Opportunities for Help

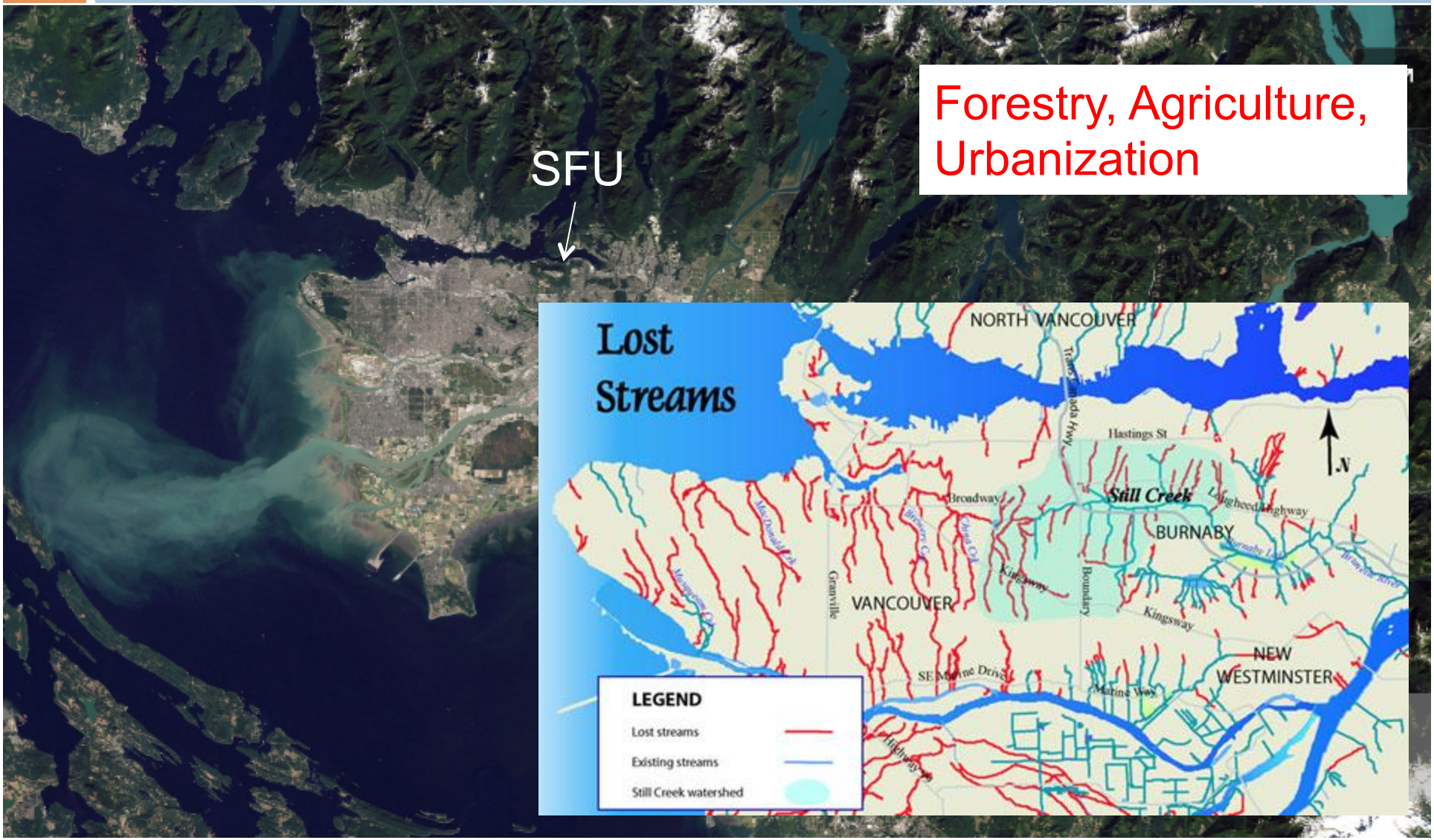
- Office Hours next week:
  - Mon. 11:00-12:00+ (Nico)
  - Tues.
    - 11:45-12:45+ (Wendy)
    - 1:00-2:00 (Rylee) (B8271)

- Exam
  - Thurs. Dec. 5, 8:30-10:30 (C9001)
  - Bring a calculator & student ID
  - not cumulative but you will need to draw on earlier material

Major Drivers of Biodiversity Loss

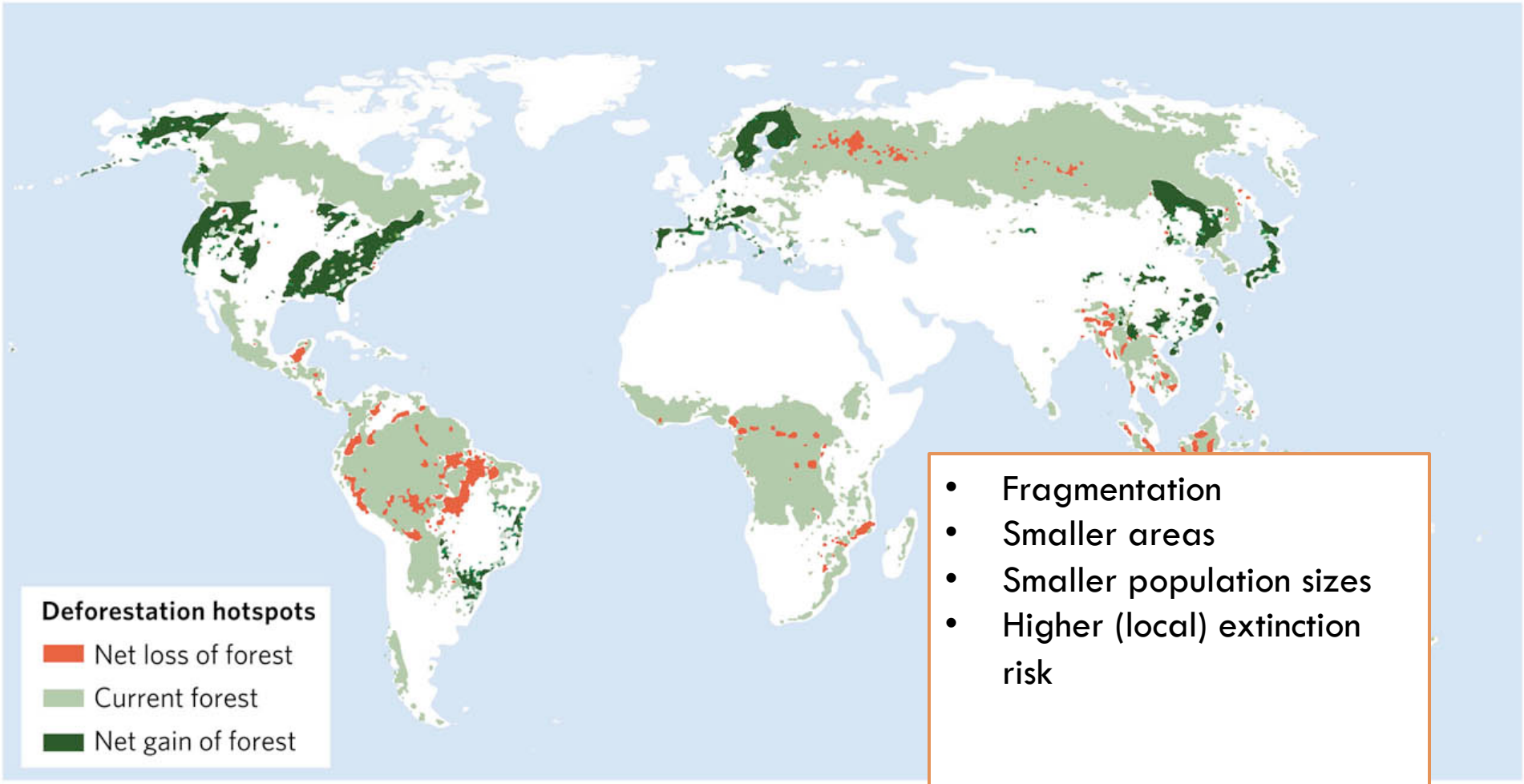
1. Exploitation (especially of top predators)
2. Invasive/exotic species
3. Land modification/habitat loss
4. Appropriation of freshwaters
5. Nutrient pollution (eutrophication)
6. Contaminant pollution
7. Stratospheric ozone depletion
8. Climate warming*

3. Changes in land-use



Global Forest Loss (BC)

Global Forest loss since 1980*



- Fragmentation
- Smaller areas
- Smaller population sizes
- Higher (local) extinction risk

Top soil erosion

Dust bowl in 1920's and 1930's in Central US & Canada
conversion of prairies →

-plow-based agriculture disrupted root mats
-replaced deep rooted natives with shallow grains
-combined with drought

*Globally, soil is eroding ~5X higher than it's being replaced
*Increasingly dependent on chemical fertilizers

Top soil erosion

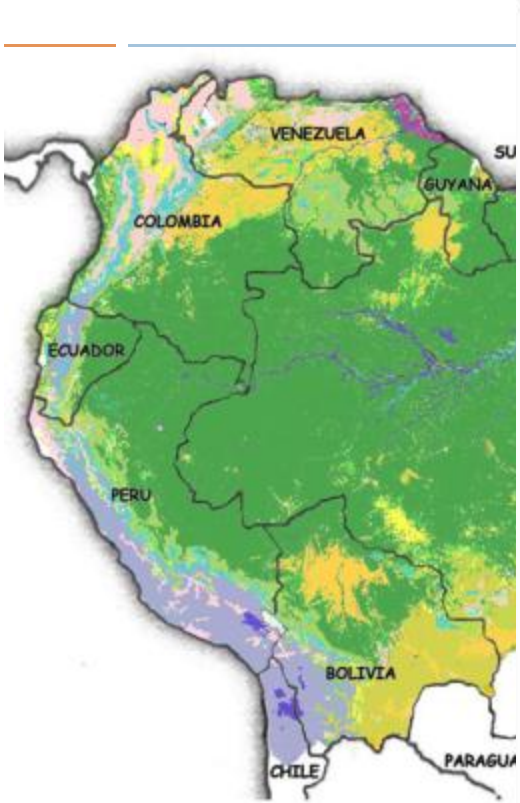
Changes in land-use

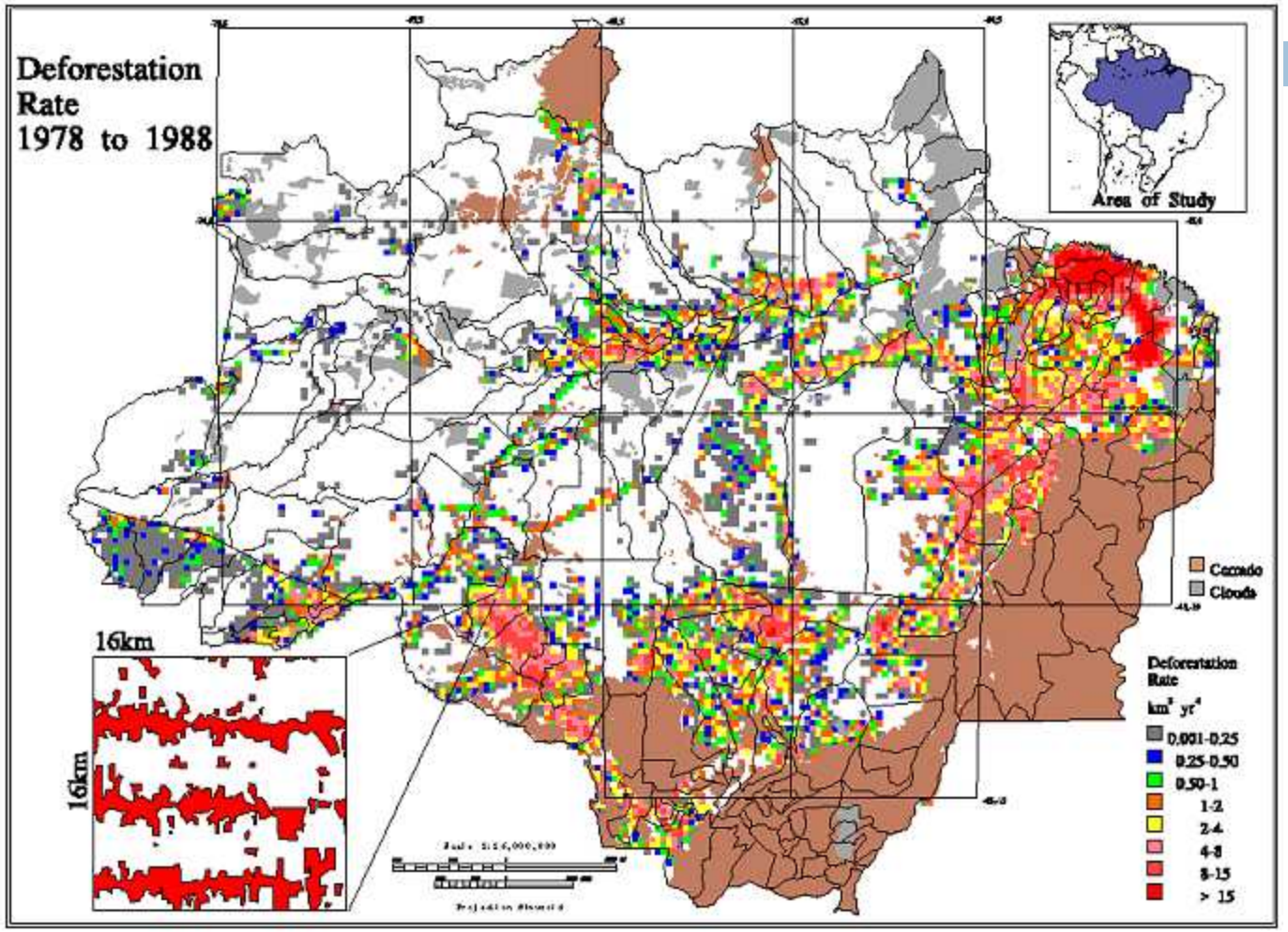
Clearing of tropical forests for non-sustainable agriculture/grazing

Remember that many tropical forests are maintained by nutrient recycling within standing forests...

... results in short term gains when converted

Top soil erosion: Amazon Basin



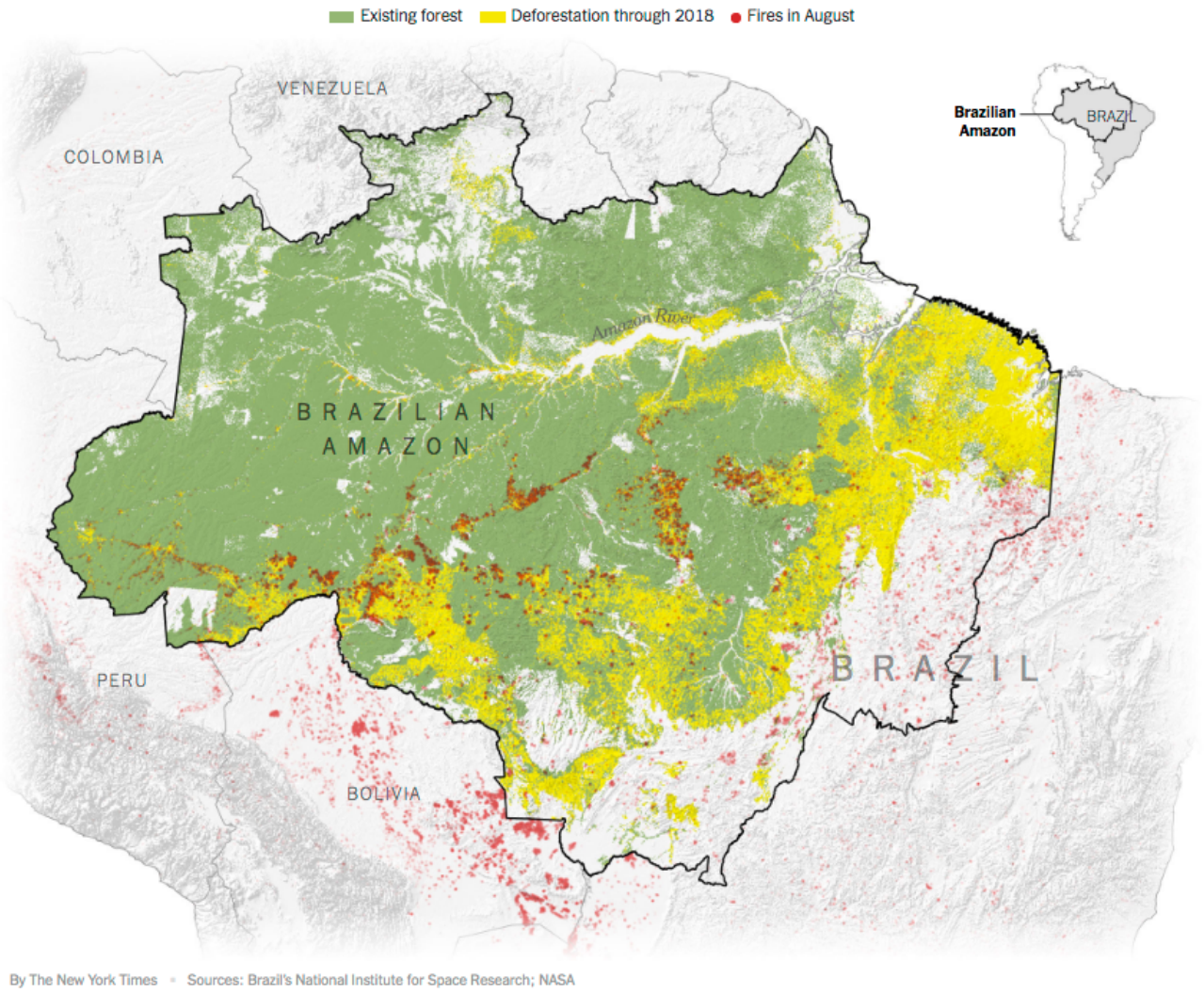


Based on the Vegetation Map of Tropical South America, H.D. Eva et al. (1999) TREES Publications Series, European Commission, with modifications by Rhett A. Butler / mongabay.com

~6-10 metric T/ha/yr in 1960

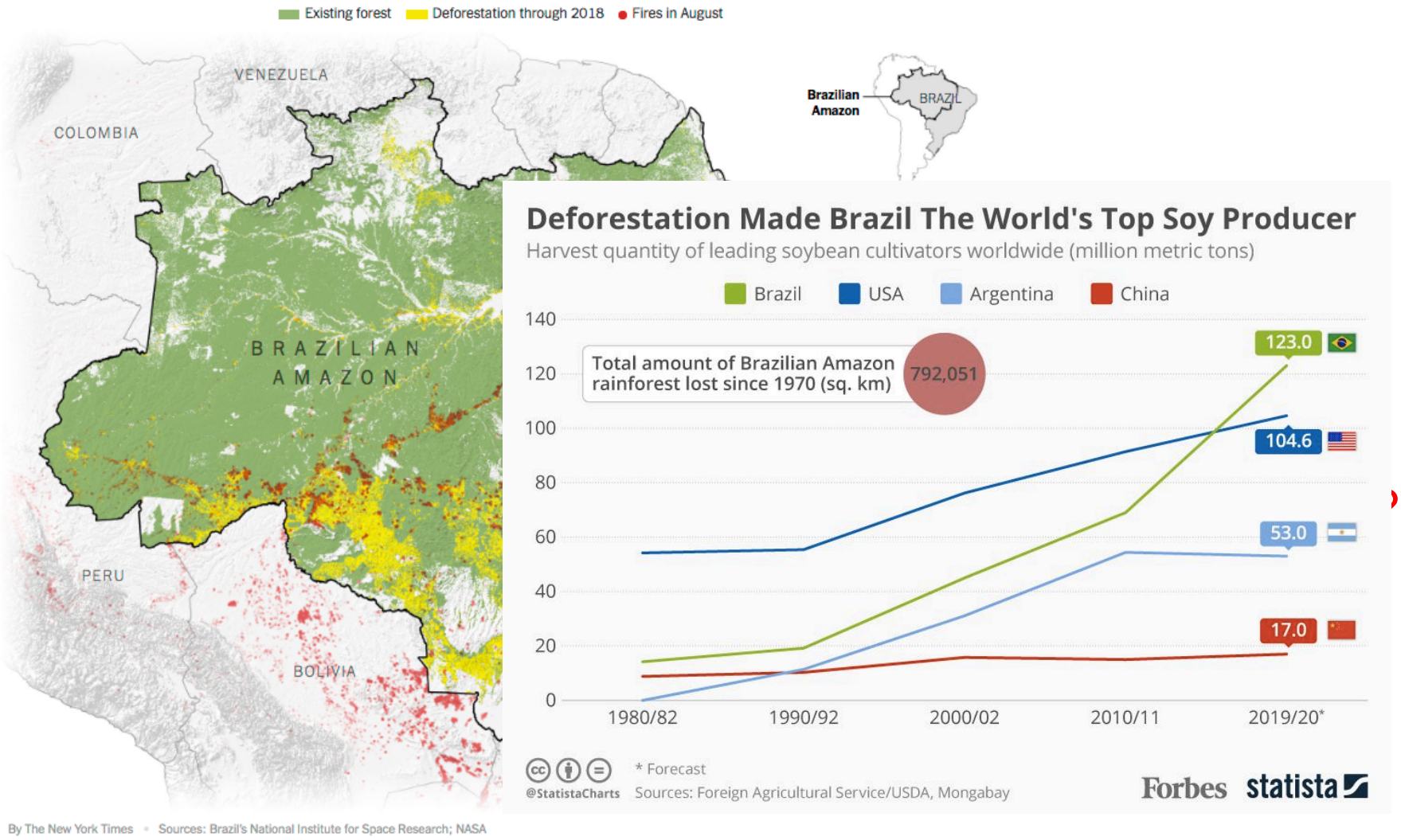
~18-190 metric T/ha/yr in 1980

Top soil erosion: Amazon Basin 2019



What is this being converted to?

Top soil erosion: Amazon Basin 2019



Changes in land-use

Tropical forests maintained by nutrient recycling within standing forests...
...relatively short term gains when converted

What is required to maintain these plantations?

