A Planet and its People under Pressure

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8 April 2013

York Environmental Sustainability Institute

Outline

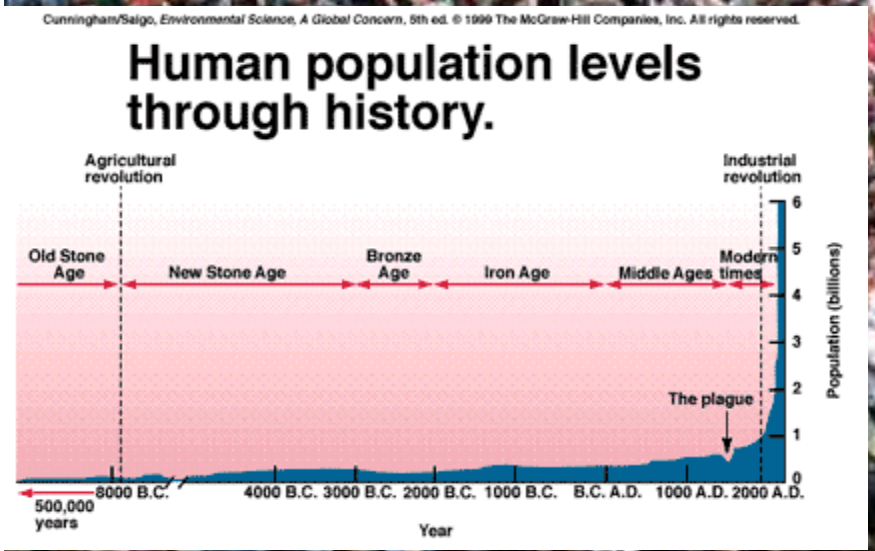
- Trends in population and consumption
- Impacts on biodiversity and ecosytems
- Why does it matter?
- What can be done?

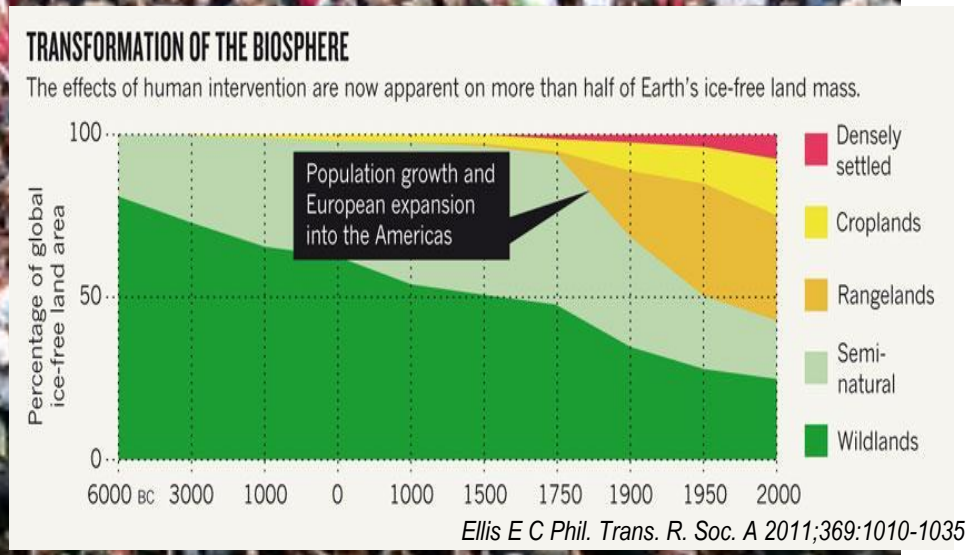
The number of people on earth…

.. has been growing rapidly, more are expected....

....as a species we dominate the planet...

Cunningham/Saigo, *Environmental Science, A Global Concern*, 5th ed. © 1999 The McGraw-Hill Companies, Inc. All rights reserved.





Ellis E C Phil. Trans. R. Soc. A 2011;369:1010-1035

Why is this a concern?

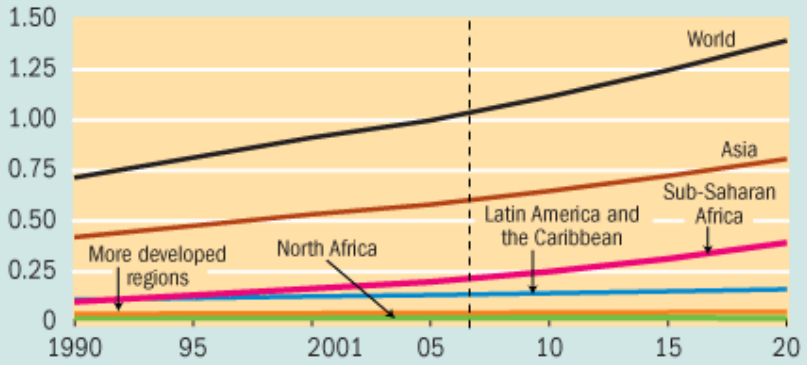
1. People are increasingly living in dense, overcrowded conditions……..

Chart 5

The growth of slums

More than one in every seven human beings now lives in an urban slum.

(slum population, billions)



Source: UN-HABITAT, Global Urban Observatory database (2005).

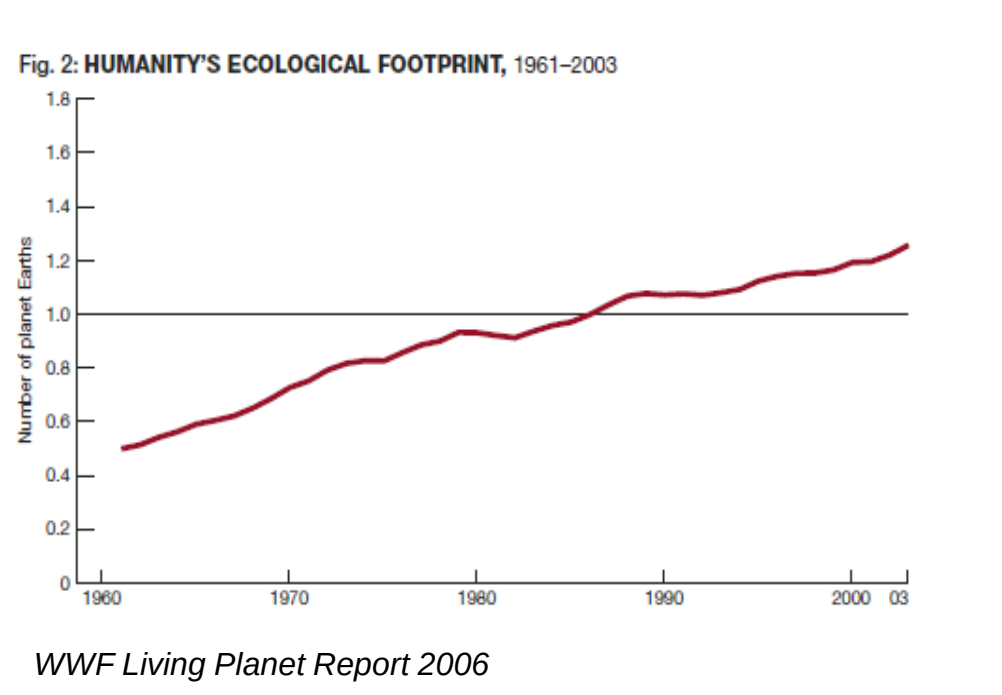
Note: Figures for 1995 are interpolated using estimates for 1990 and 2001. Figures for 2005 are projections; Australia, New Zealand, and Japan are included in the more developed regions.

- Overcrowding:
- Mental health problems
- Poor health and diseases (e.g. tuberculosis)
- In urban areas, almost 137 million people have no access to safe drinking water, and more than 600 million do not have adequate sanitation

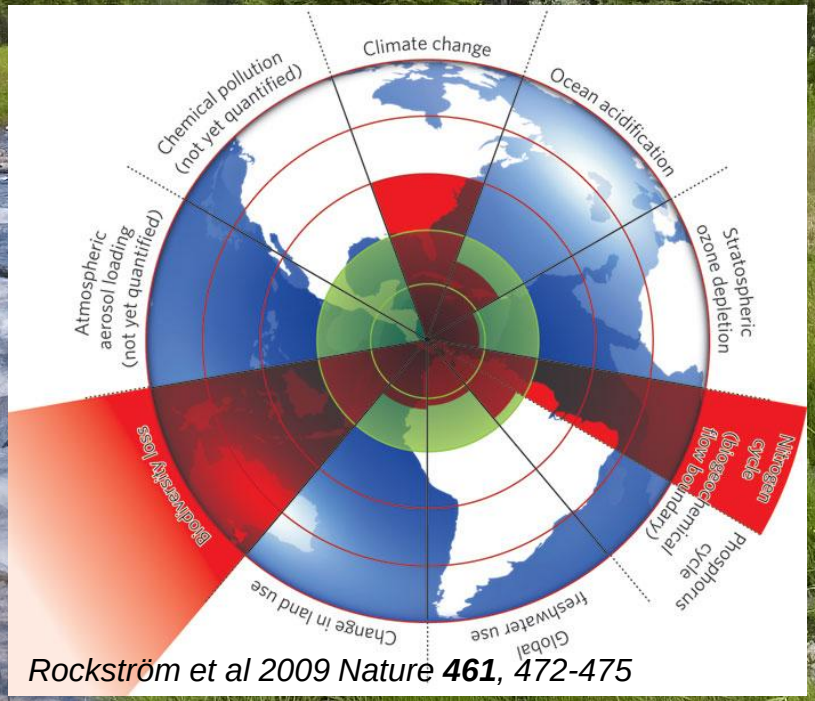
Infant mortality rate MDG is not on target

Why is this a concern?

2. We are reaching environmental limits.....

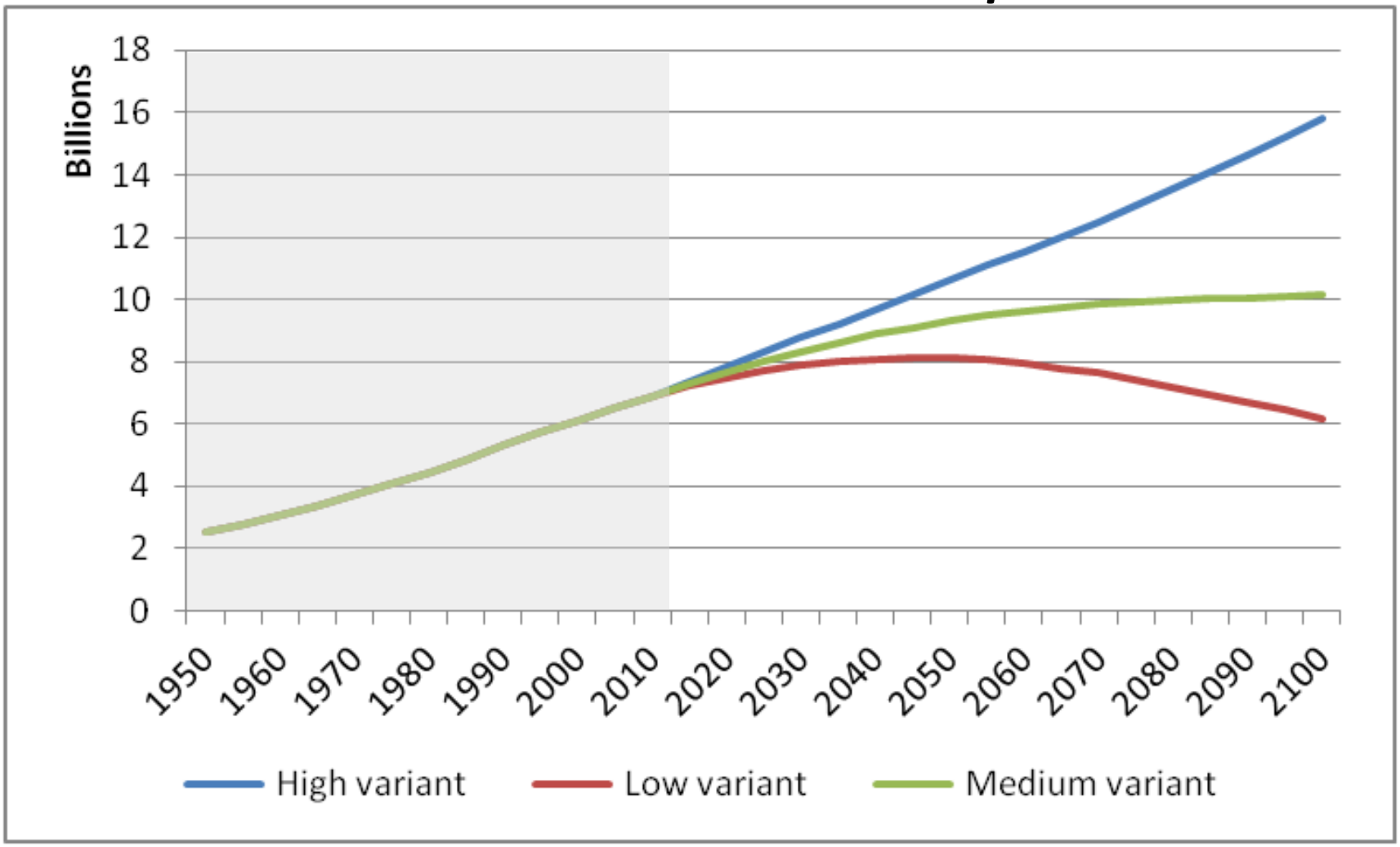


WWF Living Planet Report 2006



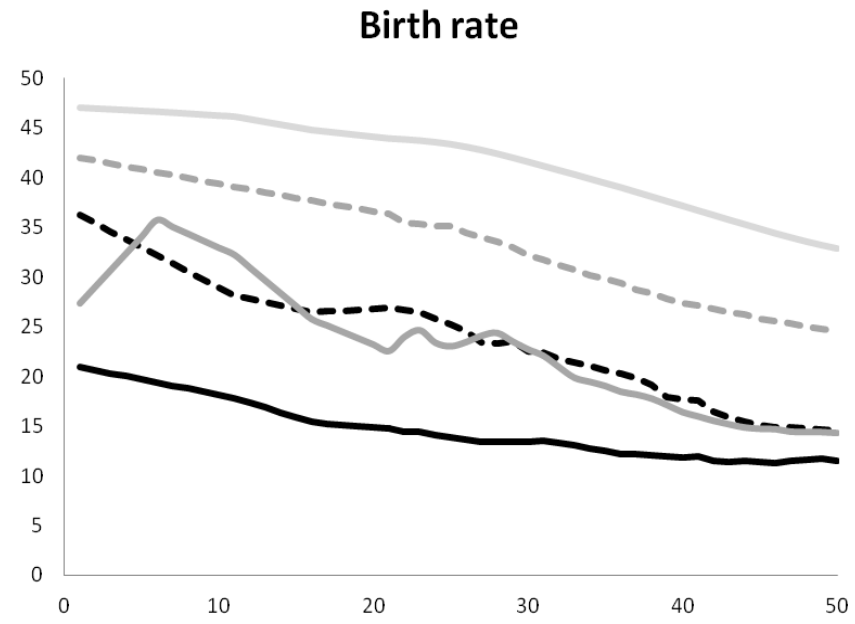
*Rockström et al 2009 Nature **461**, 472-475*

