# Bioenergy, Land-Use Change and Food Security

## Vantage Point: Views on Food, Fuel and Land Use

## 24 May, 2011
## Webinar Panel organized by the National Biodiesel Board


## Keith Kline
## Oak Ridge National Laboratory



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U.S. DEPARTMENT OF ENERGY

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# Roadmap for Talk

- Issues
  - Reliance on oil
  - Food security
  - Deforestation
  - Estimating effects of bioenergy
  - Science and models
- Solutions

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# The U.S. pays dearly in a non-competitive market

- Wealth transfer*
- Long-run GDP losses*
- Disruption costs*
- Military costs
- Foreign policy costs
- Strategic stockpile costs
- Other indirect costs

## High costs and volatility since 1972

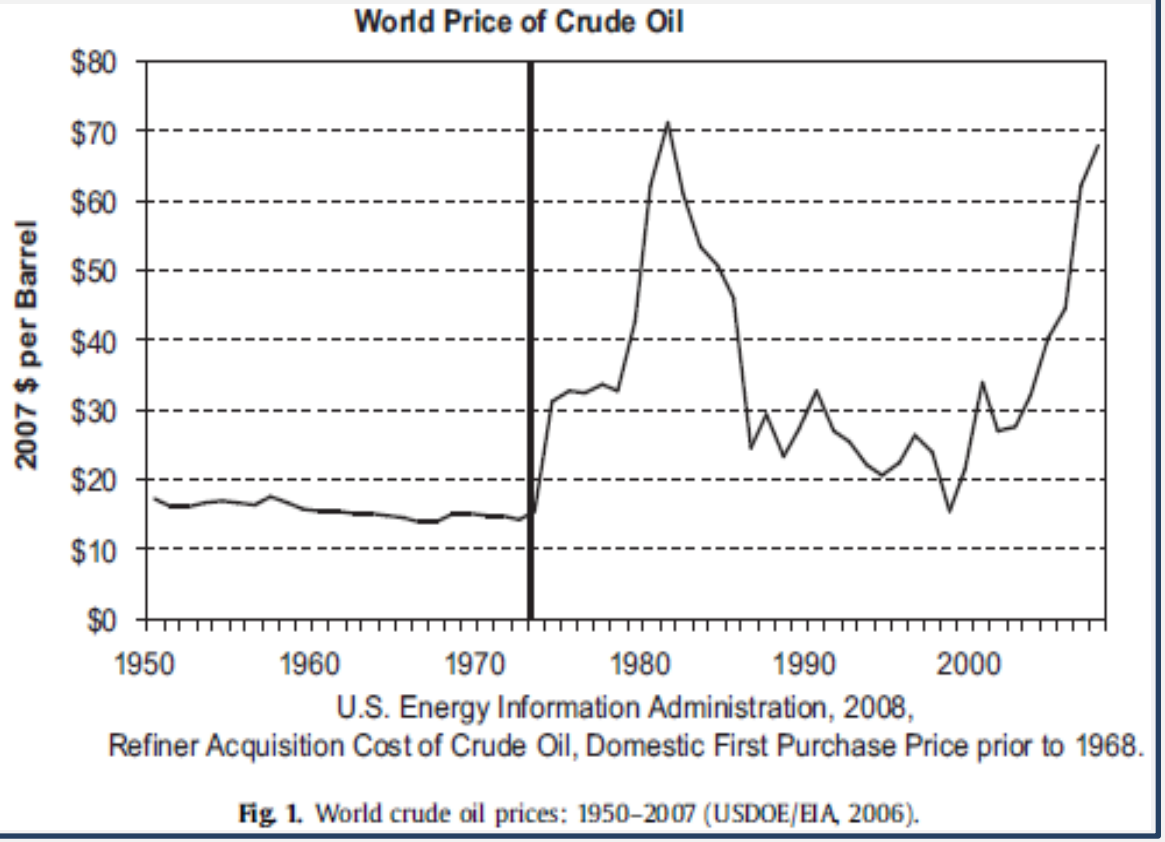


Fig. 1. World crude oil prices: 1950–2007 (USDOE/EIA, 2006).

***Economic costs estimated with the ORNL oil security metrics model**

Sources: Greene and Leiby 2006. Greene et al. 2007. Greene, 2009.



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# Cartelized, volatile market produces large direct costs to the U.S. economy: up to US$ 500 billion in 2008

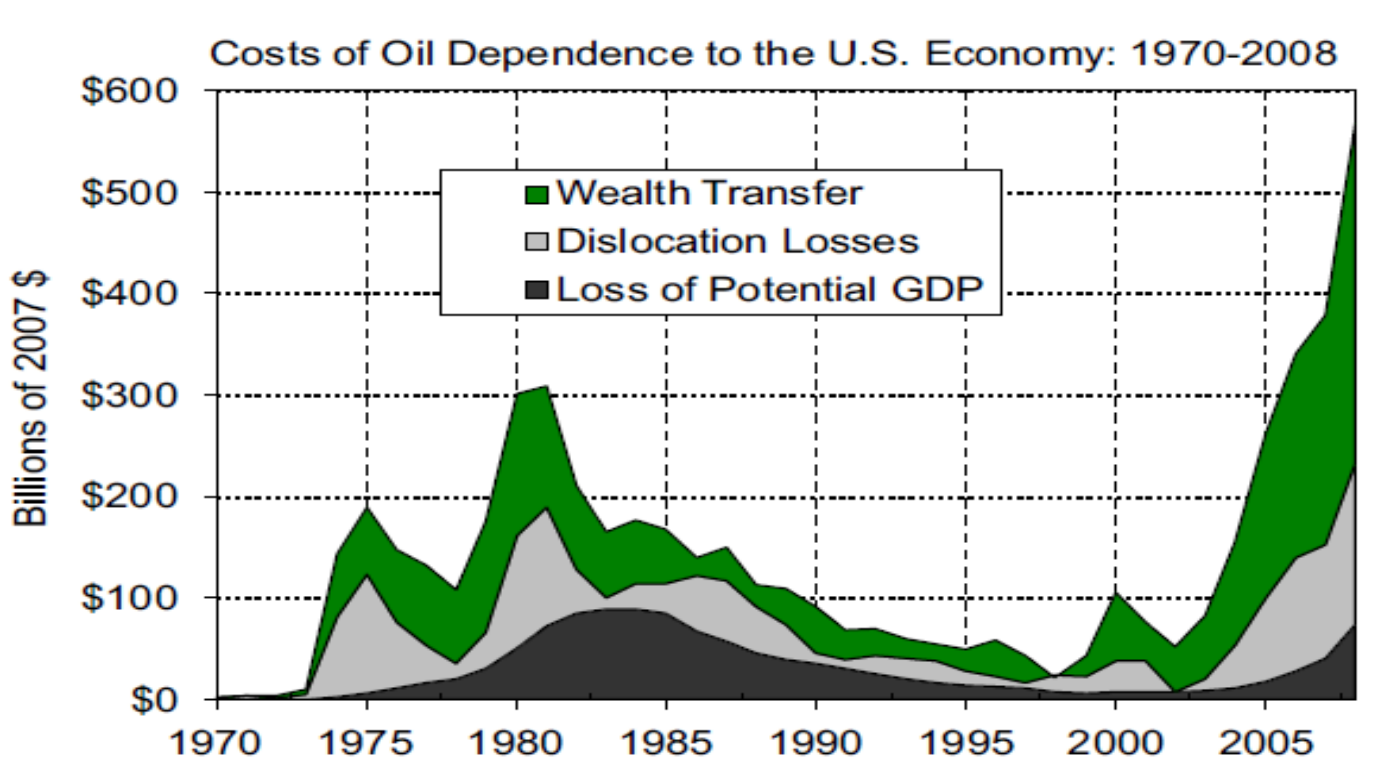


**Fig. 4.** Estimated direct economic costs of oil dependence to United States, 1970–2008.

**Oil imports also:**

1. **Exacerbate trade deficits**
2. **Erode US$**
3. **Transfer wealth to unfriendly regimes**

Sources: Chart: Greene 2009. Three other effects: Luft 2010.



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# Steps to reduce costs of oil dependence:

- **Reduce demand for transportation fuels**
  - **Fuel economy**
  - **More flex-fuel, electric-hybrid vehicles**
- **Diversify sources and accelerate development and use of efficient substitutes for oil**
  - **Expand domestic fuel production**
  - **Reduce industrial and home heating use**

Source: National Commission on Energy Policy, 2004.

