Impacts of climate change on biodiversity

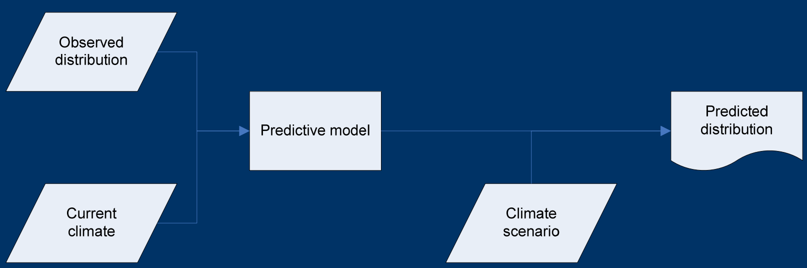
Gabriel del Barrio

Estación Experimental de Zonas Aridas (CSIC)
Almería
`gabriel@eeza.csic.es`

Biodiversity and climate change

'for mid-latitude regions, an average warming of 1-3.5 ºC over the next 100 years would be equivalent to a poleward shift of the present geographic bands of similar temperatures (or isotherms) of approximately 150-550 km, or an altitudinal shift of about 150-550 m'

IPCC on Regional Impacts of Climate Change, 1997



Impact in terms of shifting species distributions

Predicted distributions under different scenarios

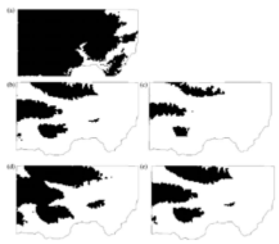


Fig. 6 – Potential climate space for *Pinus pinaster* in Almeria for (a) baseline (1961–1990); (b) HadCM3 A2 scenario for 2050; (c) HadCM3 A2 scenario for 2080; (d) PCM A2 scenario for 2050; and (e) PCM A2 scenario for 2080. The two observed presences are shown in grey along the western border of the region.

Table 1 – Gains (+) and losses (−) in regional climate space (%) under two scenarios

Species	HadCM3 A2 scenario			PCM A2 scenario		
	2020	2050	2080	2020	2050	2080
UK						
Hesperia comma[a]	+404/0	+589/0	+752/0	+301/0	+447/0	+481/0
Lysandra bellargus[a]	+182/0	+243/0	+347/0	+252/0	+206/0	+287/0
Campanula glomerata	+15/−11	+22/−14	+27/−24	+7/−12	+34/−12	+22/−16
Helictotrichon pratense	+19/−7	+20/−14	+19/−32	+16/−6	+17/−14	+16/−41
Silene gallica	+25/0	+32/0	+46/0	+22/0	+31/0	+41/0
Papaver dubium	+4/0	+5/−2	+5/−7	+4/0	+5/−2	+5/−9
Legousia hybrida	+9/−14	+9/−19	+9/−20	+8/−10	+9/−15	+12/−14
Lepus europaeus[b]	+15/−15	+15/−32	+12/−45	+17/−8	+18/−8	+23/−7
Almeria, Spain						
Pistacia lentiscus	+32/0	+50/0	+58/−20	+27/0	+39/0	+52/0
Chamaerops humilis	+4/0	+7/0	+7/0	+2/0	+5/0	+7/0
Pinus halepensis	+1/0	+1/0	+1/−7	+1/−5	+1/−6	+1/−8
Pinus pinaster	0/−53	0/−72	0/−86	0/−42	0/−55	0/−71
Quercus ilex	0/0	0/0	0/−31	0/0	0/0	0/0
Quercus faginea	0/0	0/0	0/−13	0/−4	0/−1	0/0

[a] Insect.
[b] Mammal.

