Natural capital and Ecosystem services
…what they are and
why they are important for human well-being





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Natural capital and Ecosystem services

…the stock of **natural assets** which include geological substrates and mineral compounds, soil, air, water and all organisms…

...and **ecosystem services** provided by *ecosystems* and their *processes.*

Natural capital through Ecosystem processes provides Ecosystem goods and services (clean air and water, fertile soil, pollination, hazard protection, homeostatic regulations, aesthetics inspiration, etc.) and underpins our economy and society, making human life possible.

Natural capital and Ecosystem services

NATURAL ASSETS (GOODS)

- “Natural renewable resources”: all goods available from nature or produced by ecosystem processes
- “Natural non-renewable resources”: all goods available from nature and produced by longstanding bio-geo-chemical processes
- “Human-made products“: goods deriving from farming and agriculture (activities supported by ecosystem services)

A non-renewable resource (also called a finite resource) is a resource that does not renew itself at a sufficient rate for sustainable economic extraction in meaningful human time-frames (Source: Wikipedia).

Ecosystem processes and Ecosystem services

ECOSYSTEM FUNCTIONS (OR PROCESSES)

- “Ecosystem functions” (EFs): all natural processes involving nutrients movements and energy flows within an ecosystem
- “Ecosystem services“ (ESs): benefits derived from Ecosystem functions that are useful or necessary to humans

No clear distinction between them, since many EFs directly constitute ESs, e.g.

- ✓ water retention provided by the vegetation and soil:
  - Water supply to the natural vegetation and water resource provision to humans (irrigation and drinking water)
  - Prevention of soil erosion and mitigation of flood peaks
- ✓ pollination:
  - Reproduction of natural vegetation and crops

Ecosystems: structural definition

Ecosystems (*natural* or *human-modified*) are complex systems structurally composed of:

- Biological / living components *(plant, animal and micro-organism communities*)

and

- Physical / non-living components *(solar energy, air, water, soils, geological substrates and mineral compounds, and the basic elements [i.e. nutrients] of the environment)*

Ecosystems: functional definition

Ecosystems are complex systems resulting from the interactions of their components, both within the biotic compart and between abiotic and biotic comparts. These interactions are defined as *Ecosystem functions* (or *Ecosystem processes*) that encompass…

- **movement of nutrients**, from the environment to producers, consumers and decomposers (nutrient cycling and food chains/webs):
    - occurring at the ***local level*** mainly through the action of the biota
    - occurring at the ***global*** or ***regional levels*** through biological (migration) and geological processes (atmospheric circulation, erosion and weathering)
- **energy flow**, involved in transforming inorganic nutrients into organic tissues of organisms along food chains/webs

Levels of organization of living systems

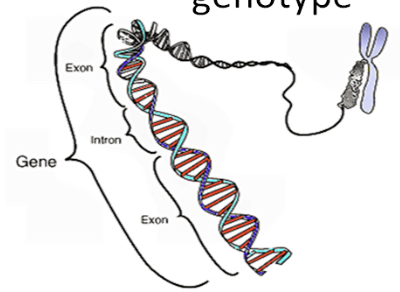
Biosphere The global ecological system (global ecosystem) integrating all species and their relationships, including their interaction with the elements of the lithosphere, geosphere, hydrosphere, and atmosphere

Ecosystem A community of different species interacting with one another and with their non-living environment, resulting form nutrients movements and energy flows

Community All the populations of different species living in the same geographical area, and interacting with each other

Population A group of individuals of the same species living in the same geographical area

Individual An organism pertaining to a recognized species with its own genotype



The genotype of an organism is the chemical composition of its DNA, which gives rise to the phenotype, or observable traits of an organism

Biodiversity

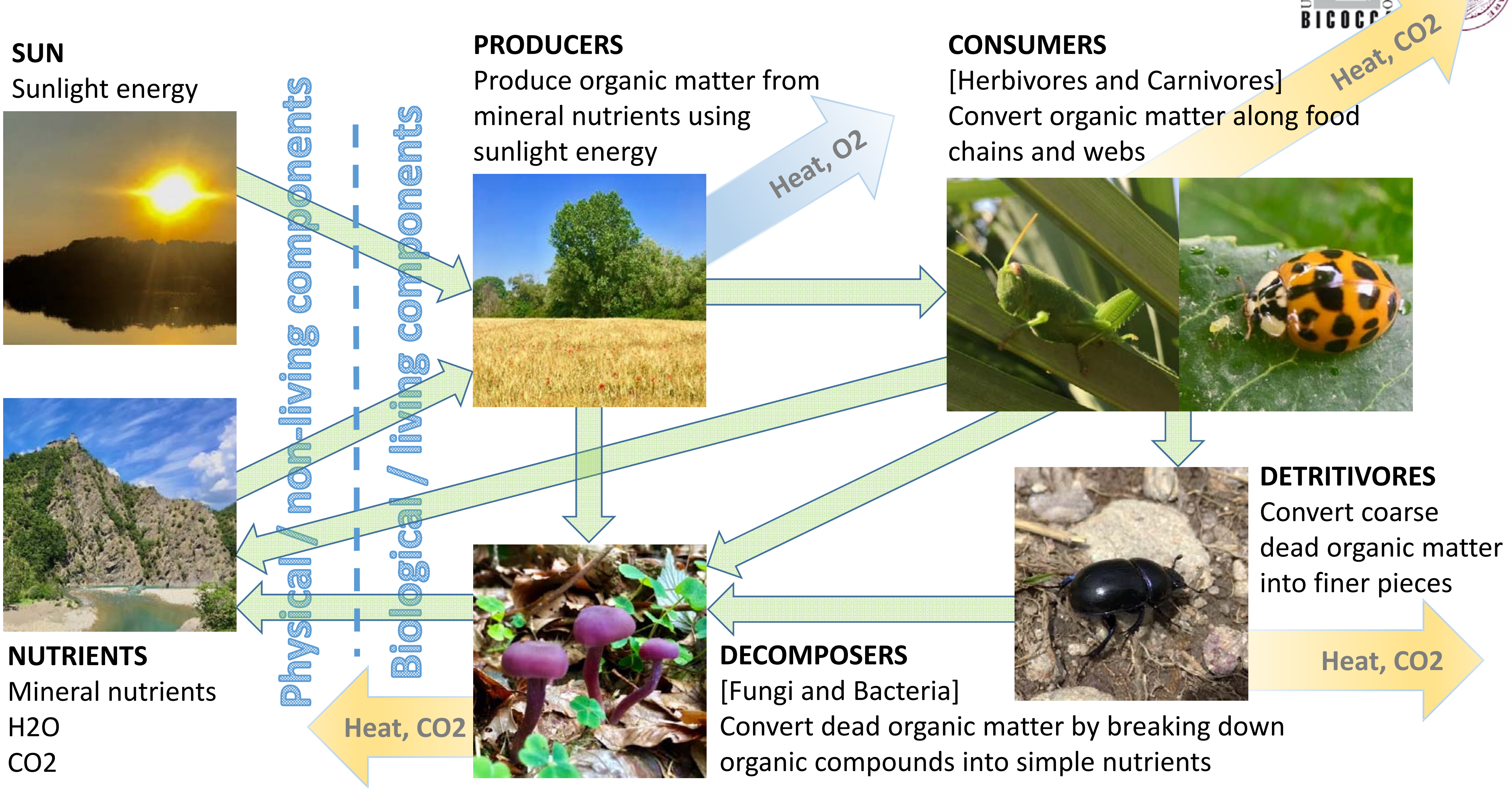
Biosphere Several different interacting ecosystems

Ecosystem Several different living (fauna, flora, fungi and micro-organism communities) and non-living components interacting with one another

