Impacts of Land Use Management on Ecosystem Services and Their Regulations

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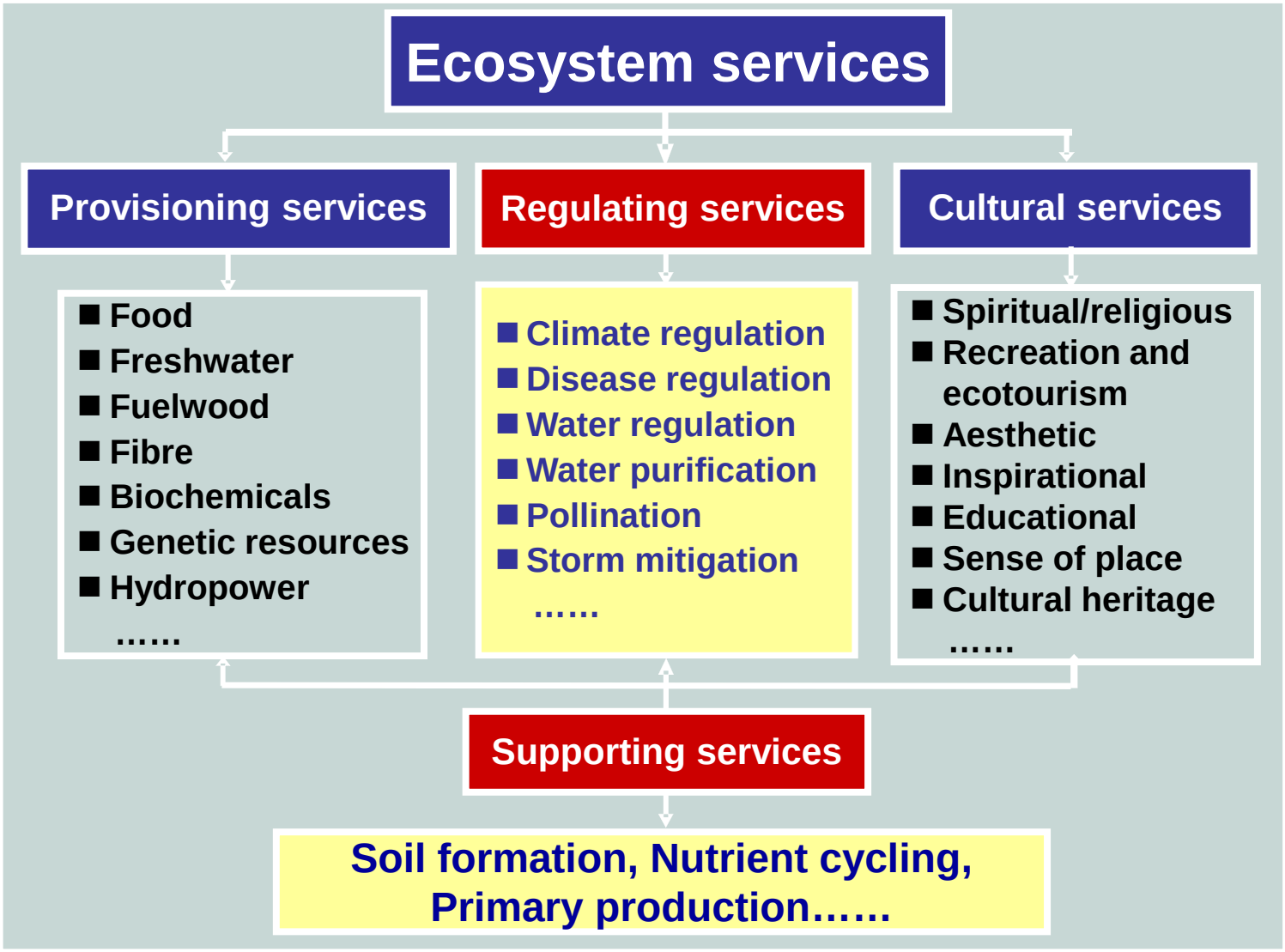
Outline

- Challenges of ecosystem service management
- Introduction of InVEST models
- Impacts of alternative land use management on multiple ES: Hainan Island case study

Challenges of ecosystem service management

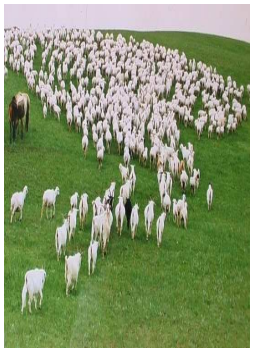
- The benefits people obtain from ecosystems (MA, 2003)



