The Global Sustainable Bioenergy Project (GSB): Reconciling land use for bioenergy production with social and environmental concerns

Presented by Keith Kline on behalf of the GSB Project

for the

American Institute of Chemical Engineers

Knoxville-Oak Ridge Section

November 18, 2010

Overview

- Excerpts from GSB convention web sites:
  - Rationale and motivation behind GSB
  - Goal, progress to date, plans
  - Opportunities for participation and collaboration
  - Discussion – How to promote collaboration on LU potential?
- More information and full presentations from conventions:
  http://engineering.dartmouth.edu/gsbproject/index.html

Slide credits to Lee Lynd and GSB Committee (next slide)

Global Sustainable Bioenergy Project

"Gracefully Reconciling Large-Scale Bioenergy Production With Competing Demands"

Acknowledgements - GSB slides: Lee Rybeck Lynd, Thayer School of Engineering, Dartmouth College and Mascoma Corp.; **Tom L. Richard**, Pennsylvania State University; and other GSB organizing committee members and contributors including: Carlos Enrique de Brito Cruz, FAPESP, Sao Paulo, Brazil; Andre Faaij, Copernicus Institute, Utrecht University, Netherlands; Jon Foley and John Sheehan, University of Minnesota; Jose Goldemberg, University of Sao Paulo, Brazil; Nathanael Greene, Natural Resources Defense Council; Mark Laser, Dartmouth; Reinhold Mann, Brookhaven National Lab; Ramlan Aziz, Universiti Teknologi Malaysia; Patricia Osseweijer, Delft University of Technology, Netherlands; August Temu and Miyuki Iiyama, World Agro-forestry Centre, Nairobi; Emile van Zyl and Annie Chimphango, University of Stellenbosch, South Africa; Jeremy Woods, Imperial College, London…



Rationale:

Where we stand in history…

Society has gone through major transformations in past; today there are indications that a third transformation is required:

	Agricultural Revolution		Industrial Revolution		**Sustainability Revolution**	
Hunting & Gathering	→	**Preindustrial Agricultural**	→	**Presustainable Industrial**	→	**Sustainable Industrial**
	~ 4000 BC		1750 AD		**Today…?**	

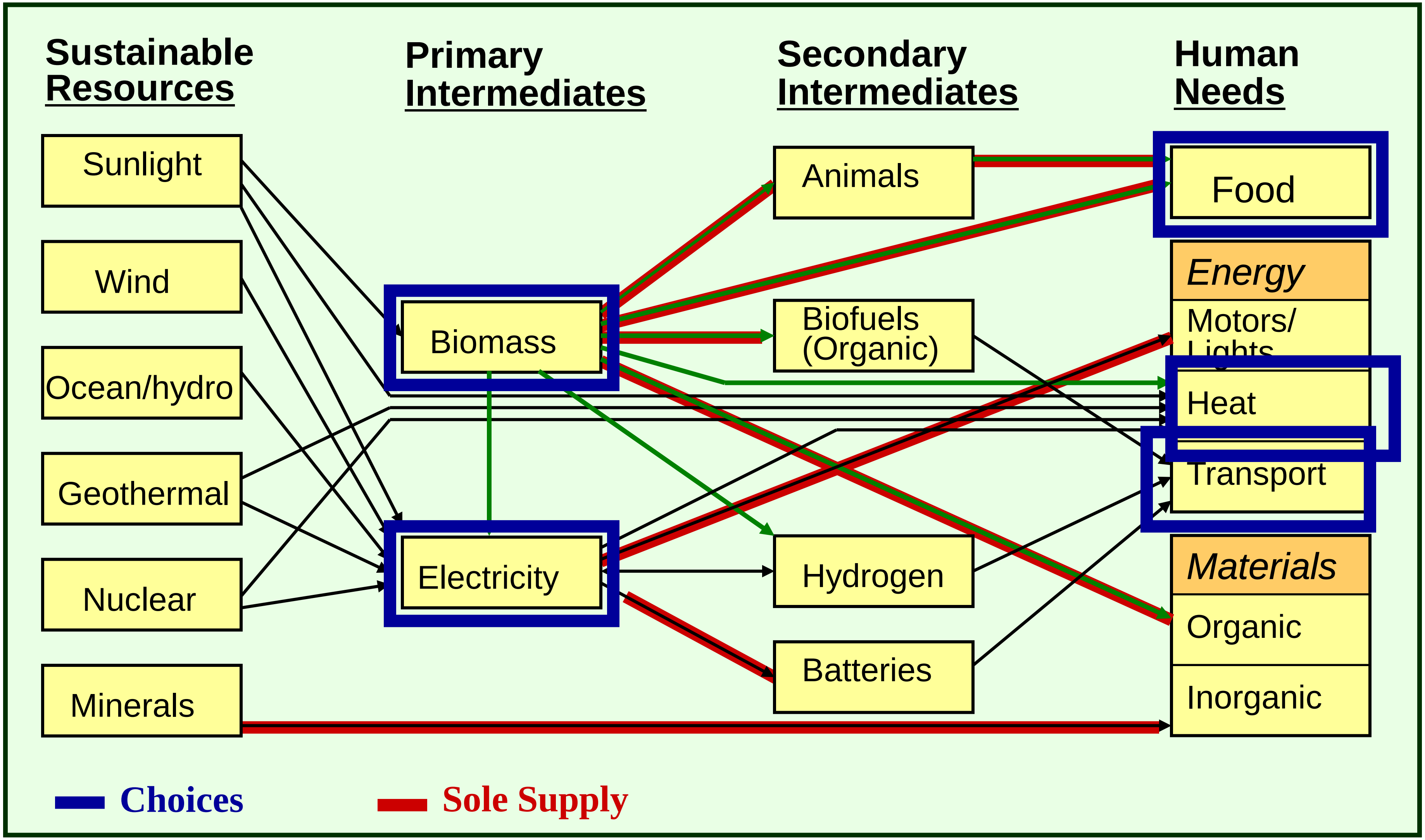
Population:	50 million	750 million	**~7 billion**
Duration:	Millennia	Several centuries	**< a century?**
Scale of societal integration/ failure:	Small groups	Farms/ villages	Cities/countries	**Global**

The sustainability revolution: More people, less time, higher risk

***** The defining challenge of our time *****

Lynd, Bioenergy: In Search of Clarity, Submitted.

Imagining a More Sustainable World



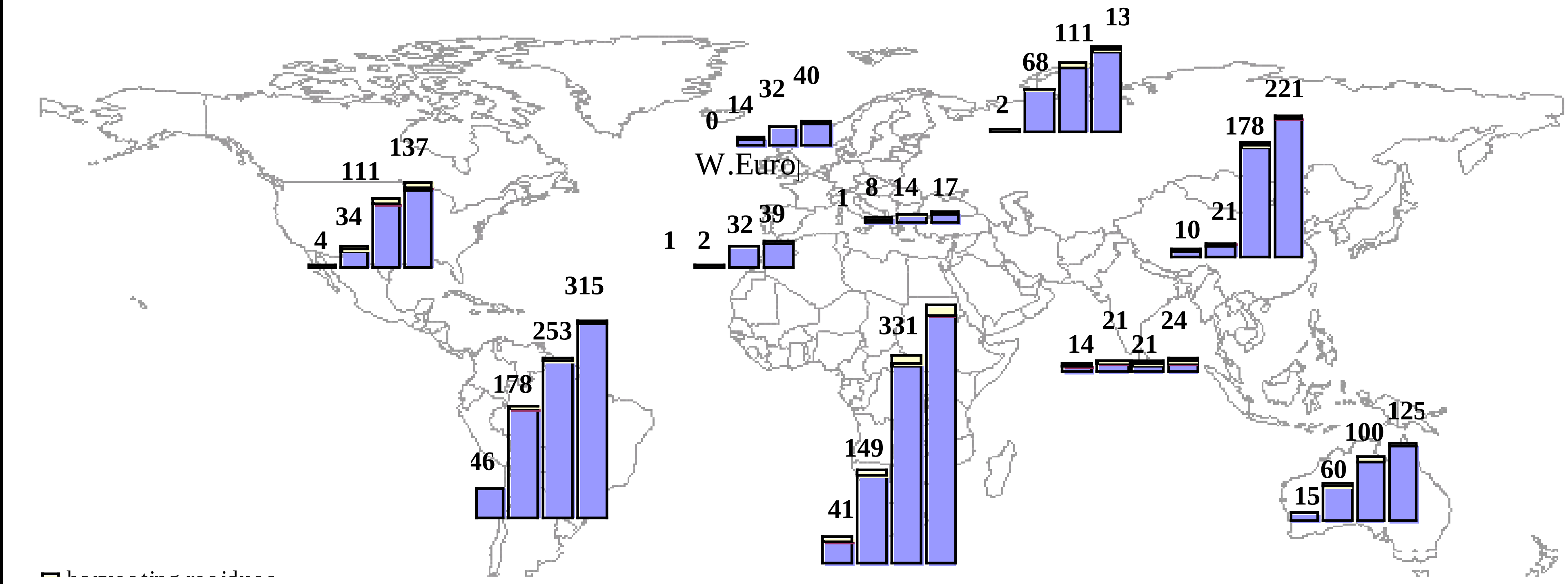
Biomass

Central and essential role in a sustainable world

The only foreseeable sustainable source of food, organic fuels, and organic materials

