


Resource Assessment and Land Use Change

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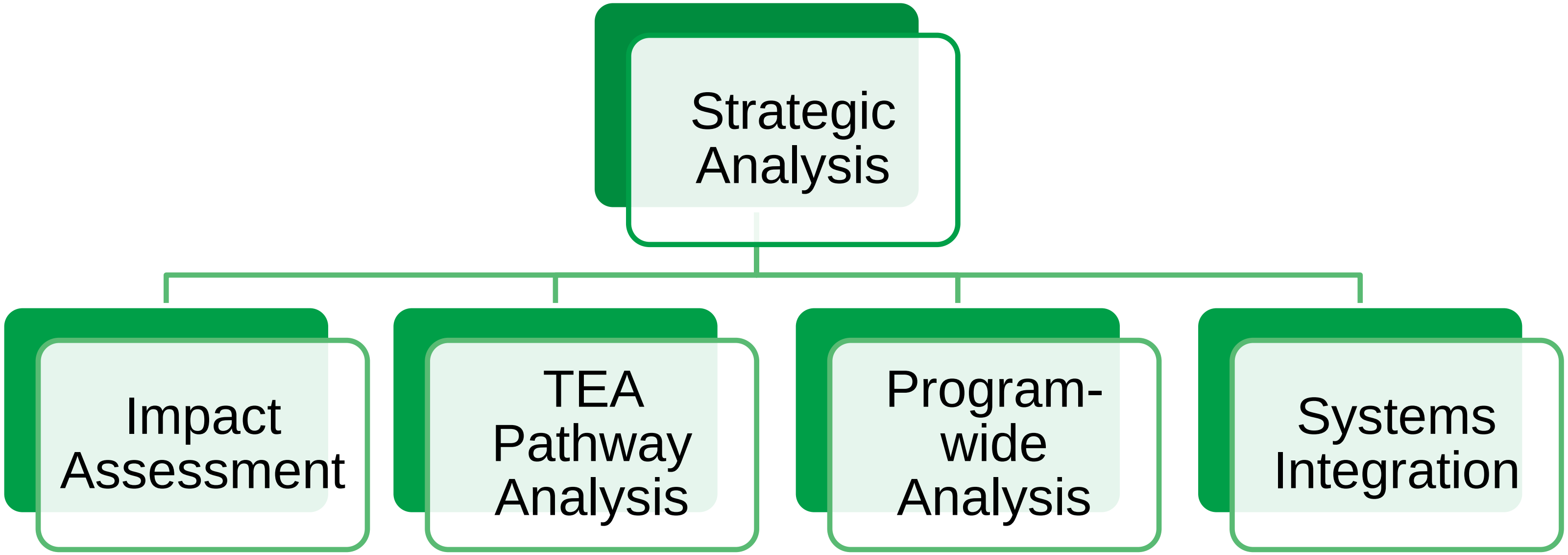
Light Duty Vehicles/Fuels
Workshop, July 26, 2010

Biomass Program Strategic Analysis Activities

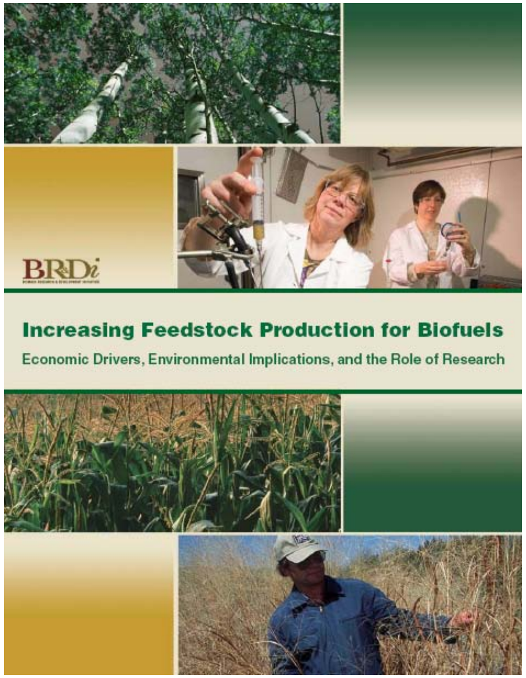


ANL, INL, ORNL, PNNL	NREL, PNNL, INL	PNNL, NREL, ORNL	

- FY10 Funding: $5.5 million strategic analysis, $2.5 million systems integration
- FY11 Funding (request): $4 million strategic analysis, $4 million sustainability, $2 million systems integration
- Resource assessment and indirect land use change

