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October 8, 2009

By Electronic Mail

Clerk of the Board
California Air Resources Board
1001 I Street, 23rd Floor
Sacramento, California 95812

15-Day Comments

Re: Notice of Availability of Modified Text and Additional Materials for Proposed Low-Carbon Fuel Standards (September 23, 2009)

Dear Madam:

Enclosed is the response of Growth Energy to the notice of availability of modified text and additional materials related to the proposed low-carbon fuel standards, released by the Executive Officer on September 23, 2009.

Sincerely,

David Bearden

David Bearden
General Counsel

STATE OF CALIFORNIA

AIR RESOURCES BOARD

PROPOSED REGULATION TO IMPLEMENT THE LOW CARBON FUEL STANDARD

GROWTH ENERGY'S RESPONSE TO THE NOTICE OF AVAILABILITY OF MODIFIED TEXT AND ADDITIONAL MATERIALS RELEASED SEPTEMBER 23, 2009

OCTOBER 8, 2009

For further information contact:

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Executive Summary

On September 23, 2009, the Executive Officer published a modified text for the proposed low-carbon fuel standards ("LCFS") and invited public comment on the new text and on additional materials that he indicated were being added to the rulemaking file.

For the reasons explained in Growth Energy's earlier comments on the proposed LCFS regulation, the Executive Officer should not finalize the proposed LCFS regulation, and should instead return the proposed regulation to the Board for further consideration. Growth Energy's prior comments explained why the proposed regulation would have serious unintended economic and environmental consequences, both for California and the nation as a whole. The notice filed on September 23 and the materials published with that notice underscore the reasons why the Executive Officer should return the proposed regulation to the Board.

These additional comments establish the following points:

1. The September 23 notice does not correct the procedural and substantive defects in the new (and now revised) cane ethanol pathways on which Growth Energy has previously commented. A declaration being filed with these comments establishes that, in addition to earlier errors and omissions, the newly revised cane ethanol pathway description fails to account for emissions associated with the processing and transport of Brazilian cane ethanol to California. (*See* pp. 1-2 below.)

2. The September 23 notice does not take account of new information concerning the reliability of the econometric model being used to develop indirect land-use change emissions estimates, nor updated results from that model that demonstrate that the carbon intensity ("CI") values assigned to corn ethanol in proposed section 95486 need reconsideration and revision. (*See* pp. 3-6 below.)

3. None of the new proposed CI values for section 95486 appear to have been given peer review, as required by the California Health & Safety Code. It is also a subject of great concern that the Executive Officer has still not responded to earlier, adverse peer review comments on the indirect land-use CI values assigned to the ethanol pathways. (*See* p. 7 below.)

As permitted by the California Public Records Act, a legal representative of Growth Energy has submitted a request for public access to records related to the cane ethanol pathways and the model being used to estimate indirect land-use impacts, among other subjects. The response to that request has been delayed, for reasons not yet fully explained. Once the records that Growth Energy has requested become publicly available, Growth Energy may submit additional comments to the Executive Officer.

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List of Selected Acronyms

AIR	Air Improvement Resource, Inc.
APA	California Administrative Procedure Act
ARB	California Air Resource Board
CA-GREET	California Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model
CEQA	California Environmental Quality Act
CI	Carbon Intensity
DGS	Distillers Grains with Solubles
g/MJ	Grams of Carbon-Dioxide-Equivalent Emissions per Megajoule Energy
GHG	Greenhouse Gas
GREET	Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model
GTAP	Global Trade Analysis Project
ISOR	Initial Statement of Reasons
LCFS	Low Carbon Fuel Standard
LHV	Lower Heating Value
NCGA	National Corn Growers Association
ORNL	Oak Ridge National Laboratory
RFA	Renewable Fuels Association

Response by Growth Energy to the Notice of Availability of Modified Text and Additional Materials for the Proposed Regulation to Implement the Low Carbon Fuel Standards Regulation (Released September 23, 2009)

Growth Energy is an association of the nation's leading ethanol manufacturers and other companies who serve the nation's need for alternative fuels. Representatives of Growth Energy testified at the hearing conducted by the Air Resources Board ("ARB" or "the Board") to consider adoption of the proposed low-carbon fuel standards ("LCFS") regulation, and submitted written comments on ARB's initial statement of reasons ("ISOR") in support of the proposed LCFS standards. Growth Energy has also submitted comments and analyses on the LCFS rulemaking and proposed standards for consideration under the California Environmental Quality Act ("CEQA") and the Board's implementing regulations at 17 C.C.R. §§ 60000-60008, which were combined with comments on the Notice of Availability of Modified Text in the LCFS rulemaking released on July 20, 2009.

Growth Energy's comments today cover three subjects: (i) the Executive Officer's revisions to the carbon intensity ("CI") values in the ARB Lookup Table in proposed section 95486; (ii) newly available information concerning the predictive model being used by ARB to determine indirect emissions CI values for certain biofuels; and (iii) the need for additional peer review of the scientific basis for the proposed revisions to the ARB Lookup Table.

I. Revised Cane Ethanol Carbon Intensity Values.

In the comments provided to the Executive Officer on August 19, 2009, Growth Energy identified a number of deficiencies in the cane ethanol pathways included in the ARB Lookup Table, which the Executive Officer proposed in his July 20 notice to include in section 95486 of the proposed regulations. The relevant issues included the following:

1. The values for the electricity co-product credit was based on an unsupported assumption that displaced electricity would come from natural gas power plants.

2. The Executive Officer's analysis of the mechanized harvest pathway did not account for greenhouse gas ("GHG") emissions from the combustion of fuel used in harvesting.

3. The analysis of the combined electricity and mechanized harvest co-product pathway did not account for differences in ethanol production from green mechanically collected cane, as opposed to burned manual collected cane.

Growth Energy also presented several objections to the inclusion of new cane ethanol pathways in the July 20 notice under the California Administrative Procedure Act (the "APA"). *See* Growth Energy's Response to the Notice of Availability of Modified Text for Proposed Section 96486, Title 17, California Code of Regulations (Aug. 19, 2005) ("Aug. 19 Growth Energy Comments") at 10-12. None of those APA objections have been addressed explicitly in the Executive Officer's September 23 notice, and none have been cured by the proposed revisions to the Lookup Table and in the cane ethanol pathway analysis released with the September 23 notice. Several additional points concerning the cane ethanol pathways presented by the September 23 notice warrant comment.

First, the Executive Officer's description of his most recent revisions in the cane ethanol pathway analysis as "minor" deserves attention. As explained in an accompanying declaration, a comparison of the prior and now-revised pathway analyses shows many changes. Those changes vary considerably from value to value, and the specific reason for each change is not documented. *See* Supplemental Declaration of James Michael Lyons ("Lyons Supp. Decl.") ¶ 3. The public has not been given sufficient information in the rulemaking file or in the Executive Officer's publications to understand adequately the basis for the original numerical values in the earlier ARB cane ethanol analysis, nor in the September 23 revised documentation. This does not substantially comply with the APA. If the Executive Officer does not take the primary step that Growth Energy has in the past requested and continues to request -- which is to return the proposed regulation to the Board for further consideration -- Growth Energy asks that the Executive Officer place all the necessary information in the rulemaking file, provide public notice of his action, and then permit adequate time for public comment and review before any further or final consideration of the cane ethanol pathways occurs.

Second, information that has become available since August 19 makes it clear that the ARB's version of the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation ("GREET") model, called "CA-GREET," does not properly account for transport of Brazilian cane ethanol to California, nor for the energy required to dehydrate the anhydrous ethanol produced in Brazil for use in the California market. *See* Lyons Supp. Decl. ¶¶ 5-8. Those deficiencies do not comport substantially with ARB's statutory obligation to use the "best available economic and scientific information." *See* Health & Safety Code § 38652(e); Aug. 19 Growth Energy Comments at 20. They also constitute a substantial defect in the environmental assessment required by CEQA, which should be corrected in the resubmission of the matter to the Board required by CEQA and ARB's implementing regulations. *See id.* at 29-30. These omissions are certainly not minor: correction of the error related to energy usage in dehydration increases the CI value for the "Baseline Brazilian Ethanol" pathway in the September 23, 2009 version of the ARB Lookup Table by about 20 percent, and the percentage increases for the other two ARB Brazilian Ethanol pathways are even larger. *See* Lyons Supp. Decl. ¶ 7.

Third, the September 23 notice does not deal adequately with Growth Energy's earlier comments on the CI values assigned to the cane ethanol pathways. While some adjustments have been made to the mechanized harvesting pathway apparently to take partial (but not complete) account of equipment emissions, *see* Lyons Supp. Decl. ¶ 9, Growth Energy's earlier questions concerning the Executive Officer's assumption that all surplus energy will replace natural gas usage have not been addressed. *See id.* ¶ 10. This creates two distinct problems under the APA and CEQA. The first is that ARB is committing a substantive, and substantial, error in its emissions analysis. The second defect is procedural. Even if the Executive Officer believes that his assumption about the displacement of natural-gas-based energy is reasonable, the public is entitled to comment on his basis for that conclusion, now that Growth Energy has questioned the basis for the Executive Officer's assumption. There is also now additional evidence, which Growth Energy could not obtain in the limited time permitted for comment on the Executive Officer's July 20 notice, that the Executive Officer's assumption concerning displaced energy is erroneous. *See id.* ¶ 11. Here as well, under his own view of his delegated powers, the Executive Officer has a duty under the APA, CEQA and the Board's CEQA regulations to explain the basis for his assumption and to permit public comment before any final action or determination is made with respect to the cane ethanol pathways.

II. New Information and Analyses Concerning the Global Trade Analysis Project Model.

Growth Energy's earlier comments have explained why ARB cannot properly rely on the results of Global Trade Analysis Project ("GTAP") model in this rulemaking and in its environmental assessment of the proposed LCFS regulations. Those comments have included submissions in response to the 30-day notice issued in July 2009. Each of Growth Energy's earlier sets of comments on GTAP, as well as these comments, are timely for purposes of ARB's environmental assessment under the Board regulations implementing CEQA, and they are relevant to the CEQA issues presented by the CI values in the ARB Lookup Table. The environmental assessment for the LCFS rulemaking is still under way, and the specific CI values included in the Lookup Table will affect the environmental impact of the regulation. *See* Aug. 19 Growth Energy Comments at 3, 19.

The new information and analyses reported here and contained in the attachments to these comments were not available to Growth Energy or other members of the public in time for inclusion in comments to ARB or the Executive Officer prior to the close of the prior comment period. While not required to meet such a threshold, this new information and analysis is of sufficient importance to warrant reconsideration by the Board or the Executive Officer of the action taken by the Board when it originally approved the regulation, and is also similar to the type of new information that would have warranted a decision to keep the record open under Gov't Code § 11346.8(e); *see also* Gov't Code § 11340.7

It would be inefficient, and prejudicial to the interests of Growth Energy and numerous other interested parties, for the Board or the Executive Officer to finalize the LCFS regulation without full consideration and analysis of the additional information and analysis provided here on the grounds that such information and analysis is better presented in a motion to reconsider or amend the final LCFS regulation. It is also important and necessary for the Board to consider this information now, because its prior action does not delegate to the Executive Officer any authority to revise the *indirect* greenhouse gas ("GHG") emissions component of the CI values assigned in the ARB Lookup Table. Accordingly, there are multiple grounds why this additional information must be considered and fully addressed by the Board and the Executive Officer.

A. GTAP Simulations By Oak Ridge National Laboratory Scientists, Applying Improved Data Sources and Analysis, Forecasts "Minimal Indirect Land-Use Impacts" Attributable to Corn Ethanol.

After the close of the 30-day comment period on August 19, researchers at the Oak Ridge National Laboratory ("ORNL") made available to the public a report on important, path-breaking work completed at ORNL using GTAP, with improved data sources and enhanced sensitivity analyses. *See* Attachment A.[1] This is precisely the type of further work recommended by one of

[1] Attachment A is a PDF file that contains a narrative document and set of presentation slides attached to the narrative, which display from a hyperlink at the end of the narrative. The presentation slides are dated August 20, 2009. Growth Energy obtained Attachment A from (Continued...)

ARB's scientific peer reviewers, Dr. Valerie Thomas of the Georgia Institute of Technology, in the review of the GTAP analysis considered by the Board earlier this year. *See* Aug. 19 Growth Energy Comments at 16. Like the work by Prof. Tyner, it must be fully considered by ARB and the Executive Officer before final regulatory action is taken, for the reasons explained above at page three and in Growth Energy's earlier comments.

The salient findings of the new analysis at ORNL, quoted from Attachment A, are as follows:

- "Once the effects of other drivers are accounted for, the simulations reported here indicate a small indirect land-use change due to the increase in biofuel production in the US from 2001-2006. ... [T]he changes after correcting for yield and petroleum prices are a small fraction of what other modelers estimated. This analysis has implications for a shift to cellulosic ethanol because many cellulosic production scenarios also involve land. Reductions in direct emissions are much larger for cellulosic ethanol than they are for corn, leaving the estimated "indirect land-use change" emissions as a primary concern."

- "The various analyses of exports, yields, and production to date provide little empirical evidence to suggest that ethanol production in the US is forcing other crops out of production and inducing indirect changes. Shifts in production that fit well within historic trends have allowed more than sufficient US farmland to be available to meet the demands for increasing ethanol production."

- "As the U.S. has attained 65% of the EISA target for conventional ethanol as of 2009 (approaching 10 billion gallons per year), the total US land area planted in crops has fallen by 1.5 million hectares (still comparing to 2001 as the baseline used for GTAP and several other modeling simulations). Contrary to the simulations that estimated corn ethanol would cause major reductions in soybeans and wheat, the area and production for soy beans and wheat are higher than in 2001. Clearly many other factors are interacting with land-use decisions and global markets."

The results of the ORNL researchers' analysis showed "minimal indirect land-use impacts."[2] This new information and analysis furnishes additional reasons why it would be unreasonable and inconsistent with statutory obligations for ARB to maintain reliance on the results of the GTAP modeling currently in the rulemaking file. The Executive Officer must return the proposed regulation to the Board and invite comment on the new research by the ORNL scientists -- which is a process that would permit the ORNL scientists to provide any necessary details of their analysis and the public to respond, and that would permit ARB to develop and rely upon a defensible estimate of indirect land-use effects.

ORNL staff after ORNL staff's presentation at the August 25-26 meeting of the National Corn Growers Association ("NCGA").

[2] *See* Attachment B at 18 (ORNL staff presentation at NCGA meeting, Aug. 26, 2009).

B. Additional GTAP Analysis Shows Significant Reductions in Predicted Greenhouse Gas Emissions Attributable to Biofuels Usage.

At a meeting to examine environmental analyses of biofuels usage convened by the National Corn Growers Association ("NCGA") on August 25-26, 2009, Professor Wallace Tyner of Purdue University presented new indirect land-use change emissions estimates based on recent applications of the GTAP model. *See* Attachment C. The NCGA meeting was attended by a large number of experts and other parties involved in the analysis of the emissions impact of biofuels usage, and individuals from government, academia and the research departments of agricultural products firms presented numerous technical and scientific presentations.

Prof. Tyner's new analysis is of central relevance to the Board's application of the GTAP model and model structure in this rulemaking, if ARB or the Executive Officer decides to rely on GTAP in any way in the currently proposed rule.[3] Prof. Tyner is one of the principals in GTAP. His recent work with GTAP is entitled to weight, and perhaps to greater weight than that of other university-based researchers who have supported the use of GTAP and who testified at last spring's public hearing, for several reasons. Prof. Tyner's longstanding work on the GTAP model gives him greater familiarity with the performance and capabilities of the model and with the relevant GTAP data sets than the researcher from the University of California who testified at the public hearing. Unlike the University of California researcher, Prof. Tyner has an extensive record of publications that have used GTAP analysis. Prof. Tyner's work is also more recent than any of that relied upon by ARB staff and the Board, and thus reflects improved analysis using the GTAP model and data bases.[4] Finally, Prof. Tyner has not taken a definitive position on the policy merits of the LCFS rulemaking, and so his scientific opinions about the appropriate uses of GTAP and the results of GTAP-enabled modeling are less likely to be affected by bias than those of individuals who have testified or filed comments on the proposed LCFS regulation.

By way of background, it will be recalled that ARB's estimate of the emissions associated with land use for corn ethanol is 30 grams of carbon-dioxide-equivalent emissions per megajoule ("g/MJ"). This was determined from seven GTAP6 modeling scenarios where several elasticities were varied. The range of estimates was from 18.3 to 44.3 g/MJ. At a land-use value of 30 g/MJ, ARB estimated that a natural gas fired ethanol plant producing dry DGS would have a total GHG value of very close to CARBOB, or about 97 g/MJ.

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[3] As explained in prior comments, Growth Energy does not believe that GTAP is appropriate for use in determining a single-point, fixed CI value for indirect land use change emissions impacts. *See, e.g.*, Aug. 19 Growth Energy comments at 15-27.

[4] Growth Energy maintains each of its objections to use of the GTAP model and data bases for the purposes to which the Board has put them, for the reasons stated by General Clark at the public hearing on the LCFS regulation, as well as those presented in Growth Energy's August 19 comments.

Prof. Tyner's new presentation is highly relevant to ARB's consideration of indirect CI values, if the indirect land-use change hypothesis upon which his application of the GTAP system is to be given any credit. Prof. Tyner's analysis claims that the appropriate single-point, GTAP-based indirect CI value for corn ethanol is 1666 g/gallon. *See* Attachment C at p. 21. That is equivalent to 20.8 g/MJ, utilizing the lower heating value (LHV) of the energy content of ethanol of 80.2 g/gallon.[5] That value is ***30 percent below*** the 30 g/MJ value that was "approved" by ARB at the public hearing. The 30 g/MJ value developed using earlier work with GTAP is no longer defensible and must be reconsidered and revised.

