Biomass, Bioenergy and Land Use

Pathways to Climate Solutions: Assessing Energy Technology and Policy Innovation
Workshop organized by the Aspen Global Change Institute
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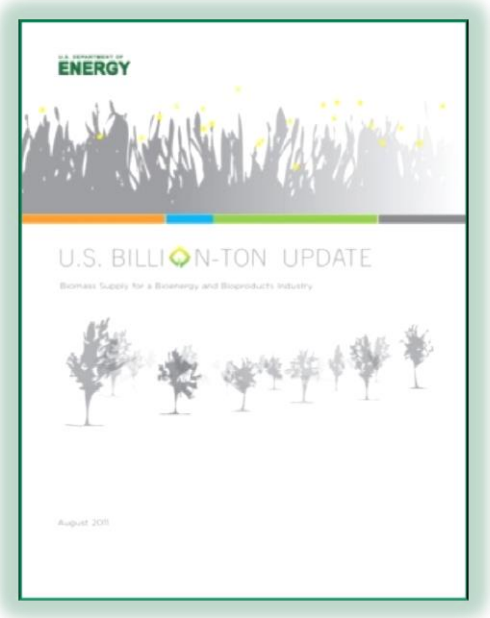
Why bioenergy?

- Do the right thing: conserve resources for future generations
  - "Living within our means"
  - Important "wedge" to reduce fossil fuel dependence
    - IEA, IPCC, WWF… all assume important role for bioenergy
    - 80-250 EJ (2050) to help meet emission targets
- Sustainable development
  - Involving stakeholders in process
  - Integrated land-use planning
  - More sustainable rural livelihoods
  - Landscapes managed for CC mitigation, adaptation, resilience
- Improve land management, efficiency (disturbances including fire and pests destroy over 500 million Ha biomass each year)
- Issues surrounding global "LUC" (land-use change)

U.S. Bioenergy supply model Billion Ton Update (USDOE 2011)



- Forecasts of potential biomass
  - POLYSYS partial equilibrium model of US agricultural and forestry sectors.
  - 20-year projections of economic availability of biomass (price, location, scenario)

- Forest resources
  - Logging residues
  - Forest thinnings (fuel treatments)
  - Conventional wood
  - Fuelwood
  - Primary mill residues
  - Secondary mill residues
  - Pulping liquors
  - Urban wood residues

- Agricultural resources
  - Crop residues
  - Grains to biofuels
  - Perennial grasses
  - Perennial woody crops
  - Animal manures
  - Food/feed processing residues
  - MSW and landfill gases
  - Annual energy crop (added for 2011)

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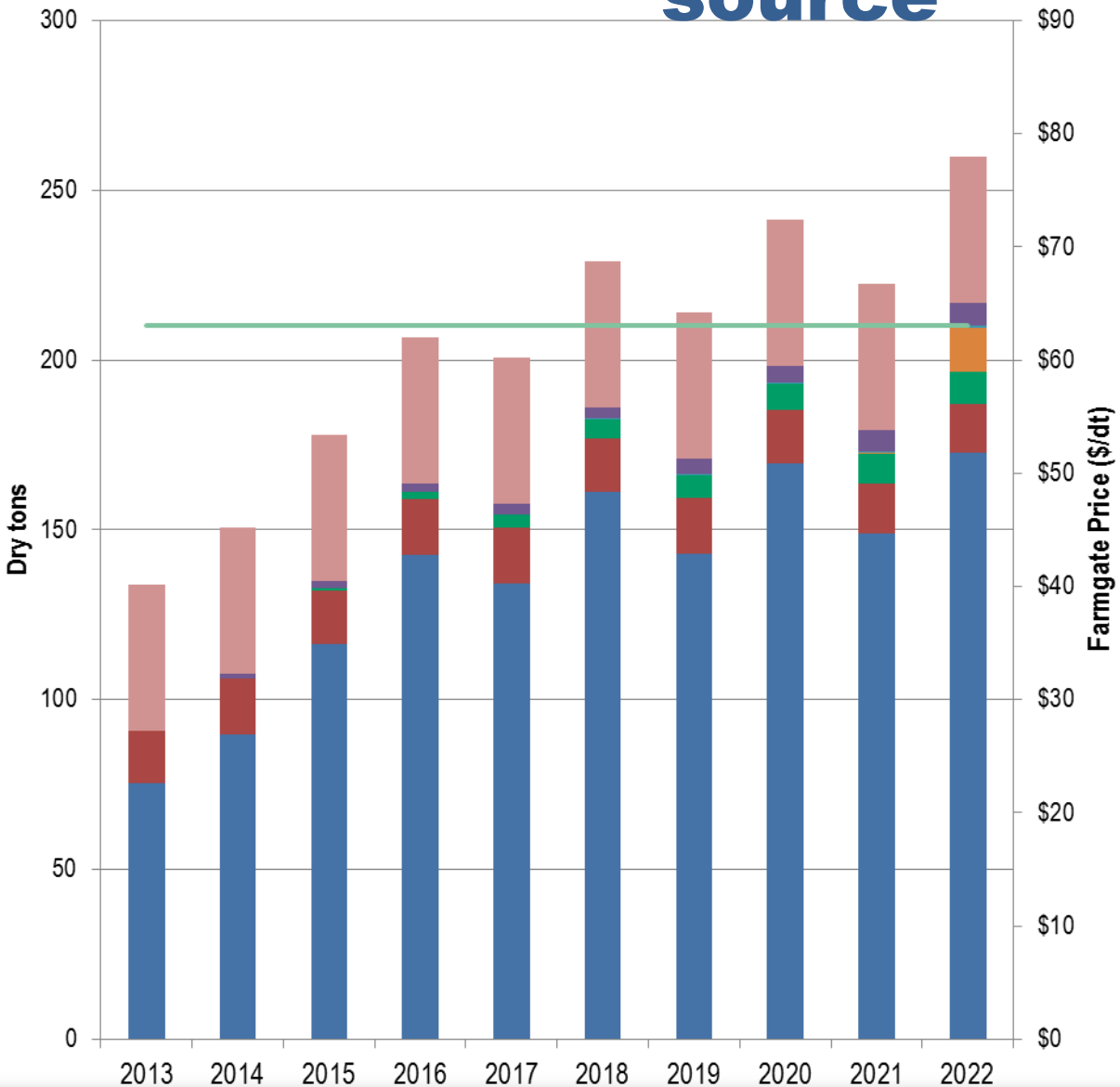
Residues now projected as primary US source



