Bending the Curves: Climate, Land Use, and Biological Diversity Changes. The Safe Way out through the Planetary Boundaries

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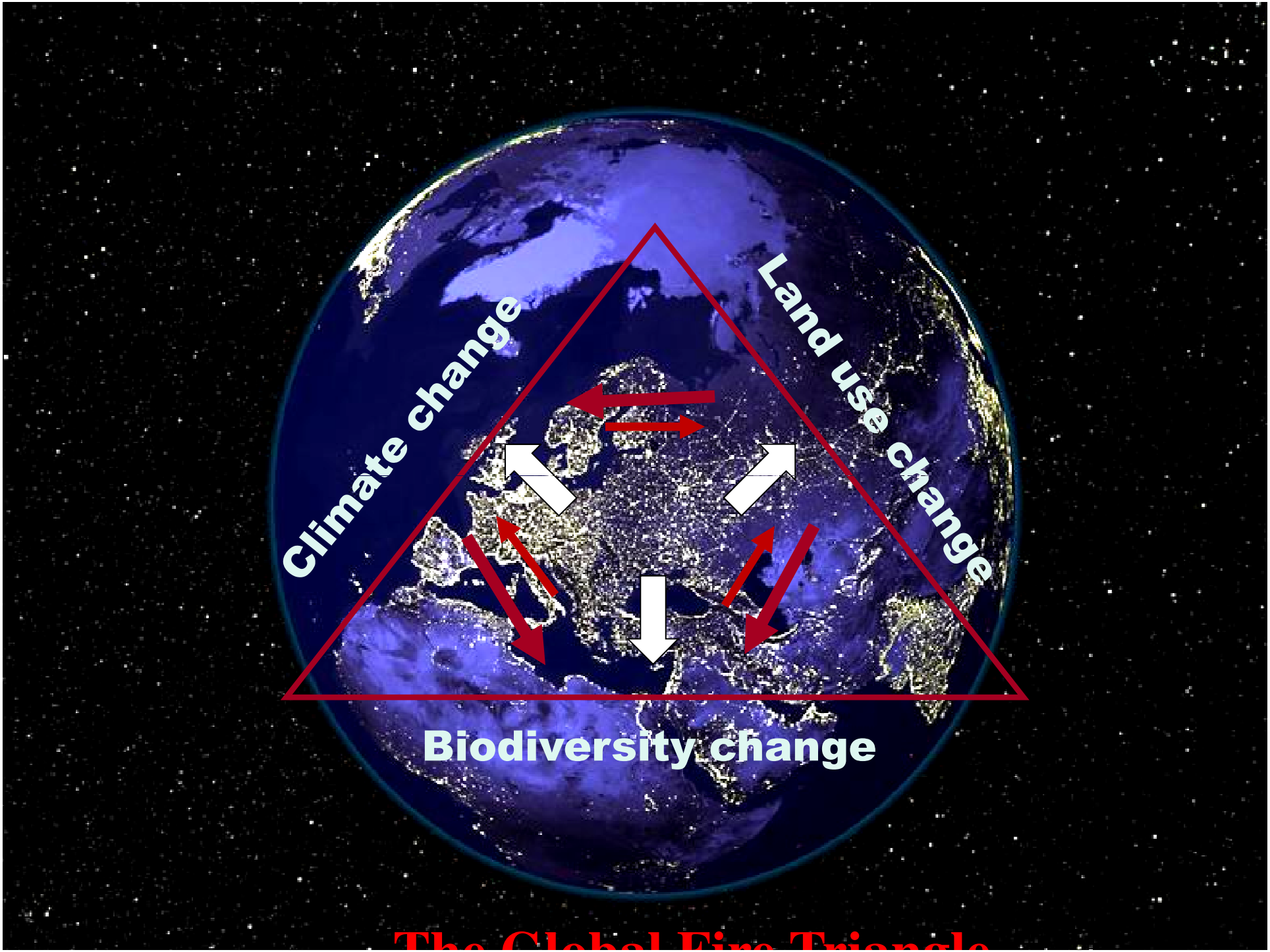
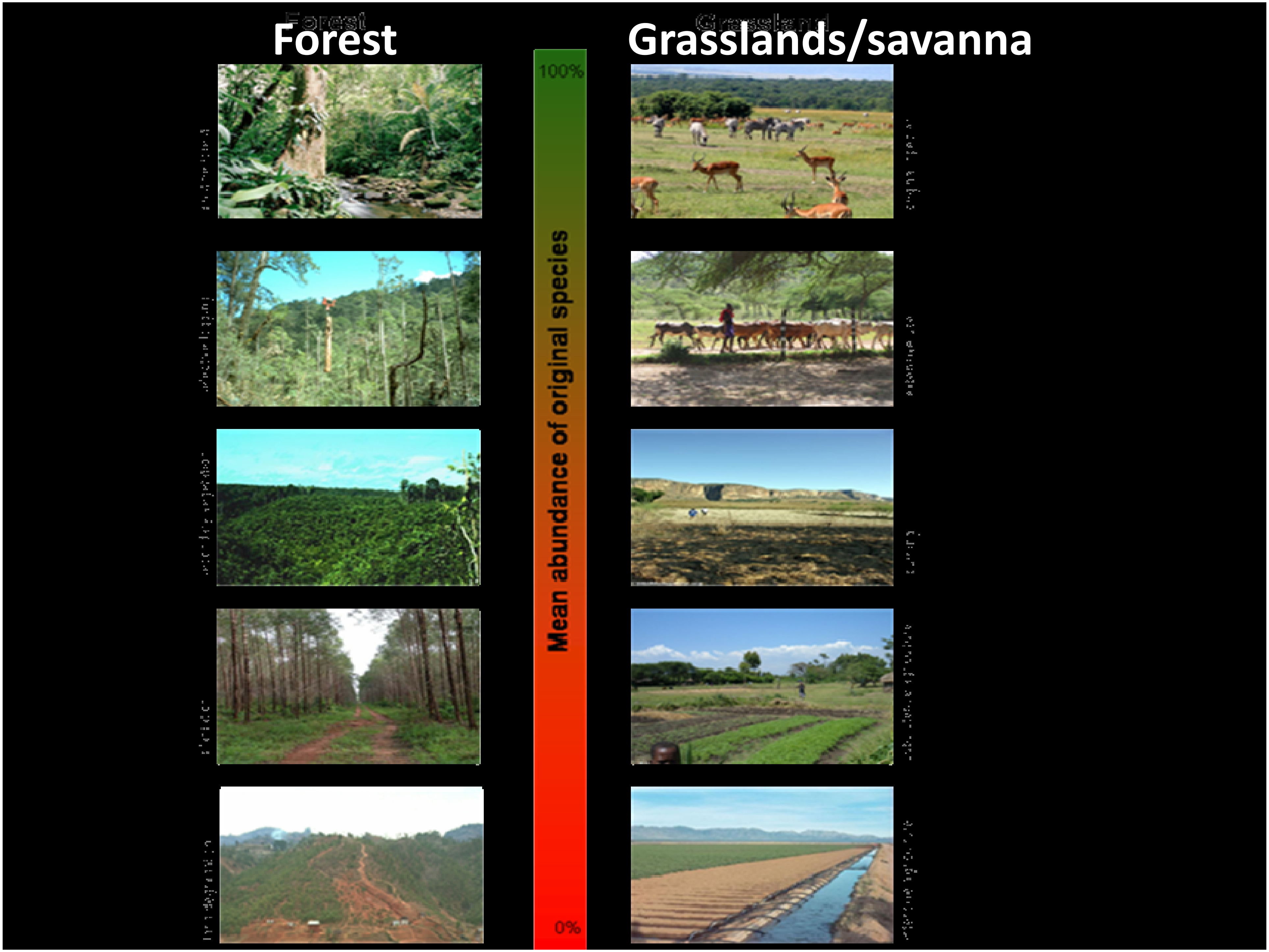
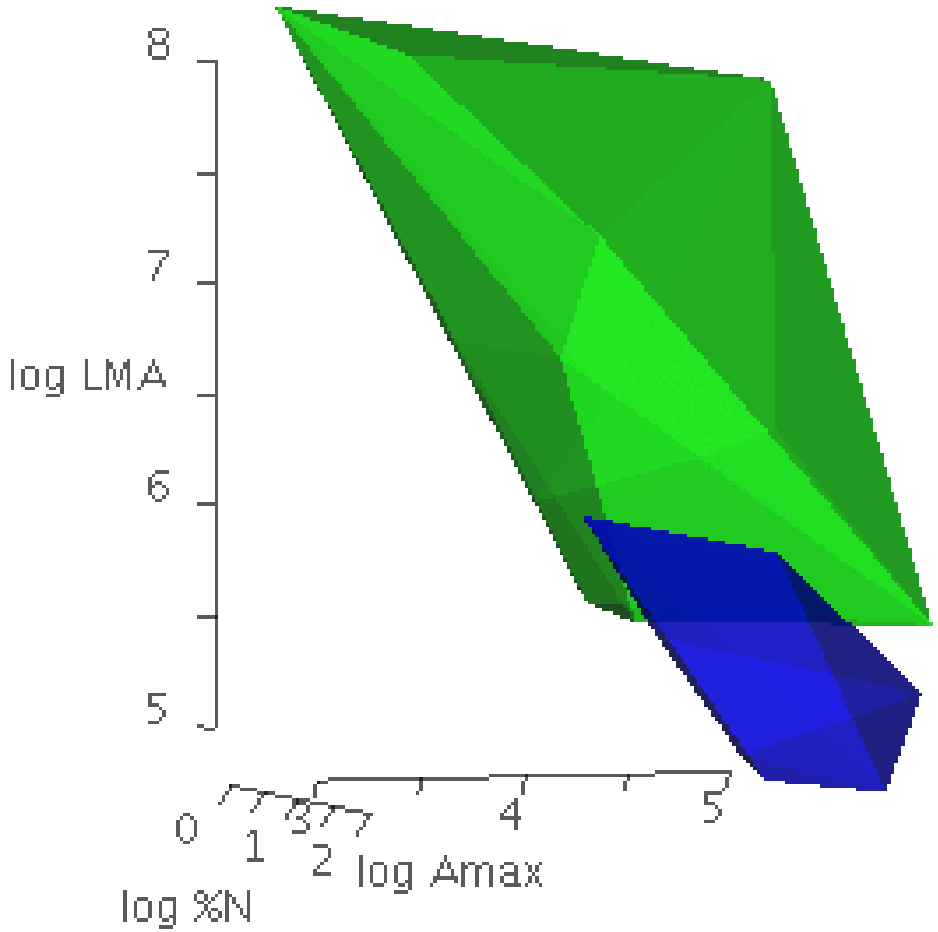
College of Medicine, November 4, 2010