It also bears noting that Prof. Tyner may have continued to use earlier protocols that relied on an assumption that dry DGS replaces only corn, resulting in a land-use credit of about 30 percent. Comments prepared by Air Improvement Resource, Inc. ("AIR") and Dr. Jerry Shurson for the Renewable Fuels Association ("'RFA") demonstrate convincingly that when distillers grains substitute for both corn and soy meal in different animal species, the land-use credit is closer to 70 percent -- more than double what is currently assumed in GTAP6. Correcting a CI value of 20.8 g/MJ (the CI derived from Prof. Tyner's new work) for improved distillers grains assumptions results in a CI value of 9 g/MJ. There are additional grounds for reduction of the CI value from 30 g/MJ. A new report from Monsanto, being supplied with these comments, shows that higher corn yields per acre will be obtained than currently assumed in ARB's GTAP modeling and results.[6] The Executive Officer must permit the Board to consider this evidence from Monsanto or consider it himself.

Even putting the Monsanto evidence aside, the Executive Officer's obligations and those of the Board to apply the best available science to the LCFS rulemaking require the Executive Officer to return the proposed regulation to ARB to consider this important new information and analysis. If the Executive Officer does not agree, he should explain fully why he disagrees, before he takes final action on the proposed regulation, and he should invite comment on his analysis. If, contrary to Growth Energy's request, the Executive Officer decides instead take final action without permitting further comment, then his mandate to use the best available scientific and economic information and to minimize leakage certainly would require him to amend the Lookup Table to reduce the 30 g/MJ CI value by at least 30 percent, based on Prof. Tyner's latest work. Growth Energy also believes that if the Executive Officer pursues final action now, he would also be required to select a 9 g/MJ CI value to replace the 30 g/MJ value in the currently proposed Lookup Table, as proposed by RFA, in light of the work by AIR and Dr. Shurson. If the Executive Officer does not make either of these adjustments, he must explain fully his reasons for not doing so.

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[5] *See* http://bioenergy.ornl.gov/papers/misc/energy_conv.html.

[6] *See* Attachment D (presentation by Monsanto scientist at the recent NCGA meeting). That evidence demonstrates increasing yield improvements in the United States, as well as even higher rates of increases in yields from lower baselines in important overseas agricultural areas. *See id.* at p. 6 (U.S. corn yields will reach 300 bushels/acre by 2030) *and* pp. 12-13 (rapid yield gains predicted overseas in a short period of time).

III. The Need for Peer Review

The new pathways included in the Executive Officer's September 23 notice require peer review under the Health & Safety Code, for the same reasons as those stated in Growth Energy's prior comments. *See* Health & Safety Code § 57004 *and* Aug. 19 Growth Energy Comments at 12. Just as the CI values in the ARB Lookup Table dating from March 2009 should have received full external peer review, those that have been added by the Executive Officer should have been subjected to peer review. Clearly many other factors are interacting with land-use decisions and global markets, as shown by the research at ORNL reviewed above. An expert who is in a far better position to opine on this issue than many participants in this rulemaking (Prof. Tyner) has now released results from GTAP modeling that demonstrate that the GTAP results on which the Board has previously relied are seriously in error. After the necessary external peer review has occurred, its results should be made available for public review and comment before the Board takes any action on the proposed additions to the Lookup Table.

IV. Conclusion

Growth Energy recommends that the Executive Officer return the LCFS regulation to the Board for further action, and that he also commission the peer review required by Health & Safety Code. Finalization of the current regulatory text proposed by the Executive Officer would not substantially comply with the Health & Safety Code or the Administrative Procedure Act, and would be contrary to ARB's obligations under CEQA and the Board's CEQA regulations.

Respectfully submitted,

GROWTH ENERGY

Dated: October 8, 2009

Attachment A

Summary of the August 2009 Forum
Center for BioEnergy Sustainability (CEBS)
"Myths, Facts and Uncertainties for Bioenergy"
August 20, 2009
Oak Ridge National Laboratory

Keith Kline began the Forum by inviting the audience to list current concerns with bioenergy. People in attendance noted that higher food prices, environmental impacts such as tropical deforestation, and high greenhouse gas emissions associated with conventional, crop-based fuels were among the most important issues. Keith noted that *land* and more specifically, some recent estimates of the land-use impacts of biofuels, underlies all these concerns. The studies reporting indirect land-use change are based on uncertain data, questionable assumptions and models that were developed for other purposes. But these are considered to be the best global models available, so they have been applied to estimate the environmental and land-use effects of the increase in U.S. biofuel production under the Energy Infrastructure and Security Act (EISA) of 2007. Many of the studies have focused on projected impacts of expanding US corn-ethanol production up to the 15 billion gallon per year maximum volume allowed from conventional sources under EISA.

Meanwhile, over the past year, 9.8 billion gallons of ethanol were produced in the United States[1]. This is nearly two-thirds of the 15 billion gallon EISA maximum. Rather than relying solely on models, we can learn a lot about what is *really* happening in terms of impacts and land use by taking the time to analyze empirical data associated with the recent increase in production. Is the expanded production causing the *direct* effects in the U.S. that models calculate? These direct price, export and land-use effects are required in order to drive the "indirect" land-use changes estimated by these models.

Many scientists believe that biofuel policies and regulations are being proposed without proper scientific analysis. Important points of reference can be identified if we gather and analyze comprehensive empirical data about what is actually happening to land, and why, around the world.

The July 15 edition of *The Economist* featured a series of articles discussing the global financial collapse titled, "What went wrong with economics?" One problem identified was that of excessive reliance on models fitted to outdated data. Could we learn from that experience?

Debo Oladosu presented his findings from a study that examines the assumptions and operations of models applied in the recent past to assess the effects of biofuel production on land use. He illustrated how the MTBE content of gasoline dropped significantly beginning in 2001 and fell to zero by 2008. The MTBE was replaced by ethanol. The ethanol content of gasoline started increasing significantly after 2001, with fuel ethanol

[1] Renewable Fuel Association Industrial Statistics. http://www.ethanolrfa.org/industry/statistics/ Data from "Monthly US Fuel Ethanol Production/Demand" for the most recent 12 months with data: June 2008-May 2009. Accessed August 12, 2009.

growing by 20% per year on average from 2001-2004 and even more rapidly from 2005 onward, as other polices and incentives for biofuels were put in place.

The first widely publicized study that attempted to estimate "indirect" land-use effects of expanding bioenergy production was by Searchinger et al. (2008). The main assumptions in that exercise were that:

- Global food and feed uses of corn are inelastic
- Global rate of yield growth remains constant
- DDGS replaces one-third of the feed otherwise diverted

And the resulting estimates of impacts included:

- Ethanol would divert 12.8 million ha of corn land in the United States in 2016
- U.S. crop exports would be severely affected:
    - corn by -62%
    - wheat by -31% and
    - soybean by -28%
    - Prices would also be significantly affected: corn (by +40%), wheat (by +17%), and soybean (by +20%)
- Global replacement corn land would be 10.8 million ha. (This is the "indirect" land use, the area that the rest of the world would need to make up for the corn used for fuels.)

The reactions to the Searchinger et al. article included:

- Wang and Haq (2008), who said that general-equilibrium modeling was needed
- Kolmes (2008) and Wassenaar and Kay (2008), who said that dietary changes could reduce land conversion and not all other land uses are critical to society
- Khosla (2008) and Mathews and Tan (2009), who said that price increases boost yields, one cannot ignore potential yield contributions, and new technologies hold the promise of rapid yield increases
- Kline and Dale (2008), who said that land-use change has multiple causes, biofuels may encourage more sustainable land use, and Searchinger's analysis omits current land uses (fires) and realistic reference cases

One major response of the modeling community was to employ a general equilibrium model, GTAP, to evaluate the issue. GTAP is well documented, widely-used, and had been adapted for biofuels by Birur et al. (2008). But, most of the assumptions used for the Searchinger analysis remained the same in the first GTAP model run – so it produced similar results in terms of indirect land-use change. However, the GTAP simulations found that the direct land-use effects were much lower than Searchinger's. While the indirect land-use effects were initially estimated by GTAP to be similar to Searchinger (Hertel, 2008), subsequent improvements in GTAP simulations and assumptions led to lower indirect land-use estimates (Hertel et al. 2009; Tyner et al. 2009).

There are many differences between models and the real world. The Purdue GTAP-BIO model allows yield to respond to prices in the model, but the net land conversion results from the model are exogenously adjusted by a factor of 0.66 based on an assumption that new land is less productive than existing cropland. But in the real world, there are intensive yield changes, extensive yield changes, technology changes, and

continuous land-use realignments that have historically played a significant role in improving yields as cropland expanded. When historic corn-production changes are decomposed, yield turns out to play a crucial role in production. The ratio of domestic corn use to corn exports fluctuated widely over the past twenty years. Since 2001, the decomposition of empirical data shows that exports' shares of production have been constant or increased in all but two years (2004 and 2007). In the model, supply and demand must match. In the real world, stocks (storage) and "disappearances" can absorb excess corn in years where supply exceeds demand and the stocks later help bolster supply when demand exceeds annual output.

In reviewing many past simulations and the results from running an ORNL simulation based on GTAP, a new issue was identified; i.e. how the increase in biofuel production is imposed on the models. Searchinger et al (2008) and the early GTAP simulations made crucial assumptions to bring ethanol into the simulated markets. Searchinger et al (2008), assumed that there are no bottlenecks to ethanol use and introduced a $10/bbl price shock, while the initial GTAP study imposed a 136% increase in oil price.

The problem is that the price increases alone will cause changes that have nothing to do with the introduction of biofuels into the market. To examine this more carefully, Debo constructed a version of the GTAP model which

- Reflects the EISA "mandate" for corn ethanol
- Incorporates a physical land cover sub-model
- Incorporates co-products of corn ethanol
- Uses the "GTAP 6 Database" with a 2001 base year for land productivity and the world economy

Several simulations were then run to examine the effects of the petroleum "biofuel drivers" versus the effects of ethanol production alone in model simulation results. ORNL-GTAP mimicked prior GTAP modeling to look at land-use change effects under similar assumptions; the simulation was repeated with only the oil price change except that the production of ethanol in the U.S. was held constant. This allowed us to examine the effects on land-use change estimates that were inherent in the other model assumptions (independent of US ethanol production). The results showed that the estimated indirect land-use effects are nearly the same in both cases (e.g. with and without ethanol production). See Figure 1. It appears that the models used to estimate the effects of ethanol were actually simulating land-use changes induced by higher petroleum prices.

Another issue identified was the co-mingling of baselines. To produce comparable results, models must make a comparison of events at the same point in time. Empirical data show dynamics are inherent in agricultural markets and ongoing land-use changes are especially large and complex. When a model depends on a single snapshot in time, or simply compares two years, it is very risky to place much trust in the results in terms of replicating real world behaviors or estimating future behavior. More valid approaches to comparative statistics are possible, but take more time. In this case, the increase in ethanol that could be validly imposed on a 2001-based model looking at land-use change in 2006 with no yield change is only about a quarter of the total increase, because 74% of the increase in output was actually due to yield. When we did this calculation in ORNL-

GTAP, we found an increase of corn ethanol of 3.1 billion gallons from 2001 to 2006 is associated with a new land conversion of only 0.004 percent globally. Under this simulation, the effects on exports were also small (decrease in coarse-grain exports of 0.2 million tons representing export share of 0.3%) and increase in area harvested of only 0.3 million ha.

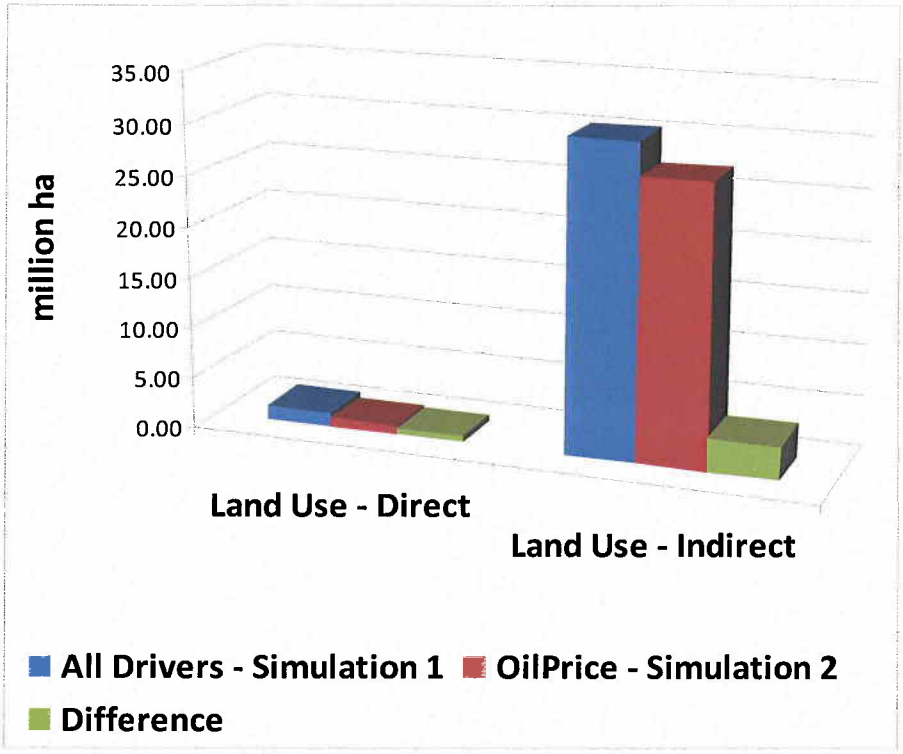


Figure 1: The difference (in green) between Simulation 1 (similar to original GTAP-BIO with all drivers and biofuel production) and Simulation 2 (same as Simulation 1 except biofuel production is not allowed to change) is only about 10% of total.

While the land-use impacts in percentage terms are minimal compared to those modeled in other simulations, the estimated effects in terms of hectares per 1000 gallons of ethanol appear large. This highlights yet another issue identified in the current modeling: uncertain baseline data. The land area data set used as a baseline for ORNL-GTAP is larger than that used by other GTAP analyses and therefore the same modeled change in percentage terms produces very different results in hectare terms.

Linear extrapolations should be avoided because dynamics are inherent to agricultural markets. Land-use data, model specification, and better analysis of empirical data are all necessary to support improved modeling in the future. We need to develop valid dynamic baseline scenarios for the economy, land use/cover, and emission accounts. We also need to improve the structure of economic models, develop new methods for linking models at various scales, perform uncertainty evaluation and standardize approaches for model comparisons.

In discussion that followed the presentation by Debo, it was noted that GTAP has been used in California and has been referenced by the Environment Protection Agency to support the current proposed rules and regulations that include significant "indirect land-use change" estimates for biofuels. The questions raised by the ORNL-GTAP simulations and other peer reviewers should be addressed prior to moving forward with indirect land-use change factors in these policies. How much of the indirect land-use change is actually attributable to non-ethanol production factors in model specifications (e.g. petroleum price increases)? And how much would the indirect land-use change estimates change if yield assumptions were adjusted to reflect empirical data and the baseline co-mingling issues were resolved?

Debo Oladosu pointed out that the GTAP model looks only at the percentage change in key factors. To get absolute values and make comparisons, that percentage must be applied to production values, land areas, etc. And when it comes to land use, these values are highly uncertain and variable. The baseline chosen for the application of the percentage can dramatically change the results; this could account for some of the variation seen in published results for land-use change effects thus far using similar modeling techniques. Yield changes between the baseline year and the current (or projected) year also have huge influences. If they are ignored, land-use change estimates will be overstated. But if they are imposed, land use change estimates might be understated. Either way, they contribute significant uncertainty.

Once the effects of other drivers are accounted for, the simulations reported here indicate a small indirect land-use change due to the increase in biofuel production in the US from 2001-2006. As shown in Figure 1, the changes after correcting for yield and petroleum prices are a small fraction of what other modelers estimated. This analysis has implications for a shift to cellulosic ethanol because many cellulosic production scenarios also involve land. Reductions in direct emissions are much larger for cellulosic ethanol than they are for corn, leaving the estimated "indirect land-use change" emissions as a primary concern. However, that is a topic for future research since we cannot say, based on the current analysis, whether the land-use implications are similar for the two systems.

Debo described how petroleum use and prices are intertwined with everything else in the world markets. These models depend on relative prices so when oil prices change it affects the supply and consumption of all commodities and, consequently, land-use.

In response to questions, it was noted that exotic species and genetic manipulation may allow increased biomass yields and decreased requirements for inputs (land, fertilizer and water). But there are many environmental, legal, social and institutional issues to address related to those developments. And again, it is risky to linearly extrapolate anything; e.g. test plot yields are not a good indicator of commercial potential. There will be many influences on markets, production and prices.

