Some Economics of Biodiversity

Nicolas Treich, TSE, INRAe

21 October 2021

Toulouse School of Economics

Some TSE colleagues

Ingela Alger, IAST director
Expertise: Economics and biology

Henrik Andersson, UT1
Expertise: Environmental valuation

Sylvain Chabé-Ferret, INRAe
Expertise: Payment for environmental services

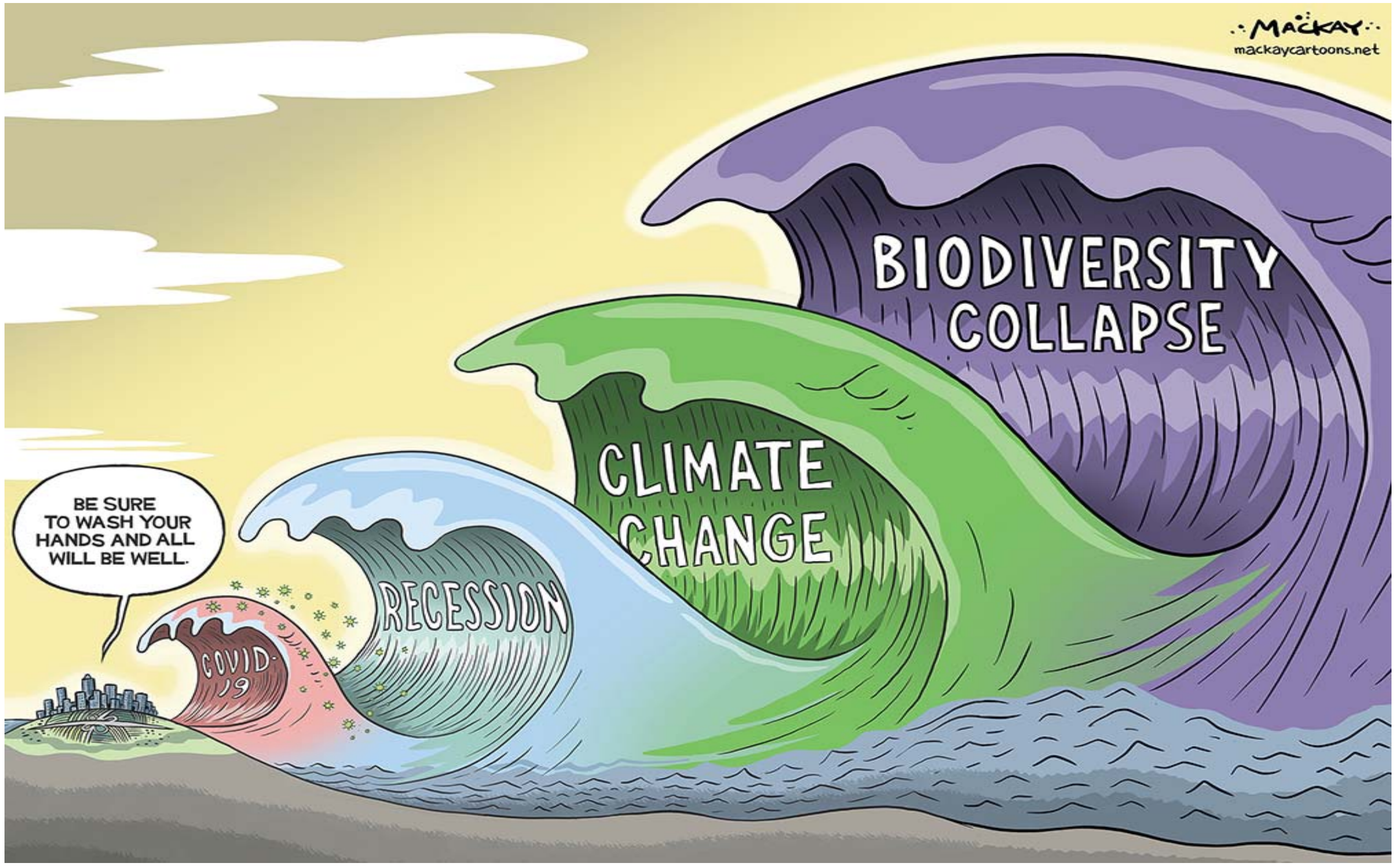
Marion Desquilbet, INRAe
Expertise: Agricultural economics, Pesticides, Biodiversity

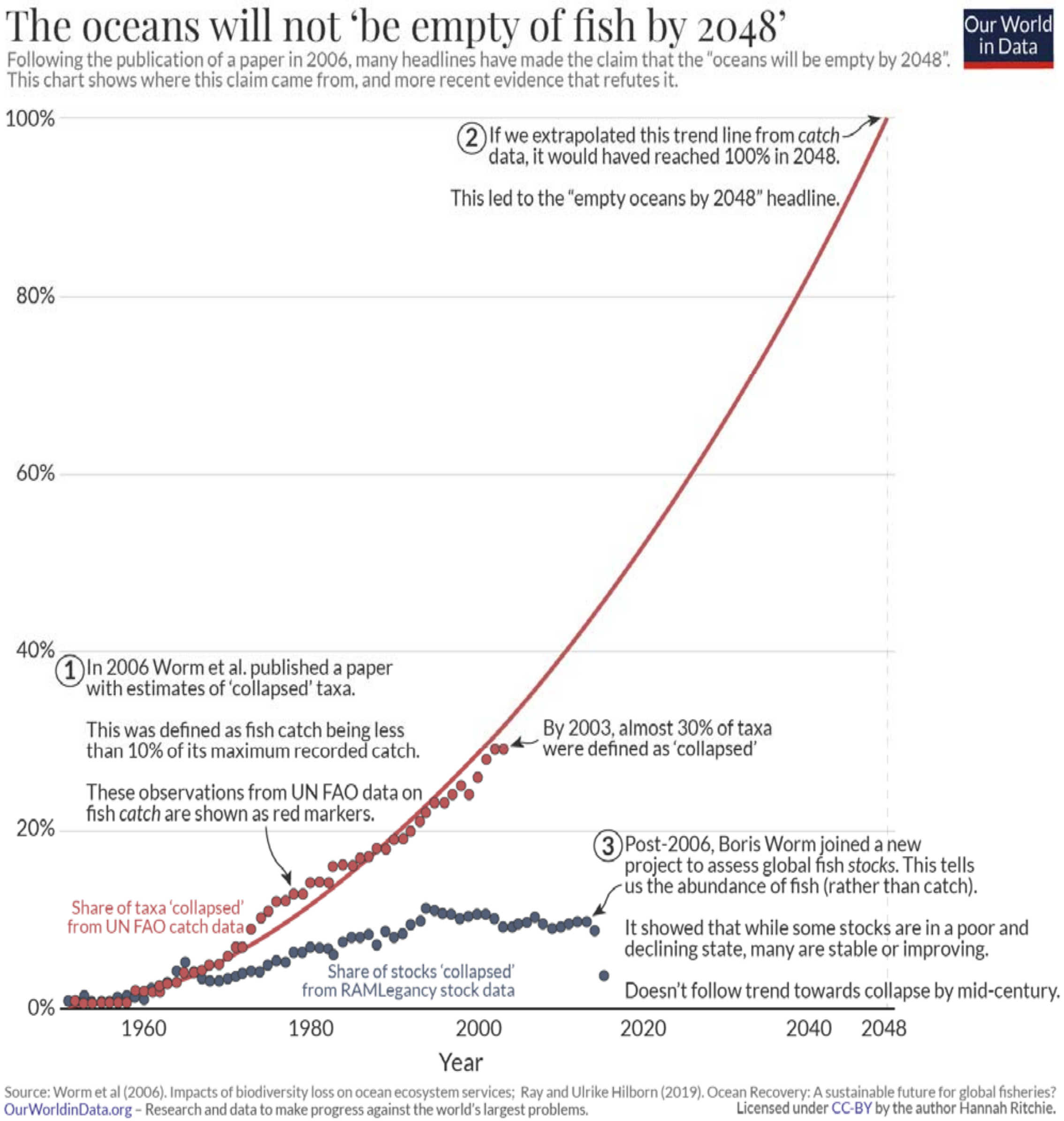
Anouch Missirian, Assistant prof.
Expertise: Ecology-economy models

