Models, Science and the Precautionary Principle: Land-Use Change and Sustainability of Biomass Systems

Presentation for the 32nd SIM Symposium
Biotechnology for Fuels and Chemicals
April 21st, 2010
Clearwater, Florida

Session 7
Biomass Sustainability and Land Use

Research supported by the U.S. Department of Energy
Office of the Biomass Program

Keith L. Kline, Virginia H. Dale, Gbadebo Oladosu
Center for Bioenergy Sustainability, Environmental Sciences Division, Oak Ridge National Laboratory

Outline

- Concerns
- Estimating land-use change (LUC) effects of biofuels
- Uncertainty
- Models and science
- Precautionary principle
- Discussion

Bioenergy Concerns:

FOOD

versus

FUEL

GHG emissions: Could biofuels cause higher emissions than fossil fuels?

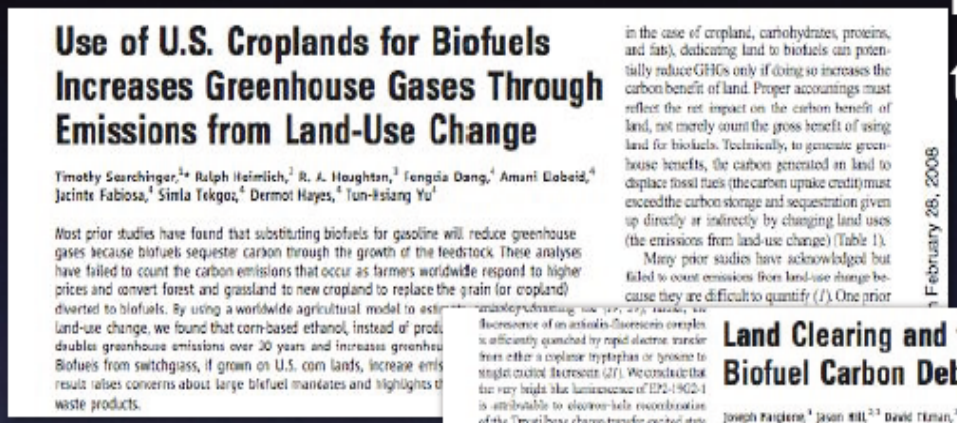
LAND
underlies both issues:

Is land available for agricultural expansion AND biofuels (AND without deforestation)?

Oak Ridge National Laboratory

The great land use debate

Tim Searchinger's paper in the same journal set off a fire storm



Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land-Use Change

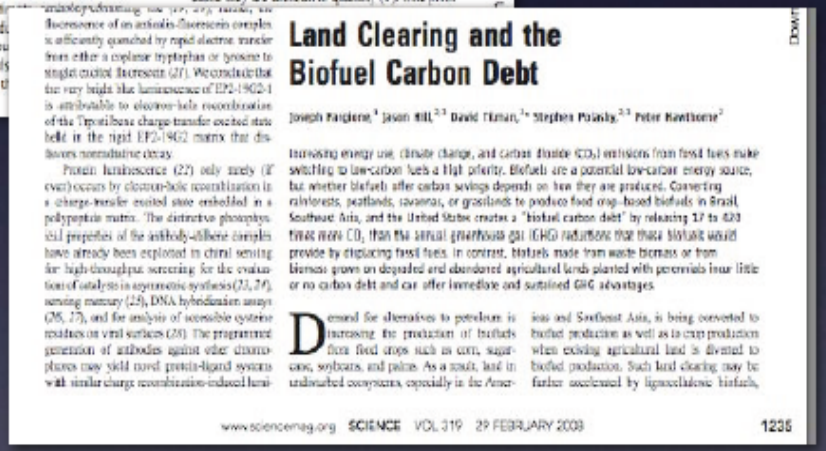
Timothy Searchinger,[1*] Ralph Heimlich,[2] R. A. Houghton,[3] Fengxia Dong,[4] Amani Elobeid,[4] Jacinto Fabiosa,[4] Simla Tokgoz,[4] Dermot Hayes,[4] Tun-Hsiang Yu[4]

Most prior studies have found that substituting biofuels for gasoline will reduce greenhouse gases because biofuels sequester carbon through the growth of the feedstock. These analyses have failed to count the carbon emissions that occur as farmers worldwide respond to higher prices and convert forest and grassland to new cropland to replace the grain (or cropland) diverted to biofuels. By using a worldwide agricultural model to est
land-use change, we found that corn-based ethanol, instead of prod
doubles greenhouse emissions over 30 years and increases greenhou
Biofuels from switchgrass, if grown on U.S. corn lands, increase emis
result raises concerns about large biofuel mandates and highlights t
waste products.

in the case of cropland, carbohydrates, proteins, and fats), dedicating land to biofuels can potentially reduce GHGs only if doing so increases the carbon benefit of land. Proper accountings must reflect the net impact on the carbon benefit of land, not merely count the gross benefit of using land for biofuels. Technically, to generate greenhouse benefits, the carbon generated on land to displace fossil fuels (the carbon uptake credit) must exceed the carbon storage and sequestration given up directly or indirectly by changing land uses (the emissions from land-use change) (Table 1).

Many prior studies have acknowledged but failed to count emissions from land-use change because they are difficult to quantify (1). One prior

February 28, 2008



Land Clearing and the Biofuel Carbon Debt

Joseph Fargione,[1] Jason Hill,[2,3] David Tilman,[1*] Stephen Polasky,[2,3] Peter Hawthorne[2]

Increasing energy use, climate change, and carbon dioxide (CO_2) emissions from fossil fuels make switching to low-carbon fuels a high priority. Biofuels are a potential low-carbon energy source, but whether biofuels offer carbon savings depends on how they are produced. Converting rainforests, peatlands, savannas, or grasslands to produce food crop–based biofuels in Brazil, Southeast Asia, and the United States creates a "biofuel carbon debt" by releasing 17 to 420 times more CO_2 than the annual greenhouse gas (GHG) reductions that these biofuels would provide by displacing fossil fuels. In contrast, biofuels made from waste biomass or from biomass grown on degraded and abandoned agricultural lands planted with perennials incur little or no carbon debt and can offer immediate and sustained GHG advantages.