The various analyses of exports, yields, and production to date provide little empirical evidence to suggest that ethanol production in the US is forcing other crops out of production and inducing indirect changes. Shifts in production that fit well within historic

trends have allowed more than sufficient US farmland to be available to meet the demands for increasing ethanol production. A decade of economic losses in cotton production have driven cotton farmers to seek other products and the increasing reliance on feedlots rather than pasture for livestock are two examples. But perhaps the most significant shift has been within coarse grains where between 2001 and 2009, the area planted in non-corn coarse grains fell 2.5 million hectares (or 28%). This can increase system efficiency in multiple ways as yields can jump by 50-150% and ethanol co-products replace the feed values of the prior coarse grains. As the U.S. has attained 65% of the EISA target for conventional ethanol as of 2009 (approaching 10 billion gallons per year), the total US land area planted in crops has fallen by 1.5 million hectares (still comparing to 2001 as the baseline used for GTAP and several other modeling simulations). Contrary to the simulations that estimated corn ethanol would cause major reductions in soybeans and wheat, the area and production for soy beans and wheat are higher than in 2001. Clearly many other factors are interacting with land-use decisions and global markets.

Keith Kline pointed out that globally there are many different potential impacts from biofuel policies and these go far beyond anything that current models attempt to estimate via supply (production), demand and price analysis. In many nations, biofuels are promoted to help address rural poverty and put marginal, underutilized lands into productive use. Emphasis on sustainable production is having significant effects by improving cultivation practices and conserving forests, soils and water supplies that were abused for decades under traditional practices. The losses, inefficiencies and distortions caused by policies leading to overproduction of low-priced grains in the 1990's, and the detrimental effects on food security and agricultural investment caused by exporting excess supplies to less developed nations, are examples of many factors not taken into consideration in these models. Food-feed-fiber-fuel production systems of the future may be fully integrated rather than competitive and involve complementary mixes of species and complex rotation systems, making current modeling assumptions irrelevant.

Most land-use changes that models projected would occur in the U.S. due to biofuels (e.g. expansion of cropland into forest areas, significant reductions in cereal exports, and sharp drops in the areas planted in soybeans and wheat) did not occur as projected and, in fact, changed in the opposite direction according to empirical evidence thus far. This contradiction does not prove anything one way or another when it comes to indirect impacts which, by their very nature, may be impossible to measure with any certainty. But the striking difference in direct land-use changes reflected by empirical data should certainly give pause to putting too much credence on current modeling results and particularly in their projections of indirect effects in other nations. We should carefully examine the theories, assumptions and input specifications that are driving the land-use change estimates in models to determine which are valid and which need to be improved.

Attachment B

Land Use Impacts of Corn Ethanol:
Reconciling Models, Empirical Data and Policy *

'Debo Oladosu

Keith Kline

NCGA Conference on Land Use and Carbon Impacts of Corn-Based Ethanol

St. Louis, Missouri 26 August 2009

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

U.S. DEPARTMENT OF ENERGY

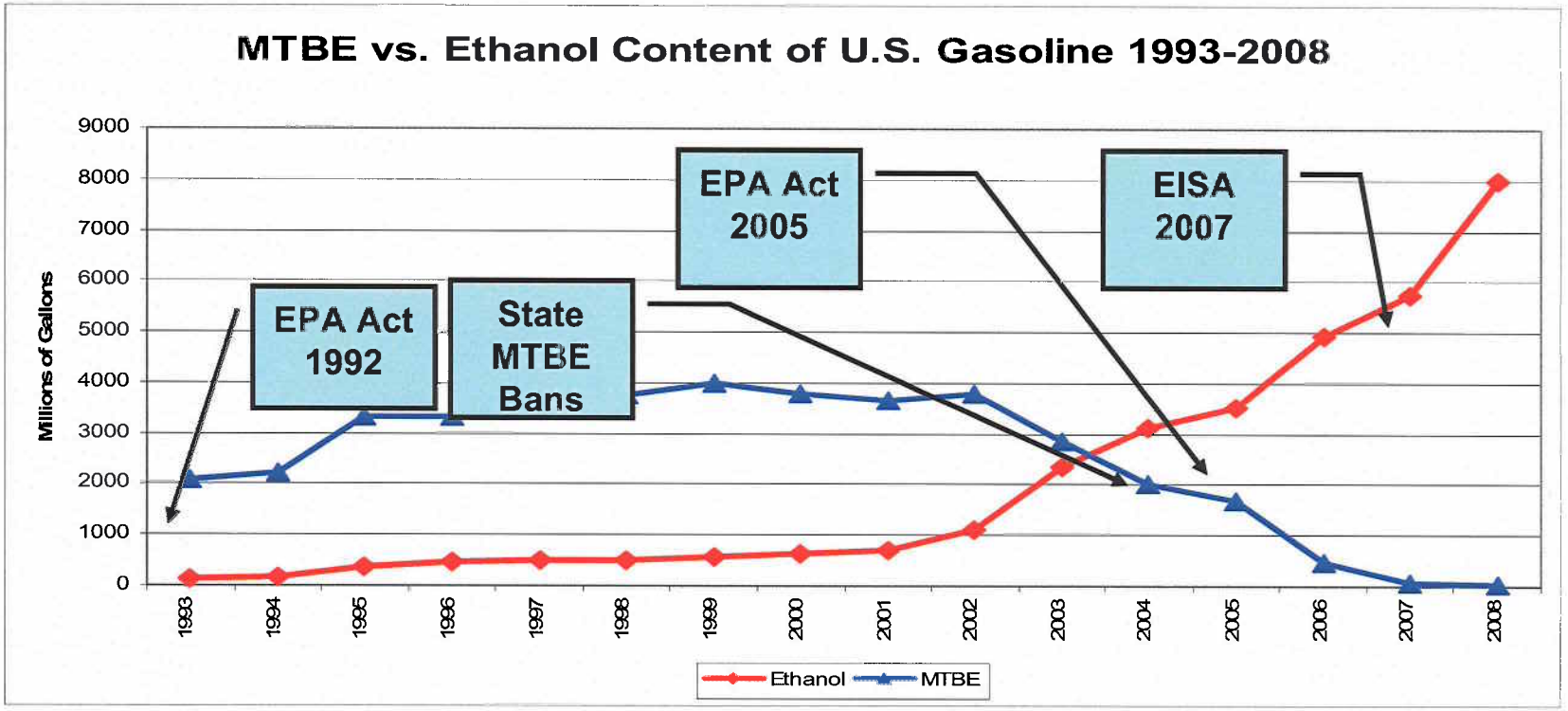
OAK RIDGE NATIONAL LABORATORY

MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

Outline

- Corn ethanol – historical production
- Estimating Land-Use Change (LUC)
  - Models
  - Issues
  - Empirical data
- GTAP simulations at ORNL
- Future research needs

Corn Ethanol: 1993-2008



- **1992: Energy Policy Act:** E-85 (limited; mostly government-owned fleets)
- **2001-2004: State MTBE Bans in CA, NY, CT** (42% of MTBE)
- **2005: Energy Policy Act –** Federal MTBE Ban/Renewable Fuel Standards (RFS)
- **2007: Energy Independence and Security Act** – Expanded RFS/Impacts Directive
- **2005-2009: Ethanol grows at average of 28% per year**

Indirect Land-use Change Modeling: Searchinger et al. (2008)*

- **Partial Equilibrium Model:** CARD/FAPRI
- **Ethanol Production:**
  - 15 billion gallons increase in 2016
    - assumes 100% corn-based
    - Total ethanol in 2016: 30 billion gallons
- **Main Assumptions:**
  - Global food and feed uses of corn are inelastic
  - Global rate of yield growth remains constant
  - DDGS replaces 1/3 of feed otherwise diverted
- **Major Ethanol Effects Estimated:**
  - Ethanol would divert 12.8 million ha of US corn land
  - U.S. Exports: Corn (-62%); Wheat(-31%); Soy(-28%)
  - Prices: Corn (+40%); Wheat(+17%); Soy(+20%)
  - Global replacement (Indirect effect) land would be 10.8 million ha

Land Use Implications

(ha/thousand gallons)

Direct: 0.86

Indirect: 0.73

*Science 319, 1238 (2008)

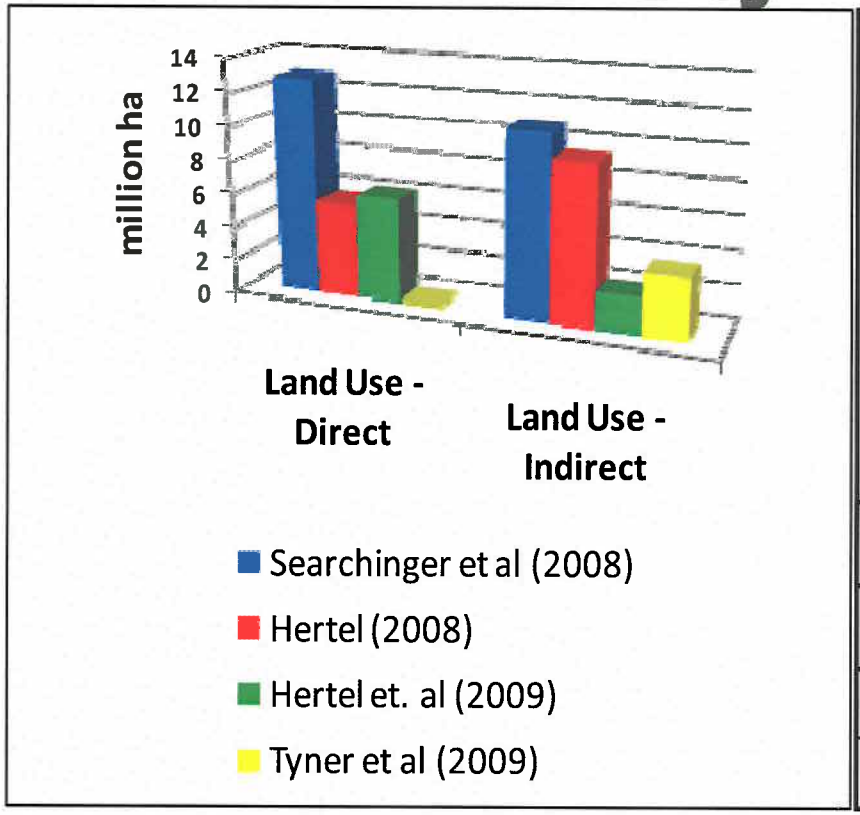
Indirect Land-use Change Modeling: Objections to Searchinger et. al. (2008)

- **Modeling Approach** - Wang and Haq (2008)
  - General equilibrium modeling needed
- **Inelastic Demand** - Kolmes (2008) / Wassenaar & Kay (2008)
  - Dietary changes could reduce land conversion
  - Not all other land uses are critical to society
- **Yield** - Khosla (2008) / Mathews and Tan (2009) / Industry
  - Yields respond to price increases
  - New technologies→potential for large yield increases
- **Other Issues** – Kline and Dale (2008)
  - Land conversion has many causes omitted from the analysis
  - Available land assets underestimated
  - Carbon & fires: biofuels may encourage more sustainable use

Indirect Land-Use Change Modeling: Purdue University – Several Studies

- **General Equilibrium Model:**
  - GTAP – Birur et al (2008) describes model
- **Ethanol Production:**
  - 2001-2006: ~3.1 billion gallon increase
  - 2001-2015: ~ 13 billion gallon increase
- **Main Assumptions:**
  - Intensive (price-induced) yield changes
  - Extensive (new land) yields decrease – adjustment factor of 0.66
  - DDGS substitutes for feed

Indirect Land-use Impacts Modeling: Purdue University – Several Studies



	Searchinger et al (2008)	Hertel (2008)	Hertel et. al (2009)	Tyner et al (2009)
Ethanol (bgallons)	15.0	13.3	13.0	13.2
Land Impacts - (ha/thousand gallons)				
Direct	0.86	0.42	0.47	N.R.*
Indirect	0.73	0.71	0.16	0.27

- Direct = Corn/Coarse Grain used for ethanol production
- Indirect = Net new land conversion to cropland
- Note: Hertel (2008) – No Co-Products

*N.R. = Not Reported

Indirect Land-use Impacts Modeling: ORNL Reviews

- Issues Highlighted Previously
  - Yield
  - Exports vs. Domestic Corn Uses
  - Model Baselines
  - Land use modeling and data
- New Issue with Biofuel Drivers used in Models
  - How increased biofuel is imposed on models
  - What is the impact on model estimates of land use?

Indirect Land-use Impacts Modeling: ORNL Reviews - Yield

- **Consider this exercise (Hertel 2009)**

Market clearing condition for *non-biofuel* corn demand:

$$A_C^{US} Y_C^{US} + A_C^{RW} Y_C^{RW} = D_C^{WLD}$$

Differentiate assuming demand is constant

$$dA_C^{RW} = -[Y_C^{US} / Y_C^{RW}]\, dA_C^{US}$$

Change in RW area depends on change in US corn area from biofuels, multiplied by yld *ratio*

- If yields grow at same rate, only deflate change in US area
- If RW yields grow more slowly, ratio rises, RW area change rises for a given area change in US

- **Real World Interaction between Yield and Land**

$$dA_c^{RW} = \frac{dA_c^{US} Y_c^{US} + A_c^{US} dY_c^{US} + A_c^{RW} dY_c^{RW}}{Y_c^{RW}}$$

-Intensive Yield Change
-Extensive Yield Change
-Technological Change
- Continuous Land-use Realignment
-Cannot be easily separated

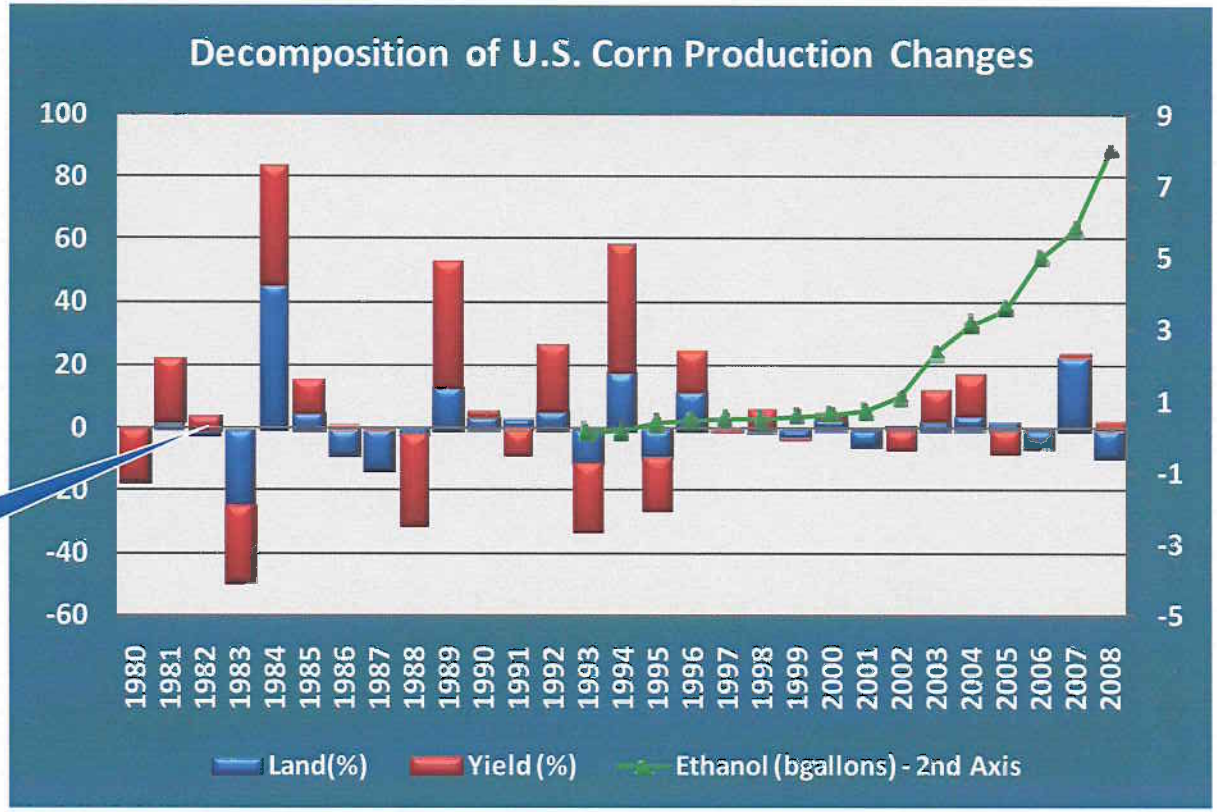
Yield changes in both the U.S. and Rest of World

