

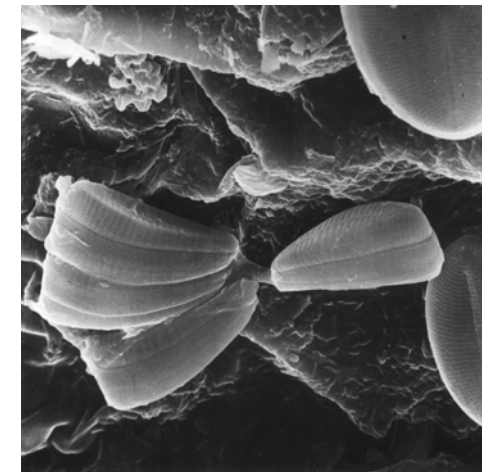
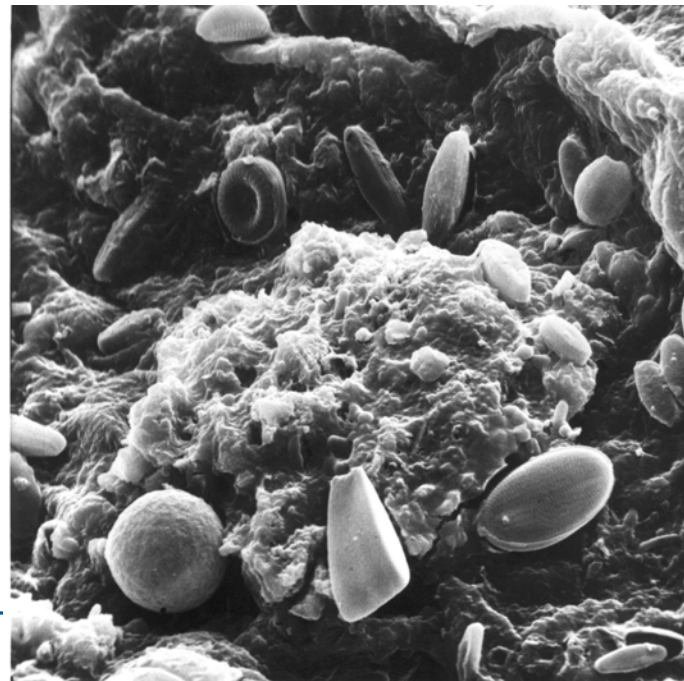
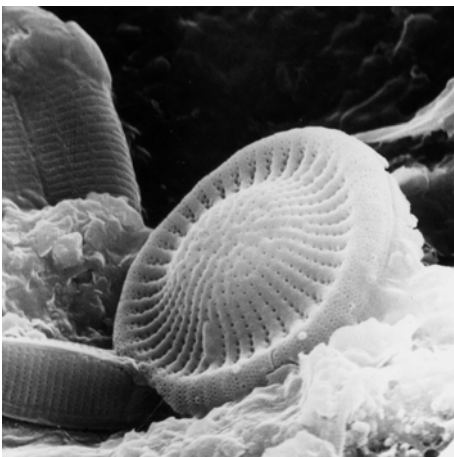
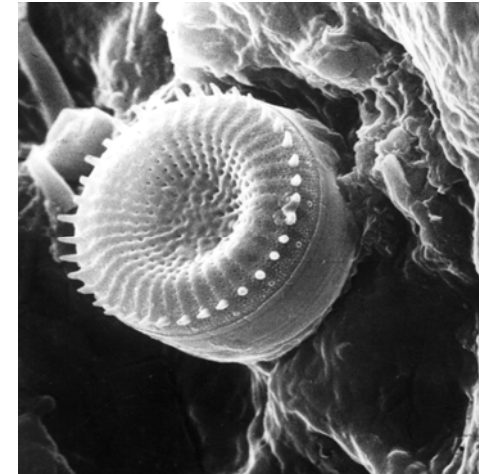
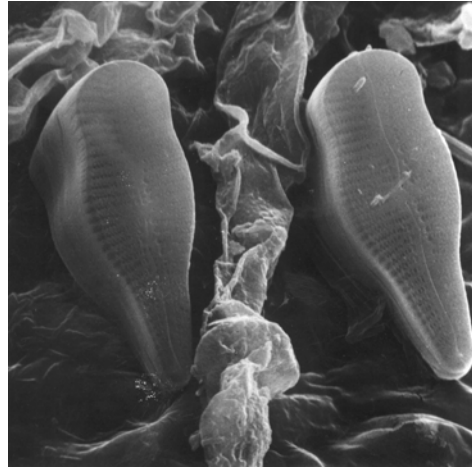
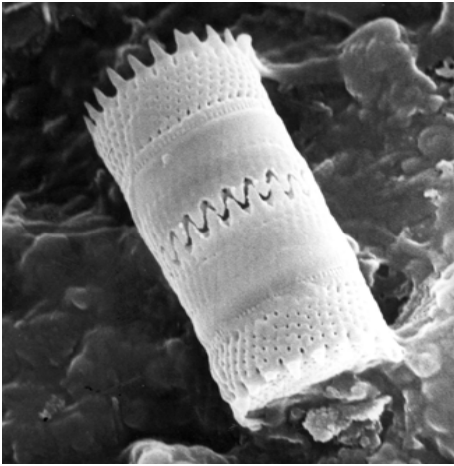


The relationship between land use and climate change: a historical overview

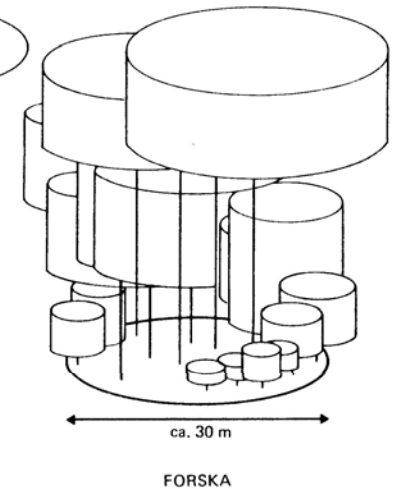
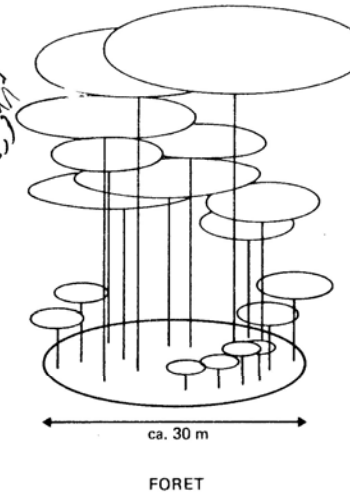
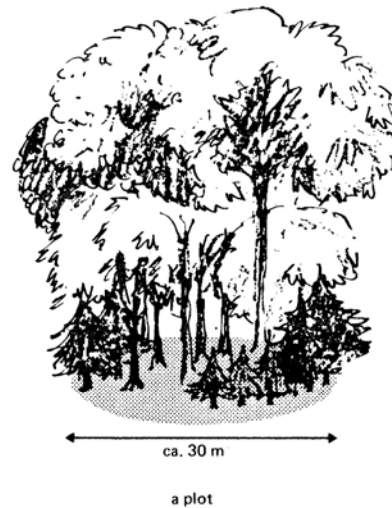
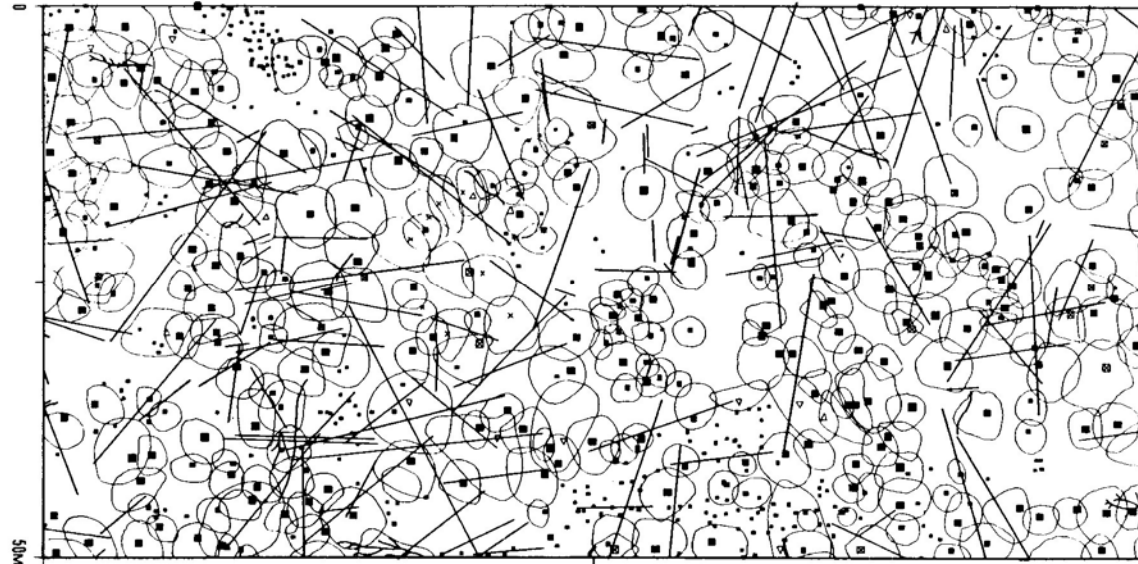
By Rik Leemans



Diatoms on the floating leaves of the waterlily



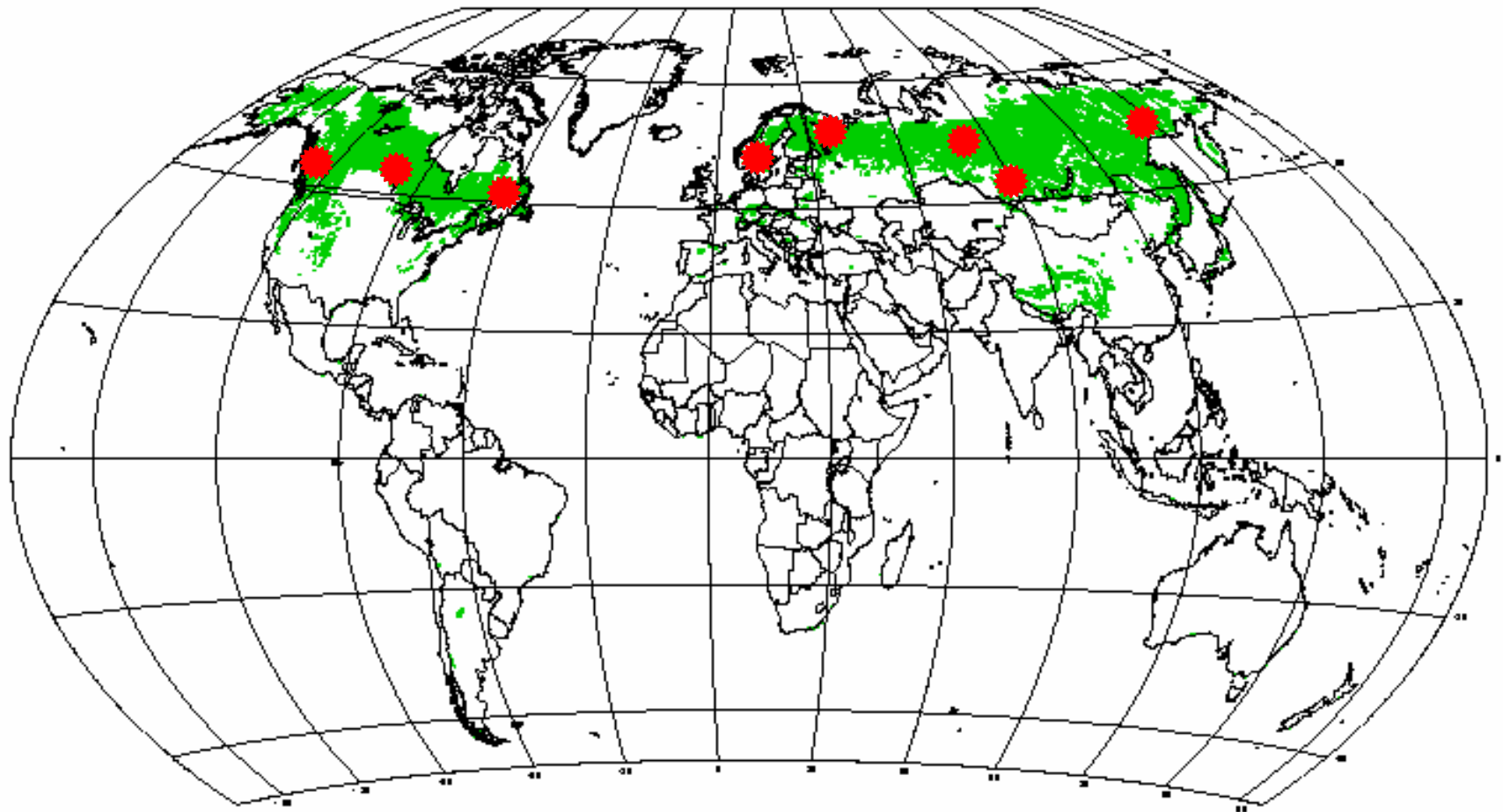
PhD Dynamics of boreal forests (seedlings & trees)



