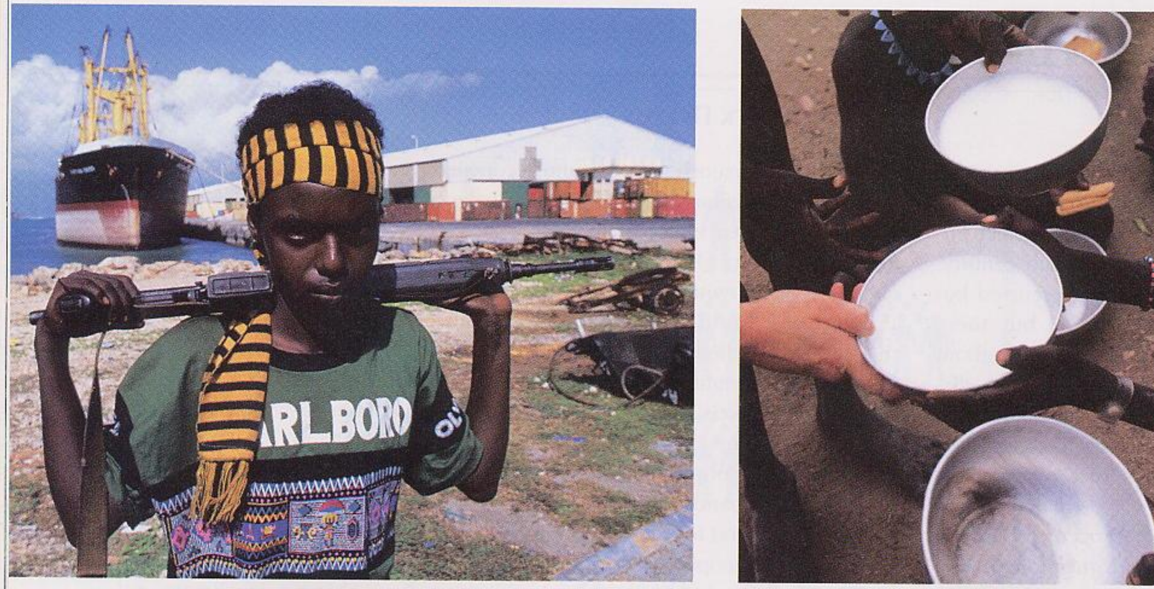
4º Aula Teórica 04-03-2020

As bases da Sustentabilidade

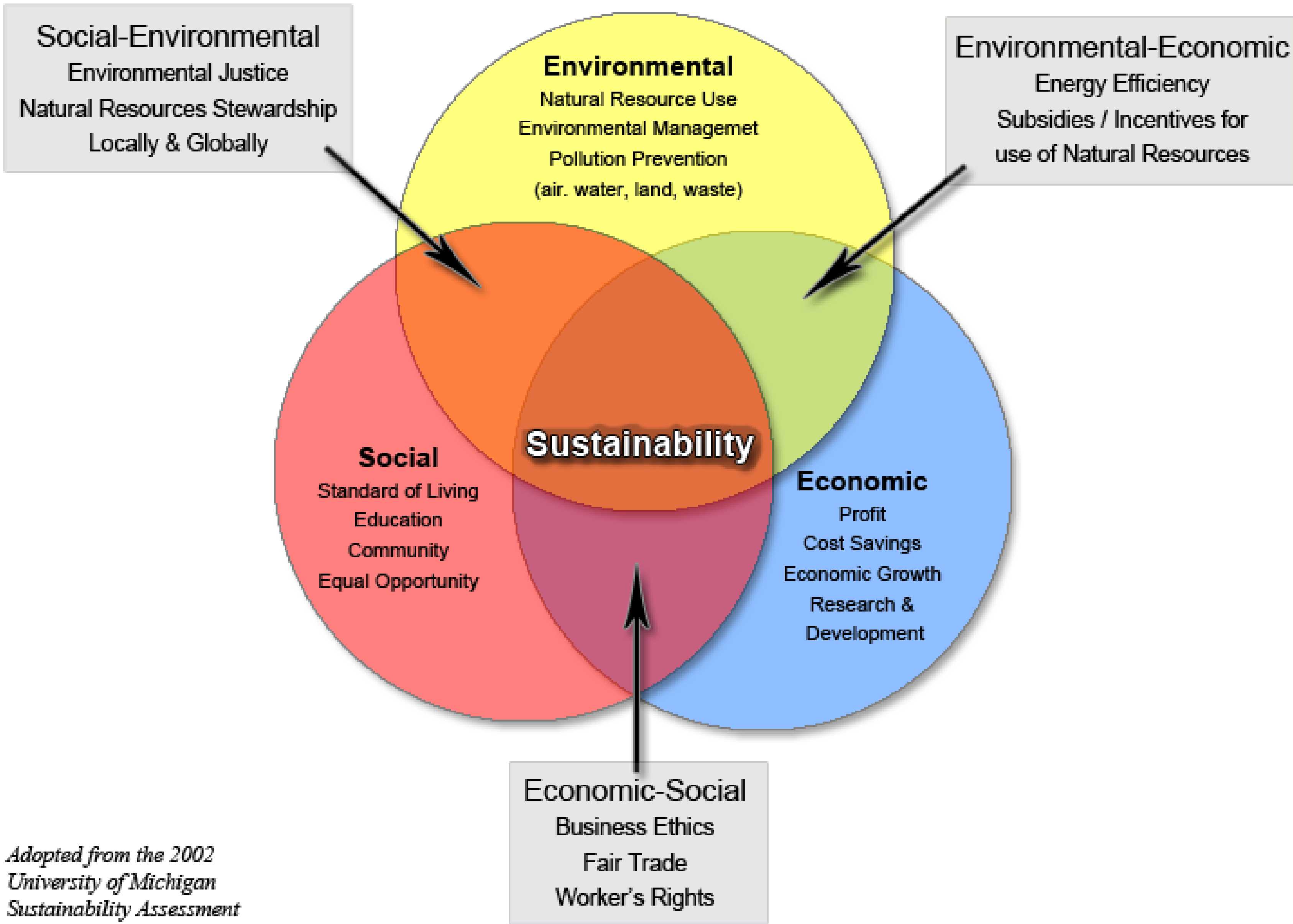
Biodiversidade e serviços dos ecossistemas



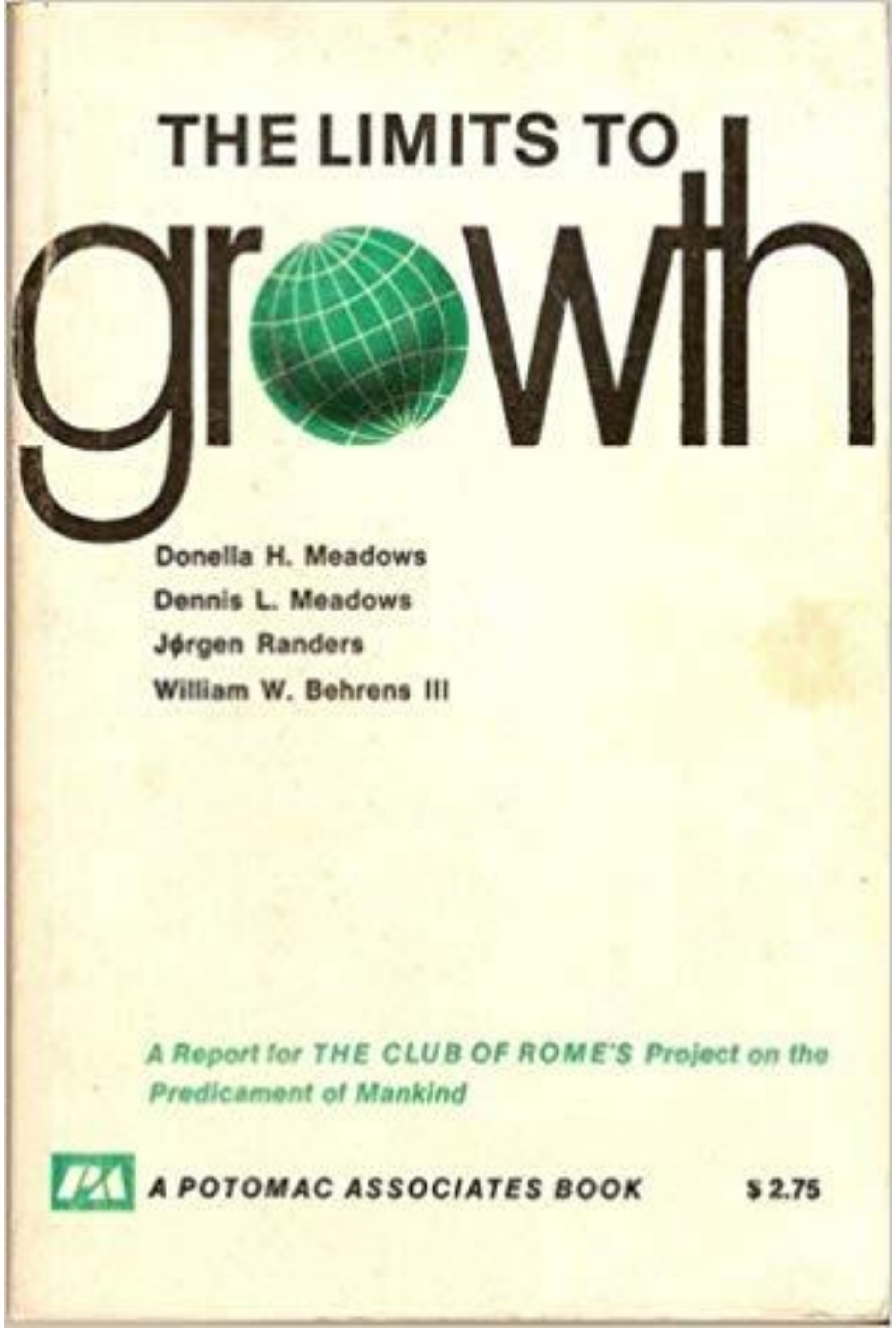
Social conditions affect the environment and the environment affects social conditions, as illustrated by a Somalian boy with a gun (left photo). Political disruption in Somalia interrupted farming and food distribution, leading to starvation. Overpopulation, climate change, and poor farming methods also lead to starvation, which in turn promotes social disruption. Famine has been common in parts of Africa since the 1980s, as illustrated by gifts of food from aid agencies in southern Sudan, as shown in photograph at right.




The Three Spheres of Sustainability



Adopted from the 2002
University of Michigan
Sustainability Assessment

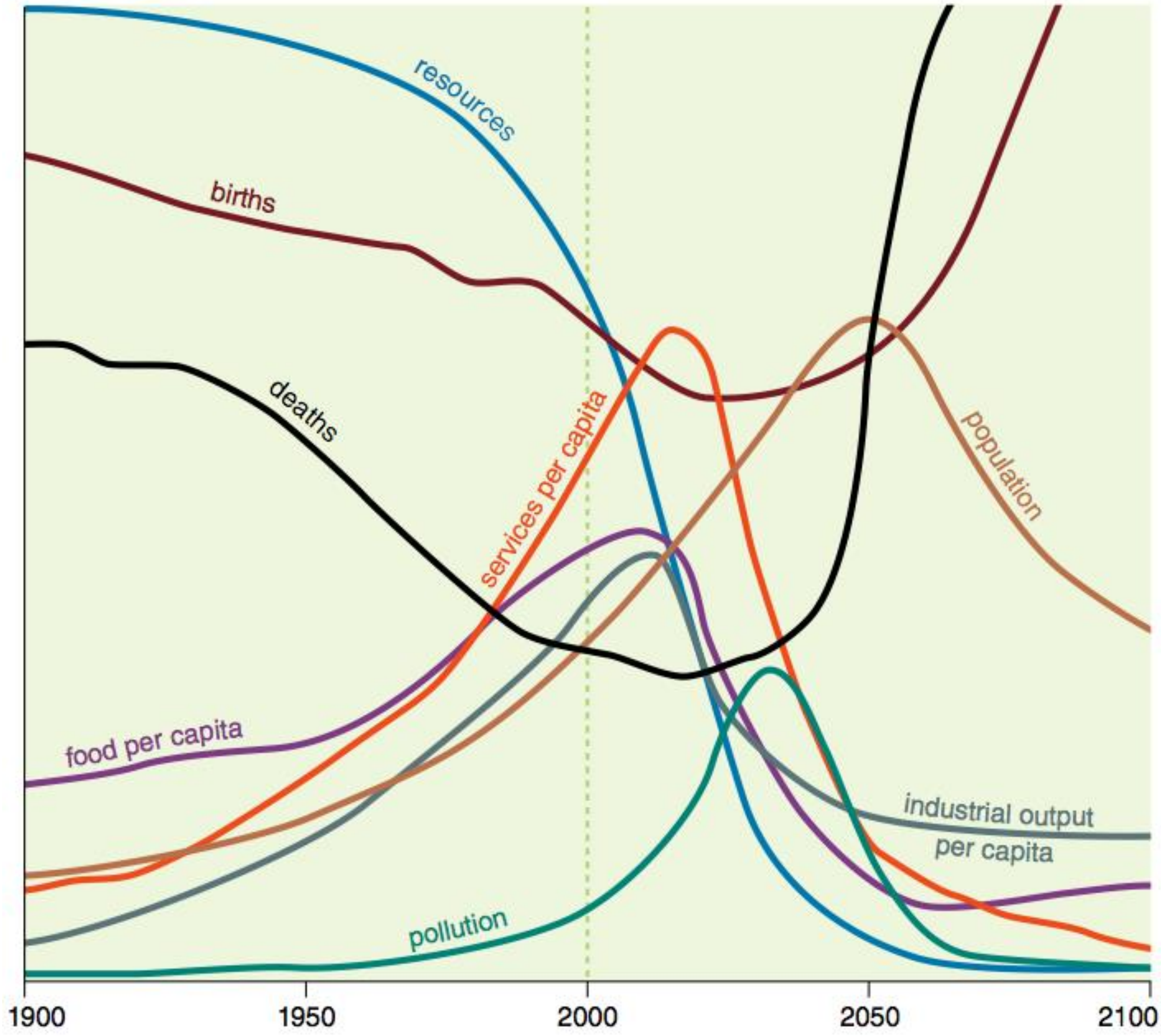


THE LIMITS TO GROWTH, Donella H. Meadows, Dennis L. Meadows, Jorgen Randers, William W. Behrens III.