Challenges of ecosystem service management

- **Uneven delivery of different kinds of services**

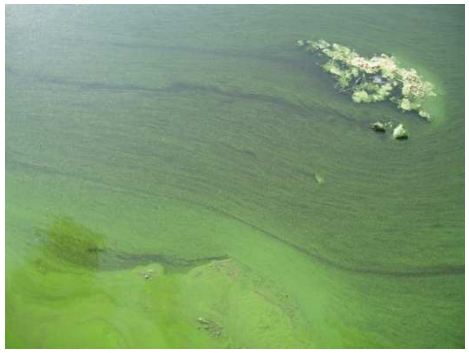
Agricultural production



Timber production

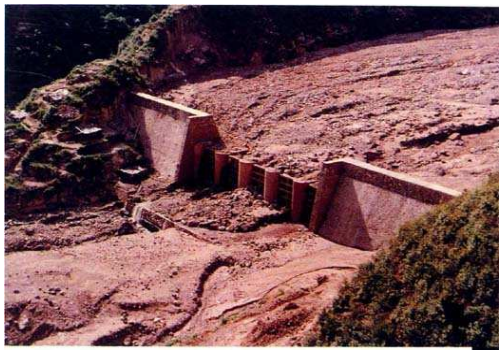
Hydropower production

Water pollution regulation



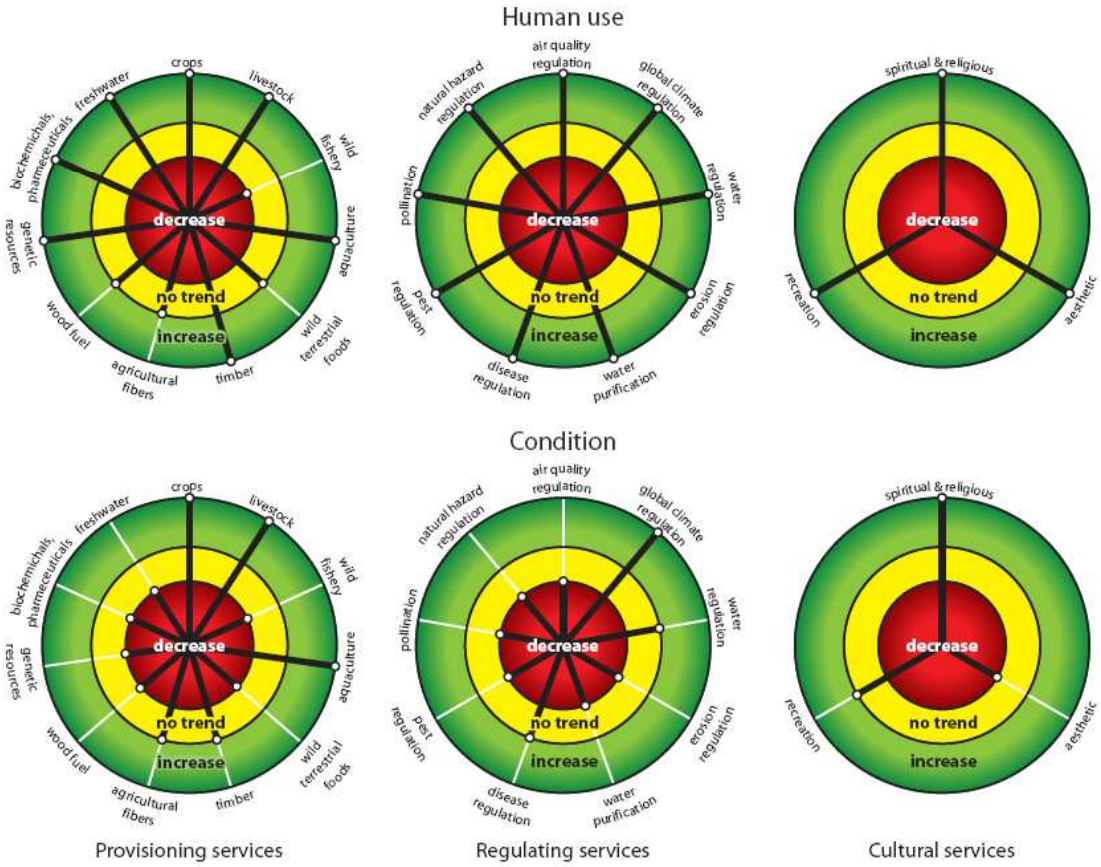
Flood mitigation

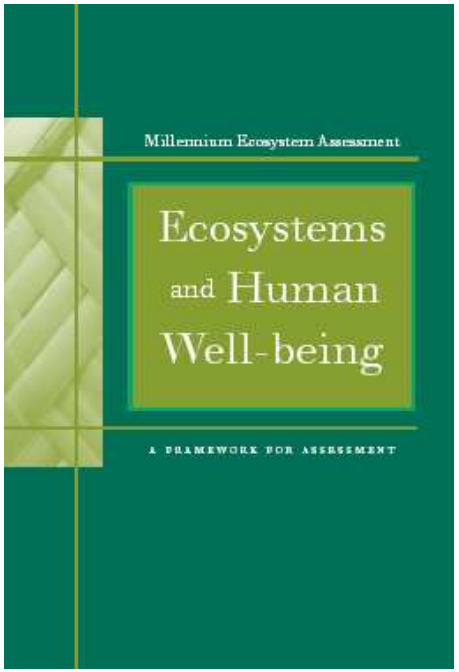
Avoided reservoir sedimentation



Challenges of ecosystem service management

- **MA (2005): Approximately 60% (15 out of 24) of the ecosystem services (70% of regulating and cultural services) are being degraded or used unsustainably.**



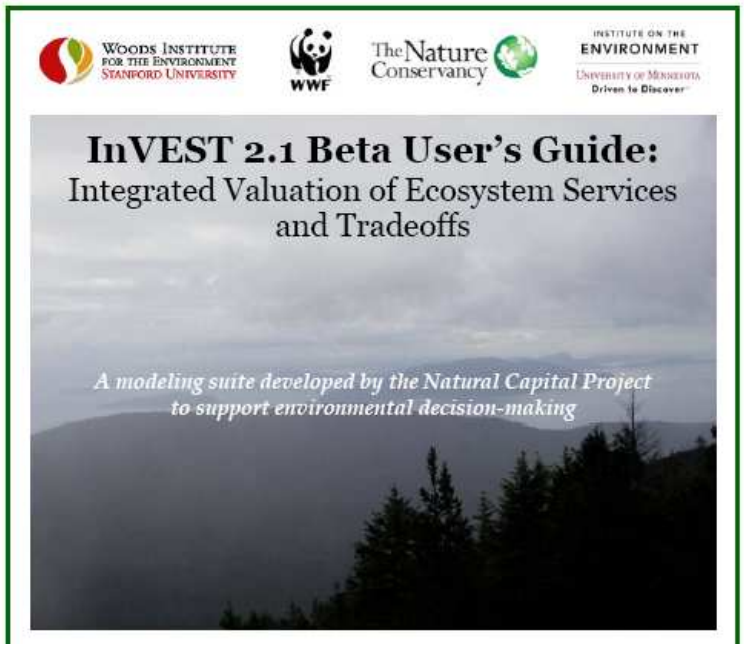


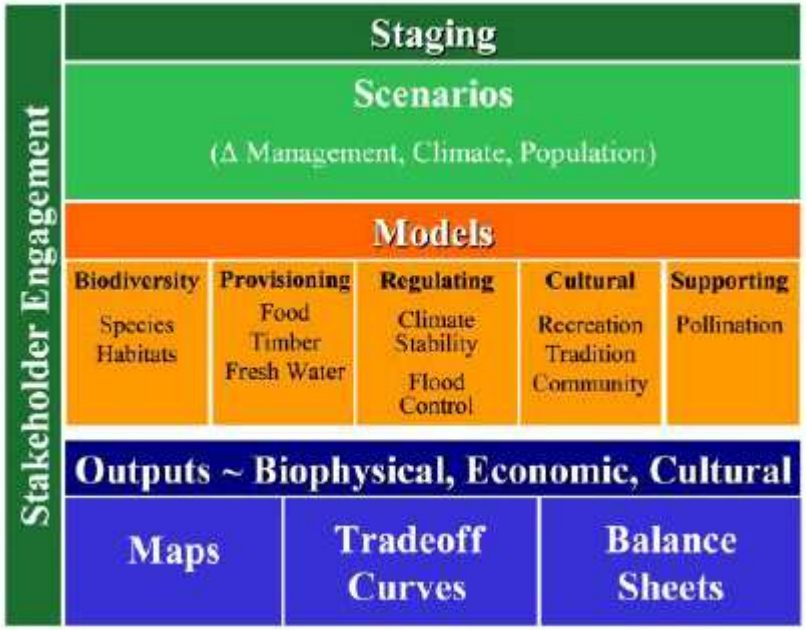
Challenges of ecosystem service management

- How to quantify and manage tradeoffs of multiple ecosystem services?
- How to sustain natural resources while promoting economic growth and quality of life?