Global Bioenergy Potential

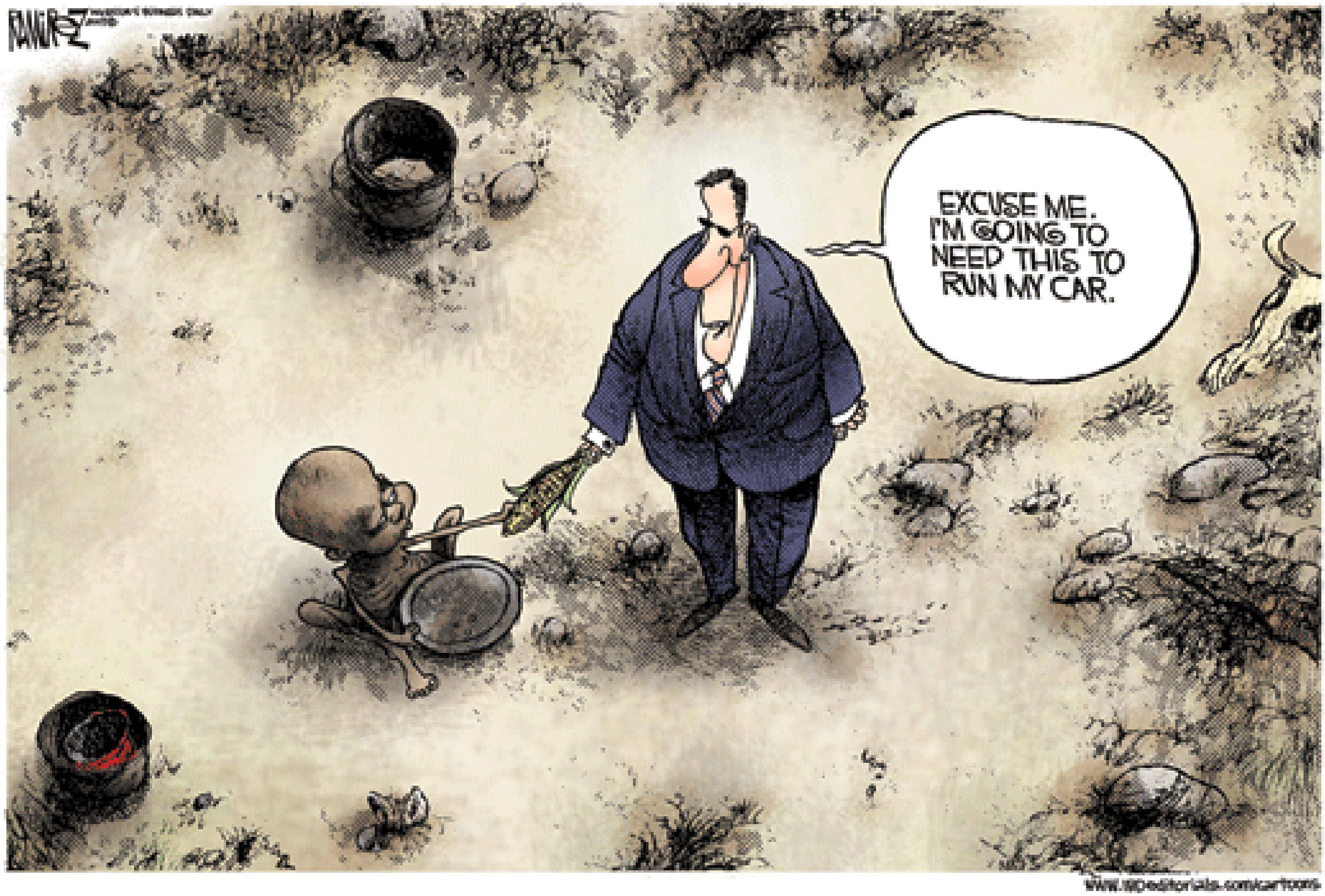
Bioenergy Production Potential in 2050 for Different Levels of Change in Agriculture and Trade (Smeets, Faaij, 2004)



Would biofuel production necessarily compete for scarce land resources, food security and environmental services?

Strong, widely popularized negative assessments

"[I]t's a crime against humanity to convert agricultural productive soil into soil… which will be burned for biofuel." (Jean Ziegler, UN Special Rapporteur, 2007)



How does bioenergy production affect food security?

Bioenergy, Food Security and Poverty

Rather than a threat, could development of biofuels be part of the solution to pressing food security and poverty alleviation challenges?

Potentially yes, more likely/extensively with 2nd generation feedstocks

Challenging, relatively underexplored, first step is to show it is possible

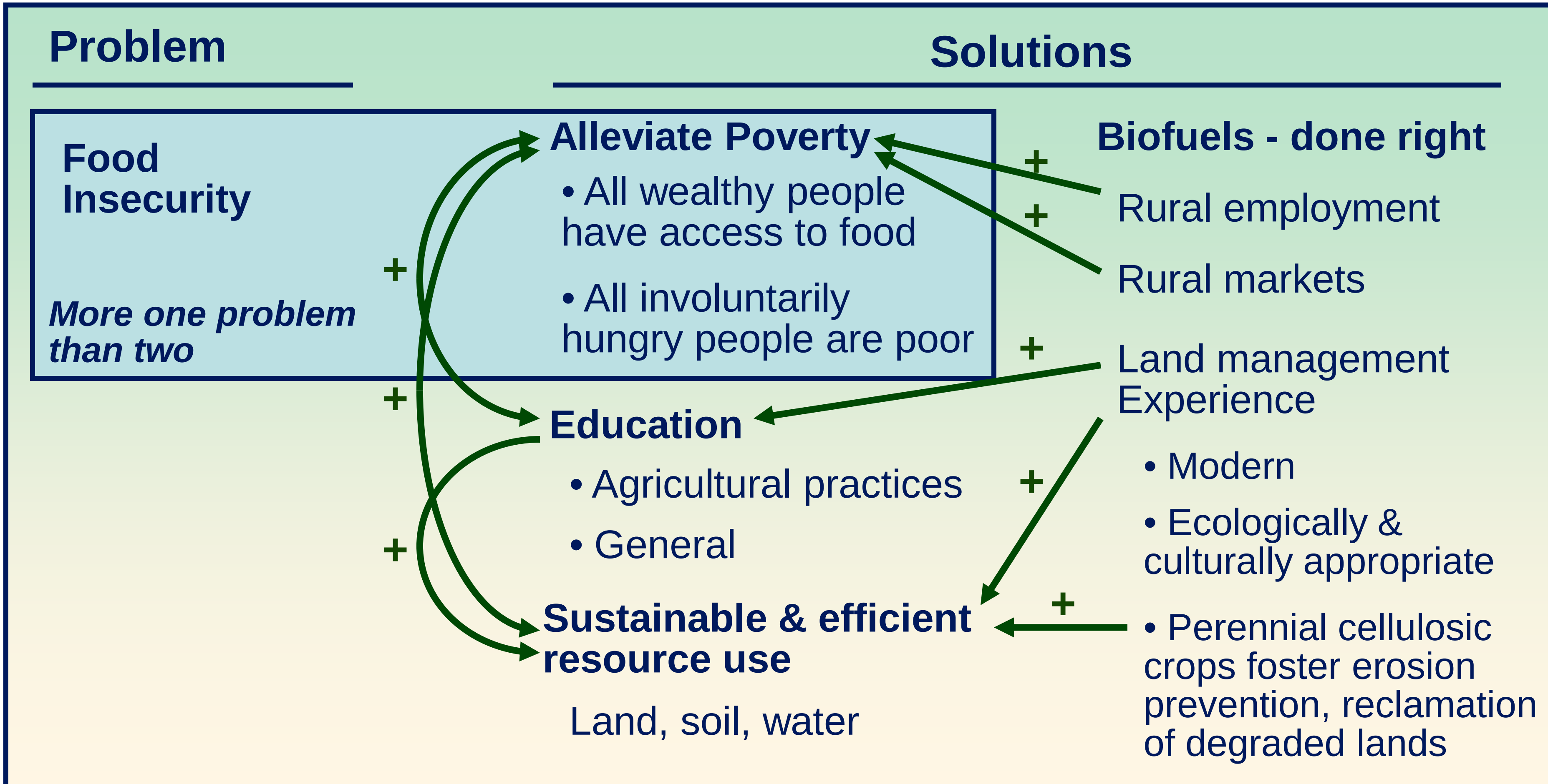
Problem	Solutions
Food Insecurity	**Alleviate Poverty** • All wealthy people have access to food • All hungry people are poor

Bioenergy, food security and poverty

Could biofuel development be part of the solution to pressing food security and poverty alleviation challenges?