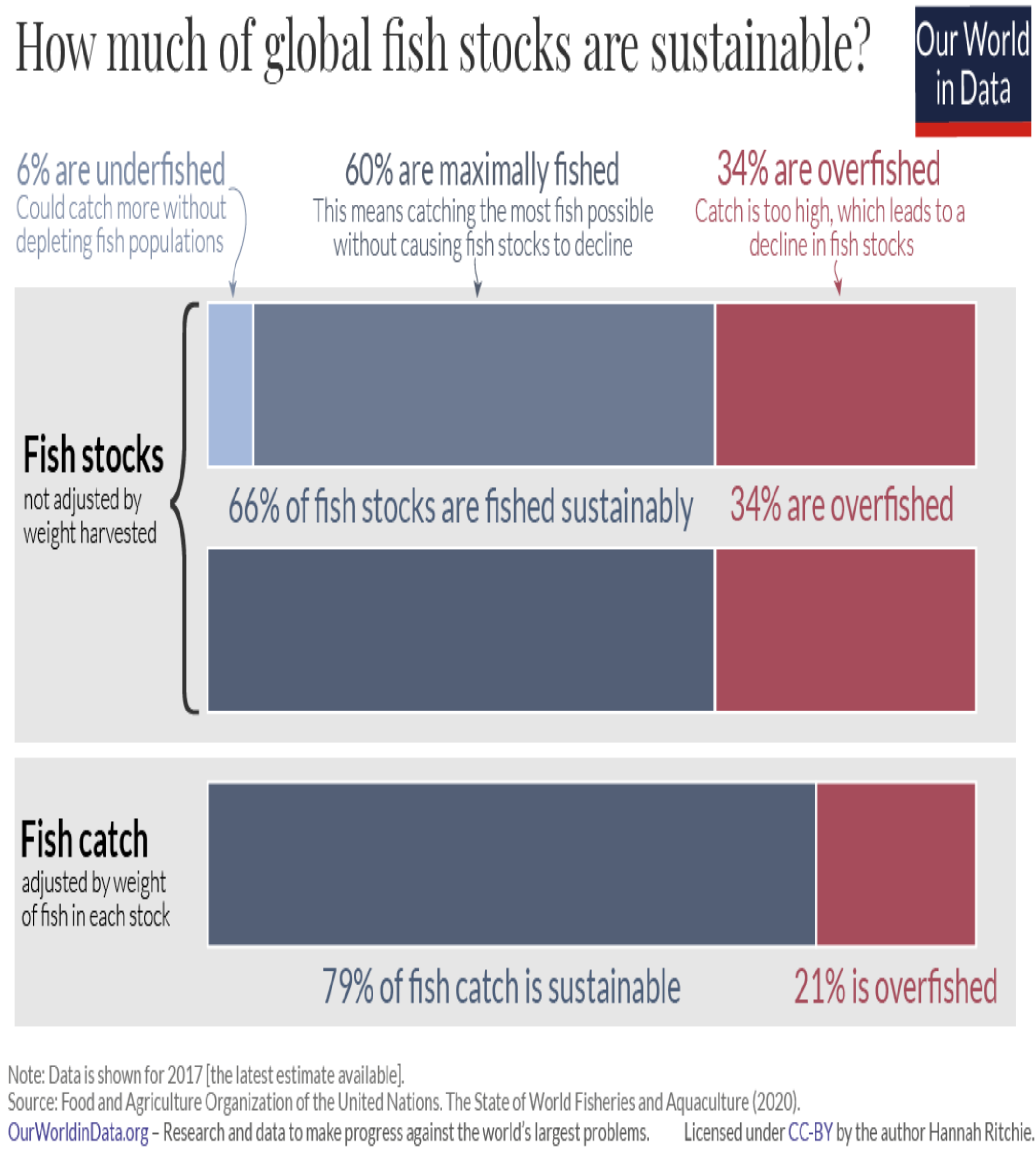
Outline

- Some data about biodiversity
- Economics research on biodiversity
- The Dasgupta Review (2021)
- The problem of anthropocentrism

Biodiversity loss as a major threat to humanity?

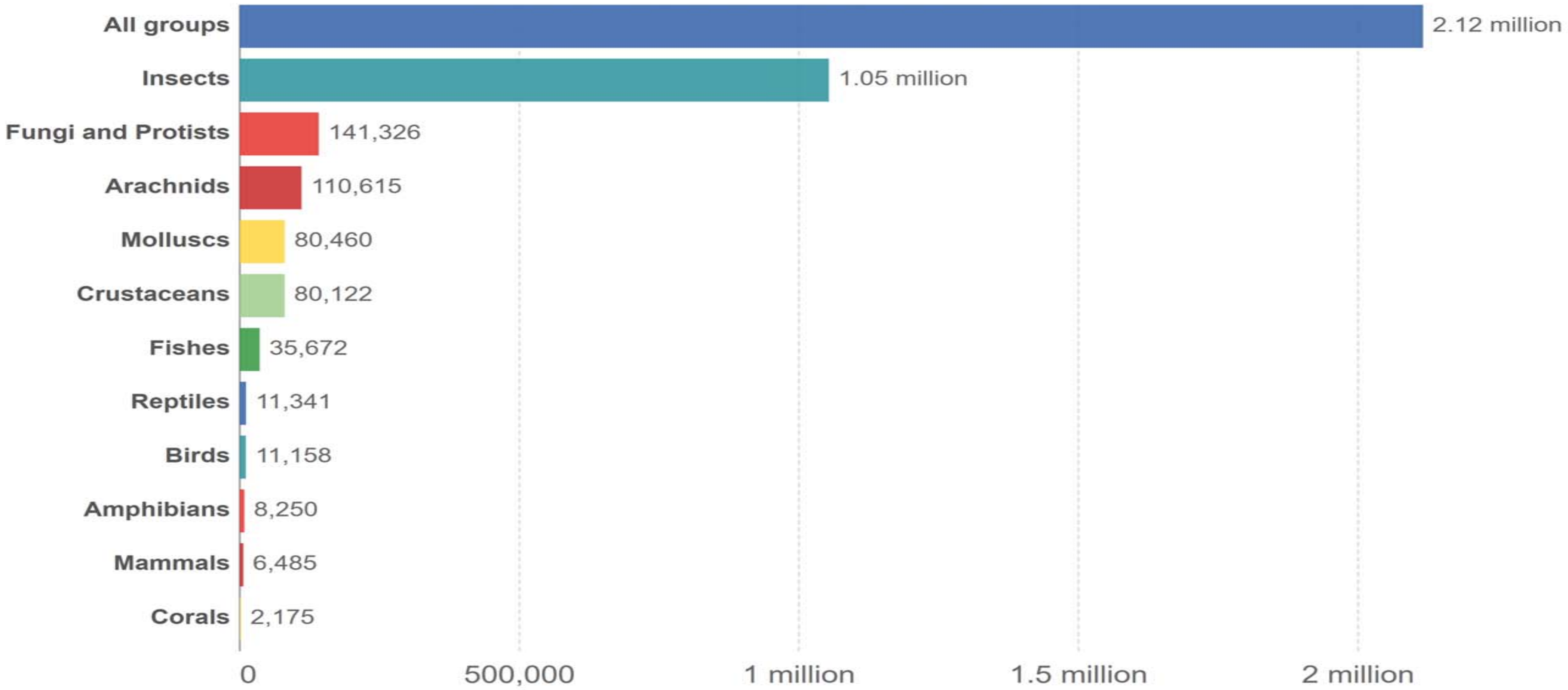



The oceans will not 'be empty of fish by 2048'
Our World in Data
Following the publication of a paper in 2006, many headlines have made the claim that the "oceans will be empty by 2048".
This chart shows where this claim came from, and more recent evidence that refutes it.
100%
80%
60%
40%
20%
0%
2 If we extrapolated this trend line from catch data, it would haved reached 100% in 2048.
This led to the "empty oceans by 2048" headline.
1 In 2006 Worm et al. published a paper with estimates of 'collapsed' taxa.
This was defined as fish catch being less than 10% of its maximum recorded catch.
These observations from UN FAO data on fish catch are shown as red markers.
By 2003, almost 30% of taxa were defined as 'collapsed'
3 Post-2006, Boris Worm joined a new project to assess global fish stocks. This tells us the abundance of fish (rather than catch).
It showed that while some stocks are in a poor and declining state, many are stable or improving.
Doesn't follow trend towards collapse by mid-century.
Share of taxa 'collapsed' from UN FAO catch data
Share of stocks 'collapsed' from RAMLegancy stock data
1960
1980
2000
2020
2040
2048
Year
Source: Worm et al (2006). Impacts of biodiversity loss on ocean ecosystem services; Ray and Ulrike Hilborn (2019). Ocean Recovery: A sustainable future for global fisheries?
OurWorldinData.org – Research and data to make progress against the world's largest problems.
Licensed under CC-BY by the author Hannah Ritchie.


How much of global fish stocks are sustainable?
Our World in Data
6% are underfished
Could catch more without depleting fish populations
60% are maximally fished
This means catching the most fish possible without causing fish stocks to decline
34% are overfished
Catch is too high, which leads to a decline in fish stocks
Fish stocks
not adjusted by weight harvested
66% of fish stocks are fished sustainably
34% are overfished
Fish catch
adjusted by weight of fish in each stock
79% of fish catch is sustainable
21% is overfished
Note: Data is shown for 2017 [the latest estimate available].
Source: Food and Agriculture Organization of the United Nations. The State of World Fisheries and Aquaculture (2020).
OurWorldinData.org – Research and data to make progress against the world's largest problems.
Licensed under CC-BY by the author Hannah Ritchie.

Number of described species

The number of identified and named species, as of 2020. Since many species have not yet been described, this is a large underestimate of the total number of species in the world.



Source: IUCN Red List

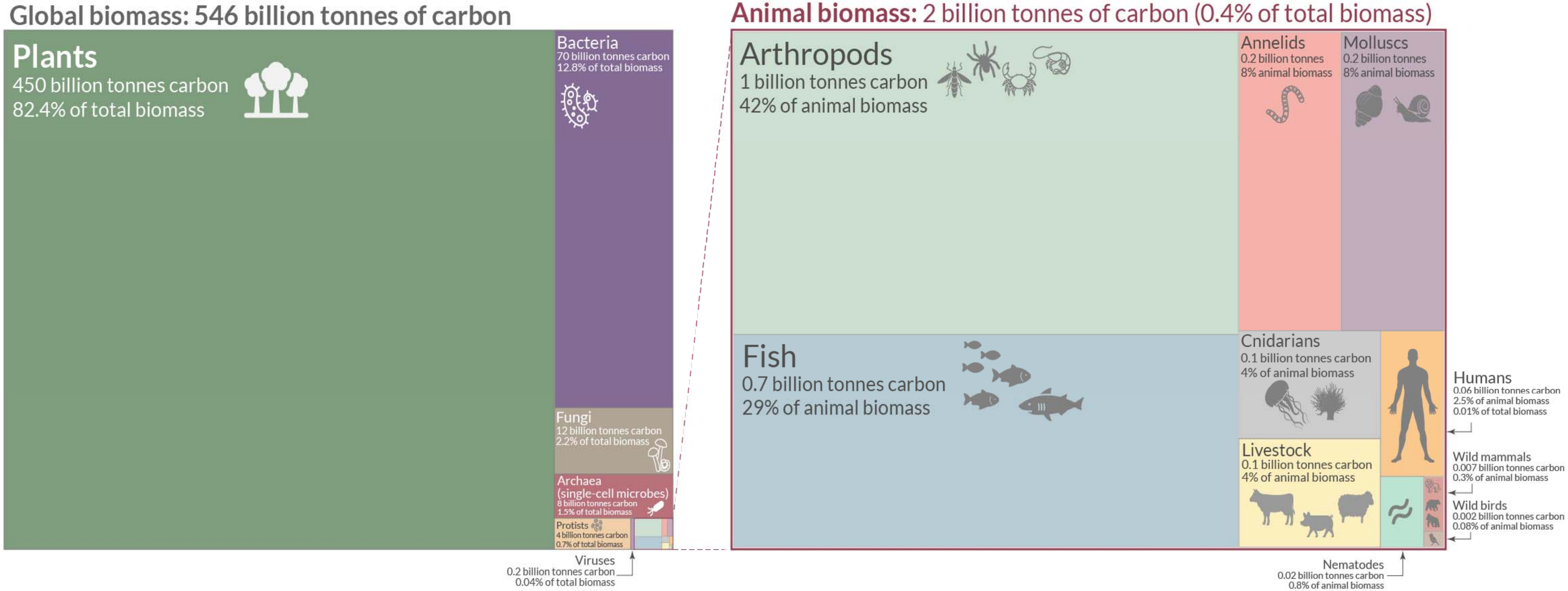
How did we estimate 1 million threatened species?

