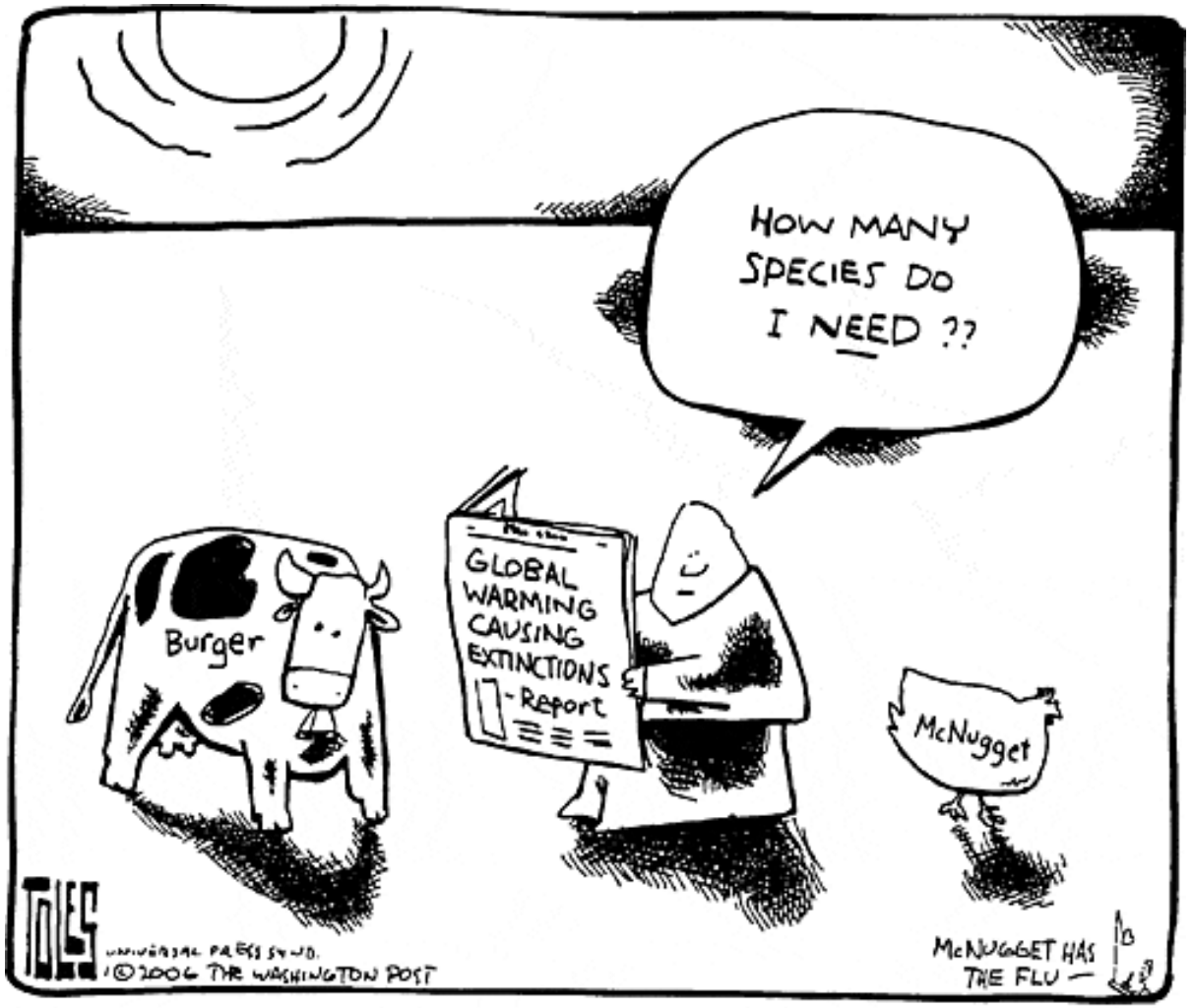
Progress and needs in evaluating and implementing the biodiversity, ecosystem functioning, ecosystem service chain

Hal Mooney

July 25, 2009

What good is biodiversity anyway?

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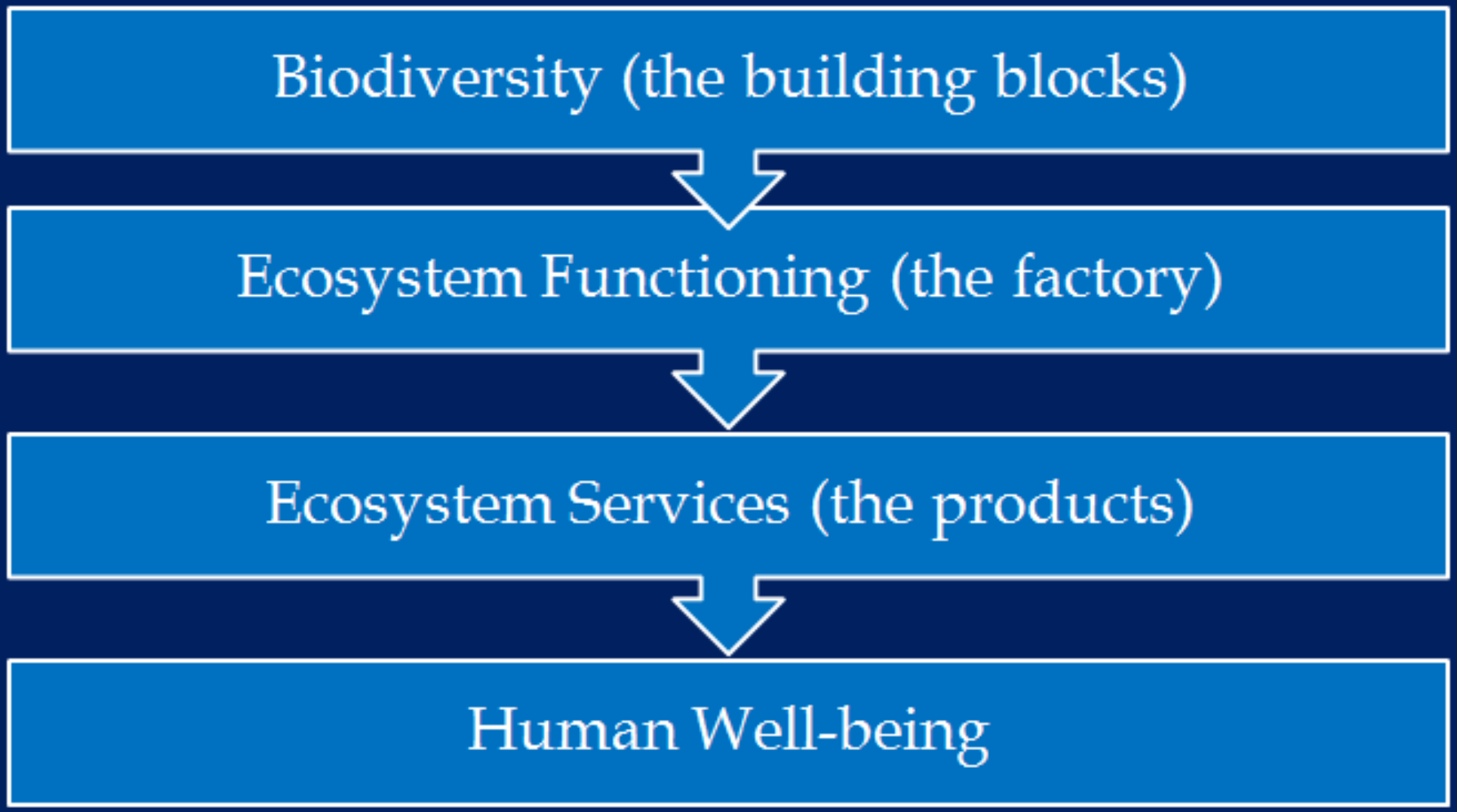
S. Diaz

