Joint Program on the Science and Policy of Global Change: Perspectives on Renewable Fuels

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Vision and Overview

MIT JOINT PROGRAM SCIENCE POLICY GLOBAL CHANGE

We explore the interplay between our global environment, economy and human activities, and the potential impact of policies intended to stabilize these relationships.

We're Supported by an International consortium of 41 major companies, 8 USA Federal Agencies and a Foundation.

Our Goals:

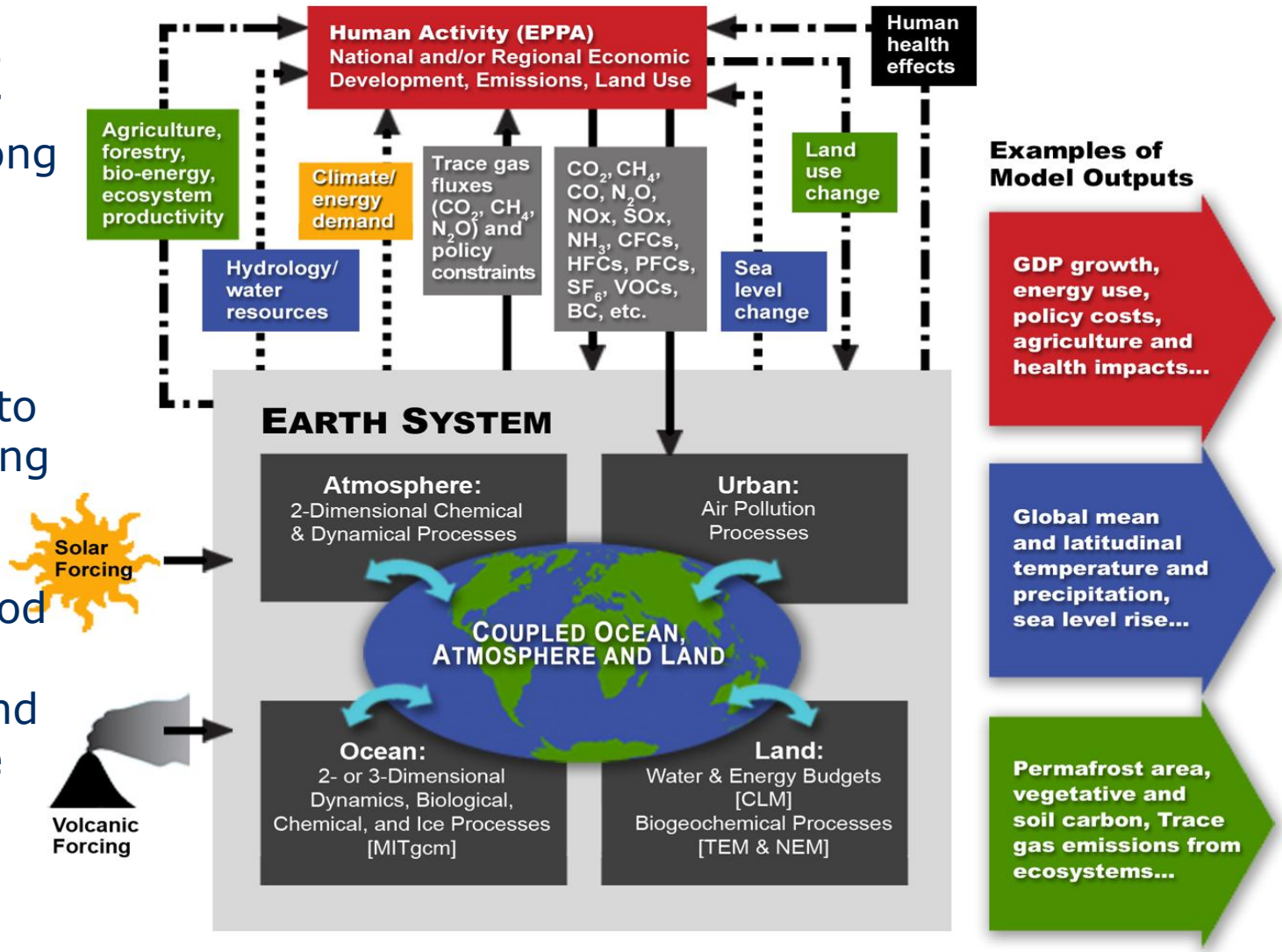
- **Discover new interactions among natural and human climate system components**
- **Objectively assess uncertainty in economic and climate projections**
- **Critically and quantitatively analyze environmental management and policy proposals**
- **Improve methods to model, monitor and verify greenhouse gas emissions and climatic impacts**
- **Understand complex connections among the many forces that will shape our future**

THE MIT INTEGRATED GLOBAL SYSTEM MODEL (IGSM)

Earth and Human System Links

The MIT IGSM is used to consider interactions among human activities and the natural earth system.