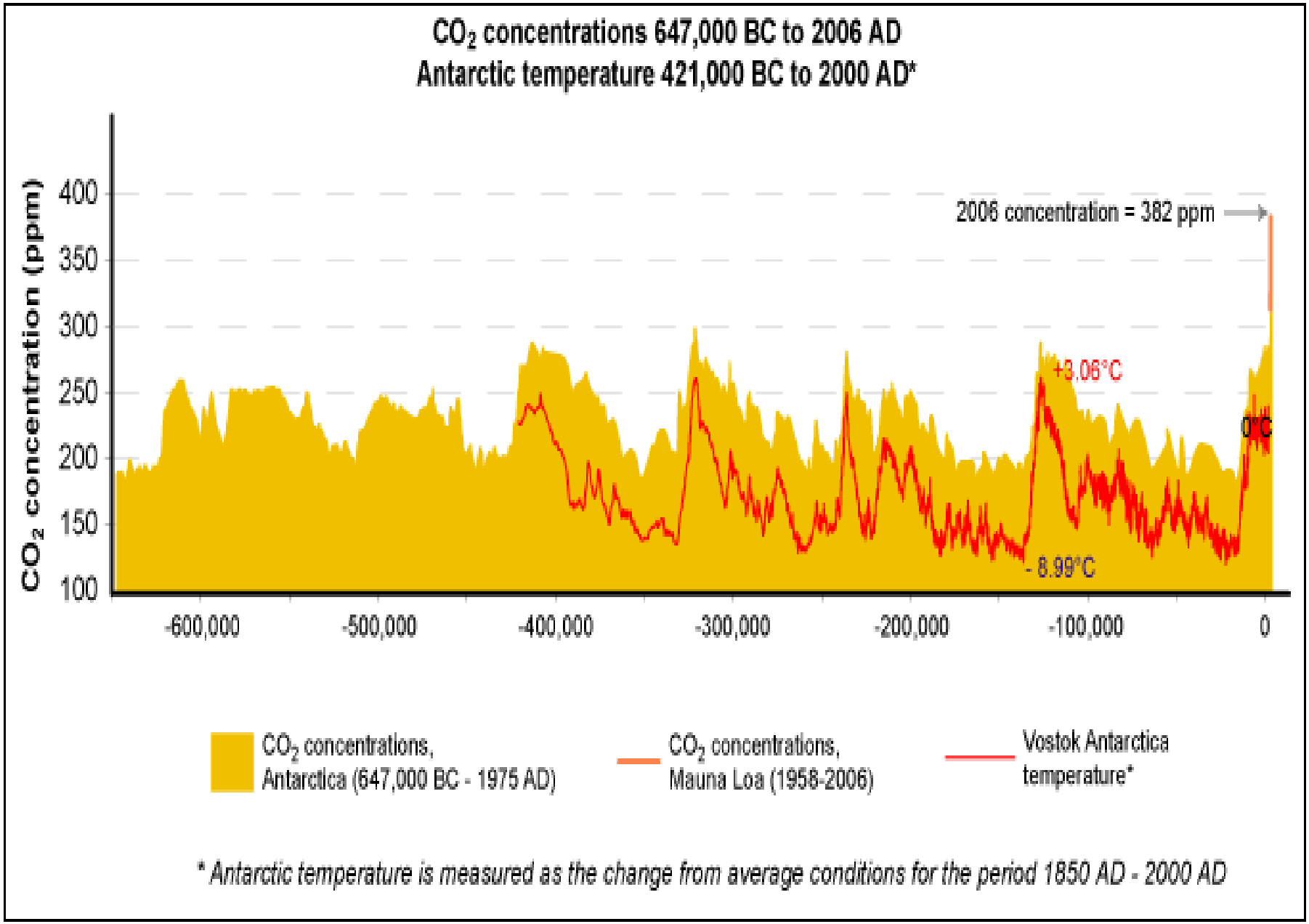
The Global Fire Triangle


Forest
Grasslands/savanna
100%
Mean abundance of original species
0%

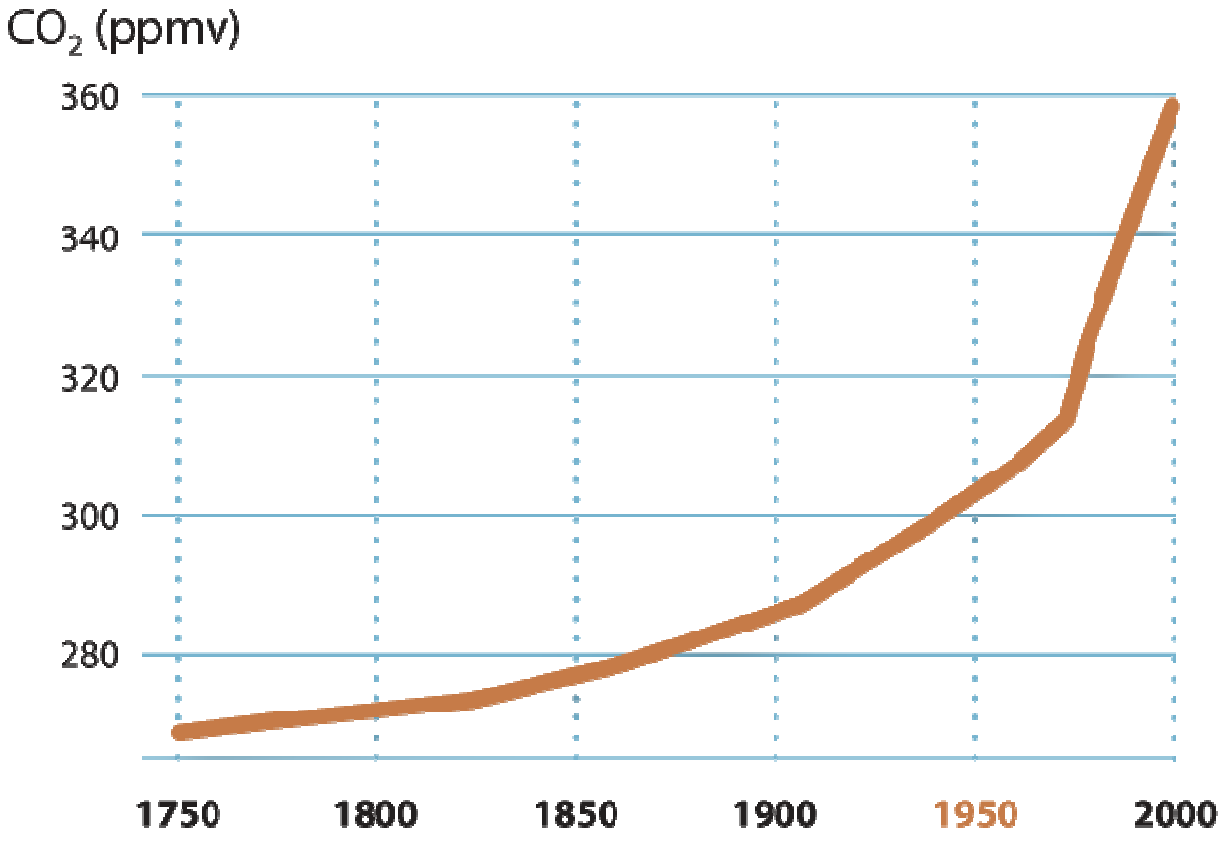
All Natives vs. All Agricultural Plants



Lin et al.


CO_2 concentrations 647,000 BC to 2006 AD
Antarctic temperature 421,000 BC to 2000 AD*
CO_2 concentration (ppm)
400
350
300
250
200
150
100
2006 concentration = 382 ppm
+3.06°C
0°C
- 8.99°C
-600,000
-500,000
-400,000
-300,000
-200,000
-100,000
0
CO_2 concentrations, Antarctica (647,000 BC - 1975 AD)
CO_2 concentrations, Mauna Loa (1958-2006)
Vostok Antarctica temperature*
* Antarctic temperature is measured as the change from average conditions for the period 1850 AD - 2000 AD