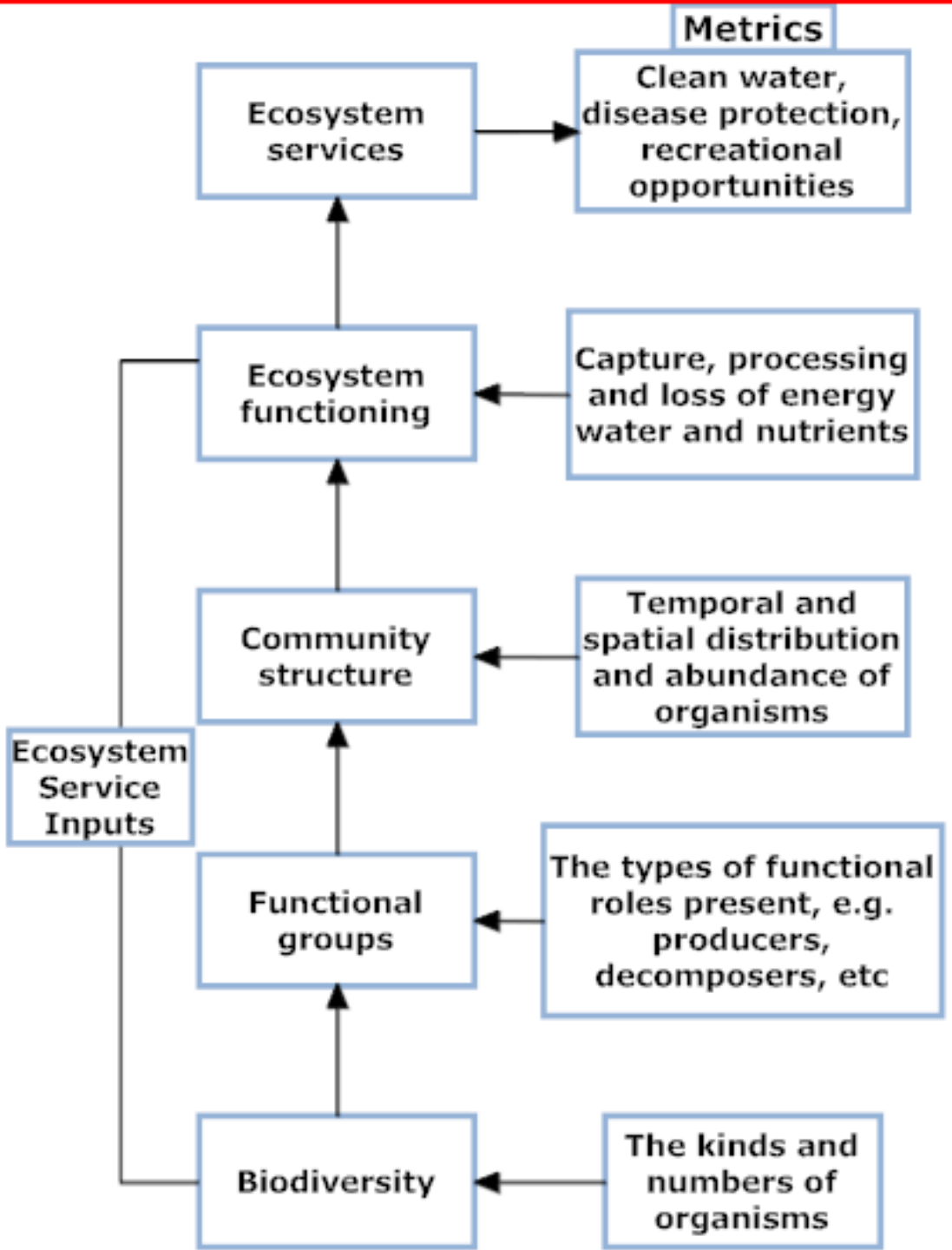
Motivation for the MA

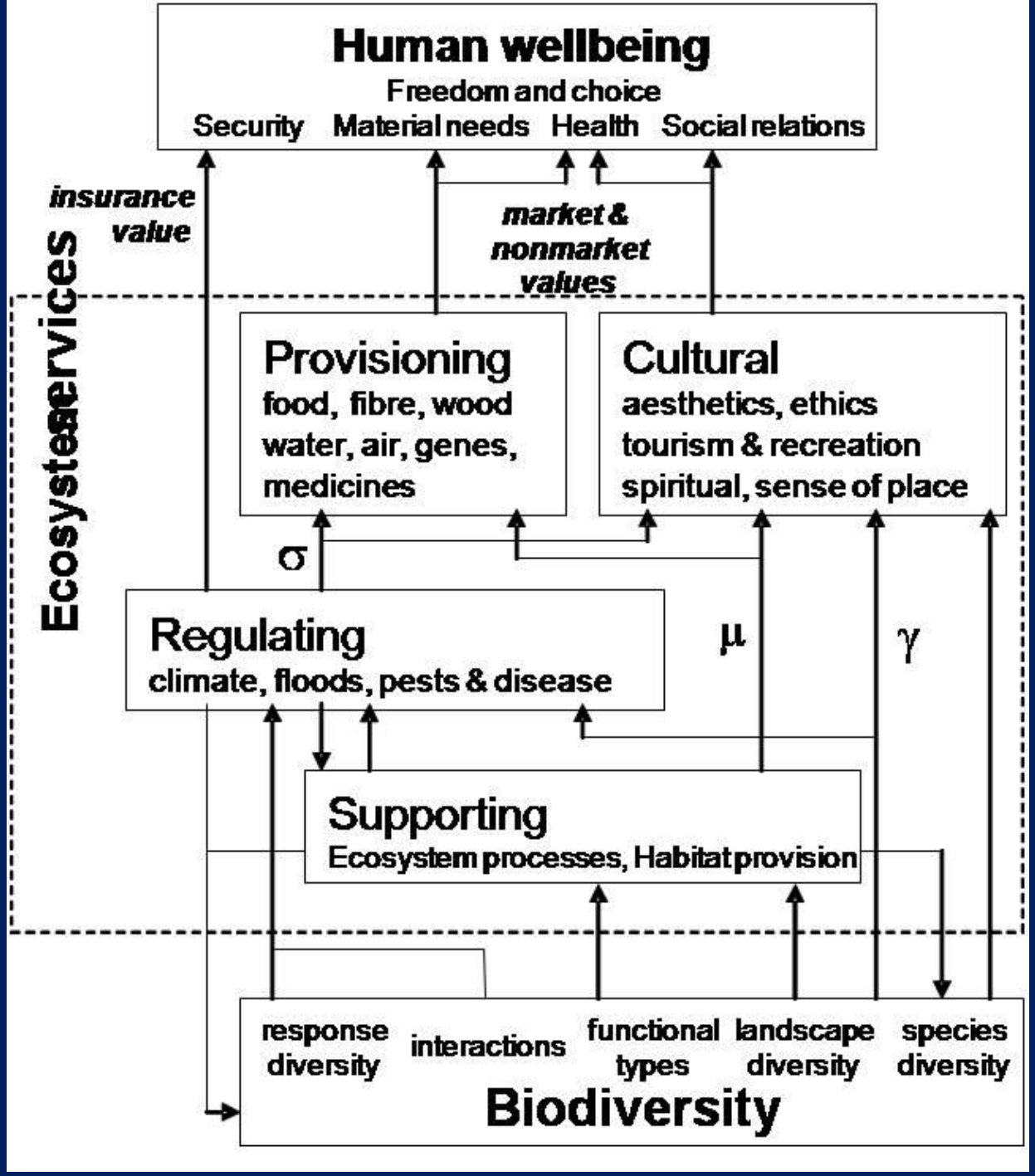
We are losing the biotic riches of the earth—does it really matter outside of major ethical concerns?

The Basic Linkages of the MA



Rapidly developing knowledge base on the delivery chain for ecosystem services


Metrics
Ecosystem services
Clean water, disease protection, recreational opportunities
Ecosystem functioning
Capture, processing and loss of energy water and nutrients
Community structure
Temporal and spatial distribution and abundance of organisms
Ecosystem Service Inputs
Functional groups
The types of functional roles present, e.g. producers, decomposers, etc
Biodiversity
The kinds and numbers of organisms

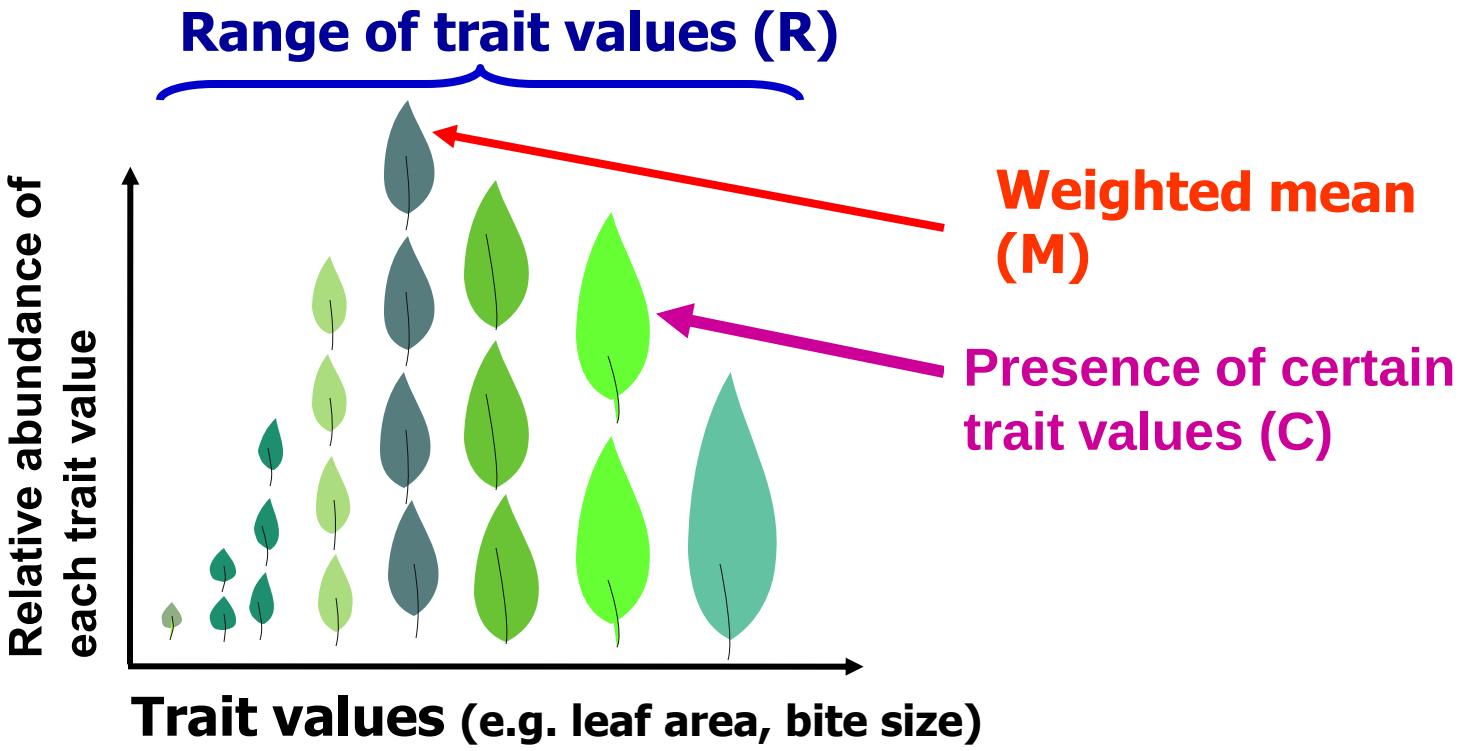


Diaz, Perrings, et al

FUNCTIONAL DIVERSITY

The value, range and relative abundance of the functional traits of the organisms present in a given ecosystem.

(Tilman 1999 Ecology; Díaz & Cabido 2001 *TREE*; Díaz et al. 2007 *PNAS)*



Ecosystem processes *ƒ* (R, M, C)

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Ecosystem services that depend mainly on the traits of the locally most abundant species

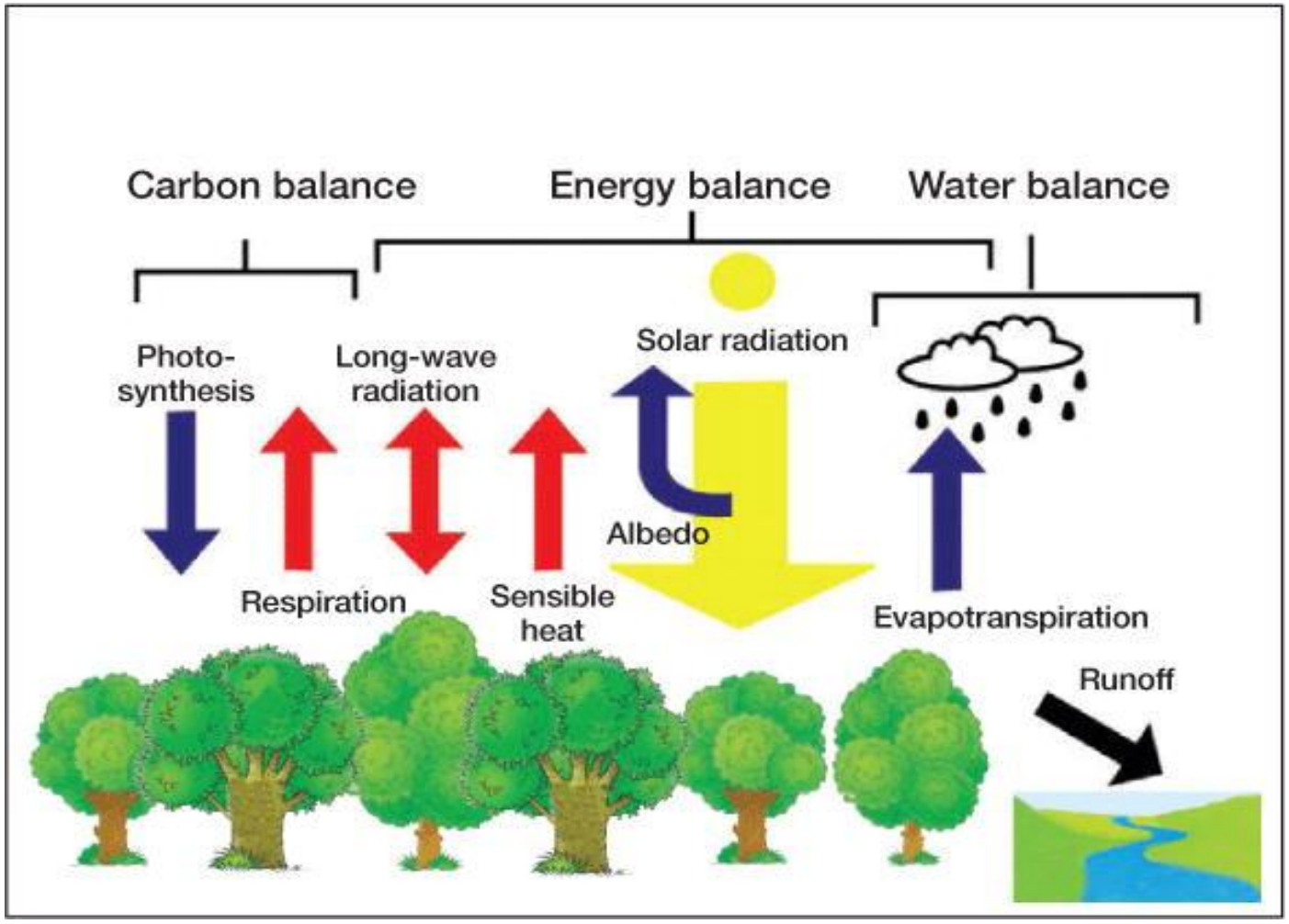
Carbon sequestration
Soil protection

Climate regulation
Protection against natural hazards

Regulation of water quality and quantity

Forage provision

Feedbacks between vegetation and climate



Chapin et al. 2008 ***FREE***

	Leaf physiology & morphology	Canopy size & architecture	Wood mechanical & chemical properties	Root depth & architecture
C storage	✓	✓	✓	✓
Albedo & sensible heat	✓	✓		
Balance between evapotranspiration, infiltration & runoff	✓	✓		✓
Vulnerability (pest outbreaks, fire, storms…)	✓	✓	✓	✓

