Necessity and challenges of knowledge integration to prepare the futur: biodiversity and its uses

Francois Lefèvre

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francois.lefevre@avignon.inra.fr

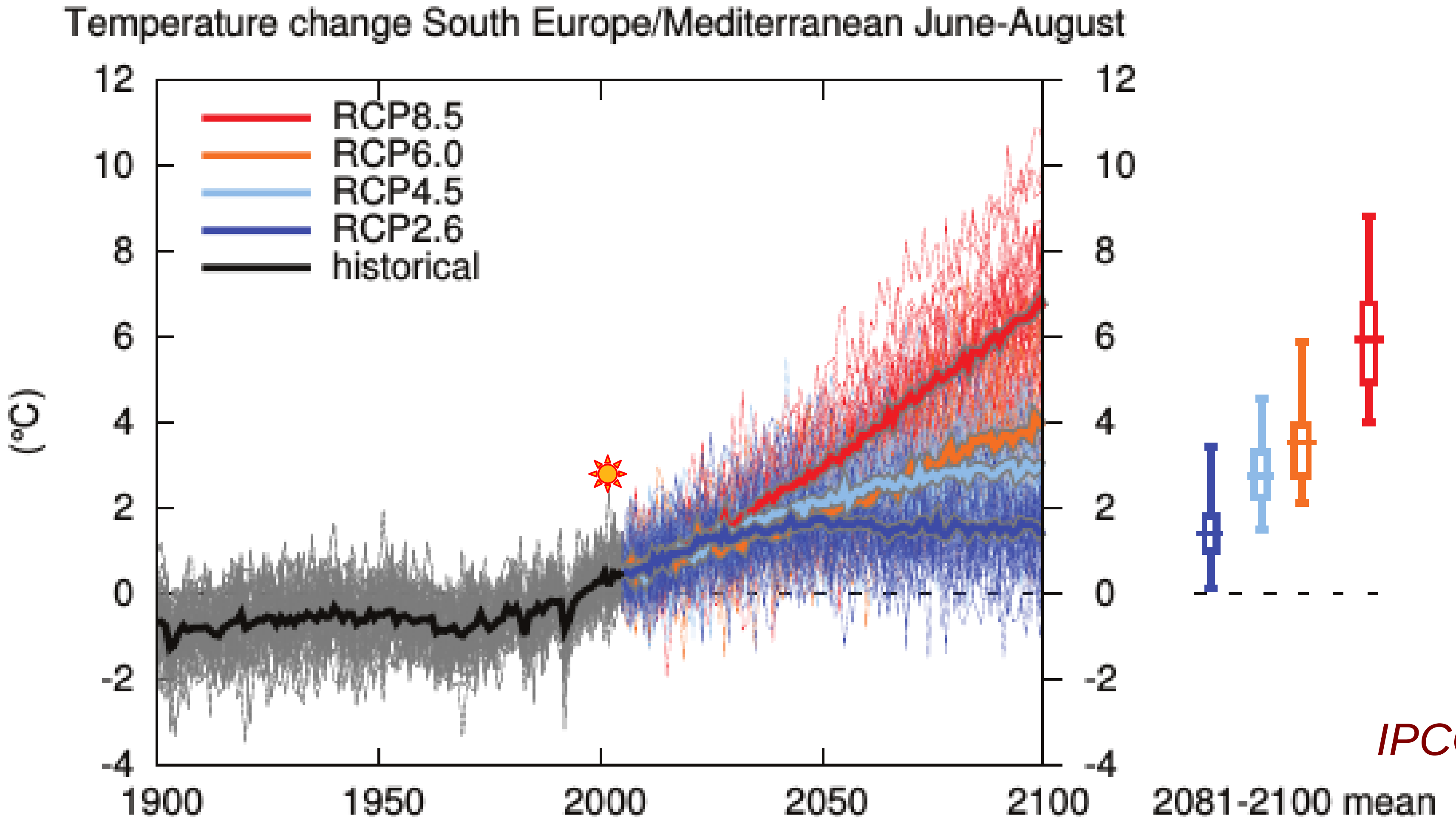
1) **Mediterranean forests facing climate change : a complex world**

2) Approach by state and future-based scenarios : transdisciplinary knowledge integration

3) Dynamic approach and decision-based scenarios : knowledge integration across scales

4) Two conclusions

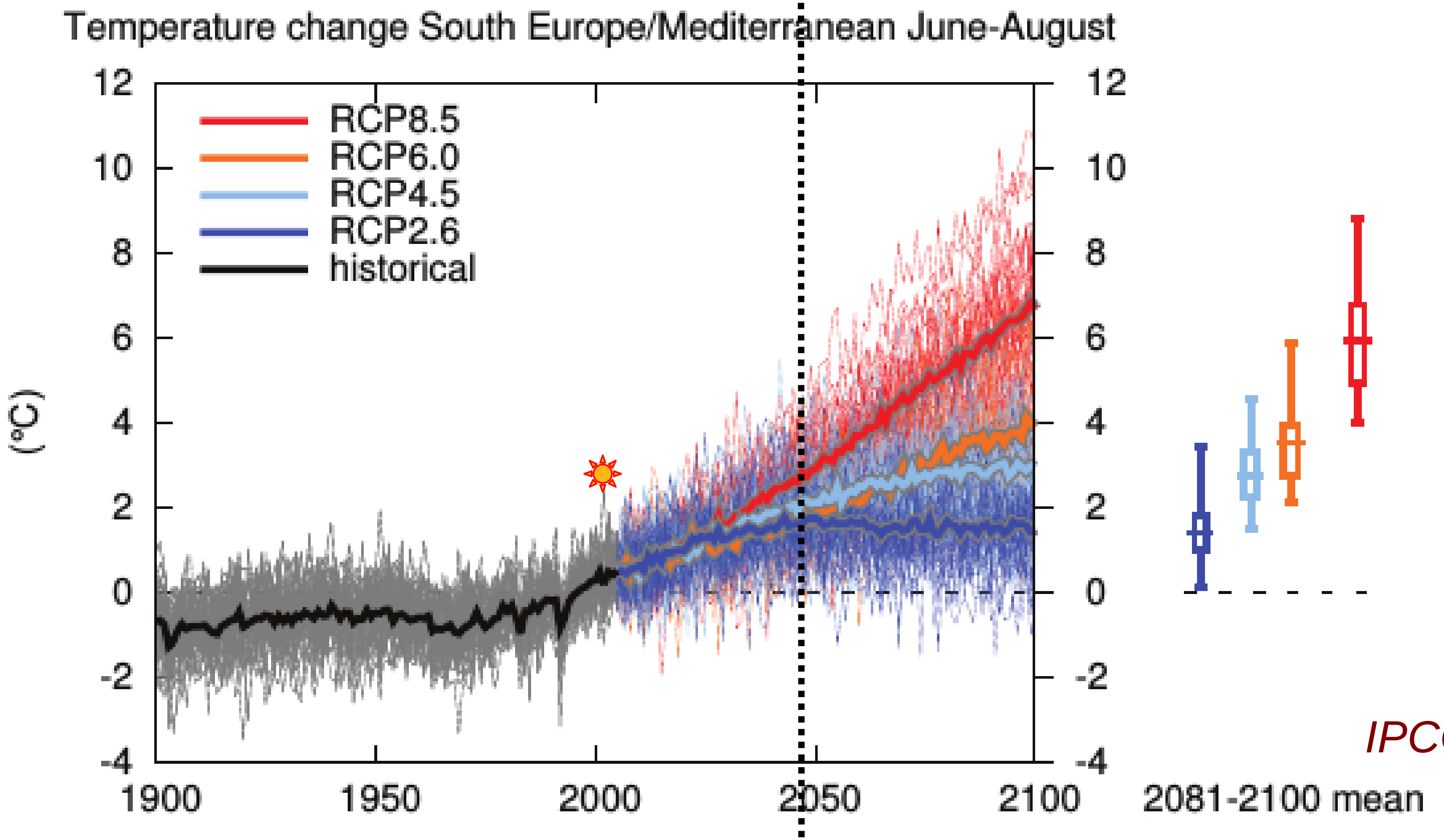
Climatic extreme events, rather than mean tendancy, drive the future of the forests : risks and uncertainties