Indirect Land-use Impacts Modeling: ORNL Reviews - Yield

- Production equation:
  - $Q = Y.L$
- Decomposition:
  - $\Delta Q/Q =$

    $\Delta Y/Y + \Delta L/L$

Notice how land and yield contribution tend to change in the same direction

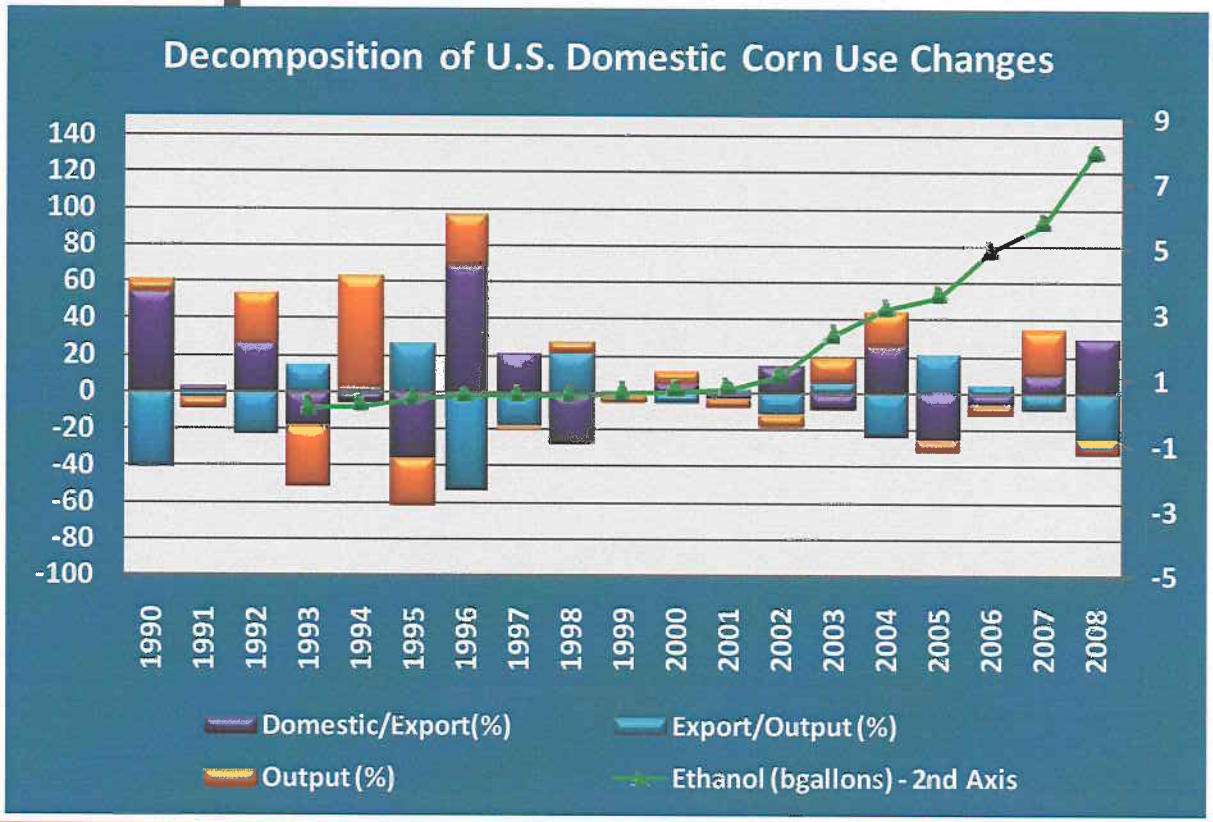


- Yield contribution to growth in production is substantial
- Since 2001, land share exceeds yield share in only 3 years*
  - 2002 & 2005 were both years of net negative output growth
  - 2007 positive output growth dominated by land increase

* Yield data are not normalized for weather

Indirect Land-use Impacts Modeling: ORNL Reviews - Export vs. Domestic Use

- Dom = (Dom/Exports)* Export/Output)* (Output)
- Ethanol Production
  - + ~ 7 billion gallons
- Note degree of fluctuations prior to ethanol…



- Has domestic corn use grown at the expense of exports?
- Net Positive Growth in Domestic Use, 2002-2004 and 2007
  - In most years since 2001 export share increased
  - 2003: output and export share both increased

Indirect Land-use Impacts Modeling: ORNL Reviews – Biofuel Drivers

- **GTAP-Birur et al (2008)**: ...key underlying driver of biofuel demand – namely **crude oil price – shocking this by historically observed amount**, and asking the model to predict the **impacts on gasoline prices and hence biofuel demands**.
- **GTAP- Hertel et al (2009)**: We model expansion of U. S. maize ethanol...by forcing 50.15 GL of additional ethanol production through **imposition of a tax on all liquid transportation fuels and a revenue-neutral subsidy on ethanol...**
- **Searchinger et al (2008)**: ...two different scenarios in the 2016 crop year: 55.84 billion liters...and 111.76 billion liters... **based on different prices of gasoline and different constraints on automobile use of ethanol**, but the accuracy of those projections regarding the absolute use of ethanol are unimportant to this analysis.
- **Fabiosa et al (2009):** Searchinger et al. (2008), ...assumed that there was **no bottleneck in the E-85 gasoline market** and **introduced a $10-per-barrel crude oil price shock.**

These drivers exert land-use impacts separate from any ethanol production

Indirect Land-use Impacts Modeling: ORNL GTAP Simulations

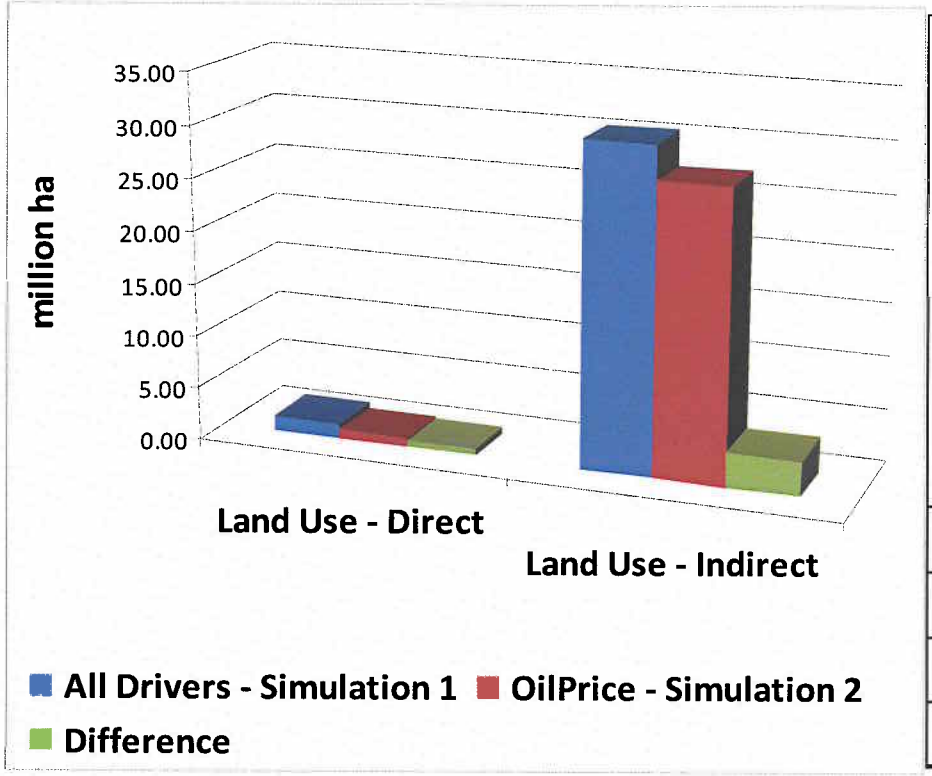
- ORNL Version of GTAP Model
  - Basic Structure similar to the Birur et al (2008) Model
  - Corn ethanol modeling reflects the "mandate" policy
  - Incorporates a physical land cover sub-model
  - Incorporates co-products of corn ethanol
  - GTAP 6 Database with 2001 Base Year
- Several Simulations were conducted
  - Examine the effect of "biofuel drivers"
  - Evaluate alternative approaches to biofuel simulations

Indirect Land-use Impacts Modeling: ORNL GTAP Simulations of Biofuel Drivers

- **Simulation 1: Oil Price and Other Price-based Drivers**
  - **136% Oil Price Increase**
  - **49% reduction in ethanol efficiency in petroleum sector**
  - **11% increase in ethanol & 7% increase in biodiesel U.S. subsidy**
  - **50% increase in ethanol & 81%** increase in **biodiesel EU-27 taxes**

- **Simulation 2: Oil Price Only with Zero Change in U.S. Biofuel Output**
  - **Only the 136% Oil Price Increase**
  - **Restrict change in U.S. ethanol and biodiesel production to zero**

Indirect Land-use Impacts Modeling: ORNL GTAP Simulations of Biofuel Drivers



	All Drivers - Simulation 1	Oil Price - Simulation 2	Difference
Ethanol (bgallons)	3.00	0.00	3.00
Land Impacts - (ha/thousand gallons)			
Direct	0.46	N.A.	0.18
Indirect	10.18	N.A.	1.08

- Total land-use impact due to oil price alone is about 90%
- Baseline issue: Percentage change estimates similar to those in Birur et al (2008), but apply to larger reference physical data
- Do oil price changes induce land-use impacts?

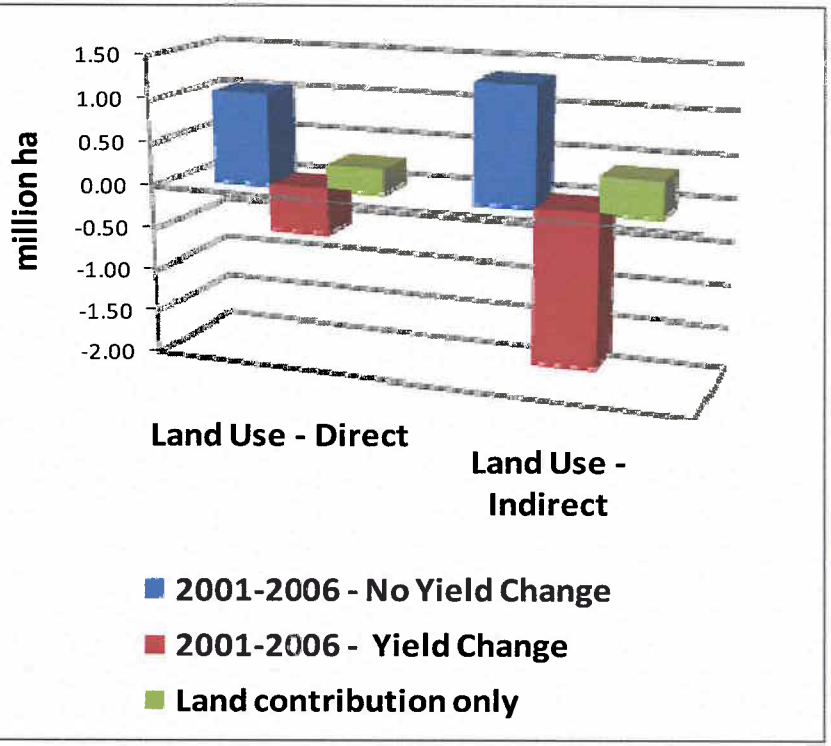
Indirect Land-use Impacts Modeling: ORNL GTAP Simulations of Biofuel Drivers

- GTAP Model is capable of simulating increases in ethanol directly
  - 2001 baseline requires additional considerations
- Three different approaches: Ethanol increase from 2001-2006
  1. No coarse grain yield change
  2. Exogenous change in coarse grain yield to 2006 level
  3. Impose ethanol production met through land-use only – How?

Decomposition of Corn Production Change between 2001-2006			
	Corn Output Change (%)	Corn Output Change Shares (%)	Corn Ethanol Change (%)
Land	2.7	26.1	46.2
Yield	7.6	73.9	130.8
Total	10.3	100.0	177.0

Indirect Land-use Impacts Modeling: ORNL GTAP Simulations of Biofuel Drivers

	No Yield Change	Exogenous Yield Change	Land contribution only	Full Ethanol Basis
Ethanol (bgallons)	2.74	2.75	0.73	3.1
Land Impacts - (ha/thousand gallons)				
Direct	0.39	-0.19	0.39	0.09
Indirect	0.49	-0.65	0.53	0.13



- The first estimate overstates land impacts of ethanol
- The second estimate understates the land impacts of ethanol
- The third estimate is an improvement (comments welcome)
  - Land per gallon impacts should be computed as in the last column
  - Applies only to year of calculation – in this case 2006

Summary: Indirect LUC

- Export/production data show little or no indirect impact
  - Observed fluctuations similar to previous periods
  - Currently > 9 bgal/yr, nearly two-thirds of EISA
    - US cropland planted in 2009 is >1% less than 2001
    - Suggests corn may not be pushing out other crops as needed to drive "indirect" effects
    - Economic changes and other larger factors are at play
- ORNL simulations show minimal indirect land-use impacts

Future Research Needs: Refine Land-use Modeling

- Linear extrapolation should be avoided
  - Dynamics are inherent to agricultural markets
  - Indirect land-use effects depend on these changes

- Improved land use/data and modeling needed
  - For corn ethanol, cellulosic ethanol and climate change
  - Other issues remain e.g. coarse grain instead of corn
  - Dynamics needs to be dealt with explicitly

Future Research Needs: Refine Land-use Modeling

- Develop valid dynamic baseline for:
  - Economy
  - Land use/cover
  - Emission accounts
- Improve land-use models
- Improve economic models
  - Methods for linking models
- Uncertainty evaluation and model comparison

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4. **Hertel T.W., A.A. Golub, A.D. Jones, M. O'Hare, R.J. Plevin and D.M. Kammen (2009) "Global land-use and greenhouse gas emission impacts of U.S. Maize ethanol: The role of market-mediated responses." GTAp Working Paper No. 55**

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7. **Tyner W.E., F. Taheripour and U. Baldos (2009) "Land use change carbon emissions due to US Ethanol Production", Department of Agricultural Economics, Purdue University**

8. **Hertel T.W. (2009) "Analyzing the implications of US Biofuels for Global Land-use", Based on Joint work with D.K. Birur, F. Taheripour and W.E. Tyner, Center fo Global Trade Analysis, Purdue University, Presented to the California Air Resources Board, Sacramento, June, 2008.**

9. **Hertel. T.W. (2009) "A few key issues in determining the effects of US biofuels production on Global Land Use",** Based on joint work with colleagues at The Center for Global Trade Analysis Purdue University and UC-Berkeley-ERG

This presentation is based on draft paper titled: "Revisiting General Equilibrium Modeling of the Land-Use Effects of U.S. Biofuel Policy."

Thank you.

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Attachment C

PURDUE UNIVERSITY

PURDUE AGRICULTURE

BioEnergy

Fueling America Through Renewable Resources

Estimating GHG Emissions Induced by Biofuels

Wally Tyner
Purdue University
August 2009

Background

- Prior to 2007, the general consensus was that corn ethanol reduced greenhouse gasses a bit more than 20% after considering all the direct effects related to growing the crop, transporting, processing, and consuming the ethanol.
- That is probably why the EISA of December 2007 included the 20% requirement for corn.

Background

- By the second half of 2007, the importance of indirect land use change induced emissions was circulating among professionals in the area.
- The EISA included a requirement that indirect land use changes be considered in estimating total GHG impacts for biofuels.
- In February 2008, *Science* published a paper by Tim Searchinger and faculty/staff from Iowa State University.

Background

- The *Science* paper argued that rather than reduce GHG, biofuels, especially corn based biofuels, actually cause substantial increases in GHG.
- Essentially, the argument is that if you divert an acre of corn from feeding animals to feeding an ethanol plant, the animals still have to be fed. As this cycles through the global economy, ultimately it results in reduction of forest and pasture thereby releasing GHG and reducing future carbon sequestration.

Conceptual Modeling Issues

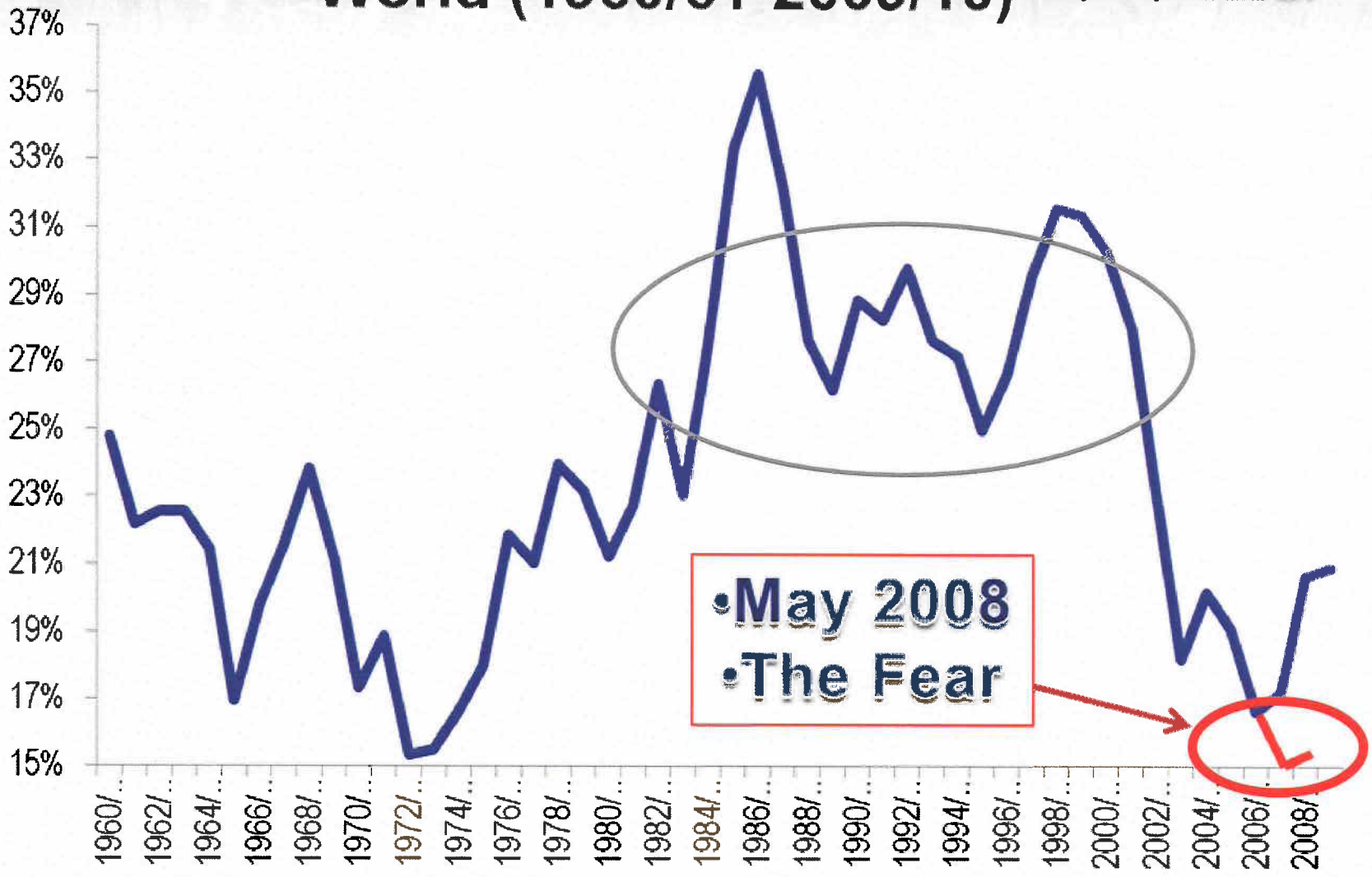
- Boundaries
- Handling of linkages among sectors and regions
- Comparing marginal with marginal or average with average
- Coming up with good ways to decide what is important to include and what we can safely ignore at least for now – a good way to screen
- Capturing the uncertainty in our analysis

More Conceptual Issues

- Getting the intensive and extensive margins correct in our models
  - Intensive margin – price induced yield increases
  - Extensive margin – bringing in the right land at the correct (lower) yield
  - Handling investments in land conversion
- Growth in consumption (demand) versus growth in yield (supply)

Stocks-to-Use Ratio for Total Grains in the World (1960/61-2009/10)

BioEnergy
Fueling America Through Renewable Resources



Baseline

- So many of the effects are linked. What do we need to consider to be able to isolate the effects of biofuels?
  - Energy prices – major biofuels driver
  - Demand – population, incomes, etc.
  - Supply – yield increases, policy on idled land, water supply issues, environmental issues
  - Exchange rates
  - Policies in the rest of the world
- Can we isolate biofuels impacts and hold the rest constant?

