers, implementing agencies

Chen, B., W.W. Yu, W.H. Liu and Z.H. Liu (2012) An Assessment on Restoration of Typical Marine Ecosystems in China: Achievements and Lessons. Ocean & Coastal Management 57: 53-61.

http://www.sciencedirect.com/science/article/pii/S096456911100189X

Coastal/Marine>Netherlands

Ecological Restoration in Coastal Areas in the Netherlands: Concepts, Dilemmas and Some Examples

This chapter gives an overview of attempts in the Netherlands to restore coastal ecosystems and habitats, and explains how scientific and non-scientific information has been used to meet the goals. Indications for successes and failures of management measures taken so far, as well as dilemmas to cope with, are given. Up to now only small scale restoration projects have been executed, while large scale projects generally are not further then the thinking or planning phase. A special type of “restoration projects” are the large civil engineering works, particularly in the south-west of the Netherlands. Although these works were not planned and executed as restoration projects, but designed for safety against flooding from the sea, they have led to significant changes in the boundary conditions of the systems concerned.

Implementing agencies, policymakers

V.N. de Jonge and D.J. de Jong (2002) Ecological Restoration in Coastal Areas in the Netherlands: Concepts, Dilemmas and Some Examples. Hydrobiologia 478(1-3): 7-28.

http://www.springerlink.com/content/x645715216r70020/

Coastal/Marine>USA

National Review of Innovative and Successful Coastal Habitat Restoration

Examples of innovative and successful components of these efforts are summarized in this review. The information on projects and programs was collected through expert interviews and through a nationwide review of scientific literature, restoration plans, and Internet sources. The examples provided cover many coastal habitat types from the four coasts of the United States. The review provides information on restoration research and the innovative and successful components of funding, partnerships, planning, restoration methods and techniques, monitoring, adaptive management, information dissemination, and community involvement. The lessons learned from the experiences of the many sources noted in this review are summarized at the end of the paper.

Implementing agencies, practitioners, indigenous and local communities

Borde, A.B., L.K. O’Rourke, G.W. Williams, R.M. Thom and H.L Diefenderfer (2004) Battelle Marine Sciences Laboratory.

http://www.floridadep.org/water/wetlands/fwric/docs/Battelle_natreview.pdf

The Rehabilitation of the Tampa Bay Estuary, Florida, USA, as an Example of Successful Integrated Coastal Management

The first suggestion that controls on eutrophication and dredging impacts were needed came in 1969. The federal Water Pollution Control Administration recommended a water quality management plan and waste abatement program to control odour and other pollution symptoms in Hillsborough Bay, and a master plan for dredging and filling the bay.

Implementing agencies, policymakers

Lewis, R. R., P.A. Clark, W.K. Fehring, H.S. Greening, R.O. Johansson and R.T. Paul (1999) The rehabilitation of the Tampa Bay Estuary, Florida, USA, as an example of successful integrated coastal management. Marine Pollution Bulletin 37(8): 468-473.

http://www.seagrassrestorationnow.com/docs/Lewis%20et%20al.%201998%20Marine%20Pollution%20Bulletin-10.pdf

Restoration of Aquatic Systems

Simplistic thinking would have us believe that by eliminating the loading of a given pollutant, an aquatic system will revert to its previous pristine state. This premise is without scientific verification. Besides the fact that typically very little documentation exists defining what exactly that previous pristine state was, it should be noted that biological processes are non-linear. They reflect adaptations by populations and corresponding responses of trophic organization that are not predictable by linear models of recovery. This book makes a clear delineation between genuine restoration and public perception of restoration efforts. This work is the final volume of a trilogy derived from 70 field-years of data garnered from 10 different coastal systems on the Atlantic and Gulf coasts. The text provides a synthetic look at the restoration of aquatic systems, emphasizing the functional basis that supports such activities, followed by a review of the evidence of recovery.

Practitioners

Livingston, R.J. (2005) Restoration of Aquatic Systems. CRC Press.

http://www.crcpress.com/product/isbn/9780849319662

Coastal/Marine>Coral Reefs

Conservation of Coral Reefs through Active Restoration Measures: Recent Approaches and Last Decade Progress

The present essay reviews past decade’s (1994-2004) approaches and advances in coral reef restoration. While direct coral transplantation is still the primer vehicle of operations used, the concept of in situ and ex situ coral nurseries (the gardening concept), where coral materials (nubbins, branches, spats) are maricultured to a size suitable for transplantation, has been gaining recognition. The use of nubbins (down to the size of a single or few polyps) has been suggested and employed as a unique technique for mass production of coral colonies. Restoration of ship grounding sites and the use of artificial reefs have become common tools for specific restoration needs. Substrate stabilization, 3-D structural consideration of developing colonies, and the use of molecular/biochemical tools are part of novel technology approaches developed in the past decade.

Practitioners, implementing agencies

Rinkevich, B. (2005) Conservation of Coral Reefs through Active Restoration Measures: Recent Approaches and Last Decade Progress. Environmental Science and Technology 39: 4333-4342.

http://www.dlist-asclme.org/sites/default/files/doclib/181%20Conservation%20of%20Coral%20Reefs%20through%20Active%20Restoration%20Measures%20Recent%20Approaches%20and%20Last%20Decade%20Progress.pdf

Applying Forest Restoration Principles to Coral Reef Rehabilitation

We compare here the rationale of forest restoration to coral reef ecosystem restoration by evaluating major key criteria. As in silviculture programs, a sustainable mariculture operation that focuses on the prime structural component of the reef ('gardening' with corals) may promote the persistence of threatened coral populations, as well as that of other reef taxa, thus maintaining genetic diversity. In chronically degrading reef sites this may facilitate a halt in biodiversity depletion.

Practitioners

Epstein, N., R.P.M. Bak and B. Rinkevich (2003) Applying forest restoration principles to coral reef rehabilitation. Aquatic Conserv: Mar. Freshw. Ecosyst. 13: 387-395.

http://www.dlist-asclme.org/sites/default/files/doclib/158%20Applying%20forest%20restoration%20principles%20to%20coral%20reef%20rehabilitation.pdf

Knowledgebase for Lessons Learned and Good Practices in the Management of Coral Reefs

Now, researchers and resource managers can get helpful tips about proven strategies – or mistakes to avoid – in coral reef management in a new "Lessons Learned and Best Practices Toolkit." It offers access to technical reports, project summaries and other practical information about coral reef management in eight key areas, such as program design, community participation, policy development, monitoring approaches and capacity building. A brief presents a review of lessons learned and best practices in the management of coral reefs based on the analysis of 30 projects funded by the Global Environment Facility (GEF) related to coral reefs and associated tropical marine ecosystems and 26 non-GEF funded projects. The key lessons learned and recommendations are grouped according to eight priority issues in coral reef management.

Implementing agencies, practitioners

ReefBase: A Global Information System for Coral Reefs, A Project of the World Fish Center, Penang.

http://www.reefbase.org/gefll/

Atlantic Coral Reefs: The Transplantation Alternative

It is suggested that a recovery could be achieved through transplantation of corals and other reef species from areas where more diverse, relatively stable ecosystems still exist. Available data on the introduction of exotic species into marine ecosystems indicate that such species are generally accommodated and do not cause extinctions among the native species.

Implementing agencies

Briggs, J.C. (2009) Atlantic Coral Reefs: The Transplantation Alternative. Biological Invasions 11(8): 1845-1854.

http://www.springerlink.com/content/b350531123h4v783/

Poor Performance of Corals Transplanted onto Substrates of Short Durability

Worldwide, coral reefs are degrading due to increasing anthropogenic pressures. Yet, management of reefs still falls short of effectively addressing these threats, and active restoration methods are increasingly being called for. Coral transplantation is frequently advocated as a possible means of coral reef rehabilitation. Fragments produced in coral nurseries or farms have been proposed as a potential source for transplantation, and culture media (inexpensive but non-durable materials such as wood or bamboo) may serve as transplantation substrate if placed directly in the reef. However, the performance of coral transplants attached to such substrates has not been examined yet. The results show that, in places were currents or waves threaten to dislocate transplants, a higher effort needs to be directed at a strong and durable attachment of transplanted corals.

Practitioners

Ferse, S.C.A. (2010) Poor Performance of Corals Transplanted onto Substrates of Short Durability. Restoration Ecology 18(4): 399-407.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2010.00682.x/full

Marine Ecosystem Restoration: Costs and Benefits for Coral Reefs

Active global ecosystem restoration strategies are urgently needed to prevent crippling economic losses to marine biodiversity, fisheries, tourism, and coastal resources. Conventional reef restoration methods fail when water quality deteriorates or temperatures increase. Biorock electrolytic technology uniquely maintains healthy coral and fish populations under high temperatures and reduced water quality that are normally fatal. Low voltage direct electrical current provides calcareous substrate for corals (or oysters) to settle on and gives coral energy to grow it's skeleton, leaving the coral with more metabolic energy for growth, reproduction, and resisting environmental stress. Reefs can be restored in locations where they can no longer grow due to global warming and pollution, helping rebuild fisheries and protecting coastlines from erosion from sea level rise and increasing storm strength.

Practitioners, implementing agencies

Goreau, T.J. (2005) Marine Ecosystem Restoration: Costs and Benefits for Coral Reefs. World Resource Review 17(3): 375-409.

http://www.globalcoral.org/WRR%20Goreau%20%26%20Hilbertz%202005.pdf

Coastal/Marine>Coral Reefs>Indonesia

Multivariate Responses of the Coral Reef Fish Community to Artificial Structures and Coral Transplants

The effects of artificial structures and coral transplants on fish abundance, number of species, and community composition were examined during a two-year study at three locations in North Sulawesi, Indonesia. At all locations, multivariate dispersion of the fish community samples decreased with increasing complexity of the experimental plots. The results underline the importance of reef context in the selection of appropriate restoration measures and show that results may differ depending on condition of the ambient reef.

Practitioners, implementing agencies

Ferse, S.C.A. (2008) Multivariate Responses of the Coral Reef Fish Community to Artificial Structures and Coral Transplants. Proceedings of the 11th International Coral Reef Symposium, Ft. Lauderdale, Florida, 7-11 July 2008.

http://www.nova.edu/ncri/11icrs/proceedings/files/m24-07.pdf

Coastal/Marine>Coral Reefs>Japan

Long-term Effect of Coral Transplantation: Restoration Goals and the Choice of Species

The transplantation is an important method for the restoration of degraded ecosystem. However, it is unclear how the choice of species and transplantation mode affects the community dynamics during recovery from a disaster, particularly for long-lived organisms such as corals. To address this issue, we study a population dynamic model of multiple species in multiple habitats connected by larval dispersal. We first consider two species showing the trade-off relationship between growth rate and mortality and examine three restoration goals to evaluate the effectiveness of transplantation: (1) total coverage; (2) species diversity; (3) spatial heterogeneity of species composition. In summary, these results indicate that both the restoration goal and the transplanted species must be carefully selected before conducting transplantation operations.

Implementing agencies, practitioners

Muko, S. and Y. Iwasa (2011) Long-term Effect of Coral Transplantation: Restoration Goals and the Choice of Species. Journal of Theoretical Biology 280(1): 127-138.

http://www.sciencedirect.com/science/article/pii/S0022519311002128

Coastal/Marine>Coral Reefs>Philippines

Successful Transplantation of a Fragmenting Coral, Montipora digitata, for Reef Rehabilitation

The scleractinian coral Montipora digitata (Acroporidae) is a common reef flat species that thrives under high levels of light and water turbulence, and propagates successfully by natural fragmentation. It was used for transplantation experiments in an attempt to restore a degraded lagoon environment in the northwestern Philippines. Branches about 5 cm high from a natural population in the lagoon were transplanted to dead coral outcrops or knolls in two locations (Binlab and Malilnep-Ac) with different environmental characteristics. These results demonstrate the potential of coral transplantation to initiate the establishment of natural communities in degraded reef areas, a concern for coastal managers in developing countries.

Practitioners, implementing agencies

Gomez, E.D., H.T. Yap, P.C. Cabaitan and R.M. Dizon (2011) Successful Transplantation of a Fragmenting Coral, Montipora digitata, for Reef Rehabilitation. Coastal Management 39(5): 556-574.

http://www.tandfonline.com/doi/abs/10.1080/08920753.2011.600240

Coral Reef Restoration (Bolinao, Philippines) in the Face of Frequent Natural Catastrophes

This study analyzes the effects of these natural catastrophes on restoration efforts, and presents the successes and failures of recently used restoration instruments. Our results show that (1) in the nursery phase, consideration should be paid to depth-flexible constructions and tenable species/genotypes prioritization and (2) for transplantation acts, site/species deliberation, timing, and specific site selections should be taken into account. Only the establishment of large-scale nurseries and large transplantation measures and the adapting of restoration management to the frequently changing environment may forestall extensive reef degradation due to the combination of continuous anthropogenic and worsening global changes.

Implementing agencies, practitioners

Shaish, L., G. Levy, G. Katzir and B. Rinkevich (2010) Coral Reef Restoration (Bolinao, Philippines) in the Face of Frequent Natural Catastrophes. Restoration Ecology 18: 285-299.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2009.00647.x/abstract

Coastal/Marine>Coral Reefs>USA

Artificial Reefs as a Restoration Tool for Alaska's Coastal Waters

Currently, viable restoration options for mitigating habitat loss in Alaska's coastal waters are limited. At the same time, restoration methods applied in lower latitude marine habitats have not been explored in sub-Arctic marine ecosystems. Testing the efficacy of potential restoration tools in these ecosystems is necessary to determine effective enhancement and restoration options for Alaska's nearshore waters. Artificial reefs (AR) are commonly deployed in temperate to tropical marine waters for the purpose of enhancing fish abundance, or restoring habitat following the degradation or loss of natural structure to anthropogenic or acute natural events.

Implementing agencies, practitioners

Reynolds, B. (2007) Artificial reefs as a restoration tool for Alaska's coastal waters. Final report to U.S. Fish and Wildlife Service, Alaska Coastal Program. Prince William Sound Science Center, Cordova.

http://digitalcorpora.org/corp/nps/files/govdocs1/173/173566.pdf

Coastal/Marine>Dunes

Are Coastal Dune Management Actions for Biodiversity Restoration and Conservation Underpinned by Internationally Published Scientific Research?

In this contribution, we review past and present, internationally published scientific research and its most important consequences for nature management and the conservation/restoration of biodiversity. Results are contrasted with contemporary management practices in order to detect management shortcomings and fields where scientific research needs to be extended and published in order to fine-tune often expensive and quite radical irreversible management practices. In general, our mini-review stresses the need for process-based research on a broad spatial scale and detailed research at a local scale for the assessment of optimal nature management actions, especially in view of potential negative feedback mechanisms.

Implementing agencies

Bonte, D. and M. Hoffmann (2005) Are Coastal Dune Management Actions for Biodiversity Restoration and Conservation Underpinned by Internationally Published Scientific Research? Pp. 165-178 in Herrier J.L., J. Mees, A. Salman, J. Seys, H. Van Nieuwenhuyse and I. Dobbelaere (eds.) Proceedings 'Dunes and Estuaries 2005' – International Conference on Nature Restoration Practices in European Coastal Habitats, Koksijde, Belgium, 19-23 September 2005, VLIZ Special Publication 19.

http://www.vliz.be/imisdocs/publications/73783.pdf

Coastal/Marine>Dunes>Brazil

Restoration of a Restinga Sandy Coastal Plain in Brazil: Survival and Growth of Planted Woody Species

Although trees and shrubs predominantly compose natural restinga vegetation, local vegetation after impact was replaced by an exotic grass cover, which meant a drastic reduction in species richness. Thus, in this experiment we removed the grass cover, introduced shrub and tree species, and monitored survival and growth of 20 plants per species for 2 years. Despite the adversities imposed by the nutrient-poor sandy soil, 70% of the species showed high survival percentage and considerable growth. This report on restoration initiatives in the restingas points out the viability of shrub and tree plantation following exotic grass removal as a strategy to restore Brazilian coastal vegetation.

Practitioners, implementing agencies

Zamith, L.R. and F.R. Scarano (2006) Restoration of a Restinga Sandy Coastal Plain in Brazil: Survival and Growth of Planted Woody Species. Restoration Ecology 14(1): 87-94.

http://www2.ib.unicamp.br/profs/cjoly/CAMPO%2008/GRUPOS%2007/Zamith_Scarano.pdf

Coastal/Marine>Dunes>France

Sand Dune Restoration in North Brittany, France: A 10-Year Monitoring Study

Dunes, which account for 13% of the Ille et Vilaine north Brittany coast, France, were degraded by high tourist pressure, and they were restored from 1988 onward. Ten years after commencing work an assessment of the restoration was made on three dunes: Les Chevrets, L'Anse Du Guesclin, and Le Verger. Annual monitoring of the vegetation and dune morphology provided an opportunity to study the restoration process. The variation in species richness and floristic composition from one zone to another can be explained by abiotic factors such as salinity and the accretion of sand. The restoration was satisfactory in terms of the geomorphology. Marram grass is a good tool for restoring the topography, but it will take a very long time to restore the conservation value of the dune.

Implementing agencies, practitioners

Roze, F. and S. Lemauviel (2004) Sand Dune Restoration in North Brittany, France: A 10-Year Monitoring Study. Restoration Ecology 12(1): 29-35.

http://www.globalrestorationnetwork.org/uploads/files/CaseStudyAttachments/218_brittany-dunes.pdf

Coastal/Marine>Dunes>Portugal

Learning with Nature: A Sand Dune System Case Study

In 2005, after balancing several alternatives, the Leirosa sand dunes were reconstructed with layers of geotextiles filled with sand. Once the sand containers were in place, this protective barrier was covered with sand and planted with A. arenaria, turning this area into an attractive and safe coastal dune system. In March 2006, some problems occurred, probably caused by poor sealing of the geotextiles layers, which led to parts of the three bottom layers breaking open. To stabilize and reinforce the sand dune in this specific weakened area, we are currently analysing the use of geotextile tubes. The attempts to promote the sustainable rehabilitation of a dune system and the implied problems related to its location on a particularly harsh Atlantic coast are discussed in the paper.

Implementing agencies, practitioners

Schreck Reis, C., J. Antunes do Carmo and H. Freitas (2008) Learning with Nature: A Sand Dune System Case Study (Portugal). Journal of Coastal Research 24(6): 1506-1515.

http://www.jcronline.org/doi/abs/10.2112/07-0858.1

Coastal/Marine>Dunes>South Africa

Landscape Composition Influences the Restoration of Subtropical Coastal Dune Forest

Successional processes should increase habitat complexity, and increase resources available for forest-associated species. However, according to the theory of Island Biogeography, the size, amount of edge, and isolation of a habitat patch will influence the probability of successful colonization. If this is true for restoring patches of coastal dune forest, then restoration managers need to mitigate for spatial characteristics. We used patch occupancy models to assess correlations between the probability of forest birds and trees being present in a patch and patch characteristics that measured age, area, isolation, and the amount of edge.

Implementing agencies, practitioners

Grainger, M.J., R.J. van Aarde and T.D. Wassenaar (2011) Landscape Composition Influences the Restoration of Subtropical Coastal Dune Forest. Restoration Ecology 19 (101): 111-120.

http://www.ceru.up.ac.za/downloads/landscape_composition_influences.pdf

An Evaluation of Habitat Rehabilitation on Coastal Dune Forests in Northern KwaZulu-Natal, South Africa

The rehabilitation program conducted by Richards Bay Minerals (RBM) of areas exposed to opencast surface mining of sand dunes north of Richards Bay (28°43'S, 32°12'E) on the coast of northern KwaZulu-Natal Province commenced 16 years before this study and has resulted in the development of a series of known-aged stands of vegetation. By assuming that these spatially separated stands develop along a similar pathway over time, instantaneous sampling should reveal successional or other changes usually associated with aging and should provide an opportunity to evaluate the success of rehabilitation.

Implementing agencies, practitioners

van Aarde, R. J., S.M. Ferreira, J.J. Kritzinger, P.J. van Dyk, M. Vogt and T.D. Wassenaar (1996) An Evaluation of Habitat Rehabilitation on Coastal Dune Forests in Northern KwaZulu-Natal, South Africa. Restoration Ecology 4: 334-345.

http://www.ceru.up.ac.za/downloads/An_evaluation_of_habitat_rehabilitation.pdf

http://www.ceru.up.ac.za/downloads/On_the_rehabilitation_of_the_coastal.pdf

Coastal/Marine>Dunes>South Korea

Ecological Restoration of Coastal Sand Dunes in South Korea

Shinduri is considered as representative Korean natural sand dune ecosystem because of undisturbed status composed of primary dune including foredune and slack, and secondary dune and higher species richness than the other sand dunes. Therefore, other disturbed sand dunes should be restored following Shinduri sand dune structure and vegetation composition. The restoration options for sand dune areas in South Korea are as follows: the restoration of other sand dune areas toward the condition of Shinduri sand dune, introduction plant species of Shinduri sand dune into other sand dune areas, prohibition of artificial building and exotic soils, and conservation of sand dune surrounding areas.

Implementing agencies

Kim, K.D. and K. Ewing (2006) Ecological Restoration of Coastal Sand Dunes in South Korea. Journal of Coastal Research SI 39: 1259-1262.

http://siaiacad09.univali.br/ics2004/arquivos/263_kim.pdf

Coastal/Marine>Dunes>Spain

Restoration of Isolated and Small Coastal Sand Dunes on the Rocky Coast of Northern Spain

This study shows the results of a program that monitored the process of natural colonization of plant species in the restored dune over a period of seven years, until the loss of the dune by the action of storms in 2008. The results show that the vegetation dynamics in the restored dune followed a process of primary succession, with a progressive increase in species number, coverage and heterogeneity. The establishment of species was driven by the strong environmental gradient present perpendicular to the coastline. The results indicate that natural colonization in this coastal sector is now possible due to the large number of dune species present, and in spite of the isolation of the restored dune system and the loss and fragmentation of the dune habitats in the region.

Practitioners, implementing agencies

Gallego-Fernández, J.B., I.A. Sánchez and C. Ley (2011) Restoration of Isolated and Small Coastal Sand Dunes on the Rocky Coast of Northern Spain. Ecological Engineering 37(11): 1822-1832.

http://www.sciencedirect.com/science/article/pii/S0925857411002047

Coastal/Marine>Dunes>UK

Can Soil Seed Banks Contribute to the Restoration of Dune Slacks under Conservation Management?

Does the soil seed bank resemble the former early successional stages of a dune slack system more than the established later successional vegetation? Does it have the potential to contribute to the conservation of a highly endangered habitat? The soil seed bank can be expected to contribute to vegetation change after disturbance. Stimulation of germination from the seed bank through management may contribute to the conservation of both characteristic and threatened species typical of dune slacks.

Practitioners, implementing agencies

Plassmann, K., N. Brown, M.L.M. Jones and G. Edwards-Jones (2009) Can soil seed banks contribute to the restoration of dune slacks under conservation management? Applied Vegetation Science 12: 199-210.

http://onlinelibrary.wiley.com/doi/10.1111/j.1654-109X.2009.01014.x/abstract

Coastal/Marine>Dunes>USA

Sand Barrens Habitat Management: A Toolbox for Managers

This document presents a management toolbox for the application of disturbances to restore and manage rare sand barrens habitats. Although rare sand barrens communities are the focus of this report, the restoration and maintenance of sand barrens habitats may be similar to those found in other rare barrens types or managed habitats in general (e.g. old field maintenance). Described in this toolbox are the practical issues involving the use of prescribed fire (Section 4), prescribed grazing (Section 5), mowing (Section 6), clearing (Section 7), and herbicides (Section 8) to restore and maintain various habitats. In Section 9, using Martha's Vineyard as a case study, these methods are tied together, looking at ways to use the tools holistically to achieve habitat management objectives

Practitioners, implementing agencies

Raleigh, L., J. Capece and A. Berry (2003) Sand Barrens Habitat Management: A Toolbox for Managers. The Trustees of Reservations, Islands Regional Office, Vineyard Haven.

http://www.thetrustees.org/assets/documents/what-we-care-about/Toolbox.pdf

Sargassum as a Natural Solution to Enhance Dune Plant Growth

In this study, we used greenhouse studies to test the hypothesis that the addition of sargassum can increase soil nutrients and produce increased growth in dune plants. We also conducted an analysis of the nutrients in the sargassum to determine the mechanisms responsible for any growth enhancement. Panicum amarum showed significant enhancement of growth with the addition of sargassum, and while Helianthus debilis, Ipomoea stolonifera, Sporobolus virginicus, and Uniola paniculata responded slightly differently to the specific treatments, none were impaired by the addition of sargassum. In general, plants seemed to respond well to unwashed sargassum and multiple additions of sargassum, indicating that plants may have adapted to capitalize on the subsidy in its natural state directly from the ocean. For coastal managers, the use of sargassum as a fertilizer could be a positive, natural, and efficient method of dealing with the accumulation of wrack on the beach.

Implementing agencies, practitioners, policymakers

Williams, A. and R. Feagin (2010) Sargassum as a Natural Solution to Enhance Dune Plant Growth. Environmental Management 46: 738-747.

http://www.springerlink.com/content/6g2044r4t270378j/

The Effects of Organic Amendments on the Restoration of a Disturbed Coastal Sage Scrub Habitat

The effectiveness of organic mulch as a simple means of enhancing the restoration of disturbed lands by providing a competitive edge to native perennials, such as Artemisia californica (California sagebrush), over exotic annuals, such as Avena fatua (wild oat), was studied by investigating the effect of organic amendments on microbial activity and nitrogen immobilization through both soil analysis and aboveground plant growth. The addition of organic amendment resulted in an increase in microbial activity, a parallel increase in nitrogen immobilization, and no significant differences in total soil nitrogen. When the availability of nitrogen was reduced through increased immobilization, amended plots established an environment more conducive to native perennial shrubs, allowing them to out compete exotic annuals for water and nutrients. This simple procedure could have major implications for enhancing the restoration of disturbed lands.

Practitioners

Zink, T.A. and M.F. Allen (1998) The Effects of Organic Amendments on the Restoration of a Disturbed Coastal Sage Scrub Habitat. Restoration Ecology 6: 52-58.

http://onlinelibrary.wiley.com/doi/10.1046/j.1526-100x.1998.00617.x/abstract

Restoring Arthropod Communities in Coastal Sage Scrub

Coastal sage scrub in California and northern Baja California has been severely affected by urban expansion and is, in places, badly in need of restoration. We measured arthropod abundance and diversity on one of its primary components, the native shrub Artemisia californica (Asteraceae; California sage), to evaluate whether arthropod communities had become reestablished after a restoration attempt. We suggest that small-scale restoration attempts can be successful at restoring basic elements of surrounding biodiversity. They do create a different community, however, both taxonomically and functionally, and are at least initially less able to support rare species.

Practitioners

Burger, J.C., R.A. Redak, E.B. Allen, J.T. Rotenberry and M.F. Allen (2003) Restoring Arthropod Communities in Coastal Sage Scrub. Conservation Biology 17(2): 460-467.

ftp://roswell.sdsu.edu/pub/IEMM/CSS/Other%20papers/BurgerEtA_2003.pdf

The Roles of Exotic Grasses and Forbs when Restoring Native Species to Highly Invaded Southern California Annual Grassland

A 3-year experiment in southern California coastal sage scrub (CSS) now dominated by exotic grasses was done to investigate the influence of both exotic grasses (mainly *Bromus* spp.) and exotic forbs (mainly *Erodium* spp.) on a restoration seeding (9 species, including grasses, forbs, and shrubs). Experimental plots were weeded to remove one, both, or neither group of exotic species and seeded at a high rate with a mix of native species. Abundance of all species varied with precipitation levels, but seeded species established best when both groups of exotic species were removed. The removal of exotic grasses resulted in an increase in exotic and native forb cover, while removal of exotic forbs led to an increase in exotic grass cover and, at least in one year, a decrease in native forb cover. Therefore, management of CSS and exotic grassland in southern California and similar areas must consider control of both exotic grasses and forbs when restoration is attempted.

Practitioners

Cox, R.D. and E.B. Allen (2011) The Roles of Exotic Grasses and Forbs when Restoring Native Species to Highly Invaded Southern California Annual Grassland. Plant Ecology 212(10): 1699-1707.

http://www.springerlink.com/content/v7h1303226668189/

Yellow Bush Lupine Invasion in Northern California Coastal Dunes: Ecological Impacts and Manual Restoration Techniques

We studied the ecological effects of the invasion of coastal dunes by *Lupinus arboreus* (yellow bush lupine), an introduced species, and used the results to develop manual restoration techniques on the North Spit of Humboldt Bay. Vegetation and soil data were collected in five vegetation types representing points along a continuum of bush lupine's invasive influence. We collected data on the number and size of shrubs, vegetation cover, and soil nutrients. One set of plots was subjected to two restoration treatments: removal of lupine shrubs only, or removal of all nonnative vegetation and removal of litter and duff. Treatments were repeated annually for four years, and emerging lupine seedlings were monitored for three years. Prior to treatment, ammonium and nitrate were found to increase along the lupine continuum, but organic matter decreased at the extreme lupine end. Yellow bush lupine was not the most significant variable affecting variation in soil nutrients.

Practitioners

Pickart, A.J., L.M. Miller and T.E. Duebendorfer (1998) Yellow Bush Lupine Invasion in Northern California Coastal Dunes: Ecological Impacts and Manual Restoration Techniques. Restoration Ecology 6: 59-68.

http://onlinelibrary.wiley.com/doi/10.1046/j.1526-100x.1998.00618.x/abstract

Restoring the Grasslands of Northern California's Coastal Dunes

Today dune restoration projects take place all along our coast, some with the goal of restoring native foredune grassland. At the Lanphere Dunes, areas once covered with monotypic stands of European beachgrass now boast mixed stands of native grasses and brilliant wildflowers.

Implementing agencies, practitioners

Pickart, A.J. (2008) Restoring the Grasslands of Northern California's Coastal Dunes. California Native Grasslands Association.

http://www.fws.gov/humboldtbay/pdfs/grasslandsarticle.pdf

Coastal/Marine>Estuaries

Ecological Restoration and Estuarine Management: Placing People in the Coastal Landscape

If we are to avoid the harsh lessons of the utilization of terrestrial resources, scientists, practitioners and coastal managers will have to find a middle ground between continued economic growth and preservation/conservation of coastal resources. Success will require broad acceptance that humans are as coastally dependent as any part of the biota, and that future plans for managing, restoring and/or rehabilitating estuarine ecosystems must recognize that humans occupy the highest level of the ecological–cultural landscape.

Practitioners, implementing agencies, policymakers

Weinstein, M.P. (2007) Ecological Restoration and Estuarine Management: Placing People in the Coastal Landscape. Journal of Applied Ecology 45(1): 296-304.

http://www.monmouth.edu/uploadedFiles/Resources/Urban_Coast_Institute/JofAppliedEcologyWeinstein.pdf

Coastal/Marine>Estuaries>Australia

Community Estuarine Monitoring Manual

This manual presents an estuarine monitoring framework that is suitable for use by a wide range of community groups including a range of activities that these groups may wish to explore.

Implementing agencies, practitioners

South Australia Environment Protection Agency

http://www.epa.sa.gov.au/xstd_files/Water/Report/cemm_a.pdf

Coastal/Marine>Estuaries>China

Habitat Management and Maintenance in a Restored Coastal Wertland: The Maipo Nature Reserve, Hong Kong Special Administrative Region, China

This case study demonstrates sustainable coastal aquaculture techniques, and how wetland habitats can be created and maintained to achieve specific conservation goals, with the ecological value of a reserve balanced by the need for public access.

Practitioners, implementing agencies

English, Chinese

Cui, L.J. and S.L. Ai (eds.) (2006) Pp. 204-213 in The Wetland Restoration Handbook: Guiding Principles and Case Studies. China Architecture and Building Press, Beijng.

http://ed.edaw.com/eNewsData/articleDocuments/75332_Wetland%20Handbook%20Launch%20Announcement-eng.PDF

Coastal/Marine>Estuaries>Europe

A New Technique for Tidal Habitat Restoration: Evaluation of its Hydrological Potentials

The inability to create an adequate tidal regime in embanked areas is a major problem for restoring estuarine habitats. The controlled reduced tide system (CRT) was previously hypothesized to overcome this constraint. As part of an estuarine management plan which combines flood protection and tidal habitat restoration, the first CRT system was implemented in the freshwater zone of the Schelde estuary (Belgium). Based on four years of high-frequency monitoring on the first CRT and the adjacent estuary, this study demonstrates the hydrological functionality of CRT.

Practitioners, implementing agencies

Beauchard, O., S. Jacobs, T.J.S. Cox, T. Maris, D. Vrebos, A. Van Braeckel and P. Meire (2011) A New Technique for Tidal Habitat Restoration: Evaluation of its Hydrological Potentials. Ecological Engineering 37(11): 1849-1858.

http://www.sciencedirect.com/science/article/pii/S0925857411001972

Ecological Rehabilitation of the Schelde Estuary (The Netherlands–Belgium; Northwest Europe): Linking Ecology, Safety Against Floods, and Accessibility for Port Development

This study focuses on the ecological rehabilitation of the estuary and the creation of sustainable nature, seeking possible alliances with security measures against floods, navigation requisites for port activities, and enhancement of the estuary's educational and recreational values. The estuary and its valley were subdivided into ecologically relevant zones. Key parameters were identified, and a conceptual rehabilitation model was developed, based on a problem analysis. Goals were set in a semi-quantified way for most attributes of the estuarine functioning and prioritized for each zone. Rehabilitation measures with maximal contribution to the priority goals were identified for each zone. Spatial analysis of the study area indicated optimal areas for the implementation of these measures. To exemplify the array of possibilities on an ecosystem level, two different rehabilitation plans were proposed, each from a different approach. The potential contribution to the rehabilitation of the estuary was compared for both alternatives.

Policymakers, implementing agencies

Van den Bergh, E., S. Van Damme, J. Graveland, D. De Jong, I. Baten and P. Meire (2005) Ecological Rehabilitation of the Schelde Estuary (The Netherlands–Belgium; Northwest Europe): Linking Ecology, Safety Against Floods, and Accessibility for Port Development. Restoration Ecology 13: 204-214.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2005.00025.x/abstract

Coastal/Marine>Estuaries>USA

Species-rich Plantings Increase Biomass and Nitrogen accumulation in a Wetland Restoration Experiment

Our test of the hypothesis that biomass and nitrogen would increase with more species-rich plantings simultaneously vegetated a salt marsh restoration site and demonstrated that on average, randomly chosen, 6-species plantings accumulated more biomass and nitrogen than the mean for 0- and 1-species assemblages, with the mean for 3-species assemblages being intermediate. Thus, ecosystem function, as measured by biomass and N accumulation, increased with species richness regardless of dominance by the highly productive Sv. We conclude that manipulating the richness and composition of plantings offers ecosystem restorationists an effective tool for accelerating the rate of functional development.

Practitioners, implementing agencies

Callaway, J.C., G. Sullivan and J.B. Zedler (2003) Species-rich Plantings Increase Biomass and Nitrogen accumulation in a Wetland Restoration Experiment. Ecological Applications 13: 1626-1639.

http://www.esajournals.org/doi/abs/10.1890/02-5144

Fish Community Responses to Ecosystem Stressors in Coastal Estuarine Wetlands: A Functional Basis for Wetlands Management and Restoration

Functional responses of estuarine fish species to environmental perturbations such as wetland impoundment, changes in water quality, and sediment accretion are investigated. The study focuses on the feeding, growth and habitat use by California killifish (Fundulus parvipinnis), topsmelt (Antherinops affinis), and juvenile California halibut (Paralichthys californicus) in impacted coastal wetlands to provide an ecological basis for guidance on the management and restoration of these ecosystems.

Practitioners, implementing agencies

Madon, S.P. (2008) Fish Community Responses to Ecosystem Stressors in Coastal Estuarine Wetlands: A Functional Basis for Wetlands Management and Restoration. Wetlands Ecology and Management 16(3): 219-236.

http://www.springerlink.com/content/u6138315003hg62l/

Living Shoreline Design Guidelines for Shore Protection in Virginia's Estuarine Environments

These guidelines are meant to address the need to educate consultants, contractors, and other professionals in the use of living shoreline strategies. It provides the necessary information to determine where they are appropriate and what is involved in their design and construction.

The guidelines focus on the use of created marsh fringes but also touch on the use of beaches for shore protection. The guidelines were created for the Virginia portion of the Chesapeake Bay estuarine system but may be applicable to other similar estuarine environments. These references and tools are for guidance only and should not replace professional judgments made at specific sites by qualified individuals.

Policymakers, implementing agencies, practitioners

Hardaway, Jr., C.S., D.A. Milligan and K. Duhring (2010) Living Shoreline Design Guidelines for Shore Protection in Virginia's Estuarine Environments. Special Report in Applied Marine Science and Ocean Engineering No. 421, Center for Coastal Resources Management, Virginia Institute of Marine Science, College of William & Mary, Gloucester Point.

http://web.vims.edu/physical/research/shoreline/docs/LS_Design_final_v1.2.pdf

http://www.cbf.org/Document.Doc?id=60

Coastal/Marine>Mangroves

Ecological Engineering for Successful Management and Restoration of Mangrove Forests

Great potential exists to reverse the loss of mangrove forests worldwide through the application of basic principles of ecological restoration using ecological engineering approaches, including careful cost evaluations prior to design and construction. Previous documented attempts to restore mangroves, where successful, have largely concentrated on creation of plantations of mangroves consisting of just a few species, and targeted for harvesting as wood products, or temporarily used to collect eroded soil and raise intertidal areas to usable terrestrial agricultural uses. I document here the importance of assessing the existing hydrology of natural extant mangrove ecosystems, and applying this knowledge to first protect existing mangroves, and second to achieve successful and cost-effective ecological restoration, if needed.

Implementing agencies, practitioners

Lewis III, R.R. (2005) Ecological engineering for successful management and restoration of mangrove forests. Ecological Engineering 24: 403–418.

http://www.mangroverestoration.com/Ecol_Eng_Mangrove_Rest_Lewis_2005.pdf

Mangrove Restoration: A Potential Tool for Coastal Management in Tropical Developing Countries

Past mangrove restoration projects in developing countries have focused only on methods of re-establishing trees, with little attention given to assessing whether ecosystem function is restored. However, the goal of mangrove restoration projects should be to actively promote a return to the natural assemblage structure and function (within the bounds of natural variation) that is self-sustaining. This goal requires: (i) identifying the natural state, including key organisms in maintaining the physical substratum, community structure and food webs maintaining fish stocks; (ii) developing biotechnology for restoring key organisms; and (iii) assessing the long-term success of the project. As restoration promises to be an important tool for maintaining coastal ecosystem health in developing countries, priority should be given to incorporating restoration projects and their evaluation into coastal management plans.

Policymakers, implementing agencies

Kaly, U.L. and G.P. Jones (1998) Mangrove Restoration: A Potential Tool for Coastal Management in Tropical Developing Countries. Ambio 27(8): 656-661.

http://www.jstor.org/discover/10.2307/4314812?uid=3739256&uid=2134&uid=2&uid=70&uid=4&sid=55992928733

Functionality of Restored Mangroves: A Review

Widespread mangrove degradation coupled with the increasing awareness of the importance of these coastal forests have spurred many attempts to restore mangroves but without concomitant assessment of recovery (or otherwise) at the ecosystem level in many areas. This paper reviews literature on the recovery of restored mangrove ecosystems using relevant functional indicators. The paper finally recommends various mangrove restoration pathways in a functional framework dependent on site conditions and emphasizes community involvement and ecosystem level monitoring as integral components of restoration projects.

Practitioners, implementing agencies, indigenous and local communities

Bosire, J.O., F. Dahdouh-Guebas, M. Walton, B.I. Crona, R.R. Lewis III, C. Field, J.G. Kairo and N. Koedam (2008) Functionality of Restored Mangroves: A Review. Aquatic Botany 89: 251-259.

http://www.vliz.be/imisdocs/publications/146393.pdf

Plant Growth-Promoting Bacteria: A Potential Tool for Arid Mangrove Reforestation

The highly productive and diverse microbial community living in tropical and subtropical mangrove ecosystems continuously transforms dead vegetation into sources of nitrogen, phosphorus, and other nutrients that can later be used by the plants. In turn, plant-root exudates serve as a food source for the microorganisms living in the ecosystem, with other plant material serving a similar role for larger organisms, such as crabs and detritus feeding fish. This speculative synthesis of recent work on growth-promoting bacteria proposes that mangrove rhizosphere bacteria be used as a tool to enhance reforestation with mangrove seedlings. This can be done by inoculating seedlings with plant growth-promoting bacteria participating in one or more of the microbial cycles of the ecosystem.

Practitioners

Bashan, Y. and G. Holguin (2002) Plant Growth-Promoting Bacteria: A Potential Tool for Arid Mangrove Reforestation. Trees 16:159-166.

http://bashanfoundation.org/gmaweb/pdfs/plantgrowth.pdf

Bioremediation of Mangroves Impacted by Petroleum

This review will present the state of the art of bioremediation in oil-contaminated mangroves, new data about the use of different mangrove microcosms with and without tide simulation, the main factors that influence the success of bioremediation in mangroves and new prospects for the use of molecular tools to monitor the bioremediation process. We believe that in some environments, such as mangroves, bioremediation may be the most appropriate approach for cleanup. Because of the peculiarities and heterogeneity of these environments, which hinder the use of other physical and chemical analyses, we suggest that measuring plant recuperation should be considered with reduction in polycyclic aromatic hydrocarbons (PAHs). This is a crucial discussion because these key marine environments are threatened with worldwide disappearance. We highlight the need for and suggest new ways to conserve, protect and restore these environments.

Practitioners

Santos, H.F., F.L. Carmo, J.E.S. Paes, A.S. Rosado and R.S. Peixoto (2011) Bioremediation of Mangroves Impacted by Petroleum. Water, Air, & Soil Pollution 216(1-4): 329-350.

http://www.springerlink.com/content/98k6064pv2345512/

Are All Intertidal Wetlands Naturally Created Equal? Bottlenecks, Thresholds and Knowledge Gaps to Mangrove and Saltmarsh Ecosystems

Intertidal wetlands such as saltmarshes and mangroves provide numerous important ecological functions, though they are in rapid and global decline. To better conserve and restore these wetland ecosystems, we need an understanding of the fundamental natural bottlenecks and thresholds to their establishment and long-term ecological maintenance. Despite inhabiting similar intertidal positions, the biological traits of these systems differ markedly in structure, phenology, life history, phylogeny and dispersal, suggesting large differences in biophysical interactions. By providing the first systematic comparison between saltmarshes and mangroves, we unravel how the interplay between species-specific life-history traits, biophysical interactions and biogeomorphological feedback processes determine where, when and what wetland can establish, the thresholds to long-term ecosystem stability, and constraints to genetic connectivity between intertidal wetland populations at the landscape level. To understand these process interactions, research into the constraints to wetland development, and biological adaptations to overcome these critical bottlenecks and thresholds requires a truly interdisciplinary approach.

Practitioners

Friess, D.A., K.W. Krauss, E.M. Horstman, T. Balke, T.J. Bouma, D. Galli and E.L. Webb (2012) Are All Intertidal Wetlands Naturally Created Equal? Bottlenecks, Thresholds and Knowledge Gaps to Mangrove and Saltmarsh Ecosystems. Biology Review 87(2): 346-366.

http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2011.00198.x/abstract

Coastal/Marine>Mangroves>Africa

Restoration and Management of Mangrove Systems: A Lesson for and from the East African Region

This paper outlines the activities of mangrove restoration and management around the world with particular emphasis on Eastern Africa. As noted here, extensive research has been carried out on the ecology, structure and functioning of the mangrove ecosystem. However, the findings have not been interpreted in a management framework, thus mangrove forests around the world continue to be over-exploited, converted to aquaculture ponds, and polluted. We strongly argue that links between research and sustainable management of mangrove ecosystems should be established.

Implementing agencies, policymakers

Kairo, J.G., F. Dahdouh-Guebas, J. Bosire and N. Koedam (2001) Restoration and Management of Mangrove Systems: A Lesson for and from the East African Region. South African Journal of Botany 67: 383-389.

http://www.vliz.be/imisdocs/publications/97846.pdf

Coastal/Marine>Mangroves>Asia-Pacific

Waves of Hope

The workshop brought together 15 national representatives from seven countries1 (India, Indonesia, Malaysia, Maldives, Myanmar, Sri Lanka, and Thailand) affected by the 26 December 2004 tsunami in Asia. They were joined by about 30 representatives from international and regional organizations. The workshop provided participants the opportunity to share information, collectively assess initial findings related to rehabilitation needs and opportunities, share plans and proposals for future rehabilitation work and develop mechanisms for collaboration and joint activities.

Policymakers, implementing agencies

FAO (2005) Waves of Hope. Report of the Regional Coordination Workshop on Rehabilitation of Tsunami-affected Forest Ecosystems: Strategies and New Directions. RAP Publication - 2005/07. Rome: FAO.

ftp://ftp.fao.org/docrep/fao/008/ae547e/ae547e00.pdf

Guidelines for the Rehabilitation of Mangroves and other Coastal Forests damaged by Tsunamis and other Natural Hazards in the Asia-Pacific Region

The Proceedings are a compendium of two meetings organised by ISME and ITTO in collaboration with a number of institutions in the host countries. This publication represents one of the outputs of the ISME/ITTO Pre-Project PPD 134/07 Rev. 1 (F) on Guidelines for the Restoration of Mangroves and other Coastal Forests damaged by Tsunamis and other Natural Hazards in the Asia-Pacific Region..

Policymakers, implementing agencies

Chan, H.T and J.E. Ong (eds.) (2008) Proceedings of the meeting and workshop on Guidelines for the Rehabilitation of Mangroves and other Coastal Forests damaged by Tsunamis and other Natural Hazards in the Asia-Pacific Region. ITTO/ISME PPD 134/07 Rev. 1 (F) Meeting: Okinawa, Japan, 15-16 June 2007, Workshop: Bangkok, Thailand, 23 August 2008

http://www.glomis.com/Proceedings_No5-2.pdf

A Unified Framework for the Restoration of Southeast Asian Mangroves: Bridging Ecology, Society and Economics

The effect of intensive human intervention, poor socio-economic conditions and little knowledge on mangrove ecology pose enormous challenges for mangrove restoration in Southeast Asia. We present a framework for tropical mangrove restoration. Our proposed restoration framework addresses the ecology, economy and social issues simultaneously by considering the causes of mangrove degradation. We provide a step by step guideline for its restoration. We argue that although, ecological issues are of prime importance, economic and social issues must be considered in the restoration plan in order for it to be successful.

Implementing agencies, practitioners, indigenous and local communities, policymakers

Biswas, S.R., A.U. Mallik, J.K. Choudhury and A. Nishat (2009) A unified framework for the restoration of Southeast Asian mangroves-bridging ecology, society and economics. Wetlands Ecology and Management 17: 365-383.

http://www.mangroverestoration.com/pdfs/Biswas%20et%20al%202009.pdf

Efficacy of Alternative Low-cost Approaches to Mangrove Restoration, American Samoa

Three mangrove restoration methods were tested at Nu'uuli, Tutuila Island, American Samoa. Since clearing 27 years ago converted the mangrove into a mudflat, the ecosystem was sufficiently altered that it could not self-correct; the ecosystem showed no natural regrowth despite an ample supply of propagules. While several years of monitoring may ultimately be required to determine the project's success, and several decades could be required to fully return the full suite of functions, the project's low-cost, nontechnical restoration techniques, using readily available materials, have proven to be modestly successful, with 38% sapling survival after six months.

Implementing agencies, practitioners

Gilman, E. and J. Ellison (2007) Efficacy of Alternative Low-cost Approaches to Mangrove Restoration, American Samoa. Estuaries and Coasts 30(4): 641-651.

http://www.botany.hawaii.edu/basch/uhnpscesu/pdfs/sam/Gilman2007aAS.pdf

Coastal/Marine>Mangroves>Caribbean

Ecology of Mangrove Growth and Recovery in the Lesser Antilles: State of Knowledge and Basis for Restoration Projects

Whereas the increasing knowledge on tropical coastal wetlands highlights the ecological and economical importance of such ecosystems, anthropogenic activities within the coastal zone have caused substantial, irreversible losses of mangrove areas in the Lesser Antilles during the last decades. Such a paradox gives strength to compensatory policy efforts toward mangrove restoration. We review the available knowledge on the ecology of mangrove growth and recovery in the Lesser Antilles as a contribution to possible restoration projects in such islands. From these results we attempt to answer the questions when, where, how to plant mangroves, and what species to use.

Implementing agencies, practitioners

Imbert, D., A. Rousteau and P. Scherrer (2000) Ecology of Mangrove Growth and Recovery in the Lesser Antilles: State of Knowledge and Basis for Restoration Projects. Restoration Ecology 8: 230–236.

http://onlinelibrary.wiley.com/doi/10.1046/j.1526-100x.2000.80034.x/full

Demonstration of a New Technology for Restoration of Red Mangrove (Rhizophora mangle) in High-Energy Environments

We present here the initial field results from a pilot test of a new technique for the restoration of R. mangle in high-energy environments, using anchored armored concrete cultivator pots to stabilize the juvenile mangrove until it can establish a network of buttress roots. Mangroves were reared in a nursery for 15 months before transplantation to fully and partially exposed field sites. Mangroves transplanted in this way on Grand Cayman Island were able to survive two direct hurricane hits shortly after transplantation during the hurricane season of 2008, with survival rates ranging from 42% to 73% depending on the exposure of the site. We discuss the implications of these results and a proposed revision to our technique, which we hope will eliminate the work-intensive and costly nursery phase while also facilitating higher survival rates by minimizing washout, which was a key source of mortality, accounting for 20%-50% of mortalities, depending on site.

Implementing agencies, practitioners

Krumholz, J. and C. Jadot (2009) Demonstration of a New Technology for Restoration of Red Mangrove (Rhizophora mangle) in High-Energy Environments. Marine Technology Society Journal 1: s64-s72.

http://www.ci.uri.edu/ciip/Publications/KrumholzJadot2009.pdf

Coastal/Marine>Mangroves>China

Mangrove Wetlands Restoration at Luoyang River, Huian Country, Fujian Province, China

The restoration of the mangrove wetlands at Luoyang River started in 2001 at the discretion of Huian County Forestry Bureau. In order to recovery mangrove area, mangrove foresting species and site were selected, the method of filling bare areas with new mangrove shoots and then expand the mangrove area outwards was employed.

Practitioners, implementing agencies

English, Chinese

Cui, L.J. and S.L. Ai (eds.) (2006) Pp. 198-203 in The Wetland Restoration Handbook: Guiding Principles and Case Studies. China Architecture and Building Press, Beijng.

http://ed.edaw.com/eNewsData/articleDocuments/75332_Wetland%20Handbook%20Launch%20Announcement-eng.PDF

Coastal/Marine>Mangroves>Colombia

Reasons for Reforestation Success and Failure with Three Mangrove Species in Colombia

The experiments with Avicennia germinans, Laguncularia racemosa, and Rhizophora mangle showed that the reforestation success depends mainly on site selection and preparation. Generally, all species developed best at sites with low salinities and a water level near the soil surface. Highest mortalities were found in set propagules and seedlings of L. racemosa and A. germinans, whereas the best survival rates occurred in R. mangle propagules as well as in L. racemosa saplings. Growth rates, especially of L. racemosa, were extremely high when the ecological factors were favourable, and flowering set in early.

Practitioners, implementing agencies

Elster, C. (2000) Reasons for Reforestation Success and Failure with Three Mangrove Species in Colombia. Forest Ecology and Management 131(1-3): 201-214.

http://www.sciencedirect.com/science/article/pii/S0378112799002145

Coastal/Marine>Mangroves>India

Manual on Mangrove Nursery Raising Techniques

The techniques for mangrove nursery design, establishment and operation, and the use of nursery stock for mangrove restoration, which are described in this manual will help in raising mangrove nurseries and in the restoration of degraded mangroves, involving local communities.

Practitioners

Ravishankar, T. and R. Ramasubramanian (2004) Manual on mangrove nursery techniques. M.S. Swaminathan Research Foundation, Chennai.

http://info.frim.gov.my/cfdocs/tsonami2/Ravishankar,%20T.%20and%20R.%20Ramasubramanian.%202004.Mangrove%20Nursery%20Manual.pdf

Impact of Eco-Restoration on the Biodiversity of Sundarbans Mangrove Ecosystem, India

A comprehensive study on biodiversity and environmental characteristics of three different selected study sites located on different estuarine networks viz. Matla, Saptamukhi, and Hooghly on eastern, central, and western regions, having different environmental features of Sundarbans Mangrove Ecosystem, India, a World Heritage Site, was conducted through six seasons of consecutive 2 years. The different sites understudy have shown variable species composition. Special emphasis was made to record the population structure of benthic fauna, which exhibited maximum density during pre-monsoon followed by monsoon and post-monsoon.

Practitioners, implementing agencies

Chakraborty, S. K., S. Giri, G. Chakravarty and N. Bhattacharya (2009) Impact of Eco-restoration on the Biodiversity of Sundarbans Mangrove Ecosystem, India. Water, Air, & Soil Pollution 9(3-4): 303-320.

http://www.springerlink.com/content/7l8l700h76u04622/

Mangrove Forest Restoration in Andhra Pradesh, India

This publication reflects the process and results of restoration activities carried out over seven years by the project Coastal Wetlands: Mangrove Conservation and Management, implemented in Godavari and Krishna wetlands by MSSRF with its field centre at Kakinada. Hence it will be necessary to make modifications as per the site conditions, mangrove ecosystem, tidal amplitude and topography of the area chosen for restoration. This publication is meant for foresters, field technicians, researchers and others interested in restoration of degraded mangroves.

Practitioners, implementing agencies

Ramasubramanian, R. and T. Ravishankar (2004) Mangrove Forest Restoration in Andhra Pradesh, India. M.S. Swaminathan Research Foundation, Chennai.

http://www.mssrf.org/csr/csr-pub/12-Mangrove%20forest%20restoration%20in%20AP.pdf

Coastal/Marine>Mangroves>Indonesia

Study of Lessons Learned from Mangrove/Coastal Ecosystem Restoration Efforts in Aceh since the Tsunami

In this study, the causes of failures have been identified and extracted from a variety of stakeholders. It is important that all stakeholders in Aceh be informed of these so that they can avoid the factors that contribute to failure. In this way, past mistakes can be prevented from being repeated in the future. In addition, this study also provides a range of information, experience, strategies and other matters relevant to supporting the rehabilitation activities undertaken by both government and NGOs.

Implementing agencies, policymakers

Wibisono, I.T.C. and I.N.N. Suryadiputra (2006) Study of Lessons Learned from Mangrove/Coastal Ecosystem Restoration Efforts in Aceh since the Tsunami. Wetlands International – Indonesia Programme, Bogor.

http://www.wetlands.or.id/PDF/buku/Lessons%20Learned%20in%20Aceh%20by%20WIIP.pdf

Coastal/Marine>Mangroves>Mexico

Conceptual Framework for Mangrove Restoration in the Yucatán Peninsula

The studies performed over the last ten years by the mangrove group at Centro de Investigación y de Estudios Avanzados (CINVESTAV), in collaboration with other institutions, resulted in a conceptual framework that we present here as a methodological approach for the ecological restoration of mangroves in the Yucatán Peninsula. The conceptual framework is based on the relationships among the geomorphology, hydrology, and structural and functional characteristics of mangroves that are associated with the environmental services offered by these ecosystems. The methodological approach is fundamentally concerned with the particular characteristics of the karstic environmental setting of the Yucatán Peninsula as well as social and economic aspects of restoration. This approach to mangrove restoration includes stages for planning, implementing, and monitoring mangrove restoration programs in karstic environments.

Practitioners, implementing agencies

Zaldívar-Jiménez, M.A., J.A. Herrera-Silveira, C. Teutli-Hernández, F.A. Comín, J.L. Andrade, C.C. Molina and R. Pérez Ceballos (2010) Conceptual Framework for Mangrove Restoration in the Yucatán Peninsula. Ecological Restoration 28(3): 333-342.

http://www.mangroverestoration.com/pdfs/Zaldivar-MangrovesRestoration%202010.pdf

Coastal/Marine>Mangroves>Panama

Mangrove Reforestation in Panama: An Evaluation of Planting in Areas Deforested by a Large Oil Spill

In Panama, and most other places, restoration of mangrove forests following large oil spills had chiefly focused on replanting in deforested oil gaps. In these instances, recovery might take at least 25-30 yr for mangroves to approach their pre-spill condition, based chiefly on plant growth estimates of Rhizophora species. The kinds of assistance applied in the past included removal of oil and/or replanting. However, in providing assistance we presume, suspect, or know, that natural processes, like recruitment and plant growth, are unable to repair habitat damage both in the short and longer term, or either. Unfortunately, our collective experience with these matters remains inadequate so all measures applied must be treated as experimental. Therefore, restoration programs must be subject to close scrutiny, and they must be carefully monitored to assess their success or failure. If this is not done, we run the risk of re-applying damaging techniques which might worsen already fragile conditions in oil-damaged mangroves.

Practitioners, implementing agencies

Duke, N.C. and C.D. Field (1996) Mangrove Reforestation in Panama: An Evaluation of Planting in Areas Deforested by a Large Oil Spill in Restoration of mangrove ecosystems. C. Field, ed., International Society for Mangrove Ecosystems, Okinawa, Japan,Publisher: International Society for Mangrove Ecosystems, Pages: 209-232.

http://www.mendeley.com/research/mangrove-reforestation-panama-evaluation-planting-areas-deforested-large-oil-spill/

Coastal/Marine>Mangroves>Philippines

Human Ecological Questions for Tropical Restoration: Experiences from Planting Native Upland Trees and Mangroves in the Philippines

The restoration efforts that were most successful were ones in which the cooperators were committed, technically able to do the tasks, and able to gain the support of the wider community. Learning from these issues, the program engaged in a different strategy for promoting soil and water conservation - offering training workshops and demonstrations with farmers in the communities. Although there was still variance in the villages' success, the soil and water component with the intensive group training and community promotion was more successful for the tree planting which trained and depended only on the village leaders. Similarly, in the mangrove planting, planting was more successful when the social organization of the community was taken into consideration. The author provides a checklist of questions that should be used to guide restoration efforts.

Practitioners, implementing agencies, indigenous and local communities

Walters, B.B. (1997) Human ecological questions for tropical restoration: Experiences from planting native upland trees and mangroves in the Philippines. Forest Ecology and Management 99(1-2): 275-290.

http://reforestation.elti.org/resource/78/

Local Mangrove Planting in the Philippines: Are Fisherfolk and Fishpond Owners Effective Restorationists?

Local fisherfolk and fishpond owners have been practicing “restoration” of mangrove forests in some parts of the Philippines for decades, well before governments and NGO’s began to promote the activity as a conservation tool. This paper examines ecological characteristics of these mangrove plantations and compares them to natural mangroves in the same areas. Important ecological and economic benefits result from local mangrove planting, but “catalyzing diverse forest regeneration” – at least in the short to medium term – is not one of them. The lesson: if you want to restore diverse mangrove forests, you have to plant diverse mangrove forests.

Implementing agencies, practitioners, indigenous and local communities

Walters, B.B. (2000) Local mangrove planting in the Philippines: Are fisherfolk and fishpond owners effective restorationists? Restoration Ecology 8(3): 237-246.

http://138.73.1.35/faculty/socsci/geograph/Walters/restoration_ecology_1.pdf

A Review of Mangrove Rehabilitation in the Philippines: Successes, Failures and Future Prospects

This paper reviews eight mangrove initiatives in the Philippines and evaluates the biophysical and institutional factors behind success or failure. The authors recommend specific protocols (among them pushing for a 4:1 mangrove to pond ratio recommended for a healthy ecosystem) and wider policy directions to make mangrove rehabilitation in the country more effective.

Implementing agencies, practitioners, indigenous and local communities

Primavera, J.H. and J.M.A. Esteban (2008) A Review of Mangrove Rehabilitation in the Philippines: Successes, Failures and Future Prospects. Wetlands Ecology and Management 16(5): 345-358.

http://www.springerlink.com/content/x6155715188v774k/fulltext.pdf

Growth Performance of Planted Mangroves in the Philippines: Revisiting Forest Management Strategies

This article synthesizes the results from several research projects assessing the performance of planted mangroves across the country. Overall, there is a widespread tendency to plant mangroves in areas that are not the natural habitat of mangroves, converting mudflats, sandflats, and seagrass meadows into often monospecific Rhizophora mangrove forests. From this evidence, this article argues that a more rational focus of the restoration effort should be the replanting of mangroves in the brackish-water aquaculture pond environments, the original habitat of mangroves. For such, a number of management options can be explored, the implementation of which will ultimately depend on the political will of local and national governments.

Implementing agencies, policymakers, indigenous and local communities

Samson, M.S. and R.N. Rollon (2008) Growth Performance of Planted Mangroves in the Philippines: Revisiting Forest Management Strategies. Ambio 37(4): 234-240.

http://www.mangroverestoration.com/pdfs/SamsonRollon2008.pdf

Using Facilitation Theory to Enhance Mangrove Restoration

Coastal populations depend on mangrove ecosystems for economic products, such as shrimp ponds, fish farms, and timber products, and for the ecosystem services they provide, such as coastal stabilization, wave attenuation, and nursery habitat for fish. These services, from both natural and converted mangrove areas, cannot be minimized, and, as Samson and Rollon (Growth Performance of Planted Mangroves in the Philippines: Revisiting Forest Management Strategies) suggest, it may not be feasible or prudent in all cases to restore former mangrove areas to mangrove forest. In many cases, the best decision will include a mix of exploitation, conservation, and restoration. Whether mangrove restorations proceed in mangrove or nonmangrove habitats, restorations are much more likely to be successful if they assume positive, rather than negative negative, density dependence during initial ecosystem development and thereby capitalize on advances in facilitation theory.

Practitioners, implementing agencies

Gedan, K.B. and B.R. Silliman (2009) Using Facilitation Theory to Enhance Mangrove Restoration. Ambio 38(2): 109.

http://www.sillimanlab.com/pdf/Geden_Silliman_2009(49).pdf

Coastal/Marine>Mangroves>Thailand

Intergrated Wetland Restoration and Aquaculture: Pak Phanang River Region Development Project, Southern Thailand

This project shows how numerous goals including economic and community sustainability, flood control, water quality improvement, and habitat rehabilitation can be solved with a thoughtful landscape approach to planning that utilizes hydrologic and biological principles, and modeling tools, through four parts include mangrove forest rehabilitation, sustainable open-water aquaculture, integrated mangrove aquaculture, and wastewater treatment mangrove areas.

Implementing agencies, practitioners

English, Chinese

Cui, L.J. and S.L. Ai (eds.) (2006) Pp. 186-197 in The Wetland Restoration Handbook: Guiding Principles and Case Studies. China Architecture and Building Press, Beijng.

http://ed.edaw.com/eNewsData/articleDocuments/75332_Wetland%20Handbook%20Launch%20Announcement-eng.PDF

Coastal/Marine>Mangroves>USA

Restoration of Biogeochemical Function in Mangrove Forests

Forest structure of mangrove restoration sites (6 and 14 years old) at two locations (Henderson Creek [HC] and Windstar [WS]) in southwest Florida differed from that of mixed-basin forests (>50 years old) with which they were once contiguous. However, the younger site (HC) was typical of natural, developing forests, whereas the older site (WS) was less well developed with low structural complexity. Structural development and biogeochemical functioning of restored mangrove forests thus depend on a number of factors, but site-specific as well as regional or local differences in hydrology and concomitant factors such as salinity and soil waterlogging will have a strong influence over the outcome of restoration projects.

Implementing agencies, practitioners

McKee, K. L. and P.L. Faulkner (2000) Restoration of Biogeochemical Function in Mangrove Forests. Restoration Ecology 8: 247-259.

http://onlinelibrary.wiley.com/doi/10.1046/j.1526-100x.2000.80036.x/full

Coastal/Marine>Mangroves>Vietnam

Reforestation of Mangroves after Severe Impacts of Herbicides during the Viet Nam War: The Case of Can Gio

This article begins by describing the detrimental impacts of chemicals used in the Viet Nam war on mangroves, and then focuses on the reforestation efforts of the mangroves of the Can Gio district. Between 1978 and 1989, 29,583 ha of Rhizophora apiriculata were planted; however, due to a lack of technical experience and a very high planting density, by 1990 only 18,125 ha remained. 35,000 ha of mangrove were replanted by 1996 and, in 2001, about 20,000 ha still survived. At the time of writing (2001), the author reported that the mangroves had almost been restored to a condition similar to what existed before the chemical degradation, with 70 mangrove species (of which 30 were true mangrove species) recorded in the restored mangrove. With restoration efforts, the soil substrate has been restored to loam and the pH value has increased. Reforestation of the mangrove has been accompanied by forest policy which allocates land to local households, increases forest personnel, and implements monitoring of forest activities.

Practitioners, implementing agencies

Hong, P.N. (2001) Reforestation of mangroves after severe impacts of herbicides during the Viet Nam war: the case of Can Gio. Unasylva 52(207): 57-60.

http://www.fao.org/docrep/004/y2795e/y2795e11.htm

Coastal/Marine>Salt Marshes

Tidal Wetland Restoration: Physical and Ecological Processes

The need for tidal wetland restoration is examined in relation to the causes of wetland loss, the impacts of wetland loss, and the impetus behind wetland restoration efforts. For restoration to be strategic, knowledge of the relevant physical and ecological processes must be improved. Research on ecosystem development under alternative restoration approaches is needed to increase the predictability of outcomes (both structural and functional attributes), as well as the time-frame required for ecosystem recovery. Increased predictability is more likely to be achieved under adaptive management strategies for wetland restoration, enhancement and preservation.

Implementing agencies, practitioners

Goodwin, P. A.J. Mehta and J.B. Zedler (2001) Tidal Wetland Restoration: Physical and Ecological Processes. Journal of Coastal Research, Special Issue No. 27: 1-211.

http://www.jstor.org/stable/i25736157

Combining Ecological and Economic Indicators to Prioritize Salt Marsh Restoration Actions

This paper discusses ongoing research that focuses on developing such a method and its application to restoration of coastal wetlands within an estuary watershed system. The research addresses three important issues related to valuing wetlands, or other natural resources, within a single watershed: spatial aspects of value, cost-effective methodologies for valuation, and transferability of methods and values.

Implementing agencies, policymakers

Mazzotta, M., J. Opaluch, R. Johnston, G. Magnusson, P. August and F. Golet (2002) Combining Ecological and Economic Indicators to Prioritize Salt Marsh Restoration Actions. American Journal of Agricultural Economics 84(5): 1362-1370.

http://www.ci.uri.edu/ciip/SummerPracticum/Docs2008/AJAE%20Wetlands%20Article.pdf

Coastal/Marine>Salt Marshes>Canada

Assisted Revegetation Trials in Degraded Salt-Marshes

At coastal sites adjacent to the Hudson Bay lowlands, intensive foraging by increasing numbers of lesser snow geese Anser caerulescens caerulescens has converted salt-marsh awards to hypersaline mudflats largely devoid of vegetation. Assisted revegetation trials were undertaken in order to determine the ability of plants to establish in degraded salt-marsh sediment Growth rate and mortality of plants both varied between sites and years, reflecting variation in the frequency of hot, dry weather from late June to early August of each year, and the salinity and water content of soils during that period. The potential for revegetation of mudflats is discussed in the context of the soil degradation processes. Fine-grain variation in soil conditions presents a major challenge for the restoration of plant assemblages in these coastal marshes.

Implementing agencies, practitioners

Handa, I.T. and R.L. Jefferies (2000) Assisted Revegetation Trials in Degraded Salt-Marshes. Journal of Applied Ecology 37(6): 944-958.

http://research.amnh.org/~rfr/hbp/handa2.pdf

Coastal/Marine>Salt Marshes>South Korea

Experimental Restoration of a Salt Marsh with Some Comments on Ecological Restoration of Coastal Vegetated Ecosystems in Korea

Since the 1980s, the coastal wetlands in Korea have been rapidly degraded and destroyed mainly due to reclamation and landfills for coastal development. In order to recover damaged coastal environments and to develop wetland restoration technologies, a 4-year study on ecological the restoration of coastal vegetated ecosystems was started in 1998. As one of a series of studies, a small-scale experiment on salt marsh restoration was carried out from April 2000 to August 2001. From these results, we suggested that designs for the restoration of salt marsh ecosystems must consider the inclusion of a tidal height exceeding CTL, as this may allow reconstruction of the previous natural ecosystem without artificial transplanting.

Practitioners, implementing agencies

Koo, B.J., J.G. Je and H.J. Woo (2011) Experimental Restoration of a Salt Marsh with Some Comments on Ecological Restoration of Coastal Vegetated Ecosystems in Korea. Ocean Science Journal 46(1): 47-53.

http://adsabs.harvard.edu/abs/2011OSJ....46...47K

Coastal/Marine>Salt Marshes>UK

Restoration of Salt-marsh Vegetation in Relation to Site Suitability, Species Pool and Dispersal Traits

Restoration of salt marshes on previously reclaimed land provides an excellent opportunity to study plant colonization and subsequent development of salt-marsh vegetation. Insight into the process of salt-marsh development can guide the design, implementation and evaluation of salt-marsh restoration schemes and help determine appropriate management strategies. The prospect of salt-marsh restoration after de-embankment is good, with target species establishing spontaneously and vegetation succession taking place. Because most salt-marsh species are dispersed over short distances, it is important that a well-developed salt marsh is adjacent to the restoration site. The rate of salt-marsh development and species diversity appears to be affected mainly by surface elevation. Proper elevation in relation to tidal inundation is therefore a prerequisite for the successful restoration of salt-marsh vegetation after de-embankment.

Implementing agencies, practitioners

Wolters, M., A. Garbutt, R.M. Bekker, J.P. Bakker and P.D. Carey (2008) Restoration of salt-marsh vegetation in relation to site suitability, species pool and dispersal traits. Journal of Applied Ecology 45: 904-912.

http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2664.2008.01453.x/abstract

Coastal/Marine>Salt Marshes>USA

Accelerating the Restoration of Vegetation in a Southern California Salt Marsh

Re-establishing plant cover is essential for restoring ecosystem functions, but revegetation can be difficult in severe sites, such as salt marshes that experience hypersalinity and sedimentation. We tested three treatments (adding tidal creeks, planting seedlings in tight clusters, and rototilling kelp compost into the soil) in a site that was excavated to reinstate tidal flows and restore salt marsh. The magnitude of responses was the reverse of expectations, with tidal creeks having the least effect and kelp compost the most.

Practitioners

O'Brien, E.L. and J.B. Zedler (2006) Accelerating the Restoration of Vegetation in a Southern California Salt Marsh. Wetlands Ecology and Management 14: 269-286.

http://www.botany.wisc.edu/zedler/images/O'Brien.pdf

Declining Diversity in Natural and Restored Salt Marshes: A 30-Year Study of Tijuana Estuary

In a 2000 restoration site, planting mortality was high for five species, but Sv recruited voluntarily and dominated by 2005. We attribute recent vegetation changes to frequent catastrophic storms, flooding, and sedimentation, which contrasted strongly with the benign conditions of decades prior to 1974. Sediment blocked tidal channels in 1984 and gradually elevated the marsh plain, degrading the diverse salt marsh and hindering efforts to restore it. Future restoration efforts will require even greater control over sediment inflows plus contouring sites to include natural topographic features that appear critical to sustaining high species richness and evenness.

Practitioners, implementing agencies

Zedler, J.B. and J.M. West (2008) Declining Diversity in Natural and Restored Salt Marshes: A 30-Year Study of Tijuana Estuary. Restoration Ecology 16(2): 249-262.

http://nctc.fws.gov/EC/Resources/fwca/Climate%20Change/Saltmarshes%20and%20CC.pdf

Wetland Restoration Thresholds: Can a Degradation Transition Be Reversed with Increased Effort?

Previous attempts to reverse the degradation of a coastal wetland and restore nesting habitat for an endangered bird showed that adding nitrogen could temporarily increase the height of Spartina foliosa, but not produce self-sustaining tall canopies. We asked if increased effort (up to five years of N fertilization) would shift canopy attributes across the hypothesized threshold. Thirty plots were treated with 0-5 yr of urea addition, and all were followed for 5 yr. Canopies were robust while urea was being added, but Spartina reverted to short stature soon after fertilization ended, supporting R. J. Hobbs and D. A. Norton's concept of an irreversible transition. However, specific outcomes depended on the choice of response variable (six comparisons), the choice of reference data (initial conditions, same-year data, and pooled data), and the choice of statistical design (repeated measures vs. complete design), indicating the need to assess experiments thoroughly before making strong recommendations for management.

Practitioners

Lindig-Cisneros, R., J. Desmond, K.E. Boyer and J.B. Zedler (2003) Wetland Restoration Thresholds: Can a Degradation Transition Be Reversed with Increased Effort? Ecological Applications 13(1): 193-205.

http://www.esajournals.org/doi/abs/10.1890/1051-0761%282003%29013%5B0193%3AWRTCAD%5D2.0.CO%3B2?journalCode=ecap

Will Restored Tidal Marshes Be Sustainable?

We assess whether or not restored marshes in the San Francisco Estuary are expected to be sustainable in light of future landscape scale geomorphic processes given typical restored marsh conditions. Our assessment is based on a review of the literature, appraisal of monitoring data for restored marshes, and application of vertical accretion modeling of organic and inorganic sedimentation. The ultimate long-term threat to the sustainability of tidal marshes is the interruption of coastal rollover-the process by which landward marsh expansion in response to sea level rise compensates for shoreline erosion. Bay front development now prevents most landward marsh expansion, while shoreline erosion is expected to accelerate as sea level rises.

Implementing agencies

Orr, M., S. Crooks and P.B. Williams (2003) Will Restored Tidal Marshes Be Sustainable? San Francisco Estuary and Watershed Science 1(1).

http://www.pwa-ltd.com/documents/WillRestoredTidalMarshesBeSust.pdf

California Dreamin': Lessons in Coastal Marsh Restoration from San Francisco Bay

To get to this point restoration science has over the past thirty years climbed a steep learning curve based upon an assessment of past experience, and publicly funded support for holistic planning. Ongoing restoration planning and design incorporates lessons learned from past projects with modelling tool to assess future conditions. Local and national level public support has been fundamental to the creation of an enormous environmental restoration program in California. This has been made possible by offering the public a stake in environmental improvements and by clearly showing that their tax and charitable contributions have been wisely invested. Many of the planning and design lessons learned in San Francisco Bay are transferable to the UK. By learning from these experiences we can save time and money (and restoration opportunities) reinventing the wheel in the UK. The time is now right to galvanize activity and build upon UK coastal management initiatives to restore our coastal lowlands and meet our biodiversity obligations.

Implementing agencies, policymakers

Cooks, S. and J. Sharpe (2007) California Dreamin': Lessons in Coastal Marsh Restoration from San Francisco Bay. Proceedings of the DEFRA Flood and Coastal Risk Management Conference, York, UK.

http://www.pwa-ltd.com/documents/CrooksandSharpe_Defra_2007.pdf

Hurricanes, Floods, Levees, and Nutria: Vegetation Responses to Interacting Disturbance and Fertility Regimes with Implications for Coastal Wetland Restoration

A primary cause of wetland loss in the Louisiana coastal zone has been the construction of flood control levees along the Mississippi River. These levees restrict the inputs of freshwater, nutrients, and sediment that historically replenished these wetlands. Wetland loss is compounded by other factors such as storms, introduced herbivores, and saltwater intrusion. How do such simultaneous changes in fertility and disturbance regimes affect the vegetation of coastal wetlands? Will proposed restoration strategies, such as freshwater diversions and protection from herbivores, increase the productivity and accretion rates of coastal wetlands without sacrificing plant species diversity?

Implementing agencies, practitioners

McFalls, T.B., P.A. Keddy, D. Campbell and G. Shaffer (2010) Hurricanes, Floods, Levees, and Nutria: Vegetation Responses to Interacting Disturbance and Fertility Regimes with Implications for Coastal Wetland Restoration. Journal of Coastal Research 26(5): 901-911.

http://drpaulkeddy.com/pdffiles/McFalls%20et%20al%202010%20--%20JCR%20--%20Fertility%20and%20disturbance%20effects%20on%20coastal%20wetlans.pdf

Coastal/Marine>Seagrass Meadows

Seagrass Restoration

This chapter updates the progress that has been made over the last decade and reviews the current status of seagrass restoration and transplant research in those areas of the world where much activity has taken place: Europe, Australasia and the United States. Within each region, a brief background is provided on seagrass geographic distribution, community species composition, causal nature of seagrass decline and an overview of attempts to facilitate recovery via transplanting. The chapter concludes with an evaluation of the ecological and economic appropriateness of restoration as a tool for conserving seagrass.

Practitioners, implementing agencies

Paling, E.I., M. Fonseca, M.M. van Katwijk and M. van Keulen (2009) Seagrass Restoration. Pp. 687-713 in Perillo, G., E. Wolanski, D. Cahoon and M. Brinson (eds.) Coastal Wetlands: An Integrated Ecosystem Approach. Elsevier Science.

http://www.seagrassrestorationnow.com/docs/Paling%20et%20al%202009%20Chap%2024%20seagrass%20rest.pdf

Planting Density, Hydrodynamic Exposure and Mussel Beds Affect Survival of Transplanted Intertidal Eelgrass

Transplantation of eelgrass Zostera marina has become a promising restoration tool since natural recolonisation during the last century failed after massive mortality, due to a combination of a wasting disease outbreak and a sequence of human impacts. We studied the interactive effects of planting density and hydrodynamic exposure on the survival of transplants of an annual population of intertidal eelgrass. Eelgrass planted in open spaces within a mussel bed survived significantly better than transplants situated 60 m seaward of the mussel bed. Thus, mussel beds facilitate eelgrass survival. The insights into the processes affecting transplantation success will be of use in eelgrass restoration around the world.

Practitioners, implementing agencies

Bos, A.R. and M.M. van Katwijk (2007) Planting Density, Hydrodynamic Exposure and Mussel Beds Affect Survival of Transplanted Intertidal Eelgrass. Marine Ecology Progress Series 336: 121-129.

http://myweb.facstaff.wwu.edu/~shulld/ESCI%20432/BosKatwijk2007.pdf

What Has Changed with Seagrass Restoration in 64 Years?

A brief appraisal of the present state of seagrass restoration in the context of the 64-year-old seminal publication by C.E. Addy reveals that early observations were prescient and have remained the basis for our collective attempts to conduct open system seagrass restoration. Our ability to ensure restoration success remains limited. A flawed philosophical framework for choosing restoration, frequently exacerbated by management inexperience and failure to apply known standards for site selection, continues to plague the process. Moreover, seagrass restoration has become an on-demand attempt to overcome hysteresis and shift a habitat from one stable state (unvegetated) to what is arguably a more complex stable state (vegetated) by artificial colonization methods. These methods are frequently overwhelmed by natural processes that ordinarily rely on orders of magnitude more propagules and years of recruitment classes. As a result, the expectations for successful seagrass restoration, like most wild community restoration projects, are often unrealistic and improperly held to an even higher standard than agricultural crops.

Practitioners, implementing agencies

Fonseca, M.S. (2011) What Has Changed with Seagrass Restoration in 64 Years? Ecological Restoration 29(1-2): 73-81.

http://er.uwpress.org/content/29/1-2/73.short

Coastal/Marine>Seagrass Meadows>Australia

Facilitating Recruitment of Amphibolis as a Novel Approach to Seagrass Rehabilitation in Hydrodynamically Active Waters

Traditional methods of seagrass restoration are expensive and have had limited success owing to high wave energy. We investigated a range of biodegradable substrates, mostly made of hessian (burlap), to enhance Amphibolis recruitment as an alternative. The technique may represent a non-destructive, cost-effective (AU \$10 000 ha^{-1}) method to restore Amphibolis over large spatial scales and in areas that are hydrodynamically too active for traditional techniques, thus helping ameliorate some of the large-scale losses of seagrasses that have occurred globally.

Practitioners, implementing agencies

Wear,R.J., J.E. Tanner and S.L. Hoare (2010) Facilitating Recruitment of Amphibolis as a Novel Approach to Seagrass Rehabilitation in Hydrodynamically Active Waters. Marine and Freshwater Research 61: 1123-1133.

http://www.publish.csiro.au/paper/MF09314

Recent Advances in Research into Seagrass Restoration

The most significant advances in seagrass restoration have arguably been the development of mechanical seagrass transplanters in Western Australia, and the development of non-destructive methods of seagrass restoration that facilitate the natural recruitment of seagrass ramets or seedlings.

Practitioners, implementing agencies

Wear, R. (2006) Recent Advances in Research into Seagrass Restoration: A Literature Review. Aquatic Sciences Publication No. RD04/0038-4. Research Report Series No. 140, Adeliade.

http://www.sardi.sa.gov.au/_media/pdf/sardi_internet/our_org/publications/research_report_series/2006/No140_RD04-0038-4_Advances_research_seagrass_restoration.pdf

Seagrass Rehabilitation: An Overview

This summary report has been prepared to provide information that has developed with regards to seagrasses during the intervening years since 1992, and to demonstrate that the current knowledge of seagrass is that: Seagrass assemblages are naturally very dynamic and can both spread and contract at significant rates due to natural causes; and Methods for seagrass rehabilitation have been developed and are continually being improved, and that seagrass rehabilitation in selected areas of Cockburn Sound is feasible.

D. A. Lord & Associates Pty Ltd (2005) Seagrass Rehabilitation: An Overview. Oceanica Consulting Pty Ltd, Western Australia.

http://www.epa.wa.gov.au/docs/capeperon/ser_capeperon_app8.pdf

Recovering Subtidal Forests in Human-dominated Landscapes

The failure of subtidal forests to recover from natural and human disturbance and their ultimate replacement by degraded habitats is recognized globally. The current lack of knowledge on whether such shifts can be reversed jeopardizes considerations of restoration policy within increasingly human-dominated landscapes. We demonstrate that future restoration is a possible outcome of polices that promote ecosystem recovery. In doing so, we reduce uncertainty about policy initiatives that aim to upgrade the recycling potential of wastewater treatment plants (e.g. nearly 45% of South Australia's metropolitan wastewater) to improve the quality of water needed to restore subtidal forests. Uncertainty about resilience-building and restoration management are redressed by demonstrating that the feedbacks maintaining regime-shifted landscapes are not necessarily permanent.

Policymakers, implementing agencies

Gorman, D. and S.D. Connell (2009) Recovering subtidal forests in human-dominated landscapes. Journal of Applied Ecology 46: 1258-1265.

http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2664.2009.01711.x/pdf

Coastal/Marine>Seagrass Meadows>Japan

Ecology and Restoration Techniques for Sargassum Beds in the Seto Inland Sea, Japan

New techniques for Sargassum bed restoration are summarized based on three coastal engineering techniques. (1) Construction of shallow and gentle sloping bottom substrata have been shown to be effective for the reestablishment of management-free seagrass and Sargassum beds on developed coasts. (2) Seeding or transplanting using artificial substratum for extension of nursery and fishing grounds around natural Sargassum beds. (3) Periodic transplanting of Sargassum plants using artificially produced seedlings is effective to produce niches to allow faunal re-colonization in severely polluted and sparsely vegetated area. However, prior to implementation, the suitability and limitations of these three techniques requires to be ascertained for effective Sargassum bed restoration.

Practitioners, implementing agencies

Terawaki, T., K. Yoshikawa, G. Yoshida, M. Uchimura and K. Iseki (2003) Ecology and Restoration Techniques for Sargassum Beds in the Seto Inland Sea, Japan. Marine Pollution Bulletin 47: 198-201.

http://www.sciencedirect.com/science/article/pii/S0025326X03000547

Trends in Literature on Seaweed Restoration Techniques on Barren Grounds in Japan

To detect the trend on seaweed restoration techniques on barren grounds in Japan, domestic literature (> 1,000) published since 1970 were surveyed. The literature contains local survey (18%), experiments and detailed observations (23%), recovery trials (43%) and reviews (16%). The literature increased chronologically with a temporal maximum in 1980-85. Among the local areas, literature was particularly abundant in western coasts of Hokkaido and Pacific coasts of middle Honshu (from the Kii Channel to Cape Inubo). The target seaweed bed types were mostly kelp and Sargassum forests and the dominant causative agents of these bed reductions were intensive grazing by sea urchins and herbivorous fishes. The literature analysis revealed that 'removal' of sea urchins and 'defense' of seaweeds were unreasonably preceded by employing stones or concrete blocks and transplanting seaweeds. Grazing by herbivorous fishes is a recent problem in southern Japan; the literature abruptly increases after 2000. These may represent some of the reasons why barren ground recovery projects were unsuccessful.

Practitioners, implementing agencies

Hisami, K. et al (2006) Trends in Literature on Seaweed Restoration Techniques on Barren Grounds in Japan. Fisheries Engineering 43(1): 81-87.

http://sciencelinks.jp/j-east/article/200619/000020061906A0659981.php

Seaweed Establishment and Restoration on the Coastal Structure

In recent years, natural seaweed beds in Japan have been depleted; at the same time artificial seaweed beds have been created in order to restore ecosystem functions of coastal waters. Vigorous efforts are being made to recover and re-establish endangered seaweed beds in Japan. Fishermen have been transplanting kelp and seedlings using a spore-bag technique for many years. Regenerated seaweed beds are being developed on artificial structures at both the prefectural and national levels. Furthermore, the concept has been extended to include the creation of "marine farms" using sea walls, coastal defenses and structures as breakwaters. The recent construction of artificial Island and underwater "mounds" have also increased seaweed bed productivity and associated fishery resources.

Practitioners, implementing agencies

Masao, O., K. Tsutomu and N. Sayuko (2003) Seaweed Establishment and Restoration on the Coastal Structure. Aquabiology 25(3): 173-179.

http://sciencelinks.jp/j-east/article/200316/000020031603A0494645.php

Restoration of Ecklonia Cava Forest on Hainan Coast, Shizuoka Prefecture

In order to avoid extinction of the kelp forest, Shizuoka Prefecture implemented a 'Fisheries Infrastructure Development Project' by deploying blocks implanted with E. cava thalli on the barren bottom formerly inhabited by the kelps. Furthermore, we also implemented another project to establish new methods of transplantation to cope with browsing by herbivorous fishes. In the project, restoration of E. cava forest was tried using ropes implanted with E. cava juveniles and removal of herbivorous fish by fixed net and gill net. The shoreline survey conducted in February 2008 revealed that 55 ha of E. cava forest was restored along the coast.

Implementing agencies, practitioners

Unno, Y. and M. Hasegawa (2010) Restoration of Ecklonia Cava Forest on Hainan coast, Shizuoka Prefecture. Bull. Fish. Res. Agen. 32: 119-124.

http://www.fra.affrc.go.jp/bulletin/bull/bull32/119-124.pdf

Restoration of Kelp Beds on an Urchin Barren: Removal of Sea Urchins by Citizen Divers in Southwestern Hokkaido

As the fishermen on the coast are aged and depopulated, the authors introduced citizen volunteer divers (CVD) for the removal of the sea urchin. The attempt was practiced on an urchin barren near Kamoenai Fishing Port on the southern coast of Shakotan Peninsula in September 2005. Twenty CVD (including a few instructors and staffs) removed sea urchins from two blocks (50 x 50 m, 4-8m in depth) during two dives (ca. 1 hr/dive) beside the control block; subsequent monthly removal by monitors (i.e., researchers) was done in one of the two blocks. In May 2006, the average standing crops of the seaweed (largely kelp) were 865g/m2 (monthly removed after the CVD activity) and 150g/m2 (removed once by CVD) but 0g/m2 in control, while the density of sea urchin were 0.1, 3.5 and 4.2/m2, respectively. The results show that the introduction of CVD can aid the restoration of kelp beds.

Implementing agencies, practitioners

Watanuki, A., T. Aota, E. Otsuka, T. Kawai, Y. Iwahashi, H. Kuwahara and D. Fujita (2010) Restoration of Kelp Beds on an Urchin Barren: Removal of Sea Urchins by Citizen Divers in Southwestern Hokkaido. Bull. Fish. Res. Agen. 32: 83-87.

http://tuna.fra.affrc.go.jp/bulletin/bull/bull32/83-87.pdf

Coastal/Marine>Seagrass Meadows>Europe

Storm-generated Fragments of the Seagrass Posidonia oceanica from Beach Wrack: A Potential Source of Transplants for Restoration

The use of fragments detached naturally from Posidonia oceanica, a threatened seagrass protected by European legislation, as non-destructive alternative to removing cuttings from donor meadows for restoration efforts has been recently proposed. A 4-year study was performed to investigate whether storm-generated fragments deposited on beaches can be salvaged and used as transplant source. Four months after collection, fragment survival was high (80–96%). Half of the fragments regenerated and survived as long as 3 years in tanks. Initial growth form and size were not predictors of fragment survival or regeneration probability. Division of fragments allowed doubling transplant number. One year after transplanting, 50% of the fragments on the artificial reef were still present and ca. half of them produced new shoots. This indicates that fragments retain the capacity to re-establish once reintroduced into the field and thus could represent a potentially important transplant source. The use of this material could have major advantages over traditional restoration techniques, including large availability with zero impact on existing populations and low collection efforts.

Practitioners, implementing agencies

Balestri, E., F. Vallerini and C. Lardicci (2011) Storm-generated Fragments of the Seagrass Posidonia oceanica from Beach Wrack: A Potential Source of Transplants for Restoration. Biological Conservation 144(5): 1644-1654.

http://www.sciencedirect.com/science/article/pii/S0006320711000814

Coastal/Marine>Seagrass Meadows>Netherlands

Guidelines for Seagrass Restoration: Importance of Habitat Selection and Donor Population, Spreading of Risks, and Ecosystem Engineering Effects

Large-scale losses of seagrass beds have been reported for decades and lead to numerous restoration programs. From worldwide scientific literature and 20 years of seagrass restoration research in the Wadden Sea, we review and evaluate the traditional guidelines and propose new guidelines for seagrass restoration.

Practitioners, implementing agencies

van Katwijk, M.M., A.R. Bos, V.N. de Jonge, L.S.A.M. Hanssen, D.C.R. Hermus and D.J. de Jong (2009) Guidelines for Seagrass Restoration: Importance of Habitat Selection and Donor Population, Spreading of Risks, and Ecosystem Engineering Effects. Marine Pollution Bulletin 58(2): 179-188.

http://www.sciencedirect.com/science/article/pii/S0025326X08004657

Positive Feedbacks in Seagrass Ecosystems: Implications for Success in Conservation and Restoration

In the 1930s, such a dramatic event happened in the Dutch Wadden Sea. Before the shift, large seagrass beds (Zostera marina) were present in this area. After the construction of a large dam and an incidence of the “wasting disease” in the early 1930s, these meadows became virtually extinct and never recovered despite restoration attempts. We investigated whether this shift could be explained as a critical transition between alternative stable states, and whether the lack of recovery could be due to the high resilience of the new turbid state. As positive feedbacks are common in seagrasses, our findings may explain both the worldwide observed collapses and the low success rate of restoration attempts of seagrass habitats. Therefore, appreciation of ecosystem resilience may be crucial in seagrass ecosystem management.

Implementing agencies, practitioners

van der Heide, T., E.H. van Nes, G.W. Geerling, A.J.P. Smolders, T.J. Bouma and M.M. van Katwijk (2007) Positive Feedbacks in Seagrass Ecosystems: Implications for Success in Conservation and Restoration. Ecosystems 10(8): 1311-1322.

http://tjisse.van-der-heide.com/wp-content/uploads/2010/03/Van-der-Heide-et-al-Ecosystems-2007.pdf

Coastal/Marine>Seagrass Meadows>USA

A Multiscale Approach to Seagrass Recovery in Tampa Bay, Florida

Recovery of seagrass coverage in Tampa Bay, Florida, to levels observed in 1950 (15,380 ha) is a long-term goal adopted by local, state, federal, and private partners participating in the Tampa Bay Estuary Program. However, seagrass coverage in all areas of the bay is not increasing at the same rate. Wave energy and tidal scour affect longshore sandbars, and in turn seagrass recovery in some areas. Localized water quality factors, including colored dissolved organic matter and turbidity may have impacts on seagrass growth in other areas. Have we had an effect on seagrass recovery in Tampa Bay? Yes, but it will take more than maintaining a successful nutrient management strategy to reach the recovery goal. A multiscale adaptive research and application approach is currently underway to ensure continuation of the upward trend in Tampa Bay seagrass coverage.

Policymakers, implementing agencies

Greening, H.S., L.M. Cross and E.T. Sherwood (2011) A Multiscale Approach to Seagrass Recovery in Tampa Bay, Florida. Ecological Restoration 29(1-2): 82-93.

http://er.uwpress.org/content/29/1-2/82.short

Eelgrass Restoration by Seed Maintains Genetic Diversity: Case Study from a Coastal Bay System

Genetic diversity is positively associated with plant fitness, stability, and the provision of ecosystem services. Preserving genetic diversity is therefore considered an important component of ecosystem restoration as well as a measure of its success. We examined the genetic diversity of restored Zostera marina meadows in a coastal bay system along the USA mid-Atlantic coast using microsatellite markers to compare donor and recipient meadows. We hypothesize that the high genetic diversity in seagrasses restored using seeds rather than adult plants confers a greater level of ecosystem resilience to the restored meadows.

Practitioners, implementing agencies

Reynolds, L.K., M. Waycott, K.J. McGlathery, R.J. Orth and J.C. Zieman (2012) Eelgrass Restoration by Seed Maintains Genetic Diversity: Case Study from a Coastal Bay System. Marine Ecology Progress Series 448: 223-233.

http://www.int-res.com/articles/theme/m448p223.pdf

Innovative Techniques for Large-scale Seagrass Restoration Using Zostera marina (eelgrass) Seeds

The use of Zostera marina (eelgrass) seeds for seagrass restoration is increasingly recognized as an alternative to transplanting shoots as losses of seagrass habitat generate interest in large-scale restoration. We explored new techniques for efficient large-scale restoration of Z. marina using seeds by addressing the factors limiting seed collection, processing, survival, and distribution. We tested an existing mechanical harvesting system for expanding the scale of seed collections, and developed and evaluated two new experimental systems. A seeding technique using buoys holding reproductive shoots at restoration sites to eliminate seed storage was tested along with new techniques for reducing seed-processing labor. A series of experiments evaluated storage conditions that maintain viability of seeds during summer storage for fall planting. Finally, a new mechanical seed-planting technique appropriate for large scales was developed and tested.

Practitioners, implementing agencies

Marion, S.R. and R.J. Orth (2010) Innovative Techniques for Large-scale Seagrass Restoration Using Zostera marina (eelgrass) Seeds. Restoration Ecology 18(4): 514-526.

http://www.chesapeake.org/OldStac/savrest/Marion_Orth2010.pdf

Evaluating a Large-Scale Eelgrass Restoration Project in the Chesapeake Bay

Submerged aquatic vegetation habitat quality based on the PTSI, median PLL during the growing season, and test plantings did not explain the decline of the plantings. Restoration site selection criteria should be expanded to include the effects of wave exposure on self-shading and epiphyte loads, and the potential for both short-term exposures to stressful conditions and long-term changes in habitat quality.

Implementing agencies, practitioners

Tanner, C. et al (2010) Evaluating a Large-Scale Eelgrass Restoration Project in the Chesapeake Bay. Restoration Ecology 18(4): 538-548.

http://www.chesapeake.org/OldStac/savrest/Tanner_etal2010.pdf

Successful Eelgrass (Zostera marina) Restoration in a Formerly Eutrophic Estuary (Boston Harbor) Supports the Use of a Multifaceted Watershed Approach to Mitigating Eelgrass Loss

From a watershed perspective, Boston Harbor, MA, USA is an ideal site for eelgrass restoration due to major wastewater improvements. Therefore, by focusing on site selection and transplant methods, high survival and expansion rates were recorded at four large eelgrass restoration sites planted in Boston Harbor as partial mitigation for a pipeline construction project. Transplanted sites met and exceeded reference and donor bed habitat function after 2 years. Hand planting and seeding in checkerboard-patterned transplant plots were efficient and effective methods for jump-starting eelgrass growth over large areas. Although restoration through planting can be successful, it is highly site specific.

Implementing agencies, practitioners

Leschen, A.S., K.H. Ford and N.T. Evans (2010) Successful Eelgrass (Zostera marina) Restoration in a Formerly Eutrophic Estuary (Boston Harbor) Supports the Use of a Multifaceted Watershed Approach to Mitigating Eelgrass Loss. Estuaries and Coasts 33(6): 1340-1354.

http://www.mass.gov/dfwele/dmf/publications/leschen_et_al_estuaries_2010.pdf

Restoration of Seagrass Habitat in Tampa Bay Using Manatee Grass (Syringodium filiforme) Sod Units

The final project monitoring results show that the manatee grass transplanting effort was completed successfully. First, the donor site monitoring indicated that disturbances caused by harvesting were fully mitigated within the two year study period. Second, about 1300m2 of manatee grass were established in an area previously devoid of this species. Third, at the end of the study period the per unit area above ground biomass of the restored manatee grass in several of the planting plots was similar to, or may have exceeded the biomass of the donor grass at the time of harvest. Finally, several of the restored meadows have been actively expanding in area coverage at a rate similar to natural growing manatee grass meadows.

Practitioners, implementing agencies

Johansson, J.O.R., W.M. Avery, K.B. Hennenfent and J.J. Pacowta (2009) Restoration of Seagrass Habitat in Tampa Bay Using Manatee Grass (Syringodium filiforme) Sod Units. Prepared for the Hillsborough County Environmental Recovery Fund, Project 06-02.

http://www.tampabay.wateratlas.usf.edu/upload/documents/TBEP_01_09_SeagrassRestorationUsingLargeManateeGrassSods_smaller.pdf

Southern California Giant Kelp Restoration Project

California Coastkeeper Alliance and participating Waterkeepers launched the six-year Kelp Project in the Southern California Bight in 2001. Participating Waterkeepers included Santa Barbara Channelkeeper, Santa Monica Baykeeper, Orange County Coastkeeper (2001-2005), and San Diego Coastkeeper. CCKA coordinated the Project, operated a laboratory to grow transplant kelp, fundraised, provided administrative support, and from 2005-2007 conducted kelp restoration, education and outreach in Orange County. The Kelp Project embodies the Waterkeeper vision of fully protecting waters and the life that inhabits them in our patrol areas.

Implementing agencies

California Coastalkeeper Alliance

http://www.cacoastkeeper.org/document/final-kelp-project-report.pdf

Coastal/Marine>Shellfish Beds

Oyster Reefs at Risk and Recommendations for Conservation, Restoration, and Management

Native oyster reefs once dominated many estuaries, ecologically and economically. Centuries of resource extraction exacerbated by coastal degradation have pushed oyster reefs to the brink of functional extinction worldwide. We examined the condition of oyster reefs across 144 bays and 44 ecoregions; our comparisons of past with present abundances indicate that more than 90% of them have been lost in bays (70%) and ecoregions (63%). In many bays, more than 99% of oyster reefs have been lost and are functionally extinct. Overall, we estimate that 85% of oyster reefs have been lost globally. Most of the world's remaining wild capture of native oysters (> 75%) comes from just five ecoregions in North America, yet the condition of reefs in these ecoregions is poor at best, except in the Gulf of Mexico. We identify many cost-effective solutions for conservation, restoration, and the management of fisheries and nonnative species that could reverse these oyster losses and restore reef ecosystem services.

Policymakers, implementing agencies

Beck, M.W. et al (2011) Oyster Reefs at Risk and Recommendations for Conservation, Restoration, and Management. BioScience 61(2): 107-116.

http://www.aibs.org/bioscience-press-releases/resources/Beck.pdf

Introduction of Non-Native Oysters: Ecosystem Effects and Restoration Implications

Introductions can greatly enhance oyster population abundance and production, as well as populations of associated native species. However, introduced oysters are also vectors for non-native species, including disease-causing organisms. Thus, substantial population, community, and habitat changes have accompanied new oysters. In contrast, ecosystem-level consequences of oyster introductions, such as impacts on flow patterns, sediment and nutrient dynamics, and native bioengineering species, are not well understood. Eco- logical risk assessments for future introductions must emphasize probabilities of establishment, spread, and impacts on vulnerable species, communities, and ecosystem properties. Many characteristics of oysters lead to predictions that they would be successful, high-impact members of recipient ecosystems. This conclusion leaves open the discussion of whether such impacts are desirable in terms of restoration of coastal ecosystems, especially where restoration of native oysters is possible.

Implementing agencies

Ruesink, J.L., H.S. Lenihan, A.C. Trimble, K.W. Heiman, F. Micheli, J.E. Byers, M.C. Kay (2005) Introduction of Non-Native Oysters: Ecosystem Effects and Restoration Implications. Annual Review of Ecology, Evolution, and Systematics 36: 643-689.

http://www.jstor.org/discover/10.2307/30033820?uid=3739256&uid=2&uid=4&sid=47698877814087

Coastal/Marine>Shellfish Beds>USA

Contemporary Approaches for Small-scale Oyster Reef Restoration to Address Substrate versus Recruitment Limitation

This paper was originally presented at the first West Coast Restoration Workshop in 2006 in San Rafael, California and is intended to summarize potential approaches for small-scale restoration projects, including some emerging methods, and highlight the logistical benefits and limitations of these approaches. Because the majority of the past efforts have been with C. viriginica, we use those examples initially to highlight efforts with the intent of enlightening current west coast United States efforts with Ostrea lurida. We also discuss site-specific characteristics including ‘‘recruitment bottlenecks’’ and ‘‘substrate limitation’’ as criteria for identifying the most appropriate approaches to use for small-scale restoration projects. Many of the included ‘‘lessons-learned’’ from the smaller-scale restoration projects being implemented today can be used to inform not only large-scale estuary wide efforts to restore C. virginica, but also the relatively nascent efforts directed at restoring the United States west coast’s native Olympia oyster, Ostrea lurida.

Practitioners

Brumbaugh, R.D. and L.D. Coen (2009) Contemporary approaches for small-scale oyster reef restoration to address substrate versus recruitment limitation: A review and comments relevant for the Olympia oyster, Ostrea lurida Carpenter 1864. Journal of Shellfish Research 28: 147-161.

http://www.bioone.org/doi/abs/10.2983/035.028.0105

Native Oyster Restoration in Maryland and Virginia: An Evaluation of Lessons Learned 1990-2007

The team's activities have highlighted the strengths and weaknesses of oyster restoration efforts over the past 18 years and the utility of the data collected to monitor them. While this examination has been informative, its greatest value is to define future oyster restoration activities — specifically, to construct guidelines that will help maximize return on the large investment of effort and funding that will be made in the coming years. Perhaps the greatest lesson of the Oyster Restoration Evaluation Team effort is the recognition that the techniques, sampling protocols and stock assessment methods used to date are inadequate to assess real changes in oyster populations, locally or regionally, and that wholesale change is necessary to design and implement sound stock assessment and monitoring protocols and procedures in order to fully assess the health and growth of a recovering oyster population.

Practitioners, implementing agencies

Kramer, J.G. and K.G. Sellner (eds.) (2009) Native Oyster (Crassostrea virginica) Restoration in Maryland and Virginia. An evaluation of lessons learned 1990-2007. Maryland Sea Grant Publication #UM-SG-TS-2009-02; CRC Publ. No. 09-168, College Park.

http://www.chesapeake.org/pubs/Oyster%20Restoration%20Report.pdf

Oyster Reef Habitat Restoration: A Synopsis and Synthesis of Approaches

This volume brings together contributions from fisheries managers and research scientists in an attempt to develop a common information base and a convergence of objectives and approaches towards oyster fisheries enhancement and reef habitat restoration. The 24 chapters in this volume review the historical distribution and morphology of unexploited oyster reefs, current fisheries enhancement efforts, some of the ecological benefits of oyster reefs, as well as ideas for new approaches towards restoring reefs and sustaining their associated fisheries.

Implementing agencies, practitioners

Luckenbach, M., R. Mann and J.A. Wesson (eds.) (1999) Oyster reef habitat restoration: A synopsis and synthesis of approaches. Virginia Institute of Marine Science Press, Gloucester Point.

http://web.vims.edu/vimsnews/OysHabResFlyer.pdf

Chesapeake Oyster Reefs, Their Importance, Destruction and Guidelines for Restoring Them

As a consequence, Hargis and Haven (unpublished reports) have urged in several public forums since early 1991 the rebuilding, or replacement, of oyster reefs as a measure in restoring the population levels and viability of C. virginica and the industry dependent thereon on the public or natural oyster grounds. We again recommend this restorative action. Doing so, whether by passive (simple recuperative closure) or active (actual replenishment by shells and/or seed, plus significant recuperative closure) restoration or by new construction (also aided by closure), will require careful planning, site selection and design. Below we develop and support these conclusions and offer some guidelines for restoration.

Implementing agencies, practitioners

Hargis, Jr., W.J. and D.S. Haven (1999) Chesapeake Oyster Reefs, Their Importance, Destruction and Guidelines for Restoring Them. Pp. 329-358 in Luckenbach, M., R. Mann and J.A. Wesson (eds.) Oyster reef habitat restoration: A synopsis and synthesis of approaches. Virginia Institute of Marine Science Press, Gloucester Point.

http://web.vims.edu/mollusc/pdffiles/HargisHaven.PDF

Drylands

Plant Species Richness and Ecosystem Multifunctionality in Global Drylands

Experiments suggest that biodiversity enhances the ability of ecosystems to maintain multiple functions, such as carbon storage, productivity, and the buildup of nutrient pools (multifunctionality). However, the relationship between biodiversity and multifunctionality has never been assessed globally in natural ecosystems. We report here on a global empirical study relating plant species richness and abiotic factors to multifunctionality in drylands, which collectively cover 41% of Earth’s land surface and support over 38% of the human population. Multifunctionality was positively and significantly related to species richness. The best-fitting models accounted for over 55% of the variation in multifunctionality and always included species richness as a predictor variable. Our results suggest that the preservation of plant biodiversity is crucial to buffer negative effects of climate change and desertification in drylands.

Policymakers, implementing agencies

Maestre, F.T. et al. (2012) Plant Species Richness and Ecosystem Multifunctionality in Global Drylands. Science 335: 214-218.

http://www.sciencemag.org/content/335/6065/214.abstract

On the Restoration of Degraded Drylands

Recent advances in our understanding of dryland ecology have improved traditional restoration techniques and fostered the development of new eco-technology. However, the refinement of eco-technological tools and the success of experimental restoration projects have not been accompanied by parallel increases in the efficiency and reliability of management-scale restoration programs. In our experience, this is the result of uncertainties about the long-term effects of restoration actions, scarce knowledge on population and community dynamics, and cultural and socioeconomic constraints to the implementation of new techniques and the improvement of traditional ones. We suggest that 1) adopting the ecosystem service approach to identify restoration targets and evaluate restoration actions, 2) integrating restoration actions into comprehensive development programs, and 3) creating networks of pilot and demonstration projects may foster participative, adaptive and integrative management plans, and contribute to livelihood quality in desertified areas.

Implementing agencies

Cortina, J., B. Amat, M. Derak, M.J. Ribeiro Da Silva, K.B. Disante, D. Fuentes, J. Tormo and R. Truba (2011) On the restoration of degraded drylands. Secheresse 22: 69-74.

http://www.jle.com/e-docs/00/04/68/CC/vers_alt/VersionPDF.pdf

Restoration and Rehabilitation of Degraded Ecosystems in Arid and Semi-Arid Lands. I. A View from the South

A general model is presented describing ecosystem degradation to help decide when restoration, rehabilitation, or reallocation should be the preferred response. The latter two pathways are suggested when one or more “thresholds of irreversibility” have been crossed in the course of ecosystem degradation, and when “passive” restoration to a presumed predisturbance condition is deemed impossible. The young but burgeoning field of ecological restoration, and the older field of rehabilitation and sustainable range management of arid and semiarid lands (ASAL), are found to have much in common, especially compared with the reallocation of lands, which is often carried out without reference to pre-existing ecosystems. After clarifying some basic terminology, we present 18 vital ecosystem attributes for evaluating stages of degradation and planning experiments in the restoration or rehabilitation of degraded ecosystems. Finally, we offer 10 hypotheses concerning ecological restoration and rehabilitation as they apply to ASAL and perhaps to all terrestrial ecosystems.

Policymakers, implementing agencies

Aronson, J., C. Floret, E. Le Floch, C. Ovalle and R. Pontanier (1993) Restoration Ecology 1(1): 8-17.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.1993.tb00004.x/abstract

Restoration and Rehabilitation of Degraded Ecosystems in Arid and Semi-Arid Lands. II. Case Studies in Southern Tunisia, Central Chile and Northern Cameroon

A model of ecosystem degradation and three possible responses to it—restoration, rehabilitation, and real-location—is applied to ongoing projects in the arid mediterranean region of southern Tunisia, the subhumid mediterranean region of central Chile, and the semiarid tropical savannas of northern Cameroon. We compare both nonhuman and human determinants of ecosystem degradation processes in these contrasted regions, as well as interventions being tested in each.

Implementing agencies, practitioners

Aronson, J., C. Floret, E. Le Floch, C. Ovalle and R. Pontanier (1993) Restoration Ecology 1(3): 168-187.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.1993.tb00023.x/abstract

El Nino as a Window of Opportunity for the Restoration of Degraded Arid Ecosystems

In this paper, we briefly review evidence for the idea that different states in these ecosystems might represent alternative equilibria and present a graphic model that summarizes the implications for their response to changing environmental conditions. We show how, in the light of this theoretical framework, climatic oscillations such as El Nino Southern Oscillation (ENSO) could be used in combination with grazer control to restore degraded arid ecosystems. We also present evidence that, depending on grazing pressure, ENSO episodes can trigger structural and long-lasting changes in these ecosystems.

Implementing agencies, practitioners

Holmgren, M. and M. Scheffer (2001) El Nino as a Window of Opportunity for the Restoration of Degraded Arid Ecosystems. Ecosystems 4: 151-159.

http://www.resource-ecology.org/publ/2001_Holmgren,Scheffer_ElNinoAsAWindowOfOpportunity.pdf

Wildland Shrub and Arid Land Restoration Symposium

The proceedings emphasize the use of revegetation to rehabilitate arid to semiarid lands for a variety of objectives. For convenience, we have divided these entries into six sections: Overview, Restoration and Revegetation, Ecology, Genetic Integrity, Management Options, and Field Trip. The symposium also included workshops on Large-Scale Rangeland Revegetation and on Revegetation Contracting and Practice.

Practitioners, implementing agencies

Roundy, B.A., E.D. McArthur, J.S. Haley and D.K. Mann (eds.) (1994). Proceedings: Wildland shrub and arid land restoration symposium. U.S. Department of Agriculture, Forest Service, Intermountain Research Station.

www.fs.fed.us/rm/pubs_int/int_gtr315.pdf

Landscape Dynamics and Arid Land Restoration

Restoration strategies that initiate autogenic succession—by using rather than by combating natural processes—have great potential for arid ecosystems. Damaged ecological processes must be restored to restoration sites. Landscape dynamics can be directed toward restoration objectives with strategies that: (1) reduce or eliminate the causes of degradation; (2) address soil degradation and initiate soil improving processes; (3) establish vegetation that addresses microsite availability, soil improvement, and nutrient cycling problems; and (4) arrange landscape components to reduce detrimental landscape interactions while increasing synergies among landscape components. Landscape configuration can be designed to: (1) encourage synergies among landscape components; (2) reduce nutrient losses to adjacent landscape components; (3) facilitate natural seed dispersal mechanisms; (4) attract beneficial animals; and (5) reduce detrimental animal activities.

Practitioners, implementing agencies

Whisenant, S.G. (1995) Landscape Dynamics and Arid Land Restoration in B.A. Roundy et al. (eds.) Proceedings of the Wildland shrub and arid land restoration symposium. U.S. Department of Agriculture Forest Service, Intermountain Research Station.

http://www.fs.fed.us/rm/pubs_int/int_gtr315/int_gtr315_026_034.pdf

Consideraciones Metodológicas para la Recuperación de Tierras Áridas Degradadas

Se entiende por restauración ecológica al conjunto de operaciones que “devuelven a un ecosistema a su situación prealterada”. En muchos casos la restauración de un ecosistema es bastante difícil al haber sido la degradación resultado de unos fenómenos climatológicos y biológicos únicos en intensidad, orden y duración, que han conducido a la desaparición de la base mínima necesaria para su restablecimiento. La dificultad para establecer especies vegetales en una superficie erosionada constituye un ejemplo de esta situación.

Implementing agencies, policymakers

Urbano, J. (2001) Consideraciones Metodológicas para la Recuperación de Tierras Áridas Degradadas. Observatorio Medioambiental 4: 49-89.

http://revistas.ucm.es/index.php/OBMD/article/download/OBMD0101110049A/21799

Alternative Irrigation Systems for Arid Land Restoration

Establishing plants in deserts can be challenging even with supplemental irrigation. The low relative humidity, extreme temperatures, lack of consistent rainfall, tremendous rate of evaporation, and high wind speeds common in desert environments all play important and interrelated roles in water loss from desert soil and plants. These factors make it critical that restorationists use the most appropriate and cost-effective means to deliver water to the root zone of newly planted plants in order to maximize survival and growth. In this paper, I discuss the pros and cons of standard and alternative means of watering plants.

Practitioners

Bainbridge, D.A. (2002) Alternative Irrigation Systems for Arid Land Restoration. Ecological Restoration 20(1): 23-30.

http://www.gaiacollege.ca/course_content/Maintenance2/alternative_irrigation.pdf

Using Hydrogel and Clay to Improve the Water Status of Seedlings for Dryland Restoration

In dryland ecosystems, post-transplant water stress produces high seedling mortality after the first summer following outplanting. Our aim was to assess the effects of clay and hydrogel, both on the water holding capacity of the growing media and on various morphological and physiological characteristics of *Quercussuber* seedlings in the nursery and, subsequently, during the first 2 years in the field. Mixing hydrogel with a peat-based growing medium to form root plugs is a suitable technique for cultivating species to be planted in areas with a strong water deficit. This technique reduces post-transplant water stress in seedlings during their first months in the field and contributes to improve forest restoration methods in dryland ecosystems.

Practitioners

Chirino, E., A. Vilagrosa and V. R. Vallejo (2011) Using Hydrogel and Clay to Improve the Water Status of Seedlings for Dryland Restoration. Plant Soil 344(1-2): 99-110.

http://avilagrosa.weebly.com/uploads/2/5/0/5/2505656/chirino_vilagrosa_vallejo_2011_ps_hydrogels_and_clays.pdf

The Role of Nurse Plants in the Restoration of Degraded Environments

Traditional ecological models have focused mainly on competition between plants, but recent research has shown that some plants benefit from closely associated neighbors, a phenomenon known as facilitation. There is increasing experimental evidence suggesting that facilitation has a place in mainstream ecological theory, but it also has a practical side when applied to the restoration of degraded environments, particularly drylands, alpine, or other limiting habitats. Where restoration fails because of harsh environmental conditions or intense herbivory, species that minimize these effects could be used to improve performance in nearby target species. Although there are few examples of the application of this “nursing” procedure worldwide, experimental data are promising, and show enhanced plant survival and growth in areas close to nurse plants. We discuss the potential for including nurse plants in restoration management procedures to improve the success rate of such projects.

Practitioners, implementing agencies

Padilla, F.M. and F.I. Pugnaire (2006) The Role of Nurse Plants in the Restoration of Degraded Environments. Front Ecol Environ 4(4): 196-202.

http://www.ag.unr.edu/leger/Courses/Restoration_files/Padilla06_nurseplants.pdf

Drylands>Australia

Rehabilitation of Semiarid Landscapes in Australia. I. Restoring Productive Soil Patches

A rehabilitation procedure designed to reestablish resource control processes in a degraded Acacia aneura woodland was successful in improving soil nitrogen and carbon content, exchange properties, and water infiltration rates. Soil respiration rates and soil fauna populations increased, and soil temperatures were moderated. The procedure comprised laying piles of branches in patches on the contour of bare, gently sloping landscapes, with the expectation that soil, water, and litter would accumulate in these branch piles, thus improving the soil habitat and its productive potential. The procedure was derived from landscape function analysis, indicating that surface water flow was the principal means of resource transfer in these landscapes. Under degradation such overland flow results in a loss of resources. This rehabilitation procedure reversed loss processes, resulting in gains in the productive potential of soils within patches. This procedure was successful despite grazing pressure being maintained throughout the experiment.

Practitioners

Tongway, D. J. and J. A. Ludwig (1996) Rehabilitation of Semiarid Landscapes in Australia. I. Restoring Productive Soil Patches. Restoration Ecology 4(4): 388–397.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.1996.tb00191.x/abstract

Rehabilitation of Semiarid Landscapes in Australia. II. Restoring Vegetation Patches

This paper describes a practical technique, tested experimentally, for rehabilitating degraded semiarid landscapes in Australia. This rehabilitation technique is based on the ecological principle that semiarid landscapes are spatially organized as patchy, source-sink systems; this patchy organization functions to conserve limited water and nutrients within the system. The aim was to rebuild vegetation patchiness, lost through decades of utilization of these landscapes as rangelands. Patches were reconstructed from large tree branches and shrubs obtained locally and placed in elongated piles along contours. These piles of branches were very effective in recreating productive soil patches within the landscape, as described in part I of this study. These new patchy habitats promoted the establishment and growth of perennial grasses. Although the foliage cover of these grasses declined into a drought, which started before the end of the experiment, plant survivorship remained high. This suggests that patches also function as refugia for organisms during droughts. The patches of branches remained robust and functional, even under grazing impacts, although plant growth and survival were significantly higher within an ungrazed paddock than in a grazed paddock.

Practitioners

Tongway, D. J. and J. A. Ludwig (1996) Rehabilitation of Semiarid Landscapes in Australia. I. Restoring Productive Soil Patches. Restoration Ecology 4(4): 398-406.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.1996.tb00192.x/abstract

Drylands>Burkina Faso

Zaï Practice: A West African Traditional Rehabilitation System for Semiarid Degraded Lands, a Case Study in Burkina Faso

For degraded soil productivity, restoration, and green cover rehabilitation, it is essential to study and improve traditional farming systems, especially in the Sudano-Sahelian areas, where technical possibilities are limited. One example is the Zaï practice, a very complex soil restoration system using organic matter localization, termites to bore channels in the crusted soils, runoff capture in microwatersheds, and seed hole cropping of sorghum or millet on sandy soils. Investigation on many fields of the Mossi Plateau (northern part of Burkina Faso) has shown a range of variations of the Zaï system in relation to soil texture, availability of labor and organic matter, and relevance for rehabilitation of these degraded crusted soils. We describe a complex soil restoration system revealed during our 2 years of inquiries and experiments testing this system in two types of soil (a shallow, poor apso1 and a deep, brown tropical inceptisol).

Indigenous and local communities, practitioners, implementing agencies

Roose, E., V. Kabore and C. Guenat (1999) Zaï Practice: A West African Traditional Rehabilitation System for Semiarid Degraded Lands, a Case Study in Burkina Faso. Arid Soil Research and Rehabilitation 13: 343-355.

http://horizon.documentation.ird.fr/exl-doc/pleins_textes/pleins_textes_7/b_fdi_51-52/010019795.pdf

Drylands>China

Law, Policy and Dryland Ecosystems in the People's Republic of China

This report summarizes the numerous activities implemented and documents prepared by the national and local-level expert groups, and presents the valuable lessons learned. The report will provide an excellent reference for all stakeholders involved in the development of legal and policy frameworks to combat LD, not only in the PRC, but also in other regions with similar LD and demographic problems, like central Asia and Africa.

Policymakers

Qun, D. and I. Hannam (eds.) (2011) Law, Policy and Dryland Ecosystems in the People's Republic of China. IUCN, Gland.

http://data.iucn.org/dbtw-wpd/edocs/EPLP-080.pdf

New Restoration Engineering in Northeast Asia

The environmental conditions of desertifed areas differ from those where natural regeneration of shrubs and trees occurs, and the revegetation process can be acceletated by planting shrubs and trees. A variety of countermeasures including constructing sand barriers, planting trees and establishing appropriate stocking rates must be implemented under careful consideration of both local socio-economic demands and the degraded environmental condition. This article presents the results of some revegetation trials the author undertook in China and Mongolia. It describes how countermeasures to prevent sand drift and soil erosion are needed in accordance with varying site conditions.

Practitioners, implementing agencies

Yoshikawa, K. (2010) New Restoration Engineering in Northeast Asia. Global Environmental Research 14: 37-46.

http://www.airies.or.jp/publication/ger/pdf/14_1-07.pdf

Shrub Facilitation of Desert Land Restoration in the Horqin Sand Land of Inner Mongolia

To understand the status and roles of shrubs in recovery processes of desertified land in the semi-arid areas of China, we investigated the effects of shrub canopy on soil properties, organic litter, seed bank and understory herbaceous community properties in the Horqin Sand Land, Mongolia. The results showed that in shifting sand dunes, content of very fine sand, silt and clay, organic matter, total N and P, available P and soil moisture at 0–20cm depth was higher under remnant shrub canopies of Caragana microphylla and Salix gordejevii than in open space. These results suggest that shrubs created significant “islands of fertility” and had an important role in maintaining or augmenting herbaceous species richness in shifting sand dunes, and could improve soil properties and facilitate vegetation recovery for controlling desertification processes.

Practitioners, implementing agencies

Zhao, H.L., R.L. Zhou, Y.Z. Su, H. Zhang, L.Y Zhao and S. Drake (2007) Shrub Facilitation of Desert Land Restoration in the Horqin Sand Land of Inner Mongolia. Ecological Engineering 31: 1-8.

http://www.sciencedirect.com/science/article/pii/S0925857407000900

Vegetation Restoration by Seasonal Exclosure in the Kerqin Sandy Land, Inner Mongolia

The aim of the reported study was to evaluate the effectiveness of this seasonal exclosure on vegetation restoration. Species compositional data were obtained from 356 quadrats and ordinated by Detrended Correspondence Analysis (DCA). Ordination indicated that landform was the most important factor influencing the species composition of the vegetation. Regardless of landform and type of grazing control, however, vegetation coverage, vegetation height and species richness were higher at sites where grazing had been controlled, than at sites lacking any control. Perennial species were dominant at the former while annual species were dominant at the latter. Both shrub and tree species were quite rare at the sites where seasonal exclosure had been carried out. It is concluded that seasonal exclosure is sufficient to restore and maintain grassland vegetation in and around the study area. When shrubby or tree vegetation is needed for reasons such as fixing sands or preventing sand dune remobilization, complete exclosure is recommended.

Implementing agencies, practitioners, indigenous and local communities

Katoh, K., K. Takeuchi, D. Jiang, Y. Nan and Z. Kou (1998) Vegetation Restoration by Seasonal Exclosure in the Kerqin Sandy Land, Inner Mongolia. Plant Ecology 139(2): 133-144.

http://www.springerlink.com/content/r2n6615115370448/

Sand Barriers of Straw Checkerboards for Habitat Restoration in Extremely Arid Desert Regions

The results indicate that the straw checkerboard enhanced the capacity of dune systems to entrap dust deposition, leading to the accumulation of soil organic matter and nutrients and to the development of soil formation on the dune surface. The straw checkerboard increased the silt and clay content, thereby changing coarse soil texture to fine. This is one of the vital prerequisites for the invasion and establishment of herbaceous plants in desert ecosystems. When a straw checkerboard was used to stabilize the dunes before establishing sand-binding vegetation, significant differences in plant species richness, herbaceous cover, dust deposition, and soil physicochemical properties were found in this study. All of these findings suggest that the use of the straw checkerboard, as one of the key techniques for restoring desert ecosystems, will be an important component of efforts to further extend ecological engineering projects in arid desert regions.

Practitioners, implementing agencies

Li, X.R., H.L. Xiao, M.Z. He and J.G. Zhang (2006) Sand Barriers of Straw Checkerboards for Habitat Restoration in Extremely Arid Desert Regions. Ecological Engineering 28: 149-157.

http://www.shapotou.ac.cn/paper/003.pdf

Long-term Effects of Restoration on Soil Hydraulic Properties in Revegetation-Stabilized Desert Ecosystems

Improving structure of soils found at 0–5 cm depth, and increasing the thickness of biological soil crusts are both associated with sand dune revegetation-stabilization in arid northwestern China. Since 1956, research on sand dune stabilization has included the use of straw chequer-boards to facilitate development of soil structure. Results of this long-term study show that changes in soil hydraulic properties and improvement in soil structure were associated with migrating dune stabilization.

Practitioners, implementing agencies

Wang, X.P., M.H. Young, Z. Yu, X.R. Li and Z.S. Zhang (2007) Long-term effects of restoration on soil hydraulic properties in revegetation-stabilized desert ecosystems. Geophys. Res. Lett. 34.

ftp://61.178.109.106/58%B7%FE%CE%F1%C6%F7%B1%B8%B7%DD(%CD%E2%B2%BF)/2008%C4%EA%B1%B8%B7%DD/2008/201-202/PDF/1B1DEC5F-82D4-4C16-B3F9-7198906030CD.pdf

Germinable Soil Seed Banks and the Restoration Potential of Abandoned Cropland on the Chinese Hilly-Gullied Loess Plateau

It has been argued that tree planting restoration is ineffective, and natural re-vegetation is an alternative ecological solution for restoring abandoned cropland and controlling soil erosion. The aims of this study were to investigate the characteristics of soil seed banks and to assess the natural restoration potential of abandoned cropland in the hilly-gullied Loess Plateau. The combination of soil seed bank characteristics, reproductive traits of the species, the specific landscape conditions indicates that the potential to restoring the abandoned croplands in the hilly-gullied Loess Plateau via natural re-vegetation could be substantial.

Practitioners, implementing agencies

Wang, N., J.Y. Jiao, Y.F. Jia, W.J. Bai and Z.G. Zhang (2010) Germinable Soil Seed Banks and the Restoration Potential of Abandoned Cropland on the Chinese Hilly-Gullied Loess Plateau. Environmental Management 46: 367-377.

http://www.ncbi.nlm.nih.gov/pubmed/20694556

Excessive Reliance on Afforestation in China's Arid and Semi-arid Regions: Lessons in Ecological Restoration

Although afforestation is potentially an important approach for environmental restoration, current Chinese policy has not been tailored to local environmental conditions, leading to the use of inappropriate species and an overemphasis on tree and shrub planting, thereby compromising the ability to achieve environmental policy goals. China's huge investment to increase forest cover seems likely to exacerbate environmental degradation in environmentally fragile areas because it has ignored climate, pedological, hydrological, and landscape factors that would make a site unsuitable for afforestation. This has, in many cases, led to the deterioration of soil ecosystems and decreased vegetation cover, and has exacerbated water shortages. Large-scale and long-term research is urgently needed to provide information that supports a more effective and flexible environmental restoration policy.

Policymakers, implementing agencies

Cao, S., L. Chen, D. Shankman, C. Wang, X. Wang, and H. Zhang (2011) Excessive Reliance on Afforestation in China's Arid and Semi-arid Regions: Lessons in Ecological Restoration. Earth-Science Reviews 104(4): 240-245.

http://www.sciencedirect.com/science/article/pii/S0012825210001571

Impact of China's Grain for Green Project on the Landscape of Vulnerable Arid and Semi-arid Agricultural Regions: A Case Study in Northern Shaanxi Province

In practical terms, the destruction of natural vegetation cover during afforestation should be avoided, as this makes the soil surface more vulnerable to erosion and reduces species diversity. Managers should reduce the intensity of farming and grazing on fragile land rather than relying on afforestation as the primary tool for ecological restoration in arid and semi-arid areas. Afforestation remains a valuable tool but should be limited to the planting of native or other species that will not exacerbate soil water shortages such as stable communities of natural desert steppe, maximum water-use efficiency dwarf shrubs, and possibly even lichen species in more severely degraded environments.

Policymakers, implementing agencies

Cao, S., L. Chen and X. Yu (2009) Impact of China's Grain for Green Project on the landscape of vulnerable arid and semi-arid agricultural regions: a case study in northern Shaanxi Province. Journal of Applied Ecology 46: 536-543.

http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2664.2008.01605.x/pdf

Drylands>India

Termites as Ecosystem Engineers and Potentials for Soil Restoration

Increasingly, it is being recognized globally that termites are an important component of agro-ecosystems, particularly in developing economies, where they are an alternative to expensive agro-inputs. Termite-mediated processes are used to improve the soil–water balance. In arid and semi-arid regions of India, predominantly in the Kachchh region, so far termite-mediated processes have not been used in land management, particularly soil rehabilitation. It seems that termite activity can be triggered by application of various mulches to the crusted soil surface.

Practitioners

Pardeshi, M.K. and B.A.K. Prusty (2010) Termites as Ecosystem Engineers and Potentials for Soil Restoration. Current Science 99(1): 11.

http://re.indiaenvironmentportal.org.in/files/Termites%20as%20ecosystem%20engineers%20and%20potentials%20for%20soil%20restoration.pdf

Drylands>Kenya

The Challenges of Rehabilitating Denuded Patches of a Semi-Arid Environment in Kenya

The aim of this study was to determine the main factors which contribute to failures in rehabilitating denuded patches in semi-arid lands of Kenya. A questionnaire was administered to capture farmer perceptions on failures on rangeland rehabilitation using grass reseeding technology. Rainfall data was collected during the study period. Moreover, rehabilitation trials using the three grasses were done under natural rainfall. Results from this study show that climatic factors mainly low amounts of rainfall to be the main contributor to rehabilitation failures.

Implementing agencies

Mganga, K.Z. et al. (2010) The Challenges of Rehabilitating Denuded Patches of a Semi-Arid Environment in Kenya. African Journal of Environmental Science and Technology 4(7): 430-436.

http://www.ajol.info/index.php/ajest/article/viewFile/71291/60244

Drylands>Mongolia

Cross-spatial-scale Patterns in the Facilitative Effect of Shrubs and Potential for Restoration of Desert Steppe

Facilitation (positive plant‑plant interactions) is a potential means to accelerate vegetation restoration in arid areas. Shrubs can accelerate vegetation recovery by means of soil amelioration, but this effect has not been evaluated at large spatial scales or across scales. Here, we examined the facilitative function of shrub change across spatial scales at a desert steppe in Mongolia. These results support the hypothesis of scale-dependent changes in the balance between facilitation and competition. Therefore, transplanting shrub saplings at high-density and a larger scale could potentially improve the success of vegetation restoration in arid regions.

Implementing agencies, practitioners

Yoshihara, Y., T. Sasaki, T. Okuro, J. Undarmaa and K. Takeuchi (2010) Cross-spatial-scale Patterns in the Facilitative Effect of Shrubs and Potential for Restoration of Desert Steppe. Ecological Engineering 36(12): 1719‑1724.

http://www.sciencedirect.com/science/article/pii/S0925857410002260

Drylands>Namibia

Determining Landscape Function and Ecosystem Dynamics: Contribution to Ecological Restoration in the Southern Namib Desert

With the long-term view to establish a research initiative focusing on restoration ecology in the southern Namib Desert, this article provides a review of current ecological knowledge and proposes potential research priorities. The aims of a research initiative would be two-fold. On the academic side, understanding processes operating at different scales will be critical to develop methods of ecological restoration suitable for southern Namib ecosystems. On the practical side, the development of appropriate methods will focus on facilitating ecological processes such as restoration of biologically active substrate, natural succession, and concentration of limited resources. The function of landscapes, plant-soil interface, soil-, vegetation- and plant population dynamics will likely provide some of the answers for ecological restoration.

Practitioners, implementing agencies

Burke, A. (2001) Determining Landscape Function and Ecosystem Dynamics: Contribution to Ecological Restoration in the Southern Namib Desert. Ambio 30(1): 29-36.

http://www.bioone.org/doi/abs/10.1579/0044-7447-30.1.29

Best Practice Guidelines for Minimising Impacts on the Flora of the Southern Namib

This booklet provides simple guidelines in a user-friendly format. It is the first practical guide for environmental management of the Succulent Karoo Biome, and the first of its kind in Namibia. It is my hope that many will read and implement these guidelines and so help make a positive contribution to the wise management and development of Namibia’s prime arid-zone biodiversity asset.

Practitioners, implementing agencies

Burke, A. (2005) Best practice guidelines for minimising impacts on the flora of the southern Namib. EnviroScience and Namibia Nature Foundation, Windhoek.

http://www.cepf.net/Documents/bestpracticeguidelines.antjeburke.pdf

Practical Measures in Arid Land Restoration after Mining - A Review for the Southern Namib

The techniques available are discussed under the headings: (a) provision of suitable landform and substrate and (b) facilitating natural processes. Landscaping man-made landforms to match their surroundings, the provision of rough surfaces and small water catchments as well as applying fresh topsoil are the main aspects to be considered. Growth-impeding soil properties such as toxicity, and acidic, saline and sodic conditions will require treatment to ensure natural plant re-establishment is feasible or replanting areas is successful. Seeding and relocating native plants are feasible options to accelerate natural plant succession that merit further development in the southern Namib.

Practitioners, implementing agencies

Burke, A. (2003) Practical Measures in Arid Land Restoration after Mining - A Review for the Southern Namib. South African Journal of Science 99(9-10): 413-417.

http://www.mendeley.com/research/practical-measures-in-arid-land-restoration-after-mining-a-review-for-the-southern-namib/

Reestablishing a Keystone Species in an Arid Coastal Environment: Saltbush (Salsola nollothensis) in Namibia

Beach hummocks are important ecological components of coastal ecosystems. Although hummocks are naturally adapted to harsh conditions, reestablishing them in arid areas poses great challenges. During a collaborative project, researchers from Namdeb Diamond Corporation and the Millennium Seed Bank Partnership investigated practical methods to reestablish saltbush (Salsola nollothensis) beach hummocks to restore areas disturbed by alluvial diamond mining. With focus on simple methods that can be implemented over large areas, collecting seed-containing debris, placing windbreaks, and seeding these with debris are some of the means currently investigated.

Practitioners, implementing agencies

Burke, A., R. Newton, D. Boyce, H. Kolberg and I. Brunner (2011) Reestablishing a Keystone Species in an Arid Coastal Environment: Saltbush (Salsola nollothensis) in Namibia. Ecological Restoration 29(1-2): 25-34.

http://er.uwpress.org/content/29/1-2/25.short

Drylands>Saudi Arabia

Forestland Degradation and Potential Rehabilitation in Southwest Saudi Arabia

Rehabilitation of the degraded forestland needs collaborative efforts and support from the different related governmental sectors as well as the locals. Protection, silvicultural practices, and sustainable management must be adopted as tools of rehabilitation.

Implementing agencies

El-Juhany, L.I. (2009) Forestland Degradation and Potential Rehabilitation in Southwest Saudi Arabia. Australian Journal of Basic and Applied Sciences 3(3): 2677-2696.

http://www.ajbasweb.com/ajbas/2009/2677-2696.pdf

Drylands>South Africa

Species, Functional Groups and Community Structure in Seedbanks of the Arid Nama Karoo: Grazing Impacts and Implications for Rangeland Restoration

The regeneration potential of grazing-affected Nama Karoo vegetation was evaluated by comparing soil seed banks of different microsites across a fence-line contrast in arid Namibia. Seed banks under low and high grazing pressure reflected the condition of the standing vegetation in terms of composition, community structure and species abundance distributions. Results indicated an advanced divergence in the vegetation at the degraded site with seed banks of species common under sustainable grazing being drastically reduced. Their low abundance, even in safe sites, suggests that long-distance dispersal is one of the main limiting factors for natural re-establishment after disturbance. The inertia in recovery of Namibian degraded rangelands through seed limitation can be overcome only by active species introduction.

Implementing agencies, practitioners

Dreber, N., J. Oldeland and G.M.W. van Rooyen (2011) Species, Functional Groups and Community Structure in Seedbanks of the Arid Nama Karoo: Grazing Impacts and Implications for Rangeland Restoration. Agriculture Ecosystems and Environment 141(3): 399-409.

http://137.215.9.22/bitstream/handle/2263/16515/Dreber_Species(2011).pdf?sequence=1

Drylands>Sub-Saharan Africa

Rehabilitation of Degraded Lands in Sub-Saharan Africa: Lessons Learned from Selected Case Studies

The GFIS Africa Synthesis initiative on “Rehabilitation of Degraded Lands in Sub-Saharan Africa” was therefore initiated in an effort to bring together African scientists working on tropical forests, woodlands and allied natural resources through networking to review and appraise existing information (both published and grey) and chart the way forward on sustainable management of the resources as a further contribution to the GFIS Africa project. Specifically, the synthesis has an emphasis on case studies in Sub-Saharan Africa in order to demonstrate what has already been done in the area of rehabilitation of degraded lands and to identify what are the gaps with respect to policy, management and research.

Policymakers, implementing agencies

Blay, D., E. Bonkoungou, S.A.O. Chamshama and B. Chikamai (2004) Rehabilitation of Degraded Lands in Sub-Saharan Africa: Lessons Learned from Selected Case Studies. FORNESSA and IUFRO-SPDC Synthesis Report.

http://www.etfrn.org/etfrn/workshop/degradedlands/documents/synthesis_all.pdf

Restoration of Degraded Semi-Arid Communal Grazing Land Vegetation Using the Exclosure Model

Degradation of communal grazing land vegetation is a widespread problem throughout Sub-Saharan Africa and its restoration is a challenge for the management of many semi-arid areas. This study assessed the effectiveness of different age (young versus old) exclosures on species composition and diversity, biomass production and woody structure in northern Ethiopia. The species composition and diversity of herbaceous and woody plants was higher in the exclosures than in the grazed areas. The mean aboveground biomass measured inside the exclosures was more than twice that of the adjacent grazed areas and more biomass was produced from the young than the old exclosures. The study showed that degraded semi-arid vegetation is able to recover in a relatively short time when protected. Extended protection, however, reduces herbaceous species diversity and biomass. Therefore, it is suggested that a slight shift in management where exclosures protected for longer periods may be moderately used by livestock.

Indigenous and local communities, implementing agencies

Yayneshet, T. (2011) Restoration of Degraded Semi-Arid Communal Grazing Land Vegetation Using the Exclosure Model. International Journal of Water Resources and Arid Environments 1(5): 382-386.

http://www.psipw.org/attachments/article/306/IJWRAE_1%285%29382-386.pdf

Drylands>USA

Process-Based Management Approaches for Salt Desert Shrublands Dominated by Downy Brome

Downy brome grass (Bromustectorum L.) invasion has severely altered key ecological processes such as disturbance regimes, soil nutrient cycling, community assembly, and successional pathways in semiarid Great Basin salt desert shrublands. Restoring the structure and function of these severely altered ecosystems is extremely challenging; however new strategies are emerging that target and attempt to repair ecological processes associated with vegetation change. In this paper, we review the essential processes required to reduce downy brome abundance and assist with creating suitable conditions for revegetation of Great Basin salt desert shrublands.

Practitioners

Hirsch, M.C. and T. Monaco (2011) Process-Based Management Approaches for Salt Desert Shrublands Dominated by Downy Brome. Natural Resources and Environmental Issues 17/9.

http://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1754&context=nrei

A Spatial Model to Prioritize Sagebrush Landscapes in the Intermountain West for Restoration

We prioritized landscapes for restoring Sagebrush habitats within the intermountain western region of the United States using geographic information system (GIS) modeling techniques to identify areas meeting a set of conditions based on (1) optimum abiotic and biotic conditions favorable for revegetation of Sagebrush; (2) potential to increase connectivity of Sagebrush habitats in the landscape to benefit wildlife; (3) location of population strongholds for Greater Sage-Grouse (*Centrocercusurophasianus*, a species of conservation concern); and (4) potential impediments to successful restoration created by Cheatgrass (*Bromustectorum*, an invasive exotic annual grass). Our results represent an integral component in a hierarchical framework after which site-specific locations for treatments can be focused within high-priority areas. Using this approach, long-term restoration strategies can be implemented that combine local-scale treatments and objectives with large-scale ecological processes and priorities.

Implementing agencies, practitioners

Meinke, C.W., S.T. Knick and D. A. Pyke (2009) A Spatial Model to Prioritize Sagebrush Landscapes in the Intermountain West (U.S.A.) for Restoration. Restoration Ecology 17(5): 652-659.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2008.00400.x/full

Rehabilitating Salt-Desert Ecosystems following Wildfire and Wind Erosion

Over time, the cost to continually contend with wildfire, restoration efforts, reduced livestock/wildlife grazing, added regulations, etc. adds up to substantial expenditures of the citizen's tax dollars. The process of changing the vegetative landscape to a more sustainable and stable system may or may not have higher initial costs than fire fighting and suppression. However, when planned and conducted successfully, stabilization of these damaged areas will provide economical and social benefits for generations to come.

Implementing agencies, policymakers

Newhall, R.L., T.A. Monaco, W.H. Horton, R.D. Harrison and R.J. Page (2004) Rehabilitating Salt-Desert Ecosystems following Wildfire and Wind Erosion. Rangelands 26(1): 3-7.

http://media.archimedes.nal.usda.gov/frrl/documents/Rehabilitating_Salt_Desert_Ecosystems.pdf

Drylands>Livelihoods

Dryland Opportunities: A New Paradigm for People, Ecosystems and Development

This Challenge Paper builds on the understanding that has emerged over the past decade about climate dynamics in drylands and the role of uncertainty, risk and resilience. It situates this debate in the context of rapid global change - of climate, economy and geopolitics. The Challenge Paper emphasises adaptive potentials, the value of dryland ecosystem services and the investment and marketing opportunities they offer, and the possibilities of strengthening the institutional environment for managing risk and rewarding resilience. It aims to apply the new scientific insights on complex dryland systems to practical options for development. A new dryland paradigm is built on the resources and capacities of dryland peoples, on new and emergent economic opportunities, on inward investment, and on the best support that dryland science can offer. The authors recommend five building blocks: strengthening the knowledge base; valuing and sustaining dryland ecosystem services; promoting public and private investment in drylands; improving access to profitable markets; and prioritising rights, reform, risk and resilience.

Policymakers

Mortimore, M. et al. (2009) Dryland Opportunities: A new paradigm for people, ecosystems and development, IUCN, Gland, Switzerland; IIED, London, UK and UNDP/DDC, Nairobi, Kenya.

http://data.iucn.org/dbtw-wpd/edocs/2009-033.pdf

Restoring Natural Capital in Arid and Semiarid Regions: Combining Ecosystem Health with Human Well-being

This document presents the major features of the ‘restoring natural capital’ (RNC) concept applied to arid and semiarid regions for the purposes of facilitating communication, information sharing and discussion. The goal is primarily: 1) to participate in promoting this approach to societies and communities most affected by degradation of the environments and resources they manage, and 2) to persuade governments and public and private assistance decision-makers to adopt this approach for their projects.

Policymakers, implementing agencies

English, French

Lacombe, M. and J. Aronson (2009) Restoring natural capital in arid and semiarid regions combining ecosystem health with human wellbeing. Les dossiers thématiques du CSFD. N° 7.

http://www.csf-desertification.org/index.php/bibliotheque/publications-csfd/les-dossiers-du-csfd-english

Traditional Knowledge and Modern Technology for the Sustainable Management of Dryland Ecosystems

One of the main objectives of the workshop was to explore the extent of traditional methods as a complement to existing modern technologies to assist dryland biosphere reserves in the rehabilitation of degraded areas in their transitional and buffer zones. The workshop also aimed at finding solutions to desertification that could specifically be incorporated into National Action Programmes within the context of the UN Convention to Combat Desertification. The workshop had thus a scientific but also an anthropological component as well as a policy-oriented purpose. UNESCO is pleased to offer the various case studies contained in the workshop proceedings to the UNCCD for its important work on reducing dryland degradation and combating desertification.

Policymakers, implementing agencies, indigenous and local communities

Shaaf, T. (ed.) (2005) Traditional Knowledge and Modern Technology for the Sustainable Management of Dryland Ecosystems. UNESCO–MAB Drylands Series No. 4, Proceedings of the International Workshop held in Elista, Republic of Kalmykia, Russian Federation.

http://unesdoc.unesco.org/images/0013/001391/139182e.pdf

Sustainable Management of Marginal Drylands

These proceedings provide up-to-date information on the ongoing sustainable management projects in the selected SUMAMAD Project sites. It also highlights the work continually being carried out in the marginal drylands in promoting the use of wise practices in the conservation of natural resources, and the importance of supporting local populations in their efforts toward the sustainable use of their natural resources. In fact, capacity-building is a major component of the project.

Implementing agencies

Shaaf, T. (ed.) (2004) Sustainable Management of Marginal Drylands. UNESCO–MAB Drylands Series No. 3, Proceedings of the International Workshop on Sustainable Management of Marginal Drylands held in Shiraz, Iran.

http://unesdoc.unesco.org/images/0013/001354/135470e.pdf

The Economics of Desertification, Land Degradation, and Drought: Toward an Integrated Global Assessment

Although recognizing the differences among desertification, land degradation, and drought, this report conceptualizes the economic valuation of DLDD in terms of its association with the change in productivity and with changes in the provision of ecosystem services and the human benefits derived from them. Ecosystem services comprise provisioning (agricultural output, fuelwood, fresh water, and so on), supporting (such as soil formation, nutrient cycling), regulating (such as water and climate regulation), and cultural services.

Policymakers

Nkonya, E., N. Gerber, P. Baumgartner, J. von Braun, A. De Pinto, V. Graw, E. Kato, J. Kloos and T. Walter (2011) The Economics of Desertification, Land Degradation, and Drought: Toward an Integrated Global Assessment. ZEF-Discussion Papers on Development Policy No. 150.

http://www.ifpri.org/sites/default/files/publications/ifpridp01086.pdf

The Nature of Drylands: Diverse Ecosystems, Diverse Solutions

The aim of this booklet is to feature cutting edge work on drylands being undertaken by IUCN Members. However with over 1,000 Members and thousands of Commission experts, we could only skim the surface.

Implementing agencies, practitioners

Kamotho, S., W. Strahm and C. Wolfangel (eds.) (2008) The Nature of Drylands: Diverse Ecosystems, Diverse Solutions. IUCN, Eastern and Southern Africa Regional Office, Nairobi, Kenya.

http://data.iucn.org/dbtw-wpd/edocs/2008-023.pdf

Rehabilitation of Degraded Drylands and Biosphere Reserves

The theme of the workshop was the establishment of capacity for the rehabilitation of degraded drylands, using site-specific examples of biosphere reserves to assess potential natural vegetation and viable wildlife populations in drylands. The project also seeks to apply scientific methods for improved management of marginal drylands. Combating desertification by rehabilitating degraded lands can be done successfully, using existing, often traditional techniques. It is for this reason that workshops such as these are paramount to providing and sharing practical and inexpensive solutions to common problem.

Implementing agencies, practitioners

Lee, C. and T. Schaaf (eds.) (2003) Rehabilitation of Degraded Drylands and Biosphere Reserves. UNESCO-MAB Drylands Series No. 2, Proceedings of the International Workshop on Combating Desertification held in Aleppo, Syria.

http://unesdoc.unesco.org/images/0013/001307/130760e.pdf

Freshwater Resources and the Rehabilitation of Degraded Areas in the Drylands

Over fifty scientists from fourteen countries and international organizations representing various scientific disciplines took part in this important event. They addressed issues of desertification, in particular with regard to restoring degraded dryland areas, and the conservation and sustained management of freshwater resources in the world's dry zones. Accordingly, these proceedings contain a series of case studies from Africa and Asia providing not only new insights into site-specific problems but also solutions which may be adapted to resolve similar problems in other desertification-affected areas of the world.

Policymakers, implementing agencies

English, French

Dupuy, A., C. Lee, and T. Schaaf (eds.) (2002) Freshwater Resources and the Rehabilitation of Degraded Areas in the Drylands. UNESCO-MAB Drylands Series No. 1, Proceedings of the International Seminar on Combating Desertification held in N'Djamena, Chad.

http://portal.unesco.org/science/en/ev.php-URL_ID=8951&URL_DO=DO_TOPIC&URL_SECTION=201.html

Drylands, People, and Ecosystem Goods and Services: A Web-Based Geospatial Analysis

This web-based analysis takes advantage of the power of geospatial technologies to examine the world's drylands. We consider drylands from the perspective of human livelihoods, examining how these livelihoods are integrated with dryland ecosystem goods and services. Our presentation is map-rich using combinations of remotely-sensed data and computer-based data management systems (GIS). Where global data are not available, we use regional and national studies. We focus on a selected set of dryland goods and services: forage and livestock; food production; biodiversity conservation; freshwater; carbon storage; energy production; and tourism and recreation. The final two sections examine drylands and trade and drylands and the impacts of human activities.

Policymakers, implementing agencies

White, R.P. and J. Nackoney (2003) Drylands, People, and Ecosystem Goods and Services: A Web-Based Geospatial Analysis. World Resources Institute, Washington, DC.

http://pdf.wri.org/drylands.pdf

Where the Land is Greener

This book contains an extensive range of case studies from around the world: 42 soil and water conservation technologies and 28 approaches in total. It provides a detailed analysis of the case studies under 'technologies' and 'approaches' and policy points for decision makers and donors. It is a prototype and sets new standards for systematic documentation, evaluation and dissemination of knowledge on sustainable land management and addresses global concerns such as desertification, poverty, water scarcity and conflict.

Practitioners, implementing agencies, indigenous and local communities

Liniger, H. and W. Critchley (2007) Where the land is greener – case studies and analysis of soil and water conservation initiatives worldwide. WOCAT.

http://www.wocat.net/en/knowledge-base/documentation-analysis/global-overview-book.html

Drylands>Livelihoods>Latin America

Pobreza, Desertificación y Degradación de los Recursos Naturales

En esta publicación se sintetizan los resultados obtenidos y las lecciones aprendidas durante la ejecución del proyecto CEPAL/GTZ "Indicadores socioeconómicos de la desertificación", ejecutado por la CEPAL en Argentina, Brasil y Chile. La información ha sido puesta a disposición de quienes adoptan las decisiones y usuarios en general, tanto en el ámbito central en las instituciones contrapartes, como también a escala comunal en Chile, en el ámbito provincial y de partidos en Argentina y de municipios en Brasil. El sistema está diseñado con gran flexibilidad, a fi n de calcular otros índices que se requieran para el análisis del impacto de la desertificación y degradación de tierras, así como para permitir su actualización.

Policymakers, implementing agencies

Morales, C. and S. Parada (eds.) (2005) Pobreza, Desertificación y Degradación de los Recursos Naturales. Comisión Económica para América Latina y el Caribe (CEPAL) de las Naciones Unidas, Santiago.

http://www.eclac.org/publicaciones/xml/8/24268/lcg2277e.pdf

Restoration and Rehabilitation of Mixed Espinales in Central Chile: 10-Year Report and Appraisal

A synthesis of progress achieved thus far is provided for a 10 - year research and development program aimed at the ecological and economic rehabilitation of agro-ecosystems in the un-irrigated portions of the central valley of Chile's Mediterranean climate region. We review our data on (1) revised management techniques aimed at restoring the gross superstructure and former levels of diversity and productivity of a mixed espinales formation; (2) selection and utilization of ecotypes of the naturalized annual Medicago polymorpha L. and the N2-fixing microsymbiont Rhizobium meliloti, for gradual improvement of espinal soil fertility; and (3) studies of the outstandingly well adapted and fast growing Canary Island tree Chamaecytisus proliferus (L. fil.) Link ssp. palmensis (Christ) Kunkel (Tagasaste), which along with about three dozen other woody nitrogen - fixing legume and several nonlegume multipurpose trees, was considered to be of potential value for deep soil layer rehabilitation combined with economic improvements.

Practitioners

Ovalle, C., J. Aronson, A.D. Alejandro and J. Avendan (1999) Restoration and Rehabilitation of Mixed Espinales in Central Chile: 10-Year Report and Appraisal. Arid Soil Research and Rehabilitation 13(4): 369-381.

http://www.tandfonline.com/doi/abs/10.1080/089030699263258

Drylands>Livelihoods>South Africa

Economic Incentives for Restoring Natural Capital in Southern African Rangelands

Technical and economic factors hinder effective ecological restoration, especially in developing countries. Three examples show how social policy, economic threats and opportunities, and national and international development policy are driving the restoration of degraded landscapes in southern Africa. First, new opportunities in nature tourism, together with the declining profitability of traditional ranching, have led to diversification into game farming, tourism, and hunting, all initiatives that rely on properly functioning ecosystems. Second, new environmental legislation is forcing industries, particularly mining, to restore land upon termination of their activities. Third, through South Africa’s “Working for Water” program, an elegant solution to problems of excessive water use, local residents are developing skills in clearing alien plants and restoring rangelands.

Policymakers, implementing agencies, indigenous and local communities

Milton, S.J., W.R.J. Dean and D.M. Richardson (2003) Economic incentives for restoring natural capital in southern African rangelands. Frontiers in Ecology and the Environment 1(5): 247–254.

http://www.esajournals.org/doi/abs/10.1890/1540-9295%282003%29001%5B0247%3AEIFRNC%5D2.0.CO%3B2?journalCode=fron

Drylands>Mediterranean

Special Issue: International Journal of Mediterranean Ecology

The seven papers presented in this special issue are derived from oral communications or from posters presented during this congress.

Practitioners, implementing agencies

English, French

Dutoit T. (ed.) (2011) Ecological restoration of Mediterranean ecosystems: specificities, hopes and limits. Proceedings of the 7th SER European conference on ecological restoration, 23-27 August 2010, Avignon, France. Special Issue of ecologia mediterranea 37(2): 1-84.

http://ecologia-mediterranea.univ-avignon.fr/uploads/media/Ecologia_mediterranea-2011-37_2.pdf

Land Restoration to Combat Desertification: Innovative Approaches, Quality Control and Project Evaluation

This book addresses key issues in land restoration that emerge from restoration science and practice in the Mediterranean Basin. On the grounds of the long-standing and well-developed afforestation experience in Mediterranean countries, we shall suggest ways to incorporate lessons learned from past experiences into new restoration approaches, to face new and old threats, and new challenges and opportunities, using new and not-so-new approaches and techniques. The first part of the book deals with missing elements in the restoration practice that are critical steps for rationalizing the incorporation of restoration activities in the economy, namely quality control, monitoring and evaluation. The second part tackles specific, innovative developments of restoration techniques. These include plant selection of species and provenances, and nursery and field techniques to overcome water stress as the major limitation in drylands – now and in the perspective of projected climate change.

Practitioners, implementing agencies

Bautista, S., J. Aronson and V.R. Vallejo (eds.) (2009) Land Restoration to Combat Desertification: Innovative Approaches, Quality Control and Project Evaluation. Fundación Centro de Estudios Ambientales del Mediterráneo (CEAM), Valencia, Spain.

http://www.ceam.es/reaction/book01.htm

Restauración de Ecosistemas Mediterráneos

El principal objetivo de esta publicación es poner a disposición de los estudiantes universitarios, de licenciatura y escuelas técnicas, pre y postdoctorales, así como de técnicos que desarrollen su profesión en empresas y administraciones, un volumen en castellano que proporcione una visión amplia, actualizada e integrada sobre la restauración ecológica en nuestros ambientes mediterráneos.

