Biodiversity & Ecosystem Services

Vânia Proença

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27 Nov. 2019

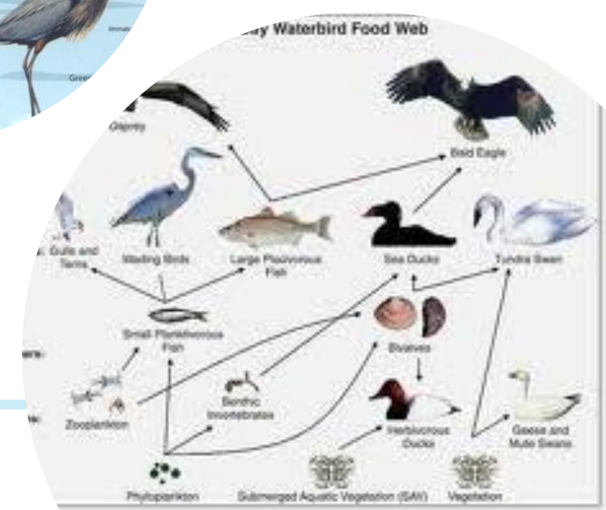
- Biodiversity change and loss
- Linking biodiversity to ecosystem services
- Trade-offs and sinergies between ecosystem services

Defining biodiversity

Genes
Populations
Species

The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems (CDB, 1992; Article 2).

Communities
Ecosystems



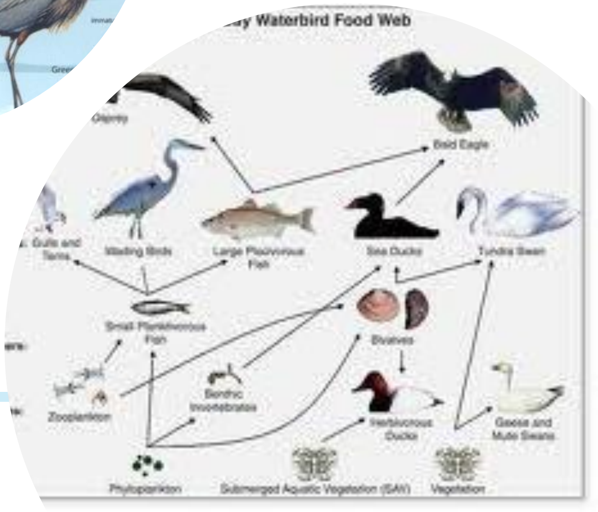
Defining biodiversity

Genes
Populations
Species

Abundance, variety and distribution of:

- genes or genotypes
- species
- functional groups
- ecosystem types or biomes

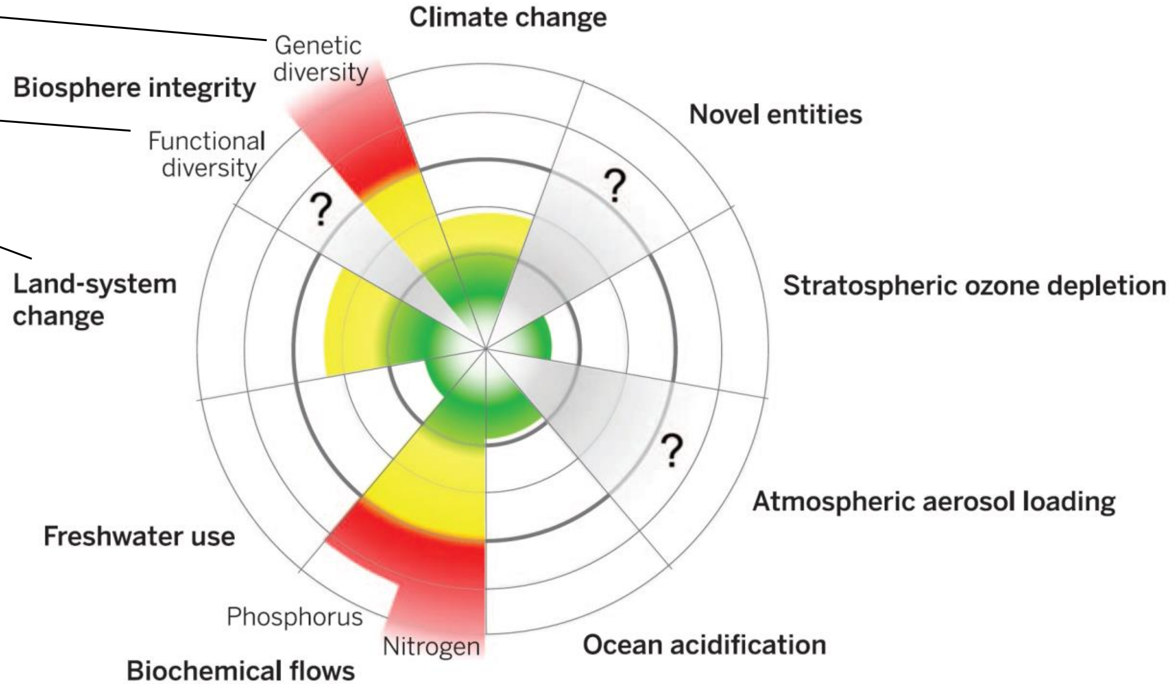
Communities
Ecosystems



The biodiversity boundary

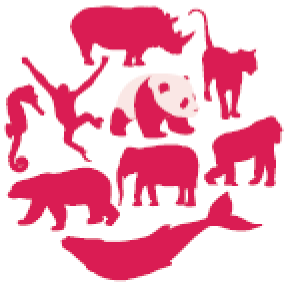
Abundance, variety and distribution of:

- genes or genotypes
- species
- functional groups
- ecosystem types or biomes

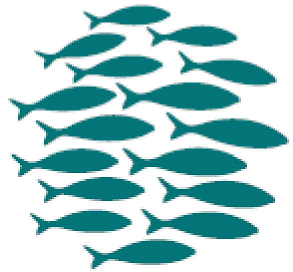


Steffen et al. 2015
DOI: 10.1126/science.1259855

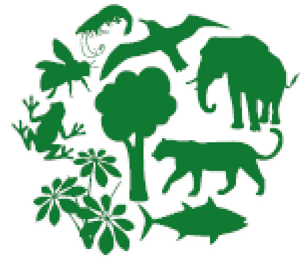
Biodiversity change dimensions



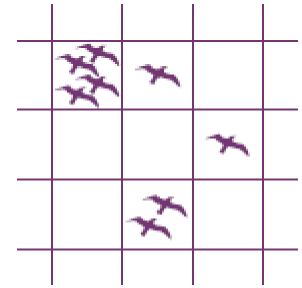
EXTINCTION RISK



ABUNDANCE



COMPOSITION



DISTRIBUTION

Abundance, variety and distribution of:

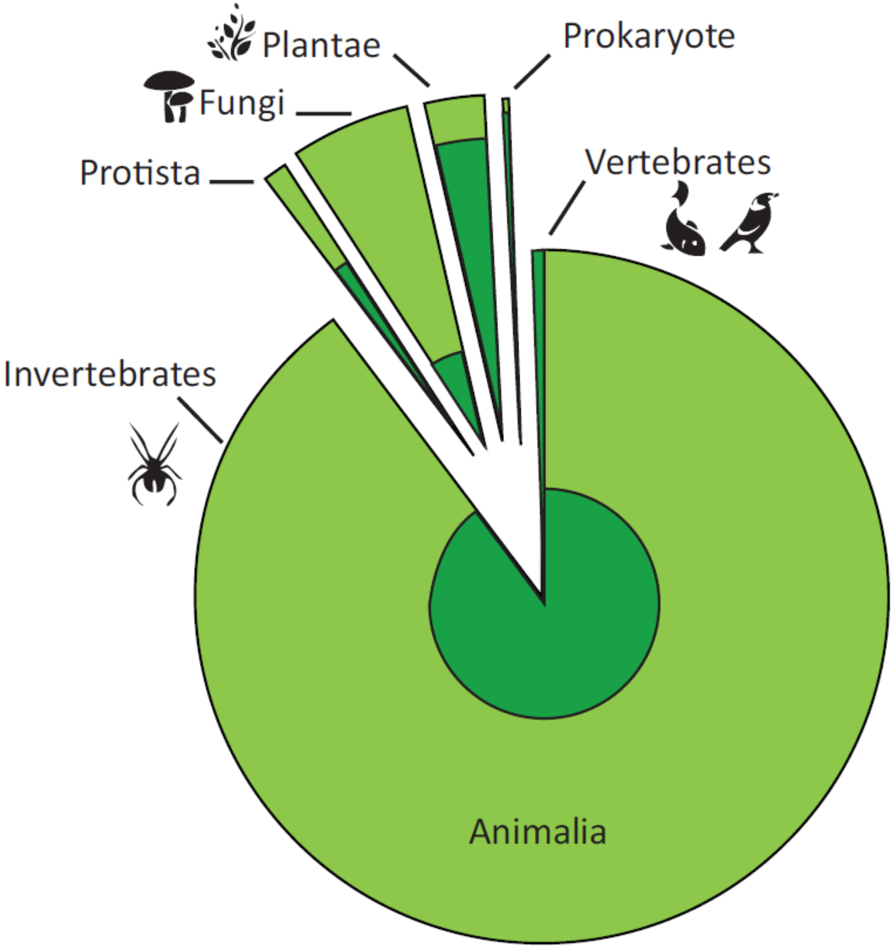
- genes or genotypes
- species
- functional groups
- ecosystem types or biomes

Levels of organization:

Populations
Species
Communities
Ecosystems

Pereira et al. 2012
DOI: 10.1146/annurev-environ-042911-093511

How many species exist on Earth?



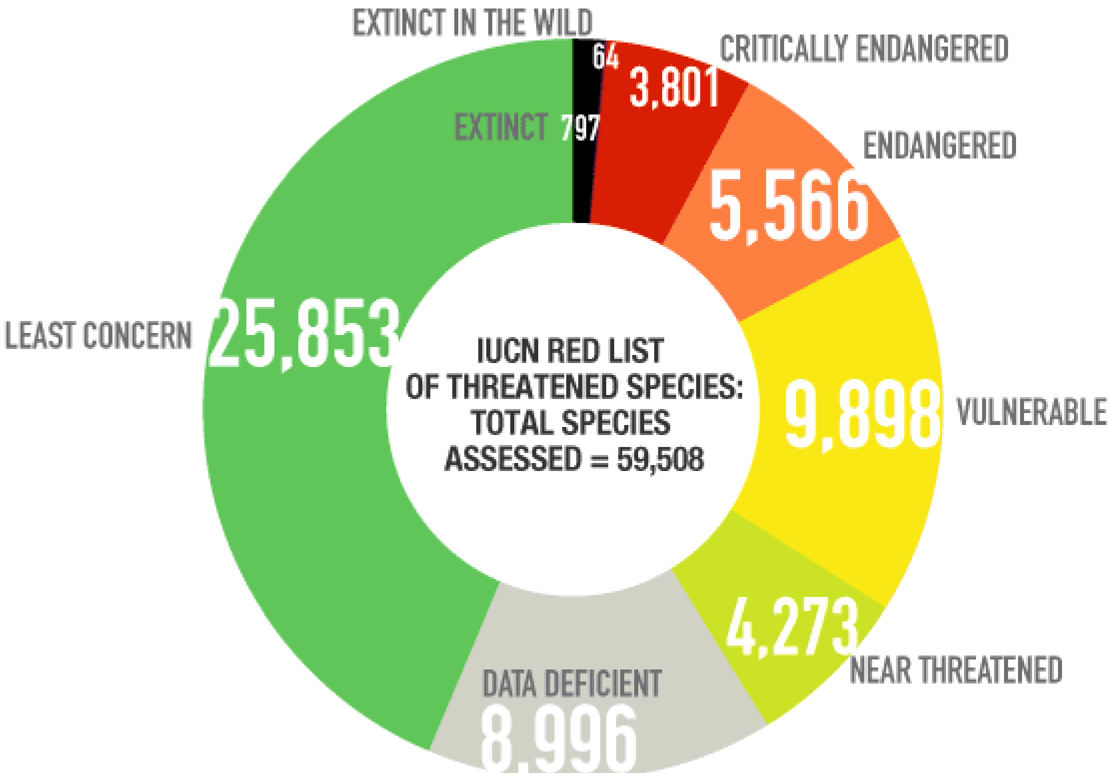
- 7.4 a 10 million estimated species
- 1.7 million described species
- Some groups are barely known

Vertebrates 52.000 (95% described)
Plants 270.000 (84%)
Insects 950.000 (12%)
Fungi 72.000 (5%)
Bacteria 4.000 (0.4%)

Pereira et al. 2012
DOI: 10.1146/annurev-environ-042911-093511

Extinction risk – Threatened Species

EXTINCTION RISK



Red List Conservation Status (IUCN 2014)

Background and modern extinction rates

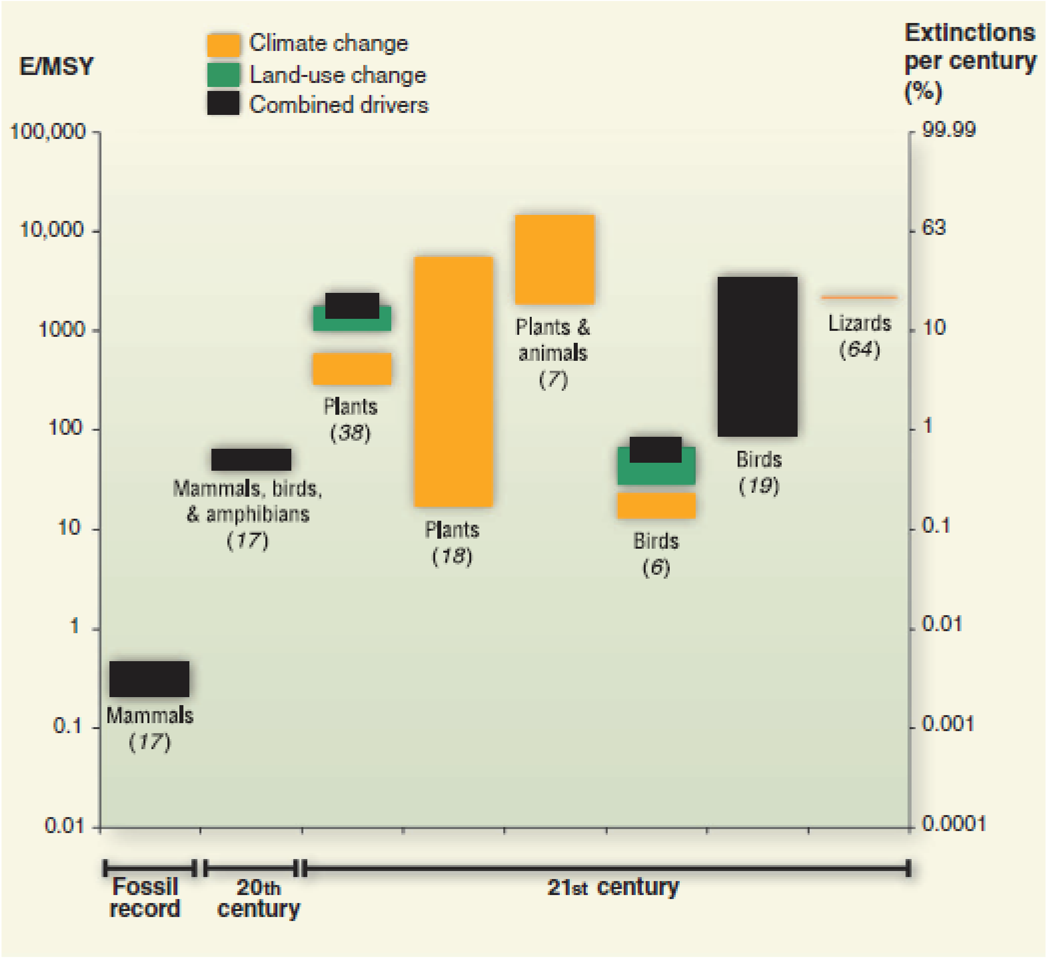


Fig. 2. Comparison of recent and distant past extinction rates with rates at which species are "committed to extinction" during the 21st century (*63*). E/MSY is number of extinctions per million species years; "Fossil record" refers to the extinction rate of mammals in the fossil record (*17*); "20th century" refers to documented extinctions in the 20th century—mammals (upper bound), birds, and amphibians (lower bound) (*17*); "21st century" refers to projections of species committed to extinction according to different global scenarios: vascular plants (*38*, *18*), plants and animals (*7*), birds (*6*, *19*), and lizards (*64*). Extinction rate caused by each driver and total extinction rates are discriminated, when possible.

Fossil record:
0.1 – 1.8 E/MSY (≈ 1 E/MSY)

E/MSY:
Extinctions per million species years

1E/MSY – background extinction rate
=
1 species extinct

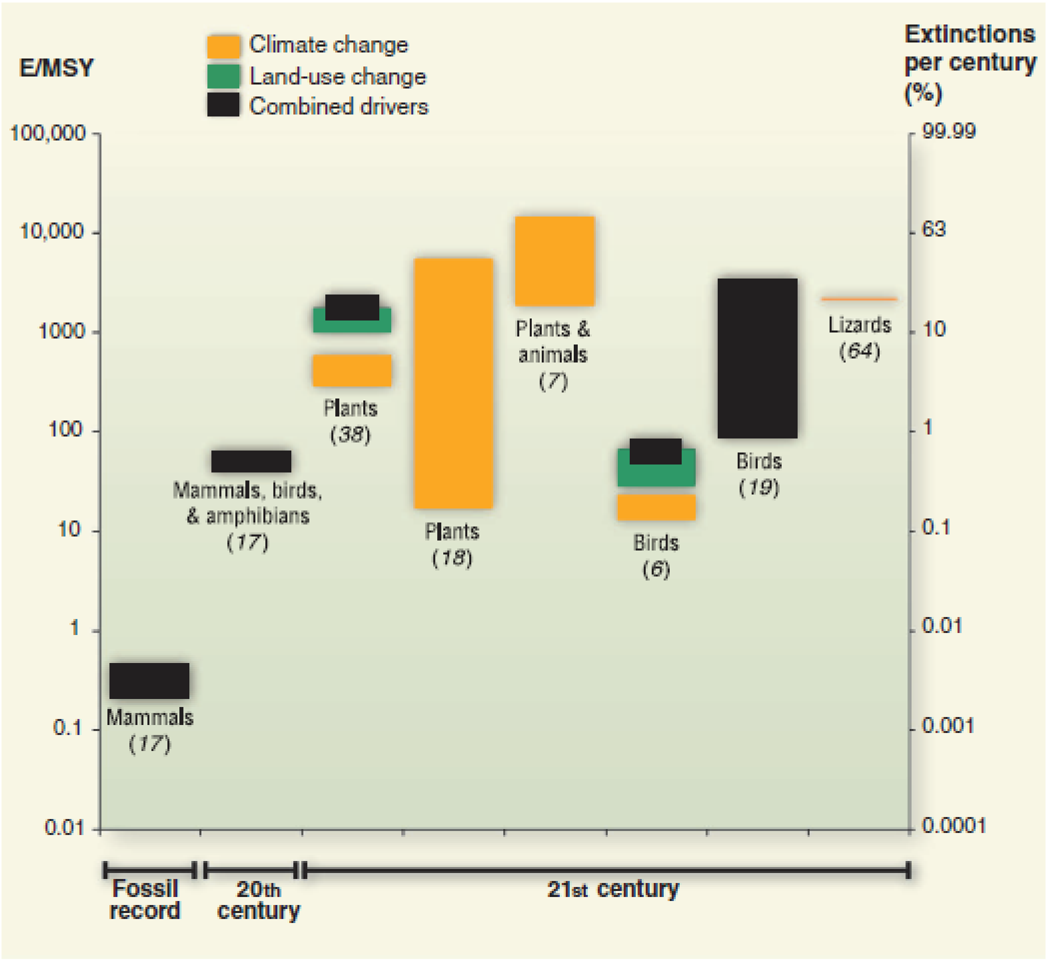
in a group of 1000 sp. in 1000 y

in a group of 10000 sp. in 100 y

Pereira et al. 2010
DOI: 10.1126/science.1196624

Pimm et al. 2014
DOI: 10.1126/science.1246752

Background and modern extinction rates



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Fossil record:
0.1 – 1.8 E/MSY (≈ 1 E/MSY)

Recent extinctions:

- 13 birds extinct,

1900 - *2014,* 1230 evaluated species
Extinction rate = 132 E/MSY

- 132 vertebrates extinct (w/o fishes)

1900 - 2014, 26 766 evaluated species
Extinction rate = 49 E/MSY

49 E/MSY << 1.8 E/MSY

At a rate of 1.8 E/MSY, it would take 2000 years instead of 100 for these 132 species to get extinct!

