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

Acknowledgements: Gbadebo ('Debo) Oladosu, Paul Leiby, Nagendra Singh, Virginia Dale

*This research was supported by the U.S. Department of Energy (DOE) under the Office of the Biomass Program and performed at Oak Ridge National Laboratory (ORNL). Oak Ridge National Laboratory is managed by the UT-Battelle, LLC, for DOE under contract DE-AC05-00OR22725. The views in this presentation are those of the authors, who are also responsible for any errors or omissions.

U.S. DEPARTMENT OF ENERGY

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

Roadmap for Talk

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

OAK RIDGE National Laboratory

Roadmap for Talk

- **Issues**
  - **Reliance on oil**
  - Food security
  - Deforestation
  - Estimating effects of bioenergy
  - Science and models
- Common solutions

OAK RIDGE National Laboratory

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

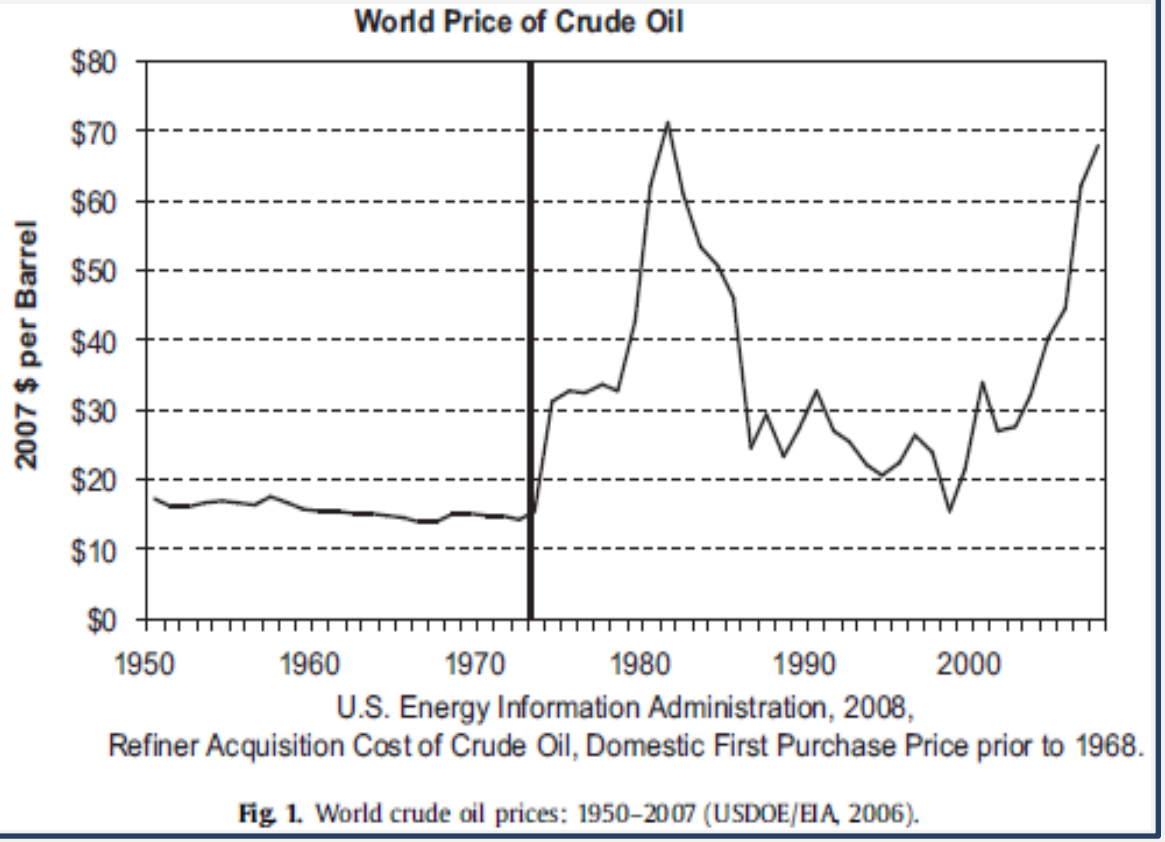


Fig. 1. World crude oil prices: 1950–2007 (USDOE/EIA, 2006).

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

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

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

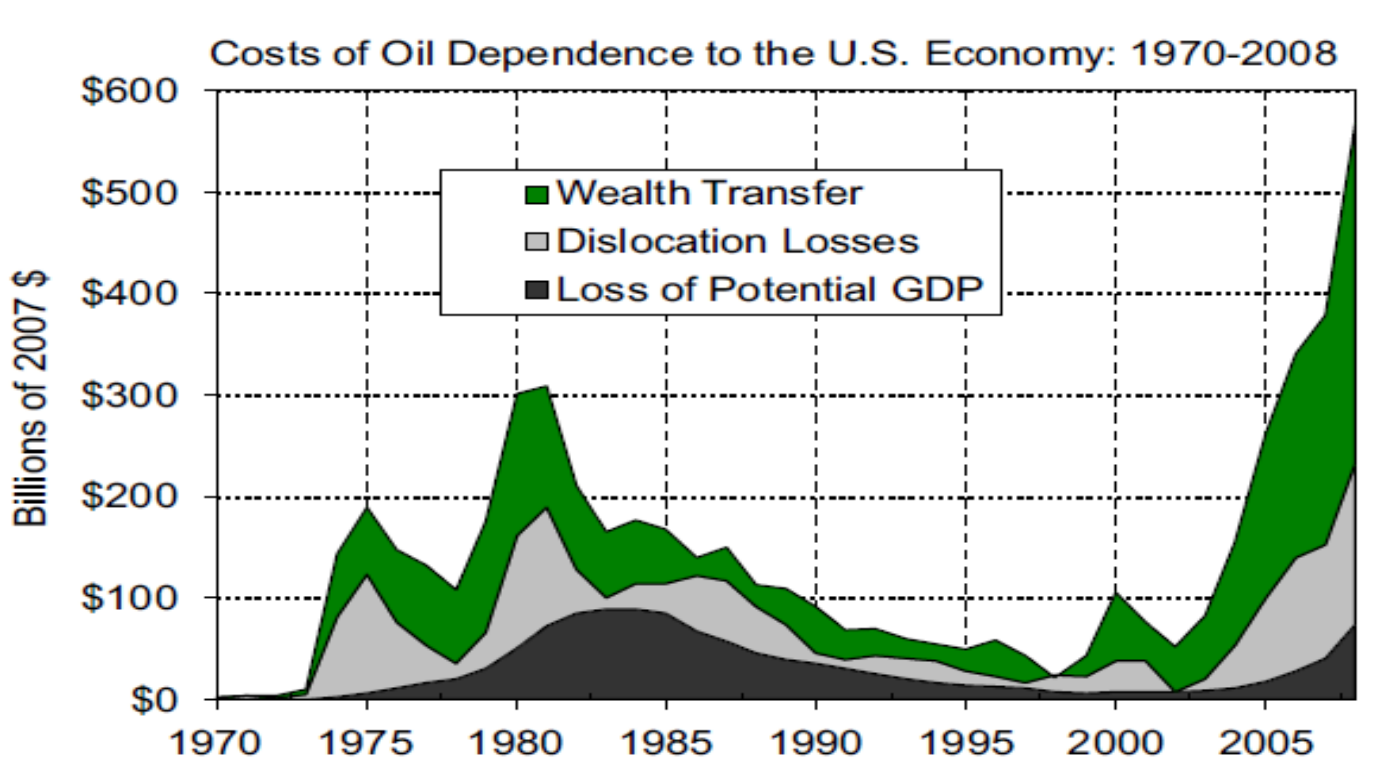


Fig. 4. Estimated direct economic costs of oil dependence to United States, 1970–2008.

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.

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.

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**

***Bioenergy markets can help (saving billions per year at the pump)**

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

Roadmap for Talk

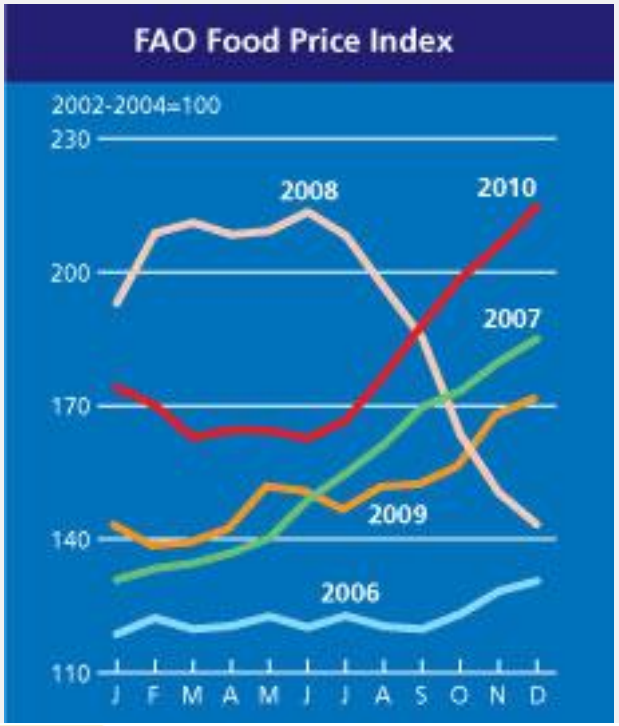
- **Issues**
  - Reliance on oil
  - **Food security**
  - Deforestation
  - Estimating effects of bioenergy
  - Science and models
- Common solutions

