75 Years: Soil Science Society of America and Soil Survey

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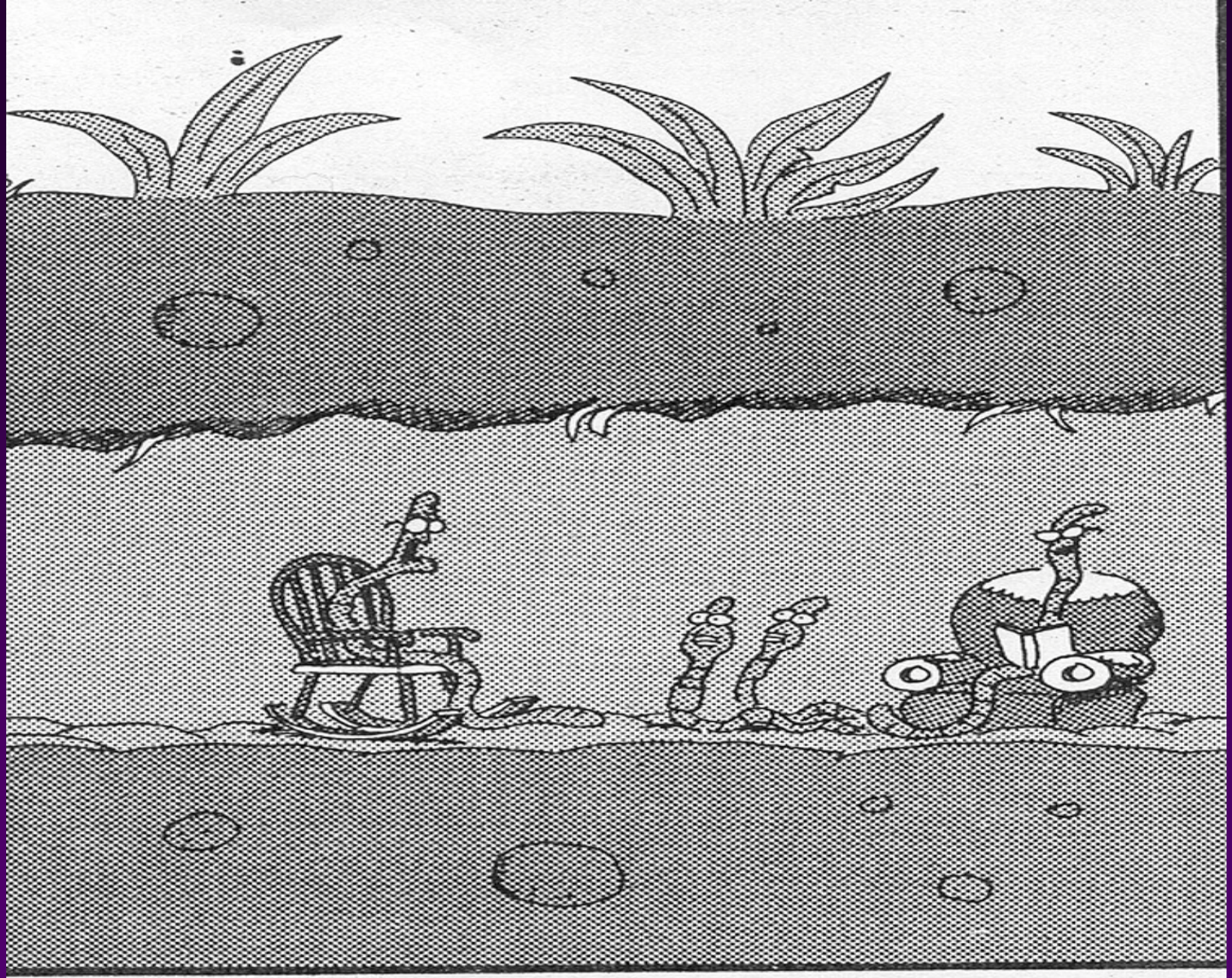
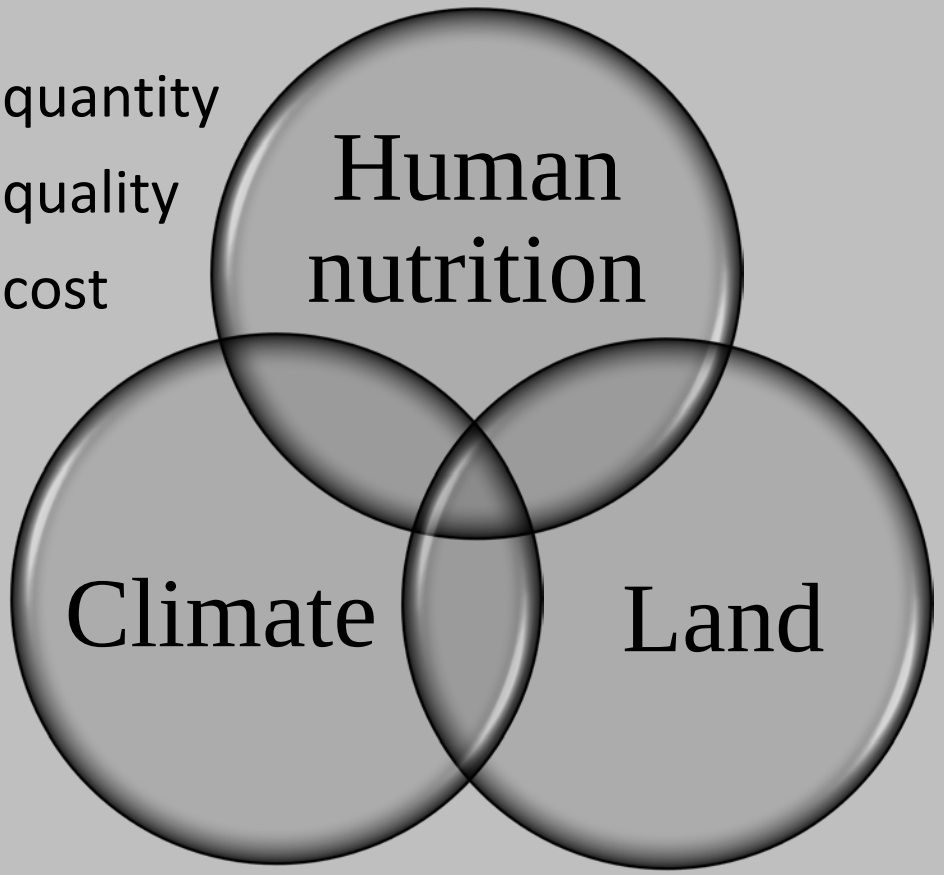


"You little softies! When *I* was your age, I had to crawl
14 inches to the surface and back! Every day! ...
Through *hardpan*, by thunder!"