Resource profile at $63 dry ton^{-1} which provides 250 million dry tons by 2022 (meeting EISA target).

Wood Residue
Biomass Sorghum
Willows
Poplars
Switchgrass
Straw
Stover
Marginal Farmgate Price, Nominal

-Langholtz et al. 2014 (in press, BioFPR)

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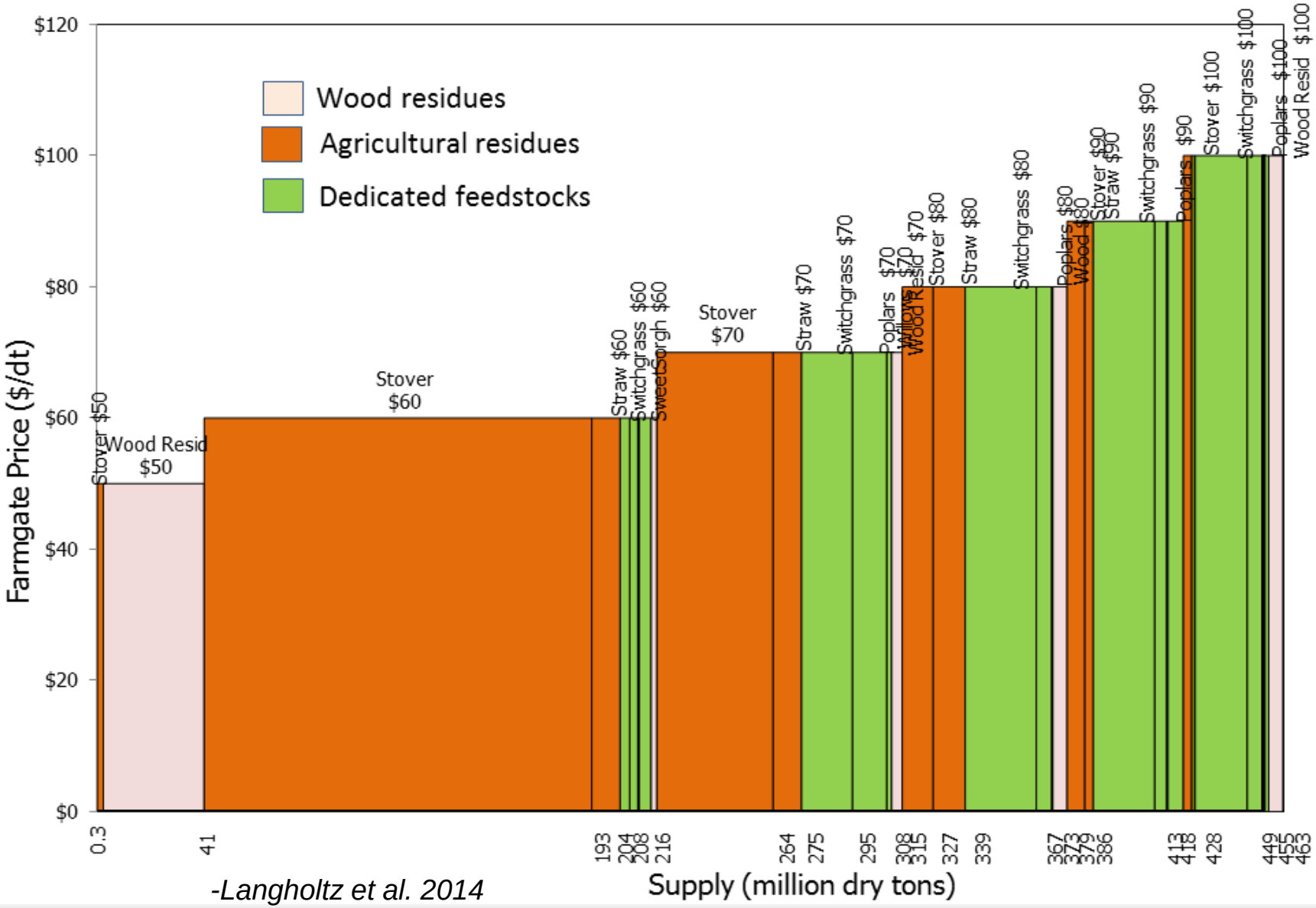
Supply curve for biomass in US, 2022



-Langholtz et al. 2014
(in press, BioFPR)

