Intergovernmental Panel on Climate Change

Agriculture: Impacts, Adaptation and Mitigation

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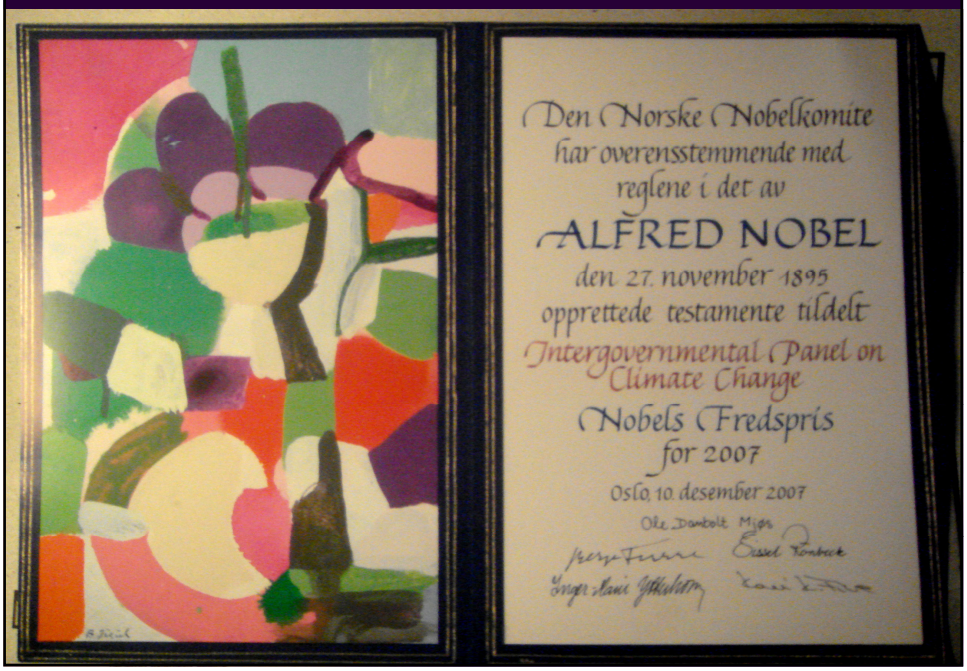
K-State Research and Extension

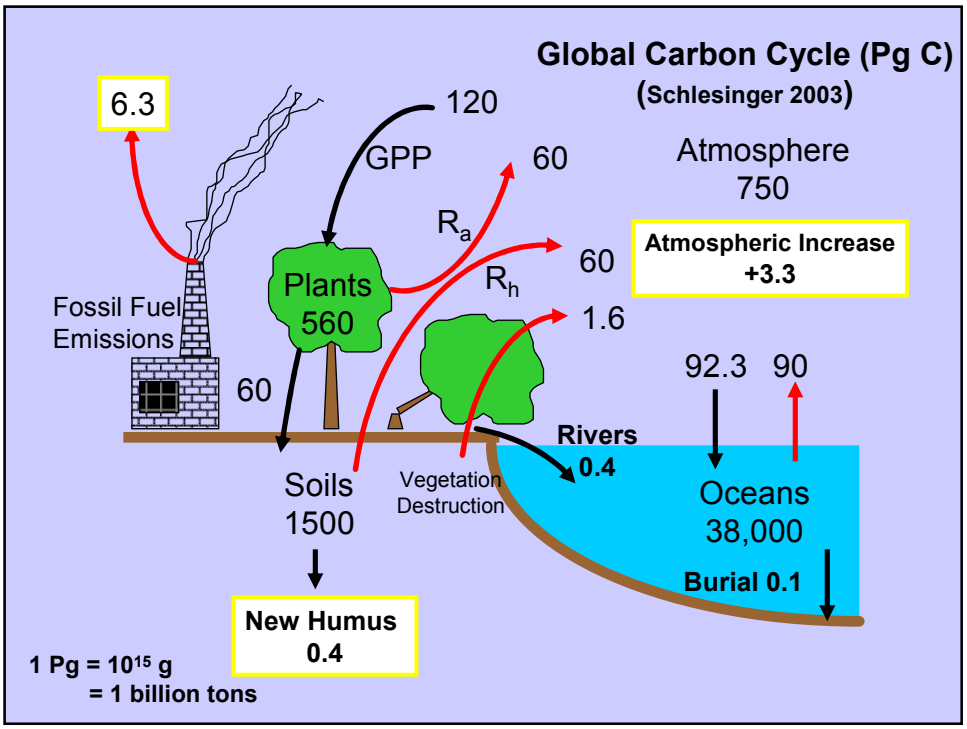
2007 Nobel Peace Prize

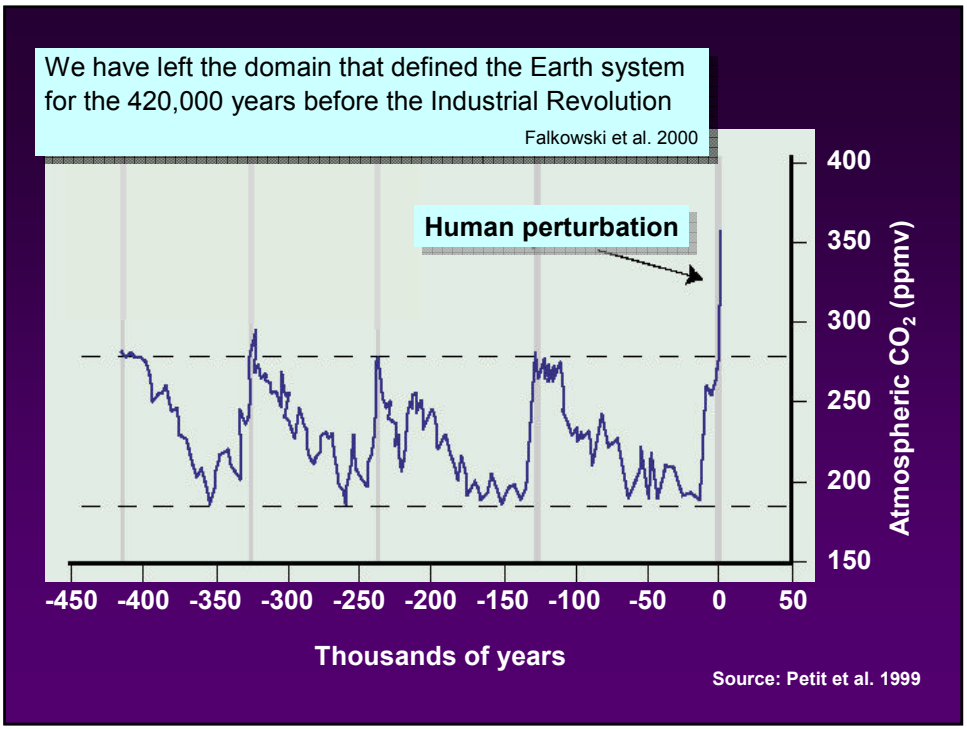
The Intergovernmental Panel on Climate Change and Albert Arnold (Al) Gore Jr. were awarded of **the Nobel Peace Prize**