Underlying factors for the challenges of the coming decades

- Food quantity
- Food quality
- Food cost



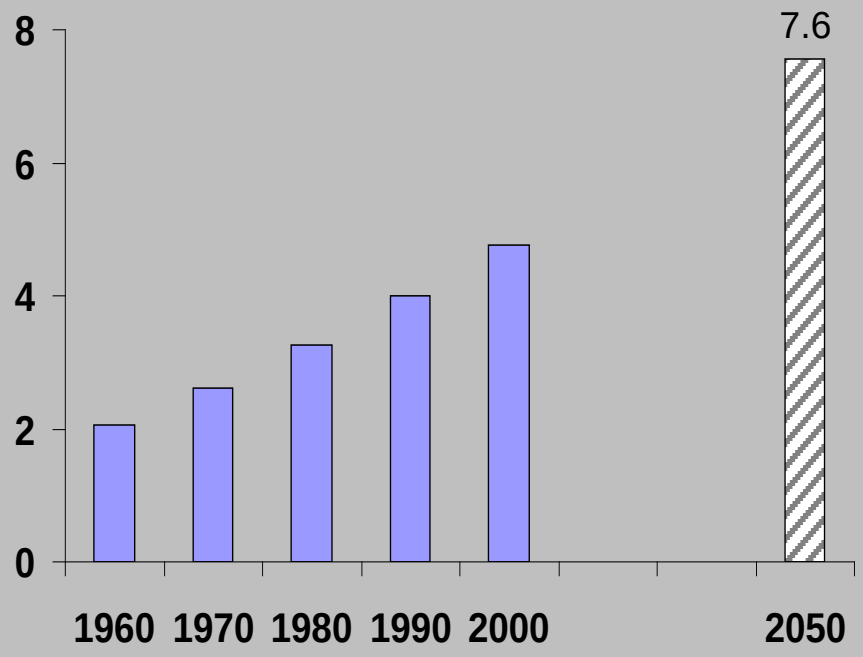
- Climate change
- Energy

- Soil
- Water

Population and Arable Land in Developing Countries

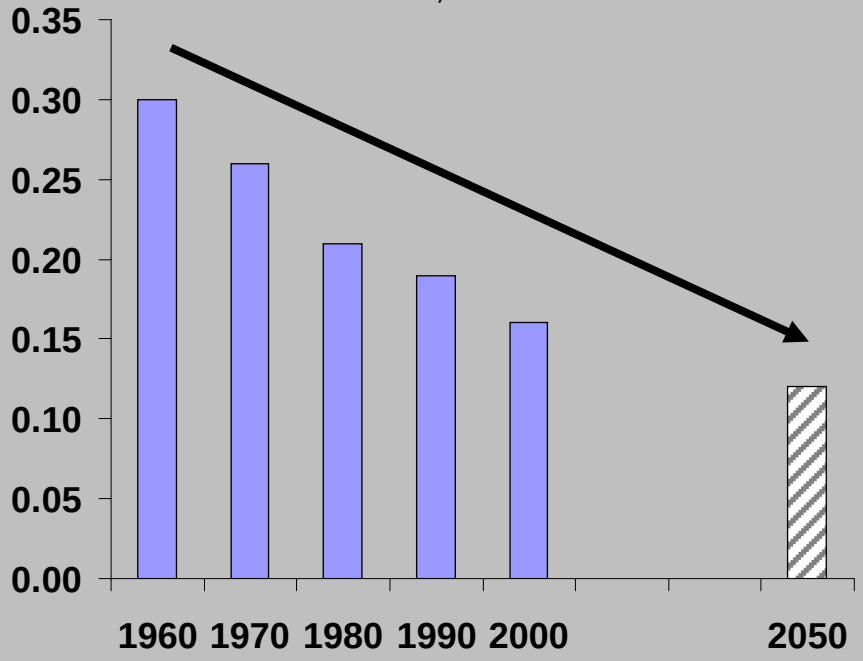
Population

Billions, 1960 - 2050



Arable land per capita

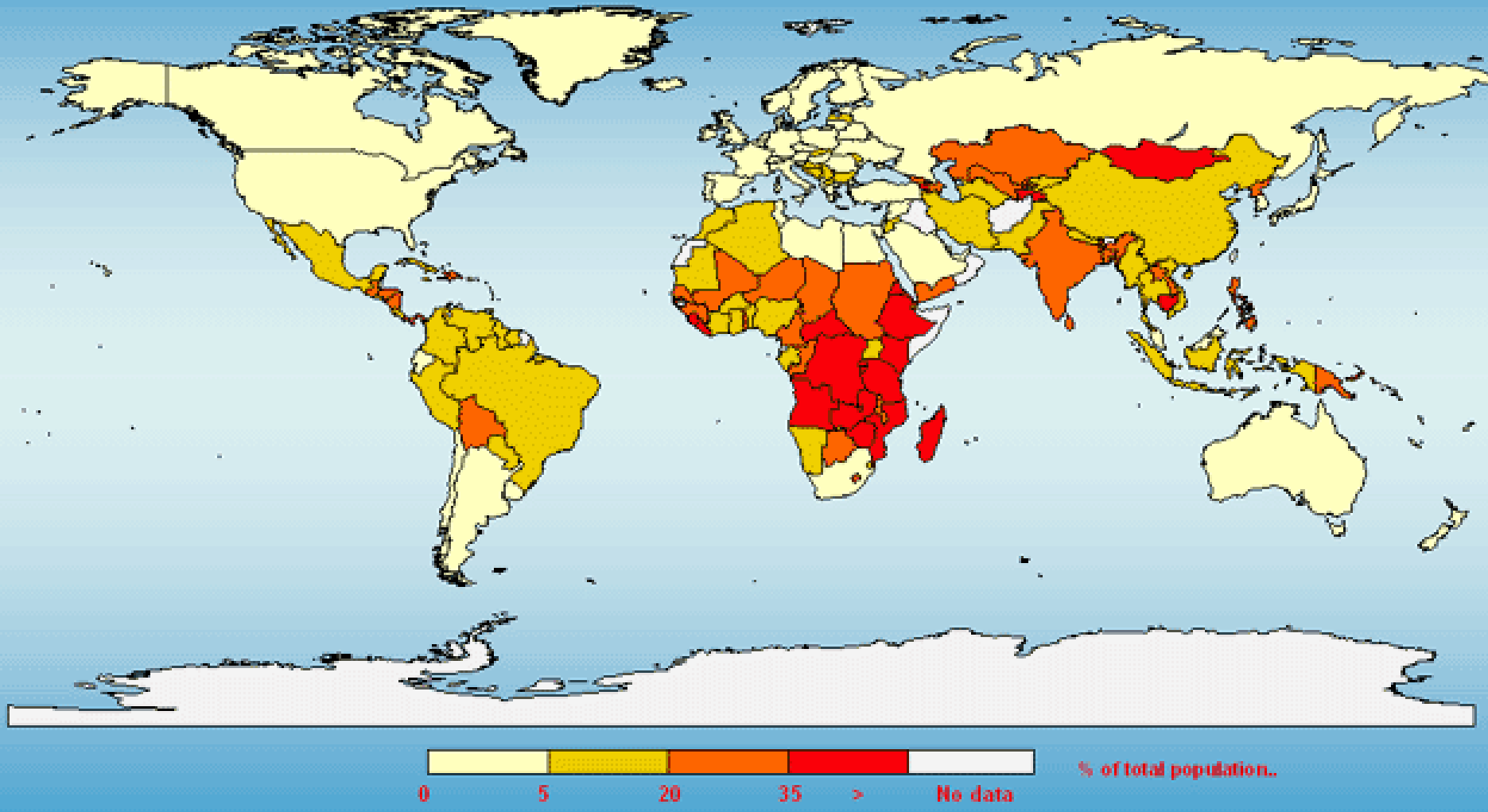
Hectares, 1960 - 2050



Food production must double to meet human needs by 2050

FAOSTAT, 2006

Undernourished Population (1999-2001)

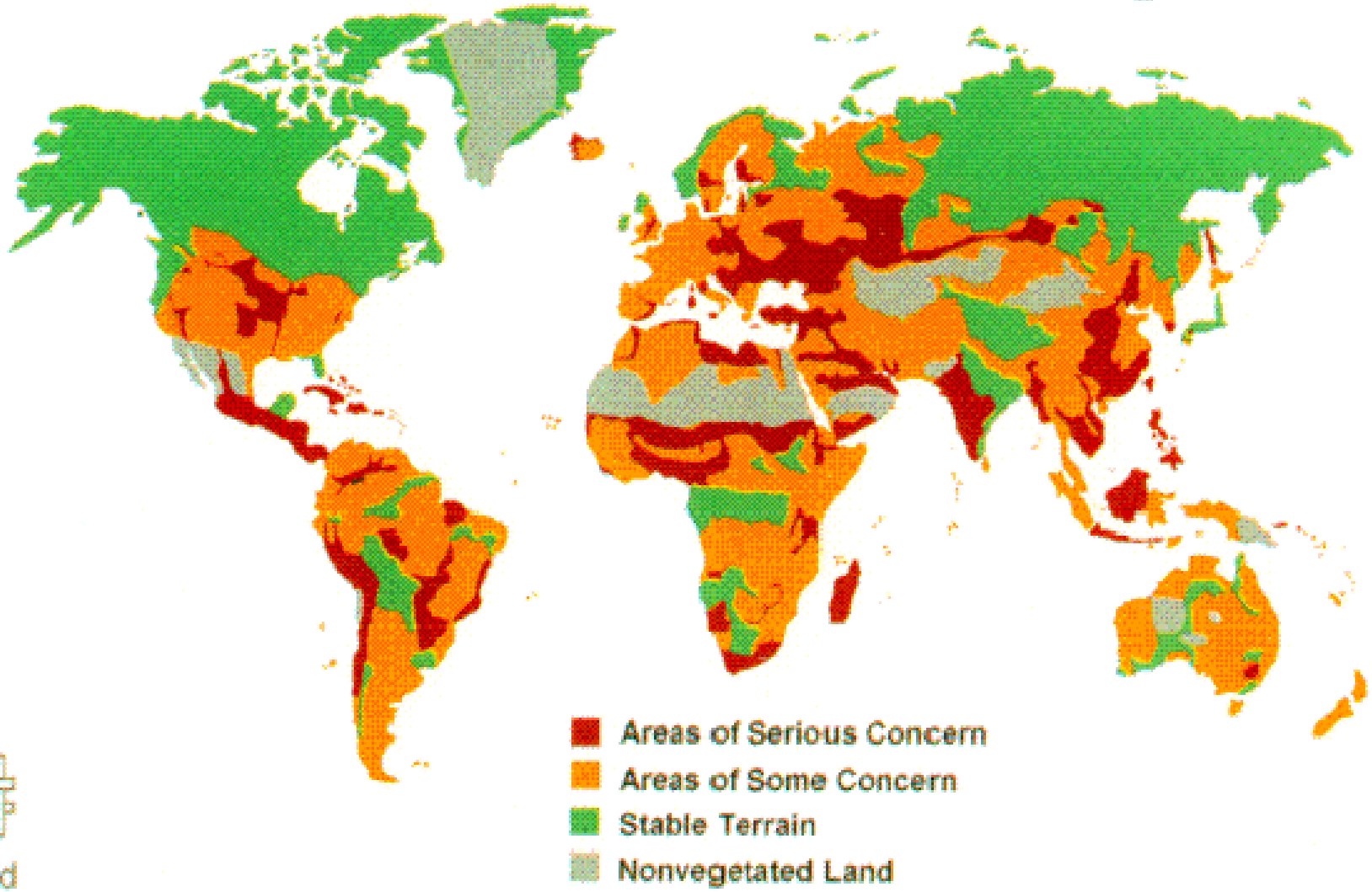


Map 1
Based on data for SOFI 2003.
Prepared by: FAO Statistics Division
Rome, 2003