EXTINCTION RISK

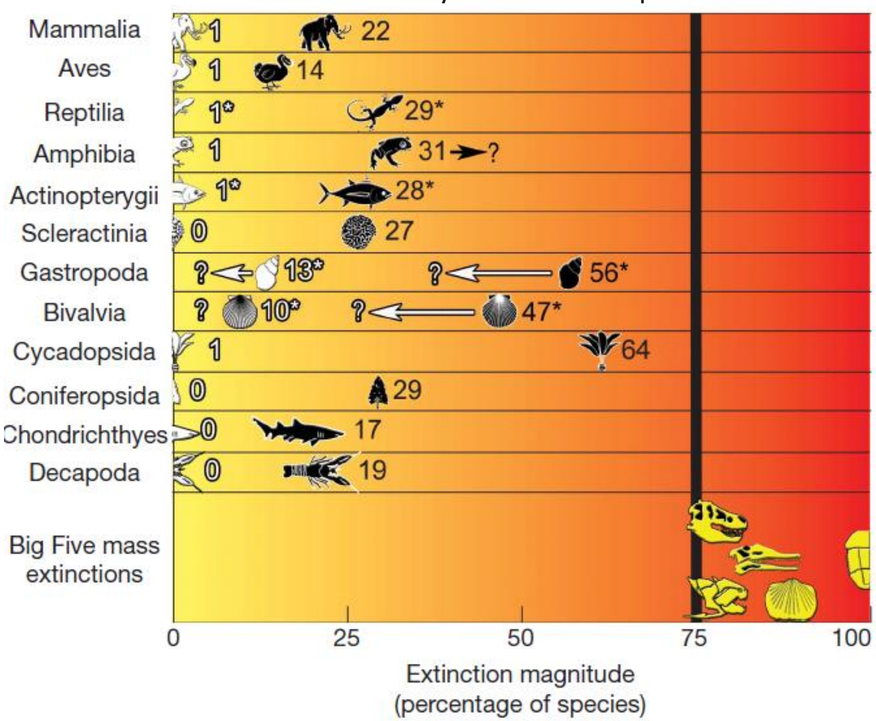
Pereira et al. 2010
DOI: 10.1126/science.1196624

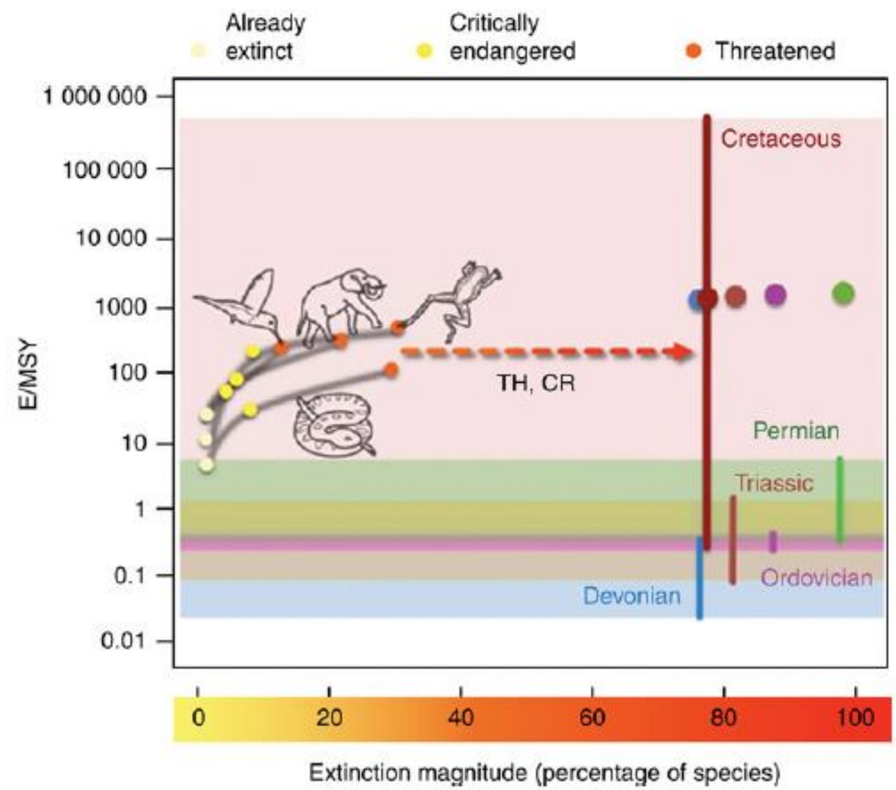
Pimm et al. 2014
DOI: 10.1126/science.1246752

Current extinction rates: sixth mass extinction?

Extinctions (%) in the past 500 years

White icons indicate % species 'extinct' and 'extinct in the wild'
Black icons also include currently 'threatened' species



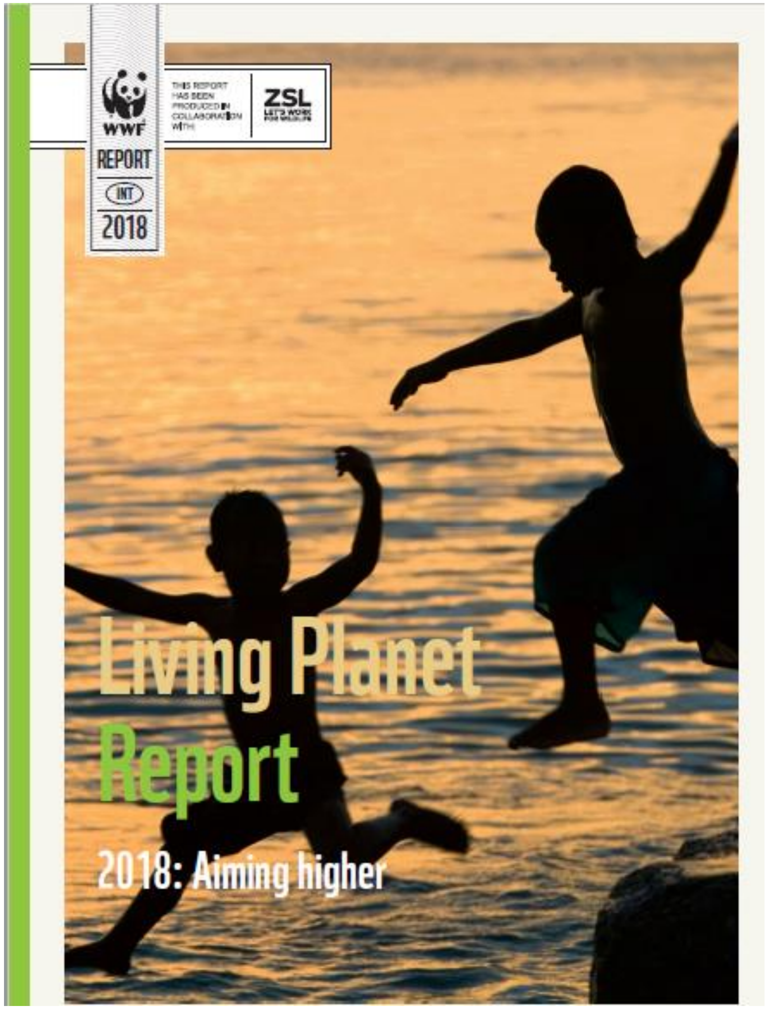


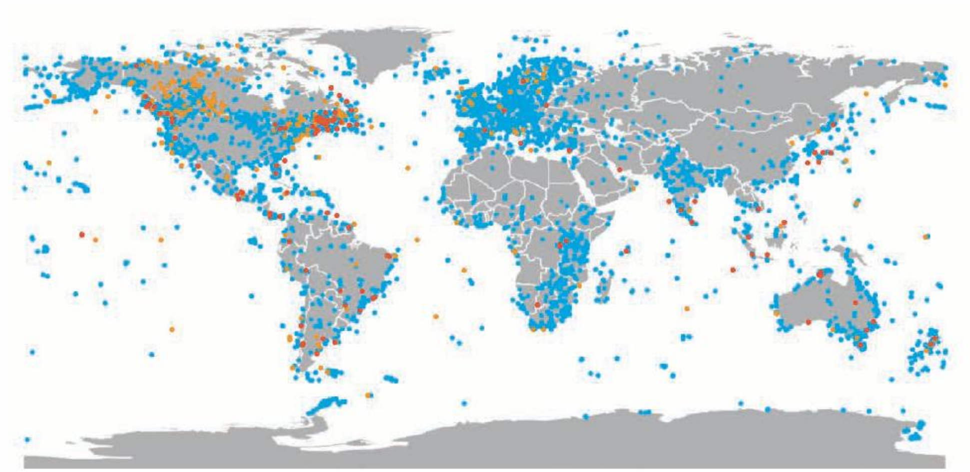
How much time to reach the a magnitude of 75% of species loss?
Extinction rate assuming the loss of threatened species in the next 100 y: 2 to 5 centuries
Extinction rate assuming the loss of critically endangered species (100y): 1 to 2 millenia

TÉCNICO LISBOA MARETEC MARINE ENVIRONMENT & TECHNOLOGY CENTER

Barnosky et al. 2011
DOI: 10.1038/nature09678

Changes in species populations size





Living Planet Index:

- Monitors the abundance of species populations
- Data from > 16.000 populations, 4000 species
- One of the best established indicators of the state of global biodiversity

ZSL: https://www.youtube.com/watch?v=6GmQAHk60Nk

WWF: https://www.youtube.com/watch?v=ufiiFGdAl5E

Changes in species populations size

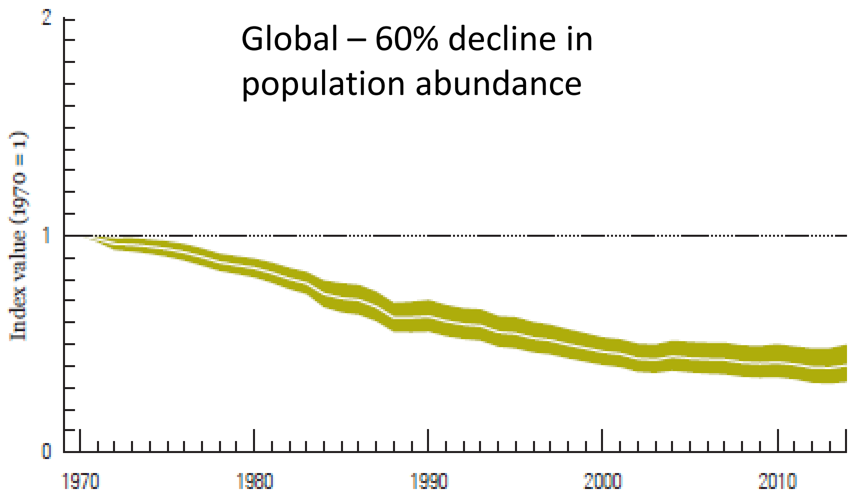
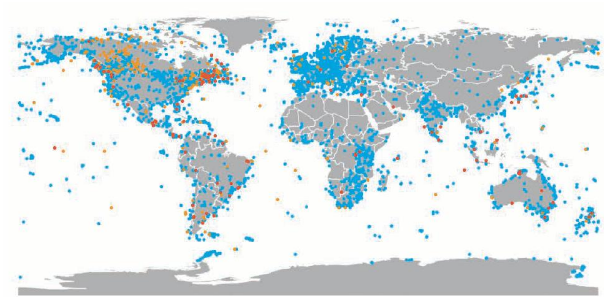
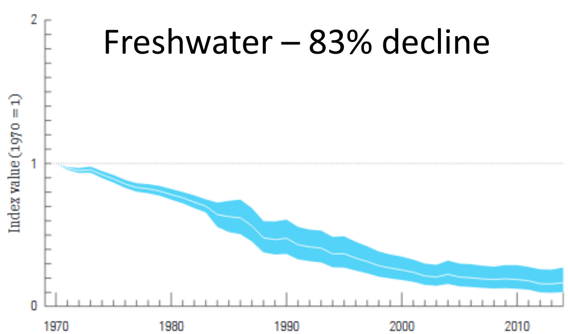


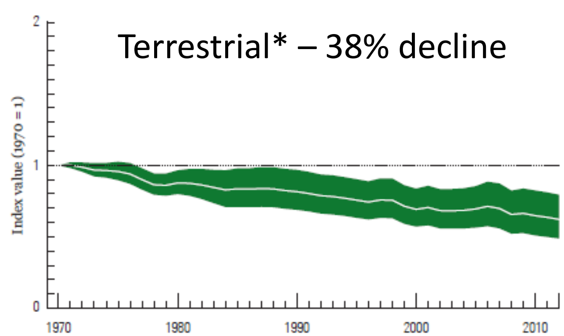
Figure 7: The Global Living Planet Index, 1970 to 2014
Average abundance of 16,704 populations representing 4,005 species monitored across the globe declined by 60%. The white line shows the index values and the shaded areas represent the statistical certainty surrounding the trend (range: -50% to -67%)[34].

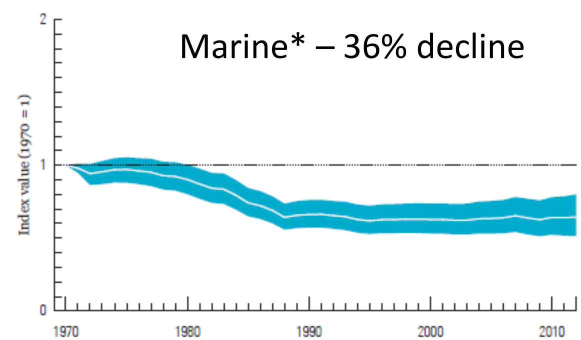
Key

Global Living Planet Index









Living Planet Report 2018 / *2016

Changes in species populations size - examples

ABUNDANCE

Sea horses at Ria Formosa, Algarve

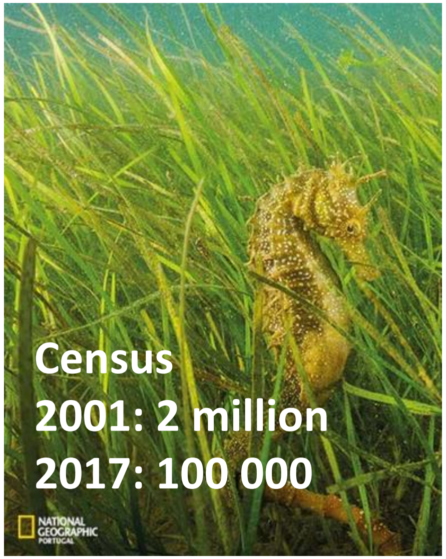
De 2015 até hoje, o impacte brutal causado pela pesca ilegal desencadeia um declínio abrupto das populações. De acordo com Jorge Palma, censos mais recentes revelaram que a ria alojava cerca de cem mil indivíduos. Parece um número razoável, mas são os últimos resistentes de uma população que, em 2001, era composta por cerca de dois milhões de indivíduos. "Nessa altura, durante um mergulho na ria, era possível encontrar vinte cavalos-marinhos; agora, se encontrarmos 3 ou 4, será um dia proveitoso", refere o biólogo.

Nem a rápida integração da espécie na Lista Vermelha da União Internacional para a Conservação da Natureza, em 2016, tem travado o declínio.

Ao longo dos últimos anos, a pressão humana sobre este ecossistema tem sido brutal e o habitat essencial destes seres vivos, constituído maioritariamente por pradarias de ervas marinhas, está a desaparecer a um ritmo alucinante. A pesca ilegal através de arrasto de vara (destinada ao caboz, choco e linguado) e o fundeamento excessivo de embarcações agravam o cenário. Estudos recentes demonstraram que a poluição sonora tem igualmente efeitos prejudiciais sobre estas espécies.

No Sudeste Asiático, um cavalo-marinho seco (a forma em que é comercializado) chega a valer mais do que vários quilogramas de peixe.Em 2016, foram apreendidos em Espanha cerca de dois mil cavalos-marinhos, pesando em conjunto sete quilogramas. Provenientes da ria Formosa, estes animais destinavam-se ao mercado chinês e iriam render aos traficantes, segundo as estimativas das autoridades, cerca de dez mil euros.

https://nationalgeographic.sapo.pt/natureza/actualidade/1684-cavalos-marinhos-na-ria-formosa



10/2019

Expresso ÚLTIMAS OPINIÃO ECONOMIA EXPRESSO CURTO PODCASTS TRIBUNA PRÉMIO PESSOA

SOCIEDADE

Cavalos-marinhos vão ter dois refúgios na Ria Formosa

27.10.2019 às 22h30

TÉCNICO LISBOA MARETEC MARINE ENVIRONMENT & TECHNOLOGY CENTER

Changes in species populations size - examples

ABUNDANCE

Mutilated dolphins wash up on French coast in record numbers

Activists say 1,100 dolphins found since January - but real figure may be 10 times higher

▲ A dead dolphin lies on a beach near Lacanau, south-west France. Photograph: Nicolas Tucat/AFP/Getty Images

A record number of dolphins have washed up on France's Atlantic coast in the last three months, many with devastating injures.