Demand for alternatives to petroleum is increasing the production of biofuels from food crops such as corn, sugarcane, soybeans, and palm. As a result, land in undisturbed ecosystems, especially in the Amer-
icas and Southeast Asia, is being converted to biofuel production as well as to crop production when existing agricultural land is diverted to biofuel production. Such land clearing may be further accelerated by lignocellulosic biofuels,

Fargione, Hill et al's *Science* paper actually tried to frame a question

Slide credit: John Sheehan, University of Minnesota

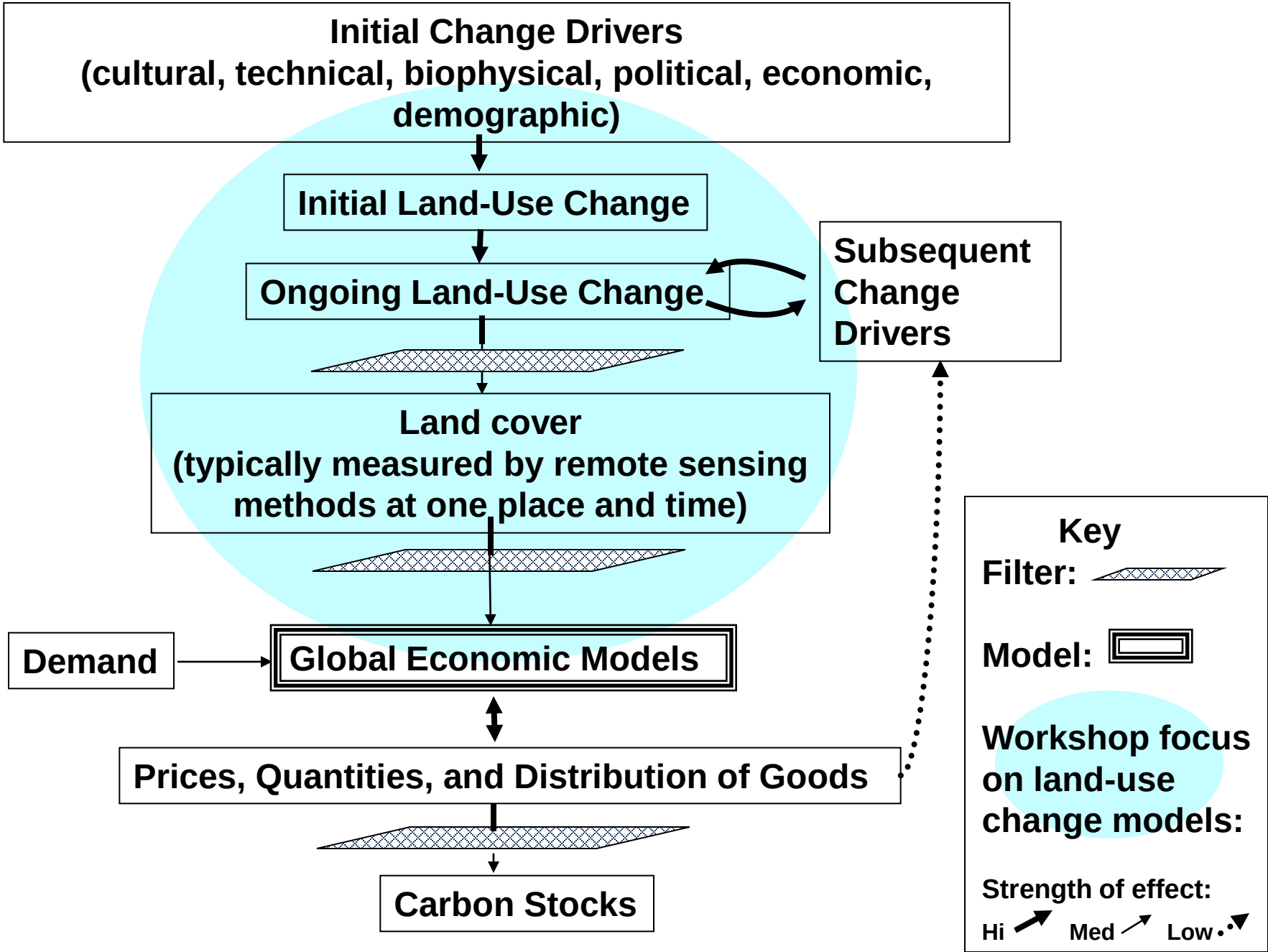
Land-Use Change (LUC) underlies popular biofuel concerns

- **Conventional Wisdom**
- **Regulatory initiatives**
  - **California**
  - **NESCAUM**
  - **EPA and EISA RFS2 requirement**
    - **direct effects plus…**
    - **"significant indirect emissions from LUC"**
- **Certification initiatives**
- **Indirect-LUC (ILUC) "wildcard"**
- **Conflicting ILUC opinions from "experts"**
- **Is policy getting ahead of science?**

