KU LEUVEN

Mediterranean Forest, Corbera d'Ebre (photo Bart Muys)

Mediterranean Forest Management: understanding the fire-water-biodiversity nexus

Bart Muys[1,2]

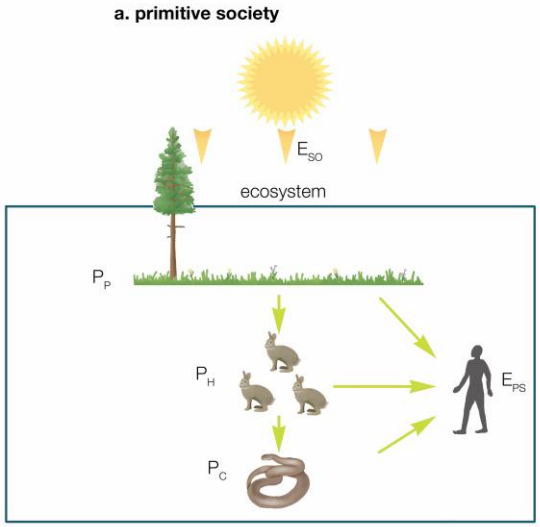
[1]Earth & Environmental Sciences, KU Leuven
[2]EFIMED

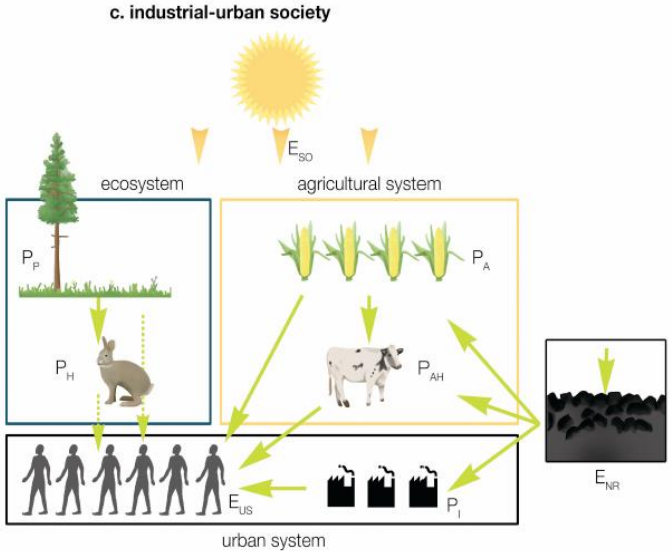
OUTLINE

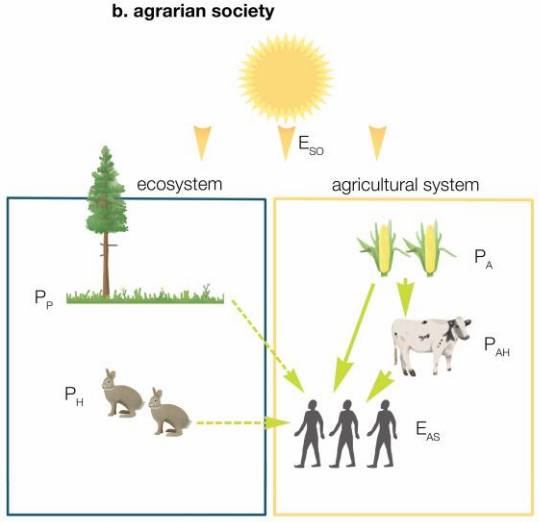
- Ecocrisis and strong sustainability
- Apply to sustainable Mediterranean forest management:
  - Fire issue
  - Water issue
  - Biodiversity issue
  - fire-water-biodiversity nexus and co-production of goods and services.

KU LEUVEN

Human appropriation of land and energy







Regime shifts in the metabolism of the social-ecological system

Muys (2013) *Challenges in Sustainability*

KU LEUVEN

Metabolic regime shifts

	Unit	Hunter-gatherers	Agrarian society*	Industrial society**
Total energy use per capita	[GJ/cap/yr]	10–20	40–70	150–400
Use of materials per capita	[t/cap/yr]	0.5–1	3–6	15–25
Population density	[cap/km²]	0.025–0.115	<40	<400
Agricultural population	[%]	–	>80%	<10%
Total energy use per unit area	[GJ/ha/yr]	<0.01	<30	<600
Use of materials per unit area	[t/ha/yr]	<0.001	<2	<50
Biomass (share of energy use)	[%]	>99	>95	10–30

Table 1. Metabolic profiles of hunter-gatherers and agrarian and industrial society. Sources: adapted from Krausmann *et al.*, 2008a, based on data from Haberl *et al.*, 2006b; Krausmann and Haberl, 2002; Malanima, 2002; Schandl and Schulz, 2002; Sieferle *et al.*, 2006; Simmons, 1989, 2008; Weisz *et al.*, 2006

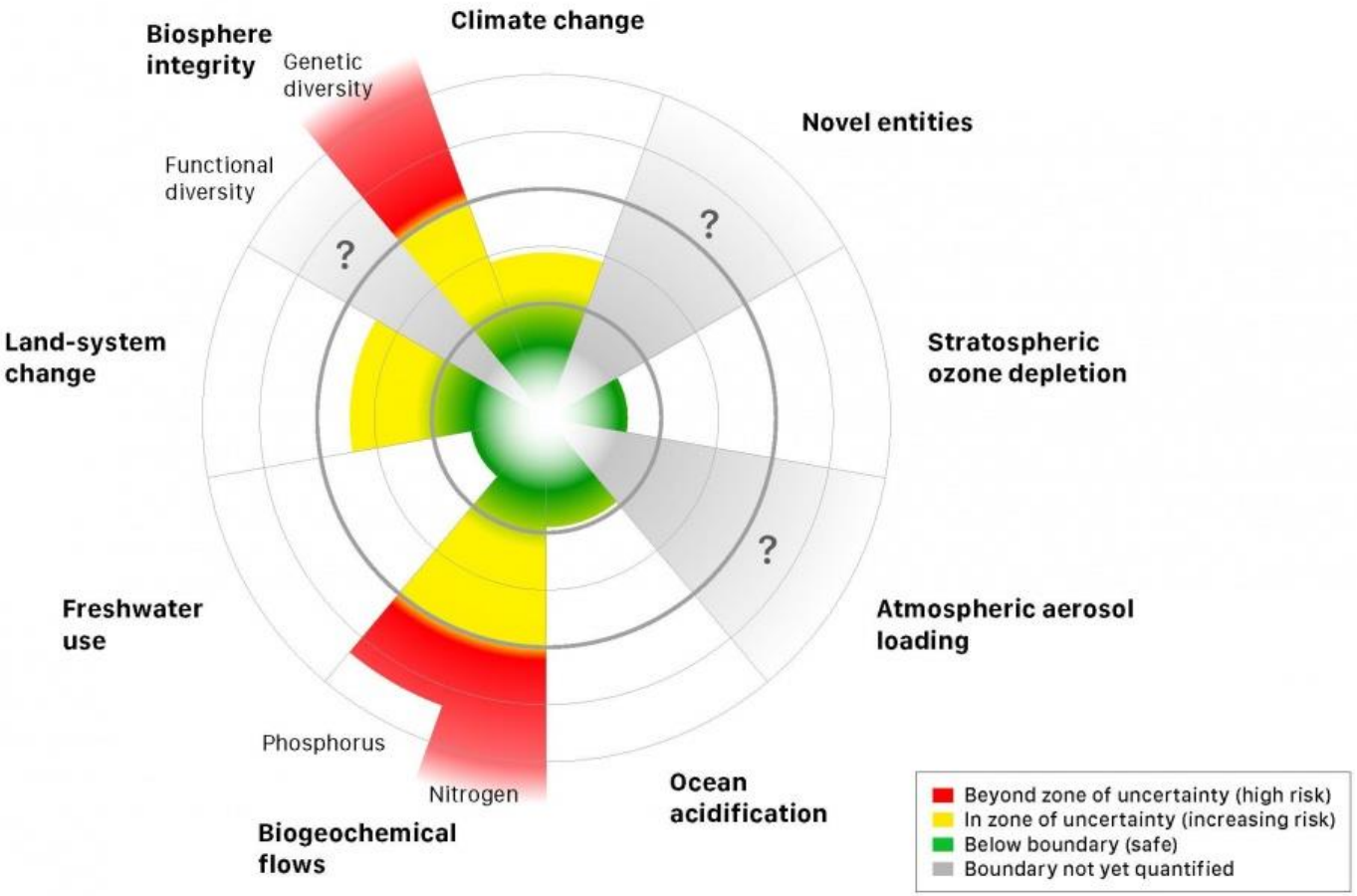
*Typical values for an advanced European agrarian socio-metabolic regime (18th century). In agrarian societies based on labour-intensive horticultural production with low significance of livestock, population density might be significantly higher, while the per capita use of materials and energy would be lower.