Environmental campaigners say 1,100 mutilated dolphins have been found since January, but the real figure could be 10 times higher as many bodies sink without trace. Activists warn the marine slaughter could threaten the extinction of the European dolphin population in the region.

The cause of the deaths is not known but it is thought fishing trawlers catching sea bass off the Atlantic coast may be responsible. Autopsies suggest the dolphins sustain catastrophic injuries attempting to escape nets or when trawler crew attempt to cut them free after they are caught.

03/2019

SOCIEDADE

Como milhares de aves estão a morrer no Alentejo

24.02.2019 às 11h41

Pássaros são sugados por máquinas durante a apanha noturna de azeitona. Quase cem mil podem estar em risco. Em Espanha já morreram mais de 2,5 milhões de aves

CARLA TOMÁS

Pelo menos 480 pássaros morreram aspirados por máquinas durante a apanha noturna de azeitona em áreas de olival superintensivo no Alentejo, em dezembro e janeiro. Esta é a constatação do Instituto da Conservação da Natureza e das Florestas (ICNF) com base na fiscalização feita a 25 cargas de azeitona colhidas em 75 hectares na zona de Avis. Nas contas do ICNF dá "uma média de 6,4 aves mortas por hectare". Se extrapolarmos para os 15 mil hectares de olival superintensivo existentes, pode indiciar a mortandade anual de mais de 96 mil aves.

Quando as máquinas de apanha começam a trabalhar à noite, durante o período de repouso das aves, o ruído e a iluminação dos aparelhos cegam os pássaros, que ficam incapazes de fugir e acabam por ser sugados em grande número. Na Andaluzia, as autoridades já admitiram que poderão ter sido dizimadas "cerca de 2,6 milhões de aves".

02/2019

Changes in species populations size - examples

ABUNDANCE

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Activists say 1,100 dolphins found since January - but real figure may be 10 times higher

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The cause of the deat
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03/2019

Olivum recomenda suspensão voluntária da colheita mecanizada noturna de azeitona

25-10-2019 | agroportal.pt

Olivum recomenda suspensão voluntária da colheita mecanizada noturna de azeitona

[Fonte: Vida Rural] A Associação de Olivicultores do Sul (Olivum) recomendou a suspensão voluntária da colheita mecanizada noturna de azeitona a todos os seus associados. Em comunicado, a associação diz que "tem-se mostrado sempre disponível para colaborar com as entidades públicas e privadas de forma a evitar a perturbação dos ecossistemas associados ao olival, bem como para sensibilizar os seus associados para as melhores práticas ambientais de colheita da azeitona".

10/2019

SOCIEDADE

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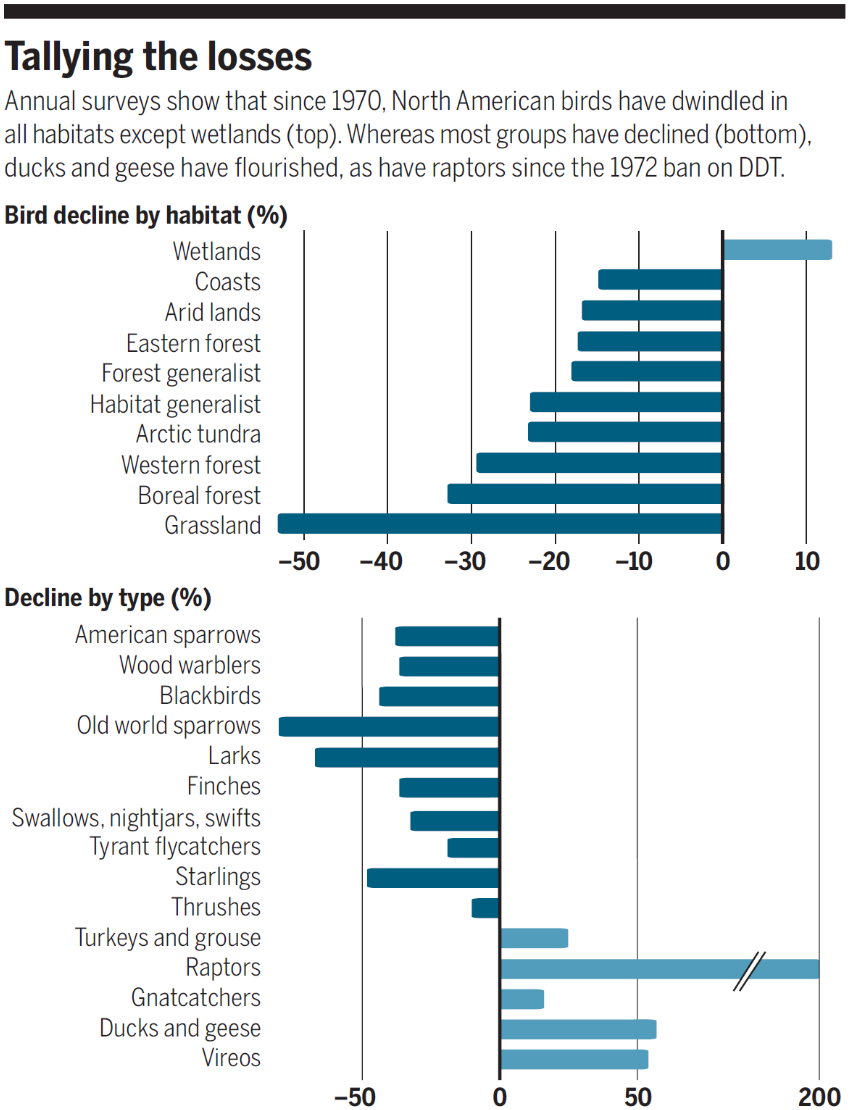
02/2019

Changes in species populations size - examples



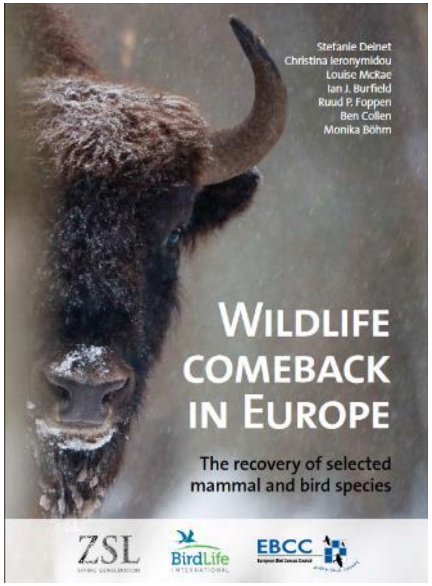
10/2019 - Science

Some of the causes may be subtle. (…) pesticides made migrating sparrows lose weight and delay their migration, which hurts their chances of surviving and reproducing. Climate change, habitat loss, shifts in food webs, and even cats may all be adding to the problem, and not just for birds.

The recovery of eagles and other raptors after the U.S. ban on the insecticide DDT in 1972 shows that when the cause of a decline is removed, "the birds come back like gangbusters."

Rosenberg et al. 2019, DOI: 10.1126/science.aaw1313
Summary: DOI: 10.1126/science.365.6459.1228

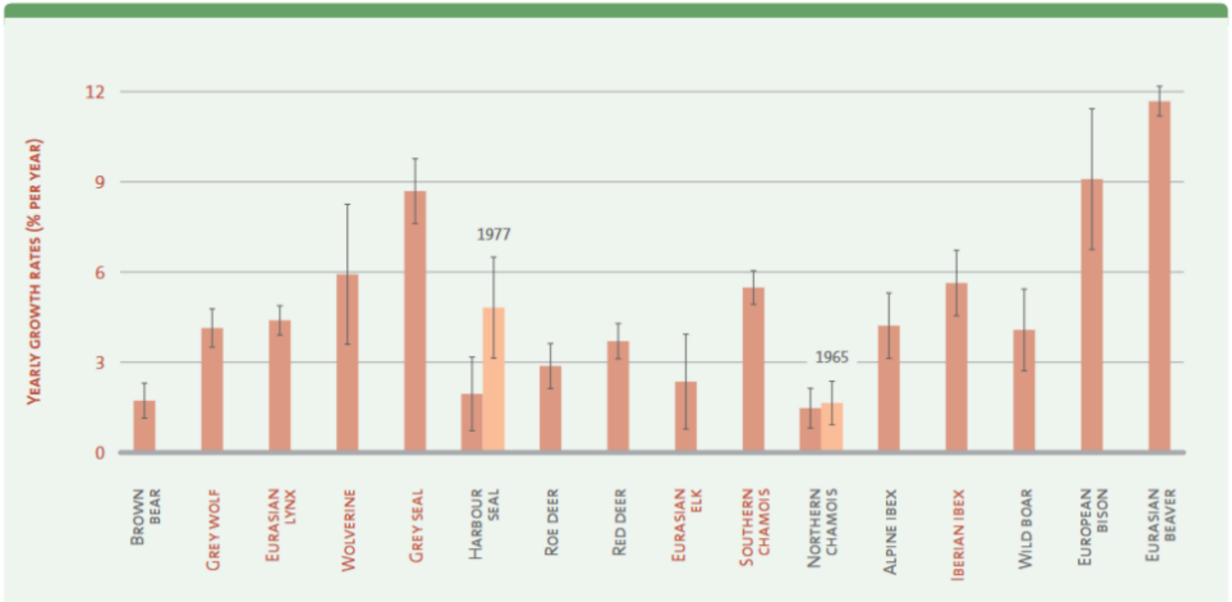
Changes in population size - population recovery



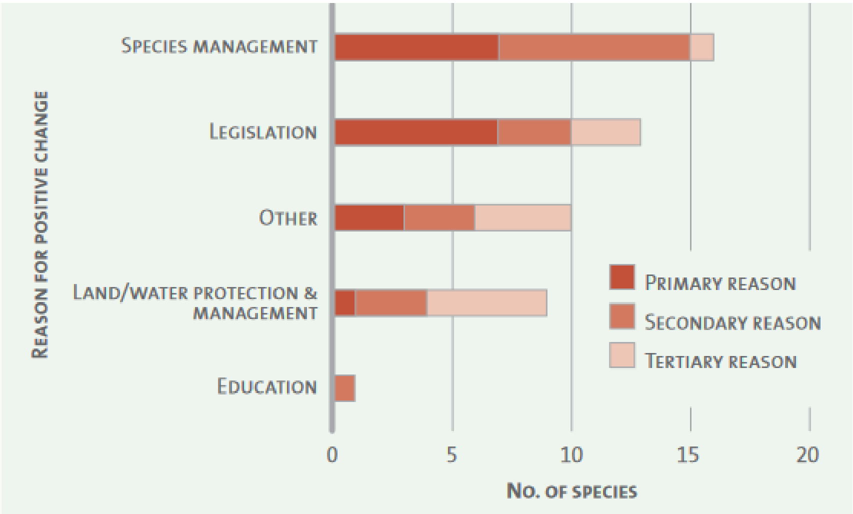
RANK	REASON FOR CHANGE	DESCRIPTION
1	**Species management — Conservation breeding, reintroductions and translocations**	First reintroduction in 1952 in the Białowieża forest, leading to successful reproduction in 1957 [3]. Changes in population size are recorded in detail in the annually updated European Bison Pedigree Book (EBPB) [3].

RANK	REASON FOR CHANGE	DESCRIPTION
1	**Species management – Reintroductions and translocations**	Translocations played a role both in the recovery of range and numbers initially, particularly during the 1980s and 1990s, with the exception of Maestrazgo, where ibex were established in 1966 [1, 7]. Reintroductions have taken place into a number of sites in Spain and northern Portugal [24].
2	**Legislation**	The Iberian ibex is protected under the Bern Convention (Appendix III) [22] and the EU Habitats and Species Directive (Annex V) [23]. Several parks and refuges have been set up for the protection of the species, e.g. the Sierra de Gredos National Refuge in 1905 [10, 18] to preserve the remaining individuals of C. p. victoriae [7].
3	**Land/water protection & management – Land use change**	New habitat becoming available as a result of rural abandonment has had positive effects on distribution and abundance [17].
4	**Species management – Reduction of threats**	Recovery from past mange outbreaks was attributed not only to game management translocations but also decreased hunting pressure [33].

Changes in population size - population recovery



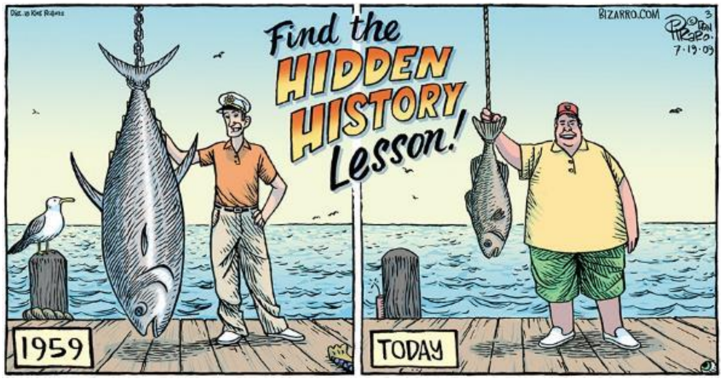
Average annual growth rates for mammal species which show resurgence in Europe.
Annual growth rates were for the period of 1961 to 2005 in most cases

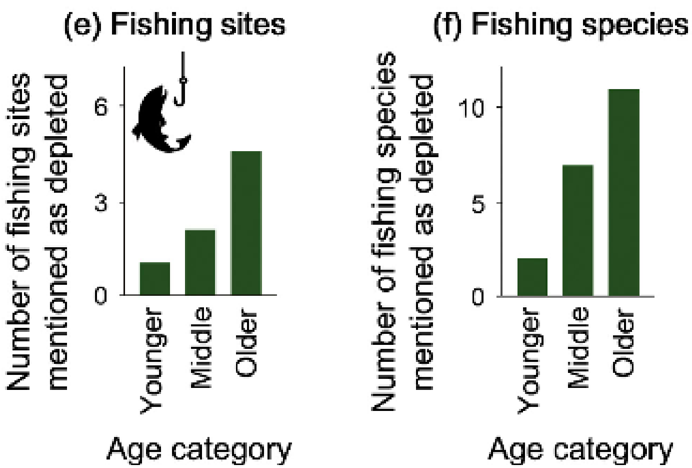


Reasons for resurgence for the 18 mammal species in this study.

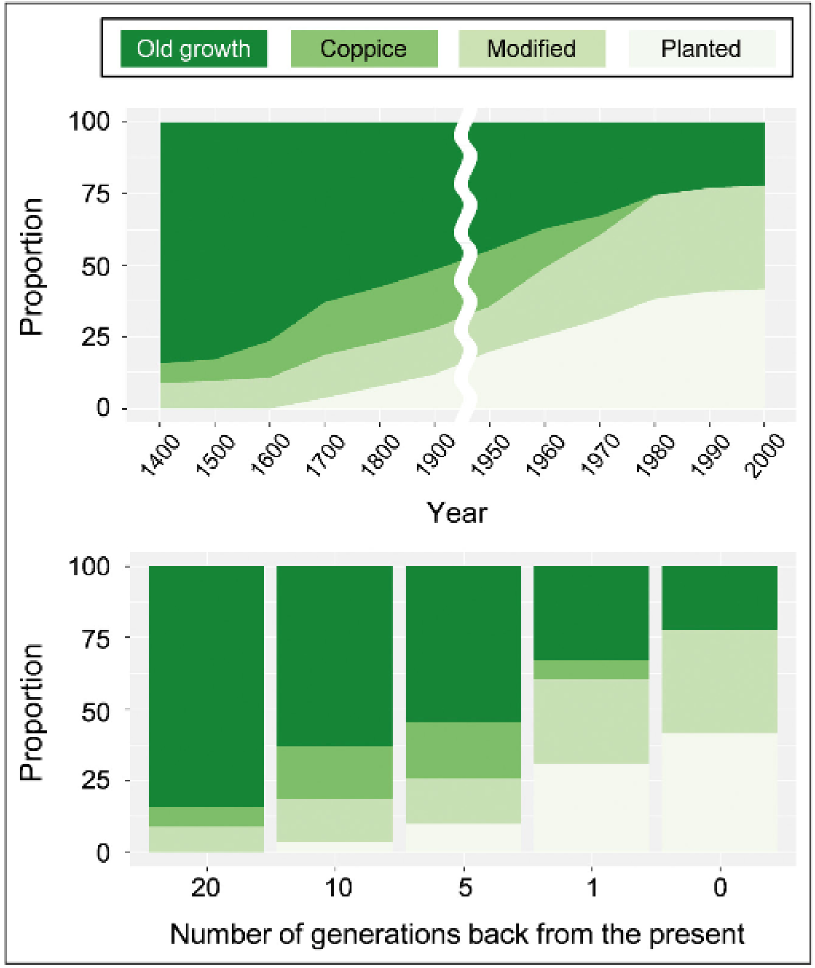
Temporal change – Shifting baseline

Daniel Pauly's Ted Talk: "The Oceans Shifting Baseline." Check it out: bit.ly/1IJ6f0n #Oceans