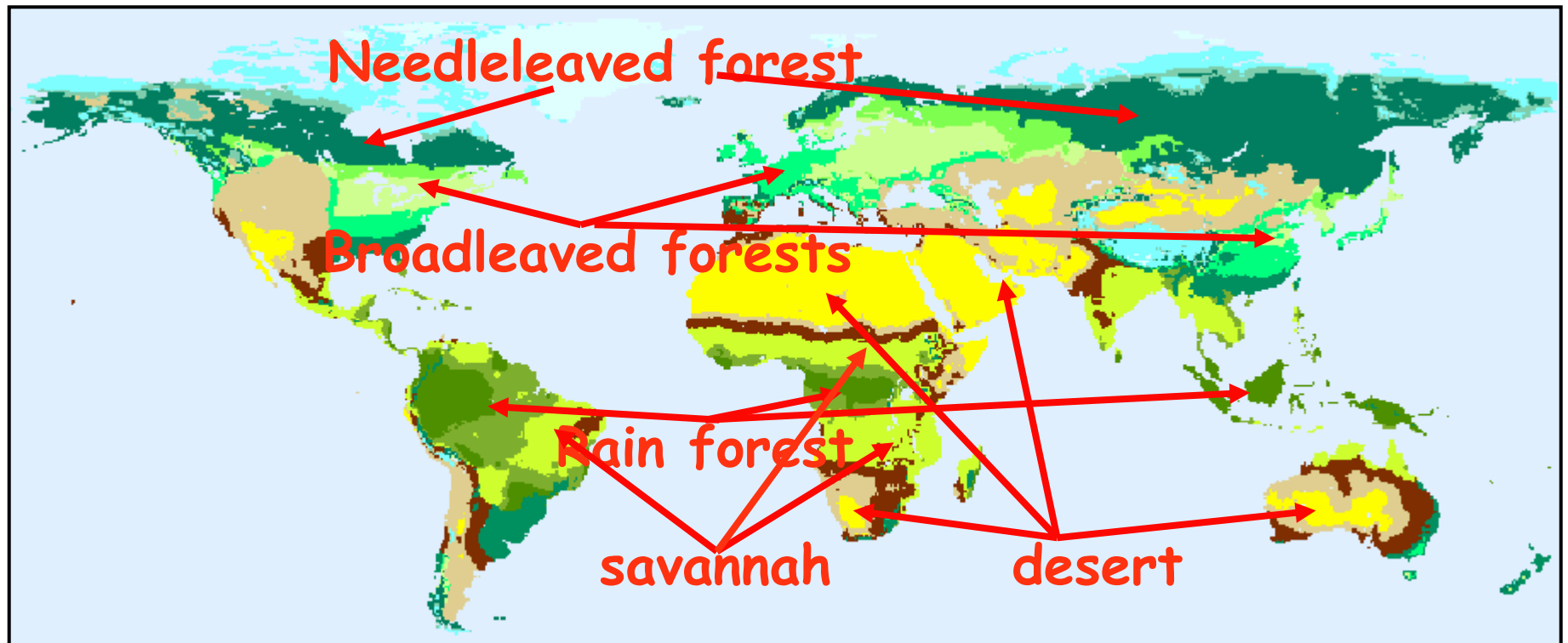
IIASA Laxenburg Austria



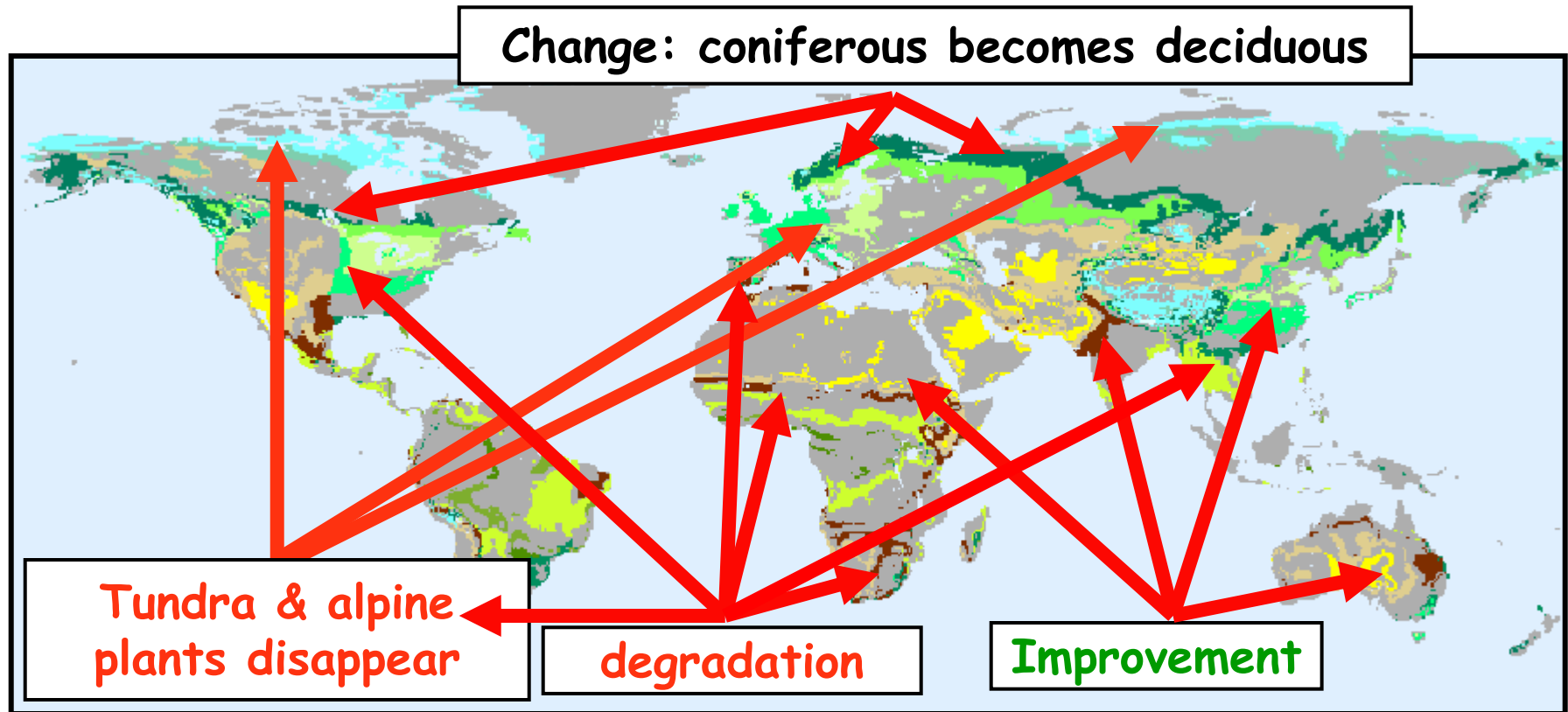
Modeling the circumolar boreal forest



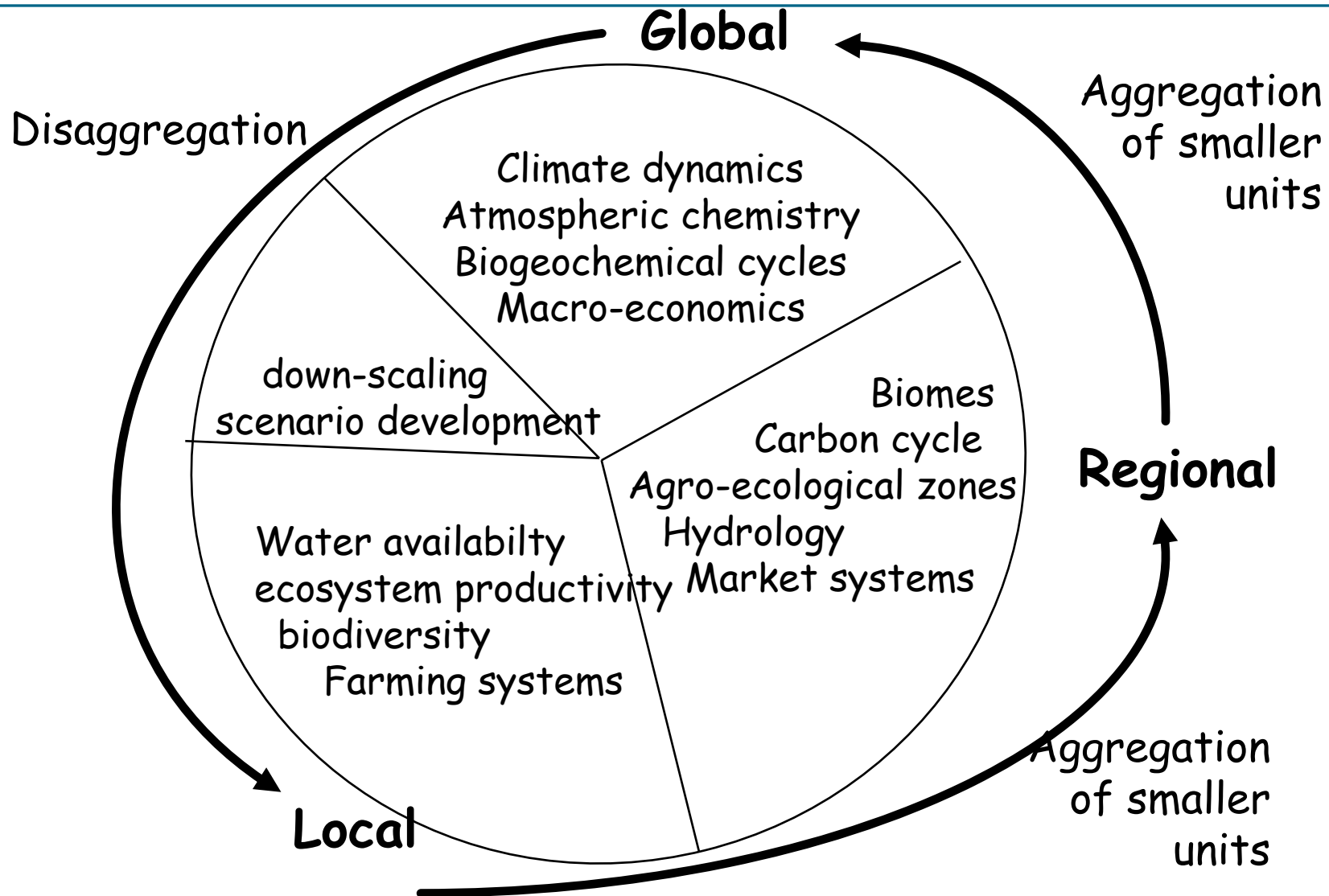
Biome: global vegetation patterns



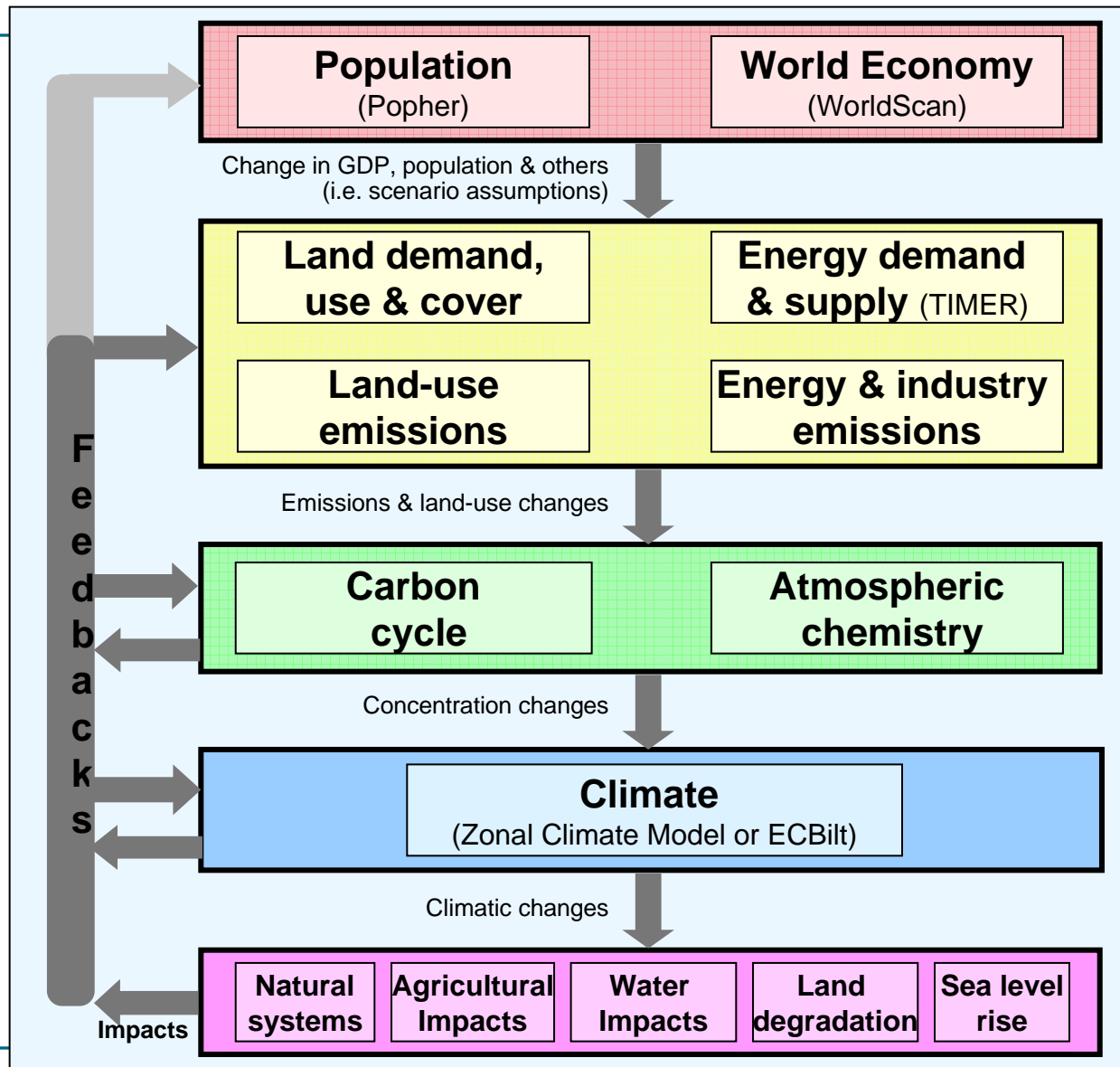
Climate change impacts (Biome shifts at 3°C)



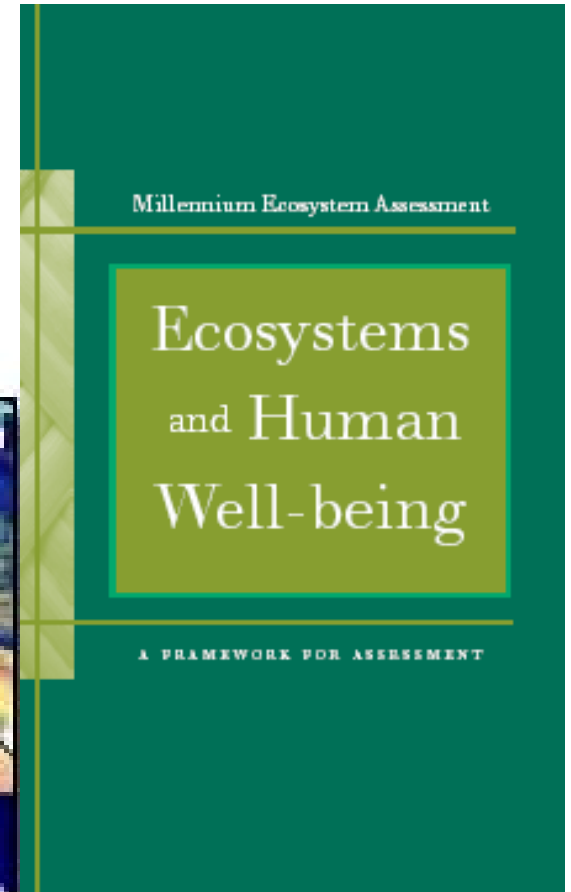
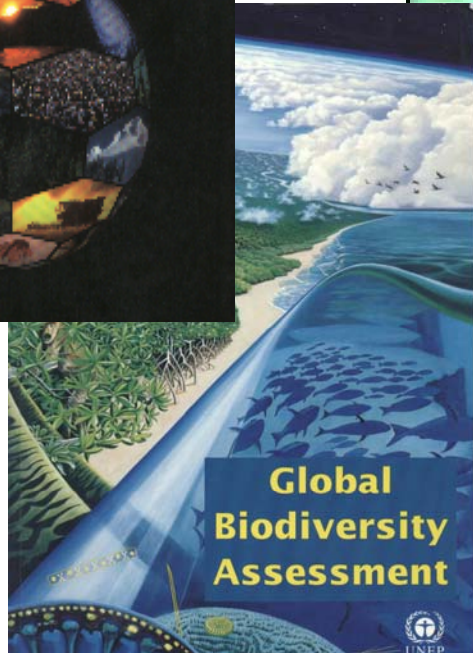
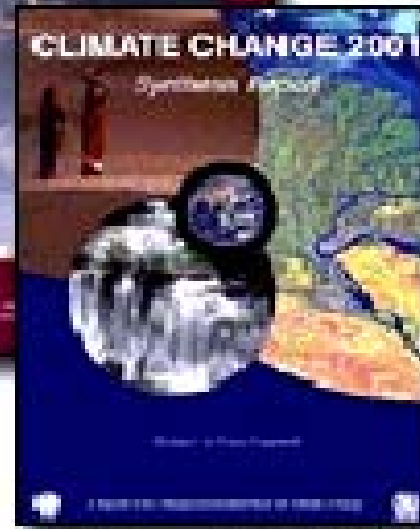
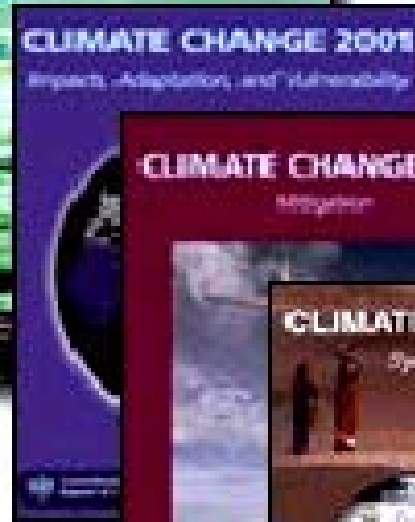
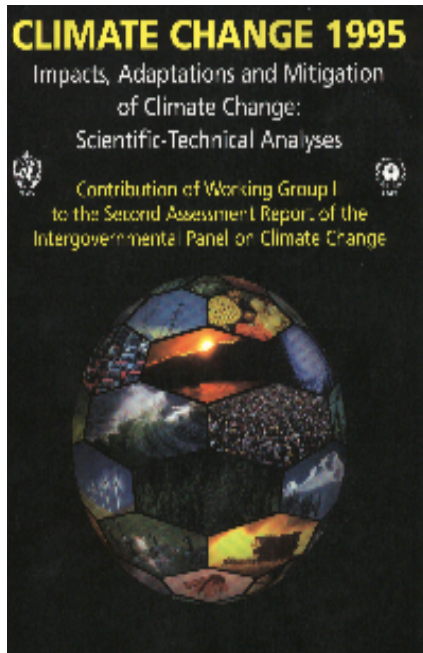
Integrative Modelling Framework



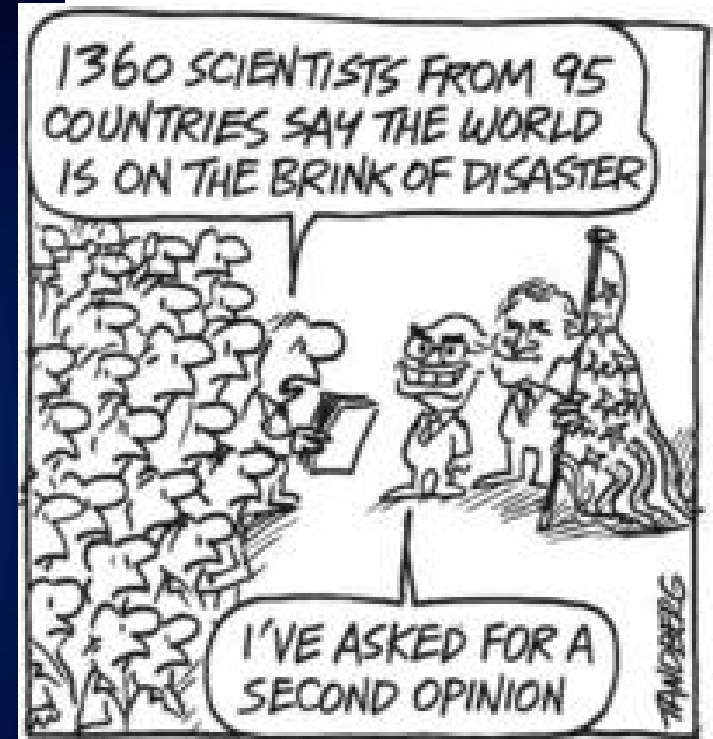
The IMAGE-2 model



Scientific assessments assessments for policy development



Chairing the Responses WG of the Millennium Ecosystem Assessment

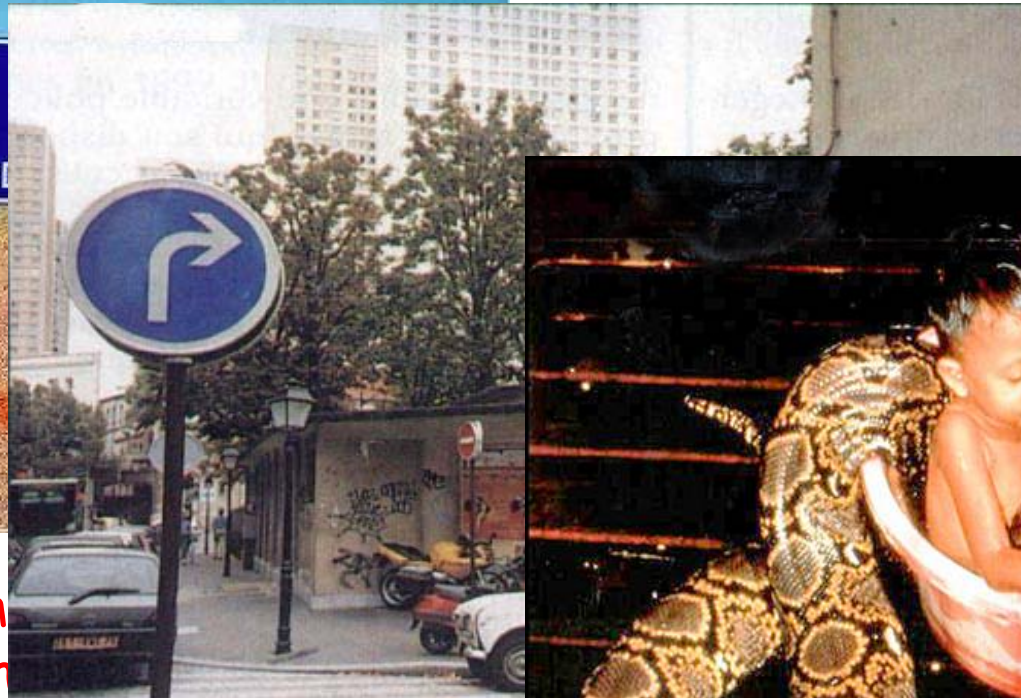


The Australian, 30 March 2005

Communicating to policymakers



There is some
with the



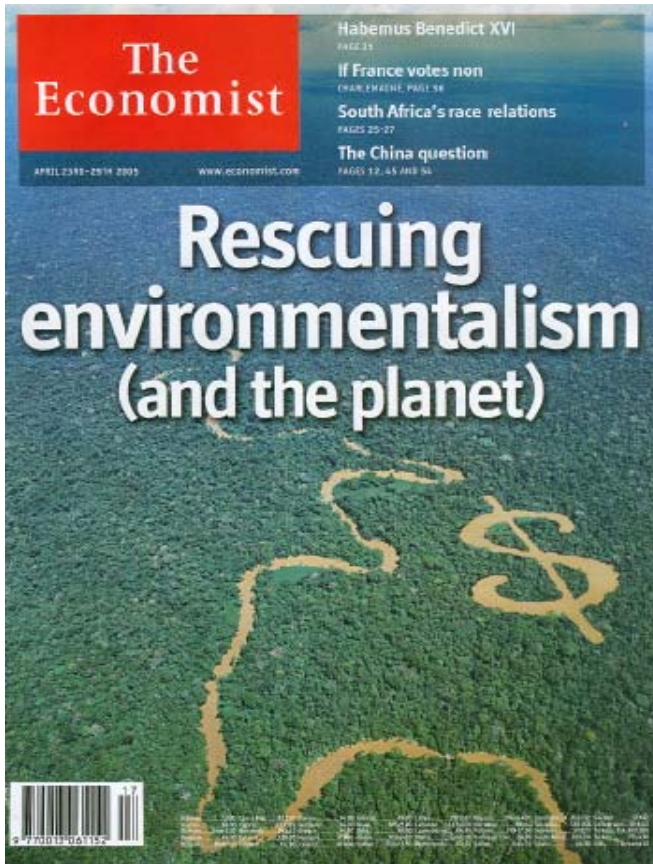
General feeling of



But perceptions of risks may differ

This MA findings are being picked up:

