PBL Netherlands Environmental Assessment Agency

Questions of ultimate urgency

biodiversity & ecosystem services

in socioeconomic scenarios

Ben ten Brink, PBL
21-10-2013, Paris

Content

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1. The big picture: 10,000 BC up to 2050
2. Global change
3. Approaching local & planetary limits?
4. Questions of ultimate urgence

The big picture:
human development 10,000 BC to 2000 AD

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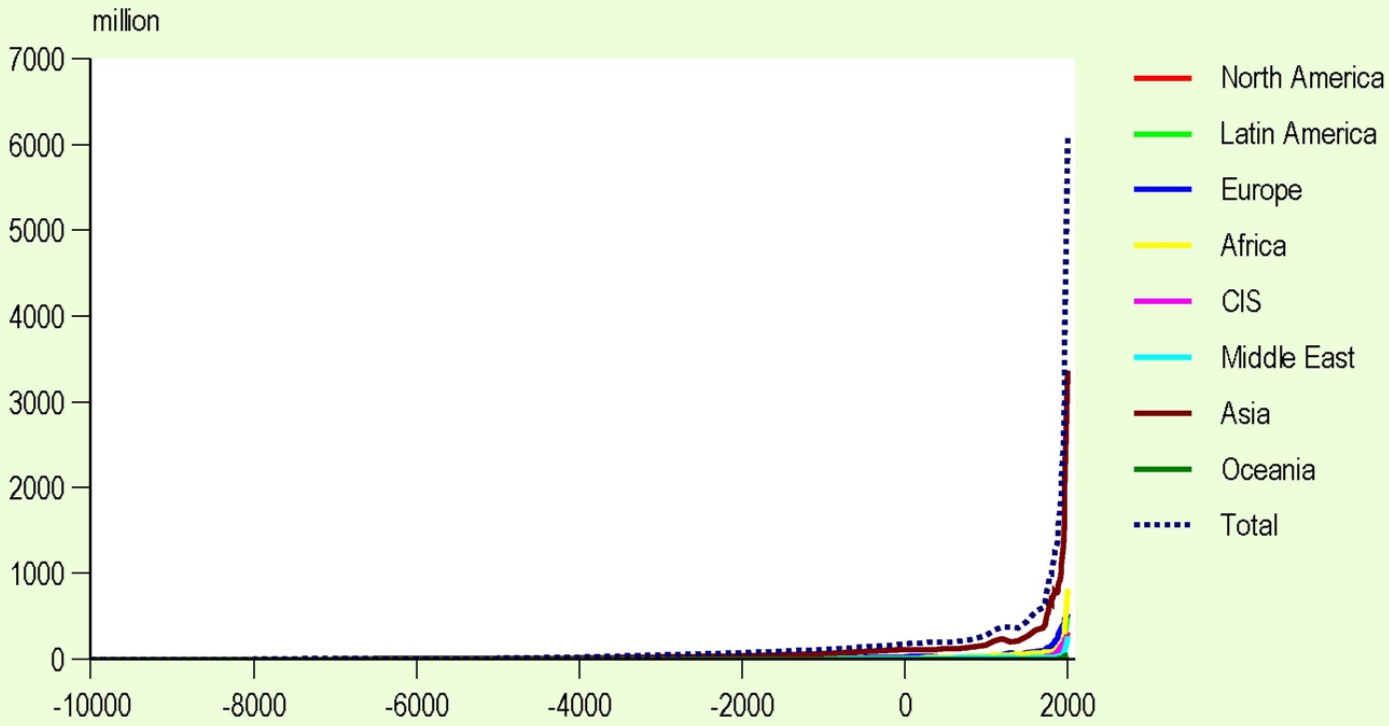
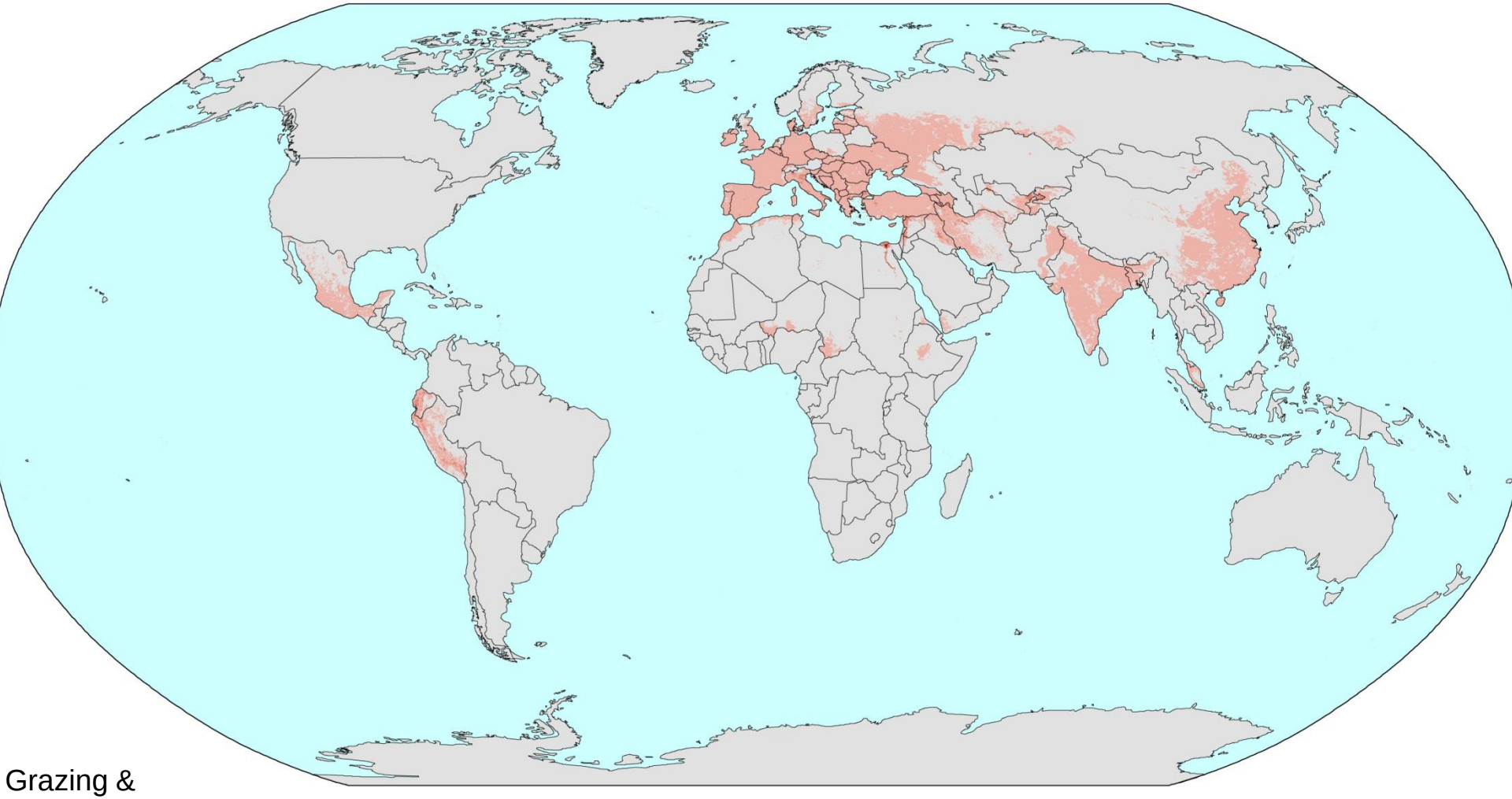
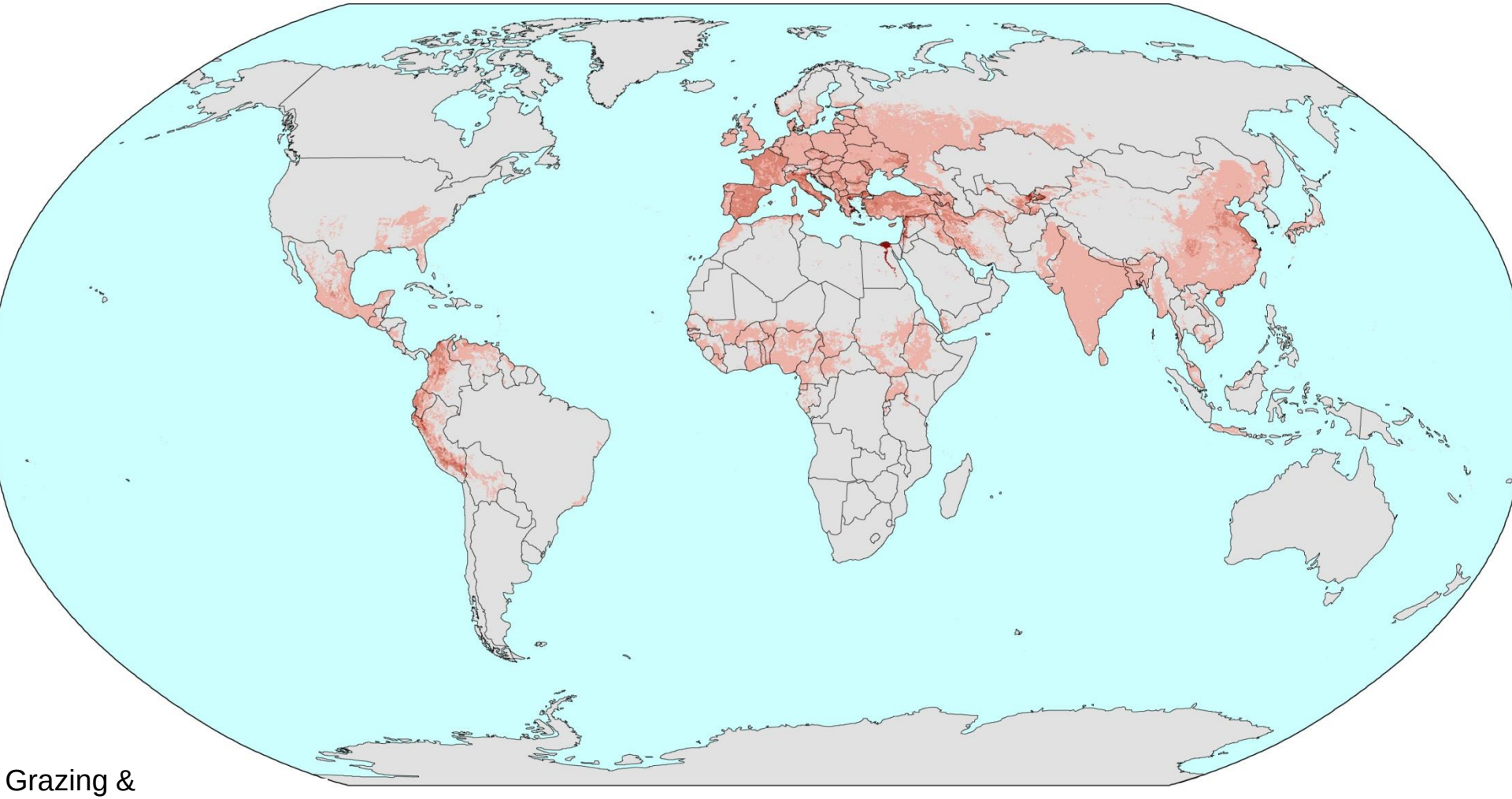


Land use in the past

3000 BC



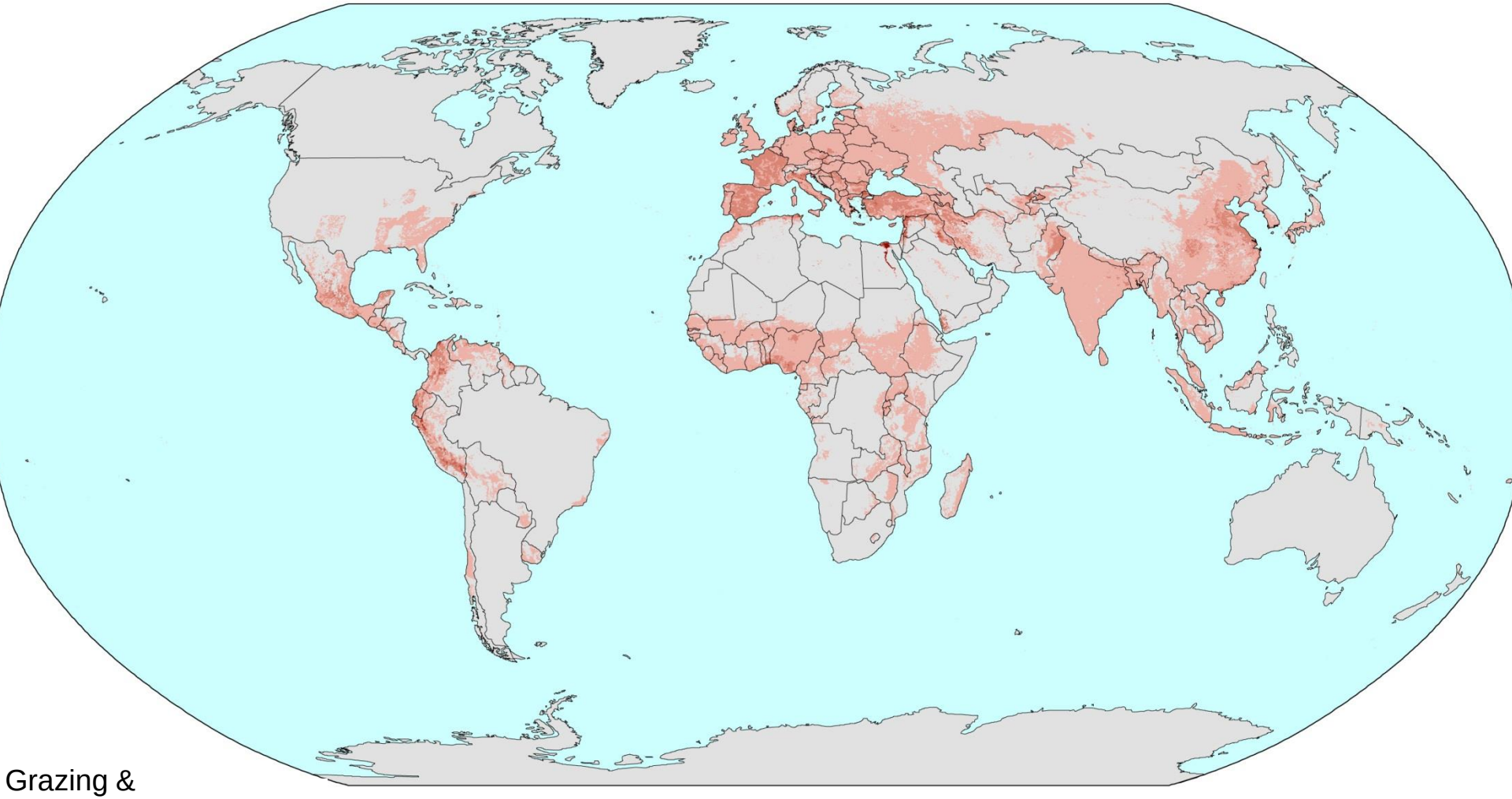
0 AD



Grazing & cropland

0 - 0.1	21 - 40
0.11 - 5	41 - 60
5.1 - 20	61 - 85

1000 AD



Grazing & cropland

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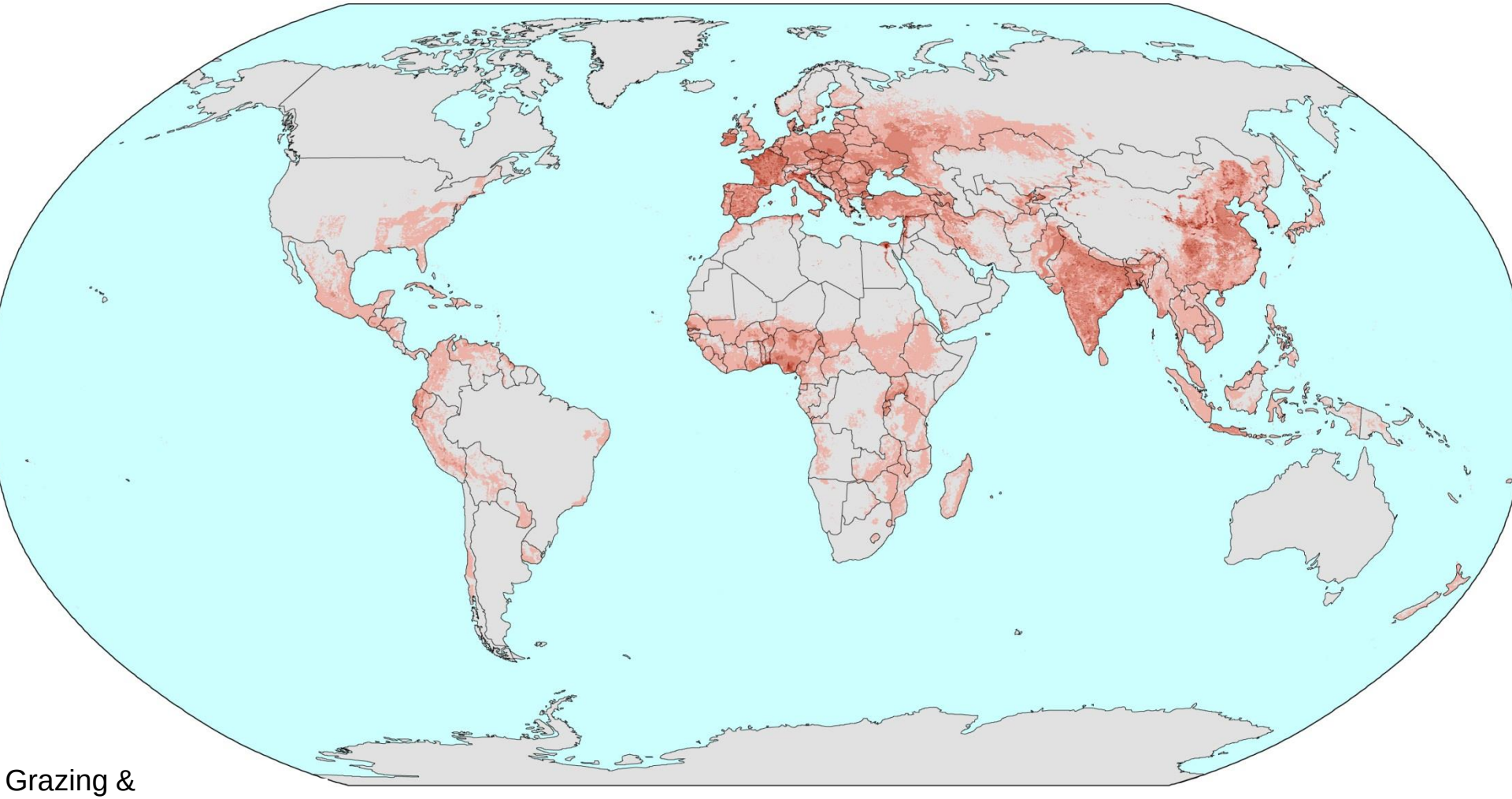
5.1 - 20	61 - 85

1700 AD



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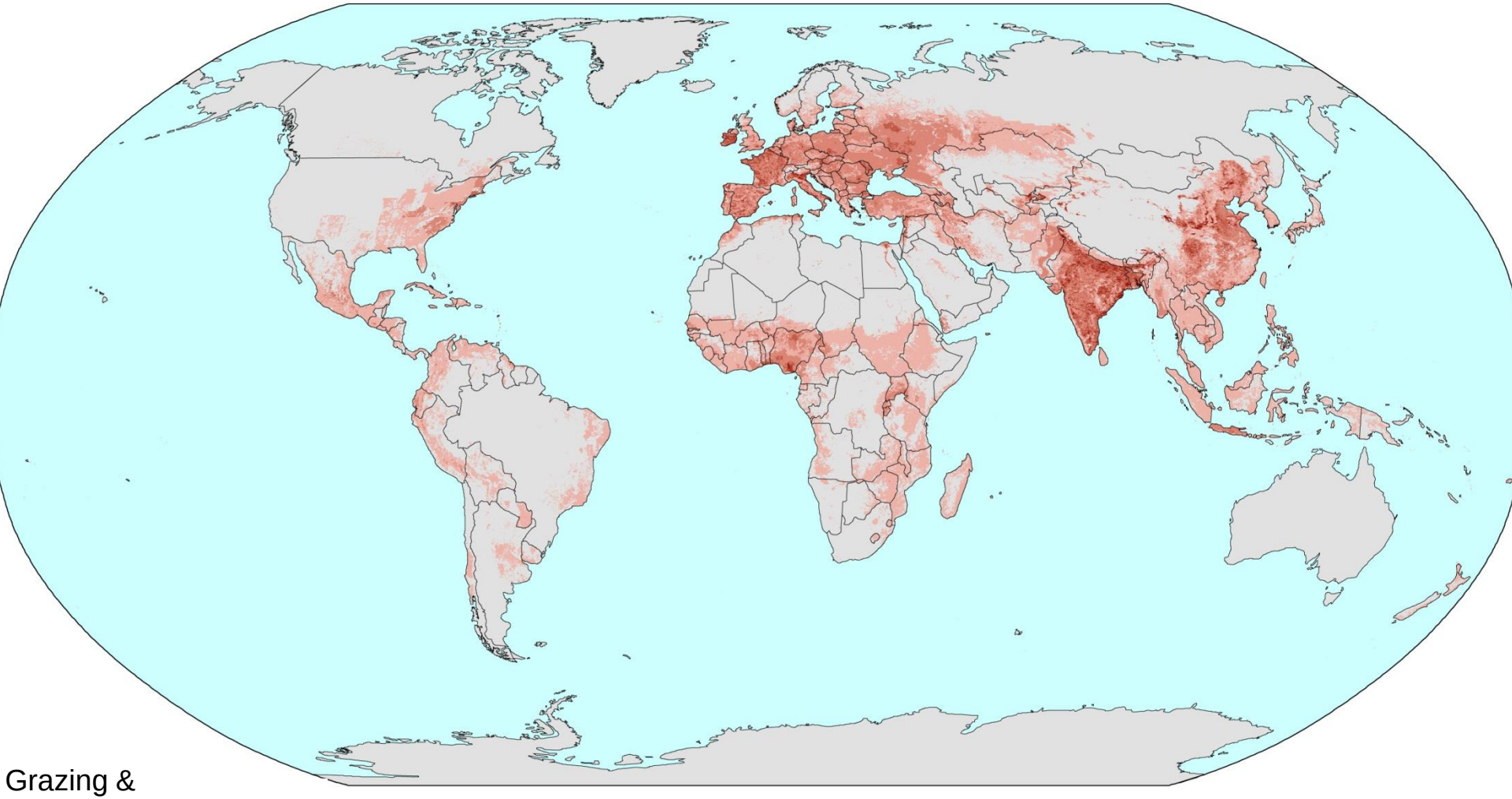
1800 AD



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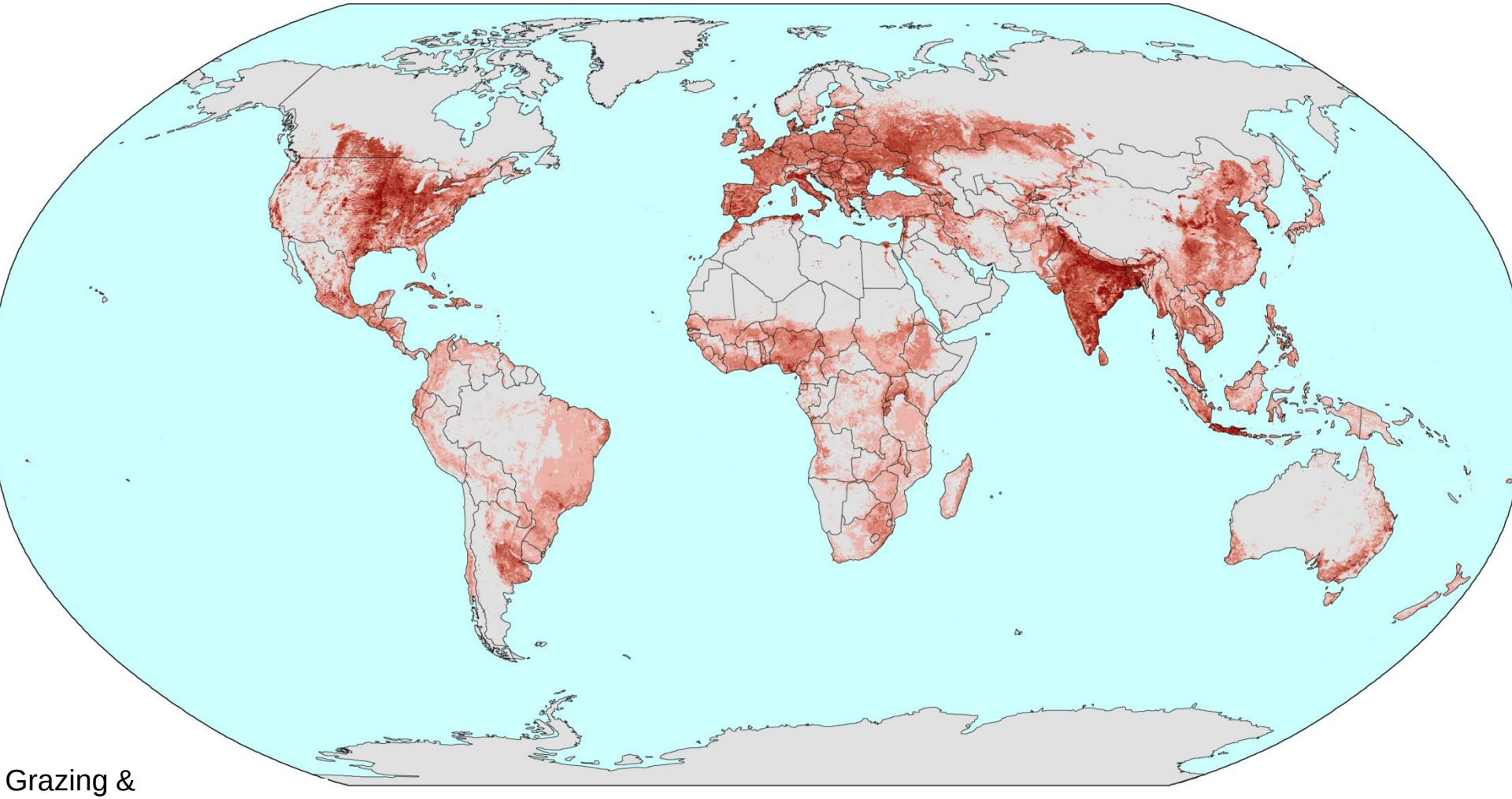
1950 AD



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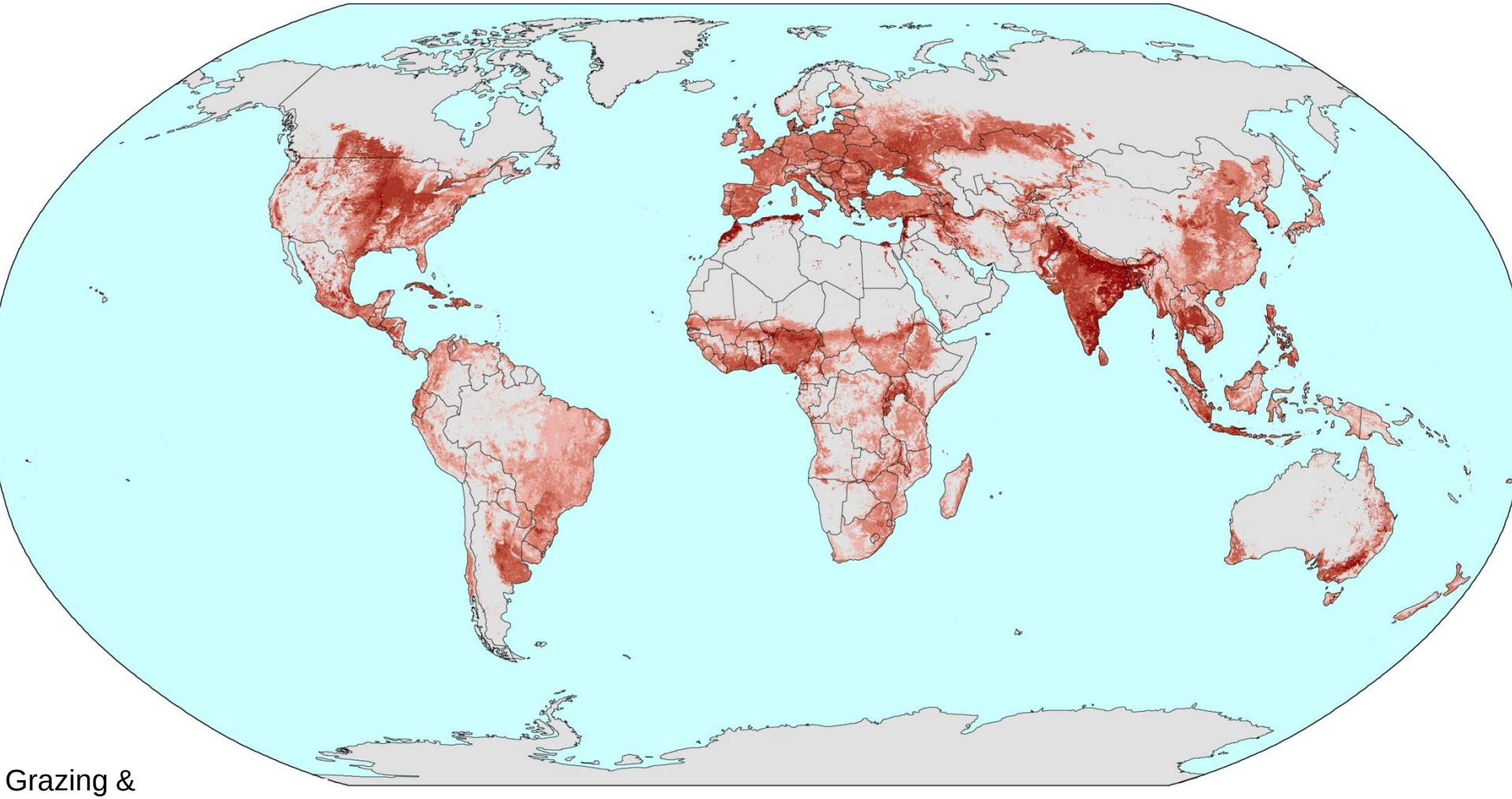
2000 AD



Grazing & cropland

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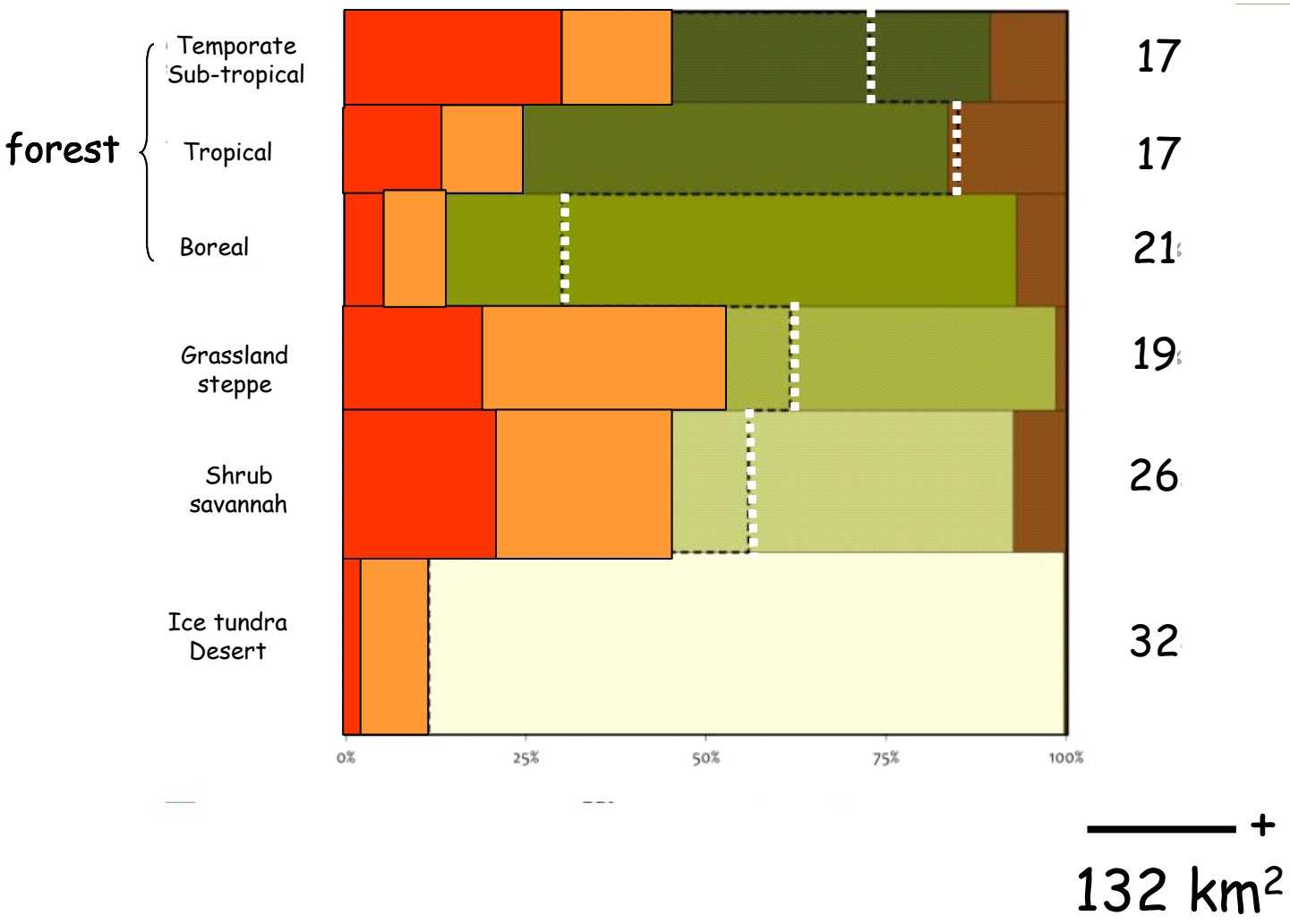
Competing claims on land & assets

2010 Land use per ecosystem type

Million km²



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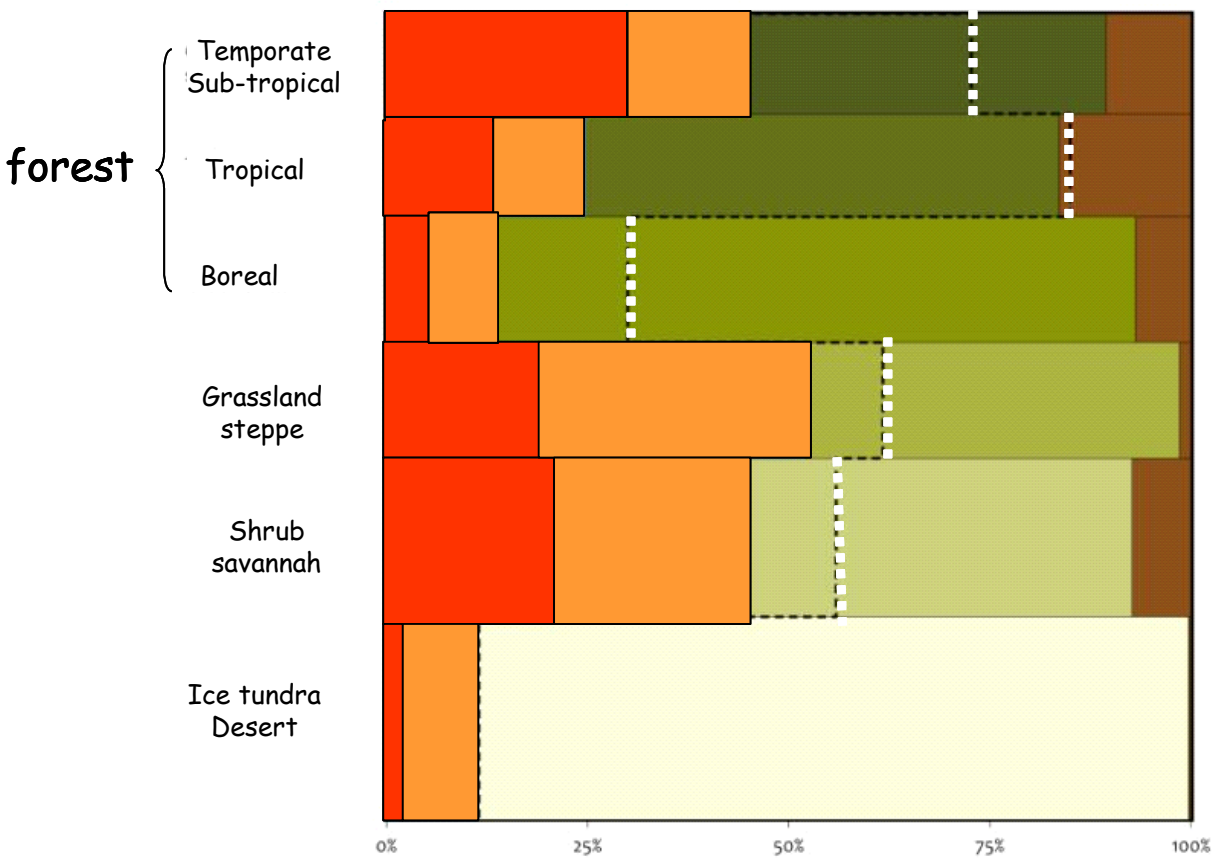
132 km²

Legend: 5 mln km²

Competing claims on land & assets (baseline scenario)

2050 Land use per ecosystem type

Million km²



17	agri	+ 6
17	agri	+ 12
21	forestry	+5
19	biofuels	+5
26	C-plantation	+1
32		

\+

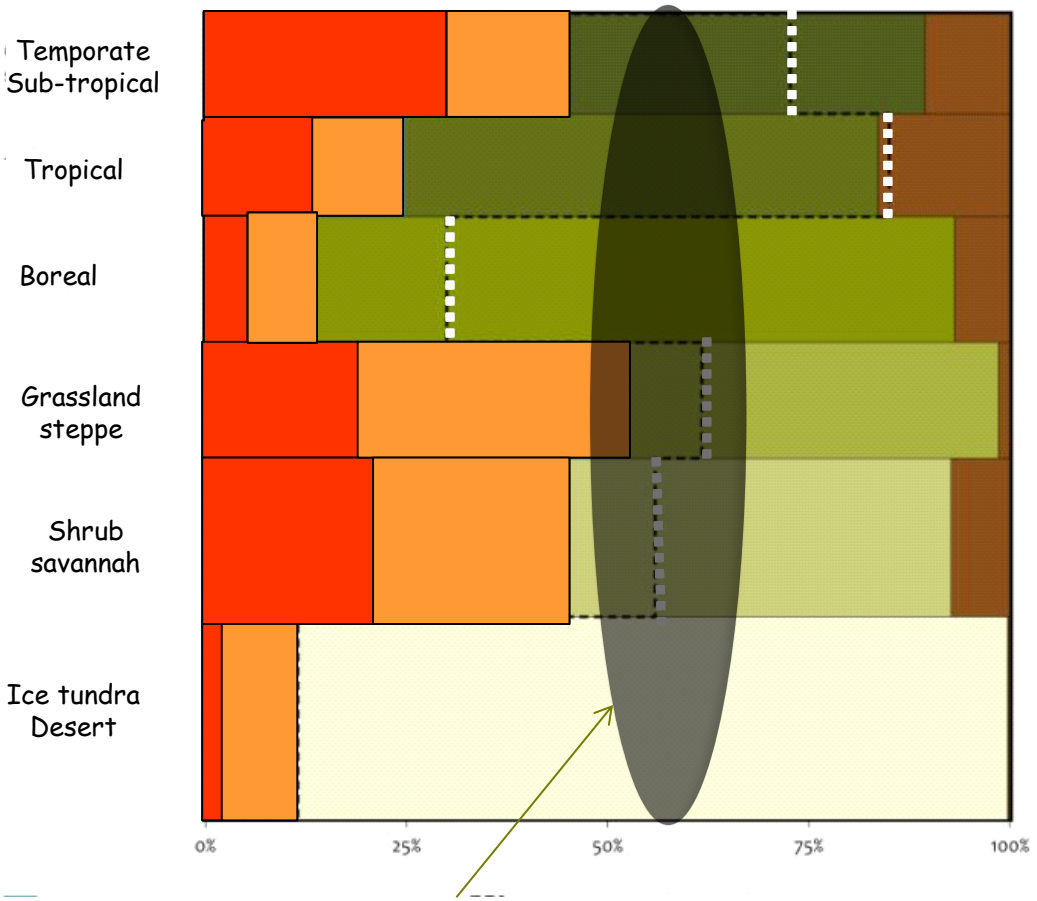
132 km²

Legend: 5 mln km²

Competing claims on land & assets (baseline scenario)

2050 Land use per ecosystem type

Million km²



17	agri	+ 6
17	agri	+ 12
21	forestry	+5
19	biofuels	+5
26	C-plantation	+1
32	degradation	+5

\+

132 km²

Legend: 5 mln km²

Zooming in:

South East Asia 1970

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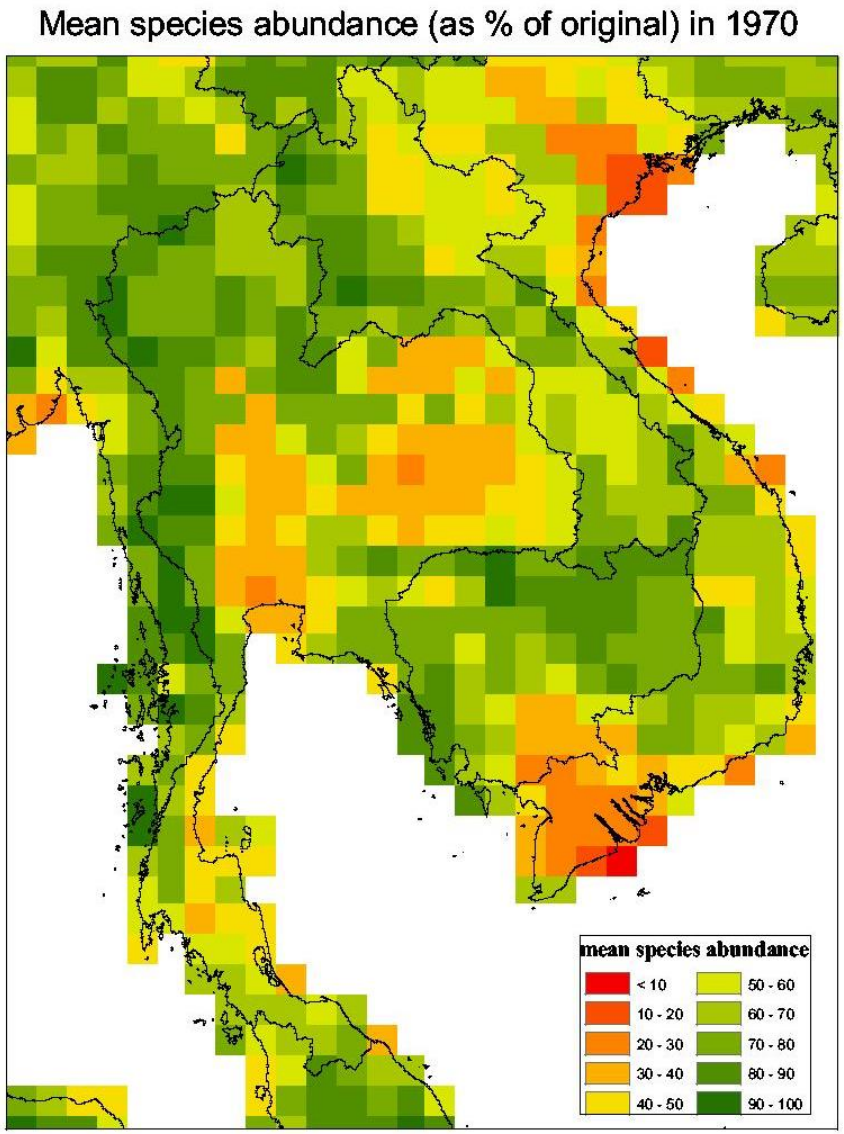

Zooming in:

South East Asia 2000

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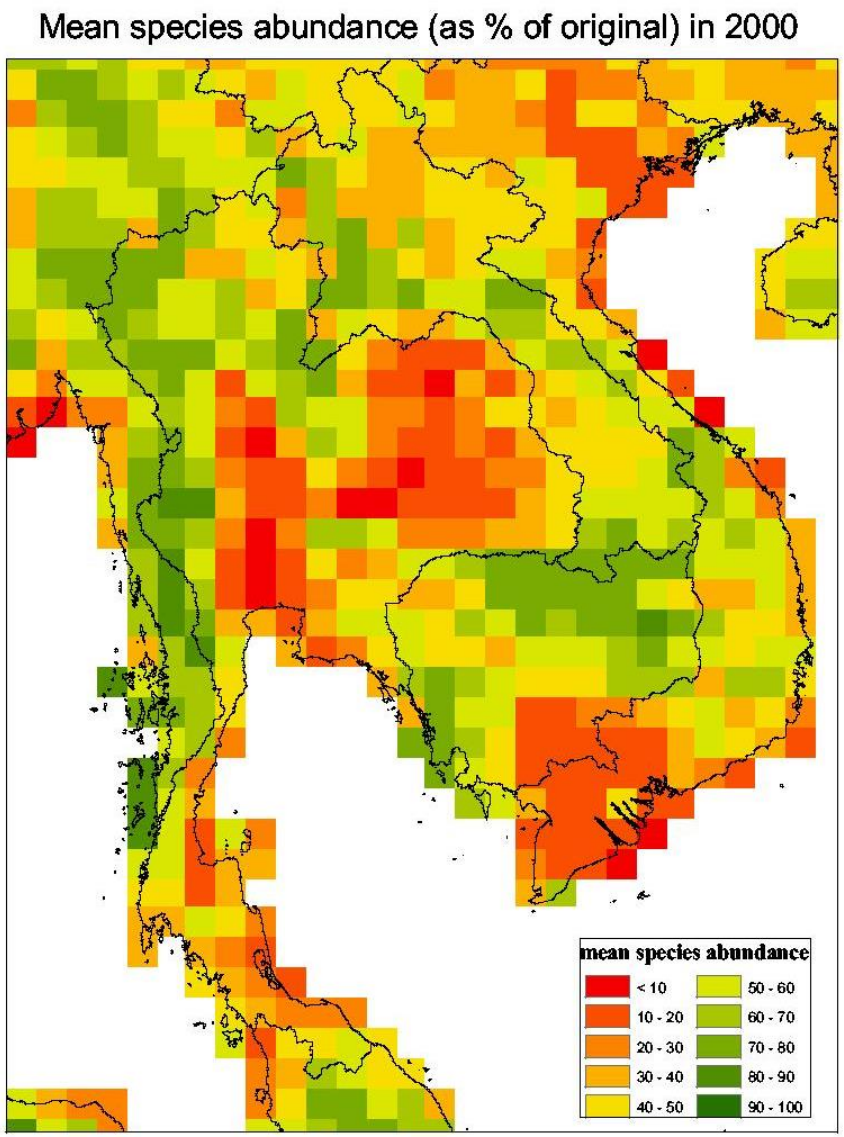

Zooming in:

South East Asia 2030

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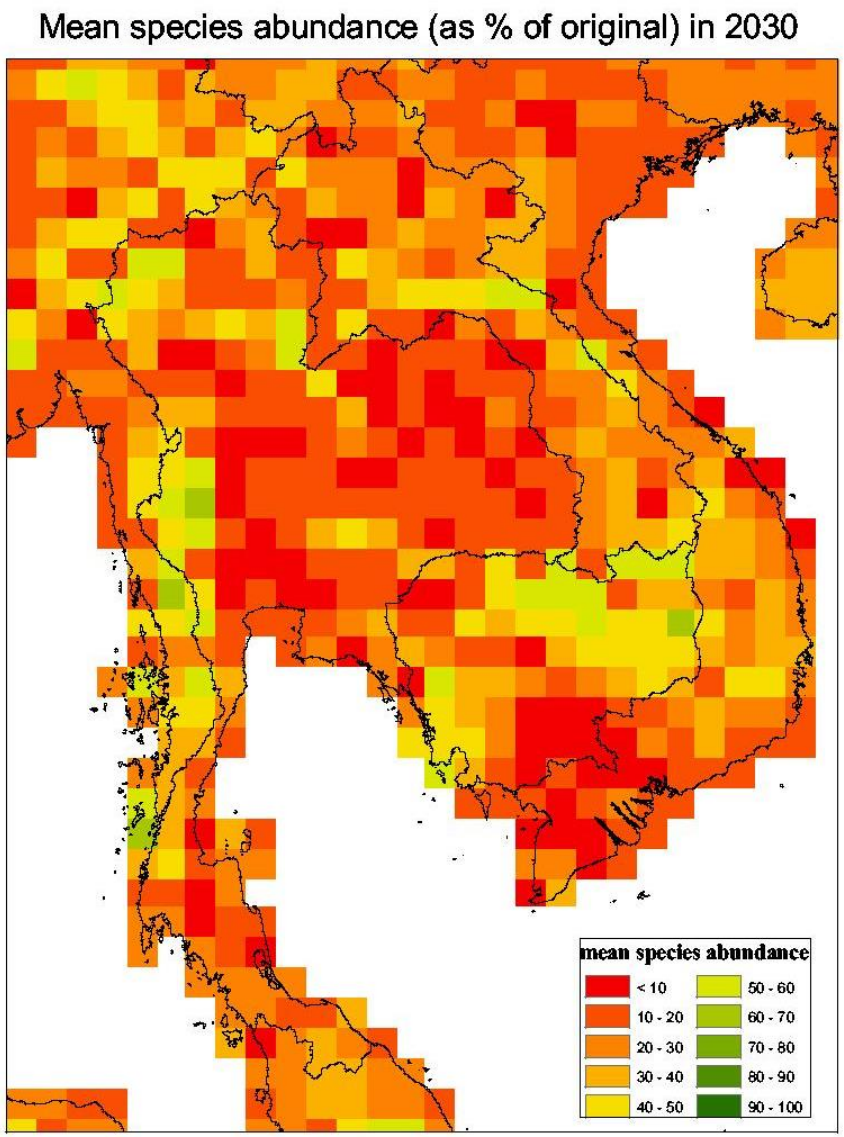
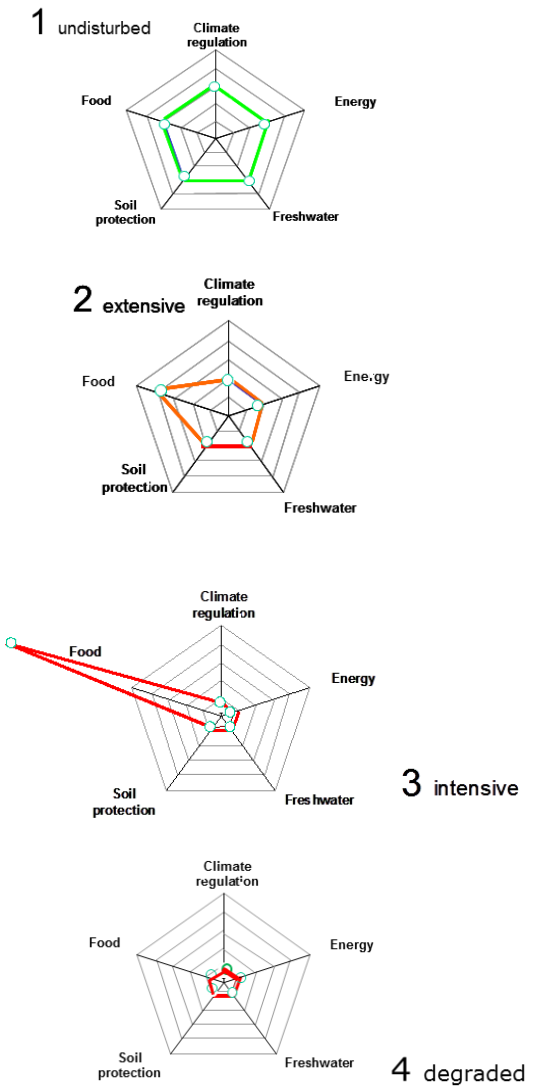
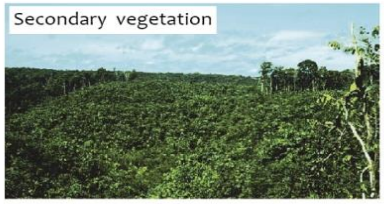
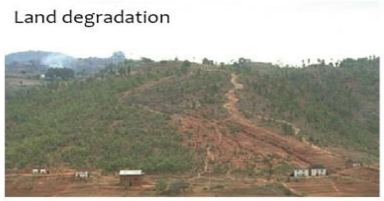


Man transforms lanscape since 8000 BP
Why?



Forest





Grassland

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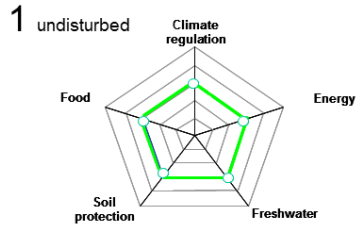
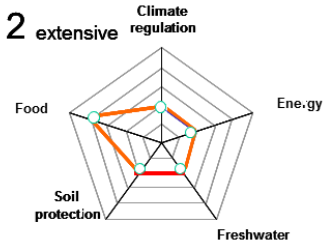
Bron: PBL, 2009

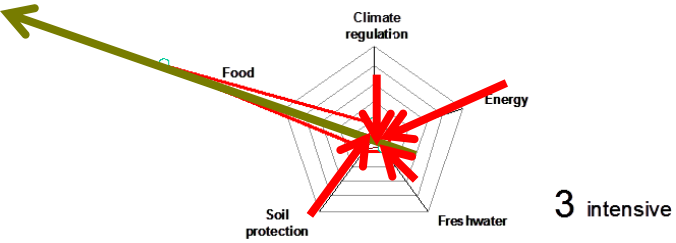
Concept

Degradation… or progress?

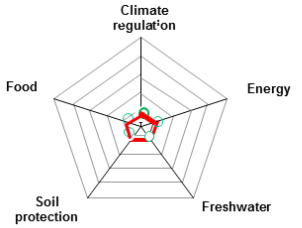




x 100

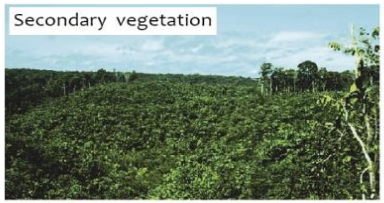


3 intensive



4 degraded

Forest



Grassland

pbl.nl

Bron: PBL, 2009

Concept

Degradation… or progress?

In general we:

de-vegetate

de-carbonate

de-hydrate

de-speciate

de-moderate

Function change

If badly managed:

de-plete

de-teriorate

Degraded?

Forest	Grassland
Pristine forest	Original species
Selective logging	Extensive use
Secondary vegetation	Burning
Agroforestry	Subsistence agriculture
Plantation	Intensive agriculture
Land degradation	Land degradation

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Bron: PBL, 2009

Concept

Preliminary estimation impacts

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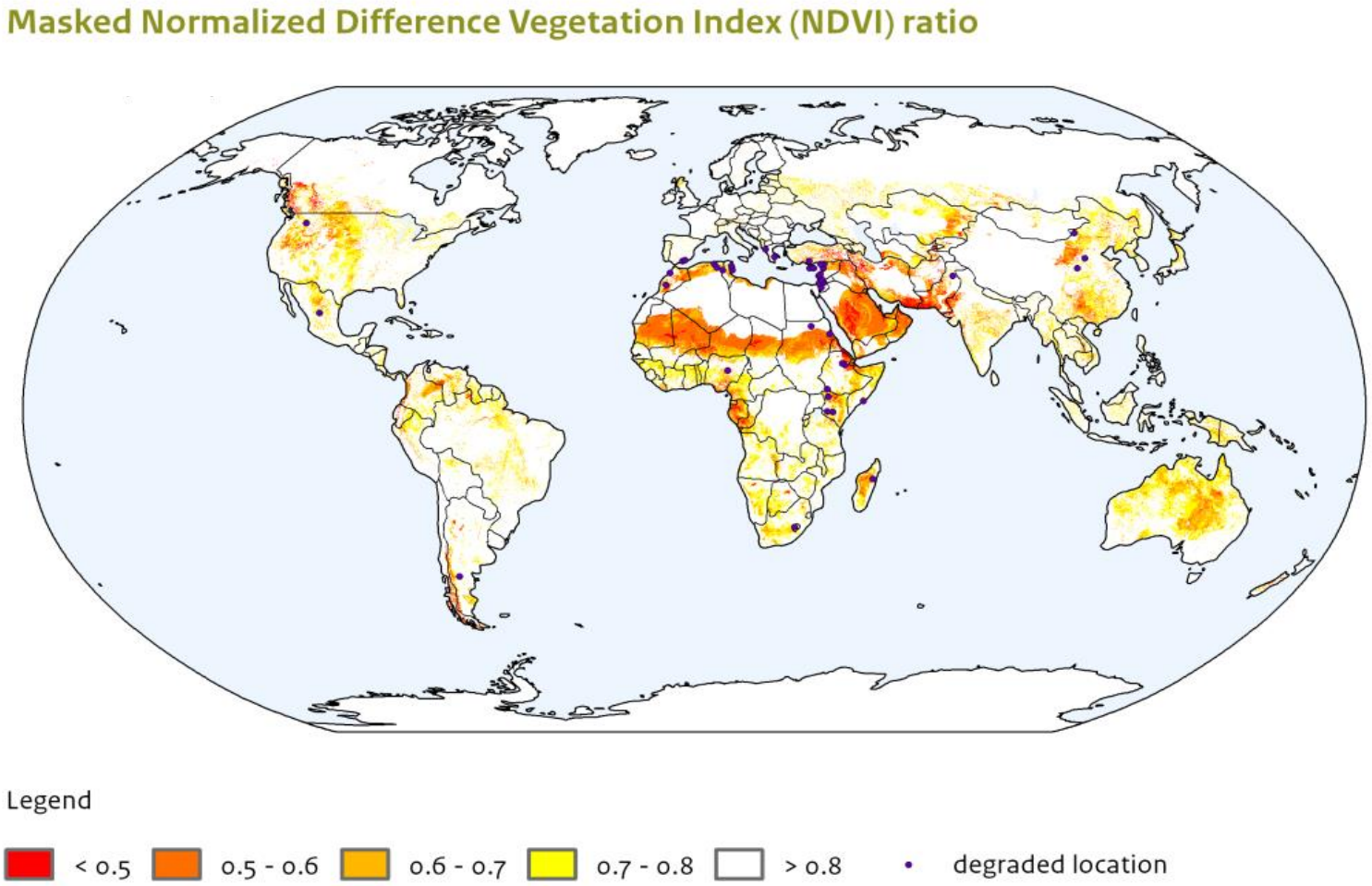
Greenness current/potential (ndvi)



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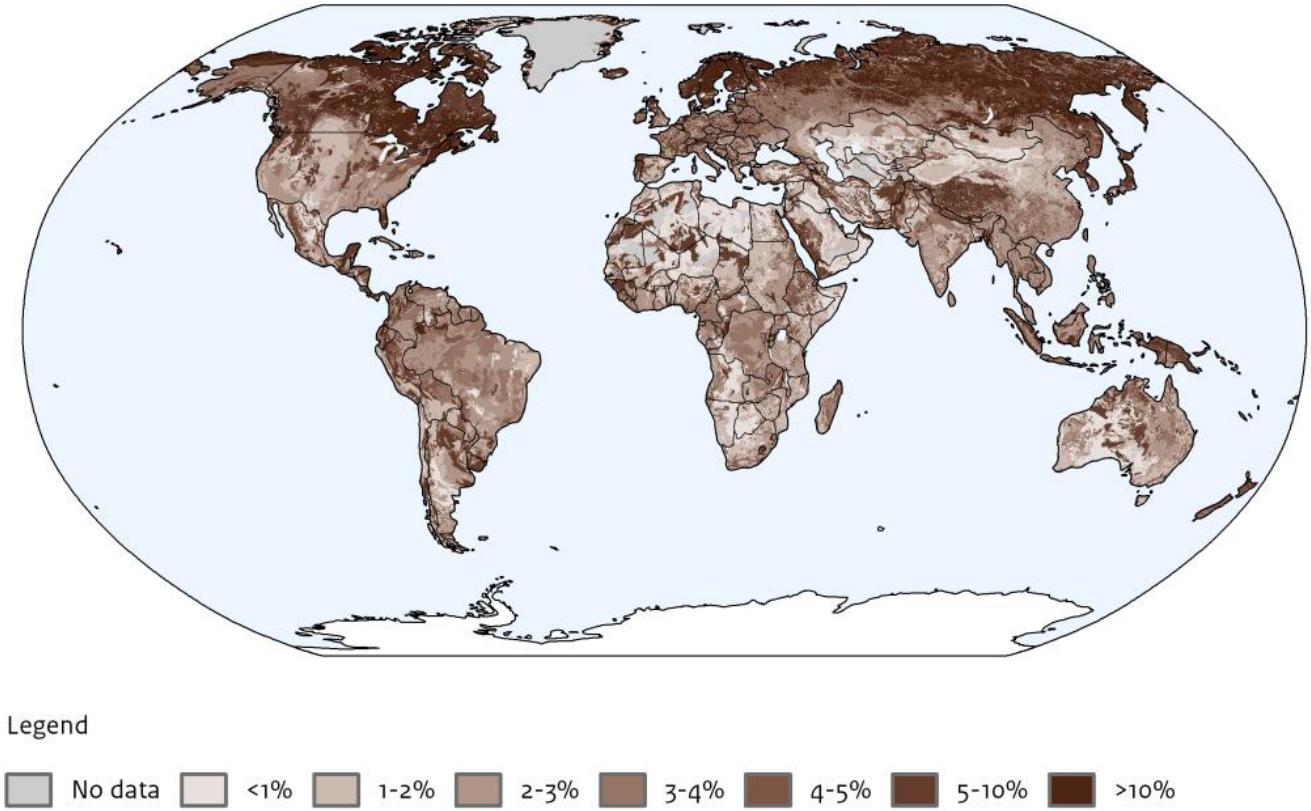
Soil organic Carbon

Modelled potential soil organic matter



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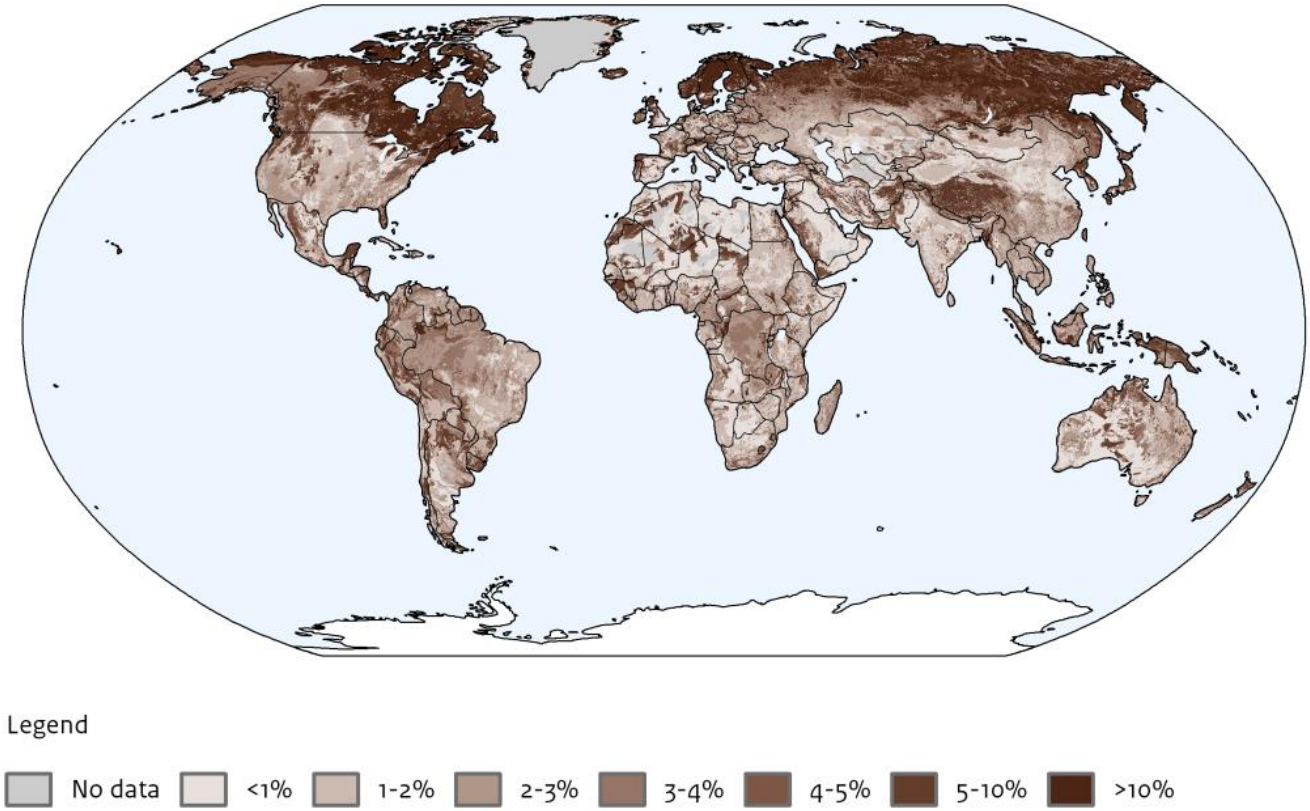
Soil organic Carbon

Modelled current soil organic matter



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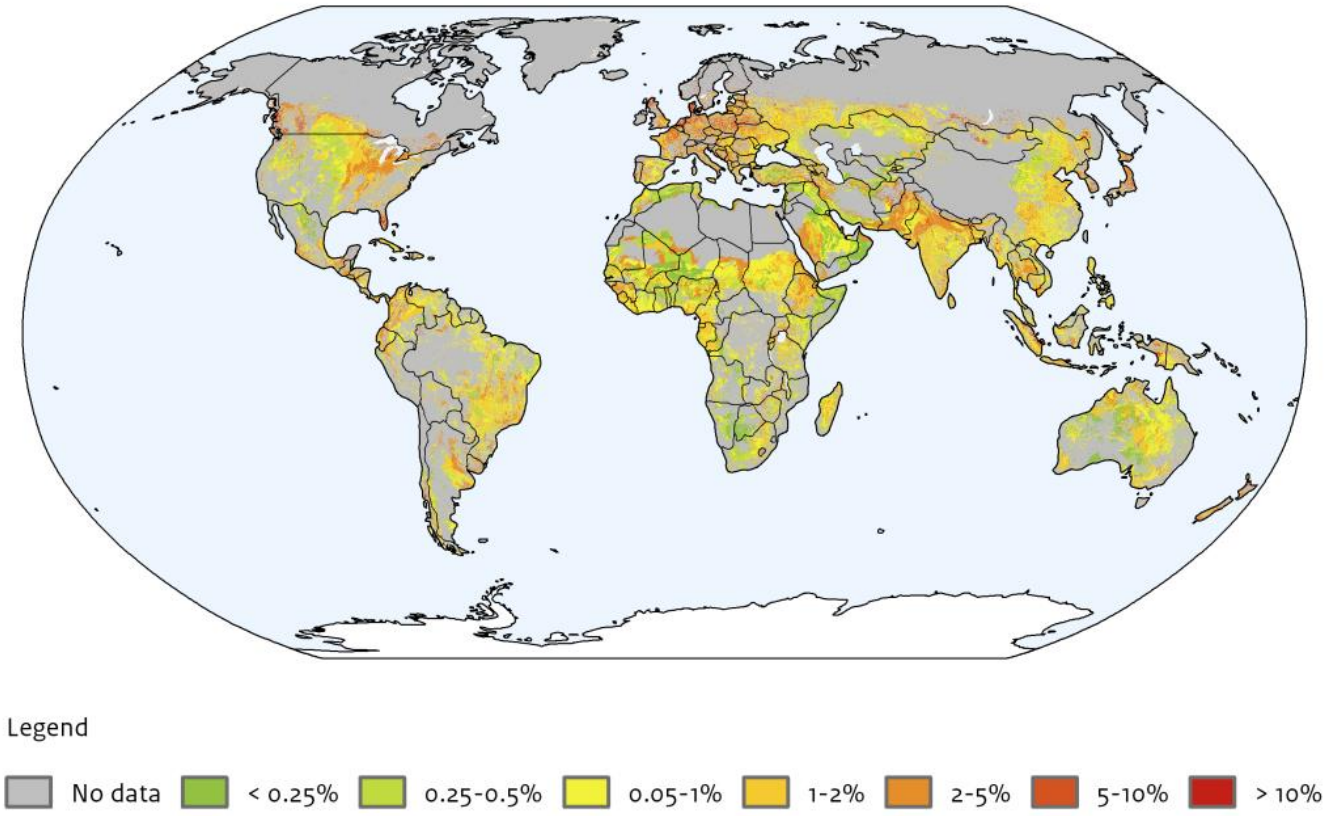
Soil organic Carbon

Modelled change soil organic matter



Preliminary estimation impacts

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Carbon sequestration & climate

Biosphere C emissions:

- Pre-1850 : 320 Gt C
- 1850-1998: 136 Gt C +/- 55
- Total : **456** Gt C (401-511) 4 Gt C = 1 ppm CO_2

Fossil C emissions 1850-1998 : **270** Gt C +/- 30 (~68 ppm)

Source: Lal (2004, 2008)

Preliminary estimation impacts

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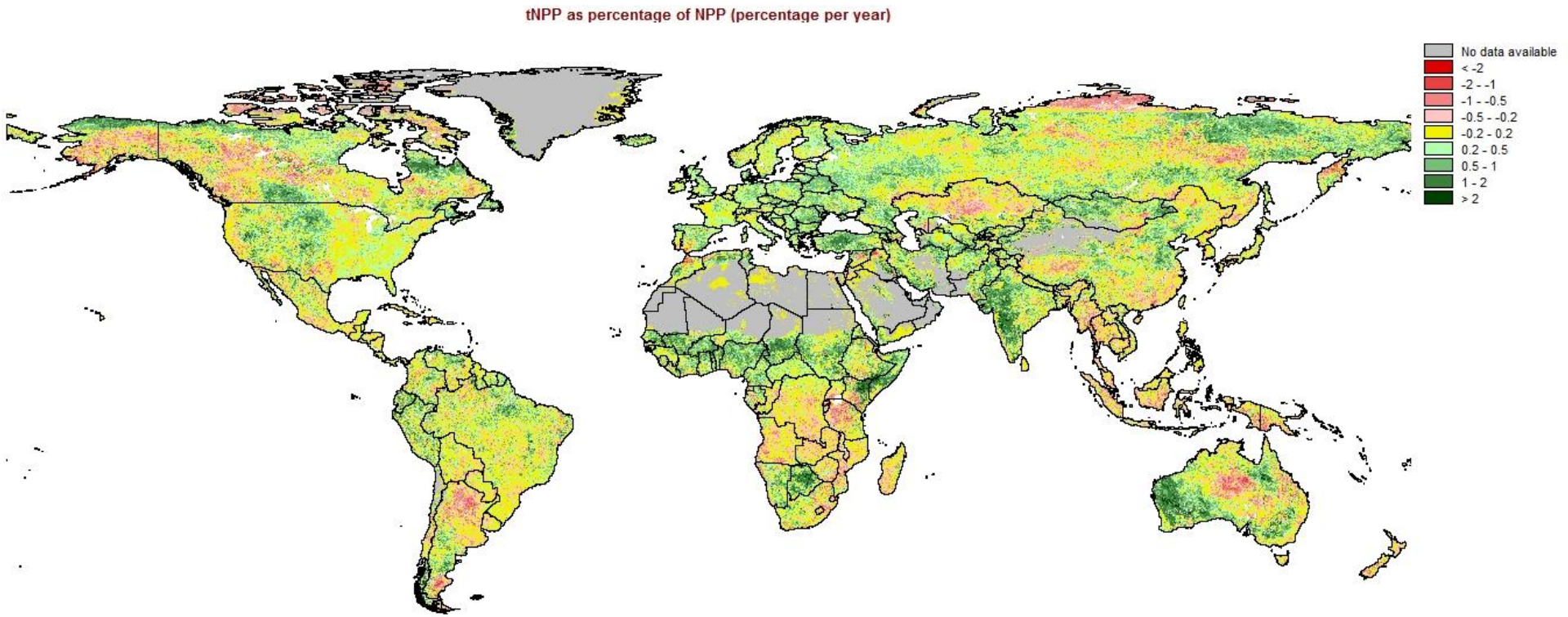
Productivity change 1982-2010 (% npp/yr)



Preliminary estimation impacts

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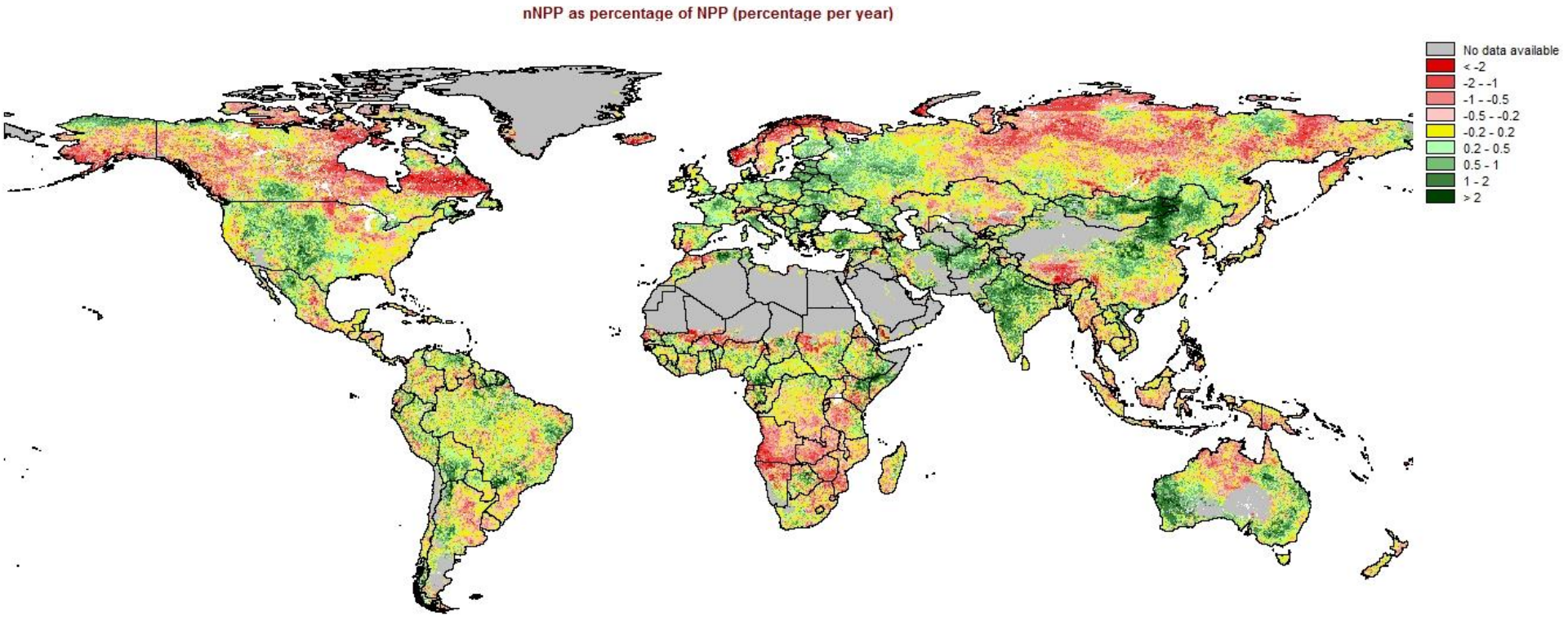
Productivity change 1982-2010 climate corrected (% npp/yr)



Preliminary estimation impacts

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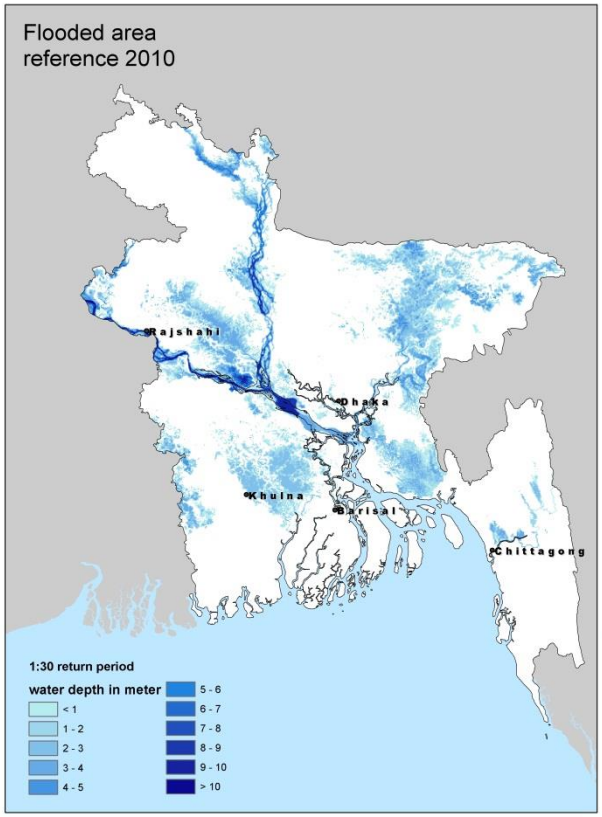
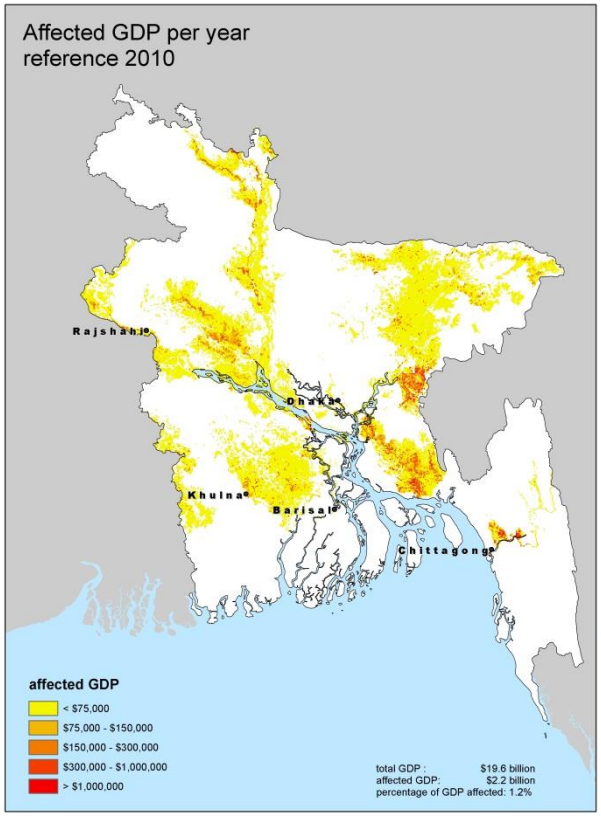
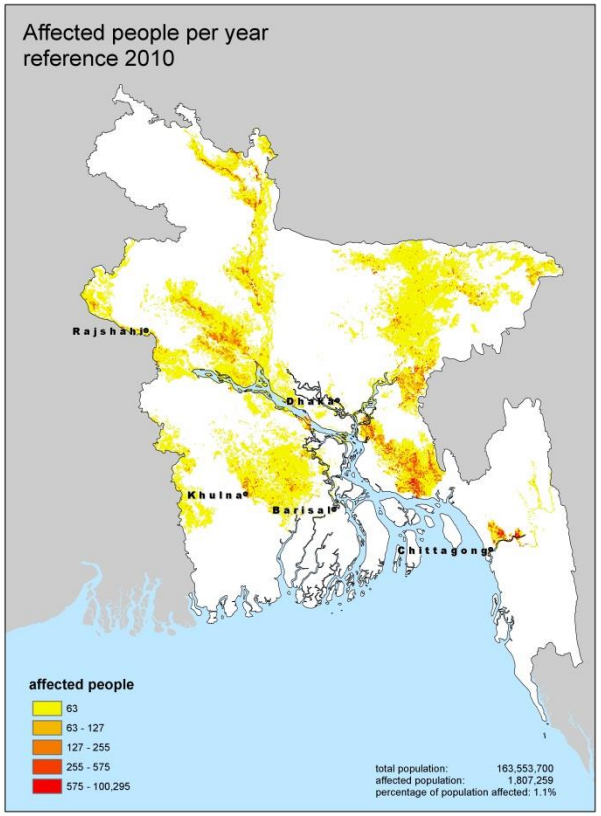
Floods



Once in 30-year flood



Affected GDP per year



Affected people per year

Preliminary estimation impacts

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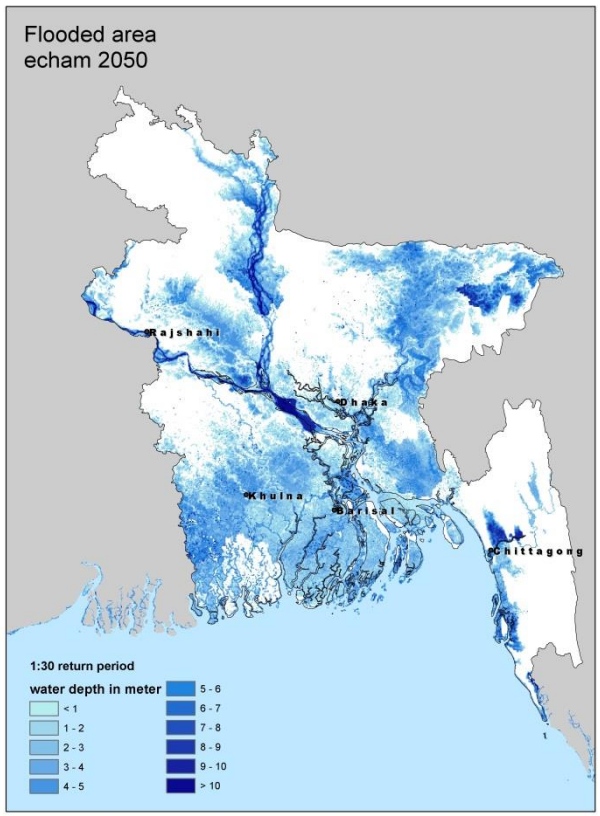
Floods



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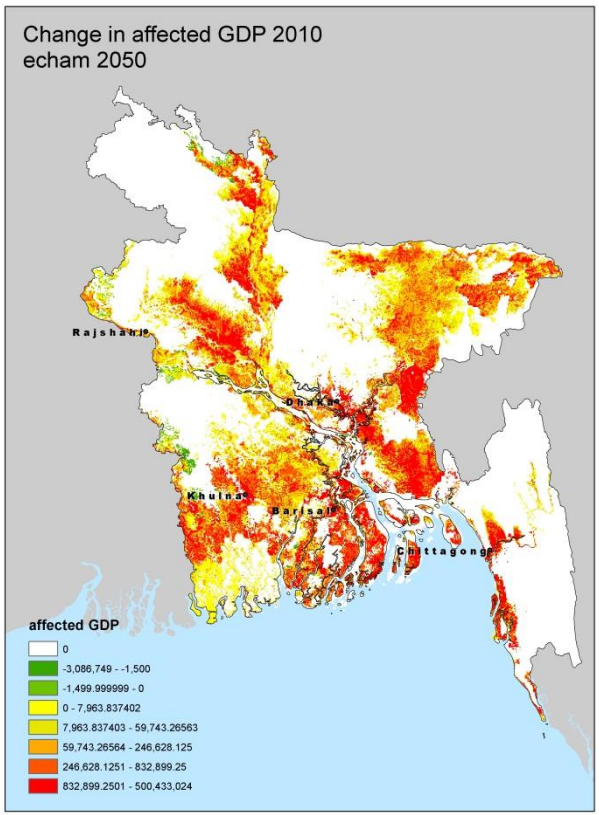

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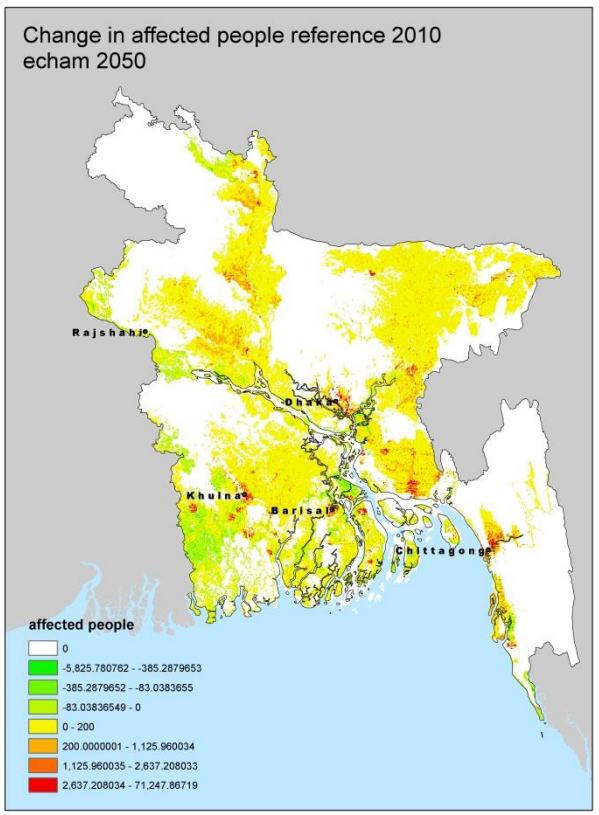

Affected people per year

Planetary bounderies?

to expected socioeconomic development

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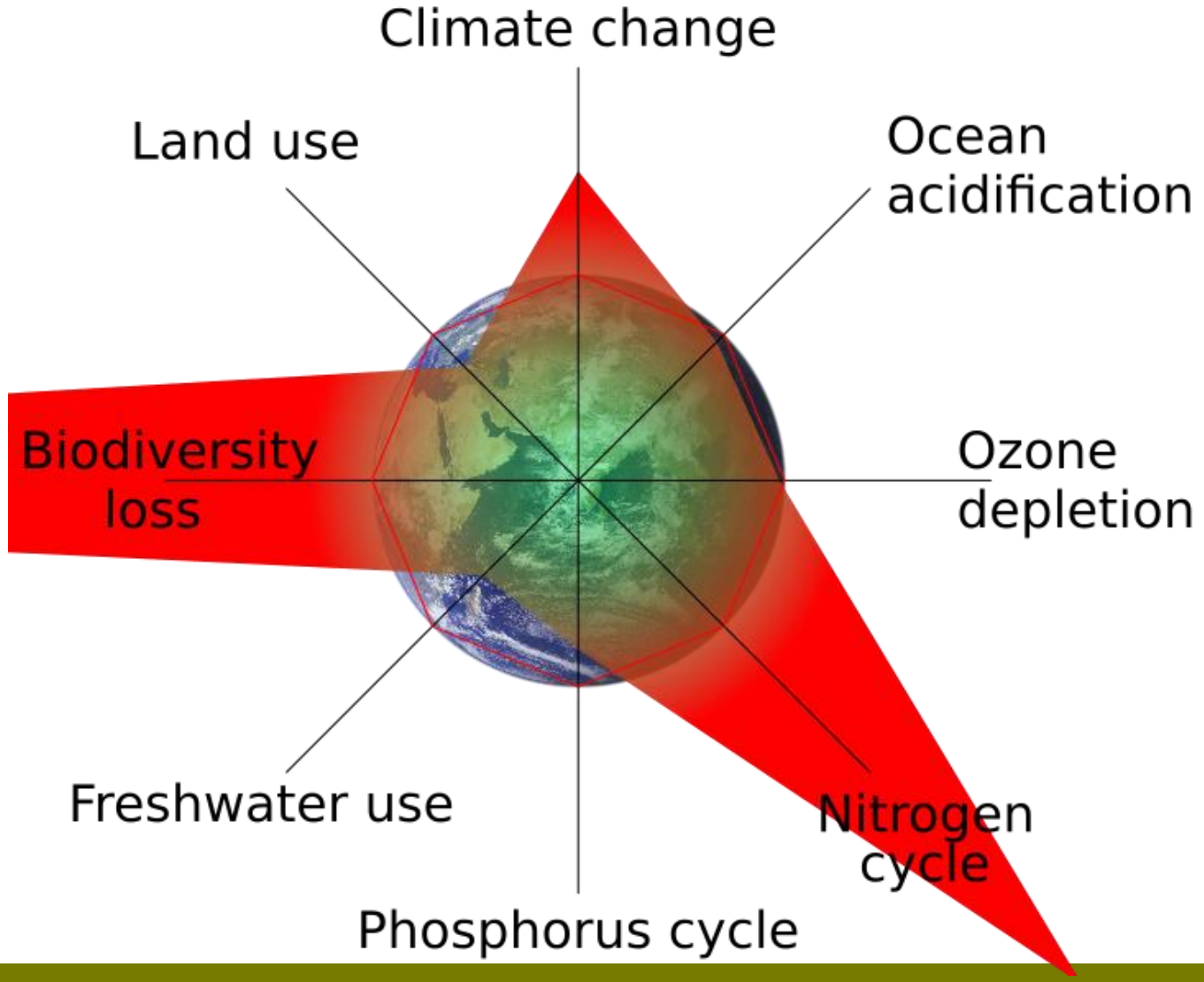
?