PERCENTAGE THREATENED	x	NUMBER OF SPECIES	=	NUMBER THREATENED
About **25%** of species are threatened with extinction on average across many animal & plant groups, except insects		There are ~**2.5 million** animal and plant species that are not insects		25% of 2.5 million is ~**0.5 million** non-insect species threatened
The proportion of threatened insects may not be so high; but is unlikely to be below ~**10%**		There are about **5.5 million** species of insects		10% of 5.5 million is ~**0.5 million** insect species threatened
				0.5 million + 0.5 million = ~1 million threatened animal & plant species

Source : IPBES (2020)

Life on Earth: the distribution of all global biomass

Biomass is measured in tonnes of carbon. The global distribution of Earth's biomass is shown by group of organism (taxa).

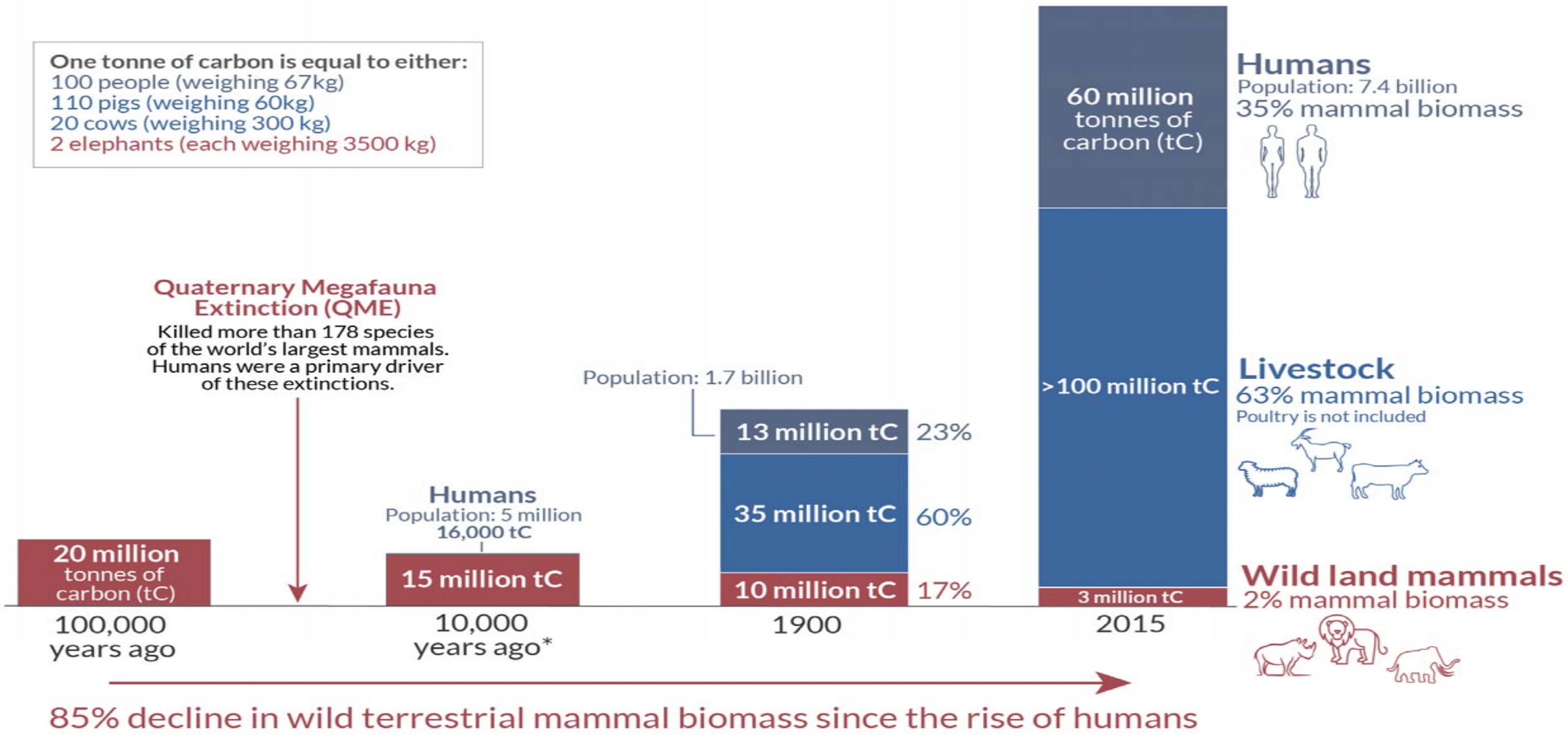


Data source: Bar-On, Y. M., Phillips, R., & Milo, R. (2018). The biomass distribution on Earth. *Proceedings of the National Academy of Sciences*. Icons from Noun Project.

OurWorldinData.org – Research and data to make progress against the world's largest problems.

Changing distribution of the world's land mammals

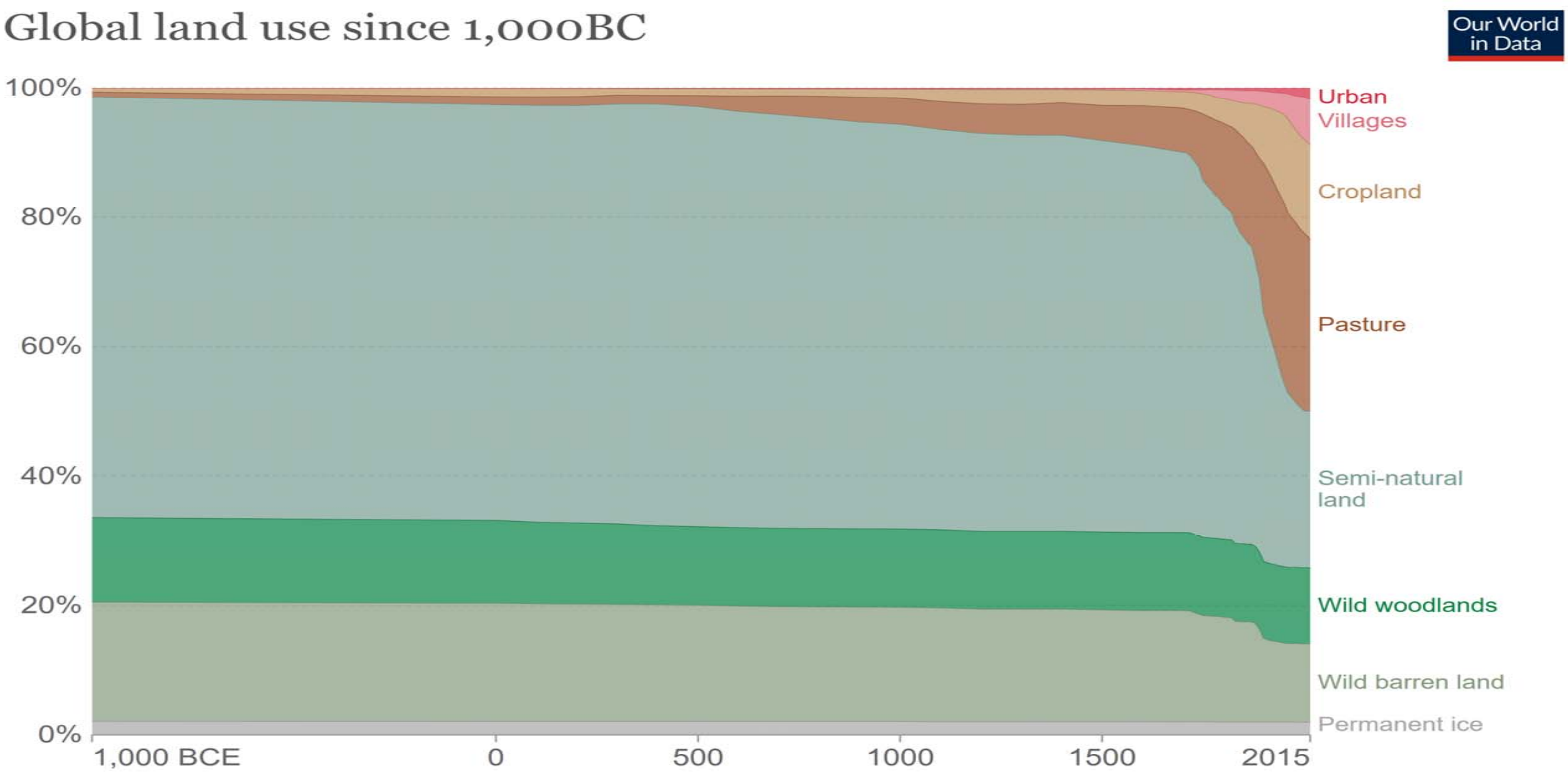
Terrestrial mammals are compared in terms of biomass – tonnes of carbon.