Presences gains/losses with respect to current distribution

Scale-dependent impacts

Species-climate envelopes:
- climate as the main driver
- climate fully realised
- species constrained within climate gradient
- gain / loss of climatic space

} Large, homogeneous regions
Coarse resolution

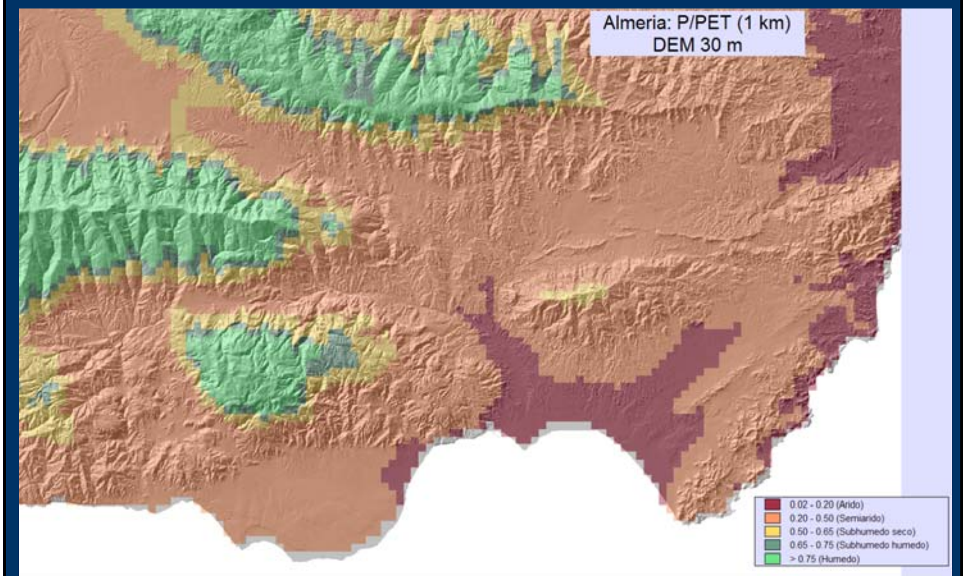
Small regions
Fine resolution {

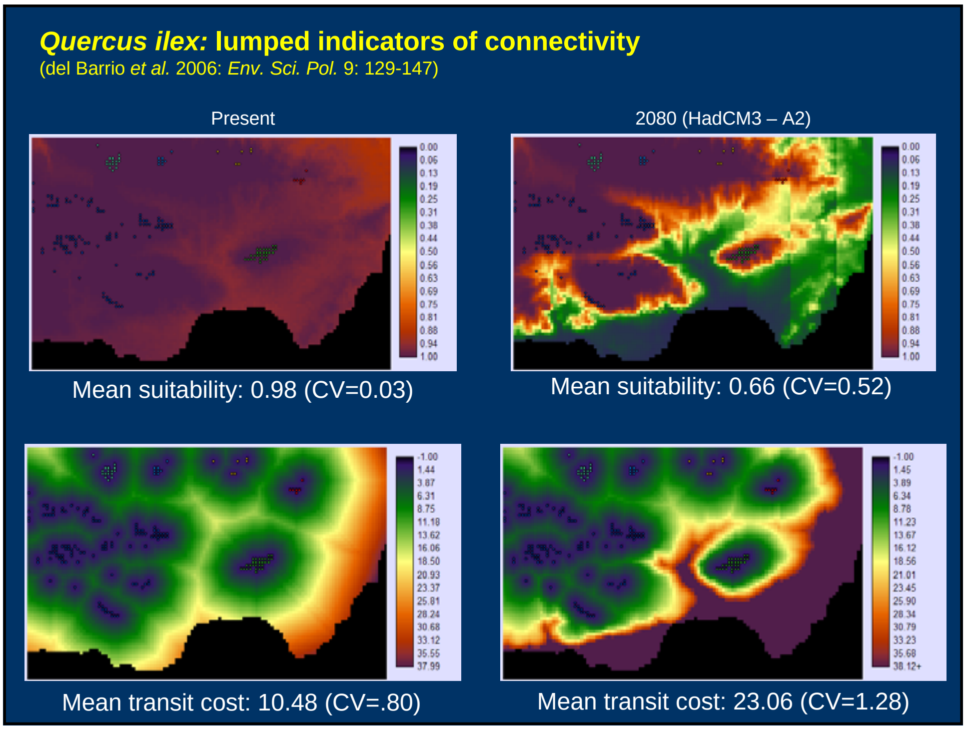
- shorter gradients (topography...)
- fragmented distributions
- connectivity