www.MAweb.org



The Economist, 25-4-2005
 Editorial, page 11, Cover article pp. 77-81



www.sciencemag.org SCIENCE VOL 308 1 APRIL 2005 41

Science, 308 (2005) 41-43

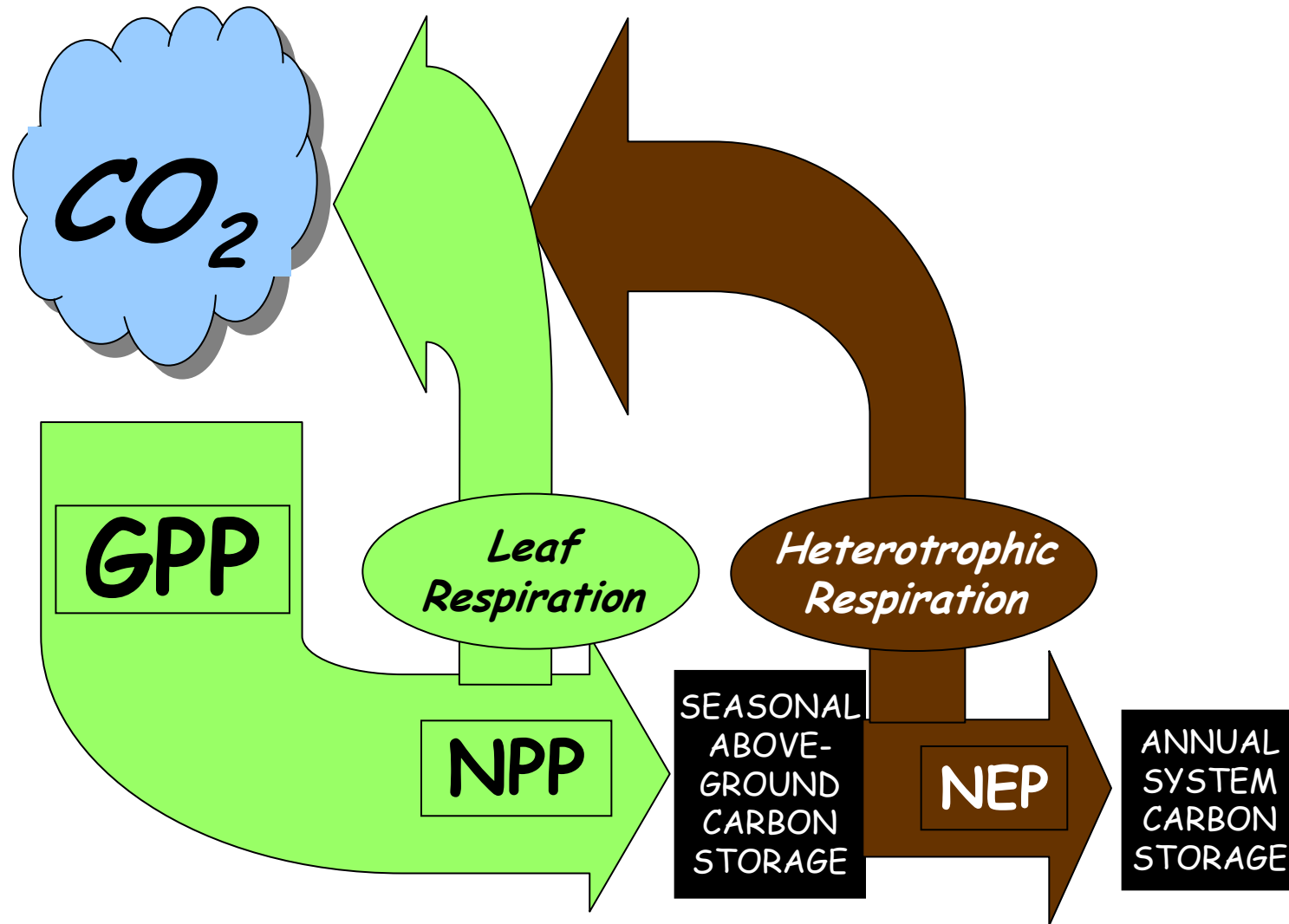
Land use change in the eighties

Early global carbon models (e.g. Goudriaan, 1984) included:

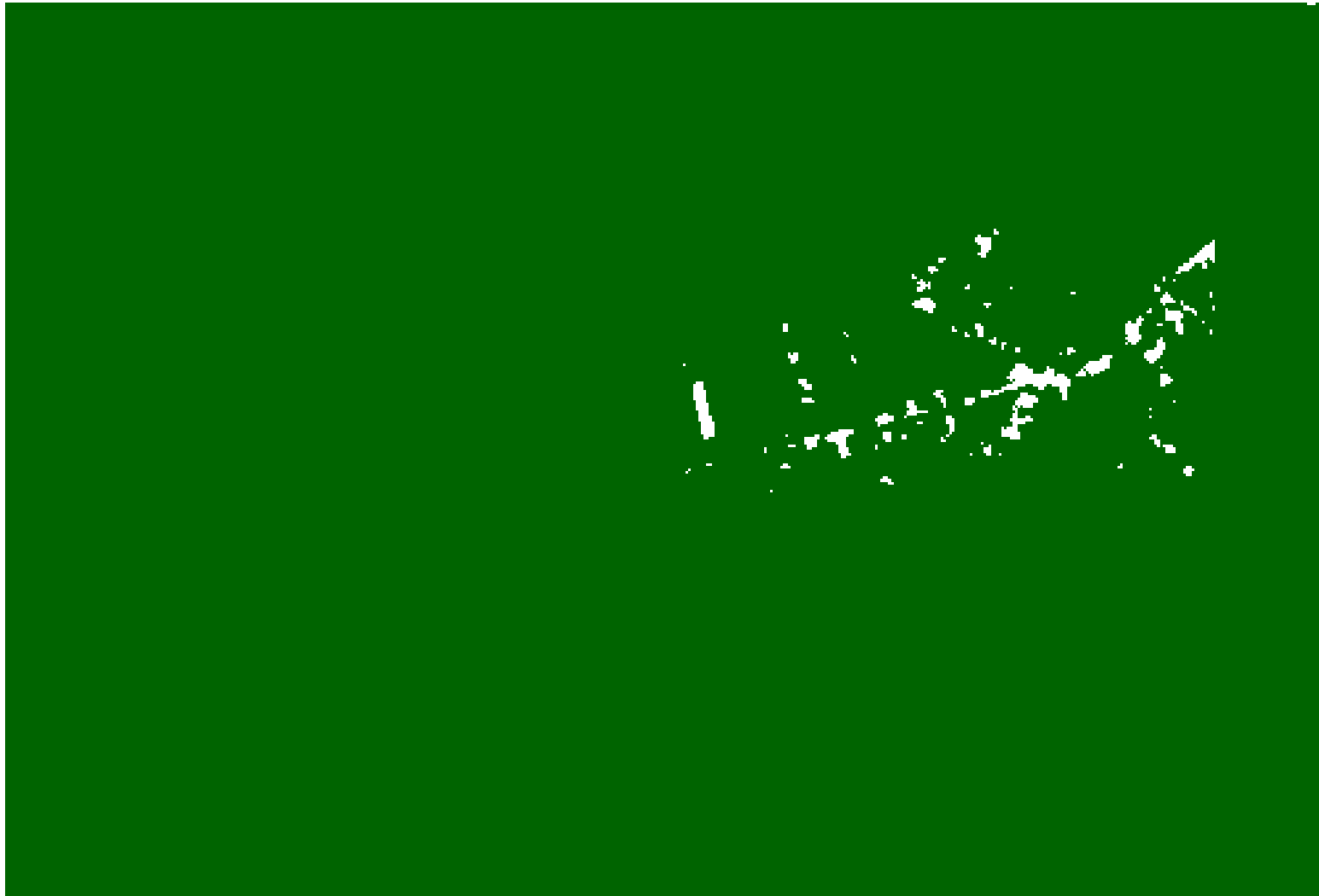
- Major vegetation types
- Deforestation rates as the major land use change
- Photosynthesis and respiration
- Vegetation development (logistic curves)
- CO_2 fertilization (β -factor)

In IS92 IPCC scenarios deforestation trends extrapolated to the future. Deforestation as the only source of land-use related CO_2 emissions.