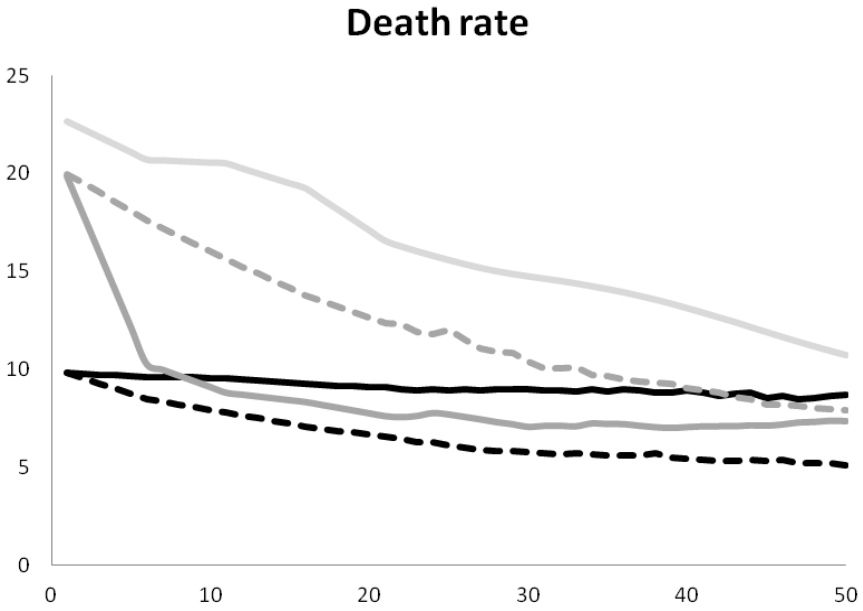
Human population numbers 1950-2100: observed and predicted

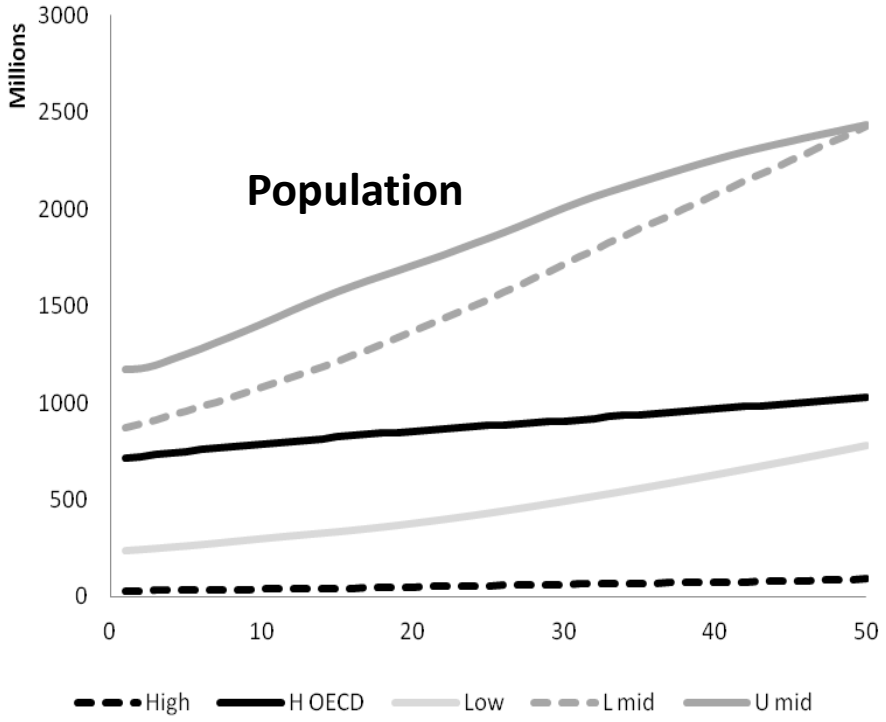


UN Population Division *World Population Prospects, the 2010 Revision*

Population change 1960-2010

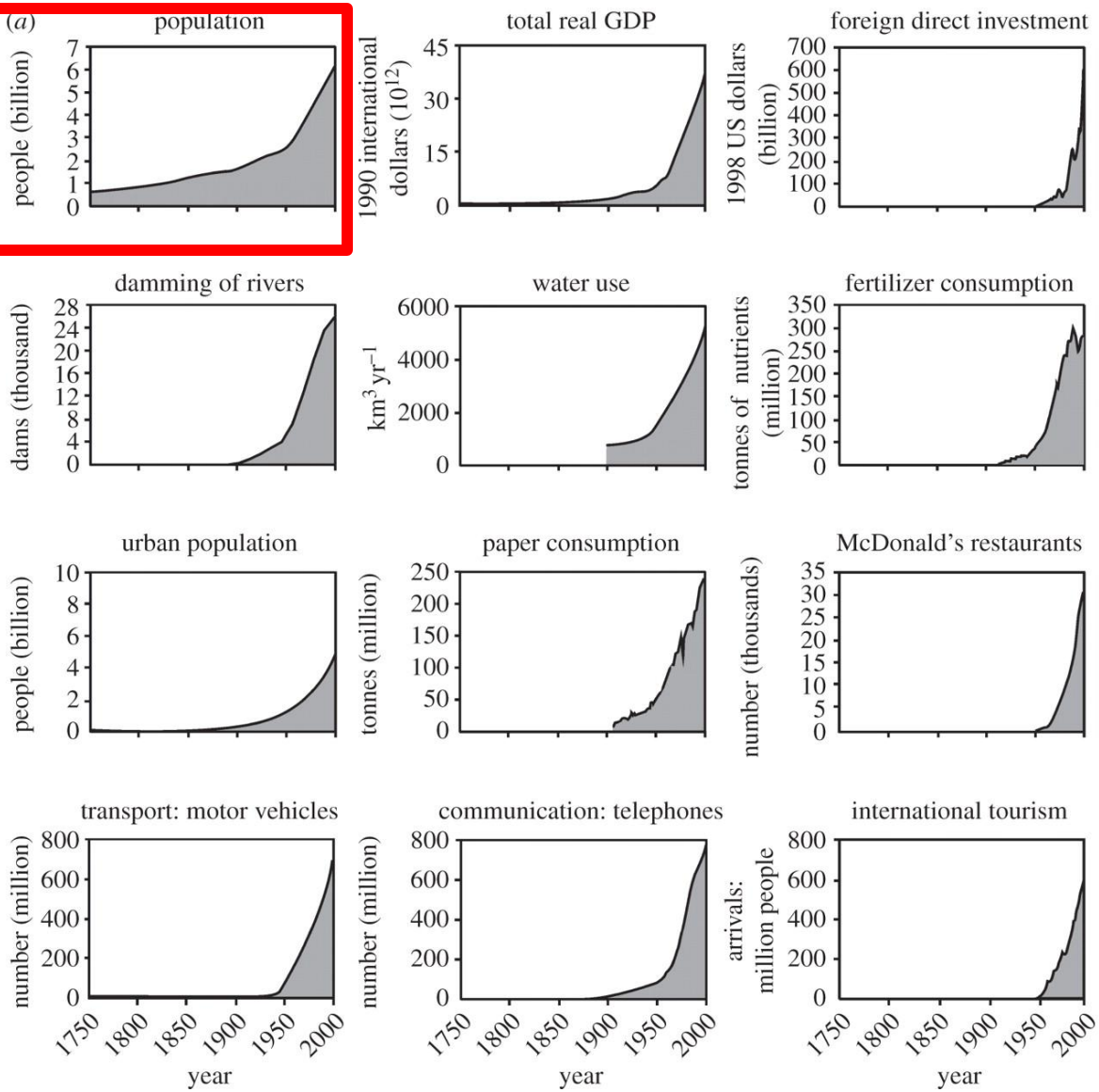






Gross birth and death rates per 1000 population from United Nations Population Division databank

The increasing rates of change in human activity since the beginning of the Industrial Revolution.



Steffen W et al. Phil. Trans. R. Soc. A 2011;369:842-867

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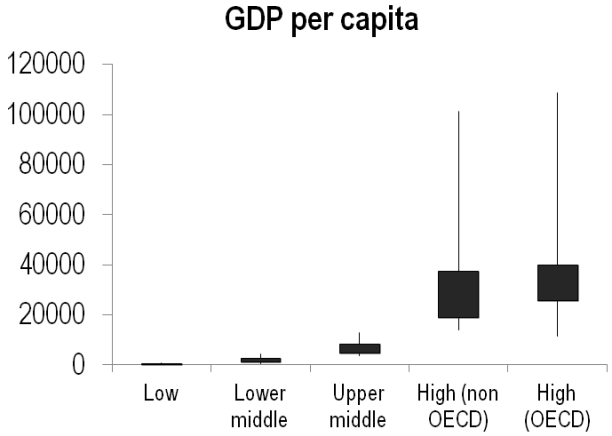
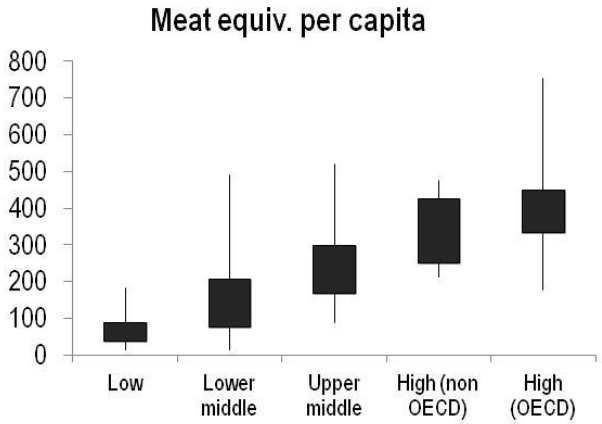
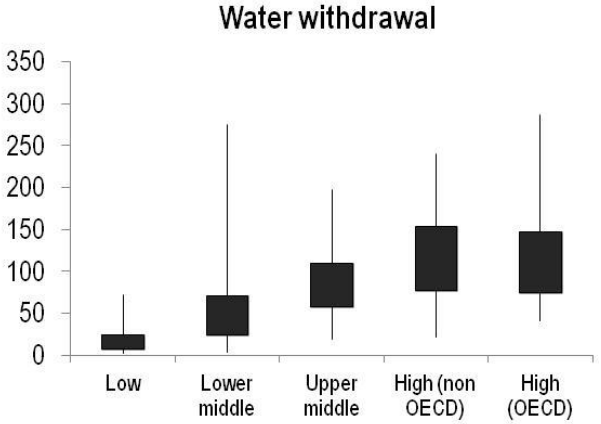
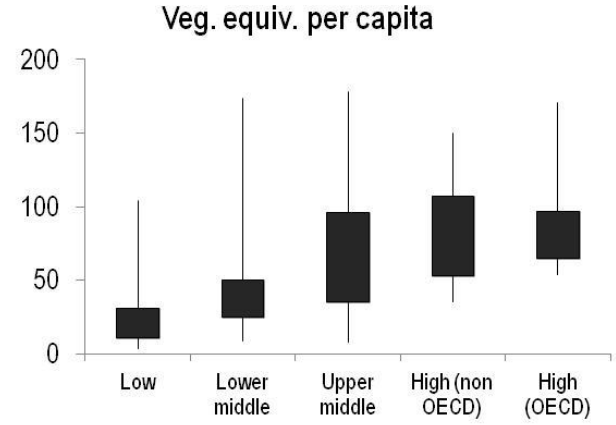
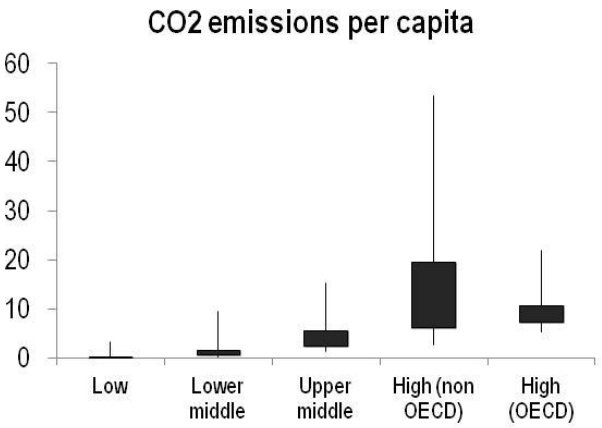
PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A

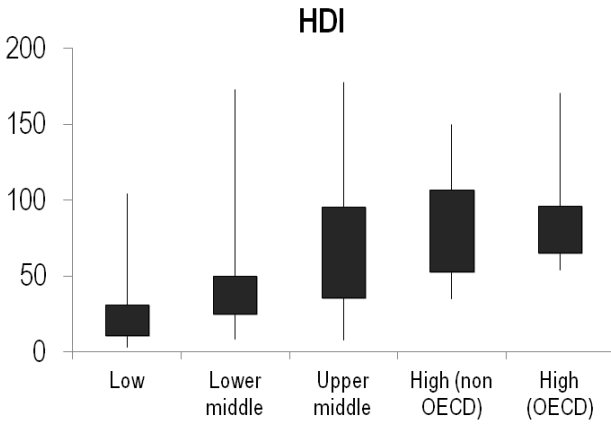






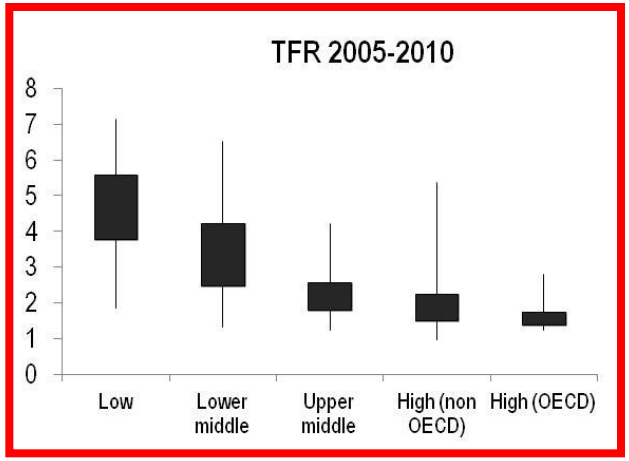




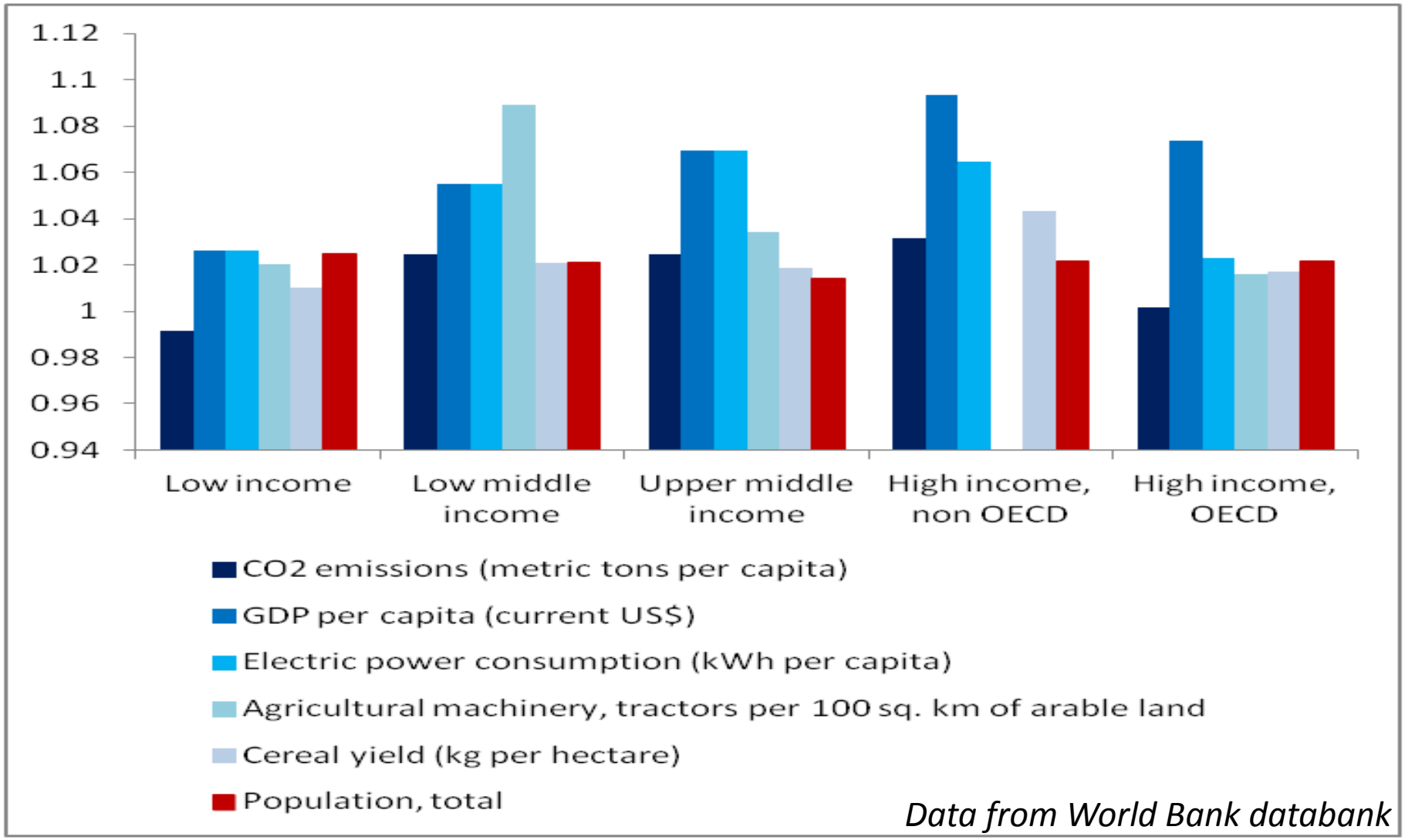


An unequal world

Consumption and population growth rates vary greatly across countries according to income groups



Consumption and population: Annual rates of change 1970-2005



Data from World Bank databank

Pressures on the Earth must increase...