*Estimates of long-run wild mammal biomass come with larger uncertainty. Biomass following the QEM event is estimated to be approximately 15 million tonnes.

Data sources: Barnosky (2008); Smil (2011) & Bar-On et al. (2018). Images sourced from the Noun Project.

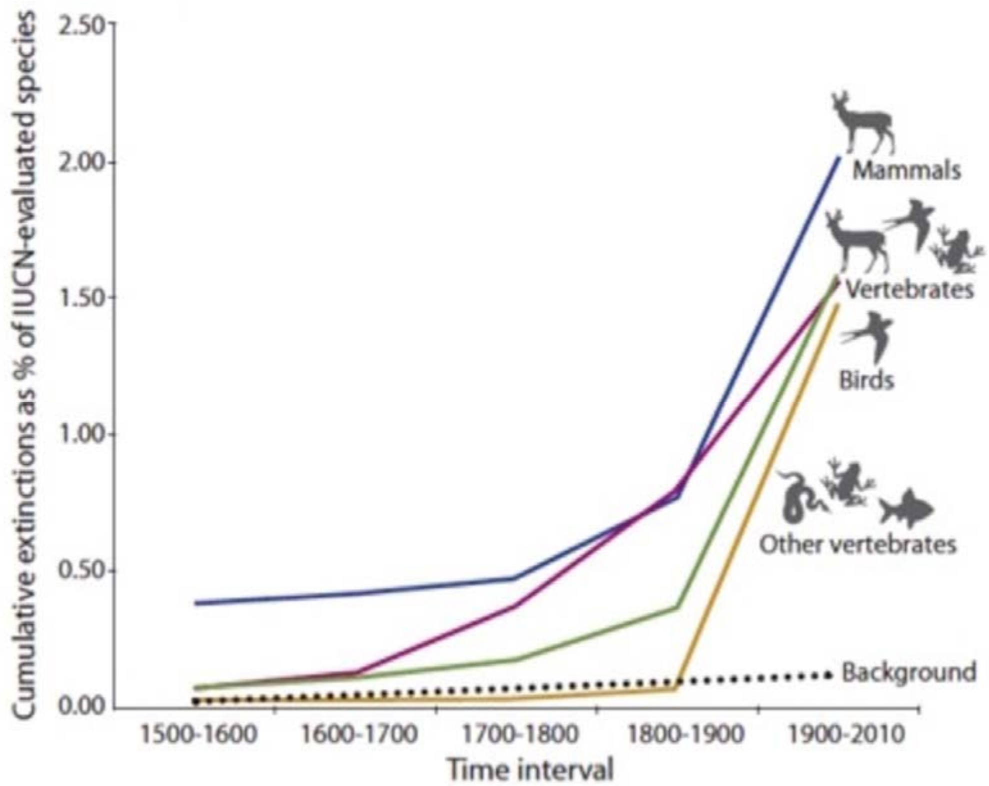
OurWorldinData.org – Research and data to make progress against the world's largest problems.



Source: Ellis, E. C., Beusen, A. H., & Goldewijk, K. K. (2020). Anthropogenic Biomes: 10,000 BCE to 2015 CE.

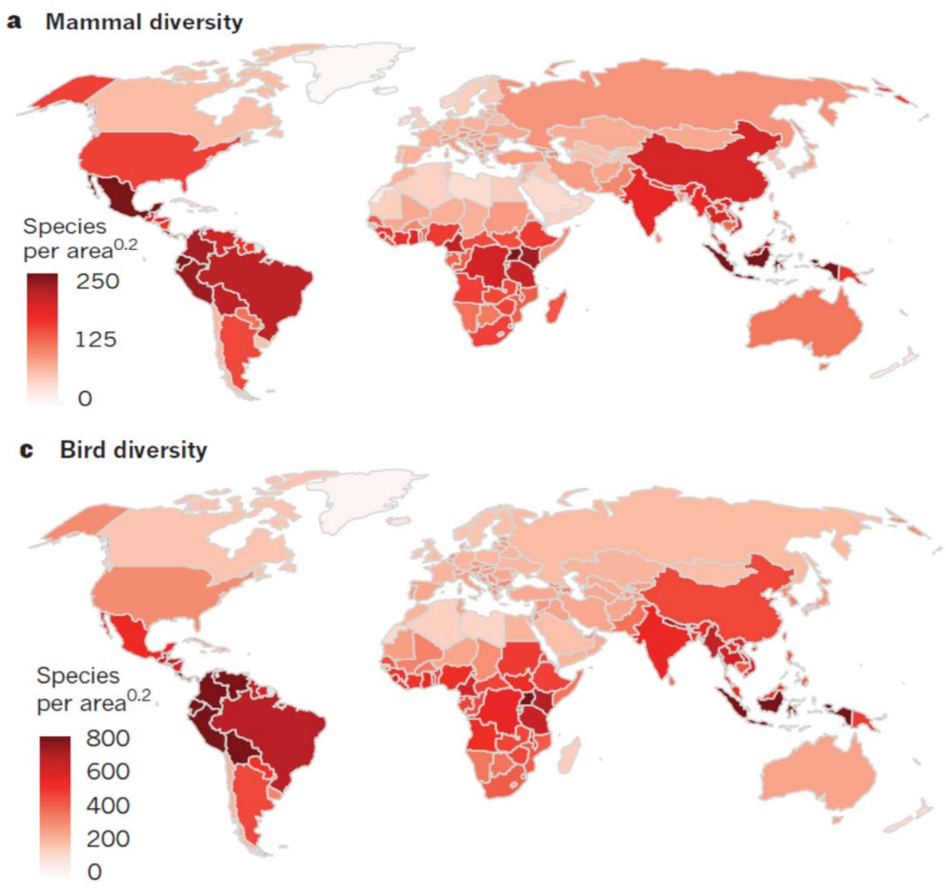
Accelerated modern human–induced species losses

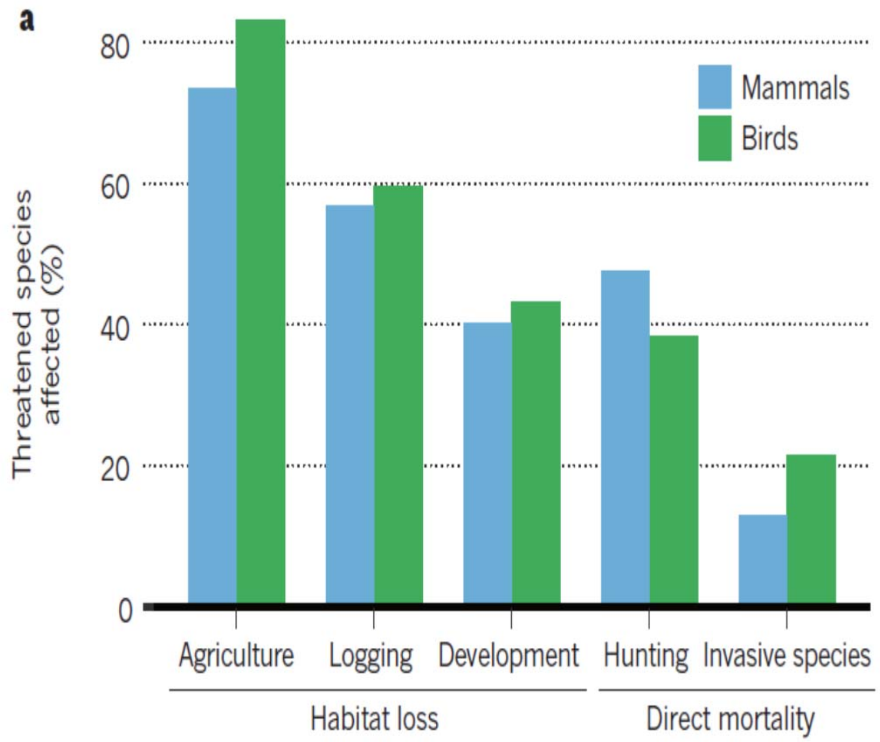
"Our analysis emphasizes that our global society has started to destroy species of other organisms at an accelerating rate, initiating a mass extinction episode unparalleled for 65 million years."



Ceballos et al (2016)

Mammal/bird land diversity and threats





Source: Tilman et al. (2017)

Tropical forests are the biggest reservoirs of biodiversity

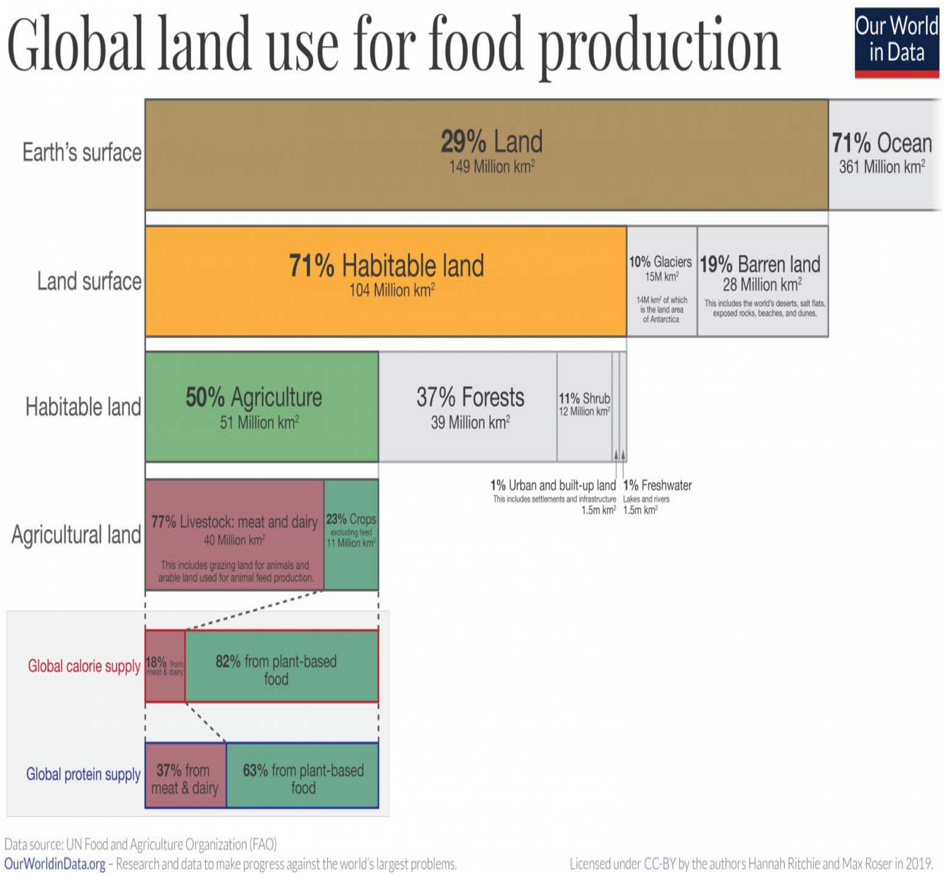
- For instance, the density of birds is about 5 times higher in tropical forests and woodlands than in cropland and pasture areas:

Table 1. Estimates of mean bird densities in different land-use types, the pre-agricultural areas of those types and the estimated global numbers of individual breeding birds in each of those types in 1990, the percentage change in numbers of birds between the two land-use states, and the numbers of birds gained and lost by these changes.
(Percentage changes in numbers of individuals cannot be calculated for cropland and pasture, because the numbers have grown from baselines of zero.)

	densities (individuals km^{-2})			area (million km^{-2})		numbers in 1990 (billions)				change in numbers (billions)		
land use	low	'typical'	high	undisturbed	1990	low	'typical'	high	change (%)	low	'typical'	high
cropland	100	300	500	0	14.66	1.47	4.40	7.33	—	+1.47	+4.40	+7.33
pasture	150	375	600	0	30.98	4.65	11.62	18.59	—	+4.65	+11.62	+18.59
ice	0	0	0	2.23	2.23	0	0	0	—	0	0	0
tundra	50	200	350	6.48	6.23	0.31	1.25	2.18	−3.94	−0.01	−0.05	−0.09
wooded tundra	100	250	400	2.70	2.58	0.26	0.65	1.03	−4.25	−0.01	−0.03	−0.05
boreal forest	150	575	1000	17.41	16.77	2.52	9.64	16.77	−3.67	−0.10	−0.37	−0.64
cool conifer forest	350	800	1250	3.59	2.79	0.98	2.23	3.48	−22.37	−0.28	−0.64	−1.00
temperate mixed forest	350	800	1250	6.96	2.96	1.03	2.36	3.69	−57.55	−1.40	−3.20	−5.01
temperate deciduous forest	350	1175	2000	6.09	2.01	0.70	2.36	4.02	−67.02	−1.43	−4.79	−8.16
warm mixed forest	500	1250	2000	6.24	2.52	1.26	3.15	5.04	−59.61	−1.86	−4.65	−7.44
grassland/steppe	100	450	800	18.31	9.25	0.92	4.16	7.40	−49.51	−0.91	−4.08	−7.25
hot desert	50	175	300	20.02	15.87	0.79	2.78	4.76	−20.72	−0.21	−0.73	−1.24
scrubland	600	1000	1400	9.79	2.50	1.50	2.50	3.50	−74.44	−4.37	−7.29	−10.20
savannah	500	850	1200	15.94	8.30	4.15	7.05	9.95	−47.97	−3.82	−6.50	−9.18
tropical woodland	1000	1875	2750	8.20	5.88	5.88	11.02	16.16	−28.32	−2.32	−4.36	−6.39
tropical forest	1500	2500	3500	10.15	8.61	12.92	21.53	30.14	−15.20	−2.32	−3.86	−5.40
total				134.12	134.12	39.34	86.70	134.04		−12.92	−24.53	−36.13

Source: Gaston et al (2003)

The issue of meat consumption



Science of the Total Environment 536 (2015) 419–431

Contents lists available at ScienceDirect

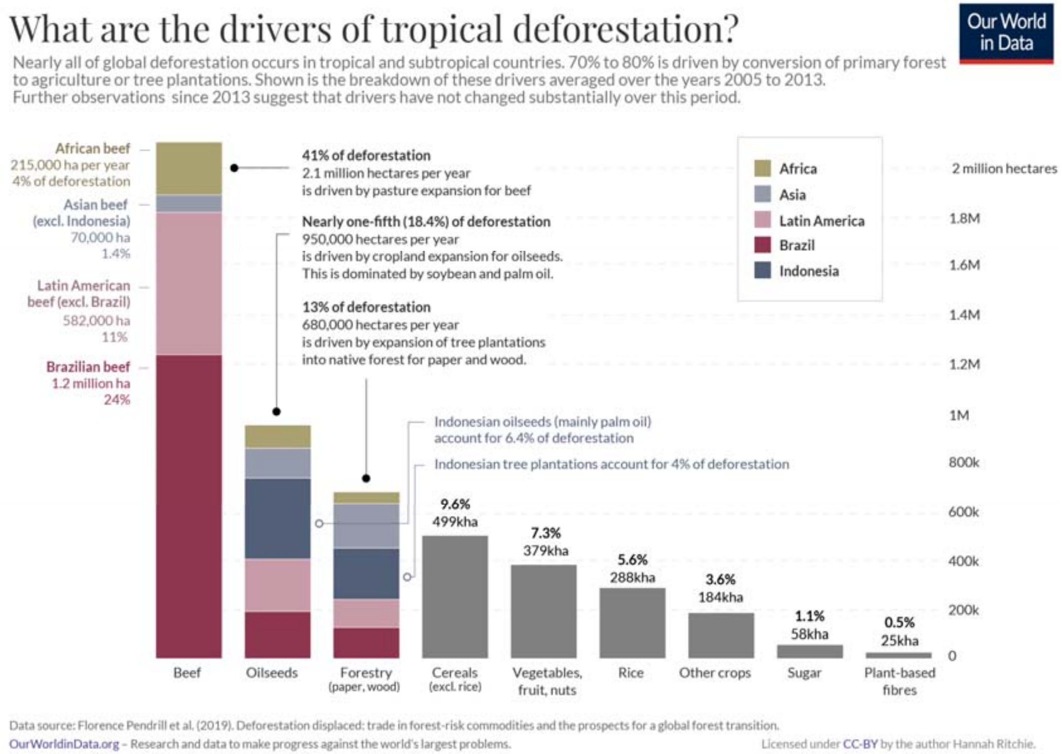
Science of the Total Environment

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

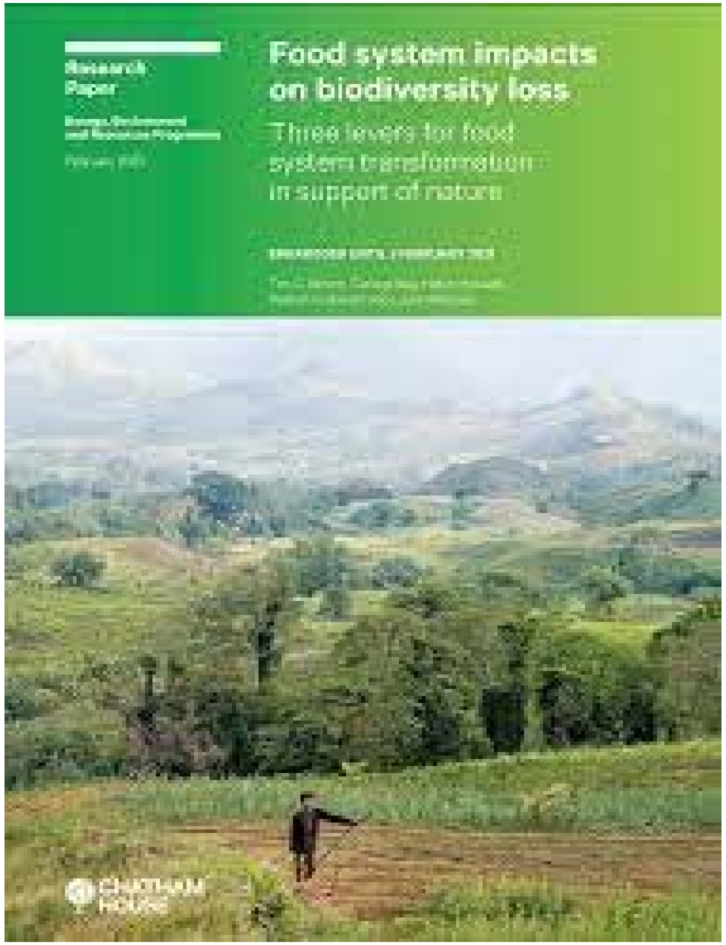
Biodiversity conservation: The key is reducing meat consumption

Brian Machovina [a,b,*], Kenneth J. Feeley [a,b], William J. Ripple [c]

[a] Florida International University, Miami, FL 33199, USA
[b] Fairchild Tropical Botanic Garden, Coral Gables FL 33156, USA
[c] Department of Forest Ecosystems and Society, Oregon State University, Corvallis, OR 97331, USA