The earth's interlocking resources- the global system of nature in which we all live- probably cannot support present rates of economic and population growth much beyond the year 2100, if that long, even with advanced technology. In the summer of 1970, an international team of researchers at the Massachusetts Institute of Technology began a study of the implications of continued worldwide growth.
They examined the five basic facts that determine and, in their interactions, ultimately limit growth on this planet- population increase, **agricultural production, nonrenewable resource depletion, industrial output, and pollution generation**.

The MIT team fed data on these five factors into a global computer model and then tested the behavior of the model under several sets of assumptions to determine alternative patters for mankind's future.

Man can create a society in which he can live indefinitely on earth if he imposes limits on himself and his productions of material goods to achieve a state of global equilibrium with population and production in carefully selected balance.



resources
births
deaths
services per capita
population
food per capita
industrial output per capita
pollution
1900
1950
2000
2050
2100

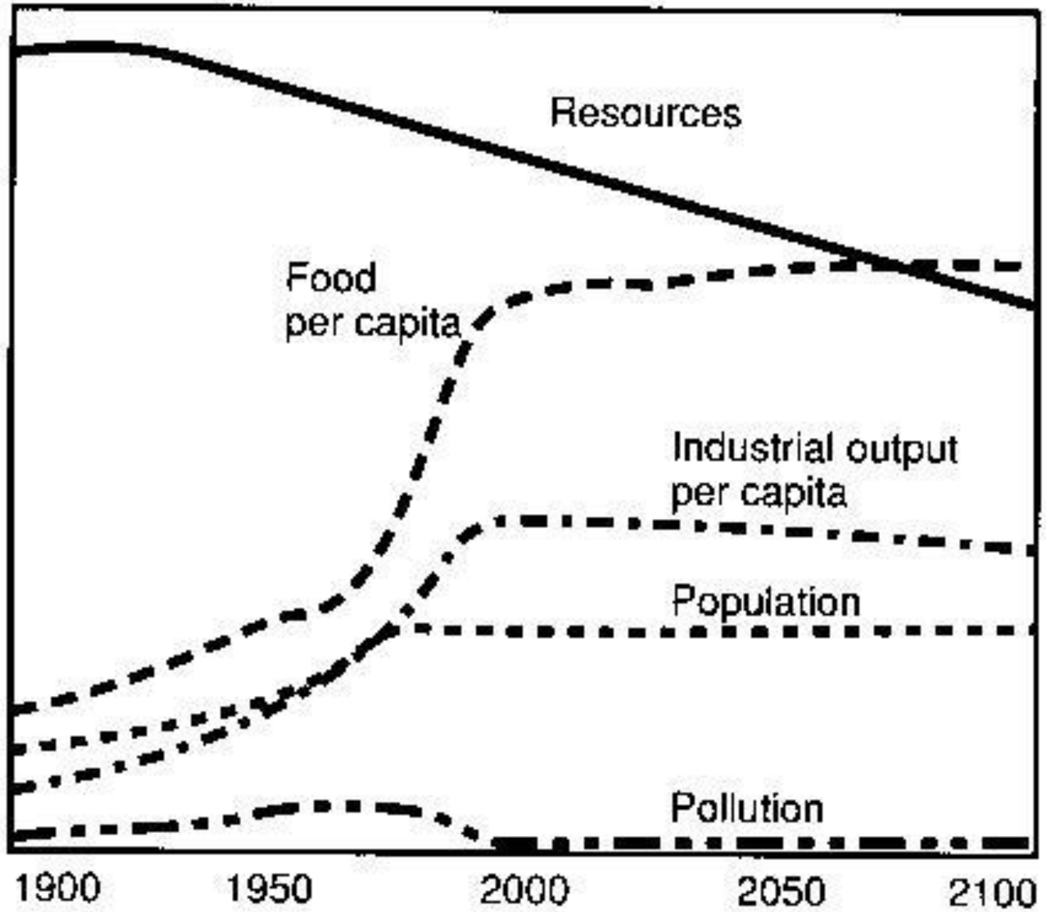
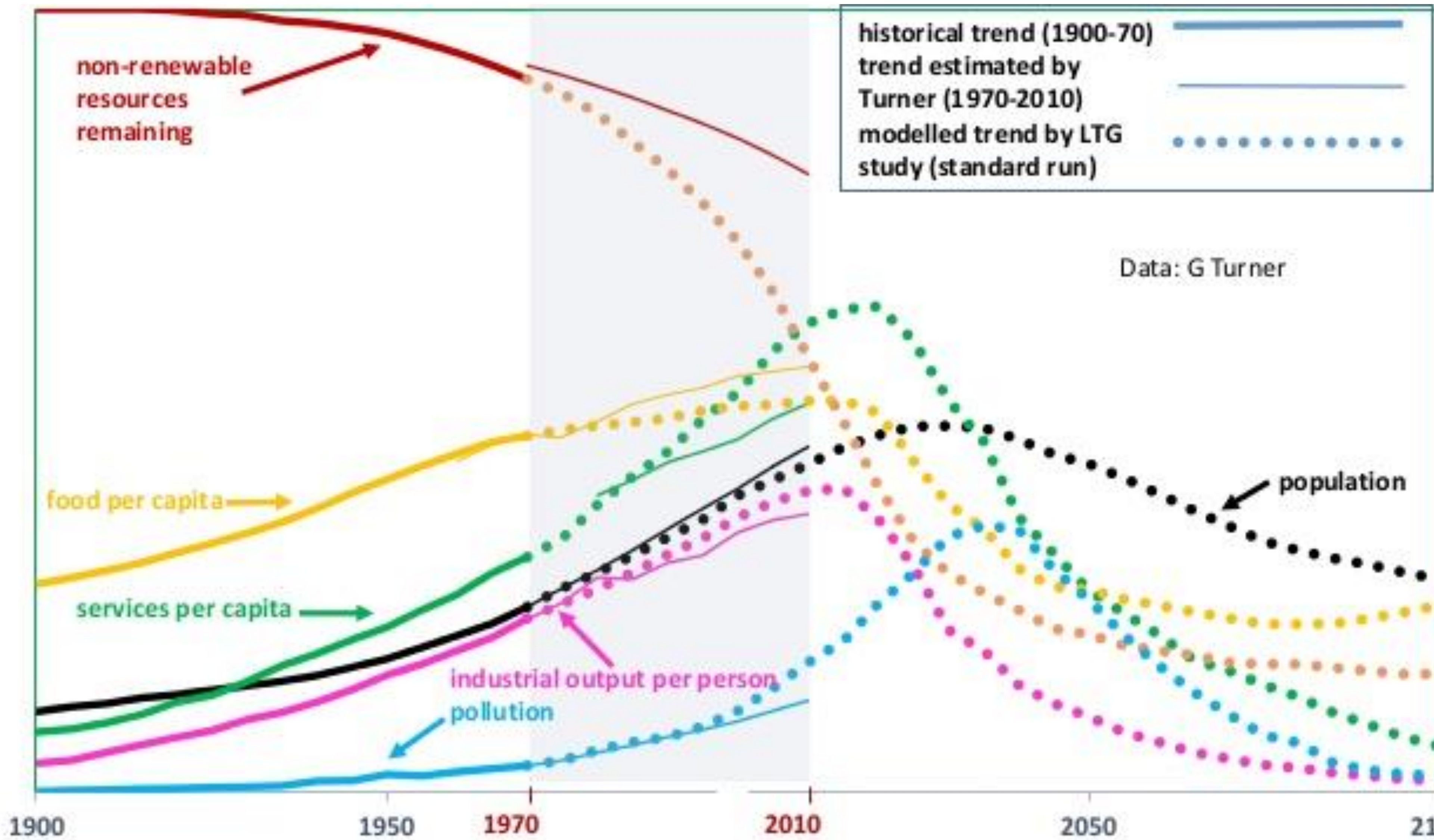
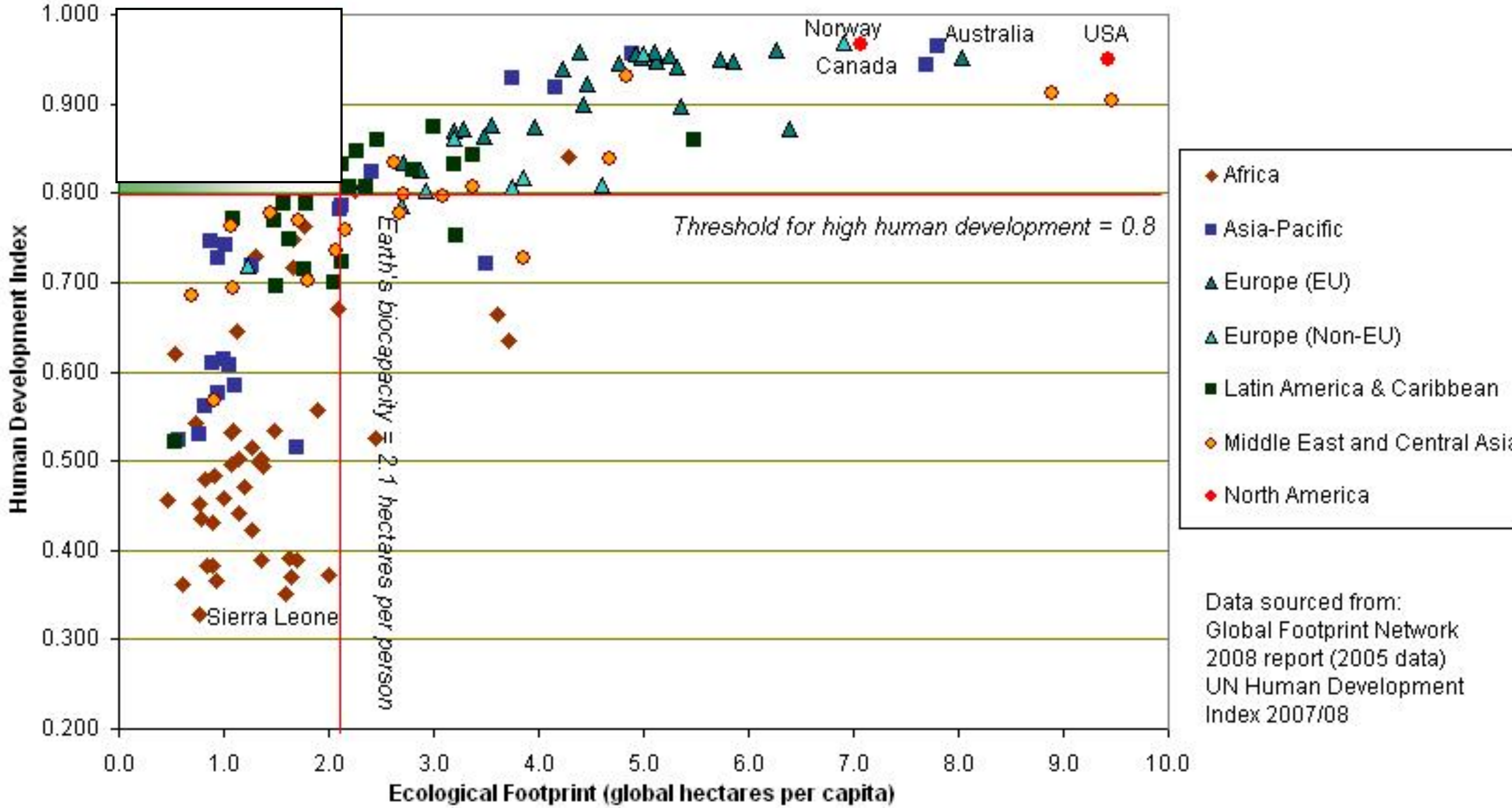


FIGURE 1.7 If strenuous attempts are made now to stabilize population size, a sustainable, steady-state type of society may be achieved by 2025. The finite resource base will continue to fall, however, suggesting the need to turn to renewable resources.



non-renewable resources remaining
historical trend (1900-70)
trend estimated by Turner (1970-2010)
modelled trend by LTG study (standard run)
Data: G Turner
food per capita
services per capita
population
industrial output per person
pollution
1900
1950
1970
2010
2050
21

Human Welfare and Ecological Footprints compared



World Scientists' Warning to Humanity: A Second Notice

WILLIAM J. RIPPLE, CHRISTOPHER WOLF, THOMAS M. NEWSOME, MAURO GALETTI, MOHAMMED ALAMGIR, EILEEN CRIST, MAHMOUD I. MAHMOUD, WILLIAM F. LAURANCE, and 15,364 scientist signatories from 184 countries

Twenty-five years ago, the Union of Concerned Scientists and more than 1700 independent scientists, including the majority of living Nobel laureates in the sciences, penned the 1992 "World Scientists' Warning to Humanity" (see supplemental file S1). These concerned professionals called on humankind to curtail environmental destruction and cautioned that "a great change in our stewardship of the Earth and the life on it is required, if vast human misery is to be avoided." In their manifesto, they showed that humans were on a collision course with the natural world. They expressed concern about current, impending, or potential damage on planet Earth involving ozone depletion, freshwater availability, marine life depletion, ocean dead zones, forest loss, biodiversity destruction, climate change, and continued human population growth. They proclaimed that fundamental changes were urgently needed to avoid the consequences our present course would bring.