Practitioners, implementing agencies

Rey-Benayas, J. M., E. Pinilla and N. Ibarra (eds.) (2007) Restauración de ecosistemas mediterráneos, 2nd edition. Universidad de Alcalá, Madrid.

http://www.agricolajerez.com/restauracion-ecosistemas-mediterraneos

Evaluating the Restoration of Dryland Ecosystems in the Northern Mediterranean

Drylands in the northern Mediterranean present significant challenges for efforts to preserve ecosystem services. Ecological restoration combined with adaptive management can be an effective approach in response to the changing climate and environment. The development of standardized monitoring and evaluation protocols on the EC REACTION project has provided powerful insights and new tools to enhance the potential for successful restoration. The integration of biophysical and socioeconomic indicators and the collaboration between researchers, managers, and decision makers make the approach effective and sustainable. Restoration in drylands can have a marked impact on water budgets through the selection of species and the influence on landscapes and vegetation patterns. Adapting to environmental change and combating land degradation in the northern Mediterranean will require understanding the tradeoffs in ecosystem services and adjusting restoration decisions in response to monitoring and evaluating both biophysical and socioeconomic metrics.

Implementing agencies, policymakers

Bautista, S., B.J. Orr, J.A. Alloza and R.V. Vallejo (2010) Evaluating the Restoration of Dryland Ecosystems in the Northern Mediterranean. Water and Sustainability in Arid Regions 3: 295-310.

http://www.springerlink.com/content/r574734728532l21/

Restoration and Rehabilitation of Arid and Semiarid Mediterranean Ecosystems in North Africa and West Asia: A Review

Mediterranean type vegetation and ecosystems have undergone intense processes of degradation for decades, centuries, or millennia under heavy and prolonged pressure from human and livestock populations. An extensive literature on exclosures, afforestation, reafforestation, rehabilitation, and other regeneration operations over several million hectares in Mediterranean bioclimatic areas from the Atlantic Ocean to the Aral Sea, combined with 50 years of personal field experience, allowed us to draw a number of conclusions on the consequences of these efforts, constraints, and limitations.

Implementing agencies, practitioners

Le Houerou, H.N. (2000) Restoration and Rehabilitation of Arid and Semiarid Mediterranean Ecosystems in North Africa and West Asia: A Review. Arid Soil Research and Rehabilitation 14: 3-14.

http://www.tandfonline.com/doi/abs/10.1080/089030600263139

Secondary Succession of Semi-arid Mediterranean Old-fields in South-eastern Spain: Insights for Conservation and Restoration of Degraded Lands

A 60-year chronosequence study of semi-arid old-fields indicates that abandonment age, litter depth, organic carbon soil content, carbonate content and soil moisture are related to vegetation ordination. The species turnover could be high in the recent abandoned fields. Species richness varies, holding a non-linear relation with time as a result of the coexistence of different functional groups. Land use history determines the ordination of communities and previous cropping influences the pathway of succession. Plant functional group and dispersal type richness and cover show significant differences between old-field age groups. The facilitation pathway of crop trees on bird-dispersed shrub species could promote the development of vegetation under these stressful conditions.

Implementing agencies, practitioners

Bonet, A. (2004) Secondary Succession of Semi-arid Mediterranean Old-fields in South-eastern Spain: Insights for Conservation and Restoration of Degraded Lands. Journal of Arid Environments 56: 213-233.

http://www.ua.es/es/internacional/internacionalizacion/aquadapt/pdf/Bonet2004.pdf

Protocols for Restoration Based on Recruitment Dynamics, Community Structure, and Ecosystem Function: Perspectives from South African Fynbos

We postulate that by adopting an approach in which an understanding of community and ecosystem dynamics is applied to restoration practices, protocols can be developed which will lead to more efficient restoration. This understanding is based on a review of the relevant ecological literature, focusing on recruitment dynamics, community structure, and ecosystem function, which are particularly relevant to restoration. We develop a conceptual framework for restoration and apply our protocols to a case study area on the Cape Peninsula.

Implementing agencies, practitioners

Holmes, P.M. and D.M. Richardson (1999) Protocols for Restoration Based on Recruitment Dynamics, Community Structure, and Ecosystem Function: Perspectives from South African Fynbos. Restoration Ecology 7: 215-230.

http://onlinelibrary.wiley.com/doi/10.1046/j.1526-100X.1999.72015.x/abstract

Pioneers and Perches—Promising Restoration Methods for Degraded Renosterveld Habitats?

The study reports on two restoration experiments, designed to re-introduce key plant functional types back into this critically endangered habitat. The first experiment concentrated on a common pioneer species in renosterveld vegetation, Otholobium hirtum. Although in vitro experiments showed a significantly elevated germination response after scarification, in vivo experiments failed to produce establishment in an abandoned field. The second restoration experiment focused on bush clumps, a sub-type of renosterveld vegetation that is characterized by broad-leaved shrubs with fleshy bird-dispersed diaspores. The experiments revealed that restoration using early-succession species and natural dispersal vectors appear not to produce demonstrable benefits, despite their promising potential and pre-testing of effectiveness. Before launching large-scale restoration programs in abandoned fields of renosterveld, preliminary studies in-field are strongly recommended.

Practitioners, implementing agencies

Heelemann, S., C.B. Krug, K.J. Esler, C. Reisch and P. Poschlod (2012) Pioneers and Perches—Promising Restoration Methods for Degraded Renosterveld Habitats? Restoration Ecology 20(1): 18-23.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2011.00842.x/full

Drylands>Mediterranean>Species Selection and Site Conditions

Plant Functional Types: A Promising Tool for Management and Restoration of Degraded Lands

We describe two case studies undertaken to evaluate the effects of logging or overgrazing on plant species diversity in pine forests of southern France and steppe ecosystems of southern Tunisia. Both studies employed the same methodology to identify plant functional traits (morphological, life history and regeneration traits) associated with community response to disturbance. The results of these analyses allowed us to develop state and transition models that could be used to plan and predict ecosystem trajectories, assess ongoing degradation processes and monitor community and ecosystem responses to management and restoration practices. We discuss the relevance and the use of plant functional types (PFTs) as tools for ecosystem management and planning and for monitoring restoration in southern Europe, northern Africa and elsewhere. Using this approach it is possible to improve management strategies for the conservation, restoration and sustainable exploitation of biodiversity and of ecosystems.

Implementing agencies, practitioners

Gondard, H., S. Jauffret, J. Aronson and S.Lavorel (2003) Plant functional types: a promising tool for management and restoration of degraded lands. Applied Vegetation Science 6: 223-234.

http://onlinelibrary.wiley.com/doi/10.1111/j.1654-109X.2003.tb00583.x/abstract

Potential for Using Facilitation by Grasses to Establish Shrubs on a Semi-Arid Degraded Steppe

In this study, we analyzed the effects of *S. tenacissima* tussocks on the survival, growth, and ecophysiological features of experimentally planted seedlings of *Medicagoarborea*, *Quercuscoccifera*, and *Pistacialentiscus* in three sites in a semiarid region in southeastern Spain. Our main objective was to test whether *S. tenacissima* was able to facilitate shrub establishment in semiarid degraded steppes. Our results suggest a direct facilitative effect of *S. tenacissima* on introduced shrubs. This study indicates that positive interactions in semiarid steppes can be of particular importance for effective restoration in degraded semiarid ecosystems.

Practitioners

Maestre, F.T., S. Bautista, J. Cortina and J. Bellot (2001) Potential for Using Facilitation by Grasses to Establish Shrubs on a Semi-Arid Degraded Steppe. Ecological Applications 11(6): 1641-1655.

http://www.esajournals.org/doi/abs/10.1890/1051-0761%282001%29011%5B1641%3APFUFBG%5D2.0.CO%3B2?journalCode=ecap

Rethinking Species Selection for Restoration of Arid Shrublands

Restoration is playing an increasingly important role in ecology as natural habitats become scarcer and chances to restore ecosystems damaged by human activities are more common. However, restoration of degraded Mediterranean arid ecosystems is hampered by drought and poor soils, which cause many establishment failures. To compare how species belonging to different successional stages establish in a very stressful site, we carried out a field experiment with 14 tree and shrub species differing in functional traits. We found that survival was highest for legumes, followed by leafless species, and C_4 shrubs, traits that are believed to maximize resource uptake in cleared and infertile areas while reducing water losses. Thus, selection of mid-successional species having such traits should be considered for successful restoration. These species would increase the success of restoration programs, but also would increase soil fertility, reduce soil erosion processes, and eventually facilitate establishment of other species, therefore accelerating secondary succession. We suggest a new approach for the restoration for arid shrublands in which species are carefully selected based on traits that best suit the environmental conditions.

Practitioners

Padilla, F.M., R. Ortega, J. Sánchez and F.I. Pugnaire (2009) Rethinking Species Selection for Restoration of Arid Shrublands. Basic and Applied Ecology 10(7): 640–647.

http://www.sciencedirect.com/science/article/pii/S1439179109000292

Use of Shrubs as Nurse Plants: A New Technique for Reforestation in Mediterranean Mountains

Common techniques currently used for afforestation in the Mediterranean basin consider the pre-existing vegetation (mainly shrubs) as a source of competition for trees, and consequently it is generally eliminated before planting. Nevertheless, it has been demonstrated that woody plants can facilitate the establishment of understory seedlings in environments that, like the Mediterranean area, are characterized by a pronounced dry season. In this study, we experimentally analyze the usefulness of shrubs as nurse plants for afforestation of two native conifers, Pinus sylvestris L. (Scots pine) and Pinus nigra Arnold (black pine). The results show that the use of shrubs as nurse plants is a technique that offers both economic and ecological advantages, in terms of savings in labor and plant material and reduced and even negligible impact on the pre-existing vegetation.

Practitioners, implementing agencies

Castro, J., R. Zamora, J.A. Hodar and J.M, Gomez (2002) Use of Shrubs as Nurse Plants: A New Technique for Reforestation in Mediterranean Mountains. Restoration Ecology 10(2): 297-305.

http://hera.ugr.es/doi/15010739.pdf

Ecological Restoration in Degraded Drylands: The Need to Improve the Seedling Quality and Site Conditions in the Field

In this paper we analyze innovative nursery and field techniques oriented to reduce outplanting stress. In the nursery, the main research lines are directed towards improving seedling quality, especially its resistance to water stress, by means of the use of containers gauged to the different root growth patterns of the species, the use of hydrogel to improve the water holding capacity of the substrate and reduce post-planting stress, the use of drought preconditioning to induce mechanisms for drought resistance, the use of fertilization according to field conditions and target seedlings for restoration projects and the use of growth regulators to control the biomass distribution within the seedlings.

Practitioners

E. Chirino et al. (2009) Ecological Restoration in Degraded Drylands: The Need to Improve the Seedling Quality and Site Conditions in the Field in S.P. Grossberg (ed.) Forest Management. Nova Science Publishers, Inc.

http://imem.ua.es/en/documentos/imem-files/research-articles/jordi-cortina/chirino-et-al-2009-book.pdf

Bases Ecológicas para la Restauración de los Espartales Semiáridos Degradados

En este estudio se analiza la interacción entre S. tenacissima y distintas especies leñosas mediterráneas introducidas mediante plantación y siembra, con el fin de evaluar el potencial de la facilitación como herramienta para la restauración ecológica de los espartales. Esta interacción es la suma de efectos positivos (mejora en las condiciones microclimáticas y edáficas y captación de agua de escorrentía) y negativos (competencia subterránea por el agua), siendo la mejora del microclima en los alrededores de S. tenacissima el principal mecanismo responsable de la facilitación observada en las especies introducidas. Los efectos positivos aumentan conforme lo hacen las condiciones climáticas adversas en un gradiente espacio-temporal de estrés hídrico. Estos resultados indican que la facilitación puede contribuir a optimizar la restauración de los espartales degradados.

Practitioners

Maestre, F. T., S. Bautista, J. Cortina, C. Bladé, J. Bellot and V.R. Vallejo (2003) Bases ecológicas para la restauración de los espartales semiáridos degradados. Ecosistemas 2003/1.

http://revistaecosistemas.net/pdfs/246.pdf

Ecología del Esparto (*Stipatenacissima* L.) y los Espartales de la Península Ibérica

Ecología del esparto (*Stipatenacissima* L.) y los espartales de la Península Ibérica. Las formaciones vegetales dominados por el esparto o atocha (*Stipatenacissima* L.) constituyen uno de los ecosistemas más representativos de las zonas semiáridas de la Península Ibérica y del norte de África. Estas formaciones han estado íntimamente ligadas a la actividad humana desde hace no menos de 4.000 años. Los espartales son formaciones vegetales abiertas, muy heterogéneas en su composición y estructura. La funcionalidad de los espartales está muy relacionada con la disposición espacial de las matas, así como con la cobertura de arbustos rebrotadores. El esparto es una especie anemócora capaz de reproducirse sexual y asexualmente, mostrando vecería en la producción de flores y semillas. Presenta una serie de adaptaciones morfoestructurales y fisiológicas que le han permitido colonizar con éxito los adversos ambientes semiáridos mediterráneos. El suelo que se encuentra bajo las matas de esparto muestra un a mayor fertilidad y mejores condiciones microclimáticas que el suelo adyacente, originando la formación de "islas de recursos". Por ello, las matas de esparto alteren la distribución y desarrollo de un gran número de organismos, como plantas vasculares, musgos y líquenes. Los avances en nuestro conocimiento sobre la composición y funcionamiento de los espartales están siendo utilizandos para mejorar su gestión.

Practioners, implementing agencies

Maestre, F.T., D.A. Ramírez and J. Cortina (2007) Ecología del Esparto (Stipatenacissima L.) y los Espartales de la Península Ibérica. Ecosistemas 16(2): 111-130.

http://rua.ua.es/dspace/bitstream/10045/7674/1/ECO_16%282%29_12.pdf

The Restoration of Vegetation Cover in the Semi-Arid Iberian Southeast

Here, we review recent advances in the restoration of semiarid vegetation cover in the Iberian southeast, discuss future challenges and suggest two key steps towards increasing the consistency and efficiency of restoration programs: emphasis on ecosystem services, and implementation of participative and adaptive management practices.

Implementing agencies, practitioners, policymakers

Cortina, J., B. Amat, V. Castillo, D. Fuentes, F.T. Maestre, F.M. Padilla and L. Rojo (2011) The Restoration of Vegetation Cover in the Semi-Arid Iberian Southeast. Journal of Arid Environments 75: 1377-1384.

http://www.escet.urjc.es/biodiversos/publica/Cortina_et_al_2011_J_Arid_Environ.pdf

Linking the Spatial Patterns of Organisms and Abiotic Factors to Ecosystem Function and Management: Insights from Semi-arid Environments

Numerous theoretical and modeling studies have demonstrated the ecological significance of the spatial patterning of organisms on ecosystem functioning and dynamics. However, there is a paucity of empirical evidence that quantitatively shows how changes in the spatial patterns of the organisms forming biotic communities are directly related to ecosystem structure and functioning. In this article, I review a series of experiments and observational studies conducted in semi-arid environments from Spain (degraded calcareous shrubland, steppes dominated by *Stipatenacissima*, and gypsum shrublands) to: 1) evaluate whether the spatial patterns of the dominant biotic elements in the community are linked to ecosystem structure and functioning, and 2) test if these patterns, and those of abiotic factors, can be used to improve ecosystem restoration.

Practitioners, implementing agencies

Maestre, F.T. (2006) Linking the spatial patterns of organisms and abiotic factors to ecosystem function and management: Insights from semi-arid environments. Web Ecol. 6: 75–87.

http://www.web-ecol.net/6/75/2006/we-6-75-2006.pdf

Drylands>Soils

Biological Soil Crust Rehabilitation in Theory and Practice: An Underexploited Opportunity

The purposes of this review were to examine the ecological roles BSCs play in succession models, the backbone of restoration theory, and to discuss the practical aspects of rehabilitating BSCs to disturbed ecosystems. Most evidence indicates that BSCs facilitate succession to later seres, suggesting that assisted recovery of BSCs could speed up succession. Because BSCs are ecosystem engineers in high abiotic stress systems, loss of BSCs may be synonymous with crossing degradation thresholds. However, assisted recovery of BSCs may allow a transition from a degraded steady state to a more desired alternative steady state. In practice, BSC rehabilitation has three major components: (1) establishment of goals; (2) selection and implementation of rehabilitation techniques; and (3) monitoring.

Practitioners, implementing agencies

Bowker, M.A. (2007) Biological Soil Crust Rehabilitation in Theory and Practice: An Underexploited Opportunity. Restoration Ecology 15(1): 13-23.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2006.00185.x/abstract

Prioritizing Conservation Effort through the Use of Biological Soil Crusts as Ecosystem Function Indicators in an Arid Region

Conservation prioritization usually focuses on conservation of rare species or biodiversity, rather than ecological processes. This is partially due to a lack of informative indicators of ecosystem function. Biological soil crusts (BSCs) trap and retain soil and water resources in arid ecosystems and function as major carbon and nitrogen fixers; thus, they may be informative indicators of ecosystem function. We believe BSCs can be used as indicators of ecosystem function in concert with other indicators (such as plant-community properties) and that such information can be used to prioritize conservation effort in drylands.

Implementing agencies, practitioners

Bowker, M.A., M.E. Miller, J. Belnap, T.D. Sisk and N.C. Johnson (2008) Prioritizing Conservation Effort through the Use of Biological Soil Crusts as Ecosystem Function Indicators in an Arid Region. Conservation Biology 22(6): 1533-1543.

http://onlinelibrary.wiley.com/doi/10.1111/j.1523-1739.2008.01036.x/abstract

Evidence for Micronutrient Limitation of Biological Soil Crusts: Importance to Arid Lands Restoration

Desertification is a global problem, costly to national economies and human societies. Restoration of biological soil crusts (BSCs) may have an important role to play in the reversal of desertification due to their ability to decrease erosion and enhance soil fertility. To determine if there is evidence that lower fertility may hinder BSC recolonization, we investigated the hypothesis that BSC abundance is driven by soil nutrient concentrations. We propose experimental trials of micronutrient addition to promote the restoration of BSC function on disturbed lands. Arid lands, where BSCs are most prevalent, cover 40% of the terrestrial surface of the earth; thus the information gathered in this study is potentially useful in many places worldwide.

Implementing agencies, practitioners

Bowker, M.A., J. Belnap, D.W. Davidson and S.L. Phillips (2005) Evidence for Micronutrient Limitation of Biological Soil Crusts: Importance to Arid Lands Restoration. Ecological Applications 15(6): 1941-1951.

http://www.esajournals.org/doi/abs/10.1890/04-1959

Importance of Biological Soil Crusts for Rehabilitation of Degraded Arid and Semi-Arid Ecosystems

Biological soil crusts are built up by cyanobacteria, green algae, soil lichens, mosses and fungi. They are important communities in arid and semi-arid ecosystems and influence the ecosystem mosaic and processes. In addition to the influence on the hydrological conditions, the biological crust also stabilizes the topsoil, reduces soil erosion, and enhances the nitrogen pools by nitrogen fixation. The crusts are important for the rehabilitation of desertified arid and semi-arid lands and provide a natural protective soil surface cover.

Implementing agencies, practitioners

Veste, M. (2005) Importance of Biological Soil Crusts for Rehabilitation of Degraded Arid and Semi-Arid Ecosystems. Science of Soil and Water Conservation 3(4): 42-47.

http://www.sswcc.org/Jweb_stbc/CN/article/downloadArticleFile.do?attachType=PDF&id=9045

Watering, Fertilization, and Slurry Inoculation Promote Recovery of Biological Crust Function in Degraded Soils

We conducted a factorial microcosm experiment to evaluate the effects of inoculation type (discrete fragments vs slurry), fertilization (control vs addition of composted sewage sludge), and watering frequency (two vs five times per week) on the cyanobacterial composition, nitrogen fixation, chlorophyll content, and net CO2 exchange rate of biological soil crusts inoculated on a semiarid degraded soil from SE Spain. Our results suggest that the inoculation of biological soil crusts in the form of slurry combined with the addition of composted sewage sludge could be a suitable technique to accelerate the recovery of the composition and functioning of biological soil crusts in drylands.

Practitioners, implementing agencies

Maestre, F.T., N. Martín, B. Díez, R. López-Poma, F. Santos, I. Luque and J. Cortina (2006) Watering, Fertilization, and Slurry Inoculation Promote Recovery of Biological Crust Function in Degraded Soils. Microbial Ecology 52(3): 365-377.

http://m.imem.ua.es/es/documentos/archivos-imem/articulos-investigadores/jordi-cortina/maestre-et-al-2006-watering.pdf

Management of Indigenous Plant-Microbe Symbioses Aids Restoration of Desertified Ecosystems

Here we demonstrate, in two long-term experiments in a desertified Mediterranean ecosystem, that inoculation with indigenous arbuscular mycorrhizal fungi and with rhizobial nitrogen-fixing bacteria not only enhanced the establishment of key plant species but also increased soil fertility and quality. The dual symbiosis increased the soil nitrogen (N) content, organic matter, and hydrostable soil aggregates and enhanced N transfer from N-fixing to nonfixing species associated within the natural succession. We conclude that the introduction of target indigenous species of plants associated with a managed community of microbial symbionts is a successful biotechnological tool to aid the recovery of desertified ecosystems.

Practitioners, implementing agencies

Requena, N., E. Perez-Solis, C. Azcon-Aguilar, P. Jeffries and J.M. Barea (2001) Management of Indigenous Plant-Microbe Symbioses Aids Restoration of Desertified Ecosystems. Applied and Environmental Microbiology 67(2): 495-498.

http://aem.asm.org/content/67/2/495.full

Microbial Populations of Arid Lands and their Potential for Restoration of Deserts

The rapid expansion of deserts in recent decades as a result of human actions combined with climatic disasters has highlighted the necessity to understand biological processes in arid environments. Whereas physical processes and the biology of flora and fauna have been relatively well studied in marginally used arid areas, knowledge of desert soil micro-organisms remains fragmentary. This chapter describes several biological phenomena in hot deserts related to microbial populations and the potential use of micro-organisms for restoring hot desert environments. A few relevant examples from colder deserts are also provided.

Practitioners

Bashan, Y. and L.E. de Bashan (2010) Microbial Populations of Arid Lands and their Potential for Restoration of Deserts in P. Dion (ed.) Soil Biology and Agriculture in the Tropics, Soil Biology 21.

www.bashanfoundation.org/gmaweb/pdfs/soilmicrobiology.pdf

Untangling the Biological Contributions to Soil Stability in Semiarid Shrublands

Communities of plants, biological soil crusts (BSCs), and arbuscular mycorrhizal (AM) fungi are known to influence soil stability individually, but their relative contributions, interactions, and combined effects are not well understood, particularly in arid and semiarid ecosystems. In a landscape-scale field study we quantified plant, BSC, and AM fungal communities at 216 locations along a gradient of soil stability levels in southern Utah, USA.

Practitioners

Chaudhary, V.B. et al. (2009) Untangling the Biological Contributions to Soil Stability in Semiarid Shrublands. Ecological Applications 19(1): 110-122.

http://archive.li.suu.edu/docs/ms130/AR/chaudhary.pdf

The Importance of Phytogenic Mounds (Nebkhas) for Restoration of Arid Degraded Rangelands in Northern Sinai

Natural accumulation of wind-borne sediments within or around the canopies of plants plays an important role in the ecological and evolutionary dynamics of many coastal and desert ecosystems. The formation of such phytogenic mounds (nebkhas) creates patches that can strongly influence the spatial distribution of plant and soil resources. In land restoration of arid and semiarid environments it is important to study the potential role of such biological patchiness that may provide sites for coexistence of species with different life and growth forms. Our main objective was to test whether the nebkhas of a leguminous shrub, Retama raetam (white broom), promote restoration of herbaceous vegetation and soil in the degraded rangelands of northern Sinai.

Practitioners

El-Bana, M.I., I. Nijs and A.H.A. Khedr (2003) The Importance of Phytogenic Mounds (Nebkhas) for Restoration of Arid Degraded Rangelands in Northern Sinai. Restoration Ecology 11(3): 317-324.

http://colleges.ksu.edu.sa/Papers/Papers/Restoration-Ecology.pdf

Ecology and Functional Roles of Biological Soil Crusts in Semi-arid Ecosystems of Spain

Biological soil crusts (BSCs), composed of lichens, cyanobacteria, mosses, liverworts and microorganisms, are key biotic components of arid and semi-arid ecosystems worldwide. Despite they are widespread in Spain, these organisms have been historically understudied in this country. This trend is beginning to change as a recent wave of research has been identifying BSCs as a model ecological system. Many studies and research projects carried out in Spain have explored the role of BSCs on water, carbon and nitrogen fluxes, the interactions between BSCs and vascular plants, their dynamics after disturbances, and their response to global change, among other topics. In this article we review the growing body of research on BSCs available from semi-arid areas of Spain, highlighting its importance for increasing our knowledge on this group of organisms. We also discuss how it is breaking new ground in emerging research areas on the ecology of BSCs, and how it can be use to guide management and restoration efforts. Finally, we provide directions for future research on the ecology of BSCs in Spain and abroad.

Practitioners, implementing agencies

Maestre, F.T., M.A. Bowker, Y. Cantón, A.P. Castillo-Monroy, J. Cortina, C. Escolar, A. Escudero, R. Lázaro and I. Martínez (2011) Ecology and Functional Roles of Biological Soil Crusts in Semi-arid Ecosystems of Spain. Journal of Arid Environments 75: 1282-1291.

http://www.escet.urjc.es/biodiversos/publica/Maestre_et_al_2011_J_Arid_Environ.pdf

Forests/Woodlands

The Restorative Imperative: Assessing Objectives, Approaches and Challenges to Restoring Naturalness in Forests

The inherent challenges in restoring "naturalness" include high temporal and spatial heterogeneity in forest conditions and natural disturbances, the long history of human influence on forests in many regions of the world, and uncertainty about future climate and disturbance regimes. Although fixed templates may be inappropriate, we still have a reasonably clear idea of the incremental steps required to make forests more natural. Because most locations can support many alternative configurations of natural vegetation, the restoration of forest naturalness necessarily involves the setting of priorities and strategic directions in the context of human values and objectives, as informed by our best understanding of ecosystem structure and function now and in the future.

Policymakers, implementing agencies

Burton, P.J. and S.E. Macdonald (2011) The restorative imperative: assessing objectives, approaches and challenges to restoring naturalness in forests. Silva Fennica 45(5): 843-863.

http://www.metla.fi/silvafennica/full/sf45/sf455843.pdf

Forest Management, Restoration, and Designer Ecosystems: Integrating Strategies for a Crowded Planet

As the global human population increases, the demand to conserve, restore, create, and sustainably manage ecosystems will increase as well. Forested ecosystems are of particular interest because of the biodiversity they support and their diverse values to people. Developments in conservation, restoration forestry, and in the study of designer ecosystems provide a diverse set of tools with which to pursue sustainable forestry goals. Nonetheless, we suggest that sustainable forestry can only be achieved by fully considering ecological, economic, and social needs in landscapes. This will require a clear realization of the trade-offs in site-specific management approaches and a multifaceted, landscape-scale perspective for evaluation of sustainability criteria. We propose collaborative creation of Sustainable Forestry

Portfolios as a means to encourage the breadth of thinking required to guide sustainable forest management.

Policymakers, implementing agencies

Sarr, D.A. and K.J. Puettmann (2008) Forest Management, Restoration, and Designer Ecosystems: Integrating Strategies for a Crowded Planet. Ecoscience 15(1): 17-26.

http://www.cof.orst.edu/cof/fs/kpuettmann/ES%2015(1)%202008.pdf

Mechanical Site Preparation for Forest Restoration

In this article, we synthesize the current state-of-knowledge concerning mechanical site preparation for improved tree establishment when carried out in different forest restoration situations, point out critical research gaps and provide some recommendations for future directions. Mechanical site preparation often results in improved seedling survival and growth. However, if not intensive methods with much soil disturbance are used, it is a rather ineffective tool for controlling competing vegetation. Methods such as scarification, mounding and subsoiling also lead to multiple interactions among soil physical and chemical properties that affect plant survival and growth, and it may be difficult to determine the actual cause–effect relationship of any positive seedling responses. Several management objectives such as soil protection and increased biodiversity are many times relevant during forest restoration, and mechanical site preparation methods should be implemented carefully because they can have large impacts on the environment.

Practitioners

Löf, M., D.C. Dey, R.M. Navarro and D.F. Jacobs (2012) Mechanical Site Preparation for Forest Restoration. New Forests online first

http://www.springerlink.com/content/735276432l3662u0/

Using Mechanistic Modeling within Forest Ecosystem Restoration

The purpose of this study is to enhance the ecophysiological representation of single tree species within an existing mechanistic model, a pre-condition for assessing forest ecosystem restoration scenarios. We changed ecophysiological constants using published literature related to Norway spruce and common beech for a wide range of central European forests and evaluated model predictions using observations on stand transpiration, seasonal water balance, leaf area index, photoassimilation, tree volume, tree ring size, and soil and litter carbon and nitrogen content. A model validation, using an independent data set on tree volume, soil carbon and nitrogen content from a total 44 spruce and beech stands across the northern part of the Austrian Alps, exhibited no bias between model predictions and field observations.

Practitioners, implementing agencies

Pietsch, S.A. and H. Hasenauer (2002) Using Mechanistic Modeling within Forest Ecosystem Restoration. Forest Ecology and Management 159(1-2): 111-131.

http://www.aseanbiodiversity.info/Abstract/51003457.pdf

Perceptions, Not Facts: How Forestry Professionals Decide on the Restoration of Degraded Forest Ecosystems

Based on the theory of social constructivism and the model of symbolic interactionism, this paper shows that a person's readiness to implement restoration measures, inter alia, depends on the urgency of the problem. However, it does not (only) hinge on the 'objective' degree of damage, but (also) on the subjective problem perception of the decision maker. The empirical survey indicates, furthermore, that these subjective perceptions are—among other things—determined by social interactions. On the basis of these findings, we can derive a number of practical recommendations not just for science and research scientists, but especially for persons and institutions working in (further) education and in the field of extension services.

Implementing agencies, practitioners

Pregernig, M. (2002) Perceptions, Not Facts: How Forestry Professionals Decide on the Restoration of Degraded Forest Ecosystems. Journal of Environmental Planning and Management 45(1): 25-38.

http://www.boku.ac.at/sfh/Documents/Preg/Perceptions.pdf

Sustainable Forest Management, Biodiversity and Livelihoods: A Good Practice Guide

This booklet is part of a series of Good Practice Guides produced by the CBD. It provides a range of case studies and other materials to make the forest sector more biodiversity-friendly, and socially beneficial. It addresses the linkages between forestry, biodiversity, and development / poverty reduction. The summaries and examples included in this booklet show how biodiversity and sustainable economic development can go hand in hand. The primary target audiences for the guide are government officers and decision-makers in the various government agencies related to forestry (at global, regional, national and local levels), as well as development practitioners. The materials presented can also be useful to corporate and NGO planners.

Policymakers, implementing agencies

Secretariat of the Convention on Biological Diversity (2009) Sustainable Forest Management, Biodiversity and Livelihoods: A Good Practice Guide. Montreal.

http://www.cbd.int/development/doc/cbd-good-practice-guide-forestry-booklet-web-en.pdf

Embracing Complexity: Meeting the Challenges of International Forest Governance - A Global Assessment Report

The report and its accompanying policy brief will provide an overview of the complex and diverse elements that currently make up the global forest governance arrangements; will identify and analyse the core components of these arrangements; and propose options for dealing with complexity and improving the effective implementation of forest governance at global, regional, national and sub-national levels.

Policymakers, implementing agencies

Rayner, J., A. Buck and P. Katila (eds.) (2010) Embracing complexity: Meeting the challenges of international forest governance. A global assessment report. Prepared by the Global Forest Expert Panel on the International Forest Regime. IUFRO World Series Volume 28, Vienna.

http://www.iufro.org/science/gfep/forest-regime-panel/report/

Assessing Forest Degradation: Towards the Development of Globally Applicable Guidelines

This document pulls together a range of views and approaches to the assessment of forest degradation. It should be regarded as precursor to the development of comprehensive, globally applicable guidelines for assessing forest degradation. There is much work yet to be done on this important topic – we trust the present paper contributes to the goal of reducing and mitigating the inevitable processes of forest degradation.

Policymakers, implementing agencies, indigenous and local communities

FAO (2011) Assessing Forest Degradation: Towards the Development of Globally Applicable Guidelines. Forest Resources Assessment Working Paper 177.

http://www.fao.org/docrep/015/i2479e/i2479e00.pdf

Prioritisation of Target Areas for Forest Restoration

Loss of forest cover not only limits the scope of biodiversity and genetic conservation but also diminishes the prospect of many rural and coastal populations throughout the developing world attaining a decent and secure livelihood. In many areas, faltering clean water supplies, catastrophic floods and landslides, declining fish stocks and unreliable local weather patterns can be traced back to impaired forest ecosystem functions. This report for WWF and IUCN shows how GIS can be used to prioritise areas for forest restoration. Candidate social and ecological criteria are identified at a regional level. The Mediterranean region is used as a case study.

Implementing agencies, policymakers

Kapos, V. and L. Miles (2000) Prioritisation of Target Areas for Forest Restoration. Produced by WCMC for WWF International.

http://www.unep-wcmc.org/medialibrary/2012/02/17/2cb9a2fc/upload%20Prioritisation%20of%20target%20areas%20for%20forest%20restoration.pdf

Forests/Woodlands>Afghanistan

Reforestation Strategies Amid Social Instability: Lessons from Afghanistan

Reforestation practitioners could benefit from the human and material resources now present as part of the international war effort. Successes and failures encountered in Afghanistan should be considered in order to address similar problems in insecure regions elsewhere when reforestation may help reverse environmental degradation and contribute to broader social stabilization efforts.

Policymakers, implementing agencies

Groninger, J.W. (2012) Reforestation Strategies Amid Social Instability: Lessons from Afghanistan. Environmental Management 49: 833-845.

http://www.springerlink.com/content/y3342157v04142r8/

Forests/Woodlands>Africa

Rehabilitation of Degraded Lands in Humid Zones of Africa

This paper therefore aims at providing background information for discussion by identified scientists and other stakeholders in order to produce the synthesis. The background information include the importance of the forest resource, the causes of deforestation and degradation, the rates of deforestation and degradation, rehabilitation techniques and strategies, policy, management and research constraints against rehabilitation as well as policy, management and research recommendations. It also includes suggestions on issues that the discussions should be centered on.

Implementing agencies, practitioners, policymakers, indigenous and local communities

Blay, D. (2002) Rehabilitation of Degraded Lands in Humid Zones of Africa. A report Prepared for IUFRO, Global Forest Information Service (GFIS) Project.

http://www.etfrn.org/etfrn/workshop/degradedlands/documents/bgphumid.PDF

Forests/Woodlands>Asia/Pacific

Creative Ecology: Restoration of Native Forests by Native Trees

Ecological devastation is becoming a serious problem locally to globally, in proportion as people seek affluent living circumstances. Environmental devastation originated mainly from nature exploitation and construction of cities and industrial institutions with non-biological materials. Humans have ignored the rules of nature, biodiversity and coexistence. One of the best measures we can take anywhere, in order to restore ecosystems indigenous to each region and to maintain global environments, including disaster prevention and C02 absorption, is to restore native, multi-stratal forests following an ecological method. I would like to refer to the experimental reforestation projects based on ecological studies and their results at about 550 locations throughout Japan and in Southeast Asia, South America, and China. We have proved that it is possible to restore quasi-natural multi-stratal forest ecosystems in 20 to 30 years if we take the ecological method.

Policymakers, implementing agencies

Miyawaki, A. (1999) Creative Ecology: Restoration of Native Forests by Native Trees. Plant Biotechnology 16(1): 15-25.

http://www.wdc-jp.biz/pdf_store/jspcmb/pdf/pb16_1/pb16_1_015.pdf

Bringing Back the Forests: Policies and Practices for Degraded Lands and Forests

Now, rehabilitation procedures seek to go beyond that of commercial timber production—trials are underway to increase biodiversity and ecological services as additional products. Fortunately, such efforts can also be linked to social development. The vast majority of forest restoration schemes can also provide additional income to rural communities, besides increasing their resources. Attempts are also underway to find more innovative ways to support such developments.

Policymakers, implementing agencies, practitioners, indigenous and local communities

Sim, H.C., S. Appanah and P.B. Durst (eds.) (2002) Bringing Back the Forests: Policies and Practices for Degraded Lands and Forests. Proceedings of an International Conference 7–10

October 2002, Kuala Lumpur, Malaysia - Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific, Bangkok.

http://coin.fao.org/cms/media/9/13171076646000/ad496e00.pdf

The Restoration of Forest Biodiversity and Ecological Values

Large investments are being made in the establishment of tree plantations on degraded land in Asia. These initiatives are often politically driven and aspire to achieve both economic and environmental benefits. However, the lack of clarity about the precise objectives of these schemes means that they often fail to yield either local economic or global environmental benefits. There is often a failure to negotiate with all concerned stakeholders and to recognize and resolve trade-offs. Subsidies have often had perverse impacts, and market forces may be better drivers of economic objectives of restoration programmes. Security of tenure and use rights is an important but often neglected requirement for achieving sustainability. Remnant patches of natural vegetation, even when degraded, are often valuable sources of local biodiversity in restoration schemes.

Policymakers, implementing agencies

Sayer, J., U. Chokkalingam and J. Poulsen (2004) The Restoration of Forest Biodiversity and Ecological Values. Forest Ecology and Management 201: 3-11.

http://www.globalrestorationnetwork.org/uploads/files/LiteratureAttachments/332_the-restoration-of-forest-biodiversity-and-ecological-values.pdf

Regreening the Bare Hills: Tropical Forest Restoration in the Asia-Pacific Region

Describing new approaches to the reforestation of degraded lands in the Asia-Pacific tropics, the book reviews current approaches to reforestation throughout the region, paying particular attention to those which incorporate native species – including in multi-species plantations. It presents case studies from across the Asia-Pacific region and discusses how the silvicultural methods needed to manage these 'new' plantations will differ from conventional methods. It also explores how reforestation might be made more attractive to smallholders and how trade-offs between production and conservation are most easily made at a landscape scale. The book concludes with a discussion of how future forest restoration may be affected by some current ecological and socio-economic trends now underway.

Implementing agencies, policymakers

Lamb, D. (2011) Regreening the Bare Hills: Tropical Forest Restoration in the Asia-Pacific Region. Springer.

http://www.springer.com/life+sciences/forestry/book/978-90-481-9869-6

Helping Forests Take Cover

This publication presents, in language bereft of technical jargon, the basic issues behind rehabilitation. It explains the definitions in simple terms, exemplifies the work with interesting case studies, and points out the environmental and market forces that go into rehabilitation of landscapes.

Policymakers, implementing agencies

Lamb, D., V. Poopathy, S. Appanah and P.B.Durst (eds.) (2005) Helping Forests Take Cover: On forest protection, increasing forest cover and future approaches to reforesting degraded tropical landscapes in Asia and the Pacific. RAP Publication - 2005/13. Bangkok: FAO.

http://coin.fao.org/cms/media/9/13171069612400/2005_13.pdf

In Search of Excellence: Exemplary Forest Management in Asia and the Pacific

The publication highlights a diversity of management approaches that have proven particularly innovative and successful in meeting challenges. Thus, it reaches out to foresters, policy-makers, planners and anyone interested in the future of forestry in Asia and the Pacific. This publication also marks a significant step forward in FAO's and RECOFTC's efforts to bring its forestry literature closer to general readers who are less familiar with the technical aspects of forest management, but no less concerned about the fate of the region's forests, natural resources and rural people.

Policymakers, implementing agencies, indigenous and local communities

Durst, P., C. Brown, H. Tacio and M. Ishikawa (eds.) (2005) In Search of Excellence: Exemplary Forest Management in Asia and the Pacific. RAP Publication - 2005/02. Food and Agricultural Organization of the United Nations, Regional Office for Asia and the Pacific and Regional Community Forestry Training Center for Asia and the Pacific. Bangkok: FAO.

http://coin.fao.org/cms/media/9/13171064338050/2005_02.pdf

Forest Restoration for Wildlife Conservation

This book presents the proceedings of a Scientific and Technical Workshop on Forest Restoration for Wildlife Conservation, held in Chiang Mai, Thailand February 2000, organized by the Forest Restoration Research Unit of Chiang Mai University and sponsored by the the International Tropical Timber Organisation. The volume includes 28 peer-reviewed papers, summarizing the status of forest restoration in the region and covering a wide range of technical subjects from seed collection to silviculture, as well as social issues. A wide range of examples of innovative techniques and best practices are included, which will be of interest to both scientists and practitioners of forest restoration.

Implementing agencies, practitioners, indigenous and local communities

Elliot, S. et al. (eds.) (2000) Forest Restoration for Wildlife Conservation. Proceedings of a Workshop with the International Tropical Timber Organisation and The Forest Restoration Research Unit, Chiang Mai University, Thailand.

http://www.forru.org/FORRUEng_Website/Pages/engpublications.htm

Secondary Forests Associated with the Rehabilitation of Degraded Lands in Tropical Asia: A Synthesis

Rehabilitated secondary forests constitute a potential new and emerging resource requiring changes in policy favouring the rehabilitation of the large areas of degraded land in tropical Asia. Conversion of degraded lands into rehabilitated secondary forests rather than into monoculture plantations of exotics may be better for meeting the diverse product needs of local people, other stakeholders, and changing markets, as well as for environmental amelioration. It is also a relatively inexpensive method, suitable for rehabilitation by local people. Government and other stakeholder interest in and scope for rehabilitating degraded lands to secondary forest systems tend to increase along a proposed land use intensification model.

Policymakers, implementing agencies

Chokkalingam, U., D.M. Bhat and G. von Gemmingen (2001) Secondary Forests Associated with the Rehabilitation of Degraded Lands in Tropical Asia: A Synthesis. Journal of Tropical Forest Science 13(4): 816-831.

http://www.cifor.org/publications/pdf_files/SecondaryForest/Chokkalingam.pdf

Forests/Woodlands>Australia

Reforestation in the Tropics and Subtropics of Australia Using Rainforest Tree Species

This peer-reviewed book documents the lessons learned as a result of their experiences. It covers some of the history of rainforest reforestation and planting schemes, and the methods that have been used to propagate and establish rainforest tree species. It also presents growth rates for a wide variety of species planted in different regions, knowledge about the pests and diseases found in rainforest plantations and discusses the management challenges of mixed species stands. As the planting of rainforest trees has occurred in some of the most biodiverse regions of Australia the book also examines some of the ecological consequences of plantation design and the emerging issues facing forest growers who desire production and biodiversity. A portion of the book also evaluates some of the socio-economic issues which arose from reforestation schemes. Finally the book offers future directions for rainforest plantation research and insights into how our Australian experience can be applied more widely throughout the altered rainforest landscapes of the tropical world.

Implementing agencies, practitioners

Erskine, P.D., D. Lamb and M. Bristow (eds.) (2005) Reforestation in the Tropics and Subtropics of Australia Using Rainforest Tree Species. RIRDC Publication No 05/087, Rural Industries Research and Development Corporation, Canberra.

https://rirdc.infoservices.com.au/downloads/05-087.pdf

Rainforest Restoration Activities in Australia's Tropics and Subtropics

This report describes the nature of efforts to restore rainforest cover to the eastern tropics and subtropics, where the largest rainforest areas were found. Since around 1990, a complex array of government-sponsored schemes has provided financial subsidies to encourage and assist restoration. A striking feature has been the high level of community involvement. Most projects targeted the banks of creeks and rivers, and were less than five hectares in area. Total areas reforested regionwide were modest (less than 1% of the area of past clearing). The unit cost of vegetation reinstatement was around AU$20,000 / ha, but costs of projects below 2.0 ha in area often greatly exceeded this. The value of such small-scale projects may be in community engagement, whereas good ecological outcomes are more likely with larger-scale projects.

Policymakers

Catterall, C. P. and D.A. Harrison (2006) Rainforest Restoration Activities in Australia's Tropics and Subtropics. Cooperative Research Centre for Tropical Rainforest Ecology and Management research Report No. 53, Cairns.

http://www.jcu.edu.au/rainforest/publications/restoration_activities_full.pdf

Restoring Rainforest Species by Direct Seeding: Tree Seedling Establishment and Growth Performance on Degraded Land in the Wet Tropics of Australia

Results indicate that direct seeding can be a viable establishment method, but the identity of species to be used, the circumstances under which they should be directly sown and the most appropriate timing of sowing will vary with situations. Species characteristics, including seed size, growth rate potential and light requirement will be important to consider in relation to the probable conditions that will develop for seedlings following germination (particularly in relation to plant competition) with or without post-sowing site management, such as removal of weeds.

Practitioners, implementing agencies

Doust, S.J., P.D. Erskine and D. Lamb (2008) Restoring rainforest species by direct seeding: Tree seedling establishment and growth performance on degraded land in the wet tropics of Australia. Forest Ecology and Management 256(5): 1178‑1188.

http://www.sciencedirect.com/science/article/pii/S0378112708005070

Assessing Rainforest Restoration: The Value of Buffer Strips for the Recovery of Rainforest Remnants in Australia's Wet Tropics

Throughout the tropics, forest remnants are under increasing pressure from habitat fragmentation and edge effects. To improve the conservation value of forest remnants, restoration plantings are used to accelerate and redirect ecological succession. Unfortunately, many restoration projects undergo little to no evaluation in achieving project goals. Here we evaluate the success of one common restoration technique, "buffer strip planting," at the Malanda Scrub in North Queensland, Australia. Results suggest that the buffer strip was successful in reducing edge effects but not in restoring the forest to original conditions within 14 years.

Sonter, L.J., M.M. Mayfield and D.J. Metcalfe (2011) Assessing Rainforest Restoration: The Value of Buffer Strips for the Recovery of Rainforest Remnants in Australia's Wet Tropics. Pacific Conservation Biology 16(4): 274-288.

http://search.informit.com.au/documentSummary;dn=869005494688291;res=IELHSS

Monitoring Revegetation Projects in Rainforest Landscapes: Toolkit Version 3

This toolkit has been written to assist community groups and restoration practitioners record details of their revegetation projects, assess their condition and monitor their outcomes for biodiversity and carbon sequestration. Additionally, the methods presented here can also be applied to other situations where there is a need to monitor and evaluate change in forest ecosystems, including assessment of the extent of degradation or recovery within remnant forest.

Practitioners, indigenous and local communities

Kanowski, J., C.P. Catterall, K. Freebody, A.N.D. Freeman, and D.A.Harrison (2010) Monitoring Revegetation Projects in Rainforest Landscapes. Toolkit Version 3. Reef and Rainforest Research Centre Limited, Cairns.

http://www.rrrc.org.au/publications/biodiversity_monitoring3.html

Direct Seeding to Restore Rainforest Species: Microsite Effects on the Early Establishment and Growth of Rainforest Tree Seedlings on Degraded Land in the Wet Tropics of Australia

This study investigated the effects of various sowing treatments (designed to create different microsite conditions for seed germination) and seed sizes on the early establishment and growth of directly sown rainforest tree species in a variety of experimental plots at three sites in the wet tropical region of north-east Queensland, Australia. The different sowing treatments were found to have significant effects on seedling establishment. Broadcast sowing treatments were ineffective and resulted in very poor seedling establishment and high seed wastage. Higher establishment rates occurred when seeds were buried. Seed size was found to be an important factor affecting establishment in relation to micro-site condition. Overall these results suggest that direct sowing of seed can be used as a tool to accelerate recolonisation of certain rainforest tree species on degraded tropical lands, but initial success will be dependent on the choice of sowing method and its suitability for the seed types selected. The results also indicate that the recruitment of naturally dispersed tree species at degraded sites is likely to be severely limited by the availability of suitable microsites for seed germination. Consequently the natural recovery of degraded sites via seed rain can be expected to be slow and unpredictable, particularly in areas where soil compaction has occurred.

Practitioners, implementing agencies

Doust, S.J., P.D. Erskine and D. Lamb (2006) Direct Seeding to Restore Rainforest Species: Microsite Effects on the Early Establishment and Growth of Rainforest Tree Seedlings on Degraded Land in the Wet Tropics of Australia. Forest Ecology and Management 234: 333-343.

http://www.sciencedirect.com/science/article/pii/S0378112706004920

Deforestation Strongly Affects Soil Seed Banks in Eucalypt Forests: Generalisations in Functional Traits and Implications for Restoration

We examined the potential role of the soil seed bank in restoration of an open eucalypt forest community following land-use change involving clearing of native eucalypt forest for grazing and subsequent abandonment, and for establishment of Pinus radiata plantation. We used plant functional traits responsive to disturbance and other traits associated with the capacity to re-colonise and form persistent seed banks as a means of assessing the effects of land-use change on soil seed banks.

Implementing agencies, practitioners

Meers, T.L., N.J. Enright, T.L. Bell and S. Kasel (2012) Deforestation Strongly Affects Soil Seed Banks in Eucalypt Forests: Generalisations in Functional Traits and Implications for Restoration. Forest Ecology and Management 266: 94-107.

http://www.sciencedirect.com/science/article/pii/S0378112711006803

The Ridgefield Multiple Ecosystem Services Experiment: Can Restoration of Former Agricultural Land Achieve Multiple Outcomes?

The ability of restoration approaches to provide valued ecosystem services needs to be assessed. The emerging carbon market provides an incentive to afforest agricultural landscapes and could potentially achieve multiple outcomes. However, planting monocultures for carbon sequestration may preclude effective delivery of other ecosystem services. Here, we describe the rationale behind the Ridgefield Multiple Ecosystem Services Experiment, a long-term investigation into trade-offs that might prevent the simultaneous provision of high levels of multiple services in the agricultural landscape of south-western Australia. Ridgefield tests the possibility of restoring and managing agricultural landscapes for multiple ecosystem services, providing a much needed experimental investigation of trade-offs among ecosystem functions.

Implementing agencies, policymakers

Perring, M.P., R.J. Standish, K.B. Hulvey, L. Lach, T.K. Morald, R. Parsons, R.K. Didham and R.J. Hobbs (2012) The Ridgefield Multiple Ecosystem Services Experiment: Can Restoration of Former Agricultural Land Achieve Multiple Outcomes? Agriculture, Ecosystems & Environment, Available online 22 March 2012

http://www.sciencedirect.com/science/article/pii/S0167880912000783

Rainforest Restoration: Approaches, Costs and Biodiversity Outcomes

In this fact sheet, we discuss the following issues: 1) What approaches have been used to achieve rainforest restoration? 2) What are the costs of these approaches? 3) What are the outcomes for biodiversity? and 4) How might 'biodiversity-friendly' rainforest plantings be designed and maintained?

Policymakers, implementing agencies

Catterall, C.P. and J. Kanowski (2010) Rainforest Restoration: Approaches, Costs and Biodiversity Outcomes. Reef & Rainforest Research Centre Ltd, Cairns.

http://www.rrrc.org.au/publications/downloads/rainforest_restoration.pdf

Forests/Woodlands>Borneo

Seeing the Fruit for the Trees in Borneo

The recent mass fruiting of forest trees in Borneo is an urgent wakeup call: existing policy instruments, financial mechanisms, and forestry infrastructure are inadequate to take full advantage of these infrequent opportunities for forest restoration and conservation. Tropical forest restoration can provide substantial benefits for biodiversity conservation, climate change mitigation, and poverty alleviation. Yet the unpredictability of the synchronized flowering and consequent mass fruiting of many forest trees in Borneo presents a distinctive set of challenges for forest restoration. Significant financing and a considerable coordinated effort are required to prepare for future mass fruiting events if we are to capitalize on opportunities for ecological restoration.

Policymakers, implementing agencies

Kettle, C.J. et al (2011) Seeing the Fruit for the Trees in Borneo. Conservation Letters 4(3): 184-191.

http://www.ecology.ethz.ch/publications/2011/Kettle_etal_2011_ConsLett.pdf

The Sabah Biodiversity Experiment: A Long-term Test of the Role of Tree Diversity in Restoring Tropical Forest Structure and Functioning

Relatively, little is known about the relationship between biodiversity and ecosystem functioning in forests, especially in the tropics. We describe the Sabah Biodiversity Experiment: a large-scale, long-term field study on the island of Borneo. The project aims at understanding the relationship between tree species diversity and the functioning of lowland dipterocarp rainforest during restoration following selective logging. The experiment is planned to run for several decades (from seed to adult tree), so here we focus on introducing the project and its experimental design and on assessing initial conditions and the potential for restoration of the structure and functioning of the study system, the Malua Forest Reserve. Our results establish the initial conditions for the Sabah Biodiversity Experiment and confirm the potential to accelerate restoration by using enrichment planting of dipterocarps to overcome recruitment limitation. What role dipterocarp diversity plays in restoration only will become clear with long-term results.

Hector, A. et al. (2011) The Sabah Biodiversity Experiment: A Long-term Test of the Role of Tree Diversity in Restoring Tropical Forest Structure and Functioning. Phil. Trans. R. Soc. B 366(1582): 3303-3315.

http://rstb.royalsocietypublishing.org/content/366/1582/3303.short

Forests/Woodlands>Brazil

Does Restoration Enhance Regeneration of Seasonal Deciduous Forests in Pastures in Central Brazil?

Our results suggest that early succession of seasonal deciduous forest in pastures in the region studied does not need to be stimulated once the perturbation is stopped and that intensive restoration efforts may actually slow recovery. We recommend only enrichment planting of seedlings that are not able to resprout.

Practitioners

Sampaio, A.B., K.D. Holl and A. Scariot (2007) Does Restoration Enhance Regeneration of Seasonal Deciduous Forests in Pastures in Central Brazil? Restoration Ecology 15(3): 462-471.

http://www.lerf.esalq.usp.br/divulgacao/recomendados/artigos/sampaio2007.pdf

Restoration of Seasonal Semi-Deciduous Forests in Brazil: Influence of Age and Restoration Design on Forest Structure

With the high rates of deforestation in tropical regions, the restoration of degraded lands has become an important way for maintaining the diversity of plant communities and for creating wildlife habitats. Evaluating the success of restored areas is essential for improving restoration designs and for successfully restoring such complex ecosystems. In this study, the development of restoration forests with respect to age (5, 9 and 10 years old) and the restoration models used (proportion of pioneer trees) was assessed along the margins of Companhia Energetica do Estado de Sao Paulo (CESP) reservoirs, located in the region of Pontal do Pananapanema, in Sao Paulo state, southeastern Brazil.

Practitioners, implementing agencies

Maluf de Souza, F. and J.L. Ferreira Batista (2004) Restoration of Seasonal Semi-Deciduous Forests in Brazil: Influence of Age and Restoration Design on Forest Structure. Forest Ecology and Management 191: 185-200.

http://www.opensailing.net/download/20100103docs/Art.%204%20Abbadie.pdf

Regeneration of Seasonal Deciduous Forest Tree Species in Long-Used Pastures in Central Brazil

We tested the relationship between the length of pasture use and the density, richness, and composition of naturally regenerating tropical seasonal deciduous forest in pastures. We sampled regenerating trees in 25 pastures distributed in four age classes ranging from < 6 to 40 yr of use. Density and composition of regenerating trees did not change with pasture age, but richness was lower in 25- and 40-yr-old pastures. Nonetheless, a number of species seem to be able to resprout even after 40 yr of ranching.

Practitioners, implementing agencies

Sampaio, A.B., K.D. Holl and A. Scariot (2007) Regeneration of Seasonal Deciduous Forest Tree Species in Long-Used Pastures in Central Brazil. Biotropica 39: 655-659.

http://onlinelibrary.wiley.com/doi/10.1111/j.1744-7429.2007.00295.x/abstract

An Evaluation of Direct Seeding for Reforestation of Degraded Lands in Central São Paulo State, Brazil

As part of a larger study evaluating several silvicultural techniques for restoring tropical moist forests on abandoned agricultural lands in southeastern Brazil, direct seeding with five early-successional Atlantic forest species was tested at three degraded sites, characterized by different soil types and land-use histories, within the Environmental Protection Area at Botucatu, SP. Despite the poor performance of the other species tested, we observed that the natural regeneration of native forest species originating from remnant forests in the general vicinity of our study sites was significantly greater within the direct-seeded plots than in unplanted control plots that were protected from fire and other disturbances.

Practitioners, implementing agencies

Lex Engel, V. and J.A. Parrotta (2001) An Evaluation of Direct Seeding for Reforestation of Degraded Lands in Central São Paulo State, Brazil. Forest Ecology and Management 152 (1-3): 169-181.

http://www.sciencedirect.com/science/article/pii/S0378112700006009

Rehabilitation of Degraded Areas of Central Amazonia Using Direct Sowing of Forest Tree Seeds

Deforestation in the Amazon Basin is still increasing, and the rehabilitation of these lands continues to be a challenge. Autoecological studies of most Amazonian species are rare, and efficient techniques for restoration of forested habitats have yet to be developed. The aim of this study was to test direct sowing as a rehabilitation technique for sites with different degrees of disturbance: bare soil, pasture, and secondary and mature forests in Central Amazonia, Brazil. At each site, we sowed seeds of 11 native tree species. Throughout the following year we evaluated germination and seedling survival. There was a positive correlation between seed size and survival. Large-seeded non-pioneer species seem to be more suitable for direct sowing than small-seeded species. We recommend a combination of direct sowing and planting of seedlings as an appropriate means to accelerate the rehabilitation of degraded areas in Central Amazonia.

Practitioners, implementing agencies

Campana Camargo, J.L., I.D. Kossman Ferraz and A.M. Imakawa (2002) Rehabilitation of Degraded Areas of Central Amazonia Using Direct Sowing of Forest Tree Seeds. Restoration Ecology 10(4): 636-644.

http://onlinelibrary.wiley.com/doi/10.1046/j.1526-100X.2002.01044.x/abstract

Restoration of Araucaria Forest: The Role of Perches, Pioneer Vegetation, and Soil Fertility

This work aims to investigate how use of perches to attract seed dispersers and the influence of pioneer vegetation and soil fertilization could affect the colonization of woody species in a degraded area. An experiment was conducted in an abandoned field where the natural establishment of seeds and seedlings of woody species was monitored under factorial combinations of the following treatments: (1) pioneer vegetation (presence and absence); (2) soil fertility (addition of NPK and control); and (3) perches (presence and absence). Seed and seedling abundance, seed and seedling species richness, and seedling mortality were recorded monthly during 12 months. Seed abundance and species richness were significantly greater in places with perches than in control plots. These results were consistent over the year and more pronounced when the surrounding forest produced a higher amount of fruit.

Implementing agencies, practitioners

Zanini, L. and G. Ganade (2005) Restoration of Araucaria Forest: The Role of Perches, Pioneer Vegetation, and Soil Fertility. Restoration Ecology 13: 507-514.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2005.00063.x/abstract

Dominance of Legume Trees Alters Nutrient Relations in Mixed Species Forest Restoration Plantings within Seven Years

Failures in reforestation are often attributed to nutrient limitation for tree growth. We compared tree performance and nitrogen and phosphorus relations in adjacent mixed-species plantings of contrasting composition, established for forest restoration on Ultisol soil, originally covered by tropical semi-deciduous Atlantic Forest in Southeast Brazil. The legume mixture succeeded in accelerating tree growth and canopy closure, but may imply periods of N losses and possibly P limitation. Incorporation of species with efficient nitrate uptake and P mobilization from resistant soil pools offers potential to optimize these tradeoffs.

Practitioners

Siddique, I., V. Lex Engel, J.A. Parrotta, D. Lamb, G.B. Nardoto, J.P.H.B. Ometto, L.A. Martinelli and S. Schmidt (2008) Dominance of Legume Trees Alters Nutrient Relations in Mixed Species Forest Restoration Plantings within Seven Years. Biogeochemistry 88(1): 89-101.

http://www.fs.fed.us/global/iitf/pubs/ja_iitf_2008_Siddique001.pdf

Forests/Woodlands>Burkina Faso

Macrotermes Mounds as Sites for Tree Regeneration in a Sudanian Woodland

The importance of mounds created by Macrotermes subhyalinus as safe site for tree regeneration was analysed in a savannah woodland of Burkina Faso. Plantlets (height <1.5 m) were sampled and followed over an year in 72 x 4 m2 quadrats located on M. subhyalinus mounds and adjacent areas. The mechanisms of regeneration and plantlet mortality were also determined. We identified three regeneration mechanisms: seedlings regenerated by seed (abundant on mounds), sprouts (abundant on adjacent areas) and root suckers (a rare case on both sites). It can thus be concluded that Macrotermes termite mounds are favourable sites for the recruitments of woody plants in savannah woodlands.

Implementing agencies, practitioners, indigenous and local communities

Traoré, S., M. Tigabu, S.J. Ouédraogo, J.I. Boussim, S. Guinko and M.G. Lepage (2008) Macrotermes Mounds as Sites for Tree Regeneration in a Sudanian Woodland (Burkina Faso). Plant Ecology 198(2): 285-295.

http://www.springerlink.com/content/43r5011k5522863q/

Forests/Woodlands>Canada

Alternative Approaches to Afforestation

The purpose of this discussion paper therefore is to gather information related to both conventional and more recently applied afforestation approaches, and provide it in a format that will assist managers in developing restoration strategies for specific sites and objectives.

The information assembled here is intended primarily for practitioners, the technical staff who are implementing field programs. It should also assist those who work at a policy level making considerations of program delivery and focusing at a broader scale.

Practitioner, implementing agencies, policymakers

Corlett, A., M. Penner, T. Clark and P. Gagnon (2010) Discussion Paper: Alternative Approaches to Afforestation. The Ontario Trillium Foundation and Trees Ontario.

http://www.tomclark.ca/home/afforestation-in-southern-ontario

A Forest of Blue: Canada's Boreal

This report highlights the unique status of the Canadian boreal forest in housing globally significant water resources. Maintaining the integrity and abundance of this "forest of blue" is still possible, and increasingly urgent. The report explores the ever-expanding list of threats to remote and abundant water resources across the Canadian boreal, and identifies opportunities to protect water resources at geographic scales that will maintain freshwater integrity and abundance into the future.

Policymakers

International Boreal Conservation Science Panel (2011) A Forest of Blue: Canada's Boreal. The Pew Environment Group.

http://www.pewenvironment.org/uploadedFiles/PEG/Publications/Report/PEGBorealWaterReport11March2011.pdf

Forests/Woodlands>Central America

Restoration of Dry Tropical Forests in Central America: A Review of Pattern and Process

Much information on restoration and management exists for wet tropical forests of Central America but comparatively little work has been done in the dry forests of this region. Such information is critical for reforestation efforts that are now occurring throughout Central America. This paper describes processes of degradation due to land use and provides a conceptual framework for the restoration of dry tropical forest. Most of this forest type was initially harvested for timber and then cleared for cattle in the last century (1930‐1970). Only 1.7% remains largely restricted to infertile soils and remote areas on the Pacific coastal side of Panama, Costa Rica, Nicaragua and Mexico. These cleared areas are again in a state of transition due to a combination of decreasing land productivity, and land speculation for tourism development. Some farms have been sold to new landowners who are interested in reforesting to increase biodiversity and forest cover. Attempts have therefore been made to reforest by protecting the land from fire and cattle, by supplementing natural regrowth with enrichment planting, or through use of tree plantations.

Implementing agencies, practitioners, indigenous and local communities

Griscom, H.P. and M.S. Ashton (2011) Restoration of Dry Tropical Forests in Central America: A Review of Pattern and Process. Forest Ecology and Management 261(10): 1564-1579.

http://www.sciencedirect.com/science/article/pii/S037811271000486X

Forests/Woodlands>Chile

Restauración Ecológica para Ecosistemas Nativos Afectados por Incendios Forestales

En esta obra se presentan los resultados de dos años de trabajo desarrollado por seis investigadores de la DC en el tema de la restauración ecológica de los ecosistemas vegetales nativos afectados por incendios forestales en Chile. El trabajo realizado incluye una exhaustiva revisión bibliográfica de las principales publicaciones relacionadas con el tema, la exploración de las iniciativas llevadas a cabo en Chile en el ámbito de la restauración ecológica y la integración de la información aportada por diversos especialistas y las campañas de terreno destinadas a evaluar los principales factores ecológicos involucrados en la regeneración de los ecosistemas afectados por incendios.

Implementing agencies, practitioners

Fernández, I., N. Morales, L. Olivares, J. Salvatierra, M. Gomez and G. Montenegro (2010) Restauración Ecológica para Ecosistemas Nativos Afectados por Incendios Forestales. Pontificia Universidad Católica de Chile, Corporación Nacional Forestal.

http://bosques.ciren.cl/xmlui/bitstream/handle/123456789/142/SAG_BD_02.pdf?sequence=1

Forests/Woodlands>China

Learning Lessons from China's Forest Rehabilitation Efforts: National Level Review and Special Focus on Guangdong Province

What has been the nature of these rehabilitation efforts and their outcomes? Did they meet or are they likely to meet their environmental, economic and social objectives? What are the constraints faced? It is imperative that China succeeds in its rehabilitation efforts in order to meet its growing demand for timber and environmental services. Failure on this front will not only affect China but also have global impacts due to continued imports of raw material (often unsustainably or illegally sourced) and environmental degradation elsewhere. Additionally, could forest rehabilitation and management contribute to China's western region development plan and help alleviate poverty in that region as proposed?

Policymakers, implementing agencies

Chokkalingam, U., Z. Zaizhi, W. Chunfeng and T. Toma (2007) Learning lessons from China's forest rehabilitation efforts: National level review and special focus on Guangdong Province. Bogor, Indonesia: Center for International Forestry Research (CIFOR).

http://www.cifor.org/publications/pdf_files/Books/BChokkalingam0603.pdf

Degradation and Restoration of Forest Ecosystems in China

China is a vast country with a diverse physical environment, rich biodiversity and complex forest types. Old China has left us with few forests and a poor base for forestry. Owing to the rapid growth of population, coupled with the development of agriculture and urban construction, as well as improper forest management, the degradation of forest resources in China has been accelerating. As a result of forest degradation, environmental problems including soil erosion and loss of biodiversity are being experienced and natural hazards are occurring with increasing frequency. The Chinese government has increased its focus on conservation of forests and restoration of degraded forest ecosystems. Particularly in recent years, a series of measures have been put in place. This paper presents a general introduction to the technical as well as policy aspects involved in the restoration of degraded forest ecosystems and the approach to sustainable forestry in China.

Policymakers, implementing agencies

Wenhua, L. (2004) Degradation and Restoration of Forest Ecosystems in China. Forest Ecology and Management 201: 33-41.

http://www.aseanbiodiversity.info/Abstract/51003805.pdf

Acceleration of Vegetation Succession on Eroded Land by Reforestation in a Subtropical Zone

Based on field investigations in the East River basin in Guangdong Province, south China, the processes of vegetation development and vegetation succession on bare slopes with high erosion rates are studied. Different reforestation measures have been applied to the slopes, which have resulted in very different processes of vegetation development and succession. On an experimental plot with burned forest but surviving roots, the vegetation restored naturally and quickly because there was little soil erosion. However, in the plots suffering from long-term severe soil erosion, natural vegetation recovery on these barren slopes is very slow. After 26 years, a barren slope has only been partly colonized by poorly developed vegetation composed of heliophilous herbages and scattered shrubs. On the other hand, plantation of some selected wood species on the slope land has dramatically accelerated the vegetation recovery and succession. The plots were reforested with plantation of Acacia auriculiformis in the early 1980s. Twelve years later, the vegetation cover of the artificial forests reached 90% and an understory vegetation community consisting of local species had naturally developed. Reforestation with suitable strategies may control erosion and greatly accelerate vegetation succession in the eroded slope land in the subtropical zones.

Practitioners, implementing agencies

Wang, F.X., Z.Y. Wang and J.H.W. Lee (2007) Acceleration of Vegetation Succession on Eroded Land by Reforestation in a Subtropical Zone. Ecological Engineering 31(4): 232-241.

http://www.sciencedirect.com/science/article/pii/S0925857407001498

Forests/Woodlands>Costa Rica

Restoring Abandoned Pasture Land with Native Tree Species in Costa Rica: Effects of Exotic Grass Competition and Light

Understanding the early establishment requirements and performance of tropical tree seedlings is essential to ensuring the success of restoration plantings. This study was designed to characterize growth and light requirements of six common neotropical tree species Pseudosamanea guachapele (Fabaceae), Tabebuia impetiginosa (Bignoniaceae), Ceiba pentandra (Bombacaceae), Pachira quinata (Bombacaceae), Dalbergia retusa (Fabaceae), and Tabebuia rosea (Bignoniaceae) in an abandoned pasture under contrasting light environments and grass competition. Field studies were conducted in the pastures of the Santa Ana Conservation Center in Costa Rica. As an initial step for restoring abandoned pasture lands we recommend using all these species in direct and moderate light conditions. Incorporating all species will create a more heterogeneous environment. Choosing light demanding species that can tolerate grass competition may help ensure success in the early stage of restoration.

Practitioners, implementing agencies

Celis, G. and S. Jose (2011) Restoring Abandoned Pasture Land with Native Tree Species in Costa Rica: Effects of Exotic Grass Competition and Light. Forest Ecology and Management 261(10): 1598-1604.

http://www.sciencedirect.com/science/article/pii/S0378112710006067

Tropical Montane Forest Restoration in Costa Rica: Overcoming Barriers to Dispersal and Establishment

This article provides a review of the factors limiting pasture recovery in tropical montane areas of Costa Rica and how forest managers can implement strategies to overcome these limitations, thereby facilitating ecosystem recovery. Firstly, the authors describe that the lack of seed dispersal from forests into pastures is one of the most important factors limiting the regeneration potential of forest species. Secondly, the competition between seedlings and pasture grasses can limit the survival and growth potential of the seedlings. Other factors include seed predation, low germination, lack of nutrients, high light intensity, and herbivory. To facilitate regeneration despite these limitations, the authors suggest planting native tree seedlings or early-succession shrubs that can shade out grasses and enhance seed dispersal. Along with shading structures that reduce grass cover, perching structures can help increase dispersal. The authors assert that the development of strategies for ecosystem recovery is highly dependent on a good understanding of the biology of an ecosystem.

Practitioners, implementing agencies

Holl, K.D., M.E. Loik, E.H.V Lin, and I.A. Samuels (2000) Tropical Montane Forest Restoration in Costa Rica: Overcoming Barriers to Dispersal and Establishment. Restoration Ecology 8(4): 339-349.

http://people.ucsc.edu/~kholl/review00.pdf

Understory Species Richness during Restoration of Wet Tropical Forest in Costa Rica

An effort to restore wet tropical forest in Costa Rica began in 1993 with plantings of native trees in abandoned pasture land. We compared understory plant species richness in three sites planted with a mix of native tree species with understory species in two monoculture plantations and in two secondary growth (unplanted) areas. Understory species in nearby primary forest remnants are also reported for comparison. We identified 356 understory species, ranging from 46 to 134 understory species per plot. Woody species were predominant (50–80%), as were plant species relying on animals for seed dispersal (60–80%). Our data indicate that substantial progress toward understory species richness can be obtained in the first decade of wet tropical forest restoration.

Practitioners, implementing agencies

Leopold, A.C. and J. Salazar (2008) Understory Species Richness during Restoration of Wet Tropical Forest in Costa Rica. Ecological Restoration 26(1): 22-26.

http://er.uwpress.org/content/26/1/22.full.pdf

Direct Seeding of Late-Successional Trees to Restore Tropical Montane Forest

Natural regeneration of large-seeded, late-successional trees in fragmented tropical landscapes can be strongly limited by a lack of seed dispersal resulting in the need for more intensive restoration approaches, such as enrichment planting, to include these species in future forests. Direct seeding may be an alternative low-cost approach to planting nursery-raised tree seedlings, but there is minimal information on its efficacy or when in the successional process this technique will be most successful. We tested directly seeding five native tree species into habitats representing passive and active restoration approaches: (1) recently abandoned pasture; (2) naturally establishing, young secondary forests; and (3) young, mixed-species (fast-growing N-fixers and commercially valuable species) tree plantations established to facilitate montane forest recovery in southern Costa Rica.

Practitioners, implementing agencies

Colea,R.J., K.D. Holl, C.L. Keene and R.A. Zahawi (2011) Direct Seeding of Late-Successional Trees to Restore Tropical Montane Forest. Forest Ecology and Management 261(10): 1590–1597.

http://people.ucsc.edu/~kholl/Cole%20et%20al%202010%20direct%20seeding.pdf

Growth in Pure and Mixed Plantations of Tree Species Used in Reforesting Rural Areas of the Humid Region of Costa Rica, Central America

This paper compares productivity of native tree species plantations, in monoculture and mixtures, at La Selva Biological Station in the Caribbean lowlands of Costa Rica. In monocultures, Jacaranda copaia, Vochysia guatemalensis, and Vochysia ferruginea were the most productive of 10 species compared. However, J. copaia and V. guatemalensis grew significantly faster in mixtures than in monocultures. A mixture of J. copaia, V. guatemalensis, and Calophyllum brasiliense produced 21% more merchantable volume than a monoculture of J. copaia, which grew the fastest of the three species. Mixed plantations of Dipteryx panamensis, Virola koschnyi, and Terminalia amazonia had productivity rates similar to monocultures of the fastest growing of these species (Virola koschnyi). The productivity of mixed plantations of V. ferruginea, Hyeronima alchorneoides, Genipa americana, and Balizia elegans was intermediate from the respective species' productivities in monocultures. Cultivating tree species in mixtures affected species' growth forms and ability to persist on the site.

Practitioners

Petit, B. and F. Montagnini (2006) Growth in Pure and Mixed Plantations of Tree Species Used in Reforesting Rural Areas of the Humid Region of Costa Rica, Central America. Forest Ecology and Management 233: 338-343.

http://ddr.nal.usda.gov/bitstream/10113/33191/1/IND43839452.pdf

Attempting Restoration of Wet Tropical Forests in Costa Rica

This report describes progress in an effort to show that restoration of wet native forest can be stimulated by planting mixed stands of native hardwoods. On a private reserve of 145 ha of abandoned pastureland, mixed stands have been established, involving up to 41 native species in the period since 1993. Sunloving species are growing as much as 3.1 m/year in height, and have exceeded 10 cm dbh in 5 years. Mixed stands of indigenous species are proposed as an alternative to monocultures, providing a possible source of income for small farmers, stabilizing the soil and stimulating the restoration of biodiversity.

Practitioners, implementing agencies

Leopold, A.C., R. Andrus, A. Finkeldey and D. Knowles (2001) Attempting Restoration of Wet Tropical Forests in Costa Rica. Forest Ecology and Management 142(1-3): 243-249.

http://www.aseanbiodiversity.info/Abstract/51003996.pdf

Methods of Facilitating Reforestation of Tropical Degraded Land with the Native Timber Tree, Terminalia amazonia

The T. amazonia trees grew best in plots with treatments of interplanted Inga edulis and mixed (Inga edulis and Gliricidia sepium) trees. Fertilizer addition did not improve tree growth after the second year since plantation establishment. The difference in soil erosion was correlated with tree growth. The authors assert that that leguminous trees can act as nurse trees for the timber species T. amazonia, whereas fertilization alone may be an ineffective means of promoting tree growth.

Practitioners, implementing agencies

Carpenter, F.L., J.D. Nichols, R.T. Pratt and K.C. Young (2004) Methods of facilitating reforestation of tropical degraded land with the native timber tree, Terminalia Amazonia. Forest Ecology and Management 202(1-3): 281-291.

http://darwin.bio.uci.edu/~flcarpen/papers/TerminaliaAmazonia.pdf

Facilitating Regeneration of Secondary Forests with the Use of Mixed and Pure Plantations of Indigenous Tree Species

The establishment of tree plantations on degraded lands can facilitate the regeneration of native species that could not otherwise grow in open micro sites or in competition by herbaceous species. The present research investigated tree regeneration under mixed and pure plantations of native species at La Selva Biological Station in the Atlantic humid lowlands of Costa Rica.

Practitioners, implementing agencies

Carnevale, N.J. and F. Montagnini (2002) Facilitating Regeneration of Secondary Forests with the Use of Mixed and Pure Plantations of Indigenous Tree Species. Forest Ecology and Management 163(1-3): 217-227.

http://www.lerf.esalq.usp.br/divulgacao/recomendados/artigos/carnevale2002.pdf

A Financial Analysis of Small-Scale Tropical Reforestation with Native Species in Costa Rica

In 1990 four Peace Corps Volunteers in Costa Rica completed their service and started a private reforestation project. The goal was to see if a small tree plantation could be profitable compared with traditional land uses. This article discusses the economics of the first 15 years of the project, using actual cash flows, and makes projections for financial outcomes. We documented the yearly expenses and revenues (cash flows) for operating a small tropical woodlot, costs and/or revenues from the specific woodlot management operations, and profit projections over the 25-year life of the project. We used realized growth rates, milling costs, and wood sale prices to show that small-scale reforestation with mixtures of native species can be financially profitable, both for an investor and a farmer/landowner.

Streed, E., J.D. Nichols and K. Gallatin (2006) A Financial Analysis of Small-Scale Tropical Reforestation with Native Species in Costa Rica. Journal of Forestry 104(5): 276-282.

http://www.ingentaconnect.com/content/saf/jof/2006/00000104/00000005/art00008

Forests/Woodlands>Dominican Republic

Forty Years of Tropical Forest Recovery from Agriculture: Structure and Floristics of Secondary and Old-Growth Riparian Forests in the Dominican Republic

Interest in tropical secondary forests has grown as large areas of agriculture have been abandoned in recent decades; yet, there are few long-term studies of post-agriculture vegetation recovery in the tropics. In this study, we compared the vegetation structure and floristic composition of old-growth and 40-year-old secondary riparian forests in the Cordillera Central, Dominican Republic. This study revealed the potential for the rapid recovery of woody plant diversity and structure in fertile secondary forests adjacent to mature forest seed sources and the more delayed recovery of nonwoody plant diversity and abundance.

Implementing agencies, practitioners

Martin, P.H., R.E. Sherman and T.J. Fahey (2004) Forty Years of Tropical Forest Recovery from Agriculture: Structure and Floristics of Secondary and Old-Growth Riparian Forests in the Dominican Republic. Biotropica 36(3): 297-317.

http://landscapeecology.agsci.colostate.edu/pdfs/Martin_et_al_2004_40_yrs_recovery_of_tropical_secondary_forests.pdf

Forests/Woodlands>Ecuador

Determinants for Successful Reforestation of Abandoned Pastures in the Andes: Soil Conditions and Vegetation Cover

The present study aims at providing basic knowledge on the early height development of native species in comparison to exotics. 12,000 seedlings of exotic and native species were planted in experimental trials at three sites of different successional stages: recently abandoned pastures (Setaria sphacelata), bracken (Pteridium arachnoideum) and shrubs. The results presented in this study refer to the status of the seedlings 3 years after planting. The results indicate that reforestation with native species in Ecuador is possible but requires intensive consideration of interactions with soil properties and accompanying vegetation. Macroscopic soil core analysis can be a suitable instrument for detecting small-scale variation of soil properties. Nevertheless, a characterisation of both small-scale variation as well as variation on higher spatial scales, for instance by aerial photographs, is essential for effective planning of reforestation measures in the Andes.

Implementing agencies, practitioners

Gunter, S., P. Gonzalez, G. Alvarez, N. Aguirre, X. Palomeque, F. Haubrich and M. Weber (2009) Determinants for Successful Reforestation of Abandoned Pastures in the Andes: Soil Conditions and Vegetation Cover. Forest Ecology and Management 258: 81-91.

http://www.rncalliance.org/WebRoot/rncalliance/Shops/rncalliance/4C15/966E/EC9A/313A/22F6/C0A8/D218/41DE/Gunter_et_al_2009_successful_0020_reforestation.pdf

Forests/Woodlands>Ethiopia

Restoration of Degraded Secondary Forest with Native Species: A Case Study in the Highland of Ethiopia

Ethiopia is losing a significant cover of natural forest every day owing to deforestation, yet surprisingly little field-based information exists on the ecological requirements and silvicultural strategies for the majority of the native species, which could be translated into plans for conservation and restoration. A study was conducted in Munessa Dry afromontane forest to evaluate the contribution of silvicultural options for sustainable management and conservation of forest resources in the highlands of Ethiopia. Therefore, by strategically planting native tree species on suitable target areas with desired spatial configuration, the maximum potential of natural conditions could be captured and secondary forests could be restored.

Implementing agencies, practitioners, indigenous and local communities

Girma, A., R. Mosandl, H. El Kateb and F. Masresha (2010) Restoration of Degraded Secondary Forest with Native Species: A Case Study in the Highland of Ethiopia. Scandinavian Journal of Forest Research 25(8): 86-91.

http://www.tandfonline.com/doi/abs/10.1080/02827581.2010.485769

Ecological Restoration and Church Forests in Northern Ethiopia

For the church forests studied we may conclude that (a) diversity and forest area protected are important, (b) each church forest fragment has its own unique species composition, (c) they harbour good wood stock compared to some of the natural state forests, (d) population structures suggest at least two major types of plants: species able to regenerate in the forest understory and species with difficulties to reproduce, (e) church traditions to conserve forest resources: tree seeds collection, traditional medicine and contemplation are permitted, while collection of fuel wood, construction wood and fodder are forbidden for the community, and (f) there is a high respect and trust of the local community with respect to the church organisation and their activities and rules. These results can be used as points of departure for restoration of the church forests themselves as well as for restoration of areas surrounding these forests.

Implementing agencies, practitioners, indigenous and local communities

Bongers, F., A. Wassie, F.J. Sterck, T. Bekele and D. Teketay (2006): Ecological restoration and church forests in northern Ethiopia. Journal of the Drylands 1(1): 35-44.

http://www.metafro.be/Members/rafaerts/JDrylands/Vol1(1)-2006/JD11_35-44.pdf

Tree Regeneration in Church Forests of Ethiopia: Effects of Microsites and Management

Tree regeneration is severely hampered in the fragmented afromontane forests of northern Ethiopia. We explored how trees regenerate in remnant forests along the gradient from open field, forest edge to closed sites and canopy gaps inside the forest. We investigated the effects of seed sowing, litter removal, and weeding on the regeneration success along this gradient. Regeneration success was investigated for four indigenous tree species, and measured in terms of seedling establishment, growth, and survival. Species performed differently according to site conditions. These results suggest that simple measures may improve seedling establishment, and that, for some species, forest edges are particularly useful for growth and survival after succesful establishment. Together with erecting fences, needed to protect seedlings against grazing, seed sowing, planting seedling, and soil scarification may contribute to maintain and restore church forests in the fragmented landscapes of northern Ethiopia.

Implementing agencies, practitioners, indigenous and local communities

Wassie, A., F.J. Sterck, D. Teketay and F. Bongers (2009) Tree Regeneration in Church Forests of Ethiopia: Effects of Microsites and Management. Biotropica 41: 110-119.

http://onlinelibrary.wiley.com/doi/10.1111/j.1744-7429.2008.00449.x/abstract

The Role of Soil Seed Banks in the Rehabilitation of Degraded Hillslopes in Southern Wello, Ethiopia

The species composition in the soil seed bank of degraded hillslopes in southern Wello, Ethiopia, was assessed using the seedling emergence method and compared with that of the standing vegetation. Although most of the species that germinated in the seed banks were herbs and grasses, they can develop a vegetative cover and contribute to reduction of soil erosion. Regeneration of the tree species (some of which have seed viability up to four years) however, requires both time and the presence of mature individuals. Together with hillside closure and soil conservation measures (e.g., terracing), planting of native woody seedlings might help to expedite rehabilitation of degraded hillslopes devoid of trees and shrubs.

Implementing agencies, practitioners

Tekle, K. and T. Bekele (2000) The Role of Soil Seed Banks in the Rehabilitation of Degraded Hillslopes in Southern Wello, Ethiopia. Biotropica 32(1): 23-32.

http://onlinelibrary.wiley.com/doi/10.1111/j.1744-7429.2000.tb00444.x/abstract

Restoration of Dry Afromontane Forest Using Pioneer Shrubs as Nurse-Plants for Olea europaea ssp. cuspidate

Shrubs are often considered competitive barriers for seedlings planted in reforestation programs, although they can facilitate tree recruitment, especially in ecosystems under high abiotic stress. An alternative reforestation technique using pioneer shrubs as nurse-plants for Olea europaea ssp. cuspidata was tested in exclosures in northern Ethiopia. Seedlings were planted in three different microhabitats, and their survival was monitored. Planting under shrubs may increase seedling survival and assist regeneration of dry Afromontane vegetation. Preserving pioneers also reduces soil erosion and conserves biodiversity. Excluding livestock is essential for Olea woodland restoration and allows persistent but morphologically modified Olea shrubs to develop vigorous regrowth. Facilitative processes are guiding principles for assisted forest restoration, but above-average rains may be critical to restore higher biomass levels in semiarid areas.

Practitioners, implementing agencies

Aerts, R., A. Negussie, W. Maes, E. November, M. Hermy and B. Muys (2007) Restoration of Dry Afromontane Forest Using Pioneer Shrubs as Nurse-Plants for Olea europaea ssp. cuspidata. Restoration Ecology 15: 129-138.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2006.00197.x/abstract

Restoring Dry Afromontane Forest Using Bird and Nurse Plant Effects: Direct Sowing of Olea europaea ssp. cuspidata Seeds

To identify the perspectives of seed sowing for reforestation of degraded dryAfromontane savanna in exclosures in northern Ethiopia, seeds of a fleshy-fruited, secondary climax tree, Olea europaea ssp. cuspidata, were placed under two pioneer shrub species (Euclea racemosa and Acacia etbaica) and in open microhabitats. Seed removal and germination rates were examined. The effects of bird ingestion, manual pulp removal and mechanical endocarp treatments on germination rates were also studied.

Practitioners

Aerts, R., W. Maes, E. November, A. Negussie, M. Hermy and B. Muys (2006) Restoring Dry Afromontane Forest Using Bird and Nurse Plant Effects: Direct Sowing of Olea europaea ssp. cuspidata Seeds. Forest Ecology and Management 230(1-3): 23-31.

http://www.sciencedirect.com/science/article/pii/S0378112706002477

The Potential and Risks of Using Exotics for the Rehabilitation of Ethiopian Dryland Forests

Case studies from South Africa are discussed to, firstly, illustrate the potential of exotics, especially eucalypts, in providing much needed timber while also protecting the natural forest. These species, when genetically improved, can reach yields of more than 20 m3·ha-1·year-1, even under relatively dry conditions. Secondly, the risk of using exotics, such as eucalypts and Australian Acacias, e.g. in terms of water use, uncontrolled spread and destruction of local biodiversity, is discussed and examples are given of management procedures to manage the risks. Finally, some suggestions are proposed on strategies to be followed for the use of exotics in the Ethiopian highlands, especially on the questions how much, where and how to use them. It is pointed out that, with sufficient control, including spatial planning, policy and legislation, exotic species could play an important role in filling economic and social demands that need not be in conflict with environmental objectives.

Implementing agencies, policymakers

van Wyk, G., D. Pepler, K. Gebrehiwot, R. Aerts and Bart Muys (2006) The Potential and Risks of Using Exotics for the Rehabilitation of Ethiopian Dryland Forests. Journal of the Drylands 1(2): 148-157.

https://lirias.kuleuven.be/bitstream/123456789/138797/1/JD12_148-157.pdf

In situ Persistence of African Wild Olive and Forest Restoration in Degraded Semiarid Savanna

The ability to produce vegetative shoots is a form of persistence in arid and semiarid savannas allowing trees to survive herbivory, fire and cutting. In terms of growth rates and survival, this form of rejuvenation may be more successful than recruitment via seed rain or dormant seeds in the seed bank. For this reason, resprouting could play an important role in the tree canopy and forest microclimate recovery and forest succession. To assess whether coppice growth of Africanwildolive (Olea europaea ssp. cuspidata) should be considered for restoration of dry Afromontane forest, this study investigated olive coppice densities and characteristics in a 100-ha grazing exclosure in northern Ethiopia using random samples and systematic samples along transects. The response to pruning, expected to reactivate a leading shoot and thus contribute to faster tree habit and canopy recovery, was tested as a secondary objective.

Practitioners, implementing agencies

Aerts R., E. November, W. Maes, I. Van der Borght, A. Negussie, E. Aynekulu, M. Hermy and B. Muys (2008) In situ persistence of African wild olive and forest restoration in degraded semiarid savanna. Journal of Arid Environments 72: 1131-1136.

http://www.sciencedirect.com/science/article/pii/S0140196307003254

Regeneration Response of Juniperus procera and Olea europaea subsp. cuspidata to Exclosure in a Dry Afromontane Forest in Northern Ethiopia

The Afromontane forests of northern Ethiopia have been degraded and fragmented for centuries. Recently, efforts have been made to restore these forests by protecting them from livestock interference. In this study, the natural regeneration of Juniperus procera Hochst. ex Endl. and Olea europaea L. subsp cuspidata (Wall. ex G. Don) Cif. is investigated under protected conditions after 3 years of enclosure and under open management systems in a dry Afromontane forest in northern Ethiopia.

Implementing agencies, practitioners

Aynekulu, E., M. Denich and D. Tsegaye (2009) Regeneration Response of Juniperus procera and Olea europaea subsp. cuspidata to Exclosure in a Dry Afromontane Forest in Northern Ethiopia. Mountain Research and Development 29(2): 143-152.

http://www.mtnforum.org/sites/default/files/pub/5532.pdf

Forests/Woodlands>Europe

LIFE and European Forests

This publication provides background details on the EU forest sector, and gives details of how LIFE has contributed in terms of: forest restoration, forest biodiversity, forest management and building partnerships to protect and improve forests.

Policymakers

Jones, W. (2006) LIFE and European forests. European Commission, Environment Directorate-General.

http://ec.europa.eu/environment/life/publications/lifepublications/lifefocus/documents/forest_lr.pdf

The Political Practice of Mountain Forest Restoration: Comparing Restoration Concepts in Four European Countries

This paper compares the Alpine countries of Switzerland, Bavaria (Germany), Austria and Slovenia, and investigates how institutions influence the development and application of mountain forest restoration concepts. In practice, different restoration approaches have been developed in these countries depending on the distribution of forest ownership and the administrative arrangements. According to the different institutional settings, different actors are involved in the policy networks. With their different interests and value systems, these actors determine the goals, the design and the outcome of restoration programmes. Policy change might become effective by including new participants in the network. As the need for restoration is often caused by unsustainable forest management, the change of institutional arrangements is crucial to facilitate advanced management systems, which aim at avoiding degradation in the future.

Policymakers, implementing agencies

Weiss, G. (2006) The Political Practice of Mountain Forest Restoration: Comparing Restoration Concepts in Four European Countries. Forest Ecology and Management 195(1-2): 1-13.

http://www.sciencedirect.com/science/article/pii/S0378112704002002

Restoration of Natural Broad-leaved Woodland in Central Europe on Sites with Coniferous Forest Plantations

In conclusion, decisions regarding extensive or intensive management, aiming at the conversion of coniferous plantations into natural broad-leaved forests, can be made following observation of the natural regeneration processes in the present-day stands. By utilising the natural regeneration processes and by applying only a few controlling silvicultural measures, a low-energy and cost-effective conversion of the forests can be accomplished.

Implementing agencies, practitioners

Zerbe, S. (2002) Restoration of Natural Broad-leaved Woodland in Central Europe on Sites with Coniferous Forest Plantations. Forest Ecology and Management 167(1-3): 27-42.

http://www.sciencedirect.com/science/article/pii/S0378112701006867

Forests/Woodlands>Finland

Forest Restoration in Finland: Monitoring Scheme and First Results

In order to evaluate the effectiveness of forest restoration a monitoring site network has been established. Effects of restoration on two focal species groups – beetles and polypores – are monitored along with the development of stand structure. The very first results obtained from the monitoring network show that increasing volume of dead wood increased the number of beetle species compared to the control plots both in pine-dominated and in spruce-dominated stands. The species communities composed largely of phloem feeders and their related species. These are usually good dispersers and thus well able to locate newly formed resources.

Practitioners

Hyvarinen, E., M. Simila and P. Virnes (2008) Forest Restoration in Finland: Monitoring Scheme and First Results. 6th European Conference on Ecological Restoration, Ghent, Belgium.

http://ser.semico.be/ser-pdf/120.pdf

Forests/Woodlands>Ghana

Assessment of Forest Degradation by Local Communities: The Case Study of Ghana

The rate of forest degradation is continuously increasing throughout Ghana. To mitigate the effect of degradation, the International Tropical Timber Organization (ITTO) funded a project to rehabilitate some degraded forests with the collaboration of local communities. Due to resource constraints, three sites were to be selected from five potential sites Asukese, Bonsam Bepo, Southern Scarp, Afrensu Brohuma and Pamu Berekum within three forest ecological zones on the basis of perceived rates of degradation. Thus to select the final three areas for the project, assessment was done using indicators developed collaboratively with the local communities based on their experience on what had been the state of the forest before degradation as well as how their livelihoods have been impacted because of degradation.

Indigenous and local communities, implementing agencies

Blay, D., F.D. Dwomoh and L. Damnyag (2009) Assessment of Forest Degradation by Local Communities: The Case Study of Ghana. FAO Forest Resources Assessment Working Paper 160.

http://www.fao.org/docrep/012/k7179e/k7179e00.pdf

Rehabilitation of Forest-Savannas in Ghana: The Impacts of Land Use, Shade, and Invasive Species on Tree Recruitment

This article examines the potential for the natural recruitment of trees from the soil seed bank following various types of agricultural land uses and conditions associated with them in the Suhum‑Kraboa‑Coaltar district of the Eastern Region. Seedling recruitment data from soil seed banks are interrogated with Repeated Measures Analyses of Variance, and these data show that, first, tree life forms are not significantly greater than other life forms, and that in fact tree life forms are the minority in the conditions of the examined agricultural land uses. Second, the analyses indicate that the natural recruitment of tree seedlings for tree rehabilitation confronts enormous competition from non-tree species. The herb/shrub species, Chromolaena odorata is identified as a primary factor for the difficulties of tree recruitment. Drawing on these findings and the detailed narratives of farmers, the article submits that the challenge for the natural recruitment of trees in the study region is for farmers to adopt land management practices that significantly increase the numbers of tree species while reducing the competition from non-tree species, such as C. odorata.

Implementing agencies, practitioners, indigenous and local communities

Awanyo, L., E.M. Attuah and M. McCarron (2011) Rehabilitation of Forest-Savannas in Ghana: The Impacts of Land Use, Shade, and Invasive Species on Tree Recruitment. Applied Geography 31(1): 181-190.

http://www.sciencedirect.com/science/article/pii/S0143622810000482

Enrichment Planting of African Mahoganies in Fire-Degraded Dry Semi-Deciduous Forests in Ghana

Dry forest ecosystems in Ghana are among the most threatened forest types in the country. With the increasing need to rehabilitate degraded dry semi-deciduous forest reserves in Ghana, the use of native species in enrichment planting have been emphasized.

Practitioners, implementing agencies

Danquah, J.A., M. Appiah and P. Ari (2011) Enrichment Planting of African Mahoganies in Fire-Degraded Dry Semi-Deciduous Forests in Ghana. European Journal of Scientific Research 52(2): 213-225.

http://www.eurojournals.com/EJSR_52_2_09.pdf

Forests/Woodlands>Honduras

Tropical Forest Restoration: Tree Islands as Recruitment Foci in Degraded Lands of Honduras

Tropical forest recovery in pastures is slowed by a number of biotic and abiotic factors, including a lack of adequate seed dispersal and harsh microclimatic extremes. Accordingly, methods to accelerate forest recovery must address multiple impediments. Here, we evaluated the ability of “tree islands” to serve as “recruitment foci” in a two-year study at three sites in northern Honduras.

Practitioners, implementing agencies

Zahawi, R.A. and C.K. Augspurger (2006) Tropical Forest Restoration: Tree Islands As Recruitment Foci In Degraded Lands Of Honduras. Ecological Applications 16:464–478

http://www.esajournals.org/doi/abs/10.1890/1051-0761%282006%29016%5B0464%3ATFRTIA%5D2.0.CO%3B2?journalCode=ecap

Forests/Woodlands>Iceland

Ecosystem Degradation and Restoration of Birch Woodlands in Iceland

This chapter describes of some of the degradation processes (land degradation, desertification, soil erosion, and grazing) that have resulted to destruction of the Icelandic birch (Betula pubescens) woodlands and the potential methods for their restoration.

Implementing agencies

Aradottir, A. L. and O. Arnalds (2001) Ecosystem Degradation and Restoration of Birch Woodlands in Iceland. Pp. 293-306 in Nordic mountain birch ecosystems (Wielgolaski, F.E. (ed.)), Man and the Biosphere Series Volume 27.

http://www.cabdirect.org/abstracts/20013133588.html;jsessionid=4C55C8F2A05AABAD8CE96D61321080F2

Evaluation of the Ecological Restoration Potential of Plant Communities in Norway Spruce Plantations Using a Life-trait Based Approach

In Europe, intensively managed coniferous plantations rarely achieve similar nature conservation functions as deciduous woodlands. The ability to identify coniferous plantations that might be successfully converted to deciduous woodland is a key goal in forest management. The herbaceous plant community composition of mature plantations may be an accurate selection criterion for stands that are most suitable for initiating the conversion process to deciduous forest. The performance of short geophytes is the key to conversion success of Norway spruce plantations to deciduous forest. Stands located on base-rich soils and in landscapes with high forest connectivity are the most appropriate candidates for initiating the conversion process. For other types of stands, future work should explore the possibility of restoring other land-use types, such as annually mown meadows.

Implementing agencies, practitioners

Herault, B., O. Honnay and D. Thoen (2005) Evaluation of the Ecological Restoration Potential of Plant Communities in Norway Spruce Plantations Using a Life-trait Based Approach. Journal of Applied Ecology 42: 536-545.

http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.68.8444&rep=rep1&type=pdf

Forests/Woodlands>India

Forest Restoration and Armed Conflicts: Challenges and Policy Options for India

Forest restoration need not be an unmixed blessing in practice. Due to both foreseen and unforeseen factors restored forests can turn into hot-beds of armed conflict thus defeating the very purpose for which they were raised. Amongst many developing countries with such bad experience is India which is facing bitter conflicts in its forested areas. The focus of the paper is to understand the impacts of the conflict on forest restoration practices and forest management and to suggest ideas towards bettering participatory forest management. Strengthening of socio-economic position and livelihoods of local communities and their empowerment is a much larger issue and should be a pre-requisite for forest restoration strategies. Neglect of local communities and their livelihoods can only endanger restored forest areas and add to their vulnerability and hence make such areas vulnerable to divisive forces. Timely interventions, continuous assessments, reflection, stock-taking and monitoring are also crucial for reforested areas.

Policymakers

Mukherjee, N. and M. Parihari (2010) Forest restoration and armed conflicts: Challenges and Policy Options for India. Proceedings of the 18th Commonwealth Forestry Conference, Edinburgh.

http://www.cfc2010.org/papers/session13/Mukherjee-s13.pdf

Restoring Natural Capital in the Tropical Dry Deciduous Forests of the Western Ghats of India

In an attempt to restore populations of some of the more exploited plant species, and also to preserve the indigenous knowledge and lifestyle, an internationally funded project worked with local indigenous groups between 1996 and 2000 to restore oonjal (Albizia amara), pulivaka (Albizia odoratissima), venga (Pterocarpus marsupium), puli (Tamarindus indica), and neermaruthu (Terminalia arjuna). These five species were selected by forest inhabitants because the plants are heavily exploited, mainly as firewood. With the participation of local indigenous groups, seedlings were planted in three pit types: namely conventional square pits and experimental ring and saucer pits. Seedling survival results showed that the seedlings planted in the non-conventional ring and saucer pits fared better than those planted in conventional square pits. This paper describes the ethnobotanical aspects of the ecosystem and efforts to develop a participatory project to restore the forest's natural capital, to sustain indigenous knowledge, and to evaluate different pit planting types.

Practitioners, implementing agencies, indigenous and local communities

Jayakumar, R., R.C. Pandalai and K.K.N. Nair (2010) Restoring Natural Capital in the Tropical Dry Deciduous Forests of the Western Ghats of India. Ecological Restoration 28(4): 485-492.

http://er.uwpress.org/content/28/4/485.abstract

Patterns of Seed Rain and Seedling Regeneration in Abandoned Agricultural Clearings in a Seasonally Dry Tropical Forest in India

Forest recovery in abandoned pastures and agricultural fields is often impeded, therefore it is important to understand the factors limiting regeneration. Patterns of seed arrival and regeneration in five abandoned agricultural clearings nested within a seasonally dry tropical forest in India were examined along five transects radiating from the forest edge into the clearings. Although wind-dispersed seeds greatly outnumbered vertebrate-dispersed seeds, seedlings and saplings of vertebrate-dispersed species were three times more abundant than those of wind-dispersed species, indicating distinct differences in patterns of actual and effective seed dispersal. This points to recruitment limitation, and suggests that seed arrival may not be the principal barrier to regeneration in these clearings. Nonetheless, the clearings are likely to revert to forest over time.

Practitioners, implementing agencies

Teegalapallia, K., A.J. Hirematha and D. Jathanna (2010) Patterns of Seed Rain and Seedling Regeneration in Abandoned Agricultural Clearings in a Seasonally Dry Tropical Forest in India. Journal of Tropical Ecology 26: 25-33.

http://journals.cambridge.org/action/displayAbstract;jsessionid=ACB9A173E7069F6A6B89E00568FFD72F.journals?fromPage=online&aid=6714772

Restoring Rainforest Fragments: Survival of Mixed-Native Species Seedlings under Contrasting Site Conditions in the Western Ghats, India

Historical fragmentation and a current annual deforestation rate of 1.2% in the Western Ghats biodiversity hotspot have resulted in a human-dominated landscape of plantations, agriculture, and developed areas, with embedded rainforest fragments that form biodiversity refuges and animal corridors. Retaining regenerating native species during weed clearing operations was crucial for rapid reestablishment of a first layer of canopy to shade out weeds and enhance survival of shade-tolerant rainforest seedlings.

Practitioners

Shankar Raman, T.R., D. Mudappa and V. Kapoor (2009) Restoring Rainforest Fragments: Survival of Mixed-Native Species Seedlings under Contrasting Site Conditions in the Western Ghats, India. Restoration Ecology 17(1): 137-147.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2008.00367.x/abstract

Forests/Woodlands>Indonesia

Forest Rehabilitation in Indonesia: Where to after Three Decades?

Rehabilitation activities in Indonesia have a long-history of more than three decades, implemented in more than 400 locations. Successful projects are characterised by the active involvement of local people, and the technical intervention used tailored to address the specific ecological causes of degradation that concern local people. However, sustaining the positive impacts beyond the project time is still the biggest challenge. Rehabilitation efforts have been lagging behind the increasing rates of deforestation and land degradation. This has been largely due to the complexities of the driving factors causing the degradation, which neither projects nor have other government programmes been able to simultaneously address.

Policymakers, implementing agencies

English, Bahasa Indonesia

Nawir, A.A. (2007) Forest rehabilitation in Indonesia: where to after three decades? Bogor, Indonesia: Center for International Forestry Research (CIFOR).

http://www.cifor.org/nc/online-library/browse/view-publication/publication/2274.html

Prioritization of Target Areas for Rehabilitation: A Case Study from West Kalimantan, Indonesia

To rehabilitate degraded forestlands and conserve the remaining forests in Kalimantan, effective measures are needed that accommodate various land uses in the landscape. We present a pragmatic model for prioritizing target areas for rehabilitation and discuss a potential approach, combining traditional reforestation and the forest management methods of local Dayak tribes with the operations of a commercial tree plantation venture, to promote the rehabilitation of elements of the tropical lowland rainforest.

Implementing agencies, indigenous and local communities

Marjokorpi, A. and R. Otsamo (2006) Prioritization of Target Areas for Rehabilitation: A Case Study from West Kalimantan, Indonesia. Restoration Ecology 14(4): 662-673.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2006.00178.x/abstract

Forests/Woodlands>Japan

Maintenance and Rehabilitation of the Mixed Conifer-Broadleaf Forests in Hokkaido, Northern Japan

We reviewed several studies on the mixed forests concerned with physiological ecology and ecosystem management in relation to the process analysis of natural regeneration. Based on these results, we proposed methods for rehabilitation practices for the disturbed and degraded mixed forests where we cannot expect natural regeneration. In order to rehabilitate those mixed conifer broadleaf forests, a bulldozer with fitted rakes was used to eliminate culm and rhizome of dwarf bamboo (such as Sasa senanensis or S. klirensis). In order to make plantations, we would also use wildings of gap phase species regenerated after scarification. However, it is still unclear how many seedlings and what species would be best suited for rehabilitation. A new practical system for restoring disturbed and degraded mixed forests should be established.

Practitioners, implementing agencies

Kyo, M., S. Masato and K. Takayoshi (2002) Maintenance and Rehabilitation of the Mixed Conifer-Broadleaf Forests in Hokkaido, Northern Japan. Eurasian J. For. Res. 5(2): 119-130.

http://eprints.lib.hokudai.ac.jp/dspace/bitstream/2115/22158/1/5(2)_P119-130.pdf

Forests/Woodlands>Laos

Restoration of Former Grazing Lands in the Highlands of Laos Using Direct Seeding of Four Native Tree Species

Direct seeding has recently regained favor as an alternative method to conventional planting for restoration of degraded and/or abandoned sites. This study reports the establishment and growth performance of 2 pioneer (Pinus kesiya and Schima wallichii) and 2 later-successional (Keteleeria evelyniana and Quercus serrata) native trees broadcasted or buried on 14 former grazing lands in Laos. Seedling establishment was assessed 9 months after sowing; height, diameter growth, and mortality were measured 1, 3, and 5 years after direct seeding and subjected to analysis of variance. We conclude that direct seeding seems to be possible for rehabilitation of abandoned sites, provided that the seeds are buried to avoid the risk of seed desiccation and predation; the seeding rate of pioneer species is reduced to avoid a high mortality rate, and species-site matching is well defined to minimize topography-induced changes in a microhabitat.

Practitioners, implementing agencies

Sovu, P. Savadogo, M. Tigabu and P.C. Odén (2010) Restoration of Former Grazing Lands in the Highlands of Laos Using Direct Seeding of Four Native Tree Species. Mountain Research and Development 30(3): 232-243.

http://www.bioone.org/doi/pdf/10.1659/MRD-JOURNAL-D-10-00031.1

Forests/Woodlands>Latin America

Restoration of Forest Ecosystems in Fragmented Landscapes of Temperate and Montane Tropical Latin America

We integrate forest restoration experiences aimed at a variety of purposes that allow us to gain insight over several years under contrasting ecological, social and economic conditions in six study regions: the Argentinian Andes, the IX and X Regions in Chile (including northern Chiloé Island), and central Veracruz and the central and northern Highlands of Chiapas (Mexico). By comparing analogous conditions and highlighting differences among the study sites, current pitfalls can be identified and used to define a minimum set of elements to be considered in a protocol for restoration practices. The restoration studies reviewed here include a wide variety of ecological and socio-economic circumstances that allow the identification of broad guidelines, criteria and indicators for planning, implementing and monitoring ecological restoration programmes. We conclude with statements that suggest approaches, strategies and concrete actions that might be considered as lessons learned and inputs for best practice in forest restoration research and programmes conducted in other developing regions.

Practitioners, implementing agencies

Gonzalez-Espinosa, M. et al (2007) Restoration of Forest Ecosystems in Fragmented Landscapes of Temperate and Montane Tropical Latin America in Newton, A.C. (ed.) Biodiversity loss and conservation in fragmented forest landscapes: the forests of montane Mexico and temperate South America. CABI.

http://www.arboreous.info/wp-content/uploads/2011/09/Newton-Ch_15.pdf

Rainfall-Tuned Management Facilitates Dry Forest Recovery

Regeneration of original dry forests and shrublands in degraded arid and semiarid ecosystems can be a slow and difficult process. It has been hypothesized that restoration efforts during periods of increased water availability may potentially trigger shifts back to a high vegetation cover depending on several environmental factors that govern the response of vegetation to rainfall. Tuning restoration efforts to climate variability will likely become increasingly important under climate change conditions. The experiences evaluated here are a pioneering effort to reforest arid South American forests. Our study shows that management tuned to forecasted rainfall events is able to trigger a long-lasting shift toward higher vegetation cover. We provide a better insight in how environmental factors shape vegetation response to increased rainfall and discuss the implications for ecosystem resilience and restoration.

Practitioners, implementing agencies

Sitters, J., M. Holmgren, J.J. Stoorvogel and B.C. Lopez (2012) Rainfall-Tuned Management Facilitates Dry Forest Recovery. Restoration Ecology 20(1): 33-42.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2010.00761.x/full

Restoration of Dry Tropical Forests in Central America: A Review of Pattern and Process

This paper describes processes of degradation due to land use and provides a conceptual framework for the restoration of dry tropical forest. Most of this forest type was initially harvested for timber and then cleared for cattle in the last century (1930‑1970). Only 1.7% remains largely restricted to infertile soils and remote areas on the Pacific coastal side of Panama, Costa Rica, Nicaragua and Mexico. These cleared areas are again in a state of transition due to a combination of decreasing land productivity, and land speculation for tourism development. Some farms have been sold to new landowners who are interested in reforesting to increase biodiversity and forest cover.

Policymakers, implementing agencies

Griscom, H.P. and M.S. Ashton (2011) Restoration of Dry Tropical Forests in Central America: A Review of Pattern and Process. Forest Ecology and Management 261(10): 1564-1579.

http://www.sciencedirect.com/science/article/pii/S037811271000486X

Manual of Methods: Human, Ecological and Biophysical Dimensions of Tropical Dry Forests

The main purpose of this guidebook is to provide all Tropi-Dry researchers and field assistants with detailed and complete methodological protocols for all the research aspects considered in the IAI-funded project "Human, ecological and biophysical dimensions of Tropical Dry Forests." The multiple localities covered and the numerous research teams involved in this investigation demand the use of standardized protocols across sites and research teams. By standardizing all methodologies, we will be able to perform valid comparisons of results across localities and propose regional patterns for some of the phenomena studied. We expect this manual to also become a primary reference for dry forest research throughout the tropics, allowing us to replicate our field research well beyond the boundaries of Tropi-Dry's current study sites.

Practitioners, implementing agencies

Nassar, J. M., J. P. Rodríguez, A. Sánchez-Azofeifa, T. Garvin and M. Quesada (eds.) (2008) Manual of Methods: Human, Ecological and Biophysical Dimensions of Tropical Dry Forests. Ediciones IVIC, Instituto Venezolano de Investigaciones Científicas (IVIC), Caracas, Venezuela.

http://tropi-dry.eas.ualberta.ca/pdf/Papers/Tropi-Dry_Manual_of_Methods.pdf

Forests/Woodlands>Madagascar

Spontaneous Regeneration of Tropical Dry Forest in Madagascar: The Social–Ecological Dimension

In contrast to other types of forests in Madagascar there are only a few, very small areas formally under protection. Informal institutions, however, play an important role in southern Madagascar in protecting forest ecosystems and maintaining their capacity to generate valuable ecosystem services. Other studies have shown the value of existing institutions and customary authority and values for the success of conservation. Few studies have, however, linked the existence of a social capital related to forest management with spatial analysis of forest dynamics.

Policymakers, implementing agencies, indigenous and local communities

Elmqvist, T., M. Pyykönen and M. Tengö (2010) Spontaneous Regeneration of Tropical Dry Forest in Madagascar: The Social–Ecological Dimension in Nagendra, H. and J. Southworth (eds.) (2010) Reforesting Landscapes: Linking Pattern and Process. Springer Landscape Series, Vol. 10.

http://www1.inecol.edu.mx/repara/download/III_1_ReforestingLandscapesLinkingPatternandProcess_IV.pdf

Forests/Woodlands>Mexico

Restauración de Ecosistemas Forestales: Guía Básica para Comunicadores

La presente guía para comunicadores sobre *Restauración de ecosistemas forestales* contiene los conceptos básicos para comprender la complejidad de las acciones que inciden en la recuperación de las funciones ecosistémicas, las estrategias para lograrlo, la operación actual de las tareas de restauración, así como algunos casos que dan ejemplo de los resultados que se pueden alcanzar en esta materia.

Policymakers, indigenous and local communities

Comisión Nacional Forestal (2009) Restauración de Ecosistemas Forestales: Guía Básica para Comunicadores. Zapopan, Jalisco, México.

http://www.conafor.gob.mx:8080/documentos/docs/7/579Restauraci%C3%B3n%20de%20ecosistemas%20forestales.pdf

Impacts of Early- and Late-Seral Mycorrhizae during Restoration in Seasonal Tropical Forest, Mexico

Disturbance of vegetation and soil may change the species composition of arbuscular mycorrhizal fungi (AMF), which may in turn affect plant species responses to AMF. Seasonal tropical forest in Mexico is undergoing rapid conversion to early-successional forest because of increased wildfire and may require restoration. The responses of six early- and late-successional tree species were tested using early- and late-successional AMF inoculum. The results suggest that early-seral AMF should be used when seedlings are inoculated for restoration, even for late-seral tree species.

Practitioners

Allen, E.B., M.F. Allen, L. Egerton-Warburton, L. Corkidi and A. Gómez-Pompa (2003) Impacts of Early- and Late-Seral Mycorrhizae during Restoration in Seasonal Tropical Forest, Mexico. Ecological Applications 13(6): 1701-1717.

http://www.reservaeleden.org.mx/publicaciones/Articulos%20Arbitrados/EDEN17.pdf

Direct Seeding to Restore Tropical Mature-Forest Species in Areas of Slash-and-Burn Agriculture

After tropical lands have been abandoned from anthropogenic pressures, often forest structure and some species recover naturally. Studies suggest, however, that mature-forest species are frequently slow to establish and an active management strategy may be necessary. We tested direct seeding of mature-forest species as a restoration strategy in sites previously used for slash-and-burn agriculture in semi-evergreen, seasonal forest in the Yucatan peninsula, Mexico, and evaluated when in the successional process this strategy had the highest success rate.

Implementing agencies, practitioners, indigenous and local communities

Bonilla-Moheno, M. and K.D. Holl (2010) Direct Seeding to Restore Tropical Mature-Forest Species in Areas of Slash-and-Burn Agriculture. Restoration Ecology 18(s2): 438-445.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2009.00580.x/full

Experimental Tree Assemblages on the Ecological Rehabilitation of a Cloud Forest in Veracruz, Mexico

The composition and richness of woody species were experimentally tested in assemblages that were put together in order to evaluate ‑ 18 months later ‑ the combination that impacts several variables of woody community development the most and thus, its value on cloud forest rehabilitation. The experiment was conducted in an area of eastern Mexico characterized by cloud forest that had been severely damaged by plant cover removal and erosion as well as soil mixing and compacting caused by heavy machinery. Ten, 1-year-old, native woody species were employed to construct the assemblages. All species used in the experiment are native to eastern Mexican cloud forest, and each was included in at least two assemblages. The relative success of all assemblages and most individual species shows that it is possible to accelerate secondary succession in cloud forest by establishing assemblages of woody species juveniles.

The results suggest that in this forest rehabilitation, any assemblage can be employed. Given the effects on each species, it is advisable to include the ones which exhibit the best survival and response under altered conditions in terms of crown size and height (Quercus, Carpinus, and Ulmus).

Practitioners, implementing agencies

Suárez Guerrero, A.I. and M. Equihua (2005) Experimental Tree Assemblages on the Ecological Rehabilitation of a Cloud Forest in Veracruz, Mexico. Forest Ecology and Management 218(1-3): 329-341.

http://www.sciencedirect.com/science/article/pii/S0378112705004986

Forests/Woodlands>Mongolia

Forest Resources Degradation Accounting in Mongolia

The results of this study show that forest degradation has increased from year to year during the entire study period. This is due to expansion of economic activity and increased global climate change impact for the forest ecosystem. The changes of forest degradation have been integrated with macroeconomic indicators of socio-economic development of the country. This study shows how degradation of resources can be analyzed in terms of future loss of goods and services in terms of indicators of monetary value. This may link physical degradation with economic indicators for sustainable development.

Policymakers, implementing agencies

Ykhanbai, H. (2009) Forest Resources Degradation Accounting in Mongolia. FAO Forest Resources Assessment Working Paper 176.

http://www.fao.org/docrep/012/k8596e/k8596e00.pdf

Forests/Woodlands>Nepal

Forest Degradation in Nepal: Review of Data and Methods

This paper aims to review the past forest resource assessments, methodologies and findings on forest degradation. The study observed that differentiation on forest quality was recognized since the first forest resources assessment in the early 1960s. Similarly, all forest resource assessments have identified criteria and indicators for capturing forest degradation. Forest degradation has been understood as reduction in production capacity of commercial timber volume. Change in tree canopy cover was used as a key criterion in assessments. Degradation was assessed through canopy closure, tree density, regeneration capacity, stand maturity, lopping, species dominancy, grazing, and soil surface erosion. The assessment methodologies include field survey, satellite images, aerial photography, ground checks or a combination of these. Finally the paper concludes by offering potential methods for assessing forest degradation in Nepal.

Policymakers, implementing agencies

Acharya, K.P. and R.B. Dangi (2009) Forest degradation in Nepal: review of data and methods. FAO Forest Resources Assessment Working Paper 163.

http://www.fao.org/docrep/012/k7608e/k7608e00.pdf

Forests/Woodlands>New Caledonia

Ecological Restoration and the Biodiversity Vision of New Caledonian Dry Forests

The present seminar on restoration is an opportunity to: 1) Assess actions taken to restore dry forest areas, 2) Benefit from international experience to promote different levels of analysis and action, 3) Draw up technical recommendations for further action, and 4) Integrate these findings into a long term strategic conservation plan for the New Caledonian Dry Forest Ecoregion.

Implementing agencies, policymakers

Geraux, H. (2005) Seminar on the ecological restoration and the biodiversity vision of New Caledonian dry forests. Gland: WWF International.

http://www.foretseche.nc/download/actes_sem_04_eng.pdf

Forests/Woodlands>Palau

Landscape Patterns of Tropical Forest Recovery in the Republic of Palau

A GIS (geographic information systems) database was constructed from aerial photographs, a vegetation map, and topographic map data of the Ngeremeduu Bay Drainage Area (NBDA), Palau, to examine relationships between upland land cover dynamics, environmental variables, and past land use. Our results indicate that areas of forest expansion were significantly ($P < 0.001$) associated with the location of abandoned agricultural communities. In addition, over 92 percent of areas of forest expansion occurred within 100 m of established forest. These results suggest that the proximity of established forest facilitate forest recovery following human disturbance.

Implementing agencies, practitioners

Endress, B.A. and J.D. Chinea (2001) Landscape Patterns of Tropical Forest Recovery in the Republic of Palau. Biotropica 33(4): 555-565.

http://onlinelibrary.wiley.com/doi/10.1111/j.1744-7429.2001.tb00214.x/abstract

Forests/Woodlands>Panama

Seedling Survival and Growth of Native Tree species in Pastures: Implications for Dry Tropical Forest Rehabilitation in Central Panama

Our study tested the effects of herbicide application and cattle removal on the survival and growth of three native tree species planted in pastures within a deforested, dry tropical region of Panama. We investigated whether enrichment planting may be a potential, complementing reforestation tool with natural regeneration. Three economically valuable tree species were chosen for the study; Cedrela odorata L., Enterolobium cyclocarpum (Jacq.) Griseb, and Copaifera aromatica Dwyer. Planted seedlings were monitored for survival, root collar diameter and height growth in the presence or absence of two factors; (1) initial herbicide application and (2) cattle.

Practitioners, implementing agencies, indigenous and local communities

Griscom, H.P., P.M.S. Ashton and G.P. Berlyn (2005) Seedling Survival and Growth of Native Tree species in Pastures: Implications for Dry Tropical Forest Rehabilitation in Central Panama. Forest Ecology and Management 218: 306-318.

http://azueroearthproject.org/aep/wp-content/themes/green-love/reference_pdfs/ARC_science/A.B3001_Griscom_2005_eng.pdf

Responses of 20 Native Tree Species to Reforestation Strategies for Abandoned Farmland in Panama

Deforestation in the tropics often leads to unproductive agriculture and results in abandoned, degraded grasslands that tree species recolonize poorly. To evaluate why forests do not regenerate naturally and to identify potential species for use in reforestation of degraded areas, we planted 15 000 seeds of 20 native tree species, varying in seed size and shade tolerance, in abandoned Panamanian farmland dominated by the exotic grass, Saccharum spontaneum.

Practitioners, implementing agencies

Hooper, E., R. Condit and P. Legendre (2002) Responses of 20 Native Tree Species to Reforestation Strategies for Abandoned Farmland in Panama. Ecological Applications 12(6): 1626-1641.

http://biol09.biol.umontreal.ca/PLcourses/Hooper_et_al_2002.pdf

Factors Affecting Community Composition of Forest Regeneration in Deforested, Abandoned Land in Panama

We tested alternative hypotheses concerning factors affecting early forest succession and community composition in deforested and abandoned areas invaded by an exotic grass, Saccharum spontaneum, in Panama. We hypothesized three barriers to natural regeneration: (1) Saccharum competition, (2) seed dispersal limitations, and (3) fire. We measured natural tree and shrub regeneration in a factorial experiment combining distances from adjacent forest, mowing treatments of the Saccharum, and a prescribed burn. To determine the applicability of the general model of neotropical succession and the nucleation model of succession to species composition of forest regeneration in these anthropogenic grasslands in Panama the effect of time since fire and distance to remnant vegetation (isolated trees, shrubs, and large monocots) was measured.

Practitioners, implementing agencies

Hooper, E.R., P. Legendre and R. Condit (2004) Factors Affecting Community Composition of Forest Regeneration in Deforested, Abandoned Land in Panama. Ecology 85(12): 3313-3326

http://si-pddr.si.edu/jspui/bitstream/10088/6757/1/Hooper_Legendre_and_Condit_2004.pdf

Forests/Woodlands>Philippines

One Century of Forest Rehabilitation in the Philippines: Approaches, Outcomes and Lessons

The main objective of the study and this volume is to enhance the success and sustainability of forest rehabilitation efforts in the Philippines, with enhanced production of forest goods and services and positive outcomes for local communities by: 1) Assessing the characteristics and outcomes of past rehabilitation efforts, 2) Identifying and disseminating the most promising approaches that could sustainably supply the targeted goods and environmental services, while benefiting local communities, and 3) Determining the enabling factors and actions different stakeholders must undertake to move forward.

Policymakers, implementing agencies

Chokkalingam, U., A.P. Carandang, J.M. Pulhin, R.D. Lasco, R.J.J. Peras and T. Toma (eds.) (2006) One century of forest rehabilitation in the Philippines: approaches, outcomes and lessons. Bogor, Indonesia: Center for International Forestry Research (CIFOR).

http://www.cifor.org/publications/pdf_files/Books/Bchokkalingam0605.pdf

Geodatabase Development for Forest Restoration and Biodiversity Conservation in the Mt. Makiling Forest Reserve, Philippines

A GIS-based database (or geodatabase) was developed for the Mt. Makiling Forest Reserve, on Luzon Island, Philippines toward the establishment of a management decision support system. The study presents initial results in the development of a geodatabase, as well as the use of geographic information system (GIS) in the planning, design and implementation of programs for forest renewal and biodiversity conservation. GIS use for data encoding is already extensive but its use as a planning and analytical tool is limited, if not altogether lacking. An outline for the establishment of a geodatabase is presented that will allow processing, analysis and modeling and, ultimately, the sustainable development and conservation of the mountain forest reserve, which is a significant watershed area and an important catchment for Laguna de Bay – the largest freshwater lake in Southeast Asia.

Implementing agencies

Bantayan, N.C., E. Rodantes, G. Abraham and E.S. Fernando (2008) Geodatabase Development for Forest Restoration and Biodiversity Conservation in the Mt. Makiling Forest Reserve, Philippines. The Philippine Agricultural Scientist 91(4): 365-371.

http://journals.uplb.edu.ph/index.php/PAS/article/viewFile/185/183

Forests/Woodlands>Southeast Asia

Rehabilitation of Degraded Forest Ecosystems in Cambodia, Lao PDR, Thailand and Vietnam: An Overview

The ultimate purpose of this work and future IUCN initiatives is to assist stakeholders in the lower Mekong countries to develop and implement ecologically and socio-economically sound forest rehabilitation policies and practices. The intentions of this report are to provide an overview and broad assessment of relevant forest policy and practices, and to encourage discussion among key decision-makers about preferred principles and criteria for guiding future forest rehabilitation programmes.

Policymakers

Gilmour, D.A., N. Van San and X. Tsechalicha (2000) Rehabilitation of Degraded Forest Ecosystems in Cambodia, Lao PDR, Thailand and Vietnam: An Overview. WWF International.

http://assets.panda.org/downloads/lowermekongregionaloverview.pdf

Improving Forest Governance in the Mekong Region, Volume 1

This report identifies opportunities for regional activities to improve forest governance in the Mekong countries of Cambodia, Lao PDR, Vietnam, Thailand, and Myanmar. The major objective of the proposed activities is to combat illegal logging and associated trade and improve forest governance in these countries. Doing so will contribute to improving livelihoods and economic development that rely on the long-term responsible and legal management of the region's forest resources.

Policymakers

Program on Forests (PROFOR) (2011) Improving Forest Governance in the Mekong Region, Volume 1. Working Paper. The World Bank, Washington DC.

http://www.profor.info/profor/sites/profor.info/files/docs/WorkingPaper-Mekong-Vol1-final.pdf

Regeneration of Native Plant Species in Restored Forests on Degraded Lands in Singapore

The results showed that reforestation has been successful in promoting native forest development, but it also illustrated the need for management intervention in restoring the floristic diversity and structural complexity of a primary forest especially where the natural successional processes are hampered by soil degradation, habitat fragmentation and the loss of native fauna.

Implementing agencies, practitioners

Shono, K., S. Davies and C. Kheng (2006) Regeneration of native plant species in restored forests on degraded lands in Singapore. Forest Ecology and Management 237(1-3): 574-582.

http://ctfs.arnarb.harvard.edu/Public/pdfs/Shono_Davies_Chua_2006_ForEcolMang.pdf

Research for Restoring Tropical Forest Ecosystems: A Practical Guide

This book is a training manual, designed to enable staff at the proposed national FORRU's in China, Laos and Cambodia, to develop the skills and knowledge needed for research programs to restore the unique forest ecosystems found in each country.

Practitioners

English, Chinese, Lao, Khmer and Thai

Forest Restoration Research Unit (2008) Research for Restoring Tropical Forest Ecosystems: A Practical Guide. Biology Department, Science Faculty, Chiang Mai University, Thailand.

http://www.forru.org/FORRUEng_Website/Pages/engpublications.htm

Restoration of Degraded Forest Ecosystems in Southeast Asia

The project Restoration of Degraded Forest Ecosystems in the Southeast Asian Tropical Region was a flagship ASEAN project supported by the Republic of Korea (ROK). AKECOP accumulated significant knowledge and sufficient experience through its cordial and firm partnership among key ASEAN and ROK forest research organizations during Phase 1 (1 July 2000 to 30 June 2005), Phase 2 (1 July 2005 to 30 June 2008) and will continue to do so in Phase 3 (1 July 2008 to 30 June 2011). Its research findings have led to an effective and efficient restoration of degraded tropical forests in ASEAN member countries.

Implementing agencies

Bae, K., D. Koo Lee and S. Young Woo (eds.) (2005) Restoration of Degraded Forest Ecosystems in Southeast Asia. ASEAN-Korea Environmental Cooperation Project.

http://www.fao.org/docrep/014/i1734e/i1734e01.pdf

Ecological Considerations for Using Dipterocarps for Restoration of Lowland Rainforest in Southeast Asia

The lowland dipterocarp forests of Southeast Asia support a substantial proportion of the world's biodiversity. They are of considerable environmental and economic value at the local, regional and global scale, providing many goods and services to a growing population. The forests of this region are among the fastest disappearing in the world and restoration is urgently required. This paper provides a review of the ecological constraints to restoration of lowland dipterocarp forest in Southeast Asia. It focuses on the production of planting stock, the significance of site-species matching and post-planting site maintenance. It identifies gaps in our knowledge and highlights priority areas of research.

Practitioners, implementing agencies

Kettle, C.J. (2010) Ecological Considerations for Using Dipterocarps for Restoration of Lowland Rainforest in Southeast Asia. Biodiversity Conservation 19: 1137-1151.

http://www.ecology.ethz.ch/publications/2010/2010/Kettle_2010_BiodiversityAndConservation.pdf

Forests/Woodlands>Sri Lanka

Restoration Pathways for Rain Forest in Southwest Sri Lanka: A Review of Concepts and Models

Restoration pathways are suggested that range from: (i) the simple prevention of disturbance to promote release of rain forest succession; (ii) site-specific enrichment planting protocols for canopy trees; (iii) sequential amelioration of arrested fern and grasslands by use of plantation analogs of old field pine to facilitate secondary succession of rain forest, and plantings of late-seral rain forest tree species; and (iv) establishment and release of successionally compatible mixed-species plantations. We summarize with a synthesis of the restoration techniques proposed for reforestation using native vegetation on cleared conservation areas and parks, and for the stabilization of eroded upland watersheds. We conclude with a comparative analysis with restoration work done in other tropical forest regions.

Implementing agencies, practitioners, policymakers

Ashton, M.S., C.V.S Gunatilleke, B.M.P Singhakumara and I.A.U.N Gunatilleke (2001) Restoration Pathways for Rain Forest in Southwest Sri Lanka: A Review of Concepts and Models. Forest Ecology and Management 154(3): 409‑430.

http://www.aseanbiodiversity.info/Abstract/51003445.pdf

Restoration of a Sri Lankan Rainforest: Using Caribbean Pine Pinus caribaea as a Nurse for Establishing Late-Successional Tree Species

This study assesses the growth potential of 5 native late-successional species of Southwestern Sri Lanka under Pinus caribaea, grown in plantations, to inform appropriate species choice and placement in enrichment plantings. The authors evaluated growth over 2 years, measuring eight, basal stem diameter, number of leaves, and mortality. They destructively sampled some individuals to also measure leaf area and dry mass of roots, stems and leaves. The study successfully demonstrates that native late-successional species can be grown under P. caribaea, though seedlings must have DPPF levels 4-5 times greater than those present beneath a closed Pinus canopy. D. zeylanicus may be best suited for sites prone to desiccation, and S. disticha and S. megistophylla best for planting under intact canopy.

Practitioners, implementing agencies

Ashton, P.M.S., S. Gamage, I.A.U.N. Gunatilleke and C.V.S. Gunatilleke (1997) Restoration of a Sri Lankan Rainforest: Using Caribbean Pine Pinus caribaea as a Nurse for Establishing Late-Successional Tree Species. Journal of Applied Ecology 34(4): 915-925.

http://www.jstor.org/discover/10.2307/2405282?uid=3739256&uid=2134&uid=2&uid=70&uid=4&sid=21100681897171

Forests/Woodlands>Sweden

Forest History as a Basis for Ecosystem Restoration: A Multidisciplinary Case Study in a South Swedish Temperate Landscape

Basic knowledge of the previous forest types or ecosystem present in an area ought to be an essential part of all landscape restoration. Here, we present a detailed study of forest and land use history over the past 2,000 years, from a large estate in southernmost Sweden, which is currently undergoing a restoration program. In particular, the aim was to identify areas with long continuity of important tree species and open woodland conditions. We employed a multidisciplinary approach using paleoecological analyses (regional and local pollen, plant macrofossil, tree ring) and historical sources (taxation documents, land surveys, forest inventories). This study gives an example of the spatial and temporal variation of the vegetation that has historically occurred within one area and emphasizes that information from one methodological technique provides only limited information about an area's vegetation history.

Implementing agencies, practitioners

Lindbladh, M., J. Brunet, G. Hannon, M. Niklasson, P. Eliasson, G. Eriksson and A. Ekstrand (2007) Forest History as a Basis for Ecosystem Restoration: A Multidisciplinary Case Study in a South Swedish Temperate Landscape. Restoration Ecology 15(2): 284-295.

http://dendrochronology.se/res/pdf_s/lindbladetal2007.pdf

Forests/Woodlands>Tanzania

Restoring Woodlands, Sequestering Carbon and Benefiting Livelihoods in Shinyanga, Tanzania

The project relied on the rich local knowledge of the Sukuma people about their natural resources and ways of managing them. "Ngitili – or "enclosures" or "fodder reserves" in the local Sukuma language were traditionally used for conservation and restoration of range-lands and governed under customary law, are now the true driver for the astounding success of the forest restoration in the region.

Implementing agencies, policymakers, indigenous and local communities

Barrow, E. and A. Shah (2011) TEEBcase: Traditional forest restoration in Tanzania.

http://www.eea.europa.eu/atlas/teeb/traditional-forest-restoration-in-tanzania-tanzania

How Agroforestry is Helping Farmers to Restore the Woodlands in Shinyanga Region

The HASHI project helped tens of thousands of smallholders to restore degraded land, and in doing so to significantly improve their incomes. One of the project's great achievements was to revive a traditional system of land management which increases the supply of livestock fodder for use during the dry season. When the project began, there were just 600 ha of documented ngitili – enclosed fodder reserves – in the region. There are now thought to be over 500,000 ha of such reserves.

Implementing agencies, policymakers, indigenous and local communities

Pye-Smith, C. (2010) A Rural Revival in Tanzania: How agroforestry is helping farmers to restore the woodlands in Shinyanga Region. ICRAF Trees for Change no. 7. Nairobi: World Agroforestry Centre.

http://www.worldagroforestry.org/downloads/publications/PDFs/B16751.PDF

Forests/Woodlands>Thailand

Rehabilitation of Degraded Forests in Thailand: Policy and Practice

This paper focuses on the significant issues affecting both the policy and practice of forest rehabilitation. Given that the large number of people whose livelihood depends on the forests for subsistence and other purposes normally has been excluded from the decision-making process in forest management, most important among these issues are the integration of the socio-economic and environmental needs into rehabilitation initiatives together with the active participation of local communities in the rehabilitation program. Case studies of reforestation and rehabilitation initiatives are also discussed.

Policymakers, implementing agencies, practitioners, indigenous and local communities

Sharp, A. and N. Nakagoshi (2006) Rehabilitation of Degraded Forests in Thailand: Policy and Practice. International Consortium of Landscape and Ecological Engineering.

http://www.aseanbiodiversity.info/Abstract/53005328.pdf

Restoration of Degraded Forest Land in Thailand: The Case of Khao Kho

This article outlines the progress of a tropical reforestation project in Thailand, beginning with an introduction to the history of the local land degradation and an early attempt at reforestation. Initial attempts to reforest the area encountered the following difficulties: a lack of acceptance by the local population, improper planting of trees in downhill rows leading to erosion, poor selection of trees and planting in monoculture blocks without regard to microclimate conditions. To improve restoration efforts, remaining forest plots were surveyed and a list of native species was compiled. The species used for reforestation in the project were diversified to include more than 30 native species which were then planted according to seven distinct site types (based on soil moisture availability, elevations, degree of erosion, and the degree of human influence and demand).

Implementing agencies

Marghescu, T. (2001) Restoration of degraded forest land in Thailand: the case of Khao Kho. Unasylva 52(207): 52-54.

http://www.fao.org/docrep/004/y2795e/y2795e10.htm

Selecting Framework Tree Species for Restoring Seasonally Dry Tropical Forests in Northern Thailand based on Field Performance

Framework tree species are indigenous forest tree species, planted to complement and accelerate natural regeneration of forest ecosystems and encourage biodiversity recovery, on degraded sites. In this paper we test the extent to which 37 native forest tree species might act as framework tree species to accelerate recovery of evergreen, seasonal forest in a degraded upper watershed in Doi Suthep-Pui National Park in northern Thailand.

Practitioners, implementing agencies, indigenous and local communities

Elliott, S., P. Navakitbumrung, C. Kuarak, S. Zangkum, V. Anusarnsunthorn and D. Blakesley (2003) Selecting framework tree species for restoring seasonally dry tropical forests in northern Thailand based on field performance. Forest Ecology and Management 184: 177–191.

http://www.dnp.go.th/fca16/file/arcdivclinc6unk.pdf

Producing Framework Tree Species for Restoring Forest Ecosystems in Northern Thailand

Since 1994, the Forest Restoration Research Unit of Chiang Mai University’s Biology Department (FORRU-CMU) has been developing methods to restore forest ecosystems to deforested sites within protected areas, for biodiversity conservation and environmental protection in northern Thailand. With support from WWF Greater Mekong Thailand Country Programme and corporate sponsor King Power Duty Free, the unit is working with Hmong hill tribe villagers from Baan Mae Sa Mai, in Doi Suthep-Pui National Park, to expand a demonstration site for the ''framework species method'' of forest restoration. The technique entails planting 20 to 30 indigenous forest tree species, capable of rapidly shading out weeds and attracting seed-dispersing animals from nearby forest remnants. This results in rapid increase in tree species richness, progressing towards the species composition of the original forest, as well as overall biodiversity recovery.

Implementing agencies, practitioners, indigenous and local communities

Elliott, S. and C. Kuaraksa (2008) Producing Framework Tree Species for Restoring Forest Ecosystems in Northern Thailand. Small-scale Forestry 7: 403-415.

http://www.forru.org/PDF_Files/Publications/ElliottKuaraksa2008Smallscaleforestry.pdf

Testing the Framework Species Method for Forest Restoration in Chiang Mai, Northern Thailand

The framework species method of reforestation, developed by FORRU (Forest Restoration Research Unit) has been used successfully to restore evergreen forest on degraded former agricultural sites in Doi Suthep-Pui National Park, Chiang Mai province, Thailand. This paper reports 3 year results of an attempt to duplicate the FORRU reforestation techniques at Ban Toong Yah, Mae Chaem district, at a similar elevation as FORRU's original plots at Ban Mae Sa Mai, Mae Rim district.

Implementing agencies, practitioners, indigenous and local communities

Wangpakapattanwong, P. and S. Elliott (2008) Testing the Framework Species Method for Forest Restoration in Chiang Mai, Northern Thailand. Walailak J Sci & Tech 5(1): 1-15.

http://www.forru.org/PDF_Files/Publications/WangpakapattanawongElliott2008Jscitech.pdf

Propagating Framework Tree Species to Restore Seasonally Dry Tropical Forest: Implications of Seasonal Seed Dispersal and Dormancy

One effective approach to forest restoration in degraded tropical forestland is the so-called 'framework species method' which involves planting 20–30 indigenous forest tree species to re-establish a basic forest structure that catalyses the recovery of biodiversity. For the seasonally dry tropical forests of Doi Suthep-Pui National Park in northern Thailand, a provisional list of 36 potential framework species was compiled, from 19 different families representing a broad spectrum of the tree flora. This paper examines the seed germination characteristics of these species when grown as a nursery 'crop' for planting to restore degraded sites, focussing on germination phenology and dormancy.

Implementing agencies, practitioners

Blakesley, D., S. Elliott, C. Kuarak, P. Navakitbumrung, S. Zangkum and V. Anusarnsunthorn (2002) Propagating Framework Tree Species to Restore Seasonally Dry Tropical Forest: Implications of Seasonal Seed Dispersal and Dormancy. Forest Ecology and Management 164: 31-38.

http://www.forru.org/PDF_Files/Publications/Propagating%20Framework%20Species.pdf

Direct Seeding for Forest Restoration on Abandoned Agricultural Land in Northern Thailand

Seed predation and desiccation present major limitations to the use of direct seeding as an efficient forest restoration technique. The study was designed based on the premise that scarifying seeds before sowing them in fields cleared of weeds would shorten seed dormancy to decrease the time available for seed predation to occur and that burial conceals seeds from potential predators. Therefore, the effects of four treatments (scarification, burial, application of mulch and scarification with burial) were tested on seed germination of four native forest tree species, sown in abandoned agricultural land in an upper watershed in Doi Suthep-Pui National Park, northern Thailand. For certain suitable species, this technique could offer an effective, cost-efficient alternative to outplanting nursery-raised seedlings for forest restoration projects, particularly in montane areas.

Practitioners, implementing agencies

Woods, K. and S. Elliott (2004) Direct Seeding for Forest Restoration on Abandoned Agricultural Land in Northern Thailand. Journal of Tropical Forest Science 16(2).

http://reforestation.elti.org/resource/210/

Effects of Seed Traits on the Success of Direct Seeding for Restoring Southern Thailand's Lowland Evergreen Forest Ecosystem

The success of direct seeding, as a low-cost approach to forest restoration, varies with tree species and seed characteristics. A system to predict which tree species are likely to be suitable for direct seeding would therefore be useful for improving forest restoration projects. Therefore, this study aimed to determine the effects of seed traits on the success of direct seeding to restore tropical forest in southern Thailand. These conditions successfully predicted the success or failure of direct seeding for 15 out of 19 species tested. Eight tree species are recommended as suitable for restoring lowland evergreen forest ecosystems in southern Thailand, by direct seeding.

Practitioners

Tunjai, P. and S. Elliott (2012) Effects of Seed Traits on the Success of Direct Seeding for Restoring Southern Thailand's Lowland Evergreen Forest Ecosystem. New Forests 43: 319-333.

http://www.springerlink.com/content/w6522n5744224805/

Forests/Woodlands>Uganda

Intensive Tree Planting Facilitates Tropical Forest Biodiversity and Biomass Accumulation in Kibale National Park, Uganda

The purpose of this study was to determine how intensive replanting affected tropical forest regeneration and biomass accumulation over ten years. We studied reforested sites in Kibale National Park, Uganda, that were degraded in the 1970s and replanted with five native tree species in 1995. We identified and measured the size of planted versus naturally regenerating trees, and felled and weighed matched trees outside the park to calculate region-specific allometric equations for above-ground tree biomass. The role of shrubs and grasses in facilitating or hindering the establishment of trees was evaluated by correlating observed estimates of percent cover to tree biomass.

Practitioners, implementing agencies

Omeja, P.A., C.A. Chapman, J. Obua, J.S. Lwanga, A.L. Jacob, F. Wanyama and R. Mugenyi (2011) Intensive Tree Planting Facilitates Tropical Forest Biodiversity and Biomass Accumulation in Kibale National Park, Uganda. Forest Ecology and Management 261: 703-709.

http://chapmanresearch.mcgill.ca/Pdf/271_FORECO12453.pdf

Forest Restoration in Abandoned Agricultural Land: A Case Study from East Africa

Millions of hectares of tropical forests have been converted to agricultural land and abandoned, so it is important that we understand the process of forest recovery and comprehend how pathways are modified by different types of disturbance in different geographic regions. In a 4-year case study, we quantified the pattern of forest recovery following clearing and 3 years of cultivation of a moist-evergreen forest in Uganda.

Practitioners, implementing agencies

Chapman, C.A. and L.J. Chapman (1999) Forest Restoration in Abandoned Agricultural Land: A Case Study from East Africa. Conservation Biology 13(6): 1301-1311.

http://chapmanresearch.mcgill.ca/Pdf/106_KibaleRestore.pdf

Expediting Reforestation in Tropical Grasslands: Distance and Isolation from Seed Sources in Plantations

To quantify the effect of distance and isolation from seed sources on the regeneration of indigenous trees, we evaluated tree species richness and stem density in four pine plantations surrounded by natural forest within Kibale National Park, Uganda, and one isolated pine plantation surrounded by agriculture near Kibale. Tree regeneration in these plantations was compared to that in natural forest and to an anthropogenic grassland similar to those upon which the plantations were established. This study demonstrates that forest reestablishment can be faster if plantations are established than if grasslands are left to recover without management. However, differences within and among plantations can lead to very different communities with respect to species composition, species richness, and stem density.

Implementing agencies, practitioners

Zanne, A.E. and C.A. Chapman (2001) Expediting Reforestation in Tropical Grasslands: Distance and Isolation from Seed Sources in Plantations. Ecological Applications 11(6): 1610-1621.

http://chapmanresearch.mcgill.ca/Pdf/128_ZanneChapmanEcolApps.pdf

Forests/Woodlands>Ukraine

Afforestation for the Provision of Multiple Ecosystem Services: A Ukrainian Case Study

This paper analyses costs and benefits of planting trees on marginal lands across forestry zones in Ukraine with the purpose of using them for timber production, erosion prevention and climate change mitigation. The research reveals that establishment of new forests to increase timber production and alleviate soil erosion is economically and environmentally justified in some regions. Incorporating the effects of afforestation through on climate change mitigation increases social benefits.

Policymakers, implementing agencies

Nijnik, M., A. Oskam and A. Nijnik (2012) Afforestation for the Provision of Multiple Ecosystem Services: A Ukrainian Case Study. International Journal of Forestry Research Volume 2012.

http://www.hindawi.com/journals/ijfr/2012/295414/ref/

Forests/Woodlands>USA

Thinning, Fire and Forest Restoration: A Science-based Approach for National Forests in the Interior Northwest

In focusing on issues relating to forest alteration and restoration in the interior Northwest, this paper is a modest attempt to find what Ruggiero and others describe as the "middle ground between demanding certainty and embracing opinion." I will attempt to explore the scientific basis for what we appear to know, how we might proceed, and what we need to learn. This is neither an exhaustive review of the literature, nor an attempt to address all issues related to forest restoration. Rather, it is an attempt to review the most pertinent scientific literature, merge these findings with policy requirements, and provide recommendations on how best to proceed. Qualitative judgment will inevitably be involved, and what follows should be viewed as general principles, considerations, or rules-of-thumb.

Policymakers, implementing agencies

Brown, R. (2002) Thinning, Fire and Forest Restoration: A Science-based Approach for National Forests in the Interior Northwest. Defenders of Wildlife, Washington, DC.

http://www.defenders.org/publication/thinning-fire-and-forest-restoration-science-based-approach-national-forests-interior

Assessing Ecosystem Restoration Alternatives in Eastern Deciduous Forests: The View from Belowground

In our study, structural restoration involves mechanically modifying the woody plant assemblage to a species composition, density, and community structure specified by the restoration goals. Functional restoration involves reintroducing dormant-season, low-severity fire at intervals consistent with the historical condition. Our approach was to quantify the effects of such restoration treatments on soil organic carbon and soil microbial activity, as these are both conservative ecosystem attributes and not ones explicitly targeted by the restoration treatments, themselves. Mechanical treatments are attractive in that they require only single entries; however, we see no indication that mechanical–structural restoration actually produced desired belowground changes. A single fire-based/functional treatment also offered little restoration progress, but comparisons with long-term experimental fire studies suggest that repeated entries with prescribed fire at intervals of 3–8 years offer potential for sustainable restoration.

Practitioners, implementing agencies

Boerner, R.E.J., A.T. Coates, D.A. Yaussy and T.A. Waldrop (2008) Assessing Ecosystem Restoration Alternatives in Eastern Deciduous Forests: The View from Belowground. Restoration Ecology 16(3): 425-434.

http://ddr.nal.usda.gov/dspace/bitstream/10113/20236/1/IND44095501.pdf

Ecological Restoration of Southwestern Ponderosa Pine Forests

The book examines: 1) the overall context for restoration—ecological, social, economic, political, and philosophical, 2) how ecosystem processes such as fire, hydrology, and nutrient cycling are affected by restoration activities, 3) treatment effects on specific ecosystem components such as trees, understory plants, animals, and rare or invasive species, and 4) the details of implementing restoration projects, including smoke management, the protection of cultural resources, and monitoring. Each section is introduced with a case study that demonstrates some of the promise and pitfalls of restoration projects.

Practitioners, implementing agencies

Friederici, P. (ed.) (2003) Ecological Restoration of Southwestern Ponderosa Pine Forests. Island Press, Washington, DC.

http://islandpress.org/ip/books/book/islandpress/E/bo3559713.html

Restoration of Longleaf Pine Ecosystems

Because longleaf pine still exists in numerous small fragments throughout its range, it is reasonable to conclude that it can be restored. Restoration efforts now underway use physical, chemical, and pyric methods to reestablish the natural structure and function in these ecosystems by adjusting species composition, modifying stand structure, and facilitating ecological processes, such as periodic fire and longleaf pine regeneration. The ecological, economic, and social benefits of restoring longleaf pine ecosystems include (1) expanding the habitat available to aid in the recovery of numerous imperiled species, (2) improving habitat quality for many wildlife species, (3) producing greater amounts of high-quality longleaf pine timber products, (4) increasing the production of pine straw, (5) providing new recreational opportunities, (6) preserving natural and cultural legacies, and (7) creating a broader range of management options for future generations.

Implementing agencies, practitioners

Brockway, D.G., K.W. Outcalt, D.J. Tomczak and E.E. Johnson (2005) Restoration of Longleaf Pine Ecosystems. USDA Forest Service Southern Research Station, General Technical Report SRS-83.

http://www.snprsip.com/resources/ecosystem-restoration/Restoration%20of%20Longleaf%20Pine%20Ecosystems%20GTR-83.pdf

The Unknown Trajectory of Forest Restoration: A Call for Ecosystem Monitoring

Restoration of forest ecosystems is a common objective of land managers throughout the western United States. Unfortunately, limited federal funding and a lack of specific enforcement of existing regulations has resulted in a lack of effectiveness monitoring (monitoring that provides information on the successes and impacts of the activity or project) after forest restoration activities on federal lands, thus inhibiting learning about, and improving the success of, restoration efforts. Monitoring could potentially be conducted on limited federal budgets through use of (1) multiparty teams composed of volunteers on a portion of restoration sites, (2) a statistical sampling strategy on a limited set of sites for intensive monitoring by federal monitoring teams, and (3) remote sensing to monitor a select set of variables across a broad portion of the affected landscape.

Implementing agencies, indigenous and local communities

DeLuca, T.H., G. H. Aplet, B. Wilmer and J. Burchfield (2010) The Unknown Trajectory of Forest Restoration: A Call for Ecosystem Monitoring. Journal of Forestry 108(6): 288-295.

http://wilderness.org/files/ecosystem%20monitoring.pdf

Restoring Hawaii's Dry Forests

Here at a region called Kaupulehu, Cabin and fellow biologists and conservationists have begun an important demonstration project for reclaiming Hawaii’s degraded dry forests. The demonstration site is protected from ungulates by a fence. In just a few years of research at the site, the biologists have begun to assemble much-needed information about how degraded forests re- spond to fencing out the enemy and about what other steps may be necessary for restoring the forests.

Implementing agencies, practitioners, indigenous and local communities

Allen, W. (2000) Restoring Hawaii's Dry Forests. BioScience 50(12): 1037-1041

http://www.jstor.org/stable/10.1641/0006-3568(2000)050[1037:RHSDF]2.0.CO;2

The Role of Nurse Trees in Mitigating Fire Effects on Tropical Dry Forest Restoration: A Case Study

The threat of fire is always a consideration when establishing a forest restoration program. Two wildfires occurred in 2006 and 2007 in an established dry forest restoration project in Puerto Rico. The original goal of the project was to determine differential growth responses of native trees under the nurse tree Leucaena leucocephala versus in open sites. In open sites, sprouting was the most common fire response and mature-forest and evergreen species had greater postfire survival than pioneers and deciduous species. Although nurse trees are typically used to help manage nutrient or light environments in reforestation projects, these trees also appear to provide a secondary benefit of limiting fire damage by reducing fuel load.

Implementing agencies, practitioners

Santiago-García, R.J., S.M. Colón, P. Sollins and S.J. Van Bloem (2008) The Role of Nurse Trees in Mitigating Fire Effects on Tropical Dry Forest Restoration: A Case Study. Ambio 37(7-8): 604-608.

http://allenpress.com/pdf/AMBI_37.8_604-608.pdf

Forests/Woodlands>Venzuela

Tropical Dry Forests in Venezuela: Assessing Status, Threats and Future Prospects

The main challenge to future dry forest conservation is a paucity of explicit policies for management and use. However, scientifically-based management can support positive dry forest policies in many ways, including identifying locations and protocols for ecological restoration, maintaining seed banks, quantifying baseline conditions, and monitoring genetic diversity and other indicators.

Policymakers, implementing agencies

Rodríguez, J.P., J.M. Nassar, K.M. Rodríguez-Clark, I. Zager, C.A. Portillo-Quintero, F. Carrasquel and S. Zambrano (2008) Tropical Dry Forests in Venezuela: Assessing Status, Threats and Future Prospects. Environmental Conservation 35: 311-318.

http://journals.cambridge.org/action/displayAbstract?fromPage=online&aid=3751700

Forests/Woodlands>Vietnam

Forest Rehabilitation in Vietnam: Histories, Realities and Future

Future efforts will need better knowledge if they are to increase their impact and cost-efficiency. Previous forest rehabilitation experiences can provide important and valuable lessons for the future. For that reason, this report assesses the experiences of forest rehabilitation in Vietnam and draws strategic lessons from these experiences to guide new forest rehabilitation projects. The report highlights lessons from Vietnam’s experiences that will be helpful beyond the country’s border.

Policymakers, implementing agencies

de Jong, W., D. Dinh Sam and T. Van Hung (2006) Forest rehabilitation in Vietnam: histories, realities and future. Bogor, Indonesia: Center for International Forestry Research (CIFOR).

http://www.cifor.org/publications/pdf_files/Books/BDeJong0601.pdf

Forest Rehabilitation Policy and Practice in Vietnam

The material presented in this report was used to inform the regional overview study, and has been updated and expanded to form the basis of broadening discussions within Vietnam. It is hoped that the material will assist the many interested groups and individuals in Vietnam to develop a greater understanding of the issues of forest degradation and loss, and the urgent need for the development and implementation of ecologically and socio-economically sound forest related policies and practices.

Policymakers, practitioners, implementing agencies

Van San, N. and D. Gilmour (1999) Forest Rehabilitation Policy and Practice in Vietnam. IUCN Regional Co-ordination Office, S &SE Asia.

http://www.mekonginfo.org/assets/midocs/0001632-environment-forest-rehabilitation-policy-and-practice-in-vietnam.pdf

Rehabilitating Degraded Forest Land in Central Vietnam with Mixed Native Species Plantings

This paper examines the use of Acacia as a nurse crop to overcome some of the ecological and economic impediments to reforestation of degraded areas dominated by grasses including Imperata cylindrica. The study site at Hai Van Pass in central Vietnam was initially reforested using Acacia auriculiformis. After 8 years these stands were thinned and under-planted with Hopea odorata, Dipterocarpus alatus, Parashorea chinensis, Tarrietia javanica, Parashorea stellata, Scaphium lychnophorum, Peltophorum dasyrhachis var. tonkinensis and other high-value native species.

Implementing agencies, practitioners, indigenous and local communities

McNamara, S., D. Viet Tinh, P.D. Erskine, D. Lamb, D. Yates and S. Brown (2006) Rehabilitating degraded forest land in central Vietnam with mixed native species plantings. Forest Ecology and Management 233(2-3): 358-365.

http://www.sciencedirect.com/science/article/pii/S0378112706003410

Reforesting “Bare Hills” in Vietnam: Social and Environmental Consequences of the 5 Million Hectare Reforestation Program

In recent years, forestry has been strongly promoted by the government of the Socialist Republic of Vietnam through large-scale projects to rehabilitate and reforest millions of hectares of land. One project to reforest 5 million hectares has received hundreds of millions of US dollars for implementation. Yet based on a case study in one area of northern Vietnam, this project appears to have had a number of unforeseen consequences. Large areas of land classified as "bare hills" have been targeted for reforestation, despite the fact that these lands already harbor a number of species that were used by local communities. The bare hills were especially economically important to poor households and to women who collected a variety of nontimber forest products there. Because the reforestation project focused most efforts on establishing new plantations rather than supporting natural regeneration, diverse sources of nontimber forest products were being replaced with monocrop exotic tree plantations. A strong inequity in the allocation of private lands for reforestation has characterized the regreening projects to date, and this may have continuing unwelcome social, environmental, and economic impacts into the future, particularly for the poor.