Chatham House (2021)'s three levers



Summary

- Biodiversity loss is accelerating around the world. The global rate of species extinction today is orders of magnitude higher than the average rate over the past 10 million years.
- The global food system is the primary driver of this trend. Over the past 50 years, the conversion of natural ecosystems for crop production or pasture has been the principal cause of habitat loss, in turn reducing biodiversity.
- Our food system has been shaped over past decades by the 'cheaper food' paradigm. Policies and economic structures have aimed to produce ever more food at ever lower cost. Intensified agricultural production degrades soils and ecosystems, driving down the productive capacity of land and necessitating even more intensive food production to keep pace with demand. Growing global consumption of cheaper calories and resource-intensive foods aggravates these pressures.
- Current food production depends heavily on the use of inputs such as fertilizer, pesticides, energy, land and water, and on unsustainable practices such as monocropping and heavy tilling. This has reduced the variety of landscapes and habitats, threatening or destroying the breeding, feeding and/or nesting of birds, mammals, insects and microbial organisms, and crowding out many native plant species.
- As a major contributor to global greenhouse gas emissions, our food system is also driving climate change, which further degrades habitats and causes species to disperse to new locations. In turn, this brings new species into contact and competition with each other, and creates new opportunities for the emergence of infectious disease.
- Without reform of our food system, biodiversity loss will continue to accelerate. Further destruction of ecosystems and habitats will threaten our ability to sustain human populations. Reform will rely on the use of three principal levers:
  - Firstly, global dietary patterns need to converge around diets based more on plants, owing to the disproportionate impact of animal farming on biodiversity, land use and the environment. Such a shift would also benefit the dietary health of populations around the world, and help reduce the risk of pandemics. Global food waste must be reduced significantly. Together, these measures would reduce pressure on resources including land, through reducing demand.
  - Secondly, more land needs to be protected and set aside for nature. The protection of land from conversion or exploitation is the most effective way of preserving biodiversity, so we need to avoid converting land for

agriculture. Restoring native ecosystems on spared agricultural land offers the opportunity to increase biodiversity.
  - Thirdly, we need to farm in a more nature-friendly, biodiversity-supporting way, limiting the use of inputs and replacing monoculture with polyculture farming practices.
- These three levers are in part interdependent. Most notably, the protection and setting aside of land for nature and the shift to nature-friendly farming both depend on dietary change, and will become increasingly difficult to achieve if continued growth in food demand exerts ever-growing pressure on land resources.

The land-sharing land-sparing debate

Farming and the Fate of Wild Nature

Rhys E. Green,[1,2*] Stephen J. Cornell,[1,3] Jörn P. W. Scharlemann,[1,2] Andrew Balmford[1,4]

World food demand is expected to more than double by 2050. Decisions about how to meet this challenge will have profound effects on wild species and habitats. We show that farming is already the greatest extinction threat to birds (the best known taxon), and its adverse impacts look set to increase, especially in developing countries. Two competing solutions have been proposed: wildlife-friendly farming (which boosts densities of wild populations on farmland but may decrease agricultural yields) and land sparing (which minimizes demand for farmland by increasing yield). We present a model that identifies how to resolve the trade-off between these approaches. This shows that the best type of farming for species persistence depends on the demand for agricultural products and on how the population densities of different species on farmland change with agricultural yield. Empirical data on such density-yield functions are sparse, but evidence from a range of taxa in developing countries suggests that high-yield farming may allow more species to persist.

ANALYSIS

doi:10.1038/nature10452

Solutions for a cultivated planet

Jonathan A. Foley[1], Navin Ramankutty[2], Kate A. Brauman[1], Emily S. Cassidy[1], James S. Gerber[1], Matt Johnston[1], Nathaniel D. Mueller[1], Christine O'Connell[1], Deepak K. Ray[1], Paul C. West[1], Christian Balzer[3], Elena M. Bennett[4], Stephen R. Carpenter[5], Jason Hill[1,6], Chad Monfreda[7], Stephen Polasky[1,8], Johan Rockström[9], John Sheehan[1], Stefan Siebert[10], David Tilman[1,11] & David P. M. Zaks[12]

Increasing population and consumption are placing unprecedented demands on agriculture and natural resources. Today, approximately a billion people are chronically malnourished while our agricultural systems are concurrently degrading land, water, biodiversity and climate on a global scale. To meet the world's future food security and sustainability needs, food production must grow substantially while, at the same time, agriculture's environmental footprint must shrink dramatically. Here we analyse solutions to this dilemma, showing that tremendous progress could be made by halting agricultural expansion, closing 'yield gaps' on underperforming lands, increasing cropping efficiency, shifting diets and reducing waste. Together, these strategies could double food production while greatly reducing the environmental impacts of agriculture.

Journal of Zoology

ZSL LET'S WORK FOR WILDLIFE

Thomas Henry Huxley Review | Free Access

Concentrating vs. spreading our footprint: how to meet humanity's needs at least cost to nature

A. Balmford

First published: 05 October 2021 | https://doi.org/10.1111/jzo.12920

Editor: Nigel Bennett

This paper is dedicated to Georgina Mace and David MacKay, who sought data-driven solutions to limiting our impacts on the planet, and who believed they are achievable.

Methods in ecology

- Observational data
  - Mark-recapture, area-based counts, etc.
- Large-scale experiments
  - E.g. defaunation
- Meso-experiments
  - E.g. Cedar Creek, ecotron
- Microcosm experiments
  - E.g. in a test tube
- Mathematical models

Subfields in ecology

- Ecosystem ecology
- Evolutionary ecology
- Landscape ecology
- Conservation biology
- Ecophysiology
- Population ecology
- Community ecology
- Biogeography
- Behavioral ecology

Biodiversity protection: A fairly recent field

- Formation of the Society for Conservation Biology in 1985
- Journal *Conservation Biology* created in 1987

- Economics can contribute: “conservation solutions will come from better understanding and management of human affairs, not from better biology alone” (Polasky et al 2005)

1) Measures of biodiversity

- Biomass, species population, species traits, genetic composition, primary productivity, endangered/vulnerable species, extinction probabilities etc

- Some key references: Weitzman (1992, 1993, 1998), Nehring and Puppe (2002), Polasky and Solow (1994, 2005), Baumgartner (2005)

An example: Weitzman (1992, QJE)

- Traditional biological measures were based on the relative abundance of species (Rényi 1961, Berger and Parker 1970, entropy)
- Introduces a distance function to measure pairwise dissimilarity between species based on simple axioms
    1. Diversity should not decrease by the addition of a species
    2. Diversity should not be increase by the addition of a species that is identical
    3. Diversity should not decrease by the addition of a more dissimilar species

ON DIVERSITY*

MARTIN L. WEITZMAN

An oft-repeated goal in many contexts is the "preservation of diversity." But what is the diversity function to be optimized? This paper shows how a reasonable measure of the "value of diversity" of a collection of objects can be recursively generated from more fundamental information about the dissimilarity-distance between any pair of objects in the set. The diversity function is shown to satisfy a basic dynamic programming equation, which in a well-defined sense generates an optimal classification scheme. A surprisingly rich theory of diversity emerges, having ramifications for several disciplines. Implications and applications are discussed.

2) Sources of value from biodiversity

- Use value, existence value, option value
- Ecosystem services
  - Ecosystem services include provision of clean air and water, climate regulation, mitigation of natural disturbances, waste decomposition, maintenance of soil fertility, pollination, pest control, among other things
  - More biodiversity enhances ecosystem productivity, stability and resilience (Elton 1958, Naeem and Li 1997, Lehman and Tilman 2000, Loreau et al 2001, Cardinale et al 2012, Tilman et al 2014)

- Some key references: Loomis and White (1996), Simpson et al (1996), Costanza et al (1997), Brown and Shogren (1998), Barbier (2000), Perrings et al (2000), Bateman et al (2013), Lanz et al (2018)

An example: Lanz et al (2018, Ecol Econ)

Ecological Economics 144 (2018) 260–277

ELSEVIER

Contents lists available at ScienceDirect

Ecological Economics

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

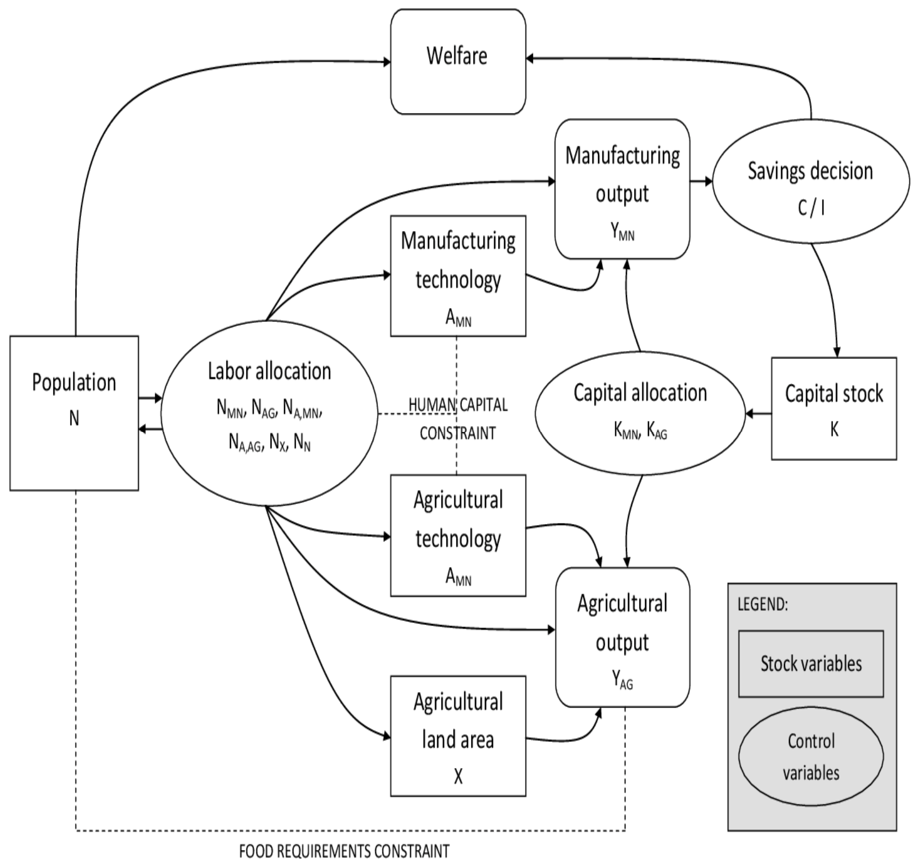
The Expansion of Modern Agriculture and Global Biodiversity Decline: An Integrated Assessment☆

CrossMark

Bruno Lanz[a,b,c,*], Simon Dietz[d], Tim Swanson[e]