Global Land-Use Change

- 12% of global land area converted for Agriculture (at the expense of forests)
- 20-30% is Pasture/Grazed land

- Increasing fastest… in tropical regions SE Asia, S America, Africa (e.g. palm oil)

- Reforestation (reversing previous forest cutting) in N. America and Europe
- ID'd as single biggest threat to terrestrial biodiversity

4. Appropriation of freshwaters

Humans currently use about 50% of global (available) freshwater, and we're depleting deep water aquifers (much slower to 'recharge')

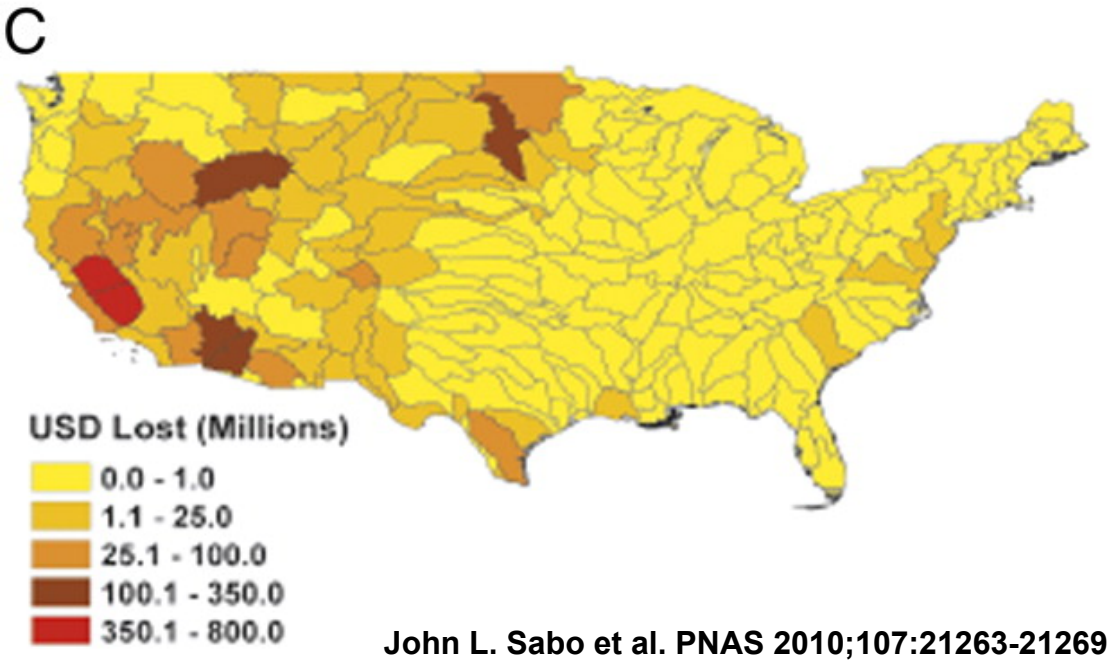
4. Appropriation of freshwater supplies

Table 4. Estimated global water use and consumption, by sector, ca. 1990.

Sector	Use (km^3/year)	Consumption (km^3/year)
Agriculture*	2880	1870
Industry†	975	90
Municipalities†	300	50
Reservoir losses‡	275	275
Subtotal	4430	2285
Instream flow needs	2350	0
Total	6780	2285
Total as a percent of AR (12,500 km^3)	54%	18%

Postel et al. 1996 Science

Water: Irrigation and salinization of soils



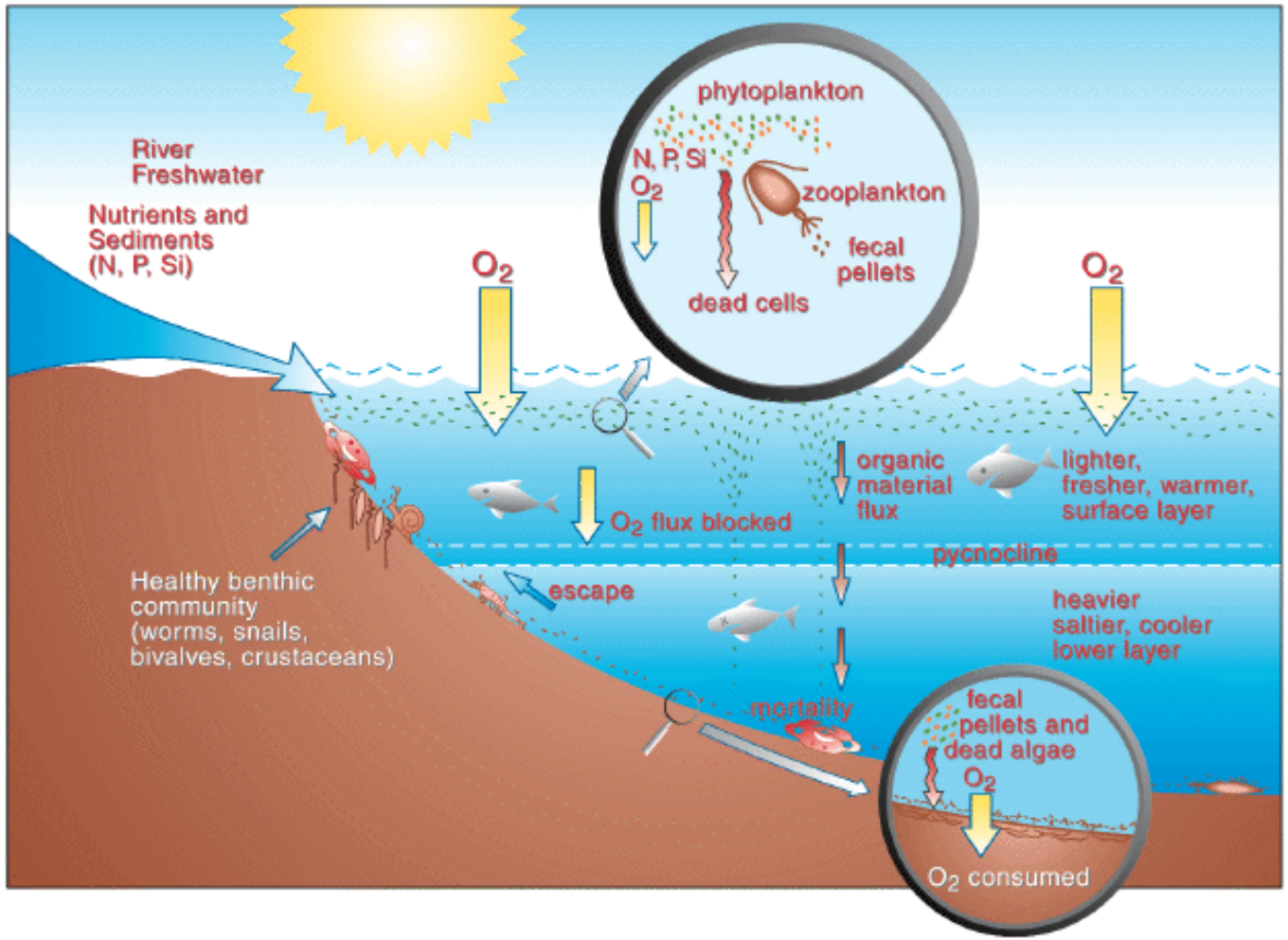
John L. Sabo et al. PNAS 2010;107:21263-21269

Irrigation can turn deserts into productive farmland. But…

accumulation of dissolved salts in water concentrate in irrigated soils

5. Eutrophication of lakes and coastal oceans

Excess nutrient inputs



photic

aphotic

5. Eutrophication of lakes and coastal oceans

Nitrogen and Phosphorus

Large inputs of available N and P by humans:

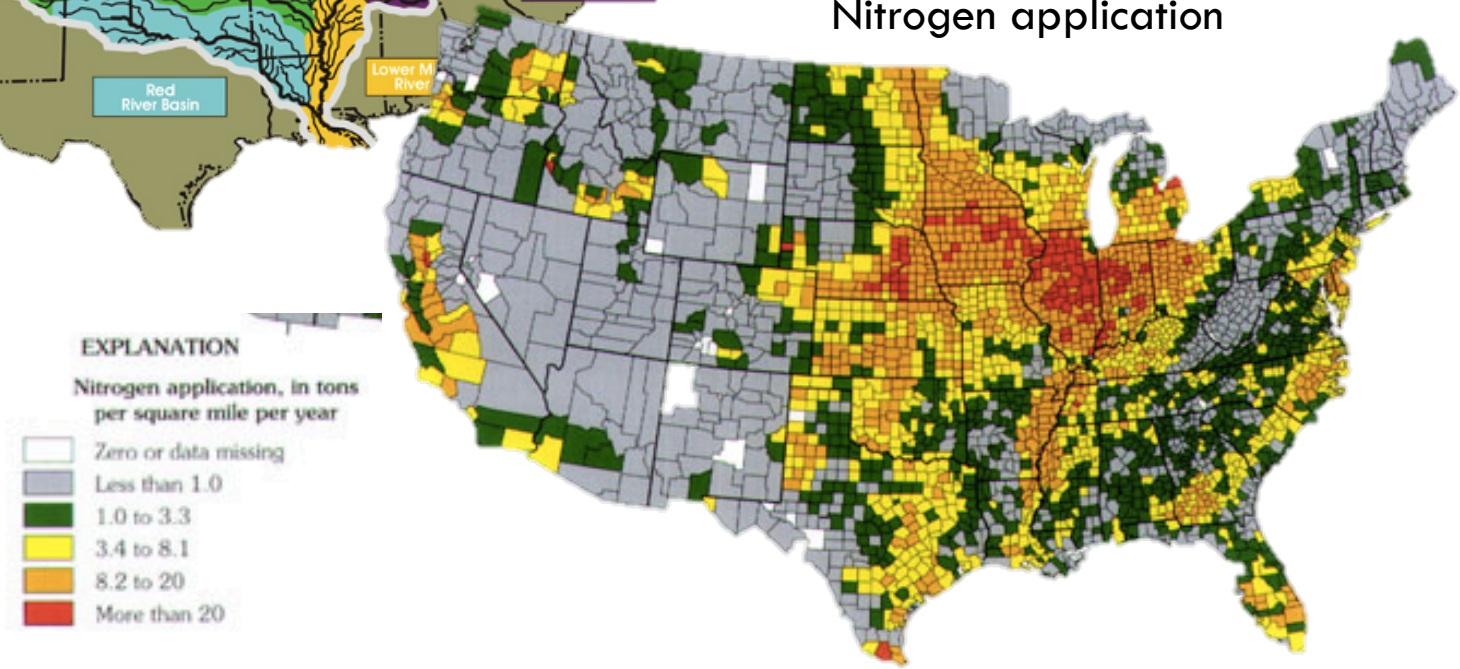
- Agriculture (fertilization and erosion)
- Industrial and residential outputs (chemlawn)
- Fossil fuel burning - release of NO_x
- Land clearing

Cultural eutrophication

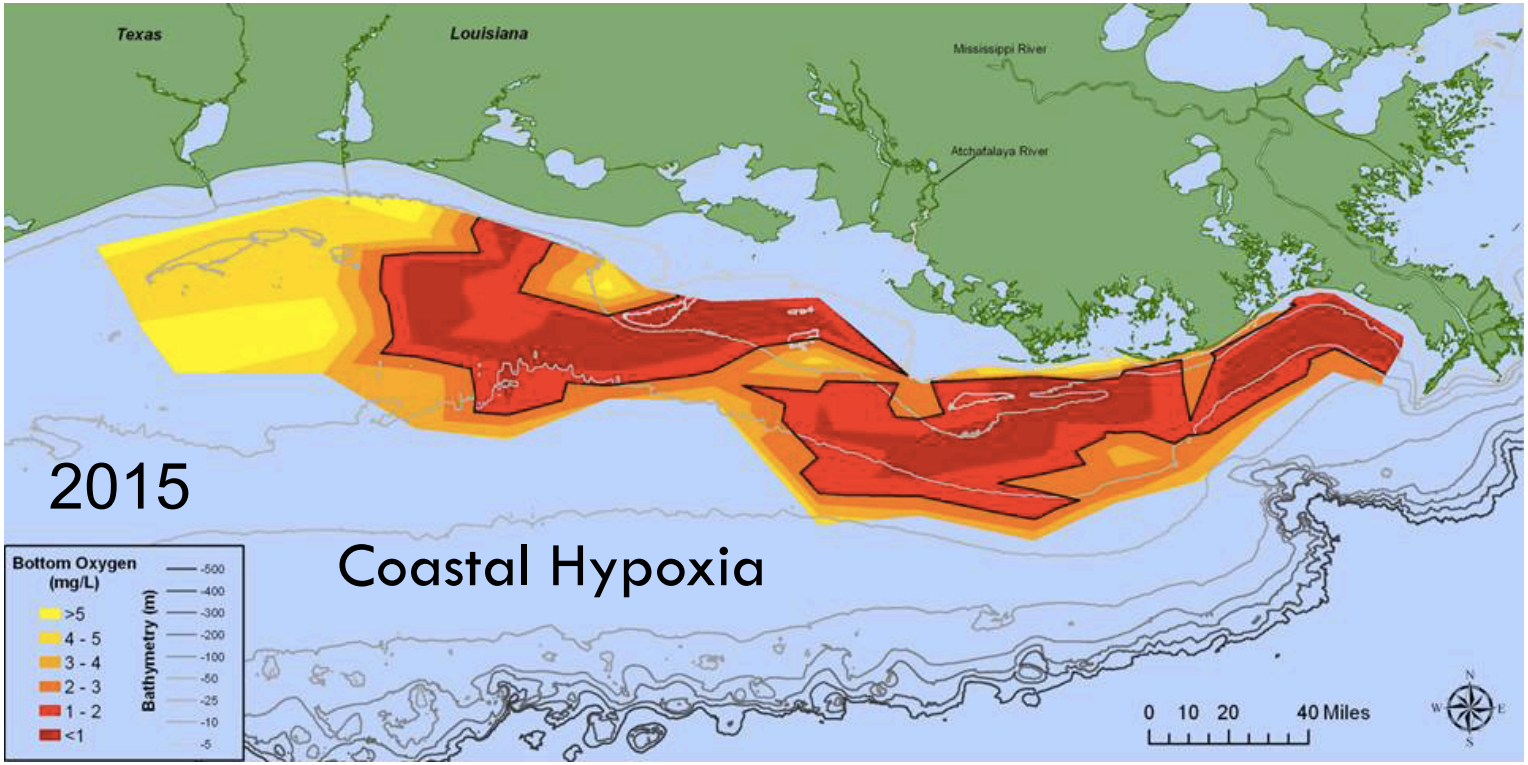
anthropogenically altered high nutrient availability, high productivity

Cultural eutrophication

Nitrogen application



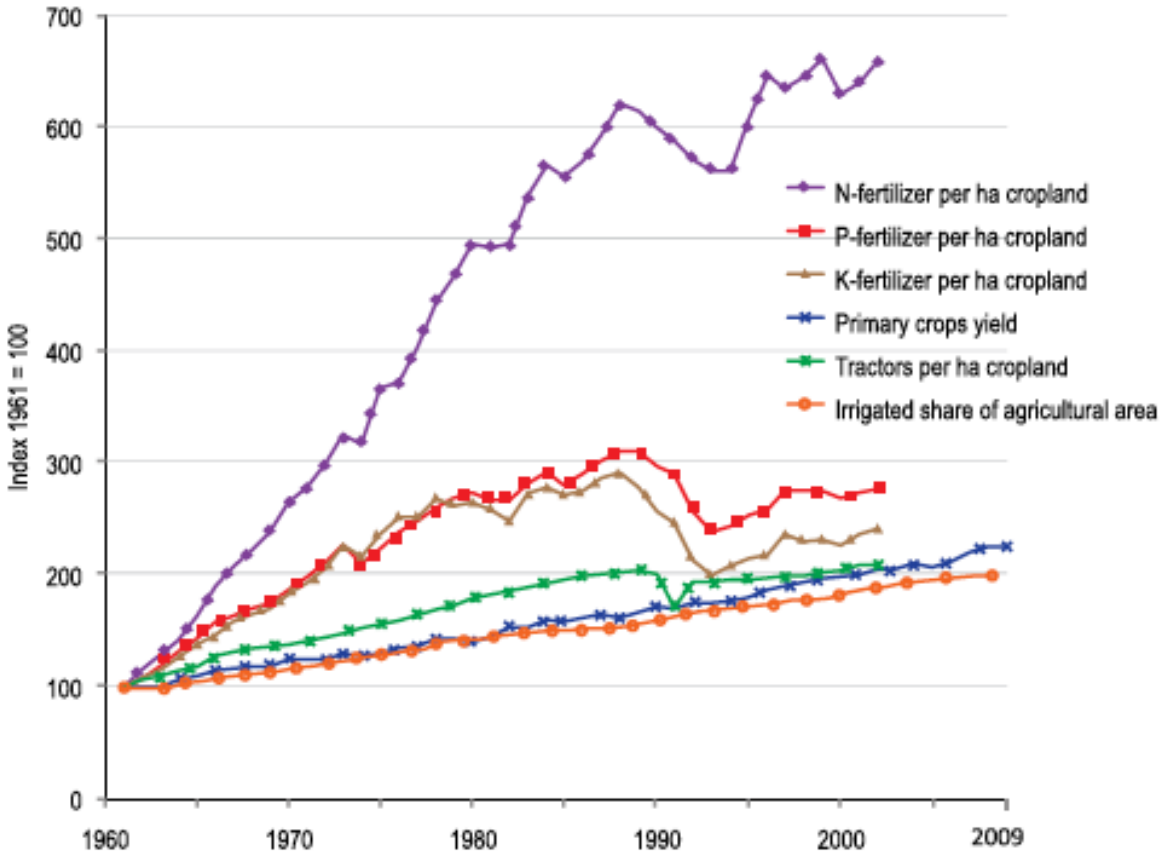
Cultural eutrophication



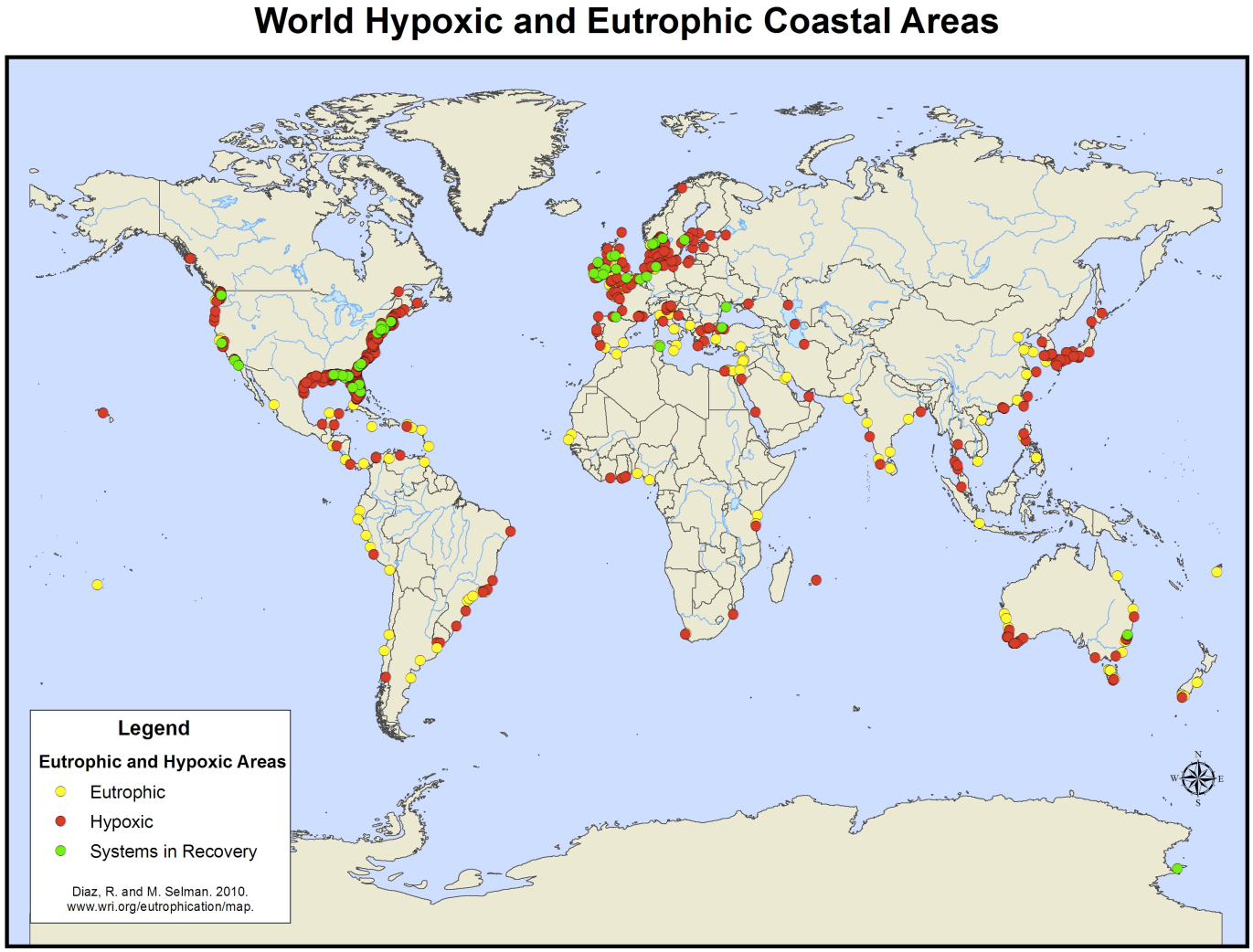
*18,000 km^2

Global Fertilizer Application

Figure 2 Global trends in the intensification of crop production, 1961 - 2002/2009



Eutrophication of lakes and coastal oceans

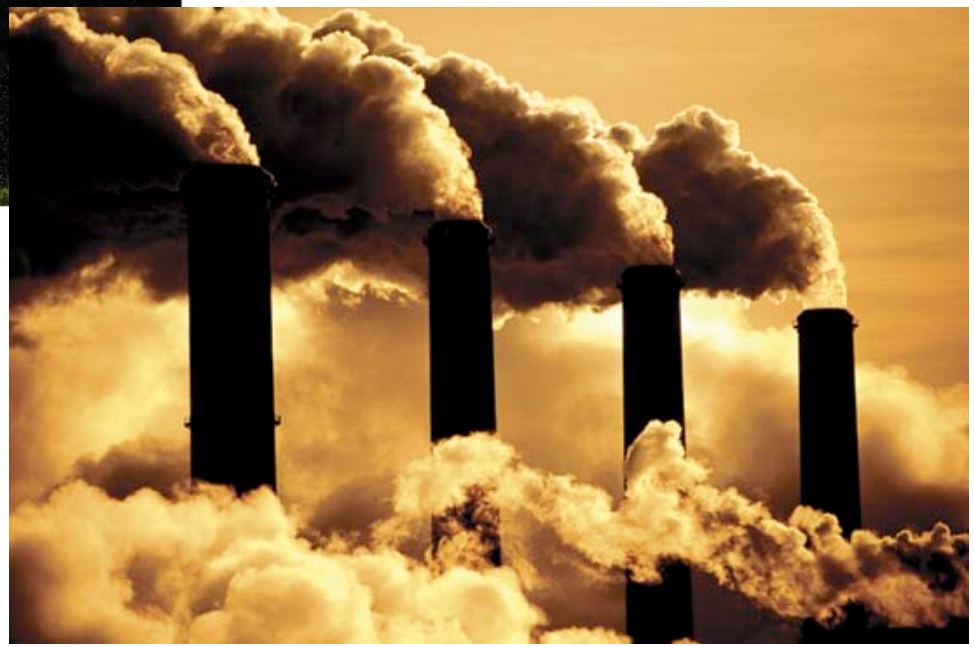


6. 'Pollutants' and contaminants – local & regional issues

Acid mine drainage-mobilization of sulfur from coal mines (= extremely low pH, mobilizes copper, lead, mercury)

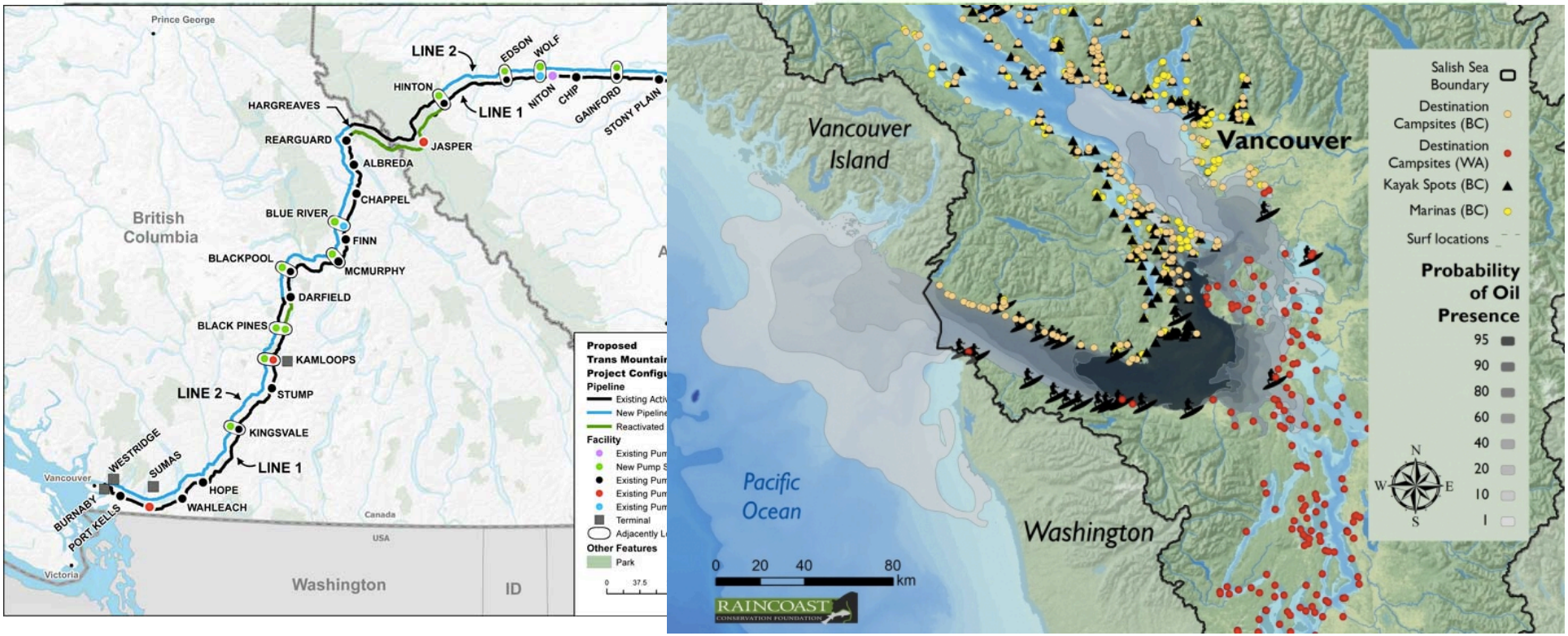
Metal smelting produces 'heavy metals' (mercury, arsenic, lead, copper, nickel, zinc, etc.)