Policymakers

McElwee, P. (2009) Reforesting "Bare Hills" in Vietnam: Social and Environmental Consequences of the 5 Million Hectare Reforestation Program. AMBIO: A Journal of the Human Environment 38(6): 325-333.

http://www.bioone.org/doi/abs/10.1579/08-R-520.1

Linking Reforestation Policies with Land Use Change in Northern Vietnam: Why Local Factors Matter

We use the Institutional Analysis and Development (IAD) framework, coupled with an historical perspective and the analysis of actors' perception and dominant narratives on land management and forests. Results show that national policies significantly interfered with local factors, leading to a complex course of decision-making and action. Substantial reforestation in the area was not a response by farmers to policy incentives but rather the unexpected outcome of the disruption of local institutions by these policies. We argue that, because national interventions have relied on false or exaggerated narratives and beliefs, their implementation is in conflict with the local reality in upland areas, leading to unpredictable and locally dependent outcomes. We defend hence the need for local level studies and also recommend considering local institutions for land use change analysis in contexts where land use systems are characterised by a high degree of human interaction.

Policymakers, implementing agencies

Clement, F. and J.M. Amezaga (2008) Linking Reforestation Policies with Land Use Change in Northern Vietnam: Why Local Factors Matter. Geoforum 39: 265-277.

http://www.futurelivestock.net/rudec/uploads/ckeditor/files/Clement_2008(1).pdf

Forests/Woodlands>Mediterranean

Avances en el Estudio de la Gestión del Monte Mediterráneo

Este libro recopila estudios y revisiones de temas candentes en el ámbito de la gestión de montes mediteráneos y su restauración. Se estructura en tres grandes líneas temáticas: 1) el análisis del impacto de los incendios forestales en los ecosistemas, con una revisión de los efectos en los suelos y un estudio profundo de qué plantas se regeneran eficientemente después del fuego y a través de qué mecanismos; 2) la restauración forestal de montes quemados y afectados por procesos de desertificación; 3) gestión forestal sostenible y revalorización de los montes.

Practitioners, implementing agencies, policymakers

Vallejo V.R. and J.A. Alloza (2004) Avances en el Estudio de la Gestión del Monte Mediterráneo. Fundación Centro de Estudios Ambientales del Mediterráneo, Valencia, Spain.

http://www.ceam.es/VentaLibros/libro_forestal/libro_forestal.htm

Cork Oak Woodlands on the Edge: Ecology, Adaptive Management, and Restoration

This book provides a synthesis of the most up-to-date, scientific and practical information on the management of cork oak woodlands and the cultural systems that depend on cork oak. It 1) considers ecological, genetic, economic, and historical perspectives surrounding cork oak trees, cork oak woodlands, and cork-based products, 2) presents scientific information regarding restoration and management, 3) offers a suite of techniques for the practice of restoring cork oak woodlands, 4) presents cost-benefit analyses of cork oak woodlands and the manufacture and trade of cork products, and 5) looks at challenges for the future, including ecoregional planning options, threats posed by climate and land-use changes, and modeling techniques that can help guide decision making.

Implementing agencies, practitioners, policymakers

Aronson, J., J. Pereira and J. Pausas (2009) Cork Oak Woodlands on the Edge: Ecology, Adaptive Management, and Restoration. Island Press, Washington, DC.

http://islandpress.org/ip/books/book/islandpress/C/bo8024988.html

Calidad de Planta Forestal para la Restauración en Ambientes Mediterráneos: Estado Actual de Conocimientos

En los últimos años, un número creciente de investigadores españoles ha dedicado sus esfuerzos al estudio de diversos aspectos de la ecología de brinzales de plantas forestales mediterráneas. Gracias a estos estudios, y a la tenaz dedicación de numerosos profesionales de la agronomía y la viverística, actualmente disponemos de conocimientos básicos sobre la producción de algunas de las especies forestales mediterráneas más comunes. No obstante, cuanto más profundizamos sobre protocolos de producción de planta o sobre las características óptimas que debe reunir un brinzal de calidad, resulta más evidente la dificultad para establecer recetas comunes. Es precisamente a partir de la constatación de estos resultados, a veces contradictorios, y de la voluntad de difundir estos conocimientos más allá del grupo de investigadores directamente involucrados en su obtención, que surge, hace algo más de dos años, el foro de discusión que ha dado lugar a esta publicación.

Practitioners

Cortina, J., J.L. Peñuelas, J. Puértolas, R. Savé and A. Vilagrosa (eds.) (2006) Calidad de Planta Forestal para la Restauración en Ambientes Mediterráneos: Estado Actual de Conocimientos. Organismo Autónomo Parques Nacionales, Ministerio de Medio Ambiente, Madrid.

http://imem.ua.es/es/documentos/archivos-imem/articulos-investigadores/jordi-cortina/cortina-et-al-2006-planta-forestal-book.pdf

Integración de la Restauración Forestal de Zonas Quemadas en la Planificación Forestal

La Fundación CEAM ha desarrollado un programa de investigación forestal orientado hacia la mejora de la gestión en condiciones mediterráneas, con dos líneas básicas de investigación: incendios forestales y restauración forestal. Uno de los objetivos previstos en el programa es facilitar una rápida transferencia de resultados para la mejora de la gestión del monte mediterráneo. En el artículo se expone una breve descripción del programa de investigación y, como ejemplo de aplicación de dicho programa, la metodología desarrollada para la evaluación de la fragilidad de la vegetación frente a los incendios forestales.

Implementing agencies, policymakers

Spanish, English

Alloza, J.A. and R. Vallejo Calzada (2004) Integración de la Restauración Forestal de Zonas Quemadas en la Planificación Forestal. Cuad. Soc. Esp. Cien. For. 17: 13-20.

http://dialnet.unirioja.es/servlet/articulo?codigo=2978414 http://www.springerlink.com/content/ml155q21535r3704/

Dimensionado del Microembalse para la Restauración Forestal en Zonas Áridas

En el proyecto de cualquier repoblación forestal en una zona seca situada en ladera, la economía del agua debe ser una de las principales consideraciones a tener en cuenta. La recolección de una cantidad suficiente de agua para los brinzales en sus primeras etapas de vida resulta decisiva para que el resultado de la repoblación sea exitoso. En este trabajo, se enumeran y desarrollan algunos criterios que sirven para fijar la capacidad del microembalse o alcorque a crear con la preparación del suelo, y que orientan al técnico encargado de la restauración forestal, con el fin de incrementar la supervivencia del repoblado, reduciendo al mismo tiempo la modificación del microrrelieve de la ladera a lo mínimo imprescindible.

Practitioners

Mongil Manso, J. and A. Martínez de Azagra Paredes (2008) Dimensionado del Microembalse para la Restauración Forestal en Zonas Áridas. Cuad. Soc. Esp. Cienc. For. 28: 25-30.

http://www.oasification.com/archivos/C28-Acta02.pdf

Are Pinushalepensis Plantations Useful as a Restoration Tool in Semi-Arid Mediterranean Areas?

In the semiarid areas of the Mediterranean basin, restoration activities during the XXth century have mainly relied on extensive plantations of *Pinushalepensis*, which now cover thousands of hectares. Here we review studies that have evaluated the effects of these plantations on soils, vegetation, faunal communities, and forest fires. Most studies performed so far have shown an overall negative effect of *P. halepensis* plantations on spontaneous vegetation. Our review contributes to the debate on the suitability of mono-specific extensive *P. halepensis* plantations, and suggests that afforestation programmes should be revised.

Implementing agencies, policymakers

Maestre, F.T. and J. Cortina (2004) Are Pinushalepensis Plantations Useful as a Restoration Tool in Semi-Arid Mediterranean Areas? Forest Ecology and Management 198:303-317.

http://80.24.165.149/drupal/sites/default/files/Foreco2004.pdf

Are Pine Plantations Valid Tools for Restoring Mediterranean Forests? An Assessment along Abiotic and Biotic Gradients

The ecological impacts of forest plantations are a focus of intense debate, from studies that consider plantations as “biological deserts” to studies showing positive effects on plant diversity and dynamics. This lack of consensus might be influenced by the scarcity of studies that examine how the ecological characteristics of plantations vary along abiotic and biotic gradients. Here we conducted a large-scale assessment of plant regeneration and diversity in plantations of southern Spain. Tree seedling and sapling density, plant species richness, and Shannon's (H′) diversity index were analyzed in 442 pine plantation plots covering a wide gradient of climatic conditions, stand density, and distance to natural forests that act as seed sources.

Implementing agencies, practitioners

Gómez-Aparicio, L., M.A. Zavala, F.J. Bonet and R. Zamora (2009) Are Pine Plantations Valid Tools for Restoring Mediterranean Forests? An Assessment along Abiotic and Biotic Gradients. Ecological Applications 19(8): 2124-2141

http://www.esajournals.org/doi/abs/10.1890/08-1656.1?journalCode=ecap

Pines and Oaks in the Restoration of Mediterranean Landscapes of Spain: New Perspectives for an Old Practice – A Review

In the present work, the use of pines and hardwoods in forest restoration is discussed in the frame of the current disturbance regime and social demands for Mediterranean forests. Large pine plantations have recently disappeared because of their sensitivity to fire (e.g., Pinus nigra) or because of the short fire-intervals (e.g., Pinus halepensis). Combined pine and oak plantations are proposed for degraded land restoration on the basis of the complementary features of both groups of species. Seeding and containerised seedling plantation, soil amendments and plantation techniques to reduce transplant shock are evaluated for reforestation under water-stressing conditions, on the basis of several experiments performed in eastern Spain. Both P. halepensis and Quercus ilex are tested.

Practitioners, implementing agencies

Pausas, J.G. et al. (2004) Pines and Oaks in the Restoration of Mediterranean Landscapes of Spain: New Perspectives for an Old Practice – A Review. Plant Ecology 171: 209-220.

http://www.uv.es/jgpausas/papers/Pausas2004PlEcol171medpine.pdf

Applying Plant Facilitation to Forest Restoration: A Meta-Analysis of the Use of Shrubs as Nurse Plants

Between 1997 and 2001, we carried out experimental reforestations in the Sierra Nevada Protected Area (southeast Spain) with the aim of comparing the survival and growth of seedlings planted in open areas (the current reforestation technique) with seedlings planted under the canopy of preexisting shrub species. Over 18 000 seedlings of 11 woody species were planted under 16 different nurse shrubs throughout a broad geographical area. We sought to explore variation in the sign and magnitude of interactions along spatial gradients defined by altitude and aspect. In the present work, we report the results of a meta-analysis conducted with seedling survival and growth data for the first summer following planting, the most critical period for reforestation success in Mediterranean areas.

Practitioners, implementing agencies

Gomez-Aparicio, L., R. Zamora, J.M. Gomez, J.A. Hodar, J. Castro and E. Baraza (2004) Applying Plant Facilitation to Forest Restoration: A Meta-Analysis of the Use of Shrubs as Nurse Plants. Ecological Applications 14(4): 1128-1138.

http://www.irnase.csic.es/users/lorena/files/Gomez-Aparicio%20et%20al%202004%20Ec%20Appl.pdf

Post-Fire Management and Restoration of Southern European Forests

The first publication to access in a comprehensive way the post-fire management in fire-prone European forest types. The main questions and recommended approaches can also be useful for other regions of the world with Mediterranean-type climates, such as parts of Australia, South Africa, North and South America. Designed to disseminate scientific knowledge on post-fire management and restoration of forests towards a target audience of professionals (forest managers, landscape planners, and forest agency staff), graduate students and researchers.

Practitioners, implementing agencies

Moreira, F., M. Arianoutsou, P. Corona and J. De las Heras (eds.) (2012) Post-Fire Management and Restoration of Southern European Forests. Springer.

http://www.springer.com/life+sciences/forestry/book/978-94-007-2207-1

Post-fire and Post-quarry Rehabilitation Successions in Mediterranean-like Ecosystems: Implications for Ecological Restoration

Our aims were to describe how the theory of succession after fire relates to rehabilitation and to use this knowledge to improve the results of rehabilitation attempts in Mediterranean-like ecosystems. Eight postfire (PF) sites, 14 post-rehabilitated (PR) quarry sites and two woodland sites were sampled. Detrended Canonical Correspondence Analysis (DCCA) showed that PF and PR successions were quite different. Both displayed an increasing abundance of resprouters over time, but seeder density increased throughout PR succession and decreased during PF succession. Nine species were common to both successions in all studied stages. The results showed that until 15–21 years of succession, the post-rehabilitation sites had not become as resilient to fires as sites populated by indigenous vegetation due to the lack of a seeder seed bank. However, after 21 years of PR succession, the exponentially increasing seeder population may allow for seed bank formation and thus eventually improve the fire resilience of the site.

Implementing agencies, practitioners

Meira-Neto, J.A.A., A. Clemente, G. Oliveira, A. Nunes and O. Correia (2011) Post-fire and Post-quarry Rehabilitation Successions in Mediterranean-like Ecosystems: Implications for Ecological Restoration. Ecological Engineering 37(8): 1132-1139.

http://www.sciencedirect.com/science/article/pii/S0925857411000735

Restoring Quercus pyrenaica Forests Using Pioneer Shrubs as Nurse Plants

How to improve reforestation success of Quercus pyrenaica. The use of shrubs as nurse plants for Q. pyrenaica reforestation is a viable technique to increase establishment success. The technique could be similarly useful in other environments with a dry period and for other Quercus species. In addition, this technique offers the advantage of following natural succession, thus minimizing the impact in the community.

Practitioners, implementing agencies

Castro, J., R. Zamora and J.A. Hódar (2006) Restoring Quercus pyrenaica Forests Using Pioneer Shrubs as Nurse Plants. Applied Vegetation Science 9(1): 137-142.

http://www.ugr.es/~rnm220/ingles/PDF/AppVegSci2006_%209_137-142.pdf

Forests/Woodlands>Temperate

Restoration Concepts for Temperate and Boreal Forests of North America and Western Europe

Throughout the boreal and temperate zones, forest restoration efforts attempt to counteract negative effects of conversion to other land use (afforestation and remediation) and disturbance and stress on existing forests (rehabilitation). Appropriate silvicultural practices can be designed for any forest restoration objective. Most common objectives include timber, wildlife habitat for game species, or aesthetics. Increasingly other objectives are considered, including carbon sequestration, biological diversity, non-game mammals and birds, endangered animals and plants, protection of water quality and aquatic resources, and recreation. Plantation forestry remains the most effective approach to restoration of forest cover to large areas, and recent trends toward more complex plantations are explored. Rehabilitation of degraded forests increasingly relies on re-establishing natural disturbance regimes and emphasizes "close-to-nature" approaches to regeneration and stand management. The objectives of this paper are to clarify concepts of forest restoration and to present examples of restoration activities in temperate and boreal forests of North America and Western Europe.

Implementing agencies, policymakers

Stanturf, J.A. and P. Madsen (2002) Restoration Concepts for Temperate and Boreal Forests of North America and Western Europe. Plant Biosystems 136(2): 143-158.

http://www.tandfonline.com/doi/abs/10.1080/11263500212331351049

Forests/Woodlands>Tropical

Planting Seedlings in Tree Islands versus Plantations as a Large-Scale Tropical Forest Restoration Strategy

Planting tree seedlings in small patches (islands) has been proposed as a method to facilitate forest recovery that is less expensive than planting large areas and better simulates the nucleation process of recovery. Our study highlights the importance of replicating restoration strategies at several sites to make widespread management recommendations.

Implementing agencies, practitioners

Holl, K.D., R.A. Zahawi, R.J. Cole, R. Ostertag and S. Cordell (2011) Planting Seedlings in Tree Islands Versus Plantations as a Large-Scale Tropical Forest Restoration Strategy. Restoration Ecology 19(4): 470-479.

http://www.fs.fed.us/psw/publications/cordell/psw_2010_cordell(holl)002.pdf

Agro-Successional Restoration as a Strategy to Facilitate Tropical Forest Recovery

With the increasing need to restore former agricultural lands worldwide and in the tropics, in particular, it is critical to explore different models for how to restore these lands in a cost-effective manner which best simulates natural forest recovery and provides for human livelihoods. We propose that agro-successional restoration, which we define as incorporating a range of agroecology and agroforestry techniques as a transition phase early in forest restoration, could be used more widely to overcome socioeconomic and ecological obstacles to restoring these lands.

Practitioners, implementing agencies, indigenous and local communities

Vieira, D.L.M., K.D. Holl and F.M. Peneireiro (2009) Agro-Successional Restoration as a Strategy to Facilitate Tropical Forest Recovery. Restoration Ecology 17(4): 451-459.

http://people.ucsc.edu/~kholl/vieira2009.pdf

Patch Size Effects on Avian Foraging Behaviour: Implications for Tropical Forest Restoration Design

As demonstrated in this study, patches of tens to a few hundreds of metres squared are likely to provide fewer food resources and potentially less cover from predators for vertebrates that use woody habitat, compared with patches of a few thousand square metres. The more limited resources in smaller patches are likely to have short-term and, potentially, long-term consequences for the fitness of organisms. When considering restoration project design, the potential economic and other benefits of planting in smaller patches must be weighed with the potentially negative ecological effects on some taxonomic groups. To increase the probability that patches provide adequate habitat for the largest number of species, we recommend that when financial resources are available, patches of at least a few thousand square metres be planted.

Implementing agencies, practitioners

Morrison, E.B., C.A. Lindell, K.D. Holl and R.A. Zahawi (2010) Patch Size Effects on Avian Foraging Behaviour: Implications for Tropical Forest Restoration Design. Journal of Applied Ecology 47: 130-138.

http://people.ucsc.edu/~kholl/Morrisonetal-JAppEcol.pdf

Catalyzing Native Forest Regeneration on Degraded Tropical Lands

The use of tree plantations to catalyze restoration of degraded forests and lands in the tropics was addressed at a symposium in Washington DC in June 1996. The conclusions and suggestions for future research to develop appropriate management options are reported. There is strong evidence that plantations can facilitate forest succession in their understories through modification of both physical and biological site conditions. Changes in light, temperature and moisture at the soil surface enable germination and growth of seeds transported to the site by wildlife and other vectors from adjacent forest remnants. Development and design of management options to assist this process are required, taking into account socio-economic realities, development priorities and conservation goals.

Implementing agencies, practitioners

Parrotta, J.A., J.W. Turnbull and N. Jones (1997) Catalyzing Native Forest Regeneration on Degraded Tropical Lands. Forest Ecology and Management 99(1-2): 1-7.

http://www.fs.fed.us/global/iitf/pubs/catalyzing_native_parrotta_etal.pdf

Listing of ITTO Projects in Tropical Forests

The International Tropical Timber Organization (ITTO), established by the ITTA, is the only international organization specialized in sustainable development of the tropical forests. ITTO includes producer and consumer countries of tropical forest products. Its 58 members, including the European Union, represent together 95 percent of the world trade in tropical timber and 75 percent of the world' s tropical forests. An evaluation of the 14 years collaboration between SECO and ITTO highlighted the constant improvement of ITTO in capacity building and its excellent levels of quality in the management of the project cycle and as a platform between producers and consumers.

Implementing agencies, policymakers

The International Tropical Timber Organization (ITTO) and Swiss State Secretariat for Economic Affairs (SECO)

http://www.tropicalforests.ch/projects.php

International Symposium on Rehabilitation of Tropical Rainforest Ecosystems 2011

Extended Abstracts

Universiti Putra Malaysia and Mitsubishi Corporation

http://www.forr2.upm.edu.my/frp/index.php/international-symposium/extended-abstract

Grasslands/Savannas

The Potential of Soil Amendments for Restoring Severely Disturbed Grasslands

Habitat destruction and land use change are among the anthropogenic influences affecting many ecosystems. After environmental degradation, restoration and reclamation efforts can be hampered by poor physio-chemical soil characteristics and reduced soil community complexity. To enhance degraded system recovery, soil manipulations may be necessary to alleviate habitat destruction. This review will (1) discuss grassland restoration in terms of ecosystem-level processes, and (2) analyze the efficacy of novel and easily applicable amendments (i.e. compost, biochar, and arbuscular mycorrhizal fungi) to facilitate grassland recovery in severely degraded habitats. We suggest that restoration practitioners emphasize soil ecological knowledge and microbial processes in tandem with native plants when restoring damaged ecosystems. This review is intended to guide practitioners in the promotion of grassland ecosystem sustainability.

Practitioners

Ohsowski, B.M., J.N. Klironomos, K.E. Dunfield and M.M. Hart (2012) The Potential of Soil Amendments for Restoring Severely Disturbed Grasslands. Applied Soil Ecology, Early View Online.

http://www.ohsowski-ecology.com/wp-content/uploads/2012/03/Ohsowski-et-al.-2012-The-potential-of-soil-amendments-for-restoring-sev.pdf

Grasslands/Savannas>Africa

An Approach to Tree Thinning to Structure Southern African Savannas for Long-term Restoration from Bush Encroachment

This paper is an attempt to summarize existing knowledge on the importance of woody plants in savanna and explore measures, based on ecosystem dynamics, which can be utilized to restore encroached areas more successfully. It is hypothesized that a more stable environment can be created by maintaining or restoring savanna structure (large trees). In a structured savanna, large trees are able to suppress the establishment of new seedlings, while maintaining the other benefits of woody plants like soil enrichment and the provision of food to browsing herbivore species. Effective restoration of encroached areas should not be considered a once-off event, but rather a long-term commitment.

Practitioners, implementing agencies, indigenous and local communities

Smit, G.N. (2004) An Approach to Tree Thinning to Structure Southern African Savannas for Long-term Restoration from Bush Encroachment. Journal of Environmental Management 71 (2): 179-191.

http://www.sciencedirect.com/science/article/pii/S0301479704000477

Agroecological Restoration of Savanna Ecosystems

Results of experiments which demonstrate that nutrient deficiency in the Sahel savanna is a more serious problem than low rainfall and that nitrogen and phosphorus are the limiting nutrients in many savanna ecosystems are reviewed. The roles played by trees in the savanna such as provision of shade, preservation of water, reduction of susceptibility to erosion and nutrient pump are highlighted and species whose cultivation must be intensified so as to promote sustainability in savanna ecosystems are listed. The principles of agroecological restoration of savanna ecosystems whose focus is on the restoration of ecological balance and which has been successfully practiced in Ghana are highlighted.

Implementing agencies, practitioners, indigenous and local communities

Badejo, M.A. (1998) Agroecological Restoration of Savanna Ecosystems. Ecological Engineering 10(2): 209-219.

http://www.sciencedirect.com/science/article/pii/S0925857498000123

Grasslands/Savannas>Australia

Restoring Ecological Function in Temperate Grassy Woodlands: Manipulating Soil Nutrients, Exotic Annuals and Native Perennial Grasses through Carbon Supplements and Spring Burns

Ecological restoration can be viewed as targeted intervention in species–environment interactions, whereby ecological conditions are manipulated to enhance establishment or vigour of key species, and these species in turn help restore ecological processes that favour the target species composition. In grassy ecosystems re-establishing a perennial sward of appropriate native tussock grasses may be critical for restoring pre-disturbance nitrogen cycles and improving resistance to invasion by exotic annuals. Carbon supplements and spring burns facilitate this process through complementary mechanisms.

Practitioners, implementing agencies

Prober, S.M., K.R. Thiele, I.D. Lunt and T.B. Koen (2005) Restoring Ecological Function in Temperate Grassy Woodlands: Manipulating Soil Nutrients, Exotic Annuals and Native Perennial Grasses through Carbon Supplements and Spring Burns. Journal of Applied Ecology 42: 1073-1085.

http://www.csu.edu.au/herbarium/FullText/Prober%20et%20al%202005%20sugar.pdf

Grasslands/Savannas>Belgium

Rapid Restoration of a Species-rich Ecosystem Assessed from Soil and Vegetation Indicators: The Case of Calcareous Grasslands Restored from Forest Stands

Calcareous grasslands have long been recognized as biodiversity hotspots in Europe. However, in recent decades these ecosystems have seen rapid decline. In Belgium, more than 100 ha of calcareous grasslands have been restored from oak coppices and pine forests since the 1990s. The aim of the present study was to provide a quantitative assessment of the success of these restoration efforts, using two sets of indicators: one related to soil conditions, the other related to vascular plant communities. Soil conditions were evaluated by comparing soil samples from pre-restoration forest stands, restored grasslands (3-age classes: 2–4 years; 5–8 years, and 10–15 years) and reference grasslands.

Practitioners, implementing agencies

Piqueray, J., G. Bottin, L.M. Delescaille, E. Bisteau, G. Colinet and G. Mahy (2011) Rapid Restoration of a Species-rich Ecosystem Assessed from Soil and Vegetation Indicators: The Case of Calcareous Grasslands Restored from Forest Stands. Ecological Indicators 11(2): 724-733.

http://www.sciencedirect.com/science/article/pii/S1470160X10001111

Vegetation and Seed Bank in a Calcareous Grassland Restored from a Pinus Forest

What is the importance of the seed bank in the maintenance of the restoration potential of a 60-year-old abandoned calcareous grassland overgrown by Pinus trees? Very few calcareous grassland species have persisted in the Pinus stand. Four years after clear-cutting, the stand was nearing restoration towards a calcareous grassland. Seed longevity in the soil was not the most explicative factor. Dispersal of propugules from adjacent sources was also important

Practitioners, implementing agencies

Bisteau. E. and G. Mahy (2005) Vegetation and Seed Bank in a Calcareous Grassland Restored from a Pinus Forest. Applied Vegetation Science 8(2): 167-174.

http://onlinelibrary.wiley.com/doi/10.1111/j.1654-109X.2005.tb00642.x/abstract

Grasslands/Savannas>Canada

Semiarid Old-Field Restoration: Is Neighbor Control Needed?

Restoration practice suggests that neighbor control is essential in semiarid grasslands, but ecological theory predicts that neighbor effects are relatively small in young fields. We investigated the effectiveness of neighbor control (mowing and herbicide) for establishing native grasses in a recently abandoned field in southwestern Saskatchewan, Canada. We also examined its interactions with common restoration techniques, such as mulching (straw and sawdust) and contrasting sowing methods (drilling, and broadcasting cleaned seeds, cleaning remainders, and native hay). Our results suggest that restorations of semiarid old fields should focus less on neighbor control and more on strategies for exploiting suitable years for germination, either by monitoring soil moisture or through repeated seeding.

Practitioners

Wilson, S.D., J.D. Bakker, J.M. Christian, X. Li, L.G.Ambrose and J. Waddington (2004) Semiarid Old-Field Restoration: Is Neighbor Control Needed? Ecological Applications 14(2): 476-484.

http://library.eri.nau.edu/gsdl/collect/erilibra/index/assoc/hash2b7f.dir/doc.pdf

Grasslands/Savannas>China

Grassland Degradation in China: Methods of Monitoring, Management and Restoration

Several technologies for grassland diagnosis have been developed to arrest grassland deterioration. Indicator plant species have been determined according to grassland types. Relations of grazing pressure and species distribution have been quantified. Several measures for restoration of degraded grasslands are proposed as the next step of development in this field, including agro-ecological measures. A promising tool for grassland monitoring is the use of remote sensing in conjunction with geographic information systems. Accurate and real-time monitoring and management of grasslands have become increasingly feasible through sensor improvement in satellite and geographic information systems generalization in recent years.

Implementing agencies

Akiyama, T. and K. Kawamura (2007) Grassland Degradation in China: Methods of Monitoring, Management and Restoration. Grassland Science 53: 1-17.

http://www.aseanbiodiversity.info/Abstract/51009791.pdf

Restoration and Management of the Inner Mongolia Grassland Require a Sustainable Strategy

Inner Mongolia covers an area of 1.1 million km2 and has a population of 20.3 million. Recent surveys have shown that nearly 90% of the grasslands now are degraded to varying degrees, which is more than twice as much as was estimated 10 years ago (3). On average, current grassland primary productivity is only about 50% of that of the undegraded steppe. The land degradation in this region is generally believed to be a major reason for the increasing frequency of severe sandstorms and dust storms in northern China (particularly in Beijing and adjacent regions) in recent decades (4, 5). Because the environmental and economic future of the Inner Mongolia grassland is at stake, scientifically sound ecosystem management strategies are urgently needed for the sustainability of this region.

Policymakers, implementing agencies

Jiang, G., X. Han and J. Wu (2006) Restoration and Management of the Inner Mongolia Grassland Require a Sustainable Strategy. Ambio 35(5): 269-270.

http://leml.asu.edu/jingle/web_pages/wu_pubs/pdf_files/jiang_etal-2006.pdf

Phytomass and Plant Functional Diversity in Early Restoration of the Degraded, Semi-arid Grasslands in Northern China

We analysed vegetation data recorded in the degraded lowland grasslands in Otindag Sandland during the first 4-years of restoration (2001–2004) to investigate: (1) the contribution of individual plant functional type (PFT) to PFT diversity of community and (2) the relationships between primary productivity and biodiversity both at species and PFT levels. Sixteen PFTs were distinguished based on the following traits: (1) life-span (annual vs. perennial); (2) photosynthetic pathway (C3 vs. C4); (3) reproductive mode (clonal vs. non-clonal); and (4) growth form (grass vs. forb). Analysis of data indicates that density, coverage, number of species, phytomass, and relative importance of PFTs depended strongly on life-span, photosynthetic pathway, reproductive mode and growth form. Phytomass was significantly correlated with PFT diversity, but not species diversity. However, the relationship between phytomass and PFT diversity varied greatly with year, with a positive relationship in 2001 and 2004 and a negative one in 2002 and 2003. As the restoration proceeds, the perennial C3 clonal grass became the greatest contributor to PFT diversity.

Practitioners

Chu, Y., W.-M. He, H.-D. Liu, J. Liu, X.-W. Zhu and M. Dong (2006) Phytomass and Plant Functional Diversity in Early Restoration of the Degraded, Semi-arid Grasslands in Northern China. Journal of Arid Environments 67(4): 678–687.

http://www.sciencedirect.com/science/article/pii/S0140196306000930

Grassland Degradation and Our Strategies: A Case from Shanxi Province, China

This paper analyzes the present state of grassland degradation and its management strategies for the future, using Shanxi Province as an example.

Policymakers

Zhang, J.T. (2006) Grassland Degradation and Our Strategies: A Case from Shanxi Province, China. Rangelands 28(1): 37-43.

http://www.bioone.org/doi/abs/10.2111/1551-501X(2006)28.1%5B37:GDAOSA%5D2.0.CO%3B2

Grasslands/Savannas>Europe

Grassland Restoration to Conserve Landscape-level Biodiversity: A Synthesis of Early Results from a Large-Scale Project

Grassland restoration was generally successful in accelerating secondary succession towards alkali steppes and loess grasslands. However, further management is necessary to counter the homogenizing effects of litter accumulation, to reduce perennial weeds and to enhance the colonization of target species. Our project provides useful practical insights into grassland restoration and in applying restoration at a number of sites within a larger area to conserve biodiversity at the landscape scale.

Practitioners, implementing agencies

Lengyel, S. et al. (2012) Grassland Restoration to Conserve Landscape-level Biodiversity: A Synthesis of Early Results from a Large-Scale Project. Applied Vegetation Science, Early View Online.

http://ecology.science.unideb.hu/ConsEcolGroup/Pdf/Lengyel%20et%20al%20%28EPuGrlRest_EarlySynth%29_online.pdf

Grassland Restoration on Former Croplands in Europe: An Assessment of Applicability of Techniques and Costs

Grasslands used to be vital landscape elements throughout Europe. Nowadays, the area of grasslands is dramatically reduced, especially in industrial countries. Grassland restoration is widely applied to increase the naturalness of the landscape and preserve biodiversity. We reviewed the most frequently used restoration techniques (spontaneous succession, sowing seed mixtures, transfer of plant material, topsoil removal and transfer)and techniques used to improve species richness (planting, grazing and mowing) to recover natural-like grasslands from ex-arable lands. We focus on the usefulness of methods in restoring biodiversity, their practical feasibility and costs.

Practitioners, implementing agencies

Török, P., E. Vid, B. Deák, S. Lengyel and B. Tóthmérész (2011) Grassland Restoration on Former Croplands in Europe: An Assessment of Applicability of Techniques and Costs. Biodiversity and Conservation 20(11): 2311-2332.

http://ecology.science.unideb.hu/ConsEcolGroup/Pdf/Torok%20et%20al%202011%20%28GrasslRestMethods_Review%29.pdf

Do Restored Calcareous Grasslands on Former Arable Fields Resemble Ancient Targets? The Effect of Time, Methods and Environment on Outcomes

A great deal of money is being invested in calcareous grassland restoration on arable land within agri-environment schemes in the European Union. There is, however, little evidence that the target ecosystem can be obtained from the restoration techniques and management practices currently used. We evaluated these techniques using a multi-site approach in order to improve the success of future restoration efforts. We recommend selecting restoration sites with low phosphorous concentrations that adjoin patches of ancient calcareous grassland. Seed mixes should be devised carefully to prevent the assembly of low-value, competitive, stable communities dominated by grasses; natural regeneration may avoid this, but will only be effective close to sources of propagules. Other methods of restoration or habitat management would undoubtedly benefit from similar multi-site evaluation.

Implementing agencies, practitioners

Fagan, K.C., R.F. Pywell, J.M. Bullock and R.H. Marrs (2008) Do restored calcareous grasslands on former arable fields resemble ancient targets? The effect of time, methods and environment on outcomes. Journal of Applied Ecology 45: 1293-1303.

http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2664.2008.01492.x/pdf

Long-term Experimental Restoration in a Calcareous Grassland: Identifying the Most Effective Restoration Strategies

Calcareous grasslands are among the most diverse habitats, supporting species-rich vegetation. Propagule limitation and availability of microsites for germination represent major constraints to the successful restoration of these grasslands. To date, little information is available on the effectiveness of seed addition and soil disturbance on the restoration success of encroached semi-natural calcareous grasslands. Here, we conducted a 1 year before – 9 year after control-impact (BACI) study aimed at testing the effect of the addition of seeds of native species and livestock grazing on calcareous grasslands. Each restoration measure and their combination differed in their impact on these communities and varied over time. Grazing had a significant, beneficial, impact on these communities, although the impact was species-specific.

Practitioners, implementing agencies

Maccherini, S. and E. Santi (2012) Long-term Experimental Restoration in a Calcareous Grassland: Identifying the Most Effective Restoration Strategies. Biological Conservation 146(1): 123-135.

http://www.sciencedirect.com/science/article/pii/S0006320711004617

Facets of Grassland Restoration: Selected Papers from the International Field Seminar held at the Galichya Gora Nature Reserve (Russia)

This book is an offspring of "The Open Country," a project started in 1999 with the Biodiversity Conservation Center that was intended to help develop an ongoing international forum on the problems of grassland conservation and restoration. The seminar was held from 16 to 22 June 2003, bringing together over 30 participants, including the reserve personnel and guests from 8 countries. During these days, each guest was asked to give a paper about her or his experiences in grassland restoration.

Practitioners, implementing agencies

Struchkov, A. and J. Kuleshova (2005) Facets of Grassland Restoration: Selected Papers from the International Field Seminar held at the Galichya Gora Nature Reserve (Russia). Biodiversity Conservation Center, Moscow.

http://theopencountry.org/files/facets2005.pdf

LIFE and Europe's Grasslands: Restoring a Forgotten Habitat

Grassland ecosystems hold an important part of Europe's biodiversity. They offer ideal conditions for a vast diversity of habitats and species, are the source of a wide range of public goods and services, and also act as carbon 'sinks'. Changes in agricultural practices and land use pressures mean that grasslands are disappearing at an alarming rate. This brochure highlights a selection of LIFE co-funded projects targeting grassland ecosystems within the Natura 2000 network.

Policymakers

Silva, J.P., J. Toland, W. Jones, J. Eldridge, E. Thorpe and E. O'Hara (2008) LIFE and Europe's grasslands: Restoring a forgotten habitat. European Commission, Environment Directorate-General.

http://ec.europa.eu/environment/life/publications/lifepublications/lifefocus/documents/grassland.pdf

Soil Microbial Community, Fertility, Vegetation and Diversity as Targets in the Restoration Management of a Meadow Grassland

The enhancement of biodiversity in meadow grassland is a long-term (> 10-year) secondary succession, most rapidly achieved in the absence of mineral fertilizer by cutting for hay in mid-July and autumn grazing with cattle. The sowing of key functional species, i.e. legumes and Rhinanthus minor, was important in facilitating the staged colonization of other sown species.

Practitioners

Smith, R.S., R.S. Shiel, R.D. Bardgett, D. Millward, P. Corkhill, G. Rolph, P.J. Hobbs and S. Peacock (2003) Soil microbial community, fertility, vegetation and diversity as targets in the restoration management of a meadow grassland. Journal of Applied Ecology 40: 51-64.

http://onlinelibrary.wiley.com/doi/10.1046/j.1365-2664.2003.00780.x/pdf

The Potential of Soil Seedbanks in the Ecological Restoration of Grasslands and Heathland Communities

This study aimed at evaluating the potential role of persistent soil seedbanks in restoring grassland and heathland communities in sites that have been afforested or are currently cultivated. To do so, we used the results of 16 case studies and an analysis of the database of Thompson et al. (1997). Generally, there is a decrease in total seed density with increasing age since abandonment or transformation. This decline is much faster for species of calcareous or alluvial grasslands than for heathland and grassheath species. During succession, seeds of target species disappear from the seedbank, owing to seed senescence.

Implementing agencies, practitioners

Bossuyt, B. and M. Hermy (2003) The Potential of Soil Seedbanks in the Ecological Restoration of Grasslands and Heathland Communities. Belg. Journ. Bot. 136(1): 23-34.

http://www.globalrestorationnetwork.org/uploads/files/LiteratureAttachments/331_the-potential-of-soil-seedbanks-in-the-ecological-resotration-of-grassland-and-heathland-communities.pdf

Heathland Restoration Techniques: Ecological Consequences for Plant-Soil and Plant-Animal Interactions

We compare the soil and plant community development during heathland restoration on improved farmland when achieved through soil stripping with that achieved through soil acidification. We also test the potential for toxic metals to be made more available to plant and animal species as a result of these treatments. Acidification with elemental sulphur was found to be more effective than soil stripping for establishing an ericaceous sward despite the high levels of phosphate still present within the soil. However, both soil acidification and soil stripping were found to have the potential to increase the availability of potentially toxic metals. Acidification increased uptake of both aluminium and zinc in two common plant species Agrostis capillaris and Rumex acetosella and decreased the abundance of surface active spiders. The potential consequences for composition of restored heathland communities and for functioning of food chains are discussed.

Practitioners

Diaz, A., I. Green and D. Evans (2011) Heathland Restoration Techniques: Ecological Consequences for Plant-Soil and Plant-Animal Interactions. ISRN Ecology Volume 2011.

http://downloads.isrn.com/journals/ecology/2011/961807.pdf

Grasslands/Savannas>Finland

Use of Sheep Grazing in the Restoration of Semi-natural Meadows in Northern Finland

The biodiversity of species-rich semi-natural meadows is declining across Europe due to ceased management. In this study we aimed to find out how successfully the local species richness of an overgrown semi-natural mesic meadow could be restored by sheep grazing after a long period of abandonment. The cover of vascular plant species in grazed plots and ungrazed exclosures was studied for five years and the responses of different functional plant groups were followed (herbs vs grasses, tall vs short species, species differing in flowering time, species representing different Grime's CSR strategies and species indicative of rich vs poor soil). We suggest that to succeed in restoration it is useful to determine the responses of different functional plant groups to grazing. Grassland managers need this information to optimize the methods and timing of management used in restoration. Additional management practices, such as mowing, may be needed in mesic meadows to decrease the dominance of tall species. The availability of propagules seemed to restrict further increase of species richness in our study area.

Implementing agencies, practitioners

Hellström, K., A.P. Huhta, P. Rautio, J. Tuomi, J. Oksanen and K. Laine (2003) Use of sheep grazing in the restoration of semi-natural meadows in northern Finland. Applied Vegetation Science 6: 45-52.

http://onlinelibrary.wiley.com/doi/10.1111/j.1654-109X.2003.tb00563.x/abstract

Grasslands/Savannas>France

Restoration and Rehabilitation of Species-Rich Grassland Ecosystems in France: a Review

Some variations are presented of a general model of restoration and rehabilitation: (1) rejuvenation of fallow land by grazing with rustic animal breeds in wetlands or chalk grasslands in south and northwestern France, (2) restoration by recovery of extensive agricultural management in intensive agricultural areas such as the Rhône or Meuse Valleys, and (3) rehabilitation by appropriate ecological engineering carried out in grasslands degraded by intensification, ski-track, or civil engineering installations. Despite some positive results, these undertakings have not always had the expected effects and therefore should not provide alibis for the destruction of natural grasslands. In general, the success of such undertakings depends on the maintenance in the surrounding areas of protected seed source reservoirs and on the persistence of a diversified landscape pattern permitting connectivity between these seed sources and the restoration or rehabilitation sites.

Practitioners, implementing agencies

Muller, S., T. Dutoit, D. Alard and F. Grévilliot (1998) Restoration and Rehabilitation of Species-Rich Grassland Ecosystems in France: a Review. Restoration Ecology 6(1): 94-101.

http://www.imep-cnrs.com/Dutoit/articles/articles%20internationaux/1998/Muller%20et%20al.,%201998%20Restor%20Ecol.%206,%2094-101.pdf

Grasslands/Savannas>Netherlands

Problems, Approaches, and Results in Restoration of Dutch Calcareous Grassland during the Last 30 Years

Chalk grassland completely lost its significance for modern agricultural production after the wide application of artificial fertilizer following World War II. This grassland has a high conservation value both for plants and animal species, of which a large number of species are exclusively restricted to this biotope. When conservation activities started at a large scale in the early 1960s, three different types of restoration activities could be distinguished: (1) restoration of fertilized sites; (2) restoration of abandoned grasslands; and (3) recreation of chalk grassland on former arable fields. The main aim of the restoration attempt is to create and/or improve sustainable conditions for both plant and animal species characteristic of the chalk grassland ecosystem.

Policymakers, implementing agencies

Willems, J.H. (2001) Problems, Approaches, and Results in Restoration of Dutch Calcareous Grassland during the Last 30 Years. Restoration Ecology 9(2): 147-154.

http://www.biol.uw.edu.pl/pl/files/docs/st_dokt/SD_SCB_Restoration_%20of_Dutch_Calcareous_Grasslands.pdf

Restoration of Species-rich Grasslands on Ex-arable Land: Seed Addition Outweighs Soil Fertility Reduction

In a three-year field experiment with ex-arable soil with intensive farming history, we tested single and combined effects of soil fertility reduction and sowing mid-successional plant species on plant community development and soil biological properties. A controlled microcosm study was performed to test short-term effects of soil fertility reduction measures on biomass production of mid-successional species.

Practitioners, implementing agencies

Kardol, P., A. Van der Walc, T.M. Bezemer, W. de Boera, H. Duytsa, R. Holtkampe and W.H. Van der Puttena (2008) Restoration of Species-rich Grasslands on Ex-arable Land: Seed Addition Outweighs Soil Fertility Reduction. Biological Conservation 141: 2208-2217.

http://www.esd.ornl.gov/~5pz/Kardol%20et%20al.,%202008%20-%20Biol%20Cons.pdf

Long-term After-effects of Fertilisation on the Restoration of Calcareous Grasslands

What are the long-term implications of former fertilisation for the ecological restoration of calcareous grasslands? The effect of artificial fertiliser with a large amount of nitrogen disappears in less than ten years when mown in August, including removal of the hay. This is a promising result for restoration of N-enriched calcareous grasslands, as the applied dose of nitrogen in this experiment largely exceeds the extra input of nitrogen via atmospheric deposition. Application of fertiliser with a large amount of phosphorus, however, has effects even more than 25 years after the last addition. There are no prospects that this effect will become reduced in the near future under the current mowing management.

Implementing agencies, practitioners

Smits, N., J. Willems and R. Bobbink (2008) Long-term after-effects of fertilisation on the restoration of calcareous grasslands. Applied Vegetation Science 11: 279-286.

http://www.b-ware.eu/content/project/publicaties/Smits-Applied-Vegetation-Science-2008.pdf

Grasslands/Savannas>Norway

Germinable Soil Seed Banks in Abandoned Grasslands in Central and Western Norway and their Significance for Restoration

There was a separation of the two regions along the first DCA axis in both the seed bank and in the vegetation analysis and also a clear separation of the seed bank from the vegetation along the second axis. These results are caused by differences in former management as well as temperature, precipitation and soil type between Gaular and Orkdal. We found more annuals, short-lived species and species demanding light open conditions in the seed bank than in the vegetation probably because these species have the capacity for producing persistent seeds.

Most of the species found only in the seed bank were found in very few samples and with few individuals. These results suggest that it may be difficult to increase vegetation biodiversity through restoration of grasslands such as those investigated if the natural soil seed bank is the main seed source.

Practitioners, implementing agencies

Rosef, L. (2008) Germinable soil seed banks in abandoned grasslands in central and western Norway and their significance for restoration. Applied Vegetation Science 11: 223-230.

http://onlinelibrary.wiley.com/doi/10.3170/2008-7-18361/abstract

Grasslands/Savannas>South Africa

Grassland Restoration after Afforestation: No Direction Home?

The coastal grasslands in north-eastern South Africa are a severely threatened vegetation type rich in plant species, particularly forbs. Many of the forbs have underground storage organs which allow them to resprout rapidly after fires. A significant portion of this land was placed under commercial pine afforestation in the 1950s. The pine plantations have since been removed starting 17 years ago and restored to grasslands within a conservation area. Our results indicate that current methods for restoring these grasslands are inadequate and that restoring grasslands may be a lot harder than previously thought. Considerable effort should be made in conserving what is left of natural grasslands.

Practitioners, implementing agencies

Zaloumis, N.P. and W.J. Bond (2011) Grassland restoration after afforestation: No direction home? Austral Ecology 36: 357-366.

http://onlinelibrary.wiley.com/doi/10.1111/j.1442-9993.2010.02158.x/abstract

Grasslands/Savannas>UK

Lowland Heaths: Ecology, History, Restoration and Management

This publication, which draws together the final threads of the conference, represents the emergence of a new and positive era for lowland heaths across a much wider landscape than hitherto has been the case. In discussions on climate change and carbon sequestration, on flood and drought and positive water management, on rural economic renaissance and tourism, on post-industrial restoration and urban commons, and in terms of nature conservation and biodiversity, these are rich landscapes with much to offer.

Practitioners, implementing agencies, policymakers, indigenous and local communities

Rotherham, I.D. and J. Bradley (eds.) (2009) Lowland Heaths: Ecology, History, Restoration and Management. Journal of Practical Ecology and Conservation Special Series No. 5, Wildtrack Publishing, Sheffield.

http://www.ukeconet.co.uk/images/stories/heathlands_proceedings.pdf

Arable Reversion to Species-Rich Grassland

The reversion of arable land to permanent grassland is a major work area funded through Environmental Stewardship. There are a number of reasons why arable land is reverted to grassland. This note focuses on the creation of species-rich grassland, that is, grassland comprising species characteristic of semi-natural grassland communities, in particular wild flowers. Other notes provide guidance on establishing a species-rich sown sward and the early management of a species-rich sward.

Practitioners, indigenous and local communities

Natural England Technical Information Notes (2010)

http://publications.naturalengland.org.uk/publication/34010

http://publications.naturalengland.org.uk/publication/33012

Plant Traits as Predictors of Performance in Ecological Restoration

This study has important implications for practical restoration programmes and policies. Efficiency might be increased by introducing only species with good performance, but this would lead to uniformity among restored grasslands and would diminish the benefits of habitat restoration for national and regional biodiversity. Future work should focus on practical methods to increase the successful establishment of the poor performing but desirable species, by (i) targeting restoration to low fertility soils, (ii) changing the abiotic environment or (iii) the 'phased introduction' of species several years after restoration, when both the plant community is more stable and the environmental conditions are more favourable for establishment.

Practitioners, implementing agencies

Pywell, R.F., J.M. Bullock, D.B. Roy, L. Warman, K.J. Walker and P. Rothery (2003) Plant Traits as Predictors of Performance in Ecological Restoration. Journal of Applied Ecology 40: 65-77.

http://onlinelibrary.wiley.com/doi/10.1046/j.1365-2664.2003.00762.x/pdf

Rhinanthus: A Tool for Restoring Diverse Grassland?

The restoration of species-rich grasslands is often hindered by high residual soil fertility as a result of, e.g., intensive farming. The establishment of a diverse range of target species on such sites requires the reduction of soil fertility or of the vigour of competitive plants. Current methods to achieve these aims are often unsuccessful or complicated and expensive. It has been suggested that Rhinanthus species could be used to decrease the growth of competitive plants and enhance species diversity. We give suggestions for further research, including: the range of species-poor grasslands into which Rhinanthus can be introduced successfully and which Rhinanthus species should be used; the mechanisms by which Rhinanthus enhances diversity in restored grasslands; whether the ecotype or subspecies of Rhinanthus used affects restoration success; how management methods affect population growth and spread of Rhinanthus; and whether other parasitic plants could be used in habitat restoration.

Practitioners, implementing agencies

Bullock, J.M. and R.F. Pywell (2005) Rhinanthus: A Tool for Restoring Diverse Grassland? Folia Geobotanica 40(2-3): 273-288.

http://www.springerlink.com/content/51wh127751258576/

Grasslands/Savannas>USA

Dominant Grasses Suppress Local Diversity in Restored Tallgrass Prairie

Mesic grasslands worldwide have been degraded by conversion to agriculture, altered disturbance regimes, fragmentation, improper grazing by domestic livestock, and exotic species invasion. Many efforts to restore productive, mesic grasslands such as North American tallgrass prairie have been plagued by relatively low initial species diversity, which decreases further over time. As a result, it has been difficult to achieve a level of species diversity in these restored grasslands, that is, characteristic of their native because a few warm-season (C4) grass species become excessively dominant shortly after establishment Understanding the ecological processes and management practices that promote dominance of the warm-season grasses and loss of subordinate species will be critical for achieving the high species diversity characteristic of native tallgrass prairie in restored grasslands. In addition, gaining knowledge of how plant communities respond to changes in abundance of dominant species will aid in understanding the role of dominance in structuring communities and predicting how restored communities will respond to management practices that alter abundance of the dominant species in restored grasslands.

Practitioners, implementing agencies

McCain, K.N.S., S.G. Baer, J.M. Blair and G.W.T. Wilson (2010) Dominant Grasses Suppress Local Diversity in Restored Tallgrass Prairie. Restoration Ecology 18(s1): 40-49.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2010.00669.x/abstract

California Grassland Restoration

Restoration of California grasslands, once thought to be nearly impossible (Sampson et al. 1951; Heady 1988) is now under way at many sites, although usually with less ambitious goals than the complete eradication of exotics or complete ecological restoration as defined above. Restoration offers the hope of creating a landscape that is more weed-resistant, maintains its productivity over time and other ecosystem services, and is somewhat tolerant or resilient to a variety of stresses. A broad continuum of effort exists from small-scale landscaping and creation of prairie gardens, to landscape architecture projects focused on native grasses, to larger scale reclamation and full "ecological restoration" as defined above.

Practitioners, implementing agencies

Stromberg, M., C.M. D'Antonio, T.P. Young and J. Wirka (2007) California Grassland Restoration. Pp. 254-280 in: Stromberg, M., J.D. Corbin, and C.M. D'Antonio (eds). Ecology and Management of California Grasslands. University of California Press, Berkeley.

http://tpyoung.ucdavis.edu/publications/2007Stromberg.pdf

Ecology and Restoration of California Grasslands with Special Emphasis on the Influence of Fire and Grazing on Native Grassland Species

This paper presents an up-to-date evaluation of the impacts of grazing and fire on the composition of grasslands in California with specific emphasis on their effects on the remaining populations of native forbs and perennial grasses. We intend that the findings will help to refine the scope of potential management regimes that might be applied to California rangeland systems to enhance the richness and abundance of native grassland species. The review is also intended to help identify gaps in our understanding of the interaction of management practices with climatic and soil variability and to help direct future experimental work in this area.

Implementing agencies, practitioners

D'Antonio, C.M., S.J. Bainbridge, C. Kennedy, J.W. Bartolome and S. Reynolds (2004) Ecology and restoration of California grasslands with special emphasis on the influence of fire and grazing on native grassland species. White Paper, Department of Integrative Biology, University of California, Berkeley.

http://www.cnga.org/library/DAntonioGrassReviewArticle.pdf

Compensation and the Stability of Restored Grassland Communities

In a large-scale experimental restoration of a California grassland community, aggregated abundance of restored grasses was more stable than were the individual species in response to disturbance, drought, and succession. Compensatory dynamics among the restored grass flora increased aggregate stability in response to natural and anthropogenic disturbances. Successful restorations must persist in the face of altered management and disturbance regimes, climactic variability, and over the course of succession. Incorporation of diversity‑stability relationships into restoration plans will likely increase restoration success. This case study further demonstrates the relevance of community ecology theory to restoration ecology.

Practitioners, implementing agencies

Seabloom, E.W. (2007) Compensation and the Stability of Restored Grassland Communities. Ecological Applications 17(7): 1876-1885.

http://www.tc.umn.edu/~seabloom/publications_files/seabloom-2007-ecap.pdf

Restoration of Prairie Community Structure and Ecosystem Function in an Abandoned Hayfield: A Sowing Experiment

Using a multispecies seed sowing experiment, we investigated the roles of seed and microsite limitation in constraining the restoration of native prairie diversity and ecosystem function in an abandoned upland hayfield in northeastern Kansas. Our findings reveal the importance of seed limitations in constraining the natural recovery of prairie vegetation, biodiversity, and ecosystem functioning in this grassland and confirm broadcast sowing as a useful tool for the restoration of upland hayfield sites.

Practitioners

Foster, B.L., C.A. Murphy, K.R. Keller, T.A. Aschenbach, E.J. Questad and K. Kindscher (2007) Restoration of Prairie Community Structure and Ecosystem Function in an Abandoned Hayfield: A Sowing Experiment. Restoration Ecology 15(4): 652-661.

http://web.ku.edu/~kindscher/wp-content/uploads/2010/10/Kindscher-Foster-Murphy-2007-Restoration.pdf

Inoculation with a Native Soil Community Advances Succession in a Grassland Restoration

Restoration on post-agricultural land may be hindered by the degradation of the soil community, which has been shown to contribute to structuring plant communities and driving succession. Our experiment tested the effect of inoculation with remnant grassland whole soil with or without nurse plants on the survival and growth of uninoculated early and late successional plant species. In 2007 and 2008, we planted uninoculated early, mid, and late successional plant species 0.25–2 m away from a central point of inoculated nurse plants. We found a negative response to inoculation on early successional plants and a positive response to inoculation on mid to late successional plants. This work suggests that the restoration of the soil community is critical to establishing a late successional plant community and that the benefit of inoculated plants can spread to neighbors.

Practitioners, implementing agencies

Middleton, E.L. and J.D. Bever (2012) Inoculation with a Native Soil Community Advances Succession in a Grassland Restoration. Restoration Ecology 20: 218-226.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2010.00752.x/abstract

Contingency of Grassland Restoration on Year, Site, Competition from Introduced Grasses

Semiarid ecosystems such as grasslands are characterized by high temporal variability in abiotic factors, which has led to suggestions that management actions may be more effective in some years than others. Here we examine this hypothesis in the context of grassland restoration, which faces two major obstacles: the contingency of native grass establishment on unpredictable precipitation, and competition from introduced species. We established replicated restoration experiments over three years at two sites in the northern Great Plains in order to examine the extent to which the success of several restoration strategies varied between sites and among years. We worked in 50-yr-old stands of crested wheatgrass (Agropyron cristatum), an introduced perennial grass that has been planted on >$10x10^6$ ha in western North America.

Practitioners, implementing agencies

Bakker, J.D., S.D. Wilson, J.M. Christian, X. Li, L.G.Ambrose and J. Waddington (2003) Contingency of Grassland Restoration on Year, Site, Competition from Introduced Grasses. Ecological Applications 13(1): 137-153.

http://faculty.washington.edu/jbakker/publications/Bakker_et_al_2003.pdf

Soil Carbon Addition Controls Weeds and Facilitates Prairie Restoration

Soil nitrogen enrichment and consequent vigorous weed growth are thought to hinder the restoration of tallgrass prairie. Adding carbon to the soil may facilitate prairie restoration by inducing immobilization of plant-available nitrogen. Early attempts to use this method, however, have had mixed results. Success of C addition depends on three conditions: weeds must suppress prairie species in the absence of C addition, weeds must be nitrophilic relative to prairie species, and C addition must result in a large enough decrease in N to alter the balance of competition among weeds and prairie species.

Practitioners

Blumenthal, D.M., N.R. Jordan and M.P. Russelle (2003) Soil Carbon Addition Controls Weeds and Facilitates Prairie Restoration. Ecological Applications 13(3): 605-615.

http://ddr.nal.usda.gov/bitstream/10113/48751/1/IND44515414.pdf

Effects of Hay Management and Native Species Sowing on Grassland Community Structure, Biomass, and Restoration

Prairie hay meadows are important reservoirs of grassland biodiversity in the tallgrass prairie regions of the central United States and are the object of increasing attention for conservation and restoration. In addition, there is growing interest in the potential use of such low-input, high-diversity (LIHD) native grasslands for biofuel production. The uplands of eastern Kansas, USA, which prior to European settlement were dominated by tallgrass prairie, are currently utilized for intensive agriculture or exist in a state of abandonment from agriculture. The dominant grasslands in the region are currently high-input, low-diversity (HILD) hay fields seeded to introduced C3 hay grasses. Our results support the shifting limitations hypothesis of community organization and highlight the importance of species pools and seed limitations in constraining successional turnover, community structure, and ecosystem productivity under conditions of low fertility. Our findings also indicate that several biological and functional aspects of LIHD hay meadows can be restored from abandoned HILD hay fields by ceasing fertilization and reintroducing native species through sowing. Declines in primary production and hay yield that result from the cessation of fertilization may be at least partially compensated for by restoration.

Foster, B.L., K. Kindscher, G.R. Houseman and C.A. Murphy (2009) Effects of Hay Management and Native Species Sowing on Grassland Community Structure, Biomass, and Restoration. Ecological Applications 19(7): 1884-1896.

http://web.ku.edu/~kindscher/wp-content/uploads/2010/10/Foster-Kinscher-2009-Effects-of-Hay-Management.pdf

Inland Waters

Inland Waters>Bottomland Forests

Restoration of Bottomland Hardwood Forests across a Treatment Intensity Gradient

We report here on a comparison of four restoration techniques in terms of survival, accretion of vertical structure, and woody species diversity. The early success of the interplanting technique demonstrated that environmental benefits can be obtained quickly by more intensive efforts. Native recolonization can augment active interventions if limitations to dispersal distance are recognized. These results should provide landowners and managers with the confidence to use techniques of varying intensity to restore ecosystem functions.

Practitioners, implementing agencies

Stanturf, J.A., E.S. Gardiner, J.P. Shepard, C.J. Schweitzer, C. J. Portwood and L.C. Dorris Jr. (2009) Restoration of Bottomland Hardwood Forests Across a Treatment Intensity Gradient. Forest Ecology and Management 257: 1803-1814.

http://ddr.nal.usda.gov/bitstream/10113/28299/1/IND44182920.pdf

Achieving Restoration Success: Myths in Bottomland Hardwood Forests

Enforcing the discipline of explicit objectives, with restoration expectations described in terms of predicted values of functions, causal mechanisms and temporal response trajectories, will hasten the development of meaningful criteria for restoration success. We present our observations about current efforts to restore bottomland hardwoods as nine myths, or statements of dubious origin, and at best partial truth.

Practitioners, implementing agencies

Stanturf, J.A., S.H. Schoenholtz, C.J. Schweitzer and J.P. Shepard (2001) Achieving Restoration Success: Myths in Bottomland Hardwood Forests. Restoration Ecology 9(2): 189-200.

http://www2.for.nau.edu/courses/for212/foresttypes/Stanturf_2001_RestEco_Bottomland.pdf

Soil Seed Banks and the Potential Restoration of Forested Wetlands after Farming

Both restoration ecologists and managers of nature conservation areas need to be cognisant of seed bank and dispersal characteristics of species to effectively restore and manage forested wetlands. In the case of baldcypress swamps, critical components of the vegetation are not maintained in seed banks, which may make these floodplain wetlands difficult to restore via natural recolonization. Ultimately, the successful restoration of abandoned farm fields to forested wetlands may depend on the re-engineering of flood pulsing across landscapes to reconnect dispersal pathways.

Practitioners, implementing agencies

Middleton, B.A. (2003), Soil seed banks and the potential restoration of forested wetlands after farming. Journal of Applied Ecology 40: 1025–1034.

http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2664.2003.00866.x/pdf

Inland Waters>Floodplains>Bangladesh

Understanding the Value of Local Ecological Knowledge and Practices for Habitat Restoration in Human-Altered Floodplain Systems: A Case from Bangladesh

The results of the study indicate that the fishers and local users of the floodplain ecosystems are rich in local ecological knowledge concerning the hydrology of the floodplains and small lakes, the habitat preferences of fish, the role of agricultural crops on fish habitats, and the impact of habitat human interventions in aquatic ecosystems. Given the apparent inadequacy of the present management regime, this article argues for an inclusion of local knowledge and practices into habitat management as a more holistic approach to floodplain habitat restoration and conservation that encourages multi-level cooperation and which builds on diversified knowledge systems.

Al Mamun, A. (2010) Understanding the Value of Local Ecological Knowledge and Practices for Habitat Restoration in Human-Altered Floodplain Systems: A Case from Bangladesh. Environmental Management 45: 922-938.

http://www.springerlink.com/content/a3q608312x400135/

Inland Waters>Floodplains>Europe

Restoring Floodplains in Europe: Policy Contexts and Project Experiences

This book addresses the complex institutional dimensions to restoring floodplains. Despite the recent surge of interest in restoring floodplains among policy and research circles, as well as in the public domain, very few schemes for restoring functional floodplains have been put into practice in Europe to date. The book explores the reasons behind this discrepancy between interest and applications with an original, comparative analysis of the institutional drivers and constraints of floodplain restoration in Europe. It explains why so few projects have been successfully implemented, how recent policy shifts are creating new opportunities for floodplain restoration and what lessons for policy development and project management can be drawn from in-depth analysis of past and present schemes. At a time of rapidly growing interest in restoring floodplains as an important component of efforts to improve flood protection, enhance riparian habitats, strengthen catchment management, raise water quality and pursue integrated rural development, the book critically appraises the relationship between macro-level policy development and enforcement and micro-level project design and implementation.

Policymakers, implementing agencies

Moss, T. and J. Monstadt (eds.) (2008) Restoring Floodplains in Europe: Policy Contexts and Project Experiences. IWA Publishing.

http://www.iwapublishing.com/template.cfm?name=isbn1843390906

Wise Use of Floodplains: A Review of 12 WWF River Restoration Projects across Europe

This study was carried out as part of the "Wise Use of Floodplains" project led by BirdLife International and supported by the EU Life- Environment Programme. It was coordinated and supported by the WWF European Freshwater Programme and supervised by the WWF Germany Floodplain Institute in Rastatt. The study tries to summarise the experiences gained from many different WWF river restoration projects across Europe. In particular it addresses the following questions: What are the lessons learned in planning, implementing and constructing river restoration? What role does WWF play? Who are the main partners? What are the ecological, social and economic benefits of the wise use of rivers? What and where are the major constraints to river restoration in Europe?

Implementing agencies

Zockler, C. (2000) Wise Use of Floodplains: A Review of 12 WWF River Restoration Projects across Europe. WWF – European Freshwater Programme.

http://www.ecrr.org/publication/guidelines_doc5.pdf

Fens and Floodplains of the Temperate Zone: Present Status, Threats, Conservation and Restoration

In this introduction we discuss the most important mire-related terms, present status, threats and conservation and restoration attempts. Floodplains and especially lowland fens are rare and vulnerable ecosystems. They are highly threatened all over the world because of direct conversion to agricultural land and especially the lack of appropriate management and altered catchment hydrology. Finally we present a framework for the conservation and restoration of these ecosystems. This consists of (1) optimising abiotic conditions; (2) safeguarding propagule availability of the target species; (3) creating and maintaining conditions for (re)establishment of these species, and (4) appropriate management to keep the conditions suitable.

Implementing agencies, practitioners

van Diggelen, R., B. Middleton, J. Bakker, A. Grootjans and M. Wassen (2006) Fens and Floodplains of the Temperate Zone: Present Status, Threats, Conservation and Restoration. Applied Vegetation Science 9: 157-162.

http://ivem.eldoc.ub.rug.nl/FILES/ivempubs/publart/2006/ApplVegScivDiggelen/2006ApplVegScivDiggelen.pdf

Wet Meadow Restoration in Western Europe: A Quantitative Assessment of the Effectiveness of Several Techniques

Techniques such as rewetting, topsoil removal, diaspore transfer or combinations of these are increasingly applied in fen meadow and flood meadow restoration in Western Europe. In this paper, we present a quantitative assessment of the effectiveness of the commonly used meadow restoration methods. We use the change in 'saturation index' to evaluate the degree of success. The index reflects the completeness of restored communities in comparison to regional target communities.

Practitioners, implementing agencies

Klimkowska, A., R. Van Diggelen, J.P. Bakker and A.P. Grootjans (2007) Wet Meadow Restoration in Western Europe: A Quantitative Assessment of the Effectiveness of Several Techniques. Biological Conservation 140: 318-328.

http://ivem.eldoc.ub.rug.nl/FILES/ivempubs/publart/2007/BiolConsKlimkowska/2007BiolConservKlimkowska.pdf

Assessing the Hydrological Suitability of Floodplains for Species-rich Meadow Restoration: A Case Study of the Thames Floodplain, UK

The physical and chemical environment of a floodplain needs to be assessed to define conservation targets for restoring it to species-rich meadows from agricultural land. A straightforward technique, widely applicable by site managers for assessing the suitability of the hydrological and hydro-chemical regime of a floodplain for wet grassland restoration, has been tested by examining the feasibility of restoring plants characteristic of NVC MG4 and MG8 communities to the Castle Meadows, Wallingford (Oxfordshire, UK).

Practitioners, implementing agencies

Duranel, A.J., M.C. Acreman, C.J. Stratford, J.R. Thompson and D.J. Mould (2007) Assessing the Hydrological Suitability of Floodplains for Species-rich Meadow Restoration: A Case Study of the Thames floodplain, UK. Hydrology and Earth System Sciences 11(1): 170-179.

http://www.hydrol-earth-syst-sci.net/11/170/2007/hess-11-170-2007.pdf

Managing Floodplain-Forest Restoration in European River Landscapes Combining Ecological and Flood-protection Issues

We developed an interdisciplinary approach for floodplain-forest restoration identifying sites suitable for reforestations from both an ecological and hydraulic point of view. In the ecological module, habitat-distribution models are developed providing information on ecologically suitable sites. The approach reported here provides a solution for a severe conflict in river-basin management that hampers the reestablishment of the strongly threatened floodplain forests in Europe. Alternative measures to enhance floodplain-forest regeneration feasible under certain preconditions are discussed in the context of the current state of European large rivers.

Implementing agencies, practitioners

Leyer, I., E. Mosner and B. Lehmann (2012) Managing floodplain-forest restoration in European river landscapes combining ecological and flood-protection issues. Ecological Applications 22: 240-249.

http://www.esajournals.org/doi/abs/10.1890/11-0021.1?journalCode=ecap

Rivers, Regulation and Restoration: Land Use History of Floodplains in a Peri-Urban Landscape in Luxembourg, 1777-2000

This paper discusses the historical changes to and the uses of floodplain landscapes in Luxembourg from 1770-2000 as a case study of a region with a rural past and a peri-urban present. Based on the historical landscape analysis approach, the study comprises historical evidence of written, cartographic and oral sources collected at a regional (Gutland) and a local (Syr Valley) level. The floodplains investigated were old cultural landscapes, shaped by agriculture, livestock husbandry, river regulation measures, land improvement, milling, navigation, mining and fisheries. Landscape change has been characterised by different periods of intensity, however it was not until the last century that these changes had a large-scale impact, inducing a complete loss of several ecological and socio-economic functions. A historical perspective of local landscape conditions and land use change is needed to maintain landscape identity in a contemporary peri-urban environment, and to base planning and restoration activities on reliable data.

Implementing agencies, policymakers

Schaich, H., J. Karier and W. Konold (2011) Rivers, Regulation and Restoration: Land Use History of Floodplains in a Peri-Urban Landscape in Luxembourg, 1777-2000. European Countryside 4: 241-264.

http://versita.metapress.com/content/m850668011u16827/fulltext.pdf

Inland Waters>Floodplains>USA

Flood Pulsing in Wetlands: Restoring the Natural Hydrological Balance

Flood Pulsing in Wetlands reflects the current movement to incorporate flood pulsing into wetland restoration efforts. Emphasizing how integral flood pulsing is to successful wetland restoration, the book's contributors provide descriptions of restoration projects across North America in which flood pulsing has been primarily used to restore beneficial hydrodynamic conditions to floodplain areas, and improve or save vegetation, wildlife, and terrain.

Practitioners, implementing agencies

Middleton, B.A. (2002) Flood Pulsing in Wetlands: Restoring the Natural Hydrological Balance. Wiley.

http://www.wiley.com/WileyCDA/WileyTitle/productCd-0471418072.html

Managing River Flows to Restore Floodplain Forests

We discuss impacts downstream from dams and recent case studies where collaborative efforts with dam operators have led to the recovery of more natural flow regimes. These restoration programs, in Nevada, USA, and Alberta, Canada, focused on the recovery of flow patterns during high flow years, because these are critical for riparian vegetation and sufficient water is available for both economic commitments and environmental needs. The restoration flows were developed using the "Recruitment Box Model", which recommends high spring flows and then gradual flow decline for seedling survival. These flow regimes enabled extensive recruitment of cottonwoods and willows along previously impoverished reaches, and resulted in improvements to river and floodplain environments. Such restoration successes demonstrate how instream flow management can act as a broadly applicable tool for the restoration of floodplain forests.

Implementing agencies

Rood, S.B., G.M. Samuelson, J.H. Braatne, C.R. Gourley, F.M.R. Hughes and J.M. Mahoney (2005) Managing River Flows to Restore Floodplain Forests. Frontiers in Ecology and the Environment 3(4): 193-201.

http://cnr.usu.edu/streamrestoration/files/uploads/2010%20Resources/Rood%20et%20al_2005.pdf

Inland Waters>Lakes

The Art and Science of Lake Restoration

Lake restoration involves first an understanding in a reductionist (scientific) way of the processes that drive lake ecosystems, but then of the ultimate reasons that create these proximate problems. Ultimate reasons lie in a much wider sphere of human nature and the organisation of society. Lake restoration, in its most trivial form, may be simply a form of gardening to allay the symptoms of problems and create the illusion of a solution. Lake restoration in its most profound form involves an understanding of cultural significance and the workings of human societies and forms an epitome for the solution of much greater, global problems. Only in this form does it become truly creative. Approval must come from both of the faces of Janus.

Implementing agencies, practitioners

Moss, B. (2007) The Art and Science of Lake Restoration. Hydrobiologia 581(1): 15-24.

http://www.springerlink.com/content/5568n73771h65073/?MUD=MP

Restoration and Management of Tropical Eutrophic Lakes

This book is an essential knowledge base for both ecological restoration and management. Although tropical lakes are not identical, and therefore require individually developed and restoration and management practices; there are general principles in both restoration and management that can be derived from the case histories in this book and the limnological literature in general.

Practitioners, implementing agencies

Reddy, M.V. (ed.) (2005) Restoration and Management of Tropical Eutrophic Lakes. CRC Press.

http://www.crcpress.com/product/isbn/9781578083701;jsessionid=TaRkOyyJZIC1hdZ3QpxN9g__

Inland Waters>Lakes>China

The Seed-Bank of a Lakeshore Wetland in Lake Honghu: Implications for Restoration

The abundance and species composition in the seed-bank and extant vegetation were investigated in a lakeshore wetland. Our results indicated that a lakeshore wetland seed-bank with viable seeds and high species richness can be used as a macrophyte pool in degraded wetland restoration. Vegetation produced from such a seed-bank will have species similar to the pre-disturbance assemblage. The large number of viable seeds that we found conserved in deeper layers suggests that the most valuable macrophyte pools are conserved at depth. With disturbance, these seeds could be brought back to the surface, and serve as a reserve in recruiting the extant vegetation. We suggest using the sediment containing rich viable propagules in the actual reconstruction project.

Implementing agencies, practitioners

Li, E.H., G.H. Liu, W. Li, L.Y. Yuan and S.C. Li (2008) The Seed-Bank of a Lakeshore Wetland in Lake Honghu: Implications for Restoration. Plant Ecology 195(1): 69-76.

http://www.springerlink.com/content/2330h2g4n0722125/

Research on Slope Wetland Restoration Technology

Both slope restoration technologies, stakes-end protection and rock slope protection, were applied to the wetland slope restoration in Xi Zhuo Jia Ying, Yanqing County, Beijing. Two kinds of stakes-end protection forms were utilized during the slope restoration processes. The single row stake protection with a total length of 95.4 m was mainly vegetated by Shrubs including willow, amorpha and mulberry, while the double stakes with a horizontal distance of one meter between two stakes were mainly vegetated by amorpha fruticosa and bidens. There were three pilot demonstration sites with a total length of 40.2 m were applied. The second demonstration site was divided into two separated components. Average sizes of stones for the three slope sites were respectively designed as 40 cm × 25 cm × 30 cm, 45 cm × 20 cm × 25 cm and 55 cm × 35 cm × 35 cm, 50 cm × 35 cm × 40 cm. Matrix for the first two slopes was mainly dominated by amorpha, bidens and cattail with the third slope open to rocks.

Implementing agencies, practitioners

Cui, L.i., W. Li, X.S. Zhao, M.Y. Zhang, Y.F. Wang, Y. Zhang and S.N. Li (2011) Research on Slope Wetland Restoration Technology. Word Forestry Research 24(3): 16-21.

http://caod.oriprobe.com/articles/28636271/Research_on_Slope_Wetland_Restoration_Technology.htm

Lake Restoration on Farmlands and Community Co-management: The Restoration of the Qingshanyuan Embankment Wetland, Western Dongting Lakes, Hunan Province, China.

The eco-environment and water quality in Qingshanyuan was improved under the implementing of community co-management, and it may become a production base for organic fisheries. The synthesis of ecological, social and economic efficiency has been achieved by this restoration project. The project today serves as a successful case study for community co-management and wetland restoration.

Policymakers, implementing agencies

English, Chinese

Cui, L.J. and S.L. Ai (eds.) (2006) Pp. 174-179 in The Wetland Restoration Handbook: Guiding Principles and Case Studies. China Architecture and Building Press, Beijng.

http://ed.edaw.com/eNewsData/articleDocuments/75332_Wetland%20Handbook%20Launch%20Announcement-eng.PDF

Ecological Restoration in Eutrophic Lake Wuli: A Large Enclosure Experiment

A large-scale enclosure experiment for lake restoration was carried out in Lake Wuli, a northern bay of shallow and eutrophic Lake Taihu in China. The large enclosure with an area of 10 ha was set up in the littoral zone and was bordered by waterproof fabric which did not cover the sediments. Multiple approaches were used and included fish removal, piscivorous fish stocking, shoreline reconstruction, aquatic macrophyte planting, benthic macro-animal stocking, and silver carp cultivation in pens for reduction of cyanobacteria.

Practitioners, implementing agencies

Chen, K.N., C.H. Bao and W.P. Zhou (2009) Ecological Restoration in Eutrophic Lake Wuli: A Large Enclosure Experiment. Ecological Engineering 35(11): 1646–1655.

http://www.sciencedirect.com/science/article/pii/S0925857408002334

Inland Waters>Lakes>Europe

Lake Restoration: Successes, Failures and Long-term Effects

In this study we evaluated data from more than 70 restoration projects conducted mainly in shallow, eutrophic lakes in Denmark and the Netherlands. Special focus was given to the removal of zooplanktivorous and benthivorous fish, by far the most common internal lake measure.

Practitioners, implementing agencies

Søndergaard, M. et al. (2007) Lake Restoration: Successes, Failures and Long-term Effects. Journal of Applied Ecology 44: 1095-1105.

http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2664.2007.01363.x/pdf

Lake Restoration Studies: Failures, Bottlenecks and Prospects of New Ecotechnological Measures

This paper critically reviews the published works on lake restoration in north-western Europe, with the aim to highlight the causes of failures of lake biomanipulation, and to identify the main bottlenecks that have impeded progress. More importantly, we explore the prospects of applying new ecotechnological measures to lakes with a focus on shallow lakes. These complementary measures are: (1) reduction of sediment resuspension; (2) water-level management; and (3) the use in shallow lakes of bivalves as effective grazers on lake seston, especially when cyanobacteria are dominant.

Practitioners, implementing agencies

Gulati, R.D., L.M. Dionisio Pires and E. Van Donk (2008) Lake Restoration Studies: Failures, Bottlenecks and Prospects of New Ecotechnological Measures. Limnologica - Ecology and Management of Inland Waters 38(3-4): 233-247.

http://www.sciencedirect.com/science/article/pii/S0075951108000327

Lake Restoration by Fish Removal: Short- and Long-Term Effects in 36 Danish Lakes

We conclude that a sufficiently extensive removal of plankti- and benthivorous fish is an efficient tool to create clear water; however, repeated fish removal is presumably required to obtain long-term effects in the most nutrient rich lakes.

Practitioners, implementing agencies

Søndergaard, M., L. Liboriussen, A.R. Pedersen and E. Jeppesen (2008) Lake Restoration by Fish Removal: Short- and Long-Term Effects in 36 Danish Lakes. Ecosystems 11(8): 1291-1305.

http://jlakes.org/web/Lake-restoration-fish-removal-Danishlakes-ECOSYSTEM2008.pdf

Restoring Lakes by Using Artificial Plant Beds: Habitat Selection of Zooplankton in a Clear and a Turbid Shallow Lake

Our results suggest that water clarity is decisive for the habitat choice of large-bodied zooplankton and that introduction of APB as a restoration measure to enhance zooplankton survival is only a useful tool when water clarity increases following loading reduction. Our results indicate that dense APB will be the most efficient.

Practitioners, implementing agencies

Overgard Schou, M. et al. (2009) Restoring Lakes by Using Artificial Plant Beds: Habitat Selection of Zooplankton in a Clear and a Turbid Shallow Lake. Freshwater Biology 54(7): 1520-1531.

http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2427.2009.02189.x/abstract

Anthropogenic Impacts on Lake and Stream Ecosystems, and Approaches to Restoration

Development of new methods, as well as derivation of more general conclusions from reviewing the effects of previous restoration efforts, are crucial to achieve progress in applied freshwater research. The papers contained in this Special Profile contribute on both counts, as well as illustrating the importance of well-designed research projects and monitoring programmes to record the effects of the interventions. Such efforts are vital if we are to improve our knowledge of freshwater systems and to elaborate the best and most cost-effective recommendations. They may also help in achieving a good ecological state or potential in water bodies by 2015, as demanded by the European WFD.

Policymakers, implementing agencies

Søndergaard, M. and E. Jeppsesn (2007) Anthropogenic Impacts on Lake and Stream Ecosystems, and Approaches to Restoration. Journal of Applied Ecology 44: 1089-1094.

http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2664.2007.01426.x/pdf

Inland Waters>Lakes>USA

Defining and Restoring Biological Integrity in Wilderness Lakes

Restoring ecosystems to some previous "natural" state is often impeded by the lack of information on what goal is to be attained. However, a target for restoration of lake ecosystems can be established by developing a multimetric tool for the assessment of biological integrity. Our study identified a set of recurring responses to disturbance that indicate impaired biological integrity in lakes that include properties of species composition, taxonomic diversity, and functional organization of the lake communities. We then tested these hypothesized responses in 12 small, isolated Adirondack lakes impacted by nonnative fish species, from collections of fish, benthic invertebrates, zooplankton, and phytoplankton over a 3-yr period. We also tested the feasibility of restoring biological integrity through fish-community manipulation in three additional lakes utilizing these integrity indicators as a recovery target.

Implementing agencies, practitioners

Harig, A.L. and M.B. Bain (1998) Defining and Restoring Biological Integrity in Wilderness Lakes. Ecological Applications 8(1): 71-87.

http://www.esajournals.org/doi/abs/10.1890/1051-0761%281998%29008%5B0071%3ADARBIW%5D2.0.CO%3B2?journalCode=ecap

Inland Waters>Peatlands

Peatland Restoration and Rehabilitation

This issue of the International Peat Society (IPS) member magazine contains a number of restoration and rehabilitation case studies from Europe, Scandinavia, and Canada.

Practitioners, implementing agencies

International Peat Society (2009)

http://old.peatsociety.org/user_files/files/pi12009final.pdf

Biodiversity and Conservation of Tropical Peat Swamp Forests

Tropical peat swamp forest is a unique ecosystem that is most extensive in Southeast Asia, where it is under enormous threat from logging, fire, and land conversion. Recent research has shown this ecosystem's significance as a global carbon store, but its value for biodiversity remains poorly understood. We review the current status and biological knowledge of tropical peat swamp forests, as well as the impacts of human disturbances. We demonstrate that these forests have distinct floral compositions, provide habitat for a considerable proportion of the region's fauna, and are important for the conservation of threatened taxa, particularly specialized freshwater fishes. However, we estimate that only 36% of the historical peat swamp forest area remains, with only 9% currently in designated protected areas. Given that peat swamp forests are more vulnerable to synergies between human disturbances than other forest ecosystems, their protection and restoration are conservation priorities that require urgent action.

Implementing agencies, policymakers

Posa, M.R.C, L.S. Wijedasa and R.T. Corlett (2011) Biodiversity and Conservation of Tropical Peat Swamp Forests. BioScience 61(1): 49-57.

http://www.jstor.org/discover/10.1525/bio.2011.61.1.10?uid=3739256&uid=2&uid=4&sid=47698878168637

Nursing Plants in Peatland Restoration: On their Potential Use to Alleviate Frost Heaving Problems

In this paper, we described the problem of frost heaving in cutover peatlands and an array of means whereby it can be diminished.

Practitioners

Groeneveld, E.V.G and L. Rochefort (2002) Nursing Plants in Peatland Restoration: On their Potential Use to Alleviate Frost Heaving Problems. Suoseura 53(3-4): 73-85.

http://servsas.fsaa.ulaval.ca/uploads/tx_centrerecherche/Groeneveld_Suo_2002_01.pdf

Impact of Rewetting on the Vegetation of a Cut-Away Peatland

We tested whether rewetting improved environmental conditions during peatland restoration and promoted colonization and development of mire vegetation. Vegetation change was monitored in a cut-away peatland one year before, and four years after, rewetting. The study showed that raising the water level to, or above, soil surface promotes conditions wet enough for a rapid succession towards closed mire vegetation.

Implementing agencies, practitioners

Tuittila, E.S., H. Vasander and J. Laine (2000) Impact of Rewetting on the Vegetation of a Cut-Away Peatland. Applied Vegetation Science 3(2): 205-212.

http://onlinelibrary.wiley.com/doi/10.2307/1478999/abstract

Inland Waters>Peatlands>Australia

Using Palaeobotanical Techniques to Guide Peatland Restoration: A Case Study from Byron Bay, Australia

This project investigated the vegetation composition that contributed to a peat layer in Byron Bay, using palaeobotanical techniques and makes suggestions to assist formulation of the restoration plan for the Byron Bay site. The major aims of this study were to: establish a chronology for the wetland sediments; detect any major temporal changes in vegetation types; and identify species that have played a key role in the accumulation of peat at this site.

Practitioners, implementing agencies

Taffs, K.H., J.F. Parr and K.G. Bolton (2006) Using palaeobotanical techniques to guide peatland restoration. A case study from Byron Bay, Australia. Ecological Management and Restoration 7(2): 133-135.

http://epubs.scu.edu.au/cgi/viewcontent.cgi?article=1115&context=esm_pubs

Inland Waters>Peatlands>Canada

Techniques for Restoring Fen Vegetation on Cut-away Peatlands in North America

Sphagnum transfer, a reintroduction technique commonly used for bog restoration in North America, was effective for establishing Sphagnum and Carex species. The hay transfer method, commonly used for fen restoration in Europe, was much less successful, probably due to questionable viability of reintroduced seeds. The treatments which included light phosphorus fertilization, had a higher Carex cover after three growing seasons. The timing of the reintroductions had no impact on the success of vegetation establishment. However, vegetation reintroduction should be carried out in the spring while the ground is still frozen to minimize other ecological impacts. The success of the diaspore reintroduction technique on small-scale units indicates that a large-scale restoration of fens using this technique is feasible.

Practitioners, implementing agencies

Graf M.D. and L. Rochefort (2008) Techniques for restoring fen vegetation on cut-away peatlands in North America. Applied Vegetation Science 11(4): 521-528.

http://www.gret-perg.ulaval.ca/uploads/tx_centrerecherche/Graf_Rochefort_AVS2008_01.pdf

North American Approach to the Restoration of Sphagnum-dominated Peatlands

A new approach addressing the North American context has been developed and is presented in this paper. The short-term goal of this approach is to establish a plant cover composed of peat bog species and to restore a water regime characteristic of peatland ecosystems. The long-term objective is to return the cutover areas to functional peat accumulating ecosystems. The approach developed for peatland restoration in North America involves the following steps: 1) field preparation, 2) diaspore collection, 3) diaspore introduction, 4) diaspore protection, and 5) fertilization.

Practitioners, implementing agencies

Rochefort, L., F. Quinty, S. Campeau, K. Johnson and T. Malterer (2003) North American approach to the restoration of Sphagnum dominated peatlands. Wetlands Ecology and Management 11: 3-20.

http://servsas.fsaa.ulaval.ca/uploads/tx_centrerecherche/Rochefort_al_WEM_01.pdf

Restoration of Degraded Boreal Peatlands

This chapter will mostly discuss the restoration of Sphagnum-dominated peatlands (bogs) that have been affected by peat mining (Chap. 16), but the overall approach can easily be adapted to the restoration of ombrotrophic peatlands that have been damaged by agriculture, fires, or certain types of erosion. The restoration of peatlands after forestry practices and drainage is discussed in depth by Laine et al. (Chap. 15). For the particular case of peatlands with serious erosion problems, the report on blanket mire degradation (Tallis et al. 1997) should be consulted.

Practitioners, implementing agencies

Rochefort, L. and E. Lode (2006) Restoration of degraded boreal peatlands in Boreal Peatland Ecosystems. Wieder, R. K. & D. H. Vitt (eds.) Ecological Studies series, Vol. 188. Springer-Verlag, Berlin.

http://servsas.fsaa.ulaval.ca/uploads/tx_centrerecherche/Rochefort_Lode_EcolStud_2006.pdf

The Impact of Peatland Restoration on the Site Hydrology of an Abandoned Block-Cut Bog

Artificial drainage networks established throughout peatlands during the peat extraction process often remain active following abandonment, maintaining a water table relatively far from the surface of the peat, and hindering the survival and reestablishment of Sphagnum mosses. As an initial restoration effort, the primary drainage network of an abandoned cutover peatland was blocked with a series of peat dams, consequently reducing the runoff efficiency and causing the site-average water table to rise by 32 cm. Changes to the system hydrology following restoration efforts produced hydrological conditions more favourable for the recolonization of Sphagnum mosses.

Implementing agencies, practitioners

Ketcheson, S.J. and J.S. Price (2011) The Impact of Peatland Restoration on the Site Hydrology of an Abandoned Block-Cut Bog. Wetlands 31(6): 1263-1274.

http://www.gret-perg.ulaval.ca/uploads/tx_centrerecherche/Ketcheson_Price_Wetlands_2011_01.pdf

Restoring Peatlands in Alberta: A Case Study of Evansburg North

In western Canada peatlands are being disturbed by the energy, forestry and peat industrial sectors. However, no comprehensive studies have been undertaken to develop restoration techniques for western peatlands. Although extensive work has been carried out in eastern Canada, it is unknown if these techniques will be applicable in the sub-humid climate of western Canada. This project will be one of the first monitored peatland restorations in western Canada. The aim of this report is to establish baseline information on the Evansburg North peatland to provide a reference before a large-scale restoration is carried out. The vegetation, hydrology as well as carbon and methane dynamics were studied. Additionally, a field-scale experiment was carried out to test various reintroduction techniques.

Implementing agencies, practitioners

Graf, M., M. Strack, D. Critchley and L. Rochefort (2009) Restoring Peatlands in Alberta: A Case Study of Evansburg North. Peatland Ecology Research Group for Sun Gro Horticulture.

http://www.gret-perg.ulaval.ca/uploads/tx_centrerecherche/Sungro-Restoring_peatlands_in_Alberta_01.pdf

Le Drainage des Tourbières: Impacts et Techniques de Remouillage

Puisque chaque tourbière est unique en raison de sa position géographique, sa composition, son hydrologie, sa topographie, son âge, le type et le degré de perturbations qu’elle a subies (par exemple, récolte de la tourbe), les répercussions du drainage diffèrent d’une tourbière à l’autre. Toutefois, le drainage entraîne des conséquences dans chacune des tourbières touchées par ce phénomène. Au Québec, spécialement dans le sud de la province, où les tourbières naturelles se font de plus en plus rares, il est essentiel de mesurer l’importance de nos actions sur ces milieux utiles en biens et services écologiques pour un meilleur support de vie, incluant l’humain.

Practitioners, implementing agencies

Landry, J. and L. Rochefort (2011) Le drainage des tourbières: impacts et techniques de remouillage. Groupe de recherche en écologie des tourbières, Université Laval, Québec.

http://www.gret-perg.ulaval.ca/uploads/tx_centrerecherche/Revue_drainage-FINAL.PDF

Inland Waters>Peatlands>Europe

Status and Restoration of Peatlands in Northern Europe

Here, we summarize different approaches and restoration techniques developed for peatland management in Estonia, Sweden, and Finland where peatlands are abundant. Without rewetting, plant colonisation on abandoned cut-away areas is slow due to harsh hydrological and microclimatic conditions. However, after restoration, cut-away peatlands may return to a functional state close to that of pristine mires, and therefore restore a net carbon sink function within a few years. In addition, restoration techniques can help to create buffer zones between terrestrial and limnic ecosystems that reduces the nutrient loading imposed on watercourses by forestry operations. Restoration may also be important for peatland conservation programs as drained peatlands are part of present and future conservation areas. Finally, restoration actions in themselves can have negative environmental impacts.

Practitioners, implementing agencies

Vasander, H., E.-S. Tuittila, E. Lode, L. Lundin, M. Ilomets, T. Sallantaus, R. Heikkilä, M.-L. Pitkänen and J. Laine (2003) Status and Restoration of Peatlands in Northern Europe. Wetlands Ecology and Management 11: 51-63.

http://www.uni-marburg.de/fb19/personal/wiss_ma/kaiser/Vasander_et_al_2003.pdf

Inland Waters>Peatlands>Finland

Boreal Peatland LIFE: Restoring Boreal Peatlands in Natura 2000 Areas in Finland

The largest LIFE Nature project in Finland started in January 2010. The project led by the Natural Heritage Services of Metsähallitus aims at restoring nearly 4,300 hectares of various kind of peatlands. This five year project includes 54 Natura 2000 sites around Finland. The main aim of the project is to restore the natural hydrology of the mires by filling in and blocking the ditches and by clearing trees to recreate the landscape as it was prior to the ditching.

Implementing agencies, practitioners

Natural Heritage Services of Metsähallitus

http://www.metsa.fi/sivustot/metsa/en/Projects/LifeNatureProjects/BorealPeatlandLife/Sivut/BorealPeatlandLife.aspx

Inland Waters>Peatlands>Indonesia

Master Plan for the Rehabilitation and Rehabilitation of the Ex-Mega Rice Project Area in Central Kalimantan

It is clear however, that the only truly sustainable use of peatland within the EMRP (and elsewhere) is as near as possible natural peat swamp forest. This ecosystem has evolved over millennia during which tree litter (leaves, woody material and roots) has contributed to peat accumulation while chemical and physical properties of the peat have influenced the biomass and nutrient cycling of the forest growing on top of it. Ecological and hydrological processes in peat swamp forest are in an equilibrium in which inputs of water and plant nutrients are balanced and large amounts are held in 'store' within the peat.

Implementing agencies, policymakers

Rieley, J. and S. Page (2008) Master Plan for the Rehabilitation and Rehabilitation of the Ex-Mega Rice Project Area in Central Kalimantan. Technical Review Number 1, The Science of Tropical Peatlands and the Central Kalimantan Peatland Development Area, Government of Indonesia.

http://www.geog.le.ac.uk/carbopeat/media/pdf/pub_technical_review%201-science.pdf

Restoration Ecology of Lowland Tropical Peatlands in Southeast Asia: Current Knowledge and Future Research Directions

Studies of restoration ecology are well established for northern peatlands, but at an early stage for tropical peatlands. Extensive peatland areas in Southeast Asia have been degraded through deforestation, drainage and fire, leading to on- and off-site environmental and socio-economic impacts of local to global significance. To address these problems, landscape-scale restoration measures are urgently required. This paper reviews and illustrates, using information from on-going trials in Kalimantan, Indonesia, the current state of knowledge pertaining to (i) land-cover dynamics of degraded peatlands, (ii) vegetation rehabilitation, (iii) restoration of hydrology, (iv) rehabilitation of carbon sequestration and storage, and (v) promotion of sustainable livelihoods for local communities.

Page, S., A. Hoscilo, H. Wösten, J. Jauhiainen, M. Silvius, J. Rieley, H. Ritzema, K. Tansey, L. Graham, H. Vasander and S. Limin (2009) Restoration Ecology of Lowland Tropical Peatlands in Southeast Asia: Current Knowledge and Future Research Directions. Ecosystems 12(6): 888-905.

http://www.springerlink.com/content/63g28g6777447834/

Inland Waters>Peatlands>Ireland

Conservation and Restoration of Raised Bogs: Geological, Hydrological and Ecological Studies

Reports on detailed studies in Raheenmoor Bog and Clara Bog, both in County Offaly, that were performed between 1989 and 2001. Containing a wealth of information on the two sites, including regional geology, regional hydrology, bog hydrology, and vegetation ecology, with much attention to hydrochemistry, this book includes an extra chapter on `soaks', areas of mesotrophic or minerotrophic vegetation, occurring on otherwise ombrotrophic bog, which are usually associated with internal drainage systems. An overview is given of the relationships between biotic and abiotic conditions, again with much attention for hydrology and hydrochemistry.

Practitioners

Schouten, M.G.C. (2002) Conservation and Restoration of Raised Bogs: Geological, Hydrological and Ecological Studies. Dúchas - The Heritage Service of the Department of the Environment and Local Government, Ireland; Staatsbosbeheer, the Netherlands; Geological Survey of Ireland; Dublin.

http://www.nhbs.com/conservation_and_restoration_of_raised_bogs_tefno_134690.html http://www.raisedbogrestoration.ie/life04/downloads/raised-bog-restoration-brochure.pdf

The Potential of Birch Afforestation as an After-Use Option for Industrial Cutaway Peatlands

In the next few decades, industrial peat extraction will cease gradually over more than 80,000 hectares of cutaway peatlands in Ireland and alternative land uses will change the landscape of these areas. This study showed that substantial natural regeneration of downy birch (Betula pubescens) can occur on abandoned as well as cutaway peatlands afforested with conifers.

Implementing agencies, practitioners

Renou-Wilson, F., M. Pöllänen, K. Byrne, D. Wilson and E.P. Farrell (2010) The Potential of Birch Afforestation as an After-Use Option for Industrial Cutaway Peatlands. Suoseura 61(3-4): 59-76.

http://www.suoseura.fi/suo/pdf/Suo61_Renou.pdf

Establishing Oak Woodland on Cutaway Peatlands: Effects of Soil Preparation and Fertilization

This research was part of a large-scale project investigating various species and silvicultural techniques in order to improve afforestation success on cutaway peatlands in Ireland. Successful establishment, in terms of fast growth and good quality may be hampered on most cutaway peatlands by harsh environmental conditions. The effects of various soil preparation techniques and fertilization rates and methods on the survival, growth and quality of pedunculate oak (Quercus robur L.) were studied in two cutaway peatland sites. Results from cultivation trials would suggest that mounding should be avoided while deep ploughing would benefit oak performance. Protection from exposure that leads to shoot die-back was found to be critical for oak development. Overall, the hypothesis that oak requires specific silvicultural management techniques adapted to various site conditions of the cutaway peatlands was confirmed.

Implementing agencies, practitioners

Renou-Wilson, F., M. Keane and E.P. Farrell (2008) Establishing Oak Woodland on Cutaway Peatlands: Effects of Soil Preparation and Fertilization. Forest Ecology and Management 255: 728-737.

http://www.ucd.ie/bogland/people/FORECO10667.pdf

Inland Waters>Peatlands>Peru

Peruvian Peatlands (Bofedales): From Andean Traditional Management to Modern Environmental Impacts

In the Andes of South America, bofedales (or high Andean peatlands) are fundamental to the traditional livelihoods of Andean pastoralists, in addition to providing numerous ecosystem services. In this document, we discuss the biology and ecological role of bofedales on a regional basis, including the intersection of water and soils that permit the formation of these unique vegetation communities, which support biodiversity, help to regulate hydrological resources, provide highly palatable and nutritious forage, and act as a carbon sink.

Implementing agencies, indigenous and local communities

Salvador Pérez, F., J. Monerris and L. Rochefort (2010) Peruvian Peatlands (Bofedales): From Andean Traditional Management to Modern Environmental Impacts. Peatlands International.

http://www.gret-perg.ulaval.ca/uploads/tx_centrerecherche/Salvador-Perez_Peatlands_International_2010_01.pdf

Inland Waters>Peatlands>Southeast Asia

Hydrological Self-regulation of Domed Peatlands in South-east Asia and Consequences for Conservation and Restoration

This article explores the hydrological constraints on the existence of forested peat domes (peat swamp forests) in the humid tropics, the self-regulation mechanisms that enable them to persist and the implications for restoration of damaged domes. The most important requirement for the preservation of peat is permanent saturation by water. The variable input of precipitation must be translated into a constant water supply to the peat mound.

Practitioners, implementing agencies

Dommain, R., J. Couwenberg and H. Joosten (2010) Hydrological Self-regulation of Domed Peatlands in South-east Asia and Consequences for Conservation and Restoration. Mires and Peat 6: 1–17.

http://www.mires-and-peat.net/map06/map_06_05.pdf

Inland Waters>Peatlands>UK

IUCN UK Commission of Inquiry on Peatlands

It provides an authoritative assessment of the available evidence, based on peer-reviewed scientific consensus about the state of peatlands, the impacts of different activities on peatland ecosystems and the services they provide and the benefits of restoring and conserving them. The assessment explores mechanisms and processes for peatland conservation action, recognising the different social, economic and environmental drivers. The evidence-gathering approach was inclusive, engaging individual land managers as well as a wide range of organisations, which in itself has helped to foster joint action for peatland conservation and restoration.

Practitioners, implementing agencies, policymakers

Bain, C.G. et al. (2011) IUCN UK Commission of Inquiry on Peatlands. IUCN UK Peatland Programme, Edinburgh.

http://www.iucn-uk-peatlandprogramme.org/sites/all/files/IUCN%20UK%20Commission%20of%20Inquiry%20on%20Peatlands%20Full%20Report%20spv%20web.pdf

A Review of Techniques for Monitoring the Success of Peatland Restoration

An important element of all peatland restoration projects is a programme of monitoring to check results and progress. Several peat project workshops identified a demand for technical guidance on monitoring techniques. So Natural England commissioned this study to: 1) Review the range of peatland restoration monitoring techniques available and 2) Identify those that were consistent, informative and easily applicable for peatland restoration projects at a range of scales and budgets.

Practitioners, implementing agencies

Bonnett, S.A.F., S. Ross, C. Linstead and E. Maltby (2009) A review of techniques for monitoring the success of peatland restoration. University of Liverpool. Natural England Commissioned Reports, Number 086.

http://publications.naturalengland.org.uk/publication/46013

Inland Waters>Rivers

Process-based Principles for Restoring River Ecosystems

We outline and illustrate four process-based principles that ensure river restoration will be guided toward sustainable actions: (1) restoration actions should address the root causes of degradation, (2) actions must be consistent with the physical and biological potential of the site, (3) actions should be at a scale commensurate with environmental problems, and (4) actions should have clearly articulated expected outcomes for ecosystem dynamics. Applying these principles will help avoid common pitfalls in river restoration, such as creating habitat types that are outside of a site's natural potential, attempting to build static habitats in dynamic environments, or constructing habitat features that are ultimately overwhelmed by unconsidered system drivers.

Practitioners, implementing agencies

Beechie, T.J., D.A. Sear, J.D. Olden, G.R. Pess, J.M. Buffington, H. Moir, P. Roni and M.M. Pollock (2010) Process-based Principles for Restoring River Ecosystems. BioScience 60(3): 209-222.

http://www.treesearch.fs.fed.us/pubs/34786

Design for Stream Restoration

Stream restoration, or more properly rehabilitation, is the return of a degraded stream ecosystem to a close approximation of its remaining natural potential. Many types of practices - dam removal, levee breaching, modified flow control, vegetative methods for streambank erosion control, etc.- are useful, but this paper focuses on channel reconstruction. A tension exists between restoring natural fluvial processes and ensuring stability of the completed project. Sedimentation analyses are a key aspect of design since many projects fail due to erosion or sedimentation. Existing design approaches range from relatively simple ones based on stream classification and regional hydraulic geometry relations to more complex two- and three-dimensional numerical models. Herein an intermediate approach featuring application of hydraulic engineering tools for assessment of watershed geomorphology, channel-forming discharge analysis, and hydraulic analysis in the form of one-dimensional flow and sediment transport computations is described.

Practitioners, implementing agencies

Shields Jr., F.D., R.R. Copeland, P.C. Klingeman, M.W. Doyle and A. Simon (2003) Design for Stream Restoration. Journal of Hydraulic Engineering 129(8): 575-584.

http://palmerlab.umd.edu/restoration_course_docs/2008resources/Shields_et_al_2003.pdf

River Restoration in the Twenty-First Century: Data and Experiential Knowledge to Inform Future Efforts

Improving restoration designs and setting watershed priorities rely on collecting and making accessible this critical information. Information within the unpublished notes of restoration project managers is useful but rarely documents ecological improvements. This special section of Restoration Ecology is devoted to the current state of knowledge on river restoration.

Practitioners, implementing agencies

Palmer, M.A., J.D. Allan, J. Meyer and E.S. Bernhardt (2007) River Restoration in the Twenty-First Century: Data and Experiential Knowledge to Inform Future Efforts. Restoration Ecology 15 (3): 472-481.

http://palmerlab.umd.edu/restoration_course_docs/2008resources/Palmer_et_al_2007.pdf

Restoring Rivers One Reach at a Time: Results from a Survey of U.S. River Restoration Practitioners

Despite expenditures of more than 1 billion dollars annually, there is little information available about project motivations, actions, and results for the vast majority of river restoration efforts. We performed confidential telephone interviews with 317 restoration project managers from across the United States with the goals of (1) assessing project motivations and the metrics of project evaluation and (2) estimating the proportion of projects that set and meet criteria for ecologically successful river restoration projects.

Practitioners, implementing agencies

Bernhardt, E.S., E.B. Sudduth, M.A. Palmer, D. Allan,J.L. Meyer, G. Alexander, J.Follastad-Shah, B. Hassett, R. Jenkinson, R. Lave, J. Rumps and L. Pagano (2007) Restoring Rivers One Reach at a Time: Results from a Survey of U.S. River Restoration Practitioners. Restoration Ecology 15(3): 482-493.

http://palmerlab.umd.edu/restoration_course_docs/2008resources/Bernhardt_et_al_2007.pdf

SPECIAL SECTION: RESTORING RIVERS: A SYNTHESIS OF FINDINGS FROM PROJECT RECORDS AND INTERVIEWS

http://onlinelibrary.wiley.com/doi/10.1111/rec.2007.15.issue-3/issuetoc

Restoring Riverine Landscapes

This special issue of Ecology and Society on restoring riverine landscapes draws together nine presentations from the Second International Symposium on Riverine Landscapes, convened in August 2004 in Storforsen, Sweden. We summarize three themes related to river restoration: (1) setting priorities, (2) identifying relevant reference conditions, and (3) choosing appropriate techniques. We discuss ways of developing river restoration and provide examples of future needs in sustaining functioning river ecosystems that can support human societies.

Practitioners, implementing agencies

Nilsson, C., R. Jansson, B. Malmqvist and R.J. Naiman (eds.) (2006) Restoring Riverine Landscapes: Special Issue of Ecology and Society 12(1).

http://www.ecologyandsociety.org/issues/view.php?sf=19

Riparian Vegetation Metrics as Tools for Guiding Ecological Restoration in Riverscapes

The present work proposes a stepwise methodological procedure over spatial scales, using quantitative descriptors (metrics) of the ecological condition of the riparian vegetation. This evaluation is based on the composition and cover of plant assemblages, species attributes, and spatial patterns, which can reflect the deviation of the structure and condition of the riparian zone from the near-natural state to an impaired situation. Landscape metrics obtained from high spatial resolution imagery are used for the evaluation of the spatial features of the riparian zone, followed by the calculation of a riparian multimetric index, based on field observations. The integration of multi-spatial scale information provided by landscape metrics and biological metrics is essential and recommended for decision support of end-users and to evaluate the success of restoration measures.

Practitioners, implementing agencies

Aguiar, F.C., M.R. Fernandes and M.T. Ferreira (2011) Riparian Vegetation Metrics as Tools for Guiding Ecological Restoration in Riverscapes. Knowl. Managt. Aquatic Ecosyst. 402 (21).

http://www.kmae-journal.org/index.php?option=com_article&access=doi&doi=10.1051/kmae/2011074&Itemid=129

River Restoration, Habitat Heterogeneity and Biodiversity: A Failure of Theory or Practice?

Stream ecosystems are increasingly impacted by multiple stressors that lead to a loss of sensitive species and an overall reduction in diversity. A dominant paradigm in ecological restoration is that increasing habitat heterogeneity (HH) promotes restoration of biodiversity. This paradigm is reflected in stream restoration projects through the common practice of re-configuring channels to add meanders and adding physical structures such as boulders and artificial riffles to restore biodiversity by enhancing structural heterogeneity. Despite the complexity of these stressors, a large number of stream restoration projects focus primarily on enhancing HH; we show that this is not a wise investment. Managers should critically diagnose the stressors impacting an impaired stream and invest resources first in repairing those problems most likely to limit restoration.

Implementing agencies, practitioners

Palmer, M.A., H.L. Menninger and E. Bernhardt (2009) River Restoration, Habitat Heterogeneity and Biodiversity: A Failure of Theory or Practice? Freshwater Biology 55(s1): 1-18.

http://palmerlab.umd.edu/Palmer_et_al_2009_restoration_effectiveness.pdf

Proposed Fluvial Island Classification Scheme and its Use for River Restoration

Fluvial islands are present in nearly all natural and regulated rivers. They are important from hydrological, biological, geopolitical and socio-economic points of view. As ubiquitous as islands are, consideration of islands is relatively absent in most river restoration concepts. The natural river processes that allow for island formation can easily be integrated into typical river classifications. To begin, an island classification scheme is proposed that can become a tool for improved river classifications and restoration projects. In developing an island classification scheme, the objectives are similar to those of previous river classification methods. By observing island characteristics, inductive generalizations may be made about the river's hydrologic and ecologic potential. In river hierarchies, the distinguishing variables used to describe streams were characteristics that could easily be discerned from their appearances, i.e. field-determinable features. A similar approach is sought for island classification.

Practitioners

Wyrick, J.R. and P.C. Klingeman (2011) Proposed Fluvial Island Classification Scheme and its Use for River Restoration. River Research and Applications 27(7): 814-825.

http://onlinelibrary.wiley.com/doi/10.1002/rra.1395/abstract

River Restoration: The Fuzzy Logic of Repairing Reaches to Reverse Catchment Scale Degradation

River restoration is an increasingly common approach utilized to reverse past degradation of freshwater ecosystems and to mitigate the anticipated damage to freshwaters from future development and resource-extraction activities. While the practice of river restoration has grown exponentially over the last several decades, there has been little empirical evaluation of whether restoration projects individually or cumulatively achieve the legally mandated goals of improving the structure and function of streams and rivers. New efforts to evaluate river restoration projects that use channel reconfiguration as a methodology for improving stream ecosystem structure and function are finding little evidence for measurable ecological improvement. While designed channels may have less-incised banks and greater sinuousity than the degraded streams they replace, these reach-scale efforts do not appear to be effectively mitigating the physical, hydrological, or chemical alterations that are responsible for the loss of sensitive taxa and the declines in water quality that typically motivate restoration efforts.

Implementing agencies, practitioners

Bernhardt, E.S. and M.A. Palmer (2011) River Restoration: The Fuzzy Logic of Repairing Reaches to Reverse Catchment Scale Degradation. Ecological Applications 21(6): 1926-1931.

http://www.caryintranet.org/sites/default/files/Bernhardt_Palmer%202011%20Eco%20Apps.pdf

Inland Waters>Rivers>Australia

Inside the "Black Box" of River Restoration: Using Catchment History to Identify Disturbance and Response Mechanisms to Set Targets for Process-Based Restoration

Despite a rich literature defining the components of restoration project planning, restoration ecology currently lacks an explicit and logical means of moving from the initial project vision through to on-ground strategies. Yet this process is fundamental because it directly links the ecological goals of the project to the on-ground strategies used to achieve them. We present a planning process that explicitly uses an interdisciplinary mechanistic model of disturbance drivers and system responses to build from the initial project vision to the implementation of on-ground works. A worked example on the Upper Hunter River in southeastern Australia shows how understanding catchment history can reveal disturbance and response mechanisms, thus facilitating process-based restoration.

Implementing agencies, practitioners

Mika, S. et al. (2010) Inside the 'black box' of river restoration: using catchment history to identify disturbance and response mechanisms to set targets for process-based restoration. Ecology and Society 15(4).

http://www.ecologyandsociety.org/vol15/iss4/art8/

Soil Seed Banks of Degraded Riparian Zones in Southeastern Australia and their Potential Contribution to the Restoration of Understorey Vegetation

We examined the composition and structure of germinable soil seed banks along lateral gradients from stream channels in both cleared and wooded riparian zones of three lowland creeks within the Goulburn Broken catchment in temperate southeastern Australia. Environmental correlates of soil seed bank characteristics and similarity to extant vegetation were also examined. We found an abundant and species-rich soil seed bank mostly comprising propagules of perennial rushes and sedges and annual and perennial grasses with many species of annual forbs. While the majority of identifiable germinants and species were native, exotic species were common at all locations. Soil seed bank composition was correlated with site openness suggesting that extant vegetation structure plays an important role in soil seed bank dynamics. Recruitment from the *in situ* soil seed bank will help restore only some components of the riparian plant community and may hinder restoration by introducing undesirable species.

Practitioners, implementing agencies

Williams, L., P. Reich, S.J. Capon and E. Raulings (2008) Soil seed banks of degraded riparian zones in southeastern Australia and their potential contribution to the restoration of understorey vegetation. River Research and Applications 24: 1002-1017.

http://onlinelibrary.wiley.com/doi/10.1002/rra.1123/abstract

Climate Change Implications for River Restoration in Global Biodiversity Hotspots

Global biodiversity hotspots contain exceptional concentrations of endemic species in areas of escalating habitat loss. However, most hotspots are geographically constrained and consequently vulnerable to climate change as there is limited ability for the movement of species to less hostile conditions. Predicted changes to rainfall and temperature will undoubtedly further impact on freshwater ecosystems in these hotspots. Southwestern Australia is a biodiversity hotspot and, as one of the first to experience significant climate change, is an example and potentially a global bellwether for issues associated with river restoration.

Implementing agencies, practitioners

Davies, P.M. (2010) Climate Change Implications for River Restoration in Global Biodiversity Hotspots. Restoration Ecology 18(3): 261-268.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2009.00648.x/full

Inland Waters>Rivers>China

Rehabilitating China's Largest Inland River

The biggest challenge facing decision makers, however, is to balance water allocation and water rights between agricultural and natural ecosystems in a sustainable way. A large number of inhabitants in the Tarim Basin depend on these limited water resources for a living. At the same time, the endangered ecosystems need to be protected. Given the ecological, socioeconomic, and sociopolitical realities in the Tarim Basin, adaptive water policies and strategies are needed for water allocation in these areas of limited water resources.

Policymakers, indigenous and local communities, implementing agencies

Li, Y., Y. Chen, Y. Zhang and Y. Xia (2009) Rehabilitating China's Largest Inland River. Conservation Biology 23: 531-536.

http://www.oede.ac.cn/Article/UploadFiles/201006/2010062313132513.pdf

Soil Bioengineering and the Ecological Restoration of Riverbanks at the Airport Town, Shanghai, China

Ecological, soil bioengineering, and traditional techniques were integrated to obtain a structurally sound, ecologically sustainable and socio-economically beneficial method for restoring the riverbanks at the Airport Town, Shanghai, which was the first project applying soil bioengineering to riverbank restoration in China. Soil bioengineering is the use of living plant materials to construct structures that perform some engineering and ecological functions and can provide an effective means for slope stabilization and site restoration of riverbanks. The restoration and management strategy was based on a plan to integrate the natural landscape using live staking, live fascines, brush layer, vegetated geo-grids and geo-gabions, along with native vegetation for riverbank preservation.

Implementing agencies, practitioners

Li, X., L. Zhang and Z. Zhang (2006) Soil Bioengineering and the Ecological Restoration of Riverbanks at the Airport Town, Shanghai, China. Ecological Engineering 26(3): 304-314.

http://www.sciencedirect.com/science/article/pii/S0925857405002272

Progress of River Restoration in China

The progress of river restoration in China is briefly introduced herein in the aspects of national policies and regulations, critical actions of different ministries, fundamental research, monitoring and assessment, special planning as well as demonstration project. Stress mechanism of hydraulic engineering on river ecosystem, holistic model of river ecosystem structure and function as well as the principle of design method following negative feedback are briefly introduced.

Practitioners, implementing agencies

Zheren, D., S. Dongya, Z. Jing, Z. Jinyong and Z. Zhengli (2009) Progress of River Restoration in China. Asian River Restoration Network 6th Forum, 29 September 2009.

http://www.a-rr.net/report/docs/6thARRNforum_ChinaFullpaper.pdf

Inland Waters>Rivers>Denmark

From Natural to Degraded Rivers and Back Again: A Test of Restoration Ecology Theory and Practice

Three Danish restoration schemes are provided as focal case studies to supplement the literature review and largely supported our findings. While the large-scale re-meandering and re-establishment of water levels at River Skjern resulted in significant recovery of riverine biota, habitat enhancement schemes at smaller-scales in other rivers were largely ineffective and failed to show long-term recovery. The general lack of knowledge derived from integrated, well-designed and long-term restoration schemes is striking, and we present a conceptual framework to help address this problem. The framework was applied to the three restoration types included in our study and highlights recurrent cause-effect chains, that is, commonly observed relationships of restoration measures (cause) and their effects on abiotic and biotic conditions (effect). Such conceptual models can provide useful new tools for devising more effective river restoration, and for identifying avenues for future research in restoration ecology in general.

Implementing agencies, practitioners

Feld, C.K. et al. (2011) From Natural to Degraded Rivers and Back Again: A Test of Restoration Ecology Theory and Practice. Advances in Ecological Research 44: 119-209.

http://vbn.aau.dk/en/publications/from-natural-to-degraded-rivers-and-back-again(87553b07-e14c-4afa-ab93-cde118ab4fa9).html

Inland Waters>Rivers>Europe

LIFE and Europe's Rivers: Protecting and Improving our Water Resources

The examples featured in this brochure form an overview of how LIFE co-funded projects have helped Member States meet the requirements of the EU's Water Framework Directive. Projects have helped to implement it by testing, validating and demonstrating procedures and approaches that aid the management and sharing of information and the development of guidance on technical issues

Policymakers

Jones, W., J. Eldridge, J.P. Silva and N. Schiessler (2007) LIFE and Europe's rivers: Protecting and improving our water resources. European Commission, Environment Directorate-General.

http://ec.europa.eu/environment/life/publications/lifepublications/lifefocus/documents/rivers.pdf

Practical River Restoration Appraisal Guidance for Monitoring Options (PRAGMO)

PRAGMO is a guidance document that aims to assist all practitioners in the process of setting monitoring protocols as part of a river restoration project. Because there is a wide range of organisations, with a range of knowledge and abilities, this guidance seeks to include monitoring strategies suitable for different groups. Steps outlined are intended to support technical staff working for competent authorities, consultancies and academic institutions as well as organisations with limited funds, which may need to demonstrate success to Trustees and funders. As a 'living' document, the techniques and methods will be updated over time.

Practitioners, implementing agencies

The River Restoration Centre (2011)

http://www.therrc.co.uk/rrc_pragmo.php

Sustainable Riparian Zones: A Management Guide

This publication is a compilation of themes related with the ecology, restoration and assessment of riparian zones. This guide is intended as a practical tool that will be very useful for managers and those professionally engaged in river and riverside conservation and/or restoration. This book aims to give the reader an overall view of what these natural systems are and how they function. This volume can be approached either in order of chapters or by singling out individual chapters as the reader's own interests and needs dictate. It attempts to address most of the main subjects and aspects that affect the integrity of riparian ecosystems, always trying to take a broad view that will be applicable to the vast majority of cases. Nevertheless, a marked Mediterranean tendency is evident, owing to the origin of most of the authors and to the context in which it arose.

Practitioners, implementing agencies

English, Spanish

Arizpe, D., A. Mendes and J.E. Rabaça (eds.) (2008) Sustainable Riparian Zones: A Management Guide. Ripidurable, Valencia.

http://www.ripidurable.eu/news_detail.php?lang=0&id_channel=3&id_page=64&id=47

Riparian Tree and Shrub Propagation Handbook: An Aid to Riverine Restoration in the Mediterranean Region

This guide has been conceived as a support tool for nursery managers, and for others who are not specialists but are in one way or another involved in the production of riparian plant species for hydrological restoration projects. It offers useful data on the production of seeds, parts of plants and plants belonging to a large series of tree, shrub and lianoid species that may be employed in fluvial systems of the Mediterranean region. It provides information on species that are dominant in the riparian vegetation of the region, on species whose propagation may be of interest due to their potential interaction with some species of fauna and on species that are traditionally used for hydrological restoration purposes. Although some of the included taxons are not strictly riparian, but originate in the Mediterranean shrub and forest communities, they can develop optimally in these environments, especially in extremely dry areas.

Practitioners

English, Spanish, Greek

Aranzazu Prada, M. and D. Arizpe (eds.) (2008) Riparian Tree and Shrub Propagation Handbook: An Aid to Riverine Restoration in the Mediterranean Region. Ripidurable, Valencia.

http://www.ripidurable.eu/news_detail.php?lang=0&id_channel=3&id_page=64&id=49

The Use of Large Wood in Stream Restoration: Experiences from 50 projects in Germany and Austria

Large wood has been used successfully in several projects in central Europe, predominantly to increase the general structural complexity using fixed wood structures. Our results recommend the use of less costly soft engineering techniques (non-fixed wood structures), higher amounts of wood, larger wood structures and improved monitoring programmes for future restoration projects comparable with those in this study. We recommend the use of ‘passive restoration’ methods (restoring the process of wood recruitment on large scales) rather than ‘active restoration’ (placement of wood structures on a reach scale), as passive restoration avoids the risk of non-natural amounts or diversity of wood loading developing within streams. Local, active placement of wood structures must be considered as an interim measure until passive restoration methods have increased recruitment sufficiently.

Practitioners

Kail, J., D. Hering, S. Muhar, M. Gerhard and S. Preis (2007) The Use of Large Wood in Stream Restoration: Experiences from 50 projects in Germany and Austria. Journal of Applied Ecology 44: 1145-1155.

http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2664.2007.01401.x/pdf

Inland Waters>Rivers>Germany

River Restoration Success Depends on the Species Pool of the Immediate Surroundings

Previous studies evaluating the success of river restorations have rarely found any consistent effects on benthic invertebrate assemblages. In this study, we analyzed data from 24 river restoration projects in Germany dating back 1 to 12 years and 1231 data sets from adjacent river reaches that lie within 0–5, 5–10, and 10–15 km rings centered on the restored sites. We calculated restoration success and recolonization potential of adjacent river reaches based on stream-type-specific subsets of taxa indicative for good or bad habitat quality. On average, the restorations did not improve the benthic invertebrate community quality. However, we show that restoration success depends on the presence of source populations of desired taxa in the surrounding of restored sites.

Practitioners, implementing agencies

Sundermann, A., S. Stoll and P. Haase (2011) River restoration success depends on the species pool of the immediate surroundings. Ecological Applications 21:1962-1971.

http://www.esajournals.org/doi/abs/10.1890/10-0607.1

Inland Waters>Rivers>Japan

River and Wetland Restoration: Lessons from Japan

River and wetland restoration has emerged as a worldwide phenomenon and is becoming a highly profitable business. Although researchers worldwide know a lot about restoration practices in Europe and the United States, we have only scant information about the activities in Japan, where more than 23,000 river restoration projects have been conducted during the past 15 years. In Japan, restoration is a daunting business because of the high human population density, urbanization, and harsh environmental conditions. Here we provide an overview of the various restoration activities in Japan and discuss the lessons that we can draw from them.

Practitioners, implementing agencies

Nakamura, K., K. Tockner and K. Amano (2006) River and Wetland Restoration: Lessons from Japan. BioScience 56(5): 419-429.

http://www.wsl.ch/land/products/rhone-thur/publikationen/419River%20and%20Wetland%20Restoration%20Lessons%20from%20Japan.pdf

Inland Waters>Rivers>Mexico

Restauración Ecológica de Riberas: Manual para la Recuperación de la Vegetación Ribereña en Arroyos de la Selva Lacandona

El manual describe los problemas y limitaciones cuando se quiere restaurar las riberas y al mismo tiempo brinda opciones para la selección de las herramientas más adecuadas en cada caso. Presenta un listado de especies con uso potencial para la restauración, y recomienda cómo sembrar y disponer estas especies en distintas situaciones.

Practitioners, implementing agencies

Meli, P. and V. Carrasco-Carballido (2011) Comisión Nacional para el Conocimiento y Uso de la Biodiversidad Mexico Serie Diálogos Número 5.

http://www.conabio.gob.mx/

Integrating Ecological and Ethnobotanical Priorities into Riparian Restoration

The riparian vegetation along many rivers is so modified by farming and grazing that forest restoration targets are far from obvious, and initial steps are hard to plan. The Ayuquila River in southern Mexico offered the opportunity to test an approach that integrates ecological data and ethnobotanical information to identify reference sites that could serve as restoration targets and prioritize woody species for initiating restoration.

Practitioners, indigenous and local communities

Allen, A.E., F.J. Santana-Michel, C. Ortiz Arrona and J.B. Zedler (2010) Integrating Ecological and Ethnobotanical Priorities into Riparian Restoration. Ecological Restoration 28(3): 377-388.

http://er.uwpress.org/content/28/3/377.abstract

Inland Waters>Rivers>New Zealand

The Restoration Indicator Toolkit: Indicators for Monitoring the Ecological Success of Stream Restoration

The Toolkit has been developed primarily for the needs of regional councils with access to laboratories and technical equipment, but it should also be useful for community groups and resource users that are undertaking stream restoration without specialist equipment. It is based around the concept of identifying the important goals of the restoration and choosing appropriate indicators to measure the success of those goals. Some of the indicators require specialist equipment or technical training. However, there are several indicators for each type of goal, and when selecting from the Toolkit, a community group may simply avoid specialist indicators and choose others that match their goals and can be measured more easily.

Alternatively, it may be possible for a community group to work with the regional council or research scientists in monitoring a restoration site.

Implementing agencies, practitioners

Parkyn, S., K. Collier, J. Clapcott, B. David, R. Davies-Colley, F. Matheson, J. Quinn, W. Shaw and R. Storey (2010) The restoration indicator toolkit: Indicators for monitoring the ecological success of stream restoration. National Institute of Water & Atmospheric Research Ltd, Hamilton, New Zealand.

http://www.envirolink.govt.nz/PageFiles/31/RestorationIndicatorToolkit_stream.pdf

Special Issue on Restoration of Aquatic Ecosystems

Together these 12 papers examine key restoration ecology concepts, provide a range of modeling tools, and review information and case studies to help aquatic restoration design and monitoring. We hope that the information and ideas will stimulate further technique and concept development and contribute to the challenging but urgent task of restoring the aquatic ecosystem attributes and services that underpin societal wellbeing.

Practitioners, implementing agencies

Quinn, J.M. (ed.) (2009) Special issue on restoration of aquatic ecosystems. New Zealand Journal of Marine and Freshwater Research 43(3): 653-856.

http://www.tandfonline.com/toc/tnzm20/43/3

Inland Waters>Rivers>Spain

River Restoration in Spain: Theoretical and Practical Approach in the Context of the European Water Framework Directive

River restoration is becoming a priority in many countries because of increasing the awareness of environmental degradation. In Europe, the EU Water Framework Directive (WFD) has significantly reinforced river restoration, encouraging the improvement of ecological status for water bodies. To fulfill the WFD requirements, the Spanish Ministry of the Environment developed in 2006 a National Strategy for River Restoration whose design and implementation are described in this paper. At the same time many restoration projects have been conducted, and sixty of them have been evaluated in terms of stated objectives and pressures and implemented restoration measures.

Policymakers, implementing agencies

González del Tánago, M., D. García de Jalón and M. Román (2012) River Restoration in Spain: Theoretical and Practical Approach in the Context of the European Water Framework Directive. Environmental Management Online First.

http://www.springerlink.com/content/k7u536130x13rw23/?MUD=MP

Inland Waters>Rivers>Sweden

Restoration of Rivers Used for Timber Floating: Effects on Riparian Plant Diversity

Fluvial processes such as flooding and sediment deposition play a crucial role in structuring riparian plant communities. In rivers throughout the world, these processes have been altered by channelization and other anthropogenic stresses. Yet despite increasing awareness of the need to restore natural flow regimes for the preservation of riparian biodiversity, few studies have examined the effects of river restoration on riparian ecosystems. In this study, we examined the effects of restoration in the Ume River system, northern Sweden, where tributaries were channelized to facilitate timber floating in the 19th and early 20th centuries.

Implementing agencies, practitioners

Helfield, J.M., S.J. Capon, C. Nilsson, R. Jansson and D. Palm (2007) Restoration of Rivers Used for Timber Floating: Effects on Riparian Plant Diversity. Ecological Applications 17(3): 840-851.

http://myweb.wwu.edu/~helfiej/publications_pdfs/Helfield_etal_2007.pdf

Inland Waters>Rivers>USA

Standards for Ecologically Successful River Restoration

Billions of dollars are currently spent restoring streams and rivers, yet to date there are no agreed upon standards for what constitutes ecologically beneficial stream and river restoration. We propose five criteria that must be met for a river restoration project to be considered ecologically successful. It is critical that the broad restoration community, including funding agencies, practitioners and citizen restoration groups, adopt criteria for defining and assessing ecological success in restoration. Standards are needed because progress in the science and practice of river restoration has been hampered by the lack of agreed upon criteria for judging ecological success. Without well-accepted criteria that are ultimately supported by funding and implementing agencies, there is little incentive for practitioners to assess and report restoration outcomes. Improving methods and weighing the ecological benefits of various restoration approaches require organized national-level reporting systems.

Implementing agencies, practitioners

Palmer, M.A. et al. (2005) Standards for Ecologically Successful River Restoration. Journal of Applied Ecology 42(2): 208-217.

http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2664.2005.01004.x/full

Synthesizing U.S. River Restoration Efforts

The authors of this Policy Forum developed a comprehensive database of >37,000 river restoration projects across the United States. Such projects have increased exponentially over the past decade with more than a billion dollars spent annually since 1990. Most are intended to enhance water quality, manage riparian zones, improve in-stream habitat, allow fish passage, and stabilize stream banks. Only 10% of project records document any form of project monitoring, and little if any of this information is either appropriate or available for assessing the ecological effectiveness of restoration activities.

Policymakers, implementing agencies

Bernhardt, E.S. et al. (2005) Synthesizing U.S. River Restoration Efforts. Science 308(5722): 636-637.

http://www.sciencemag.org/content/308/5722/636.short

http://www-personal.umich.edu/~dallan/pdfs/Jenkinson_2006.pdf

Setting River Restoration Priorities: a Review of Approaches and a General Protocol for Identifying and Prioritizing Actions

A well-crafted restoration goal identifies the biological objective of restoration, addresses underlying causes of habitat change, and recognizes that social, economic, and land use objectives may constrain restoration options. Once restoration goals are identified, one of six general approaches can be selected for prioritizing restoration actions: project type, refugia, decision support systems, single-species analysis, multispecies analysis, and cost effectiveness. Prioritizing by project type, refugia, or a decision support system requires the least quantitative information, and each approach is relatively easy to use.

Policymakers, implementing agencies, practitioners, indigenous and local communities

Beechie, T., G. Pess, P. Roni and G. Giannico (2008) Setting River Restoration Priorities: a Review of Approaches and a General Protocol for Identifying and Prioritizing Actions. North American Journal of Fisheries Management 28: 891-905.

http://fwl.oregonstate.edu/labs/giannico/html/documents/SettingRiverRestorationPriorities.pdf

Multiscale Patterns of Riparian Plant Diversity and Implications for Restoration

To inform restoration planning, we examined the biogeographic patterns of riparian plant diversity at local and regional scales within a major western U.S.A. drainage, California's Sacramento—San Joaquin Valley. We analyzed patterns of species richness and complementarity (β-diversity) across two scales: the watershed scale and the floodplain scale. At the watershed scale, spatial patterns of native riparian richness were driven by herbaceous species, whereas woody species were largely cosmopolitan across the nearly 38,000 km2 study area. At the floodplain scale, riparian floras reflected species richness and dissimilarity patterns related to hydrological and disturbance-driven successional sequences. These findings reinforce the importance of concurrently evaluating both local and regional processes that promote species diversity and distribution of native riparian flora. Furthermore, as restoration activities become more prevalent across the landscape, strategies for restoration outcomes should emulate the patterns of species diversity and biogeographic distributions found at regional scales.

Implementing agencies, practitioners

Viers, J.H., A.K. Fremier, R.A. Hutchinson, J.F. Quinn, J.H. Thorne and M.G. Vaghti (2012) Multiscale Patterns of Riparian Plant Diversity and Implications for Restoration. Restoration Ecology 20(2): 160-169.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2011.00787.x/full

Applicability of Landscape and Island Biogeography Theory to Restoration of Riparian Understorey Plants

We tested whether ideas from landscape ecology (local vs. landscape scales) and island biogeography theory (patch size and isolation) predict restoration success for understorey plant communities in a highly fragmented riparian landscape, in an effort to provide guidance on how to allocate scarce restoration resources. Local factors explained more of the variance in understorey plant communities, but much of the variance remained unexplained. Our results provide weak support for the predictions of island biogeography theory and the importance of landscape-scale variables. These theories did not have strong predictive power in this applied restoration context at this temporal scale. Given limited resources, efforts to restore understorey plant communities in this highly fragmented system should focus on local-scale restoration methodologies, such as increasing cover of native overstorey species and reducing cover of exotic plants.

Practitioners, implementing agencies

Holl, K.D. and E.E. Crone (2004) Applicability of Landscape and Island Biogeography Theory to Restoration of Riparian Understorey Plants. Journal of Applied Ecology 41: 922-933.

http://people.ucsc.edu/~kholl/holl%26crone2004.pdf

Soil Seed Banks of Two Montane Riparian Areas: Implications for Restoration

Understanding the role of seed banks can be important for designing restoration projects. Using the seedling emergence method, we investigated the soil seed banks of two montane, deciduous riparian forest ecosystems of southeastern Arizona. We contrasted the seed banks and extant vegetation of Ramsey Canyon, which is the site of riparian restoration activities, with that of Garden Canyon, which has been less affected by human land uses.

Practitioners, implementing agencies

Richter, R. and J.C. Stromberg (2005) Soil Seed Banks of Two Montane Riparian Areas: Implications for Restoration. Biodiversity and Conservation 14(4): 993-1016.

http://www.springerlink.com/content/g466186461403n67/

Water for River Restoration: Potential for Collaboration between Agricultural and Environmental Water Users in the Rio Grande Project Area

This report was commissioned by the World Wildlife Fund (WWF) to explore the potential for working with agricultural water users to direct some part of the water supply of the Rio Grande in the Chihuahuan Desert to restoration of the river. While there is a long and growing history of disputes among competing water users in the Rio Grande Basin, and agricultural and environmental groups have in particular butted heads, the two groups share many common interests in future management of the river.

Implementing agencies, indigenous and local communities

King, J.P. and J. Maitland (2003) Water for River Restoration: Potential for Collaboration between Agricultural and Environmental Water Users in the Rio Grande Project Area. Report prepared for Chihuahuan Desert Program, World Wildlife Fund.

http://www.worldwildlife.org/what/wherewework/chihuahuandesert/WWFBinaryitem2768.pdf

Riparian Restoration in the Southwest – Species Selection, Propagation, Planting Methods, and Case Studies

Riparian plant communities, though small in overall area, are among the most valuable natural areas in the Southwest. The causes of degradation of southwestern riparian zones range from excessive cattle and elk grazing in montane watersheds to invasive woody exotic species and lack of natural flooding in the cottonwood forests, “bosque”, of low elevation river valleys. Goals of riparian restoration include erosion control, channel stabilization, runoff reduction, and enhancement of wildlife and fishery habitat. Plant species and stock types selected for restoration efforts must be appropriate for the site characteristics. Relevant site characteristics include elevation, soil texture and chemistry, and depth to water table. Vegetative propagation methodologies including pole cutting production, mound layering, and large containerized stock have been developed to provide cost effective plant production of riparian species. Plant materials and planting methods range from dormant pole cuttings placed vertically or horizontally to unusual container stock types such as 30 inch tall pots. Case studies are presented on the restoration of the cottonwood forests along the middle Rio Grande and Gila River and of montane riparian areas in the Apache-Sitgreaves National Forests.

Practitioners

Dreesen, D., J. Harrington, T. Subirge, P. Stewart and G. Fenchel (2002) Riparian Restoration in the Southwest – Species Selection, Propagation, Planting Methods, and Case Studies. USDA Natural Resource Conservation Service.

http://www.plant-materials.nrcs.usda.gov/pubs/nmpmcsy03852.pdf

A Review of Stream Restoration Techniques and a Hierarchical Strategy for Prioritizing Restoration in Pacific Northwest Watersheds

The hierarchical strategy we present is based on three elements: (1) principles of watershed processes, (2) protecting existing high-quality habitats, and (3) current knowledge of the effectiveness of specific techniques. Initially, efforts should focus on protecting areas with intact processes and high-quality habitat. Following a watershed assessment, we recommend that restoration focus on reconnecting isolated high-quality fish habitats, such as instream or off-channel habitats made inaccessible by culverts or other artificial obstructions. Once the connectivity of habitats within a basin has been restored, efforts should focus on restoring hydrologic, geologic (sediment delivery and routing), and riparian processes through road decommissioning and maintenance, exclusion of livestock, and restoration of riparian areas. Instream habitat enhancement (e.g., additions of wood, boulders, or nutrients) should be employed after restoring natural processes or where short-term improvements in habitat are needed (e.g., habitat for endangered species). Finally, existing research and monitoring is inadequate for all the techniques we reviewed, and additional, comprehensive physical and biological evaluations of most watershed restoration methods are needed.

Implementing agencies, practitioners

Roni, P., T.J. Beechie, R.E. Bilby, F.E. Leonetti, M.M. Pollack and G.R. Pess (2002) A Review of Stream Restoration Techniques and a Hierarchical Strategy for Prioritizing Restoration in Pacific Northwest Watersheds. North American Journal of Fisheries Management 22: 1-20.

http://www.crab.wa.gov/LibraryData/RESEARCH_and_REFERENCE_MATERIAL/Environmental/020923StreamRestoreTechPNW.pdf

Stream Ecosystem Responses to Spatially Variable Land Cover: An Empirically-based Model for Developing Riparian Restoration Strategies

The restoration of native, forested riparian habitats is a widely accepted method for improving degraded streams. Little is known, however, about how the width, extent and continuity of forested vegetation along stream networks affect stream ecosystems. Using model parameters estimated for the mid-Atlantic Piedmont, we show how the model can be used to guide restoration planning in a case study of a small catchment. The model predicts the quantitative change in biological characteristics of the stream, such as indices of species diversity and species composition, that would occur with the implementation of a hypothetical restoration project.

Implementing agencies, practitioners

Johnson, T.E., J.N. McNair, P. Srivastava and D.D. Hart (2007) Stream Ecosystem Responses to Spatially Variable Land Cover: An Empirically-based Model for Developing Riparian Restoration Strategies. Freshwater Biology 52: 680-695.

http://ecologia.icb.ufmg.br/~rpcoelho/comunidades/Artigos_2007/johnson_ecs2007.pdf

Inland Waters>Wetlands

An International Perspective on Wetland Rehabilitation

Authors ranging from private landowners to government managers to scientists present regional overviews, case studies, and discussions of various issues. Regional overviews cover areas as small as the Commonwealth of the Northern Mariana Islands to areas as large as Australia and Africa. Case studies range from relatively small projects, such as rehabilitation of damage caused by wheel ruts in the high arctic, to much larger projects, such as attempts to rehabilitate thousands of hectares of Northern Territory wetlands in Australia.

Implementing agencies, practitioners

Streever, W.J. (ed.) (1999) An International Perspective on Wetland Rehabilitation. Springer http://www.springer.com/life+sciences/ecology/book/978-0-7923-5724-7

Restoration of Wetland Environments: Lessons and Successes

Introductory chapters address the scope and significance of wetlands globally for communities, culture and biodiversity. Subsequent sections deal with processes underpinning wetland functioning, how wetlands work, their uses and values for humans and nature, their sensitivity to external impacts, and how they may be restored. The text is illustrated by numerous examples, emphasising functional and holistic approaches to wetland management, including case studies on the wise use and rehabilitation of wetlands in farmed, urban, industrial and other damaged environments, highlighting the long-term benefits of multiple use. The Wetlands Handbook will provide an invaluable reference for researchers, managers, policy-makers and students of wetland sciences.

Policymakers, implementing agencies, practitioners

van der Valk, A.G. (2009) Restoration of Wetland Environments: Lessons and Successes, in The Wetlands Handbook (eds E. Maltby and T. Barker), Wiley-Blackwell, Oxford, UK.

http://onlinelibrary.wiley.com/doi/10.1002/9781444315813.ch32/summary

How Successful Mangrove Forest Restoration Informs the Process of Successful General Wetland Restoration

This article is derived from a more specific paper just on mangrove forest restoration published by the Society of Wetland Scientists in 2009. The intent of this article is to utilize some basic principles of successful mangrove forest restoration as a starting point to describe the routine problem with a lack of successful wetland restoration for all wetland types. This subject has been described in a number of recent articles in the National Wetlands Newsletter.

Practitioners, implementing agencies

Lewis, R.R. (2011) How Successful Mangrove Forest Restoration Informs the Process of Successful General Wetland Restoration. National Wetlands Newsletter 33(4): 23-25.

http://www.mangroverestoration.com/pdfs/Lewis%202011%20NWN.pdf

Modeling the Suitability of Wetland Restoration Potential at the Watershed Scale

The model offers a useful tool to focus and set goals for wetland restoration efforts in a spatially explicit way. A two-phase approach was used: the first is to develop criteria, or environmental indicators, to identify the total population of sites suitable for wetland restoration. Locations are identified where restoration has a high likelihood of success and will be sustainable over the long term. Criteria used include hydric soils, land use, topography, stream order, and a saturation index based on slope and flow accumulation in each grid cell in the model. The second phase "filters" the total population of available sites in order to prioritize them according to their potential to contribute to water resource integrity once restored.

Implementing agencies, practitioners

White, D. and S. Fennessy (2005) Modeling the Suitability of Wetland Restoration Potential at the Watershed Scale. Ecological Engineering 24(4): 359-377.

http://www.sciencedirect.com/science/article/pii/S0925857405000352

Does Facilitation of Faunal Recruitment Benefit Ecosystem Restoration? An Experimental Study of Invertebrate Assemblages in Wetland Mesocosms

We used wetland mesocosms (1) to experimentally assess whether inoculating a restored wetland site with vegetation/sediment plugs from a natural wetland would alter the development of invertebrate communities relative to unaided controls and (2) to determine if stocking of a poor invertebrate colonizer could further modify community development beyond that due to simple inoculation. These results suggest that facilitation of invertebrate recruitment does indeed alter invertebrate community development and that facilitation may lead to a more natural community structure in less time under conditions simulating wetland restoration.

Practitioners, implementing agencies

Brady, V.J., B.J. Cardinale, J.P. Gathman and T.M. Burton (2002) Does Facilitation of Faunal Recruitment Benefit Ecosystem Restoration? An Experimental Study of Invertebrate Assemblages in Wetland Mesocosms. Restoration Ecology 10(4): 617-626.

http://www.snre.umich.edu/cardinale/pdfs/brady_rest_ecol_2002.pdf

Wetlands: Functioning, Biodiversity Conservation, and Restoration

This book gives a broad and well-integrated overview of recent major scientific results in wetland science and their applications in natural resource management. After an introduction into the field, 12 chapters contributed by internationally known experts summarize the state of the art on a multitude of topics. The coverage is divided into three sections: Functioning of Plants and Animals in Wetlands; Conservation and Management of Wetlands; and Wetland Restoration and Creation.

Practitioners, implementing agencies

Bobbink, R., B. Beltman, J.T.A. Verhoeven and D.F. Whigham (eds.) (2006) Wetlands: Functioning, Biodiversity Conservation, and Restoration. Springer, New York.

http://www.springer.com/life+sciences/ecology/book/978-3-540-33188-9

Biomanipulation: A Useful Tool for Wetland Rehabilitation

Food web manipulation, or biomanipulation, is a frequently applied lake management tool, aiming to restore water quality and vegetation characteristics through interventions in the fish communities. Despite the strong management appeal of biomanipulations, this tool found so far little application in wetlands. This chapter highlights pros and cons of biomanipulations in wetlands, and suggests that an extension of the current biomanipulation paradigm beyond fish management, to consider interventions in other components of wetland communities, can be useful for rehabilitating degraded wetlands such as Las Tablas de Daimiel.

Practitioners, implementing agencies

Angeler, D.G. (2010) Biomanipulation: A Useful Tool for Wetland Rehabilitation. Pp. 215-228 in Sánchez-Carrillo, S. and D.G. Angeler (eds.) Ecology of Threatened Semi-Arid Wetlands. Wetlands: Ecology, Conservation and Management, Volume 2, Springer, New York.

http://www.springerlink.com/content/mh8178r3660463r7/

A Paleoecological Perspective on Wetland Restoration

Paleoecological investigations of wetland sedimentary deposits offer the possibility of obtaining accurate reconstructions of base line conditions in the past. Plant remains, such as leaves, seeds, fruits, wood, and pollen, provide a window of variable temporal and spatial resolution into past environmental conditions at a particular site. These archives of physical and biological wetland ecosystem characteristics, if preserved, may be exploited to reconstruct the plant community at a single point in time. Moreover, changes in past plant community composition, hydrology, and the dynamics of wetland ecosystems through time may be better understood. This paper reviews the range of paleoecological information archived in wetland sedimentary deposits that may be understood in the restoration science context. This type of information gleaned by applying paleoecological techniques should provide reasonable targets for restoration ecologists working to improve the quality and quantity of ecosystem functions and services in wetlands.

Practitioners, implementing agencies

Williams, C.J. (2011) A Paleoecological Perspective on Wetland Restoration. Pp. 67-91 in LePage, B.A. (ed.) Wetlands: Integrating Multidisciplinary Concepts. Springer, New York.

http://www.springerlink.com/content/g00m335211178173/

Inland Waters>Wetlands>Brazil

River Water Quality Improvement by Natural and Constructed Wetland systems in the Tropical Semi-arid Region of Northeastern Brazil

The efficiencies of a natural Typha spp wetland (Wn) formed on a river bed and its effluent treatment in a constructed wetland (Wc, subsurface horizontal flow) were investigated in northeastern Brazil (Paraiba State). The Wc system (12 tanks with stone gravel, 4.13 m2, 0.22 m3, 20 Typha spp rhizomes. m-2 each, with 38, 29, and 19 mm.d-1 hydraulic loadings, and 5, 7, and 10 days HRT) was fed daily with effluent from a Wn. Wn removal presented the highest values after Typha spp were cut during the 5th week. Removal values were (1st and 2nd periods or before and after cutting): 75% and 81% BOD5; 10-53% total phosphorus; 13%-55% ammonia; 89%-91% FC; 90-96% coliphages and bacteriophages. Wc removals increased with time with best results on 10d HRT. Removals were also higher in the 2nd period: 74%-78% BOD5; 58%-82% ammonia; 90% FC; 94-98% FS; and 92%-96% coliphages and bacteriophages. Despite the high remaining values of FC (1.4 × 104 CFU/100 ml) and FX (4 × 103 CFU/100 ml), the removals were satisfactory and HRT dependent, suggesting a gradual optimization of the system with time. The Wc exhibited good efficiency for improving water quality from polluted river.

Implementing agencies

de Ceballos, B.S.O., H. Oliveira, C.M.B.S. Meira, A. Konig, A.O. Guimarães and J.T. de Souza (2001) River water quality improvement by natural and constructed wetland systems in the tropical semi-arid region of northeastern Brazil. Water Sci Technol 44(11–12): 599-605.

http://www.emeraldinsight.com/journals.htm?articleid=1075048

Inland Waters>Wetlands>China

Constructed Wetlands in China: Recent Developments and Future Challenges

Constructed wetlands (CWs) are an emerging, environmentally friendly engineering system employed in China. They require lower investment and operation costs while providing higher treatment efficiency and more ecosystem services than conventional wastewater treatment methods. Introduced to China in 1987, CW systems used for wastewater treatment have rapidly increased in number, particularly since the late 1990s. This review summarizes the state-of-the-art application of CW systems for water pollution treatment by reviewing the basics of the technology and its historical development and performance efficiency. Current progress, limitations, future concerns, and the challenges of CW technologies are also discussed. Also highlighted is the need for sufficient and appropriate data to assist in the further development of CW systems and the implementation of integrated “bottom-up” and “top-down” approaches by both the public in general and government bodies in particular.

Implementing agencies

Liu, D., Y. Ge, J. Chang, C. Peng, B Gu, G.Y.S. Chan and X. Wu (2009) Constructed Wetlands in China: Recent Developments and Future Challenges. Frontiers in Ecology and the Environment 7(5): 261-268.

http://www.crc.uqam.ca/Peng/PDF/Liu_FEE-%20proof1.pdf

A Rehabilitated Wetland in Southeastern China that Supports Traditional Ways of Fishing and Farming: The Xixi National Wetland Park, Hangzhou, Zhejiang Province, China

There are six principle restoration and conservation goals at Xixi: a priority on minimal ecological interference; Preservation of the historic site configuration; recognition of traditional culture; consideration of human needs; and sustainable development, to restore wetland ecosystem and its biodiversity entirely. For example, during the implementing of restoration project, previously isolated water patches were integrated to allow the free association of different species in a larger space and to provide desirable food sources for birds attracted to the site. The Xixi Wetland has undergone a restoration of both its natural ecology and its cultural heritage, and it is a unique combination of city life, agriculture and traditional culture in China.

Policymakers, implementing agencies

English, Chinese

Cui, L.J. and S.L. Ai (eds.) (2006) Pp. 180-185 in The Wetland Restoration Handbook: Guiding Principles and Case Studies. China Architecture and Building Press, Beijng.

http://ed.edaw.com/eNewsData/articleDocuments/75332_Wetland%20Handbook%20Launch%20Announcement-eng.PDF

Wetlands for Treatment of Industrial Wastwater: Shanghai Chemical Industrial Park’s Natural Treatment system, Shanghai, China

While the improvement of water quality is systematically addressed in this unique design, this fusion of design disciplines would allow the treatment wetlands to evolve into an attractive natural environment suitable for both wildlife habitats and visitors. The vision calls for a recreational hub for Shanghai Chemical Industrial Park'semployees and visitors, while additionally serving as a wetland research center for academic groups.

Implementing agencies, practitioners

English, Chinese

Cui, L.J. and S.L. Ai (eds.) (2006) Pp. 214-225 in The Wetland Restoration Handbook: Guiding Principles and Case Studies. China Architecture and Building Press, Beijng.

http://ed.edaw.com/eNewsData/articleDocuments/75332_Wetland%20Handbook%20Launch%20Announcement-eng.PDF

Creating a Constructed and Natural Wetland Habitat: Restoration of Jade Lake Wetland, Haidian District, Beijing, China

Based on natural environment, the main object of the Jade Lake restoration project was to maintain the integrity and organic coordination, using ecological engineering technologies and the concept of environment art, and made its ecological, social and economic benefit maximization, and promote the harmonious development of man and nature.

Implementing agencies, practitioners

English, Chinese

Cui, L.J. and S.L. Ai (eds.) (2006) Pp. 226-231 in The Wetland Restoration Handbook: Guiding Principles and Case Studies. China Architecture and Building Press, Beijng.

http://ed.edaw.com/eNewsData/articleDocuments/75332_Wetland%20Handbook%20Launch%20Announcement-eng.PDF

Inland Waters>Wetlands>Europe

LIFE and Europe's Wetlands: Restoring a Vital Ecosystem

Wetland ecosystems hold an important part of Europe's biodiversity. They provide ideal conditions for a vast diversity of habitats and species, and are especially important for birds providing vital nesting and migratory flyway areas. Despite their importance, however, wetlands are disappearing at an alarming rate and are among Europe's most threatened ecosystems. This brochure presents a selection of wetland projects that have received LIFE co-funding since 1992. The majority of case studies focus on the restoration and management of wetlands, while a number also target key wetland species.

Policymakers

Silva, J.P., L. Phillips, W. Jones, J. Eldridge and E. O'Hara (2007) LIFE and Europe's wetlands - restoring a vital ecosystem. European Commission, Environment Directorate-General.

http://ec.europa.eu/environment/life/publications/lifepublications/lifefocus/documents/wetlands.pdf

Ecological Restoration of Wetlands in Europe

Five case-studies of wetland restoration projects that tackle different pressures are further elaborated. These large-scale projects included comprehensive approaches with different inter-related actions to improve the ecological status. Learning points from each case-study are highlighted.

Policymakers, implementing agencies

Coops, H. and G. van Geest (2007) Ecological restoration of wetlands in Europe: significance for implementing the Water Framework Directive in the Netherlands. WL/Delft Hydraulics, The Netherlands.

http://www.boku.ac.at/HFA/lehre/812001/reading/Ecological_restoration_of_wetlands_in_Europe.pdf

Creating Wetlands for the Improvement of Water Quality and Landscape Restoration in Semi-Arid Zones Degraded by Intensive Agricultural Use

Increasing interest in restoring wetlands within a multipurpose approach is observed in degraded lands submitted to intensive human uses. This study evaluates the effectiveness of constructed and natural wetlands in removing nutrients from agricultural wastewater and their potential contribution to landscape heterogeneity in semiarid Monegros area, NE Spain.

Policymakers, implementing agencies

Moreno, D., C. Pedrocchi, F.A. Comin, M. Garcia and A. Cabezas (2007) Creating Wetlands for the Improvement of Water Quality and Landscape Restoration in Semi-Arid Zones Degraded by Intensive Agricultural Use. Ecological Engineering 30(2): 103-111.

http://swamp.osu.edu/Academics/PDFs/Creating%20wetlands%20for%20improvement%20of%20water%20quality.pdf

Hydrological Science and Wetland Restoration: Some Case Studies from Europe

Throughout the world, wetlands are increasingly being recognised as important elements of the landscape because of their high biodiversity and goods and services they provide to mankind.

After many decades of wetland destruction and conversion, large areas of wetlands are now protected under the International Convention on Wetlands (Ramsar) and regional or national legislation such as the European Union Habitats Directive. In many cases, there is a need to restore the ecological character of the wetland through appropriate water management. This paper provides examples of scientific knowledge of wetland hydrology that can guide such restoration. It focuses on the need for sound hydrological science on a range of issues including water level control, topography, flood storage, wetland connections with rivers and sustainability of water supply under climate change.

Implementing agencies, practitioners

Acreman, M.C., J. Fisher, C.J. Stratford, D.J. Mould and J.O. Mountford (2007) Hydrological science and wetland restoration: some case studies from Europe. Hydrology and Earth System Sciences 11(1): 158-169.

http://hal.inria.fr/docs/00/30/56/02/PDF/hess-11-158-2007.pdf

Wetland Restoration in Central Europe: Aims and Methods

Rewetting and oligotrophication are the most common approaches to boost biodiversity in fen ecosystems in Central and Western Europe. Rewetting includes both quantitative and qualitative aspects, requiring quantitative hydrological models and chemical analyses of the groundwater in the region. In addition, re-introduction of species is often necessary, at least in heavily fragmented cultural landscapes. Transfer of hay from donor areas to severely damaged, seed-depleted peatland to restore fen meadows, was successful. However, despite short-term successes, complete restoration of wetland areas requires a long period of time.

Practitioners, implementing agencies

Pfadenhauer, J. and A. Grootjans (1999) Wetland Restoration in Central Europe: Aims and Methods. Applied Vegetation Science 2(1): 95-106.

http://ivem.eldoc.ub.rug.nl/FILES/ivempubs/publart/1999/ApplVegScPfadenhauer/1999ApplVegSciPfadenhauer.pdf

Prospects for Fen Meadow Restoration on Severely Degraded Fens

Due to irreversible changes in landscape settings, hydrology, soil and trophic conditions, a full restoration to natural mires is unlikely. Yet, an improvement of the ecosystem functions and revival of biodiversity in degraded fens is possible. A restoration of semi-natural meadows is one of the alternative targets. Important for restoration efforts to succeed are a sufficient reduction of nutrient levels and preventing acidification. In general, a combination of topsoil removal and seed transfer is an effective measure for fen meadow restoration, provided that groundwater seepage can be re-established. There are also several biotic limitations to fen meadow restoration, due to limited propagule availability of target species and the legacy of the former vegetation in form of its soil seed bank and high seed production by unwanted species. Under the present environmental conditions, the re-development of fen meadows on degraded fens will result in species compositions different from those observed in the past and such restoration may require considerable time and effort.

