Multi-Disciplinary Research: Bioenergy, Land Use Change and Food Security.

Plus: Global Calculator

Climate Change Science Institute
21 April, 2014

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U.S. DEPARTMENT OF ENERGY

Climate Change Science Institute AT OAK RIDGE NATIONAL LABORATORY

OAK RIDGE NATIONAL LABORATORY
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CCSI Multi-Disciplinary Research Series

(Source for list of Prior Talks: Sujith Surendran Nair)

- Budhu Bhaduri – Multi-disciplinary components of geospatial analysis
- Ben Preston – Why and how climate adaptation research is multi-disciplinary
- Virginia Dale – ORNL's impressive history in multi-disciplinary research
- Steve Fernandez – Energy infrastructure vulnerability
- Tom Wilbanks – Personal experiences/ journey in sustainability research
- Tony King – Thought-provoking ideas around multi-disciplinary research
- Dan Hayes – The new NSF arctic project
- Forrest Hoffman – Forest monitoring and disturbance, FOREWARN
- Jay Gulledge – Transforming science to policy
- Gary Jacobs – Knowledge Systems for Sustainability (KSS)
- Martin Keller – Framing ESD and CCSI future research
- Peter Thornton – Earth System Modeling and personal path to ORNL
- Giri Palanisamy – Data management
- Today: Keith L. Kline – Bioenergy, Land Use, Food Security and Climate Calculator

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Why bioenergy, LUC and Food?

- 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)
- Address issues surrounding global "LUC" (land-use change)

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)
- "…impossible that bioenergy could physically provide more than 250 EJ yr-1 in 2050"
  - Haberl et al. 2013 (Environ. Res. Lett. 8)
  - Land assumptions limit estimate

Slide from Kline presentation to "Pathways to Climate Solutions: Assessing Energy Technology and Policy Innovation" Workshop organized by the Aspen Global Change Institute; 24-28 February, 2014. Aspen CO.

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IPCC Special Report Renewable Energy

“most likely range is 80-190 EJ”

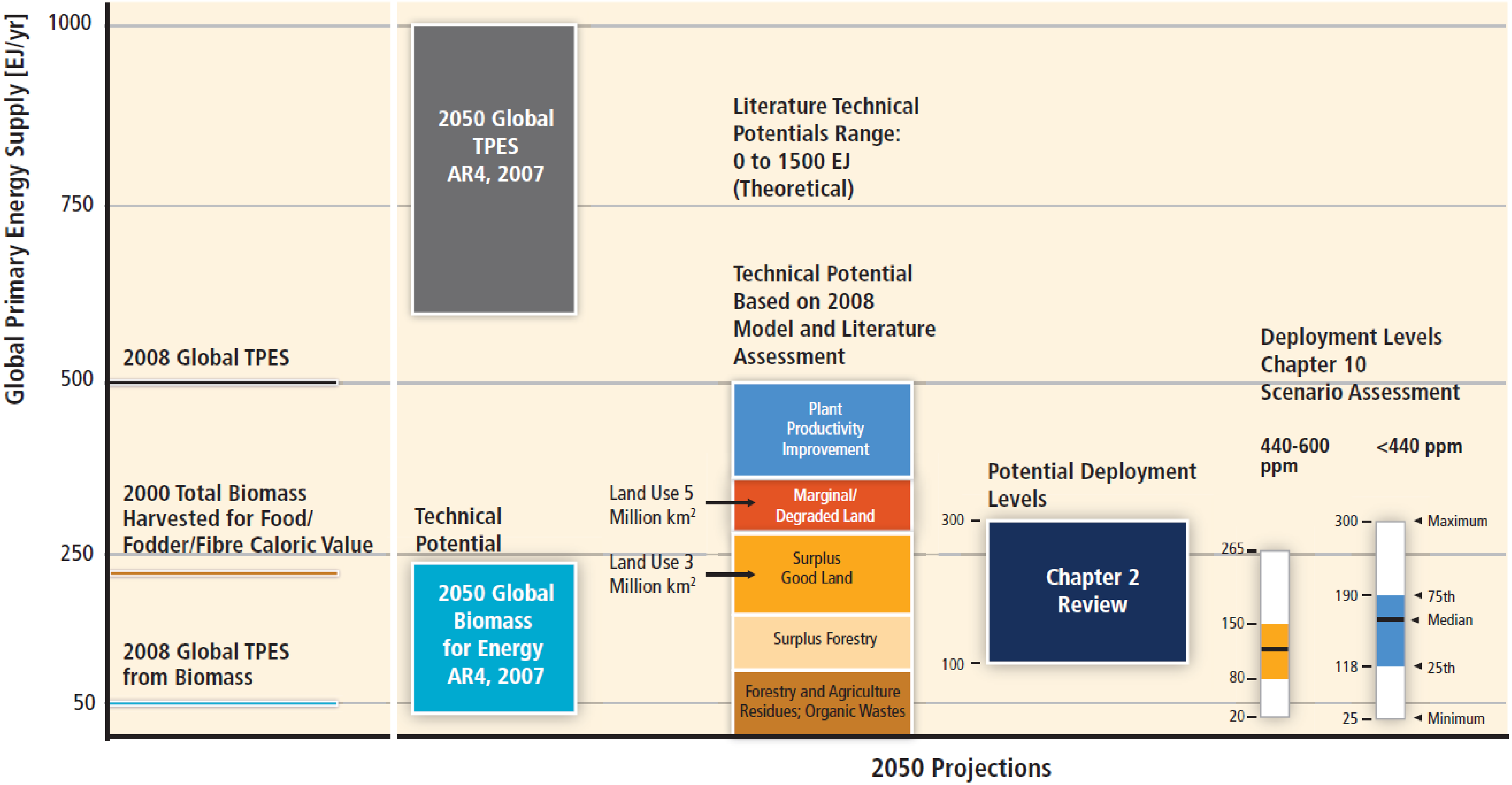
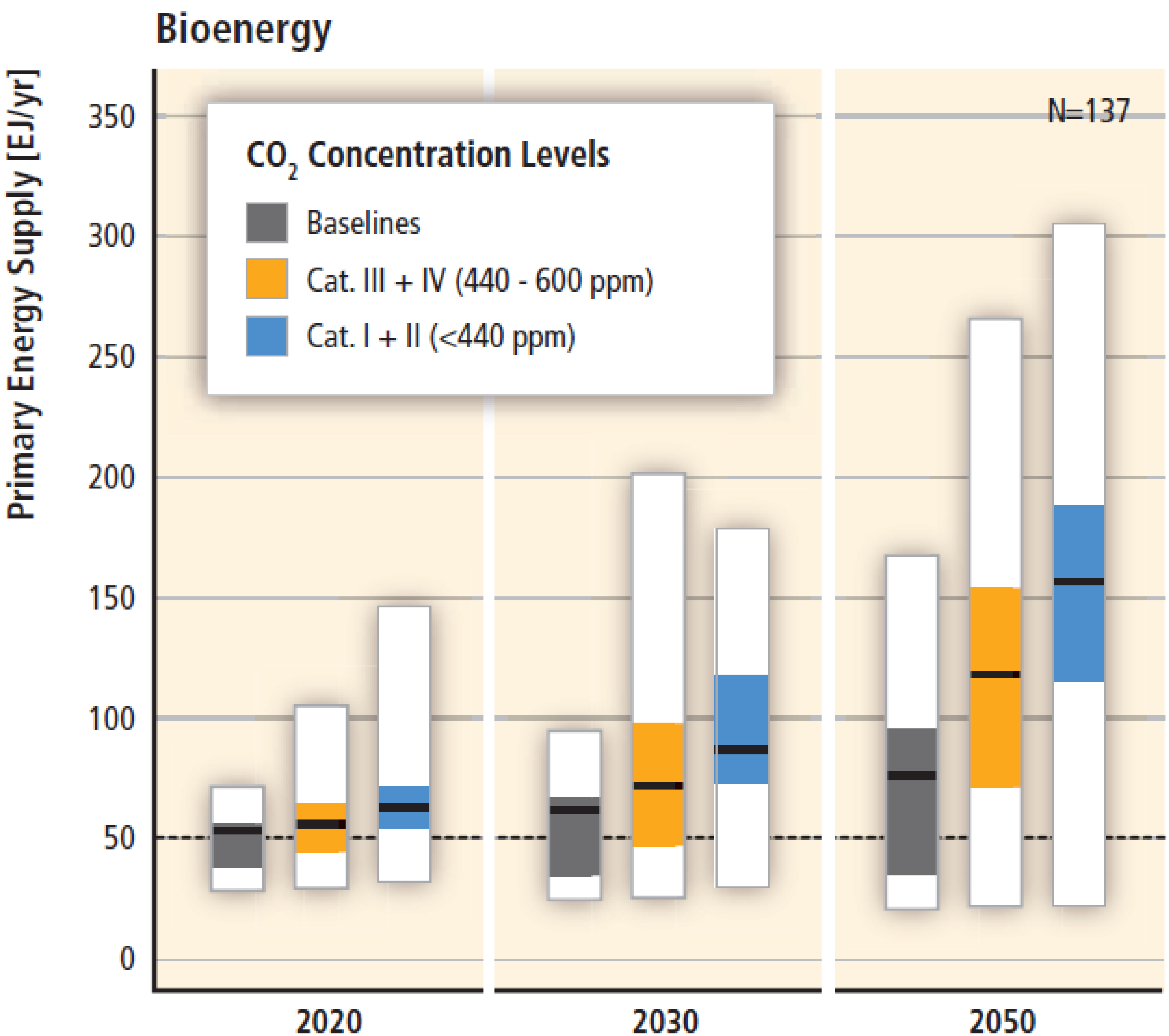


