EPA Fuel Life Cycle GHG Estimates Update

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Lifecycle Carbon Footprint of Biofuels workshop

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Recent Events

• January 2007	State of the Union Address—20-in-10 goal
• March 2007	Administration proposes Alternative Fuel Standard legislation
• April 2007	Supreme Court Decision
• May 2007	RFS Published (7.5 billion gallons of renewable fuels by 2012)
• May 2007	President's Announcement and Executive Order (35 billion gallons renewable and alternative fuel)
• December 2007	Energy Independence and Security Act (H.R. 6) was passed by Congress and signed by President Bush on December 19 (36 billion gallon renewable fuel mandate by 2022)

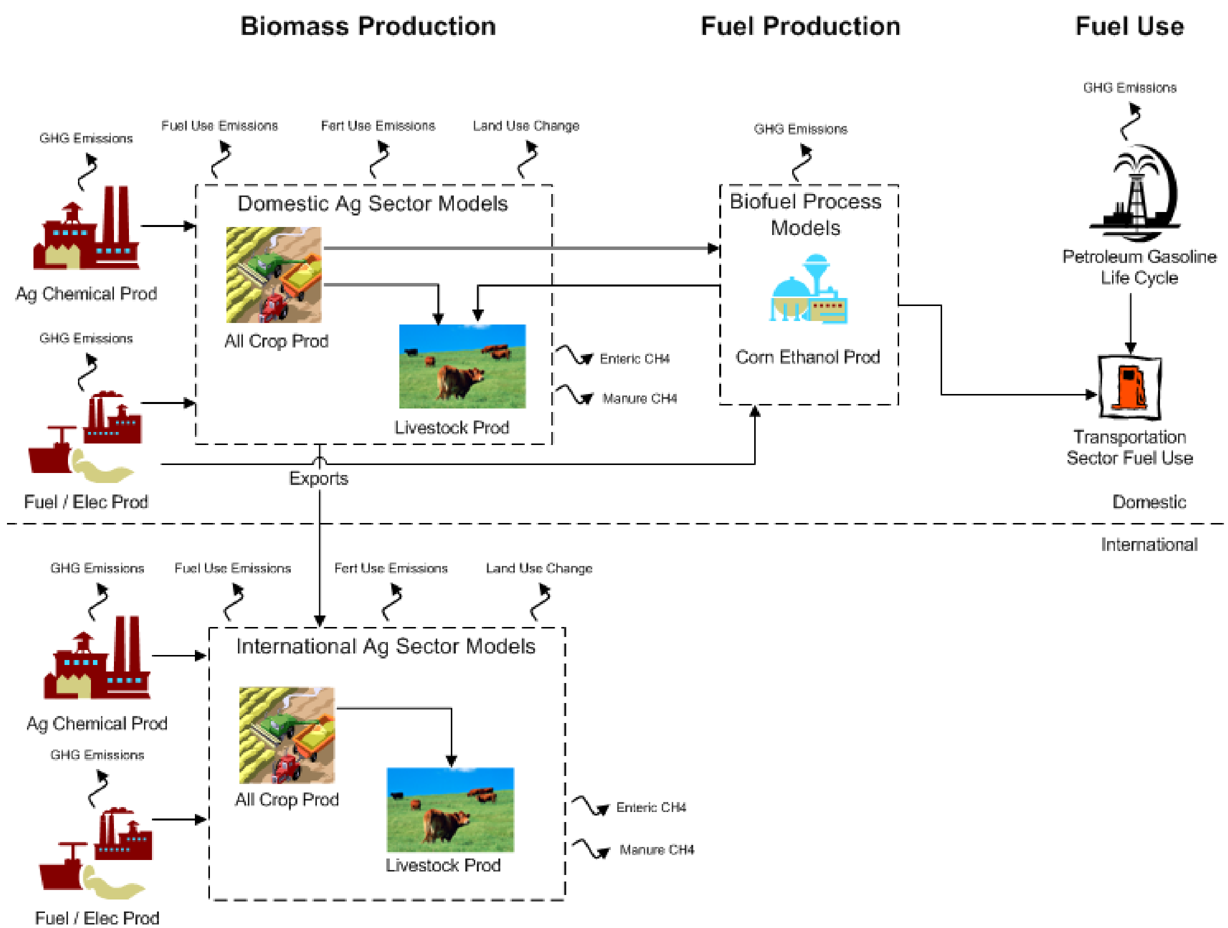
Energy Independence and Security Act Requires Life Cycle Assessment