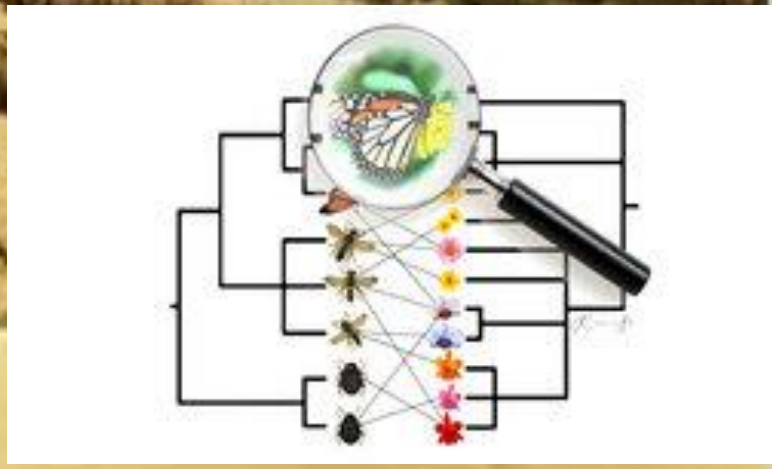
- People already dominate the Earth and manage it for immediate needs, especially food, energy and water.
- Population numbers are still increasing.
- Consumption is growing faster than population numbers, especially in developing countries where poor living standards must improve.
- Land use change continues and climate change impacts are yet to come.

We are going to need more environmental resources, for more people, distributed more equitably, in a changing environment.

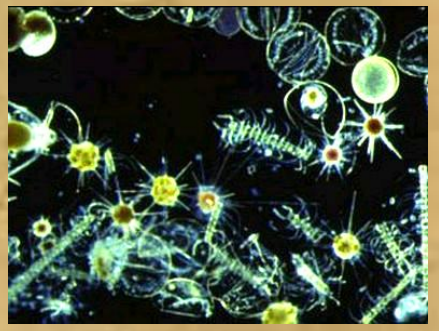
IMPACTS ON BIODIVERSITY AND ECOSYSTEMS

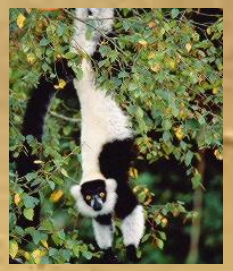
What is biodiversity?

- The variety of life
- at all levels…
- …. genes, populations, species and ecosystems…
- …. land, water and air.
- …. and the interactions between living things



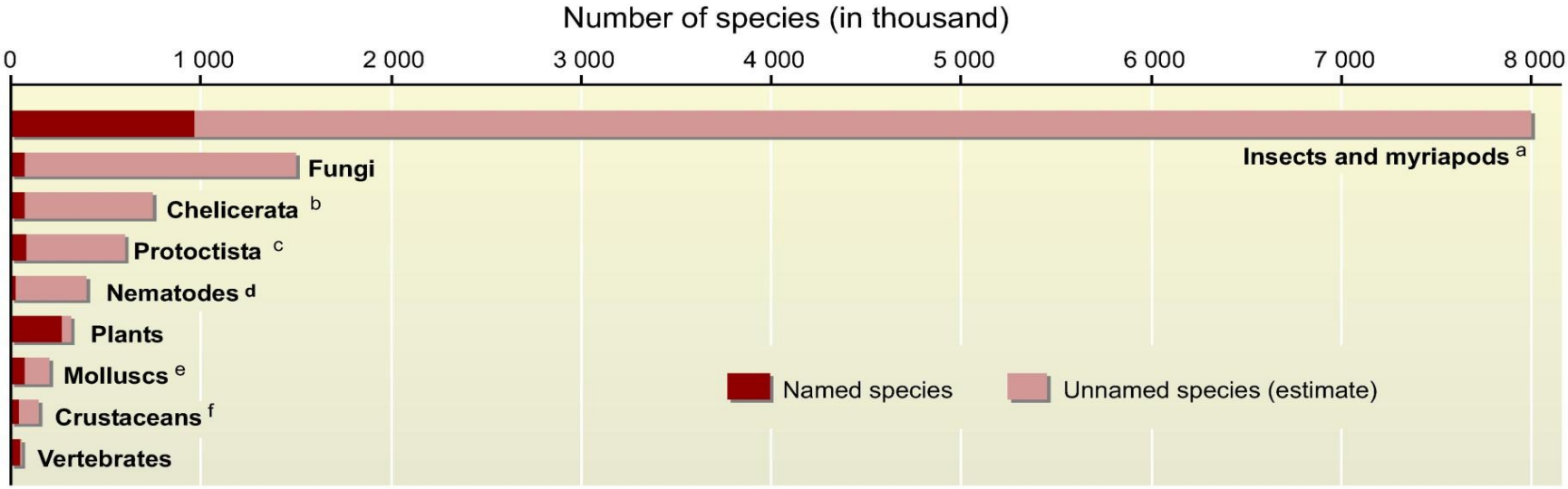
From the definition in the Convention on Biological Diversity





How many species are there?

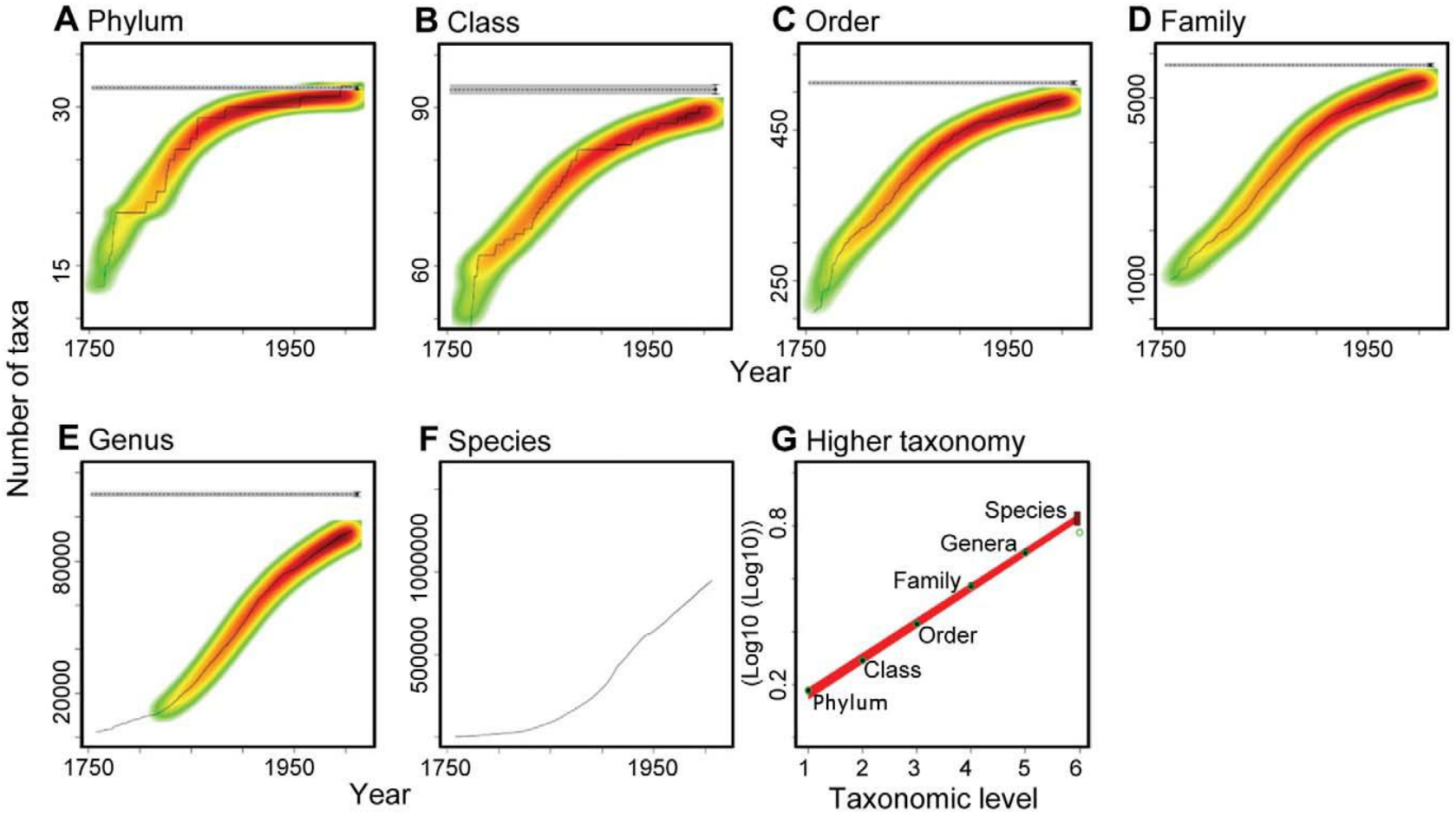
Our knowledge of the world's species is far from complete. We don't even know how many there are and we've described less than one tenth



a Myriapods: centipedes and millipedes
b Arachnids
c Algae, slime mold, amoeboids, and other single-celled organisms (excluding bacteria)
d Roundworms
e Snails, clams, squids, octopuses and kin
f Barnacles, copepods, crabs, lobsters, shrimps, krill and kin

Source: Millennium Ecosystem Assessment

Estimates based on consistent taxonomic patterns



Accumulation curves for taxonomic levels from Phyla to species

Mora et al (2011) PLoS Biology

Analysing this pattern for all kingdoms of life on Earth predicts 8.7 million (~1.2 million SE) species globally, of which 2.2 million (~0.18 million SE) are marine.

86% of the species on Earth, and 91% in the ocean, still await description.

Table 2. Currently catalogued and predicted total number of species on Earth and in the ocean.

Species	Earth			Ocean		
	Catalogued	Predicted	±SE	Catalogued	Predicted	±SE
Eukaryotes						
Animalia	953,434	7,770,000	958,000	171,082	2,150,000	145,000
Chromista	13,033	27,500	30,500	4,859	7,400	9,640
Fungi	43,271	611,000	297,000	1,097	5,320	11,100
Plantae	215,644	298,000	8,200	8,600	16,600	9,130
Protozoa	8,118	36,400	6,690	8,118	36,400	6,690
Total	1,233,500	8,740,000	1,300,000	193,756	2,210,000	182,000
Prokaryotes						
Archaea	502	455	160	1	1	0
Bacteria	10,358	9,680	3,470	652	1,320	436
Total	10,860	10,100	3,630	653	1,320	436
Grand Total	**1,244,360**	**8,750,000**	**1,300,000**	**194,409**	**2,210,000**	**182,000**

Mora et al (2011) PLoS Biology

Image courtesy of Global Mountain Biodiversity Assessment
www.diversitas-international.org/activities/research/global-mountain

Evolution Lost

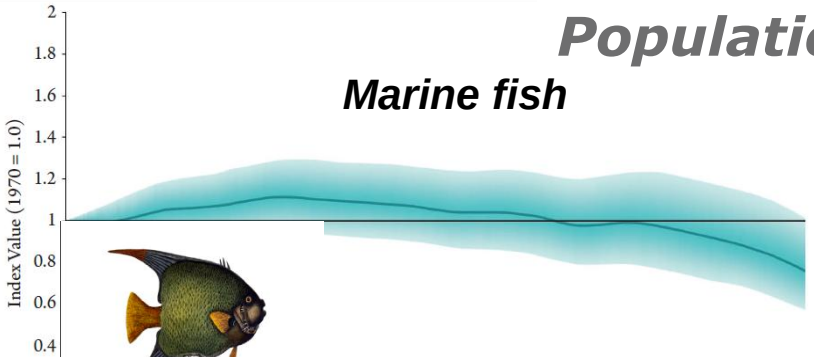
Status and Trends of the World's Vertebrates

Jonathan E. M. Baillie, Janine Griffiths, Samuel T. Turvey, Jonathan Loh and Ben Collen

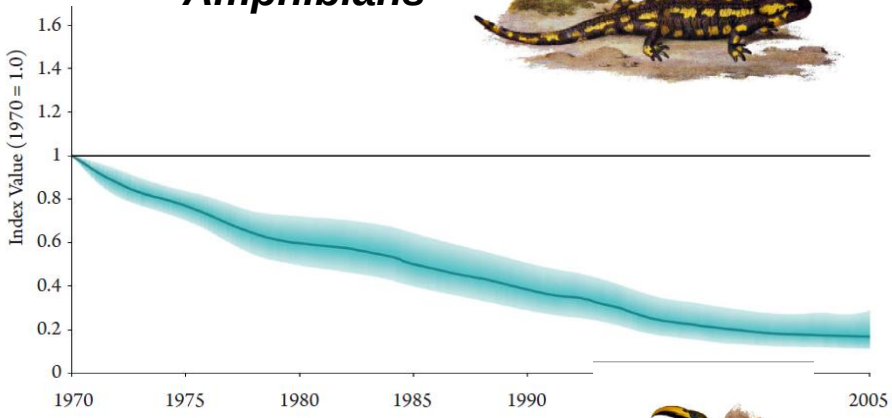
ZSL LIVING CONSERVATION
IUCN
SSC Species Survival Commission
WWF
BirdLife
NatureServe
Conservation International
Sapienza