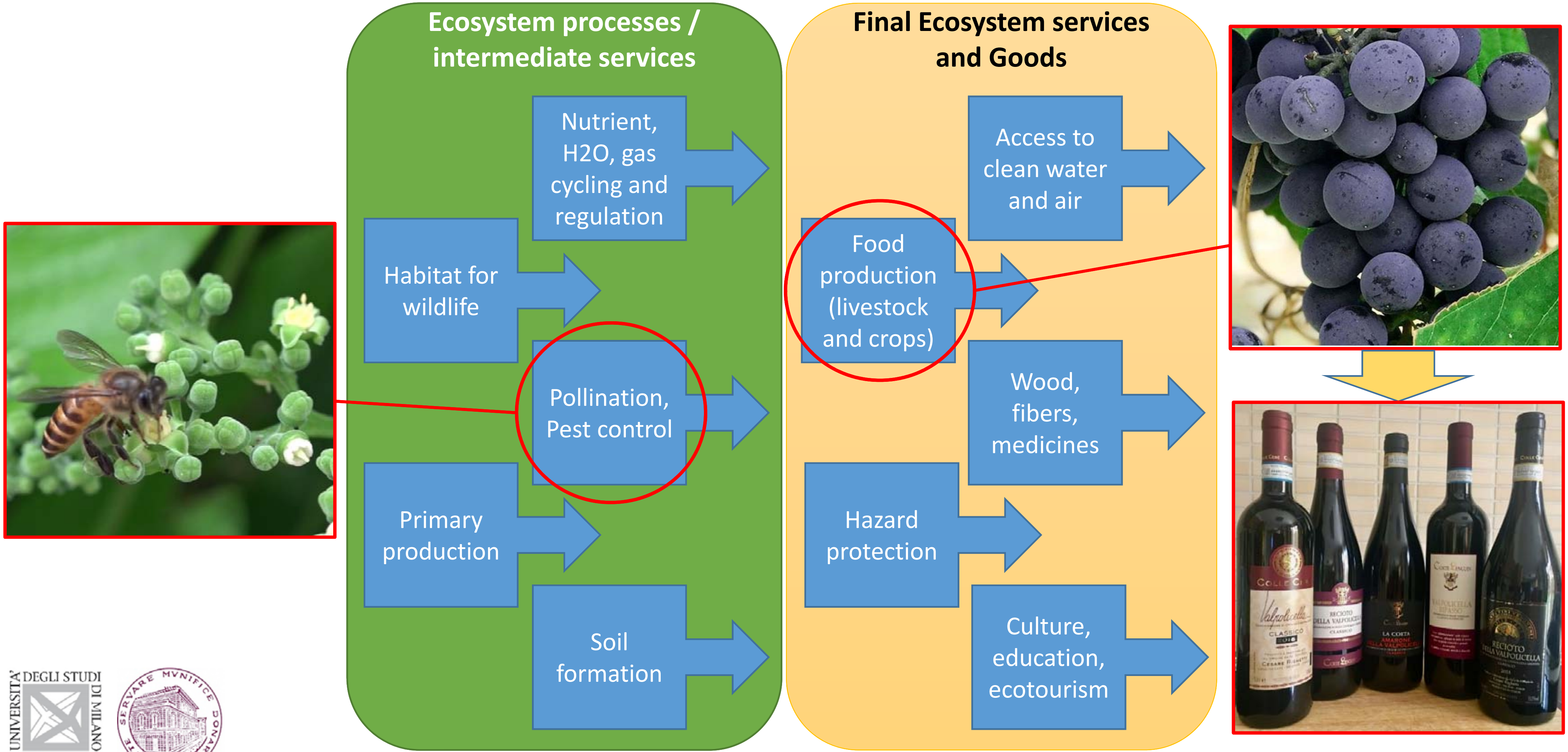
Community Several populations of different interacting species

Population Several (genetically different) individuals interacting with one another

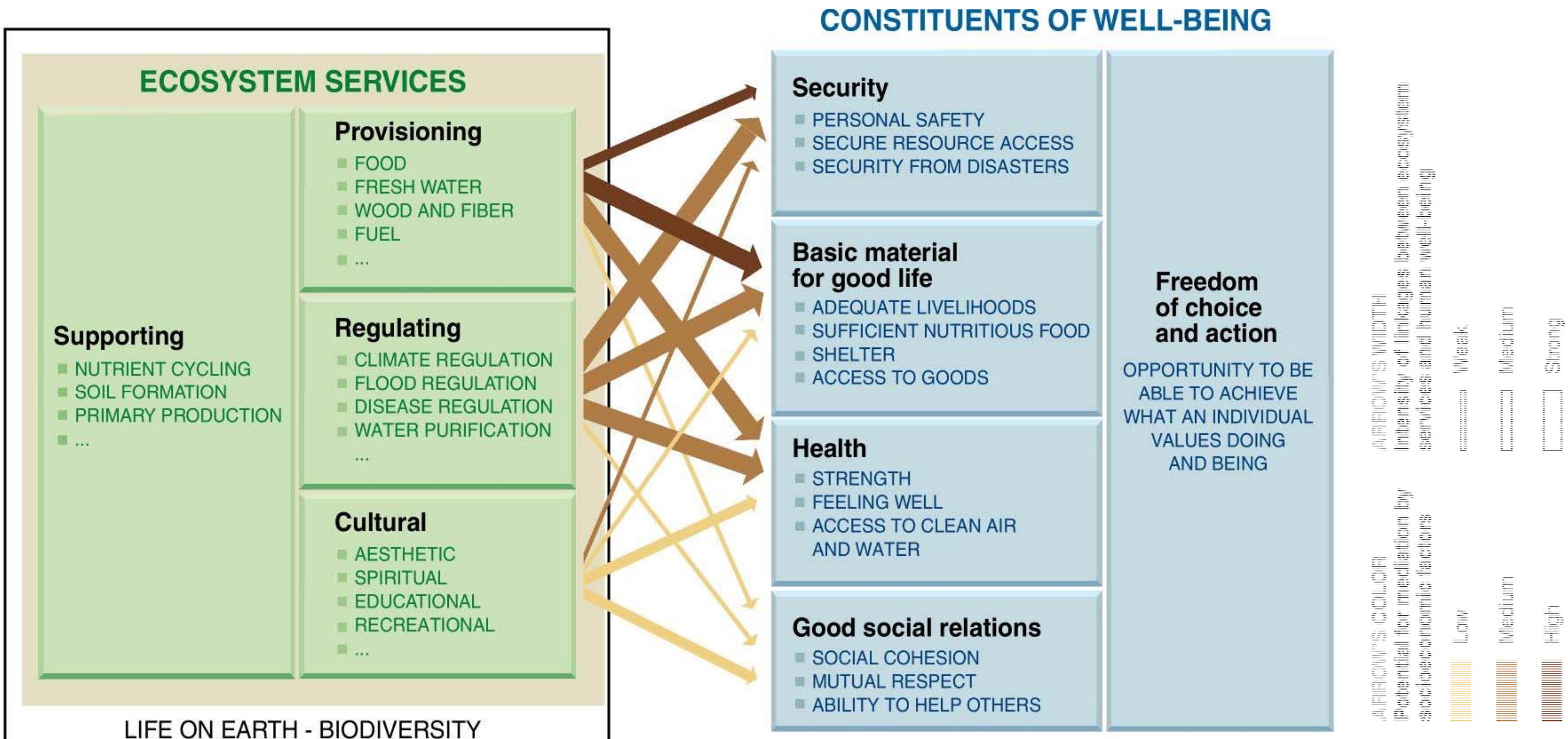
Ecosystems processes



From Ecosystem processes to Ecosystem services



Classification of Ecosystem Services (MEA)



Source: Millennium Ecosystem Assessment

Natural capital, ESs, and Human well-being

Thanks to Ecosystem processes along with the involved Natural capital, humans can benefit from Ecosystem services, and natural and derived goods, whose overall importance for **human well-being has been taken for granted by everyone**.