Drivers of LUC are not in the models used to estimate bioenergy effects

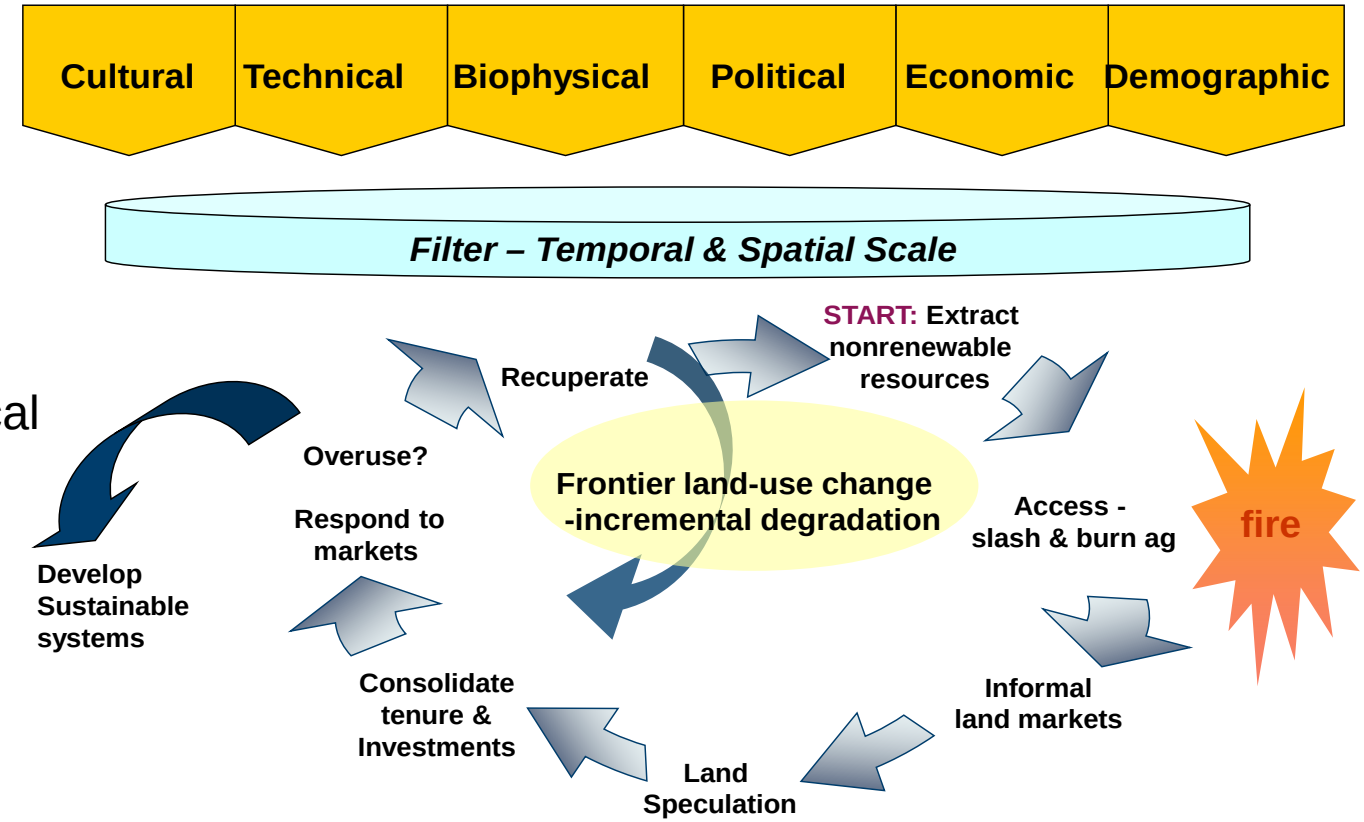
- **Simulations estimate changes driven by relative prices**
  - **Model typically has land <u>cover</u> categories: Cropland, Pasture, Forests**
  - **Missing key land asset classes**
  - **Huge variations occurs within classes**
  - **At what point do "transitions" occur?**
- **Priority: "high conservation value areas" and preventing their first-time conversion**
  - **Can we improve understanding of drivers for "first time" conversion?**
  - **What is local impact of biofuel policies?**
  - **What are the causal relationships?**

2009 LUC & BIOENERGY WORKSHOP



First-time LUC is complex

- ***Driving first-time conversion:***
  - Limited capacity for governance
  - Extractive (incl. oil/gas) industries
  - Access & biophysical conditions
  - Making/holding land claims
  - Poverty, insecurity



- ***How do energy, & biofuel policies interact with principle driving forces of first time conversion? Where do they fit in models?***

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

Challenges and Uncertainty

- **LUC is local & site specific while analytical approaches for ILUC must be global**
- **Global aggregates & averages do not account for complex factors governing initial conversion - LUC**
- **Data issues: (Quality, temporal and spatial scales, resolution, classification)**
- **Uncertainty in baseline -**
  - **Model structure**
  - **Representation of LU behavior**
  - **Aggregation**
  - **Input specifications (yield, prices, elasticity factors…)**

Of Models and Science

"models … are simplified views of the world that help us think about a complex issue, but not true representations of the complexity itself."

-Claude Diebolt, Research Director of Economics, Universite de Strasbourg [quoted in *The Economist*, Aug 6, 2009]

Why LUC is difficult for CGE Models

Economic Models	**Empirical Evidence**	**Comment**
Baseline = equilibrium state: all land assigned to use (crop, pasture) with fixed area. *All LUC driven by relative commodity prices.*		
Land is assumed to be in an optimal allocation.		
Land assets are private, owned, managed assets.		
Assumes no “excess” production, stocks, or losses.		
Previously cleared but underutilized land (unmanaged) is omitted as asset class.		