*extremely toxic to most organisms—including humans



Acid rain from burning of fossil fuels (NO_x SO_x)

‘Pollutants’ and contaminants – local & regional issues

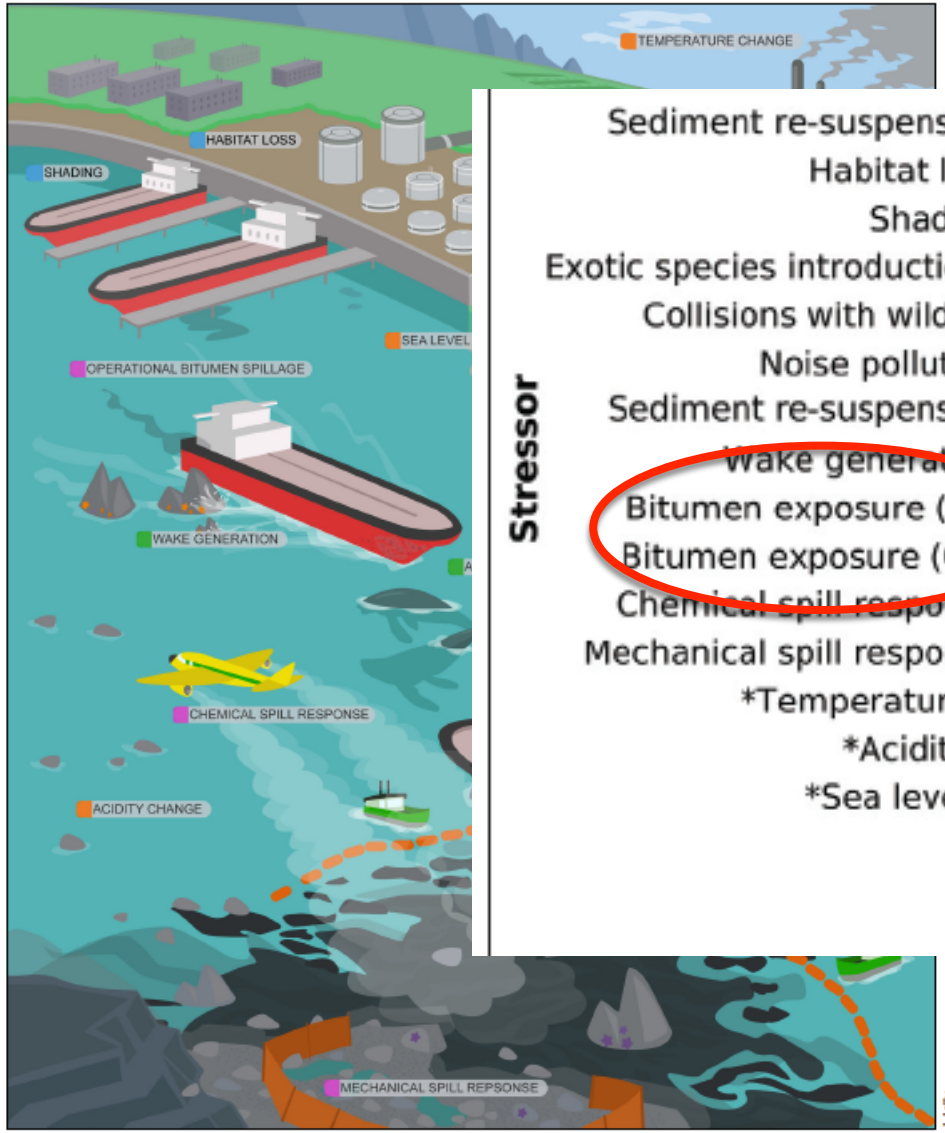


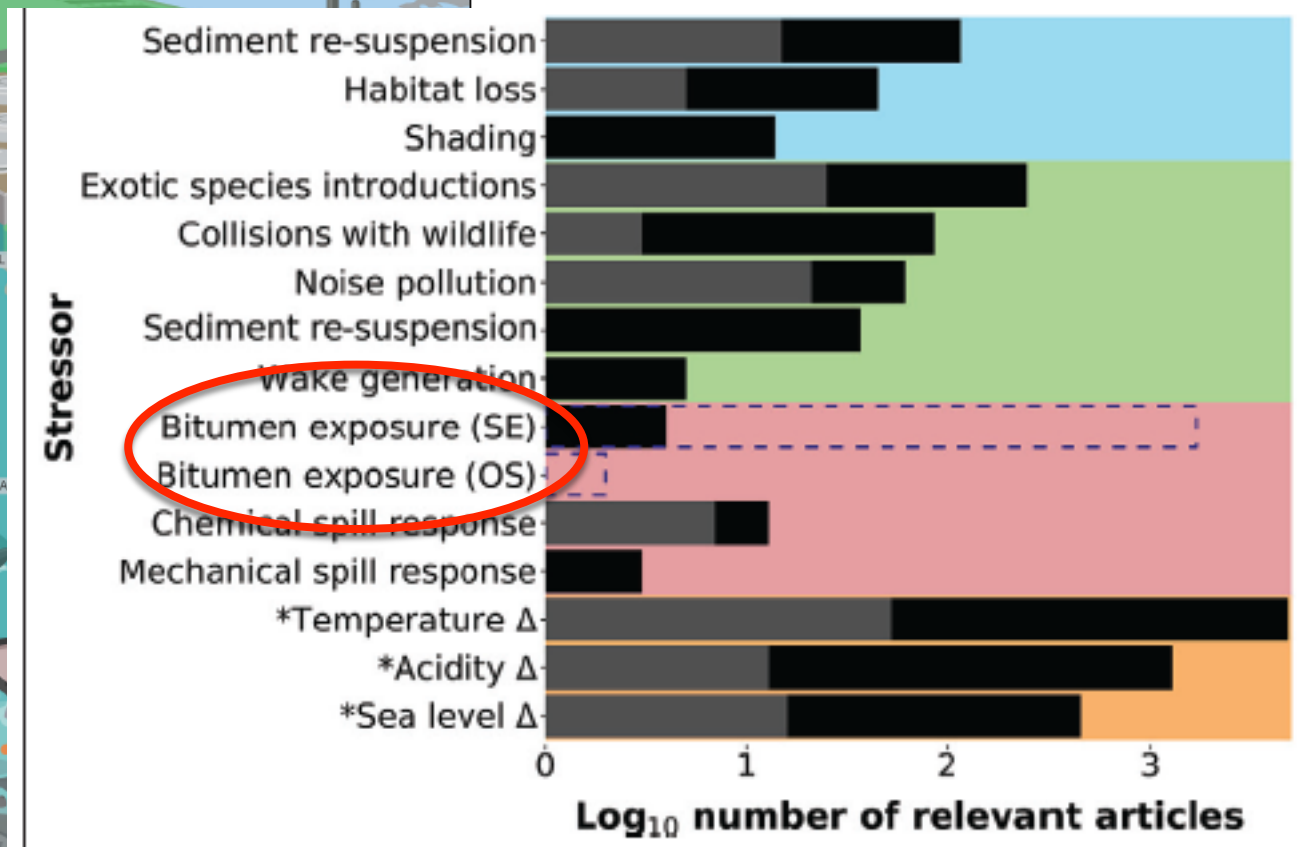
Oil spills (mix of hydocarbons, nitrogen, sulfur) : mostly coastal oceans, strong organic solvents, interferes with biological membranes

Differences between types of hydrocarbons: light vs. heavy oils, natural gas, diluted bitumen

‘Pollutants’ and contaminants – local & regional issues

Weight of evidence approach





Green et al. 2016 Front. Ecol. & Env.

‘Pollutants’ and contaminants – local & regional issues

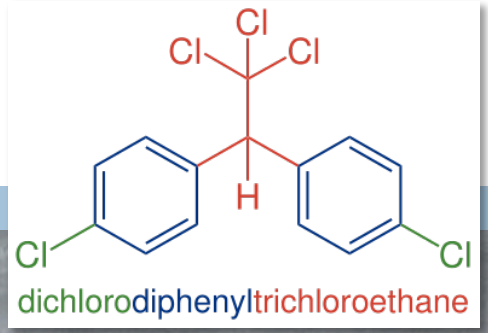
Pesticides (usually synthetic—man-made) as chemical warfare:

Insecticides, Herbicides, Fungicides, Rodenticides

Applications: agriculture, veterinary, domestic

methylmercury, chlorinated hydrocarbons (DDT), organophosphorus compounds (malathion), carbamate insecticides, triazine herbicides (roundup)

Pesticides: DDT



Insecticide first used 1939 (malaria, typhus)

Paul Müller awarded Nobel Prize

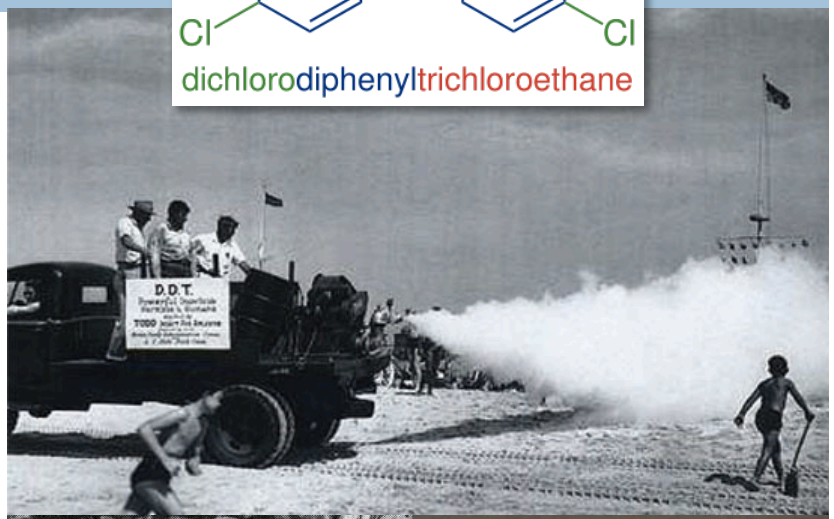
1962 Rachel Carson writes Silent Spring

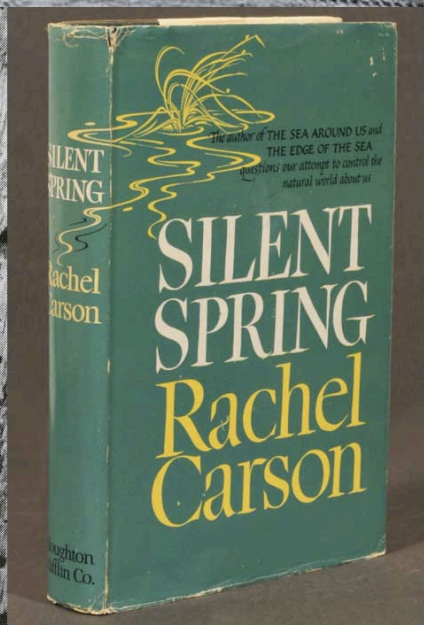
Implicated in decline of song birds and hawks, falcons, eagles

1972 DDT banned in US (1985 Canada)

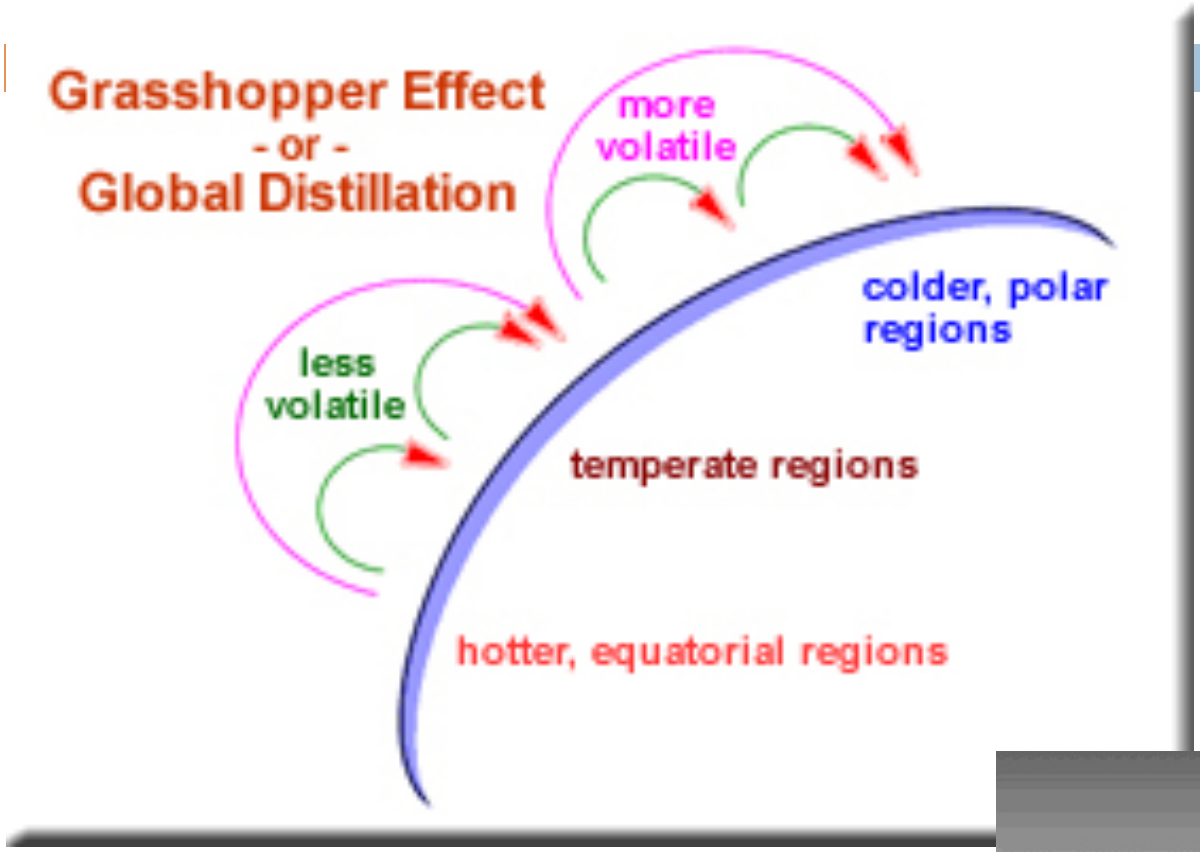
Spawned modern environmental movement

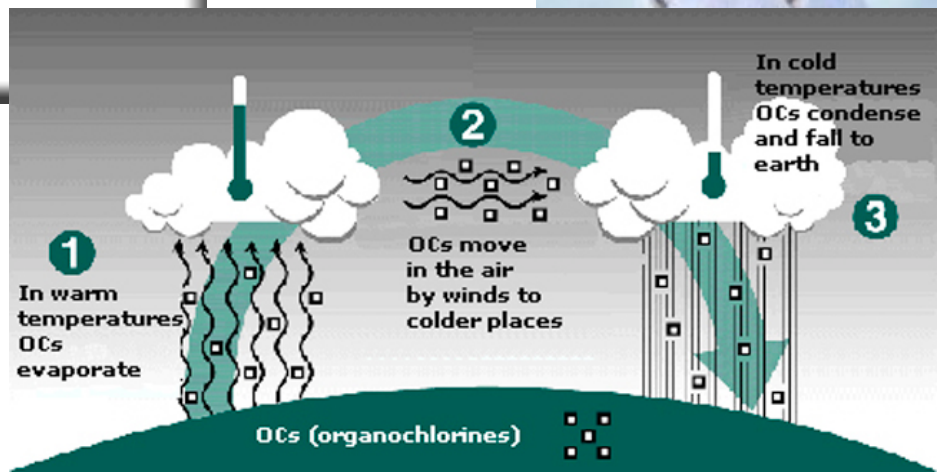
Catalyst for the US Endangered Species Act





Global redistribution of volatile contaminants - global issue

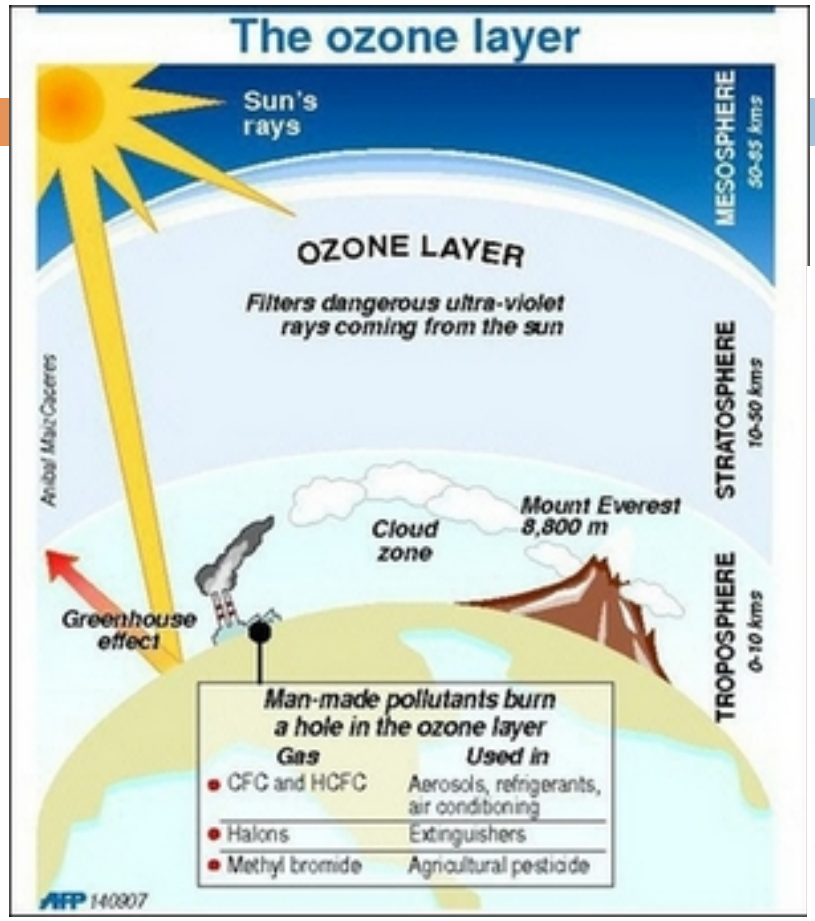


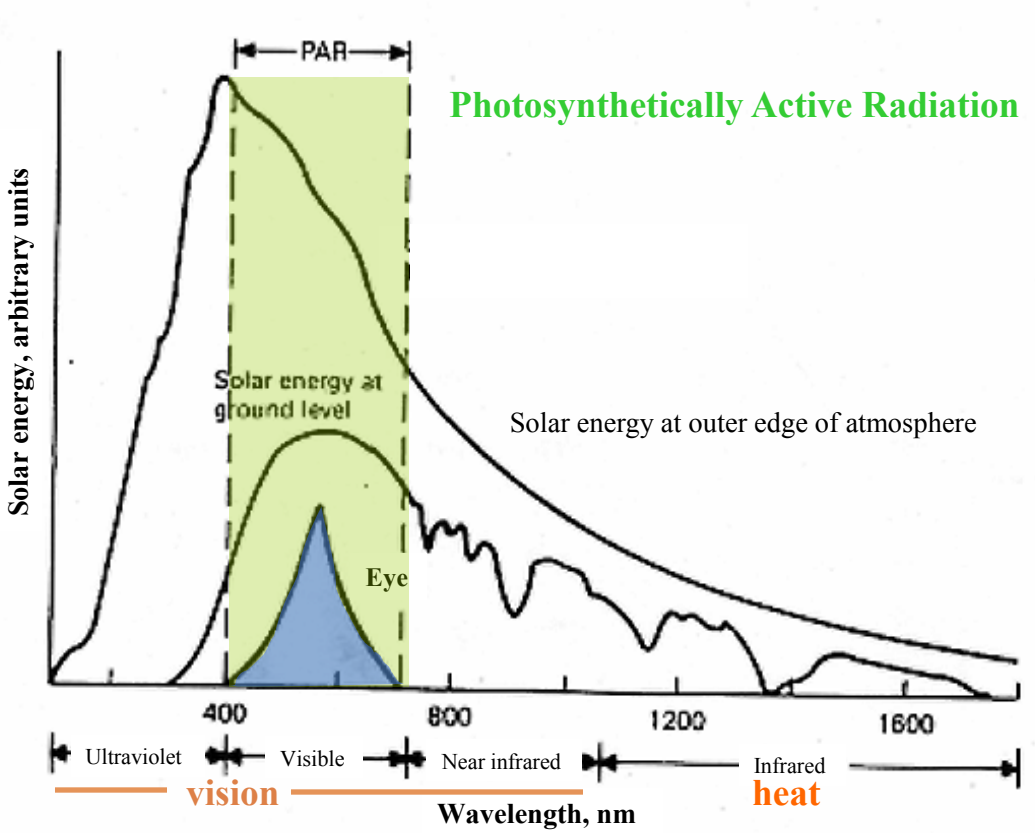


"Persistent organic pollutants"

