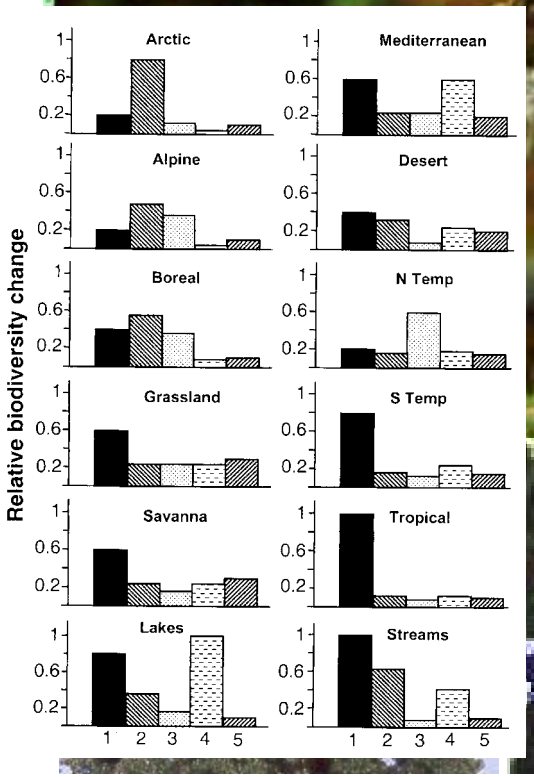
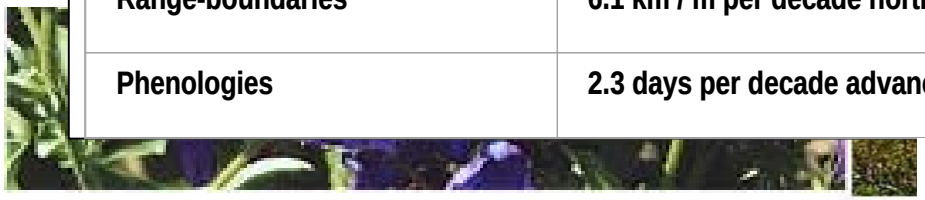

Plant diversity, climate change
and land use transitions
Sandra Lavorel, Fabien Quétier, Wilfried Thuiller,
Eric Garnier, Philippe Choler,
and many others
GDR
Utiliterres

Impacts of global change on biodiversity



1 = land use, 2 = climate, 3 = N deposition,
4 = invasions, 5 = CO2 (Sala et al. 2000)

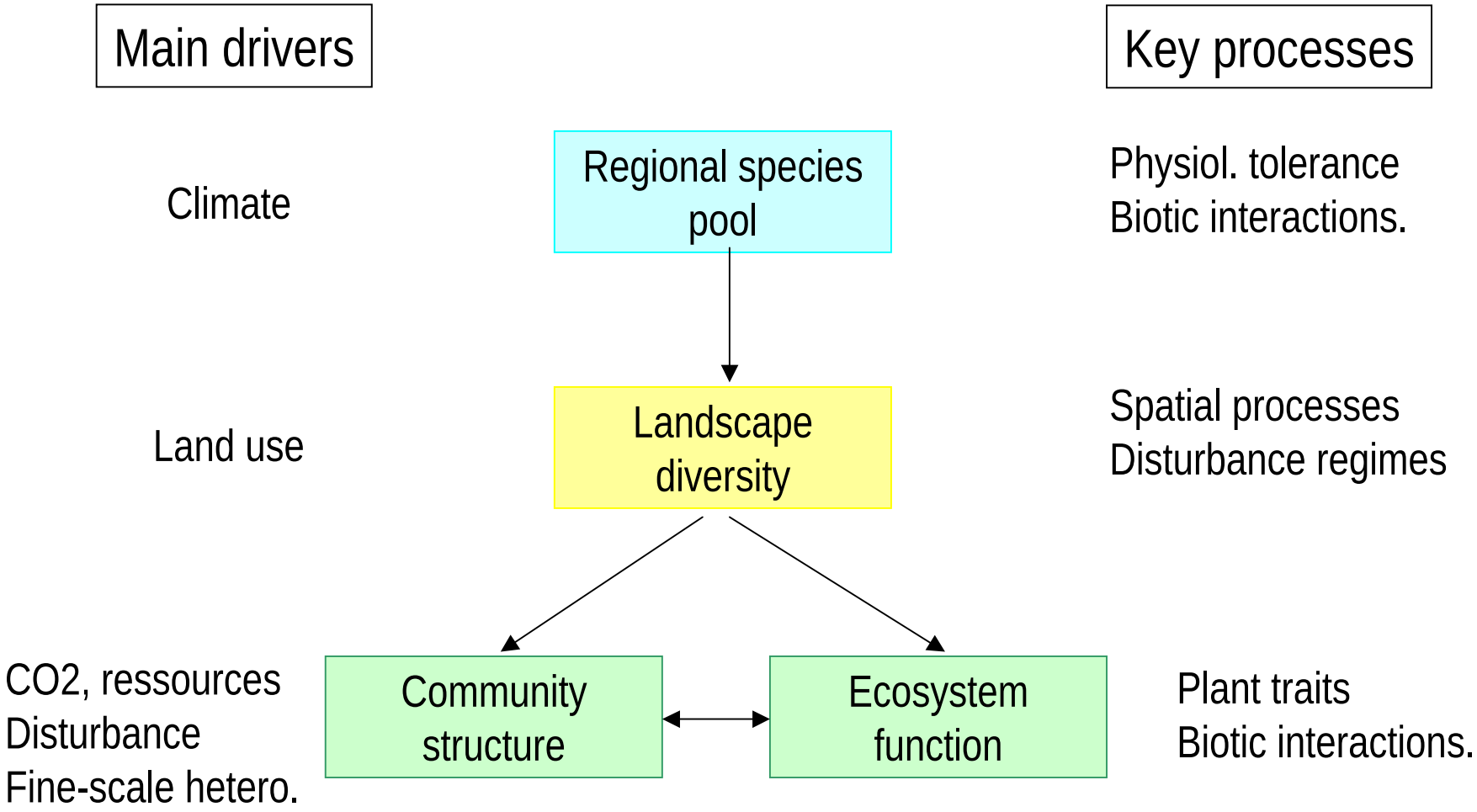


A discernible « fingerprint » of climate change effects on species distributions and phenology

Type of change	Changed as predicted	Changed opposite to prediction
Phenological	87%	13%
Distributional changes		
At poleward/upper range boundaries	81%	19%
At equatorial/lower range boundaries	75%	25%
Community (abundance) changes		
Cold-adapted species	74%	26%
Warm-adapted species	91%	9%
Overall	81%	19%
Meta-analyses		
Range-boundaries	6.1 km / m per decade northward/upward shift	
Phenologies	2.3 days per decade advancement	