It is well-suited to issues surrounding biofuels—competition for land, growing food needs, deforestation, and indirect land use emissions.



The economic component of the IGSM is a general equilibrium model of the world economy with detail on energy and agriculture sectors

Sectors

Non-Energy

- Agriculture
- Energy Intensive Ind.
- Other Industry
- Services
- Industrial Transport
- Household Transport
- Other Household Cons.

Fuels Supply

- Crude oil
- Refined oil
- Biofuel
- Shale oil
- Coal
- Natural gas
- Synthetic gas (from coa

Electric Generation

Regions

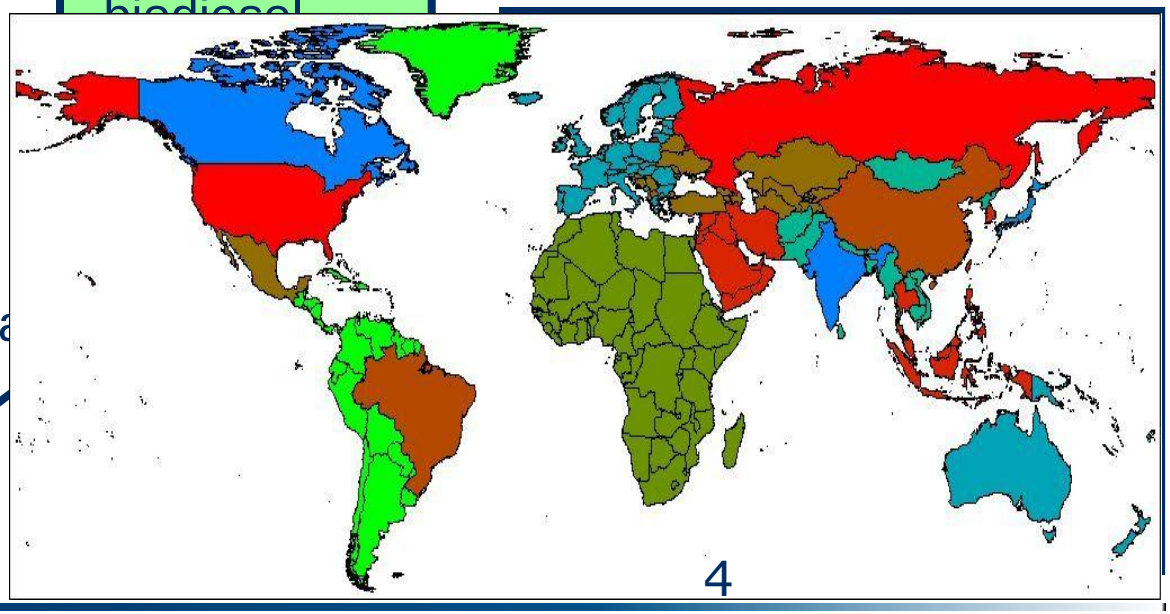
USA, EU, Rest of Eurasia, Canada, Japan, Aus. & N.Z., Russia

China, India, Middle East, Africa, Mexico, Brazil, Rest of Latin Am., Dynamic Asia, Rest of Asia