Figure 2.25 | On the left-hand side, the lines represent the 2008 global primary energy supply from biomass, the primary energy supply, and the equivalent energy of the world’s total harvest for food, fodder and fibre in 2000. A summary of major global 2050 projections of primary energy supply from biomass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

-IPCC 2012 Special Report on Renewables and Climate Change Mitigation

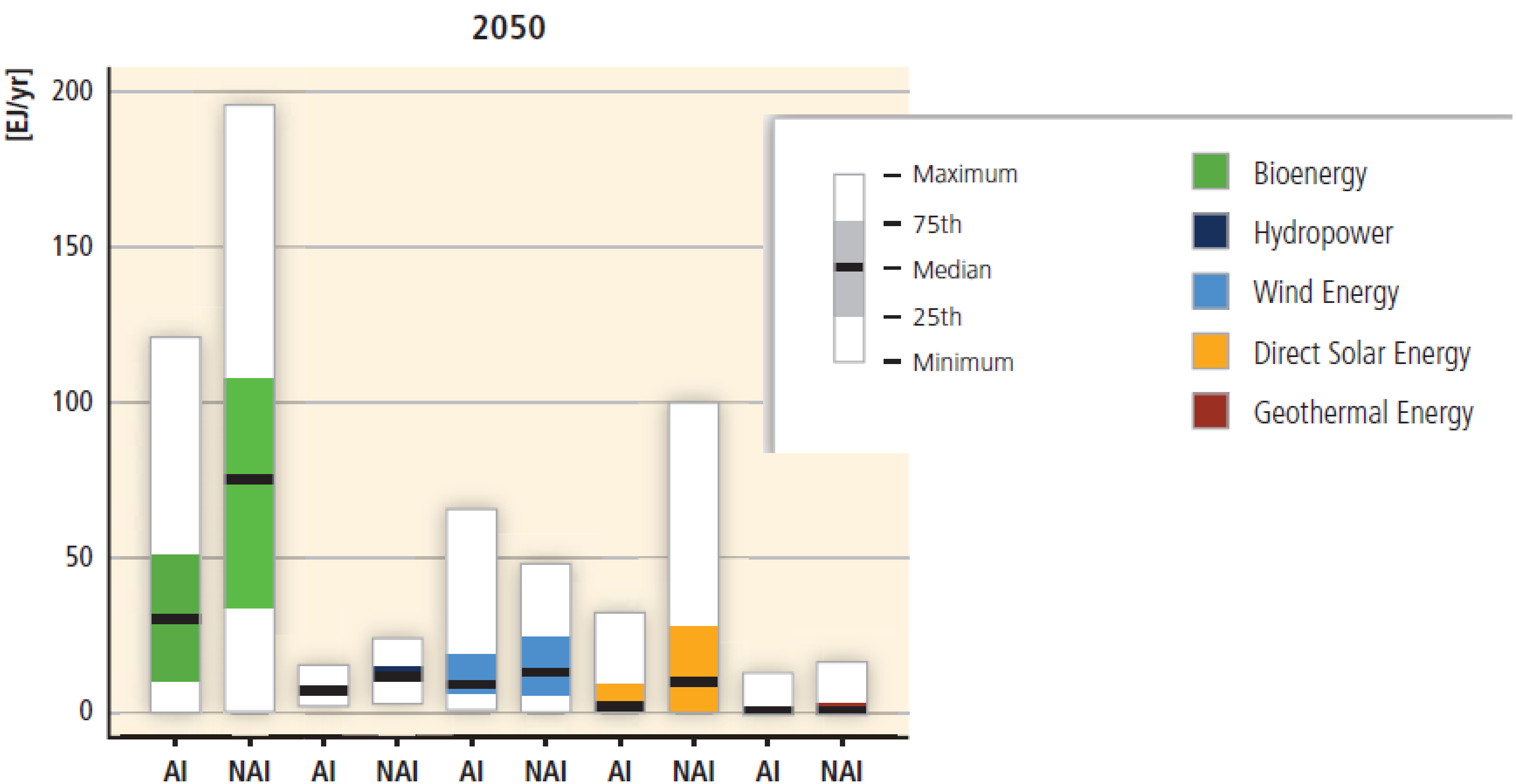
IPCC Special Report Renewable Energy



155 EJ in 2050

-IPCC 2012 Special Report on Renewables and Climate Change Mitigation

IPCC Special Report Renewable Energy
Climate mitigation scenarios



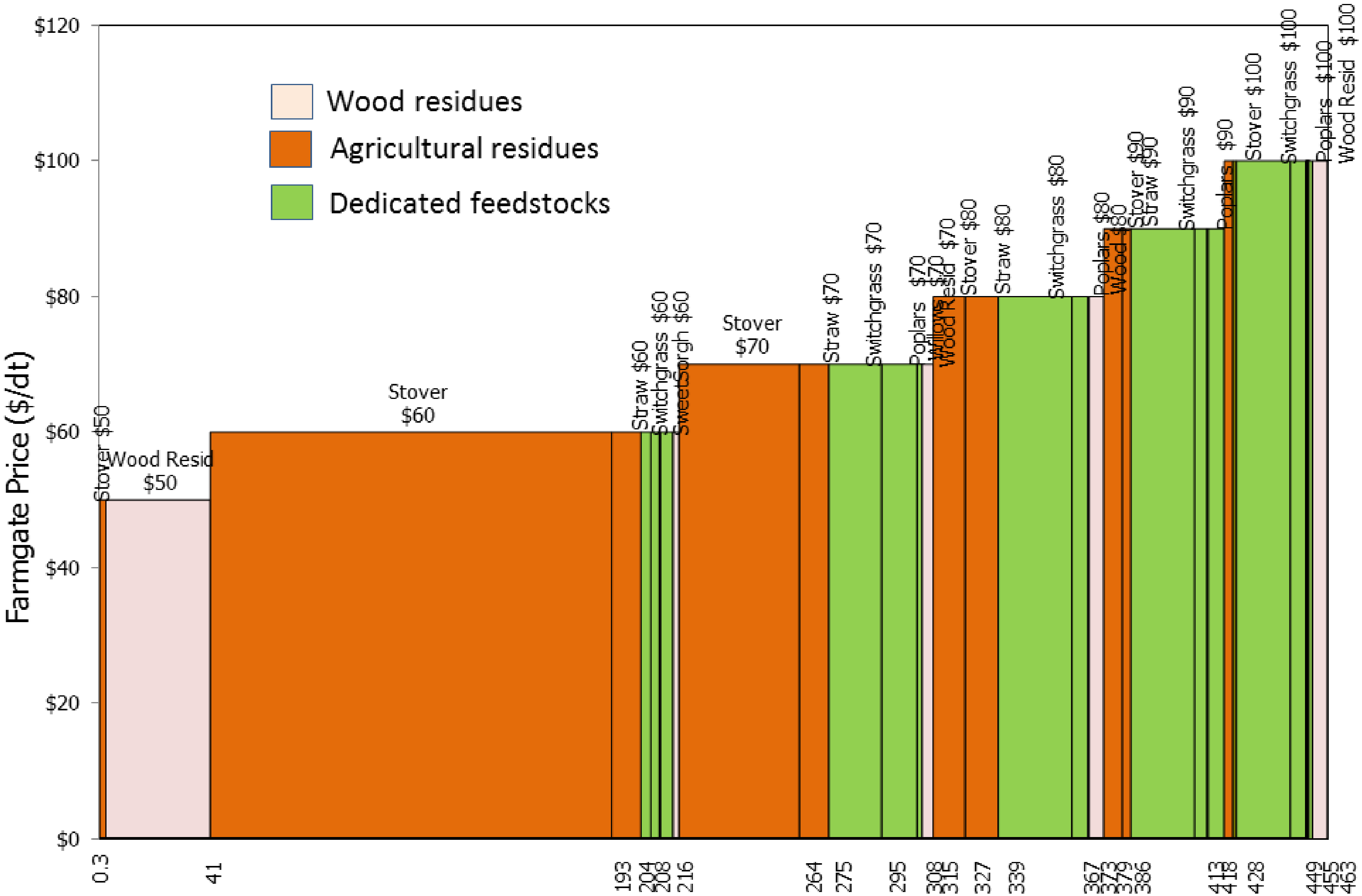
-IPCC 2012 Special Report on Renewables and Climate Change Mitigation

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)

Supply curve for biomass in US, 2022



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

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)

Source: Kline presentation to “Pathways to Climate Solutions: Assessing Energy Technology and Policy Innovation” Workshop organized by the Aspen Global Change Institute; 24-28 February, 2014. Aspen CO.

Food security

October 2013

Should the USA establish mechanism to lift ethanol mandates to address “food price crises” in other nations?

