Human-environment interaction and methods to analyze

Ecosystem Services

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“the most subtle and dangerous threat to man’s existence… is the potential destruction, by man’s own activities, of those ecological systems upon which the very existence of the human species depends” (Ehrlich and Ehrlich, 1970)

Outline

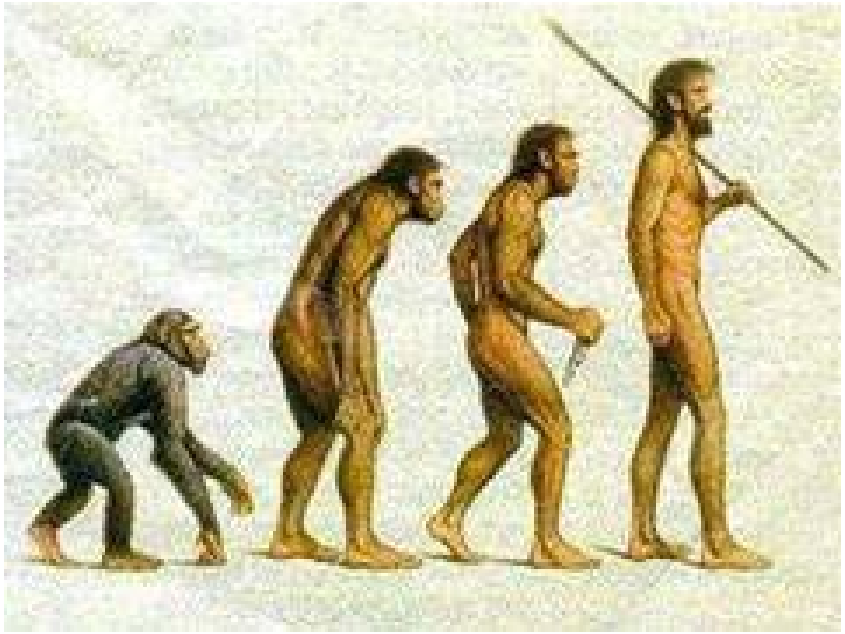
- human and environment
- ecosystem services: basic concepts
- Millennium Ecosystem Assessment (MA)
- valuing ecosystem services
- ecosystem services trade-off
- supply, demand, mapping and spatial relation

Human and environment : conflict or harmony?

conflict?

harmony?

human…



Homo economicus is a term used for an approximation or model of *Homo sapiens* that acts to obtain the highest possible well-being for himself given available information about opportunities and other constraints, both natural and institutional, on his ability to achieve his predetermined goals.

... humans have consciousness and targets.

environment…

Environment, consisting of *ecosystems*:

Any area of nature that includes living organisms and non-living substances that interact to produce an exchange of materials between the living and nonliving parts is an ecological system or ecosystem.

E. P. Odum (1959)

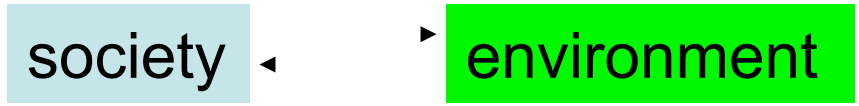
Nature is complex …
… elements, subsystems, relations
… living and non-living compartments
… structures, functions, organization
… direct effects and indirect effects
… local and delocalized effects
… short term and long-term effects

There are patterns in human behavior, related to groups, social structures and the *environment.*

Human behaviors are generally patterned and repetitious; hence we can analyze and model them with systems analytical tools.

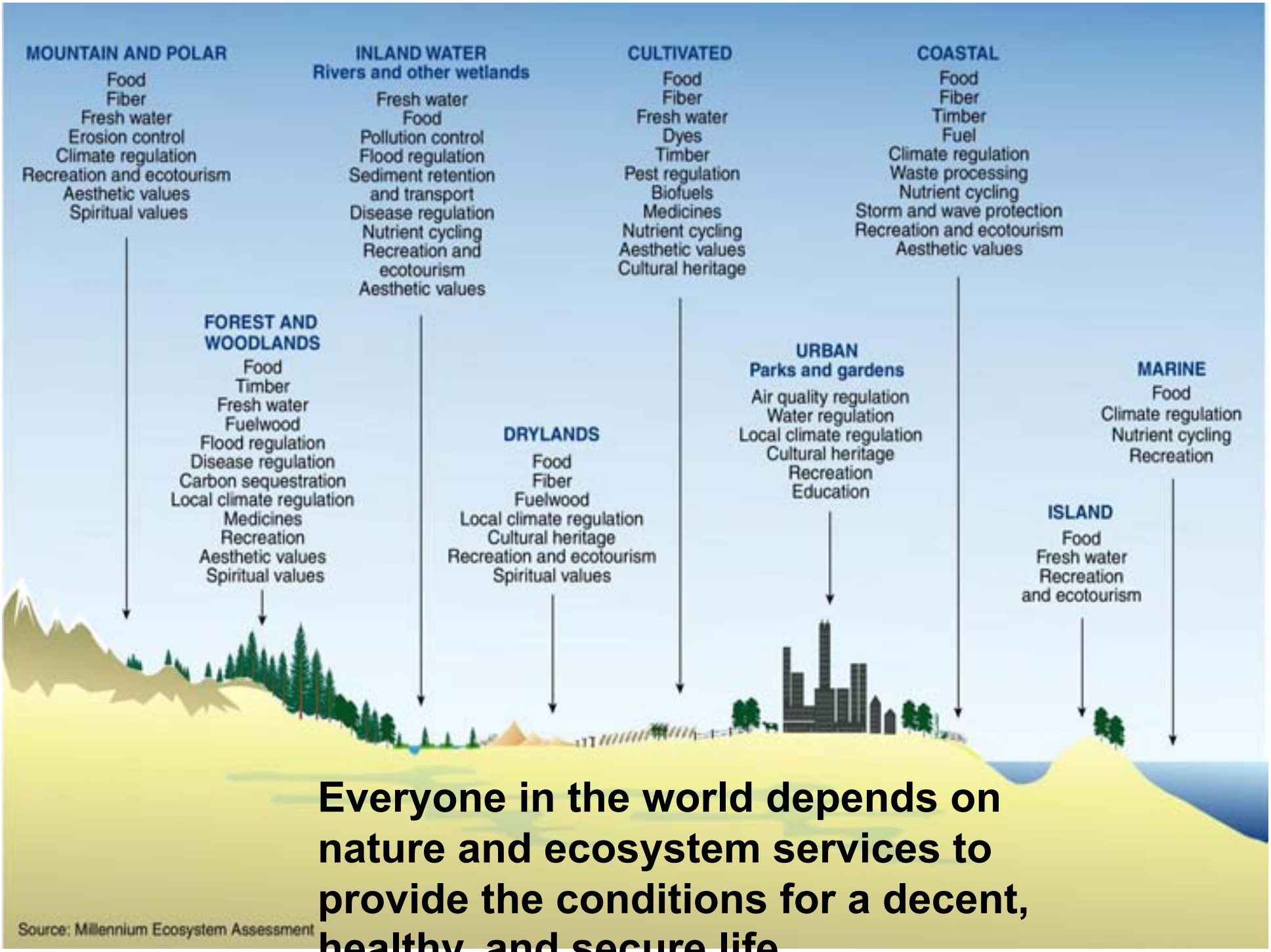
We can look for *patterns* and *processes* in human-environmental-systems.