PCB's (polychlorinated biphenyls)
DDT

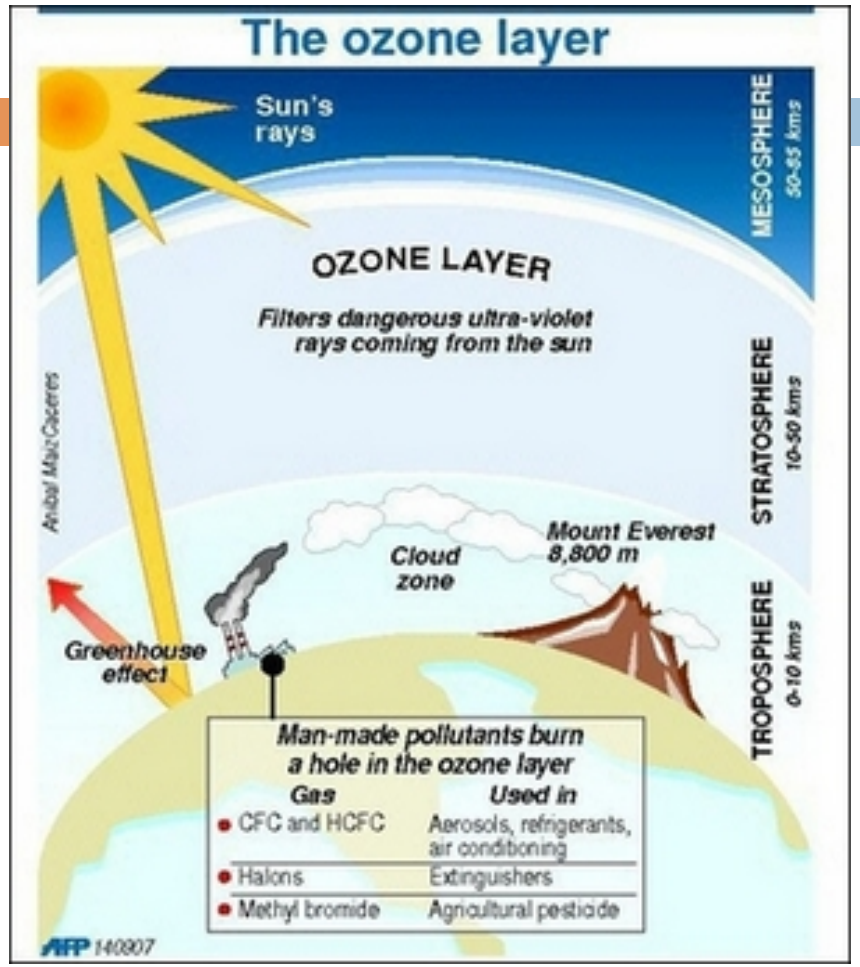
7. Stratospheric ozone (O_3) depletion





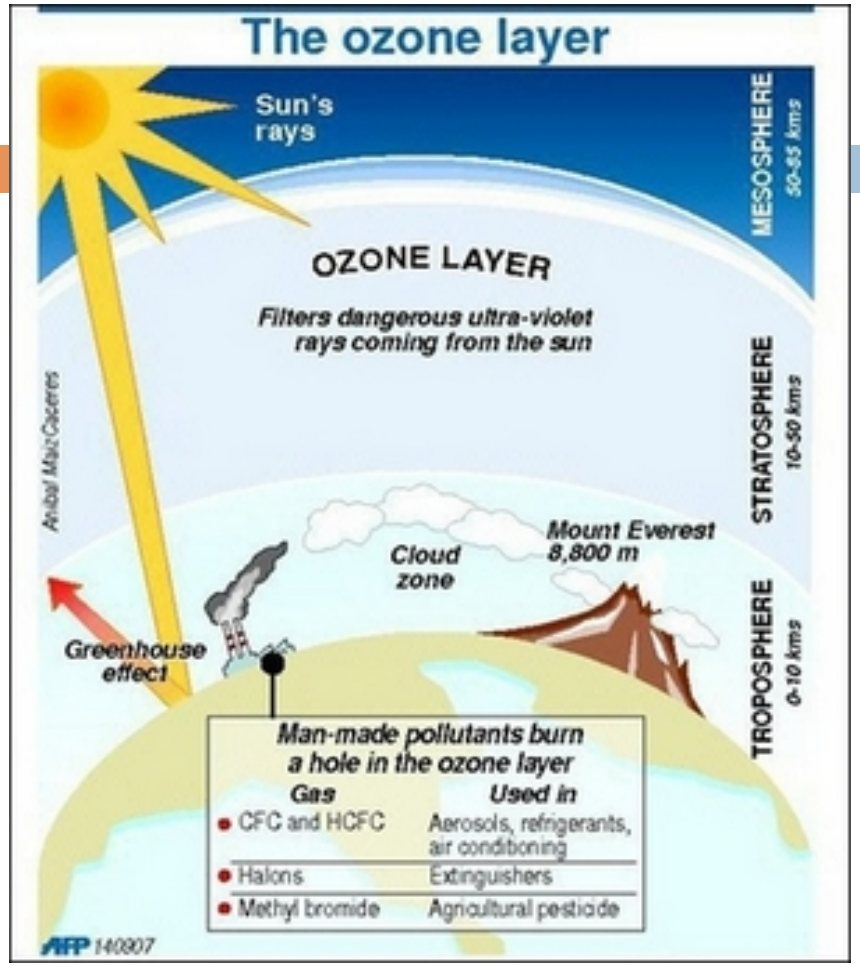
- absorbs UV-R
- destroyed by CFCs
- UV-R = DNA damage

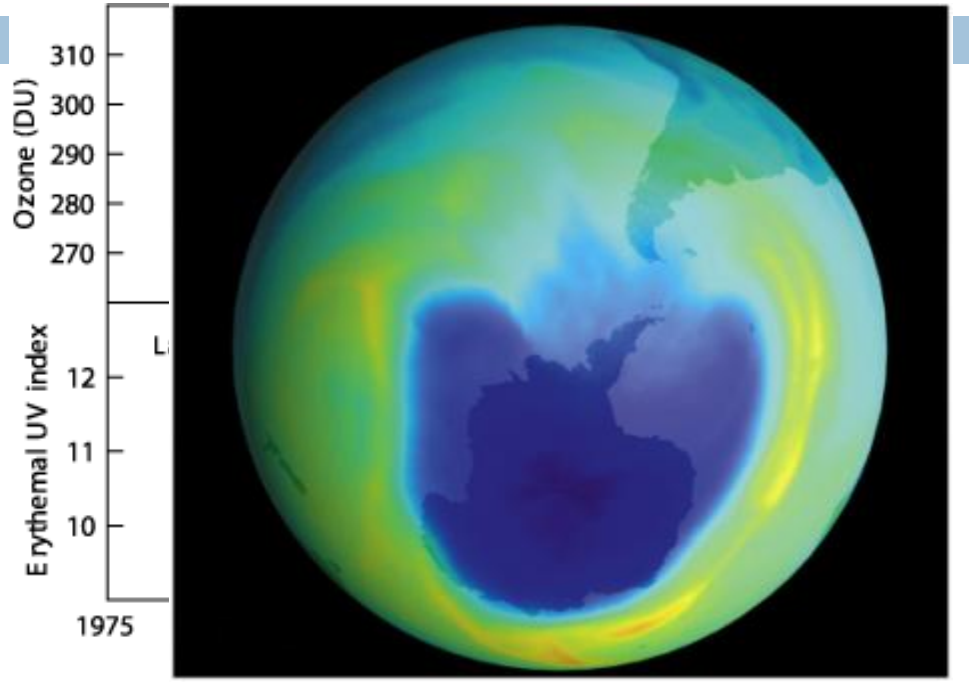
7. Stratospheric ozone (O_3) depletion



- absorbs UV-R
- destroyed by CFCs
- UV-R = DNA damage

Stratospheric ozone (O_3) depletion





Montreal protocol was ratified (1987) to phase out CFCs by the end of the 20th century. Recovery should happen!

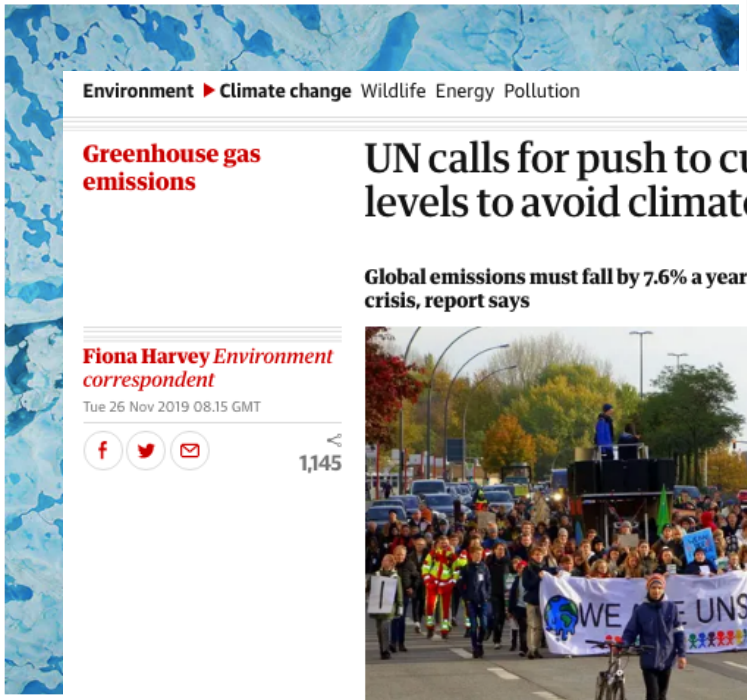
-absorbs UVR
-destroyed by CFCs
-UVR = DNA damage

Additional complication: Ozone is a strong greenhouse gas when produced at Earth's surface

8. Global Climate Change

'Extraordinarily hot' Arctic temperatures alarm scientists

Danish and US researchers say warmer air and sea surface could lead lows of sea ice at north pole next year



Environment ▸ Climate change Wildlife Energy Pollution

Greenhouse gas emissions

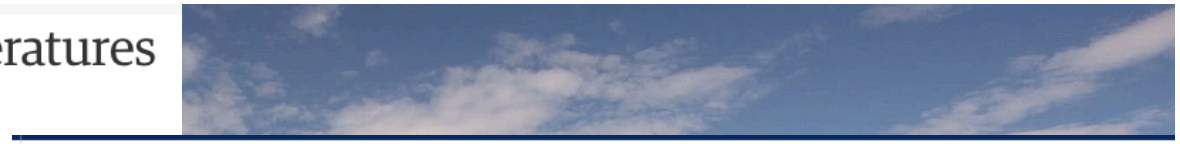
UN calls for push to cut greenhouse gas levels to avoid climate chaos

Global emissions must fall by 7.6% a year for next decade to avoid crisis, report says

Fiona Harvey *Environment correspondent*

Tue 26 Nov 2019 08.15 GMT

1,145



Environment ▸ Climate change Wildlife Energy Pollution

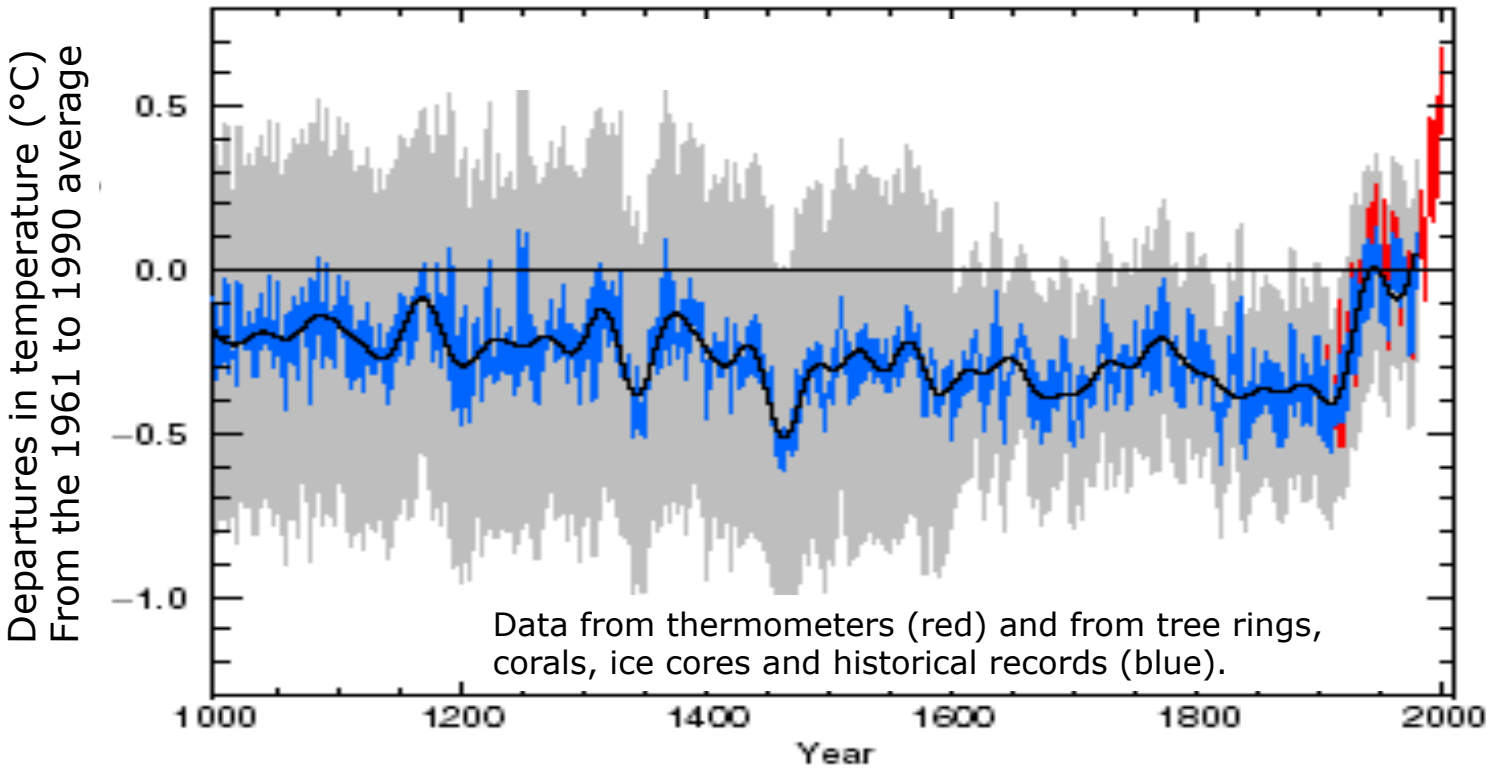
Climate change

We have 12 years to limit climate change catastrophe, warns UN

gent changes needed to cut risk of extreme heat, drought, ods and poverty, says IPCC

Overwhelmed by climate change? Here's what you can do

Northern Hemisphere Climate



From IPCC, 2001

Side note:

- Intergovernmental Panel on Climate Change
- Global community of experts
  - 1000's of scientists from 40+ countries
- Founded in 1988, under United Nations
- Goal: "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic [i.e., human-induced] interference with the climate system"

Side note:

- Reports in 1990, 1995, 2001, 2007, 2014
- Currently working on the 6th Assessment Report (Finalized in 2022)
- Reports: "the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation"

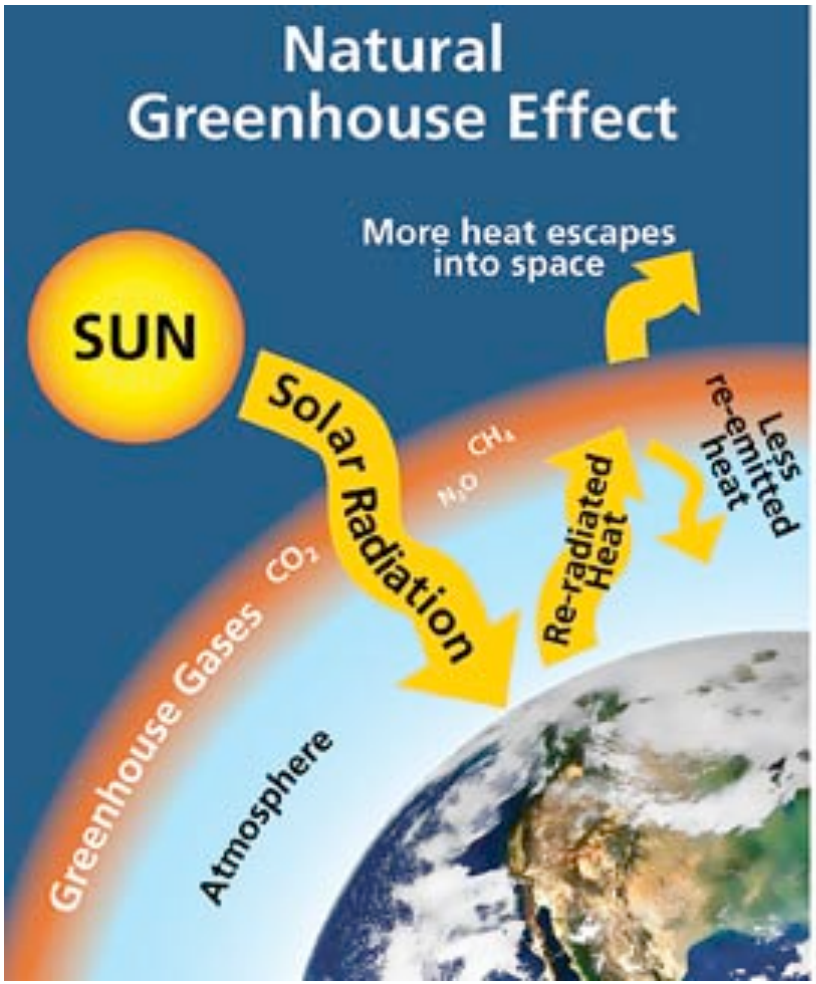
Side note:

- Reports in 1990, 1995, 2001, 2007, 2014

- Cu ort (F

- R ec ing the sc ate ch ac

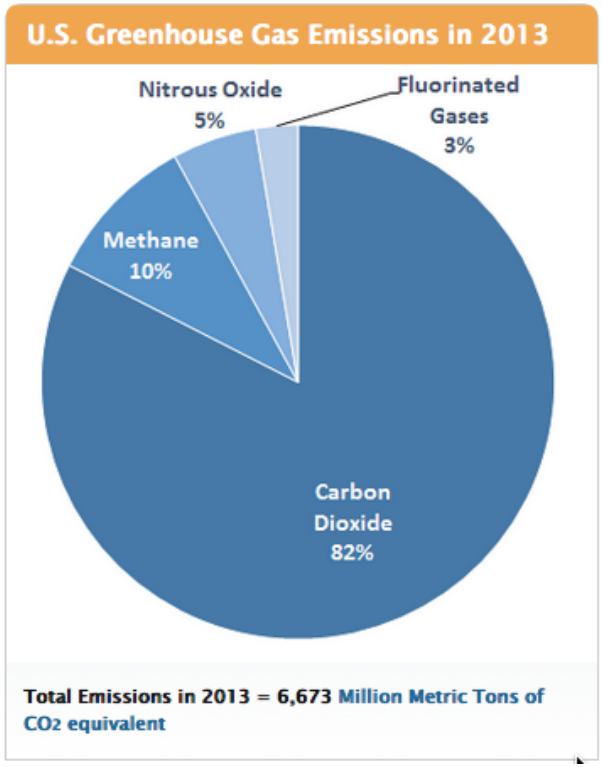
Greenhouse effect

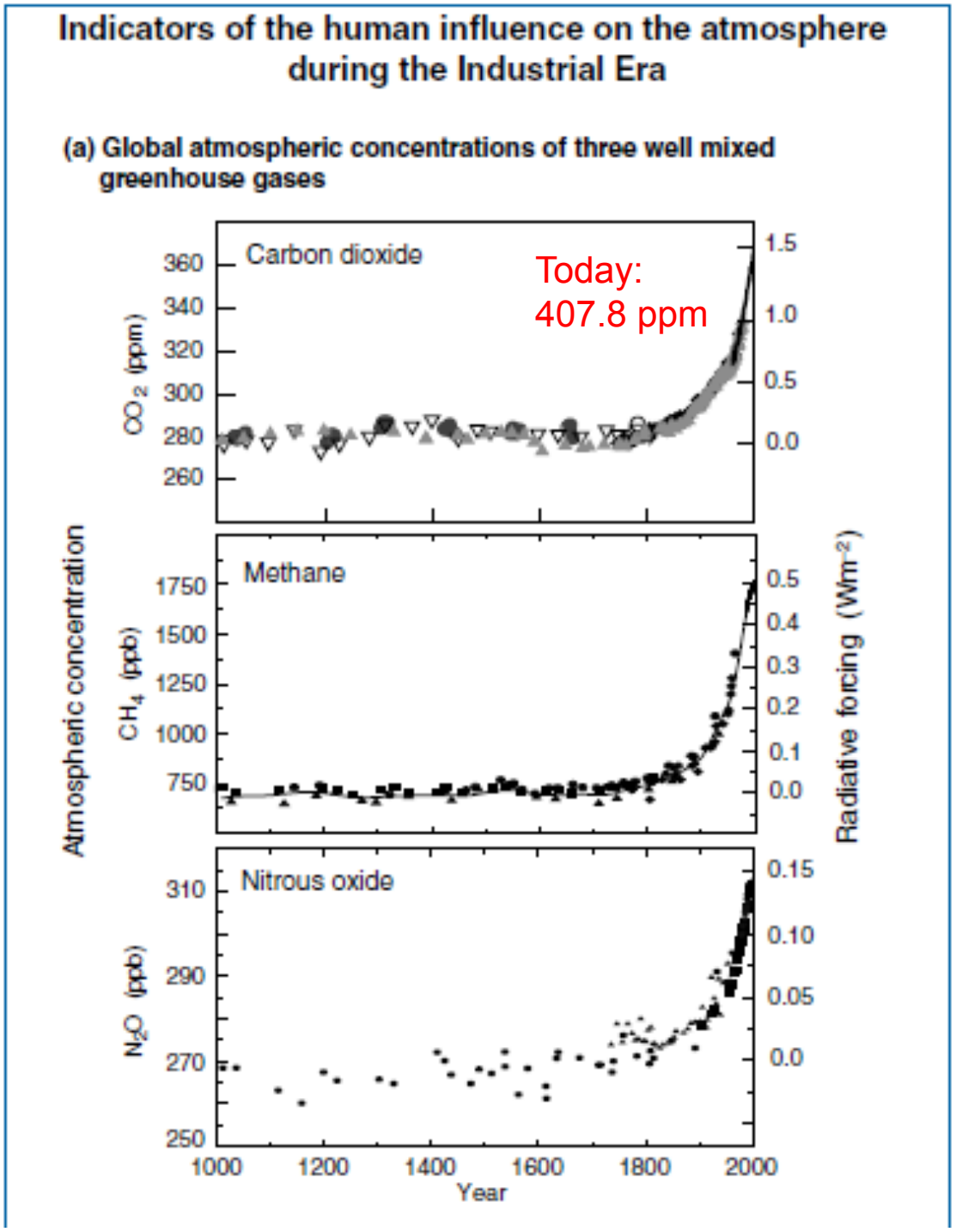


“Point of no return” ~450ppm [CO_2]