Introduction of InVEST models

- Stanford University, WWF and TNC (www.naturalcapitalproject.org).
- A software system - InVEST: Integrated Valuation of Ecosystem Services and Tradeoffs
- This tool informs managers and policy makers about the impacts of alternative resource management choices on the economy, human well-being, and the environment, in an integrated way (Daily, et al., 2009)





Introduction of InVEST models

InVEST can map & value

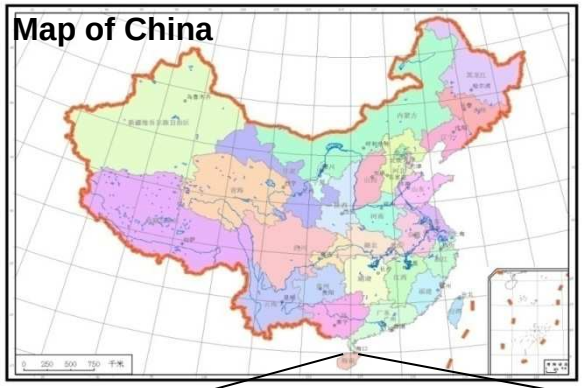
- Biodiversity
- Water pollution regulation
- Carbon sequestration & storage
- Managed timber production
- Crop pollination
- Avoided reservoir sedimentation
- Tourism & recreation
- Agricultural production
- Flood mitigation
- Hydropower production
- Irrigation
- Open access products

- **Land use**
- **Soil type**
- **Topograph**
- **Road**
- **Cities**
- **Infrastructure**

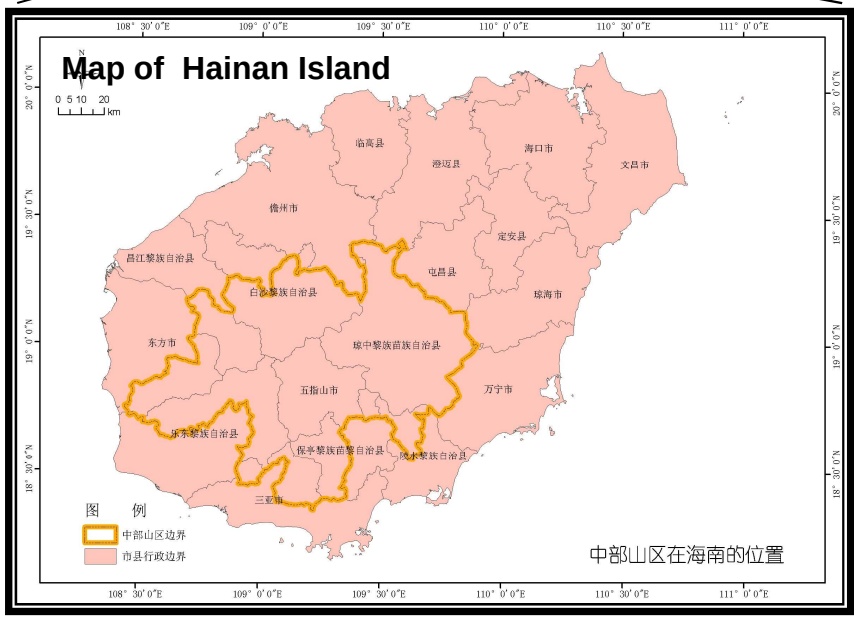
Outline

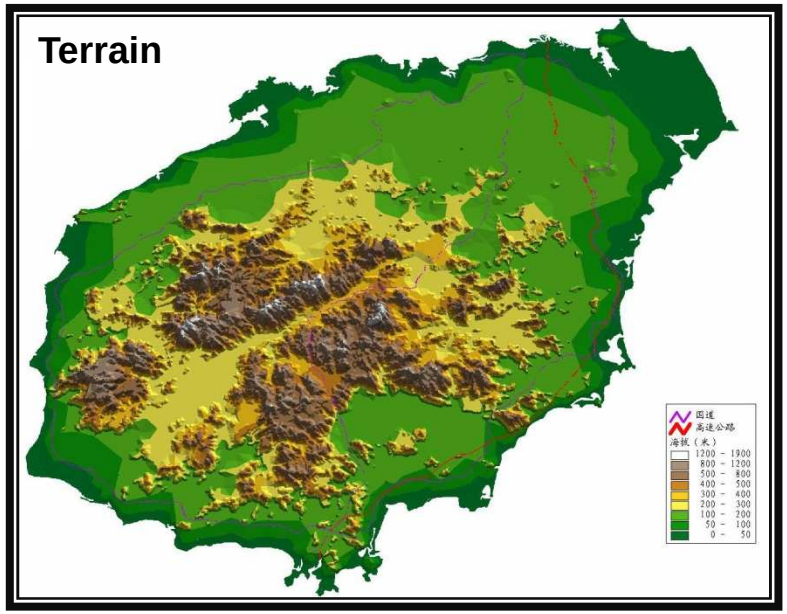
- Challenges of ecosystem service management
- Introduction of InVEST models
- Impacts of alternative land use management on multiple ES: Hainan Island case study
  - Study area: Hainan Island
  - Ecological protection challenges
  - Model selection and validation
  - Impacts of LULC change between 1998-2008
  - Alternative land use management impacts

Study area: Hainan Island



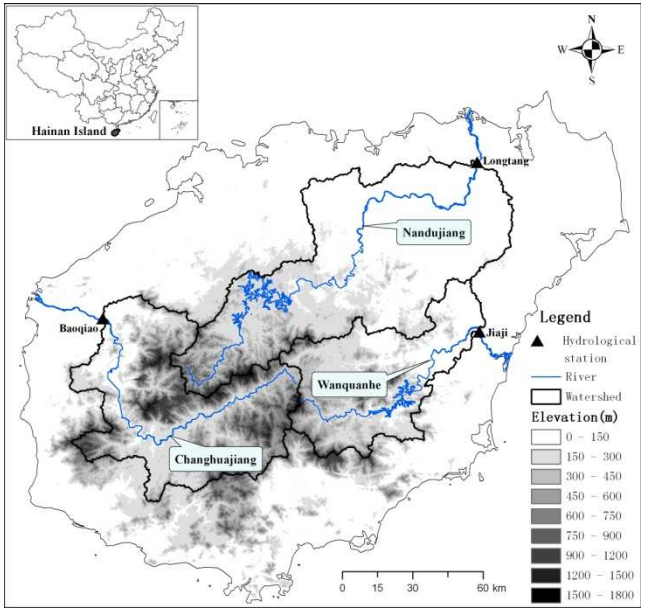
- South of China, tropical climate
- 3.4×10^4 km^2, 8.6 million people (2009)
- Center: mountains, forest land 70%.
- WuZhi Mountain; Yinggeling Mountain





Study area: Hainan Island

- **Water resource conservation**
  - Nandu River, Changhua River and Wanquan River: 47% area
- **Biodiversity conservation**
  - 23th priority ecoregion for global conservation: 11 nature reserves