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***Bioenergy markets can help**
**(and could save billions per year at the pump[1])**

Sources: National Commission on Energy Policy, 2004.
[1]Du and Hayes, 2011 (CARD, Iowa State University)

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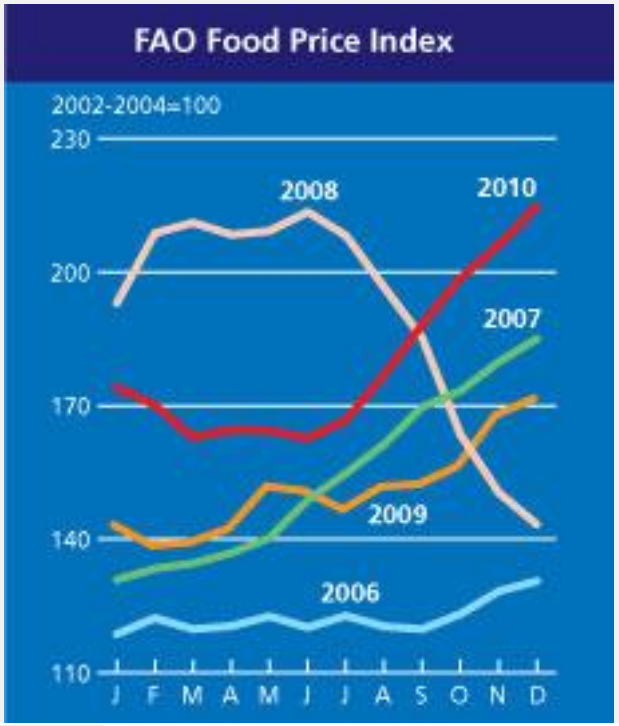
# Food security

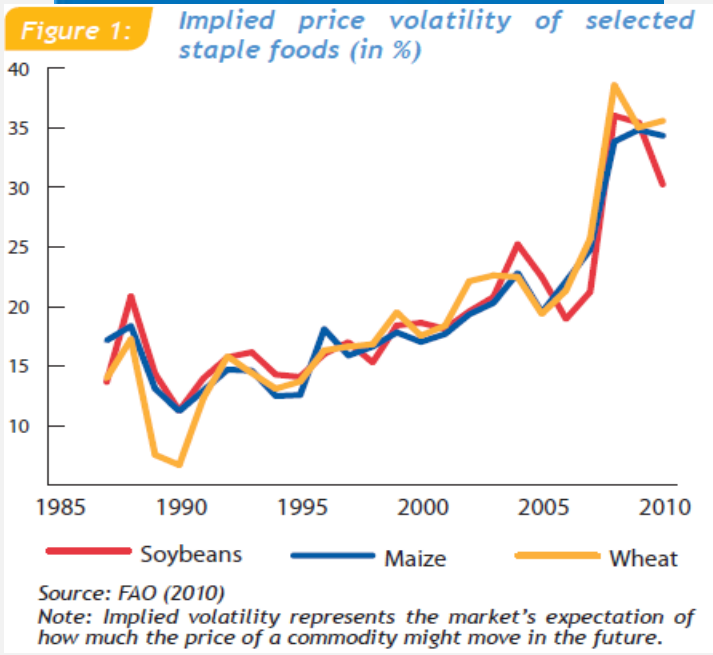
- Rising prices, volatility
- Consumers and producers suffer
- Nearly a billion undernourished (FAO)

**As long as people are hungry, this issue is not going away!**




Food and Agriculture Organization of the United Nations

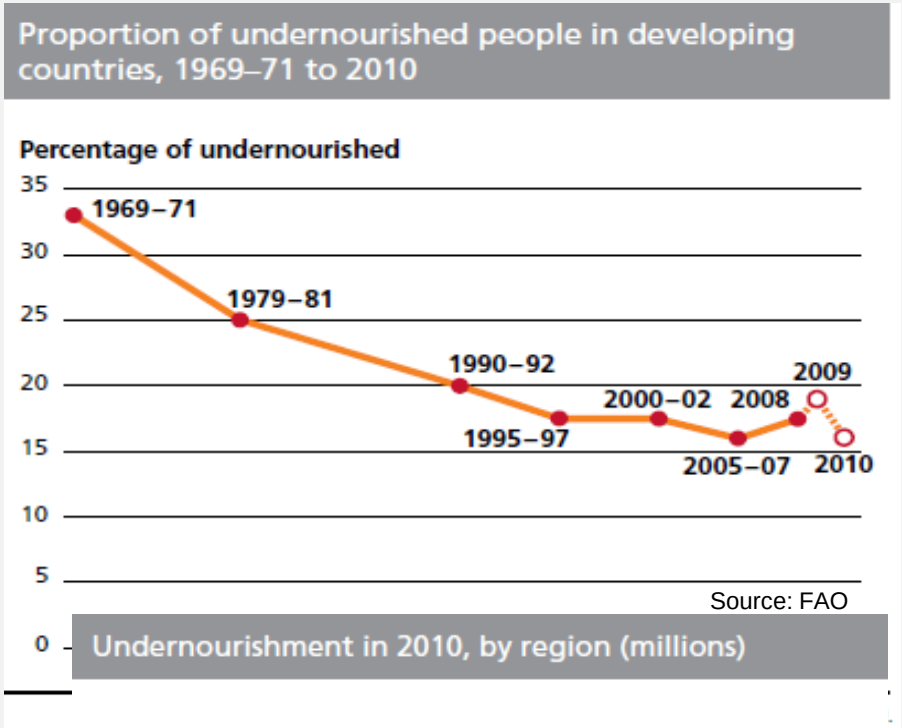
- Volatility in agricultural markets seems to have increased
- Extreme price movements of agricultural commodities pose a threat to world food security
- Policy measures should improve market functioning and increase countries' resilience to shocks




Source: FAO Policy Brief, Dec.2010, Price Volatility and Crises in Global Food Markets

# Governance issues

- **Global supply exceeds requirements**
- **Distribution, losses, infrastructure, inefficient markets**
- **All countries in protracted crisis show high levels of food insecurity**
- **Policy and governance failures contribute to market failures, hunger, poverty**




Source: FAO 2010: "The State of Food Insecurity (SOFI) in the World: Addressing food insecurity in protracted crises."

**Undernourishment statistics are a product of definitions, methods, models and available data.**

# Bioenergy and food security

**Global Sustainable Bioenergy Project "GSB"**

**Rather than a threat, could bioenergy be part of the solution?**

| Problem | Solutions |
| --- | --- |
| **Food Insecurity** | **Alleviate Poverty**<br>• All wealthy people have access to food<br>• All hungry people are poor |

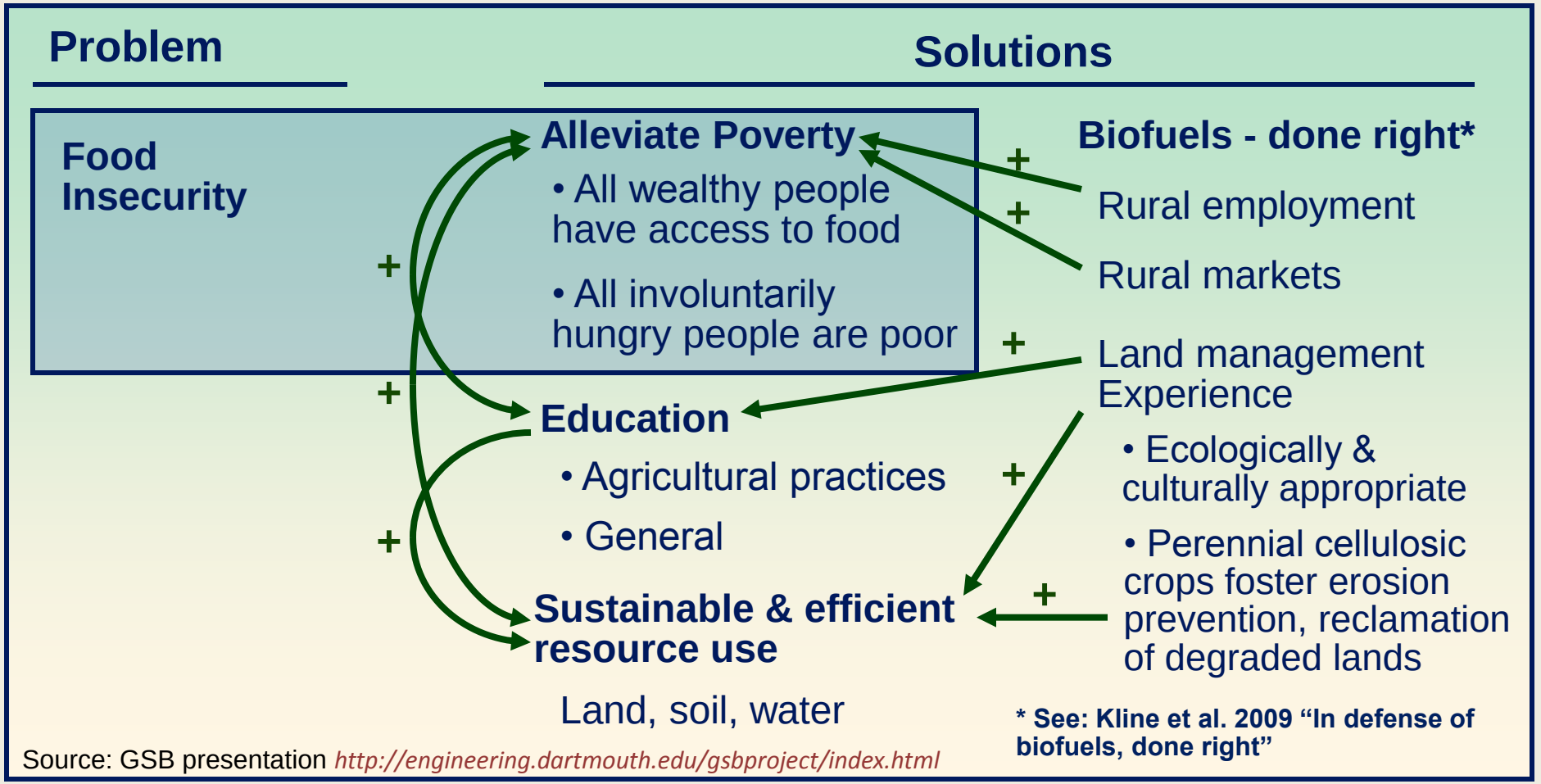
Source: Lee Lynd et al. GSB presentation *http://engineering.dartmouth.edu/gsbproject/index.html*

# Food *and* Fuel

**Developing nation perspective: grow things we can eat AND sell!**

**"…bioenergy is not only compatible with food production; it can also greatly benefit agriculture in Africa…"**

- Dr. Rocio A. Diaz-Chavez, Imperial College, London.