Data

- Current land use and land cover.
- What are the most important global areas to make sure we have right?
- Land productivity by land type.
- Yield increases induced by higher prices.
- Changes in demand for agricultural products.

EPA May 2009 Draft Ruling

- These results will be subject to further peer review.
- Cap and trade legislation may defer ruling 5 years.

Fuel Pathway	Range
Corn ethanol (natural gas)	+5% to -16%
Corn ethanol (best case)	-18% to -39%
Soy biodiesel	+4% to -22%
Sugarcane ethanol	-26% to -44%
Switchgrass ethanol	-124% to -128%
Corn stover ethanol	-116% to -115%

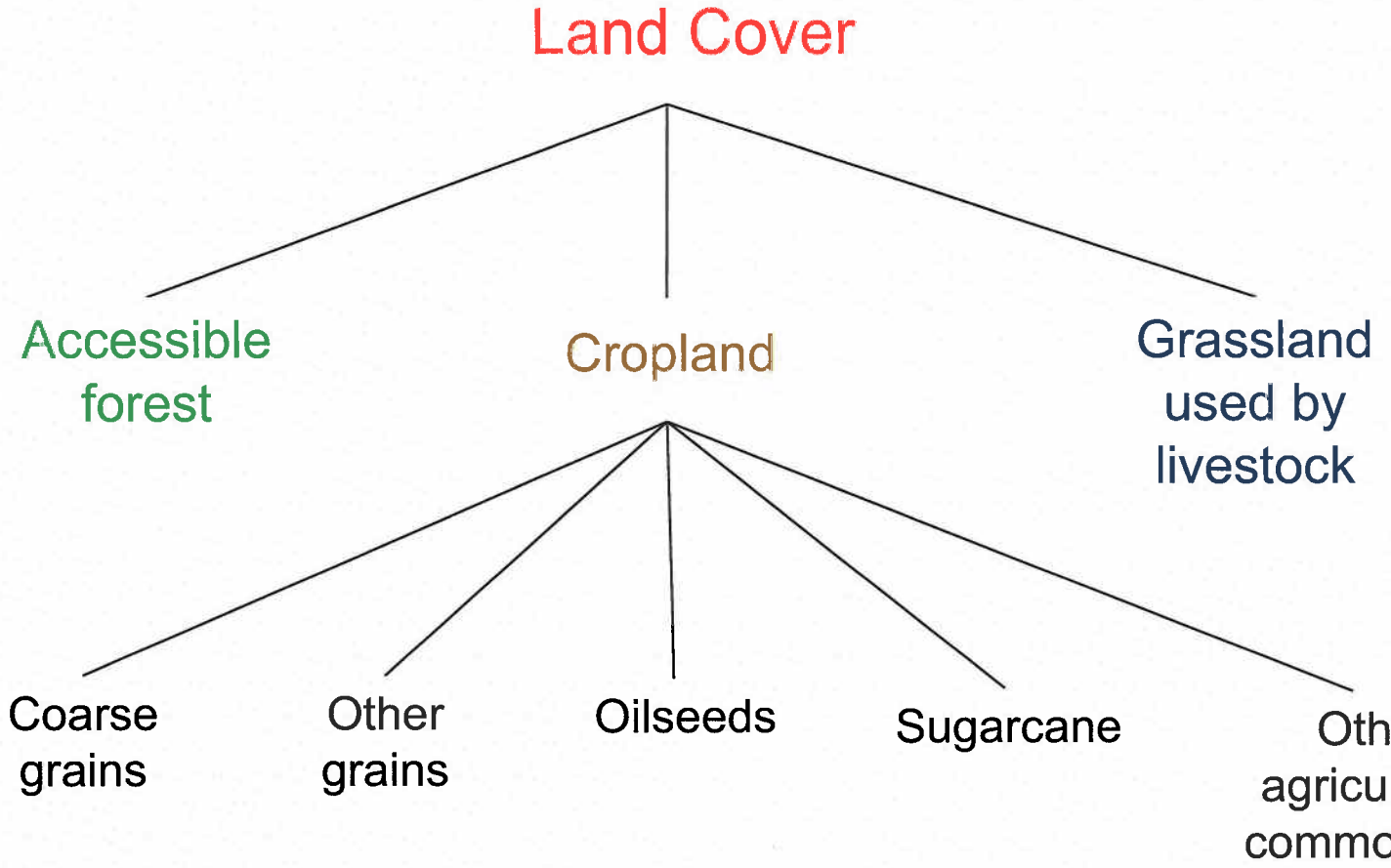
EPA May 2009 Draft Ruling

- Standard corn ethanol is marginal when compared with the 20% reduction requirement.
- All existing corn ethanol capacity is grandfathered, so it does not really matter.
- All cellulosic feedstocks meet the standard.

Introducing Biofuels into the GTAP database

- **GTAP Database Version 6:**
  - Original database represents 2001 world economy (87 regions and 57 commodities)
  - New database, GTAP-BIOA (87 regions and 60 commodities)
    - Ethanol 1 produced from coarse grains,
    - Ethanol 2 produced from sugarcane,
    - Biodiesel from oilseeds .
  - New database, GTAP-BIOB (87 regions, 62 commodities, and 60 industries)
    - DDGS - byproduct of ethanol 1,
    - Meals - byproduct of biodiesel.
  - Data on production, consumption and trade of biofuels are obtained from International Energy Agency (IEA)
  - Aggregation scheme (18 regions, 22 commodities, and 20 industries)

Land Cover in GTAP: By Region at AEZ Level

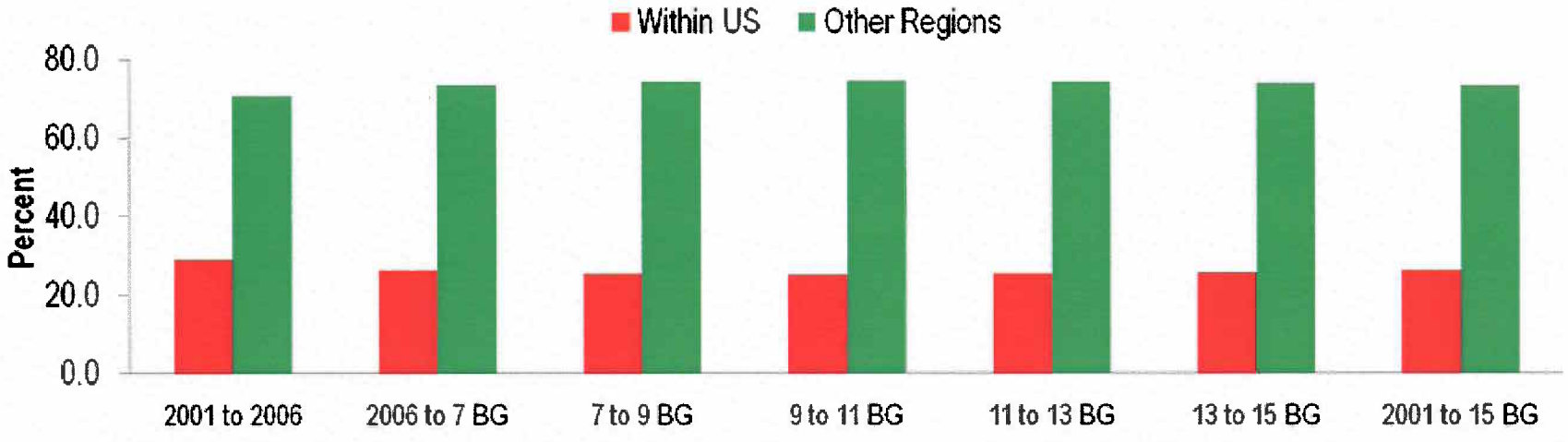


Implications of Biofuels for Agriculture & Livestock

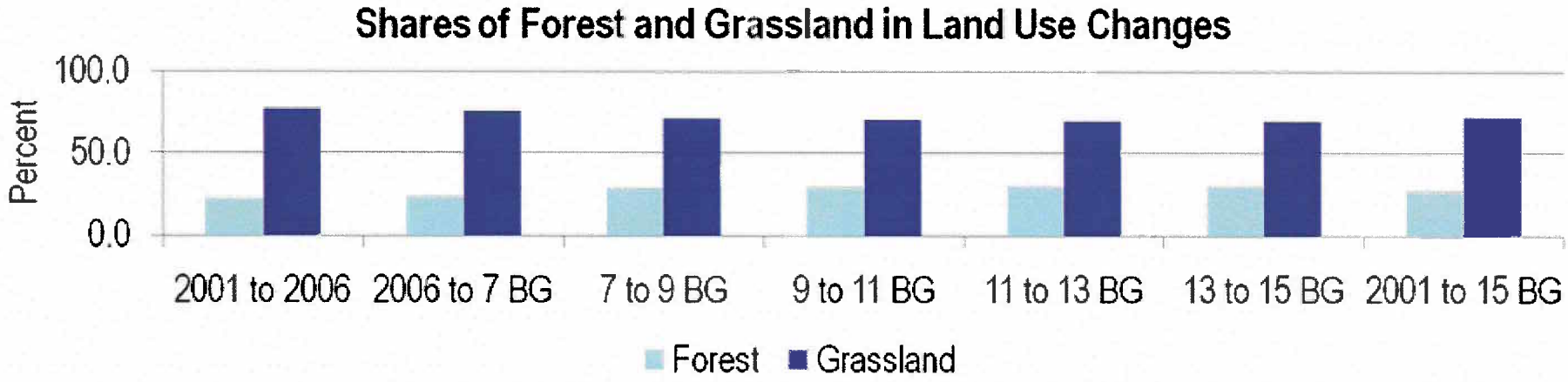
- Higher crop prices which lead to:
  - Higher input costs,
  - Higher land prices,
  - Conversion of some pastureland and forest to crops,
  - Lower demand for final products of processed livestock industries,
- Biofuels are produced in conjunction with valuable byproducts
  - Distillers dried grains with solubles (DDGS) and oilseed meals are the main biofuel byproducts,
  - These byproducts can be used in the livestock industry as animal feeds,
- Biofuel byproducts can help to offset some of the adverse cost implications of the biofuels boom for the livestock industry.

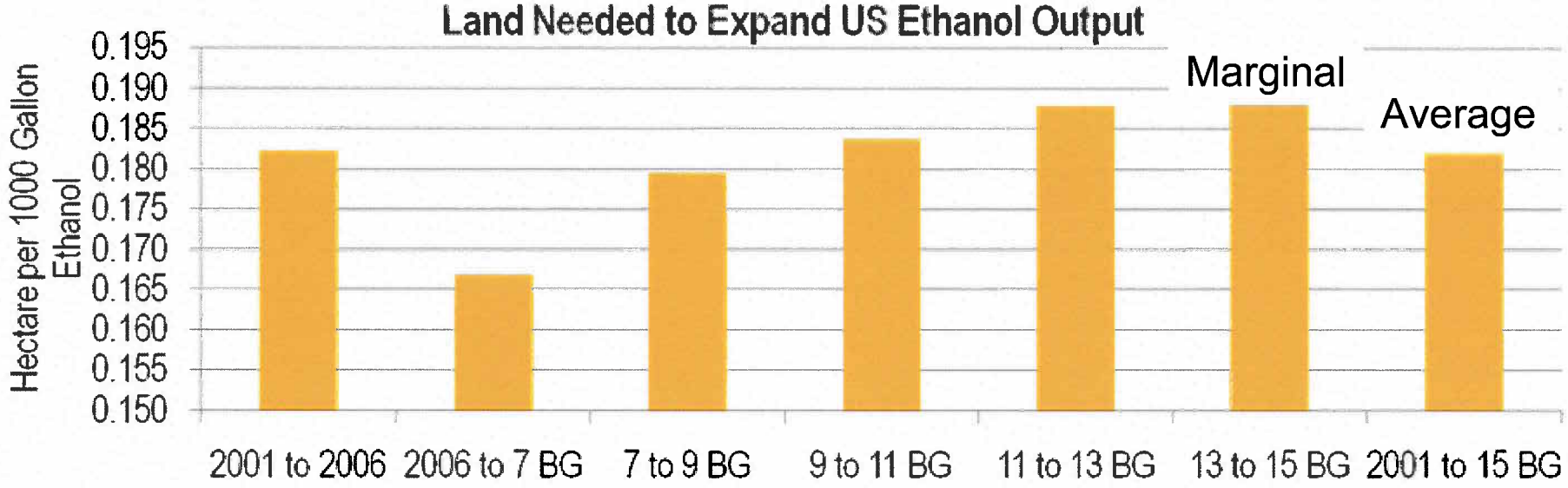
Land Use Changes Due to the US Ethanol Program

Change in ethanol	2001 to 2006	2006 to 7 BG	7 to 9 BG	9 to 11 BG	11 to 13 BG	13 to 15 BG	2001 to 15 BG
Change in Cropland (1000 Hectares)	562.0	358.0	359.0	367.6	375.6	384.4	2406.6

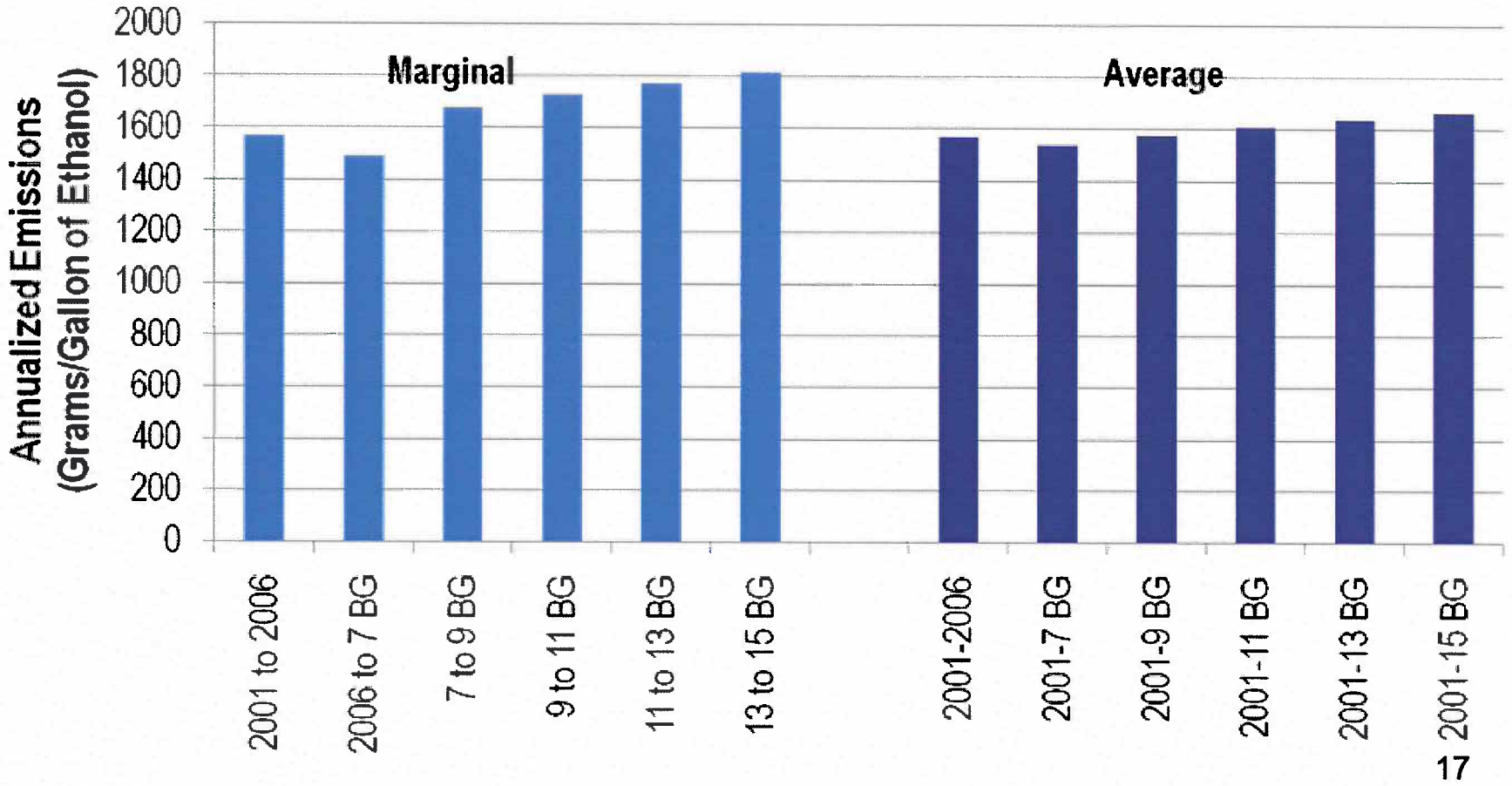


Land Use Changes Due to the US Ethanol Program





Land Use Emissions Due to the US Ethanol Program GHGs Emissions - 30 Years Woods Hole