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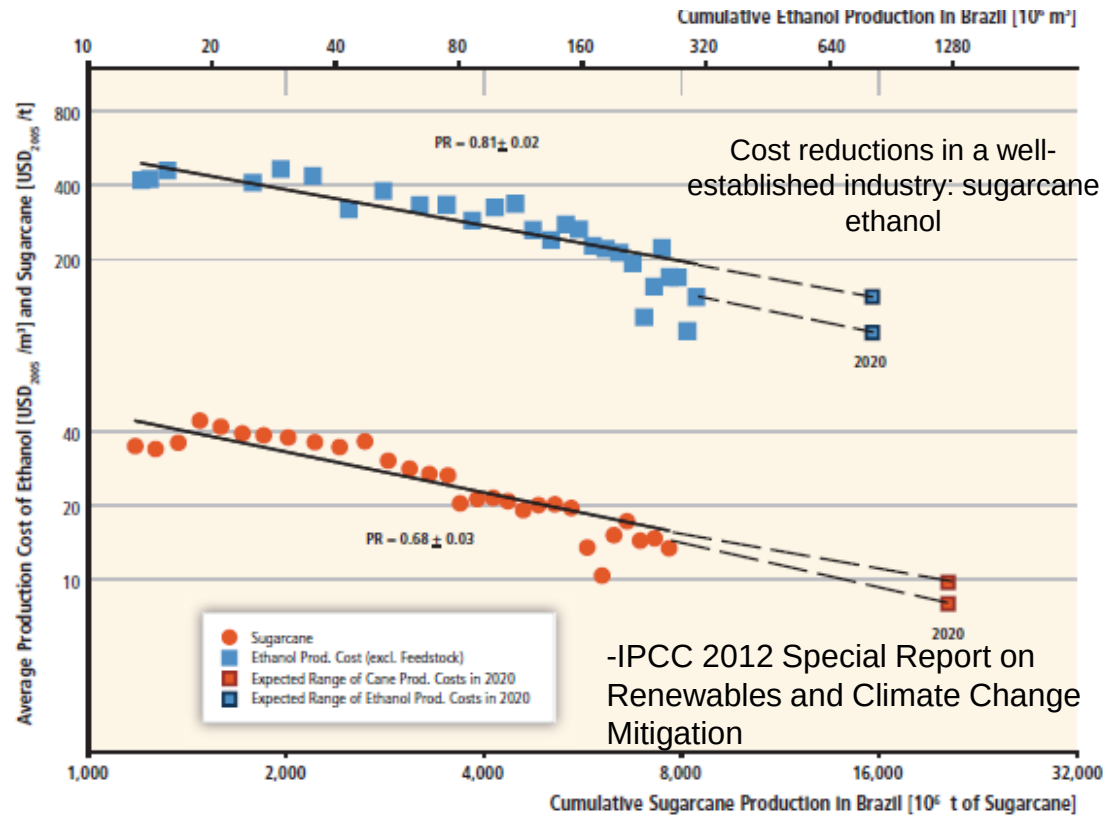
Cost reductions?

- Biofuel conversion costs projected to fall about 40% if/when technologies come to scale (e.g. 500 → 10,000 DMT/day)
  - See DOE "State of Technology" reports for biomass conversion pathways

- **Diverse bioenergy technology options in different stages of R&D**
- **Still awaiting "transformational breakthroughs" on several fronts**



Cost reductions in a well-established industry: sugarcane ethanol

-IPCC 2012 Special Report on Renewables and Climate Change Mitigation

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Global biomass potential estimates vary: 50-500 EJ (in 2050)

- "Technical Potential" 750-1500 EJ per year
- 300-500 EJ of "sustainable biomass" in 2050
  - Dornburg et al. 2010 (Energy & Env Science)
- "it seems impossible that bioenergy could physically provide more than 250 EJ yr-1 in 2050"
  - Haberl et al. 2013 (Environ. Res. Lett. 8)
  - Risks and limits result from land use assumptions

IPCC Special Report Renewable Energy

"most likely range is 80-190 EJ"