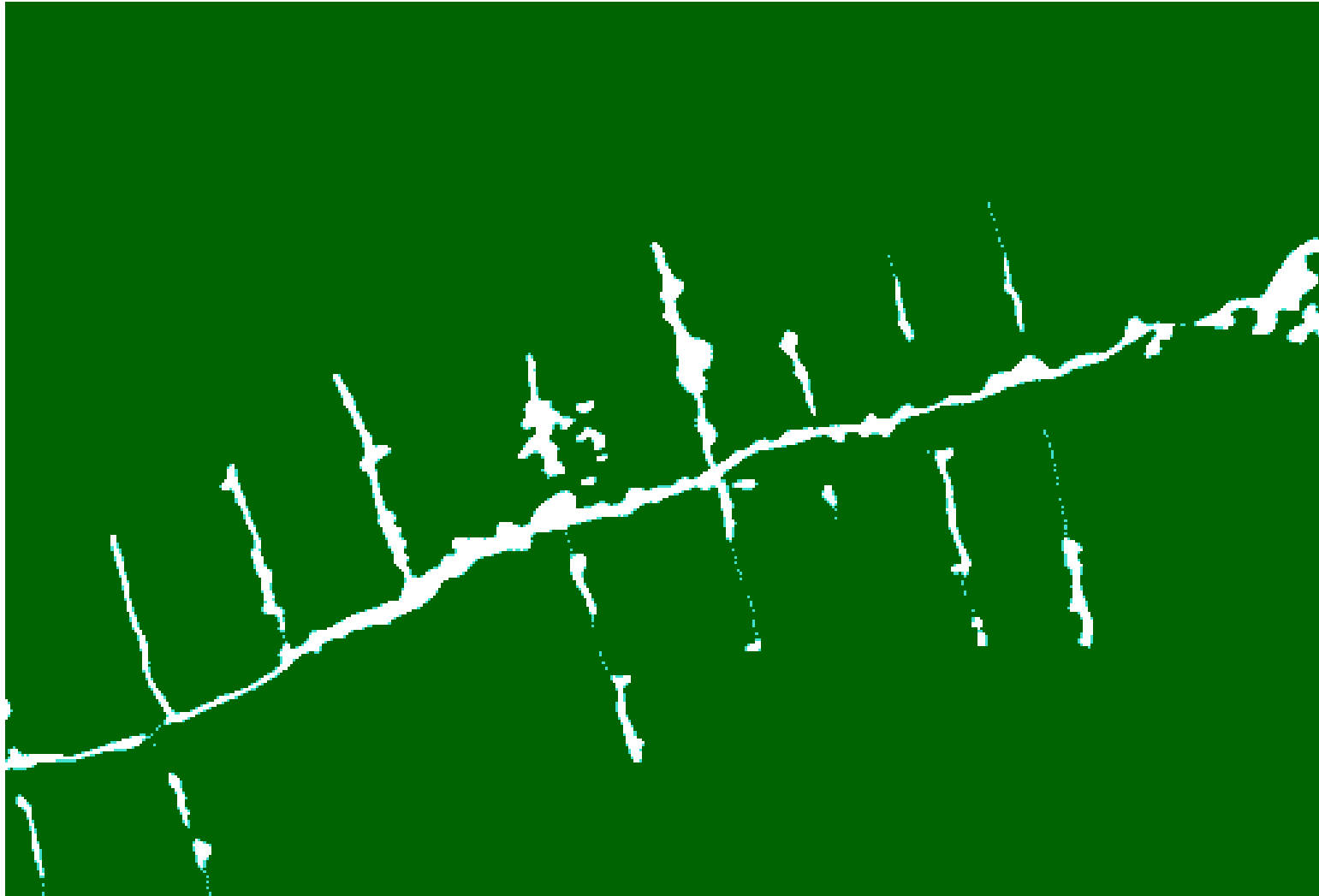
TERRESTRIAL CARBON CYCLE COMPONENTS



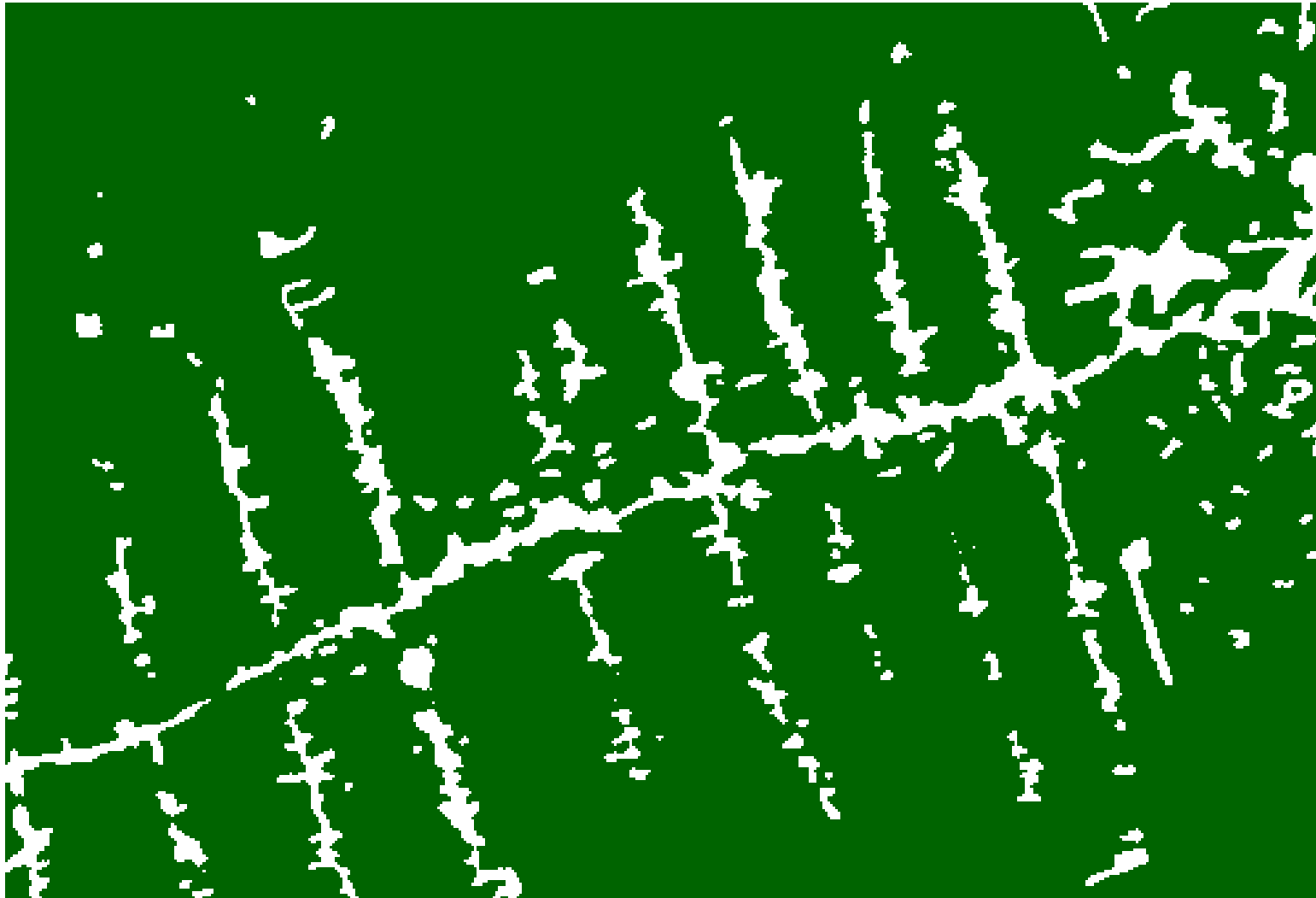
Deforestation in the Amazon 1970



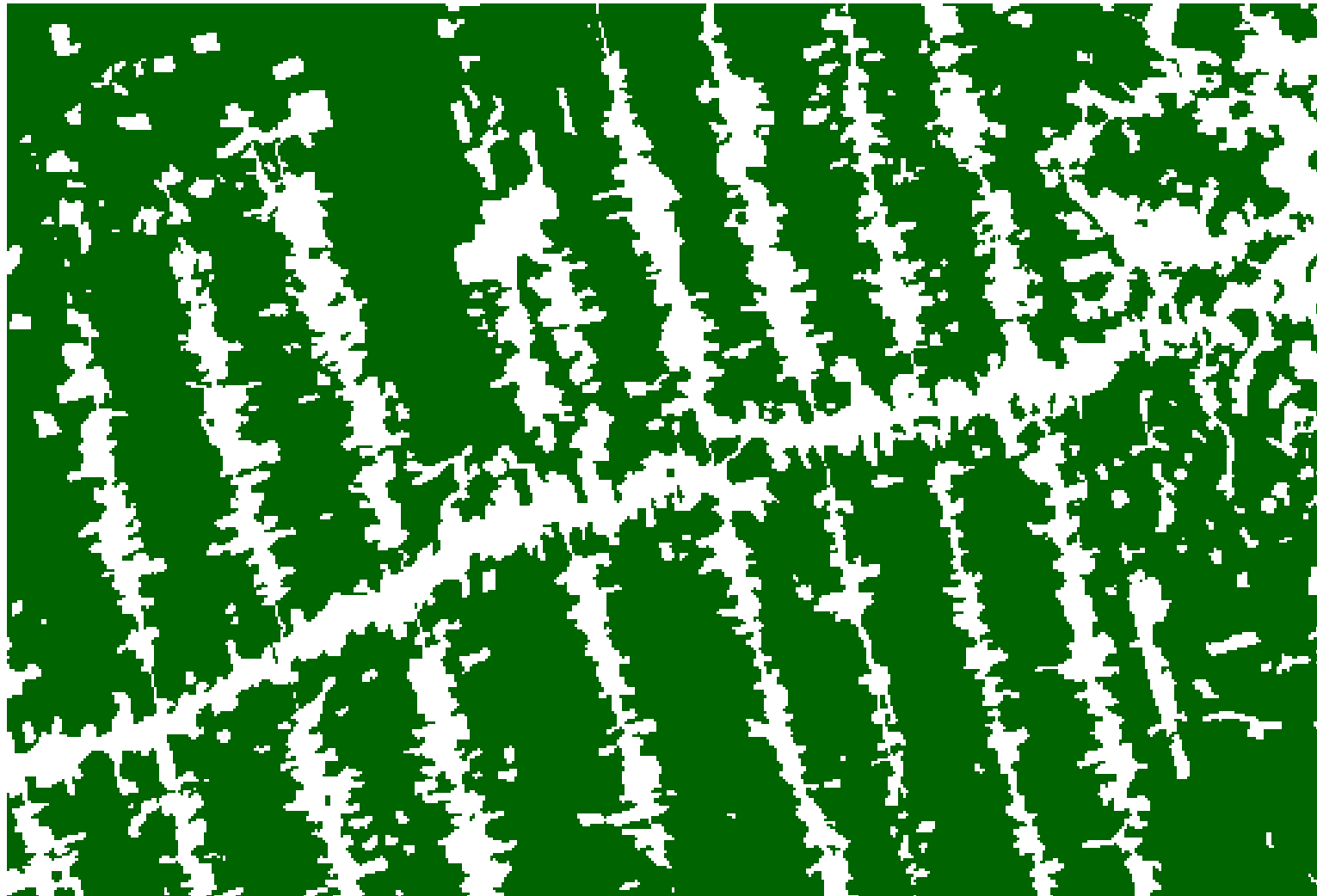
Deforestation in the Amazon 1973



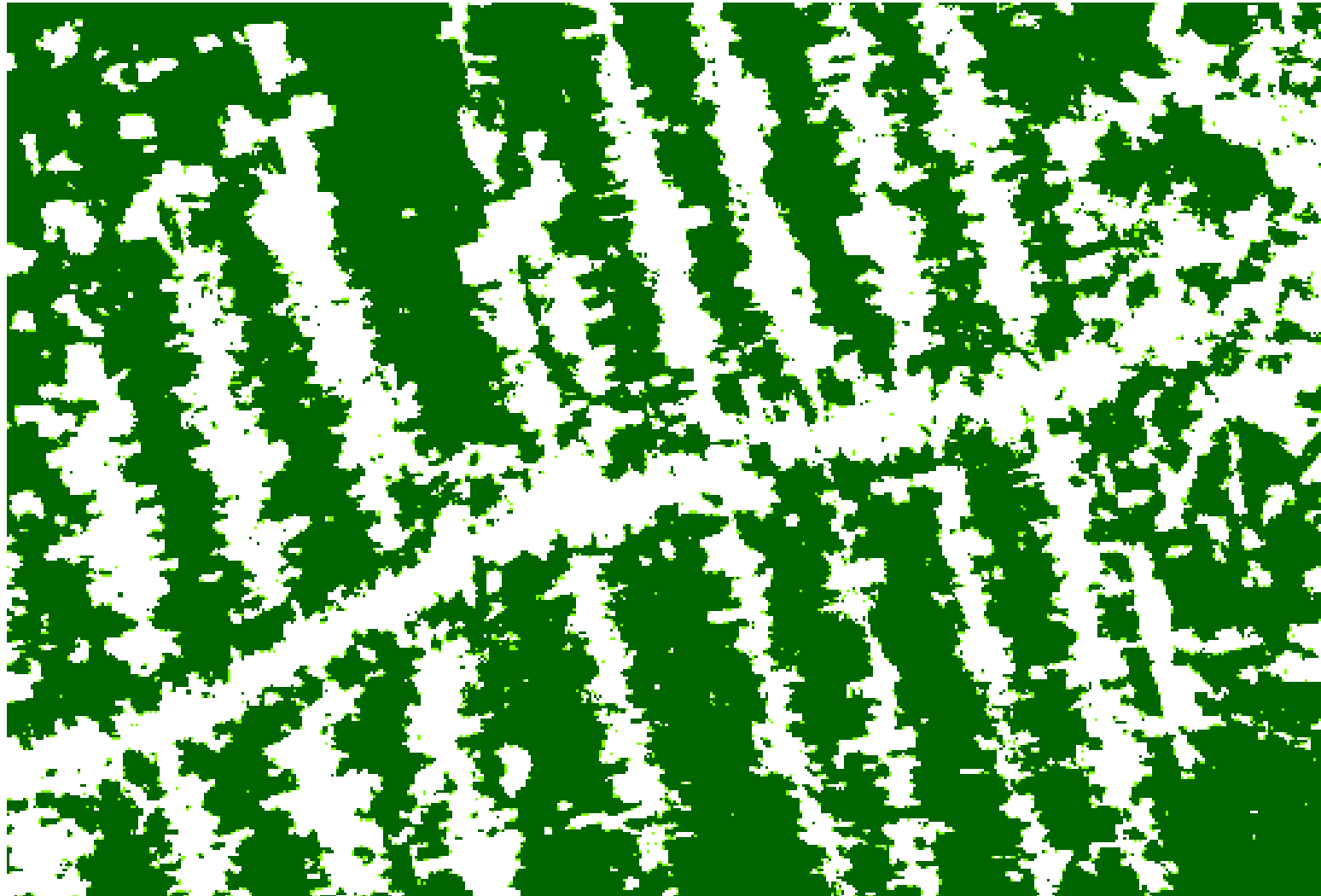
Deforestation in the Amazon 1976



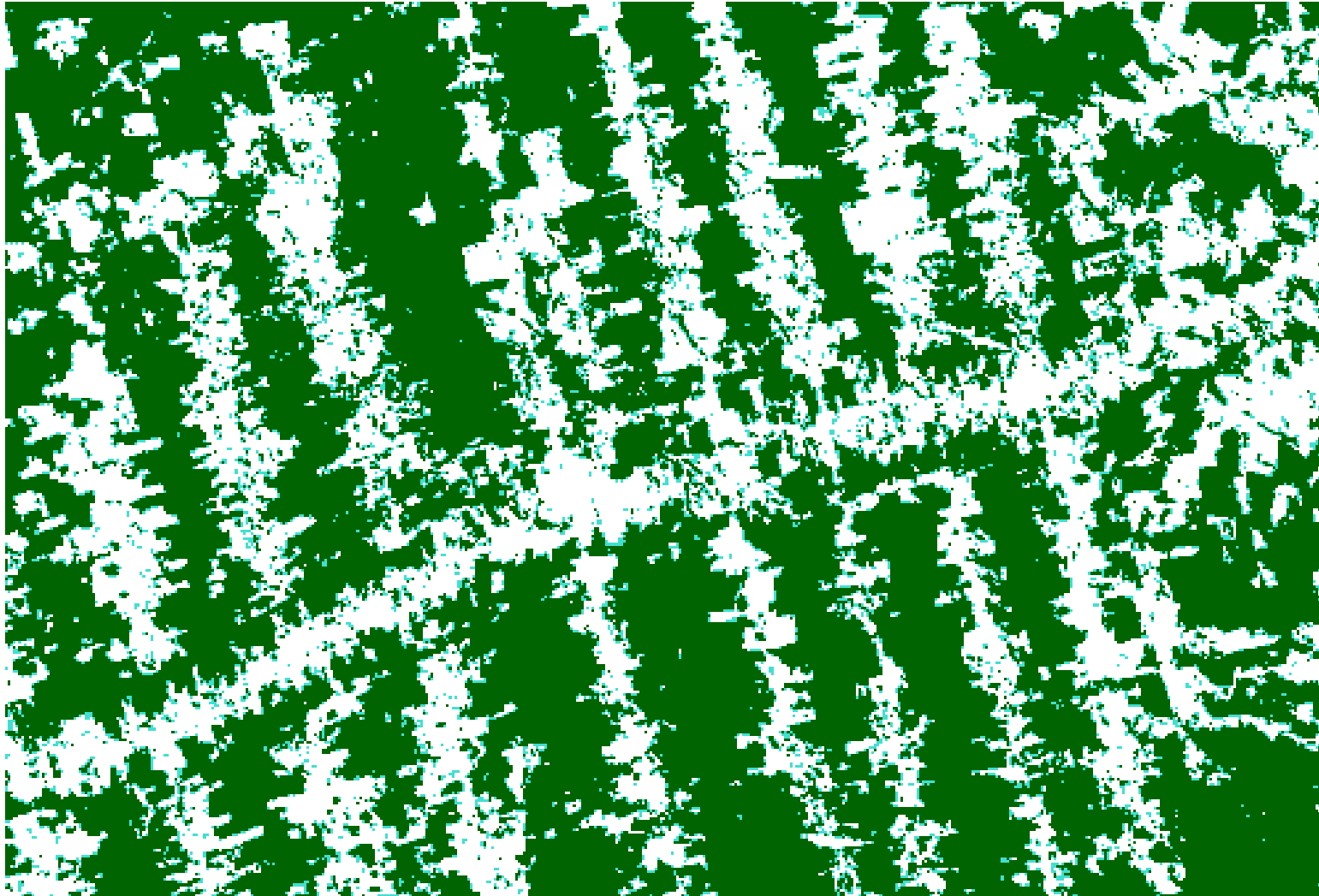
Deforestation in the Amazon 1978



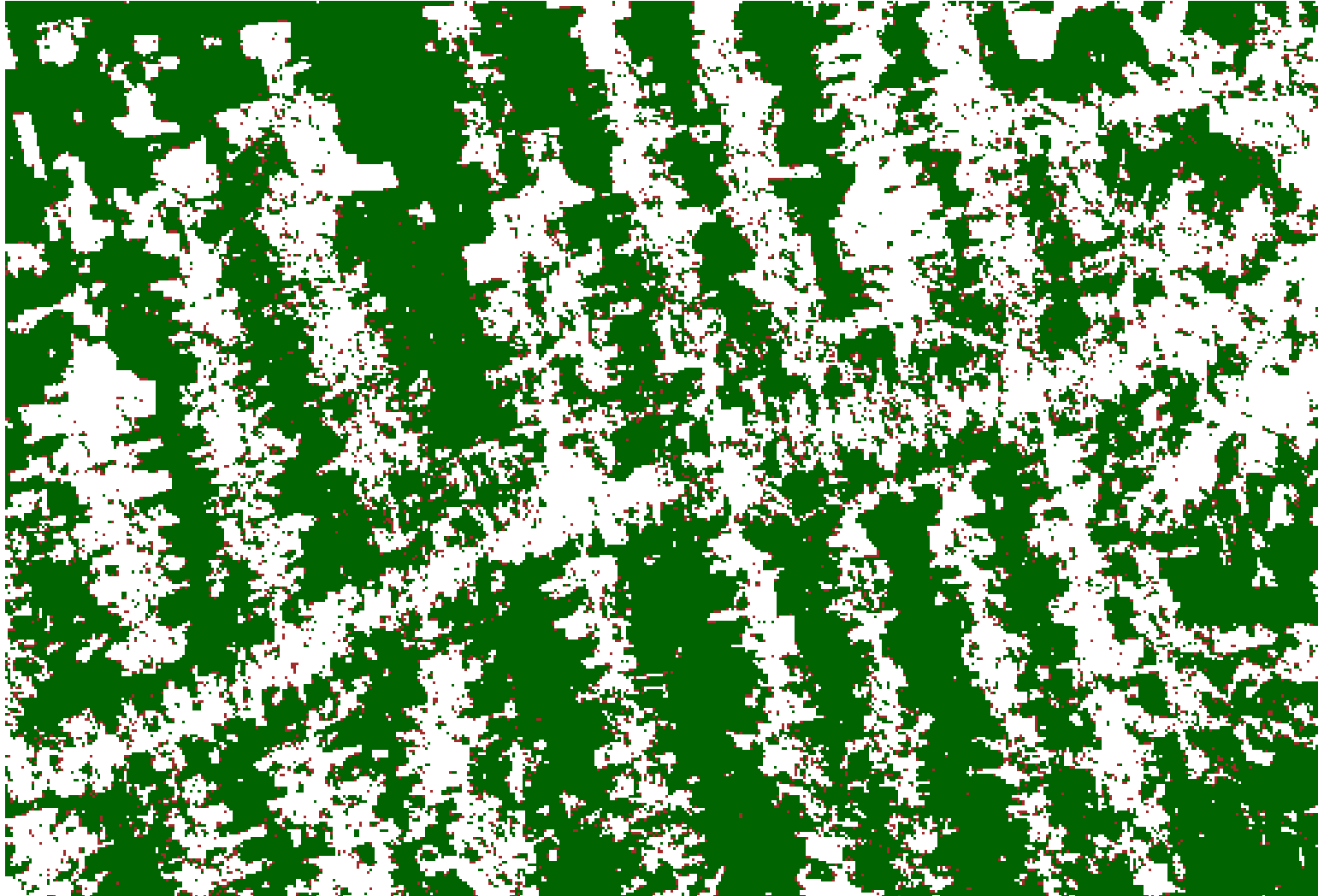
Deforestation in the Amazon 1985



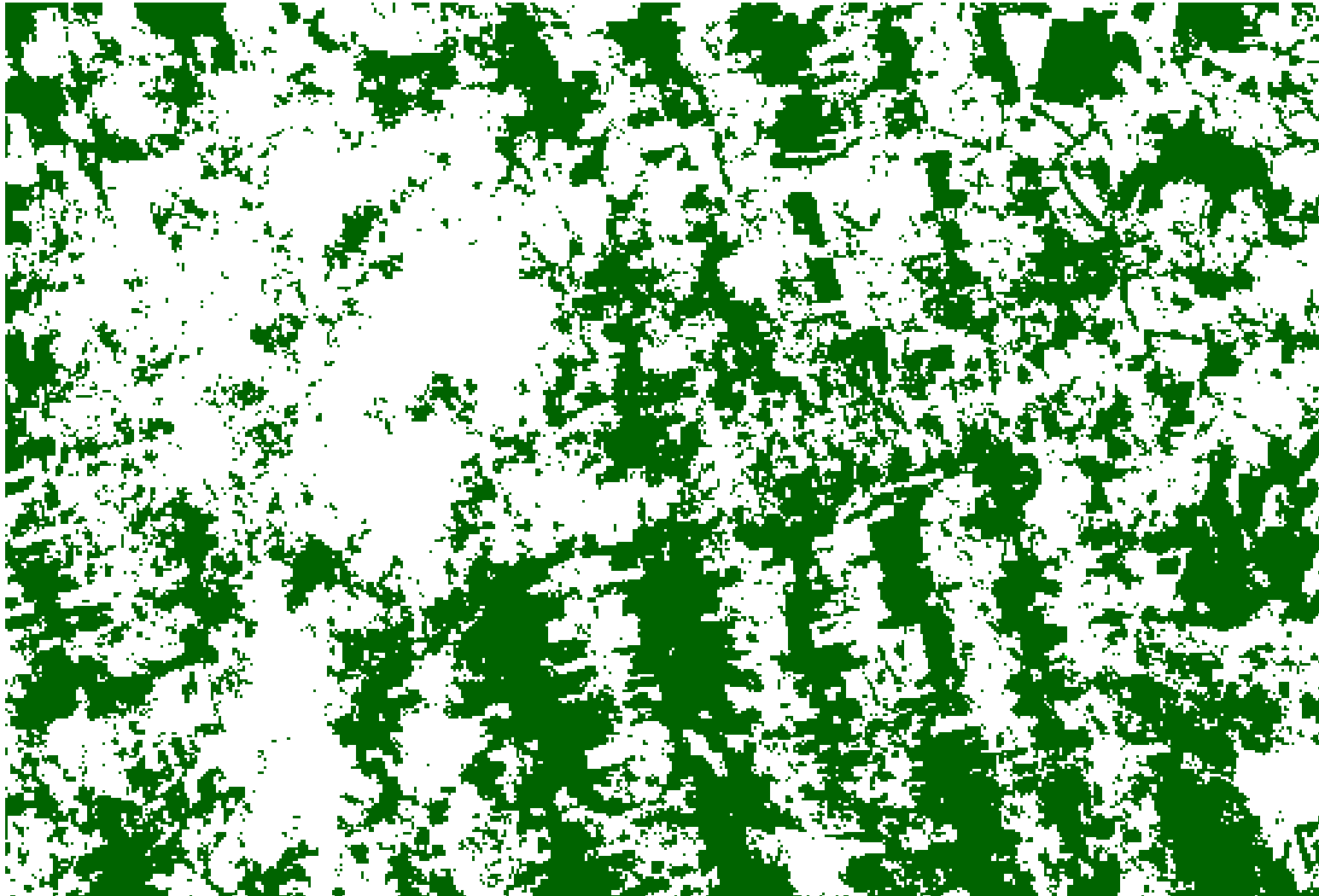
Deforestation in the Amazon 1988



Deforestation in the Amazon 1991



Deforestation in the Amazon 1996



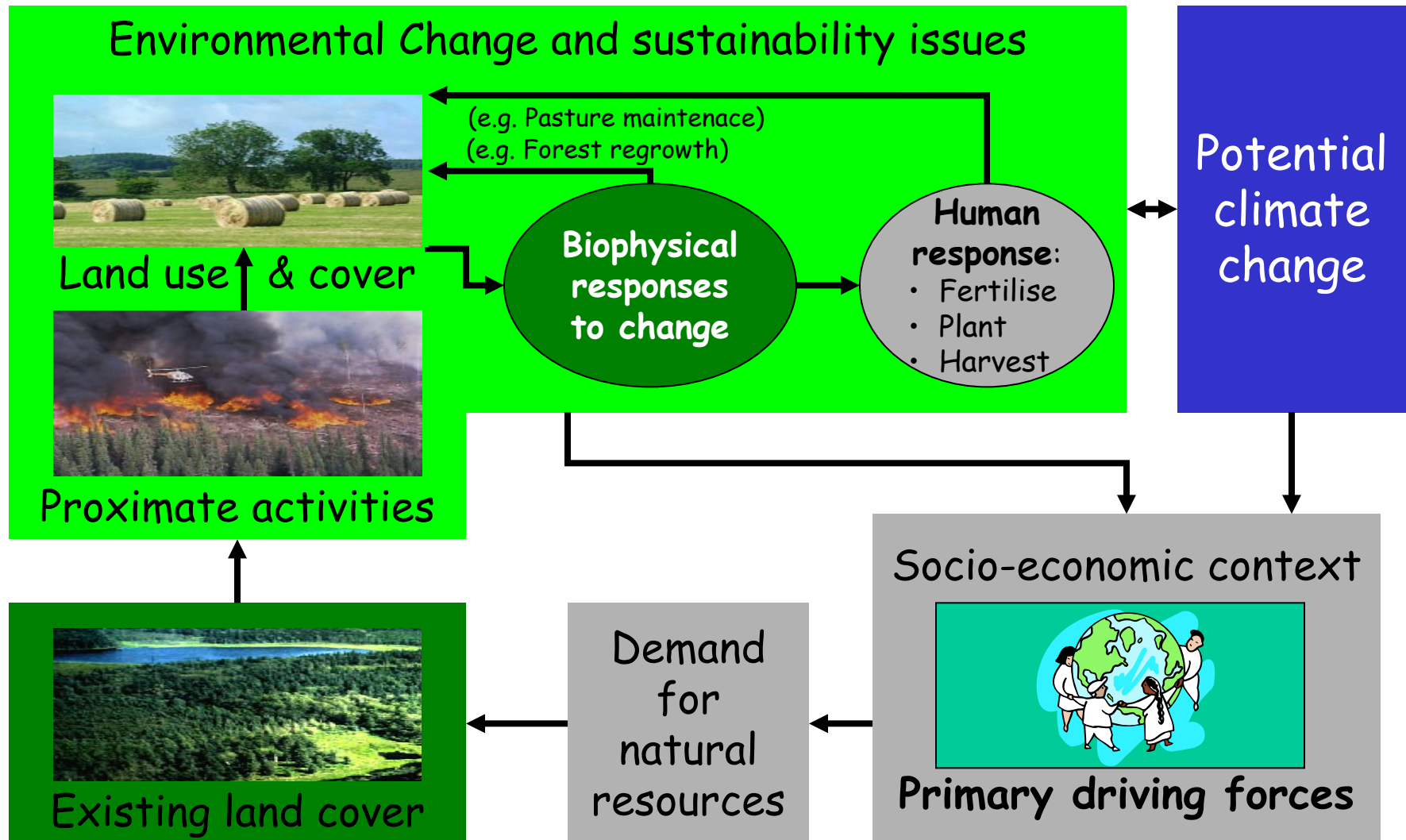
1993: IGBP-IHDP LUCC established

Major landmark in global change research