IPCC 2013

Short-term : more constraint, less uncertainty => **adaptation**

Long-term : less constraint, mo uncertainty => **preserve option**



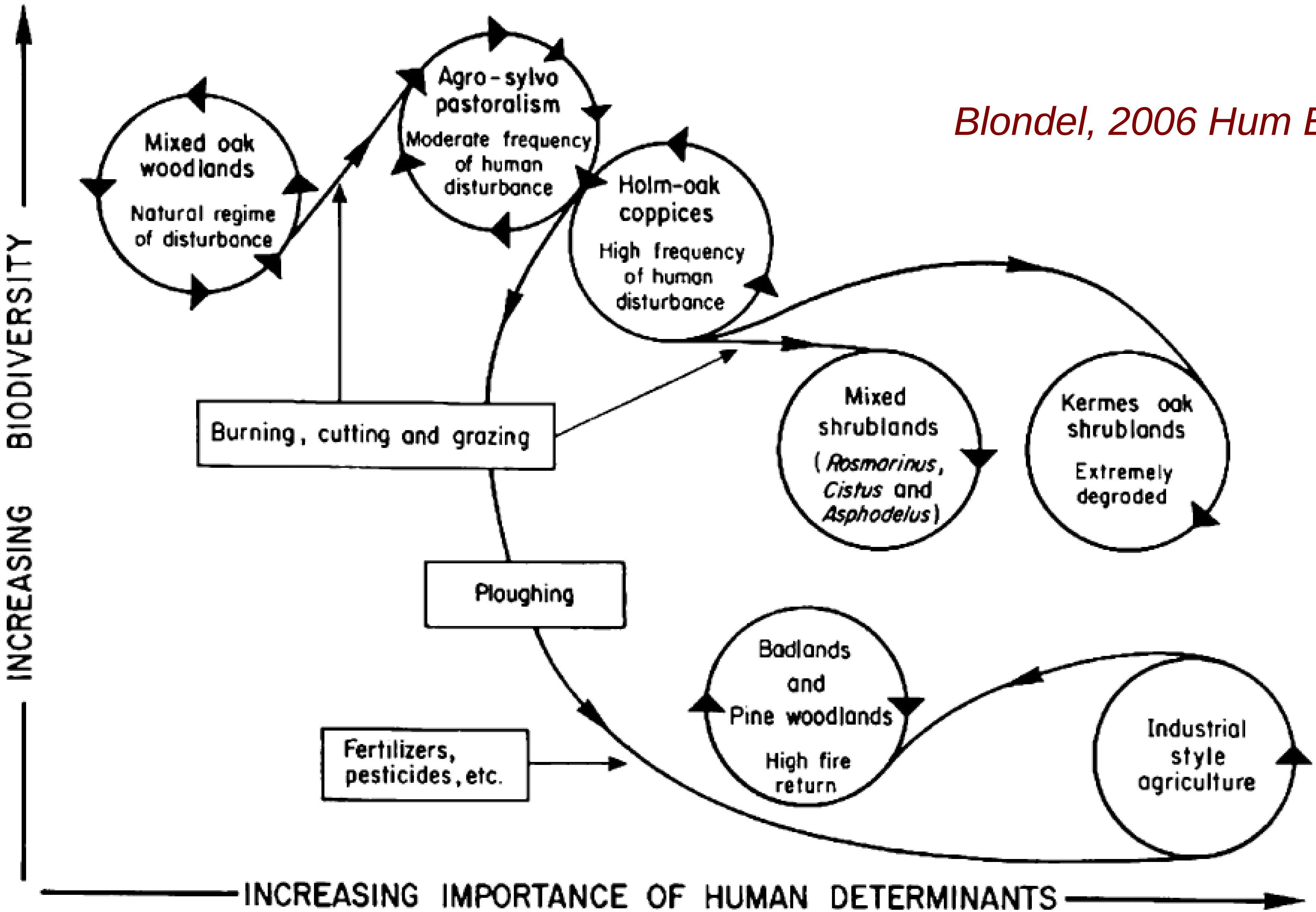
IPCC 2013

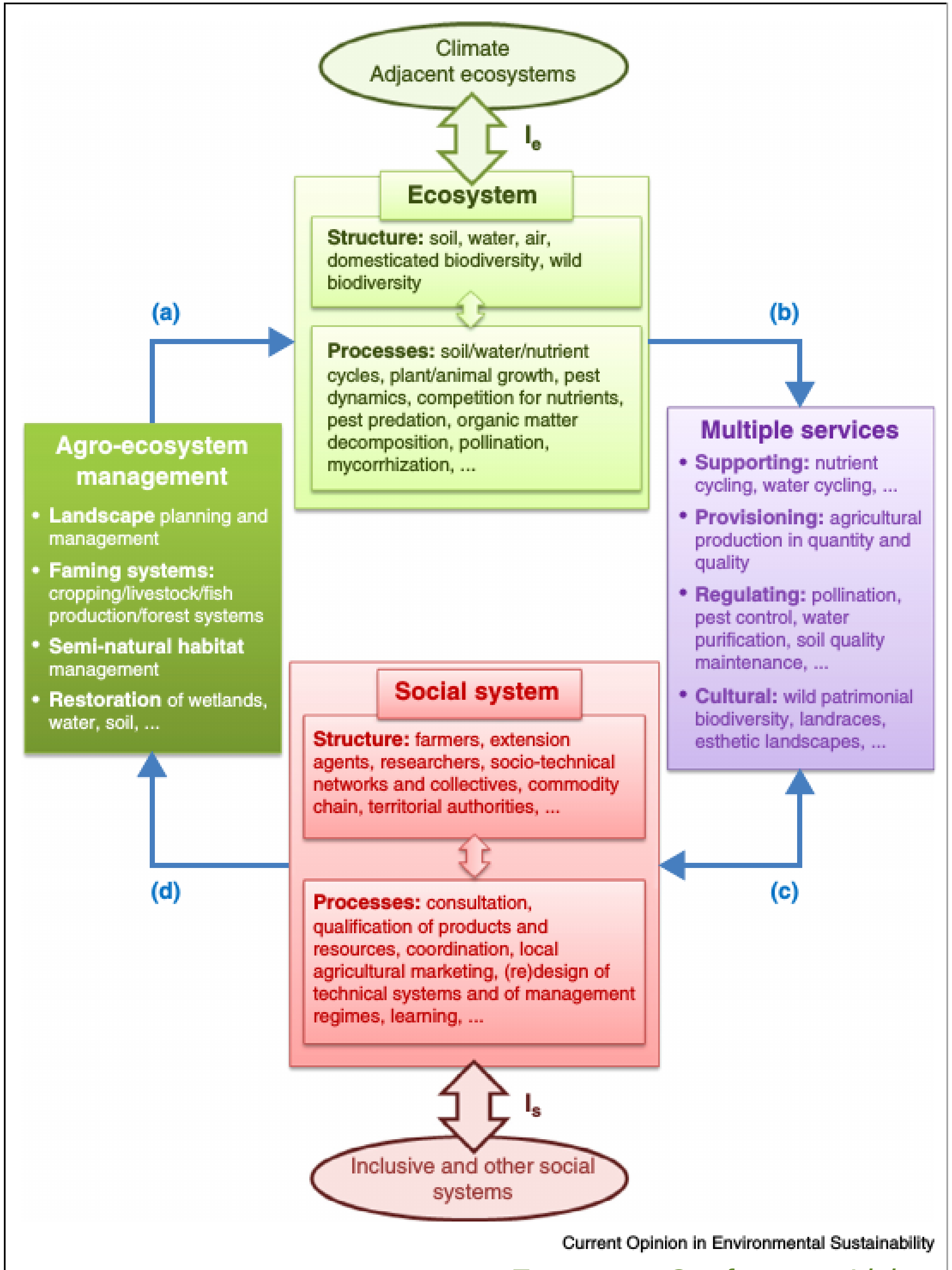
Short-term / Long-term : bad or good ?