50% change of keeping global temperature to <2*C

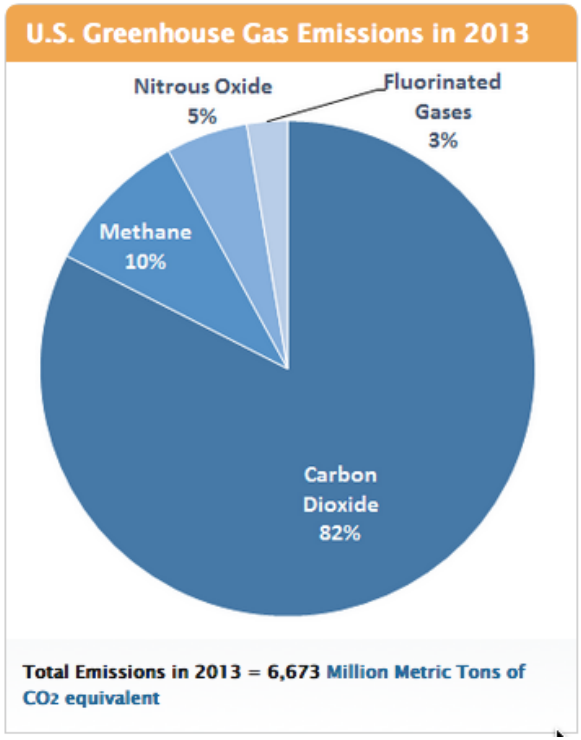
350ppm considered “safe”





Relative warming potential of GHG's

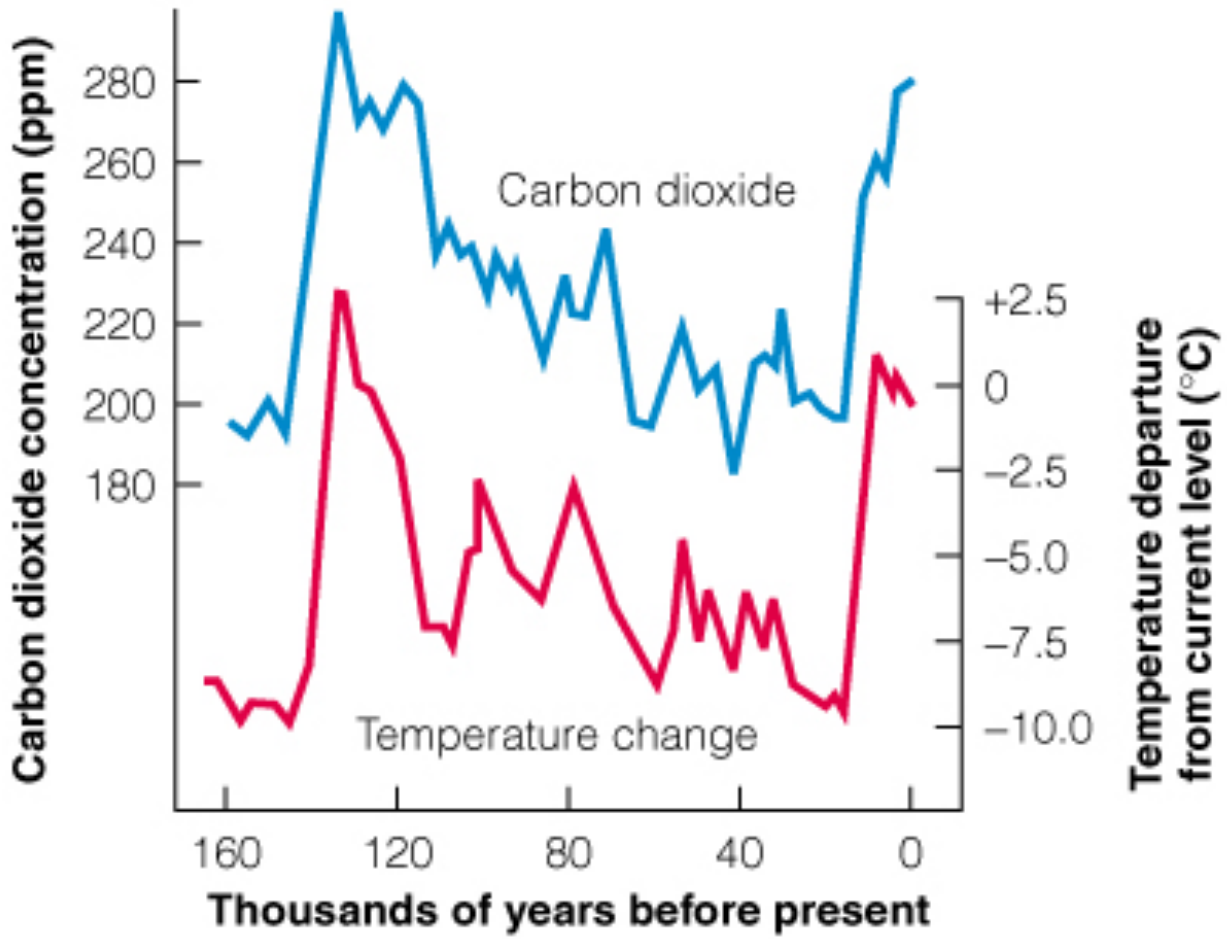
Canada (2016):
CO_2 = 79%
NH_4 = 14%
NO_x = 5%
Fluor. = 2%



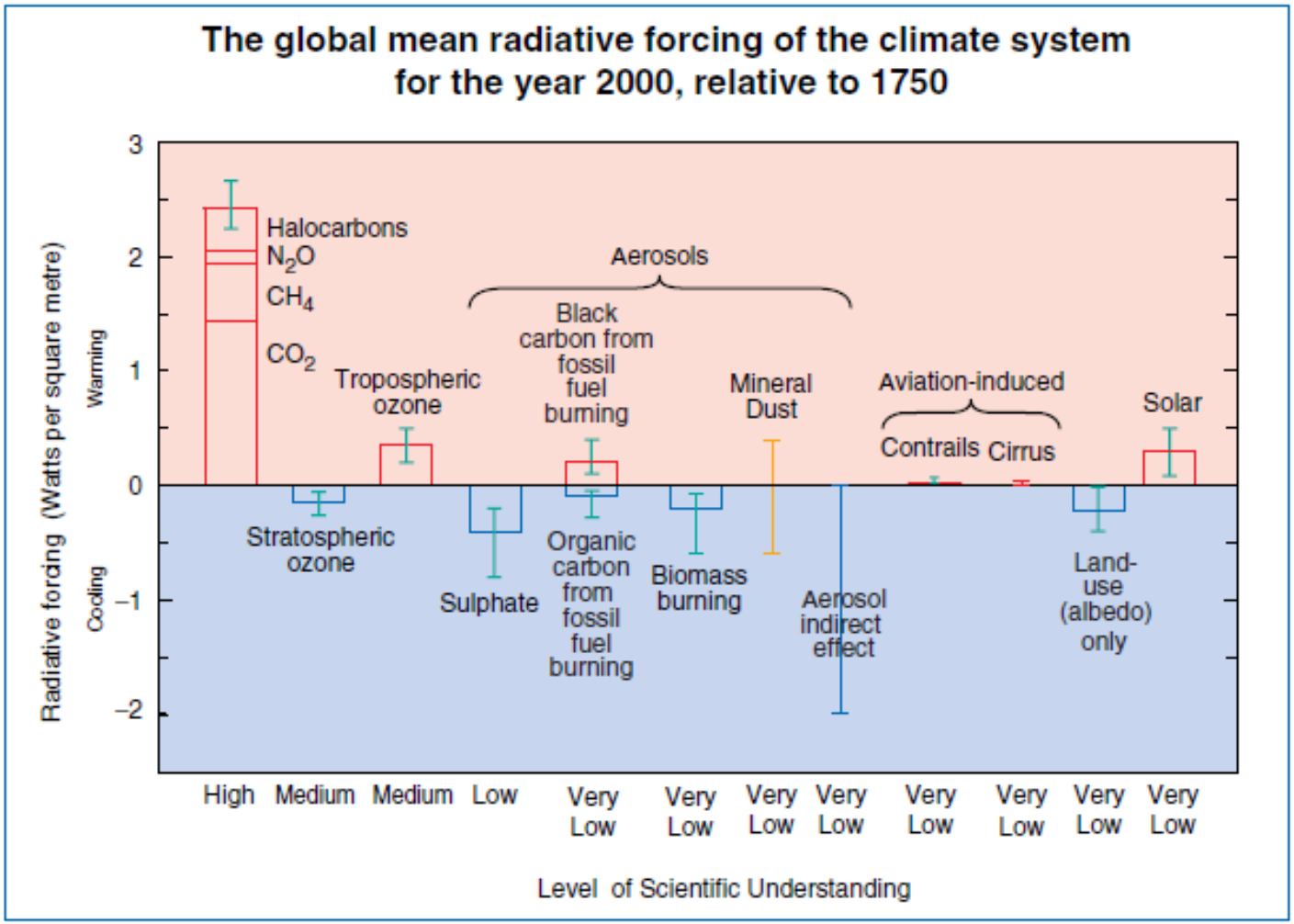
Greenhouse gas	Pre-industrial concentrations*	2008 concentrations	Human source	GWP 100 years
Carbon dioxide (CO_2)	278 ppm	365 ppm	Fossil fuel combustion, land use changes, cement production	1
Methane (CH_4)	700 ppb	1745 ppb	Fossil fuels; rice paddies; waste dumps; livestock	25
Nitrous oxide (N_2O)	270 ppb	314 ppb	Fertiliser; industrial processes; fossil fuel combustion	298
Hydrofluorocarbons (e.g. HFC-23)	0	14 ppt	Liquid coolants	14,800**
Perfluorocarbons (e.g. CF_4)	0	80 ppt	Refrigerant; electronics industry and aluminium industry	6,500
Sulphur hexafluoride (SF_6)	0	4.2 ppt	Insulator in electronics and magnesium industry	22,800

* ppm, parts per million by volume; ppb, parts per billion by volume; ppt, parts per trillion by volume.
** This figure was changed in 2007 from 11,700 to 14,800.[25]

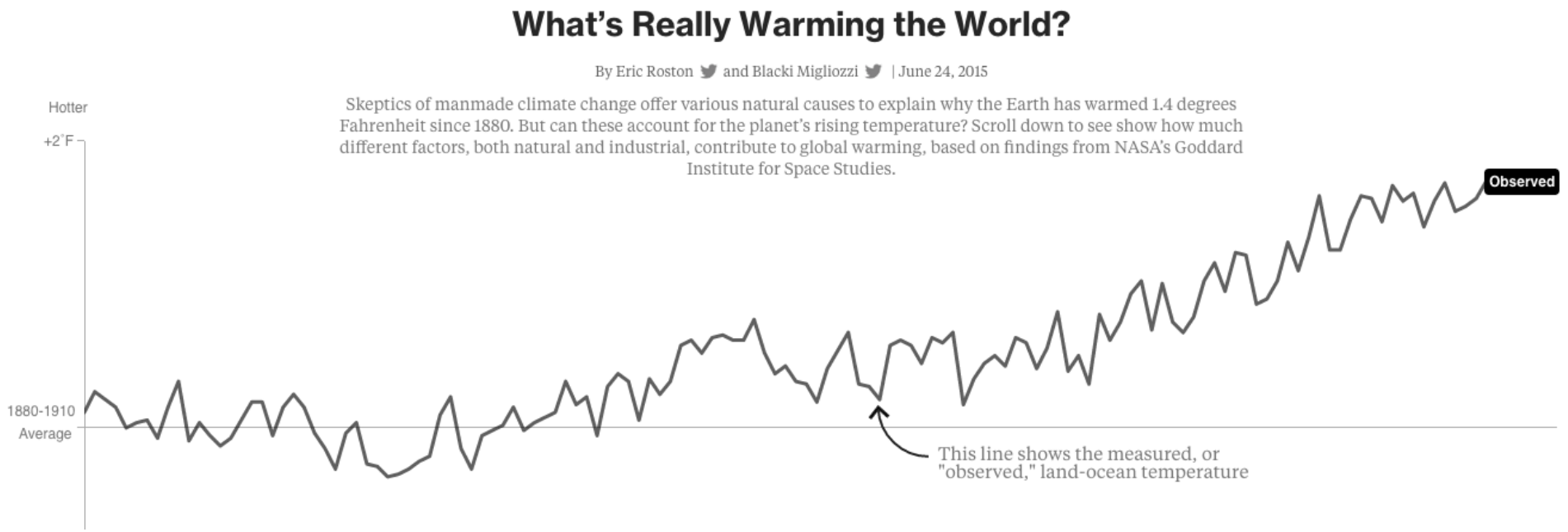
CO_2ppm and Climate change



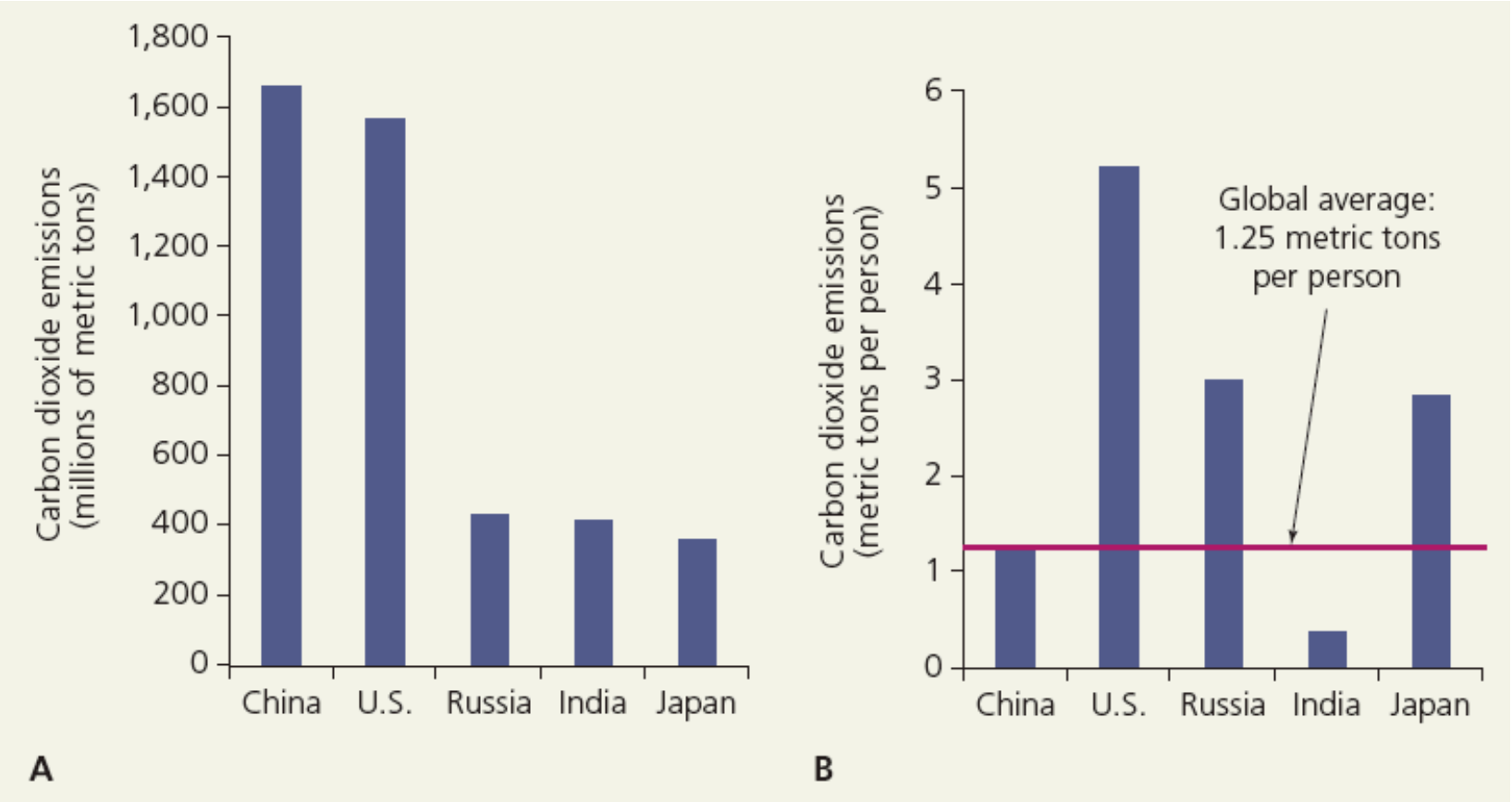
What do we know scientifically?



What do we know scientifically?