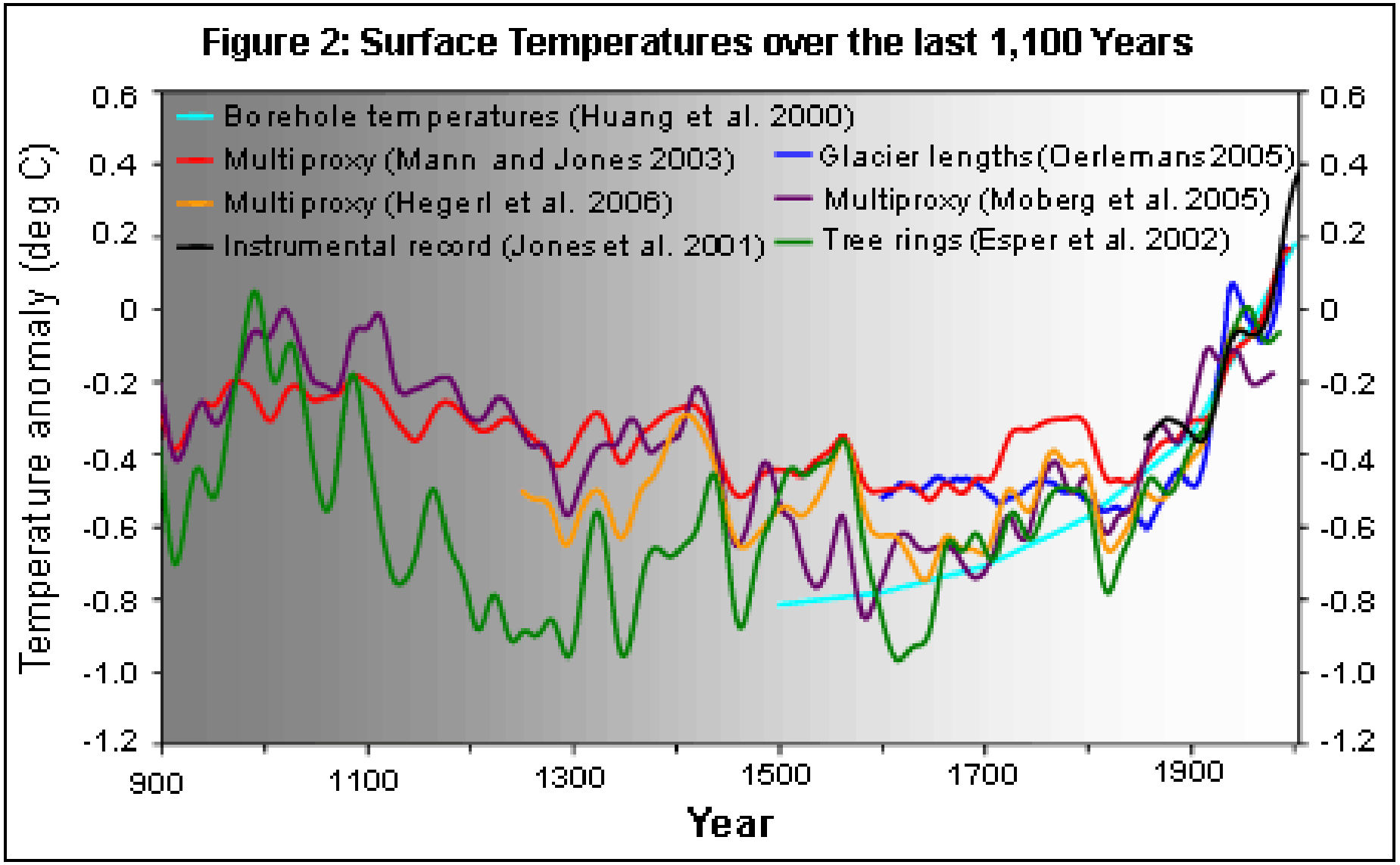
Atmospheric CO_2 concentration



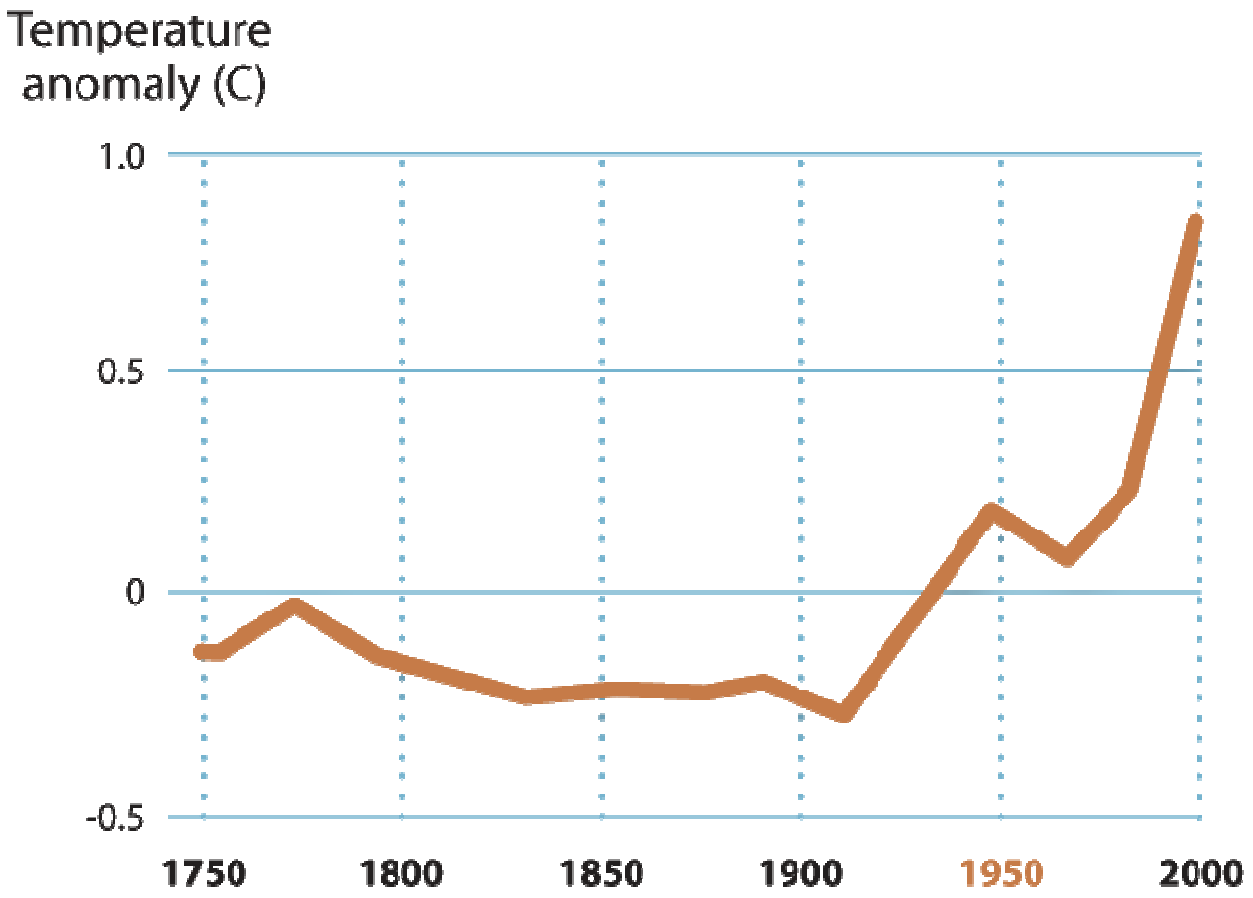
Etheridge *et al.* Geophys Res 101: 4115-4128