OAK RIDGE National Laboratory

Food security

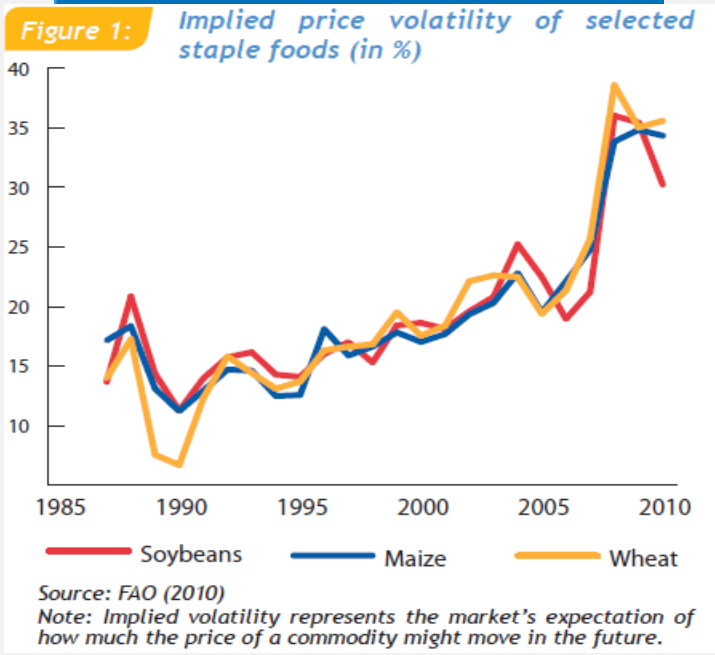
- Rising prices, volatility
- Consumers and producers suffer
- Nearly a billion undernourished (FAO)

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



Food and Agriculture Organization of the United Nations

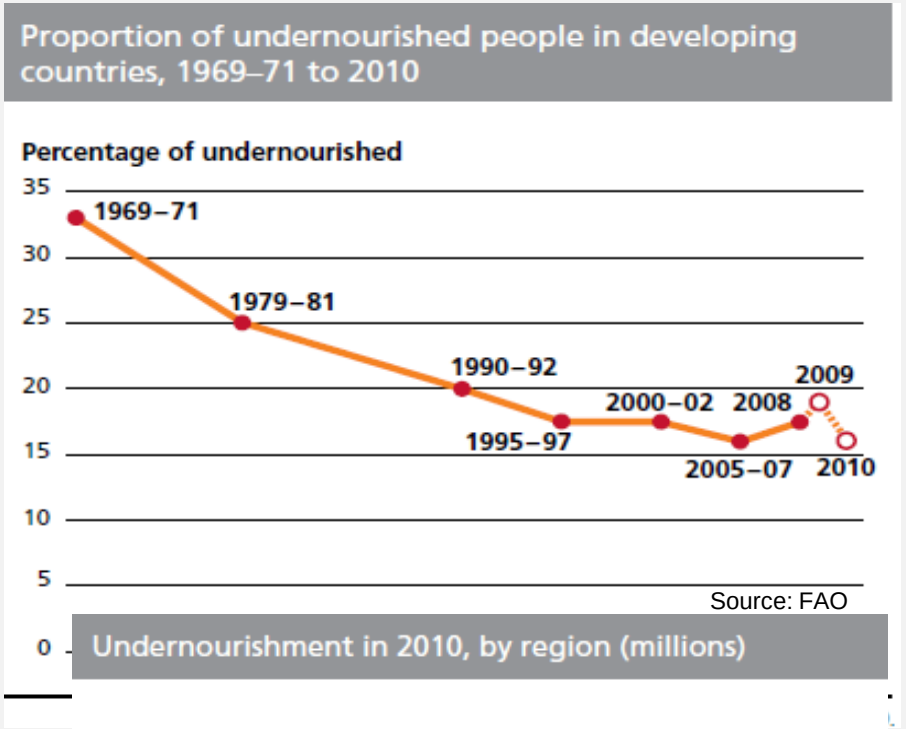
- Volatility in agricultural markets seems to have increased
- Extreme price movements of agricultural commodities pose a threat to world food security
- Policy measures should improve market functioning and increase countries' resilience to shocks

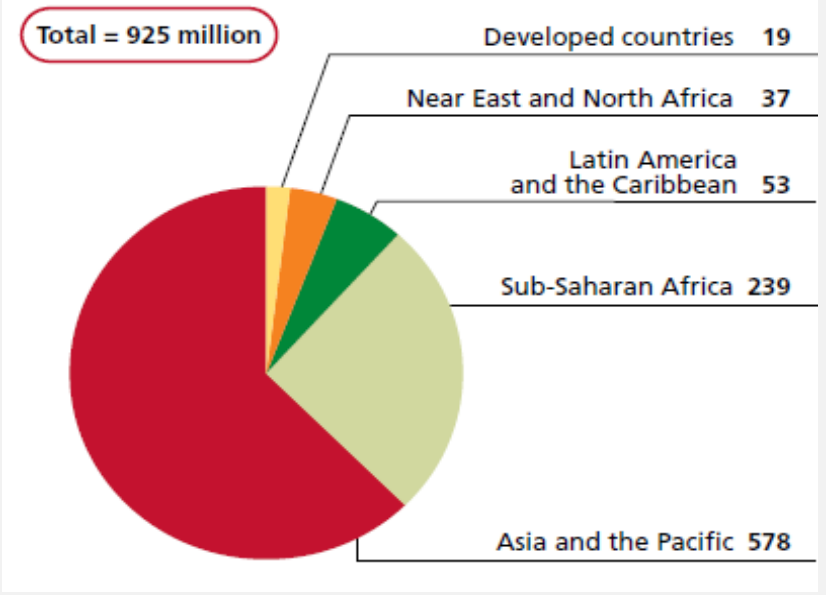


Source: FAO Policy Brief, Dec.2010, Price Volatility and Crises in Global Food Markets

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** • All wealthy people have access to food • All hungry people are poor

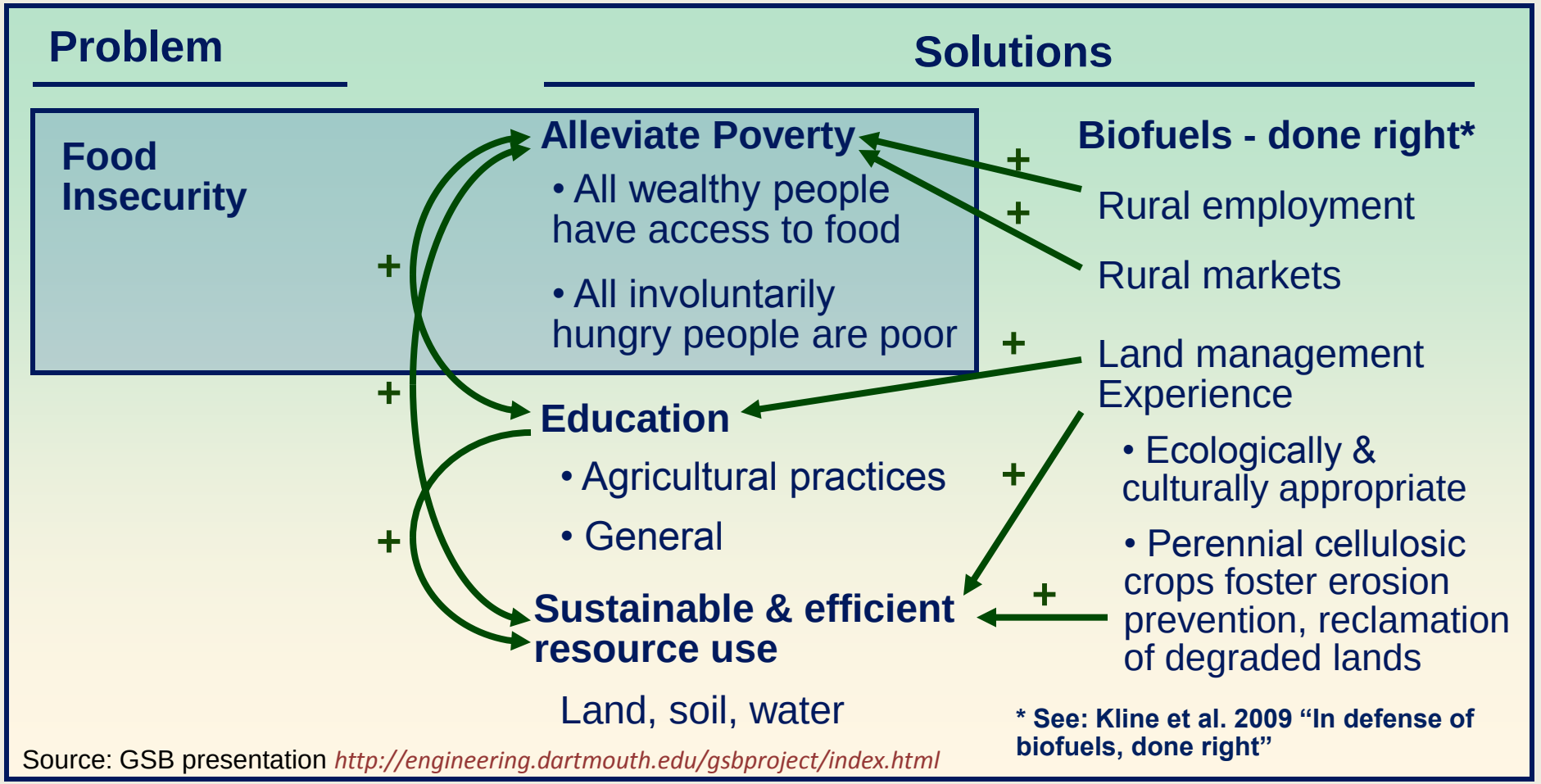
Source: Lee Lynd et al. GSB presentation *http://engineering.dartmouth.edu/gsbproject/index.html*

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.

