Biodiversity conservation and the valuation of nature

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LEEP conference Exeter

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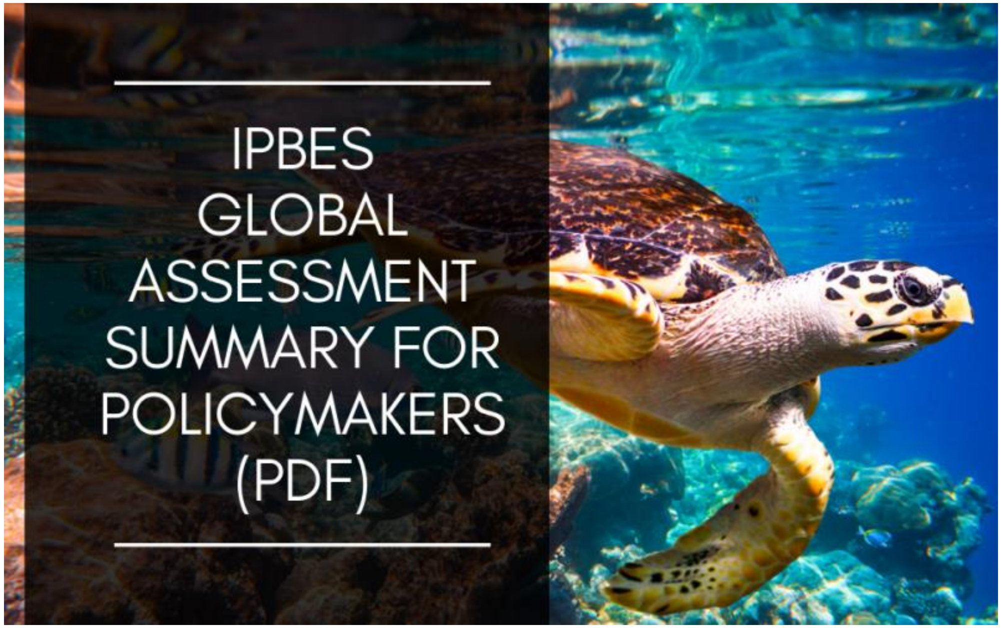
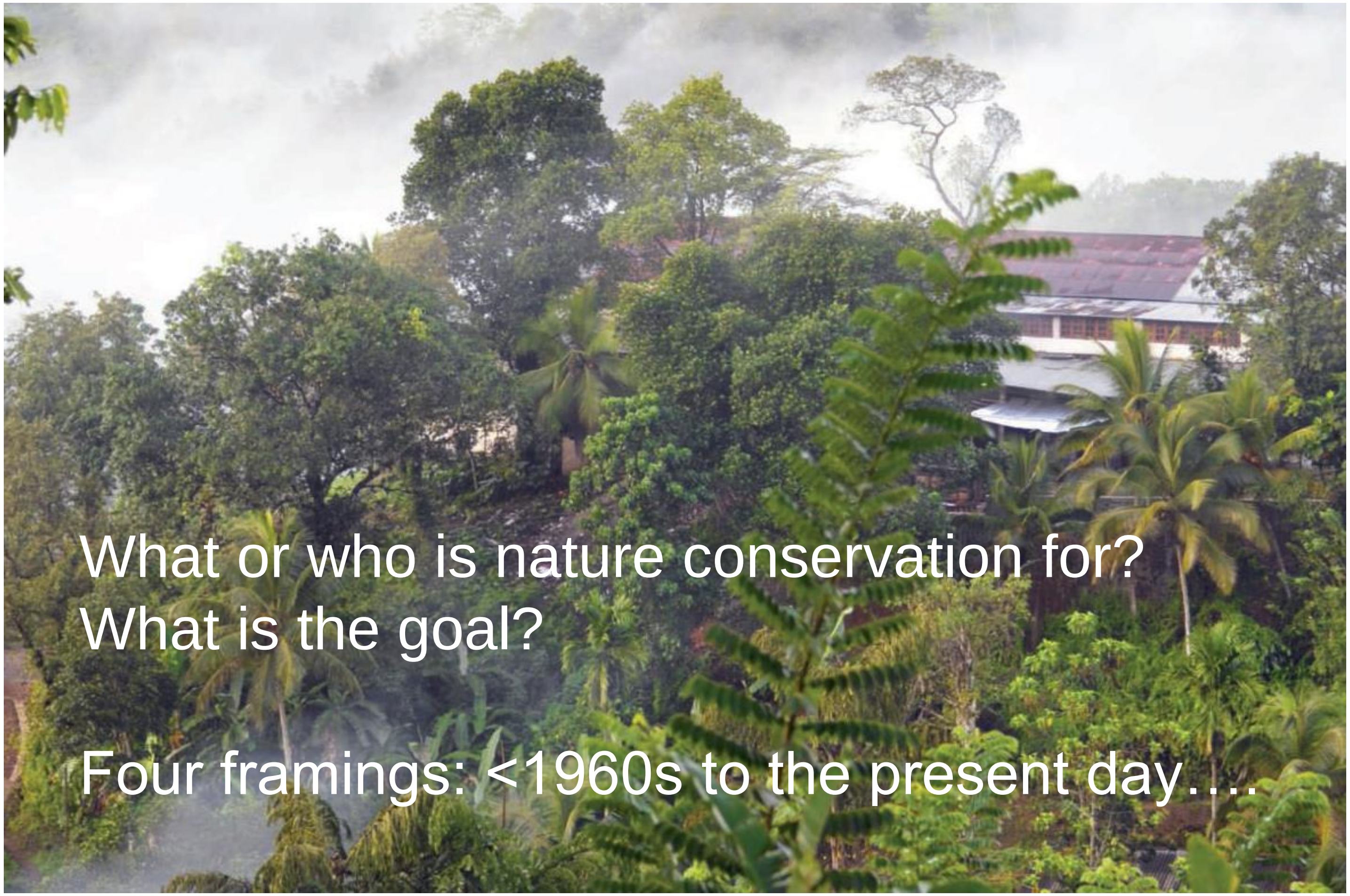


Key message A from the IPBES report, May 2019

“The biosphere, upon which humanity as a whole depends, is being altered to an unparalleled degree across all spatial scales. Biodiversity – the diversity within species, between species and of ecosystems – is declining faster than at any time in human history”.

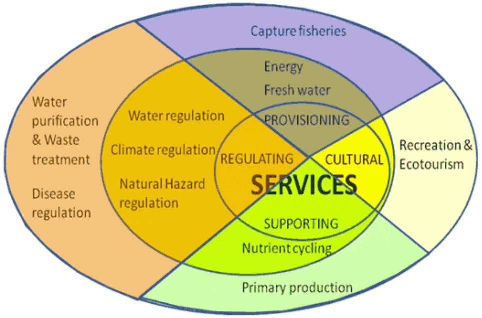
Species and ecosystems will be under pressure in a world increasingly dominated by people and their needs.