- how people have an impact on the environment
- how the environment has an impact on people



in general….

- people are **changing** their environment
- ... sometimes with heavy **consequences** for the environment
- people‘s actions have **consequences** on the environment
- environment **influences** human activities
- people are obtaining **benefits** from their environment



Everyone in the world depends on nature and ecosystem services to provide the conditions for a decent, healthy, and secure life

Brief history/background

- One of the first to understand the concept was Plato (*c.* 400 BC) who realized that deforestation could lead to soil erosion and the drying up of springs.
- Marsh in 1864 suggested that Earth's natural resources were not unlimited by pointing to changes in soil fertility in the Mediterranean.
- Three key authors, Osborn (1948), Vogt (1948), and Leopold (1949) promoted the recognition of human dependence on the environment with the idea of 'natural capital'
- In 1956, Sears brought attention to the critical role of the ecosystem in processing wastes and recycling nutrients.
- The term 'environmental services' was finally introduced in a report of the Study of Critical Environmental Problems in 1970, which listed services including insect pollination, fisheries, climate regulation and flood control.
- In the succeeding years, variations of the term were applied but eventually 'ecosystem services' became the standard in the scientific literature.

Definitions

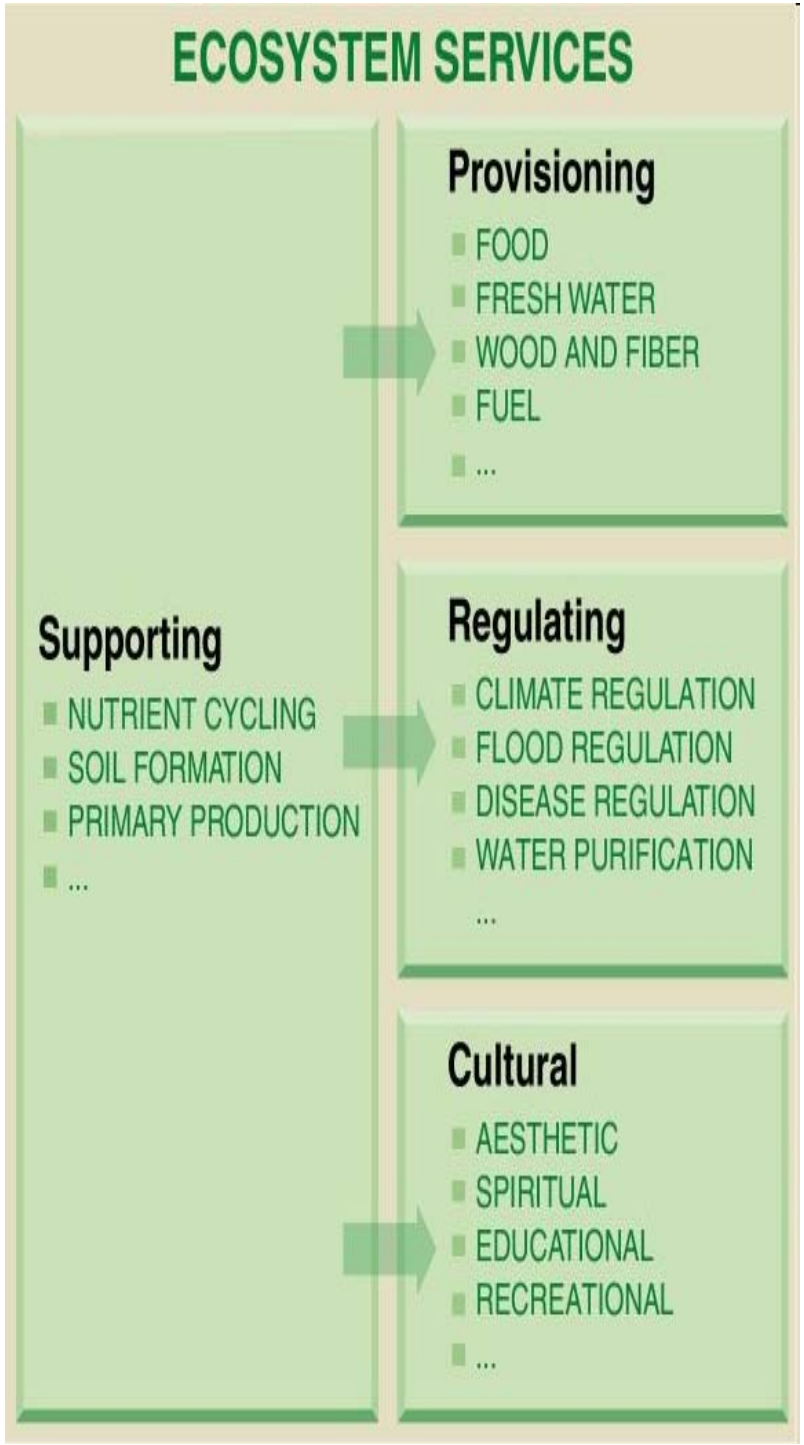
- The conditions and processes through which natural ecosystems and the species that make them up, sustain and fulfill human life. (Daily, 1997)

- The benefits human populations derive **directly or indirectly** from ecosystem functions. They consist of flows of materials, energy and information from natural capital stocks which combine with manufactured and human capital services to produce human welfare.
  (Constanza *et al.*, 1997)

- The benefits people obtain from ecosystems. **These include provisioning, regulating, and cultural services that directly affect people and the supporting services needed to maintain other services**. (M

ES classes

- ***Provisioning services*** which are the products obtained from ecosystems, including food, fiber, fuel, genetic resources, ornamental resources, freshwater,…
- ***Regulating Services*** which are the benefits obtained from the regulation of ecosystem processes including air quality regulation, climate regulation, water regulation, ...
- ***Cultural Services*** which are the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development,.. and aesthetic experiences, including cultural diversity, spiritual and religious values, knowledge systems...
- ***Supporting services*** which are necessary for the production of all other ecosystem services. These services include soil formation, photosynthesis, primary production, and nutrient and water cycling…



Millennium Ecosystem Assessment (MA)

- demands from both scientists and policymakers
- by the mid-1990s, many individuals involved in the work of international conventions such as the Convention on Biological Diversity (CBD) and the Convention to Combat Desertification (CCD) realized that the extensive needs for scientific assessments
- IPCC did exist for climate change study but was not for ecosystem change
- identified a need for an international ecosystem assessment
- existing study poorly reflected in policy discussions concerning ecosystems
- recognizing these shortcomings, a panel of 40 leading scientists prepared a draft international assessment
- The study, published in November 1998 by UNEP, NASA, and the World Bank, called for “a more integrative assessment process for selected scientific issues, a process that can highlight the linkages between questions relevant to climate, biodiversity, desertification, and forest issues.”