**Typical values for current fully industrialized economies. In countries with high population densities, per capita values of energy/materials use tend to be in the lower range, while values are high when measured per unit area. The reverse is true for countries with low population densities; in this case values per unit area can be very low.

KU LEUVEN

Haberl et al. (2011), Sust. Dev. 19, 1-14.

The ecocrisis

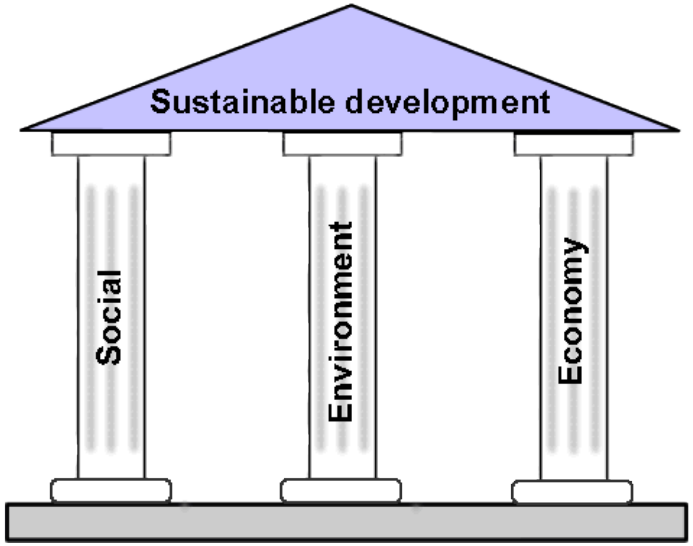


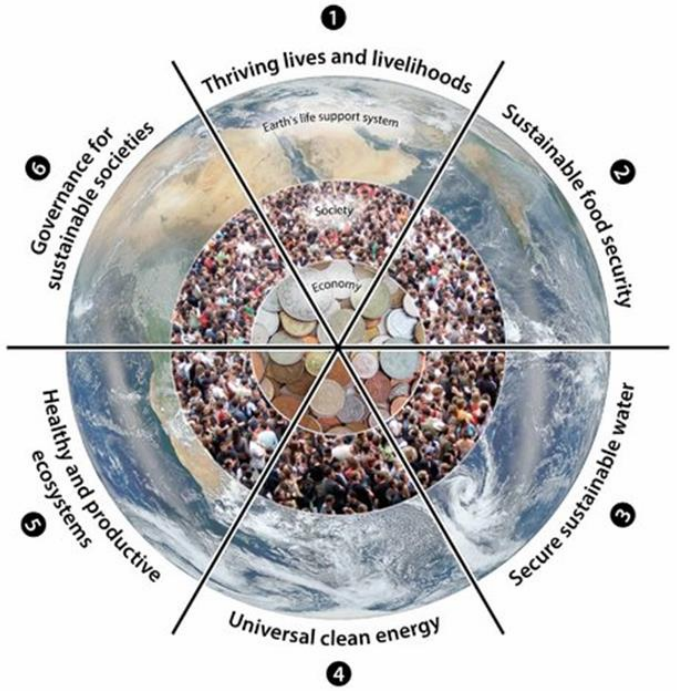
Humanity trespassing the safe operating space for key factors of planetary stability

Updated Rockström diagrama: Steffen et al. (2015) *Science*

KU LEUVEN

From weak to strong sustainability





Griggs et al. (2013) Nature

- Economy is at the service of societal well-being, and societies can prosper within the possibilities and limits offered by the natural environment.
- Things have to be ecologically sound to be economically viable (Piketty)
- Increasingly influential, as feasible alternative for the pillar model, which is failing to keep society within planetary boundaries (Rockström et al. 2009 *Nature*; Steffen et al. 2015 *Science*)

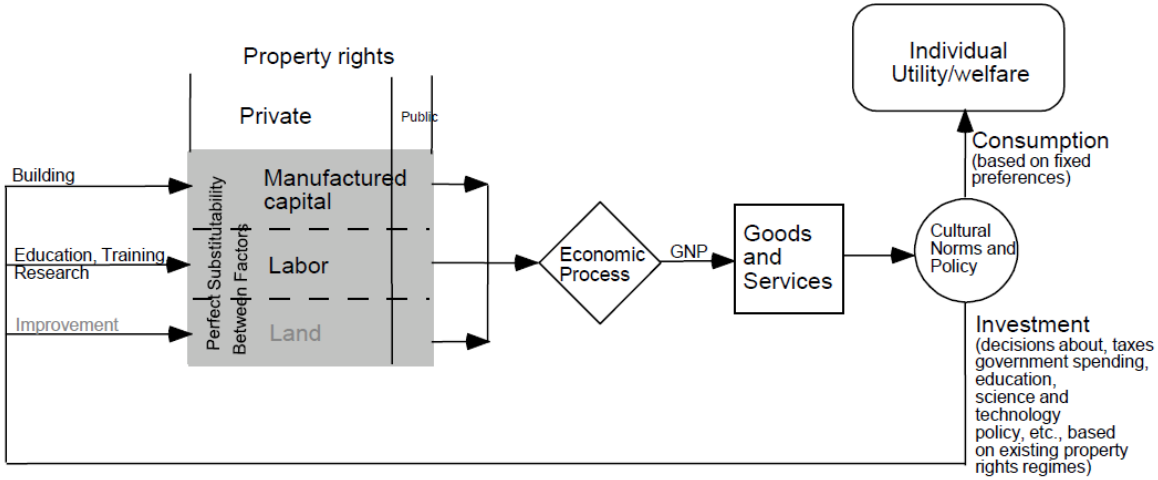
IDEA 1

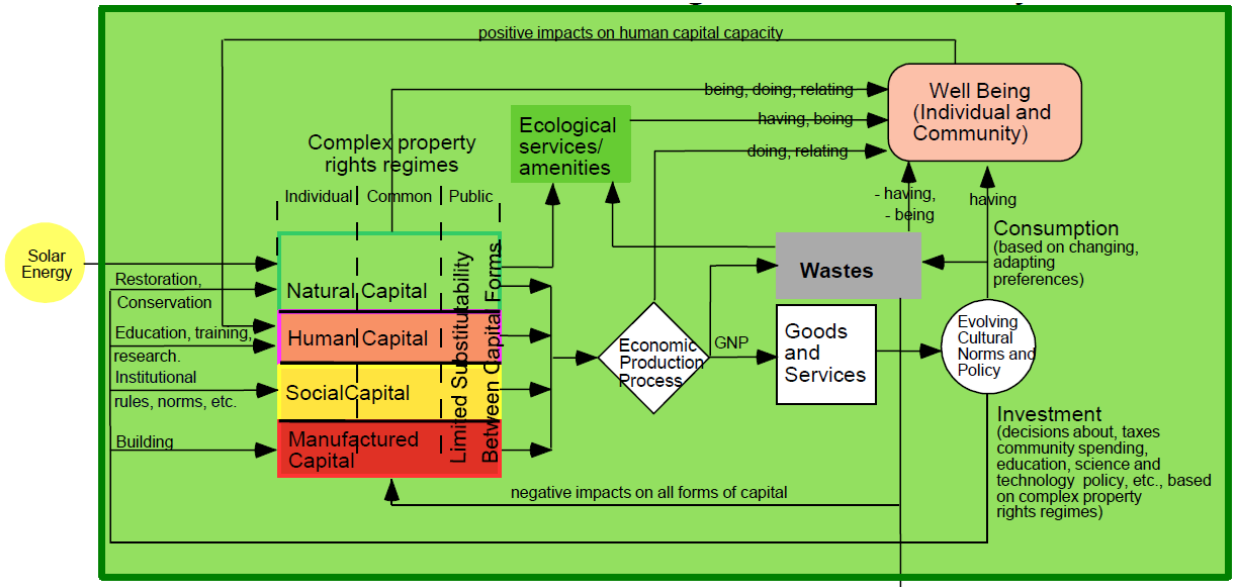
Decision makers need stronger awareness of the non-negotiable planetary boundary conditions for prosperity and well-being

Respecting safe operating space implies adoption of a strong, nested model of sustainable development