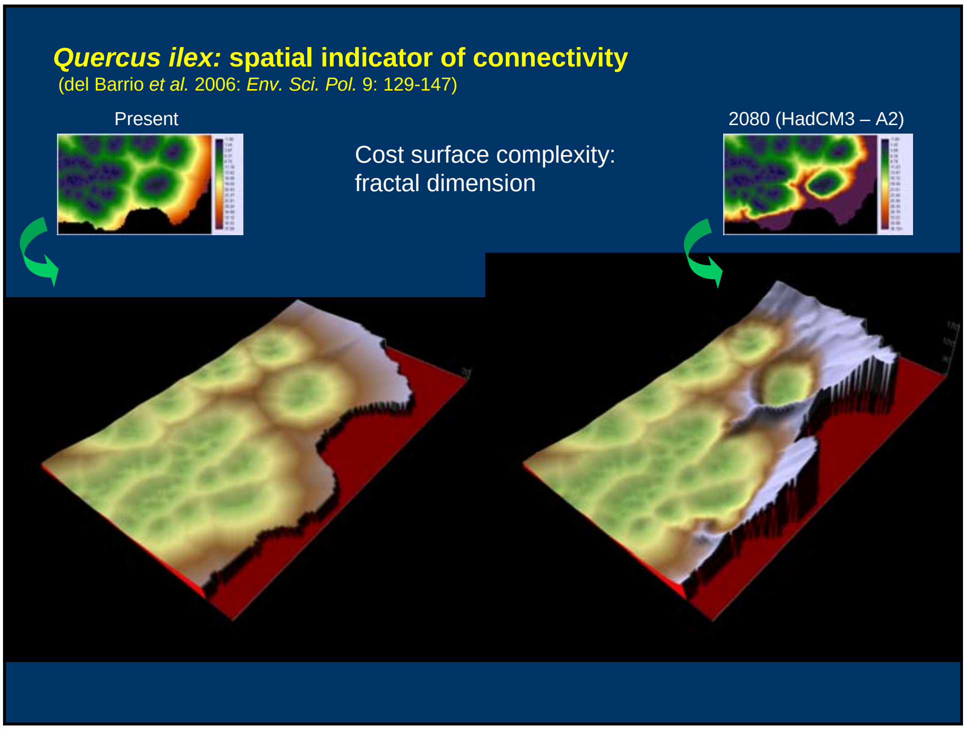
Ecological connectivity: operative definitions

- Capability of a species to transit across a landscape given:
  - The ecological niche
  - The spatial arrangement of populations
  - The spatial heterogeneity of the landscape
- Landscape attribute
  - Extrinsecal
  - Spatial
- Functional link between locations
  - Dispersal within a new potential space
  - Management of conservation networks