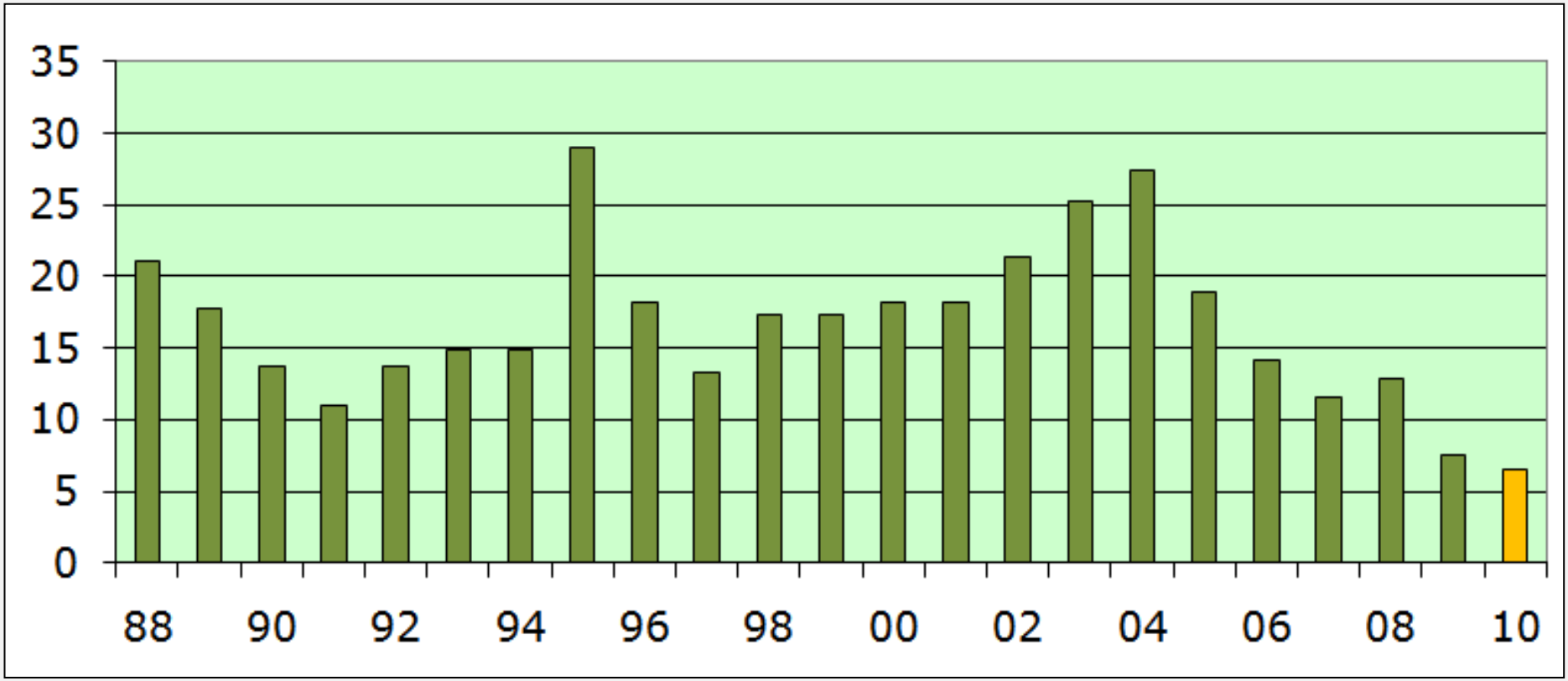
Roadmap for Talk

- **Issues**
  - Reliance on oil
  - Food security
  - **Deforestation**
  - Estimating effects of bioenergy
  - Science and models
- Common solutions