KU LEUVEN

Need for revising the economic model



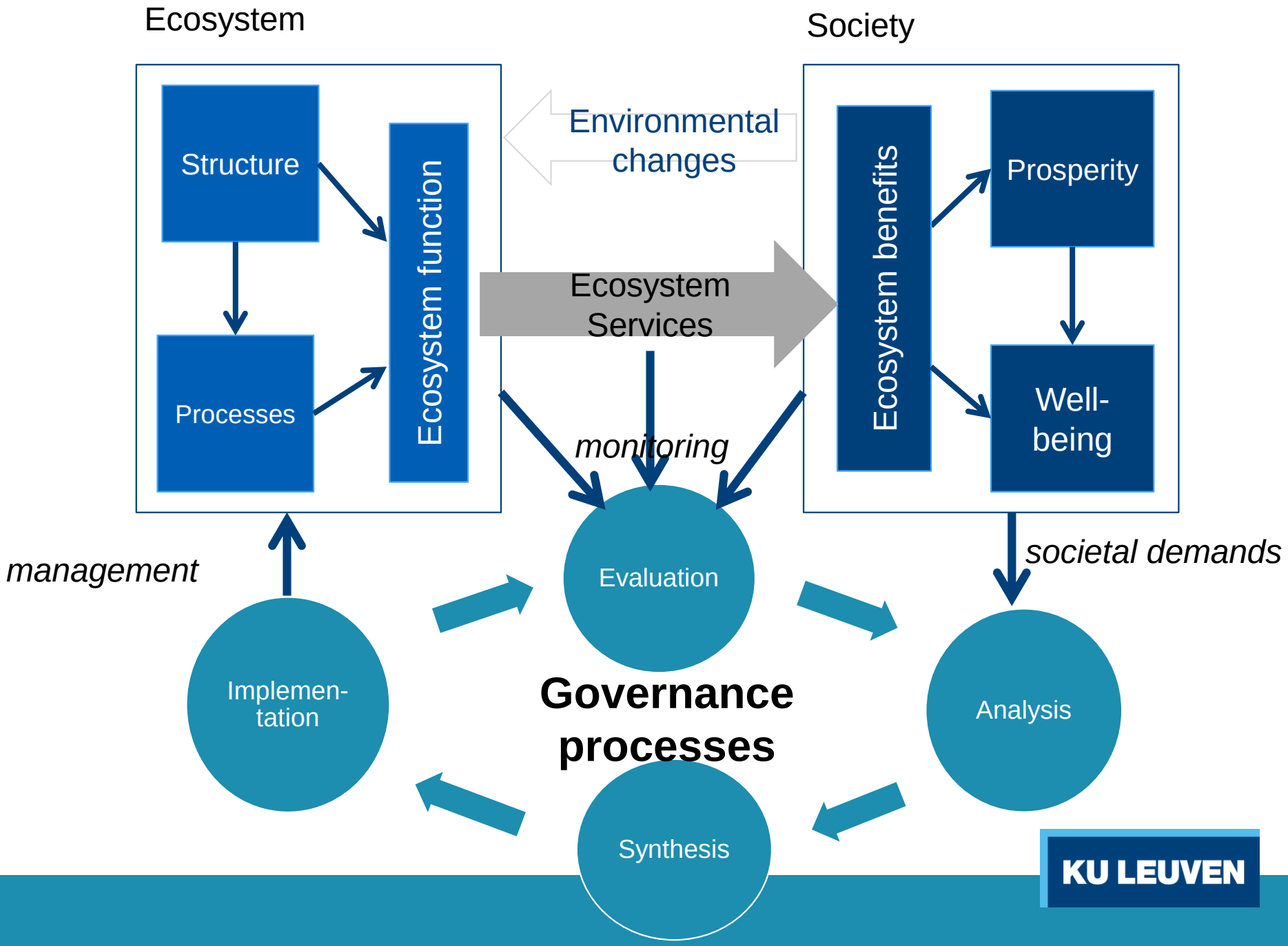


Source: Costanza et al. (1997)

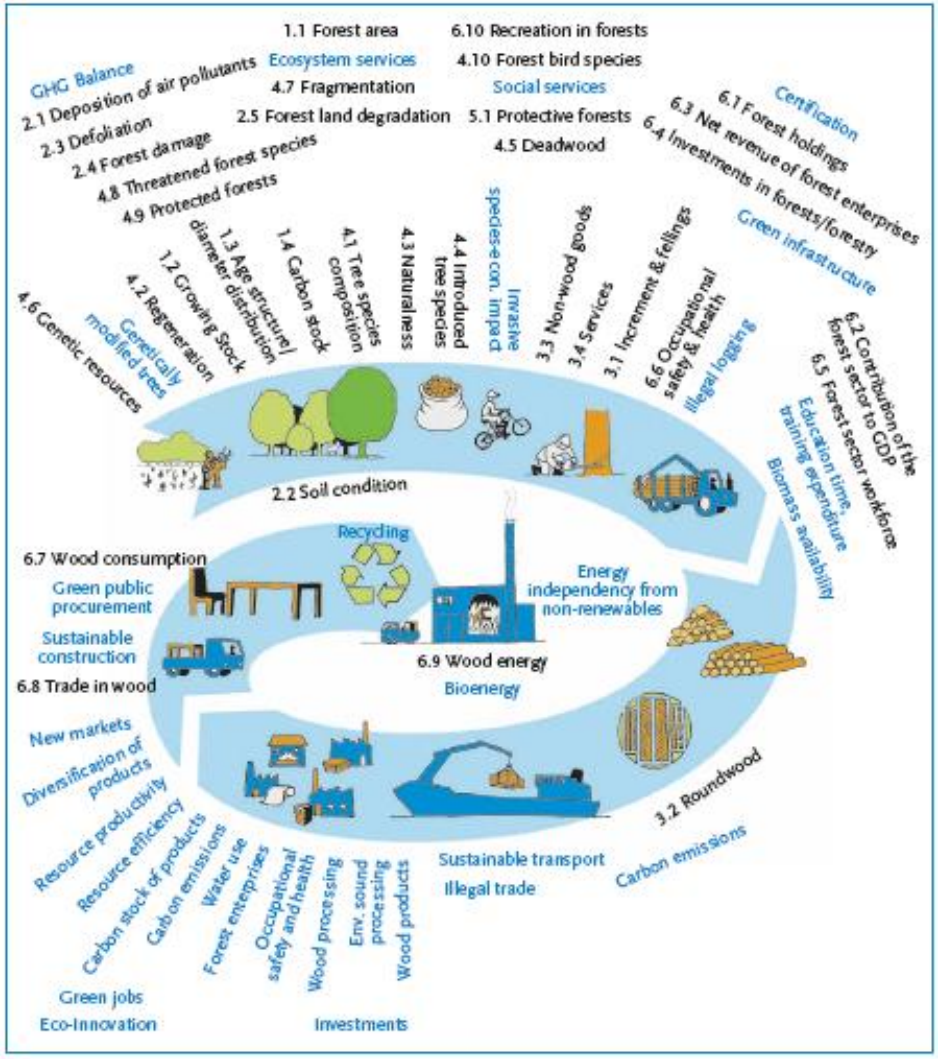
The current "empty world" model:

The "full world" model of the social-ecological system

KU LEUVEN


Ecosystem
Society
Structure
Processes
Ecosystem function
Environmental changes
Ecosystem Services
Ecosystem benefits
Prosperity
Well-being
monitoring
management
societal demands
Evaluation
Implemen-tation
Analysis
Governance processes
Synthesis

circular bio-economy: an excellent road to the full world model



- Economic activity based on natural capital
- Focusing on ecosystem services
- Avoiding the impacts of the fossil-based economy

Wolfslehner et al. 2016 EFI FSTP4

KU LEUVEN

IDEA 2

The circular bio-economy should be based on a full world economic model, generating quality and quantity of ecosystem services for human well-being

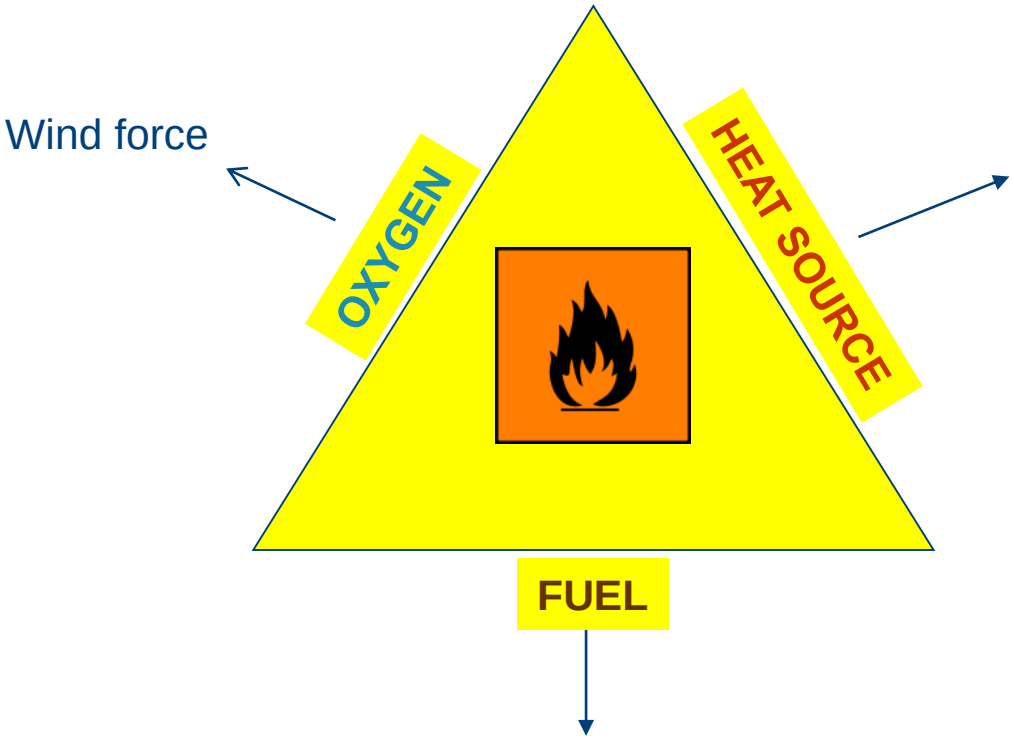
KU LEUVEN

Strong sustainability in practice: three forest-related sustainability issues of the Mediterranean

1. The fire issue
2. The water issue
3. The biodiversity issue

1. The fire issue

What are the elements that lead to forest fire?