Population declines

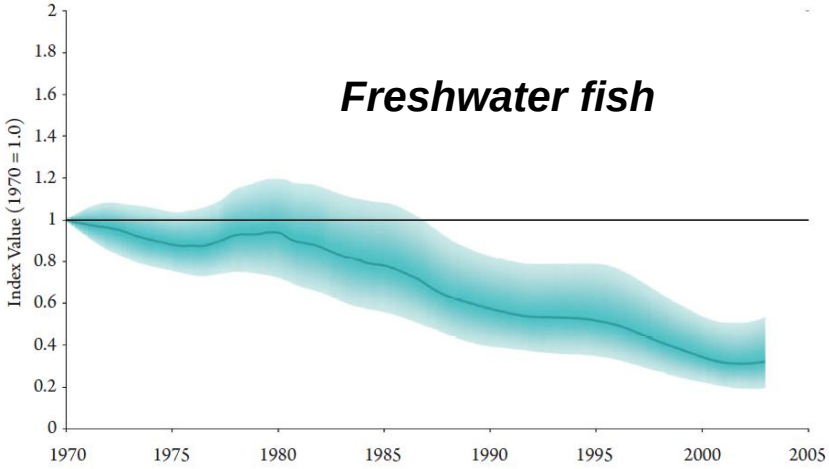
Marine fish



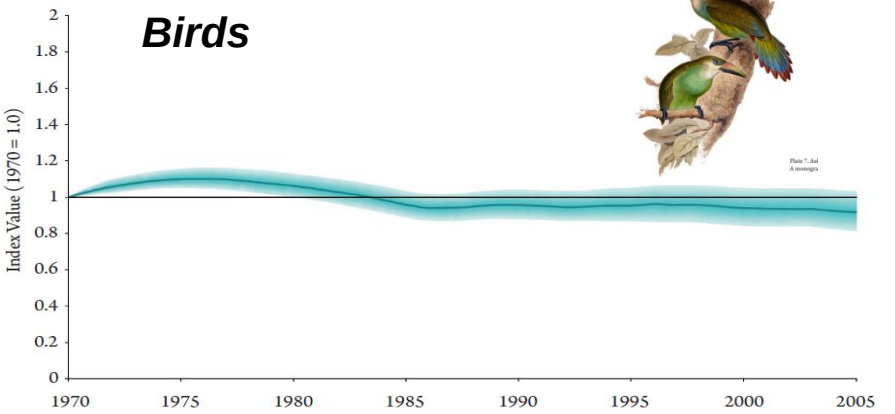
Amphibians



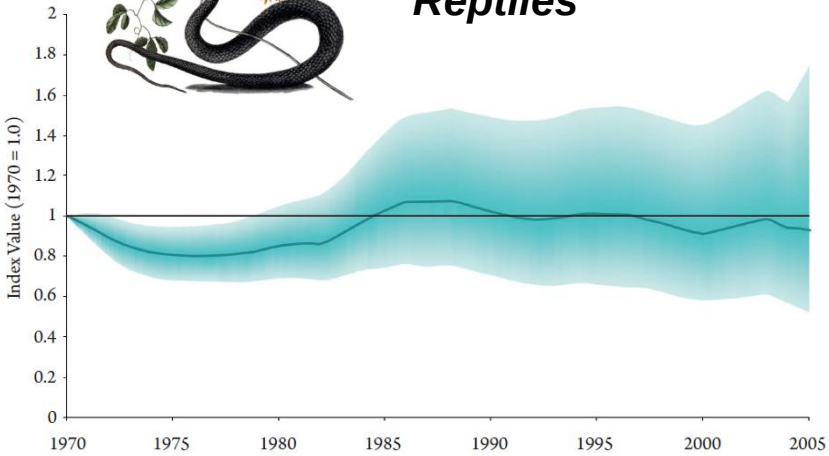
Freshwater fish



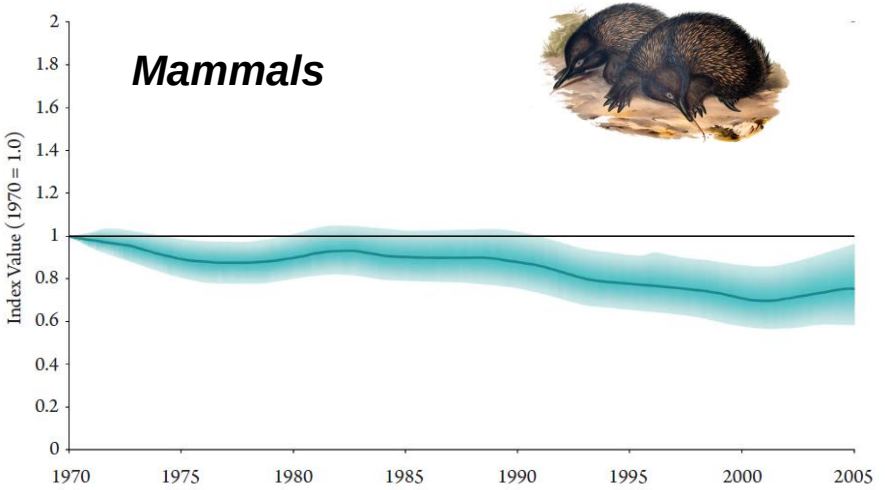
Birds



Reptiles



Mammals



Known extinctions since 1500

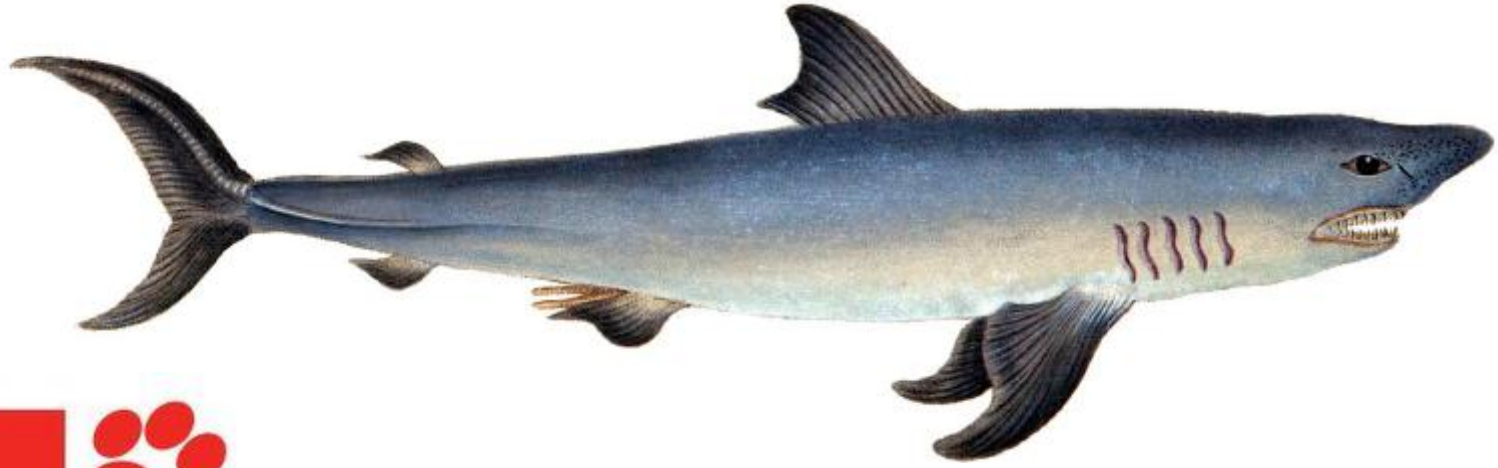
Background levels of extinction are high though knowledge is far from complete

	Number of Extinct species (including Extinct in the Wild)	Number of species assessed
Vertebrates	381	26,604
Invertebrates	372	6,161
Plants	115	12,055