Chapin et al. 2008 *FREE*
Gough et al. 2008 *Biosci.*
Luyssaert et al. 2008 *Nature*

De Deyn et al. 2008 *Ecol. Lett.*
Díaz et al. 2009

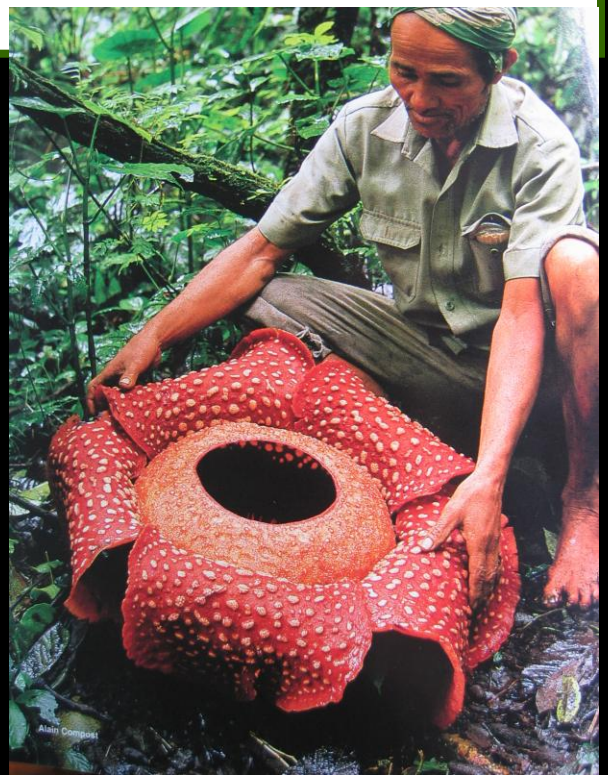
Ecosystem services that depend mainly on the presence of organisms with a a wide RANGE (variety) of functional traits.

Food security in subsistence agriculture

Aesthetic enjoyment

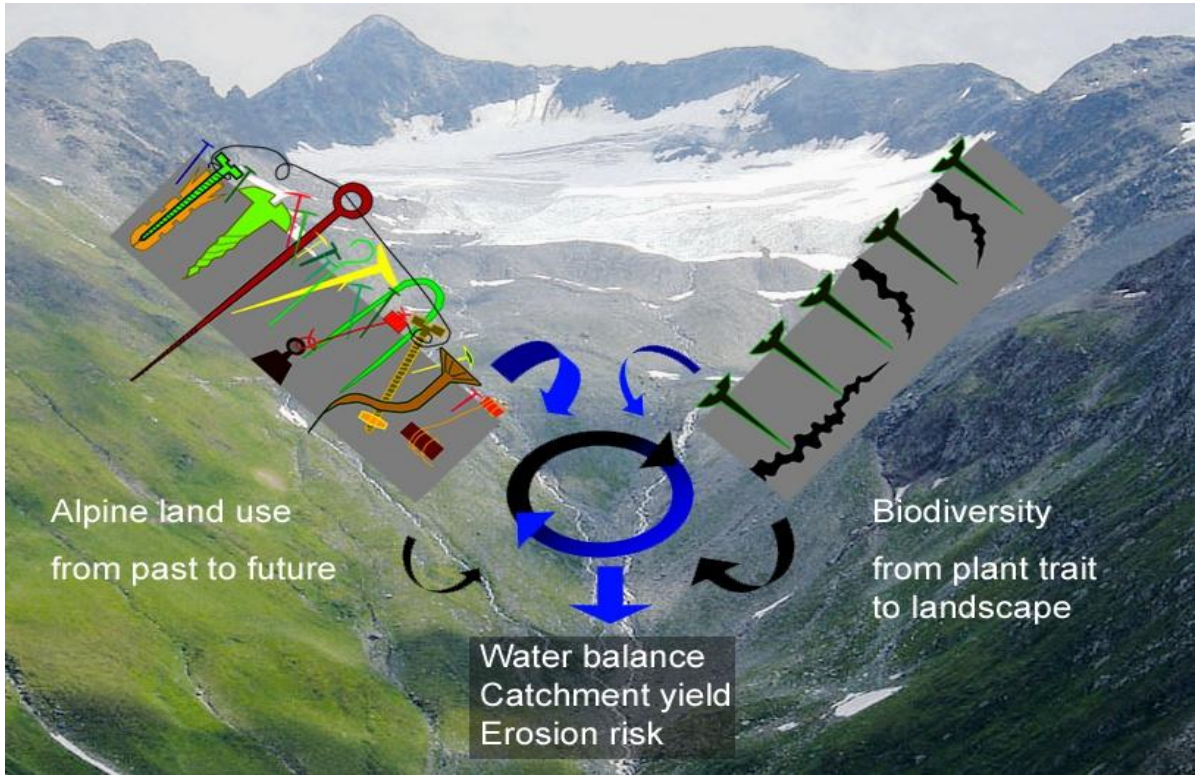
Ecosystem services depend on the presence of certain species

Cultural ecosystem services:
Sense of place and identity
Aesthetic enjoyment
Religious and spiritual
Ecotourism



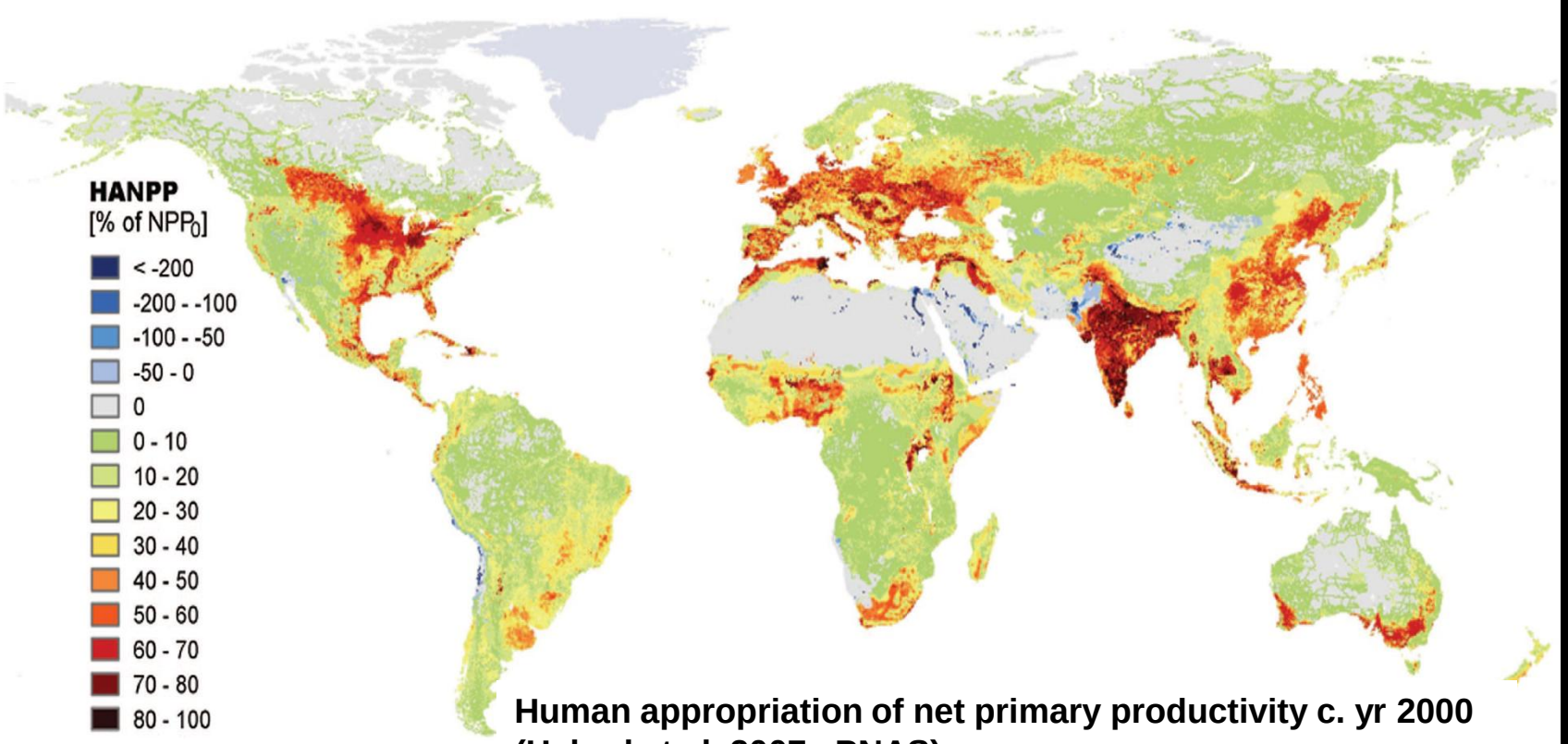
DIVERSITAS
an international programme
of biodiversity science

Land use and biodiversity effects on catchment value in mountains



European Alps (Switzerland, Austria, and France), Caucasus (Georgia), Andes (Altiplano/Bolivia) & Himalayas (Tibet/China, starting in 2009)

C. Korner



Human appropriation of net primary productivity c. yr 2000 (Haberl et al. 2007, PNAS)

The provision of many ecosystem services is scale-dependent.

The minimum ecosystem size required for sustained provision varies widely among different services.