The Almeria study region

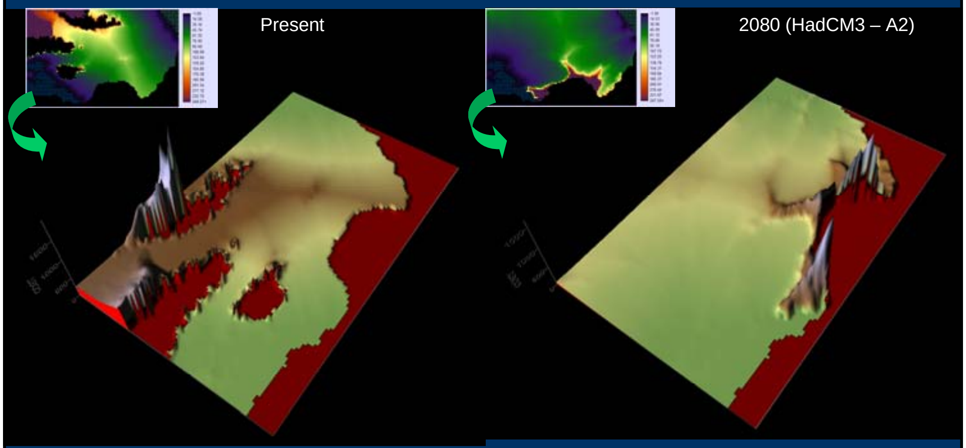



Quercus ilex: lumped indicators of connectivity
(del Barrio et al. 2006: Env. Sci. Pol. 9: 129-147)
Present
2080 (HadCM3 – A2)
Mean suitability: 0.98 (CV=0.03)
Mean suitability: 0.66 (CV=0.52)
Mean transit cost: 10.48 (CV=.80)
Mean transit cost: 23.06 (CV=1.28)


Quercus ilex: spatial indicator of connectivity
(del Barrio et al. 2006: Env. Sci. Pol. 9: 129-147)
Present
2080 (HadCM3 – A2)
Cost surface complexity:
fractal dimension

Pistacia lentiscus: lumped & spatial connectivity indicators

(del Barrio *et al.* 2006: *Env. Sci. Pol.* 9: 129-147)



Overall mean transit cost: 89 ± 4
Fractal dimension: D = 2.463

Overall mean transit cost: 54 ± 3
Fractal dimension: D = 2.695

Ecological connectivity and climate change

(del Barrio *et al.* 2006: *Env. Sci. Pol.* 9: 129-147)

- Suitability shifts along horizontal and vertical gradients
  - upwards means fragmentation
  - downwards means coalescence
- Fragmentation can favour connectivity
- Distributions can lose density

Climate change:

- Short gradients can compensate long ones
- Comparable to edge of zonal distributions

1. Zonal responses into extra-zonal ones

- Loss of density or contraction mean gap
- Zonal replacements very slow
- Transient conditions

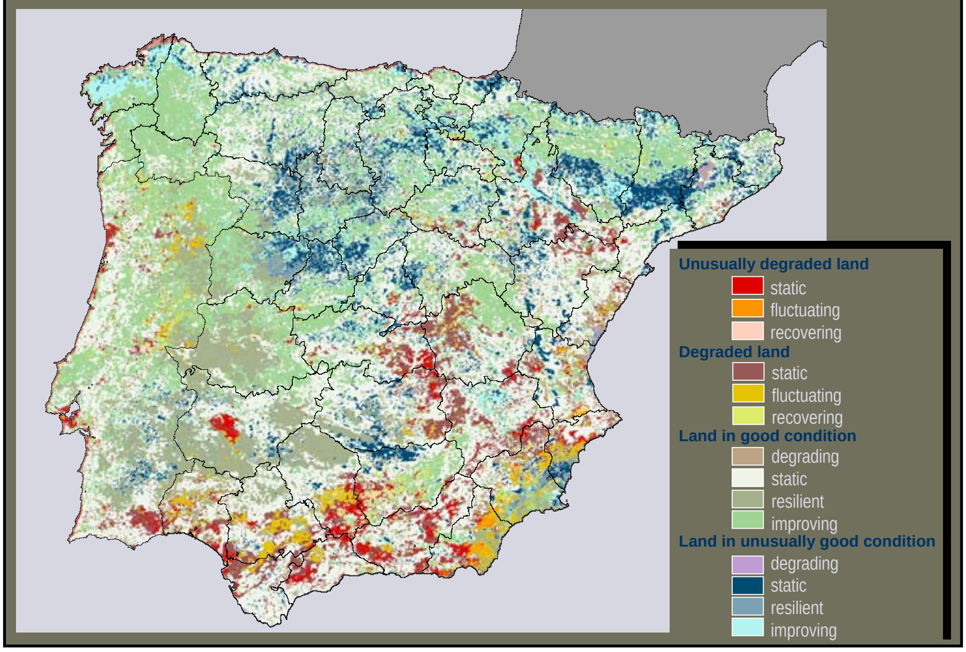
2. Not zonal shifts, but gaps colonised by early successional species