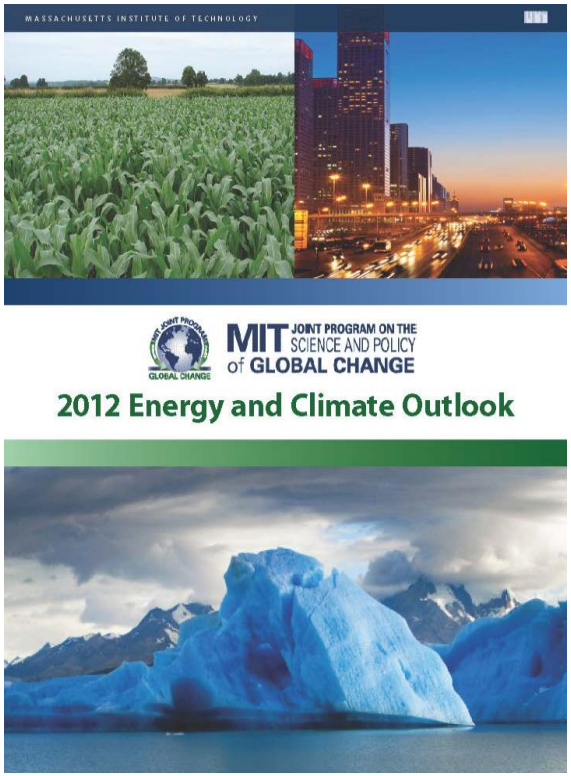
Crops
Livestock
Forestry
Biofuel crops

Crude, slate & gasoline
diesel,
petcoke
heavy oil,
biodiesel

Transport
Gasoline & diesel
PHEV, EV, Hydrogen
Biofuels, CNG



A New Feature of the Program is an Annual Energy and Climate Outlook



- Uses IGSM to look at the world's current development path and determine the associated energy and climate implications.

- Incorporates 2020 emissions reduction targets G20 nations made at the 2009 UN FCCC (i.e. Copenhagen pledges), showing how far these pledges take us, and what is at risk if we fail to push beyond these goals.

- Reports results for 3 broad groups:
  - Developed countries (USA, Canada, Europe, Japan, Australia and New Zealand)
  - Other G20 nations (China, India, Russia, Brazil, Mexico, and several fast-growing Asian economies)
  - The rest of the world

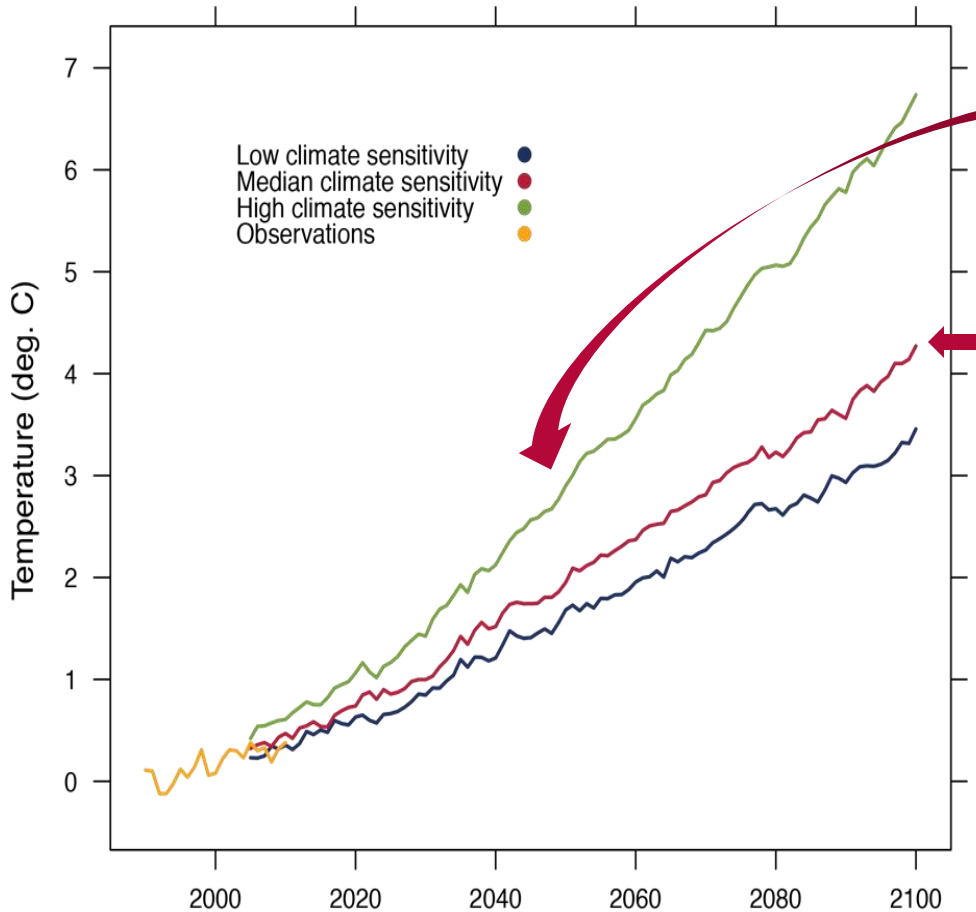
MIT Joint Program on the Science and Policy of Global Change, 2012. 2012 Energy and Climate Outlook, http://globalchange.mit.edu/research/publications/other/special/2012Outlook