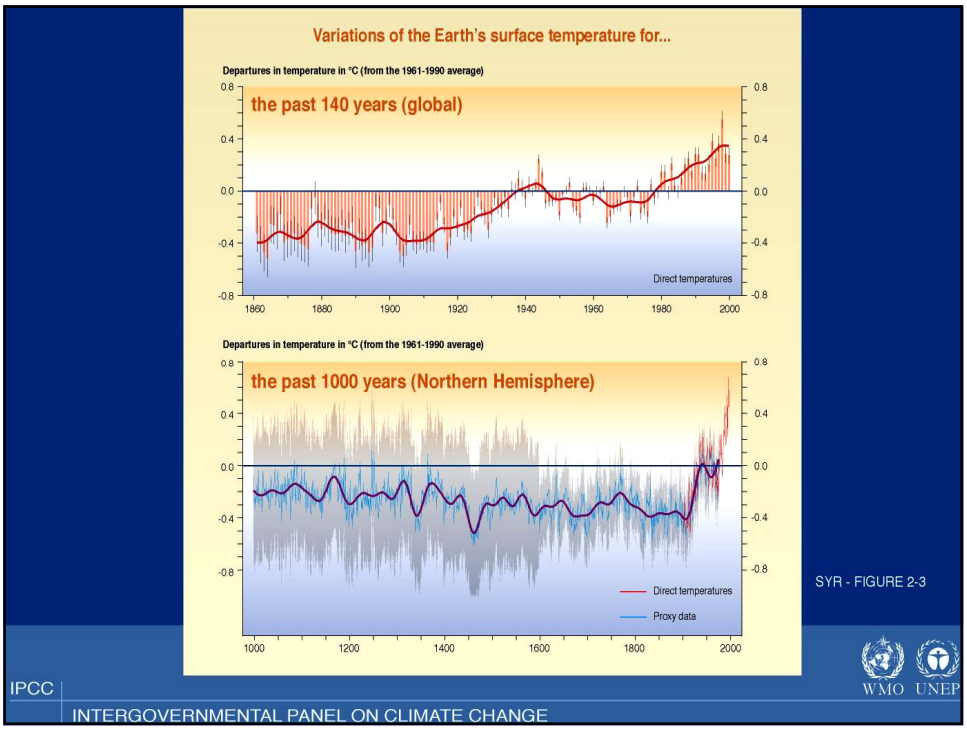
"for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change".

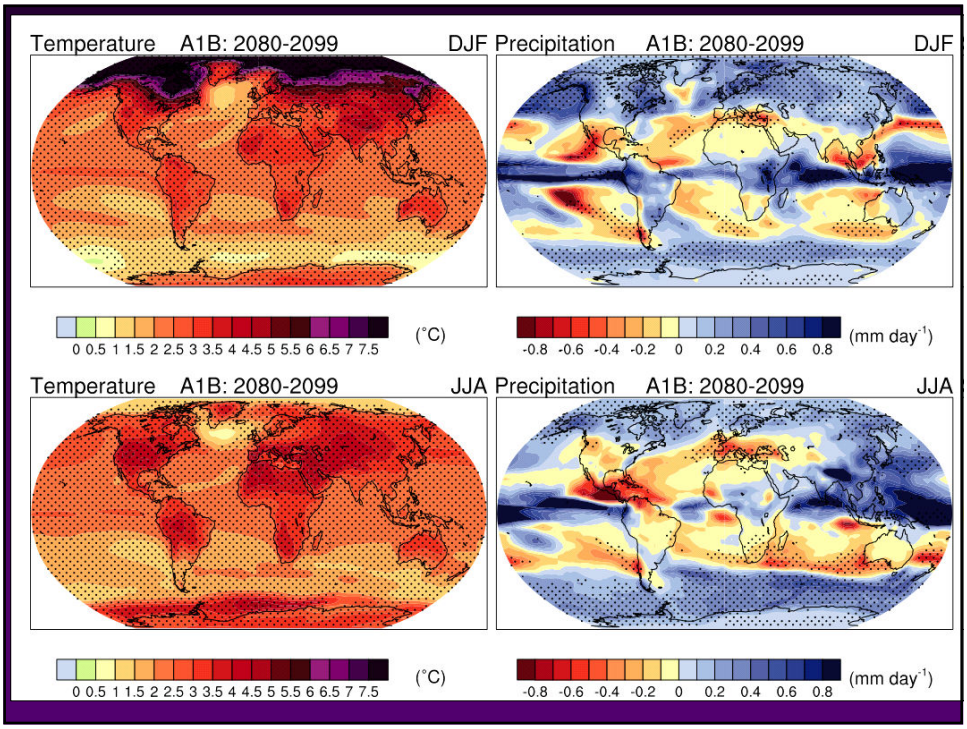
The Nobel Diploma… with an original painting of a Norwegian Artist…