Rockstrom et al., 2009

Modelling the future
Planetary bounderies?

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LEITAP – TIMER – IMAGE – GLOBIO - EcoOcean models

Baseline scenario
- Population
- Economic growth
- Technology
- Lifestyle

Options:
1. Closing yield gap
2. Post harvest loss
3. Diet change (meat)
4. Improved forestry
5. Reduced deforest
6. CCM, bio-fuels
7. Protected areas
8. Aqua-culture
9. Liberalisation trade

Indirect drivers
- Food demand
- Energy demand
- Energy mix
- Wood demand
- Food trade

Pressures
- Land use change
- Climate change
- N-deposition
- Forestry
- Infrastructure
- fragmentation

Effects

Biodiversity
- Ecosystem extent
- Ecosystem quality

EGS
- biomass & SOC
- climate
- soil depth & WHC
- NPP
- water availability/quality
- floods & droughts
- food & fish
- timber
- bio-energy

Modelling the future
Planetary bounderies?

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Key policy question:
How far can we stretch global ecosystem transformation?

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EGS-change & Tipping points

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- timber
- bio-energy

EGS-change & Tipping points

1. Water
2. Food
3. Livelihoods
4. Economic development
5. Poverty alleviation
6. Migration/conflict

Modelling the future
Planetary bounderies?

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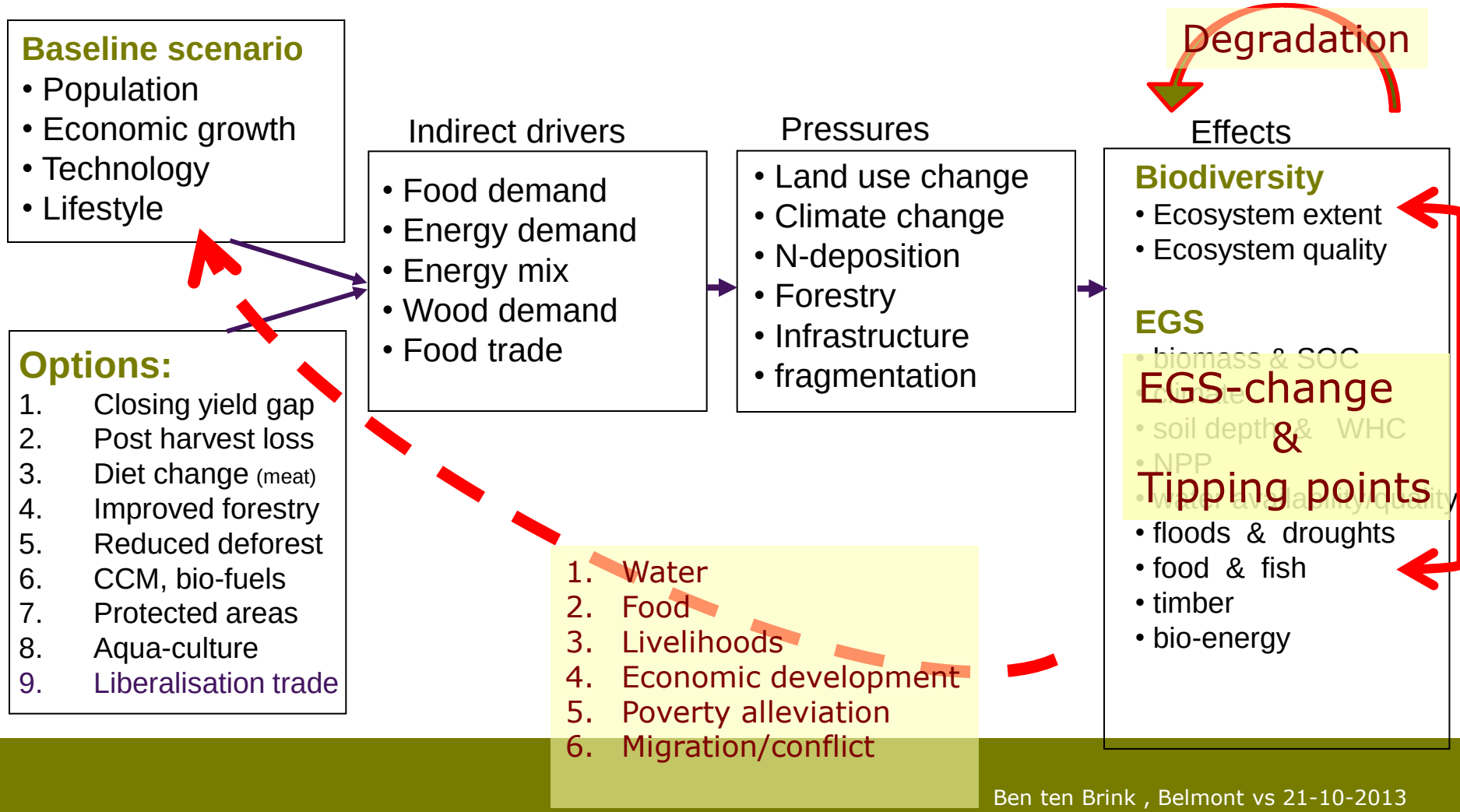

Modelling the future
Planetary bounderies?

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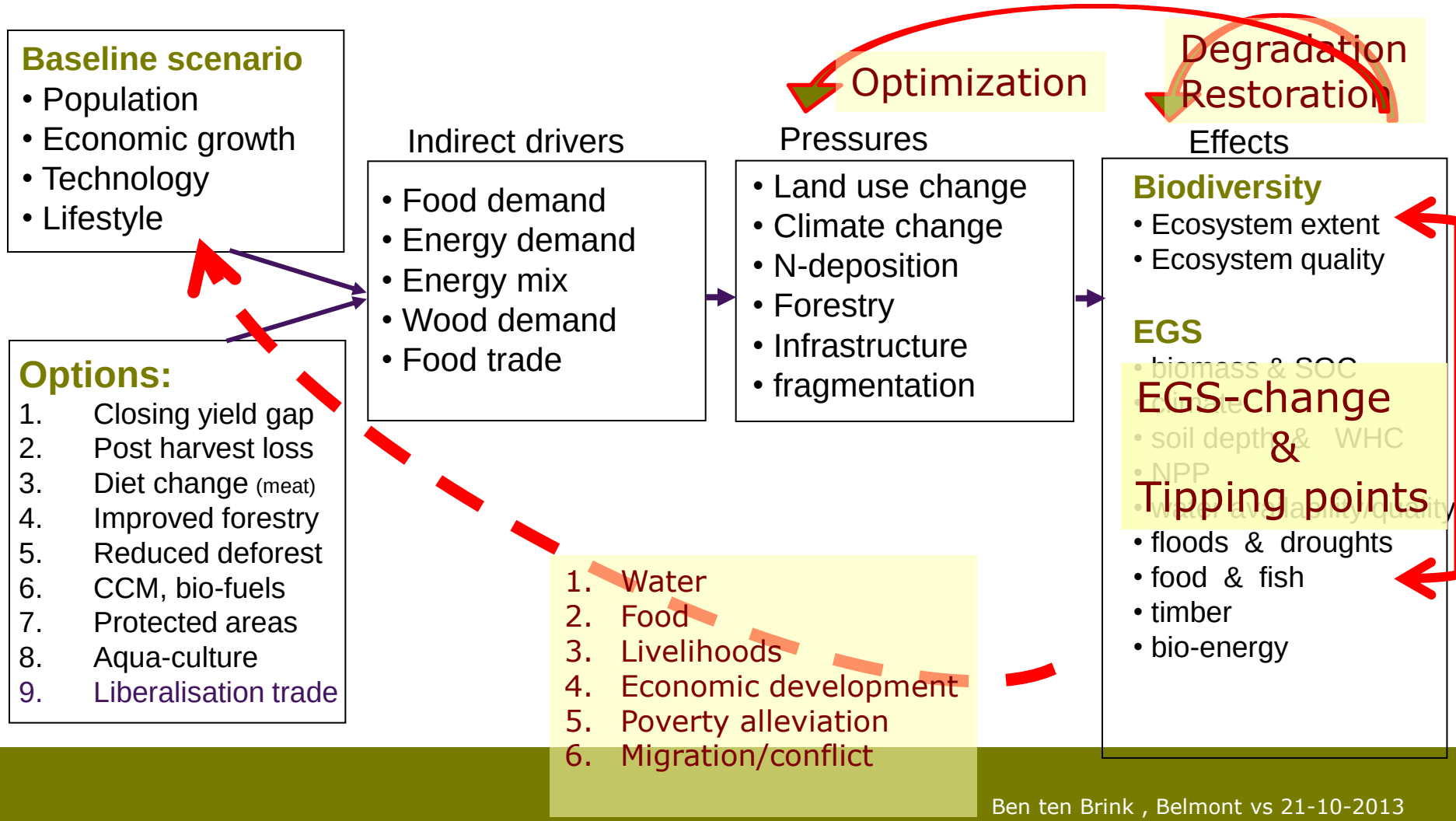

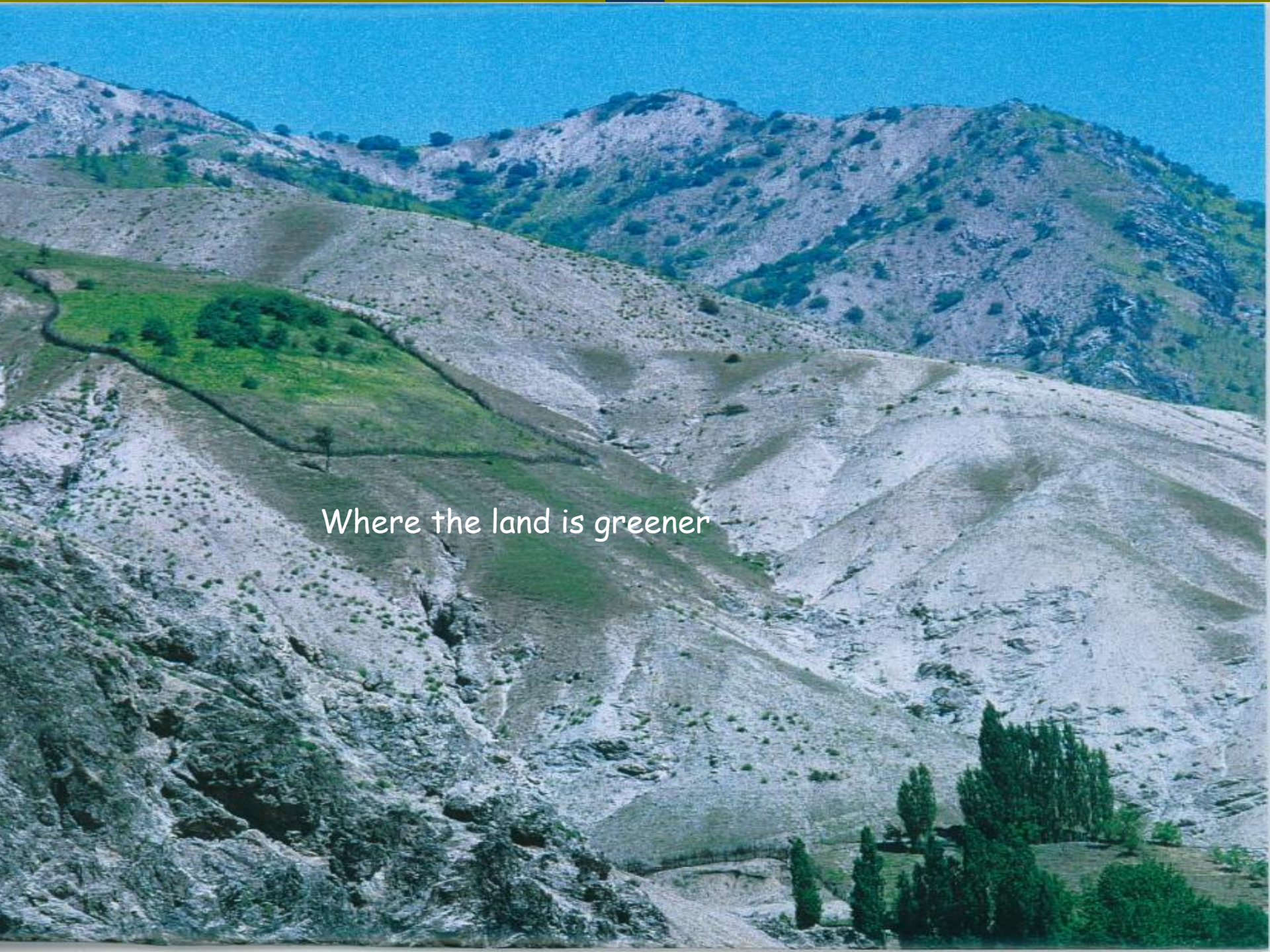
Where the land is greener

Modelling the future
Planetary bounderies?

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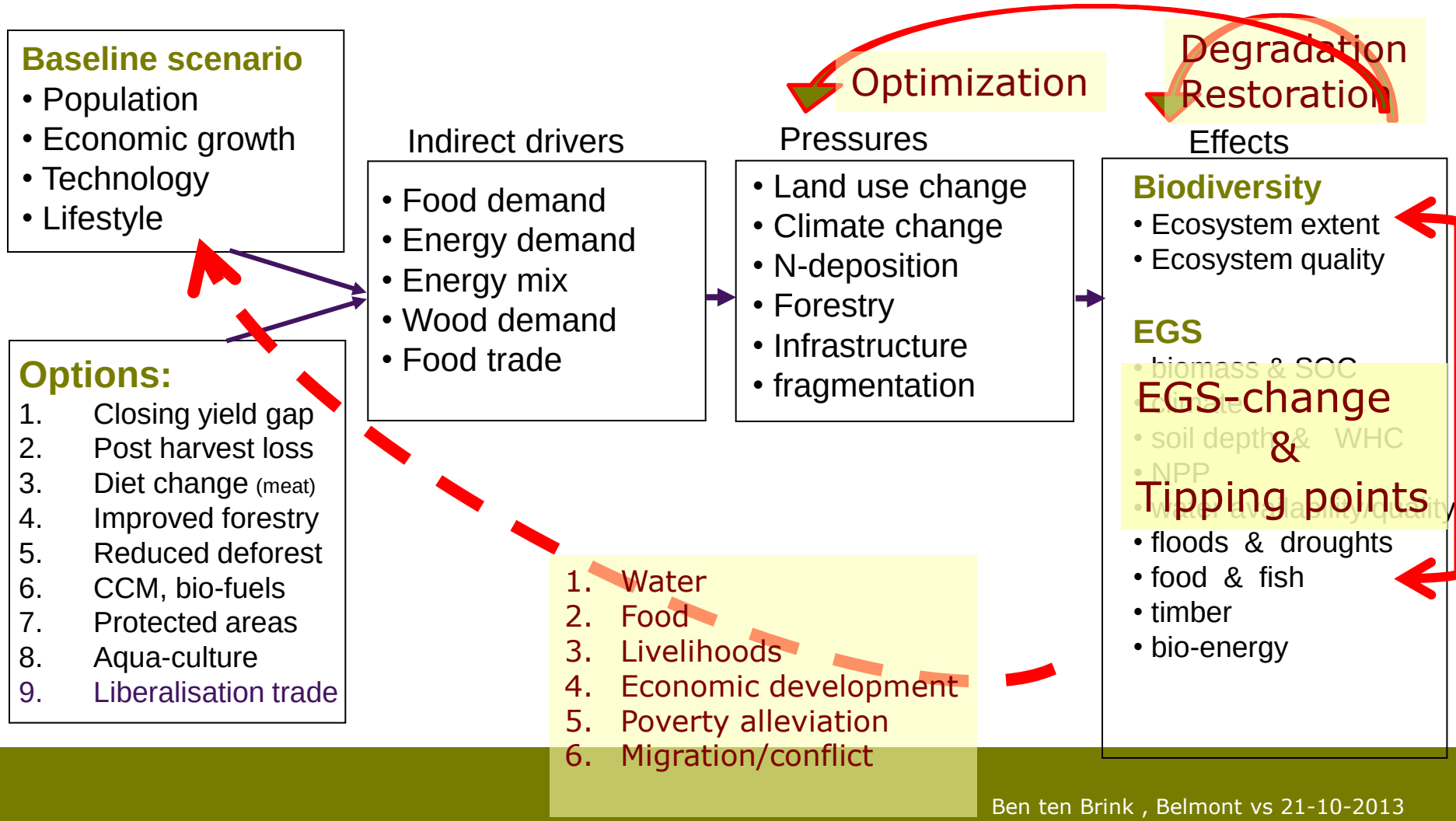

Modelling the future
Planetary bounderies?

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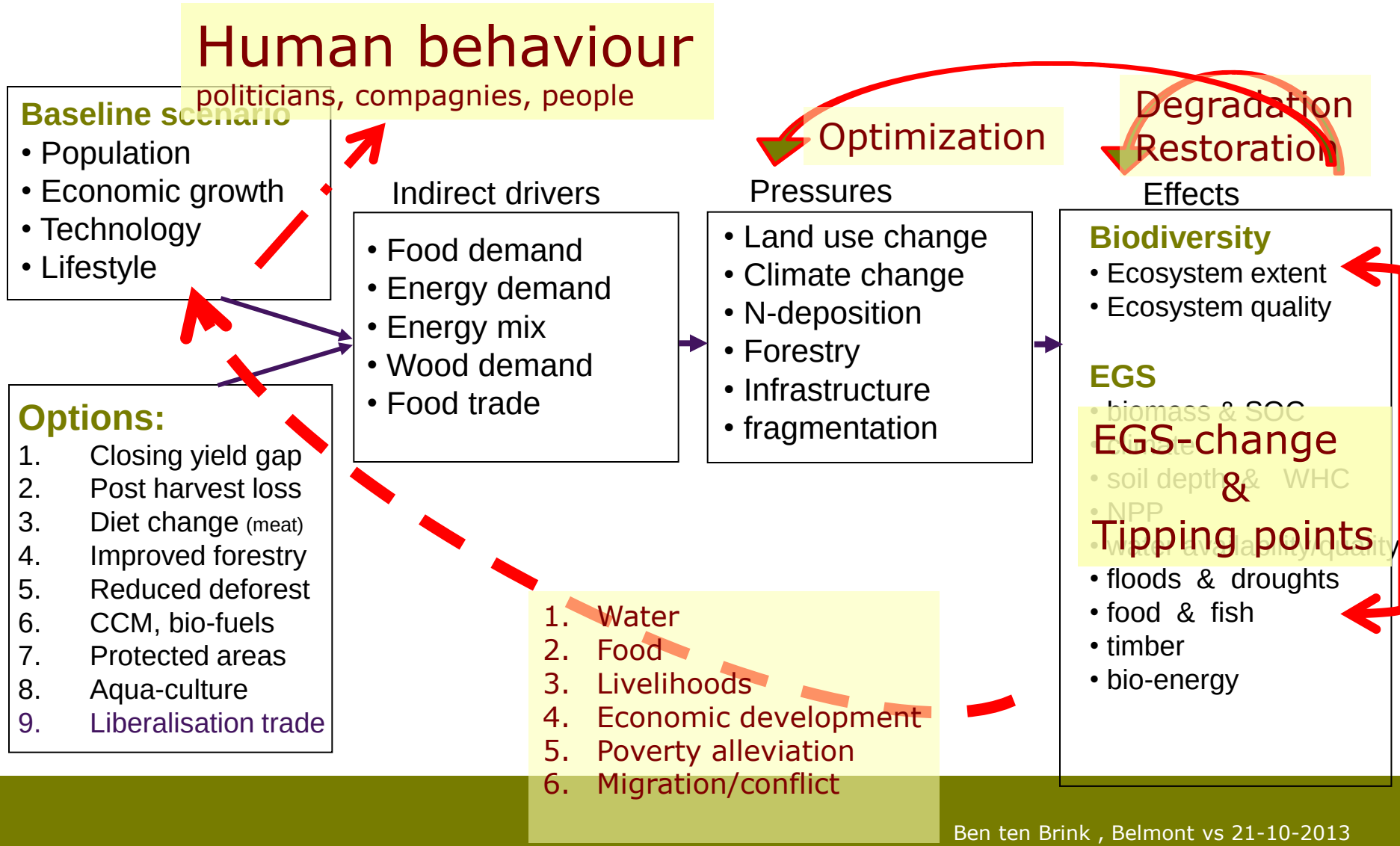

Modelling the future
Planetary bounderies?

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Human behaviour
politicians, compagnies, people

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- Climate change
- N-deposition
- Forestry
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- fragmentation

Optimization

Degradation
Restoration

Effects

Biodiversity
- Ecosystem extent
- Ecosystem quality

EGS
- biomass & SOC
- soil depth & WHC
- NPP
- floods & droughts
- food & fish
- timber
- bio-energy

EGS-change
&
Tipping points

Economic valuation change production -> function

1. Deficits
2. Desasters
3. Livelihoods
4. Economic development
5. Poverty alleviation
6. Migration/conflict

Modelling the future
Planetary bounderies?

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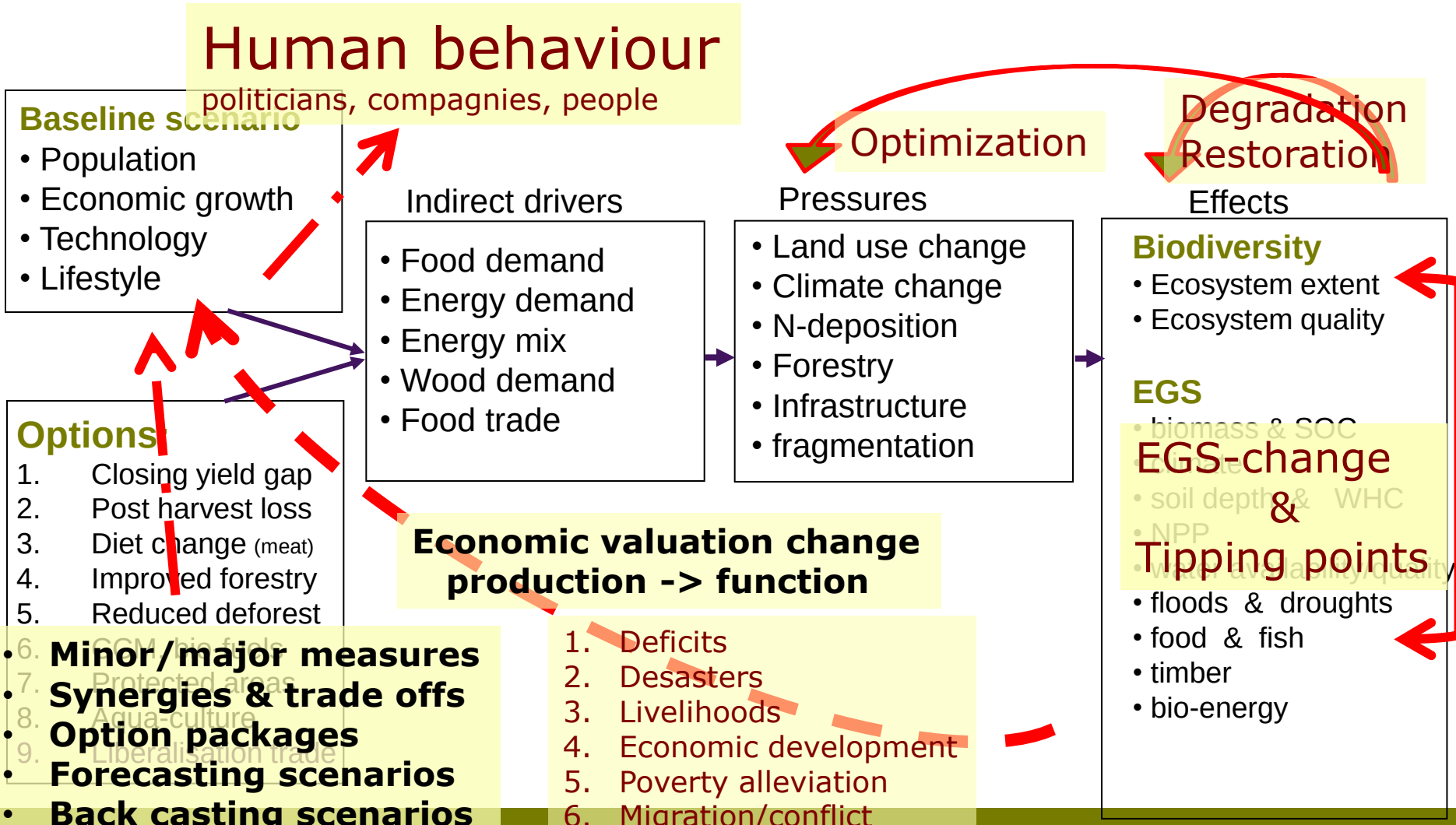

Option trade offs

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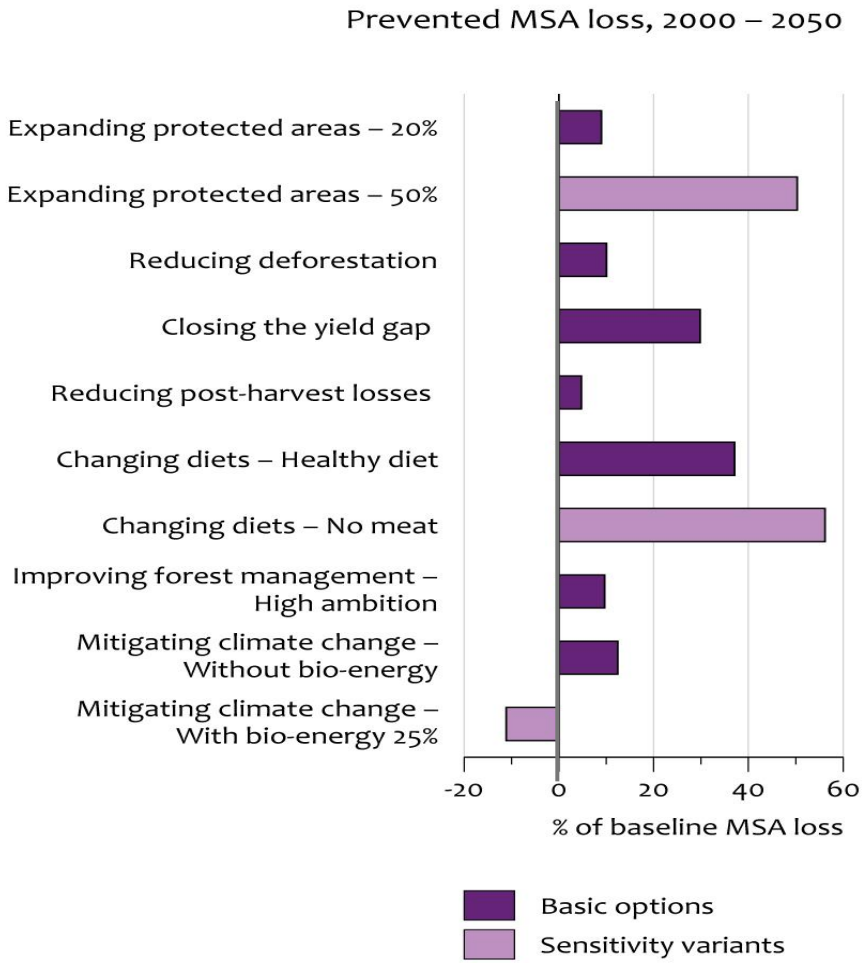
Change in global biodiversity per option compared to baseline scenario



Change in global biodiversity of options expanding protected areas and reducing deforestation by 2030

Option trade offs

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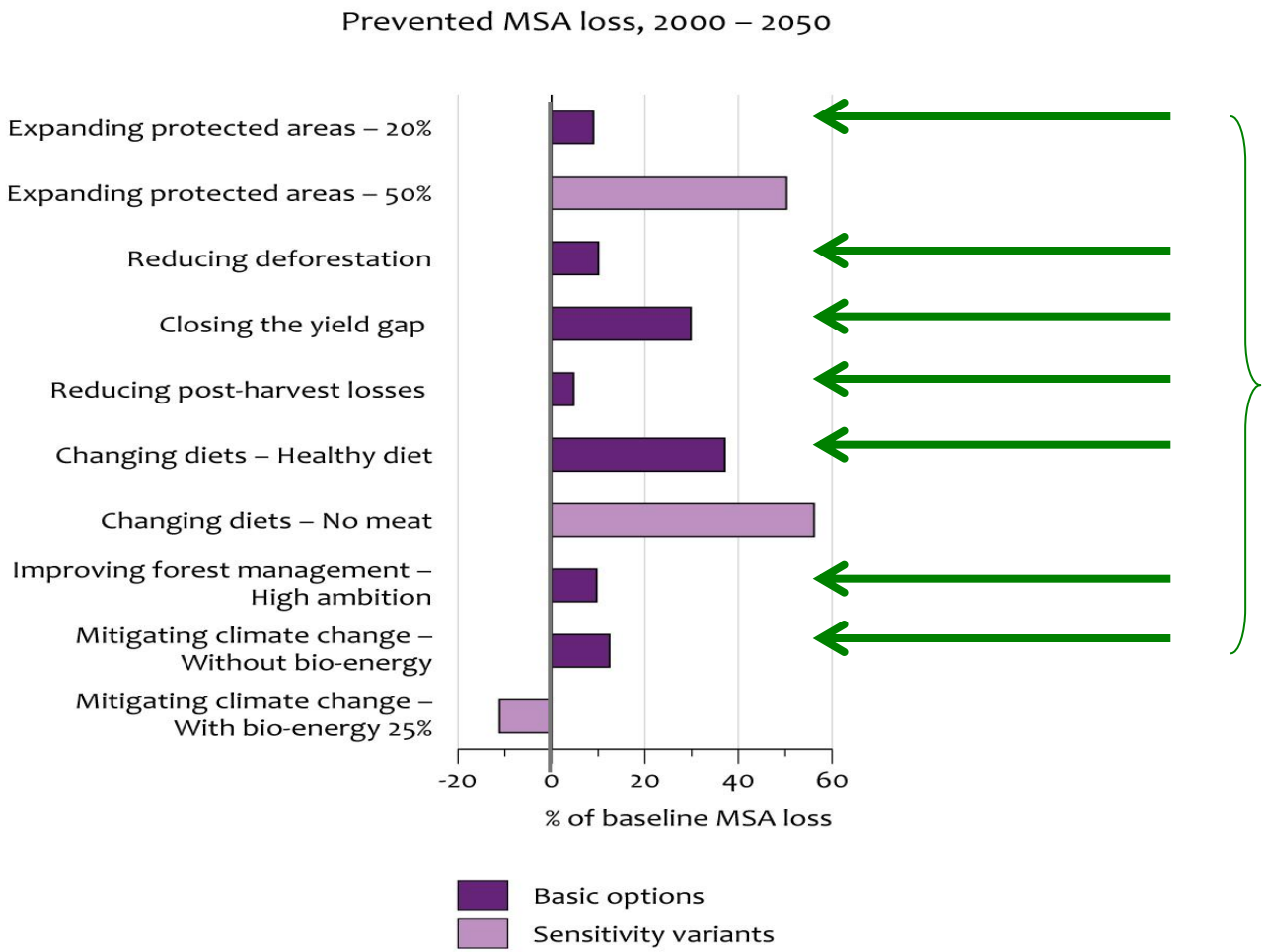
Change in global biodiversity per option compared to baseline scenario



Options included in combination

Change in global biodiversity of options expanding protected areas and reducing deforestation by 2030

Option trade offs

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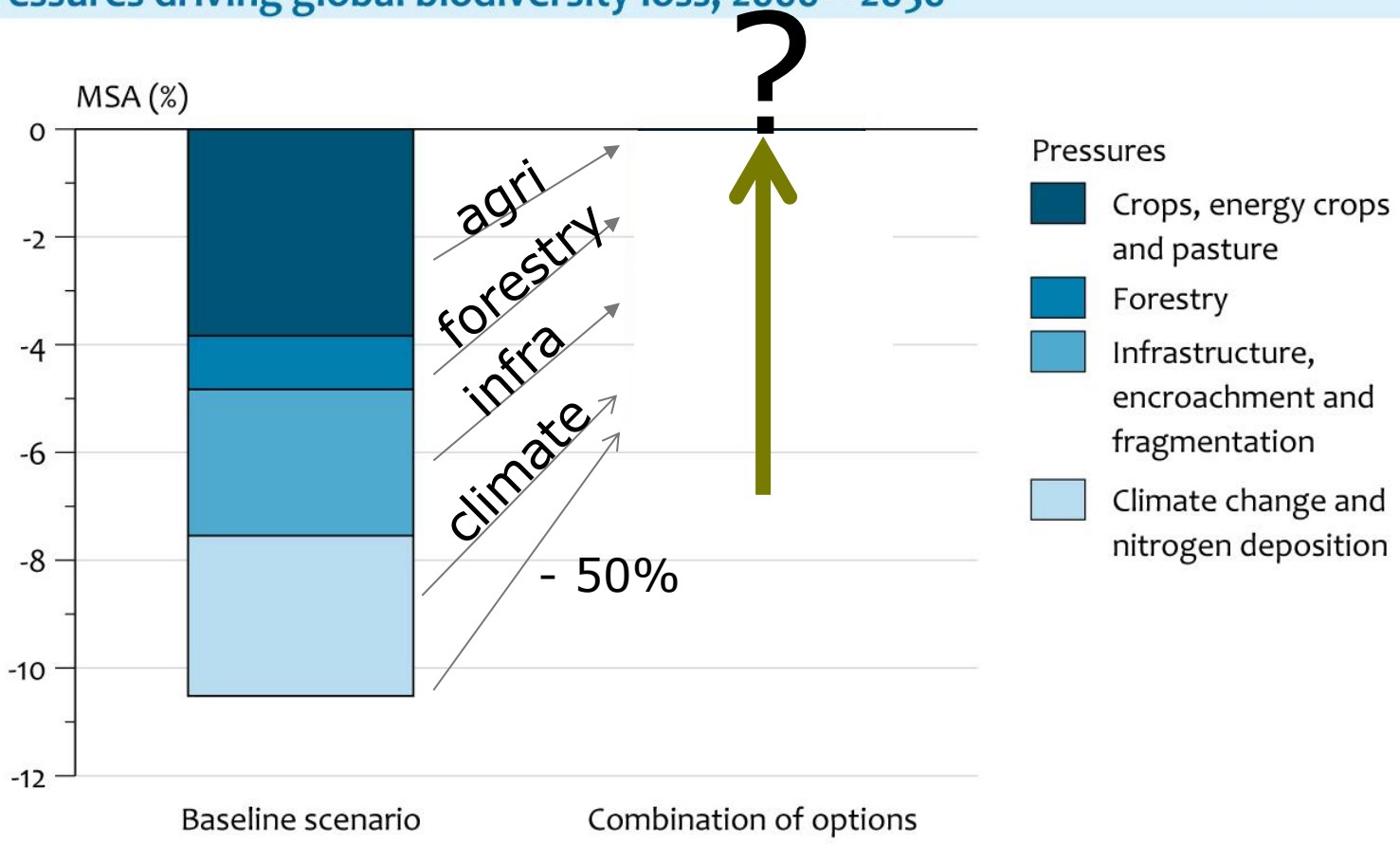
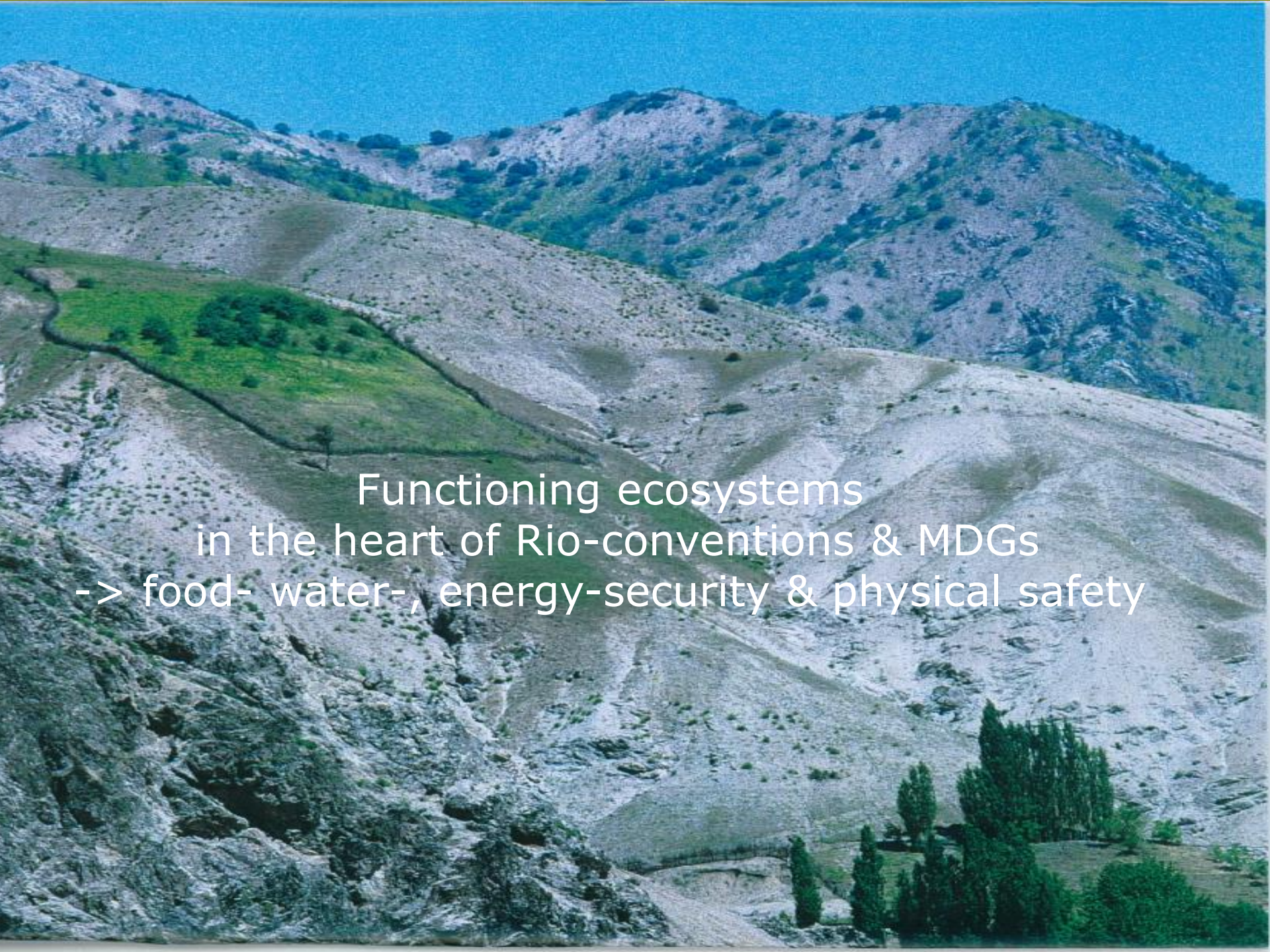
Pressures driving global biodiversity loss, 2000 – 2050