Millennium Ecosystem Assessment (MA)

Experts and Review Process

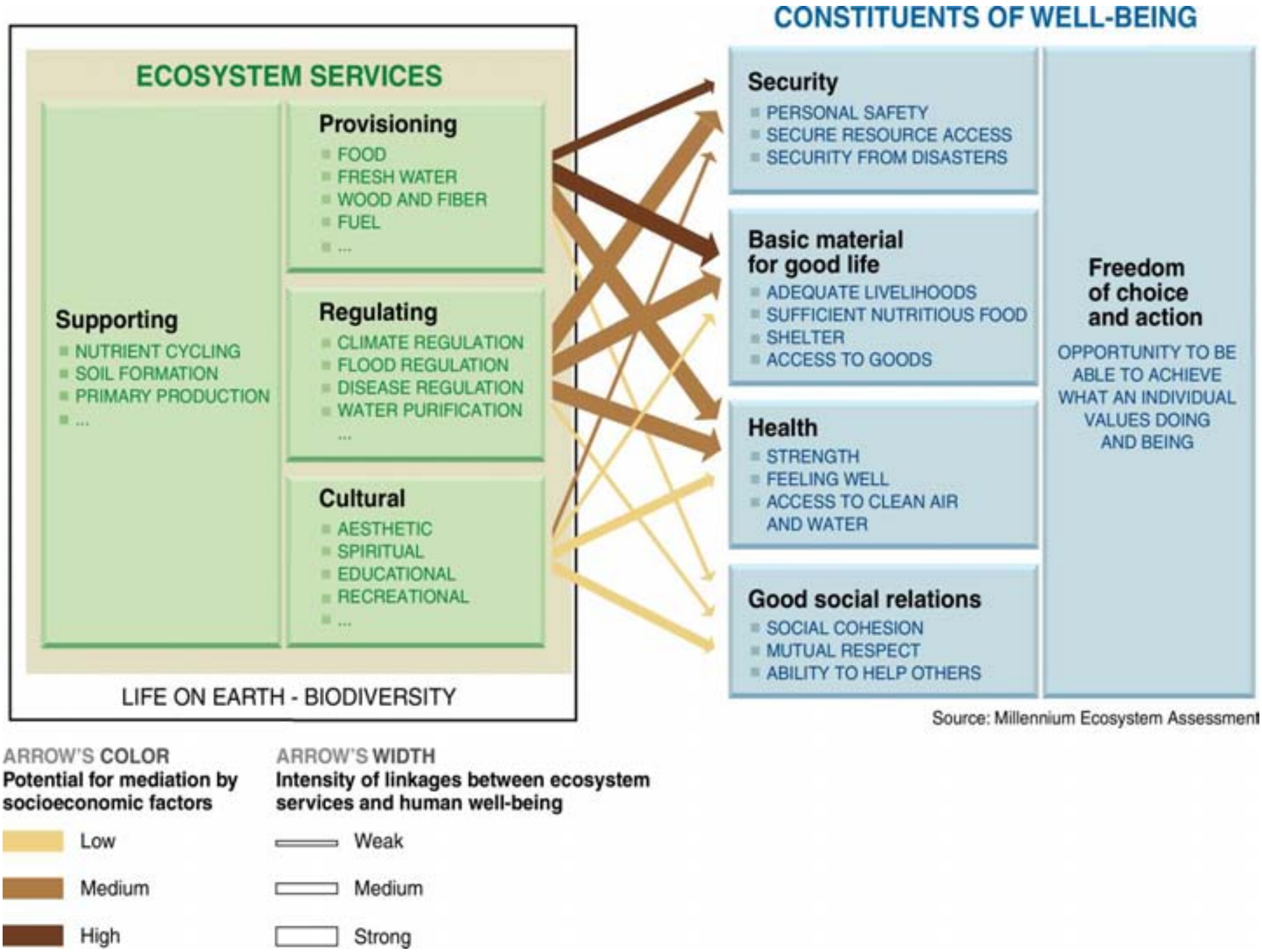
- Prepared by 1360 experts from 95 countries
- 80-person independent board of review editors
- Review comments from 850 experts and governments

Governance

- Called for by UN Secretary General in 2000
- Authorized by governments through 4 conventions
- Partnership of UN agencies, conventions, business, non-governmental organizations with a multi-stakeholder board of directors