http://www.iucnredlist.org/

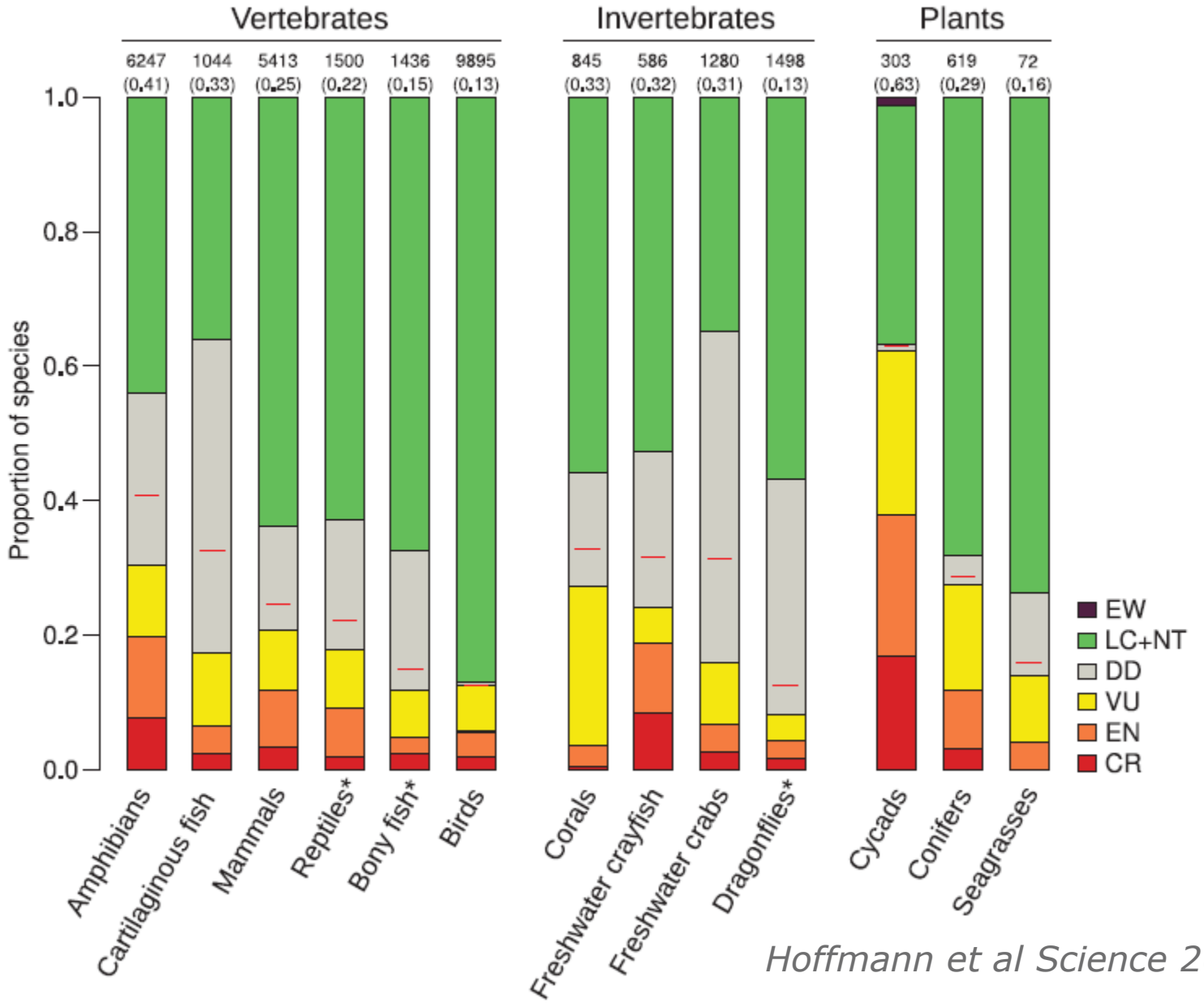
IUCN Red List 2008

Over 11,000 vertebrates threatened with extinction
- based on IUCN Red List

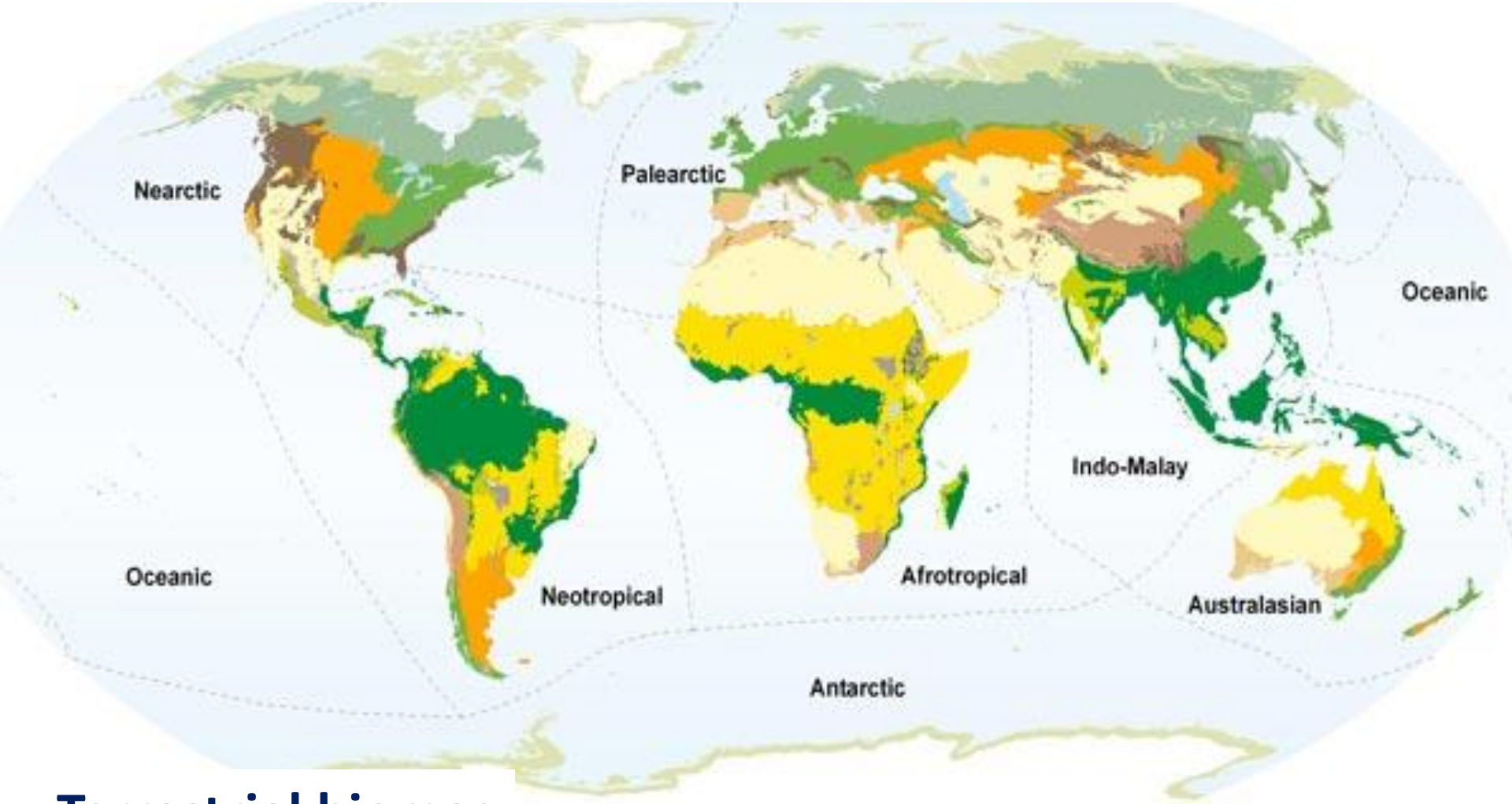


www.iucnredlist.org

Extinction risk for all assessed groups



Hoffmann et al Science 2010



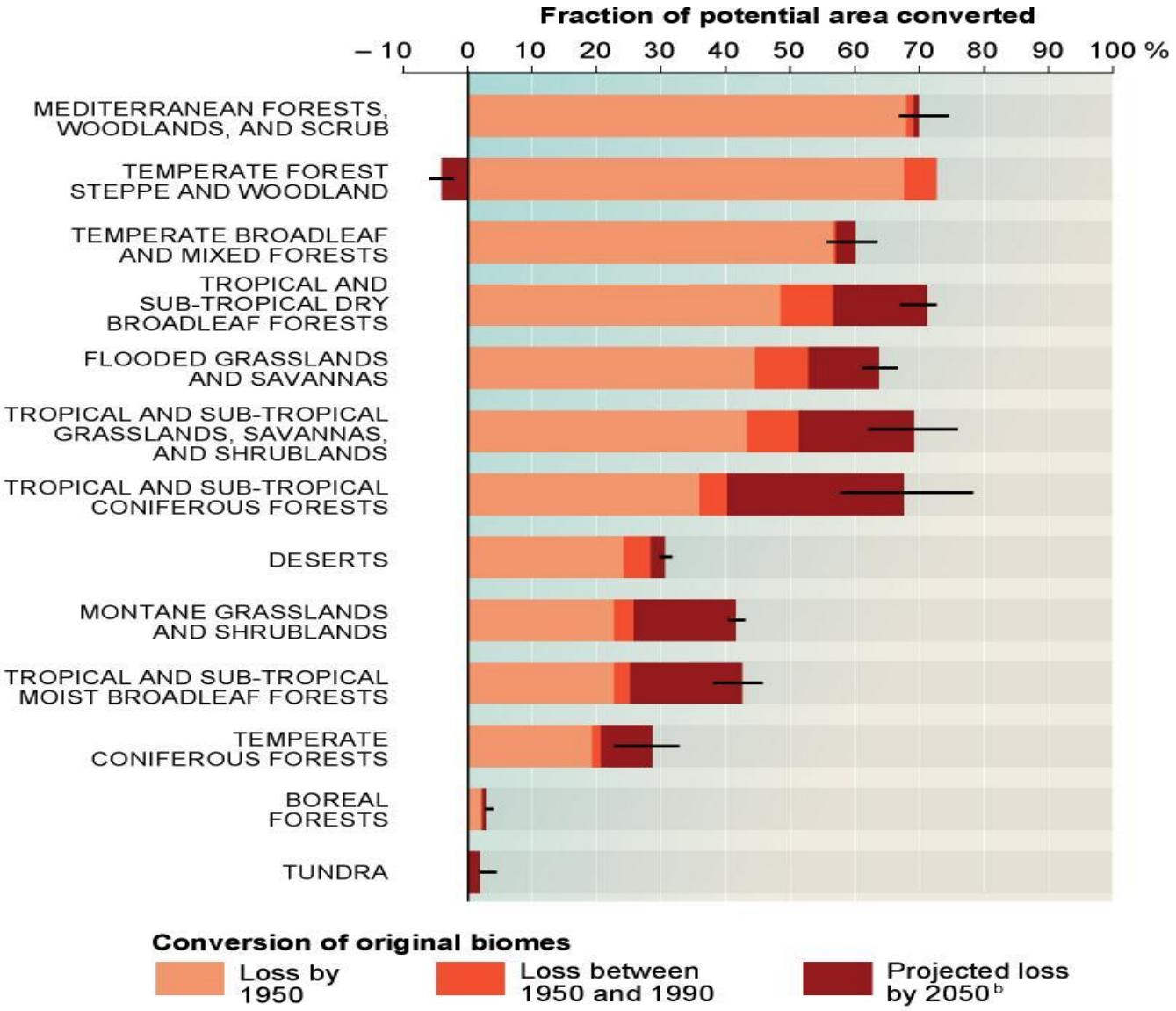
Terrestrial biomes

- Tropical and sub-tropical moist broadleaf forests
- Tropical and sub-tropical dry broadleaf forests
- Tropical and sub-tropical coniferous forests
- Temperate broadleaf and mixed forests
- Temperate coniferous forests
- Boreal forests / Taiga
- Tundra
- Mediterranean forests, woodlands, and scrub
- Tropical and sub-tropical grasslands, savannas, and shrublands
- Temperate grasslands, savannas, and shrublands
- Montane grasslands and shrublands
- Flooded grasslands and savannas
- Mangroves
- Deserts and Xeric shrublands
- Rock and ice

Realm boundaries

Source: Millennium Ecosystem Assessment

Conversion of the biomes

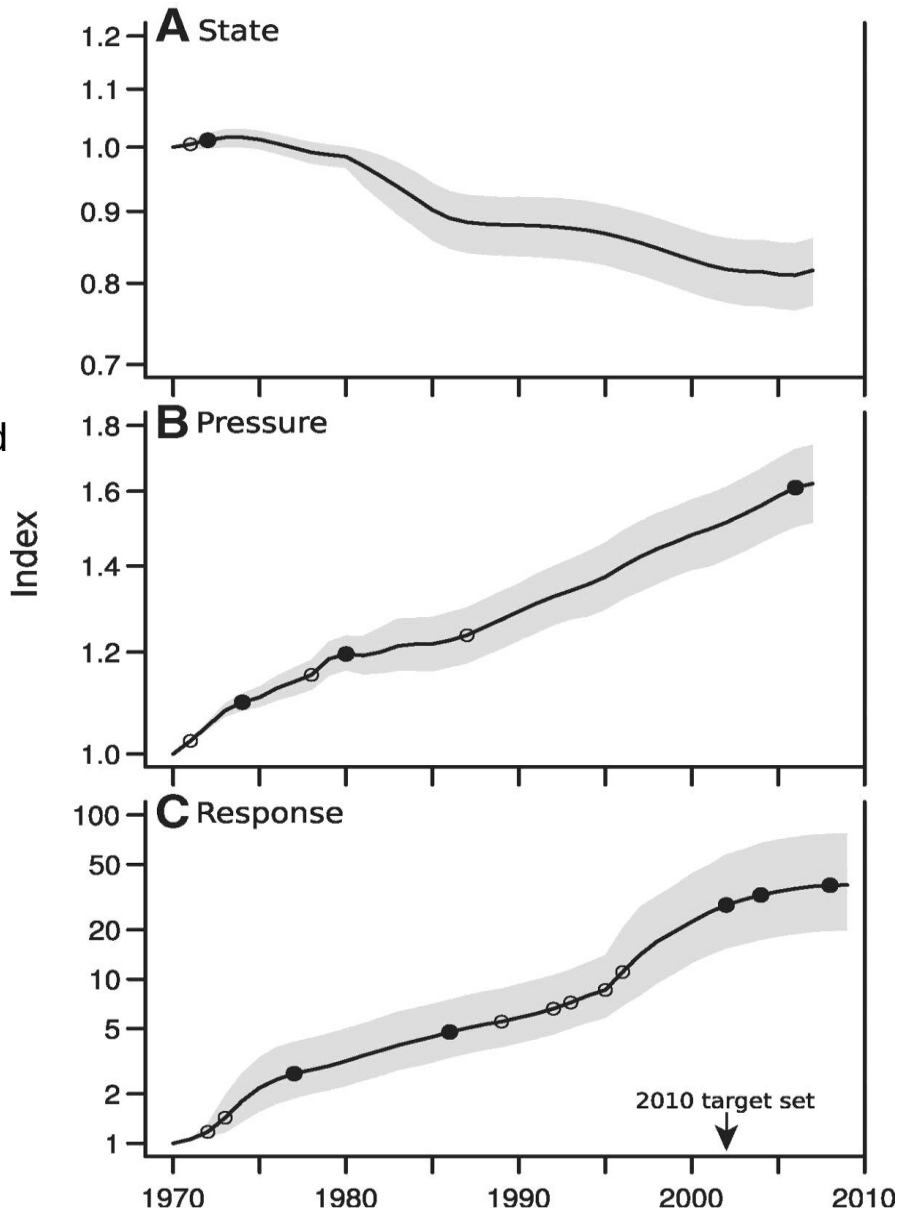


Aggregated indices of

A. **the state of biodiversity** based on nine indicators of species' population trends, habitat extent and condition, and community composition**;**

B. **pressures on biodiversity** based on five indicators of ecological footprint, nitrogen deposition, numbers of alien species, overexploitation, and climatic impacts;

C. **based on six indicators** based on six indicators of protected area extent and biodiversity coverage, policy responses to invasive alien species, sustainable forest management, and biodiversity-related aid



Science
AAAS

S H M Butchart et al. Science 2010;328:1164-1168

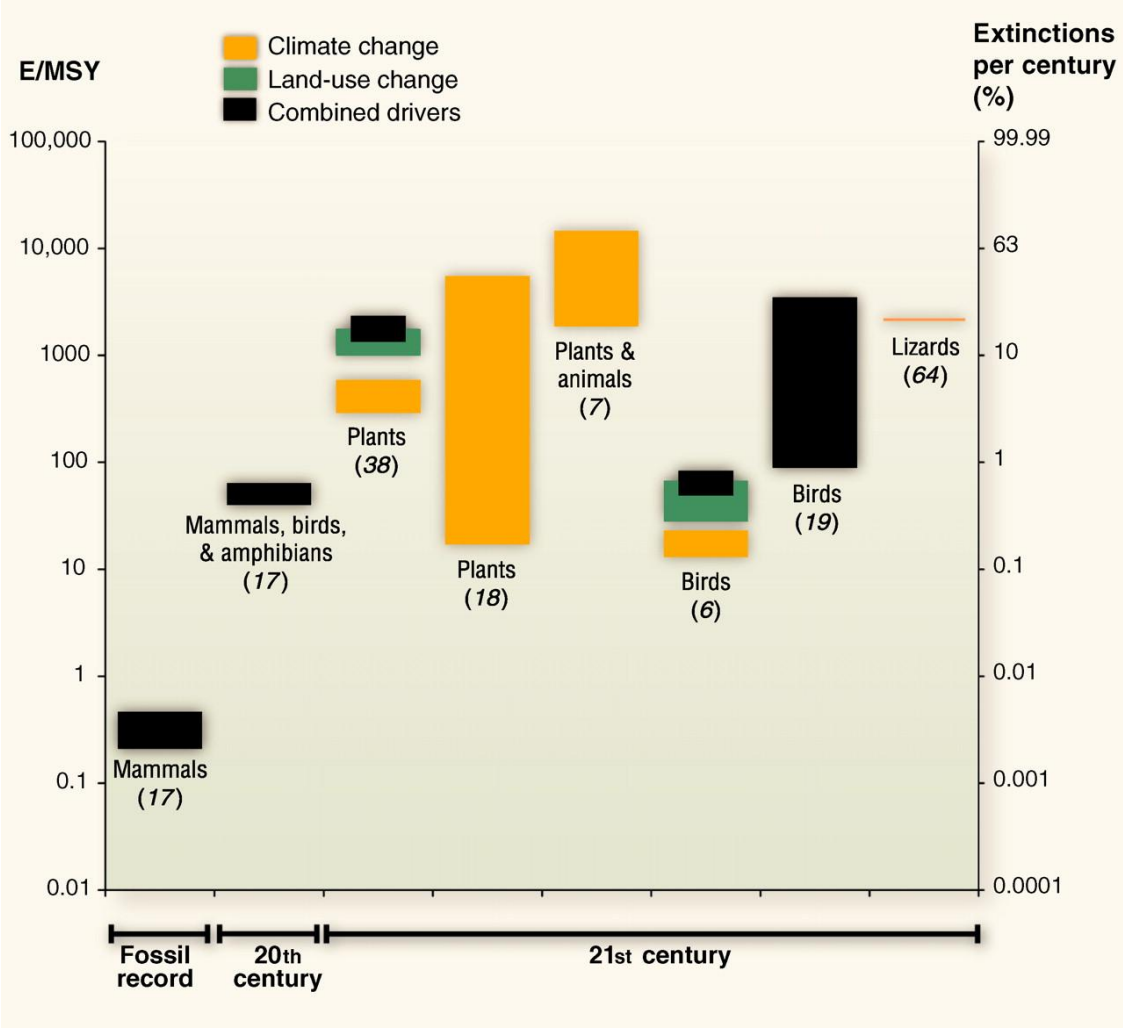
Published by AAAS

Changing threats to species

	PAST	PRESENT	NEXT 100 years
Habitat change	++	+++	+++
Invasives	+++	++	
Over-exploitation	+++	+	
Pollution	++	+++	++++
Climate change		+	++++

Species extinction rates

Comparison of recent and distant past extinction rates with rates at which species are "committed to extinction" during the 21st century.



H M Pereira et al. Science 2010;330:1496-1501

Science AAAS

Published by AAAS

Why does it matter?

Image courtesy of Global Mountain Biodiversity Assessment
www.diversitas-international.org/activities/research/global-mountain

Three roles of biodiversity

Intrinsic/inherent values.
The value of something independent of its value to anyone or anything else

The genetic library of life.
The source of all evolutionary innovation necessary for future adaptive potential and diversification

Instrumental and extrinsic values
For example as natural capital and for ecosystem services