Increasing Feedstock Production for Biofuels:
Economic Drivers, Environmental Implications and the Role of Research

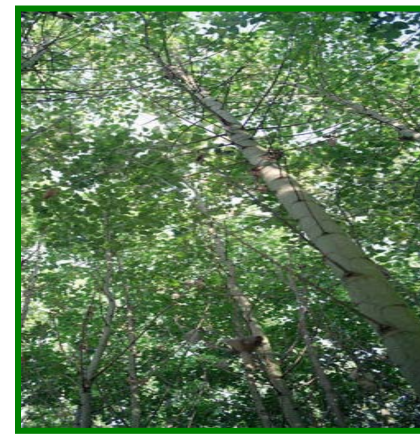
- Interagency and interdisciplinary team of researchers
- Economics
  - Co-chairs: John Ferrell (DOE), Mary Bohman (USDA, chair of feedstock team)
- GHG
  - Co-chairs: William Hohenstein (USDA), Dina Kruger (EPA)
- Sustainability
  - Co-chairs: John Houghton (DOE), Donna Perla (EPA), Bryce Stokes (Forest Service, USDA)
- Reviewers who greatly improved report
- Available at http://www.brdisolutions.com, December 2008



Goals of Report

- Inform investments in research and development to expand biofuel production
- Biomass feedstock supplies needed to meet EISA biofuels goal of 36 billion gallons/year by 2022
- Four questions
  - What feedstocks and at what price?
  - What is the regional distribution of feedstocks?
  - What are the consequences for sustainability and greenhouse gas (GHG) impacts related to feedstock production?
  - What are the implications for investments in research?

Scope and Approach of Report

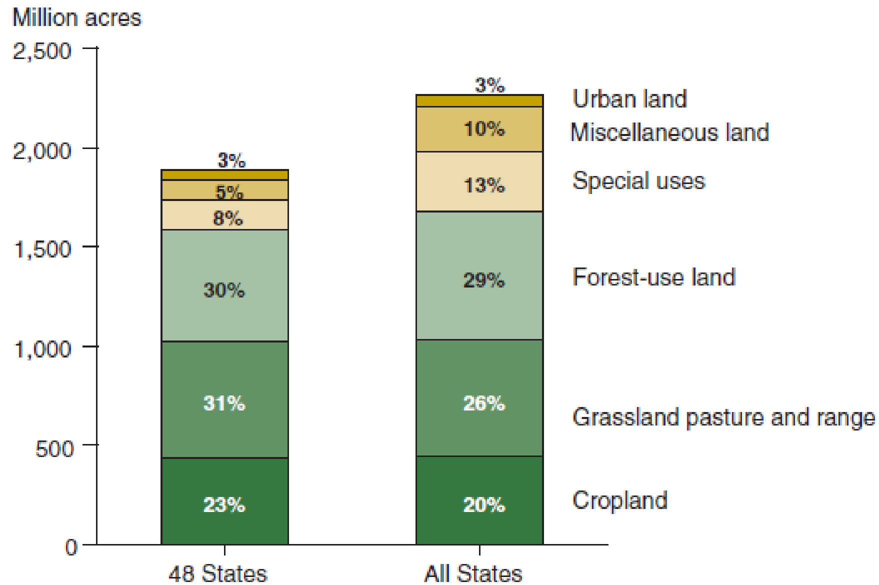


- USDA 2007 forecast used as baseline
- Feedstocks for 1st and 2nd generation biofuels from agriculture, forestry, and urban sources
- Feedstock production to farmgate or forest roadside (not transportation or conversion)
- Exogenous targets for biofuel production
- U.S. domestic focus
- Two models used
  - Regional Environment and Agriculture Programming (REAP) model maintained by USDA/ERS for first generation biofuels
  - Policy Analysis System (POLYSYS) model maintained by University of Tennessee for second generation biofuels
  - Forest sector model to derive supply of wood products to biofuels linked to POLYSYS
  - Urban wood waste exogenous in this analysis