Functioning ecosystems
in the heart of Rio-conventions & MDGs
-> food- water-, energy-security & physical safety


Thank you

Consequences
goods for services

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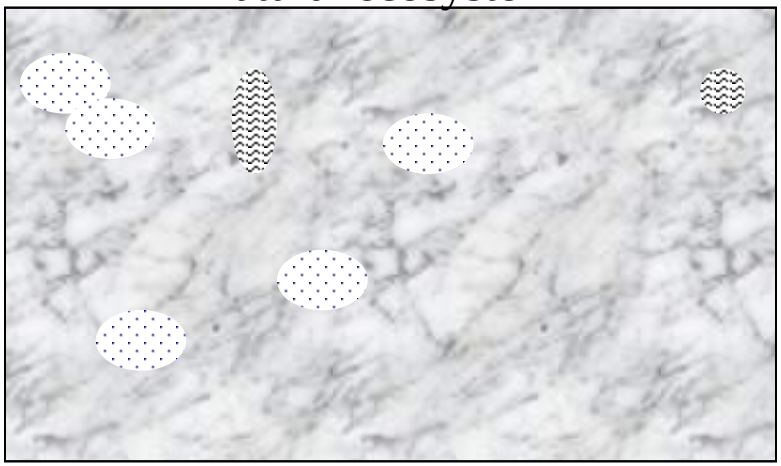
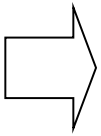
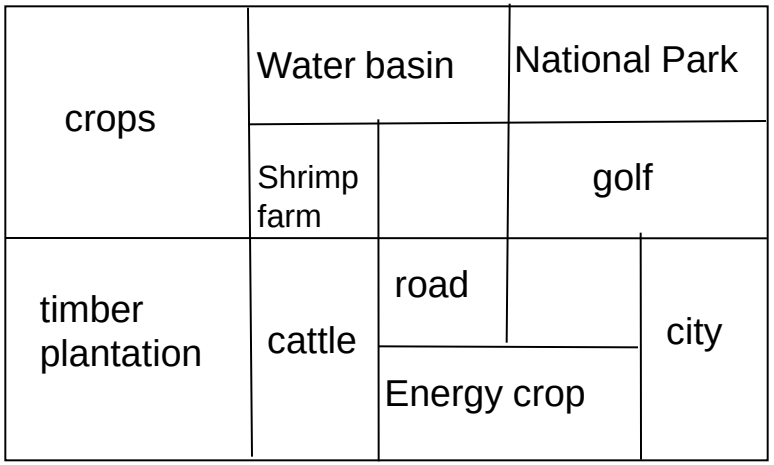
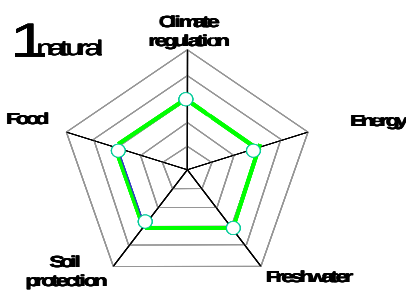
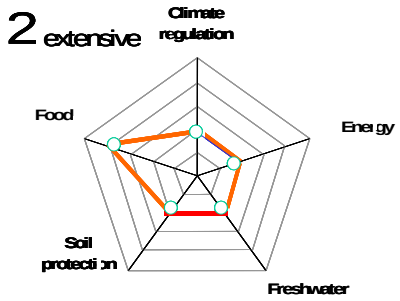
Natural ecosystem

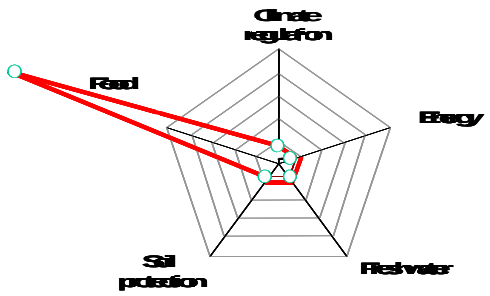












3 intensive

'We parcelate the world'

Swap services for goods

Making multiple maps
function change

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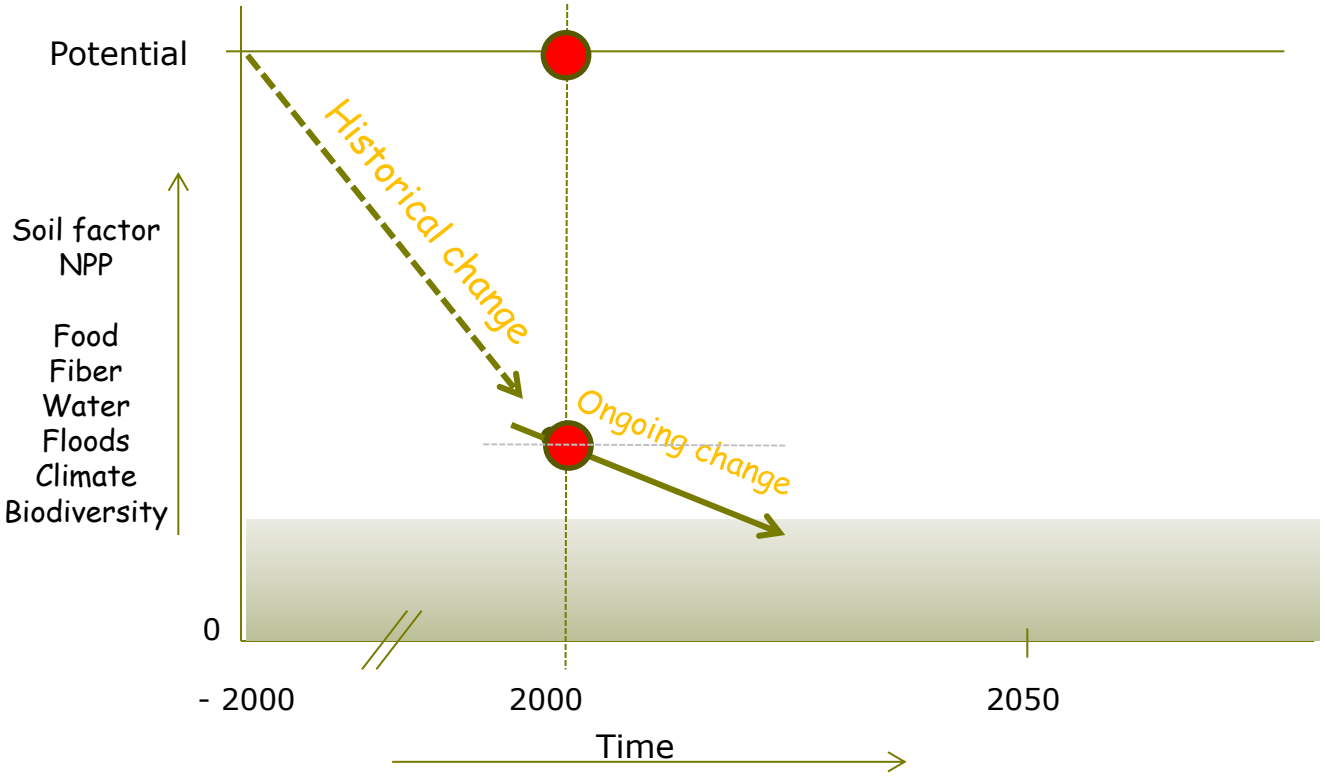

Restoration scenarios
SOC increase over time

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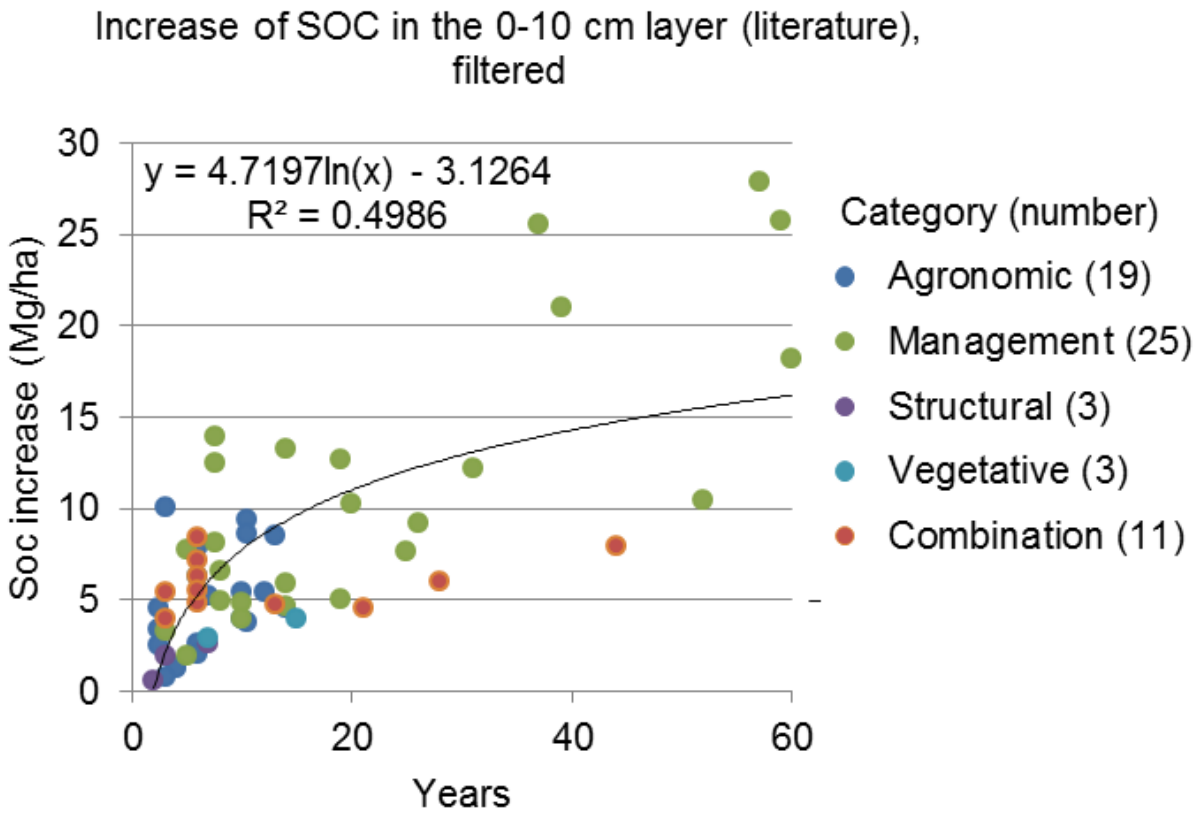

Legend:
sequestration > 0.25 Mg/ha
total dSOC > 7.5 Mg/ha

Source: WUR, WOCAT

Future scenarios

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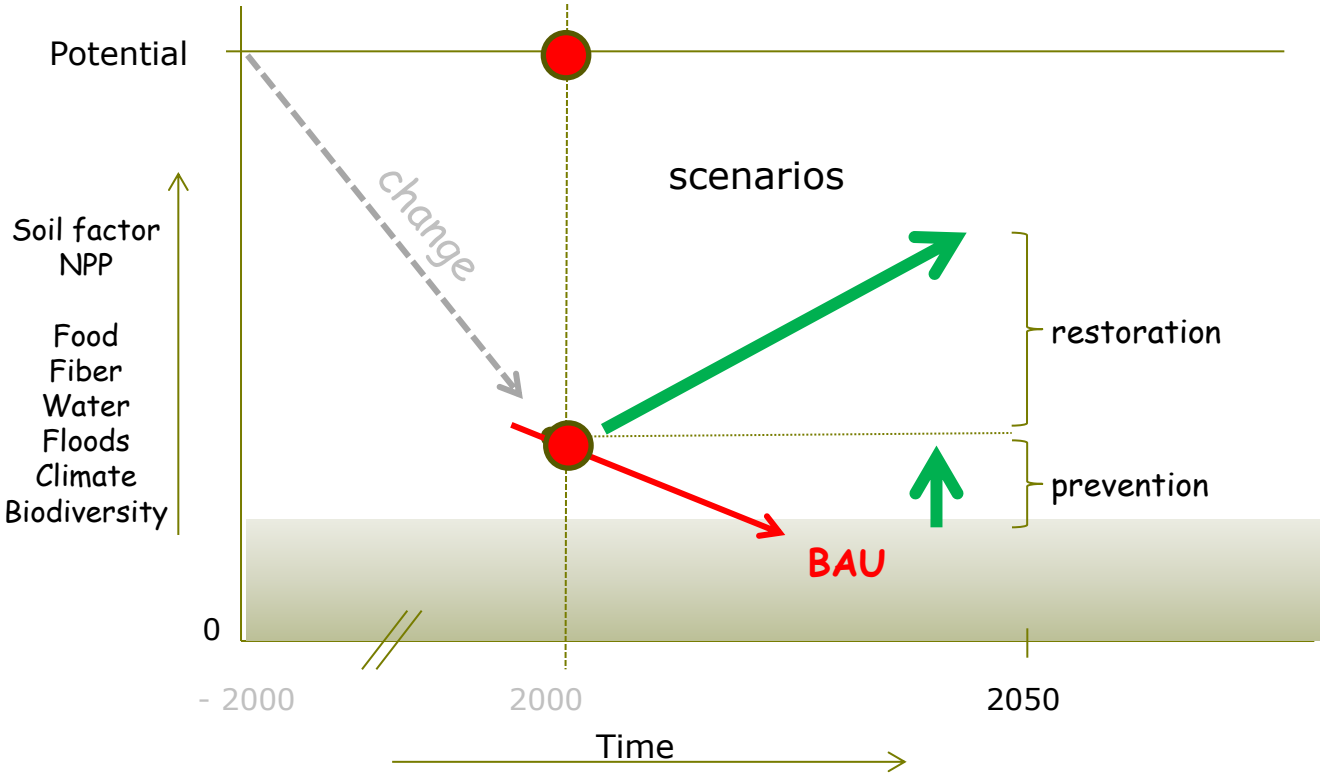
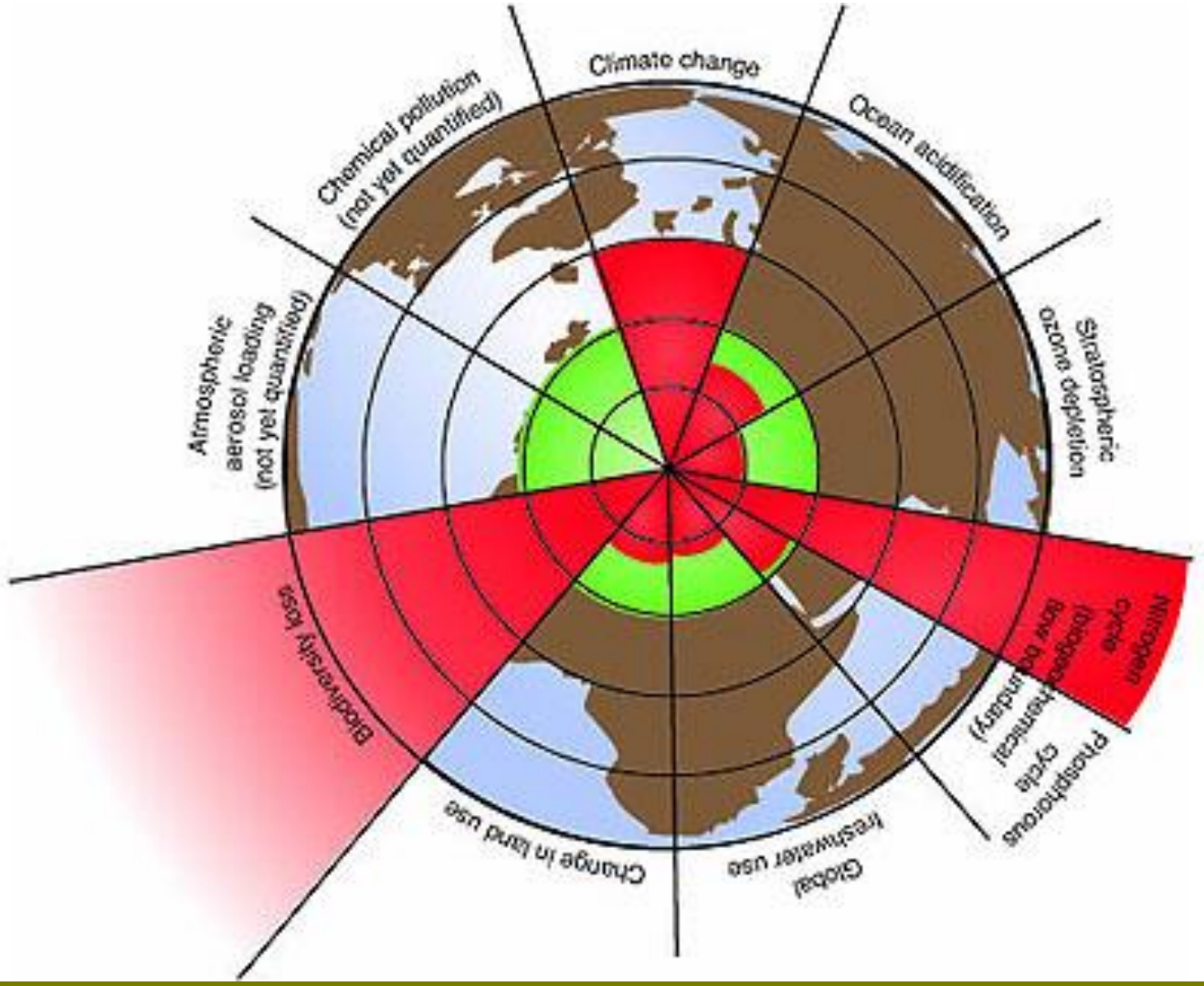
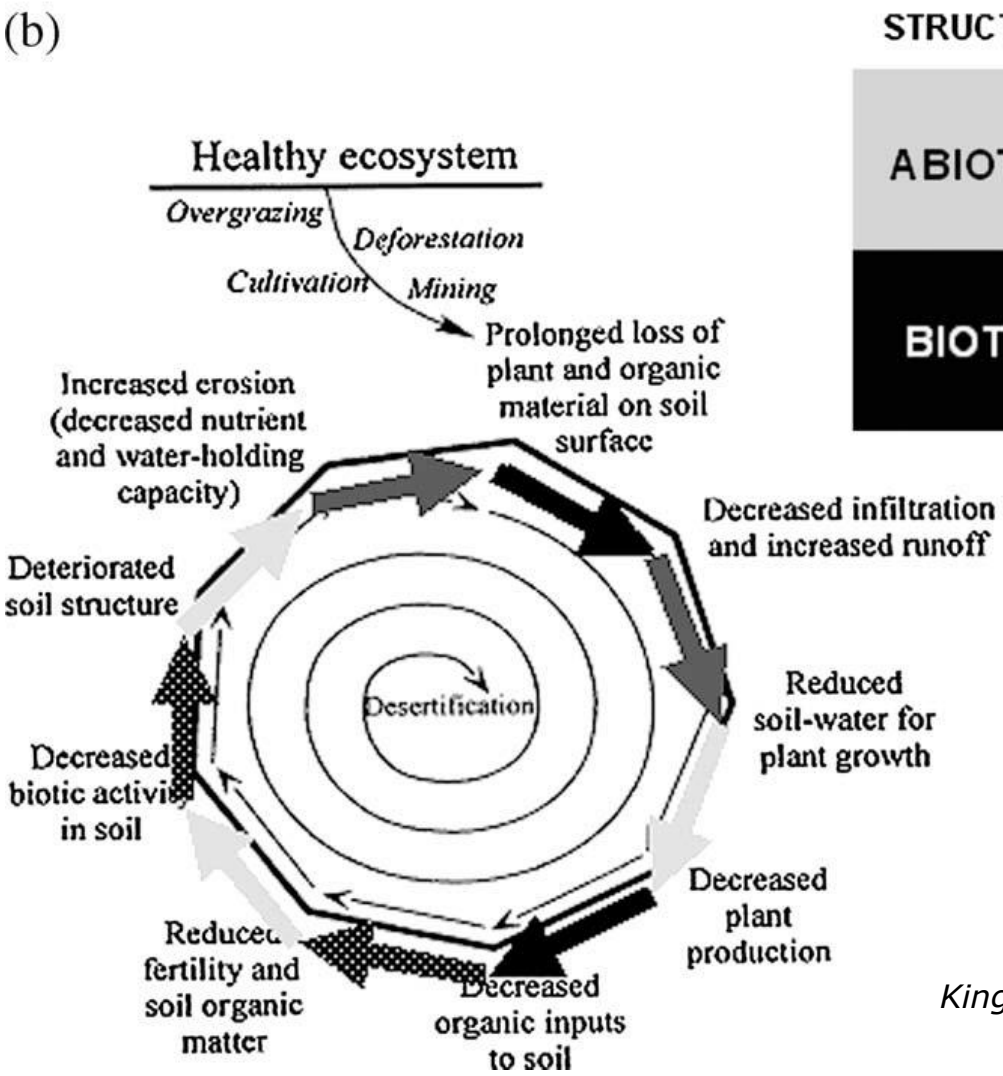


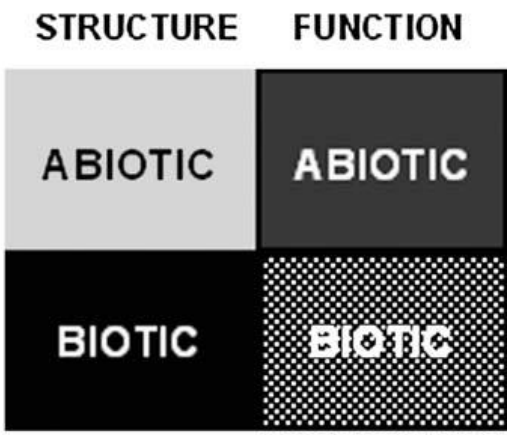

Climate change
Ocean acidification
Stratospheric ozone depletion
Nitrogen cycle (biological component)
Phosphorous cycle (chemical component)
Global freshwater use
Change in land use
Biodiversity loss
Atmospheric aerosol loading (not yet quantified)
Chemical pollution (not yet quantified)

Key process

De-vegetate
De-corbonate
De-hydrate
De-speciate
De-plete
De-teriorate
De-sertificate

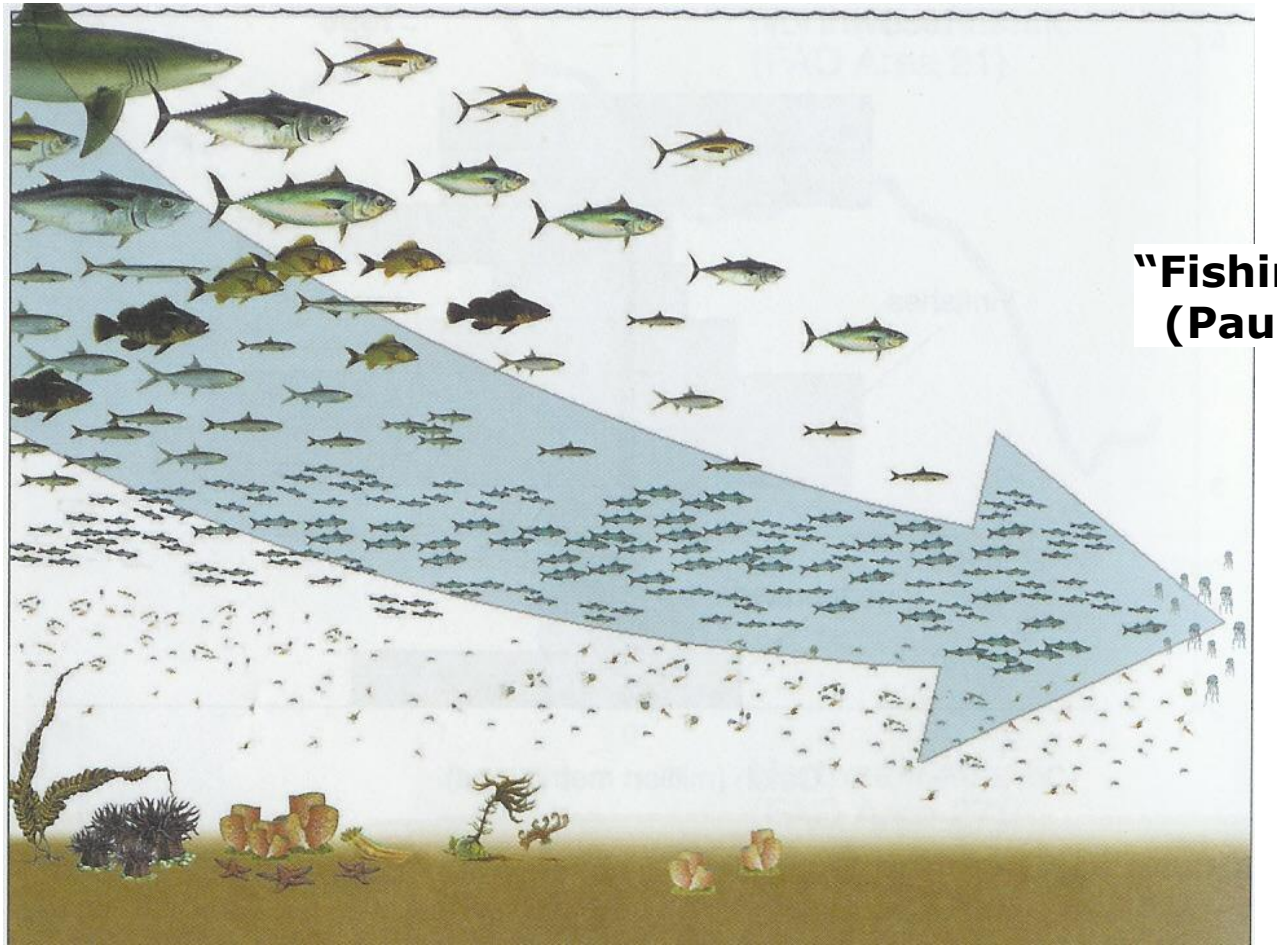
-> Ecosystem engine stops





King and Hobbs 2006

How do we measure biodiversity loss? → homogenisation



"Fishing down the foodwe
(Pauly, 2001)"

We also convert, plough, burn, log, hunt and pollute down

Global biodiversity loss: 70% -> 60% (MSA)

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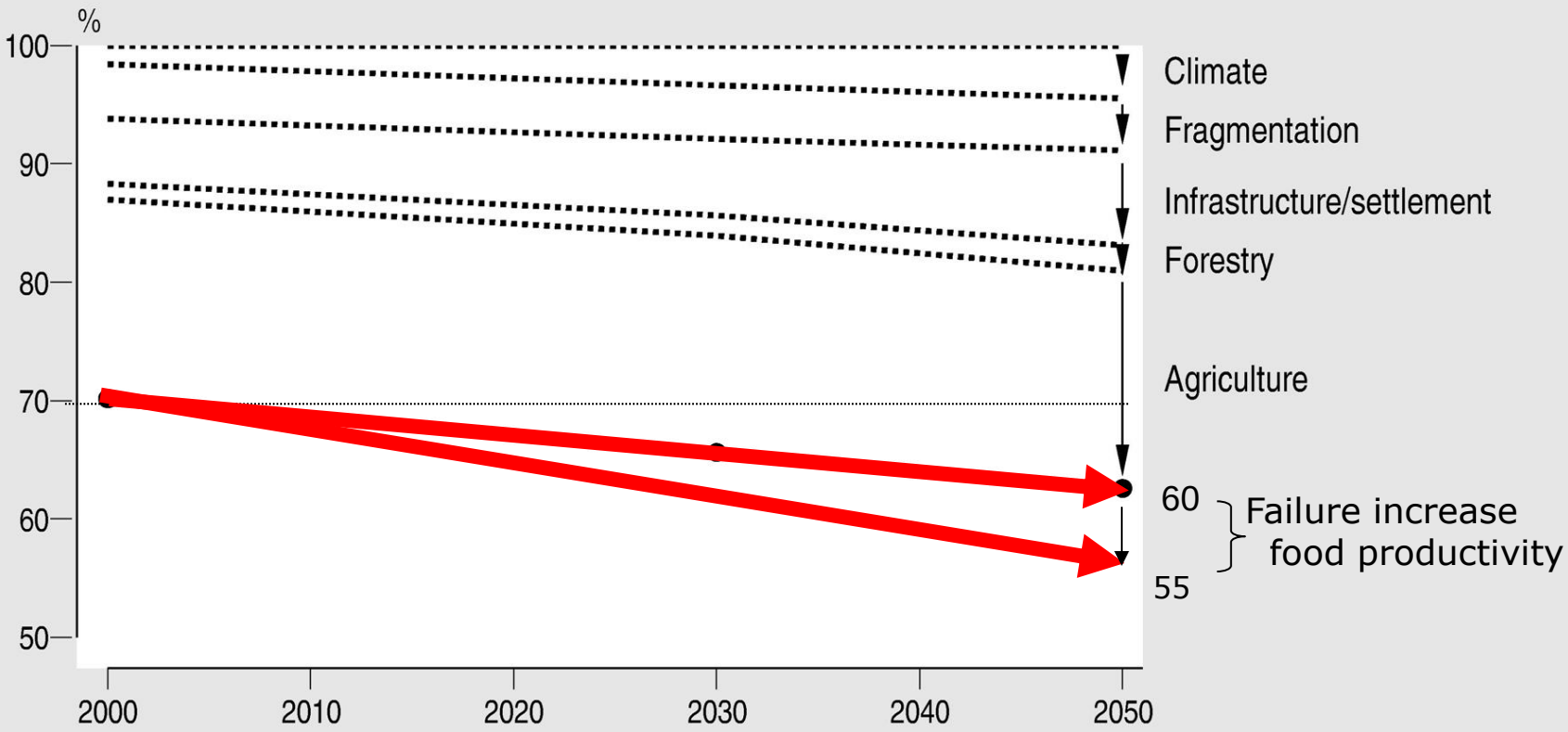

Datum: 20-dec-2005

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Rethinking global biodiversity strategies

Sector-based options to reduce biodiversity loss

as a contribution to TEEB

A cooperation between PBL, LEI and UBC

Ben ten Brink PBL, 20-10-2010

Conclusions

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1. By 2050, global biodiversity further declines from 70%->60%
2. many sub-systems to **lower** levels
3. individual options reduce loss a little
4. a combination of options **halves** the loss, and
5. has **positive** effects on climate change, water quality, and food availability
6. **more** options are possible -> further reduce

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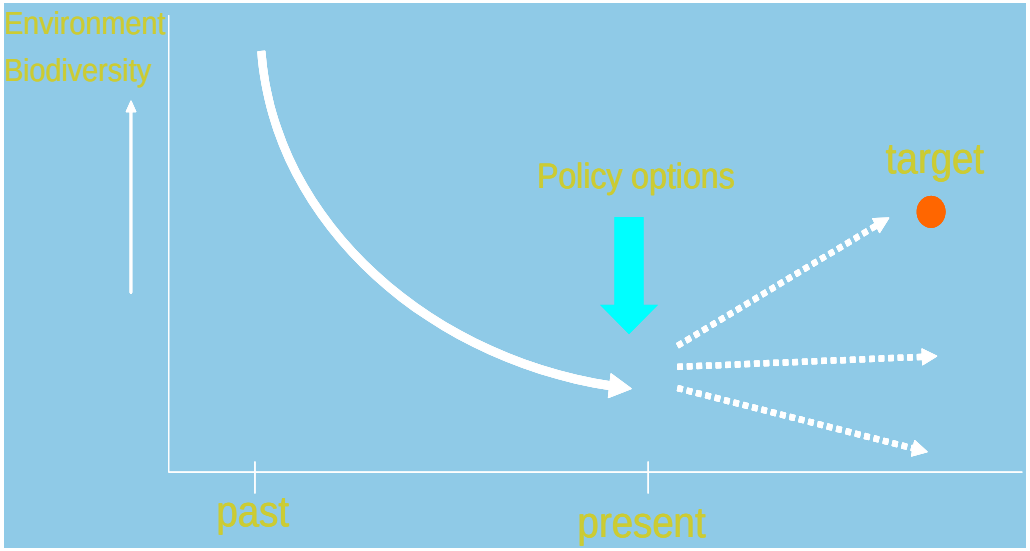
Governmental institute

Independent

Contribute to:

- –IPCC
- –MA
- –**GBO2**
- –**GEO** 1, 3,**4**
- –FAO outlook
- –**OECD outlook 2008**
- –TEEB1



- –**Contribution to TEEB -> Bio-physical effects Cost of Policy Action**
- –…

Global Biodiversity Outlook 3 concluded:

1. 2010-target not achieved at any level
2. loss proceeds at unchanged pace
3. risk at passing tipping points

Recommends measures on:

- agricultural efficiency
- forestry
- climate mitigation
- fisheries
- consumption
- ……

How much?
Do they halt loss?