The authors of the 1992 declaration feared that humanity was pushing Earth's ecosystems beyond their capacities to support the web of life. They described how we are fast approaching many of the limits of what the biosphere can tolerate without substantial and irreversible harm. The scientists pleaded that we stabilize the human population, describing how our large numbers—swelled by another 2 billion people since 1992, a 35 percent increase—exert stresses on Earth that can overwhelm other efforts to realize a sustainable future (Crist et al. 2017). They implored that we cut greenhouse gas (GHG) emissions and phase out fossil fuels, reduce deforestation, and reverse the trend of collapsing biodiversity.

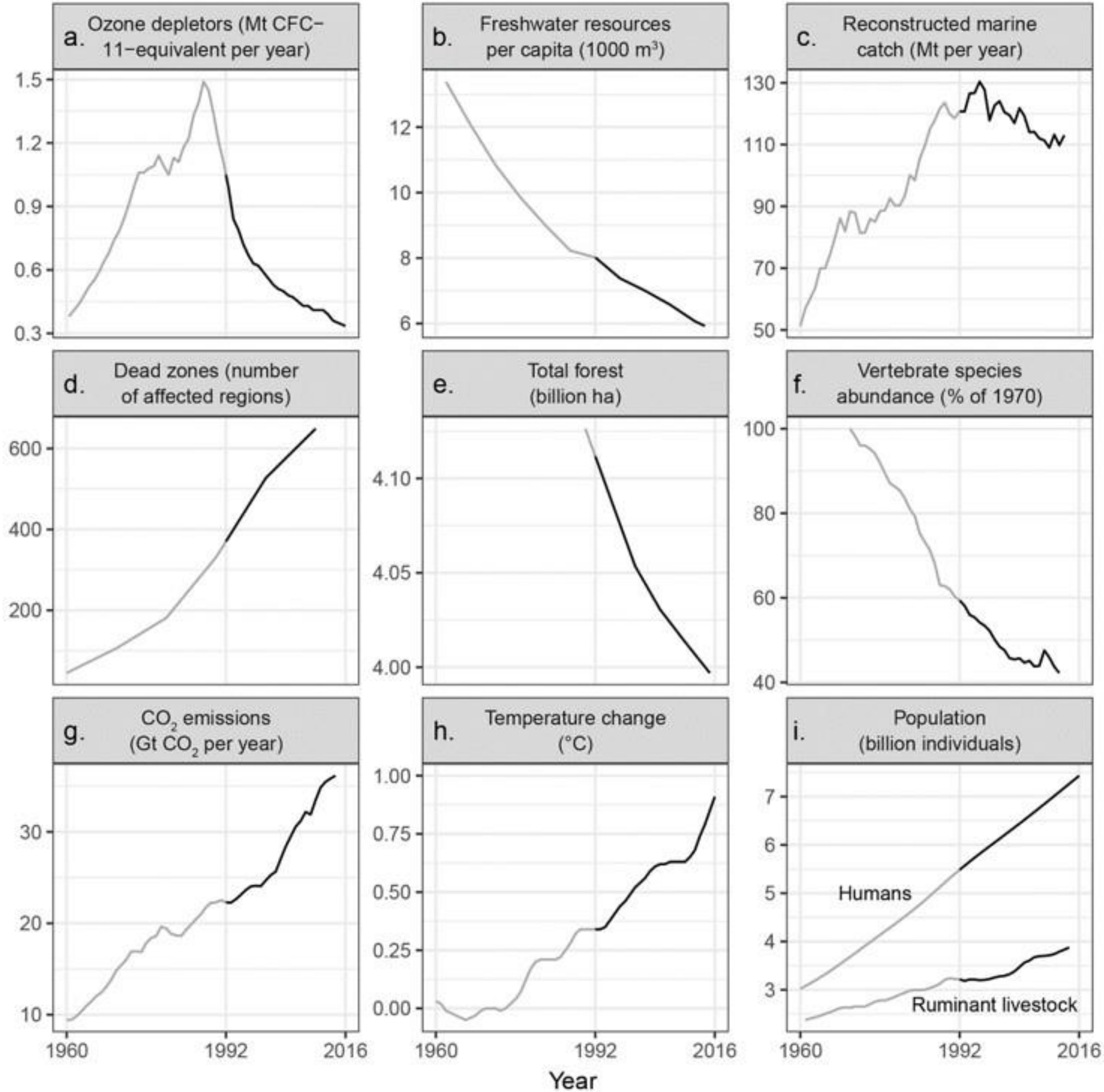
On the twenty-fifth anniversary of their call, we look back at their warning and evaluate the human response by exploring available time-series data. Since 1992, with the exception of stabilizing the stratospheric ozone layer, humanity has failed to make sufficient progress in generally solving these foreseen environmental challenges, and alarmingly, most of them are getting far worse (figure 1, file S1). Especially troubling is the current trajectory of potentially catastrophic climate change due to rising GHGs from burning fossil fuels (Hansen et al. 2013), deforestation (Keenan et al. 2015), and agricultural production—particularly from farming ruminants for meat consumption (Ripple et al. 2014). Moreover, we have unleashed a mass extinction event, the sixth in roughly 540 million years, wherein many current life forms could be annihilated or at least committed to extinction by the end of this century.

Humanity is now being given a second notice, as illustrated by these alarming trends (figure 1). We are jeopardizing our future by not reining in our intense but geographically and demographically uneven material consumption and by not perceiving continued rapid population growth as a primary driver behind many ecological and even societal threats (Crist et al. 2017). By failing to adequately limit population growth, reassess the role of an economy rooted in growth, reduce greenhouse gases, incentivize renewable energy, protect habitat, restore ecosystems, curb pollution, halt defaunation, and constrain invasive alien species, humanity is not taking the urgent steps needed to safeguard our imperilled biosphere.

As most political leaders respond to pressure, scientists, media influencers, and lay citizens must insist that their governments take immediate action as a moral imperative to current and future generations of human and other life. With a groundswell of organized grassroots efforts, dogged opposition can be overcome and political leaders compelled to do the right thing. It is also time to re-examine and change our individual behaviors, including limiting our own reproduction (ideally to replacement level at most) and drastically diminishing our *per capita* consumption of fossil fuels, meat, and other resources.

The rapid global decline in ozone-depleting substances shows that we can make positive change when we act decisively. We have also made advancements in reducing extreme poverty and hunger (*www.worldbank.org*). Other notable progress (which does not yet show up in the global data sets in figure 1) include the rapid decline in fertility rates in many regions attributable to investments in girls' and women's education (*www.un.org/esa/population*), the promising decline in the rate of deforestation in some regions, and the rapid growth in the renewable-energy sector. We have learned much since 1992, but the advancement of urgently needed changes in environmental policy, human behavior, and global inequities is still far from sufficient.

Sustainability transitions come about in diverse ways, and all require civil-society pressure and evidence-based advocacy, political leadership, and a solid understanding of policy



a. Ozone depletors (Mt CFC-11-equivalent per year)
b. Freshwater resources per capita (1000 m³)
c. Reconstructed marine catch (Mt per year)
d. Dead zones (number of affected regions)
e. Total forest (billion ha)
f. Vertebrate species abundance (% of 1970)
g. CO2 emissions (Gt CO2 per year)
h. Temperature change (°C)
i. Population (billion individuals)
Humans
Ruminant livestock
1960
1992
2016
Year

World Scientists' Warning of a Climate Emergency

WILLIAM J. RIPPLE, CHRISTOPHER WOLF, THOMAS M. NEWSOME, PHOEBE BARNARD, WILLIAM R. MOOMAW, AND 11,258 SCIENTIST SIGNATORIES FROM 153 COUNTRIES (LIST IN SUPPLEMENTAL FILE S1)

Scientists have a moral obligation to clearly warn humanity of any catastrophic threat and to "tell it like it is." On the basis of this obligation and the graphical indicators presented below, we declare, with more than 11,000 scientist signatories from around the world, clearly and unequivocally that planet Earth is facing a climate emergency.

Exactly 40 years ago, scientists from 50 nations met at the First World Climate Conference (in Geneva 1979) and agreed that alarming trends for climate change made it urgently necessary to act. Since then, similar alarms have been made through the 1992 Rio Summit, the 1997 Kyoto Protocol, and the 2015 Paris Agreement, as well as scores of other global assemblies and scientists' explicit warnings of insufficient progress (Ripple et al. 2017). Yet greenhouse gas (GHG) emissions are still rapidly rising, with increasingly damaging effects on the Earth's climate. An immense increase of scale in endeavors to conserve our biosphere is needed to avoid untold suffering due to the climate crisis (IPCC 2018).

Most public discussions on climate change are based on global surface temperature only, an inadequate measure to capture the breadth of human activities and the real dangers stemming from a warming planet (Briggs et al. 2015). Policymakers and the public now urgently need access to a set of indicators that convey the effects of human activities on GHG emissions and the consequent impacts on climate, our environment, and society. Building on prior work (see supplemental file S2), we present a suite of graphical vital signs of climate change over the last 40 years for human activities that can affect GHG emissions and change the climate (figure 1), as well as actual climatic impacts (figure 2). We use only relevant data sets that are clear, understandable, systematically collected for at least the last 5 years, and updated at least annually.

The climate crisis is closely linked to excessive consumption of the wealthy lifestyle. The most affluent countries are mainly responsible for the historical GHG emissions and generally have the greatest per capita emissions (table S1). In the present article, we show general patterns, mostly at the global scale, because there are many climate efforts that involve individual regions and countries. Our vital signs are designed to be useful to the public, policymakers, the business community, and those working to implement the Paris climate agreement, the United Nations' Sustainable Development Goals, and the Aichi Biodiversity Targets.

Profoundly troubling signs from human activities include sustained increases in both human and ruminant livestock populations, per capita meat production, world gross domestic product, global tree cover loss, fossil fuel consumption, the number of air passengers carried, carbon dioxide (CO_2) emissions, and per capita CO_2 emissions since 2000 (figure 1, supplemental file S2). Encouraging signs include decreases in global fertility (birth) rates (figure 1b), decelerated forest loss in the Brazilian Amazon (figure 1g), increases in the consumption of solar and wind power (figure 1h), institutional fossil fuel divestment of more than US$7 trillion (figure 1j), and the proportion of GHG emissions covered by carbon pricing (figure 1m). However, the decline in human fertility rates has substantially slowed during the last 20 years (figure 1b), and the pace of forest loss in Brazil's Amazon has now started to increase again (figure 1g). Consumption of solar and wind energy has increased 373% per decade, but in 2018, it was still 28 times smaller than fossil fuel consumption (combined gas, coal, oil; figure 1h). As of 2018, approximately 14.0% of global GHG emissions were covered by carbon pricing (figure 1m), but the global emissions-weighted average price per tonne of carbon dioxide was only around US$15.25 (figure 1n). A much higher carbon fee price is needed (IPCC 2018, section 2.5.2.1). Annual fossil fuel subsidies to energy companies have been fluctuating, and because of a recent spike, they were greater than US$400 billion in 2018 (figure 1o).

Especially disturbing are concurrent trends in the vital signs of climatic impacts (figure 2, supplemental file S2). Three abundant atmospheric GHGs (CO_2, methane, and nitrous oxide) continue to increase (see figure S1 for ominous 2019 spike in CO_2), as does global surface temperature (figure 2a–2d). Globally, ice has been rapidly disappearing, evidenced by declining trends in minimum summer Arctic sea ice, Greenland and Antarctic ice sheets, and glacier thickness worldwide (figure 2e–2h). Ocean heat content, ocean acidity, sea level, area burned in the United States, and extreme weather and associated damage costs have all been trending upward (figure 2i–2n). Climate change is predicted to greatly affect marine, freshwater, and terrestrial life, from plankton and corals to fishes and forests (IPCC 2018, 2019). These issues highlight the urgent need for action.