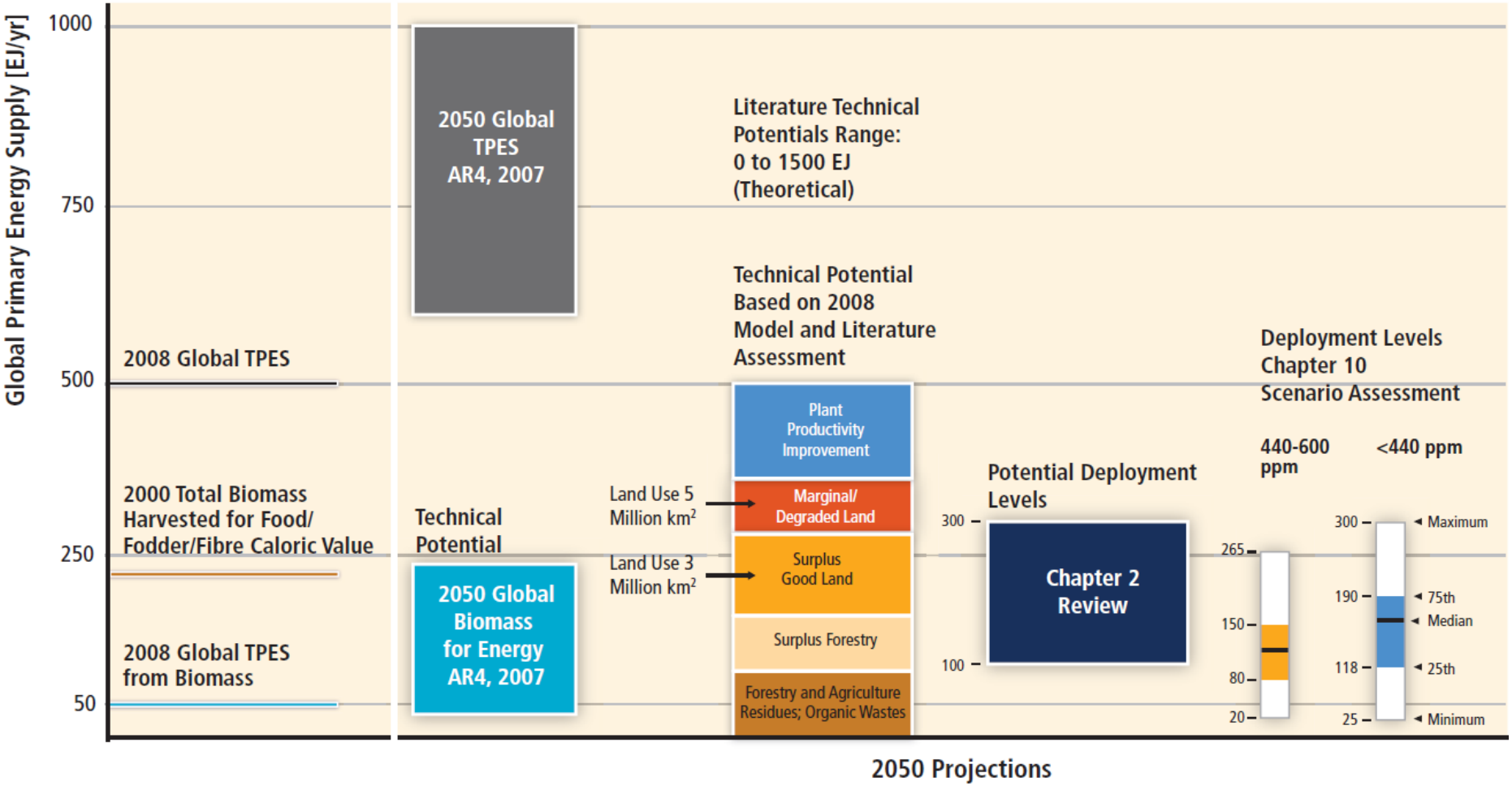
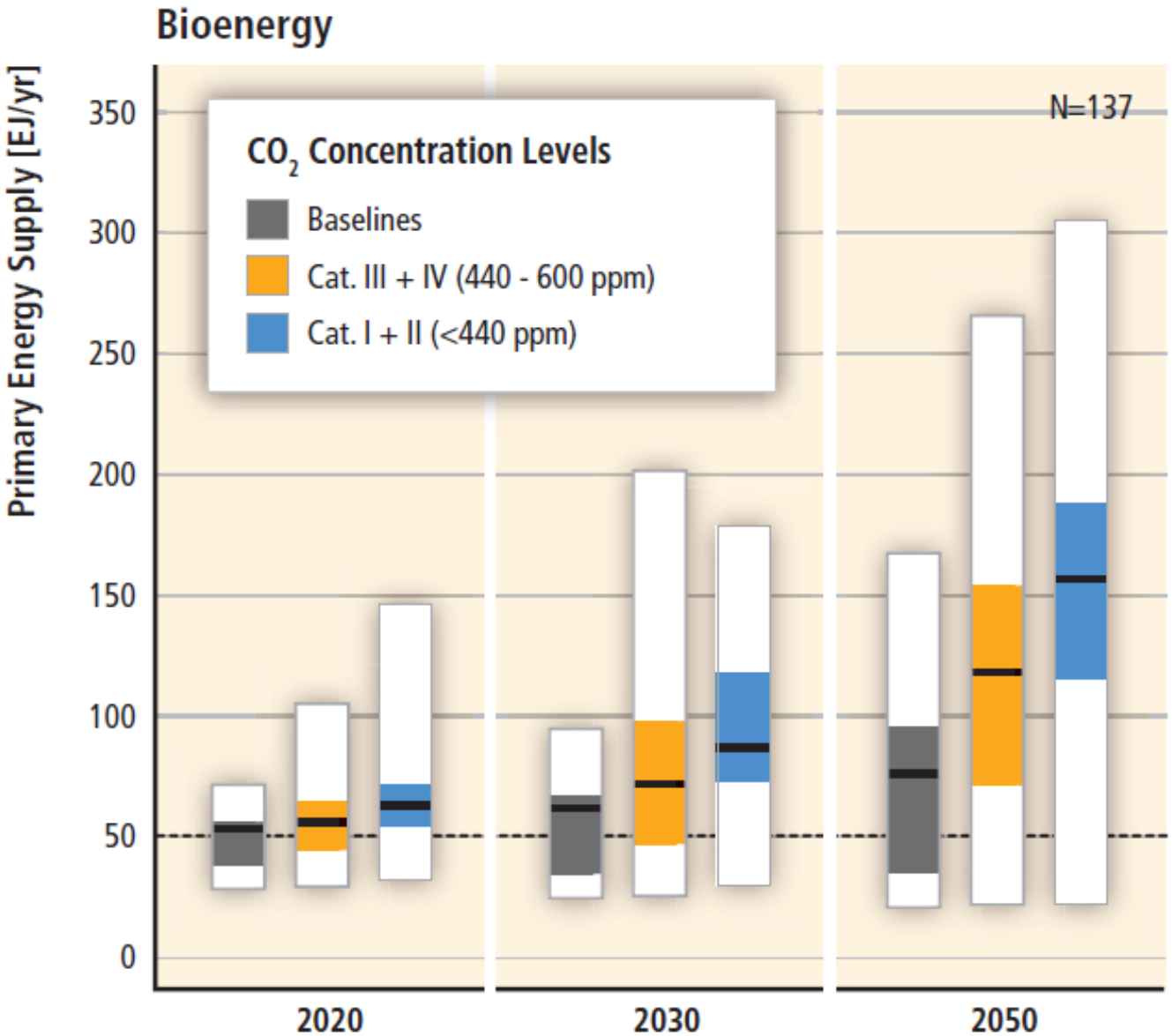