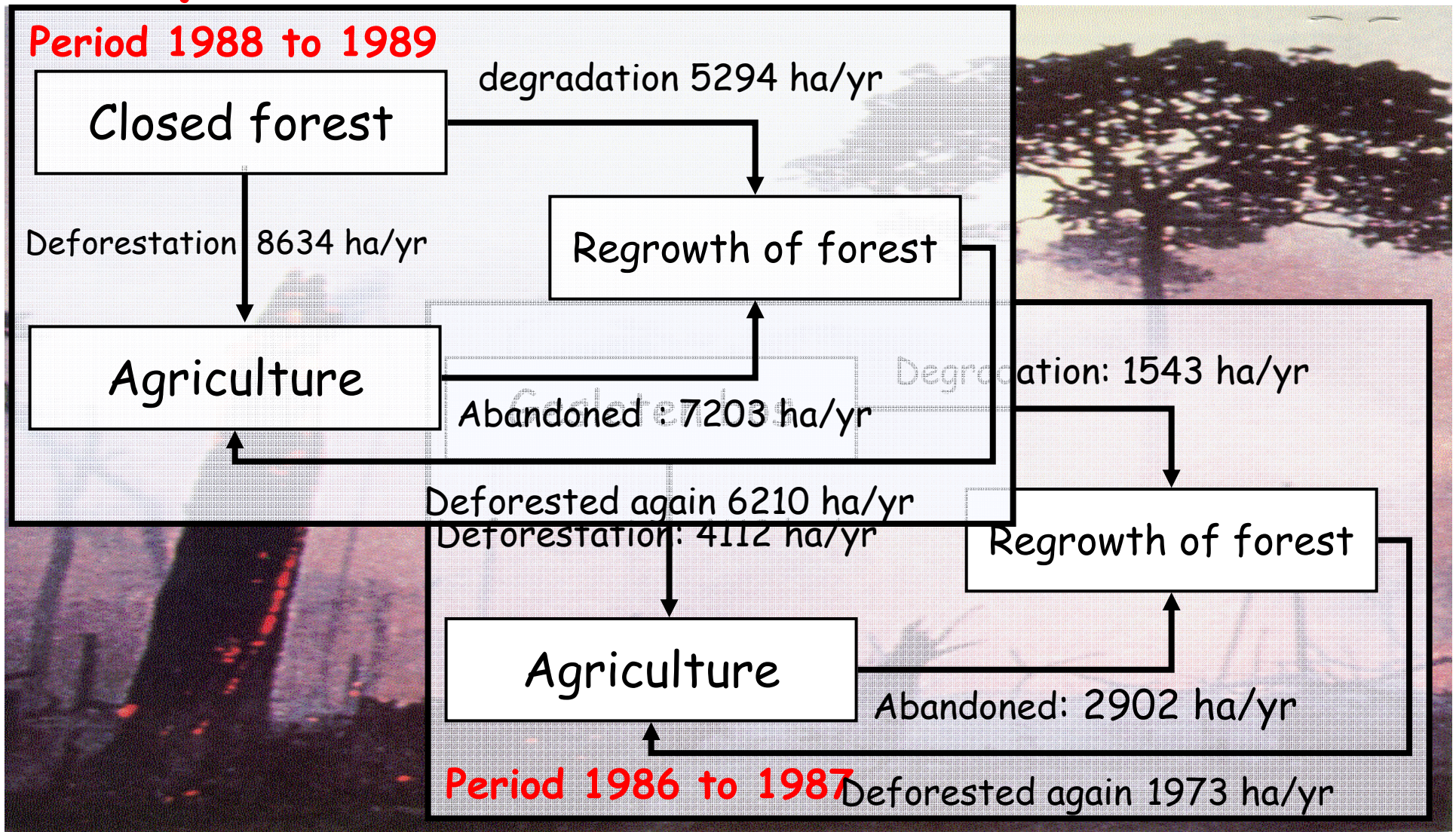
- ✓ Case studies of land use narratives
- ✓ Patterns of land use change: remote sensing
- ✓ Modeling land use change

LUCC tried to integrate understanding from natural and social sciences

Land use change dynamics

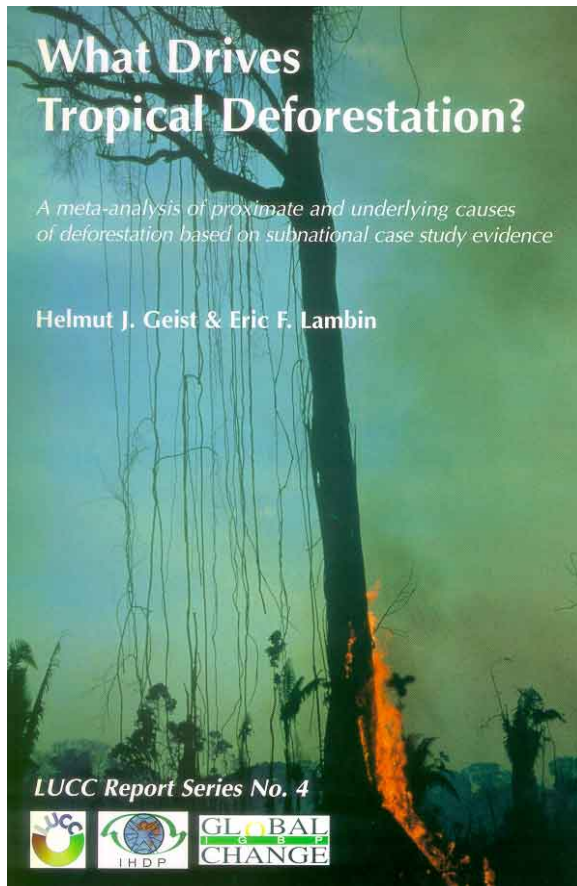


dynamics of deforestation



Land Use Trajectories:

Understanding Land Use Dynamics

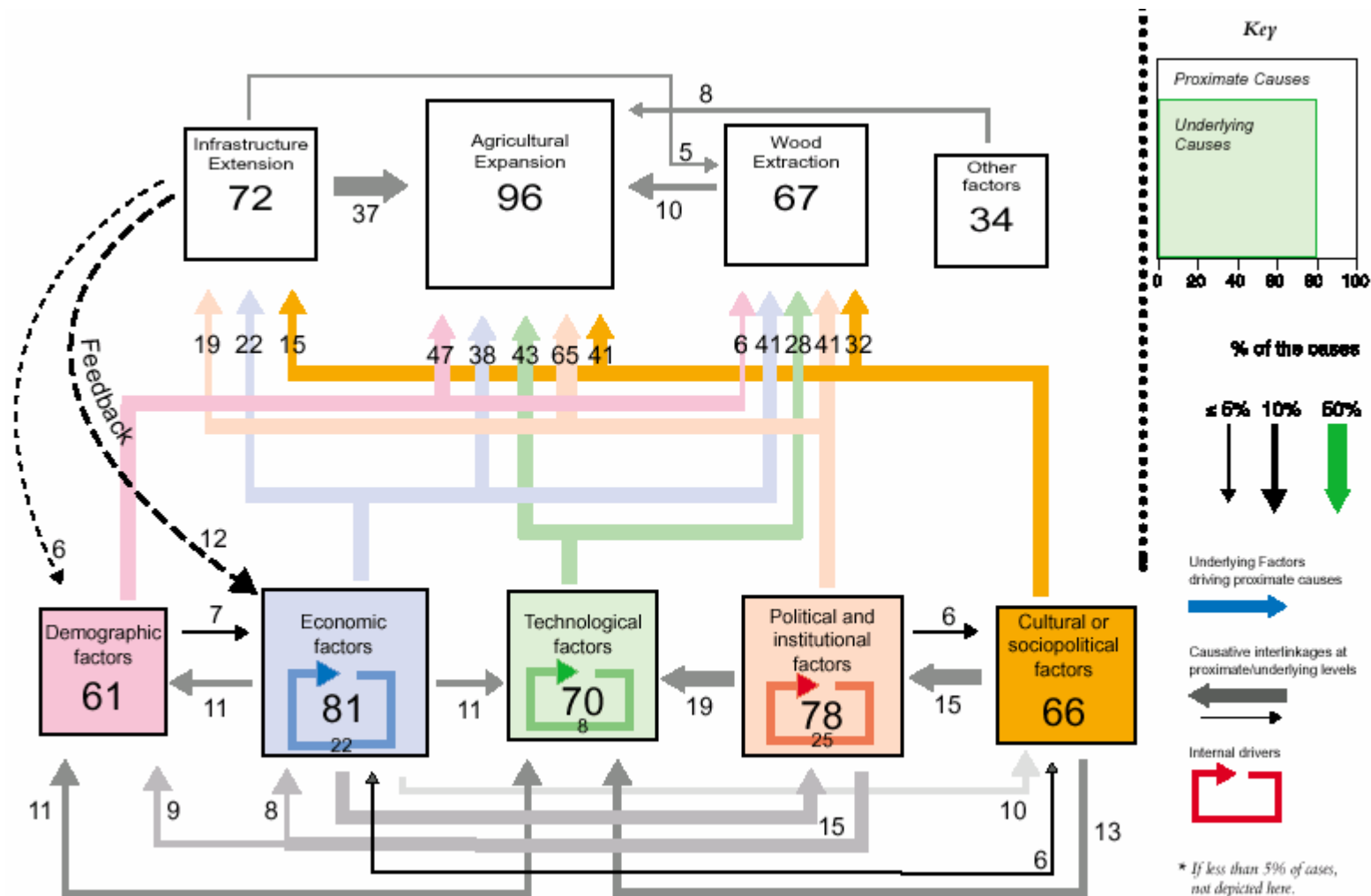


- ✓ Tropical Deforestation
- ✓ Desertification
- ✓ Agricultural Change
- ✓ Vulnerability



Land Use and
Land Cover Change

What drives deforestation?



The causes of deforestation (Geist & Lambin, 2001)

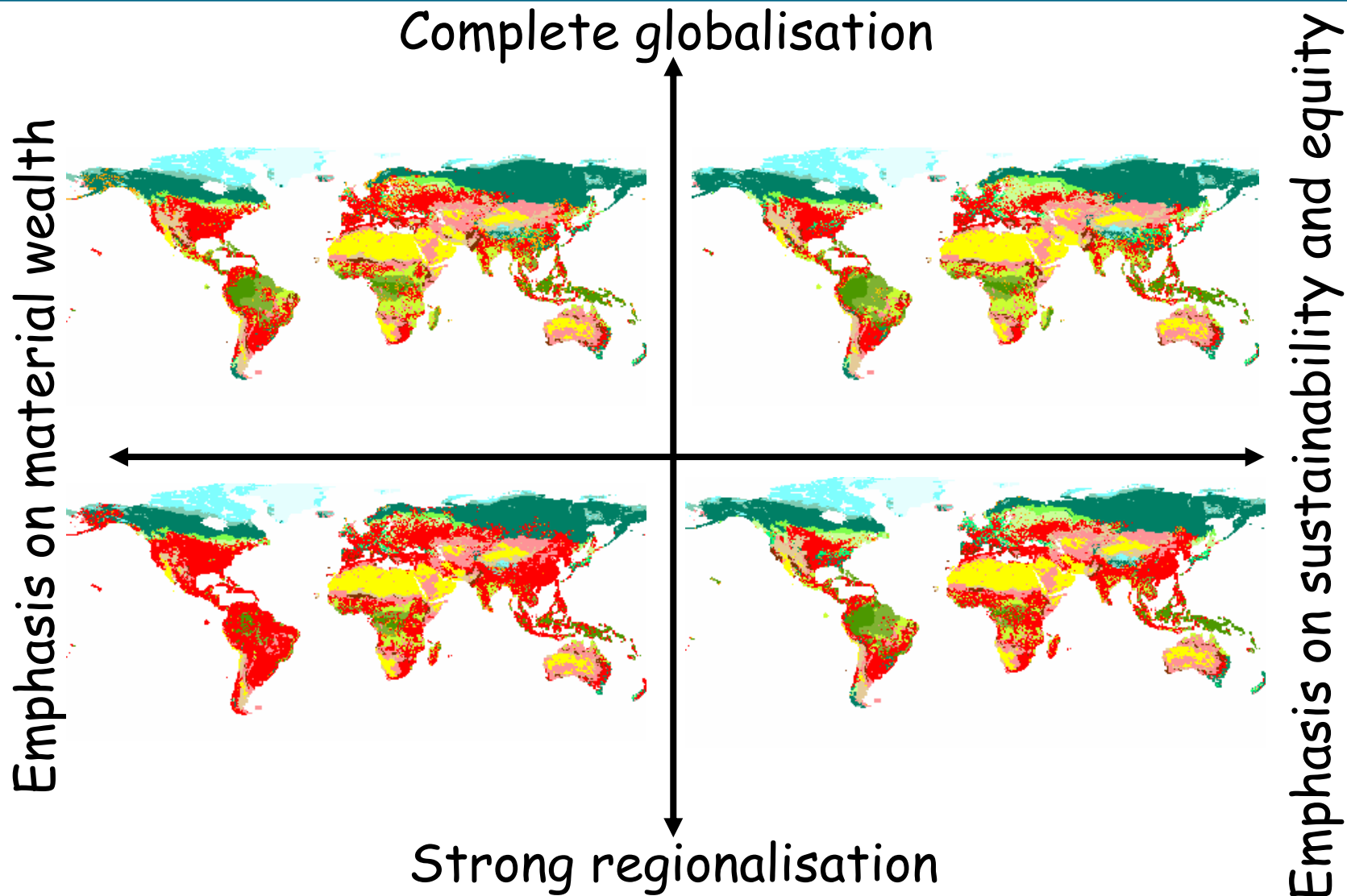
NBP Carbon Release Processes: Forest Product Harvests