Source: GSB presentation *http://engineering.dartmouth.edu/gsbproject/index.html*

# Steps to improve food security

1. Improve rural livelihoods *
   - ✓ Agriculture
   - ✓ Market access
   - ✓ Timely information
2. Reduce risk
   - ✓ Social safety net
   - ✓ Transform food aid
   - ✓ Economic resilience
     - Diversify markets *
     - Expand bases of production *
3. Improve analysis, monitoring (early warning)
4. Improve institutional capacity, policies, market functions
5. Reduce volatility*

***Bioenergy markets can help**

Sources: Oxfam 2010; FAO 2009 a and b, FAO 2010 a and b.

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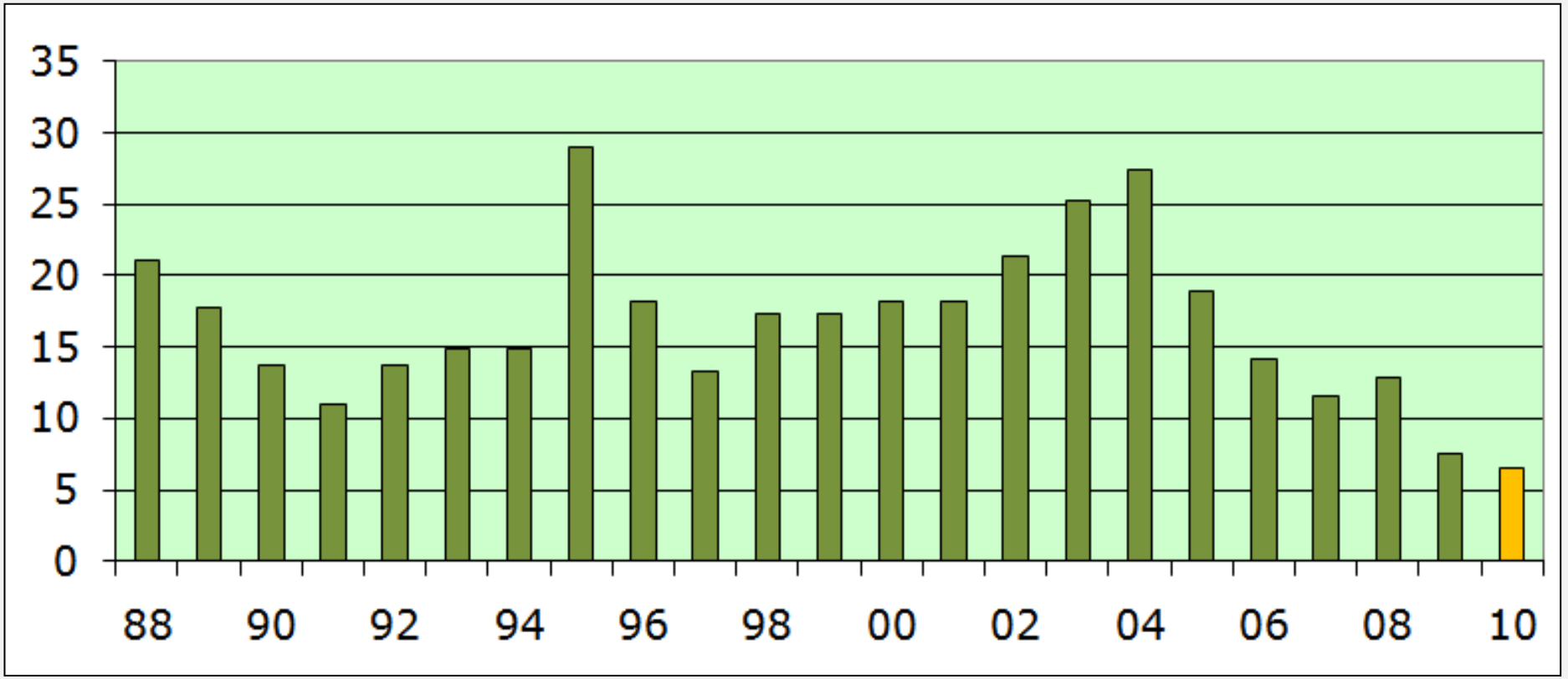
# Deforestation drops, 2005-2010
## (FAO Forest Resource Assessment 2010 - Global)

- **Global tropical deforestation rate (avg. annual loss) fell > 20% compared to prior decade, led by decline in Brazil (chart below)**

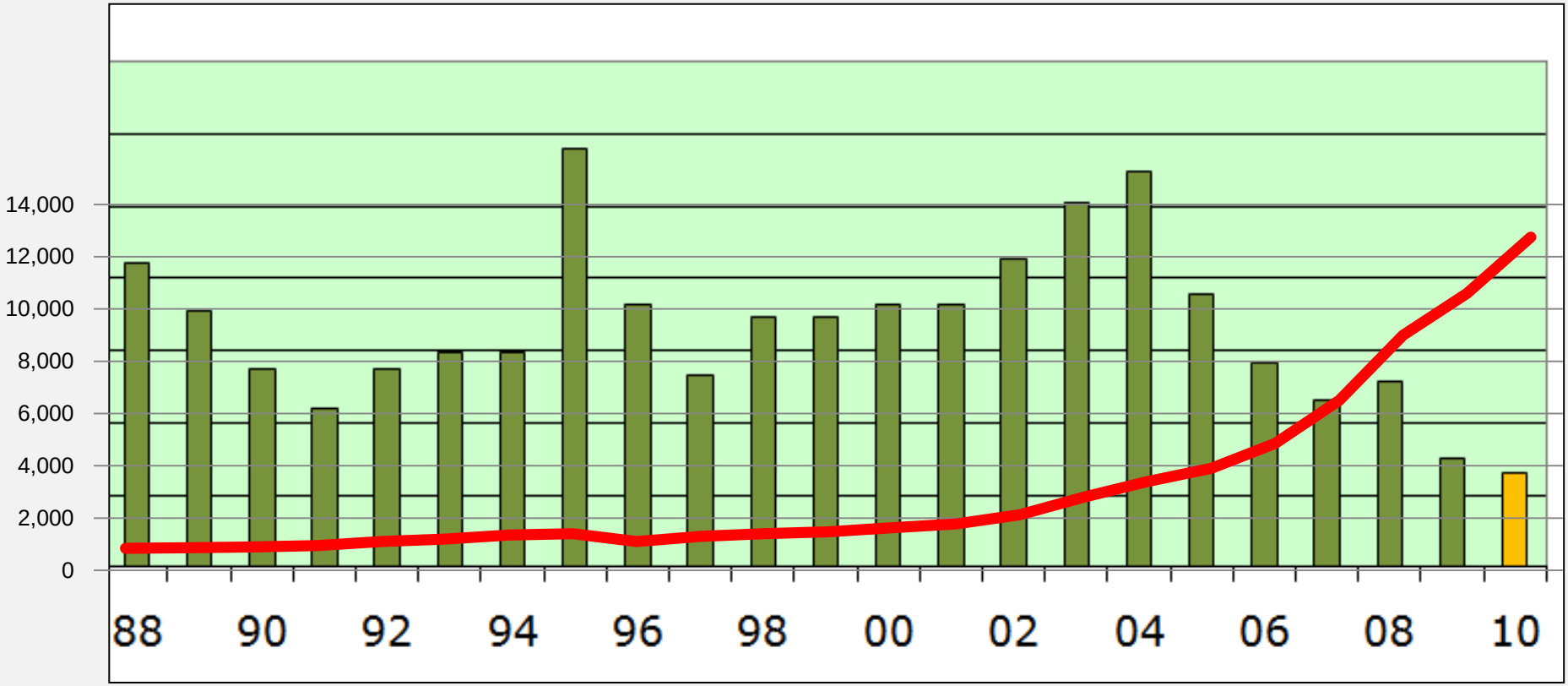



**Deforestation rate in Brazil's Amazon, thousands square km per year**

Source: INPE-PRODES Brazil Space Agency: http://www.dpi.inpe.br/gilberto/present/prodes_taxa2010.ppt Yellow bar for 2010 indicates preliminary result of analysis.

# Global deforestation rate drops 2000-2010 (FAO Forest Resource Assessment 2010)

- Amazon deforestation versus U.S. liquid biofuel output
- Correlation is not causation (need analysis, models, validation)




**U.S. Biofuel Production (thousands US gallons per year)** Source: Renewable Fuels Association

**Deforestation rate in Brazil's Amazon** Source: INPE-PRODES: http://www.dpi.inpe.br/gilberto/present/prodes_taxa2010.ppt. Yellow bar for 2010 indicates preliminary result of analysis.