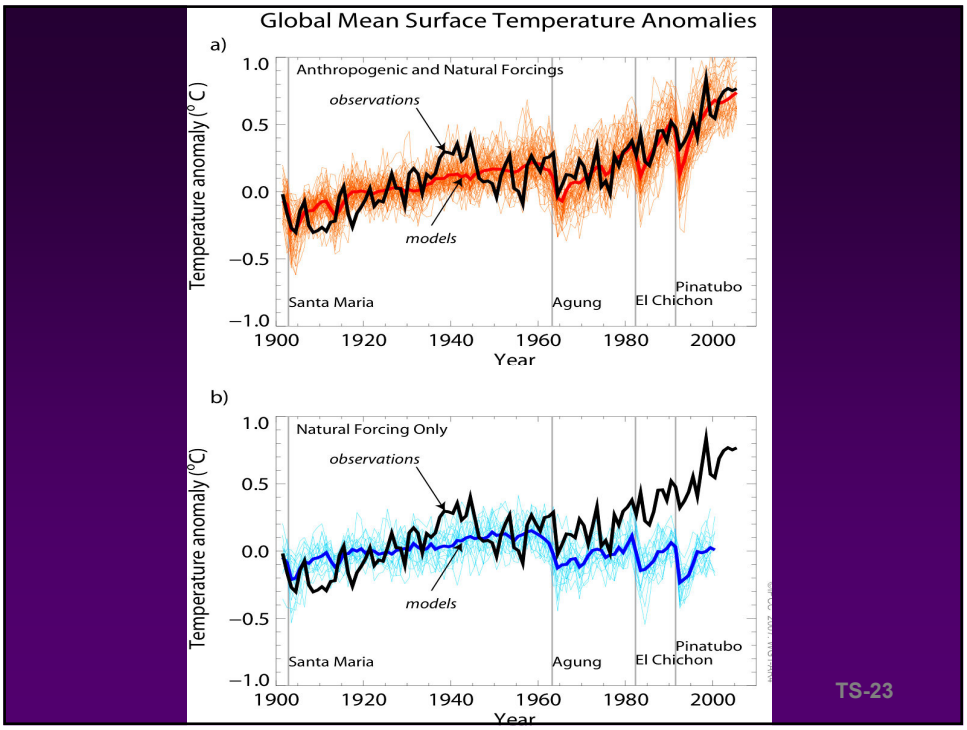




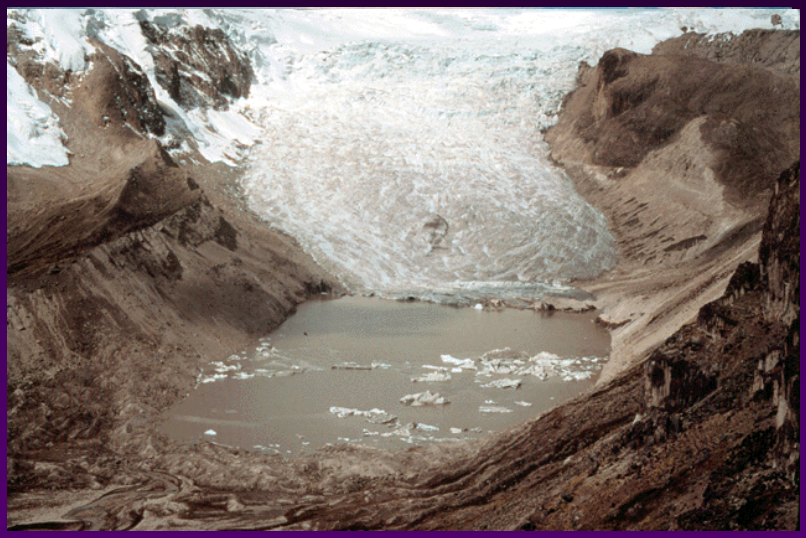

We have left the domain that defined the Earth system for the 420,000 years before the Industrial Revolution
Falkowski et al. 2000
Human perturbation
400
350
300
250
200
150
Atmospheric CO_2 (ppmv)
-450 -400 -350 -300 -250 -200 -150 -100 -50 0 50
Thousands of years
Source: Petit et al. 1999


Variations of the Earth's surface temperature for...
Departures in temperature in °C (from the 1961-1990 average)
the past 140 years (global)
Direct temperatures
1860 1880 1900 1920 1940 1960 1980 2000
Departures in temperature in °C (from the 1961-1990 average)
the past 1000 years (Northern Hemisphere)
Direct temperatures
Proxy data
1000 1200 1400 1600 1800 2000
SYR - FIGURE 2-3
IPCC
INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE
WMO UNEP


Temperature A1B: 2080-2099 DJF
Precipitation A1B: 2080-2099 DJF
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 6.5 7 7.5
(°C)
-0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8
(mm day-1)
Temperature A1B: 2080-2099 JJA
Precipitation A1B: 2080-2099 JJA
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 6.5 7 7.5
(°C)
-0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8
(mm day-1)


Global Mean Surface Temperature Anomalies
a)
Anthropogenic and Natural Forcings
observations
models
Temperature anomaly (°C)
1.0
0.5
0.0
−0.5
−1.0
Santa Maria
Agung
El Chichon
Pinatubo
1900
1920
1940
1960
1980
2000
Year
b)
Natural Forcing Only
observations
models
Temperature anomaly (°C)
1.0
0.5
0.0
−0.5
−1.0
Santa Maria
Agung
El Chichon
Pinatubo
1900
1920
1940
1960
1980
2000
Year
TS-23