Dieback on silver fir in Mt Ventoux, France (2009)

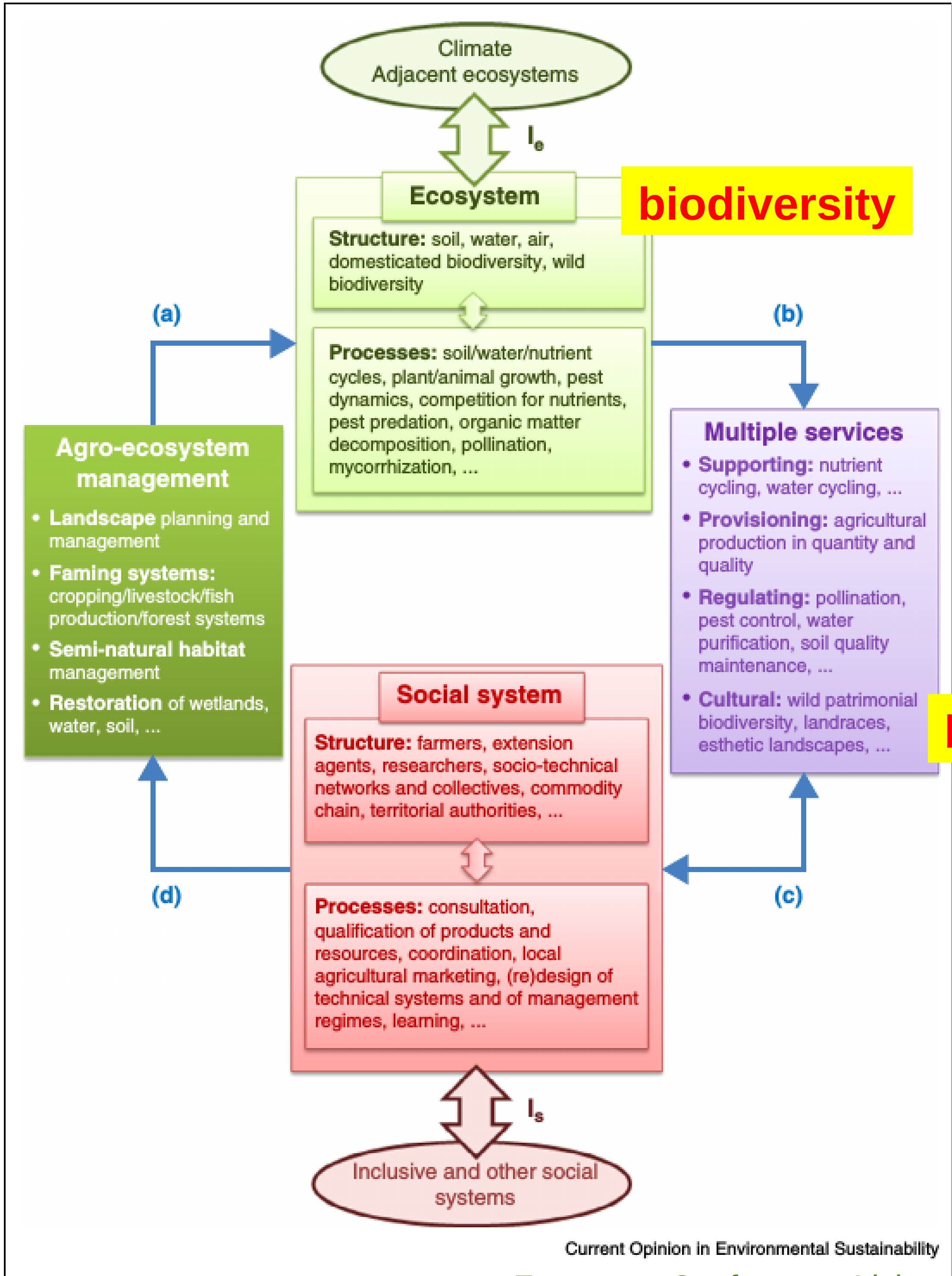
Mediterranean forests : a typical social-ecological system

Blondel, 2006 Hum Ecol





Lescourret et al 2015
CO Environmental Sustainability

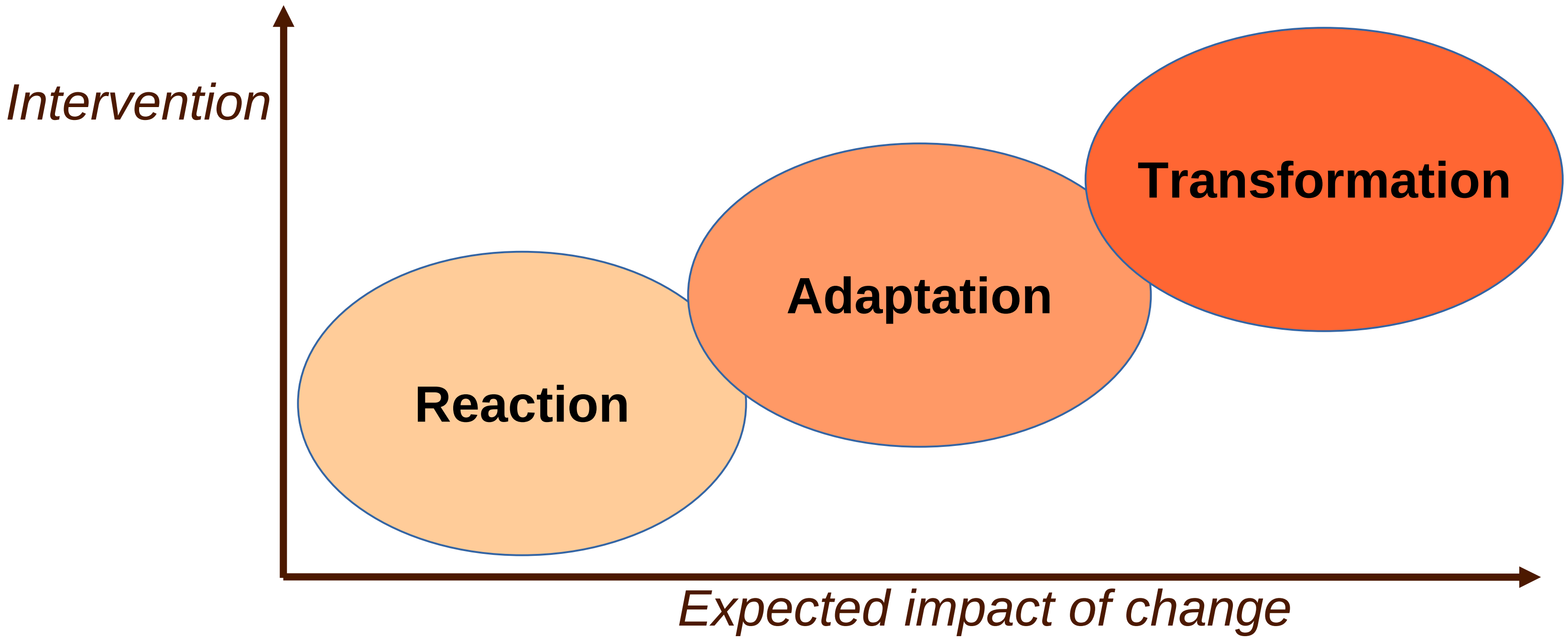


biodiversity

biodiversity

Lescourret et al 2015 CO Environmental Sustainability

Resilience and resistance



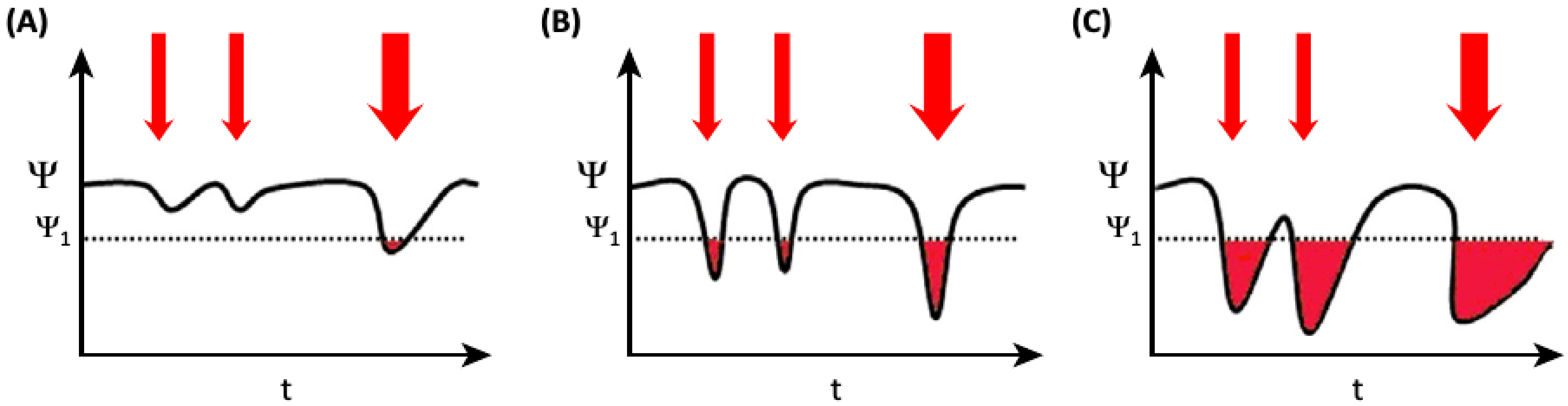
Resilience of the system :