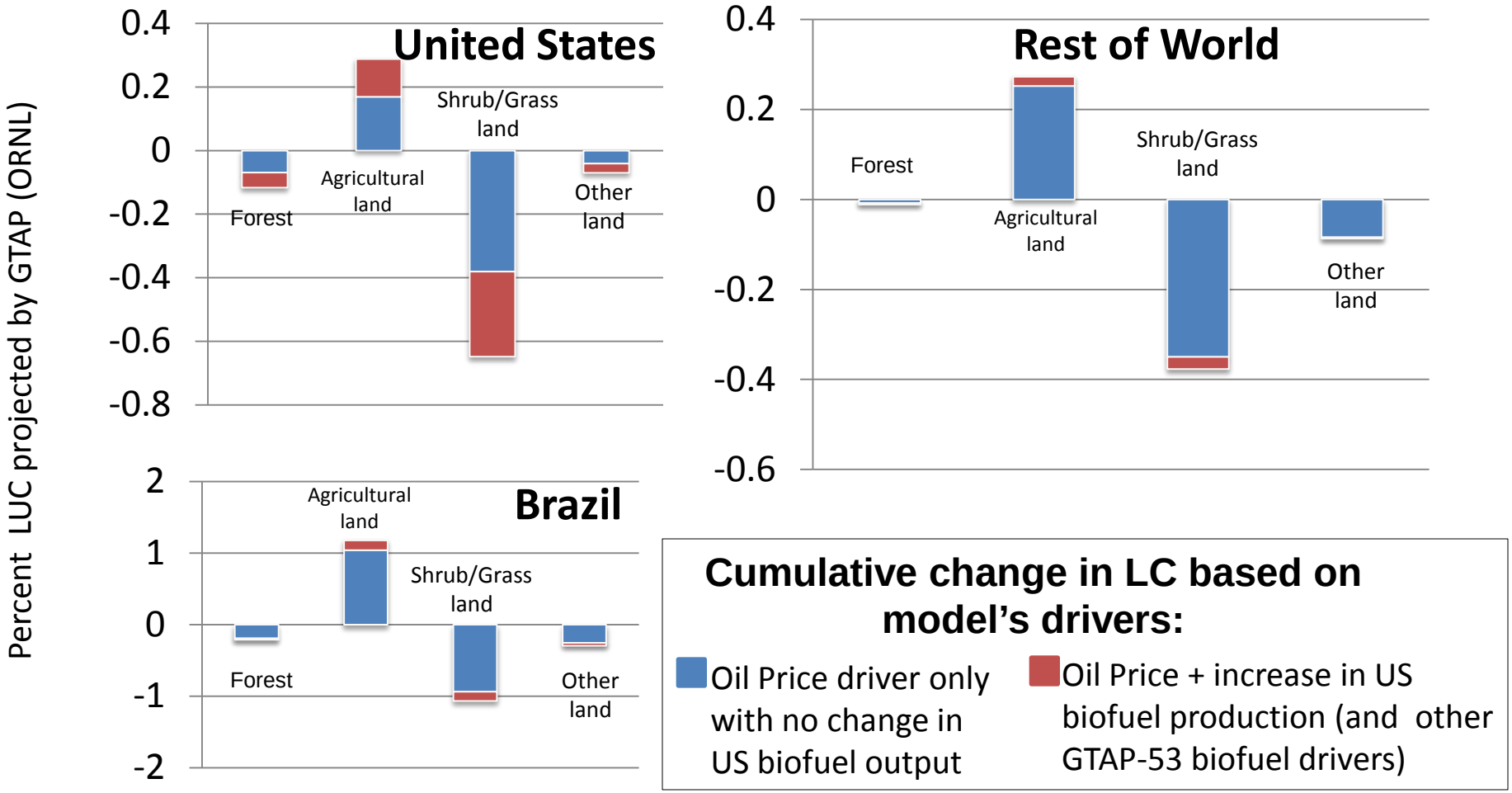
Why LUC is difficult for CGE Models

Economic Models	Empirical Evidence	Comment
Baseline = equilibrium state: all land assigned to use (crop, pasture) with fixed area. *All LUC driven by relative commodity prices.*	Baseline = land cover and use are in constant flux. *Drivers of initial conversion are distinct from later changes*	
Land is assumed to be in an optimal allocation.	Actual land use allocations are far from optimal.	
Land assets are private, owned, managed assets.	Most initial LUC occurs when tenure uncertain.	
Assumes no "excess" production, stocks, or losses.	Excess production and losses are normal (especially if price is low).	
Previously cleared but underutilized land is omitted as asset class.	Majority of available lands (previously cleared) are under-utilized or fallow in any given growing season.	

Why LUC is difficult for CGE Models

Economic Models	Empirical Evidence	Comment
Baseline = equilibrium state: all land assigned to use (crop, pasture) with fixed area. *All LUC driven by relative commodity prices.*	Baseline = land cover and use are in constant flux. *Drivers of initial conversion are distinct from later changes.*	Baseline assumptions determine results. *Local governance, policies, poverty, land claims, infrastructure - strong **initial** drivers (prices influence **what** to plant on land already cleared).*
Land is assumed to be in an optimal allocation.	Actual land use allocations are far from optimal.	Biofuel policy can accelerate shift toward more optimal use
Land assets are private, owned, managed assets.	Most initial LUC occurs when tenure uncertain.	Impossible to properly model initial conversion process
Assumes no "excess" production, stocks, or losses.	Excess production and losses are normal (especially if price is low).	Bioenergy incentives for more efficient use of resources, fewer "losses"
Previously cleared but underutilized land is omitted as asset class.	Majority of available lands (previously cleared) are under-utilized or fallow in any given growing season.	Models based on better data for available land assets and classes will have totally different LUC results.

High model uncertainty due to structure, assumptions and initial conditions



- **LUC due to oil price driver alone ~90% of total change**
- **Most LUC associated with US biofuels occurs in the US**

Derived from Oladosu and Kline (in review)

Of Models and Science

"Science is the pursuit of knowledge and understanding of the natural and social world following a *systematic methodology based on evidence*."

-Britain's Science Council http://www.sciencecouncil.org/

Questions regarding LUC and bioenergy (to consider for science-based research agenda)

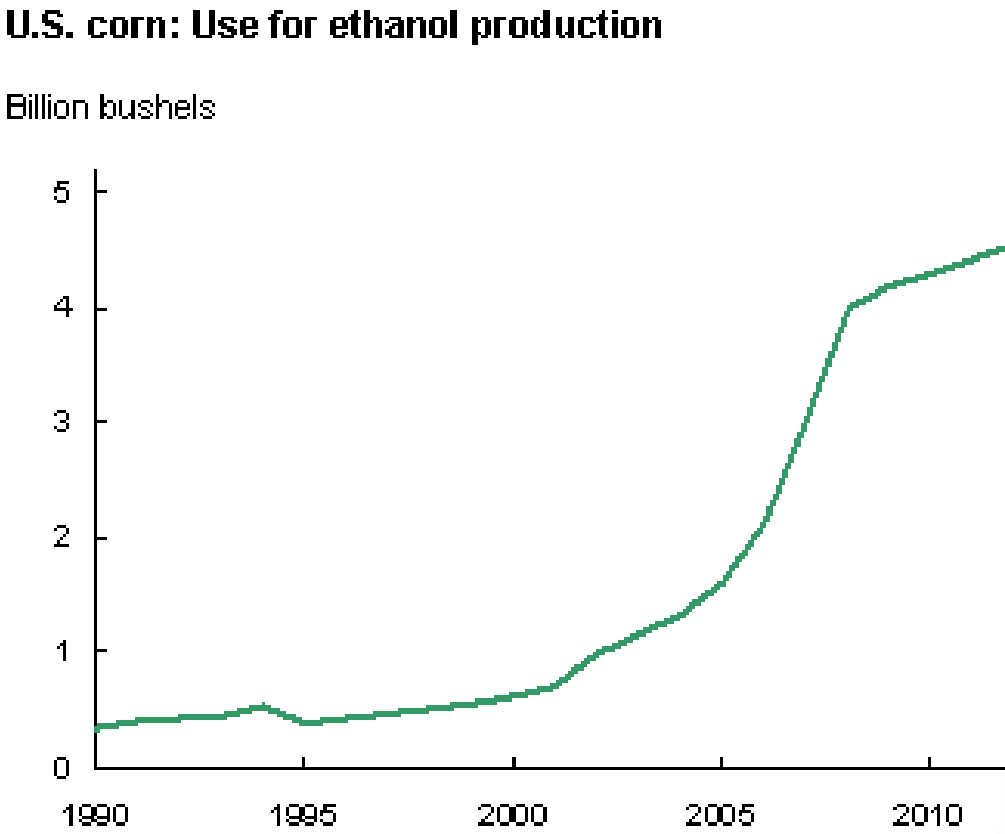
- Causality
  - How do bioenergy policies & projects affect landscapes?
  - What scientific approaches can be applied to gauge factor-specific attributions?
  - Gathering empirical evidence: what are LUC patterns in absence of biofuel policies?
  - How do biofuels interact with key drivers of LUC (governance, etc.)?
  - How to build consensus on standard approaches and reference scenarios?