IGBP synthesis: Global Change and the Earth System, Steffen et al 2004

Figure 2: Surface Temperatures over the last 1,100 Years



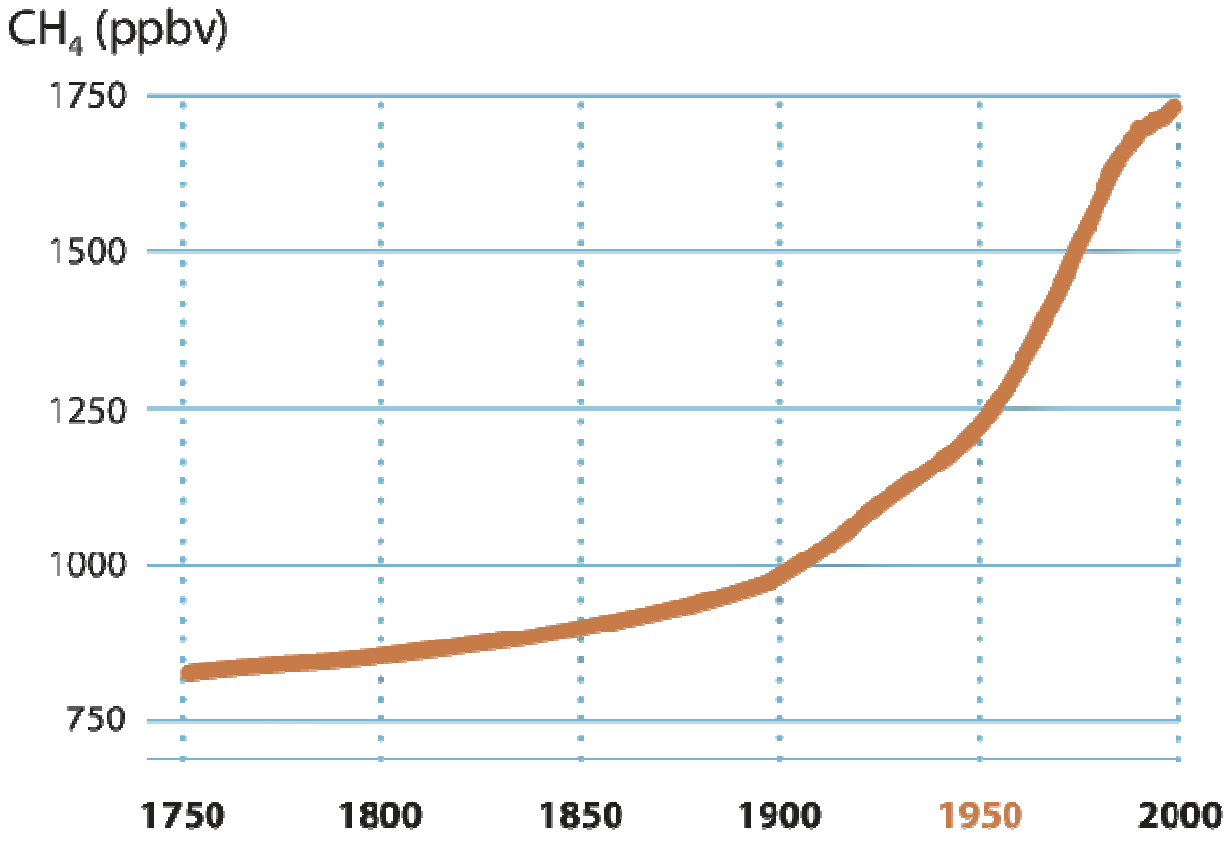
Northern hemisphere temperature



Mann et al Geophys Res Lett 26(6): 759-762

IGBP synthesis: Global Change and the Earth System, Steffen et al 2004

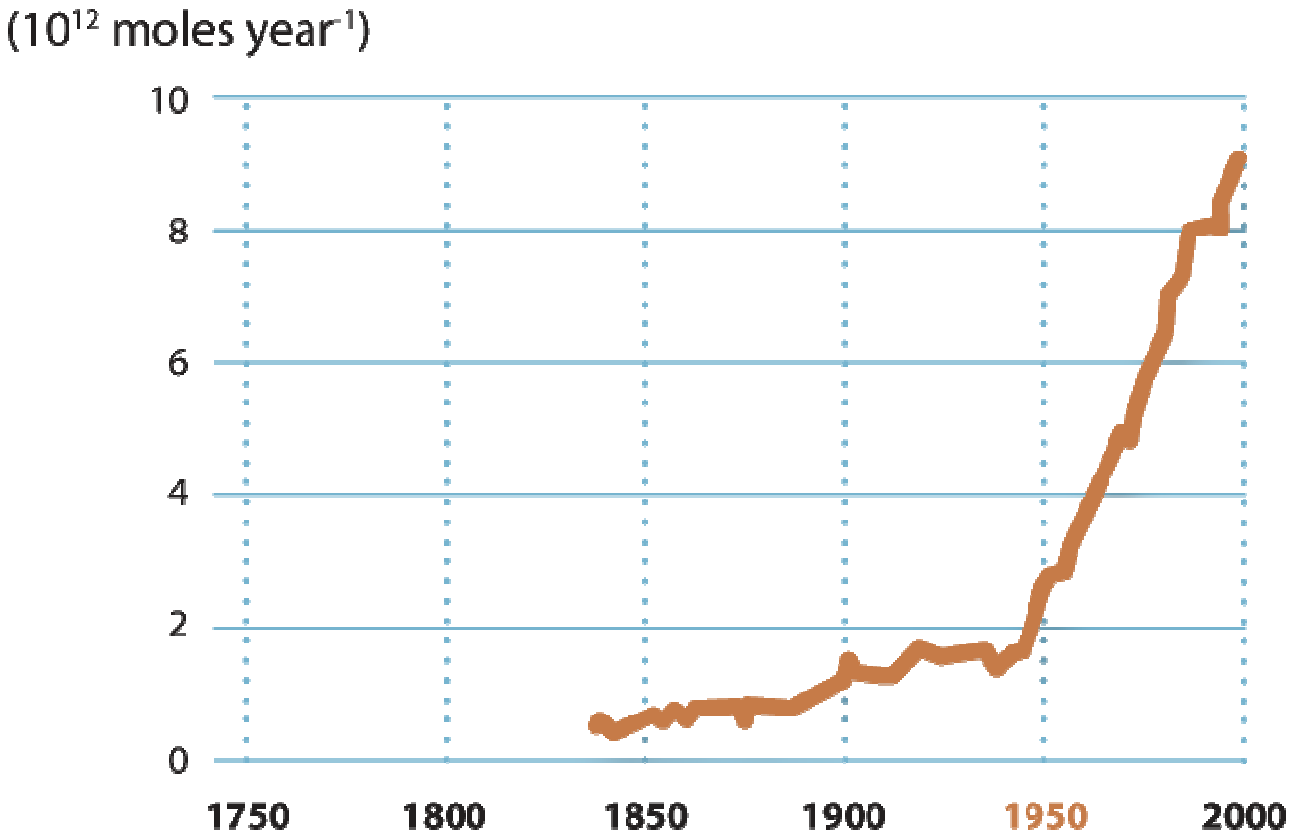
Atmospheric CH_4 concentration



Blunier *et al.* J. Geophy .Res 20: 2219-2222

IGBP synthesis: Global Change and the Earth System, Steffen *et al*/2004

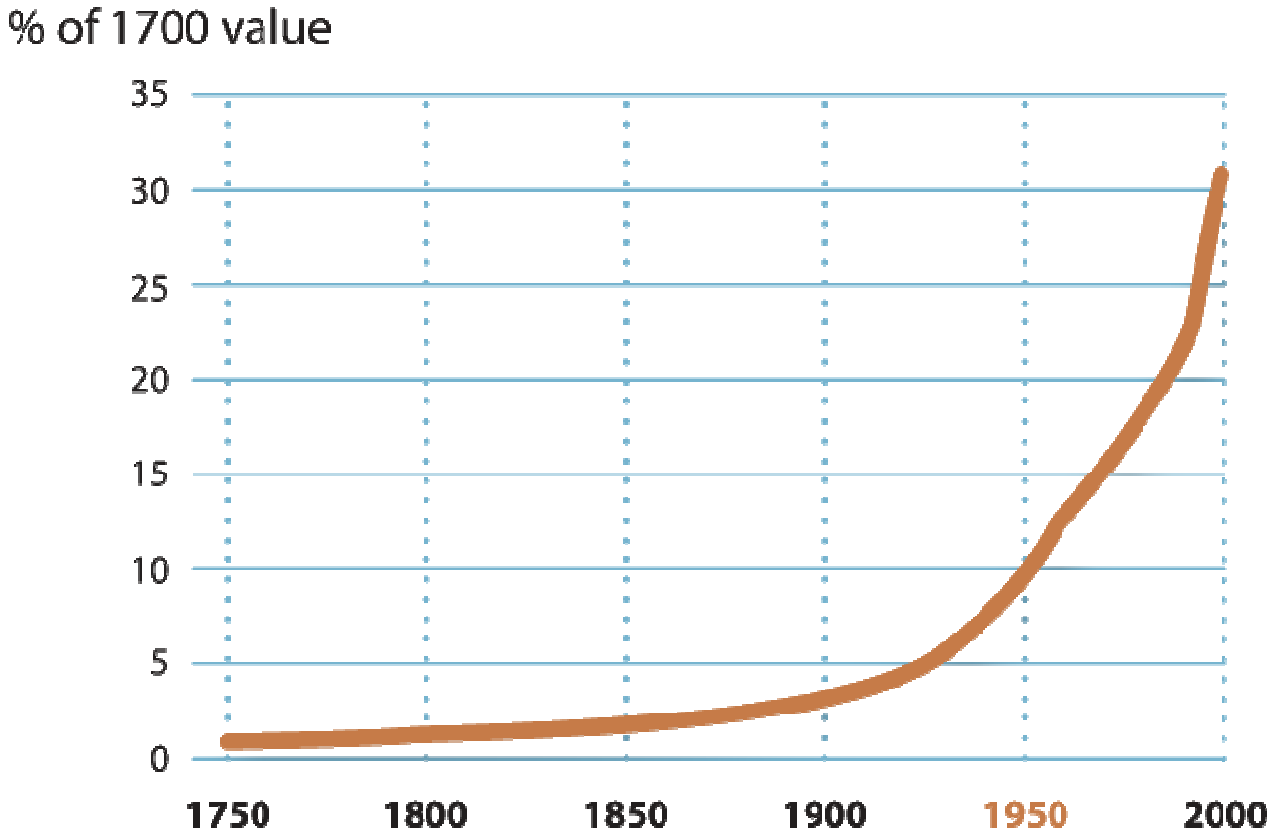
Coastal zone nitrogen flux



Mackenzie et al 2002.

