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One Health: the biodiversity–agriculture nexus

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What is One Health?

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One Health has meant different things to different people, often depending on professional perspectives

More often than not, frustratingly anthropocentric.

More often than not, focussed on infectious disease.

One Health

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…is not just Public Health

Health - a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity (Constitution of the World Health Organization: Principles; 1946)

BUT:

Pathogens, parasites and disease are important components of ecological function and are drivers of evolution.

A pathogen-free population is not a healthy population.

One Health Definition

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One Health is an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals, and ecosystems. It recognizes the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and interdependent.

The approach mobilizes multiple sectors, disciplines, and communities at varying levels of society to work together to foster well-being and tackle threats to health and ecosystems, while addressing the collective need for healthy food, water, energy, and air, taking action on climate change and contributing to sustainable development.

One Health High-Level Expert Panel (OHHLEP) et al. (2022) One Health: A new definition for a sustainable and healthy future. PLoS Pathog 18(6): e1010537. https://doi.org/10.1371/journal.ppat.1010537

One Health Definition

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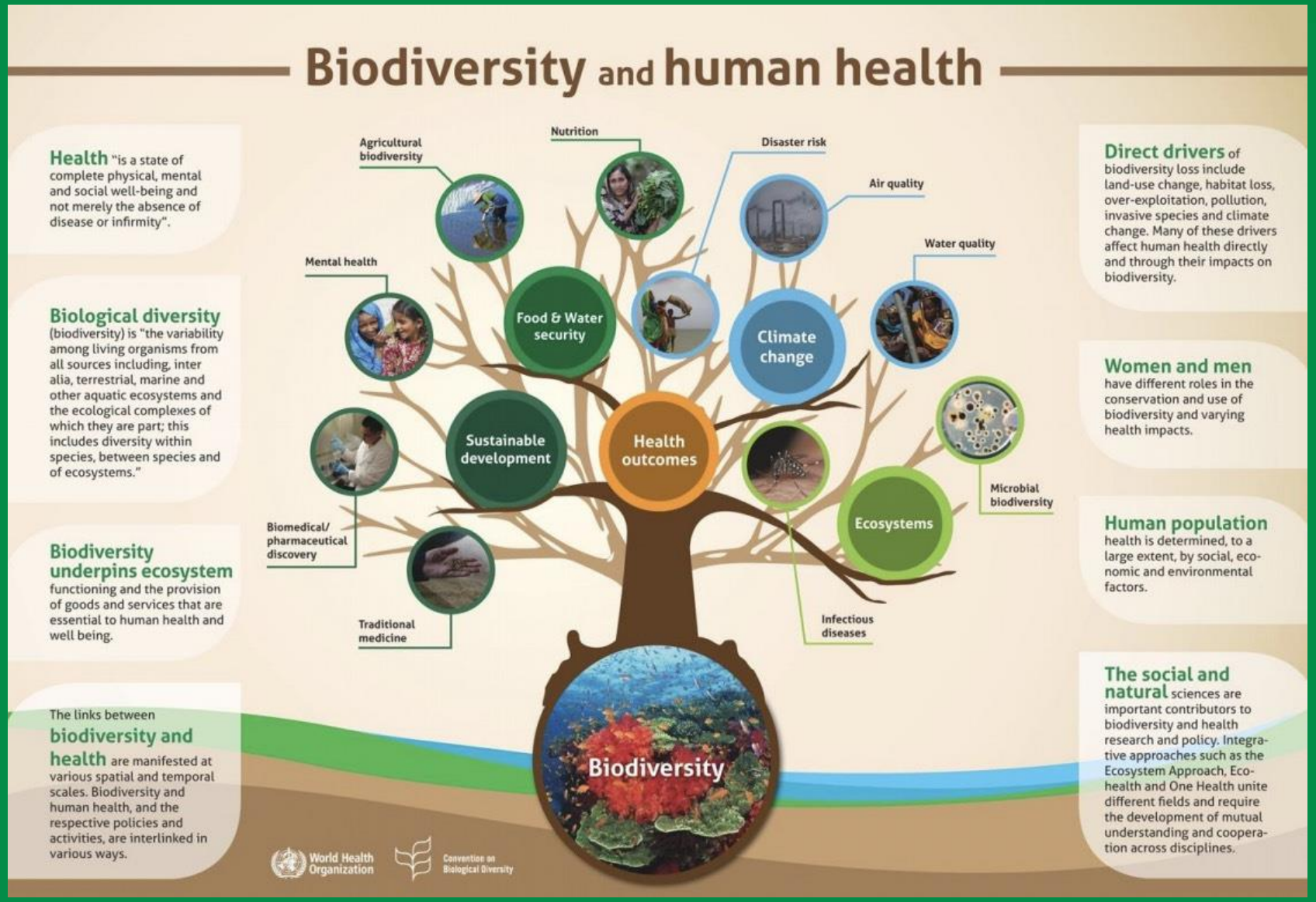
Key underlying principles

1. **equity** between sectors and disciplines;
2. sociopolitical and multicultural **parity** (the doctrine that all people are equal and deserve equal rights and opportunities) and inclusion and engagement of communities and marginalized voices;
3. socioecological **equilibrium** that seeks a harmonious balance between human–animal–environment interaction and acknowledging the importance of biodiversity, access to sufficient natural space and resources, and the intrinsic value of all living things within the ecosystem;
4. **stewardship** and the responsibility of humans to change behavior and adopt sustainable solutions that recognize the importance of animal welfare and the integrity of the whole ecosystem, thus securing the well-being of current and future generations; and
5. **transdisciplinarity** and multisectoral collaboration, which includes all relevant disciplines, both modern and traditional forms of knowledge and a broad representative array of perspectives.

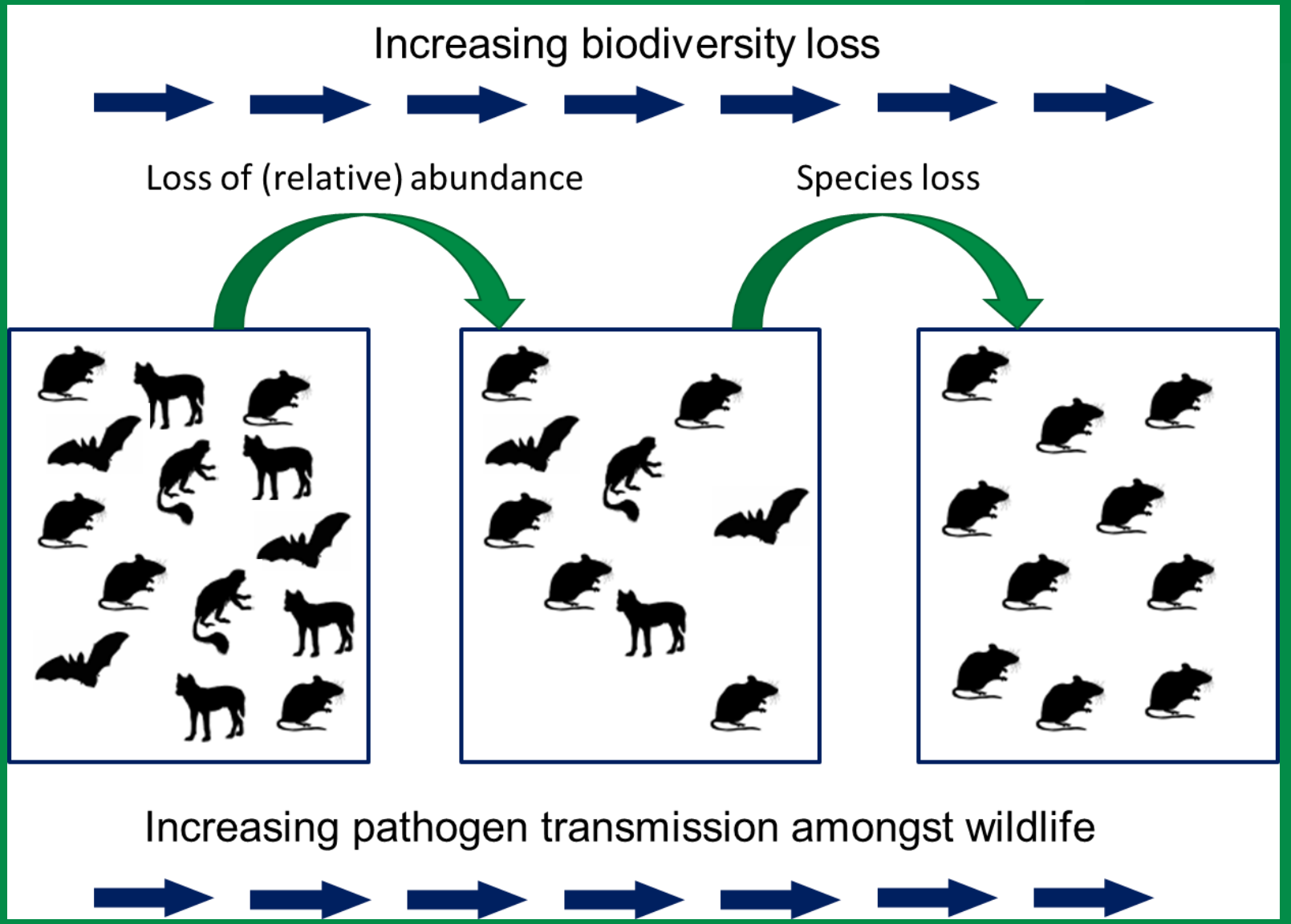
One Health High-Level Expert Panel (OHHLEP) et al. (2022) One Health: A new definition for a sustainable and healthy future. PLoS Pathog 18(6): e1010537. https://doi.org/10.1371/journal.ppat.1010537