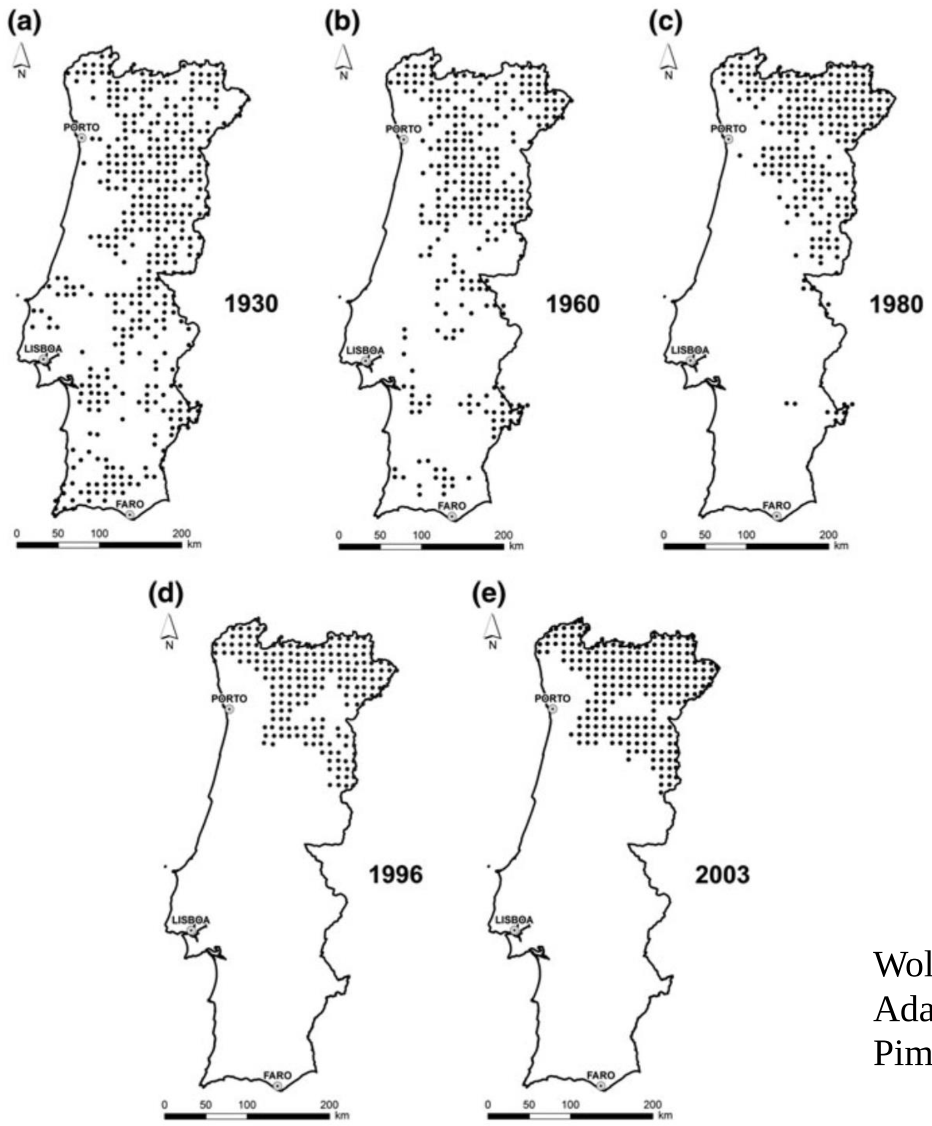


Six hundred years of change in the forest environment of Japan



Soga and Gaston 2018
DOI: 10.1002/fee.1794

Temporal change – Shifting baseline



Wolf distribution in Portugal over the last century. Adapted from Petrucci-Fonseca (1990) and Pimenta et al. (2005)

Da Costa et al2018
DOI: 10.1007/978-3-319-60351-3_5

Temporal change – Shifting baseline

Italian Alps, Cortina d' Ampezo

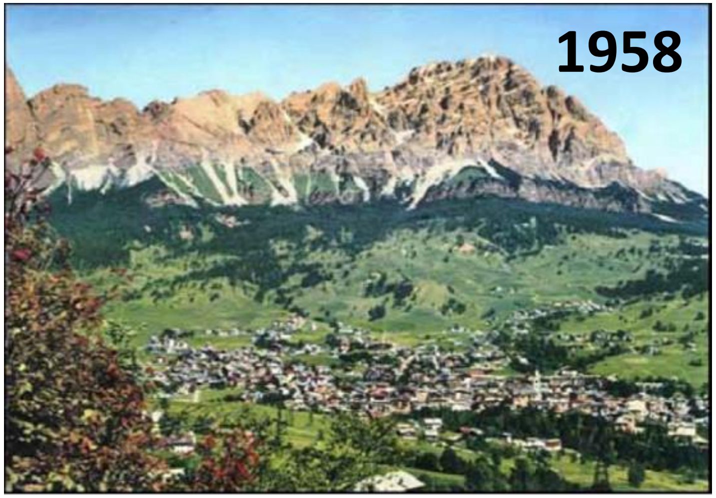
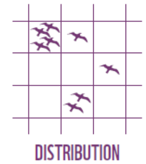


Table 2. In six European nations, approximate years of transition from shrinking to expanding forest areas, the minimum areas at transition, and the forest areas in 2005 (5–7)

	Approximate year of transition	Forest extent at time of transition, % of national area	Forest extent, 2005, % of national area
Denmark	1810s	4	11
France	1830s	14	28
Portugal	Pre-1870s	7	40
Switzerland	1860s	18	30
Scotland	1920s	5	17
European Russia	1930s	28	39

Kaupi et al. 2006
DOI: 10.1073pnas.0608343103

Linking biodiversity change to ecosystem services



Species x: Change in abundance → Local extinction → Global extinction

Species y: Change in abundance → Local extinction

Species z: Change in abundance

Species w: Change in abundance → Local invasion/ introduction

(…)

Species n (…)

Change in species relative abundance or distribution (presence)

⇩

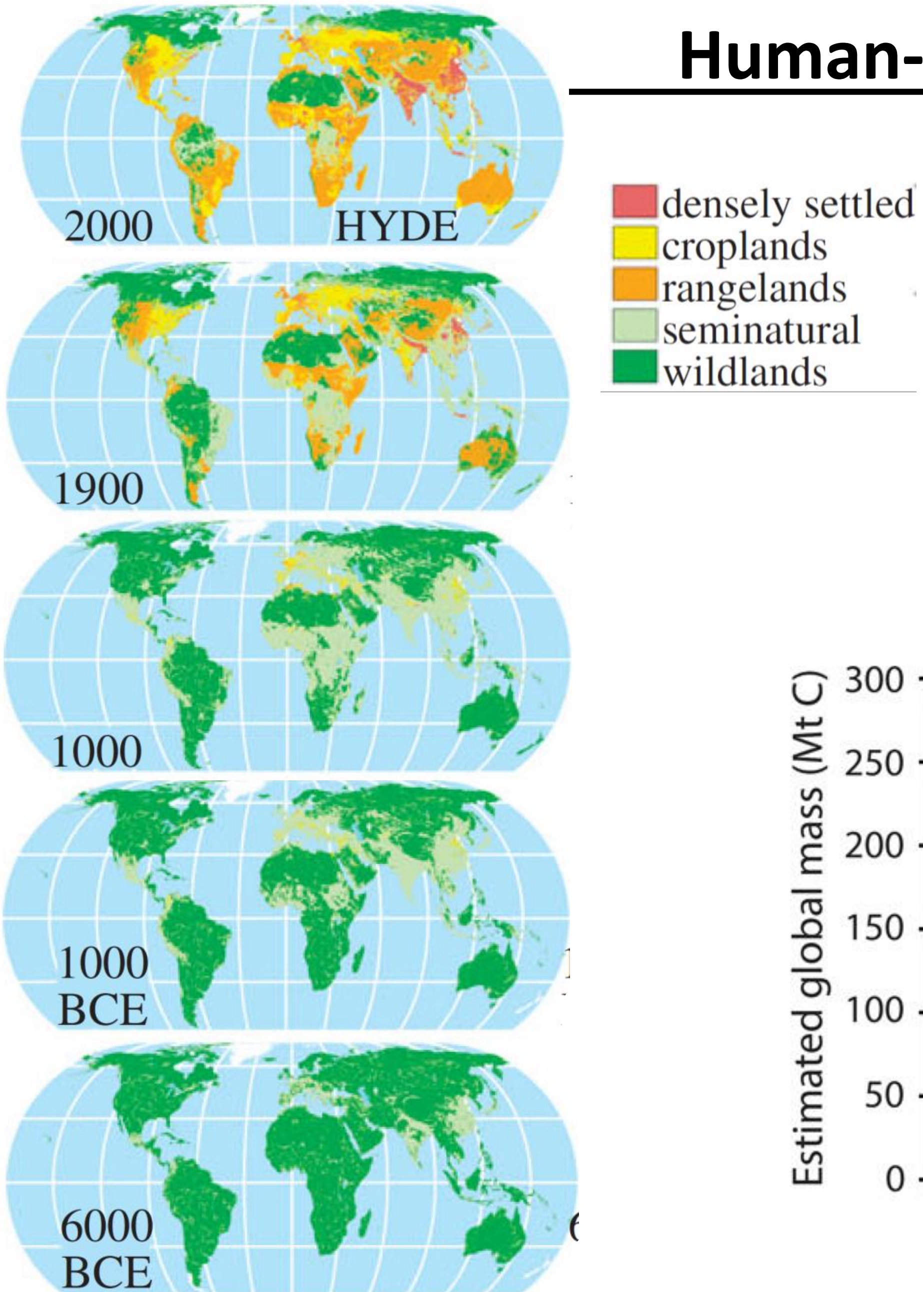
Change in community composition and structure

⇩

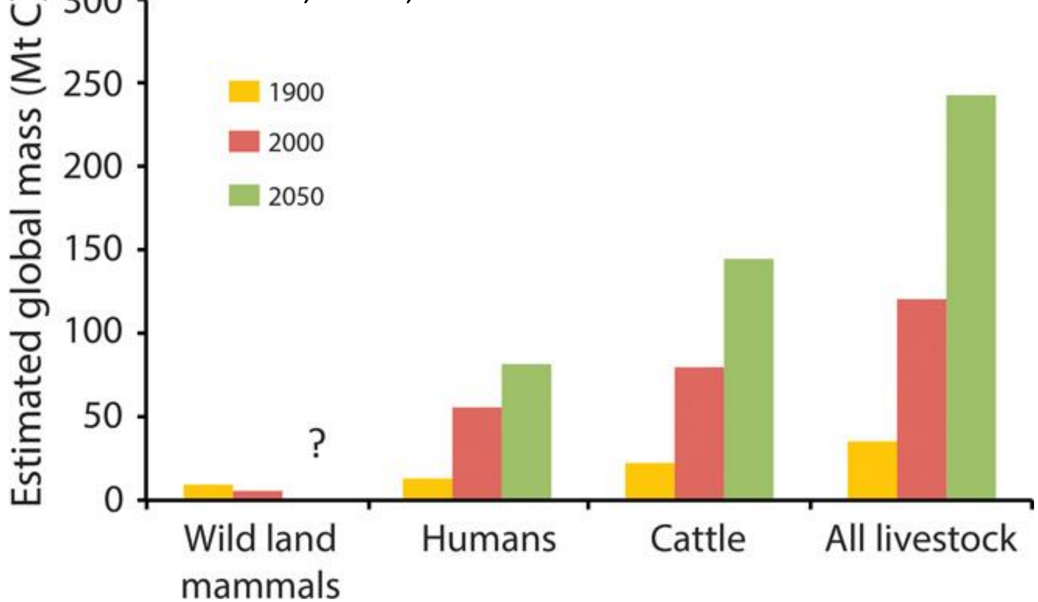
Effects on ecosystem functioning -> ecosystem services

Human-modified ecosystems

COMPOSITION



Global change in the collective mass for wild mammals, humans, cattle, and all livestock



Ellis 2011
DOI: 10.1098/rsta.2010.0331

Ripple et al. 2015
DOI: 10.1126/sciadv.1400103

Large species are among the most threatened

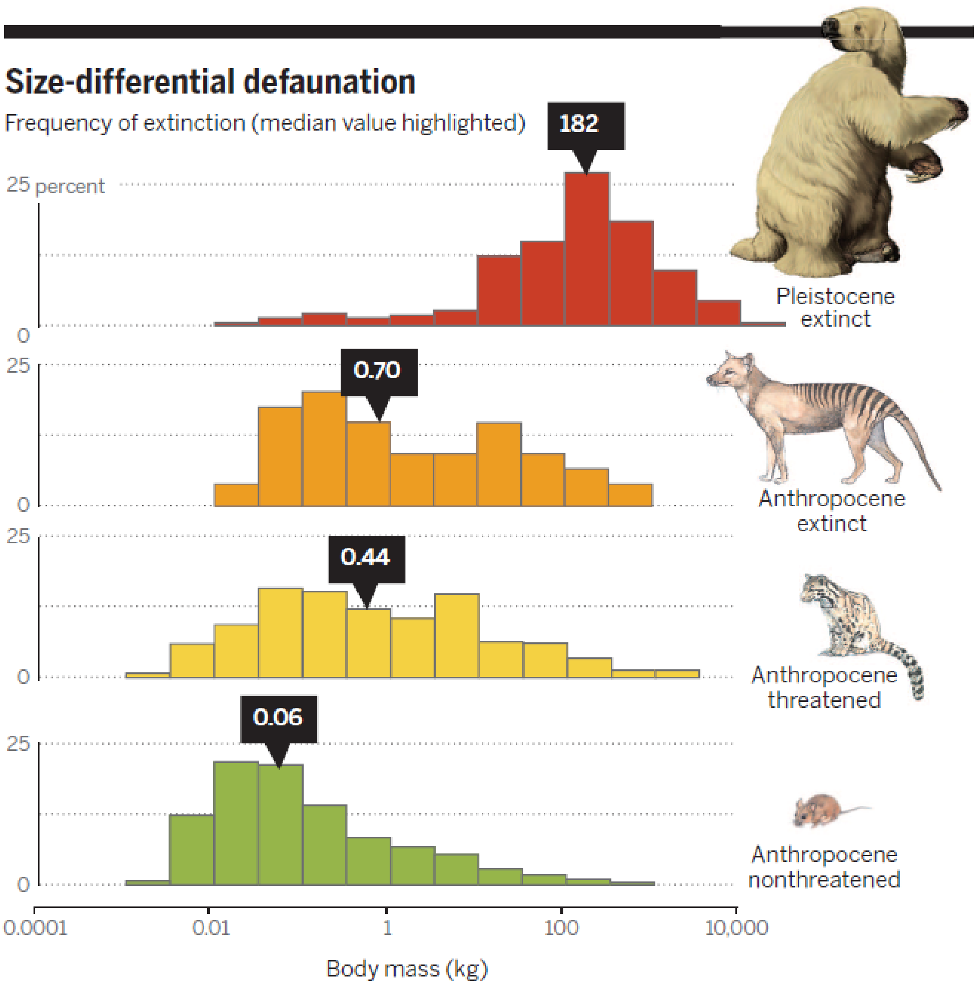
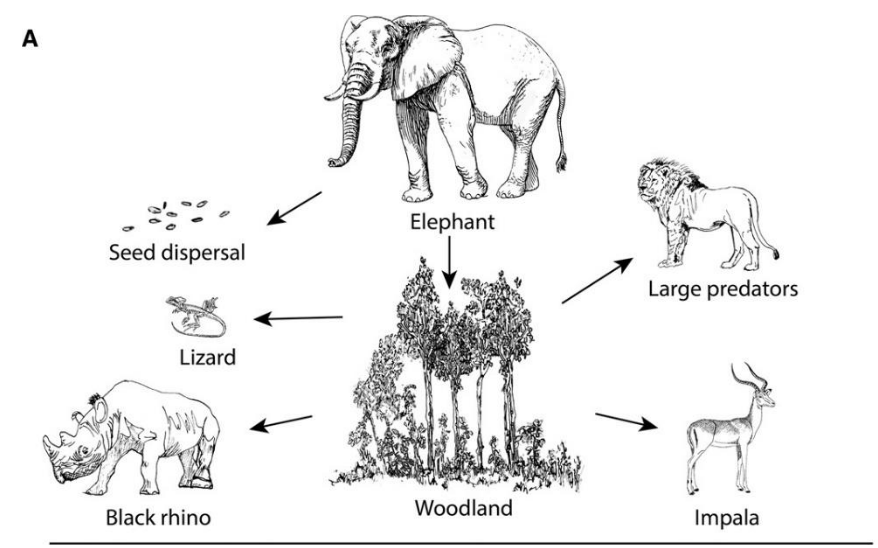


Fig. 3. Extinction and endangerment vary with body size. Comparing data on body size of all animals that are known to have gone extinct in Pleistocene or are recently extinct (<5000 years B.P.) shows selective impact on animals with larger body sizes (median values denoted with black arrow). Differences in body masses between distributions of currently threatened and nonthreatened species suggest ongoing patterns of size-differential defaunation (Kolmogorv-Smirnov test, $K = 1.3$, $P < 0.0001$) (*19*).

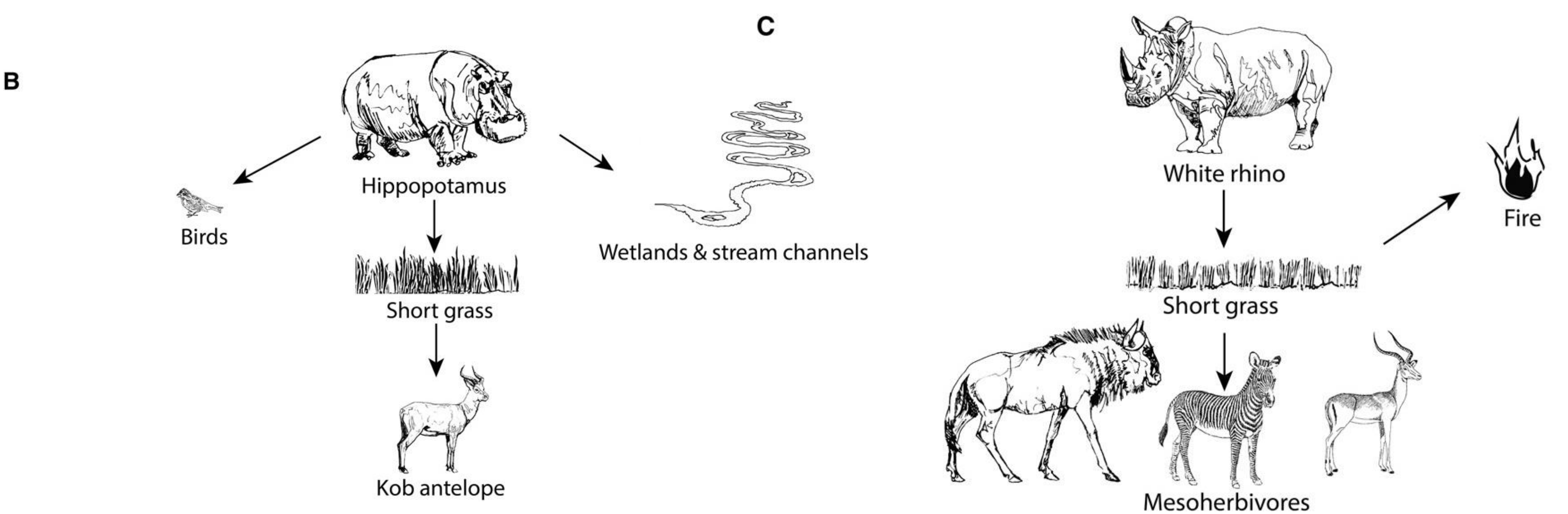
60% of the largest terrestrial herbivores and 61% of largest carnivores are listed as threatened; 77% of large carnivores undergoing population declines

Dirzo et al. 2014
DOI: 10.1126/science.1251817

Large herbivores as ecosystem engineers



Conceptual diagrams showing the effects of elephants, hippopotamus, and rhinoceros on ecosystems.



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Ripple et al. 2015
DOI: 10.1126/sciadv.1400103

Large herbivores as ecosystem engineers

https://edition.cnn.com/2019/11/25/world/bison-saving-prairie-intl-c2e/index.html

Why bringing back bison could help restore America's lost prairie

by Mark Tutton, CNN

Updated 0958 GMT (1758 HKT) November 26, 2019

Bison at Nachusa Grasslands, an area of restored prairie in Illinois.