Potentially yes, more likely/extensively with 2nd generation technologies

Relatively underexplored



Bioenergy and food security – another perspective

Factors Contributing to Food Insecurity*

Food Security Impact of Biofuel Production

Cellulosic Crops

Food crops | Cropland | Non-cropland

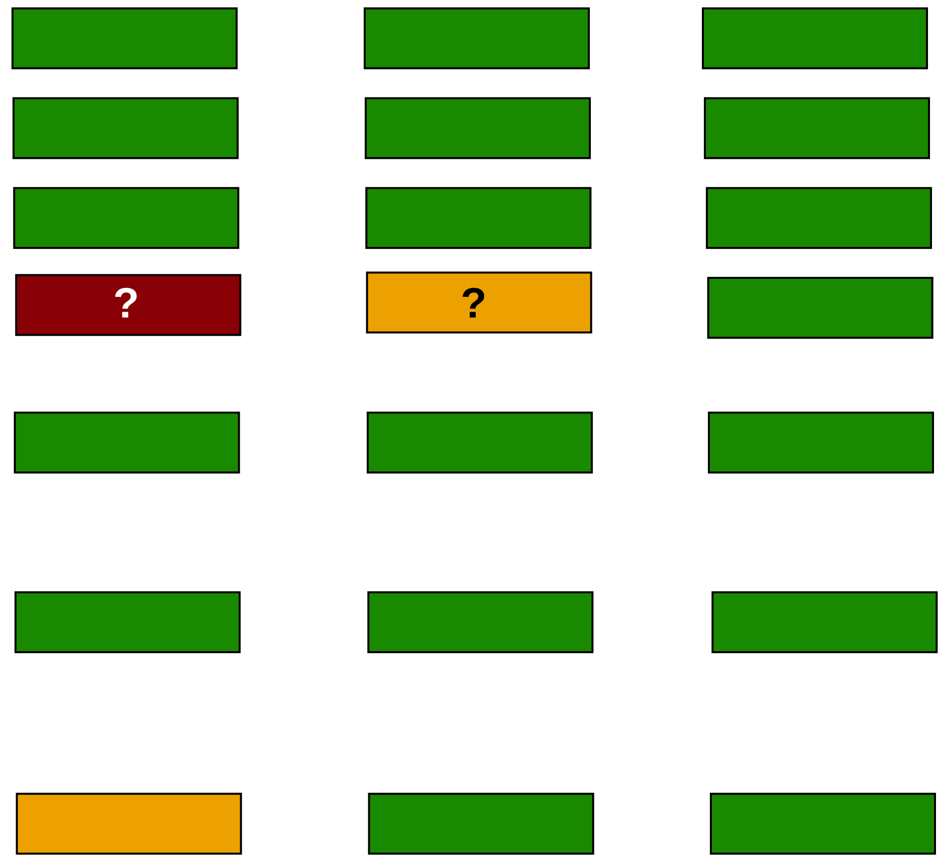
Poverty

- Rural unemployment
- Lack of marketable skills
- Low currency value
- High food prices

Local production undermined by foreign Subsidies, market failures

Poorly developed ag. infrastructure (Physical, market, know how)

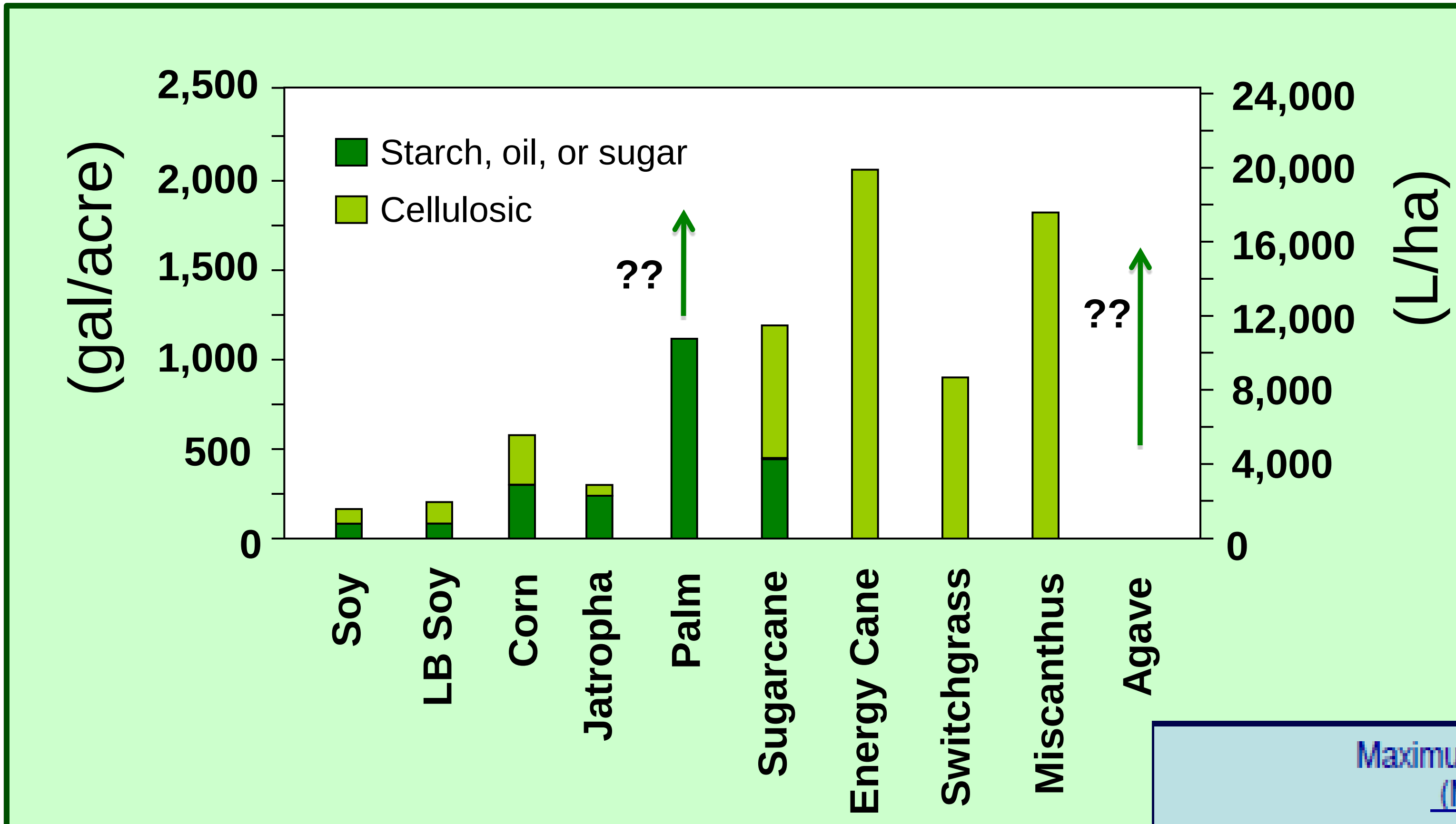
Degraded land



"… bioenergy is not only compatible with food production; it can also greatly benefit agriculture in Africa" -Dr. Rocio Diaz-Chavez, 2010.

* Thurow, R, S. Kilman. Enough: Why the World's Poor Starve in an Age of Plenty. 2009. Public Affairs.

Comparative Land Productivity of Bioenergy Feedstocks



	Maximum Productivity (Mg/ha)
C_4 perennials	70
C_3 perennials	40
Most annual crops	< 20