Profitability is Key Consideration for Feedstock Producers

- Biofuels producers must compete based on price and seek the lowest cost combination of feedstocks, logistics, and conversion technology
- Feedstocks must be profitable for both the grower and the biofuel producer
- Land will be allocated among food, feed, fiber, (and fuel), according to the highest return to input resources. Amount of available cropland is the most significant constraint.
- The amount of biofuel produced will depend on what commodity provides the highest return in the market

Figure 2.1
Major uses of land in the United States, 2002

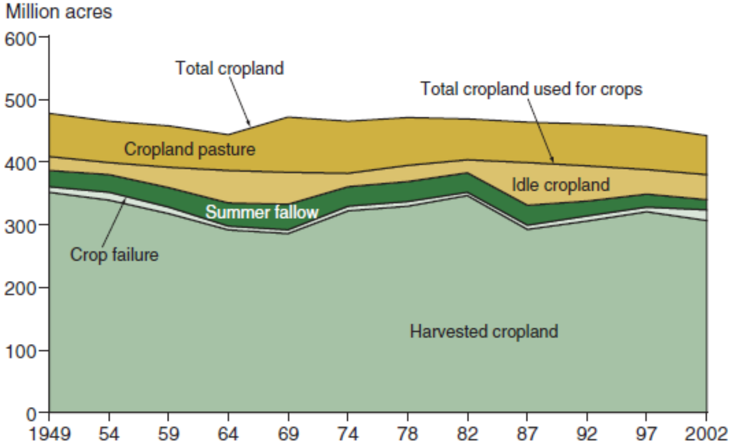


Note: Land for special use includes roads, parks, and recreational areas.
Source: USDA/ERS Major Land Uses database.

Feedstocks for First Generation Biofuels

- Meeting a 3 billion gallon increase in biofuels from 12 to 15 billion gallons would require a 3.6% in corn production with an associated increase in prices of 4.6%
- Prices for other crops increase, especially soybeans which compete directly with corn for land (3.2% soybean prices increase)
- Total crop acreage increases 1%; while corn acreage increases 4% (mostly in corn regions)
- Higher yielding corn from additional investment in R&D reduces the pressures on the agricultural sector
- Research to enhance productivity provides multiple benefits for markets, sustainability, and carbon reduction
- Changes in market conditions and policies such as a carbon tax, could reduce land pressures associated with increases in biofuels production

Figure 2.2
Major uses of U.S. cropland

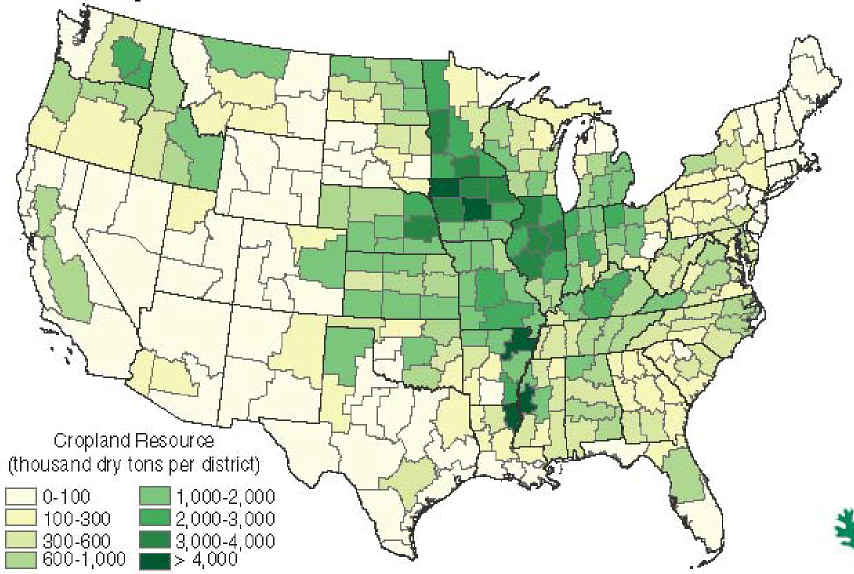


Source: USDA/ERS Major Land Uses database.