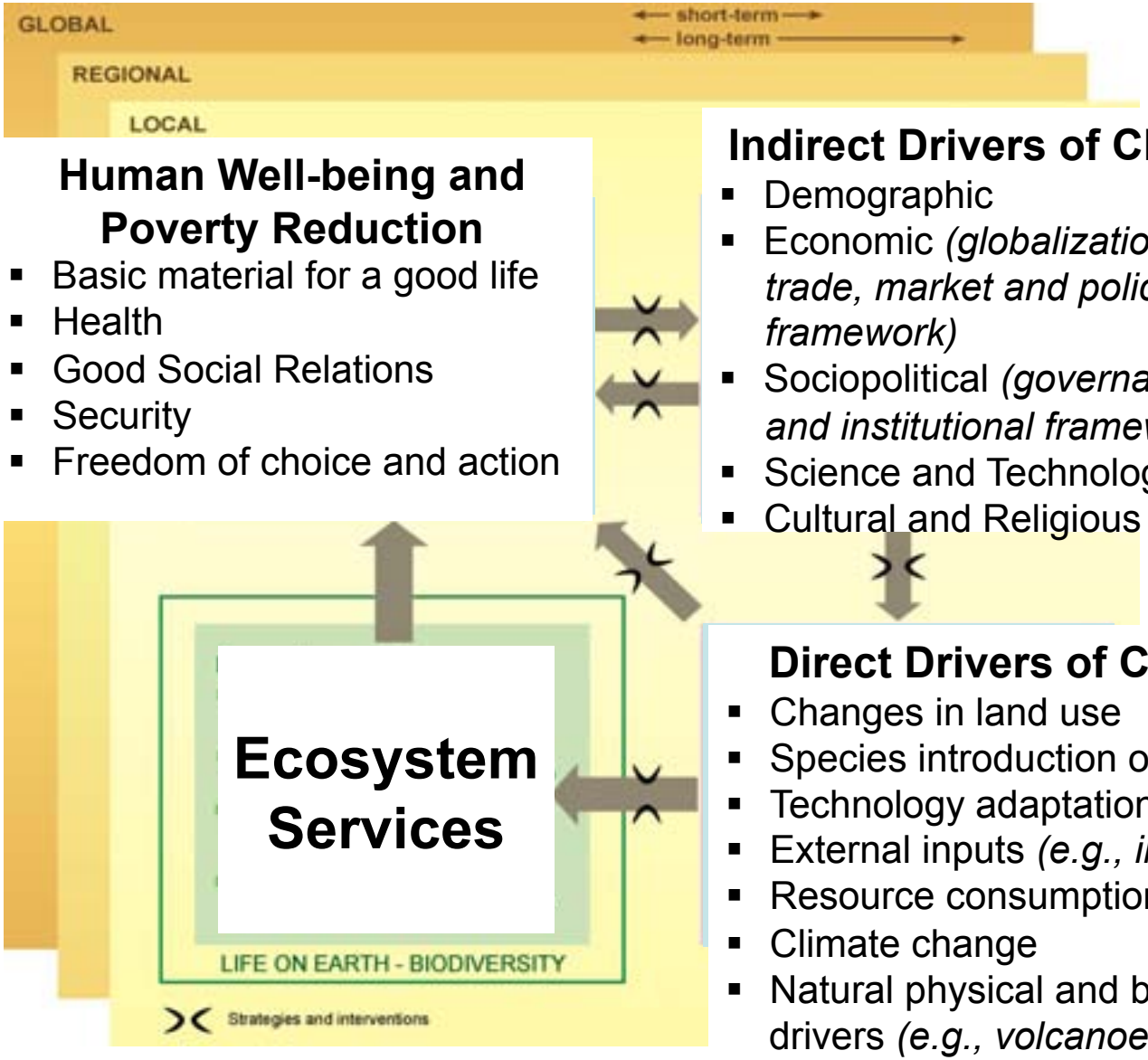
Overview of Findings

- Over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, fresh water, timber, fiber and fuel
- The changes that have been made to ecosystems have contributed to substantial net gains in human well-being and economic development, but these gains have been achieved at growing costs in the form of the degradation of many ecosystem services, increased risks of nonlinear changes, and the exacerbation of poverty for some groups of people
- The degradation of ecosystem services could grow significantly worse during the first half of this century and is a barrier to achieving the Millennium Development Goals
- The challenge of reversing the degradation of ecosystems while meeting increasing demands for their services can be partially met under some scenarios that the MA has considered but these involve significant changes in policies, institutions and practices, that are not currently under way



Source: Millennium Ecosystem Assessment

MA Framework



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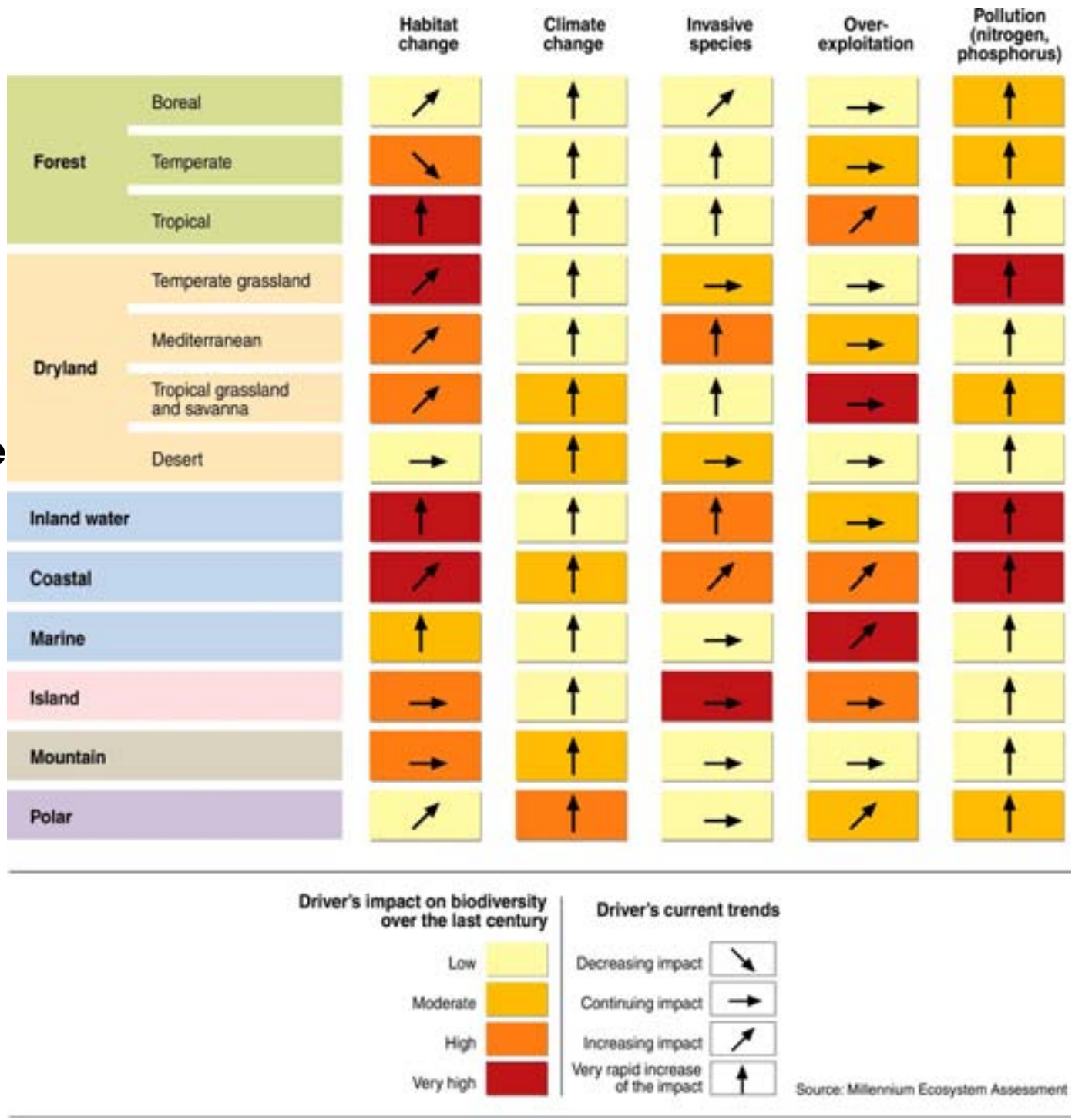
Most direct drivers of degradation in ecosystem services remain constant or are growing in intensity in most ecosystems



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Valuing ecosystem services

Ecological value

- encompasses the health state of a system
- measured with ecological indicators such as diversity and integrity

Socio-cultural value

- include the importance people give to, for example, the cultural identity and
- the degree to which that is related to ecosystem services

Economic value

- use value
- non-use value

Economic valuation

Use values

- encompass direct consumptive use values such as the value of timber, fish or other resources that ecosystems provide, and
- direct, non-consumptive use values such as those related to recreation and aesthetic appreciation

Indirect use values

- relate to the services provided by nature such as air- and water-purification, erosion prevention and pollination of crops

Non-use value

- is the importance attributed to an aspect of the environment in addition to, or irrespective of its use values
- the value attributed to the simple existence of the "object" (i.e. its existence value) also referred to as "insurance value" or "glue" value.

The sum total of use and non-use values associated with a resource or an aspect of the environment is called Total Economic Value (TEV).