Cattle at Quinta da França (Covilhã) forest test site
- Using cattle to regulate forest biomass

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Large carnivores also affect ecosystems

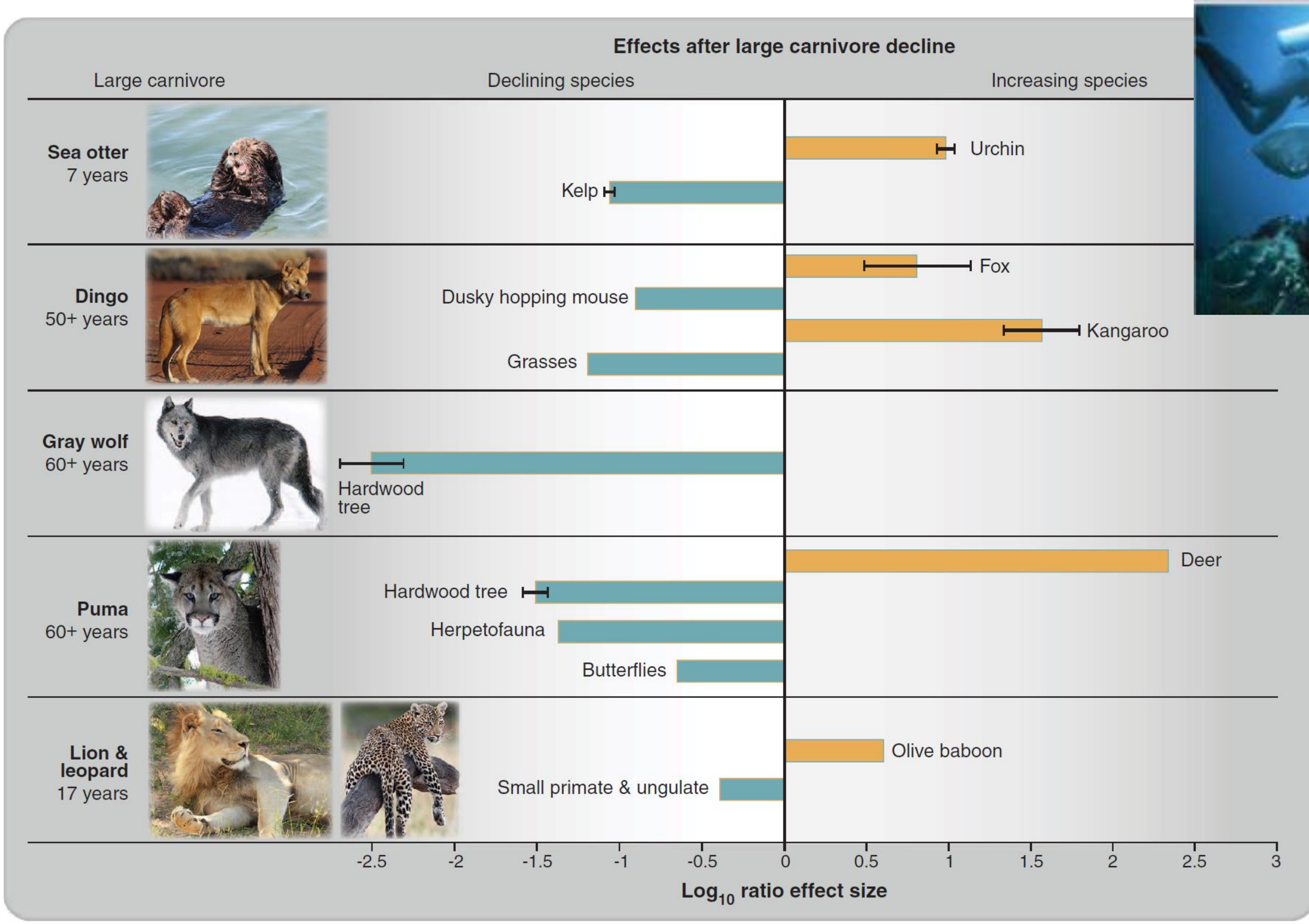
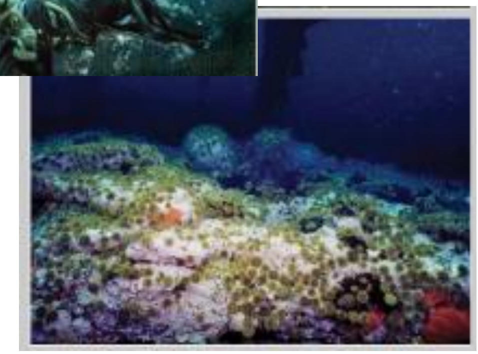


Fig. 2. Examples of effect sizes, shown as $\log_{10}$ ratios, after the removal of large-carnivore species. Sea otters (29, 92), dingoes-foxes and dingoes-kangaroo (21, 93), dingoes-mice (*Notonmys fuscus*) (93), dingoes-grasses (20), gray wolves–hardwood trees (94, 95), pumas–hardwood trees (38, 39), pumas-deer-herpetofauna-butterflies (38), and lions and leopards (18). The number of years refers to the time since large-carnivore extirpation. The $\log_{10}$ ratios were calculated by dividing the values of each response variable without predator by those with predator and then taking the $\log_{10}$ of that ratio. Positive log ratios_{10} indicate a positive effect, and negative $\log_{10}$ ratios indicate a negative effect of removing large carnivores. For studies using time-series data, we used the final sampling date in our analysis. The orange bars indicate direct effects and the blue bars indicate indirect effects. Error bars represent standard errors and were only available in some cases. [Photo credits: sea otter (N. Smith), dingo (A. McNab), gray wolf (Yellowstone National Park), puma (Washington Department of Fish and Wildlife), lion (K. Abley), leopard (A. Dey)]



The restoration of sea otter populations can allow kelp ecosystems to flourish at levels that can, in the N. American range, lead to a 4.4- to 8.7-teragram increase in stored carbon valued at $205million to $408million (in U.S. dollars) on the European Carbon Exchange

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Ripple et al. 2014
DOI: 10.1126/science.1241484

Smaller species also matter…

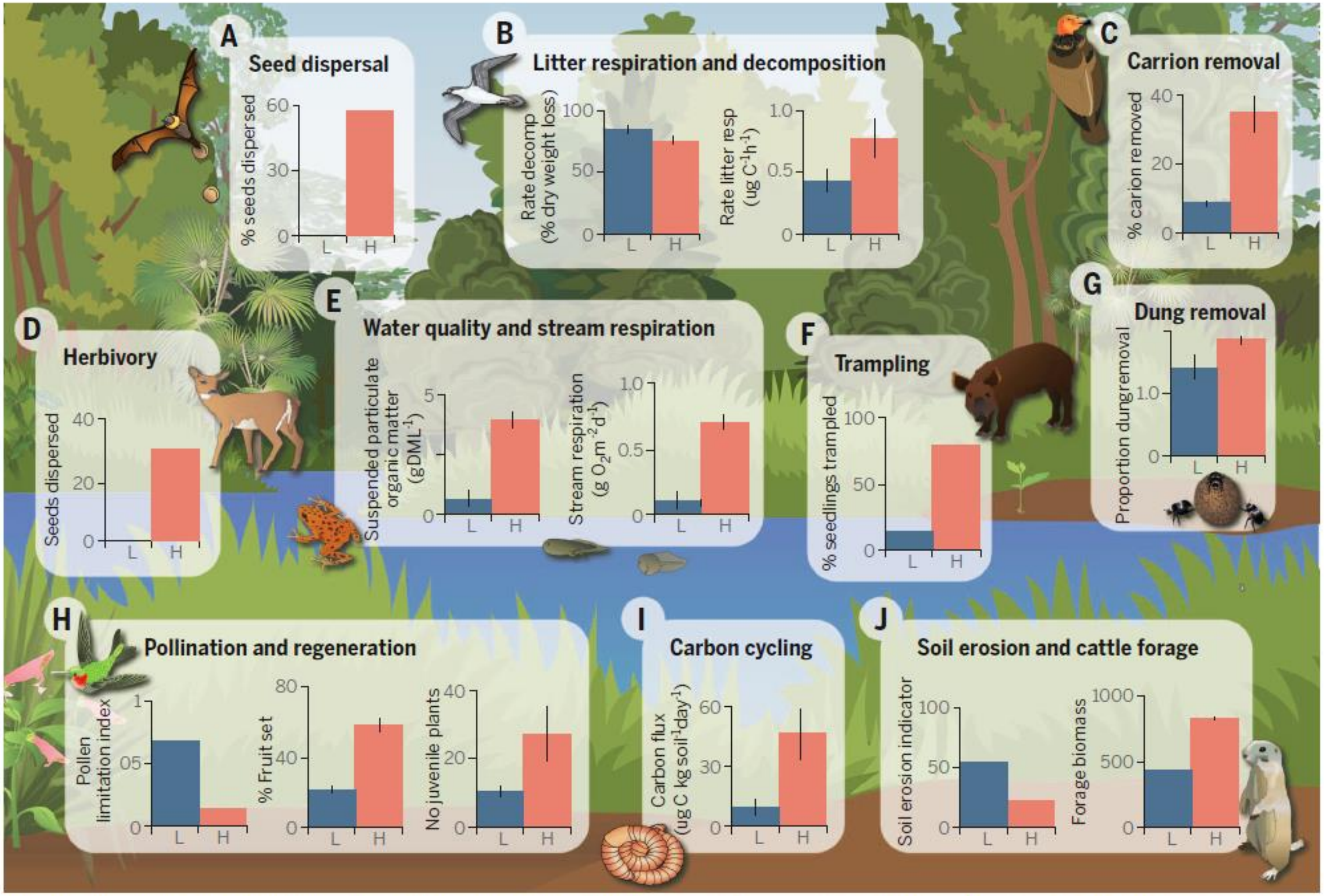
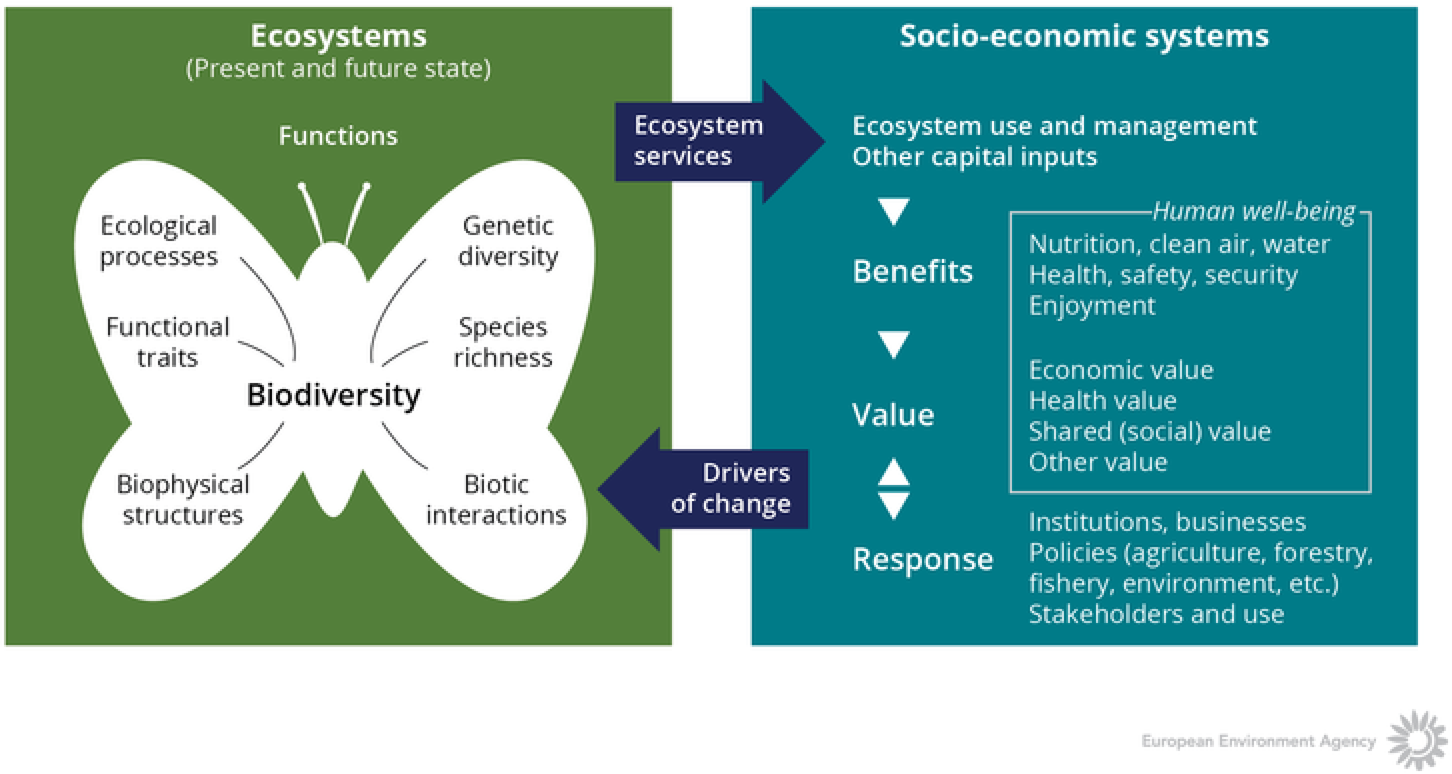


Fig. 5. Consequences of defaunation on ecosystem functioning and services. Changes in animal abundance from low (blue, L) to high (red, H) within a region have been shown to affect a wide range of ecological processes and services (*19*), including (**A**) seed dispersal (flying foxes), (**B**) litter respiration and decomposition (seabirds), (**C**) carrion removal (vultures), (**D**) herbivory (large mammals), (**E**) water quality and stream restoration (amphibians), (**F**) trampling of seedlings (mammals), (**G**) dung removal (dung beetles), (**H**) pollination and plant recruitment (birds), (**I**) carbon cycling (nematodes), and (**J**) soil erosion and cattle fodder (prairie dogs).

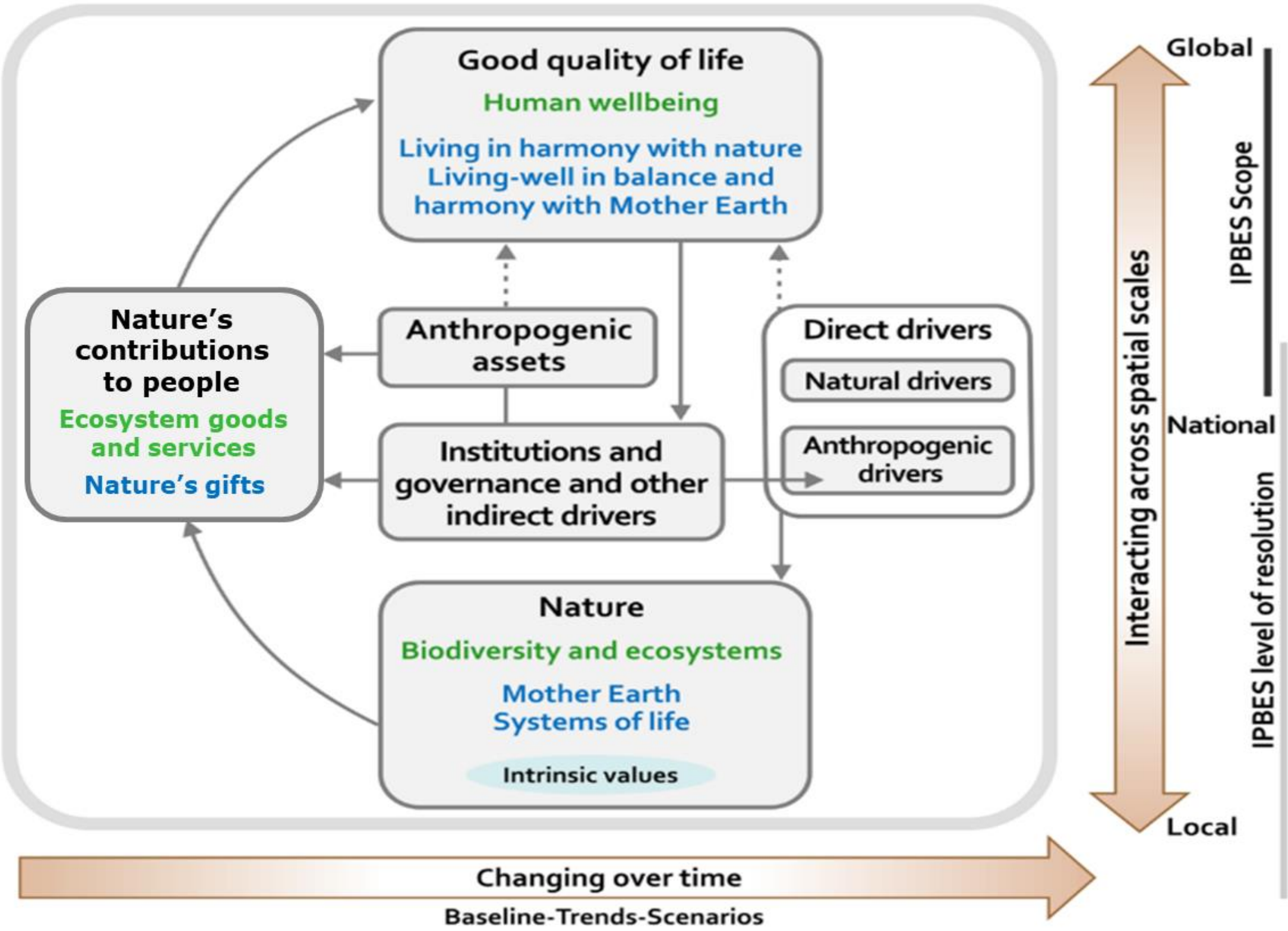
Dirzo et al. 2014
DOI: 10.1126/science.1251817

…the benefits that people obtain from ecosystems - Millennium Ecosystem Assessment 2005



Ecosystem services – IPBES Conceptual Framework

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (*IPBES*)



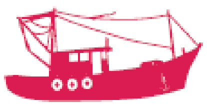
Díaz S, Demissew S, Joly C, Lonsdale WM, Larigauderie A (2015) A Rosetta Stone for Nature's Benefits to People. PLOS Biology 13(1): e1002040. https://doi.org/10.1371/journal.pbio.1002040
http://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.1002040

Main drivers of biodiversity change

HABITAT LOSS AND DEGRADATION

This refers to the modification of the environment where a species lives, by complete removal, fragmentation or reduction in quality of key habitat. Common causes are unsustainable agriculture, logging, transportation, residential or commercial development, energy production and mining. For freshwater habitats, fragmentation of rivers and streams and abstraction of water are common threats.