Practitioners, implementing agencies

Klimkowska, A., R. Van Diggelen, A.P.Grootjans and W.Kotowski (2010) Prospects for Fen Meadow Restoration on Severely Degraded Fens. Perspectives in Plant Ecology, Evolution and Systematics 12: 245-255.

http://ivem.eldoc.ub.rug.nl/FILES/ivempubs/publart/2010/PerspPlEESKlimkowska/2010PerspPlantEcolEvolSystKlimkowska.pdf

Inland Waters>Wetlands>India

Restoration and Management Strategies of Wetlands in Developing Countries

The main objectives of this study were to identify the status of wetlands based on qualitative and quantitative impacts due to urbanization and various anthropogenic activities, and explore suitable restoration, conservation, and management strategies based on pollution level.

Implementing agencies, policymakers

Ramachandra, T.V. (2001) Restoration and Management Strategies of Wetlands in Developing Countries. Electronic Green Journal 15.

http://wgbis.ces.iisc.ernet.in/energy/water/paper/restoration&management/Restoration%20And%20Management.pdf

Inland Waters>Wetlands>Iraq

Restoring the Garden of Eden: An Ecological Assessment of the Marshes of Iraq

The Mesopotamian marshes of southern Iraq had been all but destroyed by Saddam Hussein's regime by the year 2000. Earlier assessments suggested that poor water quality, the presence of toxic materials, and high saline soil conditions in the drained marshes would prevent their ecological restoration and doom the reestablishment of the Marsh Arab culture of fishing and agriculture. However, the high volume of good-quality water entering the marshes from the Tigris and Euphrates Rivers, a result of two record years of snowpack melt in Turkey and Iran, allowed 39% of the former marshes to be reflooded by September 2005. Although reflooding does not guarantee restoration success, our recent field surveys have found a remarkable rate of reestablishment of native macroinvertebrates, macrophytes, fish, and birds in reflooded marshes. However, the future availability of water for restoration is in question, which suggests that only a portion of the former marshes may be restored. Also, landscape connectivity between marshes is greatly reduced, causing concern about local species extinctions and lower diversity in isolated wetlands.

Implementing agencies, indigenous and local communities, policymakers

Richardson, C.J. and N.A. Hussain (2006) Restoring the Garden of Eden: An Ecological Assessment of the Marshes of Iraq. BioScience 56(6): 477-489.

http://www.aibs.org/bioscience-press-releases/resources/B060601.pdf

Inland Waters>Wetlands>Japan

Restoration of Wetland Vegetation Using Soil Seed Banks: Lessons from a Project in Lake Kasumigaura, Japan

A promising revegetation technique is one in which soil seed banks are utilized as the source of plant recolonization. Using such a technique, a pilot project to restore lakeshore vegetation was launched at Lake Kasumigaura, Japan, in 2002. Here, we report lessons learned from the Lake Kasumigaura restoration project as a contribution to the establishment of ecologically sound revegetation techniques.

Practitioners, implementing agencies

Nishihiro, J., M.A. Nishihiro and I. Washitani (2006) Restoration of Wetland Vegetation Using Soil Seed Banks: Lessons from a Project in Lake Kasumigaura, Japan. Landscape Ecol Eng 2: 171-176.

http://pascencio.cos.ucf.edu/classes/Restoration%20Ecology/Pam/Nishihiro%20et%20al.%202006.pdf

Inland Waters>Wetlands>Mexico

Aplicaciones Prácticas para la Conservación y Restauración de Humedales y Otros Ecosistemas Acuáticos

La necesidad de manejar los ecosistemas de manera adecuada para garantizar un provechamiento sostenible de los recursos naturales y la conservacion de la biodiversidad, obliga a incorporar de manera eficiente diversas estrategias.

Implementing agencies, practitioners

Lindig-Cisneros, R. and L. Zambrano (2007) Aplicaciones Prácticas para la Conservación y Restauración de Humedales y Otros Ecosistemas Acuáticos in Sanchez, O. et al (eds.) Perspectivas sobre conservación de ecosistemas acuáticos en México. Instituto Nacional de Ecología, Secretaría de Medio Ambiente y Recursos Naturales, México, D.F.

http://www2.ine.gob.mx/publicaciones/consultaPublicacion.html?id_pub=533

Inland Waters>Wetlands>New Zealand

Handbook for Monitoring Wetland Condition

New Zealand is obliged to monitor the health and condition of wetlands as a signatory to two international conventions (Convention on Biological Diversity and the Ramsar Convention on Wetlands). To assist with these requirements, this handbook describes a set of science-based indicators that have been developed to monitor the condition of New Zealand estuarine and palustrine wetlands. It has been designed for managers, landowners, community groups and anyone else with a need to monitor the condition of wetlands.

Implementing agencies, practitioners, indigenous and local communities

Clarkson, B.R., B.K. Sorrell, P.N. Reeves, P. D. Champion, T.R. Partridge and B.D. Clarkson (2004) Handbook for Monitoring Wetland Condition. A Ministry for the Environment Sustainable Management Fund Project (5105).

http://www.landcareresearch.co.nz/home

Inland Waters>Wetlands>Sweden

Costs and Benefits of Restoring Wetlands: Two Swedish Case Studies

Costs and benefits of restoring wetlands for nonpoint source nitrogen pollution are calculated for two Swedish regions: the Stockholm archipelago and Gotland, an island in the Baltic Sea. Costs for reducing the load of nitrogen to the Stockholm archipelago by measures involving wetlands, agriculture, sewage treatment plants, and air emissions are calculated and compared. The results show that restoration of wetlands may be the least costly measure, SEK 20/kg nitrogen abatement as compared to the next cheapest measure, SEK 25/kg. The results from Gotland indicate that the benefits per unit of investment of restored wetlands may be three times as high as associated benefits of investment in sewage treatment plants. This difference in benefits is due to two factors: the joint production of several environmental services and the self-organizing feature.

Policymakers, implementing agencies

Gren, I-M. (1995) Costs and Benefits of Restoring Wetlands: Two Swedish Case Studies. Ecological Engineering 4(2): 153-162.

http://www.sciencedirect.com/science/article/pii/0925857494000435

Inland Waters>Wetlands>Tanzania

Towards an Ecohydrology-based Restoration of the Usangu Wetlands and the Great Ruaha River, Tanzania

An open channel flow model, calibrated against field data, suggests that cattle intrusion in the eastern Usangu wetlands, as well as both dry and wet weather irrigation upstream, are responsible for the seasonal drying out of the Great Ruaha River (GRR) downstream. This human-induced change has severe socio-economic implications downstream, including hindering hydroelectricity production, as well as a devastating impact on the Ruaha National Park (RNP) ecosystem that is now shifting from wet tropics to dry tropics. To ensure sustainable development, governance is urgently needed for the Usangu catchment in a way that is compatible with ecohydrology principles for the sustainable use of water resources. In order to do that, perennial flow must be restored to the GRR. For this to happen this study suggests that all the livestock must be removed from the eastern Usangu wetlands and dry weather irrigators must return at least 25% (~4 $m^3 s^{-1}$) of the water to the river.

Implementing agencies

Mtahiko, M.G.G., E. Gereta, A.R. Kajuni, E.A.T. Chiombola, G.Z. Ng'umbi, P. Coppolillo and E. Wolanski (2006) Towards an Ecohydrology-based Restoration of the Usangu Wetlands and the Great Ruaha River, Tanzania. Wetlands Ecology and Management 14(6): 489-503.

http://www.springerlink.com/content/y0451184340x666v/

Inland Waters>Wetlands>Trinidad and Tobago

Nariva Swamp Ramsar Site, Trinidad and Tobago (West Indies): Wetland Habitat Restoration Initiative

For many years, the Ramsar Convention has been urging Contracting Parties to take a range of actions in order to promote the restoration of wetlands. However, restoration had been considered a priority mainly by developed countries (e.g., Denmark, The Netherlands, United States), with little being done in less developed countries. In Latin America and the Caribbean, restoration has been or is being carried out, more or less successfully, at a number of other

Ramsar sites (e.g., Santa Marta in Colombia and Palo Verde in Costa Rica). However, these efforts have failed to address the situation in an integral and comprehensive way, not using to their advantage the many instruments available as Contracting Parties to the Ramsar Convention. On the other hand, Trinidad and Tobago not only has used the financial mechanisms available, but also much of the guidance provided through Resolutions and Recommendations adopted by the Conference of the Contracting Parties at their different meetings. Some of these include issues such as wetland policy formulation; revision of laws and institutional structure; involvement of local communities; promotion of communication, education and public awareness; development of environmental impact assessments and management plans; and monitoring of ecological character of wetlands.

Policymakers, implementing agencies

Carbonell, M. and N. Nathai-Gyan (2005) Nariva Swamp Ramsar Site, Trinidad and Tobago (West Indies): Wetland Habitat Restoration Initiative. USDA Forest Service Gen. Tech. Rep. PSW-GTR-191.

http://www.fs.fed.us/psw/publications/documents/psw_gtr191/Asilomar/pdfs/446-449.pdf

http://www.ducks.org/media/Conservation/Conservation_Documents/_documents/Nariva%20Swamp%20Restoration%20Initiative%20Final%20Report.pdf

Inland Waters>Wetlands>UK

Creating New Wetlands: Key Principles and a Project Model

This report reviews real wetland (re-)creation schemes and two theoretical approaches to environmental projects in order to identify best practice and common pitfalls. The results of this review are used to produce a model of wetland (re-)creation which can be used as a template to plan new projects. The model aims to maximise the benefits from new projects and minimize risk of failure.

Implementing agencies, policymakers

Ecology, Land and People (2008) Creating New Wetlands: Key Principles and a Project Model, Broads Authority and Natural England.

http://www.wetlandvision.org.uk/userfiles/File/Creating%20New%20Wetlands%20Final%20Broads.pdf

Inland Waters>Wetlands>USA

Techniques for Restoring Native Plant Communities in Upland and Wetland Prairies in the Midwest and West Coast Regions of North America

After reviewing the scientific literature on prairie restoration in the Midwest and the West Coast regions of the United States, I suggest various restoration techniques for addressing the five objectives, including: cultivation, herbicides, flaming/infrared burning, solarization, carbon addition/nutrient immobilization, mycorrhizal inoculation and implementing various seeding methods and seed mixes. One of the essential lessons learned by restoration ecologists and practitioners trying to restore native prairie, is that there is not one technique or combination of techniques that work for all restoration sites. Restoration techniques will need to be site specific and may depend on many things including past disturbance events, assemblage of plants, including non-natives and natives, and site conditions such as soils, topography, hydrology, and climate.

Practitioners

Fitzpatrick, G.S. (2004) Techniques for Restoring Native Plant Communities in Upland and Wetland Prairies in the Midwest and West Coast Regions of North America. The Nature Conservancy White Paper.

https://www.zotero.org/bohsowski/items/itemKey/4EUNGQGD#./4EUNGQGD?&_suid=1344360179726009857622622253892

Restoring Prairie Pothole Wetlands: Does the Species Pool Concept Offer Decision-Making Guidance for Re-Vegetation?

Do regional species pools, landscape isolation or on-site constraints cause plants from different guilds to vary in their ability to colonize restored wetlands? Abiotic constraints seem to limit the colonization of floating/submersed aquatics into natural or restored wetlands, whereas all other guilds are potentially constrained by dispersal or biotic factors (i.e. competition from invasive species). Using species pools to evaluate restoration progress revealed that immigration potential varies considerably among guilds, that local species richness does not necessarily correspond to immigration limitations, and that some guilds (e.g. sedge-meadow perennials) will likely benefit more than others from being planted at restoration sites.

Practitioners, implementing agencies

Galatowitsch, S.M. (2006) Restoring Prairie Pothole Wetlands: Does the Species Pool Concept Offer Decision-Making Guidance for Re-Vegetation? Applied Vegetation Science 9(2): 261-270.

http://onlinelibrary.wiley.com/doi/10.1111/j.1654-109X.2006.tb00675.x/abstract

Heroic Tales of Wetland Restoration

Heroic Tales of Wetland Restoration tells of 12 rural landowners, who changed their farming practices to reclaim wetlands, streams and rivers. Their stories span Oregon from the Columbia River to Cape Blanco, and Bonanza to Bear Valley. They have worked hard to restore oxbows, lush with sedges and cattails, forging partnerships with landowners, state and federal agencies, non-profits and community groups.

Indigenous and local communities, practitioners

Lev, E. (2001) Heroic Tales of Wetland Restoration. The Wetlands Conservancy.

http://oregonwetlands.net/index.php?option=com_content&view=article&id=73&Itemid=82

3. Landscape-Scale Tools and Technologies

Insights Gained from Succession for the Restoration of Landscape Structure and Function

The study of succession provides valuable lessons for improving the quality of restoration programs. These lessons suggest that restoration tactics should focus on site amelioration, improving establishment success, and protecting desirable species from herbivory and competition during their development. Incorporation of physical heterogeneity in the early stages will foster mosaics of vegetation that better mimic natural landscapes.

Practitioners, implementing agencies

del Moral, R., L. R. Walker and J. P. Bakker (2007) Insights Gained from Succession for the Restoration of Landscape Structure and Function. Pp. 19-44 in Linking restoration and succession in theory and in practice (L.R. Walker, J. Walker and R.J. Hobbs (eds.)), Springer.

http://faculty.washington.edu/moral/publications/2007%20del%20MoralWalkerBakker.pdf

Identifying Cost-effective Hotspots for Restoring Natural Capital and Enhancing Landscape Multifunctionality

Much effort is expended toward planning for conservation, natural resource management and sustainable land use in agricultural landscapes. Although often not explicitly stated, the aims of these efforts are often to restore natural capital for the provision of ecosystem services and stimulate multifunctionality in landscapes. However, the scarcity of resources for, and the potential economic impact of, ameliorative actions that restore natural capital necessitates the identification of cost-effective geographic priorities, or hotspots, which provide multiple ecosystem goods and services. This requires the integrated spatial modelling of multiple environmental and economic processes accompanied by clear goals and performance indicators. Identification of hotspots provides guidance for highly targeted land use change that cost-effectively adds to the stocks of natural capital in a landscape.

Policymakers, implementing agencies

Crossman, N.D. and B.A. Bryan (2009) Identifying Cost-effective Hotspots for Restoring Natural Capital and Enhancing Landscape Multifunctionality. Ecological Economics 68(3): 654-668.

http://www.sciencedirect.com/science/article/pii/S0921800908002097

Creating Multifunctional Landscapes: How Can the Field of Ecology Inform the Design of the Landscape?

Here, we propose a process for designing multifunctional landscapes, guided by ecological principles in the following steps: (1) defining the project site and landscape context, (2) analyzing landscape structure and function, (3) master planning using an ecosystem approach, (4) designing sites to highlight ecological functions, and (5) monitoring ecological functions. The development of a framework for ecological design of landscapes demonstrates the importance of a multi-scale approach for connecting sites to their surroundings, the benefits of a multifunctional design for sustainability, and the value of involving ecologists throughout the entire design process.

Implementing agencies

Lovell, S.T. and D.M. Johnston (2009) Creating Multifunctional Landscapes: How Can the Field of Ecology Inform the Design of the Landscape? Frontiers in Ecology and the Environment 7(4): 212-220.

http://sequoia.bot.uc.pt/link/files/artigo_revista_frontiers_in_ecology_and_the_environment_helena_freitas.pdf

Designing Landscapes for Performance Based on Emerging Principles in Landscape Ecology

We have proposed a framework for transforming landscapes to improve performance by integrating ecological principles into landscape design. This effort would focus on the development of multifunctional landscapes, guided by the rapidly growing knowledge base of ecosystem services provided by landscape features. Although the conventional approach to landscape ecology is based on a model that assumes poor ecological quality in the human-dominated matrix, a review of recent literature reveals important opportunities to improve the quality of the landscape matrix by increasing spatial heterogeneity through the addition of seminatural landscape elements designed to provide multiple ecosystem services.

Implementing agencies, practitioners

Lovell, S.T. and D.M. Johnston (2009) Designing landscapes for performance based on emerging principles in landscape ecology. Ecology and Society 14(1).

http://www.ecologyandsociety.org/vol14/iss1/art44/ES-2009-2912.pdf

Modeling Multiple Ecosystem Services, Biodiversity Conservation, Commodity Production, and Tradeoffs at Landscape Scales

We use a spatially explicit modeling tool, Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST), to predict changes in ecosystem services, biodiversity conservation, and commodity production levels. We apply InVEST to stakeholder-defined scenarios of land-use/land-cover change in the Willamette Basin, Oregon. We found that scenarios that received high scores for a variety of ecosystem services also had high scores for biodiversity, suggesting there is little tradeoff between biodiversity conservation and ecosystem services. Scenarios involving more development had higher commodity production values, but lower levels of biodiversity conservation and ecosystem services. However, including payments for carbon sequestration alleviates this tradeoff. Quantifying ecosystem services in a spatially explicit manner, and analyzing tradeoffs between them, can help to make natural resource decisions more effective, efficient, and defensible.

Implementing agencies, policymakers

Nelson, E. et al. (2009) Modeling Multiple Ecosystem Services, Biodiversity Conservation, Commodity Production, and Tradeoffs at Landscape Scales. Frontiers in Ecology and the Environment 7(1): 4-11.

http://www.loicz.org/imperia/md/content/dahlem/nelson_et_al__2009_.pdf

Assessment & Planning for Ecological Connectivity: A Practical Guide

The guidance in this document was derived from extensive literature review and the collective wisdom of participants in the Wildlife Conservation Society's (WCS) "Best Science" for ecological connectivity held in Boulder Colorado. It is our intention to provide a quick summary of the current state of connectivity science and offer practical guidance on the best practices, tools and important considerations for conducting a science based connectivity assessment and integrating that into conservation planning. The focus of our guidance is toward terrestrial ecosystem management but many of the principles apply to conserving aquatic connectivity which is extremely important from a global and regional perspective.

Implementing agencies, practitioners

Aune, K., P. Beier, J. Hilty and F. Shilling (2011) Assessment & Planning for Ecological Connectivity: A Practical Guide. The Wildlife Conservation Society, Bozeman.

http://www.wcs-ahead.org/kaza/ecological_connectivity_07_20_11_2.pdf

Conservation Planning for Connectivity across Marine, Freshwater, and Terrestrial Realms

We present a conceptual framework for systematic conservation prioritization that explicitly accounts for the connectivity between the terrestrial, marine, and freshwater realms. We propose a classification of this connectivity that encompasses: (1) narrow interfaces, such as riparian strips; (2) broad interfaces, such as estuaries; (3) constrained connections, such as corridors of native vegetation used by amphibians to move between natal ponds and adult habitat; and (4) diffuse connections, such as the movements of animals between breeding and feeding habitats. We use this taxonomy of inter-realm connectivity to describe existing and new spatial conservation prioritization techniques that aim to promote the persistence of processes that operate between realms.

Implementing agencies, policymakers

Beger, M. et al. (2010) Conservation Planning for Connectivity across Marine, Freshwater, and Terrestrial Realms. Biological Conservation 143: 565-575.

http://www.sciencedirect.com/science/article/pii/S0006320709004716

Biodiversity, Ecosystem Function, and Resilience: Ten Guiding Principles for Commodity Production Landscapes

We suggest ten guiding principles to help maintain biodiversity, ecosystem function, and resilience in production landscapes. Landscapes should include structurally characteristic patches of native vegetation, corridors and stepping stones between them, a structurally complex matrix, and buffers around sensitive areas. Management should maintain a diversity of species within and across functional groups. Highly focused management actions may be required to maintain keystone species and threatened species, and to control invasive species. These guiding principles provide a scientifically defensible starting point for the integration of conservation and production, which is urgently required from both an ecological and a long-term economic perspective.

Policymakers, implementing agencies

Fischer, J., D.B. Lindenmayer and A.D. Manning (2006) Biodiversity, Ecosystem Function, and Resilience: Ten Guiding Principles for Commodity Production Landscapes. Front Ecol Environ 4(2): 80-86.

http://www.cfr.washington.edu/classes.esrm.201su/Reading%20assignments/Readings/Fischer.pdf

Linking Restoration and Landscape Ecology

Landscape ecology focuses on questions typically addressed over broad spatial scales. A landscape approach embraces spatial heterogeneity, consisting of a number of ecosystems and/or landscape structures of different types, as a central theme. Such studies may aid restoration efforts in a variety of ways, including (1) provision of better guidance for selecting reference sites and establishing project goals and (2) suggestions for appropriate spatial configurations of restored elements to facilitate recruitment of flora/fauna. Likewise, restoration efforts may assist landscape-level studies, given that restored habitats, possessing various patch arrangements or being established among landscapes of varying diversity and conditions of human alteration, can provide extraordinary opportunities for experimentation over a large spatial scale.

Implementing agencies, practitioners

Bell, S.S., M.S. Fonseca and L.B. Motten (1997) Linking Restoration and Landscape Ecology. Restoration Ecology 5(4): 318-323.

http://www.esalq.usp.br/lcb/lerf/divulgacao/recomendados/artigos/bell1997.pdf

Thinking Big with Whole-Ecosystem Studies and Ecosystem Restoration: A Legacy of H.T. Odum

More recently we have been engaged in whole-ecosystem experiments, partially inspired by the work of Odum, at created wetlands in northeastern Illinois to investigate effects of water turnover on ecosystem function and in Ohio to provide insight on the long-range large-scale effects of hydrology and macrophyte planting on ecosystem function. We have also carried out major ecosystem-scale studies in coastal Louisiana, investigating the value of these ecological systems in treating wastewater and restoring lost landscape in coastal Louisiana. These studies in the Midwest and Mississippi delta form the basis of determining design standards on creating and restoring wetlands in the Mississippi River Basin to reduce the Gulf of Mexico hypoxia and regain many lost ecosystem functions over a large part of North America.

Policymakers, implementing agencies

Mitsch, W.J. and J.W Day Jr. (2004) Thinking Big with Whole-Ecosystem Studies and Ecosystem Restoration: A Legacy of H.T. Odum. Ecological Modelling 178(1-2): 133-155.

http://www.sciencedirect.com/science/article/pii/S0304380003005441

When and Where to Actively Restore Ecosystems?

We recommend that all land managers consider a suite of ecological and human factors before selecting a restoration approach. Land managers should first consider what the likely outcome of a passive restoration (natural regeneration) approach would be based on the natural ecosystem resilience, past land-use history, and the surrounding landscape matrix. They should also identify the specific goals of the project and assess the resources available. Conducting these analyses prior to selecting restoration approaches should result in a more efficient use of restoration resources both within and among projects and should maximize the success of restoration efforts.

Implementing agencies, policymakers, indigenous an d local communities

Holl,K.D. and T.M. Aide (2011) When and Where to Actively Restore Ecosystems? Forest Ecology and Management 261(10): 1558-1563.

http://tcel.uprrp.edu/Publications_files/Holl%26Aide2010.pdf

A General Framework for Prioritizing Land Units for Ecological Protection and Restoration

Our objective in this paper is to provide such a framework for cases where the goal of setting priorities is to maximize the ecological benefit gained from limited resources. We provide simple and general models that can be used to prioritize sites based on the projected ecological benefit per unit restoration or protection effort and to estimate the total projected benefit of restoring or protecting a set of sites. These models, which are based on an expression of the functional relationship between an end point and effort, hold up under a variety of situations and provide a common language for prioritization. We then discuss procedures for estimating model terms—calculations from regression curves when data are available, and use of judgement indicators when data are relatively limited. Finally, we present two case studies that apply the models and examine selected past prioritizations in the context of our framework.

Policymakers, implementing agencies

Hyman, J.B. and S.G. Leibowitz (2000) A General Framework for Prioritizing Land Units for Ecological Protection and Restoration. Environmental Management 25(1): 23-35.

http://archive.li.suu.edu/docs/ms130/AR/hyman.pdf

Landscape Restoration: Moving from Generalities to Methodologies

Large-scale, landscape-level restoration actions are widely implemented but receive little attention from academic ecologists. We review the methods used to assess the role of these processes in past studies, and suggest ways to use past and ongoing restoration activities to increase our understanding of large-scale processes and improve restoration projects. To make better use of past restoration, we recommend the use of a number of alternative analytical approaches that have become widely applied in conservation biology and wildlife management but have yet to be adopted in restoration ecology.

Implementing agencies, policymakers

Holl, K.D., E.E. Crone and C.B. Schultz (2003) Landscape Restoration: Moving from Generalities to Methodologies. BioScience 53(5): 491-502.

http://people.ucsc.edu/~kholl/landscape.pdf

Using Landscape Hierarchies to Guide Restoration of Disturbed Ecosystems

Hierarchy theory provides a conceptual approach for predicting plant communities of disturbed ecosystems and, ultimately, for prioritizing restoration efforts. We demonstrate this approach using a landscape in southwestern Georgia, USA. Specifically, we used an existing hierarchical ecosystem classification, based on geomorphology, soil, and vegetation, to identify reference plant communities for each type of ecosystem in the landscape.

Implementing agencies, policymakers

Palik,B.J., P.C. Goebel, L.K. Kirkman and L. West (2000) Using Landscape Hierarchies to Guide Restoration of Disturbed Ecosystems. Ecological Applications 10(1): 189-202.

http://nrs.fs.fed.us/pubs/jrnl/2000/nc_2000_Palik_001.pdf

Systematic Landscape Restoration Using Integer Programming

In some agricultural regions, reservation of remnant natural lands will not maintain the natural biodiversity and large-scale ecological restoration is required. Geographic planning for restoration is essential to obtain the maximum ecological benefit from the limited resources available for landscape restoration. In this paper, we present a proof of concept that implements principles of systematic conservation planning, such as adequacy, representativeness, efficiency and flexibility, within an integer programming framework to identify geographic priorities for landscape restoration in a small catchment in South Australia.

Implementing agencies

Crossman, N.D. B.A. Bryan (2006) Systematic Landscape Restoration using Integer Programming. Biological Conservation 128: 369-383.

http://user.infor.org/~n0057/temp/06040811432428678.pdf

A Role for Assisted Evolution in Designing Native Plant Materials for Domesticated Landscapes

Developers of native plant propagation materials for wildland restoration may emphasize naturally occurring genetic patterns or, in contrast, the material's empirical performance in comparative field trials. We contend that both approaches have value and need not be mutually exclusive. Anthropogenic influences have pushed many ecosystems across ecological thresholds, to less desirable states, so that actively managing for "domesticated nature" – nature as modified, either intentionally or inadvertently, by humans – is more realistic and more likely to succeed than recreating the original ecosystem.

Implementing agencies, practitioners

Jones, T.A. and T.A. Monaco (2009) A Role for Assisted Evolution in Designing Native Plant Materials for Domesticated Landscapes. Front Ecol Environ 7(10): 541-547.

http://ddr.nal.usda.gov/dspace/bitstream/10113/40130/1/IND44344795.pdf

Negative Off-Site Impacts of Ecological Restoration: Understanding and Addressing the Conflict

Ecological restoration is a key component of biological conservation. Nevertheless, unlike protection of existing areas, restoration changes existing land use and can therefore be more controversial. Some restoration projects negatively affect surrounding landowners, creating social constraints to restoration success. Just as negative off-site impacts (i.e., negative externalities) flow from industrial areas to natural areas, restoration projects can generate negative externalities for commercial land uses, such as agriculture. Restoration planners should give equal consideration to off-site characteristics as to on-site characteristics when choosing sites for restoration and designing projects. Efforts to control externalities can lead to off-site ecological benefits.

Implementing agencies

Bucklet, M.C. and E.E. Crone (2008) Negative Off-Site Impacts of Ecological Restoration: Understanding and Addressing the Conflict. Conservation Biology 22: 1118-1124.

http://onlinelibrary.wiley.com/doi/10.1111/j.1523-1739.2008.01027.x/pdf

The Bowral Checklist: A Framework for Ecological Management of Landscapes

A group of leading landscape ecologists and conservation biologists came together in Bowral in 2006 to discuss whether it was possible to create such a checklist. They identified 12 important issues that need to be considered in developing approaches to landscape conservation, a set referred to as the Bowral Checklist. Issues appearing in the framework include recognising the importance of landscape mosaics (including the integration of terrestrial and aquatic areas), recognising interactions between vegetation cover and vegetation configuration, using an appropriate landscape conceptual model, maintaining the capacity to recover from disturbance, and managing landscapes in an adaptive framework. These considerations are influenced by landscape context and management goals and do not, therefore, translate directly into on-the-ground management guidelines. Rather, they should be used as a framework by researchers and resource managers when developing guidelines for specific cases.

Implementing agencies, practitioners

Salt, D. and D. Lindenmayer (2008) The Bowral Checklist: A framework for ecological management of landscapes. Land & Water Australia.

http://www.forestlandscaperestoration.org/media/uploads/File/Selected%20readings/bowral%20checklist.pdf

A Checklist for Ecological Management of Landscapes for Conservation

We assess six major themes in the ecology and conservation of landscapes. We identify 13 important issues that need to be considered in developing approaches to landscape conservation. They include recognizing the importance of landscape mosaics (including the integration of terrestrial and aquatic areas), recognizing interactions between vegetation cover and vegetation configuration, using an appropriate landscape conceptual model, maintaining the capacity to recover from disturbance and managing landscapes in an adaptive framework. These considerations are influenced by landscape context, species assemblages and management goals and do not translate directly into on-the-ground management guidelines but they should be recognized by researchers and resource managers when developing guidelines for specific cases. Two crucial overarching issues are: (i) a clearly articulated vision for landscape conservation and (ii) quantifiable objectives that offer unambiguous signposts for measuring progress.

Implementing agencies, policymakers

Lindenmayer, D. et al. (2008) A Checklist for Ecological Management of Landscapes for Conservation. Ecology Letters 11: 78-91.

http://134.117.48.8/PDF/landPub/08/08LindenmayeretalEcolLetters.pdf

Contribution of Ecosystem Restoration to the Objectives of the CBD and a Healthy Planet for All People

The tenth meeting of the Conference of the Parties to the Convention on Biological Diversity adopted the Strategic Plan for Biodiversity 2011-2020 and the 20 Aichi Biodiversity Targets as the overarching biodiversity framework for the world community. In adopting the Strategic Plan, countries noted the importance of health and restoration by explicitly referring to them in both the vision and mission of the Strategy. Furthermore, target 14 of the Aichi Biodiversity Targets directly relates to ecosystem restoration and its contribution to health and well-being, while target 15 identifies restoration as a means to contribute to climate change adaptation and mitigation and to combating desertification. Restoration can also make important contributions to the attainment of many other Aichi Biodiversity Targets.

Practitioners, implementing agencies

Secretariat of the Convention on Biological Diversity (2011). Contribution of Ecosystem Restoration to the Objectives of the CBD and a Healthy Planet for All People. Abstracts of Posters Presented at the 15th Meeting of the Subsidiary Body on Scientific, Technical and Technological Advice of the Convention on Biological Diversity, 7-11 November 2011, Montreal, Canada. Technical Series No. 62. Montreal.

http://www.cbd.int/doc/publications/cbd-ts-62-en.pdf

Adaptive Management

Adaptive Management: The U.S. Department of the Interior Applications Guide

This applications guide builds on the framework of the DOI Adaptive Management Technical Guide (2007), which describes adaptive management in terms of learning-based management of natural resources. In this guide, we use case studies to show how adaptive management can be used for both management and learning. We focus on practical applications in the areas of importance to DOI managers – climate change, water, energy, and human impacts on the landscape. We present adaptive management as a form of structured decision making, with an emphasis on the value of reducing uncertainty over time in order to improve management. The first half of the guide covers the foundations and challenges of adaptive management, and the second half documents examples that illustrate the components of adaptive management.

Practitioners, implementing agencies

Williams, B.K. and E.D. Brown (2012) Adaptive Management: The U.S. Department of the Interior Applications Guide. Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC.

http://www.doi.gov/ppa/upload/DOI-Adapative-Management-Applications-Guide.pdf

Adaptive Management

Don't wait for a cookbook for adaptive management. People learn and adapt in many ways, and the process of learning and adapting must also evolve over time. We define a range of learning and adapting strategies that can be combined into effective solutions for the great diversity of ecosystems and possible manager–scientist–citizen partnerships. We are advocating that adaptive management become an expanded focus on learning about—and adapting to—changes in society's needs and wants and in ecological capacity.

Practitioners, implementing agencies

Bormann, B.T., J.R. Martin, F.H. Wagner, G.W. Wood, J. Alegria, P.G. Cunningham, M.H. Brookes, P. Friesema, J. Berg and J.R. Henshaw (1999) Adaptive Management in NC Johnson et al. (eds.) Ecological Stewardship: A Common Reference for Ecosystem Management. Elsevier.

ftp://blm-92-59.blm.gov/pub/blmlibrary/BLMpublications/AdaptiveManagement/AdaptiveMgmtTechGuide/CDReferences/Bormann_1999_Adaptive%20Management%20Chapter_Ecological%20Stewards.pdf

Adaptive Management: A Synthesis of Current Understanding and Effective Application

Here, we trace and review the development of AM, the central roles of consultation, collaboration and of monitoring, and of quantitative models and simulations. We identify a series of formalized, structured steps included in one AM cycle and review how current AM programs build upon such cycles. We conclude that the best AM outcomes require rigorous and formalized approaches to planning, collaboration, modelling and evaluation. Finally, simulating potential outcomes of an AM cycle in the presence of existing uncertainty can help to identify management strategies that are most likely to succeed in relation to clearly articulated goals.

Implementing agencies, practitioners

Schreiber, E.S.G., A.R. Bearlin, S.J. Nicol and C.R. Todd (2004) Adaptive Management: A Synthesis of Current Understanding and Effective Application. Ecological Management and Restoration 5(3): 177-182.

ftp://ftp2.fs.fed.us/incoming/r5/Science/Schreiber%20et%20al%20%202004%20(adaptive%20management%20-%20synthesis).pdf

Adaptive Management and Ecological Restoration

Most people involved in resource management have heard of adaptive management (AM), and many claim to practice it, but few seem to really understand it. Many have a general notion that it involves adapting policies and procedures based on results, but it is a misperception that AM simply comprises “adapting as you go” based on trial and error. In this chapter we intend to shed some light on this tremendously powerful tool and to illustrate its enormous benefits for ecosystem restoration.

Implementing agencies, practitioners

Murray, C. and D. Marmorek (2003) Adaptive Management and Ecological Restoration. Pp. 417-428 in Freiderici, P. (ed.) Ecological Restoration of Southwestern Ponderosa Pine Forests. Island Press, Washington, DC.

http://geta.lunariffic.com/~inter407/essamain/wp-content/uploads/2010/09/Murray___Marmorek_Ponderosa_Pine_2003.pdf

Evaluating the Efficacy of Adaptive Management Approaches: Is There a Formula for Success?

We evaluated peer-reviewed literature focused on incorporation of adaptive management to identify components of successful adaptive management plans. Our evaluation included adaptive management elements such as stakeholder involvement, definitions of management objectives and actions, use and complexity of predictive models, and the sequence in which these elements were applied. We also defined a scale of degrees of success to make comparisons between the two adaptive management schools of thought.

Practitioners, implementing agencies

McFadden, J.E., T.L. Hiller and A.J. Tyre (2011) Evaluating the efficacy of adaptive management approaches: Is there a formula for success? Journal of Environmental Management 92: 1354-1359.

http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1303&context=natrespapers

Successful Adaptive Management: The Integration of Research and Management

We argue that there are 2 strategies that can be used to improve the success of adaptive management. The first is to start with a simple adaptive management plan and then add complexity over time. The second is to include researchers in all stages of the process to benefit from their expertise in ecology, experimental design, and data analysis. Although adaptive management takes time, rewards include increased understanding of the system, a management program that is scientifically valid, and a management strategy tailored to a particular site. In this paper we briefly explain adaptive management and then offer a step-by-step process for developing and implementing adaptive management in small reserves or on private lands. We believe increased understanding of adaptive management will lead to its widespread use and will ensure that more people benefit from its strengths.

Practitioners, implementing agencies

Reever Morghan, K.J., R.L. Sheley and T.J. Svejcar (2011) Successful Adaptive Management: The Integration of Research and Management. Rangeland Ecol Manage 59: 216–219.

http://ddr.nal.usda.gov/dspace/bitstream/10113/134/1/IND43867424.pdf

Adaptive Management for a Turbulent Future

The challenges that face humanity today differ from the past because as the scale of human influence has increased, our biggest challenges have become global in nature, and formerly local problems that could be addressed by shifting populations or switching resources, now aggregate (i.e., "scale up") limiting potential management options. Adaptive management is an approach to natural resource management that emphasizes learning through management based on the philosophy that knowledge is incomplete and much of what we think we know is actually wrong.

Implementing agencies, practitioners

Allen, C.R., J.J. Fontaine, K.L. Pope and A.S. Garmestani (2011) Adaptive Management for a Turbulent Future. Journal of Environmental Management 92: 1339-1345.

http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1079&context=ncfwrustaff

Ecological Restoration: Guidance from Theory

A review of the science and practice of ecosystem restoration led me to identify key ecological theories and concepts that are relevant to planning, implementing, and sustaining restoration efforts. From experience with actual restoration projects, I provide guidance for improving the restoration process. Despite an abundance of theory and guidance, restoration goals are not always achieved, and pathways toward targets are not highly predictable. This is understandable, since each restoration project has many constraints and unique challenges. To improve restoration progress, I advise that sites be designed as experiments to allow learning while doing. At least the larger projects can be restored in phases, each designed as experimental treatments to test alternative restoration approaches. Subsequent phases can then adopt one or more of the treatments that best achieved goals in earlier phases while applying new tests of other restoration measures. Both science and restoration can progress simultaneously. This phased, experimental approach (called "adaptive restoration") is an effective tool for improving restoration when monitoring, assessment, interpretation and research are integrated into the process.

Implementing agencies, practitioners

Zedler, J.B. (2005) Ecological restoration: guidance from theory. San Francisco Estuary and Watershed Sciences 3:2.

http://escholarship.org/uc/item/707064n0#page-1

A Framework for Risk Analysis in Ecological Restoration Projects

This report is a framework document that provides the general planner with a basic understanding of risk analysis in the USACE six-step ecosystem restoration planning process. The USACE objective in ecosystem restoration, one of the primary missions of the USACE Civil Works program, is to contribute to national ecosystem restoration by measurably increasing the net quantity and/or quality of desired ecosystem resources. The focus of this report is on risk analysis: identifying the range of possible outcomes from alternative ecosystem restoration actions, assessing the potential for achieving the desired outcome, characterizing the likelihood of adverse consequences, and communicating these findings to stakeholders and decision makers.

Policymakers, implementing agencies, indigenous and local communities

Thom, R.M., H.L. Diefenderfer, and K.D. Hofseth (2004) A Framework for Risk Analysis in Ecological Restoration Projects. Prepared for the U.S. Department of Energy under Contract DE-AC06-76RL01830.

http://ccrm.berkeley.edu/resin/pdfs_and_other_docs/background-lit/FrameworkRiskAnalysisEcologicalRestorationProjects.pdf

Adaptive Management>Coastal/Marine

Aspects of Adaptive Management of Coastal Wetlands: Case Studies of Processes, Conservation, Restoration, Impacts and Assessment

Coastal wetlands are dynamic and include the freshwater-intertidal interface. In many parts of the world such wetlands are under pressure from increasing human populations and from predicted sea-level rise. Their complexity and the limited knowledge of processes operating in these systems combine to make them a management challenge. Adaptive management is advocated for complex ecosystem management. Adaptive management identifies management aims, makes an inventory/environmental assessment, plans management actions, implements these, assesses outcomes, and provides feedback to iterate the process. This allows for a dynamic management system that is responsive to change.

Implementing agencies, practitioners

Dale, P.E.R., M.B. Dale, J. Anorov, J. Knight, M.C. Minno, B. Powell, R.C. Raynie and J.M. Visser (2006) Aspects of Adaptive Management of Coastal Wetlands: Case Studies of Processes, Conservation, Restoration, Impacts and Assessment. Ecological Studies 191(2): 197-222.

http://www.springerlink.com/content/nq67q00833476lm2/

Adaptive Management of Coastal Ecosystem Restoration Projects

The three main ingredients of an effective adaptive management plan in a restoration project are: 1. a clear goal statement; 2. a conceptual model; and 3. a decision framework. The goal 'drives' the design of the project and helps guide the development of performance criteria. The goal statement and performance criteria provide the means by which the system can be judged. With the conceptual model, the knowledge base from the field of ecological science plays an active and critical role in designing the project to meet the goal. A system-development matrix provides a simple decision framework to view the alternative states for the system during development, incorporate knowledge gained through the monitoring program, and formulate a decision on actions to take if the system is not meeting its goal.

Implementing agencies, practitioners

Thom, R.M. (2000) Adaptive Management of Coastal Ecosystem Restoration Projects. Ecological Engineering 15: 365-372.

http://www.ci.bainbridge-isl.wa.us/documents/pln/2011_smp_reference3/thom_rm_adaptive_mgmt_of_coastal_ecosystem_restoration_projects.pdf

Adaptive Restoration of Sand-mined Areas for Biological Conservation

Adaptive management approaches to ecological restoration are current best practice. The usefulness of such an approach was tested in this study by implementing repeated experiments that examined restoration options for derelict sand mine sites dominated by Imperata cylindrica. Reclamation of degraded land that is dominated by I. cylindrica is a common problem throughout the tropics. Taken together, these experiments support the hypothesis that there is a barrier restricting regeneration of native woody cover, and the barrier probably comprises both abiotic and biotic components. By adopting an adaptive management approach to the ecological restoration of sites, significant insights into their management requirements have been gained, supporting the current best practice restoration framework. Insights gained through monitoring and adaptation will be used to update the reserve plan of management, enhancing restoration of this severely degraded area and promoting connectivity of native woody cover within the conservation estate.

Implementing agencies

Cummings, J., N. Reid, I. Davies and C. Grant (2005) Adaptive restoration of sand-mined areas for biological conservation. Journal of Applied Ecology 42: 160-170.

http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2664.2005.01003.x/pdf

Success Criteria and Adaptive Management for a Large-Scale Wetland Restoration Project

The criteria for success of the project address two questions: What is the "'bound of expectation" for restoration success, and how long will it take to get there? Measurements to be made are macrophyte production, vegetation composition, benthic algal production, and drainage features including stream order, drainage density, channel length, bifurcation ratios and sinuosity. A method for combining these individual parameters into a single success index is also presented. Finally, we developed adaptive management thresholds and corrective measures to guide the restoration process.

Implementing agencies, practitioners

Weinstein, M.P., J.H. Balletto, J.M. Teal and D.F. Ludwig (1997) Success Criteria and Adaptive Management for a Large-Scale Wetland Restoration Project. Wetlands Ecology and Management 4(2): 111-127.

http://www.montclair.edu/profilepages/media/1992/user/Restoration_Success_Criteria1997.pdf

Conceptual Models and Adaptive Management in Ecological Restoration: The CALFED Bay-Delta Environmental Restoration Program

The CALFED Environmental Restoration Program is an element of a comprehensive effort to address water supply, water quality, flood risk, and ecosystem integrity in California's central valley and San Francisco Bay estuary. The program is based on two key features—a whole ecosystem approach and an adaptive management strategy. To be successful, the program must have a foundation of scientifically defensible models of the system to be managed that incorporate both ecological and sociological opportunities and constraints. This paper describes conceptual models at multiple spatial and temporal scales that support the restoration efforts, and describes the adaptive management that will accompany on-the-ground actions.

Implementing agencies, practitioners

Healey, M.C. (2004) Conceptual Models and Adaptive Management in Ecological Restoration: The CALFED Bay-Delta Environmental Restoration Program.

http://calwater.ca.gov/content/Documents/library/ERP/Big_Model_Paper_5-3-04.pdf

CERP Adaptive Management Integration Guide

The CERP Adaptive Management Integration Guide (Guide) was designed to help CERP project teams, managers, scientists, and other stakeholders understand and integrate adaptive management to make sound, collaborative decisions. The Guide is designed to be a more detailed companion document to the Adaptive Management Strategy. The Guide describes how to apply adaptive management to the CERP program and its related projects by identifying key uncertainties and incorporating adaptive management activities into existing CERP planning and implementation processes. The CERP Adaptive Management Strategy provides a high-level framework for the application of adaptive management to Everglades restoration.

Implementing agencies, practitioners

RECOVER (2010) CERP Adaptive Management Integration Guide. Restoration Coordination and Verification, C/O U.S. Army Corps of Engineers, Jacksonville District, Jacksonville, FL and South Florida Water Management District, West Palm Beach.

http://www.evergladesplan.org/pm/program_docs/adaptive_mgmt.aspx

Adaptive Management>Drylands

From Scientific Speculation to Effective Adaptive Management: A Case Study of the Role of Social Marketing in Promoting Novel Restoration Strategies for Degraded Dry Lands

This article focuses on the role of social marketing, in particular the analysis of the motivations and capabilities of stakeholder groups, in encouraging acceptance of an innovative experimental approach to semiarid shrub land restoration in Chile. Controlled scientific experiments involving herbivory control during El Niño events have proved promising, but have not yet been introduced into ecosystem management approaches. Social marketing, as a lens for focusing on and understanding stakeholders' motivations, provides a valuable framework in which strategies may be developed for diffusing promising scientific experiments into regional management contexts.

Implementing agencies

Westley, F., M. Holmgren and M. Scheffer (2010) From scientific speculation to effective adaptive management: a case study of the role of social marketing in promoting novel restoration strategies for degraded dry lands. Ecology and Society 15(3).

http://www.ecologyandsociety.org/vol15/iss3/art6/

Adaptive Management>Forest Landscapes

Adaptive Management is One of the Key Elements of Forest Landscape Restoration

This article proposes the adoption of an adaptive management approach to enable forest landscape restoration practitioners to respond to the dynamics found in natural and socioeconomic systems.

English, French, Spanish

Gilmour, D. (2005) Adaptive management is one of the key elements of forest landscape restoration. ITTO Tropical Forest Update 15/2.

http://www.itto.int/Legislation/regulations/id=10080000

Adaptive Management>Inland Waters

The Use of Conceptual Models to Guide Ecosystem Restoration in South Florida

A set of conceptual ecological models has been developed for South Florida restoration as a framework for supporting integration of science and policy and are key components of an Adaptive Management Program being developed for the Comprehensive Everglades Restoration Plan. Other large-scale restoration programs also use conceptual ecological models. This special edition of Wetlands presents 11 South Florida regional models, one total system model for South Florida, and one international regional model. This paper provides an overview of these models and defines conceptual ecological model components. It also provides a brief history of South Florida's natural systems and summarizes components common to many of the regional models.

Implementing agencies, practitioners

Ogden, J.C., S.M. Davis, K.J. Jacobs, T. Barnes and H.E. Fling (2005) The Use of Conceptual Models to Guide Ecosystem Restoration in South Florida. Wetlands 25(4): 795-809.

ftp://ftp.blm.gov/pub/blmlibrary/BLMpublications/AdaptiveManagement/AdaptiveMgmtTechGuide/CDReferences/Use%20of%20conceptual%20models.pdf

Adaptive Management>Species Re-Introductions

An Introduction to Adaptive Management for Threatened and Endangered Species

Management of threatened and endangered species would seem to be a perfect context for adaptive management. Many of the decisions are recurrent and plagued by uncertainty, exactly the conditions that warrant an adaptive approach. But although the potential of adaptive management in these settings has been extolled, there are limited applications in practice. The impediments to practical implementation are manifold and include semantic confusion, institutional inertia, misperceptions about the suitability and utility, and a lack of guiding examples. In this special section of the Journal of Fish and Wildlife Management, we hope to reinvigorate the appropriate application of adaptive management for threatened and endangered species by framing such management in a decision-analytical context, clarifying misperceptions, classifying the types of decisions that might be amenable to an adaptive approach, and providing three fully developed case studies. In this overview paper, I define terms, review the past application of adaptive management, challenge perceived hurdles, and set the stage for the case studies which follow.

Practitioners, implementing agencies

Runge, M.C. (2011) An Introduction to Adaptive Management for Threatened and Endangered Species. Journal of Fish and Wildlife Management 2(2): 220-233.

http://www.fwspubs.org/doi/full/10.3996/082011-JFWM-045

Optimal Adaptive Management for the Translocation of a Threatened Species

Active adaptive management (AAM) is an approach to wildlife management that acknowledges our imperfect understanding of natural systems and allows for some resolution of our uncertainty. Such learning may be characterized by risky strategies in the short term. Experimentation is only considered acceptable if it is expected to be repaid by increased returns in the long term, generated by an improved understanding of the system. By setting AAM problems within a decision theory framework, we can find this optimal balance between achieving our objectives in the short term and learning for the long term. We apply this approach to managing the translocation of the bridled nailtail wallaby (Onychogalea fraenata), an endangered species from Queensland, Australia.

Rout, T.M., C.E. Hauder and H.P. Possingham (2009) Optimal Adaptive Management for the Translocation of a Threatened Species. Ecological Applications 19(2): 515-526.

http://www.uq.edu.au/spatialecology/docs/Publications/2009_Rout_etal_OptimalAdaptiveManagement.pdf

Applied Nucleation

Applied Nucleation as a Forest Restoration Strategy

We review one potential strategy, applied nucleation, which involves planting small patches of trees as focal areas for recovery. Once planted, these patches, or nuclei, attract dispersers and facilitate establishment of new woody recruits, expanding the forested area over time. Applied nucleation is an attractive option in that it mimics natural successional processes to aid woody plant recolonization. These studies suggest that the applied nucleation strategy has the potential to restore deforested habitats into heterogeneous canopies with a diverse community composition, while being cheaper than projects that rely on plantation designs.

Practitioners, implementing agencies, policymakers

Corbin, J.D. and K.D. Holl (2012) Applied Nucleation as a Forest Restoration Strategy. Forest Ecology and Management 265: 37-46.

http://www.sciencedirect.com/science/article/pii/S037811271100627X

Nucleation in Tropical Ecological Restoration

The main goal of this paper is to present restoration techniques based on the concept of nucleation, in which small nuclei of vegetation are established within a degraded land. The nucleation techniques (artificial shelters for animals, planting of herbaceous shrub life forms, soil and seed bank translocation, seed rain translocation, soil and seed rain translocation's seedling set, artificial perches, planting of native trees in groups, and ecological stepping-stones with functional groups) promote the landscape connectivity on two flows: inward: receiver connectivity and outward: donor connectivity. The nuclei development represents an alternative for restoration by prioritizing the natural processes of succession. This methodology appears to take long to generate vegetation corresponding to tropical climates, but is fundamental in the formation of communities capable of acting, in the future, as a new functional nuclei within the current fragmented landscape. This strategy also encourages greater integration between the theories and projects of ecological restoration for the development of human resources and to benefit the restoration practitioner.

Practitioners, implementing agencies, policymakers

Reis, A., F. Campanhã Bechara and D.R. Tres (2010) Nucleation in Tropical Ecological Restoration. Scientia Agricola 67(2): 244-250.

http://www.scielo.br/pdf/sa/v67n2/a18v67n2.pdf

Ecological Restoration of Rainforest Using the Natural Nucleation Approach

Researchers at the Universidade Federal de Santa Catarina and Universidade Tecnológica Federal do Paraná, Brazil, have developed an innovative model of reforestation of native forests anchored on ecological theories and mechanisms of natural seed dispersal by animals, natural regeneration and pathways connecting forests in the region.

Practitioners, implementing agencies, policymakers

Bechara, F. et al. (2010) Ecological Restoration of Rainforest Using the Natural Nucleation Approach. Scientia Agricola 67(2).

http://www.scielo.br/scielo.php?pid=S0103-90162010010200001&script=sci_arttext

Scattered Trees are Keystone Structures: Implications for Conservation

This paper shows that scattered trees are keystone structures in a wide range of landscapes. At the local scale, ecological functions of scattered trees include: provision of a distinct microclimate; increased soil nutrients; increased plant species richness; increased structural complexity; and habitat for animals. At the landscape scale, ecological roles include: increased landscape-scale tree cover; increased connectivity for animals; increased genetic connectivity for tree populations; and provision of genetic material and focal points for future large-scale ecosystem restoration. Furthermore, in disturbed landscapes, scattered trees often are biological legacies that provide ecological continuity through time. In combination, these ecological functions support the argument that scattered trees are keystone structures.

Implementing agencies, practitioners

Manning, A.D., J. Fischer and D.B. Lindenmayer (2006) Scattered Trees are Keystone Structures: Implications for Conservation. Biological Conservation 132: 311-321.

http://www.bushlinks.com/Biodiversity%20reference%20docs/keystone%202006[1].pdf

The Role of Plant Interactions in the Restoration of Degraded Ecosystems: A Meta-analysis across Life-forms and Ecosystems

Pre-existing vegetation can have large impacts on species establishment in degraded habitats. Inhibition predominates in herbaceous communities typical of early-successional stages, whereas facilitation prevailes in communities dominated by shrubs and trees. Even productive systems (e.g. mesic temperate habitats) appear suitable for the application of facilitation as a restoration tool of woody communities. Whereas restoring herbaceous communities seems largely reliable on removal techniques, augmenting populations of nurse shrubs and trees should be considered a promising strategy for restoring woody late-successional communities.

Practitioners, implementing agencies

Gómez-Aparicio, L. (2009) The role of plant interactions in the restoration of degraded ecosystems: a meta-analysis across life-forms and ecosystems. Journal of Ecology 97: 1202-1214.

http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2745.2009.01573.x/full

Seed Rain under Tree Islands Planted to Restore Degraded Lands in a Tropical Agricultural Landscape

Planting native tree seedlings is the predominant restoration strategy for accelerating forest succession on degraded lands. Planting tree 'islands' is less costly and labor intensive than establishing larger plantations and simulates the nucleation process of succession. Assessing the role of island size in attracting seed dispersers, the potential of islands to expand through enhanced seed deposition, and the effect of planting arrangements on seed dispersal by birds and bats informs restoration design. Determining the relative importance of local restoration approach vs. landscape-level factors (amount of surrounding forest cover) helps prioritize methods and locations for restoration. We tested how three restoration approaches affect the arrival of forest seeds at 11 experimental sites spread across a gradient of surrounding forest cover in a 100-km2 area of southern Costa Rica.

Practitioners, implementing agencies

Cole, R.J., K.D. Holl and R.A. Zahawi (2010) Seed Rain under Tree Islands Planted to Restore Degraded Lands in a Tropical Agricultural Landscape. Ecological Applications 20(5): 1255-1269.

http://people.ucsc.edu/~kholl/Cole%20et%20al%202010%20Seed%20rain%20under%20tree%20islands.pdf

Litterfall Dynamics under Different Tropical Forest Restoration Strategies in Costa Rica

In degraded tropical pastures, active restoration strategies have the potential to facilitate forest regrowth at rates that are faster than natural recovery, enhancing litterfall, and nutrient inputs to the forest floor. We evaluated litterfall and nutrient dynamics under four treatments: plantation (entire area planted), tree islands (planting in six patches of three sizes), control (same age natural regeneration), and young secondary forest (7–9-yr-old natural regeneration). Tree islands increased litter production and nutrient inputs more quickly than natural regeneration. In addition to being less resource intensive than conventional plantations, this planting design promotes a more rapid increase in litter diversity and more spatial heterogeneity, which can accelerate the rate of nutrient cycling and facilitate forest recovery.

Practitioners, implementing agencies

Celentano, D., R.A. Zahawi, B. Finegan, R. Ostertag, R.J. Cole and K.D. Holl (2011) Litterfall Dynamics Under Different Tropical Forest Restoration Strategies in Costa Rica. Biotropica 43: 279-287.

http://onlinelibrary.wiley.com/doi/10.1111/j.1744-7429.2010.00688.x/abstract

Restoration of Damaged Land Areas: Using Nucleation to Improve Successional Processes

The restoration of damaged areas is a basic activity for conservation in situ by rebuilding biological communities and linking vegetation fragments. The nucleation has shown to be a successional principle in natural colonization of new areas. Therefore, it represents a basic technique for human activities aiming at contributing to the re-establishment of the communities. This paper discusses ways of implementing basic nucleation techniques on damaged areas, which provide high diversity in order to promote the establishment using the least artificial energy entrance. The following have been considered as nucleation techniques: soil transportation, direct seeding and hydro-seeding, artificial perches, brushwood transportation, high diversity islands and seeds collection bearing in mind the maintenance of genetic variability. The nucleation will become a usual technique when the legislation becomes clearer concerning environmental restoration and when the basic successional principles are considered as an important issue during the formation of human resources.

Practitioners, implementing agencies, policymakers

Reis, A., F.C. Bechara, M. Bazzo de Espíndola, N. Koehntopp Vieira and L. Lopes de Souza (2003) Restoration of Damaged Land Areas: Using Nucleation to Improve Successional Processes. Natureza & Conservação 1(1): 85-92.

http://www.lras.ufsc.br/images/stories/nat_conserv_eng.pdf

Assisted Natural Regeneration

Relevance of Natural Recovery to Ecological Restoration

Incorporation of natural recovery in the design of ecological restoration is a valid and important strategy. In this respect, well-informed projects maximize opportunities for natural processes in order to reduce expenditures of labor and budget and to assure a restoration "product" that is as faithful to the site and as natural as possible.

Implementing agencies, policymakers

Clewell, A. and T. McDonald (2009) Relevance of Natural Recovery to Ecological Restoration. Ecological Restoration 27: 122-124.

http://www.lerf.esalq.usp.br/divulgacao/recomendados/artigos/clewell2009.pdf

The Role of Spontaneous Vegetation Succession in Ecosystem Restoration: A Perspective

The paper summarizes ideas which were discussed during the 'Spontaneous Succession in Ecosystem Restoration' conference and elaborated through further discussion among the authors. It seeks to promote the integration of scientific knowledge on spontaneous vegetation succession into restoration programs. A scheme illustrating how knowledge of spontaneous succession may be applied to restoration is presented, and perspectives and possible future research on using spontaneous vegetation succession in ecosystem restoration are proposed.

Practitioners, implementing agencies

Prach, K., S. Bartha, C. Joyce, P. Pyšek, R. van Diggelen and G. Wiegleb (2001) The Role of Spontaneous Vegetation Succession in Ecosystem Restoration: A Perspective. Applied Vegetation Science 4: 111-114.

http://www.parkpruhonice.cz/personal/pysek/pdf/avs_perspective_2001.pdf

Spontaneous Succession versus Technical Reclamation in the Restoration of Disturbed Sites

We address the question: under which circumstances can we rely upon spontaneous succession and when are technical measures more effective in restoration programs? To answer this question, the position of a disturbed site along the productivity–stress gradient was considered. The probability of attaining a target stage by spontaneous succession decreases toward both ends of the productivity–stress gradient, whereas the acceptance of technical measures generally increases. In correspondence with that, the monetary cost of restoration increases toward the ends of the gradient. Therefore, spontaneous succession is advocated especially if environmental site conditions are not very extreme.

Implementing agencies, policymakers

Prach, K. and R.J. Hobbs (2008) Spontaneous Succession versus Technical Reclamation in the Restoration of Disturbed Sites. Restoration Ecology 16(3): 363-366.

http://www.unalmed.edu.co/~poboyca/documentos/documentos1/Biolog%EDa_Conservacion/03_2008/Ligia/Nov_14/Prach_et_al_2008.pdf

Assisted Natural Regeneration>Agriculture/Livestock

Secondary Succession and Natural Habitat Restoration in Abandoned Rice Fields of Central Korea

Floristic composition and soil characteristics (moisture, pH, nutrient contents) in abandoned upland rice paddies of different ages were analyzed to clarify the regenerative aspects of succession as a tool for habitat restoration. The study sites represented five seral stages: newly abandoned paddy fields; successional paddy fields abandoned for 3, 7, and 10 years; and a 50-year-old Alnus japonica forest. The pace and direction of recovery of native vegetation and natural soil properties in these abandoned rice paddies resembled classic old field succession, a form of secondary succession that often serves as a template for guiding restoration efforts. Active intervention, in particular dismantling artificial levees, could accelerate the recovery process, but natural habitat recovery generally appears sufficiently robust to achieve "passive" restoration of this rare community without intervention.

Implementing agencies, practitioners

Lee, C.S., Y.H. You and G.R. Robinson (2002) Secondary Succession and Natural Habitat Restoration in Abandoned Rice Fields of Central Korea. Restoration Ecology 10(2): 306-314.

http://onlinelibrary.wiley.com/doi/10.1046/j.1526-100X.2002.00003.x/abstract

Restoration of Wetlands from Abandoned Rice Fields for Nutrient Removal, and Biological Community and Landscape Diversity

A number of experimental freshwater wetlands (150 m long x 75 m wide) with different ages since they were abandoned as rice fields, were used to analyze the prospects of multipurpose wetland restoration for such degraded areas. Nitrogen and phosphorus removal rate of the wetlands were determined monthly during the flooding season to estimate their efficiency as filters to remove nutrients from agricultural sewage. The number of wetland birds was recorded regularly to identify their habitat preferences. Both the temporal dynamics and changes in the spatial pattern of land use cover during the last 20 years were determined from aerial photographs and field analysis. Apart from the improvement in water quality and the restoration of natural habitats, restoration of wetland belts around lagoons will increase spatial heterogeneity and diversity of the landscape.

Implementing agencies, practitioners

Comín, F.A., J.A. Romero, O. Hernández and M. Menéndez (2001) Restoration of Wetlands from Abandoned Rice Fields for Nutrient Removal, and Biological Community and Landscape Diversity. Restoration Ecology 9(2): 201-208.

https://www.wau.boku.ac.at/fileadmin/_/H81/H812/_TEMP_/lehre/812004/Comin_et_al_2001.pdf

Assisted Natural Regeneration>Drylands

Initiating Autogenic Restoration on Shallow Semiarid Sites

Our objectives were to evaluate the use of microcatchments in the establishment of Leucaena retusa (little-leaf leadtree) and Atriplex canescens (four-wing saltbush) and their role in the initiation of autogenic landscape restoration processes on a shallow semiarid site. These data suggest that landscape-scale procedures that concentrate scarce resources (water, organic matter, nutrients, and propagules), establish keystone species, and ameliorate microenvironmental conditions can initiate autogenic restoration of degraded semiarid ecosystems.

Practitioners

Whisenant, S.G., T.L. Thurow and S.J. Maranz (1995) Initiating Autogenic Restoration on Shallow Semiarid Sites. Restoration Ecology 3: 61-67.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.1995.tb00076.x/abstract

Assisted Natural Regeneration>Forests/Woodlands

Principles of Natural Regeneration of Tropical Dry Forests for Restoration

We reviewed the ecology of regeneration of tropical dry forests as a tool to restore disturbed lands. Dry forests are characterized by a relatively high number of tree species with small, dry, wind-dispersed seeds. Over small scales, wind-dispersed seeds are better able to colonize degraded areas than vertebrate-dispersed plants. Small seeds and those with low water content are less susceptible to desiccation, which is a major barrier for establishment in open areas. Seeds are available in the soil in the early rainy season to maximize the time to grow.

Practitioners, implementing agencies

Vieira, D.L.M and A. Scariot (2006) Principles of Natural Regeneration of Tropical Dry Forests for Restoration. Restoration Ecology 14(1): 11-20.

http://www.globalrestorationnetwork.org/uploads/files/LiteratureAttachments/296_principles-of-natural-regeneration-of-tropical-dry-forests-for-restoration.pdf

Application of Assisted Natural Regeneration to Restore Degraded Tropical Forestlands

Assisted natural regeneration (ANR) is a simple, low-cost forest restoration method that can effectively convert deforested lands of degraded vegetation to more productive forests. The method aims to accelerate, rather than replace, natural successional processes by removing or reducing barriers to natural forest regeneration such as soil degradation, competition with weedy species, and recurring disturbances (e.g., fire, grazing, and wood harvesting).

Implementing agencies, practitioners

Shono, K., E.A. Cadaweng and P.B. Durst (2007) Application of Assisted Natural Regeneration to Restore Degraded Tropical Forestlands. Restoration Ecology 15(4): 620-626.

http://www.fao.org/forestry/19102-0bf30dd3d800687636a5ddc85e409044a.pdf

Assisted Natural Regeneration>Asia/Pacific

Advancing Assisted Natural Regeneration (ANR) in Asia and the Pacific

Over the past several decades, scattered efforts have been made to develop and apply ANR approaches to forest restoration. Whilst knowledge in this area has grown considerably, it is now apparent that there are additional opportunities to diversify strategies and to expand restoration work. Given the low cost and numerous benefits from ANR, it would seem logical that ANR be accepted and applied broadly. Surprisingly, however, ANR techniques are still vastly under-appreciated and under-utilized in the region. This is in part due to the fact that few efforts have been made to promote ANR. It is in this context that this selection of papers has been compiled, to synthesize the current knowledge on ANR. This overview presents a short summary of the selected papers and some general themes emerging from the workshop.

Implementing agencies, practitioners, policymakers, indigenous and local communities

Dugan, P.C., P.B. Durst, D.J. Ganz and P.J. McKenzie (2003) Advancing Assisted Natural Regeneration (ANR) in Asia and the Pacific. FAO Regional Office for Asia and the Pacific, RAP Publication 2003/19.

ftp://ftp.fao.org/docrep/fao/004/ad466e/ad466e00.pdf

Imperata Grassland Rehabilitation using Agroforestry and Assisted Natural Regeneration

This manual is written to benefit people who live in an environment dominated by Imperata and who want to replace grasslands with agroforestry and forests. The techniques covered in this manual are most useful for medium-sized grasslands, confined to one village or community. The manual's content and format is designed for extensionists, agriculturists, foresters, development workers, and others who can assist communities and smallholders to design and implement Imperata rehabilitation activities.

Implementing agencies, practitioners, indigenous and local communities

Friday, K.S., M.E. Drilling and D. Garrity (1999) Imperata grassland rehabilitation using Agroforestry and Assisted Natural Regeneration. International Centre for Research in Agroforestry, Southeast Asian Regional Research Programme, Bogor.

http://www.worldagroforestry.org/units/library/books/PDFs/82_Imperata_grassland.pdf

Ecological Restoration of Rainforest through Aided Natural Regeneration in the Denuded Hills of Sitakunda, Chittagong, Bangladesh

Bangladesh Forest Department attempted ecological restoration of its denuded natural forests by establishing the first eco-park at Sitakunda in the South-eastern Chittagong hills in 2000. The semi-evergreen sub-tropical forest has been lying denuded of trees for years. The present study was conducted in December 2003 by taking a systematic sample of 50 circular plots each of

5.05 m in radius from a 20 ha patch of the eco-park, where non-woody vegetation has been routinely removed since 2000 in order to favor natural regeneration. The objective was to examine coppices and sprouts coming from stumps and root-suckers, respectively. In each plot regeneration were identified to species and their height measured. A total of 1401 individuals were found that represented 63 species. Most of the individuals were in the height classes 1 - 2 m (617) and < 1 m (529). It appeared that native forest ecosystem could be restored in denuded areas even when seed-bearing trees are almost absent.

Practitioners, implementing agencies

Misbahuzzaman, K. and M.J. Alam (2006) Ecological Restoration of Rainforest through Aided Natural Regeneration in the Denuded Hills of Sitakunda, Chittagong, Bangladesh. International Journal of Agriculture and Biology 8(6).

http://fspublishers.org/ijab/past-issues/IJABVOL_8_NO_6/15.pdf

Assisted Natural Regeneration>Dominican Republic

Natural Regeneration of Subtropical Montane Forest after Clearing Fern Thickets in the Dominican Republic

Forest restoration in these grasslands and fernlands can be accelerated by increasing seed arrival by attracting seed dispersers with trees or artificial perches, and by clearing herbaceous vegetation and reducing competition. To determine an efficient strategy for restoring subtropical montane forest, we evaluate the success of natural regeneration 3 y after removing the dominant fern, Dicranopteris pectinata (Willd.) Underw. (Gleicheniaceae).

Practitioners, implementing agencies

Slocum, M., T. Aide, J. Zimmerman and L. Navarro (2004) Natural regeneration of subtropical montane forest after clearing fern thickets in the Dominican Republic. Journal of Tropical Ecology 20: 483-486.

http://tcel.uprrp.edu/Publications_files/Slocum%20et%20al.%202004.pdf

Assisted Natural Regeneration>Ethiopia

Forest Rehabilitation through Natural Regeneration in Tigray, Ethiopia: From Fragments to Forests

The objective of the project is to strengthen forest research capacity in Tigray by initiating fundamental forest regeneration experiments, by training Mekelle University staff and by providing better research facilities in order to contribute to the development of sustainable management plans for Ethiopia's forest resources, in particular in Tigray.

Practitioners, implementing agencies

Aerts, R., A. Zenebe, F. Kebede, E. November, M. Behailu and B. Muys (2003) Forest Rehabilitation through Natural Regeneration in Tigray, Ethiopia: From Fragments to Forests. Laboratory for Forest, Nature and Landscape Research Institute for Land and Water Management, Belgium.

http://www.unep-wcmc.org/medialibrary/2011/04/14/df1dfa74/Ethiopia%20highres.pdf

Forest Rehabilitation: One Approach to Water Conservation in Central Tigray

Until now, one of the most effective ways to allow the regeneration of vegetation and consequently the prevention of more soil erosion was found to be the exclusion of grazing livestock from selected areas. Vegetation cover and litter in these exclosures promote rainwater infiltration and thus contribute to the raising of the water table in the long term. Although intermediate results show the benefits (and the limits) of eucalypt plantations in the closed areas, they might become a threat to the biodiversity and the water balance of the region. A joint research project between the Katholieke Universiteit Leuven (Belgium) and Mekelle University (Ethiopia) aims at the development of natural regeneration strategies and sustainable management practices in these closed areas.

Practitioners, implementing agencies

Aerts, R., E. November, M. Behailu, J. Deckers, M. Hermy, and B. Muys (2002) Forest rehabilitation: one approach to water conservation in Central Tigray. Ethiopian Journal of Water Science and Technology 6: 34-37.

https://lirias.kuleuven.be/bitstream/123456789/144884/1/Aerts+et+al+2002+AWTI.pdf

Persistent Soil Seed Banks for Natural Rehabilitation of Dry Tropical Forests in Northern Ethiopia

The aim of the present research was to test the hypothesis whether soil seed banks can contribute to natural forest regeneration in the dry forest of Ethiopia. Therefore, the composition of the seed bank in relation to vegetation and abiotic environment was analysed in four forest relics and four exclosures, i.e. demarcated land areas under strict conservation management, in the highlands of Tigray, northern Ethiopia. Results show strong relationships between natural vegetation, seed bank composition, soil chemical characteristics and environmental degradation, as evidenced through characteristics such as land use impact and soil depth.

Practitioners, implementing agencies

Reubens, B., M. Heyn, K. Gebrehiwot, M. Hermyand and B. Muys (2007) Persistent Soil Seed Banks for Natural Rehabilitation of Dry Tropical Forests in Northern Ethiopia. Tropicultura 25(4): 204-214.

http://www.tropicultura.org/text/v25n4/204.pdf

Coastal Zones

Simultaneous 'Hotspots' and 'Coldspots' of Marine Biodiversity and Implications for Global Conservation

These results have major implications for international conservation programmes which use biodiversity as a major criterion for identifying priority regions. Unpicking and prioritizing biodiversity's different threads will help environmental organisations better define and target hotspot regions. Current applications of complementarity could theoretically be expanded from a regional to a global perspective, to determine areas in which biodiversity representation is maximal but concepts are not applicable to assemblage properties (e.g. taxonomic distinctness).

Implementing agencies, practitioners

Price, A.R.G. (2002) Simultaneous 'Hotspots' and 'Coldspots' of Marine Biodiversity and Implications for Global Conservation. Marine Ecology Progress Series 241: 23-27.

http://ottokinne.de/articles/meps2002/241/m241p023.pdf

A Conceptual Model of Ecosystem Restoration Triage based on Experiences from Three Remote Oceanic Islands

A conceptual model, that illustrates restoration, ecological landscaping, rehabilitation and regreening, is developed. It considers biocentric, historical, aesthetic and engineering aspects. The term ecosystem restoration triage is used because the first step is to decide whether to ' do nothing ' (because, on the one hand, the system is too degraded to warrant restoration, or, on the other, because biological integrity is relatively intact and therefore either none, or minimal, restoration is required) or to 'do something ' (because restoration is worthwhile, urgent and feasible). This approach hinges on the definition that restoration in the strictist sense is a biocentric activity that returns the 'original ' compositional, structural and functional diversity, along with its dynamics and natural evolutionary potential. 'Original' is a difficult qualifier as it depends on just how far back in time we go. Where human values are involved, this is not restoration in the pure sense of restoring ecological integrity, but is ecological landscaping, rehabilitation or regreening. Experience from three remote oceanic islands [Easter Island, Cousine Island (Seychelles), Marion Island (Sub-Antarctic)] and which represent near extremes of this model are used to illustrate it.

Policymakers, implementing agencies

Samways, M.J. (2000) A Conceptual Model of Ecosystem Restoration Triage based on Experiences from Three Remote Oceanic Islands. Biodiversity and Conservation 9(8): 1073-1083.

http://www.springerlink.com/content/k13j660778m78xk0/

Multiscale Analysis of Restoration Priorities for Marine Shoreline Planning

This study documents an approach to determining the management strategy most likely to succeed based on current conditions at local and landscape scales. The conceptual framework based in restoration ecology pairs appropriate restoration strategies with sites based on the likelihood of producing long-term resilience given the condition of ecosystem structures and processes at three scales: the shorezone unit (site), the drift cell reach (nearshore marine landscape), and the watershed (terrestrial landscape). The analysis is structured by a conceptual ecosystem model that identifies anthropogenic impacts on targeted ecosystem functions. A scoring system, weighted by geomorphic class, is applied to available spatial data for indicators of stress and function using geographic information systems. This planning tool augments other approaches to prioritizing restoration, including historical conditions and change analysis and ecosystem valuation.

Implementing agencies

Diefenderfer, H.L., K.L. Sobocinski, R.M. Thom, C.W. May, A.B. Borde, S.L. Southard, J. Vavrinec and N.K. Sather (2009) Multiscale Analysis of Restoration Priorities for Marine Shoreline Planning. Environmental Management 44: 712-731.

http://www.vims.edu/people/sobocinski_kl/pubs/diefenderfer,%20etal.pdf

Coastal Zones>India

Studies on Vulnerability and Habitat Restoration along the Coromandel Coast

This document consolidates the learning of one of the four components of the UNDP-PTEI Phase II. The primary goal of the component was to build protocols for restoration of coastal habitats based on a combination of literature reviews and field experience. This document presents the findings of studies conducted on the impacts of the tsunami and vulnerabilities of communities and habitats along the Coromandel coast. It also presents strategies that were evolved and tested for the restoration of coastal habitats.

Implementing agencies, policymakers, indigenous and local communties

Bhalla, R.S., S. Ram and V. Srinivas (eds.) (2008) Studies on Vulnerability and Habitat Restoration along the Coromandel Coast. FERAL, UNDP-UNTRS, Pondicherry.

http://www.feralindia.org/drupal/download/file/fid/197

Ecological Restoration of Degraded Ecosystems in Tamil Nadu: Planning and Implementation

Workshop Programme and Abstracts

Implementing agencies, practitioners, indigenous and local communities

Abstracts of the Workshop on Ecological Restoration of Degraded Ecosystems in Tamil Nadu: Planning and Implementation, 19 December 2006, Chennai, organized by Tamil Nadu Forest Department, Nature Conservation Foundation, and UNDP Post-Tsunami Environment Initiative. Published by Nature Conservation Foundation, Mysore.

http://www.globalrestorationnetwork.org/uploads/files/LiteratureAttachments/113_ecological-restoration-of-degraded-ecosystems-in-tamil-nadu---planning-and-implementation.pdf

Coastal Zones>Mexico

Isla Guadalupe: Conservación y Restauración

Este libro es un esfuerzo por recopilar los resultados del trabajo de muchos investigadores, cuyos datos y análisis conforman la base del proyecto de recuperación y conservación de la isla. Y es también un homenaje a todos aquellos que se han atrevido a soñar con revertir más de un siglo de deterioro ambiental, recuperando para México y para la humanidad esta maravillosa isla del océano Pacífico.

Practioners, implementing agencies

Santos del Prado, K. and E. Peters (eds.) (2005) Isla Guadalupe: Conservación y Restauración. Instituto Nacional de Ecología, Secretaría de Medio Ambiente y Recursos Naturales, México, D.F.

http://www2.ine.gob.mx/publicaciones/consultaPublicacion.html?id_pub=592

When is Restoration Not? Incorporating Landscape-scale Processes to Restore Self-sustaining Ecosystems in Coastal Wetland Restoration

The goal of this paper is to explore restoration concepts, examples, and challenges from the Pacific and Gulf coasts. One of the fundamental concepts explored is change over time – either in the controlling processes or the restoration structure – and how such changes can be meshed with the goals of various restoration efforts. We subsequently review the concepts of ecosystem trajectories, alternative restoration approaches, and the ideal attributes of functional self-sustaining restoration in the context of realities of restoration planning, design, and implementation.

Implementing agencies, practitioners

Simenstad, C., D. Reed and M. Ford (2006) When is Restoration Not? Incorporating Landscape-scale Processes to Restore Self-sustaining Ecosystems in Coastal Wetland Restoration. Ecological Engineering 26: 27-39.

http://cmbc.ucsd.edu/content/1/docs/simenstadetal2006.pdf

Ecological Engineering

Ecological Engineering: A Field Whose Time Has Come

Ecological engineering is defined as "the design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both." It involves the restoration of ecosystems that have been substantially disturbed by human activities such as environmental pollution or land disturbance; and the development of new sustainable ecosystems that have both human and ecological value.

Policymakers

Mitsch, W.J. and S.E. Jørgensen (2003) Ecological Engineering: A Field Whose Time Has Come. Ecological Engineering 20: 363-377.

http://groups.engr.oregonstate.edu/eess/wp-content/uploads/2011/02/Ecological-engineering-A-field-whose-time-has-come.pdf

Exploiting the Attributes of Regional Ecosystems for Landscape Design: The Role of Ecological Restoration in Ecological Engineering

The principles of ecological restoration, which examine regional native ecology to guide landscape design, need not be limited to reparation or restoration projects, but may equally apply to parks, parking lots, detention ponds, green roofs, and roadsides, just as they do to re-establishing a prairie or wetland. We propose that environmental designers, whether landscape architects, civil engineers or restoration practitioners, investigate and exploit the ecological attributes of their native landscapes to provide smarter tools for solving design problems. This will improve ecological value of the project and reduce any collateral ecological damage caused by poor plant selection.

Policymakers, implementing agencies

Simmons, M.T., H.C. Venhaus and S. Windhager (2007) Exploiting the Attributes of Regional Ecosystems for Landscape Design: The Role of Ecological Restoration in Ecological Engineering. Ecological Engineering 30(3): 201-205.

http://www.sciencedirect.com/science/article/pii/S0925857407000080

Redefining Ecological Engineering to Promote its Integration with Sustainable Development and Tighten its Links with the Whole of Ecology

Ecological engineering was defined several decades ago, both in the academic field and in management. I next propose a definition of ecological engineering, in accordance with the two reasons for its French re-emergence, i.e. the prevalence of the concept of sustainable development and the development of applied ecological sub-disciplines. This leads us to suggest that ecological engineering should be ecological in the broad sense, and not only targeted to the ecosystem level. I end the paper by discussing some problems and characteristics of ecological engineering that stem from this definition.

Policymakers, implementing agencies

Gosselin, F. (2008) Redefining Ecological Engineering to Promote its Integration with Sustainable Development and Tighten its Links with the Whole of Ecology. Ecological Engineering 32(3): 199-205.

http://www.sciencedirect.com/science/article/pii/S0925857407002145

Design Principles for Ecological Engineering

Successful ecological engineering will require a design methodology consistent with, if not based on, ecological principles. We identify five design principles to guide those practicing ecological engineering. The principles are: (1) design consistent with ecological principles, (2) design for site-specific context, (3) maintain the independence of design functional requirements, (4) design for efficiency in energy and information, and (5) acknowledge the values and purposes that motivate design.

Implementing agencies, practitioners

Bergen, S.D., S.M. Bolton and J.L. Fridley (2001) Design Principles for Ecological Engineering. Ecological Engineering 18: 201-210.

http://www.iph.ufrgs.br/corpodocente/marques/Bergenetal_2001.pdf

Benefits of Ecological Engineering Practices

This paper presents the results of the workshop related to three key questions: (1) what are the benefits of ecological engineering practices to human and ecosystem well-being, (2) which concepts are used or useful to identify, reference, and measure the benefits of ecological engineering practices, and (3) how and to whom shall benefits of ecological engineering practices be promoted. While benefits of ecological engineering practices are diverse, general conclusions can be derived to facilitate communication. Identifying benefits requires valuation frameworks reaching beyond the scope of ecology and engineering.

Implementing agencies, policymakers

Brüll, A. et al. (2011) Benefits of Ecological Engineering Practices. Procedia Environmental Sciences 9: 16-20.

http://www.sciencedirect.com/science/article/pii/S1878029611007663

An Ecological Decision Framework for Environmental Restoration Projects

Ecosystem restoration projects require planning and monitoring to maximize project success relative to costs, yet many projects completed thus far have been planned on an ad hoc, consensus basis and are virtually ignored after revegetation at the site is complete. We describe a formalized planning process geared specifically to the needs of ecologicalrestoration projects (and ecosystem rehabilitation or management projects; National Research Council, 1992). This process emphasizes: 1) the importance of defining objectives related to the appropriate ecosystem structure, function, and spatial scale; 2) the role of ecological models, restoration hypotheses, and key ecological parameters; 3) explicit consideration of uncertainties in site processes and material performance in the restoration design; 4) guidelines for project design and feasibility analysis and the use of experimentation at this stage; and 5) monitoring and adaptive management of restoration projects after implementation of a design.

Practitioners, implementing agencies

Pastorok, R.A., A. MacDonald, J.R. Sampson, P. Wilber, D.J. Yozzo and J.P. Titre (1997) An Ecological Decision Framework for Environmental Restoration Projects. Ecological Engineering 9(1-2): 89-107.

http://www.sciencedirect.com/science/article/pii/S0925857497000360

Using Ecosystem Engineers to Restore Ecological Systems

Ecosystem engineers affect other organisms by creating, modifying, maintaining or destroying habitats. Despite widespread recognition of these often important effects, the ecosystem engineering concept has yet to be widely used in ecological applications. Here, we present a conceptual framework that shows how consideration of ecosystem engineers can be used to assess the likelihood of restoration of a system to a desired state, the type of changes necessary for successful restoration and how restoration efforts can be most effectively partitioned between direct human intervention and natural ecosystem engineers.

Practitioners, implementing agencies

Byers, J.E., K. Cuddington, C.G. Jones, T.S. Talley, A. Hastings, J.G. Lambrinos, J.A. Crooks and W.G. Wilson (2006) Using Ecosystem Engineers to Restore Ecological Systems. Trends in Ecology and Evolution 21(9): 493-500.

http://www.ecostudies.org/reprints/Byers_et_al_2006_TREE_21_493-500.pdf

The Concept of Organisms as Ecosystem Engineers Ten Years On: Progress, Limitations, and Challenges

The modification of the physical environment by organisms is a critical interaction in most ecosystems. The concept of ecosystem engineering acknowledges this fact and allows ecologists to develop the conceptual tools for uncovering general patterns and building broadly applicable models. Although the concept has occasioned some controversy during its development, it is quickly gaining acceptance among ecologists. We outline the nature of some of these controversies and describe some of the major insights gained by viewing ecological systems through the lens of ecosystem engineering. We close by discussing areas of research where we believe the concept of organisms as ecosystem engineers will be most likely to lead to significant insights into the structure and function of ecological systems.

Practitioners

Wright, J.P. and C.G. Jones (2006) The Concept of Organisms as Ecosystem Engineers Ten Years On: Progress, Limitations, and Challenges. BioScience 56(3): 203-209.

http://ecostudies.org/reprints/Wright_Jones_2006_Concept_BioScience_56(3)203-209.pdf

Ecological Engineering>Europe

Remediation of Ecosystems Damaged by Environmental Contamination: Applications of Ecological Engineering and Ecosystem Restoration in Central and Eastern Europe

Twenty workshop findings that resulted from workshop presentations and subsequent discussion are presented. Six papers published as part of this special issue of Ecological Engineering, and summarized here, deal with the general principles of mineland restoration, acidification effects and mitigation in Poland, reestablishment of riparian buffer strips in Estonia, recovery of forests in the Black Triangle of Czechoslovakia and Poland, restoration after 10 years near the Chernobyl nuclear plant accident in the Ukraine, and studies on remediation of contaminated soils in Belarus.

Policymakers, implementing agencies

Mitsch, W.J. and Ü Mander (1997) Remediation of Ecosystems Damaged by Environmental Contamination: Applications of Ecological Engineering and Ecosystem Restoration in Central and Eastern Europe. Ecological Engineering 8(4): 247-254.

http://www.sciencedirect.com/science/article/pii/S0925857497000219

Ecological Engineering>Japan

The Restoration of Nature in Japan: A Challenge to Ecological Engineering

The book describes in great detail a multitude of community-based projects run by engineers and biologists. These projects, carried out mostly on public lands, in general seem more concerned with ecological engineering than with ecological restoration. Conservation of biological diversity in the context of a social movement seeking development of a new relation between society and nature is the driver of these projects, which is also the case for the restoration movement in North America. The primary motivation of several of the case studies presented is the engineered creation of habitat for particular species (e.g., giant salamanders [Andrias japonicas] and Japanese Golden Eagles [Aquila chrysaetos japonica]) or the reconnection and enhancement of habitat for wild animals. Maintaining particular types of cultural landscapes, such as managed woodlands or traditional rice fields, in close proximity to cities is also discussed as is the challenge of restoring areas of “primeval nature” in national parks and controlling nonnative organisms.

Implementing agencies, practitioners

Hirose, T. (2010) The Restoration of Nature in Japan. A Challenge to Ecological Engineering. Tokai University Press, Kanagawa.

http://www.a-rr.net/jp/en/book/02river_restoration/2196.html

Ecological Engineering>USA

US Army Core of Engineers Toolbox

Ecosystem restoration projects are filled with challenges. Below are some tools developed by the Environmental Lab to address some of those challenges through decision support, habitat calculations, evaluation of environmental flows, and more.

Implementing agencies, practitioners

US Army Core of Engineers, Engineer Research and Development Center's (ERDC) Environmental Lab, Vicksburg.

http://el.erdc.usace.army.mil/ecosystem/tools.cfm?Option=Main&Type=None

US Army Core of Engineers Ecosystem Restoration Gateway

Ecosystem Restoration is one of the primary missions of the Civil Works program. The purpose of Civil Works ecosystem restoration activities is to restore significant ecosystem function, structure, and dynamic processes that have been degraded. Ecosystem restoration efforts involve a comprehensive examination of the problems contributing to the system degradation, and the development of alternative means for their solution. The intent of restoration is to partially or fully reestablish the attributes of a naturalistic, functioning, and self-regulating system.

Implementing agencies, practitioners

US Army Core of Engineers

http://cw-environment.usace.army.mil/restoration.cfm

US Army Core of Engineers Management Measures Digital Library

The purpose of this site is to identify and describe examples of selected ecosystem engineering features or management measures and their components. This site is not intended to be a design manual, but rather to provide sufficient information to stimulate plan formulation and assist planners in identifying what's out there and to "visualize" how a management measure or engineering feature may be applicable to their project.

Implementing agencies, practitioners

US Army Core of Engineers Management Measures Digital Library http://www.pmcl.com/mmdl/index.asp

Ecological Engineering>Coastal/Marine

Hydrologic Restoration of Coastal Wetlands

Hydrologic modification of coastal wetlands is pervasive, continuing and longstanding in the US. Appreciation for the subtleties of the direct and indirect effects of hydrologic changes on emergent vegetation, soils and co-dependent flora and fauna is contributing to restoration efforts. However the results of wetland restoration/rehabilitation are moslty empirical, rather than scientific in understanding. Science is contributing to the management interest by providing documentation of the past and present failures and successes, and, unveiling the fundamental understanding necessary to move from one wetland to another in an informed and adaptable manner.

Implementing agencies, practitioners

Turner, R.E. and R.R. Lewis (1997) Hydrologic Restoration of Coastal Wetlands. Wetland Ecology and Management 4(2): 65-72.

http://www.mangroverestoration.com/hydrologic_restoraton_of_coasta_wetlands.pdf

How Ecological Engineering can Serve in Coastal Protection

In this paper, the utilization of ecosystem engineering species for achieving civil-engineering objectives or the facilitation of multiple use of limited space in coastal protection is focused upon, either by using ecosystem engineering species that trap sediment and damp waves (oyster beds, mussel beds, willow floodplains and marram grass), or by adjusting hard substrates to enhance ecological functioning. Translating desired coastal protection functionality into designs that make use of the capability of appropriate ecosystem engineering species is, however, hampered by lack of a generic framework to decide which ecosystem engineering species or what type of hard-substrate adaptations may be used where and when. In this paper we review successful implementation of ecosystem engineering species in coastal protection for a sandy shore and propose a framework to select the appropriate measures based on the spatial and temporal scale of coastal protection, resulting in a dynamic interaction between engineering and ecology. Modeling and monitoring the bio-physical interactions is needed, as it allows to upscale successful implementations and predict otherwise unforeseen impacts.

Implementing agencies, practitioners

Borsje, B.W., B.K. van Wesenbeeck, F. Dekker, P. Paalvast, T.J. Bouma, M.M. van Katwijk and M.B. de Vries (2011) How Ecological Engineering can Serve in Coastal Protection. Ecological Engineering 37(2): 113-122.

http://www.sciencedirect.com/science/article/pii/S0925857410003216

Engineering Novel Habitats on Urban Infrastructure to Increase Intertidal Biodiversity

Seawalls—the most extensive artificial infrastructure—are generally featureless, vertical habitats that support reduced levels of local biodiversity. Here, a mimic of an important habitat on natural rocky shores (rock-pools) was experimentally added to a seawall and its impact on diversity assessed. The mimics created shaded vertical substratum and pools that retained water during low tide. These novel habitats increased diversity of foliose algae and sessile and mobile animals, especially higher on the shore. Many species that are generally confined to lowshore levels, expanded their distribution over a greater tidal range. Success requires melding engineering skills and ecological understanding. This paper demonstrates one cost-effective way of addressing this important issue for urban infrastructure affecting nearshore habitats.

Implementing agencies, practitioners, policymakers

Chapman, M.G. and D.J. Blockley (2009) Engineering Novel Habitats on Urban Infrastructure to Increase Intertidal Biodiversity. Oecologia 161(3): 625-635.

http://www.springerlink.com/content/ar62376404818644/

Collective Planning of Hydraulic Engineering Projects: Manual for Participation and Decision Support in Hydraulic Engineering Projects

This manual focuses on revitalisation and flood protection projects (referred to as hydraulic engineering projects). Methodological tools can also be transferred to other subject areas (e.g. natural hazard and infrastructure projects). The applicability of tools depends on the different constraints faced by specific hydraulic engineering projects and is adaptable to the needs of the individual project. The manual is aimed at those in charge of hydraulic engineering projects within local councils, cantons and the federal government, as well as contractors in engineering agencies, institutes and universities. The guidance is also useful for environmental and civil organisations, among others.

Implementing agencies, indigenous and local communities

Hostmann M., M. Buchecker, O. Ejderyan, U. Geiser, B. Junker, S. Schweizer, B. Truffer and M. Zaugg Stern (2005) Collective planning of hydraulic engineering projects: Manual for participation and decision support in hydraulic engineering projects. Eawag, WSL, LCH-EPFL, VAW-ETHZ.

http://www.rivermanagement.ch/en/docs/handbook_collective_planning.pdf

Designing Large-scale Wetland Restoration for Delaware Bay

The first step in the design process was to obtain consensus among regulators, ecologists, engineers, and the public as to marsh structure and function. Second was to reach agreement on the essential sedimentary and hydrodynamic characteristics needed to achieve the desired ecosystem. Third was to develop a two-dimensional hydrodynamic numerical model to design marsh channels that would not erode, would have typical channel cross-sections, and would have a hydro-period on the marsh plain to allow growth of the desired species. The process for design that met the restoration goals and was acceptable to the regulatory agencies and the public was complex. We discuss the social/political and the scientific/engineering steps used to reach a final design acceptable to all involved parties.

Implementing agencies

Weishar, L.L., J.M. Teal and R. Hinkle (2005) Designing Large-scale Wetland Restoration for Delaware Bay. Ecological Engineering 25: 231-239.

https://www.hs-magdeburg.de/fachbereiche/f-wasserukreislauf/personal/professoren/luederitz/download/mehr/05_04.pdf

Ecological Engineering, Adaptive Management, and Restoration Management in Delaware Bay Salt Marsh Restoration

Salt hay marshes were diked and farmed for over 50 years, reducing marsh plain elevations, obliterating many tidal channels, keeping fish out of the marsh, and encouraging invasion of Phragmites. Restoration involved setting restoration goals, careful planning, recreating major tidal channels, and opening the dikes. Ecological engineering, allowing nature to self-design, was used to create the smaller tidal channels, re-introduce fish, and adjust the elevation of the marsh plain and revegetate it. Adaptive management, specified in regulatory requirements, was used to monitor the restoration to ensure that design goals were met. Adaptive management and restoration management, less constrained by regulatory requirements but an equally intense process, were carried out by a small team of ecologists, engineers, and regulators. Ecological engineering, adaptive management, and restoration management were used to restore the structure and function of degraded salt marshes and were essential to the success of the Delaware Bay wetland restorations.

Implementing agencies

Teal, J.M. and L. Weishar (2005) Ecological Engineering, Adaptive Management, and Restoration Management in Delaware Bay Salt Marsh Restoration. Ecological Engineering 25(3): 304-314.

http://www.sciencedirect.com/science/article/pii/S0925857405000996

Physical Ecosystem Engineers and the Functioning of Estuaries and Coasts

A great diversity of organisms modify the physical structure of estuarine and coastal environments. These physical ecosystem engineers – particularly, dune and marsh plants, mangroves, seagrasses, kelps, reef-forming corals and bivalves, burrowing crustaceans and infauna – often have substantive functional impacts over large areas and across distinct geographic regions. Here we use a general framework for physical ecosystem engineering to illustrate how these organisms can exert control on sedimentary processes, coastal protection and habitat availability to other organisms. We then discuss the management implications of coastal and estuarine engineering, ending with a brief prospectus on research and management challenges.

Practitioners, implementing agencies

Gutiérrez, J.L. et al. (2012) Physical Ecosystem Engineers and the Functioning of Estuaries and Coasts, Chapter 5, in Volume 7: Functioning of Estuaries and Coastal Ecosystems, (eds., C. H. R. Heip, C. J. M., Philippart, and J. J. Middelburg) in the Treatise on Estuarine and Coastal Science (Series eds., E. Wolanski, and D. McLusky), Elsevier.

http://blackbear.ecology.uga.edu/jebyers/PDF%20of%20papers/Gutierrez%20et%20al--%20Treatise%20of%20Estuarine%20Coastal%20Science%20--%20Chpt%205%20Vol%207.pdf

Ecological Engineering>Forests/Woodlands

Promoting Ecological Engineering for Restoration of Biodiversity in Temperate Forests

In temperate forest, managers have both used civil engineering, biological engineering and ecological principles to optimize one function: wood production, flood regulation or reduction of soil erosion. Other forest practitioners used biological interactions and biotic controls to manage uneven-aged stands, especially in mountain forests. These actions just required the knowledge and control of both coarse biological and physical processes at a local scale. The challenges inherent to solve multi-scale biodiversity changes are crucial today. In order to achieve these crucial issues and optimize several ecological functions and ecosystem services, spatial modelling approaches are developed at a landscape level using species traits associated with environmental databases

Implementing agencies, practitioners

Marage, D. (2011) Promoting Ecological Engineering for Restoration of Biodiversity in Temperate Forests. Procedia Environmental Sciences 9: 118-123.

http://www.sciencedirect.com/science/article/pii/S187802961100781X

Ecological Engineering>Inland Waters>Floodplains

Ecological Engineering of Floodplains

We have proposed restoring and creating over 2 million hectares of wetlands in the 3 million km2 Mississippi-Ohio-Missouri River Basin in the USA to serve as sinks for farmland nutrients that are otherwise causing a 15 000 - 20 000 km2 hypoxic (extremely low oxygen) condition in the downstream Gulf of Mexico. We have conducted two main multi-year experiments on full-scale wetlands at the Olentangy River Wetland Research Park in Ohio, USA, to investigate proper ecological design for these wetlands. One of those experiments - a river pulsing study - is presented here.

Implementing agencies, practitioners

Mitsch, W.J., L. Zhang, D.F. Fink, M.E. Hernandez, A.E. Altor, C.L. Tuttle and A.M. Nahlik (2008) Ecohydrology & Hydrobiology 8(2-4).

http://versita.metapress.com/content/g3311652r1124734/fulltext.pdf

Ecological Engineering>Inland Waters>Rivers

Design for Stream Restoration

Stream restoration, or more properly rehabilitation, is the return of a degraded stream ecosystem to a close approximation of its remaining natural potential. Many types of practices ~dam removal, levee breaching, modified flow control, vegetative methods for streambank erosion control, etc. are useful, but this paper focuses on channel reconstruction. A tension exists between restoring natural fluvial processes and ensuring stability of the completed project. Sedimentation analyses are a key aspect of design since many projects fail due to erosion or sedimentation. Existing design approaches range from relatively simple ones based on stream classification and regional hydraulic geometry relations to more complex two- and three-dimensional numerical models. Herein an intermediate approach featuring application of hydraulic engineering tools for assessment of watershed geomorphology, channel-forming discharge analysis, and hydraulic analysis in the form of one-dimensional flow and sediment transport computations is described.

Practitioners, implementing agencies

Shields Jr., F.D., R.R. Copeland, P.C. Klingeman, M.W. Doyle and A. Simon (2003) Design for Stream Restoration. Journal of Hydraulic Engineering (August 2003): 575-584.

http://ddr.nal.usda.gov/bitstream/10113/10586/1/IND44014134.pdf

Hydraulic Design of Stream Restoration Projects

The purpose of this document is to provide a systematic hydraulic design methodology to hydraulic engineers involved in stream restoration projects. The objective of the methodology is to fit the stream restoration project into the natural system within the physical constraints imposed by other project objectives and constraints.

Practitioners, implementing agencies

Copeland, R.R., D.N. McComas, C.R. Thorne, P.J. Soar, M.M. Jonas and J.B. Fripp (2001) Hydraulic Design of Stream Restoration Projects. ERDC/CHL TR-01-28, U.S. Army Corps of Engineers, Washington, DC.

http://wildfish.montana.edu/manuals/Hydraulic_Design.pdf

Ecological Engineering Applied to River and Wetland Restoration

Ecological engineering is an emerging field dedicated to the design and construction of sustainable ecosystems that provide a balance of natural and human values. Over the past several years, ecological engineering has begun to coalesce as a distinct science. Successes of ecological engineering make it an increasingly attractive alternative to traditional engineering approaches, which are often much more expensive to construct and sustain.

Implementing agencies, policymakers

Mitsch, W.J., J.C. Lefeuvre and V. Bouchard (2002) Ecological Engineering Applied to River and Wetland Restoration. Ecological Engineering 18(5): 529-541.

http://www.citeulike.org/user/hugoc/article/10480207

Ecological Engineering>Inland Waters>Wetlands

Creating and Restoring Wetlands: A Whole-Ecosystem Experiment in Self-Design

A hydrologically open created wetland can develop, through self-design, a diverse assemblage of species even where no propugules existed before.

Implementing agencies, practitioners, policymakers

Mitsch, W.J., X. Wu, R.W. Nairn, P.E. Weihe, N. Wang, R. Deal and C.E. Boucher (1998) Creating and Restoring Wetlands: A Whole-Ecosystem Experiment in Self-Design. BioScience 48(12): 1019-1027.

http://swamp.osu.edu/news/ORWRamsar/PDFs/98-013.PDF

Restoration of our Lakes and Rivers with Wetlands: An Important Application of Ecological Engineering

The role of wetlands, both natural and man-made, in improving water quality of streams, rivers, and lakes is illustrated with examples of fringe, instream, and riparian wetlands. Fringe wetlands have been shown to reduce inputs to freshwater lakes, instream wetlands can improve habitat and provide some water quality function to small streams, and riparian wetlands along larger rivers provide important roles in both capturing sediments and nutrients from the river itself and serving as buffer between uplands and the river. Two major experimental riparian wetland sites in Midwestern USA are introduced: The Des Plaines River Wetland Demonstration Project and the Olentangy River Wetland Research Park.

Policymakers, implementing agencies

Mitsch, W.J. (1995) Restoration of our Lakes and Rivers with Wetlands: An Important Application of Ecological Engineering. Water Science and Technology 31(8): 167-177.

http://www.sciencedirect.com/science/article/pii/027312239500369X

Creating Riverine Wetlands: Ecological Succession, Nutrient Retention, and Pulsing Effects

Successional patterns, water quality changes, and effects of hydrologic pulsing are documented for a whole-ecosystem experiment involving two created wetlands that have been subjected to continuous inflow of pumped river water for more than 10 years. At the beginning of the growing season in the first year of the experiment (1994), 2400 individuals representing 13 macrophyte species were introduced to one of the wetland basins. The other basin was an unplanted control. Patterns of succession are illustrated by macrophyte community diversity and net aboveground primary productivity, soil development, water quality changes, and nutrient retention for the two basins. The planted wetland continued to be more diverse in plant cover 10 years after planting and the unplanted wetland appeared to be more productive but more susceptible to stress.

Implementing agencies, practitioners

Mitsch, W.J., L. Zhang, C.J. Anderson, A.E. Altor and M.E. Hernandez (2005) Creating Riverine Wetlands: Ecological Succession, Nutrient Retention, and Pulsing Effects. Ecological Engineering 25: 510-527.

http://swamp.osu.edu/news/ORWRamsar/PDFs/05-010.PDF

The Integrated Constructed Wetlands (ICW) Concept

The free surface flow Integrated Constructed Wetlands (ICW) concept explicitly combines the objectives of cleansing and managing water flow from farmyards with that of integrating the wetland infrastructure into the landscape and enhancing its biological diversity. This leads to system robustness and sustainability. Hydraulic dissipation, vegetation interception, and evapotranspiration create an additional freeboard at the outlet of each wetland segment and at the point of discharge, thus enhancing hydraulic residence time and cleansing capacity during hydraulic fluxes.

Implementing agencies, practitioners, policymakers, indigenous and local communities

Scholz, M., R. Harrington, P. Carroll and A. Mustafa (2007) The Integrated Constructed Wetlands (ICW) Concept. Wetlands 27(2): 337-354.

http://137.191.231.240/WaterWasteEnvironment/WasteWater/Documents/ICW%20Concept%20(Scholz%20et%20al%20-%20Society%20of%20Wetland%20Scientists%20%202007).pdf

Integrated Constructed Wetlands (ICW) for Livestock Wastewater Management

Social, economic and environmental coherence is sought in the management of livestock wastewater. Wetlands facilitate the biogeochemical processes that exploit livestock wastewater and provide opportunities to achieve such coherence and also to deliver on a range of ecosystem services. The Integrated Constructed Wetland (ICW) concept integrates three inextricably linked objectives: water quantity and quality management, landscape-fit to improve aesthetic site values and enhanced biodiversity. The synergies derived from this explicit integration allow one of the key challenges for livestock management to be addressed. An example utilizing twelve ICW systems from a catchment on the south coast of Ireland demonstrates that over an eight year period mean reduction of total and soluble phosphorus (molybdate reactive phosphorus) exceeded 95% and the mean removal of ammonium-N exceeded 98%. This paper reviews evidence regarding the capacity of ICWs to provide a coherent and sustainable alternative to conventional systems.

Implementing agencies, practitioners, policymakers, indigenous and local communities

Harrington, R. and R. McInnes (2009) Integrated Constructed Wetlands (ICW) for Livestock Wastewater Management. Bioresource Technology 100(22): 5498-5505.

http://www.sciencedirect.com/science/article/pii/S0960852409006543

Ecosystem Approach

Ecosystem Approach Sourcebook

This website has been created in response to a request of the seventh meeting of the Conference of the Parties (decision VII/11, paragraph 9) as a tool to help practitioners implement the ecosystem approach and share experiences. Once finalized, the sourcebook will have several components: a case study database, information about the ecosystem approach, and the various tools and techniques that can be used to implement it. At the present time, the first version of the case study database is operational. Other components of the sourcebook will be added shortly, so please visit this website from time to time to check on new developments.

Policymakers, implementing agencies

Convention on Biological Diversity

http://www.cbd.int/ecosystem/sourcebook/

The Ecosystem Approach: Learning from Experience

In selecting the case studies, it was CEM's view that the Ecosystem Approach, to be properly tested, had to be applied in multiple-use landscapes where Protected Areas formed no part, or only one among several parts, of the whole ecosystem. The approach also needed to be seen to be applicable in a variety of different kinds of biome. Thus we have here the analysis of overlapping ecosystems in an area of dry sahelian West Africa which contains no protected areas at all; of a Mekong delta wetland area with an very hard boundary and little relationship with the lands and livelihoods that lie beyond; of the developing symbiosis between a logging concession and protected areas in northern Congo-Brazzaville; of a Panamanian archipelago containing both protected and sustainable use areas, being overwhelmed by a rapid increase in tourism; and of Indonesian Papua where the forestry department is trying to use ecosystem approach ideas to adjudicate between the competing demands of conservation, logging, conversion of forest to oil-palm, and local community use of forest in highland, lowland and coastal areas.

Policymakers, implementing agencies

Shepherd, G. (ed.) (2008) The Ecosystem Approach: Learning from Experience. Gland, Switzerland: IUCN.

http://www.cbd.int/doc/external/iucn/iucn-ecosystem-approach-en.pdf

Forests in Landscapes: Ecosystem Approaches to Sustainability

This leads us to the overall conclusion that it is unhelpful to focus too much on any one formula for forest management. The future of forestry should lie in pluralism. Every forest system is different in its biophysical, economic, social and political attributes. Every situation needs a response tailored to its present needs and these needs will inevitably change over time. The skill of the forest manager is to be able to draw upon the rich literature on the ecology, economics and social values of forests and work with all stakeholders to develop the best management regime for the location at that point in time. The forester then has to stay engaged and be alert to the need to change management when the time comes to do so. We do not believe in management by formula or by any single "cookie-cutter" approach, guideline or criteria and indicator set. However we do conclude that the CBD Ecosystem Approach Principles and their supporting documentation are an excellent resource for forest managers and should be widely consulted and the Principles should be respected. We also conclude that the recent literature on sustainable forest management and the numerous sets of criteria and indicators that have been developed to monitor and evaluate its performance also represent valuable sources of guidance and accumulated knowledge and make valuable contributions to addressing the challenge of better management of forests worldwide.

Policymakers, implementing agencies

Sayer, J, and S. Maginnis (eds.) (2005) Forests in Landscapes: Ecosystem Approaches to Sustainability. Earthscan.

http://cmsdata.iucn.org/downloads/2005_018.pdf

Making the Ecosystem Approach Operational – Can Regime Shifts in Ecological and Governance Systems Facilitate the Transition?

Effectively reducing cumulative impacts on marine ecosystems requires co-evolution between science, policy and practice. Here, long-term social-ecological changes in the Baltic Sea are described, illustrating how the process of making the ecosystem approach operational in a large marine ecosystem can be stimulated. The existing multi-level governance institutions are specifically set up for dealing with individual sectors, but do not adequately support an operational application of the ecosystem approach. The review of ecosystem services in relation to regime shifts and resilience of the Baltic Sea sub-basins, and their driving forces, points to a number of challenges.

Implementing agencies, policymakers

Österblom, H. et al. (2010) Making the Ecosystem Approach Operational – Can Regime Shifts in Ecological and Governance Systems Facilitate the Transition? Marine Policy 34(6): 1290-1299.

http://www.sciencedirect.com/science/article/pii/S0308597X10001053

Ecosystem Approach>Africa

Green Hills, Blue Cities: An Ecosystems Approach to Water Resources Management for African Cities

This report, jointly produced by UNEP and UN-HABITAT in collaboration with the Africa Ministers' Council on Water (AMCOW) and funded by Tongji University, the Ministry of Science and Technology of China and Bayer Foundation, shows that there is a way forward for a more sustainable future where restoration of ecosystems, often in the green hills and watersheds surrounding cities, can provide cheaper, efficient and resilient water supply systems in a changing world.

Policymakers

Mafuta, C., R.K. Formo, C. Nellemann and F. Li (eds.) (2011) Green Hills, Blue Cities: An Ecosystems Approach to Water Resources Management for African Cities. A Rapid Response Assessment. United Nations Environment Programme, GRID-Arendal.

http://www.grida.no/publications/rr/blue-cities/

Ecosystem Approach>Canada

Implementing Ecosystem-based Management Approaches in Canada's Forests: A Science-Policy Dialogue

The following describes Nova Scotia's progress in implementing ecosystem-based management. A hierarchical ecological planning framework is provided by Nova Scotia's ecological land classification.

Policymakers

McAfee, B. and C. Malouin (eds.) (2008) Implementing ecosystem-based management approaches in Canada's forests: A science-policy dialogue. Natural Resources Canada, Canadian Forest Service Science and Programs Branch, Ottawa.

http://www.gov.ns.ca/natr/forestry/programs/ecosystems/pdf/ecosworks_novascotia_e.pdf

The Ecosystem Approach in Practice: Developing Sustainable Forestry in Central Labrador, Canada

This paper examines one recent example of large-scale ecosystem-based planning in central Labrador, Canada. Under an innovative agreement, the Innu Nation and the Government of Newfoundland and Labrador concluded an ecosystem-based forest management plan for 7.1 million ha in 2002. The central features of this plan are ecological and cultural protected area networks that were developed over a range of spatial scales.

Policymakers, implementing agencies

Innes, L. and L. Moores (2003) The Ecosystem Approach in Practice: Developing Sustainable Forestry in Central Labrador, Canada. Proceedings of the XII World Forestry Congress, Quebec City.

http://www.fao.org/DOCREP/ARTICLE/WFC/XII/0717-C1.HTM

Ecosystem Approach>China

Understanding Eco-complexity: Social-Economic-Natural Complex Ecosystem Approach

Human dominated landscape is a kind of Social-Economic-Natural Complex Ecosystem dominated by human behavior, sustained by natural life support system, and vitalized by ecological process, which is called ecoscape. Its natural subsystem consists of Chinese traditional five elements: metal (minerals), wood (living organism), water, fire (energy) and soil (nutrients and land). Its economic subsystem includes the components of production, consumption, reduction, transportation and regulation. While its social subsystem includes technology, institution and culture steered by man. In dealing with this eco-complexity, the key issue is how to image the complicated interactions, how to simplify and integrate the diversified relationships, and how to develop a practical instrument for cultivating the sustainability in helping local people to help themselves. Based on ancient Chinese human ecological philosophy, the SENCE approach for eco-sustainability planning and management was explored, which requires holistic rethinking, institutional reform and technological renovation. A combinatory model consists of mechanism model, planning model, and regulation model has been developed through identification of its key factors, feedback and function, simulation of its partial problems, process and alternative policies, and inducing its technological, institutional and cultural innovation towards sustainability.

Policymakers

Wang, R., Feng Li, D. Hu and B.L. Li (2011) Understanding Eco-complexity: Social-Economic-Natural Complex Ecosystem Approach. Ecological Complexity 8(1): 15-29.

http://www.sciencedirect.com/science/article/pii/S1476945X10000851

Conjugate Ecological Restoration Approach with a Case Study in Mentougou District, Beijing

Ecological restoration is a comprehensive engineering field that involves multidisciplinary and multisectoral efforts. More and more research works have been focused on ecological restoration since the 1980s. However, until now, most studies pay attention mainly on ecological technology, ecological policy, restoration of some certain ecosystem, and so on. There are few studies regarding the restoration plan of regional or the entire ecosystem. The objects of present research studies are mainly natural ecosystem; however, ecosystem is a complex system that encompasses natural, economic, and social sectors. Human society has great intimidation on nature, and if the degenerate social and economical systems do not get restored, the vicious cycle of degeneration will continue and the effects of natural ecosystem restoration cannot possibly be guaranteed.

Policymakers, implementing agencies

Jin, J., R. Wang, F. Li, J. Huang, C. Zhou, H. Zhang and W. Yang (2011) Conjugate Ecological Restoration Approach with a Case Study in Mentougou District, Beijing. Ecological Complexity 8(2): 161-170.

http://www.sciencedirect.com/science/article/pii/S1476945X11000067

Ecosystem Approach>India

Ecosystem Approach to Disaster Risk Reduction

Recognizing the benefits of the new epoch of 2nd paradigm shift in disaster management, that is ‘ecosystem approach to disaster risk reduction (Ecodrr)’ offers the benefits of community based approach as well due to its emphasis on livelihood, health and food security within the framework of vulnerability reduction. The suggested planning framework at district level, to have an integrated district plan, opens avenue for a much awaited ‘environmental action plan’ mandate at state, district and local levels. This shall help facilitate the DRR infusion with sustainable development agenda in much acceptable sense – in the governance as well as in community actions. It aims at reducing externality in dependence, improving self-reliance and local strengths for disaster mitigation and preparedness.

Policymakers, implementing agencies

Gupta, A.K. and S.S. Nair (2012) Ecosystem Approach to Disaster Risk Reduction. National Institute of Disaster Management, New Delhi.

http://nidm.gov.in/PDF/Ecosystem%20Approach.pdf

Ecosystem Approach>Latin America

Guía para la Aplicación y Monitoreo del Enfoque Ecosistémico

La presente guía es un instrumento que permite hacer una rápida valoración del nivel de aplicación del Enfoque Ecosistémico (EE), por medio de un conjunto de preguntas que abordan aspectos fundamentales de la gestión de los ecosistemas para poder afirmar que el enfoque se está aplicando en un espacio geográfico determinado, en un proyecto o en algún esquema de intervención del territorio.

Implementing agencies, policymakers

Andrade, A., S. Arguedas and R. Vides (2011) Guía para la aplicación y monitoreo del Enfoque Ecosistémico. CEM-UICN, UNESCO-Programa MAB, CI-Colombia, ELAP-UCI, FCBC.

http://data.iucn.org/dbtw-wpd/edocs/2011-100.pdf

Ecosystem Approach>Mauritania

The Rehabilitation of the Delta of the Senegal River in Mauritania

This book, which tells the story of an ecosystem approach to the rehabilitation of the lower delta of the Senegal River in Mauritania, in and around Diawling National Park, is a companion volume to that guide. Its main objective is to provide practitioners with a “feel” for what the approach can entail in the real-life setting of a remote corner of the Sahel, where people’s livelihoods are inextricably tied to the productivity of their delta. This productivity is in turn influenced by the mixing of fresh and saline waters during the floods, and by the surface area flooded.

Practitioners

Hamerlynck, O. and S. Duvail (2003) The rehabilitation of the Delta of the Senegal River in Mauritania. IUCN, Gland, Switzerland and Cambridge, UK.

http://data.iucn.org/dbtw-wpd/edocs/WTL-029.pdf

Ecosystem Approach>West Africa

An Ecosystem Approach to Restoring West African Drylands and Improving Rural Livelihoods through Agroforestry-based Land Management Interventions

The project aims to promote an ecosystems approach for sustainable management of the Parkland ecosystems (integrated crop-tree-livestock systems) of the semi-arid lowlands of West Africa. The project will build regional and local capacity in environmental policy development for restoring the West African Parklands with the ultimate aim of improving human well-being and alleviating poverty.

Policymakers

United Nations Environment Programme (2004-2007) CP/2000-04-03

http://www.worldagroforestry.org/wadrylands/resources/West%20African%20Drylands%20Project.pdf

Ecosystem Approach>Co-Management of Natural Resources

Adaptive Co-Management for Social-Ecological Complexity

Building trust through collaboration, institutional development, and social learning enhances efforts to foster ecosystem management and resolve multi-scale society–environment dilemmas. One emerging approach aimed at addressing these dilemmas is adaptive co-management. This method draws explicit attention to the learning (experiential and experimental) and collaboration (vertical and horizontal) functions necessary to improve our understanding of, and ability to respond to, complex social–ecological systems. Here, we identify and outline the core features of adaptive co-management, which include innovative institutional arrangements and incentives across spatiotemporal scales and levels, learning through complexity and change, monitoring and assessment of interventions, the role of power, and opportunities to link science with policy.

Policymakers, implementing agencies

Armitage, D.R. et al. (2009) Adaptive co-management for social–ecological complexity. Front Ecol Environ 7(2): 95-102.

http://www.forestlandscaperestoration.org/media/uploads/File/resources/Frontiers_2009_ACM_and_SE_Complexity.pdf

Acquiring and Managing a Community-Owned Forest: A Manual for Communities

This handbook provides a guide for communities interested in establishing a community -owned forest. We hope that it will be useful for communities in various stages, whether just beginning to think about a project or re-engaging community residents around land already in community ownership. As the examples in this handbook show, each community forest effort is unique to the local forest and community. Most, however, have several elements in common: outreach and information gathering to engage local residents, partners and decision -makers; an open, inclusive process to determine community priorities and governance structures for the forest; establishing relationships with local, regional and national partners; arranging financing for the purchase; and long-term planning and management of the forest. These steps, outlined in more detail in this handbook, do not necessarily happen in chronological order. Rather, some of this work can take place in parallel depending on the needs of your community and the particular forestland in question.

Indigenous and local communities

Cox, M. (2008) Acquiring and Managing a Community-Owned Forest: A Manual for Communities. Communities Committee.

http://www.communitiescommittee.org/pdfs/Acquiring_and_Managing_a_Community-Owned_Forest.pdf

Ecosystem Approach>Sustainable Development

Dead Planet, Living Planet: Biodiversity and Ecosystem Restoration for Sustainable Development

This report is a contribution to the UN's International Year of Biodiversity and is a complement to the UNEP-hosted Economics of Ecosystems and Biodiversity (TEEB) which is bringing visibility to the wealth of the world's natural capital. It documents over 30 successful case studies referencing thousands of restoration projects ranging from deserts and rainforests to rivers and coasts. The report confirms that restoration is not only possible but can prove highly profitable in terms of public savings; returns and the broad objectives of overcoming poverty and achieving sustainability. It also provides important recommendations on how to avoid pitfalls and how to minimize risks to ensure successful restoration.

Policymakers

Nellemann, C. and E. Corcoran (eds.) (2010) Dead Planet, Living Planet – Biodiversity and Ecosystem Restoration for Sustainable Development. A Rapid Response Assessment. United Nations Environment Programme, GRID-Arendal.

http://www.grida.no/publications/rr/dead-planet/

Linking Conservation and Poverty Reduction: Landscapes, People and Power

This book aims to inspire the conservation community not to regard poverty reduction as someone else's job but to take responsibility for it as part of ecosystem restoration. It offers a grand overview of the issues and a conceptual framework for addressing poverty reduction in the context of conservation, and conservation in the context of poverty reduction. It will appeal to professionals working in the field as well as to students across the fields of conservation, development and sustainability. It looks at the rationale for addressing the links between conservation and poverty reduction, arguing that such a focus is both ethically essential and a source of opportunities. It also reviews experiences in dealing with people and conservation and identifies some key lessons and concepts. The book presents cases studies illustrating various approaches and a discussion of some of the issues that appear when implementing combined conservation and poverty reduction.

Policymakers, implementing agencies, indigenous and local communities

Fisher, R., S. Maginnis, W. Jackson, E. Barrow and S. Jeanrenaud (2008) Linking Conservation and Poverty Reduction: Landscapes, People and Power. Routledge.

http://www.routledge.com/books/details/9781844076352/

Forest Landscapes

Global Map of Forest Landscape Restoration Opportunities

This restoration opportunity map is a revised and improved version of a previous map (published in 2009 and revised in 2010). The boreal forest landscapes of the north are now included; differences in forest canopy cover are reflected in greater detail; the assessment of potential forest cover has been improved; and the analysis has been updated with more recent and higher resolution data. The new map indicates a restoration opportunity twice as large as the old one. This is mainly because a more precise mapping of potential forest extent has increased the estimate of degraded lands with opportunities for restoration, not because something has changed in the real world.

Policymakers

Global Partnership on Forest Landscape Restoration, World Resources Institute, South Dakota State University, International Union for Conservation of Nature. September 2011.

http://www.wri.org/map/global-map-forest-landscape-restoration-opportunities

Global Assessment of Opportunities for Restoration of Forests and Landscapes

This assessment determines, in a coarse but globally consistent way, the extent and location of opportunities for restoration of forests and landscapes as well as the associated potential for carbon sequestration. The results should stimulate interest in restoration among international and national policy-makers, help set the global agenda on restoration, and serve as a point of departure for more detailed assessment at the national and regional levels.

Policymakers

World Resources Institute (2011) Global Assessment of Opportunities for Restoration of Forests and Landscapes. Final Report to the UNEP WCMC.

http://www.unep-wcmc.org/medialibrary/2011/12/01/b33ad955/WRI%20final%20method.pdf

Global Mapping and Monitoring the Extent of Forest Alteration: The Intact Forest Landscapes Method

This paper presents the IFL Method—a novel approach for mapping and monitoring the extent of forest alteration. High spatial resolution satellite images are used to identify and map large undegraded areas called Intact Forest Landscapes (IFL), defined as unbroken expanses of natural ecosystems in the zone of current forest landscapes extent without signs of significant human activity and at least 50,000 hectares in size. The method produces an IFL map which shows the boundary between unaltered forest landscapes (where most components, including species and site diversity, dynamics and ecological functions remain intact) and altered or fragmented forests (where some level of timber extraction, species composition change, anthropogenic fragmentation and/or alteration of ecosystem dynamics has taken place).

Policymakers, implementing agencies

Potapov, P., L. Laestadius, A. Yaroshenko and S. Turubanova (2009) Global mapping and monitoring the extent of forest alteration: the intact forest landscapes method Forest Resources. FAO Forest Resources Assessment Working Paper 166.

http://www.fao.org/forestry/fra/2560/en/

Towards a Common Set of Criteria and Indicators to Identify Forest Restoration Priorities: An Expert Panel-based Approach

This investigation aimed to verify whether this might be achieved through the elicitation of experts' opinion, when considering biodiversity conservation as the main objective of restoration. A Delphi process was performed, aimed at defining the key ecological criteria and a broad set of indicators. 389 criteria and 669 related indicators were provided in total and grouped into clusters relating to individual criteria. A total of 20 criteria referred to the need for restoration and 18 to its feasibility. In the second round of the Delphi process, 8 definitive criteria were identified along with some 90 related indicators. Finally, a face-to-face meeting was conducted to show how ready-to-use C&I can be obtained for application to a specific context starting from the Delphi's results. The study highlights the potential value of combining the Delphi process and face-to-face meetings for identifying practically applicable C&I for planning ecological restoration. However, the diversity of views identified within a single group of stakeholders suggests that the development of a generally applicable set of C&I for forest restoration will be difficult to achieve in practice.

Implementing agencies

Orsi, F., D. Geneletti and A.C. Newton (2011) Towards a Common Set of Criteria and Indicators to Identify Forest Restoration Priorities: An Expert Panel-based Approach. Ecological Indicators 11(2): 337-347.

http://www.sciencedirect.com/science/article/pii/S1470160X10001056

Forest Landscape Restoration: The Role of Forest Restoration in Achieving Multifunctional Landscapes

In many deforested, degraded and fragmented forest habitats investments in restoration and rehabilitation can yield high conservation benefits. Restoration in densely settled tropical areas can have more impact on biodiversity than further extension of "paper parks" in remote, pristine forests and can also deliver important forest goods and services to a wider range of stakeholders. Retention of even small fragments of natural vegetation is justified by their great potential value in providing the building blocks for future restoration programmes. However, care needs to be taken in planning and executing such programmes. Spatial modelling tools can be used to formulate scenarios for optimal multifunctional landscapes and indicate where restoration investments will have maximum pay-off. The use of these tools needs to be supported by a high degree of participation from, and negotiation among, the full range of stakeholders, to identify the most important goods and services that need to be delivered by a particular landscape. Spatial analysis tools can also be used to provide a framework for negotiation. The objectives of all stakeholders, including conservation organizations, should be clearly articulated in ways that are amenable to effective monitoring and evaluation.

Implementing agencies, policymakers

J. Sayer, V. Kapos, S. Mansourian and S. Maginnis (2003) Forest Landscape Restoration: The Role of Forest Restoration in Achieving Multifunctional Landscapes. Paper submitted to the XII Forestry Congress 2003, Quebec City.

http://www.fao.org/DOCREP/ARTICLE/WFC/XII/0670-B3.HTM

Lessons Learnt from WWF's Worldwide Field Initiatives Aiming at Restoring Forest Landscapes

WWF France commissioned this review with the specific intent to: 1) Extract lessons learnt to date, particularly in the last 5-6 year period, from WWF's work on the restoration of forest landscapes, and 2) Inform future restoration work, both within the WWF Network and beyond. A desk review, interviews and questionnaires all contributed to the production of this report. The ten sites selected and highlighted in this report were chosen based on prior knowledge of the programme. Furthermore, six of these ten ecoregions are biodiversity hotspots as per the commonly agreed definition (rating levels of endemism and extent of threat). These sites by no means cover all of WWF's efforts on the restoration of forests in landscapes.

Implementing agencies, indigenous and local communities, policymakers

Mansourian, S. and D. Vallauri (2012) Lessons Learnt from WWF's Worldwide Field Initiatives Aiming at Restoring Forest Landscapes. Marseille: WWF France.

http://awsassets.panda.org/downloads/mansourian_and_vallauri_2012_1.pdf

Five Years of Implementing Forest Landscape Restoration: Lessons to Date

The following publication starts by summarising the key lessons identified by the group, then discusses each in more detail, and ends with some key conclusions. Recommendations are made on the way forward for implementation of forest restoration at a landscape scale, designed to guide forest practitioners, conservationists and policymakers alike.

Practitioners, policymakers

Dudley, N. and M. Aldrich (eds.) (2007) Five Years of Implementing Forest Landscape Restoration: Lessons to date. WWF International, Gland.

http://assets.panda.org/downloads/flrlessonslearntbooklet.pdf

Reforesting Landscapes: Linking Pattern and Process

This edited volume draws together research from leading researchers to explore reforestation and forest regrowth across the world, from multiple dimensions – including ecosystem services, protected areas, social institutions, economic transitions, remediation of environmental problems, conservation and land abandonment – and at different scales. Detailing the methods and analyses used from across a wide range of disciplines, and incorporating research from North, South and Central America, Africa, Asia and Europe, this groundbreaking book provides a global overview of current trends, explores their underlying causes and proposes future forest trajectories.

Implementing agencies, policymakers

Nagendra, H. and J. Southworth (eds.) (2010) Reforesting Landscapes: Linking Pattern and Process. Springer Landscape Series, Vol. 10.

http://www.springer.com/life+sciences/ecology/book/978-1-4020-9655-6

Restoration of Degraded Tropical Forest Landscapes

The current scale of deforestation in tropical regions and the large areas of degraded lands now present underscore the urgent need for interventions to restore biodiversity, ecological functioning, and the supply of goods and ecological services previously used by poor rural communities. Traditional timber plantations have supplied some goods but have made only minor contributions to fulfilling most of these other objectives. New approaches to reforestation are now emerging, with potential for both overcoming forest degradation and addressing rural poverty.

Policymakers, implementing agencies

Lamb, D., P.D. Erskine and J.A. Parrotta (2005) Restoration of Degraded Tropical Forest Landscapes. Science 310: 1628-1632.

http://faculty.jsd.claremont.edu/emorhardt/159/pdfs/2006/Lamb.pdf

Investing in People and Nature: IUCN Demonstration Portfolio on Forest Landscape Restoration

This portfolio contains information about forest landscape restoration projects around the world. It has been compiled by the Global Partnership on Forest Landscape Restoration to illustrate the many ways in which forest landscape restoration can benefit both people and nature.

Policymakers, implementing agencies

IUCN (2002) Investing in People and Nature: IUCN Demonstration Portfolio on Forest Landscape Restoration. Case studies on Finland, Malaysia, Mexico, Nepal, Senegal, Tanzania, United Kingdom.

http://cmsdata.iucn.org/downloads/global_partnership_demo_portfolio.pdf

Integrating Forest Protection, Management and Restoration at a Landscape Scale

Protected areas, good forest management and forest landscape restoration address different aspects of forest conservation and development, but they interact in the field. The paper describes steps needed to integrate the three into a coherent approach at landscape level. The proposed approach also addresses some of the key questions that emerge during a transition from site-based to ecoregional conservation, which need to be answered on a case-by-case basis, such as: “is it better for biodiversity to have a few large strictly protected areas surrounded by generally incompatible land-uses or smaller protected areas embedded in a sea of supportive land uses?”

Policymakers, implementing agencies

Aldrich, M., A. Belokurov, J. Bowling, N. Dudley, C. Elliott, L. Higgins-Zogib, J. Hurd, L. Lacerda, S. Mansourian, T. McShane, D. Pollard, J. Sayer and K. Schuyt (2004) Integrating Forest Protection, Management and Restoration at a Landscape Scale. WWF International, Gland.

http://assets.panda.org/downloads/wwfpmrlandscapeapproach.pdf

The Role of Planted Forests in Forest Landscape Restoration

Although the conventional response of establishing planted forests as a counterweight to deforestation is seldom capable of restoring the multiple values that flow from natural forests or of adequately addressing all the needs of key interest groups, this paper argues that there is still a critical role for planted forests in restoring forest functionality at a landscape level. However in order to achieve this potential, and to move beyond the controversy that currently surrounds plantation forestry, it will be necessary for governments, the private sector and civil society to move beyond the “absolutist” rhetoric of entrenched positions.

Policymakers, implementing agencies

Maginnis, S. and W. Jackson (2003) The Role of Planted Forests in Forest Landscape Restoration. UNFF Intersessional Experts Meeting on the Role of Planted Forests in Sustainable Forest Management, New Zealand, 25–27 March 2003.

http://intranet.catie.ac.cr/intranet/posgrado/recursos_naturales/Clase%204/Clase4%20I%20TRI_2011/2010/planted-forests-landscape-restoration.pdf

Large-scale Ecological Restoration of Degraded Tropical Forest Lands: The Potential Role of Timber Plantations

Timber plantations are one of the few means by which large areas of cleared or degraded landscape can be reforested. These usually restore the productive capacity of the landscape but do little to recover biological diversity. But a number of approaches might be used to redesign such plantations so that they would both yield the timber needed to justify the investment and also contain some proportion of their former biodiversity. These approaches include using indigenous species rather than exotic species, creating species mosaics by matching species to particular sites, embedding the plantation monocultures in a matrix of intact or restored vegetation, using species mixtures rather than monocultures, or encouraging the diverse plant understories that can often develop beneath plantations.

Policymakers, implementing agencies

Lamb, D. (1998) Large-scale Ecological Restoration of Degraded Tropical Forest Lands: The Potential Role of Timber Plantations. Restoration Ecology 6(3): 271-279.

http://onlinelibrary.wiley.com/doi/10.1046/j.1526-100X.1998.00632.x/abstract

Catalyzing Natural Forest Restoration on Degraded Tropical Landscapes

In this paper, the results of recent studies conducted since 1995 in several countries in Latin America, Africa and the Asia-Pacific region on the phenomenon of plantation-catalysed native forest restoration will be summarised and their potential application in wildlife conservation programmes discussed.

Implementing agencies, practitioners

Parrotta, J.A., J.W. Turnbull and N. Jones (1997) Catalyzing Natural Forest Restoration on Degraded Tropical Landscapes. Forest Ecology and Management 99: 1-7.

http://www.fs.fed.us/global/iitf/pubs/catalyzing_native_parrotta_etal.pdf

Forest Landscapes>Argentina

Applying the Ecosystem Approach to Select Priority Areas for Forest Landscape Restoration in the Yungas, Northwestern Argentina

This paper proposes a method to select forest restoration priority areas consistently with the key principles of the Ecosystem Approach (EA) and the Forest Landscape Restoration (FLR) framework. The methodology is based on the principles shared by the two approaches: acting at ecosystem scale, involving stakeholders, and evaluating alternatives. It proposes the involvement of social actors which have a stake in forest management through multicriteria analysis sessions aimed at identifying the most suitable forest restoration intervention. The method was applied to a study area in the native forests of Northern Argentina (the Yungas). Stakeholders were asked to identify alternative restoration actions, i.e. potential areas implementing FLR.

Implementing agencies, policymakers

Ianni, E. and D. Geneletti (2010) Applying the Ecosystem Approach to Select Priority Areas for Forest Landscape Restoration in the Yungas, Northwestern Argentina. Environmental Management 46(5): 748-760.

http://www.springerlink.com/content/40n46745674831t1/

Forest Landscapes>Asia

Keep Asia Green – IUFRO World Series (4 Volumes)

This scientific publication project, led by Professor Don Koo LEE, Minister of the Korea Forest Service and Professor at the Seoul National University (SNU), has spanned over a period of several years, starting in early 2006. It has brought together around 100 forest scientists from the various regions in Asia Pacific, who jointly produced state-of-the-art assessments addressing major issues such as the status of forests in Asia Pacific, causes of forest degradation, and past and current rehabilitation efforts and achievements. But the book series also critically analyses national capacities in forest rehabilitation, existing research and education programmes on forest rehabilitation, and past and future initiatives to strengthen rehabilitation efforts.

Policymakers, implementing agencies, practitioners

Koo Lee, D. (ed.) (2007) Keep Asia Green. IUFRO World Series Volume 20 I-IV, Vienna.

http://www.iufro.org/science/special/spdc/actpro/keep/

Forest Landscapes>Brazil

Large-Scale Ecological Restoration of High-Diversity Tropical Forests in SE Brazil

We propose that plantations should be carried out with a high-diversity of native species in order to create biologically viable restored forests, and to assist long-term biodiversity persistence at the landscape scale. Finally, we propose strategies to integrate the political, socio-economic and methodological aspects needed to upscale restoration efforts in tropical forest regions throughout Latin America and elsewhere.

Implementing agencies, policymakers

Ribeiro Rodrigues, R., S. Gandolfi, A.G. Nave, J. Aronson, T. Egydio Barreto, C. Yuri Vidal and P.H.S. Brancalion (2011) Large-scale ecological restoration of high-diversity tropical forests in SE Brazil. Forest Ecology and Management 261: 1605-1613.

http://elti.fesprojects.net/2011Corridors1Colombia/rodrigues_et_al._2011.pdf

Emerging Threats and Opportunities for Large-Scale Ecological Restoration in the Atlantic Forest of Brazil

The AFRP aims to restore 15 million hectares of degraded lands in the Brazilian Atlantic Forest biome by 2050 and increase the current forest cover of the biome from 17% to at least 30%. We argue that not only should Brazilian lawmakers refrain from revising the existing Forest Law, but also greatly step up investments in the science, business, and practice of ecological restoration throughout the country, including the Atlantic Forest. The AFRP provides a template that could be adapted to other forest biomes in Brazil and to other megadiversity countries around the world.

Policymakers

Calmon, M., P.H.S. Brancalion, A. Paese, J. Aronson, P. Castro, S.C. da Silva and R.R. Rodrigues (2011) Emerging Threats and Opportunities for Large-Scale Ecological Restoration in the Atlantic Forest of Brazil. Restoration Ecology 19(2): 154-158.

http://www.pacto.org.br/media/Pacto_CF_RE_MAR_2011.pdf

Restoration of Pasture to Forest in Brazil's Mata Atlantica: The Roles of Herbivory, Seedling Defenses, and Plot Design in Reforestation

In this study, seedling growth and herbivory were monitored during the first 4 years of plot development in a large-scale reforestation experiment in Brazil's Atlantic Rainforest (Mata Atlantica). Seedlings were planted in a factorial design testing two levels of density, three levels of diversity, and the presence or absence of pioneer species at the Reserva Natural Vale in the Brazilian state of Espírito Santo. Overall, to limit insect damage and promote seedling success, plant defense characteristics and ecological interactions should be carefully considered in reforestation projects.

Implementing agencies, practitioners

Massad,T.J., J.Q. Chambers, S.G. Rolim, R.M. Jesus and L.A. Dyer (2011) Restoration of Pasture to Forest in Brazil's Mata Atlantica: The Roles of Herbivory, Seedling Defenses, and Plot Design in Reforestation. Restoration Ecology 19: 257-267.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2010.00683.x/abstract

Forest Landscapes>East Africa

Forest Landscape Restoration: Building Assets for People and Nature – Experience from East Africa

The following case studies document some of the innovative ways in which forest restoration has been implemented in the region. They also demonstrate the importance of actively involving those stakeholders most dependent on forests in decision-making. These stakeholders need to be given secure use rights and responsibilities and benefits need to be shared equitably. Perhaps the most emphatic lesson from East Africa is that one does not have to wait for more research, analysis or the allocation of more resources from central government. Communities and executive agencies can take action now, and build Forest Landscape Restoration from the ground up to restore forest goods and services, making an important and vital contribution to securing livelihoods and reducing poverty.

Policymakers, implementing agencies

Barrow, E., D. Timmer, S. White and S. Maginnis (2002). Forest Landscape Restoration: Building Assets for People and Nature - Experience from East Africa. IUCN, Gland, Switzerland and Cambridge, UK.

http://data.iucn.org/dbtw-wpd/edocs/2002-029.pdf

Forest Landscapes>Ethiopia

Forest Landscape Restoration: Initiatives in Ethiopia

The study touched upon a number of issues. Some, such as the policy matters, are sensitive and others are technical and simple. For many of the questions paused on the evaluation of the conformity of a policy or forest regeneration initiative, there were no ready-made answers. The experts of the above mentioned bureaus had to think and think before agreeing on a score to be assigned to the various parameters. This report is a result of a preliminary work and gross judgement on the functionality of the forest regeneration and policy initiatives. The study may or may not confirm to realities to a greater extent. But, it certainly gives clue and indicates the directions for more effective and efficient future studies on the subject.

Policymakers, implementing agencies

Bekele-Tesemma, A. (2002) Forest Landscape Restoration: Initiatives in Ethiopia. IUCN-EARO and WWF-EARPO.

http://assets.panda.org/downloads/ethiopiaflr.pdf

Forest Landscapes>Europe

Forest Landscape Restoration in Central and Northern Europe

The concept of forest landscape restoration is not a new idea. It builds on a number of existing rural development, conservation and natural resource management principles and approaches, bringing them together to restore multiple forest functions to degraded landscapes. Forests are addressed by several international and regional conventions and policy frameworks. In contribution to the global partnership, the Ministry of Agriculture and Forestry of Finland, in co-operation with the European Forest Institute and with financial support from the Ministry of the Environment of Finland organised an Expert Workshop on Forest Landscape Restoration in the Central and Northern European Region. The workshop took place in Hameenlinna, Finland on 6-8 October 2004. These proceedings compile the papers and presentations from the workshop.

Policymakers

Veltheim, T. and B. Pajari (eds.) (2005) Forest Landscape Restoration in Central and Northern Europe. EFI Proceedings No. 53.

http://www.efi.int/files/attachments/publications/proc53_net.pdf

Recovery of Forest Plant Communities in Post-Agricultural Landscapes

As landscapes throughout Europe and eastern North America recover from past agricultural use, forests continue to reflect their agricultural history. For centuries after agriculture has ceased, plant communities on abandoned agricultural lands remain impoverished in herbaceous species characteristic of uncleared forests. To facilitate the recovery of biological diversity in these forests, and to anticipate the effects of future land-use decisions, we need to understand the process of recolonization. The unique interactions between forest herbs and agricultural history also allow us to explore some universal questions in ecology, such as how dispersal and environment limit species distributions.

Policymakers, implementing agencies

Flinn, K.M. and M. Vellend (2005) Recovery of Forest Plant Communities in Post-Agricultural Landscapes. Front Ecol Environ 3(5): 243-250.

http://www3.botany.ubc.ca/vellend/Flinn%26Vellend_Frontiers_2005.pdf

Forest Landscapes>Latin America

Principles and Practice of Forest Landscape Restoration: Case Studies from the Drylands of Latin America

The book Principles and Practice of Forest Landscape Restoration: Case studies from the drylands of Latin America is a compendium of case studies and analysis, which will be of interest and use to people who wish to move forest landscape restoration forward, no matter what country they operate in. Practitioners and policy-makers working on forest landscape restoration are learning all the time, through experience, and from each other. It is important to continue to connect partners and collaborators around the world, from Scotland to Sudan and Moldova to Mexico, in a growing community of practice, enabling them to spread best practice, build cooperation and exchange new ideas and solutions.

Practitioners, policymakers

English, Spanish

Newton, A.C. and N. Tejedor (eds.) (2011) Principles and Practice of Forest Landscape Restoration: Case studies from the drylands of Latin America. IUCN, Gland.

http://data.iucn.org/dbtw-wpd/edocs/2011-017.pdf

http://www.iucn.org/about/work/programmes/forest/?8622/Principios-y-practica-de-la-restauracion-del-paisaje-forestal--estudios-de-caso-en-las-zonas-secas-de-America-Latina

Forest Landscapes>India

UK – India Forest Landscape Restoration

The aim of this collaboration is primarily to develop knowledge exchange between the UK and Indian forest sectors. This will lead to an increased understanding of the broad-ranging contribution forest restoration can make to biodiversity, ecosystem services, climate change mitigation and adaptation, people and economy. This summary report shows how Forest Landscape Restoration can safeguard biodiversity by taking a landscape approach using appropriate technologies and practical applications and produce real benefits for communities by working in partnership with them.

Policymakers, implementing agencies, indigenous and local communities

Smith, M. and S. Tripathi (2011) UK – India Forest Landscape Restoration. Forest Research, UK and Forest Research Institute, India.

http://www.forestry.gov.uk/pdf/UK-India-FLR-09-11.pdf/$file/UK-India-FLR-09-11.pdf

Forest Landscapes>Kenya

Forest Landscape Restoration – Kenya Country Report

This review is not a comprehensive study of the level to which policy and existing initiatives support FLR within the four countries of Kenya, Tanzania, Uganda and Ethiopia. It is the first step in a broader development process, and is primarily intended as a starting point to enhance general understanding, and promote dialogue within the region.

Policymakers, implementing agencies, indigenous and local communities

Matiru, V. (2002) Forest Landscape Restoration – Kenya Country Report. Compiled by IUCN-EARO and WWF-EARPO.

http://assets.panda.org/downloads/kenyaflr.pdf

Forest Landscapes>Nepal

From Degradation to Restoration: An Assessment of the Enabling Conditions for Community Forestry in Nepal

This paper provides an analysis of key factors and enabling conditions for community based forest resource management, which led to the emergence and consolidation of local institutions and organizations devoted to promoting community forestry in Nepal. A collective effort to establish good forest governance systems at local level was eventually able to combat forest degradation effectively, to improve forest conditions and forest agriculture interface successfully, leading to effective forest landscape restoration. It is shown that forest degradation in the past was essentially the outcome of non-consultative ways of policy making, inappropriate policies, wrong institutional arrangements and a controlling legislative framework instead of promoting active participation by local stakeholders. Learning from mistakes and continuous joint efforts of a wide range of actors have brought positive changes in the productive capacity of forests, availability of wood and non-wood forest products, improvement of agricultural productivity and supplementary income to local communities.

Policymakers, implementing agencies

B.K. Pokharel, T. Stadtmüller and J-L. Pfund (2005) From degradation to restoration: An assessment of the enabling conditions for community forestry in Nepal. Nepal Swiss Community Forestry Project, Intercooperation/SDC, Nepal.

http://www.forestrynepal.org/article/publications/269

Forest Landscapes>Tanzania

A Study on the Social, Economic and Environmental Impacts of Forest Landscape Restoration in Shinyanga Region, Tanzania

In the semi-arid Shinyanga region over 800 villages and their inhabitants improved their livelihoods by working in partnership with the government to revitalise a traditional practice of natural resource management. To date over 350,000 ha have been restored to provide much needed forest products for local use, including fuel and building material, food and medicine, as well as important products to meet contingency needs.

Policymakers, implementing agencies, indigenous and local communities

G.C. Monela, S.A.O. Chamshama, R. Mwaipopo and D.M. Gamassa (2005) A Study on the Social, Economic and Environmental Impacts of Forest Landscape Restoration in Shinyanga Region, Tanzania. Final Report: Ministry of Natural Resources and Tourism, Forestry and Beekeeping Division and the IUCN Eastern Africa Regional Office.

http://cmsdata.iucn.org/downloads/flr_final_report_shinyanga_june2005.pdf

http://www.tanzaniagateway.org/docs/Forest_landscape_restoration_East_Africa.pdf

Forest Landscapes>Uganda

Forest Landscape Restoration – Uganda Country Report

The aim of the study was to document the past and current forest regeneration initiatives with a view of identifying opportunities for a FLR approach. The study also assessed the extent to which FLR would be supportive of other development programmes like PEAP and PMA. It also evaluated the relevance of existing policies in promoting FLR. The study has found that FLR would complement the PEAP and PMA for example because they all shore the same principles. These are continued processes for consensus – building among stakeholders on priorities, long – term commitment or perspective and multi – stakeholder involvement.

Policymakers, implementing agencies, indigenous and local communities

Kazoora, C. (2001) Forest Landscape Restoration – Uganda Country Report. Compiled by IUCN-EARO and WWF-EARPO.

http://www.unep-wcmc.org/medialibrary/2011/03/14/a273351a/Uganda.pdf

Forest Landscapes>UK

The Restoration of Wooded Landscapes

This publication aims to: 1) Synthesize current knowledge relating to the ecology of wooded landscapes and design of new woodland areas, 2) Illustrate, through case studies, how ecological knowledge has been applied to the design and management of native woodland restoration schemes, the identification of opportunities and constraints, and the evaluation of ecological and economic costs and benefits. The publication is aimed at woodland managers, planners and policymakers concerned with the restoration of native woodland at the landscape scale. A number of the chapters reviewing the main themes in the field of landscape ecology will be of interest to applied ecologists and researchers.

Implementing agencies, policymakers

Humphrey, J., A. Newton, J. Latham, H. Gray, K. Kirby, E. Poulsom and C. Quine (eds.) (2003) The Restoration of Wooded Landscapes. Proceedings of a conference held at Heriot Watt University, Edinburgh, 14–15 September 2000, Forestry Commission: Edinburgh.

http://www.forestry.gov.uk/pdf/FCRP001.pdf/$FILE/FCRP001.pdf

Forest Landscapes>USA

Socio-Economic Indicators for Forest Restoration Projects

This report, developed by the New Mexico Forest and Watershed Restoration Institute through a grant from the USDA Forest Service, Southwest Region, will help us better understand the social and economic outcomes of forest restoration projects. Importantly, it provides a framework for assessing the contributions of forest restoration efforts to local economies and restoration-based businesses. Forest restoration in the southwestern United States lies at the intersection of forest health, rural economic development and wildfire prevention. Critical to restoration efforts is the ability to evaluate their effectiveness, especially as they relate to improvements in social and economic conditions of stakeholders and local communities.

Policymakers

Egan, A. and V. Estrada-Bustillo (2011) Socioeconomic indicators for forest restoration projects. New Mexico Forest and Watershed Restoration Institute, New Mexico Highlands University, Las Vegas.

http://allaboutwatersheds.org/library/Socioeconomic%20Indicators%20for%20Forest%20Restoration%20Projects.pdf

Forest Ecosystems of an Arizona Pinus Ponderosa Landscape: Multifactor Classification and Implications for Ecological Restoration

Several lines of evidence suggest that although species composition may have been altered since settlement, the same basic ecosystems occurred on this landscape in pre-settlement forests, providing reference information for ecological restoration. Red cinders/Bahia ecosystems were rare historically and > 30% of their area has been burned by crown fires since 1950, indicating that priority could be given to restoring this ecosystem's remaining mapping units. Ecosystem classifications may be useful as data layers in gap analyses to identify restoration and conservation priorities. Ecosystem turnover occurs at broad extents on this landscape, and restoration must accordingly operate across large areas to encompass ecosystem diversity. By incorporating factors driving ecosystem composition, this ecosystem classification represents a framework for estimating spatial variation in ecological properties, such as species diversity, relevant to ecological restoration.

Implementing agencies

Abella, S.R. and W.W. Covington (2006) Forest Ecosystems of an Arizona Pinus Ponderosa Landscape: Multifactor Classification and Implications for Ecological Restoration. Journal of Biogeography 33: 1368-1383.

http://library.eri.nau.edu/gsdl/collect/erilibra/index/assoc../HASH01d3.dir/doc.pdf

Determining Reference Ecosystem Conditions for Disturbed Landscapes within the Context of Contemporary Resource Management Issues

In this article, we present a framework to assess the potential influence of forest ecosystem restoration on the landscape of Sleeping Bear Dunes National Lakeshore, the core of which is an approach to determine the distribution of forest ecosystems on both the pre-European settlement landscape and the "restored" landscape. Because there has been an increased interest in the conservation and restoration of the cultural landscapes (e.g., particularly late 19th and early 20th century farmsteads) at the Lakeshore, we focus our efforts on understanding the important ecological contributions provided by these cultural landscapes to open land avian bird conservation and the potential consequences of restoring the Lakeshore's cultural landscapes to a more natural condition.

Implementing agencies

Goebel, P.C., T.C. Wyse and R.G. Corace III (2005) Determining Reference Ecosystem Conditions for Disturbed Landscapes within the Context of Contemporary Resource Management Issues. Journal of Forestry (October/November 2005): 351-356.

http://www.fws.gov/bmt/documents/JofF_article_Goebel_etal_05.pdf

Forest Landscapes>Vietnam

A Monitoring and Evaluation System for Forest Landscape Restoration in the Central Truong Son, Vietnam

The main part of the report introduces the Central Truong Son, looks at previous data gathering exercises in the area and then suggests a framework for a monitoring and evaluation system. A series of indicators are proposed along with possible sources of information and, where necessary, the steps needed to build capacity to measure particular indicators. The report also outlines steps needed to analyse data and lays out a possible format for an Annual State of the Central Truong Son report. A final section lays out the steps needed to implement the monitoring and evaluation system. The background report is supplemented by a series of annexes, which provide more detail on how some of the indicators might be measured, including draft questionnaires relating to stakeholder perceptions, poverty alleviation and biodiversity and sustainable forest management, along with a proposal for a regular transect along the Ho Chi Minh highway.

Implementing agencies

Dudley, N., N. Cu and V. Tien Manh (2004) A Monitoring and Evaluation System for Forest Landscape Restoration in the Central Truong Son, Vietnam. WWF International, Forest Landscape Restoration Programme.

http://www.equilibriumresearch.com/upload/document/Vietnam_M&E.pdf

Forest Landscapes>West Africa

Forest Landscape Restoration: Broadening the Vision of West African Forests

Forest Landscape Restoration is not a new approach in West Africa; a number of initiatives already exist in the region. One example is the flooded forest of Youwarou in the north of Mali. It is the largest wetland in West Africa and an ecosystem with tremendous ecological and socio-economic value. A combination of nature-related changes, such as climate variation and sedimentation, and human activities, such as collecting firewood and building materials, virtually destroyed this unique ecosystem, leaving less than 40 hectares of the forest intact.

Policymakers

IUCN (2005) Forest Landscape Restoration: Broadening the Vision of West African Forests. IUCN: Gland.

http://app.iucn.org/dbtw-wpd/edocs/Folder-001.pdf

Forest Landscapes>USA

Restoration of Landscape Function: Reserves or Active Management?

A 20-year programme of research suggests that old-growth forests are ecologically unique and highly valued by people, that naturally young forests with legacies from old forests sustain many, if not all, the higher organisms associated with old growth, but that many managed forests are impoverished in species. Thus, restoring landscape function entails restoring function to managed stands. Managing processes of forest development, not just providing selected structures, is necessary to restore function and biodiversity. Systems of reserves and riparian corridors that do not take into account ecological restoration of managed forests and degraded streams may be self-fulfilling prophecies of forest fragmentation and landscape dysfunction. Intentional management can reduce the need for wide riparian buffers, produce landscapes dominated by late-seral stages that are hospitable to wildlife associated with old-growth forests, provide a sustained yield of forest products and contribute to economic, social and environmental sustainability.

Implementing agencies, policymakers

Carey, A.B. (2003) Restoration of Landscape Function: Reserves or Active Management? Forestry 76(2): 221-230.

http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.157.6921&rep=rep1&type=pdf

Invasive Species

Invasives: A Major Conservation Threat

As leaders of conservation organizations with missions to protect biodiversity, we believe that the endorsement of invading species—although potentially stimulating from an academic perspective—risks trivializing the global action that is needed to address one of the most severe and fastest growing threats to biological diversity. Our organizations have promoted biosecurity programs, implemented dozens of campaigns for invasive species removal, and supported hundreds of the more than 1000 eradications so far completed, recovering ecosystems and preventing many extinctions worldwide, especially on islands. These successes demonstrate clearly that threats from invasive species can be mitigated and that biodiversity can be protected through these actions.

Policymakers, implementing agencies

Lambertini, M. et al. (2011) Invasives: A Major Conservation Threat. Science 22: 404-405.

http://www.sciencemag.org/content/333/6041/404.2.full.pdf

Turning the Tide: The Eradication of Invasive Species

Our aim in organising the 2001 ISSG Conference on Eradication of Invasive Species and editing its proceedings into a peer-reviewed volume was to bring together conservation practitioners and scientists who are at the forefront of the battle against alien invasive species. This volume is intended to share their insight and practical experience with a wider audience.

Policymakers, implementing agencies, practitioners

Veitch, C.R. and M. N. Clout (2002) Turning the Tide: The Eradication of Invasive Species. Proceedings of the International Conference On Eradication of Island Invasives, Occasional Paper of the IUCN Species Survival Commission No. 27.

http://data.iucn.org/dbtw-wpd/edocs/ssc-op-028.pdf

An Invasive Plant Management Decision Analysis Tool

The primary purpose of the Invasive Plant Management Decision Analysis Tool (IPMDAT) is to assist The Nature Conservancy (TNC) and partner agencies and organizations in deciding if an invasive plant management project is likely to be successful: i.e. to achieve desired conservation outcomes with acceptable costs. A successful invasive plant management project should not only remove or reduce an invasive plant – it should also result in long-term maintenance or restoration of the viability/health/resilience of desired species, natural communities, and/or ecosystem processes. The IPMDAT will help ensure that limited resources are used most effectively. Our approach is designed for invasive plants, but a similar method could be used for invasive animals and insects.

Implementing agencies, practitioners

Zimmerman, C., M. Jordan, G. Sargis, H. Smith and K. Schwager (2011) An Invasive Plant Management Decision Tool. Version 1.1. The Nature Conservancy, Arlington.

http://www.imapinvasives.org/IPMDAT_v1.1_06-30-11.pdf

Invasive Alien Species: A Toolkit of Best Prevention and Management Practices

The toolkit is intended to be global in its applicability, although there is a small island focus, recognizing that the impact of invasive alien species on biodiversity is greater in small island systems. In any case, we anticipate that to be most useful and effective, the toolkit will need to be locally adapted for different countries or regions (Chapter 6). In this regard we would like to note that the case studies represent the particular expertise of the workshop participants, and the people we were subsequently able to work with during the preparation of the toolkit, and are therefore not representative of the full range of experience worldwide.