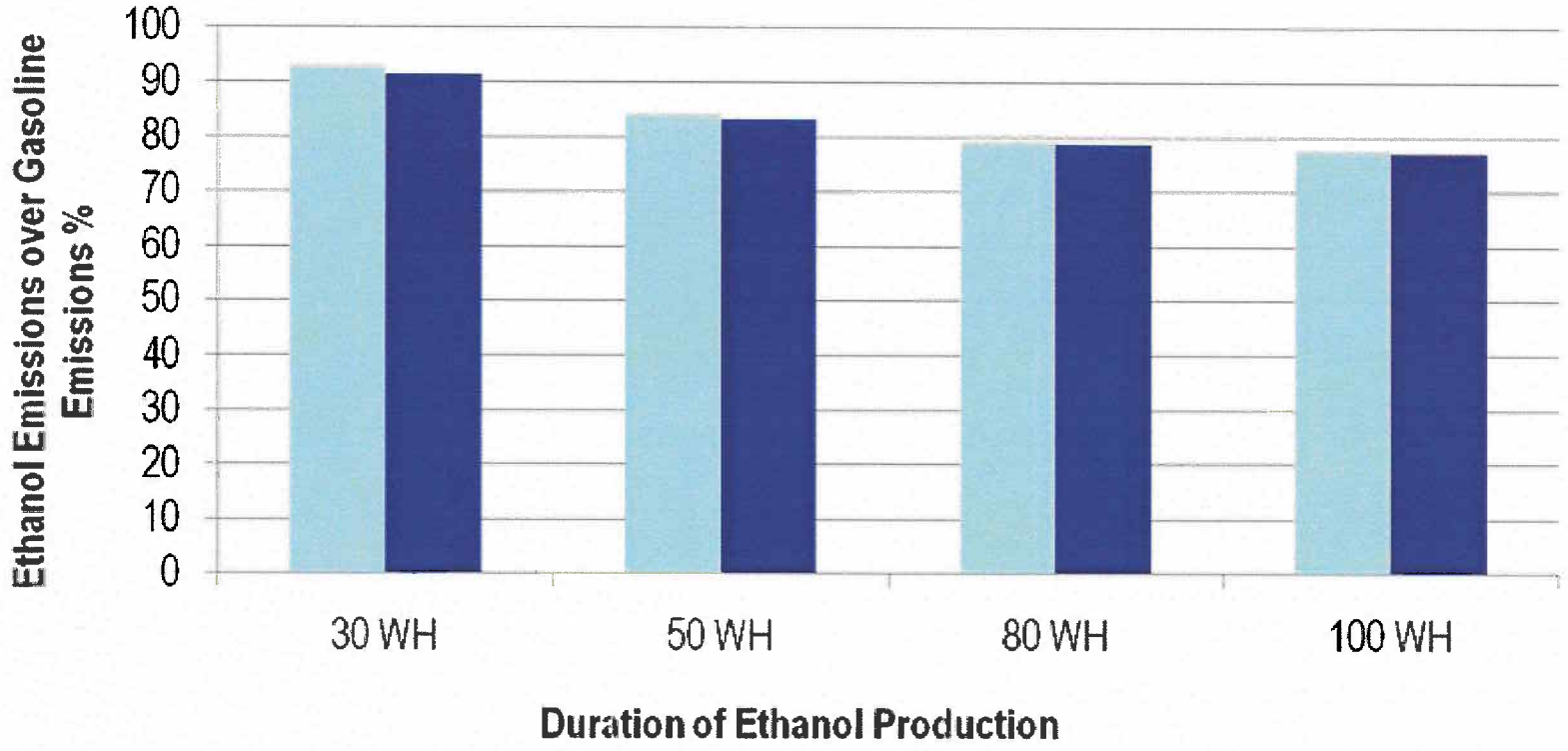


Land Use Emissions Due to the US Ethanol Program Searchinger et al. 2008 vs GTAP Results

Searchinger et al. (2008)	Total Emissions for 30 years (million metric tons)	3801
	Change in ethanol production (billion liters of ethanol)	55.92
	Total emissions for 30 years (grams per liter)	67972
	Liters per gallon	3.785
	Total emissions for 30 years (grams per gallon of ethanol)	257302
	One year emissions (grams per gallon of ethanol)	**8577**
GTAP	**One year average emissions (grams per gallon of ethanol)**	**1666**
	One year marginal emissions (grams per gallon of ethanol)	**1817**

GTAP average 19.4% of Searchinger, et al.

Land Use Emissions Due to the US Ethanol Program
Total Ethanol vs Gasoline Emissions per Mile

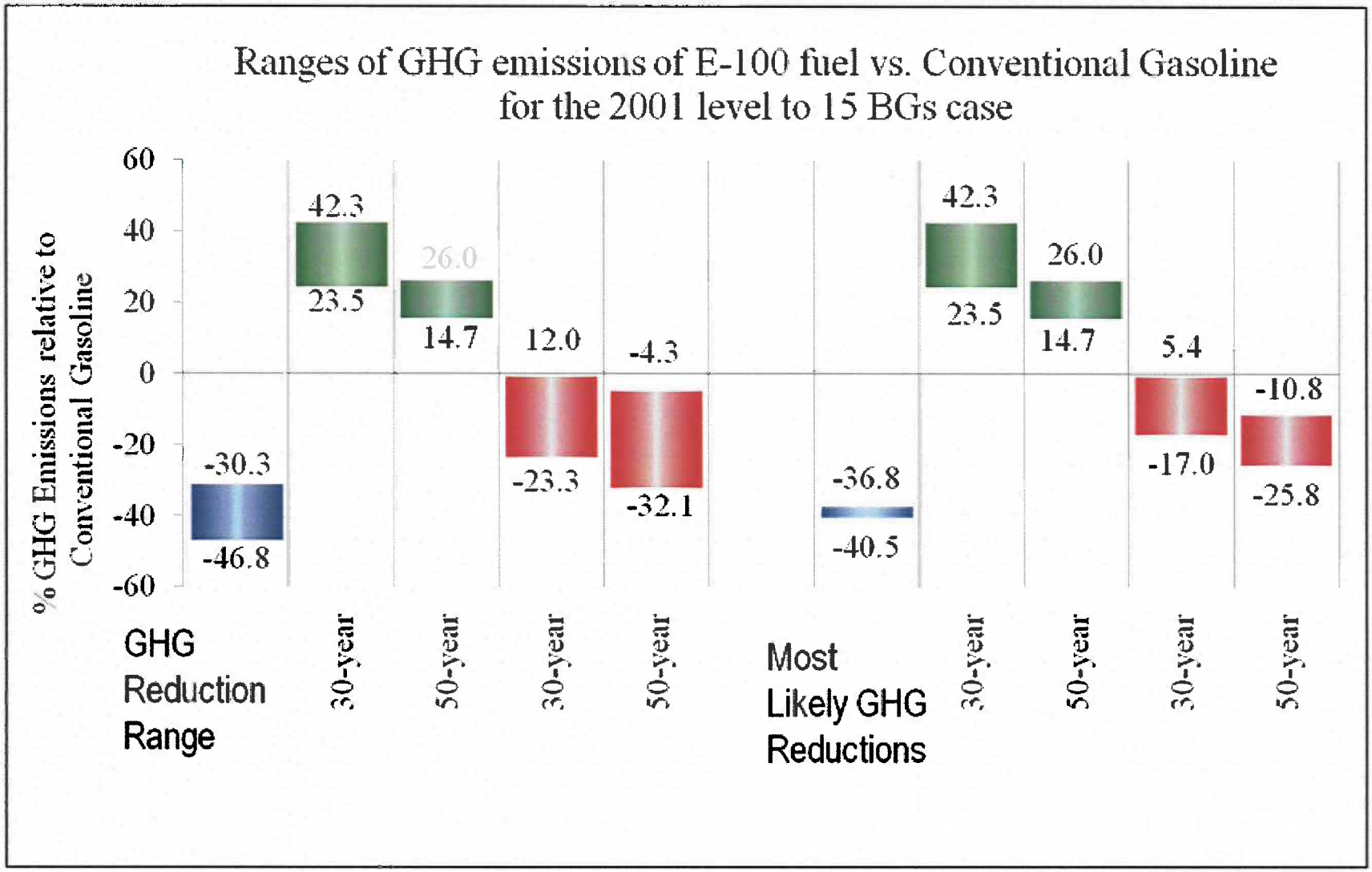


Marginal (13 to 15 BG)
Average (2001 to 15 BG)

PURDUE UNIVERSITY

PURDUE AGRICULTURE

GHG Emission Uncertainty



GTAP Results Summary

Item	Units	Value
Annual average emissions	Gm./gal.	1666
% of Searchinger	%	19.4
Average Ethanol emissions	Gm./mi.	444.5
% of gasoline	%	91.3

- For the 100 year horizon, our results are 77% of gasoline. Our range is -9 to -23 for corn ethanol.
- There is huge uncertainty surrounding these results.
- However, we know the land use change is not zero.

Comparison Basis

- As is clear from these results, there is a difference. between emissions calculated on an average basis and a marginal basis.
- The same would be true for the petroleum base case.
- Economics would argue for using a marginal comparison instead of the average we are now using.
- For petroleum, the marginal source likely would be Canadian tar sands or heavy Venezuelan crude – both of which would have higher GHG emissions than the standard sources.
- This issue deserves more attention.

Summary

- Our current corn ethanol numbers bracket the EISA standard, and they are uncertain.
- However, they represent good science, and, like other economic modeling can never be perfect.
- Technology improvements on the direct emissions side may lower the total more than any future changes in indirect emissions.

Attachment D

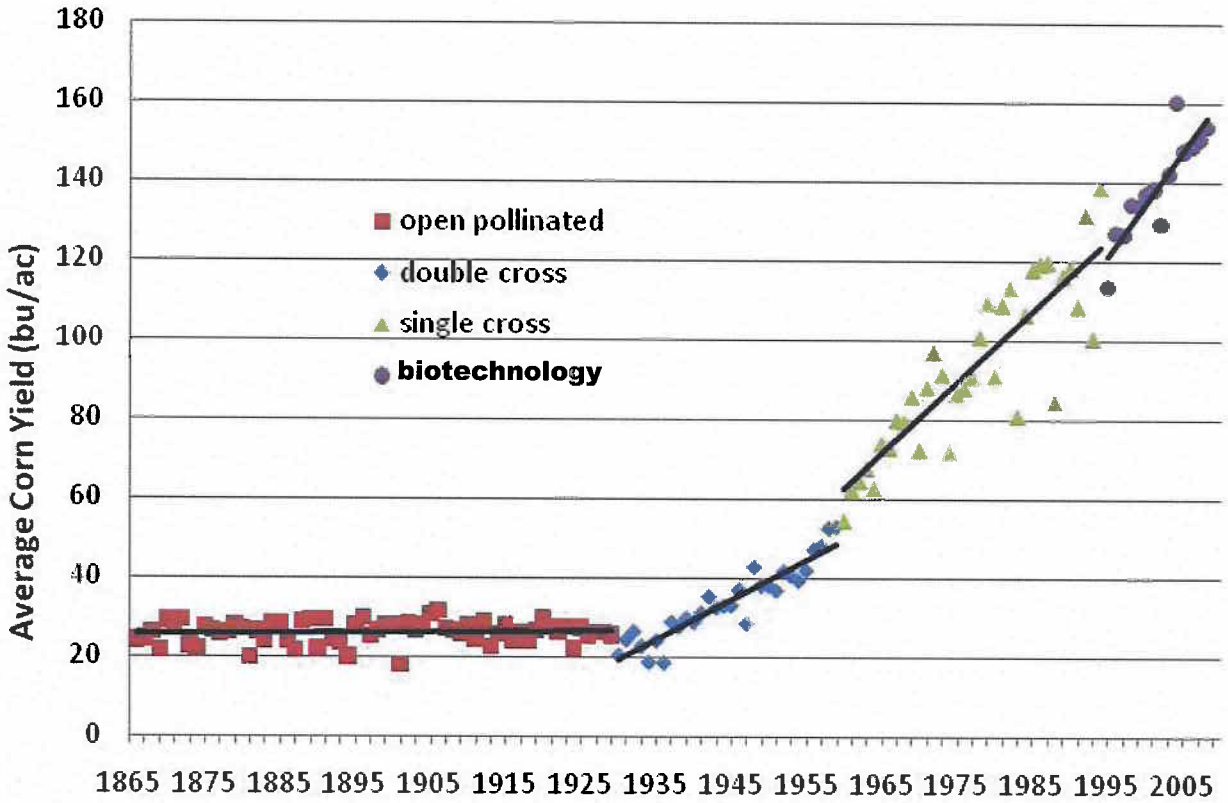
Amazing Predictions….
The future is not the past

25 August, 2009

Beth J Calabotta

MONSANTO
imagine

Corn yield gains are driven by technology innovations



Source: March 2006. Crop Science. Ref# 46:528-543

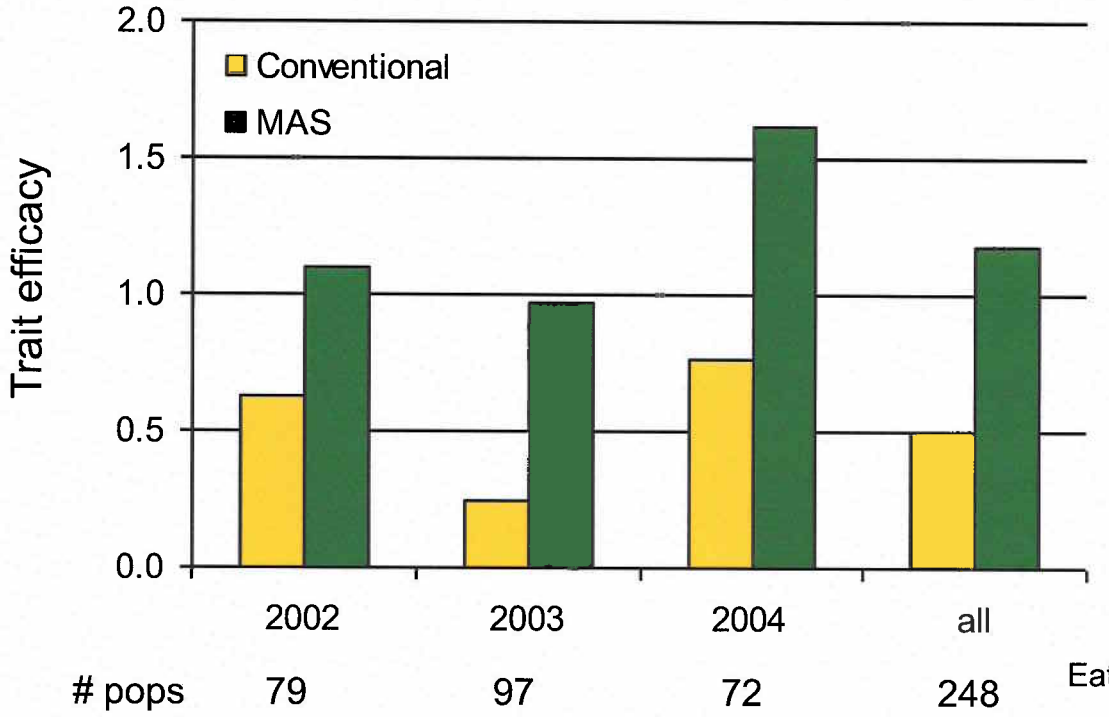
Consecutive Periods Being Compared	Difference	SE	p-value
Double cross - Open pollinated	0.9901	0.1349	<0.0001
Single cross - Double cross	0.7991	0.1639	<0.0001
Biotech GMO - Single cross	0.8767	0.4163	0.0371