Human

Pyromany
Land tenure conflicts
Imprudence (cigarettes, BBQ)
Glass
Electric sparks (railroad)
Ignition from remote fire (flying sparks, burning rabbits)

Natural

Lightning/dry storms
Spontaneous ignition by friction
Natural lenses (drops)

From ground fire to crown fire

1
Fine flammable material

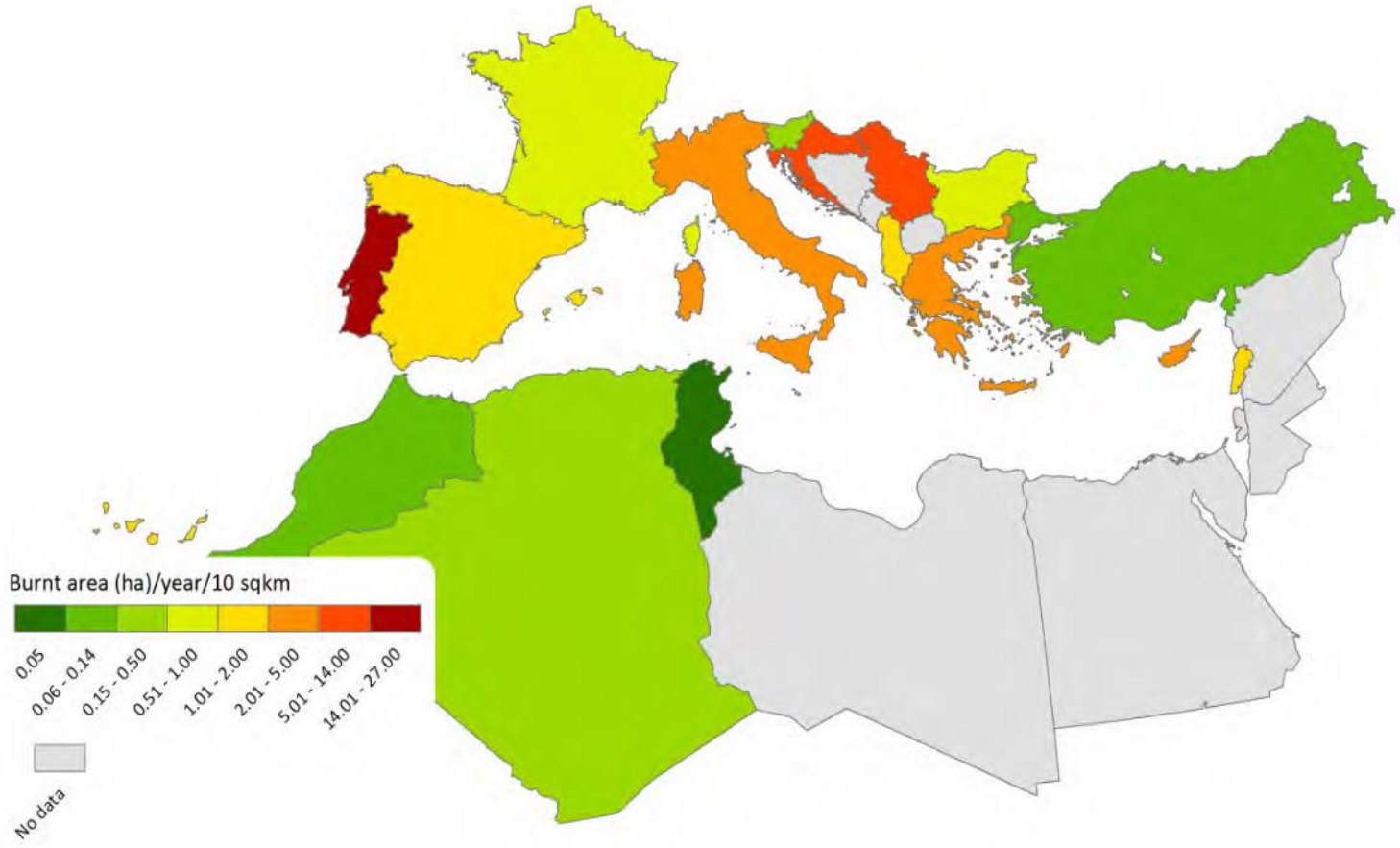
2
Dead wood, regeneration

3
Living trees
(burn only when crown fire)

4
Heavy dead wood
(often do not burn)

5
Shrub layer and dead branches
(highest risk factor, as they serve as ladders from ground fire to crown fire)

Forest fire impact in the mediterranean



FAO SoMF 2013

KU LEUVEN

Forest fire impact in the mediterranean

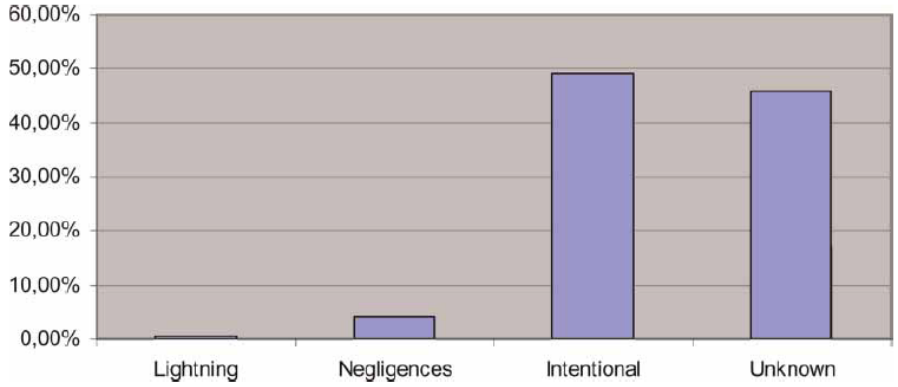


Figure 7. Causes of forest fires in Spain 1971–2005.
Source: ICONA, Ministerio de Medioambiente

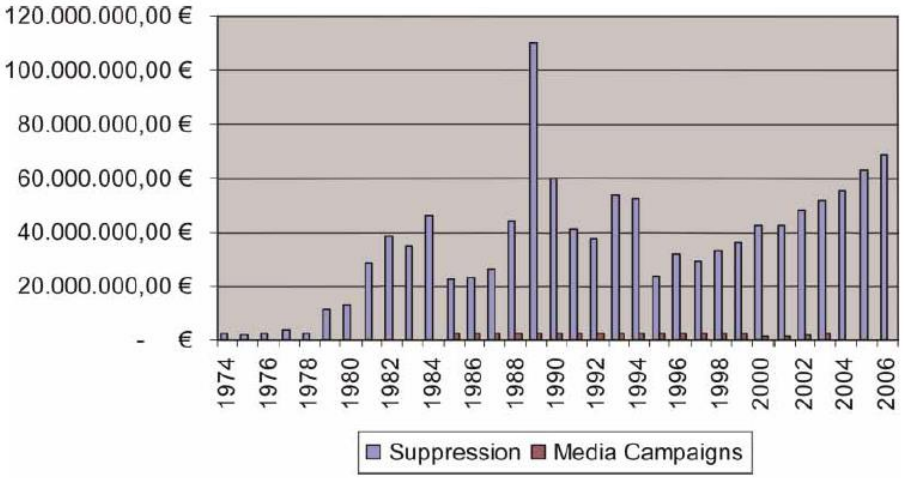
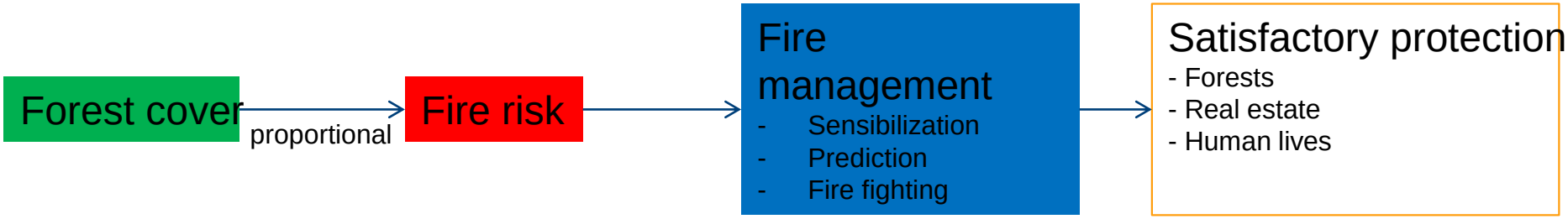