However, the **effects of the loss of Ecosystem services** resulting from the collapse of some ecological processes due to the unsustainable use of Natural capital (i.e. at a rate faster than its capacity of regeneration) is still **largely underestimated today** (*Communication*).

Natural capital, ESs, and Awareness

Many of Ecosystem functions and services are not only beneficial, but also critical to our survival (air purification, climate regulation, crop pollination).

Although people have been long aware that natural ecosystems help support human societies, the explicit recognition of Ecosystem services is relatively recent (Mooney & Ehrlich, 1997).

The Millennium Ecosystem Assessment documented that over 60% of Ecosystem services are deteriorating or already overused.

Natural capital and ESs threatening factors

- **Overfishing and overharvesting**
  (overexploitation of natural resources)
- **Habitat degradation, loss and fragmentation**
  (land use changes)
- **Pollution**
  (chemicals, pesticides, sewage, particulate matter)
- **Climate warming**
  (gas emissions form fossil fuels, agriculture, livestock)
- **Massive use of non-renewable resources**
  (fossil fuels, Earth minerals, nuclear fuels)
- **Biological invasions**
  (Pets, accidental translocations)





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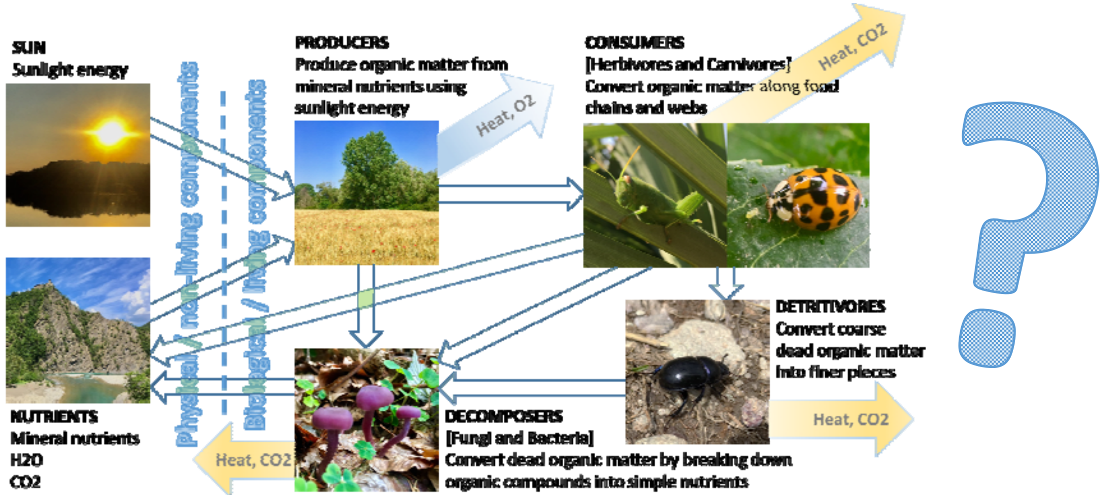
Natural capital, ESs, and Scientific knowledge

The widespread lack of awareness of the importance of ecosystem services derives also from the approximate knowledge of **how ecosystem processes work**, even within the scientific community.



This may be intrinsically due to the **complexity of the ecosystems**, but also to the **difficulty of promoting researches** that involve many specialists working on large areas and for relatively long time periods (*Data quality and Monitoring*).

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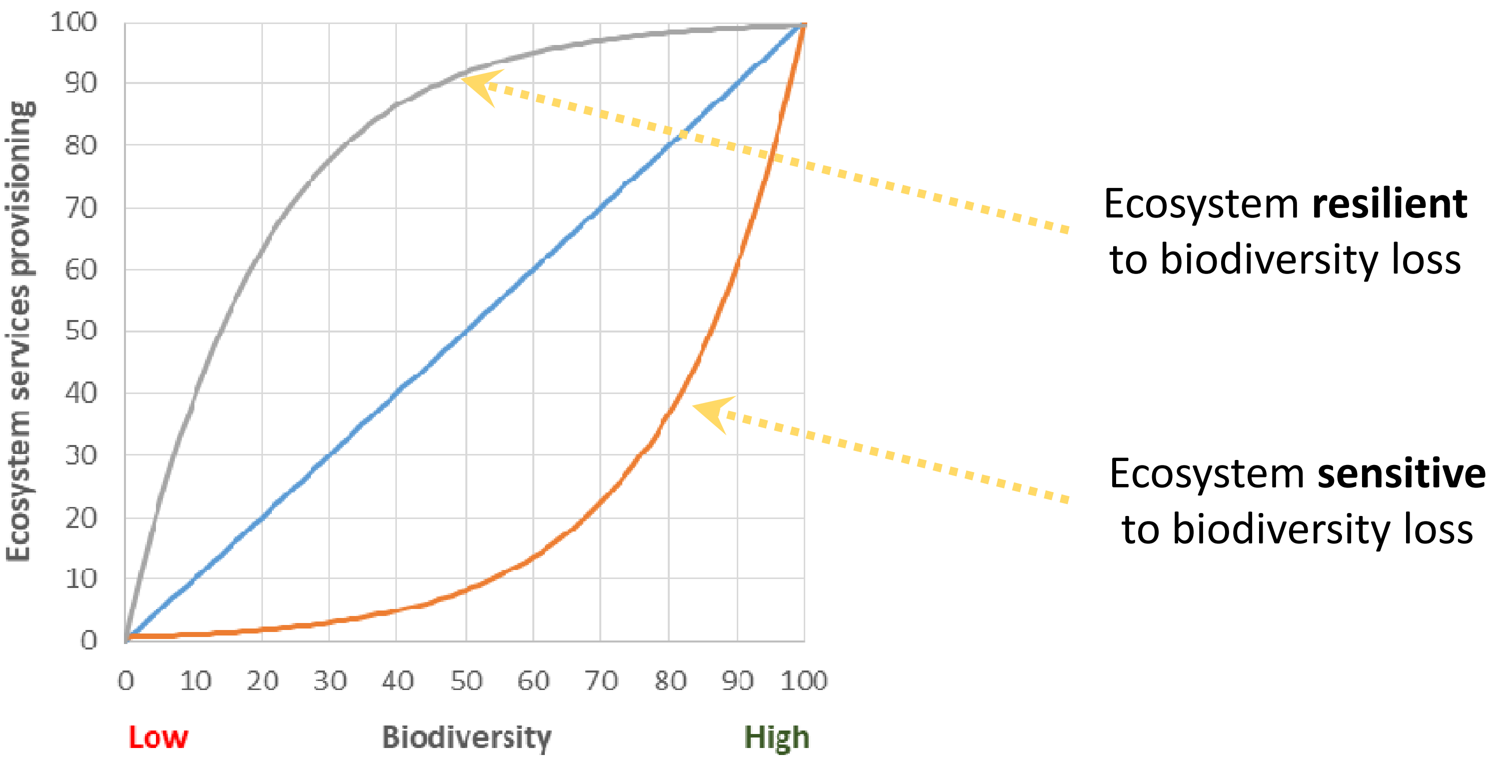
Natural capital, ESs, and Scientific knowledge