- Life cycle assessment required to determine which fuels meet mandated GHG performance thresholds (reduction compared to baseline petroleum fuel replaced)
  - Conventional Biofuel (ethanol derived from corn starch) – 20% (only applies to fuel produced in new facilities)
  - Cellulosic Biofuel (renewable fuel derived from "cellulosic feedstocks") – 60%
  - Biomass-Based Diesel (biodiesel) – 50%
  - Other Advanced Biofuels (e.g., imported sugarcane ethanol, renewable diesel, CNG/LNG made from biogas) – 50%
- Life cycle includes all major GHGs, includes production and use, includes indirect land use change impacts
- Baseline fuel for comparison is gasoline and diesel fuel in 2005 (implies level of desulfurization and tar sand use)

Overview of Updated Approach

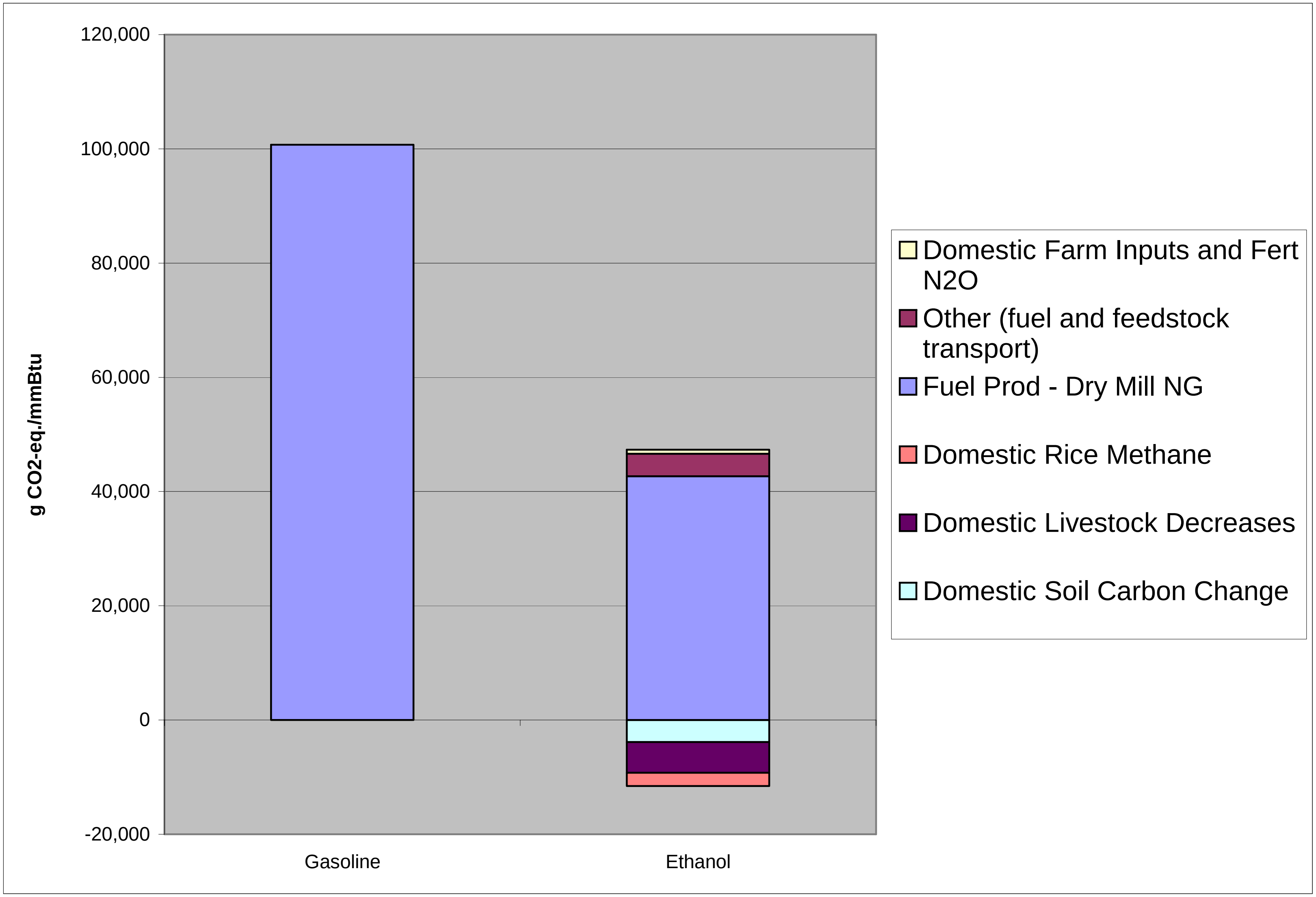
- Domestic Agricultural Sector: use comprehensive agricultural sector model (FASOM) to determine sector-wide impacts of increase biofuel production
- International Agricultural Sector: use comprehensive models for worldwide agricultural sector (FAPRI) for a reference case and policy case to determine:
  - Changes in U.S. exports due to increased domestic biofuel production
  - International increased corn production, decreases in other crops, changes in total crop acres
- GHG emissions included in FASOM, FAPRI results converted to GHG emissions based on GREET defaults and IPCC emission factors
- Ethanol process emissions based on process models
- Feedstock and ethanol transportation based on GREET
- Gasoline baseline based on GREET defaults (adjusted to include emissions from gasoline desulfurization, and tar sand imports)