GLOBALCHANGE DRIVERS

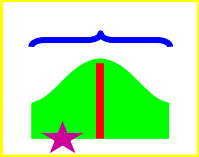
. Climate
. Biogeochemical cycles
. Land use
. Biotic exchanges

HUMAN WELL-BEING

. Material minimum
. Health
. Shelter and safety
. Good social relations
. Freedom of choice

Different social groups value different services

FUNCIONAL DIVERSITY



ECOSYSTEM SERVICES

. Food, fibre, fuel
. Genetic resources
. Medicines
. Education &recreation
. Sense of place
. Religious & spiritual

ECOSYSTEM PROCESSES

. Productivity
. Nutrient cycling
. Evapotranspiration
. Dynamic stability

. Habitat provision
. Soil fertility
. Water regulation
. Climate regulation
. Disease & pest regulation
. Erosion control

Different priorities, expectations, access to power

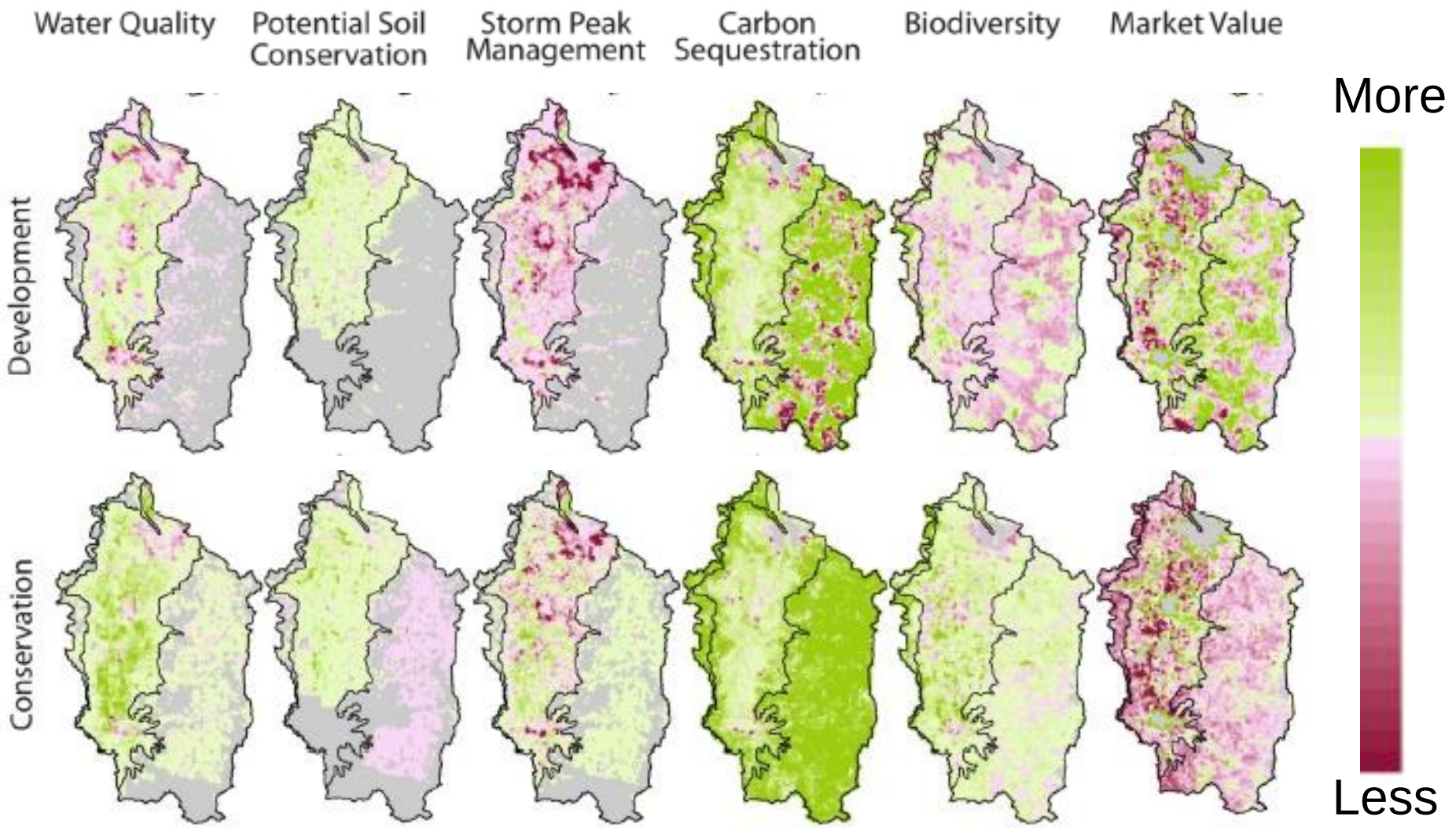
Trade-offs, alliances and conflict

S. Diaz

We need a social analog to this ecosystem analysis that encompasses values, institutions, governance, poverty level, networks, etc so we can make predictions of potential outcomes to change

Mapping ecosystem services on the landscape

Mapping change



Willamette Valley, Natural Capital Project ,Polasky

InVEST 1.0 Beta can map

natural capital PROJECT

Biodiversity

Water pollution regulation

Carbon sequestration

Managed timber production

Crop pollination

Avoided reservoir sedimentation

The next version of InVEST will add

natural capital PROJECT

Tourism and recreation

Agricultural production

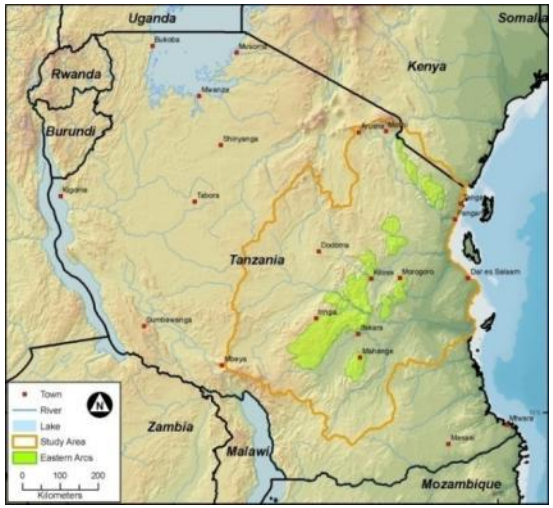
Flood mitigation

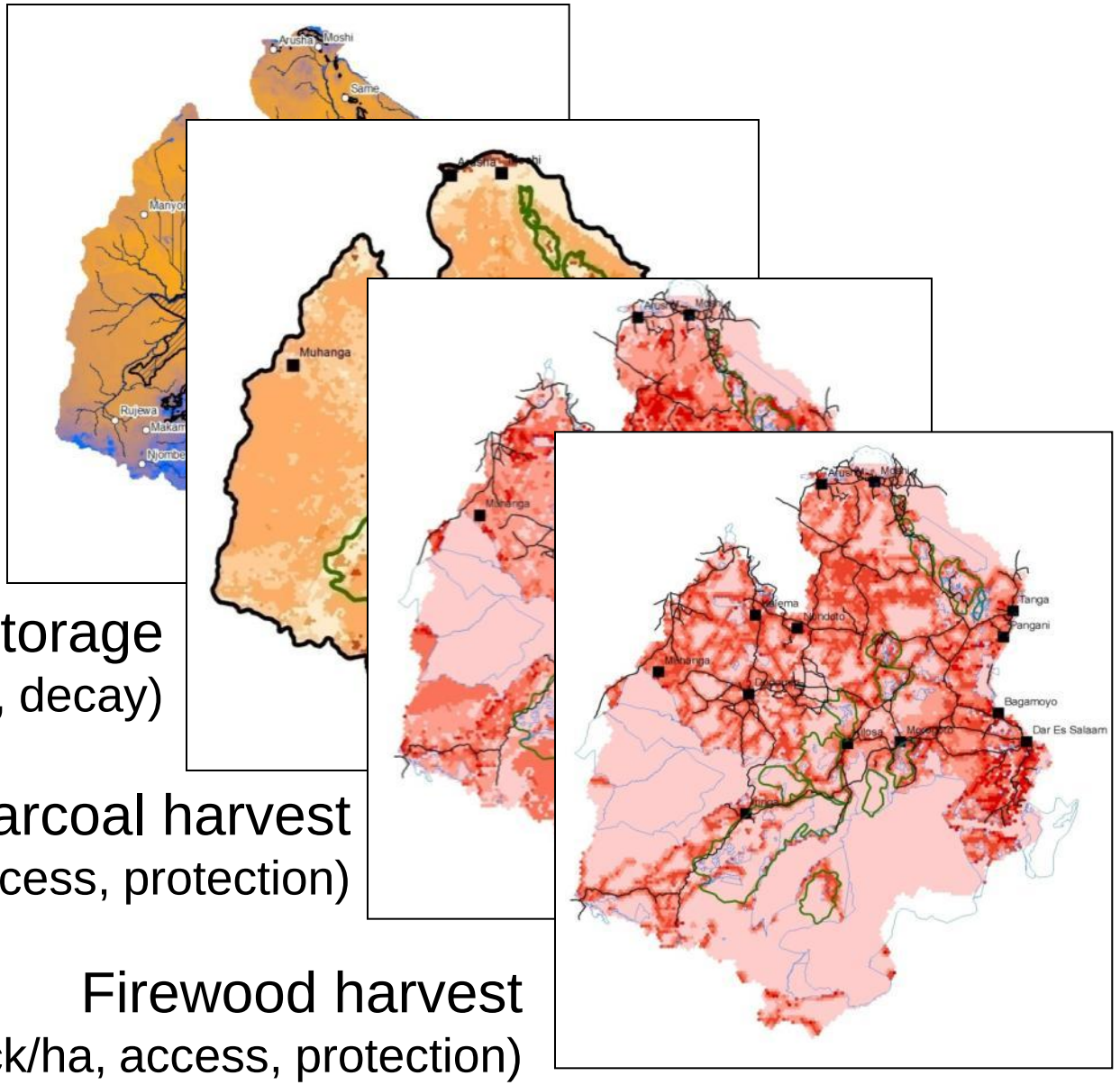
Hydropower production

Irrigation

Open access products

The Arc region of Tanzania





Water yield
~f(rain, ET, topo, soils)

Carbon storage
~f(storage/ha, harvest, decay)