Figure 2.25 | On the left-hand side, the lines represent the 2008 global primary energy supply from biomass, the primary energy supply, and the equivalent energy of the world's total harvest for food, fodder and fibre in 2000. A summary of major global 2050 projections of primary energy supply from biomass is shown from left to right:

-IPCC 2012 Special Report on Renewables and Climate Change Mitigation

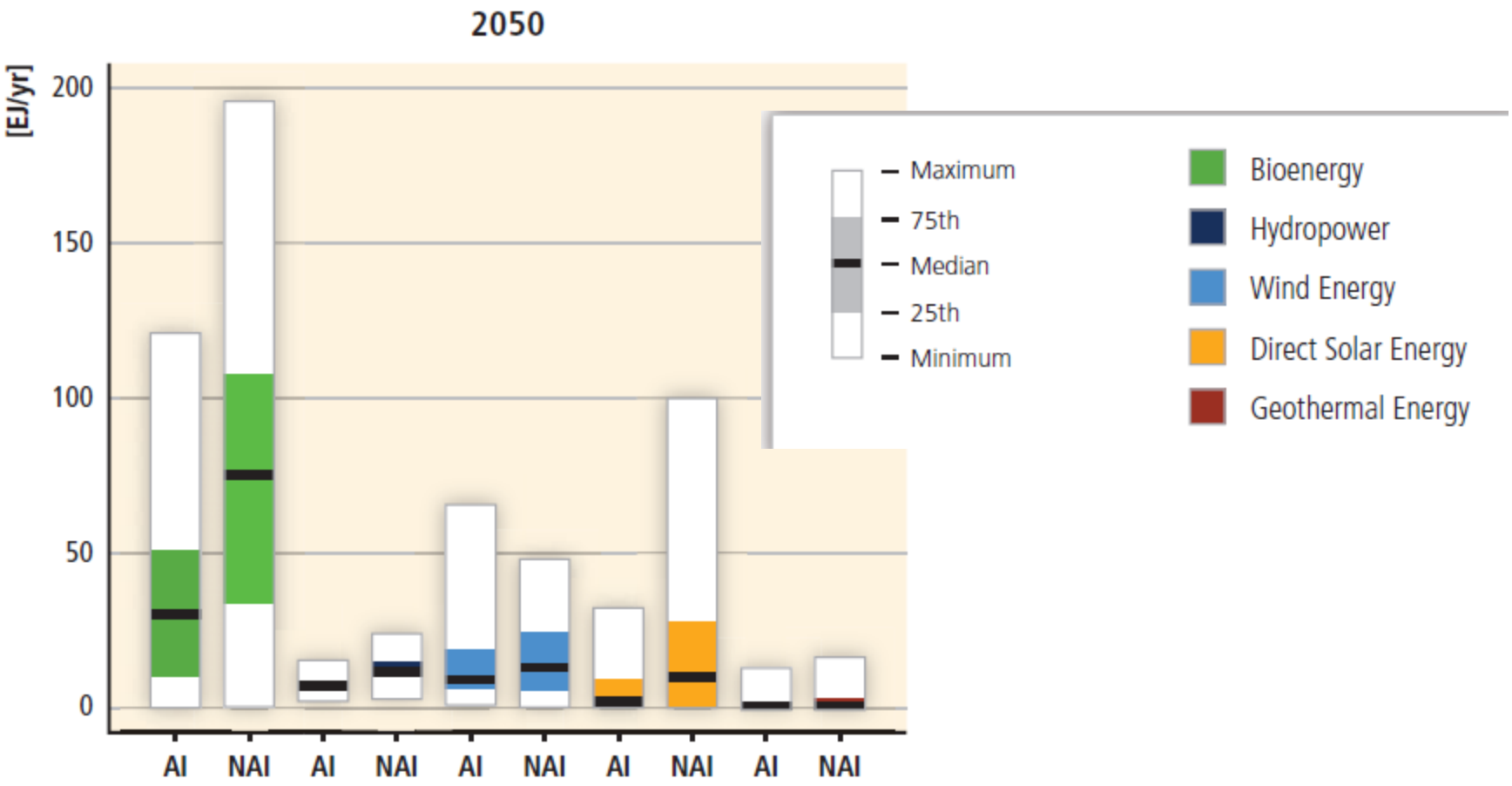
IPCC Special Report Renewable Energy



155 EJ in 2050

-IPCC 2012 Special Report on Renewables and Climate Change Mitigation

IPCC Special Report Renewable Energy
Climate mitigation scenarios



-IPCC 2012 Special Report on Renewables and Climate Change Mitigation

Obstacles to bioenergy include

- Food security and land concerns
- LUC-related effects on biodiversity, carbon debt, water
- Markets: lack of security for investment, increased production
- Distribution of benefits and costs
- Need for integrated policy across agriculture, forestry, waste, environment, energy…
- Sector- and nation-specific challenges (e.g., US “blend wall,” distribution infrastructure)

Bioenergy assessment depends on estimated "land-use change" (LUC) effects

Issues that influence estimated LUC:

1. Economic decision-making assumptions
2. Conceptual framework for drivers of 'land conversion'
3. Land supply and management specifications
4. Assumed land use dynamics (ref. scenarios, baseline choices)
5. Modeling yield change
6. Issues of time, scale
7. Fire and other disturbances
8. Differentiate correlation versus causation
9. Attribution among different drivers of change
10. Representation of bioenergy/policy in model specifications
11. Data issues related to all above, to test hypotheses