Despite 40 years of global climate negotiations, with few exceptions, we have generally conducted business

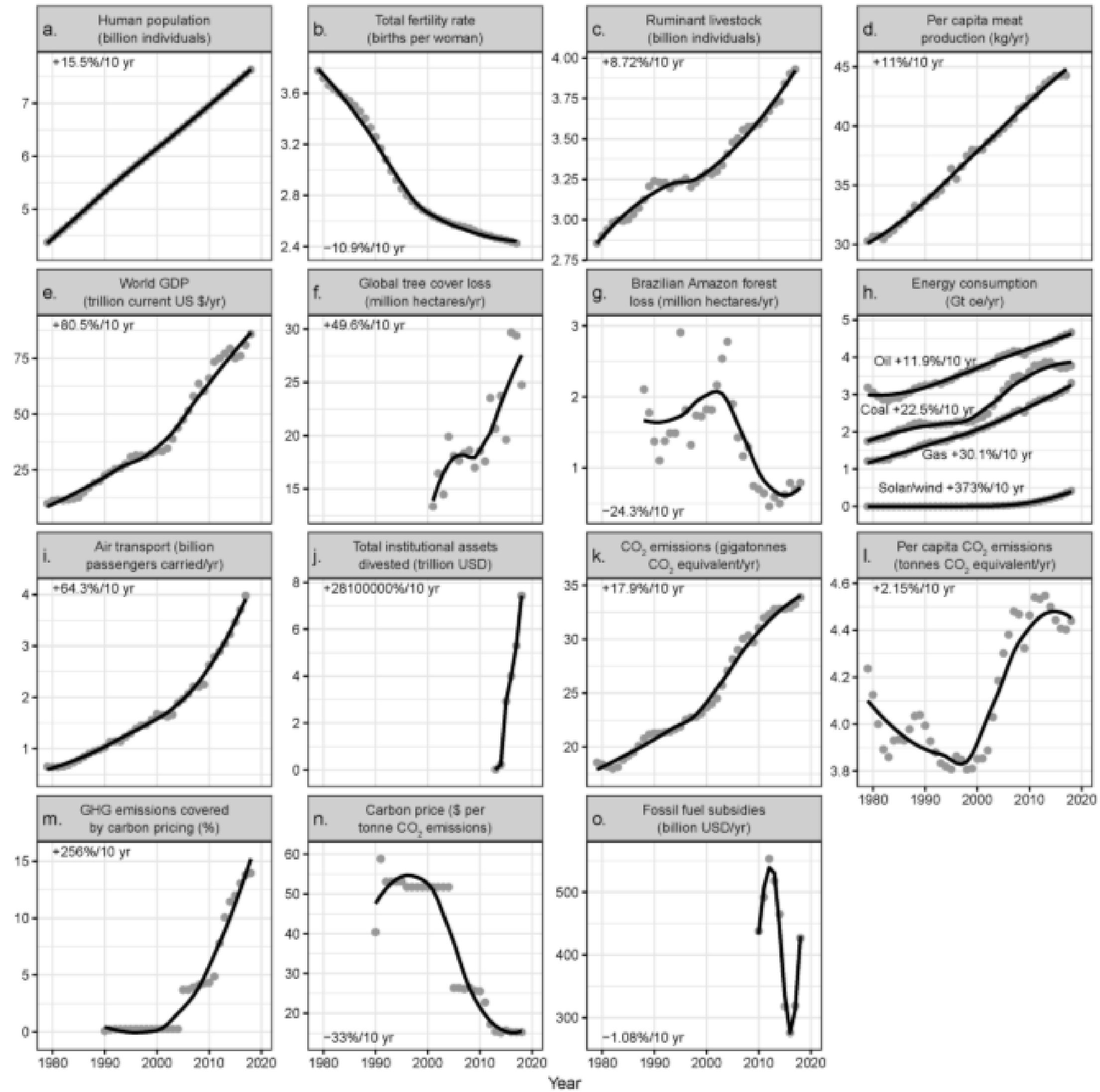


Figure 1. Change in global human activities from 1979 to the present. These indicators are linked at least in part to climate change. In panel (f), annual tree cover loss may be for any reason (e.g. wildfire, harvest within tree plantations, or conversion of forests to agricultural land). Forest gain is not involved in the calculation of tree cover loss. In panel (h), "Gt oe/yr" is short for gigatonnes of oil equivalent per year; hydroelectricity and nuclear energy are shown in Figure S2. Rates shown in panels are the percentage changes per decade across the entire range of the time series. Annual data are shown using gray points. Black lines are local regression smooth trend lines. Sources and additional details about each variable are provided in supplemental file S2, including Table S2.

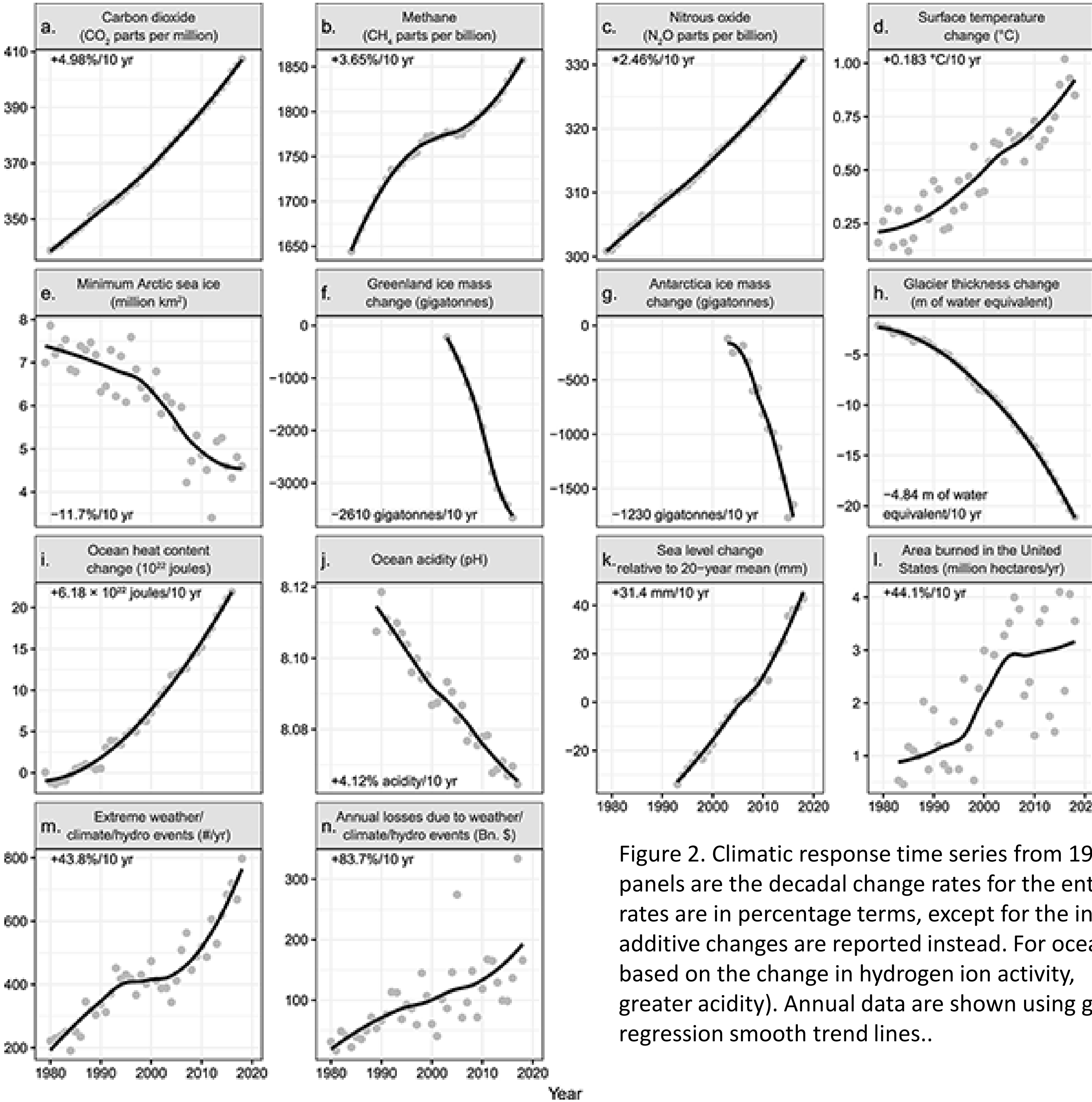
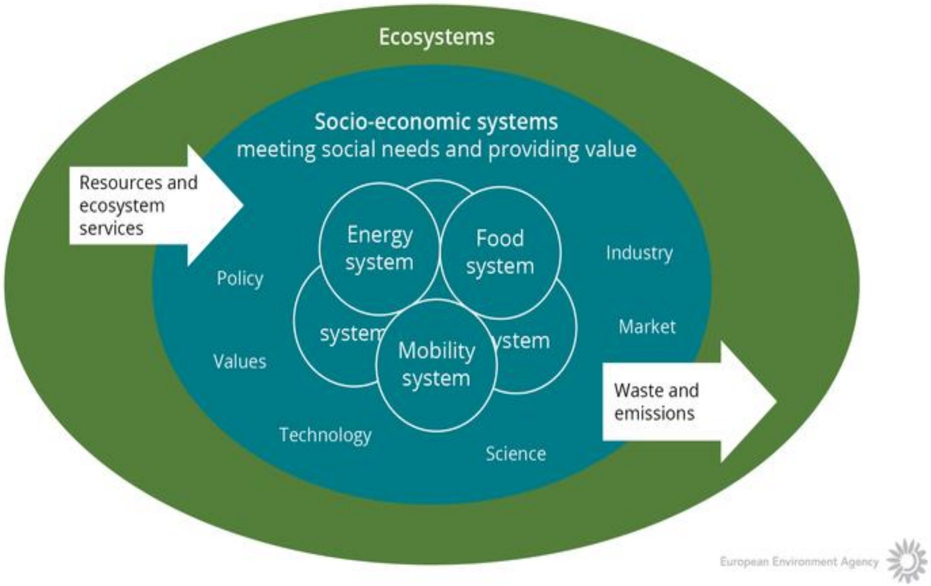


Figure 2. Climatic response time series from 1979 to the present. Rates shown in panels are the decadal change rates for the entire ranges of the time series. These rates are in percentage terms, except for the interval variables (d, f, g, h, i, m), where additive changes are reported instead. For ocean acidity (pH), the percentage rate is based on the change in hydrogen ion activity, (where lower pH values represent greater acidity). Annual data are shown using gray points. Black lines are local regression smooth trend lines..

Natural Capital



A nation's wealth is grounded in 4 core stocks of capital:

1 - manufactured capital (e.g. machines and buildings);

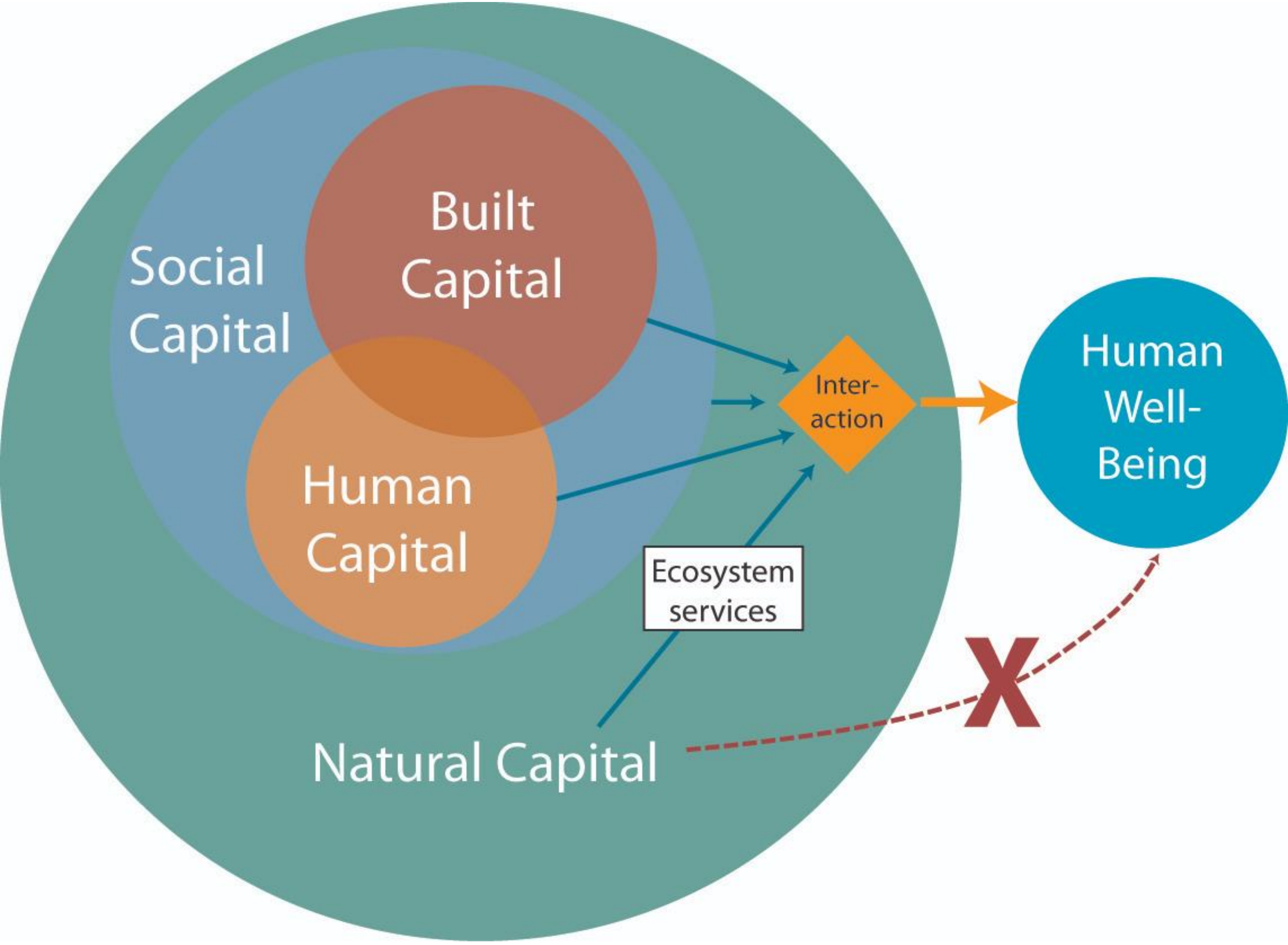
2 - human capital (e.g. people, their skills and knowledge);

3 - social capital (e.g. trust, norms and institutions):

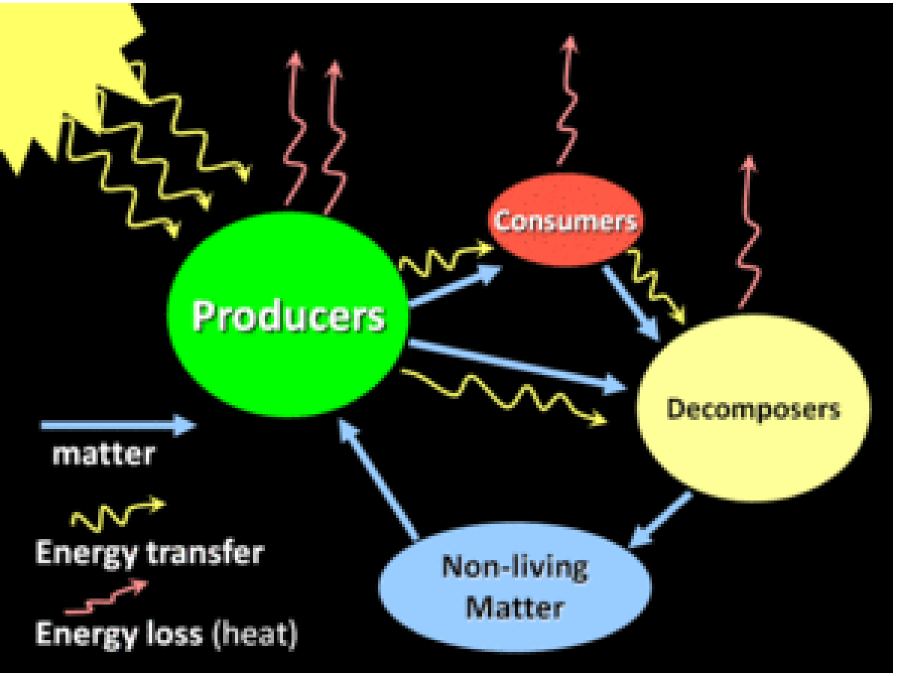
4 - natural capital (e.g. minerals and ecosystem services):

Natural capital as a fundamental role in determining a country's economic output and social well-being — providing resources and services, and absorbing emissions and wastes.