Economic valuation methods

1. direct market valuation
2. indirect market valuation
3. contingent valuation
4. group valuation

Direct market valuation

- the exchange value that ecosystem services have in trade, mainly applicable to the production services
- but also some cultural services functions (e.g. recreation) and regulation services

When there are no explicit markets for services, we must resort to more indirect means of assessing values. A variety of valuation techniques can be used to establish the (revealed) Willingness To Pay (WTP) or Willingness To Accept compensation (WTA) for the availability or loss of these services.

Indirect market valuation

Avoided Cost (AC): allow society to avoid costs that would have been incurred in the absence of those services. Examples are flood control (which avoids property damages) and waste treatment (which avoids health costs) by wetlands.

Replacement Cost (RC): could be replaced with human-made systems; an example is natural waste treatment by marshes which can be (partly) replaced with costly artificial treatment systems.

Factor Income (FI): many ecosystem services enhance incomes; an example is natural water quality improvements which increase commercial fisheries catch and thereby incomes of fishermen.

Indirect market valuation (contd..)

Travel Cost (TC): use of ecosystem services may require travel. The travel costs can be seen as a reflection of the implied value of the service. An example is recreation areas that attract distant visitors whose value placed on that area must be at least what they were willing to pay to travel to it.

Hedonic Pricing (HP): service demand may be reflected in the prices people will pay for associated goods; an example is that housing prices at beaches usually exceed prices of identical inland homes near less attractive scenery.

Contingent valuation

Service demand may be elicited by posing hypothetical scenarios that involve the description of alternatives in a social survey questionnaire. For example, a survey questionnaire might ask respondents to express their willingness to pay (i.e. their stated preference as opposed to revealed preference, see above) to increase the level of water quality in a stream, lake or river so that they might enjoy activities like swimming, boating, or fishing (Wilson and Carpenter, 1999).

Group valuation

Another approach to ecosystem service valuation that has gained increasing attention recently involves group deliberation. Derived from social and political theory, this valuation approach is based on principles of deliberative democracy and the assumption that public decision making should result, not from the aggregation of separately measured individual preferences, but from open public debate.

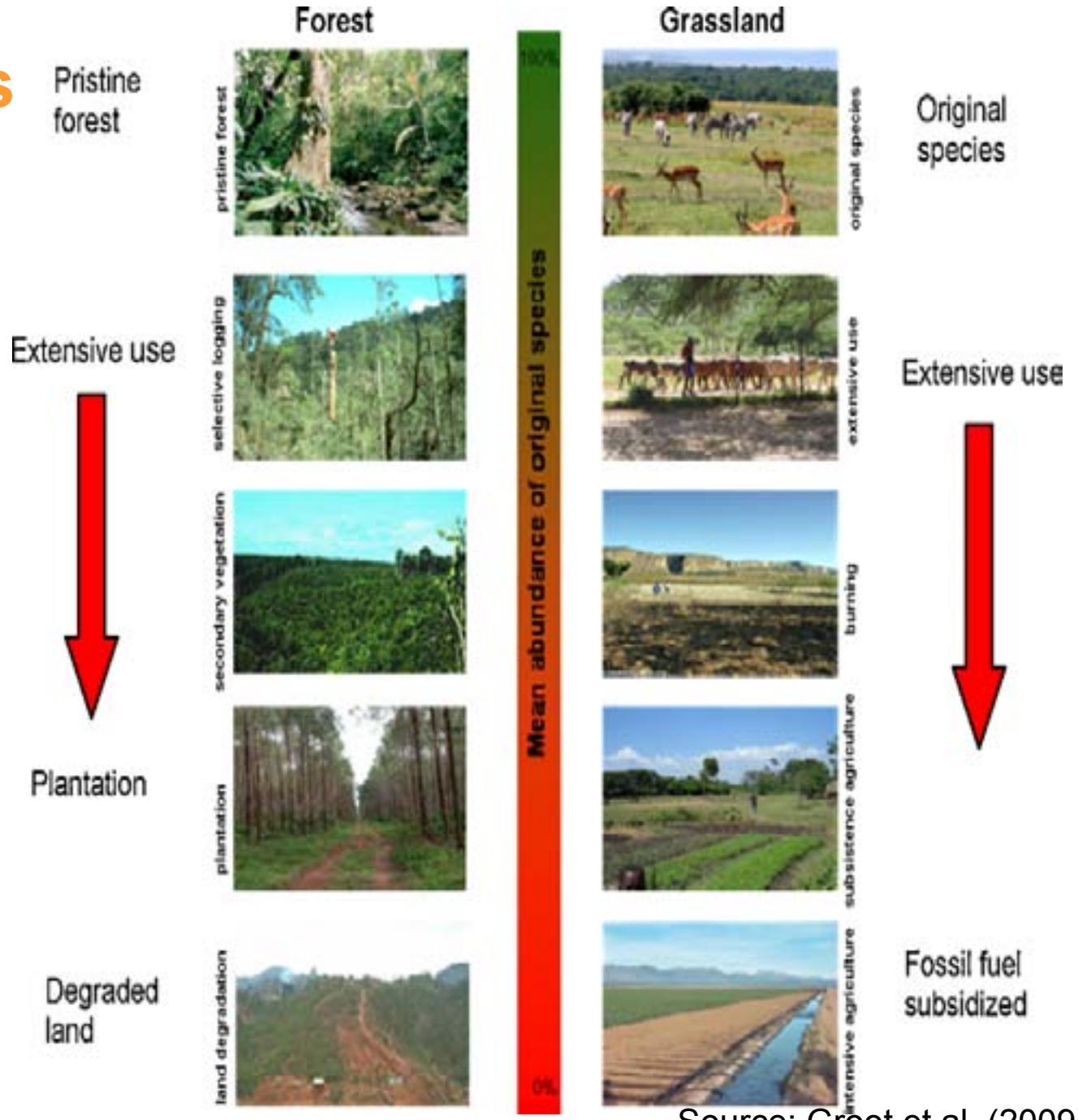
Economic and non-economic techniques available to value ecosystem services and biodiversity

Economic techniques	Non-economic techniques
Market price approaches	Consultative methods:
Market cost approaches	Questionnaires
Replacement costs approaches	In-depth interviews
Damage cost avoided approaches	Deliberative and participatory approaches:
Production function approaches	Focus groups, in-depth groups
Revealed preference methods	Citizen juries
Travel cost method	Health-based valuation approaches
Hedonic pricing method	Q-methodology
Stated preference methods	Delphi surveys
Choice modelling	Rapid rural appraisal
Contingent valuation	Participatory rural appraisal
Participatory approaches to valuation	Participatory action research
Deliberative valuation	Methods for reviewing information:
Mediated modelling	Systematic reviews
Benefits transfer	