Outlook: Findings

- Emissions in the developed countries will nearly stabilize, while global emissions will continue to grow rapidly.
- Global change will accelerate with changes in temperature, precipitation and land use, and the world's oceans will warm and acidify.
- Population and income growth will fuel a significant rise in vehicles and increase emissions, especially in developing regions.
- While further emissions cuts in developed countries would be useful, such cuts will have less impact on global emissions over time.
- A transition to alternative energy will begin in developed countries and China, but there will not be enough incentive to fully transform the energy system to avert dangerous levels of climate change.
- While emissions from fossil fuels are sizeable, other GHG and land-use emissions are important. If policies to reduce them fail, a major opportunity to limit climate change may be missed.

Outlook: Temperature Increase

To determine what this means for our climate, we developed 3 climate scenarios that capture the uncertainty in the Earth's response to the cooling from aerosols and warming from greenhouse gases: 50%, 90% and 99% probability.



2050: 1.7°-2.9°C
Median: 2°C

2100: 3.5°-6.7°C
Median: 4.3°

If both forest sequestration and biofuels are devoted to slowing climate change what pressures on food markets? (see below *)

- Consider how much land carbon sequestration would contribute to reducing warming if we could extend carbon pricing to land.
- Start with a GHG pricing policy that is based on a 550 ppm CO_2 stabilization target (520 ppm in 2100). Multigas target but excluding land use change.
- Extend same price level to create incentives for storing carbon in vegetation and soils (avoid deforestation, reforest, or more cropland, less pasture if there is more carbon)
- Implications for the climate, energy system, and agriculture.
- 4 scenarios: (1) Reference/No policy (2) Energy-only policy (3) Energy + Land (4) As in (3) but not allowing biofuels.
- A second generation non-food crop biomass fuel is represented.

**** Reilly, J., Melillo, J., Cai, Y., Kicklighter, D., Gurgel, A., Paltsev, S., Cronin, T., Sokolov, A. and Schlosser, A., 2012: Using Land to Mitigate Climate Change: Hitting the Target, Recognizing the Trade-offs, Environmental Science and Technology, 46(11): 5572–5679***

Less climate change and lower CO_2 emissions with policies. Terrestiral carbon benefits from both Energy-Only and Energy+Land