- Importance of boundaries and scale
  - Spatial
    - LUC occur due to local or regional pressures
    - Need understanding of pressures at global scale
  - Time: How did/will patterns vary over different temporal periods?

Trends and issues

Biofuels:

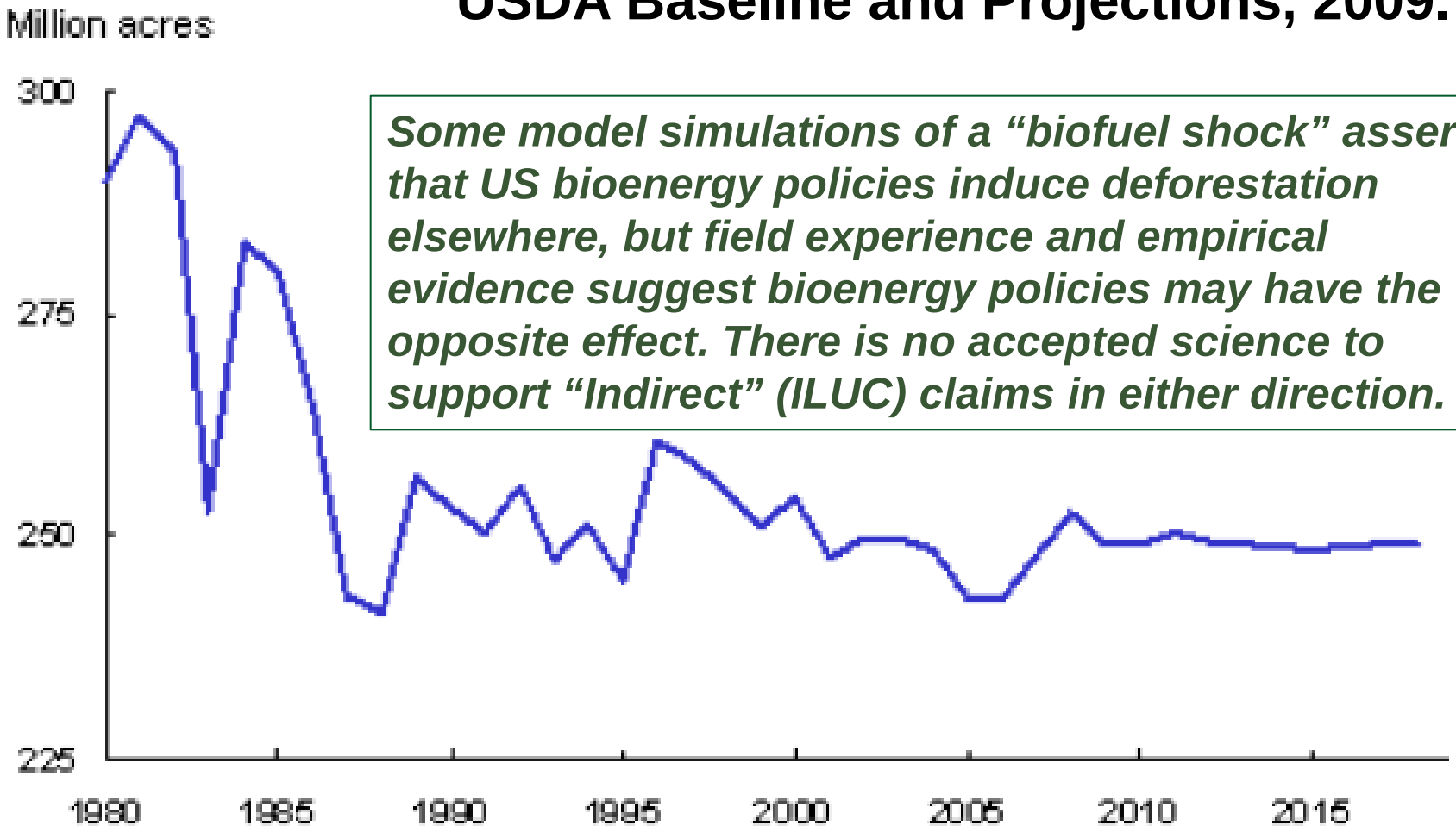
- Current US industry based on corn; sugarcane predominates production in rest of world
- Effect of market diversification for major globally traded, commodities
- "Next Generation" - cellulosic (wastes, crop residues, forestry/fuel thinning, dedicated energy crops…)



Source: *USDA Agricultural Projections to 2018*, February 2009. USDA, Economic Research Service.

U.S. planted area: Eight major crops 1/

USDA Baseline and Projections, 2009.



Some model simulations of a "biofuel shock" assert that US bioenergy policies induce deforestation elsewhere, but field experience and empirical evidence suggest bioenergy policies may have the opposite effect. There is no accepted science to support "Indirect" (ILUC) claims in either direction.

1/ The eight major crops are corn, sorghum, barley, oats, wheat, rice, upland cotton, and soybeans.

Source: *USDA Agricultural Projections to 2018*, February 2009. USDA, Economic Research Service.

Actual changes in US cropland 2001-2009

- Proportionally apply Searchinger's estimate ≈ 8.3 million ha. displaced for US ethanol with "sharp declines in soy, wheat…"
- Actual data - the opposite:
- Ethanol increased to >36 b liters/yr; soy & wheat rose while total cropland steady (fell slightly)

USDA NASS Area Planted USA data	% change	Planted Area Cha
Change from 2001 to 2009 in:	Percent	Hectares x 1000
USDA "Principal Crops"	-1.1%	-1,500
Losing acreage 2001-2009:		0
Cotton All	-42.6%	-2,718
Other Coarse Grains (not corn)	-28.1%	-2,491
Hay All (Dry)	-5.3%	-1,352
Oilseeds & peanuts exlcuding soy*	-28.5%	-748
Rice All	-9.5%	-128
Sugarcane + sugar beets	-14.3%	-139
Tobacco, potatoes, all others	-14.5%	-106
Gaining acreage 2001-2009:		0
All corn (grain + silage)	13.2%	4,369
Soybeans	4.9%	1,477
Edible beans, peas, lentils	50.0%	377
Wheat All	0.6%	139

Record thus far is consistent with BRDI projections.