OAK RIDGE National Laboratory

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)**

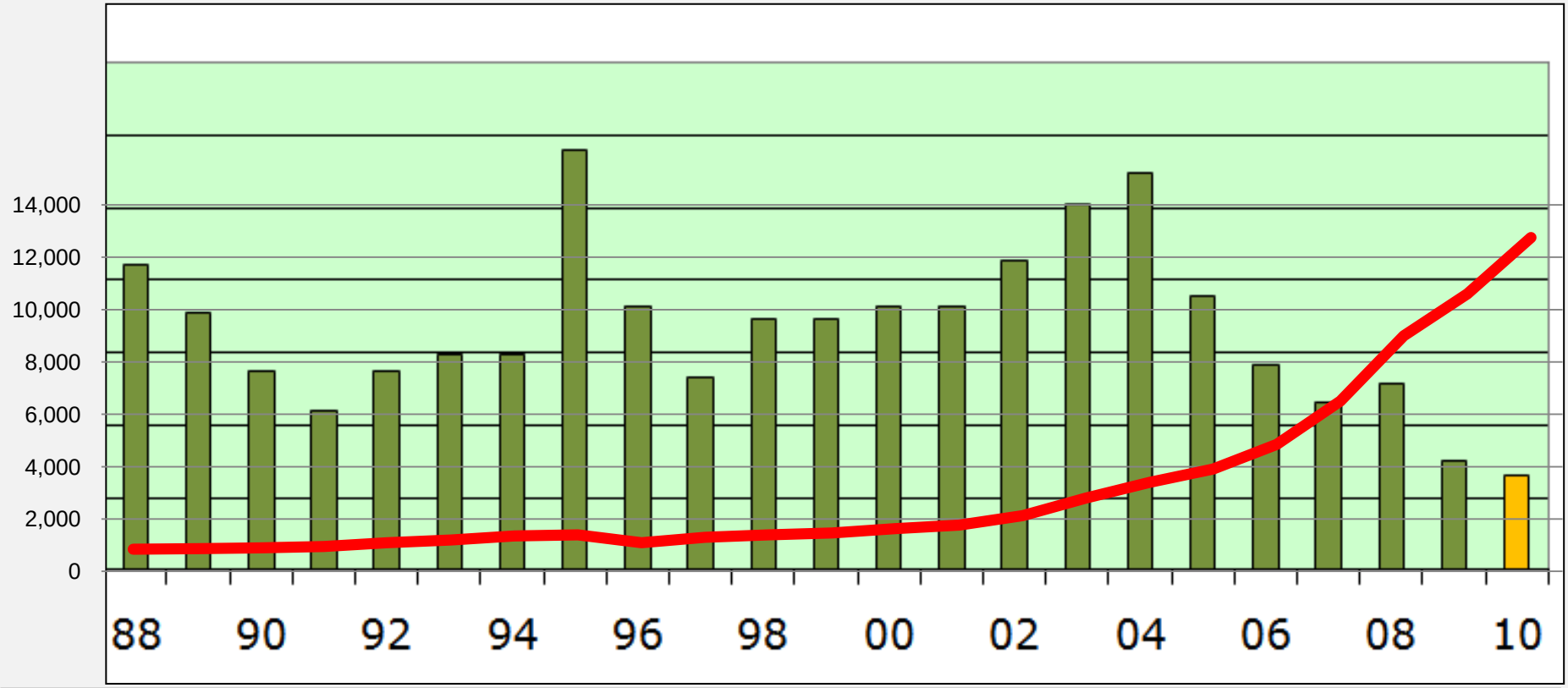


Deforestation rate in Brazil's Amazon, thousands square km per year

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

Roadmap for Talk

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

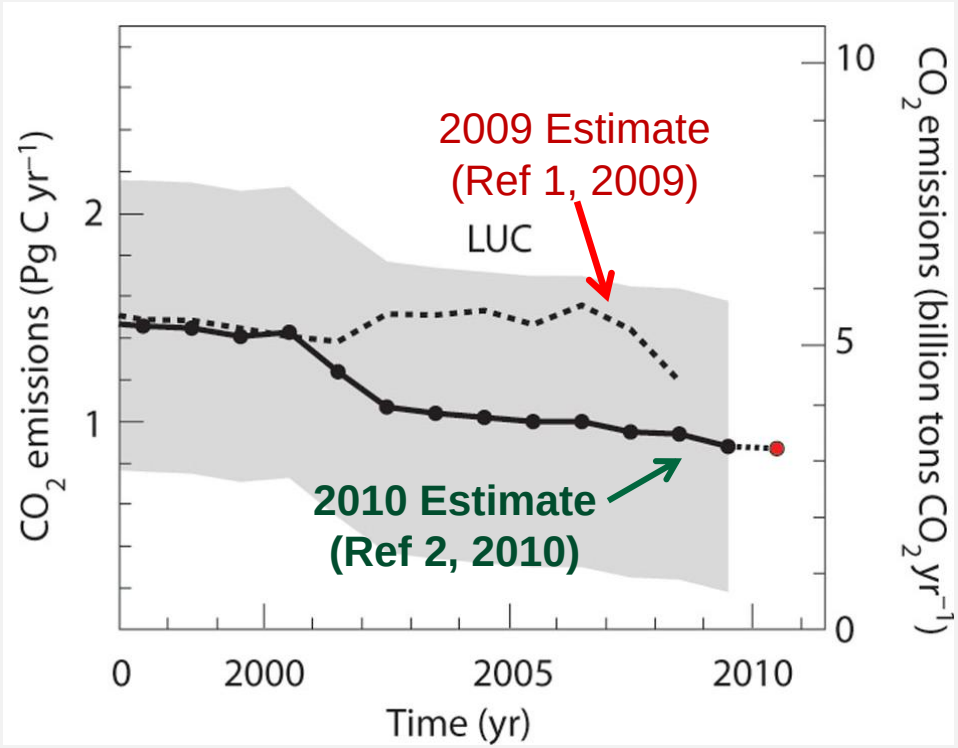
OAK RIDGE National Laboratory

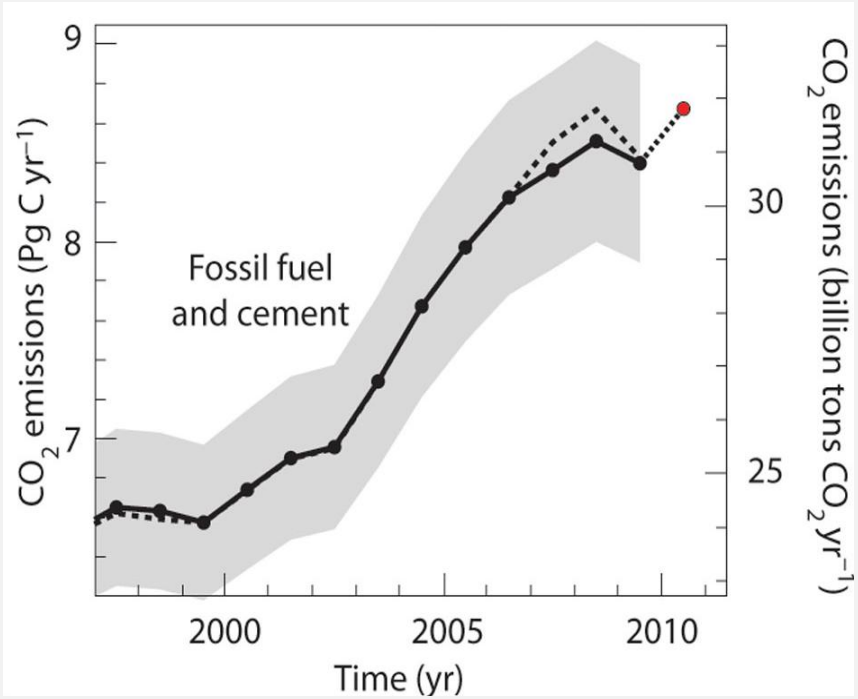
Land cover, land use:

- **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”





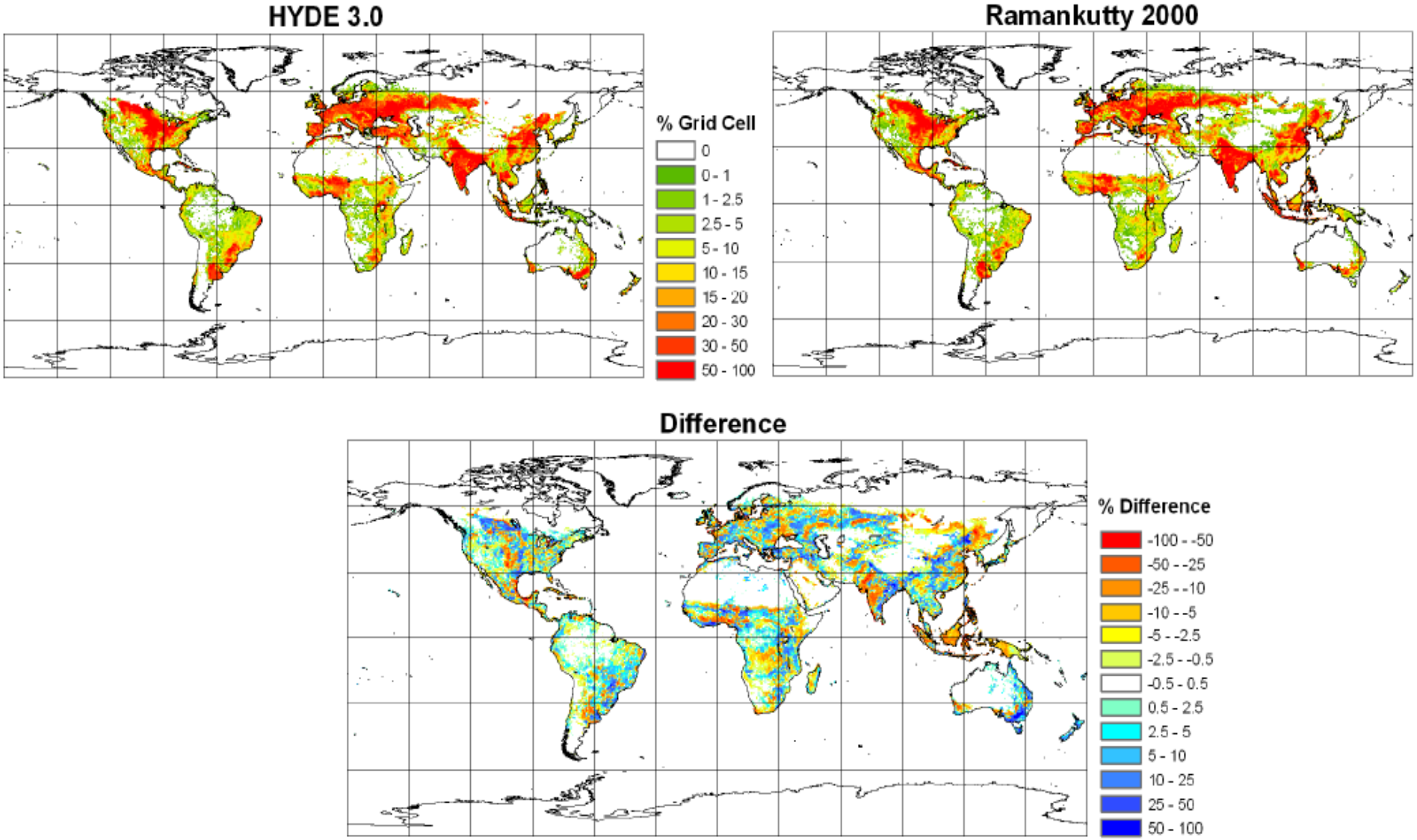
- **90% of current CO2 emissions are from fossil fuel; fossil share rapidly rising**

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)

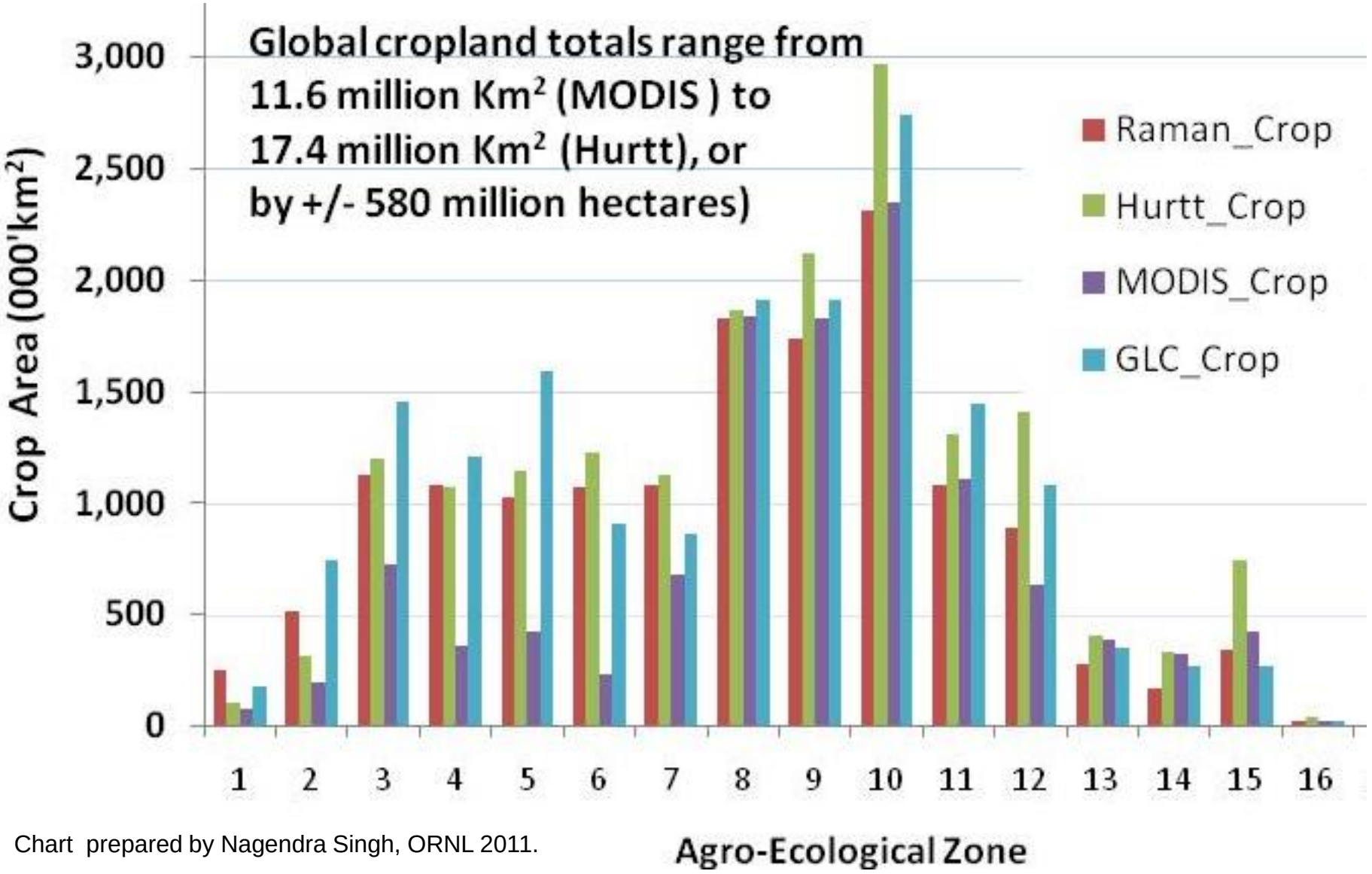


Chart prepared by Nagendra Singh, ORNL 2011.