Implementing agencies, practitioners

Wittenberg, R. and W.J.W. Cock (eds.) (2001) Invasive Alien Species: A Toolkit of Best Prevention and Management Practices. CAB International, Wallingford.

http://www.gisp.org/publications/toolkit/Toolkiteng.pdf

Beyond Control: Wider Implications for the Management of Biological Invasions

Government departments, environmental managers and conservationists are all facing escalating pressure to address and resolve a diversity of invasive alien species (IAS) problems. Yet much research to date is primarily concerned with quantifying the scale of the problem rather than delivering robust solutions and has not adequately addressed all stages of the invasion process, and only a few studies embrace the ecosystem approach. A comprehensive approach to IAS management should include consideration of the: (i) expected impacts; (ii) technical options available; (iii) ease with which the species can be targeted; (iv) risks associated with management; (v) likelihood of success; and (vi) extent of public concern and stakeholder interest. For each of these issues, in addition to targeting an individual species, the management of biological invasions must also incorporate an appreciation of other environmental pressures, the importance of landscape structure, and the role of existing management activities and restoration efforts.

Implementing agencies, policymakers

Hulmw, P.E. (2006) Beyond Control: Wider Implications for the Management of Biological Invasions. Journal of Applied Ecology 43: 835-847.

http://bioprotection.org.nz/system/files/Hulme,+PE+(2006)+J.+Appl.+Ecol.+43,+835-847.pdf

Using Ecological Restoration to Constrain Biological Invasion

Biological invasion can permanently alter ecosystem structure and function. Invasive species are difficult to eradicate, so methods for constraining invasions would be ecologically valuable. We examined the potential of ecological restoration to constrain invasion of an old field by Agropyron cristatum, an introduced C3 grass. To our knowledge, this study provides the first indication that restoration can act as a filter, constraining invasive species while allowing colonization by native species. These results suggest that resistance to invasion depends on the identity of species in the community and that restoration seed mixes might be tailored to constrain selected invaders. Restoring areas before invasive species become established can reduce the magnitude of biological invasion.

Implementing agencies, practitioners

Bakker, J.D. and S.D. Wilson (2004) Using Ecological Restoration to Constrain Biological Invasion. Journal of Applied Ecology 41: 1058-1064.

http://library.eri.nau.edu/gsdl/collect/erilibra/archives/HASH010f.dir/doc.pdf

Viewing Invasive Species Removal in a Whole-Ecosystem Context

Eradications of invasive species often have striking positive effects on native biota. However, recent research has shown that species removal in isolation can also result in unexpected changes to other ecosystem components. These secondary effects will become more likely as numbers of interacting invaders increase in ecosystems, and as exotics in late stages of invasion eliminate native species and replace their functional roles. Food web and functional role frameworks can be used to identify ecological conditions that forecast the potential for unwanted secondary impacts. Integration of eradication into a holistic process of assessment and restoration will help safeguard against accidental, adverse effects on native ecosystems.

Implementing agencies, practitioners

Zavaleta, E.S., R.J. Hobbs and H. A. Mooney (2001) Viewing Invasive Species Removal in a Whole-Ecosystem Context. Trends in Ecology and Evolution 16(8): 454-459.

http://www.ege.fcen.uba.ar/materias/general/Seminario%20Invasiones%202.pdf

Climate Change and Plant Invasions: Restoration Opportunities Ahead?

Rather than simply enhancing invasion risk, climate change may also reduce invasive plant competitiveness if conditions become climatically unsuitable. Using bioclimatic envelope modeling, we show that climate change could result in both range expansion and contraction for five widespread and dominant invasive plants in the western United States. Yellow starthistle (Centaurea solstitialis) and tamarisk (Tamarix spp.) are likely to expand with climate change. Cheatgrass (Bromus tectorum) and spotted knapweed (Centaurea biebersteinii) are likely to shift in range, leading to both expansion and contraction. Leafy spurge (Euphorbia esula) is likely to contract. The retreat of once intractable invasive species could create restoration opportunities across millions of hectares. Identifying and establishing native or novel species in places where invasive species contract will pose a considerable challenge for ecologists and land managers. This challenge must be addressed before other undesirable species invade and eliminate restoration opportunities.

Implementing agencies, practitioners

Bradley, B.A., M. Oppenheimer and D.S. Wilcove (2009) Climate change and plant invasions: restoration opportunities ahead? Global Change Biology 15: 1511-1521.

http://www.princeton.edu/step/people/faculty/michael-oppenheimer/research/Bradley-et-al.-2009.pdf

Riparian Vegetation: Degradation, Alien Plant Invasions, and Restoration Prospects

This paper examines the biogeography and the determinants of composition and structure of riparian vegetation in temperate and subtropical regions and conceptualizes the components of resilience in these systems. We consider changes to structure and functioning caused by, or associated with, alien plant invasions, in particular those that lead to breached abiotic- or biotic thresholds. These pose challenges when formulating restoration programmes. Pervasive and escalating human-mediated changes to multiple factors and at a range of scales in riparian environments demand innovative and pragmatic approaches to restoration. The application of a new framework accommodating such complexity is demonstrated with reference to a hypothetical riparian ecosystem under three scenarios: (1) system unaffected by invasive plants; (2) system initially uninvaded, but with flood-generated incursion of alien plants and escalating invasion-driven alteration; and (3) system affected by both invasions and engineering interventions. The scheme has been used to derive a decision-making framework for restoring riparian zones in South Africa and could guide similar initiatives in other parts of the world.

Implementing agencies, practitioners

Richardson, D.M., P.M. Holmes, K.J. Esler, S.M. Galatowitsch, J.C. Stromberg, S.P. Kirkman, P. Pysek and R.J. Hobbs (2007) Riparian Vegetation: Degradation, Alien Plant Invasions, and Restoration Prospects. Diversity and Distributions 13: 126-139.

http://www.ibot.cas.cz/personal/pysek/pdf/Richardson%20et%20al.-Riparian%20vegetation_DDI2007.pdf

Functional Differences between Native and Alien Species: A Global-scale Comparison

A prevalent question in the study of plant invasions has been whether or not invasions can be explained on the basis of traits. Despite many attempts, a synthetic view of multi-trait differences between alien and native species is not yet available. We compiled a database of three ecologically important traits (specific leaf area, typical maximum canopy height, individual seed mass) for 4473 species sampled over 95 communities (3784 species measured in their native range, 689 species in their introduced range, 207 in both ranges). We conclude that the simultaneous evaluation of multiple traits is an important novel direction in understanding invasion success. Our results support the phenotypic divergence hypothesis that predicts functional trait differences contribute to the success of alien species.

Implementing agencies, practitioners

Ordonez, A., I.J. Wright and H. Olff (2010) Functional Differences between Native and Alien Species: A Global-scale Comparison. Functional Ecology 24: 1353-1361.

http://bio.mq.edu.au/~iwright/pdfs/OFE10.pdf

Restoration through Reassembly: Plant Traits and Invasion Resistance

One of the greatest challenges for ecological restoration is to create or reassemble plant communities that are resistant to invasion by exotic species. We examine how concepts pertaining to the assembly of plant communities can be used to strengthen resistance to invasion in restored communities. Community ecology theory predicts that an invasive species will be unlikely to establish if there is a species with similar traits present in the resident community or if available niches are filled. Therefore, successful restoration efforts should select native species with traits similar to likely invaders and include a diversity of functional traits. The success of trait-based approaches to restoration will depend largely on the diversity of invaders, on the strength of environmental factors and on dispersal dynamics of invasive and native species.

Practitioners, implementing agencies

Funk, J.L., E.E. Cleland, K.N. Suding and E.S. Zavaleta (2008) Restoration through reassembly: plant traits and invasion resistance. Trends in Ecology & Evolution 23: 695-703.

http://www.planta.cn/forum/files_planta/restoration_through_reassembly_plant_traits_and_invasion_resistance_164.pdf

Environmental Restoration of Invaded Ecosystems: How Much Versus How Often?

In this paper, a model of environmental restoration is designed that incorporates the risk and resiliency effects associated with environmental restoration. The issue of how much restoration effort to undertake is then looked at in an inter-temporal cost-benefit analysis setting. When risks of failure may be stock dependent, the question of how much restoration versus how often becomes relevant, as the costs of continual but lower restoration must be weighed against the costs of less frequent by larger restorative efforts leading to a higher environmental quality. This also determines under what circumstances a more resilient state is desirable given the higher costs associated with its attainment. Numerical simulations reinforce the analysis.

Implementing agencies

Ranjan, R. (2005) Environmental Restoration of Invaded Ecosystems: How Much Versus How Often? International Agricultural Trade and Policy Center Working Paper Series.

http://ageconsearch.umn.edu/bitstream/19135/1/sp05ra02.pdf

Principles for Restoring Invasive Plant-Infested Rangeland

It is becoming increasingly clear that prescriptions for rangeland weed control are not sustainable because they treat the symptoms of weeds rather than their cause. Future restoration of invasive plant-infested rangeland must be based on ecological principles and concepts that provide for predictable outcomes. The processes controlling plant community dynamics can be modified to allow predictable successional trajectories. Successional management can lead to biomass optimization models for grazing management, spread vector analysis, and using resource availability to direct weedy plant communities toward those that are desired. Our challenge is to develop ecological principles on which management can be based.

Implementing agencies, practitioners

Sheley, R.L. and J. Krueger-Mangold (2003) Principles for Restoring Invasive Plant-Infested Rangeland. Weed Science 51(2): 260-265.

http://www.msuextension.org/invasiveplantsMangold/documents/Publications_Mangold/Sheley%20and%20Krueger-Mangold%202003.pdf

The Need for Flexibility in Conservation Practices: Exotic Species as an Example

To garner support for biodiversity from the World's human population, conservation biologists need an open-minded, integrated conservation strategy. We suggest that this strategy should include efforts to (1) preserve existing high quality, diverse ecosystems, (2) remediate impaired systems, (3) balance the needs of people and ecological resources, and (4) engender appreciation of nature and its services. We refer to these four key tenets as reservation, restoration, reconciliation, and reconnection. We illustrate these concepts by presenting the debate surrounding the management of exotic species from an unusual perspective, the benefits of exotic species.

Implementing agencies, practitioners, policymakers, indigenous and local communities

Prevot-Julliard, A.C., J. Clavel, P. Teillac-Deschamps and R. Julliard (2011) The Need for Flexibility in Conservation Practices: Exotic Species as an Example. Environmental Management 47: 315-321.

http://www.springerlink.com/content/a4567771qt280541/

Opportunities for Nonnative Ecological Replacements in Ecosystem Restoration

Translocations can take a variety of forms, and there is considerable debate as to what defines an acceptable translocation. This is particularly so if a proposal suggests moving a species beyond its natural range, which might be necessary for conservation purposes if habitat within the natural range is extensively modified. An extension of this approach is to use closely related ecological analogs to replace extinct species. This approach is controversial, and opportunities to do so will be rare, particularly for vertebrate species, but the use of ecological analogs is not without precedent, and ultimately will provide for more complete ecological restoration. We discuss the current use of ecological analogs to replace extinct species and conclude with a rare opportunity to replace the extinct New Zealand quail Coturnix novaezelandiae with the extant Australian brown quail Coturnix ypsilophora.

Implementing agencies

Parker, K.A., M. Seabrook-Davison and J.G. Ewen (2010) Opportunities for Nonnative Ecological Replacements in Ecosystem Restoration. Restoration Ecology 18: 269-273.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2010.00676.x/abstract

A Place for Alien Species in Ecosystem Restoration

Blanket condemnation of alien species in restoration efforts is counterproductive. Where their presence does not unduly threaten surrounding ecosystems, alien species can be tolerated or even used to good advantage, if they provide essential ecological or socioeconomic services. By speeding restoration or making it more effective, non-native species can provide economic and ecological payoffs. Risk is always an issue when alien species are involved, but greater risk taking is warranted where environmental conditions have been severely modified through human activity than where reassembly of a biological community is the sole goal of restoration.

Ewel, J.J. and F.E. Putz (2005) A Place for Alien Species in Ecosystem Restoration. Front Ecol Environ 2(7): 354-360.

http://noss.cos.ucf.edu/papers/Ewel%20and%20Putz%202004.pdf

Exotic Plant Species as Problems and Solutions in Ecological Restoration: A Synthesis

We review the types of effects exotic species may have that are important during restoration and suggest research that could increase our ability to set realistic management goals. Their control and use may be controversial; therefore we advocate consideration of exotic species in the greater context of community structure and succession and emphasize areas where ecological research could bring insight to management dilemmas surrounding exotic species and restoration.

Practitioners, implementing agencies

D'Antonio, C. and L.A. Meyerson (2002) Exotic Plant Species as Problems and Solutions in Ecological Restoration: A Synthesis. Restoration Ecology 10(4): 703-713.

http://planet.botany.uwc.ac.za/nisl/invasives/refs/dantonioandmeyerson.pdf

Invasive Species>Africa

Alien Plant Invasions in Tropical and Sub-tropical Savannas: Patterns, Processes and Prospects

We reviewed the literature, contrasting the African situation with that of Neotropical and Australian savannas. A number of drivers and explanatory factors of plant invasions in savannas have been described, mostly from the Neotropics and Australia. These include herbivore presence, residence time, intentional introductions for pasture improvements, fire regimes, the physiology of the introduced species, and anthropogenic disturbance. After comparing these drivers across the three regions, we suggest that the lower extent of alien plant invasions in African savannas is largely attributable to: (1) significantly lower rates of intentional plant introductions and widespread plantings (until recently); (2) the role of large mammalian herbivores in these ecosystems; (3) historical and biogeographical issues relating to the regions of origin of introduced species; and (4) the adaptation of African systems to fire. We discuss how changing conditions in the three regions are likely to affect plant invasions in the future.

Implementing agencies

Foxcroft, L.C., D.M. Richardson, M. Rejmanek and P. Pysek (2010) Alien Plant Invasions in Tropical and Sub-tropical Savannas: Patterns, Processes and Prospects. Biological Invasions 12: 3913-3933.

http://escholarship.org/uc/item/5j66w0kj

Invasive Species>Australia

Does Invasive Plant Management Aid the Restoration of Natural Ecosystems?

Invasive alien plants of natural ecosystems, commonly referred to as weeds, can reduce the abundance and diversity of native flora and fauna, and alter ecosystem processes. Using Australia's 20 'Weeds of National Significance' (WoNS), we investigated how natural ecosystems responded following their management. Our results emphasise the need to select sites for weed management that are less degraded and thus have a higher likelihood of natural recovery and/or to incorporate activities that facilitate recovery of native plant communities in conjunction with weed removal.

Implementing agencies, practitioners

Reid, A.M., L. Morin, P.O. Downey, K. French and J.G. Virtue (2009) Does Invasive Plant Management Aid the Restoration of Natural Ecosystems? Biological Conservation 142: 2342-2349.

http://www.canberra.edu/centres/iae/pdfs/2009-Reid-et-al-Bio-Cons-142-2342-9.pdf

Integrating Ecological Knowledge, Public Perception and Urgency of Action into Invasive Species Management

The Australian context provides us with many cases of the labeling of exotic species as harmful or not, using inputs from scientists, industry, and the public. Integration of social and scientific points of view can only improve conservation on the ground if it allows managers to use the ecological, economic and social impacts of exotic species to prioritize conservation actions in an operative way.

Policymakers, implementing agencies

Caplat, P. and S.R. Coutts (2011) Integrating Ecological Knowledge, Public Perception and Urgency of Action into Invasive Species Management. Environmental Management 48: 878-881.

http://www.springerlink.com/content/7gw3367456262215/

Habitat Management Guide—Rangelands: Ecological Principles for the Strategic Management of Weeds in Rangeland Habitats

This publication takes a habitat-level approach to weeds in rangelands. It aims to provide an understanding of the ecological and anthropogenic forces driving weed invasions in Australian rangelands, and a set of principles for countering those invasions and their impacts. It does not provide detailed information on individual species or 'operational' recommendations about how to manage them.

Practitioners, indigenous and local communities

Grice, A.C., S. Campbell, R. Breaden, F. Bebawi and W. Vogler (2008) Habitat management guide—Rangelands: Ecological principles for the strategic management of weeds in rangeland habitats. CRC for Australian Weed Management, Adelaide.

http://www.aabr.org.au/images/stories/resources/ManagementGuides/GeneralGuides/HabitatMangementGuideRangelands.pdf

Seed Ecology of the Invasive Woody Plant African Olive (Olea europaea subsp. cuspidata): Implications for Management and Restoration

In the present study, the key aspects of the seed ecology of African Olive were determined for populations in western Sydney. Extracted seed germinated at a wide range of temperatures, consistent with tolerance of a wide range of climatic conditions. A seed-burial experiment indicated a slow decrease in viability down to 70.3% during the first year, followed by a rapid decline down to 14.7% in the second year. Probit analysis indicated that under field conditions, seed persistence in the soil was ~29 months (2.4 years). In situ germination was low (3.3%) and did not occur until the mechanical constriction of the endocarp was released through decomposition. The woody seed endocarp was found to be permeable to water, indicating that physical dormancy was not imposed by providing a barrier to water uptake. Within its invasive range, African Olive produces abundant seed. However, the rapid loss of viability of soil-stored seed results in a narrow window of opportunity for germination. The short persistence of seed in the soil may provide an opportunity for managers to achieve control of African Olive once mature plants are removed.

Implementing agencies

Cuneo, P., C.A. Offord and M.R. Leishman (2010) Seed Ecology of the Invasive Woody Plant African Olive (Olea europaea subsp. cuspidata): Implications for Management and Restoration. Australian Journal of Botany 58(5): 342-348.

http://www.publish.csiro.au/?paper=BT10061

Invasive Species>Canada

An Invasive Alien Species Strategy for Canada

This Strategy seeks to establish a framework to address invasive alien species by meeting four strategic challenges, including: 1) Integrating environmental considerations into decision-making with economic and social factors; 2) Enhancing co-ordination and co-operation to respond more rapidly to new invasions and pathways of invasion; 3) Strengthening programs to protect natural resources under pressure from increased global trade and travel; and 4)

Maximizing collaboration between adhoc and regional/issue specific efforts to ensure the limited resources are used on highest priority issues.

Policymakers

Environment Canada (2004)

http://www.ec.gc.ca/eee-ias/98DB3ACF-94FE-4573-AE0F-95133A03C5E9/Final_IAS_Strategic_Plan_smaller_e.pdf

General Decision Process for Managing Invasive Plant Species in Garry Oak and Associated Ecosystems

We have replaced our former Decision Support Tool for Invasive Species Management (DST) with a new guide, the General Decision Process for Managing Invasive Plant Species in Garry Oak and Associated Ecosystems (GDP), and the more specific information for blackberry, ivy and broom removal has been moved into separate Best Management Practices (BMP). In addition, two new BMPs have been created for orchard-grass and daphne. Additional information for other invasive species is available in our field manual on Invasive Species in Garry Oak and Associated Ecosystems in British Columbia.

Practitioners, implementing agencies, indigenous and local communities

Garry Oak Ecosystem Recovery Team

http://www.goert.ca/publications_resources/invasive_species.php

Invasive Species>Europe

Technical Support to EU Strategy on Invasive Species (IAS) – Policy Options to Control the Negative Impacts of IAS on Biodiversity in Europe and the EU

This report forms part of a broader study for the European Commission to provide Technical Support for the Development of an EU framework on Invasive Alien Species (IAS). Building on evidence that IAS have significant negative impacts upon Europe's environment, key economic sectors and human well-being, it aims to identify policy measures and packages available to the Commission to minimise IAS damage to European biodiversity in an efficient and cost-effective manner.

Policymakers

Shine, C., M. Kettunen, P. Genovesi, S. Gollasch, S. Pagad and U. Starfinger (2008) Technical support to EU strategy on invasive species (IAS) – Policy options to control the negative impacts of IAS on biodiversity in Europe and the EU (Final module report for the European Commission). Institute for European Environmental Policy (IEEP), Brussels.

http://www.ieep.eu/assets/450/ias_policyoptions.pdf

Soil Recovery after Removal of the N2-fixing Invasive Acacia longifolia: Consequences for Ecosystem Restoration

Invasion by Acacia longifolia alters soil characteristics and processes. The present study was conducted to determine if the changes in soil C and N pools and processes induced by A. longifolia persist after its removal, at the Sao Jacinto Dunes Nature Reserve (Portugal). Our results suggest that after removal of an N2-fixing invasive tree that changes ecosystem-level processes, it takes several years before soil nutrients and processes return to preinvasion levels, but this legacy slowly diminish, suggesting that the susceptibility of native areas to (re)invasion is a function of the time elapsed since removal. Removal of the N-rich litter layer facilitates ecosystem recovery.

Implementing agencies

Marchante, E., A. Kjøller, S. Struwe and H. Freitas (2009) Soil Recovery after Removal of the N2-fixing Invasive Acacia longifolia: Consequences for Ecosystem Restoration. Biological Invasions 11(4): 813-823.

https://estudogeral.sib.uc.pt/bitstream/10316/7597/1/obra.pdf

How can We Effectively Restore Species Richness and Natural Composition of a Molinia-invaded Fen?

Calcareous fens are among the most threatened and declining ecosystems throughout Europe and act as refugia for many endangered species. Traditionally, calcareous fens were mown but many of them have been abandoned and invaded by Molinia. This has led to changes in species composition, heavy loss in species diversity and a decrease in bryophyte cover. Fen restoration is complicated by an effective nutrient uptake and utilization of Molinia. Experimental tests of the effects of litter removal and different mowing regimes on restoration success are needed together with studies that compare the responses of different taxonomical groups. Molinia-invaded fen vegetation can be restored through intensive mowing. We recommend twice-a-year mowing instead of traditional late annual mowing as an initial restoration measure. Since the effect of the standing Molinia crop in our long-abandoned fen turned out to be more detrimental to other plants than accumulated litter, we do not recommend any management that is based on litter removal rather than mowing.

Implementing agencies, practitioners

Hájková, P., M. Hájek and K. Kintrová (2009), How can we effectively restore species richness and natural composition of a Molinia-invaded fen? Journal of Applied Ecology 46: 417-425.

http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2664.2009.01608.x/pdf

Invasive Species >Islands

Island Invasives: Eradication and Management

The papers and abstracts published in this book are the outcome of the conference on Island Invasives: Eradication and Management held at Tamaki Campus, University of Auckland, New Zealand, from 8 to 12 February 2010, hosted by the Centre for Biodiversity and Biosecurity (University of Auckland and Landcare Research), in collaboration with the IUCN/SSC Invasive Species Specialist Group. This conference had "islands" and "eradication of invasive species" as the focus, with emphasis on the work done and results or learning achieved. The conference endeavoured to cover the full breadth of this work by breaking the subject down to: Gaining political, community, financial, and physical support; Eradication techniques tested and used; The immediate results of eradication operations; The longer-term outcomes as seen in the biota of the island and among communities involved; Biosecurity measures for such islands from planning to implementation.

Implementing agencies, practitioners

Veitch, C.R., M.N. Clout and D.R. Towns (eds.) (2011) Island Invasives: Eradication and Management. Gland, Switzerland: IUCN and Auckland, New Zealand.

http://data.iucn.org/dbtw-wpd/edocs/SSC-OP-042.pdf

Invasive Rodent Eradication on Islands

Invasive mammals are the greatest threat to island biodiversity and invasive rodents are likely responsible for the greatest number of extinctions and ecosystem changes. Techniques for eradicating rodents from islands were developed over 2 decades ago. Since that time there has been a significant development and application of this conservation tool. We reviewed the literature on invasive rodent eradications to assess its current state and identify actions to make it more effective. Worldwide, 332 successful rodent eradications have been undertaken; we identified 35 failed eradications and 20 campaigns of unknown result.

Implementing agencies, practitioners

Howald, G. et al. (2007) Invasive Rodent Eradication on Islands. Conservation Biology 21: 1258-1268.

http://advancedconservation.org/library/howald_etal_2007_wappendix.pdf

Indirect Effects of Invasive Species Removal Devastate World Heritage Island

Owing to the detrimental impacts of invasive alien species, their control is often a priority for conservation management. Whereas the potential for unforeseen consequences of management is recognized, their associated complexity and costs are less widely appreciated. Our results highlight an important lesson for conservation agencies working to eradicate invasive species globally; that is, risk assessment of management interventions must explicitly consider and plan for their indirect effects, or face substantial subsequent costs. On Macquarie Island, the cost of further conservation action will exceed AU$24 million.

Bergstrom, D.M., A. Lucieer, K. Kiefer, J. Wasley, L. Belbin, T.K. Pedersen and S.L. Chown (2009) Indirect Effects of Invasive Species Removal Devastate World Heritage Island. Journal of Applied Ecology 46: 73-81.

http://eprints.utas.edu.au/8384/4/JAppEcol_Bergstrom_etal_journal.pdf

Evaluation of Restoration Effectiveness: Community Response to the Removal of Alien Plants

Plant invasions are a key cause of biodiversity loss and motivate many restoration programs worldwide. We assessed restoration success of an invaded forest in the Azores using two complementary experimental designs: a before–after control–impact (BACI) design compared a restored and a control (unmanipulated) site over three years, while a control–impact (CI) design evaluated the short-term effects of restoration on restored–control replicated pairs. Both experiments provide evidence of the positive effects of weeding cascading through the food web from native plants to herbivorous insects, insect parasitoids, and birds. Two aspects that could prove critical to the outcome of restoration programs deserve further attention: most bird-dispersed seeds were alien, and weeding favored alien over native seedling growth.

Implementing agencies, practitioners

Heleno, R., I. Lacerda, J.A. Ramos and J. Memmott (2010) Evaluation of restoration effectiveness: community response to the removal of alien plants. Ecological Applications 20: 1191-1203.

http://www.esajournals.org/doi/abs/10.1890/09-1384.1?journalCode=ecap

Invasive Species>Mexico

Regeneration of Native Trees in the Presence of Invasive Saltcedar in the Colorado River Delta, Mexico

It has been proposed that reestablishment of a natural flow regime on these rivers might permit passive restoration of native trees, without the need for aggressive saltcedar clearing programs. We tested this proposition in the Colorado River delta in Mexico, which has received a series of large-volume water releases from U.S. dams over the past 20 years. Our results support the hypothesis that restoration of a pulse flood regime will regenerate native riparian vegetation despite the presence of a dominant invasive species, but fire management will be necessary to allow mature tree stands to develop.

Nagler, P.L., O. Hinajosa-Huerta, E.P. Glenn, J. Garcia-Hernandez, R. Romo, C. Curtis, A.R. Huete and S.G. Nelson (2005), Regeneration of Native Trees in the Presence of Invasive Saltcedar in the Colorado River Delta, Mexico. Conservation Biology 19: 1842-1852.

http://onlinelibrary.wiley.com/doi/10.1111/j.1523-1739.2005.00234.x/abstract

Invasive Species>New Zealand

Species Invasions and the Limits to Restoration: Learning from the New Zealand Experience

Species invasions impose key biotic thresholds limiting the success of ecological restoration projects. These thresholds may be difficult to reverse and will have long-term consequences for restoration because of invasion legacies such as extinctions; because most invasive species cannot be eliminated given current technology and resources; and because even when controlled to low levels, invasive species continue to exert substantial pressure on native biodiversity. Restoration outcomes in the face of biological invasions are likely to be novel and will require long-term resource commitment, as any letup in invasive species management will result in the loss of the conservation gains achieved.

Implementing agencies, practitioners

Norton, D.A. (2009) Species Invasions and the Limits to Restoration: Learning from the New Zealand Experience. Science 325: 569-571.

http://www.planta.cn/forum/files_planta/species_invasions_and_the_limits_to_restoration_learning_from_the_new_zealand_experience_593.pdf

Invasive Species>South Africa

Effects of Alien Plants on Ecosystem Structure and Functioning and Implications for Restoration: Insights from Three Degraded Sites in South African Fynbos

We investigated the type and extent of degradation at three sites on the Agulhas Plain, South Africa: an old field dominated by the alien grass Pennisetum clandestinum Pers. (kikuyu), an abandoned Eucalyptus plantation, and a natural fynbos community invaded by nitrogen fixing—Australian Acacia species. These forms of degradation are representative of many areas in the region. By identifying the nature and degree of ecosystem degradation we aimed to determine appropriate strategies for restoration in this biodiversity hotspot.

Practitioners, implementing agencies

Gaertner, M., D.M. Richardson and S.D.J. Privett (2011) Effects of Alien Plants on Ecosystem Structure and Functioning and Implications for Restoration: Insights from Three Degraded Sites in South African Fynbos. Environmental Management 48: 57-69.

http://www.ncbi.nlm.nih.gov/pubmed/21519876

Riparian Vegetation: Degradation, Alien Plant Invasions, and Restoration Prospects

This paper examines the biogeography and the determinants of composition and structure of riparian vegetation in temperate and subtropical regions and conceptualizes the components of resilience in these systems. We consider changes to structure and functioning caused by, or associated with, alien plant invasions, in particular those that lead to breached abiotic- or biotic thresholds. These pose challenges when formulating restoration programmes. Pervasive and escalating human-mediated changes to multiple factors and at a range of scales in riparian environments demand innovative and pragmatic approaches to restoration. The application of a new framework accommodating such complexity is demonstrated with reference to a hypothetical riparian ecosystem under three scenarios: (1) system unaffected by invasive plants; (2) system initially uninvaded, but with flood-generated incursion of alien plants and escalating invasion-driven alteration; and (3) system affected by both invasions and engineering interventions. The scheme has been used to derive a decision-making framework for restoring riparian zones in South Africa and could guide similar initiatives in other parts of the world.

Implementing agencies, practitioners

Richardson, DM., P.M. Holmes, K.J. Esler, S.M. Galatowitsch, J.C. Stromberg, S.P. Kirkman, P. Pyšek and R.J. Hobbs (2007) Riparian vegetation: degradation, alien plant invasions, and restoration prospects. Diversity and Distributions 13: 126-139.

http://www.ibot.cas.cz/personal/pysek/pdf/Richardson%20et%20al.-Riparian%20vegetation_DDI2007.pdf

Invasive Species>USA

National Strategy and Implementation Plan for Invasive Species Management

A strategic Forest Service response to invasive species is a large and significant undertaking. We have come far in addressing the invasive species problem in the United States, but we want to improve our effectiveness. This new strategy identifies those next steps we need to take as an agency, often by working with partners. This document is not designed to serve as a comprehensive, all-encompassing strategy. Instead it is intended to identify a strategic direction for Forest Service programs spanning Research and Development, International Programs, State and Private Forestry, and the National Forest System. To help us reach our goal, we have identified the most significant strategic actions leading us in that direction.

Policymakers

USDA Forest Service

http://www.fs.fed.us/foresthealth/publications/Final_National_Strategy_100804.pdf

Invasive Species>USA>Coastal/Marine

Stability of Exotic Annual Grasses following Restoration Efforts in Southern California Coastal Sage Scrub

In restoration of semi-arid shrub ecosystems, grass control can reduce exotic grasses over the short-term. However, recovery of grasses in the longer term indicates that restoration does not form a new stable state. Restoration and management of semi-arid shrublands may therefore require continual grass control. Exotic forbs should also be considered for control, as they may increase when exotic grasses are removed. Yearly variations in precipitation confound determination of successful restoration efforts, and require long-term observations to detect the response of native species to treatments.

Implementing agencies, practitioners

Cox, R.D. and E.B. Allen (2008) Stability of Exotic Annual Grasses following Restoration Efforts in Southern California Coastal Sage Scrub. Journal of Applied Ecology 45: 495-504.

http://www.fs.fed.us/rm/pubs_other/rmrs_2008_cox_r002.pdf

Factors Contributing to the Removal of a Marine Grass Invader (Spartina anglica) and Subsequent Potential for Habitat Restoration

Our goal is to understand how removal regime and habitat type interact to influence removal success of a marine plant invader and the subsequent potential for restoration. In particular, we investigate the management pro-gram designed to eradicate the English cordgrass, Spartina anglica C. E. Hubbard, in marine intertidal habitats of Puget Sound, Washington, United States.

Observational and manipulative experiments were used to measure the regrowth (vegetative growth), reinvasion (seedling recruitment), and restoration potential (return to native condition) of invaded habitats. Removal regime (consistent: yearly removal; interrupted: yearly removal with the last year missed) and habitat type (low salinity marsh, mudflat, cobble beach, and high salinity marsh sites) were considered.

Implementing agencies, practitioners

Reeder, T.G. and S.D. Hacker (2004) Factors Contributing to the Removal of a Marine Grass Invader (Spartina anglica) and Subsequent Potential for Habitat Restoration. Estuaries and Coasts 27(2): 244-252.

http://www.springerlink.com/content/l188301638587191/

Invasive Species >USA>Forests/Woodlands

Impacts of Restoration Treatments on Alien Plant Invasion in Pinus Ponderosa Forests, Montana, USA

Invasion by alien plant species represents a challenge to land managers throughout the world as they attempt to restore frequent fire-adapted ecosystems following decades of fire exclusion The results show that alien species, including transformers, respond to restoration treatments, especially the combined thin-burn treatment. Therefore monitoring for alien species invasion is an essential component of a restoration programme. Abundance of transformer species increased with increasing disturbance intensity, suggesting that less intense single-disturbance treatments (burn-only, thin-only) or incremental treatments may be preferred in some applications. Where more intense treatments are required to meet management objectives, specific strategies, such as seeding of native species, limiting grazing before and after treatment and harvesting over a protective winter snowpack, may be necessary to limit alien invasion.

Implementing agencies, practitioners

Dodson, E.K. and C.E. Fieldler (2006) Impacts of Restoration Treatments on Alien Plant Invasion in Pinus Ponderosa Forests, Montana, USA. Journal of Applied Ecology 43: 887-897.

http://www.fs.fed.us/ffs/docs/lubrecht/FFS109-Dodsen.pdf

Effects of Light, Alien Grass, and Native Species Additions on Hawaiian Dry Forest Restoration

Alien species invasions have already caused substantial ecological and economic damage and will likely have even greater negative consequences in the future. The results of this experiment highlight the importance of investigating species- and treatment-specific responses before attempting larger-scale restoration projects, particularly when using rare and endangered species. This study also suggests that relatively simple techniques may be used to simultaneously establish populations of vigorous understory native species and suppress alien grasses at relatively large spatial scales, and that remnant or newly created favorable microsites may be exploited to facilitate the establishment of rarer native overstory species.

Practitioners, implementing agencies

Cabin, R.J., S.G. Weller, D.H. Lorence, S. Cordell, L.J. Hadway, R. Montgomery, D. Goo and A. Urakami (2002) Effects of Light, Alien Grass, and Native Species Additions on Hawaiian Dry Forest Restoration. Ecological Applications 12(6): 1595-1610.

http://forestecology.cfans.umn.edu/Cabin%20et%20al.2002.EcoApps.pdf

Ecosystem and Restoration Consequences of Invasive Woody Species Removal in Hawaiian Lowland Wet Forest

A removal experiment was used to examine the restoration potential of a lowland wet forest in Hawaii, a remnant forest type that has been heavily invaded by non-native species and in which there is very little native species regeneration. Our results are consistent with the expectation that native species are conservative in regards to resource use and may not strongly respond to canopy removal, at least at the adult stage. Management strategies will have to incorporate the slow growth rate of Hawaiian species and the fact that weeding may be required to suppress expansion and nutrient inputs of introduced species.

Practitioners, implementing agencies

Ostertag, R., S. Cordell, J. Michaud, T.C. Cole, J.R. Schulten, K.M. Publico and J.H. Enoka (2009) Ecosystem and Restoration Consequences of Invasive Woody Species Removal in Hawaiian Lowland Wet Forest. Ecosystems 12: 503-515.

http://hilo.hawaii.edu/uhh/faculty/ostertag/documents/Ostertagetal.2009EcosystemsKMR.pdf

Invasive Species>USA>Grasslands

Plant Invaders, Global Change and Landscape Restoration

In this paper, we will provide a brief overview of the major human-induced agents of environmental change and their potential consequences on invasive species. We will also examine invasive species as agents of environmental change. For each agent of environmental change, we will discuss the potential spatial and temporal extent of the agents influence especially as it relates to rangeland management. Using Bromus tectorum (cheatgrass) as an example invasive species, we will examine spatial management options for restoration of native plants in the Great Basin of the U.S.A.

Implementing agencies

Pyke D.A. and S.T. Knick (2003) Plant Invaders, Global Change and Landscape Restoration in Proceedings of the VII International Rangelands Congress, Durban.

http://fresc.usgs.gov/products/papers/invaders.pdf

Principles and Practices for Managing Rangeland Invasive Plants

Our purpose is to describe principles and practices to consider when developing integrated strategies to manage invasive plants on rangeland. Sustainable integrated invasive plant management strategies require assessing their impacts, under-standing and managing the processes influencing invasion, knowledge of invasive plant biology and ecology, and integrating management tactics based on eco-logical principles. Ultimately, for these strategies to be successful, they must be compatible with and contribute to achieving overall rangeland ecosystem management goals and objectives.

Implementing agencies, practitioners

Masters, R.A. and R.L. Sheley (2001) Principles and Practices for Managing Rangeland Invasive Plants. Journal of Range Management 54(5): 502-517.

http://www.jstor.org/discover/10.2307/4003579?uid=3739256&uid=2&uid=4&sid=47698889547247

Evaluation of Herbicides for Restoring Native Grasses in Buffelgrass-Dominated Grasslands

Buffelgrass (Pennisetum ciliare) is an exotic grass that threatens arid and semiarid ecosystems. The objective of this study was to determine effectiveness of several herbicides at reducing competition from buffelgrass to enhance establishment of planted native grasses.

Practitioners

Tjelmeland, A.D., T.E. Fulbright, and J. Lloyd-Reilley (2006) Evaluation of Herbicides for Restoring Native Grasses in Buffelgrass-Dominated Grasslands. Restoration Ecology 16(2): 263-269.

http://www.plant-materials.nrcs.usda.gov/pubs/stpmcrj7953.pdf

Increasing Native Diversity of Cheatgrass-Dominated Rangeland through Assisted Succession

Increasing attention, resources and efforts are being focused on the conversion of weedy dominated rangelands back to perennial plant communities that resemble pre-disturbance communities in form, function and composition. Native grasses and shrubs emerged in greater numbers on treatments established on the crested wheatgrass matrix than on those established on the cheatgrass matrix. Perhaps in general, but especially in years with normal or below average precipitation, the assisted succession approach proved successful for restoration of native sagebrush-grassland steppe from cheatgrass range.

Practitioners, implementing agencies

Cox, R.D. and V.J. Anderson (2004) Increasing Native Diversity of Cheatgrass-dominated Rangeland through Assisted Succession. Rangeland Ecology & Management 57(2):203-210.

http://rtec.rangelands.org/2011Abstracts/2011%20RTEC%20References/CoxAnderson.pdf

Potential for Successional Theory to Guide Restoration of Invasive Plant-Dominated Rangeland

Successional management has been proposed as a useful model for managing and restoring invasive-plant-dominated rangeland because it provides a framework in which ecological processes can be manipulated by managers to achieve a desired plant community. Our hypothesis was that successively modifying the factors influencing the causes of succession in an integrated fashion would favor the establishment and abundance of native grasses over singularly applied treatments. In most cases, integrating treatments that addressed multiple causes of succession favored a desired plant community. Thus, we accomplished our goal of using successional management to direct plant communities toward native desired species, but the treatments used did not improve species richness. Since naturally occurring native forbs did not respond favorably to any treatment combination, ecological restoration using successional management may best be thought of as an iterative procedure where various components and processes of the system are methodically repaired or replaced over time.

Practitioners, implementing agencies

Sheley, R.L., J.M. Mangold and J.L. Anderson (2006) Potential for Successional Theory to Guide Restoration of Invasive Plant-Dominated Rangeland. Ecological Monographs 76(3): 365-379.

http://ddr.nal.usda.gov/dspace/bitstream/10113/28328/1/IND43876815.pdf

Invasive Species>USA>Inland Waters

Control of Tamarix in the Western United States: Implications for Water Salvage, Wildlife Use, and Riparian Restoration

We review the literature on saltcedar control, water use, wildlife use, and riparian restoration to provide resource managers, researchers, and policy-makers with a balanced summary of the state of the science. To best ensure that the desired outcomes of removal programs are met, scientists and resource managers should use existing information and methodologies to carefully select and prioritize sites for removal, apply the most appropriate and cost-effective control methods, and then rigorously monitor control efficacy, revegetation success, water yield changes, and wildlife use.

Implementing agencies, practitioners, policymakers

Shafroth, P.B. et al. (2005) Control of Tamarix in the Western United States: Implications for Water Salvage, Wildlife Use, and Riparian Restoration. Environmental Management 35(3): 231-246.

http://www.charlesvanriper.com/papers/control_of_tamarix.pdf

Monitoring and Evaluation

Habitat Restoration Monitoring Handbook

This handbook is designed to highlight the critical considerations at each of the main stages of the monitoring methodology as follows: 1) Preparing habitat restoration monitoring prescriptions, 2) Preparing field recording forms, and 3) Carrying out habitat restoration monitoring.

Practitioners, implementing agencies, indigenous and local communities

Mitchley, J., F. Surch, P. Buckley and T.A. Watt (2000) Habitat Restoration Monitoring Handbook. English Nature Research Report No. 378.

http://publications.naturalengland.org.uk/publication/50036

Adaptive Monitoring: A New Paradigm for Long-term Research and Monitoring

Long-term research and monitoring can provide important ecological insights and are crucial for the improved management of ecosystems and natural resources. However, many long-term research and monitoring programs are either ineffective or fail completely owing to poor planning and/or lack of focus. Here we propose the paradigm of adaptive monitoring, which aims to resolve many of the problems that have undermined previous attempts to establish long-term research and monitoring. This paradigm is driven by tractable questions, rigorous statistical design at the outset, a conceptual model of the ecosystem or other entity being examined and a human need to know about ecosystem change. An adaptive monitoring framework enables monitoring programs to evolve iteratively as new information emerges and research questions change.

Implementing agencies, practitioners

Lindenmayer, D.B. and G.E. Likens (2009) Adaptive monitoring: a new paradigm for long-term research and monitoring. Trends in Ecology and Evolution 24:482–486.

http://www.cell.com/trends/ecology-evolution/abstract/S0169-5347(09)00121-9

Adaptive Monitoring Based on Ecosystem Services

Monitoring consists of repetitive data collection to determine trends in parameters monitored. Unfortunately, too often monitoring consists of "fishing expeditions" where data collection is justified after the fact rather than being based on a priori technically defensible and testable hypotheses. Monitoring conducted following legal (e.g., regulatory) stipulations is not always useful. Ideally, monitoring should be conducted to determine the current status of the parameters monitored, their temporal and spatial trends (to assist in predicting future status), and the possible need for management actions. The most effective and productive scientific monitoring is adaptive, and is based on assessment endpoints that comprise ecosystem services, in other words, the benefits of Nature to human beings.

Implementing agencies, practitioners

Chapman, P.M. (2012) Adaptive Monitoring Based on Ecosystem Services. Science of The Total Environment 415(15): 56-60.

http://www.sciencedirect.com/science/article/pii/S0048969711002890

Effectiveness Monitoring Guidelines for Ecosystem Restoration

This document provides a conceptual framework and guidelines for effectiveness monitoring (EM) of restoration projects. It reviews the rationale for conducting effectiveness monitoring, and describes the sequence of steps involved in designing, implementing and summarizing the results of EM. Effectiveness monitoring addresses the question of how successful a project ultimately is at restoring the ecosystem or component parts. It involves assessing restoration progress in relation to initial objectives, and refining treatment prescriptions, where required, to increase their effectiveness. EM is a critical component of an adaptive management approach to ecosystem restoration.

Implementing agencies, practitioners

Machmer, M. and C. Steeger (2002) Effectiveness Monitoring Guidelines for Ecosystem Restoration. Habitat Branch, Ministry of Water, Land and Air Protection, BC, Canada.

http://www.env.gov.bc.ca/fia/documents/rest_effect_mon_guidelines_s.pdf

Quick Guide to Monitoring Economic Impacts of Ecosystem Restoration and Stewardship

This guide is a companion to A Quick Guide to Conducting an Ecosystem Workforce Assessment, which describes how to conduct a workforce assessment and A Quick Guide for Planning a Quality Jobs Program, which describes how to use assessment tools to create an action plan for improving local economic benefit from restoration. The guide can be used with economic forecasting tools such as the Ecosystem Workforce Program's Restoration Economic Impact Calculator for Oregon Counties and the U.S. Forest Service's Treatments for Restoration Economic Analysis Tool (TREAT).

Implementing agencies

Ecosystem Workforce Program (2011) Quick Guide to Monitoring Economic Impacts of Ecosystem Restoration and Stewardship. Institute for a Sustainable Environment, University of Oregon, Eugene.

http://ewp.uoregon.edu/sites/ewp.uoregon.edu/files/downloads/resources/Jobs_Monitoring_Guide.pdf

Restoration Success: How Is It Being Measured?

Most of the reviewed studies are using multiple measures to evaluate restoration success, but we would encourage future projects to include: (1) at least two variables within each of the three ecosystem attributes that clearly related to ecosystem functioning and (2) at least two reference sites to capture the variation that exist in ecosystems.

Practitioners, implementing agencies

Ruiz-Jaen, M.C. and T.M. Aide (2005) Restoration Success: How Is It Being Measured? Restoration Ecology 13(3): 569-577.

http://arbimon.uprrp.edu/weblab/Publications_files/Ruiz-Jaen%20and%20Aide%202005.pdf

Vegetation Structure, Species Diversity, and Ecosystem Processes as Measures of Restoration Success

To provide an example on how to assess restoration success, we compared four measures of vegetation structure, four measures of species diversity, and six measures of ecosystem processes among pre-reforested, reforested, and reference sites. In addition, we described how Bray Curtis Ordination could be used to evaluate restoration success. By including vegetation structure, species diversity, and ecosystem processes measures we have better information to determine the success of a restoration project. Moreover, the Subjective Bray Curtis Ordination is a useful approach for evaluating different restoration techniques or identifying measures that are recovering slowly and would benefit from additional management.

Implementing agencies, practitioners

Ruiz-Jaén, M.C. and T.M. Aide (2005) Vegetation Structure, Species Diversity, and Ecosystem Processes as Measures of Restoration Success. Forest Ecology and Management 218(1-3): 159-173.

http://www.sciencedirect.com/science/article/pii/S0378112705004597

Monitoring Ecological Processes for Restoration Projects

Long-term (up to 75 years) studies in the western United States show that short-term monitoring of plant community composition alone incorrectly predicted the failure of treatments that were ultimately successful, and the success of treatments that ultimately failed. We propose that vegetation composition monitoring be combined with one or more ecological process indicators reflecting changes in three fundamental ecosystem attributes on which restoration success depends: soil and site stability, hydrologic function and biotic integrity. These simple, rapid, plot-level indicators reflect changes in resource redistribution and vegetation structure. We include a case study involving restoration of mixed grass prairie on mineland in the west-central United States.

Implementing agencies, practitioners

Herrick, J.E., G.E. Schuman and A. Rango (2006) Monitoring Ecological Processes for Restoration Projects. Journal for Nature Conservation 14: 161-171.

http://jornada.nmsu.edu/bibliography/06-032.pdf

How to Define Targets for Ecological Restoration?

The eight papers presented in this Special Feature result from the Second International Conference on Restoration Ecology held in Groningen, The Netherlands, 25-30 August 1998. The conference was organized under auspices of the Society for Ecological Restoration (SER), the European Ecological Federation (EEF), the Dutch Flemish Ecological Society (NECOV) and the International Ecological Engineering Society (IEES).

Implementing agencies, practitioners

Bakker, J.P., A.P. Grootjans, M. Hermy and P. Poschlod (eds.) (2000) Special Feature of Applied Vegetation Science 3(1): 3-134.

http://onlinelibrary.wiley.com/doi/10.1111/avsc.2000.3.issue-1/issuetoc

Ecological Forecasting Tools and Planning of Ecosystem Restoration Projects

This technical note reviews some of the most commonly used USACE forecasting tools and models in ecological restoration. It outlines an approach for comparing these tools that will help USACE planners and their project stakeholders better identify and select appropriate forecasting models. Although this technical note is not a primer or a selection metatool (i.e., a tool to select tools), it is hoped that this note will contribute to a long-term goal of USACE staff (both planners and researchers) to become better-informed developers and consumers of ecological forecasting tools. Secondarily, this note is intended to give researchers a clearer view of what USACE planners need (but do not have available) with regard to ecological forecasting capabilities.

Practitioners, implementing agencies

Foran, C. M., I. Linkov, E. A. Moberg, D. Smith, and D. M. Soballe (2011) Ecological forecasting tools and planning of ecosystem restoration projects. EMRRP Technical Notes Collection. ERDC TN-EMRRP-EM-10. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

http://el.erdc.usace.army.mil/elpubs/pdf/em10.pdf

Measurements of the Soil Microbial Community for Estimating the Success of Restoration

Recent research has shown quantitatively how by measuring the soil microbial community we can assess degradation and the effects of management designed to reverse it. The size, composition and activity of the soil microbial community convincingly distinguish between systems, and between the impact of management strategies upon them. Measurements of these characteristics of the microbial community provide invaluable information for restoring degraded land and are ready for routine use. Specifically, profiles of phospholipid fatty acid contents, and substrate induced respiratory responses to different carbon substrates, will yield significant data upon which management decisions may be based.

Practitioners, implementing agencies

Harris, J.A. (2003) Measurements of the Soil Microbial Community for Estimating the Success of Restoration. European Journal of Soil Science 54: 801-808.

http://image.sciencenet.cn/olddata/kexue.com.cn/upload/blog/file/2010/4/201042114844375496.pdf

Monitoring and Evaluation>Coastal/Marine

Science-Based Restoration Monitoring of Coastal Habitats

This first volume contains a background on restoration and monitoring, stages of a restoration and monitoring plans, how to create a monitoring plan, and important information that should be considered when monitoring specific habitats. The second volume, to be published in 2004, provides detailed information on the habitats, an inventory of coastal restoration monitoring programs, a review of monitoring techniques manuals and quality control/quality assurance documents, an overview of governmental acts affiliated with monitoring, a cost analysis of monitoring expenses, a glossary of terms, and a discussion of socioeconomic issues affiliated with coastal habitat restoration.

Implementing agencies, practitioners

Thayer, Gordon W., Teresa A. McTigue, Russell J. Bellmer, Felicity M. Burrows, David H. Merkey, Amy D. Nickens, Stephen J. Lozano, Perry F. Gayaldo, Pamela J. Polmateer, and P. Thomas Pinit. 2003. Science-Based Restoration Monitoring of Coastal Habitats, Volume One: A Framework for Monitoring Plans Under the Estuaries and Clean Waters Act of 2000 (Public Law 160-457). NOAA Coastal Ocean Program Decision Analysis Series No. 23, Volume 1. NOAA National Centers for Coastal Ocean Science, Silver Spring.

http://coastalscience.noaa.gov/documents/restorationmntg.pdf

Thayer, Gordon W., Teresa A. McTigue, Ronald J. Salz, David H. Merkey, Felicity M. Burrows, and Perry F. Gayaldo, (eds.). 2005. Science-Based Restoration Monitoring of Coastal Habitats, Volume Two: Tools for Monitoring Coastal Habitats. NOAA Coastal Ocean Program Decision Analysis Series No. 23. NOAA National Centers for Coastal Ocean Science, Silver Spring.

http://coastalscience.noaa.gov/documents/rmv2/WholeDocument.pdf

A Monitoring Protocol to Assess Tidal Restoration of Salt Marshes on Local and Regional Scales

We developed a hierarchical approach to evaluate the performance of tidal restorations at local and regional scales throughout the Gulf of Maine. The cornerstone of the approach is a standard protocol for monitoring restored and reference salt marshes throughout the region. The monitoring protocol was developed by consensus among nearly 50 restoration scientists and practitioners. The protocol is based on a suite of core structural measures that can be applied to any tidal restoration project. The protocol also includes additional functional measures for application to specific projects. Consistent use of the standard protocol to monitor local projects will enable pooling information for regional assessments. Ultimately, it will be possible to establish a range of reference conditions characterizing natural tidal wetlands in the region and to compare performance curves between populations of restored and reference marshes for assessing regional restoration effectiveness.

Implementing agencies, practitioners

Neckles, H.A., M. Dionne, D.M. Burdick, C.T. Roman, R. Buchsbaum and E. Hutchins (2002), A Monitoring Protocol to Assess Tidal Restoration of Salt Marshes on Local and Regional Scales. Restoration Ecology 10: 556-563.

http://onlinelibrary.wiley.com/doi/10.1046/j.1526-100X.2002.02033.x/abstract

Developing Multimetric Indices for Monitoring Ecological Restoration Progress in Salt Marshes

Effective tools for monitoring the status of ecological restoration projects are critical for the management of restoration programs. Such tools must integrate disparate data comprised of multiple variables that describe restoration status, including the condition of environmental stressors, landscape connectivity, ecosystem resilience, and ecological structure and function, while communicating these concepts effectively to a wide range of stakeholders. In this paper we describe the process of constructing multimetric indices (MMIs) for monitoring restoration status for restoration projects currently underway on the eastern coast of Saudi Arabia. During this process, an initial suite of measurements is filtered for response and sensitivity to ecosystem stressors, eliminating measurements that provide little information and reducing future monitoring efforts. The retained measurements are rescaled into comparable domain metrics and assembled into MMIs. The MMIs are presented in terms of established restoration theories, including restoration trajectory and restoration endpoint targets.

Practitioners, implementing agencies

Langman, O.C., J.A. Hale, C.D. Cormack, M.J. Risk and S.P. Madon (2012) Developing Multimetric Indices for Monitoring Ecological Restoration Progress in Salt Marshes. Marine Pollution Bulletin 64(4): 820-835.

http://www.sciencedirect.com/science/article/pii/S0025326X12000537

Terrestrial Arthropods as Indicators of Ecological Restoration Success in Coastal Sage Scrub (California, U.S.A.)

Success of a restoration project often is evaluated on the basis of plant cover only. Recovery of a native arthropod fauna is also important to achieve conservation goals. I sampled arthropod communities by pitfall trapping in undisturbed, disturbed, and restored coastal sage scrub habitats in southern California. Vegetation characteristics did not differ significantly between the newly restored site and disturbed sites, or between mature restoration sites and undisturbed sites. In contrast, arthropod communities at all restored sites were, as a group, significantly different from both disturbed and undisturbed sites. As found in other studies of other restoration sites, arthropod communities are less diverse and have altered guild structure. If restoration is to be successful as compensatory mitigation, restoration success standards must be expanded to include arthropods.

Practitioners, implementing agencies

Travis Longcore (2003) Terrestrial Arthropods as Indicators of Ecological Restoration Success in Coastal Sage Scrub (California, U.S.A.). Restoration Ecology 11(4): 397-409.

http://www.urbanwildlands.org/Resources/2003LongcoreResEco.pdf

A Framework for Managing and Monitoring Bush Regeneration Programs: A Case Study from Lake Macquarie, NSW

While general guidelines for monitoring are available, few examples of effective site monitoring and reporting exist in practice. The note describes a framework developed for managing and monitoring a bush regeneration programme for coastal NSW and evaluates it against a set of principles for monitoring ecological restoration programmes. The example illustrates how tools could be developed to improve management and monitoring practice.

Practitioners, implementing agencies

Fallding, M. (2011) A Framework for Managing and Monitoring Bush Regeneration Programs: A Case Study from Lake Macquarie, NSW. Ecological Management & Restoration 12(3): 244-246.

http://onlinelibrary.wiley.com/doi/10.1111/j.1442-8903.2011.00612.x/pdf

Monitoring and Evaluation>Drylands

Are Ecosystem Composition, Structure, and Functional Status Related to Restoration Success? A Test from Semiarid Mediterranean Steppes

We conducted experimental plantings of the native late successional shrub Pistacia lentiscus in 10 semiarid steppes located in southeast Spain and related seedling survival rates to measures of ecosystem structure and composition and to surrogates of ecosystem functioning. Our results suggest, but cannot confirm, that the functional status of the ecosystem may not limit the early stages of establishment of P. lentiscus in semiarid steppes and that abiotic conditions play an overriding role in this process. If true, its introduction in these areas would not necessarily need a previous phase of recovery of ecosystem functions like nutrient cycling and infiltration.

Practitioners, implementing agencies

Maestre, F.T., J. Cortina and R. Vallejo (2006) Are Ecosystem Composition, Structure, and Functional Status Related to Restoration Success? A Test from Semiarid Mediterranean Steppes. Restoration Ecology 14(2): 258-266.

http://m.imem.ua.es/en/documentos/imem-files/research-articles/jordi-cortina/maestre-et-al-2006-restoration.pdf

Monitoring and Evaluation>Forests/Woodlands

A Practical Technique for Non-destructive Monitoring of Soil Surface Invertebrates for Ecological Restoration Programmes

This study investigates the suitability of using wooden discs as facsimiles for natural fallen logs to non-destructively monitor invertebrates. Wooden discs cut from tree trunks were placed on the ground at five sites and monitored. A diverse range of species was found under the discs including large numbers of some species. Wooden discs are a useful tool for the ecological management of terrestrial invertebrate fauna in restoration programmes for monitoring and considerable potential exists for discs to provide habitat for restoration of terrestrial invertebrate taxa.

Practitioners, implementing agencies

Bowie, M.H. and C.M. Frampton (2004) A Practical Technique for Non-destructive Monitoring of Soil Surface Invertebrates for Ecological Restoration Programmes. Ecological Management and Restoration 5(1): 34-42.

http://www.aseanbiodiversity.info/Abstract/51010062.pdf

Evaluating Restoration Success in Urban Forest Plantings in Hamilton, New Zealand

To evaluate the success of restoration efforts in young urban plantings, we assessed 66 experimental plots in gully systems in Hamilton City, New Zealand, and adjacent areas. We compared vegetation change in restored patches planted with native species to vegetation in naturally regenerating patches and mature native forest. A range of variables was used to assess ecosystem functional, structural, and compositional attributes. Different planting and maintenance regimes and environmental factors likely to affect the success of plantings were also evaluated. Vegetation change towards the mature forest reference state was found to be rapid in twenty plots. However, twelve plots showed limited progress towards this state, with low numbers of lianas and epiphytes and low native species recruitment, regeneration, and species diversity.

Implementing agencies, practitioners

MacKay, D.B., P.M. Wehi and B.D. Clarkson (2011) Evaluating Restoration Success in Urban Forest Plantings in Hamilton, New Zealand. Urban Habitats 6(1).

http://urbanhabitats.org/v06n01/hamilton_full.html

Ecosystem Thermal Buffer Capacity as an Indicator of the Restoration Status of Protected Areas in the Northern Ethiopian Highlands

Restoration status of forest rehabilitation areas can be assessed by comparing their ecosystem characteristics with those of a reference system, most often what is considered the natural climax vegetation. However, comprehensive measurements needed for a traditional vegetation description are often hard or impractical in complex sub-tropical ecosystems. Therefore, an alternative approach is the identification of simple indicators of ecosystem integrity. The use of such indicators can speed up the availability of resource inventories and thus contribute to the accelerated implementation of successful rehabilitation practices. Thermal buffer capacity (TBC) of ecosystems has been previously proposed as an overall indicator of ecosystem integrity. In this article, sequential surface-temperature measurements are proposed as a method for TBC assessment of different land-use types.

Implementing agencies

Aerts, R., T. Wagendorp, E. November, M. Behailu, J. Deckers and B. Muys (2004) Ecosystem Thermal Buffer Capacity as an Indicator of the Restoration Status of Protected Areas in the Northern Ethiopian Highlands. Restoration Ecology 12: 586-596.

http://onlinelibrary.wiley.com/doi/10.1111/j.1061-2971.2004.00324.x/abstract

Using Soil and Litter Arthropods to Assess the State of Rainforest Restoration

The present study investigated recolonization patterns of selected soil and litter arthropods following replanting of pasture with rainforest species in the Mary River catchment of eastern subtropical Australia. While extensive research has been conducted in rehabilitated mined sites in Australian dry sclerophyll forests, very little attention has been paid to rainforest restoration on previously pastoral land. We examined the utility of soil and litter arthropod groups for monitoring the progress of restoration, and the relationship between arthropod assemblage patterns and environmental factors potentially under the control of those doing the replanting.

Implementing agencies, practitioners

Nakamura, A., H. Proctor and C.P. Catterall (2003) Using Soil and Litter Arthropods to Assess the State of Rainforest Restoration. Ecological Management and Restoration 4: s20-s28.

http://www.aseanbiodiversity.info/Abstract/51010142.pdf

Assessing the Success of Restoration Plantings in a Temperate New Zealand Forest

The success of restoration plantings in restoring indigenous forest vascular plant and ground invertebrate biodiversity was assessed on previously grass-covered sites in the eastern South Island, New Zealand. The composition and structure of grassland, three different aged restoration plantings (12, 30, and 35 years old), a naturally regenerating forest (100 years old), and a remnant of the original old-growth forest of the area were measured. The strong correlations between plant and invertebrate community composition and study-site suggest that the restoration site plant and invertebrate communities are undergoing change in the direction of the naturally regenerating and mature forest communities. Without restoration, colonization of grassland by forest plants is very slow in the study area and the restoration plantings studied here have been successful because they have considerably accelerated the return to forest at these sites.

Implementing agencies, practitioners

Reay, S.D. and D.A. Norton (1999) Assessing the Success of Restoration Plantings in a Temperate New Zealand Forest. Restoration Ecology 7: 298-308.

http://onlinelibrary.wiley.com/doi/10.1046/j.1526-100X.1999.72023.x/abstract

Measuring Success: Evaluating the Restoration of a Grassy Eucalypt Woodland on the Cumberland Plain, Sydney, Australia

We compared the floristic composition and structure of restoration areas of eucalypt woodland with untreated pasture (control) and remnant vegetation (reference) in western Sydney. The restored areas comprised over 1,000 ha of abandoned pasture, which had been treated to reduce weeds and planted with seedlings of 26 native plant species raised from seed obtained locally from remnant vegetation. Plantings were carried out 0–9 years ago. The results therefore suggest either failure of restoration treatments or a restoration trajectory that is too slow to detect within 10 years of establishment. Our conclusions agree with those of similar studies in other ecosystems and support: (1) the need to monitor restoration projects against ecological criteria with rigorous sampling designs and analytical methods, (2) further development of restoration methods, and (3) regulatory approaches that seek to prevent damage to ecosystems rather than those predicated on replacing losses with reconstructed ecosystems.

Implementing agencies, practitioners

Wilkins, S., D.A. Keith and P. Adam (2003) Measuring Success: Evaluating the Restoration of a Grassy Eucalypt Woodland on the Cumberland Plain, Sydney, Australia. Restoration Ecology 11: 489-503.

http://onlinelibrary.wiley.com/doi/10.1046/j.1526-100X.2003.rec0244.x/abstract

Aiming to Restore Forests: Evaluation with SER Criteria

The Society for Ecological Restoration Primer on Ecological Restoration (SERPER) states, "Ecological restoration is an intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity, and sustainability" and attempts to return an ecosystem to its historic condition. Active, intentional management (AIM) is a conservation approach that emphasizes a full range of active and passive management techniques to manage important ecological and hydrologic processes to conserve biodiversity; reconcile conflicts over management of natural resources; and provide various goods, ecological services, and recreational and spiritual opportunities to people over the long term. AIM includes intangibles such as knowing that rare species exist, that "wild" places are deliberately in place, and that ecological services important to the biosphere are maintained. How does AIM compare to restoration? Can AIM meet restoration goals? Specifically, can AIM reproduce the 10 traits of pristine ecosystems identified by SERPER? Measures can be used to evaluate success.

Implementing agencies

Carey, A.B. (2006) Aiming to Restore Forests: Evaluation with SER Criteria. Northwestern Naturalist 87(1): 31-42.

http://www.fs.fed.us/pnw/pubs/journals/pnw_2006_biodiversity_005_carey.pdf

Assessing the Long-term Contribution of Nurse Plants to Restoration of Mediterranean Forests through Markovian Models

Based on short-term experimental data, facilitative interactions between woody plants (nurse-recruit interactions) have been described as essential for the restoration of Mediterranean forests. However, the long-term effects of nurse plants on vegetation dynamics are unknown. This study aims to project post-fire vegetation dynamics from easily retrieved data, and to assess the long-term contribution of nurse plants to forest restoration. Our Markov chain successional model is an analytical tool which can be applied rapidly and easily to determine successional trajectories for forest restoration. It allows: (i) evaluation of post-fire dynamics and identification of areas in need of intensive intervention (i.e. where secondary succession remains arrested leading to stasis in the pioneer state); (ii) assessment of the role of long-term facilitative nurse effects on restoration; and (iii) identification of species-pair combinations and functional nurse groups of value for further planting efforts.

Practitioners, implementing agencies

Siles, G., P.J. Rey, J.M. Alcántara and J.M. Ramírez (2008) Assessing the Long-term Contribution of Nurse Plants to Restoration of Mediterranean Forests through Markovian Models. Journal of Applied Ecology 45: 1790-1798.

http://ebd06.ebd.csic.es/pdfscazorla/Siles.et.al.2008.J.Appl.Ecol.pdf

Monitoring and Evaluation>Grasslands/Savannas

Monitoring Manual for Grassland, Shrubland and Savanna Ecosystems

This manual describes how to monitor three rangeland attributes: soil and site stability, watershed function and biotic integrity. Nearly everything we value about rangelands depends on these attributes. Monitoring these three attributes is like monitoring the foundation of our rangeland ecosystems. The measurements used to monitor these attributes also can be used to generate indicators relevant to specific management objectives, such as maintaining wildlife habitat, biodiversity conservation or producing forage.

Practitioners, indigenous and local communities

Herrick, J.E., J.W. Van Zee, K.M. Havstad, L.M. Burkett and W.G. Whitford (2009) Monitoring Manual for Grassland, Shrubland and Savanna Ecosystems. USDA-ARS Jornada Experimental Range, Las Cruces.

http://californiarangeland.ucdavis.edu/Publications%20pdf/Quick_Start.pdf

http://californiarangeland.ucdavis.edu/Publications%20pdf/Volume_II.pdf

An Assessment of Grassland Restoration Success Using Species Diversity Components

We quantified three success criteria for 8–10-year-old grassland plantings in large-scale tallgrass prairie restoration (reconstruction) sites relative to three nearby prairie remnant sites. The restoration sites included management of native ungulates and fire, important regulators of diversity and patchiness in intact grasslands. These have not been incorporated simultaneously into previous studies of restoration success. We have shown that current restoration methods are unable to restore plant diversity in tallgrass prairie. Grassland restoration will be improved if the number of species that co-exist can be increased. New, local-scale restoration techniques are needed to replicate the high levels of diversity observed in tallgrass prairie remnant sites.

Practitioners, implementing agencies

Martin, L.M., K.A. Moloney and B.J. Wilsey (2005) An Assessment of Grassland Restoration Success Using Species Diversity Components. Journal of Applied Ecology 42: 327-336.

http://www.globalrestorationnetwork.org/uploads/files/LiteratureAttachments/29_an-assessment-of-grassland-restoration-success-using-species-diversity-components.pdf

Assessing Grassland Restoration Success: Relative Roles of Seed Additions and Native Ungulate Activities

Grassland restorations often lack rare forb and grass species that are found in intact grasslands. The possible reasons for low diversity include seed limitation, microsite limitation and a combination of both. Native ungulates may create microsites for seedling establishment in tallgrass prairie restorations by grazing dominant species or through trampling activities, but this has never been tested in developing prairies. These results suggest that tallgrass prairie restorations are primarily seed limited and that grazing alone may not be able to increase seedling emergence of rare species without the addition of seeds. Therefore, adding seeds to grassland restorations may increase seedling emergence of rare species, and mimicking effects of grazing may increase emergence when seeds are added.

Practitioners, implementing agencies

Martin, L.M. and B.J. Wolsey (2006) Assessing Grassland Restoration Success: Relative Roles of Seed Additions and Native Ungulate Activities. Journal of Applied Ecology 43(6): 1098-1109.

http://www.public.iastate.edu/~bwilsey/MartinWilsey06.pdf

Monitoring and Evaluation>Inland Waters

Monitoring and Evaluation>Inland Waters>Bottomland Forests

Conceptual Assessment Framework for Forested Wetland Restoration: The Pen Branch Experience

We propose a quantitative, ecosystem level assessment method similar to that developed by the US EPA's Wetland Research Program (WRP approach) that includes both biotic and abiotic metrics. Similar to the IBI and HGM approaches, biotic and abiotic parameters are compared to those of reference communities, however, the proposed comparisons are quantitative. In developing the assessment method, bottomland reference systems at various stages of succession were compared to a recently restored site in South Carolina (Pen branch). Studies involving hydrology, soil organic matter and nutrient dynamics, vegetation communities, seedling establishment and competition, and avian, small mammal, herpetofauna, fish and macroinvertebrate communities were implemented. In this paper, we discuss the conceptual framework in which we developed our assessment technique.

Practitioners, implementing agencies

Kolka, R.K., E.A. Nelson and C.C. Trettin (2000) Conceptual Assessment Framework for Forested Wetland Restoration: The Pen Branch Experience. Ecological Engineering 15: S17-S21.

http://www.nrs.fs.fed.us/pubs/jrnl/2000/nc_2000_Kolka_002.pdf

Monitoring and Evaluation>Inland Waters>Peatlands

Guidelines for Monitoring Peatland Restoration

The aim of this guidance is to provide information to enable peatland restoration projects to develop appropriate monitoring programmes. Degraded peatlands are restored for a wide range of reasons. Restoration objectives can include protecting and enhancing biodiversity, improving water quality, reducing flood risk and protecting cultural heritage or carbon stores. Restoration projects need monitoring programmes to show whether these objectives are being met and to help them to adapt practices to respond to environmental changes.

Implementing agencies, practitioners

Natural England (2011) Guidelines for Monitoring Peatland Restoration. Natural England Technical Information Note TIN097.

http://publications.naturalengland.org.uk/publication/24008

Using Long-term Monitoring of Fen Hydrology and Vegetation to Underpin Wetland Restoration Strategies

How can long-term monitoring of hydrological and ecological parameters support management strategies aimed towards wetland restoration and re-creation in a complex hydrological system? Drought impact and subsequent hydrological recovery over a 22-year period are quantified. Vegetation data display strong moisture and successional gradients. Analysis shows a shift from grassland communities toward mire communities across much of the site. The site is regionally unique in that it has a detailed long-term monitoring record. Hydrological data and vegetation survey have allowed the impact of the most recent 'groundwater' drought (1989–1997) to be quantified. This information on system resilience, combined with eco-hydrological analyses of plant community-water regime/quality relationships, provide a basis for recommendations concerning conservation and restoration.

Implementing agencies, practitioners

Large, A., W. Mayes, M. Newson and G. Parkin (2007) Using long-term monitoring of fen hydrology and vegetation to underpin wetland restoration strategies. Applied Vegetation Science 10: 417-428.

http://onlinelibrary.wiley.com/doi/10.1111/j.1654-109X.2007.tb00441.x/abstract

Monitoring and Evaluation>Inland Waters>Rivers

Developing a Monitoring Program for Riparian Revegetation Projects

Private landowners, ecosystem restoration professionals, and resource agency staff can work together to increase native vegetation on the banks of streams and rivers. This publication gives practical advice on how to make this kind of project work.

Implementing agencies

Lewis, D., M. Lennox and S. Nossaman (2009) Developing a Monitoring Program for Riparian Revegetation Projects. University of California, Division of Natural Resources and Agriculture Publication 8363.

http://ucanr.org/freepubs/docs/8363.pdf

Guidelines for Establishing Monitoring Programs to Assess the Success of Riparian Restoration Efforts in Arid and Semi-arid Landscapes

This technical note is a product of the Ecosystem Management and Restoration Research Program (EMRRP) work unit titled "Techniques for Reestablishing Riparian Hardwoods in Arid and Semi-arid Regions." The objectives of this work are to provide technology to improve capabilities of restoring riparian areas in arid and semiarid regions. The work unit focuses on site evaluation and selection, hardwood species selection, planting techniques, and long-term monitoring protocols. This publication addresses the establishment of a monitoring program to gauge progress toward meeting restoration project objectives.

Practitioners, implementing agencies

Guilfoyle, M.P. and R.A. Fischer (2006) Guidelines for Establishing Monitoring Programs to Assess the Success of Riparian Restoration Efforts in Arid and Semi-arid Landscapes. Ecosystem Management and Restoration Research Program (EMRRP).

http://www.dmg.gov/documents/GDE_Est_Mntrng_Prgrms_to_Assess_the_Sccss_of_%20Rip_Rest_Effrts_in_Arid_Semi_Arid_Lndscps_EMRIP_081606.pdf

Monitoring Riparian Restoration

This section provides a general overview of the riparian management monitoring programs.

Implementing agencies

Monitoring Riparian Restoration. Washington State Department of Natural Resources, Riparian Forest Restoration Strategy.

http://www.dnr.wa.gov/Publications/lm_hcp_rfrs_sec4.pdf

Handbook for Evaluating Rehabilitation Projects in Rivers and Streams

The handbook presents a tool for assessing if and to what extent the different objectives of a rehabilitation project were achieved. In the present handbook, such an assessment is defined as project evaluation. The presented evaluation method is based on a comparison of selected key elements and processes before and after rehabilitation. With the help of this tool, users can determine tendencies toward improvement and identify persisting deficits and deteriorations. Project evaluation is carried out at the level of project objectives. Indicators serve as tools for project evaluation. Indicators are parameters, which provide important information on a system's elements and processes. Their assessment can be quantitative, semi-quantitative or qualitative.

Implementing agencies, practitioners

Woolsey, S., C. Weber, T. Gonser, E. Hoehn, M. Hostmann, B. Junker, C. Roulier, S. Schweizer, S. Tiegs, K. Tockner and A. Peter (2005) Handbook for evaluating rehabilitation projects in rivers and streams. Rhone-Thur project. Eawag, WSL, LCH-EPFL, VAW-ETHZ.

http://www.rivermanagement.ch/en/docs/handbook_evaluation.pdf

River Restoration Success: A Question of Perception

What defines success and failure of river restoration measures is a strongly debated topic in restoration science, but standardized approaches to evaluate either are still not available. The debate is usually centered on measurable parameters, which adhere to scientific objectivity.

More subjective aspects, such as landscape aesthetics or recreational value, are usually left out, although they play an important role in the perception and communication of restoration success. In this paper, we show that different perceptions of restoration success exist by analyzing data from 26 river restoration measures in Germany. We addressed both objective parameters, such as hydromorphological changes and changes in fish and benthic invertebrate assemblages, from field investigations, and subjective parameters, such as opinions and perceptions, from water managers via an online survey.

Implementing agencies

Jähnig, S.C., A.W. Lorenz, D. Hering, C. Antons, A. Sundermann, E. Jedicke and P. Haase (2011) River restoration success: a question of perception. Ecological Applications 21: 2007-2015.

http://www.esajournals.org/doi/abs/10.1890/10-0618.1?journalCode=ecap

A Strategy to Assess River Restoration Success

A strategy is proposed according to which a set of indicators is selected from the total of 49 indicators to ensure that indicators match restoration objectives and measures, and that the required effort for survey and analysis of indicators is appropriate to the project budget. Indicator values are determined according to methods described in detailed method sheets. Restoration success is evaluated by comparing indicator values before and after restoration measures have been undertaken. To this end, values are first standardised on a dimensionless scale ranging from 0 to 1, then averaged across different indicators for a given project objective, and finally assigned to one of five overall success categories. To illustrate the application of this scheme, a case study on the Thur River, Switzerland, is presented.

Implementing agencies

Woolsey, S. et al. (2007) A Strategy to Assess River Restoration Success. Freshwater Biology 52: 752-769.

http://palmerlab.umd.edu/restoration_course_docs/2008resources/Woolsey_et_al_2007.pdf

Monitoring Stream and Watershed Restoration

This book provides a practical resource for designing and implementing monitoring and evaluation programs for restoration activities at various scales--from individual, site-specific actions to multiple projects throughout a watershed. Chapters are organized around the major types of restoration techniques, including road improvements, riparian silviculture, fencing and grazing management, floodplains, estuarine, instream, nutrient enrichment, and acquisitions and conservation easements. Also includes chapters on economic evaluation and monitoring design. The book will particularly appeal to scientists evaluating restoration techniques, to groups implementing restoration, and to agencies and entities responsible for funding restoration efforts.

Practitioners, implementing agencies

Roni, P. (2005) Monitoring Stream and Watershed Restoration. American Fisheries Society.

http://www.afsbooks.org/x55047xm

Monitoring and Evaluation>Inland Waters>Wetlands

Evaluating Urban Wetland Restorations: Case Studies for Assessing Connectivity and Function

Restoration of preferred vegetation and hydrology is expected to net an overall improvement in habitat quality for fishery and wildlife species. Common metrics have been identified for evaluating the functional success of restoration on individual sites in urban wetlands. We argue, however, that alternative, larger-scale metrics are needed in order to monitor and evaluate the success of restoring functional connectivity to the patchwork of wetlands that compose urban estuarine systems. We present here a literature review of measurements that have been used in wetland restorations throughout the United States to assess restoration success of ecological functions at the ecosystem and/or landscape scale. Our goal is to stimulate discussion of alternative metrics to be included in future and ongoing assessments of urban restoration sites, especially those in the Meadowlands.

Implementing agencies, practitioners

Windham, L., M.S. Laska and J. Wollenberg (2004) Evaluating Urban Wetland Restorations: Case Studies for Assessing Connectivity and Function. Urban Habitats 2(1).

http://www.urbanhabitats.org/v02n01/evaluating_pdf.pdf

Evaluating the Ecological Performance of Wetland Restoration in the Yellow River Delta, China

Long-term monitoring is essential to evaluate the effects of wetland restoration projects. A monitoring program before and after restoration has been carried out in the study area located in the Yellow River Delta since 2001. Water quality, soil salinity, soil organic matter, plant community, and bird species were chosen as indicators in this program. During the past seven years, the restored wetland showed increasing efficiency in reducing water pollution levels. Soil quality was constantly improved through salinity reduction and soil organic matter accumulation. The vegetation community quickly re-established after the restoration was initiated in 2002. The restored vegetation communities provide favorable habitat conditions for birds and thirty-seven bird species were observed in October 2007.

Implementing agencies, practitioners

Cui, B., Q. Yang, Z. Yang and K. Zhang (2009) Evaluating the Ecological Performance of Wetland Restoration in the Yellow River Delta, China. Ecological Engineering 35(7): 1090-1103.

http://www.sciencedirect.com/science/article/pii/S0925857409001165

Perspectives on Setting Success Criteria for Wetland Restoration

Measurements of vegetation are most commonly used in evaluations of restoration projects, with less frequent analysis of soils, fauna, and hydrologic characteristics. Although particular characteristics of projects, such as vegetative cover and production, can resemble those in similar naturally occurring wetlands, overall functional equivalency has not been demonstrated. However, ongoing research is providing information on what can and cannot be accomplished, valuable insights on how to correct mistakes, and new approaches to defining success. The challenge is how to recognize and deal with the uncertainty, given that projects are ecologically young and that our knowledge of the process of restoration is evolving. One way to deal with the uncertainty is to use scientific principles of hypothesis testing and model building in an adaptive management framework. In this way, options can be systematically evaluated and needs for corrective actions identified when a project is not progressing toward goals. By taking such an approach we can improve our ability to reliably restore wetlands while contributing to our understanding of the basic structure and function of ecosystems.

Implementing agencies, practitioners

Kentula, M.E. (2000) Perspectives on Setting Success Criteria for Wetland Restoration. Ecological Engineering 15(3-4): 199-209.

http://www.sciencedirect.com/science/article/pii/S0925857400000768

Spider Communities as Evaluation Tools for Wet Heathland Restoration

By using a functional trait-approach, we tested if the time since restoration affects trait distribution of spiders in wet heathlands. Typical wet heathland spider species were less common with increasing vegetation encroachment and lower water content. New patches were inhabited by summer active, eurytopic (non-heathland) spiders, while more typical heathland species were found in middle-aged and old patches. Our results suggest that time-related changes in vegetation structure and moistness of restored wet heathlands are clearly reflected by spider communities. Although mobile spiders quickly recolonize the restored heathlands, it takes time for typical heathland spiders to settle. Restoration measures should prevent the negative effects of a vegetation encroachment and a high density of forested edges and should rehabilitate the hydrological cycle in order to preserve rare heathland spiders. We discuss that accounting for responses of spiders provides additional information to guide wet heathlands restoration.

Practitioners, implementing agencies

Cristofoli, S., G. Mahy, R. Kekenbosch and K. Lambeets (2010) Spider Communities as Evaluation Tools for Wet Heathland Restoration. Ecological Indicators 10(3): 773-780.

http://www.sciencedirect.com/science/article/pii/S1470160X0900199X

Ramsar Convention: An Integrated Framework for Wetland Inventory, Assessment, and Monitoring

The integrated framework provided here focuses on the purposes of and interrelationships among the different aspects and tools for wetland inventory, assessment and monitoring and provides summary information on each aspect of the relevant guidance adopted by the Convention. The integrated framework provides a rationale for applying the mechanisms of the Convention for inventory, assessment and monitoring in order to increase public and political awareness and understanding of the critical values and functions of wetlands in supporting sustainable development and human well-being; provides general guidance for further steps to be taken to improve inventory, assessment and monitoring processes; and recognizes some key topics requiring further guidance and elaboration under the Convention to support full implementation of the framework.

Policymakers, implementing agencies

Ramsar Convention Secretariat (2010) Inventory, assessment, and monitoring: an Integrated Framework for wetland inventory, assessment, and monitoring. Ramsar handbooks for the wise use of wetlands, 4th edition, vol. 13. Ramsar Convention Secretariat, Gland, Switzerland.

http://www.ramsar.org/pdf/lib/hbk4-13.pdf

Monitoring and Evaluation>Wildlife

Measuring the Success of Wildlife Community Restoration

It is difficult to measure the success of wildlife community restoration when the restoration goal concerns a relatively broad geographic area, rather than a particular piece of land, since many restored sites need to be compared to many reference sites simultaneously. A review of the methods used to measure success in previous restoration efforts indicated the potential value of multimetric methods to make the comparison. We designed a new method that retains some of the advantages of multimetric methods but also removes some of the associated problems. The new method was applied to data from 30 restored sites (phosphate-mined land) and 30 reference sites in central Florida (USA), and it showed the difference in wildlife composition between restored and reference sites to be large, relative to the maximum possible difference.

Implementing agencies, practitioners

McCoy, E.D. and H.R. Mushinsky (2002) Measuring the Success of Wildlife Community Restoration. Ecological Applications 12:1861-1871.

http://www.esajournals.org/doi/abs/10.1890/1051-0761(2002)012%5B1861:MTSOWC%5D2.0.CO%3B2

Prescribed Fire

Fire as a Restoration Tool: A Decision Framework for Predicting the Control or Enhancement of Plants Using Fire

We provide a decision framework that integrates fire regime components, plant growth form, and survival attributes to predict how plants will respond to fires and how fires can be prescribed to enhance the likelihood of obtaining desired plant responses. Fires are driven by biotic and abiotic factors that dictate their temporal (seasonality and frequency), spatial (size and patchiness), and magnitude (intensity, severity, and type) components. Plant resistance and resilience to fire can be categorized by a combination of life form, size, and ability to disperse or protect seeds. We use a combination of life form and vital plant attributes along with an understanding of fire regime components to suggest a straightforward way to approach the use of fire to either reduce or enhance particular species.

Practitioners, implementing agencies

Pyke, D.A., M.L. Brooks and C. D'Antonio (2010) Fire as a Restoration Tool: A Decision Framework for Predicting the Control or Enhancement of Plants Using Fire. Restoration Ecology 18: 274-284.

http://www.nationalfiretraining.net/userfiles/RockyMountain/pykeetal2010fireasarestorationtoolforplants.pdf

A Climate-Based Approach to the Restoration of Fire-Dependent Ecosystems

Recurrent fires are integral to the function of many ecosystems worldwide. The management of fire-frequented ecosystems requires the application of fire at the appropriate frequency and seasonality, but establishing the natural fire regime for an ecosystem can be problematic. Historical records of fires are often not available, and surrogates for past fires may not exist. We suggest that the relationship between climate and fire can provide an alternative means for inferring past fire regimes in some ecosystems.

Implementing agencies

Beckage,B., W.J. Platt and B. Panko (2005) A Climate-Based Approach to the Restoration of Fire-Dependent Ecosystems. Restoration Ecology 13(3): 429-431.

http://www.uvm.edu/~bbeckage/Manuscripts/Beckage_etal.rec.Sep05.pdf

Prescribed Fire>Australia

Fire Management in Tasmania's Wilderness World Heritage Area: Ecosystem Restoration using Indigenous-style Fire Regimes?

In many natural areas, changes in fire regimes since European settlement have resulted in adverse impacts on elements of biological diversity that survived millennia of land management by Indigenous people. Some of the rainforest and alpine elements that depend on south-west Tasmania's World Heritage Area have been in decline since European settlement of Tasmania due to an increase in the incidence of landscape-scale fires in the period 1850–1940. Some of the buttongrass moorland elements that also depend on the region are in decline or impending decline because of a decreased incidence and/or size of burns since 1940. Will an Indigenous-style fire regime serve the interests of biological diversity? We examine this question in the context of the fire ecology and fire history of south-west Tasmania. From this assessment we argue that a return to Indigenous-style burning, modified to address contemporary issues such as the prevention of unplanned ignition, suppression of wildfires and burning to favour rare and threatened species may help to reverse trends towards ecosystem degradation in this region.

Implementing agencies

Marsden-Smedley, J.B. and J.B. Kirkpatrick (2000) Fire management in Tasmania's Wilderness World Heritage Area: Ecosystem restoration using Indigenous-style fire regimes? Ecological Management and Restoration 1(3): 195-203.

http://faculty.fortlewis.edu/korb_j/global%20fire/tasmania%20fire%20management.pdf

Effectiveness of Repeated Autumn and Spring Fires for Understorey Restoration in Weed-invaded Temperate Eucalypt Woodlands

Can strategic burning, targeting differing ecological characteristics of native and exotic species, facilitate restoration of native understorey in weed-invaded temperate grassy eucalypt woodlands? While fire is often considered to increase ecosystem invasibility, our study showed that strategic use of fire, informed by the relative responses of available native and exotic taxa, is potentially an effective step towards restoration of weed-invaded temperate eucalypt woodlands.

Implementing agencies, practitioners

Prober, S., S. Taylor, R. Edwards and B. Mills (2009) Effectiveness of repeated autumn and spring fires for understorey restoration in weed-invaded temperate eucalypt woodlands. Applied Vegetation Science 12: 440-450.

http://onlinelibrary.wiley.com/doi/10.1111/j.1654-109X.2009.01039.x/abstract

Aboriginal Fire Management in Southeastern Australia: Aims and Frequency

Although I have interpreted the Aboriginal treatment of the landscape in material terms, this is not to gainsay the attachment which existed between the people and the land. Land management cannot be carried out without the deep sense of responsibility which was conveyed by the totality of Aboriginal culture. It was this close identification with the land that enabled Australia's indigenous people to manage their environment in a way that enabled them to survive and prosper on this most difficult continent. We need to take account of Aboriginal management of the ecosystems and its long evolutionary history if we are to succeed in our own management.

Policymakers, implementing agencies, indigenous and local communities

Gott, B. (2005) Aboriginal Fire Management in Southeastern Australia: Aims and Frequency. Journal of Biogeography 32: 1203-1208.

http://faculty.fortlewis.edu/KORB_J/global%20fire/aboriginal%20fire%20management%20australia.pdf

Prescribed Fire>Canada

Fire-Smart Forest Management: A Pragmatic Approach to Sustainable Forest Management in Fire-dominated Ecosystems

Sustainable forest management in many of Canada's forest ecosystems requires simultaneously minimizing the socioeconomic impacts of fire and maximizing its ecological benefits. A pragmatic approach to addressing these seemingly conflicting objectives is fire-smart forest management. This involves planning and conducting forest management and fire management activities in a fully integrated manner at both the stand and landscape levels. This paper describes the concept of fire-smart forest management, discusses its need and benefits, and explores challenges to effective implementation.

Implementing agencies, practitioners

Hirsch, K., V. Kafka, C. Tymstra, R. McAlpine, B. Hawkes, H. Stegehuis, S. Quintilio, S. Gauthier and K. Peck (2001) Fire-Smart Forest Management: A Pragmatic Approach to Sustainable Forest Management in Fire-dominated Ecosystems. The Forestry Chronicle 77(2).

ftp://ftp.nofc.forestry.ca/pub/fire/docs/Hirsch/Hirsch%20et%20al.%20For%20Chronicle.pdf

Fire-Maintained Ecosystem Restoration in BC's Rocky Mountain Trench: Principles, Strategy, Progress - Blueprint for Action

Over the decades, at least 31 reports, studies and inquiries–including an investigation by the provincial ombudsman – have documented deteriorating East Kootenay rangeland conditions and the attendant economic, social and ecological consequences. Many of these publications focused on resolution of the high-profile agriculture/wildlife conflict. Most recommended various remedies. Some of these were never implemented, others were adopted and then abandoned, a few evolved and remain part of resource management practice today. After four contentious decades, the prospect of a lasting remedy emerged when resource users and managers alike embraced the concept of ecosystem restoration as a means of returning ecological function and structure to Crown rangelands.

Policymakers, implementing agencies

Rocky Mountain Trench Ecosystem Restoration Steering Committee (2006)

http://www.trenchsociety.com/setup/content/Blueprint_for_Action_2006.pdf

Natural Fire Regime: A Guide for Sustainable Management of the Canadian Boreal Forest

The combination of certain features of fire disturbance, notably fire frequency, size and severity, may be used to characterize the disturbance regime in any region of the boreal forest. As some consequences of fire resemble the effects of industrial forest harvesting, conventional forest management is often considered as a disturbance that has effects similar to those of natural disturbances. Although the analogy between forest management and fire disturbance in boreal ecosystems has some merit, it is important to recognise that it also has its limitations. Short fire cycles generally described for boreal ecosystems do not appear to be universal; rather, important spatial and temporal variations have been observed in Canada.

Implementing agencies, practitioners

Bergeron, Y., A. Leduc, B.D. Harvey and S. Gauthier (2002) Natural Fire Regime: A Guide for Sustainable Management of the Canadian Boreal Forest. Silva Fennica 36(1): 81-95.

http://www.metla.eu/silvafennica/full/sf36/sf361081.pdf

Prescribed Fire>Eurasia

White Paper on the Use of Prescribed Fire in Land Management, Nature Conservation and Forestry in Temperate-Boreal Eurasia

The symposium will provide a platform for the exchange of data, expertise, and views of institutions and individuals who are actively applying or conducting research in prescribed burning for the purpose of nature conservation (biodiversity management, habitat management), land and landscape management, and forestry, notably in forest fire management. As the EFNCN is operating at the science-management and science-policy interface, representatives of institutions representing land managers and owners, public services, e.g. fire services, are invited to attend to discuss and share views on professional capacity building in the use of prescribed fire. Overall, the symposium will support the advancement of the use of prescribed fire in Eurasia; particularly by considering the involvement of local communities in land and fire management. The region of interest covered by the symposium is temperate-boreal Eurasia with a focus on Europe North of the Alps and the adjoining countries of East / Southeast Europe, Caucasus, Central and Northeast Asia.

Practitioners, indigenous and local communities

Symposium on Fire Management in Cultural and Natural Landscapes, Nature Conservation and Forestry in Temperate-Boreal Eurasia Freiburg, Germany, 25-27 January 2008. UNECE/FAO Team of Specialists on Forest Fire and the Global Fire Monitoring Center (GFMC).

http://www.fire.uni-freiburg.de/iffn/iffn_38/19-IFFN-38-White-Paper.pdf

Full report with case studies

http://www.fire.uni-freiburg.de/iffn/iffn_38/IFFN-38.pdf

Prescribed Fire>South Africa

Recovery of South African Fynbos Vegetation following Alien Woody Plant Clearing and Fire: Implications for Restoration

The recovery of fynbos vegetation after invasion by dense stands of alien trees, and clearing by either 'burn standing', 'fell and burn', or 'fell, remove and burn' treatments, was investigated in two watersheds in the Western Cape Province, South Africa. Native plant density, cover, functional and biological guilds and species richness were compared with matched control sites that were not invaded, but were burnt in the same fires. Our results illustrate the dangers of this, and highlight the need for intervention before areas become densely invaded. They also highlight the need for effective biological control agents to reduce rates of spread of aggressively invasive species.

Implementing agencies

Holmes, P.M., D.M. Richardson, B.W. Van Wilgen and C. Gelderblom (2000) Recovery of South African Fynbos Vegetation following Alien Woody Plant Clearing and Fire: Implications for Restoration. Austral Ecology 25: 631-639.

http://researchspace.csir.co.za/dspace/bitstream/10204/522/1/Holmes_2000.pdf

Prescribed Fire>Sweden

Maintaining and Restoring Biodiversity in European Boreal Forests by Developing Natural Disturbance Regimes

Three main disturbance regimes are distinguished in the European boreal forest, based on the complex interactions between probabilistic (e.g. mean fire intervals at different site types) and random events (e.g. where and when a fire occurs): (1) gap-phase Picea abies dynamics; (2) succession from young to old-growth mixed deciduous/coniferous forest; and (3) multi-cohort Pinus sylvestris dynamics. The model stems mainly from studies in Fennoscandia, but some studies from outside this region are reviewed to provide support for a more general application of the model. The model has been implemented in planning systems on the landscape level of several large Swedish forest enterprises, and is also used as an educational tool to help private land owners with the location and realization of forest management regimes. Finally, the model can be used to develop an administrative system for the monitoring of biodiversity in boreal forest.

Implementing agencies, practitioners

Angelstam, P.K. (1998) Maintaining and Restoring Biodiversity in European Boreal Forests by Developing Natural Disturbance Regimes. Journal of Vegetation Science 9(4): 593-602.

http://onlinelibrary.wiley.com/doi/10.2307/3237275/abstract

Prescribed Fire>USA

Forest Restoration and Fire: Principles in the Context of Place

There is broad consensus that active management through thinning and fire is urgently needed in many forests of the western United States. This consensus stems from physically based models of fire behavior and substantial empirical evidence. But the types of thinning and fire and where they are applied are the subjects of much debate. We propose that low thinning is the most appropriate type of thinning practice. Treating surface fuels, reducing ladder fuels, and opening overstory canopies generally produce fire-safe forest conditions, but large, fire-resistant trees are also important components of fire-safe forests. The context of place is critical in assigning priority for the limited resources that will be available for restoration treatments. Historical low-severity fire regimes, because of their current high hazards and dominance by fire-resistant species, are the highest priority for treatment. Mixed-severity fire regimes are of intermediate priority, and high-severity fire regimes are of lowest priority. Classification systems based on potential vegetation will help identify these fire regimes at a local scale.

Implementing agencies

Brown, R.T., J.K. Agee and J.F. Franklin (2004) Forest Restoration and Fire: Principles in the Context of Place. Conservation Biology 18: 903-912.

http://faculty.washington.edu/jff/Brown_Agee_Franklin_Forest_Restoration_Fire_CB_2004.pdf

The Use of Fire in Forest Restoration

This document is a synthesis of knowledge and applications of fire as an agent of both disturbance and ecosystem restoration in forest ecosystems of the Northwestern United States.

Practitioners, implementing agencies

Hardy, C. and S. Arno (eds.) (1996) The Use of Fire in Forest Restoration. The United States Department of Agriculture, Forest Service. General Technical Report, Annual Meeting of the Society for Ecological Restoration. Seattle, September 14-16, 1995.

http://www.fs.fed.us/rm/pubs_int/int_gtr341.pdf

Thinning, Fire and Forest Restoration: A Science-based Approach for National Forests in the Interior Northwest

This is neither an exhaustive review of the literature, nor an attempt to address all issues related to forest restoration. Rather, it is an attempt to review the most pertinent scientific literature, merge these findings with policy requirements, and provide recommendations on how best to proceed. Qualitative judgment will inevitably be involved, and what follows should be viewed as general principles, considerations, or rules-of-thumb.

Implementing agencies, policymakers

Brown, R. (2000) Thinning, Fire and Forest Restoration: A Science-based Approach for National Forests in the Interior Northwest. Defenders of Wildlife, Washington, DC.

http://www.defenders.org/publication/thinning-fire-and-forest-restoration-science-based-approach-national-forests-interior

Effects of an Intense Prescribed Forest Fire: Is It Ecological Restoration?

Relatively intense burning has been suggested as a possible alternative to the restoration of pre-European settlement forest conditions and fire regime in mixed conifer forests, in contrast to thinning of trees and light prescribed burning. In 1993 a management-ignited fire in a dense, never-harvested forest in Grand Canyon National Park escaped prescription and burned with greater intensity and severity than anticipated. The intentional use of severe burning would be challenging to managers because of the increased risk of escaped fires, but the ecological outcome of this particular wildfire was not inconsistent with ecological restoration goals for this ecosystem type.

Implementing agencies

Fule, P.Z., A.E. Cocke, T.A. Heinlein and W.W. Covington (2004) Effects of an Intense Prescribed Forest Fire: Is It Ecological Restoration? Restoration Ecology 12(2): 220-230.

http://library.eri.nau.edu/gsdl/collect/erilibra/import/FuleEtal.2004.EffectsOfAnIntensePrescribed.pdf

The Role of Indigenous Burning in Land Management

This article highlights the findings of the literature on aboriginal fire from the human- and the land-centered disciplines, and suggests that the traditional knowledge of indigenous peoples be incorporated into plans for reintroducing fire to the nation’s forests. Traditional knowledge represents the outcome of long experimentation with application of fire by indigenous people, which can inform contemporary policy discussions.

Policymakers, implementing agencies, indigenous and local communities

Kimmerer, R.M. and F.K. Lake (2001) The Role of Indigenous Burning in Land Management. Journal of Forestry (November 2001): 36-42.

http://www.nwtf.org/NAWTMP/downloads/Literature/Indigenous_Buring.pdf

Restoring Riparian Corridors with Fire: Effects on Soil and Vegetation

In many riparian corridors of the semi-arid west, stream incision has resulted in lowered water tables, basin big sagebrush (Artemisia tridentata var. tridentata Nutt.) encroachment and the loss of the dominant herbaceous vegetation. To determine the potential for restoring basin big sagebrush-dominated riparian corridors to greater herbaceous cover, a fall prescribed burn on sites with relatively shallow (-153 to -267 cm) and deep (-268 to > -300 cm) water tables was conducted. The results indicate that burning alone is an appropriate restoration treatment for shallow water table sites because of minimal C and N loss and increased available nutrients for regrowth of understory herbaceous species. Deep water table sites require a burning prescription that minimizes fire severity because of higher potential C and N loss, and reseeding due to a lack of perennial understory herbaceous species and more xeric conditions.

Implementing agencies, practitioners

Blank, R.R., J.C. Chambers and D. Zamudio (2003) Restoring Riparian Corridors with Fire: Effects on Soil and Vegetation. Journal of Range Management 56: 388-396.

http://ddr.nal.usda.gov/dspace/bitstream/10113/19522/1/IND43647061.pdf

Cold Desert Fire and Invasive Species Management: Resources, Strategies, Tactics, and Response

The cold desert of western North America faces multiple challenges with regard to fi re and invasive species management. Speakers at the Wildfire and Invasive Plants in American Deserts conference identified several critical management and research issues in cold deserts.

Practitioners, implementing agencies

Chambers, J.C., E. Leger and E. Goergen (2003) Cold Desert Fire and Invasive Species Management: Resources, Strategies, Tactics, and Response. Rangelands 31(3):14-20.

http://www.treesearch.fs.fed.us/pubs/34148

Effects of Prescribed Fire and Season of Burn on Recruitment of the Invasive Exotic Plant, Potentilla recta, in a Semiarid Grassland

Prescribed fire is often used to restore grassland systems to presettlement conditions; however, fire also has the potential to facilitate the invasion of exotic plants. Managers of wildlands and nature reserves must decide whether and how to apply prescribed burning to the best advantage in the face of this dilemma. Herbicide is also used to control exotic plants, but interactions between fire and herbicides have not been well studied. Results suggest that prescribed fire will enhance germination of P. recta, but this will not always lead to increased population growth. Prescribed fire may reduce the long-term efficacy of herbicide applied to control P. recta and will be most beneficial at Dancing Prairie when conducted in the spring rather than the fall. Results of prescribed fire on exotic plant invasions in semiarid environments will be difficult to predict because they are strongly dependent on stochastic climatic events.

Practitioners

Lesica, P. and B. Martin (2003) Effects of Prescribed Fire and Season of Burn on Recruitment of the Invasive Exotic Plant, Potentilla recta, in a Semiarid Grassland. Restoration Ecology 11(4): 516-523.

http://onlinelibrary.wiley.com/doi/10.1046/j.1526-100X.2003.rec0298.x/abstract

Fire and Restoration of Sagebrush Ecosystems

Wildlife managers often resort to prescribed fire to restore sagebrush (Artemisia spp.) ecosystems thought to have been affected by fire exclusion. However, a fire mosaic of burned and unburned areas may be tolerated by certain wildlife but can be detrimental to sagebrush obligates. This article assesses evidence about the historical frequency and pattern of fire in sagebrush ecosystems and the need for prescribed fire. Fire-scar data from nearby forests require adjustment to estimate fire rotation, the time required to burn once through a sagebrush landscape. Estimates from forests require correction for unburned area and because sagebrush burns less often than forests. Recovery time also might indicate fire rotation.

Practitioners, implementing agencies

Baker, W. (2006) Fire and Restoration of Sagebrush Ecosystems. Wildlife Society Bulletin 34(1): 177-185.

http://www.colorado.edu/geography/class_homepages/geog_4430_f10/Baker_SagebrushFireRestoration_WildSocBull06.pdf

Death Rides the Forest: Perceptions of Fire, Land Use, and Ecological Restoration of Western Forests

Large wild fires occurring in forests, grasslands, and chaparral in the last few years have aroused much public concern. Many have described these events as “catastrophes” that must be prevented through aggressive increases in forest thinning. Yet the real catastrophes are not the fires themselves but those land uses, in concert with fire-suppression policies that have resulted in dramatic alterations to ecosystem structure and composition. The first step in the restoration of biological diversity (forest health) of western landscapes must be to implement changes in those factors that have caused degradation or are preventing recovery. This includes changes in policies and practices that have resulted in the current state of wildland ecosystems. Restoration entails much more than simple structural modifications achieved though mechanical means. Restoration should be undertaken at landscape scales and must allow for the occurrence of dominant ecosystem processes, such as the natural fire regimes achieved through natural and/or prescribed fires at appropriate temporal and spatial scales.

Policymakers, implementing agencies

Kauffman, J.B. (2004) Death Rides the Forest: Perceptions of Fire, Land Use, and Ecological Restoration of Western Forests. Conservation Biology 18(4): 878-882.

http://www.arcfuels.org/maggie/AGER%202011%20maggie%20Copy.Data/PDF/kauffman%20fire%20and%20policy%20CONS%20BIOL%202004-0897720832/kauffman%20fire%20and%20policy%20CONS%20BIOL%202004.pdf

Key Issues in Fire Regime Research for Fuels Management and Ecological Restoration

The basic premise behind many projects aimed at wildfire hazard reduction and ecological restoration in forests of the western United States is the idea that unnatural fuel buildup has resulted from suppression of formerly frequent fires. This premise and its implications need to be critically evaluated by conducting area-specific research in the forest ecosystems targeted for fuels or ecological restoration projects. Fire regime researchers need to acknowledge the limitations of fire history methodology and avoid over-reliance on summary fire statistics such as mean fire interval and rotation period. While fire regime research is vitally important for informing decision making in the areas of wildfire hazard mitigation and ecological restoration, there is much need for improving the way researchers communicate their results to managers and the way managers use this information.

Implementing agencies

Veblen, T.T. (2003) Key issues in fire regime research for fuels management and ecological restoration. Pages 259-276 in: P. Omi and L. Joyce (technical eds). Fire, Fuel Treatments and Ecological Restoration: Conference proceeedings; 2002 16-18 April; Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

http://www.colorado.edu/geography/biogeography/publications/VeblenFireConfPaper2003.pdf

Evaluating the Purpose, Extent, and Ecological Restoration Applications of Indigenous Burning Practices in Southwestern Washington

In this article, we evaluated paleoecological, archaeological, ethnographic, and ethnobotanical information about the Upper Chehalis River basin prairies of southwestern Washington to better understand the extent to which TEM influenced prairie distribution, composition. and availability of wild plant tool resources. We also surveyed areas that had been burned at differing frequencies to test whether frequent fires increase camas {Camassia quamash) productivity. Preliminary results support the hypothesis that camas productivity increases with fire-return intervals of one to two years.

Storm, L. and D. Shebitz (2006) Evaluating the Purpose, Extent, and Ecological Restoration Applications of Indigenous Burning Practices in Southwestern Washington. Ecological Restoration 24(4): 256-268.

http://faculty.fortlewis.edu/korb_j/global%20fire/washington_indigenous%20burning.pdf

Prescribed Fire in Oak Savanna: Fire Frequency Effects on Stand Structure and Dynamics

Attempts to preserve and maintain savannas as a viable ecosystem type in this region will require a long-term commitment to restoration-based management, with prescribed fire as a central tool. Burn frequency treatments with four or more fires per decade produce similar reductions in stem density and stand basal area but may lead to unsustainable oak tree populations. Within this general range, fire frequencies at a decadal scale should be chosen to address other management objectives, including suppressing shrubs and promoting increased cover of grasses and other herbaceous species. Fire management with a long-term view may also require periodic respites to allow for new cohorts of mature oak trees.

Implementing agencies, practitioners

Peterson, D.W. and P.B. Reich (2001) Prescribed Fire in Oak Savanna: Fire Frequency Effects on Stand Structure and Dynamics. Ecological Applications 11(3): 914-927.

http://cedarcreek.umn.edu/biblio/fulltext/t1817.pdf

Protected Areas

Simulated Indigenous Management: A New Model for Ecological Restoration in National Parks

If land managers, ecologists, and archaeologists understand the intricacies and mechanics of how and why native people shaped ecosystems, this will enrich their inventory of management methods, and they will be in a better position to make informed, historically based decisions.

Implementing agencies, indigenous and local communities

Anderson, M.K. and M.G. Barbour (2003) Simulated Indigenous Management: A New Model for Ecological Restoration in National Parks. Ecological Restoration 21: 269-277.

http://www.nafri.gov/courseinfo/rx510/2011_pages/LP_HO/Unit%20II/II-E-Lake/HO6-II-E_AndersonBarbour2003.pdf

Protected Areas>Australia

Experimental Manipulation of Restoration Barriers in Abandoned Eucalypt Plantations

Regeneration of native potential canopy trees, understorey trees, shrubs and woody climbers, and perennial forbs all increased with canopy retention. Grass cover dominated the regeneration where canopy cover was less than 50%. In the absence of weed control, the cover of introduced shrubs increased with reduction in canopy cover, as did the rate of understorey regeneration generally. These responses indicate that thinning and weed control can reinstate succession, leading to structurally and compositionally diverse forest. Given the abundance of native woody regeneration under retained canopy, the lantana understorey was more important in inhibiting native regeneration. The experimental approach will promote efficient use of resources across the remaining 200 ha of low conservation value plantations in this national park.

Implementing agencies, practitioners

Cummings, J., N. Reid, I. Davies and C. Grant (2007) Experimental Manipulation of Restoration Barriers in Abandoned Eucalypt Plantations. Restoration Ecology 15: 156-167.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2006.00200.x/abstract

Connectivity Conservation and the Great Eastern Ranges Corridor

A revised conservation science consensus is beginning to emerge in response to the limitations of conservation efforts to date and the enormity of the challenge. The term 'connectivity conservation' is now being widely used to capture this emerging scientific consensus among researchers and practitioners. A connectivity conservation approach recognises that: 1) conservation management is needed on the lands around formal protected areas to, among other things, buffer them from threatening processes originating off-reserve and to care for biodiversity assets found on other land tenures; 2) on land that has been heavily cleared and fragmented, there is a need for large-scale ecological restoration and rehabilitation so that protected areas do not remain isolated islands and 'extinction vortices'; and 3) in largely intact areas, the option remains to maintain ecological integrity in toto through a combination of formal protected areas and complementary off-reserve conservation management areas.

Policymakers, implementing agencies

Mackey, B., J. Watson and G.L. Worboys (2011) Connectivity conservation and the Great Eastern Ranges corridor. An independent report to the Interstate Agency Working Group (Alps to Atherton Connectivity Conservation Working Group) convened under the Environment Heritage and Protection Council/Natural Resource Management Ministerial Council.

http://www.environment.nsw.gov.au/resources/nature/ccandger.pdf

Protected Areas>Canada

Parks Canada: Restoration Case Studies

This compendium of case studies is a companion to the Principles and Guidelines for Ecological Restoration in Canada's Protected Natural Areas. The case studies are from a variety of parks and other protected natural areas across Canada and illustrate a broad range of restoration challenges and solutions. They demonstrate approaches to ecological restoration that are 1) Effective in restoring and maintaining ecological integrity, 2) Efficient in using practical and economic methods to achieve functional success, and 3) Engaging through implementing inclusive processes and by recognizing and embracing interrelationships between culture and nature.

Implementing agencies

Parks Canada

http://www.pc.gc.ca/eng/progs/np-pn/re-er/ec-cs/index.aspx

Ecological Restoration in Parks and Protected Areas: Using Protected Areas for Testing Methods of Restoring Forest Communities

Severe disturbances usually denude an ecological community of its structure (based on its species composition) and function. Restoration requires that the community be re-assembled, but the question is what key aspects need attention and in what order or priority? Parks and protected areas offer some challenges but the opportunities offered by the existence of good, protected 'reference states' for comparison to degraded areas and restored areas are attractive to researchers. To begin to test methods of ecological restoration of forest communities, I compared four sites within a medium sized municipality (Region of Waterloo, Ontario, Canada). Two sites were relatively undisturbed forest communities in protected areas; the other sites were disturbed by construction of housing developments.

Implementing agencies

Murphy, S.D. (2004) Ecological Restoration in Parks and Protected Areas: Using Protected Areas for Testing Methods of Restoring Forest Communities. Parks Research Forum of Ontario.

http://casiopa.mediamouse.ca/wp-content/uploads/2010/05/PRFO-2004-Proceedings-p69-79-Murphy.pdf

Prospects for Canada's Protected Areas in an Era of Rapid Climate Change

This paper examines a number of climate-related issues that now confront agencies and organizations responsible for the protection of natural heritage areas, including the roles of protected areas, representation targets, ecological integrity, protected area design, management techniques, research and monitoring needs, and agency capacity to respond. Potential avenues for adaptation are proposed in light of these issues. The development and implementation of a cross-jurisdictional landscape-scale strategic conservation framework focused on protecting, connecting, and restoring ecosystems will be fundamental to enhancing ecological resilience to climate change. We conclude that even though climate change presents unprecedented and significant challenges, the protected area contribution to ecosystem function and human health and well-being will remain an essential and worthwhile investment in the 21st century.

Policymakers, implementing agencies

Lemieux, C.J., T.J. Beechey and P.A. Gray (2011) Prospects for Canada's Protected Areas in an Era of Rapid Climate Change. Land Use Policy 28(4): 928-941.

http://www.sciencedirect.com/science/article/pii/S0264837711000299

Protected Areas>Ecuador

Tropical Forest Restoration within Galapagos National Park: Application of a State-transition Model

We applied a state-transition model as a decision-making tool to identify and achieve short- and long-term restoration goals for a tropical, moist, evergreen forest on the island of Santa Cruz, Galapagos. The model guided the process of identifying current and desirable forest states, as well as the natural and human disturbances and management actions that caused transitions between them. This process facilitated assessment of opportunities for ecosystem restoration, expansion of the definition of restoration success for the system, and realization that, although site- or species-specific prescriptions may be available, they cannot succeed until broader landscape restoration issues are identified and addressed. The model provides a decision-making framework to allocate resources effectively to maximize these opportunities across the landscape, and to achieve long-term restoration success.

Implementing agencies, practitioners

Wilkinson, S.R., M.A. Naeth and F.K.A. Schmiegelow (2005) Tropical Forest Restoration within Galapagos National Park: Application of a State-transition Model. Ecology and Society 10(1).

http://www.ecologyandsociety.org/vol10/iss1/art28/

Protected Areas>Italy

Planning Restoration in a Cultural Landscape in Italy Using an Object-based Approach and Historical Analysis

We present a proposal for a standardized method to develop restoration practices capable of increasing the efficacy of landscape management and create the necessary bridge between restoration planning and landscape ecology. This methodology was developed in order to identify the reference landscape and to define areas within that landscape that possess different degrees of potential for restoration purposes in a cultural landscape. We utilized retrospective data to compare former ecosystem arrangements, taking into account ecological, spatial and temporal issues, such as historical information on changes in land use, in addition to diachronically analyzed aerial photos taken between 1954 and 2002, using an object-based approach. The test area is a Nature Reserve in Tuscany (Italy) that preserves the cultural landscape of biancane badlands – erosion forms generated on Plio-Pleistocene marine clay outcrops – which is characterized by a high erosion rate.

Implementing agencies

Marignani, M., D. Rocchini, D. Torri, A. Chiarucci and S. Maccherini (2008) Planning Restoration in a Cultural Landscape in Italy Using an Object-based Approach and Historical Analysis. Landscape and Urban Planning 84(1): 28-37.

http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.178.6127&rep=rep1&type=pdf

Protected Areas>Mexico

Resolving the Conflict between Ecosystem Protection and Land Use in Protected Areas of the Sierra Madre de Chiapas, Mexico

The objectives of this paper are: (a) to analyze the conflict between people's livelihoods and ecosystem protection in the PAs of the Sierra Madre de Chiapas (SMC), paying special attention to the rates and causes of deforestation and (b) to review policy options to ensure forest and ecosystem conservation in these PAs, including the existing payments for environmental services system and improvements thereof as well as options for sustainable land management.

Policymakers, implementing agencies

Cortina-Villar, S., H. Plascencia-Vargas, R. Vaca, G. Schroth, Y. Zepeda, L. Soto-Pinto and J. Nahed-Toral (2012) Resolving the Conflict Between Ecosystem Protection and Land Use in Protected Areas of the Sierra Madre de Chiapas, Mexico. Environmental Management 49: 649-662.

http://rd.springer.com/article/10.1007/s00267-011-9799-9

Protected Areas>Poland

Living Stands and Dead Wood in the Białowieża Forest: Suggestions for Restoration Management

The Białowieża Primeval Forest (BPF) is the only forest area in temperate Europe where forest communities have developed a natural stand structure and a natural distribution of coarse woody debris ((CWD)=standing dead trees (SDT)+down woody material (DWM)). Stand and dead wood characteristics are influenced by ancient and recent historical factors and current processes, such as fires, competitive exclusion, storms, insect outbreaks, and forest management. The aim of the present study was to relate CWD to stand characteristics in mesic deciduous forest (Tilio‑Carpinetum (TC)) and riparian forest (Circaeo‑Alnetum (CA)). In conclusion, special measures aimed at the restoration of ecological capacity of forest communities, including legacy retention and management for decadence, have been recommended. There is an urgent need for complementary studies to supply information necessary for successful adaptive management of the Białowieża Primeval Forest.

Implementing agencies

Bobiec, A. (2002) Living Stands and Dead Wood in the Białowieża Forest: Suggestions for Restoration Management. Forest Ecology and Management 165(1-3): 125-140.

http://www.sciencedirect.com/science/article/pii/S0378112701006557

Protected Areas>Spain

From Pine Plantations to Natural Stands: Ecological Restoration of a Pinus canariensis Sweet, Ex Spreng Forest

The main objective of the plantations analyzed in this study is to restore the Canarian pine (Pinus canariensis Sweet, ex Spreng) forest, heavily disturbed as a result of intense logging over the last 5 centuries, following the European colonization of the Canary Islands (Parsons 1981). In the last 60 years large areas of Tenerife have been reforested, but these initiatives have not been followed up with subsequent manage ment or monitoring. In recent years, public authority forest managers have re-considered the usefulness of plantations, moving away from the idea of using them solely as a tool to control erosion towards management practices that will restore natural pine forest.

Implementing agencies

Arévalo, J.R. and J.M. Fernández-Palacios (2005) From Pine Plantations to Natural Stands: Ecological Restoration of a Pinus canariensis Sweet, Ex Spreng Forest. Plant Ecology 181(2): 217-226.

http://www.springerlink.com/content/u31729246252v6v6/

Protected Areas>UK

The Influence of Time on the Soil Seed Bank and Vegetation across a Landscape-Scale Wetland Restoration Project

Wicken Fen National Nature Reserve (NNR) in Cambridgeshire, U.K. is a wetland of international importance isolated in a landscape dominated by arable farming. The prospect of species extinctions within the NNR led to the creation of the Wicken Fen Vision, an ambitious project that will eventually expand the reserve boundary by the purchase and restoration of c.50 km2 of arable land. We sampled three fields from each of three distinct age-categories of restoration land (5, 15, and 60 years post-arable), and three fields within the adjacent, undrained NNR, to determine (1) differences in seed bank composition across age-categories, (2) relationships between restoration age, the seed bank and standing vegetation, and (3) changes in species traits across age-categories.

Implementing agencies

Stroh, P.A., F.M.R. Hughes, T.H. Sparks and J.O. Mountford (2012) The Influence of Time on the Soil Seed Bank and Vegetation across a Landscape-Scale Wetland Restoration Project. Restoration Ecology 20(1): 103-112.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2010.00740.x/abstract

Protected Areas>Vietnam

Restoration of Wetlands in the Tram Chim Nature Reserve

A major goal of the restoration was to bring back Grus antigone sharpii into the area. A habitat that could support Grus antigone sharpii and the plants necessary for its survival needed to be restored. To rebuild the wetland habitat it was essential that historic physical, chemical, and biological conditions be restored (Barzen, 1993). Once the natural biotic and abiotic processes were reestablished the area would invite other wetland animals and support a higher diversity of wetland plants. Recreating the historic hydrology of the area was the key component of the system that had to be replaced before any other habitat improvements were possible (Beilfuss and Barzen, 1994).

Implementing agencies

Pacovsky, J. (2001) Restoration of Wetlands in the Tram Chim Nature Reserve. Restoration and Reclamation Review 7(3).

http://conservancy.umn.edu/bitstream/60130/1/7.3.Pacovsky.pdf

Protected Areas>Climate Change

Natural Solutions: Protected Areas Helping People Cope with Climate Change

Protected areas are an essential part of the global response to climate change. They are helping address the cause of climate change by reducing greenhouse gas emissions. They are helping society cope with climate change impacts by maintaining essential services upon which people depend. Without them, the challenges would be even greater, and their strengthening will yield one of the most powerful natural solutions to the climate crisis.

Policymakers

Dudley, N., S. Stolton, A. Belokurov, L. Krueger, N. Lopoukhine, K. MacKinnon, T. Sandwith and N. Sekhran (eds.) (2010) Natural Solutions: Protected areas helping people cope with climate change. IUCNWCPA, TNC, UNDP, WCS, The World Bank and WWF, Gland, Switzerland, Washington DC and New York, USA.

http://data.iucn.org/dbtw-wpd/edocs/2009-045.pdf

Protected Areas>Governance

Governance as Key for Effective and Equitable Protected Area Systems

Governance is about power, relationships, responsibility and accountability. It is about who has influence, who decides, and how decision-makers are held accountable. There are many important decisions to be made about protected areas and, related to those, come specific powers and responsibilities.

Policymakers

CBD Programme of Work on Protected Areas (2008) Briefing Note 8

http://cmsdata.iucn.org/downloads/governance_of_protected_areas_for_cbd_pow_briefing_note_08_1.pdf

Protected Areas>Marine

Scientific Design of a Resilient Network of Marine Protected Areas – Kimbe Bay

The Nature Conservancy’s vision for Kimbe Bay is to “Harness traditional and community values to protect and use land and sea resources in ways that maintain the exceptional natural and cultural heritage of the bay”. This will be achieved by working with local communities, governments and other stakeholders to establish a resilient network of Marine Protected Areas (MPAs), and develop strategies for improved management of marine resources and land use practices. This report focuses on a critical step in this process– designing a resilient network of MPAs for Kimbe Bay.

Indigenous and local communities

Green, A., P. Lokani, S. Sheppard, J. Almany, S. Keu, J. Aitsi, J. Warku Karvon, R. Hamilton and G. Lipsett-Moore (2007) Scientific Design of a Resilient Network of Marine Protected Areas. Kimbe Bay, West New Britian, Papua New Guinea. TNC Pacific Island Countries Report No 2/07.

http://www.conservationgateway.org/sites/default/files/Kimbe%20Bay%20MPA%20Design-Final-Dec09.pdf

Scientific Design of a Resilient Network of Marine Protected Areas - Lesser Sunda Ecoregion

In this document, we describe the process to develop a scientific design of a resilient network of MPAs for the Lesser Sunda Ecoregion, based on a detailed scientific assessment and an extensive stakeholder consultation process. This process included developing a GIS database of best available information, identifying key conservation features, threats and uses of the area, applying state of the art conservation planning tools and facilitating input from relevant government agencies, local stakeholders and scientific experts though a series of workshops and meetings.

Implementing agencies

Wilson, J., A. Darmawan, J. Subijanto, A. Green and S. Sheppard (2011) Scientific design of a resilient network of marine protected areas. Lesser Sunda Ecoregion, Coral Triangle. Asia Pacific Marine Program. Report 2/11.

http://www.conservationgateway.org/sites/default/files/LSE%20MPA%20Design-%2014%20April.pdf

Best Practices for Improved Governance of Coral Reef Marine Protected Areas

This review examines the governance of coral reef MPAs and the means to improve coral reef MPA management. It highlights common governance challenges, such as confused goals, conXict, and unrealistic attempts to scale up beyond institutional capacity. Recommendations, based on Weld experience and empirical evidence from around the world, are made for best practices at various stages of MPA implementation.

Policymakers

Christie, P. and A.T. White (2007) Best Practices for Improved Governance of Coral Reef Marine Protected Areas. Coral Reefs 26: 1047-1056.

http://depts.washington.edu/smea/sites/default/files/patrickc/Christie%20and%20White.2007.Coral%20Reefs.pdf

Science-based and Stakeholder-driven Marine Protected Area Network Planning: A Successful Case Study from North Central California

The planning process for California's Marine Life Protection Act in north central California represents a case study in the design of a regional component of a statewide network of marine protected areas (MPAs) for improved ecosystem protection. We describe enabling factors, such as a legislative mandate, political will, and adequate capacity and funding that fostered a successful planning process. We identify strategic principles that guided the design of a transparent public planning process that delivered regional MPA network proposals, which both met science guidelines and achieved a high level of support among stakeholders. We also describe key decision support elements (spatial data, planning tools, and scientific evaluation) that were essential for designing, evaluating, and refining alternative MPA network proposals and for informing decision-makers.

Policymakers

Gleason, M., S. McCreary, M. Miller-Henson, J. Ugoretz, E. Fox, M. Merrifield, W. McClintock, P. Serpa and K. Hoffman (2010) Science-based and Stakeholder-driven Marine Protected Area Network planning: A Successful Case Study from North Central California. Ocean & Coastal Management 53: 52–68.

http://www.pelagicos.net/MARS6910_spring2010/readings/Gleason_et_al_2010.pdf

Lessons for Marine Conservation Planning: A Comparison of Three Marine Protected Area Planning Processes

Various approaches have been used to establish marine protected areas (MPAs) in different countries. In this paper we compare and review three processes to establish MPAs within the United States and Australia. These two countries share many similarities in their cultures, but their approaches to managing marine resources differ considerably. Each of these efforts to establish or review MPAs was motivated by concern about declines of targeted marine species or habitats. However, the government actions varied because of differences in governance, planning process including public input, and the role of science. Comparing these processes highlights effective approaches for protecting marine ecosystems and gaining public support.

Policymakers

Osmond, M., S. Airame, M. Caldwell, and J. Day (2010) Lessons for Marine Conservation Planning: A Comparison of Three Marine Protected Area Planning Processes. Ocean & Coastal Management 53: 41-51.

http://www.sciencedirect.com/science/article/pii/S0964569110000037

Marine Protected Areas – ICSF Studies

The International Collective in Support of Fishworkers (ICSF) commissioned studies in six countries to understand the social dimensions of implementing MPAs, with the following specific objectives: 1) to provide an overview of the legal framework for, and design and implementation of, MPAs; 2) to document and analyze the experiences and views of local communities, particularly fishing communities, with respect to various aspects of MPA design and implementation; and 3) to suggest ways in which livelihood concerns can be integrated into the MPA Programme of Work, identifying, in particular, how local communities, particularly fishing communities, could engage as equal partners in the MPA process. The studies were undertaken in Brazil, India, Mexico, South Africa, Tanzania and Thailand.

Indigenous and local communities

English, French, Spanish

The International Collective in Support of Fishworkers (2007-2010)

http://www.icsf.net/en/monographs.html

Lessons Learned and Good Practices in the Management of Coral Reef Marine Protected Areas

The objective of this project is to formalize the experiences, outcomes and lessons learned from previous GEF projects, as well as major non-GEF initiatives involving marine protected areas (MPAs) in coral reefs and associated ecosystems. The project aims to comprehensively identify, analyze, and translate lessons into good practices and information resources, and then disseminate this information globally for use in future project design and development. Based on its history of supporting coral reef biodiversity, management and sustainable development, this project will help the GEF fulfill a major mandate to identify what has worked and what could be improved upon in supporting biodiversity conservation. In combination with other GEF projects, this effort will also help the GEF and other major non-GEF projects achieve a markedly improved return on investment for future projects involving coral reefs MPAs.

Implementing agencies

World Fish Centre

http://www.reefbase.org/gefll/pdf/mpa%20case%20studies.pdf

The Need and Practice of Monitoring, Evaluating and Adapting Marine Planning and Management—Lessons from the Great Barrier Reef

Over the last 30 years, the Great Barrier Reef Marine Park (GBRMP) has successfully established a multiple-use spatial management approach that allows both high levels of environmental protection and a wide range of human activities. Drawing on this unique long-term experience in the GBRMP, this article discusses key aspects of effective monitoring and evaluation, and summarises lessons learned from over two decades of adaptive management.

Implementing agencies, practitioners

Day, J. (2008) The Need and Practice of Monitoring, Evaluating and Adapting Marine Planning and Management—Lessons from the Great Barrier Reef. Marine Policy 32: 823– 831.

http://www.unesco-ioc-marinesp.be/uploads/documentenbank/7210a8c9fb506667d642a09b846ad805.pdf

Evaluating the Management Effectiveness of Marine Protected Areas

This report examines key issues in relation to the management effectiveness of two types of UK MPAs – Marine Nature Reserves and marine Special Areas of Conservation. It includes: 1) a consideration of potential criteria for evaluating effectiveness; 2) case studies that try to apply these criteria; and 3) a discussion of some of the constraints and barriers to the effective management of MPAs in the UK.

Gubbay, S. (2005) Evaluating the Management Effectiveness of Marine Protected Areas. A report for WWF-UK.

http://www.wwf.org.uk/filelibrary/pdf/mpa_mgmteff0705.pdf

People and Reefs: Successes and Challenges in the Management of Coral Reef Marine Protected Areas

This report includes seven case studies from the Wider Caribbean Region. The first one focuses on the capacity building opportunity provided by the UNEP-CEP training of trainers programme, while the second study looks at the community-based coastal resource management and marine biodiversity conservation experience in Sian Ka'an Biosphere Reserve, Mexico. The third project analyses rules and zoning issues in the management plan of Chinchorro Banc Biosphere Reserve, Mexico. The opportunities and challenges of using admission fees as a funding source at a small scale, tourism dependant MPA, Bonaire, are presented in the fourth study. The fifth example of reserve management, describes how – from MPA implementation to today – relationships have been strengthened to ensure effective management in the Soufriere Marine Management Area (SMMA). The sixth case study details the role of the honorary game wardens and fisheries inspectors of the Portland Bight Protected Area, Jamaica, in the context of community policing and the country's "culture of system-beating". The seventh study depicts the process of conflict resolution between inter-sectoral stakeholders in the Buccoo Reef Marine Park coastal zone, Tobago, using Pigeon Point as an example.

Implementing agencies, indigenous and local communities

UNEP (2004) People and reefs: successes and challenges in the management of coral reef marine protected areas. UNEP Regional Seas Reports and Studies No. 176.

http://www.unep.org/regionalseas/publications/reports/RSRS/pdfs/rsrs176.pdf

Scaling Up to Networks of Marine Protected Areas in the Philippines: Biophysical, Legal, Institutional, and Social Considerations

The study found that while social and ecological criteria are shaping MPA networks through science-based planning, integrated management, and coordination, there exist numerous institutional issues related to scaling up to networks from single MPAs. Issues pertain to:

limiting access to resources, boundary delineation, monitoring compliance, finding common goals and identity, and conflict resolution. Factors correlated with management success included common institutional processes and legal support, improved understanding of benefits from a network and improved habitat conditions and fishery yields associated with MPAs.

Implementing agencies, policymakers

Lowry, G.K., A.T. White and P. Christie (2009) Scaling Up to Networks of Marine Protected Areas in the Philippines: Biophysical, Legal, Institutional, and Social Considerations. Coastal Management, 37:274–290.

http://oneocean.org/download/db_files/Scaling-up-to-MPA-Networks_CMJ_09.pdf

Revegetation

Managing Trade-Offs in Landscape Restoration and Revegetation Projects

We develop a model of the possibilities and choices for an agency seeking to achieve two environmental objectives in a region through revegetation of a number of sites. A graphical model of the production possibilities sets for a single revegetation project is developed, and different trade-off relationships are discussed and illustrated. Then the model is used to demonstrate the possibilities for managing all such projects within a region. We show that, where there are thresholds in the trade-off relationship between two objectives, specialization (single- or dominant-objective projects) should be considered. This is illustrated using a case study in which revegetation is used to meet avian biodiversity and salinity mitigation objectives. We conclude that where there are sufficient scientific data, explicit consideration of different types of trade-offs can assist in making decisions about the most efficient mix and type of projects to better achieve a range of objectives within a region.

Implementing agencies

Maron, M. and G. Cockfield (2008) Managing Trade-Offs in Landscape Restoration and Revegetation Projects. Ecological Applications 18(8): 2041-2049.

http://www.esajournals.org/doi/abs/10.1890/07-1328.1?journalCode=ecap

Assessing Genetic Risk in Revegetation

Implementation of revegetation programmes within a risk management framework will help to ensure that significant environmental benefits are captured with minimal concomitant negative impacts on the surrounding biodiversity. A genetic risk protocol provides a tool for evaluation of potential adverse genetic impacts on native populations from revegetation and can be implemented in conjunction with weed risk assessment. Risk assessment as an integral part of evaluation of environmental impact for large-scale revegetation programmes will contribute to the development of informed decision-making processes in the implementation of revegetation systems, and ultimately, it will aid in the development of land uses that protect and enhance biodiversity in degraded landscapes.

Practitioners, implementing agencies

Byrne, M., L. Stone and M.A. Millar (2011) Assessing Genetic Risk in Revegetation. Journal of Applied Ecology 48(6): 1365-1373.

http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2664.2011.02045.x/abstract

Ecological Genetics and the Restoration of Plant Communities: Mix or Match?

We present a conceptual framework for choosing native plant material to be used in restoration projects on the basis of ecological genetics. We evaluate both the likelihood of rapid establishment of plants and the probability of long-term persistence of restored or later successional communities. In addition, we consider the possible harmful effects of restoration projects on nearby ecosystems and their native resident populations. Two attributes of the site to be restored play an important role in determining which genetic source will be most appropriate: (1) degree of disturbance and (2) size of the disturbance. Local plants or plants from environments that "match" the habitat to be restored are best suited to restore sites where degree of disturbance has been low. Hybrids or "mixtures" of genotypes from different sources may provide the best strategy for restoring highly disturbed sites to which local plants are not adapted. Cultivars that have been modified by intentional or inadvertent selection have serious drawbacks. Nevertheless, cultivars may be appropriate when the goal is rapid recovery of small sites that are highly disturbed.

Practioners, implementing agencies

Lesica, P. and F.W. Allendorf (1999) Ecological Genetics and the Restoration of Plant Communities: Mix or Match? Restoration Ecology 7(1): 42-50.

http://onlinelibrary.wiley.com/doi/10.1046/j.1526-100X.1999.07105.x/abstract

Are Functional Guilds More Realistic Management Units than Individual Species for Restoration?

Functional guilds condense species lists by grouping species according to similarities in characteristics we believe to be important in a particular context. These groupings can allow us to (1) ensure community and ecosystem structural and functional attributes, (2) increase competitiveness of the community to deter the establishment of undesirable species, (3) simplify and test models of community assembly including resistance to invasion, succession, and species coexistence, and (4) facilitate cross-site comparisons. As useful as functional guilds can be, we must not overlook the potentially important roles of individual species. In restoration, including multiple species that represent each functional type within a target community may provide a buffer against environmental change. Functional guilds provide realistic conceptual units to ensure that restored plant communities include species that confer the ecological functions of most importance the majority of the time.

Practitioners, implementing agencies

Brown, C.S. (2004) Are Functional Guilds More Realistic Management Units than Individual Species for Restoration? Weed Technology 18: 1566-1571.

http://www.globalrestorationnetwork.org/uploads/files/LiteratureAttachments/40_are-functional-guilds-more-realistic-management-units-than-individual-species-for-restoration.pdf

The Role of Seed Banks in Vegetation Dynamics and Restoration of Dry Tropical Ecosystems

This paper reviews studies on seed banks in tropical dry vegetation and, for comparison, some wet tropical and dry subtropical vegetation. A first general conclusion is that tropical seed banks are smaller than those in temperate ecosystems. Many studies are devoted to only one species, among which are several *Acacia* species, both tropical and subtropical, some of which reach densities in the seed bank of up to 10000 seeds/m^2. The lesser importance of the seed bank strategy in tropical species may be related to higher risks of seed loss through higher mortality (fire, predation, pathogens etc.), or to intermittent germination occasions in relation to ephemeral favourable conditions (e.g. rains during the dry season). Regarding vegetation dynamics, the importance of seed banks and regeneration from seeds is most pronounced in larger forest gaps. Examples are discussed of rapid succession to forest of savannas after protection from fire, which is partly due to regeneration from the seed bank. The significance of seed banks in vegetation restoration projects is outlined and the need for additional sowing of seeds of important species underlined.

Implementing agencies, practitioners

Skoglund, J. (1992) The role of seed banks in vegetation dynamics and restoration of dry tropical ecosystems. Journal of Vegetation Science 3: 357-360.

http://onlinelibrary.wiley.com/doi/10.2307/3235760/abstract

The Role of Vegetation Succession in Ecosystem Restoration

The papers presented in this Special Feature result from an international workshop 'Spontaneous succession in ecosystem restoration' which was held from 7 to 10 September 1999 in České Budějovice, Czech Republic and organized by the University of České Budějovice, and the Institute of Botany, Academy of Sciences of the Czech Republic, Průhonice.

Pyšek, P., K. Prach, J. Müllerová and C. Joyce (2001) The Role of Vegetation Succession in Ecosystem Restoration. Special Feature in Applied Vegetative Science 4(1): 1-156.

http://onlinelibrary.wiley.com/doi/10.1111/avsc.2001.4.issue-1/issuetoc

Revegetation>Africa

Termite- and Mulch-Mediated Rehabilitation of Vegetation on Crusted Soil in West Africa

The rehabilitation of vegetation on structurally crusted soils by triggering termite activity through mulch was studied on three soil types in northern Burkina Faso, West Africa. A split-plot design was used in a fenced environment for the experiment. Insecticide (Dieldrin) was used at a rate of 500 g a.i. (active ingredient)/ha to create nontermite and termite plots. Three mulch types consisting of straw (Pennisetum pedicellatum), woody material (Pterocarpus lucens), and a composite mulch (straw and woody material) applied at a rate of 3, 6, and 4 tons/ha, respectively, were used to trigger termite activity. Analysis of the termite and mulch interaction indicated that mulch plots without termites did not perform better than bare plots, especially in the case of woody plant regeneration. Vegetation rehabilitation was best with composite and straw mulches with termites, followed by woody mulch with termites; it was worst on bare plots.

Practitioners

Mando, A., L. Brussaard and L. Stroosnijder (1999) Termite- and Mulch-Mediated Rehabilitation of Vegetation on Crusted Soil in West Africa. Restoration Ecology 7(1): 33-41.

http://onlinelibrary.wiley.com/doi/10.1046/j.1526-100X.1999.07104.x/full

Revegetation>Australia

Revegetation Techniques: A Guide for Establishing Native Vegetation in Victoria

Revegetation Techniques is a 'how to' guide for establishing native plants from seed or seedlings. The information is based on what has worked at a practical level for landholders, community groups, land management agencies and project managers. It covers the steps involved in a revegetation program, from planning and preparation to monitoring and then outlines the different techniques available to direct seed or plant seedlings. Natural regeneration, mechanical and hand methods of revegetation are described and a comprehensive resource section is provided.

Practitioners, implementing agencies

Greening Australia Victoria (2003)

http://www.greeningaustralia.org.au/community/vic

An Innovative Approach to Local Landscape Restoration Planning: Lessons from Practice

Working on the principle that scarce restoration funding is best directed to areas of higher recovery capacity, a pilot project was carried out in the South-west Slopes, NSW, commissioning expert panels to identify priority 'local landscapes' with high levels of biodiversity assets. A rapid assessment method was then trialled in two out of 26 such landscapes to detect areas of higher recovery potential. The dramatically higher levels of connectivity and restorability found (compared to tree cover mapping) have implications for future catchment management planning and highlight the benefits of conducting targeted, rapid assessments at this scale.

Implementing agencies, indigenous and local communities

Davidson, I., M. Sheahan and R. Thackway (2011) An innovative approach to local landscape restoration planning: Lessons from practice. Ecological Management and Restoration 12: 175-188.

http://onlinelibrary.wiley.com/doi/10.1111/j.1442-8903.2011.00607.x/pdf

Revegetation>Europe

Special Feature on Vegetation Restoration (2010)

The present volume contains twelve papers presented at the 7th European Conference on Ecological Restoration held from 23 to 27 August 2010 in Avignon, France.

Practitioners, implementing agencies

Holzel, N., E. Buisson and T. Dutoit (2012) Special Feature on Vegetation Restoration. Applied Vegetation Science 15(2): 161-298

http://onlinelibrary.wiley.com/doi/10.1111/avsc.2012.15.issue-2/issuetoc

Special Feature on Vegetation Restoration (2003)

The 19 papers presented in this Special Feature result from the Conference on Restoration Ecology, held from 25-31 August 2002 in Budapest, Hungary.

Practitioners, implementing agencies

R. van Diggelen and R.H. Marrs (2003) Special Feature on Vegetation Restoration. Applied Vegetation Science 6(2): 106-278.

http://onlinelibrary.wiley.com/doi/10.1111/avsc.2003.6.issue-2/issuetoc

Can the Seed Bank be Used for Ecological Restoration? An Overview of Seed Bank Characteristics in European Communities

Can seeds in the seed bank be considered as a potential source of material for the restoration of European plant communities including forest, marsh, grassland and heathland? The absence of target species and the high dominance of early successional species, in particular Juncus spp., indicate that restoration of target plant communities relying only on seed germination from the seed bank is in most cases not feasible. The exceptions are heathland and early successional plant communities occurring after temporally recurring disturbances. Restoration of plant communities composed of late successional species, such as woody species or herbaceous species typical of woodland or forest rely mainly on seed dispersal and not on in situ germination.

Implementing agencies

Bossuyt, B. and O. Honnay (2008) Can the seed bank be used for ecological restoration? An overview of seed bank characteristics in European communities. Journal of Vegetation Science 19: 875-884.

http://onlinelibrary.wiley.com/doi/10.3170/2008-8-18462/abstract

Un Guide pour de Meilleures Pratiques de Revégétalisation dans les Pyrénées

Ce guide a pour objectifs de permettre aux maîtres d'ouvrage des aménagements dans les Pyrénées: de préciser leurs objectifs et critères de réussite des opérations de revégétalisation, des points de vue technique et écologique, de favoriser auprès de leurs services mais aussi de leurs prestataires techniques et financiers, une meilleure prise en compte de la revégétalisation, d'améliorer la préservation de la flore et des milieux naturels lors de ces aménagements.

Practitioners, implementing agencies

Malaval, S. (ed.) (2008) Un guide pour de meilleures pratiques de revégétalisation dans les Pyrénées. Conservatoire botanique national des Pyrénées et de Midi-Pyrénées, Bagnères-de-Bigorre.

http://www.ecovars.fr/ressources/actualites/33-un-guide-pour-de-meilleures-pratiques-de-revegetalisation-dans-les-pyrenees.html

Revegetation>New Zealand

Restoring the Balance: Biodiversity Self–Help Kit

This resource kit aims to help you 1) Identify the existing biodiversity values of your land and protect what you've already got, 2) Find out about pest control, planting trees, habitat protection (both physical and legal) and access to outside funding, 3) Find and record essential information that is often requested when seeking funds, and 4) Set up an action plan. From this you will have the information to start making informed decisions about protecting and enhancing what lives around you. You can also use the kit as a personal diary about the comings and goings of native animals in the changing landscape around you, a personal story about your own environment.

Practitioners

Northland Biodiversity Enhancement Group (2004)

http://www.landcare.org.nz/files/file/374/restoring-the-balance.pdf

Revegetation>South Africa

Guidelines for Veld Restoration

These notes give a brief introduction to common veld problems and their treatment.

Practitioners

Esler, K.J, S.J. Milton, W. Richard and J. Dean (2006) Guidelines for Veld Restoration in Karoo Veld Ecology and Management. Briza

http://www.renu-karoo.co.za/Veld%20seeding%20guide.pdf

Revegetation>USA

Revegetation Manual for the Environmental Restoration Contractor

The purpose of this manual is to provide guidance and general guidelines for the revegetation of remediated waste sites and other disturbed areas on the Hanford Site. Specific revegetation plans will be developed using guidance from this manual. Locations, resources, and funding will dictate the specific revegetation design at each disturbed area.

Practitioner, implementing agencies

McLendon, T. and E.F. Redente (1997) Revegetation Manual for the Environmental Restoration Contractor. Prepared for the U.S. Department of Energy, Office of Environmental Restoration by Bechtel Hanford, Inc., Richland.

http://www5.hanford.gov/pdw/fsd/AR/FSD0001/FSD0071/0093415/BHI-00971_Rev%200_1997.pdf

An Introduction to Using Native Plants in Restoration Projects

Native plants are valued for their economic, ecological, genetic, and aesthetic benefits in addition to the growing societal belief in their intrinsic value as living species. Native plant species provide the keystone elements for ecosystem restoration. Native plants help to increase the local population of native plant species, providing numerous benefits. There are specific associations of mycorrhizae with plants, invertebrates with woody debris, pollinators with flowers, and birds with structural habitat that can only be rebuilt by planting native plants.

Practitioners

Dorner, J. (2002) An introduction to using native plants in restoration projects. Plant Conservation Alliance, Bureau of Land Management, US Department of Interior.

http://www.nps.gov/plants/restore/pubs/intronatplant/intronatplant.pdf

Restoration Manual for Native Habitats of South Texas

The purpose of this manual is to encourage landowners and land managers to restore native plant communities. Native plants, wildlife, and humans all benefit from restoration and conservation efforts of good land stewards. Restoration of complex prairie and native rangeland to a state similar to pre-settlement times is challenging because vegetation communities and the factors that influence them continually change in time and space. It is rewarding to watch the landscape change and produce benefits after restoration has been implemented.

Practitioners, indigenous and local communities

Maywald, P.D. and D. Doan-Crider (eds.) (200?) Restoration Manual for Native Habitats of South Texas. Caesar Kleberg Wildlife Research Institute, Texas A&M University, Kingsville.

http://ckwri.tamuk.edu/fileadmin/user_upload/docs/STN/STN_Restoration_Manual-Full_Book.pdf

Species Re-Introductions

Global Re-Introduction Perspectives: Case-studies from Around the Globe

These three issues in the Global Re-introduction Perspectives series have been produced in the same standardized format as the previous one. The case-studies are arranged in the following order: Introduction, Goals, Success Indicators, Project Summary, Major Difficulties Faced, Major Lessons Learned, Success of Project with reasons for success or failure.

Practitioners, implementing agencies

Soorae, P. S. (ed.) (2008, 2010, and 2011) Global Re-Introduction Perspectives: Case-studies from around the globe. IUCN/SSC Re-introduction Specialist Group, Abu Dhabi.

http://www.iucnsscrsg.org/rsg_book.php

Plant Reintroduction in a Changing Climate: Promises and Perils

This volume presents a comprehensive review of reintroduction projects and practices, the circumstances of their successes or failures, lessons learned, and the potential role for reintroductions in preserving species threatened by climate change. Contributors examine current plant reintroduction practices, from selecting appropriate source material and recipient sites to assessing population demography. The findings culminate in a set of Best Reintroduction Practice Guidelines, included in an appendix. These guidelines cover stages from planning and implementation to long-term monitoring, and offer not only recommended actions but also checklists of questions to consider that are applicable to projects around the world.

Practitioners, implementing agencies

Maschinski, J. and K.E. Haskins (2012) Plant Reintroduction in a Changing Climate: Promises and Perils. Island Press, Washington, DC.

http://islandpress.org/ip/books/book/islandpress/P/bo8073733.html

Are Re-introductions an Effective Way of Mitigating Against Plant Extinctions?

This review evaluates the effectiveness of re-introductions as a conservation tool by using the available evidence to determine in what context plant translocations have improved the status of threatened species.

Practitioners, implementing agencies

Dalrymple, S. E., G.B. Stewart and A.S. Pullin (2011) Are re-introductions an effective way of mitigating against plant extinctions? CEE Review 07-008 (SR32).

http://www.environmentalevidence.org/Documents/Completed_Reviews/SR32.pdf

Reintroduction of Top-Order Predators

Large predators are among the most threatened species on the planet and ways of conserving them in the face of increasing human populations and associated resource requirements are becoming critical. This book draws upon the experiences of some of the world's foremost large carnivore specialists to discuss the numerous issues associated reintroducing large predators back into their natural habitats. Reviews of internationally renowned reintroduction programs for wolves, European lynx and African wild dog reveal the successes and failures of these actions. Experts on tigers, snow leopards and jaguars contend that there are other conservation options of higher priority that will ensure their security in the long-term. Other experts discuss more theoretical aspects such as whether we know enough about these species to be able to predict their behavioural or ecological response to the reintroduction process. Social, economic, political and genetic considerations are also addressed.

Implementing agencies

Hayward, M.W. and M.J. Somers (eds.) (2009) Reintroduction of Top-Order Predators. John Wiley and Sons, New York.

http://www.wiley.com/WileyCDA/WileyTitle/productCd-1405176806.html

Restoration of Endangered Species: Conceptual Issues, Planning and Implementation

As the human impact on the earth leads to ever increasing environmental degradation, the restoration of dwindling populations of numerous plant and animal species is becoming ever more important. In this unique volume, the political, biological and experimental procedures affecting the restoration of natural populations are examined using a range of case studies.

Practitioners, implementing agencies

Bowles, M.L. and C.J. Whelan (eds.) (1996) Restoration of Endangered Species: Conceptual Issues, Planning and Implementation. Cambridge University Press.

http://www.cambridge.org/gb/knowledge/isbn/item5708245/?site_locale=en_GB

Combining the Fields of Reintroduction Biology and Restoration Ecology

We believe that the emerging science of reintroduction biology can be usefully integrated with the already established field of restoration ecology. Both are relatively young endeavors with obvious philosophical and practical convergences. Indeed, the current division between them is largely artificial and reflects more their distinct historical backgrounds than it does any real epistemological difference. Accordingly, the disciplines of reintroduction biology and restoration ecology have much to gain from one another.

Implementing agencies, practitioners

Lipsey, M.K., M.F. Child, P.J. Seddon, D.P. Armstrong and R.F. Maloney (2007) Combining the Fields of Reintroduction Biology and Restoration Ecology. Conservation Biology 21(6): 1387-1390.

http://onlinelibrary.wiley.com/doi/10.1111/j.1523-1739.2007.00806.x/abstract

Species Re-Introductions>India

Assessing the Potential for Reintroducing the Cheetah in India

In this report we assess 10 sites from seven landscapes located in the states of Rajasthan, Gujarat, Madhya Pradesh, Uttar Pradesh and Chhattisgarh, for their potential to harbour viable reintroduced cheetah populations. We conduct field surveys to collect data on prey abundances, local community dependencies on forest resources and their attitudes towards wildlife, and use remotely sensed data to assess habitat size. We compute current and potential carrying capacity of the sites to support cheetah as well as assess the long-term viability of the introduced population, using Population Habitat Viability Analysis.

Policymakers, implementing agencies, practitioners, indigenous and local communities

Ranjitsinh, M.K. and Y.V. Jhala (2010) Assessing the potential for reintroducing the cheetah in India. Wildlife Trust of India, Noida, & the Wildlife Institute of India, Dehradun.

http://www.wti.org.in/pages/cheetah-report.pdf

Species Re-Introductions>Russia

Methodological Recommendations for Botanic Gardens on the Reintroduction of Rare and Threatened Plants

Methodological approaches for the reintroduction of rare species of plants are given. Issues of terminology and the selection of objects for reintroduction are discussed. Features of preliminary studies, selection of initial material, determination of natural habitats, and processes for the creation and monitoring of reintroduced populations are described. Special attention is paid to the necessity of providing genetic diversity within created populations and thorough documentation of conducted works. A separate section is dedicated to the method of reintroduction of plant communities (agrosteppe creation method). Examples of practical experience of reintroduction of rare species in various regions of Russia (Bashkortostan, the Far East, Irkutsk and Vladimir regions) are given.

Practitioners, implementing agencies

English, Russian

Gorbunov, Y.N., D.S. Dzybov, Z.E. Kuzmin and I.A. Smirnov (2008) Methodological Recommendations for Botanic Gardens on the Reintroduction of Rare and Threatened Plants. Botanic Gardens Conservation International, London.

http://www.bgci.org/files/Worldwide/Publications/reintroduction_manual_engl.pdf

Species Re-Introductions>South Africa

Restoring Lions Panthera leo to Northern KwaZulu-Natal, South Africa: Short-term Biological and Technical Success but Equivocal Long-term Conservation

The success of efforts to re-establish mammalian carnivores within their former range is dependent on three key factors: methodological considerations, the biological requirements of the target species, and the involvement of local human communities for whom large carnivores pose a threat. We consider the role of these factors in the first 13 years of an effort to re-establish wild lions in northern KwaZulu-Natal Province, South Africa.

Implementing agencies

Hunter, L.T.B., K. Pretorius, L.C. Carlisle, M. Rickelton, C. Walker, R. Slotow and J.D. Skinner (2007) Restoring Lions Panthera leo to Northern KwaZulu-Natal, South Africa: Short-term Biological and Technical Success but Equivocal Long-term Conservation. Oryx 41(2): 196-204.

http://www.wildwatch.com/images/pdf/reintroducing_lionskzn.pdf

Species Re-Introductions>UK

Rewilding – A New Paradigm for Nature Conservation in Scotland?

In Scotland, where many native species have been extirpated in the relatively recent past, rewilding has clear relevance and may provide an overarching set of objectives for current programmes of native woodland restoration and species reintroductions. Nevertheless, rewilding is not widely used as a term or strategy in Scottish conservation. This review considers the development of the concept and its possible application in Scotland, and identifies substantial scope for rewilding, in terms of the restoration and protection of large areas of wild land, and of the reintroduction of native species which have been driven to extinction by human activity. As the environmental, social and economic benefits which are likely to result from a programme of rewilding in Scotland outweigh the potential drawbacks, the adoption of rewilding is recommended as one aim of environmental policy.

Policymakers, implementing agencies

Brown, C., R. Mcmorran and M.F. Price (2011) Rewilding – A New Paradigm for Nature Conservation in Scotland? Scottish Geographical Journal 127(4): 288-314.

http://www.tandfonline.com/doi/pdf/10.1080/14702541.2012.666261

Species Re-Introductions>USA

Toward Successful Reintroductions: The Combined Importance of Species Traits, Site Quality, and Restoration Technique

First, reintroduction success will be highest for endangered species that share traits with non-rare native species, invasive plants, and species that excel in restoration plantings as reviewed from the ecological literature. Ten traits are identified as common to at least two of these groups. Second, reintroductions will do best in habitats ecologically similar to existing wild populations and with few local threats, such as non-native plants and herbivores. And third, the methods used to establish plants, such as planting seeds vs. transplants or selecting appropriate microsites, will influence outcomes. For any reintroduction project, potential pitfalls associated with a particular species, site, or technique may be overcome by integrating information from all three areas. Conducting reintroductions as designed experiments that test clearly stated hypotheses will maximize the amount and quality of information gained from each project and support adaptive management.

Practitioners, implementing agencies

Kaye, T.N. (2011) Toward Successful Reintroductions: The Combined Importance of Species Traits, Site Quality, and Restoration Technique. Proceedings of the California Native Plant Society Conservation Conference, 17–19 Jan 2009: 99-106.

http://appliedeco.org/about-us/staff/Kaye%202011%20Toward%20succesful%20reintroductions.pdf

Pleistocene Rewilding: An Optimistic Agenda for Twenty-First Century Conservation

Large vertebrates are strong interactors in food webs, yet they were lost from most ecosystems after the dispersal of modern humans from Africa and Eurasia. We call for restoration of missing ecological functions and evolutionary potential of lost North American megafauna using extant conspecifics and related taxa. We refer to this restoration as Pleistocene rewilding; it is conceived as carefully managed ecosystem manipulations whereby costs and benefits are objectively addressed on a case-by-case and locality-by-locality basis.

Policymakers, implementing agencies

Donlan, C.J. et al. (2006) Pleistocene Rewilding: An Optimistic Agenda for Twenty-First Century Conservation. The American Naturalist 168(5): 660-681.

http://eebweb.arizona.edu/Courses/Ecol406R_506R/DonlanEA-2006_AmNat_PleistoceneRewild.pdf

The Pleistocene Re-wilding Gambit

Re-wilding parts of North America with exotic Old-World species is an exciting but controversial conservation proposal hijacked by opinions over appropriate conservation baselines and details of implementation. Debate over its worth has become partisan. Here, I summarize the multifaceted issues surrounding Pleistocene re-wilding and edge debate from hazy conceptual arguments to empirical questions that can plug gaps in knowledge and begin to resolve this divisive conservation issue.

Policymakers, implementing agencies

Caro, T. (2007) The Pleistocene Re-wilding Gambit. Trends in Ecology and Evolution 22(6): 281-283.

http://www.columbia.edu/~dr2497/PRESS_files/TREE2007.pdf

Watersheds

Putting Watershed Restoration in Context: Alternative Future Scenarios Influence Management Outcomes

We estimated how the choice of the best management strategy might differ among alternative future scenarios. Results suggest that dam passage will provide access to large amounts of high-quality habitat that will benefit fish populations. Moreover, conservation of existing riparian areas, if implemented, has the potential to improve conditions to a much greater extent than restoration strategies examined, despite expected urban growth. We found that the relative performance of management strategies shifted when fish were allowed to migrate above dams, but less so among alternative futures examined. We discuss how predicted outcomes from these seven hypothetical management strategies could used for developing an on-the-ground strategy to address a real management situation.