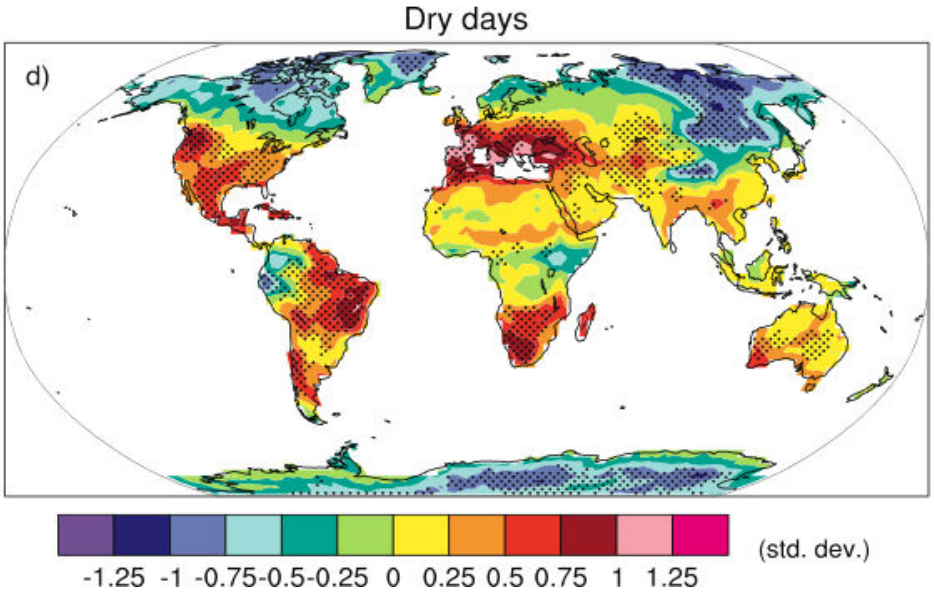
Qori Kalis, Peruvian Andes
1978… …And Today



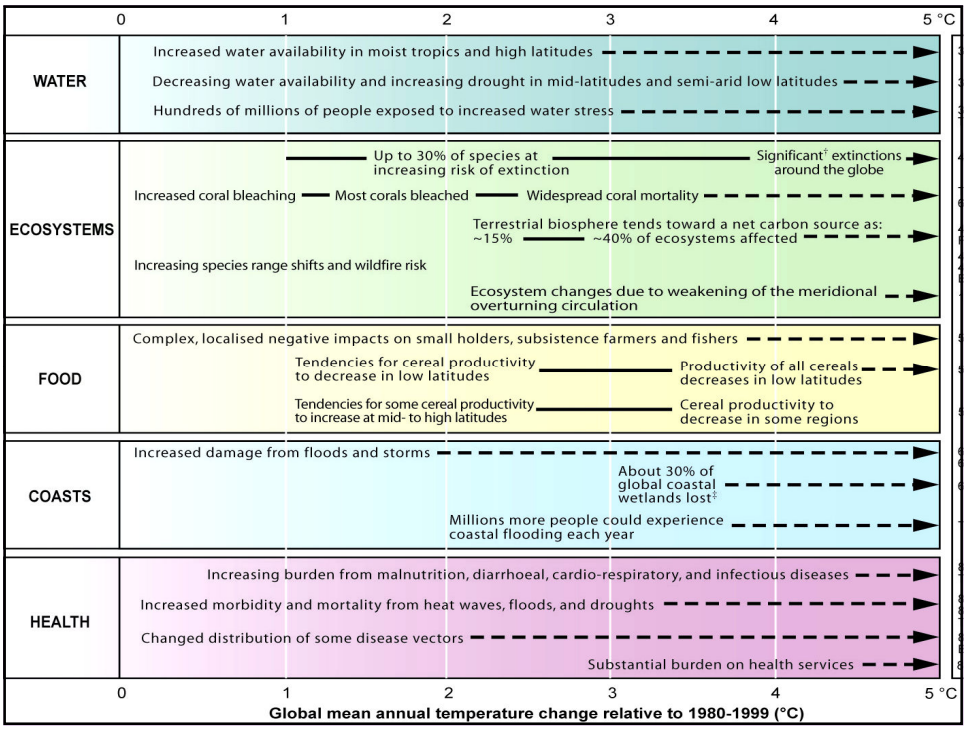
- In 1978, the Qori Kalis Glacier looked like this, flowing out from the Quelccaya Ice Cap in the Peruvian Andes Mountains.

Glaciers are shrinking nearly worldwide

Source: L. Thompson



Impact, Vulnerability, and Adaptation

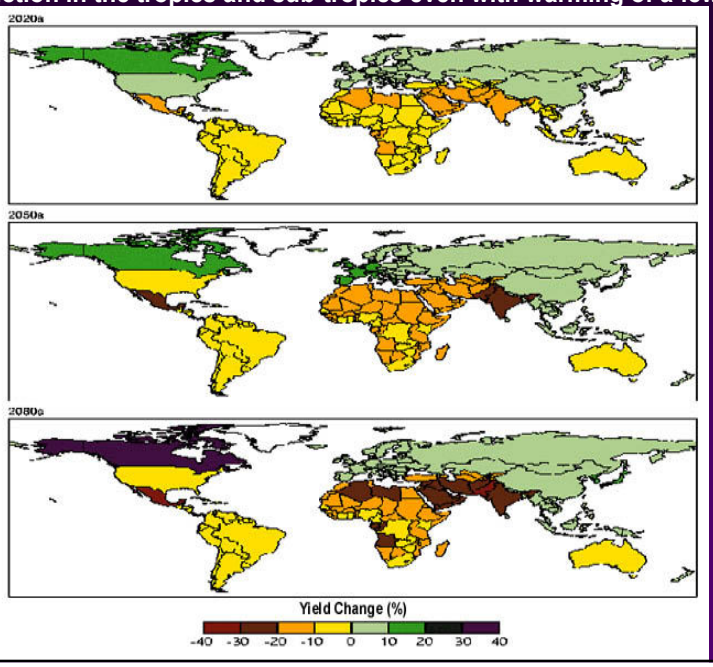


Initially increased agricultural productivity in some mid-latitude regions & reduction in the tropics and sub-tropics even with warming of a few degrees