Parmesan & Yoh 2003

Drivers and processes across scales

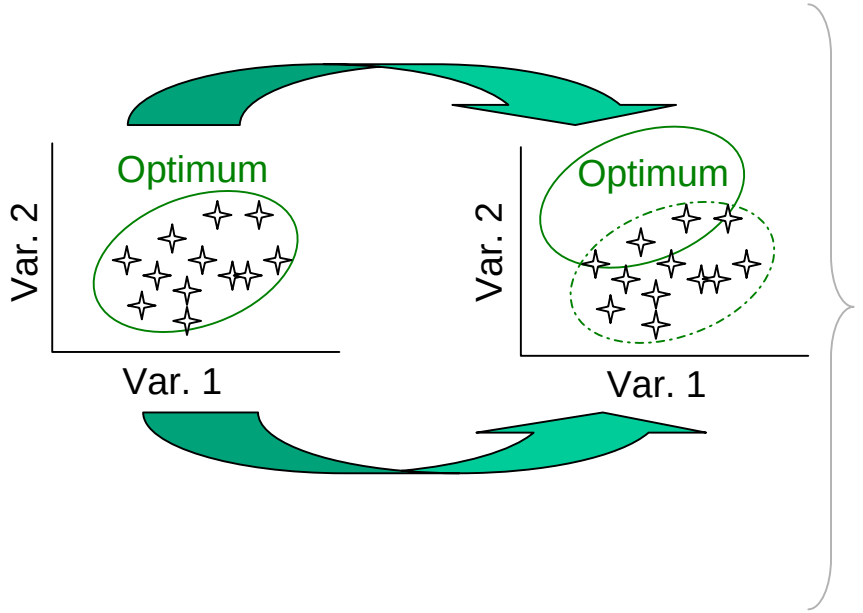


Changing species pools: climate effects

Advanced
Terrestrial
Ecosystem
Analysis and
Modelling

ATEAM

Niche-based modelling of species response to changing environments

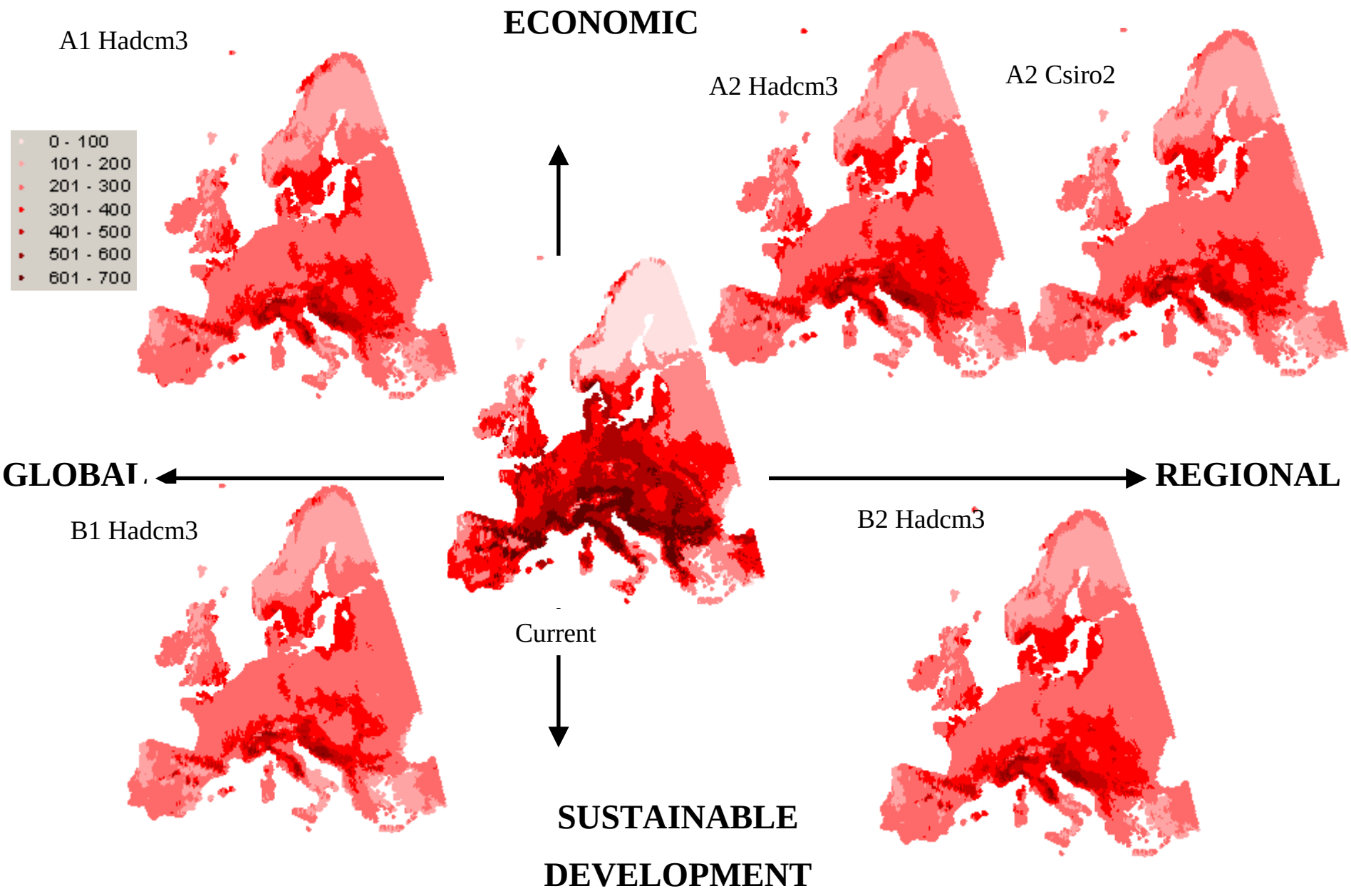


Two extreme options:

- species extinction or ‘standing dead’