Natural capital is the most fundamental form of capital since it provides the basic conditions for human existence, delivering food, clean water and air, and essential resources.


Built
Capital
Social
Capital
Human
Capital
Inter-
action
Human
Well-
Being
Ecosystem
services
X
Natural Capital

Natural Ecosystems



Natural capital comprises 2 components:

1. Abiotic natural capital (e.g. fossil fuels, minerals, metals) and abiotic flows (e.g. wind and solar energy).

2. Biotic natural capital or ecosystem capital consists of ecosystems.

Artificial Ecosystems

Natural ecosystems are sustainable:

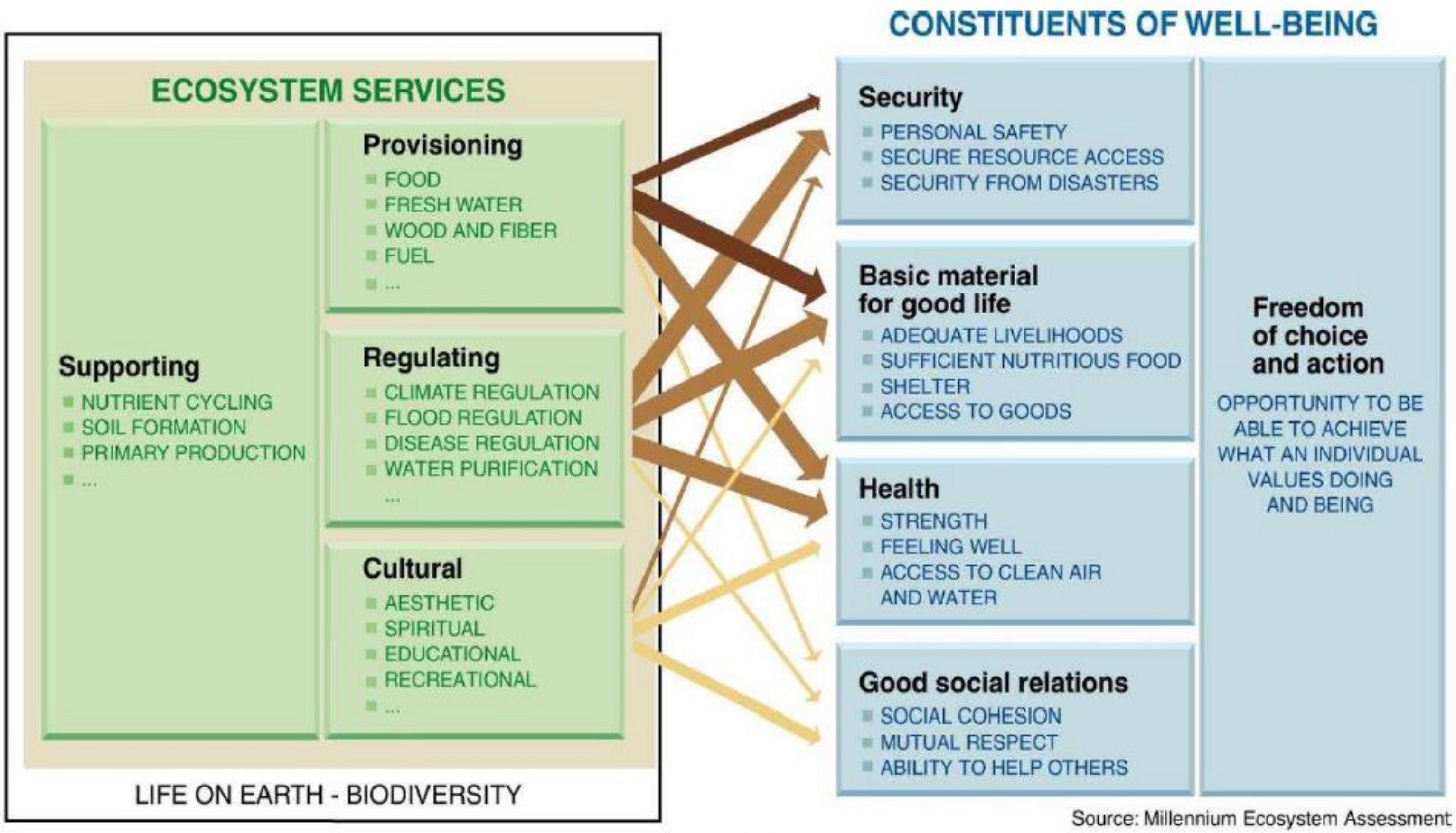
1. They have the ability to maintain the processes and functions without interruption, weakening, or loss of value indefinitely;

2. Artificial ecosystems are usually not sustainable, they require the input of energy to maintain the processes;

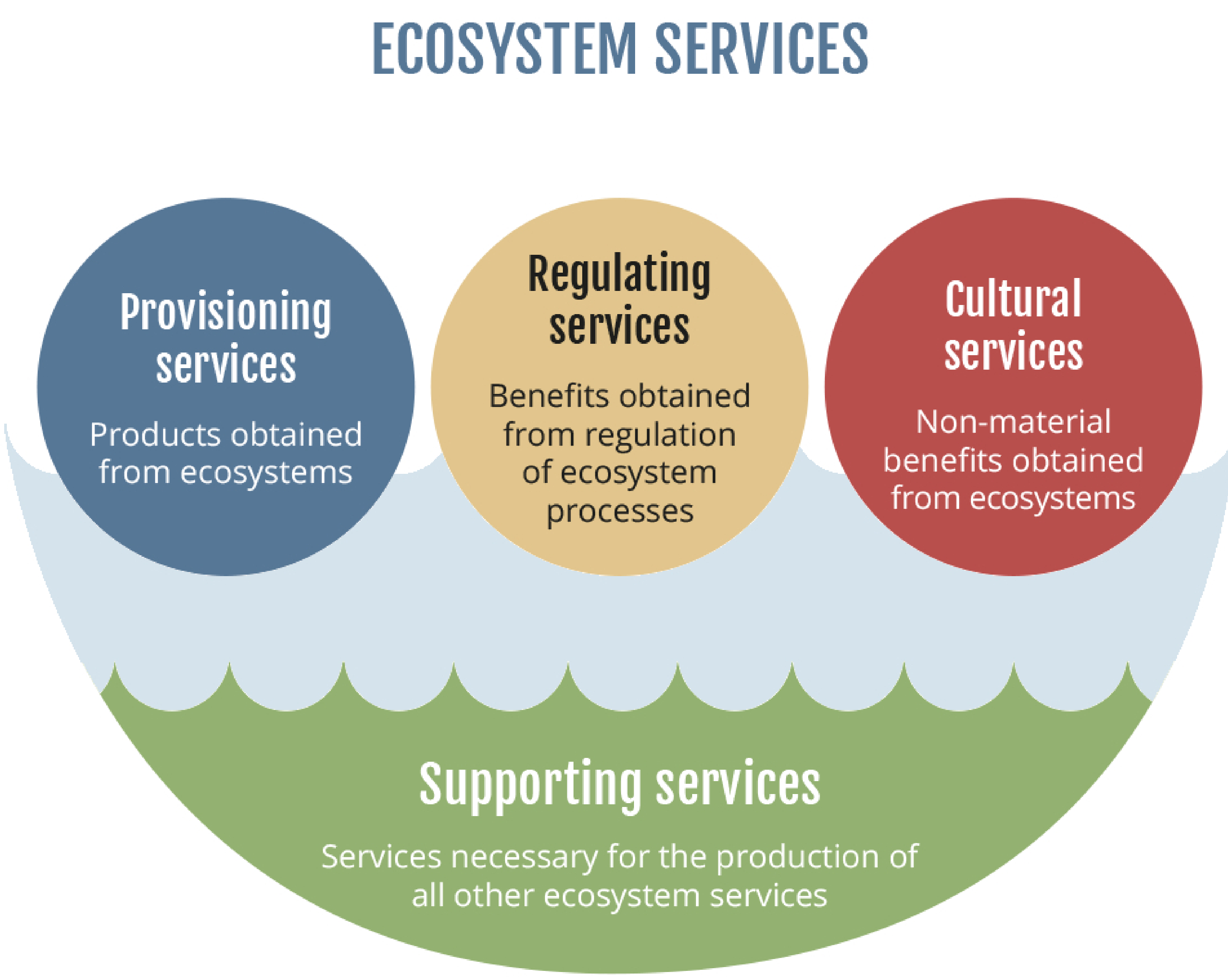
Ecosystem Services

"Benefits that humans recognize as obtained from ecosystems that support, directly or indirectly, their survival and quality of life"

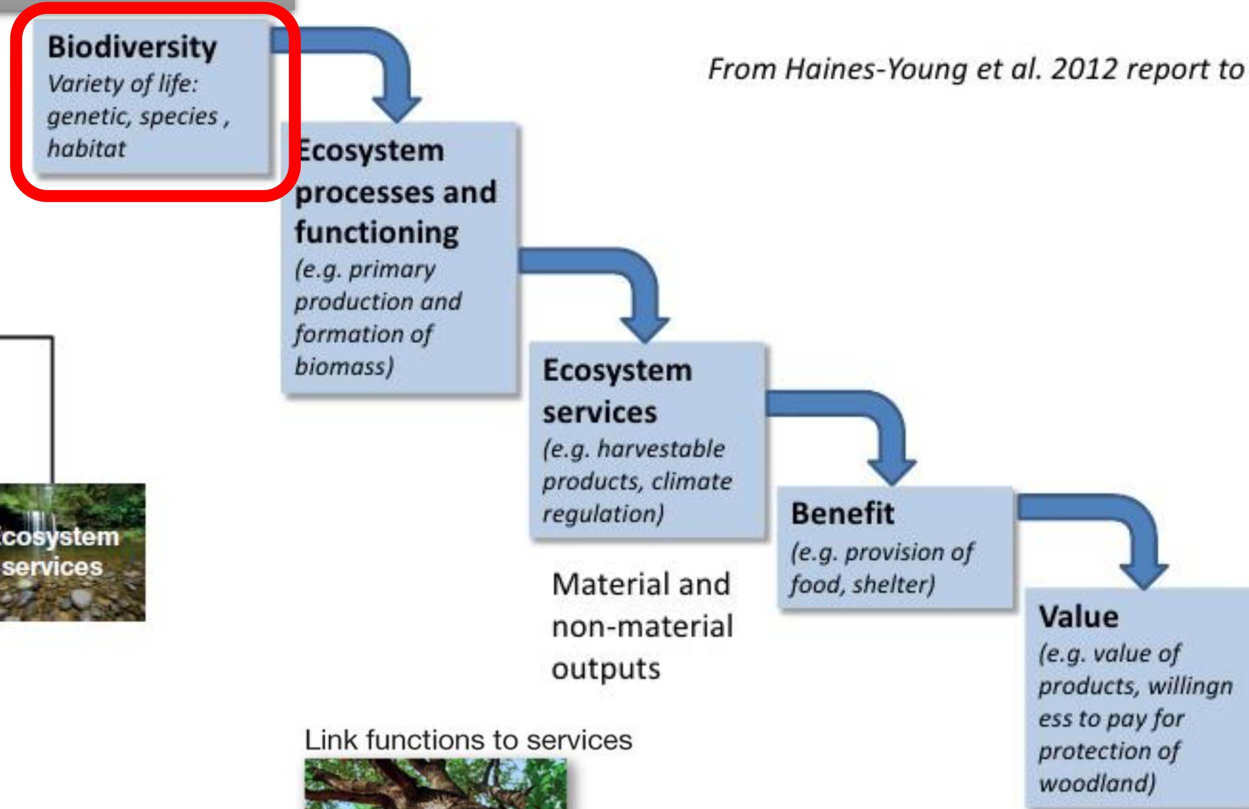
(Harrington et al., 2010, Biodiversity and Conservation 19: 2773-2790)



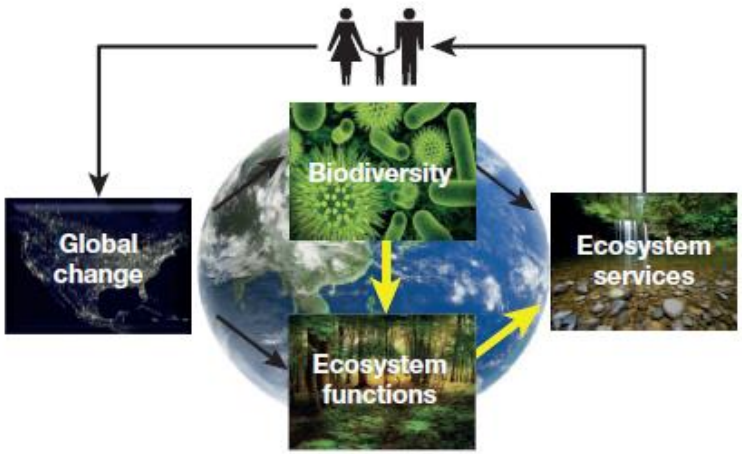
(MEA, 2005)