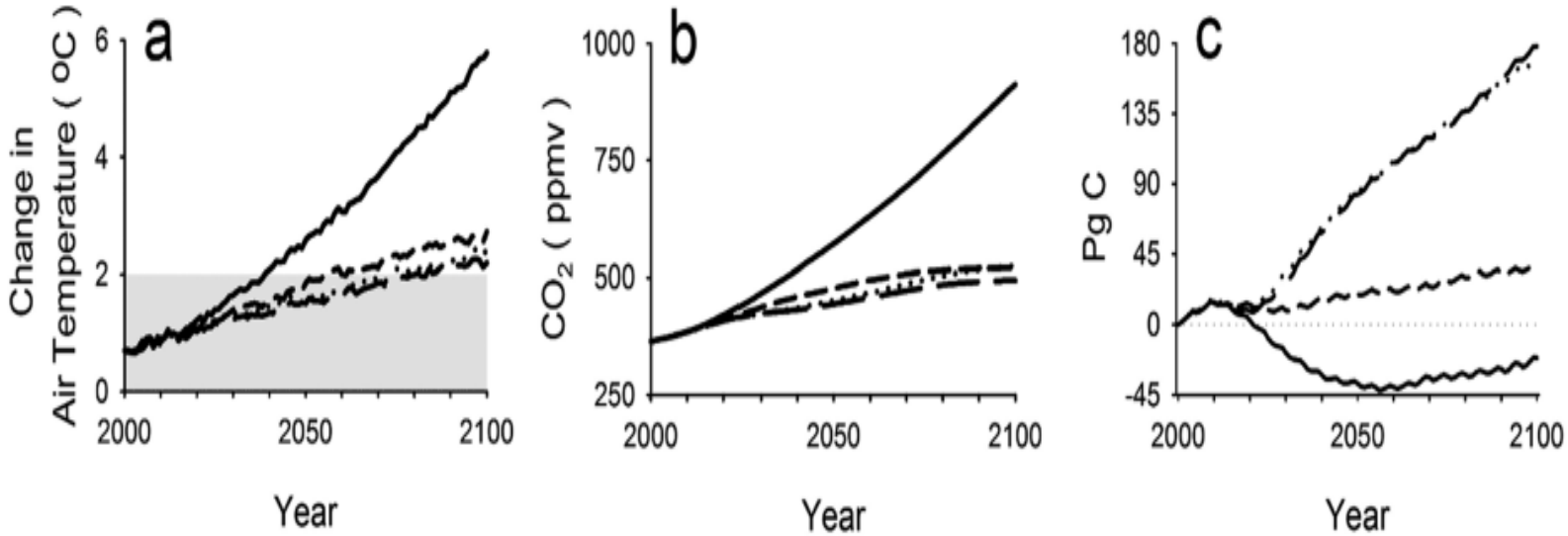
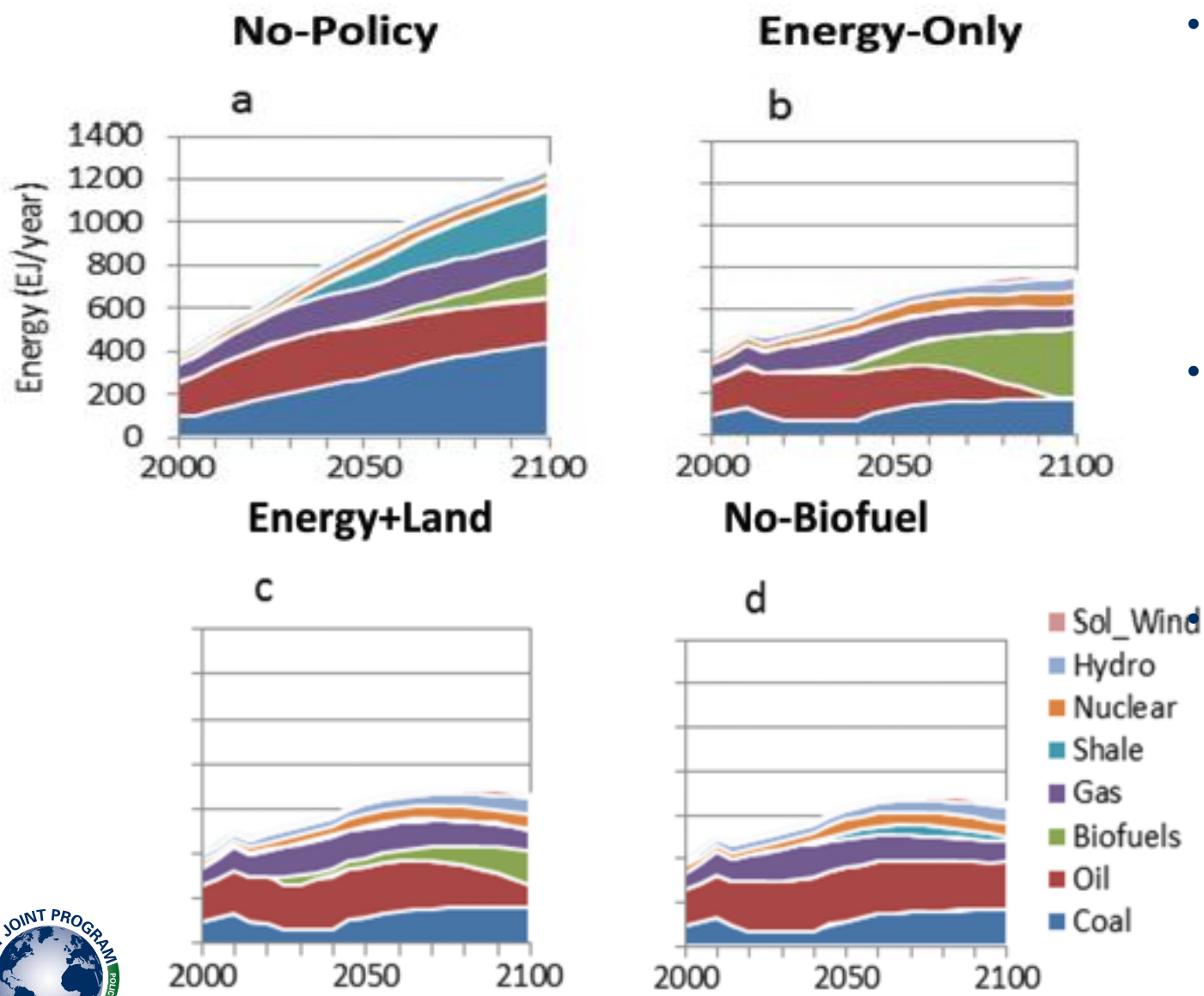


Figure 2. Changes in global mean temperature from preindustrial level (a), atmospheric carbon dioxide (CO_2) concentrations (b), and changes in cumulative land carbon fluxes (c) over the 21st century for different climate/energy policies: *No-Policy* (solid line), *Energy-Only* (short dashed line), *Energy+Land* (long dashed line), and *No-Biofuel* (dotted line). The shaded area in (a) represents the temperature goal of 2 °C above preindustrial of the Copenhagen agreement. Positive values in (c) represent net terrestrial carbon sequestration, while negative values represent net loss of terrestrial carbon to the atmosphere.