Figure 6. Costs of media campaigns and fire suppression in Spain.
Source: ICONA, Ministerio de Medio Ambiente

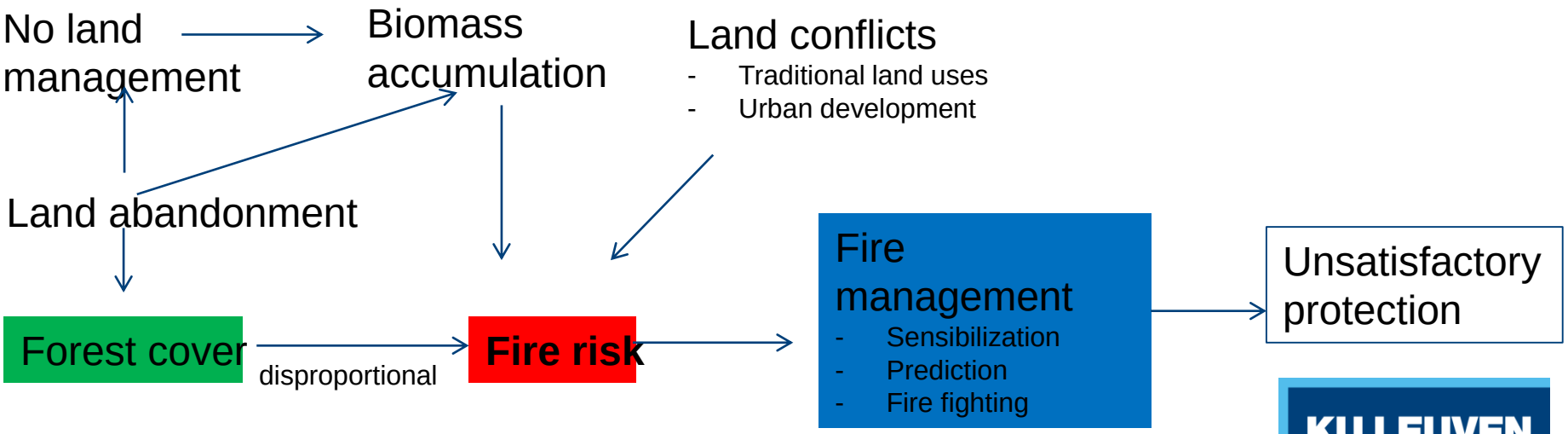
KU LEUVEN

Complex behaviour

- Linear thinking



- Complex non-linear reality



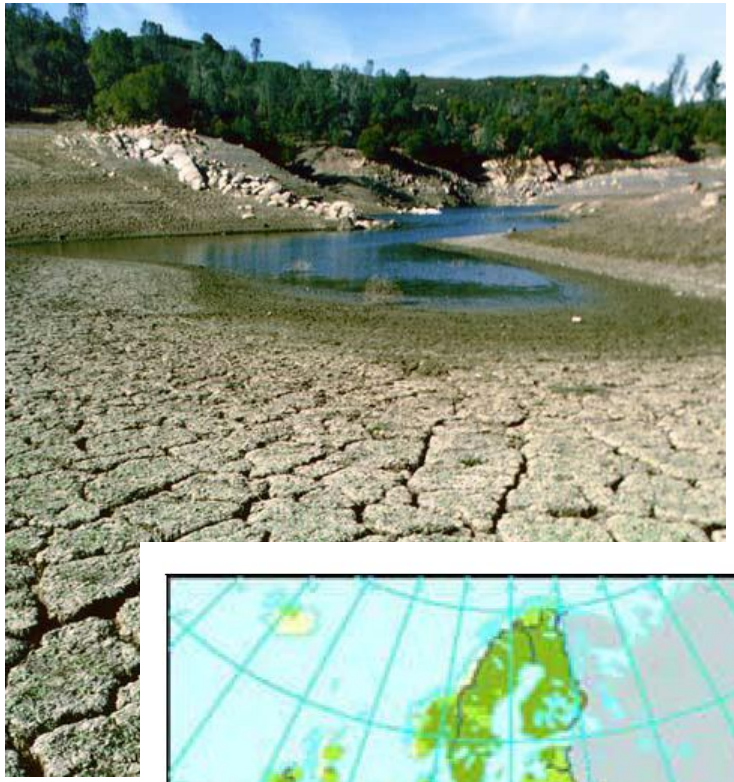
KU LEUVEN

IDEA 3

- Fire is a global change issue (climate, land use, politics)
- Most fires are anthropogenic
- Land abandonment leads to continuous forest landscapes prone to fire
- The foresters paradigm has decreased the economic viability of pastoralism and has increased the incidence of big fires
- The fire fighting paradigm has marginalized preventive measures

KU LEUVEN

2. The water issue
climate change and water scarcity



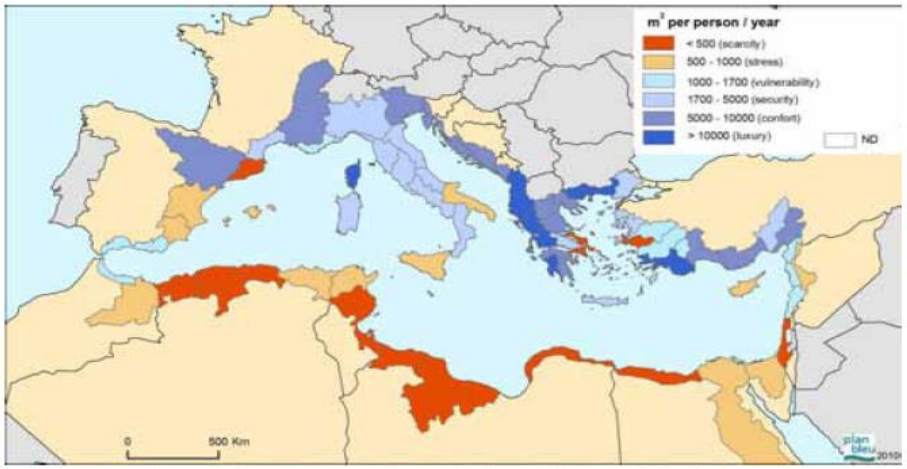
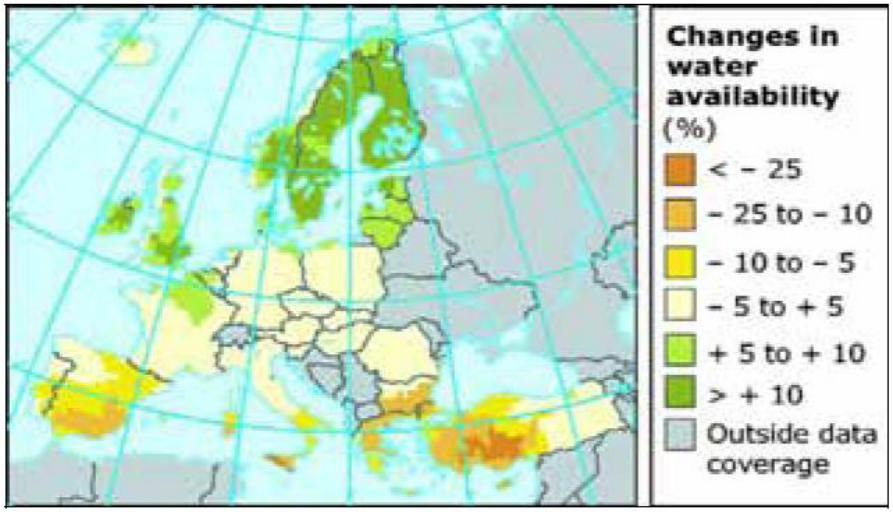


Figure 9. Renewable natural water resources (internal and external) per capita in elementary catchment basins (1995–2008). Source: Plan Bleu estimates from national sources.