SPECIES OVEREXPLOITATION

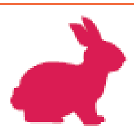


There are both direct and indirect forms of overexploitation. Direct overexploitation refers to unsustainable hunting and poaching or harvesting, whether for subsistence or for trade. Indirect overexploitation occurs when non-target species are killed unintentionally, for example as bycatch in fisheries.

POLLUTION

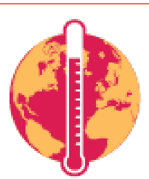
Pollution can directly affect a species by making the environment unsuitable for its survival (this is what happens, for example, in the case of an oil spill). It can also affect a species indirectly, by affecting food availability or reproductive performance, thus reducing population numbers over time.

INVASIVE SPECIES AND DISEASE



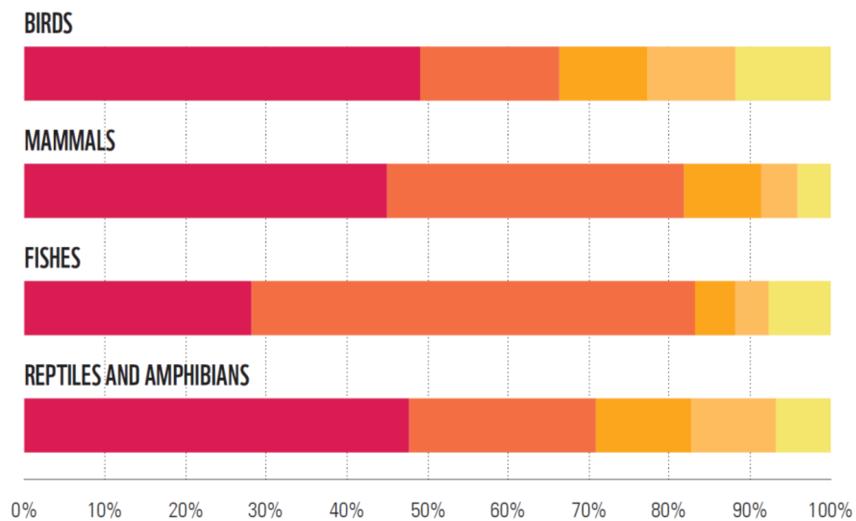
Invasive species can compete with native species for space, food and other resources, can turn out to be a predator for native species, or spread diseases that were not previously present in the environment. Humans also transport new diseases from one area of the globe to another.

CLIMATE CHANGE



As temperatures change, some species will need to adapt by shifting their range to track suitable climate. The effects of climate change on species are often indirect. Changes in temperature can confound the signals that trigger seasonal events such as migration and reproduction, causing these events to happen at the wrong time (for example misaligning reproduction and the period of greater food availability in a specific habitat).

Figure 15: Relative frequency of major threats by taxonomic group
Threat data is available for 3,789 populations in the global LPI database. Each of these populations could be associated with up to three different threats. There were 6,053 threats recorded in all[98].



Ecosystem services – Provisioning services

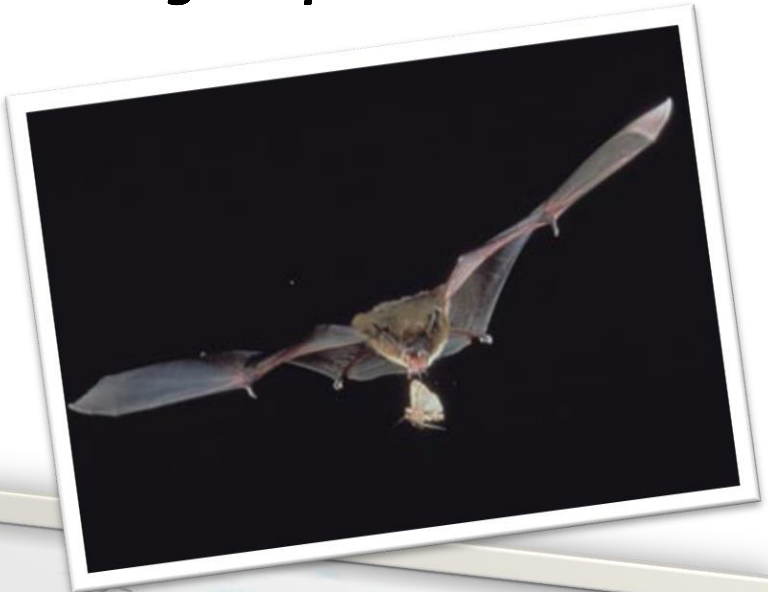
Material and energetic outputs from ecosystems that contribute to human well-being

- Food
- Water
- Fibres
- Organic fertilizers
- Wood fuel
- Medicinal resources
- Ornamental resources
- …

Ecosystem services – Regulating services

Benefits associated to the regulation of ecological processes

- Water/air purification
- Climate regulation
- Water flow regulation
- Pest and disease control
- Soil fertility and structure
- Erosion control
- Costal protection
- Pollination, seed dispersal
- Habitat for wildlife
- …



Ecosystem services – Cultural services

Non-material benefits that affect physical and mental states

- Recreation areas
- Areas of great natural beauty
- Charismatic species
- Sense of well-being, sense of place
- Information and knowledge
- Spiritual and cultural values
- Inspiration for technology and design …

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Biodiversity underpins ecosystem services

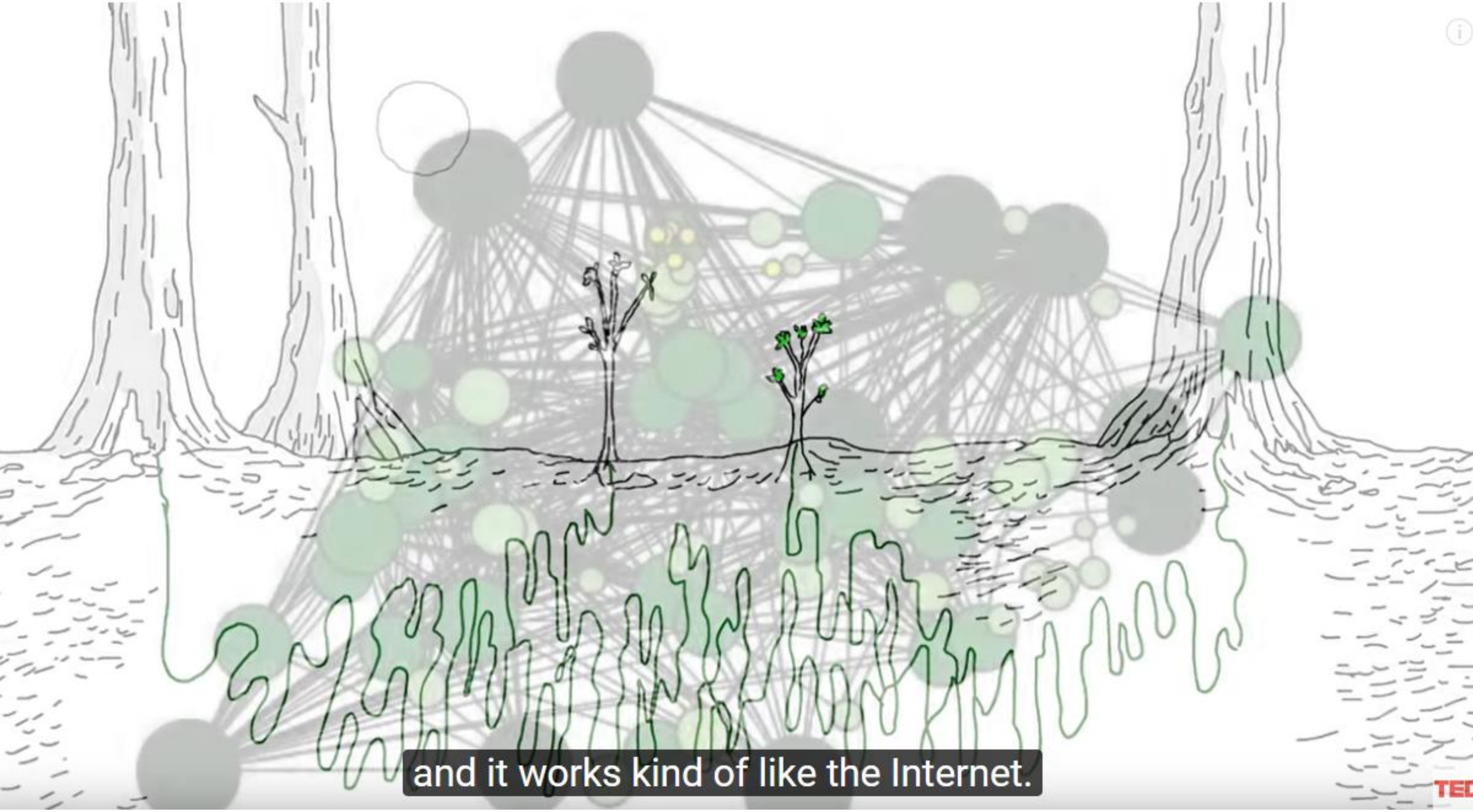
Biodiversity has an essential role in the structure and functioning of ecosystems

Foto: Martin Sharman

Biodiversity & Ecosystem Services

Suzanne Simard: How trees talk to each other

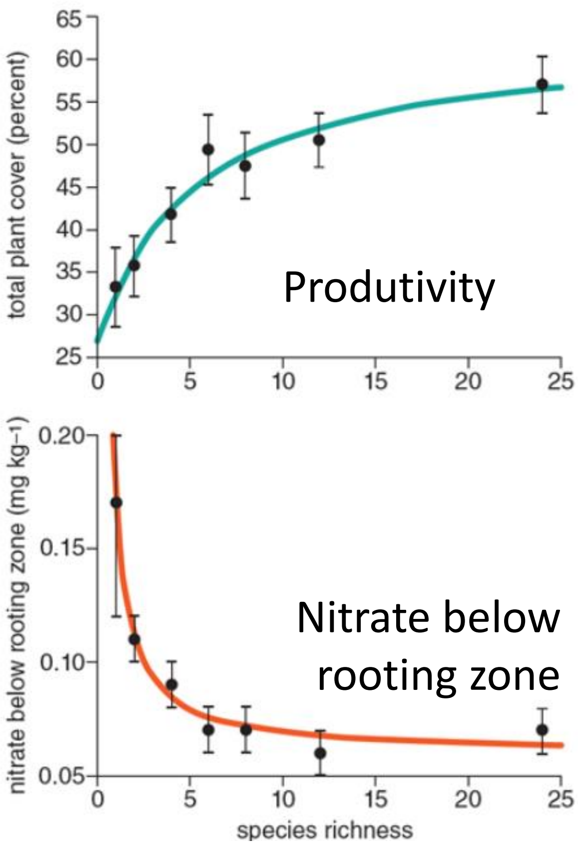
Biodiversity & Ecosystem Services

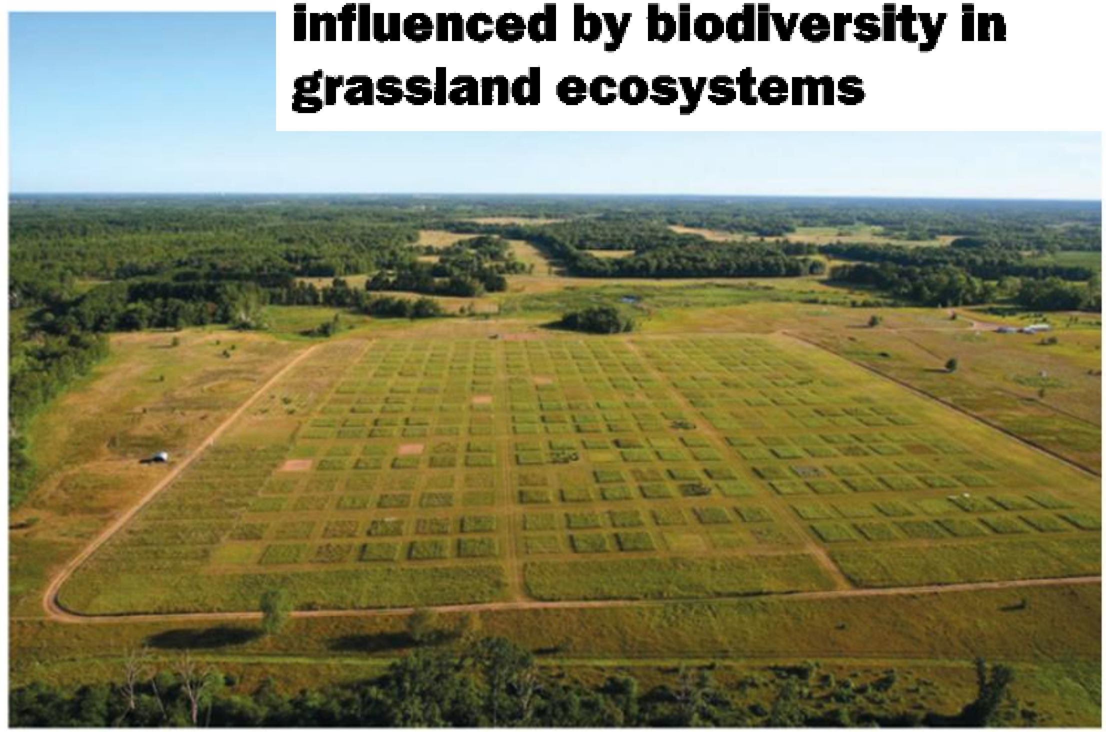


Suzanne Simard: How trees talk to each other

Biodiversity and ecosystem functioning

Productivity and sustainability influenced by biodiversity in grassland ecosystems



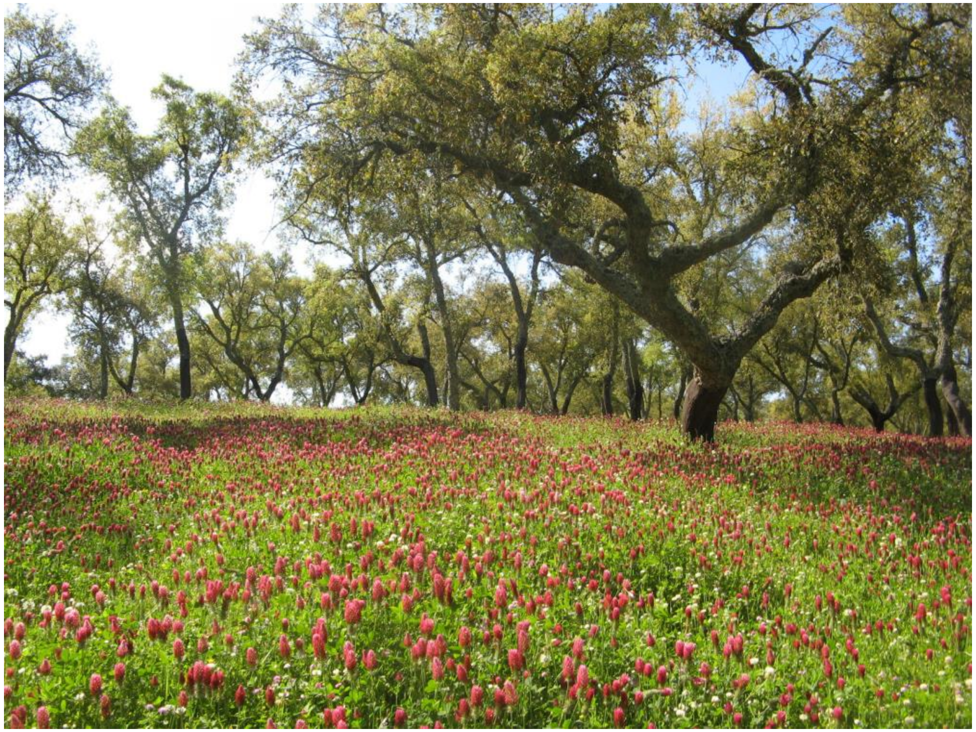


Experiments such as this one in the Cedar Creek Ecosystem Science Reserve in Minnesota show that biodiversity (in this case, species richness) increases ecosystem functions, such as preventing nutrient loss and storing carbon.

Graphs from Tilman et al. 1996; photograph courtesy of David Tilman.