- Land policy gets us another ½ degree of avoided warming.
- Little/no difference between the no biofuels and biofuels policy.
- With land incentives, land is a major sink.
- Energy-Only avoids vegetation and soil carbon loss due to less need for land for crops because of less climate and ozone damage, even with a large biofuels production.

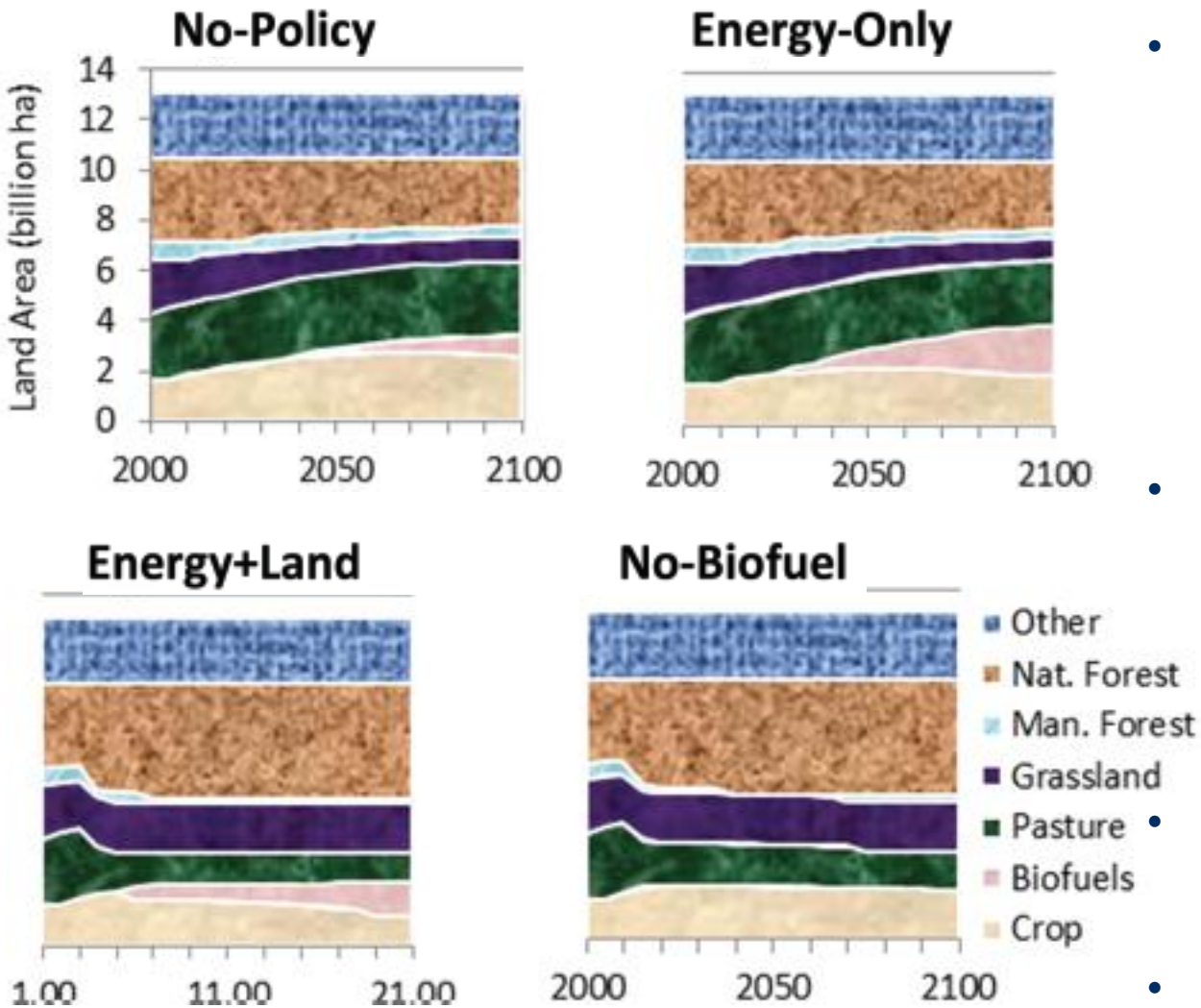
With No-Policy large growth in energy/fossil fuel use, some biofuels as oil prices rise.