1. ***Nature for itself***

2. Nature *despite* people

3. Nature *for* people



4. People *and* Nature

… the focus of conservation has shifted…

From preserving

- components (species & habitats)
- patterns

.. implicitly for people

To maintaining future

- form and function,
- adaptability,
- resilience

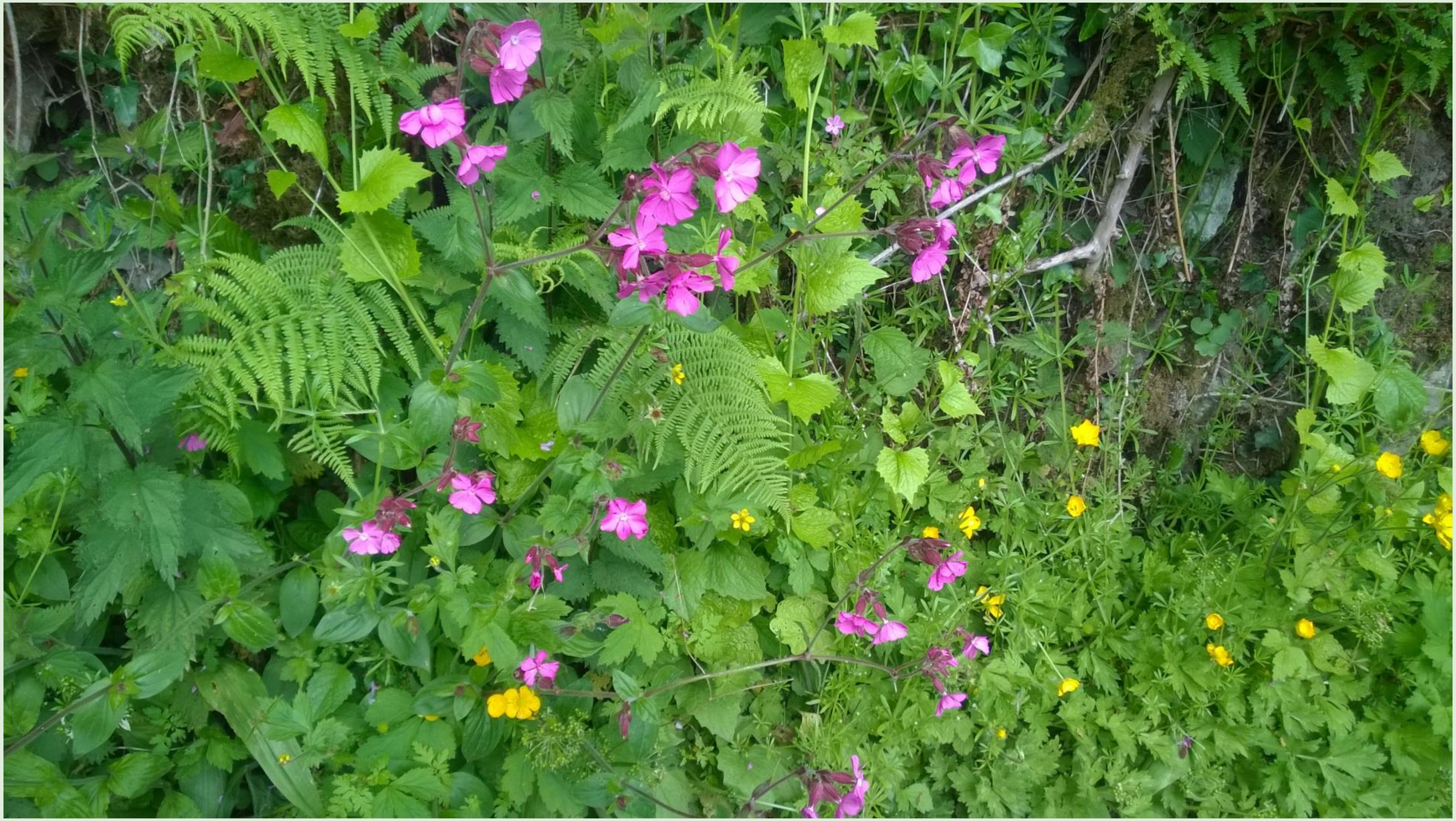
..explicitly for people

Rough timeline	Framing of conservation	Key ideas	Science underpinning
1960 1970	Nature for itself 	Species Wilderness Protected areas	Species, habitats and wildlife ecology
1980 1990	Nature despite people 	Extinction, threats and threatened species Habitat loss Pollution Overexploitation	Population biology, natural resource management
2000 2005	Nature for people 	Ecosystems Ecosystem approach Ecosystem services Economic values	Ecosystem functions, environmental economics
2010	People and nature 	Environmental change Resilience Adaptability Socioecological systems	Interdisciplinary, social and ecological sciences

Mace, GM. Science 2014

Some features of the 'People & Nature' framing:

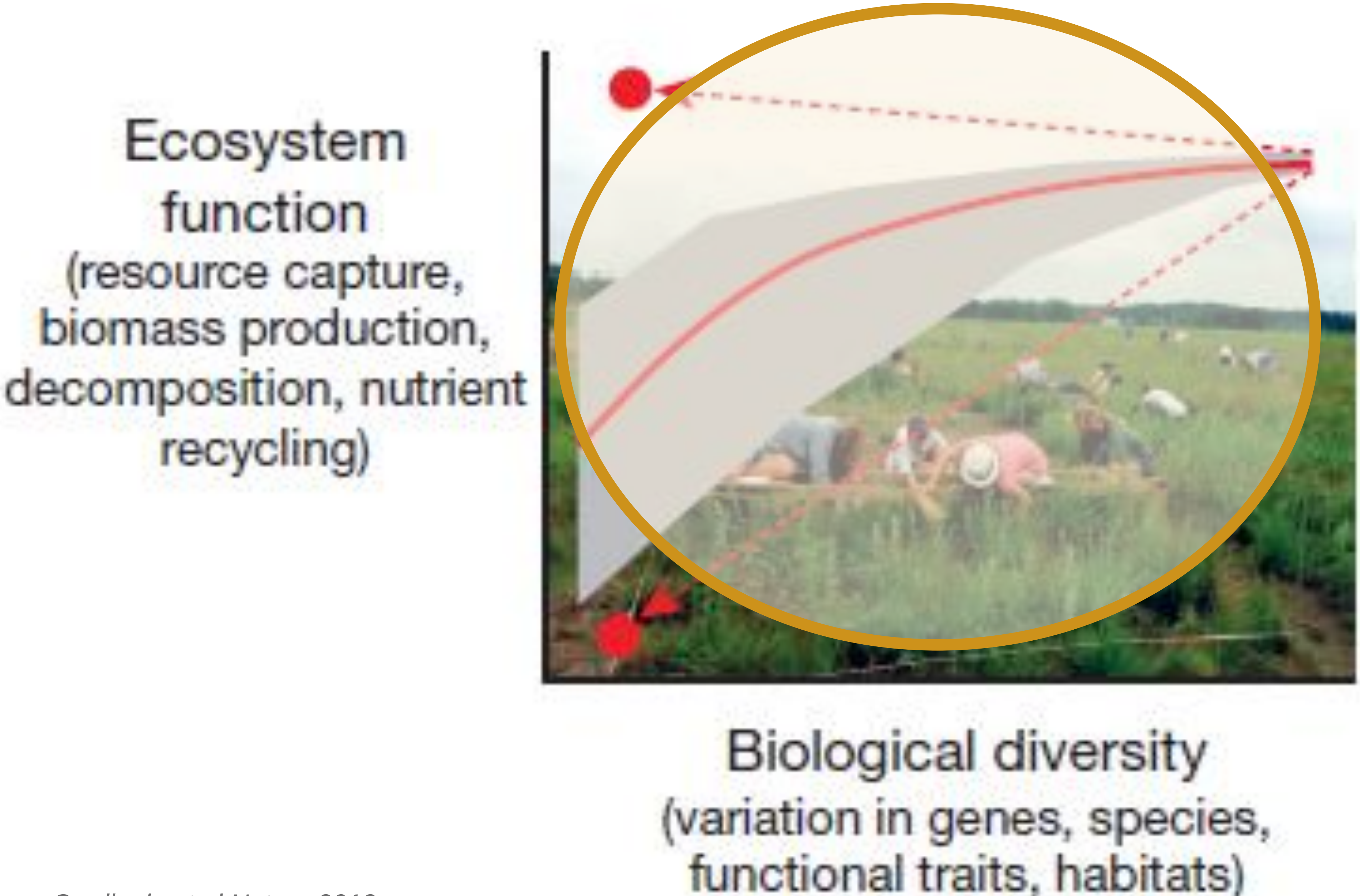
- It is implicitly **anthropocentric** and recognises the role that dynamic biological systems have in responding to and interacting with human systems – consistent with *social-ecological* systems approaches,
- It explicitly addresses the risks and opportunities from ongoing **environmental change** (climate, land use, urbanisation).
- It is **forward-looking**, but not ignoring the past – so can accommodate significant cultural contexts and history.
- It incorporates the importance of **biodiversity** for adaptation, resilience and multi-functionality, not only preservation.



THE FUNCTIONAL ROLES OF BIODIVERSITY

How does biodiversity benefit people?

- Underpinning ecosystem processes (production, nutrient cycling, etc.)
- Biodiversity -> ecosystem functioning
- Resilience and adaptability
- Multifunctionality



Cardinale et al Nature 2012

Diversity-function relationships: strong overall evidence but much variation

Species richness effects on

(a) abundance or biomass
(b) depletion of resources .

Aquatic (black)

Terrestrial (grey)