Rate of yield gain is increasing

MONSANTO imagine

Marker assisted breeding has doubled breeding rate of gain

Increased rate of gain with marker assisted breeding



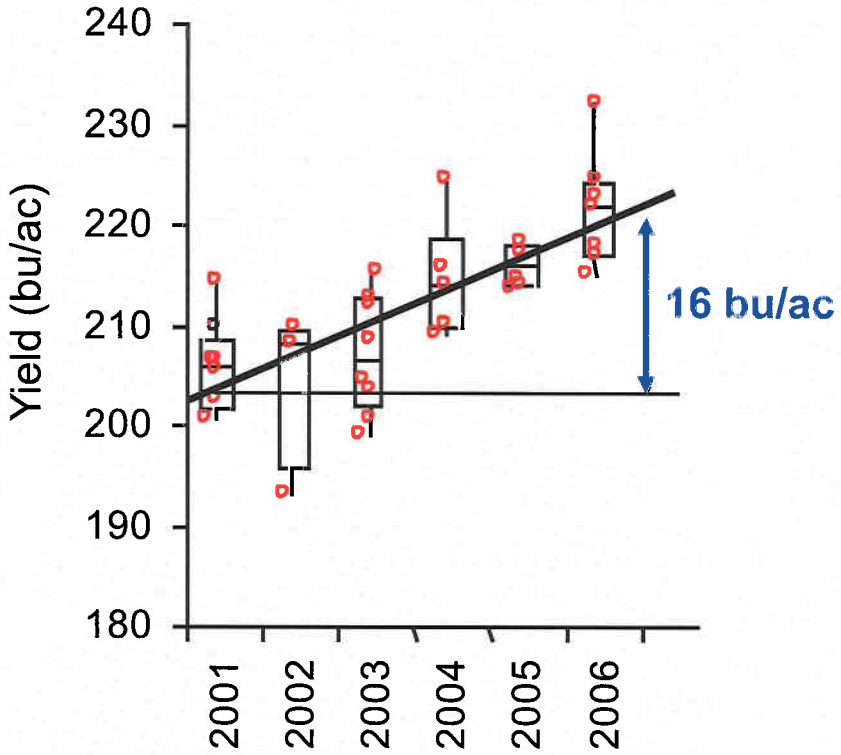
Eathington et al (2007) Crop Sci

Marker assisted breeding has doubled the rate of gain in breeding, with the 1st products are just beginning to come on the market

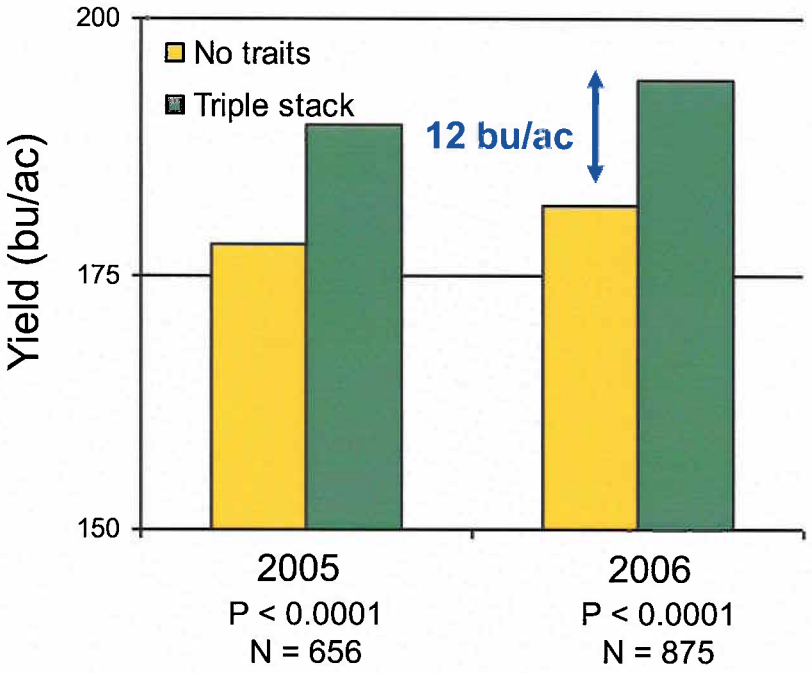
MONSANTO imagine

Breeding traits protect against insect and weed pressure and deliver increased yields

Yields of Dekalb RM110 hybrids released from 2001 - 2006



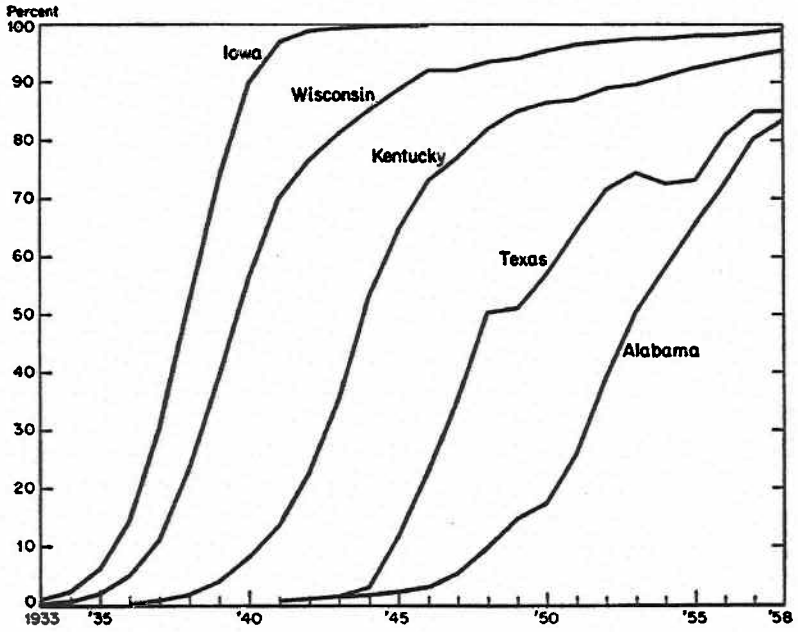
Increase in yield due to protective traits



MONSANTO imagine

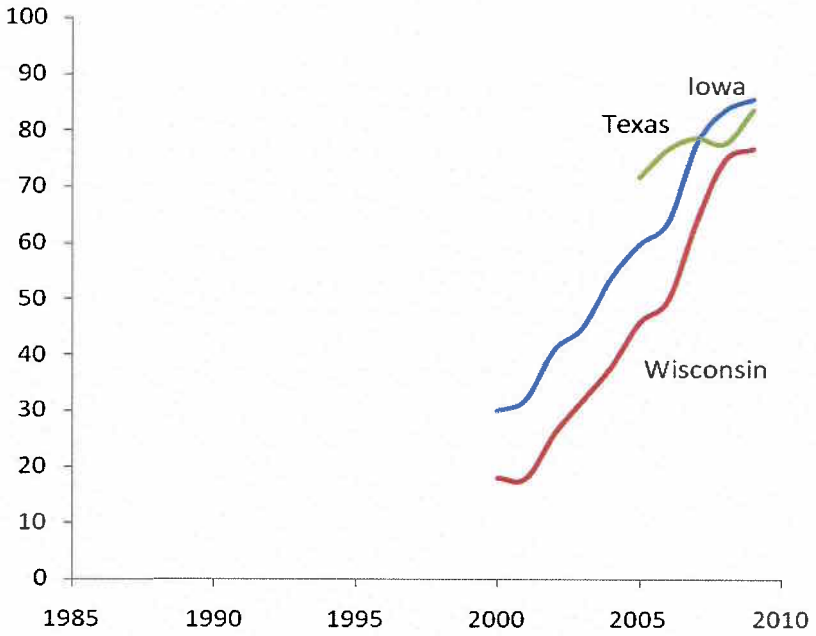
Farmers have readily adopted new technologies

Percentage of hybrid corn



Source: Science: 132:275-280

Percentage of biotech corn

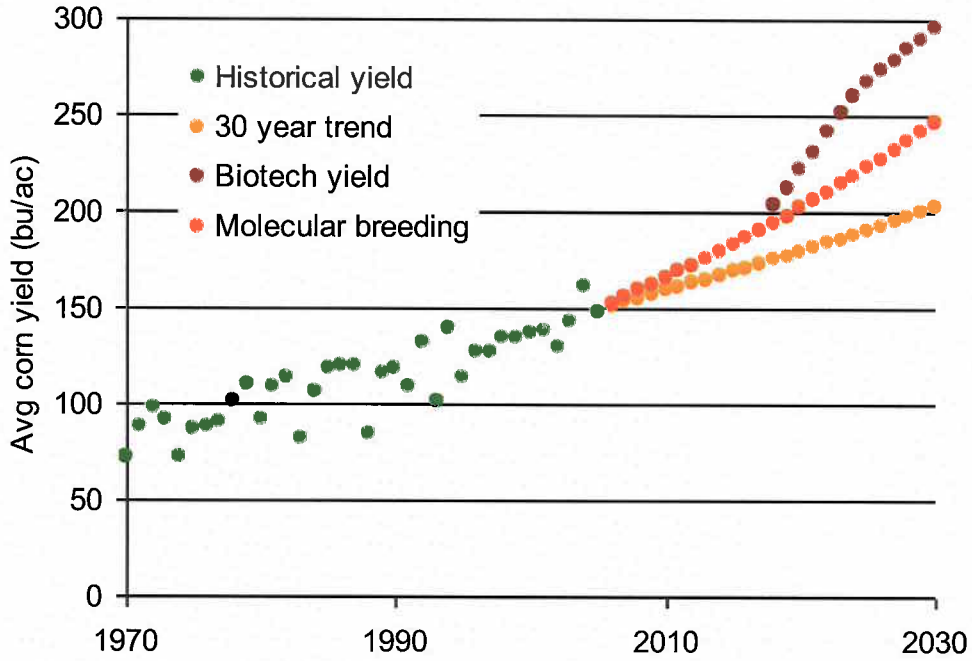


Source: USDA

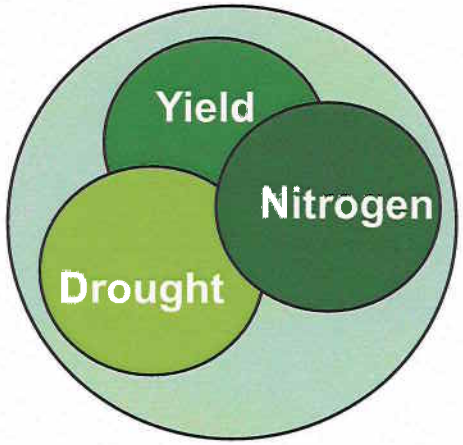
MONSANTO imagine

United States Corn yields will reach 300 bu/ac

Future yield potential based on Monsanto estimates



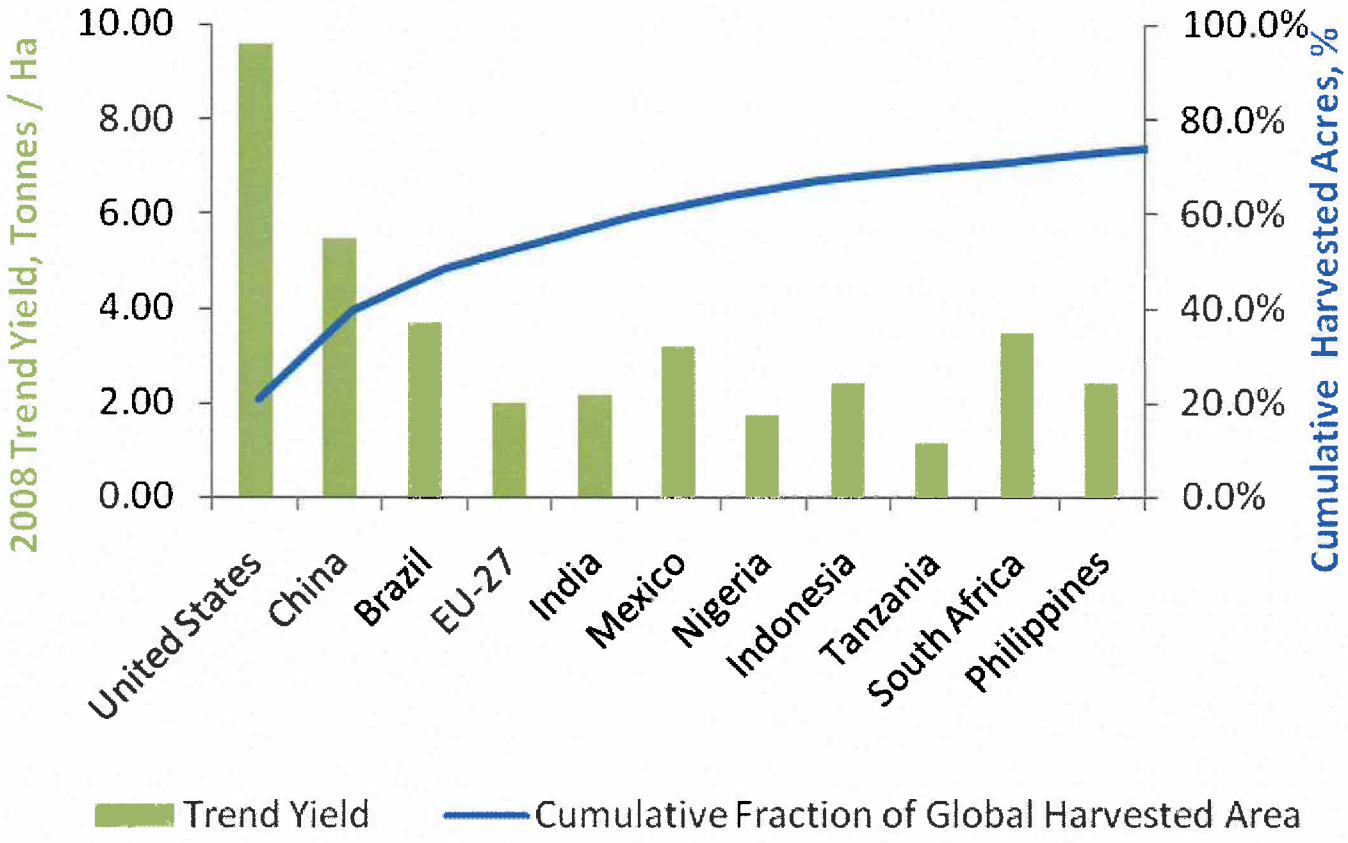
- Marker assisted breeding has doubled breeding gain
- Current biotech traits protect genetic potential
- Next generation biotech traits will further protect and increase yield potentials



MONSANTO imagine

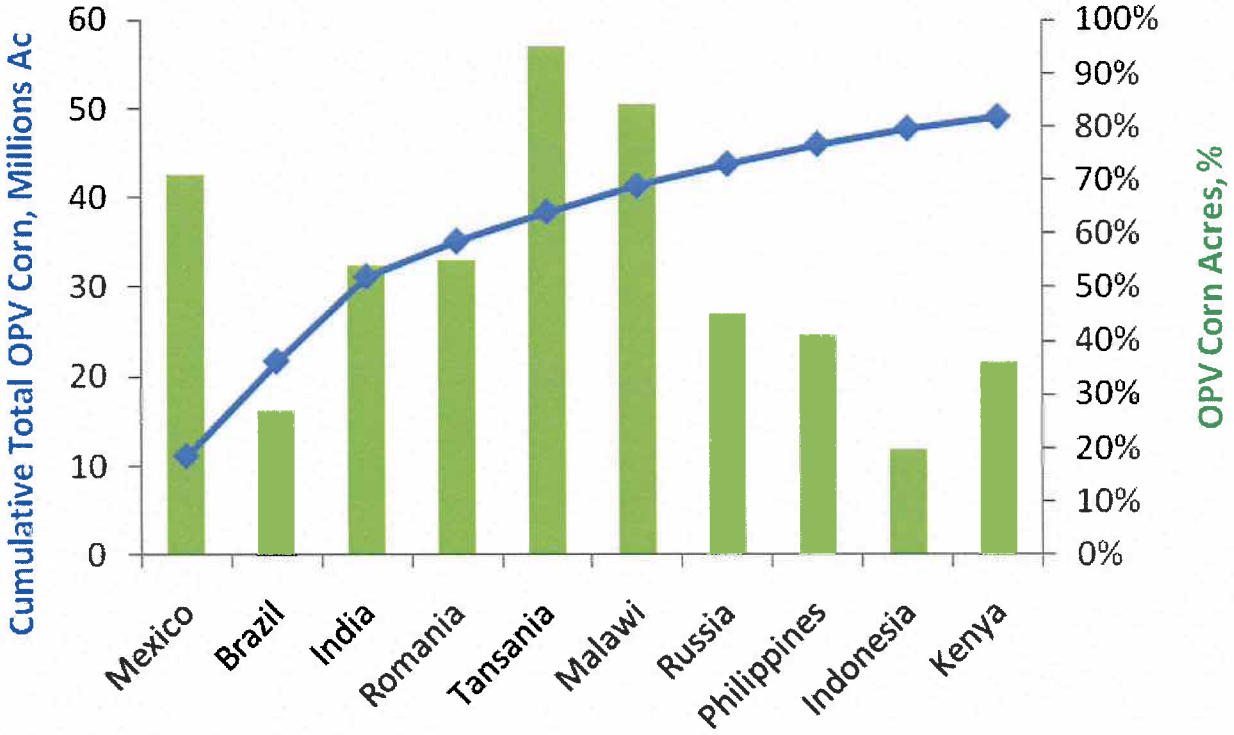
Broad-acre yield family of traits

Global corn yields are significantly lower than the US



MONSANTO imagine

About 50 million ac of open pollinated varieties (OPV) of maize are grown each year



Economics of hybrid adoption have been studied for many years

Griliches Z (1957) Hybrid corn: An exploration in the economics of technological change. J Econometric Soc. 25:501