- amount of change supported with the same controls on function and structure
- degree to which the system is capable of self-organization
- ability to build and increase the capacity for learning and adaptation

Resistance

Gunderson & Holling 2002 Panarchy

Biodiversity components of resilience



Species (Intraspecific)	Community (Interspecific)	Landscape (Ecosystem Context)
Sensitivity to environmental change (RES)	Correlation between response and effect traits (RES)	Local environmental heterogeneity (RES)
Intrinsic rate of population increase (RES/REC)	Functional redundancy (RES/REC)	Landscape-level functional connectivity (RES/REC)
Adaptive phenotypic plasticity (RES/REC)	Network interaction structure (RES)	Potential for alternative stable states (RES/REC)
Genetic variability (RES/REC)	–	Area of natural habitat cover at the landscape scale (RES/REC)
Allee effects (RES/REC)	–	–

Oliver et al 2015 TREE

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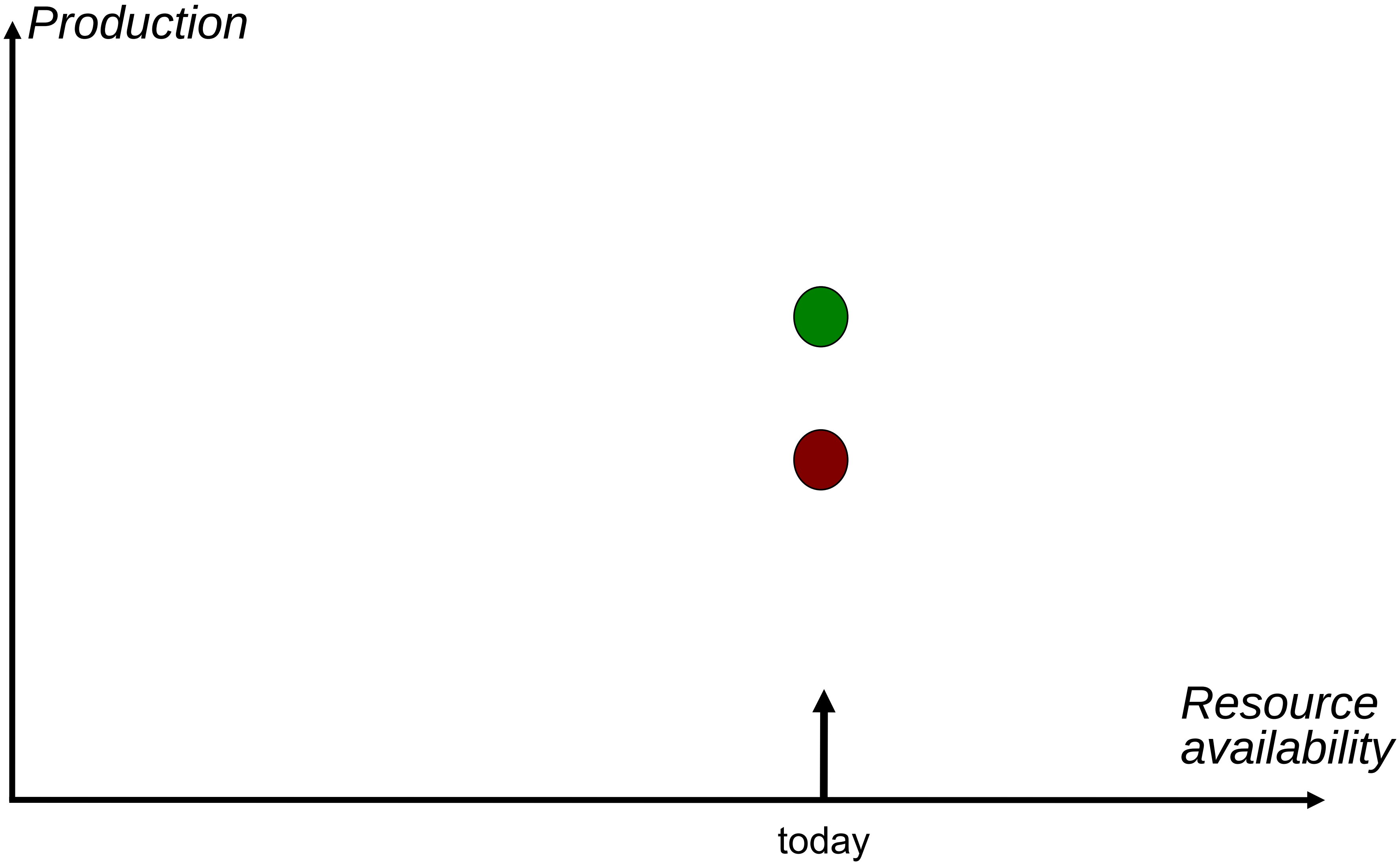
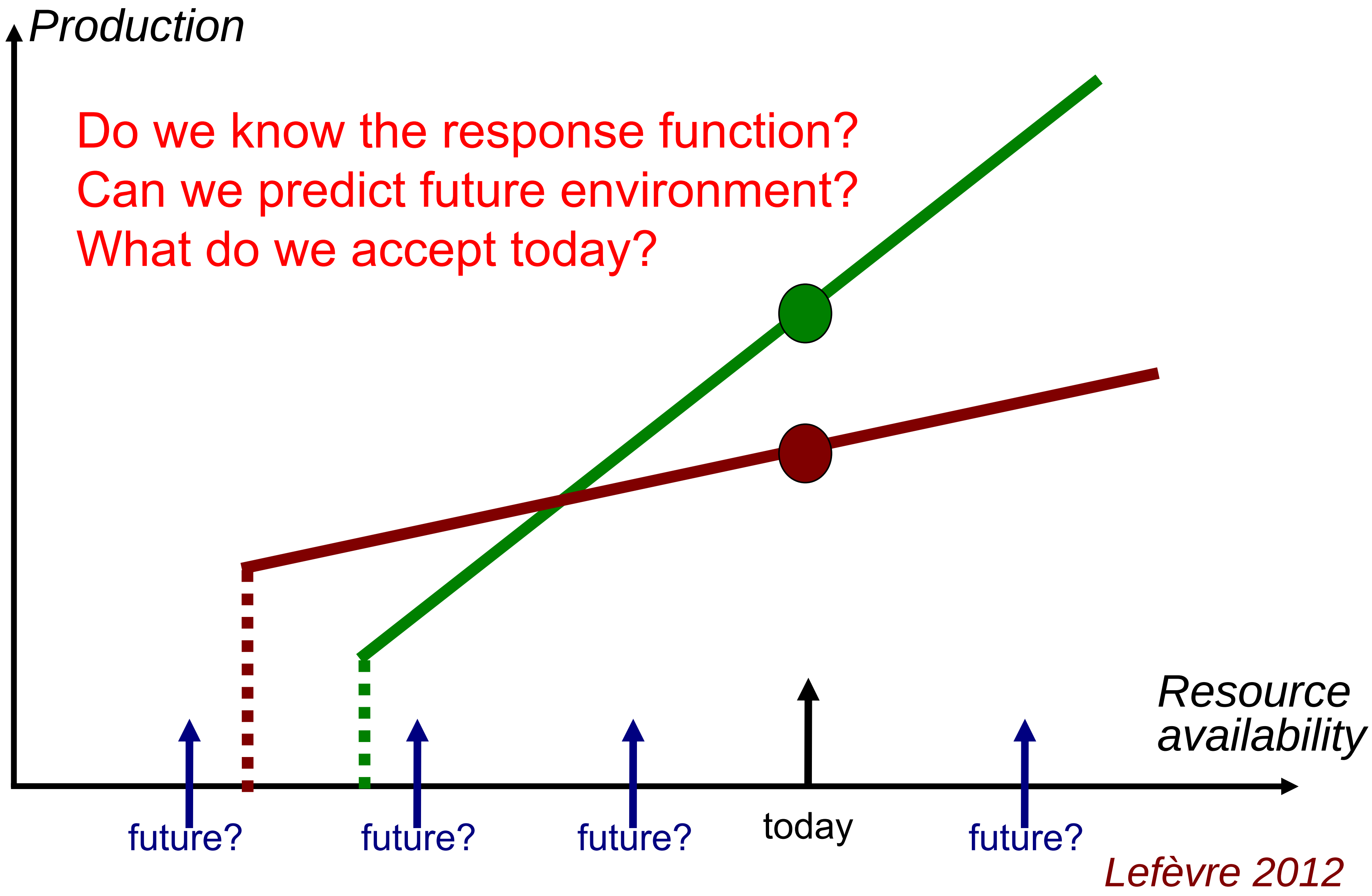
Choice of reproductive material for planting