IGBP synthesis: Global Change and the Earth System, Steffen *et al*/2004

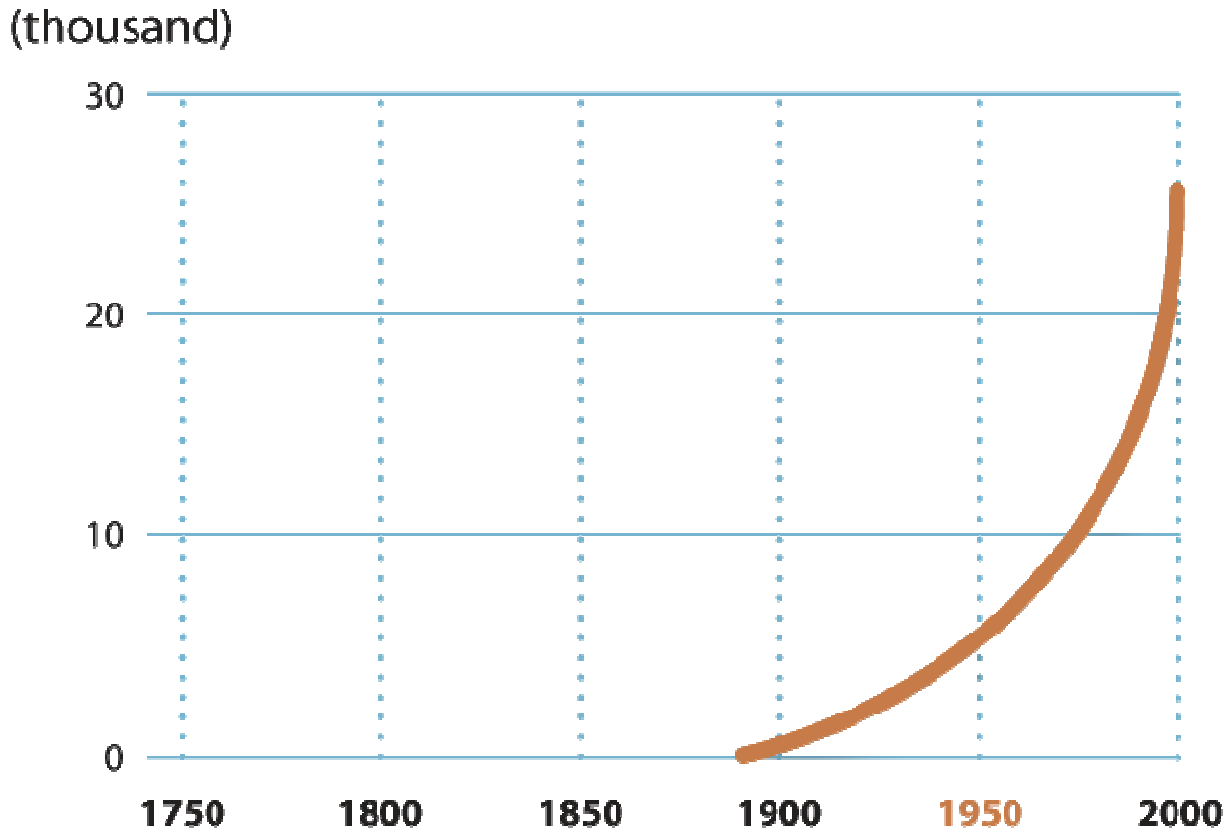
Tropical rainforest and woodland loss



Richards, the Earth as transformed by human action, Cambridge University Press