Implementing agencies

Fullerton, A.H., E.A. Steel, Y. Caras, M. Sheer, P. Olson and J. Kaje (2009) Putting Watershed Restoration in Context: Alternative Future Scenarios Influence Management Outcomes. Ecological Applications 19(1): 218-235.

http://www.esajournals.org/doi/abs/10.1890/07-1040.1

Reforming Watershed Restoration: Science in Need of Application and Applications in Need of Science

I identify five ways in which our ecological knowledge should be influencing restoration to a far greater extent than at present including a need to: shift the focus to restoration of process and identification of the limiting factors instead of structures and single species, add ecological insurance to all projects, identify a probabilistic range of possible outcomes instead of a reference condition, expand the spatial scale of efforts, and apply hierarchical approaches to prioritization. Prominent examples of restoration methods or approaches that are commonly used despite little evidence to support their efficacy are highlighted such as the use of only structural enhancements to restore biodiversity. There are also major gaps in scientific knowledge that are of immediate need to policy makers, managers, and restoration practitioners including: predictive frameworks to guide the restoration of ecological processes, identification of social-ecological feedbacks that constrain ecosystem recovery and data to support decisions of where and how to implement restoration projects to achieve the largest gains.

Policymakers, implementing agencies, practitioners

Palmer, M.A. (2008) Reforming Watershed Restoration: Science in Need of Application and Applications in Need of Science. Estuaries and Coasts 32(1): 1-17.

http://www.palmerlab.umd.edu/docs/Palmer_2008_Reforming_watershed_restoration_Est_&_Coasts.pdf

Modeling the Suitability of Wetland Restoration Potential at the Watershed Scale

Despite the fact that landscape level processes dominate wetland ecosystem development and sustainability, restoration decisions (including those for compensatory mitigation) are typically made on a project-by-project basis. Watershed planning designed to strategically restore wetlands has the potential to provide dramatic benefits by restoring ecosystem-level processes (functions) that maintain water resource integrity. We developed a GIS-based model to predict the suitability for wetland restoration for all locations in the Cuyahoga River watershed (2107 km2), in northeastern Ohio (U.S.A.). The model offers a useful tool to focus and set goals for wetland restoration efforts in a spatially explicit way.

White, D. and S. Fennessy (2005) Modeling the Suitability of Wetland Restoration Potential at the Watershed Scale. Ecological Engineering 24(4): 359-377.

http://www.sciencedirect.com/science/article/pii/S0925857405000352

Creating a Catchment Scale Perspective for River Restoration

One of the major challenges in river restoration is to identify the natural fluvial landscape in catchments with a long history of river control. Intensive land use on valley floors often predates the earliest remote sensing: levees, dikes, dams, and other structures alter valley-floor morphology, river channels and flow regimes. Consequently, morphological patterns indicative of the fluvial landscape including multiple channels, extensive floodplains, wetlands, and fluvial-riparian and tributary-confluence dynamics can be obscured, and information to develop appropriate and cost effective river restoration strategies can be unavailable. This is the case in the Pas River catchment in northern Spain (650 km2), in which land use and development have obscured the natural fluvial landscape in many parts of the basin.

Implementing agencies, practitioners

Benda, L., D. Miller and J. Barquın (2011) Creating a Catchment Scale Perspective for River Restoration. Hydrology and Earth Systems Science 15: 2995-3015.

http://www.hydrol-earth-syst-sci.net/15/2995/2011/hess-15-2995-2011.pdf

Environmental Economics for Watershed Restoration

A handbook for advocates and stakeholders, Environmental Economics for Watershed Restoration provides guidance to those who are interested in understanding and incorporating economic valuation in project prioritization and other decision-making aspects of stream or watershed restoration. It provides background on the types of ecological goods and services that are often valued and details the types of questions that must be asked in watershed project analysis. The book allows those who are not economists to be comfortable discussing things like contingent valuation, marginal costs, nonmarket goods, and other terms needed to satisfy the economic analysis requirements often needed to secure funding for projects.

Policymakers, implementing agencies

Thurston, H.W., M.T. Heberling and A. Schrecongost (eds.) (2009) Environmental Economics for Watershed Restoration. CRC Press.

http://www.routledge.com/books/details/9781420092622/

Watersheds>Canada

A Multiple Watershed Approach to Assessing the Effects of Habitat Restoration Actions on Anadromous and Resident Fish Populations

The purpose of this pilot project was to explore methods for evaluating past habitat restoration actions and their effects on fish populations. By doing so, the project will provide a foundation of retrospective analyses, on which to build prospective, multi-watershed designs for future habitat restoration actions. By addressing questions about habitat restoration and monitoring (in coordination with other related efforts), we hope that this project will catalyze a shift in the Basin's paradigm of habitat restoration, moving from implementation of individual watershed projects towards rigorously designed and monitored, multiwatershed, adaptive management experiments.

Implementing agencies, practitioners

Marmorek, D.R., I.J. Parnell, M. Porter, C. Pinkham, C.A.D. Alexander, C.N. Peters, J. Hubble, C.M. Paulsen and T.R. Fisher (2004) A Multiple Watershed Approach to Assessing the Effects of Habitat Restoration Actions on Anadromous and Resident Fish Populations. Prepared by ESSA Technologies Ltd., Vancouver, B.C. for Bonneville Power Administration, Portland.

http://essa.com/wp-content/uploads/2010/09/ESSA-Multi-watershed-report-H00012481-1.pdf

Watersheds>Haiti

Designing Environmental Restoration Programs in Politically Fragile States: Lessons from Haiti

Multiple community groups and organizations with expert knowledge are already in place across Haiti and within watersheds, ready to implement integrated programs if sustained funding commitments are offered by donors and communities and their participation is institutionalized within the project management structure. These efforts could bring the change required to stabilize development in positive growth directions and improve the resilience to the multiple vulnerabilities facing Haiti's degraded landscape. These efforts could also provide the underlying foundation required for reducing political instability and invigorating progress towards integrated development.

Policymakers, implementing agencies

Fischer, A. and M.A. Levy (2011) Designing Environmental Restoration Programs in Politically Fragile States: Lessons from Haiti in Harnessing Natural Resources for Peacebuilding. Environmental law Institute.

http://www.eli.org/pdf/CGP%20Chapters/CGP_012_Fischer.pdf

Watersheds>South Africa

Linking Ecosystem Services and Water Resources: Landscape-scale Hydrology of the Little Karoo

This paper describes the linkage between landscape-scale hydrology and ecosystem services, and how degradation of the landscape is believed to have altered the delivery of those services. The Little Karoo, an arid environment in South Africa that encompasses a remarkable diversity of plant species, has been degraded by inappropriate agricultural practices, mainly overgrazing, cultivation, and irrigation. Landscape linkages, such as hydrological flows and the recycling of organic matter and nutrients, have been disrupted, resulting in net losses at all scales, from the shrub patch to the river basin. Land rehabilitation, while in most cases too expensive at the farm scale, may be economically feasible at the river basin scale, provided that some of the economic benefits are used to rehabilitate and manage areas as socioecological systems.

Le Maitre, D.C., S.J. Milton, C. Jarmain, C.A. Colvin, I. Saayman and J.H.J. Vlok (2007) Linking Ecosystem Services and Water Resources: Landscape-scale Hydrology of the Little Karoo. Front Ecol Environ 5(5): 261-270.

http://www.rncalliance.org/WebRoot/rncalliance/Shops/rncalliance/47DC/62F2/A82E/A446/7614/CA94/8D31/A047/Little_Karoo.pdf

Watersheds>USA

Restoring the Pacific Northwest: The Art and Science of Ecological Restoration in Cascadia

The Pacific Northwest is a global ecological "hotspot" because of its relatively healthy native ecosystems, a high degree of biodiversity, and the number and scope of restoration initiatives that have been undertaken there. Restoring the Pacific Northwest gathers and presents the best examples of state-of-the-art restoration techniques and projects. It is an encyclopedic overview that will be an invaluable reference not just for restorationists and students working in the Pacific Northwest, but for practitioners across North America and around the world.

Practitioners, implementing agencies

Apostol, D. and M. Sinclair (eds.) (2006) Restoring the Pacific Northwest: The Art and Science of Ecological Restoration in Cascadia. Island Press, Washington, DC.

http://islandpress.org/ip/books/book/islandpress/R/bo4106613.html

Putting It Back Together: Making Ecosystem Restoration Work

This review explores 6 major restoration efforts nationally and distills lessons to guide future initiatives—specifically the effort to restore the San Francisco Bay-Delta ecosystem. In crafting major legislation for the Bay-Delta and elsewhere, we should examine what has gone right, and what has worked less well, in other ecosystem management initiatives around the country. The last few years have seen a flurry of new, often creative solutions to restoration problems; however, the jury is still out on these more recent efforts.

Policymakers

Koehler, C. (2001) Putting It Back Together: Making Ecosystem Restoration Work. Save San Francisco Bay Association.

http://www.savesfbay.org/sites/default/files/PIBT_Report.pdf

Large-Scale Ecosystem Restoration: Lessons for Existing and Emerging Initiatives

Large-scale ecosystem restoration presents a highly complex set of challenges that require unprecedented levels of knowledge, coordination, money, governance, and committed actions over time. This report explores these challenges by examining seven case histories – the Chesapeake Bay, Coastal Louisiana, Columbia River, Great Lakes, San Francisco Bay-Delta, South Florida Everglades, and Upper Mississippi River. The project's overall goals were to inventory these restoration initiatives, compare and contrast them, and evaluate them for lessons relevant to existing and emerging restorations across the country.

Policymakers, implementing agencies

Vigmostad, K.E., N. Mays, A. Hance and A. Cangelosi (2005) Large-Scale Ecosystem Restoration: Lessons for Existing and Emerging Initiatives. Northeast Midwest Institute.

http://www.nemw.org/images/stories/documents/restoration.pdf

Restoration of Degraded Lands in the Interior Columbia River Basin: Passive vs. Active Approaches

Evidence for success of passive and active restoration is presented for interior conifer forest, sagebrush steppe, and riparian ecosystems, with a focus on the Columbia River basin. Passive restoration, defined as removal of the stresses that cause degradation, may be most appropriate for higher elevation forests, low-order riparian ecosystems, and for sagebrush steppe communities that are only slightly impaired. More active approaches, in which management techniques such as planting, weeding, burning, and thinning are applied, have been successful in forests with excessive fuels and in some riparian systems, and may be necessary in highly degraded sagebrush steppe communities.

Implementing agencies

McIver, J and L. Starr (2001) Restoration of Degraded Lands in the Interior Columbia River Basin: Passive vs. Active Approaches. Forest Ecology and Management 153: 15-28.

http://www.fs.fed.us/pnw/pubs/journals/pnw_2001_mciver001.pdf

Establishing Aquatic Restoration Priorities Using a Watershed Approach

To successfully improve water quality, restoration practitioners must start with an understanding of what ecosystem processes are operating in the watershed and how they have been affected by outside variables. A watershed-based analysis template developed in the Pacific Northwest can be a valuable aid in developing that level of understanding. The watershed analysis technique identifies four ecosystem scales useful to identify stream restoration priorities: region, basin, watershed, and site. The watershed analysis technique is based on a set of technically rigorous and defensible procedures designed to provide information on what processes are active at the watershed scale, how those processes are distributed in time and space.

Policymakers, implementing agencies

Bohn, B.A. and J.L. Kershner (2002) Establishing Aquatic Restoration Priorities Using a Watershed Approach. Journal of Environmental Management 64(4): 355-363.

http://www.nrmsc.usgs.gov/files/norock/products/jema0496.pdf

Integrated Stream and Wetland Restoration: A Watershed Approach to Improved Water Quality on the Landscape

Water quality in Upper Sandy Creek, a headwater stream for the Cape Fear River in the North Carolina Piedmont, is impaired due to high N and P concentrations, sediment load, and coliform bacteria. The creek and floodplain ecosystem had become dysfunctional due to the effects of altered storm water delivery following urban watershed development where the impervious surface reached nearly 30% in some sub-watersheds. At Duke University, an 8-ha Stream and Wetland Assessment Management Park (SWAMP) was created in the lower portion of the watershed to assess the cumulative effect of restoring multiple portions of stream and former adjacent wetlands, with specific goals of quantifying water quality improvements.

Practitioners, implementing agencies

Richardson, C.J., N.E. Flanagan, M. Ho and J.W. Pahl (2011) Integrated Stream and Wetland Restoration: A Watershed Approach to Improved Water Quality on the Landscape. Ecological Engineering 37(1): 25-39.

http://swamp.osu.edu/Academics/ENR726/12.%20CLARISSA_Richardson_Freshwater

A Synoptic Assessment for Prioritizing Wetland Restoration Efforts to Optimize Flood Attenuation

The placement of wetland restoration projects in a landscape to optimize the functional performance of wetlands on a regional scale is often overlooked. To address this problem, the U.S. Environmental Protection Agency's Landscape Function Project developed the synoptic approach to assign restoration priority to landscape subunits according to selected functional criteria. The approach provides a flexible, ecologically-based framework for allocating limited restoration-resources and preserving valued wetland functions on a landscape scale.

McAllister, L.S., B.E. Peniston, S.G. Leibowitz, B. Abbruzzese and J.B. Hyman (2000) A Synoptic Assessment for Prioritizing Wetland Restoration Efforts to Optimize Flood Attenuation. Wetlands 20(1): 70-83.

http://www.springerlink.com/content/n00432045575g805/

Restoring Watersheds Project by Project: Trends in Chesapeake Bay Tributary Restoration

Restoration of aquatic ecosystems is a high priority regionally and globally, yet only recently have such efforts adopted holistic approaches that include the restoration of streams and rivers flowing to coastal areas. As the largest estuary in the US, the Chesapeake Bay has been the focus of one of the most high-profile restoration programs ever undertaken in North America. While the primary emphasis has been on tidal waters, freshwater tributary clean-up strategies have recently been developed. We have compiled the first comprehensive database of over 4700 existing river and stream restoration projects in the Chesapeake Bay Watershed (CBW) to examine where dollars are being spent, what issues motivate restoration, and what approaches are used.

Policymakers, implementing agencies

Hassett, B., M.A. Palmer, E. Bernhardt, S. Smith, J. Carr and D. Hart (2005) Restoring Watersheds Project by Project: Trends in Chesapeake Bay Tributary Restoration. Front Ecol Environ 3(5): 259-267.

http://www.palmerlab.umd.edu/docs/Hassett_et_al_2005.pdf

The Penobscot River, Maine, USA: A Basin-Scale Approach to Balancing Power Generation and Ecosystem Restoration

Although hydropower is a source of low-carbon energy, without careful consideration and management, dams have the potential to degrade river ecosystems and the goods and services they provide to society. Today, a broad range of hydropower interests and stakeholders are seeking approaches to hydropower development and operation that are more environmentally and socially sustainable. The Penobscot River Restoration Project ('the Project') illustrates that basin-scale approaches can provide a broader set of solutions for balancing energy and riverine environmental resources than can be achieved at the scale of individual projects.

Policymakers, implementing agencies

Opperman, J.J., J. Royte, J. Banks, L.R. Day and C. Apse (2011) The Penobscot River, Maine, USA: a basin-scale approach to balancing power generation and ecosystem restoration. Ecology and Society 16(3): 7.

http://dlc.dlib.indiana.edu/dlc/bitstream/handle/10535/7654/ES-2011-4117.pdf?sequence=1

Watersheds>Governance

Governance of Shared Waters: Legal and Institutional Issues

This book seeks to reposition the law as a tool for implementing higher good, or, in other words, for providing justice by seeking to ensure individuals have access to the services that ecosystems naturally provide, and guaranteeing the right to water for human well-being. States should be aware, in addition to those parties involved in the governance and management of water, of the imperative need to guarantee the access to water, and should make sure the necessary steps are taken to ensure inhabitants can enjoy such resources, without forgetting the needs of future generations. It is therefore essential that States optimize their cooperation on shared waters, and seek joint benefits through the appropriate coordination of their policies, legislation and institutional frameworks. The ultimate aim of this book is to try and strengthen the capacity of various stakeholders, and to help reach the ideal that water should be considered as a vehicle of integration rather than as a source of conflict.

Indigenous and local communities, policymakers, implementing agencies

Aguilar Rojas, G. and A. Iza (2011). Governance of Shared Waters. Legal and Institutional Issues. Gland, Switzerland: IUCN.

http://data.iucn.org/dbtw-wpd/edocs/EPLP-058-rev-En.pdf

Social Infrastructure to Integrate Science and Practice: The Experience of the Long Tom Watershed Council

Ecological problem solving requires a flexible social infrastructure that can incorporate scientific insights and adapt to changing conditions. As applied to watershed management, social infrastructure includes mechanisms to design, carry out, evaluate, and modify plans for resource protection or restoration. Efforts to apply the best science will not bring anticipated results without the appropriate social infrastructure. For the Long Tom Watershed Council, social infrastructure includes a management structure, membership, vision, priorities, partners, resources, and the acquisition of scientific knowledge, as well as the communication with and education of people associated with and affected by actions to protect and restore the watershed. Key to integrating science and practice is keeping science in the loop, using data collection as an outreach tool, and the Long Tom Watershed Council's subwatershed enhancement program approach. Resulting from these methods are ecological leadership, restoration projects, and partnerships that catalyze landscape-level change.

Policymakers, implementing agencies, indigenous and local communities

Flitcroft, R.L., D.C. Dedrick, C.L. Smith, C.A. Thieman and J.P. Bolte (2009) Social infrastructure to integrate science and practice: the experience of the Long Tom Watershed Council. Ecology and Society 14:36.

http://www.ecologyandsociety.org/vol14/iss2/art36/

Wilderness

Connectivity Conservation: International Experience in Planning, Establishment and Management of Biodiversity Corridors

This background paper surveys international experience in the development and use of mechanisms to establish and manage connectivity conservation. Specifically it seeks to provide an understanding of the range of mechanisms including laws, regulations, and other regulatory instruments and agreements which have been used in other countries to support connectivity conservation. The information in this background paper will enable practitioners in Viet Nam to understand what other countries have learned from experience with connectivity conservation and to adapt approaches to the national context. This review draws upon examples and case studies from the literature and from the knowledge of experts in IUCN's technical networks.

Policymakers, implementing agencies

IUCN (2010) Connectivity Conservation: International Experience in Planning, Establishment and Management of Biodiversity Corridors. IUCN: Gland.

http://cmsdata.iucn.org/downloads/070723_bci_international_report_final.pdf

Repairing Damaged Wildlands: A Process-Orientated, Landscape-Scale Approach

The interesting approach to ecological restoration described in this book will appeal to anyone interested in improving the ecological conditions, biological diversity, or productivity of damaged wildlands. Using sound ecological principles, the author describes how these ecosystems are stabilised and directed toward realistic management objectives using natural recovery processes rather than expensive subsidies. An initial emphasis on repairing water and nutrient cycles, and increasing energy capture, will initiate and direct positive feedback repair systems that drive continuing autogenic recovery. This strategy is most appropriate where land use goals call for low-input, sustainable vegetation managed for biological diversity, livestock production, timber production, wildlife habitat, watershed management, or ecosystem services. Providing a comprehensive strategy for the ecological restoration of any wildland ecosystem, this is an invaluable resource for professionals working in the fields of ecological restoration, conservation biology and rangeland management.

Implementing agencies, practitioners, indigenous and local communities

Whisenant, S. (1999) Repairing Damaged Wildlands: A Process-Orientated, Landscape-Scale Approach. Cambridge University Press.

http://www.cambridge.org/gb/knowledge/isbn/item5708453/?site_locale=en_GB

http://assets.cambridge.org/97805214/70018/excerpt/9780521470018_excerpt.pdf

Restoring Remote Ecosystems

Significant and often indirect impacts on alpine ecosystems, the primary ecosystem under consideration in this article, threaten historical-reference conditions and the viability of some species. The impetus for restoration is similar to projects involving more direct and proximate impacts, but the issues are more complicated in remote ecosystems. Restoration efforts in remote ecosystems might do more harm than good, and the effort required for effective restoration might be greater than easily justified given the shortfall of resources for restoring more heavily impacted ecosystems.

Policymakers, implementing agencies

Higgs, E.S. and W.M. Roush (2011) Restoring Remote Ecosystems. Restoration Ecology 19(5): 553-558.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2011.00821.x/abstract

From the Adirondacks to Acadia: A Wildlands Network Design for the Greater Northern Appalachians

This report presents a proposed wildlands network design for the Greater Northern Appalachian region of the northeastern United States and southeastern Canada. This region spans 388,541 km2 (96,010,538 acres) and encompasses two ecoregions, the Northern Appalachian/Acadian and St. Lawrence/Champlain, and all or part of ten states and provinces. A network design is a conservation plan that uses the most recent research and data to identify areas of high biological value for very large regions, integrating core protected areas with wildlife linkages and economically active stewardship lands. The wildlands network design is an effective, science-based model for understanding where land and biodiversity conservation is both needed and possible.

Policymakers, implementing agencies

Reining, C., K. Beazley, P. Doran and C. Bettigole (2006) From the Adirondacks to Acadia: A Wildlands Network Design for the Greater Northern Appalachians. Wildlands Project Special Paper No. 7. Richmond, VT: Wildlands Project.

http://www.twp.org/sites/default/files/Adirondacks_to_Acadia_08Mar07.pdf

A Checklist for Wildlands Network Designs

The checklist consists of eight general standards, each of which includes several specific criteria that relate to the qualifications of staff, choice of biodiversity surrogates and goals, methodological comprehensiveness and rigor, replicability, analytic rigor, peer review, and overall quality of scholarship. Application of the checklist is meant to be flexible and to encourage creativity and innovation. Nevertheless, every plan must be scientifically defensible and must make the best use of available data, staff, and resources. Moreover, some degree of consistency is required to link individual plans together into a continental-scale network. The checklist may provide a template that other conservation organizations, agencies, scientists, and activists can adapt to their programs.

Implementing agencies

Noss, R.F. (2003) A Checklist for Wildlands Network Designs. Conservation Biology 17(5): 1270-1275.

http://www.juniata.edu/projects/it110/ms/References/362_Island%20Ecosystems/Protected%20areas%20and%20management/21_Wildlife%20Network%20Design%20checklist.pdf

Wildlife

Restoring Wildlife: Ecological Concepts and Practical Applications

The book interweaves theoretical and practical aspects of wildlife biology that are directly applicable to the restoration and conservation of animals. It provides an understanding of the fundamentals of wildlife populations and wildlife-habitat relationships as it explores the concept of habitat, its historic development, components, spatial temporal relationships, and role in land management. It applies these concepts in developing practical tools for professionals.

Practitioners, implementing agencies

Morrison, M.L. (2009) Restoring Wildlife: Ecological Concepts and Practical Applications. Island Press, Washington, DC.

http://islandpress.org/ip/books/book/islandpress/R/bo8026608.html

Linkages in the Landscape: The Role of Corridors and Connectivity in Wildlife Conservation

The loss and fragmentation of natural habitats is one of the major issues in wildlife management and conservation. Habitat "corridors" are sometimes proposed as an important element within a conservation strategy. Examples are given of corridors both as pathways and as habitats in their own right. This document includes detailed reviews of principles relevant to the design and management of corridors, their place in regional approaches to conservation planning, and recommendations for research and management.

Policymakers

Bennett, A.F. (2003). Linkages in the Landscape: The Role of Corridors and Connectivity in Wildlife Conservation. IUCN, Gland, Switzerland and Cambridge, UK.

http://app.iucn.org/dbtw-wpd/edocs/FR-021.pdf

Living Planet: Connected Planet – Preventing the End of the World's Wildlife Migrations through Ecological Networks

Through the air, over land and in water, over ten thousand species numbering millions of animals travel around the world in a network of migratory pathways. The very foundation of these migratory species is their connection to places and corridors across the planet. The loss of a single point in their migration can jeopardize the entire population, while their concentrations make them highly vulnerable to overharvesting and poaching.

Policymakers

English, French, Spanish

Kurvits, T., C. Nellemann, B. Alfthan, A. Kühl, P. Prokosch, M. Virtue and J.F Skaalvik (eds.) (2011) Living Planet: Connected Planet – Preventing the End of the World's Wildlife Migrations through Ecological Networks. A Rapid Response Assessment. United Nations Environment Programme, GRID-Arendal.

http://www.grida.no/publications/rr/living-planet/

Ecosystem Restoration with Teeth: What Role for Predators?

Recent advances highlight the potential for predators to restore ecosystems and confer resilience against globally threatening processes, including climate change and biological invasions. However, releasing the ecological benefits of predators entails significant challenges. Here, we discuss the economic, environmental and social considerations affecting predator-driven ecological restoration programmes, and suggest approaches for reducing the undesirable impacts of predators.

Implementing agencies, practitioners, indigenous and local communities

Ritchie, E.G., B. Elmhagen, A.S. Glen, M. Letnic, G. Ludwig and R.A. McDonald (2012) Ecosystem Restoration with Teeth: What Role for Predators? Trends in Ecology & Evolution 2012.

http://www.cell.com/trends/ecology-evolution/abstract/S0169-5347(12)00006-7

Restoration of Abandoned Agricultural Lands toward Habitats for Umbrella Species

This study analyzes the suitability of agricultural lands with risk of abandonment for restoration to suitable habitats for animal species of conservation interest. As a case study, the main focus was on olive plantations (Olea europaea L.) of mountainous areas of Southern Spain and the Iberian lynx (Lynx pardinus Temminck, 1827). The method weighs the judgement of experts on the effect of landscape elements on the habitat via an analytic hierarchy process and spots areas most suitable for restoration through geographical information systems. The results suggest that the edge of major agricultural areas and areas with natural vegetation adjacent to the Natural Park of Sierra de Cardeña and Montoro would be most suitable for restoration of the lynx habitat. The precise location of olive groves suitable for restoration are discussed, as revealed by experts' decision-making processes. The main interest of the study relies on the potential of the method to combine territorial analysis with biological requirements of endangered species to facilitate their dispersal.

Implementing agencies

Nekhay, O. and M. Arriaza (2009) Restoration of Abandoned Agricultural Lands toward Habitats for Umbrella Species. Spanish Journal of Agricultural Research 7(2): 375-389.

http://revistas.inia.es/index.php/sjar/article/download/429/426

The Role of Wildlife Science in Wetland Ecosystem Restoration: Lessons from the Everglades

This paper traces the evolution of wetland ecosystem restoration in North America and proposes three roles for wildlife science in wetland ecosystem restoration: (1) contribute to conceptual ecosystem models, (2) develop quantitative performance measures and restoration targets that track the progress of restoration, and (3) achieve social feasibility by sustaining long-term public support for a project.

Implementing agencies, practitioners

Gawlik, D.E. (2006) The Role of Wildlife Science in Wetland Ecosystem Restoration: Lessons from the Everglades. Ecological Engineering 26: 70-83.

http://www.briarcliff.edu/departments/biol/BIOL%2052IR/lessons.pdf

Large Mammal Restoration: Ecological and Sociological Challenges In The 21st Century

Large Mammal Restoration brings together for the first time detailed case studies of those efforts, from restoring elk in Appalachia to returning bison herds to the Great Plains to the much-publicized effort to bring back the gray wolf to Yellowstone National Park. Together these case studies offer important lessons and new ways of thinking for wildlife managers and conservation biologists involved with restoration programs.

Implementing agencies, practitioners

D.S. Maehr, R.F. Noss and J.L. Larkin (2001) Large Mammal Restoration: Ecological and Sociological Challenges In The 21St Century. Island Press, Washington, DC.

http://islandpress.org/ip/books/book/islandpress/L/bo3559157.html

Guidelines for Subspecific Substitutions in Wildlife Restoration Projects

In some cases, however, a subspecies may have become extinct in the wild and in captivity. A substitute form may then be chosen for possible release. Such substitutions are actually a form of benign introduction. Considerations include assessment of the value of a substitution project and the selection of a suit-able substitute. Species substitutions increase biodiversity, conserve related forms, improve public awareness of conservation issues, educate the public, and may be implemented for aesthetic or economic reasons. Selection of a suitable substitute should focus on extant subspecies and consider genetic relatedness, phenotype, ecological compatibility, and conservation value of potential candidates. An example of a substitution project is the reintroduction of the North African Red-necked Ostrich (Struthio camelus camelus) into areas once occupied by the now extinct Arabian Ostrich (Struthio camelus syriacus). S. c. camelus was chosen as a substitute because of its geographic proximity, phenotypic similarity, and conservation value. The World Conservation Union's reintroduction guidelines should be consulted before a project is begun.

Implementing agencies, practitioners

Seddon, P.J. and P.S. Soorae (1999) Guidelines for Subspecific Substitutions in Wildlife Restoration Projects. Conservation Biology 13(1): 177-184.

http://www.freewebs.com/psoorae/ConsBiol1999.pdf

The Use of Extant Non-Indigenous Tortoises as a Restoration Tool to Replace Extinct Ecosystem Engineers

We argue that the introduction of non-native extant tortoises as ecological replacements for extinct giant tortoises is a realistic restoration management scheme, which is easy to implement. This case study further highlights the feasibility, versatility and low-risk nature of using tortoises in restoration programs, with particular reference to their introduction to island ecosystems. Overall, the use of extant tortoises as replacements for extinct ones is a good example of how conservation and restoration biology concepts applied at a smaller scale can be microcosms for more grandiose schemes and addresses more immediate conservation priorities than large-scale ecosystem rewilding projects.

Implementing agencies, practitioners

Griffiths, C.J., C. G. Jones, D.M. Hansen, M. Puttoo, R.V. Tatayah, C.B. Muller and S. Harris (2010) The Use of Extant Non-Indigenous Tortoises as a Restoration Tool to Replace Extinct Ecosystem Engineers. Restoration Ecology 18(1): 1-7.

http://www.torreyaguardians.org/articles/griffiths2010.pdf

4. Sector-Specific Tools and Technologies

Agriculture/Livestock

Long-term Enhancement of Agricultural Production by Restoration of Biodiversity

Experimental manipulations have shown positive impacts of increased species richness on ecosystem productivity, but there remain some questions about this relationship. First, most studies last < 4 years, which raises issues about whether diversity–productivity relationships are maintained in mature communities. Secondly, the conservation relevance of many studies is debatable. We addressed both issues using long-term experimental studies of the agriculturally relevant hay yield of recreated species-rich grasslands. The aims of conservationists and farmers can often be in conflict. This study has shown that the recreation of diverse grasslands of conservation value can have a positive impact on hay yield, which benefits the farm business, and this is repeated across differing sites. Because the effect is maintained over time, farm income will be increased in the long term.

Implementing agencies, indigenous and local communities

Bullock, J.M., R.F. Pywell and K.J. Walker (2007) Long-term Enhancement of Agricultural Production by Restoration of Biodiversity. Journal of Applied Ecology 44: 6-12.

http://pmk.agri.ee/pkt/files/f27/BD_bullock.pdf

Managing Agricultural Resources for Biodiversity Conservation: A Guide to Best Practices

The guide adopts a structure for looking at agrobiodiversity that has emerged from expert meetings and the CBD's liaison group on agrobiodiversity: of farm genetic resources, ecosystem services, knowledge systems, and landscape level issues. The case studies touch on measures and experiences to conserve these aspects of agrobiodiversity in Brazil, Mexico, Cuba, Russia, the Commonwealth of Independent States region, Yunnan province in China, Ghana, Nigeria, Kenya, Ethiopia, Zimbabwe, South Africa, India, the Philippines and Vietnam.

Practitioners, implementing agencies, indigenous and local communities

Gemmill, B. (ed.) (2001) Managing Agricultural Resources for Biodiversity Conservation: A Guide to Best Practices. Environment Liaison Centre International, Nairobi.

http://www.ukabc.org/agbioguide.pdf

Agroecosystem Restoration through Strategic Integration of Perennials

One major and widely held conclusion developed over the last several decades is that agroecosystems need to be designed and managed to serve multiple functions: they should satisfy society's needs for food, fiber, and perhaps energy at an affordable price while protecting environmental quality and human health, conserving nonrenewable resources, fostering economic development, and providing desirable places to live in rural areas. We suggest that the strategic integration of perennial plants in agricultural landscapes is a fundamental strategy for restoring agroecosystem health and function.

Practitioners, implementing agencies, indigenous and local communities

Schulte, L.A., M. Liebman, H. Asbjornsen and T.R. Crow (2006) Agroecosystem Restoration through Strategic Integration of Perennials. Journal of Soil and Water Conservation 61(6): 165-169.

http://www.nrem.iastate.edu/landscape/Publications/Schulte%20et%20al.%202006%20JWSC.pdf

Planning for Implementation: Landscape-Level Restoration Planning in an Agricultural Setting

The conservation of biodiversity in highly fragmented landscapes often requires large-scale habitat restoration in addition to traditional biological conservation techniques. The selection of priority restoration sites to support long-term persistence of biodiversity within landscape-scale projects however remains a challenge for many restoration practitioners. Techniques developed under the paradigm of systematic conservation planning may provide a template for resolving these challenges. The application of an irreplaceability analysis to landscape-level restoration planning allowed the identification of varying needs throughout the planning region, resulting from underlying differences in topography and settlement patterns, and allowed the effective prioritization of potential restoration projects. Engagement with rural landowners and agricultural commodity groups, as well as the irreplaceability maps developed, ultimately resulted in a substantial increase in the number and total area of habitat restoration projects in the planning region.

Policymakers, implementing agencies

Thompson, B.A. (2011) Planning for Implementation: Landscape-Level Restoration Planning in an Agricultural Setting. Restoration Ecology 19(1): 5-13.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2010.00666.x/abstract

Integrating Objectives and Scales for Planning and Implementing Wetland Restoration and Creation in Agricultural Landscapes

Traditionally, wetland management strategies have focused on single familiar objectives, such as improving water quality, strengthening biodiversity, and providing flood control. Despite the relevant amount of studies focused on wetland creation or restoration with these and other objectives, still little is known on how to integrate objectives of wetland creation or restoration at different landscape scales. We have reviewed the literature to this aim, and based on the existing current knowledge, we propose a four step approach to take decisions in wetland creation or restoration planning.

Policymakers, implementing agencies

Moreno-Mateos, D. and F.A. Comin (2011) Integrating Objectives and Scales for Planning and Implementing Wetland Restoration and Creation in Agricultural Landscapes. Journal of Environmental Management 91(11): 2087-2095.

http://www.sciencedirect.com/science/article/pii/S030147971000160X

Establishment and Growth of Living Fence Species: An Overlooked Tool for the Restoration of Degraded Areas in the Tropics

The use of living fence species as a restoration tool has been overlooked. Aside from the advantages of planting tree species vegetatively, species can act as seed recruitment foci by attracting seed dispersers and provide shade to improve microclimatic conditions for seedling establishment. The technique described is simple and could have broad application throughout tropical regions.

Practitioners, indigenous and local communities

Zahawi, R.A. (2005) Establishment and Growth of Living Fence Species: An Overlooked Tool for the Restoration of Degraded Areas in the Tropics. Restoration Ecology 13(1): 92-102.

http://www.globalrestorationnetwork.org/uploads/files/CaseStudyAttachments/94_zahawi-1.pdf

Creating Woodland Islets to Reconcile Ecological Restoration, Conservation, and Agricultural Land Use

Restoration initiatives seek to address widespread deforestation and forest degradation, but face substantial problems. “Passive restoration”, whereby abandoned agricultural land undergoes secondary succession, is often slow, owing to biotic and abiotic limitations. “Active restoration”, chiefly accomplished by planting trees, can be very expensive if large areas are to be restored. We suggest “woodland islets” as an alternative way to achieve ecological restoration in extensive agricultural landscapes, particularly in low productivity environments.

This approach involves the planting of many small, dense blocks of native trees to enhance biodiversity and provide a range of ecosystem services. If the surrounding land is abandoned, the islets act as sources of woodland species and seed, which can accelerate woodland development. Alternatively, if the surrounding area is used for cultivation or pasture, the islets will increase the conservation value of the land and offer the potential for income generation. Here, we review existing approaches to woodland restoration and evaluate the relative strengths and weaknesses of the woodland islets approach.

Practitioners, implementing agencies, indigenous and local communities

Rey Benayas, J.M., J.M. Bullock and A.C. Newton (2008) Creating woodland islets to reconcile ecological restoration, conservation, and agricultural land use. Front Ecol Environ 6(6): 329-336.

http://www2.uah.es/josemrey/Reprints/Woodland_islets_FEE_Aug08.pdf

Soil Management Practices for Sustainable Agro-Ecosystems

This paper addresses the importance of soil organic carbon (SOC) for agro-ecosystems and GHG uptake and emission in agriculture, especially SOC changes associated with soil management. Soil management strategies have great potential to contribute to carbon sequestration, since the carbon sink capacity of the world's agricultural and degraded soil is 50–66% of the historic carbon loss of 42–72 Pg (1 Pg=1015 g), although the actual carbon storage in cultivated soil may be smaller if climate changes lead to increasing mineralization. Since increasing SOC may also be able to mitigate some local environmental problems, it will be necessary to have integrated soil management practices that are compatible with increasing SOM management and controlling soil residual nutrients. Cover crops would be a critical tool for sustainable soil management because they can scavenge soil residual nitrogen and their ecological functions can be utilized to establish an optimal nitrogen cycle. In addition to developing soil management strategies for sustainable agro-ecosystems, some political and social approaches will be needed, based on a common understanding that soil and agro-ecosystems are essential for a sustainable society.

Practitioners, indigenous and local communities

Komatsuzaki, M. and H. Ohta (2007) Soil Management Practices for Sustainable Agro-Ecosystems. Sustainability Science 2: 103-120.

http://www.environmental-expert.com/Files%5C6063%5Carticles%5C15087%5Cart10.pdf

Old Fields: Dynamics and Restoration of Abandoned Farmland

The book gives readers a broad understanding of why agricultural land is abandoned, the factors that determine the ecological recovery of old fields, and how this understanding contributes to theoretical and applied ecology. Twelve case studies from diverse geographical and climatic areas—including Australian rainforest, Brazilian Amazonia, New Jersey piedmont, and South African renosterveld—offer a global perspective on the causes and results of land abandonment. Concluding chapters consider the similarities and differences among the case studies, examine them in the context of ecological concepts, and discuss their relevance to the growing field of restoration ecology.

Practitioners, implementing agencies

Cramer, V. and R.J. Hobbs (eds.) (2007) Old Fields: Dynamics and Restoration of Abandoned Farmland. Island Press, Washington, DC.

http://islandpress.org/ip/books/book/islandpress/O/bo7019261.html

Agriculture/Livestock>Africa

Adaptation at the Interface of Forest Ecosystem Goods and Services and Livestock Production Systems in Northern Mali

The study was designed as demand-oriented research combining national and local activities. In order to feed research results immediately into on-going adaptation processes, the site selection was based on an initial interview phase at national level to harmonise research activities with national processes. This was followed by further interviews at regional level (Tombouctou) and a workshop on vulnerability and adaptation to climate change at district level (Goundam). An intense field research was then undertaken at two sites north of the Lake Faguibine area (Tin Aicha and Raz'al'Ma), combining bio-physical (transects: forest cover, density, estimation of biomass production, etc.) and participatory social research related to livestock production systems, natural resource utilization and adaptation strategies.

Implementing agencies, practitioners, indigenous and local communities

Brockhaus, M. and H. Djoudi (2008) Adaptation at the Interface of Forest Ecosystem Goods and Services and Livestock Production Systems in Northern Mali. Center for International Forestry Research (CIFOR) Info Brief No. 19, Bogor.

http://www.cifor.org/publications/pdf_files/Infobrief/019-infobrief.pdf

Agriculture/Livestock>Australia

Ecological Restoration of Cleared Agricultural Land in Gondwana Link: Lifting the Bar at 'Peniup'

Large scale ecological restoration in a highly heterogeneous and species-rich landscape requires big commitment to fine scale planning. In the southwest of Western Australia, in the Fitz-Stirling area of Gondwana Link, the Peniup Restoration project aimed to improve on such works. A multi-faceted approach was employed to re-establish a self-replicating biologically diverse plant system, ecologically informed in its design and consistent with the heterogeneous mosaic of plant associations found in the surrounding landscape. Outcomes from the project included a 950-ha restoration map composed of nine newly developed soil landscape/vegetation associations. A new 6 m wide direct seeding machine was developed to improve delivery and spatial configuration of establishing plants. These two developments were put to the test in 2008 through a 250 ha biodiverse carbon-funded restoration effort. This paper summarises the approaches used and initial results of those works.

Implementing agencies, practitioners, indigenous and local commmunities

Jonson, J. (2010) Ecological Restoration of Cleared Agricultural Land in Gondwana Link: Lifting the Bar at 'Peniup'. Ecological Management & Restoration 11(1): 16-26.

http://onlinelibrary.wiley.com/doi/10.1111/j.1442-8903.2010.00508.x/full

Agriculture/Livestock>China

Rangeland Degradation and Restoration Management in China

Rangelands of China have for centuries provided forage for livestock but now their role in water, soil, and biodiversity conservation is being recognised by Governments and people. However, much of the rangelands has recently degraded and desertification is now a widespread problem. The cause of the degradation is over-grazing and over-cultivation. Climate change is exacerbating the problem. The Chinese Governments have begun to address these severe problems through policy adjustments and projects. In parallel, some research and development is taking place. There are major impediments to addressing the problem; the importance of rangelands to China and its people are generally underestimated, legislative protection is incomplete and often ineffective, little attention is paid to scientific knowledge for development of management of natural resources, there is insufficient technological support, and Governments are not able to invest sufficiently to effectively restore and develop rangeland natural resources. However, with this background we propose how the problems might be more effectively addressed in the future.

Policymakers, implementing agencies

Han, J.G., Y.J. Zhang, C.J. Wang, W.M. Bai, Y.R. Wang, G.D. Han and L.H. Li (2008) Rangeland Degradation and Restoration Management in China. The Rangeland Journal 30: 233-239.

http://www.cwru.edu/affil/tibet/tibetanNomads/documents/Hanetal2008.pdf

Application of Design Theory for Restoring the "Black Beach" Degraded Rangeland at the Headwater Areas of the Qinghai-Tibetan Plateau

A ten-year research program of restoring the "black-beach" degraded rangelands at the headwater areas of the Qinghai-Tibetan Plateau was summarized in this study to clarify the restoration theory guiding the interventions for rehabilitating these rangelands and provide some examples of successful rehabilitations for worldwide alpine rangeland ecosystems. It was found that the design theory was more applicable than the self-design theory in guiding the restoration interventions for "black-beach" degraded rangeland. Replanting guided by the design theory was effective in reconstructing the alpine rangeland vegetation and improving the ecological and economic values of the alpine rangeland ecosystem at the headwater areas of the Qinghai-Tibetan Plateau. Seed rain, seed bank and seedling germination should be included in post-restoration monitoring and assessment of restoration practices.

Implementing agencies, practitioners

Dong, S.K. et al. (2010) Application of Design Theory for Restoring the "Black Beach" Degraded Rangeland at the Headwater Areas of the Qinghai-Tibetan Plateau. African Journal of Agricultural Research 5(25): 3542-3552.

http://www.academicjournals.org/ajar/pdf/pdf%202010/25%20Dec/Dong%20et%20al.pdf

Agriculture/Livestock>India

Rehabilitation of Degraded Lands in India: Ecological and Social Dimensions

In a developing country such as India, rehabilitation of degraded lands must be closely linked with sustainable community development. Achieving this demands integration of disciplinary approaches by Geologists and sociologists who have traditionally worked separately. This paper considers such a possible synergy using case studies: a multidisciplinary analysis of the shifting agriculture (jhum) system in northeastern India, and an examination of water management as a key factor in successful restoration.

Implementing agencies, practitioners, indigenous and local communities

Ramakrishnan, P.S. (1994) Rehabilitation of Degraded Lands in India: Ecological and Social Dimensions. Journal of Tropical Forest Science 7(1): 39-63.

http://info.frim.gov.my/cfdocs/infocenter/jtfsonline/jtfs/v7n1/39-63.pdf

Agriculture/Livestock>Latin America

Integrating Agricultural Landscapes with Biodiversity Conservation in the Mesoamerican Hotspot

Here we use an integrated landscape approach to highlight opportunities for achieving long-term conservation in Mesoamerica. We provide an overview of the potential for agricultural landscapes and traditional smallholder farming to conserve biodiversity, propose an urgent action agenda to guide conservation in agricultural landscapes and stem the loss of biodiversity and traditional farming systems, and outline key socioeconomic, legal, and political conditions needed for successful implementation of the action plan. Although our examples and recommendations focus on Mesoamerica, our approach is relevant to other regions where there are similar challenges to conserving biodiversity in human-modified landscapes.

Policymakers, implementing agencies

Harvey, C.A. et al. (2008) Integrating Agricultural Landscapes with Biodiversity Conservation in the Mesoamerican Hotspot. Conservation Biology 22(1): 8-15.

http://orton.catie.ac.cr/repdoc/A2719I/A2719I.PDF

Agriculture/Livestock>Niger

Dryland Tree Management for Improved Household Livelihoods: Farmer Managed Natural Regeneration in Niger

Farmer Managed Natural Regeneration (FMNR), a set of practices farmers use to foster the growth of indigenous trees on agricultural land, has drawn substantial attention as a contributing factor to a trend of increasing vegetation greenness in the Republic of Niger. This paper identifies drivers of FMNR adoption and assesses its impacts on rural households in the Region of Maradi, Niger, an area covering 42,000 square kilometers. It is estimated that FMNR raises the annual gross income of the region by between 17 and 21 million USD and has contributed an additional 900,000 to 1,000,000 trees to the local environment. These findings support the value of continued promotion of FMNR as an inexpensive means of enhancing rural livelihoods and an attractive alternative to reforestation efforts relying on tree planting.

Implementing agencies, indigenous and local communities

Haglund, E., J. Ndjeunga, L. Snook and D. Pasternak (2011) Dryland Tree Management for Improved Household Livelihoods: Farmer Managed Natural Regeneration in Niger. Journal of Environmental Management 92(7): 1696-1705.

http://www.sciencedirect.com/science/article/pii/S030147971100051X

Agriculture/Livestock>South and Central Asia

Ecosystem Rehabilitation of the Rural Landscape in South and Central Asia: An Analysis of Issues

In the following account, we have tried to raise a number of hypotheses based on certain assumptions, arising from a number of detailed case studies. Some of these case studies are outlined, setting the tone for deriving assumptions, general hypotheses and more focussed hypotheses concerning Private, Common and Public resources (considering ecological and social issues separately) and appropriate institutional development. Each of the four sets of hypotheses are embellished by specific points from the case studies.

Policymakers, implementing agencies

Ramakrishnan, P.S., J. Campbell, L. Demierre, A. Gyi, K.C. Malhotra, S. Mehndiratta, S.N. Rai and E.M. Sashidharan (1994) Ecosystem Rehabilitation of the Rural Landscape in South and Central Asia: An Analysis of Issues. UNESCO, New Delhi.

http://unesdoc.unesco.org/images/0009/000978/097852eo.pdf

Agriculture/Livestock>South Africa

Impacts of Cattle on Ecological Restoration of Coastal Forests in KwaZulu-Natal, South Africa

Livestock from communities bordered by dune mining, urban areas and commercial forestry in northern KwaZulu-Natal spend substantial time foraging in the coastal forest that the mining company is obliged to restore. A survey of livestock owners and an experimental study of impacts of cattle on restoration processes were conducted to develop better knowledge of the perceptions of livestock owners neighbouring the mine, and the impacts of their cattle on rehabilitating coastal dune forest. Shortages of grazing and livestock diseases were perceived to be the major constraints on livestock operations. The study concluded that: (1) the proximity of livestock owners to large-scale commercial land uses influenced their perceptions and their resources, and (2) grazing and trampling by cattle in the rehabilitating dune forest may hinder the ecological restoration process.

Implementing agencies, indigenous and local communities

Mpanza, T.D.E., P.F. Scogings, N.W. Kunene and A.M. Zobolo (2009) Impacts of Cattle on Ecological Restoration of Coastal Forests in KwaZulu-Natal, South Africa. African Journal of Range Forage Science 26(1): 1-7.

http://www.tandfonline.com/doi/abs/10.2989/AJRFS.2009.26.1.1.696

Agroforestry

Agroforestry as a Tool for Landscape Restoration

This book compiles a set of articles from a technical session, "Agroforestry as a Tool for Landscape Restoration", held in August 2009 as part of the "2nd World Agroforestry Congress: The future of global land use". The articles selected provide an overview of recent efforts to apply agroforestry technologies to landscape restoration in degraded lands located in tropical and temperate regions worldwide. The book is directed at a broad audience including academics, practitioners, and policy makers.

Policymakers, implementing agencies, practitioners, indigenous and local communities

Montagnini, F., W. Francesconi and E. Rossi (eds.) (2011) Agroforestry as a Tool for Landscape Restoration. Nova Science Publishers, New York.

https://www.novapublishers.com/catalog/product_info.php?products_id=16423

Agroforestry for Ecosystem Services and Environmental Benefits: An Overview

As prelude to the special issue, this paper examines four major ecosystem services and environmental benefits of agroforestry: (1) carbon sequestration, (2) biodiversity conservation, (3) soil enrichment and (4) air and water quality. Past and present evidence clearly indicates that agroforestry, as part of a multifunctional working landscape, can be a viable land-use option that, in addition to alleviating poverty, offers a number of ecosystem services and environmental benefits. This realization should help promote agroforestry and its role as an integral part of a multifunctional working landscape the world over.

Policymakers, implementing agencies

Jose, S. (2009) Agroforestry for Ecosystem Services and Environmental Benefits: An Overview. Agroforestry Systems 76: 1-10.

http://www.nrem.iastate.edu/class/assets/NREM471_571/Agroforestry%20readings_2009/Week%201/Jose_2009_Agroforestry%20for%20ecosystem%20services.pdf

The Role of Plantation Forests in Rehabilitating Degraded Tropical Ecosystems

Plantations of multi-purpose tree species can play an important role in restoring productivity, ecosystem stability, and biological diversity to degraded tropical lands. The present study, conducted at a degraded coastal pasture site in Puerto Rico, compares 4.5-year-old Aibizia lebbek (L.) Benth. plantation stands and adjacent control areas with respect to biomass production, understorey species diversity and nutrient storage patterns within vegetation, forest floor organic matter, and mineral soil compartments. Species richness was considerably greater in plantation than control plots for grasses, vines, and forbs. Seedlings of several secondary forest species were abundant in the plantation understorey but absent in control plots, suggesting an important role for such plantations in accelerating natural regeneration of native forest species on certain sites.

Implementing agencies, practitioners

Parrotta, J.A. (1992) The Role of Plantation Forests in Rehabilitating Degraded Tropical Ecosystems. Agriculture, Ecosystems and Environment 41: 115-133.

http://www.fs.fed.us/global/iitf/pubs/role_plantation_parrotta.pdf

Agroforestry>Australia

Production versus Rainforest Biodiversity: Trade-offs or Synergies in Farm Forestry Systems?

These are the proceedings of a workshop discussing production and biodiversity trade-offs in farm forestry systems on former rainforest areas of tropical and sub-tropical Australia. The workshop was held in Cairns, Queensland in November 2003 as part of the 10th Annual Conference of the Rainforest CRC. The multiple goals of farm forestry make the trade-offs between productivity and biodiversity a difficult balancing act and the primary purpose of this workshop was to allow speakers to share their experience and/or research findings in tropical and sub-tropical rainforest regions of Australia.

Policymakers, implementing agencies

Erskine, P.D. and C.P. Catterall (eds.) (2004) Production Versus Rainforest Biodiversity: Trade-offs or Synergies in Farm Forestry Systems? Cooperative Research Centre for Tropical Rainforest Ecology and Management. Rainforest CRC, Cairns.

http://www.jcu.edu.au/rainforest/publications/production_biodiversity.pdf

Agroforestry>Latin America

Native Trees and Shrubs for the Productive Rehabilitation of Tropical Cattle Ranching Lands

We discuss research progress and adoption of intensive silvopastoral systems in Colombia and Mexico. Intensive silvopastoral systems (ISS) are a sustainable form of agroforestry for livestock production that combines fodder shrubs planted at high densities (more than 10,000 plants ha–1), trees and palms, and improved pastures. High stocking and the natural production of milk and meat in these systems are achieved through rotational grazing with electric fencing and a permanent supply of water for the cattle. While milk and meat production and cattle reproduction are enhanced, production costs decline as external inputs are replaced by natural processes related to fertility and biological control. We also discuss the importance of the ISS with native trees for climate change adaptation and mitigation, the barriers for their adoption, and how these have been successfully addressed using payment for environmental services, special credits and technical assistance. Finally, we highlight the need for enhancing landscape connectivity by integrating SPS to conservation corridors with native species to promote biodiversity conservation and other environmental services demanded by society.

Practitioners, indigenous and local communities

Murgueitio, E., Z. Calle, F. Uribea, A. Calle and B. Solorioc (2011) Native Trees and Shrubs for the Productive Rehabilitation of Tropical Cattle Ranching Lands. Forest Ecology and Management 261: 1654-1663.

http://web.catie.ac.cr/gamma/SSP2011/FORECO12368.pdf

Lacandon Maya Forest Management: Restoration of Soil Fertility Using Native Tree Species

In southern Mexico, where rainforests are being degraded rapidly, the Lacandon Maya use an agroforestry system that both restores and conserves the rainforest. Their system cycles through field and fallow stages that produce food, medicines, and raw materials, and regenerates tall secondary forest. This investigation identified plants managed by Lacandon to restore soil fertility during fallow. Our research shows that the Lacandon are cognizant of the natural abilities of certain species to fulfill the restoration needs in their systems. It demonstrates that Maya agroforestry and local knowledge could contribute to efforts to conserve and restore rainforests, and reduce deforestation by accelerating fallow in tropical agriculture.

Indigenous and local communities, practitioners, implementing agencies

Diemont, S.A.W., J.F. Martin, S.I. Levy-Tacher, R.B. Nigh, P. Ramirez Lopez and J.D. Golicher (2006) Lacandon Maya Forest Management: Restoration of Soil Fertility Using Native Tree Species. Ecological Engineering 28: 205-212.

http://www.iph.ufrgs.br/corpodocente/marques/Diemontetal_2006.pdf

Comparisons of Mayan Forest Management, Restoration, and Conservation

Mayan agroforestry systems in geographically and ecologically distinct areas of Mesoamerica were evaluated to better understand traditional agroforestry system components and how indigenous Mayan agroforestry could be a part of regional forest conservation and restoration. Systems were within Mexican land grant areas (ejidos) or on contested land. Although these systems rely upon different woody species and management techniques, common among them are: (1) the use of multi-stage and successional pathways with forest as a part of the larger system, (2) species that are believed by traditional ecological knowledge (TEK) to accelerate forest regeneration – more than 30 tree species are recognized and managed as potential facilitators of forest regeneration and (3) direct human consumption of forest products at all stages of regeneration.

Implementing agencies, practitioners, indigenous and local communities

Diemont, S.A.W., J.L. Bohna, D.D. Rayome, S.J. Kelsen and K. Cheng (2011) Comparisons of Mayan Forest Management, Restoration, and Conservation. Forest Ecology and Management 261(10): 1696-1705.

http://www.sciencedirect.com/science/article/pii/S0378112710006651

Direct Seeding to Restore Tropical Mature-Forest Species in Areas of Slash-and-Burn Agriculture

After tropical lands have been abandoned from anthropogenic pressures, often forest structure and some species recover naturally. Studies suggest, however, that mature-forest species are frequently slow to establish and an active management strategy may be necessary. We tested direct seeding of mature-forest species as a restoration strategy in sites previously used for slash-and-burn agriculture in semi-evergreen, seasonal forest in the Yucatan peninsula, Mexico, and evaluated when in the successional process this strategy had the highest success rate. Our results suggest that direct seeding these mature-forest species after the first few years of natural succession could be a successful strategy to accelerate and guarantee their establishment.

Implementing agencies, practitioners

Bonilla-Moheno, M. and K.D. Holl (2010), Direct Seeding to Restore Tropical Mature-Forest Species in Areas of Slash-and-Burn Agriculture. Restoration Ecology 18: 438-445.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2009.00580.x/abstract

The Role of Native Species Plantations in Recovery of Understory Woody Diversity in Degraded Pasturelands of Costa Rica

Tropical timber plantations provide a variety of environmental services, including recovery of biodiversity on degraded lands. For example, plantations can speed forest successional processes by improving microsite conditions and attracting seed dispersers, thus promoting woody regeneration. Timber species have been hypothesized to differ in understory recruitment success. In the present research, understory regeneration of woody plants was compared for six native timber species on tropical plantations in the Atlantic humid lowlands of Costa Rica.

Practitioners

Cusack, D. and F. Montagnini (2004) The Role of Native Species Plantations in Recovery of Understory Woody Diversity in Degraded Pasturelands of Costa Rica. Forest Ecology and Management 188: 1-15.

http://nature.berkeley.edu/silverlab/DFC2004.pdf

The Tree Planting and Protecting Culture of Cattle Ranchers and Small-scale Agriculturalists in Rural Panama: Opportunities for Reforestation and Land Restoration

To examine the opportunities available for designing diverse tree planting and land restoration initiatives in agricultural landscapes that contain tropical dry forests, the tree planting and protecting practices of cattle ranchers and small-scale agriculturalists were examined in two study sites in rural Panama. Ninety-nine tree species were identified that they utilize, plant, or protect on their land, the majority of which are native to Panama. The farmers had diverse reasons for maintaining trees, including improving the environment, providing food and shade for cattle, and generating a source of wood for construction, furniture, and firewood. Most of the trees mentioned in the study provide multiple uses and values and the majority of farmers wanted to plant additional trees. Some differences in species preferences and motivations for planting and protecting trees were seen between sites, thereby suggesting that land restoration and tree planting projects should be site specific. Our data indicate that there are ample opportunities to increase native tree cover in our study sites and highlight the need to incorporate farmer input into project design, implementation, and evaluation as a necessary and continuous feature throughout projects.

Practitioners, indigenous and local communities

Garena, E.J., K. Saltonstall, M.S. Ashton, J.L. Slusser, S. Mathias and J.S. Hall (2011) The Tree Planting and Protecting Culture of Cattle Ranchers and Small-scale Agriculturalists in Rural

Panama: Opportunities for Reforestation and Land Restoration. Forest Ecology and Management 261(10): 1684-1695.

http://www.sciencedirect.com/science/article/pii/S0378112710006122

Cattle and Weedy Shrubs as Restoration Tools of Tropical Montane Rainforest

This article details an experiment in Colombian montane pastures dominated by two African grasses, Pennisetum clandestinum and Melinis minutiflora, to determine the effect of cattle grazing and seed addition on the establishment and growth of woody species. The results show that a low density of grazing cattle may increase the total density, number of branches, and basal area of woody species while decreasing overall woody species diversity. Where seed was added to the pasture, woody species seedling establishment significantly increased and an interaction effect was found to exist between added seed and grazing suggesting that grazing increases seedling establishment due to added seed. The authors exert that grazing cattle may aide restoration by limiting grassy vegetation and allowing for the establishment of woody shrubs which provide a favorable microclimate for the establishment of tree species.

Practitioners, implementing agencies, indigenous and local communities

Posada, J.M., T.M. Aide and J. Cavelier (2000) Cattle and Weedy Shrubs as Restoration Tools of Tropical Montane Rainforest. Restoration Ecology 8(4): 370-379.

http://arbimon.uprrp.edu/weblab/Publications_files/Posada,%20J.M.%20et%20al.%202000.pdf

Tree Plantations on Farms: Evaluating Growth and Potential for Success

The manuscript describes survivorship and growth of four native tree species on farms over five years in the dry arc of Panama. The manuscript also provides five year growth data for 61 native tree species grown at two experimental or “species selection” trials at two sites adjacent to farm sites and discusses growth in relation to local farmer species preferences. Native species can grow well on rural farms but growth and survivorship depend upon both local site conditions and farmer management. Rural farmers will stay engaged with tree planting projects over long periods of time as long as expectations are managed and extension services are provided.

Implementing agencies, practitioners, indigenous and local communities

Hall, J.S., B.E. Love, E.J. Garen, J.L. Slusser, K. Saltonstall, S. Mathias, M.V. Breugel, D. Ibarra, E.W. Bork, D. Spaner, M.H. Wishnie and M.S. Ashton (2011) Tree plantations on farms: Evaluating growth and potential for success. Forest Ecology and Management 261(10): 1675-1683.

http://www.sciencedirect.com/science/article/pii/S0378112710005840

Strategies for the Recovery of Degraded Ecosystems: Experiences from Latin America

Physical and biological barriers can delay natural regeneration in degraded ecosystems. Tropical tree plantations can contribute to restore soils and accelerate forest regeneration. In a program on ecosystem rehabilitation in three regions of Latin America, about 50% of a total of 29 tree species tested had positive effects on soils and good growth, making them attractive to farmers for reforestation. In plantations with indigenous tree species in the humid lowlands of Costa Rica, tree regeneration was higher under plantations than in abandoned pastures. Tree regeneration was high under mixed-species plantations. Open pastures had the highest proportion of wind-dispersed seeds, while bird and bat seed dispersal was predominant in the plantations. High litter accumulation on the plantation floor diminished grass growth and encouraged woody invasion.

Implementing agencies, practitioners

Montagnini, F. (2001) Strategies for the recovery of degraded ecosystems: experiences from latin america. INCI 26(10): 498-503.

http://www.scielo.org.ve/scielo.php?pid=S0378-18442001001000013&script=sci_arttext

An Evaluation of Farmers' Experiences Planting Native Trees in Rural Panama: Implications for Reforestation with Native Species in Agricultural Landscapes

This study evaluates the experiences of farmers participating in a native species reforestation initiative in rural Panama to identify lessons learned that can guide on-going or future tree planting efforts. Based on the results of a questionnaire administered to program participants and non-participants (n = 68), we found that trees are important to farmers for multiple reasons, primary a variety of environmental and economic benefits.

Implementing agencies, practitioners, indigenous and local communties

Garen, E.J., K. Saltonstall, J.L. Slusser, S. Mathias, M.S. Ashton and J.S. Hall (2009) An Evaluation of Farmers' Experiences Planting Native Trees in Rural Panama: Implications for Reforestation with Native Species in Agricultural Landscapes. Agroforestry Systems

http://ctfs.arnarb.harvard.edu/Public/pdfs/Garen_etal_2009_AgroforestSyst.pdf

Using the Maya Nut Tree to Increase Tropical Agroecosystem Resilience to Climate Change in Central America and Mexico

The Maya Nut tree increases agroecosystem resilience to climate change by ensuring food security during periods of drought and other extreme events such as hurricanes. Its deep and extensive root system helps retain soil during natural erosion or extreme events and enable the tree to access deeper ground water. The Maya Nut tree plays an important role in stabilizing riverbanks and maintaining flows from natural springs.

Practitioners, implementing agencies, indigenous and local communities

Ecosystem and Livelihoods Adaptation Network (ELAN)

http://elanadapt.net/sites/default/files/siteimages/maya_nut_0.pdf

Agroforestry>India

Multifunctional Agroforestry Systems in India: Science-Based Policy Options

Drawing on the representative literature from peer-reviewed research, this paper critically examines the contribution of agroforestry systems in India to: (i) biodiversity conservation; (ii) yield of goods and services to society; (iii) augmentation of the carbon storage in agroecosystems; (iv) enhancing the fertility of the soils; and (v) providing social and economic well-being to people. Agroforestry systems in India contribute variously to ecological, social and economic functions, but they are only complementary—and not as alternative—to natural forests. A winning strategy for conservation and human welfare can be achieved by protecting the largest possible area of natural ecosystems while growing food on the smallest possible area to reconcile food production with conservation. Yet, this combination is not always feasible. Therefore, a trade-off strategy for addressing multiple functions is required.

Policymakers, implementing agencies

Singh, V.S. and D.N. Pandey (2011) Multifunctional Agroforestry Systems in India: Science-Based Policy Options. Climate Change and CDM Cell, Rajasthan State Pollution Control Board, Occasional Paper No. 4/2011, Jaipur.

http://210.212.96.131/rpcb/ReportsAndPaper/multi_Ag_System.pdf

Indigenous Knowledge of Nyishi Tribes on Traditional Agroforestry Systems

The ethno-botanically important species in traditional agroforests of Nyishi community of Arunachal Pradesh, India, was studied during the year 2004-2005. The plants used by the local people for food, medicine and other ethnobotanical purposes including the utilization and related ethnobotanical aspects were assessed during the survey. A total of 80 useful plants belonging to 45 families and 69 genera were collected from 20 randomly selected agroforestry plots. Of the plants documented under 10 major categories, 47 species are used for food, 21 species are used in medicine and 35 species are used for other purposes.

Indigenous and local communities, implementing agencies

Deb, S., A. Arunachalam and A.K. Das (2009) Indigenous Knowledge of Nyishi Tribes on Traditional Agroforestry Systems. Indian Journal of Traditional Knowledge 8(1): 41-46.

http://www.environmentportal.in/files/India%20Jour%20of%20Trad%20Knowle.pdf

Agroforestry>Philippines

Rainforestation Farming: A Farmers' Guide to Biodiversity Management

This book describes a peoples based reforestation concept that aims at restoring the tropical forest ecosystem with all its species. A must-read for foresters and ecologist working in the tropics.

Practitioners, indigenous and local agencies

Po Milan, P. (2009) Rainforestation Farming: A Farmers' Guide to Biodiversity Management, 2nd edition. Foundation for the Philippine Environment.

http://fpe.ph/rainforestation-farming-a-farmers-guide-to-sustainable-forest-biodiversity-management

New Options for Land Rehabilitation and Landscape Ecology in Southeast Asia by "Rainforestation Farming"

One innovative approach to combine the necessities of rural development, safe natural resource management and biodiversity restoration was developed under the acronym ''Rainforestation Farming'' on the island of Leyte in the Philippines. More than 100 different local forests and fruit tree species were tested and planted in a near-to-nature planting scheme concerning species composition in a former degraded area covered by Imperata cylindrica.

Practitioners, indigenous and local communities

Göltenboth, F. and C-P. Hutter (2004) New Options for Land Rehabilitation and Landscape Ecology in Southeast Asia by "Rainforestation Farming". Journal for Nature Conservation 12: 181-189.

http://www.rainforestation.ph/resources/pdf/publications/Goltenboth_and_Hutter_2004_New_options_for_land_rehabilitation.pdf

Most Significant Changes Experienced by Farmers from Adopting Rainforestation Farming

The Visayas State University (VSU) developed the rainforestation farming (RF) system to replace the more destructive forms of kaingin or slash-and-burn practices commonly practiced by farmers and provide them with a stable and higher income. VSU disseminated the technology through training and establishment of demonstration farms coupled with various extension materials. The most important changes experienced by farmers from adopting RF were increase in income, greater social skills, improvement of their water and air conditions, and enhancement of biodiversity in their rainforestation farms.

Practitioners, indigenous and local communities

Velarde, G.L.M., R.S. Gravoso, E.G. Cagasan and C.A. Gabrillo (2007) Most Significant Changes Experienced by Farmers from Adopting Rainforestation Farming. Annals of Tropical Research 29(3): 109-122.

http://espace.library.uq.edu.au/eserv/UQ:188407/RotachioFINAL09.pdf

Agroforestry>Tanzania

Ngitili Agrosilvipastoral Systems in the United Republic of Tanzania

Ngitili are farmer-led initiatives evolved from traditional strategies for grazing and food security. The system involves retaining an area of standing vegetation (grasses, trees, shrubs and forbs) from the onset to the end of the rainy season. The ngitili area remains closed to livestock at the beginning of the wet season and is opened up for grazing at the peak of dry season.

Indigenous and local communities, implementing agencies

Kamwenda, G.J. (2002) Ngitili Agrosilvipastoral Systems in the United Republic of Tanzania. Unasylva 211, Vol. 53: 46-50.

http://www.globalrestorationnetwork.org/uploads/files/CaseStudyAttachments/95_ngitili---agrosilvipastoral-system.pdf

Agroforestry>USA

Transitioning to a Restoration Economy: A Case Study of Oregon's Forestry Sector

This case study is from a collection of four case studies of wealth creation and rural-urban linkages (Dabson, Jensen et al, 2012). These are part of a broader effort supported by the Ford Foundation, known as the Wealth Creation in Rural Communities initiative. The primary purpose of these case studies is to stimulate learning, discussion and further inquiry about the application of the rural wealth creation framework. The cases were selected to illustrate different facets of this framework in action, and to further clarify the ways in which the framework could prove to be instrumental in achieving sustainable economic prosperity for rural people and places. The subjects of each of these cases represent decades of dedication and hard work by many people and organizations often in extremely challenging economic, social, and political contexts.

Policymakers, implementing agencies

Dabson, B. (2012) Transitioning to a Restoration Economy: A Case Study of Oregon's Forestry Sector. Columbia, MO: Rural Futures Lab.

http://www.yellowwood.org/TransitioningtoaRestorationEconomyCaseStudyFINAL.pdf

Climate Change

Restoration, Ecosystem

In this article, we first review how restoration ecology is being applied in different types of ecosystems. For each ecosystem, we consider how global change is expected to affect species and communities and how restoration ecology might address problems that emerge. We focus on climate change, rather than other aspects of global change, because changes in climate are expected to affect virtually all ecosystems, and because prevention measures that might reduce impacts of changing climate have not been widely adopted.

Policymakers

McCarty, J.P. and J.B. Zedler (2002) Restoration, Ecosystem. Pp 532–539 in Volume 2, The Earth system: biological and ecological dimensions of global environmental change (H.A Mooney and J.G. Canadell (eds.)) in Encyclopedia of Global Environmental Change, John Wiley & Sons, Ltd, Chichester.

http://www.unomaha.edu/environmental_studies/McCartyHomePage/Papers/McCarty_Zedler_Reprint.pdf

Ecological Restoration and Global Climate Change

There is an increasing consensus that global climate change occurs and that potential changes in climate are likely to have important regional consequences for biota and ecosystems. Ecological restoration, including (re)-afforestation and rehabilitation of degraded land, is included in the array of potential human responses to climate change. However, the implications of climate change for the broader practice of ecological restoration must be considered. In particular, the usefulness of historical ecosystem conditions as targets and references must be set against the likelihood that restoring these historic ecosystems is unlikely to be easy, or even possible, in the changed biophysical conditions of the future.

Policymakers, implementing agencies, practitioners

Harris, J.A., R.J. Hobbs, E. Higgs and J. Aronson (2006) Ecological restoration and global climate change. Restoration Ecology 14(2): 170-176.

http://nctc.fws.gov/CSP/Resources/fwca/Climate%20Change/Ecological%20restoration%20and%20CC.pdf

Wetlands and Global Climate Change: The Role of Wetland Restoration in a Changing World

The following global recommendations are offered to scientists, practitioners and policymakers to provide some perspective as well as a stimulus for discussion with a goal toward developing a new direction for global wetland conservation in a changing world.

Policymakers, implementing agencies, practitioners

Erwin, K.L. (2009) Wetlands and global climate change: the role of wetland restoration in a changing world. Wetlands Ecol Manage 17:71-84.

http://www.wetlands.org/_strp/cfforum/fileattachments/fulltext.pdf

Forest Restoration in a Mixed-Ownership Landscape under Climate Change

We used a spatially explicit forest ecosystem model, LANDIS-II, to simulate the interaction of climate change and forest management in northeastern Minnesota, USA. We assessed the relevance of restoration strategies and conservation targets based on the RNV in the context of future climate change. Three climate scenarios (no climate change, low emissions, and high emissions) were simulated with three forest management scenarios: no harvest, current management, and a restoration-based approach where harvest activity mimicked the frequency, severity, and size distribution of historic natural disturbance regimes.

Implementing agencies

Ravenscroft, C., R.M. Scheller, D.J. Mladenoff and M.A. White (2010) Forest Restoration in a Mixed-Ownership Landscape under Climate Change. Ecological Applications 20(2): 327-346.

http://www.esajournals.org/doi/abs/10.1890/08-1698.1

Climate Change Implications for River Restoration in Global Biodiversity Hotspots

Global biodiversity hotspots contain exceptional concentrations of endemic species in areas of escalating habitat loss. However, most hotspots are geographically constrained and consequently vulnerable to climate change as there is limited ability for the movement of species to less hostile conditions. Predicted changes to rainfall and temperature will undoubtedly further impact on freshwater ecosystems in these hotspots. Southwestern Australia is a biodiversity hotspot and, as one of the first to experience significant climate change, is an example and potentially a global bellwether for issues associated with river restoration.

Policymakers, implementing agencies

Davies, P.M. (2010) Climate Change Implications for River Restoration in Global Biodiversity Hotspots. Restoration Ecology 18: 261-268.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2009.00648.x/abstract

Why Climate Change Makes Riparian Restoration More Important than Ever: Recommendations for Practice and Research

Over the next century, climate change will dramatically alter natural resource management. Specifically, historical reference conditions may no longer serve as benchmarks for restoration, which may foster a “why bother?” attitude toward ecological restoration. We review the potential role for riparian restoration to prepare ecological systems for the threats posed by climate change. Riparian ecosystems are naturally resilient, provide linear habitat connectivity, link aquatic and terrestrial ecosystems, and create thermal refugia for wildlife: all characteristics that can contribute to ecological adaptation to climate change. Because riparian systems and the projected impacts of climate change are highly variable geographically, there is a pressing need to develop a place-based understanding of climate change threats to riparian ecosystems. Restoration practitioners should consider how they can modify practices to enhance the resilience of riparian ecosystems to climate change. Such modifications may include accelerating the restoration of private lands, participating in water management decisions, and putting the emerging field of restoration genetics into practice.

Practitioners, implementing agencies

Seavy, N.E., T. Gardali, G.H. Golet, F.T. Griggs, C.A. Howell, R. Kelsey, S.l. Small, J.H. Viers and J.F. Weigand (2009) Why Climate Change Makes Riparian Restoration More Important than Ever: Recommendations for Practice and Research. Ecological Restoration 27(3): 330-338.

http://er.uwpress.org/content/27/3/330.full.pdf+html

Climate Change>Adaptation

Building Resilience to Climate Change: Ecosystem-based Adaptation and Lessons from the Field

This book is one of the main contributions of the Commission on Ecosystem Management (CEM) of the International Union for the Conservation of Nature (IUCN) to the international discussions on how we should address climate change impacts on natural and human systems, including ecosystems and the services they provide to society and communities. Eleven case studies were selected by a team of editors, covering different ecosystems and regions around the world. The criteria for selection included the availability of an impact assessment of climate change on local communities, or biodiversity at ecosystem level, a clear analysis of the climate change vulnerability of ecosystems and human communities, a proposal for adaptation measures or set of actions being implemented – all based on the concept of ecosystem management – and, ultimately, an analysis of implementation results with future prospects.

Policymakers, implementing agencies

Andrade Pérez, A., B. Herrera Fernandez and R. Cazzolla Gatti (eds.) (2010) Building Resilience to Climate Change: Ecosystem-based adaptation and lessons from the field. Gland, Switzerland: IUCN.

http://data.iucn.org/dbtw-wpd/edocs/CEM-009.pdf

Ecosystem-based Adaptation: A Natural Response to Climate Change

This report presents 10 examples of Ecosystem-based Adaptation taking place in both developing and developed countries, at national, regional, and local scales, and in marine, terrestrial, and freshwater environments. The case studies demonstrate how Ecosystem-based Adaptation is being implemented at project and programmatic levels

Policymakers, implementing agencies, practitioners

Colls, A., N. Ash and N. Ikkala (2009) Ecosystem-based Adaptation: a natural response to climate change. Gland, Switzerland: IUCN.

http://data.iucn.org/dbtw-wpd/edocs/2009-049.pdf

Does EbA Work? A Review of the Evidence on the Effectiveness of Ecosystem-based Approaches to Adaptation

Ecosystem-based approaches to adaptation (EbA) integrate the use of biodiversity and ecosystem services into an overall strategy for helping people adapt to climate change. To date, however, insight into these approaches has often been based on anecdotal case studies of local people's use of ecosystems. Although they are informative, they can provide rather limited insight in terms of measuring and evaluating the effectiveness of EbA, especially compared with technical or structural adaptation measures. A new, systematic review of EbA evidence has been carried out to interrogate the scientific literature and review studies from around the world, from many different ecosystems and adopting a wide range of adaptation approaches utilising ecosystems. We conclude that EbA approaches are effective and deserve greater policy attention and political support to reach their full potential.

Policymakers

Munroea, R., N. Doswald, D. Roe, H. Reid, A. Giuliani, I. Castelli and I. Möller (2011) Does EbA Work? A review of the evidence on the effectiveness of ecosystem-based approaches to adaptation. UNEP World Conservation Monitoring Centre, Cambridge.

http://www.unep-wcmc.org/medialibrary/2011/11/30/e33d5149/Durban%20briefing_Does%20EbA%20work_A%20review%20of%20the%20evidence-base.pdf

UNFCCC Database on Ecosystem-based Approaches to Adaptation

There is a growing recognition of the role that healthy ecosystems can play in increasing resilience and helping people adapt to climate change through the ongoing delivery of a range of ecosystem services. The examples below capture some of the ways in which various types of ecosystem based measures have contributed to several sectors, including livelihood sustenance and food security, sustainable water management, disaster risk reduction and biodiversity conservation.

Policymakers

UNFCCC

http://unfccc.int/adaptation/nairobi_work_programme/knowledge_resources_and_publications/items/6227.php

Assessing Resilience in Social-Ecological Systems: Workbook for Practitioners

The recently updated workbook for practitioners uses strategic questions and activities to guide in constructing a conceptual model of a social-ecological system - a place along with its associated resources, stakeholders, institutions, and issues. Building on the model, the assessment aids in identifying potential thresholds between alternative systems states and helps reveal what is contributing to or eroding resilience. A resilience assessment can thus provide insight into developing strategies for buffering or coping with both known and unexpected change.

Practitioners, implementing agencies, indigenous and local communities

Resilience Alliance

http://www.resalliance.org/index.php/resilience_assessment

Buying Time: A User's Manual for Building Resistance and Resilience to Climate Change in Natural Systems

The manual addresses all of the major biomes with practical ideas of how to begin increasing the resiliency of ecosystems and plan our protected areas in response to the threat of climate change. Some of these strategies are in line with the conservation strategies we have been working on for years—reducing fragmentation, building corridors, reducing threats, and increasing resiliency in general.

Implementing agencies, indigenous and local communities

WWF International (2003)

http://www.worldwildlife.org/climate/Publications/WWFBinaryitem4922.pdf

Climate Change>Adaptation>Africa

Ecosystem Management for Improved Human Well-Being in the Lake Faguibine System: Conflict Mitigation and Adaptation to Climate Change

In June 2008 the government of Mali called upon the UN system to support the rehabilitation of the LFS and a pre-identification mission was conducted by UNEP in August. One of the main conclusions of the mission was that the current state of knowledge about the LFS is inadequate to be able to describe in detail what can and should be done for its full rehabilitation.

Policymakers, implementing agencies

Hamerlynck, O., T. Chiramba and M. Pardo (2008) Ecosystem management for improved human well-being in the Lake Faguibine System: conflict mitigation and adaptation to climate change. UNEP, Nairobi.

http://www.unep.org/pdf/Lake-Faguibine.pdf

Climate Change>Adaptation>Europe

Floodplain Restoration along the Lower Danube: A Climate Change Adaptation Case Study

In assessing ongoing floodplain restoration work that commenced in 1993, this paper finds the following. (a) Along the lower Danube River, restoration of floodplains by decommissioning under-performing flood protection infrastructure has provided many benefits. The benefits of these adaptation measures include improved natural capacity to retain and release floodwaters and remove pollutants, enhanced biodiversity, and strengthened local economies through diversification of livelihoods based on natural resources. (b) The drivers for more successful adaptation measures in the Danube included EU expansion, legal mechanisms, and local desire to improve livelihoods.

Policymakers, implementing agencies

Ebert, S., O. Hulea and D. Strobel (2009) Floodplain Restoration along the Lower Danube: A Climate Change Adaptation Case Study. Climate and Development 1(3): 212-219.

http://www.tandfonline.com/doi/abs/10.3763/cdev.2009.0022

Ecosystem-based Approaches to Adaptation and Mitigation: Good Practice Examples and Lessons Learned in Europe

This report documents and analyses good practice examples of ecosystem-based approaches to climate change mitigation and adaptation in Europe. Case studies on ecosystem-based approaches to mitigation involved peatland restoration or conservation (11 projects) and forest conservation, restoration and reforestation (2 projects). The main additional benefits from these approaches were nature conservation of important ecosystems, as well as adaptation benefits through the areas providing water regulation. Case studies on ecosystem-based approaches to adaptation were divided into inland waters (28 projects), coastal zone (10 projects), agriculture and forestry (11 projects) and cities (9 projects).

Policymakers, implementing agencies

Doswald, N. and M. Osti (2011) Ecosystem-based Approaches to Adaptation and Mitigation: Good Practice Examples and Lessons Learned in Europe. UNEP-WCMC and the German Federal Agency for Nature Conservation.

http://www.bfn.de/fileadmin/MDB/documents/service/Skript_306.pdf

Assessment of the Potential of Ecosystem-based Approaches to Climate Change Adaptation and Mitigation in Europe

At a national and regional level, given the importance of technical capacity highlighted in the explored case studies, an increased knowledge and understanding of specific design characteristics for projects using ecosystem-based approaches and their implications should further be supported. Both positive experiences as well as barriers were encountered during implementation. These can serve as a useful knowledge basis for increasing the success and efficiency of emerging projects. Further, such information could help to create successful management frameworks and a more appropriate selection of measures. Systems of institutional learning can enhance these efforts, ensuring that knowledge can be transferred to a wider audience and that the utilization of lessons learned is maximized. Finally, increased stakeholder involvement and a higher level of awareness amongst policy makers and the general public are necessary. Governments can be seen as serving a central, guiding role here in acting as a motivating actor and providing impetus to action at the local level.

Policymakers, implementing agencies

Naumann, S., G. Anzaldua, P. Berry, S. Burch, M. Davis, A. Frelih-Larsen, H. Gerdes and M. Sanders (2011) Assessment of the potential of ecosystem-based approaches to climate change adaptation and mitigation in Europe. Final report to the European Commission, DG Environment, Contract no. 070307/2010/580412/SER/B2, Ecologic institute and Environmental Change Institute, Oxford University Centre for the Environment.

http://ww.ecologic.eu/files/attachments/Projects/2345_eba_ebm_cc_finalreport_23nov2011.pdf

Climate Change>Adaptation>South Africa

Biodiversity for Development: South Africa's Landscape Approach to Conserving Biodiversity and Promoting Ecosystem Resilience

This Primer showcases tools that have been developed in South Africa as part of such a landscape approach. It describes how these tools have been developed and used by government and civil society role-players in the period since South Africa's first democratic elections with universal franchise in 1994, to manage, conserve and use biodiversity sustainably in support of socio-economic development. The Primer explains, with the use of selected case studies, how adoption of the landscape approach can: 1) enable implementation of the ecosystem approach to biodiversity conservation, 2) facilitate working in co-operative partnerships to address the interconnected issues faced by biodiversity and society in an integrated way, and 3) promote the resilience of ecosystems and society to climate change.

Policymakers

Cadman, M., C. Petersen, A. Driver, N. Sekhran, K. Maze and S. Munzhedzi (2010) Biodiversity for Development: South Africa's landscape approach to conserving biodiversity and promoting ecosystem resilience. South African National Biodiversity Institute, Pretoria.

http://www.undp.org/biodiversity/docs/PRIMER.pdf

South Africa: Ecosystem-Based Planning for Climate Change

The intervention outlined in this case study is South Africa's emerging strategy of ecosystem-based adaptation to climate change, based on maintaining sufficient intact natural habitat in an optimal configuration identified through systematic biodiversity planning. This has been done through: (i) producing biodiversity maps and guidelines in several provinces and municipalities that feed into spatial and development planning; and (ii) developing a national strategy for expanding protected areas. Climate change design principles (e.g prioritization of corridors, refugia areas where species may move to survive temperature increases, slopes with marked altitudinal changes in climate and large, connected remaining fragments) are explicitly used in the systematic biodiversity planning methodology underpinning both these interventions.

Policymakers

Petersen, C. and S. Holness (?) South Africa: Ecosystem-Based Planning for Climate Change. World Resources Report, WRI, Washington DC.

http://www.worldresourcesreport.org/files/wrr/wrr_case_study_south_africa_ecosystem_based_planning.pdf

Climate Change>Adaptation>Western Pacific

Principles and Practice of Ecosystem-Based Management: A Guide for Conservation Practitioners in the Tropical Western Pacific

This guide seeks to inform and influence conservation practice in the tropical Western Pacific and to share lessons from the region with conservation practitioners around the world, particularly in developing nations where EBM approaches used in industrialised countries may not be feasible or appropriate. EBM can be applied at a range of scales and context at any stage in the planning process for site-based projects to national policies and programmes.

Practitioners, implementing agencies

Clarke P. and S. Jupiter (2010) Principles and Practice of Ecosystem-Based Management: A Guide for Conservation Practitioners in the Tropical Western Pacific. Wildlife Conservation Society, Suva, Fiji.

http://s3.amazonaws.com/WCSResources/file_20111008_132145_Principles+and+Practice+of+Ecosystem-Based+Management-+A+guide+for+conservation+practitioners+in+the+Tropical+Western+Pacific_ikA.pdf

Climate Change>Adaptation>Coastal/Marine

Managing Mangroves for Resilience to Climate Change

This paper is an attempt to provide some considerations for conservation practitioners as they design conservation strategies for mangroves. This paper provides an overview of mangrove ecosystems, discusses the benefits of mangroves to people, and the human and global threats that compromise mangrove ecosystems. This document describes the impacts of climate change on mangroves and outlines tools and strategies that enhance mangrove resilience.

Indigenous and local communities, implementing agencies, policymakers

McLeod, E. and R.V. Salm (2006) Managing Mangroves for Resilience to Climate Change. IUCN: Gland.

http://data.iucn.org/dbtw-wpd/edocs/2006-041.pdf

Managing Seagrasses for Resilience to Climate Change

This paper presents an overview of seagrasses, the impacts of climate change and other threats to seagrass habitats, as well as tools and strategies for managers to help support seagrass resilience.

Practitioners, implementing agencies

Björk, M., F. Short, E. Mcleod and S. Beer (2008) Managing Seagrasses for Resilience to Climate Change. IUCN: Gland.

http://data.iucn.org/dbtw-wpd/edocs/2008-024.pdf

Threats to Mangroves from Climate Change and Adaptation Options: A Review

Adaptation measures can offset anticipated mangrove losses and improve resistance and resilience to climate change. Coastal planning can adapt to facilitate mangrove migration with sea-level rise. Management of activities within the catchment that affect long-term trends in the mangrove sediment elevation, better management of other stressors on mangroves, rehabilitation of degraded mangrove areas, and increases in systems of strategically designed protected area networks that include mangroves and functionally linked ecosystems through representation, replication and refugia, are additional adaptation options.

Policymakers, implementing agencies

Gilman, E.L., J. Ellison, N.C. Duke and C. Field (2008) Threats to Mangroves from Climate Change and Adaptation Options: A Review. Aquatic Botany 89: 237-250.

http://cmsdata.iucn.org/downloads/aquatic_botany_mangrove_article2008.pdf

Natural Barriers to Natural Disasters: Replanting Mangroves after the Tsunami

The Indian Ocean tsunami disaster of December 2004 has increased interest in replanting degraded and deforested mangrove areas in Asia to improve coastal protection. Evidence from Thailand suggests that concern over mangrove deforestation by shrimp farms is an important motivation for many coastal households to participate in mangrove rehabilitation. However, successful re-establishment and management of mangroves as effective coastal barriers will require developing new institutions and policies, and must involve coastal communities in Thailand and other Indian Ocean countries in the conservation and protection of their local mangrove forests.

Policymakers, indigenous and local communities

Barbier, E.B. (2006) Natural Barriers to Natural Disasters: Replanting Mangroves after the Tsunami. Frontiers in Ecology and the Environment 4(3): 124-131

http://www.hawaiistateassessment.info/library/Hawaii_Coastal_Hazards/Document_Library/VEGETATION/Mangroves/barbier_2006_naturalbarrierstotsunami.pdf

Climate Change>Adaptation>Coastal/Marine>India

Toolkit for Establishing Coastal Bioshield

Both mangrove and non-mangrove components of bioshield can be integrated with livelihood options and eco-restoration of coastal systems by developing different site-specific models. Thus, the community based bioshield movement will provide multiple benefits to local communities as well as to India as a whole. All these indicate the necessity for developing and demonstrating models of community based bioshields with mangrove and other coastal vegetation, which can be replicated in other suitable areas so as to mitigate the impact of natural calamities such as cyclones, storm surges and tsunami.

Selvam, V., T. Ravishankar, V.M. Karunagaran, R. Ramasubramanian, P. Eganathan and A. K. Parida (2005) Toolkit for Establishing Coastal Bioshield. MSSRF/MA/05/26, M. S. Swaminathan Research Foundation, Chennai.

http://www.mssrf.org/csr/csr-pub/17-Toolkit%20for%20establishing%20coastal%20biosheid.pdf

Climate Change>Adaptation>Coastal/Marine>Vietnam

Mangrove Restoration and Rehabilitation for Climate Change Adaptation in Vietnam

This case study examines the governance enabled by Vietnam's socialist-oriented market economy to meet the uncertainties posed by climate change scenarios and ongoing system-level shocks. More specifically, the governance of mangrove restoration and rehabilitation as a climate change adaptation measure is examined in this regard.

Policymakers, implementing agencies

Powell, N., M. Osbeck, S.B. Tan and V.C. Toan (?) Mangrove Restoration and Rehabilitation for Climate Change Adaptation in Vietnam. World Resources Report, Washington, DC.

http://www.worldresourcesreport.org/files/wrr/wrr_case_study_mangrove_restoration_vietnam.pdf

Climate Change>Adaptation>Coastal/Marine>USA

Restore-Adapt-Mitigate: Responding to Climate Change through Coastal Habitat Restoration

The purpose of this report is to educate habitat restoration professionals, policy makers, and the public on the impacts climate change will have on coastal habitats and the possible role habitat restoration could play in mitigating those impacts. This is the first report that clearly demonstrates the opportunity to link the interconnectedness between coastal habitat restoration and adaptation and mitigation strategies related to reducing climate change impacts. They are not exclusive of each other, and if designed and managed correctly, can share mutual benefits. Much of this report is focused on policies and programs based in the United States, but many of the concepts, ideas and recommendations translate easily to other locales.

Policymakers, implementing agencies, indigenous and local communities

Needelman, B.A., S. Crooks, C.A. Shumway, J.G. Titus, R.Takacs and J.E. Hawkes (2012) Restore-Adapt-Mitigate: Responding to Climate Change through Coastal Habitat Restoration. Restore America's Estuaries, Washington DC.

http://www.estuaries.org/images/stories/RAE_Restore-Adapt-Mitigate_Climate-Chg-Report.pdf

Climate Change>Adaptation>Forests/Woodlands

Forests and Society – Responding to Global Drivers of Change

The essential idea for this book originated from an acknowledgement of the changing social and natural circumstances, and the related drivers of change affecting forests, forestry, human society, and the environment, globally and locally. We are convinced that forests and forest-related matters can no longer be addressed in isolation from the surrounding society and natural environment; instead, these need to be seen as an integral part of interrelated social and natural systems.

Policymakers, implementing agencies, practitioners, indigenous and local communities

Mery, G., P. Katila, G. Galloway, R.I. Alfaro, M. Kanninen, M. Lobovikov and J. Varjo (eds.) (2010) Forests and Society – Responding to Global Drivers of Change. IUFRO World Series Volume 25. Vienna.

http://www.iufro.org/science/special/wfse/forests-society-global-drivers/

Forests and Climate Change: Adaptation and Mitigation

This issue of ETFRN News aims to contribute to a better understanding of the role of forests and their management in climate change mitigation and adaptation. It presents some promising approaches and measures and the enabling conditions needed. The articles in this issue are the result of an open call for papers. They do not cover all issues and initiatives that are relevant to the forest-climate connection; this was not the goal. Nevertheless, the issue brings together a lively mix of articles with a wide range of perspectives, varying from papers with an international policy focus and conceptual pieces, to field experiences written by individuals who do not often address an international audience. Collectively, the articles constitute a broad-ranging insight to the importance of forests in climate change and some of the challenges that need to be addressed at the different levels — from local to global, from policy to practice — to make things work.

Policymakers

Van Bodegom, A.J., H. Savenije and M. Wit (eds.) (2009) Forests and Climate Change: adaptation and mitigation. Tropenbos International, Wageningen, The Netherlands.

http://www.etfrn.org/etfrn/newsletter/news50/ETFRN_50_Forests_and_Climate_Change.pdf

Using Tropical Forest Ecosystem Goods and Services for Planning Climate Change Adaptation with Implications for Food Security and Poverty Reduction

This paper presents some preliminary outcomes of the Tropical Forests and Climate Change Adaptation (TroFCCA) project of the Center for International Forestry Research (CIFOR) whose overall mission is to underscore the importance of tropical forests for livelihood adaptation to climate change and mainstreaming adaptation into national development processes. The paper also highlights TroFCCA's approach in engaging stakeholders from the onset in setting the agenda with the identification and prioritization of forest-based sectors as the entry point in the process of assessing the vulnerability to climate change and developing adaptation strategies for these selected development sectors. This is a highly crucial area with great policy implications.

Policymakers

Nkem, J., H. Santoso, D. Murdiyarso, M. Brockhaus and M. Kanninen (2007) Using tropical forest ecosystem goods and services for planning climate change adaptation with implications for food security and poverty reduction. Journal of ICRISAT Agricultural Research 4(1): 4-23.

http://www.cifor.org/online-library/browse/view-publication/publication/2404.html

Prioritisation for Adaptation in Tropical Forest Ecosystems

This paper uses the experiences gained under the Tropical Forests and Climate Change Adaptation project of the Center for International Forest Research across three continents to propose a priority-setting process with active participation of multiple stakeholders in tropical ecosystems in developing countries perceived in their judgment to be crucial for adaptation to climate change. By attributing values to forest ecosystem goods and services for all stakeholders, prioritization represents a common position by multiple stakeholders linking their interests and practices for a common purpose.

Practitioners, indigenous and local communities

Nkem, J., M. Idinoba, H. Santoso, C.J. Perez, C. Forner, B. Locatelli and M. Kanninen (2008) Prioritisation for Adaptation in Tropical Forest Ecosystems. CIFOR Working Paper No. 44.

http://www.cakex.org/sites/default/files/Prioritisation%20for%20Adaptation%20in%20Tropical%20Forest%20Ecosystems.pdf

Forest Resilience, Biodiversity, and Climate Change: A Synthesis of the Biodiversity/Resilience/Stability Relationship in Forest Ecosystems

Protecting primary forests and restoring managed or degraded forest ecosystems make a vital contribution to both reducing anthropogenic emissions and aiding societal adaptation to unavoidable climate change. It is the resilience inherent to intact forest ecosystems - fully functional units of plants, animals, micro-organisms, and fungi ‐ that provides the best insurance against climate change and prospects for ensuring forests meet the needs of present and future generations.

Policymakers

Thompson, I., B. Mackey, S. McNulty and A. Mosseler (2009) Forest Resilience, Biodiversity, and Climate Change: A synthesis of the biodiversity/resilience/stability relationship in forest ecosystems. CBD Technical Series no. 43, Secretariat of the Convention on Biological Diversity, Montreal.

http://www.cbd.int/doc/publications/cbd-ts-43-en.pdf

Adapting to Climate Change

The question of how forests and forest-dependent people will adapt to climate change is a growing area of research and has been at the heart of a number of recent conferences. One of these, the international conference on Adaptation of Forests and Forest Management to Changing Climate with Emphasis on Forest Health: A Review of Science, Policies and Practices (Umeå, Sweden, August 2008), spawned the contents of this special double issue of Unasylva. The conference, organized by FAO, the International Union of Forest Research Organizations (IUFRO) and the Swedish University of Agricultural Sciences, brought together over 300 researchers, managers and decision-makers from 50 countries.

Policymakers, implementing agencies

Perlis, A. (ed.) (2009) Adapting to Climate Change. Unasylva No. 231/232, Vol. 60, 2009/1-2, Food and Agriculture Organization of the United Nations, Rome.

ftp://ftp.fao.org/docrep/fao/011/i0670e/i0670e00.pdf

Climate Change>Adaptation>Forests/Woodlands>Ghana

Modified Taungya System in Ghana: A Win-Win Practice for Forestry and Adaptation to Climate Change?

The formulation and implementation of an adaptation strategy is of growing concern to governments. The adaptation policy framework (APF) sets out indicative activities and features of an adaptation strategy. Understanding the extent to which existing practices can support adaptation in societies and ecosystems is an important step towards the solution. This study uses vulnerability, policy and financial analyses to investigate the compatibility of the modified taungya system (MTS) (a reforestation programme) in Ghana with the indicative activities of the APF. We conclude that MTS is a potential win‑win practice for forestry and adaptation. The legalization of all contractual arrangements coupled with continuous monitoring, evaluation and improvement may drive MTS to become a lasting activity that will support the long-term horizon of an adaptation strategy.

Policymakers, implementing agencies, indigenous and local communities

Kalame, F.B., R. Aidoo, J. Nkem, O.C. Ajayie, M. Kanninen, O. Luukkanen and M. Idinoba (2011) Modified Taungya System in Ghana: A Win-Win Practice for Forestry and Adaptation to Climate Change? Environmental Science & Policy 14(5): 519-530.

http://www.sciencedirect.com/science/article/pii/S1462901111000451

Climate Change>Mitigation

Carbon Offsets as Ecological Restorations

A variety of reforms are needed to ensure that biosequestration projects deliver real, additional, and permanent removals of carbon dioxide. In particular, developing and adopting social and environmental impact assessment tools, changing accounting practices to allow for natural disturbances, universal adoption of strong additionality testing, and supporting critical research through tonnage fees could substantially improve what is accomplished through carbon offsets. Given the magnitude and importance of what carbon markets are attempting to achieve, insights from restoration ecologists are urgently needed to help shape their future.

Policymakers

Galatowitsch, S.M. (2009) Carbon Offsets as Ecological Restorations. Restoration Ecology 17(5): 563-570.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2009.00587.x/abstract

The Natural Fix? The Role of Ecosystems in Climate Mitigation

Implementation of widespread ecosystem carbon management policies presents great challenges, raising significant institutional and regulatory issues and complex political and socio-economic dilemmas. In particular, an effective policy will need to achieve a balance between rural livelihoods and carbon management policies that may threaten those livelihoods. It is often difficult to ensure that the rewards for good carbon management reach the communities involved. It is crucial that the voices of the rural poor and indigenous people are not lost in a rush to secure carbon gains.

Policymakers

Trumper, K., M. Bertzky, B. Dickson, G. van der Heijden, M. Jenkins and P. Manning (2009) The Natural Fix? The role of ecosystems in climate mitigation. A UNEP rapid response assessment. United Nations Environment Programme, UNEP WCMC, Cambridge.

http://www.grida.no/_res/site/file/publications/natural-fix/BioseqRRA_scr.pdf

Stepping Up the Ambition for Carbon Management: A Vision for Carbon-rich, Cross-continental Biodiversity Corridors

We have the chance to create our own positive story of restoration on a grand scale. Managing land to store terrestrial carbon and provide biodiversity corridors is a strong linking thread through this narrative of hope. However, it must go hand-in-hand with stopping ongoing degradation (including halting deforestation), whether it is caused by economic development or poverty.

Policymakers

Lovejoy, T.E. and R. Ashton (2011) Stepping Up the Ambition for Carbon Management: A Vision for Carbon-rich, Cross-continental Biodiversity Corridors. Carbon Management 2(2): 101-103.

http://www.terrestrialcarbon.org/Terrestrial_Carbon_Group__soil_%26_vegetation_in_climate_solution/Opeds_and_Journal_Articles_files/Lovejoy%20Ashton%20Carbon%20Management%202011%202%202%20101%20103.pdf

The Plan Vivo Experience with Carbon Service Provision and the Potential Lessons for Watershed Service Projects

This report provides a detailed description of the Plan Vivo system for generating carbon services from rural communities for sale in the voluntary carbon market. The objective is to provide project developers of water service projects with a model for possible application to their sites. Carbon services are generated either by sequestering carbon through afforestation and reforestation activities, or by reducing greenhouse gas emissions through efficient, cleaner energy or fuel generation or usage. The Plan Vivo is a set of procedures and administrative systems for managing carbon assets across a mosaic of numerous small-scale farmers or community groups.

Implementing agencies

Orrego, J. (2005) The Plan Vivo experience with carbon service provision and the potential lessons for watershed service projects. International Institute for Environment and Development, London, UK and ECCM, Edinburgh, UK.

http://pubs.iied.org/pdfs/G00367.pdf

Climate Change>Mitigation>Coastal/Marine

Mitigating Climate Change through Restoration and Management of Coastal Wetlands and Near-shore Marine Ecosystems: Challenges and Opportunities

The technical report, prepared by consolidates information from the literature and provides analysis on the climate change mitigation potential of seagrasses and coastal wetlands, including coastal peats, tidal freshwater wetlands, salt marshes and mangroves.

Policymakers, implementing agencies

Crooks, S., D. Herr, J. Tamelander, D. Laffoley, and J. Vandever (2011) Mitigating Climate Change through Restoration and Management of Coastal Wetlands and Near-shore Marine Ecosystems: Challenges and Opportunities. Environment Department Paper 121, World Bank, Washington, DC.

http://siteresources.worldbank.org/ENVIRONMENT/Resources/MtgtnCCthruMgtofCoastalWetlands.pdf

The Potential for Mangrove Carbon Projects in Vietnam

The importance of mangroves in providing ecological services has been highlighted in discussions on global climate change, in particular with reference to Reduced Emissions from Forest Degradation and Deforestation Plus (REDD+). Mangroves have a relatively high Greenhouse Gas (GHG) removal capacity and thus higher potential to earn carbon revenues. The aim of this paper is to examine the potential for mangrove carbon projects in Vietnam.

Policymakers, implementing agencies

McNally, R., A. McEwin and T. Holland (2011) The Potential for Mangrove Carbon Projects in Vietnam. SNV-Netherlands Development Organisation, REDD+ Programme.

http://www.snvredd.com/images/stories/demo/Publication_PDF_Files/2011/mangrove%20report%20publication-dec%2011.pdf

Salt Marsh Restoration and Creation: Ways to Global Climate Change Adaptation and Mitigation

Salt marsh restoration and creation are a necessity since this ecosystem plays many important social, cultural, economic and ecological functions and it has been destroyed or degraded all around the world. In addition, salt marsh creation and restoration may be used to affront the negative consequences of Global Climate Change and to reduce greenhouse gasses in the atmosphere. Thus, salt marsh bioengineering may be used to reduce deleterious effects of flooding events after torrential rains or the impacts of storms, sea level rise and hurricanes on coastal areas. On the other hand, the creation and restoration of European salt marshes using native species such as Spartina maritima (small cordgrass) may be used as a mitigation strategy.

Policymakers, implementing agencies

Castillo, J.M., A.M. Abbas and E. Figueroa (2008) Salt Marsh Restoration and Creation: Ways to Global Climate Change Adaptation and Mitigation. 6th European Conference on Ecological Restoration Ghent, Belgium, 8-12/09/2008.

http://ser.semico.be/ser-pdf/054.pdf

Whole-island Carbon Stocks in the Tropical Pacific: Implications for Mangrove Conservation and Upland Restoration

Management of forest carbon (C) stocks is an increasingly prominent land-use issue. Knowledge of carbon storage in tropical forests is improving, but regional variations are still poorly understood, and this constrains forest management and conservation efforts associated with carbon valuation mechanisms (e.g., carbon markets). This deficiency is especially pronounced in tropical islands and low-lying coastal areas where climate change impacts are expected to be among the most severe. This study presents the first field estimate of island-wide carbon storage in ecosystems of Oceania, with special attention to the regional role of coastal mangroves, which occur on islands and coastal zones throughout the tropics. Sustainable management of mangrove forests and their large C stocks is of high importance at the regional scale, and climate change mitigation programs such as REDD+ could play a large role in avoiding deforestation of mangroves where this is a management objective.

Policymakers, implementing agencies

Donato, D.C., J.B. Kauffman, R.A. Mackenzie, A. Ainsworth and A.Z. Pfleeger (2012) Whole-island Carbon Stocks in the Tropical Pacific: Implications for Mangrove Conservation and Upland Restoration. Journal of Environmental Management 97: 89-96.

http://www.sciencedirect.com/science/article/pii/S0301479711004294

Climate Change>Mitigation>Drylands

Restoration of Degraded and Desertified Lands: Experience from Iceland

Climate mitigation through carbon sequestration in soil and vegetation with land restoration and revegetation must give full consideration to multiple goals, including those of the conventions of combating desertification and conserving biological diversity. In Iceland carbon sequestration is regarded as an added benefit of land restoration efforts, but not a goal in itself. Ecosystem restoration and carbon sequestration through revegetation demonstrates the synergic effects of land degradation and desertification on other environmental goals.

Runólfsson, S. and A.M. Ágústsdóttir (2011) Restoration of Degraded and Desertified Lands: Experience from Iceland. Pp. 153-161 in Lal, R. et al Climate Change and Food Security in South Asia, Springer, New York.

http://www.springerlink.com/content/g3434t82l8707870/

Climate Change>Mitigation>Forests/Woodlands

Forest Restoration: UNEP World Conservation Monitoring Centre

Forest ecosystems can play a key role in climate mitigation. They regulate climate in several different ways. The high rates of evapotranspiration of tropical forests decrease surface air temperature and surface roughness of the trees attracts precipitation. However, the main focus on forest in climate mitigation policy is due to their carbon sequestration and storage potential (see Table), both of which have been damaged by deforestation and degradation. Forest ecosystem restoration can therefore contribute extensively to climate change mitigation. While the role of forest restoration within REDD+ is still emerging, it can already be funded through the voluntary carbon market. Some case studies on forest restoration are made available.

Implementing agencies, policymakers

UNEP World Conservation Monitoring Centre

http://www.unep-wcmc.org/restoration_626.html

Forest Governance and Climate Change Mitigation

This policy brief summarizes the main findings of five workshops that were jointly funded and convened by ITTO and FAO in Southeast Asia, West Africa, Central Africa, the Amazon Basin and Mesoamerica, between August 2006 and July 2008 to promote a multi-sectoral dialogue between countries on improving forest law compliance. It highlights the lessons learned from experiences on the ground and sets out the key elements of an approach to forest law compliance and governance that will ensure the optimal role of forests in mitigating climate change.

Policymakers

FAO and ITTO (2009) Forest Governance and Climate Change Mitigation. Policy Brief prepared by the FAO and ITTO.

http://www.itto.int/technical_report/?pageID=1

Opportunities and Constraints for Forest Climate Mitigation

Reversing forest losses through restoration, improvement, and conservation is a critical goal for greenhouse gas mitigation. Here, we examine some ecological, demographic, and economic opportunities and constraints on forest-loss mitigation activities. Reduced deforestation and forest degradation could cut global deforestation rates in half by 2030, preserving 1.5 billion to 3 billion metric tons of carbon dioxide–equivalent (tCO2e) emissions yearly. Our new economic modeling for the United States suggests that greenhouse gas payments of up to $50 per tCO2e could reduce greenhouse gas emissions by more than 700 million tCO2e per year through afforestation, forest management, and bioelectricity generation. However, simulated carbon payments also imply the reduction of agricultural land area in the United States by 10% or more, decreasing agricultural exports and raising commodity food prices, imports, and leakage. Using novel transgenic eucalypts as our example, we predict selective breeding and genetic engineering can improve productivity per area, but maximizing productivity and biomass could make maintaining water supply, biodiversity, and other ecosystem services a challenge in a carbon-constrained world.

Implementing agencies, policymakers

Jackson, R.B. and J.S. Baker (2010) Opportunities and Constraints for Forest Climate Mitigation. BioScience 60(9): 698-707.

http://152.3.12.176/jackson/bs2010.pdf

Biodiversity in Forest Carbon Sequestration Initiatives: Not Just a Side Benefit

One way of mitigating global climate change is protecting and enhancing biosphere carbon stocks. The success of mitigation initiatives depends on the long-term net balance between carbon gains and losses. The biodiversity of ecological communities, including composition and variability of traits of plants and soil organisms, can alter this balance in several ways. This influence can be direct, through determining the magnitude, turnover rate, and longevity of carbon stocks in soil and vegetation. It can also be indirect through influencing the value and therefore the protection that societies give to ecosystems and their carbon stocks. Biodiversity of forested ecosystems has important consequences for long-term carbon storage, and thus warrants incorporation into the design, implementation, and regulatory framework of mitigation initiatives.

Policymakers, implementing agencies

Dıaz, S., A. Hector and D.A. Wardle (2009) Biodiversity in Forest Carbon Sequestration Initiatives: Not Just a Side Benefit. Current Opinion in Environmental Sustainability 1: 55-60.

http://www.nucleodiversus.org/uploads/file/Papers/Diaz_etal_2009_COEnvSust.pdf

The Potential for Carbon Sequestration through Reforestation of Abandoned Tropical Agricultural and Pasture Lands

Approximately half of the tropical biome is in some stage of recovery from past human disturbance, most of which is in secondary forests growing on abandoned agricultural lands and pastures. Reforestation of these abandoned lands, both natural and managed, has been proposed as a means to help offset increasing carbon emissions to the atmosphere. In this paper we discuss the potential of these forests to serve as sinks for atmospheric carbon dioxide in aboveground biomass and soils. A review of literature data shows that aboveground biomass increases at a rate of 6.2 Mg ha^{-1} yr^{-1} during the first 20 years of succession, and at a rate of 2.9 Mg ha^{-1} yr^{-1} over the first 80 years of regrowth. During the first 20 years of regrowth, forests in wet life zones have the fastest rate of aboveground carbon accumulation with reforestation, followed by dry and moist forests.

Implementing agencies

Silver, W.L., R. Ostertag and A.E. Lugo (2000) The Potential for Carbon Sequestration through Reforestation of Abandoned Tropical Agricultural and Pasture Lands. Restoration Ecology 8(4): 394-407.

http://www.cnr.berkeley.edu/silverlab/pdfs/Silver%20et%20al.%20Restoration%20Ecology%202000.pdf

Community Forest Management as a Carbon Mitigation Option: Case Studies

The collection of case studies presented in this document attempts to explore opportunities to promote the participation of local communities in various countries with a range of socio-economic settings and institutional challenges. They fall into two groups. The first considers cases of communities that are already involved in community-based forest management in a variety of settings and have been trained to make assessment of the changes in carbon stock in these forests over time. The second group concerns small-scale AR CDM projects.

Implementing agencies, indigenous and local communities

Murdiyarso, D. and M. Skutsch (eds.) (2006) Community Forest Management as a Carbon Mitigation Option: Case Studies. Center for International Forestry Research (CIFOR) Bogor, Indonesia.

http://www.communitycarbonforestry.org/Case%20study%20bookWeb.pdf

Ecological Restoration, Carbon Sequestration and Biodiversity Conservation: The Experience of the Society for Wildlife Research and Environmental Education (SPVS) in the Atlantic Rain Forest of Southern Brazil

Since 1999, SPVS has been involved in three projects that combine two fundamental goals over the course of 40 years: the conservation of one of Brazil's most important remnants of Atlantic Forest and the implementation of projects for carbon sequestration. In addition, there is an interest in replicating these projects in order to restore other degraded areas, protect the Brazilian biomes, and help to diminish deforestation and forest fire, therefore reducing carbon emissions. The acquisition of 19,000 ha of degraded areas of high biological importance in southern Brazil was the first step towards the implementation of the projects. These areas are owned by SPVS, a Brazilian NGO, and are being restored, conserved and transformed into Private Natural Reserves, in partnership with the NGO ‐ The Nature Conservancy, and financed by the companies ‐ American Electric Power, General Motors and Chevron Texaco.

Policymakers, implementing agencies

Rocha Ferretti, A. and R. Miranda de Britez (2006) Ecological Restoration, Carbon Sequestration and Biodiversity Conservation: The Experience of the Society for Wildlife Research and Environmental Education (SPVS) in the Atlantic Rain Forest of Southern Brazil. Journal for Nature Conservation 14(3-4): 249-259.

http://www.sciencedirect.com/science/article/pii/S1617138106000185

Investing in Sustainability: Restoring Degraded Thicket, Creating Jobs, Capturing Carbon and Earning Green Credit

This document presents the case for restoration of degraded thicket as a means to revive the rural economy in the Eastern Cape. Its purpose is to stimulate investment in the large-scale restoration of degraded thicket, basing its case on sound practical and scientific evidence and economic models built on existing working programmes. It is aimed at corporates seeking green credit, and also at government, given that restoration is aligned with strategies identified in the government's Accelerated and Shared Growth Initiative for South Africa (AsgiSA).

Policymakers, implementing agencies

Mills, A. et al. (2009) Investing in Sustainability: Restoring Degraded Thicket, Creating Jobs, Capturing Carbon and Earning Green Credit. Climate Action Partnership and Subtropical Thicket Restoration Project, South Africa.

http://www.rncalliance.org/WebRoot/rncalliance/Shops/rncalliance/4B45/777F/46E7/8C2D/D572/C0A8/D218/F935/Final_CAP_Thicket_Restoration.pdf

Mapping Restoration Opportunity for Collaborating with Land Managers in a Carbon Credit-Funded Restoration Program in the Makana Municipality, Eastern Cape, South Africa

Spatial prioritization techniques are commonly used in conservation planning, but are relatively new for planning restoration programs. Typically, ecological data, and more recently data on economic costs and vulnerability of sites, are used. However, the effectiveness of restoration action ultimately relies on a combination of the appropriate ecological restoration techniques and the human and social dynamics of social-ecological systems. Surveys were conducted with 29 land managers within the Makana Municipality of the Eastern Cape, South Africa, to identify a range of human and social factors hypothesized to define the potential effectiveness of restoration action. Identifying and incorporating human and social factors that directly influence restoration prioritization should promote efficient and effective implementation of restoration actions by the Working for Woodlands programme, who are looking to funding landscape-scale restoration through carbon trading.

Policymakers, implementing agencies

Curran, P., D. Smedley, P. Thompson and A.T. Knight (2012) Mapping Restoration Opportunity for Collaborating with Land Managers in a Carbon Credit-Funded Restoration Program in the Makana Municipality, Eastern Cape, South Africa. Restoration Ecology 20(1): 56-64.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2010.00746.x/full

Rate of Carbon Sequestration at Two Thicket Restoration Sites in the Eastern Cape, South Africa

Restoration of thicket using cuttings of the dominant succulent shrub Portulacaria afra could return biodiversity to the transformed landscape, earn carbon credits on international markets, reduce soil erosion, increase wildlife carrying capacity, improve water infiltration and retention, and provide employment to rural communities. Carbon storage in two thicket restoration sites was investigated to determine potential rates of carbon sequestration. Potential earnings through carbon credits are likely to rival forest planting schemes, but costs are likely to be less due to the ease of planting cuttings, as opposed to propagating forest saplings.

Implementing agencies, practitioners, policymakers

Mills, A.J. and R.M. Cowling (2006) Rate of Carbon Sequestration at Two Thicket Restoration Sites in the Eastern Cape, South Africa. Restoration Ecology 14(1): 38-49.

http://www.betteru.co.za/documents/richardcowling/Restoration%20Ecology_spekboom_Mills%20and%20Cowling%202006.pdf

Restore and Sequester: Estimating Biomass in Native Australian Woodland Ecosystems for their Carbon-funded Restoration

This study contributes the predictive equations required to accurately quantify the carbon sequestered in native woodland ecosystems in the low rainfall region of south-western Australia.

Implementing agencies

Jonson, J.H. and D. Freudenberger (2011) Restore and Sequester: Estimating Biomass in Native Australian Woodland Ecosystems for their Carbon-funded Restoration. Australian Journal of Botany 59(7): 640-653.

http://www.publish.csiro.au/paper/BT11018.htm

Carbon Sequestration and Biodiversity of Re-growing Miombo Woodlands in Mozambique

Land management in tropical woodlands is being used to sequester carbon (C), alleviate poverty and protect biodiversity, among other benefits. Our objective was to determine how slash-and-burn agriculture affected vegetation and soil C stocks and biodiversity on an area of miombo woodland in Mozambique, and how C stocks and biodiversity responded once agriculture was abandoned.We sampled twenty-eight 0.125 ha plots that had previously been cleared for subsistence agriculture and had been left to re-grow for 2 to _25 years, and fourteen 0.25 ha plots of protected woodlands, recording stem diameter distributions and species, collecting wood for density determination, and soil from 0 to 0.3 m for determination of %C and bulk density.

Implementing agencies, practitioners

Williams, M., C.M. Ryan, R.M. Rees, E. Sambane, J. Fernando and J. Grace (2008) Carbon Sequestration and Biodiversity of Re-growing Miombo Woodlands in Mozambique. Forest Ecology and Management 254: 145-155.

http://www.geos.ed.ac.uk/homes/mwilliam/williams08fem.pdf

Climate Change>Mitigation>Inland Waters

Planning Hydrological Restoration of Peatlands in Indonesia to Mitigate Carbon Dioxide Emissions

In this study we present a strategy for improved planning of rewetting measures by dam constructions. The study area is a vast peatland with limited accessibility in Central Kalimantan, Indonesia. Field inventory and remote sensing data are used to generate a detailed 3D model of the peat dome and a hydrological model predicts the rise in groundwater levels once dams have been constructed. Successful rewetting of a 590 km^2 large area of drained peat swamp forest could result in mitigated emissions of 1.4–1.6 Mt CO_2 yearly. This equates to 6% of the carbon dioxide emissions by civil aviation in the European Union in 2006 and can be achieved with relatively small efforts and at low costs. The proposed methodology allows a detailed planning of hydrological restoration of peatlands with interesting impacts on carbon trading for the voluntary carbon market.

Policymakers, implementing agencies

Jaenicke, J., H. Wösten, A. Budiman and F. Siegert (2010) Planning Hydrological Restoration of Peatlands in Indonesia to Mitigate Carbon Dioxide Emissions. Mitigation and Adaptation Strategies for Global Change 15(3): 223-239.

http://www.springerlink.com/content/w09502h2768192mw/

Climate Change>Mitigation>CDM

Evaluation Tool for Reforestation and Afforestation-based Carbon Sequestration Projects in the United States

Evaluation Tool) is designed to estimate the following for reforestation and afforestation projects: the expected carbon gains (live tree, standing dead tree, understory, down dead wood and forest floor) from the project activities; the present value of potential carbon revenue based on the expected carbon gains; the present value of the expected sampling costs attributable to measuring above ground carbon; the net present value of the potential carbon revenue and expected sampling costs. The Evaluation Tool is designed to provide first-order estimates of expected carbon revenue and expected carbon measurement costs that are unique to reforestation and afforestation based carbon sequestration projects

Implementing agencies

Kant, Z., M. Bennett and S. Mooney (2005) Evaluation Tool for Reforestation and Afforestation-based Carbon Sequestration Projects in the United States. The Nature Conservancy, Department of Energy National Energy Technology Laboratory (DOENETL), WestWater Research.

http://conserveonline.org/docs/2005/06/Carbon_Project_Evaluation_Tool.zip

Simplified Modalities and Procedures for Small-scale Afforestation and Reforestation Project Activities under the Clean Development Mechanism

This technical paper was prepared based on submissions by Parties and on the work by the clean development mechanism (CDM) Executive Board. It presents options on the following issues: further clarifications on definitions of eligible small-scale afforestation and reforestation project activities, including on the calculation of project size; possible categories of projects for which methodologies can be simplified; draft simplified modalities and procedures for small-scale afforestation and reforestation project activities; a simplified project design document; the structure of an indicative simplified baseline and monitoring methodologies for selected types of small-scale afforestation and reforestation project activities under the CDM; and criteria for determining the occurrence of debundling of projects.

Implementing agencies

UNFCCC/TP/2004/2 – Technical Paper

http://unfccc.int/resource/docs/tp/tp0402.pdf

Climate Change>Mitigation>CDM>Ethiopia

Poverty Alleviation and Environmental Restoration Using the Clean Development Mechanism: A Case Study from Humbo, Ethiopia

The Humbo Project assists communities affected by environmental degradation including loss of biodiversity, soil erosion and flooding with an opportunity to benefit from carbon markets while reducing poverty and restoring the local agroecosystem. Involving the regeneration of 2,728 ha of degraded native forests, it brings social, economic and ecological benefits—facilitating adaptation to a changing climate and generating temporary certified emissions reductions (tCERs) under the Clean Development Mechanism. A key feature of the project has been facilitating communities to embrace new techniques and take responsibility for large-scale environmental change, most importantly involving Farmer Managed Natural Regeneration (FMNR). This technique is low-cost, replicable, and provides direct benefits within a short time.

Policymakers, implementing agencies, practitioners, indigenous and local communities

Brown, D.R., P. Dettmann, T. Rinaudo, H. Tefera and A. Tofu (2011) Poverty Alleviation and Environmental Restoration Using the Clean Development Mechanism: A Case Study from Humbo, Ethiopia. Environmental Management 48: 322-333.

http://www.springerlink.com/content/h6v13j3l7r285330/

Climate Change>Mitigation>CDM>Mexico

Analysis of the Carbon Sequestration Costs of Afforestation and Reforestation Agroforestry Practices and the Use of Cost Curves to Evaluate their Potential for Implementation of Climate Change Mitigation

The objective of this paper is to analyze the sequestration costs of agroforestry afforestation and reforestation projects (ARPs) following a partial market equilibrium using average cost curves and economic break even analysis to identify the supply costs. The modelling done in this work contrasts the voluntary and clean development mechanism transaction costs. Data is based on the voluntary project, Scolel Té, being implemented in Mexico. Cost curves are developed for seven different sequestration options considering transaction and implementation costs; information from agricultural production in Chiapas Mexico is used to integrate opportunity costs of two agroforestry practices suggesting that sequestration costs may follow a "U" shape, with an initial reduction due to economies of scale and a subsequent increase caused by high opportunity costs.

Implementing agencies, indigenous and local communities

Balderas Torres, A., R. Marchant, J.C. Lovett, J.C.R. Smart and R. Tipper (2010) Analysis of the Carbon Sequestration Costs of Afforestation and Reforestation Agroforestry Practices and the Use of Cost Curves to Evaluate their Potential for Implementation of Climate Change Mitigation. Ecological Economics 69(3): 469-477.

http://www.sciencedirect.com/science/article/pii/S0921800909003942

Ecosystem Services

Can the Concept of Ecosystem Services be Practically Applied to Improve Natural Resource Management Decisions?

Applying ecosystem service valuation principles to natural resources management has the potential to encourage the efficient use of resources, but can decision support systems built on these principles be made both practical and robust? The limitations to building such systems are the practical limits on managers' time to develop or learn tools and the state of the science to support decision-making components. We address this question by applying a cost-effectiveness analysis framework and optimization model to support the targeting of restoration funds to control an invasive grass (Bromus tectorum) in agro-ecosystems. The optimization aims to maximize benefits derived from a suite of ecosystem services that may be enhanced through site restoration.

Policymakers, implementing agencies

Wainger, L.A., D.M. King, R.N. Mack, E.W. Price and T. Maslin (2010) Can the Concept of Ecosystem Services be Practically Applied to Improve Natural Resource Management Decisions? Ecological Economics 69: 978-987

http://www.sciencedirect.com/science/article/pii/S0921800910000030

Realizing the Potential of Ecosystem Services: A Framework for Relating Ecological Changes to Economic Benefits

Here, we describe a step-by-step framework for producing ecological models and metrics that can effectively serve an economic-benefits assessment of a proposed change in policy or management. A focus of the framework is developing comparable units of ecosystem goods and services to support decision-making, even if outcomes cannot be monetized. Because the challenges to translating ecological changes to outcomes appropriate for economic analyses are many, we discuss examples that demonstrate practical methods and approaches to overcoming data limitations.

Policymakers, implementing agencies

Wainger, L. and M. Mazzotta (2011) Realizing the Potential of Ecosystem Services: A Framework for Relating Ecological Changes to Economic Benefits. Environmental Management 48(4): 710-733.

http://waingerlab.cbl.umces.edu/docs/Wainger_Mazzotta_2011_eprint.pdf

Investing in Ecological Infrastructure

Investing in 'ecological infrastructure' makes economic sense in terms of cost effectiveness and rates of return, once the whole range of benefits provided by maintained, restored or increased ecological services are taken into account. Well-documented examples include investing in mangroves or other wetland ecosystems as well as watersheds, instead of man-made infrastructure like dykes or waste water treatment plants, in order to sustain or enhance the provision of ecosystem services. It is usually much cheaper to avoid degradation than to pay for ecological restoration. This is particularly true for biodiversity: species that go extinct cannot be brought back. Nonetheless, there are many cases where the expected benefits from restoration far exceed the costs. If transformation of ecosystems is severe, true restoration of pre-existing species assemblages, ecological processes and the delivery rates of services may well be impossible. However, some ecosystem services may often be recovered by restoring simplified but well-functioning ecosystems modeled on the pre-existing local system.

Policymakers

TEEB (2009) Investing in Ecological Infrastructure, Chapter 9 in The Economics of Ecosystems and Biodiversity (TEEB) for National and International Policy Makers.

http://www.teebweb.org/LinkClick.aspx?fileticket=9NUqttjb3bo%3D&tabid=1019&language=en-US

Restoring Natural Capital: Science, Business, and Practice

Restoring Natural Capital brings together economists and ecologists, theoreticians, practitioners, policy makers, and scientists from the developed and developing worlds to consider the costs and benefits of repairing ecosystem goods and services in natural and socio-ecological systems. It examines the business and practice of restoring natural capital, and seeks to establish common ground between economists and ecologists with respect to the restoration of degraded ecosystems and landscapes and the still broader task of restoring natural capital. Nineteen case studies from around the world illustrate challenges and achievements in setting targets, refining approaches to finding and implementing restoration projects, and using restoration of natural capital as an economic opportunity.

Policymakers

Aronson, J., S. Milton, and J. Blignaut (eds.) (2008) Restoring Natural Capital: Science, Business, and Practice. Island Press, Washington, DC.

http://islandpress.org/ip/books/book/islandpress/R/bo5488233.html

Restoration of Ecosystem Services and Biodiversity: Conflicts and Opportunities

Ecological restoration is becoming regarded as a major strategy for increasing the provision of ecosystem services as well as reversing biodiversity losses. Here, we show that restoration projects can be effective in enhancing both, but that conflicts can arise, especially if single services are targeted in isolation. Furthermore, recovery of biodiversity and services can be slow and incomplete. Despite this uncertainty, new methods of ecosystem service valuation are suggesting that the economic benefits of restoration can outweigh costs. Payment for Ecosystem Service schemes could therefore provide incentives for restoration, but require development to ensure biodiversity and multiple services are enhanced and the needs of different stakeholders are met. Such approaches must be implemented widely if new global restoration targets are to be achieved.

Policymakers, implementing agencies

Bullock, J.M., J. Aronson, A.C. Newton, R.F. Pywell and J.M. Rey-Benayas (2011) Restoration of Ecosystem Services and Biodiversity: Conflicts and Opportunities. Trends in Ecology and Evolution 26(10): 541-549.

http://www2.uah.es/josemrey/Reprints/Bullock_RestorationReview_TREE_2011_online.pdf

Beyond Deforestation: Restoring Forests and Ecosystem Services on Degraded Lands

Despite continued forest conversion and degradation, forest cover is increasing in countries across the globe. New forests are regenerating on former agricultural land, and forest plantations are being established for commercial and restoration purposes. Plantations and restored forests can improve ecosystem services and enhance biodiversity conservation, but will not match the composition and structure of the original forest cover. Approaches to restoring forest ecosystems depend strongly on levels of forest and soil degradation, residual vegetation, and desired restoration outcomes. Opportunities abound to combine ambitious forest restoration and regeneration goals with sustainable rural livelihoods and community participation. New forests will require adaptive management as dynamic, resilient systems that can withstand stresses of climate change, habitat fragmentation, and other anthropogenic effects.

Policymakers, implementing agencies

Chazdon, R.L. (2008) Beyond Deforestation: Restoring Forests and Ecosystem Services on Degraded Lands. Science 320:1458-1460.

http://climatelab.org/@api/deki/files/316/=Beyond_Deforestation_Restoring_Forests_and_Ecosystem_Services_on_Degraded_Lands.pdf

The Road to Sustainability Must Bridge Three Great Divides

We argue here that this disconnection between our knowledge and our actions is largely caused by three "great divides": an ideological divide between economists and ecologists; an economic development divide between the rich and the poor; and an information divide, which obstructs communications between scientists, public opinion, and policymakers. These divides prevent our economies from responding effectively to urgent signals of environmental and ecological stress. The restoration of natural capital (RNC) can be an important strategy in bridging all of these divides.

Policymakers

Aronson, J. et al. (2010) The Road to Sustainability must Bridge Three Great Divides. Ann. N.Y. Acad. Sci. 1185: 225-236.

http://www.rncalliance.org/WebRoot/rncalliance/Shops/rncalliance/4DE4/2021/FF7F/7F40/24F2/C0A8/D2F8/3CF3/The_Road_to_sustainability_AnnalsNYAS2010.pdf

Restoration Ecology and Sustainable Development

The problem of ecosystem damage is international; a recent estimate suggests that 43% of the earth's terrestrial surface has a reduced capacity to supply benefits to humanity because of recent direct impacts of land use. The discipline of restoration ecology aims to provide a scientifically sound basis for the reconstruction of degraded or destroyed ecosystems and to produce self-supporting systems which are, to some degree, resilient to subsequent damage. This book looks at the main issues with a broad perspective, using case studies where appropriate and considering the economic and social context in which restoration is carried out. It is essential to reverse current trends by developing and using our knowledge of how to restore ecosystems. The book is therefore important for scientists, professionals in ecological restoration, landscape architects and environmental engineers, and more generally for those involved in sustainable development.

Policymakers, implementing agencies, indigenous and local communities

Urbanska, K.M., N.R. Webb and P.J. Edwards (eds.) (1997) Restoration Ecology and Sustainable Development. Cambridge University Press.

http://www.cambridge.org/gb/knowledge/isbn/item5708268/?site_locale=en_GB

Challenges in Integrating the Concept of Ecosystem Services and Values in Landscape Planning, Management and Decision Making

Despite the growing body of literature on ecosystem services, still many challenges remain to structurally integrate ecosystem services in landscape planning, management and design. This paper therefore aims to provide an overview of the challenges involved in applying ecosystem service assessment and valuation to environmental management and discuss some solutions to come to a comprehensive and practical framework.

Implementing agencies, policymakers

de Groot, R.S., R. Alkemade, L. Braat, L. Hein and L. Willemen (2010) Challenges in Integrating the Concept of Ecosystem Services and Values in Landscape Planning, Management and Decision Making. Ecological Complexity 7: 260-272

http://www.sciencedirect.com/science/article/pii/S1476945X09000968

Integrating Ecology and Economics for Restoration: Using Ecological Indicators in Valuation of Ecosystem Services

Because it can uniquely furnish insights into nonuse values for ecosystem services, survey-based Stated Preference (SP) valuation is widely used to estimate the benefits of ecological restoration. SP surveys ask respondents to select among restoration options yielding different ecological outcomes. This review examines the representation of ecological outcomes in SP studies seeking to quantify values for restoration of aquatic ecosystems. To promote the validity of ecological indicators used in SP valuation, we identified four standards: indicators should be measurable, interpretable, applicable, and comprehensive. We reviewed recent SP studies estimating the value of aquatic ecosystem services to assess whether ecological indicators in current use had these desirable properties.

Implementing agencies

Schultz, E.T., R.J. Johnston, K. Segerson and E.Y. Besedin (2012) Integrating Ecology and Economics for Restoration: Using Ecological Indicators in Valuation of Ecosystem Services. Restoration Ecology 20: 304-310.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2011.00854.x/abstract

Valuing Ecosystem Services: Theory, Practice, and the Need for a Transdisciplinary Synthesis

Ecosystem services valuation (ESV) is the method to tackle such a challenge. ESV is the process of assessing the contributions of ecosystem services to sustainable scale, fair distribution, and efficient allocation. It is a tool that (1) provides for comparisons of natural capital to physical and human capital in regard to their contributions to human welfare; (2) monitors the quantity and quality of natural capital over time with respect to its contribution to human welfare; and (3) provides for evaluation of projects that will affect natural capital stocks.

Policymakers, implementing agencies

Liu,S., R. Costanza, S. Farber and A. Troy (2010) Valuing Ecosystem Services: Theory, Practice, and the Need for a Transdisciplinary Synthesis. Ann. N.Y. Acad. Sci. 1185: 54-78.

https://www.pdx.edu/sites/www.pdx.edu.sustainability/files/Liu%20et%20al.%202010%20-%20Valuing%20Ecosystem%20Services.pdf

Water Security and Ecosystem Services: The Critical Connection

These case study summaries illustrate how ecosystem services were valued in specific cases, and demonstrate that it is possible to restore degraded ecosystems and the diversity of services they provide, within the context of sustainable management of water resources. The examples range from largely technical and technological approaches to socioeconomic approaches, and encompass both developed and developing nations.

Policymakers, implementing agencies

United Nations World Water Assessment Programme (2009) Water Security and Ecosystem Services: The Critical Connection. United Nations Environment Programme, Nairobi.

http://www.unep.org/themes/freshwater/pdf/the_critical_connection.pdf

Ecosystem and Human Well-being: Synthesis

This synthesis is organized around the core questions originally posed to the assessment: How have ecosystems and their services changed? What has caused these changes? How have these changes affected human well-being? How might ecosystems change in the future and what are the implications for human well-being? And what options exist to enhance the conservation of ecosystems and their contribution to human well-being?

Policymakers

Millennium Ecosystem Assessment (2005) Ecosystem and Human Well-being: Synthesis. Island Press, Washington, DC.

http://www.maweb.org/documents/document.356.aspx.pdf

Ecosystem Services>Australia

Multiple Environmental Services as an Opportunity for Watershed Restoration

This paper highlights the value of bundling payments for environmental services (PES) from watershed restoration, including water quality improvement and carbon sequestration coupled with wood production, and compares the net returns with the existing agricultural land-use, using as an example the 408 000 ha Warren–Tone watershed (WT) in south-western Australia. Payments for activities that lead to improvements in water quality could represent a new, additional source of income for landholders on the proviso that there is sufficient reforestation to reach the potable threshold. Alternatively, costs could be imposed on those whose land-use practices cause the release of salt into waterways.

Policymakers, implementing agencies

Townsend, P.V., R.J. Harper, P.D. Brennan, C. Dean, S. Wu, K.R.J. Smettem and S.E. Cook (2012) Multiple Environmental Services as an Opportunity for Watershed Restoration. Forest Policy and Economics 17: 45-58.

http://www.sciencedirect.com/science/article/pii/S1389934111000888

Ecosystem Services>China

A Policy-Driven Large Scale Ecological Restoration: Quantifying Ecosystem Services Changes in the Loess Plateau of China

As one of the key tools for regulating human-ecosystem relations, environmental conservation policies can promote ecological rehabilitation across a variety of spatiotemporal scales. However, quantifying the ecological effects of such policies at the regional level is difficult. A case study was conducted at the regional level in the ecologically vulnerable region of the Loess Plateau, China, through the use of several methods including the Universal Soil Loss Equation (USLE), hydrological modeling and multivariate analysis. An assessment of the changes over the period of 2000–2008 in four key ecosystem services was undertaken to determine the effects of the Chinese government's ecological rehabilitation initiatives implemented in 1999.

Policymakers, implementing agencies

Lu, Y., B. Fu, X. Feng, Y. Zeng, Y. Liu, R. Chang, G. Sun and B. Wu (2012) A Policy-Driven Large Scale Ecological Restoration: Quantifying Ecosystem Services Changes in the Loess Plateau of China. PLoS ONE 7(2).

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3280995/pdf/pone.0031782.pdf

China Ecosystem Services and Poverty Alleviation Situation Analysis and Research Strategy

This report, commissioned by NERC/ESRC/DfID, presents key findings in four sections of a situation analysis and research strategy for ecosystem services and poverty alleviation in China.

Policymakers

Final Report Submitted to: NERC, ESRC and DFID, 23 May 2008.

http://www.nerc.ac.uk/research/programmes/espa/documents/Final%20Report%20China%20-%20report.pdf

Ecosystem Service Values and Restoration in the Urban Sanyang Wetland of Wenzhou, China

Over the course of a year, we conducted a study on future restoration work in the Sanyang wetland, a degraded permanent river wetland that is close to the center of Wenzhou city, China. Our main objective was to plan the restoration by using both structural indices and a valuation of thewetland's ecosystem services, thereby linking the science to human welfare. Based on field surveys and research into the history of the study area, we calculated both the potential and current values of the main ecosystem services. The results showed that the potential value at the Sanyang wetland was 55,332 yuan ha–1 yr–1, while the current value was only 5807 yuan ha^{-1} yr^{-1}. In other words, 89.5% of the service value needs to be restored for the wetland to reach its potential value. We recommend that the service provided by the wetland's ability to purify the environment needs to be the top priority in restoration. In addition, water and sediment quality should also be greatly improved.

Policymakers, implementing agencies

Tonga, C., R.A. Feagin, J. Lu, X. Zhang, X. Zhu, W. Wang and W. He (2007) Ecosystem Service Values and Restoration in the Urban Sanyang Wetland of Wenzhou, China. Ecological Engineering 29: 249-258.

http://swamp.osu.edu/Academics/PDFs/Tong_Chunfu_Ecosystem_Svc_values.pdf

Emergy Synthesis of an Agro-forest Restoration System in Lower Subtropical China

The low subtropical zone is the most populated and seriously degraded area in China; therefore, highly efficient restoration of degraded lands is the key to sustainable development of this region. An agro-forest restoration mode consisting of an Acacia mangium forest, a Citrus reticulata orchard, a Pennisetum purpureum grassland, and a fishpond has been applied widely in this region. Emergy synthesis was performed at the system and subsystem levels of organization to clarify the structural and functional attributes of this restoration system for further optimization. Emergy indices, including four new indices, the emergy restoration ratio (ERR), the ecological economic product (EEP), the emergy benefit ratio (EBR), and the emergy benefit after exchange (EBE), were formulated to evaluate the ecological and economic benefits of this restoration mode.

Policymakers, implementing agencies

Lu, H.F., D.E. Campbell, Z.A. Li and H. Ren (2006) Emergy Synthesis of an Agro-forest Restoration System in Lower Subtropical China. Ecological Engineering 27(3): 175-192.

http://www.sciencedirect.com/science/article/pii/S0925857405002417

Ecosystem Services>Europe

Green Infrastructure: Sustainable Investments for the Benefit of Both People and Nature

Its main aim is to explain the basics of green infrastructure – a relatively new concept with many facets – relevant to Regional Policy. It also presents some approaches to this concept as identified in partner regions and describes the status of protected areas in Europe, the services that healthy ecosystem provide people with and the need to maintain their ecological coherence.

Policymakers

Lucius, I., R. Dan, D. Caratas, F. Mey, J. Steinert and P. Torkler (2011) Green Infrastructure: Sustainable Investments for the Benefit of Both People and Nature. SURF-nature project.

http://www.surf-nature.eu/uploads/media/Thematic_Booklet_Green_Infrastructure.pdf

Ecosystem Services>India

Assessing Wetland Ecosystem Services and Poverty Interlinkages: A General Framework and Case Study

The wise use of wetlands is expected to contribute to ecological integrity, as well as to secure livelihoods, especially of communities dependent on their ecosystem services for sustenance. This paper provides a conceptual framework capable of examining the goals of wetland management, poverty reduction and sustainable livelihoods. The framework highlights ecological character as a social construct and, with the notion of wetlands as settings for human well-being, builds a concept for assessing the inter-linkages between ecosystem services and livelihoods. The value and broader applicability of our framework is then tested by applying it to a case study from India (Lake Chilika) to evaluate the degree to which the mutual goals of improving both human well-being and the ecological character of wetlands have been achieved. The case study maps changes in human well-being induced in the basin communities due to external vulnerability contexts, institutions and freedoms. It further assesses the response strategies in terms of their impacts on ecological character and poverty status.

Policymakers, implementing agencies

Kumar, R., P. Horwitz, R.G. Milton, S.S. Sellamuttu, S.T. Buckton, N.C. Davidson, A.K. Pattnaik, M. Zavagli and C. Baker (2011) Assessing wetland ecosystem services and poverty interlinkages: a general framework and case study. Hydrological Sciences Journal 56(8): 1602-1621.

http://www.tandfonline.com/doi/abs/10.1080/02626667.2011.631496

Socio-Economic and Ecological Benefits of Mangrove Plantation: A Study of Community Based Mangrove Restoration Activities in Gujarat

This report deals with the assessment of social and ecological benefits accrued to the community after the implementation of the project. The study covered four different districts of Gujarat which includes Kachchh, Surat, Bharuch and Khambhat. The study is an attempt to prepare an interdisciplinary document by assessing the growth rate of planted mangroves under the REMAG project as well as benefits gained by the community in direct and indirect manner.

Policymakers, implementing agencies

Viswanathan, P.K., K. Pathak and I. Mehta (2010) Socio-Economic and Ecological Benefits of Mangrove Plantation: A Study of Community Based Mangrove Restoration Activities in Gujarat. Gujarat Ecology Commission (GEC), Gandhinagar.

http://www.esocialsciences.org/Articles/ShowArticle.aspx?acat=Institutional+Papers&aid=3852

Ecosystem Services>Latin America

The Ecology and Ecosystem Services of Native Trees: Implications for Reforestation and Land Restoration in Mesoamerica

This Special Issue includes articles produced as the result of a conference held in Panama City, Panama in January 2010 with the goal to summarize the state of knowledge of native species reforestation and associated ecosystems services in Mesoamerica. The introduction concludes with a call for continued research, including a mechanistic understanding of tree interactions with the biophysical environment in order to advance or knowledge of ecosystem services and their interactions. Results from these and other studies aimed at socioeconomic aspects of reforestation are critical to land use planning.

Implementing agencies, practitioners, indigenous and local communities

Hall, J.S., M.S. Ashton, E.J. Garen and S. Jose (2011) The Ecology and Ecosystem Services of Native Trees: Implications for Reforestation and Land Restoration in Mesoamerica. Forest Ecology and Management 261(10): 1553-1557.

http://www.sciencedirect.com/science/article/pii/S0378112710007115

Cost-effectiveness of Dryland Forest Restoration Evaluated by Spatial Analysis of Ecosystem Services

Although ecological restoration is widely used to combat environmental degradation, very few studies have evaluated the cost-effectiveness of this approach. We examine the potential impact of forest restoration on the value of multiple ecosystem services across four dryland areas in Latin America, by estimating the net value of ecosystem service benefits under different reforestation scenarios. The values of selected ecosystem services were mapped under each scenario, supported by the use of a spatially explicit model of forest dynamics. We explored the economic potential of a change in land use from livestock grazing to restored native forest using different discount rates and performed a cost–benefit analysis of three restoration scenarios. Results show that passive restoration is cost-effective for all study areas on the basis of the services analyzed, whereas the benefits from active restoration are generally outweighed by the relatively high costs involved.

Implementing agencies, policymakers

Bircha, J.C., A.C. Newton, C. Alvarez Aquino, E. Cantarello, C. Echeverría, T. Kitzbergerd, I. Schiappacasse and N. Tejedor Garavito (2010) Cost-effectiveness of Dryland Forest Restoration Evaluated by Spatial Analysis of Ecosystem Services. PNAS 107(50): 21925-21930.

http://www.pnas.org/content/107/50/21925.full.pdf+html

Ecosystem Services>Rwanda

Maintenance of Hydropower Potential in Rwanda Through Ecosystem Restoration

Today, through protection of the watershed surrounding the Ntaruka hydropower station, the plant has returned to full operational capacity. But the electricity crisis also spurred Rwanda to diversify its energy portfolio with support from the private sector. These initiatives include the capture of methane gas from Lake Kivu, use of geothermal energy and promotion of the country's abundant peat deposits for electricity production. The story of Rwanda's electricity sector demonstrates the need for diverse approaches to addressing complex problems and, in particular, the importance of integrated watershed management in promoting energy security.

Policymakers, implementing agencies

Hove, H., J-E. Parry and N. Lujara (?) Maintenance of Hydropower Potential in Rwanda Through Ecosystem Restoration. World Resources Report, Washington, DC.

http://www.worldresourcesreport.org/files/wrr/wrr_case_study_ecosystem_restoration_rwanda.pdf

Ecosystem Services>South Africa

Identifying Priority Areas for Ecosystem Service Management in South African Grasslands

Grasslands provide many ecosystem services required to support human well-being and are home to a diverse fauna and flora. Degradation of grasslands due to agriculture and other forms of land use threaten biodiversity and ecosystem services. Various efforts are underway around the world to stem these declines. The Grassland Programme in South Africa is one such initiative and is aimed at safeguarding both biodiversity and ecosystem services.

Policymakers, implementing agencies

Egoh, B.N., B. Reyers, M. Rouget and D.M. Richardson (2011) Identifying priority areas for ecosystem service management in South African grasslands. Journal of Environmental Management 92(6): 1642-1650.

http://137.215.9.22/bitstream/handle/2263/15971/Egoh_Identifying%282011%29.pdf?sequence=1

Provision of Ecosystem Services by Large Scale Corridors and Ecological Networks

Large scale landscape transformation and contingent habitat loss are among the greatest threats to ecological integrity and ecosystem health. One of the mitigation approaches used to deal with these pressures is to leave interconnected corridors and nodes as remnant ecological networks (ENs) within the transformed landscape. The South African forestry industry has already allocated 500,000 ha, one-third of the plantation holdings, consisting predominantly of natural grassland, as ENs among and within timber plantations. These ENs are intended to maintain structural, compositional and functional biodiversity. However, little scientific research is available on the effectiveness of these huge ENs for biodiversity conservation and maintenance of natural ecosystem function, although initial findings are encouraging.

Policymakers, implementing agencies

Samways, M.J., C.S. Bazelet and J.S. Pryke (2010) Provision of Ecosystem Services by Large Scale Corridors and Ecological Networks. Biodiversity Conservation 19: 2949-2962.

http://www.wetlands.za.net/kwazulunatal/papers/Samways%20et%20al%202010.pdf

Multi-functional Landscapes in Semi Arid Environments: Implications for Biodiversity and Ecosystem Services

Synergies between biodiversity conservation objectives and ecosystem service management were investigated in the Succulent Karoo biome (83,000 km2) of South Africa, a recognised biodiversity hotspot. Our study complemented a previous biodiversity assessment with an ecosystem service assessment. Stakeholder engagement and expert consultation focussed our investigations on surface water, ground water, grazing and tourism as the key services in this region. The key ecosystem services and service hotspots were modelled and mapped. We conclude that regional scale (biome level) approaches need to be combined with local level investigations (municipal level). Given the regional heterogeneity and varied nature of the impacts of drivers and threats, diverse approaches are required to steer land management towards sustainable multifunctional landscape strategies.

Policymakers, implementing agencies

O’Farrell, P.J. et al. (2010) Multi-functional Landscapes in Semi Arid Environments: Implications for Biodiversity and Ecosystem Services. Landscape Ecology 25(8): 1231-1246.

http://www.springerlink.com/content/n6p4942j265083l2/

Ecosystem Services>USA

Comparing Ecosystem Goods and Services Provided by Restored and Native Lands

We determined the relative benefits for eight categories of ecosystem goods and services associated with native and restored lands across the conterminous United States. Less than 10% of most native US ecosystems remain, and the proportion that is restored varies widely by biome. Restored lands offer 31%to 93%of native land benefits within a decade after restoration, with restored wetlands providing the most economic value and deserts providing the least. Restored ecosystems that recover rapidly and produce valuable commodities return a higher proportion of total value. The relative values of the benefits provided by restoration vary both by biome and by the ecosystem goods and services of interest. Our analysis confirms that conservation should be the first priority, but that restoration programs across broad geographic regions can have substantial value. “No net loss” policies should recognize that restored lands are not necessarily equivalent to native areas with regard to estimated ecosystem benefits.

Implementing agencies, policymakers

Dodds, W.K., K.C. Wilson, R.L. Rehmeier, G.L. Knight, S. Wiggam, J.A. Falke, H.J. Dalgleish and K.N. Bertrand (2008) Comparing Ecosystem Goods and Services Provided by Restored and Native Lands. BioScience 58(9): 837-845.

http://www.caryintranet.org/sites/default/files/Dodds%20et%20al%202008.pdf

Valuing Ecosystem Services from Wetlands Restoration in the Mississippi Alluvial Valley

This study assesses the value of restoring forested wetlands via the U.S. government's Wetlands Reserve Program (WRP) in the Mississippi Alluvial Valley by quantifying and monetizing ecosystem services. The three focal services are greenhouse gas (GHG) mitigation, nitrogen mitigation, and waterfowl recreation. Site- and region-level measurements of these ecosystem services are combined with process models to quantify their production on agricultural land, which serves as the baseline, and on restored wetlands. We adjust and transform these measures into per-hectare, valuation-ready units and monetize them with prices from emerging ecosystem markets and the environmental economics literature. By valuing three of the many ecosystem services produced, we generate lower bound estimates for the total ecosystem value of the wetlands restoration.

Policymakers

Jenkins, W.A., B.C. Murray, R.A. Kramer and S.P. Faulkner (2010) Valuing Ecosystem Services from Wetlands Restoration in the Mississippi Alluvial Valley. Ecological Economics 69: 1051-1061.

http://fds.duke.edu/db/attachment/1201

Privatizing Stream Restoration in the US

In this paper, we use a case study of the stream restoration field to demonstrate how the particular state and market logics of neoliberalism are shifting both the practice of restoration scientists and the relations between public and private sector science. In particular, the embrace of neoliberal environmental management regimes has intensified the demand for environmental scientists to produce applied science that can: (1) be taught as a standardized package; (2) be used by agencies to justify decisions; and (3) form the basis for new markets in ecosystems services. At this point, private sector science produces the most influential knowledge claims, the most widely used applications, and the primary educational system for stream restoration in the US. We argue that the needs of markets and regulatory agencies are heavily implicated in this privatization process, and that the resulting impacts on restoration science and the dynamics of the stream restoration field in the US thus cannot be described without attention to political–economic relations.

Policymakers, implementing agencies, indigenous and local communities

Lave, R., M. Doyle and M. Robertson (2010) Privatizing stream restoration in the US. Social Studies of Science 40: 677-703.

http://www.mitigationcredits.com/sites/default/files/Privatizing%20stream%20restoration.pdf

Linking Ecosystem Services, Rehabilitation, and River Hydrogeomorphology

Assignment of values for natural ecological benefits and anthropocentric ecosystem services in riverine landscapes has been problematic, because a firm scientific basis linking these to the river's physical structure has been absent. We highlight some inherent problems in this process and suggest possible solutions on the basis of the hydrogeomorphic classification of rivers. We suggest this link can be useful in fair asset trading (mitigation and offsets), selection of sites for rehabilitation, cost-benefit decisions on incremental steps in restoring ecological functions, and general protection of rivers.

Implementing agencies, policymakers

Thorp, J.H., J.E. Flotemersch, M.D. Delong, A.F. Casper, M.C. Thoms, F. Ballantyne, B.S. Williams, B.J. O'Neill and C.S. Haase (2010) Linking Ecosystem Services, Rehabilitation, and River Hydrogeomorphology. BioScience 60(1): 67-74.

http://www.people.ku.edu/~fb4/pubs/bioscience_rivers_2010.pdf

Ecosystem Services>Coastal/Marine

Ecosystem Services of the Tropical Seascape: Interactions, Substitutions and Restoration

The tropical coastal “seascape” often includes a patchwork of mangroves, seagrass beds, and coral reefs that produces a variety of natural resources and ecosystem services. By looking into a limited number of attempts at substitution and restoration of ecosystem services (e.g. artificial reefs, aquaculture in mangroves, artificial seawalls), we address the questions: (1) To what degree can technologies substitute for ecosystem services in the seascape? (2) How can ecosystem restoration reestablish not only the functions of direct value to humans, but also the ability of the systems to cope with future disturbance? Substitutions often imply the replacement of a function provided free by a solar powered, self-repairing resilient ecosystem, with a fossil-fuel-powered, expensive, artificial substitute that needs maintenance. Further, restoration usually does not focus on large-scale processes such as the physical, biological and biogeochemical interactions between mangroves, seagrass beds and coral reefs. Nonetheless, restoration might be the only viable management alternative when the system is essentially locked into an undesired community state (stability domain) after a phase-shift. We conclude that ecosystem services cannot be readily replaced, restored or sustained without extensive knowledge of the dynamics, multifunctionality and interconnectedness of ecosystems.

Policymakers, implementing agencies

Moberg, F. and P. Rönnbäck (2003) Ecosystem Services of the Tropical Seascape: Interactions, Substitutions and Restoration. Ocean & Coastal Management 46(1-2): 27-46.

http://www.sciencedirect.com/science/article/pii/S0964569102001199

Economic Valuation and Policy Priorities for Sustainable Management of Coral Reefs

The overall goal of the workshop was to identify future economic and policy research directions relevant to the sustainable management of coral reefs. The directions were to be identified through review and discussion of the effectiveness of policy instruments; analysis of past research findings; and analysis of the interdependency of community livelihood, coral reefs and their resources. For more effective policy instruments to be introduced by any government, we believe that economic valuation and cost benefit analysis are important processes. They will provide information on the various values of coral reefs, which could allow decision-makers to devise policies that optimize the services and functions provided by the reef ecosystems and their capacity to support the livelihood of coastal communities.

Policymakers, implementing agencies

Ahmed, M., C.K. Chong and H. Cesar (eds.) (2005) Economic Valuation and Policy Priorities for Sustainable Management of Coral Reefs, 2nd Edition. WorldFish Center Conference Proceedings 70.

http://www.worldfishcenter.org/resource_centre/CoralReef_14March2006_low%20res.pdf

Coral Reef Restoration and Artificial Reef Management, Future and Economic

On a global scale, the value of the total economic goods and services provided by coral reefs have been estimated to be US$375 billion per year with most of this coming from recreation, sea defence services and food production, this equates to an average value of around US$6,075 per hectare of coral reef per year. Degradation of reefs means the loss of these economic goods and services, and the loss of food security and employment for coastal peoples, many of them in developing countries and many of them living in poverty. In a healthy reef system which has not been physically damaged, an impacted area might be expected to recover naturally to its pre-disturbance state along a successional trajectory. If degradation is sufficiently severe or spatially extensive, then active restoration e.g. transplantation, in combination with management actions to reduce anthropogenic stress are necessary. Recoverability depends on the stressor, the impacted species/community and the temporal and spatial intensities of the stressor.