Biodiversity underpins human health



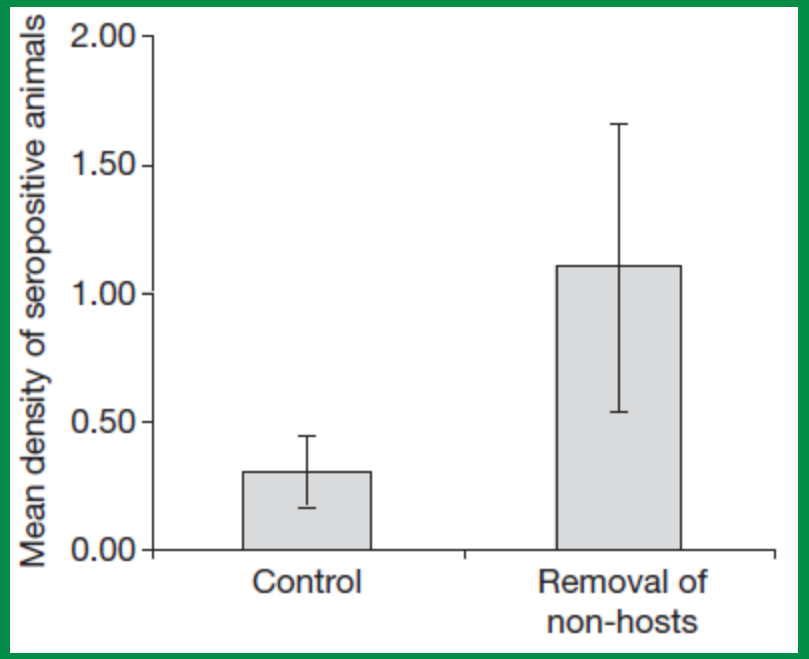
Connecting global priorities: biodiversity and human health: a state of knowledge review, 2015

Biodiversity & One Health



Biodiversity & One Health

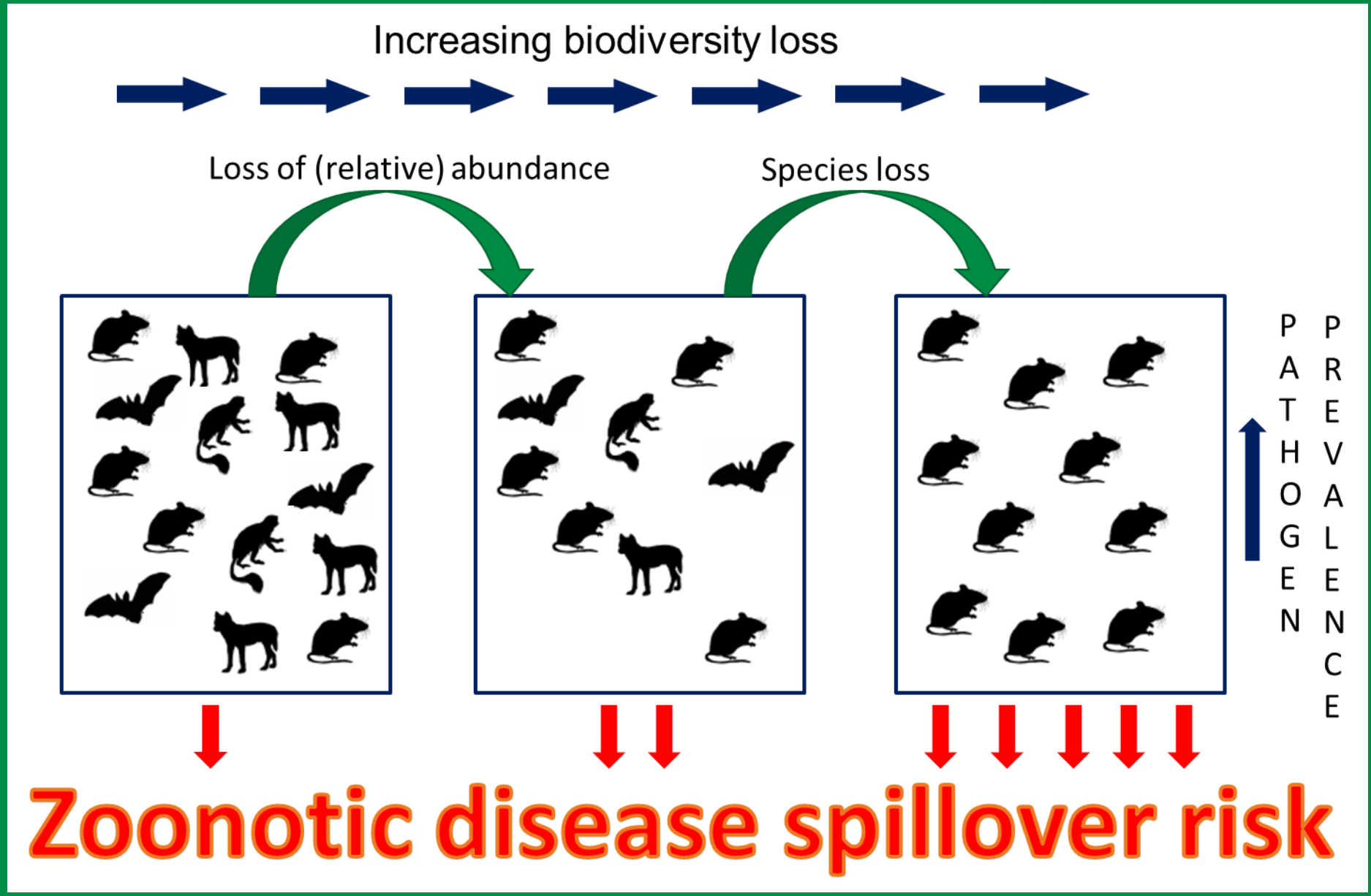
Hantavirus infection of small mammals in Panama



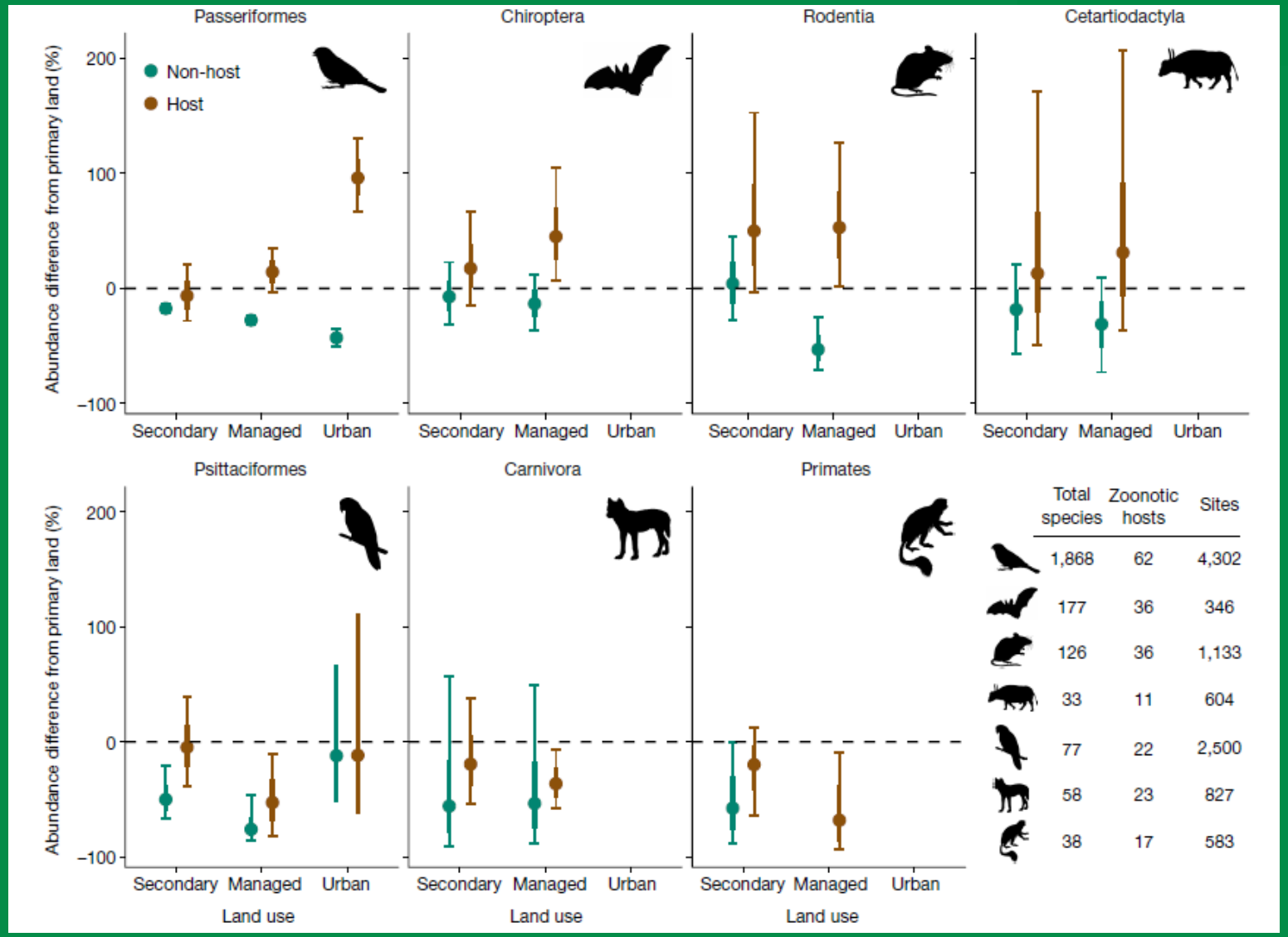
Mean (+/- standard error) density of hantavirus seropositive animals on plots from which non-hosts had been removed and on control plots.