2020s

2050s

2080s



Consequences of Climate Change on Agriculture

- Increased productivity potential
  - Water Availability
    - Drought
    - Erosion
  - Nitrogen availability
    - Impacts forage quality
    - Grain quality
  - Increased pests
    - Warmer nights
    - Warmer winters
  - Hasten maturity and shorten growing season
- Increased risk and uncertainty

Consequences of Increased Temperature: Effect on Water Resources

- Crop water requirements will increase
- Warmer winters
  - Reduced winter storage thus low stream flows in late summer and early fall
- Increased competition for water resources
  - Agriculture, urban, industrial, domestic

Future risks-Kansas

- Decreasing water availability (& quality)
- More frequent and more severe heat waves
- Heat stress for some plants and animals
- More inputs and associated costs
- Greater variability and uncertainty

Mitigation

UNFCC- Bali

- *Recognizing* that deep cuts in global emissions will be required and emphasizing the urgency to address climate change as indicated in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,

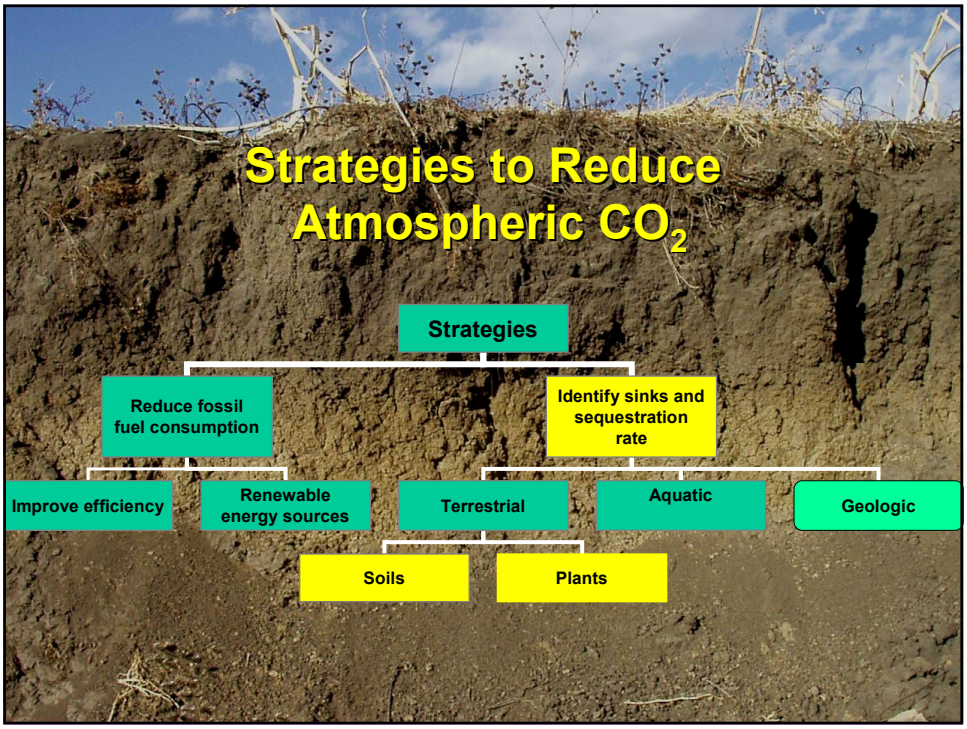
1. *L*aunch a comprehensive process to enable the full, effective and sustained implementation of the Convention

(a)A shared vision for long-term cooperative action, including a long-term global goal for emission reductions ….;

(b) Enhanced national/international action on mitigation of climate change, including,

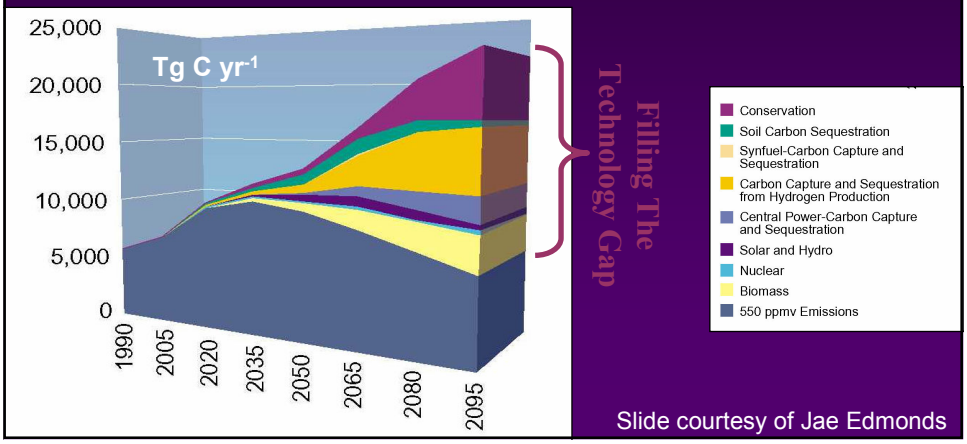
(i) Measurable, reportable and verifiable nationally appropriate mitigation commitments or actions, including quantified emission limitation and reduction objectives, ..;

(ii) Nationally appropriate mitigation actions by developing country Parties in the context of sustainable development…;