COMMITTEE ON WORLD FOOD SECURITY

Fortieth Session

Rome, Italy, 7-11 October 2013

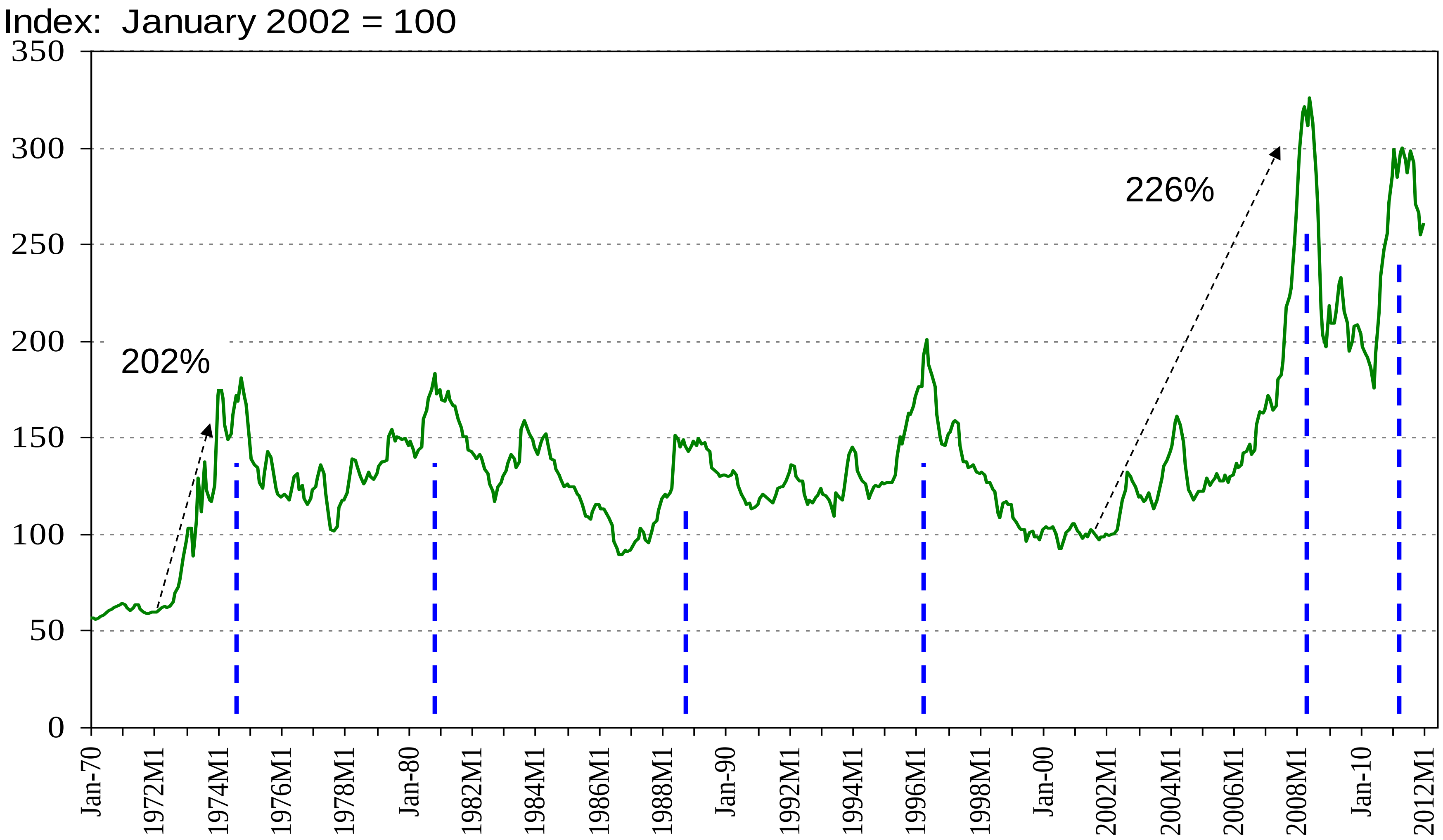
DRAFT FINAL REPORT

ii) Production and consumption of biofuels, amongst many other factors, influence international agricultural commodity prices. The interaction between biofuels, food prices and supply responses is dynamic and complex, and requires a distinction between short-term and long-term impacts;

iii) In some cases, current biofuel production creates competition between biofuel crops and food crops. Significant guidance exists and is further needed to ensure that biofuels policies are coherent with food security to minimize the risks and maximize the opportunities of biofuels in relation to food security. This includes, the CFS

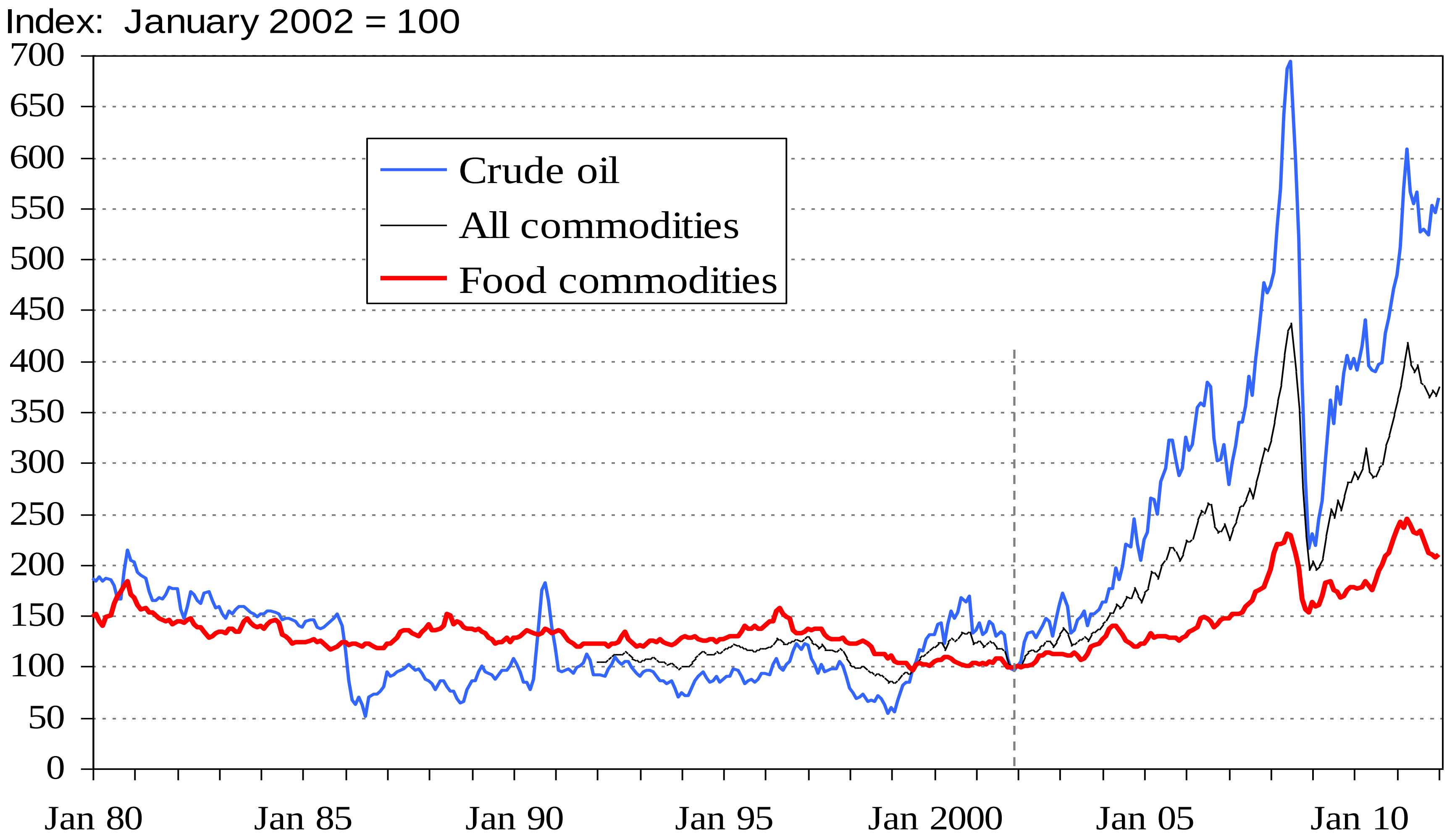
6 price spikes since 1970

Weighted average of 4 crops (wheat, soybeans, corn & rice) 1/



Source: Ron Trostle, ERS; based on International Monetary Fund: International Financial Statistics, Jan 2012p