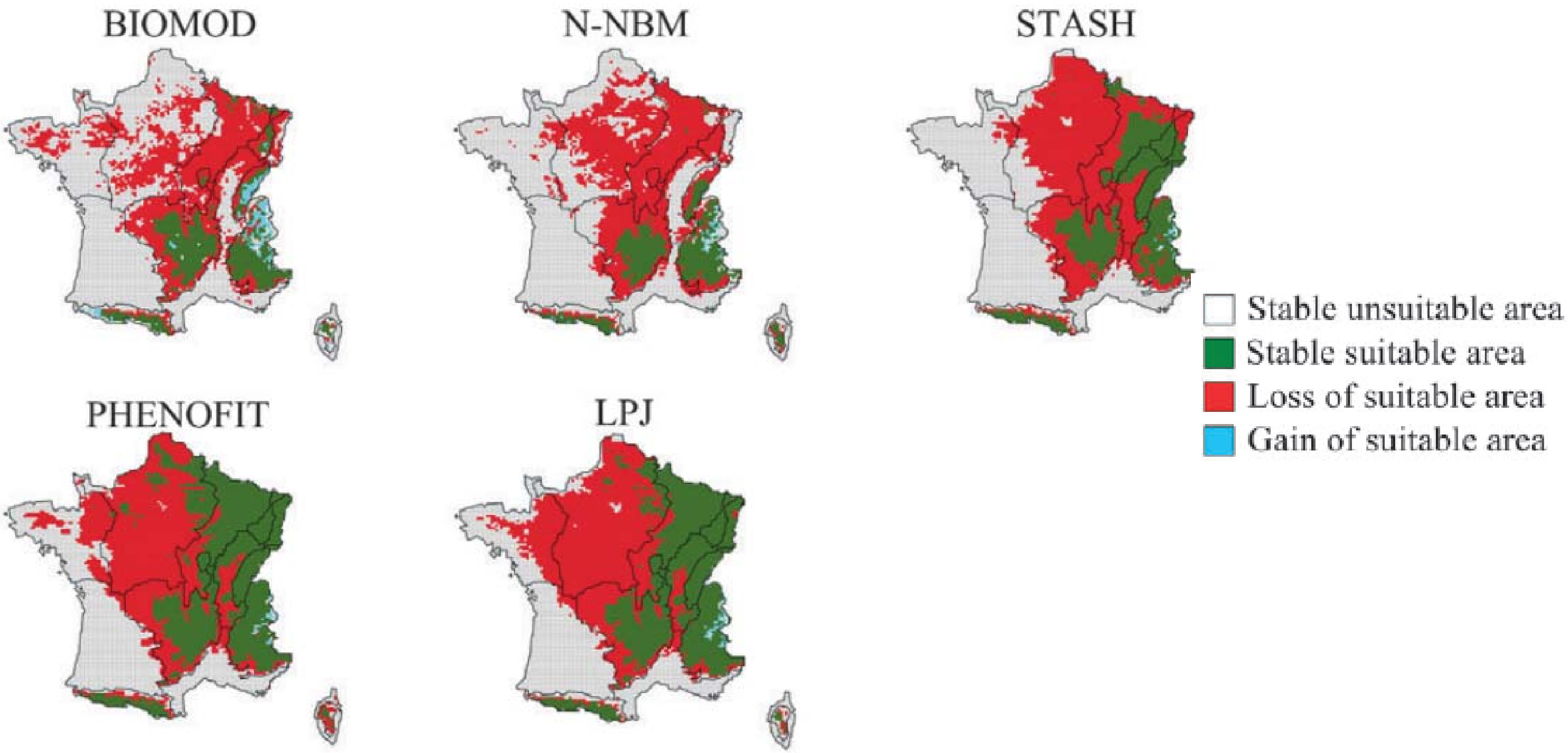
Lefèvre 2012

Choice of reproductive material for planting



predicting future potential species range

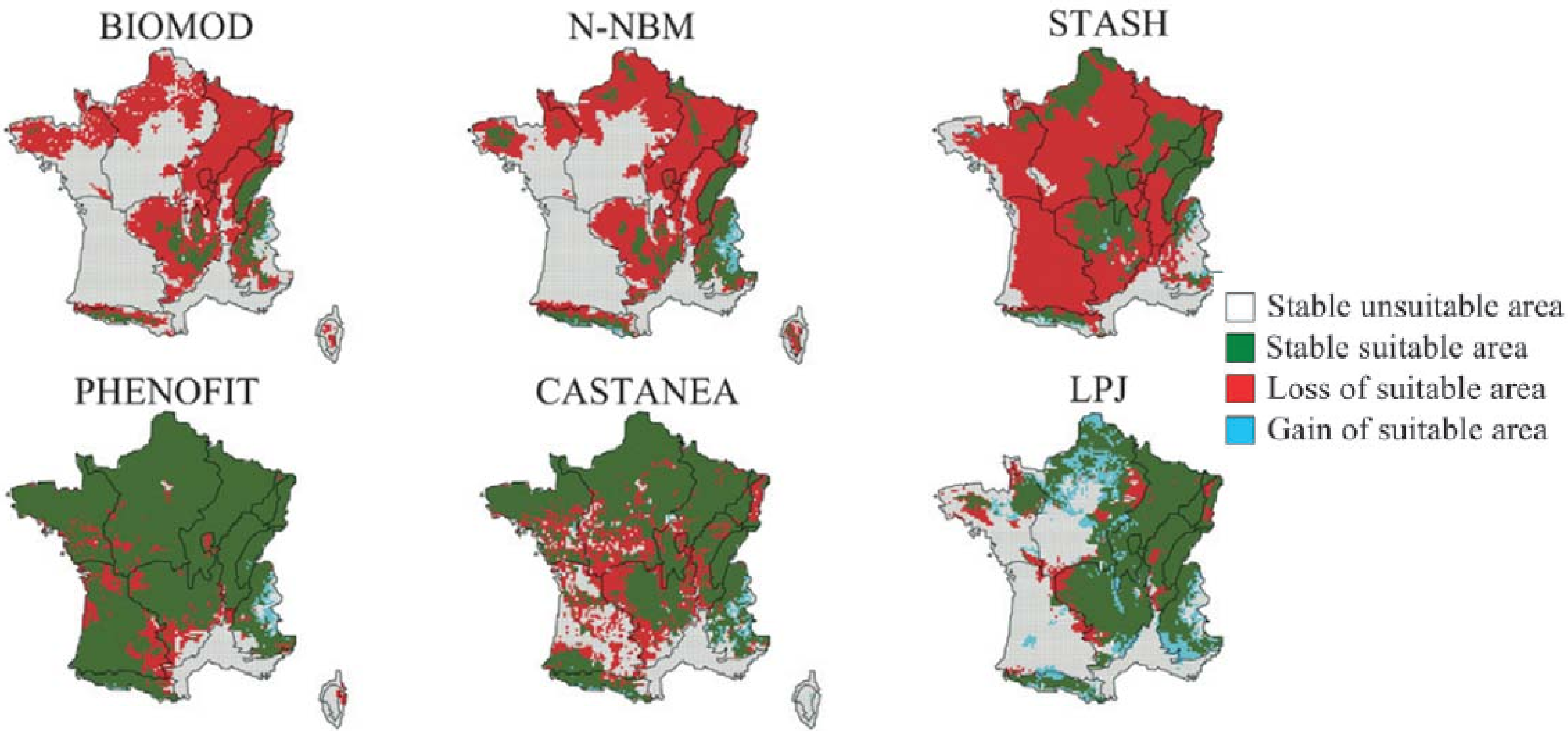
sometimes ≠ models converge (predictions for scots pine in 2055, A1B)...