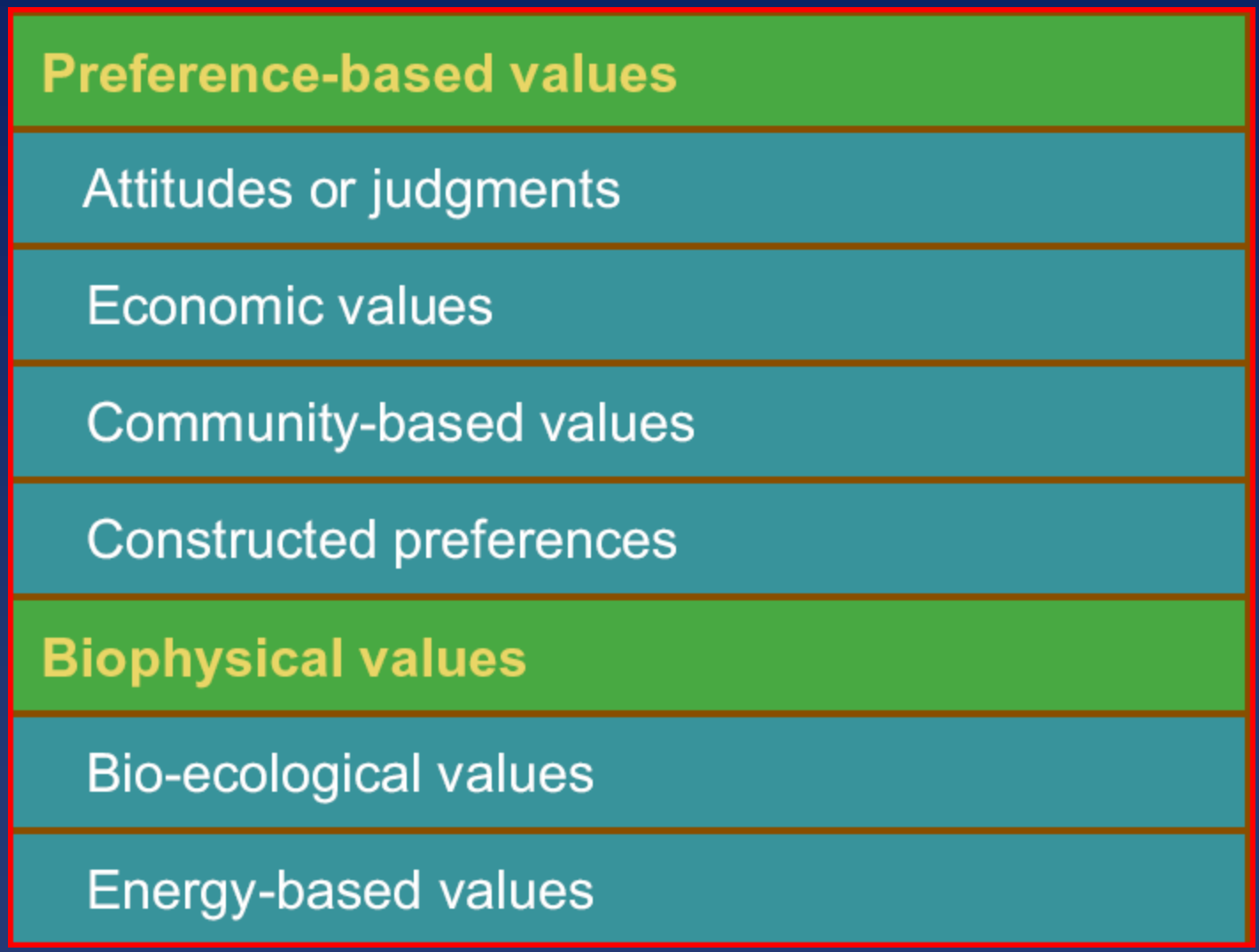
Charcoal harvest
~f(stock/ha, access, protection)

Natural Capital
Project-Ricketts

Firewood harvest
~f(stock/ha, access, protection)

Once ecosystem services are mapped then landscape level valuation can be made—lots of activity in the valuation arena

On Valuation

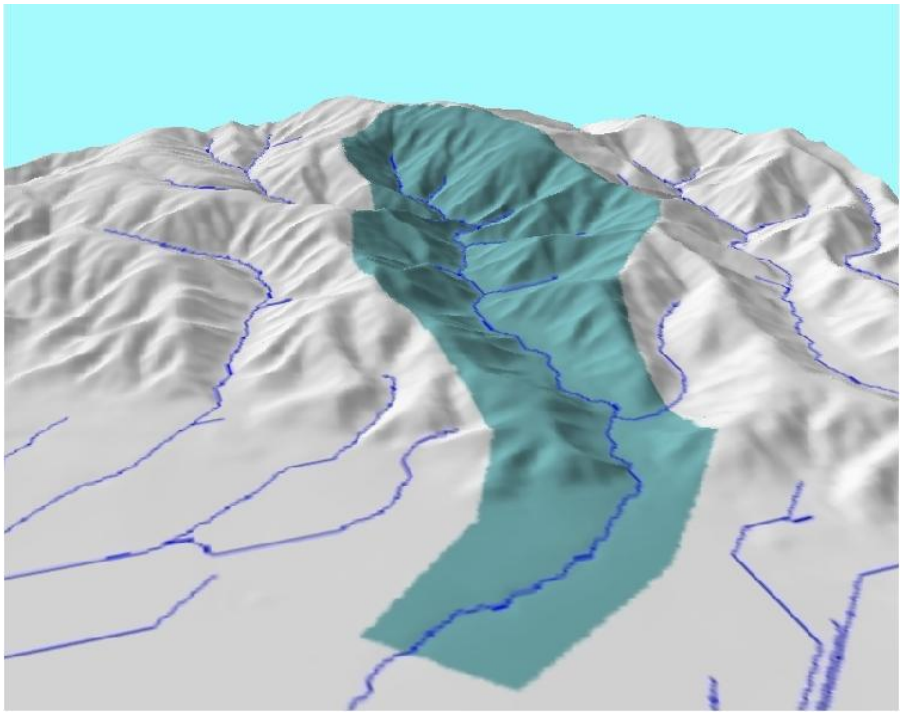


EPA, 2009

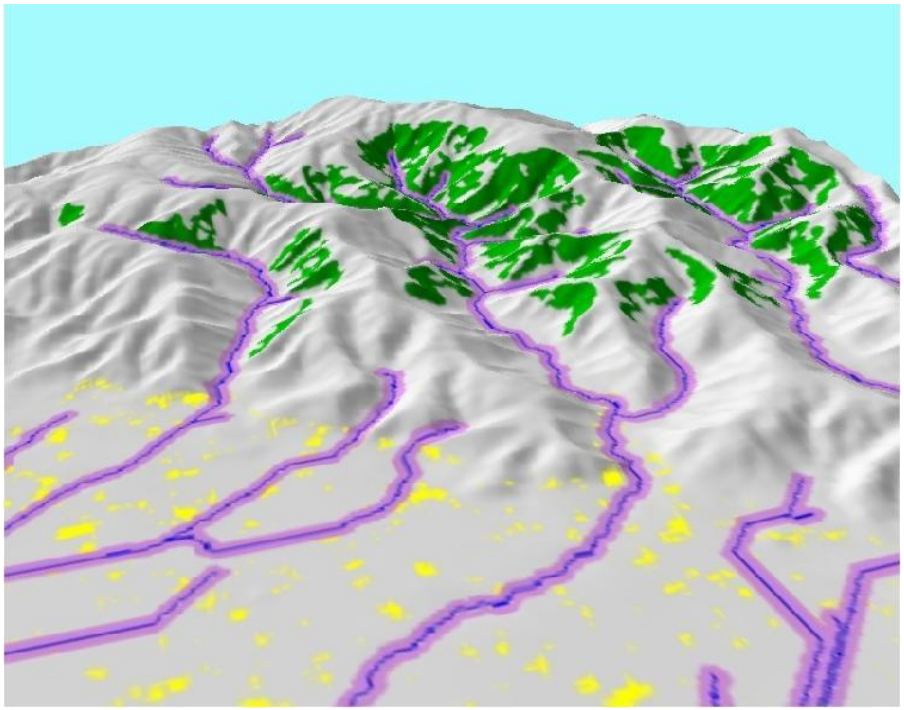
Can human intervention enhance and conserve biodiversity and ecosystem services ?

Congruence of Conservation Priorities?

Biodiversity Focus



Ecosystem Services Focus



(Balvanera et al. 2001 *Science*)

Maas, et al.