IGBP synthesis: Global Change and the Earth System, Steffen *et al*/2004

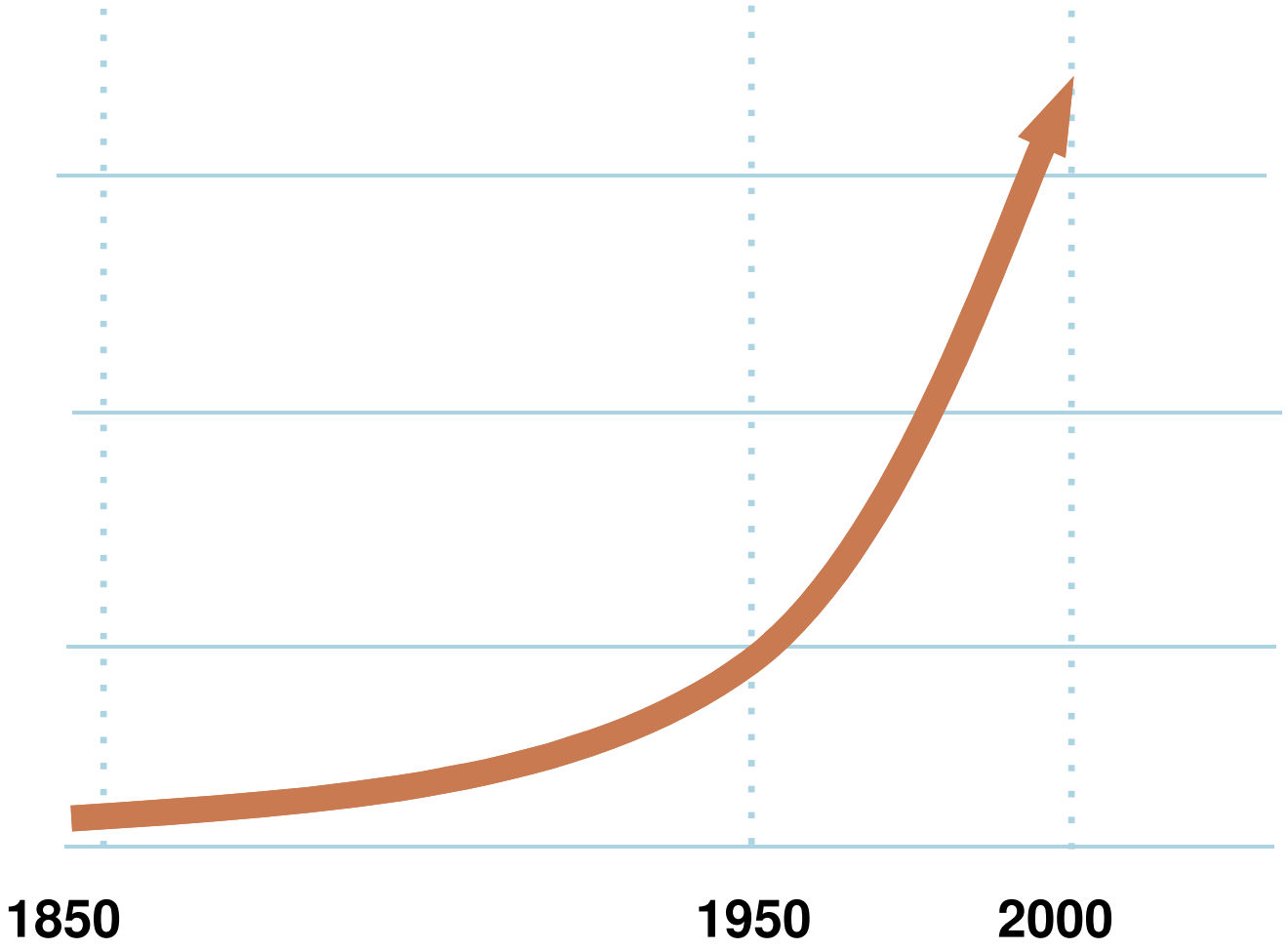
Species extinctions



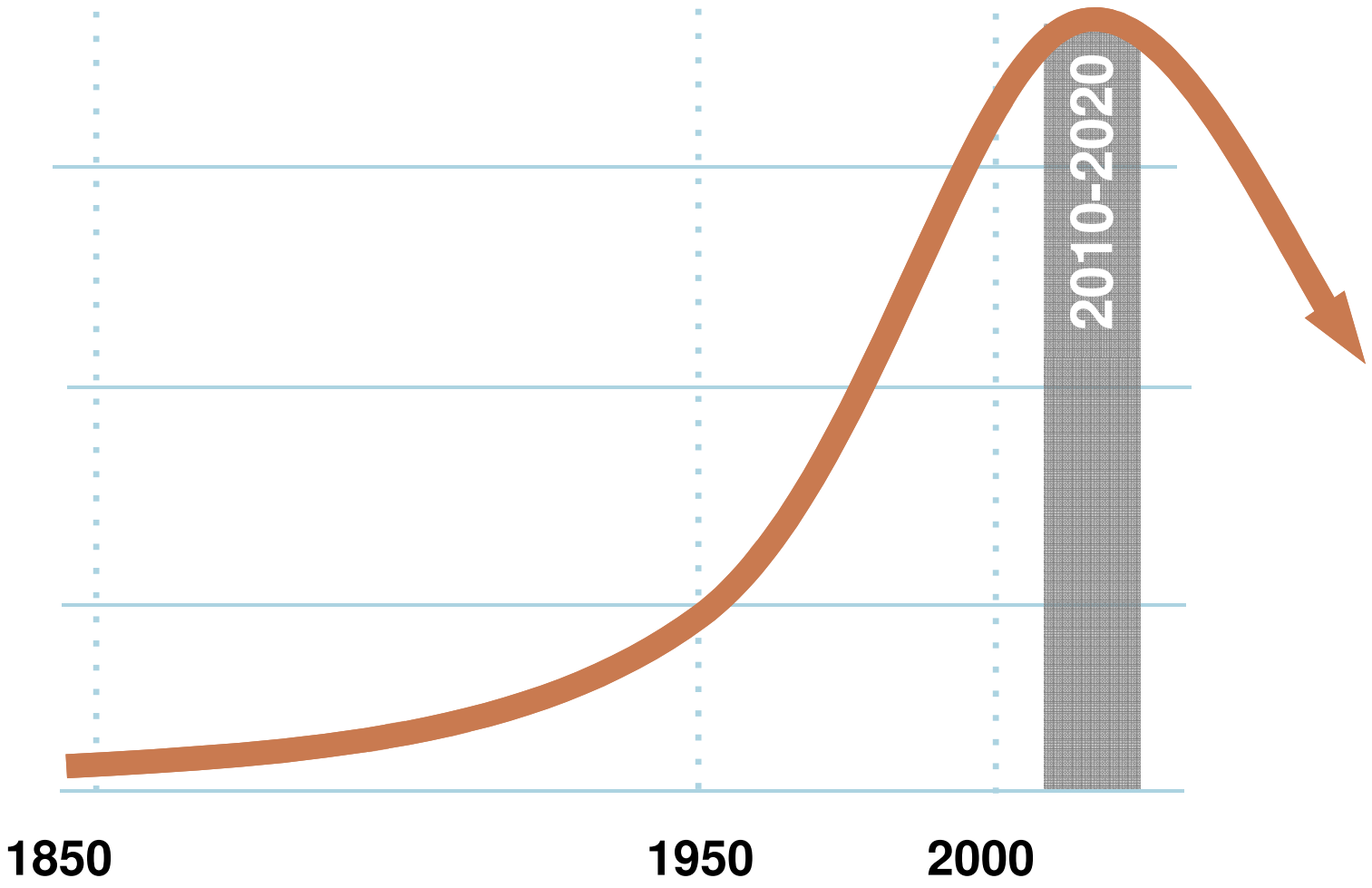
Wilson, the Diversity of Life.