Analysis of threats to tropical forests: poverty, corruption, lack of governance, insecurity

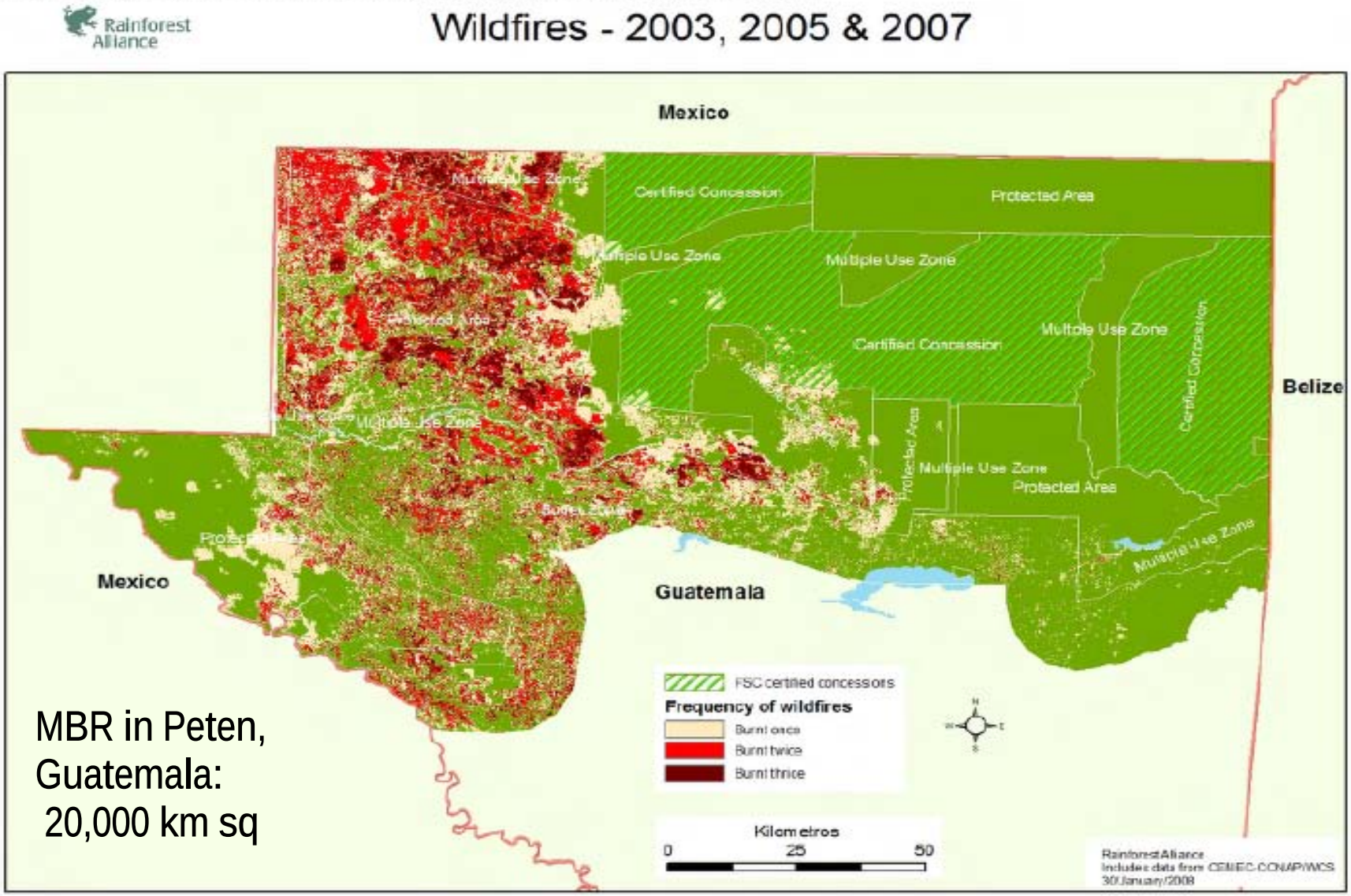
Solutions involve support for:

- **Sustainable rural livelihoods – improve prices for products (increase security, land practices that reduce fire)**
- **Improved land tenure**
- **Inventory & protect key conservation areas**
- **Improved governance, local participation & capacity, enforcement**
- **LU plans & management**

Source: USAID – FAA Sec. 118/119 Reports 2000-2008

Uncertainty in fossil fuel LUC
Example: Maya Biosphere Reserve - Deforestation and fire legacies of oil industry

Map 4. Frequency of wildfires for 2003, 2005 and 2007 fire seasons in the MBR.