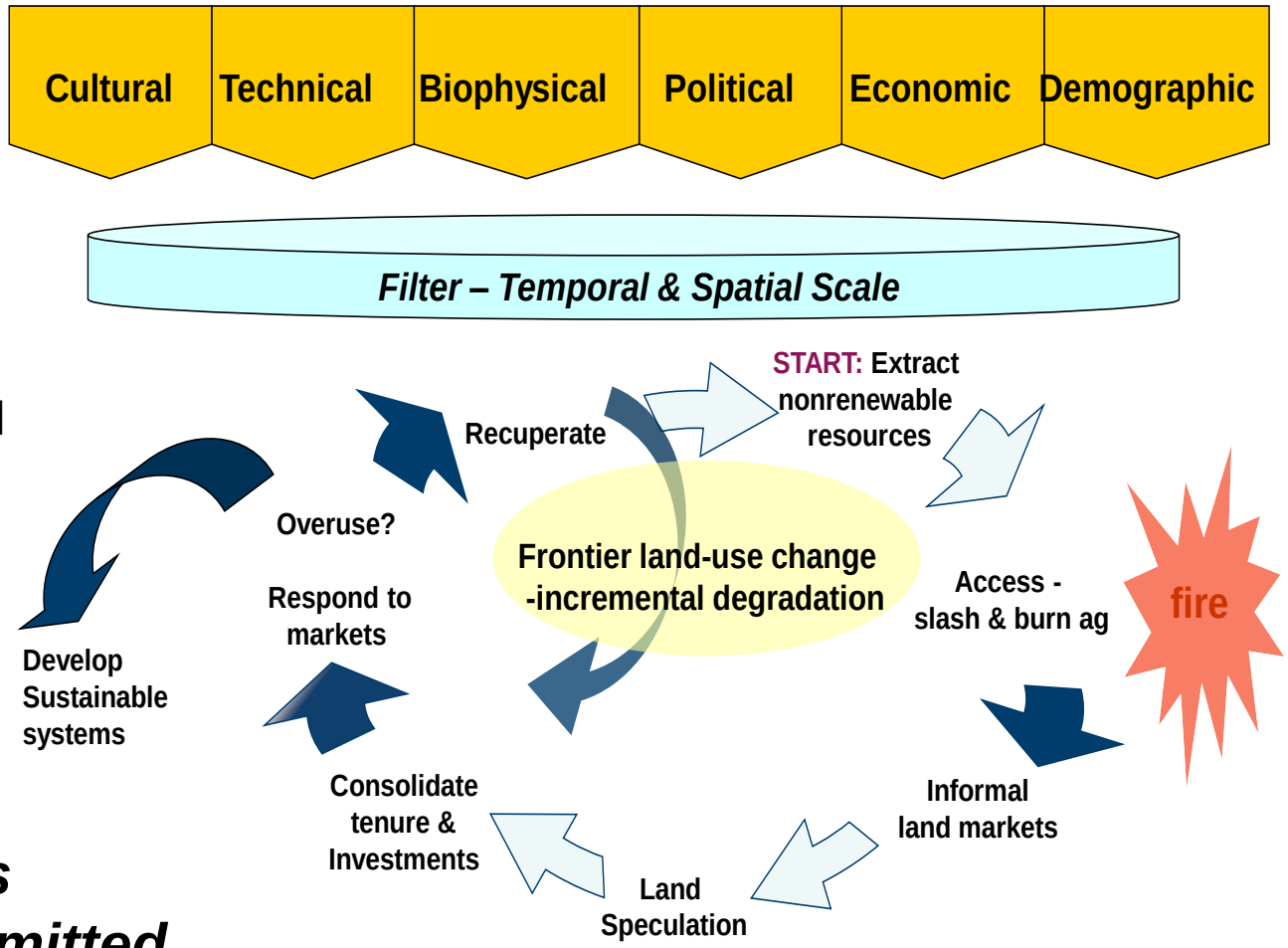
Roadmap for Talk

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

OAK RIDGE National Laboratory

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

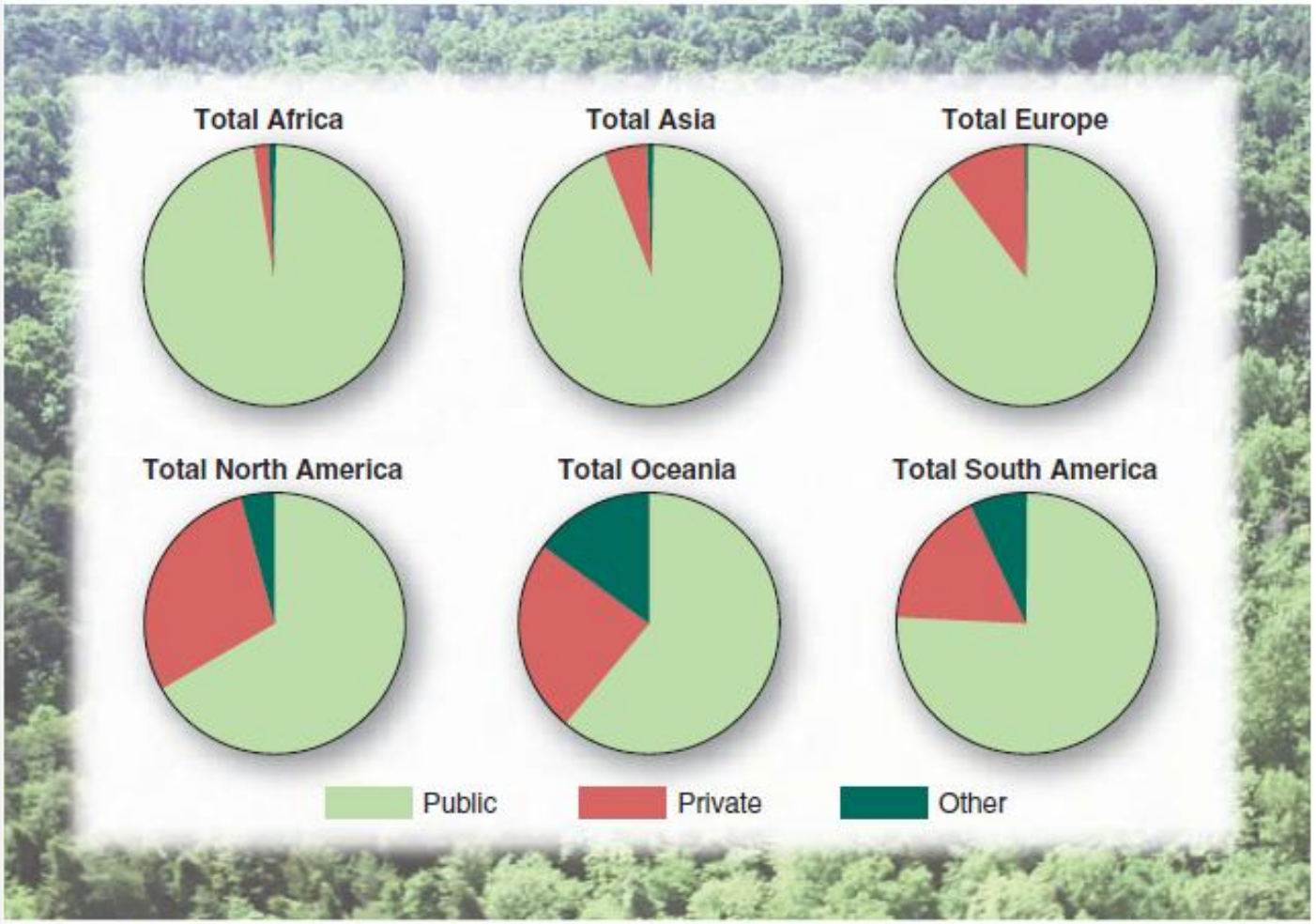
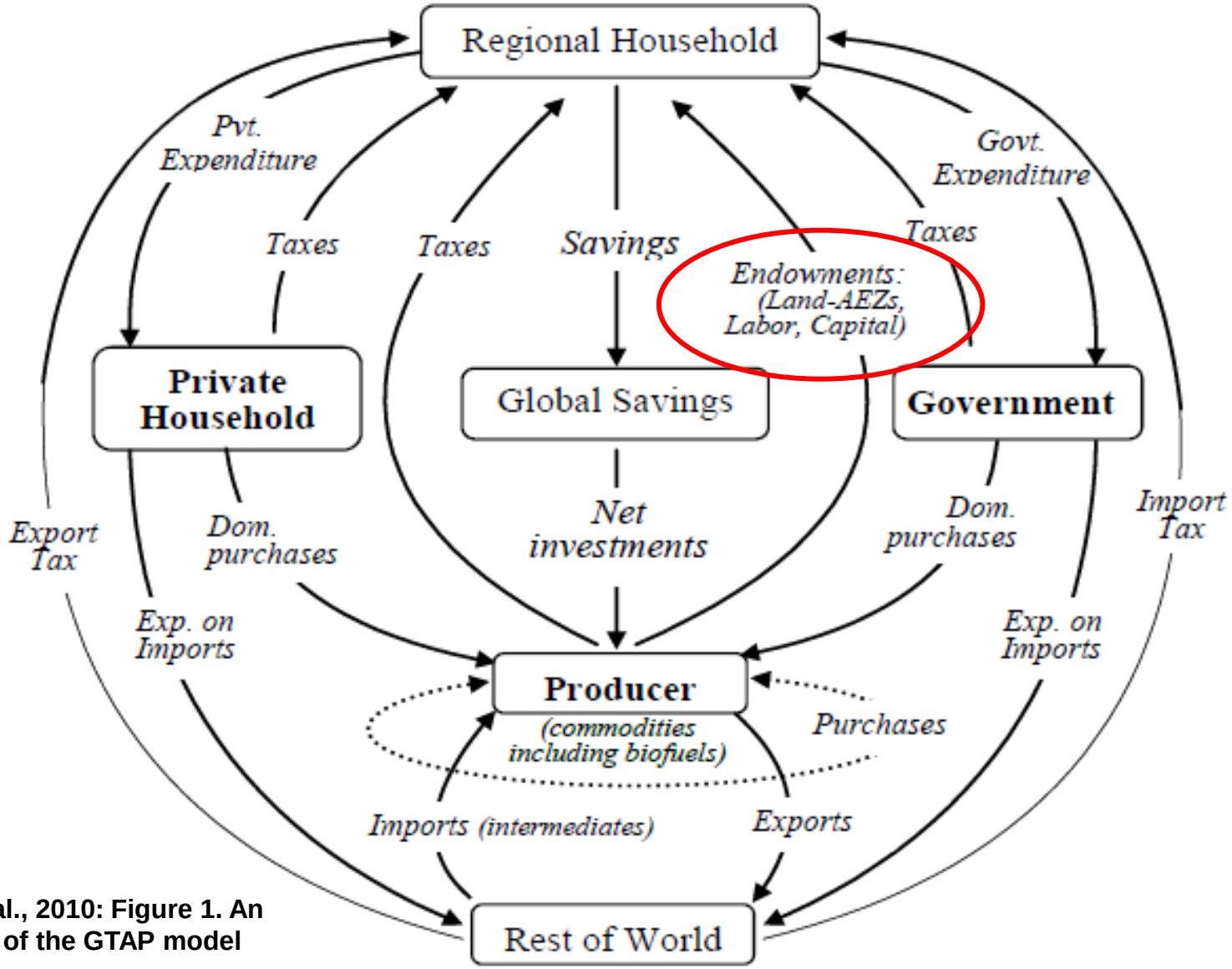


Fig. 1. Distribution of forest ownership by world regions.