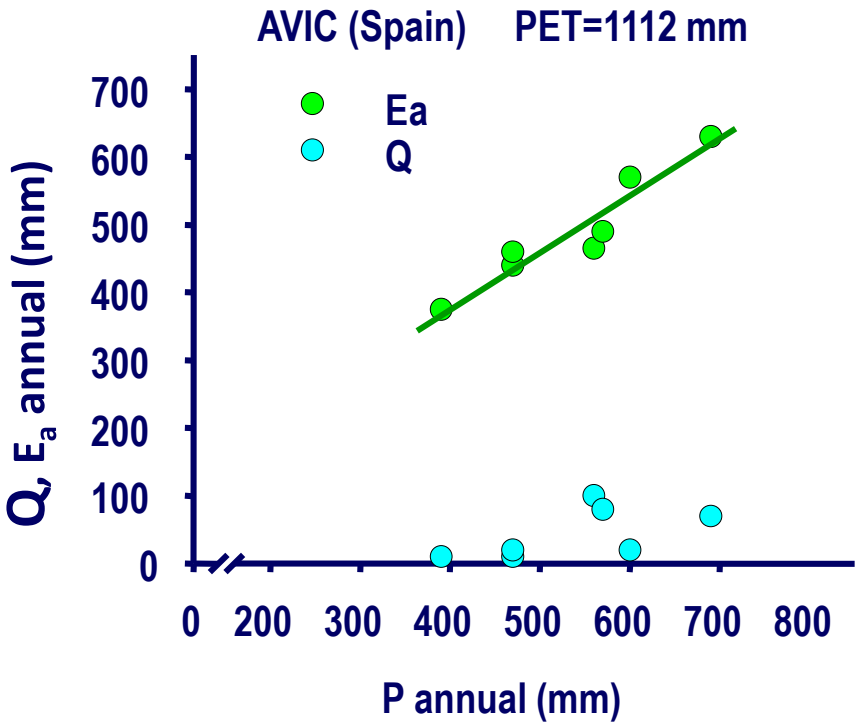
- ❑ Precipitation trend
- ❑ Consumption trend
- ❑ Role of forests?

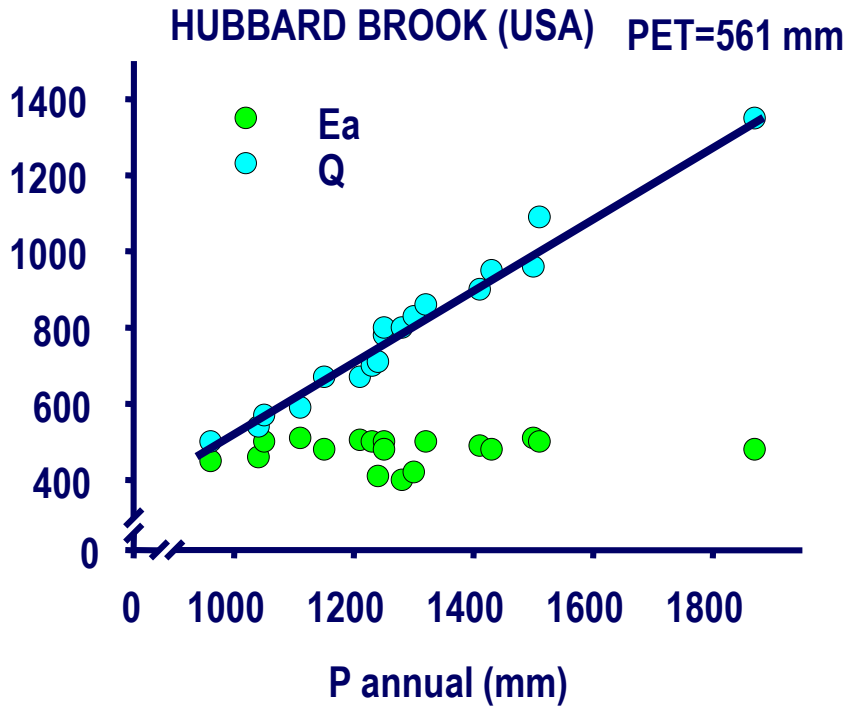
KU LEUVEN

Bassins versants Méditerranéens vs. tempérés

● E_a: évapotranspiration actuelle ● Q: ruissellement P: précipitation

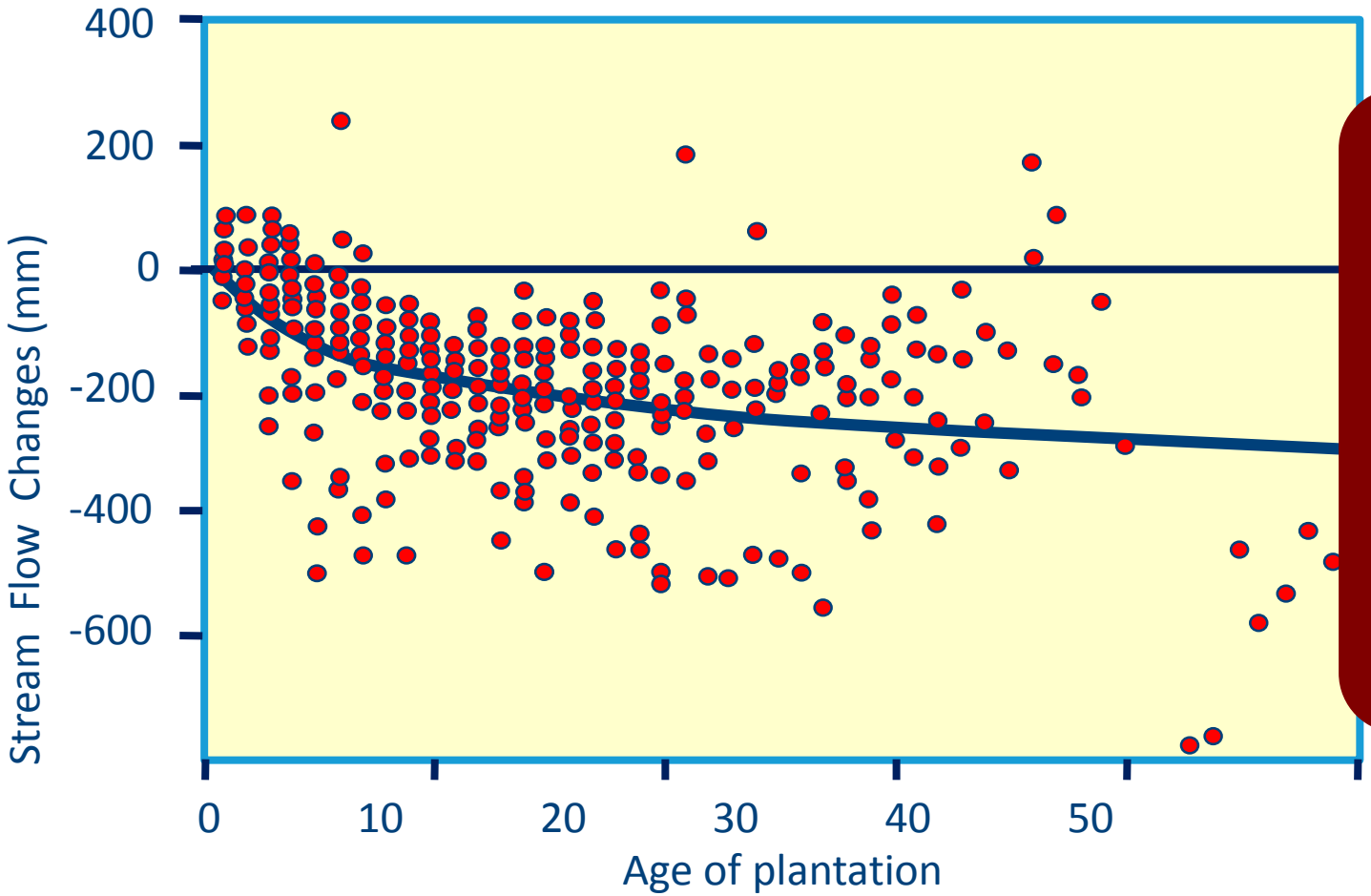
$P = Q + E_a$





From Piñol et al 1991, 1995

le modèle «éponge» : une mythe forestière
les forêts sont des consommateurs en eau et réduisent le débit d'eau



In a set of 600 observations:

Plantations decreased stream flow by 227 mm per year globally (52%), with 13% of streams drying completely for at least 1 year.