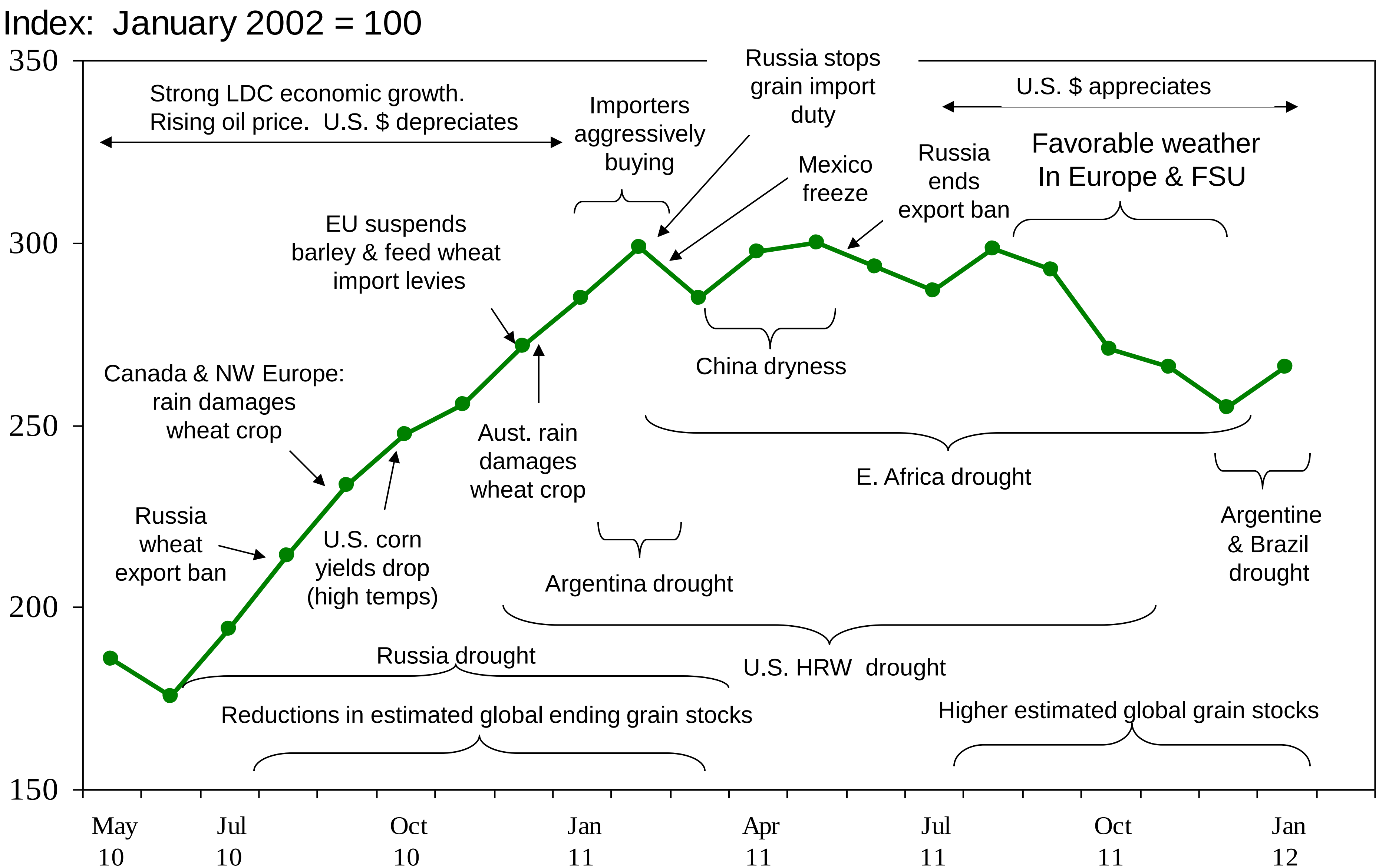
Non-food commodity prices have risen even more



Source: Ron Trostle, ERS; based on International Monetary Fund: International Financial Statistics, Jan 2012p

ERS ECONOMIC RESEARCH SERVICE

Primary factors affecting crop prices[1] (June 2010 – Jan 2012)



Source: Ron Trostle, ERS

[1]4-crop monthly price index: Wheat, rice, corn, & soybean prices; based on IMF price and trade share data.

Food Prices versus field crop prices

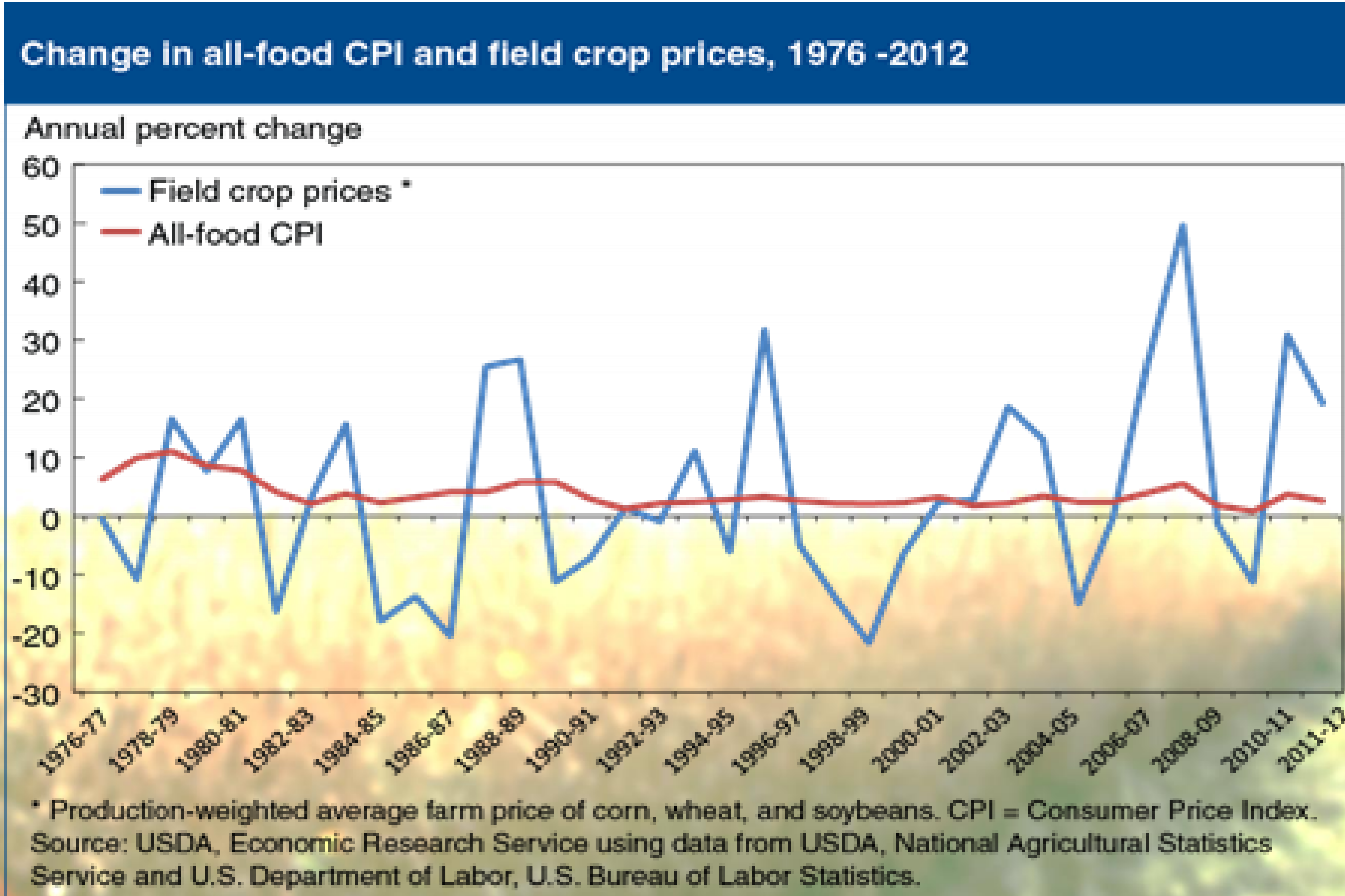
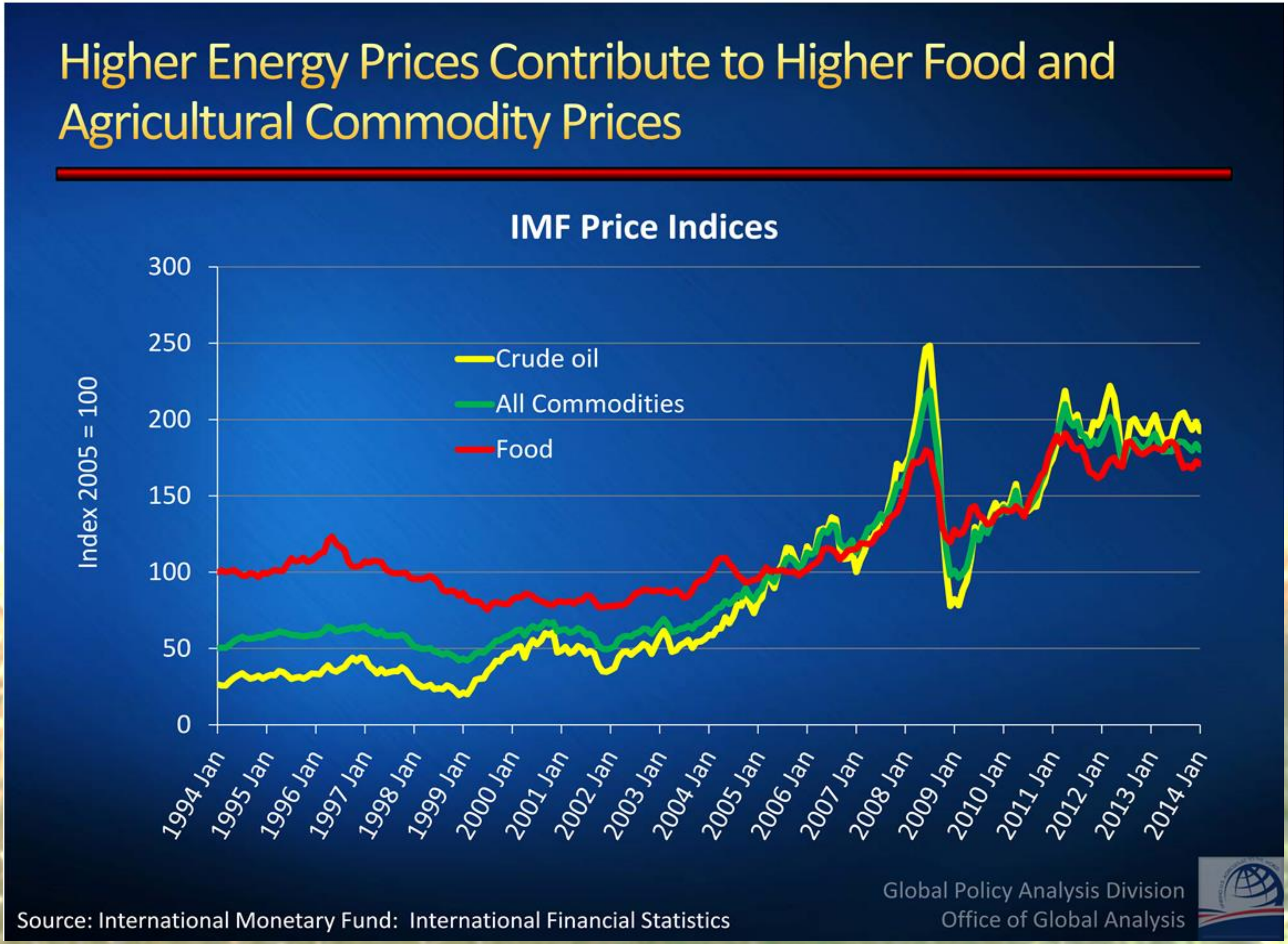