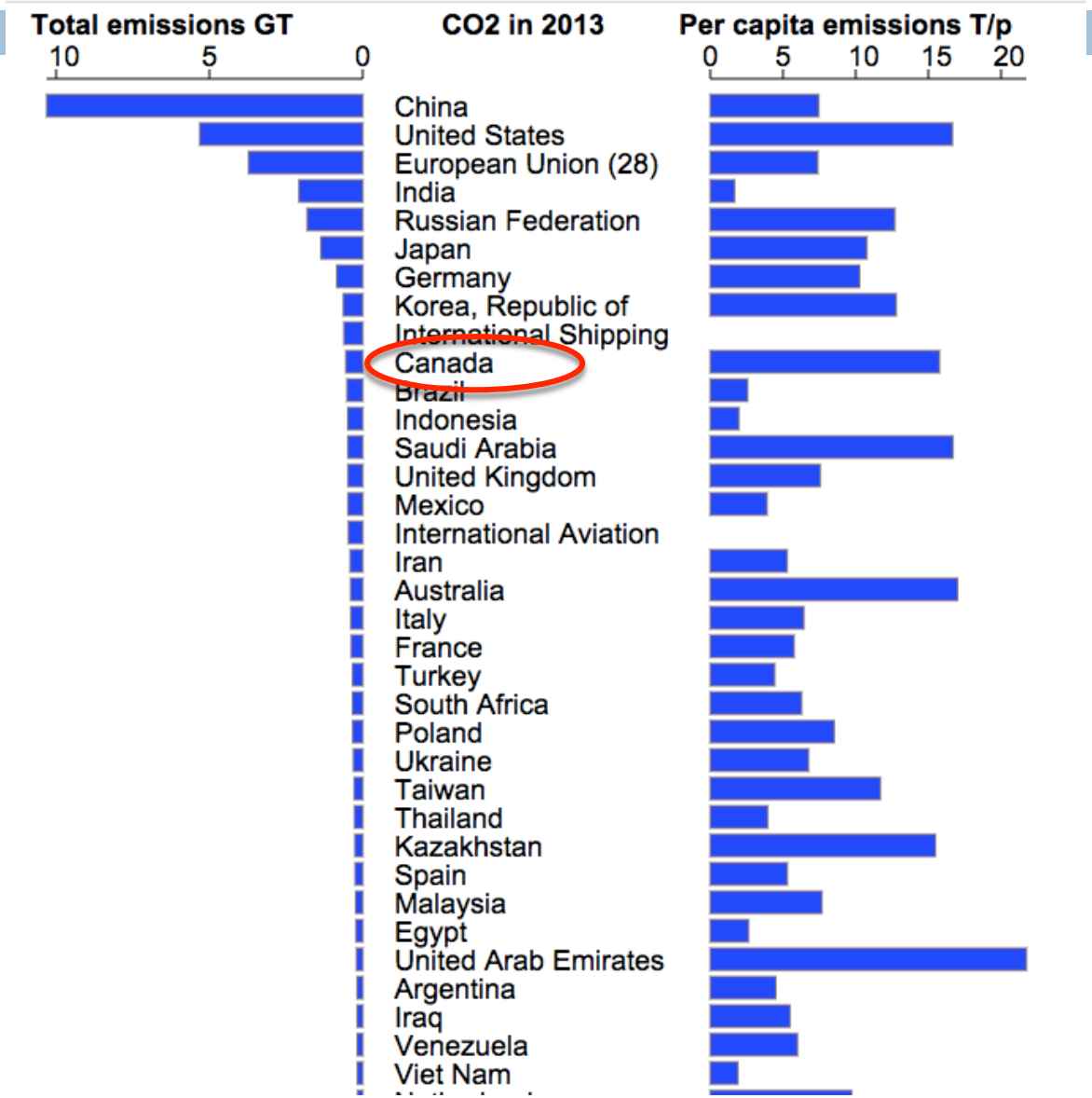


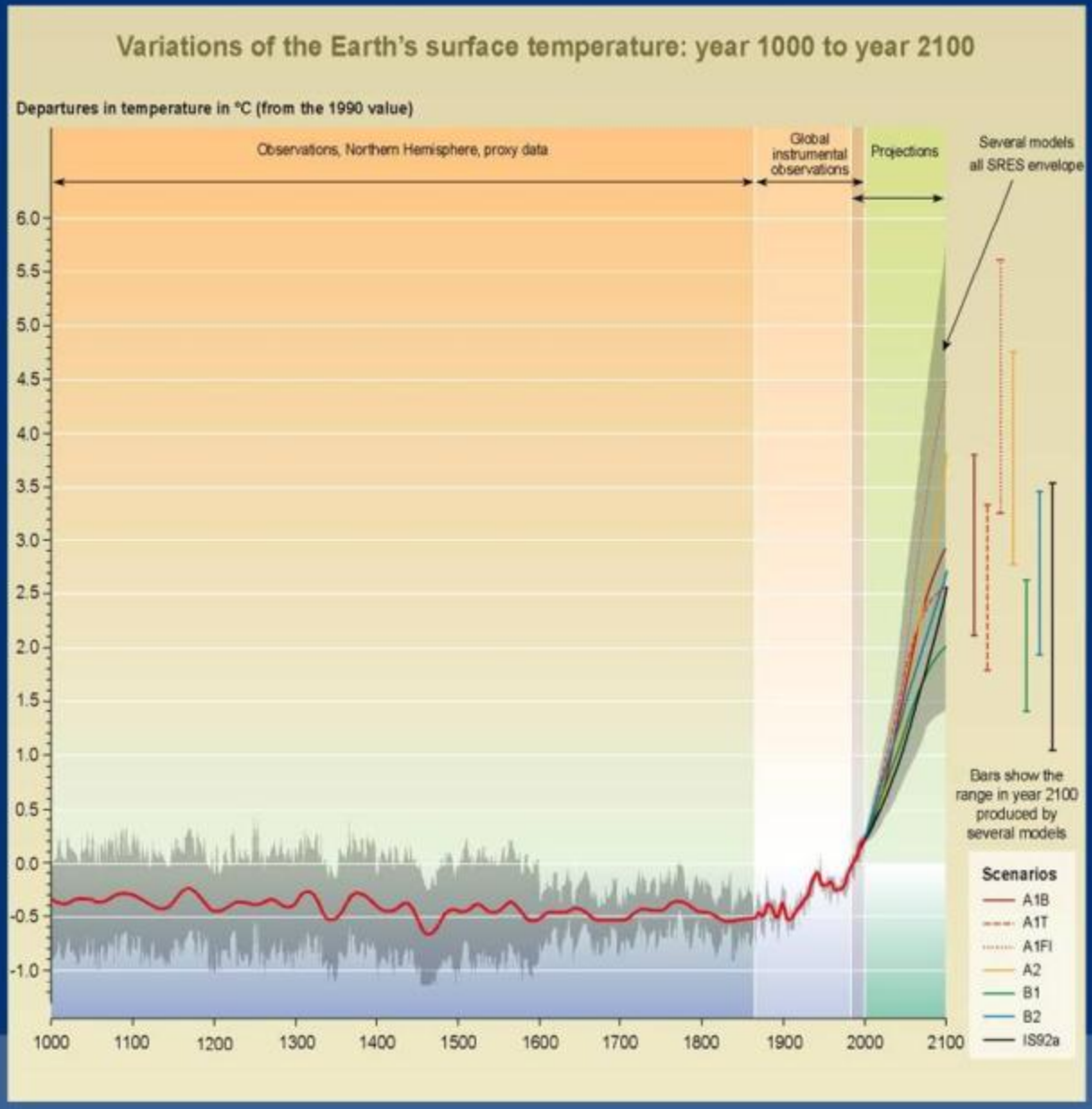
Top GHG emitters



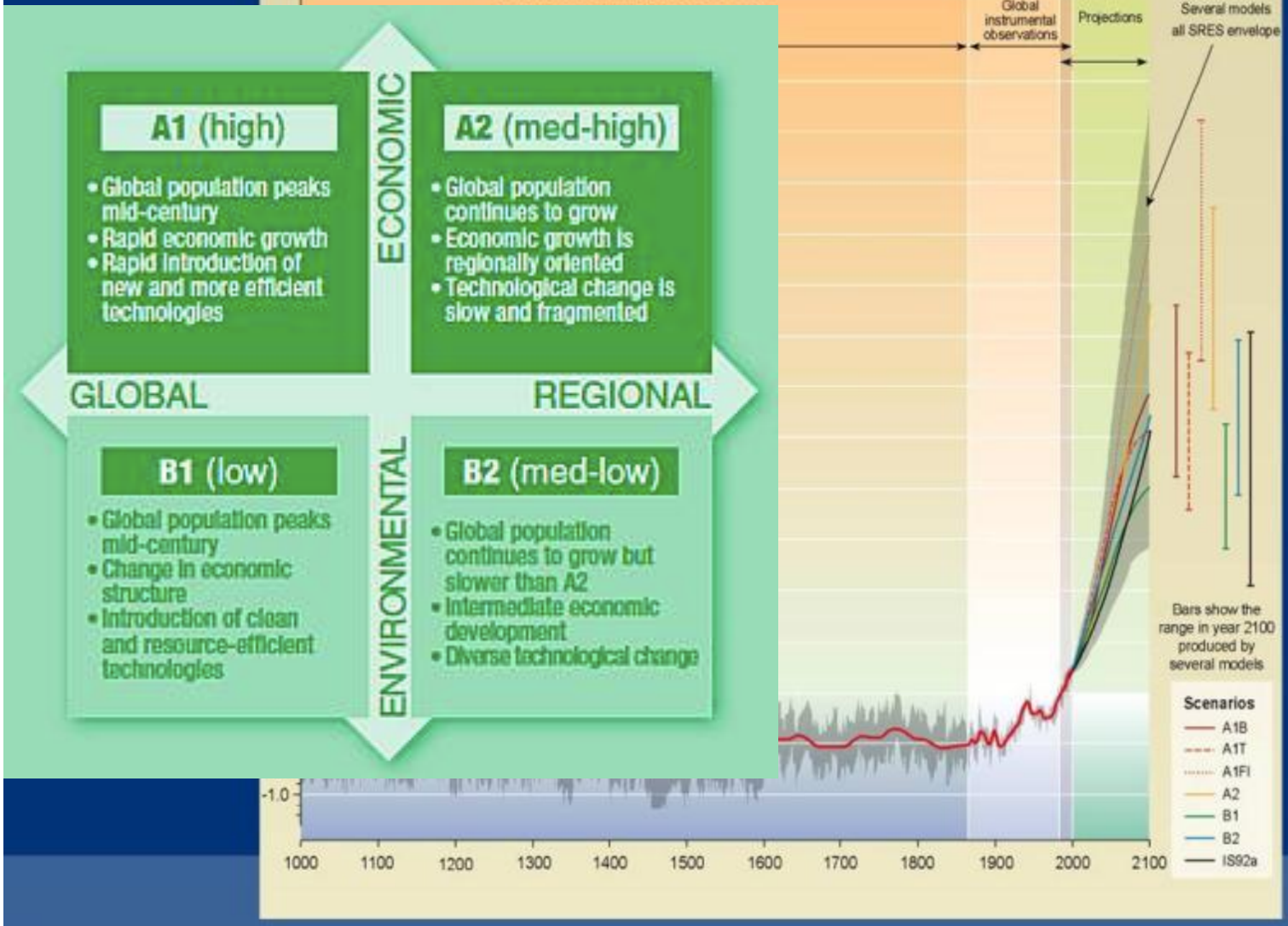
Boden et al. (2009)

Top GHG emitters (and per capita)





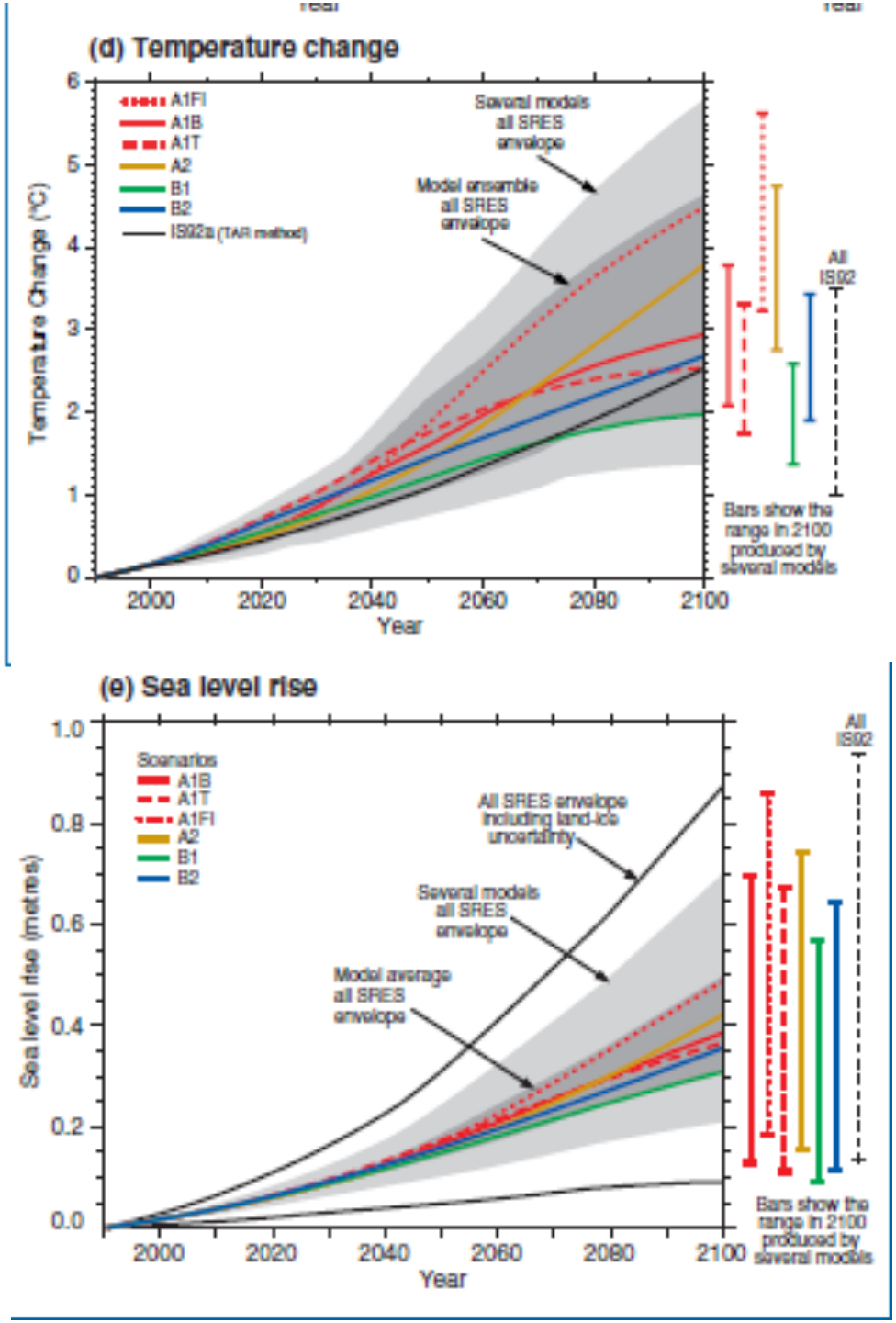
SYR - FIGURE 9-1b



Variations of the Earth's surface temperature: year 1000 to year 2100

Departures in temperature in °C (from the 1990 value)

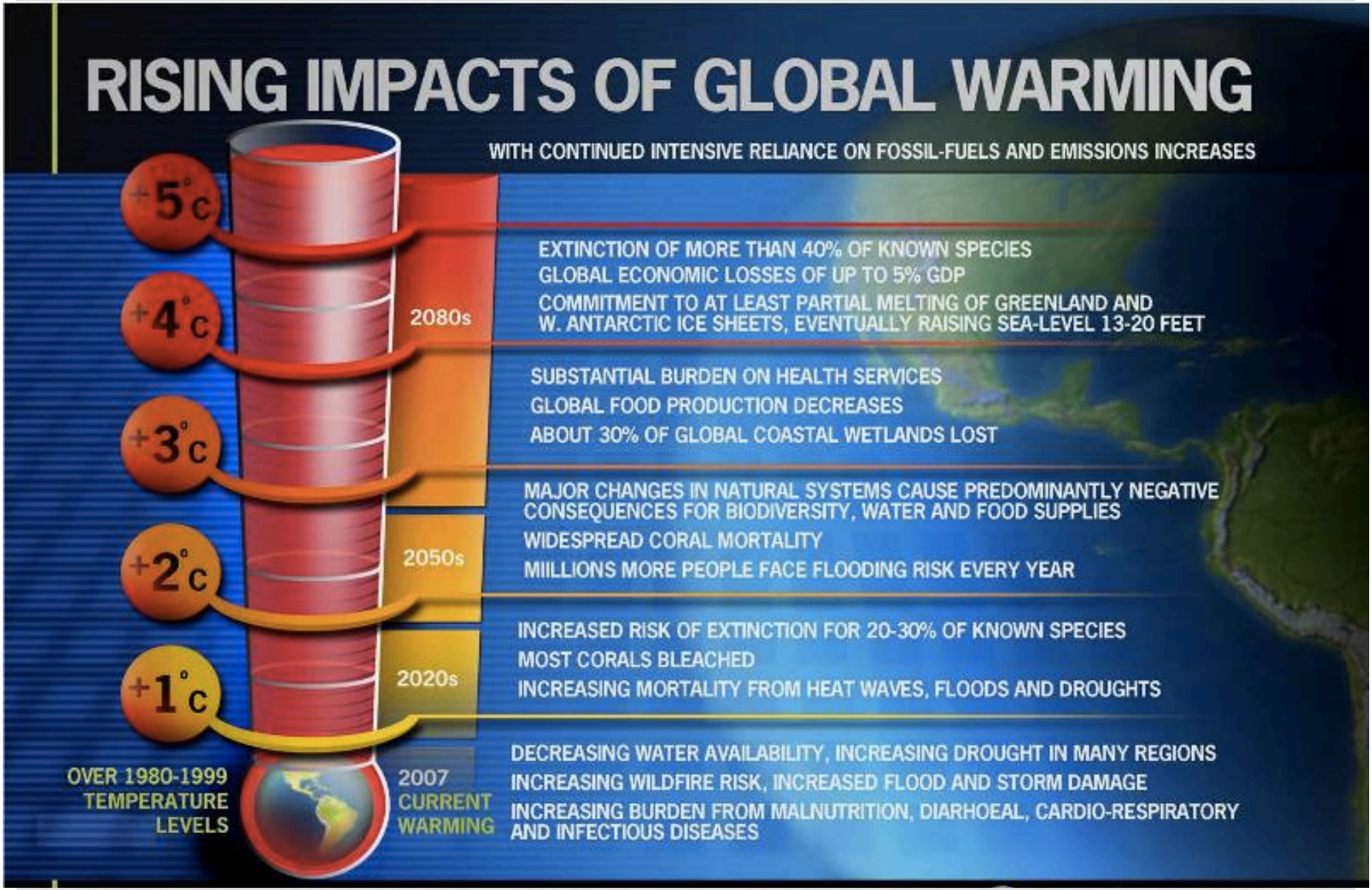
SYR - FIGURE 9-1b



Vancouver regional sea-level rise

seeing.climatecentral.org

BIODIVERSITY IMPACTS


RISING IMPACTS OF GLOBAL WARMING
WITH CONTINUED INTENSIVE RELIANCE ON FOSSIL-FUELS AND EMISSIONS INCREASES
+5°C
+4°C
+3°C
+2°C
+1°C
2080s
2050s
2020s
EXTINCTION OF MORE THAN 40% OF KNOWN SPECIES
GLOBAL ECONOMIC LOSSES OF UP TO 5% GDP
COMMITMENT TO AT LEAST PARTIAL MELTING OF GREENLAND AND W. ANTARCTIC ICE SHEETS, EVENTUALLY RAISING SEA-LEVEL 13-20 FEET
SUBSTANTIAL BURDEN ON HEALTH SERVICES
GLOBAL FOOD PRODUCTION DECREASES
ABOUT 30% OF GLOBAL COASTAL WETLANDS LOST
MAJOR CHANGES IN NATURAL SYSTEMS CAUSE PREDOMINANTLY NEGATIVE CONSEQUENCES FOR BIODIVERSITY, WATER AND FOOD SUPPLIES
WIDESPREAD CORAL MORTALITY
MIILLIONS MORE PEOPLE FACE FLOODING RISK EVERY YEAR
INCREASED RISK OF EXTINCTION FOR 20-30% OF KNOWN SPECIES
MOST CORALS BLEACHED
INCREASING MORTALITY FROM HEAT WAVES, FLOODS AND DROUGHTS
DECREASING WATER AVAILABILITY, INCREASING DROUGHT IN MANY REGIONS
INCREASING WILDFIRE RISK, INCREASED FLOOD AND STORM DAMAGE
INCREASING BURDEN FROM MALNUTRITION, DIARHOEAL, CARDIO-RESPIRATORY AND INFECTIOUS DISEASES
OVER 1980-1999 TEMPERATURE LEVELS
2007 CURRENT WARMING

Biological feedbacks to climate change?

Amphibian breeding and climate

Trevor J. C. Beebee
School of Biology, University of Sussex, Falmer, Brighton BN1 9QG, UK

Charles Monnett · Jeffrey S. Gleason

Observations of mortality associated with extended open-water swimming by polar bears in the Alaskan Beaufort Sea

Rapid Changes in Flowering Time in British Plants

A. H. Fitter[1]* and R. S. R. Fitter[2]

UK birds are laying eggs earlier

Crick et al. 1997

Poleward shifts in geographical ranges of butterfly species associated with regional warming

Camille Parmesan*†, Nils Ryrholm‡, Constantí Stefanescu§, Jane K. Hill‖, Chris D. Thomas¶, Henri Descimon#, Brian Huntley‖, Lauri Kaila☆, Jaakko Kullberg☆, Toomas Tammaru**, W. John Tennent††, Jeremy A. Thomas‡‡ & Martin Warren§§

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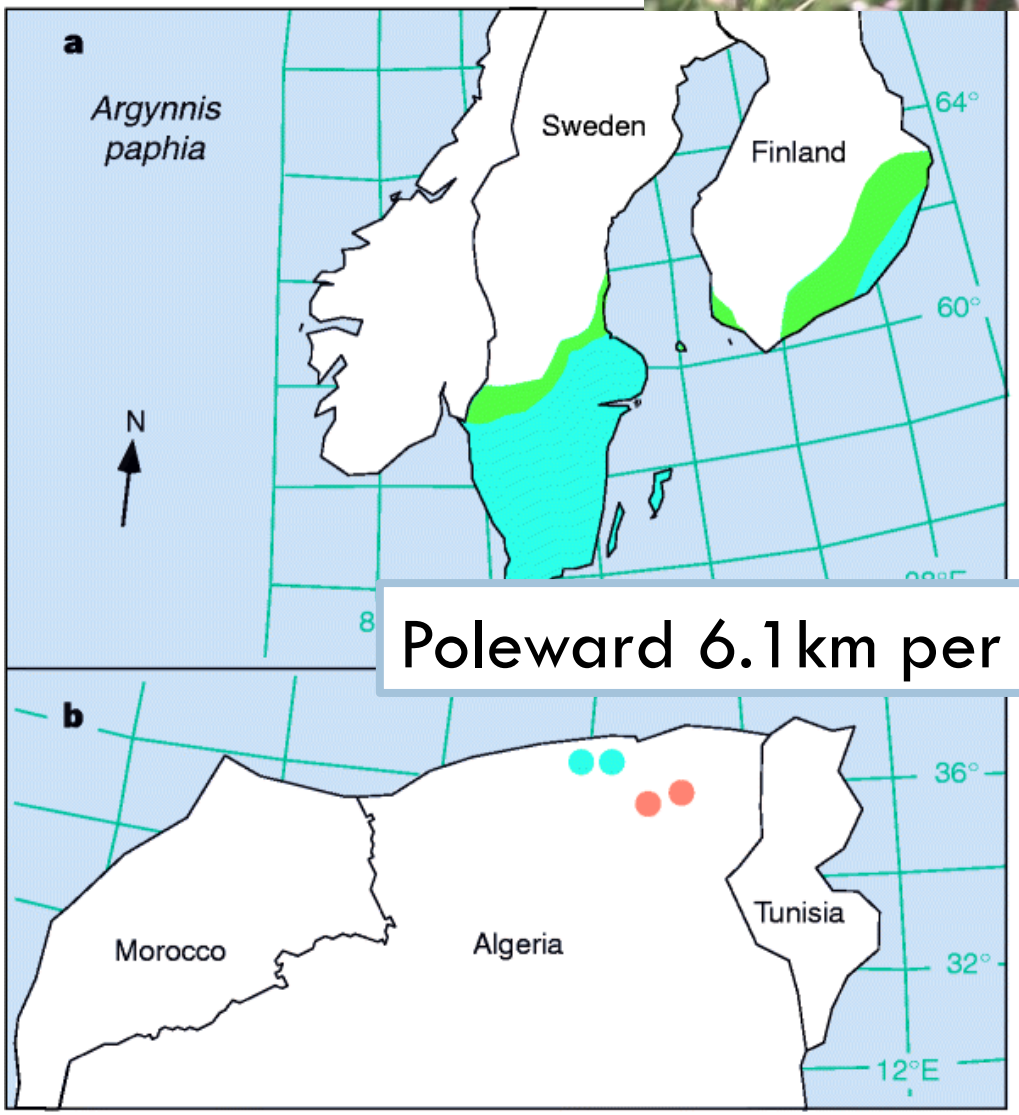
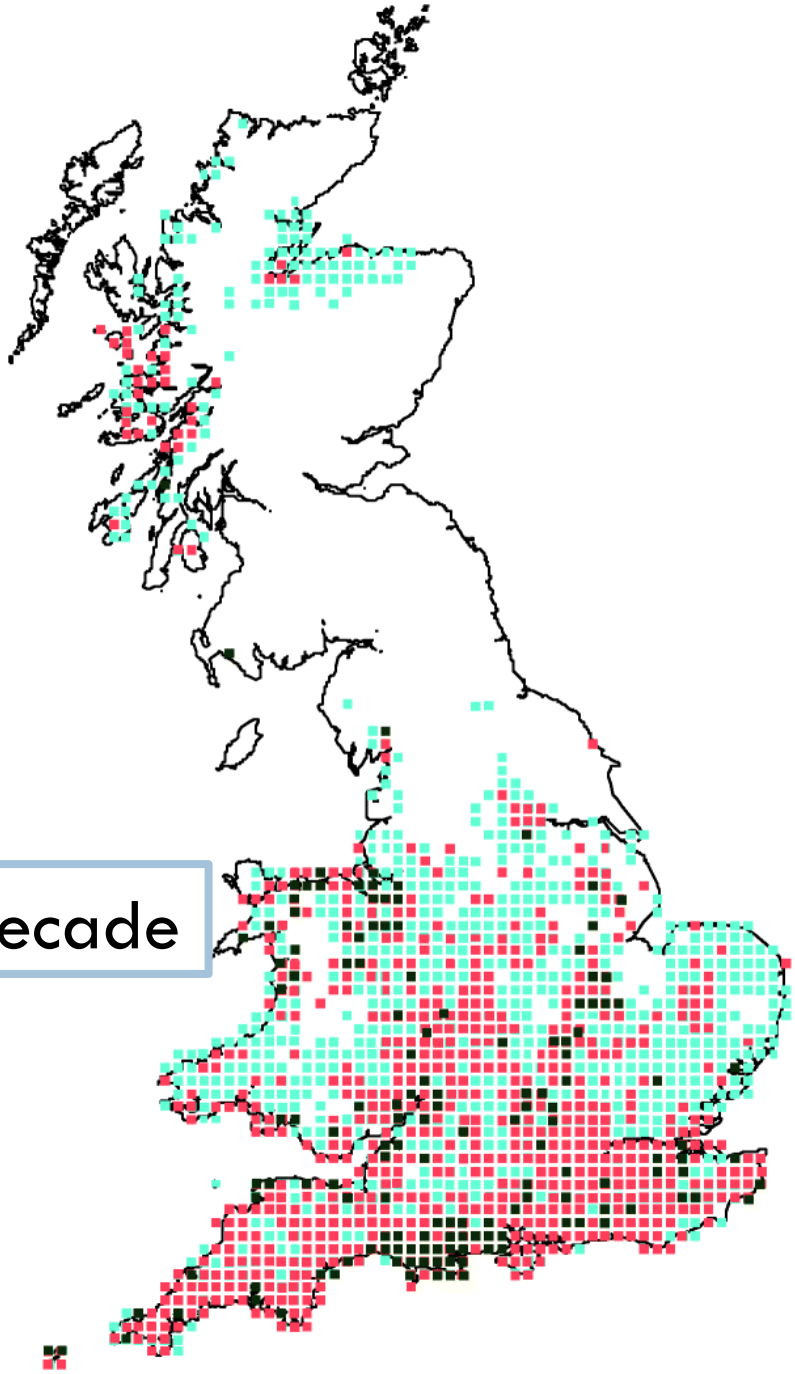
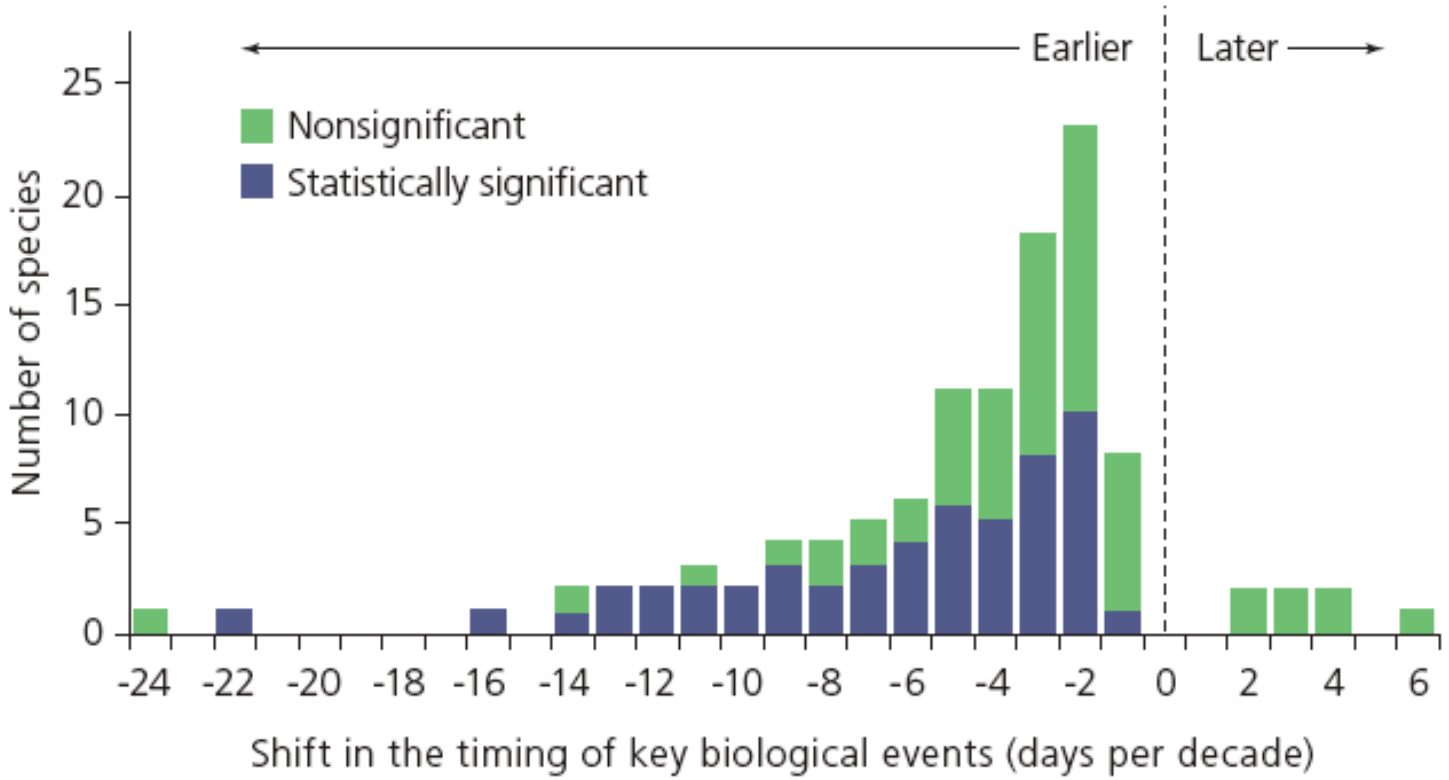


Poleward 6.1km per decade



Shifts in timing of biological events



Trends for migration, breeding, nesting, flowering

Root et al. (2003)

Biological impacts of climate change

1. Advance of spring events (bud burst, flowering, breaking hibernation, migrating, breeding)

2. Poleward range shifts for individual species and expansions of warm-adapted communities.

3. Observed changes have been **linked to local or regional climate change** (long-term correlations between climate and biological variation, experimental manipulations in the field and laboratory, and basic physiological research).