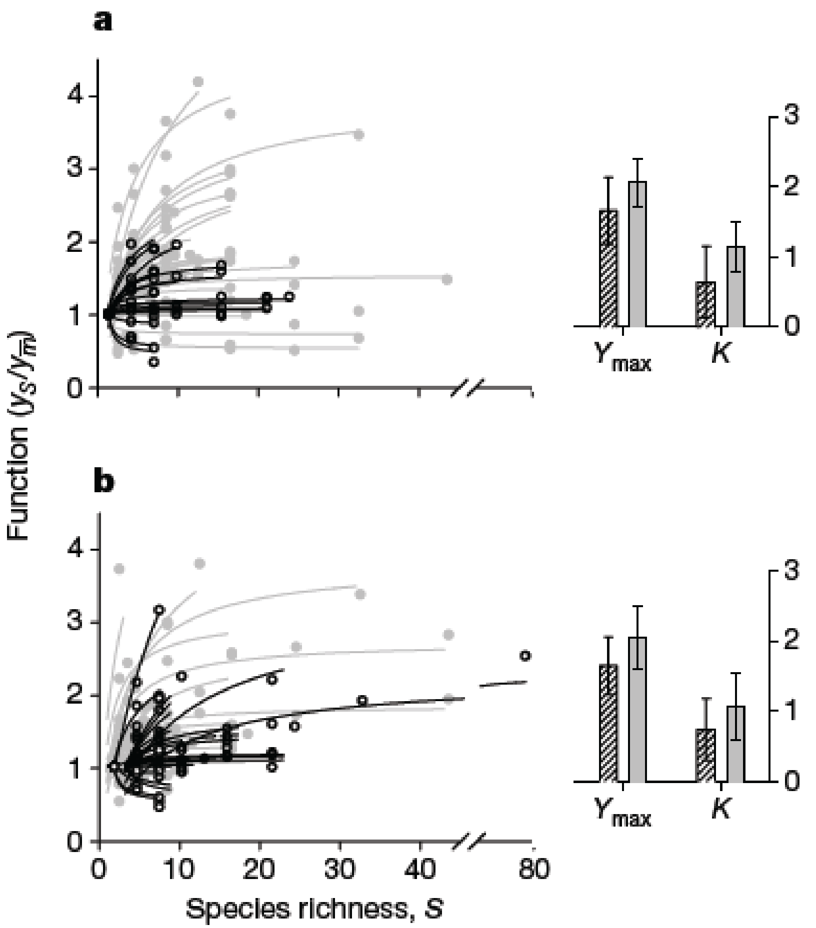
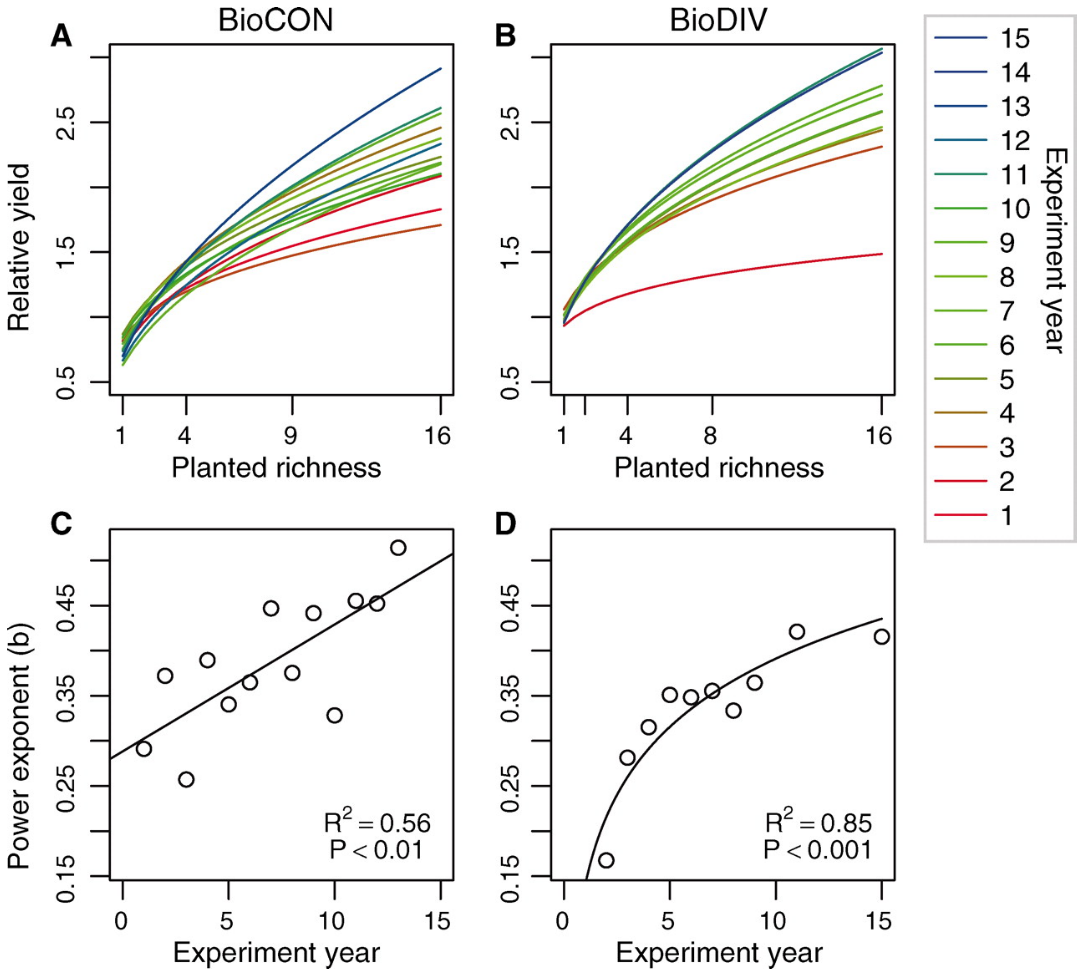


Fig 2, Cardinale et al. Nature 2006

The diversity-biomass function continues to grow larger and less saturating over time…

In these field experiments it is apparently due to the accumulating effects of complementarity of resource acquisition and use and of ecosystem feedback effects, such as on soil N cycling.



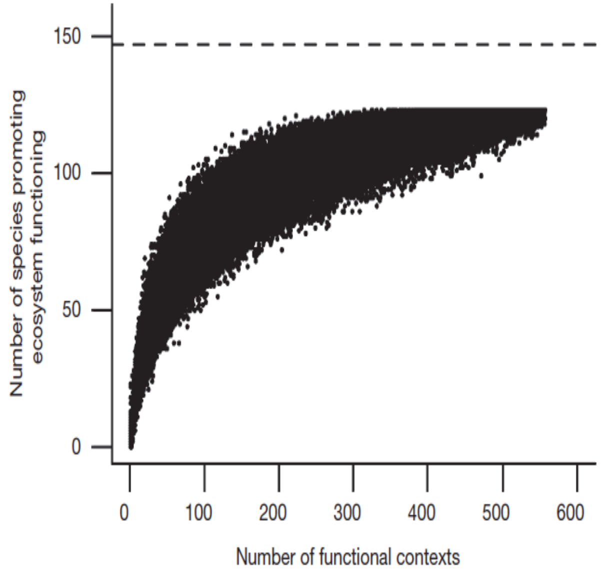
P B Reich et al. *Science* *2012;336:589-592*

The contributions of species are difficult to predict and vary over time, space, function and context

In 147 grassland experiments 84% plant species promoted ecosystem functioning at least once.

Different species acted in different years, places, for different functions and under different environments.

Species that promoted one function during multiple years were not the same as those promoting multiple functions within one year.



…. many species are needed to maintain multiple functions at multiple times and places in a changing world