R.B.Jackson et al., Science 2005

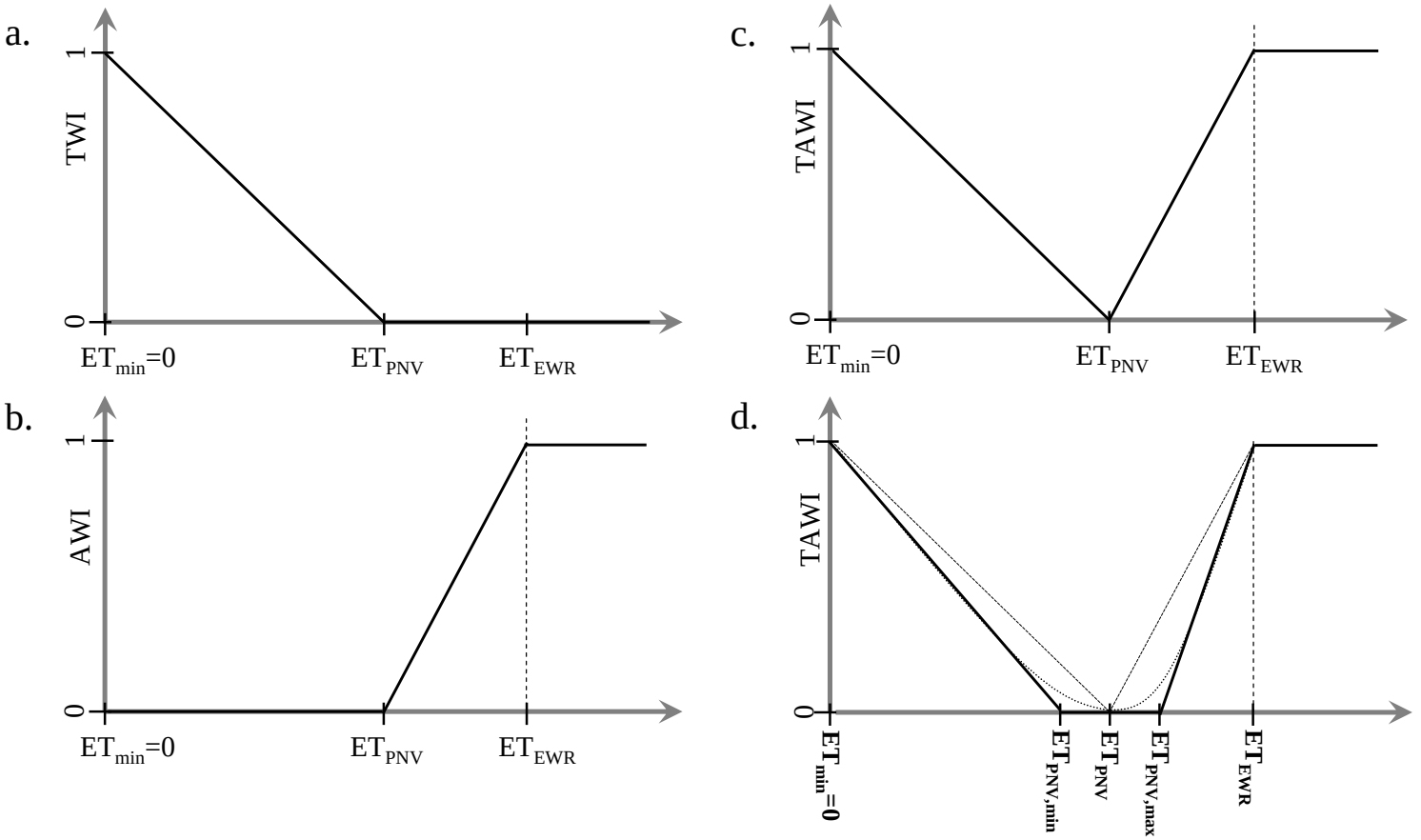
KU LEUVEN

Water footprint (m^3 of water/m^3 of wood) in *Pinus sylvestris*

Soil depth cm	optimal management	non optimal management
50	584	782
150	739	1263

Water footprint of forest products is strongly dependent on the management regime. It is crucial to understand the responses of forests not just in terms of carbon and biomass but in terms of water .

The water issue: integrated assessment of terrestrial/aquatic Water Impact

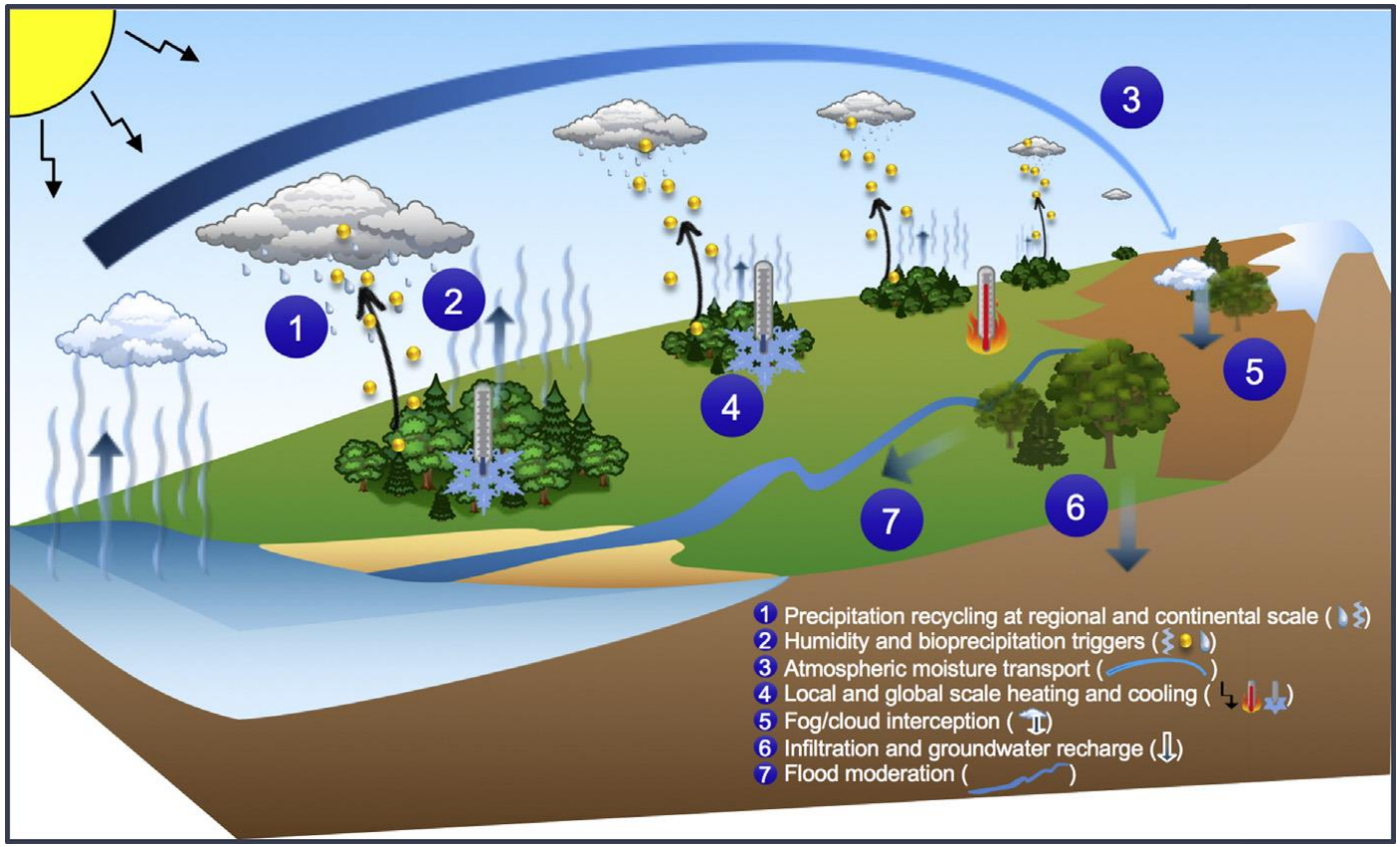


Water quantity impact as a function of land management a. in terrestrial ecosystems (TWI), b. in aquatic ecosystems (AWI), c. and d. on both aquatic and terrestrial ecosystems (TAWI) as a function of evapotranspiration (ET) of the potential natural vegetation (PNV) and a threshold ET_{EWR} determined by the minimum ecological water requirement (EWR) of the aquatic system

Maes et al. (2009) Env. Sci. Techn

KU LEUVEN

The water issue



- Trees, forests and water: Cool insights for a hot world
  (Ellison et al. 2017, *Global Environmental Change*)