It depends

See IEA Joint Task 38-40-43 presentation on LUC: http://ieabioenergy-task38.org/workshops/campinas2011 on CBES website

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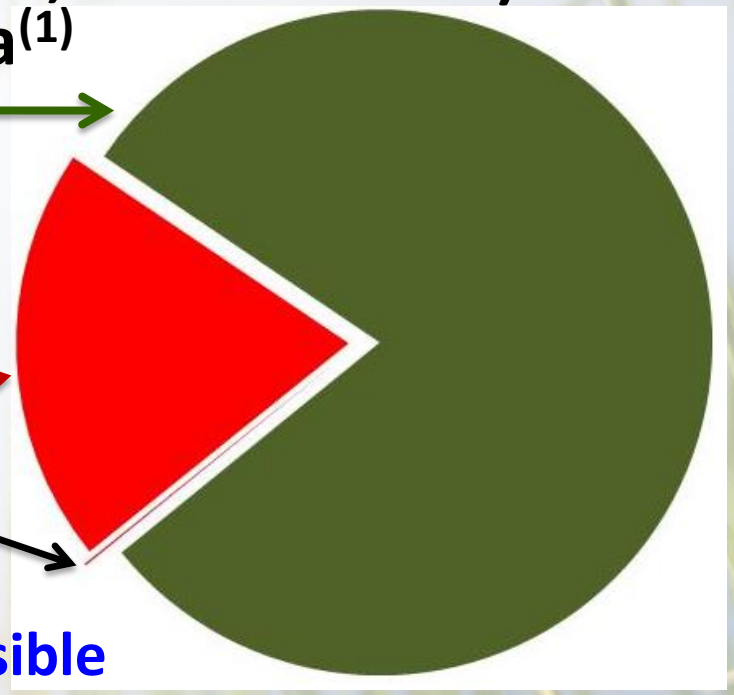
LUC estimates, compared to what?

- **Land available for ag-expansion without deforestation (previously cleared, underutilized) = 500 million to 4 000 million ha[1]**
  Circle size assumes 1500

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



[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 = 0.2/year)

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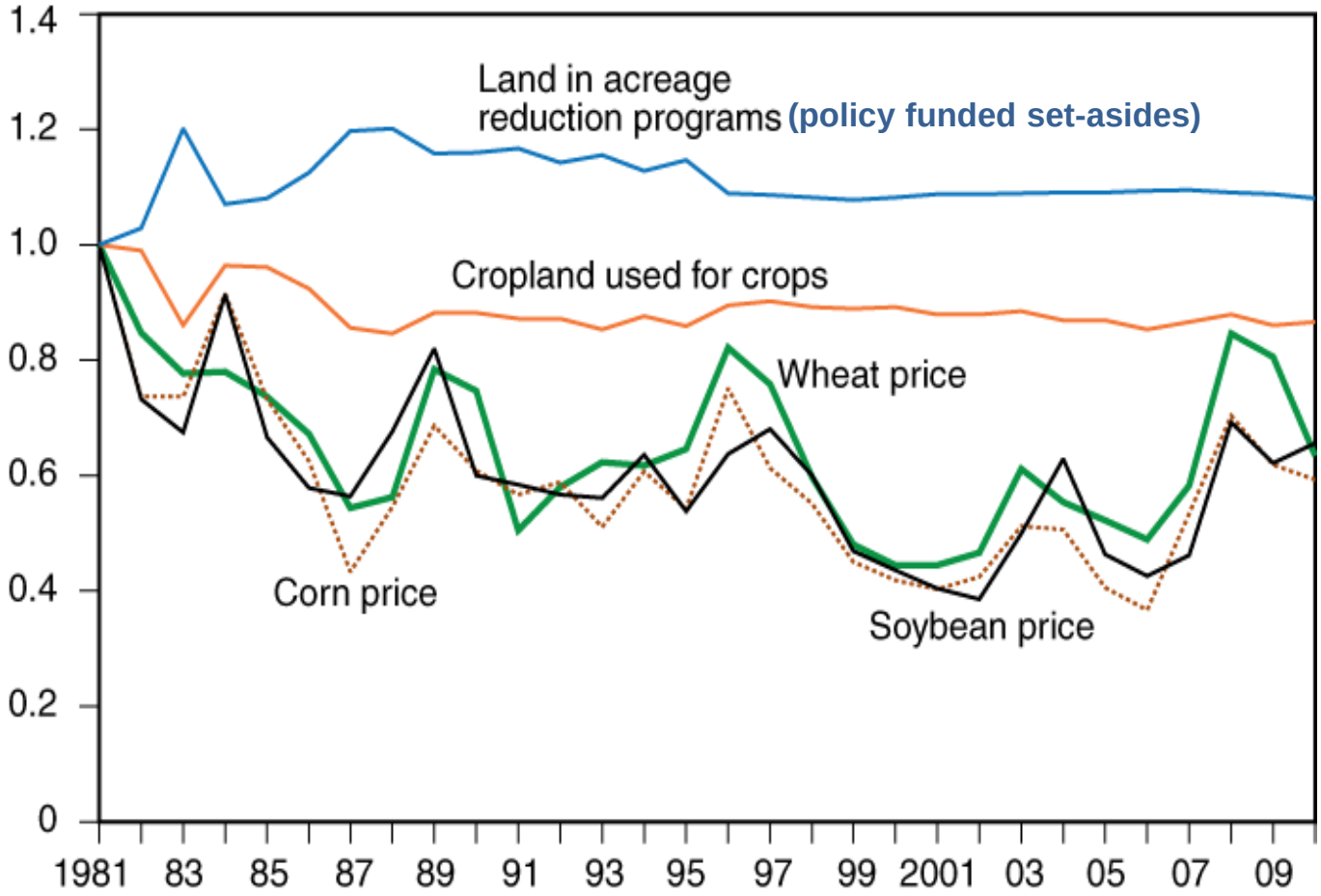
Check assumptions about price-driven LUC