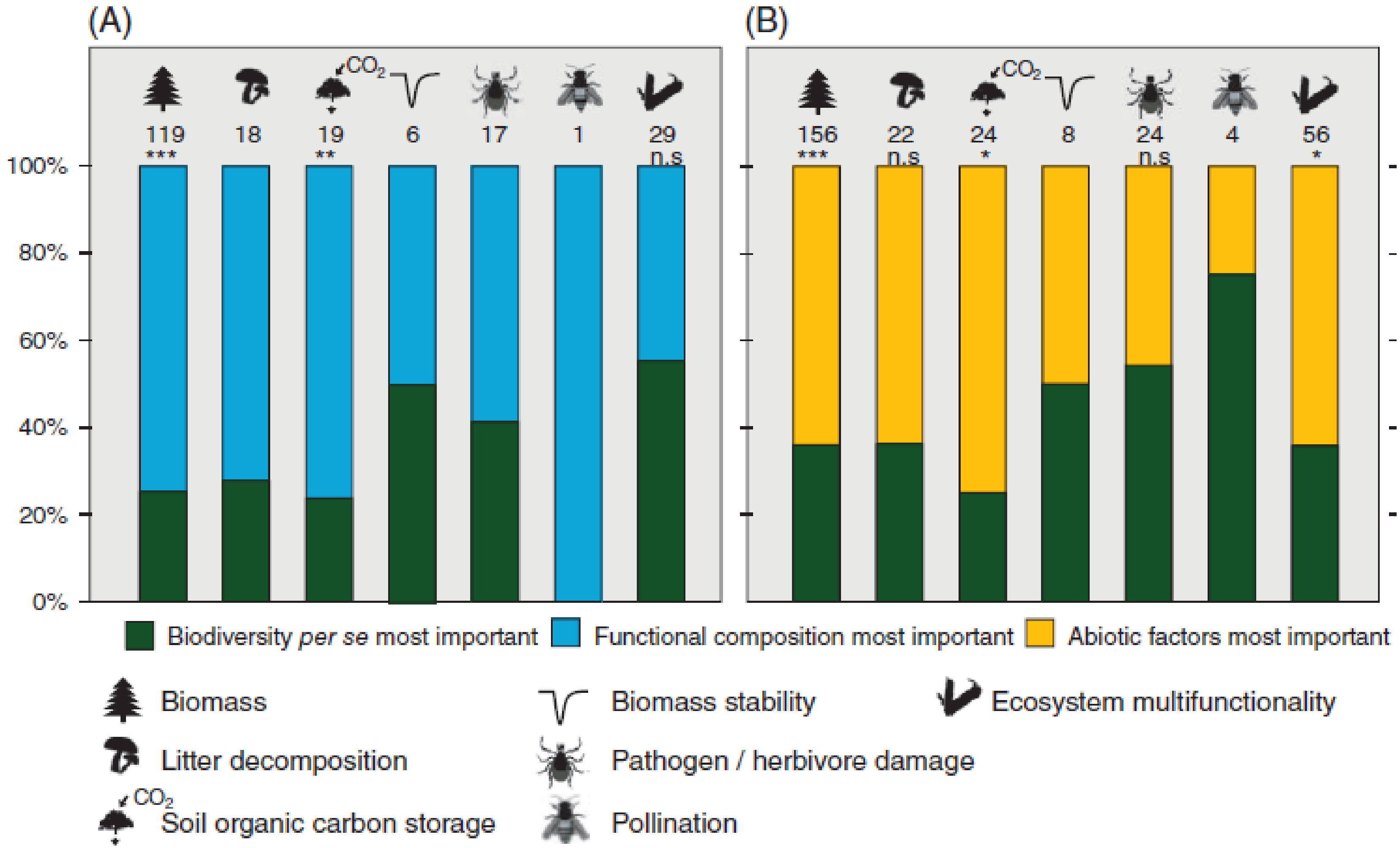
Isbell et al. Nature 2011

Biodiversity – ecosystem functioning: moving into the real world

					Observed relationships	
						Non-experimental studies
Category of function	Ecosystem function	Ecosystem type	Focal group	Theory	Experiments	N	
Biomass	Tree biomass stock	Temperate forests	Trees	↗ [a,b,c]	↗ [m]	38	↗
	Tree biomass production	Temperate forests	Trees	↗ [a,b,c]		61	↗
	Tree biomass stock	Tropical forests	Trees	↗ [a,b,c]	↗ [m]	44	⇨
	Tree biomass production	Tropical forests	Trees	↗ [a,b,c]		17	⇨
	Plant biomass*	Grasslands	Plants	↗ [a,b,c]	↗ [n]	102	↗
	Plant biomass*	Aquatic systems	Plants	↗ [a,b,c]	↗ [n]	21	↗
	Consumer biomass	All	Consumers	↗ [a,b,c]		24	↗
Decomposition	Decomposition	All	Plants	↘ [d]	↗ [o]	33	↗
	Decomposition	All	Decomposers	↗ [d]	↗ [p]	20	⇨
Soil carbon storage	Soil organic carbon stock	All	Plants		↗ [o]	35	⇨
Biomass stability	Plant biomass stability	All	Plants	↗ [e,f,g]	↗ [q,r]	27	↗
	Consumer biomass stability	All	Consumers	↗ [e,f,g]		13	↗
Pathogen / herbivore damage	Overall pathogen damage	All	Hosts		↘ [o]	17	⇨
	Damage by specialist pathogen	All	Hosts	↘ [h]		18	↘
	Herbivore damage	All	Plants	↘ [h,j]	↘⇨ [o]	45	⇨
	Herbivore damage	All	Herbivores	↗ [j,k]		10	⇨
	Herbivore damage	All	Predators	↘ [k]	⇨ [o]	11	⇨
Pollination	Fruit or seed set	All	Plants			8	⇨
	Fruit or seed set	All	Pollinators	↗ [l]		96	↗
Ecosystem multi-functionality	Ecosystem multifunctionality	All	All		↗ [s]	111	↗
	Ecosystem multifunctionality	Temperate forests**	All			16	↗
	Ecosystem multifunctionality	Tropical forests**	All			17	⇨
	Ecosystem multifunctionality	Grasslands**	All			55	⇨

Van der Plas Biol Rev 2019

Biodiversity – ecosystem functioning: the importance of functional composition and abiotic factors



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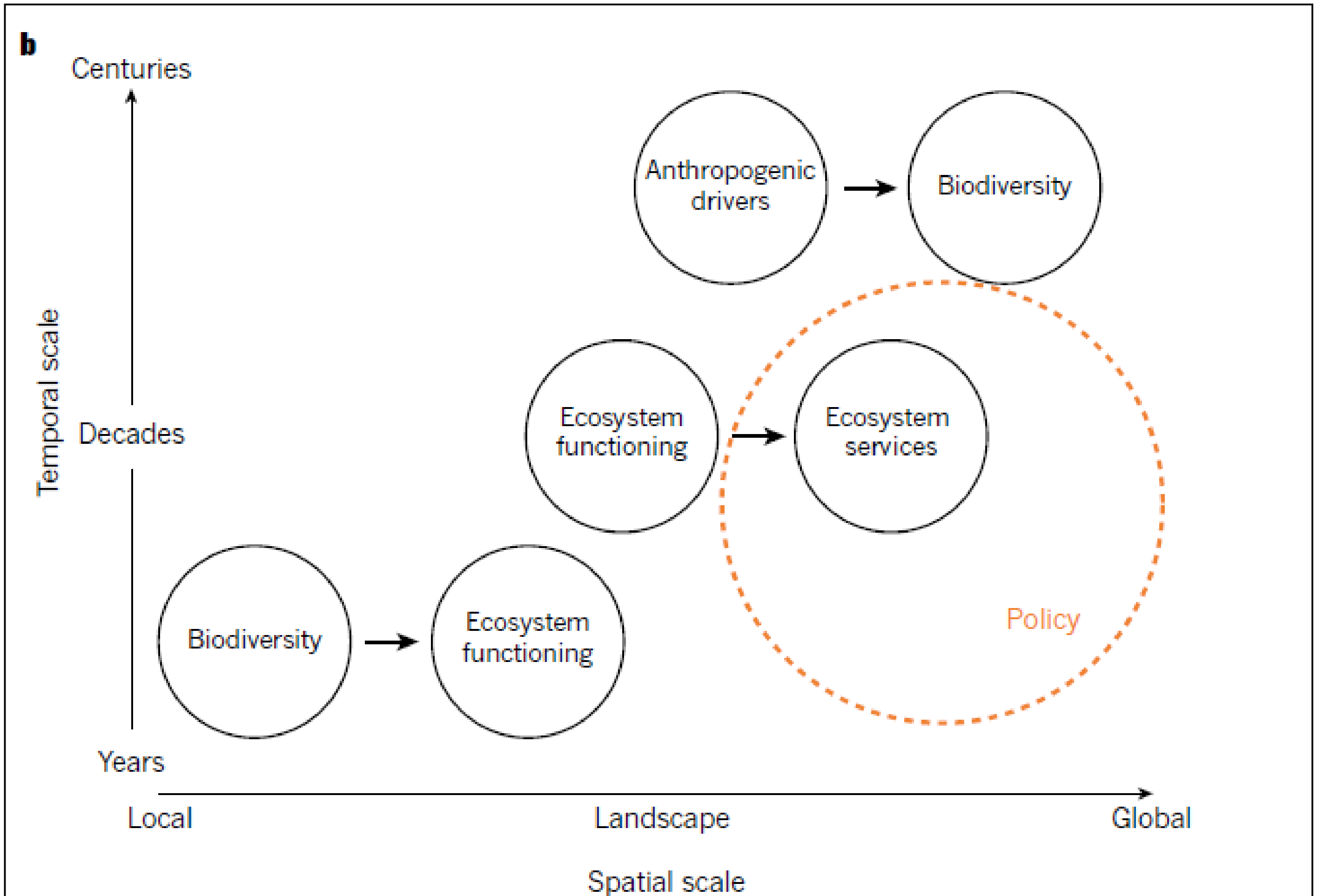
The mismatch between scales at which biodiversity - ecosystem function studies and what policy needs.



Isbell et al. *Nature* 2017

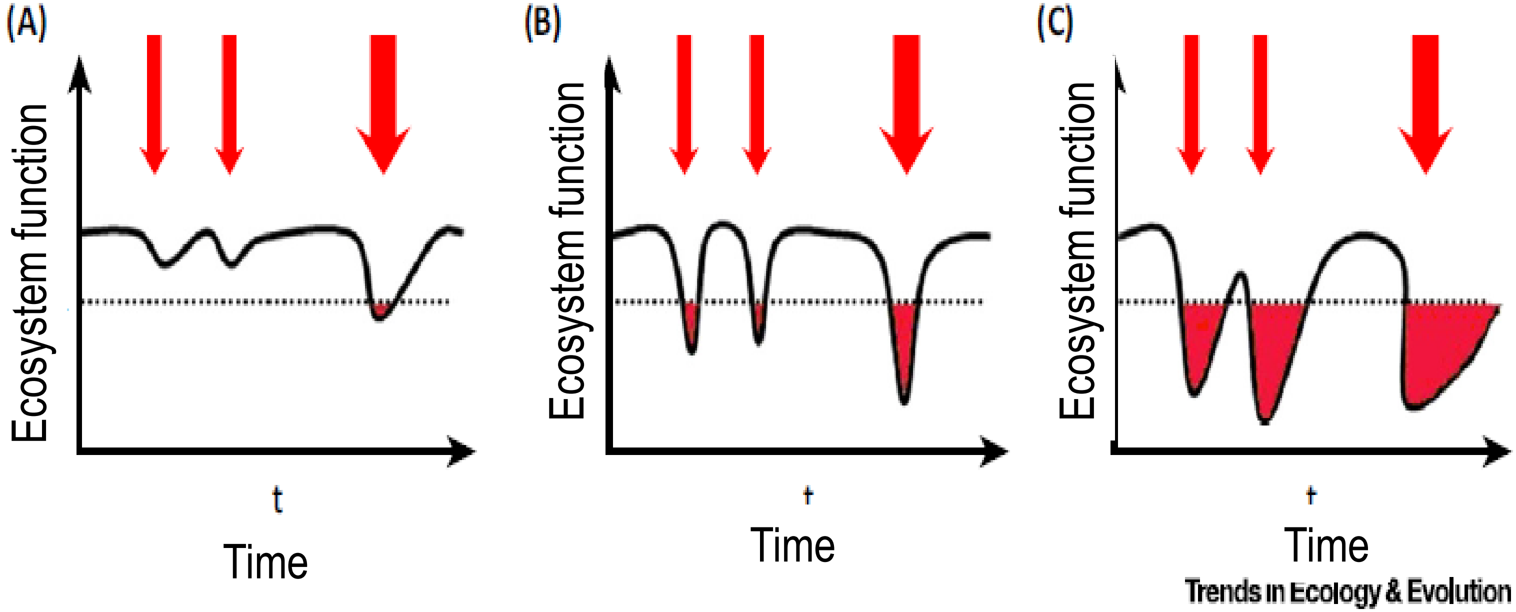
The role of biodiversity at policy and decision-relevant scales

Beyond the field/plot scale and experimental systems.