Policymakers, implementing agencies

Ahmed Ammar, M.S. (2009) Coral Reef Restoration and Artificial Reef Management, Future and Economic. The Open Environmental Engineering Journal 2: 37-49.

http://www.benthamscience.com/open/toenviej/articles/V002/37TOENVIEJ.pdf

Ecosystem Services Related to Oyster Restoration

The importance of restoring filter-feeders, such as the Eastern oyster Crassostrea virginica, to mitigate the effects of eutrophication (e.g. in Chesapeake Bay) is currently under debate. The argument that bivalve molluscs alone cannot control phytoplankton blooms and reduce hypoxia oversimplifies a more complex issue, namely that ecosystem engineering species make manifold contributions to ecosystem services. Although further discussion and research leading to a more complete understanding is required, oysters and other molluscs (e.g. mussels) in estuarine ecosystems provide services far beyond the mere top-down control of phytoplankton blooms, such as (1) seston filtration, (2) benthic–pelagic coupling, (3) creation of refugia from predation, (4) creation of feeding habitat for juveniles and adults of mobile species, and for sessile stages of species that attach to molluscan shells, and (5) provision of nesting habitat.

Implementing agencies, policymakers

Coen, L.D., R.D. Brumbaugh, D. Bushek, R. Grizzle, M.W. Luckenbach, M.H. Posey, S.P. Powers and S.G. Tolley (2007) Ecosystem Services Related to Oyster Restoration. Marine Ecology Progress Series 341: 303-307.

http://www.ci.uri.edu/ciip/fallclass/Docs_2008/Coen_etal_2007.pdf

Restoring Oyster Reefs to Recover Ecosystem Services

Declines in the abundance of oysters are a consequence of degradation of oyster reefs via destructive harvesting practices as well as overfishing, oyster disease, sedimentation, and water quality degradation, which collectively have greatly reduced the quantity and quality of intact reef habitat. Although restoration efforts have proceeded for several decades in estuaries throughout the eastern U.S., these efforts have traditionally focused on reversing the trend of declining landings rather than rebuilding sustainable oyster reefs that create habitat and other ecosystem services.

Implementing agencies, policymakers

Grabowski, J.H. and C.H. Peterson (2007) Restoring Oyster Reefs to Recover Ecosystem Services. Theoretical Ecology Series 4: 281-298.

http://www.sciencedirect.com/science/article/pii/S1875306X07800177

Management of the Marine Environment: Integrating Ecosystem Services and Societal Benefits with the DPSIR Framework in a Systems Approach

Taking a systems approach incorporating an understanding of The Ecosystem Approach, we integrate the DPSIR framework with ecosystem services and societal benefits, and the focus this gives allows us to create a specific framework for supporting decision making in the marine environment. Based on a linking of these three concepts, we present a set of basic postulates for the management of the marine environment and emphasise that these postulates should hold for marine management to be achieved. We illustrate these concepts using two case studies: the management of marine aggregates extraction in UK waters and the management of marine biodiversity at Flamborough Head, UK.

Policymakers, implementing agencies

Atkins, J.P., D. Burdon, M. Elliott and A.J. Gregory (2011) Management of the Marine Environment: Integrating Ecosystem Services and Societal Benefits with the DPSIR Framework in a Systems Approach. Marine Pollution Bulletin 62(2): 215-226.

http://www.sciencedirect.com/science/article/pii/S0025326X10005357

Discounting, Amenity Values, and Marine Ecosystem Restoration

We hope to initiate a conversation among marine resource economists on the role of discounting on ecosystem restoration and the long-term, sustainable management of marine resources. We relate the problem of discounting benefits of ecosystem restoration to that of valuing the amenities that restored ecosystems could produce, and suggest how empirical research might contribute to the debate over the proper discount rate to apply in valuing natural and ecosystem resources.

Policymakers, implementing agencies

Berman, M. and U.S. Sumaila (2006) Discounting, Amenity Values, and Marine Ecosystem Restoration. Marine Resource Economics 21: 211-219.

http://ageconsearch.umn.edu/bitstream/8587/1/21020211.pdf

Ecosystem Services>Forests/Woodlands

The Role of Forest Biodiversity in the Sustainable Use of Ecosystem Goods and Services in Agro-forestry, Fisheries, and Forestry

This symposium has been organized for providing further information to the 10th Conference of the Parties to the Convention on Biodiversity (CBD/COP10) which will be held in Nagoya, Japan in October, 2010. One of the objectives of CBD is to harmonize the conservation of bio-diversity with the sustainable use of the components of biodiversity. Recently, it has been recognized that conserving forest ecosystem leads to serve various goods and services to forests and their surrounding environments. In the symposium, we have focused on forest biodiversity and its importance for agriculture, forestry and fishery so that we can increase our understanding on values of forest biodiversity as ecosystem services which are vital to our society.

Policymakers, implementing agencies

Koizumi, T., K. Okabe, I. Thompson, K. Sugimura, T. Toma and K. Fujita (eds.) (2010) The role of forest biodiversity in the sustainable use of ecosystem goods and services in agro-forestry, fisheries, and forestry. Forestry and Forest Products Research Institute, Ibaraki.

http://www.ffpri.affrc.go.jp/pubs/chukiseika/documents/2nd-chukiseika18.pdf

Ecosystem Services>Inland Waters

Ecosystem Services of Peatlands: Implications for Restoration

The aim of this overview paper is to analyse the inclusion and use of the ecosystem services concept in scientific studies of degraded peatlands and peatland restoration. Publications indexed by the Institute of Science Information (ISI) Web of Science (WoS) from 1980 to October 2009 were analysed. Word combinations relevant to peatland ecosystem services in the title, keywords and abstract were used. We followed the division of ecosystem services into four categories: supporting, regulating, provisioning and cultural, as provided by the Millennium Ecosystem Assessment (2005). The analysis indicated that the concept of ecosystem services is not referred to explicitly in ISI WoS studies on peatland restoration. The interpretation of the content identified using search phrases related to various beneficial functions of peatlands showed that they mainly include information on regulating and supporting ecosystem services critical to sustaining vital ecosystem functions that deliver benefits to people. There are only a few articles addressing provisioning and cultural ecosystem services. One of the key issues concerning the effect of peatland restoration in the provisioning of ecosystem services is the balance of greenhouse gases and their role in global climate regulation.

Policymakers, implementing agencies

Kimmel, K. and Ü. Mander (2010) Ecosystem Services of Peatlands: Implications for Restoration. Progress in Physical Geography 34(4): 491-514.

http://ppg.sagepub.com/content/34/4/491.short

Extractive Industries

Mining and Biodiversity: A Collection of Case Studies - 2010

ICMM's 2010 edition of case studies is a snapshot of how field experience and good practices have developed since ICMM first started working on biodiversity: from our engagement in a Dialogue with the International Union for Conservation of Nature (IUCN) in 2004 and a publication of case studies to the 2006 release of Good Practice Guidance for Mining and Biodiversity. The 2010 case studies indicate that growing attention to biodiversity by ICMM members – and by the industry as a whole – is accompanied by the appearance of increasingly structured approaches to managing company impacts.

Implementing agencies, practitioners

International Council on Mining and Minerals (2010) Mining and Biodiversity: A Collection of Case Studies 2010. ICMM.

http://www.icmm.com/biodiversity-case-studies

IUCN-ICMM Roundtable Report on Restoration of Legacy Sites

The roundtable sought to take a forward-thinking and constructive approach, building on the examples of good practice in mine closure and post-mining regeneration projects identified in the survey, to determine how lessons can be transferred and developed for wider benefit. The roundtable served as a stimulus for improved understanding and trust-building among key stakeholders and provided a valuable initial forum for dialogue amongst all of those involved with legacy site restoration.

Implementing agencies

IUCN-ICMM (2008) Roundtable Report on Restoration of Legacy Sites. The Old Mill Inn, Toronto.

http://www.icmm.com/document/511

Rio Tinto and Biodiversity: Achieving Results on the Ground

Rio Tinto's goal is to have a "net positive impact" (NPI) on biodiversity. This means minimising the impacts of our business and contributing to biodiversity conservation to ensure a region ultimately benefits as a result of our presence. Our biodiversity strategy was launched in 2004 at the IUCN World Congress in Bangkok. This booklet provides information about Rio Tinto's biodiversity strategy, our approach and progress in its implementation and the tools and processes we have developed to help achieve our NPI goal.

Policymakers, implementing agencies

Rio Tinto

http://www.riotinto.com/documents/ReportsPublications/RTBidoversitystrategyfinal.pdf

Ecological Restoration of Land with Particular Reference to the Mining of Metals and Industrial Minerals: A Review of Theory and Practice

A restoration planning model is presented where the presence or absence of topsoil conserved on the site has been given the status of the primary practical issue for consideration in ecological restoration in mining. Examples and case studies are used to explore the important problems and solutions in the practice of restoration in the mining of metals and minerals. Even though ecological theory lacks general laws with universal applicability at the ecosystem level of organization, ecological knowledge does have high heuristic power and applicability to site-specific ecological restoration goals.

Implementing agencies

Cooke, J.A. and M.S. Johnson (2002) Ecological Restoration of Land with Particular Reference to the Mining of Metals and Industrial Minerals: A Review of Theory and Practice. Environmental Review 10: 41-71.

http://www.globalrestorationnetwork.org/uploads/files/LiteratureAttachments/115_ecological-restoration-of-land-with-particular-reference-to-the-mining-of-metals-and-industrial-minerals.pdf

The Use of Mycorrhizal Biotechnology in Restoration of Disturbed Ecosystem

This chapter discusses the different types of mycorrhizas, which play an essential function in altering disturbed lands into productive lands, the mechanisms by which disturbed ecosystem benefits through symbiotic associations and their interactions in the rhizosphere. The importance of reinstallation of mycorrhizal systems in the rhizosphere is emphasized and their impact in landscape regeneration and in bioremediation of contaminated soils are discussed.

Implementing agencies, practitioners

Quoreshi, A.M. (2008) The Use of Mycorrhizal Biotechnology in Restoration of Disturbed Ecosystem. Pp. 303-320 in Z.A. Siddiqui et al (eds.), Mycorrhizae: Sustainable Agriculture and Forestry, Springer.

http://www.krishibid.com/ebook/Mycorrhizae%20-%20Sustainable%20Agriculture%20and%20Forestry%20(Springer,%202008).pdf#page=310

Plantations as a Tool for Mine Spoil Restoration

Because of large-scale destruction of natural areas due to mining operations, a restoration strategy is needed as a part of the overall mining management plan. In restoration, emphasis is given first to build soil organic matter, nutrients and vegetation cover to accelerate natural recovery process. Tree plantations can be used as a tool for mine spoil restoration as they have ability to restore soil fertility and ameliorate microclimatic conditions. We discuss here various approaches of ecosystem restoration on mine spoil, criteria for the selection of plantation species and future research needs in this regard.

Implementing agencies, practitioners

Singh, A.N., A.S. Raghubanshi and J.S. Singh (2002) Plantations as a Tool for Mine Spoil Restoration. Current Science 82(12): 1436-1441.

http://www.iisc.ernet.in/currsci/jun252002/1436.pdf

The Potential of Earthworms to Restore Ecosystem Services after Opencast Mining: A Review

Among the potential species that are likely to be important early in mine land restoration, earthworms are particularly good candidates. They provide several ecosystem services that are likely to accelerate soil restoration, improve primary production and facilitate the restoration of a functional ecosystem in mining areas. These services include the following: increase in topsoil fertility, food for a wide range of predators and recycling of waste organic materials on rehabilitated areas. Here, we outline some of the challenges specifically facing opencast mining restoration and describe how the ecosystem services provided by earthworms may address some of these challenges.

Implementing agencies, practitioners

Boyer, S. and S.D. Wratten (2010) The Potential of Earthworms to Restore Ecosystem Services after Opencast Mining: A Review. Basic and Applied Ecology 11(3): 196-203.

http://www.sciencedirect.com/science/article/pii/S1439179110000101

Ecological Perspectives in Restoring Mine Waste Management Areas

Ecological Engineering (EE) in mining waste restoration aims to apply knowledge of natural biological systems known to be present on rocks or minerals, and in sediments to practically and beneficially achieve human and industrial objectives in a natural self-sustaining way. Omitting or discarding ecological processes in the engineering of the mine waste management areas severely prolongs the longevity of current mining practices, when chemical treatment must be provided for hundreds of years. The mining industry needs to adapt to the values and aims of contemporary environmental engineering, to develop systems, structures, methods, tools and infrastructures to protect human and environmental health. The progress made in our EE projects has been brought about through the enhancement of ecosystem function. We will here briefly describe the transformation of an acid mine drainage dump into a productive, biologically-active polishing lake.

Implementing agencies

Kalin, M. and W.N. Wheeler (2009) Ecological Perspectives in Restoring Mine Waste Management Areas. Procedia Environmental Sciences 9: 90-95.

http://www.sciencedirect.com/science/article/pii/S1878029611007778

Ecological Restoration of Novel Lake Districts: New Approaches for New Landscapes

Mine void pit lakes often contain water of poor quality with potential for environmental harm that may dwarf other mine closure environmental issues in terms of severity, scope, and longevity. This is particularly so when many pit lakes occur close together and thus form a new "lake district" landscape. Pit lakes that can be developed into healthy lake or wetland ecosystems as a beneficial end use provide opportunities for the mining industry to fulfil commitments to sustainability. Clearly articulated restoration goals and a strategic closure plan are necessary to ensure pit lake restoration toward a new, yet regionally-relevant, aquatic ecosystem, which can achieve sustainability as an out-of-kind environmental offset. Such an approach must also consider obstacles to development of a self-sustaining aquatic ecosystem, such as water quality and ecological requirements. We recommend integration of pit lakes into their catchments as a landscape restoration planning exercise with clearly-identified roles and objectives for each new lake habitat and its surrounds.

Implementing agencies, practitioners

McCullough, C.D. and E.J.B. van Etten (2011) Ecological Restoration of Novel Lake Districts: New Approaches for New Landscapes. Mine Water and the Environment 30(4): 312-319.

http://www.springerlink.com/content/r681w0h43x975383/?MUD=MP

Extractive Industries>Australia

Innovative Techniques for Promoting Fauna Return to Rehabilitated Sites Following Mining

This project stemmed from a recognition that, whilst many companies are attempting to establish native ecosystems following mining, little is documented regarding the best ways to promote fauna recolonisation. To review innovative techniques that companies around Australia are using to promote the return of fauna to native ecosystems established following mining. The findings were synthesized into practical recommendations that can be incorporated into rehabilitation operations and management plans to increase the rate at which faunal communities become re-established, and rare or uncommon species recolonise.

Implementing agencies, practitioners

Brennan K.E.C, O.G. Nichols and J.D. Majer (2005) Innovative Techniques for Promoting Fauna Return to Rehabilitated Sites Following Mining. Australian Center for Minerals Extension and Research (ACMER), Brisban and Minerals and Energy Research Institute of Western Australia MERIWA Report 248, Perth.

http://www.acmer.uq.edu.au/research/attachments/M362PromotingFaunaReturnFinalReportMERIWAJun05R.pdf

Revegetation of Mined Land in the Wet-Dry Tropics of Northern Australia: A Review

This review aims to assist the Alligator Rivers Region Technical Committee (ARRTC) in determining whether current practices and plans for revegetation at Ranger mine and elsewhere in the Alligator Rivers Region (ARR) are appropriate, and to establish research priorities in this region. The majority of information regarding revegetation in the wet-dry tropics (WDT) of northern Australia pertains to Ranger mine.

Practitioners, implementing agencies

Corbett, M.H. (1999) Revegetation of Mined Land in the Wet-Dry Tropics of Northern Australia: A Review. Supervising Scientist Report 150, Canberra.

http://www.environment.gov.au/ssd/publications/ssr/pubs/ssr150.pdf

Native Understorey Species Regeneration at NSW Coal Mines

This 3-year project, which was initiated by the Centre with funding from ACARP, had the objectives of investigating seed germination and viability of a range of understorey plant species native to coal mining areas in New South Wales and of developing methods of establishing these species on post-mined land.

Practitioners, implementing agencies

Gillespie, M.J., K. Baker and D.R. Mulligan (2001) Native understorey species regeneration at NSW coal mines. ACARP Project C7010, University of Queensland: Centre for Mined Land Rehabilitation.

http://www.acarp.com.au/abstracts.aspx?repId=C4009

Large-scale Mine Site Restoration of Australian Eucalypt Forests after Bauxite Mining: Soil Management and Ecosystem Development

Australia has developed some world leading practices in mine site restoration after bauxite mining (Bell 2001; Mulligan et al. 2006). Restoration techniques are underpinned by two key practices: (i) incremental rehabilitation, restoring land progressively to forest after it has been mined out (Fourie & Tibbett 2006; Koch 2007a) and (ii) integrating mining with restoration, a practice that requires joint planning by both ecological and mining engineers (Hinz 1992; Koch 2007a).

Implementing agencies

Tibbett, M. (2010) Large-scale Mine Site Restoration of Australian Eucalypt Forests after Bauxite Mining: Soil Management and Ecosystem Development. Pp309-327 in Ecology of Industrial Pollution (Batty, L.C. and K.B. Hallberg (eds.)), Cambridge University Press, New York.

http://faculty.ksu.edu.sa/Almutaz/Documents/Enviro_courses/ENVS-561/Ecology%20of%20Industrial%20Pollution_Ecological%20Reviews.pdf

Ecosystem Restoration Following Bauxite Mining in the Jarrah Forest of Western Australia – Supplement to Restoration Ecology

The native jarrah (Eucalyptus marginata) forest ecosystem of the Darling Range of southwestern Western Australia provides the people of the state with a source of timber, its major source of potable water, sites for recreation and leisure activity, and a number of mineral resources. Alcoa World Alumina Australia (Alcoa) under agreement with the State of Western Australia mines bauxite. The commercial potential of the alumina-rich laterites of the Darling Plateau was established in 1957, and by 1963, the company had developed a small, integrated bauxite mining and alumina refining operation, which has grown more or less continuously. In Western Australia, Alcoa operates two mines and three refineries, which produce about 13% of the world's annual alumina production, currently employs a staff of 4,000, and provides a return of more than $1 billion per annum to the economy of the state. The operation presently clears, mines, and restores approximately 550 ha of native forest each year. Early post-mining activity in the late 1960s involved little more than land stabilization; however, the overall aim of the today's restoration is to reestablish a stable forest ecosystem capable of sustaining all the premining elements of the native jarrah forest ecosystem.

Implementing agencies, practitioners, policymakers

Bell, D.T. and R.J. Hobbs (eds.) (2007) Ecosystem Restoration Following Bauxite Mining in the Jarrah Forest of Western Australia – Supplement to Restoration Ecology 15: S1–S144.

http://onlinelibrary.wiley.com/doi/10.1111/rec.2007.15.issue-s4/issuetoc

Extractive Industries>Brazil

Restoration of Tropical Moist Forests on Bauxite-Mined Lands in the Brazilian Amazon

We evaluated forest structure and composition in 9- to 13-year-old stands established on a bauxite-mined site at Trombetas (Pará), Brazil, using four different reforestation techniques following initial site preparation and topsoil replacement. These techniques included reliance on natural forest regeneration, mixed commercial species plantings of mostly exotic timber trees, direct seeding with mostly native early successional tree species, and mixed native species plantings of more than 70 tree species (the current operational restoration treatment at this site). Of these, the mixed native species plantings appeared to be at least risk of arrested succession due to the dominance of a broader range of tree species of different successional stages or expected life spans. In all treatments, several locally important families of primary forest trees (Annonaceae, Chrysobalanaceae, Lauraceae, Palmae and Sapotaceae) were markedly underrepresented due to a combination of poor survival of initial plantings and limitations on seed dispersal from the surrounding primary forest.

Implementing agencies, practitioners

Parrotta, J.A. and O.H. Knowles (1999) Restoration of Tropical Moist Forests on Bauxite-Mined Lands in the Brazilian Amazon. Restoration Ecology 7(2): 103-116.

http://onlinelibrary.wiley.com/doi/10.1046/j.1526-100X.1999.72001.x/abstract

Extractive Industries>Canada

Landscape Restoration after Oil Sands Mining: Conceptual Design and Hydrological Modeling for Fen Reconstruction

This study proposes a conceptual model to replace fen systems with fen peat materials supported by groundwater inflow from a constructed watershed. A numerical model is used to determine the optimum system geometry, including the ratio of upland to fen area, thickness and slope of sand materials, and thickness of peat and of the liner that would result in flows that sustain peat wetness to a critical threshold soil water pressure of 100 cm of water at a peat depth of 10 cm. We also test the sensitivity of the system to variations in the value and spatial configuration of the hydraulic conductivity (K) of locally available materials.

Practitioners, implementing agencies

Price, J.S., R.G. McLaren and D.L. Rudolph (2010) Landscape restoration after oil sands mining: conceptual design and hydrological modeling for fen reconstruction. International Journal of Mining, Reclamation and Environment 24(2): 109-123.

http://www.gret-perg.ulaval.ca/uploads/tx_centrerecherche/Price_etal_IntJMining_2010_01.pdf

Oil Sands Mining and Reclamation Cause Massive Loss of Peatland and Stored Carbon

We quantified the wholesale transformation of the boreal landscape by open-pit oil sands mining in Alberta, Canada to evaluate its effect on carbon storage and sequestration. Contrary to claims made in the media, peatland destroyed by open-pit mining will not be restored. Current plans dictate its replacement with upland forest and tailings storage lakes, amounting to the destruction of over 29,500 ha of peatland habitat. Landscape changes caused by currently approved mines will release between 11.4 and 47.3 million metric tons of stored carbon and will reduce carbon sequestration potential by 5,734–7,241 metric tons C/y. These losses have not previously been quantified, and should be included with the already high estimates of carbon emissions from oil sands mining and bitumen upgrading. A fair evaluation of the costs and benefits of oil sands mining requires a rigorous assessment of impacts on natural capital and ecosystem services.

Policymakers, implementing agencies

Rooney, R.C., S.E. Bayley and D.W. Schindler (2012) Oil Sands Mining and Reclamation Cause Massive Loss of Peatland and Stored Carbon. PNAS 2012 online.

http://www.pnas.org/content/early/2012/03/06/1117693108.full.pdf+html?with-ds=yes

Restoration of Alberta's Boreal Wetlands Affected By Oil, Gas and In Situ Oil Sands Development

Within the last ten years the energy sector has developed best management practices (BMPs) to lessen its impact on wetlands. Seismic lines, for example, have reduced their width from 6 m to 1.7 m. New technologies allow several wells to be placed on the same pad, greatly reducing infrastructure and resulting fragmentation. This literature review outlines a multitude of other BMPs that could greatly reduce the energy sector's impact on these fragile ecosystems. Unfortunately, provincial regulations do not require BMPs to be carried out; this means that stewardship relies on the good-will of oil and gas companies.

Implementing agencies

Graf, M.D. (2009) Restoration of Alberta's Boreal Wetlands Affected By Oil, Gas and In Situ Oil Sands Development. Ducks Unlimited Canada.

http://www.wlu.ca/documents/49597/Wetland_Restoration_Review1.pdf

Extractive Industries>China

Land Use-Based Landscape Planning and Restoration in Mine Closure Areas

This paper analyzes the periodic impact of mining activities on landscapes and then proposes planning concepts and principles. According to the landscape characteristics in mine closure areas, this paper classifies available landscape resources in mine closure areas into the landscape for restoration, for limited restoration and for protection, and then summarizes directions for their uses. This paper establishes the framework of spatial control planning and design of landscape elements from ‘‘macro control, medium allocation and micro optimization’’ for the purpose of managing and using this kind of special landscape resources. Finally, this paper applies the theories and methods to a case study in Wu’an from two aspects: the construction of a sustainable land-use pattern on a large scale and the optimized allocation of typical mine landscape resources on a small scale.

Policymakers, implementing agencies

Zhang, J., M. Fu, F.P. Hassani, H. Zeng, Y. Geng and Z. Bai (2011) Land Use-Based Landscape Planning and Restoration in Mine Closure Areas. Environmental Management 47: 739-750.

http://dept.cugb.edu.cn/deptweb/kjc/web_dizhi/yuanxi/upload/news_201192215224.pdf

Ecological Restoration and Land Reclamation in Open-cast Mines in Shanxi Province, China

Large areas of degraded mining land remains barren preventing agricultural, social and economically sustainable development in affected areas. As land is under short supply in China, exacerbated by the rapidly expanding population, it is now policy to restore or reclaim land degraded by mining. The aim is to develop sustainable and healthy arable-land ecosystems. This paper outlines the principles and approaches to ecological restoration, which have been adopted in Shanxi Province with reference to three typical surface mines.

Implementing agencies

Miao, Z. and R. Marrs (2000) Ecological Restoration and Land Reclamation in Open-cast Mines in Shanxi Province, China. Journal of Environmental Management 59(3): 205-215.

http://www.sciencedirect.com/science/article/pii/S0301479700903530

Ecological and Landscape Rehabilitation of a Quarry Site in Hong Kong

Quarrying for granite in Hong Kong, mainly for construction aggregates, has left huge and unsightly scars on the landscape. Recent government policy demands rehabilitation of the disturbed lands and restoration of the landscape adopting the ecological approach. At an active quarry, a method was tested for controlled restoration: blasting of the vertical rocky production faces to pile up the debris and to form artificial slopes that mimic those of the environs in a landform replication approach. On the scree blast piles, a soil cap of fine-earth materials with organic amendments was installed to grow mainly tropical leguminous trees. The restoration trial largely failed, with extensive death or poor performance of most plants. Recommendations are given on the application of organic amendments to establish and maintain soil structure, restore decomposition regime, and raise nutrient and moisture storage capacities for a modified approach that could overcome the site difficulties.

Implementing agencies, practitioners

Jim, C.Y. (2001) Ecological and Landscape Rehabilitation of a Quarry Site in Hong Kong. Restoration Ecology 9: 85-94.

http://onlinelibrary.wiley.com/doi/10.1046/j.1526-100x.2001.009001085.x/abstract

Ecological Restoration of Mineland with Particular Reference to the Metalliferous Mine Wasteland in China: A Review of Research and Practice

Metal-mined derelict land is often more metal toxic and deficient of macronutrients and is tougher for revegetation. Many substrate amelioration techniques were proposed and tolerant plant species were tested for use of reclamation of the metal-mined tailings. Five hyperaccumulator species have been reported in China for the potential use in phytoremediation. However, these accomplishments were all at laboratory or small-scale field demonstration stage and still far from the practical use in reality. To accelerate the restoration and utilization of mine wasteland, several recommendations are put forward in this review. Above these suggestions, the commitment and efficiency of the government at all levels are vital.

Policymakers, implementing agencies

Li, M.S. (2006) Ecological Restoration of Mineland with Particular Reference to the Metalliferous Mine Wasteland in China: A Review of Research and Practice. Science of The Total Environment 357(1-3): 38-53.

http://www.sciencedirect.com/science/article/pii/S0048969705003712

Extractive Industries>Czech Republic

Ecological Restoration of Central European Mining Sites: A Summary of a Multi-site Analysis

Sites disturbed by mining were surveyed in the Czech Republic, central Europe. The sites included spoil heaps from coal mining, sand and gravel pits, extracted peatlands and stone quarries. The following main conclusions emerged: i) potential for spontaneous succession to be used in restoration projects is between 95 and 100% of the total area disturbed; ii) mining sites, if mining is properly designed and then the sites are left to spontaneous succession, often act as refugia for endangered and retreating organisms, and may contribute substantially to local biodiversity.

Implementing agencies, practitioners

Prach, K., K. Řehounková, J. Řehounek and P. Konvalinková (2011) Ecological Restoration of Central European Mining Sites: A Summary of a Multi-site Analysis. Landscape Research 36(2): 263-268.

http://www.tandfonline.com/doi/abs/10.1080/01426397.2010.547571

Spontaneous Succession in Limestone Quarries as an Effective Restoration Tool for Endangered Arthropods and Plants

The view of post-mining sites is rapidly changing among ecologists and conservationists, as sensitive restoration using spontaneous succession may turn such sites into biodiversity refuges in human-exploited regions. However, technical reclamation, consisting of covering the sites by topsoil, sowing fast-growing herb mixtures and planting trees, is still commonly adopted. Until now, no multi-taxa study has compared technically reclaimed sites and sites left with spontaneous succession. Our results show that the high conservation potential of limestone quarries could be realized by allowing succession to progress spontaneously with minimal intervention. Given the threat to semi-natural sparsely vegetated habitats in many regions, active restoration measures at post-mining sites should be limited to maintenance of early successional stages, instead of acceleration of succession.

Practitioners, implementing agencies

Tropek, R. et al. (2010) Spontaneous Succession in Limestone Quarries as an Effective Restoration Tool for Endangered Arthropods and Plants. Journal of Applied Ecology 47: 139-147.

http://arachnology.cz/cas/app_contents/downloads/bibliography/ARA940.pdf

Extractive Industries>Greece

Land Reclamation and Ecological Restoration in a [Marine] Area

This study proposes the forestry as the future land use of the mining area because this concentrates the most advantages and this was the previous land use of the area (degraded forest land, used for animals grazing and firewood production). According to the results of the soil analysis, the soil as well as the topsoil of the study area is very poor in nutrients, with low content of clay and medium organic matter and very alkaline. This study proposes that the minimum depth of topsoil, which will be used for spoils covering, must be over 40 cm in order to support effectively the established species. Also, the topsoil should be enriched with organic matter (2% at least) and with the appropriate fertilizers in order to improve soil fertility and reduce alkalinity. Since the deposition peals are visible from a long distance due to the relief change and the colour contrast, the principles of landscape architecture must be applied for the ecological restoration of the disturbed land according to the visual characteristics of the landscape of the wider area.

Implementing agencies, practitioners

Zagas, T., T. Tsitsoni, P. Ganatsas, M. Tsakaldimi, T. Skotidakis and D. Zagas (2010) Land Reclamation and Ecological Restoration in a [Marine] Area. Int. J. Environ. Res. 4(4): 673-680.

http://www.sid.ir/en/VEWSSID/J_pdf/108220100412.pdf

Extractive Industries>India

Phytoremediation of Coal Mine Spoil Dump through Integrated Biotechnological Approach

Field experiment was conducted on mine spoil dump on an area of 10 ha, to restore the fertility and productivity of the coal mine spoil dump using integrated biotechnological approach. The approach involves use of effluent treatment plant sludge (ETP sludge), as an organic amendment, biofertilizers and mycorrihzal fungi along with suitable plant species. The results of the study indicated that amendment with effluent treatment plant sludge (ETP sludge), @ 50 ton/ha improved the physico-chemical properties of coal mine spoil. Thus, amendment and biofertilizer application provided better supportive material for anchorage and growth of the plant on coal mine spoil dump.

Practitioners, implementing agencies

Juwarkar, A.A. and H.P. Jambhulkar (2008) Phytoremediation of Coal Mine Spoil Dump through Integrated Biotechnological Approach. Bioresource Technology 99(11): 4732-4741.

http://www.sciencedirect.com/science/article/pii/S0960852407008061

Biotechnological Approach for Ecosystem Restoration of Mine Spoil Dump in India

Mine-degraded land (mine spoil dumps) has been restored through plantation in India by eco-friendly and cost-effective approach. This technology involves selection of suitable native plant species, isolation and inoculation of site-specific nitrogen-fixing microbial strains and nutrient mobilising vesicular arbuscular mycorrhizal species in combination with organic amendments to control the limiting factors associated with mine degraded land and to build up functional ecosystem. The approach improved the survival rate of the plants over 83-99% and attained the level of restoration to that in a productive soil. Results also indicated that the biodiversity of degraded land could be achieved within a short period of time through amendment and microbial intervention.

Practitioners

Juwarkar, A.A., S.K. Yadav and P.R. Thawale (2010) Biotechnological Approach for Ecosystem Restoration of Mine Spoil Dump in India. International Journal of Environment and Pollution 43(1-3): 251-263.

http://inderscience.metapress.com/content/u072800476021764/

Developmental Strategies for Sustainable Ecosystem on Mine Spoil Dumps: A Case of Study

An important goal of ecological rehabilitation is to accelerate natural successional processes to increase biological productivity, soil fertility and biotic control over biogeochemical fluxes within the recovering ecosystems. A new approach called Microbe Assisted Green Technology (MAGT) is an integrated biotechnological approach developed at National Environmental Engineering Research Institute (NEERI) through exhaustive laboratory as well as field studies and serve as a model for land reclamation and development of lush green vegetation on mine overburdens.

Implementing agencies, practitioners

Juwarkar, A.A., S.K. Yadav, P.R. Thawale, P. Kumar, S.K. Singh and T. Chakrabarti (2009) Developmental Strategies for Sustainable Ecosystem on Mine Spoil Dumps: A Case of Study. Environmental Monitoring and Assessment 157(1-4): 471-481.

http://www.springerlink.com/content/vv6536r2810r7623/

Ecological Restoration Strategies for Mining Areas of Gujarat

This study was undertaken at the instance of Gujarat Mineral Development Corporation to step up the protection and conservation of natural environment in mining areas. The study provided an action plan for long-term ecological rehabilitation of the three mining sites: 1) Panandhro Lignite mine; 2) Ambamata multimetal Mine; and 3) Ambadungar Fluorspar mine. Suitable guidelines and strategies have also been proposed for efficient development of mineral resources in the State without disturbing the balance of nature.

Policymakers, implementing agencies

Gujarat Ecology Commission (1997)

http://www.gesindia.org/eco.htm

http://www.worldcat.org/title/ecological-restoration-of-mining-sites-of-gmdc/oclc/54372769

Mine Spoil Restoration: A Strategy Combining Rainwater Harvesting and Adaptation to Random Recurrence of Droughts in Rajasthan

Here we propose a strategy for mine spoil restoration aimed at creating a multifunctional ecosystem in mine waste dumps. We suggest that dredging and sediment removal from traditional tanks and ponds can potentially be used to prepare the substratum over the mine wastes for direct seeding. It will also create enhanced decentralized water storage capacity for wildlife and people. Our strategy combines the concomitant revival of traditional water harvesting systems, ground water recharge, enhanced biomass production and an adaptation to random recurrence of droughts in Rajasthan.

Implementing agencies, practitioners, indigenous and local communities

Pandey, D.N., A.C. Chaubey, A.K. Gupta and H. Vardhan (2005) Mine Spoil Restoration: A Strategy Combining Rainwater Harvesting and Adaptation to Random Recurrence of Droughts in Rajasthan. International Network on Ethnoforestry, Jaipur.

http://www.indiaenvironmentportal.org.in/files/INEFWP2005.pdf

Experiments on Ecological Restoration of Coal Mine Spoil using Native Trees in a Dry Tropical Environment, India: A Synthesis

A series of experiments was conducted on the rehabilitation of mine spoil in a dry tropical region of India for determining the suitability of tree species for plantation, growth performance of selected indigenous species in monoculture and impact of the plantations on the restoration of biological fertility of soil. All of the 17 indigenous species examined could grow in the mine spoil and the growth of a majority of them could be improved by amending the mine spoil with NPK fertilizer.

Implementing agencies, practitioners

Singh, A.N. and J.S. Singh (2006) Experiments on Ecological Restoration of Coal Mine Spoil using Native Trees in a Dry Tropical Environment, India: A Synthesis. New Forests 31(1): 25-39.

http://www.springerlink.com/content/y100368465n25875/

Soil Reclamation of Abandoned Mine Land by Revegetation: A Review

Mining of mineral resources results in extensive soil damage, altering microbial communities and affecting vegetation leading to destruction of vast amounts of land. Reclamation is the process to restore the ecological integrity of these disturbed mine land areas. It includes the management of all types of physical, chemical and biological disturbances of soils such as soil pH, fertility, microbial community and various soil nutrient cycles that makes the degraded land soil productive. Productivity of soil can be increased by adding various natural amendments such as saw dust, wood residues, sewage sludge, animal manures, as these amendments stimulate the microbial activity which provides the nutrients (N, P) and organic carbon to the soil.

Practitioners, implementing agencies

Sheoran, V., A.S. Sheoran and P. Poonia (2010) Soil Reclamation of Abandoned Mine Land by Revegetation: A Review. International Journal of Soil, Sediment and Water 3(2).

http://scholarworks.umass.edu/cgi/viewcontent.cgi?article=1107&context=intljssw

Extractive Industries>Ireland

Rehabilitation of Industrial Cutaway Atlantic Blanket Bog in County Mayo, North-West Ireland

Even though Sphagnum mosses are not easy plants to manipulate on artificial substrates or in nonnatural environments, it is possible to revegetate large expanses of cutover peatland at a relatively low cost (in the range of US $900–1400 per hectare). Only long term monitoring of the current restoration projects will confirm if it is possible to restore the ecological functions of the cutover peatland to bring it back to a peat-accumulating ecosystem. Fen restoration of peat fields used for agriculture has been mostly studied in central Europe but much research is needed to develop sound restoration procedures for cutover peatlands and learn how to grow true mosses. Sphagnum farming (cultivation in nurseries) is promising and research in that area should be promoted.Not only would it be useful for supplying plant material for reintroduction in countries with low supply, but it could prove a useful source of biomass to ameliorate growing substrates.

Practitioners, implementing agencies

Farrell, C.A. and G.J. Doyle (2003) Rehabilitation of Industrial Cutaway Atlantic Blanket Bog in County Mayo, North-West Ireland. Wetlands Ecology and Management 11: 21-35.

http://www.springerlink.com/content/xgvu71410526x563/

Extractive Industries>Mexico

The Santa Maria Ecological Restoration Initiative

A company's biodiversity record influences its ability to access land, sea and other natural resources essential for its operations, as well as its ability to obtain both the legal and social right to operate in an area. It also affects a company's access to capital and insurance, particularly given that impact on biodiversity loss is increasingly recognized as a material risk for business by investors, financial institutions and insurance companies. For CEMEX, the protection of ecosystem services is fundamental to its ability to be a real conservation player and ensure the continuity of its business. CEMEX's Santa Maria Ecological Restoration Initiative aims to establish special relationships with key stakeholders, including government, NGOs, educational and research institutions. These relationships allow CEMEX to show its commitment to and respect for ecosystems, ensuring the sustainability of the natural resources needed by the company, ultimately impacting on its image and credibility in terms of environmental activities.

Implementing agencies

World Business Council for Sustainable Development Case Study (2008) The Santa Maria Ecological Restoration Initiative. WBCSD.

http://teebforbusiness.earthmind.net/files/The_Santa_Maria_Ecological_Restoration_Initiative.pdf

Extractive Industries>Portugal

Effect of Substrate Treatments on Survival and Growth of Mediterranean Shrubs in a Revegetated Quarry: An Eight-year Study

In 1998, a field experiment was performed in a limestone quarry at Outão (Serra da Arrábida, SW Portugal) to test different types of substrate improvement: NPK fertilizer, water-holding polymer, mycorrhizal inoculum, and combinations of these. Two-year old plants of three native woody species were planted ‐ carob (Ceratonia siliqua), wild-olive tree (Olea europaea var. sylvestris) and mastic (Pistacia lentiscus). Reports concerning the short-term results showed some differential effects of the assayed treatments on plant growth and physiology. The monitoring program was maintained, and here we report on the survival and growth of the introduced plants over eight years after planting. This prolonged study showed that, with the limited exception of fertilization, none of the assayed treatments added major advantages for plant survival or growth. Regardless of the tested substrate treatment, mortality was low and these native species became established in the revegetated area.

Practitioners, implementing agencies

Oliveira, G., A. Nunes, A. Clemente and O. Correia (2011) Effect of Substrate Treatments on Survival and Growth of Mediterranean Shrubs in a Revegetated Quarry: An Eight-year Study. Ecological Engineering 37(2): 255-259.

http://www.sciencedirect.com/science/article/pii/S0925857410003095

Extractive Industries>South Africa

Approaches to Biodiversity on Rehabilitated Minelands in South Africa

Rehabilitation of South African minelands has shifted from an emphasis on preventing erosion to the establishment of productive grasslands, to the restoration land creation) of a diversity of landscapes or habitats. Each of these might be characterised by greater or lesser biodiversity; this has resulted in an increasing diversity of post-mining land uses. Although such post mining land use is determined in a large measure by the local resources, regulatory organisations (once very dictatorial) increasingly take the desires of the local populace (interested and affected parties) into consideration, when considering the approval of post-mining land use objectives as set out in environmental management programs.

Implementing agencies, indigenous and local communities

Rethman, N. (2000) Approaches to Biodiversity on Rehabilitated Minelands in South Africa. Tropical Grasslands 34(3-4): 251-253.

http://www.tropicalgrasslands.asn.au/Tropical%20Grasslands%20Journal%20archive/PDFs/Vol_34_2000/Vol_34_03-04_00_pp251_253.pdf

Extractive Industries>USA

Restoring Forests and Associated Ecosystem Services on Appalachian Coal Surface Mines

Although forested ecosystems are valued by society for both marketable products and ecosystem services, forests have not been restored on most Appalachian mined lands because traditional reclamation practices, encouraged by regulatory policies, created conditions poorly suited for reforestation. Reclamation scientists have studied productive forests growing on older mine sites, established forest vegetation experimentally on recent mines, and identified mine reclamation practices that encourage forest vegetation re-establishment. Based on these findings, they developed a Forestry Reclamation Approach (FRA) that can be employed by coal mining firms to restore forest vegetation. Scientists and mine regulators, working collaboratively, have communicated the FRA to the coal industry and to regulatory enforcement personnel.

Implementing agencies, policymakers

Zipper, C.E., J.A. Burger, J.G. Skousen, P.N. Angel, C.D. Barton, V. Davis and J.A. Franklin (2011) Restoring Forests and Associated Ecosystem Services on Appalachian Coal Surface Mines. Environmental Management 47: 751-765.

http://anr.ext.wvu.edu/r/download/118333

Extractive Industries>Coastal/Marine

Gravel Seeding: A Suitable Technique for Restoring the Seabed Following Marine Aggregate Dredging?

Restoration of offshore marine habitats is a relatively new concept, with attempts in the European Union being largely instigated by requirements of various strategic directives. In this experiment, we investigate the practicality and effectiveness of gravel seeding, using a commercial aggregate dredging vessel, in order to recreate a gravel habitat. Although financial and practical constraints limited replication of the Treatment to one area, and so precluded strong statistical conclusions, our results suggested that the technique was both practically feasible, and successful in terms of returning the physical and biological attributes at the Treatment site to a state more representative of gravelly substrata in the wider, un-impacted environment.

Implementing agencies, policymakers

Cooper, K., S. Ware, K. Vanstaen and J. Barry (2011) Gravel Seeding: A Suitable Technique for Restoring the Seabed Following Marine Aggregate Dredging? Estuarine, Coastal and Shelf Science 91: 121-132.

http://www.sciencedirect.com/science/article/pii/S0272771410003537

Seabed Restoration Following Marine Aggregate Dredging: Do the Benefits Justify the Costs?

Given that it may be possible to undertake restoration there is a need to consider whether it is appropriate to do so. The purpose of this study is to try to answer this question through examination of a case study site (Area 222) in the Thames estuary, where impacts of dredging are shown to persist. Three issues are central to decisions about whether it is sensible to attempt seabed restoration following marine aggregate dredging. They include: i) necessity (e.g. a clear scientific rationale for intervention and/or a policy/legislative requirement), ii) technical feasibility (i.e. whether it is possible to restore the impacts), and iii) whether is it affordable (i.e. cost effective).

Implementing agencies, policymakers

Cooper, K., D. Burdon, J. Atkins, L. Weiss, P. Somerfield, M. Elliott, K. Turner, S. Ware and C. Vivian (2010) Seabed Restoration following marine aggregate dredging: Do the benefits justify the costs? MEPF-MALSF Project 09-P115, Cefas, Lowestoft.

http://cefas.defra.gov.uk/media/462981/mepf%2009%20p115%20final%20report.pdf

Extractive Industries>Coastal/Marine>Mangroves

Oil Spills in Mangroves: Planning and Response Considerations

This is not intended to be a specific guide for choosing cleanup methods, as many comprehensive versions of these exist already. Rather, we summarize current research on mangroves from the perspective of those who may need to make decisions about response in mangroves and present the information in an accessible format for people with some science or response background. Experienced responders unfamiliar with mangroves may want background on mangrove ecology, while biologists may want an overview of oil toxicity and mangroves and response and cleanup applied to mangrove ecosystems.

Policymakers, implementing agencies

Hoff, R. (ed.) (2010) Oil Spills in Mangroves: Planning and Response Considerations. Office of Response and Restoration, National Ocean Service, National Oceanic and Atmospheric Administration, Seattle.

http://response.restoration.noaa.gov/sites/default/files/Oil_Spill_Mangrove.pdf

Extractive Industries>Coastal/Marine>Salt Marshes

In Situ Burning Restores the Ecological Function and Structure of an Oil-Impacted Coastal Marsh

As the use of in situ burning for oil spill remediation in coastal wetlands accelerates, the capacity of this procedure to restore the ecological structure and function of oil-impacted wetlands becomes increasingly important. Thus, our research focused on evaluating the functional and structural recovery of a coastal marsh in South Louisiana to an in situ burn following a Hurricane Katrina-induced oil spill. We conclude that in situ burning is an effective way to remove oil and allow ecosystem recovery in coastal marshes.

Practitioners, implementing agencies

Baustian, J., I. Mendelssohn, Q. Lin and J. Rapp (2010) In Situ Burning Restores the Ecological Function and Structure of an Oil-Impacted Coastal Marsh. Environmental Management 46: 781-789.

http://www.springerlink.com/content/u6q337056j0765x1/

Finance Mechanisms

Paying for Restoration

The question of how society is going to pay for restoration has received little open discussion. We review existing literature and examples to explore two questions: How should ecological and economic considerations be balanced in determining expenditures on restoration projects? and How is society going to pay for the substantial costs involved? We discuss a number of different techniques for determining the amount of money to allocate to restoration efforts, including ecosystem replacement costs, quantifying ecosystem services, contingent valuation, and surrogate market price techniques. We then review different strategies for paying for restoration including private funding by the party responsible for the damage, public funding through taxes, voluntary contributions, and various public/private partnerships. We conclude by discussing other considerations in developing strategies to pay for restoration, including uncertainty, time-scale, evaluating success, and regional planning.

Policymakers, implementing agencies

Holl, K.D. and R.B. Howarth (2000) Paying for Restoration. Restoration Ecology 8(3): 260-267.

http://onlinelibrary.wiley.com/doi/10.1046/j.1526-100x.2000.80037.x/abstract

Finance Mechanisms>Eco-Loans

Forest Conservation and Restoration using Eco-loan Financing (ELF) in Costa Rica: Report on a Working Model

Nectandra Institute initiated a zero (monetary) interest loan program to qualifying rural community water management associations to buy watershed land in northern Costa Rica. Each borrowing community repays the capital and eco-interest (e.g., reforestation, regeneration of native forest on the properties, watershed restoration and management, continuing environmental education, etc). The project's effectiveness since 2007 in achieving its conservation and education objectives was due to: (1) the facility and flexibility of the negotiations between borrowers (entire communities) and lender (conservation promoter), (2) the communities' involvement and enthusiastic acceptance of the project's ecosystem conservation insured its post-loan continuance at the grassroots level, (3) the rapid reloaning of repaid capital fund, thereby amplifying the donors' investment several times, and (4) the potential for its replication and scalability elsewhere in Central America.

Implementing agencies, policymakers

Lennette, E.T., L.V. Villa, R.V. Chaves, M.E. Villalobos and A.U. Viquez (2011) Forest conservation and restoration using eco-loan financing (ELF) in Costa Rica: report on a working model. Conservation Letters 4: 402–407.

http://onlinelibrary.wiley.com/doi/10.1111/j.1755-263X.2011.00193.x/full

Microfinance, Social Capital and Natural Resource Management Systems: Conceptual Issues and Empirical Evidences

This is a review of various papers on microfinance programmes undertaken in natural resource management projects. An attempt is made to understand how the building of social capital enhances the propensity to develop natural capital. It is argued that there is lack of evidence to show that social capital increases the chance of improving natural capital and discusses various issues associated with natural resource management. The paper also stresses the need to adopt an integrated approach to seek evidence of natural resource building efforts through improving social capital.

Policymakers, implementing agencies

Murali, K.S. (2006) Microfinance, Social Capital and Natural Resource Management Systems: Conceptual Issues and Empirical Evidences. Int. J. Agricultural Resources Governance and Ecology 5(4): 327-337.

ftp://ftp.solutionexchange.net.in/public/mf/comm_update/res-02-050207-05.pdf

Finance Mechanisms>Payments for Ecosystem Services

Payments for Ecosystem Services - Getting Started: A Primer

This primer forms part of the activities implemented within the Global Strategy for the Millennium Ecosystem Assessment Follow-Up, and offers a starting point from which to assess the potential for PES in specific communities around the world. It also provides pointers for designing and planning PES transactions. Community-benefit driven, or “pro-poor” PES, is the main focus of this work.

Policymakers, implementing agencies, indigenous and local communities

UNEP (2008) Payments for Ecosystem Services - Getting Started: A Primer. Forest Trends, The Katoomba Group, and UNEP.

http://www.unep.org/pdf/PaymentsForEcosystemServices_en.pdf

Payments for Environmental Services: Some Nuts and Bolts

This paper aims to help demystify PES for non-economists, starting with a simple and coherent definition of the term. It then provides practical 'how-to' hints for PES design. It considers the likely niche for PES in the portfolio of conservation approaches. This assessment is based on a literature review, combined with field observations from research in Latin America and Asia. It concludes that service users will continue to drive PES, but their willingness to pay will only rise if schemes can demonstrate clear additionality vis-à-vis carefully established baselines, if trust-building processes with service providers are sustained, and PES recipients' livelihood dynamics is better understood. PES best suits intermediate and/or projected threat scenarios, often in marginal lands with moderate conservation opportunity costs.

Policymakers, implementing agencies, indigenous and local communities

Wunder, S. (2005) Payments for Environmental Services: Some Nuts and Bolts. CIFOR Occasional Paper No. 42.

http://www.cifor.org/publications/pdf_files/OccPapers/OP-42.pdf

Making Payments for Ecosystem Services Work

For over fifty years economists have developed instruments to address the market failures behind the collapse of ecosystem services reported by the Millennium Ecosystem Assessment (MA). These instruments include taxes, subsidies, user-charges, access-fees, penalties for non-compliance, and more recently, payments for ecosystem services (PES). PES schemes offer financial incentives for local actors to provide a wide range of ecosystem services untouched by normal market transactions. This Policy Brief explores the factors that make PES schemes work.

Policymakers, implementing agencies, indigenous and local communities

Arriagada, R. and C. Perrings (2009) Making Payments for Ecosystem Services Work. United Nations Environment Programme in collaboration with the ecoSERVICES Group, Arizona State University, on behalf of DIVERSITAS.

http://www.diversitas-international.org/resources/outreach/ArriagadaPerrings_2009_UNEPpolicybriezfESPayment.pdf

Payments for Ecosystem Services

Because ecosystem services are necessary for human survival, the GEF has pioneered the funding of mechanisms that reward good stewardship of natural resources, by promoting the concept and application of Payment for Ecosystem Services (PES) schemes. For the GEF, the concept of PES includes a variety of arrangements through which the beneficiaries of ecosystem services pay those providing the services. This publication summarizes the investments of GEF on PES schemes from a variety of institutional, thematic and geographic perspectives. The publication also highlights some of the trends and opportunities for the establishment of PES schemes to generate global environmental benefits.

Policymakers, implementing agencies

Global Environmental Facility

http://www.thegef.org/gef/sites/thegef.org/files/publication/PES_english.pdf

The Efficiency of Payments for Environmental Services in Tropical Conservation

Here I aim to demystify PES and clarify its scope for application as a tool for tropical conservation. I focus on the supply side of PES (i.e., how to convert PES funding into effective conservation on the ground), which until now has been widely neglected. I reviewed the PES literature for developing countries and combined these findings with observations from my own field studies in Latin America and Asia.

Policymakers, implementing agencies

Wunder, S. (2007) The Efficiency of Payments for Environmental Services in Tropical Conservation. Conservation Biology 21(1): 48-58.

http://dss.ucsd.edu/~ccgibson/docs/Wunder%20-%20The%20Efficiency%20of%20payments.pdf

Payments for Ecosystem Services: Legal and Institutional Frameworks

The overall goal of this publication is to 'close' this gap of legal and institutional analysis. It has the objective to give recommendations for the future development of legal and institutional frameworks which support water-related PES schemes and their implementation.

Policymakers, implementing agencies

Greiber, T. (ed.) (2009) Payments for Ecosystem Services: Legal and Institutional Frameworks. IUCN, Gland.

http://cmsdata.iucn.org/downloads/eplp_78_1.pdf

Payments for Environmental Services: A Survey and Assessment of Current Schemes

One finding of this report is that PES schemes may not constitute a cost-optimal instrument in all circumstances. Indeed, their success depends in great part from pre-existing conditions. PES systems work best when services are visible and beneficiaries are well organized, and when land user communities are well structured, have clear and secure property rights, strong legal frameworks, and are relatively wealthy or have access to resources.

Policymakers, implementing agencies

Mayrand, K. and M. Paquin (2004) Payments for Environmental Services: A Survey and Assessment of Current Schemes. By Unisféra International Centre for the Commission for Environmental Cooperation of North America.

http://www.cec.org/Storage/56/4894_PES-Unisfera_en.pdf

Economic Incentives for SFM and Landscape Restoration

Forests are lost because conservation and sustainable management is less profitable then deforestation, at least in the short-term. Payments for environmental services - such as watershed management, carbon storage, and biodiversity conservation - can alter this equation and make standing forests more profitable. Various mechanisms to generate payments for such services are emerging, from public payment systems to user rights and new trading schemes. Several cases of practical experience with payments for environmental services now exist and provide insights as to how such markets might function.

Policymakers, implementing agencies

Program on Forests (PROFOR) (2004) Economic Incentives for SFM and Landscape Restoration. Innovative Financing for SFM 1(2), The World Bank, Washington, DC.

http://www.profor.info/profor/sites/profor.info/files/docs/PES_English.pdf

Designing Payments for Ecosystem Services

The workshop was attended by more than 50 people, who came to Hanoi from as far afield as Samoa and India. Participants represented GEF International Waters projects and partner institutions from government and NGOs. Some brought perspectives mostly from freshwater systems, others from marine ecosystems. All brought an interest in understanding the principles behind PES and practical approaches to designing and implementing workable payment schemes.

Policymakers

IUCN (2008) Designing Payments for Ecosystem Services. Report from the East Asian Regional Workshop, Hanoi.

http://cmsdata.iucn.org/downloads/hanoi_pes_workshop_report_300608.pdf

Ecosystem-based Adaptation to Climate Change: What Scope for Payments for Environmental Services?

This paper addresses this gap by analyzing the opportunities and constraints of PES as an instrument for EBA. Specifically, we examine the potential for PES to address key elements for adaptation by focusing on three pathways: the user side, the provider side, and institutional and societal change. In addition, we assess whether PES fulfils key requirements for adaptation policy instruments, notably effectiveness, efficiency, and equity and legitimacy. We find that PES are not a panacea for all environmental services and country contexts, but can be promising adaptation policy instruments where certain preconditions are met and synergies prevail.

Policymakers, implementing agencies

Wertz-Kanounnikoff, S., B. Locatelli, S. Wunder and M. Brockhaus (2011) Ecosystem-based adaptation to climate change: what scope for payments for environmental services? Climate and Development 3(2): 143-158.

http://agents.cirad.fr/pjjimg/bruno.locatelli@cirad.fr/Wertz_2011_EBA_and_PES_manuscript.pdf

Restoration of Ecosystem Services for Environmental Markets

Ecological restoration is an activity that ideally results in the return of an ecosystem to an undisturbed state. Ecosystem services are the benefits humans derive from ecosystems. The two have been joined to support growing environmental markets with the goal of creating restoration-based credits that can be bought and sold. However, the allure of these markets may be overshadowing shortcomings in the science and practice of ecological restoration. Before making risky investments, we must understand why and when restoration efforts fall short of recovering the full suite of ecosystem services, what can be done to improve restoration success, and why direct measurement of the biophysical processes that support ecosystem services is the only way to guarantee the future success of these markets. Without new science and an oversight framework to protect the ecosystem service assets on which people depend, markets could actually accelerate environmental degradation.

Policymakers, implementing agencies, indigenous and local communities

Palmer, M.A. and S. Filoso (2009) Restoration of Ecosystem Services for Environmental Markets. Science 325: 575-576.

http://palmerlab.umd.edu/Palmer_and_Filoso_2009.pdf

Reconciling Theory and Practice: An Alternative Conceptual Framework for Understanding Payments for Environmental Services

This article provides an alternative and novel theoretical approach to the conceptualization and analysis of payments for environmental services (PES). We devote special emphasis to institutional and political economy issues, which have been somewhat neglected in the literature on PES. We argue that the Coasean and pure market approach dominating the conceptualization of PES in the literature cannot be easily generalized and implemented in practice. By contrast, taking into account complexities related to uncertainty, distributional issues, social embeddedness, and power relations permits acknowledging the variety of contexts and institutional settings in which PES operate. The alternative approach presented in this introductory article to the special section may be more appealing to PES practitioners, since while avoiding restrictive and prescriptive standpoints, it allows some key sources of complexities they usually deal with on the ground to be more easily understood.

Implementing agencies

Muradian, R., E. Corbera, U. Pascual, N. Kosoy and P.H. May (2010) Reconciling Theory and Practice: An Alternative Conceptual Framework for Understanding Payments for Environmental Services. Ecological Economics 69: 1202-1208.

http://www.ru.nl/publish/pages/561051/reconcilingtheory-muradian.pdf

Finance Mechanisms>Payments for Ecosystem Services>Asia/Africa/Latin America

Payments for Environmental Services in Latin America as a Tool for Restoration and Rural Development

We present evaluations of carbon stocks and biodiversity in pure and mixed native tree plantations in Costa Rica. To illustrate how monetary values can be assigned, we discuss a project that awarded PES to silvopastoral systems in Costa Rica, Nicaragua, and Colombia based on carbon stocks and biodiversity. PES can promote positive environmental attitudes in farmers. Currently this project is being scaled up in Colombia based on their positive experiences with PES as a tool to promote adoption. Compared to PES systems that include only one environmental service, systems that incorporate bundling or layering of multiple services can make sustainable land uses more attractive to farmers and reduce perverse incentives.

Policymakers, implementing agencies

Montagnini, F. and C. Finney (2011) Payments for Environmental Services in Latin America as a Tool for Restoration and Rural Development. Ambio 40(3): 285-297.

http://www.springerlink.com/content/u776378044253787/

Pro-Poor Compensation and Rewards for Environmental Services in the Tropics: Saving the Commons in Asia, Africa and Latin America?

Agroforestry can provide many 'environmental services' while also providing goods for local consumption and trade. The World Agroforestry Centre is proud that along with the International Fund for Agricultural Development it was an early investor in this field through the innovative RUPES project in Asia that now has a counterpart in Africa in the PRESA project. We are happy to share this bundle six recent peer-reviewed papers that advance the theory and praxis of a more responsible way of managing natural resources along with poverty reduction.

Policymakers, implementing agencies, indigenous and local communities

World Agroforestry Centre (2010) Pro-poor compensation and rewards for environmental services in the tropics: Saving the Commons in Asia, Africa and Latin America?

http://www.worldagroforestry.org/sea/Publications/files/book/BK0144-10/BK0144-10-1.PDF

http://www.ecologyandsociety.org/issues/view.php?sf=36

Payments for Environmental Services in Watersheds: Insights from a Comparative Study of Three Cases in Central America

We have compared three cases of payments for water-related environmental services (PES) in Central America, in terms of socioeconomic background, opportunity costs of forest conservation and stakeholders' perceptions of the conditions of water resources and other issues. We found that, in general, the opportunity costs are larger than the amounts paid, which apparently contradicts the economic foundation of PES schemes and suggests that the role of "intangibles" is important in inducing participation. The results also show that trade-offs between different environmental and social goals are likely to emerge in PES schemes, posing some doubts as to their ability to be multipurpose instruments for environmental improvement and rural development. We also found that PES schemes may work as a conflict-resolution instrument, facilitating downstream–upstream problem solving, though at the same time they might introduce changes in social perceptions of property rights.

Policymakers, implementing agencies

Kosoy, N., M. Martinez-Tuna, R. Muradian and J. Martinez-Alier (2007) Payments for Environmental Services in Watersheds: Insights from a Comparative Study of Three Cases in Central America. Ecological Economics 61: 446-455.

http://www.bio-nica.info/Biblioteca/Kosoy2007Payments.pdf

Finance Mechanisms>Payments for Ecosystem Services>China

An Eco-Compensation Policy Framework for the People's Republic of China: Challenges and Opportunities

This paper credits the PRC with having gained a wealth of experience with eco-compensation, which should influence both domestic and international understanding of the role of government in sustainable ecosystem services. This paper discusses the evolution of eco-compensation policy within the PRC's environmental regulatory framework, summarizes important national and international developments, provides policy recommendations, and suggests further action. The paper concludes that the PRC government would benefit from greater understanding of other countries' experience with PES programs and other market-based environmental policy instruments as it continues to work on an eco-compensation policy framework, which would enable private sector participation.

Policymakers

Zhang, Q. et al. (2010) An eco-compensation policy framework for the People's Republic of China: challenges and opportunities. Asian Development Bank, Mandaluyong City.

http://www.adb.org/publications/eco-compensation-policy-framework-peoples-republic-china-challenges-and-opportunities

Finance Mechanisms>Payments for Ecosystem Services>Costa Rica

Costa Rica's Payment for Environmental Services Program: Intention, Implementation, and Impact

We evaluated the intention, implementation, and impact of Costa Rica's program of payments for environmental services (PSA), which was established in the late 1990s. Payments are given to private landowners who own land in forest areas in recognition of the ecosystem services their land provides. To characterize the distribution of PSA in Costa Rica, we combined remote sensing with geographic information system databases and then used econometrics to explore the impacts of payments on deforestation. Payments were distributed broadly across ecological and socioeconomic gradients, but the 1997–2000 deforestation rate was not significantly lower in areas that received payments. Other successful Costa Rican conservation policies, including those prior to the PSA program, may explain the current reduction in deforestation rates. The PSA program is a major advance in the global institutionalization of ecosystem investments because few, if any, other countries have such a conservation history and because much can be learned from Costa Rica's experiences.

Sanchez-Azofeifa, G.A., A. Pfaff, J.A. Robalino and J.P. Boomhower (2007) Costa Rica's Payment for Environmental Services Program: Intention, Implementation, and Impact. Conservation Biology 21(5): 1165-1173.

http://www2.fiu.edu/~glows/readings/sanchez-azofeifaetal_2007.pdf

Paying for Environmental Services: An Analysis of Participation in Costa Rica's PSA Program

Costa Rica has long been a leader among developing countries in the design of and experimentation with innovative environmental programs. Since 1997, Costa Rica's 'Pagos de Servicios Ambientales' (Payments for Environmental Services) Program has provided payments to more than 4,400 farmers and forest owners for reforestation, forest conservation, and sustainable forest management activities. Econometric analysis of a survey of farmers and forest owners, including both PSA participants and nonparticipants, shows that farm size, human capital and household economic factors, and information variables significantly influence participation in PSA program alternatives. Large farmers and forest owners are disproportionately represented among program participants.

Policymakers, implementing agencies

Zbinden, S. and D.R. Lee (2005) Paying for Environmental Services: An Analysis of Participation in Costa Rica's PSA Program. World Development 33(2): 255-272.

http://intranet.catie.ac.cr/intranet/posgrado/politica_gober/2011/GOBERNANZA%20INTRANET%20MODULO%20III/seminario%203/Lecturas%20Seminario%203/12%20Paying%20for%20environmental%20services.pdf

Finance Mechanisms>Payments for Ecosystem Services>Mexico

Institutional Dimensions of Payments for Ecosystem Services: An Analysis of Mexico's Carbon Forestry Programme

From a performance point of view, the paper shows that the programme has been well received by rural communities, and carbon payments have contributed to increase household income and to enhance forest management practices and organisational skills. The paper also highlights sources of institutional interplay with local institutions and international climate policy, and it reveals the importance of capacity and scale issues in securing an effective and fair implementation of PES. The conclusion provides some policy recommendations for the future development of PES initiatives in Mexico and elsewhere.

Policymakers, implementing agencies

Corbera, E., C. González Soberanis and K. Brown (2009) Institutional Dimensions of Payments for Ecosystem Services: An Analysis of Mexico's Carbon Forestry Programme. Ecological Economics 68: 743-761.

http://era-mx.org/biblio/Forest_carbon_in_Mexico.pdf

Finance Mechanisms>Payments for Ecosystem Services>South Africa

The Working for Water Programme: Evolution of a Payments for Ecosystem Services Mechanism that Addresses both Poverty and Ecosystem Service Delivery in South Africa

A payments for ecosystem services (PES) system came about in South Africa with the establishment of the government-funded Working for Water (WfW) programme that clears mountain catchments and riparian zones of invasive alien plants to restore natural fire regimes, the productive potential of land, biodiversity, and hydrological functioning. The success of the programme is largely attributed to it being mainly funded as a poverty-relief initiative, although water users also contribute through their water fees. Nevertheless, as the hydrological benefits have become apparent, water utilities and municipalities have begun to contract WfW to restore catchments that affect their water supplies. This emerging PES system differs from others in that the service providers are previously unemployed individuals that tender for contracts to restore public or private lands, rather than the landowners themselves. The model has since expanded into other types of ecosystem restoration and these have the potential to merge into a general programme of ecosystem service provision within a broader public works programme.

Policymakers

Turpie, J.K., C. Marais, and J.N. Blignaut (2008) The Working for Water Programme: Evolution of a Payments for Ecosystem Services Mechanism that Addresses both Poverty and Ecosystem Service Delivery in South Africa. Ecological Economics 65(4): 788-798.

http://environmentportal.in/files/Ecological%20Economics%202008..pdf

The Working for Water Programme in South Africa: The Science Behind the Success

The Working for Water programme is remarkable in many ways, but in particular it has had extraordinary success in linking pressing environmental, social and economic issues in a country with many such issues to deal with. The initial premise that invasive plant species, particularly woody species from Australia and elsewhere, posed a major threat to the extraordinary biodiversity found in South Africa, and in particular the Cape region was complemented by research indicating that invasive woody species were likely to use more water than the native vegetation and hence would reduce runoff into streams, adversely affecting water supplies. This and subsequent research was then communicated by a special working group of scientists to key politicians in the newly elected democratic government.

Policymakers, implementing agencies

Hobbs, R.J. (2004) The Working for Water programme in South Africa: the science behind the success. Diversity and Distributions 10: 501-503.

http://onlinelibrary.wiley.com/doi/10.1111/j.1366-9516.2004.00115.x/pdf

Finance Mechanisms>Payments for Ecosystem Services>UK

Cost-Effectiveness Analysis of Woodland Ecosystem Restoration

In this study, the cost-effectiveness of government expenditure is investigated by comparing the cost of grant aid with the ecosystem restoration potential of new woodlands. An expert-based system for scoring ecosystem restoration potential is described and applied to over 200 new woodlands in a Geographic Information System. New woodlands varied considerably with respect to both cost and ecosystem restoration score, with the most cost-effective woodlands established close to existing woodlands using natural colonisation techniques. Overall ecosystem score was negatively correlated with government expenditure. Alternative approaches to improving the cost-effectiveness of grant aid are discussed.

Policymakers, implementing agencies

MacMillan, D.C., D. Harley and R. Morrison (1998) Cost-Effectiveness Analysis of Woodland Ecosystem Restoration. Ecological Economics 27(3): 313-324.

http://www.sciencedirect.com/science/article/pii/S0921800998000238

Finance Mechanisms>Payments for Ecosystem Services>Vietnam

How Can Governments Promote Strategic Approaches to Payments for Environmental Services (PES)? An Exploratory Analysis for the Case of Viet Nam

The aim of the study is to support governments by elaborating a methodological framework to inform PES development at the national level. The proposed framework is applied to Viet Nam, which has unique experience with forest allocation and PES-like programs, and is currently developing a national PES policy – one of the first in Asia to do so. Specifically, this study explores how objectives for PES development that reflect the socio-economic and bio-geographic context, as well as national development objectives, can be defined by governments, and how these objectives can influence the design of PES schemes. The study reveals substantial scope for defining such objectives in the context of Viet Nam and for their accommodation in PES design.

Policymakers

Wertz-Kanounnikoff, S. and H. Rankine (2008) Institute for Sustainable Development and International Relations (IDDRI), Paris.

http://www.iddri.org/Publications/Collections/Analyses/An_0308_Rankine-Wertz_PES-Viet-Nam.pdf

Finance Mechanisms>REDD+

Implications of the REDD Negotiations for Forest Restoration

This briefing provides an update on negotiations under the climate change convention on REDD (Reducing Emissions from Deforestation and forest Degradation), and their relevance to forest restoration. It has been prepared as part of the REFORLAN project, European Community Sixth Framework Programme contract number 032132. REFORLAN has carried out research on dry forest restoration in Mexico, Chile and Argentina.

Policymakers

Miles, L. (2010) Implications of the REDD negotiations for forest restoration. v2. UNEP World Conservation Monitoring Centre, Cambridge.

http://www.unep-wcmc.org/medialibrary/2010/09/26/05251f45/Implications%20REDD%20Negotiations%20Forest%20Restoration.pdf

What are the Ecosystem-Derived Benefits of REDD+ and Why Do They Matter?

The paper provides an analysis of the ecosystem-derived multiple benefits of REDD+. The range of different ecosystem-derived benefits is surveyed and the most important ones identified. There is the risk of environmental harms as well as benefits from REDD+. Some of the benefits are closely related to each other, and tend to co-occur. Benefits are delivered at different scales; some are primarily local while others may be national or global. Different REDD+ activities may give rise to different benefits and risks.

Policymakers

Dickson, B. and M. Osti (2010) What are the ecosystem-derived benefits of REDD+ and why do they matter? Multiple Benefits Series 1. Prepared on behalf of the UN-REDD Programme. UNEP World Conservation Monitoring Centre, Cambridge.

http://www.unep-wcmc.org/medialibrary/2011/08/30/fa1a374e/What%20are%20the%20ecosystemderived%20benefits%20of%20REDDplus.pdf

Opportunities and Challenges for Ecological Restoration within REDD+

Now that the REDD+ mechanism, which is not yet operational, has expanded beyond a sole focus on activities that affect carbon budgets to also include those that enhance ecosystem services and deliver other co-benefits to biodiversity and communities, forest restoration could play an increasingly important role. However, in many nations, there is a lack of practical tools and guidance for implementing effective restoration projects and programs that will sequester carbon and at the same time improve the integrity and resilience of forest ecosystems. Restoration scientists and practitioners should continue to engage with potential REDD+ donors and recipients to ensure that funding is targeted at projects and programs with ecologically sound designs.

Policymakers

Alexander, S. et al. (2011) Opportunities and Challenges for Ecological Restoration within REDD+. Restoration Ecology 19(6): 683-689.

http://www.wetlands.org/Portals/0/specialist%20groups/WRSG/Alexander%20et%20al%202011.pdf

Realising REDD+: National Strategy and Policy Options

This book seeks to answer these questions by examining what REDD+ at the national level might look like in four areas: institutions and processes to build the REDD+ framework, broad policy reforms to enable REDD+ implementation, sectoral policies to change incentives, and demonstration activities to test and learn from different approaches. There are no ‘one size fits all’ recommendations. Most chapters present a menu of options and discuss their merits in terms of their climate effectiveness, cost efficiency and equity outcomes, in addition to their generation of co-benefits: biodiversity and other environmental services, poverty reduction and sustainable livelihoods, governance and rights, and climate change adaptation.

Policymakers

English, French, Spanish, Bahasa Indonesia

Angelsen, A. et al. (eds.) (2009) Realising REDD+: National strategy and policy options. CIFOR, Bogor.

http://www.cifor.org/nc/online-library/browse/view-publication/publication/2871.html

Climate, Community & Biodiversity Project Design Standards

The CCB Standards have become the most widely used and respected international standard for the multiple-benefits of land-based carbon projects. As of November 2008, six projects had completed the validation process and ten projects were in the public comment phase. These 16 CCB projects aim to reduce greenhouse gas emissions by over 4.4 million tons of CO2e per year and cover 1,385,190 ha.

Policymakers, implementing agencies, indigenous and local communities

CCBA (2008) Climate, Community & Biodiversity Project Design Standards Second Edition. CCBA, Arlington.

http://www.climate-standards.org/standards/pdf/ccb_standards_second_edition_december_2008.pdf

A REDD+ Manual for Botanic Gardens

This booklet outlines the results and recommendations from a study which identified some of the capacity gaps in a series of pilot projects, and investigates whether the skills and expertise within botanic gardens have the potential to address these.

Policymakers, implementing agencies

Probert, C., S. Sharrock and N. Ali (2011) A REDD+ manual for botanic gardens. Botanic Gardens Conservation International (BGCI), Richmond, United Kingdom & Royal Botanic Gardens, Kew, London.

http://www.bgci.org/files/Worldwide/REDDplus/REDDplus.pdf

Methods for Assessing and Monitoring Change in the Ecosystem-derived Benefits of Afforestation, Reforestation and Forest Restoration

This report summarises the steps needed to design a system to assess and monitor change in ecosystem services resulting from afforestation, reforestation and forest restoration projects or programmes. Design of a monitoring scheme involves identifying how the results will be used, selecting appropriate indicators, defining a methodology for obtaining data and calculating indicators, and deciding how frequently monitoring will be undertaken. This report also refers to useful existing guidance on monitoring and indicators that will be of help in deciding what sort of monitoring to undertake and how to do so.

Policymakers

Doswald, N., M. Osti and L. Miles (2010) Methods for assessing and monitoring change in the ecosystem-derived benefits of afforestation, reforestation and forest restoration. Multiple Benefits Series 6. Prepared on behalf of the UN-REDD Programme. UNEP World Conservation Monitoring Centre, Cambridge.

http://www.unep-wcmc.org/medialibrary/2011/08/30/f85ec91c/Methods%20for%20assessing%20monitoring%20change%20in%20ARFR.pdf

Ecosystem Services from New and Restored Forests: Tool Development

This document, and the related Multiple Benefits Series 6 on Methods for assessing and monitoring change in the ecosystem-derived benefits of afforestation, reforestation and forest restoration have been produced to support Viet Nam in its goals of attaining multiple benefits from forest. This document provides a basis for estimating the probable impacts of different forest cover creation approaches on the ecosystem-derived benefits of biodiversity, water provision, soil conservation and non-timber forest products. The companion paper provides guidance on designing a monitoring system and selecting to provide direct evidence of impacts.

Policymakers

Miles, L., V. Kapos and E. Dunning (2010) Ecosystem services from new and restored forests: tool development. Multiple Benefits Series 5. Prepared on behalf of the UN-REDD Programme. UNEP World Conservation Monitoring Centre, Cambridge.

http://www.unep-wcmc.org/medialibrary/2011/08/30/ceb7812d/Ecosystem%20services%20biodiversity%20from%20new%20restored%20forests%20-%20tool%20dvpt.pdf

Approaches to Classifying and Restoring Degraded Tropical Forests for the Anticipated REDD+ Climate Change Mitigation Mechanism

With negotiations about REDD+ intensifying, an urgent issue now is how to restore degraded forests in socially viable, environmentally acceptable, and economically cost-effective manners. Restoration strategies should be a key element of any REDD+ agreement, and therefore such strategies need to be clarified. Here we focus on the causes of degradation, propose a classification scheme that reflects the severity of degradation, and point to ways to restore degraded forests that are appropriate for the classes proposed.

Policymakers

Sasaki, N., G.P. Asner, W. Knorr, P.B. Durst, H.R. Priyadi and F.E. Putz (2011) Approaches to Classifying and Restoring Degraded Tropical Forests for the Anticipated REDD+ Climate Change Mitigation Mechanism. International Society of Tropical Foresters Special Report.

http://www.istf-bethesda.org/specialreports/Sasaki-Durst/degraded-forests.pdf

Fisheries

Rebuilding Global Fisheries

After a long history of overexploitation, increasing efforts to restore marine ecosystems and rebuild fisheries are under way. Here, we analyze current trends from a fisheries and conservation perspective. In 5 of 10 well-studied ecosystems, the average exploitation rate has recently declined and is now at or below the rate predicted to achieve maximum sustainable yield for seven systems. Yet 63% of assessed fish stocks worldwide still require rebuilding, and even lower exploitation rates are needed to reverse the collapse of vulnerable species. Combined fisheries and conservation objectives can be achieved by merging diverse management actions, including catch restrictions, gear modification, and closed areas, depending on local context. Impacts of international fleets and the lack of alternatives to fishing complicate prospects for rebuilding fisheries in many poorer regions, highlighting the need for a global perspective on rebuilding marine resources.

Policymakers, implementing agencies

Worm, B. (2009) Rebuilding Global Fisheries. Science 325: 578-585.

http://www.sciencemag.org/content/325/5940/578.abstract

Reef Restoration as a Fisheries Management Tool

Conventional methods of reef restoration fail when water quality deteriorates from excessive temperature, pollution, or sediments. In contrast the Biorock method of coral reef restoration greatly increases coral growth rates and survival from stress, allowing rapid recovery of coral reefs where natural regeneration has failed, greatly increasing fish and shellfish populations, and even turning severely eroding beaches into growing ones. This is done without monoculture or food addition, and avoids the genetic impoverishment, disease, and nutrient pollution problems of conventional mariculture. Some fisherfolk in Indonesia, the Philippines, and elsewhere are now using the Biorock method to grow whole reefs and become sustainable harvesters of the ecosystems they create and manage.

Implementing agencies, practitioners

Goreau, T.J. and R.L. Hayes (2008) Reef Restoration as a Fisheries Management Tool in Fisheries and Aquaculture (P. Safran (ed.)) in Encyclopedia of Life Support Systems (EOLSS), Developed under the Auspices of the UNESCO, Eolss Publishers, Oxford.

http://www.eolss.net/Sample-Chapters/C10/E5-05-13.pdf

Back-to-the-Future: A Fresh Policy Initiative for Fisheries and a Restoration Ecology for Ocean Ecosystems

'Back-to-the-future' (BTF) is an integrative approach to a restoration ecology of the oceans that attempts to solve the fisheries crisis. To this end, it harnesses the latest understanding of ecosystem processes, developments in whole ecosystem simulation modelling, and insight into the human dimension of fisheries management. BTF includes new methods for describing past ecosystems, designing fisheries that meet criteria for sustainability and responsibility, and evaluating the costs and benefits of fisheries in restored ecosystems. Evaluation of alternative policy choices, involving trade-offs between conservation and economic values, employs a range of economic, social and ecological measures.

Implementing agencies, policymakers

Pitcher, T.J. (2005) Back-to-the-Future: A Fresh Policy Initiative for Fisheries and a Restoration Ecology for Ocean Ecosystems. Phil. Trans. R. Soc. B 360(1453): 107-121.

http://rstb.royalsocietypublishing.org/content/360/1453/107.full.pdf

Coral Reef and Fisheries Habitat Restoration in the Coral Triangle: The Key to Sustainable Reef Management

So much Coral Triangle reef habitat is now severely degraded that conservation alone is inadequate to preserve the ecosystems along with the species and people who depend on them. Only active, large-scale coral reef and fisheries habitat restoration can maintain fisheries, shore protection, ecotourism, and biodiversity ecosystem services of the Coral Triangle. Turning fisher folks from hunters into sustainable reef farmers will be essential to maintain fisheries and biodiversity in the future. The techniques to do so have been developed in Indonesia, but large-scale investment by governments and funding agencies is needed for training and application of new technologies within the context of community based restoration and management programs.

Policymakers, implementing agencies, indigenous and local communities

Goreau, T.J. (2009) Coral Reef and Fisheries Habitat Restoration in the Coral Triangle: The Key to Sustainable Reef Management in Proceeding of Coral Reef Management Symposium on Coral Triangle Area, Manado, Sulawesi, Indonesia, May 11-16, 2009.

http://globalcoral.org/Coral%20Reef%20and%20Fisheries%20Habitat%20Restoration%20in%20the%20Coral%20Triangle.pdf

Artificial Habitats and the Restoration of Degraded Marine Ecosystems and Fisheries

Artificial habitats in marine ecosystems are employed on a limited basis to restore degraded natural habitats and fisheries, and more extensively for a broader variety of purposes including biological conservation and enhancement as well as social and economic development. Included in the aims of human-made habitats classified as artificial reefs are: Aquaculture/marine ranching; promotion of biodiversity; mitigation of environmental damage; enhancement of recreational scuba diving; eco-tourism development; expansion of recreational fishing; artisanal and commercial fisheries production; protection of benthic habitats against illegal trawling; and research.

Implementing agencies, practitioners

Seaman, W. (2007) Artificial Habitats and the Restoration of Degraded Marine Ecosystems and Fisheries. Hydrobiologia 580:143-155.

http://www.sfrc.ufl.edu/faculty/Seaman/Seaman-Hydrobiologia2007.pdf

Biomanipulation: A Tool in Marine Ecosystem Management and Restoration?

Widespread losses of production and conservation values make large-scale ecosystem restoration increasingly urgent. Ecological restoration by means of biomanipulation, i.e., by fishing out planktivores to reduce the predation pressure on herbivorous zooplankton, has proved to be an effective tool in restoring degraded lakes and coastal ecosystems. Whether biomanipulation may prove a useful restoration method in open and structurally complex marine ecosystems is, however, still unknown. To promote a recovery of the collapsed stock of Eastern Baltic cod (Gadus morhua), large-scale biomanipulation of sprat (Sprattus sprattus), the main planktivore in the Baltic Sea, has been suggested as a possible management approach.

Implementing agencies, practitioners

Lindegren, M., C. Möllmann and L.A. Hansson (2010) Biomanipulation: a tool in marine ecosystem management and restoration? Ecological Applications 20: 2237-2248.

http://www.esajournals.org/doi/abs/10.1890/09-0754.1?journalCode=ecap

Alternatives to Conventional Management: Lessons from Small-Scale Fisheries

Based on long-term research on community-based resource management, and using small-scale fisheries as an example, alternatives to conventional management may be characterized by: a shift in philosophy to embrace uncertainty and complexity; an appreciation of fisheries as social-ecological systems and more broadly as complex adaptive systems; an expansion of scope of management information to include fishers. knowledge; formulation of management objectives that incorporate livelihood issues; and development of participatory management with community-based institutions and cross-scale governance. Such alternative management is adaptive as well as participatory in nature, as it engages the knowledge of resource users, their adaptive learning, and their institutions for self-governance.

Implementing agencies, indigenous and local communities

Berkes, F. (2003) Alternatives to Conventional Management: Lessons from Small-Scale Fisheries. Environments 31(1): 5-19.

http://www.umanitoba.ca/institutes/natural_resources/canadaresearchchair/Alternatives%20to%20Conventional%20Management%20-%20Lessons%20from%20Small-Scale%20Fisheries.pdf

Indigenous and Local Communities

Human Dimensions of Ecological Restoration: Integrating Science, Nature, and Culture

This book delves into the often-neglected aspects of ecological restoration that ultimately make the difference between projects that are successfully executed and maintained with the support of informed, engaged citizens, and those that are unable to advance past the conceptual stage due to misunderstandings or apathy. The lessons contained will be valuable to restoration veterans and greenhorns alike, scholars and students in a range of fields, and individuals who care about restoring their local lands and waters. For each category, the book offers an introductory theoretical chapter followed by multiple case studies, each of which focuses on a particular aspect of the category and provides a perspective from within a unique social/political/cultural setting.

Indigenous and local communities, practitioners, implementing agencies

Egan, D., E.E. Hjerpe and J. Abrams (2011) Human Dimensions of Ecological Restoration: Integrating Science, Nature, and Culture. Island Press, Washington, DC.

http://islandpress.org/ip/books/book/islandpress/H/bo8057440.html

Reciprocal Model for Meeting Ecological and Human Needs in Restoration Projects

We propose a model that shows that the ecological needs of the restoration area have the greatest potential to be met when human contributions are greatest. In turn, humans benefit increasingly as the restored ecosystem recovers. As human needs are addressed over time, their potential contributions to the restoration area increase. The extent to which contributions meet needs is enhanced or constrained by factors ranging from available technology and funding to community support. This ongoing loop of interactions between needs and contributions provides a basis for restoration planning and implementation which potentially reduces both ecological and human roadblocks to success. The model suggests that community-based projects will be most successful when experts train the group in restoration decision making, when expertise and leadership are developed within the group, and when participants experience group cohesiveness and a sense of personal reward.

Implementing agencies, practitioners, indigenous and local communities

Geist, C. and S.M. Galatowitsch (1999) Reciprocal Model for Meeting Ecological and Human Needs in Restoration Projects. Conservation Biology 13(5): 970-979.

http://onlinelibrary.wiley.com/doi/10.1046/j.1523-1739.1999.98074.x/abstract

The Role of Ecological Theory and Practice in Poverty Alleviation and Environmental Conservation

The fight against global poverty has gained momentum following the creation of the Millennium Development Goals, which aim to halve extreme poverty by 2015. Traditionally, ecologists have not played leading roles in poverty alleviation. Yet, knowledge of ecosystem functions and processes can be applied to improve the lives of millions of people, suffering from hunger, lacking clean drinking water and reliable, efficient energy sources, dying from preventable diseases, and suffering disproportionately from natural disasters. Here, we describe ways in which ecologists can apply ecological theory and tools to help improve the efficacy of poverty alleviation programs.

Policymakers, implementing agencies

DeClerck, F., J.C. Ingram and C.M. Rumbaitis del Rio (2006) The Role of Ecological Theory and Practice in Poverty Alleviation and Environmental Conservation. Frontiers in Ecology and the Environment 4(10): 533-540.

http://faculty.cveg.uark.edu/soerens/BelizeClass/EcologicalPoverty.pdf

The Role of Indigenous Peoples in Biodiversity Conservation

A principal aim of this study is to get a better sense of what the World Bank (WB) needs to know in order to engage Indigenous Peoples (IPs) more effectively in biodiversity conservation projects and programs. It is in this sense that the reporting is geared to Bank Task Team leaders, advisors, directors, and managers and also government and nongovernmental organization (NGO) personnel engaged in biodiversity conservation programs. Indigenous peoples might also benefit from the report´s presentation of tools to seeking international funding for biodiversity-related activities in their ancestral territories. In addition, the report assesses some of the current forms of engagement with indigenous peoples in biodiversity and identifies concrete recommendations for improving that engagement.

Policymakers, implementing agencies, indigenous and local communities

Sobrevila, C. (2008) The Role of Indigenous Peoples in Biodiversity Conservation. The World Bank, Washington, DC.

http://siteresources.worldbank.org/INTBIODIVERSITY/Resources/RoleofIndigenousPeoplesinBiodiversityConservation.pdf

Cultural Keystone Species: Implications for Ecological Conservation and Restoration

Given that biological conservation and ecological restoration embody human cultures as crucial components, one approach that may improve success in overall conservation or restoration efforts is to recognize and focus on cultural keystone species. In this paper, we explore the concept of cultural keystone species, describe similarities to and differences from ecological keystone species, present examples from First Nations cultures of British Columbia, and discuss the application of this concept in ecological restoration and conservation initiatives.

Policymakers, implementing agencies, indigenous and local communities

Garibaldi, A. and N. Turner (2004) Cultural keystone species: implications for ecological conservation and restoration. Ecology and Society 9:1.

http://www.ecologyandsociety.org/vol9/iss3/art1/main.html

Who's In and Why? A Typology of Stakeholder Analysis Methods for Natural Resource Management

Stakeholder analysis means many things to different people. Various methods and approaches have been developed in different fields for different purposes, leading to confusion over the concept and practice of stakeholder analysis. This paper asks how and why stakeholder analysis should be conducted for participatory natural resource management research. The range of methods that can be used to carry out each type of analysis is reviewed. These methods and approaches are then illustrated through a series of case studies funded through the Rural Economy and Land Use (RELU) programme. These case studies show the wide range of participatory and non-participatory methods that can be used, and discuss some of the challenges and limitations of existing methods for stakeholder analysis. The case studies also propose new tools and combinations of methods that can more effectively identify and categorise stakeholders and help understand their inter-relationships.

Implementing agencies

Reed, M.S., A. Graves, N. Dandy, H. Posthumus, K. Hubacek, J. Morris, C. Prell, C.H. Quinn, L.C. Stringer (2009) Who's In and Why? A Typology of Stakeholder Analysis Methods for Natural Resource Management. Journal of Environmental Management 90: 1933–1949.

http://www.fao.org/nr/lada/index.php?option=com_docman&task=doc_download&gid=339&Itemid=166&lang=en

Indigenous and Local Communities>Australia

Desert Knowledge: Integrating Knowledge and Development in Arid and Semi-arid Drylands

The value of the knowledge that local traditions and science have generated about living sustainably in deserts is being promoted and extended through the 'desert knowledge' movement in Australia. The Australian research reported here, together with a contribution from Niger that offers a contrast and some lessons for Australia, is largely underpinned by a neopopulist paradigm of development stressing respect for local knowledge, participatory practice and empowerment. Research in partnership with desert Aboriginal groups is contributing to their engagement with new livelihood opportunities. The local knowledge of livestock graziers is also being engaged to support sustainable management of desert water sources and landscapes for multiple values.

Indigenous and local communities, implementing agencies, practitioners, policymakers

Davies, J. and S. Holcombe (2009) Desert Knowledge: Integrating Knowledge and Development in Arid and Semi-arid Drylands. Geojournal 74(5): 363-375.

http://www.springerlink.com/content/l69gw86346lv8439/

Australian Approaches for Managing 'Country' Using Indigenous and Non-Indigenous Knowledge

This paper synthesises the lessons learnt and challenges encountered when applying Indigenous and non-Indigenous knowledge and methods in natural and cultural resource management (NCRM) in northern and central Australia. We primarily draw on the papers within this special issue of Ecological Management & Restoration, which originated largely from the Indigenous land management symposium at the 2010 Ecological Society of Australia conference. Many of the papers and therefore this article discuss practical experiences that offer insight for enhanced on-ground cross-cultural NCRM and can inform broader thinking and theoretical critiques. A wider literature is also drawn upon to substantiate the points and broaden the scope of the synthesis.

Policymakers, indigenous and local communities

Ens, E.J., M. Finlayson, K. Preuss, S. Jackson and S. Holcombe (2012) Australian Approaches for Managing 'Country' Using Indigenous and Non-Indigenous Knowledge. Ecological Management and Restoration 13(1).

http://onlinelibrary.wiley.com/doi/10.1111/j.1442-8903.2011.00634.x/pdf

Threatened Species Recovery Planning and Aboriginal Community Involvement

The Aboriginal Involvement in Recovery Planning Project has sought to address numerous issues. Most importantly, it has focused on assessing collaborative mechanisms, which will allow ongoing partnerships in this area of planning across NSW. It has also attempted to assess how the NPWS might meet the new legislative requirement to consider Indigenous interests while at the same time having limited resources and a heavy workload which requires hundreds of Recovery Plans to be produced in the next few years.

Implementing agencies, policymakers

English, A. and L. Baker (2003) Threatened Species Recovery Planning and Aboriginal Community Involvement. NSW Environment Discussion Paper.

http://www.environment.nsw.gov.au/resources/cultureheritage/aboriginalInvolvementThreatenedSpecies.pdf

Dugong and Marine Turtle Project Final Report

The Australian Government's Performance Story evaluation of the NAILSMA Dugong and Marine Turtle Project (DMTP) concluded the project was a "standout success" that had "outstripped the original expectations". The project has created innovative communication and management tools and established on-ground monitoring and research activities that address many dugong and marine turtle management issues including sustainable catch management. The networks established by the project bring together Indigenous and non-Indigenous people in effective partnerships across the range of these iconic migratory species.

Indigenous and local communities, implementing agencies, policymakers

North Australian Indigenous Land and Sea Management Alliance (2009) Dugong and Marine Turtle Project Final Report. Natural Heritage Trust Regional Competitive Component.

http://www.nailsma.org.au/nailsma/publications/downloads/Final-Report-web.pdf

Community Participation in Restoring Australian Forest Landscapes

Australian communities actively participate in protecting and restoring forests on both public and private land. This paper examines the national, regional and local work of communities engaged in restoring Australian forest landscapes.

Policymakers, implementing agencies

Bartlett, A.G. (2010) Community Participation in Restoring Australian Forest Landscapes. Proceedings of the 18th Commonwealth Forestry Conference.

http://www.cfc2010.org/papers/session11/Bartlett-s11.pdf

Indigenous and Local Communities>Borneo

Restoring a 'Biological Desert' on Borneo

For 30 years in Indonesia, Willie Smits observed how one conservation project after another would fail without local community support. Finally, Smits hit upon a solution: An economic incentive for area residents became a cornerstone of his Samboja Lestari project, an ambitious effort to transform a clear-cut site in Borneo into a mix of agroforestry plots and orangutan habitat.

Policymaker, implementing agencies, indigenous and local communities

Normile, D. (2009) Restoring a 'Biological Desert' on Borneo. Science 325(5940): 557.

http://www.sciencemag.org/content/325/5940/557.short

Indigenous and Local Communities>Brazil

Public Awareness Generation for the Reforestation in Amazon Tropical Lowland Region

Based on the great success the senior author had in Japan and other places in SE Asia, the two authors started similar activities in the Brasilian Amazon lowland cities. In order to demonstrate to the concerned citizens and to the youth, experiments were undertaken in which one could demonstrate how the population in general could assist the reforestation of the largely threatened tropical forest. Two kinds of experiments were carried out to demonstrate the reforestation with native trees from the Amazon lowland tropical forest.

Indigenous and local communities, implementing agencies, policymakers

Miyawaki, A. and S. Abe (2004) Public Awareness Generation for the Reforestation in Amazon Tropical Lowland Region. Tropical Ecology 45(1): 59-65.

http://www.tropecol.com/pdf/open/PDF_45_1/45105.pdf

Indigenous and Local Communities>Cambodia

Adaptive Co-Management: Lessons from Coastal Cambodia

This paper focuses on how community-based management is unfolding in coastal Cambodia through the facilitation of a donor-funded, Cambodian-led government research team. Coastal communities in Peam Krasaop Wildlife Sanctuary illustrate the strong potential for community-government partnerships. Several lessons are highlighted: community-based management requires support from the provincial and national level; facilitation between stakeholders is important; and experimentation is an essential component of management. Creative models of community-based management, emerging despite the absence of a legal framework, may be best described as systems of adaptive co-management combining the elements of trial and error, learning-by-doing, and the sharing of management responsibility.

Indigenous and local communities, implementing agencies, policymakers

Marschke, M. and K. Nong (2003) Adaptive Co-Management: Lessons from Coastal Cambodia. Canadian Journal of Development Studies 24(3): 369-383.

http://www.umanitoba.ca/institutes/natural_resources/canadaresearchchair/Adaptive%20Co-Management%20-%20Lessons%20from%20Coastal%20Cambodia.pdf

Indigenous and Local Communities>Canada

Communities Connecting to Place: A Strategy for Eelgrass Restoration in British Columbia

Discussions with coastal conservation groups which have mapped eelgrass beds in twenty communities in British Columbia over the last three years have culminated in the production of this document. These stewardship groups make up the B.C. Eelgrass Network, which is part of the Seagrass Conservation Working Group (SCWG), a consortium of scientists, stewardship groups, governmental agencies and researchers committed to the conservation and protection of seagrasses in B.C.

Policymakers, implementing agencies, indigenous and local communities

Wright, N. (2005) Communities Connecting to Place: A Strategy for Eelgrass Restoration in British Columbia. Seagrass Conservation Working Group, British Columbia, Canada.

http://www.nilecreek.org/pdf/Strategy-Eelgrass-Restoration.pdf

Ecological Rehabilitation and Public Participation: General Considerations and Empirical Evidence from a Creek Rehabilitation Scheme near Cologne, Germany

Ecological rehabilitation of rivers and streams has become a common practice in environmental planning and water management throughout Europe. With regard to rehabilitation projects public participation and bottom-up planning processes are favoured by state and local regulations alike. However, there are mixed experiences about public support of rehabilitation schemes. Whereas people support environmental improvements on a general level, acceptance is dwindling when conflicts of use arise or access to certain areas is going to be restricted. This study focuses on the assessment of public attitudes to rehabilitation and on improving the understanding of people's preferences. The results of a representative questionnaire survey conducted in three villages along a rehabilitated creek in a densely populated suburban area near Cologne show that local support for rehabilitation is generally high.

Indigenous and local communities, implementing agencies, policymakers

Braun, B. and A.Z.M. Shoeb (2011) Ecological Rehabilitation and Public Participation: General Considerations and Empirical Evidence from a Creek Rehabilitation Scheme near Cologne, Germany. Journal of Life and Earth Sciences 6: 1-11.

http://www.banglajol.info/index.php/JLES/article/download/9714/7202

Indigenous and Local Communities>Ghana

Involving Local Farmers in Rehabilitation of Degraded Tropical Forests: Some Lessons from Ghana

The role of community-based plantation development in forest rehabilitation and poverty alleviation is a pressing issue for the government of Ghana. In this paper, we present an analysis of the prospects of a community-based plantation using taungya systems and indigenous trees as means to forest rehabilitation and livelihood improvement in Ghana. The project management strategies, communication process and incentive mechanism and their impact on local participation are discussed with the aim to recommending a mechanism through which local farmers can best be involved in rehabilitation of degraded sites in the future in Ghana.

Indigenous and local communities, implementing agencies, practitioners

Blay, D., M. Appiah, L. Damnyag, F.K. Dwomoh, O. Luukkanen and A. Pappinen (2008) Involving Local Farmers in Rehabilitation of Degraded Tropical Forests: Some Lessons from Ghana. Environment, Development and Sustainability 10(4): 503-518.

http://reforestation.elti.org/resource/616/

Indigenous and Local Communities>India

What Makes Joint Forest Management Successful? Science-Based Policy Lessons on Sustainable Governance of Forests in India

This review presents fresh interpretation of available research and provides justification for instituting local monitoring and enforcement systems in the field for sustainable governance of India's forests. The review also aims to identify lessons for consolidation of joint forest management as a tool for sustaining the forests and improving livelihoods of people.

Policymakers, implementing agencies

Singh, V.S. and D.N. Pandey (2010) What Makes Joint Forest Management Successful? Science-Based Policy Lessons on Sustainable Governance of Forests in India. Rajasthan State Pollution Control Board Occasional Paper No. 3/2010, Jaipur.

http://dlc.dlib.indiana.edu/dlc/bitstream/handle/10535/6511/Singh%26Pandey2010.pdf?sequence=1

Joint Mangrove Management in Tamil Nadu

The aim of this project was to build the capacities of the local communities, government agencies and grass-root institutions such as Panchayats, to restore, conserve and utilise the mangrove wetlands in a sustainable manner through participatory analysis and action. The project's integrated approach to mangrove restoration, conservation and management is visible in a wide range of activities-technical, socio-economic and administrative. The approach encompasses many implementing agencies, and includes all the stakeholders: the mangrove user communities, MSSRF, the FD of different states, other government departments, rural agencies such as Panchayats, local NGOs, schools and private companies.

Policymakers, implementing agencies, indigenous and local communities

Selvam, V., V.M. Karunagaran, K.K. Ravichandran and G. Evanjalin Jessie Beula (?) Joint Mangrove Management in Tamil Nadu. M.S.Swaminathan Research Foundation, Chennai.

http://www.mssrf.org/csr/csr-pub/16-joint%20Mangrove%20Mgt%20in%20TN(english).pdf

In-Depth Reports: Parts 1-4

http://www.mssrf.org/csr/csr-pub1.html

The Padu System of Community-based Fisheries Management: Change and Local Institutional Innovation in South India

As a commons institution, the padu system in Vallarpadam Island, Cochin, Kerala, defines the group of rights holders and resource boundaries and fishingsites. It is caste-specific, gear-specific (stake-nets) and species specific (shrimp). As used in Vallarpadam, and elsewhere in Kerala, Tamil Nadu and Sri Lanka, padu is characterized by the use of lottery for rotational access. The institution functions in providing equitable access, collective social responsibility, and rule-makingand conflict resolution. The emergence of the institution in the study area is a response to change in markets and legislation in the 1970s. It may also be seen a response of fishing communities to keep their options open, that is, to be resilient.

Policymakers, implementing agencies, indigenous and local communities

Lobe, K. and F. Berkes (2004) The Padu System of Community-based Fisheries Management: Change and Local Institutional Innovation in South India. Marine Policy 28: 271-281.

http://www.umanitoba.ca/institutes/natural_resources/canadaresearchchair/Kenton%5B1%5D.Mar.Pol.04.pdf

Indigenous and Local Communities>Indonesia

Community-Based Coastal Resources Management in Indonesia: Examples and Initial Lessons from North Sulawesi

This paper describes the experiences and lessons learned by Proyek Pesisir in establishing community-based marine sanctuaries at one field site within the Minahasa Regency. It is argued that community-based and decentralized coral reef and coastal management initiatives can be established within the current institutional framework given the new openness within government and demands by the public for governance reforms.

Policymakers, implementing agencies

Crawford, B.R., I. M. Dutton, C. Rotinsulu and L.Z. Hale (1998) Community-Based Coastal Resources Management in Indonesia: Examples and Initial Lessons from North Sulawesi. International Tropical Marine Ecosystems Management Symposium Townsville, Australia, November 23- 26, 1998.

http://pdf.usaid.gov/pdf_docs/PNACN150.pdf

Ecological Mangrove Rehabilitation, Sustainable Livelihoods, Adaptive Collaborative Management and Carbon Finance in Critical Mangrove Systems in Indonesia

To build the social, economic and ecological resilience of mangrove biodiversity "hotspots," by restoring substantial critical mangrove habitats, developing sustainable mangrove resource based cooperative businesses, and strengthening existing adaptive collaborative management policies and practices. Development of Carbon Financing Scheme – Based on minimal 500 hectares restored forest valued at Voluntary Carbon Standards and minimum 1000 hectares of mangrove conservation valued at Voluntary REDD standards.

Policymakers, implementing agencies

Brown, B. (2009) Ecological Mangrove Rehabilitation, Sustainable Livelihoods, Adaptive Collaborative Management and Carbon Finance in Critical Mangrove Systems in Indonesia. A Concept Paper for Danone Group/CBD/LifeWeb Initiative.

http://www.cbd.int/lifeweb/eoi/map%20concept%20paper%20for%20danone%20group.pdf

Indigenous and Local Communities>Japan

Reed Community Restoration Projects with Citizen Participation: An Example of the Practical Use of Satoyama Landscape Resources in Shiga Prefecture, Japan

The area today faces two major challenges: first, how to use local natural resources in a sustainable way to avoid further neglect or destruction of Satoyama landscapes; and second, how to reorganize the management of Satoyama forest and lakeshore resources. The results of our investigation showed how solutions to the above issues were found in the context of lakeshore projects aimed at restoring reed (Phragmites communis) communities, which are important component of the Lake Biwa Satoyama landscape. Since 2002, four such projects have been successfully undertaken through the efficient use of local forest resources, mainly wood and bamboo, in wave dissipation structures and jetties which facilitate the expansion of reed communities. Management was reorganized and now consists of stakeholders which include the original Satoyama management communities, governmental bodies, resident and nonresident citizens, and nongovernmental and nonprofit organizations. The projects are a unique attempt to revive Satoyama watershed landscapes, and may serve as models in other watershed areas.

Implementing agencies, indigenous and local communities

Horiuchi, M., K. Fukamachi and H. Oku (2011) Reed Community Restoration Projects with Citizen Participation: An Example of the Practical Use of Satoyama Landscape Resources in Shiga Prefecture, Japan. Landscape Ecology and Engineering 7: 217-222.

http://trove.nla.gov.au/work/152955104

Indigenous and Local Communities>Kenya

The Return of Ecosystem Goods and Services in Replanted Mangrove Forests: Perspectives from Local Communities in Kenya

This paper assesses how resource users value natural versus planted mangroves and how they perceive plantation initiatives. Semi-structured interviews with 48 resource users from two Kenyan villages show marked mangrove dependence. Respondents identified 24 ecosystem goods, and ranked a variety of food items, traditional medicine, fuel and construction materials as very important resources.

Indigenous and local communities, policymakers

Ronnback, P., B. Crona and L. Ingwall (2007) The Return of Ecosystem Goods and Services in Replanted Mangrove Forests: Perspectives from Local Communities in Kenya. Environmental Conservation 34(4): 313-324.

http://journals.cambridge.org/action/displayAbstract?fromPage=online&aid=1778504

Indigenous and Local Communities>Malawi

Perceptions of Land-degradation, Forest Restoration and Fire Management: A Case Study from Malawi

We interviewed local households to understand local awareness and impacts of land-degradation, its perceived cause and preferred methods for restoration. All households were aware of the presence of gullies and reported associated problems of flood damage. Most households believed erosion was a result of deforestation. Burning practices were seen to have exacerbated erosion problems. Changing fire management practice was not seen as realistic as it risked reducing the productivity of grasses and fires were perceived to be too difficult to control. Tree planting was the community's preferred approach to tackling erosion. Their focus was on planting exotic fruit and timber trees around houses and they often requested that such work be done by volunteers. Such attitudes may have been influenced by recent extension work and a desire to secure ownership of utilisable resource. Ecologists in the miombo zone should focus on improving fire management practices and involving communities in creating diverse secondary woodlands that provide a range of goods and services.

Implementing agencies, indigenous and local communities

Davies, G.M., L. Pollard and M.D. Mwenda (2010) Perceptions of land-degradation, forest restoration and fire management: A case study from Malawi. Land Degradation and Development 21: 546-556.

http://onlinelibrary.wiley.com/doi/10.1002/ldr.995/abstract

Indigenous and Local Communities>Mexico

Lacandon Maya Ecosystem Management: Sustainable Design for Subsistence and Environmental Restoration

The effects on biodiversity and soil ecology coupled with productivity for agricultural subsistence indicate that Lacandon TEK may offer tools for environmental conservation that would provide for a family's basic needs while maintaining a biodiverse rain forest ecosystem. Tools such as these may offer options for regional restoration and conservation efforts such as the Mesoamerican Biological Corridor in Mexico and Central America, where attainment of environmental goals must include methods to provide resources to local inhabitants.

Indigenous and local communities, practitioners

Diemont, S.A. and J.F. Martin (2009) Lacandon Maya Ecosystem Management: Sustainable Design for Subsistence and Environmental Restoration. Ecological Applications 19(1): 254-266.

https://kb.osu.edu/dspace/bitstream/handle/1811/49028/fac_MartinJ_EcologicalApplications_2009_19_1.pdf?sequence=1

Applying Indigenous Knowledge to the Restoration of Degraded Tropical Rain Forest Clearings Dominated by Bracken Fern

The Lacandon Maya of Chiapas, southern Mexico, have traditionally used a long fallow rotational slash-and-burn system for maize production in small clearings within tropical forest. Although successional processes usually lead to rapid restoration of abandoned fields, the invasive fern, Pteridium aquilinium (commonly known as Bracken), can block natural succession. The Lacandon are aware of this and use the fast-growing tree Balsa (Ochroma pyramidale) to accelerate succession toward mature forest. We carried out a 12-month-long experiment in a Bracken-infested area to test the effectiveness of the Lacandon's low-input restoration techniques.

Indigenous and local communities, implementing agencies, practitioners

Douterlungne, D., S.I. Levy-Tacher, D.J. Golicher and F. Roman Danobeytia (2010) Applying Indigenous Knowledge to the Restoration of Degraded Tropical Rain Forest Clearings Dominated by Bracken Fern. Restoration Ecology 18(3): 322-329.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2008.00459.x/abstract

Indigenous and Local Communities>Nepal

Drivers of Reforestation in Human-Dominated Forests

This article draws on a dataset of 55 forests from the middle hills and Terai plains of Nepal to examine the factors associated with forest clearing or regeneration. Results affirm the central importance of tenure regimes and local monitoring for forest regrowth. In addition, user group size per unit of forest area is an important, independent explanator of forest change. These variables also can be associated with specific practices that further influence forest change such as the management of social conflict, adoption of new technologies to reduce pressure on the forest, and involvement of users in forest maintenance activities. Such large-N, comparative studies are essential if we are to derive more complex, nuanced, yet actionable frameworks that help us to plan better policies for the management of natural resources.

Indigenous and local communities, policymakers

Nagendra, H. (2007) Drivers of Reforestation in Human-Dominated Forests. PNAS 104 (39): 15218-15223.

http://www.pnas.org/content/104/39/15218.full.pdf+html

Indigenous and Local Communities>New Zealand

Ecological Restoration and the Law: A Guide for Community Conservation Groups

This handbook has been written for members of community conservation groups who wish to find out more about the legal implications of their work. It includes information about how to deal with some of the relevant aspects of the law, and provides references to other sources of legal information that expand upon what is said in this handbook.

Indigenous and local communities

Ewing, K. (2008) Ecological Restoration and the Law: A Guide for Community Conservation Groups. University of Waikato, New Zealand.

http://cber.bio.waikato.ac.nz/images/URBAN_RESTORATION_Legal_Issues_Handbook_15_Dec_2008.pdf

Defending Community? Indigeneity, Self-determination and Institutional Ambivalence in the Restoration of Lake Whakaki

Conservation practitioners have scrutinized the credibility and effectiveness of community-based natural resource management, noting its romantic misconceptions about communities and their capacities. Early approaches failed to acknowledge the heterogeneity of collective agents, the synergy between decentralization and neoliberalism, or the need to affirm rural peoples' entitlements to resources. A Maori community's attempt to restore Lake Whakaki on New Zealand's east coast confirms many of these critiques. The restoration confronts institutional ambivalence, obstructive forces from beyond the zone of Maori influence and non-correspondence between community and catchment dynamics. Fulfilment of the project requires exogenous resources and authority, but state conservation agencies are ambivalent towards local demands for self-determined development. Nonetheless, an uncommon degree of agency which is grounded within community aspirations for sovereignty suggests that the motivational characteristics of community retain their importance in debates about integrated conservation and development.

Indigenous and local communities, implementing agencies

Coombes, B. (2007) Defending Community? Indigeneity, Self-determination and Institutional Ambivalence in the Restoration of Lake Whakaki. Geoforum 38(1): 60-72.

http://www.sciencedirect.com/science/article/pii/S0016718506000637

Indigenous and Local Communities>Thailand

Forest Restoration and Community Participation: Case Studies in Thailand

Case studies in Thailand show how people can be mobilised to address local concerns and in doing so make substantial gains in restoring lost habitat and developing sustainable resource use systems. Community participation, capacity building and resolution of underlying resource and land use conflicts were the basis of these successful restoration efforts. The role of community participation should be considered from the onset of any restoration effort. Gains made in the area of habitat restoration are likely to be based on the development of equal partnerships with local communities as well as effective support in the form of local community capacity-building and conflict resolution.

Implementing agencies, indigenous and local communities

Sukwong, S. (2000) Forest Restoration and Community Participation: Case Studies in Thailand. In Elliot, S. et al (eds.) Forest Restoration for Wildlife Conservation. Proceedings of a Workshop with the International Tropical Timber Organisation and The Forest Restoration Research Unit, Chiang Mai University, Thailand.

http://www.forru.org/PDF_Files/frfwcpdf/part6/p62%20Sukwong%20forest%20restoration.pdf

Indigenous and Local Communities>USA

Community-Based Watershed Management: Lessons from the National Estuary Program

Community-Based Watershed Management: Lessons from the National Estuary Program (NEP) is designed for all individuals and organizations involved in watershed management, including states, tribes, local governments, and nongovernmental organizations. This document describes innovative approaches to watershed management implemented by the 28 National Estuary Programs (NEPs). The NEPs are community-based watershed management organizations that restore and protect coastal watersheds. Drawing on nearly 20 years of experience, readers will learn how the NEPs organize and maintain effective citizen involvement efforts, collect and analyze data, assess and prioritize problems, develop and implement management plans, and communicate results of program activities. While estuaries and their coastal watersheds are the focus of the NEPs, the estuary program experience can also be adapted to non-coastal watershed initiatives.

Indigenous and local communities, implementing agencies

U.S. Environmental Protection Agency, Coastal Management Branch (2005) Community-based watershed management: Lessons from the National Estuary Program. EPA-842-B-05-003.

http://water.epa.gov/type/oceb/nep/upload/2007_04_09_estuaries_nepprimeruments_srNEPPrimer.pdf

Collaborative Ecological Restoration

UW-REN offers a model for collaborative education among science and nonscience students. We feel it has been effective in (i) fostering their ability to apply scientific understanding to practical problems in the field, (ii) tackling challenges in a multidisciplinary context and applying their knowledge in a framework with other disciplines, and (iii) developing their abilities to communicate broadly.

Implementing agencies, indigenous and local communities

Gold,W., K. Ewing, J. Banks, M. Groom, T. Hinckley, D. Secord and D. Shebitz (2006) Science 312: 1880-1881.

http://www.sciencemag.org/content/312/5782/1880.summary

Building Local Community Commitment to Wetlands Restoration: A Case Study of the Cache River Wetlands in Southern Illinois, USA

While extensive research efforts have been directed toward understanding the biophysical dimensions of wetland conservation, the literature provides less guidance on how to successfully integrate community stakeholders into restoration planning. Therefore, this study explores the social construction of wetlands locally, and community members' perceptions of the wetland restoration project in the Cache River Watershed of southern Illinois, where public and private agencies have partnered together to implement a large-scale wetlands restoration project. Findings illustrate that the wetlands hold diverse and significant meanings to community members and that community members' criteria for project success may vary from those identified by project managers. The case study provides managers with strategies for building community commitment such as engaging local citizens in project planning, minimizing local burdens, maximizing local benefits, and reducing uncertainty.

Implementing agencies, indigenous and local communities

Davenport, M.A., C.A. Bridges, J.C. Mangun, A.D. Carver, K.W.J. Williard and E.O. Jones (2010) Building Local Community Commitment to Wetlands Restoration: A Case Study of the Cache River Wetlands in Southern Illinois, USA. Environmental Management 45: 711-722.

http://www.springerlink.com/content/r088523j8u6k0608/

Restoring Ecological Functions and Increasing Community Awareness of an Urban Tidal Pond Using Blue Mussels

Blue mussels (Mytilus edulis) were transplanted into South Mill Pond, a degraded tidal salt pond in Portsmouth NH. As part of a larger community-based project volunteers helped create three mussel reefs in each of two locations within the pond in May 2001. Information collected to date indicates that mussel reefs constructed at the pond appear to be functioning as a natural system, acting to improve water quality and provide shelter for small fish and other nektonic and epibenthic invertebrates. In addition, volunteer action garnered city involvement and increased local awareness of the pond as an ecosystem rather than a sewage lagoon. Community awareness along with habitat improvements will increase the long-term prospects for rehabilitation of South Mill Pond.

Indigenous and local communities, implementing agencies

McDermott, S., D. Burdick, R. Grizzle and J. Greene (2008) Restoring Ecological Functions and Increasing Community Awareness of an Urban Tidal Pond Using Blue Mussels. Ecological Restoration 26(3): 254-262.

http://er.uwpress.org/content/26/3/254.short

Cultural Foundations for Ecological Restoration on the White Mountain Apache Reservation

Myths, metaphors, and social norms that facilitate collective action and understanding of restoration dynamics serve as foundations for ecological restoration. The experience of the White Mountain Apache Tribe demonstrates how such cultural foundations can permeate and motivate ecological restoration efforts. Through interviews with tribal cultural advisors and restoration practitioners, we examined how various traditions inform their understanding of restoration processes.

Implementing agencies, indigenous and local communities

Long, J., A. Tecle, and B. Burnette (2003) Cultural foundations for ecological restoration on the White Mountain Apache Reservation. Conservation Ecology 8(1): 4.

http://www.ecologyandsociety.org/vol8/iss1/art4/

Oak-hickory Ecosystem Restoration to Support Sustainable Appalachian Communities

The Collaborative Forest Landscape Restoration Strategy outlined in this proposal will leverage core restoration work and existing partnerships to accomplish in ten years what would take 20-25 years under current funding trends. The leveraged funding would accomplish more restoration in a shorter timeframe, and also give additional momentum and incentive for formalizing collaborative processes, finding efficiencies and striving toward an all-lands approach.

Policymakers, indigenous and local communities

USDA Forest Service (2011) Oak-hickory Ecosystem Restoration to Support Sustainable Appalachian Communities, Wayne National Forest Eastern Region.

http://www.fs.fed.us/restoration/CFLR/documents/2011Proposals/Region9/Wayne/CLRPWNFApplication.pdf

Cultural Survival, Tribal Sovereignty and River Restoration on the Central Northwest Coast, North America

The Elwha River system on the Olympic Peninsula in Washington state (USA) is a storied land. For the Klallam (Coast Salish) people who claim it as their homeland, it is a place filled with narratives about culture, place, and the past. Even so, they have not been able to access many of their sacred sites for several generations because of the development of two hydroelectric dams on the Elwha River. In 1992 the U.S. Congress passed the Elwha River Ecosystem and

Fisheries Restoration Act. This legislation brings together tribal, federal, and regional partners in an effort to restore the Elwha River through dam removal, which will allow the river's salmon and steelhead populations to access pristine spawning ground in the upper reaches of the river, rehabilitate salmon habitat, and replenish beaches starved by the loss of the sediment now trapped behind the dams. For the last two decades, the Elwha Klallam and the U.S. National Park Service have been intergovernmental partners in the effort to implement this act.

Policymakers, indigenous and local communities

Boyd, C.E. and J.B. Boyd (2012) Cultural Survival, Tribal Sovereignty and River Restoration on the Central Northwest Coast, North America. Pp. 387-402 in Johnston, B.R. et al (eds.) Water, Cultural Diversity, and Global Environmental Change. Springer, New York.

http://www.springerlink.com/content/q99rn45485527233/

Indigenous and Local Communities>Zimbabwe

Transforming Traditional Institutions for Sustainable Natural Resource Management: History, Narratives and Evidence from Zimbabwe's Communal Areas

This paper traces the emergence of traditional institutions from the pre-colonial times to the present, and draws a comparison with one fundamental principle of common property management: exclusivity of resource use. Evidence from Zimbabwe shows that traditional rules governing natural resources contradict this principle. The study suggests that the gap between traditional institutions and design principles for sustainable common property resource management can be bridged by making small continuous institutional changes over an extended period of time. It also recommends that longitudinal studies – based on historical precedent rather than contemporary narratives – and cross-sectional studies are required for informed policy decision-making in order to transform traditional institutions.

Implementing agencies, indigenous and local communities

Dore, D. (2001) Transforming Traditional Institutions for Sustainable Natural Resource Management: History, Narratives and Evidence from Zimbabwe's Communal Areas. African Studies Quarterly 5(3): 1-18.

http://www.africa.ufl.edu/asq/v5/v5i3a1.pdf

Recreation/Tourism

Ecotourism and Ecological Restoration

The fast pace of tourism development around the world is causing untold damage to some of the most endangered ecological systems. From Dubai to Honolulu and from Cancun to Beijing, the environmental impacts of tourism are alarming. Ecological restoration (ER) of disturbed lands should be an important approach to sensitive tourism planning. This paper addresses the need for restoring biodiversity and how ecotourism has shown to be a strong force in the field of ER. Two examples (one each of private and community based ecotourism) incorporating ER will be highlighted in this paper: Phinda Game Reserve, South Africa and the Baboon Sanctuary in Belize. We call for greater dialogue across disciplines, notably ER, conservation science and ecotourism.

Policymakers, implementing agencies, indigenous and local communities

Blangy, S. and H. Mehta (2006) Ecotourism and Ecological Restoration. Journal for Nature Conservation 14: 233-236.

http://wildonesniagara.com/images/economicsand_biodiversity.pdf

Community-based Mangrove Rehabilitation and Ecotourism Development and Management in the Red Sea Coast, Egypt

The community-based approach of mangrove rehabilitation and ecotourism enterprises should include the following components/activities: 1. awareness creation and social mobilization through a social marketing strategy; 2. capacity building of the local people as partners in mangrove rehabilitation and ecotourism; 3. liaison and networking by creating and institutionalizing a national coordinating agency or committee; and 4. capacity building of the technical staff of involved agencies to strengthen their social, technical and organizational knowledge and skills in implementing community- based mangrove projects.

Policymakers, implementing agencies, indigenous and local communities

Cabahug, D. M. (2002) Community-based Mangrove Rehabilitation and Ecotourism Development and Management in the Red Sea Coast, Egypt. Ministry of Agriculture and Land Reclamation, Ministry of State for Environment, and FAO.

ftp://ftp.fao.org/docrep/fao/007/ae213e/ae213e00.pdf

Análisis de la Restauración de un Espacios Degradado en el Sur de la Comunidad de Madrid

This book examines a case study in the Community of Madrid: Bosque Sur, a restoration project that has enabled a significant area of unused and degraded lands in municipalities in the south of the Madrid region to be turned into a large peri-urban park designed for public amenity and recreational use. A comprehensive analysis of this project opens the door to a broader and more evidence-based understanding of ecological restoration and government-led environmental measures.

Policymakers

Rodríguez-Rodríguez, D. (2010) Análisis de la restauración de un espacios degradado en el sur de la Comunidad de Madrid. Colección de Estudios Ambientales y Socioeconómicos. Consejo Superior de Investigaciones Científicas. Madrid.

http://libros.csic.es/product_info.php?products_id=130

Soils/Contaminated Lands

Integrating Soil Ecological Knowledge into Restoration Management

Here, we propose that the usefulness of this soil ecological knowledge (SEK) for restoration is best considered in the context of the severity of the original perturbation, the goals of the project, and the resilience of the ecosystem to disturbance. A straightforward manipulation of single physical, chemical, or biological components of the soil system can be useful in the restoration of a site, especially when the restoration goal is loosely defined in terms of the species and processes that management seeks to achieve. These single-factor manipulations may in fact produce cascading effects on several ecosystem attributes and can result in unintended recovery trajectories. When complex outcomes are desired, intentional and holistic integration of all aspects of the soil knowledge is necessary. We provide a short roster of examples to illustrate that SEK benefits management and restoration of ecosystems and suggest areas for future research.

Practitioners, implementing agencies

Heneghan, L., S.P. Miller, S. Baer, M.A. Callaham, Jr., J. Montgomery, M. Pavao-Zuckerman, C.C. Rhoades and S. Richardson (2008) Integrating Soil Ecological Knowledge into Restoration Management. Restoration Ecology 16(4): 608-617.

http://ddr.nal.usda.gov/bitstream/10113/27809/1/IND44130784.pdf

A Striking Profile: Soil Ecological Knowledge in Restoration Management and Science

Although soils are universally regarded as critical to restoration success, and much research has included manipulations of soil variables, we found that better integration of soil ecological principles could still contribute much to the practice of ecosystem restoration. Here we offer four potential points of departure for increased dialog between restoration ecologists and soil ecologists. We hope to encourage the view that soil is a complex, heterogeneous, and vital entity and that adoption of this point of view can positively affect restoration efforts worldwide.

Implementing agencies, practitioners

Callaham, Jr., M.A., C.C. Rhoades and L. Heneghan (2008) A Striking Profile: Soil Ecological Knowledge in Restoration Management and Science. Restoration Ecology 16(4): 604-607.

http://ddr.nal.usda.gov/bitstream/10113/27812/1/IND44130783.pdf

A Comprehensive Overview of Elements in Bioremediation

In this review, we discuss the various in situ and ex situ bioremediation techniques and elaborate on the anaerobic digestion technology, phytoremediation, hyperaccumulation, composting and biosorption for their effectiveness in the biotreatment, stabilization and eventually overall remediation of contaminated strata and environments. The review ends with a note on the recent advances genetic engineering and nanotechnology have had in improving bioremediation. Case studies have also been extensively revisited to support the discussions on biosorption of heavy metals, gene probes used in molecular diagnostics, bioremediation studies of contaminants in vadose soils, bioremediation of oil contaminated soils, bioremediation of contaminants from mining sites, air sparging, slurry phase bioremediation, phytoremediation studies for pollutants and heavy metal hyperaccumulators, and vermicomposting.

Implementing agencies, practitioners

Juwarkar, A.A., S.K. Singh and A. Mudhoo (2010) A Comprehensive Overview of Elements in Bioremediation. Reviews in Environmental Science and Biotechnology 9(3): 215-288.

http://www.springerlink.com/content/8554q07680322x72/

Phytostabilization of Mine Tailings in Arid and Semiarid Environments: An Emerging Remediation Technology

Harsh climatic conditions in arid and semiarid environments along with the innate properties of mine tailings require specific considerations. Plants suitable for phytostabilization must be native, be drought-, salt-, and metal-tolerant, and should limit shoot metal accumulation. Factors for evaluating metal accumulation and toxicity issues are presented. Also reviewed are aspects of implementing phytostabilization, including plant growth stage, amendments, irrigation, and evaluation. Phytostabilization of mine tailings is a promising remedial technology but requires further research to identify factors affecting its long-term success by expanding knowledge of suit-able plant species and mine tailings chemistry in ongoing field trials.

Practitioners

Mendez, M.O. and R.M. Maier (2008) Phytostabilization of Mine Tailings in Arid and Semiarid Environments: An Emerging Remediation Technology. Environmental Health Perspectives 116(3): 278-283.

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2265025/

Ecological Restoration of Mine Degraded Soils, with Emphasis on Metal Contaminated Soils

This paper reviews the ecological aspects of mined soil restoration, with special emphasis on maintaining a long-term sustainable vegetation on toxic metal mine sites. The metal mined soils are man-made habitats which are very unstable and will become sources of air and water pollution. Establishment of a vegetation cover is essential to stabilize the bare area and to minimize the pollution problem. In addition to remediate the adverse physical and chemical properties of the sites, the choice of appropriate vegetation will be important. Phytostabilization and phytoextraction are two common phytoremediation techniques in treating metal-contaminated soils, for stabilizing toxic mine spoils, and the removal of toxic metals from the spoils respectively. Soil amendments should be added to aid stabilizing mine spoils, and to enhance metal uptake accordingly.

Practitioners, implementing agencies

Wong, M.H. (2003) Ecological Restoration of Mine Degraded Soils, with Emphasis on Metal Contaminated Soils. Chemosphere 50: 775-780.

http://144.206.159.178/ft/166/74062/1271438.pdf

A Review of Biochars' Potential Role in the Remediation, Revegetation and Restoration of Contaminated Soils

Biochars are biological residues combusted under low oxygen conditions, resulting in a porous, low density carbon rich material. Their large surface areas and cation exchange capacities, determined to a large extent by source materials and pyrolysis temperatures, enables enhanced sorption of both organic and inorganic contaminants to their surfaces, reducing pollutant mobility when amending contaminated soils. Liming effects or release of carbon into soil solution may increase arsenic mobility, whilst low capital but enhanced retention of plant nutrients can restrict revegetation on degraded soils amended only with biochars; the combination of composts, manures and other amendments with biochars could be their most effective deployment to soils requiring stabilisation by revegetation. Specific mechanisms of contaminant-biochar retention and release over time and the environmental impact of biochar amendments on soil organisms remain somewhat unclear but must be investigated to ensure that the management of environmental pollution coincides with ecological sustainability.

Practitioners, implementing agencies

Beesley, L., E. Moreno-Jiménez, J.L. Gomez-Eyles, E. Harris, B. Robinson and T. Sizmur (2011) Environmental Pollution 159(12): 3269-3282.

http://www.sciencedirect.com/science/article/pii/S0269749111003939

Lessons from Primary Succession for Restoration of Severely Damaged Habitats

Successional studies benefit restoration in six areas: site amelioration, development of community structure, nutrient dynamics, species life history traits, species interactions, and modeling of transitions and trajectories. Primary succession provides valuable lessons for understanding temporal dynamics through direct, long-term observations on severely disturbed habitats. These lessons assist restoration efforts on infertile or even toxic substrates. Restoration that uses scientific protocols (e.g., control treatments and peer-reviewed publications) can offer insights into successional processes.

Practitoners, implementing agencies

Walker, L.R. and R. del Moral (2008) Lessons from Primary Succession for Restoration of Severely Damaged Habitats. Applied Vegetation Science 12: 55-67.

http://faculty.washington.edu/moral/publications/2009WalkerdelMoralAVS.pdf

Soils/Contaminated Lands>Asia-Pacific

Remediation and Management of Degraded Lands

This collection reviews the extent of resource debasement and offers solutions for their restoration. The 14-part first section deals with mine management and rehabilitation. Topics include the devastating results of open-cut mining, open-pit mining, lignite surface mining and acid mining. Despite such ruin, the articles reveal the possibilities for reclamation. Part two devotes nine chapters to the management of derelict lands. Reforestation, soil fertility prognosis, and the uses of nitrogen are just a few of the covered subjects. This portion of the book pays special attention to the successful results of remediation in China and Hong Kong. The final division addresses soil contamination and reclamation.

Practitioners, implementing agencies

Wong, M.H. (1999) Remediation and Management of Degraded Lands. CRC Press.

http://www.crcpress.com/product/isbn/0849341183

Soils/Contaminated Lands>Europe

The STRATEGY Project: Decision Tools to Aid Sustainable Restoration and Long-term Management of Contaminated Agricultural Ecosystems

The STRATEGY project (Sustainable Restoration and Long-Term Management of Contaminated Rural, Urban and Industrial Ecosystems) aimed to provide a holistic decision framework for the selection of optimal restoration strategies for the long-term sustainable management of contaminated areas in Western Europe. A value matrix approach was suggested as a method of addressing social and ethical issues within the decision-making process, and was designed to be compatible with both the countermeasure compendia and the decision support system. The applicability and usefulness of STRATEGY outputs for food production systems in the medium to long term is assessed.

Implementing agencies

Howard, B.J. et al. (2005) The STRATEGY Project: Decision Tools to Aid Sustainable Restoration and Long-term Management of Contaminated Agricultural Ecosystems. Journal of Environmental Radioactivity 83: 275-295.

http://sanrem.cals.vt.edu/1048/00009.pdf

Soils/Contaminated Lands>UK

Earthworms in Soil Restoration: Lessons Learned from United Kingdom Case Studies of Land Reclamation

Here, case study material relates the use of earthworms at selected sites in the United Kingdom. Due to their soil-forming capabilities, these organisms may be essential to reconstruction of soils when drastic activities have despoiled an area. While describing in brief the type of work undertaken, these case studies seek to illustrate some of the misunderstandings/problems/deliberately negative acts that have too often accompanied use of earthworms in soil restoration. From such experiences, implications for practice are suggested that should lead to a greater understanding and appropriate utilization of earthworms in future projects.

Practitioners

Butt, K.R. (2008) Earthworms in Soil Restoration: Lessons Learned from United Kingdom Case Studies of Land Reclamation. Restoration Ecology 16(4): 637–641.

http://pascencio.cos.ucf.edu/classes/Restoration%20Ecology/Pam/Butt%202008.pdf

Experimental Tree Planting on U.K. Containment Landfill Sites: Results of 10 Years' Monitoring

A series of experiments was set up in England in the early 1990s on five containment landfill sites engineered to modern standards to test the relative performance of 14 native and nonnative woodland tree species. This article describes the results of monitoring their survival, growth, and nutrition over a 10-year period. The experiments demonstrated that several species, notably ash, whitebeam, white poplar, and wild cherry, can usually be established on landfill sites with survival rates comparable to other brownfield sites. Despite general site infertility, growth of many tree species (for example, ash, beech, English oak, sycamore, Italian alder, silver maple, white poplar, and whitebeam) was similar to that expected on greenfield sites in the locality of the landfill sites. As well as infertility, soil droughtiness and mammal browsing were identified as limiting tree performance of particular species on some sites. After 10 years, there was no evidence of interaction with landfill containment systems or landfill gas.

Practitioners, implementing agencies

Moffat, A., K. Foot, F. Kennedy, M. Dobson and G. Morgan (2008) Experimental Tree Planting on U.K. Containment Landfill Sites: Results of 10 Years' Monitoring. Arboriculture & Urban Forestry 34(3): 163-172.

http://www.cfeaguisamo.org/webcfea/images/documentos/documentacion_tecnica/arboricultura/REVISTAS/ARBORICULTURE_AND_URBAN_FORESTRY/2008/MAY/request_5.pdf

Soils/Contaminated Lands>USA

Ecological Revitalization: Turning Contaminated Properties into Community Assets

This document (1) provides an overview of EPA's cleanup programs and resources available to support ecological revitalization; (2) addresses technical considerations to help cleanup project managers and other stakeholders carry out ecological revitalization at contaminated properties; and (3) presents general planning and process considerations for ecological revitalization of wetlands, streams, and terrestrial ecosystems as well as successful long-term stewardship. Appendix A at the end of the document presents additional case studies on ecological revitalization.

Implementing agencies, practitioners, indigenous and local communities

EPA's Office of Solid Waste and Emergency Response (2009) Ecological Revitalization: Turning Contaminated Properties into Community Assets. EPA/National Service Center for Environmental Publications, EPA 542-R-08-003.

http://www.clu-in.org/download/issues/ecotools/ecological_revitalization_turning_contaminated_properties_into_community_assets.pdf

Restoration of Woody Plants to Capped Landfills: Root Dynamics in an Engineered Soil

Closed or abandoned landfills represent significant land areas, often in or near urban centers, that are potential sites for ecological restoration of native woodlands. But current guidelines in many jurisdictions do not allow for the installation of trees or shrubs above landfill clay caps, although these plants have many environmental, functional, and aesthetic advantages, including a rapid start to community succession. Typical closure procedures for capped landfills include only a grass cover to control moisture infiltration and impede soil erosion. The main concern that limits the application of a woody cover to a closed landfill is that roots may penetrate and weaken the clay cap. As part of a comprehensive experimental program on woodland restoration, we installed 22 tree and shrub species on Staten Island, New York (the Fresh Kills Sanitary Landfill). We found no evidence that roots of the transplanted woody plants penetrate caps used on these landfills.

Practitioners, implementing agencies

Handel, S.N., G.R. Robinson, W.F.J. Parsons and J.H. Mattei (1997) Restoration of Woody Plants to Capped Landfills: Root Dynamics in an Engineered Soil. Restoration Ecology 5(2): 178-186.

http://onlinelibrary.wiley.com/doi/10.1046/j.1526-100X.1997.09721.x/abstract

Potential Tree Species for Use in the Restoration of Unsanitary Landfills

Given that they represent the most economical option for disposing of refuse, waste landfills are widespread in urban areas. However, landfills generate air and water pollution and require restoration for landscape development. A number of unsanitary waste landfills have caused severe environmental problems in developing countries. This study aimed to investigate the colonization status of different tree species on waste landfills to assess their potential for restoring unsanitary landfills in South Korea.

Practitioners, implementing agencies

Kim, K.D. and E.J. Lee (2005) Potential Tree Species for Use in the Restoration of Unsanitary Landfills. Environmental Management 36(1): 1-14.

http://www.springerlink.com/content/tt5795700h731270/

Mounding as a Technique for Restoration of Prairie on a Capped Landfill in the Puget Sound Lowlands

Closed landfills create large open spaces that are often proposed as sites for restored or created ecosystems. Grasslands are probably prescribed most often because of the presumption that grass root systems will not breach the landfill cap. Capped landfills have a number of soil degradation problems, including compaction, decreased permeability, lack of organic material, diminished soil fauna, inappropriate texture, and lack of structure. In this study in the Puget Sound lowlands, Washington, U.S.A., mounding (low sandy-loam mounds, about 20 cm high and 2 m in diameter), addition of fertilizer, and mulching with yard-waste compost were applied to landfill sites as treatments in a factorial-design experiment. Mounds should probably be used as one element of a complex of habitats on restored landfills.

Practitioners, implementing agencies

Ewing, K. (2002) Mounding as a Technique for Restoration of Prairie on a Capped Landfill in the Puget Sound Lowlands. Restoration Ecology 10(2): 289-296.

http://www.cfr.washington.edu/classes.esrm.302/2007%20Reading/Ewing%202002.pdf

Transport

Transport>Canada

Restoration of Nova Scotian Salt Marshes, Streams and Riparian Zones

Construction and repairs to Nova Scotia's roads and bridges occasionally disrupt waterways and wetlands. Transportation and Infrastructure Renewal, Nova Scotia Environment, and Fisheries and Oceans Canada (DFO) ensure that three things happen on jobs near waterways. First, habitat loss is minimized or avoided whenever possible; second, efforts are made to protect the environment during and after construction; and, third, damaged habitats are restored and enhanced or new habitats will be created to compensate for lost or damaged habitat.

Implementing agencies, practitioners

Nova Scotia Department of Transportation and Infrastructure Renewal

http://www.gov.ns.ca/tran/works/enviroservices/enviroSaltMarsh.asp

http://www.gov.ns.ca/tran/works/enviroservices/enviroStreamRest.asp

Transport>China

Long-Term Ecosystem Effects of Sand-Binding Vegetation in the Tengger Desert, Northern China

The planting of sand-binding vegetation in the Shapotou region at the southeastern edge of the Tengger Desert began in 1956. Over the past 46 years, it has not only insured the smooth operation of the Baotou–Lanzhou railway in the sand dune section but has also played an important role in the restoration of the local environment; therefore, it is viewed as a successful model for desertification control and ecological restoration along the transport line in the arid desert region of China.

Policymakers, implementing agencies

Li, X.R., H.L. Xiao, J.G. Zhang and X.P. Wang (2004) Long-Term Ecosystem Effects of Sand-Binding Vegetation in the Tengger Desert, Northern China. Restoration Ecology 12(3): 376-390.

http://www.shapotou.ac.cn/paper/014.pdf

Transport>Dams

Aging Infrastructure and Ecosystem Restoration

As a result of recent infrastructure failures, particularly the tragic failure of the Interstate-35 bridge in Minnesota, the U.S. Senate passed the National Infrastructure Improvement Act (NIIA), which would create the National Commission on the Infrastructure of the U.S.A. The commission's broad mandate would be to assess the nation's infrastructure and its ability to meet current and future demands. Such policy development coincides with ongoing efforts to manage and restore degraded ecosystems. This provocative intersection of aging infrastructure and environmental degradation provides unprecedented and largely unappreciated opportunities for ecosystem restoration.

Policymakers

Doyle, M.W., E.H. Stanley, D.G. Havlick, M.J. Kaiser, G. Steinbach, W.L. Graf, G.E. Galloway and J.A. Riggsbee (2008) Aging Infrastructure and Ecosystem Restoration. Science 319: 286-287.

http://limnology.wisc.edu/personnel/ehstanley/files/doyle_et_al_science_2008.pdf

Dams, Ecosystem Functions and Environmental Restoration

There are four principal categories of measures that may be incorporated into dam design or operating regime in order to respond to the environmental impacts identified through an EIA. These are: i) measures that avoid anticipated adverse effects of a dam; ii) mitigation measures that are incorporated into a new or existing dam design or operating regime in order to eliminate, offset or reduce ecosystem impacts to acceptable levels; iii) measures that compensate for existing or anticipated adverse effects that cannot be avoided or mitigated; iv) de-commissioning of the dam and restoration of the riverine ecosystem. Within this framework of avoidance, mitigation, compensation and restoration, there are a wide range of specific measures that can be taken appropriate to specific circumstances of each dam.

Policymakers, implementing agencies

Berkamp, G., M. McCartney, P. Dugan, J. McNeely and M. Acreman (2000) Dams, Ecosystem Functions and Environmental Restoration. Thematic Review II.1 prepared as an input to the World Commission on Dams, Cape Town.

http://oldwww.wii.gov.in/eianew/eia/dams%20and%20development/kbase/thematic/tr21main.pdf

Urban Areas

Habitat Analogues for Reconciliation Ecology in Urban and Industrial Environments

Identifying analogous habitats and ecosystems could enhance biodiversity conservation and ecosystem services in anthropogenic environments. Abiotic and biotic differences between artificial analogues and natural systems can be frequently overcome by ecological engineering to make the environment more suitable for native biodiversity, and/or assisted dispersal to allow suitable native organisms to reach appropriate sites within artificial ecosystems. Altering some habitats to become less analogous may help reduce impacts of pest species in urban and industrial areas.

Policymakers, implementing agencies

Lundholm, J.T. and P.J. Richardson (2010) Habitat analogues for reconciliation ecology in urban and industrial environments. Journal of Applied Ecology 47: 966-975.

http://academic.udayton.edu/RyanMcEwan/Courses/EcolRest/Lundholm_ReconciliationEcology.pdf

Remembering Our Roots: A Possible Connection between Loss of Ecological Memory, Alien Invasions and Ecological Restoration

The loss of ecological memory for the natural stability domain of a site reduces ecosystem resilience and enables alien invasive species to become established more easily. These invasives may eventually create a new ecosystem with its own ecological memory and resilience. These new ecosystems are described here as novel ecosystems and are placed in the context of adaptive cycles. Ecological restoration of urban ecosystems requires removing the ecological legacy of invasive alien species. To be successful, invasive species control must address both internal within patch memory of invasives and external between patch memory.

Implementing agencies, policymakers

Schaefer, V.H. (2011) Remembering Our Roots: A Possible Connection between Loss of Ecological Memory, Alien Invasions and Ecological Restoration Urban Ecosystems 14(1): 35-44.

http://www.urbanecology.ca/documents/Journal%20Articles/RememberingOurRoots.pdf

Urban Park Restoration and the "Museumification" of Nature

Ecological restoration is becoming an increasingly popular means of managing urban natural areas for human and environmental values. But although urban ecological restorations can foster unique, positive relationships between people and nature, the scope of these interactions is often restricted to particular activities and experiences, especially in city park settings. Drawing on personal experiences and research on urban park restorations in Chicago and San Francisco, I explore the phenomenon of this "museumification" in terms of its revision of landscape and land use history, how it presents nature through restoration design and implementation, and its potential impacts on the nature experiences of park users, particularly children. I conclude that although museum-type restorations might be necessary in some cases, alternative models for the management of urban natural areas may provide a better balance between goals of achieving authenticity in ecological restorations and authenticity of nature experiences.

Policymakers, implementing agencies

Gobster, P.H. (2007) Urban Park Restoration and the "Museumification" of Nature. Nature and Culture 2(2): 95-114.

http://ncrs.fs.fed.us/pubs/jrnl/2007/nrs_2007_gobster_005.pdf

The Nature of Urban Soils and Their Role in Ecological Restoration in Cities

This article highlights the varied impacts of cities on soils and their implications for restoration planning and expectations of restoration ''success.'' Urban soils exist in different historical and formational trajectories than their local nonurbanized counterparts due to direct anthropogenic disturbance and indirect environmental impacts from urbanization. Therefore, urban soils often exhibit altered physical, chemical, and biological characteristics in comparison to local nonurbanized soils. Soils in urban restorations are a medium that can be deliberately manipulated to improve site conditions or in the monitoring of soil conditions as indices of ecosystem status. Including an explicit role for strong manipulations of soils in urban ecosystems changes how we approach baselines, management, and reference conditions in urban ecological restoration. With an understanding of urban soil ecological knowledge, we can guide aspects of urban ecological restoration toward successful outcomes.

Practitioners

Pavao-Zuckerman, M.A. (2008) The Nature of Urban Soils and Their Role in Ecological Restoration in Cities. Restoration Ecology 16(4): 642-649.

http://www.eebweb.arizona.edu/faculty/huxman/mitch/Pavao-Zuckerman%202008%20Restoration%20Ecology.pdf

Scaling Up from Gardens: Biodiversity Conservation in Urban Environments

As urbanisation increases globally and the natural environment becomes increasingly fragmented, the importance of urban green spaces for biodiversity conservation grows. In many countries, private gardens are a major component of urban green space and can provide considerable biodiversity benefits. Gardens and adjacent habitats form interconnected networks and a landscape ecology framework is necessary to understand the relationship between the spatial configuration of garden patches and their constituent biodiversity. A scale-dependent tension is apparent in garden management, whereby the individual garden is much smaller than the unit of management needed to retain viable populations. To overcome this, here we suggest mechanisms for encouraging 'wildlife-friendly' management of collections of gardens across scales from the neighbourhood to the city.

Policymakers, implementing agencies, indigenous and local communities

Goddard, M.A., A.J. Dougill and T.G. Benton (2010) Scaling Up from Gardens: Biodiversity Conservation in Urban Environments. Trends in Ecology and Evolution 25(2): 90-98.

http://www.intertropi.ufam.edu.br/docs/parques_urbanos_godard_et_al_2010.pdf

Urban Areas>China

A Study of Land Reclamation and Ecological Restoration in a Resource-exhausted City: A Case Study of Huaibei in China

Eco-city construction is a powerful method which can advance a city from traditional industrial civilisation to ecological civilisation. The city of Huaibei, with 50 years of coal mining history, has been listed as a national resource-exhausted city. The city's sustainable development and ecological restoration work face severe challenges. This study presents a time-space evolution analysis of mining subsidence to show the evolution and the distribution of the subsidence area in Huaibei. Intensive use was made of land evaluation to formulate land use measures. According to this analysis, and based on the popular eco-reconstruction movement, suggestions for land reclamation and eco-reconstruction are proposed for the city of Huaibei. The paper aims to make strategic recommendations to help Huaibei city transform from a resource-exhausted city to an eco-city.

Policymakers, implementing agencies

Xiao, W., Z. Hu, J. Li, H. Zhang and J. Hu (2011) A Study of Land Reclamation and Ecological Restoration in a Resource-exhausted City: A Case Study of Huaibei in China. International Journal of Mining, Reclamation and Environment 25(4): 332-341.

http://www.tandfonline.com/doi/abs/10.1080/17480930.2011.608888

Urban Areas>Finland

The Role of Local Ecological Knowledge in Sustainable Urban Planning: Perspectives from Finland

The results indicate that LEK exists among nature enthusiast, as well as local residents, and planners can obtain the knowledge in several ways, most notably through networks of knowledgeable key informants and local nature associations. Considering LEK in urban planning is important because it complements scientific ecological data and indicates places important to locals. Some of the challenges of using LEK include collecting it through participatory planning processes, distinguishing it from other information, valuing subjective knowledge, and empowering planning officials to use LEK. To enhance communication between stakeholders, social scientists should be integrated in the planning process. Furthermore, technical improvements, such as registers of key informants and more efficient use of nature associations' knowledge, would be useful in applying LEK.

Implementing agencies

Yli-Pelkonen, V. and J. Kohl (2005) The Role of Local Ecological Knowledge in Sustainable Urban Planning: Perspectives from Finland. Sustainability Science, Practice, & Policy 1(1).

http://sspp.proquest.com/archives/vol1iss1/0410-007.yli-pelkonen.html

Urban Areas>India

Urban Forests and Open Green Spaces: Lessons for Jaipur, Rajasthan, India

Here, we review the present status of urban forestry across the world, and draw lessons that can be applied for the governance of urban green spaces during the development of Jaipur as a world-class city in Rajasthan. We find wide variation both in coverage as well as per capita availability of green spaces. There are, however, some discernible trends emerging from cities renowned for their urban green spaces: approximately 20 to 30% coverage of the total geographical area, and 15 to 25 m2 urban green spaces per capita. World Health Organization suggests ensuring at least a minimum availability of 9 m2 green open space per city dweller. Finally, we provide strategies and lessons for connecting science to decisionmaking aimed at creating multifunctional landscapes to enhance urban resilience and human well-being.

Policymakers, implementing agencies

Singh, V.S., D.N. Pandey and P. Chaudhry (2010) Urban Forests and Open Green Spaces: Lessons for Jaipur, Rajasthan, India. Rajasthan State Pollution Control Board Occasional Paper No. 1/2010, Jaipur.

http://www.indiaenvironmentportal.org.in/files/RSPCB-OP-1-2010.pdf

Urban Areas>New Zealand

Bringing Back Nature into Cities: Urban Land Environments, Indigenous Cover and Urban Restoration

The restoration of urban ecosystems is an increasingly important strategy to maintain and enhance indigenous biodiversity as well as reconnecting people to the environment. High levels of endemism, the sensitivity of species that have evolved without humans, and the invasion of exotic species have all contributed to severe depletion of indigenous biodiversity in New Zealand. In this work, we analysed national patterns of urban biodiversity in New Zealand and the contribution that urban restoration can make to maximising and enhancing indigenous biodiversity.

Policymakers, implementing agencies

Clarkson, B.D., P.M. Wehi and L. Brabyn (2007) Bringing Back Nature into Cities: Urban Land Environments, Indigenous Cover and Urban Restoration. Centre for Biodiversity and Ecology Research Report No. 52, University of Waikato, Hamilton.

http://cber.bio.waikato.ac.nz/PDFs/CBER_52_Urban_ecology_data_to_cities.pdf

Restoring Native Ecosystems in Urban Auckland: Urban Soils, Isolation, and Weeds as Impediments to Forest Establishment

New Zealand urban environments are currently dominated by exotic plant species. Restoring native vegetation and its associated native biodiversity in these landscapes is desirable for both cultural and ecological reasons. We report on the first four years of an ongoing vegetation restoration experiment in Waitakere City, Auckland, that addresses four challenges to urban restoration: weeds, Anthropic Soils, attraction of frugivorous birds, and patch isolation.

Implementing agencies, practitioners, indigenous and local communities

Sullivan, J.J., C. Meurk, K.J. Whaley and R. Simcock (2009) Restoring Native Ecosystems in Urban Auckland: Urban Soils, Isolation, and Weeds as Impediments to Forest Establishment. New Zealand Journal of Ecology 33(1): 60-71.

http://www.newzealandecology.org.nz/nzje/new_issues/NZJEcol33_1_60.pdf

Urban Areas>Forests/Woodlands

Restoring the Urban Forest Ecosystem

This CD-ROM explains basic ecological principles for the urban forest's water, soil, plant and animal communities. It discusses problems common in the urban forest such as aquatic eutrophication, soil aeration, invasive plants and loss of biodiversity. Solutions, strategies, examples, and additional resources are presented to help make urban forest restoration projects successful. Its goal is to inspire the restoration of urban forest ecosystems which will, in turn, restore and conserve our planet for future generations.

Implementing agencies, indigenous and local communities

Duryea, M.L., E. Kämpf Binelli and L.V. Korhnak (eds.) (2000) Restoring the Urban Forest Ecosystem. CD-ROM produced by the School of Forest Resources and Conservation, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida.

http://www.ufei.org/files/pubs/RestoringUFEcosystem.pdf

Seed Rain and Soil Seed Banks Limit Native Regeneration within Urban Forest Restoration Plantings in Hamilton City, New Zealand

Restoration of native forest vegetation in urban environments may be limited due to isolation from native seed sources and to the prevalence of exotic plant species. To investigate urban seed availability we recorded the composition of seed rain, soil seed banks and vegetation at native forest restoration plantings up to 36 years old in Hamilton City and compared these with naturally regenerating forest within the city and in a nearby rural native forest remnant.

Implementing agencies, practitioners

Overdyck, E. and B.D. Clarkson (2012) Seed Rain and Soil Seed Banks Limit Native Regeneration within Urban Forest Restoration Plantings in Hamilton City, New Zealand. New Zealand Journal of Ecology 36(2):

http://www.nzes.org.nz/nzje/new_issues/NZJEcol36_2_177.pdf

Urban Tree Planting Guide

This guide provides detailed guidance on urban tree planting that is applicable at both the development site and the watershed scales. Topics covered include site assessment, planting design, site preparation and other pre-planting considerations, and planting and maintenance techniques. An Urban Tree Selection Guide is included for use in selecting the best tree and shrub species for the planting site.

Implementing agencies, indigenous and local communities

Cappiella, K., T. Schueler, J. Tomlinson and T. Wright (2006) Urban Tree Planting Guide in Urban Watershed Forestry Manual. Center for Watershed Protection and USDA Forest Service.

http://www.urbanforestrysouth.org/resources/library/copy2_of_urban-watershed-forestry-manual-part-i/file

Urban Areas>Green Roofs

Hydrologic Restoration in the Urban Environment Using Green Roofs

Loss of natural soil and vegetation within the urban environment can significantly affect the hydrologic cycle by increasing storm water runoff rates and volumes. In order to mitigate these modifications in urban areas engineered systems are developed, such as green roofs, to mimic and replace functions (evapo-transpiration, infiltration, percolation) which have been altered due to the impact of human development. Green roofs, also known as vegetated roof covers, eco-roofs or nature roofs, are composite complex layered structures with specific environmental benefits.

Implementing agencies, policymakers

Palla, A., I. Gnecco and L.G. Lanza (2010) Hydrologic Restoration in the Urban Environment Using Green Roofs. Water 2: 140-154.

http://www.mdpi.com/2073-4441/2/2/140

Green Roofs as Urban Ecosystems: Ecological Structures, Functions, and Services

Green roofs (roofs with a vegetated surface and substrate) provide ecosystem services in urban areas, including improved storm-water management, better regulation of building temperatures, reduced urban heat-island effects, and increased urban wildlife habitat. This article reviews the evidence for these benefits and examines the biotic and abiotic components that contribute to overall ecosystem services. We emphasize the potential for improving green-roof function by understanding the interactions between its ecosystem elements, especially the relationships among growing media, soil biota, and vegetation, and the interactions between community structure and ecosystem functioning. Further research into green-roof technology should assess the efficacy of green roofs compared to other technologies with similar ends, and ultimately focus on estimates of aggregate benefits at landscape scales and on more holistic cost-benefit analyses.

Implementing agencies, policymakers, indigenous and local communities

Oberndorfer, E. et al. (2007) Green Roofs as Urban Ecosystems: Ecological Structures, Functions, and Services. BioScience 57(10): 823-833.

http://www.aibs.org/bioscience-press-releases/resources/11-07.pdf

Urban Areas>Marshes/Wetlands

Restoring Complex Vegetation in Urban Settings: The Case of Tidal Freshwater Marshes

To illustrate some of the mechanisms affecting vegetation development in restored tidal freshwater marshes in urban areas, I present a case study on one of these wetlands, Kingman Marsh, that also includes research at another restored wetland and two natural reference sites. Studies by my research groups indicate that the restored wetlands undergo essentially a planting-modified process of primary succession. Recent literature and the case study indicate that the environmental conditions of urban settings impose constraints in restored wetlands that result in plant communities more like those of urban natural wetlands than those of wetlands in less urbanized watersheds. This suggests that rather than design wetland restoration projects with the goal of creating “pristine” wetland vegetation, restorationists must identify, accept, and if possible capitalize on the ecological constraints of the urban environment in setting achievable and desirable restoration goals.

Implementing agencies, practitioners

Baldwin, A.H. (2004) Restoring Complex Vegetation in Urban Settings: The Case of Tidal Freshwater Marshes. Urban Ecosystems 7: 125-137.

http://www.bre.umd.edu/baldwin%202004%20urban%20ecosystems.pdf

Restoration of an Urban Salt Marsh: An Interdisciplinary Approach

This issue becomes especially prominent when trying to restore damaged environments where large numbers of people live, most particularly in the modern city. Whenever large numbers of people are involved, we must address in specific, persuasive, and precise ways that goods and services are provided by restored environments, as well as the costs and sacrifices people may be required to make to achieve this end. We must also recognize that restoration cannot be accomplished lacking the understanding, appreciation, and support of local communities. At the least, this necessitates a deep and sympathetic knowledge of the characteristics, interests, attitudes, and needs of varying human populations.