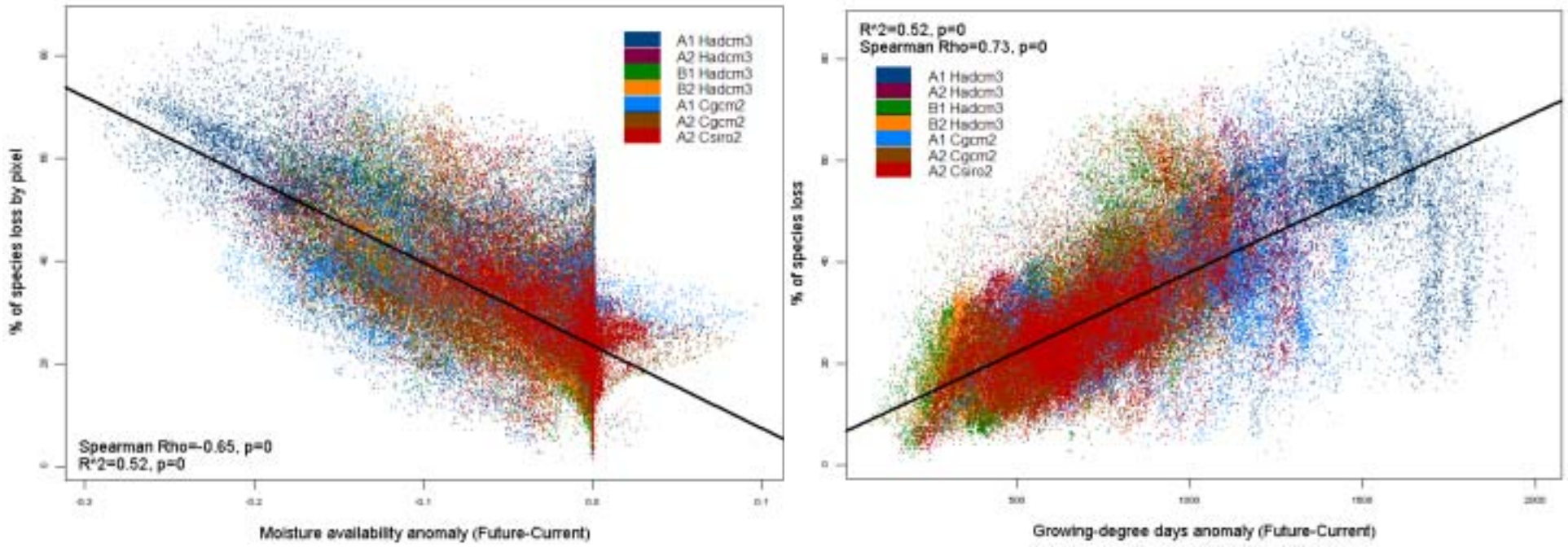
- species migration

Climate change impacts on plant species richness



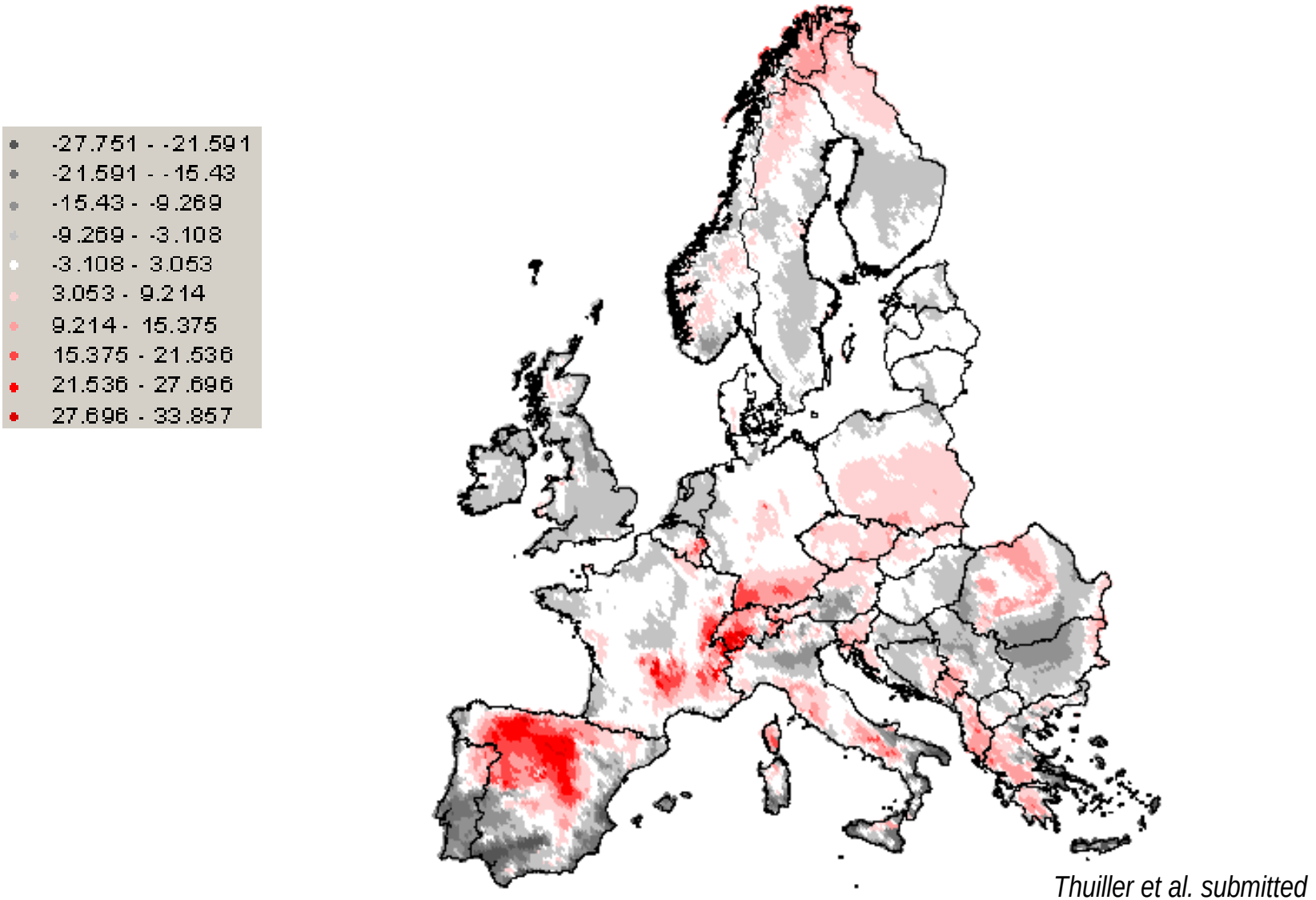
A generic rule of sensitivity per unit of climate change…

Species loss is strongly correlated, across regions and across scenarios, to changes in temperature and humidity