Chart: http://www.ers.usda.gov/data-products/chart-gallery/detail.aspx?chartId=41700&ref=collection&embed=True&widgetId=39734

Weather, energy and import/export policy shifts are key factors in food price spikes



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 Kline presentation on LUC: http://ieabioenergy-task38.org/workshops/campinas2011 on CBES website

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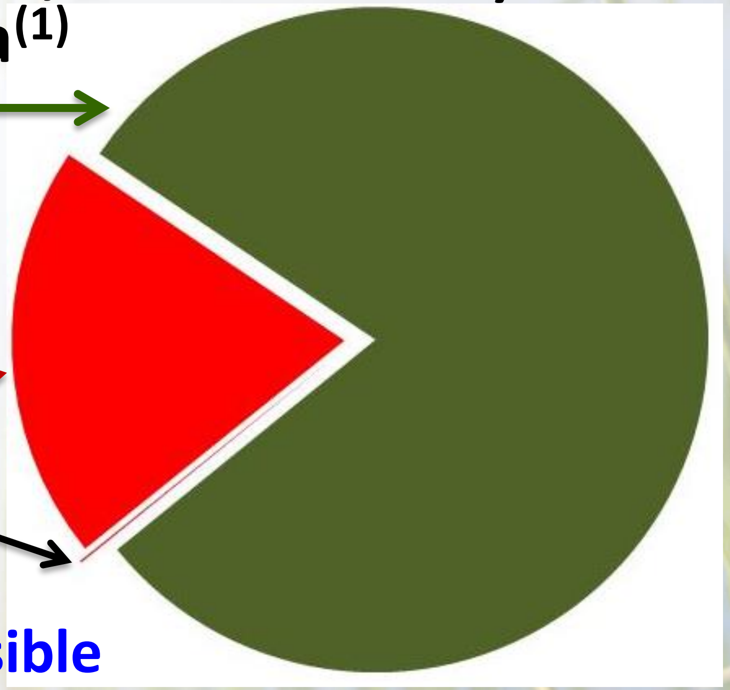
LUC estimates, compared to what?

- **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**

not visible

[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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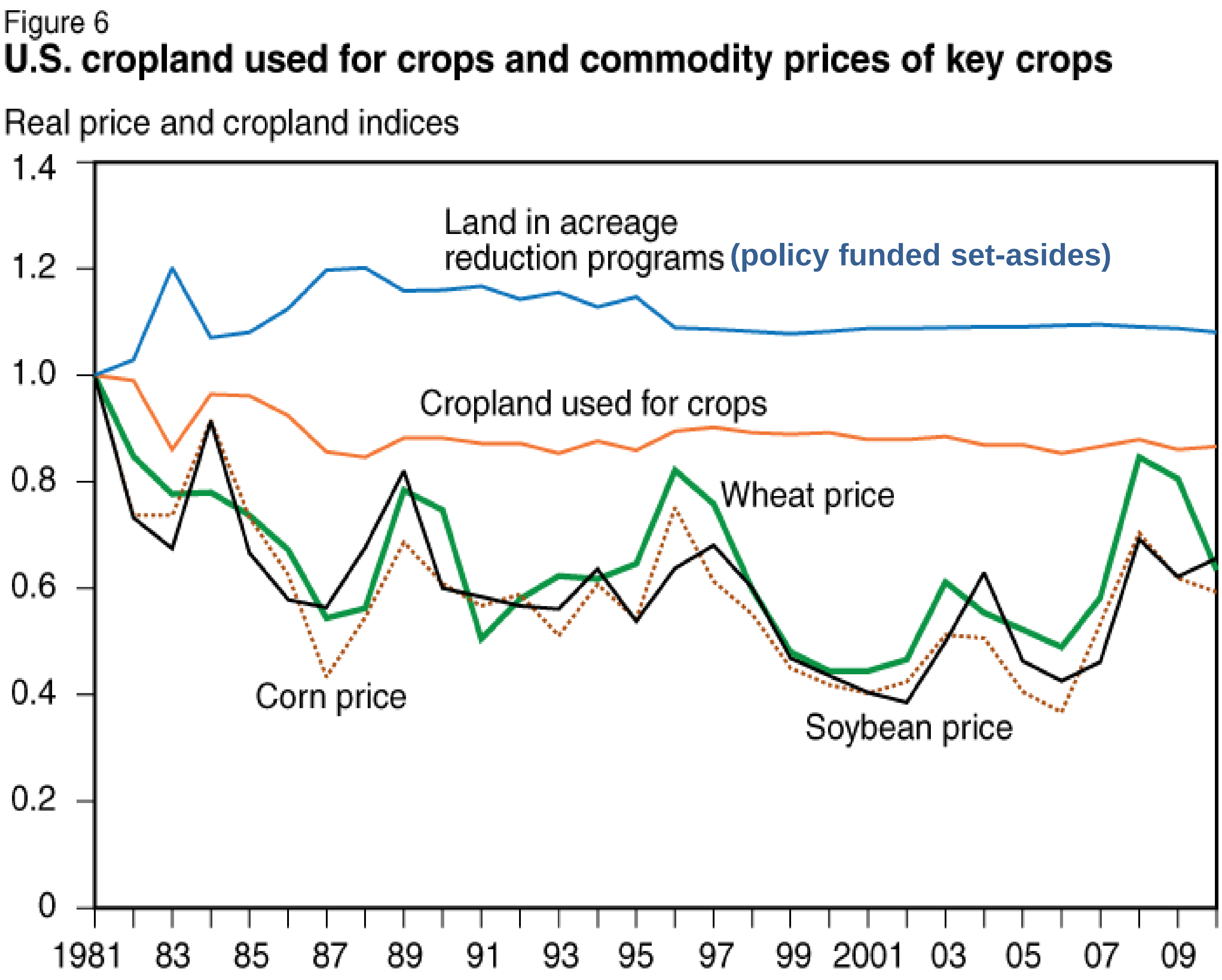
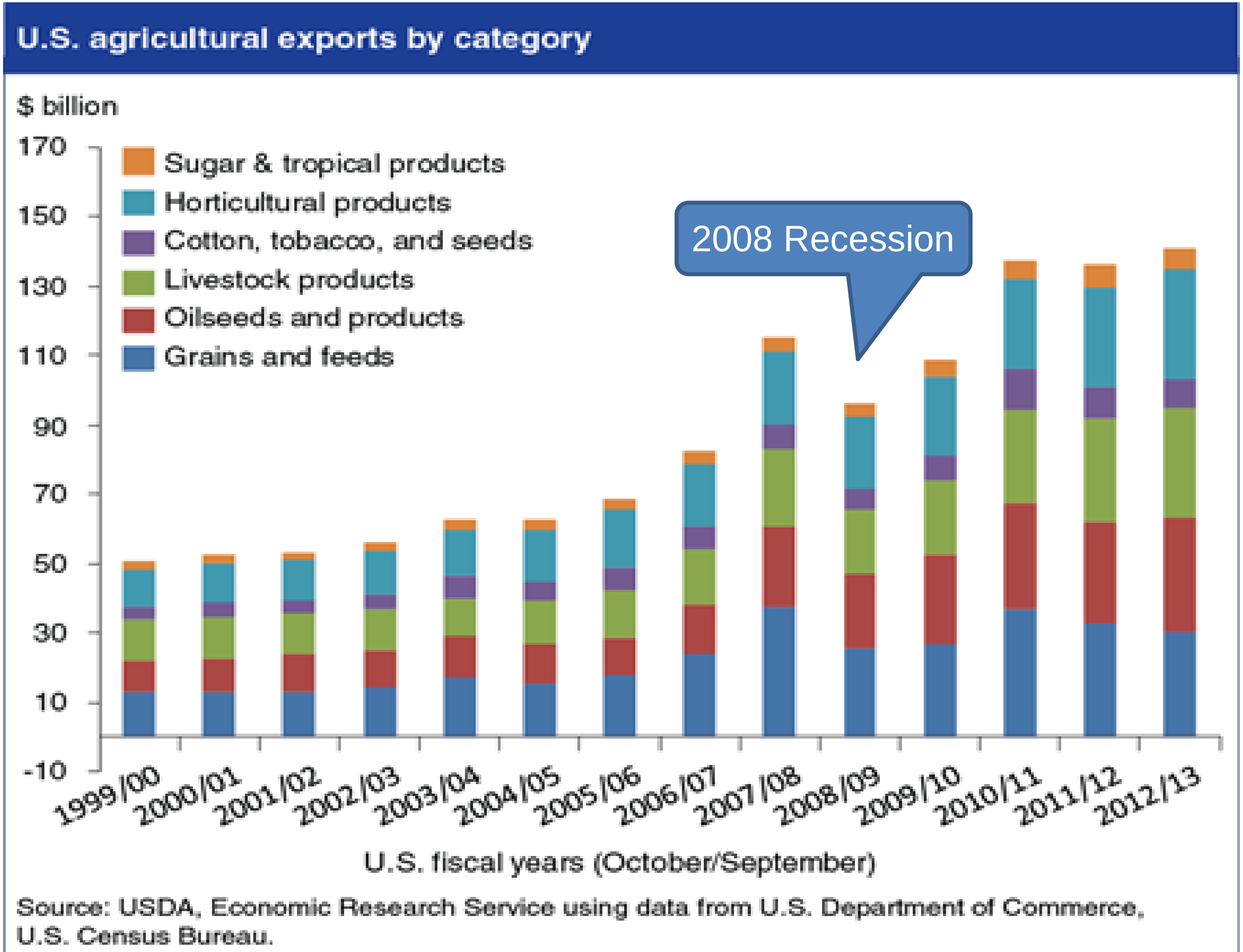
Check assumptions about price/LUC