Tilman et al. 1996 (in Vellend 2017, DOI: 10.1511/2017.105.2.94)

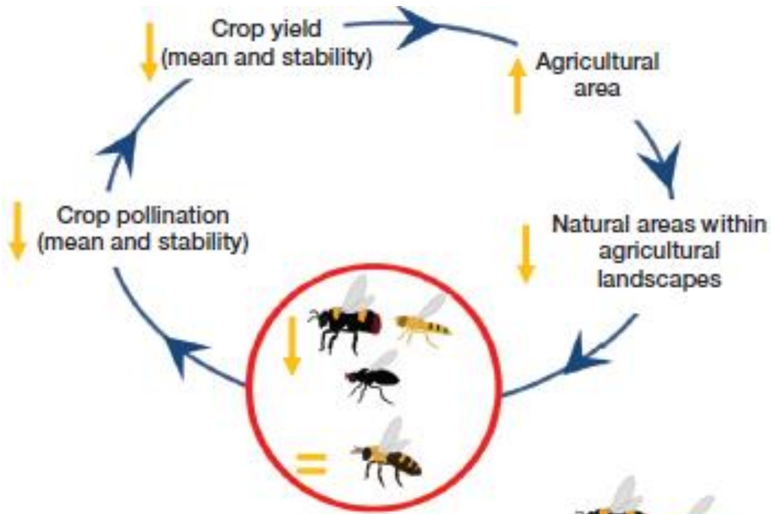
Biodiversity and ecosystem functioning

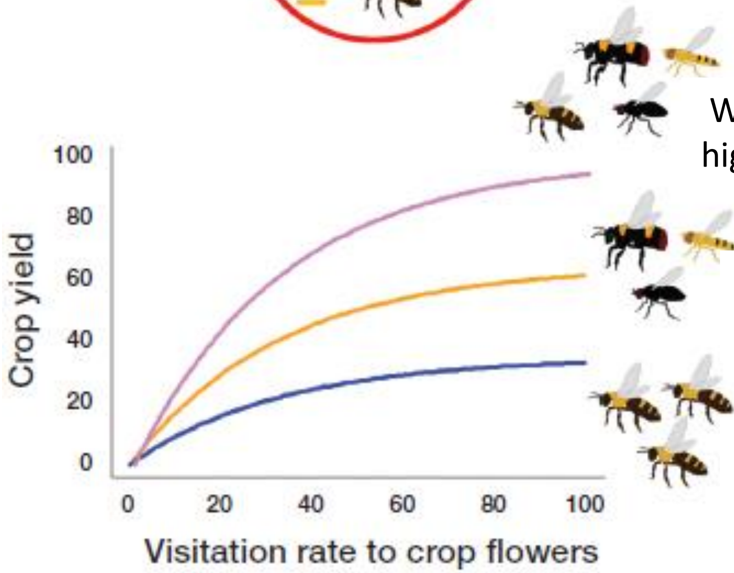


Sown biodiverse pastures

- Higher productivity
- Increase in soil organic matter
- Soil carbon sequestration
- Enhanced regulation of soil fertility
- Enhanced water regulation (erosion and drought)

Biodiversity & EF – wild plants, wild insects, crop yield



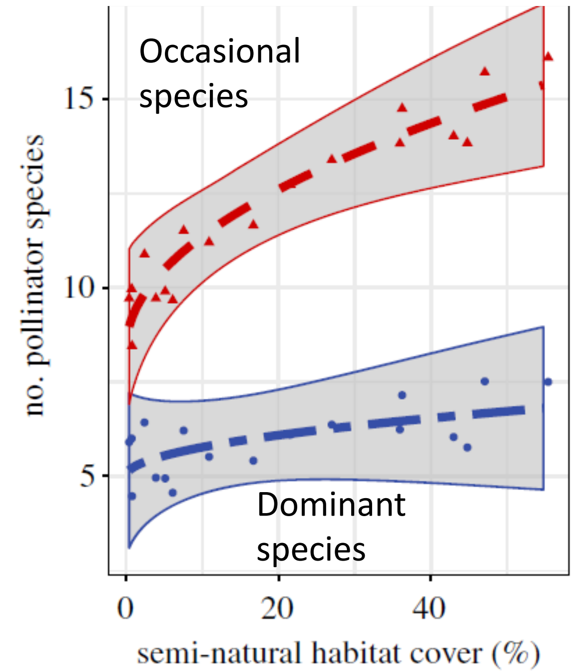


Wild pollinators, high diversity

Wild pollinators, low diversity

Only honey bees
Increasing the abundance of only honey bees does not compensate for the pollination losses of fewer wild insets

Pollinators in cropland (southern Italy)



Garibaldi et al. 2014
DOI: 10.1890/130330

Fijen et al. 2019
DOI: 10.1098/rspb.2019.0387

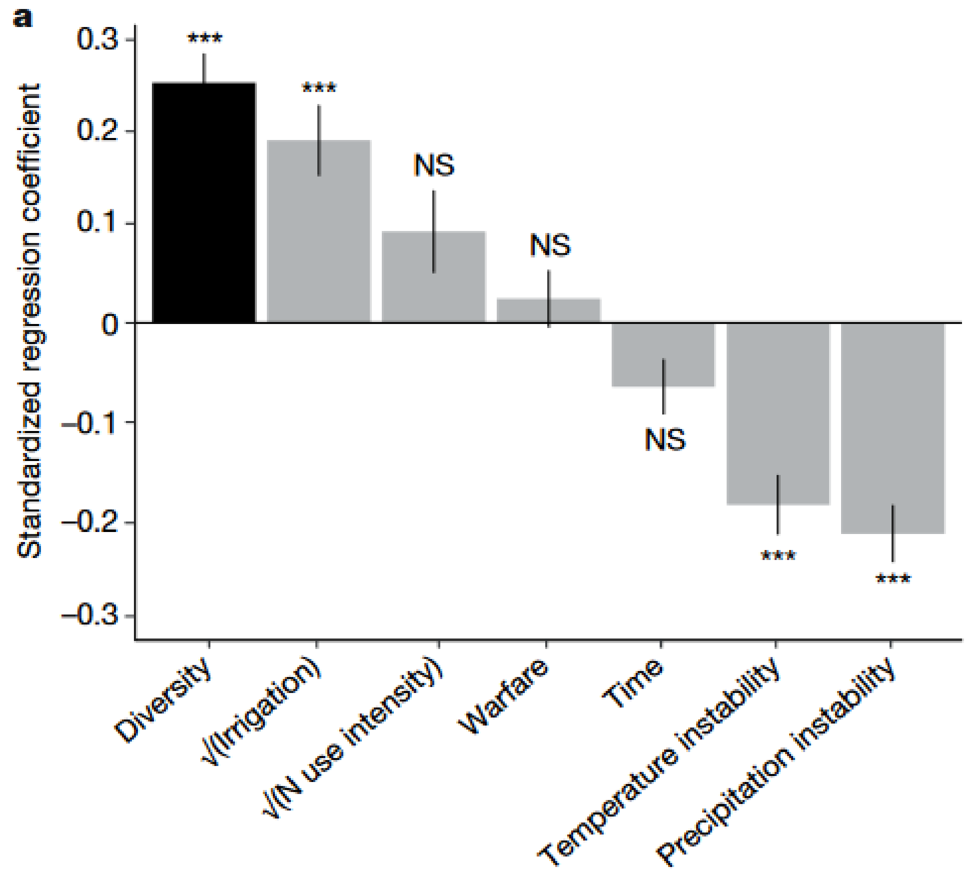
Crop diversity and stability of food production

National food production stabilized by crop diversity

Delphine Renard[1,2]* & David Tilman[1,3]

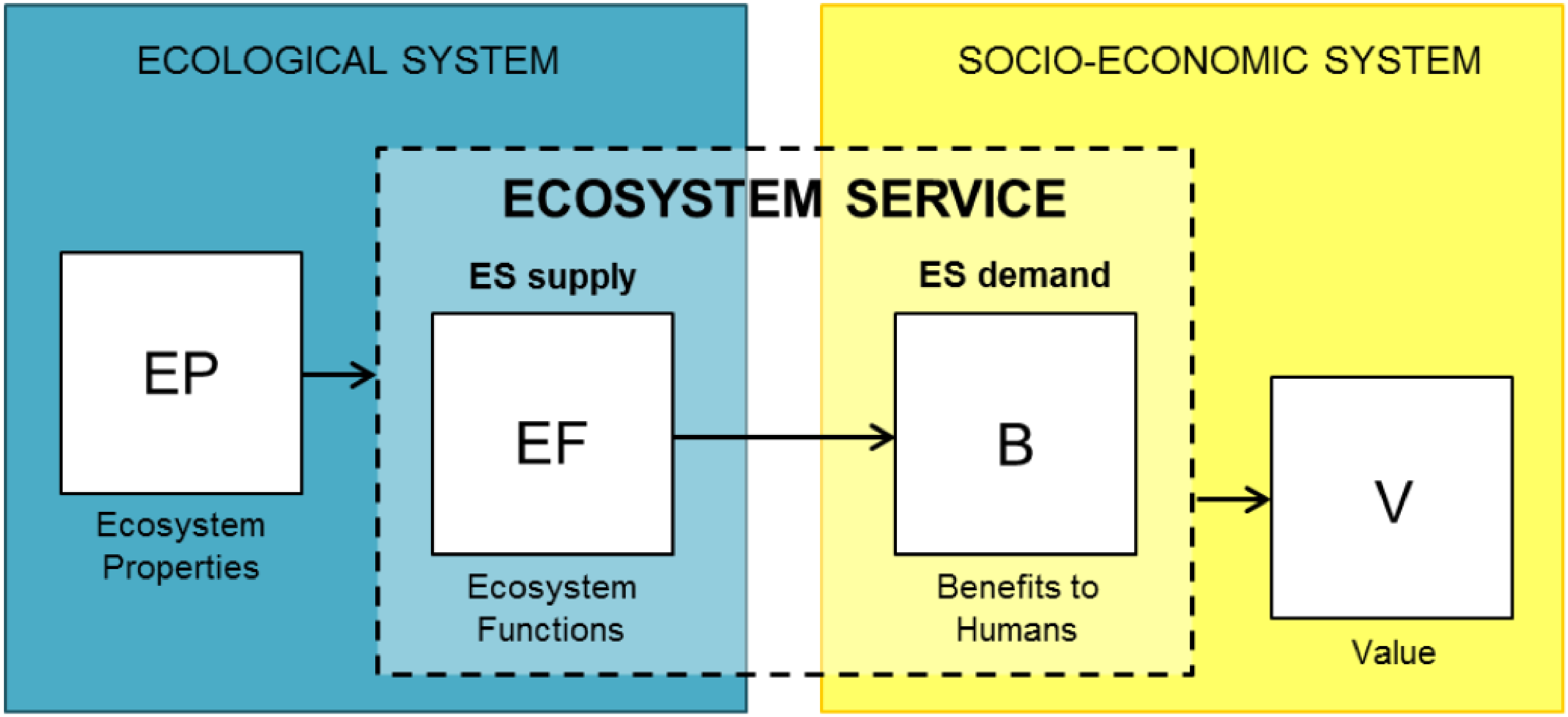
Global analysis: data from 176 crop types, 91 countries, 1961-2010

Factors associated to temporal stability of national food production



Renard and Tilman 2019
DOI: 10.1038/s41586-019-1316-y

The ecosystem services cascade framework



Boerema et al. 2017
DOI: 10.1111/1365-2664.12696

Ecosystem functions and services

Ecosystem functions: output from ecosystem functioning, exist regardless of human demand, define the **capacity or the potential to deliver** ecosystem services.

Ecosystem services: derived from ecosystem functions and represent the **realized flow** of services for which there is demand (functions that benefit people)

Ecosystem services flow to people uses other capital inputs

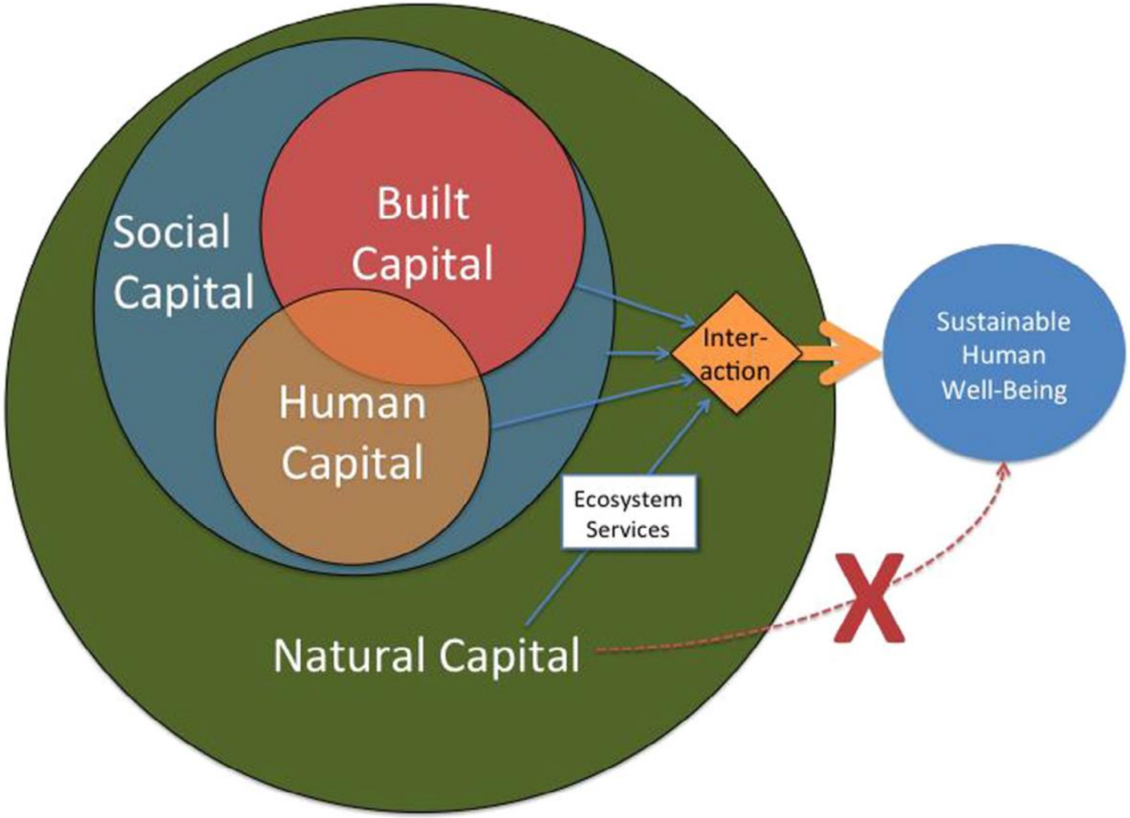


Fig. 1. The interaction between built, social, human and natural capital affects human wellbeing (Costanza et al., 2014b) (built capital and human capital (the economy) are embedded in society, which is embedded in the rest of nature. Ecosystem services are the relative contribution of natural capital to human wellbeing, they do not flow directly. It is therefore essential to adopt a broad, transdisciplinary perspective in order to address ecosystem services).

Costanza et al. 2017
DOI: 10.1016/j.ecoser.2017.09.008

Trade-offs and sinergies

TradeOff: When the improvement of one ecosystem service results in negative effects on other services, the net benefits are often smaller than initially believed..

Synergy : Actions to conserve or enhance a particular component of an ecosystem or its services can also produce positive synergies which benefit other services or other stakeholders

Trade-offs and sinergies

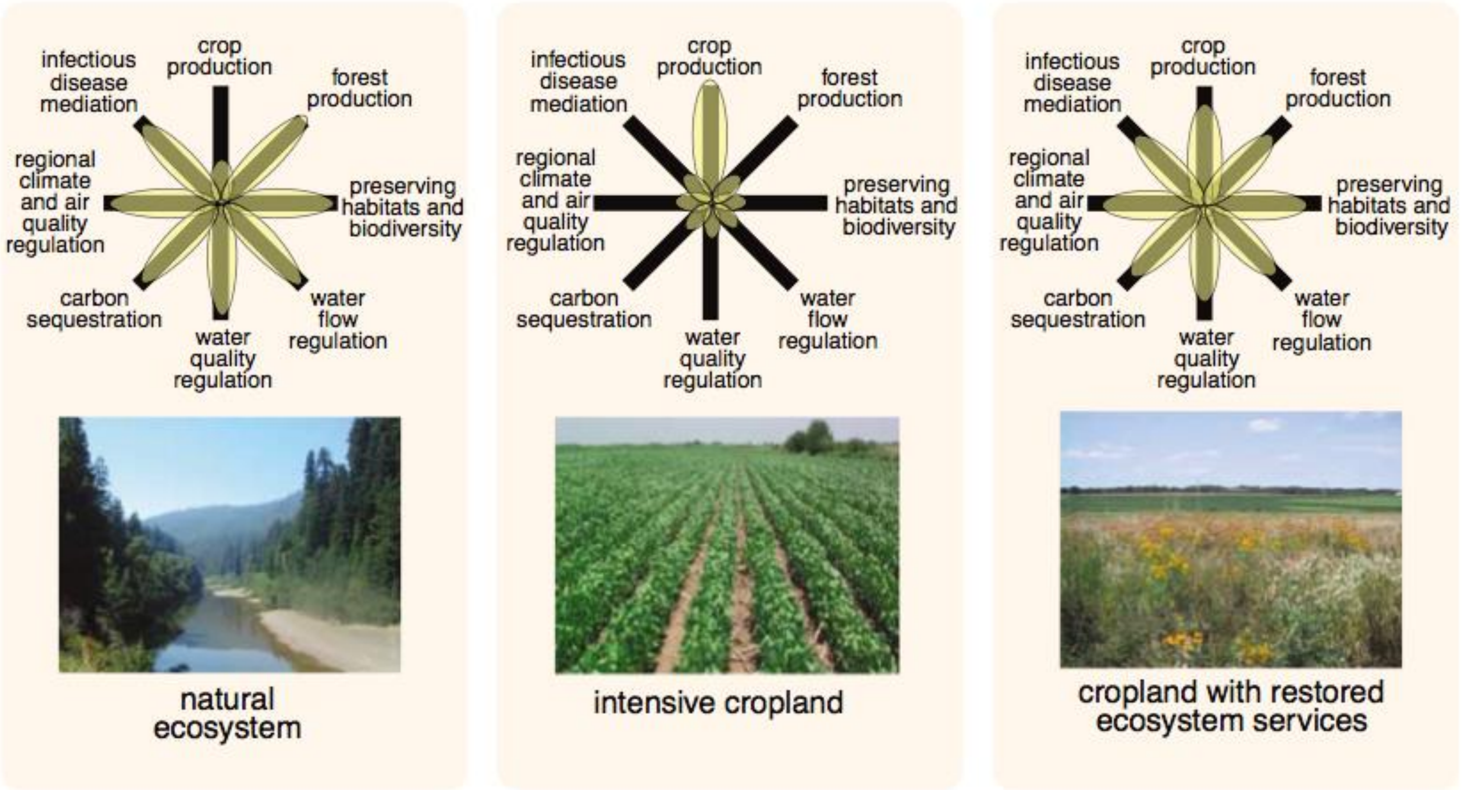
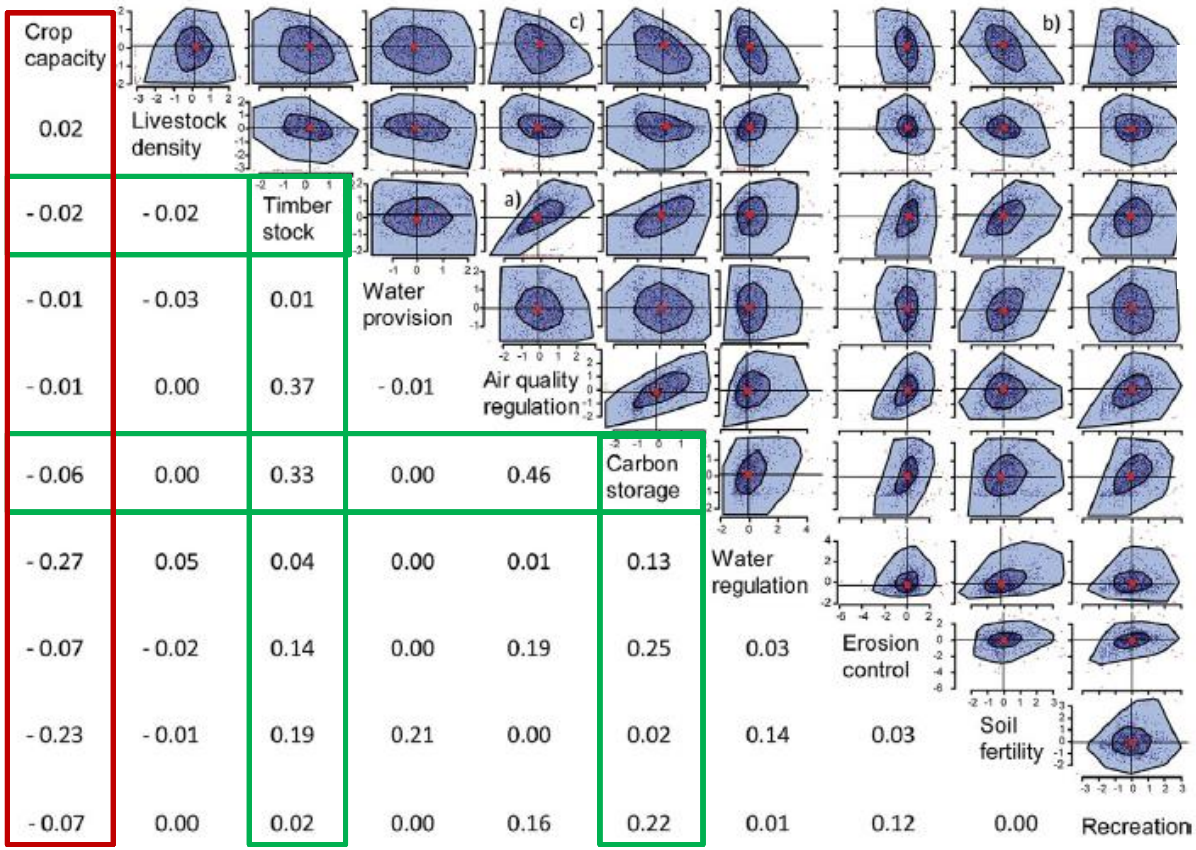


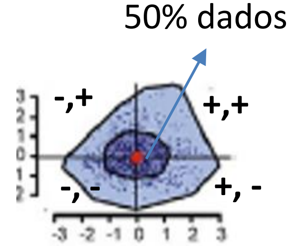
Fig. 3. Conceptual framework for comparing land use and trade-offs of ecosystem services. The provisioning of multiple ecosystem services under different land-use regimes can be illustrated with these simple "flower" diagrams, in which the condition of each ecosystem service is indicated along each axis. (In this qualitative illustration, the axes are not labeled or normalized with common units.) For purposes of illustration, we compare three hypothetical landscapes: a natural ecosystem (left), an intensively managed cropland (middle), and a cropland with restored ecosystem services (right). The natural ecosystems are able to support many ecosystem services at high levels, but not food production. The intensively managed cropland, however, is able to produce food in abundance (at least in the short run), at the cost of diminishing other ecosystem services. However, a middle ground—a cropland that is explicitly managed to maintain other ecosystem services—may be able to support a broader portfolio of ecosystem services.