Desertification, biodiversity and climate change

'The Conference of the Parties requests the Executive Secretary, in cooperation with the FAO of the UN, the UN CCD and other relevant organizations and collaborators to explore harmonized reporting between relevant conventions and strengthen collaboration on the assessment of status, trends and threats in dry and sub-humid lands'

Decisions adopted by the COP to the
Covention on Biological Diversity at its 9th meeting
Bonn, 19-30 May 2008
Advance copy – subject to final clearance

Desertification in the Iberian Peninsula (1989-2000)



Validating desertification at the landscape level using independent data for which a condition can be safely assumed: Natura 2000 Network

- •Natura 2000 in mainland Spain: 853 Sites of Community Interest, 22% of the territory
- •The SCI represent a variety of landscapes and habitats and can be assumed in a good condition
- •Method: chi-square test between land condition and conservation status

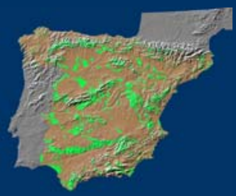


Table of residual frequencies (Observed *minus* Expected)

χ^2=427,df=13,N=45731,p<10^{-4}	Non SCI	SCI
Unus. Degr. – Static	45	-45
Unus. Degr. – Recovering	11	-11
Unus. Degr. – Fluctuating	20	-20
Degraded – Static	252	-252
Degraded – Recovering	28	-28
Degraded – Fluctuating	112	-112
Good – Static	-392	392
Good – Degrading	8	-8
Good – Improving	-304	304
Good – Resilient	89	-89
Unus. Good – Static	-39	39
Unus. Good – Degrading	14	-14
Unus. Good – Improving	101	-101
Unus. Good - Resilient	56	-56

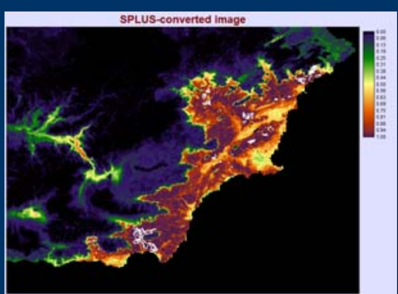
Negative association between SCI and degraded or degrading land

Positive association between SCI and land in good or very good condition

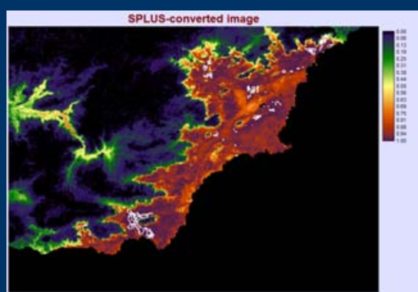
Negative association between SCI and land in good or very good condition if under agricultural use

Predictive distribution of a shrubland associated to degraded sites:

***Atriplici glaucae-Salsoletum genistoidis* O. Bolòs 1957 em. O.Bolós 1967**



Using only physical factors

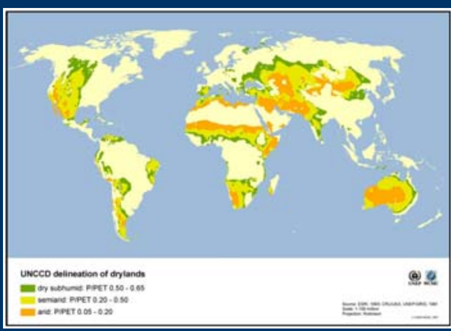


Using physical factors and land degradation

Biodiversity and global change: concluding remarks

- Impact on texture rather than on extent of current distributions
- Gaps of degradation with local species rather than invasion of adjacent zones
- Land degradation creates fragmentation
- Biodiversity assessments may be dramatically overestimated
- Convergency between CBD and CCD

Milennium Assessment: Dryland Systems



- 41% Earth surface, $2x10^9$ people
- Lag far behind on well-being and development
- Water shortages projected to increase
- Transformation of rangelands to croplands leads to decrease in productivity
- Semiarid are most vulnerable
- 10-20% of drylands are degraded
- Desertification has off-site effects on non-drylands
- Relatively rich biodiversity