Figure 6
U.S. cropland used for crops and commodity prices of key crops

Real price and cropland indices



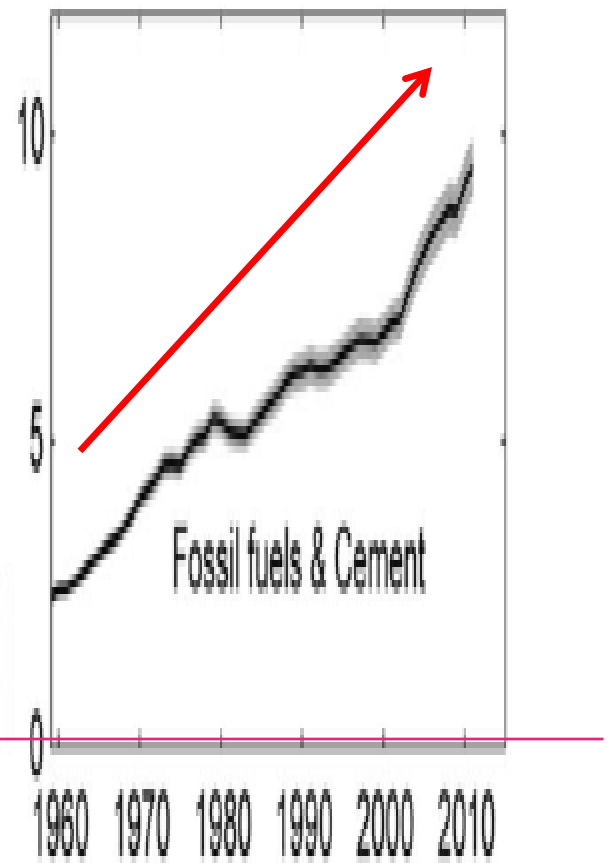
Source: USDA ERS 2011. http://www.ers.usda.gov/publications/eib89/

Contrary to some modeling assumptions, in the US, expectations of commodity prices and risk affect choices of *what* to grow on previously defined agricultural landscapes, not *how much* total area is dedicated to agriculture

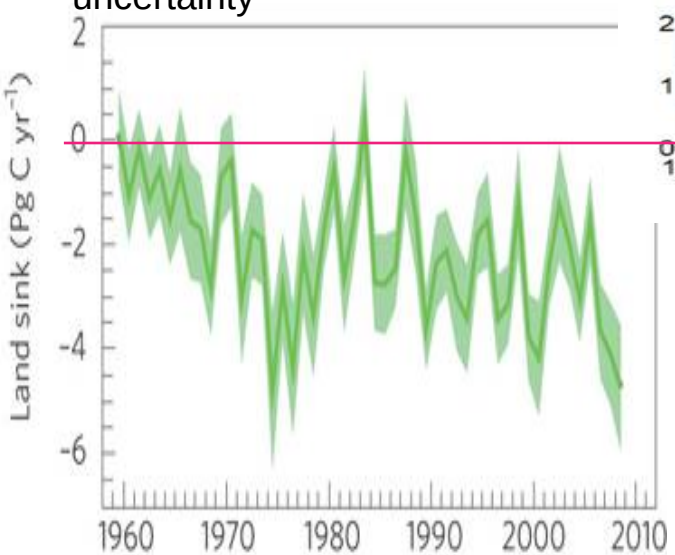
Putting global "Land Use Change" emissions into perspective (1960-2012)

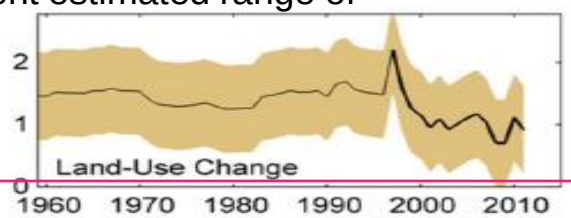
- Over 90% of current CO2 emissions from fossil fuels (GCP 2013)
- LUC emissions, uncertain, small and shrinking
- Land management: high importance as potential sink