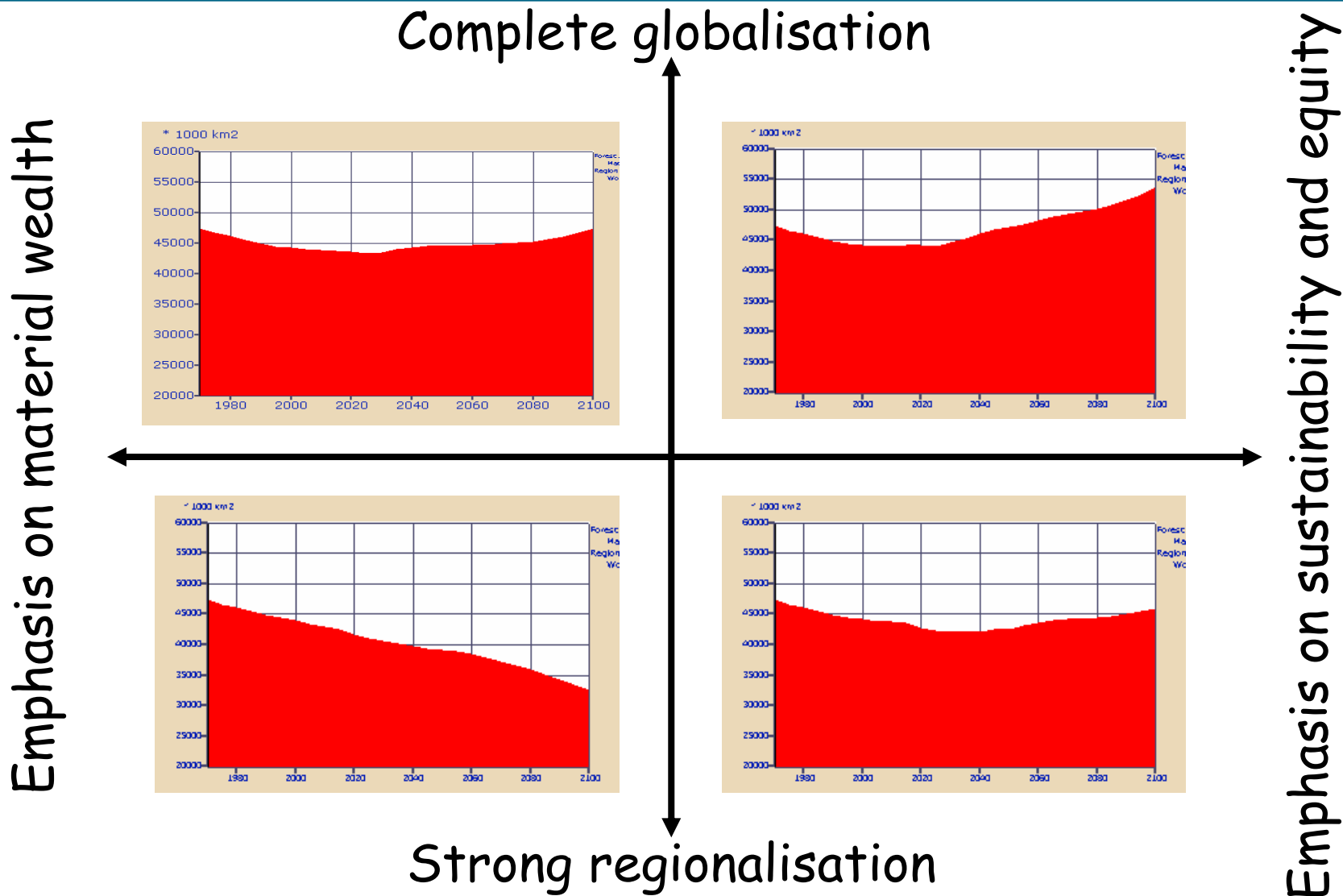
NEP Carbon Release Processes: Agricultural Land Uses



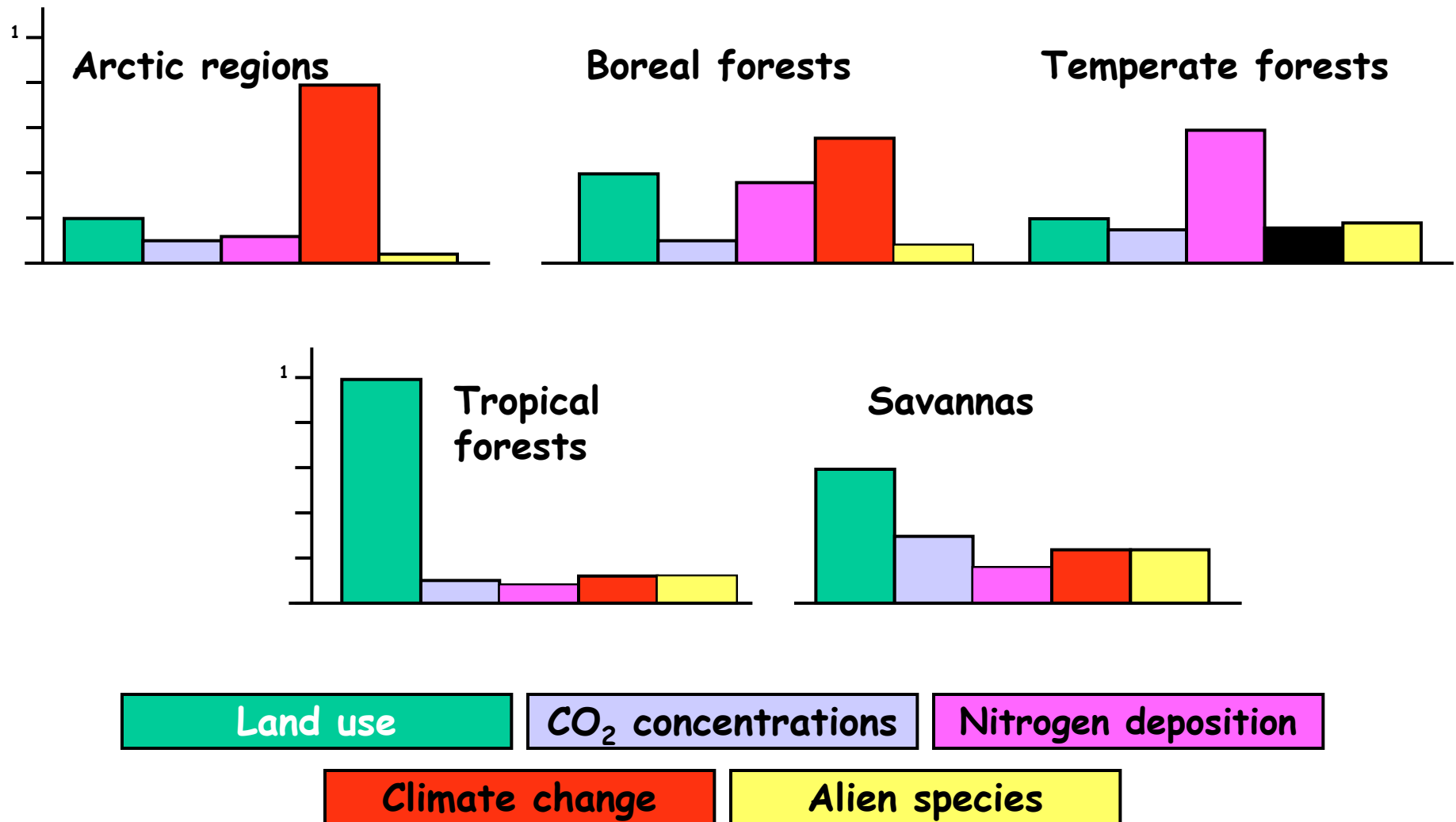
The IPCC scenarios: land cover in 2100



The IPCC scenarios: forest area



Combining climate change and other global change aspects: Impacts on biodiversity



NBP Carbon Release Processes: Enhanced Forest Dieback



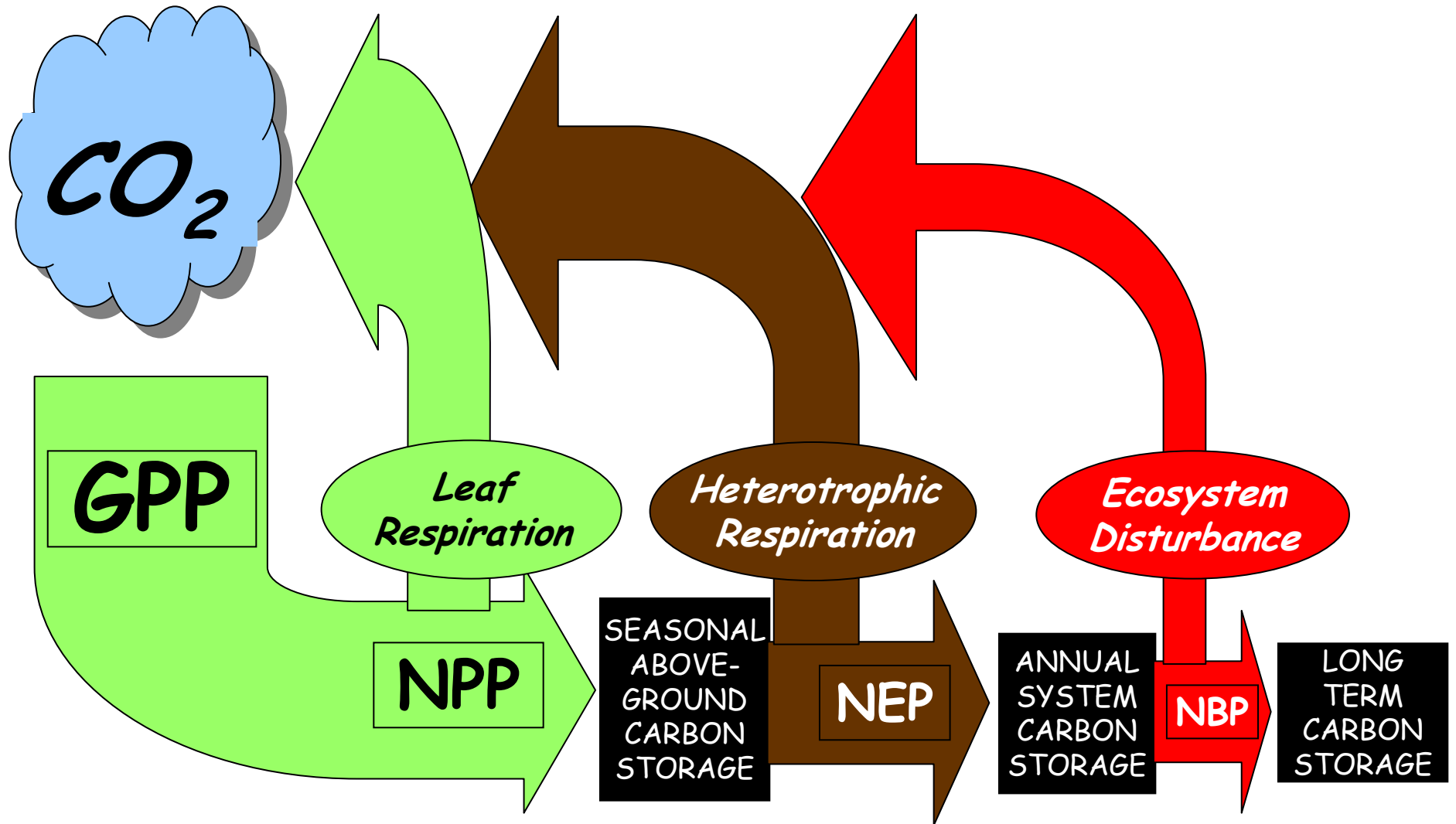
Disturbance Tomakomai Larch forest

Two towers collapsed due to strong winds caused by the typhoon on Sep.8, 2004.

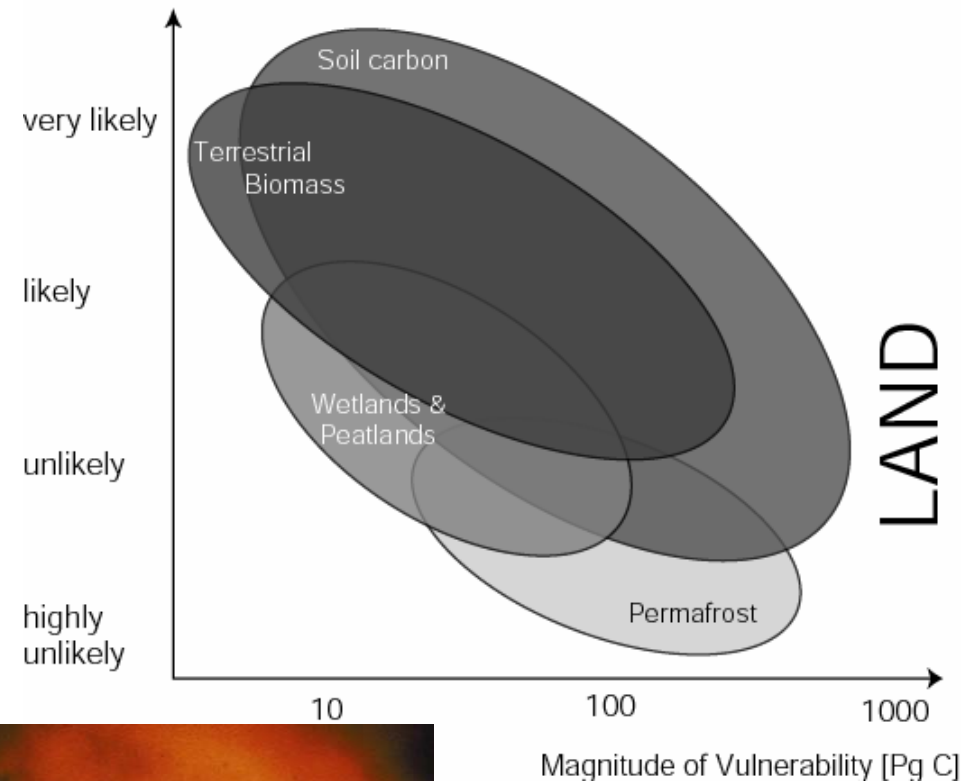


About 90 % of the trees fell down. NIES is now discussing an alternative site to continue studies of Larch forest.

TERRESTRIAL CARBON CYCLE COMPONENTS



Carbon pools at risk in this century



Including feedbacks

- ✓ Temperature on photosynthesis and respiration
- ✓ CO₂ fertilization
- ✓ Land use (including biomass for energy production)
- ✓ Albedo (snow vs vegetation)

Importance of feedbacks in IMAGE for 2050

Simulation	CO ₂ concentration (ppm)	Living biomass (Pg)	dead biomass (Pg)	NPP (Pg yr ⁻¹)	NEP (Pg yr ⁻¹)
All feedbacks	522	601	1668	82.5	8.1
CC on plant growth	479	584	1800	79.1	10.4
CO ₂ fertilization	583	509	1603	66.9	4.8
CC on soil respiration	621	509	1508	66.2	2.8
No feedbacks	587	505	1601	65.3	4.4

Acceleration of global warming due to carbon-cycle feedbacks in a coupled climate model

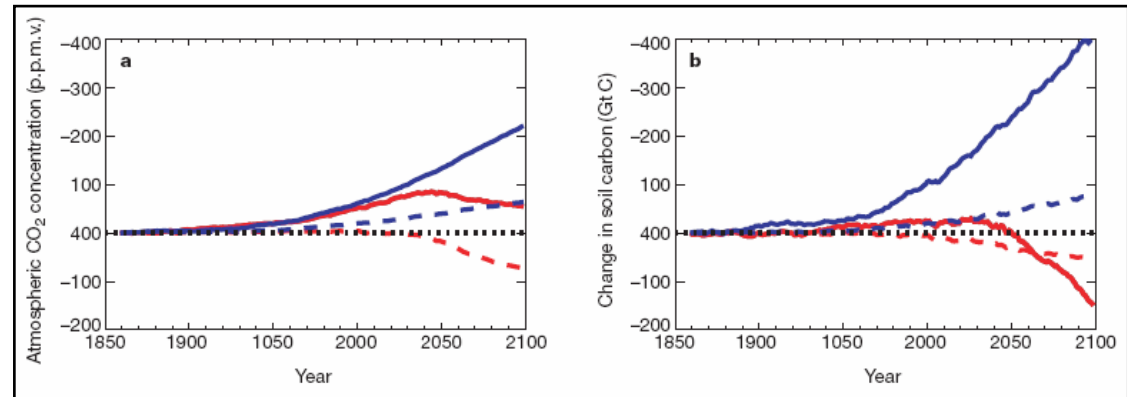
Acceleration of global warming due to carbon-cycle feedbacks in a coupled climate model

Peter M. Cox*, Richard A. Betts*, Chris D. Jones*, Steven A. Spall* & Ian J. Totterdell†

* Hadley Centre, The Met Office, Bracknell, Berkshire RG12 2SY, UK

† Southampton Oceanography Centre, European Way, Southampton SO14 3ZH, UK

The continued increase in the atmospheric concentration of carbon dioxide due to anthropogenic emissions is predicted to lead to significant changes in climate¹. About half of the current emissions are being absorbed by the ocean and by land ecosystems², but this absorption is sensitive to climate^{3,4} as well as to atmospheric carbon dioxide concentrations⁵, creating a feedback loop. General circulation models have generally excluded the feedback between climate and the biosphere, using static vegetation distributions and CO₂ concentrations from simple carbon-cycle models that do not include climate change⁶. Here we present results from a fully coupled, three-dimensional carbon-climate model, indicating that carbon-cycle feedbacks could significantly accelerate climate change over the twenty-first century. We find that under a 'business as usual' scenario, the terrestrial biosphere acts as an overall carbon sink until about 2050, but turns into a source thereafter. By 2100, the ocean uptake rate of 5 Gt C yr⁻¹ is balanced by the terrestrial carbon source, and atmospheric CO₂ concentrations are 250 p.p.m.v. higher in our fully coupled simulation than in uncoupled carbon models², resulting in a global-mean warming of 5.5 K, as compared to 4 K without the carbon-cycle feedback.



Cox, P. et al. 2000. Nature 408:180-184.

Kyoto Protocol, Article 3, sub. 3

The net changes in greenhouse gas emissions from sources and removals by sinks resulting from direct human-induced land use change and forestry activities, *limited to afforestation, reforestation, and deforestation since 1990*, measured as the *verifiable* changes in stocks in each commitment period, shall be used to meet the commitments in this article of each party included in Annex-1.

The greenhouse gas emissions from sources and removals by sinks associated with those activities shall be reported in a transparent and verifiable manner and reviewed in accordance with the other articles.

Consequences of mitigation

Carbon uptake by forestation is one method proposed to reduce net carbon dioxide emissions to the atmosphere and so limit the radiative forcing of climate change. But the overall impact of forestation on climate will also depend on other effects associated with the creation of new forests. In particular, the albedo of a forested landscape is generally lower than that of cultivated land, especially when snow is lying, and decreasing albedo exerts a positive radiative forcing on climate.