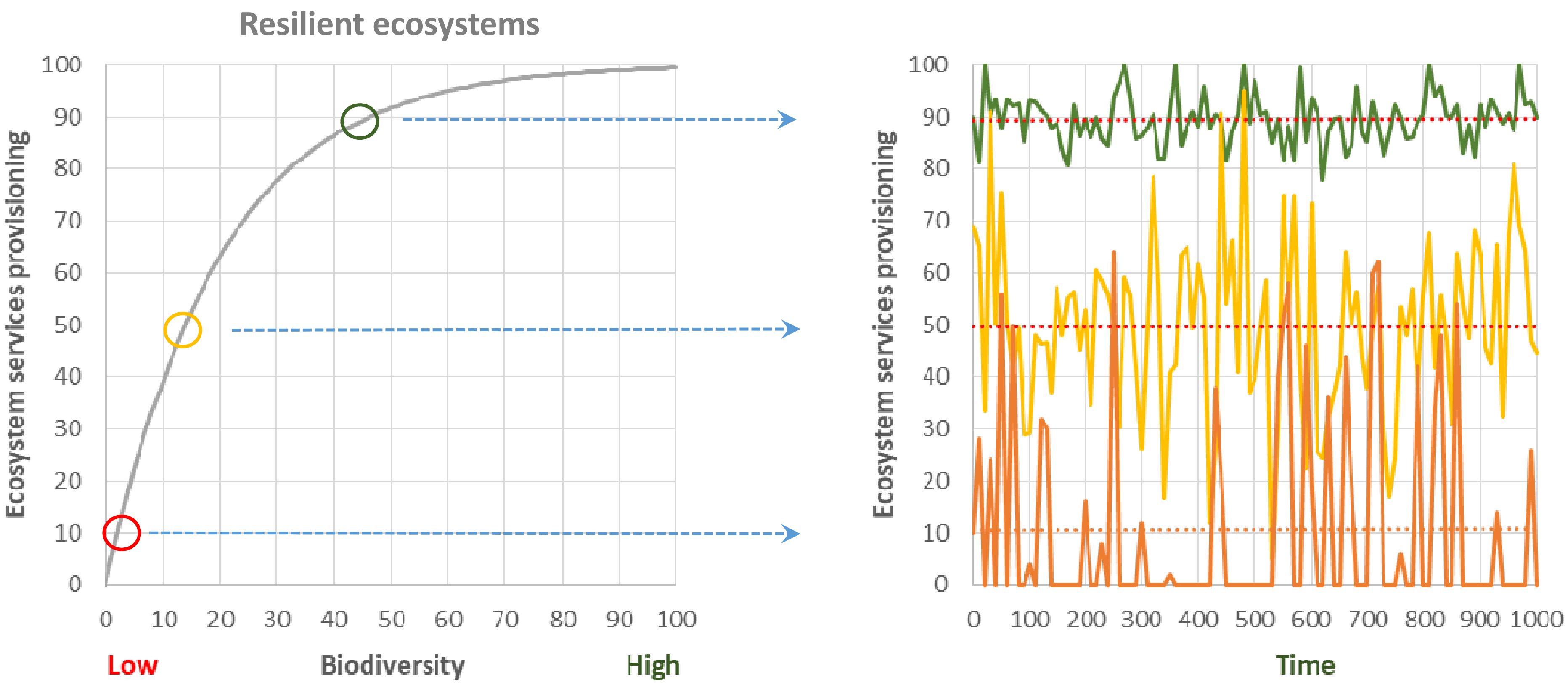
Ecosystem services and Biodiversity



Differences in Ecosystem services provisioning between resilient and sensitive ecosystems (*Data quality and Monitoring*).

Natural capital, ESs, and Scientific knowledge

Ecosystem services and Biodiversity



Provisioning services become more variable as biodiversity declines (*Data quality and Monitoring*).

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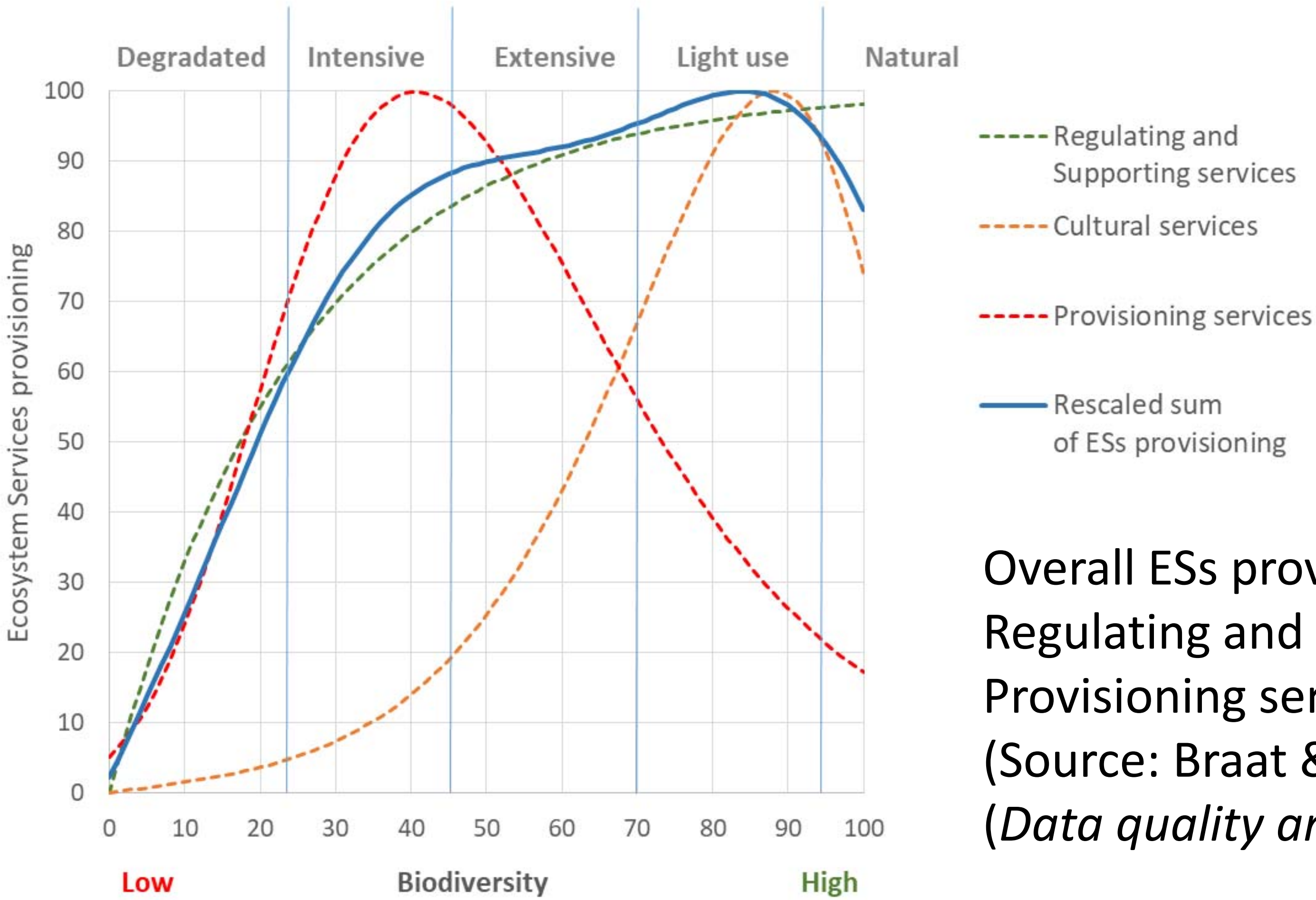
Natural capital, ESs, and Scientific knowledge