Corn Ethanol Scenarios Modeled



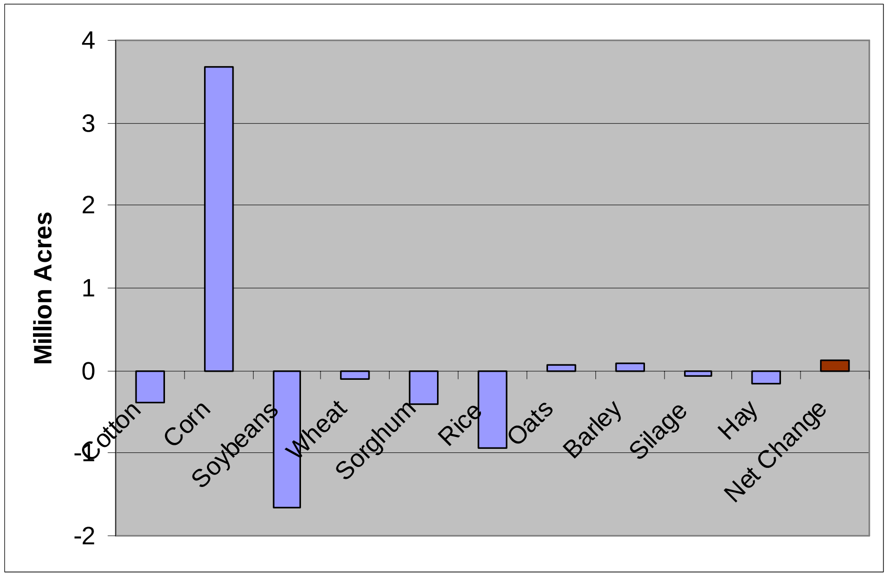
- Compared two similar corn ethanol volumes in both agricultural sector models
- Other fuel volumes held constant to isolate impacts of corn ethanol
- **Results represent per mmBtu "average marginal" impact of going from ~12 to 18 Bgal**

Domestic Emissions Only



Domestic Impact Discussion

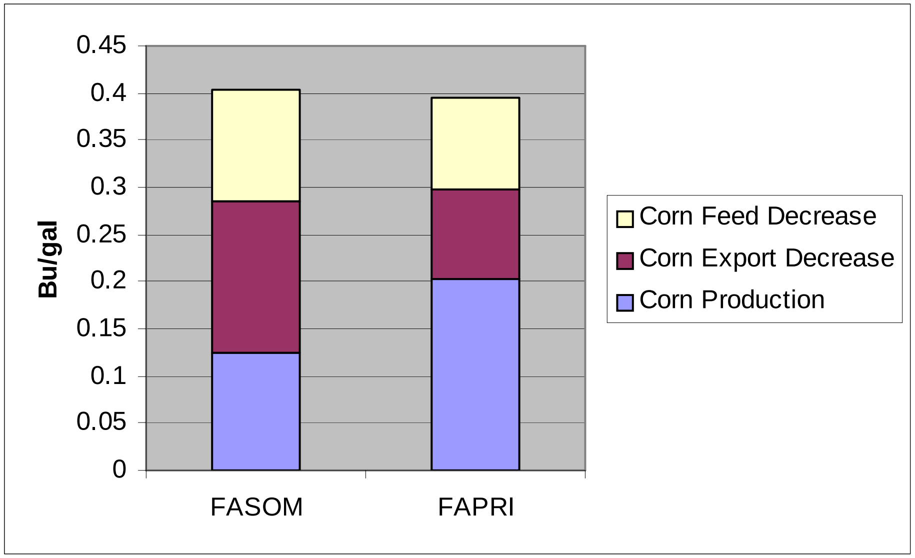
- Looking at domestic impacts only of increased ethanol production results in a net decrease in total GHG emissions
  - Shift in crop production results in no net crop acreage increase (small increase in agricultural sector inputs)
  - Decrease in rice acres and livestock production (due to increased feed prices) results in GHG emission reductions