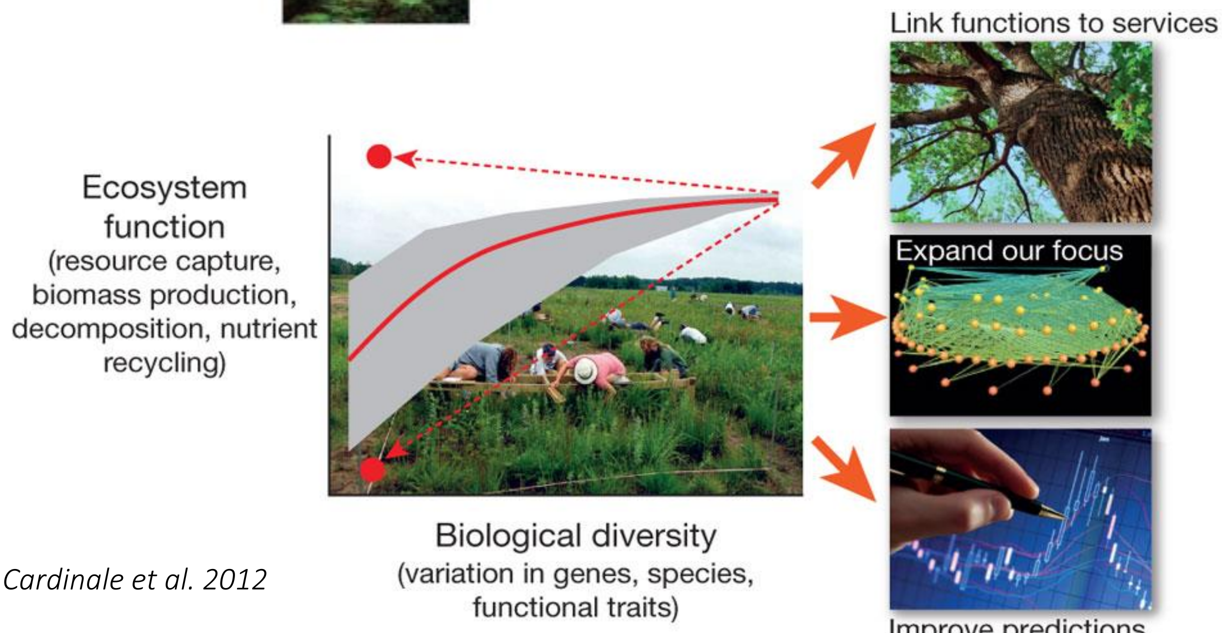

ECOSYSTEM SERVICES
Provisioning services
Products obtained from ecosystems
Regulating services
Benefits obtained from regulation of ecosystem processes
Cultural services
Non-material benefits obtained from ecosystems
Supporting services
Services necessary for the production of all other ecosystem services

Linking biodiversity to ecosystem functioning



From Haines-Young et al. 2012 report to EEA

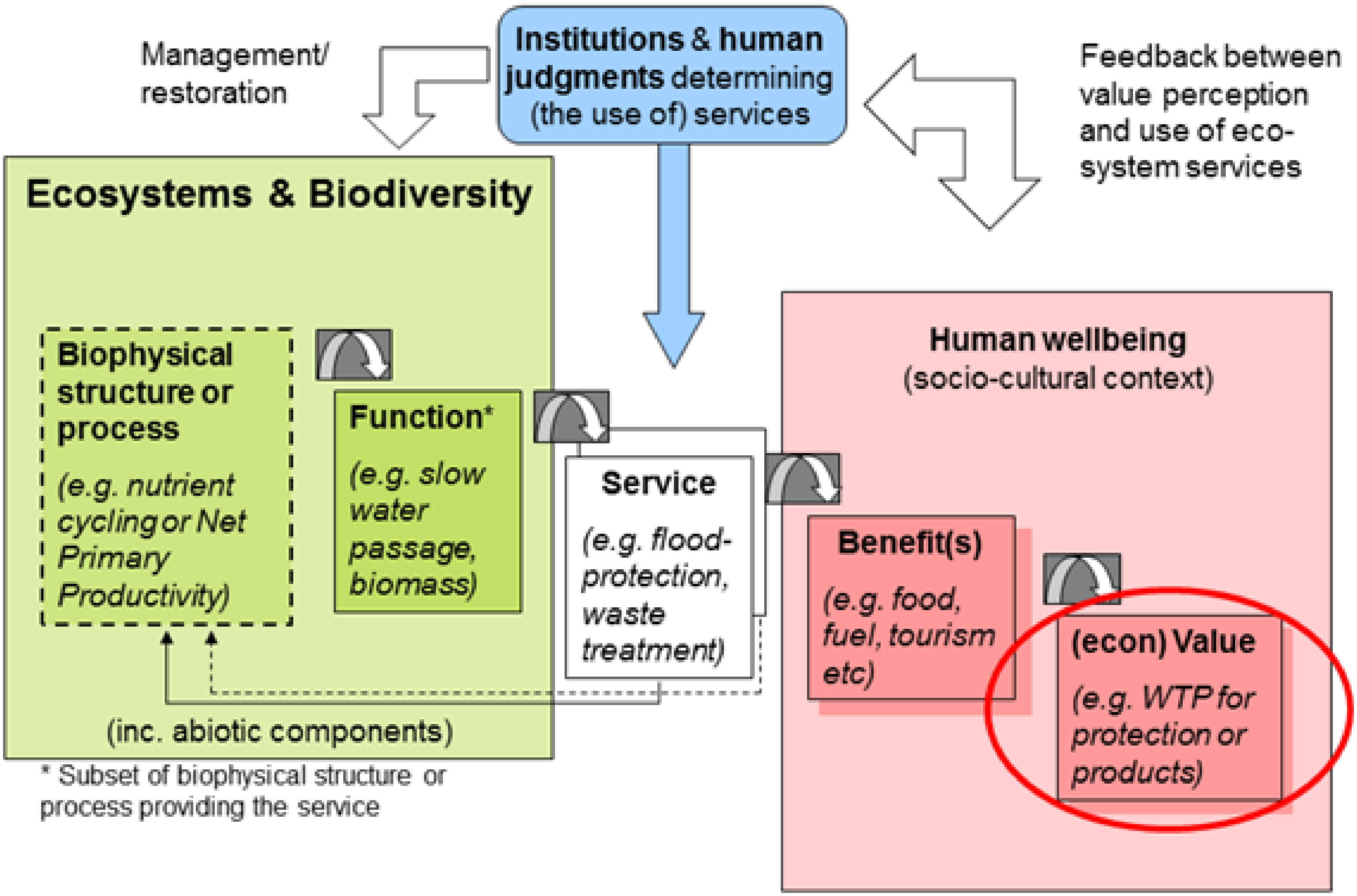


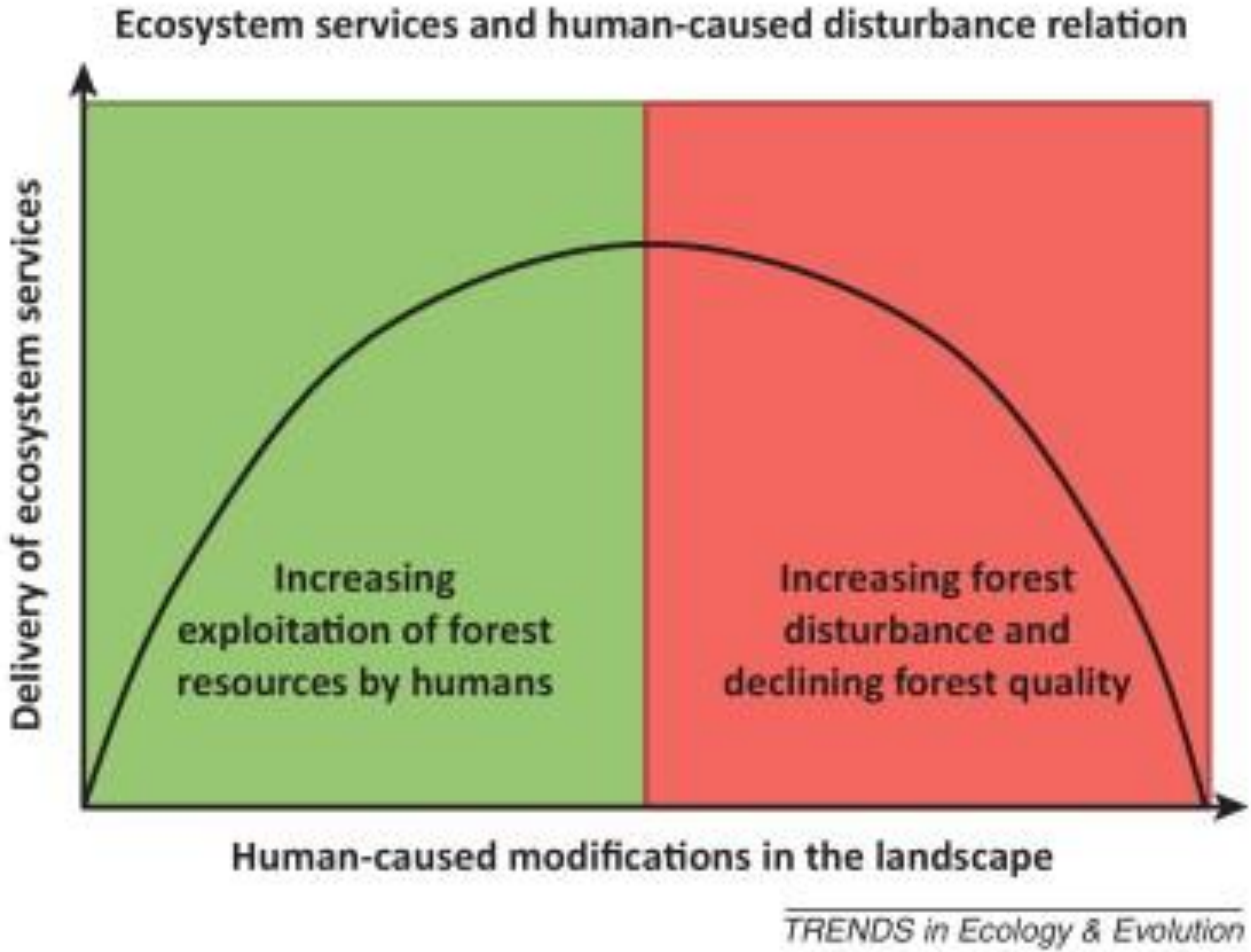


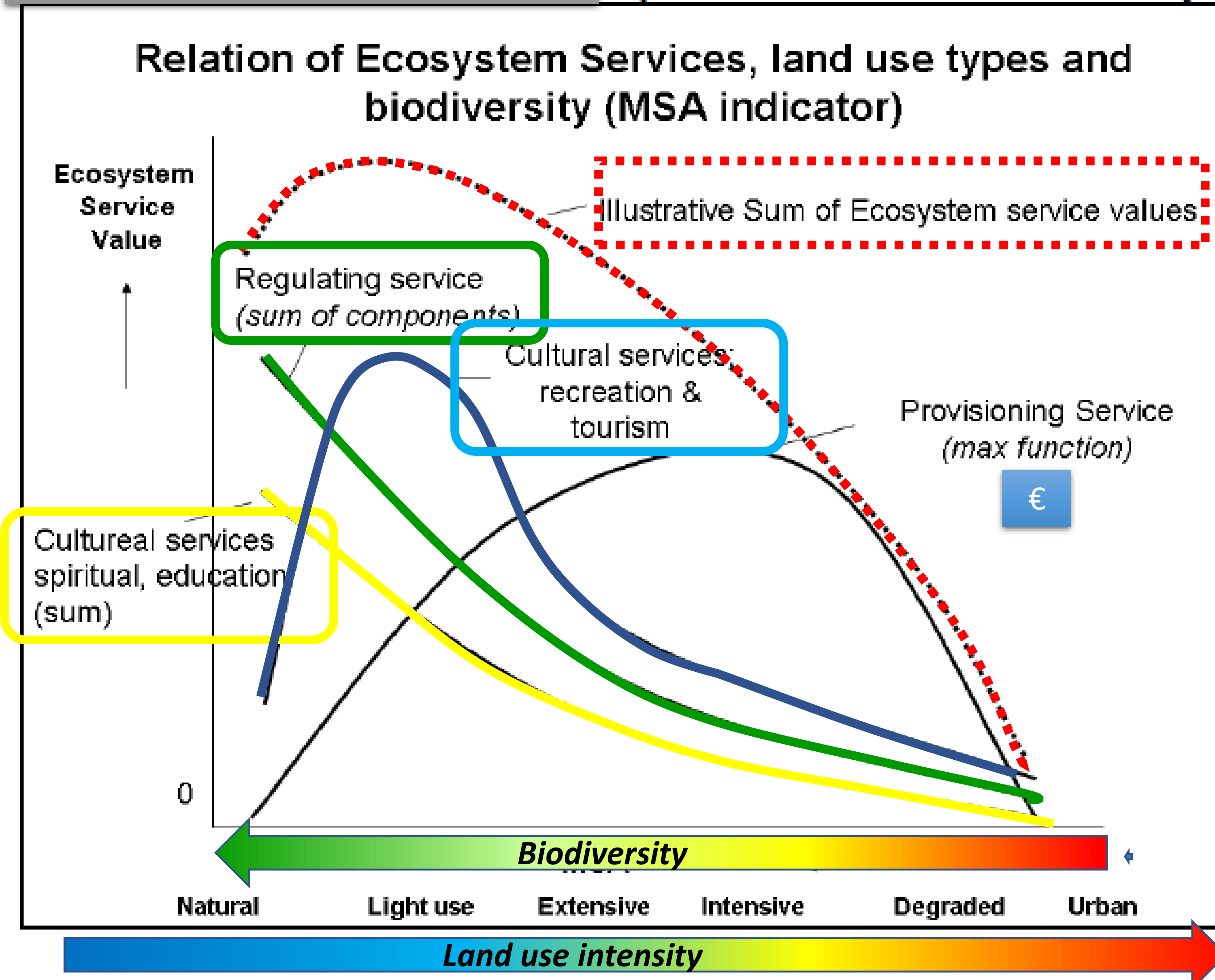
Cardinale et al. 2012

Ecosystem services rely on biodiversity

Maintaining biodiversity is essential to the supply of ecosystem services, as well as their health and resilience