- Energy-Only: All liquid fuels from biomass, large reduction in energy use, coal w/CCS
- Energy+Land: Less biofuels, some petroleum, less energy use.

No-biofuels: similar, more petroleum

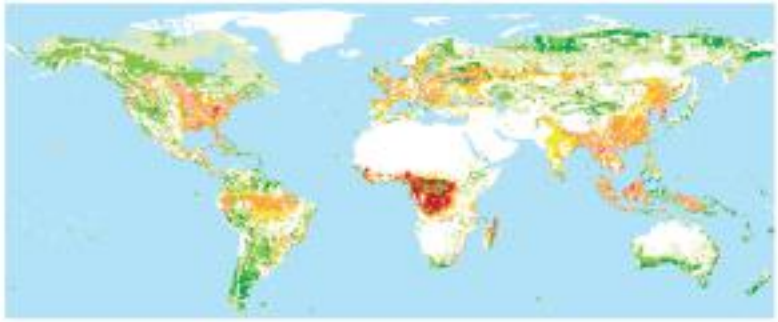
No Policy continued, but slowing, deforestation, more crop land because of climate/ozone damage to crops.



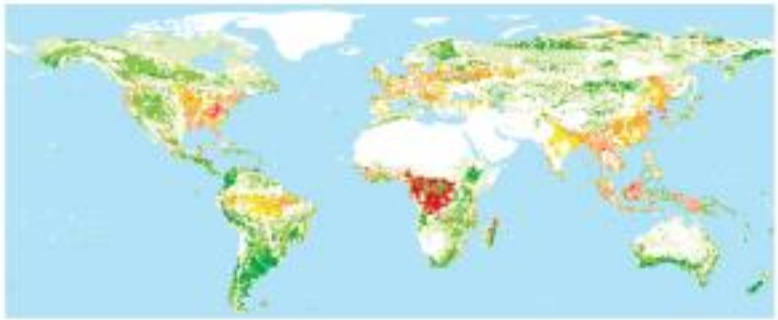
- Energy-only: more land biofuels, less to cropland due to competition from biomass crops and less damage to crops from ozone.
- Energy+Land: significant reforestation, with biofuels further push into crop and pasture land
- No-Biofuel: somewhat less impact on cropland.
- In all cases substantial yield growth in crops is assumed to continue