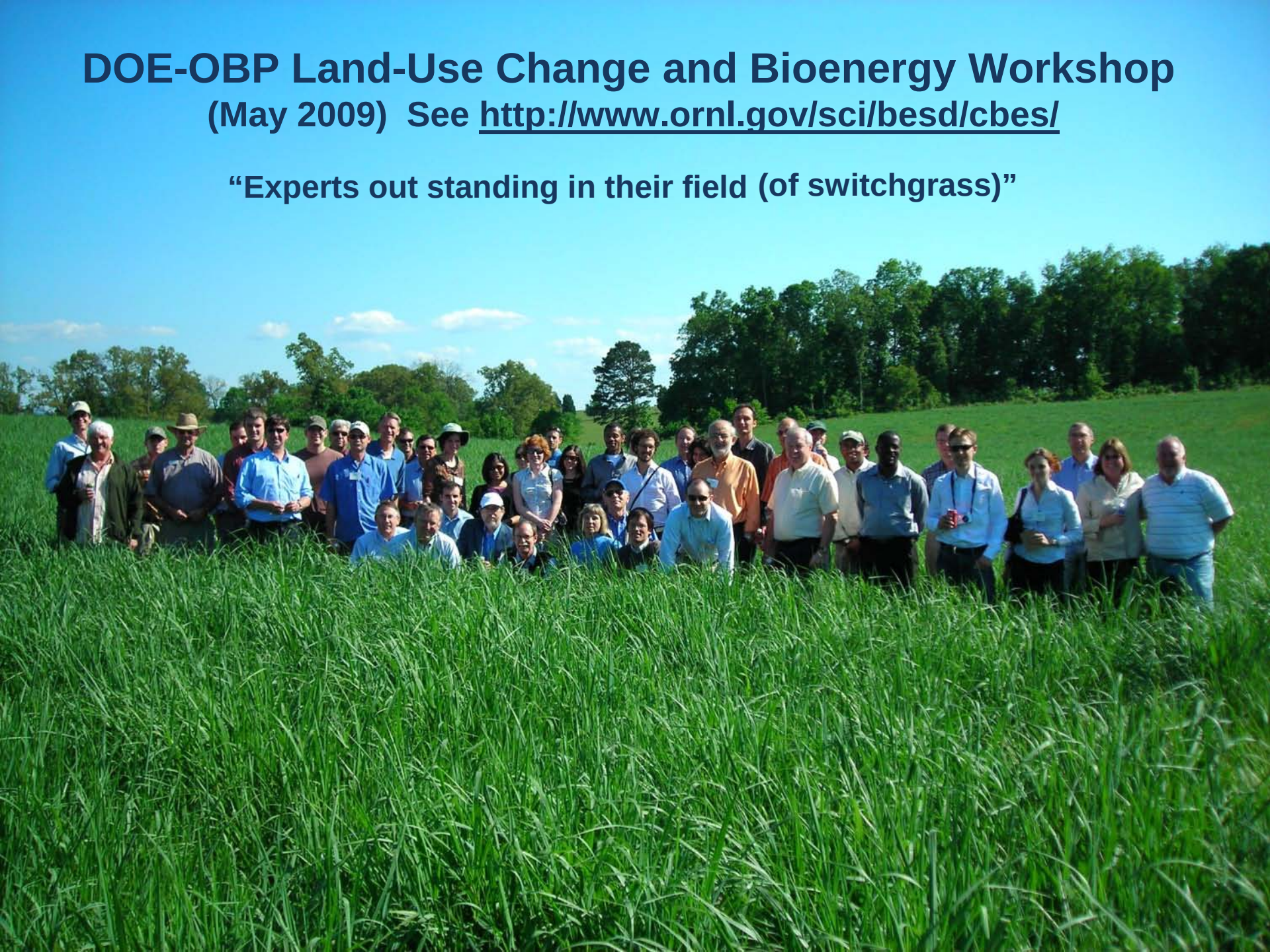


MBR in Peten, Guatemala:
20,000 km sq

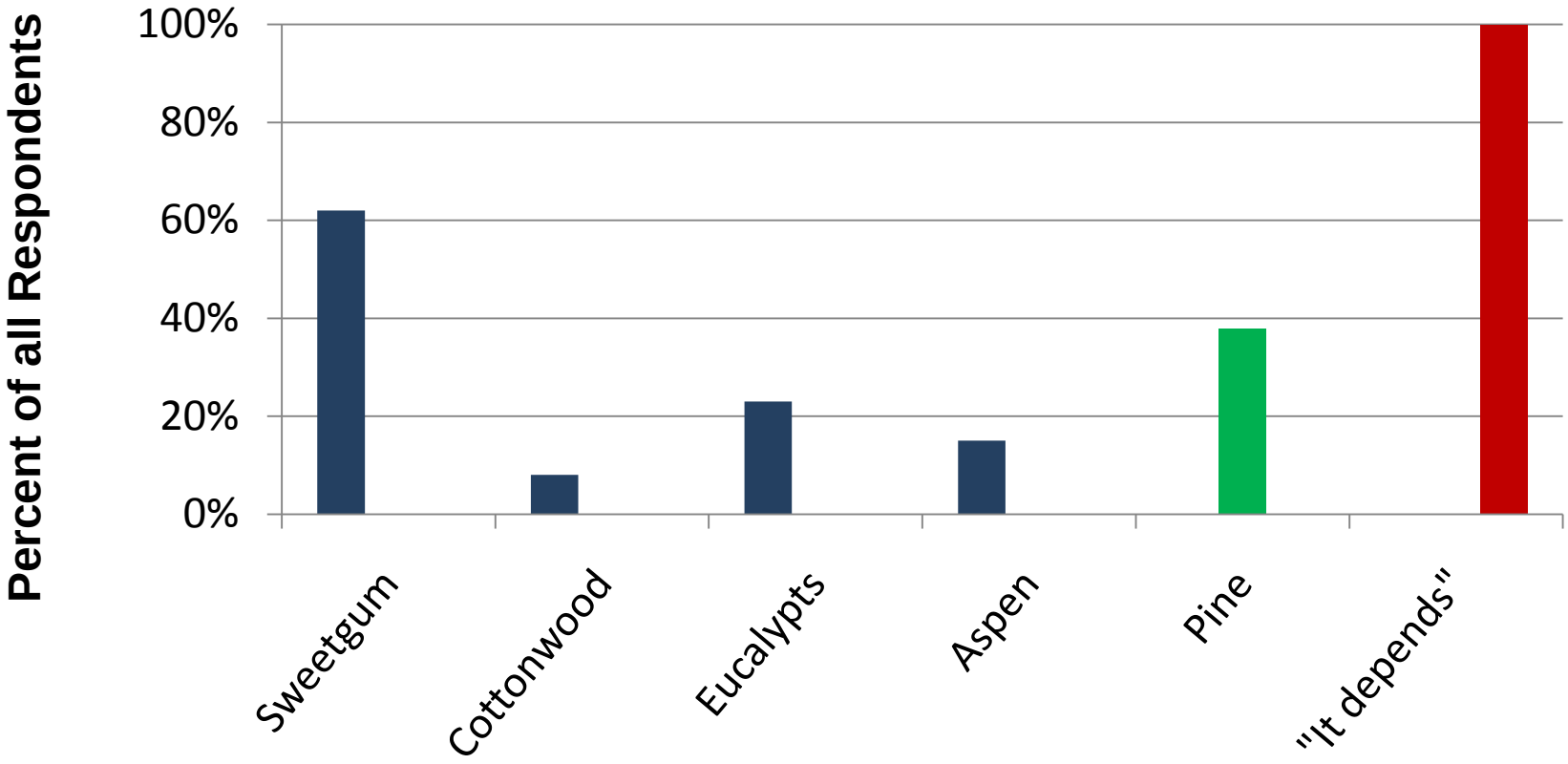
DOE-OBP Land-Use Change and Bioenergy Workshop

(May 2009) See http://www.ornl.gov/sci/besd/cbes/

"Experts out standing in their field (of switchgrass)"



Responses to "What is best hardwood species for biomass in Southeast?"