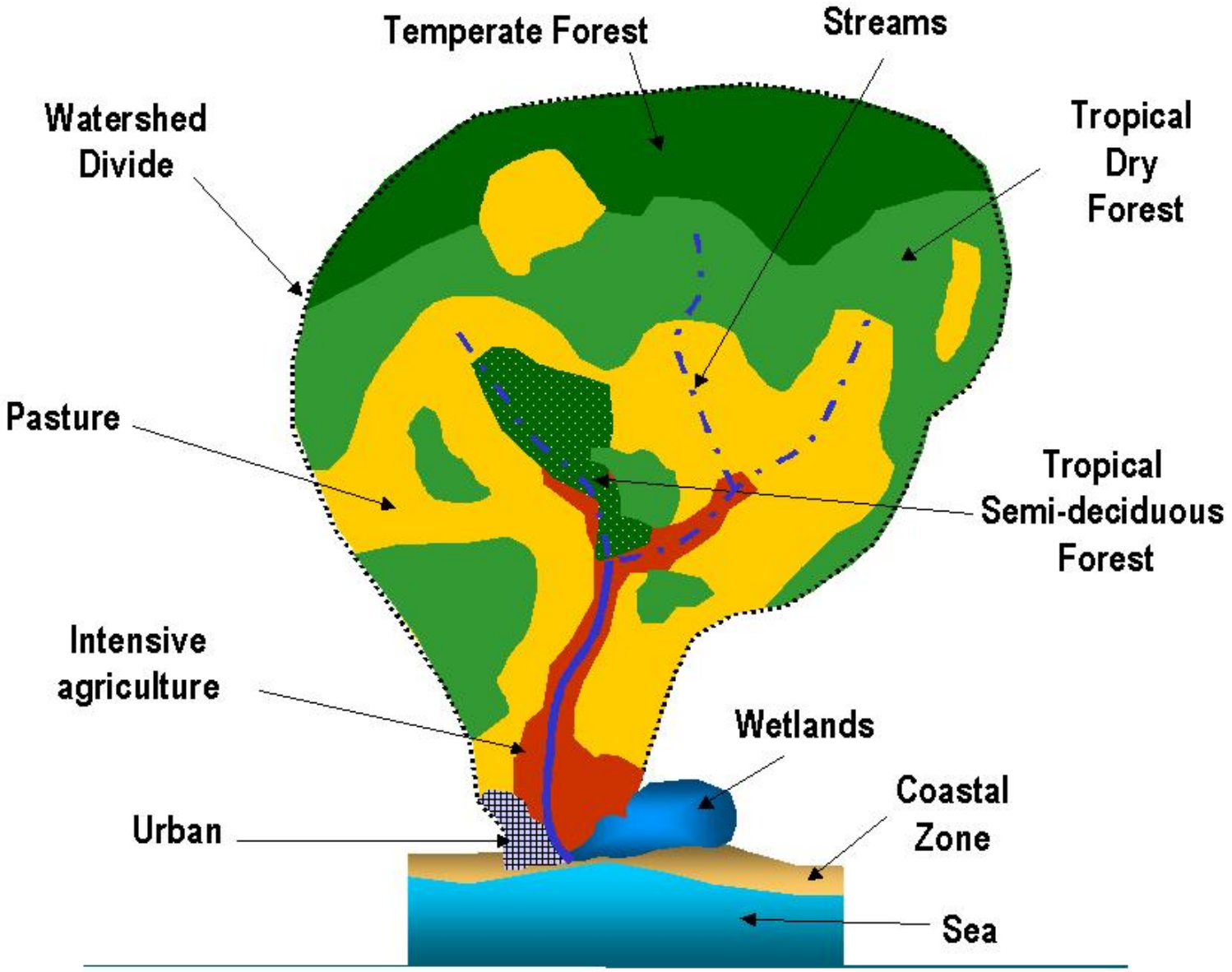


FIG. 3

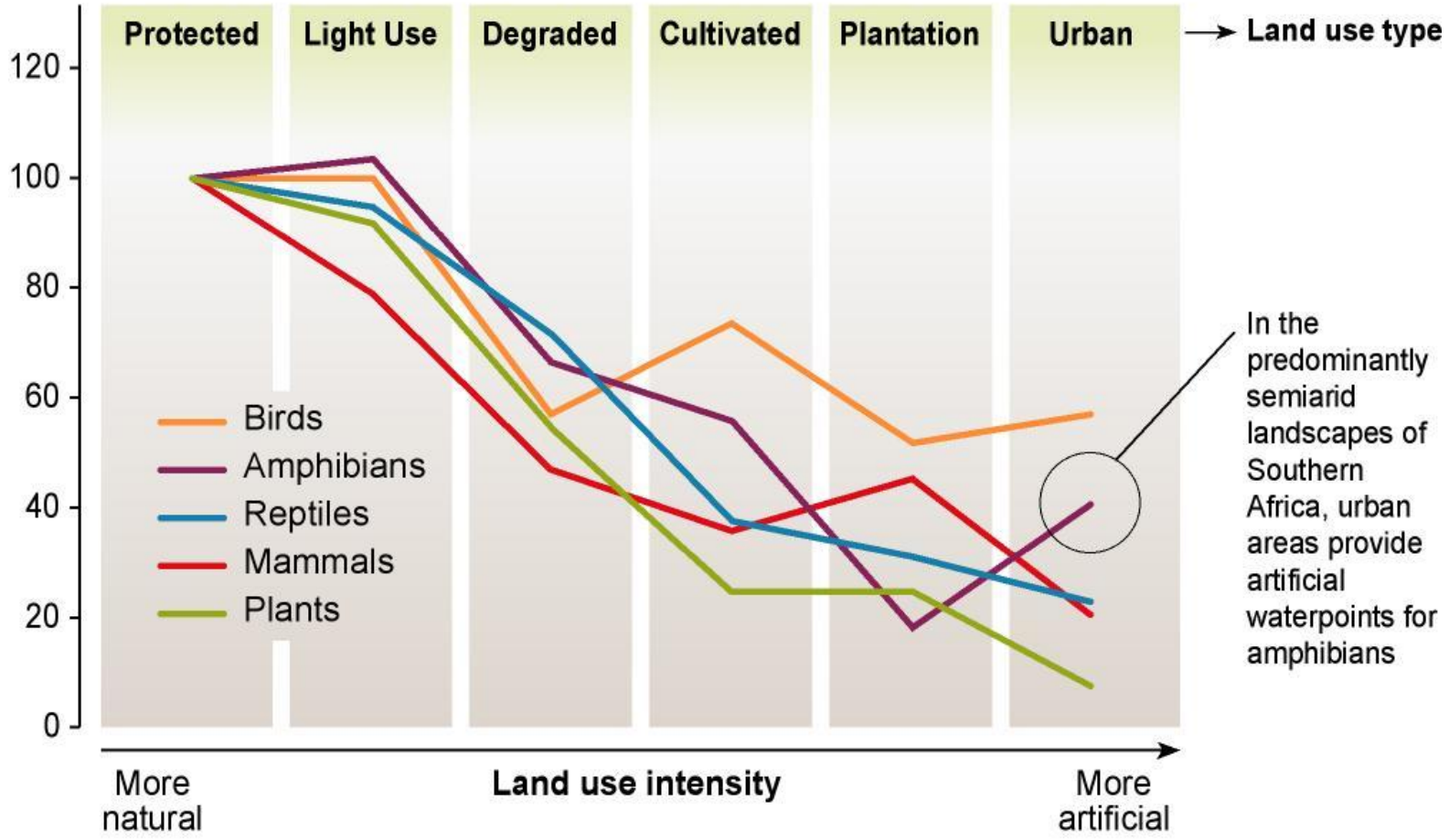
Freshwater

Soil fertility maintenance

Bioregulation

Maas, et al.

Average remaining percentage of population under each land use
compared with the pre-colonial period (index =100), 300 years ago



Protected areas: assumed to have intact biodiversity and therefore used as a reference
Light use: natural vegetation productively used (e.g., for grazing) within the limits of sustainability
Degraded: natural vegetation where intensity of use exceeds the natural productive capacity
Cultivated: cropland and planted pastures
Plantation: monocultures of exotic trees, mainly eucalyptus and pine species
Urban: built-up urban and high-impact mining landscapes

Source: Scholes and Biggs 2005

Some community-based examples of biodiversity conservation coupled to human use of landscapes

Translating traditional knowledge into global metrics

Re-inventing lost ways of managing productive landscapes

Multifunctional traditional Mediterranean landscapes

"Multifunctionality at the landscape level integrates the various functions in the same space and is highest when maintained at various levels—field, farm and landscape"

These systems "offer a broad variety of functions that nowadays are much more valued than the agricultural value itself."

Pinto-Correia,2004

“Multifunctional agriculture is recognized as crucial for maintaining the viability of rural areas in Europe and has particular significance for resource and nature conservation”

Sal and Garcia, 2007

This systems have co-evolved with society over centuries and are resilient to interannual climate variability

Spanish Dehesa landscape

http://zapico.aminus3.com/image/2009-03-26.html

http://commons.wikimedia.org/wiki/File:Dehesa_Pigs

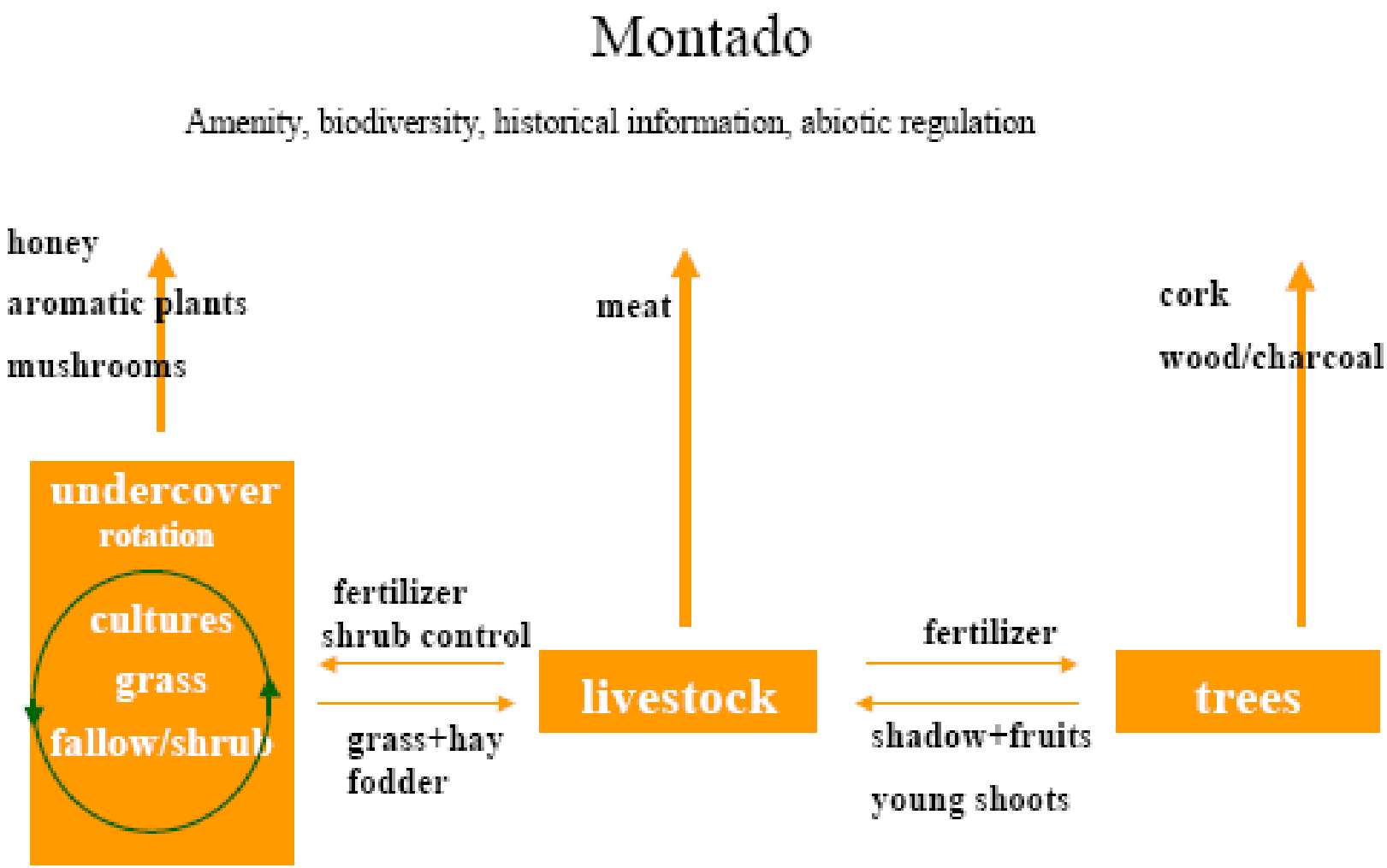
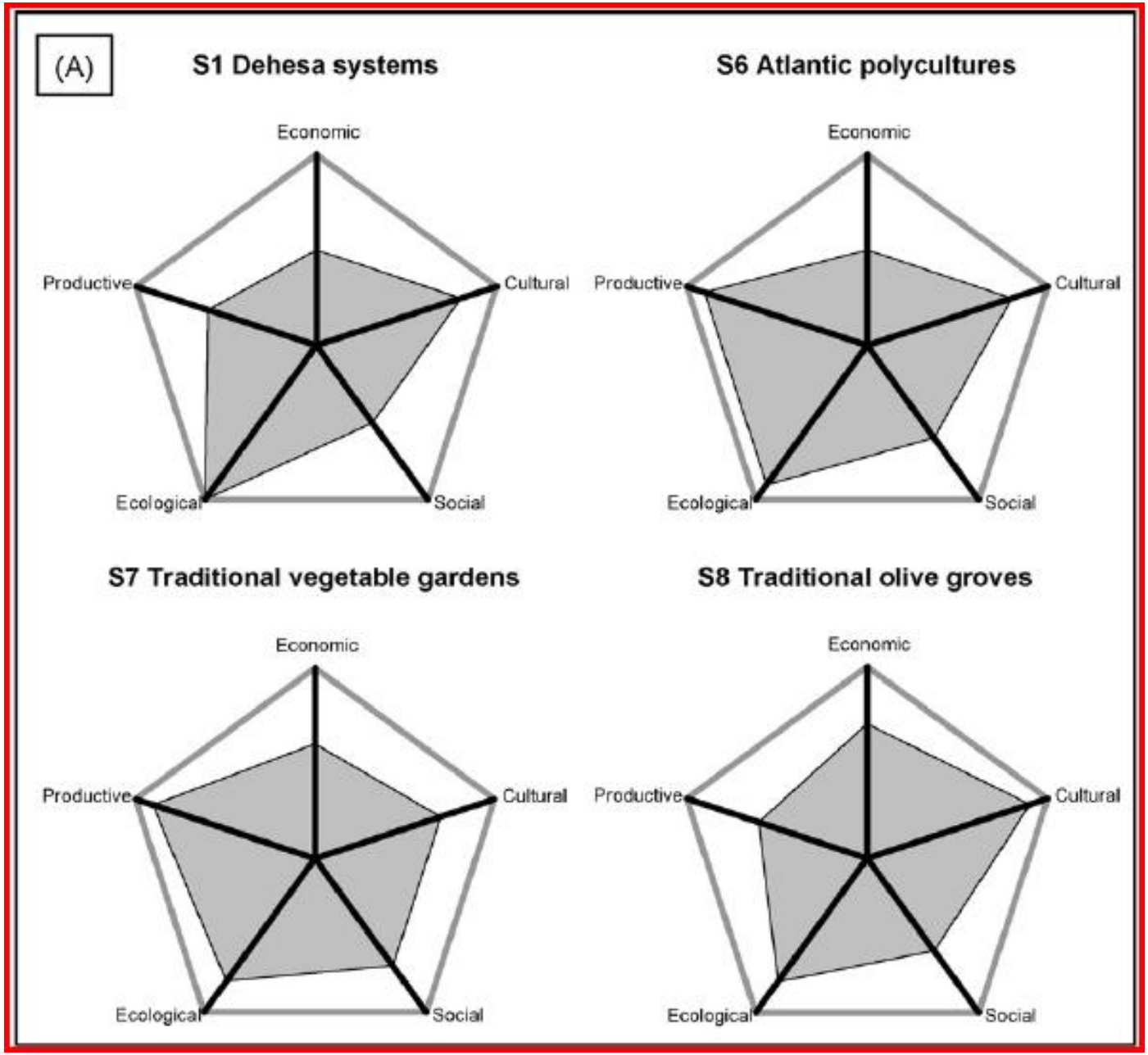
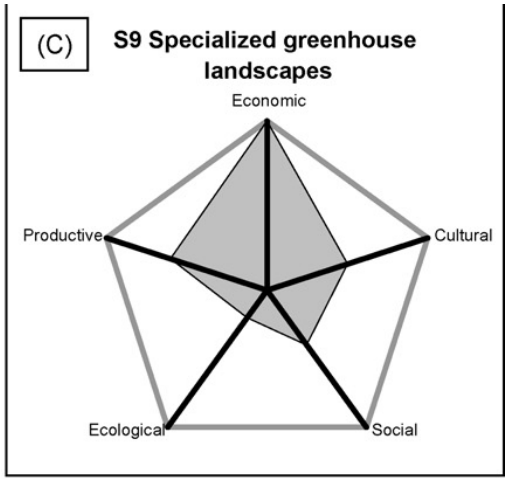