Nobel et al., 1992

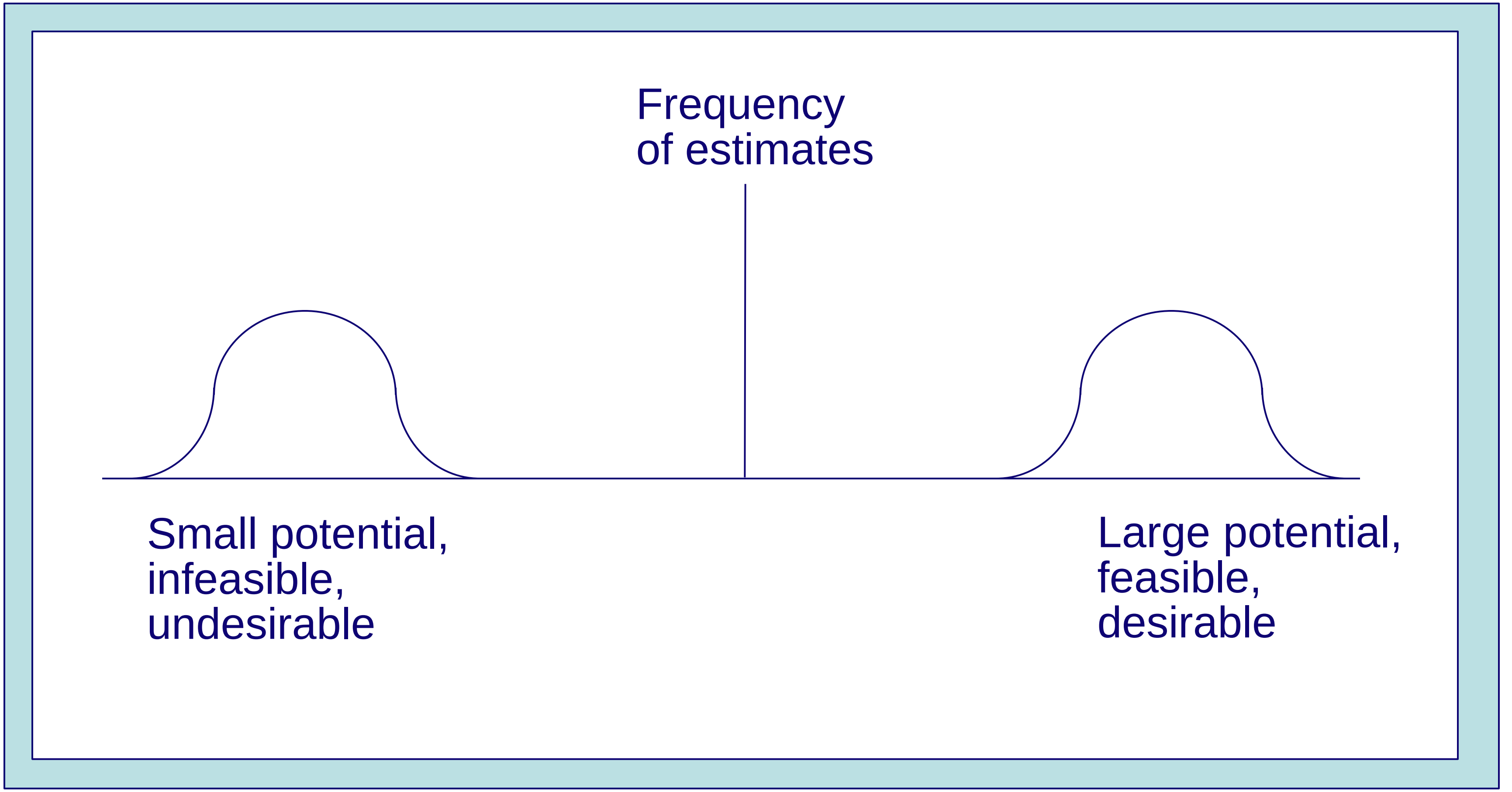
Acknowledging uncertainties & simplifications in single-valued representations, robust conclusions about land-efficient biofuel production can be drawn:

a) **Harvest as much of the plant as sustainable land management permits**

b) Grow plants with compositions optimized for photosynthesis and end uses, rather than merely accumulation of sugar, starch, or oil **(if dedicated to bioenergy)**

Sharply-Divergent Assessments of Bioenergy

Rather than clustering about a mean, estimates for the potential energy contribution of biomass exhibit a bimodal distribution with most such estimates envisioning a very small or very large energy supply role for this resource[1]



[1]Lynd et al. in Sovacol and Brown (eds.) Energy and American Society. Thirteen Energy Myths. Springer. 2007.

Sharply-Divergent Assessments of Bioenergy have Consequences:

Policy makers are understandably confused

Absence of clear understanding leads to uncertainty with respect to -

- Feasibility and desirability of a sustainable bioenergy-intensive future
- What should such a future look like?
- What should be done to realize it?
- How to get incentives right for sustainability?

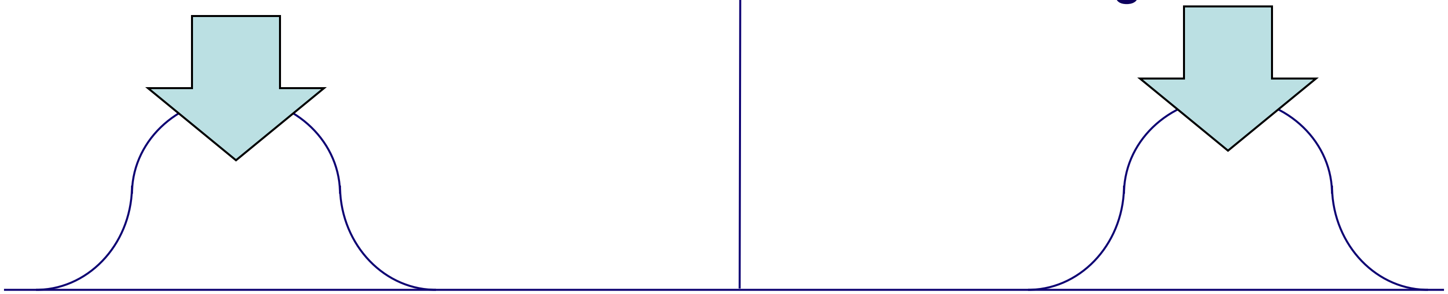
Clear, consistent, coherent support is difficult to motivate

This is an unacceptable state of affairs in light of the urgency of the challenges inherent in the sustainability revolution

Sharply-Divergent Assessments: Reconciliation?

What are the impacts of adding large-scale use of today's biofuels to a world based on extrapolating current practices?

What role could biofuels play in a world reconfigured to more sustainably meet energy, food and other challenges?



Small potential, infeasible, undesirable

Large potential, feasible, desirable

Focus

What we can't do. (Impossible to achieve a sustainable and secure future by extrapolating an unsustainable and insecure present)

Identify what we could do

Biggest limitation

Does not illuminate solutions

Requires a vision - not consistent with current reality

It may be more productive and accurate to view divergent assessments of bioenergy as answers to different questions rather than irreconcilable answers to the same question. Decision-makers need guidance…

Exploring feasibility & implementation paths for global sustainable bioenergy: the "GSB Project"

"Project" initiated (June, 2009)

- International organizing committee
- Joint statement in *Issues in Science and Technology* *(letter supporting ORNL paper, "Biofuels Done Right")*
- 2010 – web sites launched; five continental conventions held…

Test a working hypothesis:

It is possible to gracefully reconcile large-scale bioenergy production ($\geq$ 25% of global mobility or equivalent) with:

- feeding humanity
- meeting other needs from managed lands
- preserving wildlife habitat and environmental quality

GSB Project focus: *"most comprehensive, forward-looking analysis to date"*

Land / Resource issues – a more definitive answer to the physical possibility of producing bioenergy on much larger scales consistent with the GSB working hypothesis

Analysis addressing not only **if** the working hypothesis can be confirmed, but also **how** – anticipating that there may be multiple paths

Consideration of **transition paths** and policy informed by global analysis

The GSB Project is not focused on:

Processing technology (although it will enter analysis, it is done by others)

Advocacy

Dimensions of Innovation & Change Impacting Biofuel Feedstock Availability = Research Areas

1. Integrate feedstock production into available lands (better characterize opportunities)

- Double crops
- Coproduce feed and feedstocks - e.g. early-cut grass in lieu of soy, perhaps other strategies
- Increase yields from pasture and range (improve management), and selected CRP land
- Improve planning and sustainable production systems (new crop rotations)
- Develop crop varieties with increased residue yields
- Sustainably harvest forest residues and thinnings
- Document environmental services (reclaim and stabilize abandoned, eroding, degraded lands)

2. Produce food more land-efficiently

- Change animal feeding practices, e.g. pasture intensification, forage pretreatment, leaf protein, alternative animal feed rations
- Increase crop productivity/yields (feed/fodder)

3. Change diet

- Amount & kind of animal products

4. Mature biomass production

- High productivity/ low inputs
- Broad site range (water-efficient suitable for semi-arid areas)
- High digestibility

5. Mature conversion technology

Bioenergy is only one of many components needed for a more sustainable future. Reduce, reuse and recycle – energy efficiency and conservation – are at the top of the list.

Next steps include research on priority bioenergy land efficiency levers – opportunities for collaborations:

- **GSB Project** – Contact Lee Lynd or other project participants (slide 3) Lee.R.Lynd@Dartmouth.edu
- **Land availability**: previously disturbed and underutilized land, land reclamation; regional and national estimates of available areas and yield gaps – Contact Keith Kline klinekl@ornl.gov
- **Double crops** – field based experiments and estimates of larger scale effects and importance. Contact Tom Richard, Penn State University tlr20@engr.psu.edu
- **Water and ecosystem effects:** evaluate bioenergy crops at watershed scale (eco-system services with minimum measurements for water and soils). Contact Esther Parish, CBES parishes@ornl.gov

Big systemic challenges – paths to a more sustainable world – require big systemic solutions and cooperation in many small steps to get there. Your participation is welcome!

Thank you!