Fossil emissions rising rapidly



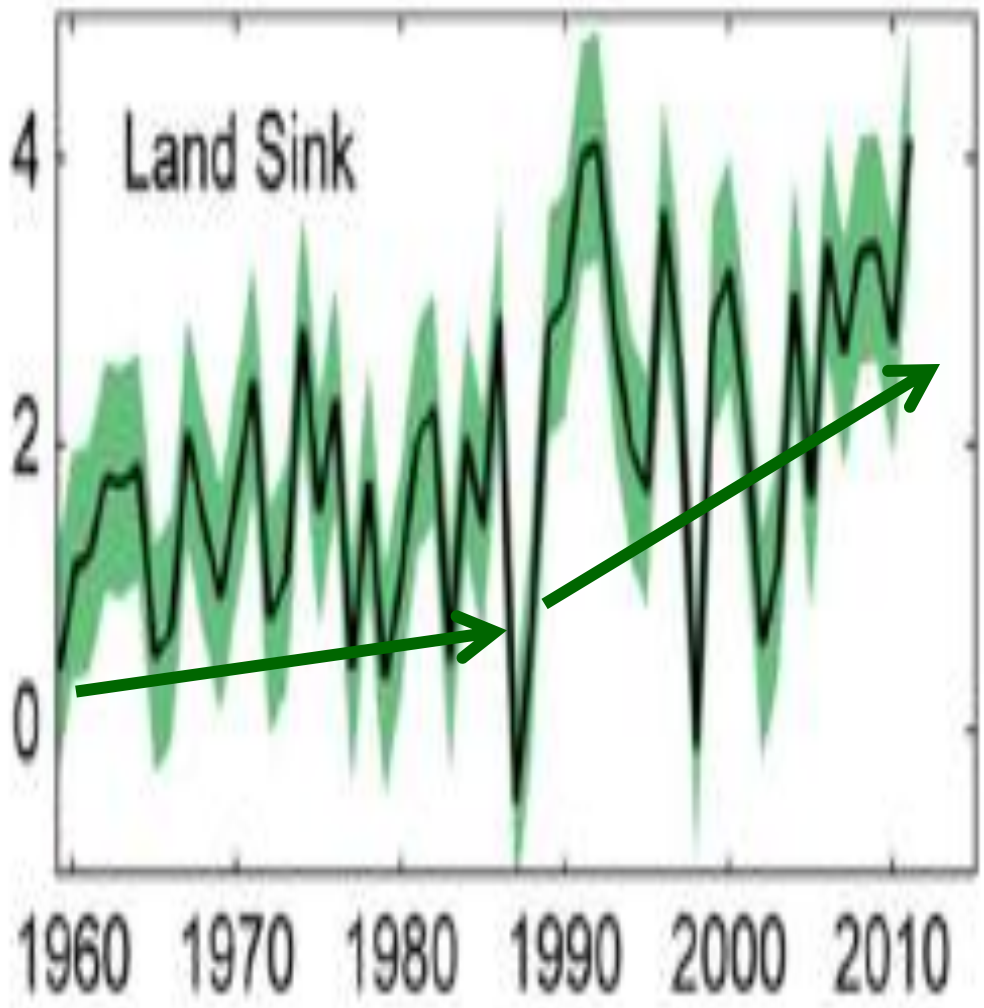
Shaded areas around lines represent estimated range of uncertainty





GCP "Land-Use Change" estimate based on emission factors associated with global reported deforestation and fires

Source: Le Quéré, C. et al. Nature Geosci.v2, 831–836 (2009) for sink; Global Carbon Project (2013) for LUC and fossil.



Source: Global Carbon Project 2013

Opportunity:

Improve NET land SINK via better management.

Investments in management requires incentives.

Who pays?
For what services?
On whose land?

Other opportunities

- More emphasis on win-win scenarios
- Build consensus on:
  - Goals
    - Criteria and indicators
    - How to measure them
    - Speak “common language”
  - Models
- Empirical data to test hypotheses
- International collaboration to resolve contentious issues

Thoughts for discussion

- Is further debate over the EJ of sustainable energy potential from biomass useful?
- Analyses all begin with land, but land is not the primary constraint
  - Social, political, economic/market issues
  - Institutions, governance… water
- Needed: Incentives for improved soil/water resource management
  - Increase carbon and nutrient retention
  - And capacity to store carbon
- On the radar
  - Integrated production systems (ILUP)
  - Urban food-energy systems (nutrient and energy recycling)

Thank you!

CBES

Center for BioEnergy Sustainability

http://www.ornl.gov/sci/ees/cbes/

Win-Win Opportunities

Improve soil & water management

- Precision management and nutrient recycling
- Reduce disturbance/tillage intensity
- Crop mix, rotations, cover crops
- Land restoration
- Technology (seed, microbe, equipment)

Increase Efficiency

- Reduce inputs/increase ***yields***
- Open, transparent markets
- Minimize transaction costs
- Prioritize, incentivize, measure

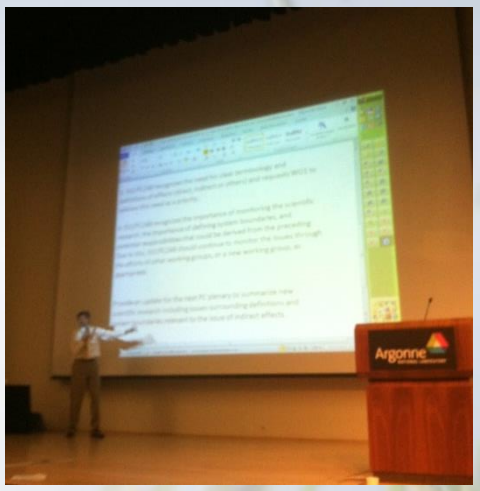
Diversify

- Uses and markets
- Substitution options
- Bases of production

Adopt Systems Perspective

- Multi-scale
- Long term and adaptive
- Integrated land-use plans

Research challenges for consistent measures of LUC



- Accurate representations based on clear **definitions** for variables and conditions of concern:
  - land attributes
  - management practices
  - baseline trends and change dynamics
- **Causal analysis** that can be validated at multiple scales
- Adequate empirical **data** to test models and hypotheses
- Multi-disciplinary, multi-institutional **learning** and problem-solving mechanisms
- ***Approaches with low transaction costs and high value-added***

How to effectively involve society?

- Stakeholder engagement in process: define problem, goals and priorities, assess options, and validate proposed solutions
  - How does society define the problem?
  - What are priority objectives?
    - Define spatial and temporal scales
    - Consider constraints and opportunities
  - Apply tools to obtain range of solutions
  - Analyze trade-offs and complementarities
  - Extract general rules, guidance for decision makers
  - Monitor to guide further improvements over time
    - Use of indicators to measure change

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