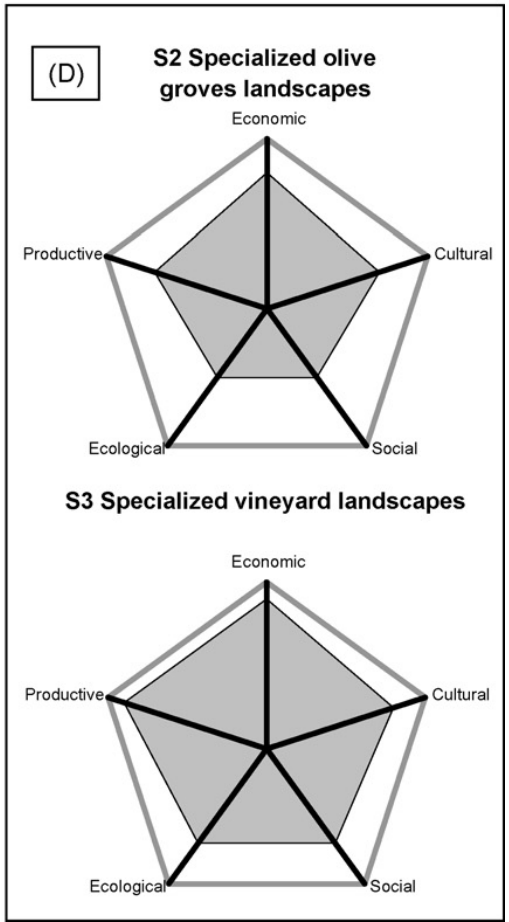
Figure 13. Scheme of the *montado* land-use system

Pinto-Correia and Vos, 2004

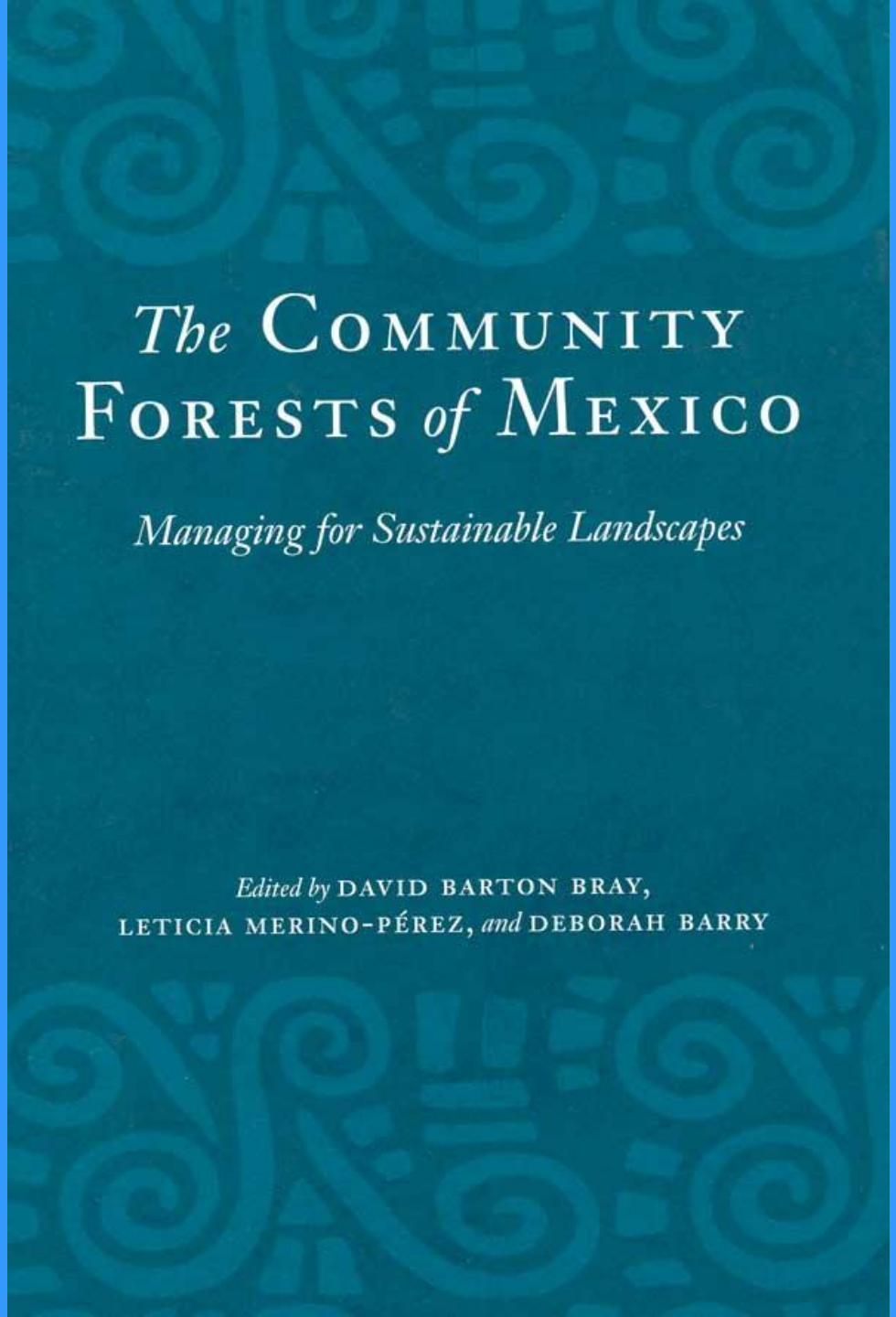


Sal and Garcia. 2007





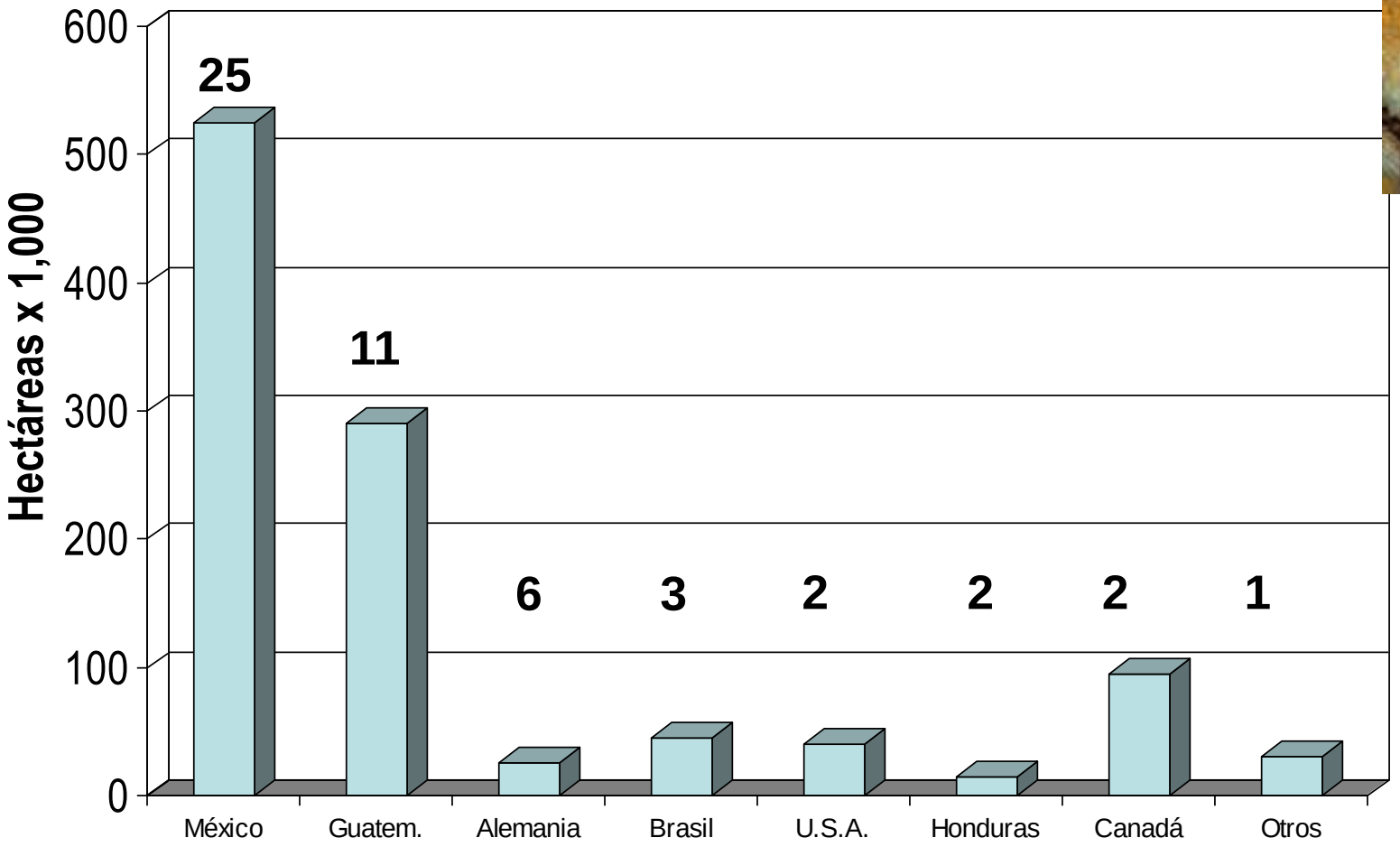
Sal and Garcia. 2007



UT Press, 2005

Courtesy J. Sarukhán

Number of certified communal forests (data for 2000, now we have in Mexico 43 certified enterprises and just under 1 million ha.)