We assessed 8 options and 1 combination

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8 single options:

1. Closing yield gap (efficiency)
2. Reducing post harvest loss (50%)
3. Diet change (less meat - no meat)
4. Climate mitigation & biofuels (max + 2°C)
5. Wood plantations + RIL
6. Reduced deforestation
7. Protected areas (20%-50% per biome)
8. Restoring marine stocks & aquaculture

Compared to no new policie scenario (BAU)

+ Option package (ambitious but feasible)

Indicator: mean species abundance

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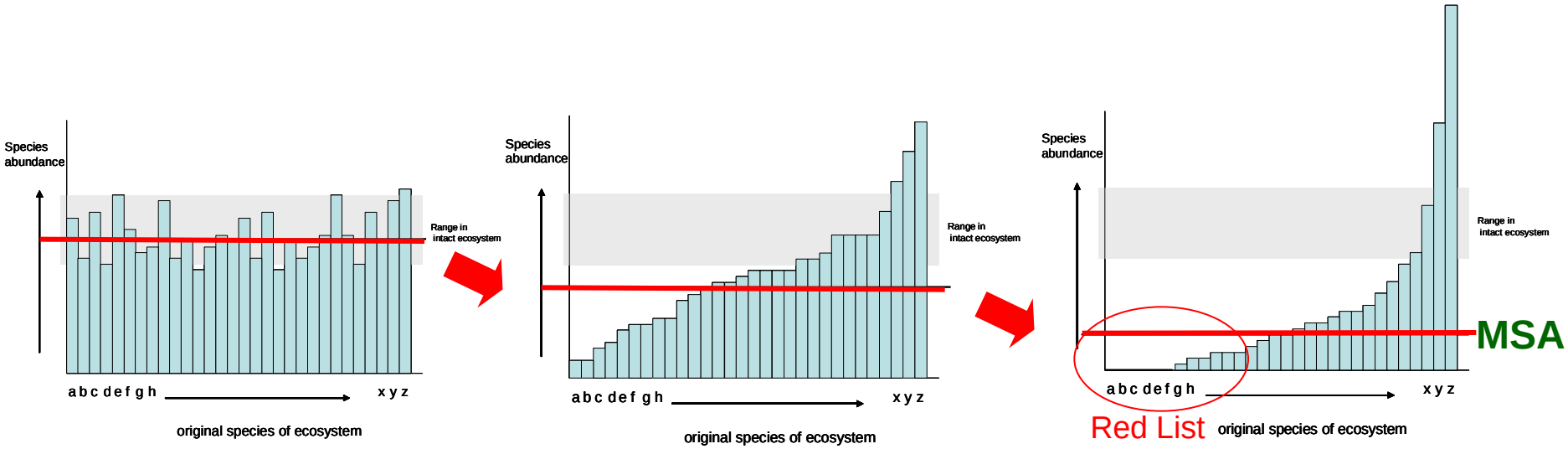
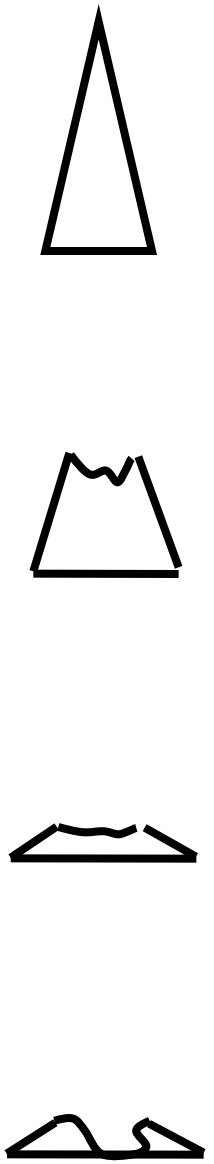
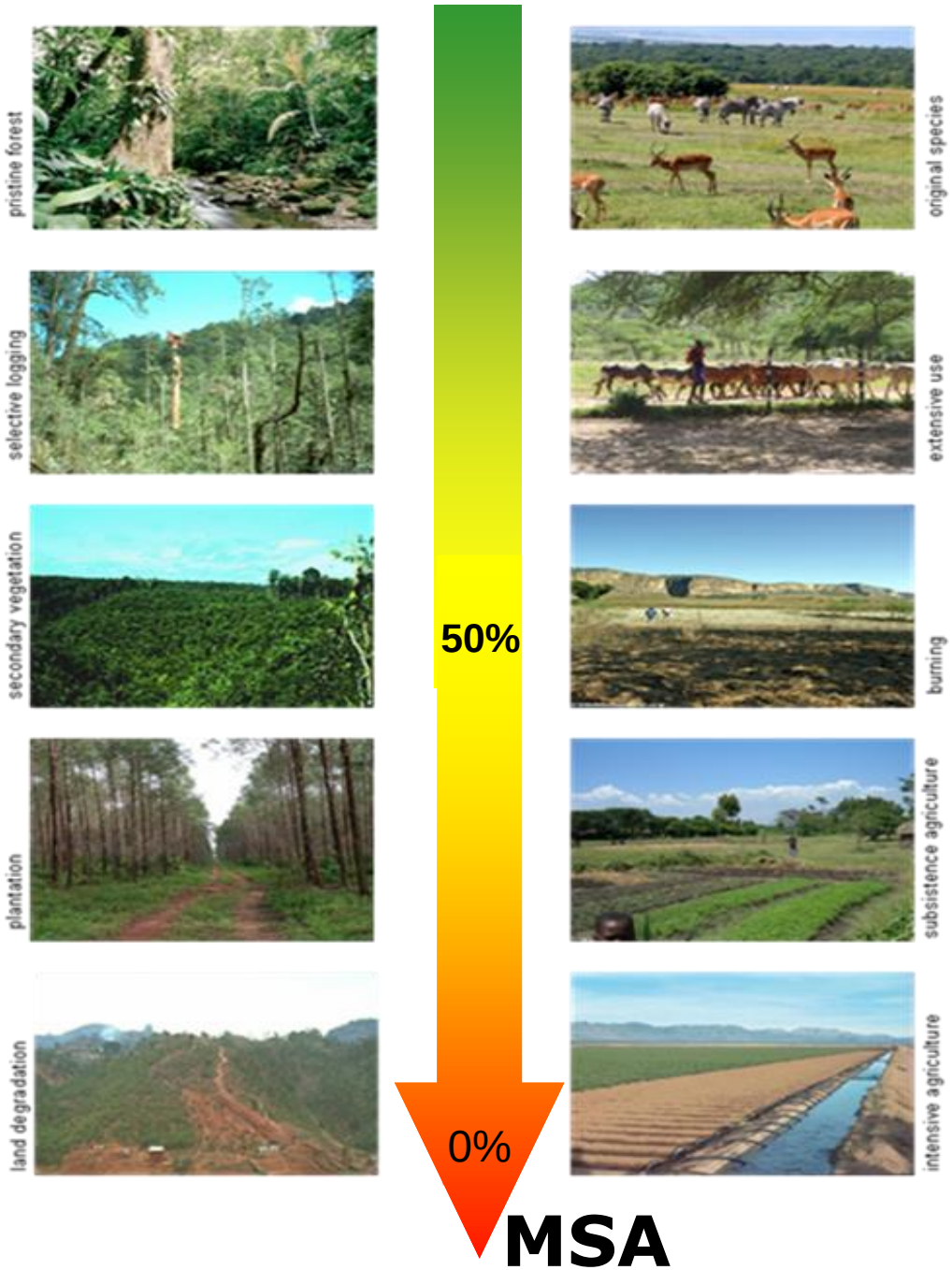


Mean Species Abundance (MSA)

MSA
A landscape view





Baseline scenario: no new policies

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Characteristics 2000-> 2050:

1.5 x global population

1.6 x food productivity

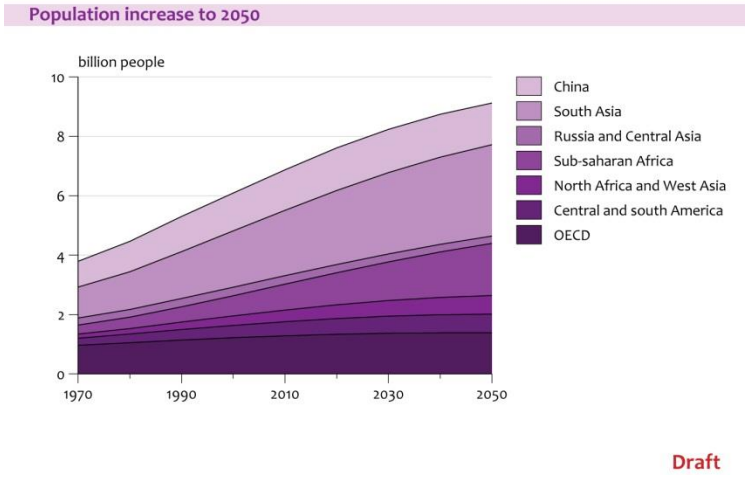
1.6 x fish demand

1.4 x wood demand

2.5 x global energy use

3 x income per person

Kyoto implemented



Sources: OECD, IEA, FAO,

Cork et al,

Baseline 1970

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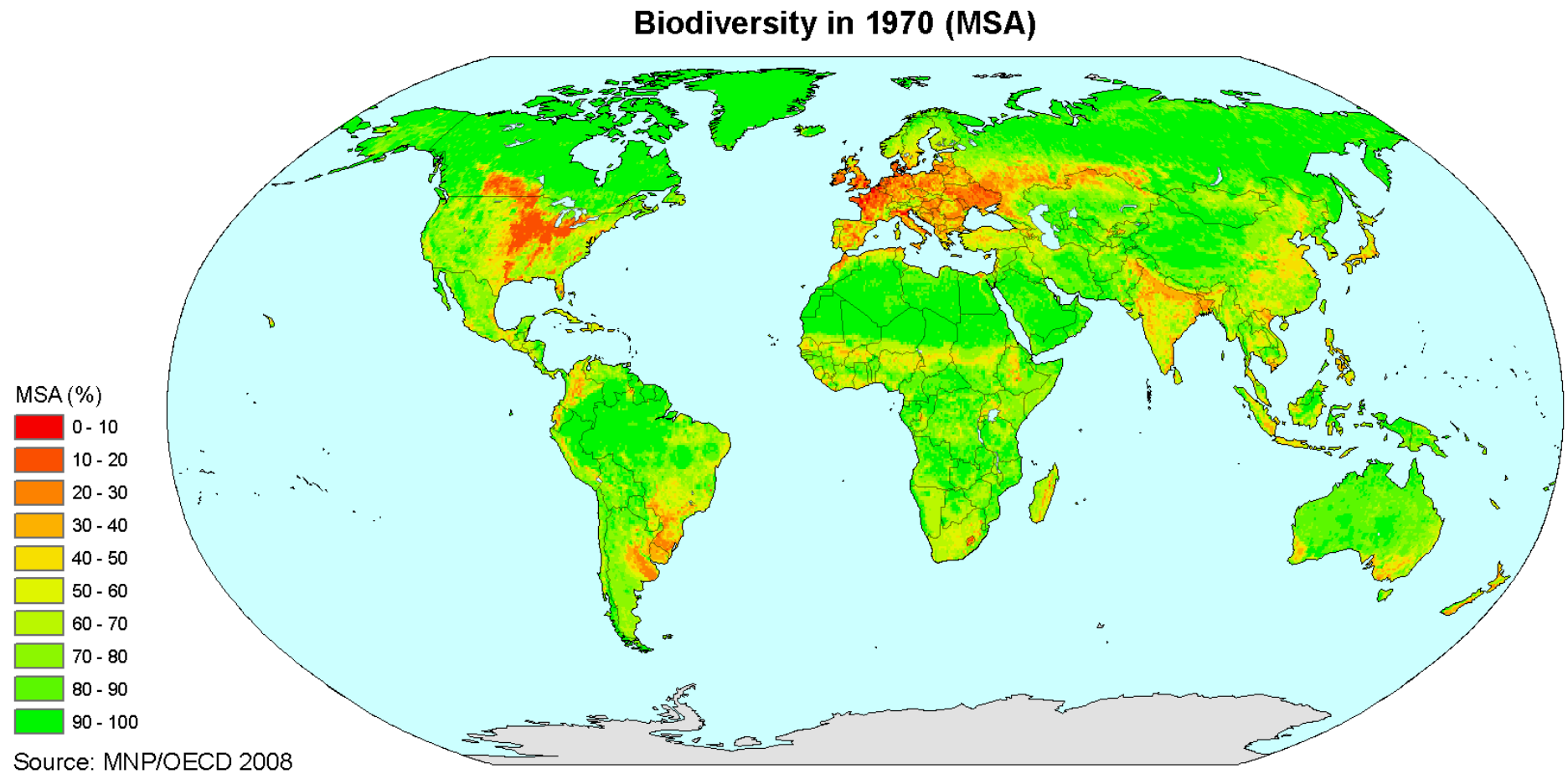

Baseline 2000

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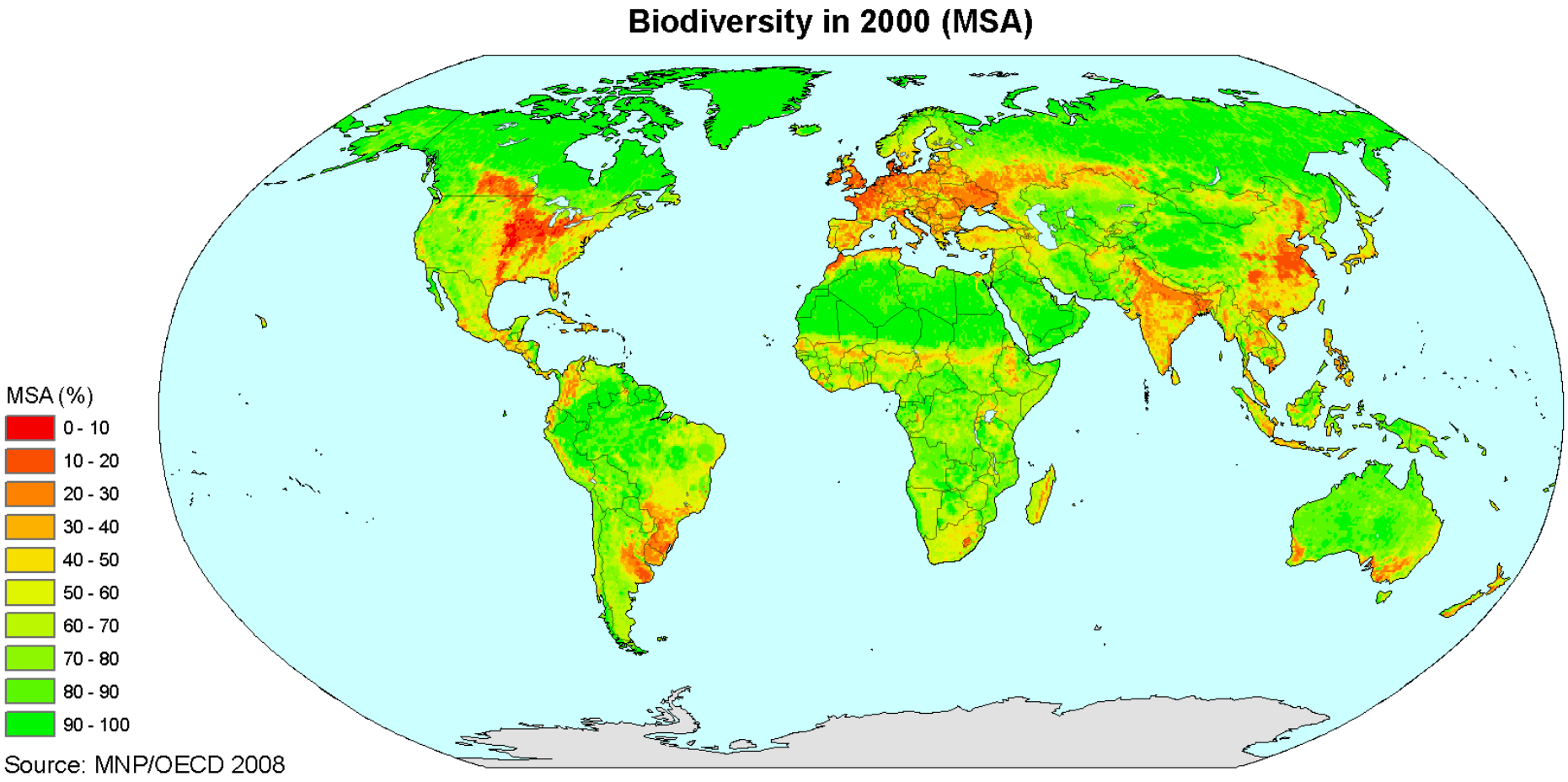

Baseline 2010

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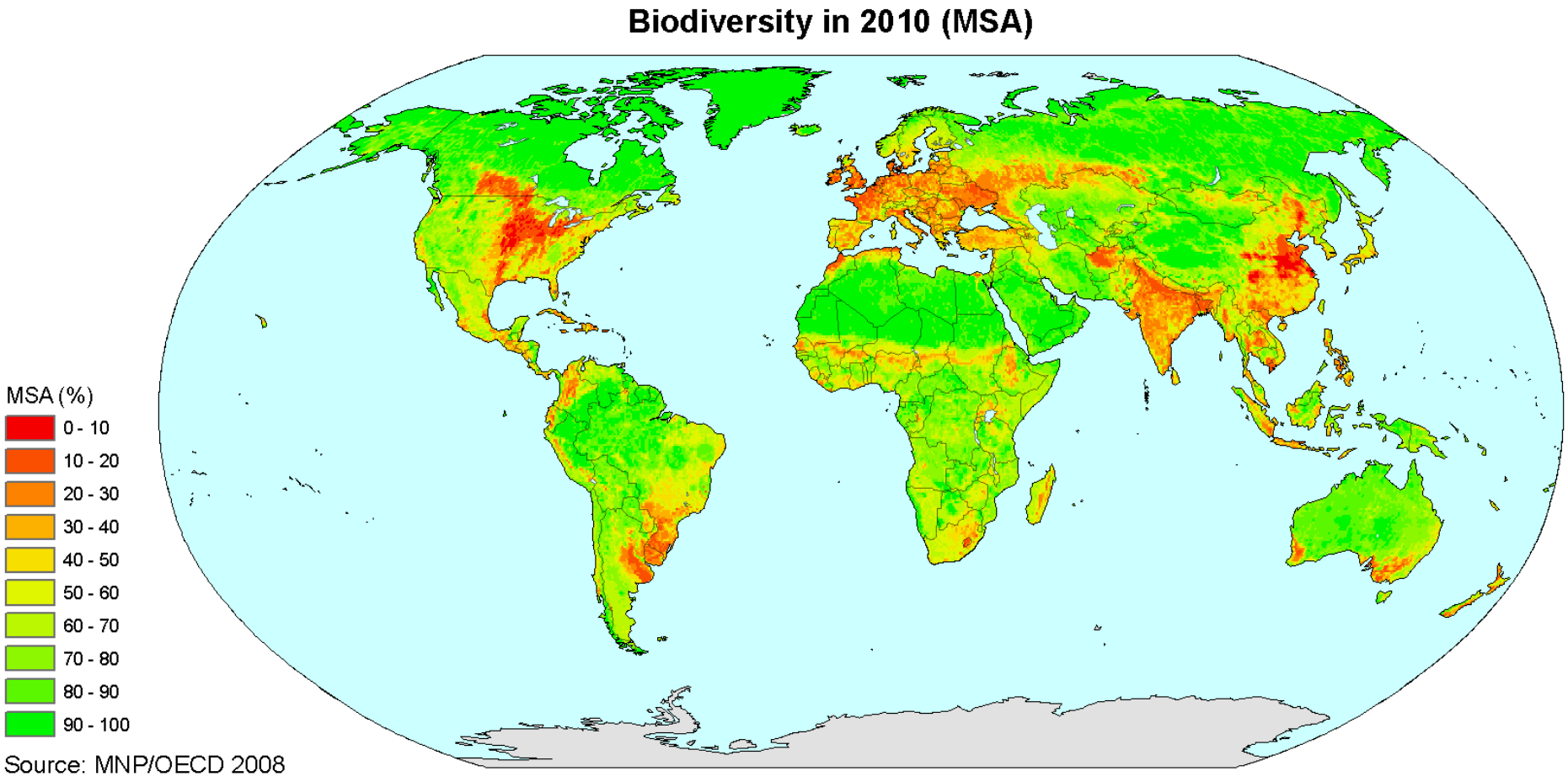

Baseline 2030

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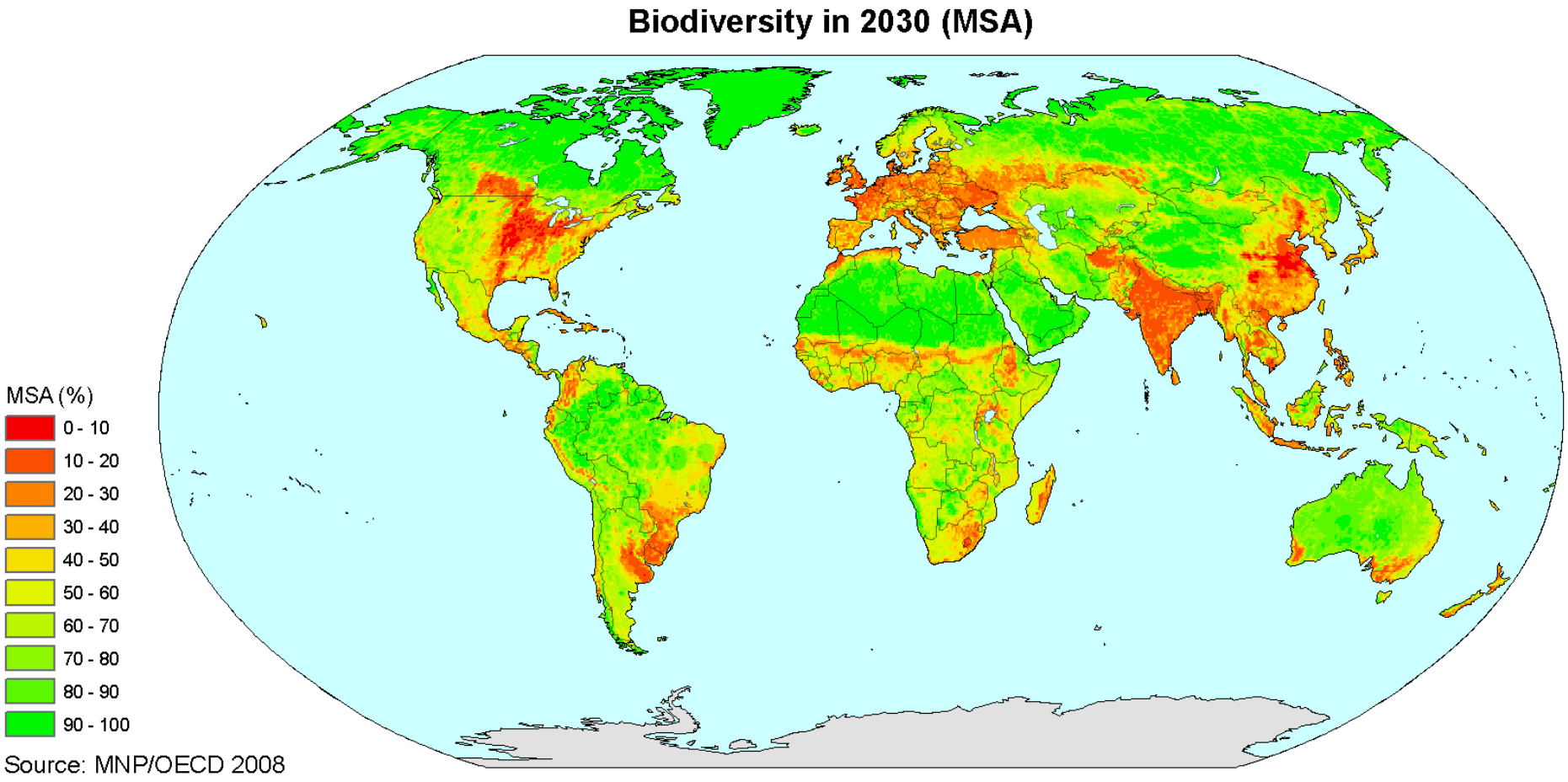

Baseline 2050

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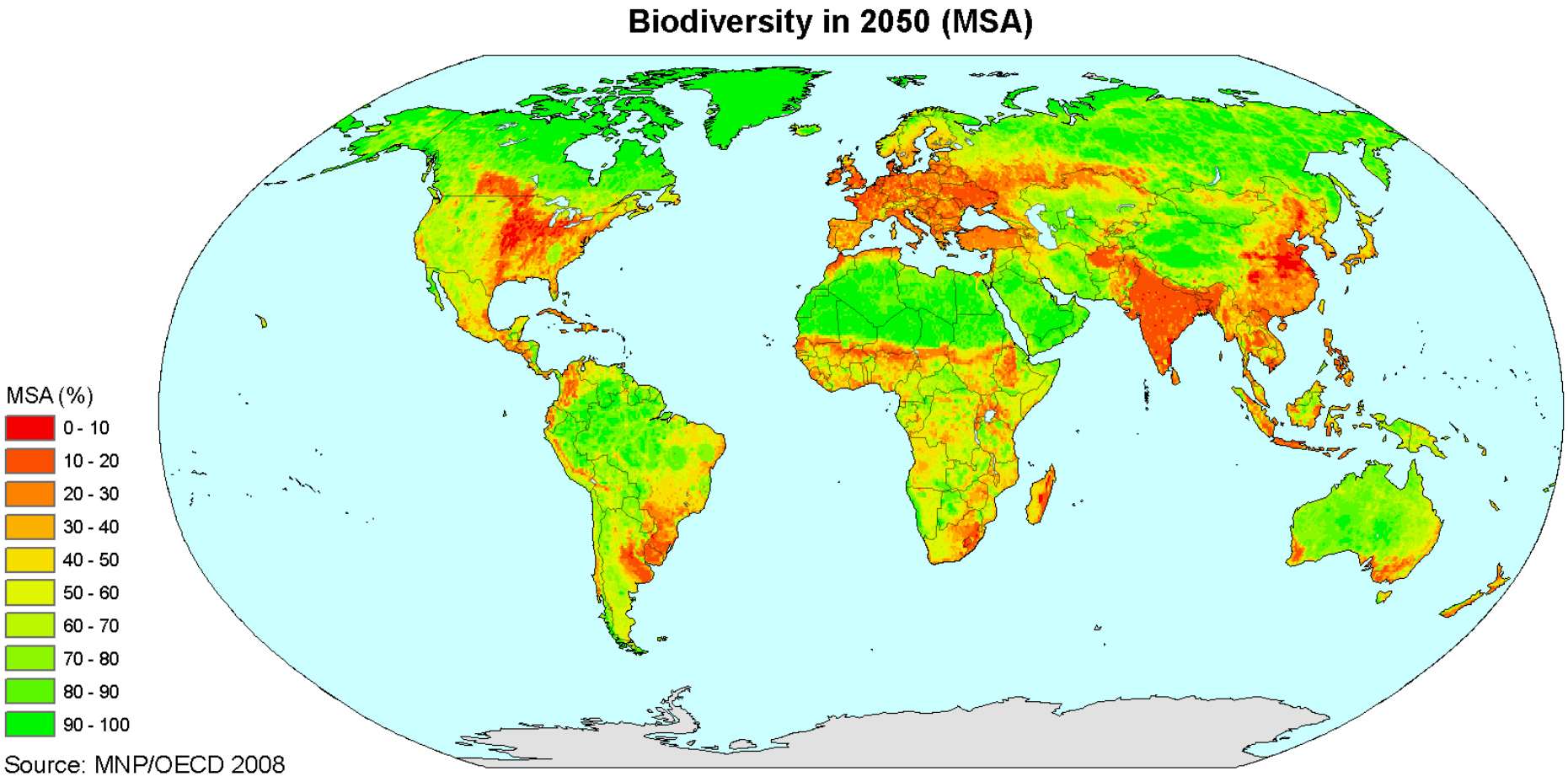

Biodiversity loss continues (MSA)

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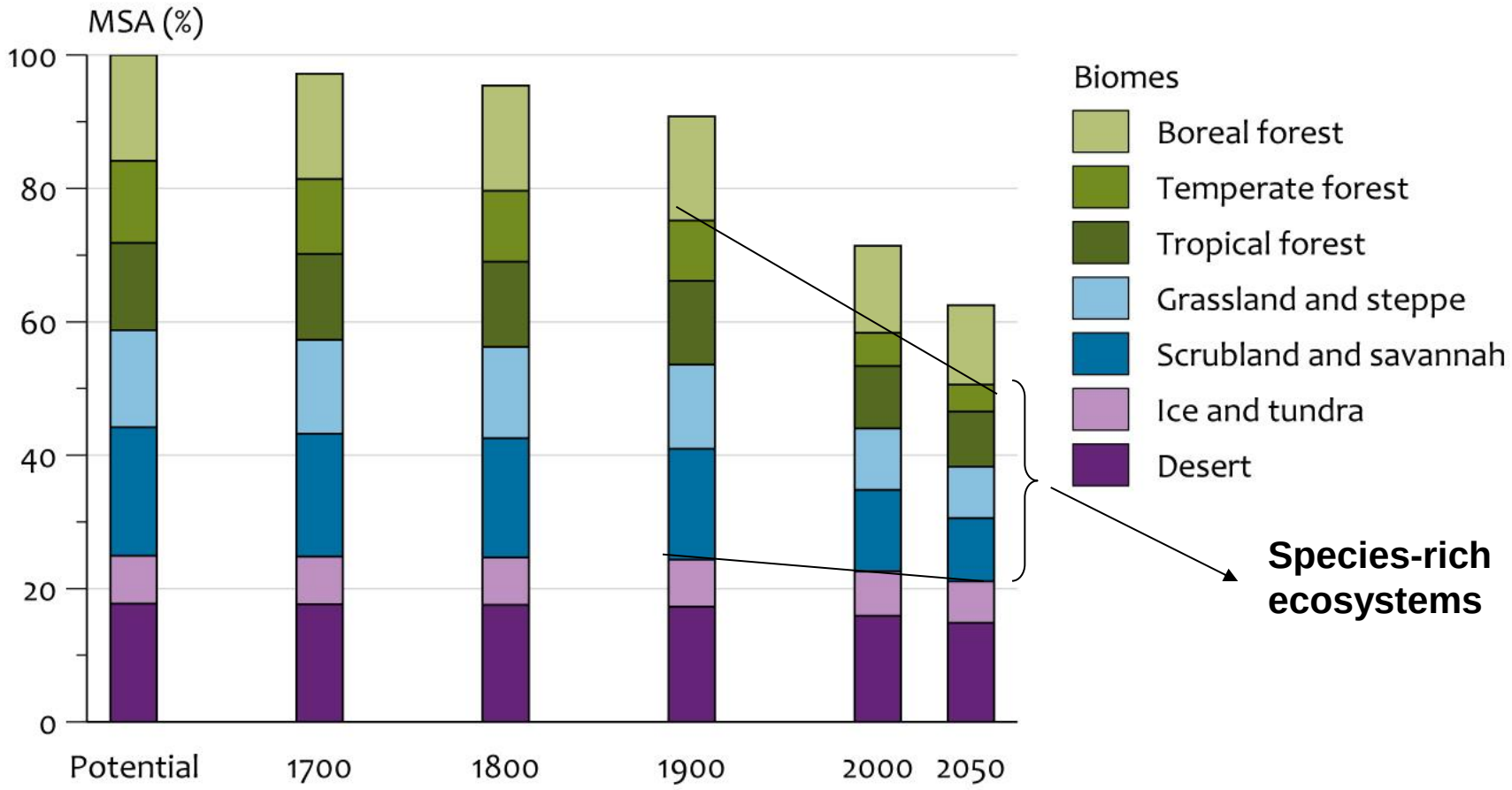
Global MSA in baseline scenario



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Methods

We will be synthesizing a <u>wide variety</u> of scenarios and models as the basis of our analysis. Some of these will be new analyses undertaken for the GBO4.

<u>Types of models and scenarios used:</u>

- **Extrapolations from current trends – statistical**
- **Extrapolations from current trends – with hypotheses or probablistic**
- **Socio-economic storylines - e.g. MA, GEO, IPCC storylines.**
- **Storylines + policy options - e.g., Rethinking scenarios**
- **Backcasting analyses: working backwards from sustainable endpoints - e.g., Rio+20 scenarios**

‘Backcasting’ as an innovative way to explore alternative pathways for reaching agreed upon objectives

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The ‘Storyline’ approach to developing plausible socio-economic scenarios

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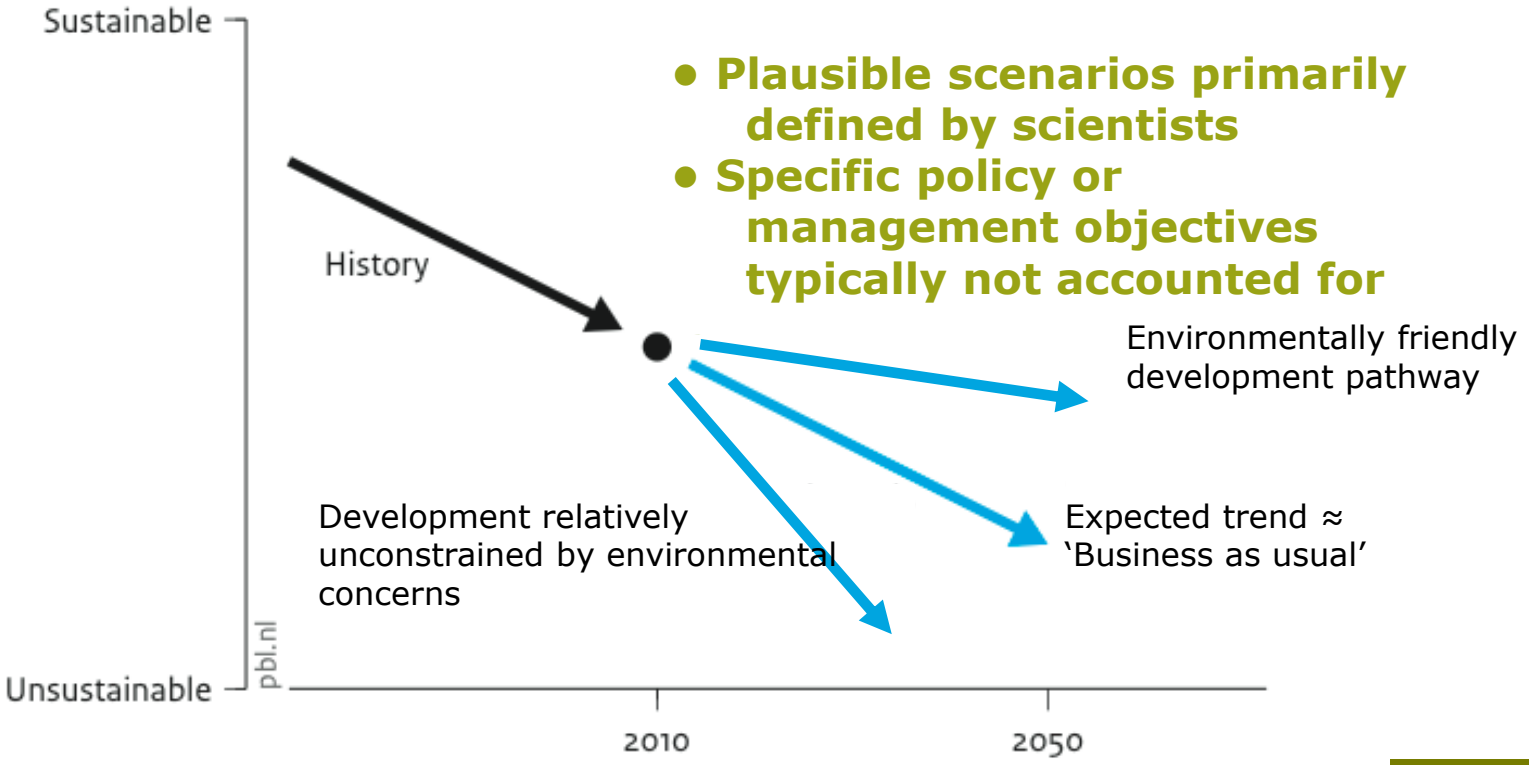
Roads from Rio+20

Pathways to achieve global sustainability goals by 2050

- **Plausible scenarios primarily defined by scientists**
- **Specific policy or management objectives typically not accounted for**



‘Backcasting’ as an innovative way to explore alternative pathways for reaching agreed upon objectives

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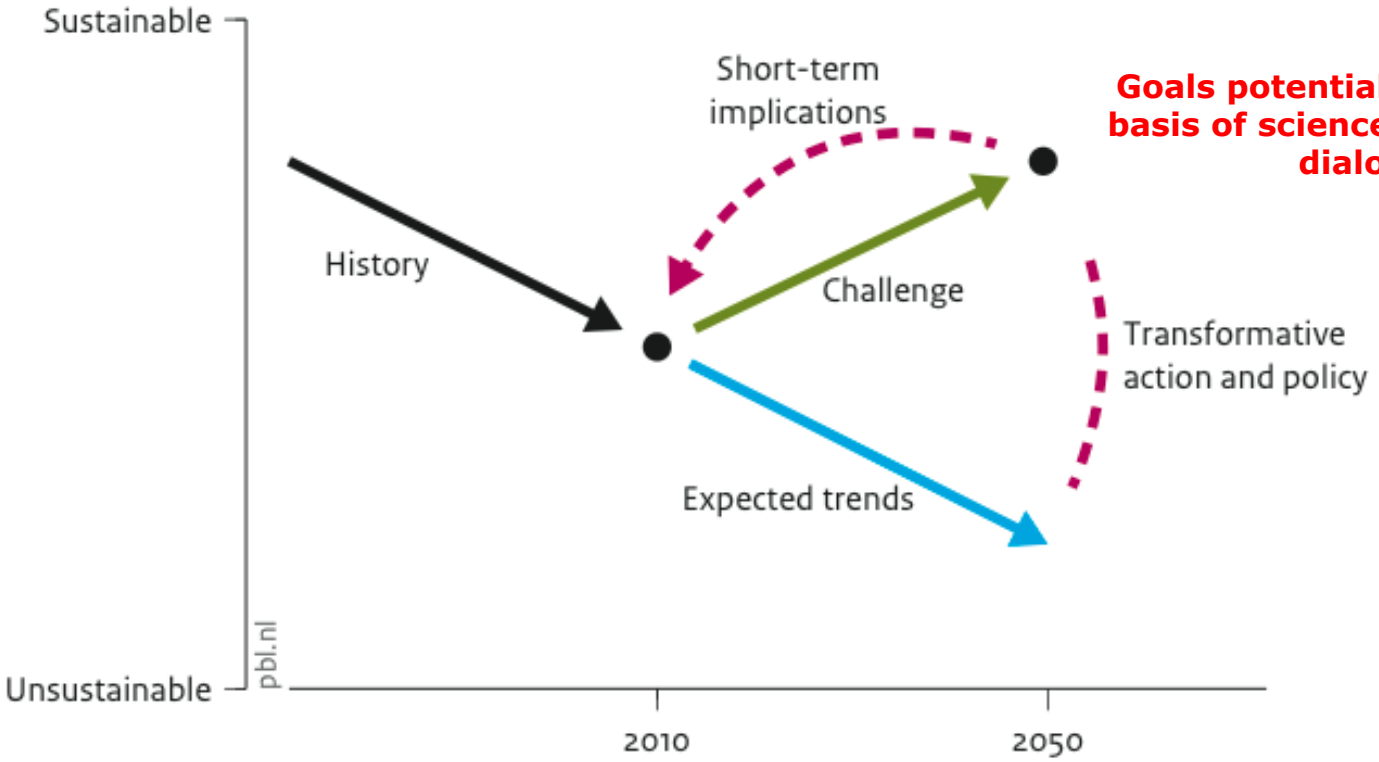
Roads from Rio+20

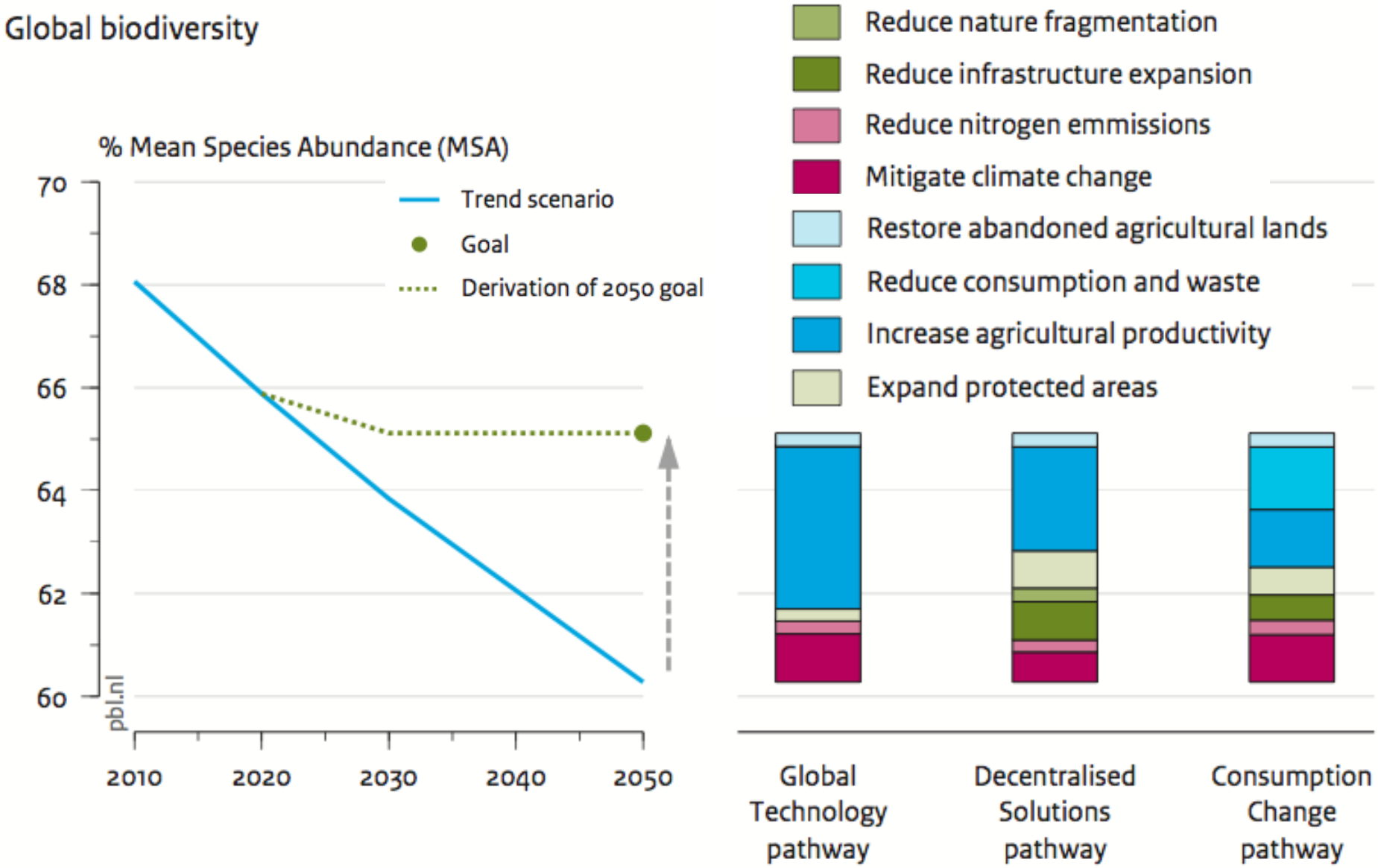
Pathways to achieve global sustainability goals by 2050

Backcasting analysis, working back from a sustainable end point to determine actions for today