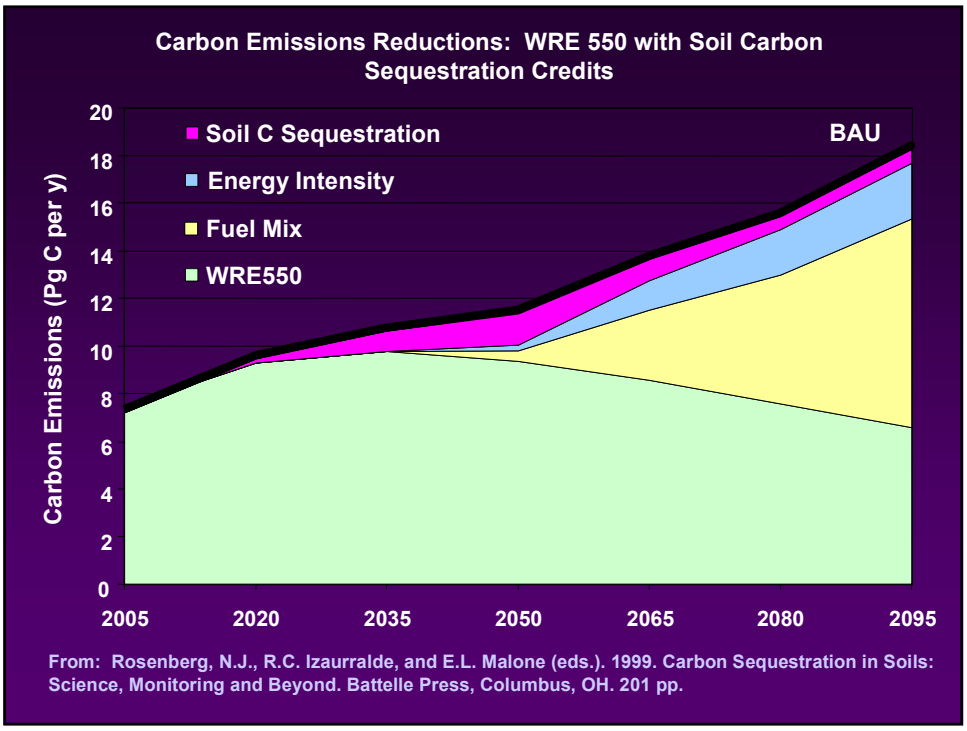


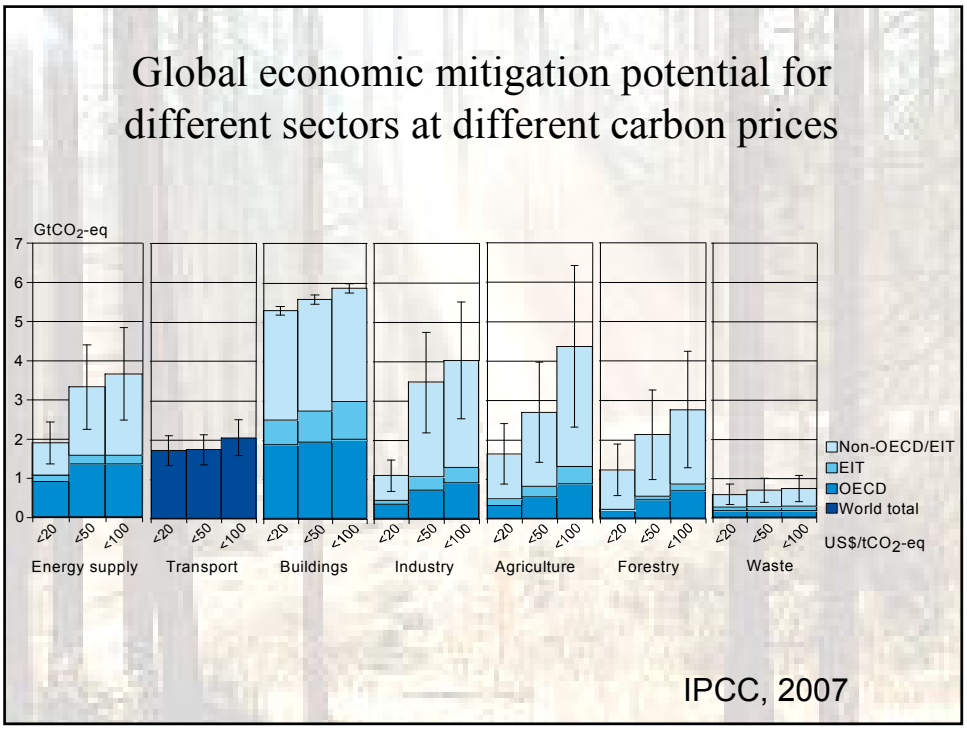
Stabilizing CO_2 concentrations means…

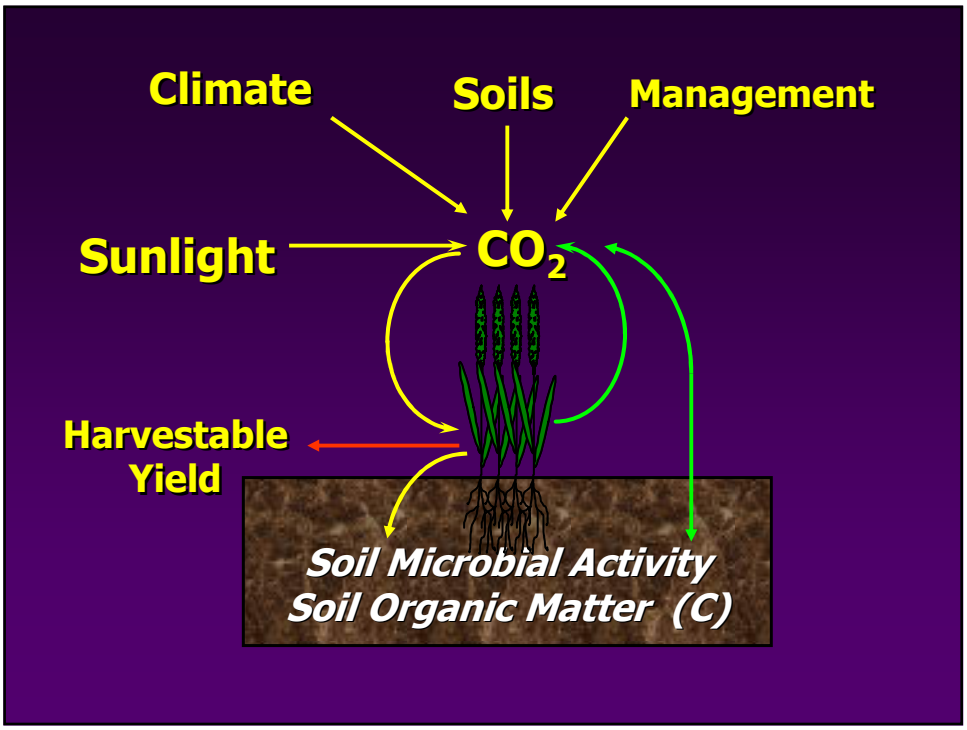
- Changing the global energy system
- Developing a least-cost technology portfolio