MONSANTO imagine

Tropical corn has increased pest and disease pressure …

Supression

Spodoptera frugiperda

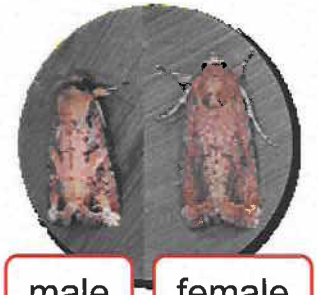


Photo: Negri

Potential Damage – 40%

Supression

Helicoverpa zea

Photo: Negri

Potential Damage – 8%

Control

Diatraea saccharalis

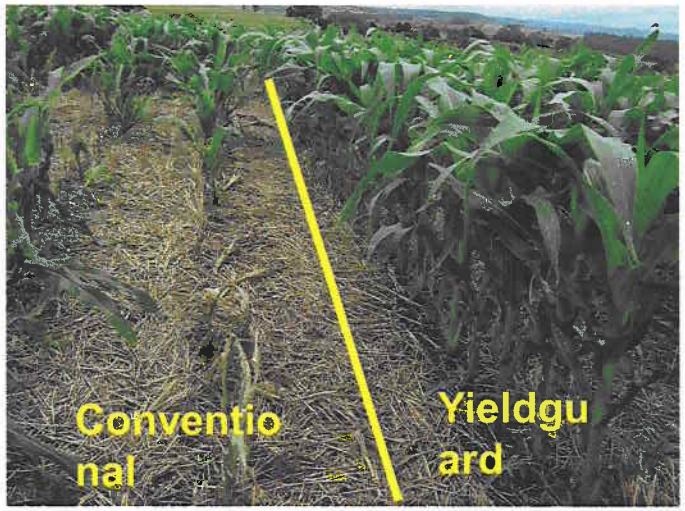
Photo: Negri

Potential Damage – 21%

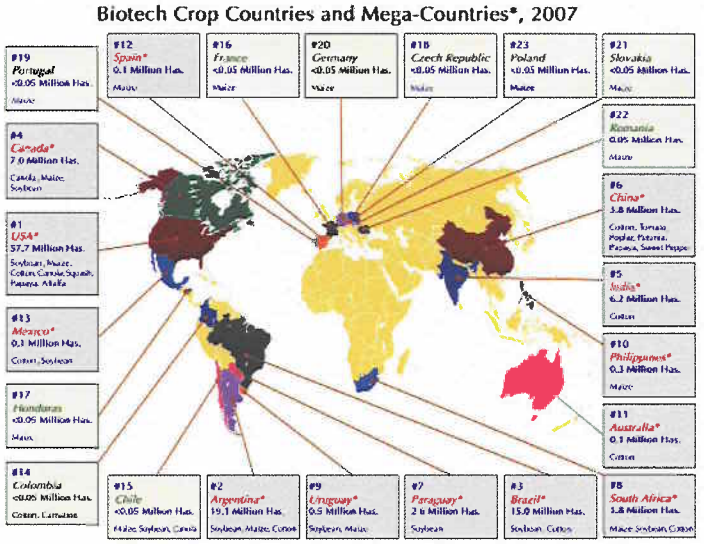
MONSANTO imagine

Biotech traits have only recently been approved in Brazil

- Six traits approved since 2007.
- Currently in early phase of adoption curve.
- Heavy disease and pest pressure highlight value of traits.

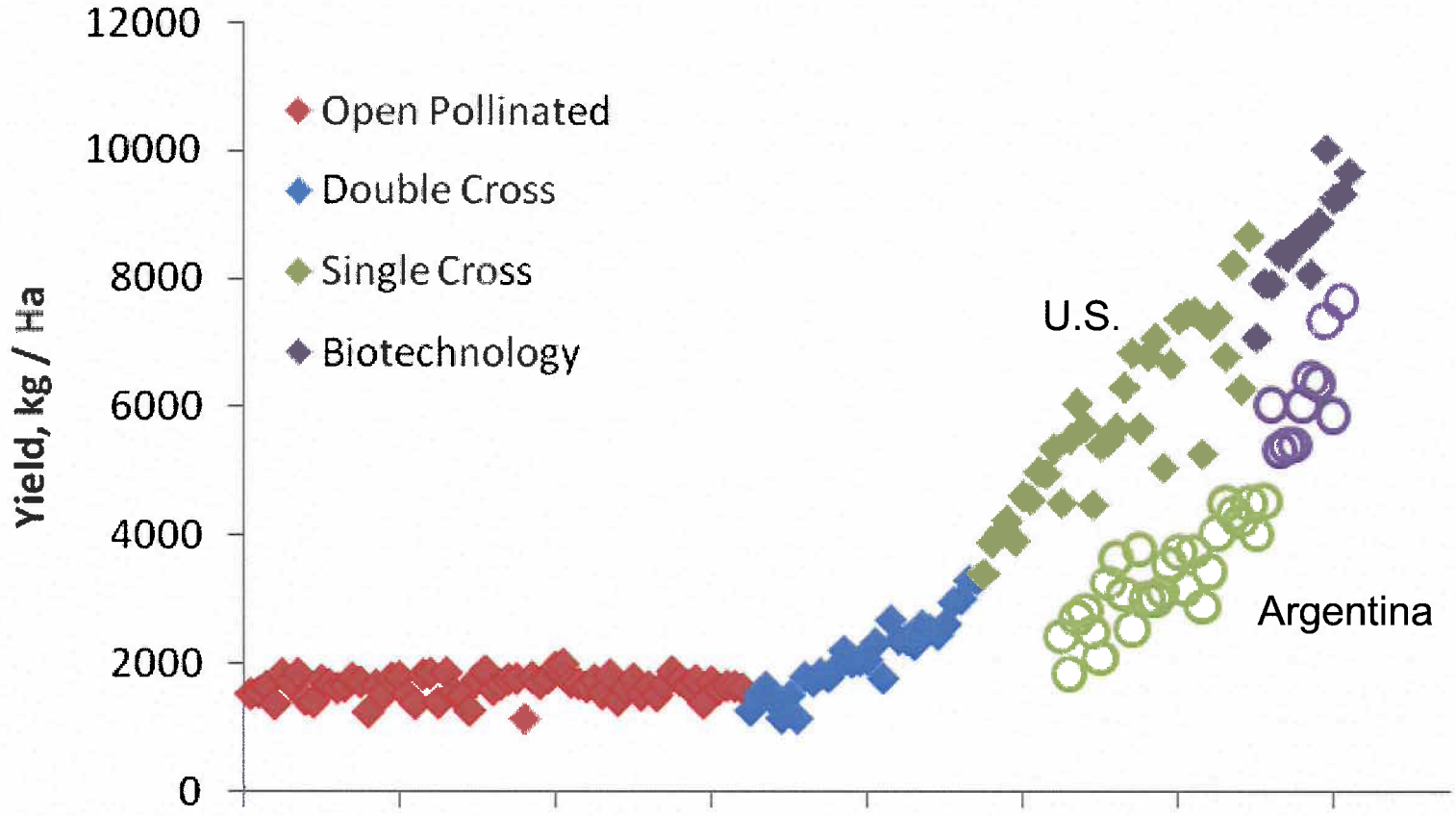


Area of high spodoptera pressure



MONSANTO imagine

Significant opportunities exist ex-US to increase rate of yield gain



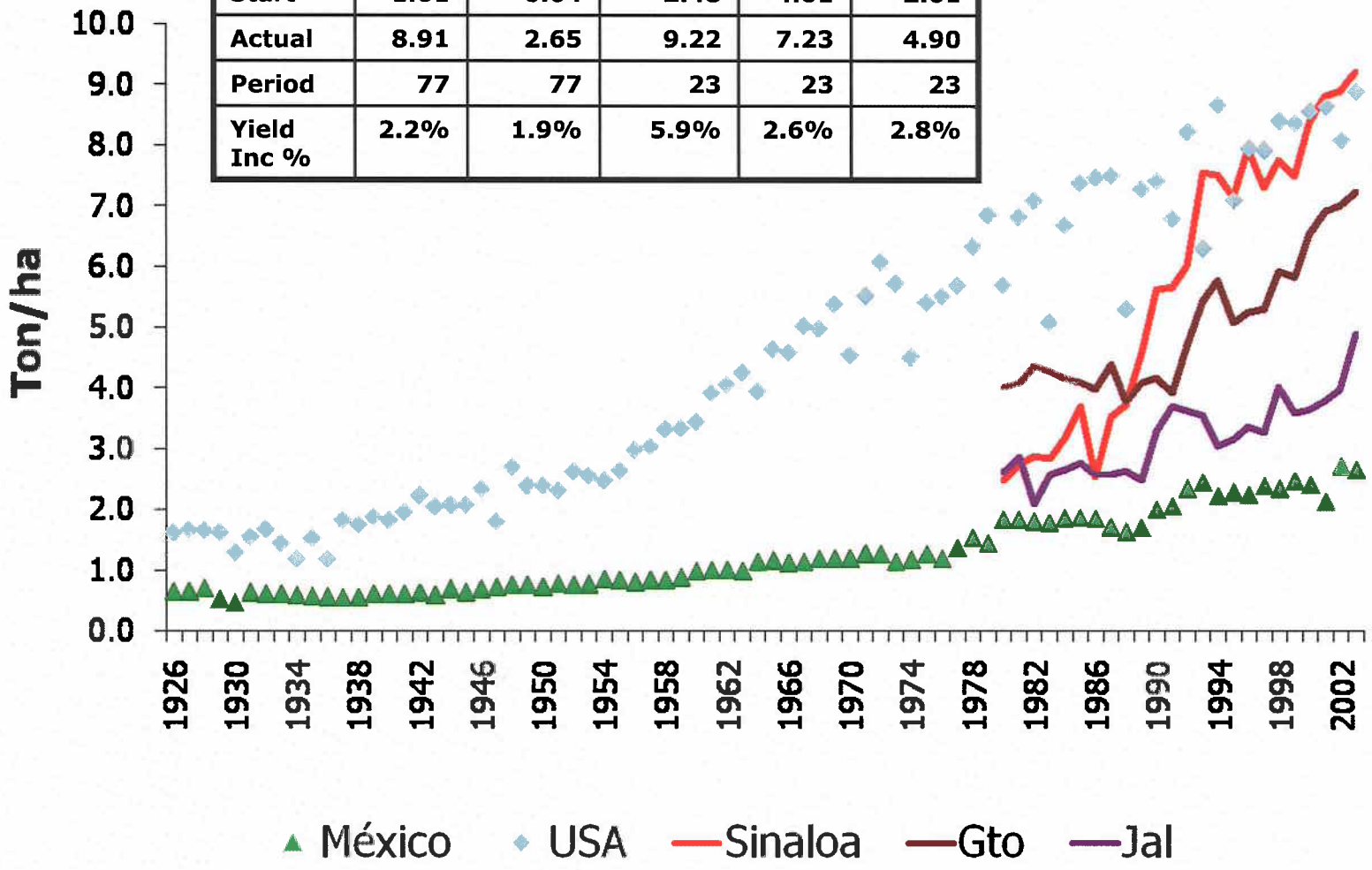
INDIA
NIGERIA
INDONESIA
ETHIOPIA

PHILLIPINES RSA MEXICO BRASIL UKRAINE CHINA ARGENTINA FRANCE ITALY

Source: Crop Science. Ref# 46:528-543, USDA and FAO

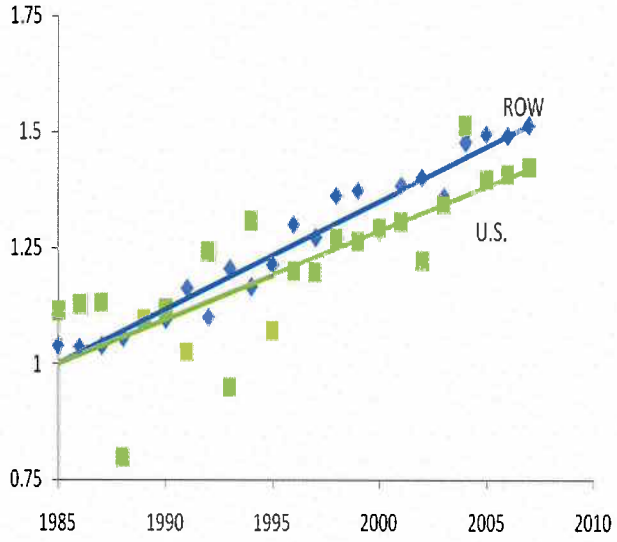
Rapid yield gains are possible within a short period of time

	USA	Mexico	Sinaloa	Gto	Jalisco
Start	1.61	0.64	2.48	4.01	2.61
Actual	8.91	2.65	9.22	7.23	4.90
Period	77	77	23	23	23
Yield Inc %	2.2%	1.9%	5.9%	2.6%	2.8%

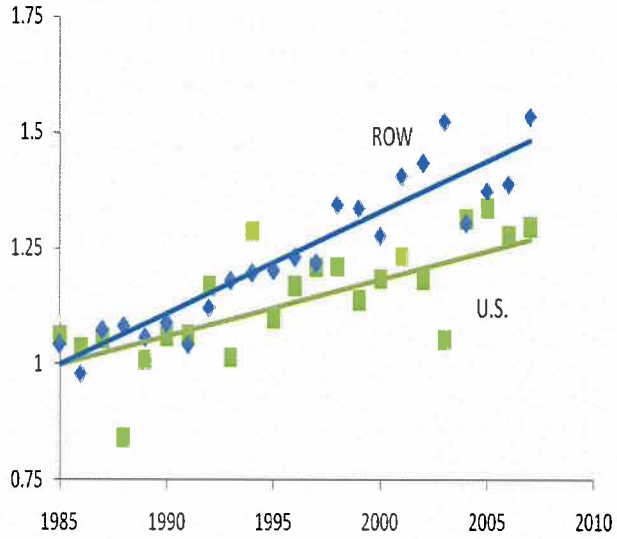


On a percentage basis, yields are improving faster globally than in the United States

Corn



Soybeans

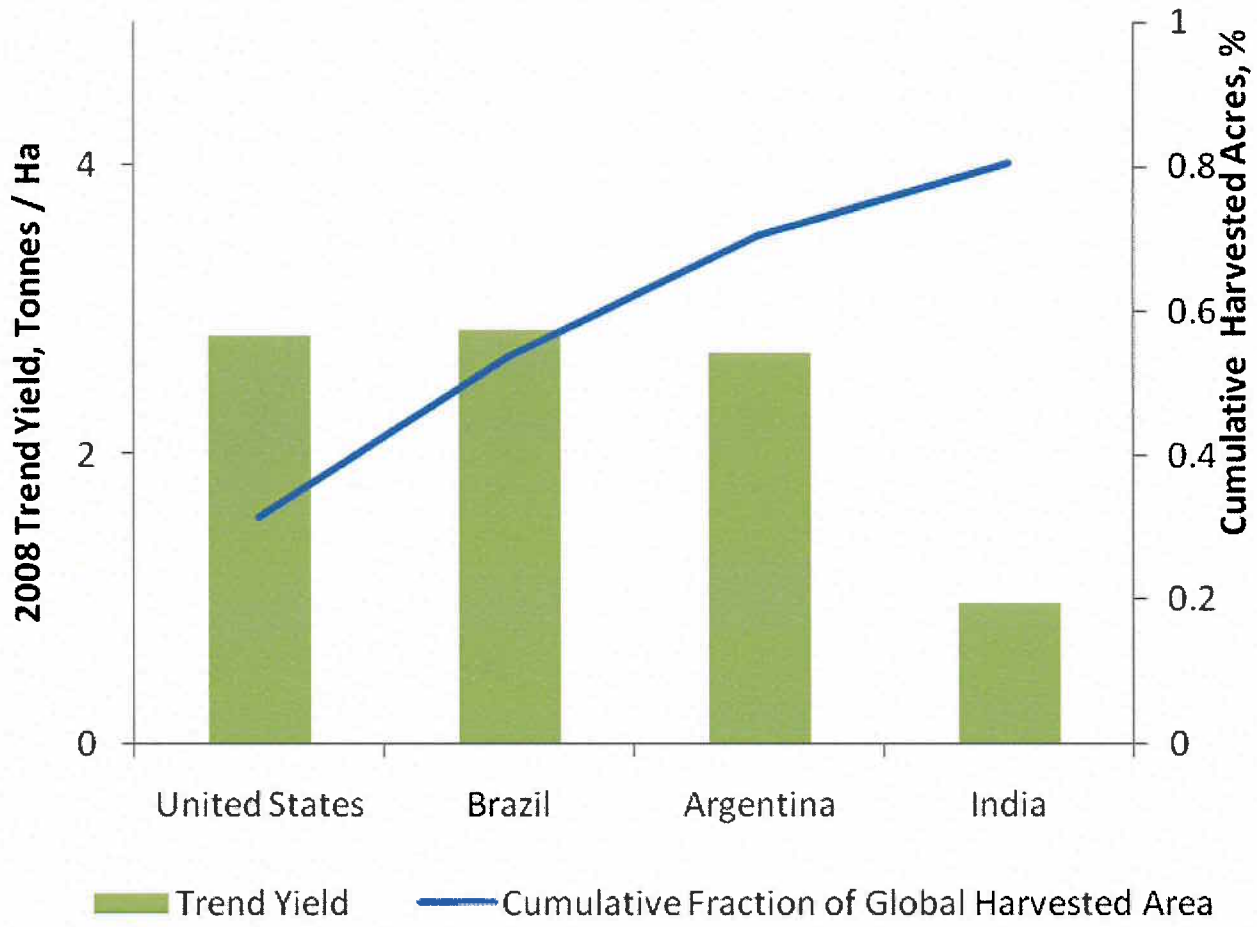


MONSANTO imagine

Summary

- The rate of gain of crop yields are driven in large part by breeding technologies.
- The rates of yield gain has been increasing due to molecular breeding and biotechnology.
- Outside of the U.S., there is significant opportunity for crop yield improvement

Global soy yields



MONSANTO imagine