Feedstocks for Second Generation Biofuels

- Agricultural residues and energy crops can produce 20 billion gallons of cellulosic ethanol by 2022
- 16 to 19 million acres of land is required for energy crops to produce 12 to 20 billion gallons of biofuels (CRP acerage 34 million acres)
- Wider distribution of feedstock sources
- Forestland can produce 4 billion gallons of renewable biofuels
- Producer decisions are sensitive to profitability
  - Crop residues: sustainability and economic viability
  - Energy crop share increases with higher productivity

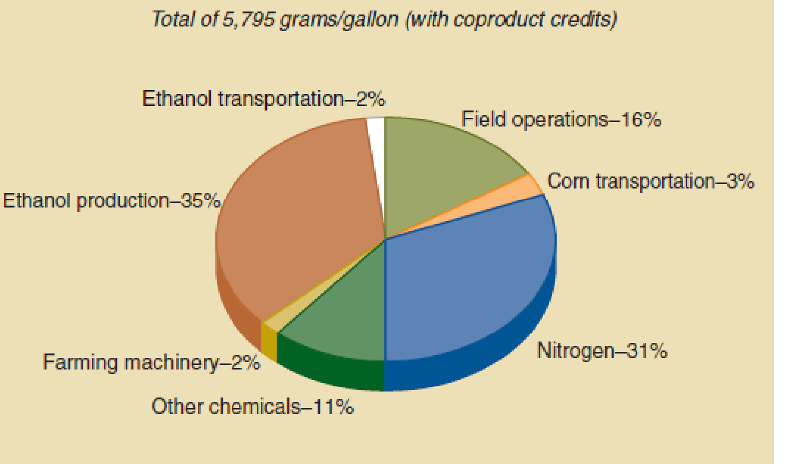
Location of cropland resources for production of 20 BGY of second generation biofuels



GHG Implications

- Total U.S. farm-sector GHG emissions increases by less than 10 million metric tonnes of CO2e
- Changes in farm activities generating the largest reductions in GHG emissions differ across scenarios
  - Supports a comprehensive approach to reducing the farm-sector share of GHG emissions related to biofuels
  - Emissions can be reduced by including a broad set of incentives targeting a variety of farm-sector activities and management decisions
  - Carbon market could be an effective way to increase biofuels production and reduce their GHG footprint

Figure 7.1
Shares of GHG emission for corn-based ethanol, by source



Source: GREET Model, Argonne National Laboratory.

GHG Mitigation via Agricultural Intensification

- Agriculture is a source of GHG emissions with opportunities for mitigation
- Future agricultural productivity is critical to minimize conversion of land for food, feed, and biofuels production
- A Stanford University study quantified the net effect on GHG emissions of agricultural intensification between 1961 and 2005
- The study found that emissions from input factors have gone up due to fertilizer application, however, the net effect of higher yields has resulted in reduced GHG emissions of up to 590 gigatonnes of CO2e since 1961
- The study recommends that further yield improvements should be prominent among efforts to reduce future GHG emissions