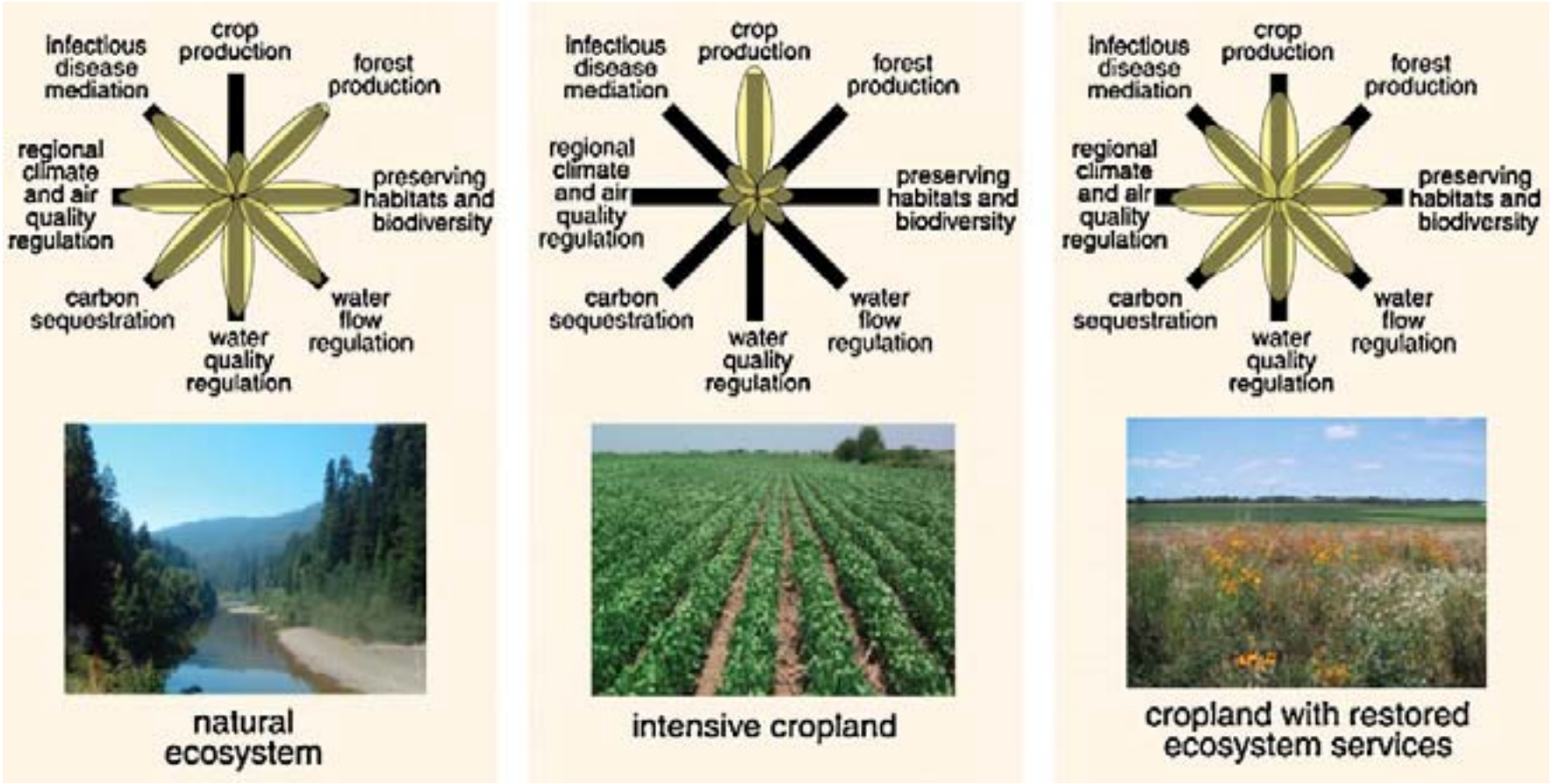
Source: Christie et al. (2008).

ES trade-offs

trade-offs arise from management choices made by humans, which can change the type, magnitude, and relative mix of services provided by ecosystems

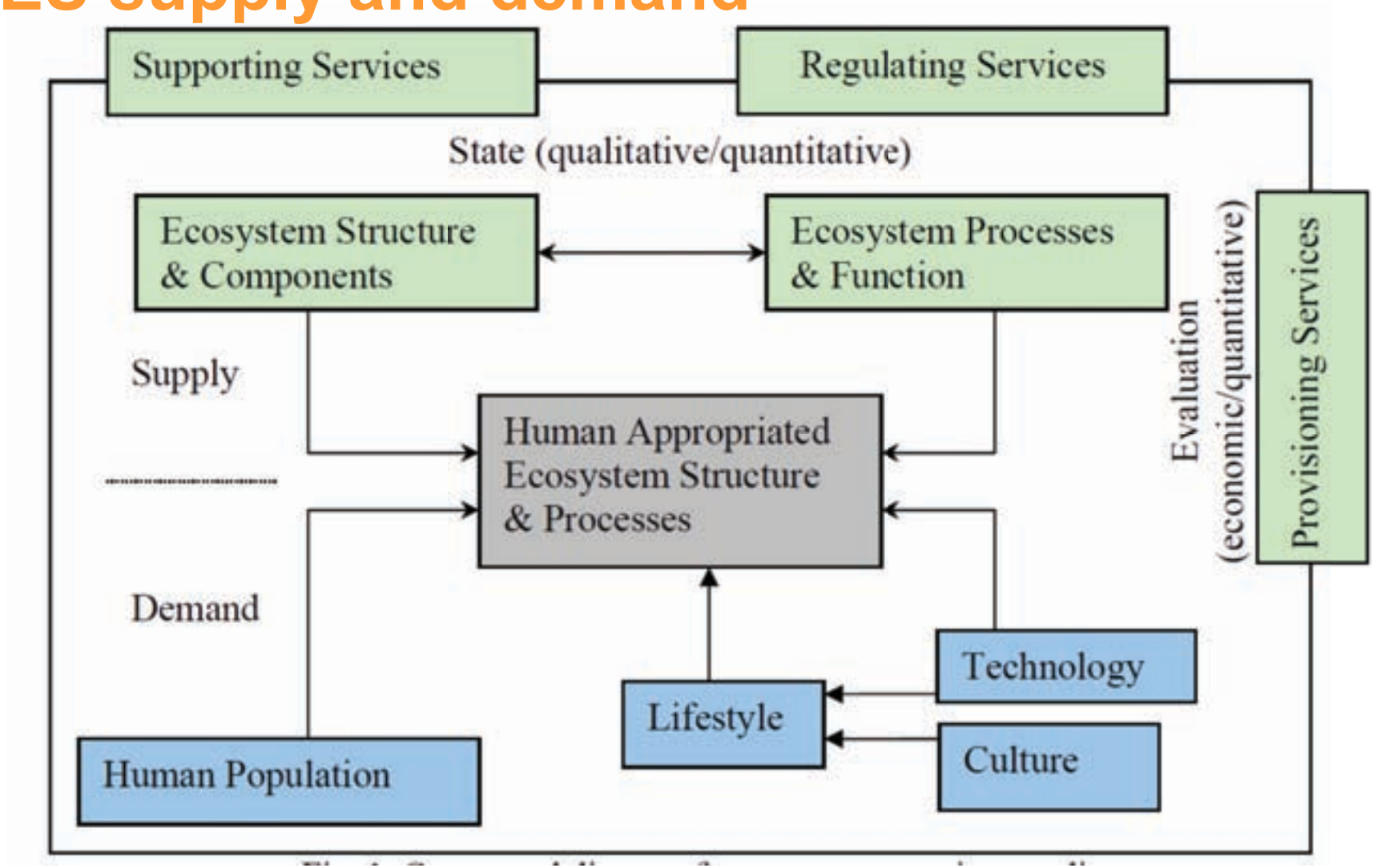


Source: Groot et al. (2009)



Foley et al. (2005).