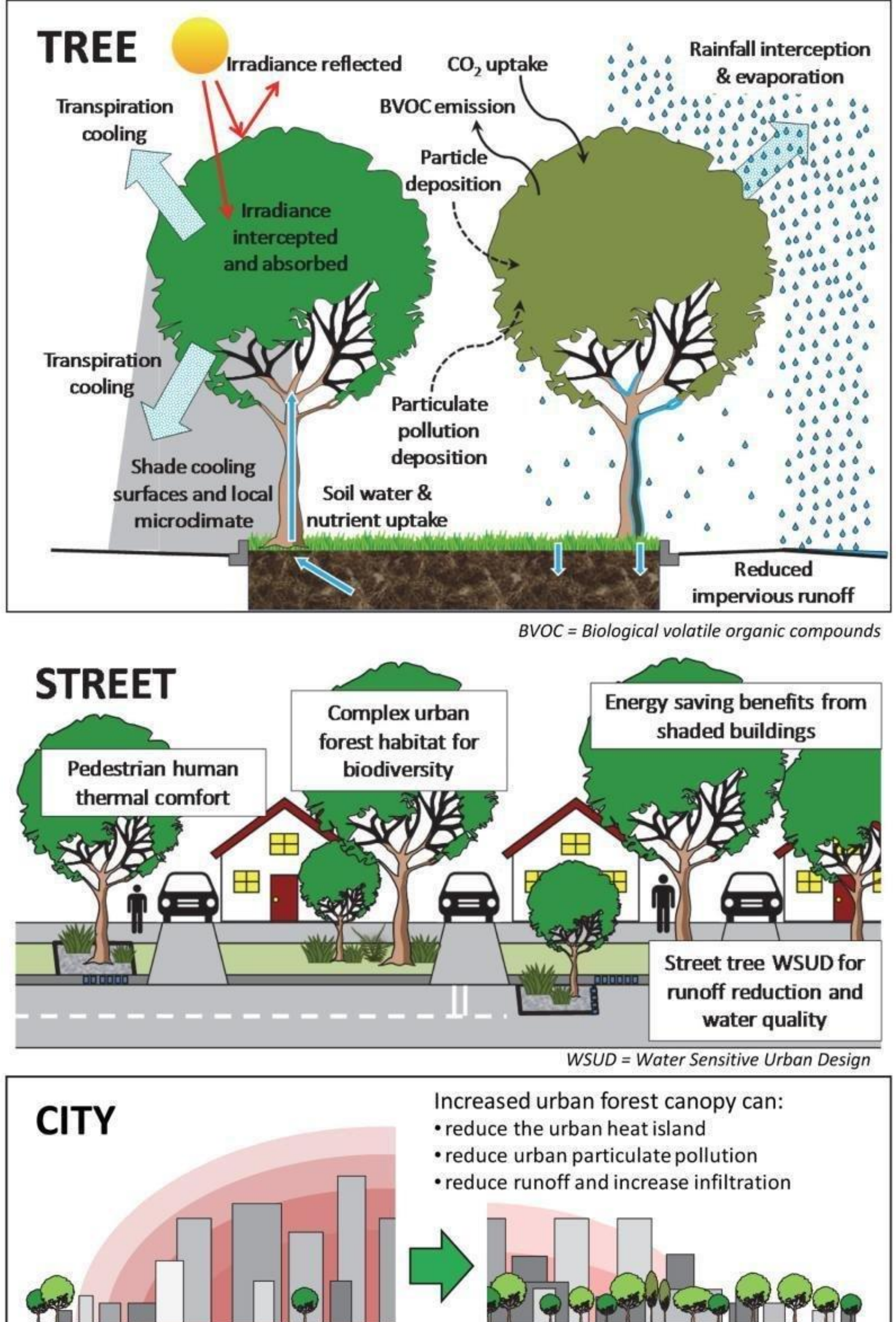

Institutions & human judgments determining (the use of) services
Management/ restoration
Feedback between value perception and use of eco-system services
Ecosystems & Biodiversity
Biophysical structure or process
(e.g. nutrient cycling or Net Primary Productivity)
Function*
(e.g. slow water passage, biomass)
Service
(e.g. flood-protection, waste treatment)
Human wellbeing
(socio-cultural context)
Benefit(s)
(e.g. food, fuel, tourism etc)
(econ) Value
(e.g. WTP for protection or products)
(inc. abiotic components)
* Subset of biophysical structure or process providing the service


Ecosystem services and human-caused disturbance relation
Delivery of ecosystem services
Increasing exploitation of forest resources by humans
Increasing forest disturbance and declining forest quality
Human-caused modifications in the landscape
TRENDS in Ecology & Evolution


Relation of Ecosystem Services, land use types and biodiversity (MSA indicator)
Ecosystem Service Value
0
Illustrative Sum of Ecosystem service values
Regulating service (sum of components)
Cultural services: recreation & tourism
Provisioning Service (max function)
€
Cultureal services spiritual, education (sum)
Biodiversity
Natural
Light use
Extensive
Intensive
Degraded
Urban
Land use intensity

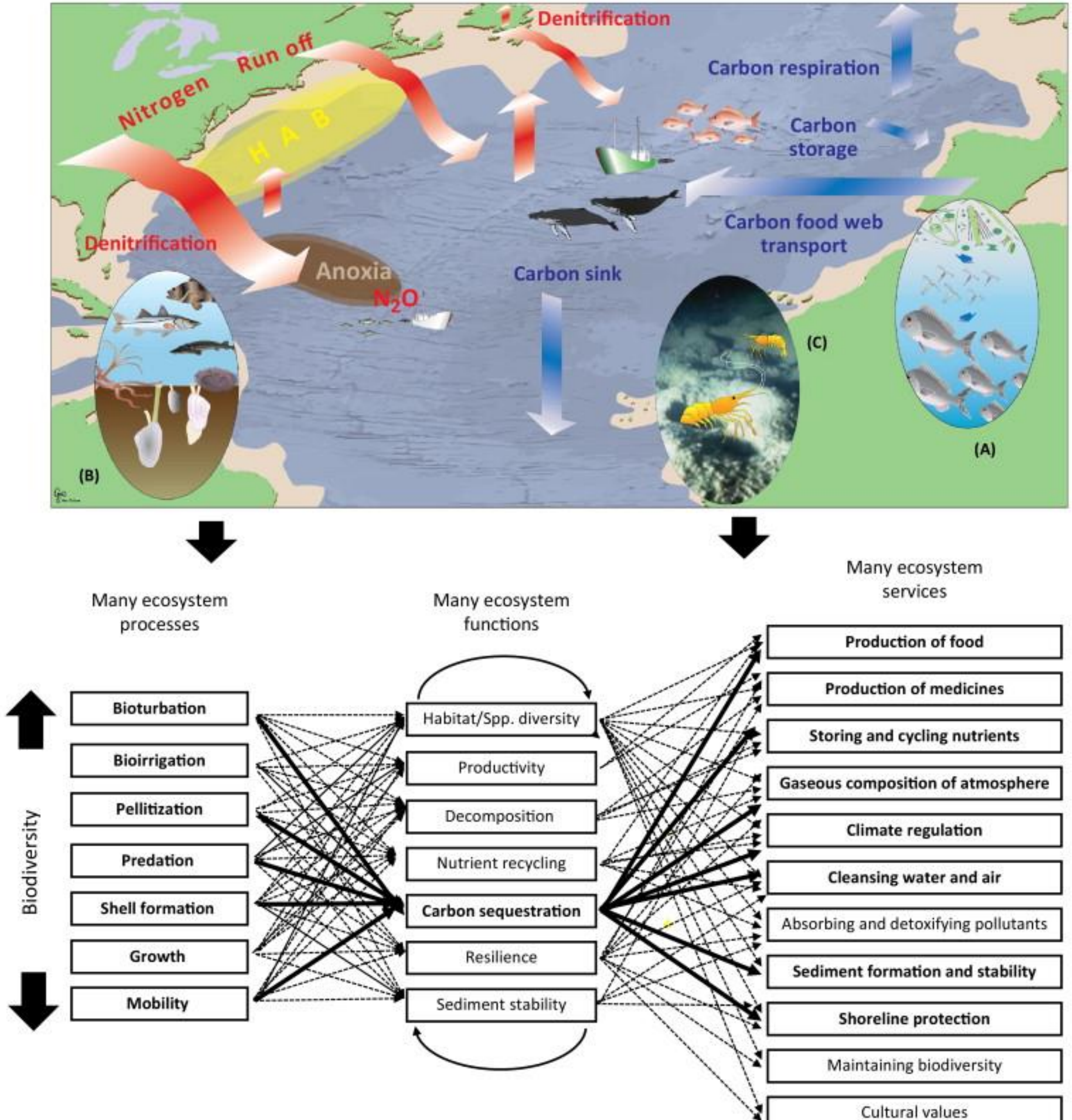
COPI, 2008

WHAT DO WE GET FROM ECOSYSTEMS?

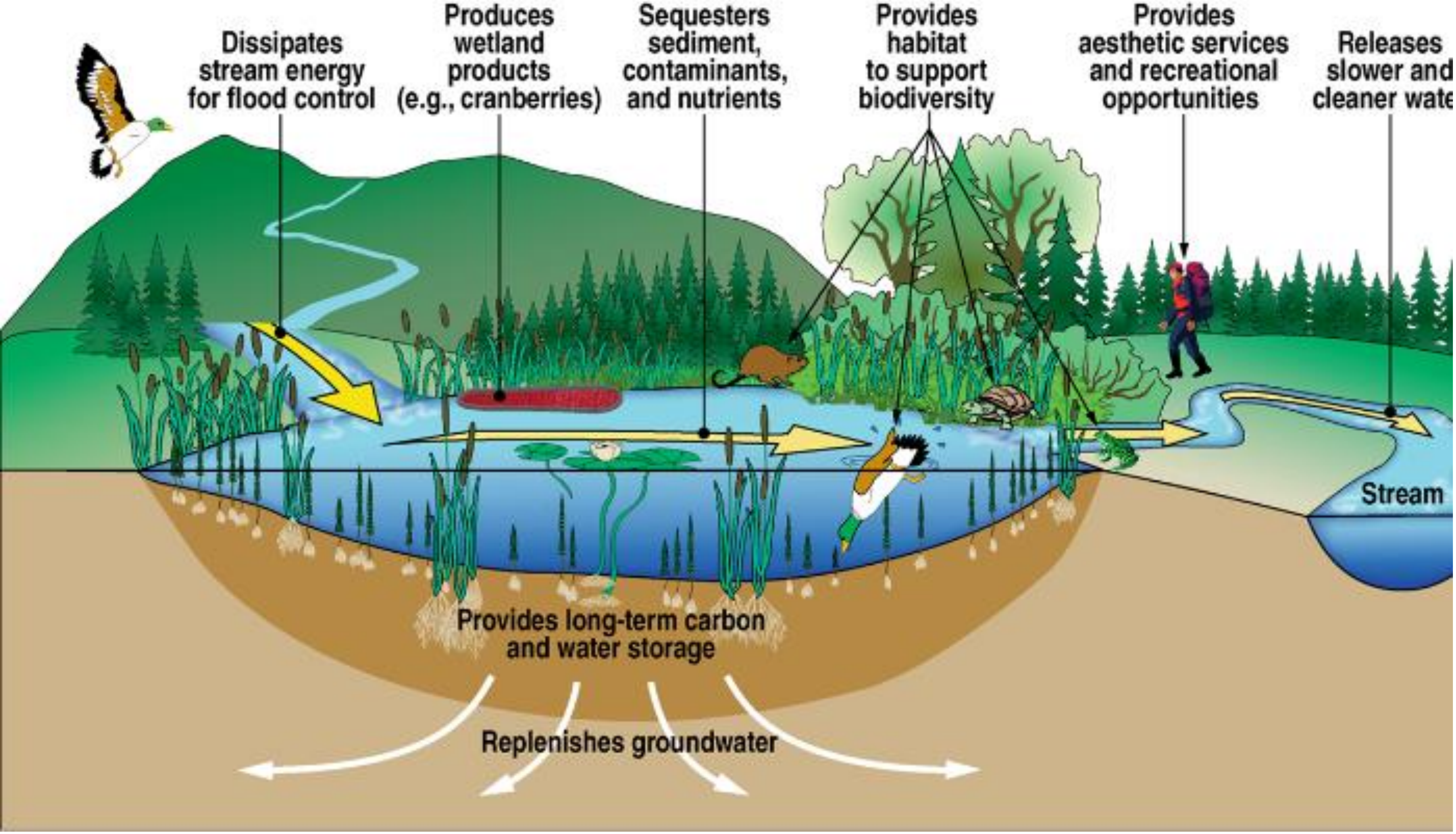

TREE
Irradiance reflected
CO2 uptake
Rainfall interception & evaporation
Transpiration cooling
BVOC emission
Particle deposition
Irradiance intercepted and absorbed
Transpiration cooling
Particulate pollution deposition
Shade cooling surfaces and local microclimate
Soil water & nutrient uptake
Reduced impervious runoff
BVOC = Biological volatile organic compounds
STREET
Complex urban forest habitat for biodiversity
Energy saving benefits from shaded buildings
Pedestrian human thermal comfort
Street tree WSUD for runoff reduction and water quality
WSUD = Water Sensitive Urban Design
CITY
Increased urban forest canopy can:
• reduce the urban heat island
• reduce urban particulate pollution
• reduce runoff and increase infiltration