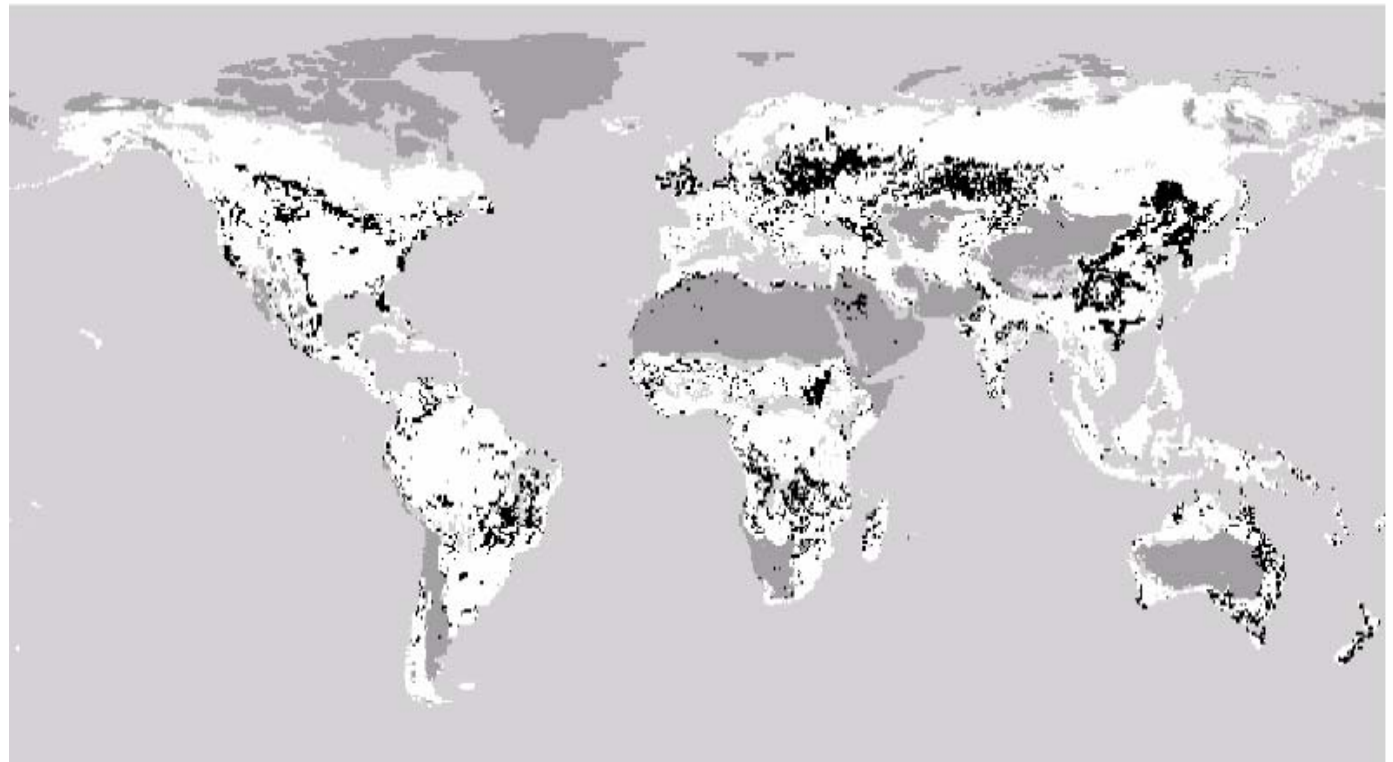
In many boreal forest areas, the positive forcing induced by decreases in albedo can offset the negative forcing that is expected from carbon sequestration. **Some high-latitude forestation activities may therefore increase climate change, rather than mitigating it as intended.**

Betts, R. A. 2000. Offset of the potential carbon sink from boreal forestation by decreases in surface albedo. *Nature* 408:187-190.

Decrease of agriculture in the A1 scenario (2050)

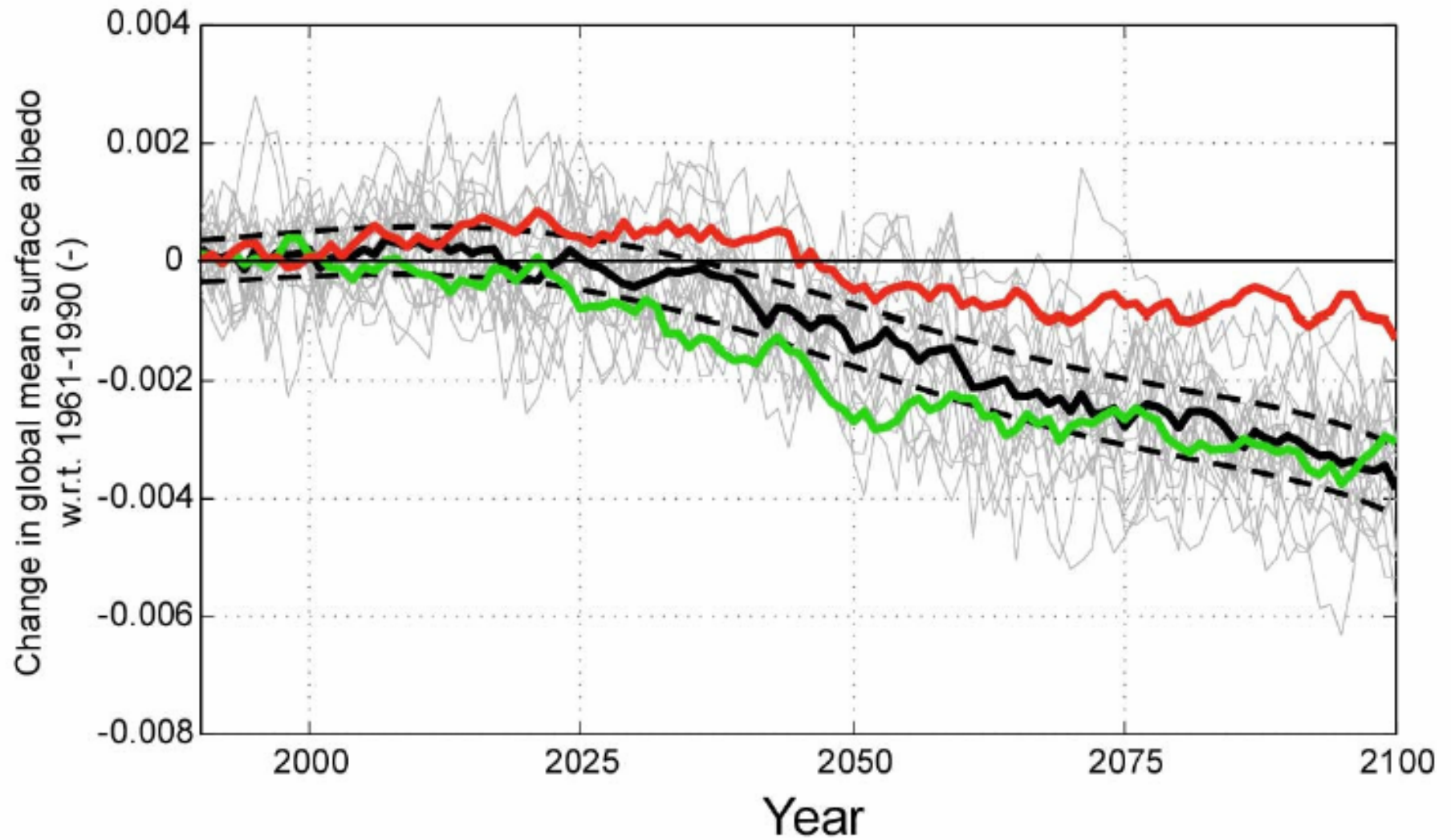
The large-scale implementation of either carbon-sequestration or modern-biofuel plantations decreases the CO_2 concentration with 70-80 ppmv in 2100 compared to a non-mitigation baseline.


Abandoned land

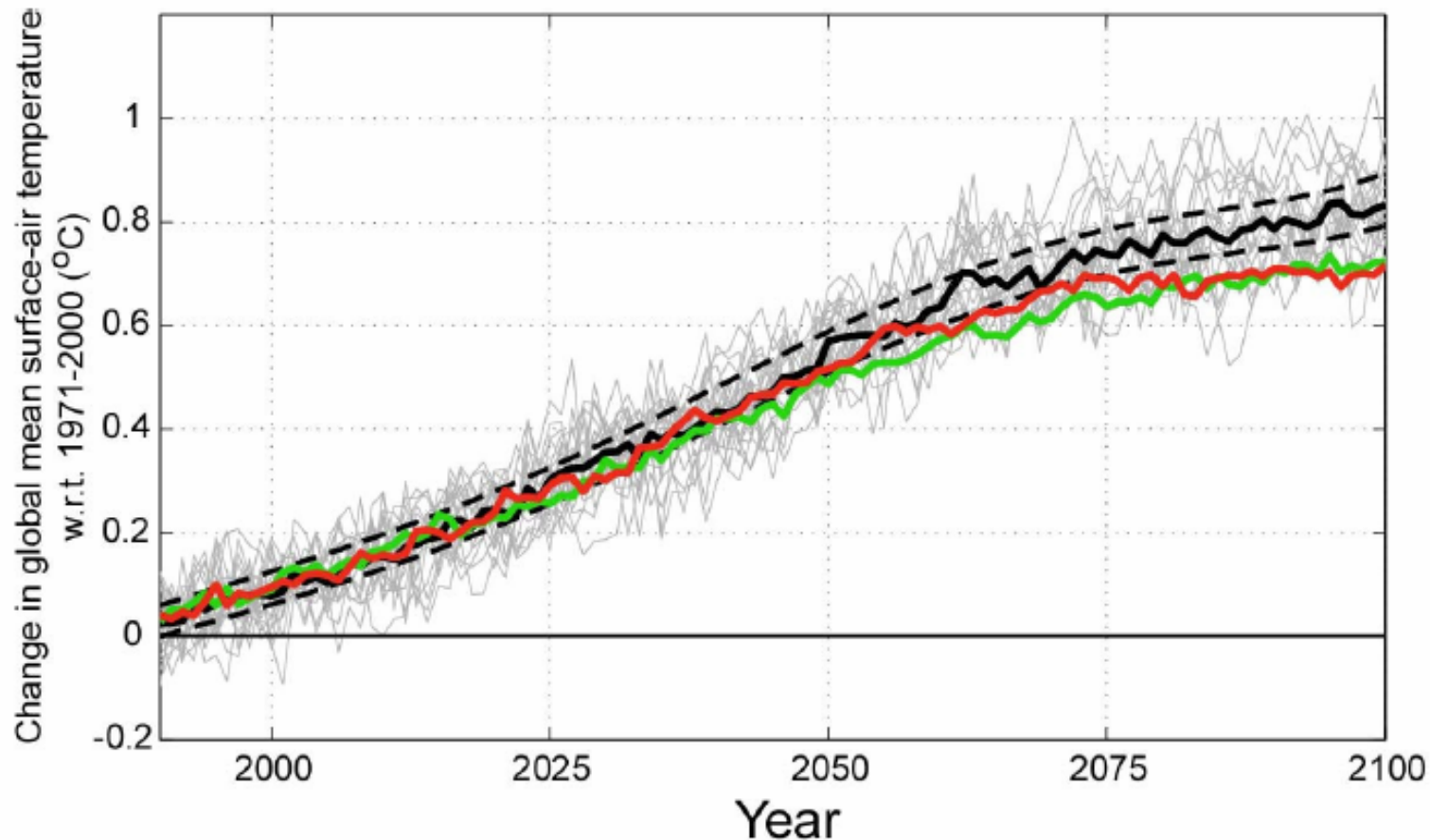


Schaeffer et al. 2005. CO_2 and albedo climate impacts of extra-tropical carbon and biomass plantations. *Global Biogeochemical Cycles* (in press).

Carbon sequestration or biomass plantations?

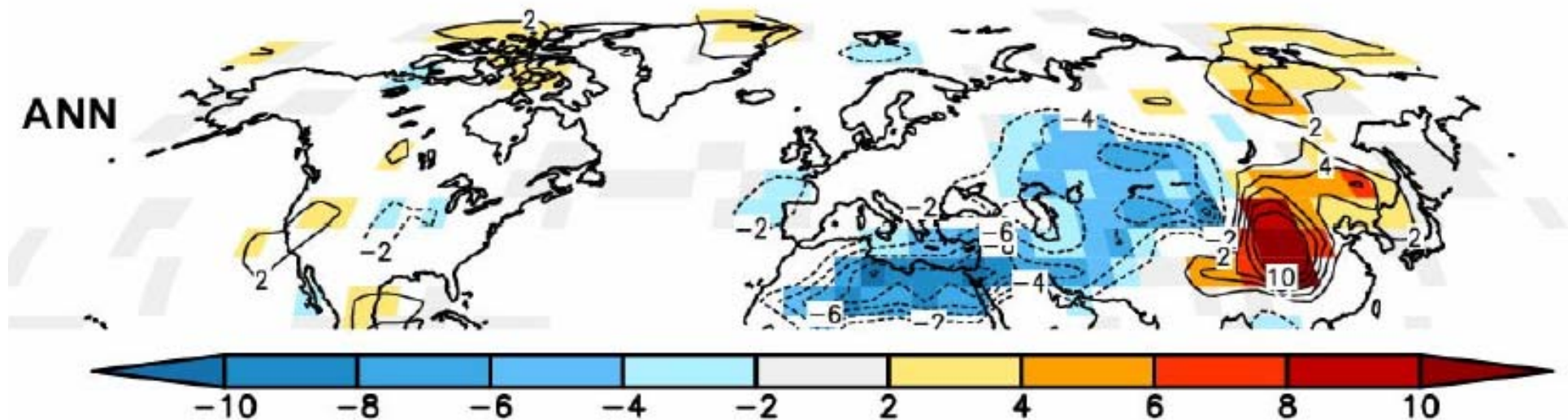


Carbon sequestration or biomass plantations?



The albedo-induced difference in global-mean temperature is as large as the mitigation by CO_2 changes compared to the baseline.

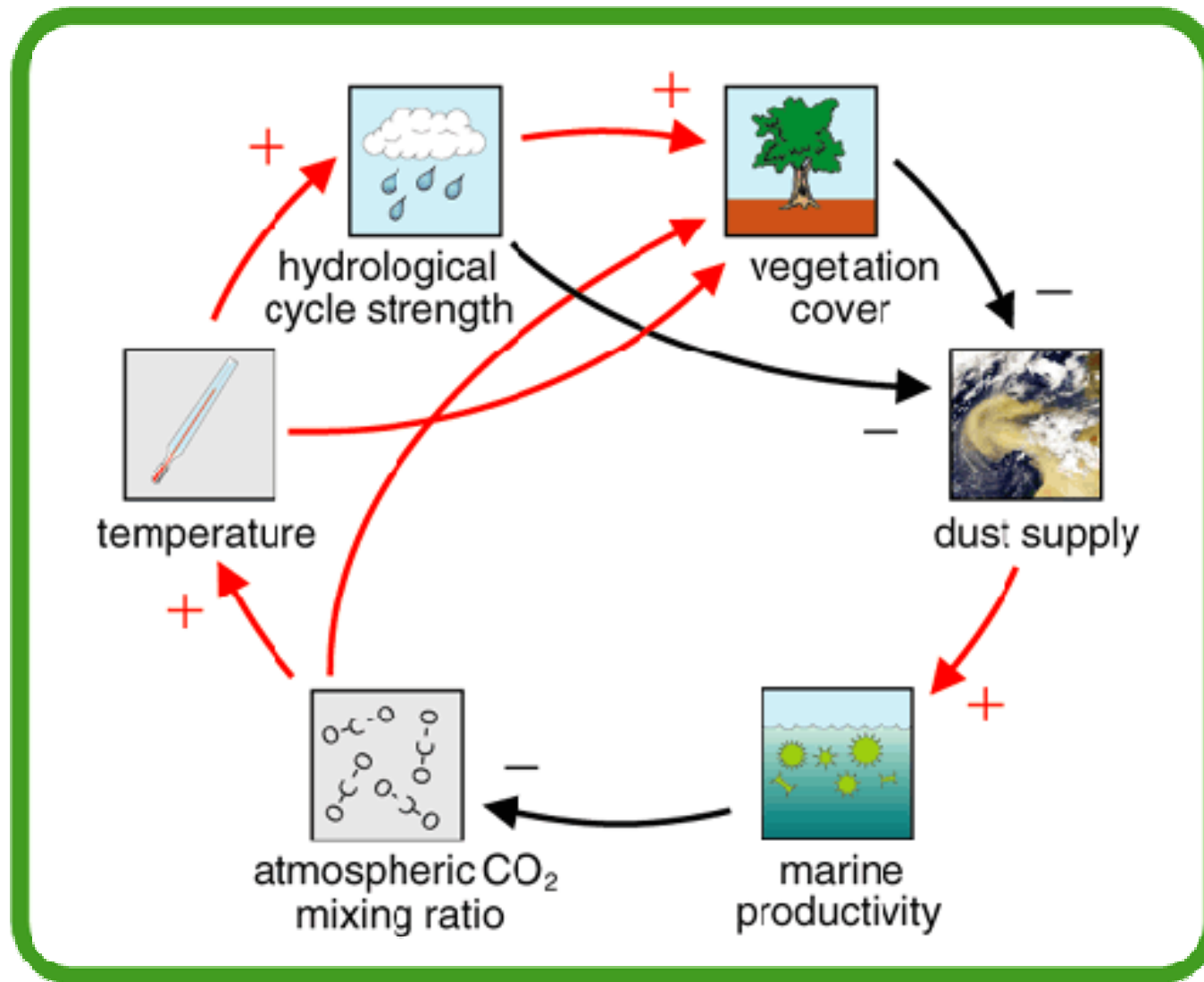
Carbon sequestration or biomass plantations?



Difference in precipitation in 2071-2100 (mm) including the albedo effects of carbon-plantation w.r.t. biomass-plantation.

An atmospheric circulation change in the carbon-plantation scenario weakens the supply of moisture from the oceans to North Africa and central Eurasia. This decreases annual-mean precipitation over North Africa by up to 10% and further increases summer temperatures over Eurasia.