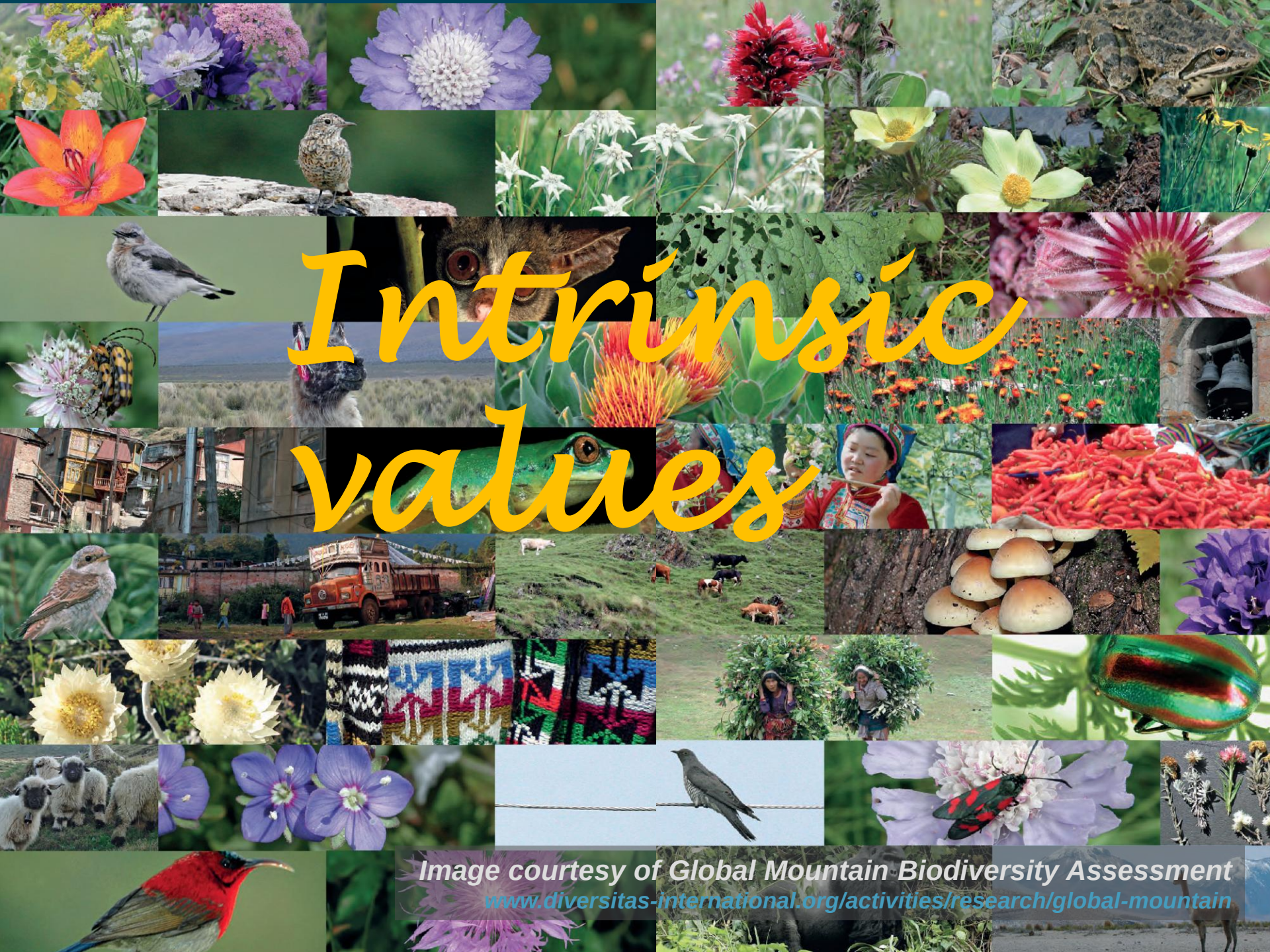
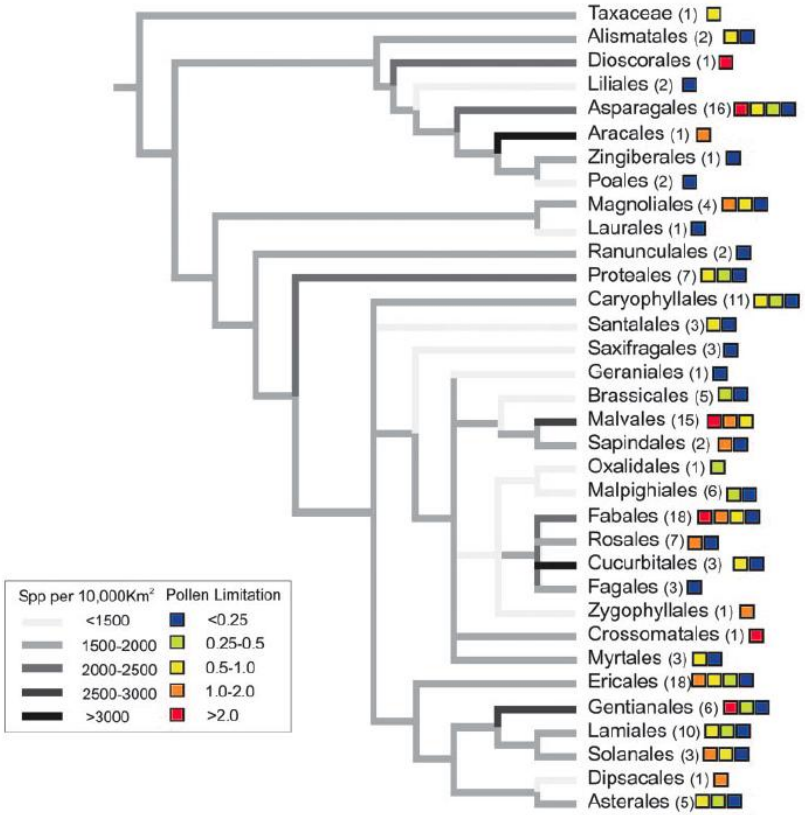
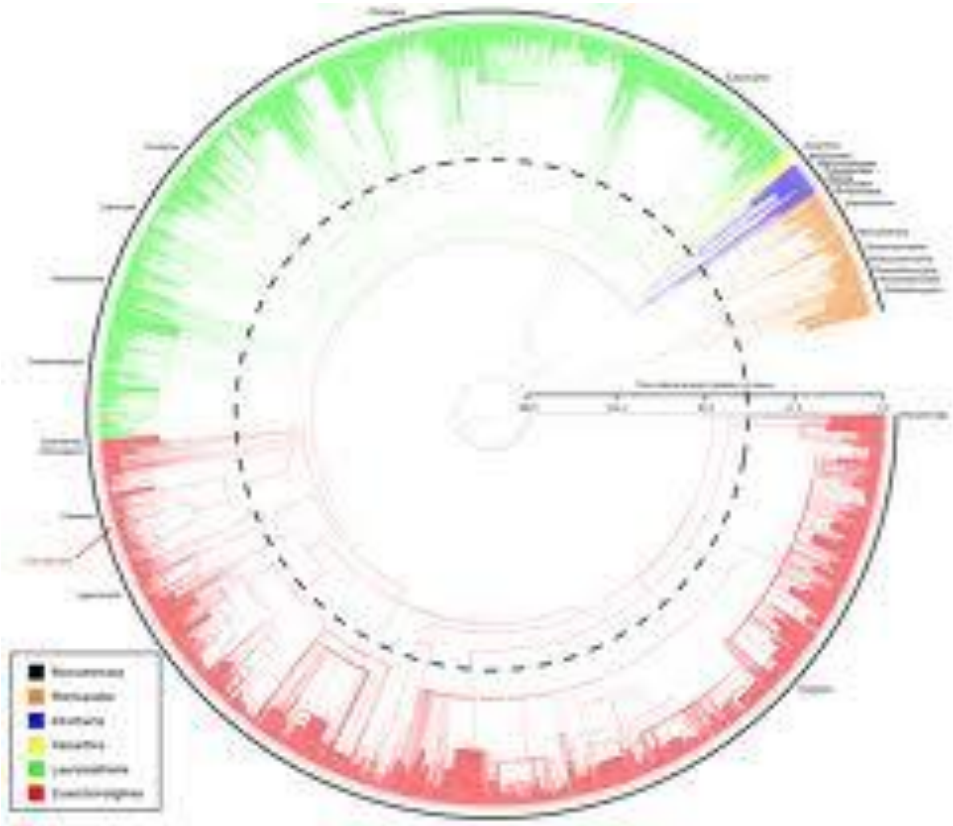


Image courtesy of Global Mountain Biodiversity Assessment
www.diversitas-international.org/activities/research/global-mountain

2. Loss of the genetic library of life (source of innovation, adaptability and resilience)



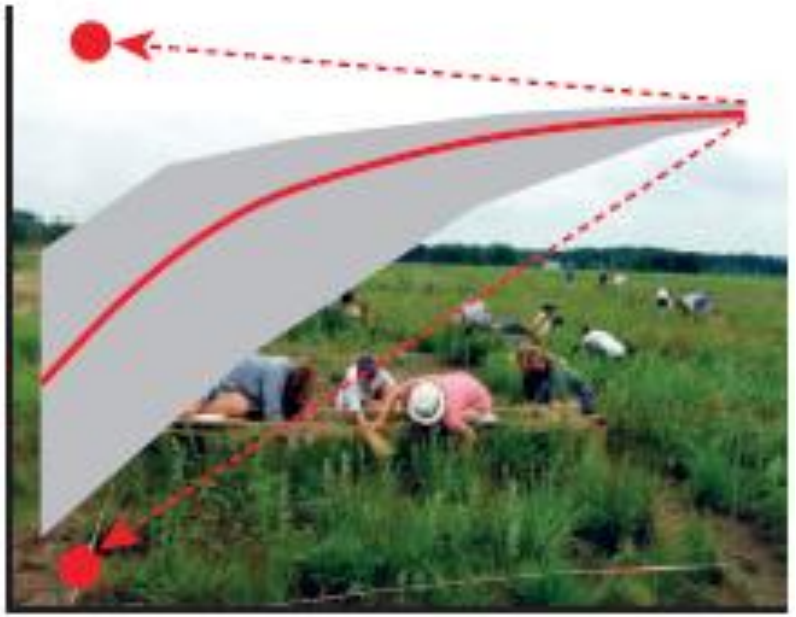


3. Extrinsic values derived from ecosystems (ecosystem services)

quality & quantity

Thanks to Sandra Diaz

- The biodiversity–ecosystem functioning relationship from several hundred experiments.
- The red line shows the average change across all combinations of genes, species, or traits (95% ci)
- Red dots give maximum and minimum values of the most or least productive species grown alone in monoculture



Cardinale et al Nature 2012

Biodiversity – ecosystem services

Cardinale et al Nature 2012

Table 1. Balance of evidence linking biodiversity to ecosystem services.

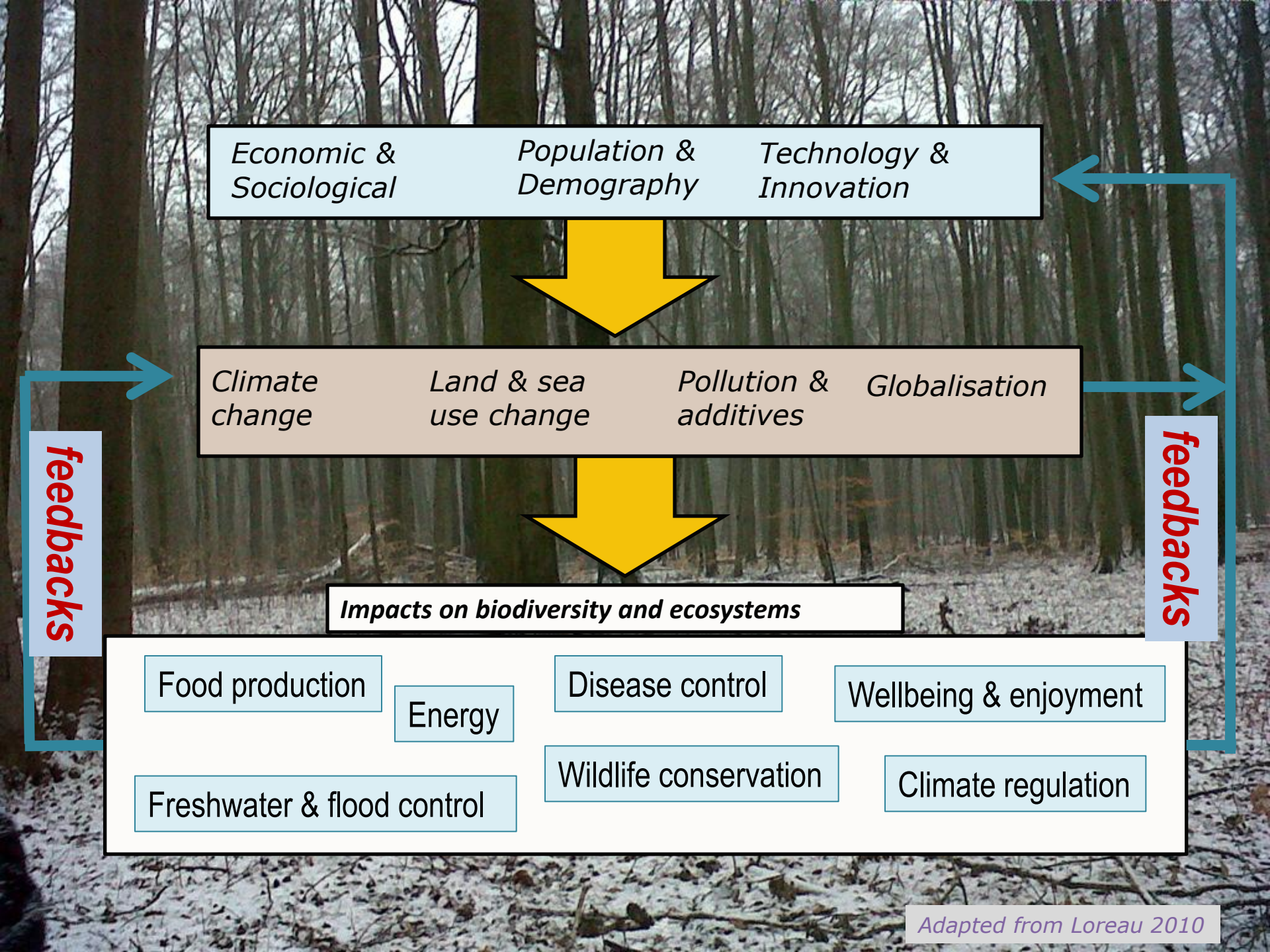
Category		Ecosystem service	S.P.U.	D.L.	Source	Study type	N	Relationship	
								Pred	Act
Provisioning	Crops	Crop yield	Pl	G	DS	Exp	575	↑	↑
				S	DS	Exp	100	↑	↕
	Fisheries	Stability of fishery yield	Fi	S	PS	Obs	8	↑	↑
	Wood	Wood production	Pl	S	DS	Exp	53	↑	↑
	Fodder	Fodder yield	Pl	S	DS	Exp	271	↑	↑
Regulating	Biocontrol	Control of herbivorous pests *(bottom-up effect of plant diversity)*	Pl	S	DS[a]	Obs	40	↑	↑
					DS[b]	Exp	100	↑	↑
					DS[c]	Exp	287	↑	↕
					DS[d]	Exp	100	↑	0
		Control of herbivorous pests *(top-down effect of natural enemy diversity)*	NE	S/T	DS[a]	Obs	18	↑	↑
				S	DS[b]	Exp/Obs	266	↑	↑
					DS[c]	Exp	38	↑	↕
		Resistance to plant invasion	Pl	S	DS	Exp	120	↑	↑
		Disease prevalence *(on plants)*	Pl	S	DS	Exp	107	↑	↑
	Climate	Primary production	Pl	S	DS	Exp	7	↑	0
		Carbon sequestration	Pl	S	DS	Exp	479	↑	↑
		Carbon storage	Pl	S/T	PS	Obs	33	↑	↕
	Soil	Soil nutrient remineralization	Pl	S	DS	Exp	103	↑	↑
		Soil organic matter			DS	Exp	85	↑	↑
	Water	Freshwater purification	M	G/S	PS	Exp	8	↑	0
	Pollination	Pollination	In	S	PS	Obs	7	↑	↕

Biodiversity loss is continuing, with damaging consequences

- Biodiversity loss is continuing, often at increasing rates.
- It matters for many reasons: intrinsic and instrumental.
- Biodiversity plays a critical, if poorly understood, role in ecosystem services and functions.

Biodiversity may be more important in future than now, because of increasing pressures, multiple demands on ecosystems and a changing environment.