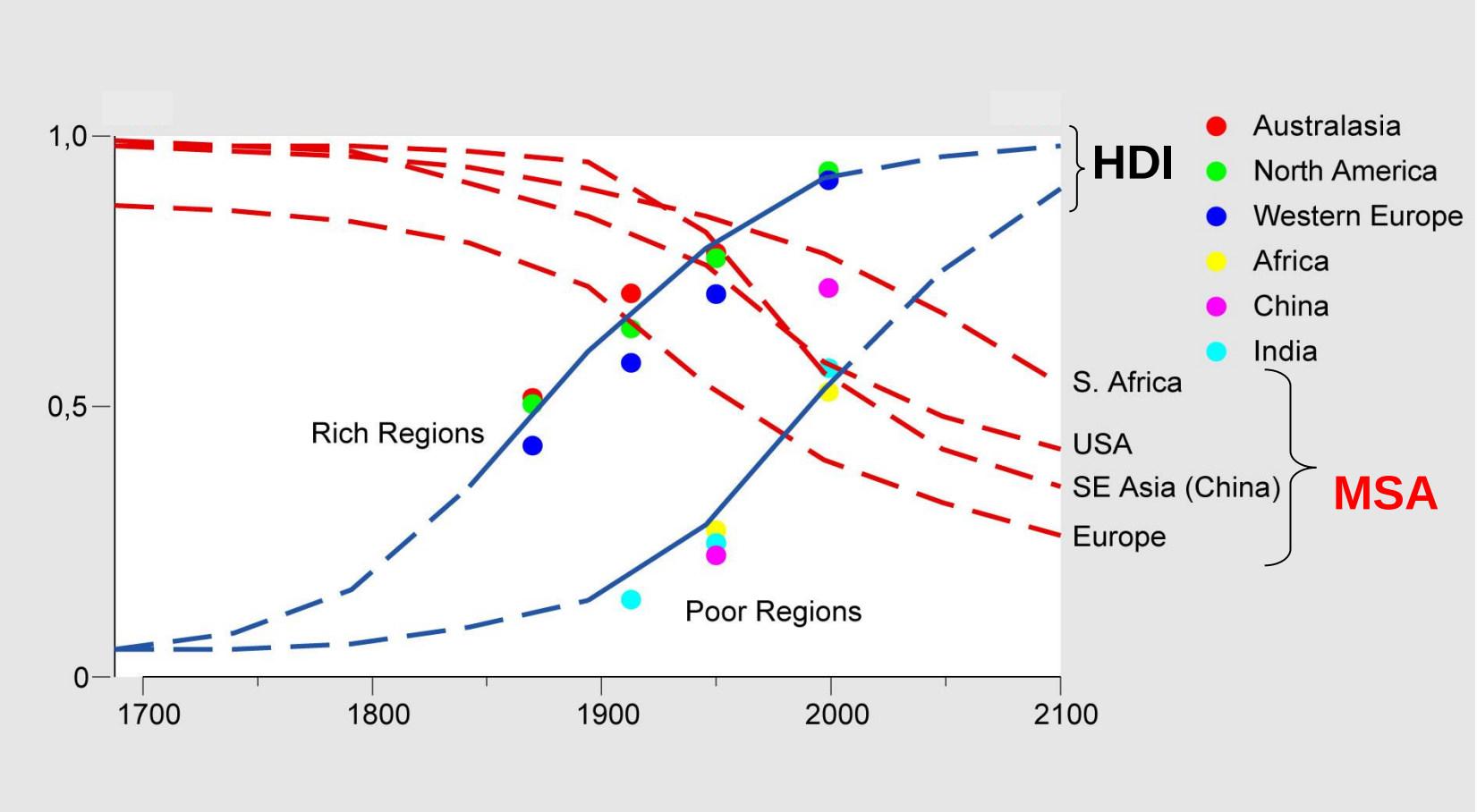


Goals potentially set on the basis of science-stakeholder dialogs

Global biodiversity and options to prevent biodiversity loss



Development & biodiversity inversely related



3. Why is it important?

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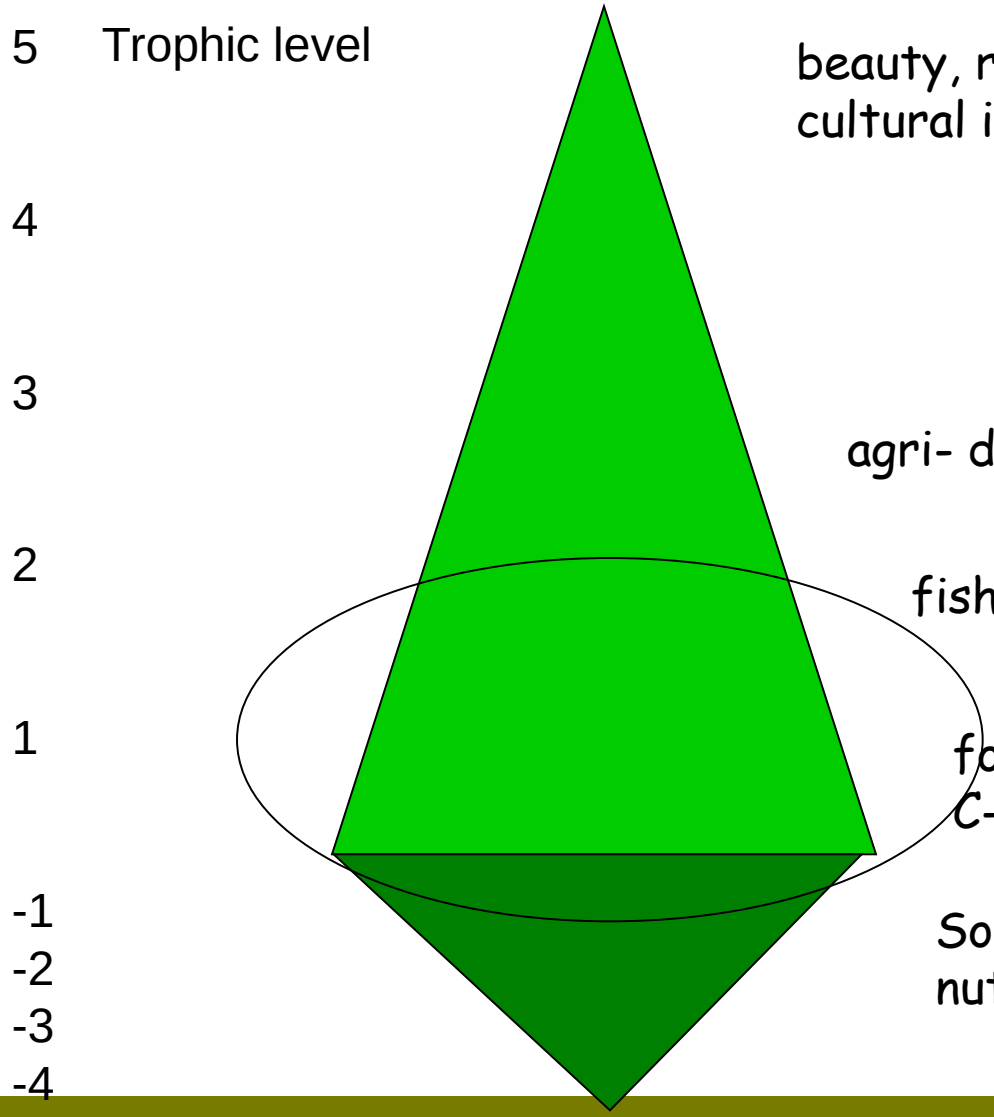

Avoid a lose-lose

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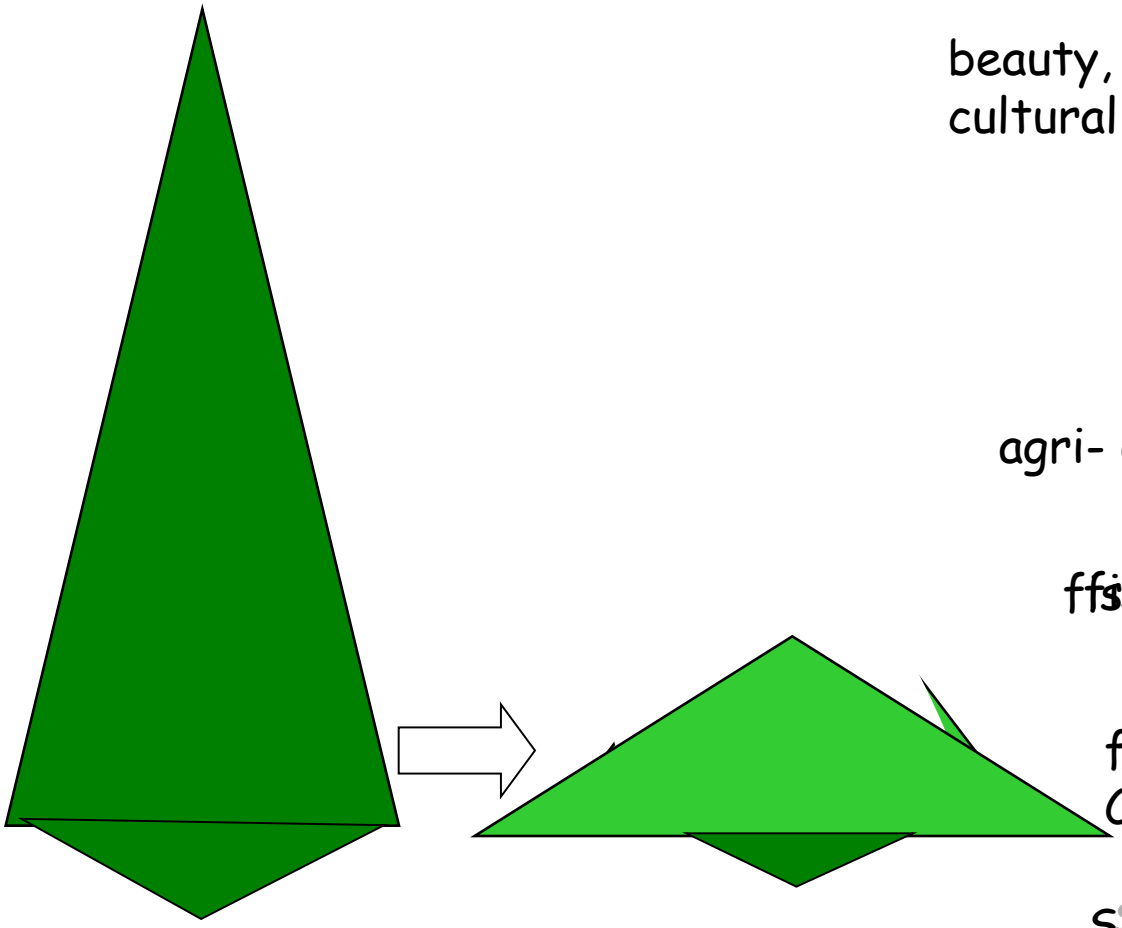

beauty, recreation, education
cultural identity

agri- disease regulation

ffish, meat pollination

ffood, fiber, fuelwood, freshwater
C-seq, soil formation, flood control

Soil fertility, water purification,
nutrient recycling

original

deteriorated

Soil fertility, water purification,
nutrient recycling

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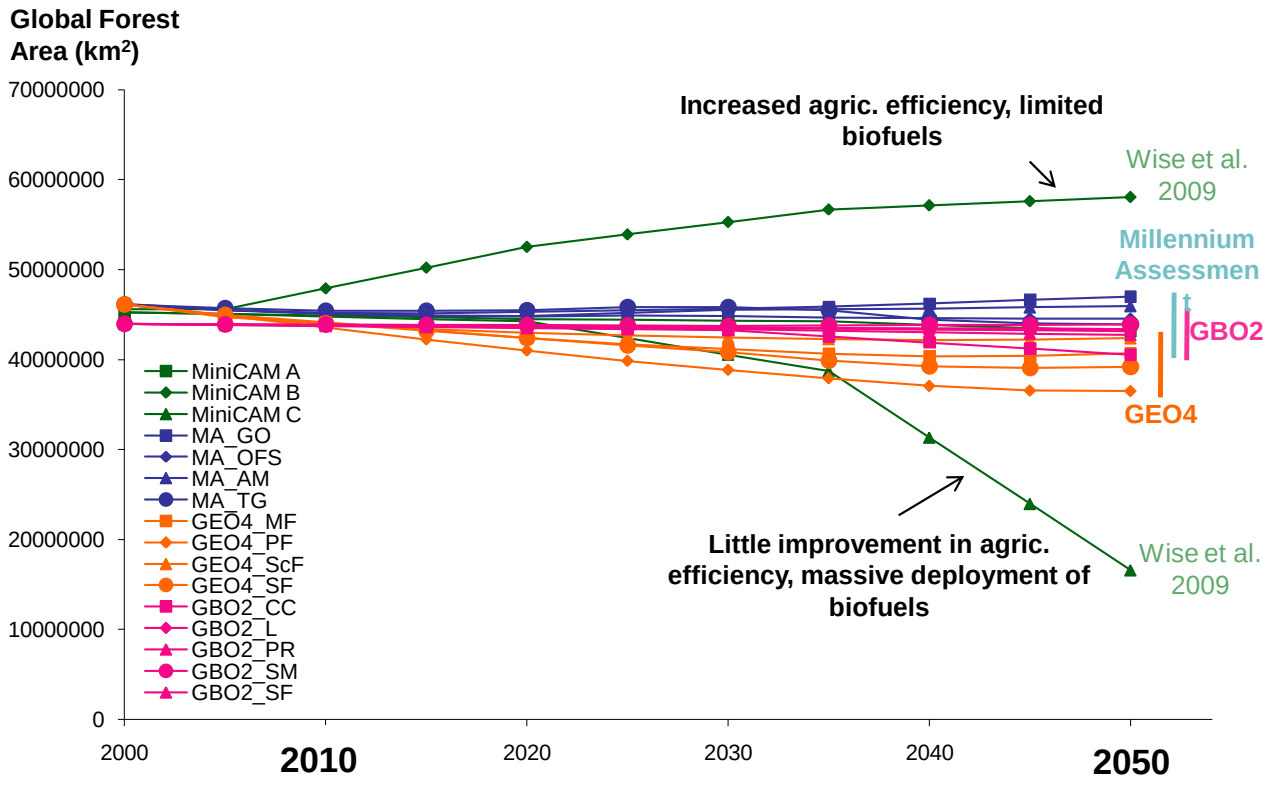
Biodiversity Futures for the 21st Century

Global Biodiversity Outlook 3

HABITAT LOSS



Current protected areas, and expansion to 20% and 50%

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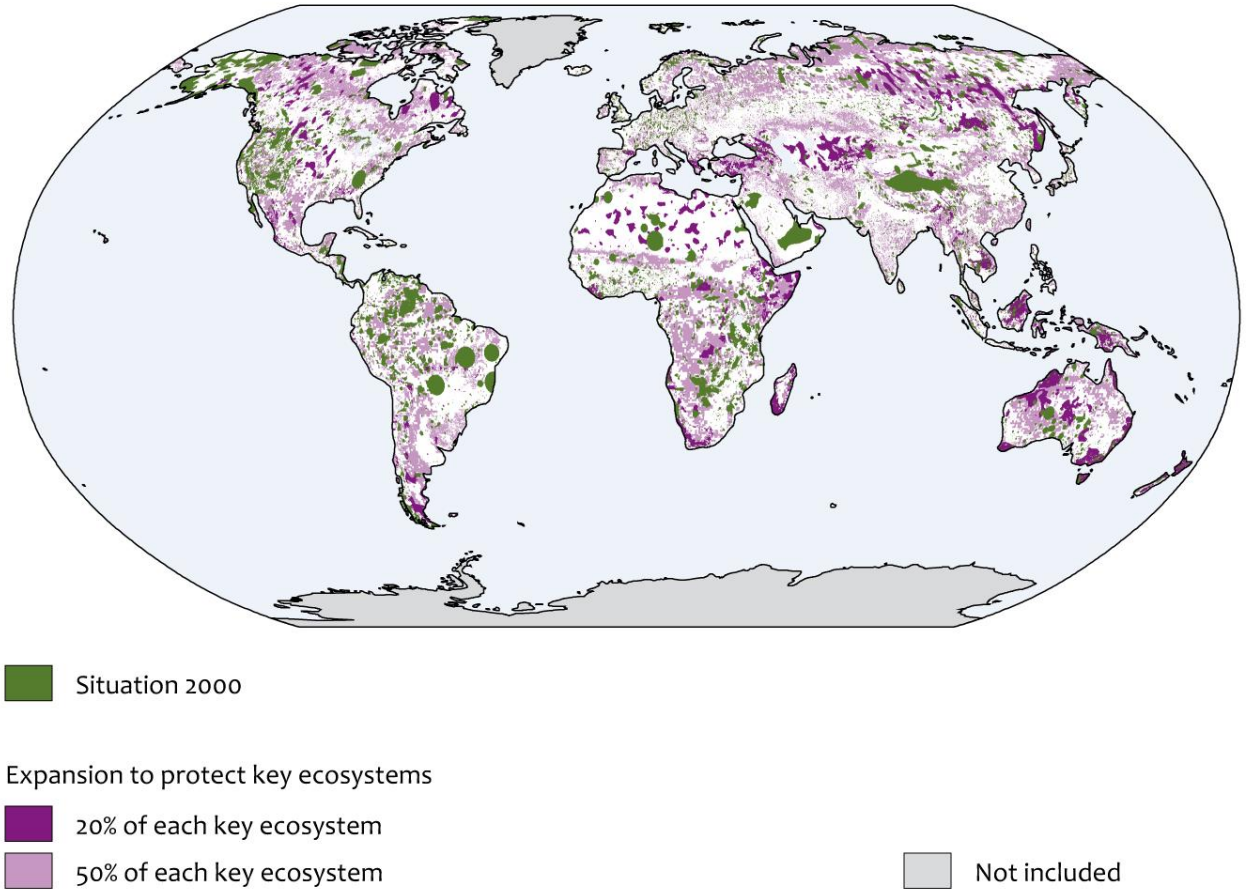
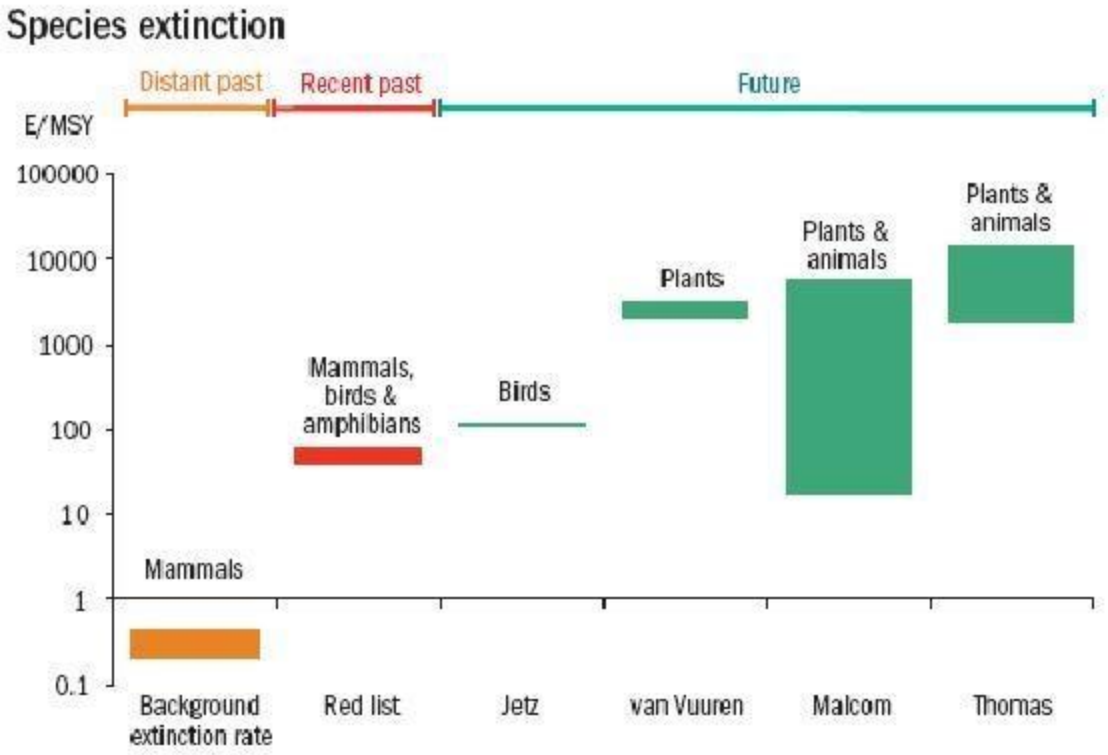
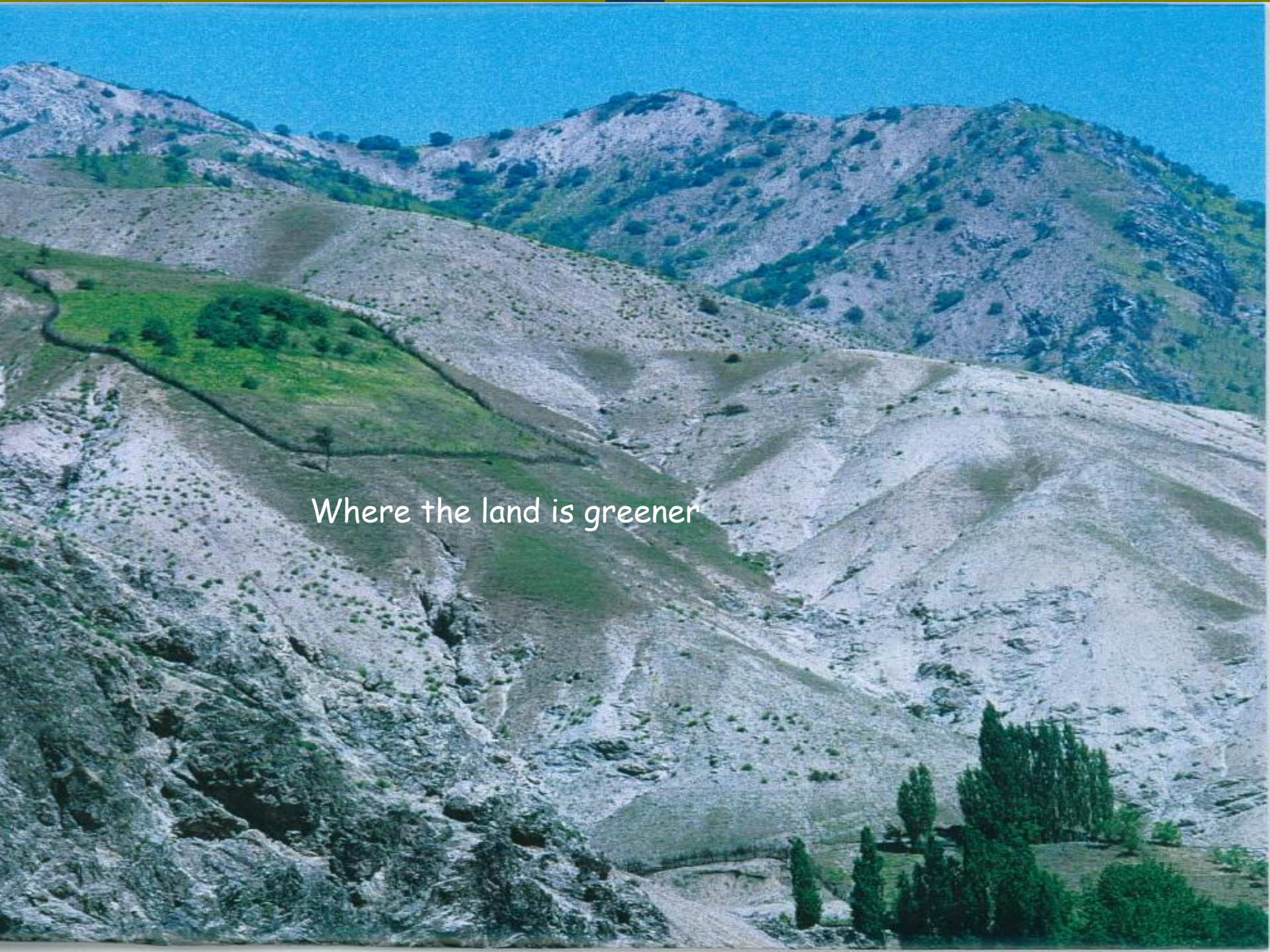
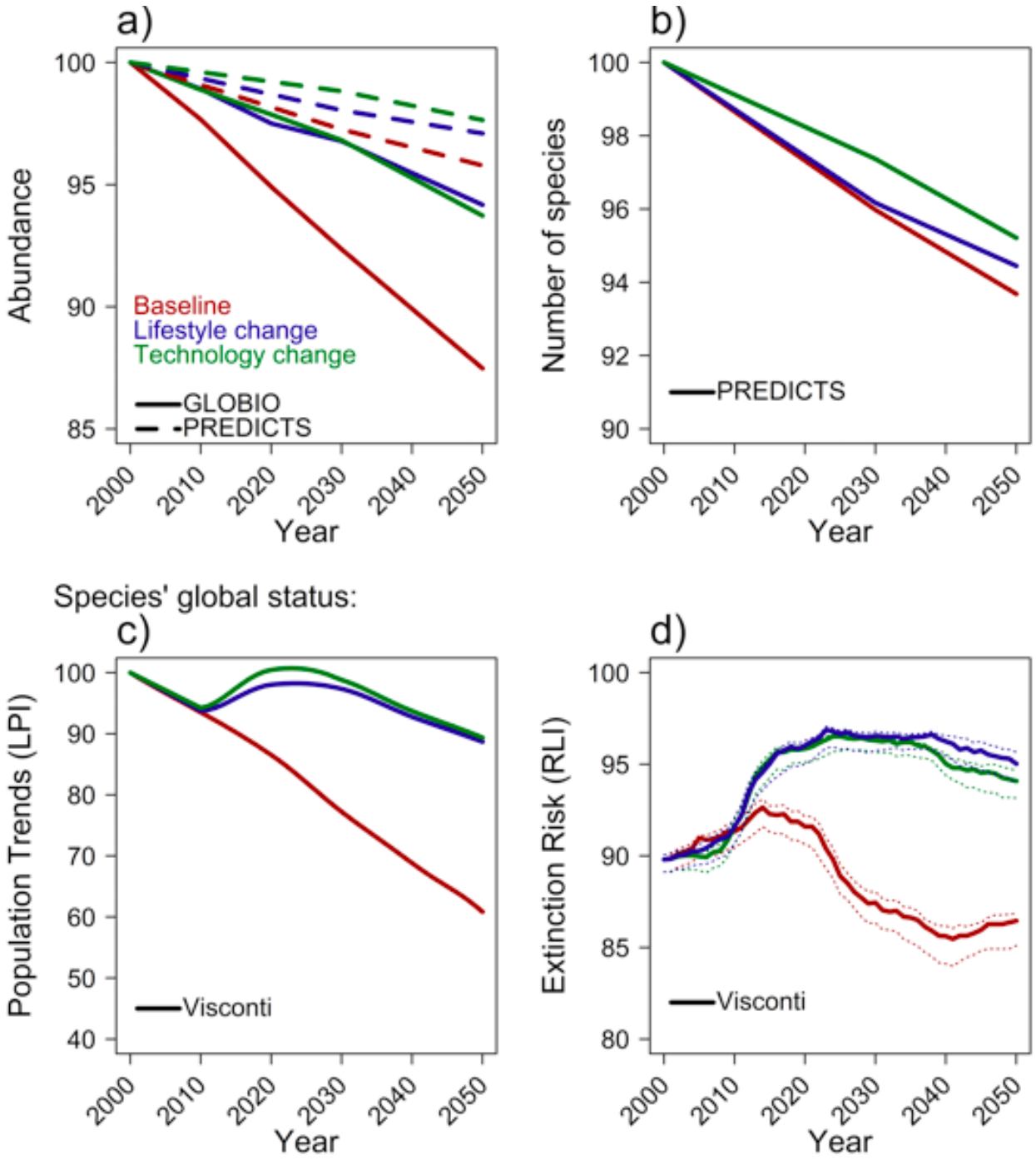
Protected areas for preserving biodiversity




Species extinction
Distant past
Recent past
Future
E/MSY
100000
10000
1000
100
10
1
0.1
Mammals
Mammals, birds & amphibians
Birds
Plants
Plants & animals
Plants & animals
Background extinction rate
Red list
Jetz
van Vuuren
Malcom
Thomas


Where the land is greener



Target 12 (and beyond)

Comparing multiple indicies of impacts using the Rio+20 socio-economic scenarios

Note: PREDICTS results provisional!

Biodiversity protection, climate mitigation and improving human well being

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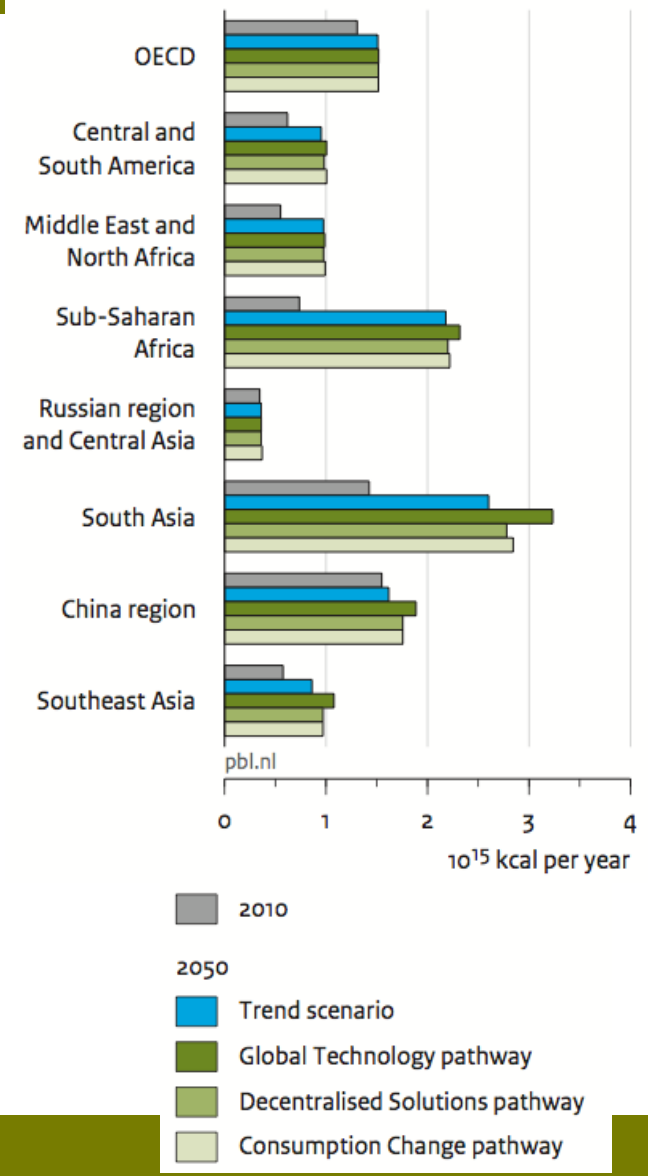
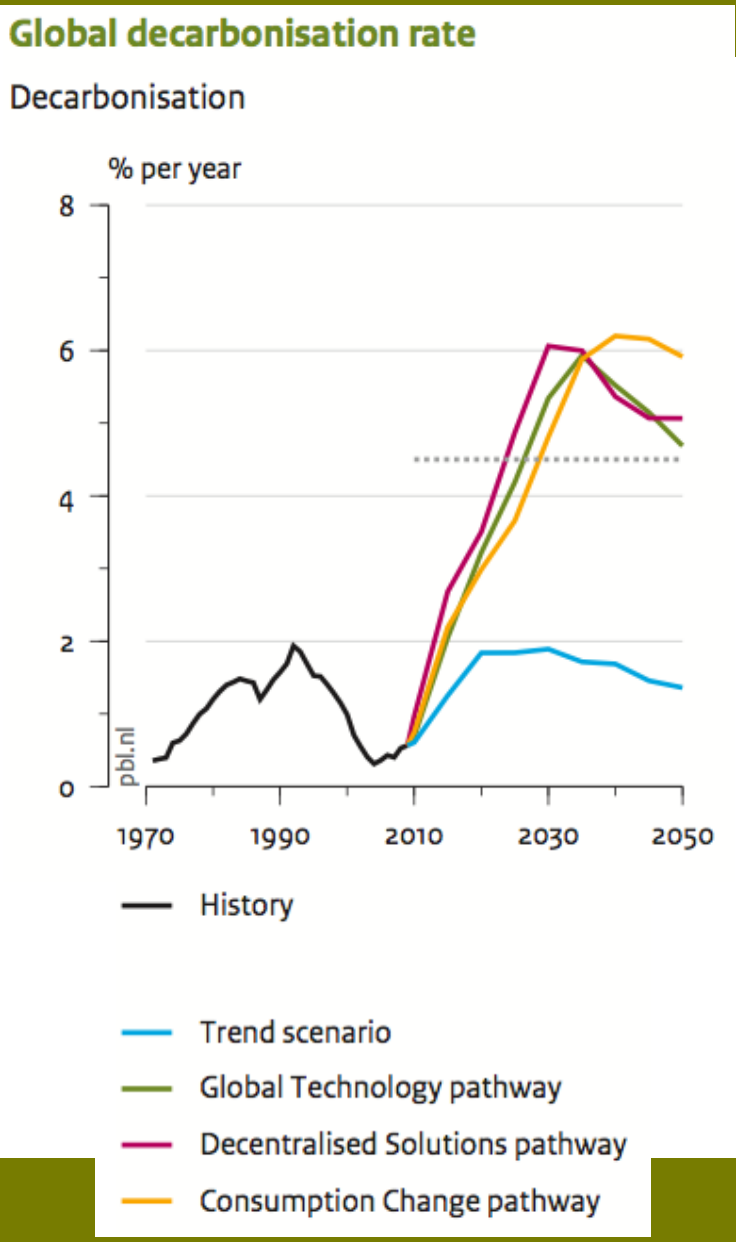
Global calorie consumption



Global decarbonisation rate



Zooming in:
Grasslands - 2000

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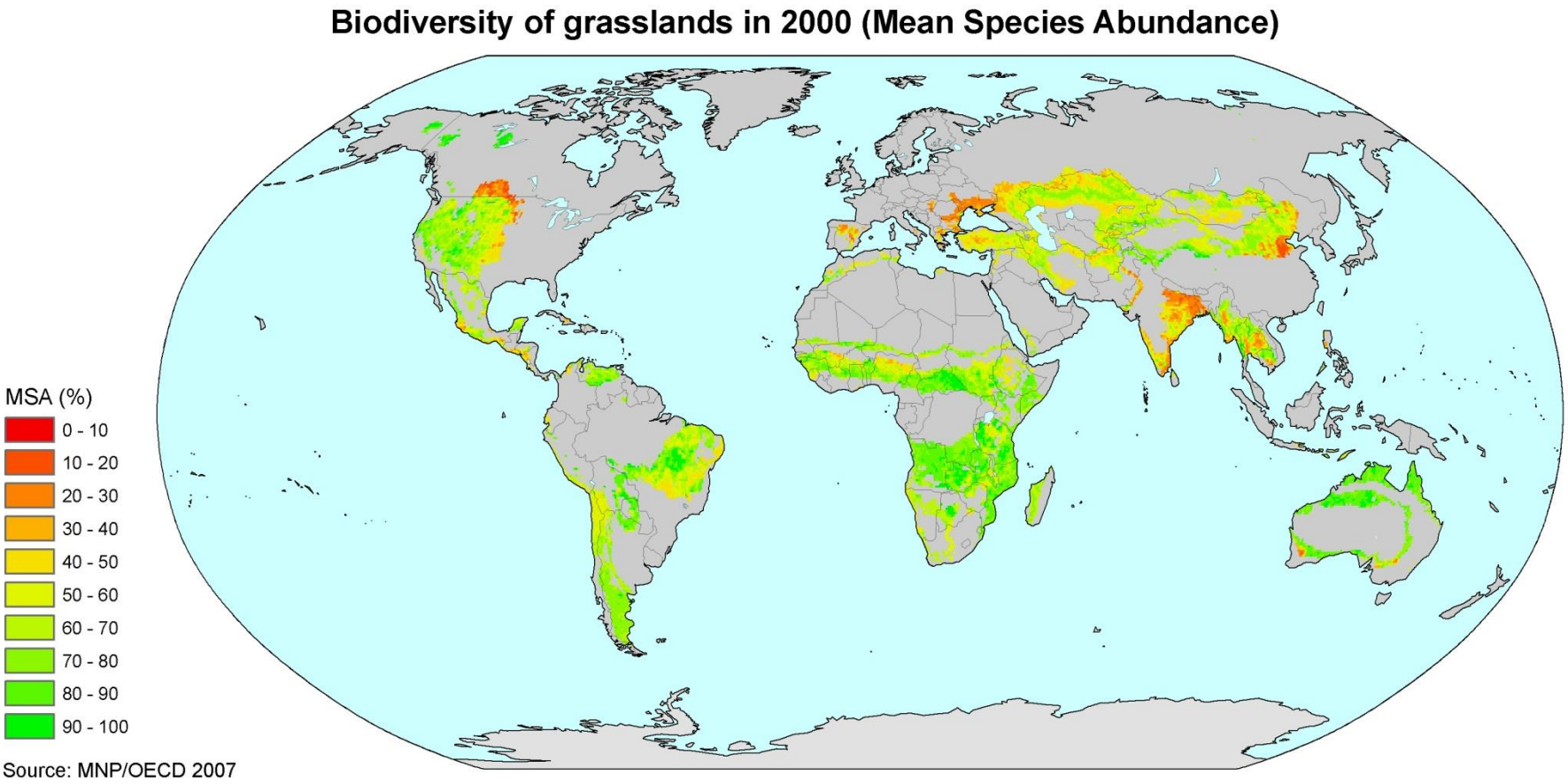

Zooming in:

Grasslands baseline - 2050

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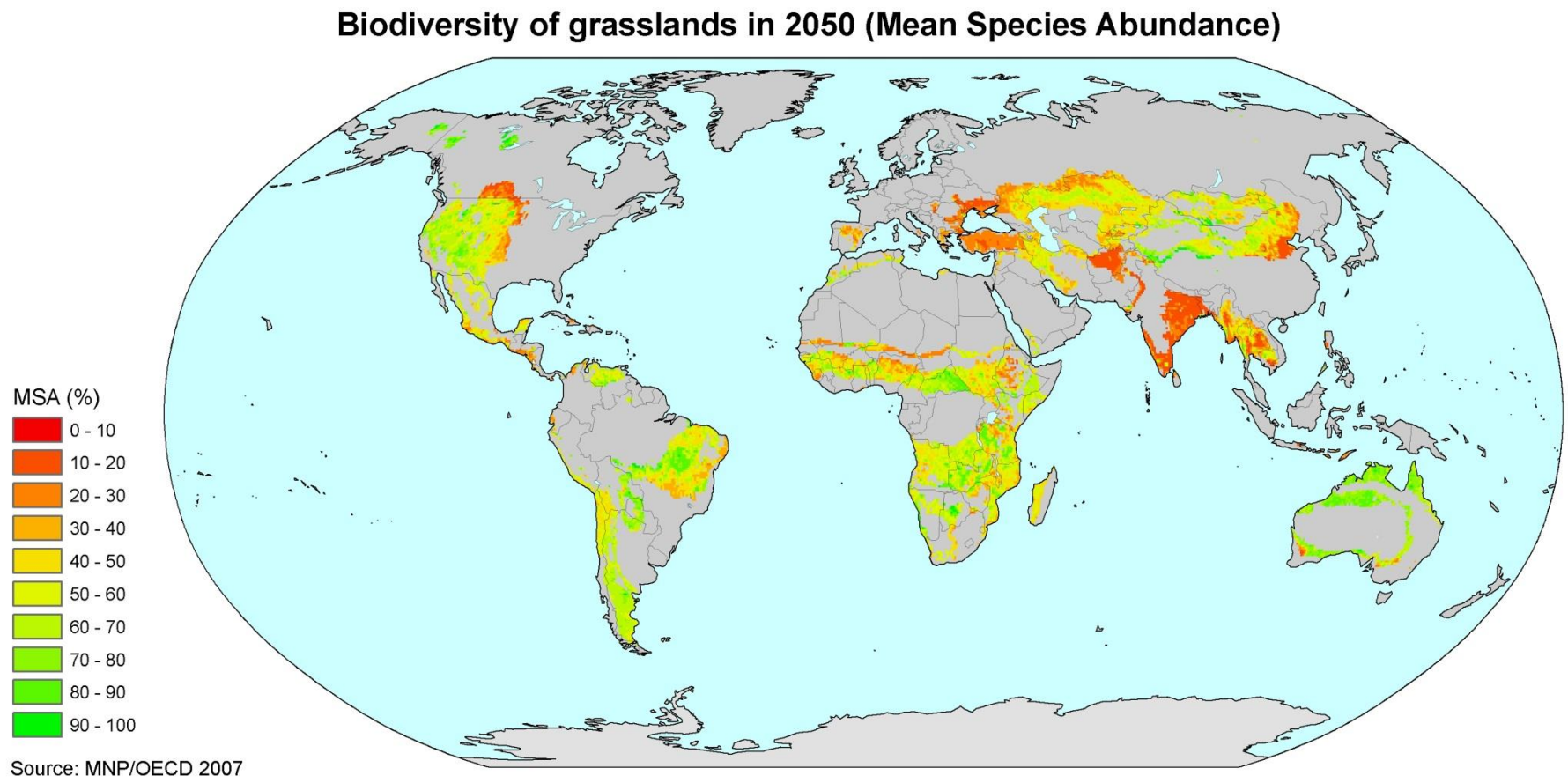

Zooming in:

Temperate & tropical forests - 2000

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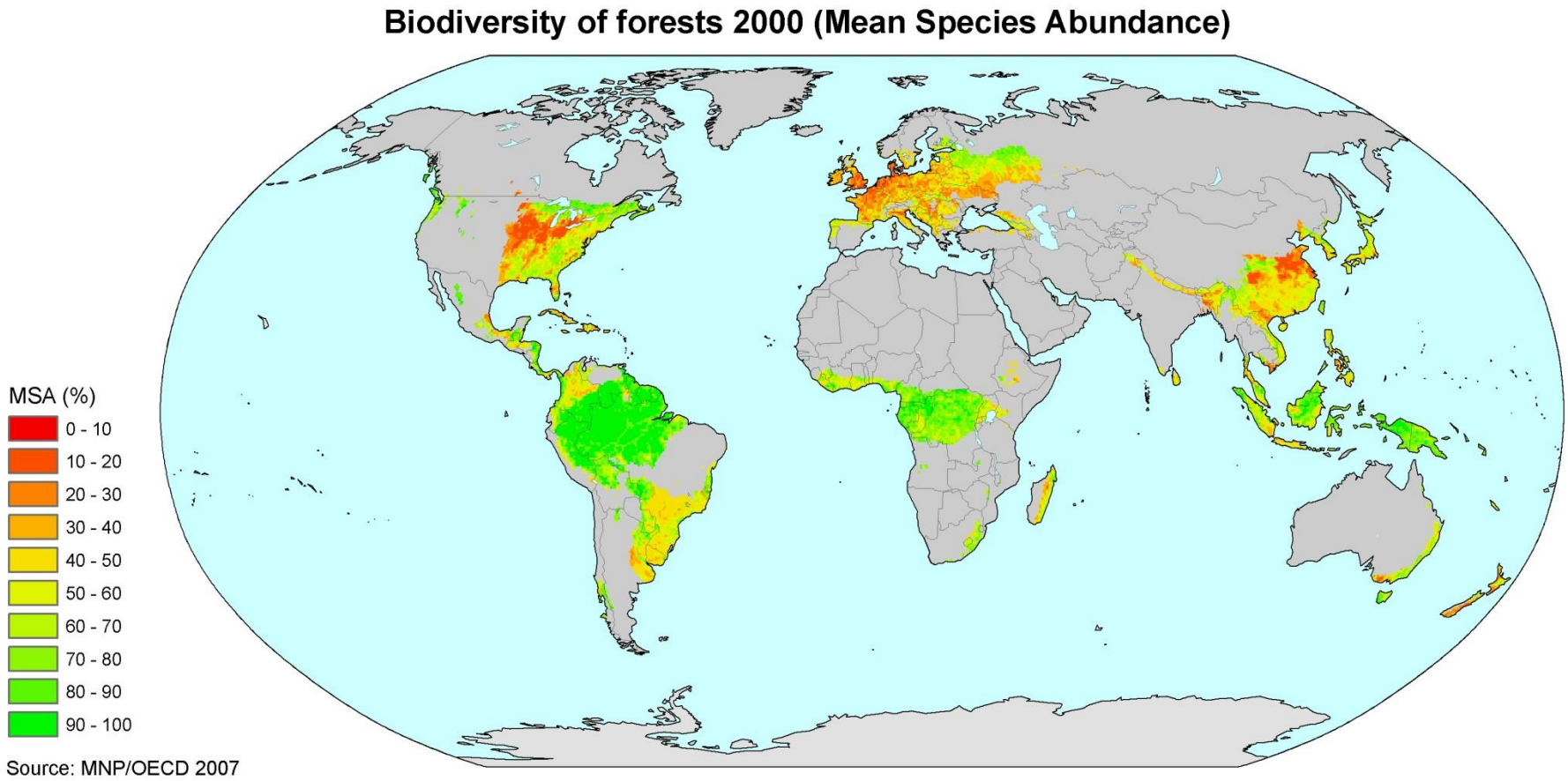