# Threats to forests: governance issues (policy, corruption, poverty, insecurity), fire and pests…

## Solutions:

- Rural livelihoods*
- Land tenure
- Inventory & protect key conservation areas*
- Improved governance, local participation and capacity, enforcement
- Land-use plans, soil management, productive uses to reduce fire*

***Bioenergy markets can help**

Source: Kline, 2008 California Biomass Collaborative., based on USAID-FAA Sec. 118/119 Reports for 2000-2008. FAO 2010c and forest management and conservation best practices: http://www.fao.org/bestpractices/content/05/05_02_en.htm

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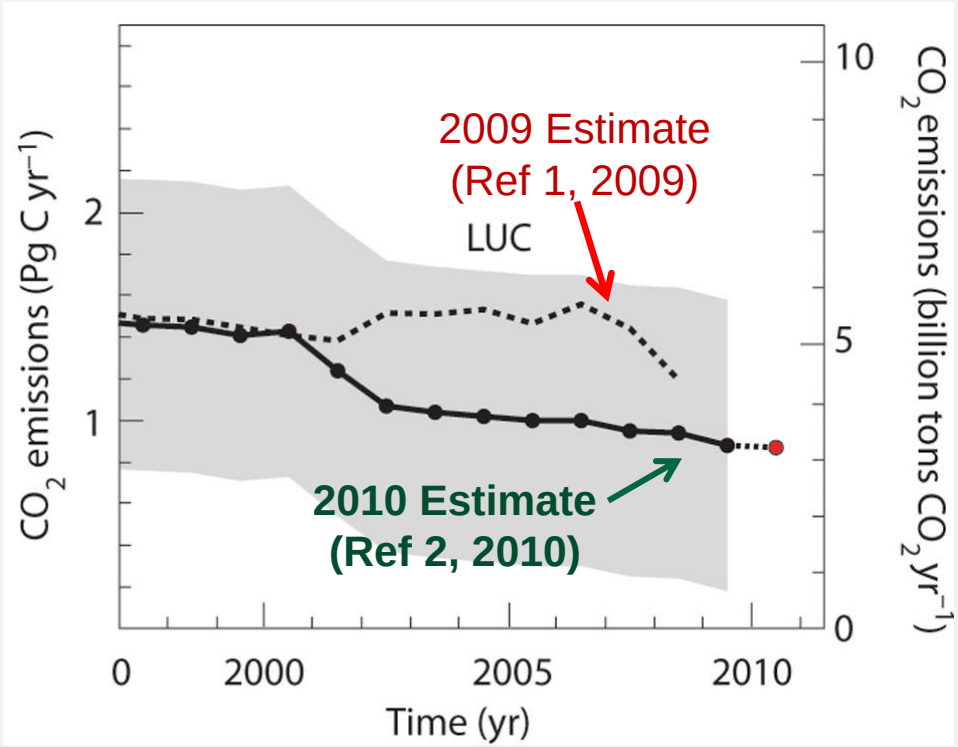
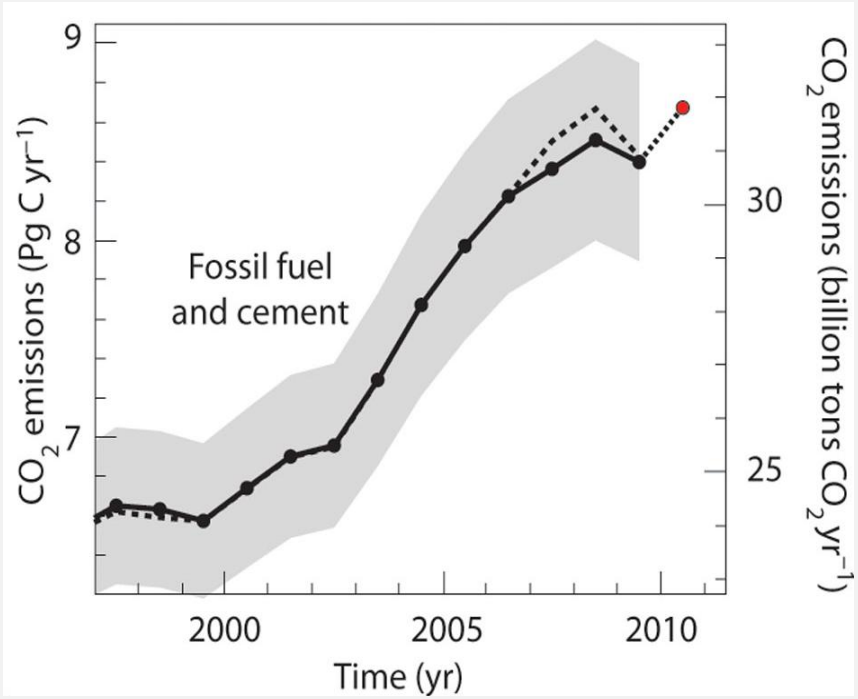
# Land cover, land use:

- **Constantly changing**
  - Cropland shifting → becomes fallow → to grassland, eventually → secondary forest → and partially returns to crops…
  - Lines between classes blur, overlap
  - Use / Cover: distinct, different values
- **Difficult to measure**
  - Data aggregated and homogenized
  - Data at different temporal and spatial scales differ greatly, inconsistent
- **Small adjustments in data (available land; assumed carbon stocks) have huge effects on modeling results***

* For examples see: CBES 2010, EC 2010, CARB 2011.

# Global LUC emissions revised down, still “guesstimates”



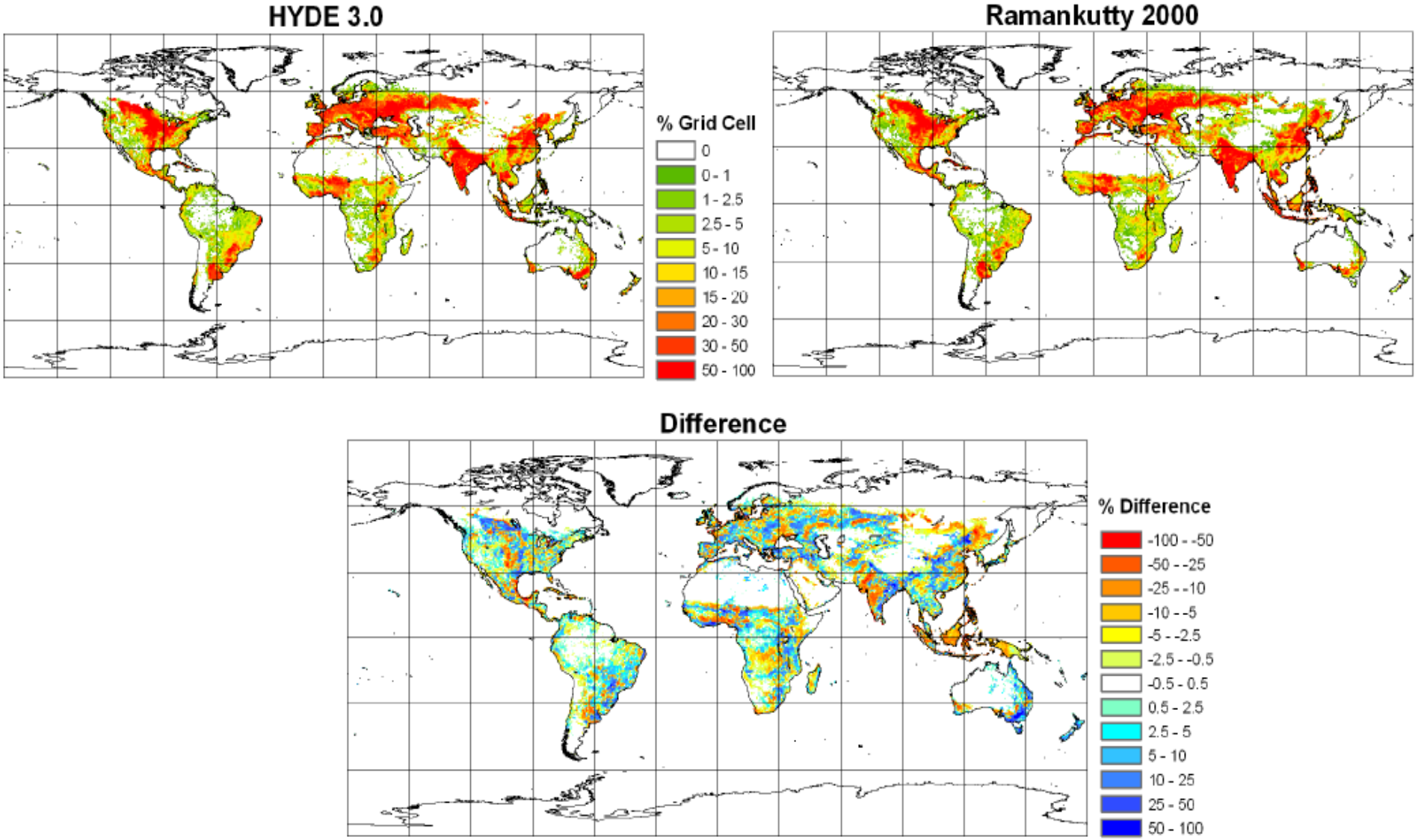

- **90% of current CO2 emissions are from fossil fuel; fossil share rapidly rising**

**Shaded areas around lines represent estimated range of uncertainty**

Sources: (1) Le Quéré, C. et al. Nature Geosci.v2, 831–836 (2009). (2) Friedlingstein et al. Nature Geosci.v3, 811–812, (Nov. 2010).

# Global data uncertainty: large cropland differences

## (forest data worse; grassland horrid)




Source: Preliminary results, Johannes Feddema, Geography Department, University of Kansas