- 40% of corn used for ethanol comes from reductions in exports (highlighting need to include international impacts)

Modeled Export Changes

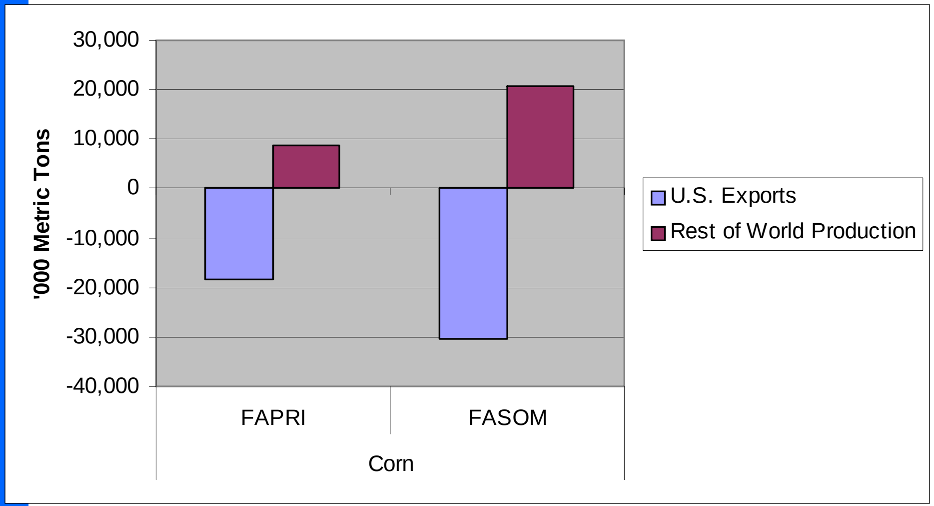
- International impacts are dependent on domestic modeling of export changes
- FASOM and FAPRI predict different export response (not just corn but other crops as well)
- Inconsistent to compare FASOM domestic impacts with FAPRI international impacts as is