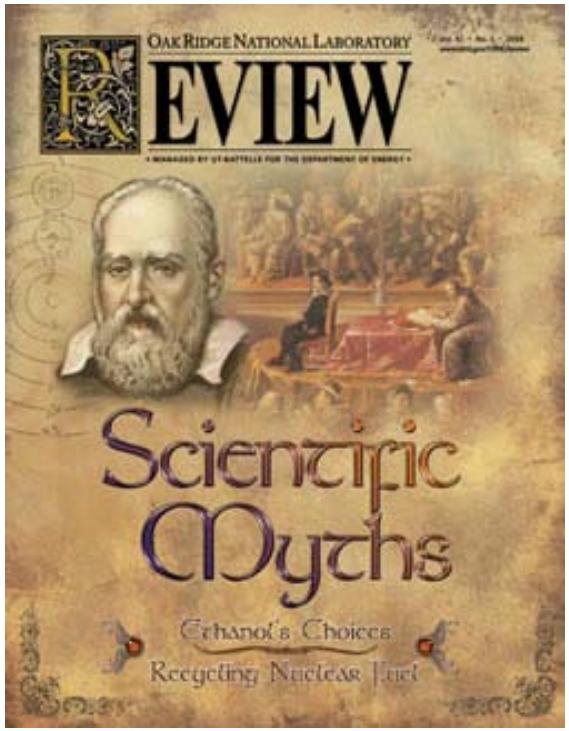
Kline,K.L., Coleman, M.D., 2010. Woody Energy Crops in the Southeastern United States: Two Centuries of Practitioner Experience. *Biomass and Bioenergy [in press]*.

Precautionary Principle - details

Rio Declaration of 1992, Principle 15: “In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall be not used as a reason for postponing cost-effective measures to prevent environmental degradation.”

Precautionary Principle

- **Do No Harm**
- **Precautionary - most relevant for potentially irreversible actions, loss of life, biodiversity, health at risk.**



Thank you!

Acknowledgements: This research was supported by the U.S. Department of Energy (DOE) under the Office of the Biomass Program.

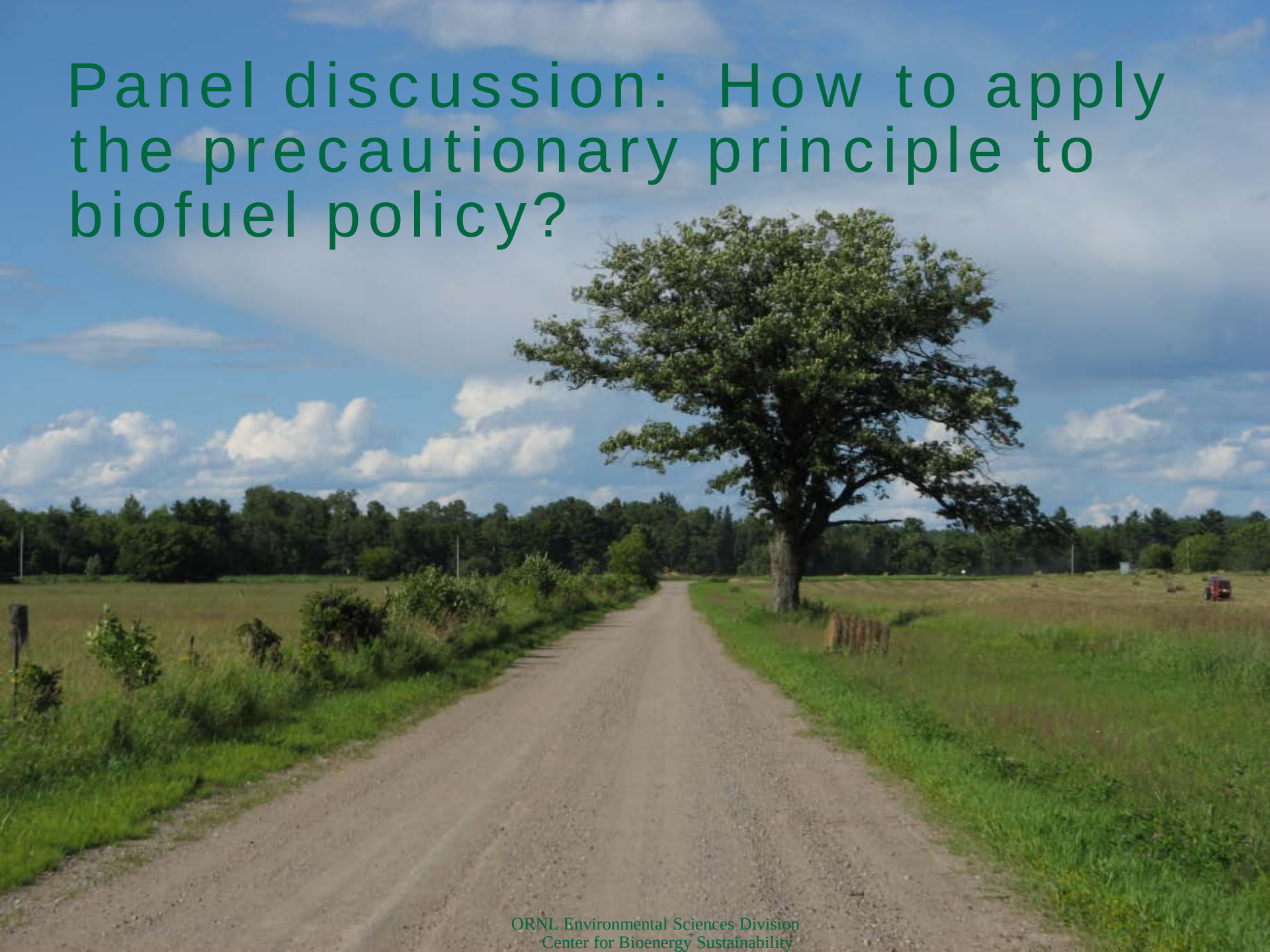
Oak Ridge National Laboratory is managed by the UT-Battelle, LLC, for DOE under contract DE-AC05-00OR22725.

Photo Credits: Virginia Dale, ORNL (fieldwork in Brazil)

Contact information: Keith L Kline klinekl@ornl.gov, Gbadebo Oladosu oladosuga@ornl.gov, Virginia Dale dalevh@ornl.gov

The views in this presentation are those of the authors and not necessarily those of ORNL or DOE.

Panel discussion: How to apply the precautionary principle to biofuel policy?



Some Information Resources

- ORNL Center for Bioenergy Sustainability: http://www.ornl.gov/sci/besd/cbes/
- DOE Biomass and Biofuels Program: www.eere.energy.gov/biomass/
- 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/
- 2009 DOE-OBP Peer Reviews (see Feedstock Platform, Review Presentations: http://www.obpreview2009.govtools.us/