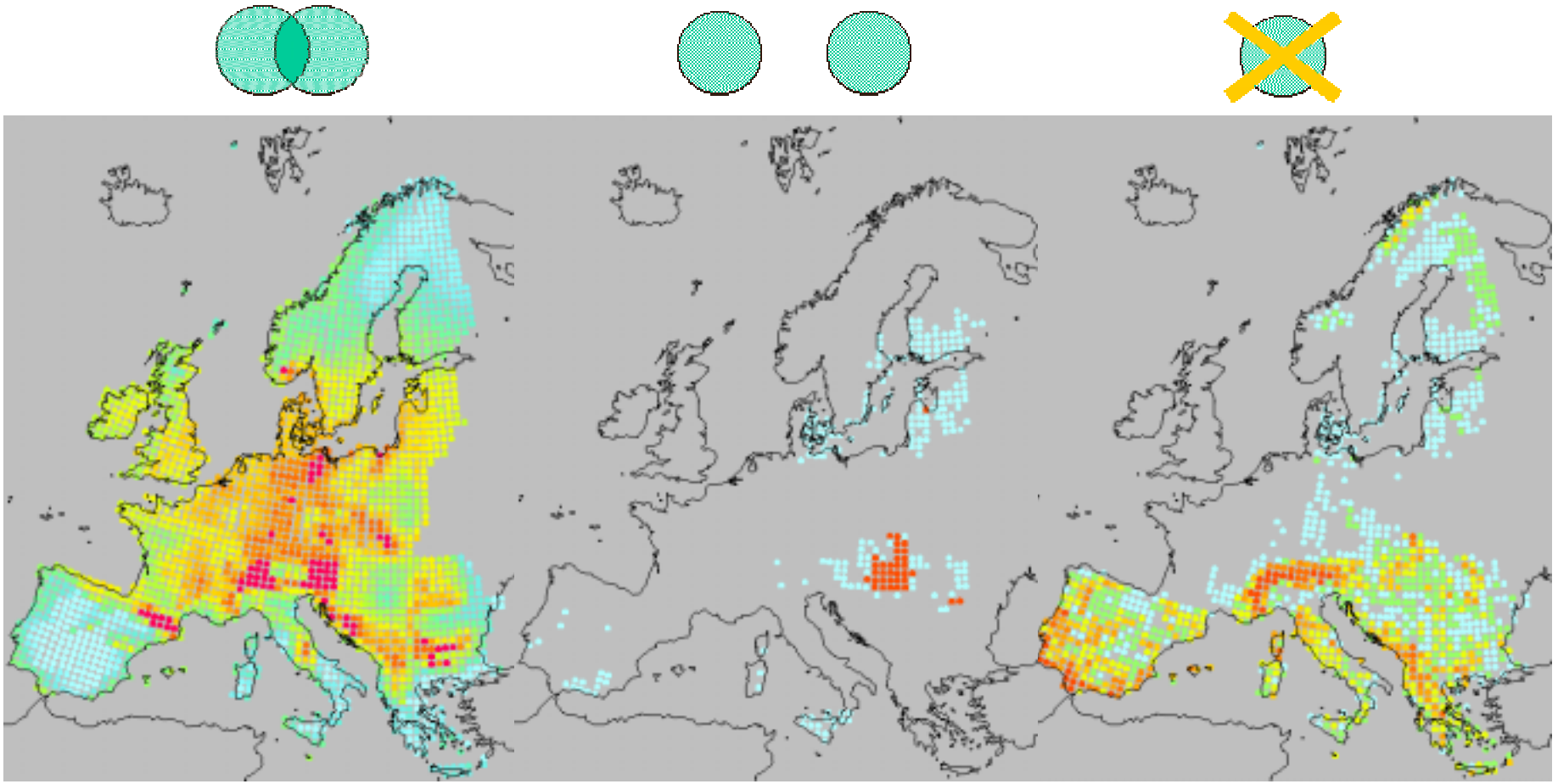
Thuiller et al. submitted

… with interesting deviations



Thuiller et al. submitted

Different types of extinction risk



93% species will have overlapping distributions

2% will not have overlapping distributions

5% will lose their habitat entirely

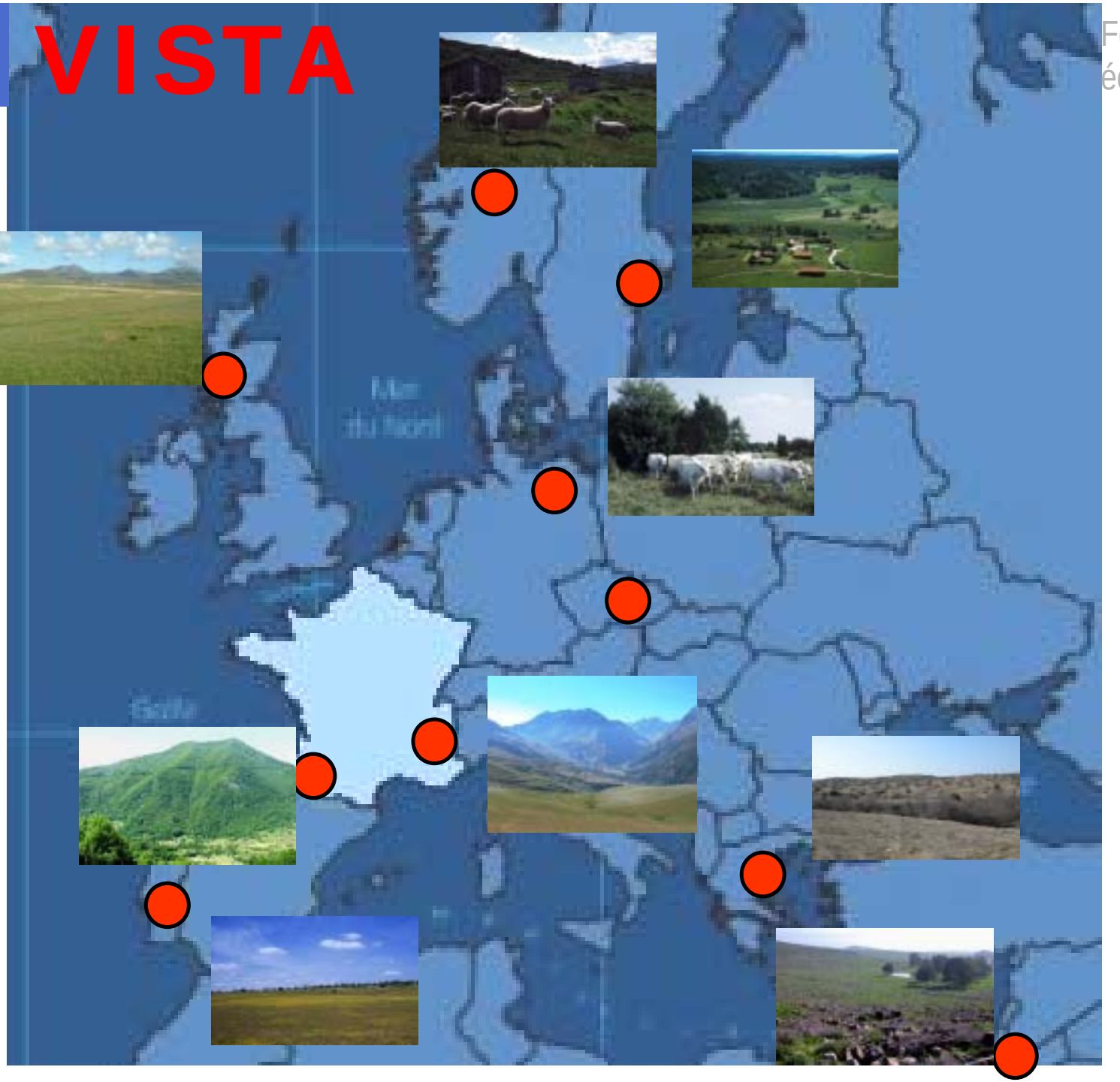
Araùjo et al. 2004

What about land use effects?

- At the resolution of European data sets, land use is driven by climate, therefore land use effects on species distributions can not be detected by the niche modelling method.
- To analyse land use effects we need to move down to the landscape and community/ecosystem scales