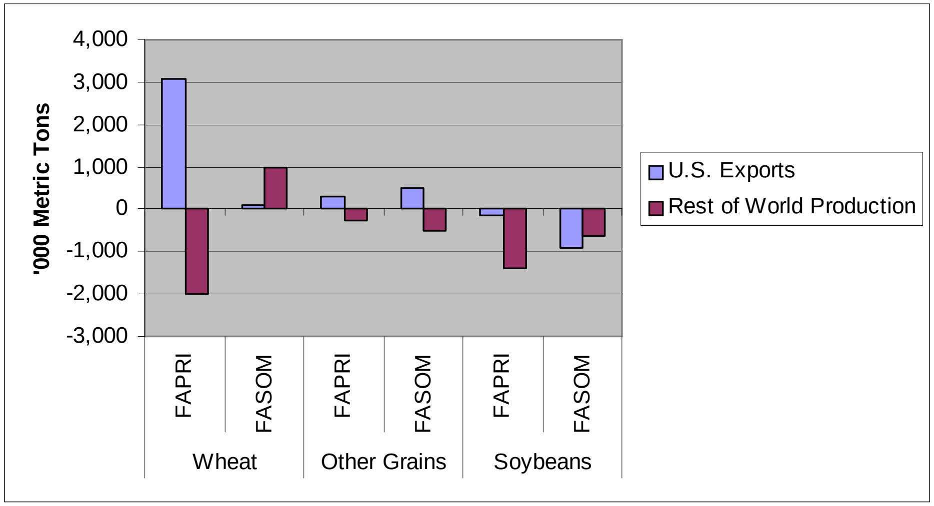


Basis for International Adjustment

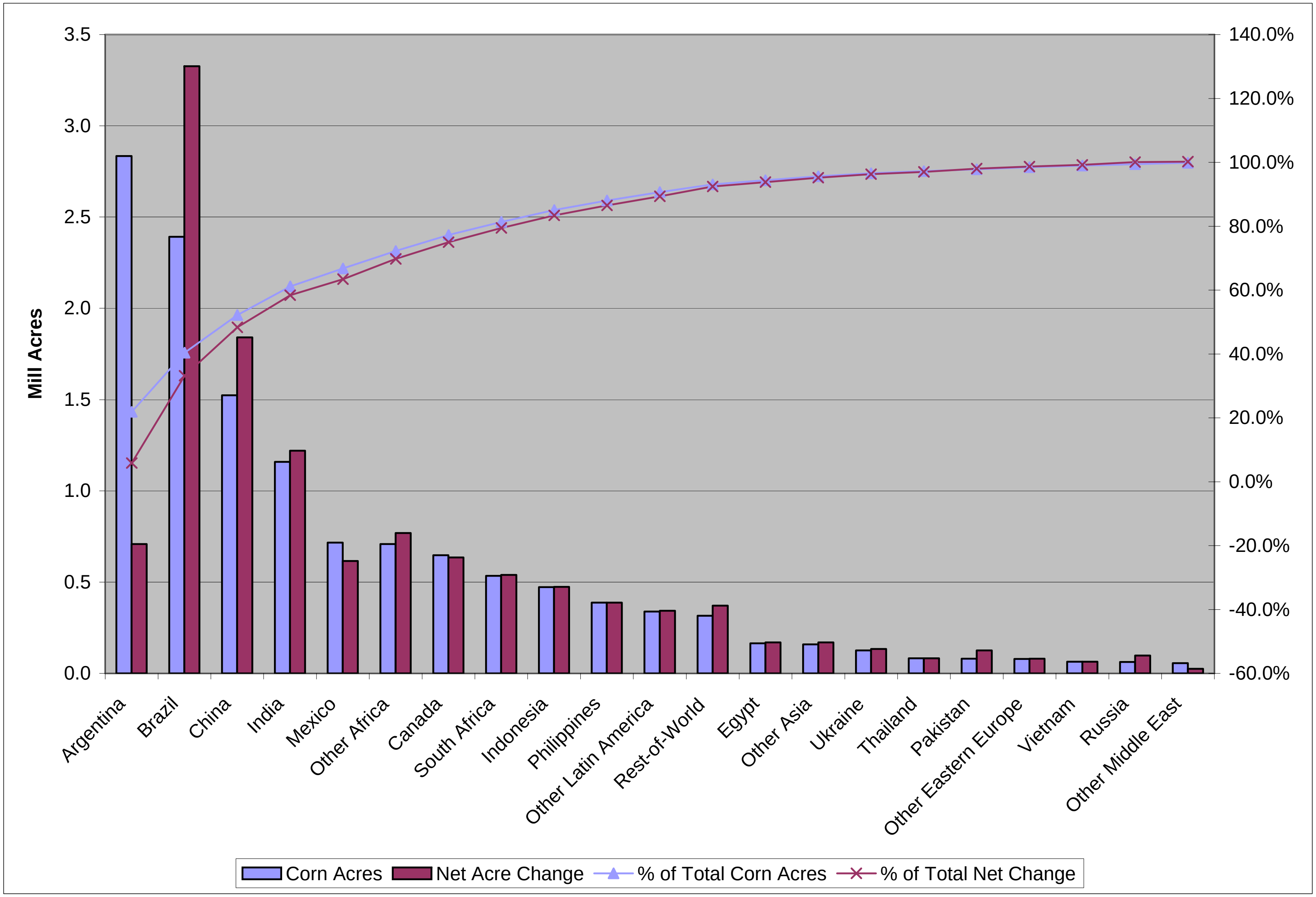
- Adjust production of all crops internationally to make up for changes in U.S. exports
- Adjust production in all countries based on weighted percent of production in baseline
- Changes in crop acres based on yields in different countries
- Assumed net increase in all crop acres results in land use change
- FAPRI does not include international rice production, conservative assumption assumed that international rice production offsets domestic decrease