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

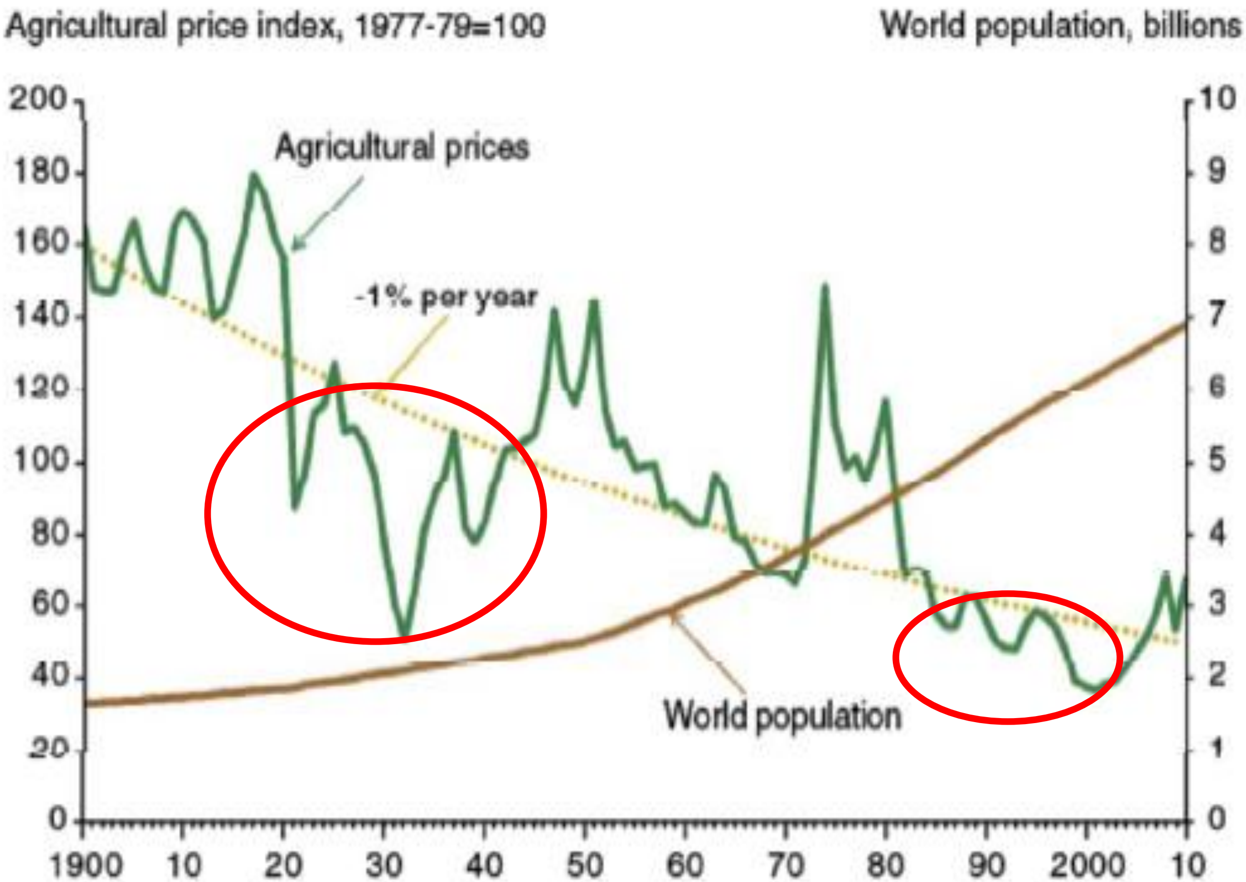
Contrary to some modeling assumptions, in the US, expectations of commodity prices and risk affect choices of ***what*** to grow on previously defined agricultural landscapes, not ***how much*** **total area** is dedicated to agriculture

U.S. agricultural exports nearly tripled from 2000 to 2013



http://www.ers.usda.gov/data-products/chart-gallery/detail.aspx?chartId=43538&ref=collection

Real agricultural prices have fallen since 1900, even as world population growth accelerated



Source: USDA, Economic Research Service using Fuglie, Wang, and Ball (2012). Depicted in the chart is the Grilli-Yang agricultural price index adjusted for inflation by the U.S. Gross Domestic Product implicit price index. The Grilli-Yang price index is a composite of 18 crop and livestock prices, each weighted by its share of global agricultural trade (Pfaffenzeller et al., 2007). World population estimates are from the United Nations.

Consider historic data and trends

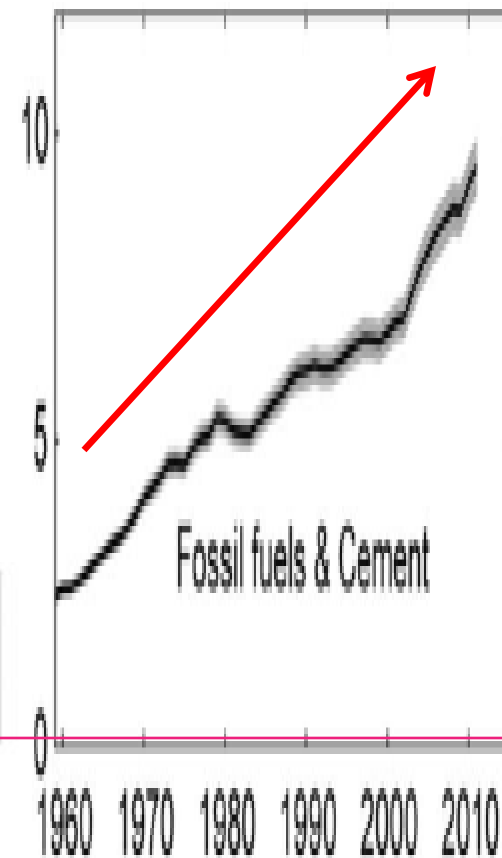
What drives destructive land transitions?

Crop prices?

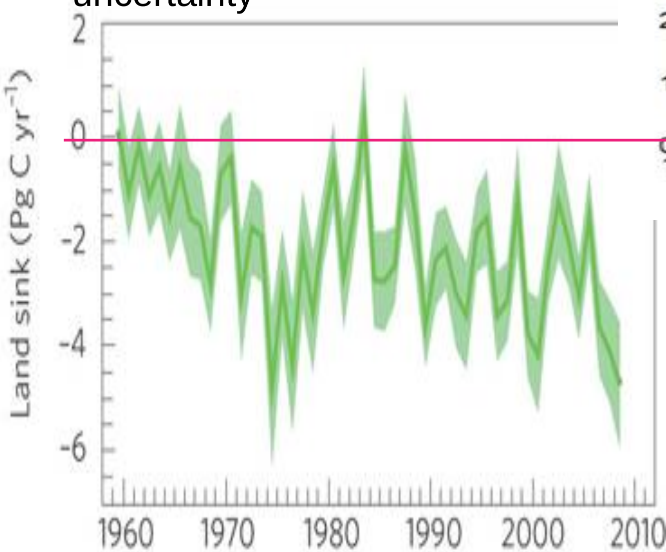
Putting global “Land Use Change” emissions into perspective (1960-2012)

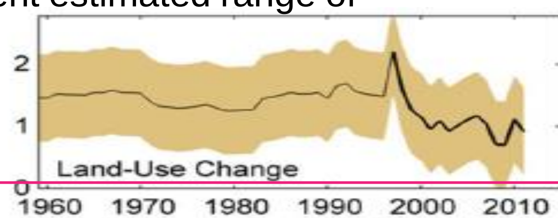
- Over 90% of current CO2 emissions from fossil fuels (GCP 2013)
- LUC emissions, uncertain, small and shrinking
- Land management: high importance as potential sink