Keesing et al. *Nature* 2010

Biodiversity & One Health



Land Use, Biodiversity & One Health



Gibb et al. *Nature* 2020

Biodiversity, Agriculture & One Health

Human-modified habitat is less suitable for some species, but more suitable for others.

As people encroach into and modify natural habitats, the range of species (known as the species complement) in that habitat is changed.

And the species that are more able to live in human-modified habitat tend to have a higher likelihood of carrying zoonotic pathogens than those that decline or disappear.

These species will also have higher likelihood of direct or indirect contact with people than would the wildlife that has been lost – leading to increased likelihood of zoonotic disease transmission.

Therefore, habitat loss and biodiversity loss is a lose-lose situation when it comes to human health, increasing the risk of zoonotic disease outbreaks and future pandemics.

One Health - Emerging infectious diseases of people

Over recent decades, there has been an increase in the number and rate of emergence of infectious diseases arising from spill-over from wild animals.

These have included high impact diseases, often with high case fatality rates, such as:

- Ebola
- Marburg
- Nipah
- Hendra
- HIV/AIDS
- SARS
- MERS
- COVID-19

One Health - Emerging infectious diseases of wildlife

Over recent decades, there has been an increase in the number and rate of emergence of infectious diseases affecting free-living wild animals.

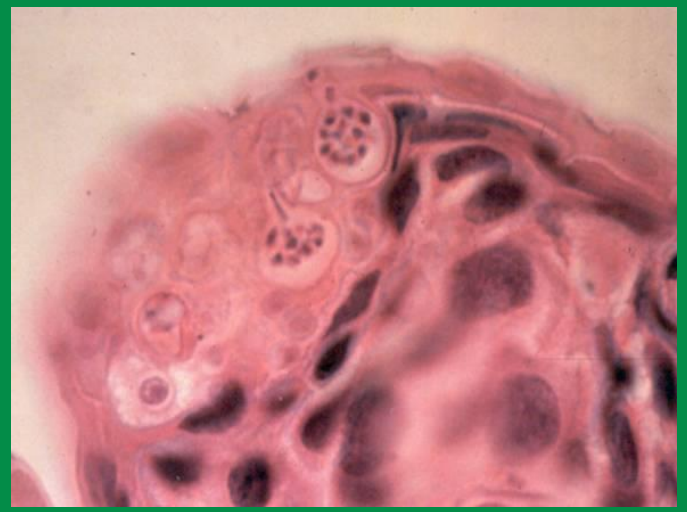
These have included high impact diseases, often with high case fatality rates, such as:

- pilchard herpesvirus
- Bd & Bsal chytridiomycosis
- H5N1 avian influenza
- seal morbillivirus
- amphibian ranavirosis
- snake fungal disease
- finch trichomonosis
- white nose syndrome

Biodiversity loss due to infectious disease

Amphibian chytridiomycosis

Due to infection with
Batrachochytrium dendrobatidis,
a non-hyphal zoosporic chytrid
fungus



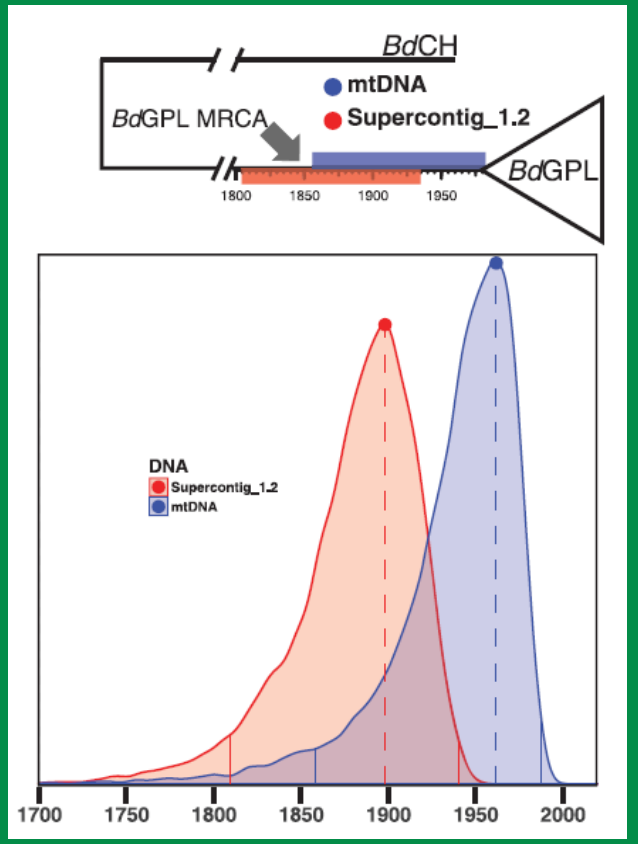
First identified as a cause of amphibian mortality in 1998, contemporaneously in Australia & Central America.

Berger *et al. Proc. Natl. Acad. Sci.* 1998

Biodiversity loss due to infectious disease

20th Century emergence of BdGPL

Using both nuclear and mitochondrial DNA data, the emergence of BdGPL has been dated to between ~ 70 and ~ 140 years ago – i.e. most likely in the first half of the 20th century.



O'Hanlon *et al. Science* 2018

Biodiversity loss due to infectious disease

Anthropogenic spread of Bd

Bd infection confirmed in:

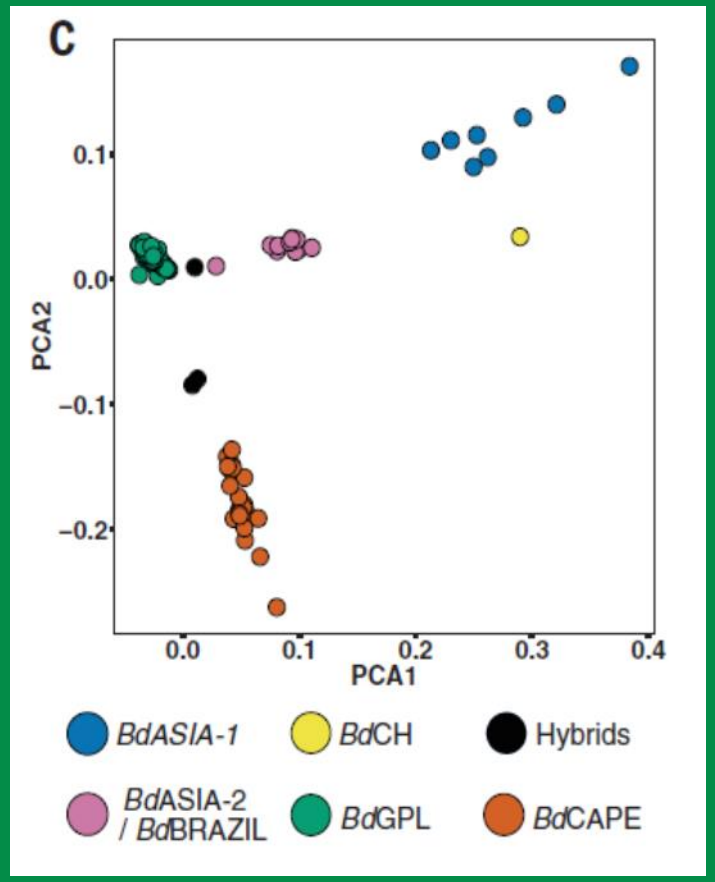
- **Pet trade** (e.g. dendrobatid frogs)
- **Food trade** e.g. bullfrog farms in Uruguay & Brazil

  > 5 million live amphibians imported p.a. into USA (majority wild caught)

  > 2500 tons of frog legs exported annually from China
- **Lab animal trade** (*Xenopus* spp.)
- **Zoo animal trade**
- **Invasive species** e.g. bullfrogs, alpine newts

Biodiversity loss due to infectious disease

Bd lineages and hybrids



Principal components analysis of 3900 SNPs in linkage equilibrium. Each point represents an isolate, coloured by phylogenetic lineage. The axes plot the first and second principal components.

O'Hanlon *et al. Science* 2018

Biodiversity loss due to infectious disease

- Hosts: anurans, urodeles & caecilians
- Distribution: global
  - population declines & species extinctions, mainly in the neotropics
- Impact: decline of > 500 species & presumed extinction of ~ 90 species

Scheele *et al. Science* 2019

"the worst infectious disease ever recorded among vertebrates in terms of the number of species impacted, and it's propensity to drive them to extinction" (Amphibian Conservation Summit, 2005)

Biodiversity loss due to infectious disease - UK

Squirrel poxvirus – 92% reduction in red squirrel population over ~200 years.