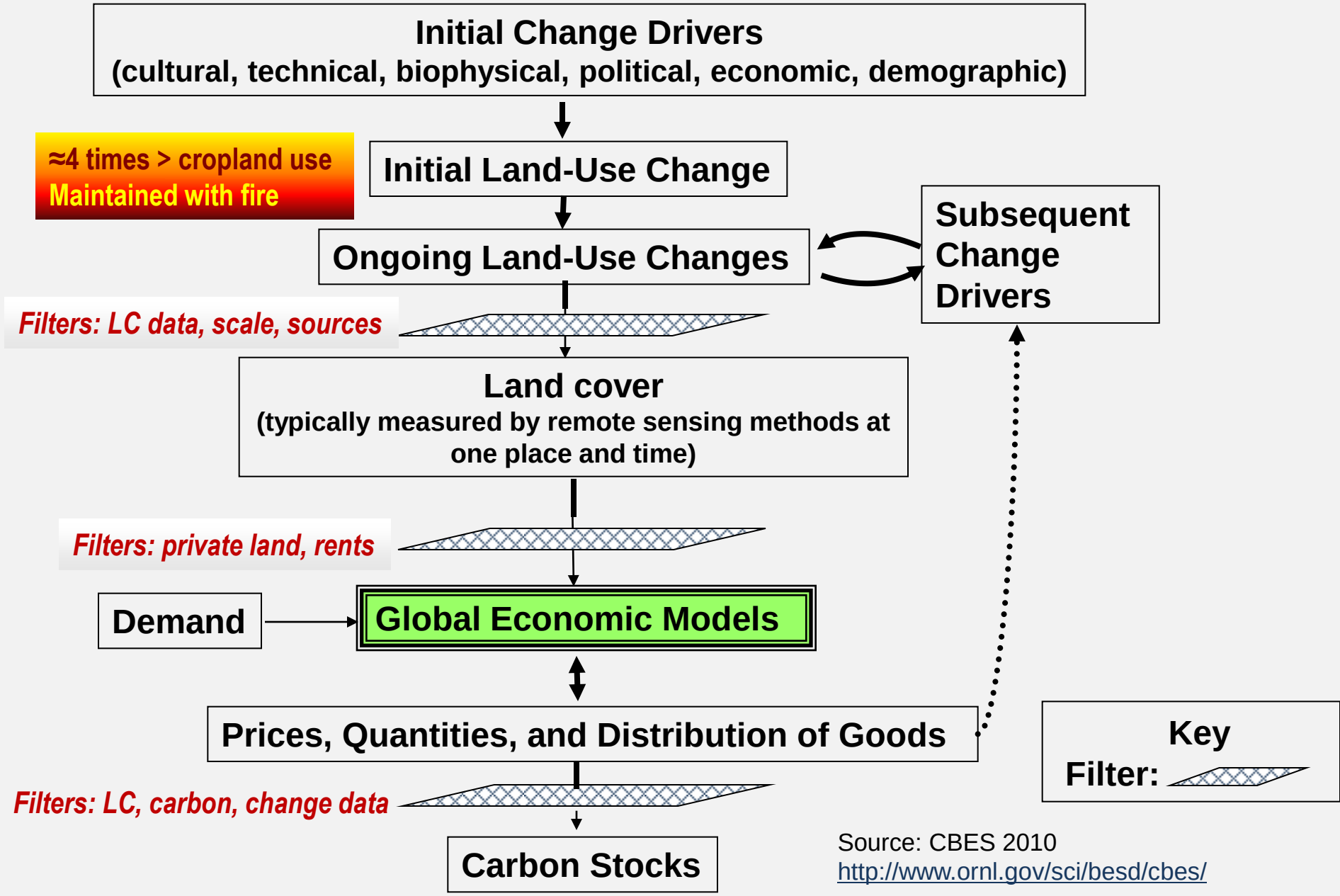
Source: Agrawal et al., 2008, Science 320

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

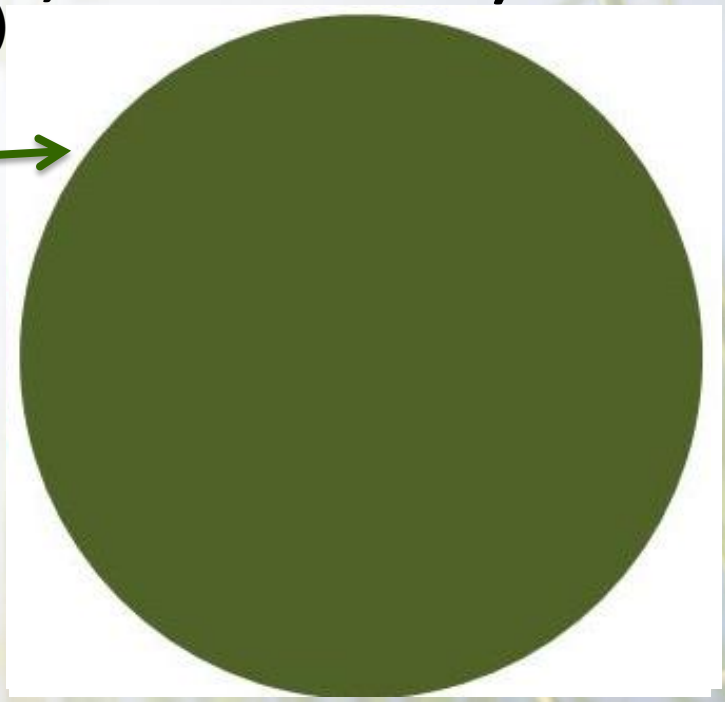


Source: CBES 2010
http://www.ornl.gov/sci/besd/cbes/

LUC estimates, compared to what?

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

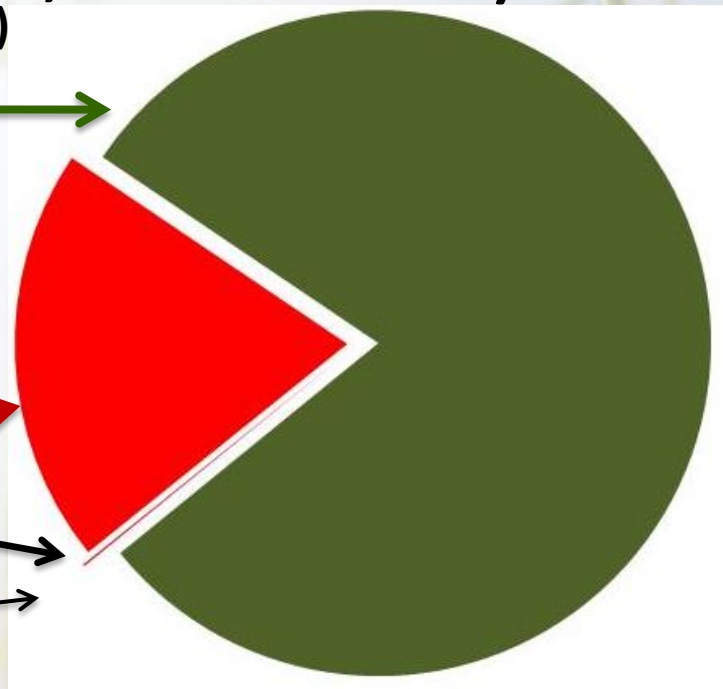
Circle size assumes 1500



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

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



- **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)

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!