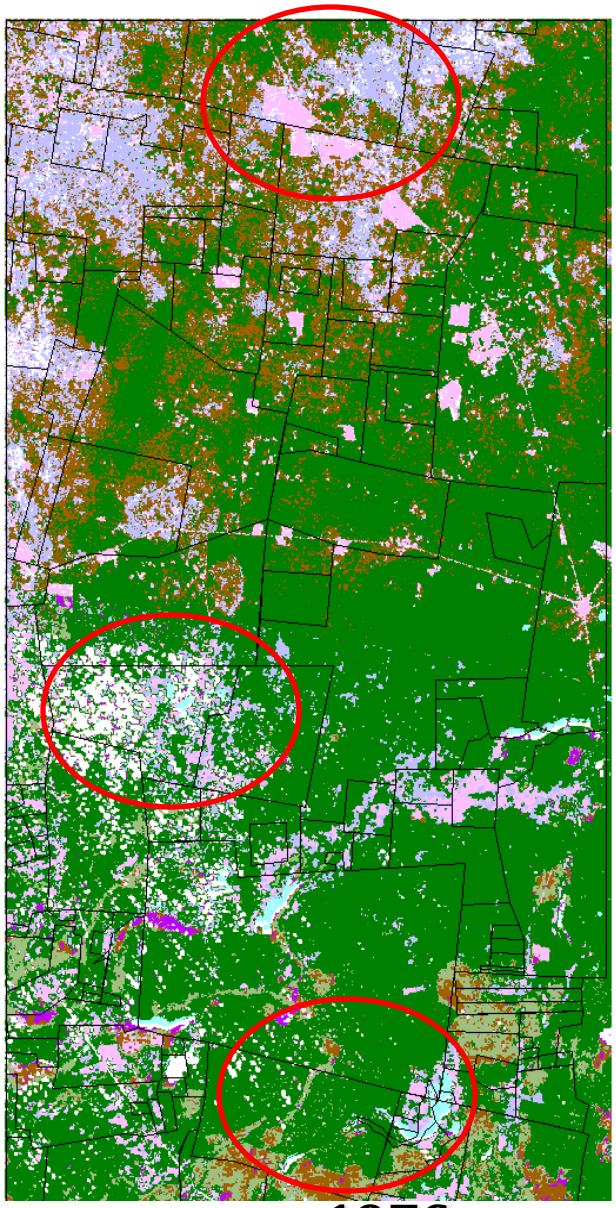
Courtesy Sarukhán

Contributions of communal forest enterprises

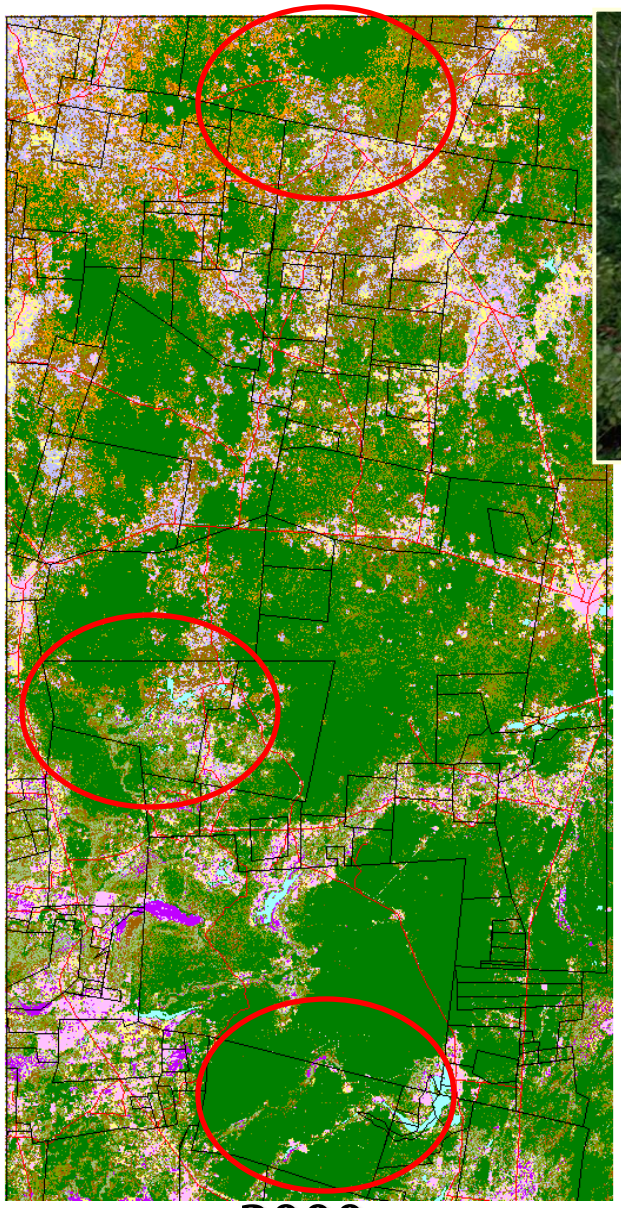
- Employment, better salaries and employment benefits (social security, etc.)
- Reinvestment of benefits to strengthen the communal industry
- Social investments in community infrastructure and social well being (clinics, schools, etc.)
- Equitable profit sharing
- Conservation of Natural Capital and the ecosystem services it provides

Courtesy J. Sarukhán

Conservation effects of comunal forestry management



1976



2000

“Zona Maya” Carrillo Puerto, Q. Roo

Análisis realizado por la Universidad de Quintana Roo

Management of forests protects original vegetation as much as Natural Protected Areas

The new drivers of change

Prepare for an uncertain future

- *A world of rapid change in climate and biota with unique combinations arising*
- *A world of increasing extreme events*
- *A world of weeds and diseases*
- *A world of regime shifts*
- *A world of rising seas and acidifying oceans*
- *A world that has been diced and replumbed*
- *A world of increasing nitrogen and phosphorus redistribution*
- *A world of venture capital moving quickly among nations to places of investment "opportunity" and often environmental sensitivity (shrimp farms, biofuels, etc)*

Japan virtual benefits from imports for pigs and poultry production

- *290, 000 tons of N lost to environments in other countries*
- *Save 5% of total Japanese water use*
- *Save 50 % of total arable land in Japan*

Galloway, et al, Ambio 2007

Good news—nations poor in given resource can trade with those rich in these resources—eg. virtual water

Bad news-invasion vulnerability is related to trade intensity
-trade does not take into account left behind externalities

We are already seeing dramatic changes in response to climate change

Not only are we seeing species shifts in distributions but also differential movement of species thus the beginnings of the formation new community types

We are seeing examples in both terrestrial and marine systems of trophic interactions being broken by differential phenological responses of hosts and herbivores

So what do we need to do?

Develop an integrated system for mapping the stocks and flows of ecosystem services, and their values

Strengthen the understanding of the linkages among biological diversity, ecosystem functioning, ecosystem services and societal needs and adaptability

Develop conservation, restoration and natural resource management plans that are proactive and based on maximizing ecosystem service delivery, considering tradeoffs among services, and that are resilient to projected global changes.

These plans must take into account that we may not be able to manage to return natural ecosystems to previous states or conditions

Building Societal Resilience

Adaptive capacity, the incremental and frequent adjustments by business and social actors undertaken more or less daily to deal with change in order to maintain the status quo, *i.e. to sustain the current development pathways,* versus

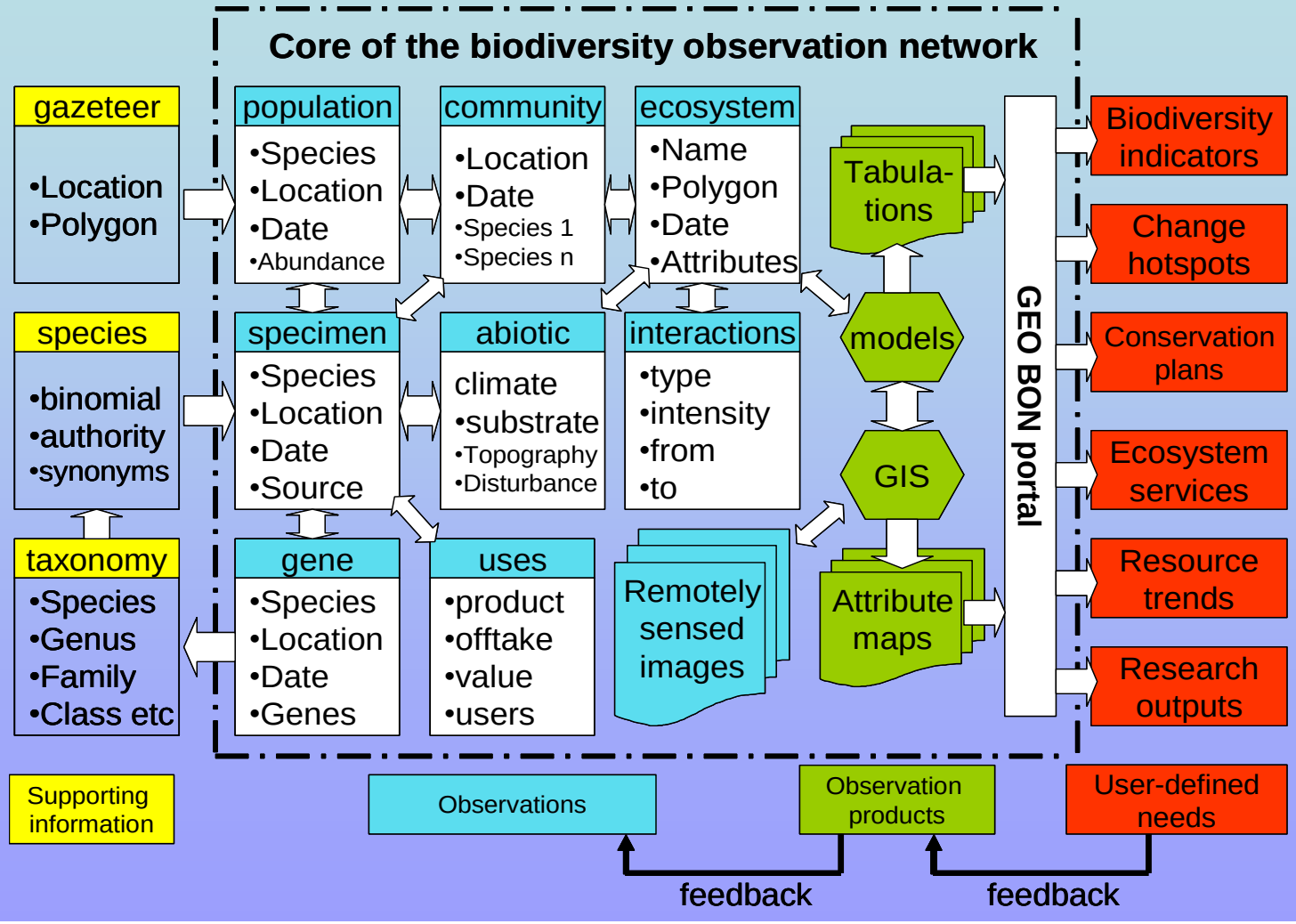
Transformative capacity, the ability to *fundamentally alter* the nature of the system over the long-term, when current ecological, social, or economic conditions become untenable or are undesirable.

A new integrated research program on ecosystem services and human well-being (focuses on place based studies) PECS

Adds to Diversitas' efforts on Biodiversity and Ecosystem Services

International Council for Science, UNU, UNESCO initiative

An integrated biodiversity observation system



GROUP ON EARTH OBSERVATIONS

Biodiversity
Observation
Network

Need to make the regional and national BON's compatible

JBON, Asia Pacific BON, EBONE, NEON, etc

While repeatable metrics of biodiversity elements are established

Thank You