# Estimates of Global Cropland circa 2000 can vary by over 100% within Agro-Ecological Zones (AEZ)

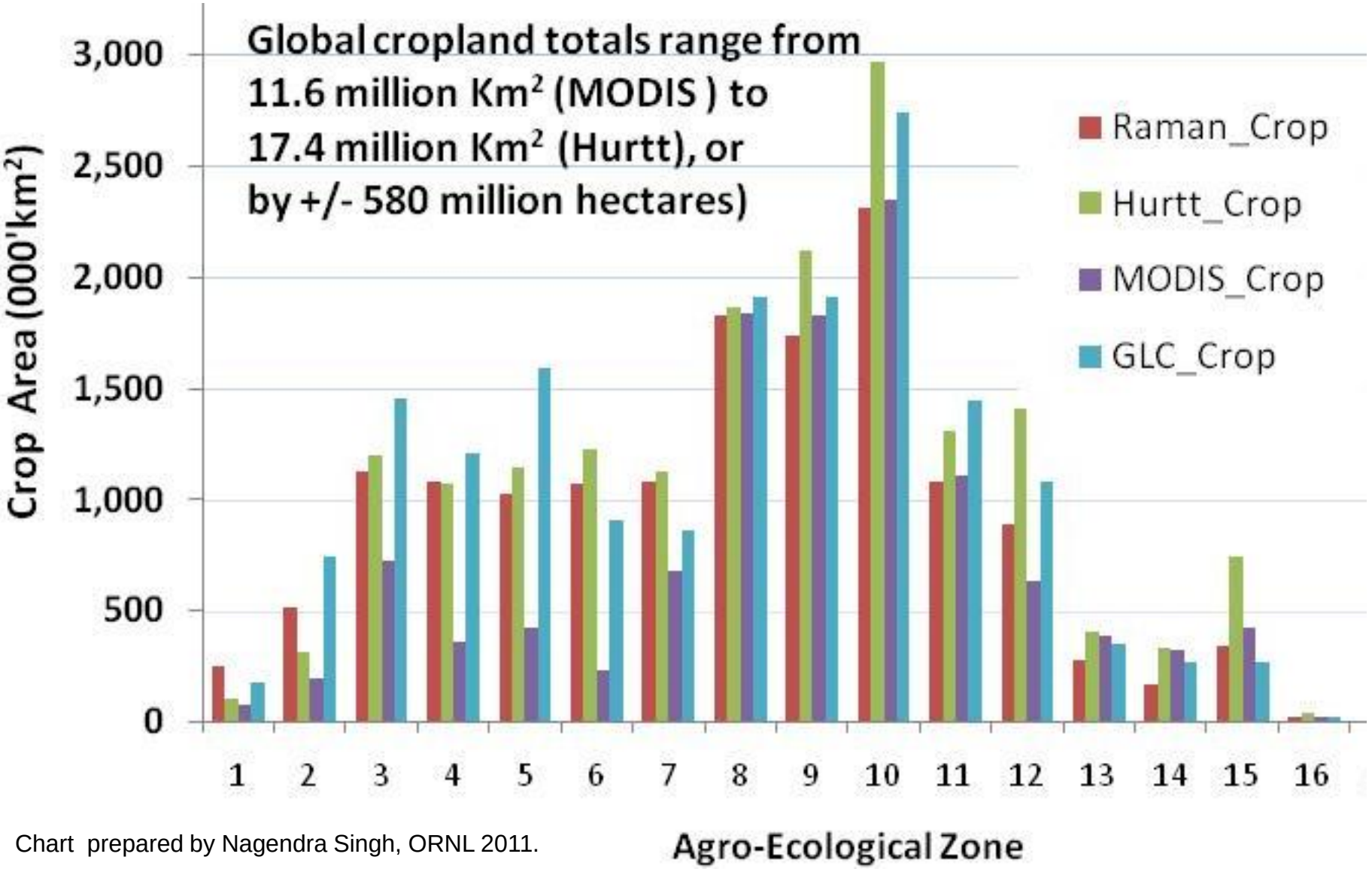



Chart prepared by Nagendra Singh, ORNL 2011.

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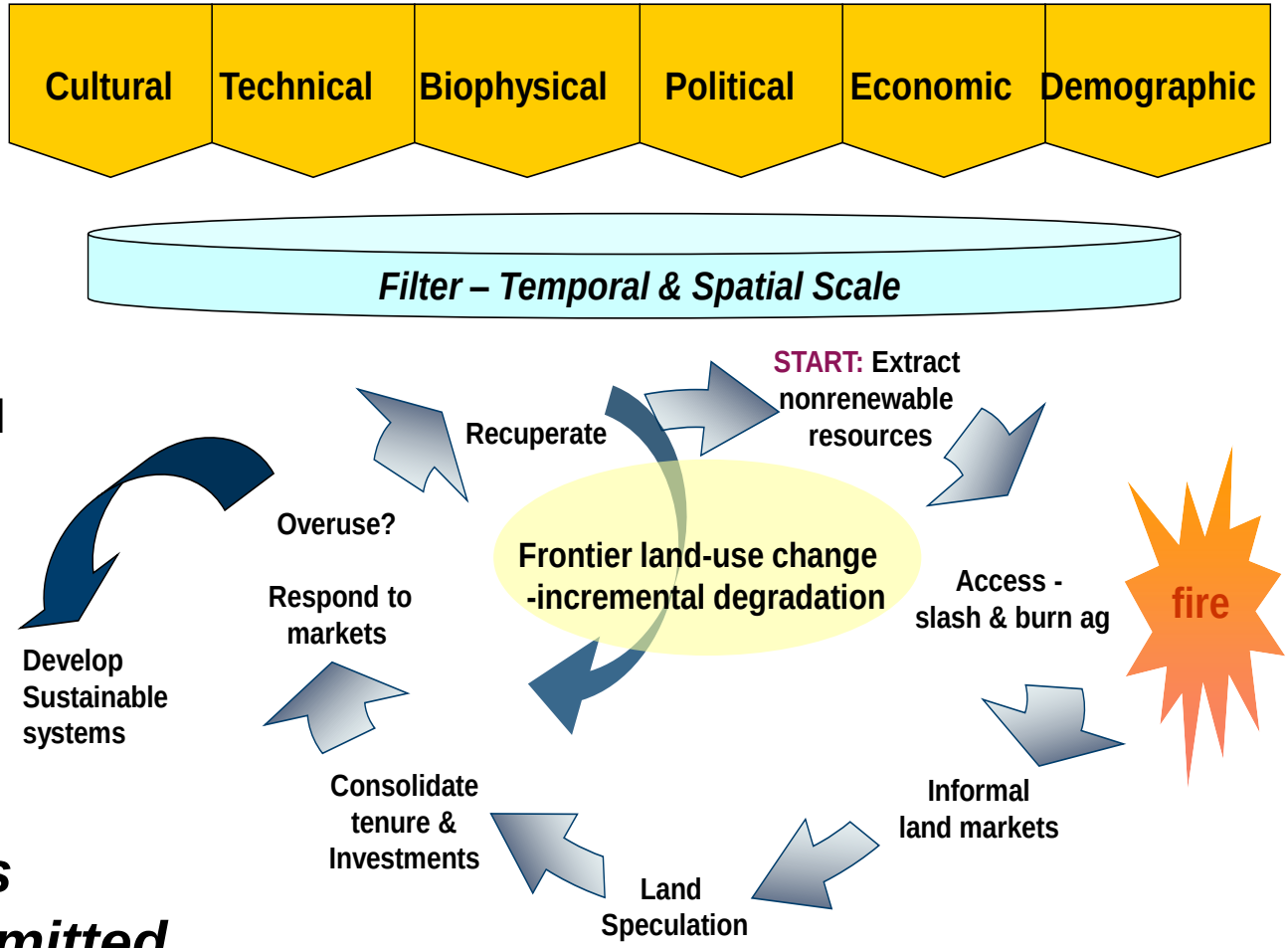
# Observed LUC is complex, dynamic process

- ***Driving first-time conversion:***
  - Limited capacity for governance, policies
  - Extractive (incl. oil/gas) industries
  - Access, biophysical conditions
  - Making/holding land claims
  - Poverty - this is the safety net




- ***Major land assets and drivers are omitted from the global economic models used to estimate LUC***

Source: Kline and Dale 2008. Science 321:199-200.