Acknowledgements

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Center for Bioenergy Sustainability http://www.ornl.gov/sci/besd/cbes

Selected References/Sources

- Note: Materials presented are based on multiple presentations from five GSB continental conventions in 2010. See the GSB web site for links to each convention, full presentations, reports and references: http://engineering.dartmouth.edu/gsbproject/index.html
- Related information and references are also available at ORNL Center for Bioenergy Sustainability web site: http://www.ornl.gov/sci/besd/cbes
- Other references and background material of interest:

- Pete Smith, Peter J. Gregory, Detlef van Vuuren, Michael Obersteiner, Petr Havlík, Mark Rounsevell, Jeremy Woods, Elke Stehfest, andJessica Bellarby. **Competition for land.** Phil. Trans. R. Soc. B September 27, 2010 365:2941-2957; doi:10.1098/rstb.2010.0127. http://rstb.royalsocietypublishing.org/content/365/1554.toc
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- Grainger A., 2010: The bigger picture - tropical forest change in context, concept and practice. In Nagendra H. and Southworth J. eds.. Reforesting Landscapes, Linking Pattern and Process. Springer, Berlin, 15-43
- Biomass Research & Development Initiative (BRDI) http://www.brdisolutions.com

Sustainable Bioenergy Vision

Responsive to most pressing needs

- Poverty alleviation/economic development
- Food security and other ecosystem services

GSB analyses at multiple scales

Local Understanding

- Needs & aspirations
- Regional diversity
- Constraints
- Opportunities

Different circumstances may require different answers

Understanding of Bioenergy

- Feedstocks
- Conversion systems
- New technology

The potential with new technology & feedstocks is more expansive than with current technology only

Some conclusions (from a presentation by B.Dale et al. the GSB North American Convention, Sept. 2010)

- Large-scale biofuel production is possible by improving productivity on existing lands without disrupting food production or provoking indirect land use change (ILUC)
- Double crops, animal feed ration adjustments, and yields are three major “levers” to increase bioenergy production along with environmental benefits
- Effective “levers” create opportunities for productive collaborations between farmers, bioenergy producers, government agencies & environmental interests
  (US, China, elsewhere)
- **GSB Seeks Collaborators**

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

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

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

Oak Ridge National Laboratory

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

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 esti… land-use change, we found that corn-based ethanol, instead of produ… 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

…n February 28, 2008

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

fluorescence of an antibody-fluorescein complex is efficiently quenched by rapid electron transfer from either a coplanar tryptophan or tyrosine to singlet excited fluorescein (21). We conclude that the very bright blue luminescence of EP2-19G2-1 is attributable to electron-hole recombination of the Tyr… charge-transfer excited state held in the rigid EP2-19G2 matrix that disfavors nonradiative decay.

Protein luminescence (22) only rarely (if ever) occurs by electron-hole recombination in a charge-transfer excited state embedded in a polypeptide matrix. The distinctive photophysical properties of the antibody-stilbene complex have already been exploited in chiral sensing for high-throughput screening for the evaluation of catalysts in asymmetric synthesis (23, 24), sensing mercury (25), DNA hybridization assays (26, 27), and for analysis of accessible cysteine residues on viral surfaces (28). The programmed generation of antibodies against other chromophores may yield novel protein-ligand systems with similar charge recombination-induced lumi-

Land Clearing and the Biofuel Carbon Debt

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

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 palms. As a result, land in undisturbed ecosystems, especially in the Americas 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,

Down…

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

Slide credit: John Sheehan, University of Minnesota

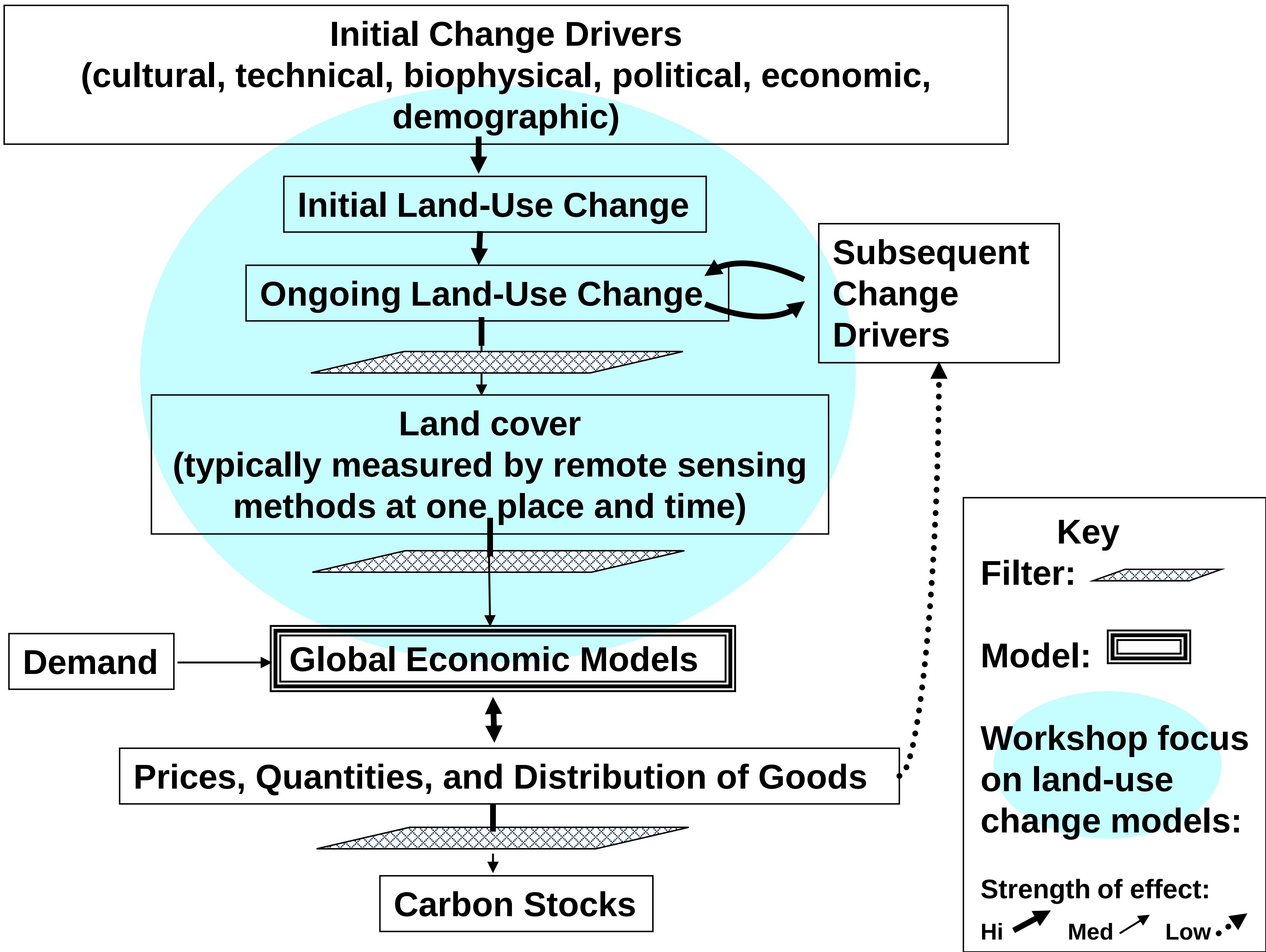
Land-Use Change (LUC) underlies popular biofuel concerns