Resilience Multi-functionality Adaptability

Resilience to changes and to perturbations

Varying resilience levels of an ecosystem function to environmental perturbations (red arrows).



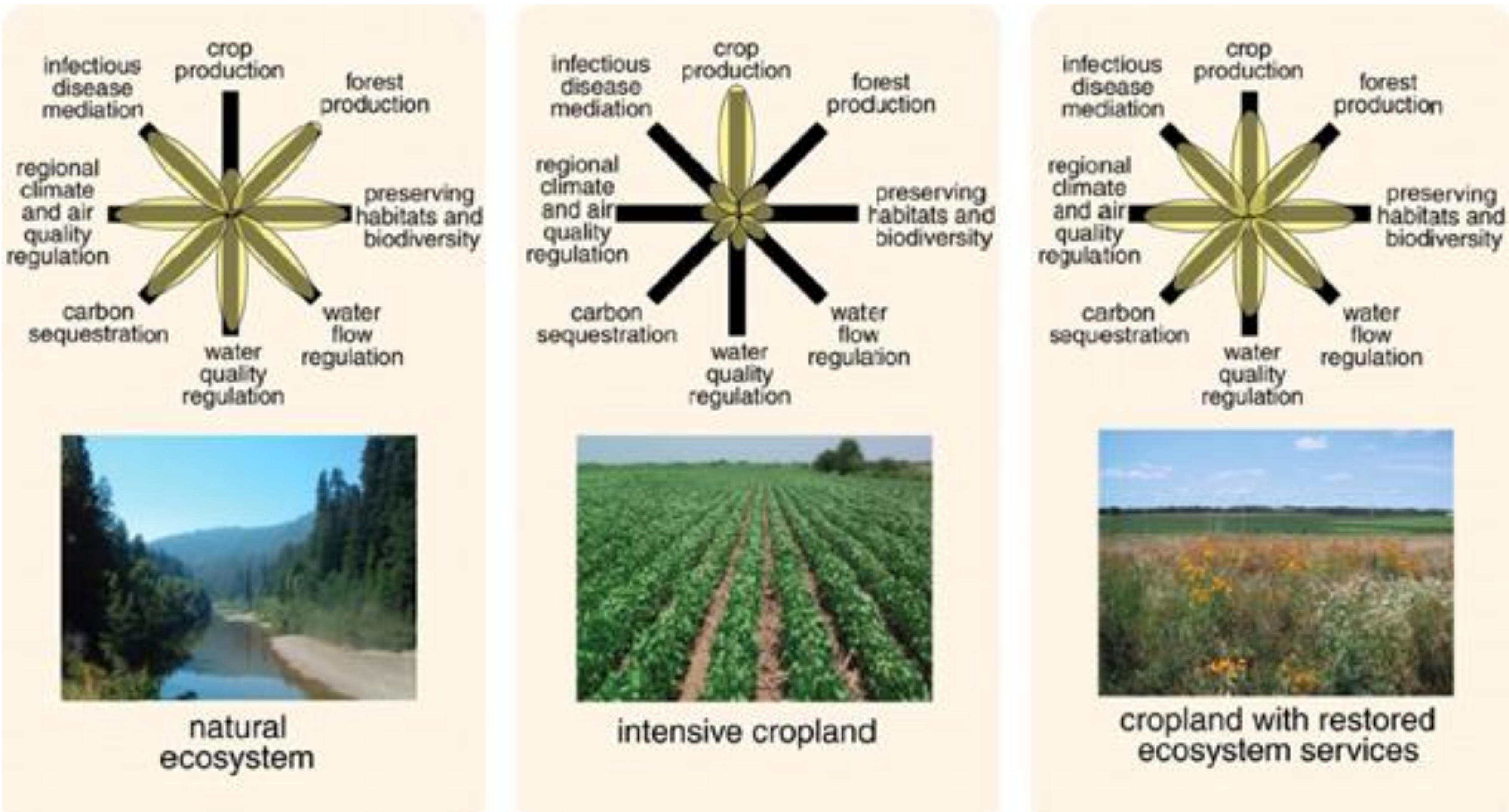
Oliver et al. 2015 TREE

Ecological mechanisms underpinning resistance & recovery of ecosystem functions to perturbation

1. Species	2. Ecological Community	3. Landscape
Sensitivity to change	Correlations between responses to environmental change and their effects	Local environmental heterogeneity
Population growth rate	Functional redundancy	Functional connectivity
Adaptive plasticity	Network interaction structure	Potential for alternate stable states
Genetic diversity		Area of natural habitat
Density dependent responses		

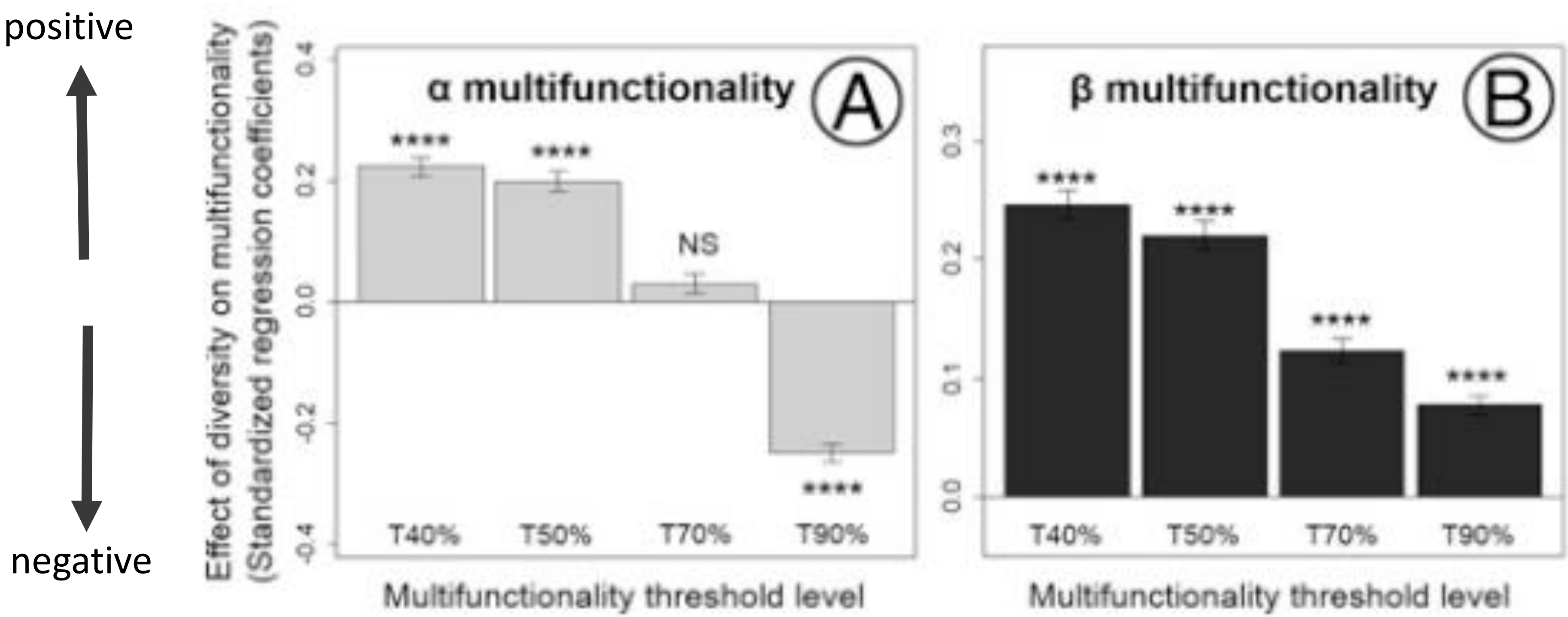
Oliver et al. 2015 TREE

Intensive land uses are more productive; but extensive land uses provide more functions and services