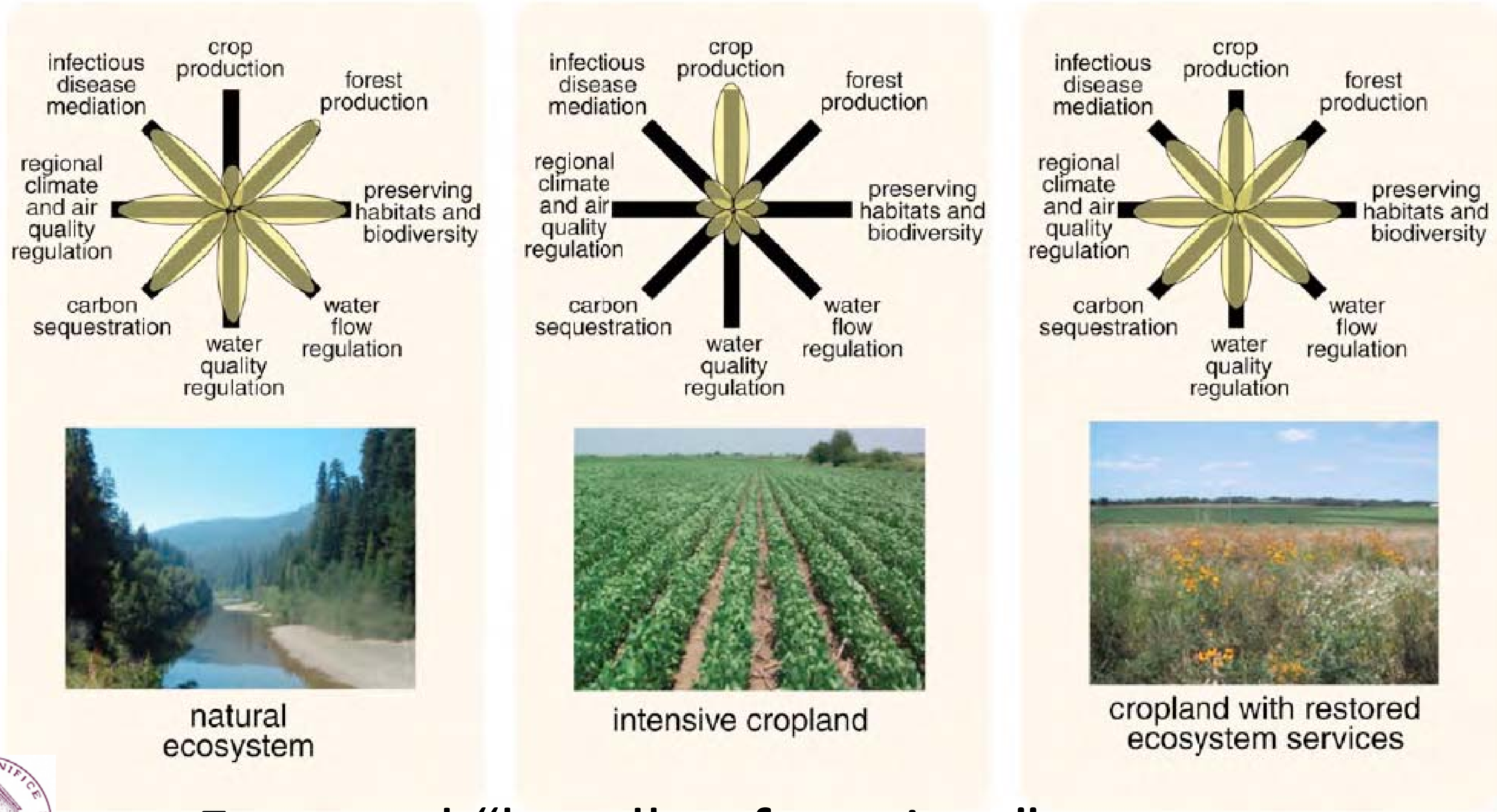
Ecosystem services and Biodiversity



Overall ESs provisioning accounting for the Regulating and Supporting, Cultural and Provisioning services
(Source: Braat & ten Brink, 2008)
(*Data quality and Monitoring*).

Natural capital, ESs, and Scientific knowledge

Ecosystem services and Biodiversity



Expected “bundle of services”

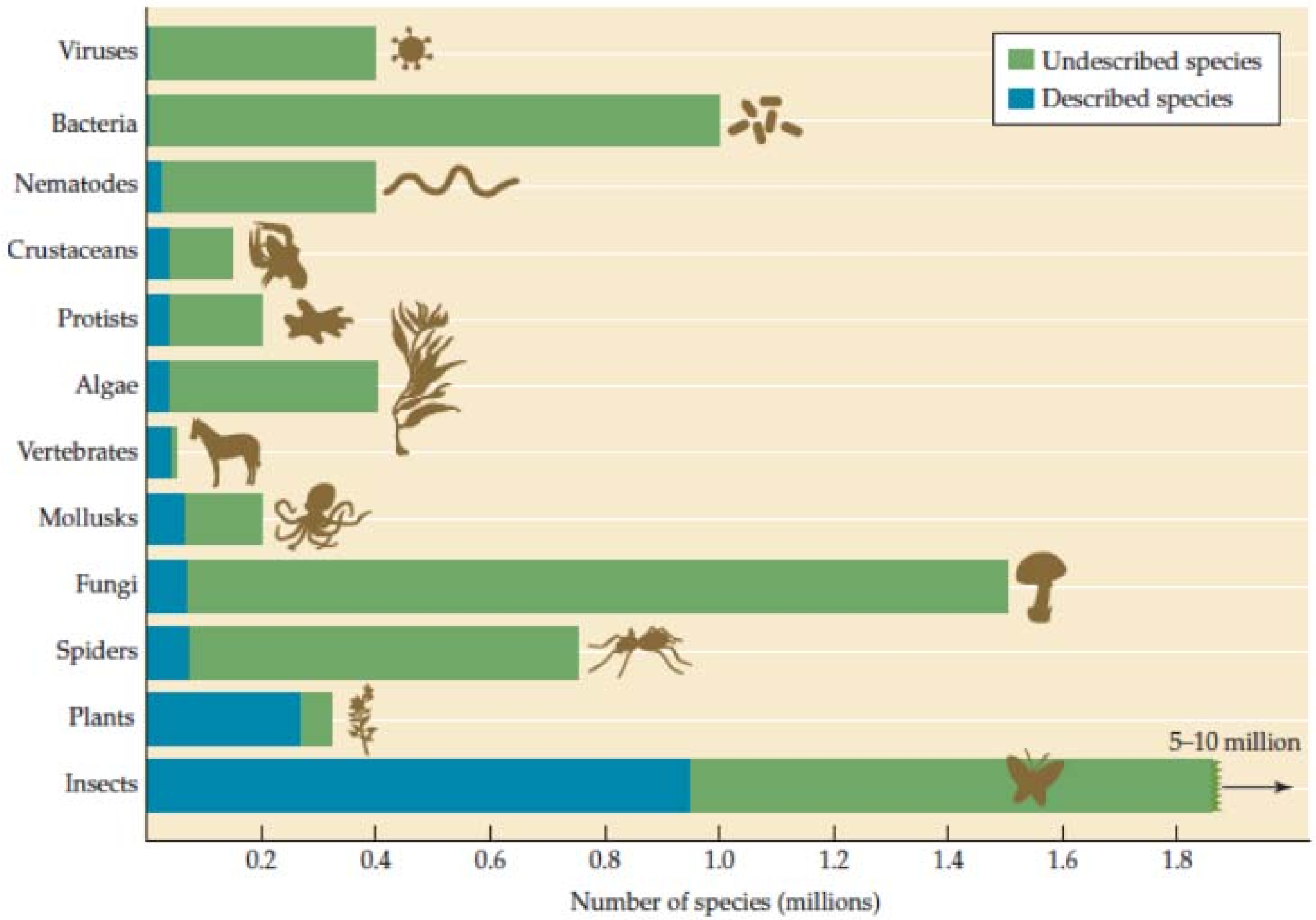
(Foley et al. 2005 Science)

Natural capital, ESs, and Scientific knowledge

Ecosystem services and Biodiversity

How we can correctly asses the **ESs performances** without knowing the **actual biodiversity** taking part in Ecosystem processes?