Soil degradation and its impact on other systems (hydrosphere, atmosphere, biosphere)

- Erosion
  - leads to eutrophication, sedimentation, poor air quality
- Decline in organic matter
  - erosion, less filtering of pollutants
- Contamination (local and diffuse)
  - loss of usable land, loss of clean water, human health
- Sealing
  - loss of land
- Compaction
  - loss of biodiversity
- Loss of biodiversity
  - loss of ecosystem resilience
- Salinization
  - loss of agricultural land, loss of potable and irrigation water
- Floods and landslides

Areas of Concern for Soil Degradation



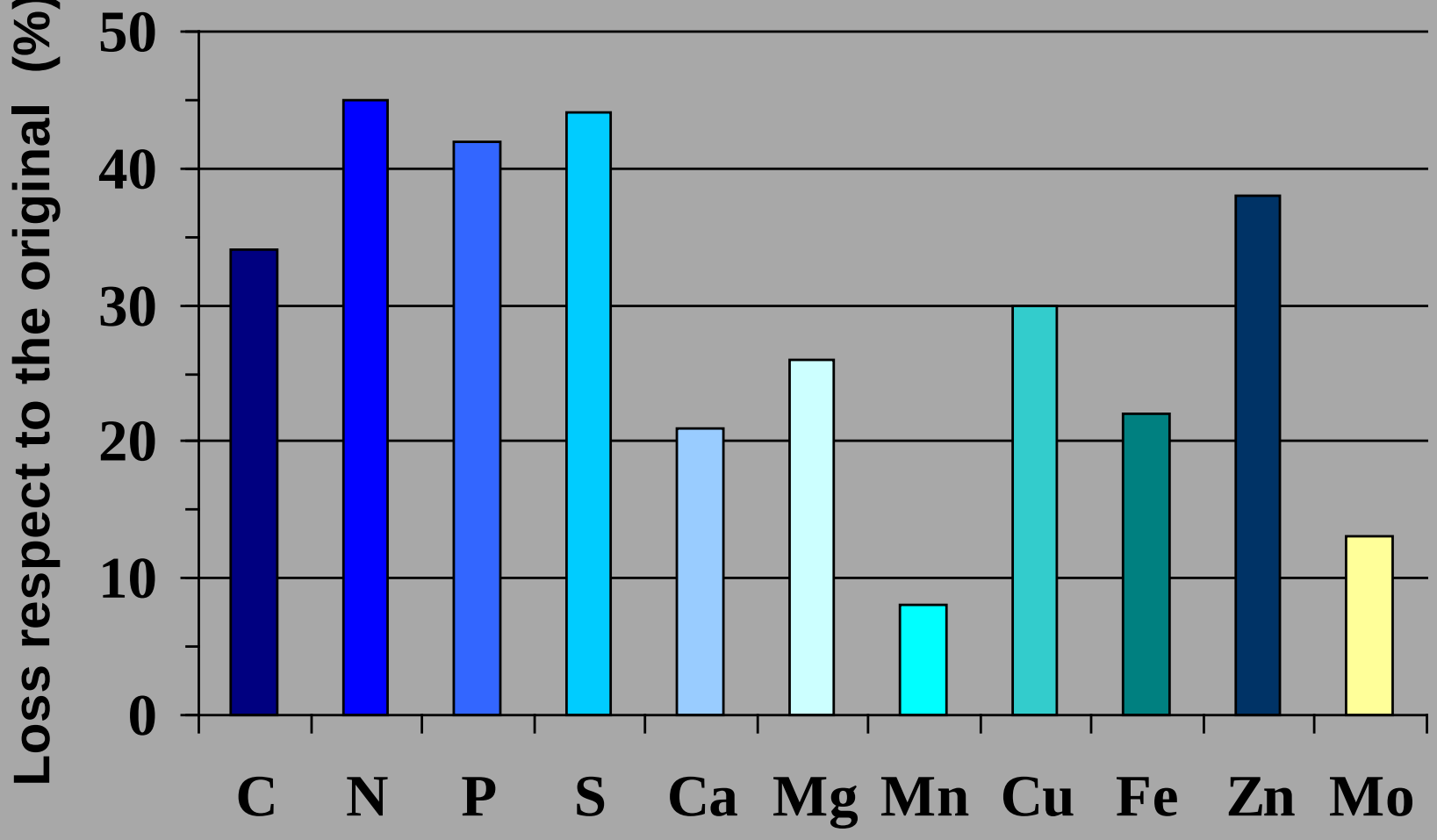
World Resources Institute

Source: International Soil Reference and Information Centre, unpublished map (Wageningen, the Netherlands, 1990)

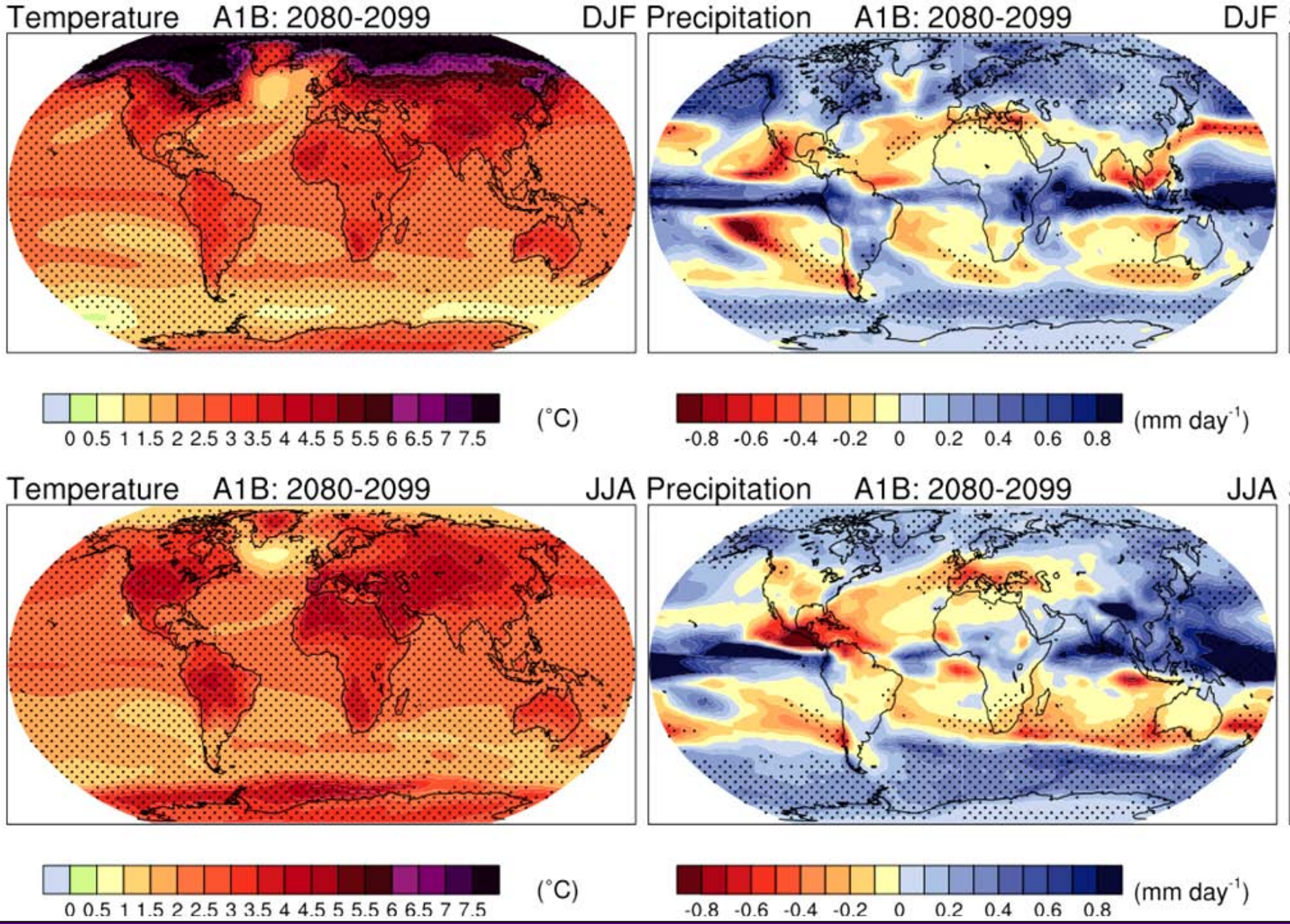
Soil degradation in the Pampean Region of Argentina