Slide courtesy of Jae Edmonds


Carbon Emissions Reductions: WRE 550 with Soil Carbon Sequestration Credits
Soil C Sequestration
Energy Intensity
Fuel Mix
WRE550
BAU
Carbon Emissions (Pg C per y)
0
2
4
6
8
10
12
14
16
18
20
2005
2020
2035
2050
2065
2080
2095
From: Rosenberg, N.J., R.C. Izaurralde, and E.L. Malone (eds.). 1999. Carbon Sequestration in Soils: Science, Monitoring and Beyond. Battelle Press, Columbus, OH. 201 pp.


Global economic mitigation potential for different sectors at different carbon prices
GtCO2-eq
0
1
2
3
4
5
6
7
<20
<50
<100
Energy supply
Transport
Buildings
Industry
Agriculture
Forestry
Waste
Non-OECD/EIT
EIT
OECD
World total
US$/tCO2-eq
IPCC, 2007



Agricultural management plays a major role in greenhouse gas emissions and offers many opportunities for mitigation

- **Cropland**
  - Reduced tillage
  - Rotations
  - Cover crops
  - Fertility management
  - Erosion control
  - Irrigation management

No-till seeding in USA

- **Rice paddies**
  - Irrigation
  - Chemical and organic fertilizer
  - Plant residue management

Rice fields in The Philippines

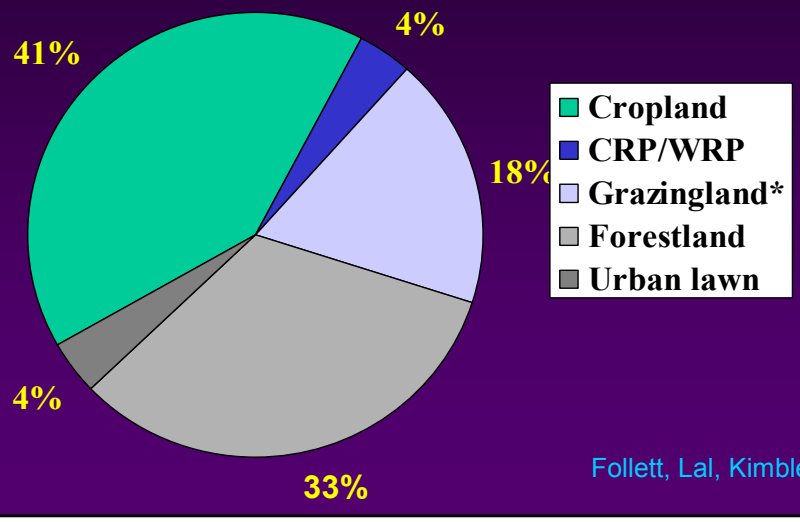
- **Agroforestry**
  - Improved management of trees and cropland

Maize / coffee fields in Mexico

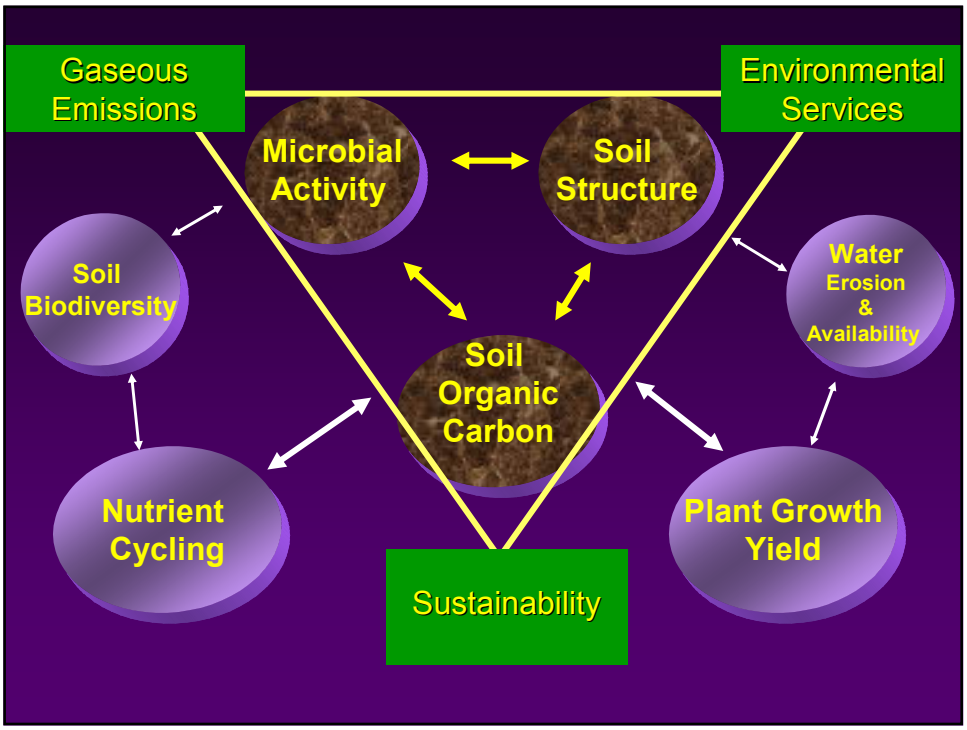
No-Tillage Cropping Systems
Conservation Agriculture