- **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

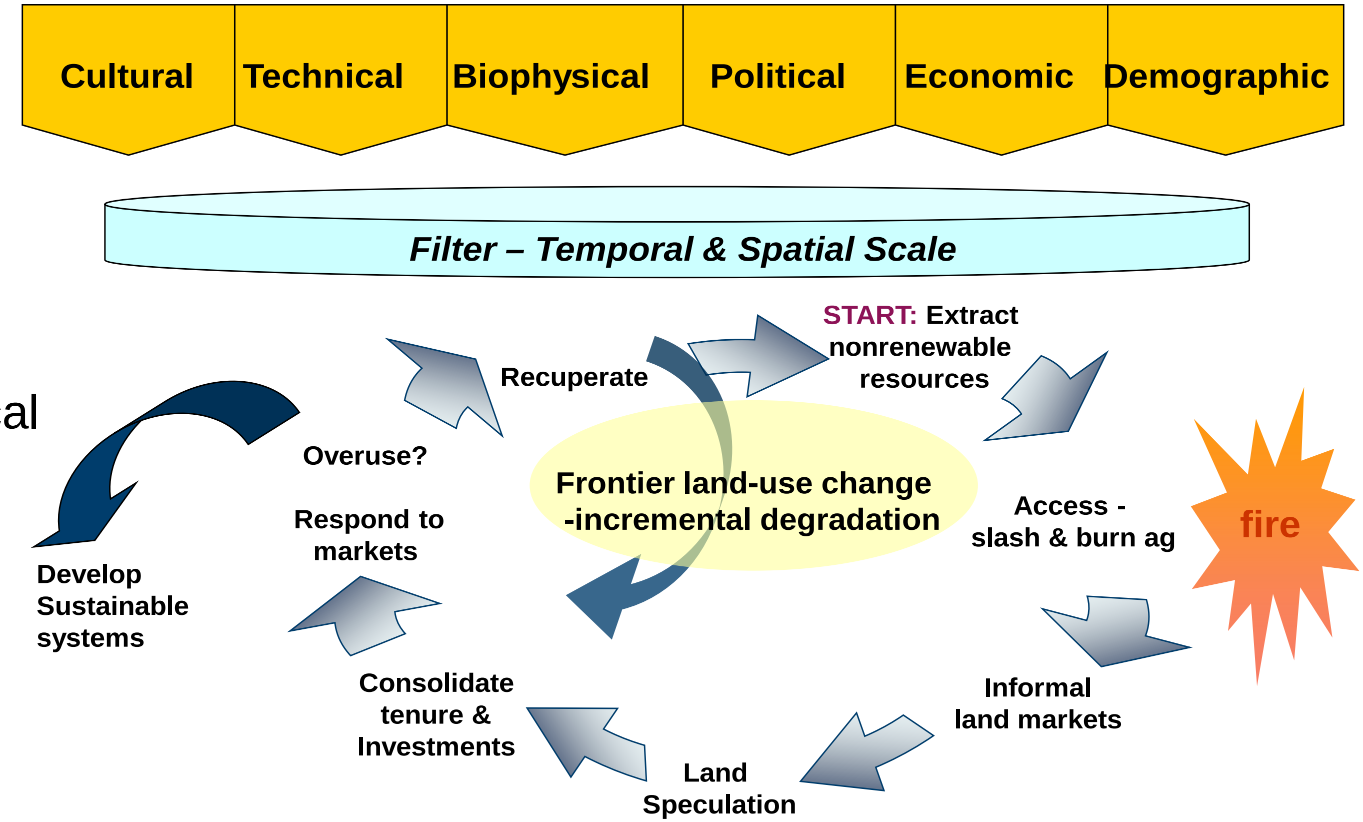
- **Simulations estimate changes driven by relative prices**
  - **Model typically has land <u>cover</u> categories: Cropland, Pasture, Forests**
  - **Missing key land asset classes**
  - **Huge variations occurs within classes**
  - **At what point do "transitions" occur?**
- **Priority: "high conservation 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.		

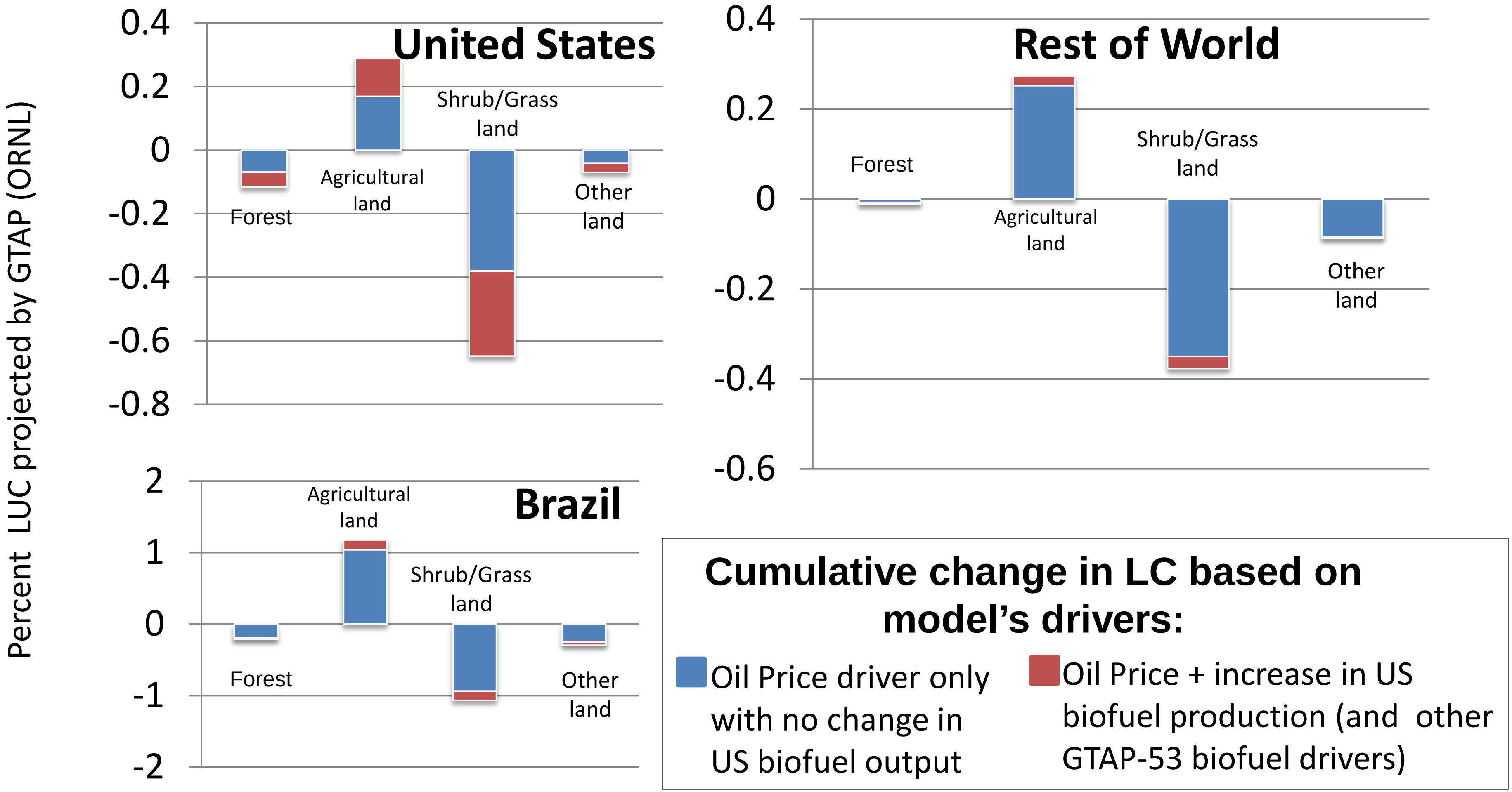
Why LUC is difficult for CGE Models

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)

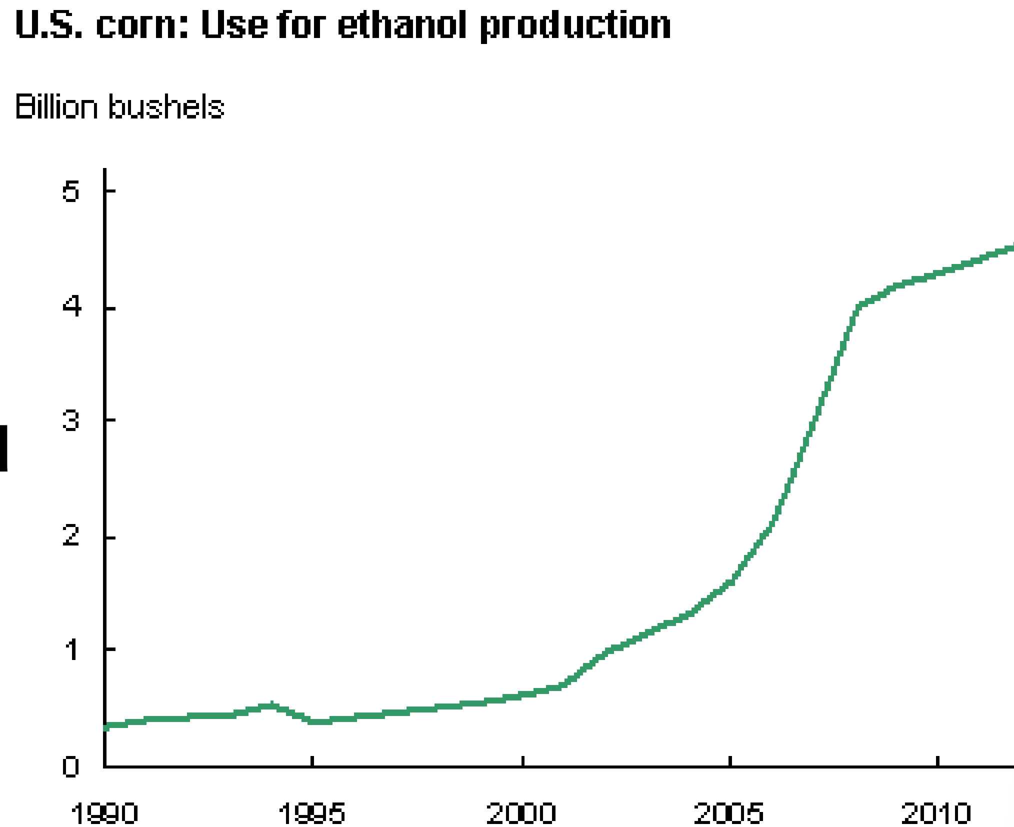
- Causality
  - How do bioenergy policies & projects affect landscapes?
  - What scientific approaches can be applied to gauge factor-specific attributions?
  - Gathering empirical evidence: what are LUC patterns in absence of biofuel policies?
  - How do biofuels interact with key drivers of LUC (governance, 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…)**