Nutrient losses after 80 years of continuous agriculture

Pergamino series - Typic Argiudoll

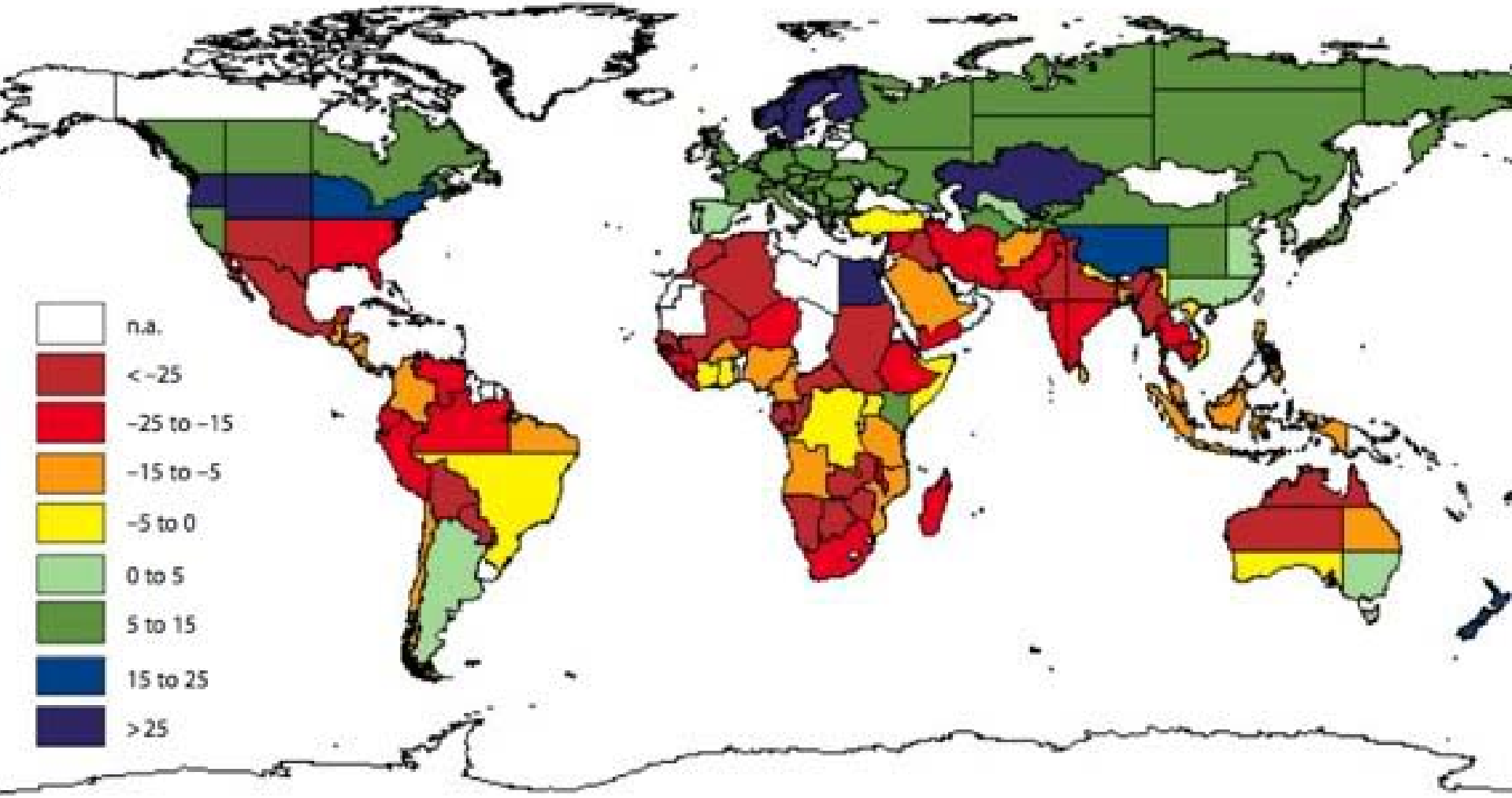


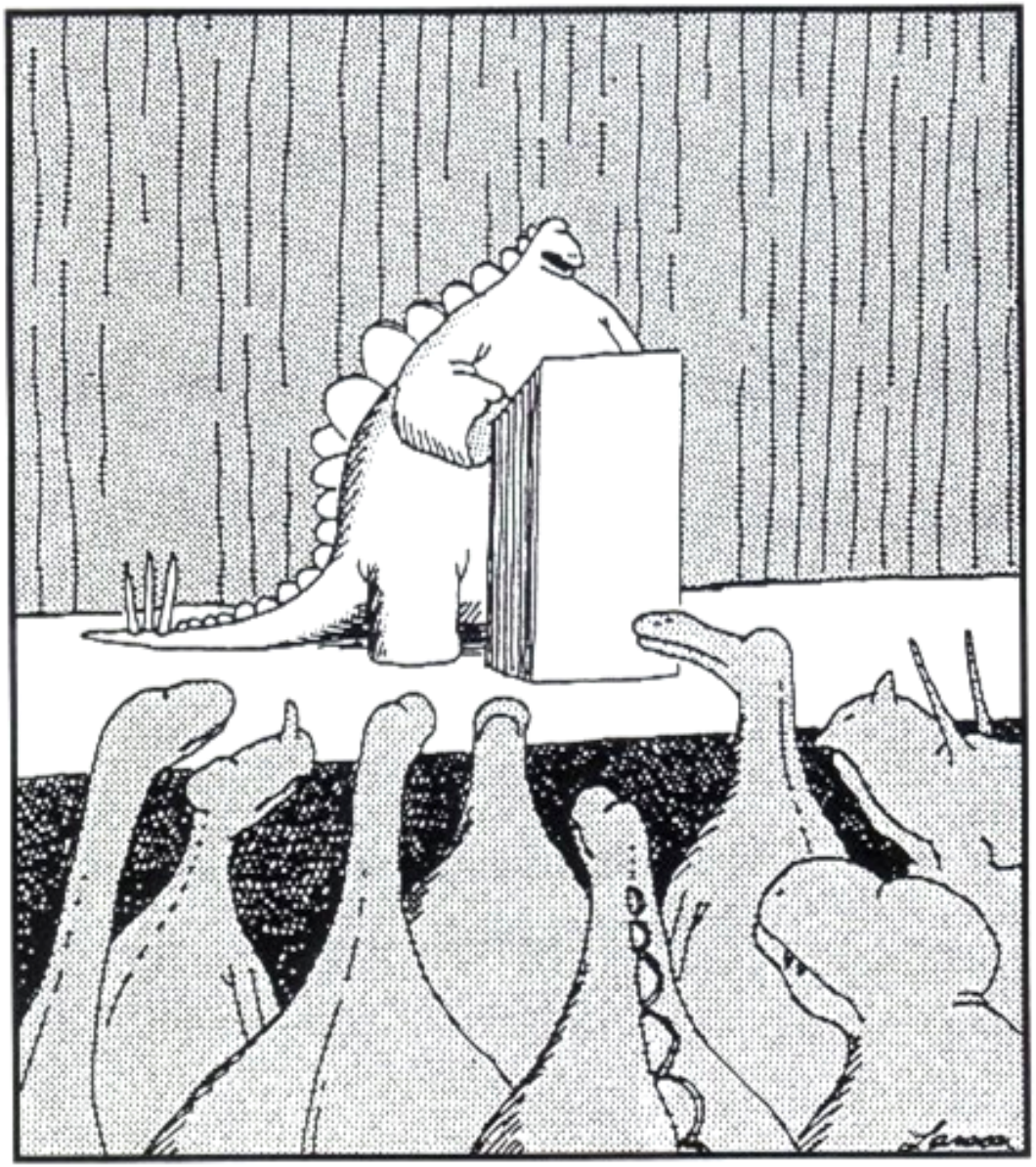
Source :Andriulo, Galantini y Abrego (1996)



IPCC Fourth Assessment Report, Working Group III, 2007

Change in Agricultural Productivity





"The picture's pretty bleak, gentlemen. ... The world's climates are changing, the mammals are taking over, and we all have a brain about the size of a walnut."

The Far Side®

LAST IMPRESSIONS

2002

March

Saturday 23

Critical issues facing humanity and how soil scientists can address them (Janzen et al SSSAJ75:1–8)

- **Food**:
  - How Can We Feed the World without Harming Soils or the Environment?
- **Fresh Water:**
  - How Can We Manage Our Soils to Use Dwindling Pools More Wisely?
- **Nutrients:**
  - How Do We Preserve and Enhance the Fertility of Our Soils?
- **Energy:**
  - How Can We Manage Our Lands to Accommodate Increasing Demands?
- **Climate Change:**
  - How Will It Affect the Productivity and Resilience of Our Soils?
- **Biodiversity:**
  - How Can We Better Understand and Enhance Soil Biotic Communities to Create More Resilient Ecosystems?

Soil Science Grand Challenges (SSSA)

1. **Food and Energy Security**. Develop site-specific soil management solutions that maximize soil agroeosystem services, minimize soil disturbance, and concurrently increase soil carbon reserves while reducing the nutrient, water, and pesticide inputs

2. **Climate Change**. Determine the mechanisms controlling greenhouse gas emissions from organic soils, particularly tundra and permafrost soils, and identify methods to control these emissions.