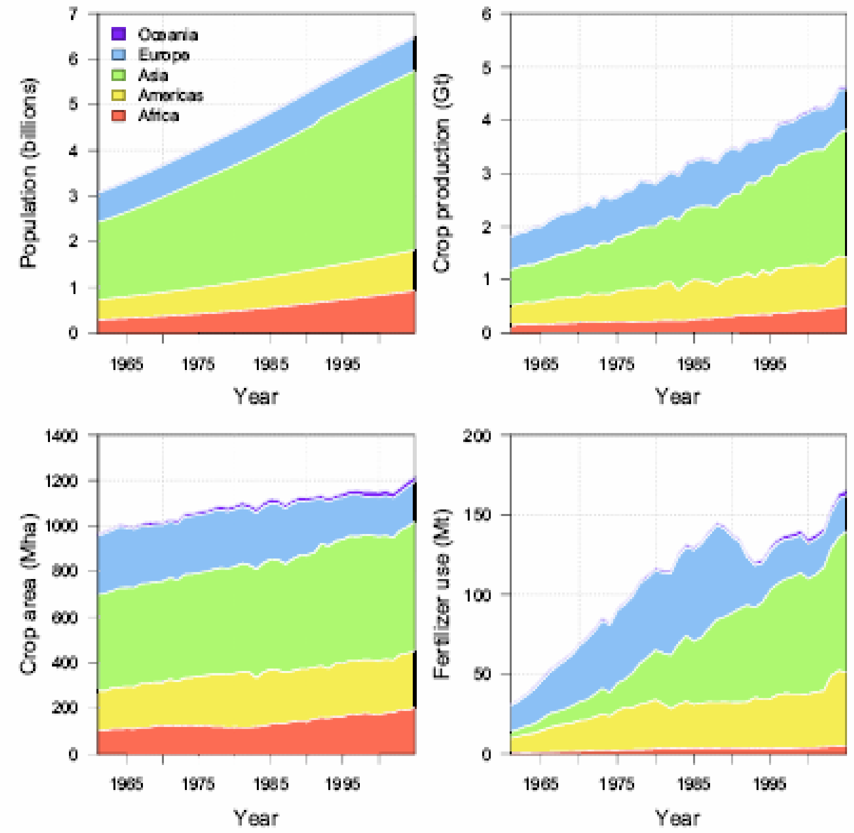


Fig. 1. Regional and global trends in population (*Upper Left*), crop production (*Upper Right*), crop area (*Lower Left*), and fertilizer use (*Lower Right*), 1961–2005.

Source: Jennifer Burney, Steven Davis, and David Lobell, "Greenhouse Gas Mitigation by Agricultural Intensification", Proceedings of the National Academy of Science, http://www.pnas.org/content/107/26/12052, May 4, 2010.

Sustainability Implications

- Combinations of different perennial crops (e.g. grasses and woody crops) can provide more diversity for species and habitat than do monocultures
- The amount of sustainably harvested crop residues varies depending on climate, soil texture, and production practices
- Improved corn yield reduced environmental impacts
  - Smaller footprint requires less intensive cultivation
  - Reduced quantities of inputs—even though each acre might require higher inputs
- Increased energy price also reduced impact
  - Farmer practices affected by higher fertilizer and diesel costs
  - Apply less fertilizer and employ conservation tillage at higher rates

Implications for Research Priorities

- Support research on a broad portfolio of feedstocks that reduces pressure on cropland
- GHG mitigation
  - Increases in crop productivity not tied to additional use of fossil fuel inputs
  - Reduce uncertainties in N_2O emissions associated with nitrogen fertilizer use
- Support research that leads to feedstocks that are profitable for farmers and forest managers to produce

Research Priorities for Modeling and Data

- Integrated agriculture, forestry & energy market models
- Upgrade the capabilities of economic models to analyze the GHG implications of changes in various programs, policies, and market conditions
- Capacity to analyze global land-use changes
- Integrate biophysical and behavioral models
- Capacity to analyze more complex solutions, e.g. uncertainty analyses
- Capacity to analyze variability over time
- Data for second and third generation feedstocks

Greenhouse Gas Emissions of Gasoline and Alternatives

Fuel	Pathway	Direct emissions (g CO2e/MJ)	Land use and other effects (g CO2e/MJ)	Total emissions (g CO2e/MJ)
Gasoline	CARBOB – avg. crude delivered to CA and avg. refinery efficiencies	95.86	0	95.86
Corn ethanol	CA – dry mill: wet DDGS: 80% NG: 20% biomass	47.44	30	77.44
Sugarcane ethanol	Brazilian sugarcane using average production processes	27.40	46	73.40
Compressed natural gas	North American natural gas delivered via pipeline compressed in CA	68.0	0	68.0
Liquefied natural gas	Overseas sourced LNG delivered to Baja, regasified and reliquefied at 80% efficiency	93.37	0	93.37
Electricity	California average electricity mix	124.10	0	124.10
Hydrogen	Compressed H2 from central reforming of NG	142.20	0	142.20

Source: California Air Resources Board, Low Carbon Fuel Standard, "LCFS Lookup Tables", Table 6, http://www.arb.ca.gov/fuels/lcfs/lcfs.htm