Difference from Baseline



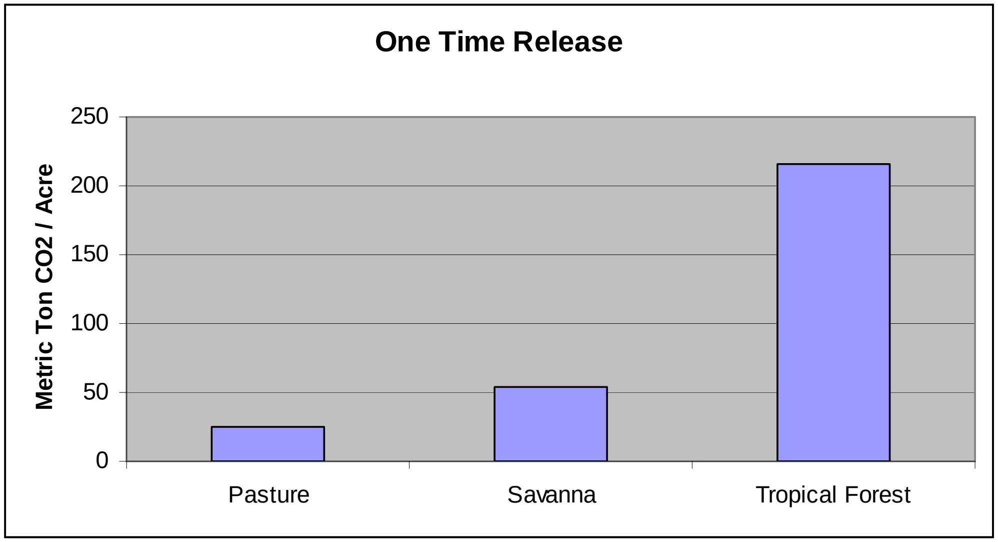


Adjusted Land Use Change



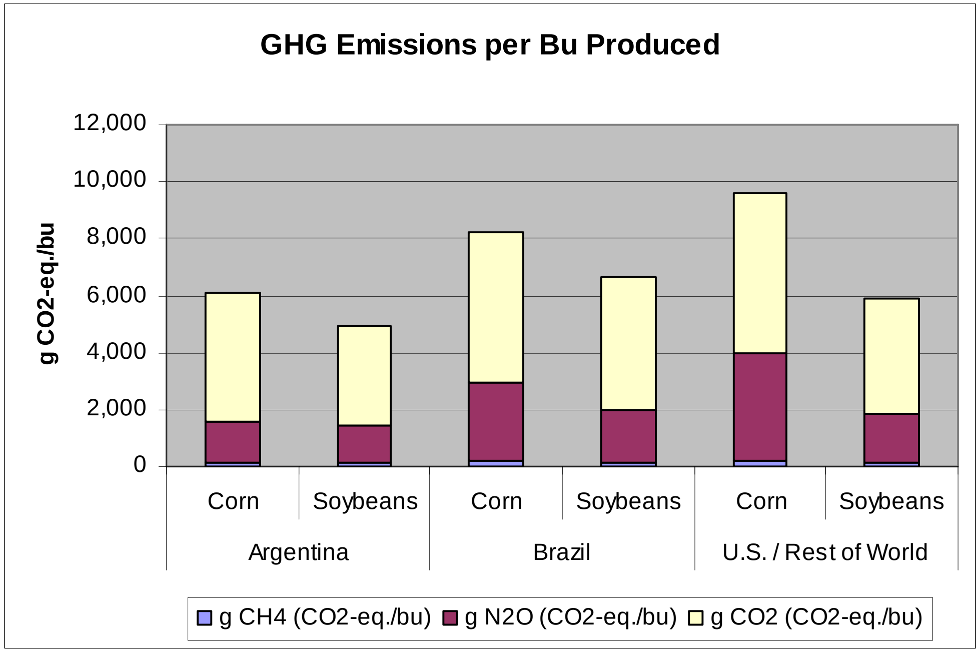
Land Use Change Assumptions

- Need to consider carbon per acre for different land types
- What type of land is converted in different countries, for example:
  - Argentina (Savanna)
  - Brazil Case 1 (Pasture)
  - Brazil Case 2 (Savanna)
  - Brazil Case 3 (Pasture + Tropical Forest)
  - Indonesia (Tropical Forest)
- Brazil has biggest land use change impact so considered different scenarios
- One time land use change impact was put on annual basis - over 30 year time frame