Regional patterns of change in land carbon

a) No-Policy



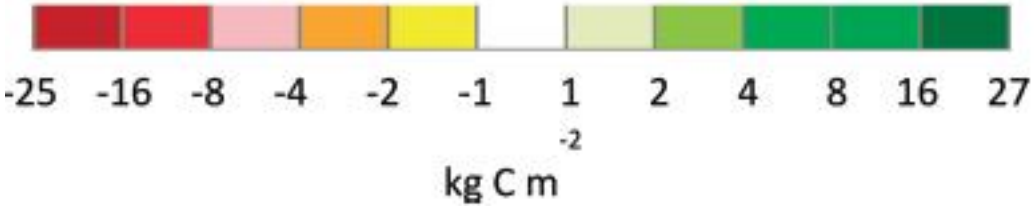
b) Energy-Only



Much loss, especially Africa, Asia

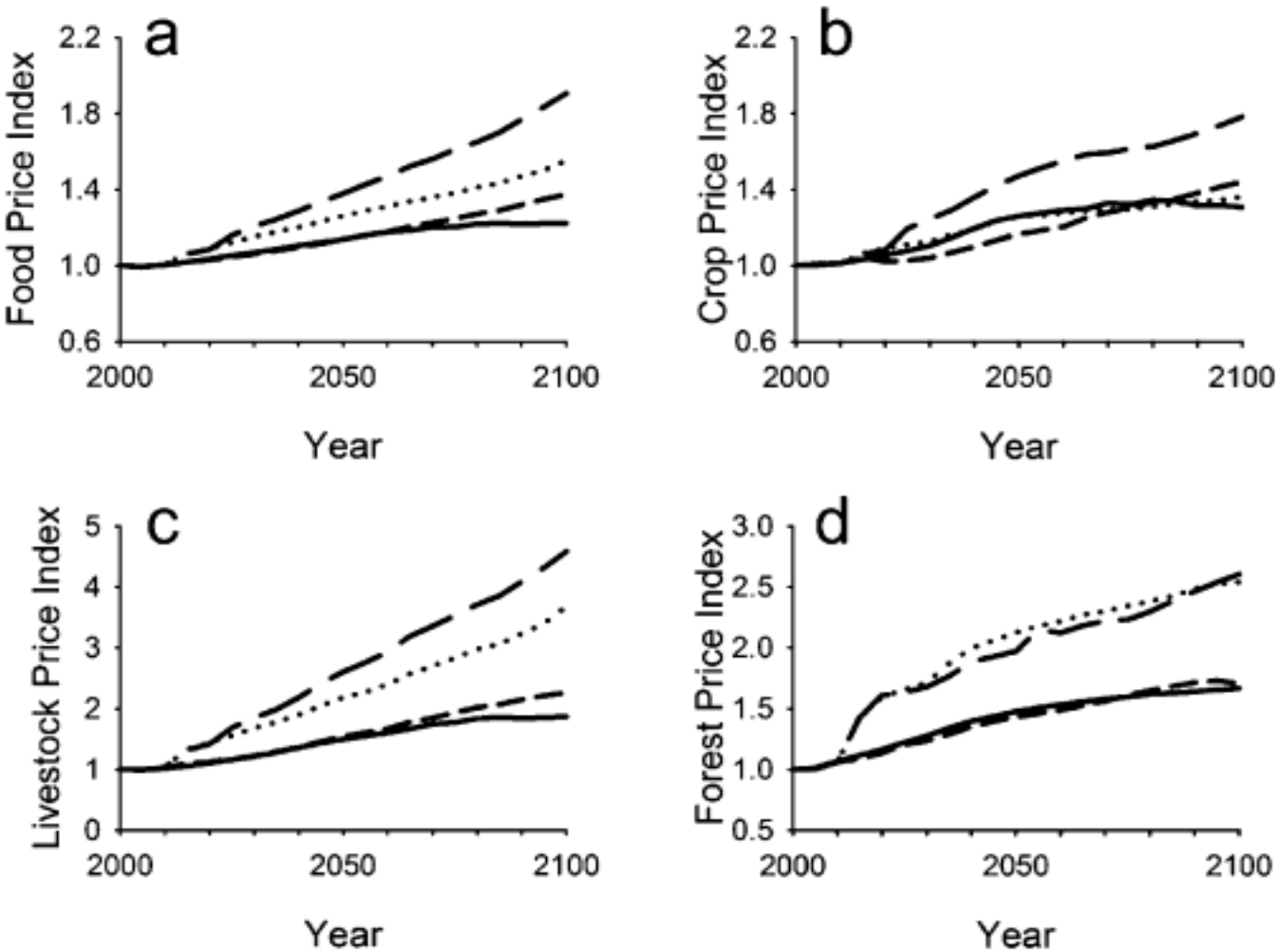
c) Energy+Land

d) No-Biofuel



Mostly gain

Big effects on food prices when land carbon is priced



Surprising result: No-policy and energy only about the same.

Less environmental damage w/ energy policy, but higher energy and GHG control costs offset benefit to crops.

Energy+Land has big price impacts. w/o biofuels some pressure off.

Solid: no-policy
Dots: No biofuels
Short Dash: Energy-Only
Long Dash:Energy+ Land

Insights on Biofuels Policy

- Very large biofuel production—all liquid fuel in some cases.
- Deforestation effect offset with land policies.
- Food price effects of existing biofuels policies have been highly exaggerated—in other work we find current EU/US policies impact food prices by 1% or less—consistent with the share of cropland diverted to biofuels production/supply elasticities for agriculture.
- Isolating biofuels to non-food crops still has food price effects transmitted through competition for land.
- Good biofuel policy: Attend to forest protection and food security for all, and biofuels will take care of themselves.
- If we go all out with biofuels and forest incentives we can put a big squeeze on food prices.
- But climate change and climate policy (through energy prices and cost of CH4, N2O control) will also affect food prices

Reilly, J., Melillo, J., Cai, Y., Kicklighter, D., Gurgel, A., Paltsev, S., Cronin, T., Sokolov, A. and Schlosser, A., 2012: Using Land to Mitigate Climate Change: Hitting the Target, Recognizing the Trade-offs, Environmental Science and Technology, 46(11): 5572–5679