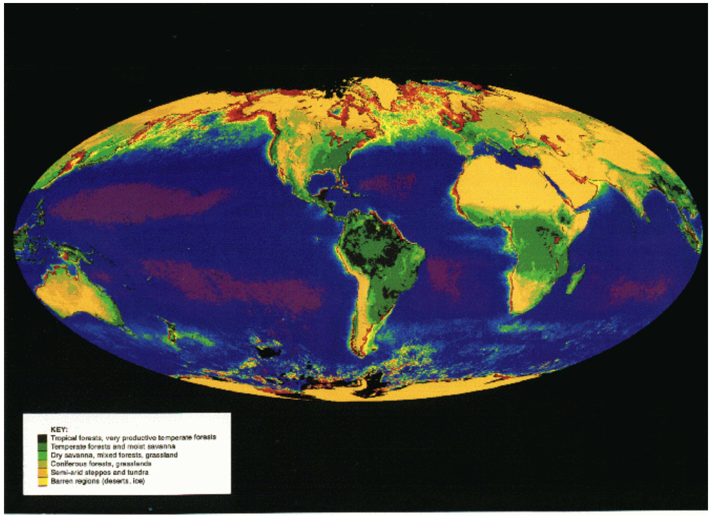
Greenhouse Gas Emissions of Diesel and Alternatives

Fuel	Pathway	Direct emissions (g CO2e/MJ)	Land use and other effects (g CO2e/MJ)	Total emissions (g CO2e/MJ)
Diesel	ULSD – avg. crude delivered to CA and avg. refinery efficiencies	94.71	0	94.71
Biodiesel	Conversion of Midwest Soybeans to biodiesel (fatty acid methyl esters – FAME)	21.25	62	83.25
Compressed natural gas	North American natural gas delivered via pipeline compressed in CA	68.00	0	68.00
Liquefied natural gas	Overseas sourced LNG delivered to Baja, regasified and reliquefied at 80% efficiency	93.37	0	93.37
Electricity	California avg. electricity mix	124.10	0	124.10
Hydrogen	Compressed H2 from central reforming of NG	142.20	0	142.20

Source: California Air Resources Board, Low Carbon Fuel Standard, "LCFS Lookup Tables", Table 7, http://www.arb.ca.gov/fuels/lcfs/lcfs.htm