Tianchi in Jianfengling


Hainan Peacock Pheasant


Hainan Hill Partridge

endemic and endangered species


Daguangba reservoir in Ledong county

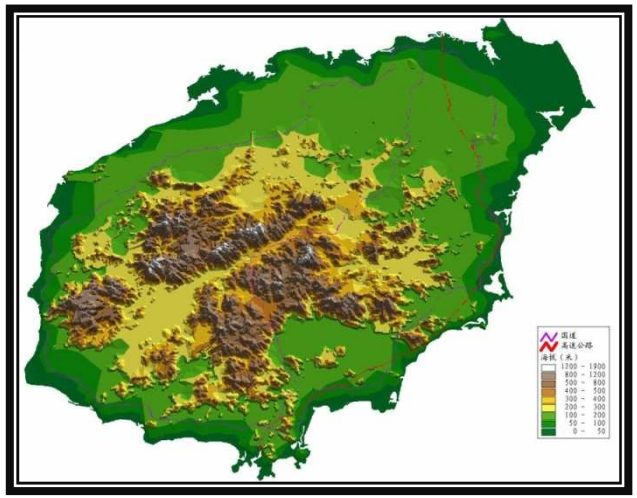

Homalium hainanense


Tree-fern

ES protection challenges

Challenges on ES protection

- Large economy difference among the regions
- Low compensative standard for Ecological Forest
- Increasing area in Rubber tree (Hevea brasiliensis) is threatening the water quality and biodiversity of Hainan Island



ES protection challenges

- Poverty


Simple house

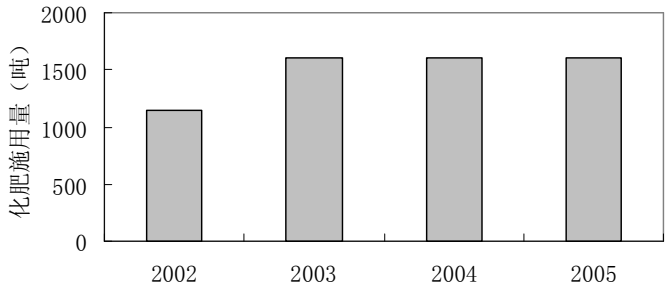

Simple house


Simple kitchen

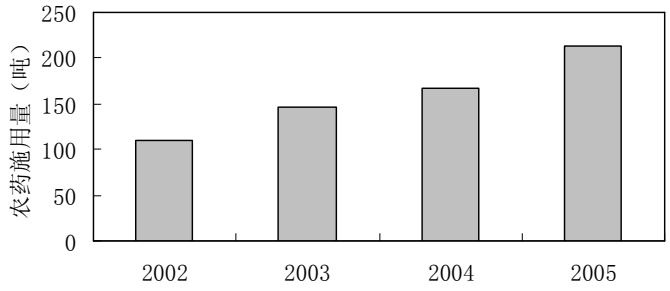

papaya

ES protection challenges

Rubber plantation and increased impacts



Used amount of fertilizer in Wuzhishan City



Used amount of pesticide in Qiongzhong County

ES protection challenges

- Sharp contradiction between population and usable land


Destruction of tropical rain forest


Destruction of natural forest


Nibbling into natural forest

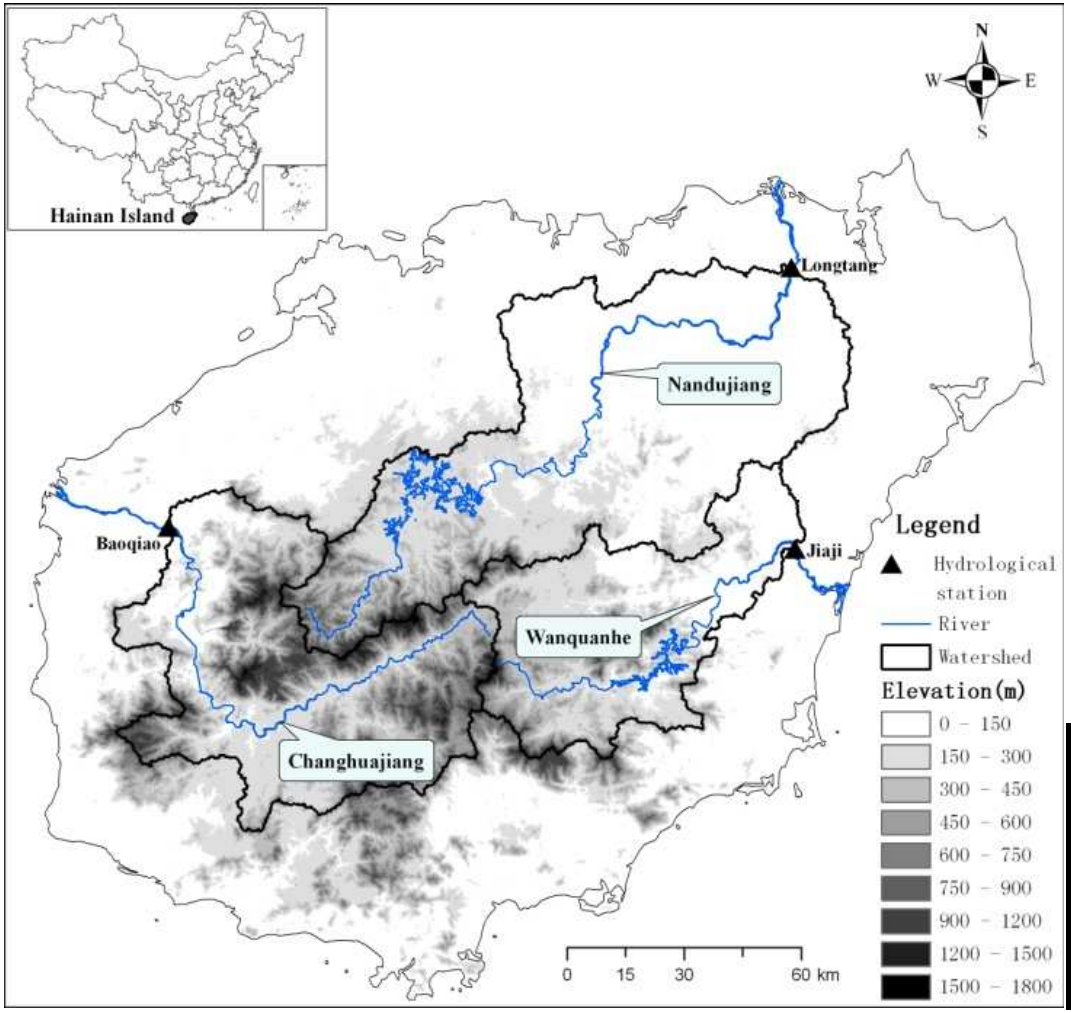

Killing of wildlife

ES protection challenges

Questions:

- What are the impacts of LULC on important ES?
- How to improve regional ES by sustainable land use management in the future?
- How to coordinate regional development and ES conservation by scientific policy design?