Foley et al. 2005
DOI: 10.1126/science.1111772

Spatial trade-offs and sinergies - Europe



Synergies (*n*)	1	2	7	2	5	7	6	6	5	5
Trade-offs (*n*)	8	4	2	2	1	1	2	2	2	1
Neutral (*n*)	0	3	0	5	3	1	1	1	2	3



- Spatial analysis – NUTS 3
- Shape of plot also informs on relationship
- Biodiversity not analysed

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Jopke et al. 2015
DOI: 10.1016/j.ecolind.2014.09.037

Temporal trade-offs and sinergies - Europe

IPBES Regional Assessment for Europe and Central Asia

Temporal analysis

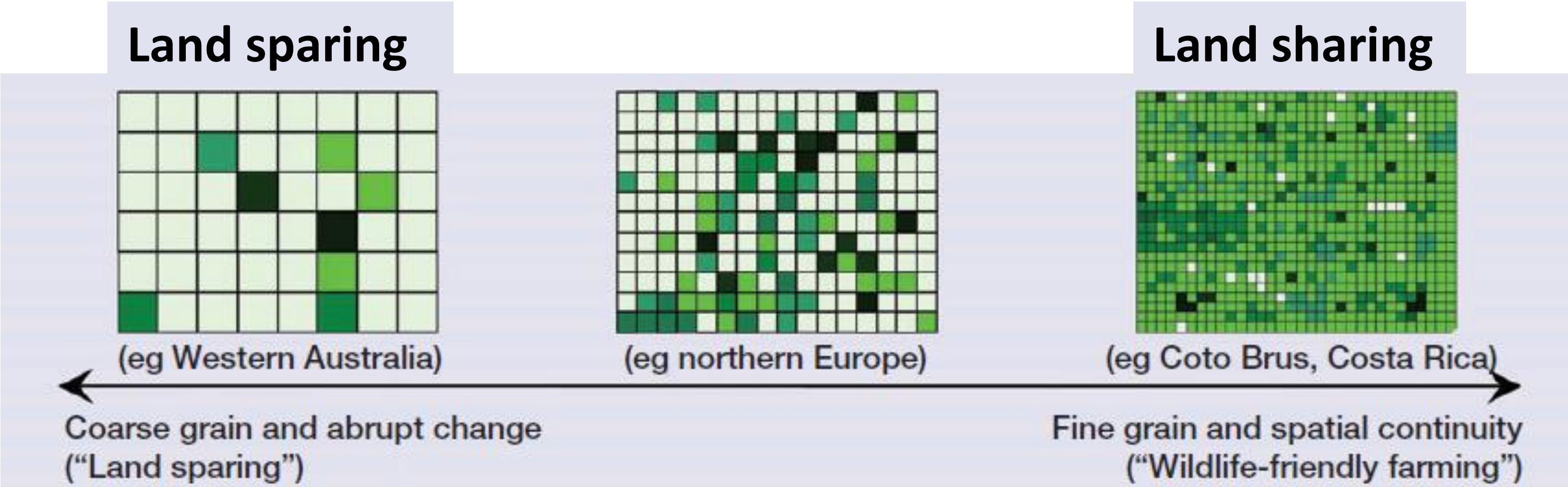
1960 - 2016

			WE	CE	EE	CA	ECA
REGULATING	REGULATING NATURE'S CONTRIBUTIONS TO PEOPLE	Habitat maintenance	Decrease	Decrease	Decrease	Lack of evidence	Decrease
		Pollination	Decrease	Decrease	Decrease	Lack of evidence	Decrease
		Regulation of air quality	Variable	Increase	Increase	Variable	Increase
		Regulation of climate	Increase	Variable	Increase	Variable	Variable
		Regulation of ocean acidification	Lack of evidence	Lack of evidence	Lack of evidence	Lack of evidence	Variable
		Regulation of freshwater quantity	Decrease	Variable	Decrease	Decrease	Decrease
		Regulation of freshwater quality	Decrease	Decrease	Decrease	Lack of evidence	Decrease
		Formation and protection of soils	Decrease	Decrease	Decrease	Decrease	Decrease
		Regulation of coastal and fluvial floods	Variable	Decrease	Decrease	Variable	Decrease
		Regulation of organisms (removal of carcasses)	Increase	Variable	Increase	Increase	Increase
MATERIAL	MATERIAL NATURE'S CONTRIBUTIONS TO PEOPLE	Food	Increase	Increase	Increase	Increase	Increase
		Biomass-based fuels	Increase	Stable	Stable	Lack of evidence	Increase
		Materials (wood and cotton)	Stable	Stable	Stable	Stable	Stable
NON - MATERIAL	NON-MATERIAL NATURE'S CONTRIBUTIONS TO PEOPLE	Learning derived from indigenous and local knowledge	Decrease	Decrease	Decrease	Decrease	Decrease
		Physical and psychological experiences	Variable	Decrease	Decrease	Lack of evidence	Variable
		Supporting identities	Lack of evidence	Lack of evidence	Lack of evidence	Lack of evidence	Variable

Increase
Stable
Lack of evidence
Decrease
Variable

Confidence level
Well established
Established but incomplete/ unresolved
Inconclusive

Managing trade-offs – Biodiversity and Farming



Land sparing: Production and biodiversity conservation spatially segregated; maximizing yield to allow other land to be set aside for conservation

Land sharing: Production and biodiversity conservation spatially integrated; agricultural landscapes used less-intensively, biodiversity friendly farming



***"Rather than seeing wildlife friendly farming [land sharing] and land sparing as mutually exclusive options for land management, it should be recognized that both offer different, and sometimes complementary, advantages"* (Fischer et al. 2008)**

Fischer et al. 2008
DOI: 10.1890/070019

Phalan et al. 2018
DOI:10.3390/su10061760

Managing trade-offs – Biodiversity and Farming

Sustainable intensification: aims to enhance resource use and productivity while reducing environmental impacts – linked to *land sparing*

Ecological intensification: aims to enhance or maintain current productivity by enhancing ecosystem services (i.e., intensification in the use of the natural functionalities that ecosystems offer) – linked to *land sharing*

Related concepts, both aim at reducing impacts, use innovation/technology and external inputs, but the implementation often targets different dimensions of sustainable production, and different spatial scales

Strawberry production in Central Coast, California. On the left, a homogeneous landscape of strawberry monoculture, including organic fields, supports fewer wild species then a diversified, organic farm (right) in the same region, which includes a small field of strawberry, surrounded by orchards, hedgerows, diverse vegetable crops, and natural habitats. The monoculture landscape creates barriers to wildlife dispersal, whereas the diversified landscape is more permeable.

PHOTO: C. KREMEN

Kremen *et al.*, *Science* **362**, 304 (2018) 19 October 2018 **1 of 1**

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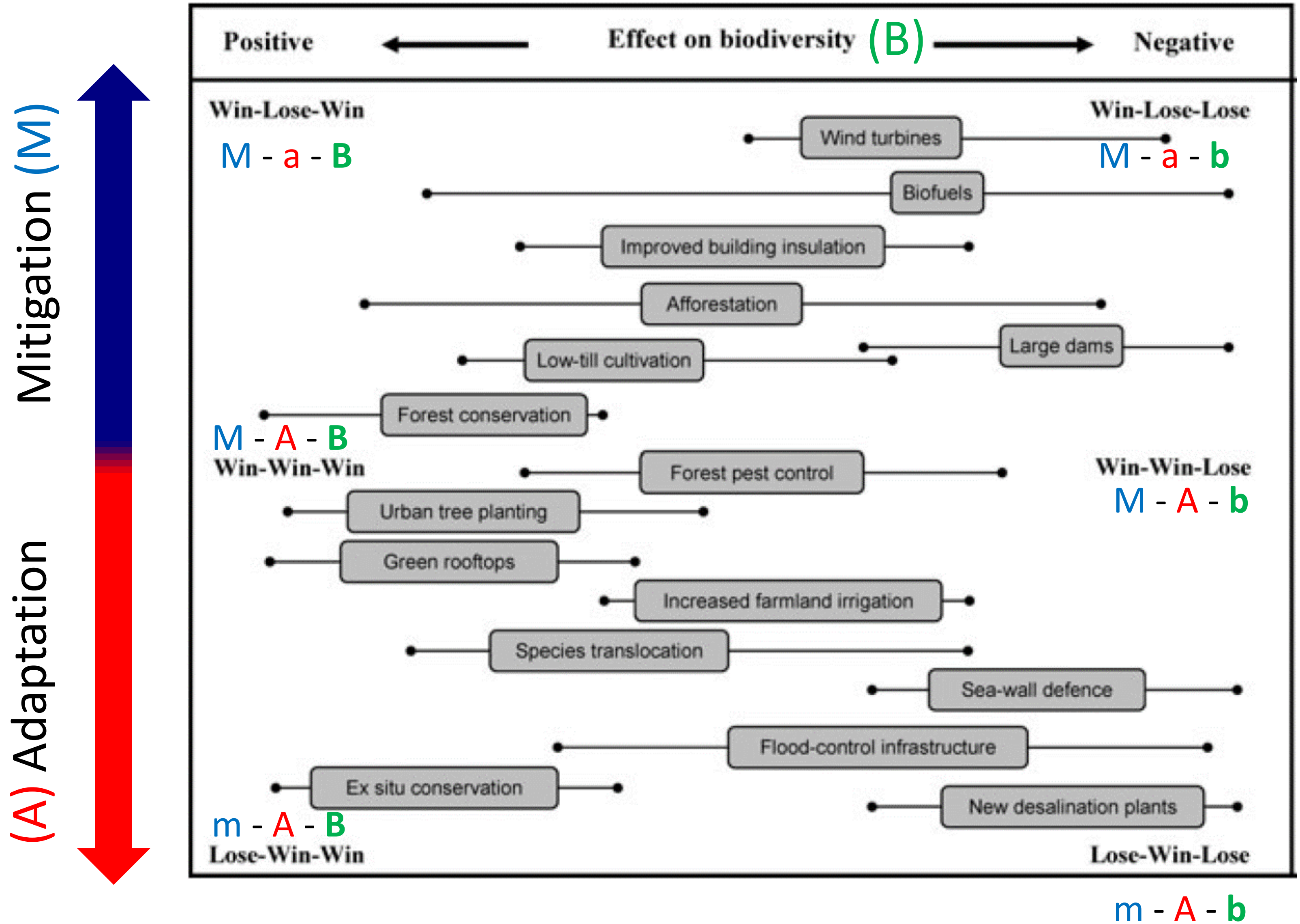
Kremen 2018
DOI: 10.1111/nyas.12845

Managing trade-offs – Biodiversity and Climate action



Paterson et al. 2008, DOI:10.1111/j.1523-1739.2008.01042.x
https://www.cbd.int/doc/publications/cbd-ts-42-en.pdf

Managing trade-offs – Biodiversity and Climate action

Negative effects on biodiversity

Mitigation:

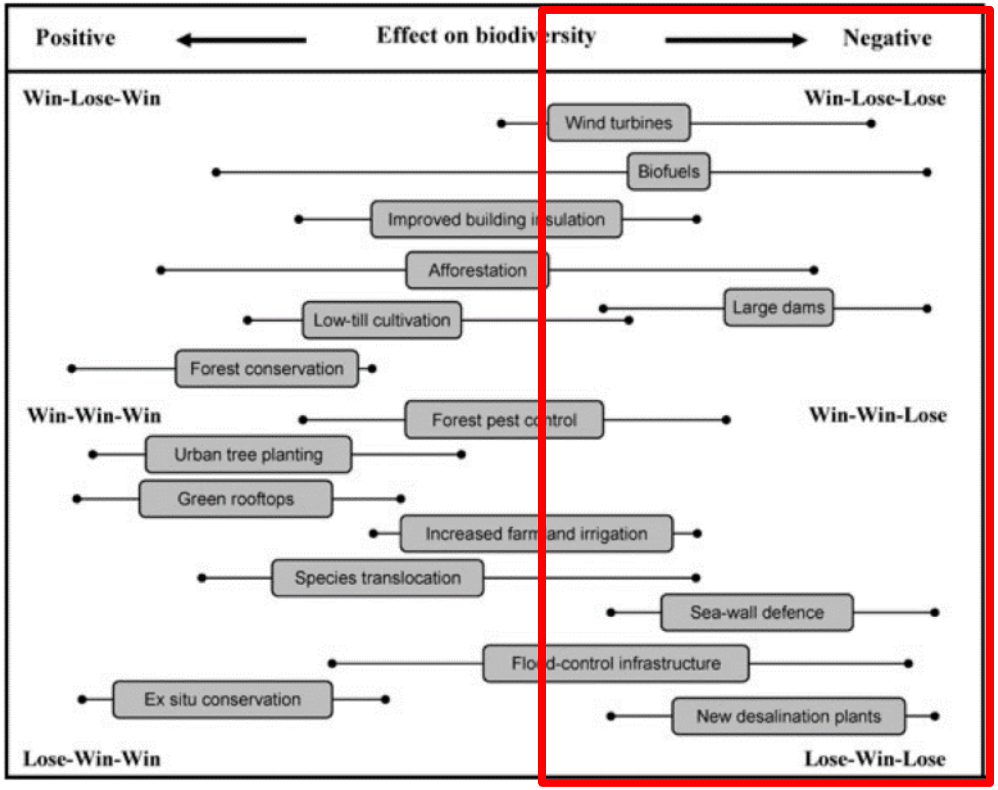
Wind turbines (0/-)

Large dams (-)

Biofuels (+/-)

Adaptation

Infrastructures for adaptation

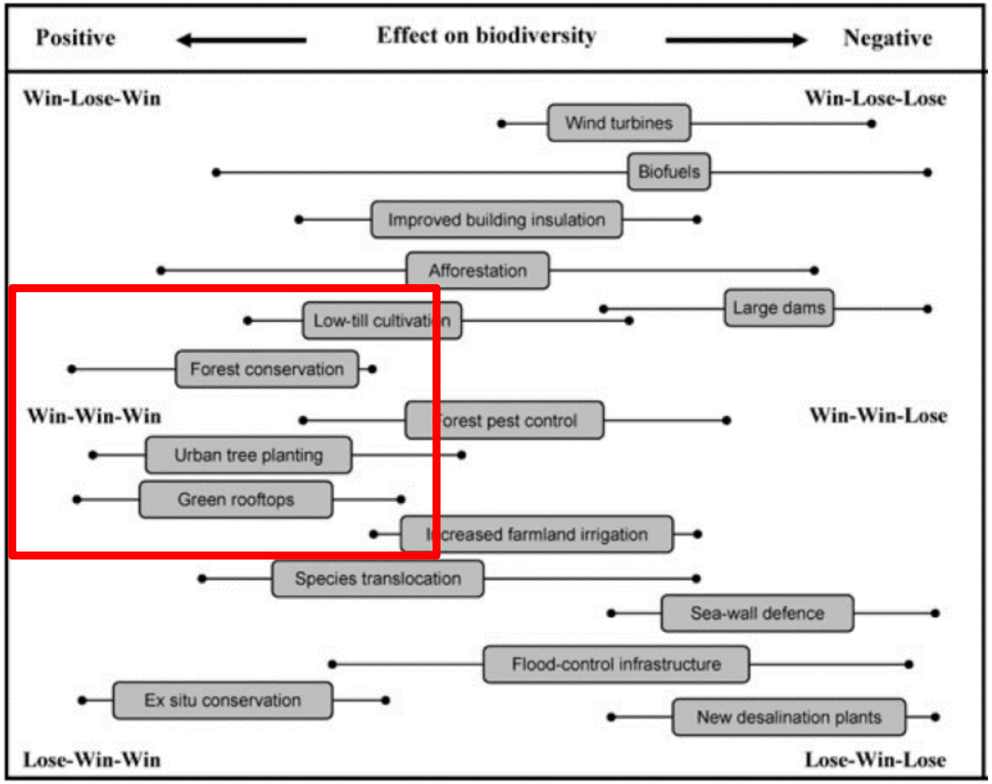


Paterson et al. 2008, DOI:10.1111/j.1523-1739.2008.01042.x
https://www.cbd.int/doc/publications/cbd-ts-42-en.pdf

Managing trade-offs – Biodiversity and Climate action

Nature based solutions
(“triple win”)

- Soil protection (+/0)
- Forest conservation (+)
- Urban green areas (+/0)
- Green rooftops (+)



NBS involve working with and enhancing nature to help address societal challenges (e.g. climate change, food and water security or natural disasters)

Paterson et al. 2008, DOI:10.1111/j.1523-1739.2008.01042.x
https://www.cbd.int/doc/publications/cbd-ts-42-en.pdf

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E-learning

Module 1 - The IPBES conceptual framework

https://www.ipbes.net/e-learning

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