Taxonomic biodiversity: number of described species and an estimate of the number of undescribed species per group (Source: Primack, 2010).



Surrogate species of Ecosystem services

Surrogate species (bioindicators) may help in simplify the ESs assessment.



The big challenge: Establish a strong link between indicators and performances of ESs (*Data quality and Monitoring*).



Surrogate species of Ecosystem services

Agriculture, Ecosystems and Environment 254 (2018) 138–148

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Agriculture, Ecosystems and Environment

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ELSEVIER

Local and landscape drivers of butterfly richness and abundance in a human-dominated area

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ARTICLE INFO

Keywords:
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Agricultural landscape
Habitat management
Butterfly conservation
Hedgerows
Multi-scale models

ABSTRACT

In Europe, butterflies have declined over the last decades mainly because of the increasing urbanization and the agricultural intensification occurred in lowlands areas. Drivers of butterfly decline were identified in changes of both local scale habitat characteristics and landscape-scale land-use coverage. Thus, to counteract the negative trend of butterfly populations, management actions that simultaneously have an effect on local and landscape scale environments are needed.

The present research was performed in northern Italy, in a human-dominated area of about 170 km^2. From April to September 2014 and 2015, we surveyed butterflies in 494 50-m sections, grouped into 44 line transects.

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Surrogate species of Ecosystem services

Journal of Biogeography (*J. Biogeogr.*) (2017) **44**, 1041–1052

ORIGINAL ARTICLE

How does forest species specialization affect the application of the island biogeography theory in fragmented landscapes?

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ABSTRACT

Aim Overall species richness in habitat remnants is seldom explained by the island biogeography theory (IBT). In this study, we tested the effectiveness of the IBT in explaining species richness of forest birds with or without considering the effect of the different forest specialization of species (*generalist*, *edge* and *interior*; community analysis). We also identified single species and groups of species that could serve as indicators of different fragmentation degrees (indicator species analysis).

Location Broadleaved forests in western Lombardy (northern Italy).

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Surrogate species of Ecosystem services

Ecological Indicators 55 (2015) 44–51

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Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

ELSEVIER

Original articles

A method to evaluate the combined effect of tree species composition and woodland structure on indicator birds

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ARTICLE INFO

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Basal area (BA)
Diameters at breast height (DBH)

ABSTRACT

Providing quantitative management guidelines is essential for an effective conservation of forest-dependent animal communities. Traditional forest practices at the stand scale simultaneously alter both physical and floristic features with a negative effect on ecosystem processes. Thus, we tested and proposed a method to define forestry prescriptions taking into account the combined effect of woodland structure and tree species composition on the presence of four bird indicator species (Marsh Tit *Poecile palustris*, European Nuthatch *Sitta europaea*, Short-toed Tree-creeper *Certhya brachydactyla* and Blue Tit *Cyanistes caeruleus*). The study was carried out in Lombardy (Northern Italy), from 2002 to 2005. By

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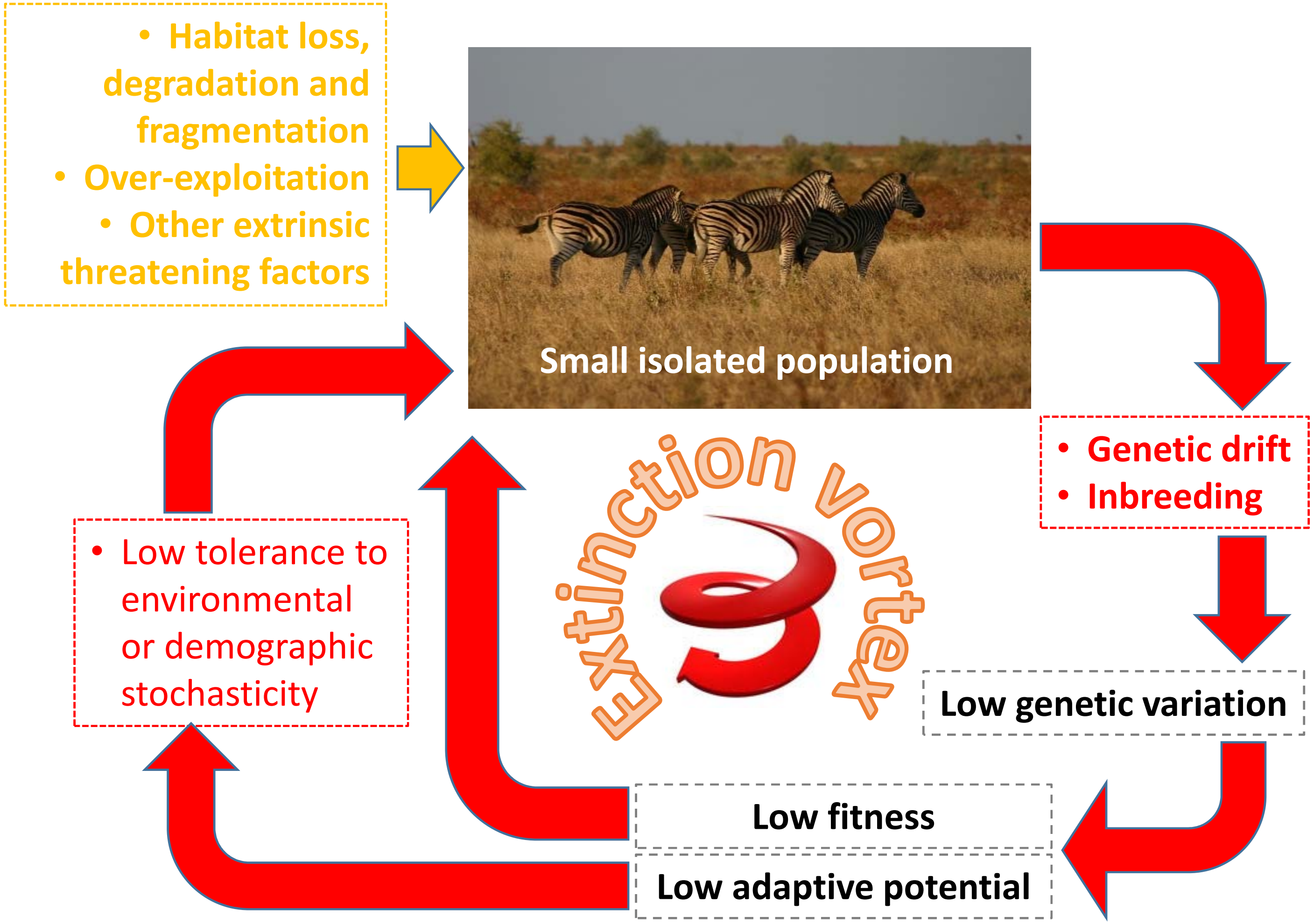
Ecosystem services and Spatial scale

How much the spatial scale matters?
The spatial scale is of crucial importance, since the area extent over which the ecosystem processes take place are larger than usually expected!