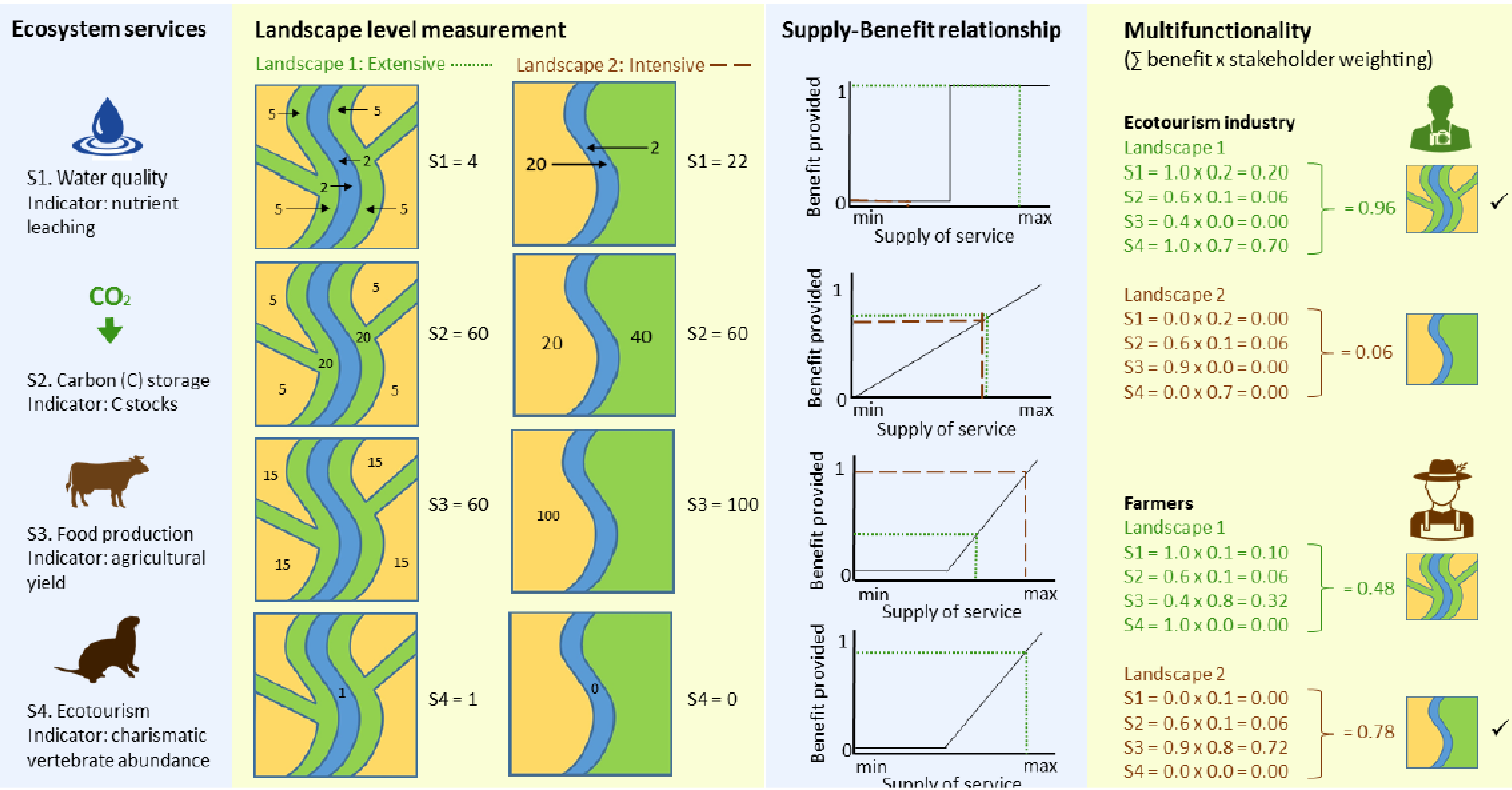
Foley et al 2005 Science

Biodiversity – multi-functionality relationships in European forest landscapes



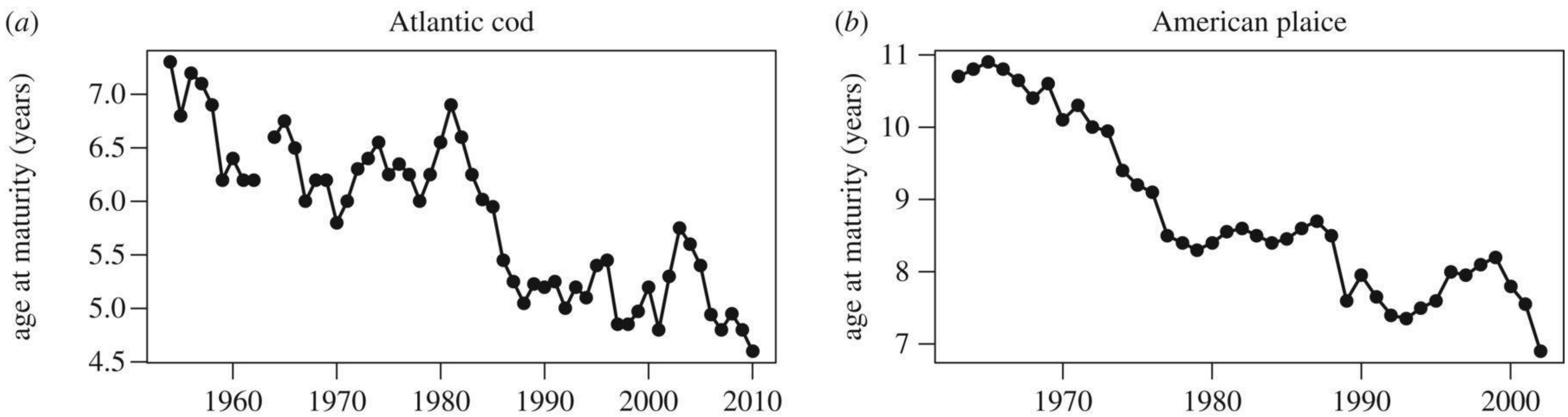
Van der Plas et al. 2016 PNAS

The ‘best’ land use depends on the demand side – what is needed and/or wanted..



P. Manning et al. *Nature Ecology & Evolution (2018)*

Adaptability: Evolutionary change in harvested fish stocks



Commercial fisheries typically target fishes of large size. Over time fish have become smaller and an increasing proportion reached maturity at a younger age and smaller size in line with predictions from evolution theory

Sharpe & Hendry 2009

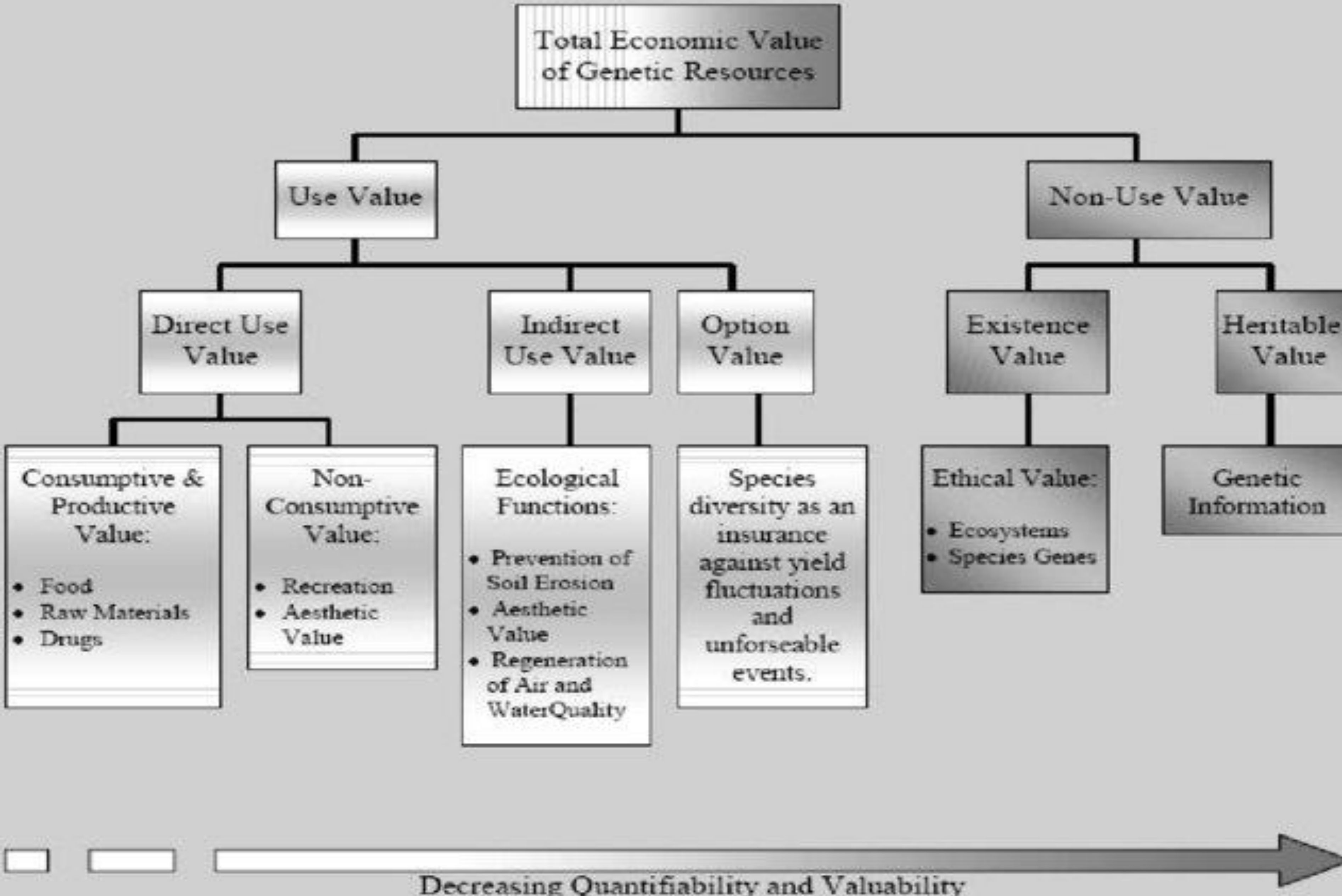
Sarrazin & Lecomte 2016

Evolutionary roots, challenges, and consequences of conservation strategies and ethics