4. Species respond differently. Can disrupt predator-prey and insect-plant interactions

5. Shifts in abundances or range of parasites and their vectors are beginning to influence **human disease dynamics.**

6. Range-restricted species, esp. polar and mountaintop species, show more-severe range contractions (1st groups for climate-based extinctions, esp. tropical coral reefs and amphibs)

7. Evolutionary responses can't 'keep up' with climate-induced changes. Evolution will not prevent predicted species extinctions.

Biodiversity loss

Effects on functioning of ecosystems

↓

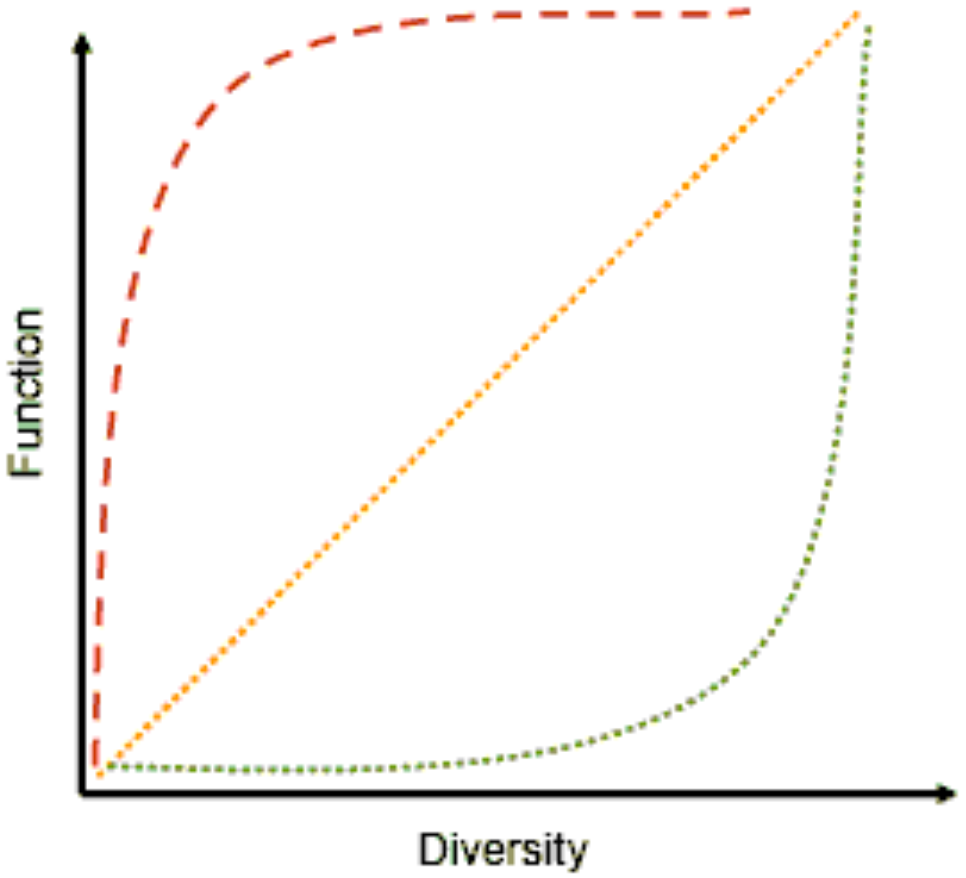
Effects on services and products provided to humans (“ecosystem services”)

How does biodiversity loss relate to ecosystem function?

I. Every species contributes a new function

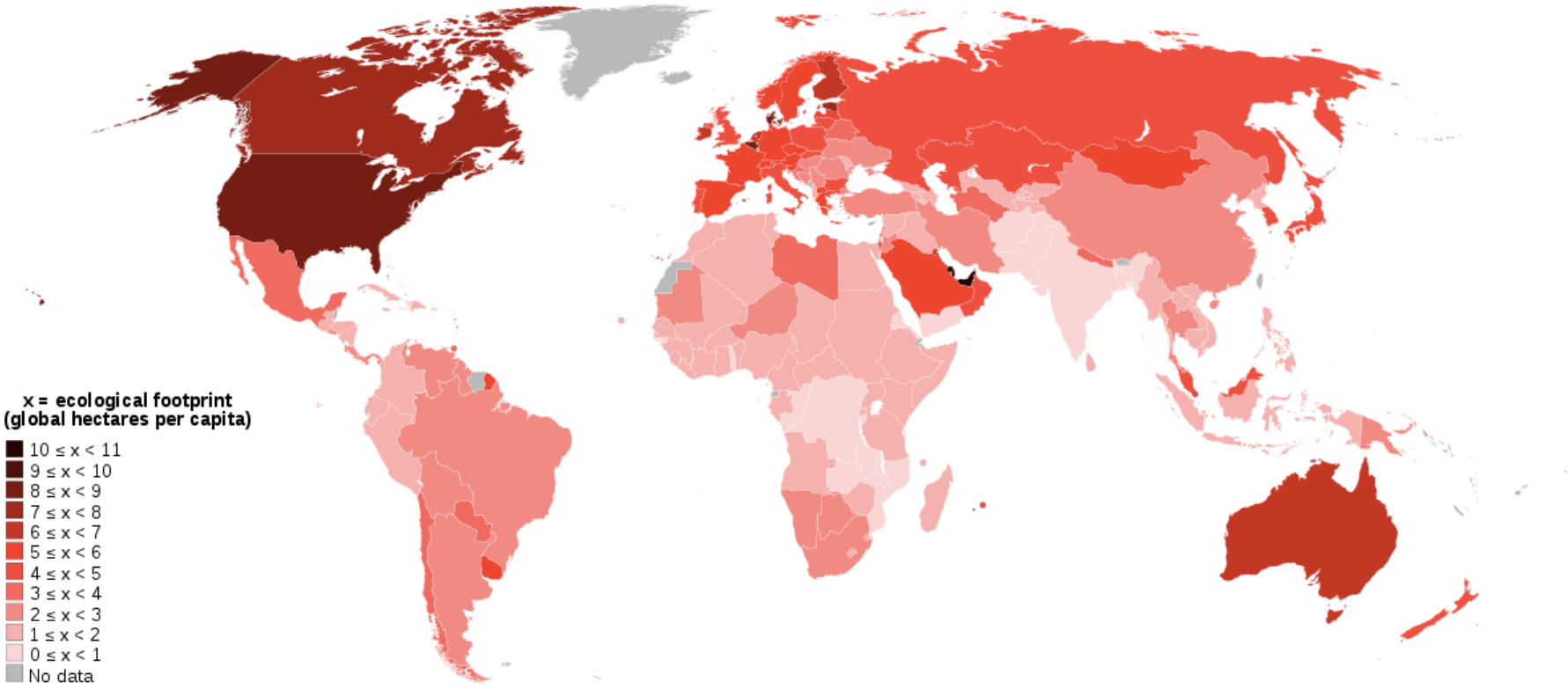
II. Many species functionally important

III. Few species functionally singular



Millennium Ecosystem Assessment

What can we do?
ecological footprint



global hectares/person

Ecological Footprint

What can we do?

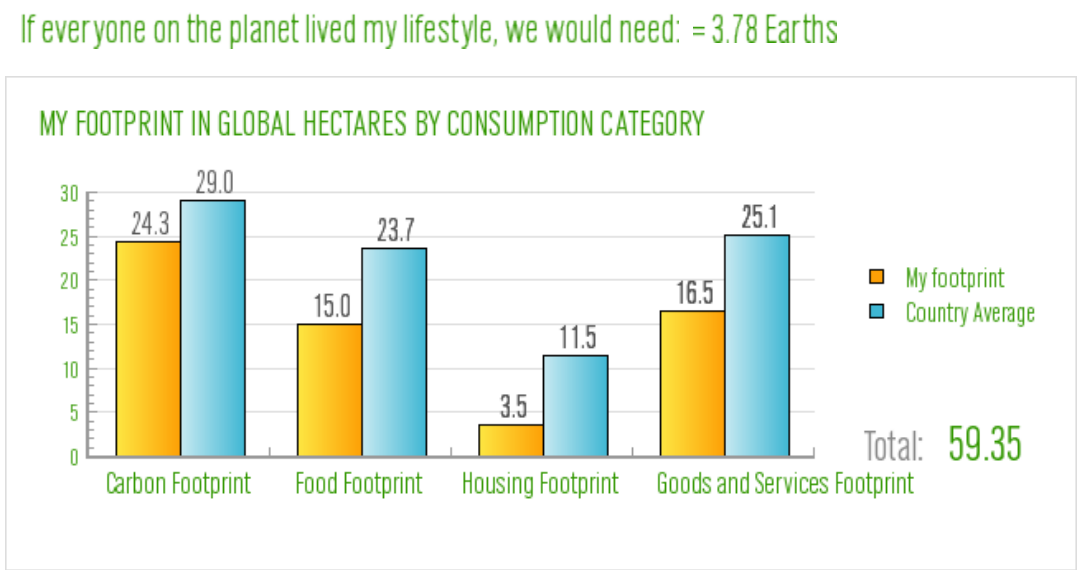
What's your personal 'ecological footprint'?

www.myfootprint.org or http://www.livesmartbc.ca/homes/h_calc.html

How does it compare to the N. American average?

…to the global average?

How can you reduce your footprint?



Your responsibility as an educated global citizen…

Get informed.
Read and understand the science behind these issues.

Ecological Research Opportunities

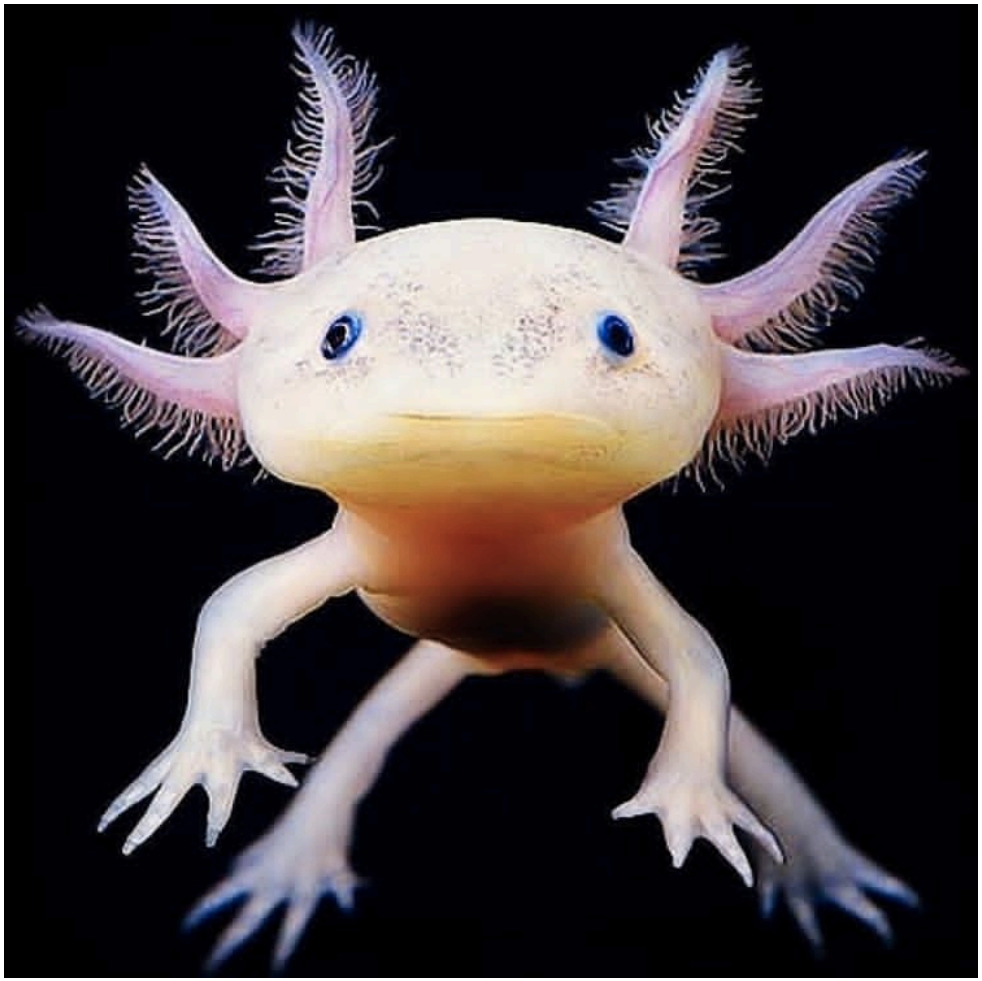
- **Field station courses** (small, intensive, lots of hands on learning)
  - Bamfield Marine Sciences Ctr.
  - Rocky Mountain Biological Lab
  - Mountain Lake Biological Station
  - Flathead Lake Biological Station

- **NSERC** (Nat'l Science & Engineering Research Council)
  - Undergraduate Summer Research Apprenticeship (paid, 12 weeks)

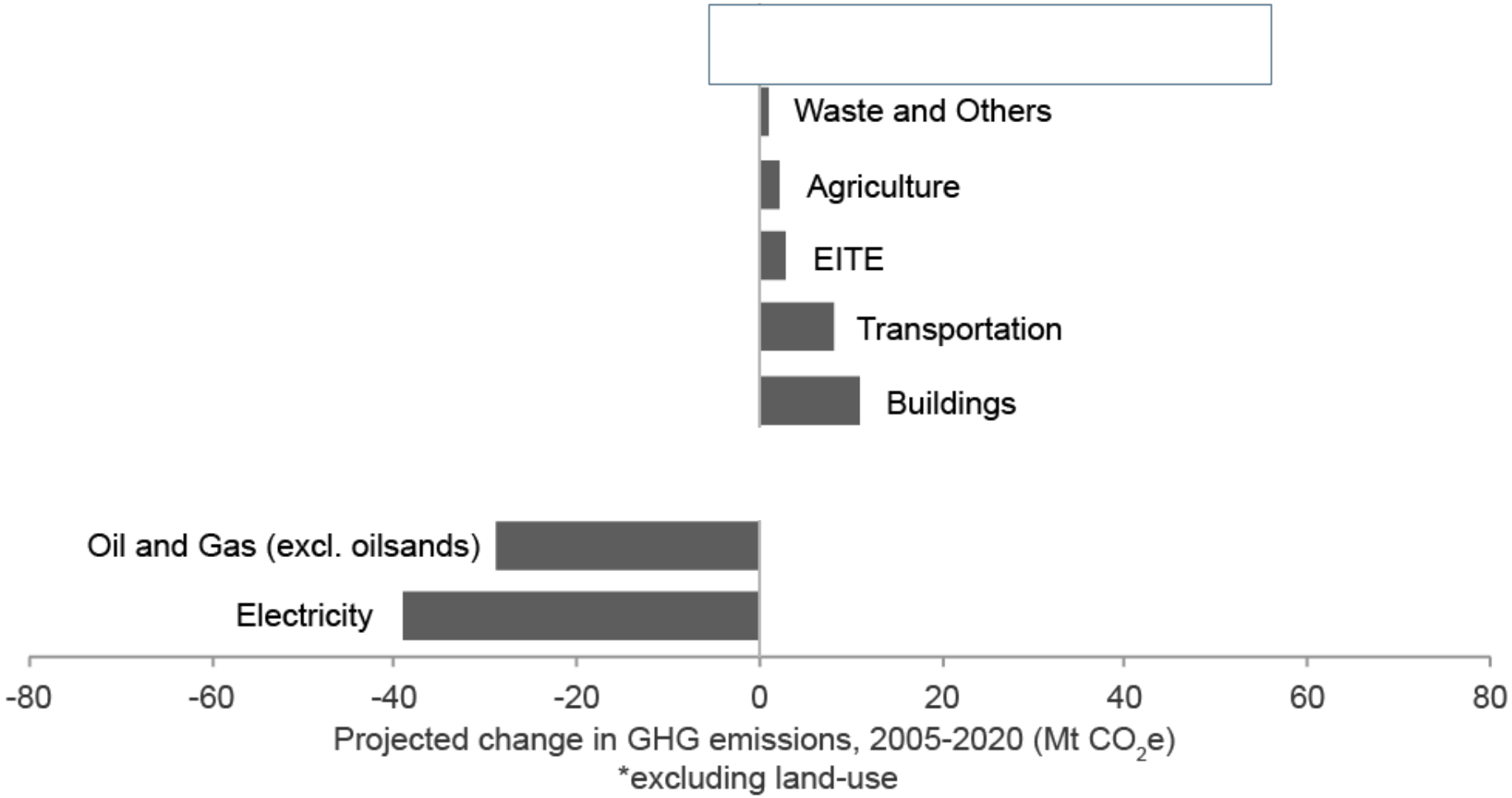
- **Volunteer** (or paid once you have skills) for faculty members
  - Biology website: research opportunity descriptions
  - Or contact anyone by email

- **Research for credit courses** (BISC 498/497)
  - Approach a faculty member and ask if they'll supervise you

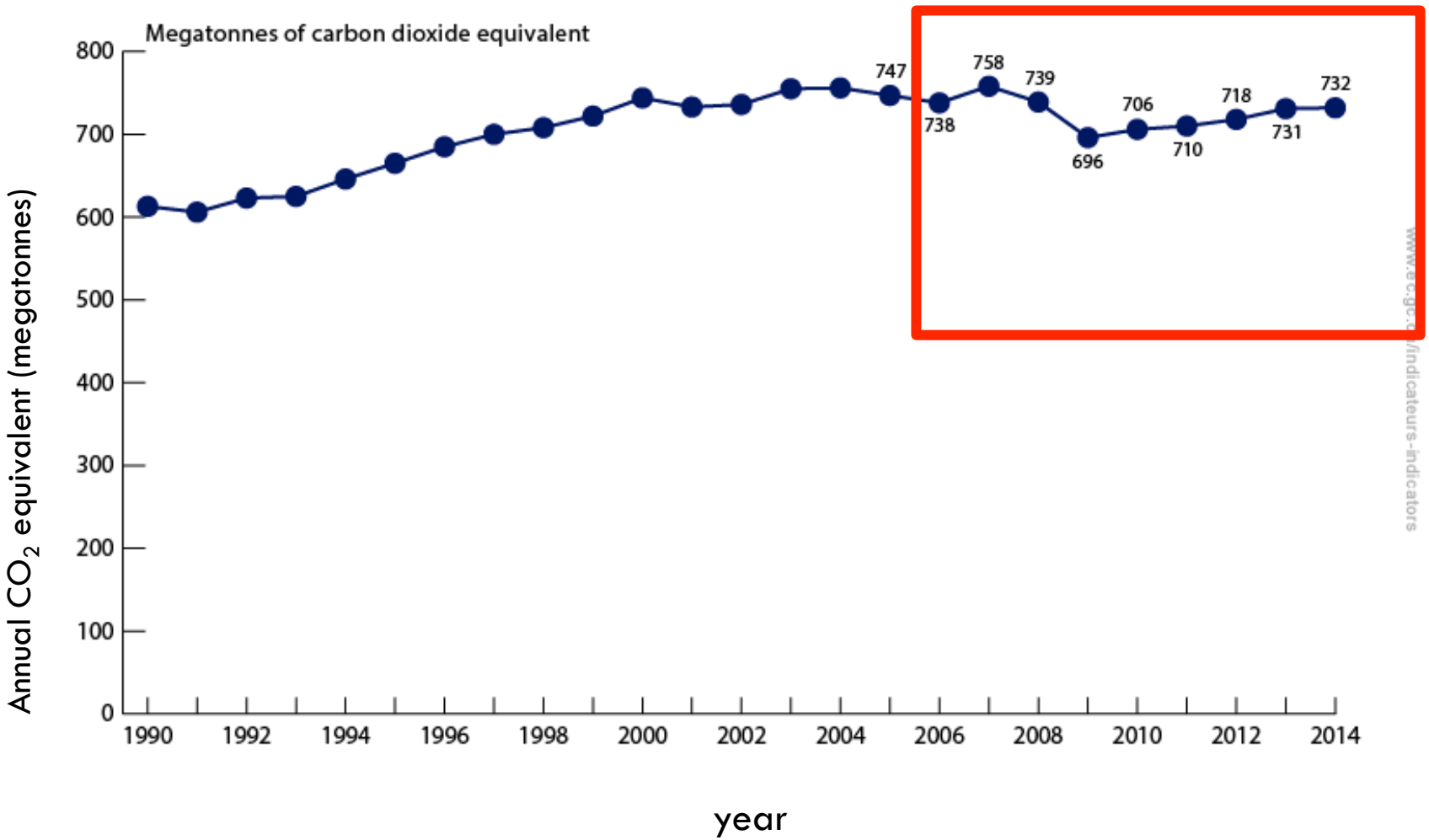
Thanks!