Fossil emissions rising rapidly



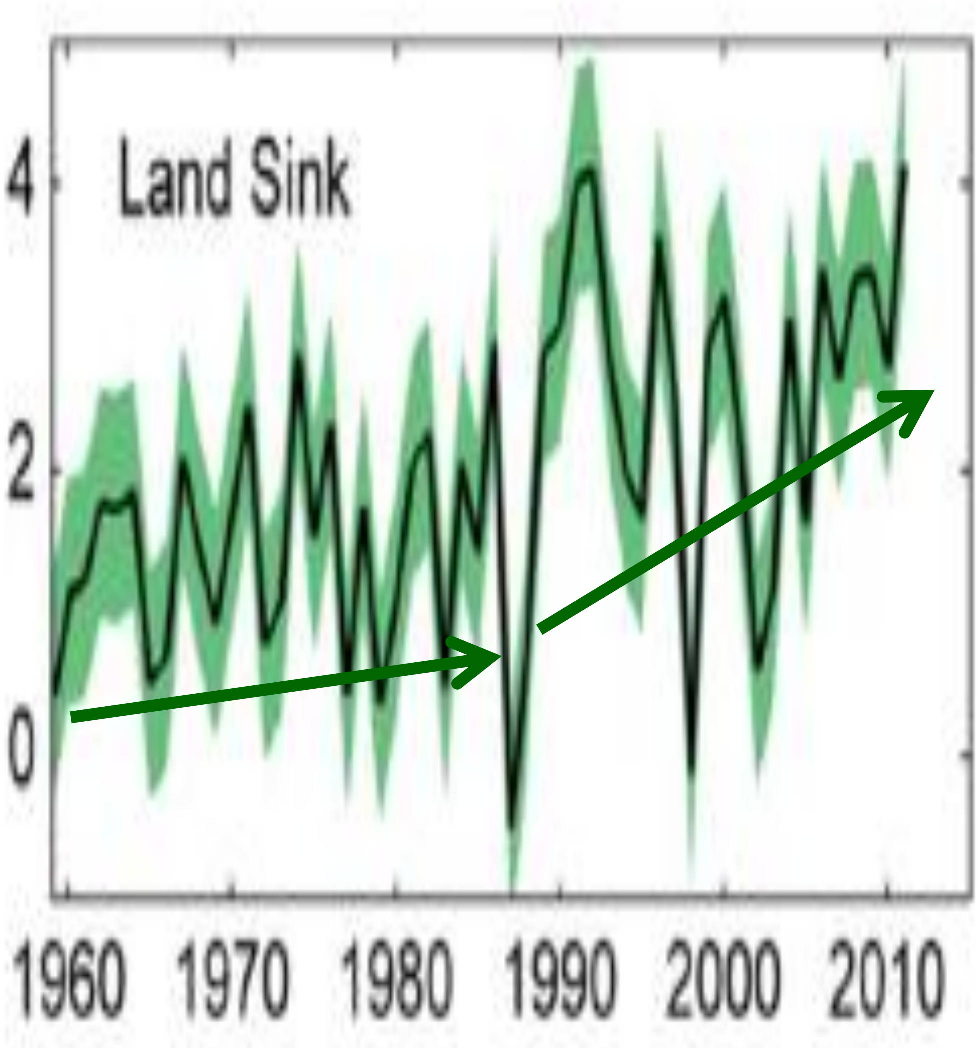
Shaded areas around lines represent estimated range of uncertainty





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?

Opportunities

- More emphasis on win-win policy and planning scenarios
- Build consensus on:
  - Goals
    - Criteria and indicators
    - How to measure them
    - Speak “common language”
  - Better models of human behavior ref. LUC
- Empirical data to test hypotheses
- International collaboration to resolve contentious issues…

Source: Adapted from Kline presentation to “Pathways to Climate Solutions: Assessing Energy Technology and Policy Innovation” Workshop organized by the Aspen Global Change Institute; 24-28 February, 2014. Aspen CO.

Opportunity to contribute to global multi-disciplinary collaboration

Sophie Hartfield, Global Calculator project leader

Department of Energy & Climate Change
eit Climate-KIC
WORLD RESOURCES INSTITUTE
Energy R&D International
CLIMACT
LSE THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE
Imperial College London
国家发展和改革委员会能源研究所
EY Building a better working world
CLIMATE MEDIA FACTORY

– Global initiative modeled on national tools http://2050-calculator-tool.decc.gov.uk/

User	Questions answered
Environmental NGOs and governments	Show at a glance how pathways from other models compare (e.g. IEA 2, 4 and 6D pathways).
All users	To make the case for tackling climate change by: • Showing detrimental impacts • Illustrating aspirational low emission pathways.

Opportunity to contribute to global multi-disciplinary collaboration

- The Global Calculator models carbon and land use dynamics for: Transport; Manufacturing; Electricity; Land, Bioenergy and Food (“Land/Bio/Food”); and Buildings.
- Many collaborating institutions:
  - Imperial College leads Land/Bio/Food with University of Versailles, PIK-Potsdam, Universities of Reading and Oxford
  - World Resources Institute leads Transport
  - ClimAct (Brussels, Belgium) - Manufacturing
  - Ernst & Young (Delhi, India) - Electricity
  - Energy Research and Development International (Beijing, China) - Buildings
  - Climate Media Factory at PIK-Potsdam - Visuals and online version of Calculator… London School of Economics and Political Science (LSE) is managing the climate science contribution.
- For more info see: http://globalcalculator.org/

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Global calculator – opportunity for multi-disciplinary collaboration

The level 1-4 range is simply a synthesis of what a wide range of credible experts believe could be possible by 2050.

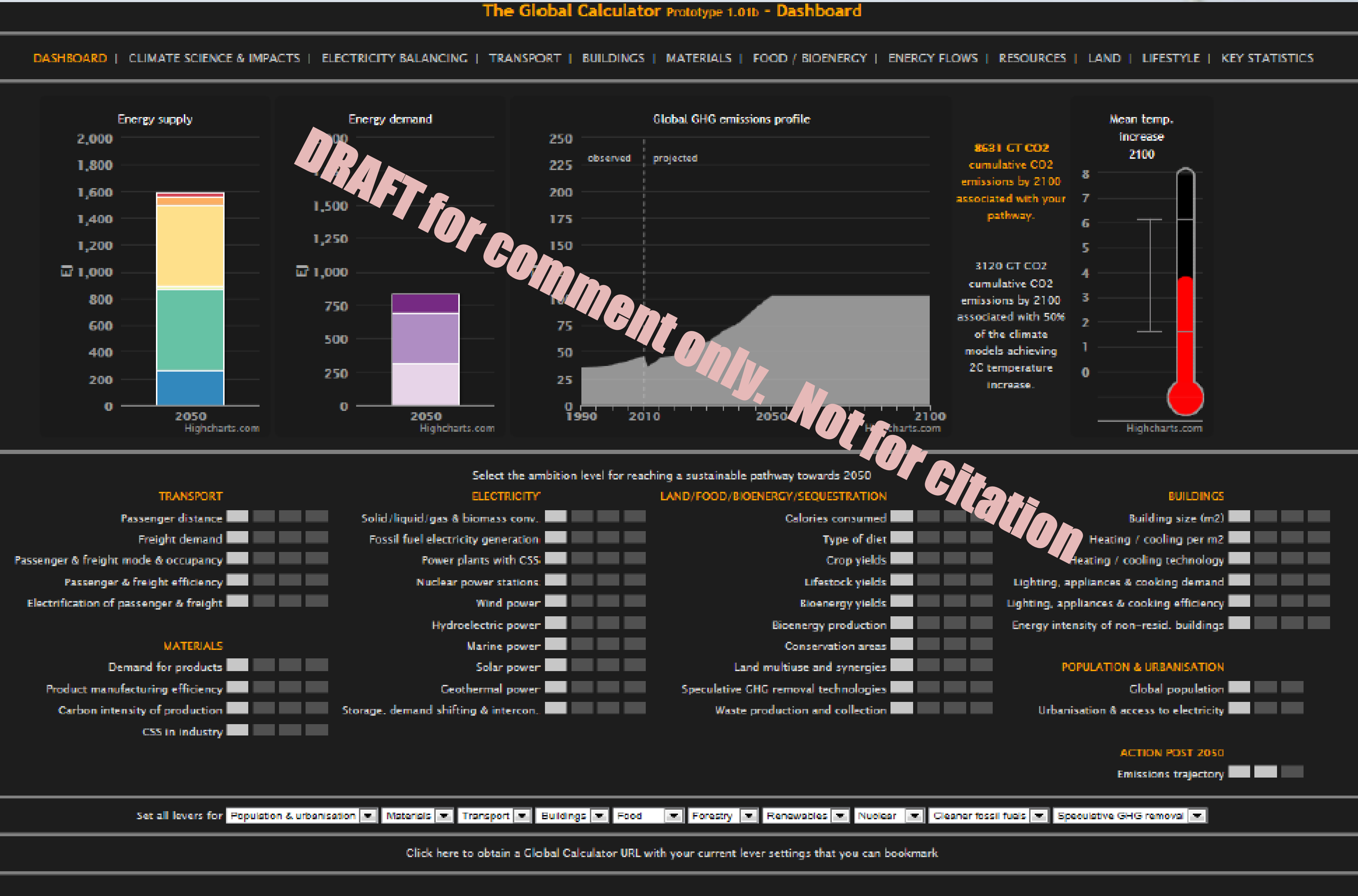
More abatement effort

Level 1: Minimum abatement effort	Level 2: ambitious but achievable	Level 3: very ambitious but achievable	Level 4: extraordinarily ambitious and extreme

Most experts will tend to congregate here

Only a minority of experts will think this is possible. An extreme view.