# Most remaining forests are public lands: clearing is (a) illegal or (b) policy-driven.

## Global economic models omit these, other key factors

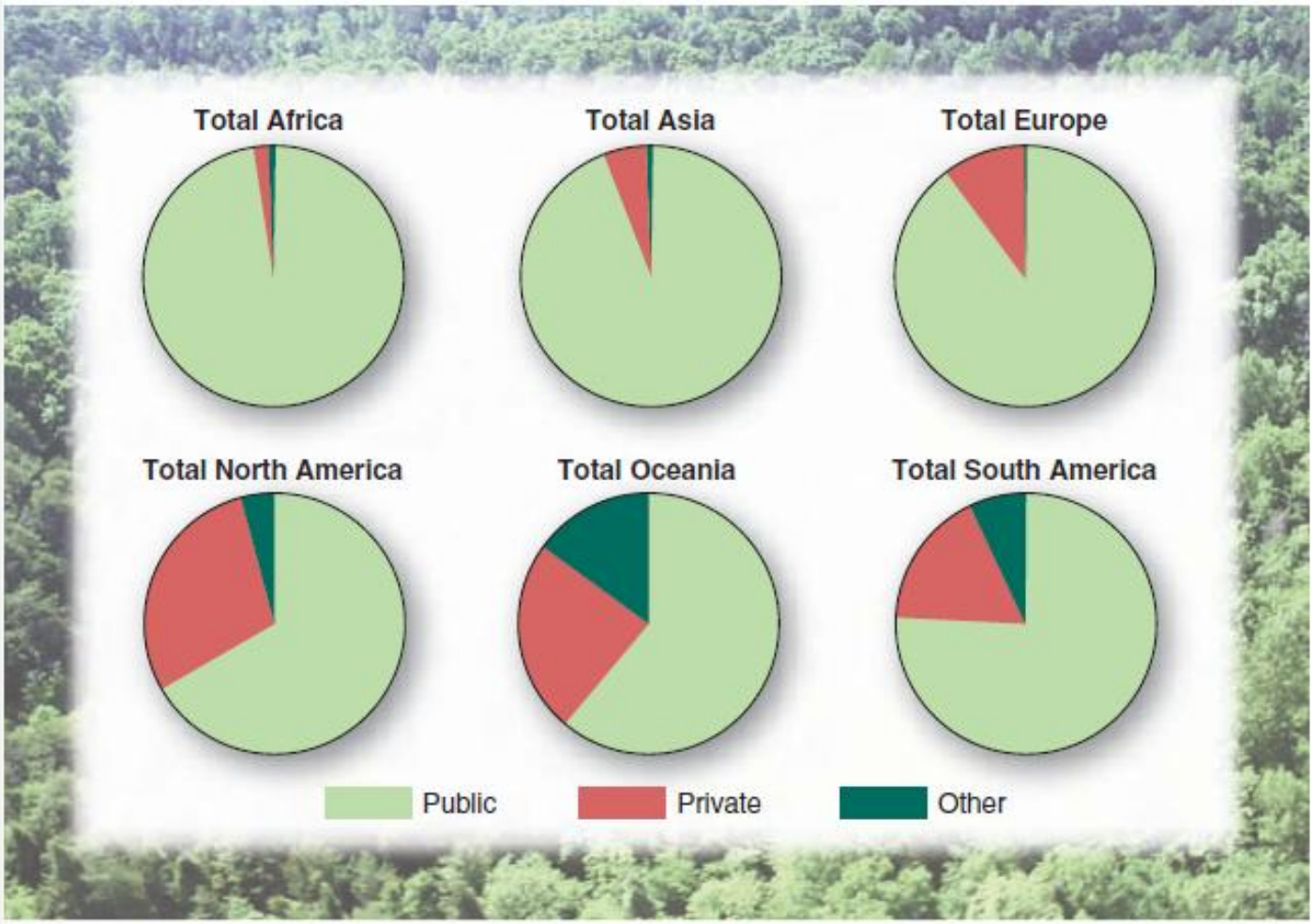
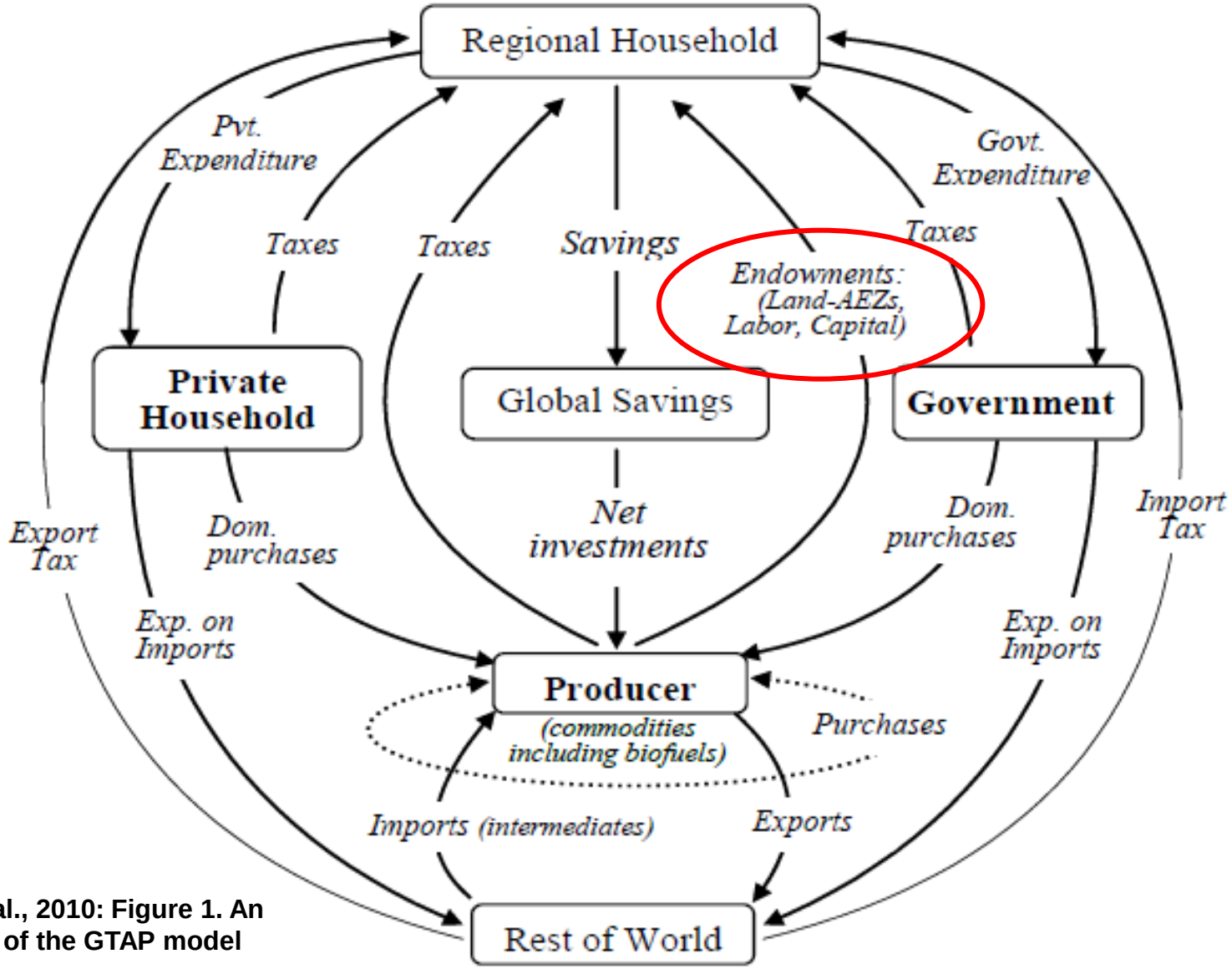



**Fig. 1.** Distribution of forest ownership by world regions.

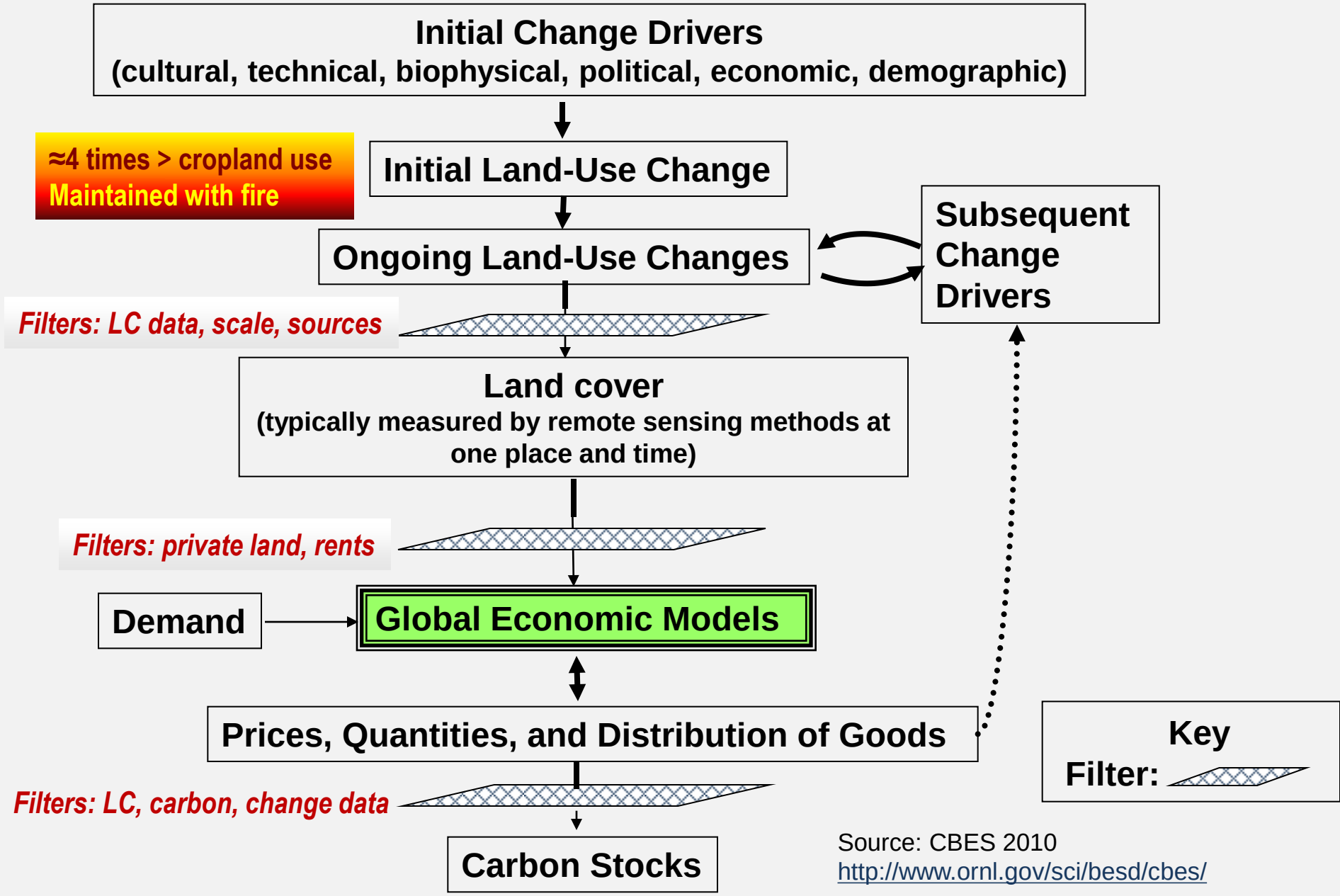
**Source: Agrawal et al., 2008, Science 320**