3. **Waste Treatment and Water Quality**. Manage the soil-based re-use of waste—industrial and stormwaters – in rural and urban environments to maximize water infiltration and storage and minimize damage to aquatic systems and reduce dependence on groundwater.

4. **Human and Ecosystem Health**. Harness the microbial diversity of soil to develop new pharmaceuticals, deactivate pathogens in waste material and contaminated water, and prevent impairment of watersheds.

Soil Science and Soil Survey

Time for a Universal Soil Classification System

M.Golden, E. Micheli, C. Ditzler, H. Eswaran, P. Owens, G. Zhang, A. McBratney, J. Hempel, Luca Montanarella, Peter Schad. 2010
19th World Congress of Soil Science, Soil Solutions for a Changing World

- Soil science, unlike many other scientific disciplines, does not have a universally accepted classification system.
- Attempts have been made through efforts such as the FAO Legend for the Soil Map of the World, the World Reference Base for Soil Resources, and Soil Taxonomy to address the need for a globally accepted soil classification system.
- Develop a universal soil classification system.

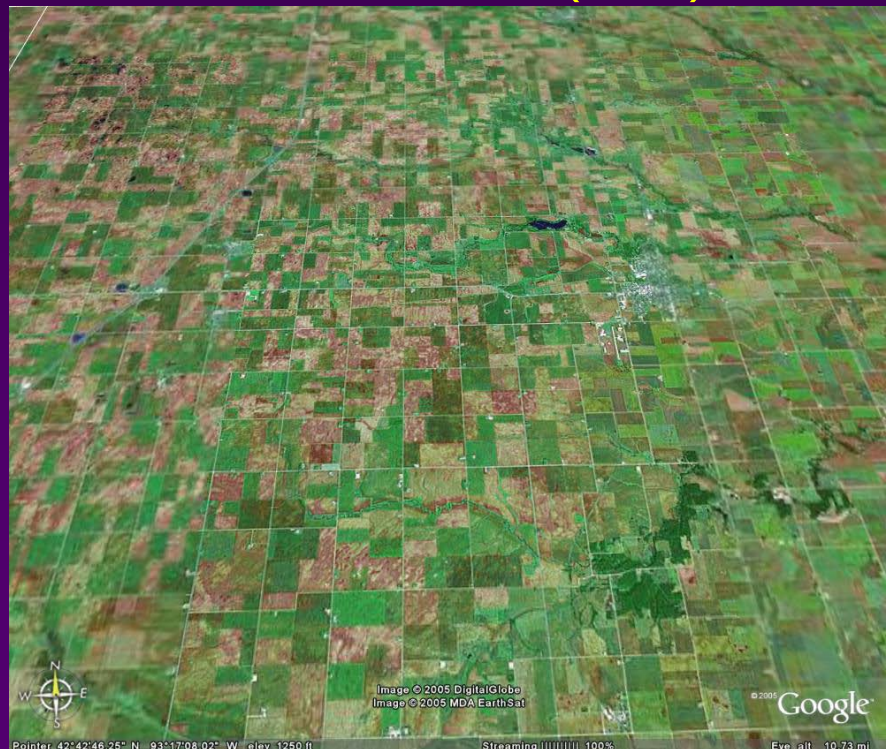
- **Digitized world soil map**

Landscapes are our habitat

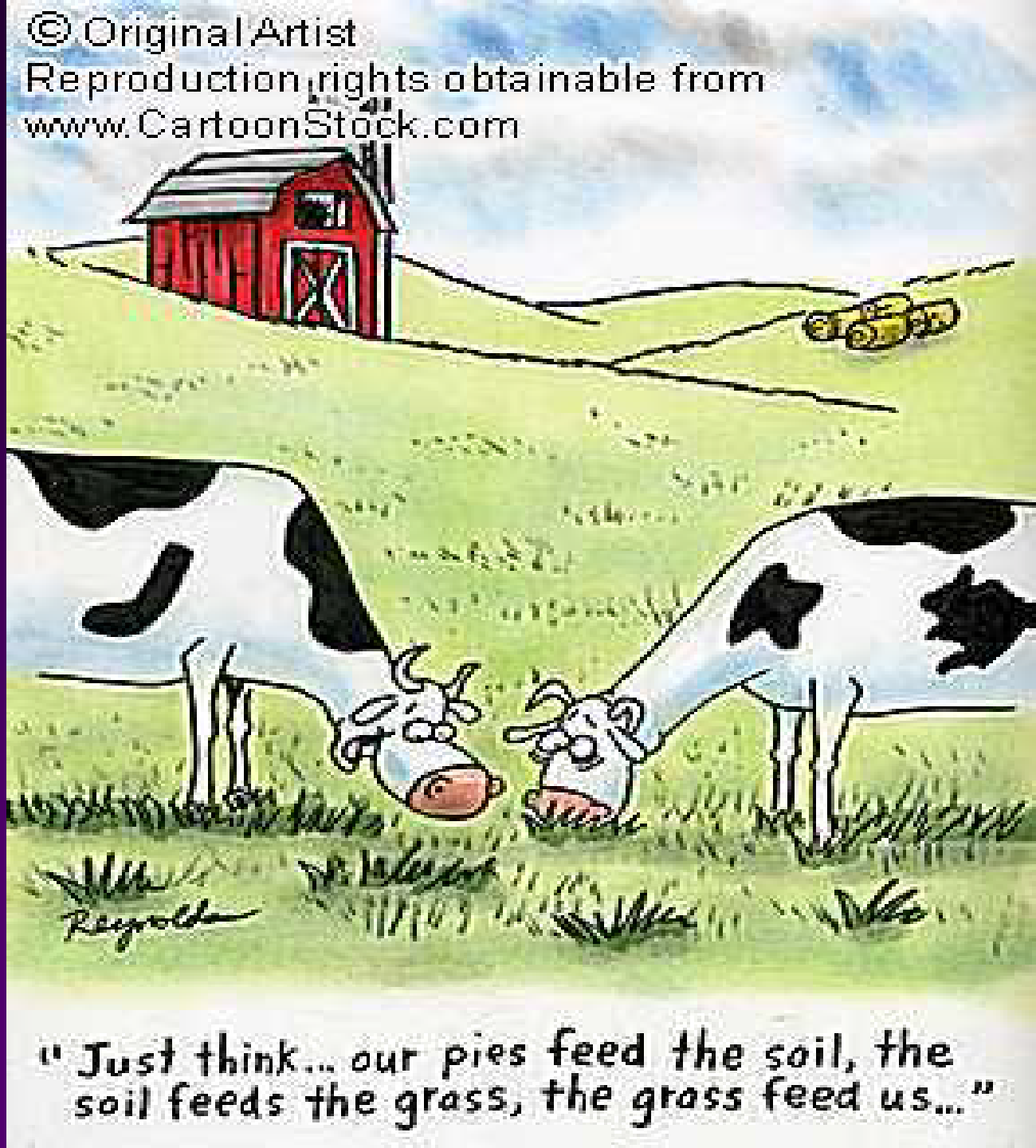
- Landscape modifications affect many processes
  - Cycling of water, carbon and nitrogen
  - Heat exchange between the land and the atmosphere
  - Lateral transport of soil by wind and water
  - Rate and extent of physical, chemical, and biological soil reactions

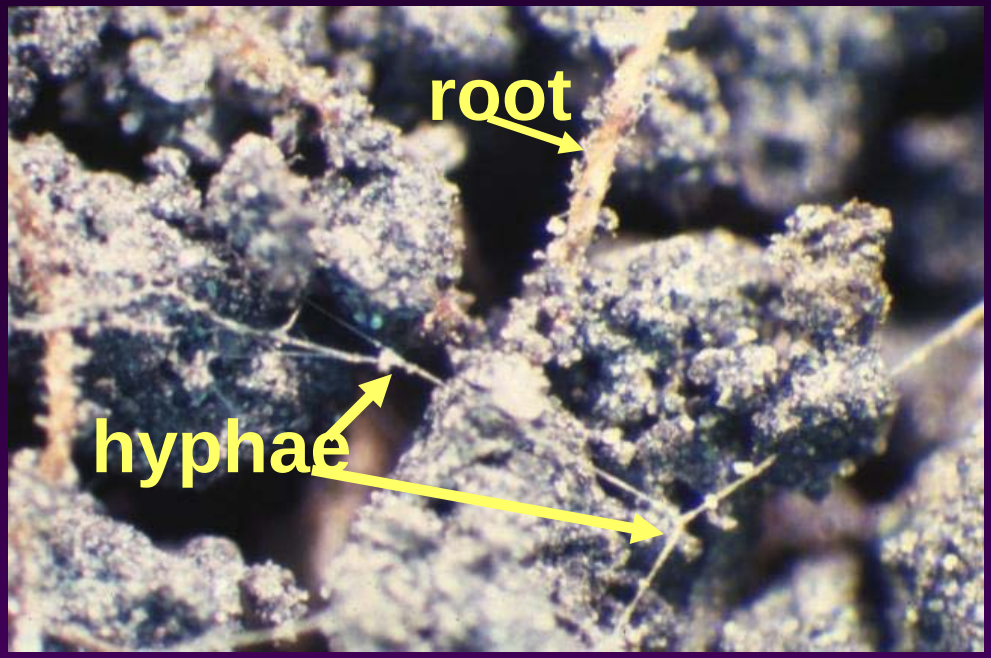
Rondonia (Brazil)