Model selection and validation



Watershed name	Area (km^2)
Nandujiang	6841
Changhuajiang	4635
Wanquanhe	3235

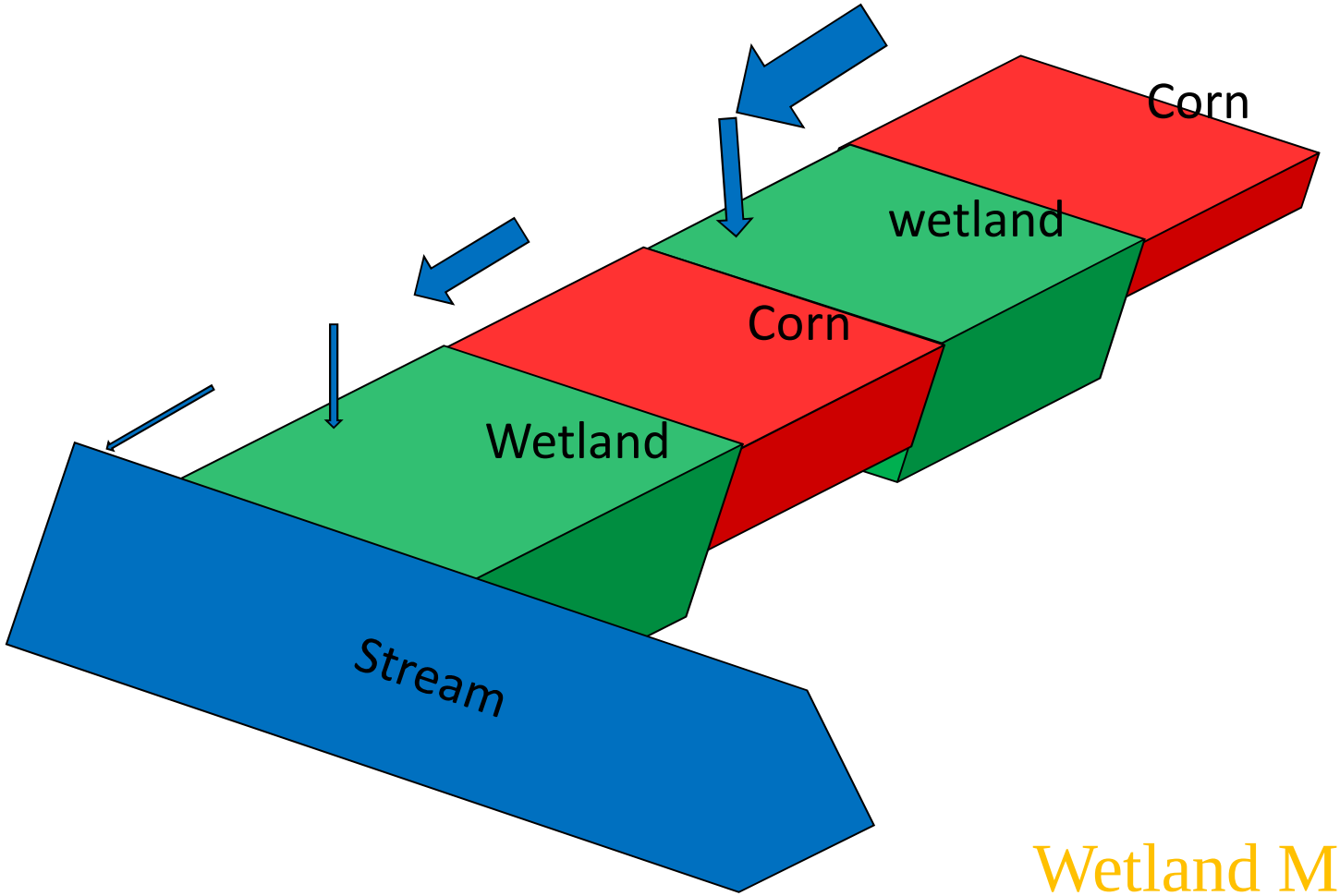
Model selection and validation

Model application

- Rubber production
- Natural habitat
- **Water yield model**
- **Water purification models (TN & TP): E&R**
- **Sedimentation retention model: E&R**
- **Storm peak mitigation model: Time to outlet; E&R**
- Carbon sequestration

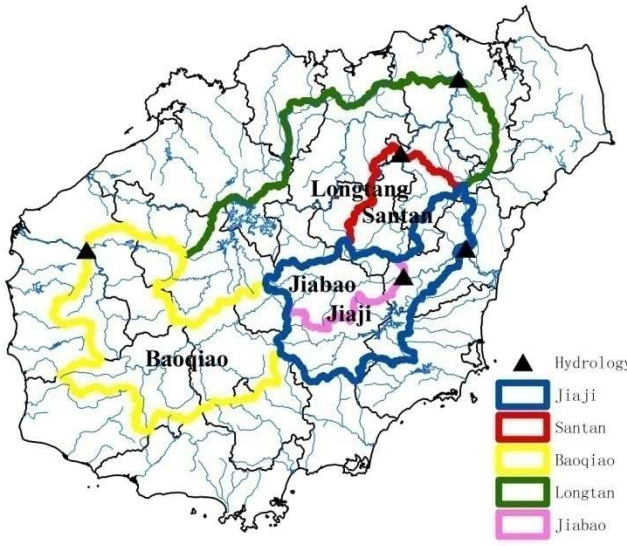
Model selection and validation

Example: Storm Peak Mitigation Model



Model selection and validation

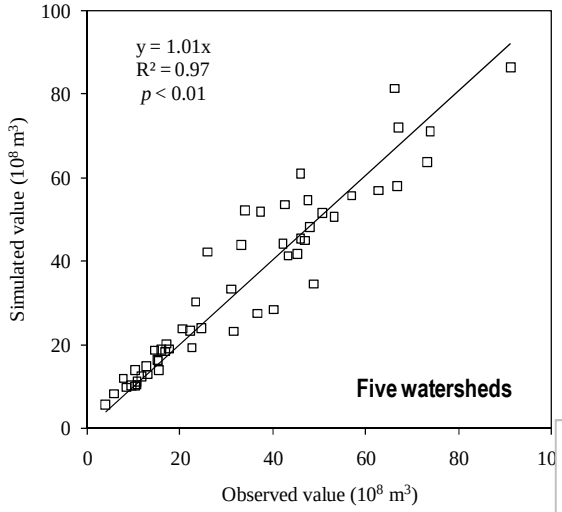
- **Model application – Regulating Services**
  - **Water yield model**
  - **Water purification models (TN & TP)**
  - **Sedimentation retention model**



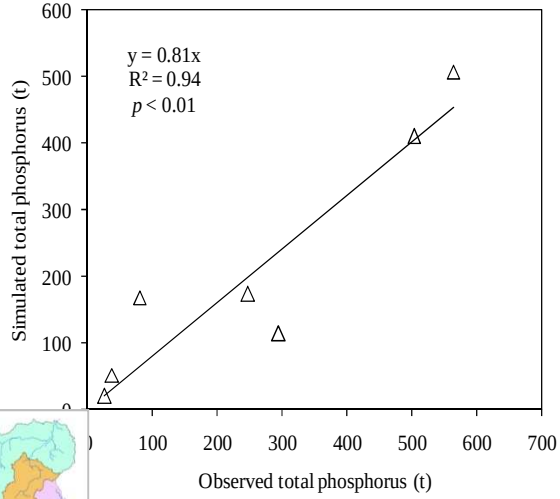
Hydrological stations	Main LULC in 2008	Area (km^2)
Longtang	AL: 24%; RP: 40%; NF: 13%	6841
Santan	-	1215
Jiaji	AL: 4%; RP: 52%; NF: 25%	3235
Jiabao	-	1157
Baoqiao	AL: 6%; RP: 20%; NF: 52%	4635