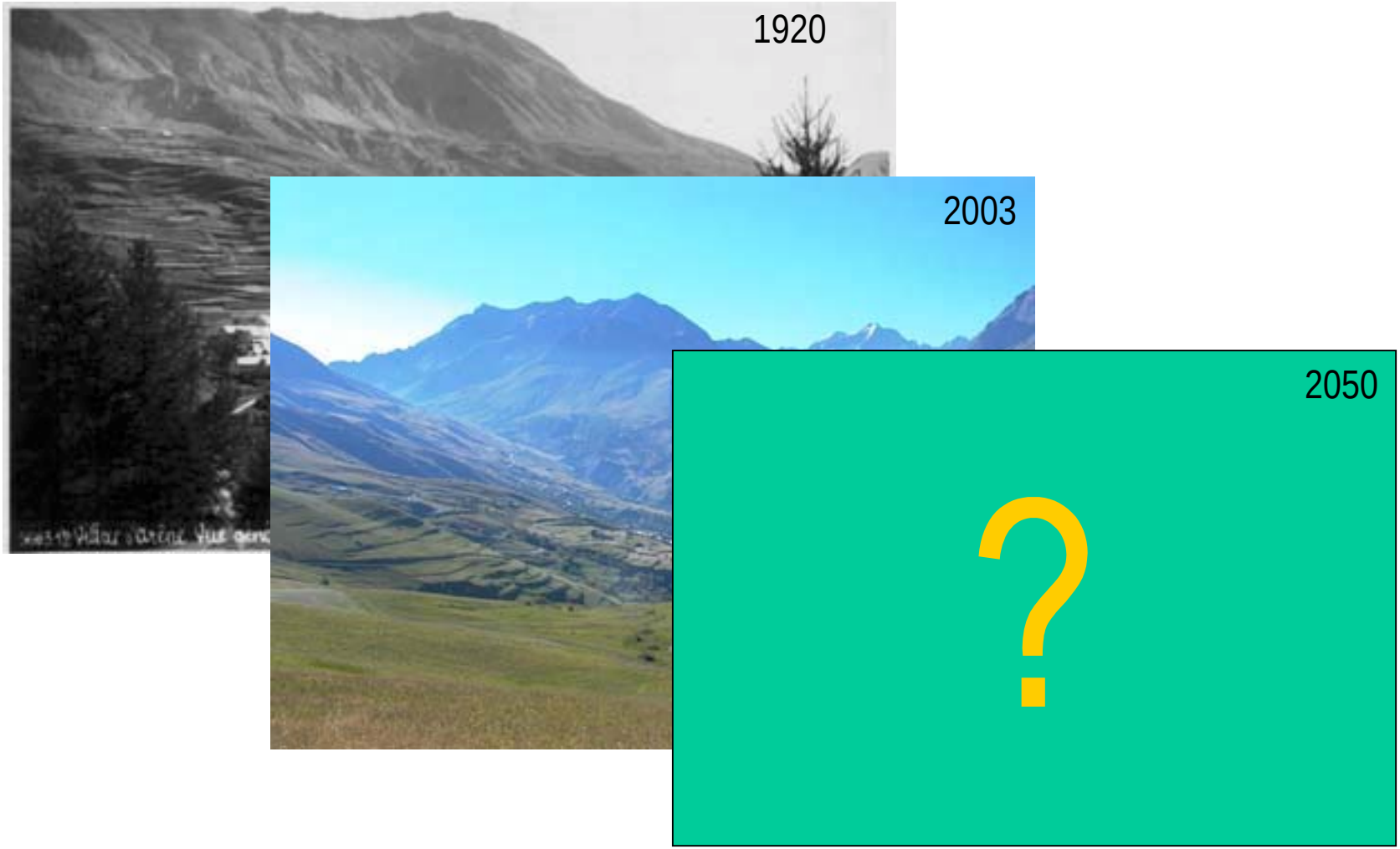
VISTA

Fonction écosystème

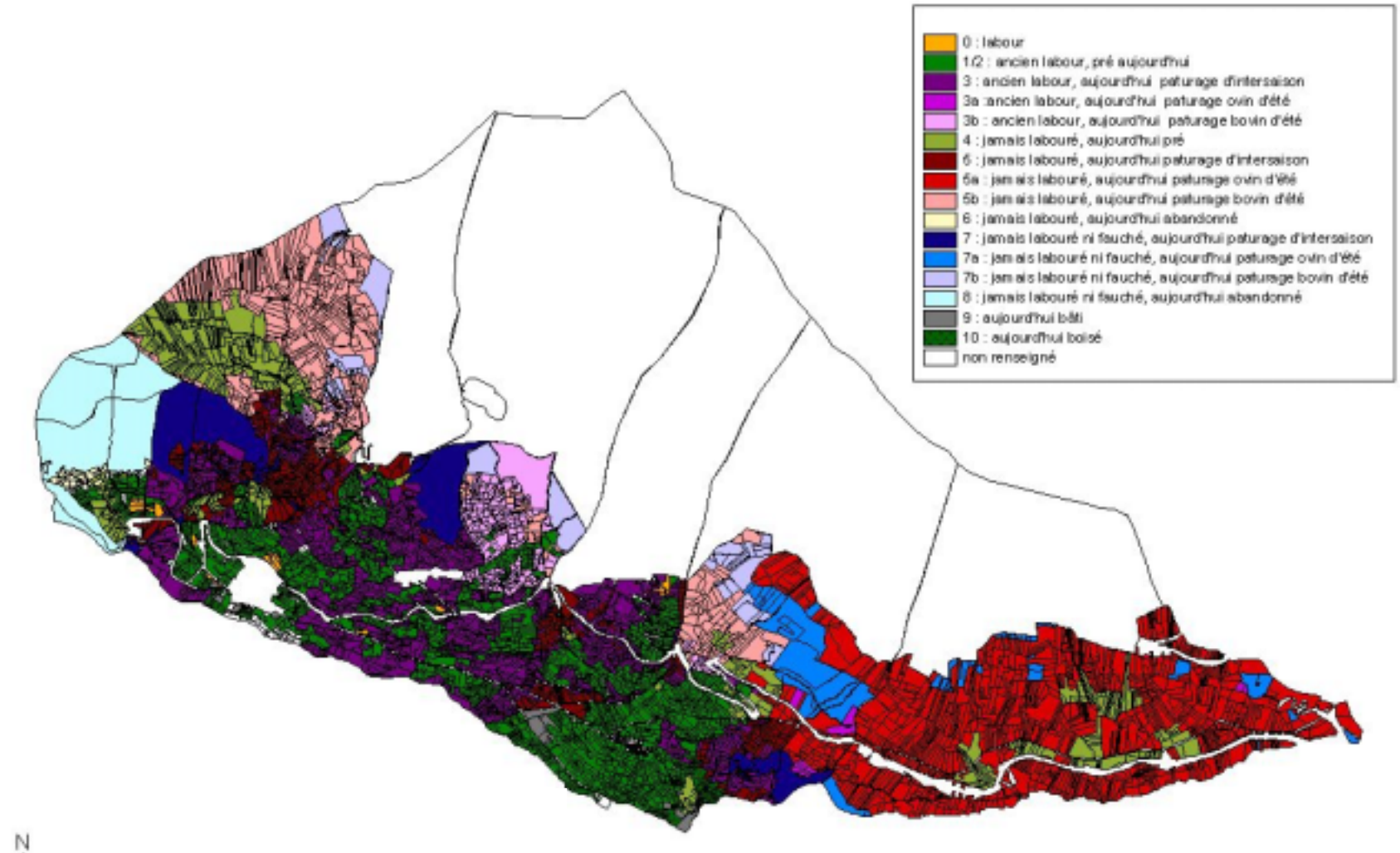


Project context: Land use change in ‘ Less Favoured Areas ’ of Europe

- Less Favoured Areas
  - biophysical conditions leading to low ecosystem productivity
  - marginal socio-economic conditions
- Recent dynamics of land abandonment or de-intensification
  - rapid landscape transformation
  - recent efforts (EU and individual countries) to work towards new sustainable development avenues


1920
2003
2050
?

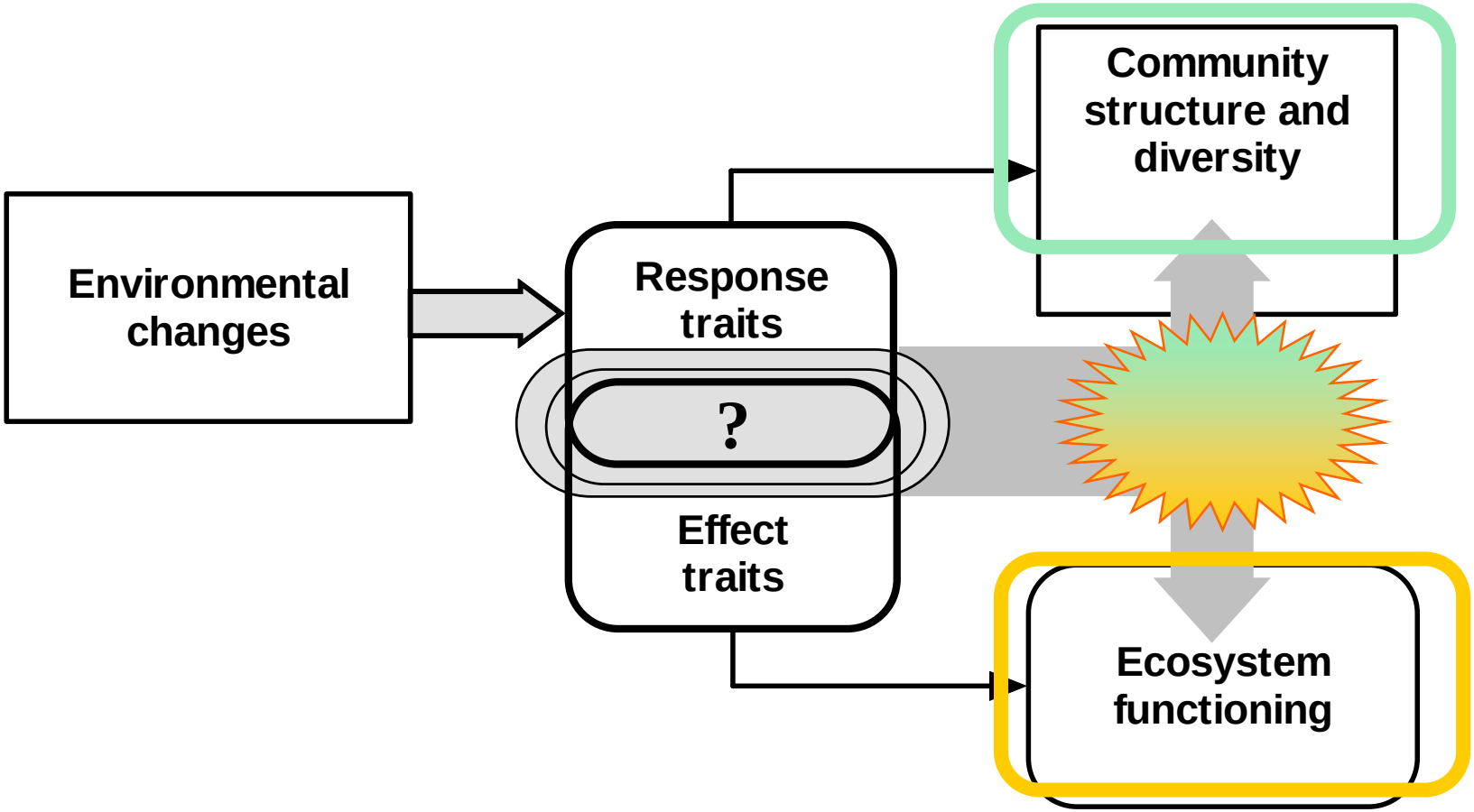
Land Use Trajectory Map for the Lautaret site (France)



* Cadastre : 1810, 1971, 1996 & 2003
* Aerial photos : 1952, 1960, 1970, 1986, 1994 & 2001