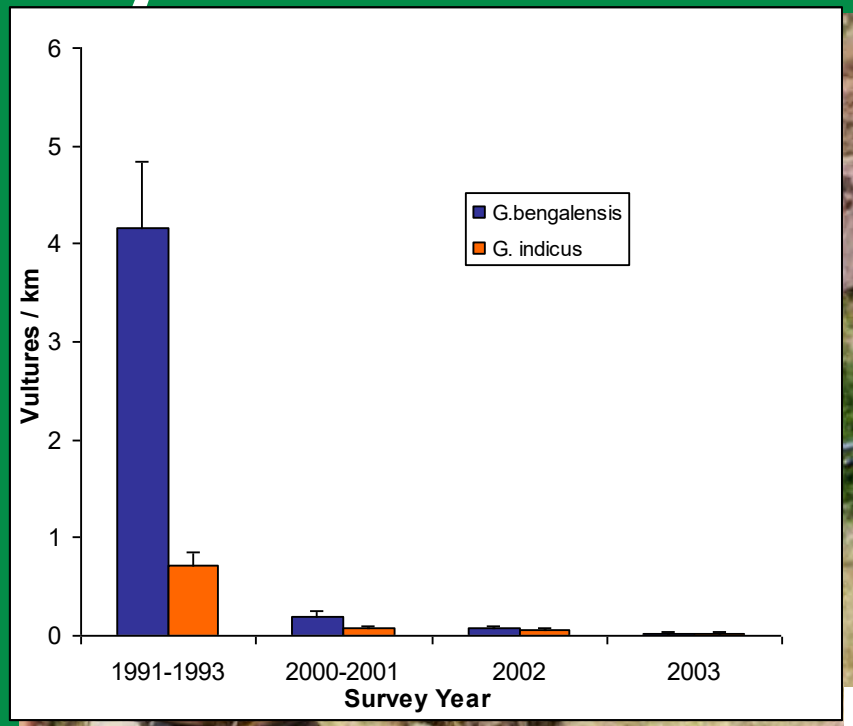
Crayfish plague – near-extinction of the native white-clawed crayfish throughout the country since the co-introduction of *Aphanomyces astaci* with the American signal crayfish in the 1970s.

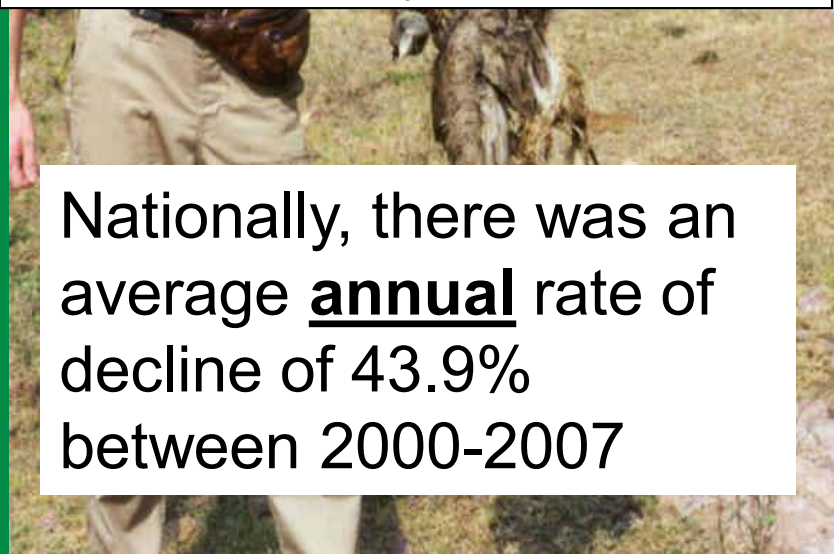
Finch trichomonosis – Clonal spread of A1 strain, causing > 70% decline of greenfinch and ~ 30% decline of chaffinch within 20 years of the disease emergence.

Dutch Elm disease - *Ophiostoma novo-ulmi* introduced in the 1960s has killed tens of millions of mature elm trees.

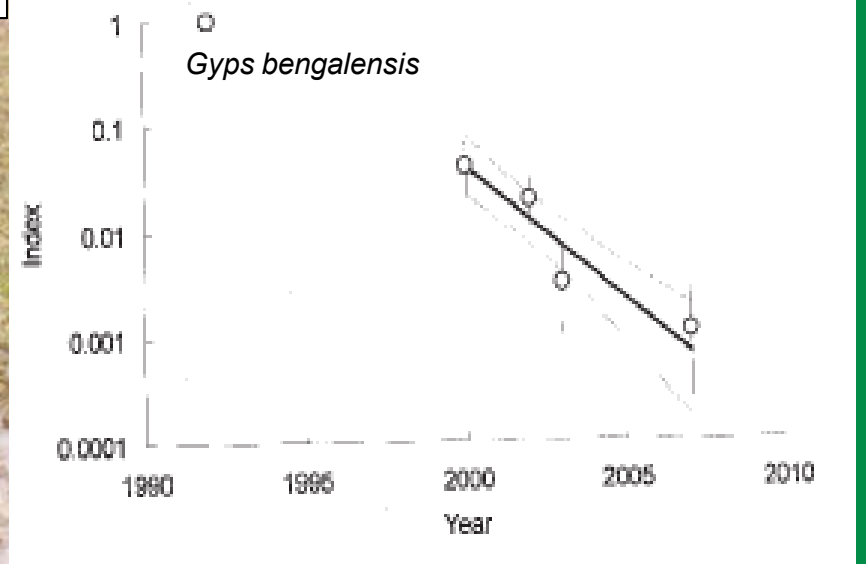
Ash dieback - *Hymenoscyphus fraxineus* introduced to UK in 2012, now widespread although still at early stages of the epidemic. Expected to have profound ecological and financial impacts.

Biodiversity loss due to non-infectious disease

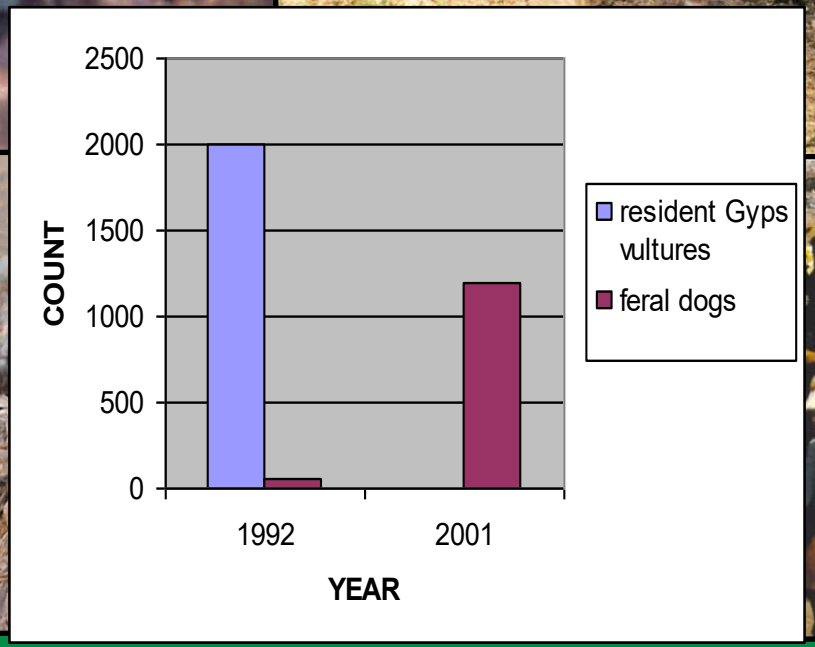




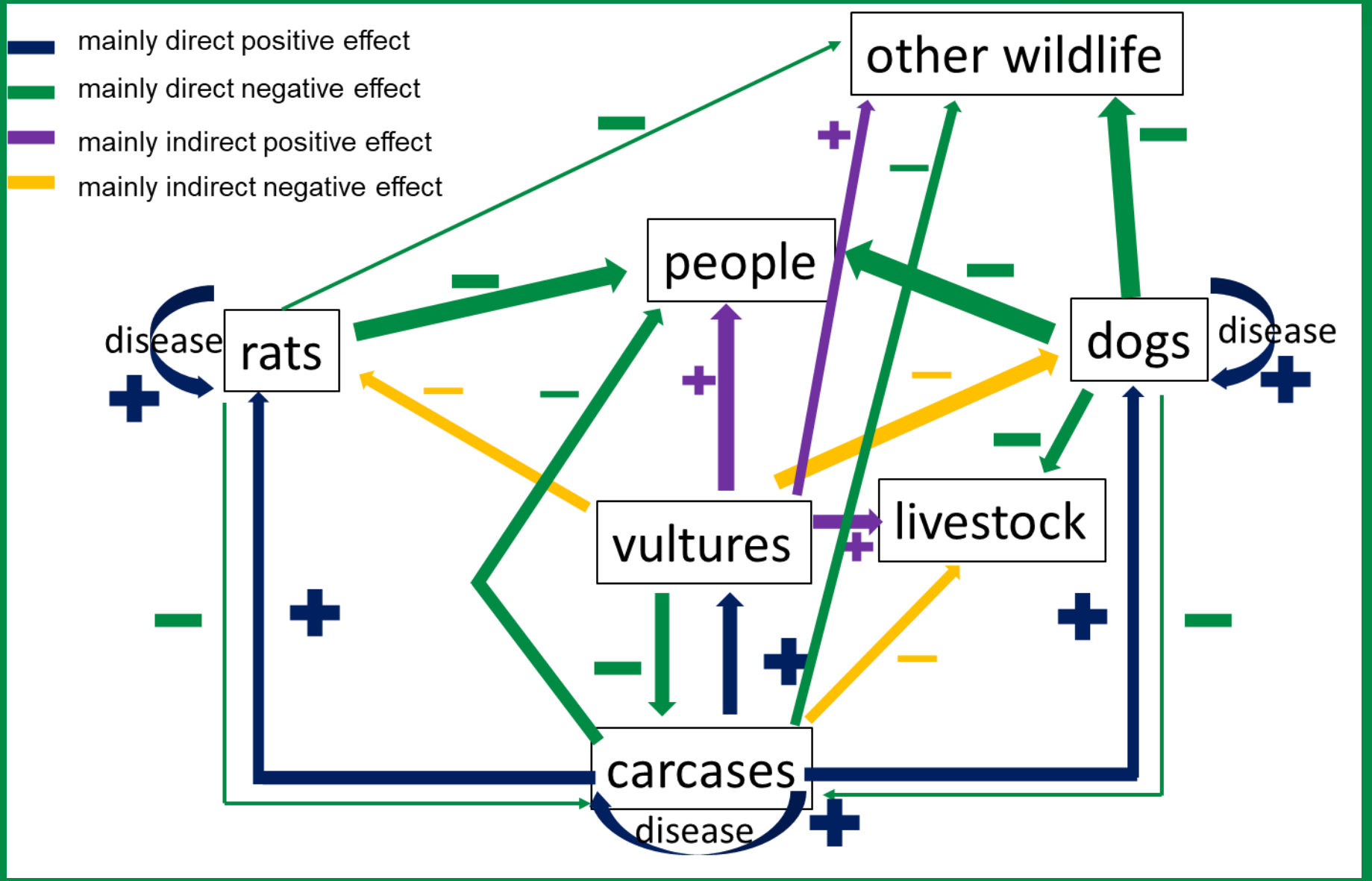
Nationally, there was an average **annual** rate of decline of 43.9% between 2000-2007