Cheaib et al 2012 Ecology Letters

predicting future potential species range

… sometimes not (predictions for beech in 2055, A1B)

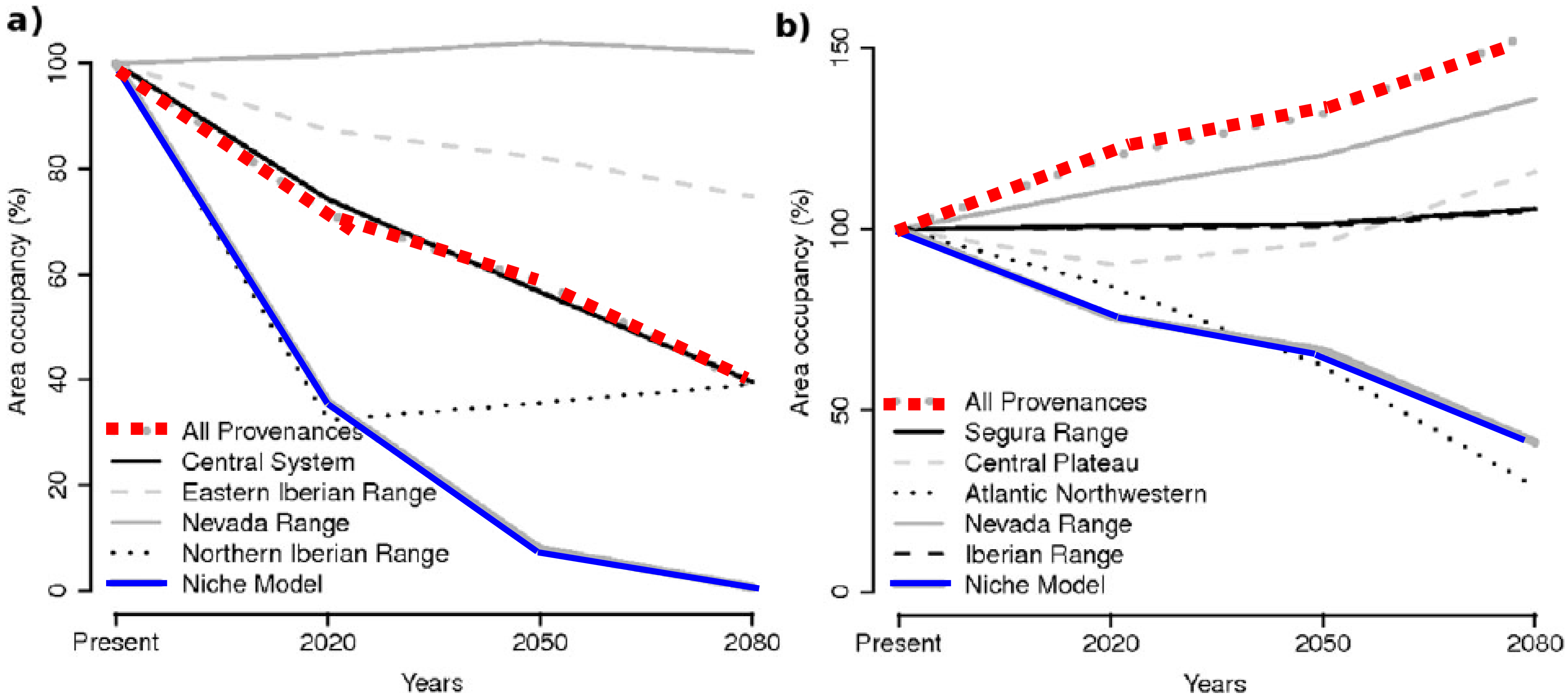


Cheaib et al 2012 Ecology Letters

predicting future potential species range

the genetic diversity matters...

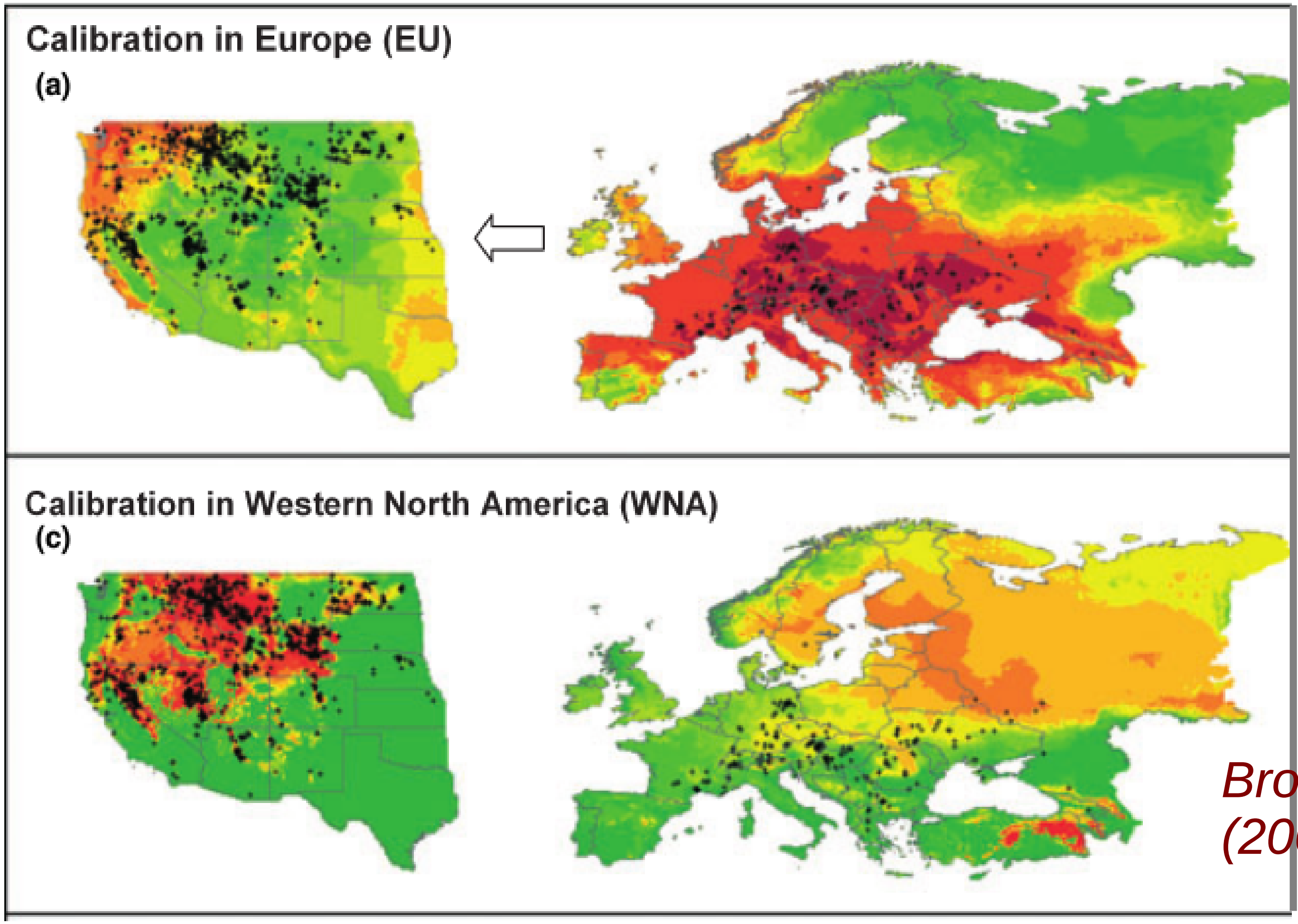
Pinus sylvestris *Pinus pinaster*



Benito-Garzón et al 2011 Global Ecol Biog

predicting future potential species range

and the adaptive capacity too !