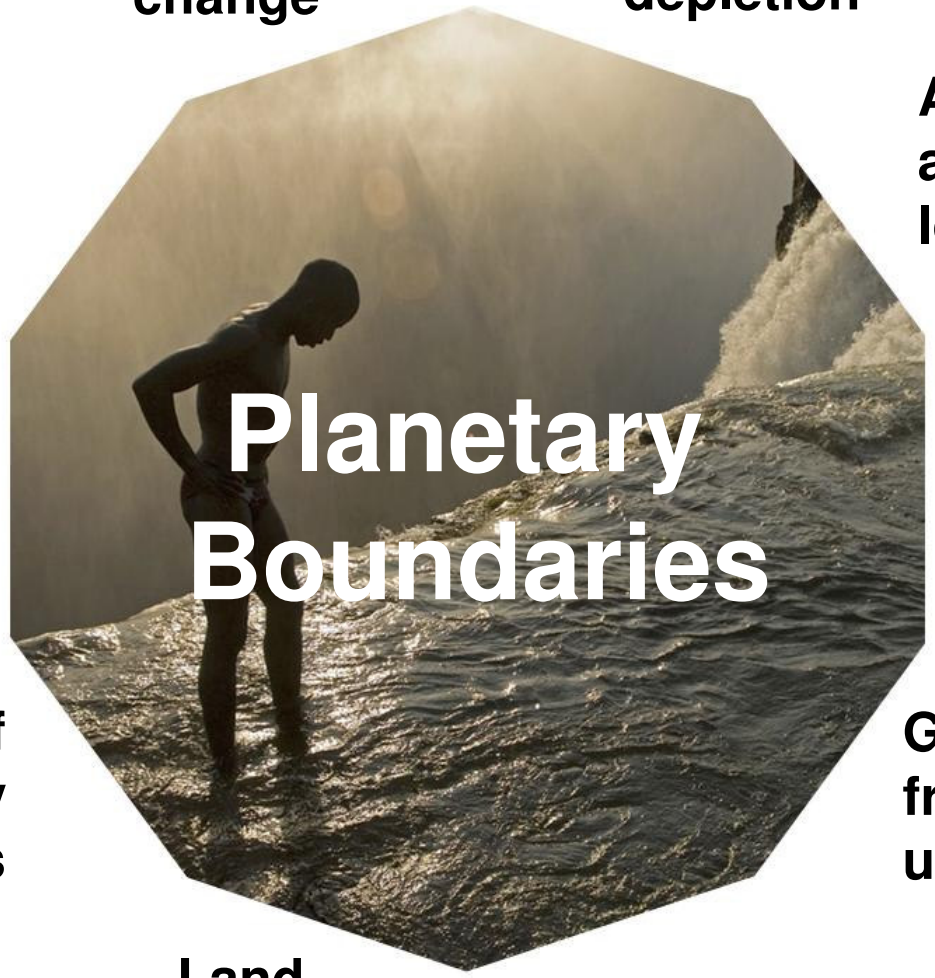
IGBP synthesis: Global Change and the Earth System, Steffen *et al*/2004

The great acceleration



Bend the curves!