Modeling the Land Use Impacts of Corn Ethanol

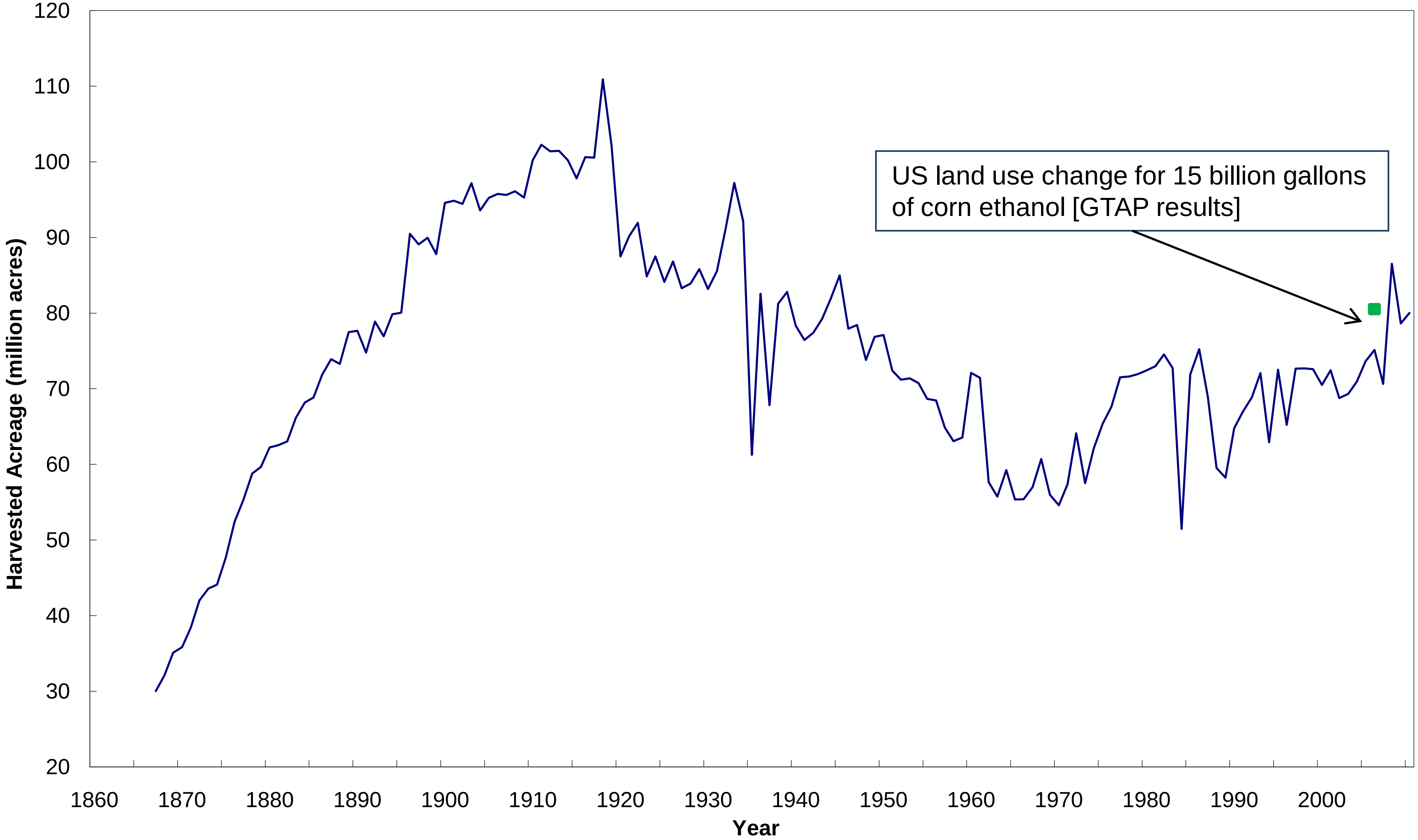
- Joint project funded by DOE and performed by Argonne National Laboratory and Purdue University
- Objective is to simulate the potential impacts of 15 billion gallons per year of corn-based ethanol (as per the Energy Independence and Security Act) on global land use patterns
- Purdue University used a global computable general equilibrium model Global Trade Analysis Project (GTAP) to simulate these potential modeled impacts
- GTAP-BIO modifications:
  - Updated database to move baseline from 2001 to 2006 world economy
  - Improved representation of ethanol, biodiesel, DDGS, and animal feeds
  - Improved assumptions of yield extensification (change in yield due to cropland expansion)
- Results:
  - Corn land use change impacts estimated to be 14 g CO2/MJ compared to 107 g CO2/MJ by Searchinger
  - Significant uncertainties remain



The patterns of plant life both on the land and in the oceans as observed from space.
Source: NASA