Small isolated populations generated by habitat fragmentation are prone to extinction

- *Even removing extrinsic threatening factors, they can not counteract the **intrinsic threatening factors** such as genetic drift, inbreeding and environmental and demographic stochasticity*
- *They need the restoration of the **ecological connectivity** between habitat fragments, so that at least some individuals have the possibility to reproduce in fragments different from that of birth (maintaining dispersal potential).*



Ecosystem services and Spatial scale

How much the spatial scale matters?

Ecology and Evolution

Open Access

Detecting a hierarchical genetic population structure: the case study of the Fire Salamander (*Salamandra salamandra*) in Northern Italy

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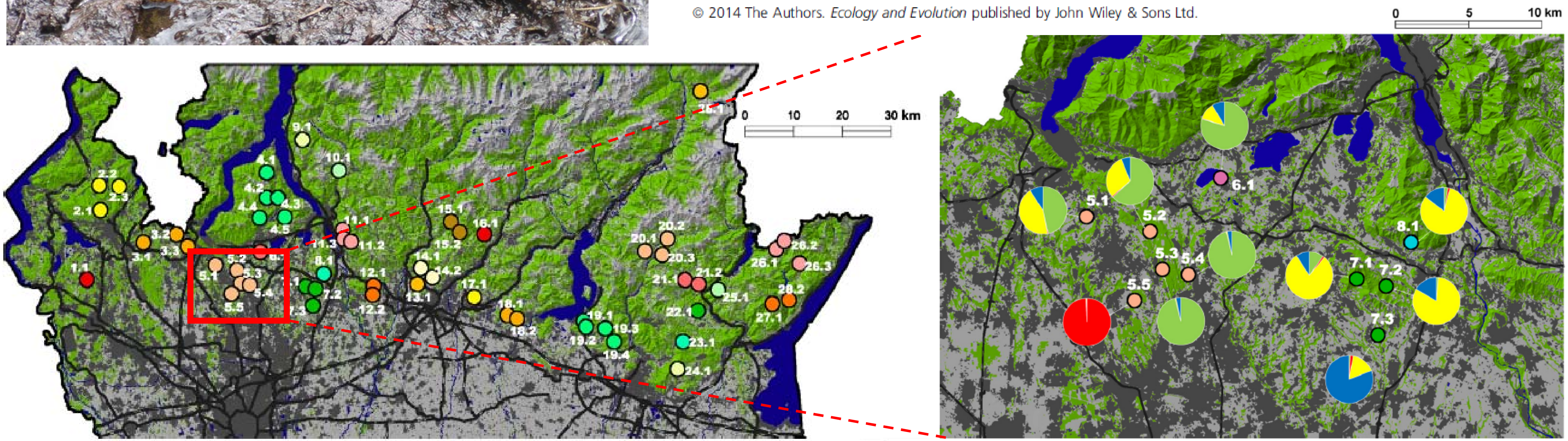

Ecosystem services and Spatial scale

How the climate warming affects the change and contraction of species ranges?

- *The factors inducing the climate warming act worldwide*
- *Stopping the global warming requires policies on a global scale*
- *However, we can also act locally to mitigate its effects, by promoting socio-economic activities in rangeland areas*

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DOI: 10.1002/ece3.4838

ORIGINAL RESEARCH

WILEY Ecology and Evolution Open Access

Winners and losers: How the elevational range of breeding birds on Alps has varied over the past four decades due to climate and habitat changes

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Abstract

Climate warming and habitat transformation are widely recognized as worrying threatening factors. Understanding the individual contribution of these two factors to the change of species distribution could be very important in order to effectively counteract the species range contraction, especially in mountains, where alpine species are strongly limited in finding new areas to be colonized at higher elevations. We

Natural capital, ESs, and Economy

The lack of **economic quantification** of Ecosystem services has also contributed to neglect their importance.

Their quantification usually happens only after dramatic events!
Or better... the economic assessment occurs for the damage produced by the effects caused by dramatic events as a consequence of the loss of ESs! (*PES*).

Natural capital, ESs, and Human involvement

The human domain of the Earth is so immense today that the biodiversity necessary for the ecosystems functioning, essential for our survival, requires a broad awareness of the importance of **human involvement for its conservation**.

Natural capital, ESs, and Sustainability

Today, in the light of the increasingly serious effects produced by the loss of Ecosystem services, we need (or rather we are forced to) a fundamental step, which leads recognizing to Natural capital the role of **driver of Ecosystem processes,** and derived goods and services, and **not as an asset to be exploited *ad libitum***.

This implies the **conservation and the rationale use** of the living and non-living components that take part in ecosystem processes, which allow the regeneration of natural capital, in order to make the humans able to benefit from renewable natural goods, as well as derived goods and ecosystem services (i.e. the Natural capital) in the long term. This is called **Sustainability**.

Natural capital, ESs, and Conservation: An Ethical duty beyond the Economic convenience

The conservation of ecosystems should be perceived as an **Ethical duty** (**Intrinsic Value of Biodiversity**),…

…however it becomes a practical necessity (**Instrumental Value of Biodiversity**) in order to conserve ecosystem goods and services in the light of **economic convenience**, both for individual stakeholders and whole society (*Communication*).

From ESs to the Payment for ESs (PES)

Today we have to **switch from the free exploitation** (more often a free unsustainable over-exploitation) of benefits produced by Ecosystems to **paying what they produce** (goods and services).

This does not mean entering into a market perspective according to which one is entitled to sell off resources to the highest bidder!

Conversely, payments make us **more aware** and **less willing to waste**.

Thus, payments should generate a more rational use of (renewable) resources which, being **exploited at a lower rate, should have the chance to regenerate** over time, instead to be depleted (in some case permanently).

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From ESs to the Payment for ESs (PES)

It is not a matter of "making money", but of finally giving the **right value to the Natural capital**, to which it has never been previously given, and to what it provides through **Ecosystem processes**.
From the socio-economic point of view, it should not lead to an increase in the overall life costs, rather to the maintenance of the current well-being condition with a reduction of waste.

The introduction of PES should generate a reduction in social costs instead, leading to an increasingly **widespread equalization**, with even a possible **economic savings**.