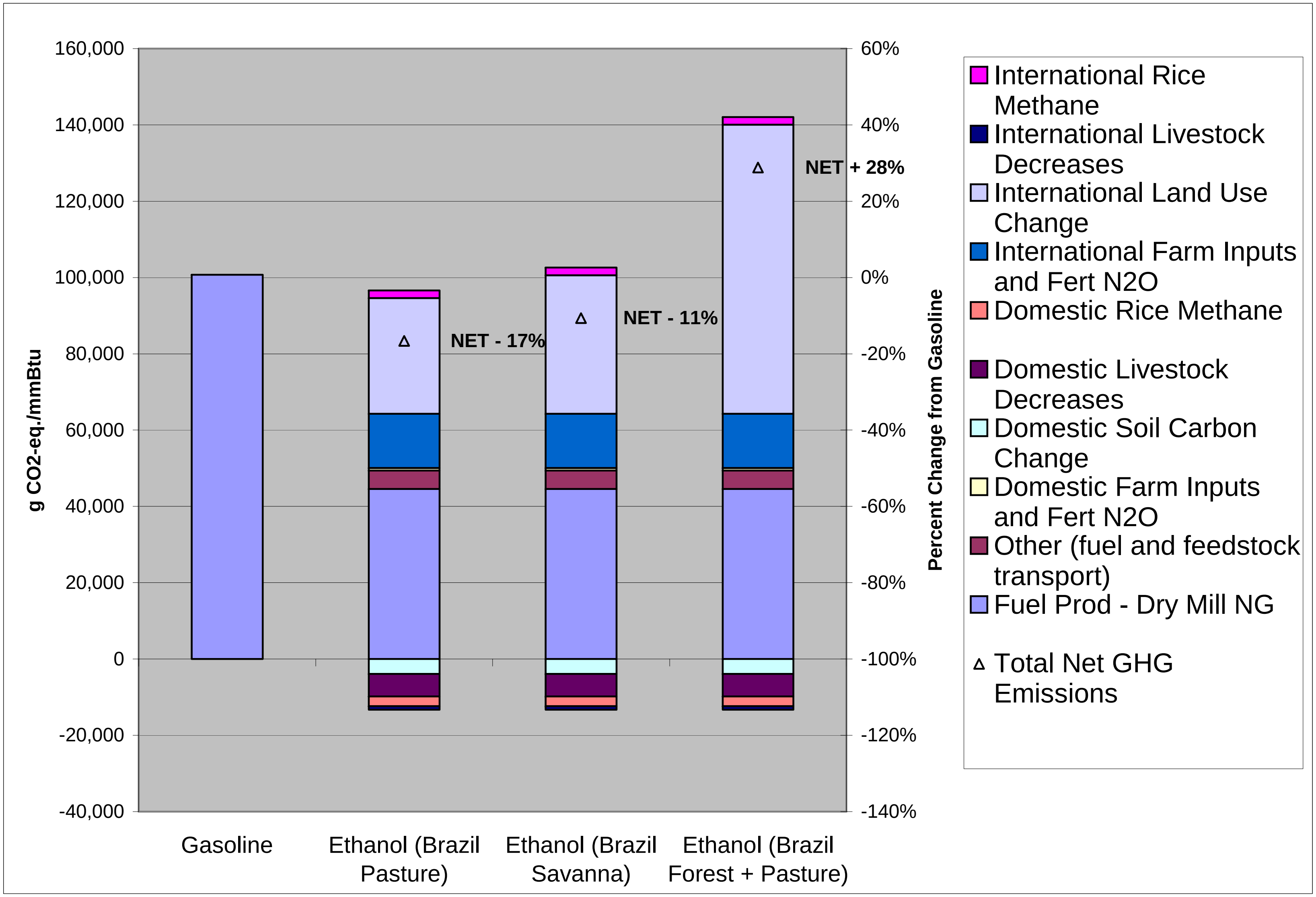
International Agricultural Sector GHG Impacts

- Corn & soybean production emissions based on GREET defaults
  - Brazil and Argentina fertilizer use adjusted
  - Rest of world assumed to be same as U.S. defaults



- Also included impacts on livestock internationally
  - Enteric fermentation and manure management based on IPCC defaults for different regions