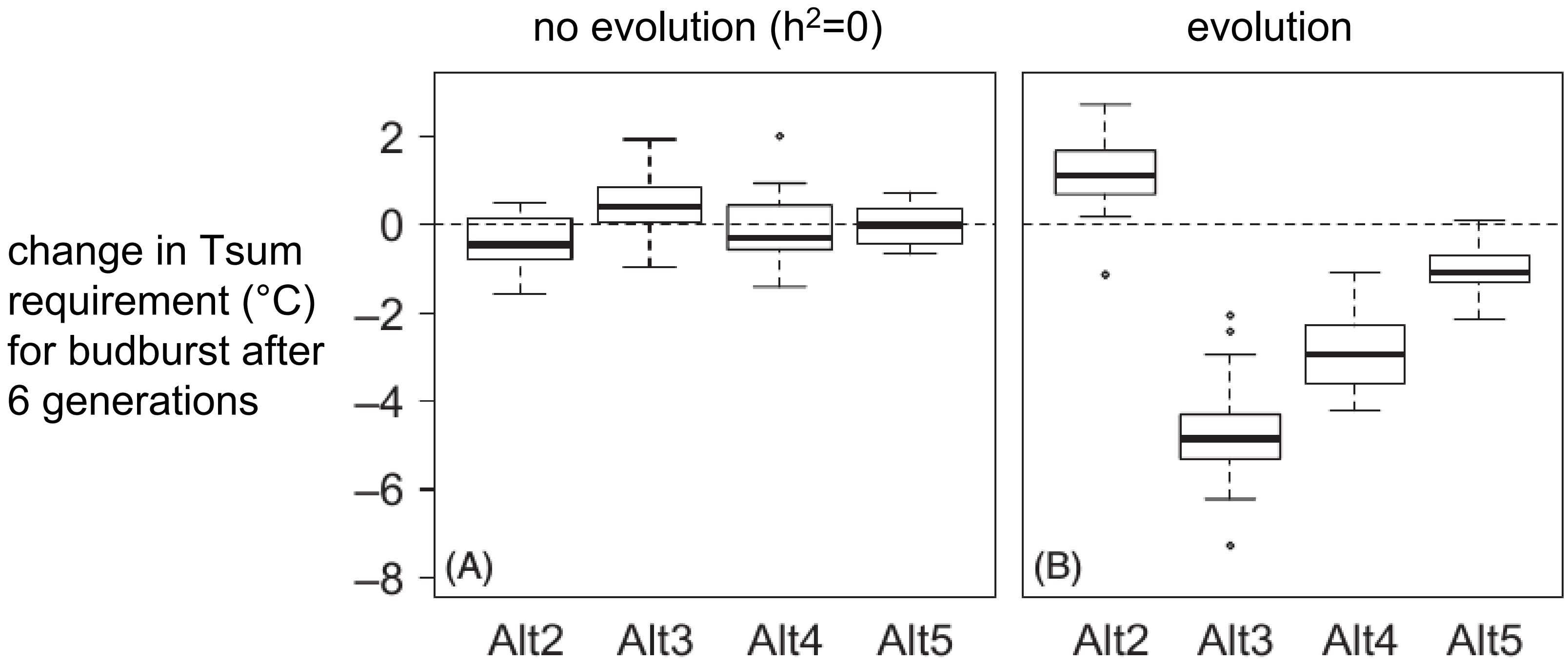
Broennimann et al (2007) Ecology Letters

Centaurea maculosa, introduced in the USA in 1890, 32 climatic variables

Physio-demo-genetic model : coupling functional model, population dynamics, genetic architecture and heredity

1 genetically variable parameter for budburst,

mortality driven by reserves, seed production driven by growth

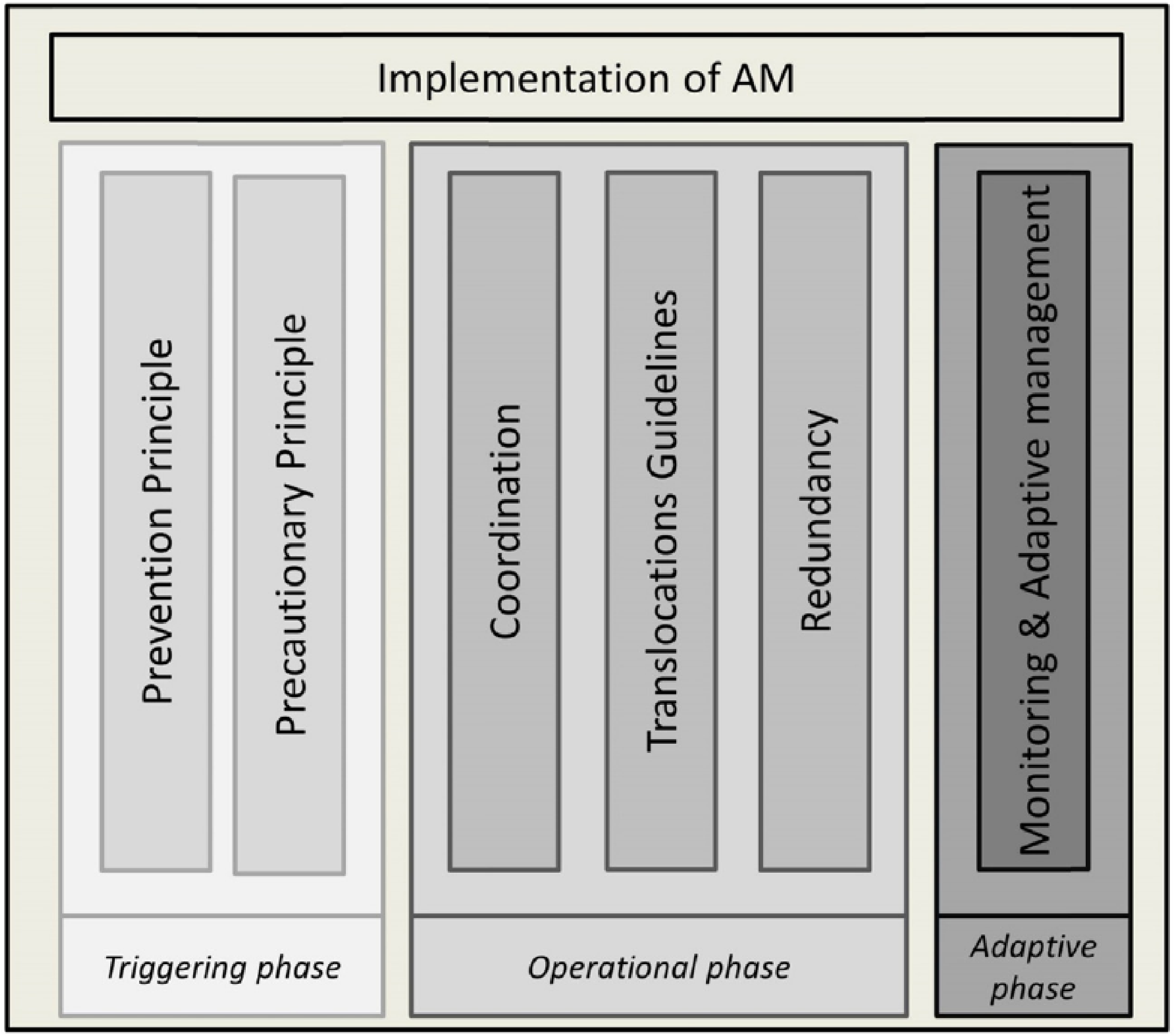


- integrates inter-individual variation
- physiological variables are evolvable
- demography responds to environmental change
- fitness dynamically results from the physiology