Global calculator – opportunity



Land-Bioenergy-Food “Levers” in calculator

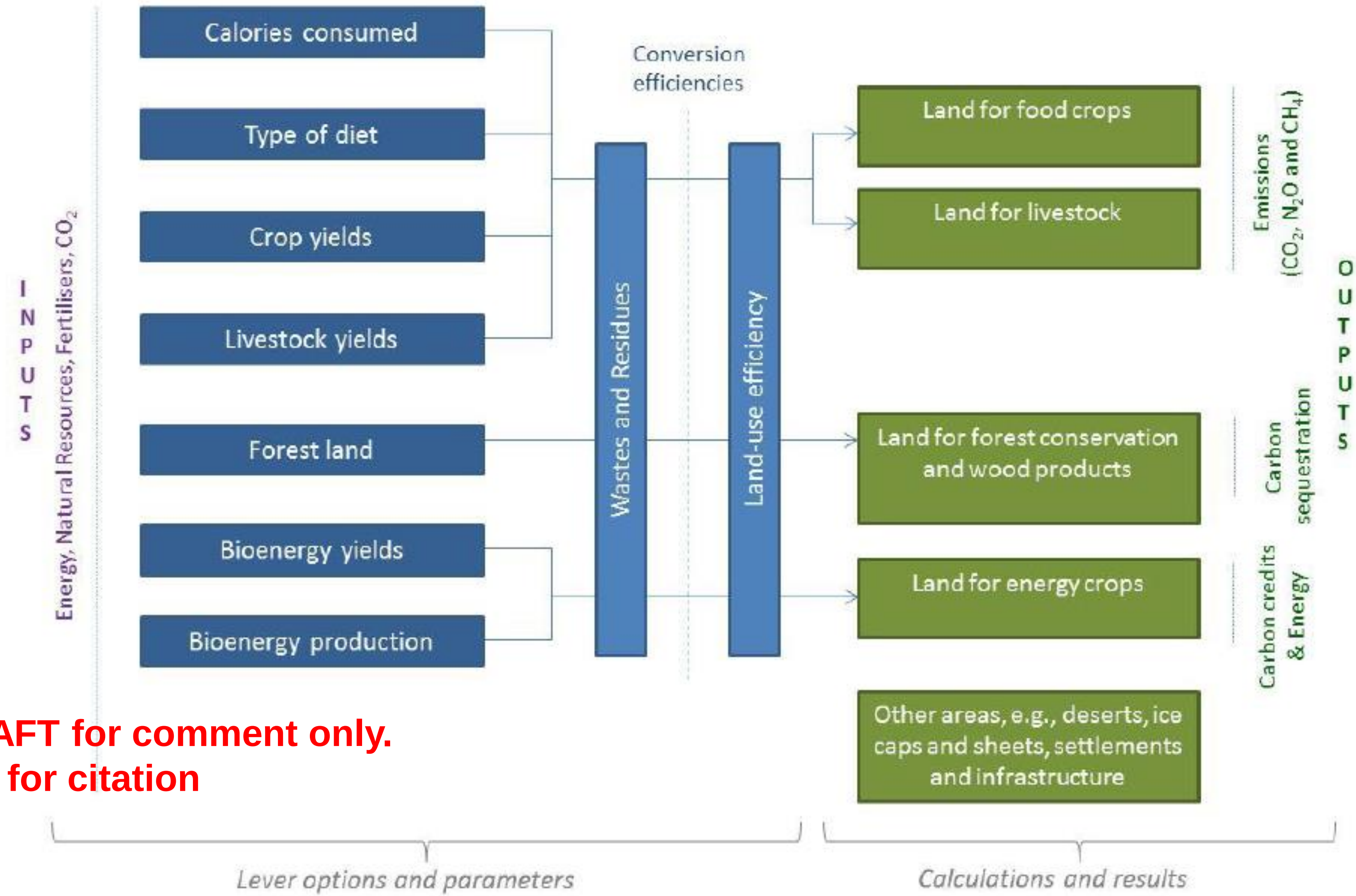


Figure 1: Land/Bio/Food Diagram of the Global Calculator

DRAFT for comment only.
Not for citation

Global calculator – opportunity for multi-disciplinary collaboration

You can help in the following ways:

- Send evidence on specific issues raised in the April workshops (do so by end April/early May).
- After release in July, send the link to 5 people in your organisation.
- After release in July, develop an example pathway we can include in the November/December version of the tool.
- After release in July, put link to tool on their web sites.
- After release in July, use and adapt the tool for your own purposes (it's an Open Government licence).
- After release in July, help with translation for the December re-release.
- Become a Global Calculator Ambassador... [see next slide]"

Global calculator – opportunity for multi-disciplinary collaboration

Global Calculator Ambassadors will be:

- Given access to an early release of the tool (e.g. 2-7 days early, depending on our project timings nearer the time)
- Encouraged to present the Global Calculator at any conferences/event, etc they attend using a standard slide pack prepared by our team.

Would you like to join the email distribution list to be a Global Calculator Ambassador? *If so, please contact Kerenza.McFaul@decc.gsi.gov.uk*

Thoughts for discussion

- Many research studies and analyses of potential begin with land. Is land the primary constraint? No…
  - 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)

Source: Kline presentation to “Pathways to Climate Solutions: Assessing Energy Technology and Policy Innovation” Workshop organized by the Aspen Global Change Institute; 24-28 February, 2014. Aspen CO.

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

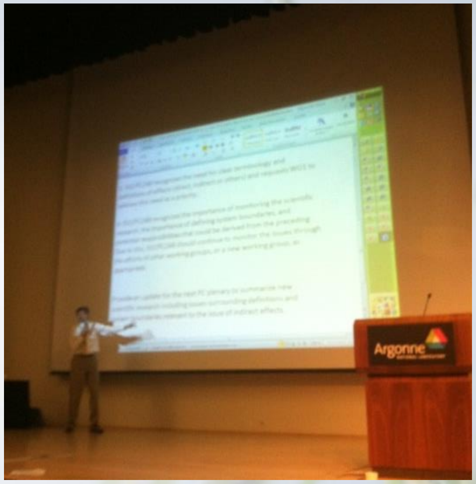
- Uses and markets
- Substitution options
- Bases of production

Adopt Systems Perspective

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

Source: Kline presentation to Coordinating Research Council CRC, Argonne IL, 13 Oct 2013

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***

Source: Kline presentation to "Pathways to Climate Solutions: Assessing Energy Technology and Policy Innovation" Workshop organized by the Aspen Global Change Institute; 24-28 February, 2014. Aspen CO.

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Example lever in DRAFT Climate Calculator

Levels 1-4 of the 'Bioenergy yields' lever are defined as follows (subject to the sub-levers described above):

- **Level 1** means a low yield increase of energy production per area, 50% overall by 2050, or approximately 1% a year. This is based on the current crop yield growth rate and includes the use of crops with low energy balance (e.g., corn-based ethanol, and oilseed-rape-based biodiesel).
- **Level 2** assumes a moderate increase in yields, 80% overall by 2050, or approximately 1.5% a year. It represents the global trend of using more efficient energy crops and technologies for bioenergy. It also requires better farm management and industrial integration with the production systems.
- **Level 3** considers a high yield increase, 120% overall by 2050, or about 2% a year by 2050. This yield growth is expected through an expansion of some new biofuels technologies, e.g.,
- **Level 4** represents an extreme increase of bioenergy yields, 280% overall by 2050, or 3.5% a year. This is based on advanced fuel technologies, biotechnology, state-of-the-art farm management, and further use of irrigation and fertilisers. This level assumes highly efficient energy crops (e.g., sugarcane, oil palm, switchgrass), would dominate the market and consequently also increase the average yield of bioenergy crops.

Example lever in DRAFT Climate Calculator

Levels 1-4 of the 'Crop yields' lever are defined as follows:

- **Level 1** represents a low productivity increase, 20% overall by 2050, or approximately 0.5% a year. This is much lower than the world yield growth presented in the past decades and may include some potential negative impacts of climate change on agriculture or availability of natural resources, e.g. water and fertilisers.
- **Level 2** assumes a moderate yield growth, 50% overall by 2050, or approximately 1.0% a year, which is a similar to FAO forecasts. It presumes that the current growth rates of productivity would be slightly reduced by 2050.
- **Level 3** represents that the global yield growth would increase 80% by 2050, or approximately 1.5% a year. This increase would be slightly higher than a linear trend from the past two decades. This level assumes a significant contribution from biotechnology, better farm management and technology transfer in order to reduce the yield gap, as well as capacity development programmes, and low climate change impacts on agriculture.
- **Level 4** presents extreme yield growth, 120% by 2050, or approximately 2.0% a year. This

Finally, the global calculator is a work in process and, therefore, the methodology here discussed and the calibration of all lever's levels are subject to further updates and improvements,

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

Source: Kline presentation to Vital Signs Trade-Offs Workshop, Oxford, UK, 6 Feb. 2014

Recommendation International Committee Food Security

20. Governments and other appropriate stakeholders are encouraged to review biofuels policies - where applicable and if necessary - according to balanced science-based assessments of the opportunities and risks they may present for food security, and so that biofuels can be produced according to the three pillars of sustainable development.

- McPhail et al. (2012) noted that speculation and oil price spikes are both important in the short run while in the long run petroleum price grows in importance and the role of speculation diminishes (see Table). However, ***in all time periods, speculation and other factors analyzed are more important in affecting corn prices than ethanol demand for biofuel***, often by an order of magnitude or more.

Table 1. Percent Contribution of Each Shock to the Variability in Real Corn Prices

Months	Global Demand Shocks	Crude Oil Price Shocks	Ethanol Demand Shocks	Corn Speculation Demand Shocks	Corn Market Shocks
1	1.18	9.48	3.02	13.56	72.76
6	16.81	10.54	1.08	6.43	65.14
12	13.05	17.97	0.92	3.74	64.33
24	7.44	26.42	0.76	2.08	63.31
36	5.14	30.27	0.69	1.43	62.47
48	3.95	32.34	0.66	1.09	61.97
60	3.22	33.60	0.64	0.88	61.66

- Note to Table 1: McPhail et al. tried to identify the share attributable to four specific types of “shock:” in global demand, crude oil price, ethanol demand, and corn speculation. “Corn market shocks” represented everything else not studied explicitly (weather, policies, exchange rates, etc.).

Source: Kline comments to FAO on draft report for contingency plans for “food price crises” April 18, 2014

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Acknowledgements

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M Wang (ANL), MTU-PIRE project, others

Research 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.

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