Climate change

Ozone depletion

Atmospheric aerosol loading

Biogeochemical loading: Global N & P cycles

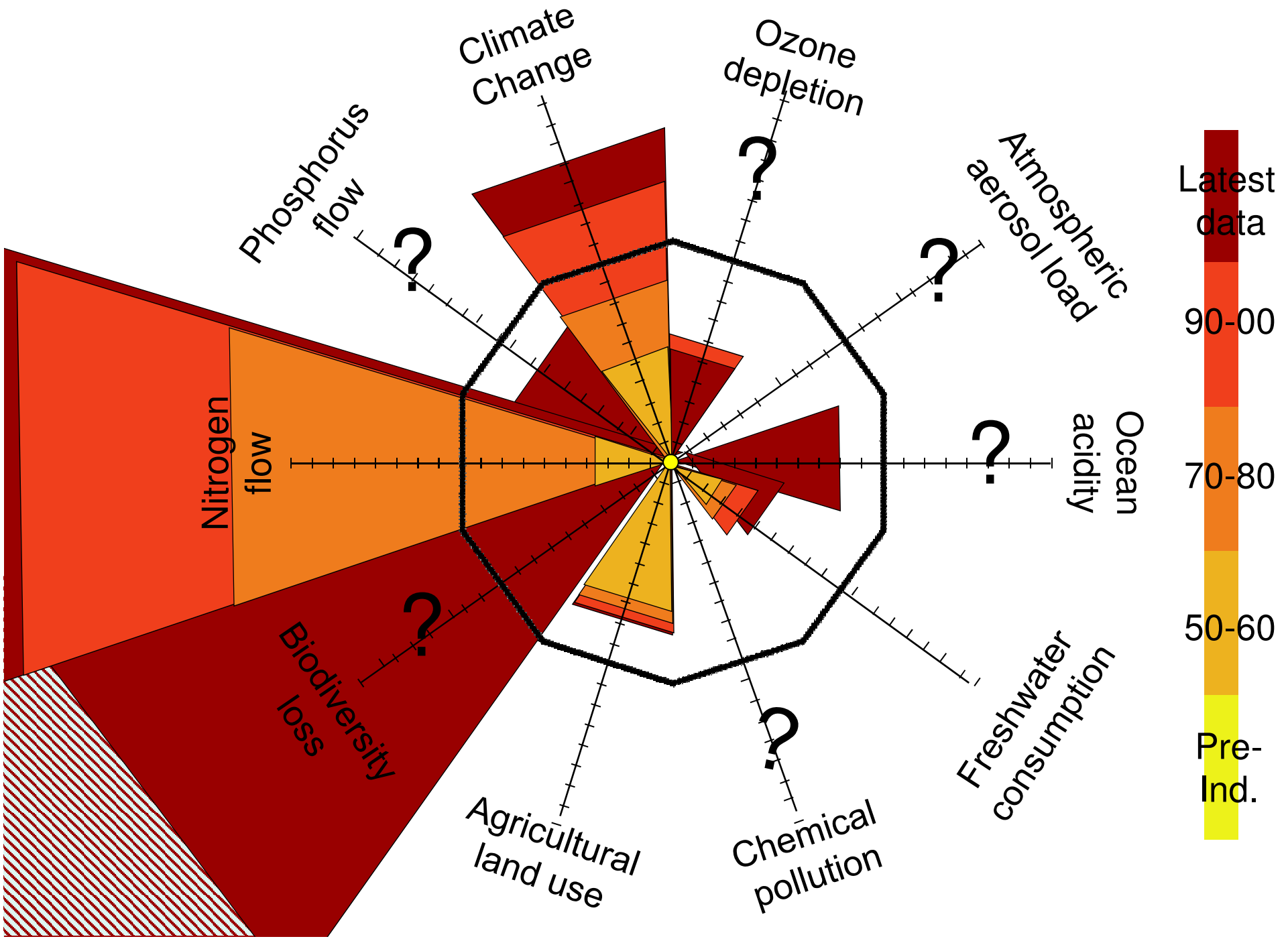
Ocean acidification

Rate of biodiversity loss

Global freshwater use

Land system change

Chemical pollution


Climate Change
Ozone depletion
Atmospheric aerosol load
Ocean acidity
Freshwater consumption
Chemical pollution
Agricultural land use
Biodiversity loss
Nitrogen flow
Phosphorus flow
?
?
?
?
?
?
?
?
Latest data
90-00
70-80
50-60
Pre-Ind.

Causes of Climate Changes Prior to the Industrial Era (pre-1780)

Changes in the Earth's Orbit

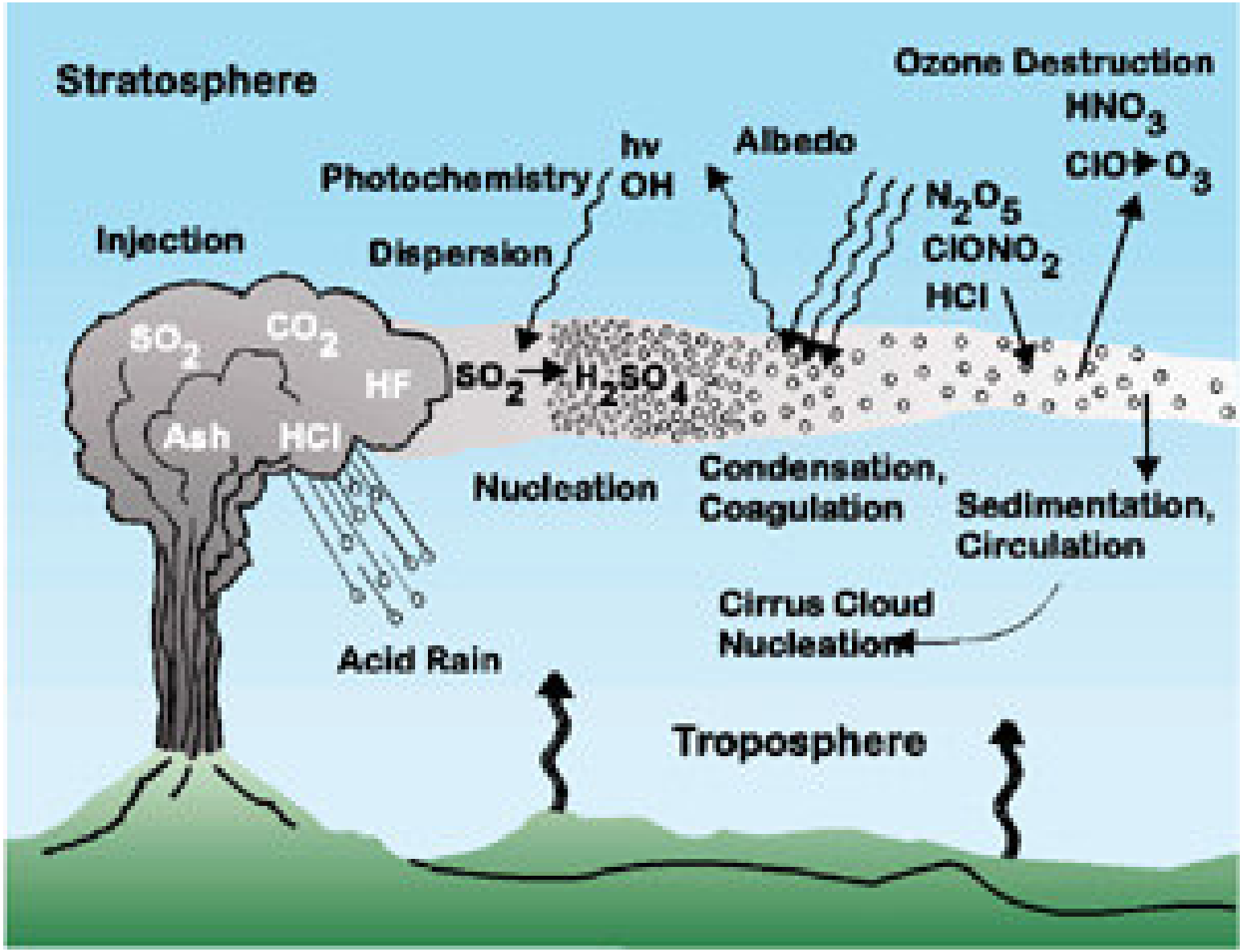
Changes in the shape of the Earth's orbit (or eccentricity) as well as the Earth's tilt and precession affect the amount of sunlight received on the Earth's surface. These orbital processes -- which function in cycles of 100,000 (eccentricity), 41,000 (tilt), and 19,000 to 23,000 (precession) years -- are thought to be the most significant drivers of ice ages according to the theory of Mulitin Milankovitch, a Serbian mathematician (1879-1958).

Changes in the Sun's Intensity

Changes occurring within (or inside) the sun can affect the intensity of the sunlight that reaches the Earth's surface. The intensity of the sunlight can cause either warming (for stronger solar intensity) or cooling (for weaker solar intensity). According to NASA research, reduced solar activity from the 1400s to the 1700s was likely a key factor in the “Little Ice Age” which resulted in a slight cooling of North America, Europe and probably other areas around the globe.

Volcanic Eruptions

Volcanoes can affect the climate because they can emit aerosols and carbon dioxide into the atmosphere.


Stratosphere
Ozone Destruction
HNO_3
ClO → O_3
hv
OH
Photochemistry
Albedo
N_2O_5
$ClONO_2$
HCl
Injection
Dispersion
SO_2
CO_2
HF
Ash
HCl
SO_2 → H_2SO_4
Nucleation
Condensation,
Coagulation
Sedimentation,
Circulation
Cirrus Cloud
Nucleation
Acid Rain
Troposphere

Aerosol Emissions

Volcanic aerosols tend to block sunlight and contribute to short term cooling. Aerosols do not produce long-term change because they leave the atmosphere not long after they are emitted. According to the United States Geological Survey (USGS), the eruption of the Tambora Volcano in Indonesia in 1815 lowered global temperatures by as much as 5ºF and historical accounts in New England describe 1816 as “the year without a summer.”

Carbon Dioxide Emissions

•Volcanoes also emit carbon dioxide (CO2), a greenhouse gas, which has a warming effect.

•While volcanoes may have raised pre-historic CO2 levels and temperatures, according to the USGS Volcano Hazards Program, human activities now emit 150 times as much CO2 as volcanoes (whose emissions are relatively modest compared to some earlier times).

Do the Earth's volcanoes emit more CO_2 than human activities?

"No." Human activities, responsible for some 36,300 million metric tons of CO_2 emissions in 2008 [Le Quéré et al., 2009], release at least a hundred times more CO_2 annually than all the world's degassing subaerial and submarine volcanoes (Gerlach, 2010).