Zooming in:

Temperate & tropical forests baseline - 2050

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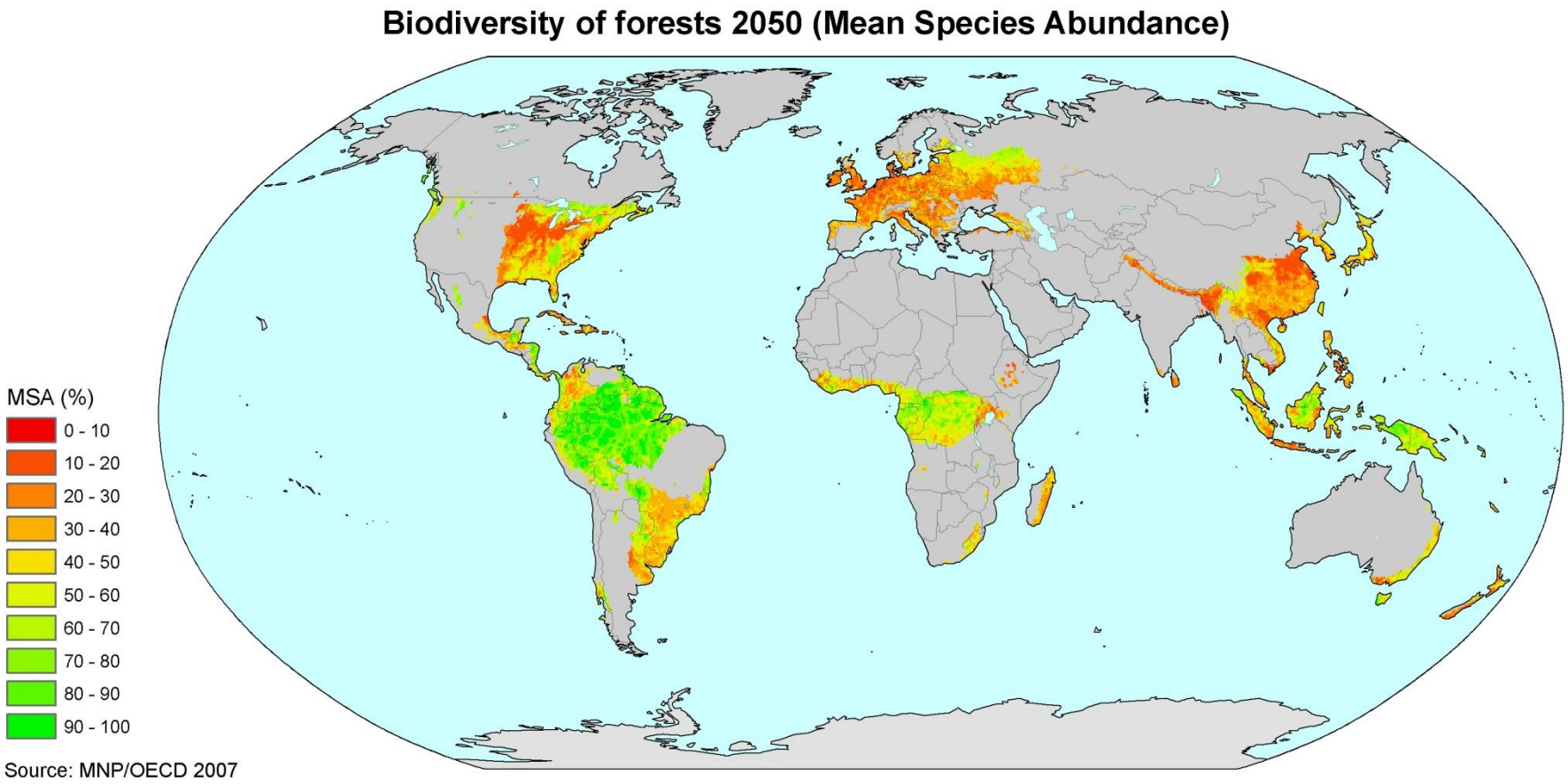
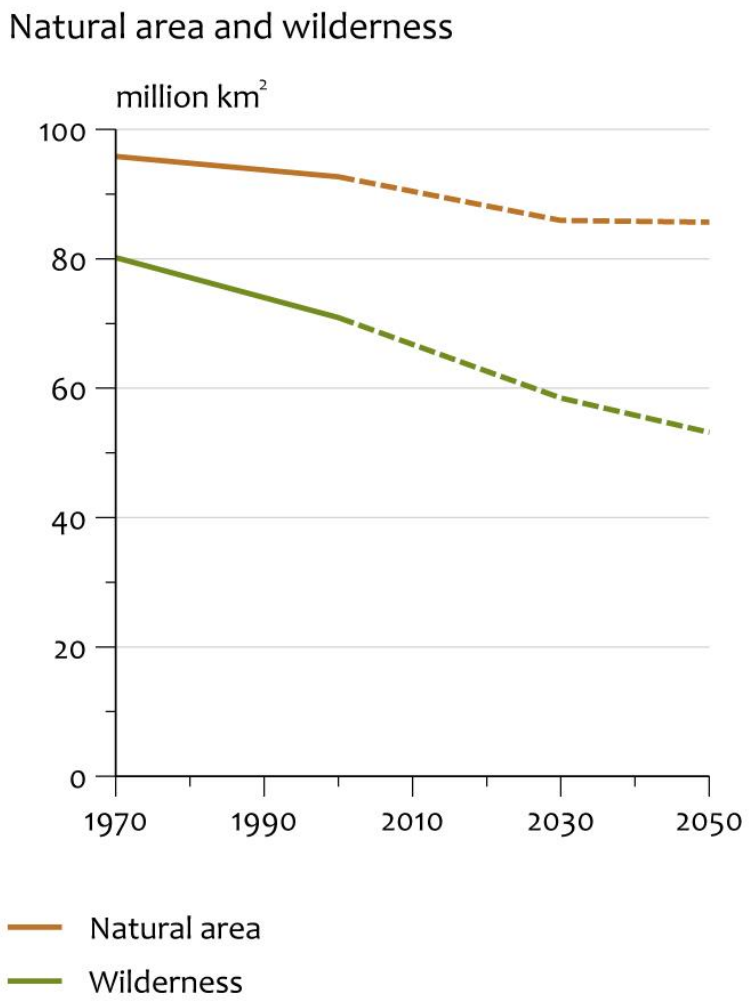


Baseline: natural area & wilderness

Global land use and natural area in baseline scenario



(Earth total: 130 million km²

8 options

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1. Closing yield gap (production efficiency)
2. Reducing food chain losses
3. Diet: Less meat (healthy, none)
4. Climate mitigation & biofuels (max + 2°C)
5. Improving forest management (wood plantations + RIL)
6. Reduced deforestation
7. Expanding protected areas (20%-50% per biome)
8. Restoring marine fish stocks & aquaculture

+ Option combination (ambitious but feasible)

Effects in Prevented Loss (Pl
of baseline loss (10%)

Overview prevented loss per option (MSA, NA, wilderness)

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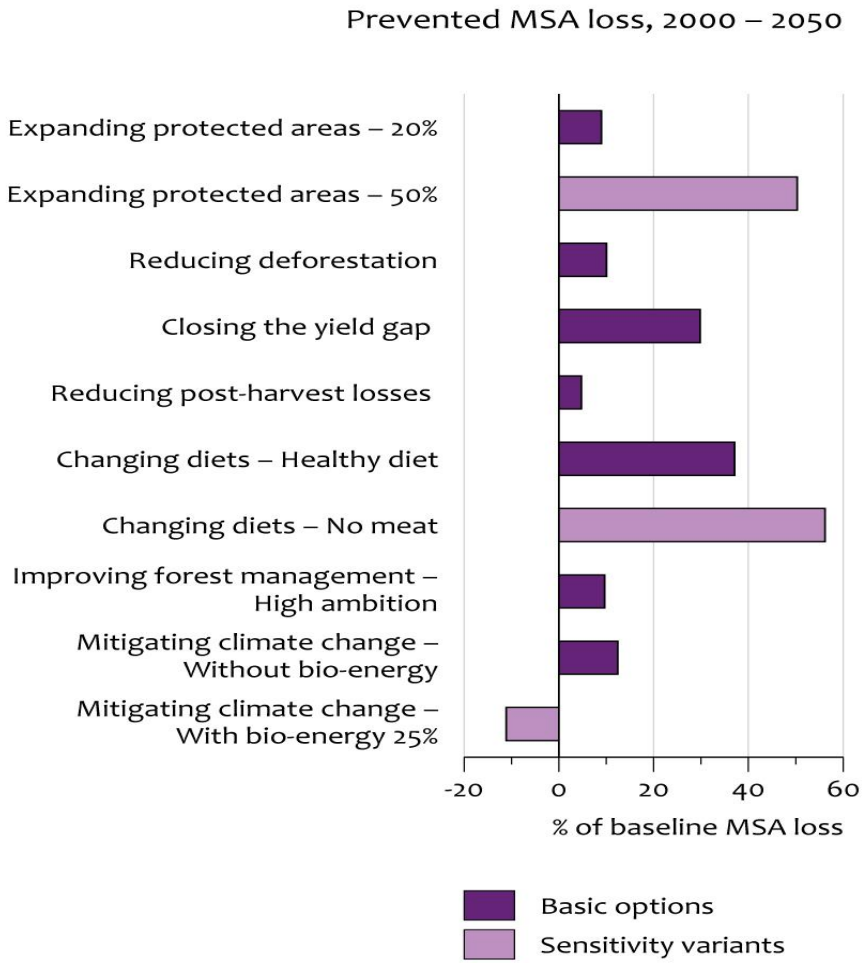
Change in global biodiversity per option compared to baseline scenario



Change in global biodiversity of options expanding protected areas and reducing deforestation by 2030

Option combination

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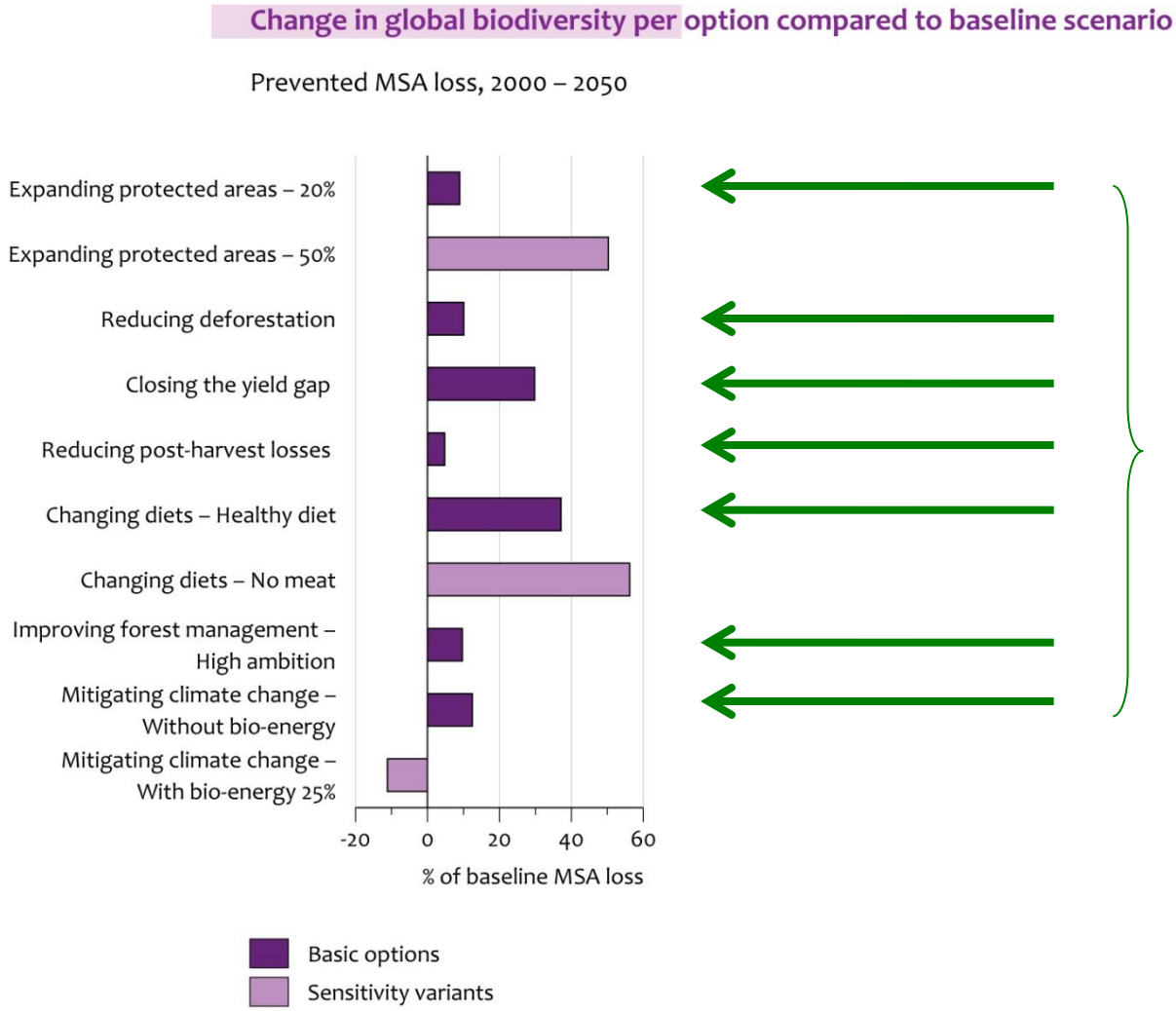

Options included in combination

Change in global biodiversity of options expanding protected areas and reducing deforestation by 2030

Option combination: halving the loss (MSA)

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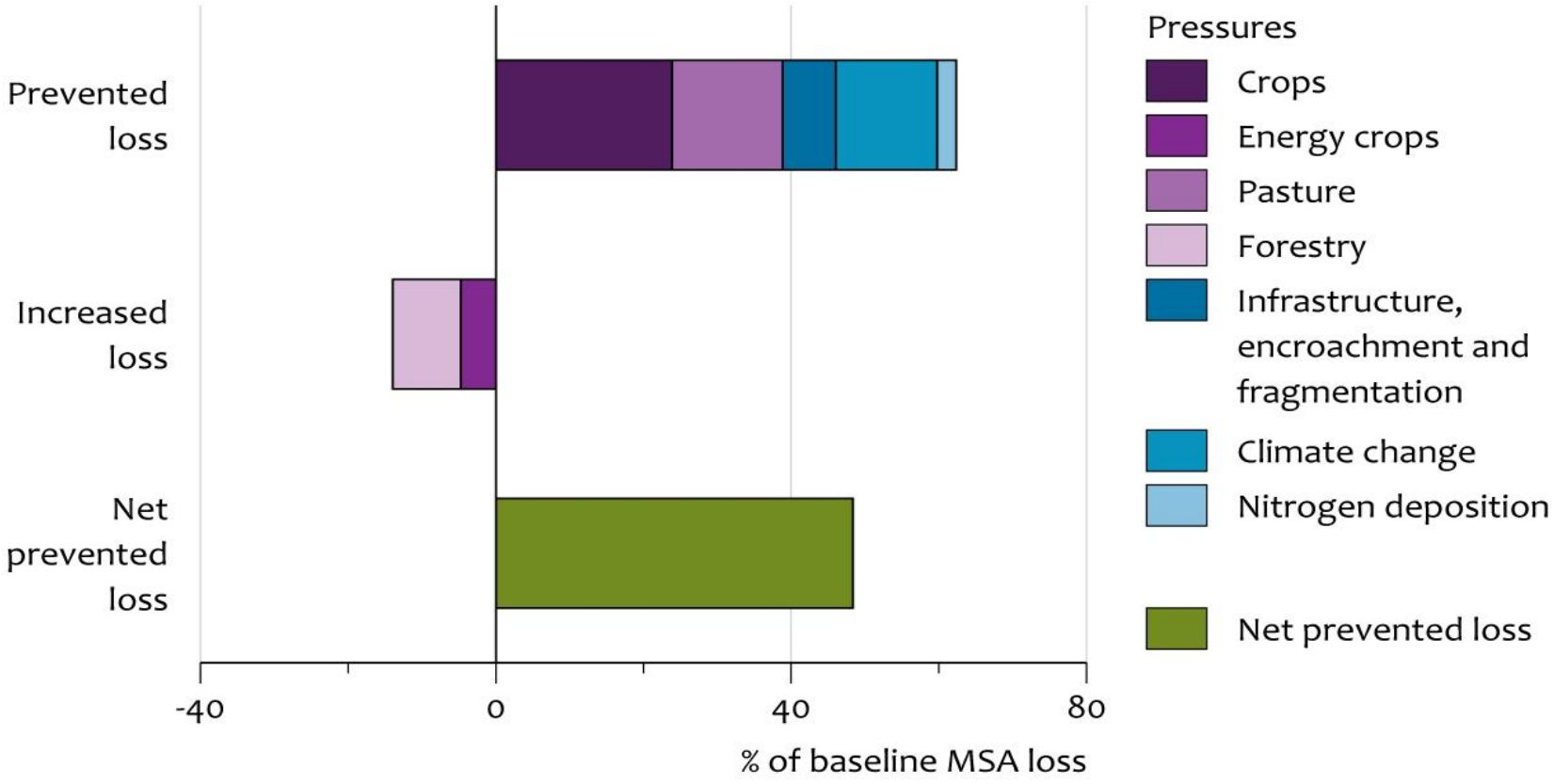
Prevented global MSA loss compared to baseline scenario, 2000 – 2050

Combination of options



Option combination: natural area and wilderness

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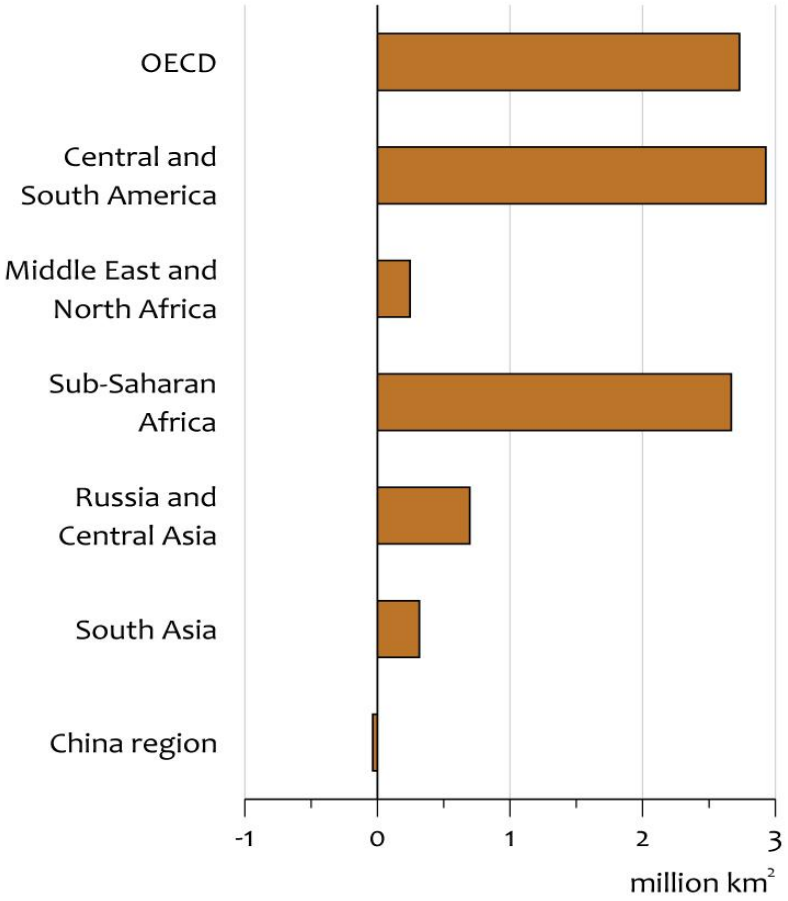
Change in natural area and wilderness compared to baseline scenario, 2050

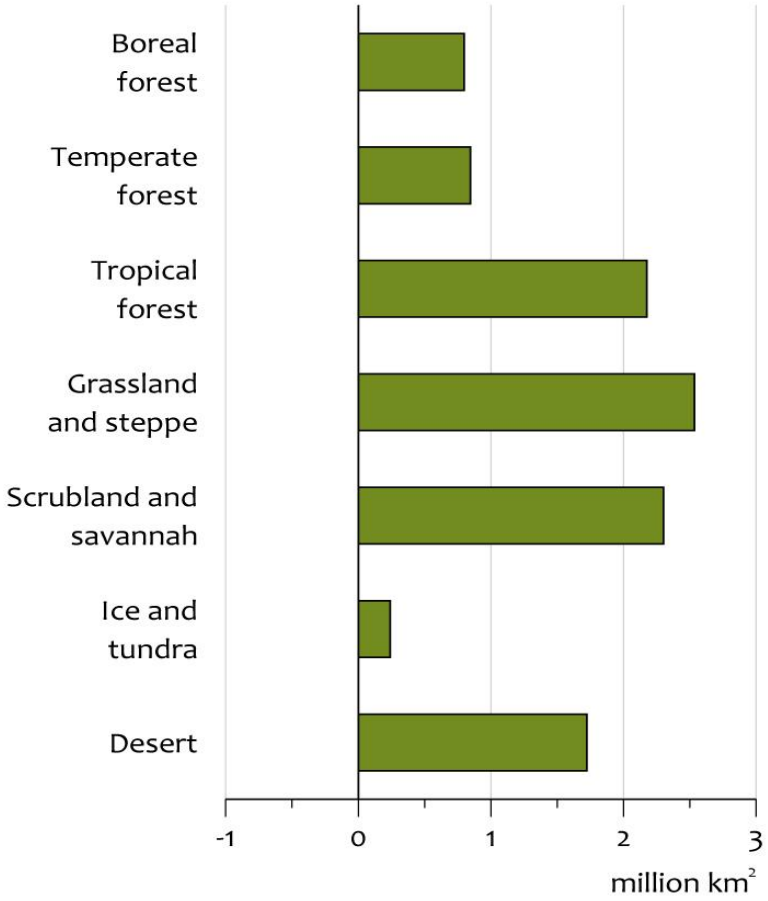
Combination of options;
Natural area per region

+ 10 mln km²

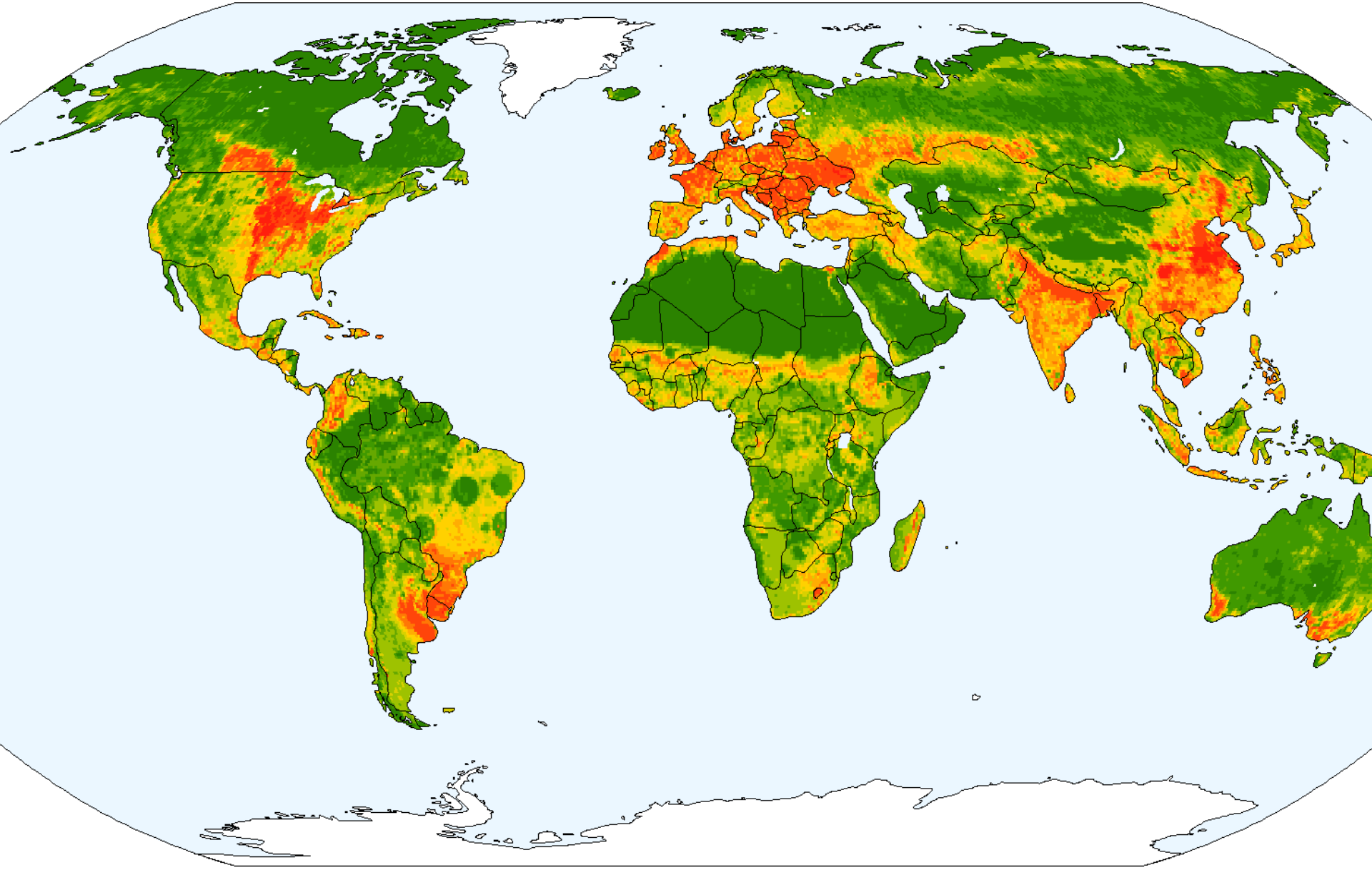


Combination of options;
Wilderness per biome

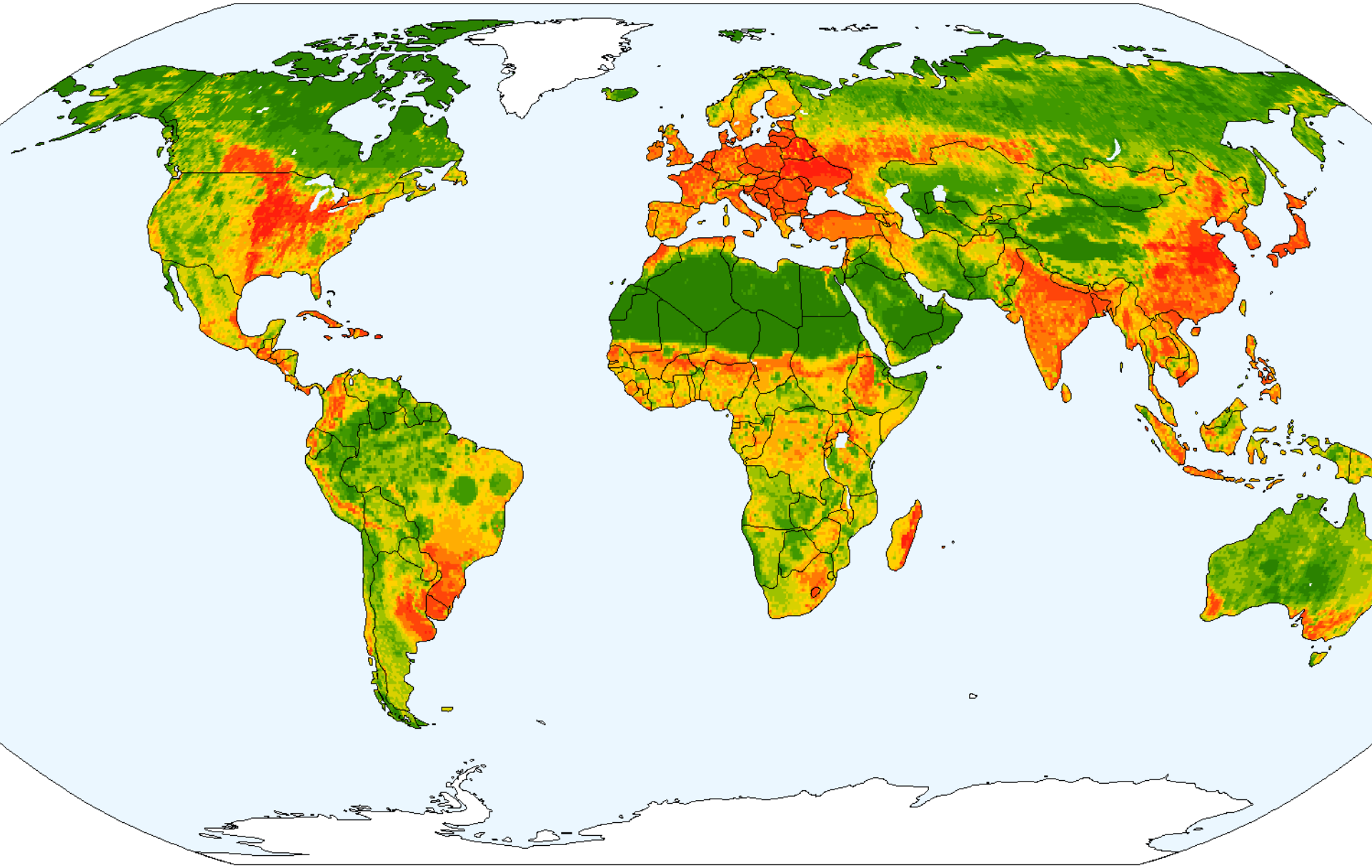
+ 11 mln km²



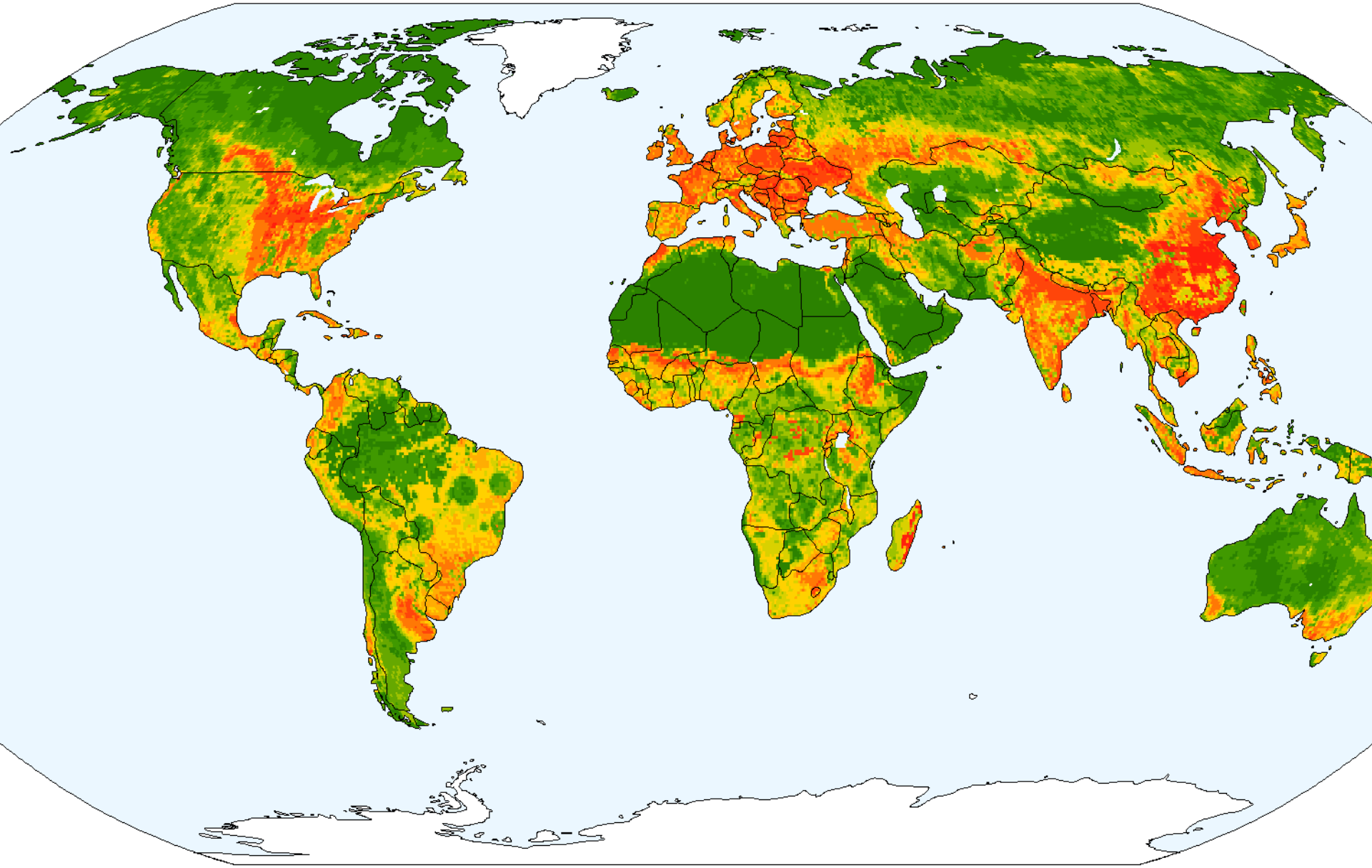
2010



2050 baseline



2050 option combination



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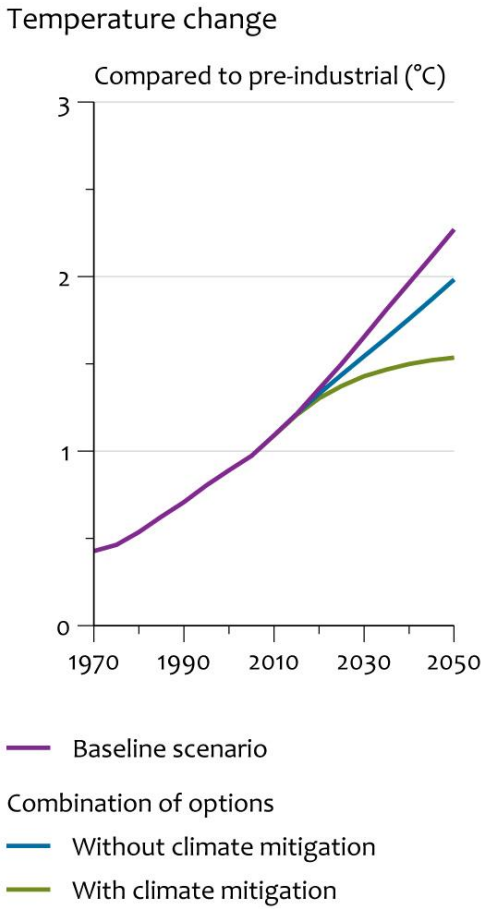
Global greenhouse gas emissions, concentration and temperature change



← Less conversion effect

← Energy change effects

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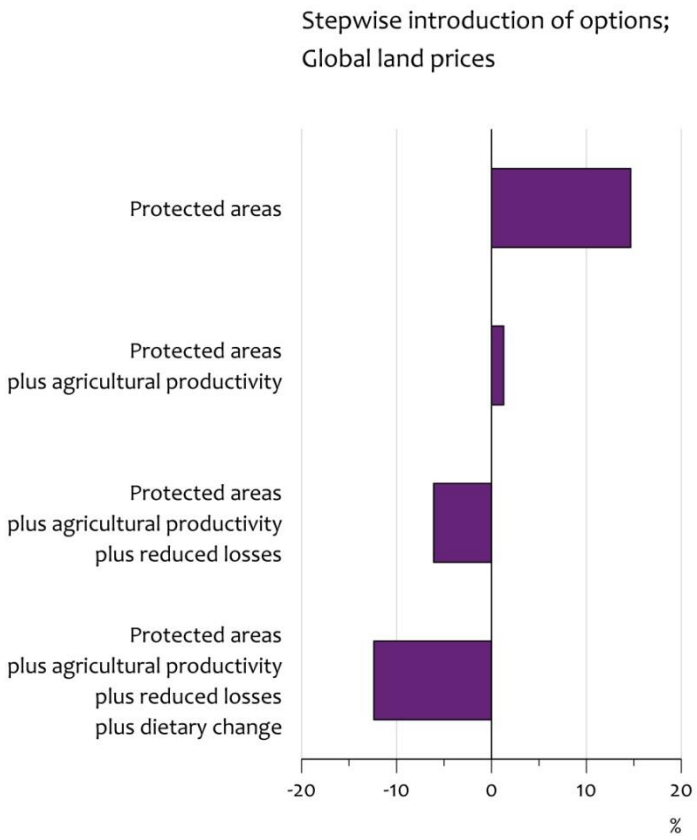
Change in land prices and food consumption compared to baseline scenario, 2030



Conclusions

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1. Ambitious option package can half loss by 2050, but not halt

2. Autonomous socio-economic growth is huge:
   - PA alone not sufficient to significantly reduce loss
   - Integrated sector-based approach required

3. Productivity increase is key (if not..)

4. Combine land demanding with land relieving options (price effects)

   (PA, plantations, bio fuels, REDD) (productivity, reduce food loss, diet)

5. Align with climate change, MDGs, food & wood & energy policies

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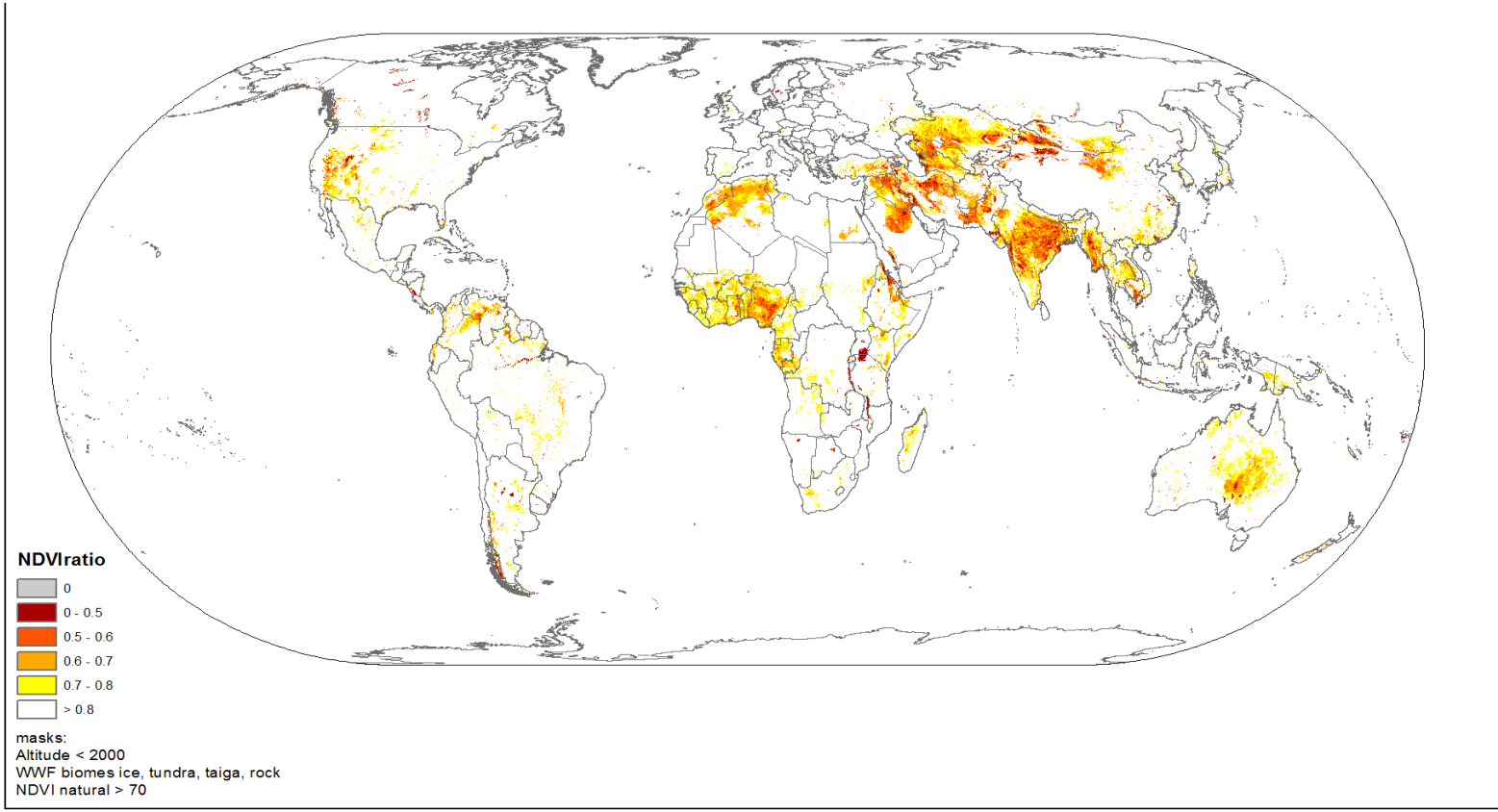
Greenness change Current/Potential method B