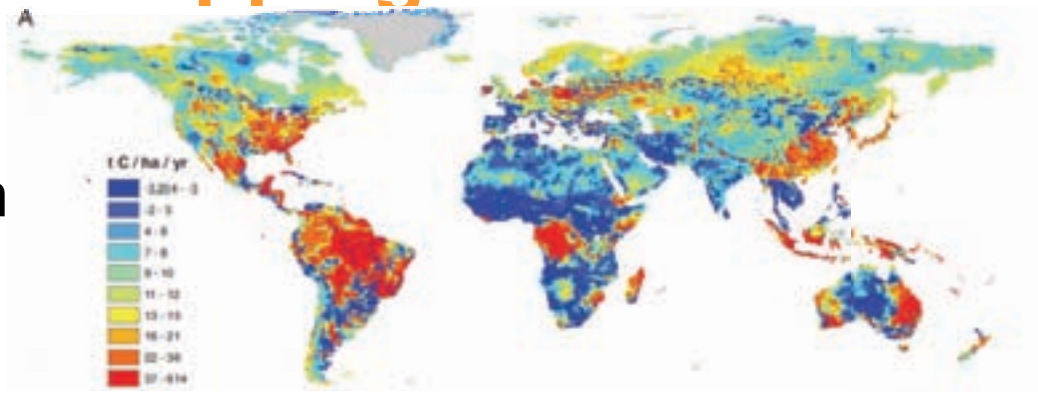
ES supply and demand

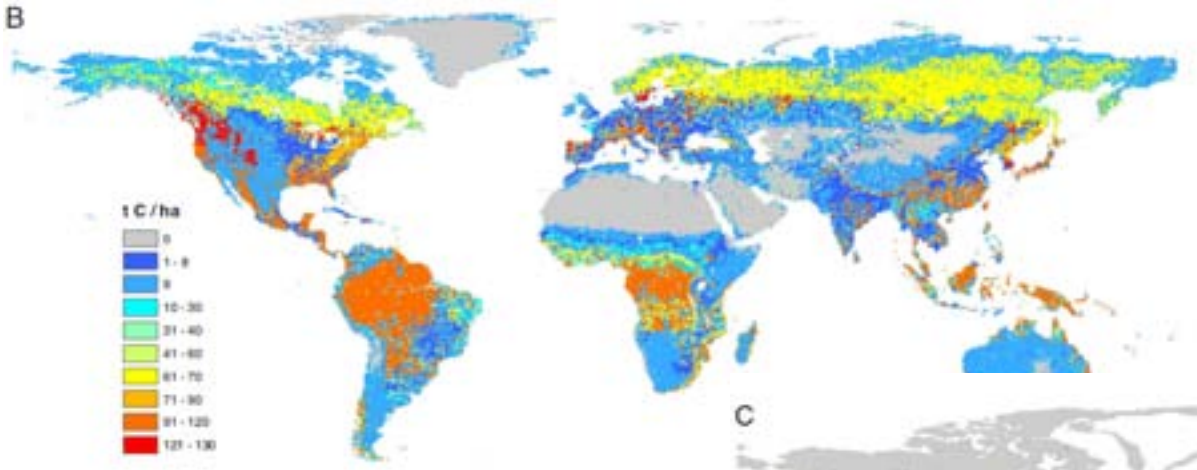


The supply of ecosystem services is strongly linked to natural conditions, e. g. land cover (vegetation), hydrology, soil conditions, fauna, elevation, slope and climate.