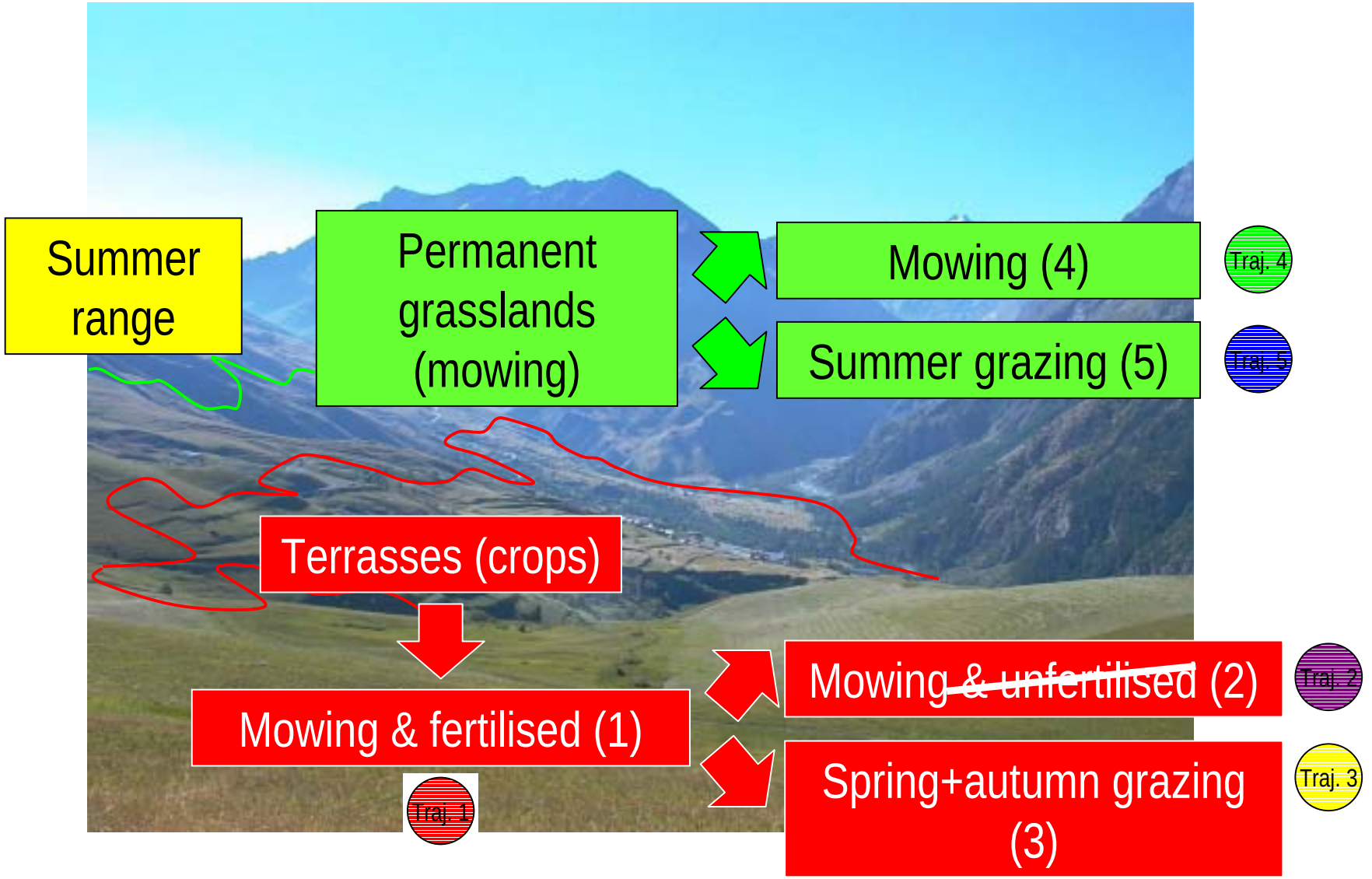
Ana Garcia Bautista 2004

Conceptual model : functional composition and ecosystem function



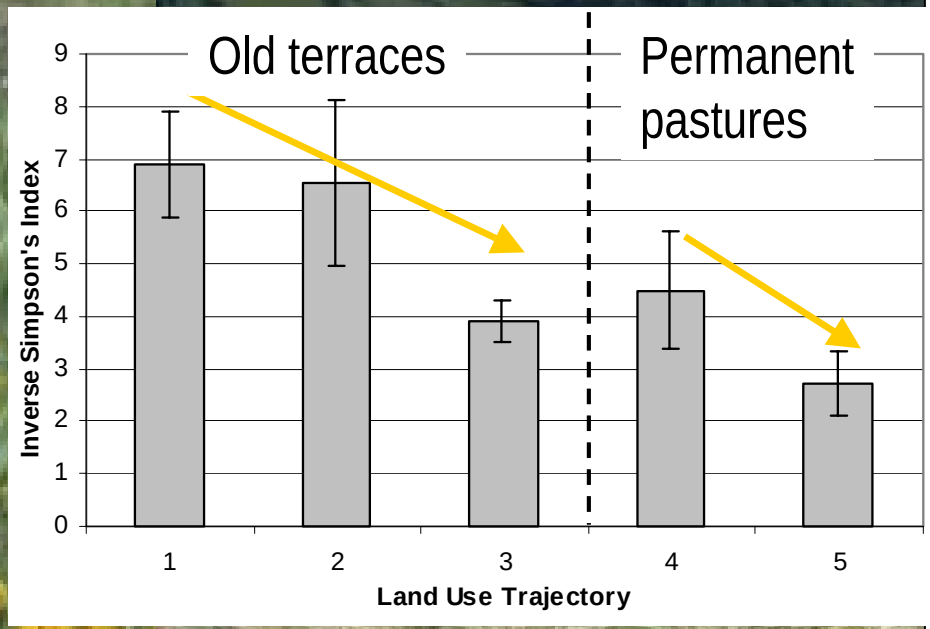
Chapin et al. Nature 2000, Lavorel & Garnier Funct. Ecol. 2002

Five main land use trajectories at Lautaret

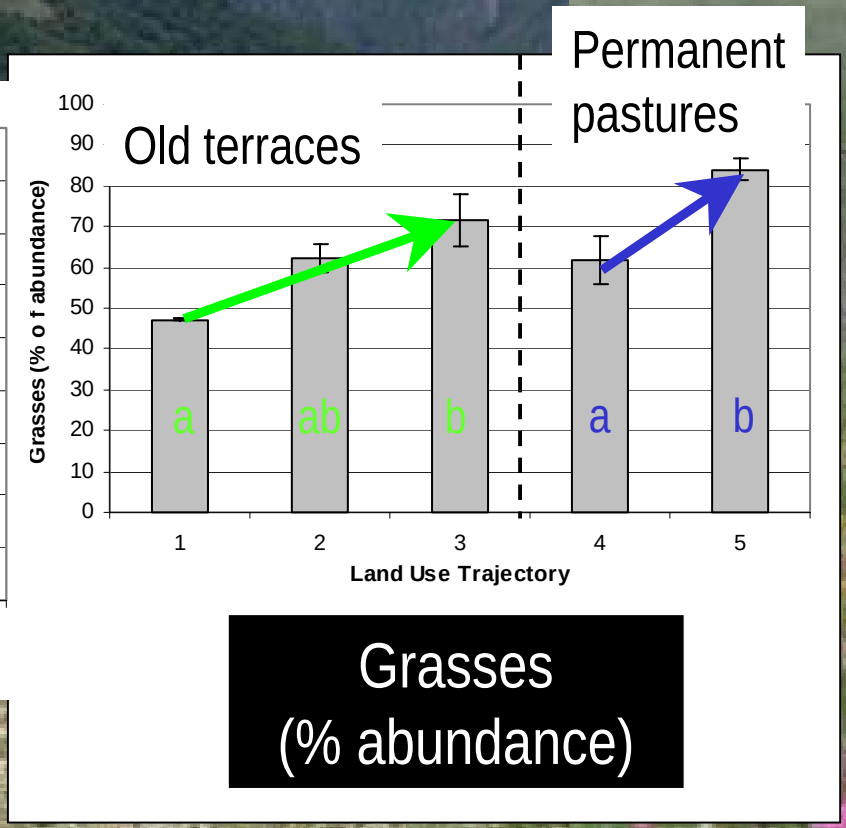


Cadastre napoléonien 1810 (Mallen, 2002)

Decreases in plant diversity in response to decreasing land use intensity



Plant Diversity

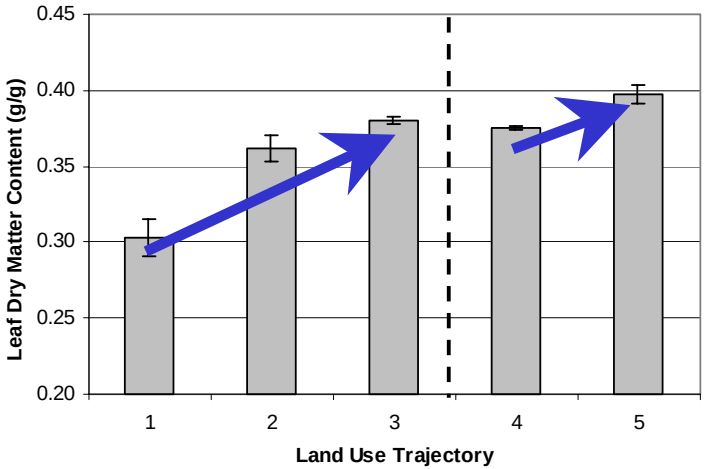


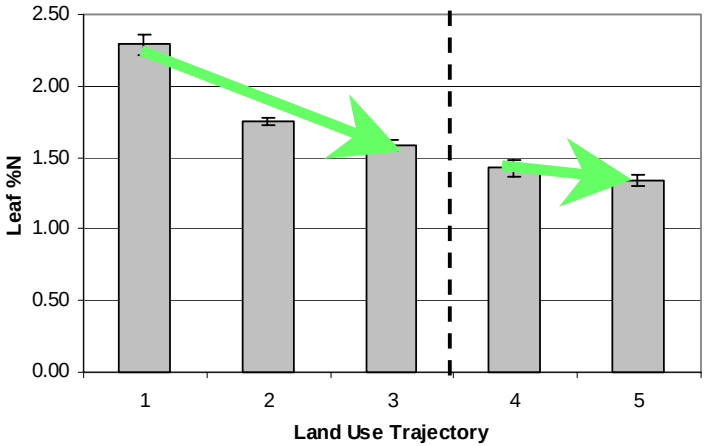
Grasses (% abundance)