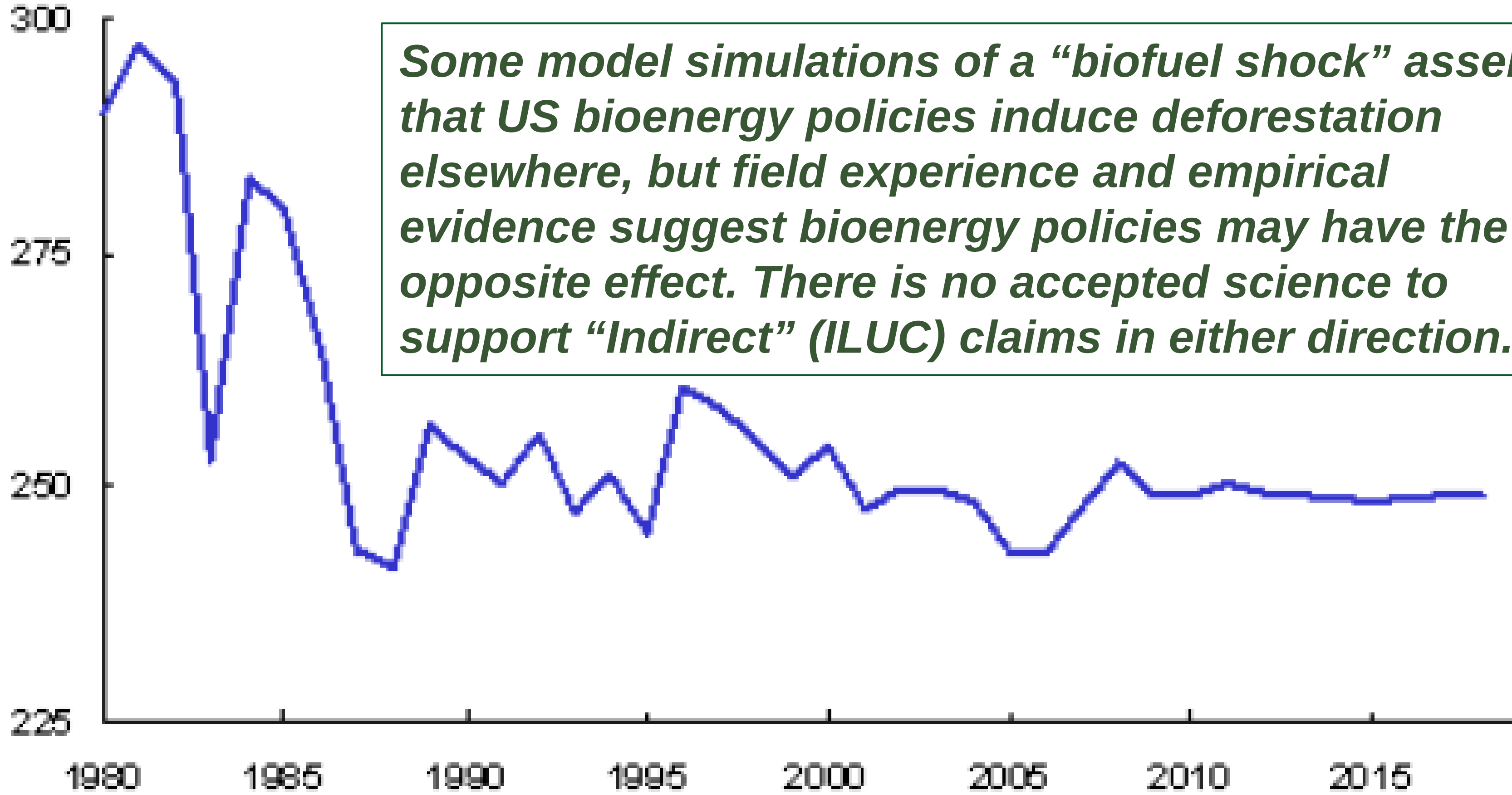


Source: *USDA Agricultural Projections to 2018*, February 2009. USDA, Economic Research Service.

USDA Baseline and Projections, 2009.

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

Million acres



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 Char
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

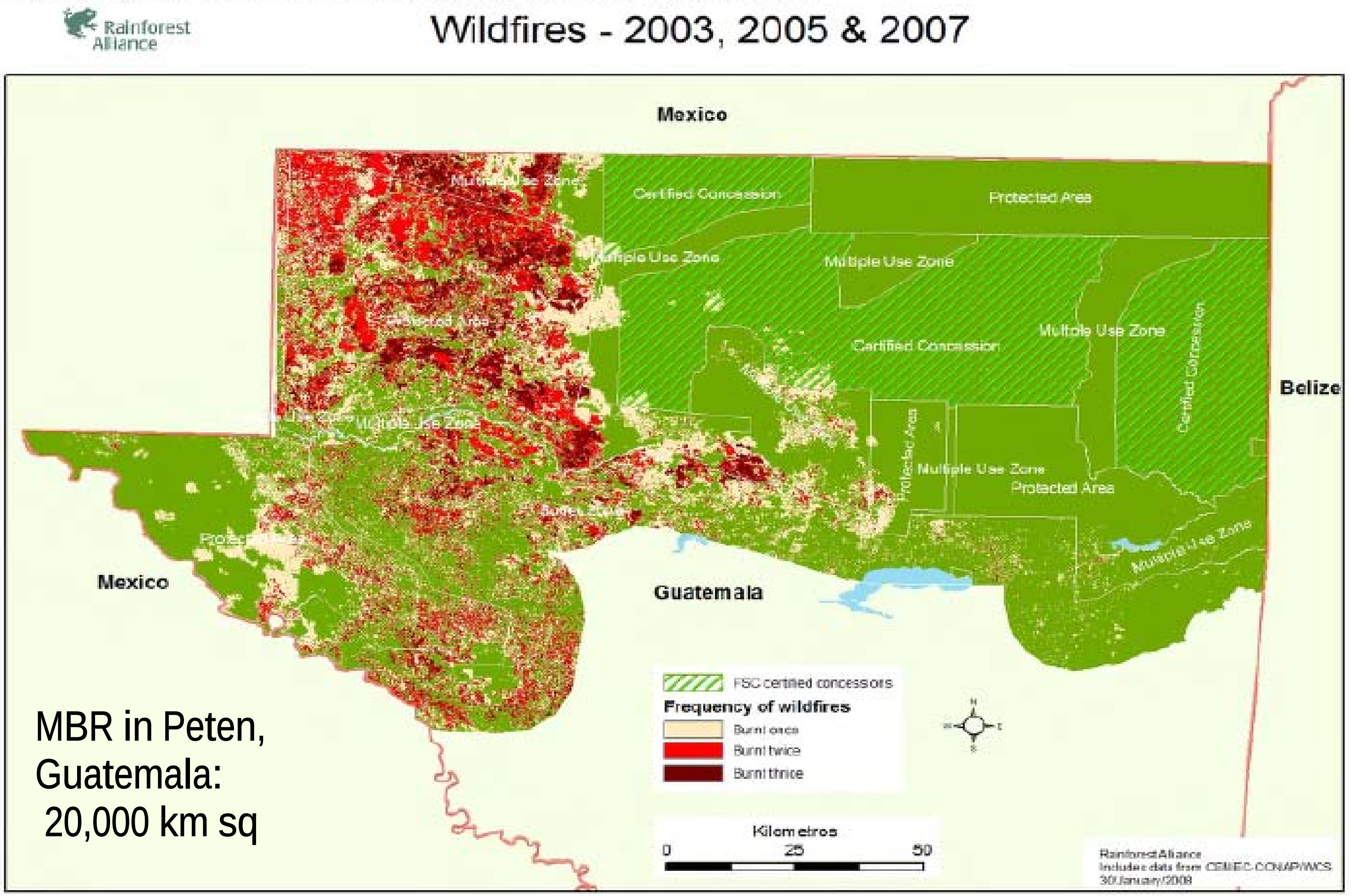
Solutions involve support for:

- 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.