# Example: GTAP Model (Tyner et al. 2010)




**Tyner et al., 2010: Figure 1. An overview of the GTAP model**

# Land use models - constrained by data, filters

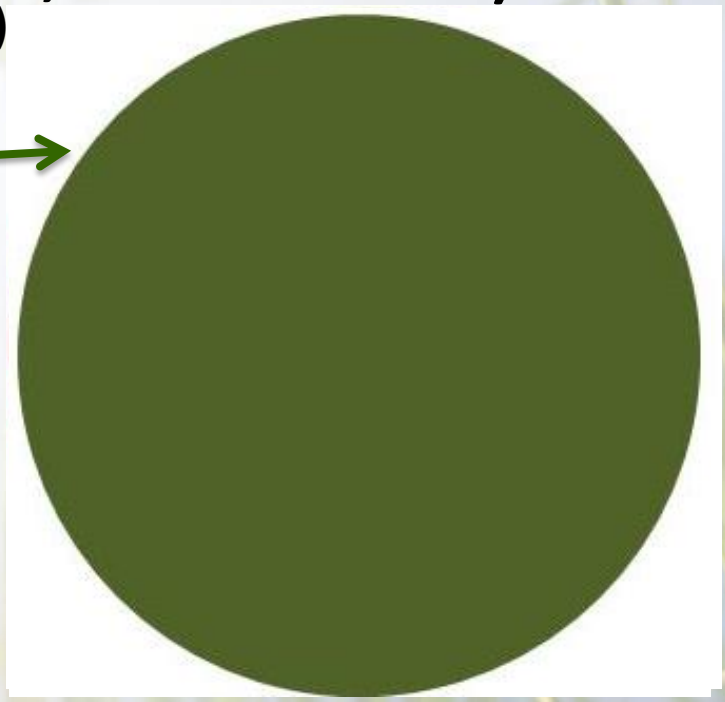



Source: CBES 2010
http://www.ornl.gov/sci/besd/cbes/

# LUC estimates, compared to what?

- **Land available for crop expansion without deforestation (previously cleared, underutilized) = 500 to 5000 million hectares[(1)]**

**Circle size assumes 1500**



**[(1)] Enormous range due to pasture, grassland, marginal land estimates**

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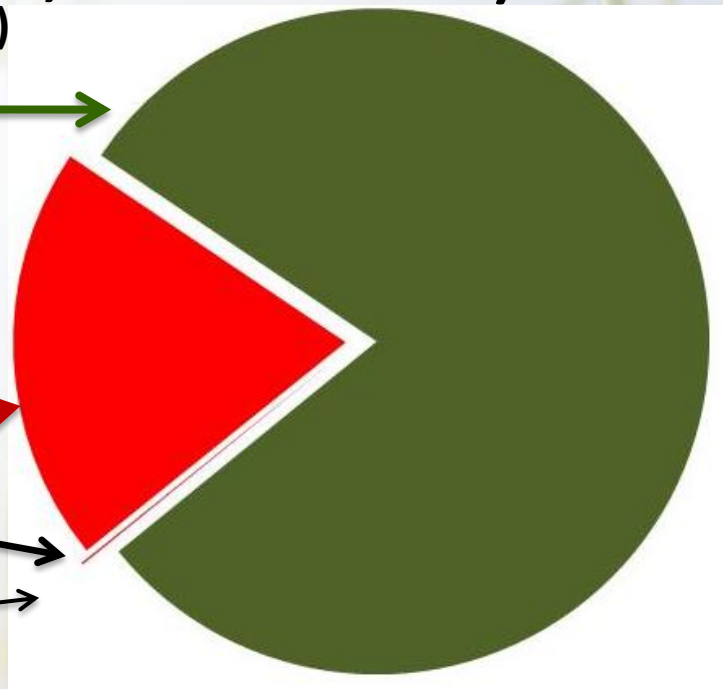

- **Global land area impacts: [million hectares per year]**
  - **Fire = 330-430 [2]** **380**
  - **Dev./Urban exp. [1] = 1.5**
  - **LUC bioenergy est. [3] = 0.2**
    **(too small to illustrate)**

**[1] Enormous range due to pasture, grassland, marginal land estimates**

Sources: [1] Kline et al. 2009; calc. by author based on FAO 2007.
[2] Giglio et al. 2010. [3] Tyner et al. 2010 (3 m ha total/14 years)

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# Science and Models

Science follows a *systematic methodology based on evidence**

Models are simplified views of the world, not true representations of complexity

Models explore specific relationships

- E.g. "shock" prescribed system to estimate biofuel effects on land
- Results reflect assumptions, baseline, input data, conceptual view
- **Science (data + time) needed to assess and verify**

There is no scientific consensus on methods or estimates of indirect land use change from bioenergy**

Don't forget to look outside!

*Source: Science Council of Britain http://www.sciencecouncil.org/

** CARB 2011, final reports from Expert Work Group on LUC. CBES 2010. EC 2010.

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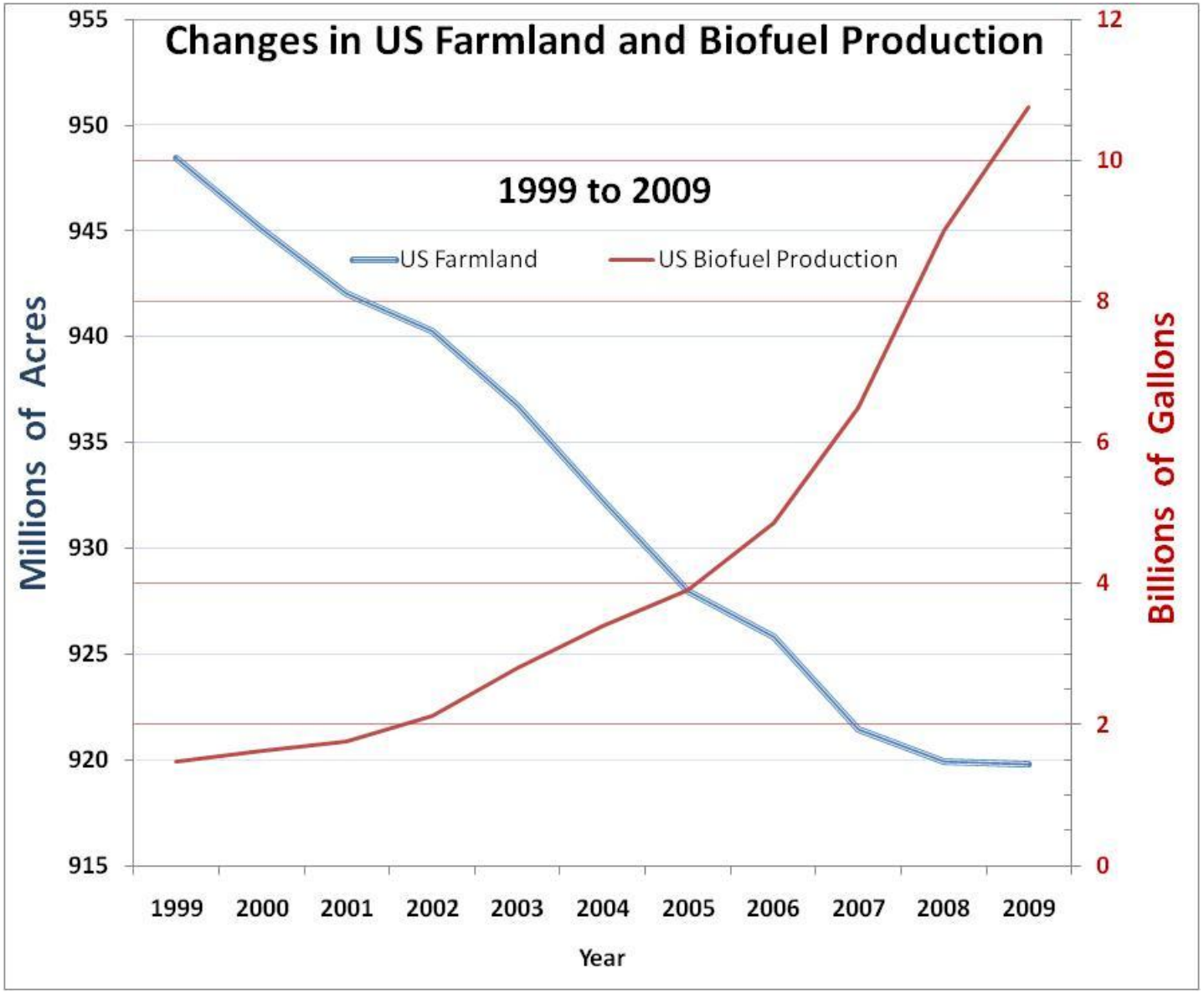
# What LUC is most important?

Farmland, change, drivers ≠ cropland, change, drivers.




**US farmland avg. loss 1999-2007: 3.4 M acres per year (USDA NASS 2010).**

**NRI states that "developed" land class grew 27 M acres 1992-07 as cropland fell by 24 M acres same period (USDA 2009)**

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- **What are solutions?**

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# Win–Win options

## Good policy and governance are key

| | | |
|---|---|---|
| Improve livelihoods, resilience | Build capacity | Reduce volatility |
| Provide incentives (for things we can measure) | Start with what is most important | Cooperate (plenty we *can* agree on) |