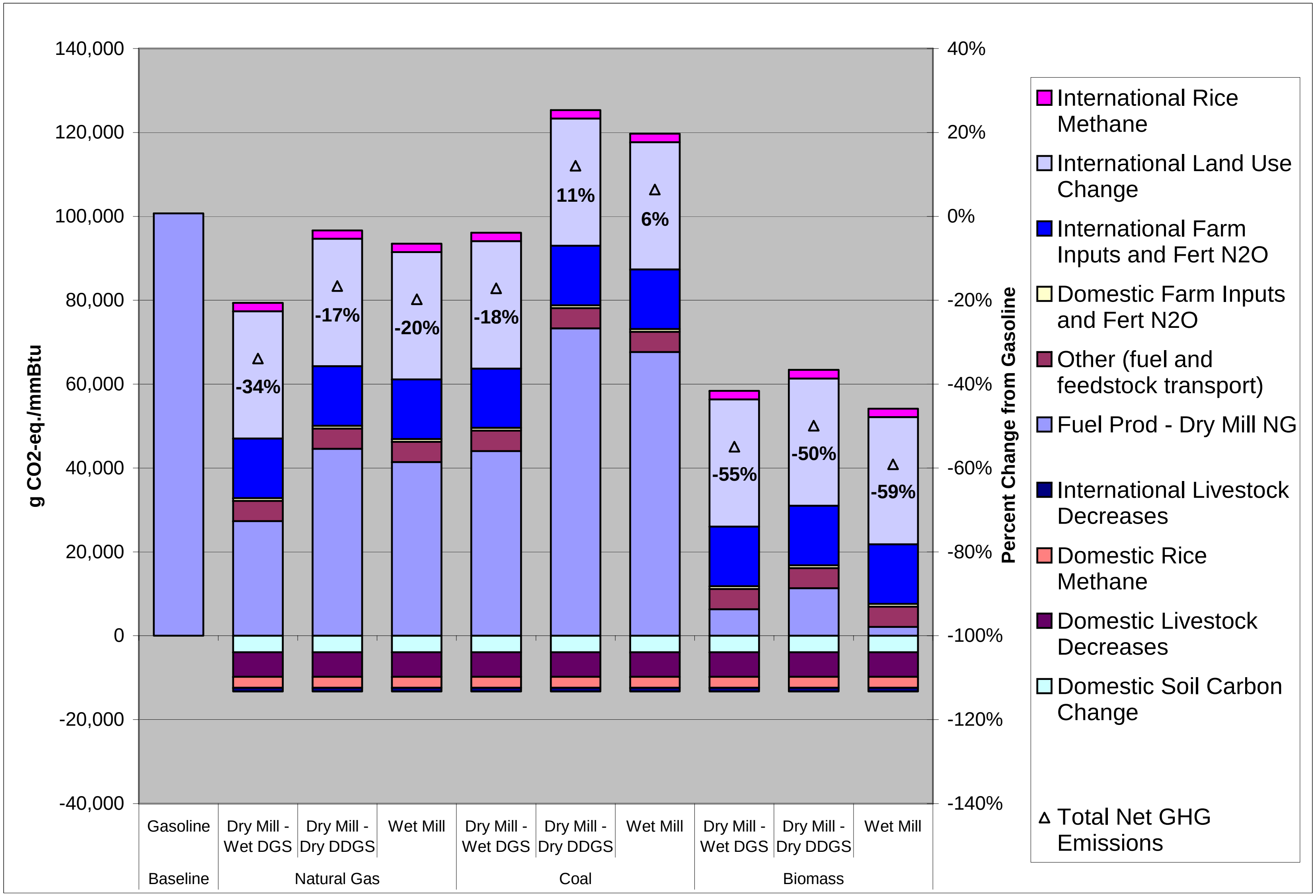
Impact of Land Use Change Assumptions
(Dry Mill, Natural Gas, Dry and Pelletized DDGS)



Land Use Change Scenario Discussion

- There is land available for crop expansion in Brazil without affecting environmentally sensitive areas
- Infrastructure availability suggests crop expansion in pasture land areas before savanna
  - Total modeled land impacts less than 1% of current pasture
  - Could be less with more intensive use of existing lands
- Forest reduction is occurring
  - Increased crop production could push pasture into these areas
  - Economic benefit of raising cattle in the Amazon is relatively small (e.g., lack of infrastructure, foot and mouth disease, etc.)
- Exact land use change impact in unknown
  - Pasture most likely

Impact of Ethanol Plant Energy Use
(Pasture Land Use Change in Brazil)



Further Work on Life Cycle Modeling

- **Specific areas of improvement that we are working on include:**
  - Building a consistent modeling framework that captures both domestic and international agricultural sector changes and GHG impacts
  - Working with experts to improve understanding of agricultural N2O emissions
  - Developing country specific GHG emissions factors associated with land use change and agricultural practices
  - Updating petroleum baseline
- **Updating other biofuel life cycle GHG factors with this approach**
  - Biodiesel
  - Imported ethanol
  - Cellulosic ethanol
- **We continue to have discussions with**
  - Industry groups
  - Academics and other experts
  - CA and EU regulators