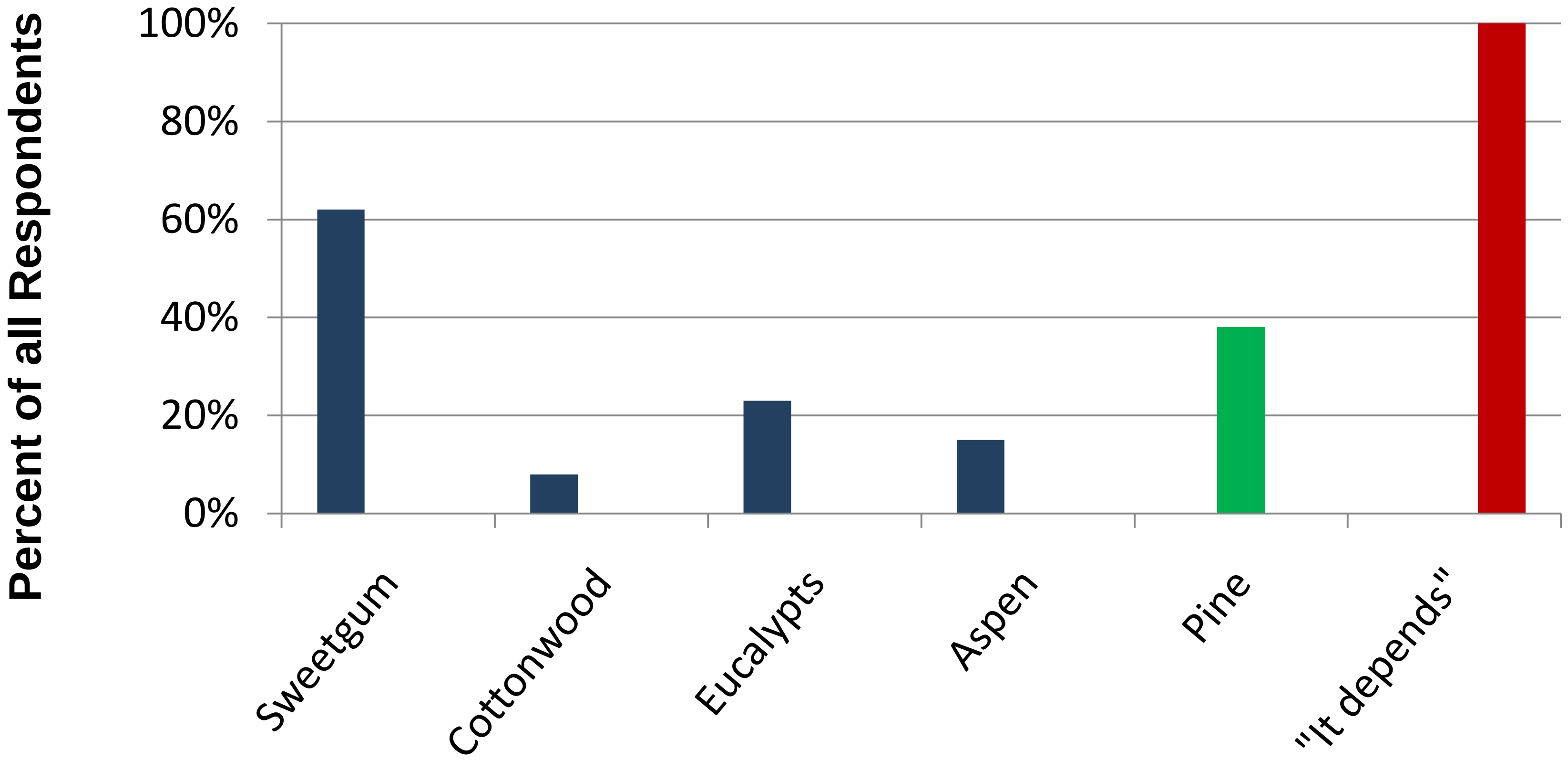
MBR in Peten, Guatemala: 20,000 km sq

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?"



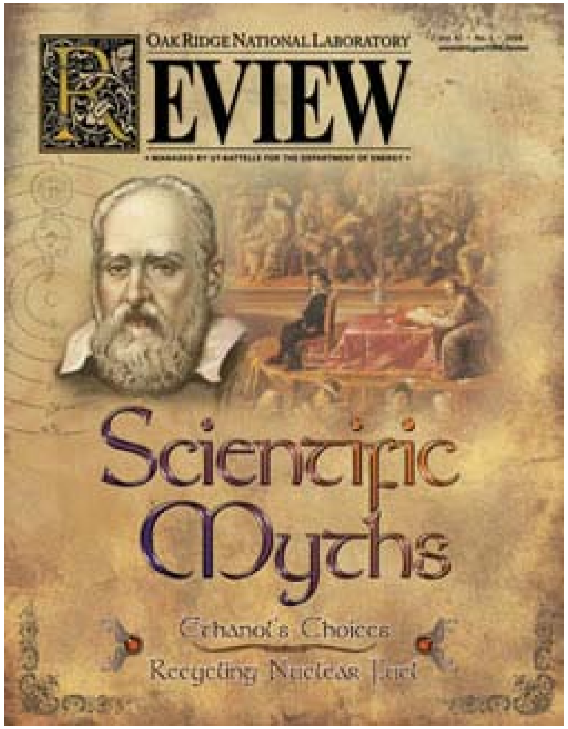
Kline,K.L., Coleman, M.D., 2010. Woody Energy Crops in the Southeastern United States: Two Centuries of Practitioner Experience. *Biomass and Bioenergy [in press]*.

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.**



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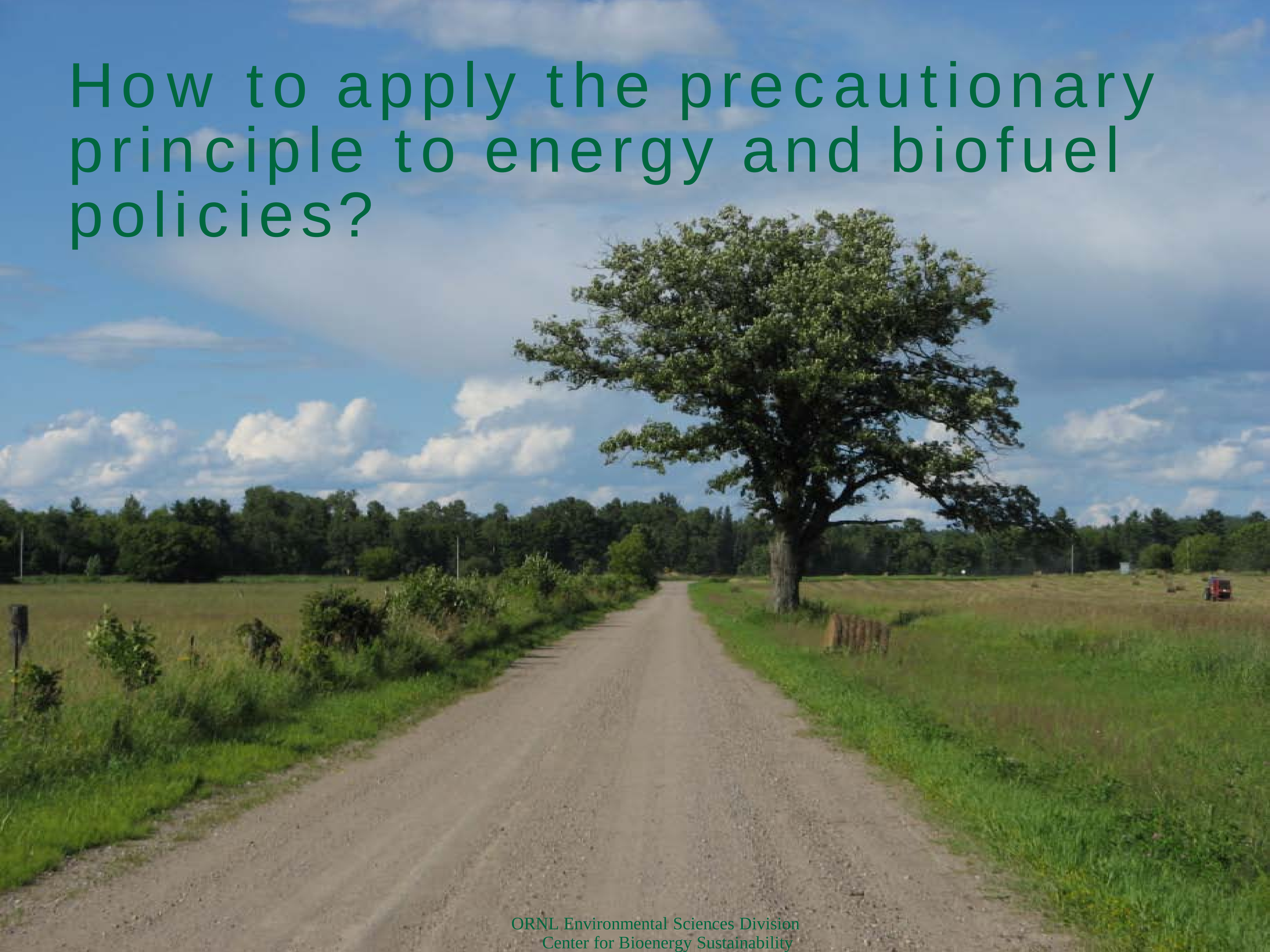
How to apply the precautionary principle to energy and biofuel policies?



ORNL Environmental Sciences Division
Center for Bioenergy Sustainability

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

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/