**Increase system efficiency and system capacity to provide multiple services over long term**

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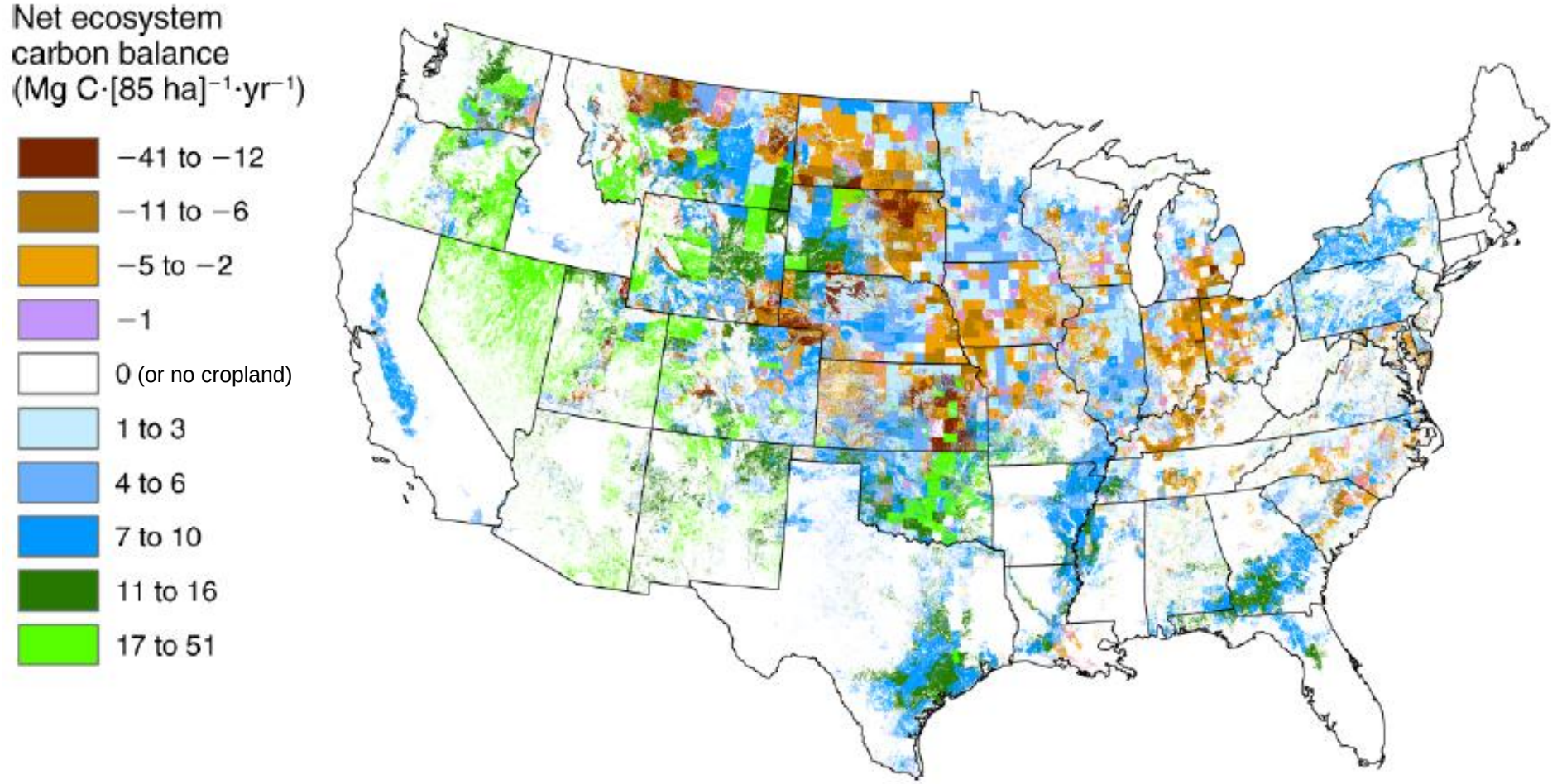
# Cropland can be net sink (or source) of carbon, with potential to increase C storage






Source: Energy Use and Carbon Dioxide Emissions from Cropland Production in the United States, 1990–2004 in J Environ Qual 38:418-425. R.G.Nelson, C.M.Hellwinckel, C.Brandt, T.West, et al. (2010)

# Common Solutions for food and fuel

| | |
|---|---|
| Improve soil management | • Tillage intensity<br>• Crop mix, rotations, cover crops<br>• Land restoration<br>• Technology (plants, microbes, biochar) |
| Increase Efficiency | • Open, transparent markets<br>• Minimize transaction costs<br>• Prioritize, incentivize, measure<br>• Reduce inputs, increase yields |
| Diversify | • Uses and markets<br>• Substitution options<br>• Bases of production |
| Adopt Systems Perspective | • Multi-scale<br>• Long-term , adaptive<br>• Integrated land-use plans |

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# Thank you!

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- **Additional information:**
  - **Resources**
  - **References**
  - **One-slide summary**

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# Some Information Resources

- DOE Biomass and Biofuels Program: www.eere.energy.gov/biomass/
- ORNL Center for Bioenergy Sustainability: http://www.ornl.gov/sci/besd/cbes/
- DOE Office of Science, Bioenergy Research Centers: http://genomicsgtl.energy.gov/centers/
- Alternative Fuels Data Center - http://www.eere.energy.gov/afdc/fuels/ethanol.html
- Bioenergy Feedstock Information Network: http://bioenergy.ornl.gov/
- Biomass R&D Initiative: www.biomass.govtools.us
- EERE INFO CENTER: http://www1.eere.energy.gov/informationcenter/

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# Additional Slide: Summary of Key Points



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# Summary of key points:

- Dependence on imported oil brings high costs
- Global market prices reflect supply/demand issues:
  - Supply constrained by monopolies, weather, policies
  - Demand driven by emerging economies' and excess liquidity
- Failures of policy, markets and governance underlie food insecurity, deforestation, and poverty
- LC/LU/LCC data are uncertain; models reflect assumptions
  - Analysis of empirical data offers different LUC perspectives
  - Changing world requires adaptive approaches
- Effects of bioenergy on food, forests, climate… can be positive or negative
- Win-win solutions (security +food +fuel +forests +climate +livelihoods...) are possible and needed now

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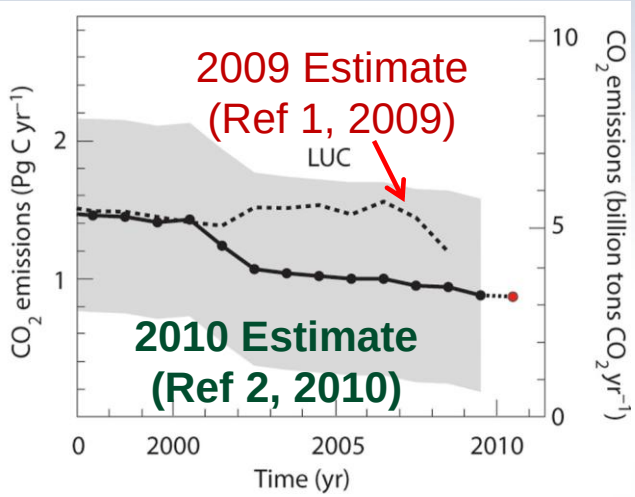
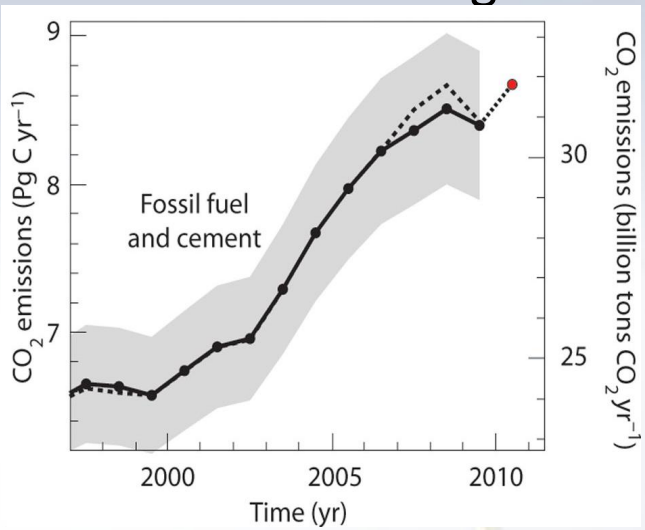
# Global LUC emissions are still “guesstimates”

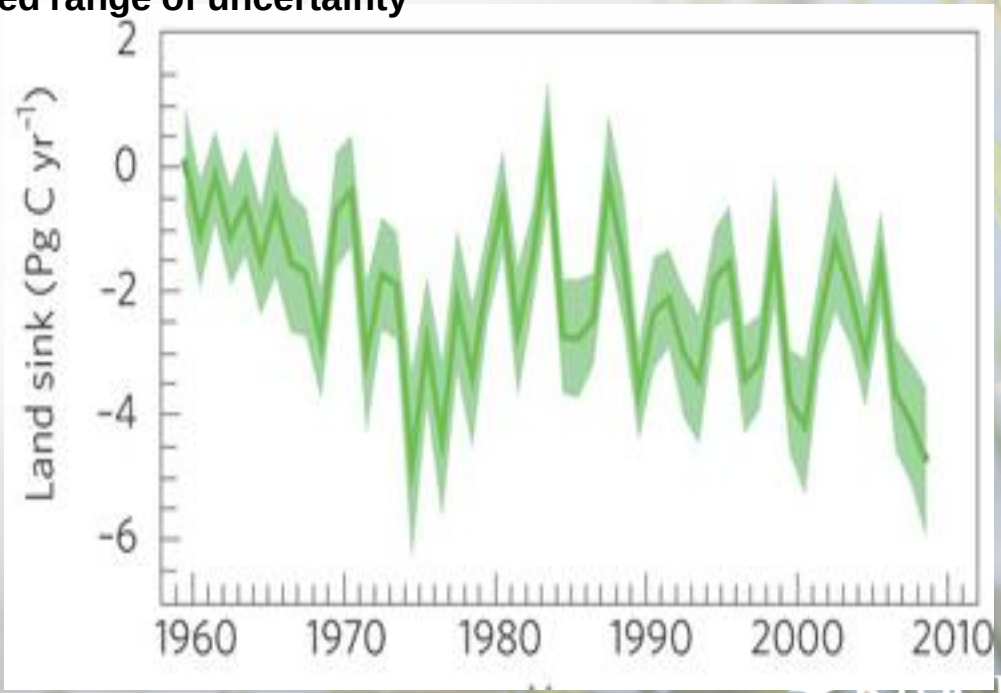



**About 90% of current CO2 emissions are from fossil fuel; fossil share rapidly rising. These comparisons ignore terrestrial sink (graph below)**

**Shaded areas around lines represent estimated range of uncertainty**

**Global land sink estimate varies each year with weather, but typically offsets LUC emissions by factor of about three**

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