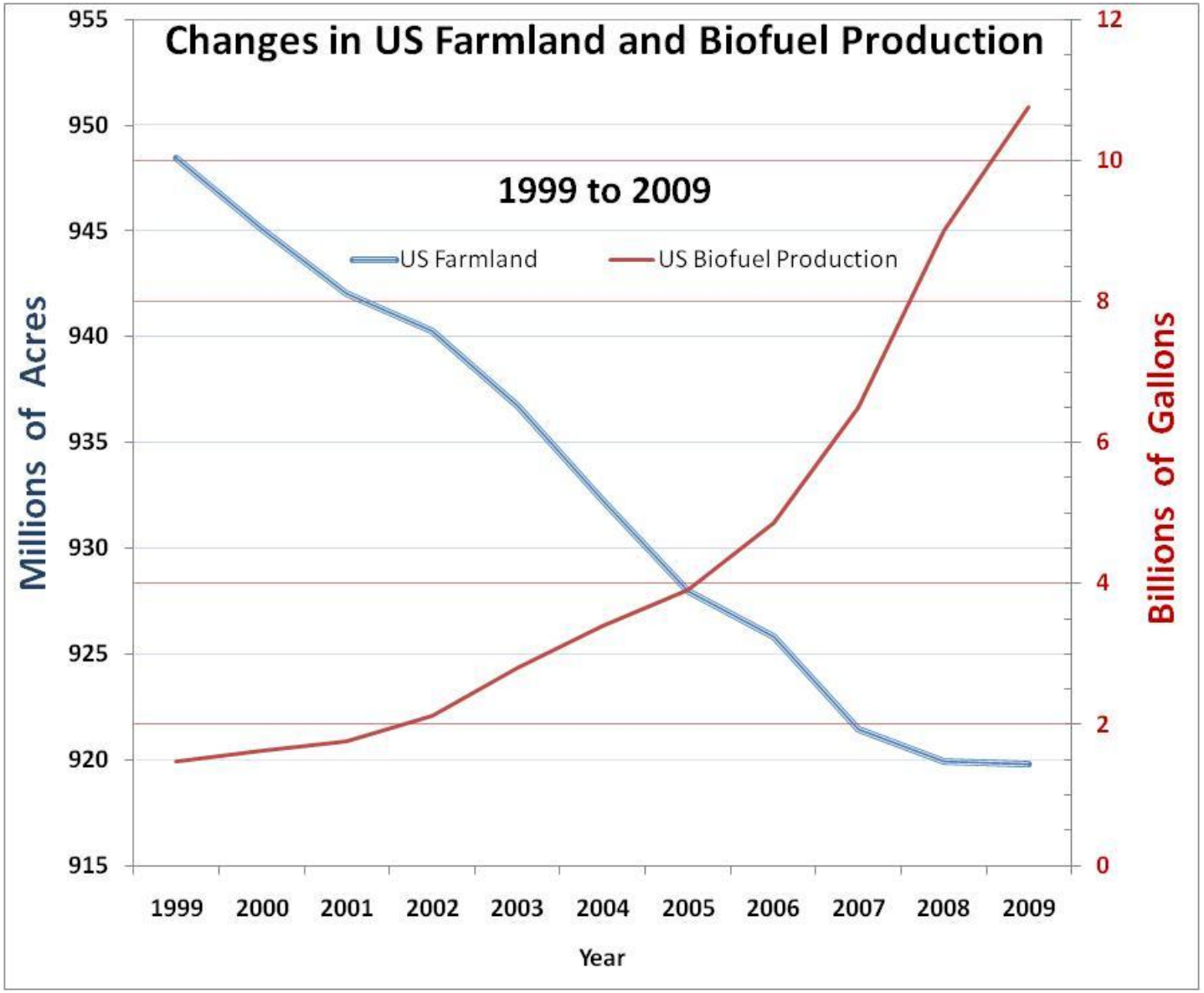
*Source: Science Council of Britain http://www.sciencecouncil.org/

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

OAK RIDGE National Laboratory

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)

Roadmap for Talk

- Issues
  - Reliance on oil
  - Food security
  - Deforestation
  - Estimating effects of bioenergy
  - Science and models
- **What are solutions?**

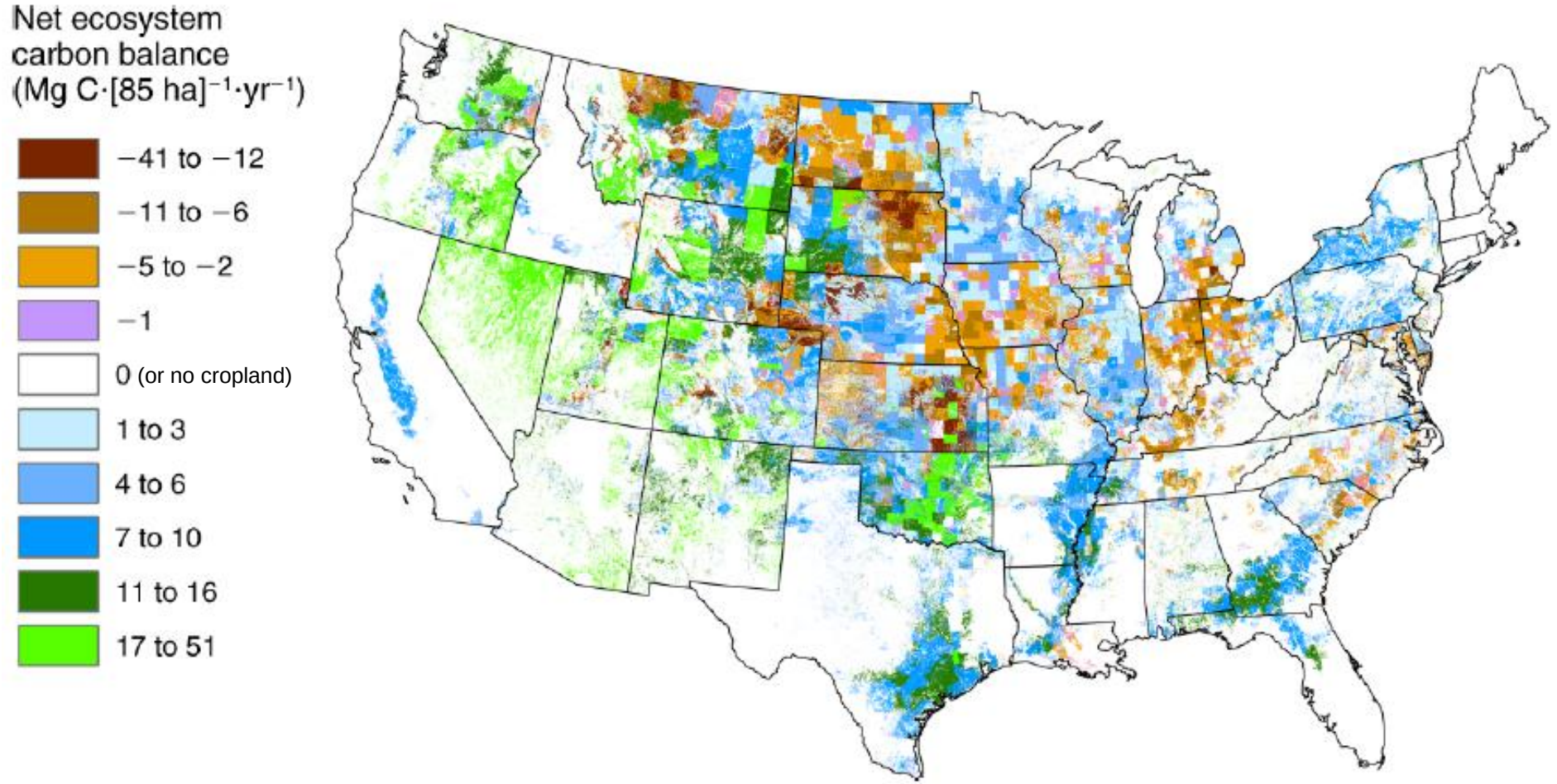
Win–Win options

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

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

Thank you!

Contact information:
Keith L. Kline
ORNL
klinekl@ornl.gov

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

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/

References

- Agrawal et al., 2008. A. Agrawal, A. Chhatre and R. Hardin, Changing governance of the world's forests, Science 320 (2008)
- Diaz-Chavez R, Mutimba S, Watson H, Rodriguez-Sanchez S and Nguer M. 2010. Mapping Food and Bioenergy in Africa. A report prepared on behalf of FARA. Forum for Agricultural Research in Africa, Ghana.
- EC 2010. The impact of Land Use Change on Greenhouse Gas Emissions from Biofuels and Bioliquids - Literature review. July 2010 (in-house review conducted for DG Energy as part of the European Commission's analytical work on indirect land use change)
- FAO 2010. SOFI Report: State of Food Insecurity in the World: http://www.fao.org/publications/sofi/en/
- FAO 2010a. SOFI Technical Notes (methodology). The State of Food Insecurity in the World 2010 Technical notes
- FAO 2010b. Food Outlook. Nov 2010. http://www.fao.org/giews/english/gfpm/index.htm
- FAO 2010c. Forestry Paper 163, Global Forest Resources Assessment, 2010, Main Report. Food and Agriculture Organization of the United Nations (FAO) Rome. ISBN 978-92-5-106654-6
- FAO 2009a. Hunger in the Face of Crisis: Global Economic Slowdown Underscores Urgency of Addressing Long-Term Challenges. http://www.fao.org/economic/es-policybriefs/briefs-detail/en/?no_cache=1&uid=35540 Economic and Social Perspectives, Policy Brief #6. September 2009. This and other policy briefs at http://www.fao.org/economic/es-policybriefs
- FAO. 2009b. The State of Food Insecurity in the World. http://www.fao.org/publications/sofi
- FAO-IIASA (2007). “Mapping biophysical factors that influence agricultural production and rural vulnerability.” Food and Agriculture Organization and International Institute for Applied Systems Analysis, Rome 2007.
- Feddema, Johnannes. University of Kansas (KU), Geography Dept. faculty home page (accessed January 24, 2011). http://www2.ku.edu/~geography/peoplepages/Feddema_J.shtml#research
- Feddema, J.J., K. Oleson, G. Bonan, L.O. Mearns, L. Buja, W.M. Washington, and G. Meehl. (2005). How important is land cover change for simulating future climates? Science 310(5754): 1674-1678.