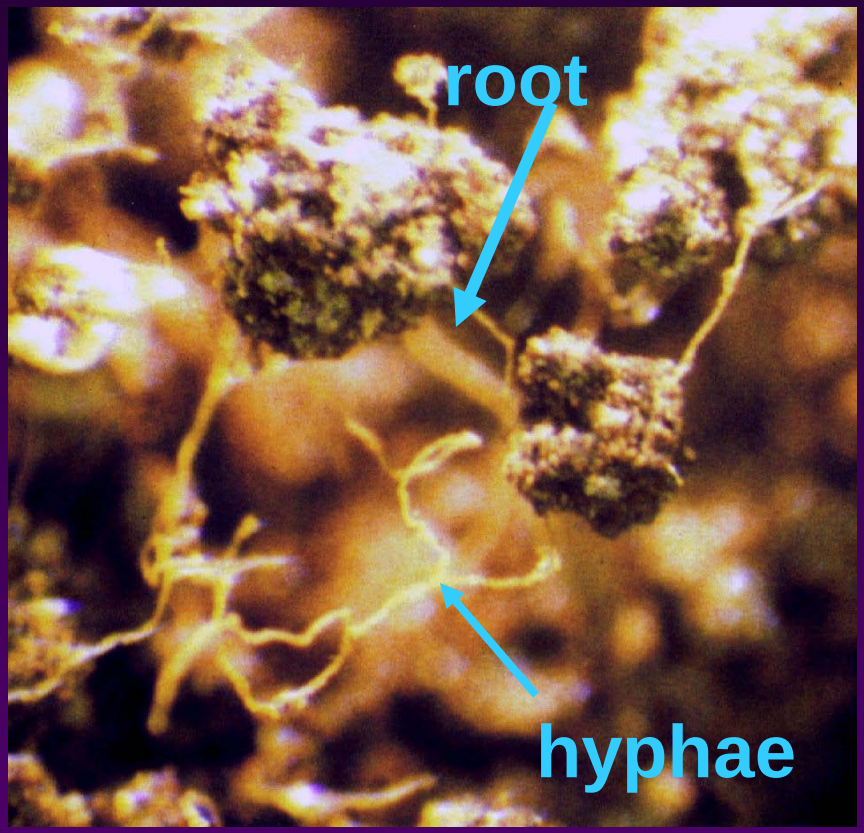
Central Iowa (USA)