Policymakers, implementing agencies, practitioners, indigenous and local communities

Casagrande, D.G. (1997) Restoration of an Urban Salt Marsh: An Interdisciplinary Approach. Yale School of Forestry and Environmental Studies, Bulletin Series No. 100, New Haven.

http://environment.research.yale.edu/documents/downloads/0-9/100frontmatter.pdf

Managing Urban Wetlands for Multiple Use: Research, Restoration, and Recreation

Conservation of urban wetland habitat is challenging, because multiple uses must coexist. We use examples from California and Wisconsin to describe potential synergies among recreation, restoration and research activities (the 3 R's). Allowing passive recreation is often essential to garner public support for habitat protection, restoration, and research. In turn, restoration activities can improve the appearance of degraded sites, and designing the work as a research experiment can serve the scientific community.

Practitioners, implementing agencies, indigenous and local communities

Zedler, J.B. and M.K. Leach (1998) Managing Urban Wetlands for Multiple Use: Research, Restoration, and Recreation. Urban Ecosystems 2: 189-204.

http://carmelacanzonieri.com/library/6123/Zedler-ManagingWetlandsMultipleUse.pdf

Urban Areas>Rivers

Restoring Streams in an Urbanizing World

To be effective, urban stream restoration efforts must be integrated within broader catchment management strategies. A key scientific and management challenge is to establish criteria for determining when the design options for urban river restoration are so constrained that a return towards reference or pre-urbanization conditions is not realistic or feasible and when river restoration presents a viable and effective strategy for improving the ecological condition of these degraded ecosystems.

Implementing agencies, practitioners

Bernhardt, E.S. and M.A. Palmer (2007) Restoring Streams in an Urbanizing World. Freshwater Biology 52: 738-751.

http://www.palmerlab.umd.edu/docs/Bernhardt_and_Palmer_2007.pdf

Integrated Planning Framework for Urban River Rehabilitation

This paper identifies how the analytical frameworks of the principal URRI participating agencies (U.S. Army Corps of Engineers and EPA) can be integrated to serve the goals of the URRI in ways that highlight incremental effects on costs and benefits from choosing among alternative plans and presented in a manner enabling collaborators to compare the benefits from different combinations and permutations of all the potential measures for given budgets. The conclusion discusses the contribution of the integrated planning framework to building consensus among federal agencies, nonfederal agencies, and other stakeholders on a URRI implementation plan

Deason, J.P., G.E. Dickey, J.C. Kinnell and L.A. Shabman (2010) Integrated Planning Framework for Urban River Rehabilitation. J. Water Resour. Plann. Manage. 136(6).

http://ascelibrary.org/wro/resource/1/jwrmd5/v136/i6/p688_s1?isAuthorized=no

Why Rehabilitate Urban River Systems?

This paper addresses the philosophical question: 'why rehabilitate urban river systems?' within an Australian context. Rehabilitation of river systems has become an important objective of many local, state and national governments around the world, who allocate substantial investment into various river projects. An understanding of the various factors influencing stream condition and potential rehabilitation options is essential in order to determine how the process is undertaken, and how success is measured. This paper examines the triple bottom line (economic, social and environmental) factors that influence decision-making with respect to urban stream rehabilitation and management and considers their relative value and importance.

Policymakers

Findlay, S.J. and M.P. Taylor (2006) Why Rehabilitate Urban River Systems? Area 38(3): 312-325.

http://isites.harvard.edu/fs/docs/icb.topic281447.files/River_Rehab.pdf

Managing and Rehabilitating Ecosystem Processes in Regional Urban Streams in Australia

Urbanization is acknowledged as one of the most severe threats to stream health, spawning recent research efforts into methods to ameliorate these negative impacts. Attention has focused on streams in densely-populated cities but less populous regional urban centres can be equally prone to some of the same threats yet might not meet the conventional definitions of urban. Understanding the interactions of hydrology, drainage pattern, leaf input and biological attributes of a stream is crucial for managers trying to restore stream ecosystem services without incurring public concern about the appearance of regional urban streams.

Practitioners, implementing agencies

Miller, W. and A.J. Boulton (2005) Managing and Rehabilitating Ecosystem Processes in Regional Urban Streams in Australia. Hydrobiologia 552(1): 121-133.

http://www.springerlink.com/content/30065152l31q203p/

Challenges and Prospects for Restoring Urban Streams: A Perspective from the Pacific Northwest of North America

In the absence of effective hydro-logic mitigation, appropriate short-term rehabilitation objectives for urban channels should be to 1) eliminate point sources of pollution, 2) reconstruct physical channel elements to resemble equivalent undisturbed channels, and 3) provide habitat for self-sustaining biotic communities, even if those communities depart significantly from predisturbance conditions. Long-term improvement of stream conditions is not feasible under typical urban constraints, so large sums of money should not be spent on unrealistic or unreachable targets for stream rehabilitation. However, such a strategy should not be an excuse to preclude potential future gains by taking irreversible present-day development or rehabilitative actions.

Implementing agencies, policymakers

Booth, D.B. (2005) Challenges and Prospects for Restoring Urban Streams: A Perspective from the Pacific Northwest of North America. Journal of the North American Benthological Society 24(3): 724-737.

http://cnr.usu.edu/streamrestoration/files/uploads/Resources%20from%20Peter%20Wilcock/Booth_05_RestoringUrbStrms_PNW_Mgt.pdf

Resilience, Restoration, and Riparian Ecosystems: Case Study of a Dryland, Urban River

The Salt River in Phoenix, Arizona has been impounded, dewatered, channelized, but also re-watered with urban effluent and storm drain runoff. To determine whether riparian vegetation is resilient to these various perturbations, paired comparisons were made in the vegetation and seed bank between a non-diverted reference reach, a diverted reach, and a re-watered urban reach. In the diverted reach, composition had shifted to that of a stress tolerant xeroriparian shrubland with low diversity in both the seed bank and extant vegetation. Most surprisingly, few differences were observed in the composition and structure of the vegetation and soil seed banks between the reference reach and the urban reach, particularly in the wet patches, suggesting that hydric riparian plant communities have the capacity to adapt to these modified conditions. These results provide support for a process-oriented approach to restoration on the Salt River and other urban dryland rivers using patches of persisting vegetation as models for achievable restoration targets.

Implementing agencies, practitioners

White, J.M. and J.C. Stromberg (2011) Resilience, Restoration, and Riparian Ecosystems: Case Study of a Dryland, Urban River. Restoration Ecology 19: 101-111.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2009.00531.x/abstract

Waste Not, Want Not: The Need to Utilize Existing Artificial Structures for Habitat Improvement along Urban Rivers

Most river restoration techniques are not feasible within large urban rivers, and so there is a need to develop novel methodologies. Artificial structures such as river walls can function as habitat for plant and invertebrate species in urban rivers, and in some cases can be more diverse than remnant habitat. Along the River Thames through central London, plant species richness was found to be significantly higher on river walls than intertidal foreshore, which represents the only remnant habitat for riparian species. Both this survey and other studies have suggested that the physical and environmental characteristics of river walls are likely to influence their capacity to function as ecological habitat, for example, walls composed of more complex construction materials (brick and boulders) being more diverse than simpler structures (concrete and sheet piling).

Practitioners, implementing agencies

Francis, R.A. and S.P.G. Hoggart (2008) Waste Not, Want Not: The Need to Utilize Existing Artificial Structures for Habitat Improvement along Urban Rivers. Restoration Ecology 16(3): 373-381.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2008.00434.x/abstract

5. National Plans, Strategies and Experiences

Argentina

Corredor Verde – Misiones (Ley 3.631)

Generar condiciones favorables para la preservación de las masas selváticas del "Corredor Verde de la Provincia de Misiones", con el objeto de lograr la unión de los tres principales bloques de las Áreas Naturales Protegidas existentes en la Provincia…

Policymakers

http://www.jaguares.com.ar/legislacion/ley-corredor-verde.html

http://awsassets.wwfar.panda.org/downloads/las_leyes_ambientales_de_misiones.pdf

Australia

Australia's Biodiversity Conservation Strategy 2010–2020

Australia's Biodiversity Conservation Strategy is a new approach to addressing biodiversity conservation in a rapidly changing world. The strategy is a call to action. It sets a national direction for biodiversity conservation over the next decade and it asks all Australians to contribute.

Policymakers

National Biodiversity Strategy Review Task Group (2009) Australia's Biodiversity Conservation Strategy 2010–2020, Consultation draft. Commonwealth of Australia.

http://www.environment.gov.au/biodiversity/strategy/pubs/biodiversity-conservation-strategy2010-2020.pdf

Wetlands Strategy for South Australia

The Wetlands Strategy will ensure wetlands are given appropriate status, and are managed accordingly in South Australia. The Strategy will do this by delivering the key elements of wetland conservation and management to the Government, business, industry, private landholders and the broader community. Of critical importance is the need for all stakeholders to use this Strategy as a mechanism to achieve more integrated approaches for the management of wetlands.

Policymakers

Department for Environment and Heritage & Department of Water, Land and Biodiversity Conservation (2003).Wetlands Strategy for South Australia. Department for Environment and Heritage, South Australia.

http://www.environment.sa.gov.au/Conservation/Rivers_Wetlands/Wetlands_of_SA/Wetlands_strategy_for_SA

NSW Rivers Environmental Restoration Program

This report presents the outcomes resulting from the $181.12-million investment in wetland health made through the NSW Rivers Environmental Restoration Program (RERP). The completion of the program provides an opportunity to reflect upon its achievements and assess progress towards the program objective: arrest the decline of the most stressed and iconic rivers and wetlands in New South Wales through market-based water recovery focused on the voluntary acquisition and effective, active management of environmental water.

Policymakers, implementing agencies

New South Wales Government (2011) NSW Rivers Environmental Restoration Program – Final Report. Department of Environment, Climate Change and Water NSW.

http://141.243.32.146/resources/environmentalwater/110240RERPFinalRpt.pdf

Applying Landscape-Ecological Principles to Regional Conservation: The Wild Country Project in Australia

Amidst other nongovernment initiatives such as Greening Australia (2004), The Wilderness Society Australia has launched the Wild Country Project (hereinafter Wild-Country) in partnership with other civil society organizations, government at state and local levels, industry and private landowners, and the Wildlands Project USA. Wild Country builds upon the Wilderness Society's mission, namely, "to protect, promote and restore wilderness and natural processes for the wellbeing and ongoing evolution of the community of life across Australia."

Policymakers, implementing agencies

Mackey, B.G. et al. (2007) Applying landscape-ecological principles to regional conservation: theWild Country Project in Australia. Pp. 192-213 in Key Topics in Landscape Ecology (ed. J.Wu and R. Hobbs). Cambridge University Press.

http://www.uq.edu.au/spatialecology/docs/Publications/2007_Mackey_etal_Key%20Topics_Landscape_Ecology.pdf

Brazil

An Overview of Public Policies and Research on Ecological Restoration in the State of Sao Paulo, Brazil

The restoration of native vegetation in Brazil started in the 19th century with pioneering and very successful initiatives; however, the rapid increase in native biodiversity restoration occurred in the last three decades in the country has been undeniably driven by environmental legislation and its requirements and public policies, and, most recently, by ecological marketing and certification. As the scenarios and motivations changed over time, so did restoration goals, challenges, stakeholders, biomes, researches and techniques.

Policymakers

Durigan, G. and A.C. Galvão de Melo (2011) An Overview of Public Policies and Research on Ecological Restoration in the State of Sao Paulo, Brazil in Biodiversity Conservation in the Americas: Lessons and Policy (E. Figueroa B. (ed.)). Ocho Libros Editores Ltda., Santiago.

http://www.ocholibros.cl/7001645f-6e51-4367-8ce7-683163f4dfbc/Biodiversity-Conservation-in-the-Americas-Lessons-and-Policy-Recommendations.aspx

What Role Should Government Regulation Play in Ecological Restoration? Ongoing Debate in Sao Paulo State, Brazil

Around the world, there is growing desire and momentum for ecological restoration to happen faster, with better quality, and in more extensive areas. The question we ask is how can laws and governmental regulations best contribute to effective, successful, and broad-scale restoration? In the state of Sao Paulo, Brazil, there is a legal instrument (SMA 08-2008) whose aim is to increase the effectiveness of tropical forest restoration projects in particular. It establishes, among other things, requirements regarding the minimum number of native tree species to be reached within a given period of time in restoration projects and the precise proportion of functional groups or threatened species to be included when reforestation with native species is used as a restoration technique.

Policymakers

Aronson, J. et al. (2011) What Role Should Government Regulation Play in Ecological Restoration? Ongoing Debate in Sao Paulo State, Brazil. Restoration Ecology 19(6): 690-695.

http://www.lcb.esalq.usp.br/publications/articles/2011/2011rev19n6p690-695.pdf

Canada

Ecosystem Restoration Provincial Strategic Plan

The Ministry of Forests and Range (MFR) will provide leadership through its ER program to facilitate a multi-sectoral ER initiative that achieves the mission and goals related in this strategy, and creates synergies with other related programs and initiatives. From 2009 to 2012, a provincial ER initiative will be implemented that initially focuses on the fire-maintained ecosystems. This will be accomplished by addressing three core goals through a set of strategic priorities.

Policymakers

Neal, A. and G.C. Anderson (2009) Ecosystem restoration provincial strategic plan. B.C. Min. For. Range, Range Br., Kamloops, B.C.

http://www.for.gov.bc.ca/hra/Restoration/Draft%20-%20Ecosystem%20Restoration%20Prov%20Strategic%20Plan.pdf

East Kootenay Grassland Ecosystem Restoration: Project Synthesis: 2005-2010

The projects identified in this report lie primarily within the Rocky Mountain Trench, an area that has been impacted over the past six decades by accelerated forest encroachment onto historic grasslands and a lack of natural fire. Within this geographic area, a wide range of public groups and stakeholders have developed a strategic Ecosystem Restoration Plan, "A Blueprint for Action" (2006, Rocky Mountain Trench Ecosystem Restoration Steering Committee). This document, and associated updates, describes a collaborative approach to conducting ER planning activities and treatments consistent with higher level planning documents and strategies. Approximately 4500 hectares of ER treatment on Crown lands are targeted annually through partnerships within the East Kootenay Trench to mitigate ongoing open habitat losses across the land base. A total of over 5.2 million dollars has been invested to complete ER associated activities in the East Kootenay Trench between 2005 and 2010.

Policymakers, implementing agencies, indigenous and local communities

Crowley, S. and M. Gall (2011) East Kootenay Grassland Ecosystem Restoration: Project Synthesis: 2005-2010. Ministry of Environment, Habitat Conservation Trust Fund Project 4-299.

http://trench-er.com/public/library/files/east-kootenay-grassland-restoration.pdf

Canada's Federal Marine Protected Areas Strategy

This Strategy defines the following goal: The establishment of a network of marine protected areas, established and managed within an integrated oceans management framework, that contributes to the health of Canada's oceans and marine environments. In support of this goal, this Strategy will aim to fulfill its objectives to: 1) establish a more systematic approach to marine protected area planning and establishment; 2) enhance collaboration for management and monitoring of marine protected areas; 3) increase awareness, understanding and participation of Canadians in the marine protected area network; and 4) link Canada's network of marine protected areas to continental and global networks.

Policymakers

Government of Canada (2005) Canada's Federal Marine Protected Areas Strategy. Fisheries and Oceans Canada.

http://www.dfo-mpo.gc.ca/oceans/publications/fedmpa-zpmfed/pdf/mpa-eng.pdf

Ecosystem Restoration Program - Rocky Mountain Trench Forest Stewardship Plan 2012-2017

This plan outlines the process, management objectives and proposed Ecosystem Restoration projects for the Rocky Mountain Trench Ecosystem Restoration Program. It should be noted at the start that although co-ordinated by the Ministry of Forests, Lands and Natural Resource Operations out of the Rocky Mountain Resource District, the Rocky Mountain Trench Ecosystem Restoration Program is a coalition of forest and range licensees, naturalist, hunting, angling and environmental clubs, and government agencies united in a goal of restoring the grasslands and historic open forest conditions of the Rocky Mountain Trench.

Harris, B.J.R. (2011) Ecosystem Restoration Program - Rocky Mountain Trench Forest Stewardship Plan 2012-2017. Ministry of Forests, Lands and Natural Resource Operation, British Columbia.

http://bcwildfire.ca/ftp/DRM/external/!publish/Web/Ecosystem-Restoration/Companion%20Document-draft.pdf

China

Preliminary Strategic Environmental Assessment of the Great Western Development Strategy: Safeguarding Ecological Security for a New Western China

The Great Western Development Strategy (GWDS) is a long term national campaign aimed at boosting development of the western area of China and narrowing the economic gap between the western and the eastern parts of China. The Strategic Environmental Assessment (SEA) procedure was employed to assess the environmental challenges brought about by the western development plans. These plans include five key developmental domains (KDDs): water resource exploitation and use, land utilization, energy generation, tourism development, and ecological restoration and conservation.

Policymakers

Li, W., Y.J. Liu and Z. Yang (2012) Preliminary Strategic Environmental Assessment of the Great Western Development Strategy: Safeguarding Ecological Security for a New Western China. Environmental Management 49: 483-501.

http://rd.springer.com/article/10.1007/s00267-011-9794-1

Assessing China's Ecological Restoration Programs – Special Feature

This Special Feature represents one of the few publications that can be collectively viewed as an integrative assessment of China's ERPs, and the overwhelming evidence reported in it leads us to the conclusion that, by and large, these programs have already made significantly positive impacts, both socioeconomically and environmentally. Thus, the government agencies, local farmers, business employees, policy practitioners, and other stakeholders ought to be encouraged by these affirmative findings.

Policymakers, implementing agencies, practitioners, indigenous and local communities

Yin, R. (ed.) (2010) Assessing China's Ecological Restoration Programs –Special Feature. Environmental Management 45(3).

http://www.springerlink.com/content/0364-152x/45/3/

Degraded Ecosystems in China: Status, Causes, and Restoration Efforts

The total area of China is about 9.6 million km2. Among the terrestrial ecosystems, cropland area is about 1.33 billion ha, 78% of which is degraded land; forestland area is about 1.75 billion ha, 72% of which is forest deterioration; grassland area is 3.99 billion ha, 90% of which has already degraded. Derelict mining land area is about 6 million ha, which is increasing by 12,000 ha/year. So far, only 8% of the total derelict mining land area has been reclaimed. A total lake area of 1.3 million ha has been lost since 1950; 50% of the coastal wetlands has been reclaimed. The mangrove area has declined from 40,000 ha in 1957 to 18,841.7 ha in 1986. With a total of 0.18 billion ha of water area, over 50% of it has been polluted to type III–V in terms of the Chinese Water Quality Standard Classification System. Oceanic area is about 4.73 billion ha, over 1.6% of which is also polluted. The reasons for the deterioration of China's environment are diverse, such as the pressure of a large population, industrialization, and its markets. The deterioration of the ecological index has already affected the current economic index and prospective economic growth directly and obviously.

Policymakers

Ren, H., W.J. Shen, H.F. Lu, X.Y. Wen and S.G. Jian (2007) Degraded Ecosystems in China: Status, Causes, and Restoration Efforts. Landscape and Ecological Engineering 3(1): 1-13.

http://www.springerlink.com/content/n4q4242j65701717/

Development and Testing of a Sustainable Environmental Restoration Policy on Eradicating the Poverty Trap in China's Changting County

Here, we present the results of a study that illustrates how development that combines environmental and economic perspectives and that provides appropriate compensation to affected populations can improve both nature and society, thereby eradicating the ‘‘poverty trap.’’ The results show that if we cannot improve the livelihood of local residents, we will be unable to restore degraded environments when state-owned property is transferred to private ownership to encourage better management by residents. In contrast, measures to eliminate poverty, combined with the development of green enterprises that improve the livelihoods of private land owners in the long term, is the precondition for successful ecological restoration.

Policymakers

Cao, S., B. Zhong, H. Yue, H. Zeng, J. Zeng and G.C. Daily (2009) Development and Testing of a Sustainable Environmental Restoration Policy on Eradicating the Poverty Trap in China's Changting County. PNAS 106(26): 10712-10716.

http://www.pnas.org/content/106/26/10712.full.pdf+html

Economic Development, Rural Livelihoods, and Ecological Restoration: Evidence from China

This article uses a case study in Southeast China to demonstrate how the substantial changes in rural livelihoods have been driven by a combination of ‘‘pull’’ forces from external economic development, and ‘‘push’’ forces from local areas, leading to a shift in rural household economic activities: household outmigration and de-population of the countryside, changes in energy consumption, and most importantly, changes in land uses and eventually, ecological restoration. Such dramatic changes are becoming common across the Chinese countryside. It is pointed out that economic development has generally caused a deterioration of the environment at least at the early period of economic growth, but the positive impacts, especially in some ecosystem in rural areas, have become more apparent.

Policymakers

Wang, C., Y. Yang and Y. Zhang (2011) Economic Development, Rural Livelihoods, and Ecological Restoration: Evidence from China. Ambio 40(1):78-87.

https://fp.auburn.edu/sfws/yaoqizhang/Economic%20Development,%20Rural%20livelihoods,%20and%20Ecological.pdf

Colombia

Plan Nacional de Restauración de Ecosistemas

Tomando como punto de partida el ejercicio de planeación "Visión Colombia Segundo Centenario", en 2019 Colombia deberá alcanzar sus metas de desarrollo económico y social con fundamento en el aprovechamiento sostenible del medio ambiente, los recursos naturales y la biodiversidad. Aunado a lo anterior, el presente plan da respuesta a la estrategia dirigida a Promover la restauración de ecosistemas degradados y de especies amenazadas" de la Política Nacional de Biodiversidad PNB, 1998 y a la de adoptar e implementar el Plan Nacional de Restauración para el desarrollo de procesos de recuperación, rehabilitación y restauración de áreas disturbadas, incluida en la propuesta actual de la Política Nacional para la Gestión integral de la Biodiversidad y sus Servicios Ecosistémicos 2010, en adelante PNGIBSE. Éste plan incluye la conceptualización relacionada con los impulsores o motores de pérdida y transformación identificados en la Evaluación de Ecosistemas del Milenio y retomados en la PNGIBSE3, como las fuerzas que influyen y afectan directamente el suministro de servicios ecosistémicos. Dentro de éstas fuerzas, surgen los disturbios como eventos no planeados que afectan la estructura y la función de los ecosistemas generando áreas disturbadas.

Policymakers

República de Colombia (2011) Plan Nacional de Restauración de Ecosistemas: Restauración Ecológica, Rehabilitación y Recuperación de Áreas Disturbadas. Ministerio de Ambiente y Desarrollo Sostenible, Bogotá.

http://www.minambiente.gov.co/documentos/DocumentosBiodiversidad/proyectos_norma/comentarios/240910_oficio_plan_nal_rest.pdf

La Restauración Ecológica en la Practica: Memorias del I Congreso Colombiano de Restauración Ecológica

El I Congreso Colombiano de Restauracion tuvo los siguientes objetivos: 1. Contribuir a la difusion de las experiencias de restauracion ecologica desarrolladas en diferentes regiones del pais y otros paises, 2. Brindar un espacio para que entidades, grupos, investigadores y personas naturales interesadas en la restauracion ecologica, interactuen e intercambien experiencias, 3. Aportar un espacio para el fortalecimiento de la Red Colombiana de Restauracion Ecologica y la revision de los logros obtenidos hasta ahora, 4. Promover la cooperacion e intercambio de informacion, en torno al desarrollo de la Restauracion Ecologica en Colombia y 5. Generar acciones concretas que permitan el desarrollo academico de nuevas lineas de investigacion dentro de la Ecologia de la Restauracion y la implementacion de nuevos programas de restauracion en el pais.

Practitioners, implementing agencies, policymakers, indigenous and local communities

Vargas Rios, O. and S.P. Reyes B. (eds.) (2011) La Restauración Ecológica en la Practica: Memorias de I Congreso Colombiano de Restauración Ecológica. Universidad Nacional de Colombia

http://www.mtnforum.org/sites/default/files/pub/la_restauracion_ecologica_en_practica.pdf

Europe

Our Life Insurance, Our Natural Capital: An EU Biodiversity Strategy to 2020

This strategy is aimed at reversing biodiversity loss and speeding up the EU's transition towards a resource efficient and green economy. It is an integral part of the Europe 2020 Strategy, and in particular the resource efficient Europe flagship initiative.

Policymakers

Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions, Brussels, 3.5.2011.

http://ec.europa.eu/environment/nature/biodiversity/comm2006/pdf/2020/1_EN_ACT_part1_v7%5b1%5d.pdf

EU Habitat Directive

The aim of this Directive shall be to contribute towards ensuring bio-diversity through the conservation of natural habitats and of wild fauna and flora in the European territory of the Member States to which the Treaty applies. Measures taken pursuant to this Directive shall be designed to maintain or restore, at favourable conservation status, natural habitats and species of wild fauna and flora of Community interest. Measures taken pursuant to this Directive shall take account of economic, social and cultural requirements and regional and local characteristics.

Policymakers

Council Directive 92/43/EEC of 21 May 1992

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:01992L0043-20070101:EN:NOT

EU Water Directive

The purpose of this Directive is to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater which…

Policymakers

Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32000L0060:EN:NOT

EU Birds Directive

The directive recognises that habitat loss and degradation are the most serious threats to the conservation of wild birds. It therefore places great emphasis on the protection of habitats for endangered as well as migratory species (listed in Annex I), especially through the establishment of a coherent network of Special Protection Areas (SPAs) comprising all the most suitable territories for these species.

Policymakers

Directive of 30 November 2009 on the conservation of wild birds 2009/147/EC

http://ec.europa.eu/environment/nature/legislation/birdsdirective/index_en.htm

France

National Biodiversity Strategy 2011-2020

The National Biodiversity Strategy is the outcome of French commitments under the Convention on Biological Diversity (CBD), ratified by France in 1994. The Minister for the Environment at that time was tasked with presenting a strategy which could be implemented across all government departments with the precise aim of: "halting the loss of biodiversity by 2010", in line with the commitment made by all the other European Union members. This aim was applied in the NBS to each of the key components of the living world: genes, species, habitats, ecosystems and their translation into an ecological framework.

Policymakers

Government of France

http://www.developpement-durable.gouv.fr/IMG/pdf/1_bis_-_French_National_Biodiversity_Strategy_-_May_2011.pdf

Germany

Evaluation of the Implementation of a Goal-Oriented Peatland Rehabilitation Plan

Ecological restoration is a problem-driven scientific discipline. Thus an evaluation of the restoration strategies is needed periodically to improve the concepts. In Northern Germany, the Environmental Ministry adopted a peatland action plan in 2002 with the goal to (I) rehabilitate the water quality improvement potential of degraded peatlands and (II) to create suitable habitat conditions for endangered wetland species. The plan is implemented in a series of stages. To improve goal-oriented site selection and planning, local authorities need more training and a better hydrological understanding. To improve the effectiveness of ecological restoration projects, training and capacity building are as important as tool development and research.

Policymakers, implementing agencies

Michael Trepel (2007) Evaluation of the Implementation of a Goal-Oriented Peatland Rehabilitation Plan. Ecological Engineering 30(2): 167-175.

http://www.sciencedirect.com/science/article/pii/S092585740600276X

Iceland

Restoration Challenges and Strategies in Iceland

Methods of restoration in Iceland are shifting from being primarily agronomic in character to being increasingly based on ecological principles, where the aim is to promote ecosystem development and direct succession. The use of native species, including trees and shrubs is increasing, and there is growing emphasis on low input approaches instead of intense methods involving wholesale planting or sowing. Research efforts are being directed at the underlying processes of succession and how it is affected by different reclamation treatment, the ecology and behavior of key species, the use of native species in restoration, and various technical aspects of revegetation.

Policymakers, implementing agencies

Aradóttir, A.L. (?) Restoration Challenges and Strategies in Iceland. Soil Conservation and Protection for Europe.

http://eusoils.jrc.ec.europa.eu/projects/scape/uploads/6/Aradottir.pdf

India

National Mission for a Green India

The National Mission for a Green India, as one of the eight Missions under the National Action Plan on Climate Change (NAPCC), recognizes that climate change phenomena will seriously affect and alter the distribution, type and quality of natural biological resources of the country and the associated livelihoods of the people. Mission for a Green India (henceforth referred to as Mission) acknowledges the influences that the forestry sector has on environmental amelioration though climate mitigation, food security, water security, biodiversity conservation and livelihood security of forest-dependent communities. GIM puts "greening" in the context of climate change adaptation and mitigation. Greening is meant to enhance ecosystem services such as carbon sequestration and storage (in forests and other ecosystems), hydrological services and biodiversity; as well as other provisioning services such as fuel, fodder, small timber and non-timber forest products (NTFPs).

Policymakers

Draft submitted to Prime Minster's Council on Climate Change (2010) Ministry of Environment and Forests, Government of India

http://moef.nic.in/downloads/public-information/GIM-Report-PMCCC.pdf

Integrated Coastal Zone Management Plan: Mangrove Restoration & Coral Transplantation Project

Integrated management of coastal zones appears to be the most appropriate tool for the sustained development of this eco-social system, because it reconciles development with the good ecological health of the resources, and links environmental, social, and economic issues. The area of Gulf of Kutch has already been proposed for demarcation for the ICZM Activities. This Report includes the Detailed Project Report of Component – A, Coastal Resources Conservation and Management for the preparation of Integrated Coastal Zone Management Plan (ICZM) for the State of Gujarat.

Policymakers

Forests and Environment Department, Government of Gujarat (2009)

http://www.geciczmp.com/Data/Sites/1/docs/project-documents/detailed-project-report.pdf

Indian Sundarbans Delta: A Vision

The Vision Document has been created in response to a priority action point identified at a multi-stakeholder workshop held in Kolkata, in March 2009, on Sundarbans: Climate Change Impacts and Adaptation. The priority action point was identified because of consensus among the participants that highly informed policy decisions are necessary to guide action to cope with pressures of predicted changes in the Sundarbans ecoregion. The mere fact that population is growing means that regardless of climate change, more people will be put in harm's way. With climate change, new adaptive solutions are needed to prevent exposing the population to these impacts and to reduce their vulnerability.

Policymakers

Danda, A.A., G. Sriskanthan, A. Ghosh, J. Bandyopadhyay and S. Hazra (2011) Indian Sundarbans Delta: A Vision (New Delhi, World Wide Fund for Nature-India).

http://assets.wwfindia.org/downloads/indian_sundarbans_delta__a_vision.pdf

Mangroves for the Future (MFF) National Strategy and Action Plan (NSAP) India

The present document on 'National Strategy and Action Plan' for India has been prepared in consonance with National policies and programmes, to analyze, identify and tackle various facets of coastal and marine biodiversity, while mangrove ecosystems are at the centre-stage for conservation and management of coastal and marine biodiversity under the IUCN-MFF initiative.

Policymakers

Ministry of Environment and Forests, Government of India (2008)

http://moef.nic.in/divisions/cs/mangroves/NSAP/NSAP.pdf

Governing Biodiversity Conservation and Sustainable Livelihoods in the Warna River Basin, India: An Analysis of Law, Policy, Institutions and Actors

While environmental protection and biodiversity conservation may be more prominently apparent in legislation, it appears that these strengths are undermined by qualitative problems that limit their effective application. Activities at the smaller end of the scale escape much of the regulation imposed on larger projects – for example, small scale mining requires no prior environmental clearance unless it sits within the 10km boundary of a protected area. The evaluation of projects requiring the felling of less than 40ha of trees avoid close scrutiny or the application of the factors that may limit the scope for felling permits. Statistically (Mines 2010), this means that 66% of licensed mines beyond this 10km buffer zone require neither full forest felling permits nor prior environmental clearance. The irrigation of sugar cane plantations, other than those linked directly to the construction of the big dams, are unregulated.

Policymakers

Allan, A. and Y. Yasuda (2011) Governing Biodiversity Conservation and Sustainable Livelihoods in the Warna River Basin, India: An analysis of Law, Policy, Institutions and Actors. LiveDiverse Milestone 9.2 Report.

http://cdn.livediverse.eu/wp-content/uploads/2011/05/M9.2-India-Final.pdf

Kenya

Rehabilitation of the Mau Forest Ecosystem

This Project Concept identifies key priority interventions to be undertaken by GoK in line with the Task Force recommendations to restore the Mau forest ecosystem and provide a sustainable basis for future conservation and management of this vital resource. The sustainability of the ecosystem will be secured by moving the Mau Forests Complex from a single-asset system, where timber extraction, charcoal and human settlements are seen as the only real value of the forest, to a multiple-asset approach, which recognizes the wide variety of values of the ecosystem and diversifies revenue streams by capitalizing on most, if not all, of the ecosystem values, thereby maximizing both conservation and economic returns on the investment. This diversified approach will result in additional non-monetary benefits such as: water sources, biodiversity protection, improved relations among local communities and with other stakeholders, land appreciation, risk reduction and positive public relations. This approach will assist in setting and promoting new standards and models for the sustainable management of other critical forest ecosystems.

Policymakers

A Project Concept prepared by the Interim Coordinating Secretariat, Office of the Prime Minister, on behalf of the Government of Kenya, September 2009.

http://www.kws.org/export/sites/kws/info/maurestoration/maupublications/Mau_Forest_Complex_Concept_paper.pdf

Forest Landscape and Kenya's Vision 2030

Forest practitioners, researchers, educators, managers and decision makers are faced with the challenge of laying the groundwork, clarifying the vision on the future of our forests and determining the promising strategies to make Vision 2030 a reality. Past experience has underscored the vital importance of forests, as much for their capacity to provide goods as well as contributing to maintaining ecological functions essential to society.

Policymakers

Ogweno D.O., P.S. Opanga and A.O. Obara (eds.) (2009) Forest Landscape and Kenya's Vision 2030. Proceedings of the 3rd Annual Forestry Society of Kenya (FSK) 2008 Conference and Annual General Meeting held at the Sunset Hotel, Kisumu.

http://www.ke.undp.org/index.php/resources/download/18

Japan

Basic Policy for Nature Restoration

Today, the realization of a society in harmony with nature and conservation of the global environment have become important challenges. To this end, we must see the value of the natural environment in a new light, and take actions to protect existing species of indigenous animals and plants and conserve the ecosystem that have been nurtured in the area throughout its long history. At the same time, we must carry out nature restoration to actively recover the local natural environments that have been damaged in the past.

Policymakers

Ministry of the Environment, Government of Japan (2003)

http://www.env.go.jp/en/nature/npr/bpnr.pdf

Nature Restoration Projects in Japan: Towards Living in Harmony with the Natural Environment

In January 2003, the "Law for the Promotion of Nature Restoration" was enforced, and in April of that year, the Cabinet approved the "Basic Policy for Nature Restoration." Afterward, various restoration efforts are underway across the nation. This brochure compiles the descriptions of restoration projects sponsored by MOE and local governments, with an emphasis on their specific actions in order to expand the restoration opportunities further. We expect this brochure to be used by more communities for taking a first step in ecological restoration.

Policymakers, implementing agencies, indigenous and local communities

English, Japanese

Ministry of the Environment, Government of Japan (2011)

http://www.env.go.jp/en/nature/npr/nrp_japan/index.html

Netherlands

The State of the Art of Aquatic and Semi-aquatic Ecological Restoration Projects in the Netherlands

Only very recently, some 25 years ago, the tide has been turned and ecological rehabilitation and restoration of disturbed ecosystems are in full swing now, enhanced by the European Union policy to set aside agricultural land in the Netherlands in favour of the development of 'nature'. The state of the art of aquatic and semi-aquatic ecological restoration projects in the Netherlands is given. Starting from the conceptual basis of restoration ecology, the successes and failures of hundreds of restoration projects are given. Numerous successful projects are mentioned. In general, ecological restoration endeavours are greatly benefiting from progressive experience in the course of the years. Failures mainly occur by insufficient application of physical, chemical or ecological principles.

Policymakers, implementing agencies

Nienhuis, P.H., J.P. Bakker, A.P. Grootjans, R.D. Gulati and V.N. de Jonge (2002) The State of the Art of Aquatic and Semi-aquatic Ecological Restoration Projects in the Netherlands. Hydrobiologia 478: 219-233.

http://ivem.eldoc.ub.rug.nl/FILES/ivempubs/publart/2002/HydrobiolNienhuis/2002HydrobiolNienhuis.pdf

New Zealand

Ecosystem Restoration on Mainland New Zealand

In this address, I want to show how this situation in New Zealand is being turned around. I will do it by demonstrating: 1) Successes we have had with redressing the declines of species, communities and ecosystems on islands, 2) How we are applying lessons learned on islands to active management of selected ecosystems on the mainland, and 3) How this approach to ecosystems has been made possible through a mandate that focuses on conservation and provides a foundation for integrated conservation management.

Policymakers, implementing agencies

Mansfield, B. (1996) Ecosystem Restoration on Mainland NZ. Department of Conservation, Auckland.

http://www.doc.govt.nz/publications/conservation/land-and-freshwater/land/ecosystem-restoration-on-mainland-nz/

Restoring Waikato's Indigenous Biodiversity: Ecological Priorities and Opportunities

This document highlights priorities and opportunities for restoring depleted ecosystems across the Waikato region. It also identifies ecosystems that are in most need of restoration. More importantly, it provides a context of indigenous ecosystem restoration in the Waikato, so that people who want to be involved in restoration projects can see where they fit into the bigger picture.

Policymakers, implementing agencies, indigenous and local communities

Waikato Biodiversity Forum (2006) Restoring Waikato's Indigenous Biodiversity: Ecological Priorities and Opportunities. Environment Waikato, New Zealand.

http://www.waikatobiodiversity.org.nz/biodiversity_information/restoring_waikato_s_indigenous_b/

Korapuki Island as a Case Study for Restoration of Insular Ecosystems in New Zealand

Success with eradicating invasive species from islands around New Zealand raises the prospect of reversing the loss of species by restoring biotic communities on modified islands. I seek to identify methods that can be used to clarify restoration targets on Korapuki Island, which was modified by introduced mammals until 1987. Ecological restoration of island ecosystems has been likened to reconstituting the ambiguous because of conceptual and practical difficulties. Goals for restoration of island systems are often dependent on value judgements. Biological outcomes or targets can be clarified by the use of unmodified neighbouring islands as benchmarks. However, successional pathways on the restored island may not converge with the benchmarks because of environmental differences between sites.

Implementing agencies, practitioners

Towns, D.R. (2002) Korapuki Island as a case study for restoration of insular ecosystems in New Zealand. Journal of Biogeography 29: 593-607.

http://onlinelibrary.wiley.com/doi/10.1046/j.1365-2699.2002.00709.x/abstract

Rwanda

Rwanda Forest and Landscape Restoration

The Government of Rwanda announced in the beginning of 2011 an ambitious plan to integrate landscape restoration into it's national development plans and to pursue a goal that would witness large-scale border to border restoration of land, soil, forest and water resources for the benefit of the Rwandan population over the next twenty five years based on an Memorandum of Understanding signed by the Government of Rwanda, IUCN and the United Nations Forum on Forests.

Policymakers

Stakeholder Consultative Meeting Outcomes. Kigali, Rwanda 18th to 21st July, 2011.

http://www.cbfp.org/docs/research_docs/Facilitation%20canadienne%202011/Rwanda%20Forest%20Landscape%20Restoration_Workshop%20Report.pdf

South Africa

Restoration in South Africa

Restoration can provide a wide range of direct and indirect benefits to society. However, there are very few projects that have attempted to properly quantify those benefits and present them in such a way that society is motivated to invest in restoration. Describing and quantifying these benefits requires people who understand ecosystems and their restoration, as well as people who know how to assess benefits. However, it is not a matter of simply combining knowledge. We need to understand how differently our sciences view the world and organise their knowledge of it.

Policymakers, implementing agencies

Blignaut, J. (2010) Restoration in South Africa. Quest 6(1).

http://www.rncalliance.org/WebRoot/rncalliance/Shops/rncalliance/4B9F/F813/C907/677B/8BEA/C0A8/D218/5A0C/P26-30_002E_EcologicalRestoration.pdf

Economic Incentives for Restoring Natural Capital in Southern African Rangelands

Technical and economic factors hinder effective ecological restoration, especially in developing countries. Three examples show how social policy, economic threats and opportunities, and national and international development policy are driving the restoration of degraded landscapes in southern Africa. First, new opportunities in nature tourism, together with the declining profitability of traditional ranching, have led to diversification into game farming, tourism, and hunting, all initiatives that rely on properly functioning ecosystems. Second, new environmental legislation is forcing industries, particularly mining, to restore land upon termination of their activities. Third, through South Africa's "Working for Water" program, an elegant solution to problems of excessive water use, local residents are developing skills in clearing alien plants and restoring rangelands.

Policymakers

Milton, S.J., W.R.J. Dean and D.M. Richardson (2003) Economic incentives for restoring natural capital in southern African rangelands. Frontiers in Ecology and the Environment 1: 247-254.

http://www.esajournals.org/doi/abs/10.1890/1540-9295%282003%29001%5B0247%3AEIFRNC%5D2.0.CO%3B2?journalCode=fron

Investing in Natural Capital and Economic Development: South Africa's Drakensberg Mountains

We describe a proposed large-scale restoration and land use management project planned for a portion of the Drakensberg Mountains in South Africa. Some 250,000 ha of high-lying land in the Drakensberg range are a protected conservation area and also a World Heritage Site. Bordering this conservation enclave is another 250,000 ha of increasingly degraded land subject to a variety of competing land uses. Conflicting land use objectives could, in theory, be mitigated and reconciled by identifying and developing a market for the delivery of ecosystem services such as water use and quality, carbon sequestration, erosion and siltation reduction, combating desertification, and the promotion of biodiversity conservation.

Policymakers

Blignaut, J., J. Aronson, M. Mander and C. Marais (2008) Investing in Natural Capital and Economic Development: South Africa's Drakensberg Mountains. Ecological Restoration 26(2): 143-150.

http://er.uwpress.org/content/26/2/143.abstract

UK

Biodiversity 2020: A Strategy for England's Wildlife and Ecosystem Services

This strategy will guide our conservation efforts in England over the next decade, including setting our ambition to halt overall loss of England's biodiversity by 2020. In the longer term, our ambition is to move progressively from a position of net biodiversity loss to net gain.

Policymakers

Department of Environment, Food and Rural Affairs (DEFRA), UK

http://www.defra.gov.uk/publications/files/pb13583-biodiversity-strategy-2020-111111.pdf

The Natural Choice: Securing the Value of Nature

Nature is sometimes taken for granted and undervalued. But people cannot flourish without the benefits and services our natural environment provides. Nature is a complex, interconnected system. A healthy, properly functioning natural environment is the foundation of sustained economic growth, prospering communities and personal wellbeing.

Policymakers

Presented to Parliament by the Secretary of State for Environment, Food and Rural Affairs by Command of Her Majesty, June 2011

http://www.official-documents.gov.uk/document/cm80/8082/8082.pdf

Making Space for Nature: A Review of England's Wildlife Sites and Ecological Network

Do England's wildlife sites comprise a coherent and resilient ecological network? If not, what needs to be done? These are the questions that we aim to answer in this report. We first consider why these questions are important in the context of past, current and future pressures on the environment, and describe what ecological networks are and the benefits they bring. We go on to consider the strengths and weaknesses of our current wildlife sites, before setting out a prioritised set of ecological solutions to improve the network. Finally, we make 24 recommendations for practical action to Make Space for Nature and achieve a coherent and resilient ecological network.

Policymakers

Lawton, J.H. et al. (2010) Making Space for Nature: a review of England's wildlife sites and ecological network. Report to Defra, UK.

http://archive.defra.gov.uk/environment/biodiversity/documents/201009space-for-nature.pdf

Natural Environment: Adapting to Climate Change

In March 2010 all Government Departments published a Departmental Adaptation Plan. Defra's Climate Change Plan recognises that climate change is the most serious long term threat to the natural environment and human well-being, but at the same time our natural environment is our greatest asset: the basis on which we can build a future in a rapidly changing climate. Ecosystems provide the services that clean our air and water, and give us food, medicines, energy, and raw materials. They regenerate soils and pollinate crops, regulate the climate, cool cities; and help to control floods. Defra recognises the importance of enhancing the resilience of ecosystems, and of working effectively with natural processes to offer protection from climate change to homes, infrastructure, livelihoods, and human life.

Policymakers

Defra

http://archive.defra.gov.uk/environment/climate/documents/interim2/natural-environment-adaptation.pdf

Lake Restoration Strategy for The Broads

The response strategy set out in the following report has been designed to fit an approach which seeks to adaptively manage waterbodies within a more naturally functioning flood plain over a long time horizon (50 to 80 years). It is further conditioned by compliance with existing legislation such as the Water Framework Directive. It has twin dimensions in that it is targeted, i.e. focused on the protection and enhancement of those existing good quality sites that have the greatest chance of retaining freshwater habitat over the long term. But it also seeks to uniformly prevent, as far as is feasible, any further deterioration of any of the existing waterbodies. In short, it aims to combine efficiency, effectiveness and prudence principles.

Policymakers, implementing agencies

Kelly, A. (2008) Lake Restoration Strategy for The Broads. Broads Authority, UK.

http://www.broads-authority.gov.uk/broads/live/authority/publications/conservation-publications/LakeRestorationStrategy.pdf

Wetland Vision Technical Document: Overview and Reporting of Project Philosophy and Technical Approach

The Vision provides a philosophical and technical framework that highlights the potential for wetland creation and supports those who want to make a difference through delivery at the local level. This project re-affirms the partnership's commitment to the creation and restoration of wetlands and, by sharing the details of our work, we hope others are inspired to do the same.

Policymakers

Hume, C. 2008. Wetland Vision Technical Document: overview and reporting of project philosophy and technical approach. The Wetland Vision Partnership.

http://www.wetlandvision.org.uk/userfiles/File/Technical%20Document%20Website%20Version.pdf

USA

Big Canyon Creek Watershed Ecological Restoration Strategy

This plan was created to demonstrate the ongoing need and potential for aquatic resources and fish habitat restoration within the watershed, and to ensure continued implementation of restoration actions and activities. It was developed not only to guide the District and the Tribe, but also to encourage cooperation among all stakeholders, including landowners, government agencies, private organizations, tribal governments, and elected officials. Through sharing information, skills, and resources in active, cooperative relationships, all concerned parties will have the opportunity to join together to strengthen and maintain a sustainable natural resource base for present and future generations within the watershed.

Indigenous and local communities, implementing agencies, policymakers

Rasmussen, L., S. Richardson and C. Chandler (2009) Big Canyon Creek Watershed Ecological Restoration Strategy. Nez Perce Soil and Water Conservation District, USA.

http://www.nezperceswcd.org/Portals/2/Watersheds/BigCanyonStrategy2009.pdf

The Everglades Experiments: Lessons for Ecosystem Restoration

This book is a synthesis of the key findings and a summary of the experiments conducted during a fourteen-year period (1989-2003) by the Duke University Wetland Center and its partner institutions. The findings are the result of extensive experimental research on the effects of water, nutrients, and fire on the Everglades communities. This work covers both the structural and functional responses of the Everglades ecosystem via experimental and gradient studies on microbial activity, algal responses, macroinvertebrate populations, macrophyte populations, and productivity in response to alterations to nutrients in soil and water, hydrologic changes, and fire. Importantly, this volume reclassifies the Everglades, provides a comparison of historic and current ecological processes, and presents a new working hydrologic paradigm, which collectively provides essential lessons for the restoration of this vast peatland complex.

Practitioners, implementing agencies

Richardson, C. (2008) The Everglades Experiments: Lessons for Ecosystem Restoration. Springer Ecological Studies Vol. 201, New York.

http://www.springer.com/life+sciences/ecology/book/978-0-387-98796-5

Cedar River Municipal Watershed Riparian Restoration Strategic Plan

Riparian restoration is a component of the watershed management mitigation and conservation strategies included in the Cedar River Municipal Watershed (CRMW) Habitat Conservation Plan (HCP) (City of Seattle, 2000). The CRMW-HCP identified two primary management activities to achieve riparian restoration goals: conifer underplanting and restoration and ecological thinning. In order to effectively implement riparian restoration in the CRMW, this Strategic Plan describes a process to identify riparian restoration needs and opportunities and to plan restoration activities. This document is linked to other strategic plans for CRMW restoration that discuss aquatic and upland restoration, watershed characterization, monitoring, and landscape-level prioritization. The plan explicitly incorporates an asset management approach to riparian restoration.

Implementing agencies, policymakers

Chapin, D., T. Bohle, M. Borsting, M. Joselyn and A. LaBarge (2008) Cedar River Municipal Watershed Riparian Restoration Strategic Plan. Seattle Public Utilities, Watershed Management Division.

http://www.seattle.gov/util/groups/public/@spu/@ssw/documents/webcontent/spu02_015195.pdf

Puget Sound: Washington State's Best Investment

A 21st Century Washington State approach to economic development recognizes that long-term job creation and environmental restoration and investment must go hand-in-hand. When management of flood protection, fish and wildlife habitat, wastewater, drinking water, and other important natural and human functions are treated as whole systems at the scale of their physical boundaries, we gain dramatic improvements in economic efficiency. Healthy ecosystems provide raw materials and core infrastructure functions that simultaneously provide profound and direct positive benefits to Washington's economy.

Policymakers

Harrison-Cox, J., D. Batker, Z. Christin, and J. Rapp (2012) Puget Sound: Washington State's Best Investment. Earth Economics.

http://www.eartheconomics.org/FileLibrary/file/Reports/Puget%20Sound%20and%20Watersheds/Earth%20Economics%20Puget%20Sound%20Summary%20Report.pdf

Venezuela

La Restauración Ecológica en Venezuela: Fundamentos y Experiencias

Dada la importancia que reviste el conocimiento de la teoría ecológica para mitigar problemas de conservación de recursos a los que actualmente nos enfrentamos, hemos incluido en una primera sección como el conocimiento de la sucesión ecológica, de las especies y los mecanismos involucrados, son la piedra angular en la recuperación de diferentes tipos de ecosistemas venezolanos, desde paramos merideños, pasando por bosques de los Llanos Occidentales, sabanas y bosques del estado Bolívar, hasta los del noroeste del estado Amazonas. Estos estudios son la primera fase para establecer, con base científica, estrategias de gestión para la recuperación de nuestros ecosistemas degradados.

Policymakers, implementing agencies

Herrera F. and I. Herrera (eds.) (2011) La Restauración Ecológica en Venezuela: fundamentos y experiencias. Ediciones IVIC, Instituto Venezolano de Investigaciones Científicas (IVIC). Caracas, Venezuela.

http://bitacora.ivic.gob.ve/?p=3421&upm_export=print

6. New and Emerging Themes for Ecosystem Restoration

Assisted Migration ● Biodiversity and Ecosystem Functioning ● Functional Traits ● New Paradigms ● Novel Ecosystems ● Pollination and Mutualisms ● Seed Banks, Botanic Gardens, and Genetic Materials ● Paleoecology ● Red List ● Trophic Cascades

The Rise of Restoration Ecology (Special Issue of Science)

In art, restoration involves recapturing an object's aesthetic value. In ecology, the stakes are arguably much higher: Our planet's future may depend on the maturation of the young discipline of ecological restoration. In this issue, we sample restoration projects around the world and consider the state of the science of this emerging field.

Policymakers, implementing agencies

Roberts, L., R. Stone and A. Sugden (2009) Introduction to The Rise of Restoration Ecology – Special Issue of Science 325: 555.

http://www.sciencemag.org/content/325/5940/555.full.pdf

Rapid Recovery of Damaged Ecosystems

Recent reports on the state of the global environment provide evidence that humankind is inflicting great damage to the very ecosystems that support human livelihoods. The reports further predict that ecosystems will take centuries to recover from damages if they recover at all. Accordingly, there is despair that we are passing on a legacy of irreparable damage to future generations which is entirely inconsistent with principles of sustainability. We tested the prediction of irreparable harm using a synthesis of recovery times compiled from 240 independent studies reported in the scientific literature. We provide startling evidence that most ecosystems globally can, given human will, recover from very major perturbations on timescales of decades to half-centuries. Accordingly, we find much hope that humankind can transition to more sustainable use of ecosystems.

Policymakers

Jones H.P. and O.J. Schmitz (2009) Rapid Recovery of Damaged Ecosystems. PLoS ONE 4(5): e5653.

http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0005653

Assisted Migration

A Framework for Debate of Assisted Migration in an Era of Climate Change

Assisted migration is a contentious issue that places different conservation objectives at odds with one another. This element of debate, together with the growing risk of biodiversity loss under climate change, means that now is the time for the conservation community to consider assisted migration. Our intent here is to highlight the problem caused by a lack of a scientifically based policy on assisted migration, suggest a spectrum of policy options, and outline a framework for moving toward a consensus on this emerging conservation dilemma.

Implementing agencies, policymakers

McLachlan, J.S., J.J. Hellmann and M.W. Schwartz (2007) A framework for debate of assisted migration in an era of climate change. Conservation Biology 21:297–302.

http://www.cakex.org/sites/default/files/A%20Framework%20for%20Debate%20of%20Assisted%20Migration%20in%20an.pdf

Reframing the Debate over Assisted Colonization

Assisted colonization – also known as managed relocation or assisted migration – is one way of facilitating range shifts for species that are restricted in their ability to move in response to climate or other environmental changes. Over the past decade, a healthy debate has evolved in the scientific community over the costs and benefits of assisted colonization as a climate-adaptation strategy. This discussion has focused largely on the specific risks and benefits of intentionally moving species, and has led to the development of multiple frameworks and numerous recommendations for weighing and evaluating these factors. Here, we argue that this debate is, in part, misguided, and that a more productive discussion would result if the issue were reframed in light of (1) the goals of assisted colonization, (2) the realities of projected climate impacts, and (3) the use of complementary adaptation strategies, such as enhancing landscape connectivity.

Policymakers, implementing agencies

Lawler, J.J. and J.D. Olden (2011) Reframing the Debate over Assisted Colonization. Frontiers in Ecology and the Environment 9(10): 569-574.

http://www.fish.washington.edu/research/oldenlab/pdf/2011/FrontiersEcoEnv_2011.pdf

When Worlds Collide

Human-assisted migration is a solution that some people find scary. It pits our desire to prevent extinctions against deep-rooted values of preserving ecosystems in their native state. And it involves a level of human meddling that some have called hubris. But the big picture is more complicated than that. If predictions are right, then climate change over the next 200 years will make anything that a few wayward naturalists do look tame. It will melt away biological communities that we know today, shuffling the deck of surviving species into new ecosystems.

Implementing agencies, policymakers

Fox, D. (2007) When worlds collide. Conservation 8: 28-34.

http://www.conservationmagazine.org/2008/07/when-worlds-collide/

Climate Change and Moving Species: Furthering the Debate on Assisted Colonization

I think it is useful to advance this exercise by considering three issues that can also be construed as continua: species that are more or less acceptable to translocate, sites that are more or less acceptable for receiving translocations, and projects that are more or less acceptable because of their socioeconomic ramifications and feasibility. I have used the term assisted colonization in contrast to assisted migration used by McLachlan et al. because many animal ecologists reserve the word migration for the seasonal, round-trip movements of animals and because the real goal of translocation goes beyond assisting dispersal to assuring successful colonization, a step that will often require extended husbandry.

Implementing agencies, policymakers

Hunter, Jr. M.L. (2007) Climate Change and Moving Species: Furthering the Debate on Assisted Colonization. Conservation Biology 21(5): 1356-1358.

http://ecologia.icb.ufmg.br/~rpcoelho/comunidades/Artigos_2008/ecs08_10.pdf

An Assessment of Invasion Risk from Assisted Migration

To reduce the risk of extinction due to climate change, some ecologists have suggested human-aided translocation of species, or assisted migration (AM), to areas where climate is projected to become suitable. Such intentional movement, however, may create new invasive species if successful introductions grow out of control and cause ecologic or economic damage. We conclude that the risk of AM to create novel invasive species is small, but assisted species that do become invasive could have large effects. Past experience with species reintroductions may help inform policy regarding AM.

Implementing agencies, policymakers

Mueller, J.M. and J.J. Hellman (2008) An Assessment of Invasion Risk from Assisted Migration. Conservation Biology 22(3): 562-567.

http://onlinelibrary.wiley.com/doi/10.1111/j.1523-1739.2008.00952.x/abstract

Biodiversity and Ecosystem Functioning (BEF)

Biodiversity and Ecosystem Function

How is the biodiversity within an ecosystem related to the ecosystem's function? Quantifying and understanding this relationship— the biodiversity ecosystem function (BEF) —is important because socio-economic development is almost always accompanied by the loss of natural habitat and species. Short-term economic gains may thus trump longer-term benefits for human society, creating vulnerabilities that could be avoided or corrected with enough knowledge about the role of biodiversity.

Policymakers

Midgley, G.F. (2012) Biodiversity and Ecosystem Function. Science 335: 174-175

http://www.planta.cn/forum/files_planta/2012_1_13_perspectivesbiodiversity_and_ecosystem_function_194.pdf

Biodiversity, Ecosystem Functioning, and Human Wellbeing

In an age of accelerating biodiversity loss, this volume summarizes recent advances in biodiversity-ecosystem functioning research and explores the economics of biodiversity and ecosystem services. The first section summarizes the development of the basic science and provides a meta-analysis that quantitatively tests several biodiversity and ecosystem functioning hypotheses. The second section describes the natural science foundations of biodiversity-ecosystem functioning research, including: quantifying functional diversity, the development of the field into a predictive science, effects of stability and complexity, methods to quantify mechanisms by which diversity affects functioning, the importance of trophic structure, microbial ecology, and spatial dynamics. The third section takes research on biodiversity and ecosystem functioning further than it has ever gone into the human dimension.

Practitioners, implementing agencies

Naeem, S., D.E. Bunker, A. Hector, M. Loreau and C. Perrings (eds.) (2009) Biodiversity, Ecosystem Functioning, and Human Wellbeing. Oxford Scholarship Online.

http://www.oxfordscholarship.com/view/10.1093/acprof:oso/9780199547951.001.0001/acprof-9780199547951

Biodiversity and Ecosystem Functioning: Current Knowledge and Future Challenges

The ecological consequences of biodiversity loss have aroused considerable interest and controversy during the past decade. Major advances have been made in describing the relationship between species diversity and ecosystem processes, in identifying functionally important species, and in revealing underlying mechanisms. There is, however, uncertainty as to how results obtained in recent experiments scale up to landscape and regional levels and generalize across ecosystem types and processes. Larger numbers of species are probably needed to reduce temporal variability in ecosystem processes in changing environments. A major future challenge is to determine how biodiversity dynamics, ecosystem processes, and abiotic factors interact.

Practitioners, implementing agencies

Loreau, M. et al. (2001) Biodiversity and Ecosystem Functioning: Current Knowledge and Future Challenges. Science 294: 804-808.

http://pascencio.cos.ucf.edu/classes/Plant%20Ecology/Loreau%20et%20al%202001.pdf

Biodiversity and Ecosystem Functioning: Synthesis and Perspectives

The relationship between biodiversity and ecosystem functioning has emerged as one of the most exciting and dynamic areas in contemporary ecology. Increasing domination of ecosystems by humans is steadily transforming them into depauperate systems. How will this loss of biodiversity affect the functioning and stability of natural and managed ecosystems? This volume provides the first comprehensive and balanced coverage of recent empirical and theoretical research on this question. It reviews the evidence, provides bases for the resolution of the debate that has divided scientists on these issues, and offers perspectives on how current knowledge can be extended to other ecosystems, other organisms and other spatial and temporal scales. It cuts across the traditional division between community ecology and ecosystem ecology, and announces a new ecological synthesis in which the dynamics of biological diversity and the biogeochemical functioning of the earth system are merged.

Practitioners, implementing agencies

Loreau, M., S. Naeem and P. Inchausti (eds.) (2003) Biodiversity and Ecosystem Functioning: Synthesis and Perspectives. Oxford University Press.

http://ukcatalogue.oup.com/product/9780198515715.do

Disentangling Biodiversity Effects on Ecosystem Functioning: Deriving Solutions to a Seemingly Insurmountable Problem

We review how functional traits, functional groups, and the relationship between functional and taxonomic diversity have been used in current BEF research. Several points emerged from our review. First, it is critical to distinguish between response and effect functional traits when quantifying or manipulating FD. Second, although it is widely done, using trophic position as a functional group designator does not fit the effect-response trait division needed in BEF research. Third, determining a general relationship between taxonomic and FD is neither necessary nor desirable in BEF research. Fourth, fundamental principles in community and biogeographical ecology that have been largely ignored in BEF research could serve to dramatically improve the scope and predictive capabilities of BEF research. We suggest that distinguishing between functional response traits and functional effect traits both in combinatorial manipulations of biodiversity and in descriptive studies of BEF could markedly improve the power of such studies. We construct a possible framework for predictive, broad-scale BEF research that requires integrating functional, community, biogeographical, and ecosystem ecology with taxonomy.

Practitioners

Naeem, S. and J.P. Wright (2003) Disentangling Biodiversity Effects on Ecosystem Functioning: Deriving Solutions to a Seemingly Insurmountable Problem. Ecology Letters 6: 567-579.

http://onlinelibrary.wiley.com/doi/10.1046/j.1461-0248.2003.00471.x/pdf

Biodiversity and Ecosystem Services: A Multilayered Relationship

The relationship between biodiversity and the rapidly expanding research and policy field of ecosystem services is confused and is damaging efforts to create coherent policy. Using the widely accepted Convention on Biological Diversity definition of biodiversity and work for the UK National Ecosystem Assessment we show that biodiversity has key roles at all levels of the ecosystem service hierarchy: as a regulator of underpinning ecosystem processes, as a final ecosystem service and as a good that is subject to valuation, whether economic or otherwise. Ecosystem science and practice has not yet absorbed the lessons of this complex relationship, which suggests an urgent need to develop the interdisciplinary science of ecosystem management bringing together ecologists, conservation biologists, resource economists and others.

Practitioners, implementing agencies

Mace, G.M., K. Norris and A.H. Fitter (2012) Biodiversity and Ecosystem Services: A Multilayered Relationship. Trends in Ecology and Evolution 27(1): 19-26.

http://www.sciencedirect.com/science/article/pii/S0169534711002424

Ecosystem Structure, Function, and Restoration Success: Are They Related?

A direct relationship between ecosystem structure and function has been widely accepted by restoration ecologists. According to this paradigm, ecosystem degradation and aggradation represent parallel changes in structure and function, restoration following the same path as spontaneous succession. But the existence of single bidirectional trajectories and endpoints is not supported by empirical evidence. On the contrary, multiple meta-stable states, irreversible changes and hysteresis are common in nature. These situations are better described by state- and transition models. Merging those models into the structure–function framework may help to develop new hypotheses on ecosystem dynamics, and may provide a suitable framework for planning restoration activities.

Practitioners, implementing agencies

Cortina, J., F.T. Maestre, R. Vallejo, M.J. Baez, A. Valdecantos and M. Perez-Devesac (2006) Ecosystem Structure, Function, and Restoration Success: Are They Related? Journal for Nature Conservation 14: 152-160.

http://xa.yimg.com/kq/groups/22969879/308223857/name/Ecosystem+structure,+function,+and+restoration.pdf

Biodiversity and Ecosystem Services: Complementary Approaches for Ecosystem Management?

The concept of ecosystem services introduced a new view on the relationship between biodiversity and human well being. But are both concepts, biodiversity and ecosystem services, mutually beneficial? We will try to unravel part of this much debated question in three steps. A division of ecosystem management into these three zones confirms the complementarity of biodiversity and ecosystem services for policy and management strategies. The concept of this triple division can help to facilitate the discussion of a joint achievement of the goals for biodiversity and ecosystem services in the field.

Policymakers, implementing agencies

Schneiders, A., T. Van Daele, W. Van Landuyt and W. Van Reeth (2012) Biodiversity and Ecosystem Services: Complementary Approaches for Ecosystem Management? Ecological Indicators 21: 123-133.

http://www.sciencedirect.com/science/article/pii/S1470160X11001920

Biodiversity-Ecosystem Function Research: Is It Relevant to Conservation?

In general, the conservation case is stronger for stability measures of function than stock and flux measures, in part because it is easier to attribute value unambiguously to stability and in part because stock and flux measures of functions are anticipated to be more affected by multitrophic dynamics. Nor is biodiversity-ecosystem function theory likely to help conservation managers in practical decisions, except in the particular case of restoration. We give recommendations for increasing the relevance of this area of research for conservation.

Practitioners, implementing agencies

Srivastava, D.S. and M. Vellend (2005) Biodiversity-Ecosystem Function Research: Is It Relevant to Conservation? Annual Review of Ecology, Evolution, and Systematics 36: 267-294.

http://www3.botany.ubc.ca/vellend/Srivastava&Vellend_AREES_2005.pdf

Biodiversity and Ecosystem Functioning: It Is Time for Dispersal Experiments

The experimental study of the relationship between biodiversity and ecosystem function has mainly addressed the effect of species and number of functional groups. In theory, this approach has mainly focused on how extinction affects function, whereas dispersal limitation of ecosystem function has been rarely discussed. A handful of seed introduction experiments, as well as numerous observations of the effects of long-distance dispersal of alien species, indicate that ecosystem function may be strongly determined by dispersal limitation at the local, regional and/or global scales. We suggest that it is time to replace biodiversity manipulation experiments, based on random draw of species, with those addressing realistic scenarios of either extinction or dispersal.

Practitioners, implementing agencies

Zobel, M., M. Öpik, M. Moora and M. Pärtel (2006) Biodiversity and Ecosystem Functioning: It Is Time for Dispersal Experiments. Journal of Vegetation Science 17(4): 543-547.

http://moritz.botany.ut.ee/mari.moora/Zobel_et_al_2006_JVS.pdf

Enhancement of Biodiversity and Ecosystem Services by Ecological Restoration: A Meta-Analysis

Ecological restoration is widely used to reverse the environmental degradation caused by human activities. However, the effectiveness of restoration actions in increasing provision of both biodiversity and ecosystem services has not been evaluated systematically. A meta-analysis of 89 restoration assessments in a wide range of ecosystem types across the globe indicates that ecological restoration increased provision of biodiversity and ecosystem services by 44 and 25%, respectively. However, values of both remained lower in restored versus intact reference ecosystems. Increases in biodiversity and ecosystem service measures after restoration were positively correlated. Results indicate that restoration actions focused on enhancing biodiversity should support increased provision of ecosystem services, particularly in tropical terrestrial biomes.

Policymakers

Rey Benayas, J.M., A.C. Newton, A. Diaz and J.M. Bullock (2009) Enhancement of Biodiversity and Ecosystem Services by Ecological Restoration: A Meta-Analysis. Science 325: 1121-1124.

http://www2.uah.es/josemrey/Reprints/ReyBenayas_Restoration_Science_pr2009.pdf

Forest Restoration, Biodiversity and Ecosystem Functioning

The BEF-approach provides a useful framework to evaluate forest restoration in an ecosystem functioning context, but it also highlights that much remains to be understood, especially regarding the relation between forest functioning on the one side and genetic diversity and above-ground-below-ground species associations on the other. The strong emphasis of the BEF-approach on functional rather than taxonomic diversity may also be the beginning of a paradigm shift in restoration ecology, increasing the tolerance towards allochthonous species.

Policymakers, implementing agencies

Aerts, R. and O. Honnay (2011) Forest Restoration, Biodiversity and Ecosystem Functioning. BMC Ecology 11:29.

http://www.biomedcentral.com/content/pdf/1472-6785-11-29.pdf

Forest Biodiversity and the Delivery of Ecosystem Goods and Services: Translating Science into Policy

Focusing on forest and agroforest systems, we synthesize recent research on the role of biodiversity in the provision of ecosystem services and provide examples of biodiversity science that informs ecosystem management and policy. Finally, we highlight barriers to the transfer of knowledge from scientists to decision-makers and suggest that scientists can be much more effective at informing policy and improving resource management by asking policy-relevant questions and providing timely and consistent information to decision-makers and the public on the linkages among biodiversity, ecosystem services, and their value to people.

Policymakers, implementing agencies

Thompson, I.D., K. Okabe, J.M. Tylianakis, P. Kumar, E.G. Brockerhoff, N.A. Schellhorn, J.A. Parrotta and R. Nasi (2011) Forest Biodiversity and the Delivery of Ecosystem Goods and Services: Translating Science into Policy. BioScience 61(12): 972-981.

http://www.jstor.org/discover/10.1525/bio.2011.61.12.7?uid=3739832&uid=2129&uid=2&uid=70&uid=4&uid=3739256&sid=56191300563

Diversity-Function Relationships Changed in a Long-term Restoration Experiment

The central tenet of biodiversity–ecosystem function (BEF) theory, that species richness increases function, could motivate restoration practitioners to incorporate a greater number of species into their projects. But it is not yet clear how well BEF theory predicts outcomes of restoration, because it has been developed through tests involving short-run and tightly controlled (e.g., weeded) experiments. Thus, we resampled our 1997 BEF experiment in a restored salt marsh to test for long-term effects of species richness (plantings with 1, 3, and 6 species per 2 x 2 m plot), with multiple ecosystem functions as response variables. Where species-rich plantings are unlikely to ensure long-term restoration of functions, as in our salt marsh, we recommend dual efforts to establish (1) dominant species that provide high levels of target functions, and (2) subordinate species, which might provide additional functions under current or future conditions.

Practitioners, implementing agencies

Doherty, J.M., J.C. Callaway and J.B. Zedler (2011) Diversity–function relationships changed in a long-term restoration experiment. Ecological Applications 21: 2143-2155.

http://www.esajournals.org/doi/abs/10.1890/10-1534.1?journalCode=ecap

Biodiversity and Ecosystem Functioning in Restored Ecosystems: Extracting Principles for a Synthetic Perspective

In a nutshell, the BEF perspective considers all ecosystems in the modern landscape as biogeochemical systems on or displaced from a fundamental relationship between biodiversity and ecosystem functioning. From this perspective, restoration is the activity that seeks to restore displaced ecosystems to this fundamental relationship.

Implementing agencies, policymakers

Naeem, S. (2006) Biodiversity and Ecosystem Functioning in Restored Ecosystems: Extracting Principles for a Synthetic Perspective. Pp. 210-235 in Foundations of Restoration Ecology (Falk, D.A., M.A. Palmer and J.B. Zedler (eds.)), Island Press, Washington, DC.

http://www1.inecol.edu.mx/repara/download/III_1_FoundationsofRestorationEcologyThe%20ScienceandPracticeof%20EcologicalRestoration.pdf#page=223

Managing Ecosystem Services: What Do We Need to Know About their Ecology?

Previous work maps the supply and demand for services, assesses threats to them, and estimates economic values, but does not measure the underlying role of biodiversity in providing services. In contrast, experimental studies of biodiversity–function examine communities whose structures often differ markedly from those providing services in real landscapes. A bridge is needed between these two approaches. To develop this research agenda, I discuss critical questions and key approaches in four areas: (1) identifying the important ecosystem service providers; (2) determining the various aspects of community structure that influence function in real landscapes, especially compensatory community responses that stabilize function, or non-random extinction sequences that rapidly erode it; (3) assessing key environmental factors influencing provision of services, and (4) measuring the spatio-temporal scale over which providers and services operate. I show how this research agenda can assist in developing environmental policy and natural resource management plans.

Practitioners, implementing agencies, policymakers

Kremen, C. (2005) Managing Ecosystem Services: What Do We Need to Know About their Ecology? Ecology Letters 8: 468-479.

http://soilcrop.colostate.edu/undergrad/pdf/580/Managing%20Ecosystem%20Services_Kremen%202005.pdf

Changes in Biodiversity and Ecosystem Function during the Restoration of a Tropical Forest in South China

Based on a 45-year restoration study in south China, we found that a tropical rain forest, once completely destroyed, could not recover naturally without deliberate restoration efforts. We identified two kinds of thresholds that must be overcome with human ameliorative measures before the ecosystem was able to recover. The first threshold was imposed primarily by extreme physical conditions such as exceedingly high surface temperature and impoverished soil, while the second was characterized by a critical level of biodiversity and a landscape context that accommodates dispersal and colonization processes. Our three treatment catchments (un-restored barren land, single-species plantation, and mixed-forest stand) exhibited dramatically different changes in biodiversity and ecosystem functioning over 4 decades. The mixed forest, having the highest level of biodiversity and ecosystem functioning, possesses several major properties of tropical rain forest. These findings may have important implications for the restoration of many severely degraded or lost tropical forest ecosystems.

Implementing agencies, policymakers

Ren, H., Z. Li, W. Shen, Z. Yu, S. Peng, C. Liao, M. Ding and J. Wu (2007) Changes in Biodiversity and Ecosystem Function during the Restoration of a Tropical Forest in South China. Science China Series 50(2): 277-284.

http://www.xiaoliangstation.org/sites/default/files/upload/ren_etal-2007-xiaoliang.pdf

Functional Traits

Ecological Restoration and Physiology: An Overdue Integration

There is growing recognition that opportunities exist to use physiology as part of the conservation and management of populations and ecosystems. However, this idea has rarely been extended to the field of restoration ecology. Physiological metrics (e.g., gas exchange, energy transfer and metabolism, stress response, nutritional condition, gene expression) from a range of taxa can be used to understand the function of ecosystems as well as the factors that influence their structure. Such knowledge can assist the development and implementation of effective restoration strategies that recognize the role of habitat quality on organismal performance.

Practitioners

Cooke, S.J. and C.D. Suski (2008) Ecological Restoration and Physiology: An Overdue Integration. BioScience 58(10): 957-968.

http://www.jstor.org/discover/10.1641/B581009?uid=3739832&uid=2&uid=4&uid=3739256&sid=21101138392897

Plant Traits – A Tool for Restoration?

Plant trait models determined what proportion of this explanatory power can be attributed to plant traits. The two model types addressed the following specific questions: (1) how much of the variability in field responses (changes in cover) of plants to restoration management treatments is explained by plant traits; and (2) how well do plant traits explain the variability of field responses (changes in cover) following restoration management treatments compared to models relating field responses to species identity? Strong explanatory power of plant trait models supports the feasibility of using plant traits instead of species taxonomic identity as a common language to characterize plant field responses (changes in cover) to restoration treatments.

Practitioners

Clark, D.L., M. Wilson, R. Roberts, P.W. Dunwiddie, A. Stanley and T.N. Kaye (2012) Plant traits – a tool for restoration? Applied Vegetation Science, Early View Online.

http://onlinelibrary.wiley.com/doi/10.1111/j.1654-109X.2012.01198.x/abstract

An Application of Plant Functional Types for Predicting Restoration Outcomes

We evaluated the restoration of native plant assemblages by topsoil translocation in the Hunter Valley, south-east Australia. Species' responses were characterized by defining nine plant functional types (PFTs) based on combinations of four response mechanisms (seed bank persistence, germination cues, resprouting mechanisms, and longevity) through which species were predicted to persist or decline following translocation. The effects of community type and delay in topsoil restoration on restoration outcomes were tested in an orthogonal experiment. We conclude that PFTs based on fire-response traits represent a practical means of predicting species' responses to translocation and a basis for prioritizing species for supplementary planting.

Practitioners

Tozer, M.G., B.D.E. Mackenzie and C.C. Simpson (2011) An Application of Plant Functional Types for Predicting Restoration Outcomes. Restoration Ecology, Early View Online.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2011.00828.x/abstract

Plant Traits as Predictors of Performance in Ecological Restoration

There are few studies of the performance of species in restored vegetation communities. Here we report the results of a meta-analysis of 25 experiments concerned with species-rich grassland restoration on ex-arable land and agriculturally improved grasslands situated at a wide range of locations throughout lowland Britain. Differences in species' performance were related to 38 physiological and morphological traits. This study has important implications for practical restoration programmes and policies. Efficiency might be increased by introducing only species with good performance, but this would lead to uniformity among restored grasslands and would diminish the benefits of habitat restoration for national and regional biodiversity. Future work should focus on practical methods to increase the successful establishment of the poor performing but desirable species, by (i) targeting restoration to low fertility soils, (ii) changing the abiotic environment or (iii) the 'phased introduction' of species several years after restoration, when both the plant community is more stable and the environmental conditions are more favourable for establishment.

Practitioners, implementing agencies

Pywell, R.F., J.M. Bullock, D.B. Roy, L. Warman, K.J. Walker and P. Rothery (2003) Plant Traits as Predictors of Performance in Ecological Restoration. Journal of Applied Ecology 40: 65-77.

http://www.globalrestorationnetwork.org/uploads/files/LiteratureAttachments/503_plant-traits-as-predictors-of-performance-in-ecological-restoraation.pdf

Restoration through Reassembly: Plant Traits and Invasion Resistance

One of the greatest challenges for ecological restoration is to create or reassemble plant communities that are resistant to invasion by exotic species. We examine how concepts pertaining to the assembly of plant communities can be used to strengthen resistance to invasion in restored communities. Community ecology theory predicts that an invasive species will be unlikely to establish if there is a species with similar traits present in the resident community or if available niches are filled. Therefore, successful restoration efforts should select native species with traits similar to likely invaders and include a diversity of functional traits. The success of trait-based approaches to restoration will depend largely on the diversity of invaders, on the strength of environmental factors and on dispersal dynamics of invasive and native species.

Practitioners, implementing agencies

Funk, J.L., E.E. Cleland, K.N. Suding and E.S. Zavaleta (2008) Restoration through Reassembly: Plant Traits and Invasion Resistance. Trends in Ecology and Evolution 23(12): 695-703.

http://www.planta.cn/forum/files_planta/restoration_through_reassembly_plant_traits_and_invasion_resistance_164.pdf

Plant Functional Types: A Promising Tool for Management and Restoration of Degraded Lands

We describe two case studies undertaken to evaluate the effects of logging or overgrazing on plant species diversity in pine forests of southern France and steppe ecosystems of southern Tunisia. Both studies employed the same methodology to identify plant functional traits (morphological, life history and regeneration traits) associated with community response to disturbance. The results of these analyses allowed us to develop state and transition models that could be used to plan and predict ecosystem trajectories, assess ongoing degradation processes and monitor community and ecosystem responses to management and restoration practices. We discuss the relevance and the use of plant functional types (PFTs) as tools for ecosystem management and planning and for monitoring restoration in southern Europe, northern Africa and elsewhere. Using this approach it is possible to improve management strategies for the conservation, restoration and sustainable exploitation of biodiversity and of ecosystems.

Implementing agencies, practitioners

Gondard, H., S. Jauffret, J. Aronson and S. Lavorel (2003) Plant functional types: a promising tool for management and restoration of degraded lands. Applied Vegetation Science 6: 223-234.

http://onlinelibrary.wiley.com/doi/10.1111/j.1654-109X.2003.tb00583.x/abstract

Using Plant Functional Traits to Understand the Landscape Distribution of Multiple Ecosystem Services

Spatially explicit understanding of the delivery of multiple ecosystem services (ES) from global to local scales is currently limited. New studies analysing the simultaneous provision of multiple services at landscape scale should aid the understanding of multiple ES delivery and trade-offs to support policy, management and land planning. Analyses of ES using plant functional variation across landscapes are a powerful approach to understanding the fundamental ecological mechanisms underlying ES provision, and trade-offs or synergies among services. Sustainable management of species and functionally diverse grassland could simultaneously aim at conserving biodiversity and locally important ES by taking advantage of correlations and trade-offs among different plant functional traits.

Practitioners

Lavorel, S., K. Grigulis, P. Lamarque, M-P. Colace, D. Garden, J. Girel, G. Pellet and R. Douzet (2011) Using Plant Functional Traits to Understand the Landscape Distribution of Multiple Ecosystem Services. Journal of Ecology 99: 135-147.

http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2745.2010.01753.x/abstract

New Nature by Sowing? The Current State of Species Introduction in Grassland Restoration, and the Road Ahead

Semi-natural grasslands are some of the most threatened habitats on the planet, due to the abandonment of small-scale farming and its replacement with intensive agriculture. The fragmented landscape of today has created dispersal limitation that makes improbable the natural dispersal of target species into the remaining patches of grassland. This paper reviews the current status of species introduction into semi-natural grasslands, and summarises the results of published literature in this field. Our review shows that restoration through species introduction is an effective method of establishing dispersal limited species. However, the field of species introduction in restoration ecology has yet to make use of the value that Functional Diversity can add to restoration. No single study in our search has followed up species introduction by measuring any of the currently available indices of functional diversity. This approach is necessary to gain knowledge on what traits are likely to be sorted out in species introduction cases in various environments.

Practitioners, implementing agencies

Hedberg, P. and W. Kotowski (2010) New Nature by Sowing? The Current State of Species Introduction in Grassland Restoration, and the Road Ahead. Journal for Nature Conservation 18: 304-308.

http://www.biol.uw.edu.pl/pl/files/docs/st_dokt/SD_SCB_New_nature_by_sowing.pdf

Using Plant Functional Traits to Guide Restoration: A Case Study in California Coastal Grassland

Restoration ecology can benefit greatly from developments in trait-based ecology that enable improved predictions of how the composition of plant communities will respond to changes in environmental conditions. Plant functional traits can be used to guide the restoration of degraded habitats by closely tailoring treatments to the local species pool. We tested this approach in two heavily invaded coastal California grasslands. Our study indicates that trait-based ecology is sufficiently mature to provide useful predictions in the realm of restoration ecology. Trait screening at a site can help predict the success of a particular restoration measure in that community.

Practitioners

Sandel, B., J.D. Corbin and M. Krupa (2011) Using plant functional traits to guide restoration: A case study in California coastal grassland. Ecosphere 2:art23.

http://www.esajournals.org/doi/pdf/10.1890/ES10-00175.1

Species, Functional Groups, and Thresholds in Ecological Resilience

On the basis of our results, we believe an ecosystem with a full complement of species can sustain considerable species losses without affecting the distribution of functions within and across aggregations, although ecological resilience is reduced. We propose that the mechanisms responsible for shaping discontinuous distributions of body mass and the nonrandom distribution of functions may also shape species losses such that local extinctions will be nonrandom with respect to the retention and distribution of functions and that the distribution of function within and across aggregations will be conserved despite extinctions.

Practitioners

Sundstrom, S.M., C.R. Allen and C. Barichievy (2012) Species, Functional Groups, and Thresholds in Ecological Resilience. Conservation Biology 26(2): 305-314.

http://onlinelibrary.wiley.com/doi/10.1111/j.1523-1739.2011.01822.x/abstract

Altering Light Availability to Restore Invaded Forest: The Predictive Role of Plant Traits

Many studies have demonstrated that reduced light availability, which can be manipulated at local scales by planting or seeding canopy species, can curtail the growth of invasive species and promote the growth of native species. Species differences in functional traits, such as light use and stress tolerance, may be used to determine how native and invasive species will respond to these resource manipulations. Our data suggest that differences in light use among native and invasive species can help to determine the utility of resource manipulation as a restoration tool and, more specifically, to predict which native species will be optimal for restoration efforts that manipulate light availability.

Practitioners, implementing agencies

Funk, J.L. and S. McDaniel (2010) Altering Light Availability to Restore Invaded Forest: The Predictive Role of Plant Traits. Restoration Ecology 18(6): 865-872.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2008.00515.x/abstract

A Distance-based Framework for Measuring Functional Diversity from Multiple Traits

A new framework for measuring functional diversity (FD) from multiple traits has recently been proposed. This framework was mostly limited to quantitative traits without missing values and to situations in which there are more species than traits, although the authors had suggested a way to extend their framework to other trait types. The main purpose of this note is to further develop this suggestion. We describe a highly flexible distance-based framework to measure different facets of FD in multidimensional trait space from any distance or dissimilarity measure, any number of traits, and from different trait types (i.e., quantitative, semi-quantitative, and qualitative). This new approach allows for missing trait values and the weighting of individual traits.

Practitioners

Laliberte, E. and P. Legendre (2010) A Distance-based Framework for Measuring Functional Diversity from Multiple Traits. Ecology 91(1): 299-305.

http://www.bio.umontreal.ca/legendre/reprints/laliberte_legendre_ecology_2010.pdf

Rethinking Species Selection for Restoration of Arid Shrublands

Restoration is playing an increasingly important role in ecology as natural habitats become scarcer and chances to restore ecosystems damaged by human activities are more common. However, restoration of degraded Mediterranean arid ecosystems is hampered by drought and poor soils, which cause many establishment failures. To compare how species belonging to different successional stages establish in a very stressful site, we carried out a field experiment with 14 tree and shrub species differing in functional traits. We suggest a new approach for the restoration for arid shrublands in which species are carefully selected based on traits that best suit the environmental conditions.

Practitioners, implementing agencies

Padilla, F.M., R. Ortega, J. Sánchez and F.I. Pugnaire (2009) Rethinking Species Selection for Restoration of Arid Shrublands. Basic and Applied Ecology 10(7): 640-647.

http://www.sciencedirect.com/science/article/pii/S1439179109000292

Traits, Neighbors, and Species Performance in Prairie Restoration

Are traits related to the performance of plant species in restoration? Are the relationships between traits and performance consistent across the functional groups of annual forbs, perennial forbs and grasses? Do the relationships between traits and performance depend on neighboring functional groups? Multiple-trait models should be a useful way of predicting the performance of species prior to sowing in restoration. The functional group identity of each species and the other species being sown may need to be taken into account when making predictions.

Practitioners, implementing agencies

Roberts, R.E., D.L. Clark and M.V. Wilson (2010) Traits, neighbors, and species performance in prairie restoration. Applied Vegetation Science 13: 270-279.

http://onlinelibrary.wiley.com/doi/10.1111/j.1654-109X.2009.01073.x/abstract

Plant Traits in Response to Raising Groundwater Levels in Wetland Restoration: Evidence from Three Case Studies

Is raising groundwater tables successful as a wetland restoration strategy? The prevalent traits of the restored wetlands do not coincide with traits belonging to generally targeted plant species of wetland restoration. Long-term observations in restored and control wetlands with different groundwater regimes are needed to determine whether target plant species eventually revegetate restored wetlands.

Practitioners, implementing agencies

van Bodegom, P.M., A.P. Grootjans, B.K. Sorrell, R.M. Bekker, C. Bakker and W.A. Ozinga (2006) Plant Traits in Response to Raising Groundwater Levels in Wetland Restoration: Evidence from Three Case Studies. Applied Vegetation Science 9: 251-260.

http://ivem.eldoc.ub.rug.nl/FILES/ivempubs/publart/2006/ApplVegScivBodegom/2006ApplVegScivBodegom.pdf

Composition and Dynamics of Functional Groups of Trees During Tropical Forest Succession in Northeastern Costa Rica

We compared the functional type composition of trees less than 10 cm dbh in eight secondary forest monitoring plots with logged and unlogged mature forest plots in lowland wet forests of Northeastern Costa Rica. Five plant functional types were delimited based on diameter growth rates and canopy height of 293 tree species. Tree stature and growth rates capture much of the functional variation that appears to drive successional dynamics. Results further suggest strong linkages between functional types defined based on adult height and growth rates of large trees and abundance of seedling and sapling regeneration during secondary succession.

Practitioners

Chazdon, R.L., B. Finegan, R.S. Capers, B. Salgado-Negret, F. Casanoves, V. Boukili and N. Norden (2010) Composition and Dynamics of Functional Groups of Trees During Tropical Forest Succession in Northeastern Costa Rica. Biotropica 42(1): 31-40.

http://www.eeb.uconn.edu/people/capers/ChazdonEtAl2010.pdf

Species' Traits and Ecological Functioning in Marine Conservation and Management

Marine conservation increasingly focuses on describing and maintaining ecosystem functioning. However, it is difficult to find suitable measures for whole-ecosystem functioning because the concept incorporates many different processes and includes physical, chemical and biological phenomena. An approach is presented here for describing functioning based on traits exhibited by members of biological assemblages. Species' traits determine how they contribute to ecosystem processes, so the presence and distribution of such traits can be utilised to indicate aspects of functioning. This multi-trait approach is relatively new to marine ecology and the few studies to-date have mainly described patterns of functioning with respect to environmental variability and investigated the impacts of bottom trawling. Areas where the approach can make a significant contribution to conservation and marine management are discussed, such as monitoring the effects of human activities and success of subsequent management strategies, identifying species likely to become invasive or those particularly vulnerable to extinction and predicting the effects of future disturbance such as climate change.

Practitioners, implementing agencies

Bremner, J. (2008) Species' Traits and Ecological Functioning in Marine Conservation and Management. Journal of Experimental Marine Biology and Ecology 366(1-2): 37-47.

http://www.sciencedirect.com/science/article/pii/S0022098108003274

Trait Divergence and the Ecosystem Impacts of Invading Species

Plant functional traits are often used as proxies to determine whether species have different ecological strategies for reproduction and resource capture, and may provide mechanisms to explain which species are likely to invade, and which communities are likely to be invaded.

Practitioners

Cleland, E.E. (2011) Trait Divergence and the Ecosystem Impacts of Invading Species. New Phytologist 189: 649-652.

http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8137.2010.03607.x/pdf

Plant Functional Group Diversity as a Mechanism for Invasion Resistance

We investigated the invasion resistance of several plant functional groups against the nonindigenous forb Spotted knapweed (Centaurea maculosa). The study consisted of a factorial combination of seven functional group removals (groups singularly or in combination) and two C. maculosa treatments (addition vs. no addition) applied in a randomized complete block design replicated four times at each of two sites. Our study suggests that establishing and maintaining a diversity of plant functional groups within the plant community enhances resistance to invasion. Indigenous plants of functionally similar groups as an invader may be particularly important in invasion resistance.

Practitioners, implementing agencies

Pokorny, M.L., R.L. Sheley, C.A. Zabinski, R.E. Engel, T.J. Svejcar and J.J. Borkowski (2005) Plant Functional Group Diversity as a Mechanism for Invasion Resistance. Restoration Ecology 13(3): 448-459.

http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1461&context=usdaarsfacpub

Interpopulation Variation in Allelopathic Traits Informs Restoration of Invaded Landscapes

Invasive species can show substantial genetic variation in ecologically important traits, across ranges as well within the introduced range. If these traits affect competition with native species, then management may benefit from considering the genetic landscape of the invader.

These results suggest that the impact of this invader varies across landscapes and that knowledge of this variation could improve the efficacy and efficiency of restoration activities.

Practitioners, implementing agencies

Lankau, R.A. (2012) Interpopulation variation in allelopathic traits informs restoration of invaded landscapes. Evolutionary Applications 5: 270-282.

http://onlinelibrary.wiley.com/doi/10.1111/j.1752-4571.2011.00218.x/pdf

Functional Trait Assembly through Ecological and Evolutionary Time

A classic community assembly hypothesis is that all guilds must be represented before additional species from any given guild enter the community. We conceptually extend this hypothesis to continuous functional traits, refine the hypothesis with an eco-evolutionary model of interaction network community assembly, and compare the resultant continuous trait assembly rule to empirical data. A "revised" assembly rule did, however, emerge from the eco-evolutionary model: as communities assemble, the range in trait values will increase to a maximum and then remain relatively constant irrespective of further changes in species richness. This rule makes the corollary prediction that the trait range will, on average, be a saturating function of species richness.

Practitioners

Stegen, J.C. and N.G. Swenson (2009) Functional Trait Assembly through Ecological and Evolutionary Time. Theoretical Ecology 2: 239-250.

http://www.oeb.harvard.edu/faculty/pringle/jc/Stegen_2010.pdf

New Paradigms

New Models for Ecosystem Dynamics and Restoration

This book aims to widen the scope and increase the application of threshold models by critiquing their application in a wide range of ecosystem types. It will also help scientists and restorationists correctly diagnose ecosystem damage, identify restoration thresholds, and develop corrective methodologies that can overcome such thresholds.

Practitioners, implementing agencies

Hobbs, R.J. and K.N. Suding (eds.) (2008) New Models for Ecosystem Dynamics and Restoration. Island Press, Washington, DC.

http://www.islandpress.org/ip/books/book/islandpress/N/bo8023657.html

Restoration Ecology to the Future: A Call for New Paradigm

This paper calls for a new paradigm of ecological restoration to the future. A future-oriented restoration should (1) establish the ecosystems that are able to sustain in the future, not the past, environment; (2) have multiple alternative goals and trajectories for unpredictable endpoints; (3) focus on rehabilitation of ecosystem functions rather than recomposition of species or cosmetics of landscape surface; and (4) acknowledge its identity as a ''value-laden'' applied science within economically and socially acceptable framework.

Implementing agencies, practitioners

Choi, Y.D. (2007) Restoration Ecology to the Future: A Call for New Paradigm. Restoration Ecology 15(2): 351-353.

http://friendsofboulderopenspace.org/documents/restoration_choi.pdf

The Dynamic Regime Concept for Ecosystem Management and Restoration

Ecosystem regimes that are obvious at one scale may not be at another. Regimes are maintained by internal relationships and feedbacks between species, and these internal dynamics can interact with large-scale external forces (such as global weather patterns) and trigger shifts to alternative regimes. The dynamic regime concept is commonly used in ecosystem management, restoration, and sustainability efforts, in what are known as "state-and-transition," "threshold," or "alternative stable state" models. Here we review the application of this concept to ecosystem management and restoration, and discuss how dynamic processes at multiple scales can affect this application.

Implementing agencies, practitioners

Mayer, A.L. and M. Rietkerk (2004) The Dynamic Regime Concept for Ecosystem Management and Restoration. BioScience 54(11): 1013-1020.

http://igitur-archive.library.uu.nl/milieu/2008-0111-200758/rietkerk-04-dynamic.pdf

The Restoration of Biodiversity: Where has Research Been and Where does it Need to Go?

The practice of ecological restoration is a primary option for increasing levels of biodiversity by modifying human-altered ecosystems. The scientific discipline of restoration ecology provides conceptual guidance and tests of restoration strategies, with the ultimate goal of predictive landscape restoration. I construct a conceptual model for restoration of biodiversity, based on site-level (e.g., biotic and abiotic) conditions, landscape (e.g, interpatch connectivity and patch geometry), and historical factors (e.g., species arrival order and land-use legacies). I then ask how well restoration ecology has addressed the various components of this model. During the past decade, restoration research has focused largely on how the restoration of site-level factors promotes species diversity—primarily of plants. Relatively little attention has been paid to how landscape or historical factors interplay with restoration, how restoration influences functional and genetic components of biodiversity, or how a suite of less-studied taxa might be restored.

Practitioners, implementing agencies

Brudvig, L.A. (2011) The Restoration of Biodiversity: Where has Research Been and Where does it Need to Go? American Journal of Botany 98(3): 549-558.

http://www.amjbot.org/content/98/3/549.full.pdf+html

Toward an Era of Restoration in Ecology: Successes, Failures, and Opportunities Ahead

As an inevitable consequence of increased environmental degradation and anticipated future environmental change, societal demand for ecosystem restoration is rapidly increasing. Here, I evaluate successes and failures in restoration, how science is informing these efforts, and ways to better address decision-making and policy needs.

Policymakers

Suding, K.N. (2011) Toward an Era of Restoration in Ecology: Successes, Failures, and Opportunities Ahead. Annual Review of Ecology, Evolution, and Systematics 42: 465-487.

http://www.annualreviews.org/doi/abs/10.1146/annurev-ecolsys-102710-145115?journalCode=ecolsys

When is Open-endedness Desirable in Restoration Projects?

A low-intervention approach to restoration that also allows restoration outcomes to be framed as trajectories of ecosystem change can be described as "open-ended" restoration. It is an approach which recognizes that long-term ecosystem behavior involves continual change at small and large spatial and temporal scales. There are a number of situations in which it is appropriate to adopt an open-ended approach to restoration including: in remote and large areas, where ecological limiting factors will be changed by future climates, where antecedent conditions cannot be replicated, where there are novel starting points for restoration, where restoration relies strongly on processes outside the restoration area, in inherently dynamic systems, where costs are high and where the public demands "wildness." Where this approach is adopted managers need to explain the project and deal with public expectations and public risk. Monitoring biotic and abiotic components of the project are very important as an open-ended approach does not equate to "abandon and ignore it."

Implementing agencies, practitioners

Hughes, F.M.R., W.M. Adams and P.A. Stroh (2012) When is Open-endedness Desirable in Restoration Projects? Restoration Ecology 20(3): 291-295.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2012.00874.x/abstract

On the Status of Restoration Science: Obstacles and Opportunities

One obstacle is demonstration science, or an overreliance on simplistic experiments with few treatment factors and few levels of those factors. Complex, multivariate experiments yield greater insights, especially when teamed with sophisticated methods of data analysis. A second key obstacle is myopic scholarship that has led to little synthesis and weak conceptual theory. A greater awareness of and explicit references to ecological principles will help develop the conceptual basis of restoration science.

Practitioners, implementing agencies

Weiher, E. (2007) On the Status of Restoration Science: Obstacles and Opportunities. Restoration Ecology 15(2): 340-343.

https://www.uwec.edu/weiher/weiher_restecol2007.pdf

Stretch Goals and Backcasting: Approaches for Overcoming Barriers to Large-Scale Ecological Restoration

There are numerous barriers that prevent large-scale ecological restoration projects from being proposed, initiated, or carried through. Common barriers include the ‘‘shifting baseline syndrome,’’ the scale and complexity of restoration, the long-term and open-ended nature of res There are numerous barriers that prevent large-scale ecological restoration projects from being proposed, initiated, or carried through. Common barriers include the ‘‘shifting baseline syndrome,’’ the scale and complexity of restoration, the long-term and open-ended nature of restoration, funding challenges, and preemptive constraint of vision. Two potentially useful approaches that could help overcome these barriers are stretch goals and backcasting. Stretch goals are ambitious long-term goals used to inspire creativity and innovation to achieve outcomes that currently seem impossible. Backcasting is a technique where a desired end point is visualized, and then a pathway to that end point is worked out retrospectively. A case study from the Scottish Highlands is used to illustrate how stretch goals and backcasting could facilitate large-scale restoration. The combination of these approaches offers ways to evaluate and shape options for the future of ecosystems, rather than accepting that future ecosystems are victims of past and present political realities.

Practitioners, implementing agencies

Manning, A.D., D.B. Lindenmayer and J. Fischer (2006) Stretch Goals and Backcasting: Approaches for Overcoming Barriers to Large-Scale Ecological Restoration. Restoration Ecology 14(4): 487-492.

http://faculty.unlv.edu/abellas2/Restoration_course/Manning%202006%20stretch%20goals%20in%20ER%20Rest%20Ecol.pdf

Societal Challenges in Understanding and Responding to Regime Shifts in Forest Landscapes

This paper describe the concept of regime shifts in forest landscapes that represent landscape traps in that "entire landscapes are shifted into a state in which major functional and ecological attributes are compromised [and] lead to feedback processes that either maintain an ecosystem in a compromised state or push it into a further regime shift in which an entirely new type of vegetation cover develops." Such state changes can result in dramatic reductions in functionality (e.g., carbon sequestration, water yields) and biodiversity, as with their primary example of mountain ash forests (Eucalyptus regnans) in southeastern Australia.

Policymakers, implementing agencies

Franklin, J.F. and K.N. Johnson (2011) Societal Challenges in Understanding and Responding to Regime Shifts in Forest Landscapes. PNAS 108(41): 16863-16864.

http://www.pnas.org/content/108/41/16863.short

Global Resilience of Tropical Forest and Savanna to Critical Transitions

It has been suggested that tropical forest and savanna could represent alternative stable states, implying critical transitions at tipping points in response to altered climate or other drivers. So far, evidence for this idea has remained elusive, and integrated climate models assume smooth vegetation responses. We analyzed data on the distribution of tree cover in Africa, Australia, and South America to reveal strong evidence for the existence of three distinct attractors: forest, savanna, and a treeless state. Empirical reconstruction of the basins of attraction indicates that the resilience of the states varies in a universal way with precipitation. These results allow the identification of regions where forest or savanna may most easily tip into an alternative state, and they pave the way to a new generation of coupled climate models.

Policymakers

Hirota, M., M. Holmgren, E. H. Van Nes and M. Scheffer (2011) Global Resilience of Tropical Forest and Savanna to Critical Transitions. Science 334(6053): 232-235.

http://www.sciencemag.org/content/334/6053/232

Determining Appropriate Goals for Restoration of Imperilled Communities and Species

In this review, we draw on our experiences working with land-managers to restore native ecosystems in the Pacific Northwest (USA) to discuss some of the challenges in using pre-settlement conditions as a restoration target. We suggest that rather than focusing on historic benchmarks, restoration goals should be based on ecological principles that will lead to resilient, functioning ecosystems. We provide real-world examples for how scientists and managers can work together to define and test appropriate and effective restoration methods and targets.

Implementing agencies, practitioners

Thorpe, A.S. and A.G. Stanley (2011) Determining Appropriate Goals for Restoration of Imperilled Communities and Species. Journal of Applied Ecology 48(2): 275-279.

http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2664.2011.01972.x/abstract

Restore, Repair or Reinvent: Options for Sustainable Landscapes in a Changing Climate

We define three restoration pathways based largely on existing land use and the degree of modification: restoration for areas of natural ecosystems; repair for production landscapes; and reinvention for urban areas. Challenges and research priorities include understanding: the effects of mean climate change and climate extremes on species distribution and ecosystem composition; how restoration can be used for carbon sequestration; the effects of proximate and endogenous drivers on landscape change; how to better bio-design landscapes for multiple functions; integration of different scales of restoration planning and design; and the establishment of long-term monitoring and adaptive management.

Practitioners, implementing agencies

Seabrook, L., C.A. Mcalpine and M.E. Bowen (2011) Restore, Repair or Reinvent: Options for Sustainable Landscapes in a Changing Climate. Landscape and Urban Planning 100(4): 407-410.

http://www.sciencedirect.com/science/article/pii/S0169204611000739

Ecological Restoration for Future Sustainability in a Changing Environment

Restoration with past-focused, idealistic, and/or ad hoc goals may not work in the future because an ecosystem that is restored for the past environment is not likely to be sustainable in the changing environment of the future, simple recomposition of isolated and fragmented naturalistic patches is not likely to restore ecosystem functions, and unrealistic goals and work plans are not likely to gain public support. We advocate directing the principles and practice of ecological restoration to the future. Future-aimed restoration should acknowledge the changing and unpredictable environment of the future, assume the dynamic nature of ecological communities with multiple trajectories, and connect landscape elements for improving ecosystem functions and structures. In this paper, we discuss the predictability of restoration trajectories under changing environmental conditions, the application of ecological theories to restoration practice, the importance of interdisciplinary approaches and human interventions in ecosystem recovery, and the social context of ecological restoration.

Policymakers, implementing agencies, practitioners

Choi, Y.D. et al. (2008) Ecological Restoration for Future Sustainability in a Changing Environment. Ecoscience 15 (1): 53-64.

http://ivem.eldoc.ub.rug.nl/FILES/ivempubs/publart/2008/EcosciChoi/2008EcosciChoi.pdf

Threshold Models in Restoration and Conservation: A Developing Framework

The recognition that a system can appear resilient to changes in the environment, only to reach a critical threshold of rapid and unexpected change, is spurring work to apply threshold models in conservation and restoration. Here we address the relevance of threshold models to habitat management. Work to date indicates these concepts are highly applicable: human impacts can widen the range of habitats where threshold dynamics occur and shift communities into new states that are difficult to reverse. However, in many applied settings, threshold concepts are being adopted without evaluation of evidence and uncertainty. We suggest a framework for incorporating threshold models that reflects an emphasis on applicability to decision making and management on relatively short timescales and in human impacted systems.

Implementing agencies, practitioners

Suding, K.N. and R.J. Hobbs (2009) Threshold Models in Restoration and Conservation: A Developing Framework. Trends in Ecology and Evolution 24(5): 271-279.

http://www.sciencedirect.com/science/article/pii/S0169534709000470

Restoration Ecology: Repairing the Earth's Ecosystems in the New Millennium

We argue that restoration ecology has to be an integral component of land management in today's world, and to be broadly applicable, has to have a clearly articulated conceptual basis. This needs to recognize that most ecosystems are dynamic and hence restoration goals cannot be based on static attributes. Setting clear and achievable goals is essential, and these should focus on the desired characteristics for the system in the future, rather than in relation to what these were in the past. Goal setting requires that there is a clear understanding of the restoration options available (and the relative costs of different options). The concept of restoration thresholds suggests that options are determined by the current state of the system in relation to biotic and abiotic thresholds.

Implementing agencies, practitioners

Hobbs, R.J. and J.A. Harris (2001) Restoration Ecology: Repairing the Earth's Ecosystems in the New Millennium. Restoration Ecology 9(2): 239-246.

http://planet.botany.uwc.ac.za/nisl/invasives/assignment1/hobbsandharris.pdf

The Ecology of Restoration: Historical Links, Emerging Issues and Unexplored Realms

Evolving models of succession, assembly and state-transition are at the heart of both community ecology and ecological restoration. Recent research on seed and recruitment limitation, soil processes, and diversity–function relationships also share strong links to restoration. Further opportunities may lie ahead in the ecology of plant ontogeny, and on the effects of contingency, such as year effects and priority effects. Ecology may inform current restoration practice, but there is considerable room for greater integration between academic scientists and restoration practitioners.

Practitioners, implementing agencies

Young, T.P., D.A. Petersen and J.J. Clary (2005) The Ecology of Restoration: Historical Links, Emerging Issues and Unexplored Realms. Ecology Letters 8: 662-673.

http://ucce.ucdavis.edu/files/filelibrary/5733/28426.pdf

Linking Restoration and Ecological Succession

Restoration ecology is deeply rooted in ecological succession yet seems, as a fast-emerging discipline, to be largely unaware of the potential benefits a closer examination of succession can provide. These benefits address both how to restore ecosystem function and structure as quickly as possible and the longer-term consequences of current restoration activities. Successfully restored ecosystems can be more or less sustainable without constant care. This state is only achievable within a framework that recognizes, implicitly or explicitly, the temporal dynamics that constitute successional processes.

Practitioners

Walker, L.R., J. Walker and R.J. Hobbs (eds.) (2007) Linking Restoration and Ecological Succession. Springer, New York.

http://www1.inecol.edu.mx/repara/download/III_1_LinkingRestorationandEcologicalSuccession.pdf

Biogeography and Environmental Restoration: An Opportunity in Applied Research

Environmental restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. This is a broadly defined endeavor, where directed manipulation of the environment, the effects of anthropogenic disturbance, and processes interconnecting communities, species, and populations with each other and their physical environment fall within the conceptual boundaries. Restoration requires a broad perspective and range of expertise, and biogeographers provide the interdisciplinary background inherent to geographic training that squarely situates us to make significant contributions. The avenues for involvement include pre- and post-restoration monitoring, reference-site selection, data collection and analysis for sound project planning, development and testing of foundational theory, social perceptions and public involvement, and others. This article illustrates the areas where biogeographers from the ecological biogeography, historical biogeography, and cultural biogeography sub-fields can apply their expertise for the benefit of restoration science, student training, and research application and funding.

Practitioners

Markwith, S.H. (2011), Biogeography and Environmental Restoration: An Opportunity in Applied Research. Geography Compass 5: 531–543.

http://onlinelibrary.wiley.com/doi/10.1111/j.1749-8198.2011.00438.x/abstract

Engage the Hodgepodge: Management Factors are Essential when Prioritizing Areas for Restoration and Conservation Action

Restoration and conservation initiatives, such as the eradication of invasive alien plants, should be guided by scientific evidence. Typically, ecological data alone is used to inform the decision-making of these initiatives. Recent advances in the mapping of conservation opportunity include a diverse range of scientifically identified factors that determine the feasibility and likely effectiveness of conservation initiatives, and include, for example, data on the willingness and capacity of land managers to be effectively involved. Social research techniques such as interview surveys, phenomenology, and social network analysis are important approaches for securing useful human and social data. These approaches are yet to be widely adopted in restoration initiatives, but could be usefully applied to improve the effective implementation of these initiatives. Restoration and conservation planners will deliver spatial prioritisations which provide more effective and cost-efficient decision-making if they include not simply ecological data, but also data on economic, human, management, social and vulnerability factors that determine implementation effectiveness.

Implementing agencies

Knight, A.T., S. Sarkar, R.J. Smith, N. Strange and K.A. Wilson (2011) Engage the Hodgepodge: Management Factors are Essential when Prioritizing Areas for Restoration and Conservation Action. Diversity and Distributions 1–5.

http://192.38.112.111/pdf-reprints/Knight_DaD_2011.pdf

Managing Micro-evolution: Restoration in the Face of Global Change

Evidence is mounting that evolutionary change can occur rapidly and may be an important means by which species escape extinction in the face of global change. Consequently, biologists need to incorporate evolutionary thinking into management decisions in conservation and restoration ecology. Here, we review the genetic and demographic properties that influence the ability of populations to adapt to rapidly changing selective pressures. To illustrate how evolutionary thinking can influence conservation and restoration strategies, we compare the potential of two California plant communities (vernal pools and blue oak woodlands) to evolve in response to global change. We then suggest ways in which restoration biologists can manipulate the genetic architecture of target populations to increase their ability to adapt to changing conditions. While there may not be any universal rules regarding the adaptive potential of species, an understanding of the various processes involved in microevolution will increase the short- and long-term success of conservation and restoration efforts.

Rice, K.J. and N.C. Emery (2003) Managing Micro-evolution: Restoration in the Face of Global Change. Frontiers in Ecology and the Environment 1(9): 469-478.

http://www.bio.purdue.edu/people/faculty/faculty_files/publications/36121_1838168986.PDF

Restoring Ecosystems around the Mediterranean Basin: Beyond the Frontiers of Ecological Science

Based on concrete examples gathered from the Mediterranean region, this article shows why restoration ecology around the Mediterranean Basin must go beyond ecological science to embrace a contrasting local vision which integrates social and political realities. By taking into account the growing gap between the northern and southern/eastern shores of the Mediterranean, we propose the adoption of a double agenda for restoration around the Mediterranean to overcome the fact that restoration objectives are often jeopardized by political decisions initially aimed to promote conservation and lack of available technical means (even when appropriate scientific and political means are secured), and to enhance local actions with lasting impacts on the ecosystems. Our discussion illustrates how current ecological problems have become extremely complex and how the success of restoration projects depends on effective social interactions.

Practitioners, implementing agencies, policymakers, indigenous and local communities

Khater, C., V. Raevel, J. Sallantin, J.D. Thompson, M. Hamze and A. Martin (2012) Restoring Ecosystems around the Mediterranean Basin: Beyond the Frontiers of Ecological Science. Restoration Ecology 20(1): 1-6.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2011.00827.x/abstract

Novel Ecosystems

Ecological Restoration in the Light of Ecological History

Ecological history plays many roles in ecological restoration, most notably as a tool to identify and characterize appropriate targets for restoration efforts. However, ecological history also reveals deep human imprints on many ecological systems and indicates that secular climate change has kept many targets moving at centennial to millennial time scales. Past and ongoing environmental changes ensure that many historical restoration targets will be unsustainable in the coming decades. Ecological restoration efforts should aim to conserve and restore historical ecosystems where viable, while simultaneously preparing to design or steer emerging novel ecosystems to ensure maintenance of ecological goods and services.

Policymakers, implementing agencies

Jackson, S.T. and R.J. Hobbs (2009) Ecological Restoration in the Light of Ecological History. Science 325: 567-569.

http://academic.uprm.edu/~jchinea/cursos/ecolplt/lectesc/jackson_e2009.pdf

Novel Ecosystems: Implications for Conservation and Restoration

Many ecosystems are rapidly being transformed into new, non-historical configurations owing to a variety of local and global changes. We discuss how new systems can arise in the face of primarily biotic change (extinction and/or invasion), primarily abiotic change (e.g. land use or climate change) and a combination of both. Some changes will result in hybrid systems retaining some original characteristics as well as novel elements, whereas larger changes will result in novel systems, which comprise different species, interactions and functions. We suggest that these novel systems will require significant revision of conservation and restoration norms and practices away from the traditional place-based focus on existing or historical assemblages.

Policymakers, implementing agencies, practitioners

Hobbs, R.J., E. Higgs and J.A. Harris (2009) Novel ecosystems: implications for conservation and restoration. Trends in Ecology and Evolution 24(11): 599-605.

http://cmapspublic3.ihmc.us/rid=1K7PBR9LC-1318ZTM-2J2/Hobbs%202009%20novel%20ecosystems.pdf

Management of Novel Ecosystems: Are Novel Approaches Required?

Most ecosystems are now sufficiently altered in structure and function to qualify as novel systems, and this recognition should be the starting point for ecosystem management efforts. Under the emerging biogeochemical configurations, management activities are experiments, blurring the line between basic and applied research. Responses to specific management manipulations are context specific, influenced by the current status or structure of the system, and this necessitates reference areas for management or restoration activities. Attempts to return systems to within their historical range of biotic and abiotic characteristics and processes may not be possible, and management activities directed at removing undesirable features of novel ecosystems may perpetuate or create such ecosystems. Management actions should attempt to maintain genetic and species diversity and encourage the biogeochemical characteristics that favor desirable species. Few resources currently exist to support the addition of proactive measures and rigorous experimental designs to current management activities. The necessary changes will not occur without strong input from stakeholders and policy makers, so rapid information transfer and proactive research–management activities by the scientific community are needed.

Implementing agencies, practitioners, policymakers

Seastedt, T.R., R.J. Hobbs and K.N. Suding (2008) Management of Novel Ecosystems: Are Novel Approaches Required? Front Ecol Environ 6: 547-553.

http://culter.colorado.edu:1030/~tims/Seastedt_Hobbs_Suding08.pdf

Restoration Ecology: Interventionist Approaches for Restoring and Maintaining Ecosystem Function in the Face of Rapid Environmental Change

Key issues relating to ecosystem restoration in a rapidly changing world include understanding how potentially synergistic global change drivers interact to alter the dynamics and restoration of ecosystems and how novel ecosystems without a historic analogue should be managed.

Policymakers, implementing agencies, practitioners

Hobbs, R.J. and V.A. Cramer (2008) Restoration Ecology: Interventionist Approaches for Restoring and Maintaining Ecosystem Function in the Face of Rapid Environmental Change. Annu. Rev. Environ. Resour. 33: 39-61.

http://www.lerf.esalq.usp.br/divulgacao/recomendados/artigos/hobbs2008.pdf

Intervention Ecology: Applying Ecological Science in the Twenty-first Century

Escalating global change is resulting in widespread no-analogue environments and novel ecosystems that render traditional goals unachievable. Policymakers and the general public, however, have embraced restoration without an understanding of its limitations, which has led to perverse policy outcomes. Therefore, a new ecology, free of pre- and misconceptions and directed toward meaningful interventions, is needed. Interventions include altering the biotic and abiotic structures and processes within ecosystems and changing social and policy settings. Interventions can be aimed at leverage points, both within ecosystems and in the broader social system—particularly, feedback loops that either maintain a particular state or precipitate a rapid change from one state to another.

Policymakers, implementing agencies, practitioners

Hobbs, R.J., L.M. Hallett, P.R. Ehrlich and H.A. Mooney (2011) Intervention Ecology: Applying Ecological Science in the Twenty-First Century. BioScience 61(6): 442-450.

http://www.environment.ucla.edu/media_IOE/files/Hobbs-et-al.-BioScience-2011---restoration-w4-ie0.pdf

Understanding Restoration Volunteering in a Context of Environmental Change: In Pursuit of Novel Ecosystems or Historical Analogues?

By focusing on (the politics of) knowledge, our approach draws attention to the relationship between volunteers and scientists engaged in ecological restoration. Volunteers are not only the workers whom scientists ask to carry out various activities without requiring much understanding or input and critical engagement. They also bring in different social values and are a source of local knowledge and insights. A critical political ecology perspective also argues that there is a need for “greater public participation in the formulation of environmental science” and that ecological science is no longer to be viewed as the singular and neutral source of information that informs policymakers.

Policymakers, implementing agencies

Buizer, M., T. Kurz and K. Ruthrof (2012) Understanding Restoration Volunteering in a Context of Environmental Change: In Pursuit of Novel Ecosystems or Historical Analogues? Human Ecology 40: 153-160.

http://www.springerlink.com/content/l375804270236150/

The Emerging Era of Novel Tropical Forests

We live in the era of secondary forests that is rapidly giving way to a new era of novel tropical forests. Research in Puerto Rico documents the emergence of novel forests, which are different in terms of species composition, dominance, and relative importance of species from forests that were present before the island was deforested. These novel forests emerged without assistance. They are a natural response to the new environmental conditions created by human activity. Natural processes have remixed or reassembled native and introduced plant and animal species into novel communities adapted to anthropogenic environmental conditions. Novel forests are expected to protect soils, cycle nutrients, support wildlife, store carbon, maintain watershed functions, and mitigate species extinctions. The dawn of the age of tropical novel forests is upon us and must not be ignored.

Implementing agencies, practitioners, policymakers

Lugo, A.E. (2009) The Emerging Era of Novel Tropical Forests. Biotropica 41(5): 589-591.

http://ddr.nal.usda.gov/bitstream/10113/37271/1/IND44257636.pdf

A Method for Evaluating Outcomes of Restoration When No Reference Sites Exist

Ecological restoration typically seeks to shift species composition toward that of existing reference sites. Yet, comparing the assemblages in restored and reference habitats assumes that similarity to the reference habitat is the optimal outcome of restoration and does not provide a perspective on regionally rare off-site species. When no such reference assemblages of species exist, an accurate assessment of the habitat affinities of species is crucial. We present a method for using a species by habitat data matrix generated by biodiversity surveys to evaluate community responses to habitat restoration treatments. We apply this procedure to an open woodland restoration project in north Mississippi (U.S.A.) by evaluating initial plant community responses to restoration. Results showed a substantial increase in open woodland indicators, a modest decrease in generalists historically restricted to floodplain forests, and no significant change in disturbance indicators as a group. These responses can be interpreted as a desirable outcome, regardless of whether species composition approaches that of reference sites. The broader value of this approach is that it provides a flexible and objective means of predicting and evaluating the outcome of restoration projects involving any group of species in any region, provided there is a biodiversity database that includes habitat and location information.

Implementing agencies, practitioners

Brewer, J.S. and T. Menzel (2009) A Method for Evaluating Outcomes of Restoration When No Reference Sites Exist. Restoration Ecology 17: 4-11.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2008.00456.x/abstract

Pollination and Mutualisms

Pollination and Restoration

Pollination services underpin sustainability of restored ecosystems. Yet, outside of agri-environments, effective restoration of pollinator services in ecological restoration has received little attention. This deficiency in the knowledge needed to restore pollinator capability represents a major liability in restoration programs, particularly in regions where specialist invertebrate and vertebrate pollinators exist, such as global biodiversity hotspots. When compounded with the likely negative impacts of climate change on pollination services, the need to understand and manage pollinator services in restoration becomes paramount.

Implementing agencies, practitioners

Dixon, K.W. (2009) Pollination and Restoration. Science 325: 571-573.

http://www.dodpollinators.org/Pollination_and_Restoration_article.pdf

Reconnecting Plants and Pollinators: Challenges in the Restoration of Pollination Mutualisms

Ecological restoration of plant–pollinator interactions has received surprisingly little attention, despite animal-mediated pollination underpinning reproduction of the majority of higher plants. Here, we offer a conceptual and practical framework for the ecological restoration of pollination mutualisms. Through the use of targeted restoration plantings to attract and sustain pollinators and increased knowledge of the ecological requirements of pollinators, we propose that pollination could be successfully restored in degraded ecosystems. The challenge for pollination biologists is to integrate their findings with those of plant restoration ecologists to ensure sustainable pollination in restored ecosystems.

Practitioners, implementing agencies

Menz, M.H.M., R.D. Phillips, R. Winfree, C. Kremen, M.A. Aizen, S.D. Johnson and K.W. Dixon (2011) Reconnecting Plants and Pollinators: Challenges in the Restoration of Pollination Mutualisms. Trends in Plant Science 16(1): 4-12.

http://winfreelab.rutgers.edu/documents/MenzEtAl2011_TrendsPlantBiology.pdf

Understanding and Planning Ecological Restoration of Plant–Pollinator Networks

Theory developed from studying changes in the structure and function of communities during natural or managed succession can guide the restoration of particular communities. We constructed 30 quantitative plant–flower visitor networks along a managed successional gradient to identify the main drivers of change in network structure. We then applied two alternative restoration strategies in silico (restoring for functional complementarity or redundancy) to data from our early successional plots to examine whether different strategies affected the restoration trajectories. Changes in network structure were explained by a combination of age, tree density and variation in tree diameter, even when variance explained by undergrowth structure was accounted for first. A combination of field data, a network approach and numerical simulations helped to identify which species should be given restoration priority in the context of different restoration targets. This combined approach provides a powerful tool for directing management decisions, particularly when management seeks to restore or conserve ecosystem function.

Implementing agencies, practitioners

Devoto, M., S. Bailey, P. Craze and J. Memmott (2012) Understanding and planning ecological restoration of plant–pollinator networks. Ecology Letters 15: 319-328.

http://onlinelibrary.wiley.com/doi/10.1111/j.1461-0248.2012.01740.x/abstract

Restoration of Nontarget Species: Bee Communities and Pollination Function in Riparian Forests

Nontarget species such as pollinators may be of great importance to the restoration process and the long-term functioning of restored habitats, but little is known about how such groups respond to habitat restoration. I surveyed bee communities at five equal-aged restored sites, paired with five reference sites (riparian remnants) along the Sacramento River, California, United States. Patterns of visitation to native plant species suggest that pollination function is restored along with pollinator abundance and richness; however, function may be less robust in restored habitats. An examination of interaction networks between bees and plant species found at both restored and remnant riparian sites showed less redundancy of pollinators visiting some plants at restored habitats.

Practitioners, implementing agencies

Williams, N.M. (2011) Restoration of Nontarget Species: Bee Communities and Pollination Function in Riparian Forests. Restoration Ecology 19(4): 450-459.

http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2010.00707.x/abstract

The Restoration of Ecological Interactions: Plant–Pollinator Networks on Ancient and Restored Heathlands

Ecological networks provide a powerful tool for assessing the outcome of restoration programmes. Our results indicate that heathland restoration does not have to occur immediately adjacent to ancient heathland for functional pollinator communities to be established. Moreover, in terms of restoring pollinator interactions, heathland managers need only be concerned with the most common insect species. Our focus on pollination demonstrates how a key ecological service can serve as a yardstick for judging restoration success.

Implementing agencies, practitioners

Forup, M.L., K.S.E. Henson, P.G. Craze and J. Memmott (2008) The Restoration of Ecological Interactions: Plant–Pollinator Networks on Ancient and Restored Heathlands. Journal of Applied Ecology 45: 742-752.

http://pascencio.cos.ucf.edu/classes/Restoration%20Ecology/Eran/pollen.pdf

Realising Multiple Ecosystem Services based on the Response of Three Beneficial Insect Groups to Floral Traits and Trait Diversity

Beneficial insects in agro-ecosystems provide humans with many invaluable ecosystem services including crop pollination and pest control. The creation of wildflower strips has emerged as a key tool to conserve beneficial insect groups in these systems. Yet, the efficacy of these schemes in delivering multiple ecosystem services is usually limited by our poor understanding of how plant species composition, functional traits and trait diversity affect insect visitation and resource use. Here we investigate the effects of plant floral traits and trait diversity on flower visitation by three functionally distinct beneficial insect groups, which provide crop pollination and pest control services: bumblebees, hoverflies and parasitoid wasps.

Practitioners, implementing agencies

Campbell, A.J., J.C. Biesmeijer, V. Varma and F.L. Wäckers (2012) Realising Multiple Ecosystem Services based on the Response of Three Beneficial Insect Groups to Floral Traits and Trait Diversity. Basic and Applied Ecology, Available online 15 May 2012 http://www.sciencedirect.com/science/article/pii/S143917911200045X

Conservation and Restoration of Plant-Animal Mutualisms on Oceanic Islands

We highlight past and present threats to island plant–animal mutualisms, as well as the challenges and opportunities inherent to these interactions. In particular, we (1) argue that mutualistic networks provide an ideal approach to collect information and advance our knowledge on the systems, (2) suggest the use of interactions as biodiversity monitoring and assessment tools, (3) highlight the differences and similarities between pollination and seed dispersal interactions in the context of restoration, and (4) briefly discuss the ambiguous role of alien invasive species in the management of mutualistic interactions. Finally, we highlight how a recently proposed but controversial restoration strategy, rewilding, can be gainfully applied to and further advanced in island settings.

Practitioners, implementing agencies

Kaiser-Bunbury, C.N., A. Traveset and D.M. Hansen (2010) Conservation and Restoration of Plant-Animal Mutualisms on Oceanic Islands. Perspectives in Plant Ecology, Evolution and Systematics 12(2): 131-143.

http://www.torreyaguardians.org/articles/kaiser-bunbury2010.pdf

The Role of Plant-Animal Mutualisms in the Design and Restoration of Natural Communities

I would like to explore how a focus on the principles of plant-animal mutualisms can improve both the demographic functioning of an ecological restoration, and also the economic balance sheet that is integral to projects aimed at improving our natural areas.

Practitioners, implementing agencies

Handel, S.N. (1997). The role of plant–animal mutualisms in the design and restoration of natural communities. In: Restoration Ecology and Sustainable Development (eds Urbanska, K.M., Webb, N.R. & Edwards, P.J.). Cambridge University Press, New York, NY, pp. 111–132.

http://www.clu-in.info/conf/tio/ecorestoration4_092106/resources/Handel.pdf

The Robustness and Restoration of a Network of Ecological Networks

Understanding species' interactions and the robustness of interaction networks to species loss is essential to understand the effects of species' declines and extinctions. In most studies, different types of networks (such as food webs, parasitoid webs, seed dispersal networks, and pollination networks) have been studied separately. We sampled such multiple networks simultaneously in an agroecosystem. We show that the networks varied in their robustness;

networks including pollinators appeared to be particularly fragile. We show that, overall, networks did not strongly covary in their robustness, which suggests that ecological restoration (for example, through agri-environment schemes) benefitting one functional group will not inevitably benefit others. Some individual plant species were disproportionately well linked to many other species. This type of information can be used in restoration management, because it identifies the plant taxa that can potentially lead to disproportionate gains in biodiversity.

Practitioners, implementing agencies

Pocock, M.J.O., D.M. Evans and J. Memmott (2012) The Robustness and Restoration of a Network of Ecological Networks. Science 335: 973-977.

http://www.planta.cn/forum/files_planta/2012_2_24_the_robustness_and_restoration_of_a_network_of_ecological_networks_129.pdf

How Understanding Aboveground‐Belowground Linkages can Assist Restoration Ecology

The topic of aboveground‐belowground linkages has seen much recent activity, resulting in several conceptual advances regarding plant‐soil feedbacks, multitrophic interactions, and how organisms drive ecosystem processes. Although restoration ecology has been rapidly evolving as a scientific discipline, the principles that have developed regarding aboveground‐belowground linkages have yet to be thoroughly integrated into it. In this review, we conceptually integrate the role of aboveground‐belowground linkages with the principles of restoration ecology through a framework that transcends multiple levels of ecological organization, and illustrate its application through three examples: restoration of abandoned land, reversal of biological invasions, and restoration of natural disturbances. We conclude that this integration can greatly assist restoration ecology, through aiding identification of effective invention practices and prediction of ecosystem recovery.

Practitioners, implementing agencies

Kardol, P. and D.A. Wardle (2010) How Understanding Aboveground‐Belowground Linkages can Assist Restoration Ecology. Trends in Ecology and Evolution 25(11): 670-679.

http://www.sciencedirect.com/science/article/pii/S0169534710002132

Soil Microbial Communities and Restoration Ecology: Facilitators or Followers?

Microorganisms have critical roles in the functioning of soil in nutrient cycling, structural formation, and plant interactions, both positive and negative. These roles are important in reestablishing function and biodiversity in ecosystem restoration. Measurement of the community indicates the status of the system in relation to restoration targets and the effectiveness of management interventions, and manipulation of the community shows promise in the enhancement of the rate of recovery of degraded systems.

Practitioners, implementing agencies

Harris, J. (2009) Soil Microbial Communities and Restoration Ecology: Facilitators or Followers? Science 325: 573-574.

http://image.sciencenet.cn/olddata/kexue.com.cn/upload/blog/file/2010/4/2010421142048468783.pdf

Embracing Variability in the Application of Plant–Soil Interactions to the Restoration of Communities and Ecosystems

Plant–soil interactions are the foundation of effective and sustained restoration of terrestrial communities and ecosystems. Recent advances in ecological science have greatly contributed to our understanding of the effects of soil conditions on plant community dynamics and our understanding of plant composition impacts on almost every aspect of soil structure and function. Although these theories provide important guidelines for the practice of restoration, they often fall short of providing the level of information required to make effective site-specific management decisions. This is largely because of ecology's search for simple unifying theories and the resulting tendency to generalize from studies at one or only a few sites.

Implementing agencies, practitioners

Eviner, V.T. and C.V. Hawkes (2008) Embracing Variability in the Application of Plant–Soil Interactions to the Restoration of Communities and Ecosystems. Restoration Ecology 16(4): 713-729.

http://www.plantsciences.ucdavis.edu/plantsciences_faculty/eviner/pdfs%20of%20pubs/Link%207.pdf

The Restoration of Parasites, Parasitoids, and Pathogens to Heathland Communities

Higher trophic level species such as parasites, parasitoids, and pathogens are frequently ignored in community studies, despite playing key roles in the structure, function, and stability of ecological communities. Furthermore, such species are typically among the last in a community to reestablish due to their reliance upon lower trophic level resources and a requirement for persistent, stable ecological conditions. Consequently their presence alone can be indicative of healthy ecosystems. Using replicated, quantitative food webs we studied the impacts of a restoration treatment upon the interactions of a tri-trophic community consisting of plants, their bumble bee pollinators, and the parasites, parasitoids, and pathogens of the bumble bees at heathland sites.

Practitioners, implementing agencies

Henson, K.S.E., P.G. Craze and J. Memmott (2009) The restoration of parasites, parasitoids, and pathogens to heathland communities. Ecology 90: 1840-1851.

http://www.esajournals.org/doi/abs/10.1890/07-2108.1

The Role of Plant-Soil Feedbacks and Land-Use Legacies in Restoration of a Temperate Steppe in Northern China

Plant–soil feedbacks affect plant performance and plant community dynamics; however, little is known about their role in ecological restoration. Here, we studied plant–soil feedbacks in restoration of steppe vegetation after agricultural disturbance in northern China. We conclude that the occurrence of positive land-use legacies for old-field species may retard successional replacement of old-field species by steppe species. However, high levels of idiosyncrasy in responses of old-field and steppe plant species to con- and heterospecific soils indicate interspecific variation in the extent to which soil legacies and plant–soil feedbacks control successional species replacements in Chinese steppe ecosystems.

Practitioners

Jiang, L., X. Han, G. Zhang and P. Kardol (2010) The role of plant–soil feedbacks and land-use legacies in restoration of a temperate steppe in northern China. Ecological Research 25(6): 1101-1111.

http://www.springerlink.com/content/622662670q4x2115/

Seed Banks, Botanic Gardens and Genetic Material

Seed Supply for Broadscale Restoration: Maximizing Evolutionary Potential

Restoring degraded land to combat environmental degradation requires the collection of vast quantities of germplasm (seed). Sourcing this material raises questions related to provenance selection, seed quality and harvest sustainability. Restoration guidelines strongly recommend using local sources to maximize local adaptation and prevent outbreeding depression, but in highly modified landscapes this restricts collection to small remnants where limited, poor quality seed is available, and where harvesting impacts may be high. We review three principles guiding the sourcing of restoration germplasm: (i) the appropriateness of using 'local' seed, (ii) sample sizes and population characteristics required to capture sufficient genetic diversity to establish self-sustaining populations and (iii) the impact of over-harvesting source populations.

Practitioners, implementing agencies

Broadhurst, L.M., A. Lowe, D.J. Coates, S.A Cunningham, M. McDonald, P.A. Vesk and C. Yates (2008) Seed supply for broadscale restoration: maximizing evolutionary potential. Evolutionary Applications 1: 587-597.

http://onlinelibrary.wiley.com/doi/10.1111/j.1752-4571.2008.00045.x/pdf

Restoration Seed Banks—A Matter of Scale

With nearly two-thirds of the world's ecosystems degraded, the October 2010 meeting of the Conference of the Parties to the Convention on Biological Diversity (COP-10) highlighted ecological restoration as a significant opportunity for achieving global conservation goals. The restoration of nature, natural assets, and biodiversity is now a global business worth at least $1.6 trillion annually and likely to grow substantially. Although seed banks have emerged as a tool to protect wild plant species, off-site (ex situ) conservation measures at seed banks must be complementary to “on the ground” management at the conservation site. For example, whereas global targets are for restoration or management of at least 15% of each ecological region or vegetation type, recognition of the mechanisms required to achieve these goals is largely absent from policies.

Policymakers, implementing agencies

Merritt, D.J. and K.W. Dixon (2011) Restoration Seed Banks—A Matter of Scale. Science 332 (6028): 424-425.

http://www.sciencemag.org/content/332/6028/424.summary

Rapid Genetic Identification of Local Provenance Seed Collection Zones for Ecological Restoration and Biodiversity Conservation

The ecological restoration of native plant communities requires the collection of large amounts of seed. Use of non-local provenance seed can have detrimental consequences for the success of restoration if there is a home-site advantage, and for nature conservation through the erosion of natural patterns of population genetic structuring and/or genetic swamping (and extirpation) of locally significant genotypes. As part of an ongoing project to genetically delineate local provenance seed collection zones for species within a large urban bushland remnant of high conservation value, we assessed population genetic differentiation in two widespread coastal leguminous species, Acacia rostellifera and A. cochlearis (Fabaceae), commonly used in restoration programmes in SW Australia.

Krauss, S.L. and T.H. He (2006) Rapid Genetic Identification of Local Provenance Seed Collection Zones for Ecological Restoration and Biodiversity Conservation. Journal for Nature Conservation 14(3-4): 190-199.

http://www.sciencedirect.com/science/article/pii/S1617138106000215

''How Local Is Local?''—A Review of Practical and Conceptual Issues in the Genetics of Restoration

Here we focus on genetic concerns arising from ongoing restoration efforts, where often little is known about ''How local is local?'' (i.e., the geographic or environmental scale over which plant species are adapted). We review the major issues regarding gene flow and local adaptation in the restoration of natural plant populations. Finally, we offer some practical, commonsense guidelines for the consideration of genetic structure when restoring natural plant populations.

Practitioners, implementing agencies

McKay, J.K., C.E. Christian, S. Harrison and K.J. Rice (2005) ''How Local Is Local?''—A Review of Practical and Conceptual Issues in the Genetics of Restoration. Restoration Ecology 13(3): 432-440.

http://www.esalq.usp.br/lcb/lerf/divulgacao/recomendados/artigos/mckay2005.pdf

Seed Provenance Matters: Effects on Germination of Four Plant Species Used for Ecological Restoration

The use of local seed provenances is often recommended in restoration and habitat creation because they are thought to be better adapted to local habitat conditions. However, spatial scales and the degree of population differentiation are not well known and germination is often not included in comparisons between provenances. We analysed germination as a key trait of plant development in five provenances of four species used for ecological restoration on arable land (wildflower strips). Germination was tested under different conditions in growth chambers (early vs. late spring) and in the field (non-competition vs. competition). We also examined the contribution of non-genetic (maternal) effects to population differentiation.

Practitioners, implementing agencies

Bischoff, A., B. Vonlanthen, T. Steinger and H. Muller-Scharer (2006) Seed Provenance Matters: Effects on Germination of Four Plant Species Used for Ecological Restoration. Basic and Applied Ecology 7(4): 347-359.

http://doc.rero.ch/lm.php?url=1000,43,2,20060901151141-HN/mullerscharer_egf.pdf

Farming for Restoration: Building Bridges for Native Seeds

In both Europe and the United States, certification of native seed and plants across biogeographic regions, developing new market niches for growers, and providing increased stability in demand are all critical issues to increasing the availability and expanding the use of native materials. Tools to aid in selection of appropriate plant materials for restoration in light of climate change, issues of ex situ and in situ conservation of species and communities and discussions surrounding assisted migration are all critical to the future of ecological restoration on both continents.

Implementing agencies

Tischew, S., B. Youtie, A. Kirmer and N. Shaw (2011) Farming for Restoration: Building Bridges for Native Seeds. Ecological Restoration 29(3): 219-222

http://www.fs.fed.us/rm/pubs_other/rmrs_2011_tishew_s001.pdf

The Role of Botanic Gardens in the Science and Practice of Ecological Restoration

Many of the skills and resources associated with botanic gardens and arboreta, including plant taxonomy, horticulture, and seed bank management, are fundamental to ecological restoration efforts, yet few of the world's botanic gardens are involved in the science or practice of restoration. Thus, we examined the potential role of botanic gardens in these emerging fields. We believe a reorientation of certain existing institutional strengths, such as plant-based research and knowledge transfer, would enable many more botanic gardens worldwide to provide effective science-based support to restoration efforts. We recommend botanic gardens widen research to include ecosystems as well as species, increase involvement in practical restoration projects and training practitioners, and serve as information hubs for data archiving and exchange.

Policymakers, implementing agencies

Hardwick, K.A. et al. (2011) The Role of Botanic Gardens in the Science and Practice of Ecological Restoration. Conservation Biology 25(2): 265-275.

http://onlinelibrary.wiley.com/doi/10.1111/j.1523-1739.2010.01632.x/abstract

Botanic Gardens, Endangered Trees and Reforestation in Africa

This report considers the current and potential roles that African botanic gardens can play in the restoration of forests and other forms of tree planting using the material maintained in their living collections and the skills and expertise of their staff. A particular emphasis has been placed on the potential to use tree species that are under threat of extinction in the wild. Africa has over 150 botanic gardens (see figure 1). This report focuses specifically on the work of botanic gardens in three countries DRC, Kenya and Uganda. Initial contacts have also been made with gardens in Cameroon and Ghana and further consultation is anticipated.

Policymakers, implementing agencies

BGCI (2011)

http://www.bgci.org/files/Africa/pdfs/african-trees.pdf

A Restoration Practitioner's Guide to the Restoration Gene Pool Concept

Choosing plant materials for each desired species is often one of the most difficult steps in developing a restoration plan. The Restoration Gene Pool concept was developed to clarify the options available to the ecological restoration practitioner in terms of plant materials. We present a decision-making flowchart incorporating the issues delineated in the Restoration Gene Pool concept. We intend to provide practitioners with a framework to make objective and defensible plant materials choices in keeping with the objectives and philosophy of the restoration project.

Practitioners, implementing agencies

Jones, T.A. and T.A. Monaco (2007) A Restoration Practitioner's Guide to the Restoration Gene Pool Concept. Ecological Restoration 25(1): 12-19.

http://www.fs.fed.us/rm/pubs_other/rmrs_2007_jones_t001.pdf

The Importance of Plant Provenance and Genotypic Diversity of Seed Material Used for Ecological Restoration

The increased translocation of plant species for biodiversity restoration and habitat creation has provoked a debate on provenance and genotypic diversity of the used plant material. Nonlocal provenances are often not adapted to the local environmental conditions, and low population genotypic diversity may result in genetic bottlenecks hampering successful establishment. We tested provenance differentiation of four plant species used in agri-environment schemes to increase biodiversity of agricultural landscapes (wildflower strips).

Implementing agencies, practitioners

Bischoff, A., T. Steinger and H. Müller-Schärer (2010) The Importance of Plant Provenance and Genotypic Diversity of Seed Material Used for Ecological Restoration. Restoration Ecology 18: 338-348.

http://www.unifr.ch/biol/ecology/muellerschaerer/group/mueller/webpage/pdf/publications/Bischoff08.pdf

Appropriate Use of Genetic Manipulation for the Development of Restoration Plant Materials

The diversity of approaches for developing restoration plant material reflects a variety of philosophies that represent what can and should be accomplished by restoration. The "natural" approach emphasizes emulation of putative naturally occurring patterns of genetic variation. The "genetically manipulated" approach involves such techniques as artificial selection, hybridization, bulking, and chromosome doubling to create populations that are ostensibly as well or better equipped to restore ecosystem function than the extirpated natural populations that they are designed to replace. A number of caveats have been issued regarding manipulated plant materials, including concerns regarding improper genetic identity, outbreeding depression, maladaptation, and inappropriate amounts of genetic variation. Here we detail (1) when these concerns are likely to be valid or inconsequential, (2) how precautions may be taken to minimize these concerns, and (3) how to respect, as much as possible, the principles cherished by proponents of natural plant materials, yet still take advantage of the benefits of genetic manipulation.

Practitioners, implementing agencies

Jones, T.A. and J.G. Robins (2011) Appropriate Use of Genetic Manipulation for the Development of Restoration Plant Materials. Progress in Botany 72(5): 249-264.

http://www.springerlink.com/content/n5348416552288p6/?MUD=MP

Predicting Performance for Ecological Restoration: A Case Study Using Spartina alterniflora

The success of population-based ecological restoration relies on the growth and reproductive performance of selected donor materials, whether consisting of whole plants or seed. Accurately predicting performance requires an understanding of a variety of underlying processes, particularly gene flow and selection, which can be measured, at least in part, using surrogates such as neutral marker genetic distances and simple latitudinal effects. We suggest that dispersal distance and latitude should provide an adequate means of predicting performance in future S. alterniflora restorations and propose a maximum sampling distance of 300 km (holding latitude constant) to avoid the sampling of inappropriate ecotypes.

Practitioners, implementing agencies

Travis, S.E. and J.B. Grace (2010) Predicting Performance for Ecological Restoration: A Case Study Using Spartina alterniflora. Ecological Applications 20(1): 192-204.

http://www.blm.gov/pgdata/etc/medialib/blm/wy/programs/pcp/docs/lit.Par.48373.File.dat/restoration.pdf

Paleoecology

Paleoecology and "inter-situ" Restoration on Kaua`i, Hawai`i

On the Hawaiian Island of Kaua`i, human-caused extinctions are currently occurring in a microcosm of island endemics. Recent studies of endangered plants suggest that conventional in-situ and ex-situ conservation strategies are losing the battle here. Paleoecological findings support the idea that creating new populations in formerly much larger, late prehistoric and early historical ranges of declining species may provide a reliable and cost-effective hedge against extinction. On Kaua`i, several paleoecological sites have played key roles in planning and implementing ecological and cultural restoration projects.

Implementing agencies, practitioners

Burney, D.A. and L. Pigott Burney (2007) Paleoecology and "inter-situ" Restoration on Kaua`i, Hawai`i. Front Ecol Environ 5(9): 483-490.

http://anthropology.hawaii.edu/Fieldschools/Kauai/Publications/Publication%206.pdf

Paleoecology and Ecosystem Restoration: Case Studies from Chesapeake Bay and the Florida Everglades

Climate extremes that cause droughts, floods, or large temperature fluctuations can complicate ecosystem restoration efforts focused on local and regional human disturbance. Restoration targets are often based primarily on monitoring data and modeling simulations, which provide information on species' short-term response to disturbance and environmental variables. Consequently, the targets may be unsustainable under the spectrum of natural variability inherent in the system or under future climate change. Increasingly, ecologists and restoration planners recognize the value of the long temporal perspective provided by paleoecological data. Advances in paleoclimatology, including better climate proxy methods and temporal resolution, contribute to our understanding of ecosystem response to anthropogenic and climatic forcing at all time scales. We highlight paleoecological research in the Chesapeake Bay and the Florida Everglades and summarize the resulting contributions to restoration planning. Integration of paleoecological, historic, monitoring, and modeling efforts will lead to the development of sustainable, adaptive management strategies for ecosystem restoration.

Implementing agencies, practitioners

Willard, D.A. and T.M. Cronin (2007) Paleoecology and Ecosystem Restoration: Case Studies from Chesapeake Bay and the Florida Everglades. Front Ecol Environ 5(9): 491-498.

http://www.frontiersinecology.org/paleoecology/willard.pdf

Red List

Establishing IUCN Red List Criteria for Threatened Ecosystems

The potential for conservation of individual species has been greatly advanced by the International Union for Conservation of Nature's (IUCN) development of objective, repeatable, and transparent criteria for assessing extinction risk that explicitly separate risk assessment from priority setting. At the IV World Conservation Congress in 2008, the process began to develop and implement comparable global standards for ecosystems. A working group established by the IUCN has begun formulating a system of quantitative categories and criteria, analogous to those used for species, for assigning levels of threat to ecosystems at local, regional, and global levels.

Policymakers

Rodríguez, J.P. et al. (2010) Establishing IUCN Red List Criteria for Threatened Ecosystems. Conservation Biology 25(1): 21-29.

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3051828/

Trophic Cascades

Trophic Downgrading of Planet Earth

Until recently, large apex consumers were ubiquitous across the globe and had been for millions of years. The loss of these animals may be humankind's most pervasive influence on nature. Although such losses are widely viewed as an ethical and aesthetic problem, recent research reveals extensive cascading effects of their disappearance in marine, terrestrial, and freshwater ecosystems worldwide. This empirical work supports long-standing theory about the role of top-down forcing in ecosystems but also highlights the unanticipated impacts of trophic cascades on processes as diverse as the dynamics of disease, wildfire, carbon sequestration, invasive species, and biogeochemical cycles. These findings emphasize the urgent need for interdisciplinary research to forecast the effects of trophic downgrading on process, function, and resilience in global ecosystems.

Policymakers, implementing agencies, practitioners

Estes, J.A. et al. (2011) Trophic Downgrading of Planet Earth. Science 333(6040): 301-306.

http://www.sciencemag.org/content/333/6040/301

Trophic Cascades: Predators, Prey, and the Changing Dynamics of Nature

Trophic Cascades is the first comprehensive presentation of the science on this subject. It brings together some of the world's leading scientists and researchers to explain the importance of large animals in regulating ecosystems, and to relate that scientific knowledge to practical conservation. It provides a scientific basis and justification for the idea that large predators and top-down forcing must be considered in conservation strategies, alongside factors such as habitat preservation and invasive species. It is a groundbreaking work for scientists and managers involved with biodiversity conservation and protection.

Practitioners, implementing agencies

Terborgh, J. and J.A. Estes (2010) Trophic Cascades: Predators, Prey, and the Changing Dynamics of Nature. Island Press, Washington, DC.

http://islandpress.org/ip/books/book/islandpress/T/bo8022716.html

The Assembly, Collapse and Restoration of Food Webs

If our understanding of food webs is to have a firm empirical basis, we need to describe and attempt to model the structure of webs for a variety of natural and human-modified ecosystems. At present, a significant proportion of ecosystem management is based upon a blend of 'conventional wisdom', insights from single-species studies, pressure to conserve charismatic vertebrates, attempts to balance the integrity of the natural ecosystem with the benefits it is expected to provide to the local community ('community conservation'), and occasional adaptive management.

Practitioners, implementing agencies

Dobson, A., S. Allesina, K. Lafferty and M. Pascual (2009) The assembly, collapse and restoration of food webs. Phil. Trans. R. Soc. B 364: 1803-1806.

http://rstb.royalsocietypublishing.org/content/364/1524/1803.full.pdf+html

Reintroduction of Top-Order Predators

Large predators are among the most threatened species on the planet and ways of conserving them in the face of increasing human populations and associated resource requirements are becoming critical. This book draws upon the experiences of some of the world's foremost large carnivore specialists to discuss the numerous issues associated reintroducing large predators back into their natural habitats. Reviews of internationally renowned reintroduction programs for wolves, European lynx and African wild dog reveal the successes and failures of these actions. Experts on tigers, snow leopards and jaguars contend that there are other conservation options of higher priority that will ensure their security in the long-term. Other experts discuss more theoretical aspects such as whether we know enough about these species to be able to predict their behavioural or ecological response to the reintroduction process. Social, economic, political and genetic considerations are also addressed.

Policymakers, implementing agencies

Hayward, M.W. and M.J. Somers (eds.) (2009) Reintroduction of Top-Order Predators. Wiley-Blackwell, Oxford.

http://onlinelibrary.wiley.com/book/10.1002/9781444312034

A Conditional Trophic Cascade: Birds Benefit Faster Growing Trees with Strong Links between Predators and Plants

Our results suggest that this trophic system is predominately bottom-up driven, but under certain conditions the influence of top predators can stimulate whole tree growth. When the most limiting factor for tree growth switched from water availability to herbivory, the avian predators gained the potential to reduce herbivory. This potential could be realized when strong links between the birds and plant, i.e., species that were both abundant herbivores and preferred prey, were present.

Implementing agencies, practitioners

Bridgeland, W.T., P. Beier, T. Kolb and T.G. Whitham (2010) A Conditional Trophic Cascade: Birds Benefit Faster Growing Trees with Strong Links between Predators and Plants. Ecology 91(1): 73-84.

https://oak.ucc.nau.edu/pb1/vitae/Bridgeland_etal.2010.TrophicCascade.pdf

Large Predators and Trophic Cascades in Terrestrial Ecosystems of the Western United States

Herein we synthesize outcomes of recent tri-trophic cascades studies involving the presence and absence of large predators for five national parks in the western United States, including Olympic, Yosemite, Yellowstone, Zion, and Wind Cave. Where ungulates have significantly altered native plant communities in the absence of large predators, restoration of native flora is urgently needed to recover former ecosystem services. Following the reintroduction of previously extirpated gray wolves Canis lupus into Yellowstone National Park, a spatially patchy recovery of woody browse species (e.g., aspen Populus tremuloides, willow Salix spp., cottonwood Populus spp.) has begun, indicating that large predator recovery may represent an important restoration strategy for ecosystems degraded by wild ungulates.

Implementing agencies, policymakers

Beschta, R.L. and W.J. Ripple (2009) Large Predators and Trophic Cascades in Terrestrial Ecosystems of the Western United States. Biological Conservation 142: 2401-2414.

http://www.acsu.buffalo.edu/~jcallen/large%20predators%20and%20trophic%20cascades%20in%20w%20US.pdf

Recovering Riparian Plant Communities with Wolves in Northern Yellowstone, USA

Results are consistent with the reestablishment of a tri-level trophic cascade involving wolves, ungulates, and riparian vegetation. We additionally present conceptual models of vegetation recovery, illustrating differences in plant height responses to behaviorally and density-mediated trophic cascades. Northern Yellowstone's ''experiment in time,'' whereby wolves were removed and then reintroduced, provides new insights regarding how top predators can influence the structure and biodiversity of terrestrial ecosystems. Restoration ecologists and policymakers should consider the potential benefits of large predators as an option for helping restore degraded ecosystems.

Policymakers, implementing agencies

Beschta, R.L. and W.J. Ripple (2010) Recovering Riparian Plant Communities with Wolves in Northern Yellowstone, USA. Restoration Ecology 18(3): 380-389.

http://www.cof.orst.edu/leopold/papers/2010_BeschtaRipple_RestEcol.pdf

Trophic Cascades in Yellowstone: The First 15 Years after Wolf Reintroduction

Synthesis results generally indicate that the reintroduction of wolves restored a trophic cascade with woody browse species growing taller and canopy cover increasing in some, but not all places. After wolf reintroduction, elk populations decreased, but both beaver (Caster canadensis) and bison (Bison bison) numbers increased, possibly due to the increase in available woody plants and herbaceous forage resulting from less competition with elk. Trophic cascades research during the first 15 years after wolf reintroduction indicated substantial initial effects on both plants and animals, but northern Yellowstone still appears to be in the early stages of ecosystem recovery. In ecosystems where wolves have been displaced or locally extirpated, their reintroduction may represent a particularly effective approach for passive restoration.

Policymakers, implementing agencies

Ripple, W.J. and R.L. Beschta (2012) Trophic Cascades in Yellowstone: The First 15 Years after Wolf Reintroduction. Biological Conservation 145: 205-213.

http://www.greateryellowstone.org/uploads/RippleBeschtaYellowstone_BioConserv.pdf

Restoring Landscapes of Fear with Wolves in the Scottish Highlands

Understanding the relative likely contributions of both lethal and nonlethal effects in the Scottish context will be challenging because nonlethal impacts result from an interaction between deer behaviour in response to wolf predation and particular landscapes and ecosystem features. While a full reintroduction may be far off, research must begin in the near term. There would be considerable scientific merit in establishing a large, controlled experiment (for example on an island or in a fenced area) in the Scottish Highlands to examine the relative lethal and nonlethal effects of wolves on deer and ecosystem restoration. In this paper, a long-term pathway for scientific research to provide sound ecological evidence to inform future decision-makers is proposed.

Policymakers, implementing agencies

Manning, A.D., I.J. Gordon and W.J. Ripple (2009) Restoring Landscapes of Fear with Wolves in the Scottish Highlands. Biological Conservation 142(10): 2314-2321.

http://www.cof.orst.edu/leopold/papers/Manning%20et%20al%20%202009.pdf

Annex 1 – A Short Note on New and Emerging Technologies

The compilation of information requested in Paragraph 2(d) is contained in the various sections of this Information Document, however the Secretariat has asked for a short note to specifically comment on the application of these new and emerging technologies.

The science of restoration ecology and its practical applications in the field of ecological restoration is continually advancing at all spatial scales. As a result, the science-practice interface is also expanding rapidly and making substantial progress across a variety of ecosystem types. These recent advances in ecosystem restoration knowledge and the experiences gained – whether science-based, traditional or ad hoc – provide a growing suite of effective tools and technologies applicable to one or several types of ecosystems requiring restoration. In addition, professional restoration businesses – small, medium, and large – are emerging to meet this demand for repairing ecological infrastructure and restoring natural capital. This international trend is of great significance, especially when innovation and entrepreneurship are combined with science, and government and community support.

The effective, lasting restoration of degraded and damaged ecosystems and landscapes requires science and technology. However, this is a field where there is no "one size fits all" solution. Social, political, cultural and historical components all have a role in determining which tools and technologies are best suited to a specific site or biophysical context and how they are used. In most cases, institutions and governance structures will determine restoration success far more than mere technical prowess or expert knowledge on say the breeding behavior of birds or the germination ecology of a specific functional group of plants. Notwithstanding, without field-based knowledge and experience, restoration efforts are unlikely to succeed.

A sampling of recent, significant advances in the specific tools and technologies relevant to ecological restoration in a variety of contexts was presented in previous sections. As examples, one could site the progress related to applied nucleation techniques and framework species approaches in tropical forest restoration, the use of prescribed fire in prairies and woodlands, and fine-tuned smoke treatments to promote the germination of fire-dependent plant species in Mediterranean-type ecosystems. Ecological engineering is playing an increasing important role in the restoration of ecosystems that have been significantly transformed, particularly with regard to their hydrology and other geomorphologic characteristics. The effective management of harmful invasive species has been enhanced as the result of new and emerging technologies. Greater attention is now being given to interventions based on the increased knowledge of plant-animal mutualisms, above ground-below ground interactions in terrestrial ecosystems, trophic cascades in aquatic ecosystems, and ecosystem interlinkages at the landscape scale.

In sum, the interface between restoration science, engineering, and practice is supporting the development and application of new and emerging technologies. These can be further enhanced if governments and private corporations provide stronger support and incentives for ecosystem restoration through sustainable natural resource management, legislation and regulation, financing and investments, education and communication. NGOs and other organizations, such as botanical gardens, zoos, and marine research institutions, are rising to the challenge as well. One example is the Botanical Gardens Conservation International which launched an Ecological Restoration Alliance in May 2012 to help create synergy among the botanical research and exploration, horticultural, educational and outreach programmes of the more than 100 botanical gardens and arboreta around the world who are actively participating in restoration projects at this time.