[a] University of Neuchâtel, Department of Economics and Business, Switzerland
[b] ETH Zurich, Chair for Integrative Risk Management and Economics, Switzerland
[c] Massachusetts Institute of Technology, Joint Program on the Science and Policy of Global Change, USA
[d] London School of Economics and Political Science, Grantham Research Institute on Climate Change and the Environment, and Department of Geography and Environment, UK
[e] Graduate Institute of International and Development Studies, Department of Economics and Centre for International Environmental Studies, Switzerland

- Quantitative economy model (growth, population, food demand, innovations, land)
  - With a biodiversity externality module
- Main result: Biodiversity loss justifies a moratorium on further land conservation



3) Strategies to preserve biodiversity

- Habitat protection (e.g., protected areas)
- Laws to protect endangered species
- Harvesting regulation and monitoring
- Property rights
- Payment for ecosystem services

- Some key references: Ando et al (1998), Besley and Ghatak (2001), Sanchirico and Wilen (2001), Heal (2005), Engel et al (2008), Chabe-Ferret and Subervie (2013), Harstad (2021)

An example: Heal (2005, JEEA)

- Biodiversity is a public good

=> underprovision (free riding)

- In some cases, biodiversity conservation can be bundled with private goods
- Example:
  - Ecotourism may lead "ranchers to stop cattle ranching and restore their land to its natural state, with native vegetation and animals, so as to charge tourists for viewing the animals"
- Explores theoretical conditions leading to (in)efficient provision

BUNDLING BIODIVERSITY

Geoffrey Heal
Columbia Business School

Abstract
Biodiversity provides essential services to human societies. Many of these services are provided as public goods, so that they will typically be underprovided both by market mechanisms (because of the impossibility of excluding non-payers from using the services) and by government-run systems (because of the free rider problem). I suggest here that in some cases the public goods provided by biodiversity conservation can be bundled with private goods and their value to consumers captured in the price realized by the private goods. This may lead to an efficient level of provision. (JEL: H41, Q2, R41)


The Economics
of Biodiversity:
The Dasgupta
Review

Enthusiastic first reactions

- UK Government response: “This reports sets out the ways in which the Government will go further in response to many of the Review’s conclusions”
- Andrew Bailey, Governor, Bank of England: “We are engaging with other central banks and the Network for Greening the Financial System on these issues”
- Already about 200 citations on GoogleScholar, several public lectures, podcasts and interviews, Journal special issues, Kew International medal etc.
- See the webpage of the Review for a list of reactions

Headline messages (1/4)

- Nature is an asset:
  - “Nature is (…) an asset, just as produced capital (roads, buildings and factories) and human capital (health, knowledge and skills) are assets.”
  - “Biodiversity enables Nature to be productive, resilient and adaptable.” “Just as diversity within a portfolio of financial assets reduces risk and uncertainty, so diversity within a portfolio of natural assets increases Nature’s resilience to shocks, reducing the risks to Nature’s services.”
- Biodiversity is declining:
  - “Biodiversity is declining faster than at any time in human history.” “Many ecosystems, from tropical forests to coral reefs, have already been degraded beyond repair, or are at imminent risk of ‘tipping points’.”
  - “We have collectively failed to engage with Nature sustainably”. This “is endangering the prosperity of current and future generations.”

Headline messages (2/4)

- Markets and institutions fail:
  - “Nature’s worth to society – the true value of the various goods and services it provides – is not reflected in market prices because much of it is open to all at no monetary charge.”
  - “But this is not simply a market failure: it is a broader institutional failure too. Many of our institutions have proved unfit to manage the externalities. Governments almost everywhere exacerbate the problem by paying people more to exploit Nature than to protect it”
- We are embedded in Nature:
  - “While most models of economic growth and development recognise that Nature is capable only of producing a finite flow of goods and services, the focus has been to show that technological progress can, in principle, overcome that exhaustibility. This is to imagine that, ultimately, humanity is ‘external’ to Nature.”
  - “The *Review* develops the economics of biodiversity on the understanding that we – and our economies – are ‘embedded’ within Nature, not external to it.”

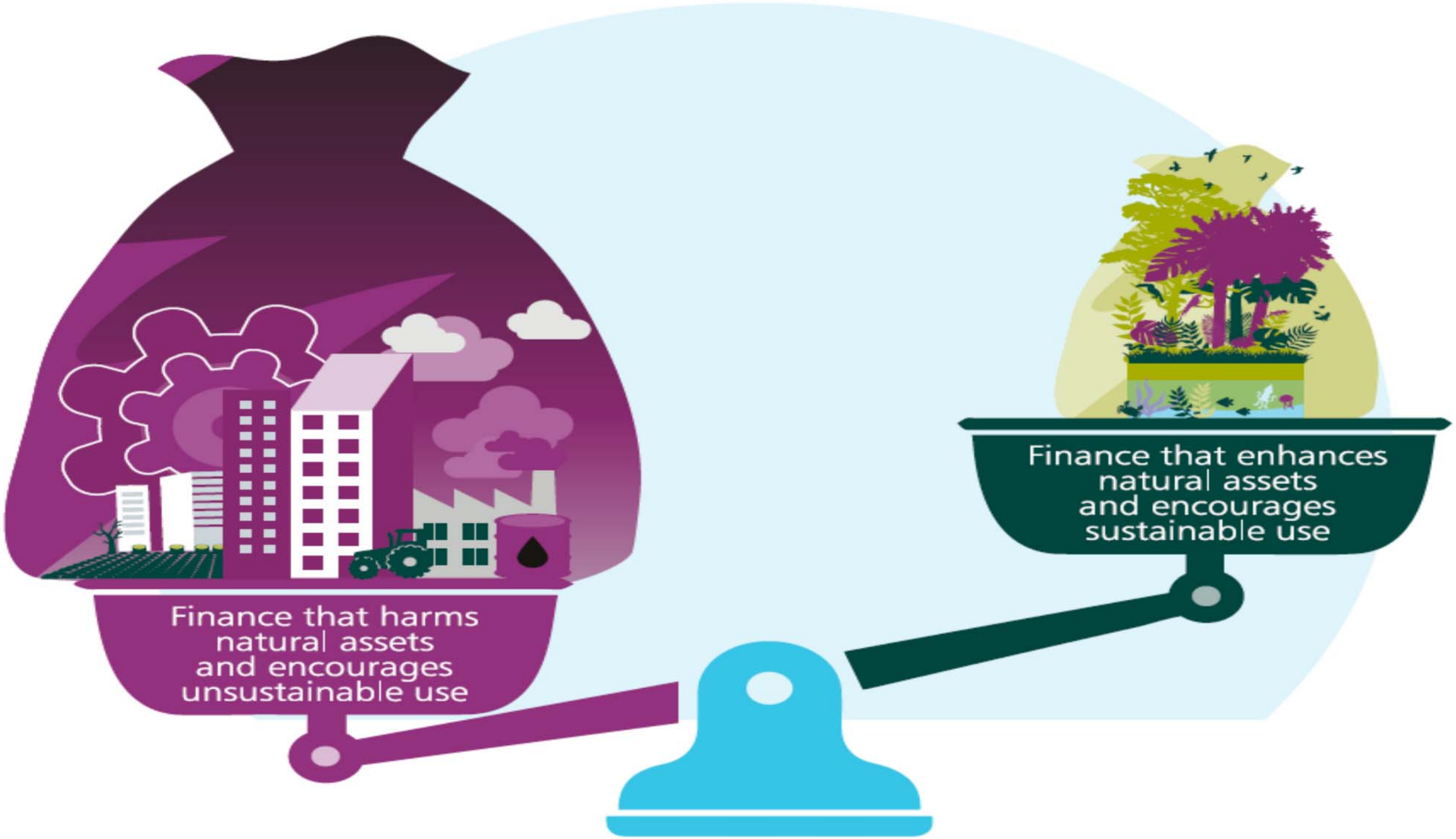
Headline messages (3/4)

- Food is the main driver:
  - “Food production is the most significant driver of terrestrial biodiversity loss. As the global population grows, the enormous problem of producing sufficient food in a sustainable manner will only intensify.”
  - “Some innovations – such as precision agriculture, vertical farming and cellular agriculture – have the potential to improve efficiency by reducing agriculture’s contribution to damaging natural assets and pressures on biodiversity loss ”
- The need to consider demography:
  - “Growing human populations have significant implications for our demands on Nature, including for future patterns of global consumption. Fertility choices are influenced not only by individual preferences, they are also shaped by the choices of others. As well as improving women’s access to finance, information and education, support for community-based family planning programmes can shift preferences and behaviour, and accelerate the demographic transition. There has been significant underinvestment in such programmes.”

