Land use science in the 21st century

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MACSUR mid-term Conference, Sassari 1-4th April 2014
Do we still need land use science in the 21\textsuperscript{st} century?

No!

After development, agriculture is not important anymore!

Source: Several Professors of Economics
Agricultural Income (GDP Share)

- Least Developed
- Upper middle income
- Sub-Saharan Africa
- World
- EU

Source: own compilation based on data from OECD.stat
What about GDP of agricultural non-market impacts?
Value of ecosystems: US$33 trillion
1.8 times the current global GNP

Costanza et al. The value of the world’s ecosystem services and natural capital, Nature, 1997
Potential ecosystem service values

• Yes, agricultural GDP is declining.

• “GDP measures everything, in short, except that which makes life worthwhile” R. Kennedy (1968)

• Sustainable development calls for consideration and valuation of ecosystem services

• Besides, higher valued secondary GDP contributors are multipliers of primary sector values

Agricultural assessments are still important but include much more than food production
What is the research focus of high-impact agricultural models?

WEB OF SCIENCE

Basic Search

(agriculture OR agricultural)

AND

model
1991-2000 (citations)

- **Habitat management** to conserve natural enemies of arthropod pests in agriculture, *ANNUAL REVIEW OF ENTOMOLOGY* (2000), 759
- Soil macroaggregate turnover and microaggregate formation: a mechanism for C sequestration under no-tillage agriculture, *SOIL BIOLOGY & BIOCHEMISTRY*, (2000), 620
- Source approach for estimating soil and vegetation energy fluxes in observations of directional radiometric surface-temperature, *AGRICULTURAL AND FOREST METEOROLOGY* (1995), 491
2001-2010 (citations)

• **Agricultural intensification** and the collapse of Europe's **farmland bird populations**, PROCEEDINGS OF THE ROYAL SOCIETY B-BIOLOGICAL SCIENCES, (2001), 661

• Global dimming: a review of the evidence for a widespread and significant **reduction in global radiation** with discussion of its probable causes and possible **agricultural consequences**, AGRICULTURAL AND FOREST METEOROLOGY, (2001), 436

• Single- and multi-component **adsorption of cadmium and zinc using activated carbon** derived from bagasse - an agricultural waste, WATER RESEARCH, (2002), 392

• Hyperspectral vegetation indices and novel algorithms for **predicting green LAI of crop canopies**: Modeling and validation in the context of **precision agriculture**, REMOTE SENSING OF ENVIRONMENT, (2004), 385

The “optimal” land use assessment model

Insights from agro-environmental assessments
Agricultural Sector Analysis

- Global Average Calorie Intake
- Agricultural Sector Analysis
- Carbon price
- Emission Mitigation
- Economic Potential
- Technical Potential
- Agricultural greenhouse gas emission abatement

2005
- Land, Water Population
- Land, Water Population, GDP
- Land, Water Population, GDP, Yields

2030
- Vegetarian Food
- Animal Food

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EU Nature Reserve Distribution
1) Model scope

- Regions
- Sectors
- Goods
- Time Horizon
- Technologies
- Resources
US Carbon Benefits of Reduced Tillage

![Graph showing the relationship between soil carbon sequestration and carbon price.](image)

- Economic Potential
- Competitive Economic Potential
- Technical Potential

Schneider et al., Agr. Syst., 2007
US Agricultural GHG Emission Mitigation

Schneider and McCarl, Agr. Econ., 2006
Insights

• Low scope assessments ignore synergies and tradeoffs

• Independent regional assessments tend to overestimate mitigation potentials
2) Model detail (resolution)
More flexibility → more mitigation

Climate change mitigation through livestock system transitions
Havlik et al., PNAS, 2013
Homogenous Response Units

5 altitude classes

5 soil classes

Maps compiled by R. Sos based on GEOBENE Project Data
Insights

• Low resolution tends to underestimate response (adaptation, mitigation, resilience)
• High resolution increases computational costs
• Heterogeneous resolution and/or implicit depiction of resolution may help
3) Interdisciplinarity

Involved disciplines

- Strong assumptions
- Strong results
- Real assumptions
- Real results
Global biogeophysical interactions between forest and climate
Brovkin et al., Geophysical Research Letters 36(7) 2009
Scales

- Genes
- Cells
- Individuals
- Communities
- Fields
- Farms
- Coun(r)ties, Biomes
- Global Markets

Source: The Royal Society, Gastner

Source: Uwe A. Schneider, Diploma thesis
Small scale analysts’ tasks

• Transferability

• Aggregation

• Reduced form representation

Large scale analysts’ tasks

• Heterogeneous resolution

• Disaggregation, Downscaling

• Implicit integration
4) Land use model development

• More complex models
• Method trade
• New datasets
• More model intercomparison
• Less Intuition
• More skeletons in closets
Crop models

**EPIC**
Effect of soil erosion on soil productivity.

**CropSyst**
Effect of climate, soils, and management on cropping systems productivity and the environment.

**CERES**
Prediction of the duration of growth, the average growth rates, and the amount of assimilate partitioned to the economic yield components of the plant.

**Soil carbon dynamics**
Phosphorus cycling
CO$_2$ effects, etc.

Models with similar features but different specifications and details

Source: L. Rasche
Method trade (e.g. Bioeconomics)

- General equilibrium models of ecosystems (e.g. work of J. Tschirhart)
- Vegetation models are solved as a Nash equilibrium
- Interactive ecological models (e.g. work of K.P. Freier, M. Hauhs)

See also: http://www-iam.nies.go.jp/aim/AlM_workshop/emf22/s5/Session5_07_Richard.pdf
David Finnoff, John Tschirhart
Linking dynamic economic and ecological general equilibrium models
Scientific Evolution

Methods / Models

Data
The “optimal” land use assessment model
Thank you