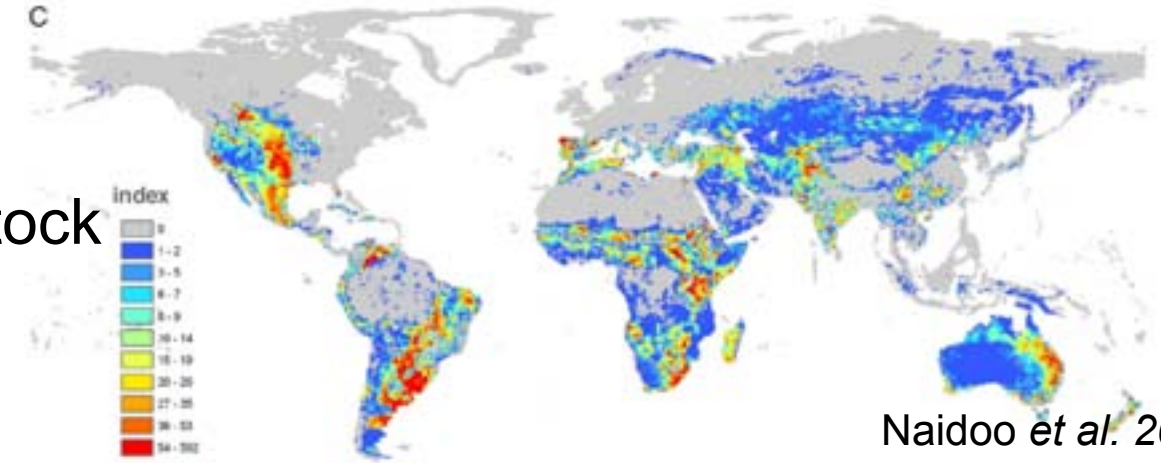
Ecosystem services mapping

carbon sequestration



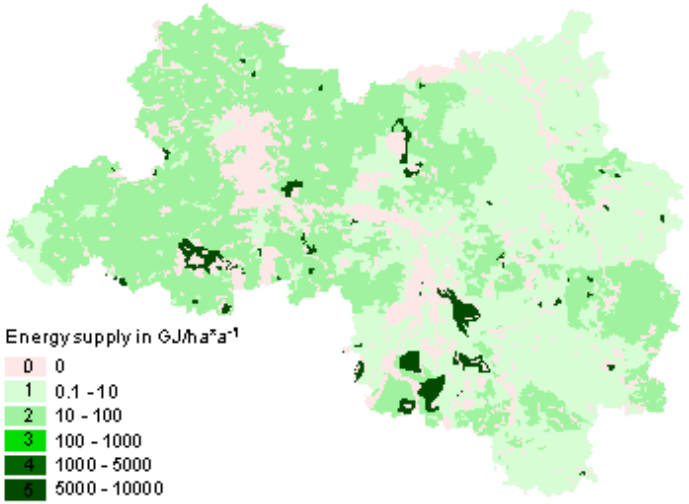


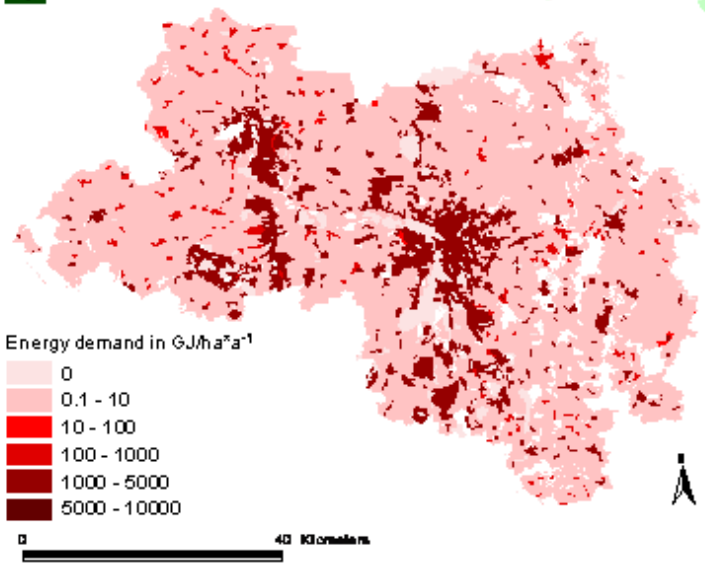
carbon storage

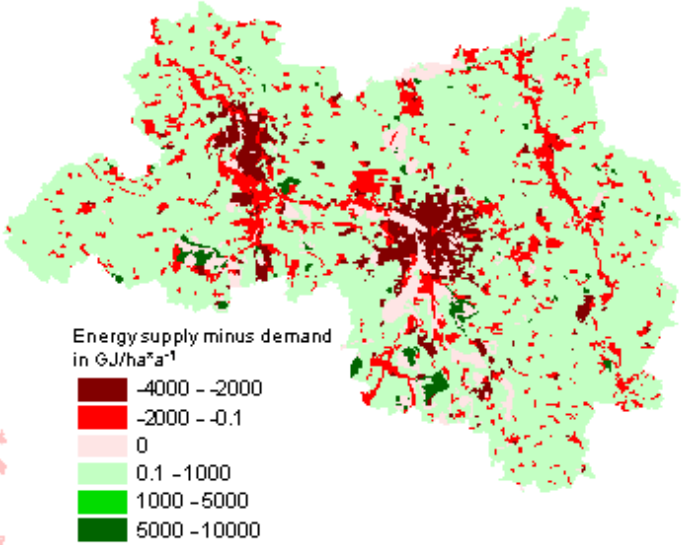


production of livestock

Naidoo *et al. 2007*







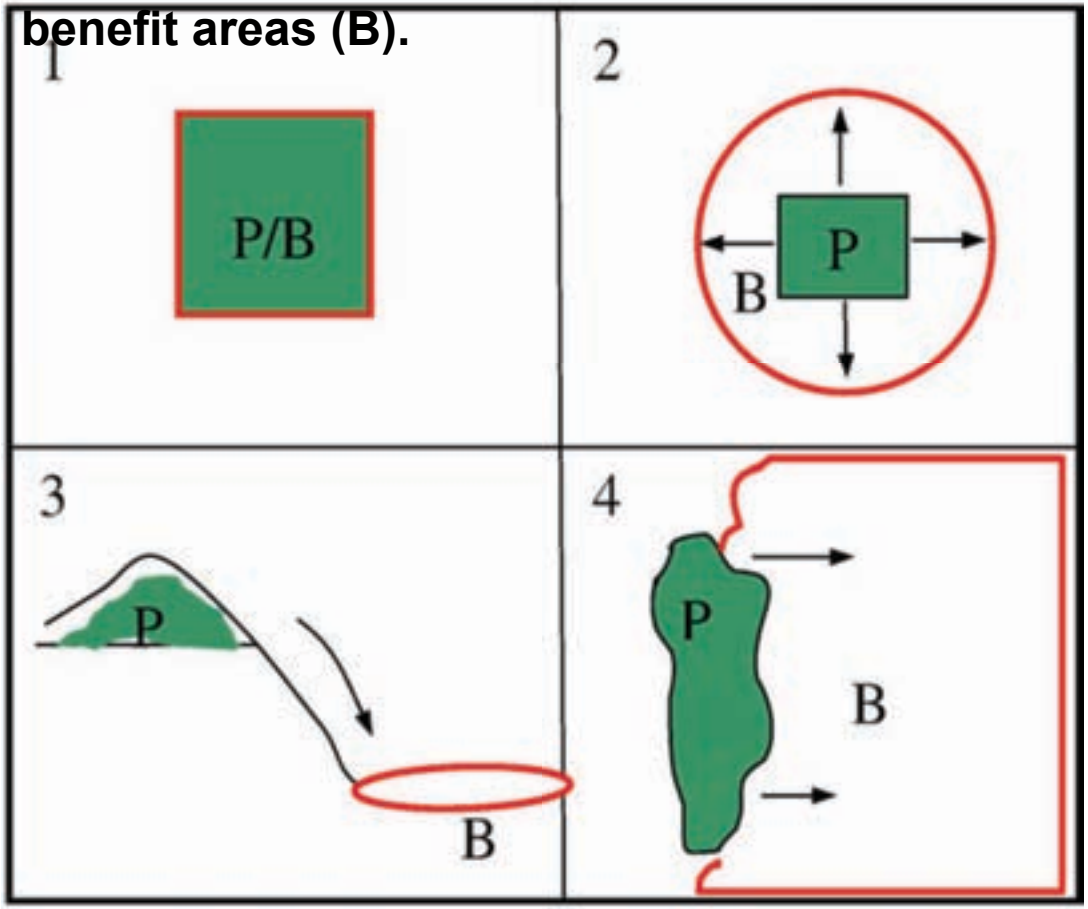
exemplary maps of energy supply and demand for an eastern German region including the two cities Leipzig and Halle

http://www.eoearth.org/article/Maps_of_ecosystem_services,_supply_and_demand

Spatial relationships between ES

1. both the service provision and benefit occur at the same location (e.g. soil formation, provision of raw materials).
2. the service is provided omni-directionally and benefits the surrounding landscape (e.g. pollination, carbon sequestration).
3. down slope units benefit from services provided in uphill areas, for example water regulation services provided by forested slopes.
4. the service provision unit could be coastal wetlands providing storm and flood protection to a coastline.

Possible spatial relationships between service production areas (P) and service benefit areas (B).



Fisher_et_al_2009

Summary

- human beings and human well-being dependent on ecosystems and ecosystem services
- human-environment interference can go in win-win direction and also in lose-lose direction
- ecosystem services concepts can be used for human well-beings and natural conservation
- ecosystem services concepts can be used as a holistic tools to evaluate human-environment interaction
- evaluation of supply and demand of ecosystem services may provide information on sustainability of human-environmental-system

A good news in that there is positive improvement on discussion to establish

an Intergovernmental Panel for Biodiversity and Ecosystem Services (IPBES)

as IPCC for climate change.

Thank you