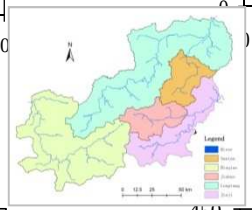
Model selection and validation

Water yield model

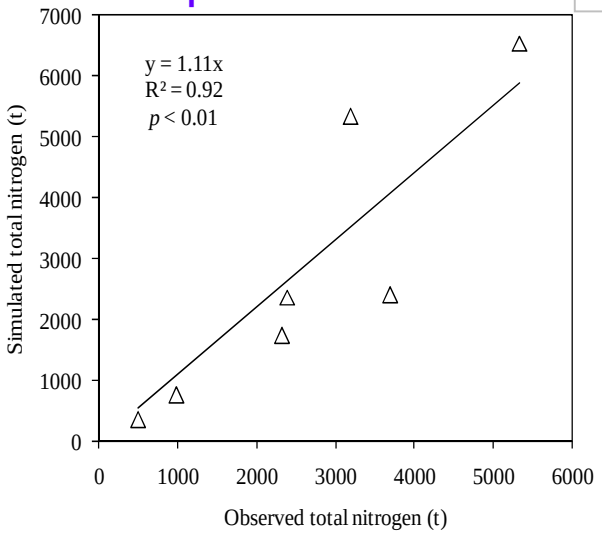


Water purification model – TP

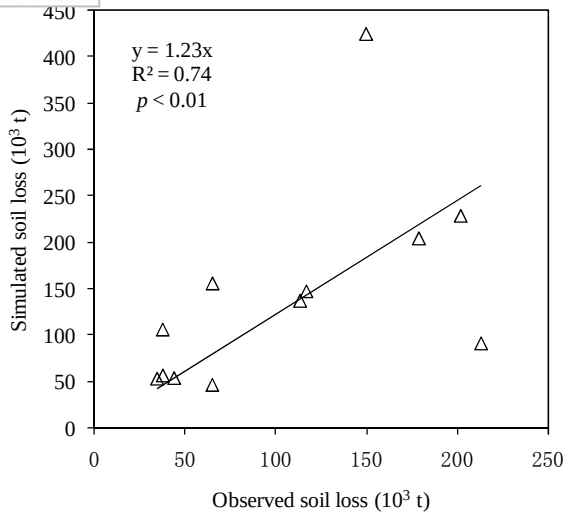




Water purification model – TN

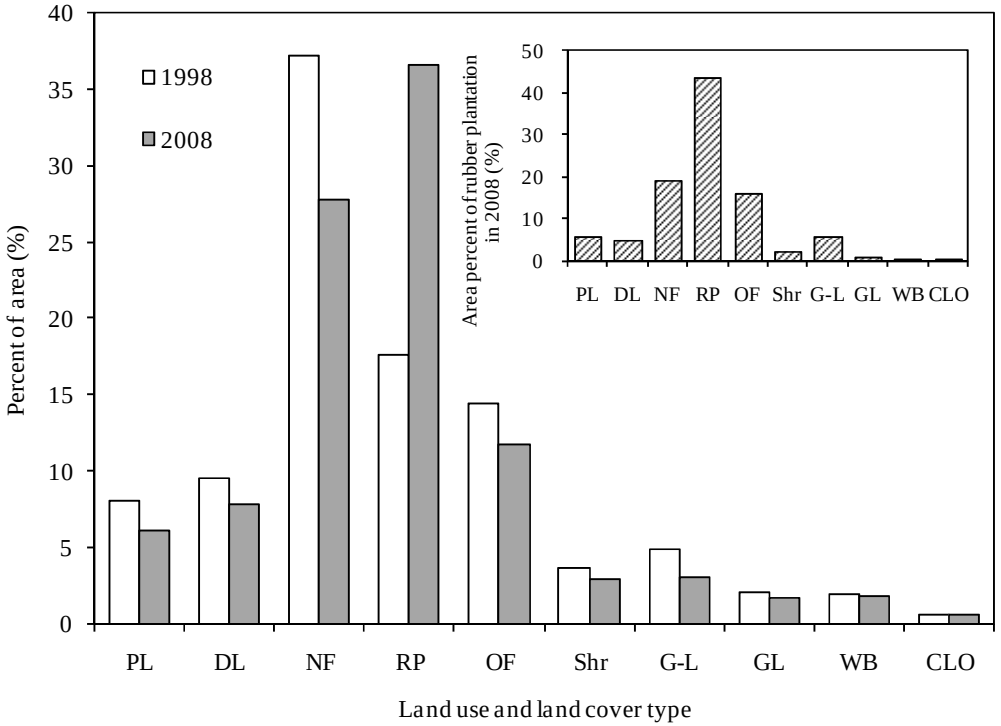


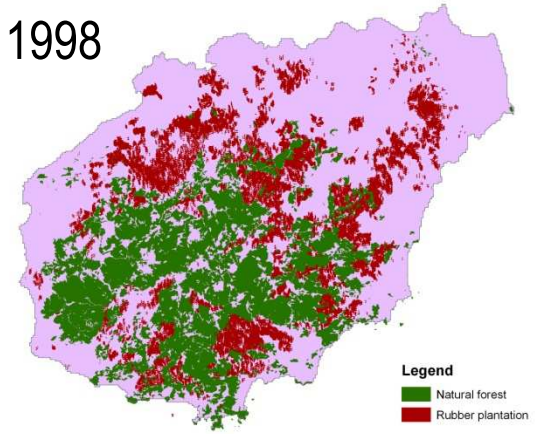
Sedimentation retention model

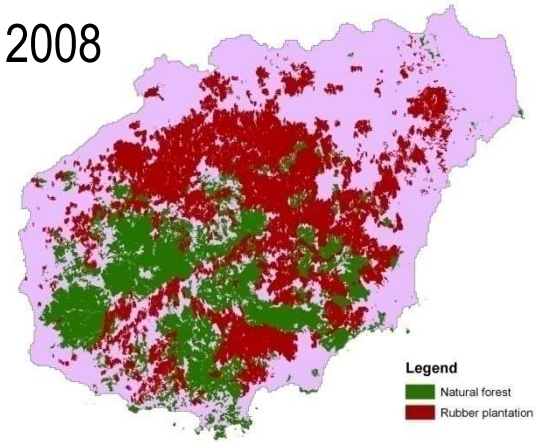


Impacts of LULC change on ecosystem services

LULC change in Hainan Island

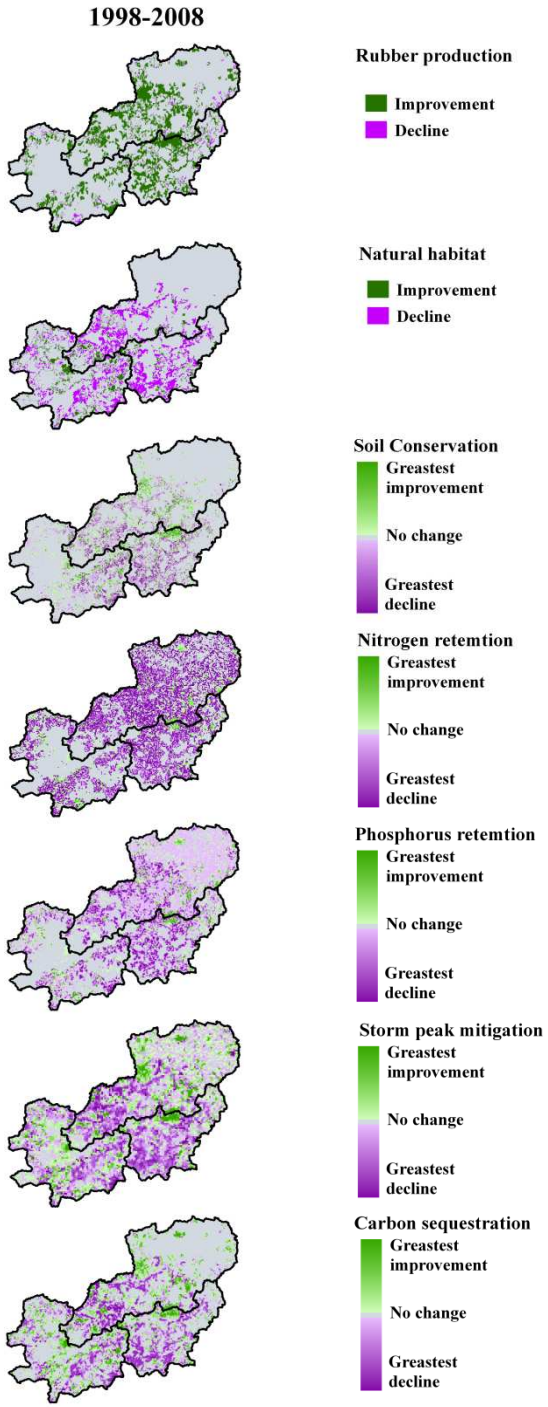


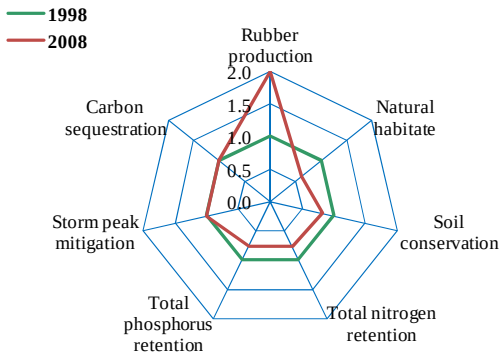