Headline messages (4/4)

- Prevention vs. adaptation:
  - “It is less costly to conserve Nature than to restore it once damaged or degraded, all else being equal.” “Expanding and improving the management of Protected Areas therefore has an essential role to play”
- We must redefine economic metrics:
  - “Nature needs to enter economic and finance decision-making in the same way buildings, machines, roads and skills do.” “The *Review* demonstrates that in order to judge whether economic development is sustainable, an inclusive measure of wealth is needed.”
- The role of the financial system:
  - “Central banks and financial regulators can support increased understanding by assessing the systemic extent of Nature-related financial risks.”
  - “Interventions to enable people to understand and connect with Nature would not only improve our health and well-being, but also help empower citizens to make informed choices and demand the change that is needed; for example by insisting that financiers invest our money sustainably and that firms disclose environmental conditions along their supply chains, and even boycotting products that do not meet certain standards”

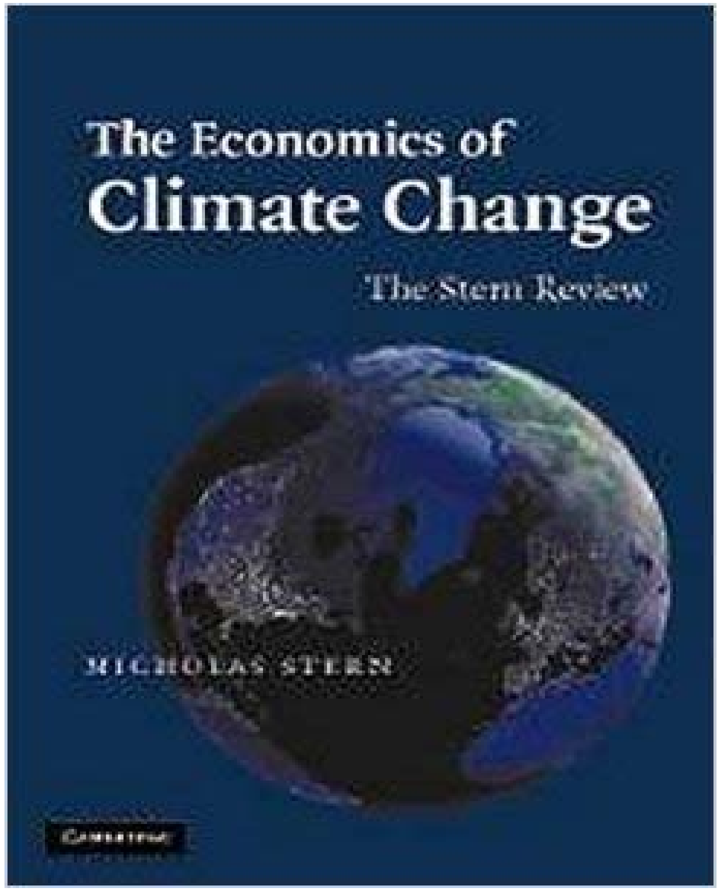
Figure 20.1 Balance of Nature Positive and Negative Financial Flows



Dasgupta (2021), in Chapter 20: Finance for Sustainable Engagement with Nature

Comparison with the Stern Review (2006)

- Released for the UK government
- High mediatic and academic impact
- Clear metrics: GHG emissions
- Global problem, future generations
- Main polluting sectors: Transport, electricity, industry, agriculture
- World/region projections



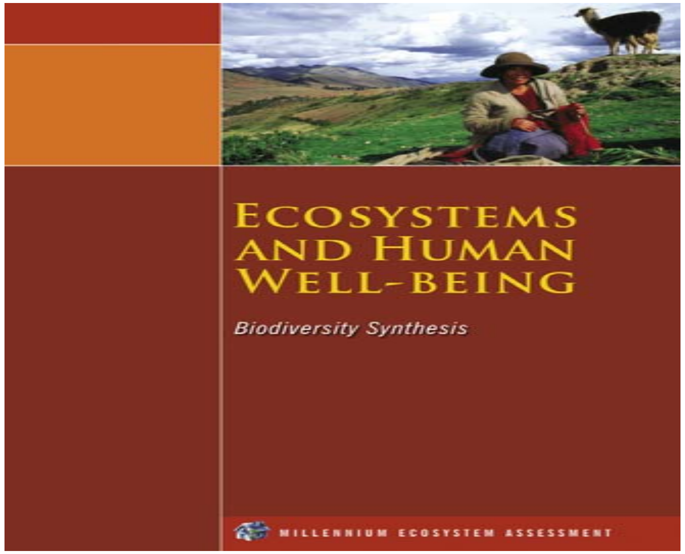
Some frontier topics in biodiversity economics

- Biodiversity-economy models
- Risk/uncertainty
- Tipping points
- Fertility/population
- Political economy
- Behavioral economics
- Finance
- Wellbeing footprint

Anthropocentrism in the research on biodiversity

- Almost all research on biodiversity (implicitly or explicitly) is ultimately concerned by human wellbeing only

- All current biodiversity metrics measure a certain quantity of life, not its quality => morally troublesome consequences
  - McSchane (2018): “To see the force of this point, consider what difference it would make if we thought the aim of human morality was only to ensure that certain kinds of people exist, but with no attention to the quality of their lives.”



REVIEW

doi:10.1038/nature11148

Biodiversity loss and its impact on humanity

Bradley J. Cardinale[1], J. Emmett Duffy[2], Andrew Gonzalez[3], David U. Hooper[4], Charles Perrings[5], Patrick Venail[1], Anita Narwani[1], Georgina M. Mace[6], David Tilman[7], David A. Wardle[8], Ann P. Kinzig[5], Gretchen C. Daily[9], Michel Loreau[10], James B. Grace[11], Anne Larigauderie[12], Diane S. Srivastava[13] & Shahid Naeem[14]

The most unique feature of Earth is the existence of life, and the most extraordinary feature of life is its diversity. Approximately 9 million types of plants, animals, protists and fungi inhabit the Earth. So, too, do 7 billion people. Two decades ago, at the first Earth Summit, the vast majority of the world's nations declared that human actions were dismantling the Earth's ecosystems, eliminating genes, species and biological traits at an alarming rate. This observation led to the question of how such loss of biological diversity will alter the functioning of ecosystems and their ability to provide society with the goods and services needed to prosper.

The problem of anthropocentrism

- Dasgupta (2021, p. 49): "In the chapters that follow, we mostly adopt an anthropocentric viewpoint – the value of biodiversity is studied in terms of its contributions to humanity, that is human well-being."

$\Rightarrow$ Among the millions of species on Earth, only one has a moral value; ours.

- Fleurbaey and Leppanen (2021): "anthropocentrism in normative concepts is suspect, unfounded, ominously similar to the old religious and racist doctrines that gave the White Christian Man the right to own the Earth, and apparently too weak as a normative compass to fight pervasive destruction in the age of mass extinction."

Who/what deserves moral consideration?

- Humans = anthropocentrism

- Sentient animals = sentientism (or pathocentrism)
  - Rousseau (1755), Bentham (1780), Singer (1975), Regan (1983)

- Living things = biocentrism (or more broadly ecocentrism, holism)
  - Schweitzer (1923), Leopold (1949), Naess (1973), Callicott (1989)

Animals vs. plants

- Neuroscientists' Cambridge Declaration (2010) about animals' consciousness:
  - "the weight of evidence indicates that humans are not unique in possessing the neurological substrates that generate consciousness. Nonhuman animals, including all mammals and birds, and many other creatures, including octopuses, also possess these neurological substrates."

Plants Neither Possess nor Require Consciousness

Lincoln Taiz,[1,*] Daniel Alkon,[2] Andreas Draguhn,[3] Angus Murphy,[4] Michael Blatt,[5] Chris Hawes,[6] Gerhard Thiel,[7] and David G. Robinson[8]

In claiming that plants have consciousness, 'plant neurobiologists' have consistently glossed over the remarkable degree of structural and functional complexity that the brain had to evolve for consciousness to emerge. Here, we outline a new hypothesis proposed by Feinberg and Mallat for the evolution of consciousness in animals. Based on a survey of the brain anatomy, functional complexity, and behaviors of a broad spectrum of animals, criteria were established for the emergence of consciousness. The only animals that satisfied these criteria were the vertebrates (including fish), arthropods (e.g., insects, crabs), and cephalopods (e.g., octopuses, squids). In light of Feinberg and Mallat's analysis, we consider the likelihood that plants, with their relative organizational simplicity and lack of neurons and brains, have consciousness to be effectively nil.

Highlights

Although 'plant neurobiologists' have claimed that plants possess many of the same mental features as animals, such as consciousness, cognition, intentionality, emotions, and the ability to feel pain, the evidence for these abilities in plants is highly problematical.

Proponents of plant consciousness have consistently glossed over the unique and remarkable degree of structural, organizational, and functional complexity that the animal brain had to evolve before consciousness could emerge.

Recent results of neuroscientist Todd E. Feinberg and evolutionary biologist Jon M. Mallatt on the minimum brain structures and functions required for consciousness in animals have implications for plants.

Their findings make it extremely unlikely that plants, lacking any anatomical structures remotely comparable to the complexity of the threshold brain, possess consciousness.

The Vexed History of 'Plant Neurobiology'

Since its debut on the pages of *Trends in Plant Science* in 2006 [1], the subfield of 'plant neurobiology' (PN) has been dogged by controversy [2]. Not surprisingly, the controversy became a publicity bonanza for the new paradigm, transforming some of its more provocative advocates into media darlings [3–5].

As reported by Michael Pollan in his *New Yorker* article, the initial obstacle to PN's acceptance was the group's name. Neurobiology refers to the biology of the nervous system, and plants manifestly lack nervous systems. This particular lexical complaint was soon resolved when the group quietly changed its name a few years later from the Society for Plant Neurobiology to the more acceptable Society for Plant Signaling and Behavior. However, self-identification of the group with neurobiology and its associated terminology has largely persisted, and some proponents continue to use the term plant neurobiology in their internet publications.

The defence

- The main argument to defend anthropocentrism is human exceptionalism (e.g., Gruen 2017, Dasgupta 2021)
- Although humans are exceptional in many ways, the once popular belief that it is unscientific to attribute emotions or thoughts to animals is now viewed as inconsistent, with support from evolutionary theory, experimental evidence, and any reasonable burden of proof (Sekar and Shiller 2020)

=> Biological continuities between humans and animals hardly justify a moral discontinuity (where only humans would have moral value)

The misalignment issue

- Dasgupta (2021): “There is a second reason. (…) But if biodiversity is worth preserving and promoting for purely anthropocentric reasons, it would be even more deserving of protection and promotion if it had sacred status. Therein lies the advantage of a limited point of view.”

- But preserving biodiversity while adopting an anthropocentric view might differ greatly from preserving it under a non-anthropocentric view
  - Reintroduction of carnivores
  - Endangered species
  - Invasive species
  - Aquaculture vs. fish catch

Conclusion

- The Dasgupta Review, and more generally the research on biodiversity, misses what matters most morally about biodiversity preservation: the welfare of sentient animals
- To conclude, I advocate for a change in mindset in the research on biodiversity: We should protect current ecosystems to the extent that this enhances the global welfare of humans AND of sentient animals involved in these ecosystems

=> Many challenges (e.g., requires a measure of the welfare of animals)