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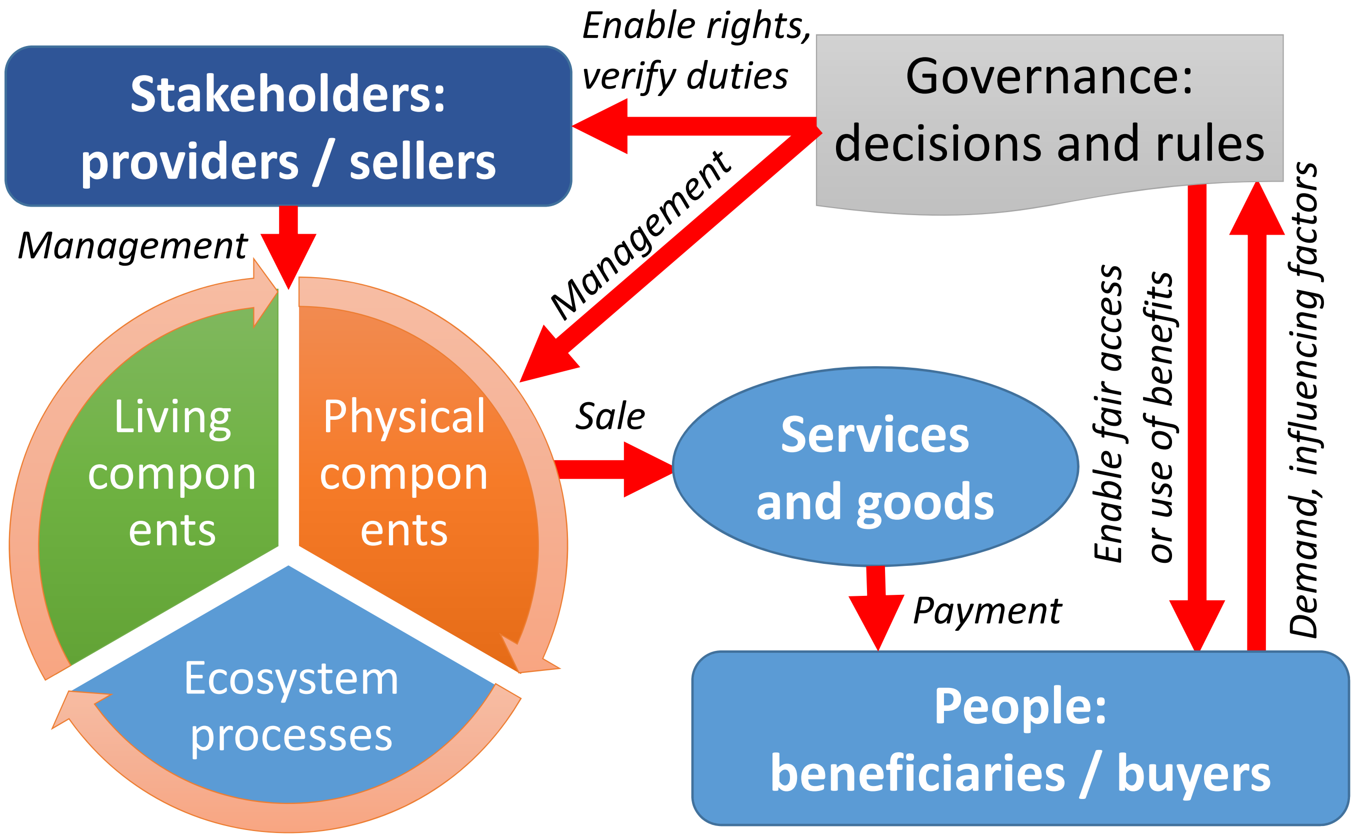
How does a PES work?

General framework

1. **Recognition of the goods and services** provided by Natural capital for which a price can be paid
   - What Ecosystem services and goods are generated by natural/semi-natural ecosystems and by agro-ecosystems?
   - Which services are marketable?

2. **Supply and demand analysis**
   - How much are buyers willing to pay?
   - What are sellers need for rewards?
   - What type of payment do buyers want, and can sellers provide?

3. **Ensure that property, access and use rights are well established**



What makes a PES a PES is that in every payment the beneficiaries / buyers are aware that they are paying for an Ecosystem service that is valuable to them, and providers / sellers that receive the payments engage in meaningful and measurable management activities to secure the ***sustainable supply of the Ecosystem services and goods guaranteed by an effective governance****.*

From PES to Governance

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We must not be hypocrites and **we must give a value**, also from an **economic** point of view, **to Natural capital**.

Indeed, **each of us**, even considering the biodiversity conservation as an ethical duty, **uses** electricity, gas for heating, cars, airplanes or other means of transport that consume various types of fuel, as well as other several **goods provided by the Natural capital**.

From PES to Governance

We will therefore have to frame the Ecosystem services and the related PES in a logic of the **conservation of mechanisms** that will allow us to use goods they offer to a **cost that remains affordable over time**, instead of preventing their use.

This is a real **Economic revolution**, like technological and scientific ones.

We need to **switch** from a logic of **short-term over-use** to one aimed at guaranteeing **rational use over time**, without an overall increase of costs or constraints.

It is a vision that could even see among the major supporters those who, in the past, have seen the protection of the environment (ESs and Natural capital) as a hindrance against the economic development.

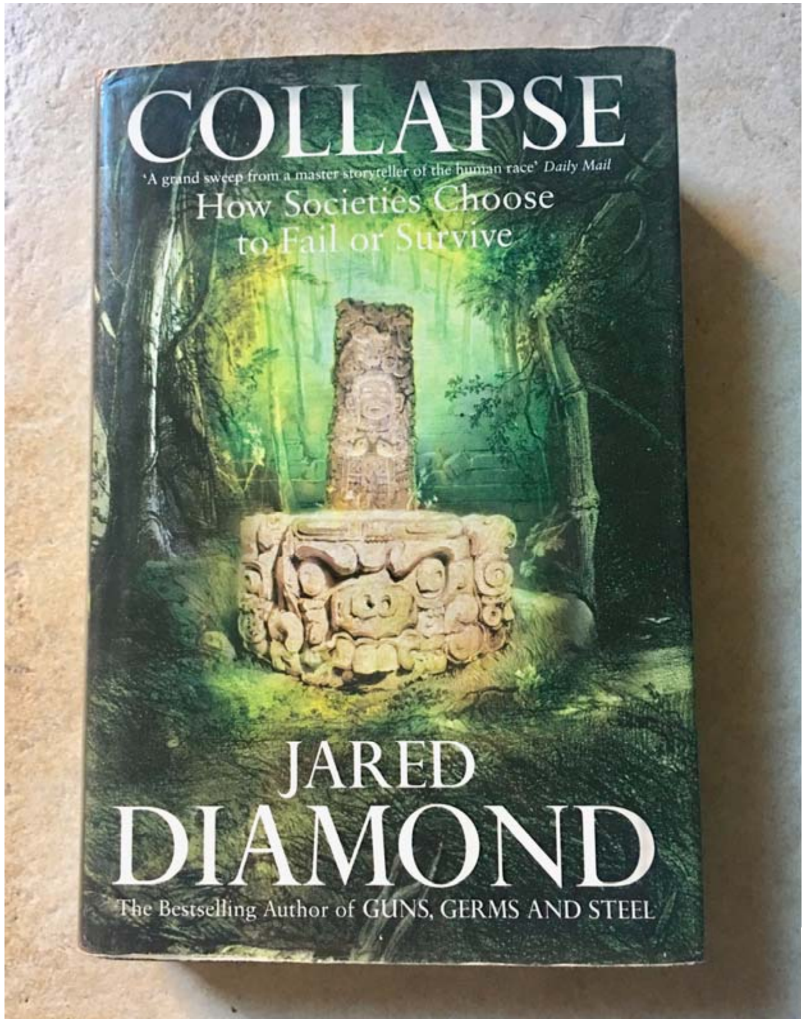
From PES to Governance

A question:
Should we be ashamed to give an economic value to ESs and goods, and request a fee for them?

Answers:
- **No**, because in our most common sense, **what is free is worthless… and can be wasted**.

- **No**, because, today we are under a big risk, due to ESs **collapse**, and it is the most promising way to get out of this dangerous situation.

- We do not have a PLANet B!



Socioecology 2.0:
Linking Ethical duty to Economic convenience

Each species tries to get the maximum benefit from the environment in which it lives, making the most of its available resources, as long as it does not find an ecological brake.

The "technology", the result of the intrinsic capabilities of *Homo sapiens*, allowed him to loosen or eliminate the multiple ecological brakes that he encountered on his path.

However, the development of such an efficient technology has not been accompanied by an adequate growth in awareness of the medium- and long-term consequences of the use of this technology.

Ethics, that is, the rules of behaviour of a community based on ideas about what is morally good and bad, should "evolve" to counteract the effects produced by a technology without limits.

In this context, the "conservation" (intrinsic value of biodiversity) and the "need to conserve" (instrumental value of biodiversity) lose a clear distinction, becoming the foundation of a "**New Socioecology**", *as adaptive behavioural responses of individuals to variation in resource size and distribution*.

Socioecology emerged as a subdiscipline of behavioural ecology in the 1960s examining systematic relationships between ecology and social behaviour of animals, using an evolutionary approach.