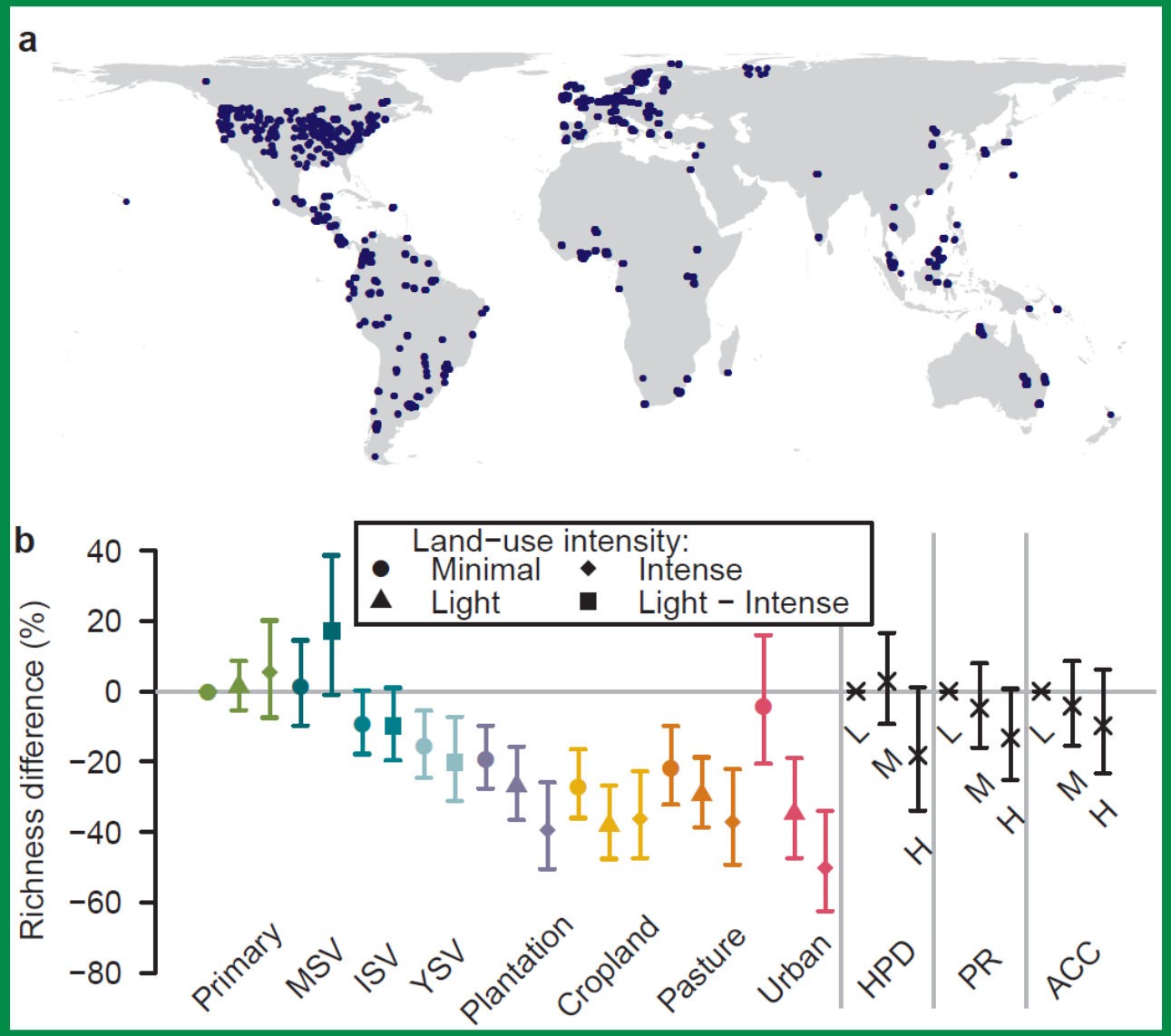
Biodiversity loss due to non-infectious disease

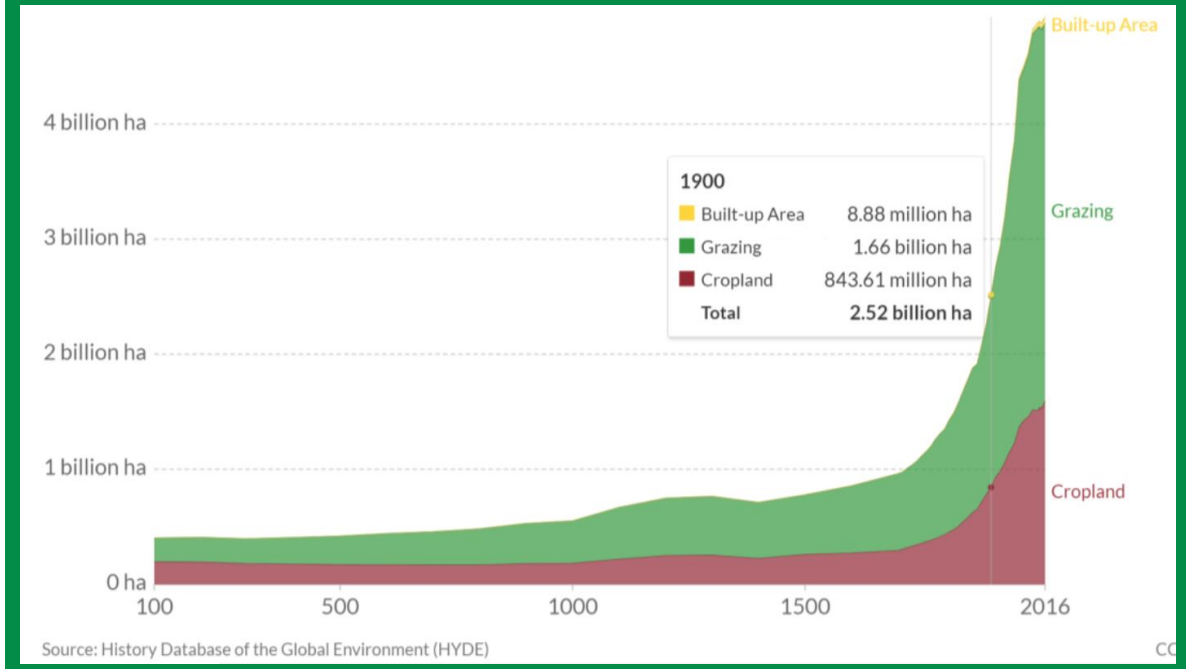


One Health implications of vulture declines in South Asia



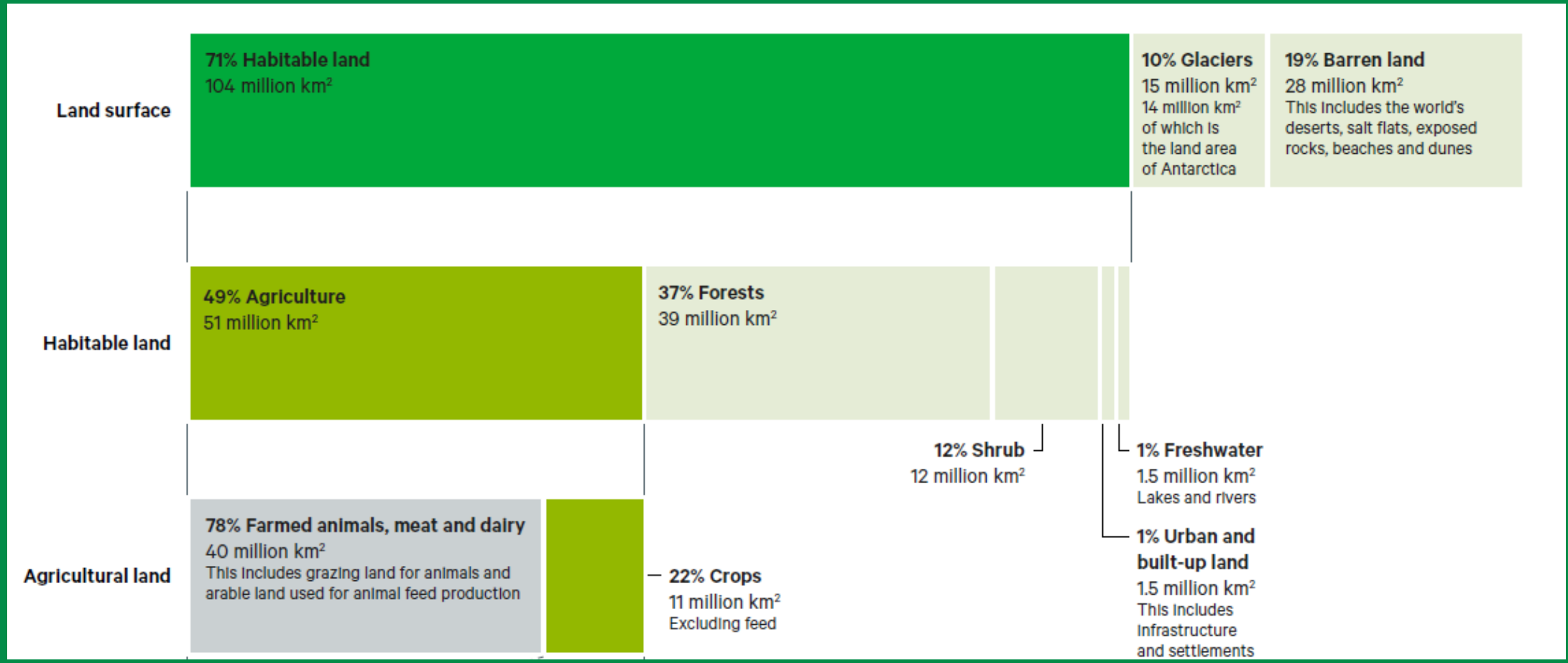
Habitat Loss is the Main Driver of Biodiversity Loss