References (pg 2)

- Feddema J.J., K. Oleson, G. Bonan, L. Mearns, W. Washington, G. Meehl, D. Nychka (2005). A comparison of a GCM response to historical anthropogenic land cover change and model sensitivity to uncertainty in present-day land cover representations, Climate Dynamics, 25: 581-609.
- Friedlingstein et al. 2010. Update on CO2 emissions (P. Friedlingstein, R. A. Houghton, G. Marland, J. Hackler, T. A. Boden, T. J. Conway, J. G. Canadell, M. R. Raupach, P. Ciais, C. Le Quéré). Nature Geoscience, Vol. 3, Pg: 811–812. DOI: doi:10.1038/ngeo1022
- Giglio L., J. T. Randerson, G. R. van derWerf, P. S. Kasibhatla, G. J. Collatz, D. C. Morton, and R. S. DeFries. Assessing variability and long-term trends in burned area by merging multiple satellite fire products. Biogeosciences, 7, 1171–1186, 2010.
- Gilbert C. L. and C. W. Morgan. 2010. Food price volatility. Philos Trans R Soc Lond B Biol Sci. 2010 September 27; 365(1554): 3023–3034. doi: 10.1098/rstb.2010.0139.
- Gilbert C. L. 2010a. How to understand high food prices. J. Agric. Econ. 61, 398–425
- Greene, D.L., Leiby,P.N., 2006.The Oil Security Metrics Model, ORNL/TM-2006/505, Oak Ridge National Laboratory, Oak Ridge, TN. http://cta.ornl.gov/cta/Publications/Reports/ORNL_TM_2006_505.pdf
- Greene, D.L., Leiby, P.N., Patterson, P.D., Plotkin, S.E., Singh, M.K. 2007. Oil independence: achievable national goal or empty slogan? Transportation Research Record 1(2017), 47–53 (Transportation Research Board, National Research Council, Washington, DC).
- Greene, D.L., Measuring energy security: Can the United States achieve oil independence? Energy Policy (2009), doi:10.1016/j.enpol.2009.01.041
- Hansen J, Sato M, Kharecha P, Beerling D, Berner R, Masson-Delmotte V, Pagani M, Raymo M, Royer DL, Zachos JC. 2008. Target atmospheric CO2: Where should humanity aim? Open Atmospheric Science Journal 2: 217–231.
- Hertel, T.W., A. Golub, A.D. Jones, M. O'Hare, R.J. Plevin and D.M. Kammen, "Effects of US Maize Ethanol on Global Land Use and Greenhouse Gas Emissions: Estimating Market mediated Responses", BioScience, Vol. 60 No. 3, March 2010.

References (pg 3)

- INPE-PRODES Brazil Space Agency: http://www.dpi.inpe.br/gilberto/present/prodes_taxa2010.ppt Accessed January 27, 2011.
- IMF 2011: Cevik Serhan and Tahsin Saadi Sedik. A Barrel of Oil or a Bottle of Wine: How Do Global Growth Dynamics Affect Commodity Prices? IMF Working Paper (WP 11/1), Middle East and Central Asia Department. January, 2011
- Kline KL, Dale VH, Lee R, Leiby P. 2009. In Defense of Biofuels, Done Right. Issues in Science and Technology 25(3): 75-84. http://www.issues.org/25.3/kline.html
- Kline and Dale. 2008. Science 321:199-200.
- Lal R. 2004. Soil carbon sequestration impacts on global climate change and food security. Science 304: 1623–1627.
- Lal R. 2006. Enhancing crop yield in the developing countries through restoration of the soil organic carbon pool in agricultural lands. Land Degradation and Development 17: 197–209.
- Lal, Rattan. 2010. Managing Soils and Ecosystems for Mitigating Anthropogenic Carbon Emissions and Advancing Global Food Security. BioScience 60: 708-721.
- Le Quéré, C. et al. Nature Geosci. 2, 831–836 (2009).
- National Commission on Energy Policy, 2004. Ending the Energy Stalemate: A Bipartisan Strategy to Meet America's Energy Challenges.
- Oxfam 2010. Hunger in the Sahel: A permanent emergency? Oxfam Briefing Note (Etienne du Vachat; Eric Hazard) 15 December 2010. http://www.oxfam.org.uk/resources/policy/conflict_disasters/downloads/bn-hunger-in-the-sahel-15122010-en.pdf Accessed January 24, 2011.
- Ramankutty N., et al., "Farming the Planet: 1. Geographic distribution of global agricultural lands in the year 2000" and Monfreda C. et al., "Farming the Planet: 2. Geographic distribution of crop areas, yields, physiological types, and net primary production" both in: Glob. Biogeochemical Cycles 22, GB1022, March 2008.

References (pg 4)

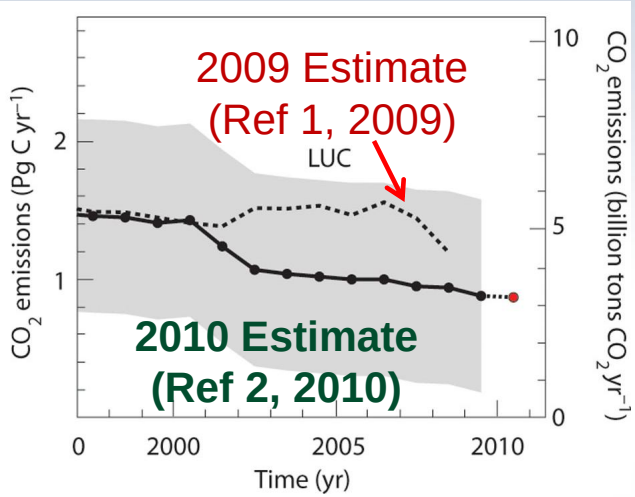
- RFA 2010. Renewable Fuels Association, Industry statistics: http://www.ethanolrfa.org/industry/statistics/
- Thurow R., Kilman S. 2009. Enough: why the world's poorest starve in an age of plenty. New York: Perseus Books Group, for Public Affairs.
- Tyner, W.E., F. Taheripour, Q. Zhuang, D. Birur and U. Baldos, "Land Use Changes and Consequent CO2 Emissions due to US Corn Ethanol Production: A Comprehensive Analysis", 2010
- UNCTAD 2009. The 2008 Food Price Crisis: Rethinking Food Security Policies. G-24 Discussion Paper Series No. 56, June 2009. by Anuradha Mittal for the United Nations Conference on Trade and Development (UNCTAD).
- USDA NASS 2010. USDA 2010: “Farms, Land in Farms, and Livestock Operations 2009 Summary: Released February 12, 2010, by the National Agricultural Statistics Service (NASS), Agricultural Statistics Board, U.S. Department of Agriculture.”
- USDA NRI 2009. The 2007 US Natural Resource Inventory (NRI). United States Department of Agriculture, Natural Resources Conservation Service. 2009. http://www.nrcs.usda.gov/NRI

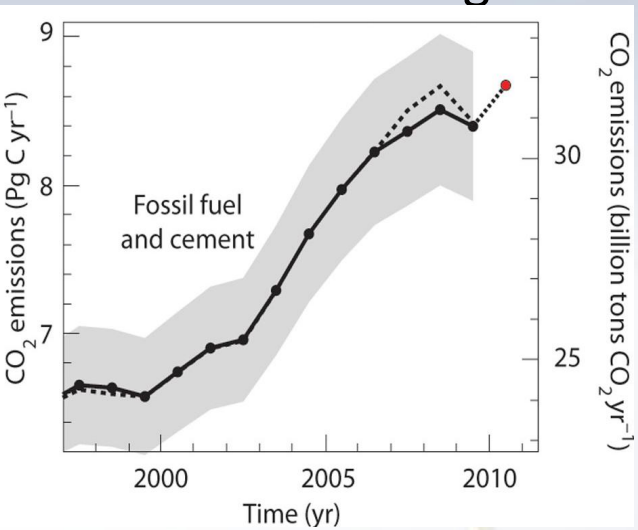
Additional Slide: Summary of Key Points

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

Global LUC emissions are still “guesstimates”

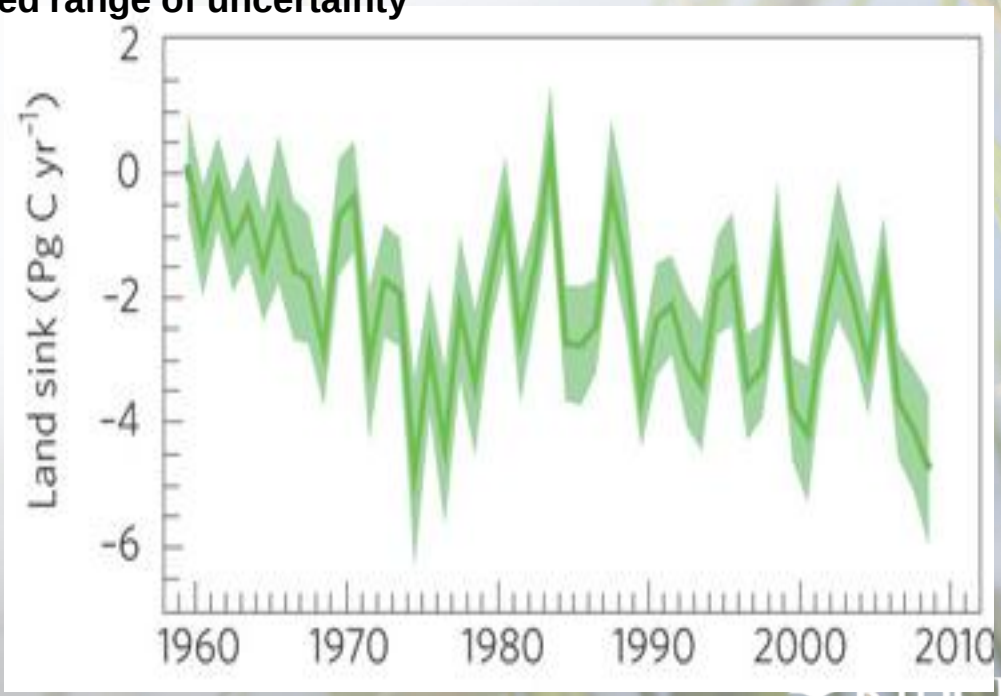




About 90% of current CO2 emissions are from fossil fuel; fossil share rapidly rising. These comparisons ignore terrestrial sink (graph below)

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



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