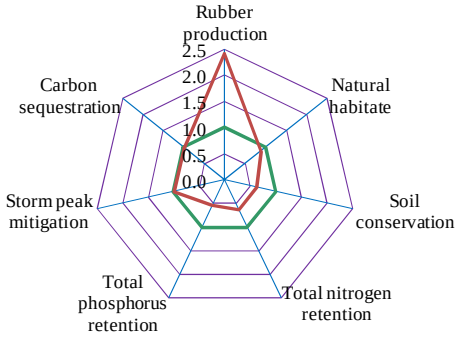
- Rubber plantation: 17.3% - 36.1%
- Natural forest: 37.4% - 28.0%

Impacts of LULC change on ecosystem services

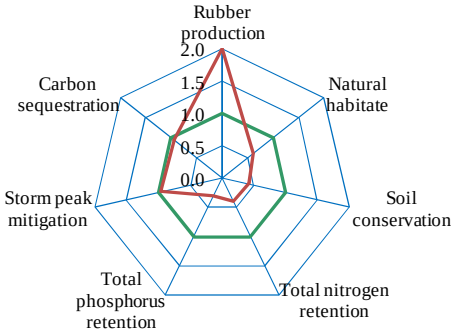




(A) Nandujiang watershed



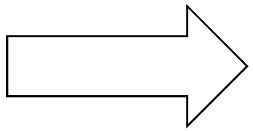
(B) Changhuajiang watershed



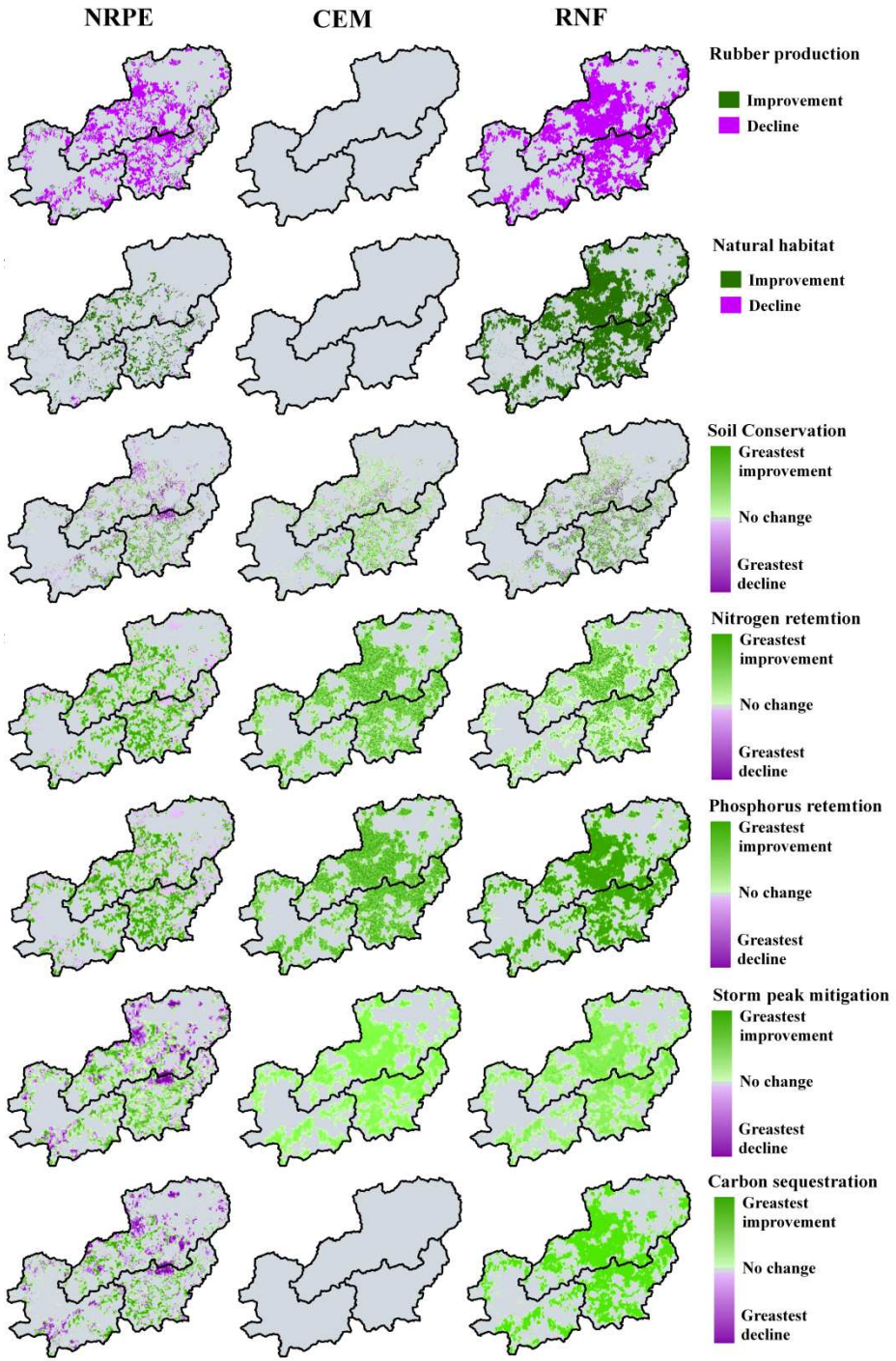
(C) Wanquanhe watershed

Impacts of LULC change on ecosystem services

- **Scenarios**
  - NRPE: No Rubber Plantation Expansion
  - CEM: Complex Ecosystem Management
  - REP: Restoration of Natural Forest