WHAT CAN BE DONE?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Land & sea use change
Pollution & additives
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Impacts on biodiversity and ecosystems
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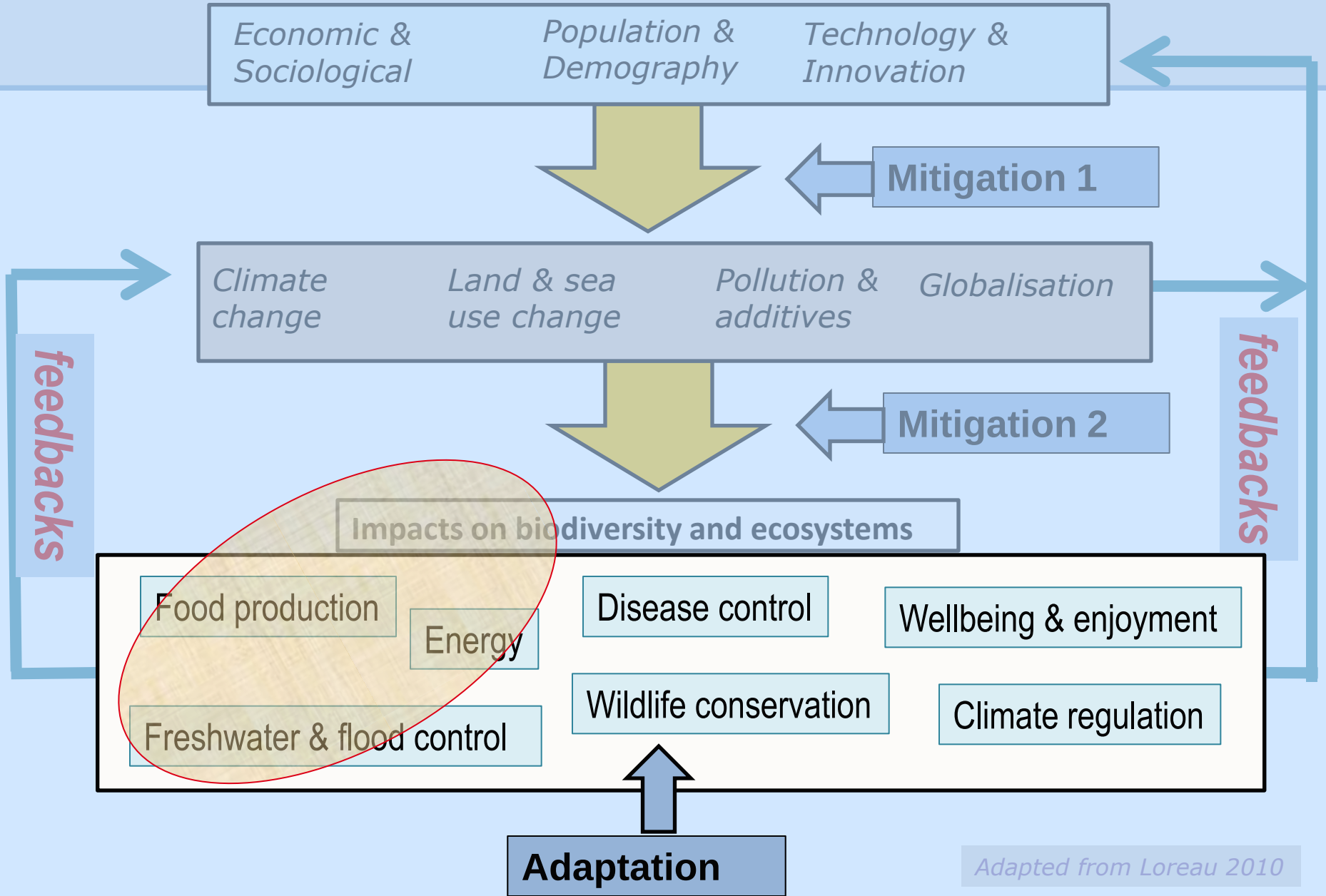
Energy
Disease control
Wellbeing & enjoyment
Wildlife conservation
Climate regulation
Freshwater & flood control
Adapted from Loreau 2010

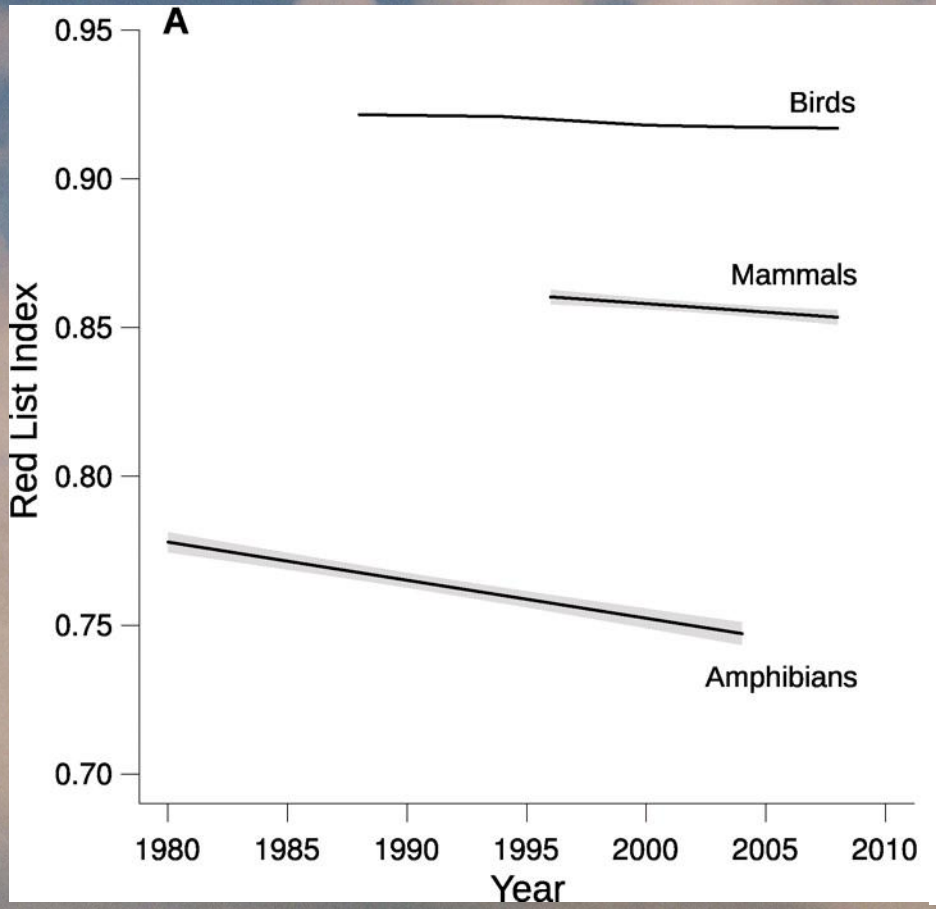
Imperial College London



Adapted from Loreau 2010

Conservation of species and habitats has been successful

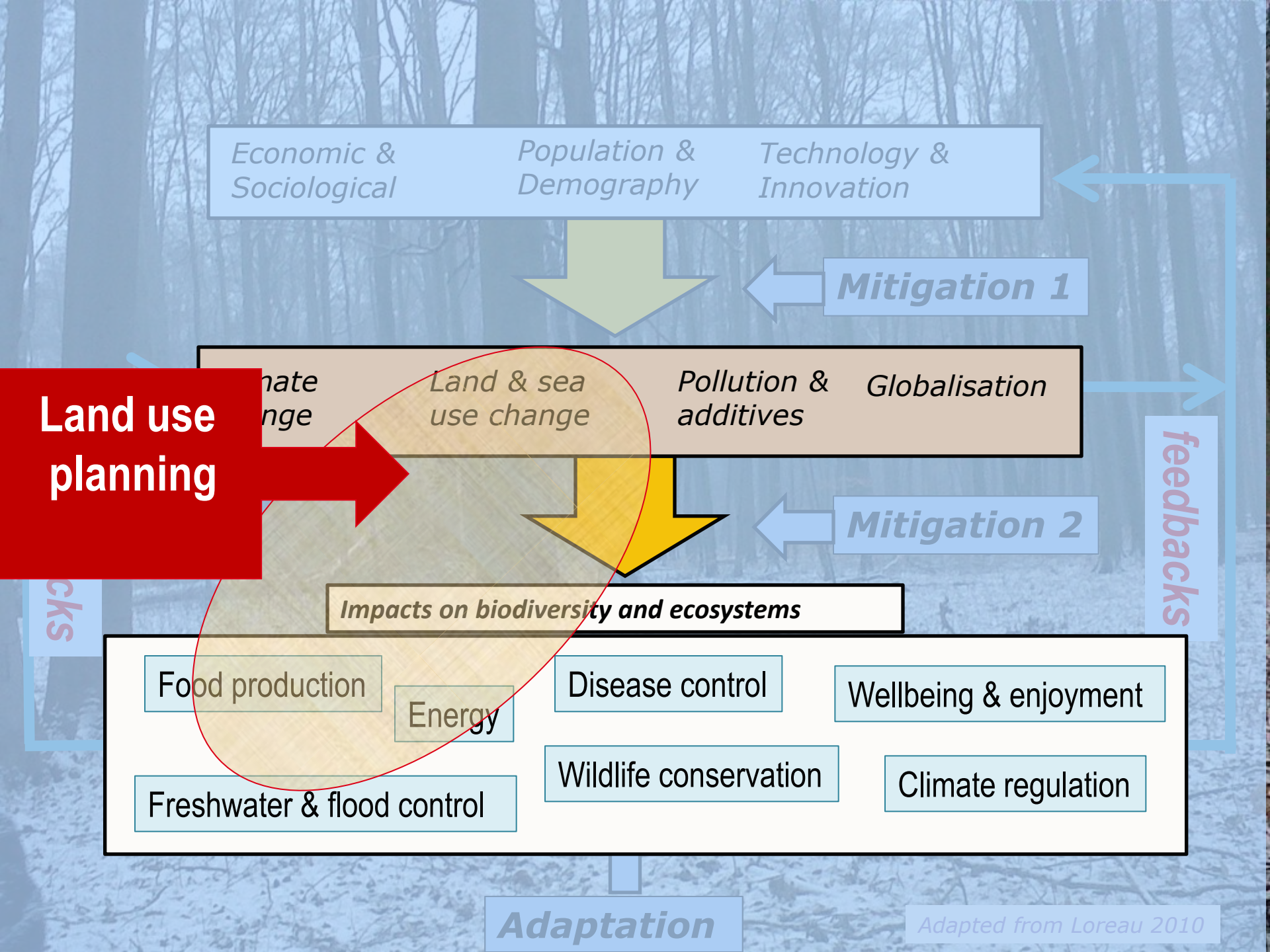
1. Species and habitat conservation



Trends in the conservation status of mammals, birds and amphibians are deteriorating

… but conservation actions have made a significant difference

Science
AAAS
Published by AAAS
M Hoffmann et al. Science 2010;330:1503-1509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Adaptation
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uknea.unep-wcmc.org/Home/tabid/38/Default.aspx
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Living With Environmental Change

UK National Ecosystem Assessment

Shared Document Area

Thursday, March 10, 2011

Understanding nature's value to society

News

Economic Analysis for Ecosystem Service Assessments, Oct 2010

The first output of the UK NEA has recently been published online in the journal *Environmental and Resource Economics*. The paper, authored by a small team of economists and natural scientists working on the UK NEA, seeks to contribute to the expanding literature on ecosystem service assessment by considering its integration with economic analyses of such services...click **here** to view the full paper.

Draft key messages from the UK NEA Co-Chairs, Oct 2010

Click **here** to download the document.

How might UK ecosystems and

What is the UK National Ecosystem Assessment?

The UK National Ecosystem Assessment (UK NEA) is the first analysis of the UK's natural environment in terms of the benefits it provides to society and continuing economic prosperity. Part of the Living With Environmental Change (LWEC) initiative, the UK NEA - which commenced in mid-2009 - will be reporting in early 2011. It is an inclusive process involving many government, academic, NGO and private sector institutions.

Meetings

There are no further meetings planned.

Click **here** to view the full list of past UK NEA Meetings.

All UK NEA Communications are available to download.

Hover here, then click toolbar to edit content

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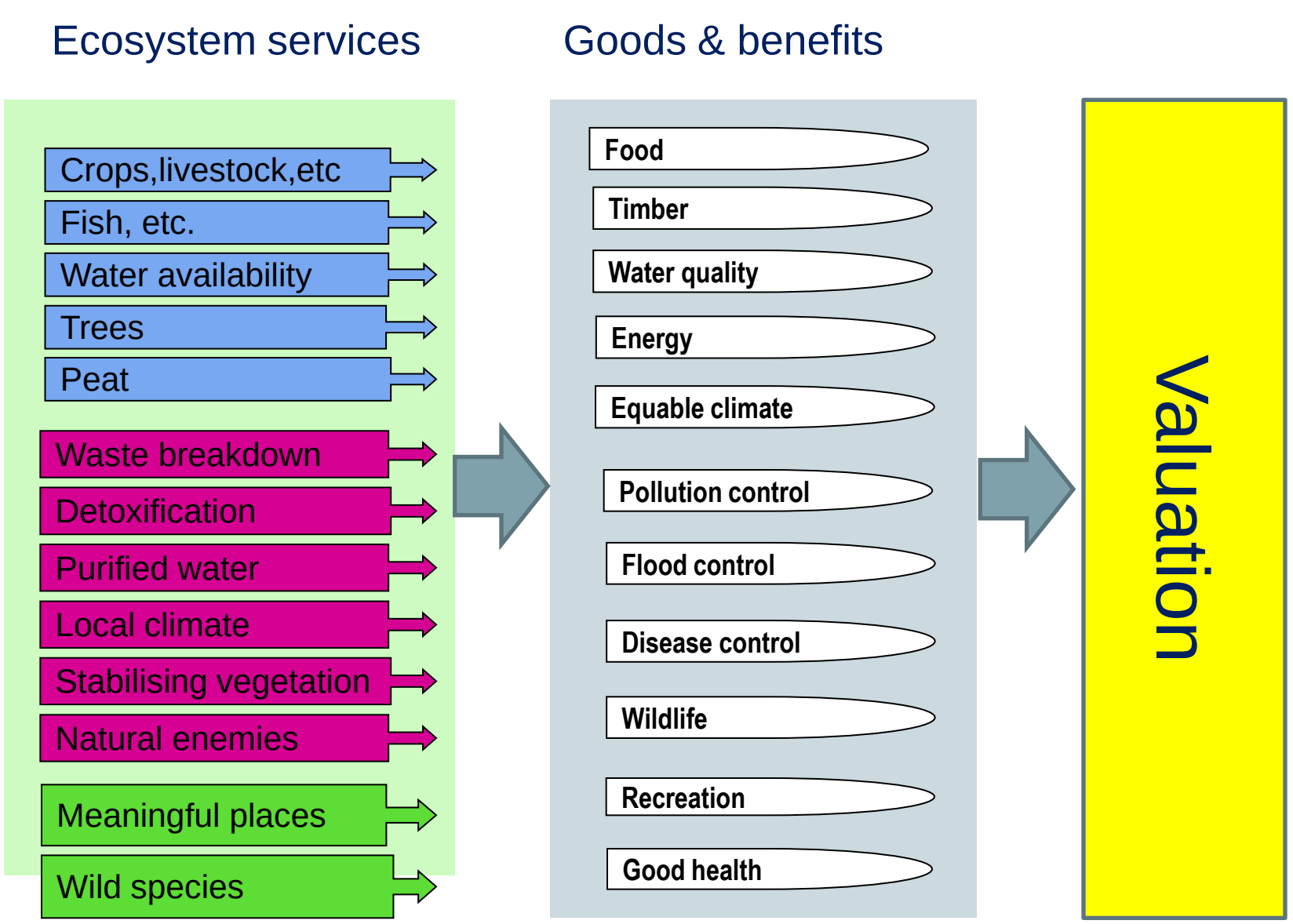

Ecosystem services
Goods & benefits
Crops,livestock,etc
Fish, etc.
Water availability
Trees
Peat
Waste breakdown
Detoxification
Purified water
Local climate
Stabilising vegetation
Natural enemies
Meaningful places
Wild species
Food
Timber
Water quality
Energy
Equable climate
Pollution control
Flood control
Disease control
Wildlife
Recreation
Good health
Valuation