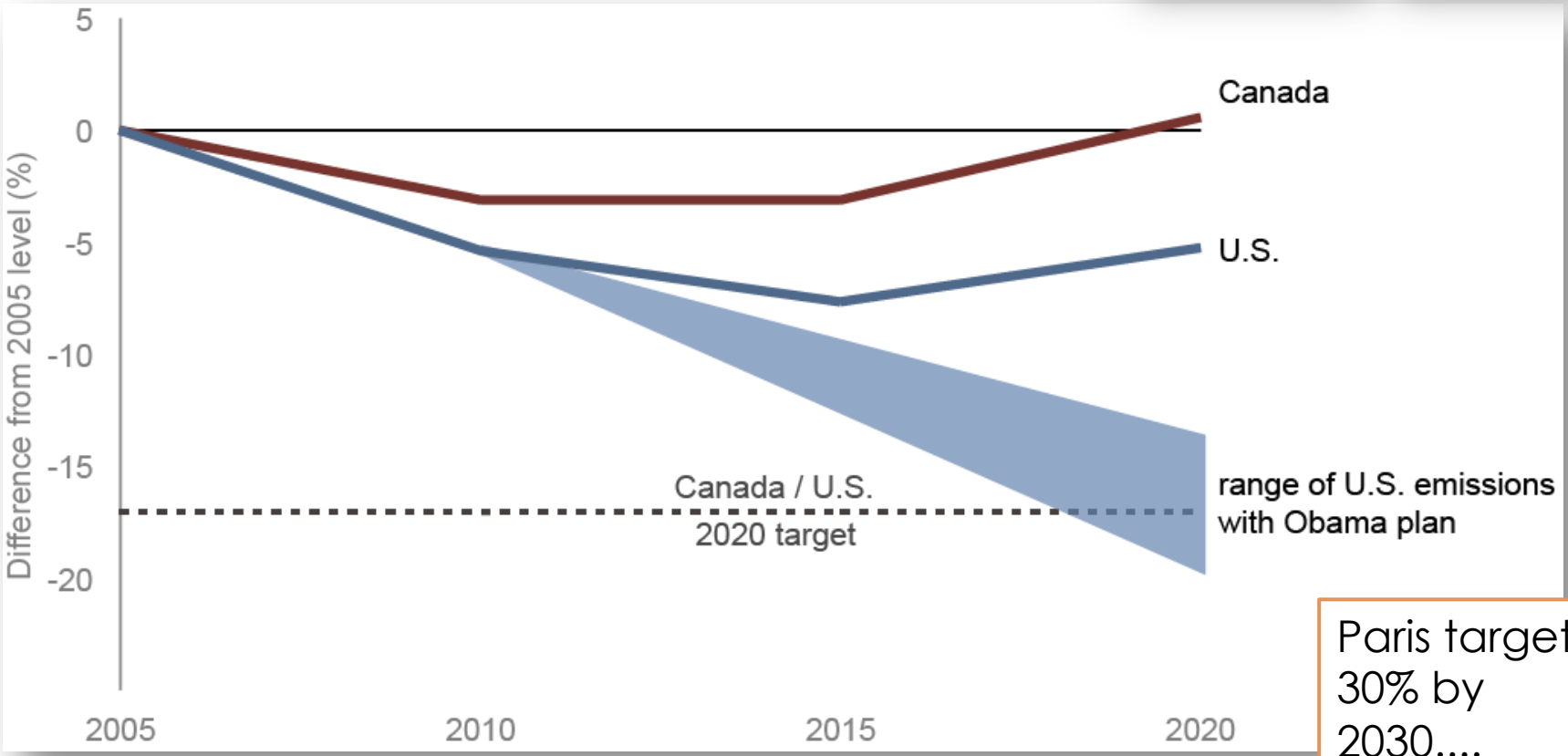
Canada's GHG Emissions



Canada's GHG Emissions



US & Canada: Emissions to 2020

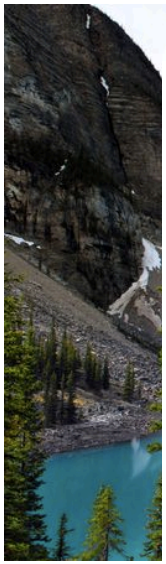


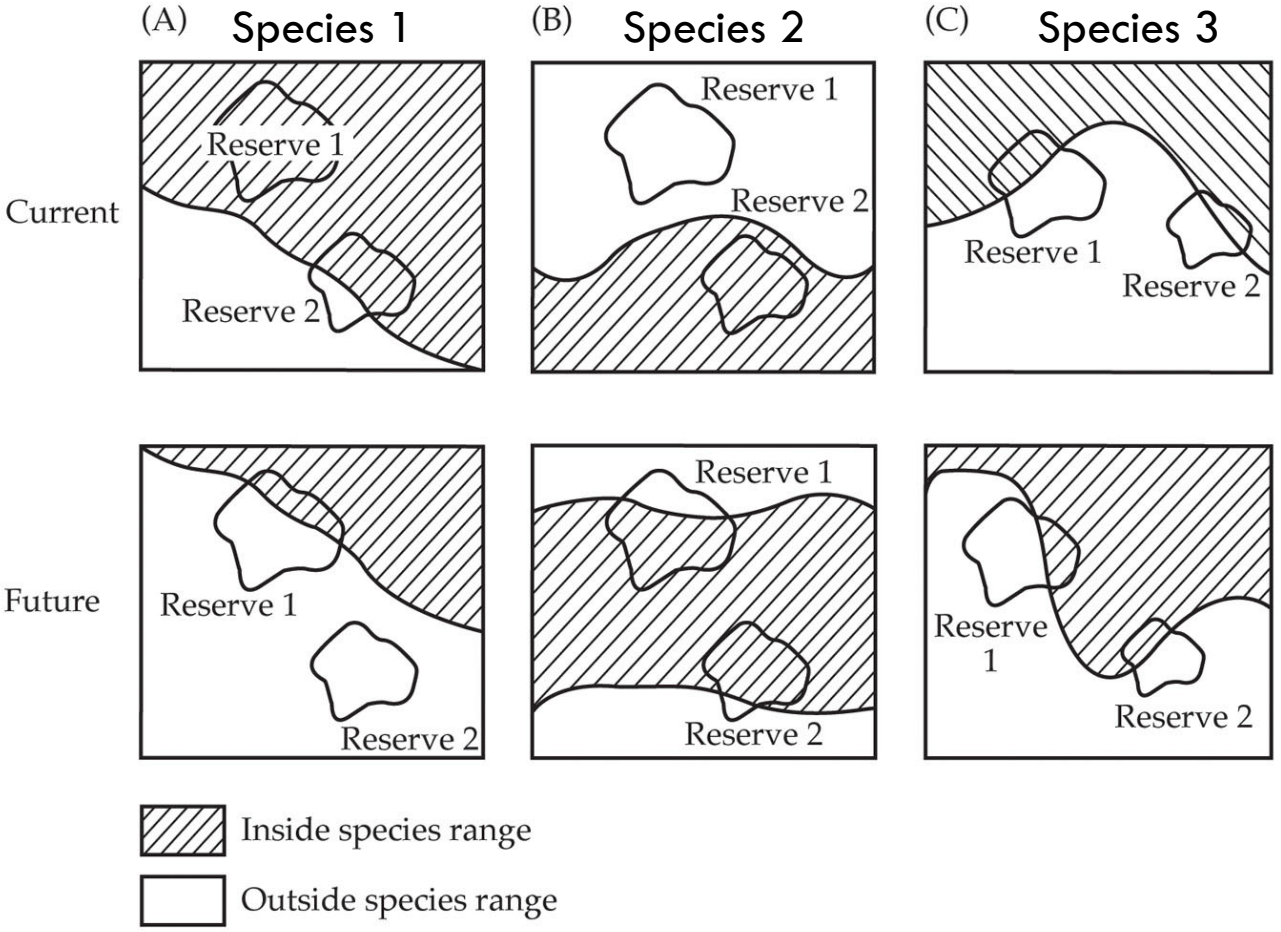
Paris target: 30% by 2030....

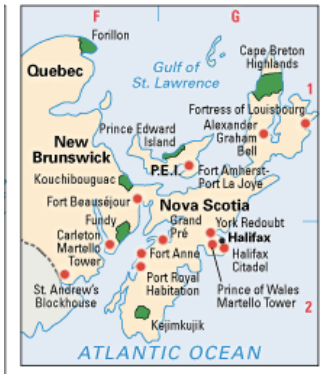
X

Changing relationships between species ranges & reserve boundaries

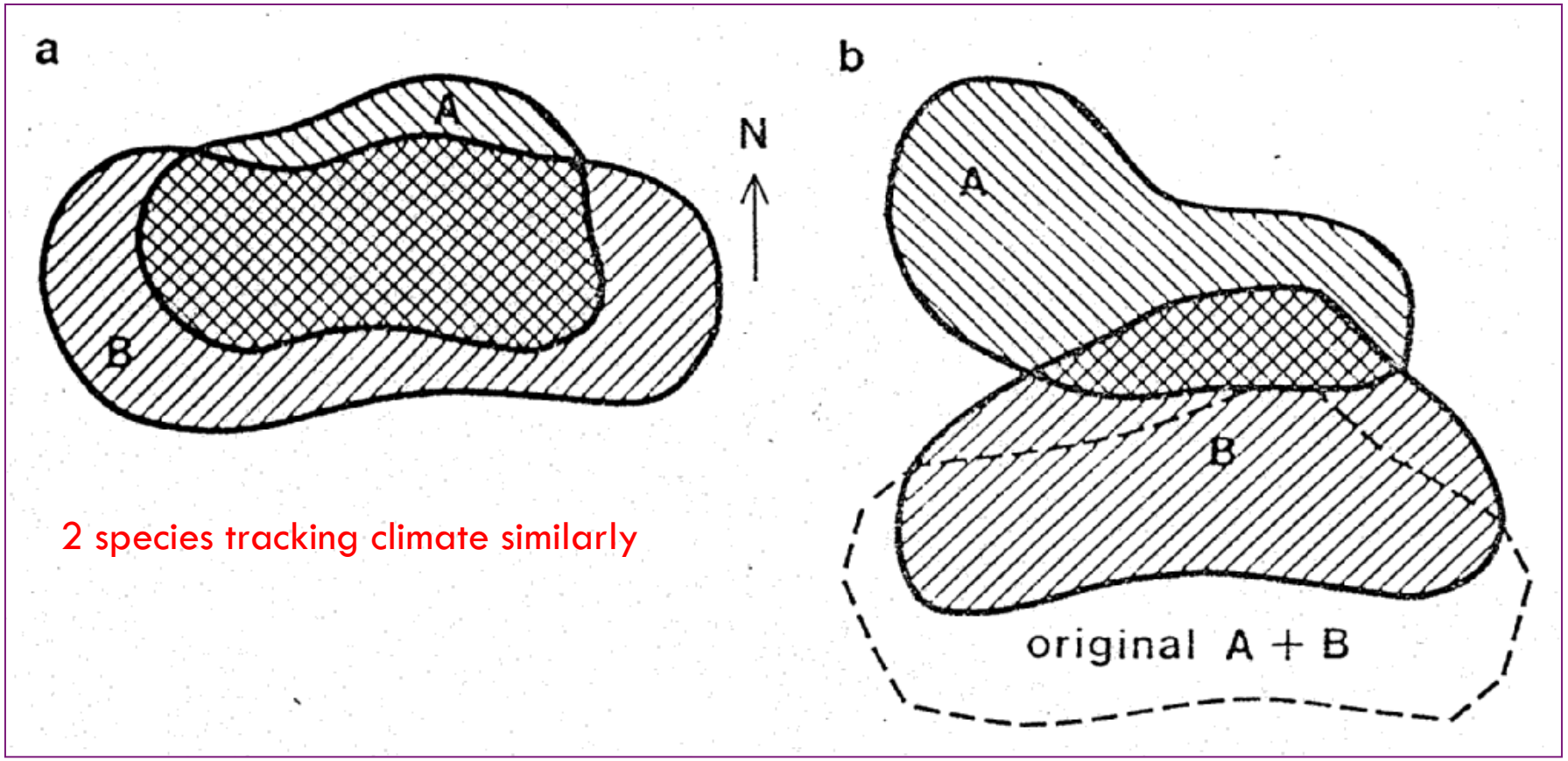
Changing relationships between species ranges & reserve boundaries







Species will track changes at different rates



2 species tracking climate similarly

2 species tracking climate differently

Your responsibility as an educated global citizen…

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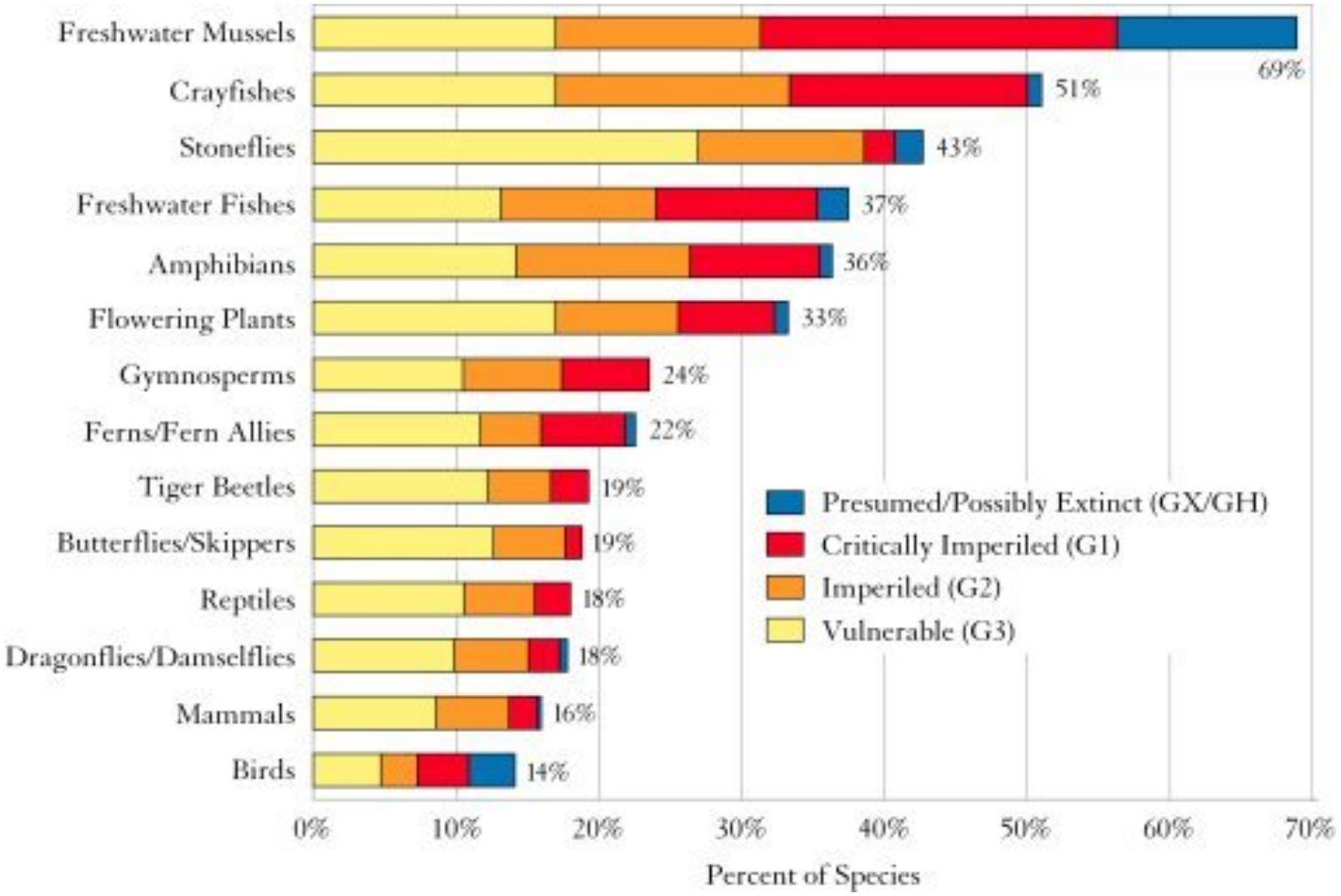
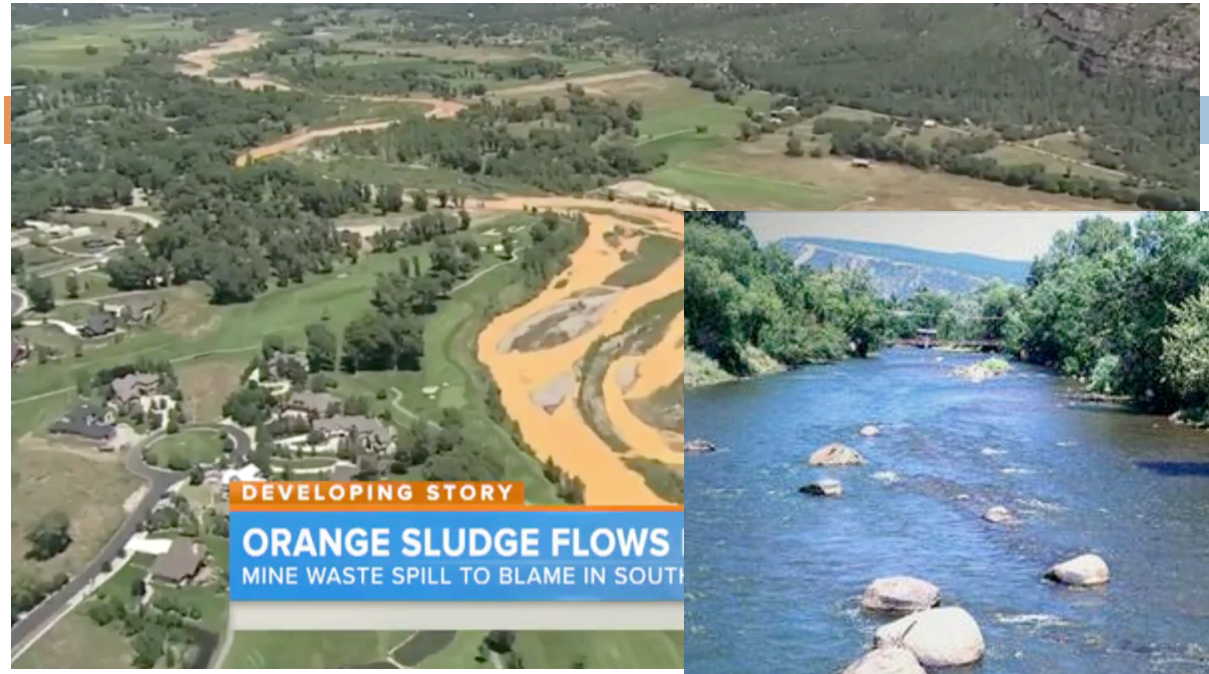
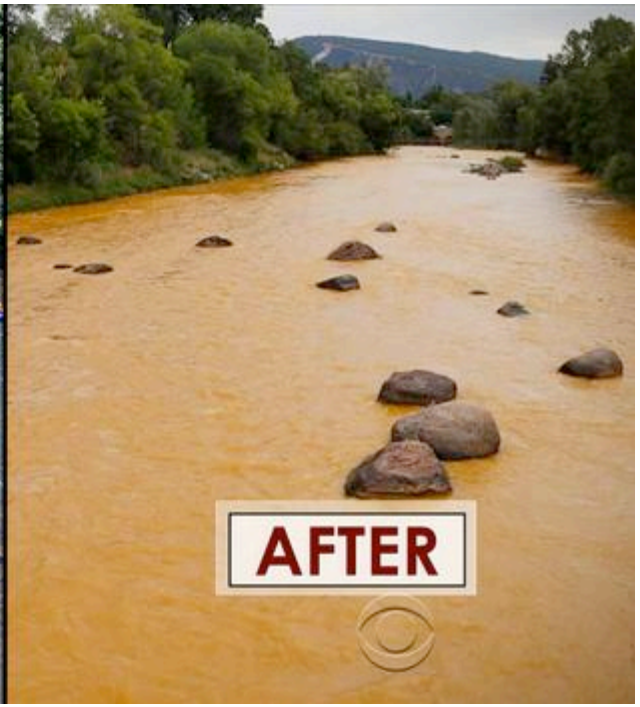
Local exotic species introductions



Cultural Eutrophication

6. 'Pollutants' and contaminants – local & regional issues





Acid mine drainage-mobilization of sulfur from mines (= extremely low pH)

mobilizes other toxic heavy metals

low pH mobilizes copper, lead, mercury (extremely toxic in water)

Changes in land-use

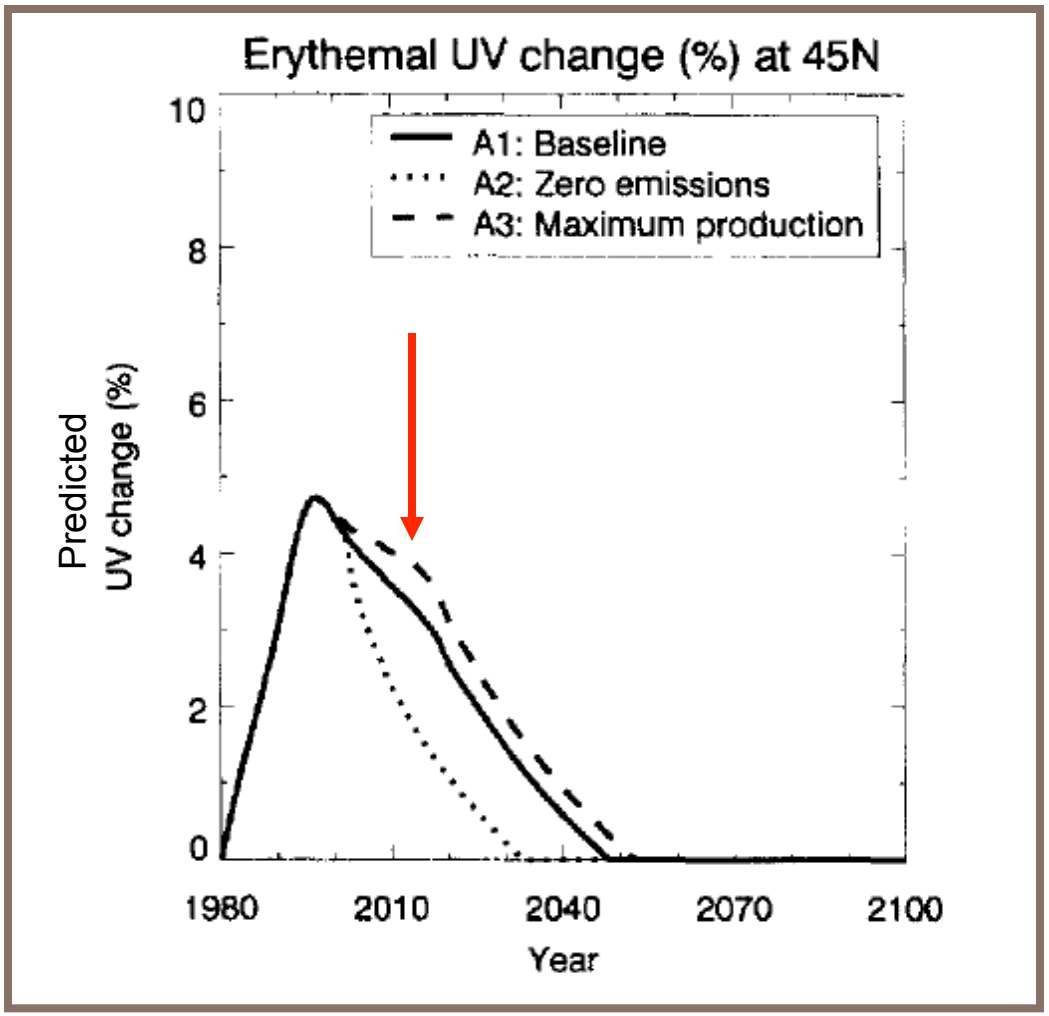
Changes in land-use

Tropical forests maintained by nutrient recycling within standing forests...
...relatively short term gains when converted

What is required to maintain these plantations?

Atmospheric UV-B flux

Recovery from ozone depletion?



From Madronich et al. (1998)

- Montreal Protocol (1987)
- Mid-latitude predictions (~5% increase since 1980)