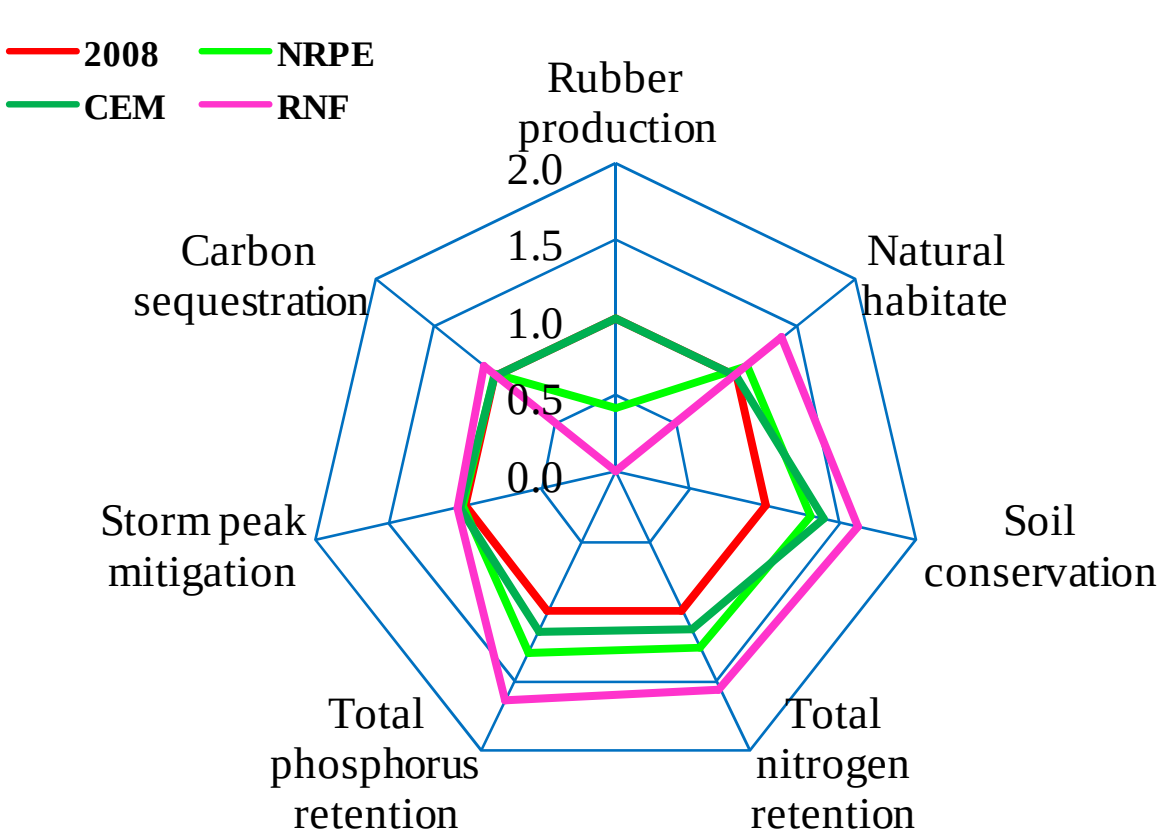


Impacts of LULC change on ecosystem services

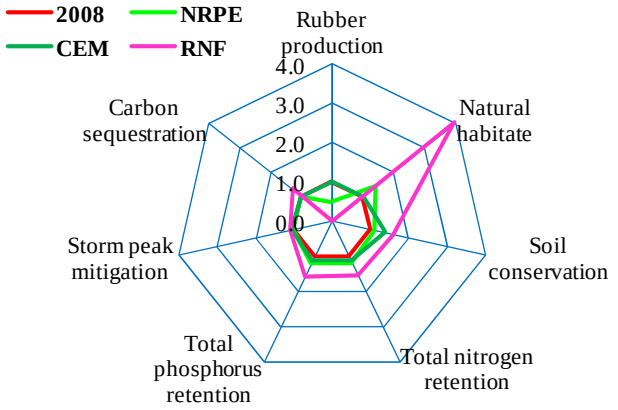


Impacts of LULC change on ecosystem services

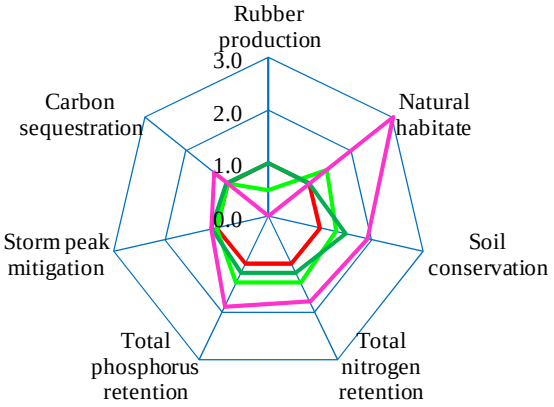
Tradeoffs between ecosystem provisioning and regulating services



(B) Changhuajiang Watershed



(A) Nandujiang watershed



(C) Wanquanhe watershed

Conclusions and recommendations

- One service may be gained at the expense of another. Rubber provisioning service production undermined the ecosystem regulating services: sediment, TN, TP retention, natural habitat, storm peak mitigation and the sustainability of productivity.
- Actively adaptive management will improve sediment/TN/TP retention, storm peak mitigation and conserve regulating services.
- The analysis of spatial patterns of ecosystem services with the InVEST models helped us understand how ecosystem services change and are distributed across the landscape.
- The case provides a general methodology for managing tradeoffs between the ecosystem provisioning and regulating service, showing investment returns through time.

Conclusions and recommendations

- **Suggestions：**
  - Accounting regulating ecosystem services for regional sustainable land use planning and restoration planning;
  - Excluding rubber plantation from the classification of ecological forest due to its great impacts;
  - Reforming water resource fee price system and implementing ecological compensation to coordinate ES conservation and development;
  - Implementing adaptive management for rubber plantation to improve the ecosystem regulating services.


Many thanks to Professor Gretchen Daily and NatCap team!