Two Storylines for environmental policy priorities

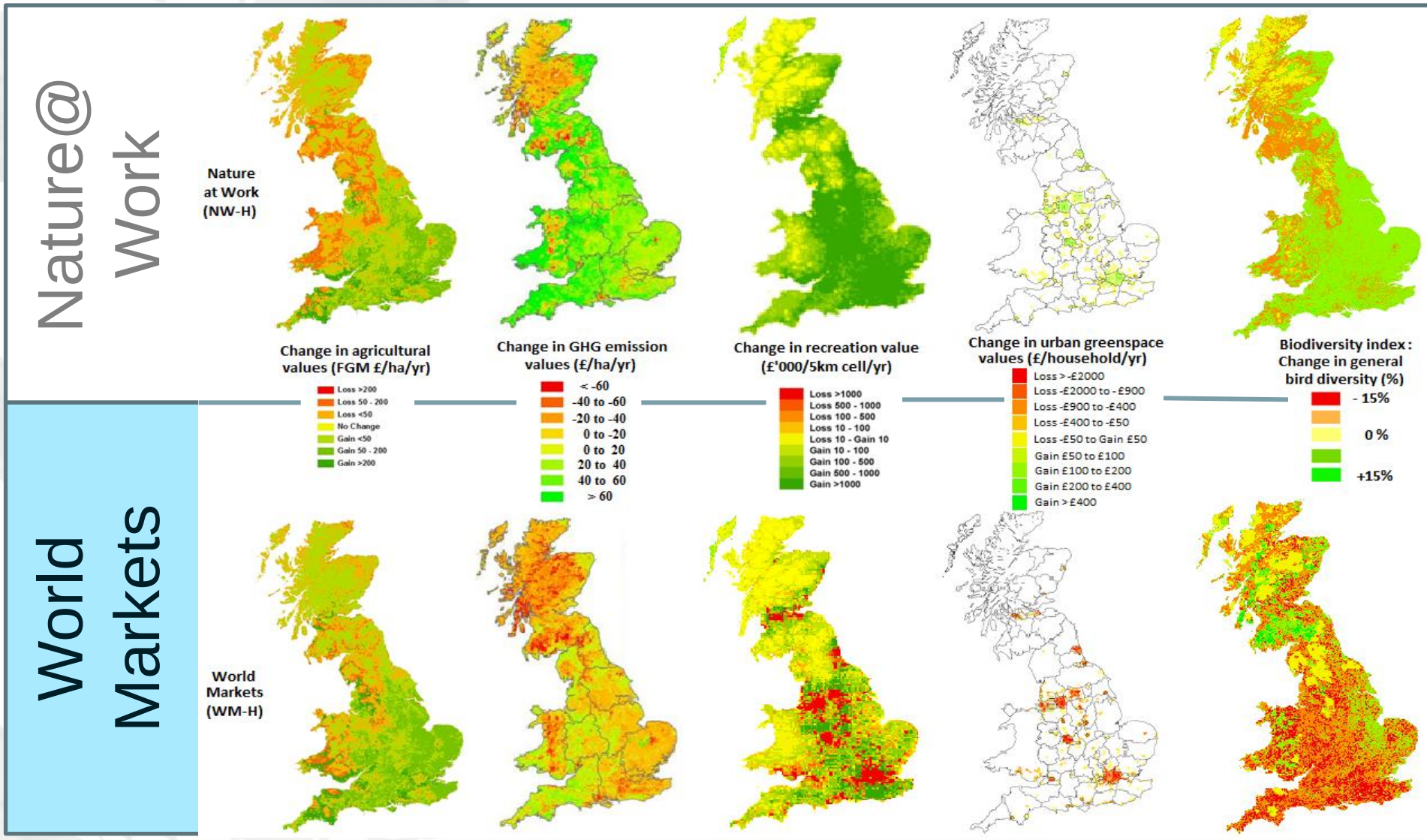
Nature@ Work

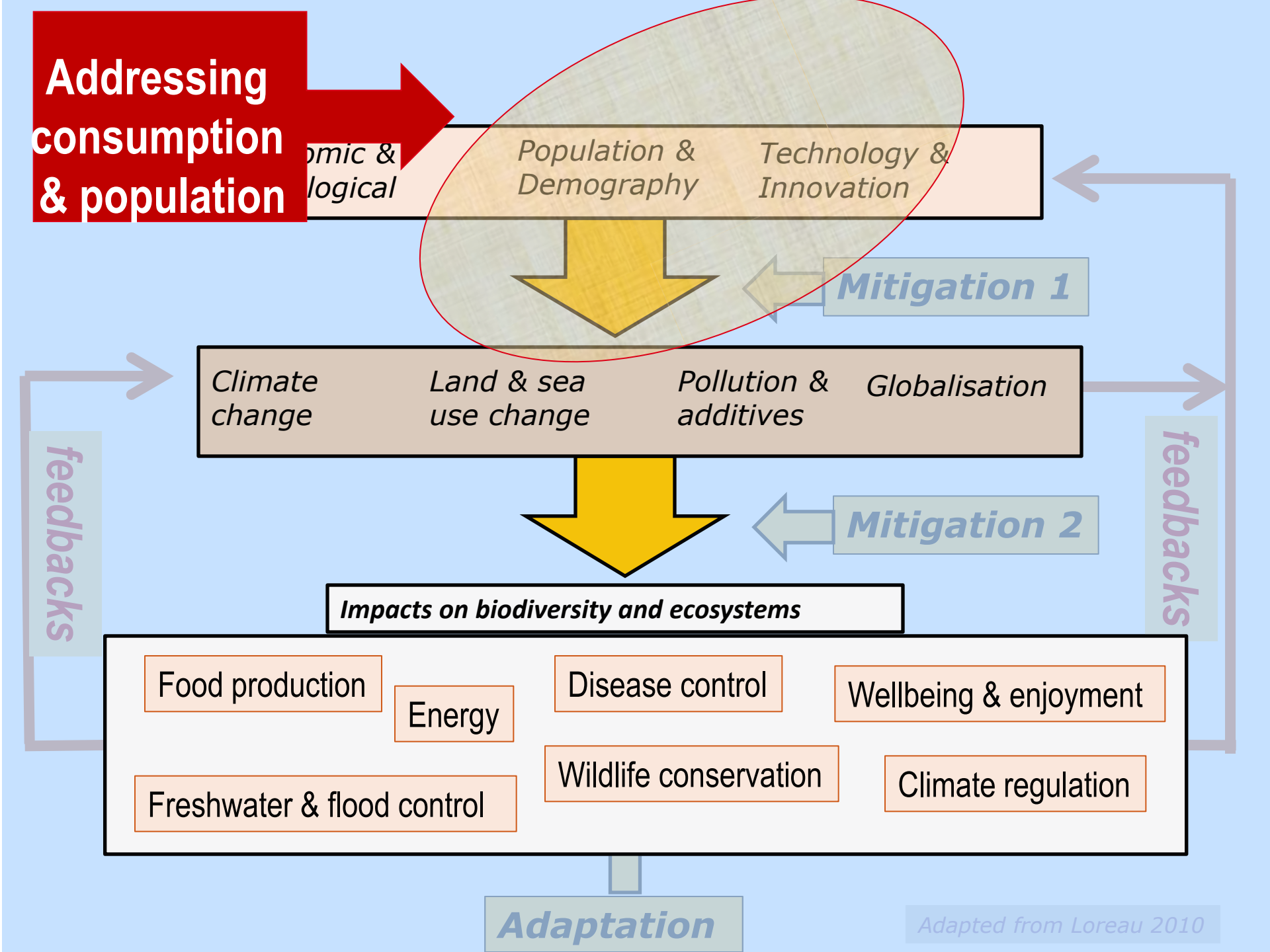
The promotion of ecosystem services through the creation of multifunctional landscapes for maintaining the quality of life in the UK.

World Markets

High economic growth with a greater focus on removing barriers to trade.

The economic consequences of two storylines in 2050

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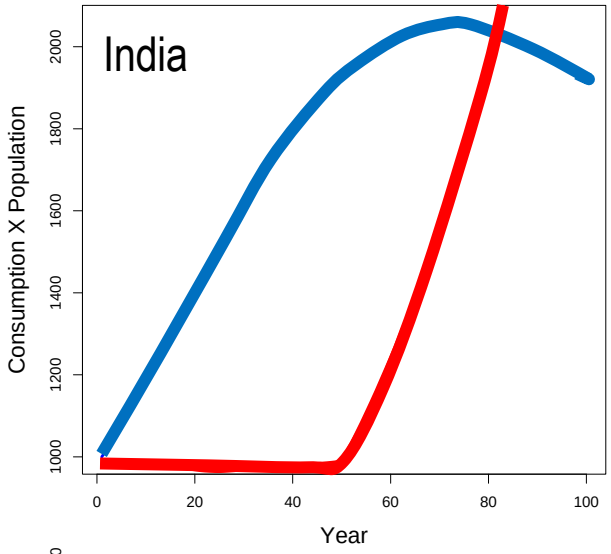
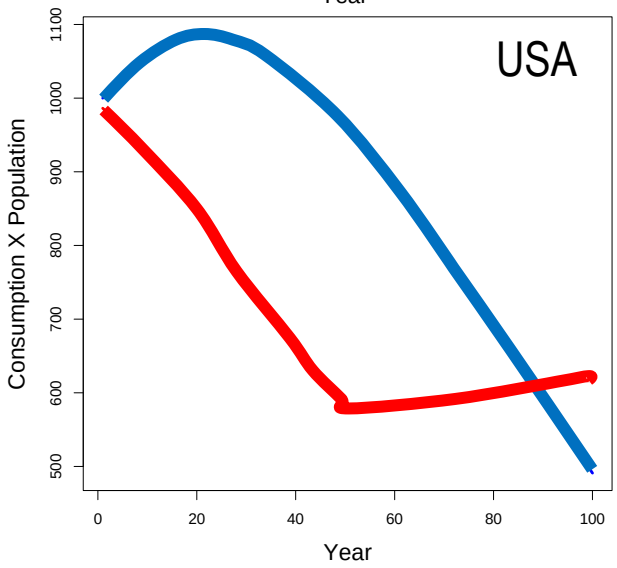
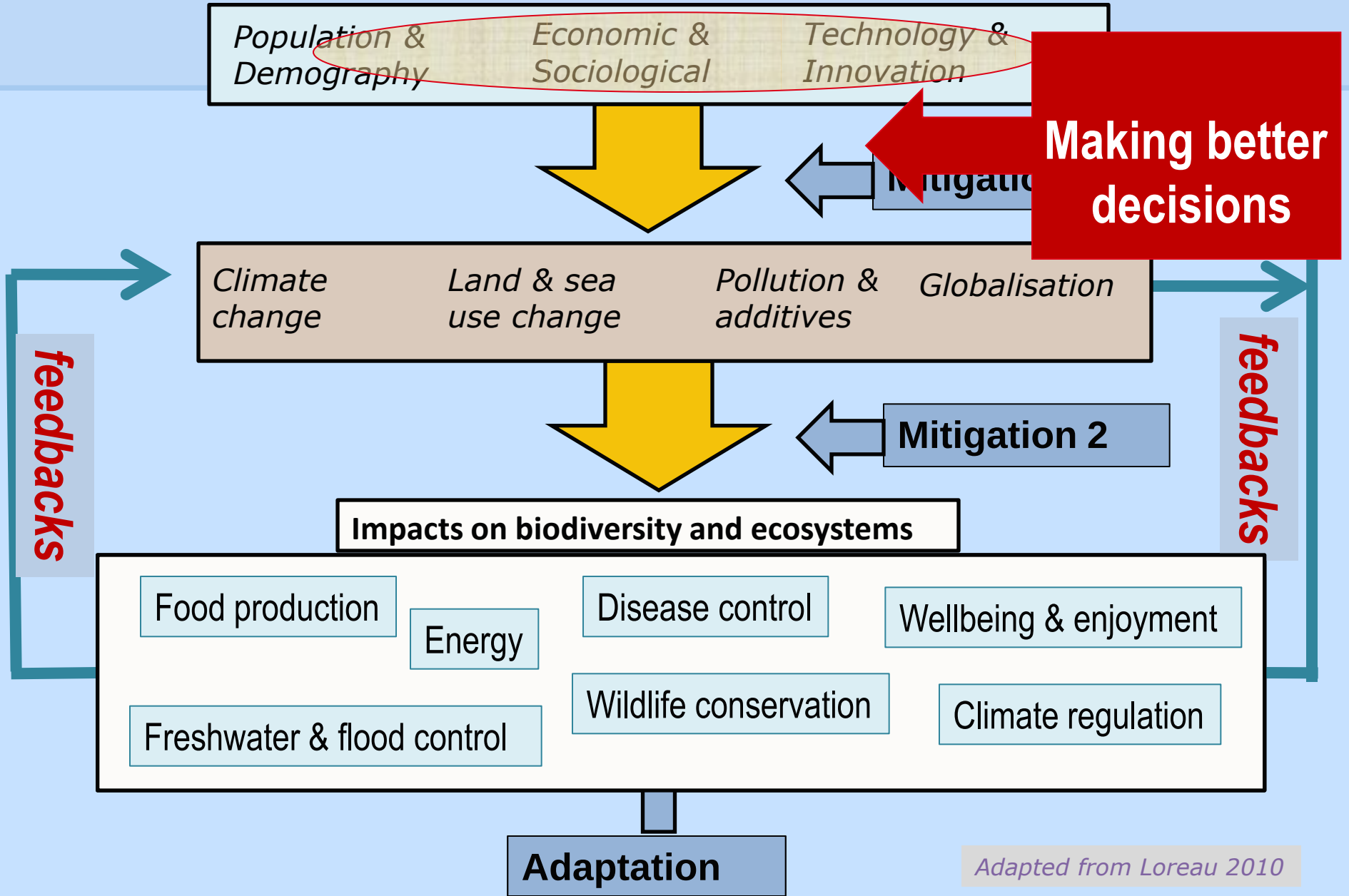
Reduce population growth or reduce consumption?

- In a developing country (India) and a developed country (USA)..
- using real population demography..
- assuming each person has a consumption of 1 unit per year..
- What is the effect of reducing fertility by 1% per year for 50 years compared to reducing consumption by 1% per year for 50 years?





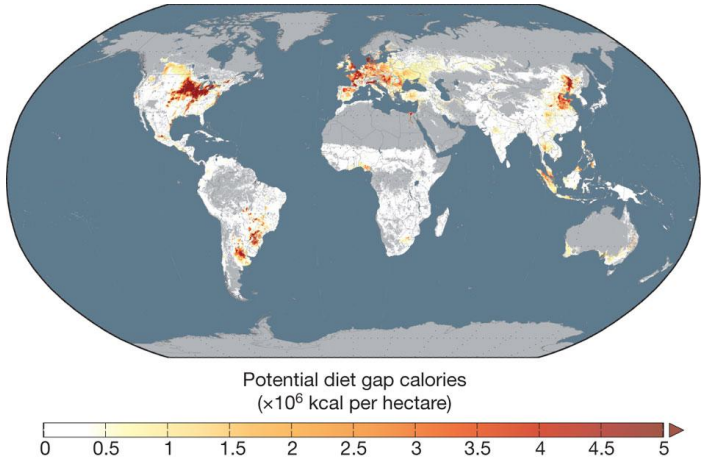


Adapted from Loreau 2010

Solutions for a cultivated planet

1. Stop expanding agricultural land
2. Increase agricultural efficiency
3. Close the diet gap, reducing waste and choosing the right crops
4. Close yield gaps on underperforming landscapes

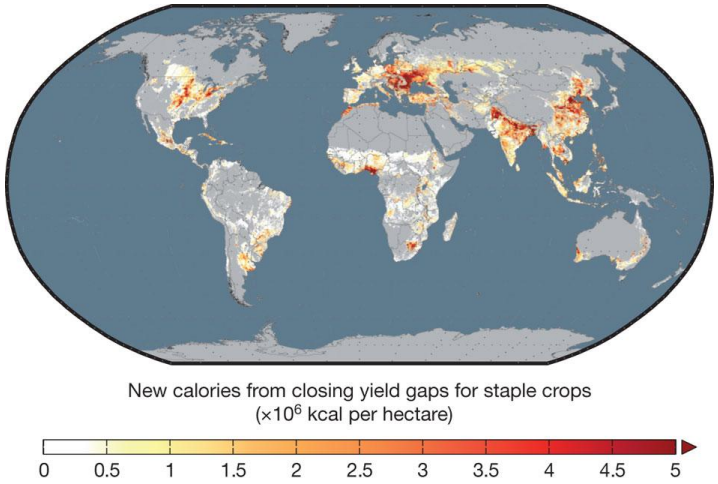
Closing the diet gap.



Deployed simultaneously these strategies can increase food availability by 100-180%.

At the same time - reducing greenhouse gas emissions, biodiversity loss, pollution and water use.

Closing global yield gaps.



*JA Foley et al. Nature **478:** 2011*

What are the obstacles?

There are are many opportunities but most are stalled:

- Gaps in knowledge and information. Uncertainty – when do we know enough to act?
- Market failures in current policy mechanisms.
- Environmental governance at all scales - local, regional and global.