Newbold et al. *Nature* 2015

Livestock & One Health



Benton et al. Food System Impacts on Biodiversity Loss. Chatham House 2021

Livestock & One Health

Agricultural Land

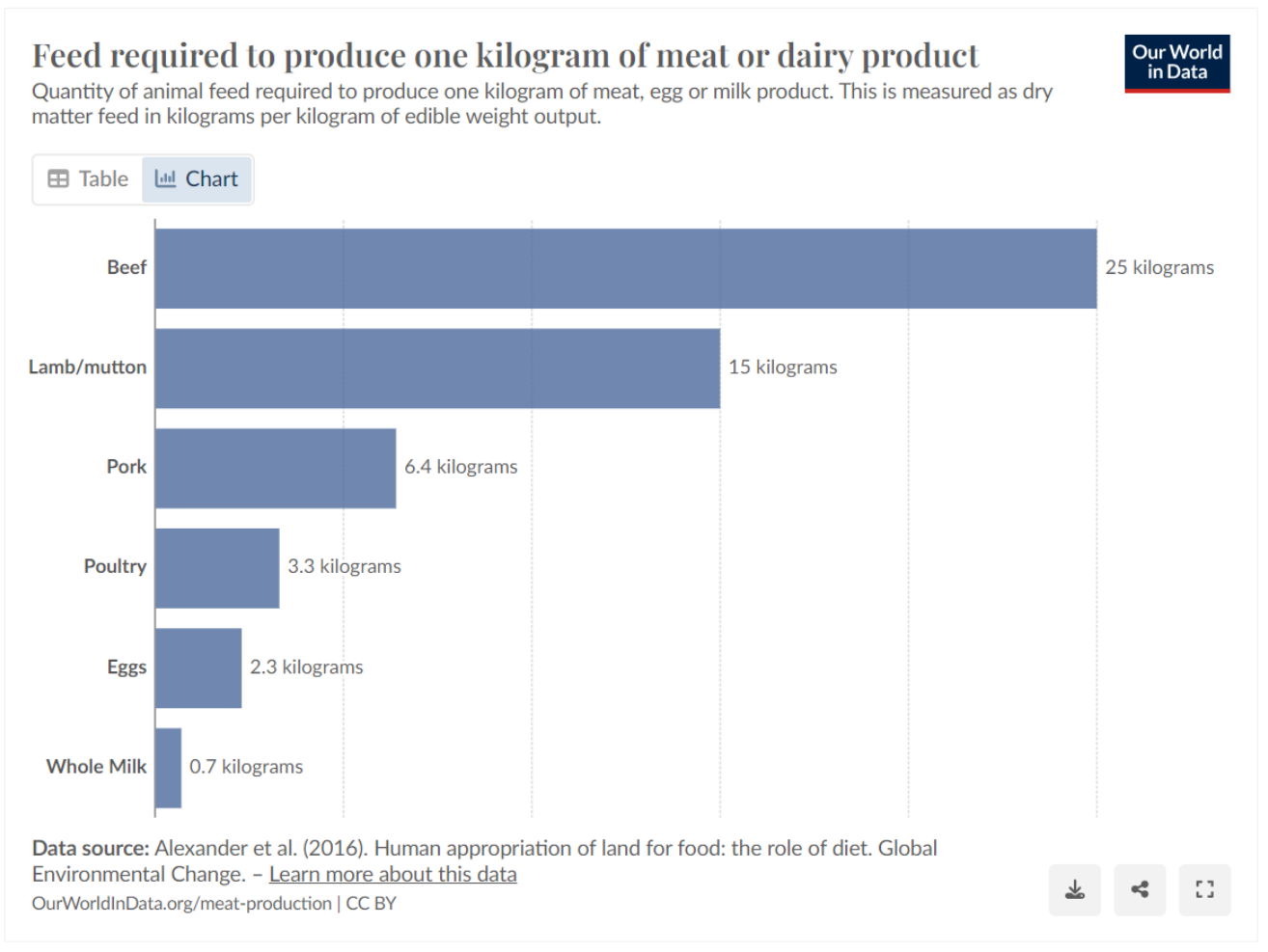
Global protein supply

Global calorie supply

Livestock's Long Shadow, FAO 2006

Benton et al. Food System Impacts on Biodiversity Loss. Chatham House 2021

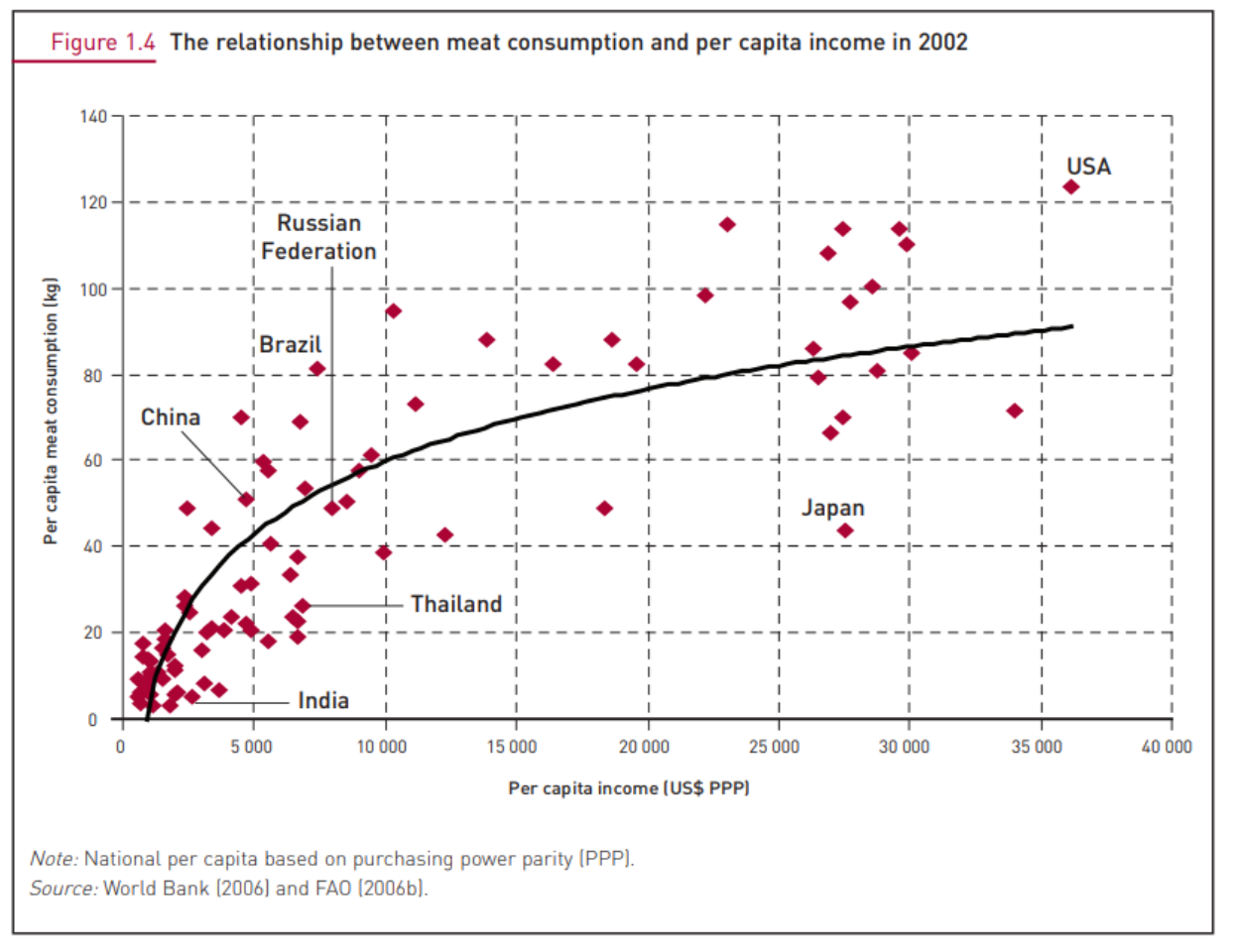
Livestock & One Health

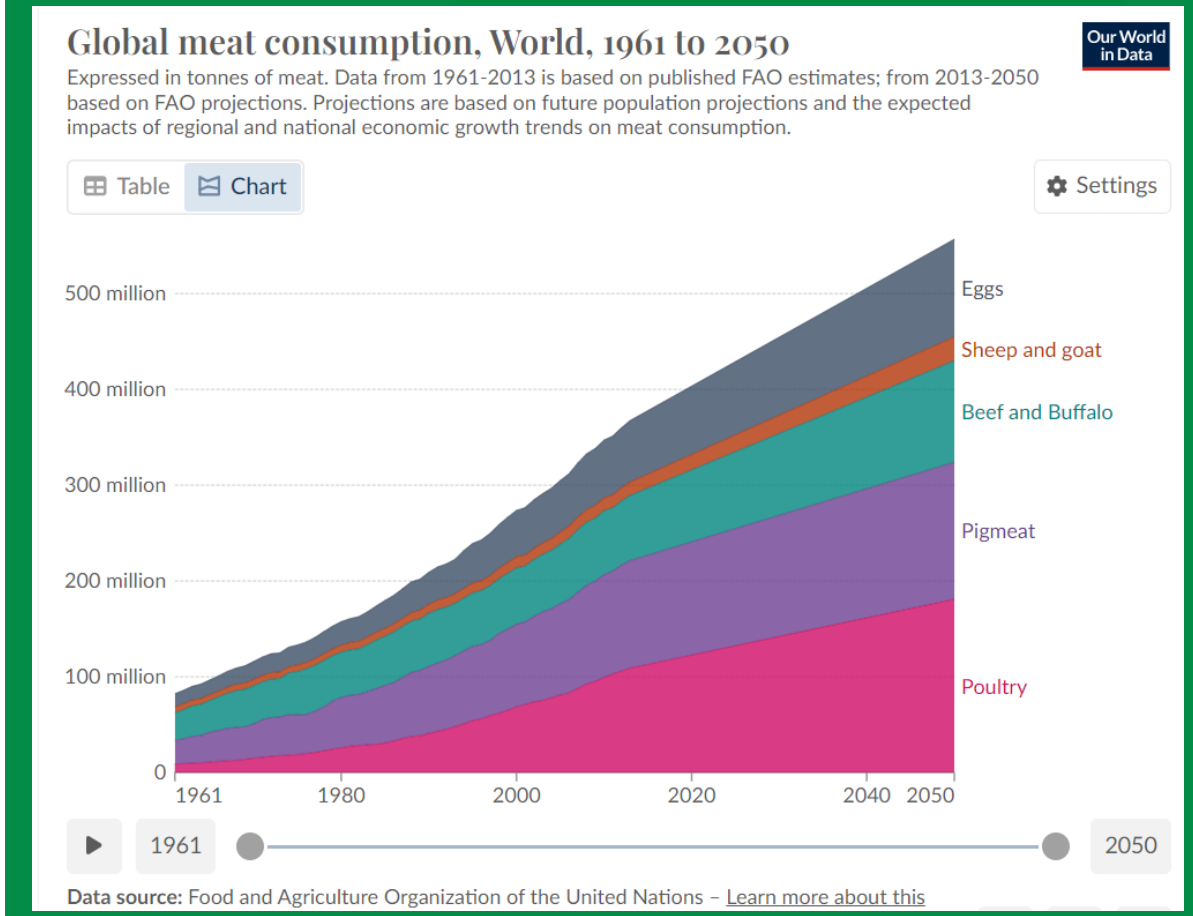


Illegal deforestation for soybean production in Novo Progresso, State of Pará – Brazil 2004

Benton et al. Chatham House 2021
Livestock's Long Shadow, FAO 2006

Livestock & One Health





Meat consumption increases with increasing wealth

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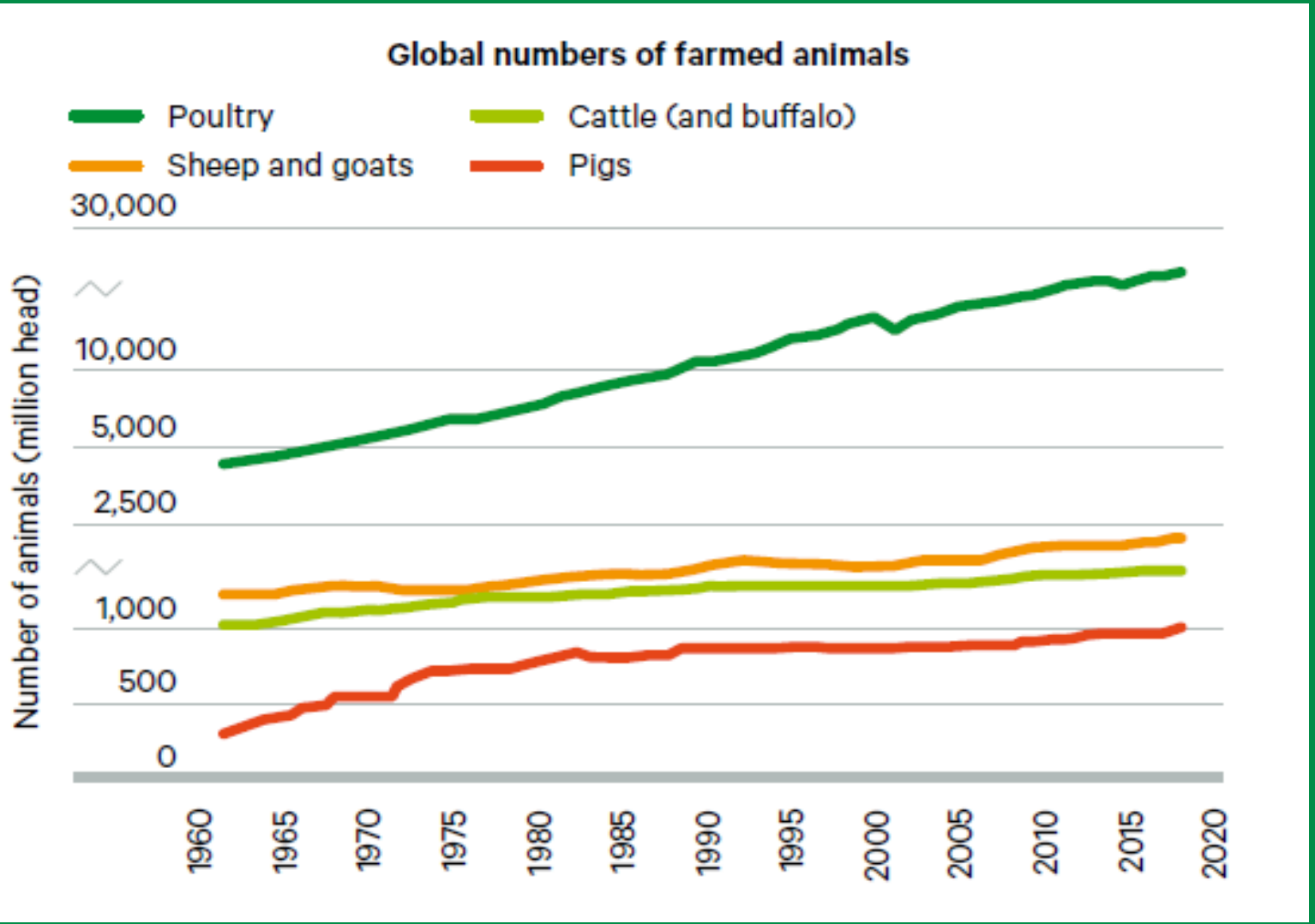

Food and Agriculture Organization of the United Nations (2018), FAOSTAT, www.fao.org/faostat/en/#data/OA

Livestock & One Health

PNAS

Zoonosis emergence linked to agricultural intensification and environmental change

Bryony A. Jones[a,b,1], Delia Grace[b], Richard Kock[c], Silvia Alonso[a], Jonathan Rushton[a], Mohammed Y. Said[b], Declan McKeever[c], Florence Mutua[b], Jarrah Young[b], John McDermott[b], and Dirk Udo Pfeiffer[a]

[a]Veterinary Epidemiology, Economics and Public Health Group and [c]Department of Pathology and Infectious Diseases, Royal Veterinary College, University of London, Hertfordshire AL9 7TA, United Kingdom; and [b]International Livestock Research Institute, Nairobi 00100, Kenya

Edited by Jeffrey Sayer, James Cook University, Cairns, QLD, and accepted by the Editorial Board December 21, 2012 (received for review June 14, 2012)

Intensive pig farming linked to dangerous zoonotic pathogens, study warns

100/100

Geographical and Historical Patterns in the Emergences of Novel Highly Pathogenic Avian Influenza (HPAI) H5 and H7 Viruses in Poultry

*Madhur S. Dhingra [1,2], Jean Artois [1], Simon Dellicour [3], Philippe Lemey [3], Gwenaelle Dauphin [2], Sophie Von Dobschuetz [2], Thomas P. Van Boeckel [4,5], David M. Castellan [6], Subhash Morzaria [2] and Marius Gilbert [1,7]**

frontiers in Veterinary Science

"From 1959 onwards, we identified a total of 39 independent H7 and H5 LPAI to HPAI conversion events. All but two of these events were reported in commercial poultry production systems…"