Lavorel et al. 2004

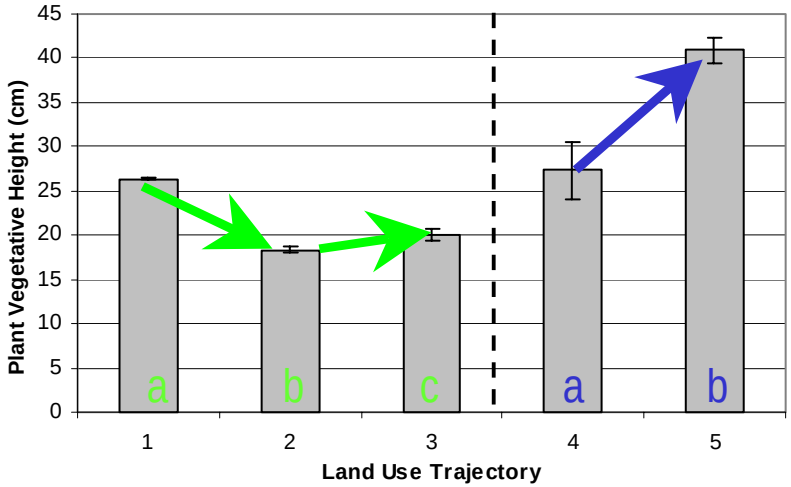
… associated to changes in plant functional traits

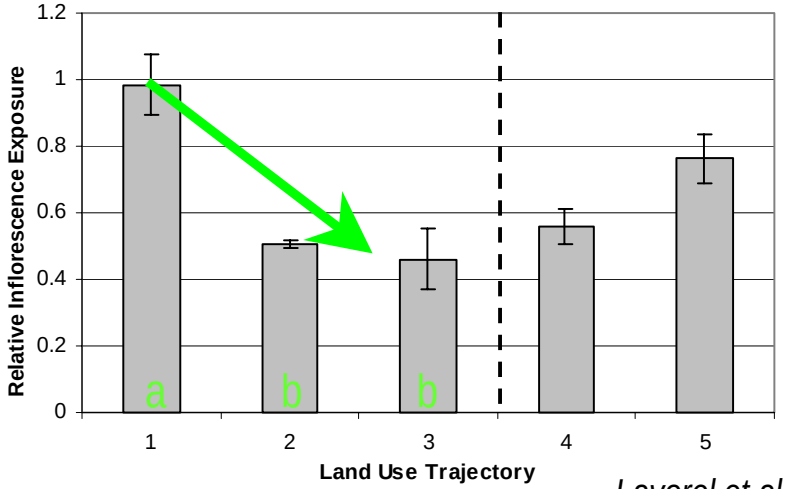
Leaf composition plant resource economy





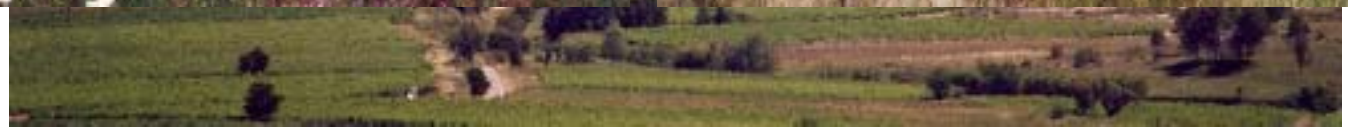
Morphology competition and exposure to disturbance





Lavorel et al. 2004

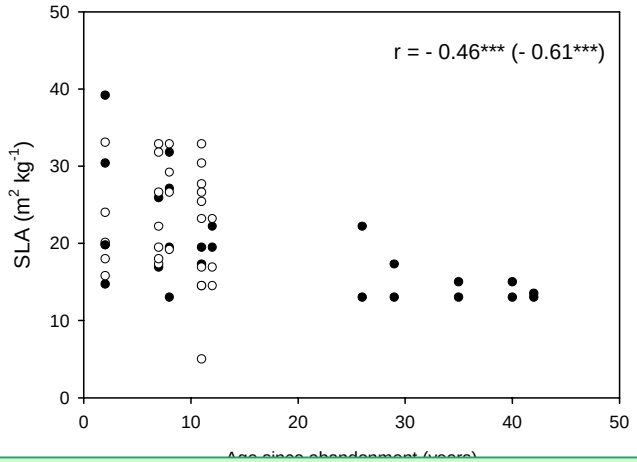
Post-cultural old-fields (ex vineyards) in the mediterranean region

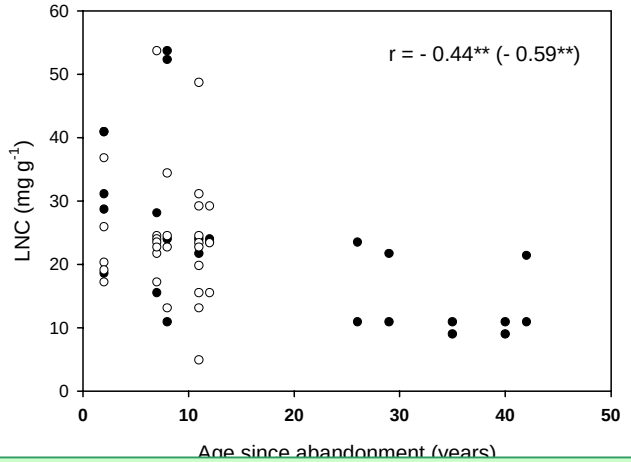


5 years

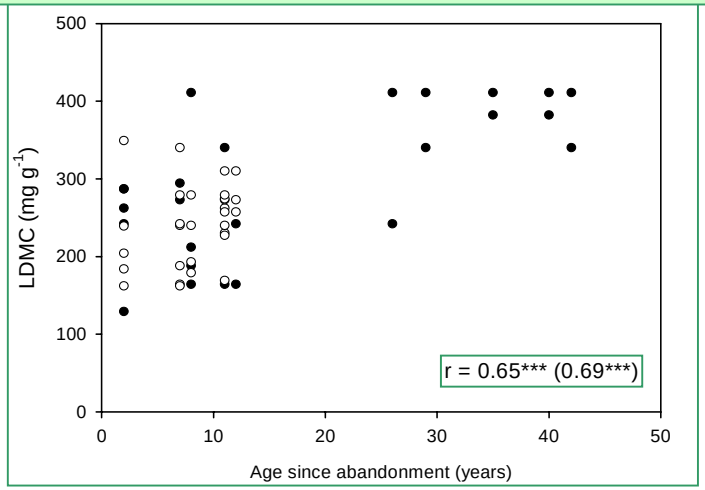
45 years

Resource acquisition:
specific leaf area and leaf nitrogen concentration



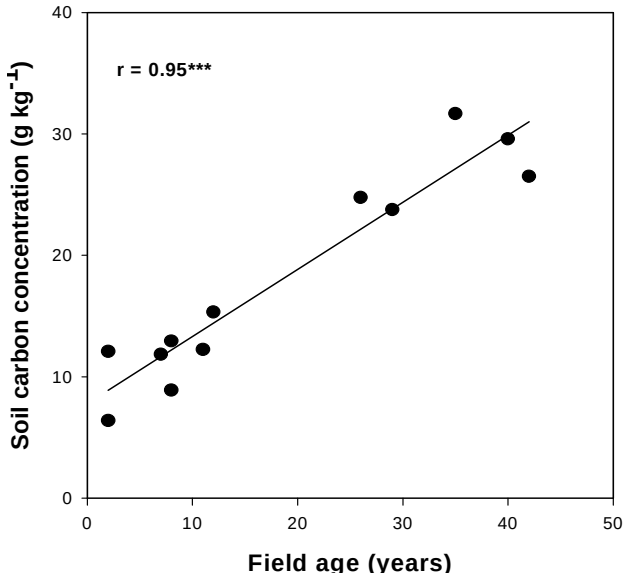


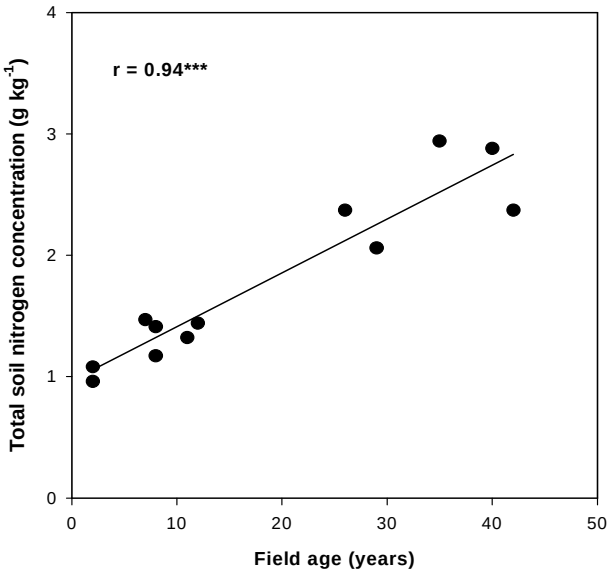
Resource conservation: *leaf dry matter content*