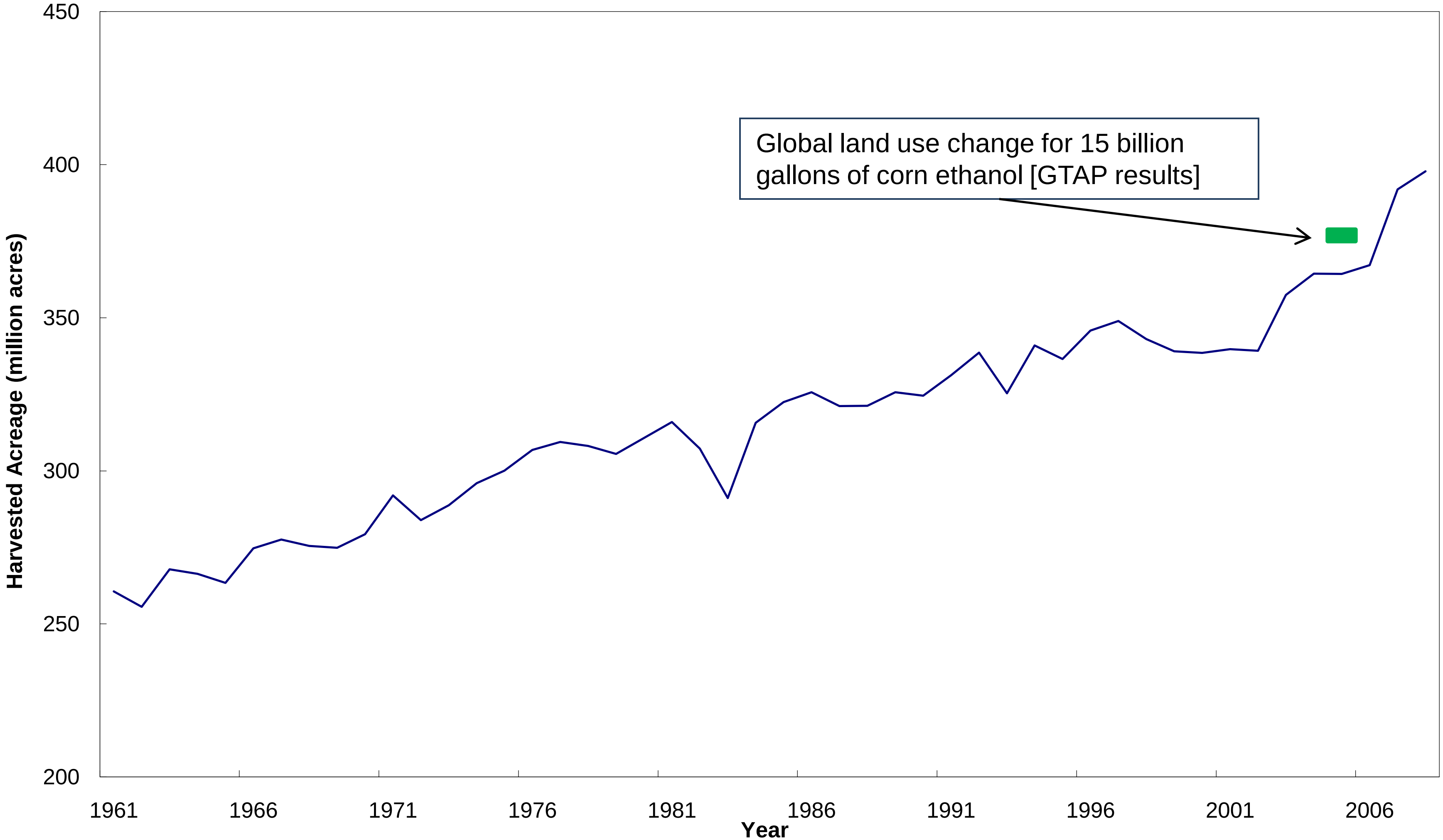
Full report available at: https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=3288 or http://www.transportation.anl.gov/pdfs/MC/625.PDF

Historical Acreage in Corn (U.S.)



Source: Corn acreage data from USDA, NASS
Ethanol land requirement data from "Land Use Change Carbon Emissions due to US Corn Ethanol Production: A Comprehensive Analysis", by Wallace Tyner et. al., Purdue University, Table 9, page 32, available at http://www.transportation.anl.gov/pdfs/MC/625.PDF April 2010

Historical Acreage in Corn (world)



Source: Corn acreage data from FAO, FAOSTAT database
Ethanol land requirement data from "Land Use Change Carbon Emissions due to US Corn Ethanol Production: A Comprehensive Analysis", by Wallace Tyner et. al., Purdue University, Table 9, page 32, available at http://www.transportation.anl.gov/pdfs/MC/625.PDF April 2010

Elements of a Land Use Change Model

- Global
- General equilibrium (agriculture, energy, forestry)
- Geo-spatially referenced
- Ability to back-cast and forecast
- Incorporate economic and social aspects of land use change
- Ability to generate policy-based scenarios and sensitivity studies
- Ability to establish cause-and-effect among the different drivers of land use change
- Ability to quantify the contributions of land use change drivers
- Ability to rapidly interchange different feedstocks, conversion technology pathways, and land use data
- Transparent, peer-reviewed, and in the public domain

Lessons Learned in Land Use Change

- Corn ethanol industry is becoming more efficient – new survey data will be reflected in GREET
- Residue based cellulosic biofuels are expected to have near zero land use change impacts
- Crop based cellulosic biofuels are expected to have lower land use change impacts than corn ethanol
- Biofuels induced land use impacts are manageable but need to be quantified
- Significant uncertainty remains despite work done to date – we do not have the appropriate tools to address this issue
- Better models and data are needed – earth observatory to inventory and track agricultural, forest, pasture, marginal lands
- Technologies to improve yield growth (particularly in developing countries) will be critical to meet future demands on land for food, feed, fuel, and fiber