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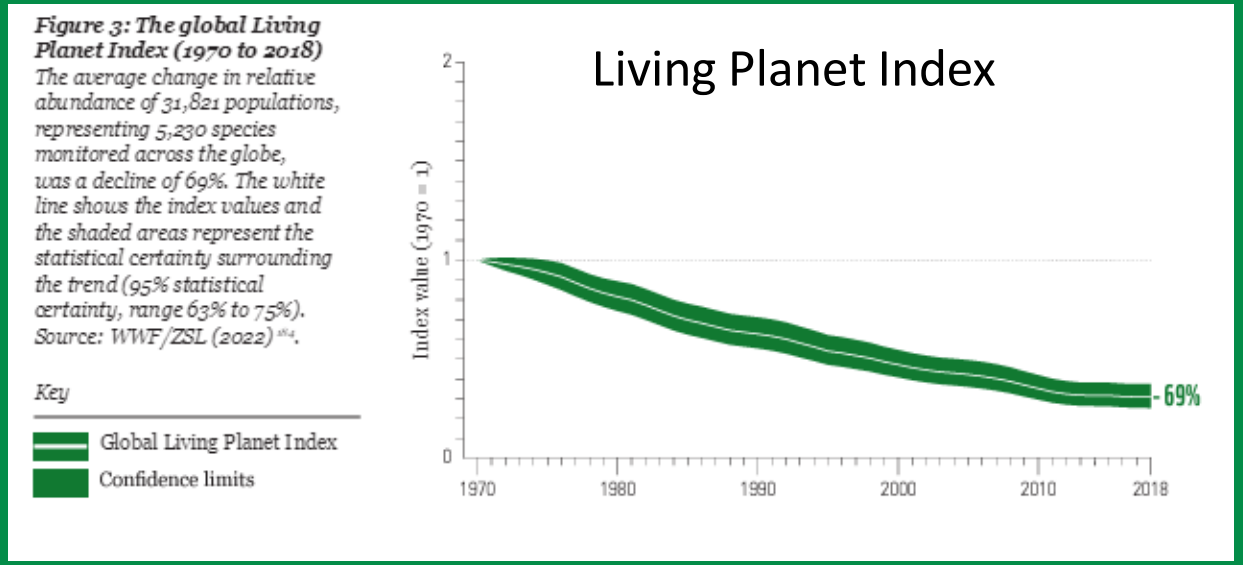
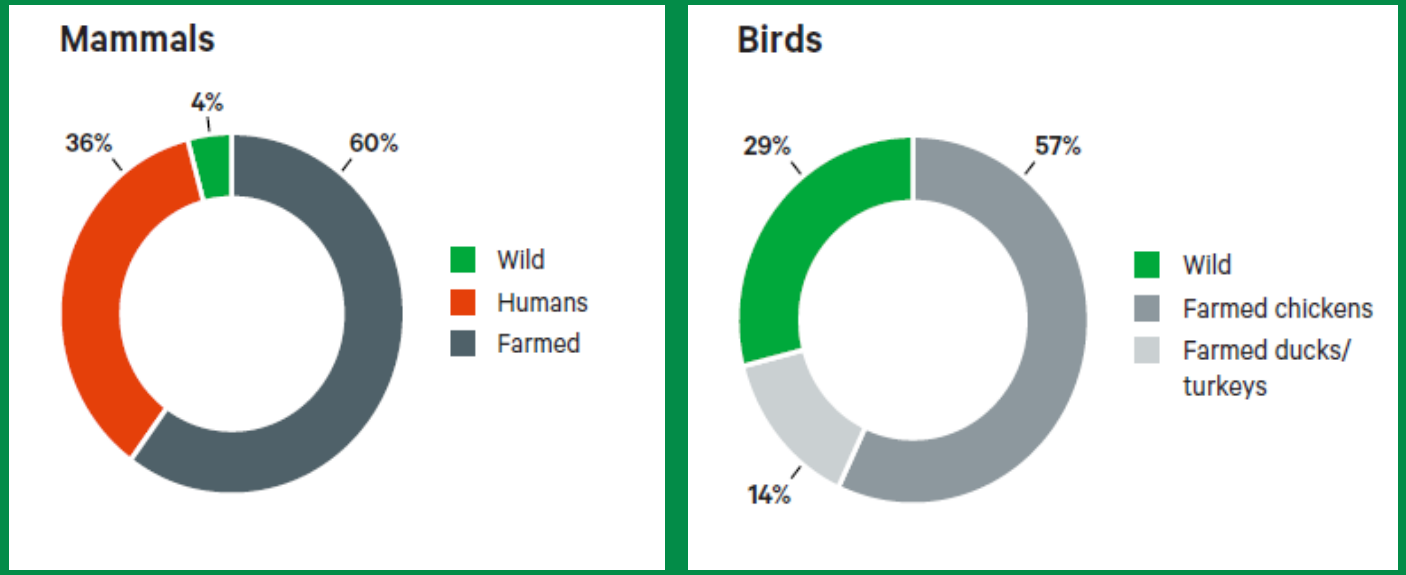
The relative population abundance of monitored mammals, birds, reptiles, amphibians and fish declined, on average, by 69% between 1970 and 2018.



Distribution of global biomass across all mammals and birds



Bar-On et al. *Proc. Natl. Acad. Sci. USA*. 2018

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While land-use change, primarily for agriculture, has been the principal driver of biodiversity loss since pre-industrial times, climate change is becoming an increasingly important factor.

Benton et al. Food System Impacts on Biodiversity Loss.
Chatham House 2021

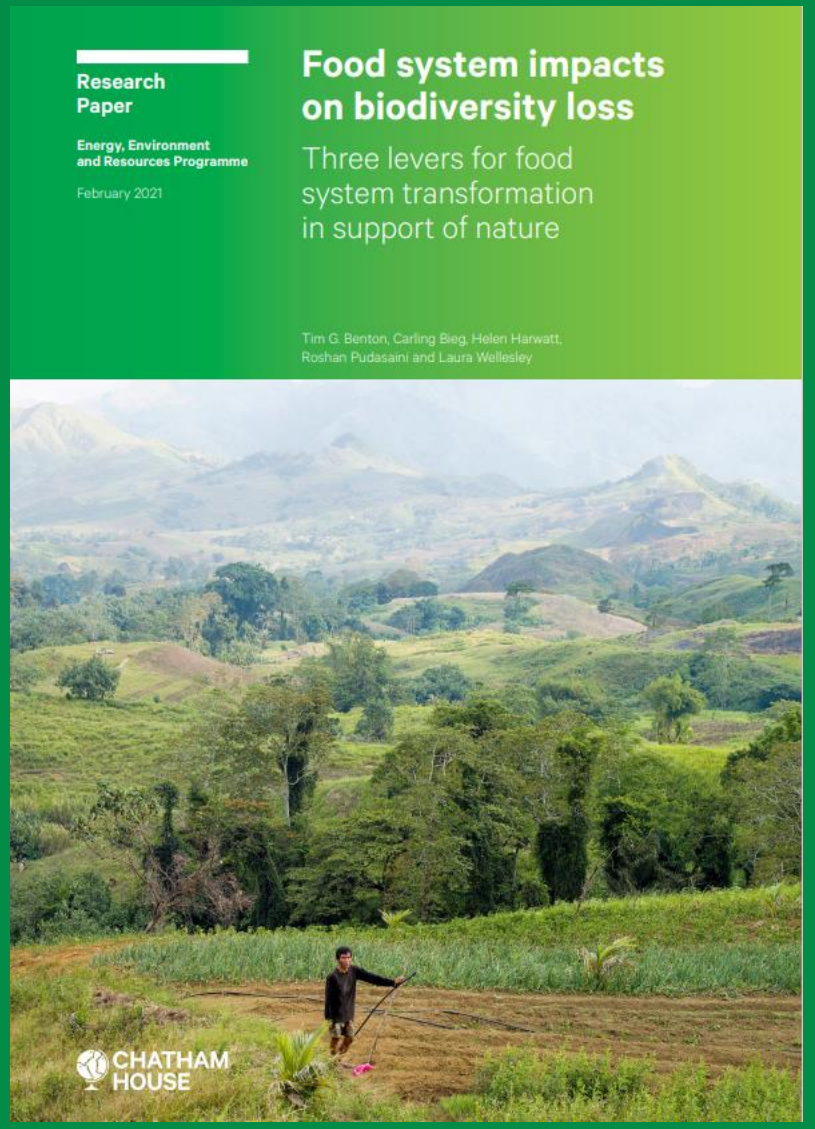
Greenhouse gases

Based on 2010 data, moving from current diets to a diet that excludes animal products reduces:

- food's GHG emissions by 6.6 billion metric tons of CO2eq (a 49% reduction)
- acidification by 50%
- eutrophication by 49%
- scarcity-weighted freshwater withdrawals by 19%

Poore et al. *Science* 2018

Livestock & One Health



- Biodiversity loss will continue to accelerate, unless we change the way we produce food. Further destruction of ecosystems and habitats will threaten our ability to sustain human populations.

- The report calls for an urgent reform of food systems, suggesting three interdependent actions: changing global dietary patterns, protecting and setting aside land for nature, and farming in a more nature-friendly and biodiversity-supporting way.

- Policy makers are urged to take a system-wide approach to account for the impacts of food systems, develop global guidance for change, and translate this to national targets.

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Compared to 2010 (as a reference year), moving from current diets to a diet that excludes animal products would reduce the amount of land used for food production by 3.1 billion ha (a 76% reduction).

That's equivalent to the area of the USA, EU (2018), Australia and China combined.

Poore et al. *Science* 2018

Biodiversity, Agriculture & One Health

Biodiversity, agriculture and safeguarding public health are inextricably linked through a range of complex ecological and socio-economic pathways.

One Health implementation includes the promotion of biodiversity conservation and restoration (e.g. rewilding) to improve human, wildlife and ecosystem health.

For infectious disease threats to people and to wildlife, eradication often is impossible by the time the infection has been identified. For non-infectious threats, reversal may be impossible or may take many years, decades or centuries.

Prevention is much easier and cheaper than cure.

Human society still hasn't learned the lessons of current and previous wildlife and human disease threats, no matter how devastating these have been.