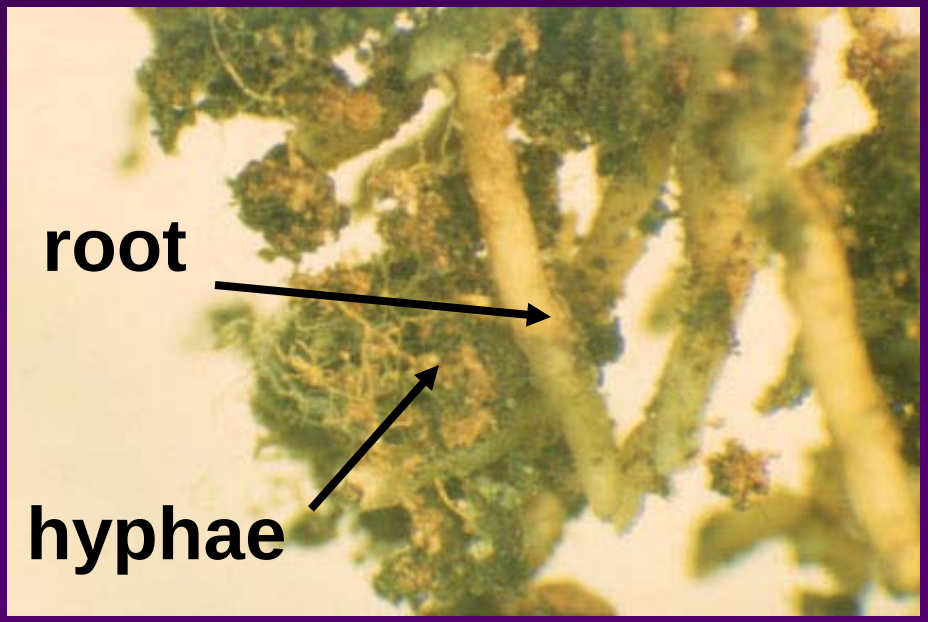


- Its all about processes and cycles



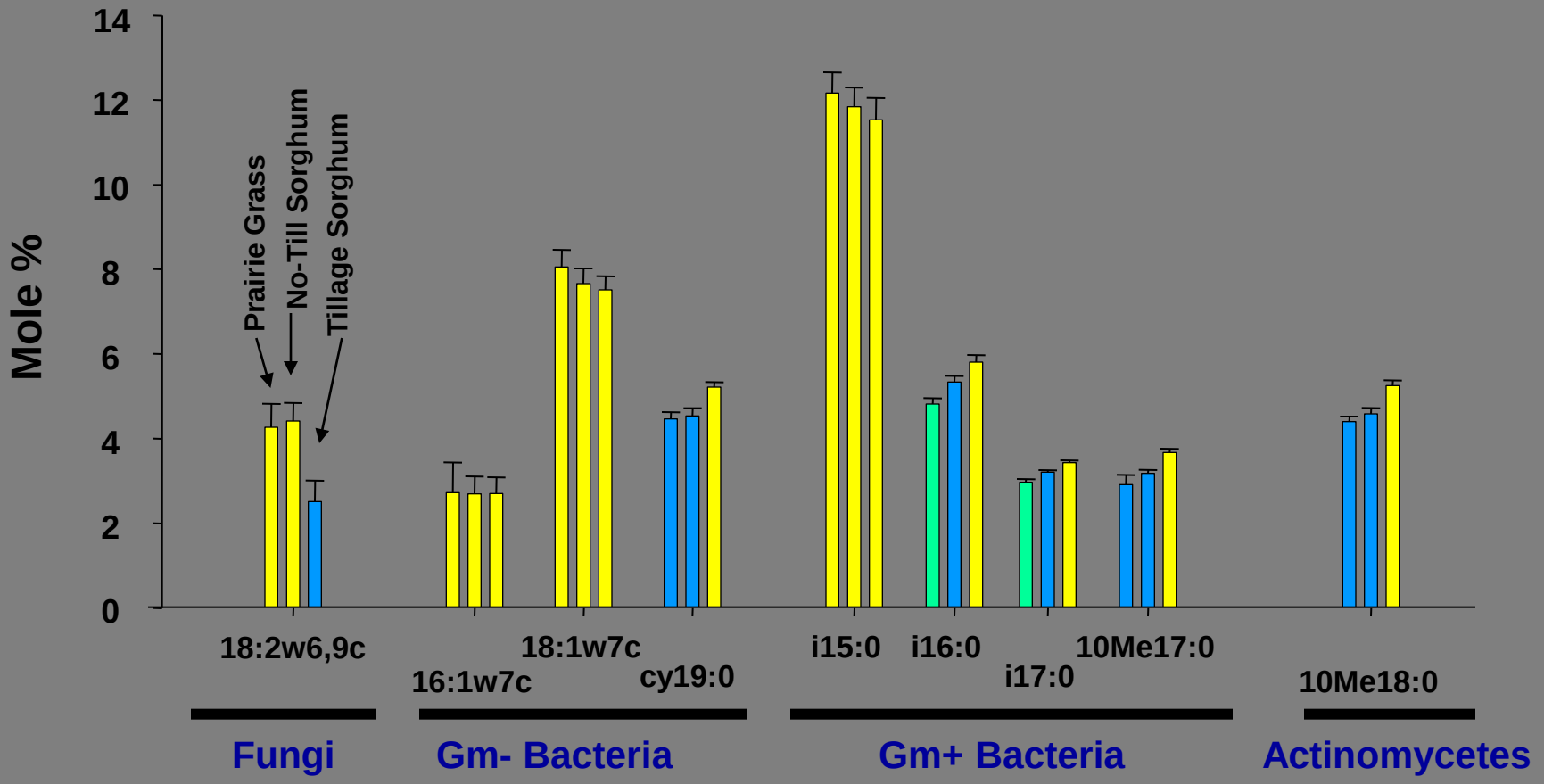






Photos provided by:
Mike Miller and Julie Jastrow

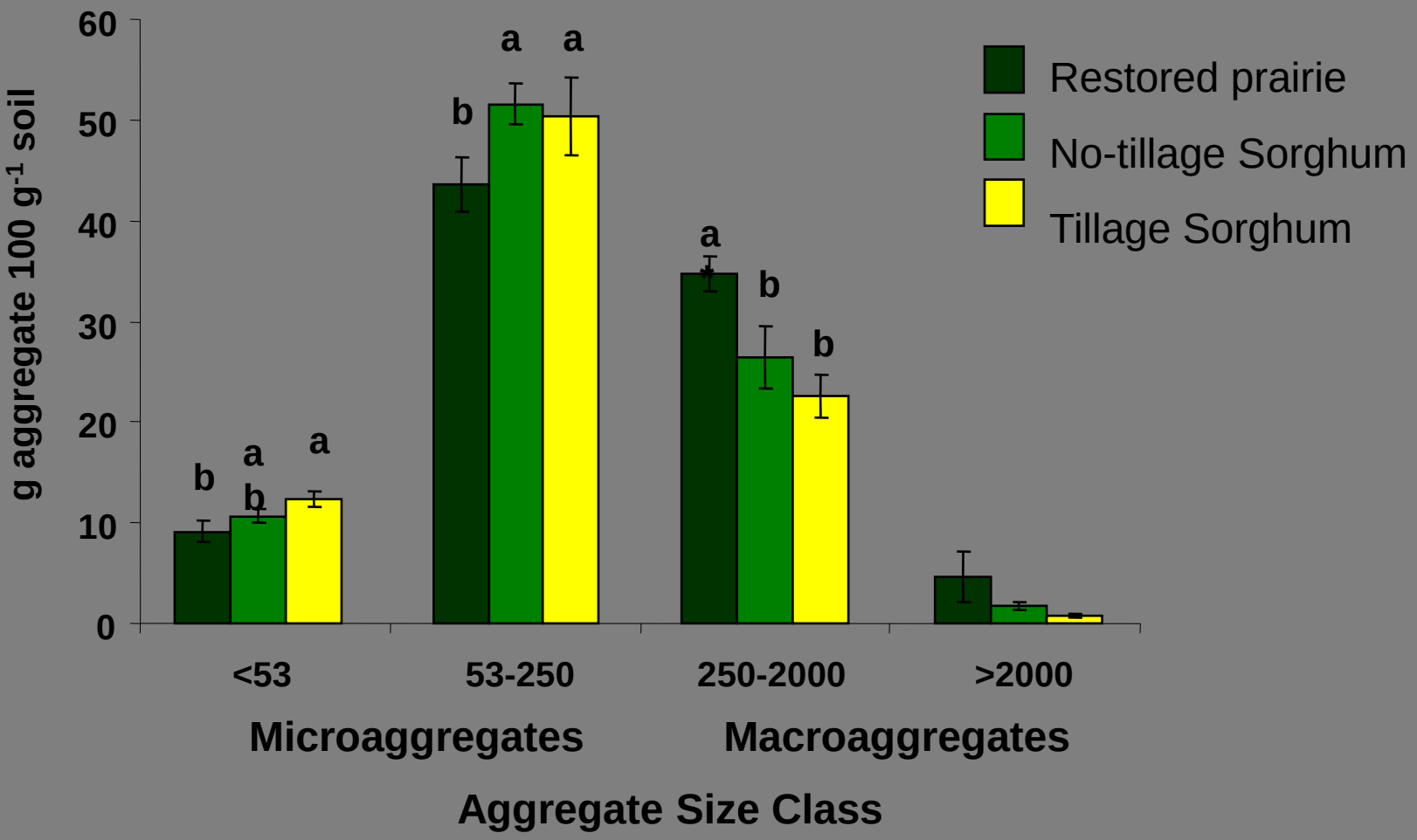
Microbial community - Phospholipid fatty acid levels (0-5 cm depth)



Bars of the same color for a given PLFA biomarker are not different ($p \leq 0.10$).
Lines are 1 standard error.

White and Rice, 2007

Soil Aggregation



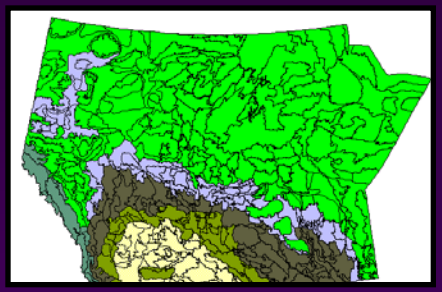
White and Rice, 2007

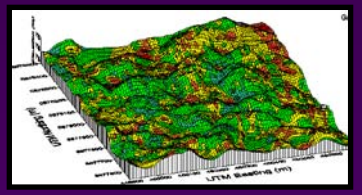
Upscaling from sites to regions across time

Time arrow

Databases, remote observations

Experiments





10^{12} m^2

10^{9} m^2

10^{6} m^2

10^{3} m^2

10^{1} m^2

10^{-6} m^2

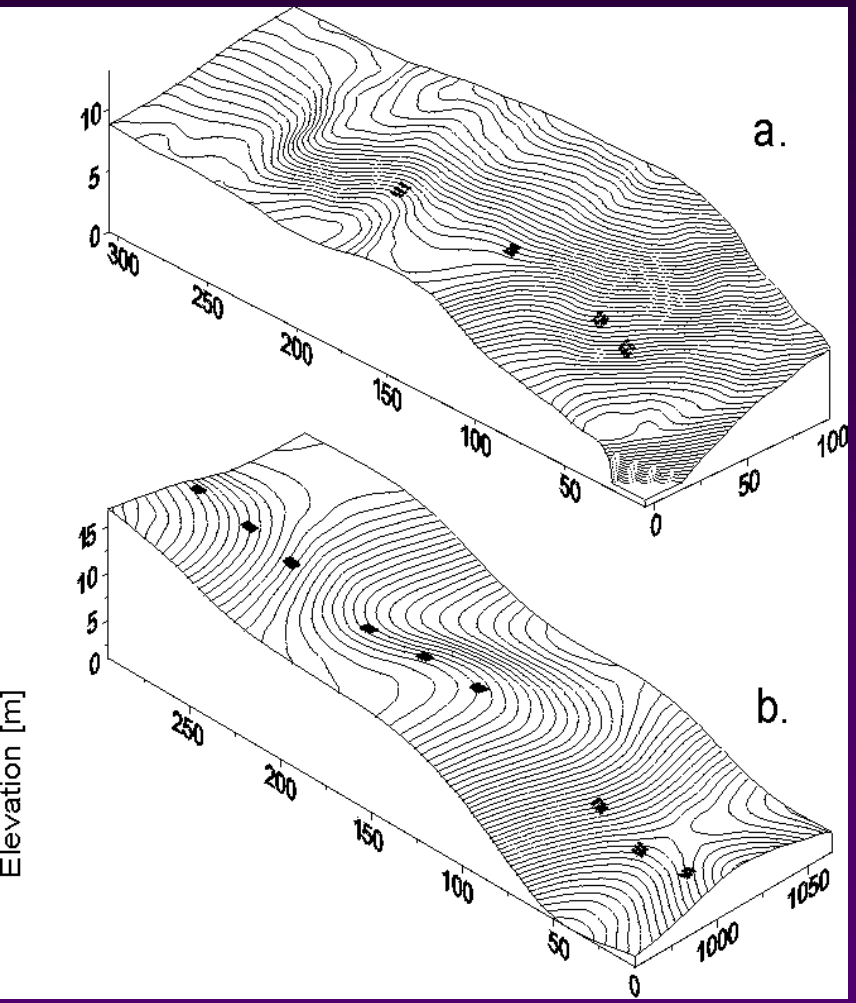
Simpler models, metamodels?