Masked Normalized Difference Vegetation Index (NDVI) ratio



Global biodiversity loss: natural area & wilderness

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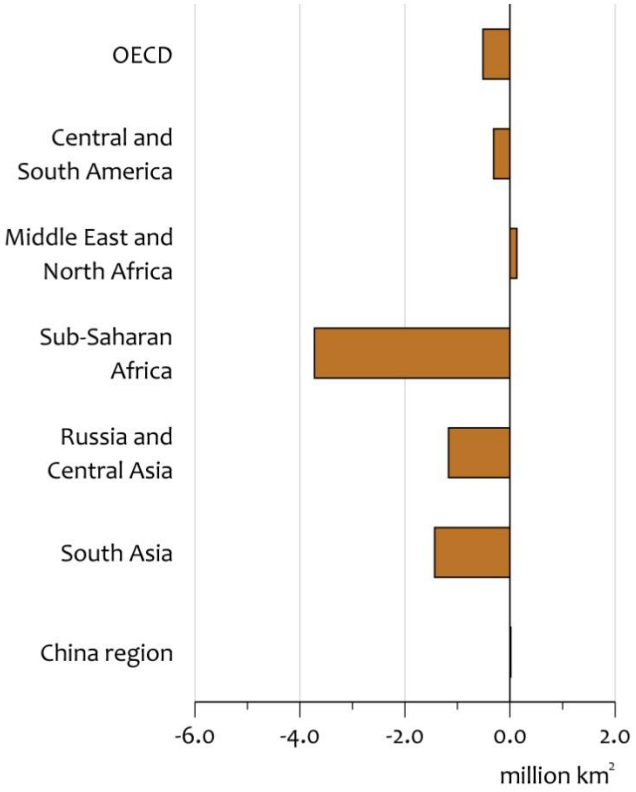
Change in natural area and wilderness in baseline scenario, 2000 – 2050

Natural area per region



Biodiversity loss: per biome

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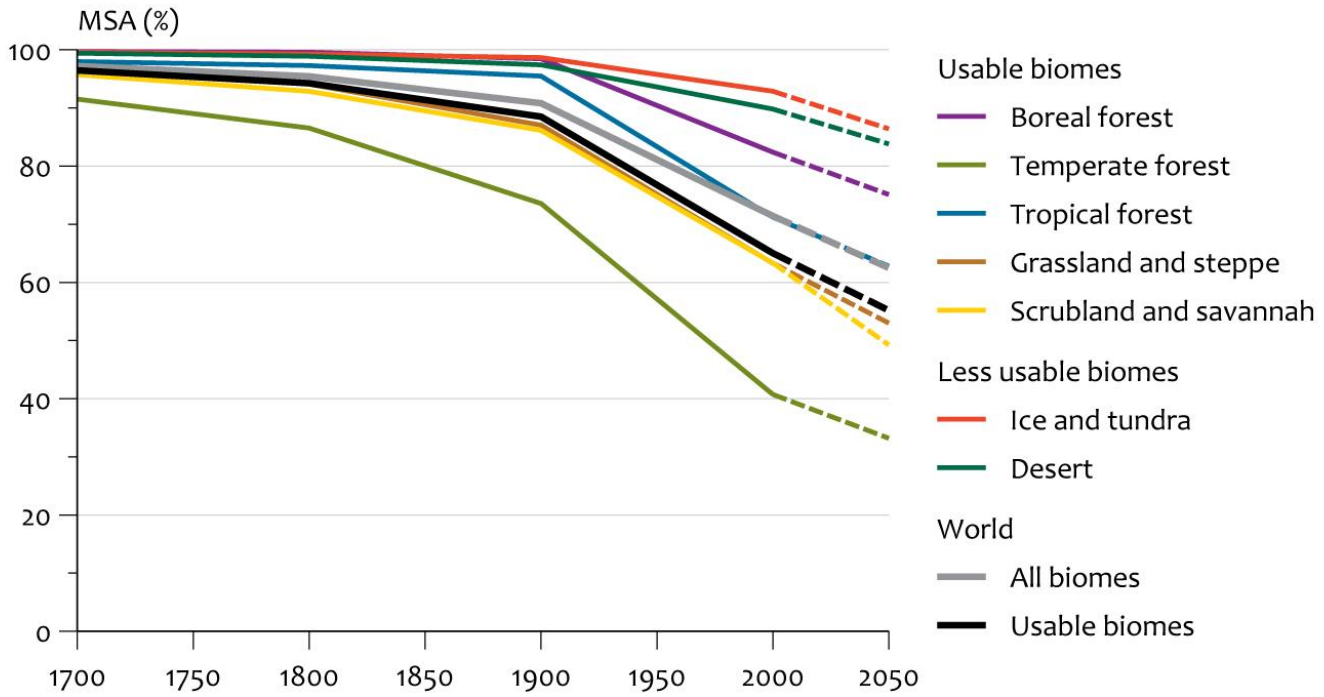
MSA per biome in baseline scenario



Biodiversity loss: per region

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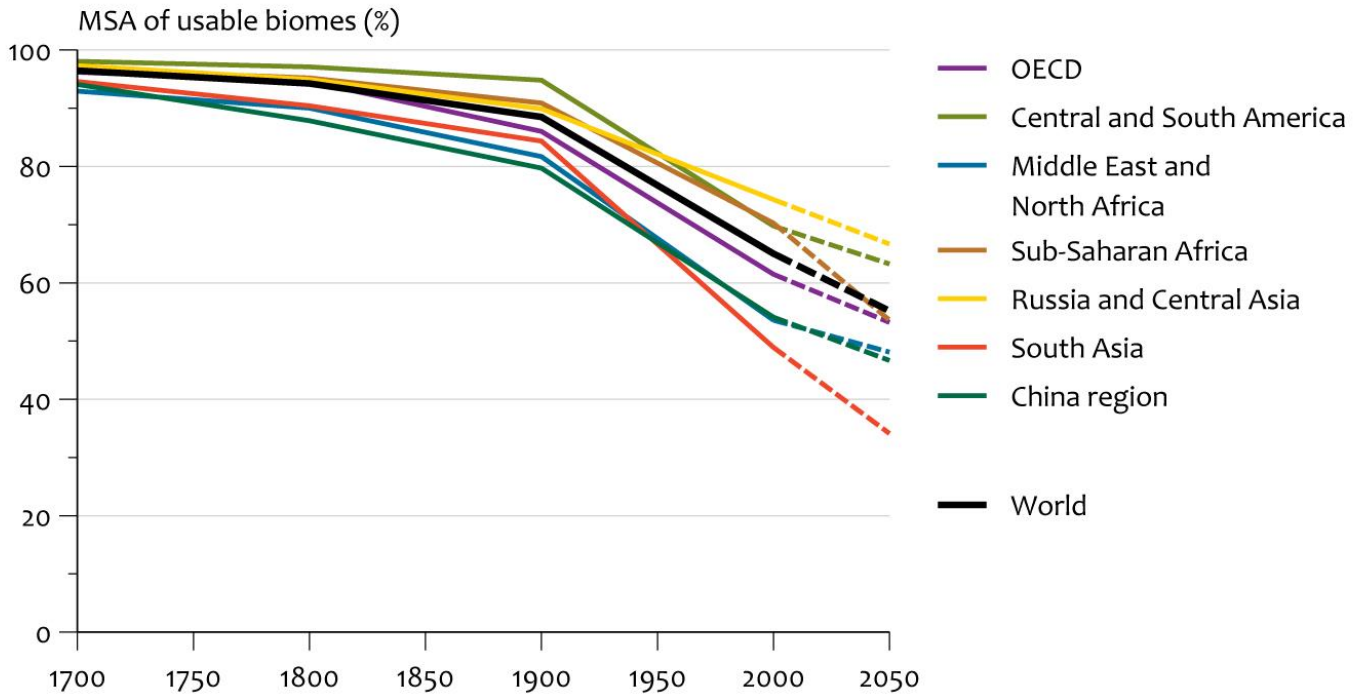
MSA of usable biomes per region in baseline scenario



Yield gap for various staple foods, in baseline and option

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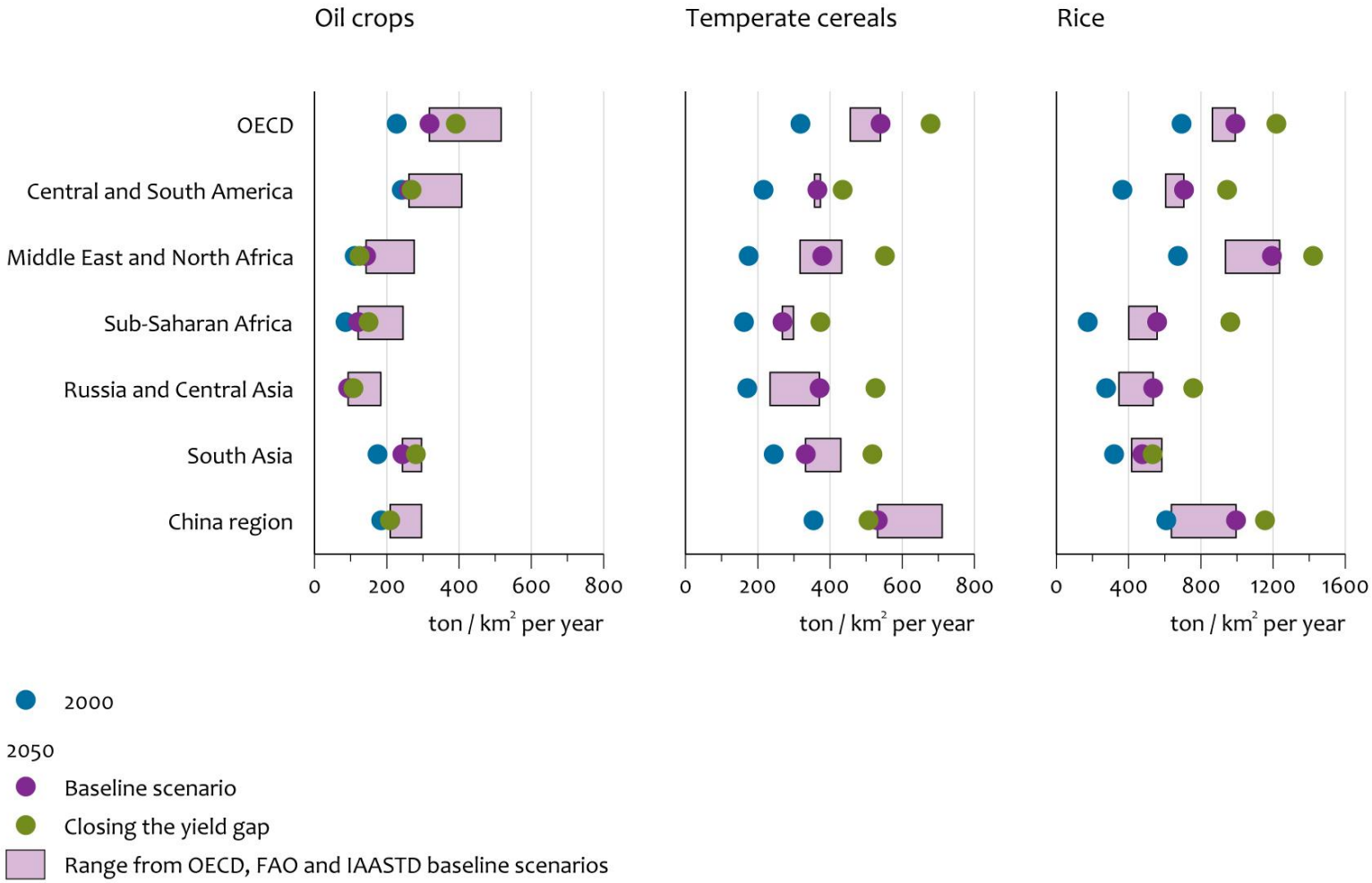
Regional yields



Timber and pulp demand over time

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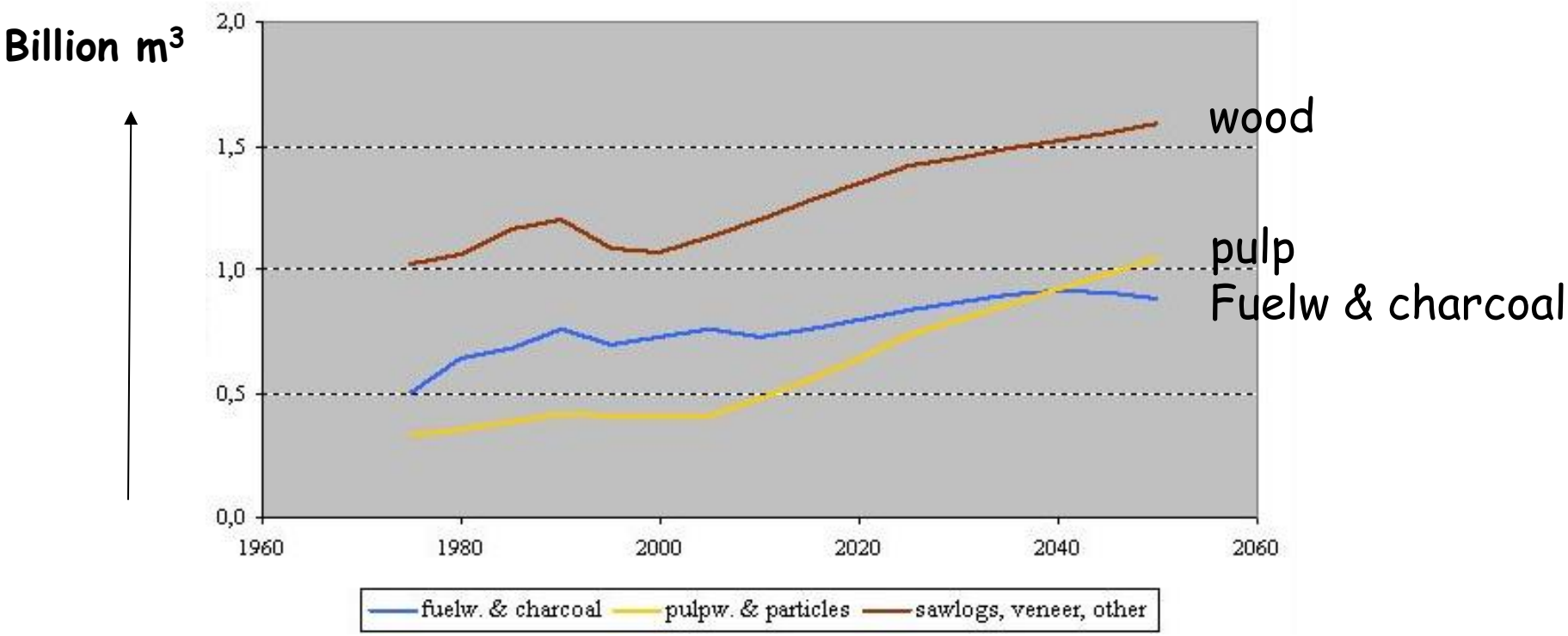
- Global wood demand increase from 2.5 -> 3.5 billion m^3/yr



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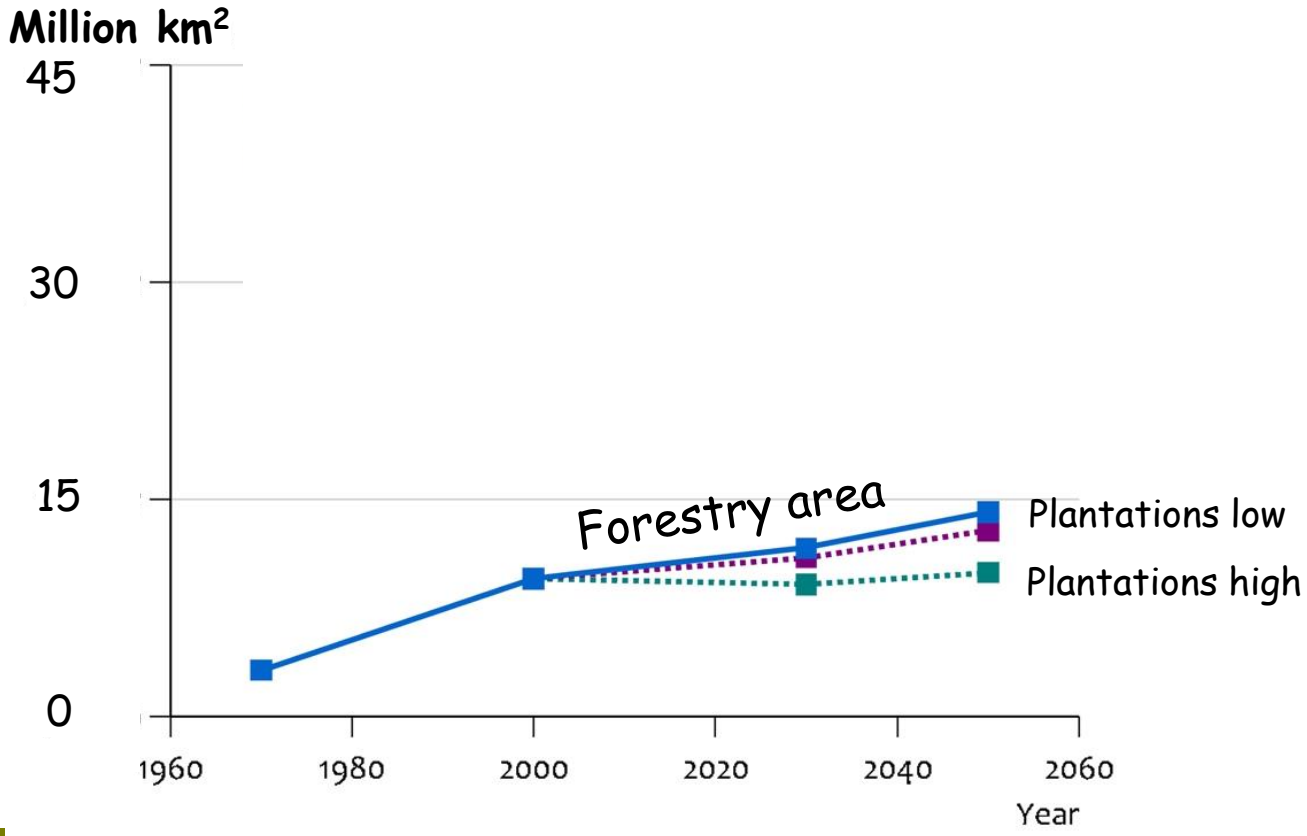
Plantations produce 40% demand by 2050 + RIL

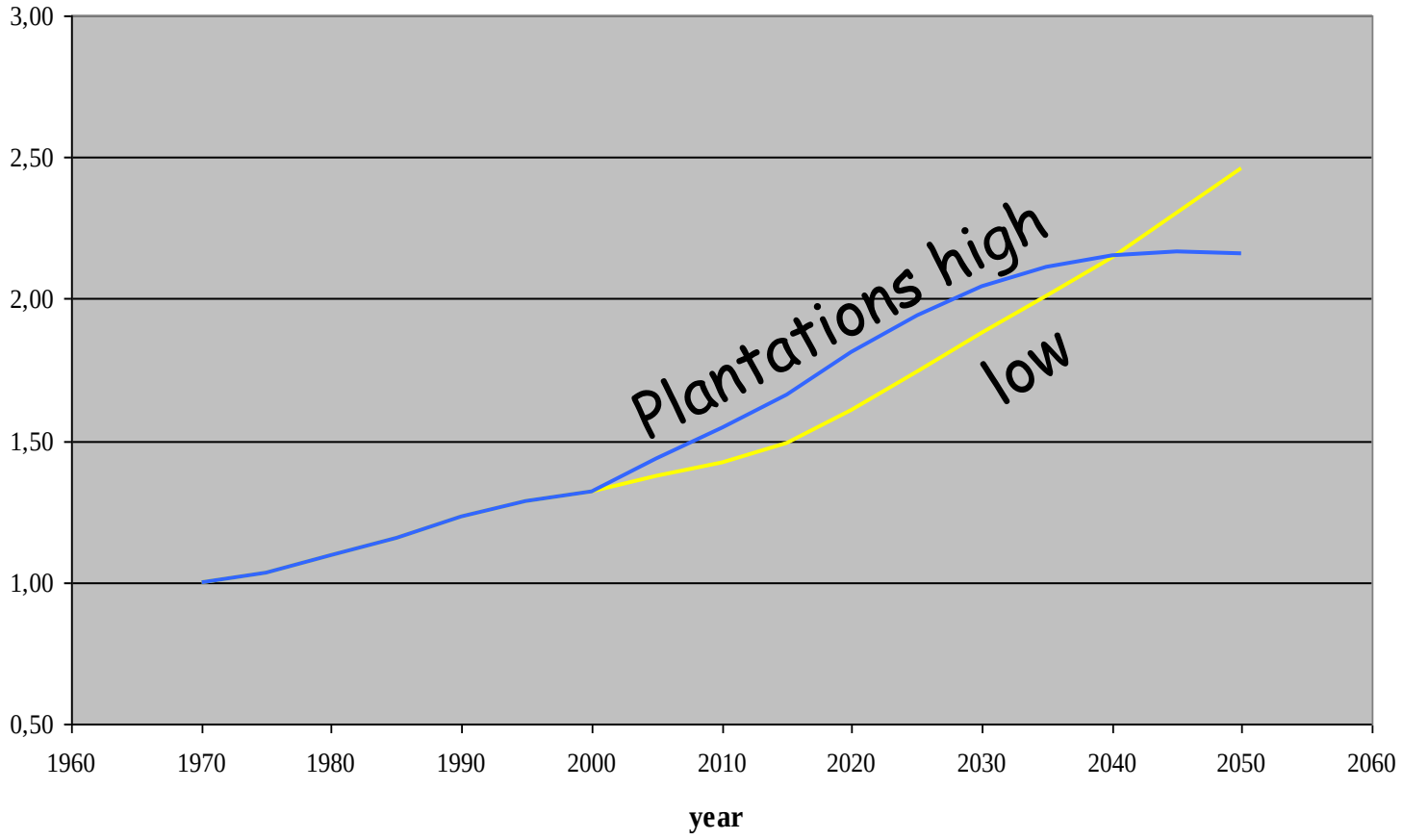
Total Forests and Forestry (>90% cover)



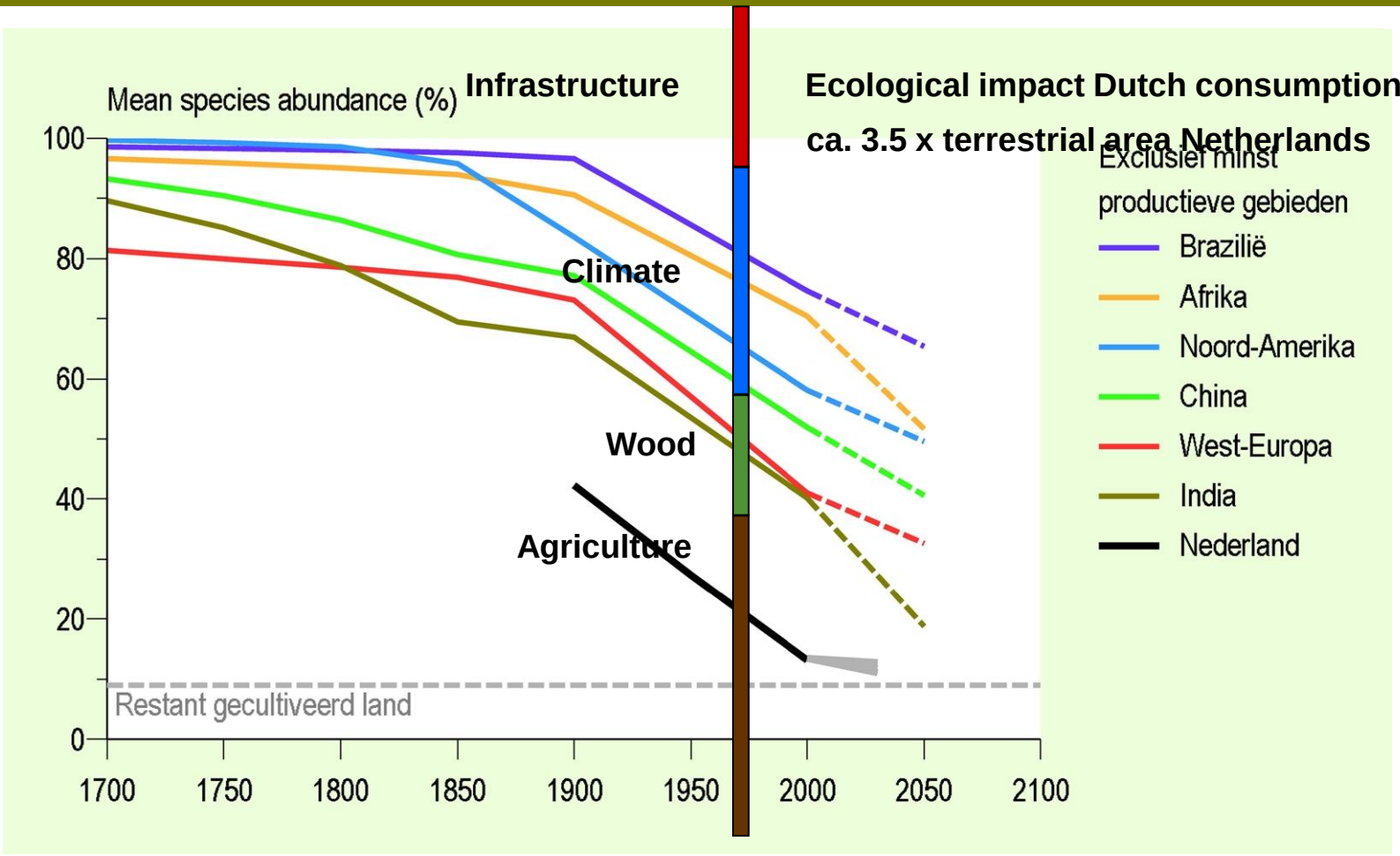
Grafieknummer: VIB-Option 4 SFM Forest-areas
Datum: 09-apr-2010

Concept

Biodiversity loss (msa)



High biodiversity footprint



Conclusions

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1. Ambitious but feasible option package can half the rate of loss by 2050
2. But not halt the loss

3. Sector-based policies far more effective then PA alone
4. Directly effective: diet change, closing yield gap, PA, RIL and lowering catch
5. Long term effective: forest plantations
6. Biofuels & unguided trade liberalisation would lead to net loss

7. Options in multiple sectors behave in cumulative way
8. Options in one sector behave in a multiplicative way (½ x ½ = ¼)

9. Efficiency increase is key
10. Combine land demanding with land relieving options (price effects)
11. Climate policies beneficial, without biofuels
12. Align with climate change, MDGs, food & wood & energy policies

Towards a smart option-package

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1. Technical high ambitious potential *
2. Policy oriented package (survey) under development

Combine:

- Carbon-rich area protection (forest, grassland and peat)
- with biofuels on degraded grounds plus waste utilization
- with protection of EGS in brittle ecosystems (sub-humid and mineral soils)
- with effective protection of 25% per eco-region incl. biodiv hot spots
- with eco-efficient production increase in agriculture & forestry & aquaculture in current under performing production systems
- as a means to alleviate poverty
- With micro-finance, capacity building, law and law inforcement, technology transfer, better redistribution of food, ……
- strong efficiency increas in energy and water use
- temporary reduction of fisheries
- guided trade libealization
- taxation on land conversion and meat
- Fair distribution of cost and benefits of global public goods (biodiv) by GDM
- Introduction of healthy diet consumpion patterns
- …….

REDD: limited match with hot spots

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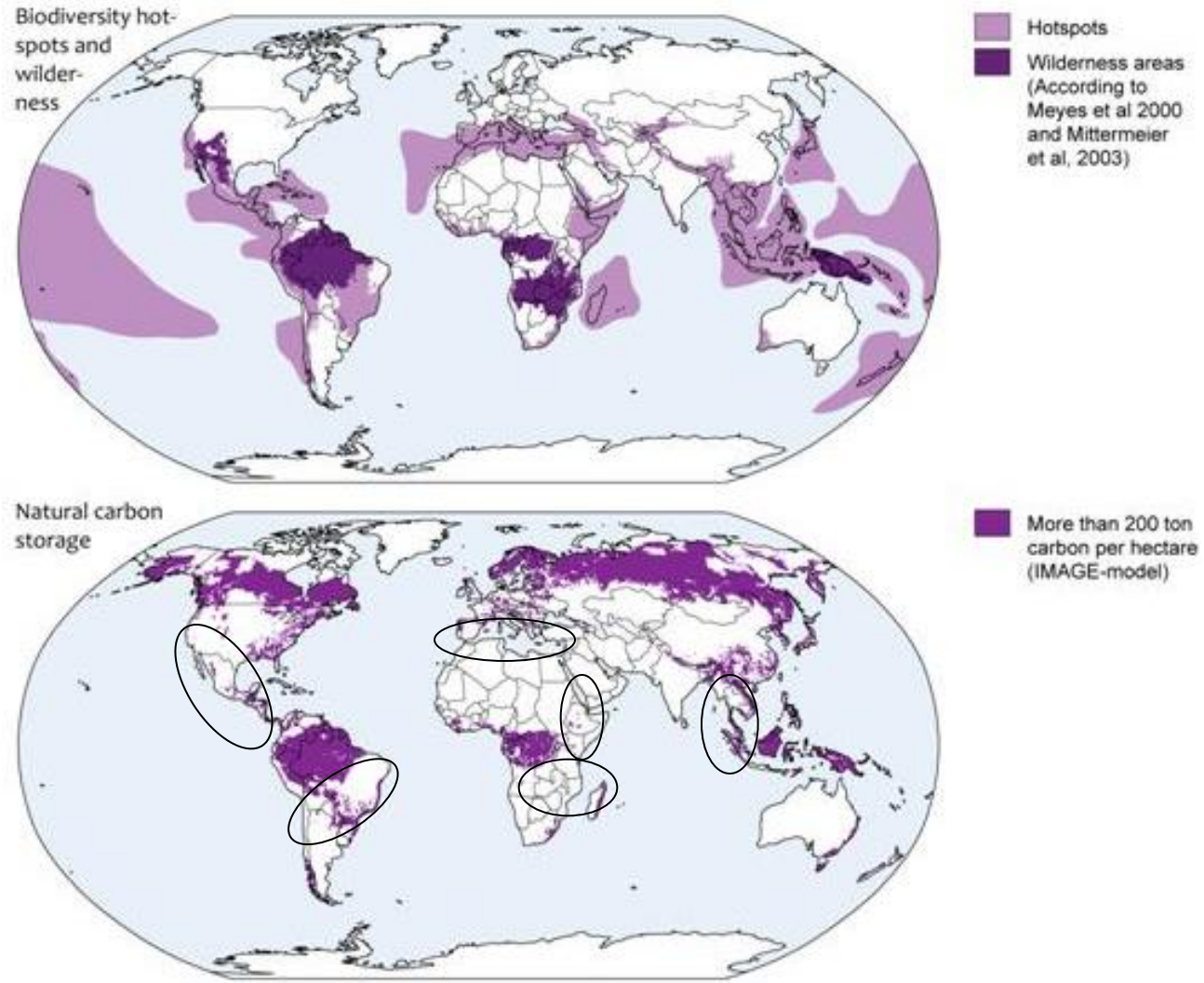

Causes and what can we do about it? Competing claims

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Potential losses from growing demand of commodities

Growing habitat loss from:

- food, feed, forestry plantations, bio-fuel,
- Carbon plantation, built up area

Growing quality loss from

- climate change, eutrophication,
- exploiting fish and wood in natural ecosystems
- ongoing land degradation

Options

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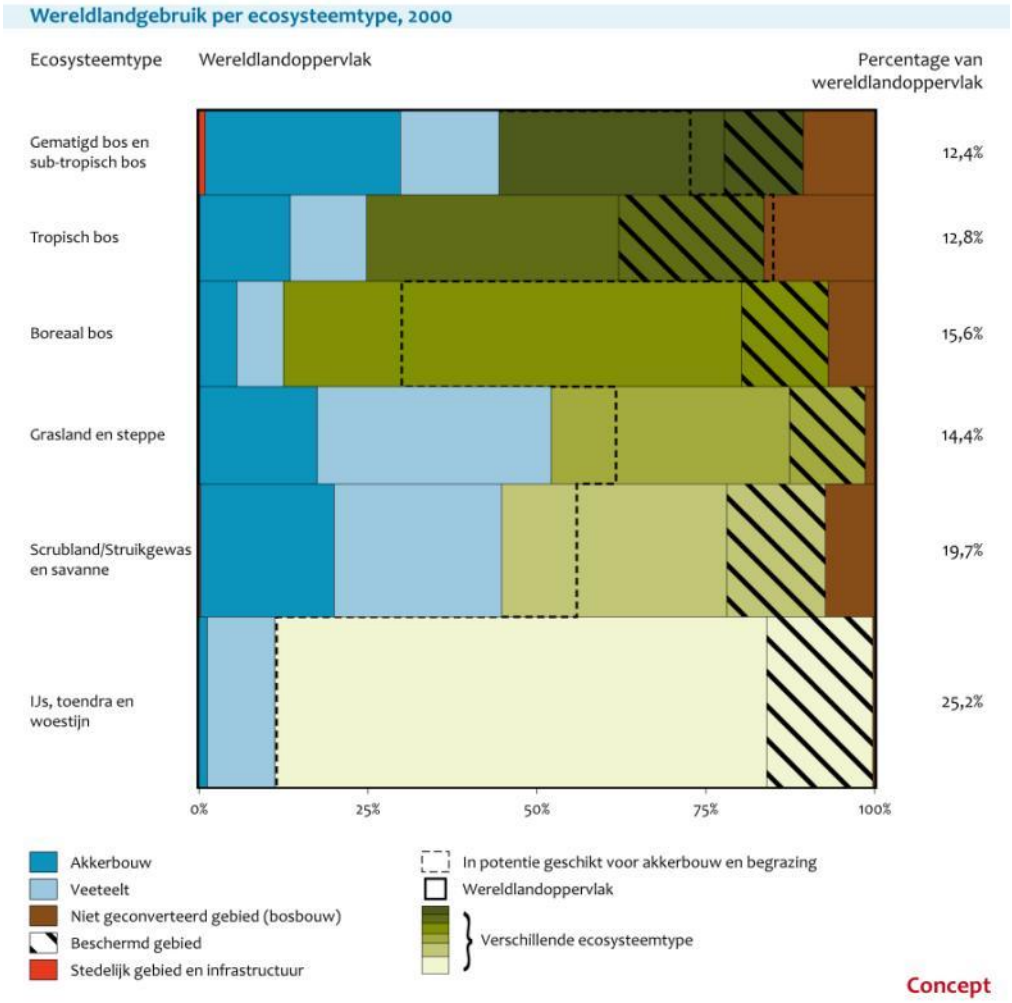
Baseline BAU future development

1. Food production efficiency
    1. higher increase than BAU scenario
    2. Failure to increase future yields as in BAU scenario
2. Reducing post-harvest loss
3. Diet change
    1. Reduction in meat consumption
    2. Increase in meat consumption
4. Timber production efficiency
    1. Efficiency increase through forest plantation
    2. No forest plantation
5. REDD protect high-carbon forest areas & reduced impact techniques
6. Climate objective in alternative 450 ppm scenarios
    1. by 2nd generation bio fuels
    2. by food crops
7. Expansion of protected areas incl. substitution effects outside PAs

Additional:

1. Liberalization of trade in agricultural products
2. Aquaculture replacing partly marine capture fisheries (needs UBC)

Land use in 2000 arable land + extensive grazing + forestry



+ 10% protected area per biome

Land use in 2050 arable land + extensive grazing + forestry

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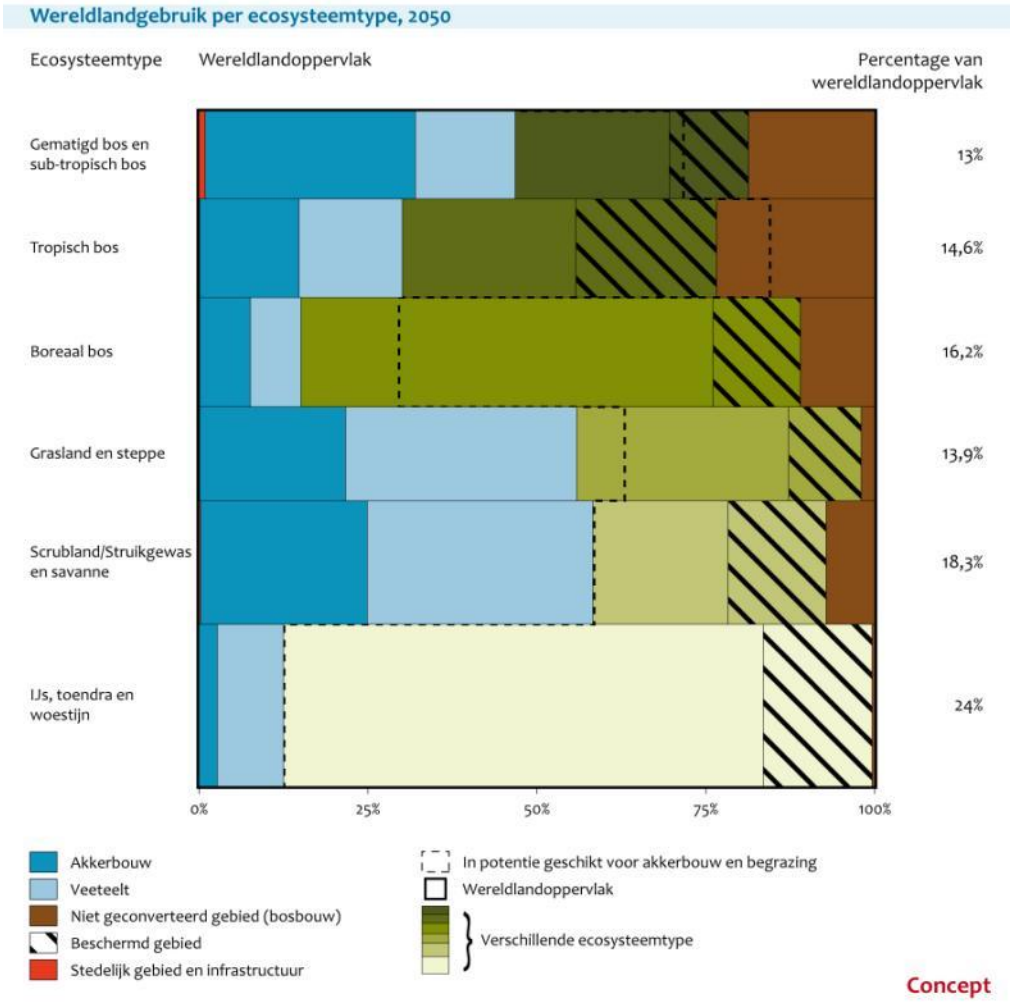

1.8 x Δ production

Land use in 2050 (arable land + extensive grazing + forestry)

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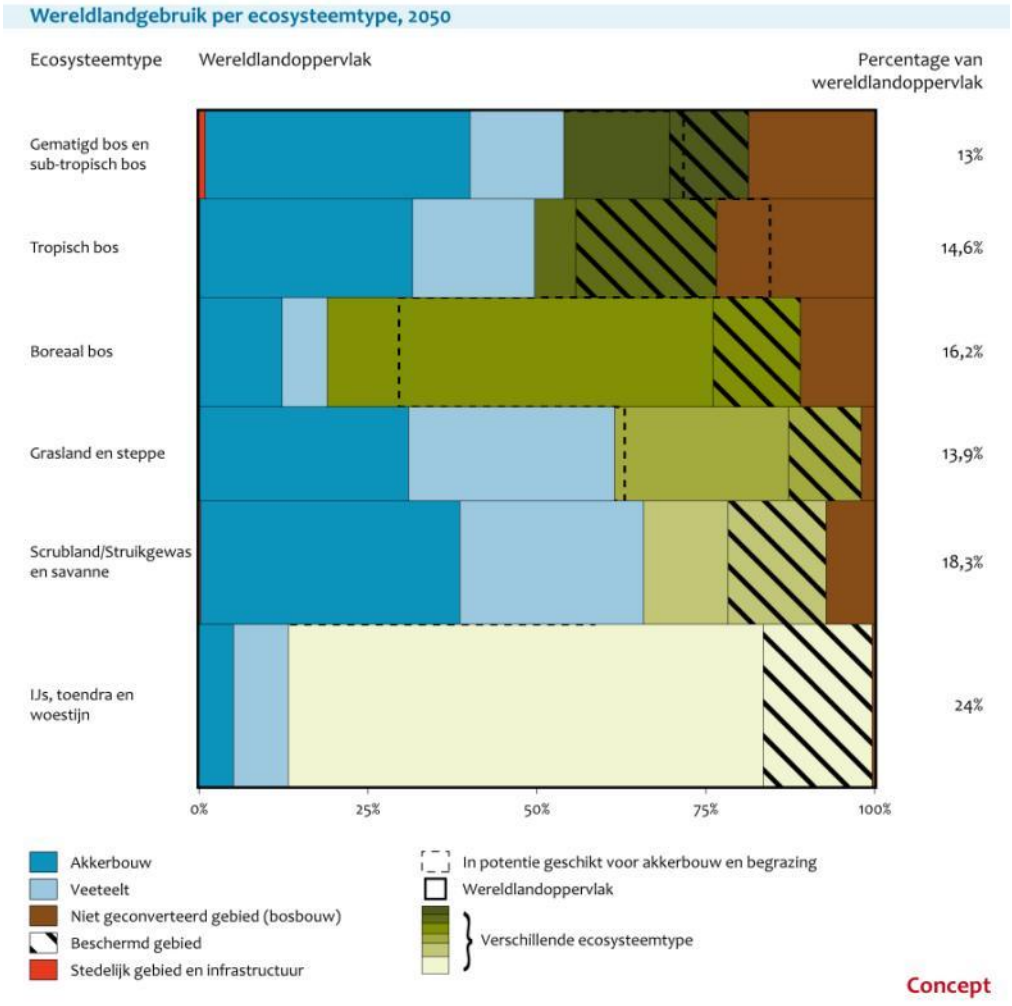

In million km^2

Failure: additional agriculture

forestry

biofuel 5

C plantation

Degradati 4-8

Abandonm

Zooming in:

Europe

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