Land as an integral part of the Earth system



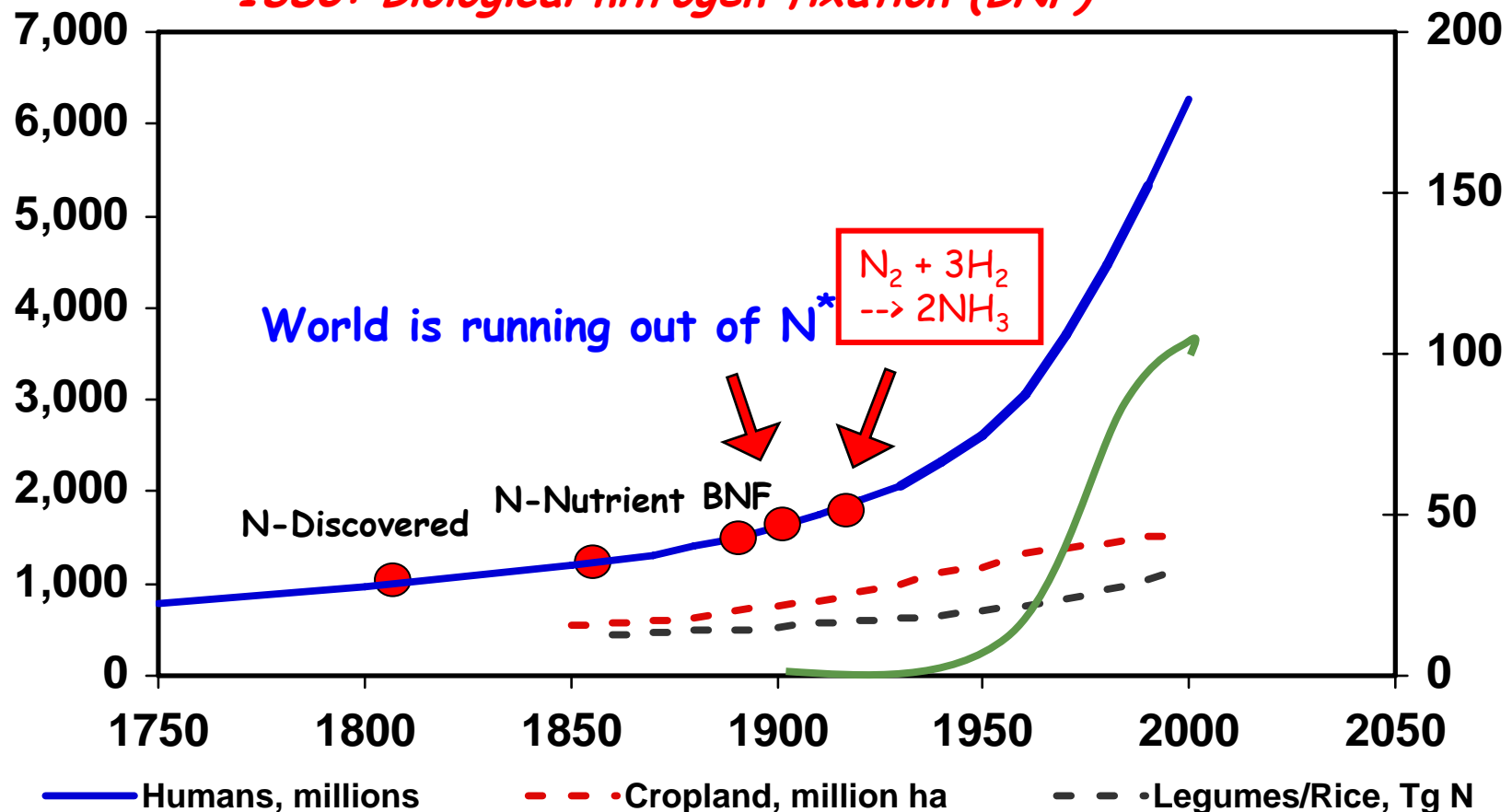
The History of Nitrogen: *People and Cropland*

1800: Discovery of Nitrogen as an Element

1900: N becomes limiting?

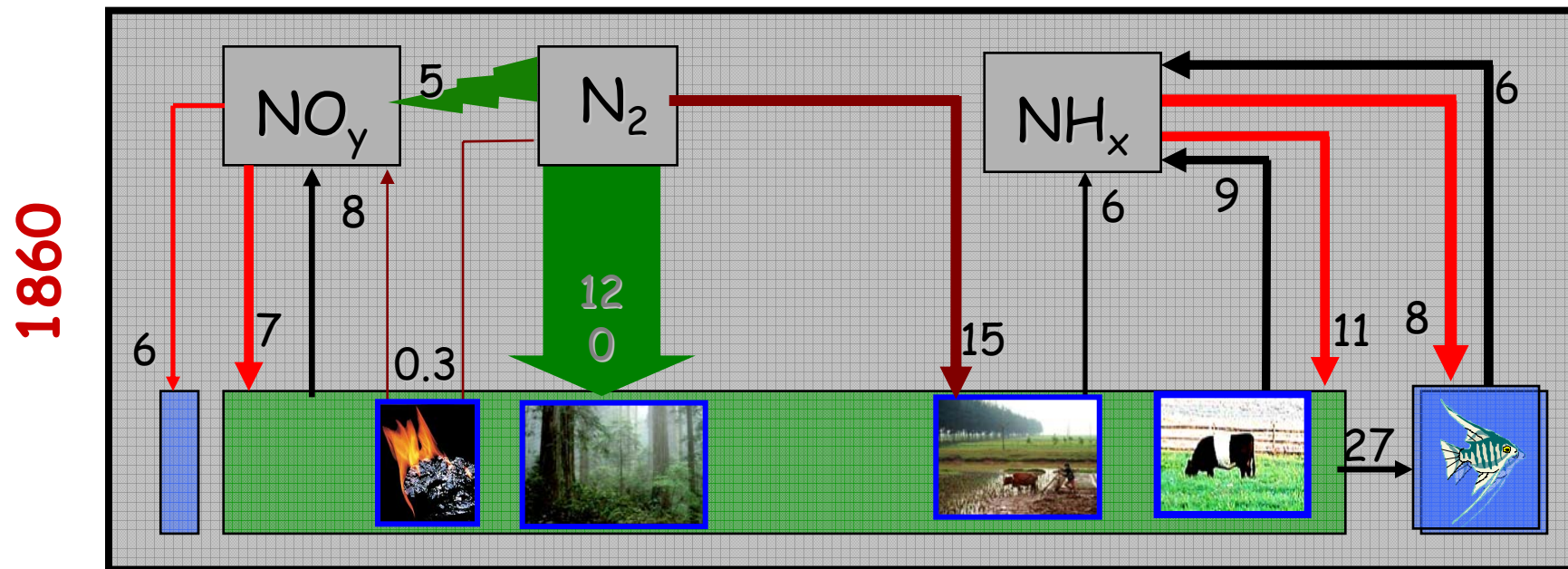
1850: Nitrogen is Nutritious

1880: Biological nitrogen fixation (BNF)



1910: Nr Creation, Haber Bosch process

The Global Nitrogen Budget in 1860 and mid-1990s, TgN/yr



Nitrogen Drivers in 1860 & 1995



**Grain
Production**

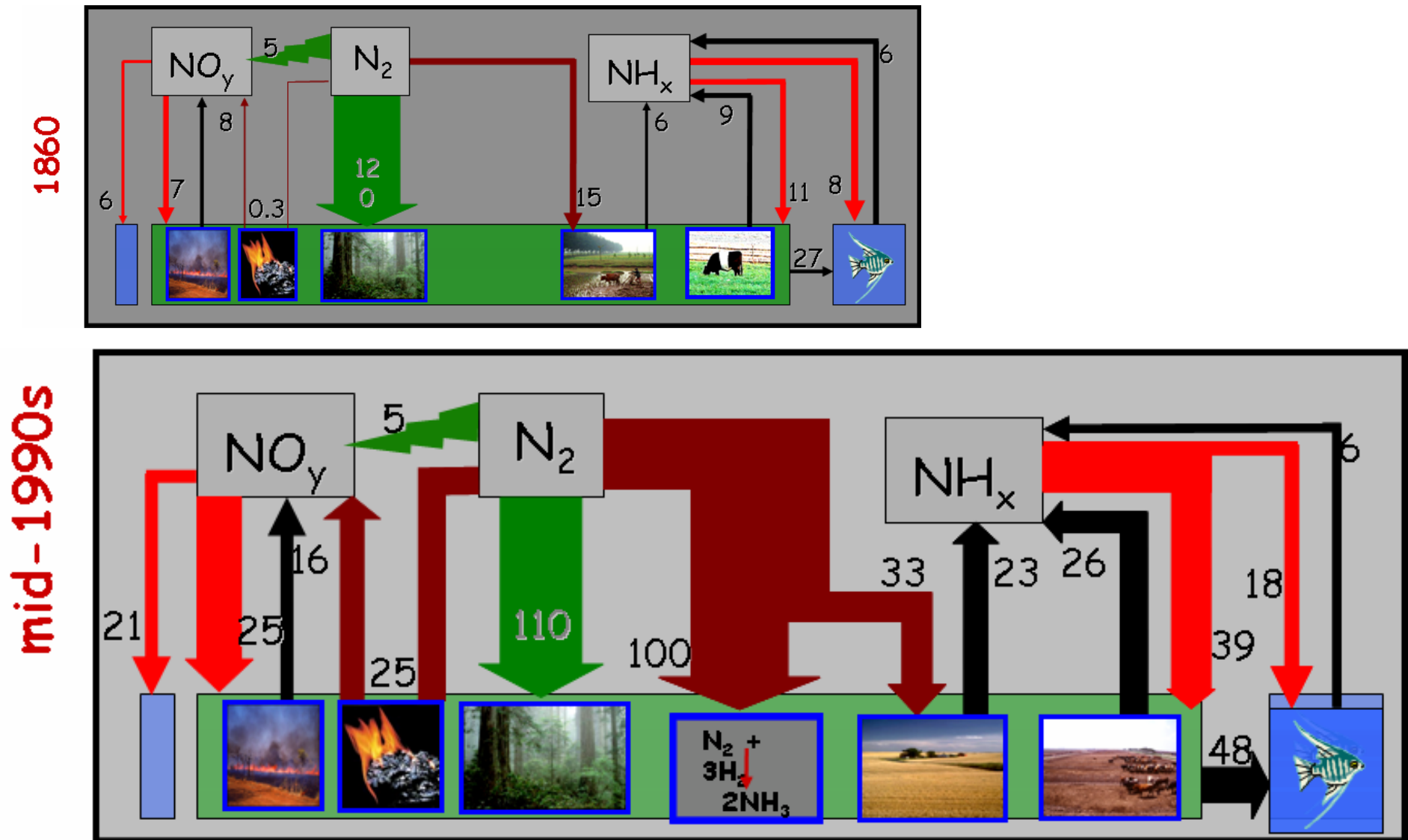


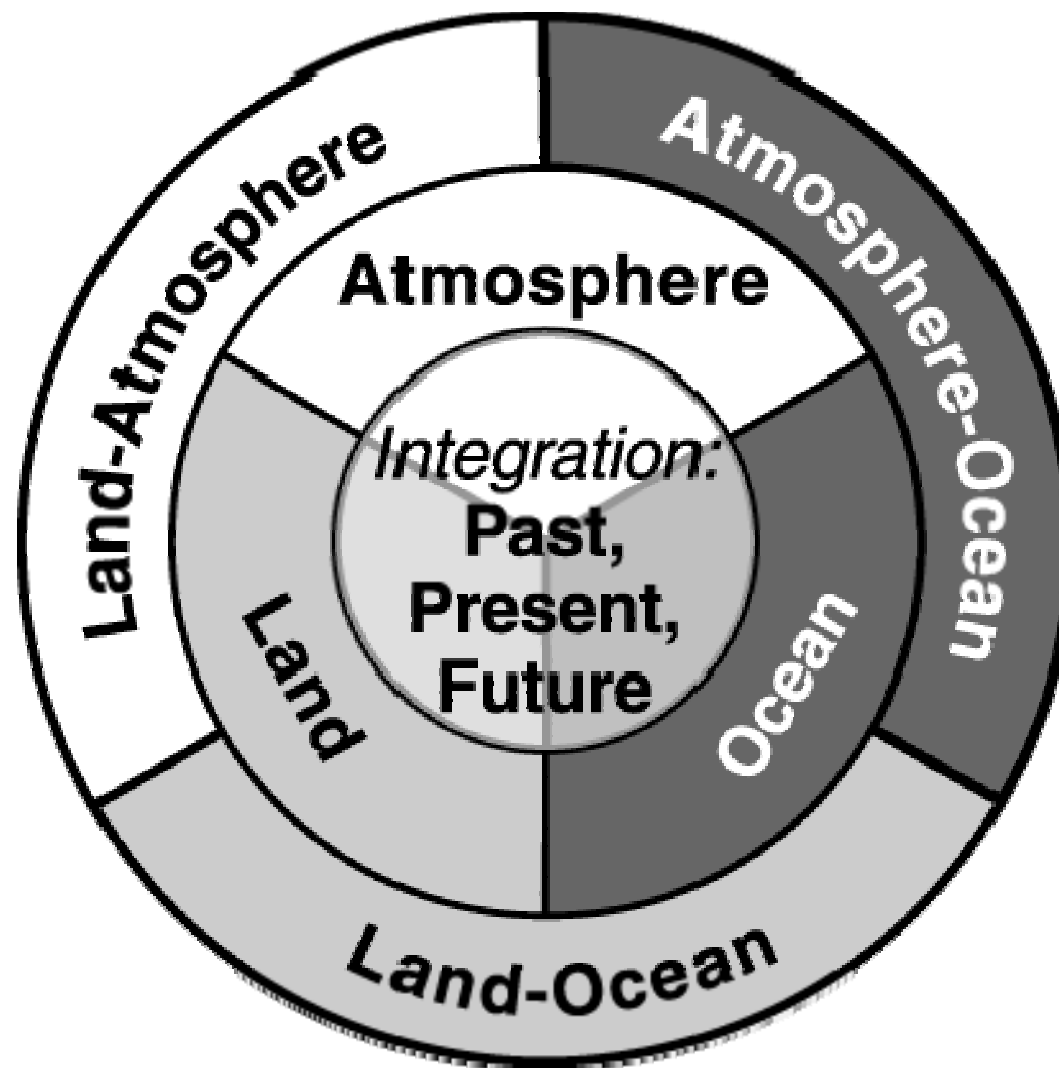
**Meat
Production**



**Energy
Production**

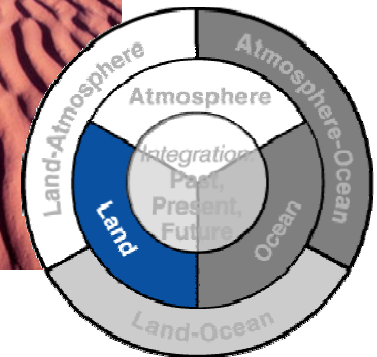
The Global Nitrogen Budget in 1860 and mid-1990s, TgN/yr





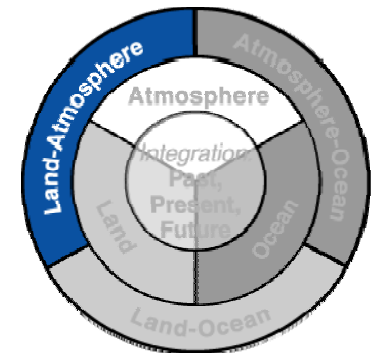
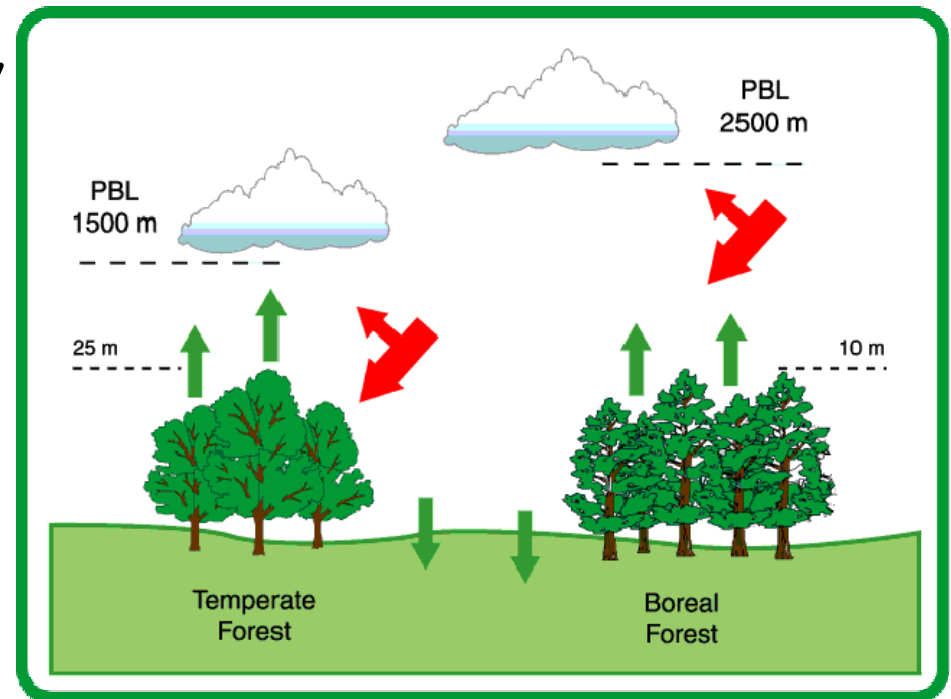
Land project

- What are the drivers and dynamics of variability and change in terrestrial human-environment systems?
- How is the provision of environmental goods and services affected by changes in terrestrial human-environment systems?
- What are the characteristics and dynamics of vulnerability in terrestrial human-environment systems?



Land-Atmosphere

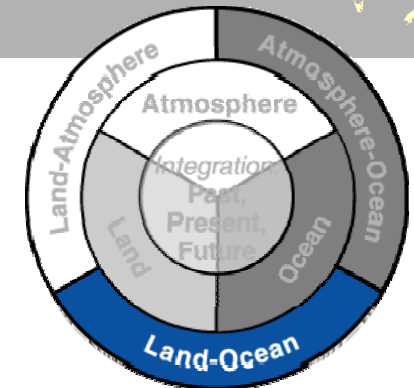
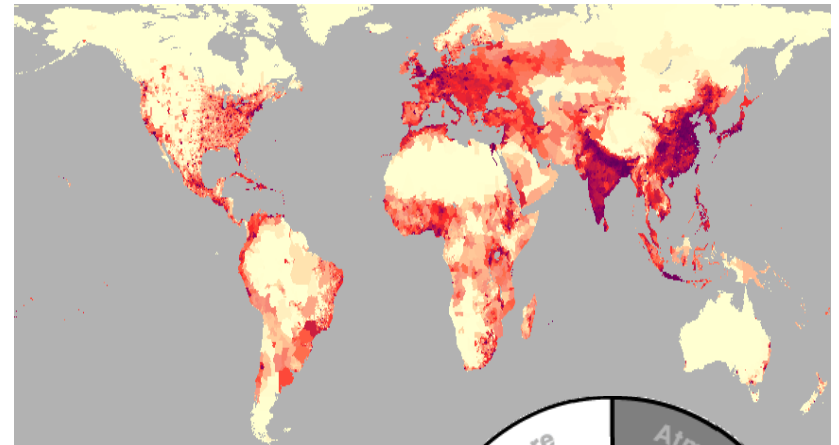
- How do interacting physical, chemical and biological processes transport and transform energy and materials through the land-atmosphere system?
- What are the implications for the dynamics of the Earth System?
- How are human activities influencing the land-atmosphere system (and vice versa)?



Land-Ocean

- ✓ River basins and human dimensions
- ✓ Coastal development and change: implications of land use and sea use changes
- ✓ Fate and transformation of materials in coastal and shelf waters
- ✓ System sustainability and resource management issues
- ✓ Risk and safety

44% of the world's population live within 150km of a coastline



Earth System Science Partnership

DIVERSITAS, IGBP, IHDP, WCRP



- A partnership for:
- the integrated study of the Earth System,
 - the changes that are occurring to the System
 - the implications of these changes for global sustainability.



GLOBAL
I G B P
CHANGE