- Restores soil carbon
- Conserves moisture
- Saves fuel
- Saves labor
- Lowers machinery costs
- Reduces erosion
- Improved soil fertility
- Controls weed
- Planting on the best date
- Improves wildlife habitat

Soil C sequestration potential of different US land Categories (% of 322 MMT C/yr) **

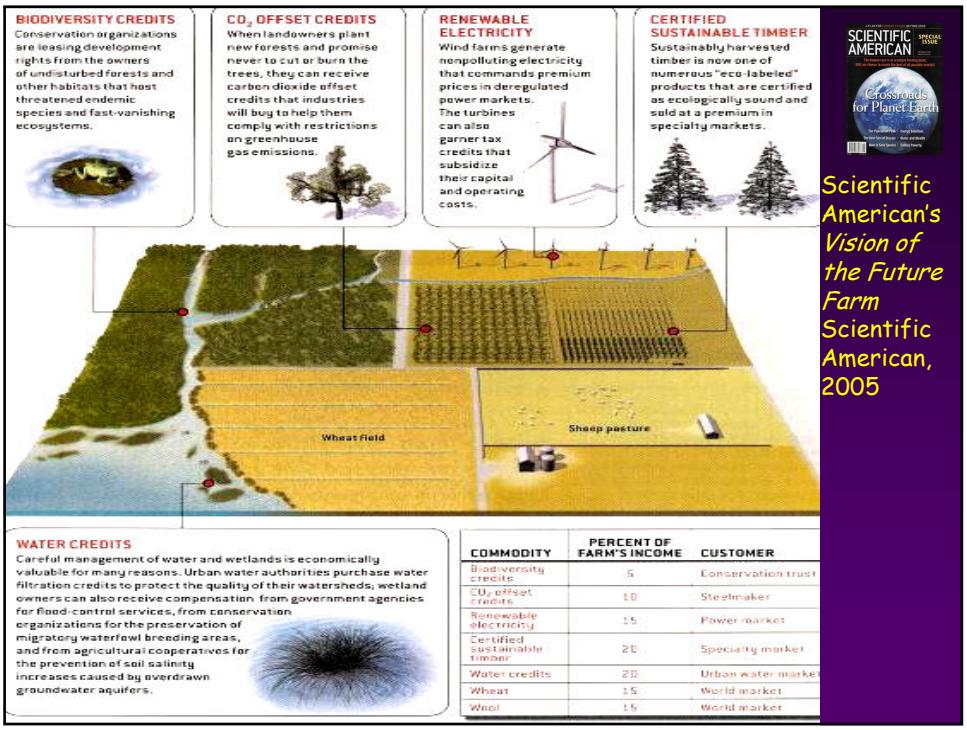


Follett, Lal, Kimble



Mitigation Opportunities for Agriculture

- Offsets
  - **Soil Carbon**
    - **Cropping systems: No-tillage, rotations**
    - **Grasslands**
    - **Rangelands**
  - **Methane reduction**
    - **livestock facilities**
    - **landfills**
  - Nitrous oxide reductions from fertilizers
  - Fuel reductions (no-till)
- Biofuel offsets
  - Production
  - Consumption
- Wind energy
- Energy efficiency



Scientific American's *Vision of the Future Farm* Scientific American, 2005

Conclusions Adaptation

- Competition for water resources
- Stress on human, animal and plant systems from infectious diseases
- Stress on natural resources
  - Soil
  - Water
  - Natural ecosystems
- Agriculture may adapt but at some costs

Conclusions: Mitigation

- Agriculture has a significant role to play in climate mitigation
- Agriculture is cost competitive with mitigation options in other sectors
- Bio-energy crops and improved energy efficiency in agriculture can contribute to further climate mitigation
- Agricultural mitigation should be part of a portfolio of mitigation measures to reduce emissions / increase sinks whilst new, low carbon energy technologies are developed.

Summary

- Agricultural soil C sequestration
  - Keeps land in production
  - Improves soil quality
  - In many cases increases profitability for the farmer
  - Provides other environmental benefits to society
    - Water quality (less runoff, less erosion)
    - Flood control
    - Wildlife habitat
  - May help adapt to climate change as well as mitigate

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- Websites

www.oznet.ksu.edu/kccm

www.soilcarboncenter.k-state.edu/

www.oznet.ksu.edu/ctec

www.casmgs.colostate.edu/

K-State Research and Extension

Potential CO_2 Stabilization Options

	Rapidly Deployable	Not Rapidly Deployable
Minor Contributors <0.2 PgC/y	• **Biomass co-fire electric generation** • Cogeneration (small scale) • Hydropower • Natural Gas Combined cycle • Niche options (geothermal, solar)	• Integrated photovoltaics • **Forest management (fire suppression)** • Ocean fertilization
Major Contributors >0.2 PgC/y	• **C sequestration in ag. soils** • Improved appliance efficiency • Improved buildings • Improved vehicle efficiency • Non-CO_2 gas abatement from industry • **Non-CO_2 gas abatement from agriculture** • **Reforestation** • Stratospheric sulfates	• **Biomass to hydrogen** • **Biomass to fuel** • **Cessation of deforestation** • Energy-efficient urban and transportation systems • Fossil-fuel C separation with geologic or ocean storage • High efficiency coal technology • Large-scale solar • Next generation nuclear fission • Wind with H_2 storage • Speculative technologies

Caldeira et al. 2004. A portfolio of carbon management options, p. 103-130, *In* C. B. Field and M. R. Raupach, eds. The Global Carbon Cycle. Island Press, Washington, DC.

Additional mitigation from agriculture

- Additional mitigation of 770 Mt CO_2-eq. yr^{-1} could be achieved by 2030 by **improved energy efficiency** in agriculture

- **Feed-stocks for bio-energy**.

Smith et al. (2007a)