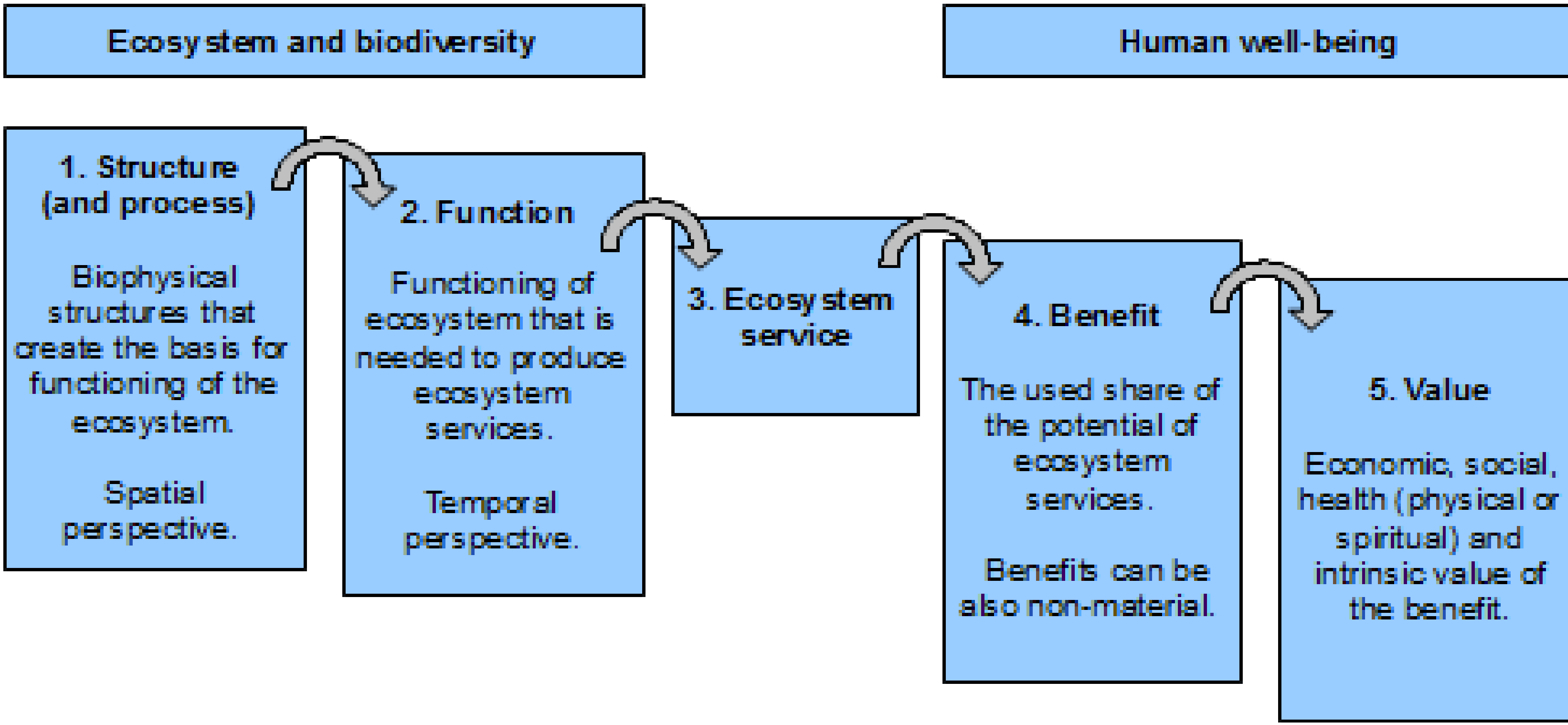
	Roots			**Challenges**		
SHOULD WE . . .	INTRINSIC VALUE	CONSERVATION	WILDERNESS	ECOSYSTEM SERVICES (ES)		
abandon attempts at biodiversity conservation?	None	None	None	Runaway consumption of biodiversity resources		**Blind Anthropocene**
conserve for the resilience of future human generations?	Human fitness		None	Long-term provisioning and regulating ES		
conserve for the immediate well-being of human individuals?	Human well-being	Anthropocentric	Scenic wilderness	Short-term provisioning and cultural ES		**Deliberate Anthropocene**
conserve for the well-being of future human generations?	Human well-being and fitness		Scenic wilderness	Long-term provisioning, regulating, and cultural ES		
conserve for the well-being of future human generations and nature?	Human well-being and fitness Nonhuman fitness	Evocentric	Wildness beyond wilderness	Long-term evolutionary trajectories beyond ES		**Deliberate overcoming of the Anthropocene**

HOW DO ECONOMIC FRAMEWORKS INCORPORATE BIODIVERSITY?

Total Economic Value



Cascade model (CICES)



Adapted from Haines-Young & Potschin 2010.

Biodiversity, ecosystem processes and ecosystem services

1. Biodiversity as a regulator of ecosystem processes e.g. soil communities
2. Biodiversity as an ecosystem service e.g. wild relatives of crop strains.
3. Biodiversity as a “good” e.g. charismatic species valued by people.