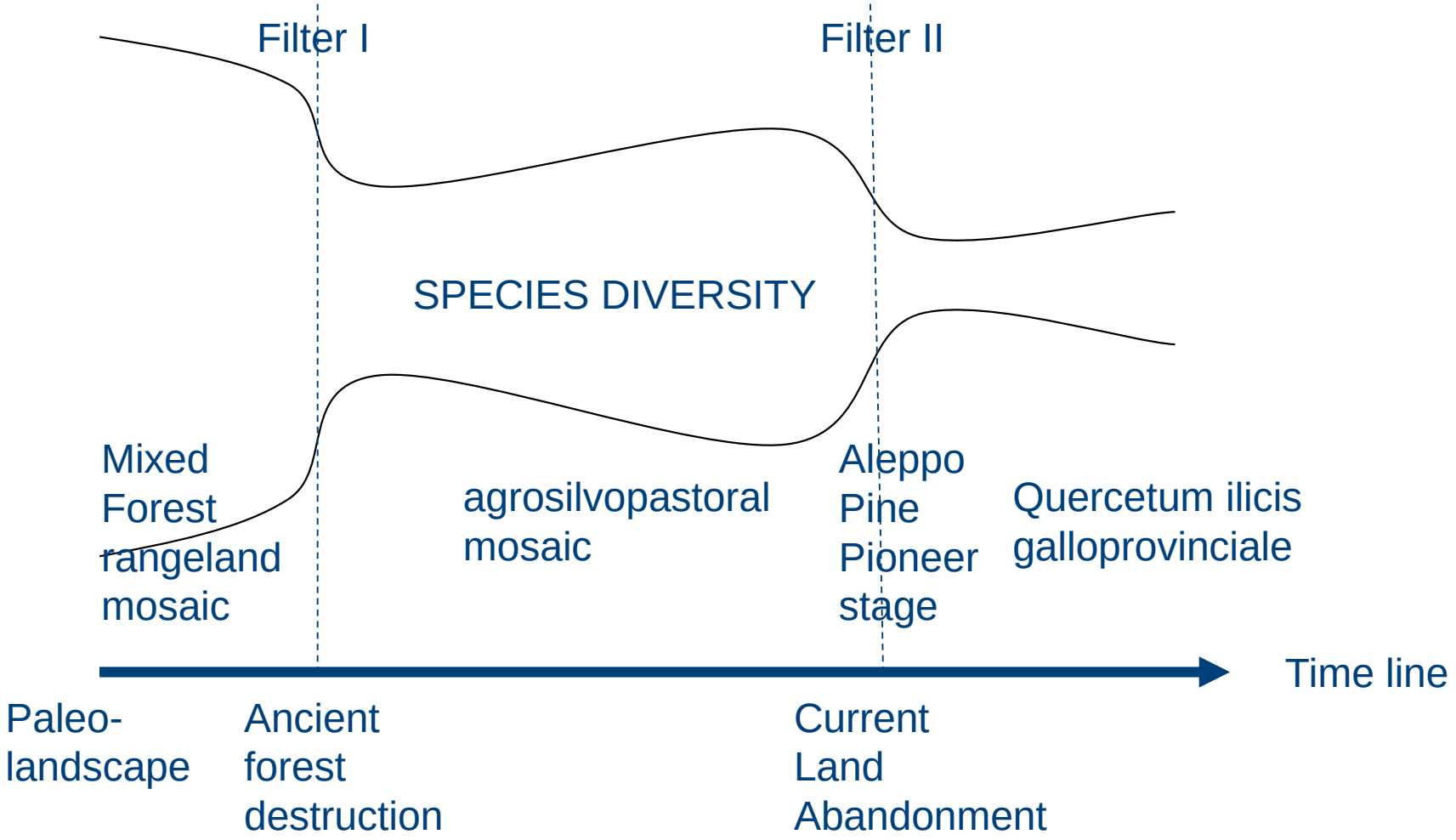
KU LEUVEN

IDEA 4

- Trees evaporate water to grow
- This is positive for erosion control, and recycling of precipitation over land
- If too high densities, this is negative for water bodies and aquatic systems
- Too low densities lead to loss of microclimate and infiltration capacity

KU LEUVEN

The biodiversity issue

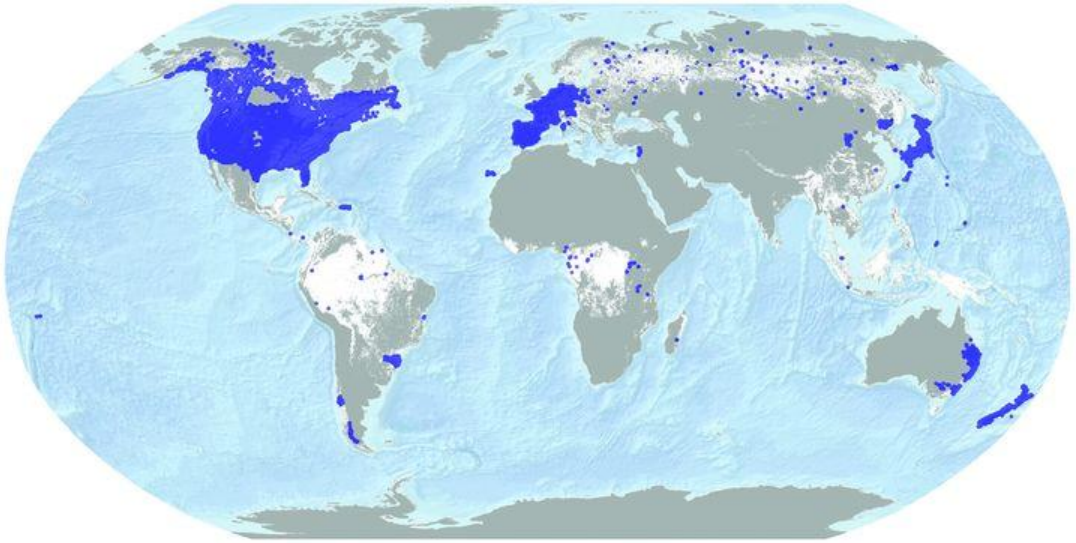


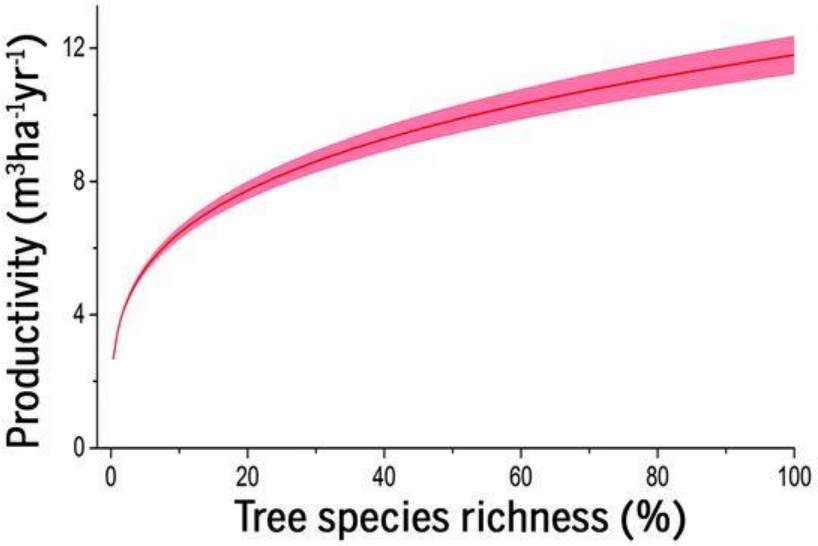
Biodiversity conservation management is context dependent:

Conservation type	Conservation status	Examples	Management needs
	Legacy: No extinction filters passed Current: High naturalness, high diversity	Old growth forests Ancient woodlands	Zero management
	Legacy: Result of first extinction filter and medium disturbance regime Current: Medium naturalness; high diversity	Oak forests Coppice forests Heathlands Agrosilvopastoral systems	Intensive management
	Legacy: Result of second extinction filter Current: low to high naturalness, low diversity	Plantation forests New forests after land abandonment	Zero management (rewilding) OR intensive management (semi-natural system restoration)

The power of mixture

- Growing evidence of positive diversity-productivity and diversity-stability relationships (global inventory data, FunDivEUROPE exploratories, TREEDIVNET experiments





Liang et al. 2016 Positive biodiversity-productivity relationship predominant in global forests, *Science*

IDEA 5

- Large scale transformations of the landscape lead to biodiversity loss
- Stability or medium disturbance regimes increase biodiversity
- In the Mediterranean edaphological diversity is neutralized by forest succession: very diverse grassland vegetations may converge to a single forest type
- Tree diversity is a factor of productivity, yield stability and insurance

KU LEUVEN

Bioenergy from the mediterranean forest

Strengths	Weaknesses
Income for forest owners	Expensive mobilisation in mountain areas
Large resource potential	Low photosynthetic efficiency – space needs – insufficient potential
Cheap energy source	Dirty fuel, particle emissions
Versatile technology	Better technology for smart grids existing
Renewable energy source	Waste of valuable resource for biorefinery

IDEA 5

- The fire-water-biodiversity nexus is the recognition of a complex of co-benefits and trade-offs between these issues
- This gives space to optimization potential of the forest management

KU LEUVEN

The full fire/water/biodiversity nexus

Virtual exercise: compose your sustainable management for the Montseny area (30,000 hectares).

Land cover, biomass density, etc.: look at google maps in satellite view on a smart phone

KU LEUVEN

The full fire/water/biodiversity nexus

Virtual exercise: compose your sustainable management for the Montseny area (30,000 hectares).

Your budget: 1,000,000 for a period of 5 years

Your options:

- Investment in fire fighting equipment: 500,000
- Investment in municipal biomass heating system: 200,000
- Establishment of a fire break of 1 km: 100,000
- Maintaining existing fire break of 1 km: 10,000
- Cleaning forest undergrowth of 10 ha: 20,000
- Thinning forest favouring mixture of 10 ha: 20,000
- Annual subsidy to sheppard with 200 sheep and goats: 5,000

Every option yields a score for fire, water and biodiversity, based on their discussed nexus

Thanks for your attention

bart.muys@kuleuven.be

DEPARTMENT OF **EARTH AND ENVIRONMENTAL SCIENCES**
K.U.LEUVEN - BELGIUM

DIVISION OF
FOREST, NATURE & LANDSCAPE
for nature based solutions

KU LEUVEN