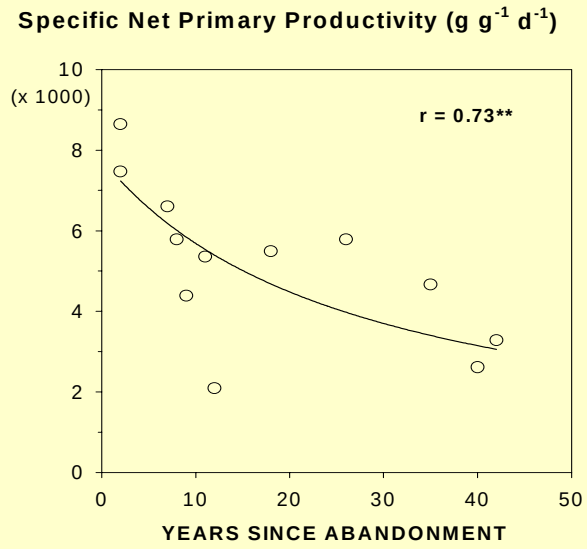


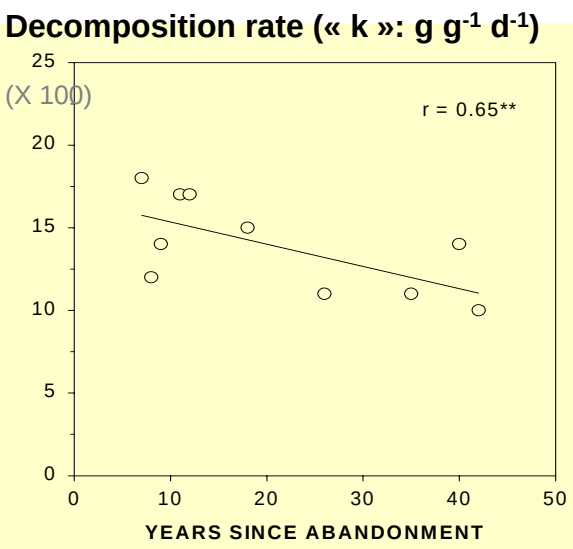
Garnier et al. 2004

Ecosystems pools and fluxes change along succession…









Garnier et al. 2004

… and are related to plant traits rather than to species richness

	Community-aggregated			Two dominant species			NbSp
	SLA_{agg}	$LDMC_{agg}$	LNC_{agg}	SLA_{dom}	$LDMC_{dom}$	LNC_{dom}	
SANPP	0.78**	-0.71**	0.87***	0.88***	-0.70**	0.69**	0.41 n.s.
SMLoss	0.78**	-0.81**	0.74*	0.55 §	-0.64*	0.33 n.s.	0.80**
Csoil	-0.88***	0.84***	-0.96***	-0.89***	0.84***	-0.90***	- 0.61*
Nsoil	-0.84***	0.83***	-0.93***	-0.90***	0.87***	- 0.87***	- 0.59*

- Ecosystems pools and fluxes are related to leaf traits associated with plant nutrient economy
- Weak effects of species richness on ecosystem properties
- Functional traits of two most abundant species at least as good as taking into account species making 80% of the biomass

Using PFTs as links across levels of organisation

- Plant functional traits make it possible using experimental analyses with differing levels of control, over the long term :
  - To elucicate causal links across levels of organisation of plant diversity
  - To analyse feedback loops between changes in plant diversity and ecosystem function

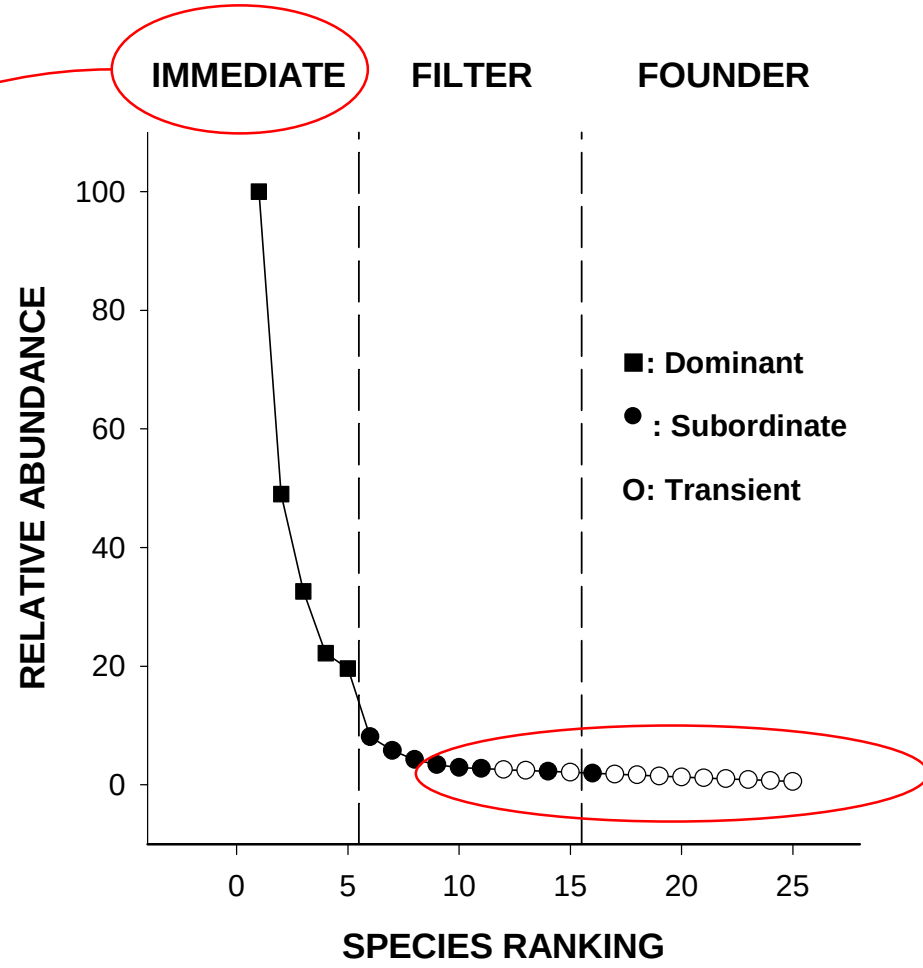
Level of organization	**High fertility High disturbance**	**Low fertility Low disturbance**
Individual traits	high SLA, low LDMC, low leaf C:N; allocation to leaves & stems; high plasticity Numerous, persistent small seeds with high dispersal; Selfing	large size, long-lived, low SLA, high LDMC, high leaf C:N; allocation to roots; low plasticity Few larger seeds with low dispersal and no seed bank; Outcrossing
Species interactions	Rapid depletion of resources; symmetric interactions Predominance of competition	Tolerance to low resource levels; asymmetric interactions Predominance of facilitation and allelopathy
Community	Abundance of forbs and some stoloniferous grasses	Abundance of bunchgrasses
Ecosystem Processes	Fast rates of biogeochemical cycling; rapid litter decomposition; high NPP	Slow rates of biogeochemical cycling; slow litter decomposition; low NPP

Linking ecosystem measurements to ecosystem services

Final Descriptor Matrix	Inverse Simpson's biodiversity Index	% grasses	% legumes	% rosettes	Vegetation density	Vegetation height	Synthetic valued species index	Flowering index
Medicinal & culinary value	0	0	0	0	0	0	+1	0
Ecological value	+1	-1	0	+1	0	0	0	+1
Aesthetic value	0	0	0	0	0	0	+1	+1
Cultural & historical heritage value	0	0	0	0	0	0	0	0
Educational value	0	0	0	0	0	0	+1	+1
Agricultural value	0	-1	+1	0	+1	+1	0	+1
Slope stability value	0	0	0	0	0	0	0	0
"living" value	0	0	0	0	0	0	0	0
Wildlife habitat value	0	0	0	0	+1	+1	0	0

New challenges: Effects on ecosystem structure

Mass ratio hypothesis:
Effects on biogeo-
chemistry



Diversity
Stability

Grime (1998)