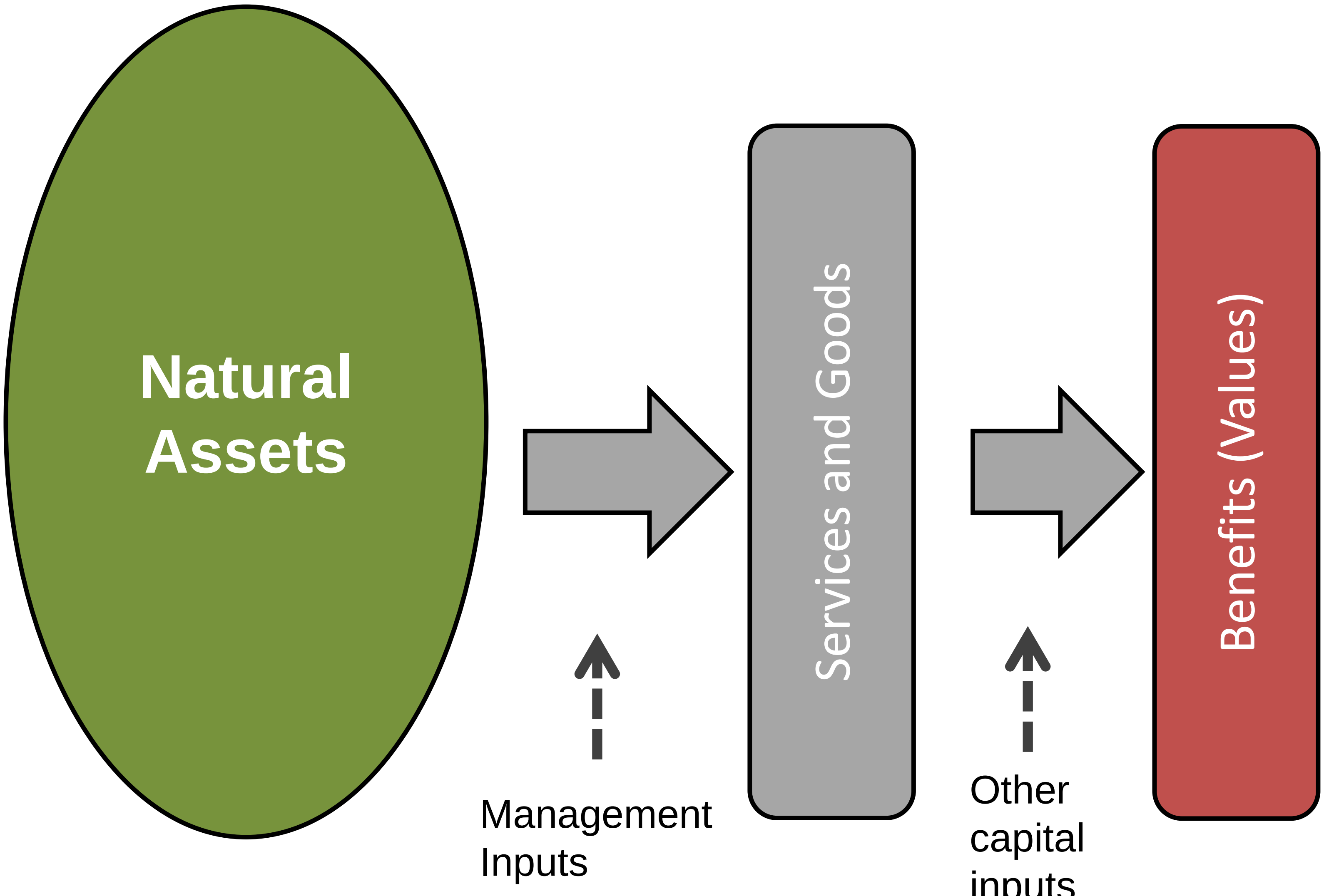
ECOSYSTEM PROCESSES

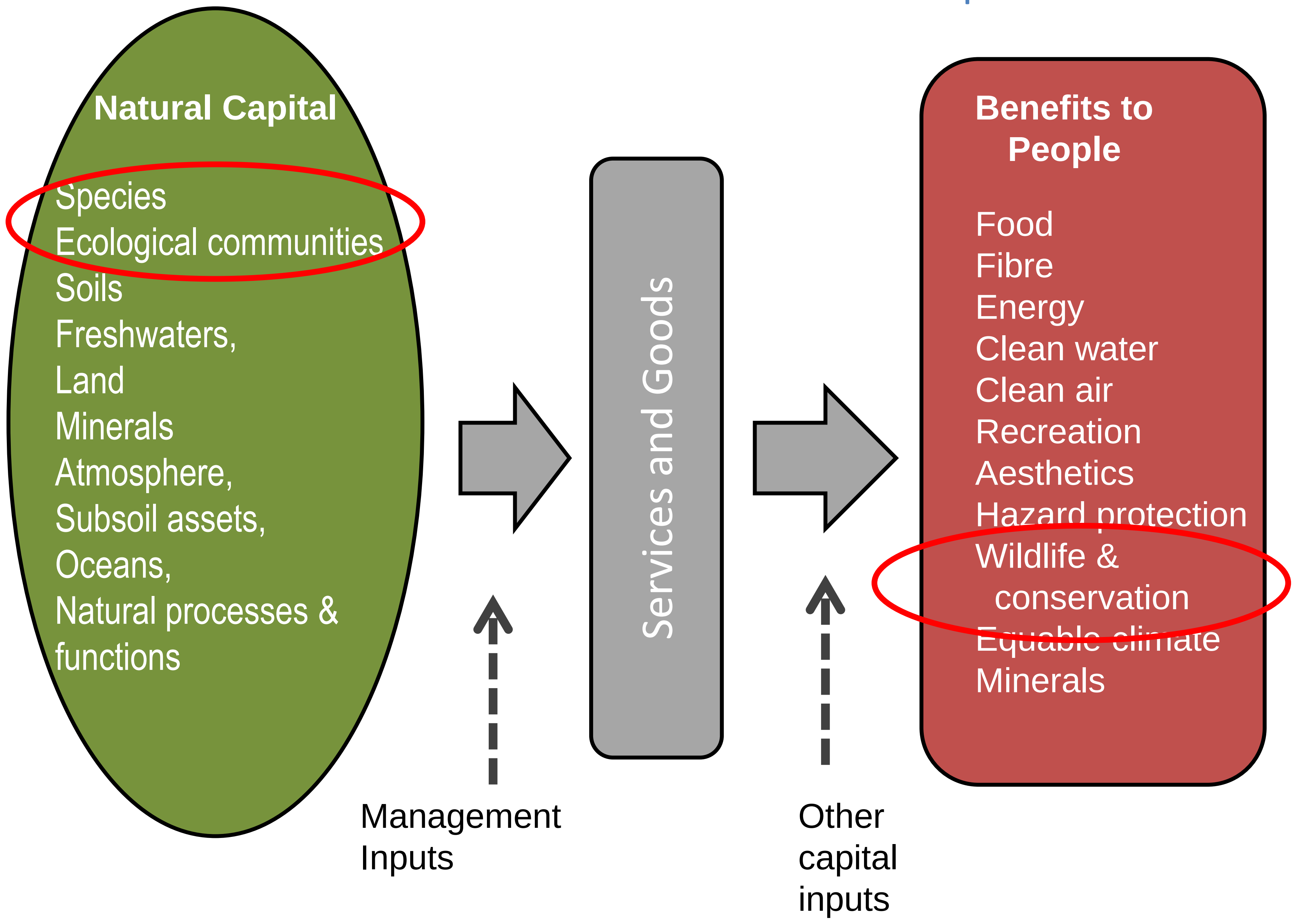
ECOSYSTEM SERVICES

GOODS/BENEFITS

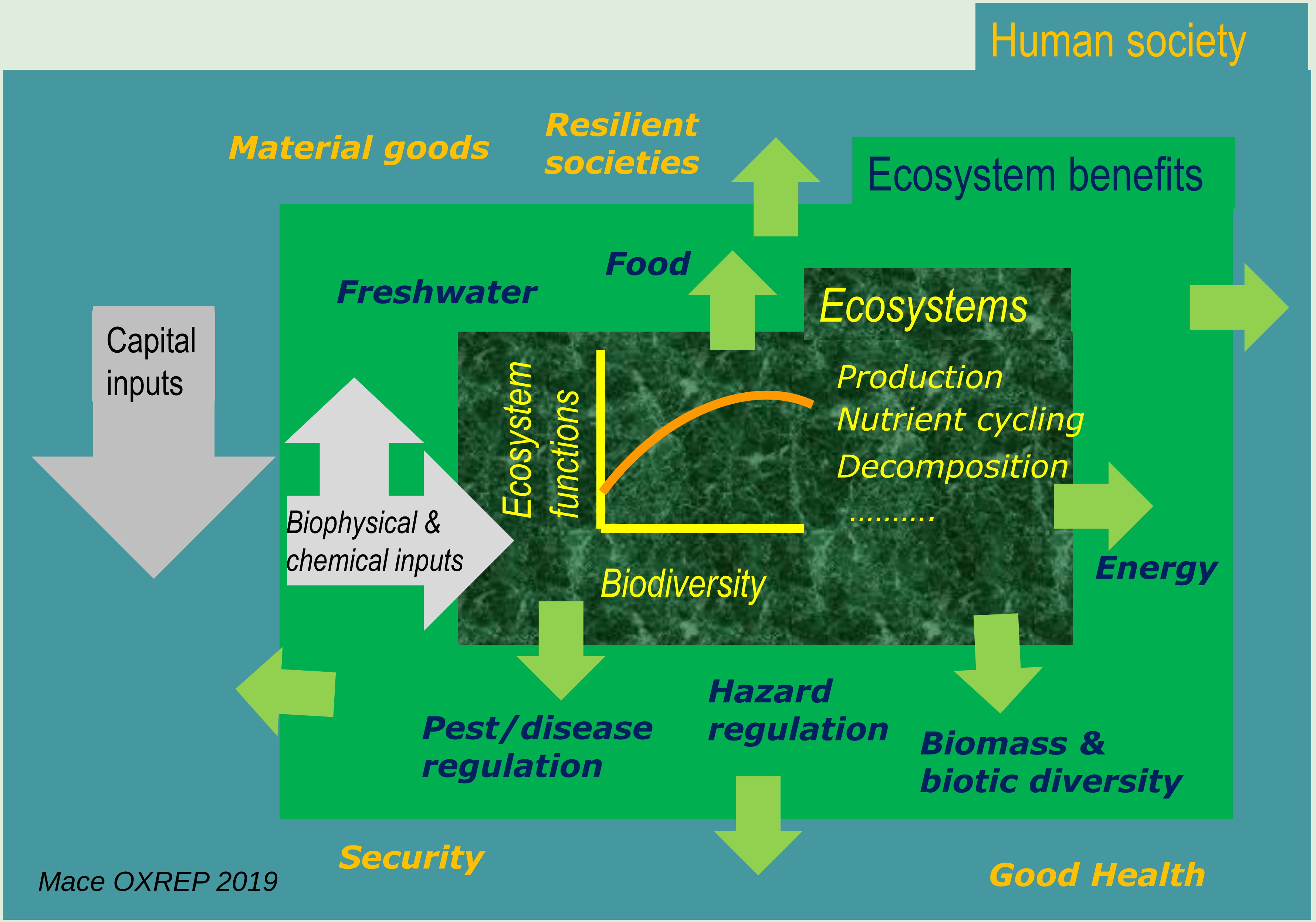
Biodiversity acting as:		
A regulator of ecosystem processes	**A final ecosystem service**	**A good**
What kind of organism?		
Microorganisms: decomposition and nutrient cycling Primary producers (plants on land and in water): biomass production and carbon capture Top predators, parasites: population regulation Pollinators: stability of nonagricultural ecosystems	Wild crop and livestock relatives: ensuring genetic diversity to provide resilience of food production systems against future climate change/diseases and so on Organisms with secondary compounds: potential for commercial exploitation, for example novel pharmaceuticals Pollinators: security of many food crops	Large vertebrates, especially birds, mammals and conspicuous flowering plants: recognised for their charisma and aesthetic appeal Flagship or umbrella species: providing protection for wider communities and habitats Phylogenetically distinct species:

A natural capital approach




Natural Capital
Species
Ecological communities
Soils
Freshwaters,
Land
Minerals
Atmosphere,
Subsoil assets,
Oceans,
Natural processes & functions
Services and Goods
Benefits to People
Food
Fibre
Energy
Clean water
Clean air
Recreation
Aesthetics
Hazard protection
Wildlife & conservation
Equable climate
Minerals
Management Inputs
Other capital inputs

Why is biodiversity important?



Conclusions

- Biodiversity has importance for environmental sustainability and ecosystem services well beyond simple consideration of species or habitat conservation.
- Dynamic changes in human-dominated systems will affect ecosystem services, but can be managed if ecological and evolutionary processes are considered.
- This means conserving core functions and processes (production, decomposition, nutrient cycling) governed by and underpinning biodiversity (genes, species communities) at landscape scale.
- A natural capital approach is helpful here.