Oddou-Muratorio & Davi 2014 Evol Appl

Changing the reproductive material for planting

from knowledge to practice



Sansilvestri et al (2015) Envir Sci Pol

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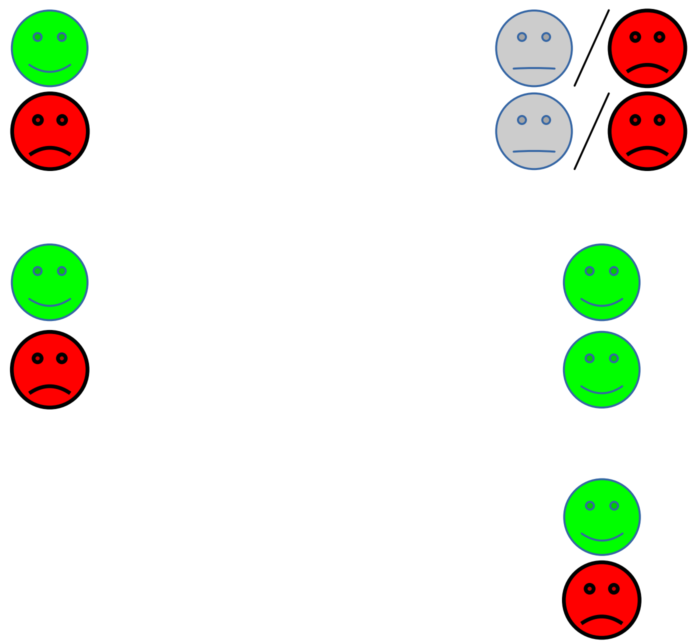
Biodiversity (FGR) and adaptive management

A process-based approach to assess the impact of practices on FGR drivers

	short-term **adaptation**	long-term **diversity**
local selection (desired) **local selection** (counter) **gene flow** (adapted) **gene flow** (maladapted) **increase Ne** **decrease Ne**		



Biodiversity (FGR) and adaptive management

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Practices

?

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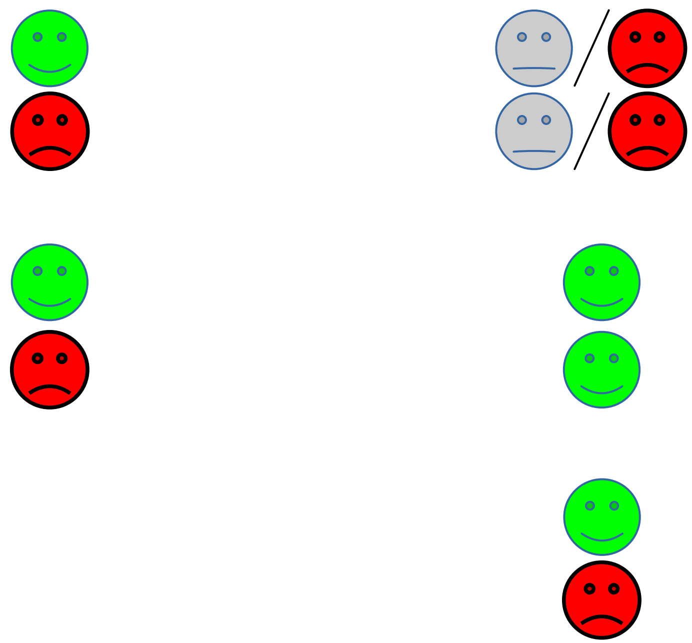

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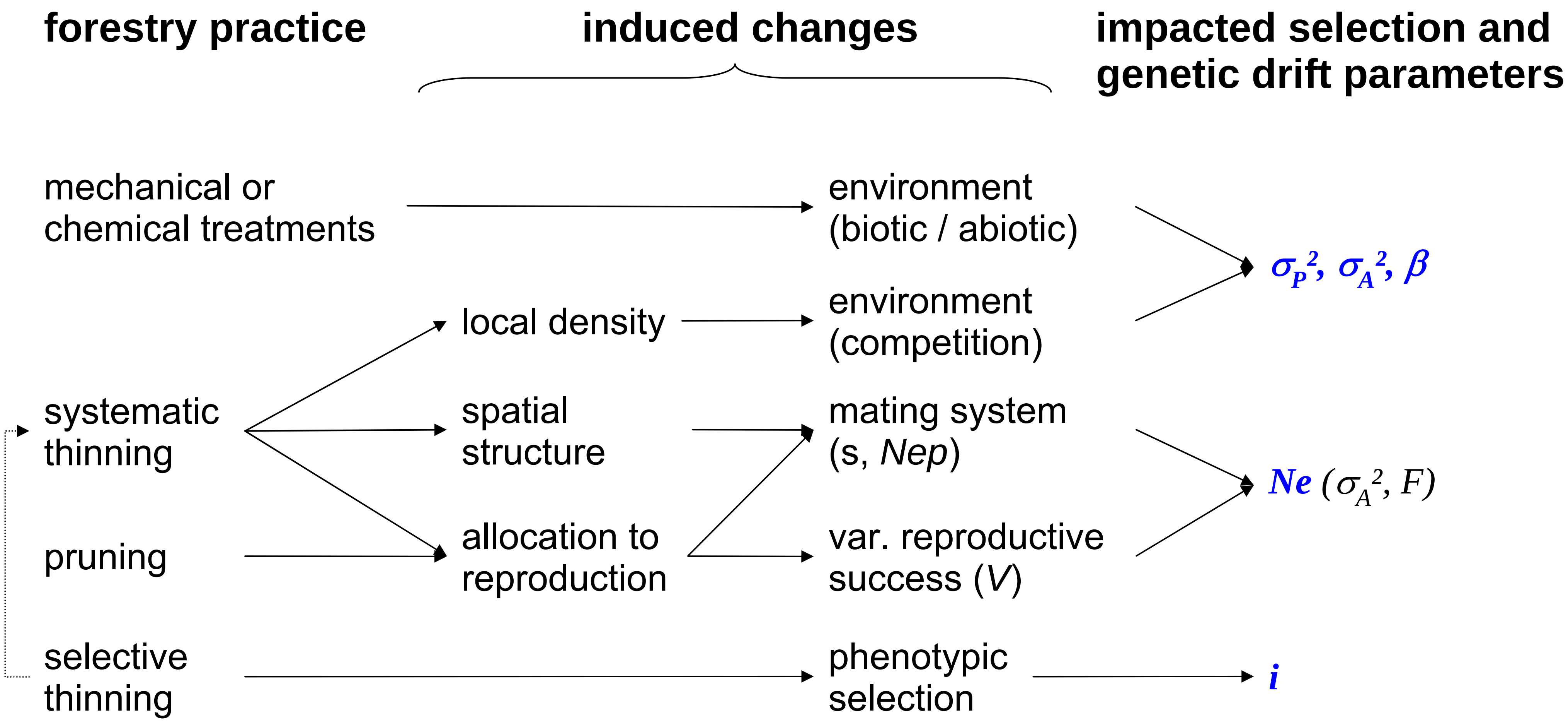

Lefèvre et al 2014 Ann For Sci

biodiversity (FGR) and adaptive management

Practices	Expected benefits	Associated costs and risks
regulation of density and spatial distribution to equalize reproductive success	- reduce genetic drift in small populations - reduce inbreeding in the next generation	- no supplementary cost - slow down selection (prefer equalization per patch)
in heterogeneous environment, dissociate areas of production & areas of evolution, allow gene flow	- increase reproductive contribution of highly selected individuals	- simulations needed for a cost / benefit analysis in different contexts
save the lone tree, collect seeds for local assisted regeneration	- diversify the mating pairs - promote adaptation to margibal conditions	- limited supplementary cost - risk of inbreeding if self-pollinated seeds not purged

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In a complex world, each new piece of knowledge does not simplify understanding => integration is needed :

- across disciplines, science and pragmatism
- integrate multiple processes across scales, trajectories may be more predictable than future states

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Adaptation to a changing world requires a new paradigm :

- evaluate risk/opportunities and uncertainties as such
- think multi-dimensional : short-term / long-term impacts, multiple ecosystem functions and services
- manage multiple options