Process models, landscape models

Soil Organic Carbon

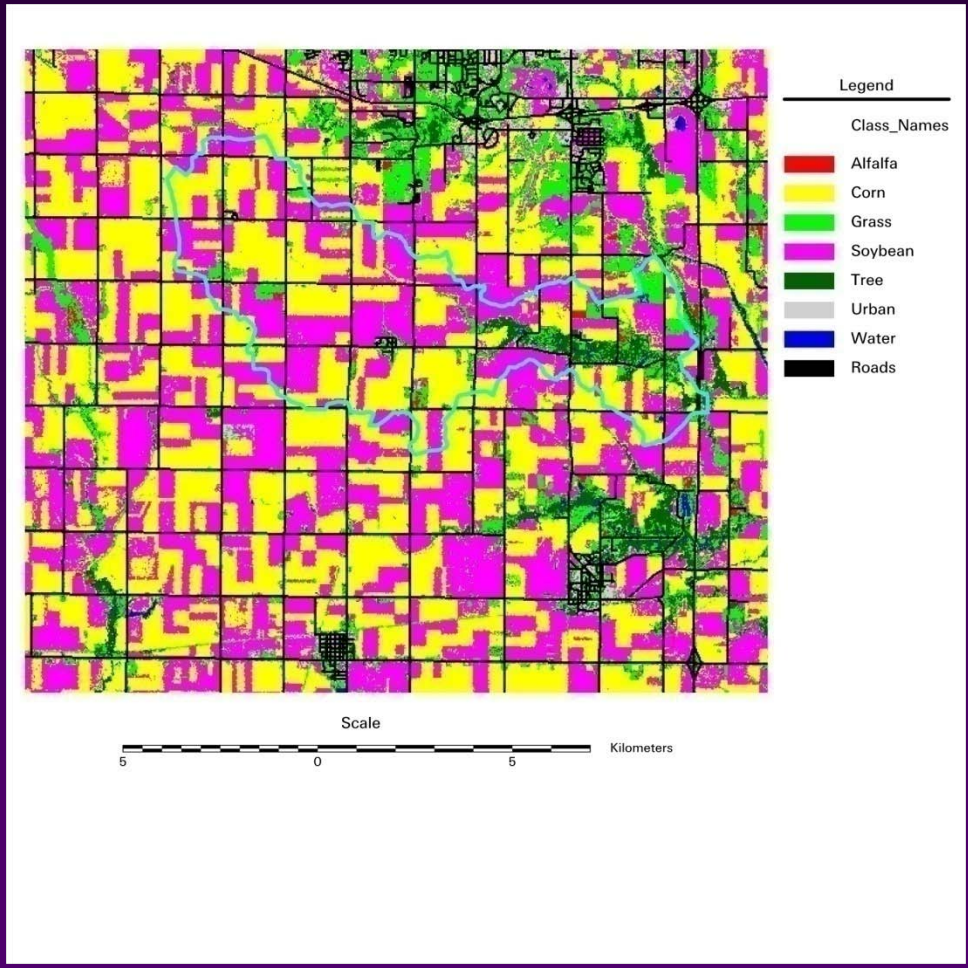
- Quantify regional SOC changes at the resolution of individual agricultural management units for diverse environmental conditions and cropping systems.

Sampling strategies: account for variable landscapes



Remote Sensing and Carbon Sequestration

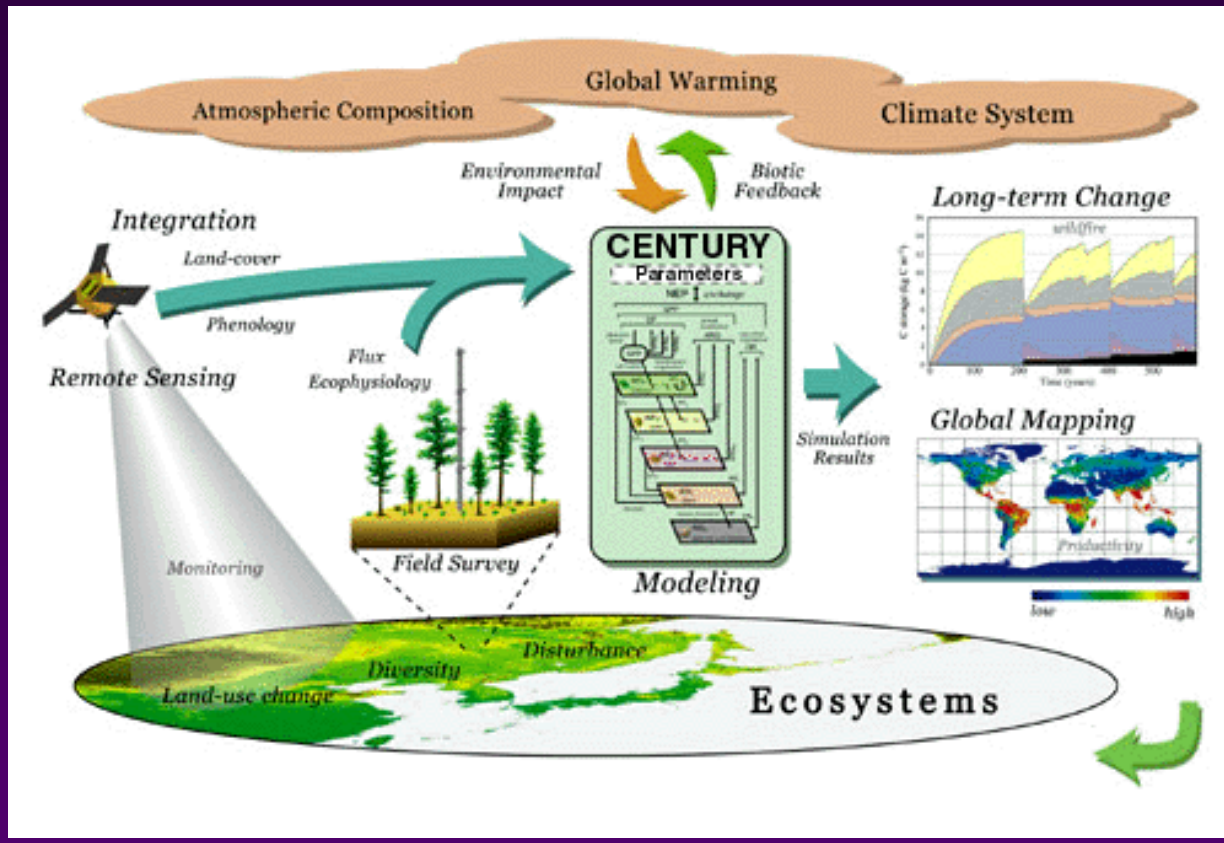
- Remote sensing cannot be used to measure soil C directly unless soil is bare.
- Remote sensing useful for assessing:
  - Vegetation
    - Type
    - Cover
    - Productivity
  - Water, soil temperature
  - Tillage intensity



Crop identification for spatial modeling. Courtesy: P Doraiswamy, USDA-ARS, Beltsville, MD

Methods to Extrapolate Measurements and Model Predictions from Sites to Regional Scales

- Models
  - CENTURY
    - Comet VR
  - EPIC
  - RothC
  - Other models also being developed



CENTURY MODEL

http://www.cometvr.colostate.edu/images/ecosystem.gif

Resources Available for National-level Assessments

- NRCS soil data
- Daily Climate data from NOAA
- 1997 NRI area weights
- NRCS/ERS Cropping Practices Survey
- NRCS/National Soils Laboratory Pedon Database

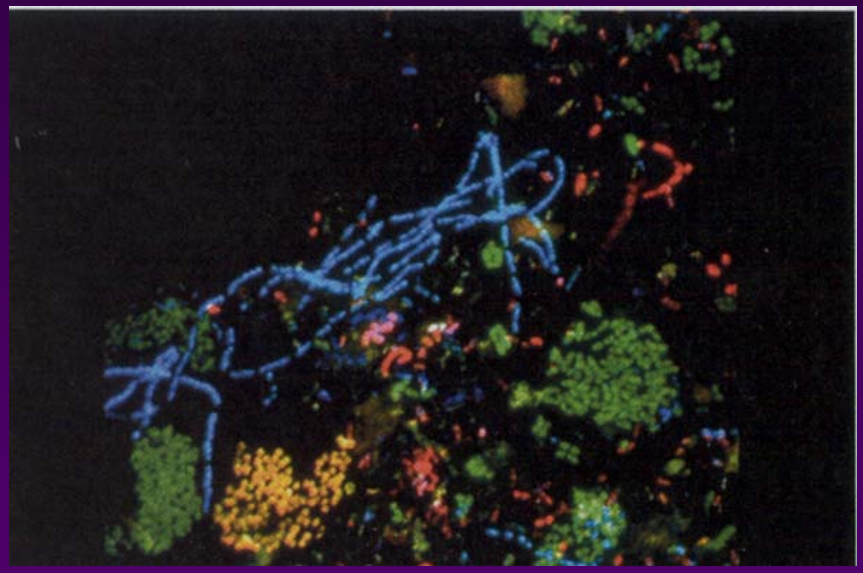
Challenges

- **Collaborate across soil science and with other disciplines to advance soil science research**
  - **Soil scientists should look for ways to enhance collaboration and integration with**
    - **Ecology**
    - **Geostatistics**
    - **Earth and Planetary Sciences**
    - **Hydrology**
    - **Computer Science**
    - **GIS and Remote Sensing**
    - **Mathematics and Statistics**

- **Collaborations with Social Scientists will help in better understanding and predicting land use changes and communicate with the public**

Soil Microbial Populations
Points to Ponder

- A nononillion (10^{30}) bacteria on earth, 10^{9} times more than the number of stars in the universe



- One teaspoon of topsoil
  - > a billion (10^{9}) bacteria
  - 120,000 fungi
  - 25,000 algae
- 500,000 species in 30 g soil
- We have cultured only 0.1 to 1% of bacterial species

- Value of ecosystem services

	value ($trillion)
–soil	20
–clean water	2.3
–food etc.	0.8
–genetic resources	0.8

- Total ($24T) is about twice global GNP
- Single most valuable ecosystem

Boumans et al. 2002 Ecol. Econom. 41

SUMMARY

- Soil provides valuable ecosystem services, including
  - providing food, freshwater, fuel, wood, fiber
  - regulating water purification, climate, diseases
  - Supporting cultural aspects (recreational, educational, spiritual)
- Global value of soil as an ecosystem estimated to be $20 trillion

Need to get the message out

Soil is fundamental to life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HE CAN LEARN ABOUT THE "WEB OF NATURE"
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