Examples of ecosystem services

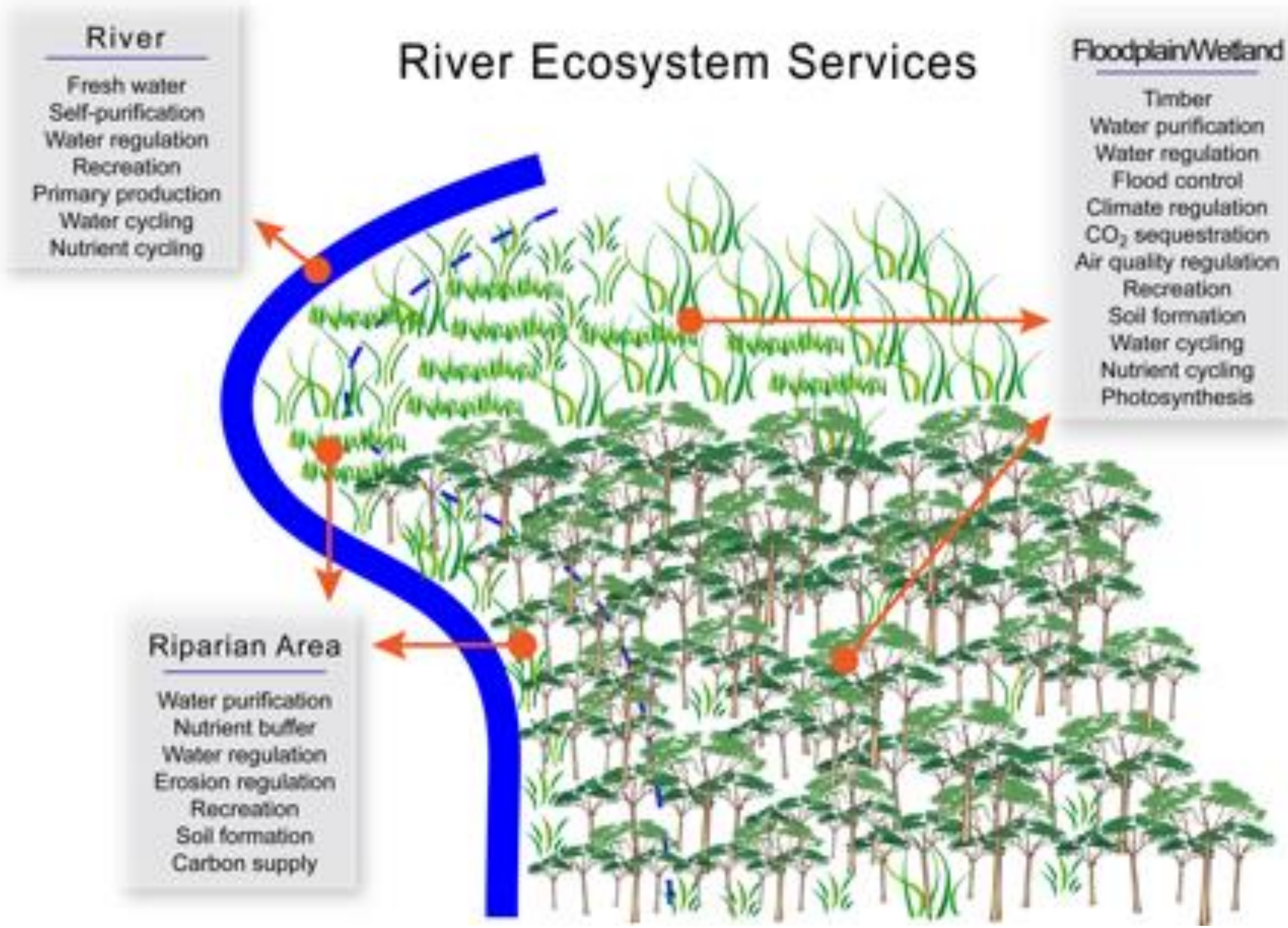
Source: PBL, WUR, CICES 2014



TRENDS in Ecology & Evolution



Dissipates stream energy for flood control
Produces wetland products (e.g., cranberries)
Sequesters sediment, contaminants, and nutrients
Provides habitat to support biodiversity
Provides aesthetic services and recreational opportunities
Releases slower and cleaner wate
Stream
Provides long-term carbon and water storage
Replenishes groundwater


River Ecosystem Services
River
Fresh water
Self-purification
Water regulation
Recreation
Primary production
Water cycling
Nutrient cycling
Floodplain/Wetland
Timber
Water purification
Water regulation
Flood control
Climate regulation
CO2 sequestration
Air quality regulation
Recreation
Soil formation
Water cycling
Nutrient cycling
Photosynthesis
Riparian Area
Water purification
Nutrient buffer
Water regulation
Erosion regulation
Recreation
Soil formation
Carbon supply

Services \ Ecosystems	Agro ecosystems	Forests	Grasslands	Heath and scrubs	Wetlands	Lakes and rivers
Provisioning						
Crops/timber	↓ (Mixed)	↑ (Enhanced)	(Not applicable)	(Not applicable)	↓ (Degraded)	(Not applicable)
Livestock	↓ (Mixed)	= (Degraded)	= (Degraded)	= (Degraded)	↓ (Degraded)	(Not applicable)
Wild Foods	= (Degraded)	↓ (Degraded)	↓ (Degraded)	(Unknown)	= (Mixed)	(Unknown)
Wood fuel	(Not applicable)	= (Mixed)	(Not applicable)	= (Degraded)	(Not applicable)	(Not applicable)
Capture fisheries	(Not applicable)	(Not applicable)	(Not applicable)	(Not applicable)	= (Degraded)	= (Degraded)
Aquaculture	(Not applicable)	(Not applicable)	(Not applicable)	(Not applicable)	↓ (Degraded)	↓ (Degraded)
Genetic	= (Degraded)	↓ (Mixed)	↓ (Degraded)	= (Degraded)	= (Mixed)	(Unknown)
Fresh water	(Not applicable)	↓ (Degraded)	(Unknown)	(Unknown)	↑ (Mixed)	↑ (Mixed)
Regulating						
Pollination	↑ (Mixed)	↓ (Degraded)	= (Degraded)	(Unknown)	(Not applicable)	(Not applicable)
Climate regulation	(Not applicable)	↑ (Enhanced)	(Unknown)	= (Mixed)	= (Degraded)	= (Degraded)
Pest regulation	↑ (Mixed)	(Unknown)	= (Degraded)	(Not applicable)	(Unknown)	(Not applicable)
Erosion regulation	(Not applicable)	= (Mixed)	= (Degraded)	= (Degraded)	(Unknown)	(Unknown)
Water regulation	(Unknown)	= (Mixed)	(Unknown)	↑ (Mixed)	↑ (Enhanced)	= (Degraded)
Water purification	(Not applicable)	(Unknown)	(Unknown)	(Unknown)	= (Mixed)	= (Degraded)
Hazard regulation	(Not applicable)	(Unknown)	(Unknown)	(Unknown)	= (Mixed)	= (Degraded)
Cultural						
Recreation	↑ (Mixed)	= (Mixed)	↓ (Degraded)	↑ (Mixed)	↑ (Mixed)	= (Mixed)
Aesthetic	↑ (Mixed)	= (Mixed)	= (Degraded)	= (Degraded)	↑ (Mixed)	= (Degraded)

Status for period 1990–present Degraded Mixed Enhanced Unknown Not applicable

Trend between periods

↑ Positive change between the periods 1950–1990 and 1990 to present

↓ Negative change between the periods 1950–1990 and 1990 to present

= No change between the two periods

Valuation of Ecosystem Services

Pollinators

€535 Million UK Economy

Natural Enemies

€3.6 Billion US Economy

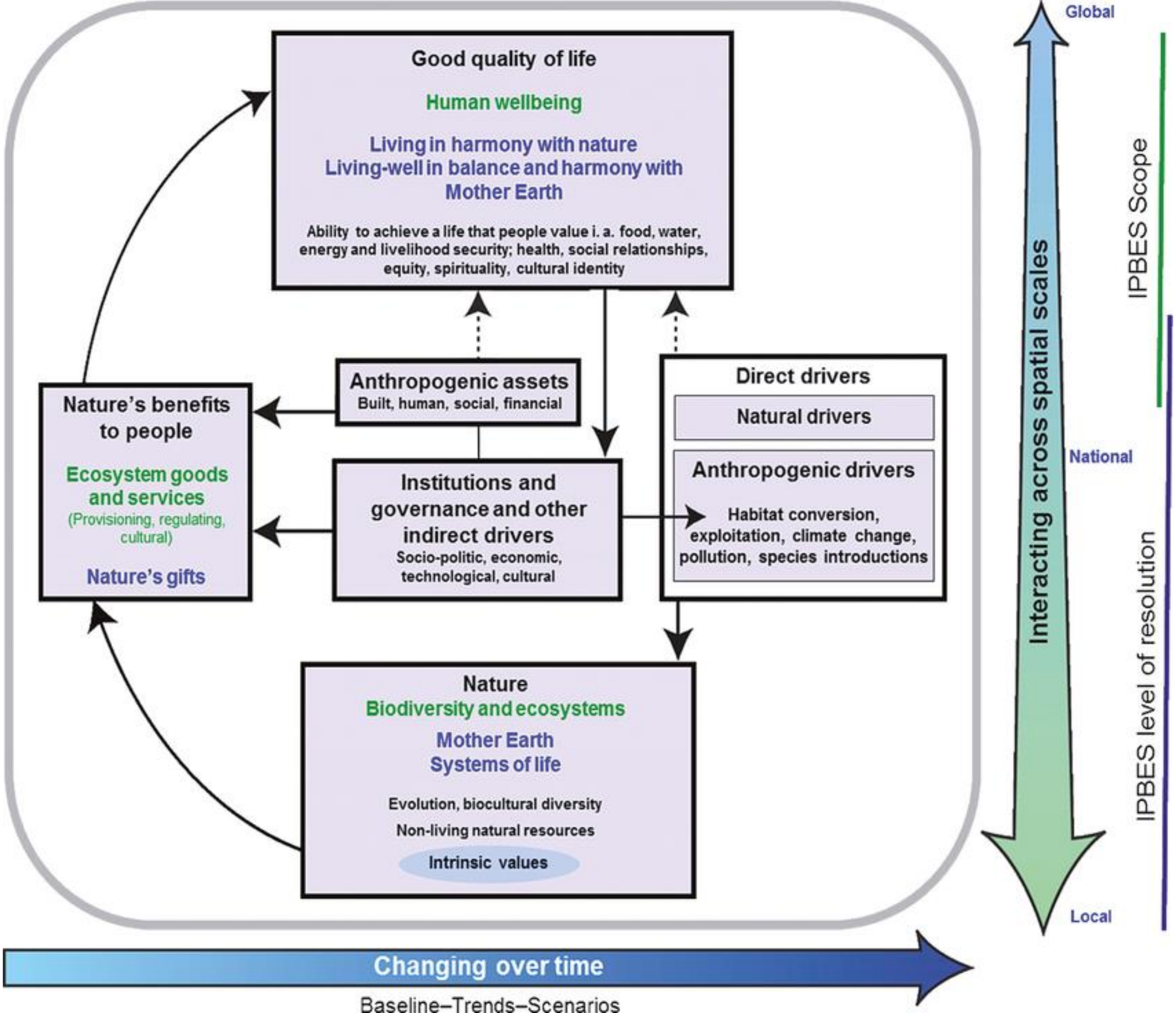
Arable Plants

?Unknown?

Carbon Seq.

€847 Million UK Economy

NEA (2011), Power (2010)


Good quality of life
Human wellbeing
Living in harmony with nature
Living-well in balance and harmony with Mother Earth
Ability to achieve a life that people value i. a. food, water, energy and livelihood security; health, social relationships, equity, spirituality, cultural identity
Anthropogenic assets
Built, human, social, financial
Direct drivers
Natural drivers
Anthropogenic drivers
Habitat conversion, exploitation, climate change, pollution, species introductions
Nature's benefits to people
Ecosystem goods and services
(Provisioning, regulating, cultural)
Nature's gifts
Institutions and governance and other indirect drivers
Socio-politic, economic, technological, cultural
Nature
Biodiversity and ecosystems
Mother Earth
Systems of life
Evolution, biocultural diversity
Non-living natural resources
Intrinsic values
Global
National
Local
Interacting across spatial scales
IPBES Scope
IPBES level of resolution
Changing over time
Baseline–Trends–Scenarios

- Nature and its vital contributions to people, which together embody biodiversity and ecosystem functions and services, are deteriorating worldwide.
- Nature underpins quality of life by providing basic life support for humanity (regulating), as well as material goods (material) and spiritual inspiration (non-material).
- Most of nature’s contributions to people (NCP) are co-produced by biophysical processes and ecological interactions with anthropogenic assets such as knowledge, infrastructure, financial capital, technology and the institutions that mediate.

- Many of nature's contributions to people are essential for human health and their decline thus threatens a good quality of life
- Most of nature's contributions are not fully replaceable, yet some contributions of nature are irreplaceable
- Humanity is a dominant global influence on life on earth, and has caused natural terrestrial, freshwater and marine ecosystems to decline
- The global rate of species extinction is already at least tens to hundreds of times higher than the average rate over the past 10 million years and is accelerating