PURDUE UNIVERSITY

PURDUE AGRICULTURE

CALCULATION OF INDIRECT LAND USE CHANGE (ILUC) VALUES FOR LOW CARBON FUEL STANDARD (LCFS) FUEL PATHWAYS

Preliminary Analysis

Alla Golub, Economist
Farzad Taheripour, Energy Economist
Wallace E. Tyner, Professor
Purdue University

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Biofuels Covered

- US Corn ethanol
- US soybean biodiesel
- Brazilian ethanol

Sensitivity Analyses

- Sensitivity of land cover changes with respect to changes in the food demand induced by higher food prices due to biofuel production.
- Sensitivity of land cover changes with respect to yield-to-price elasticity.
- Sensitivity of land cover changes with respect to cropland transformation elasticity.
- Sensitivity of land cover changes with respect to endogenous productivity change for cropland pasture.

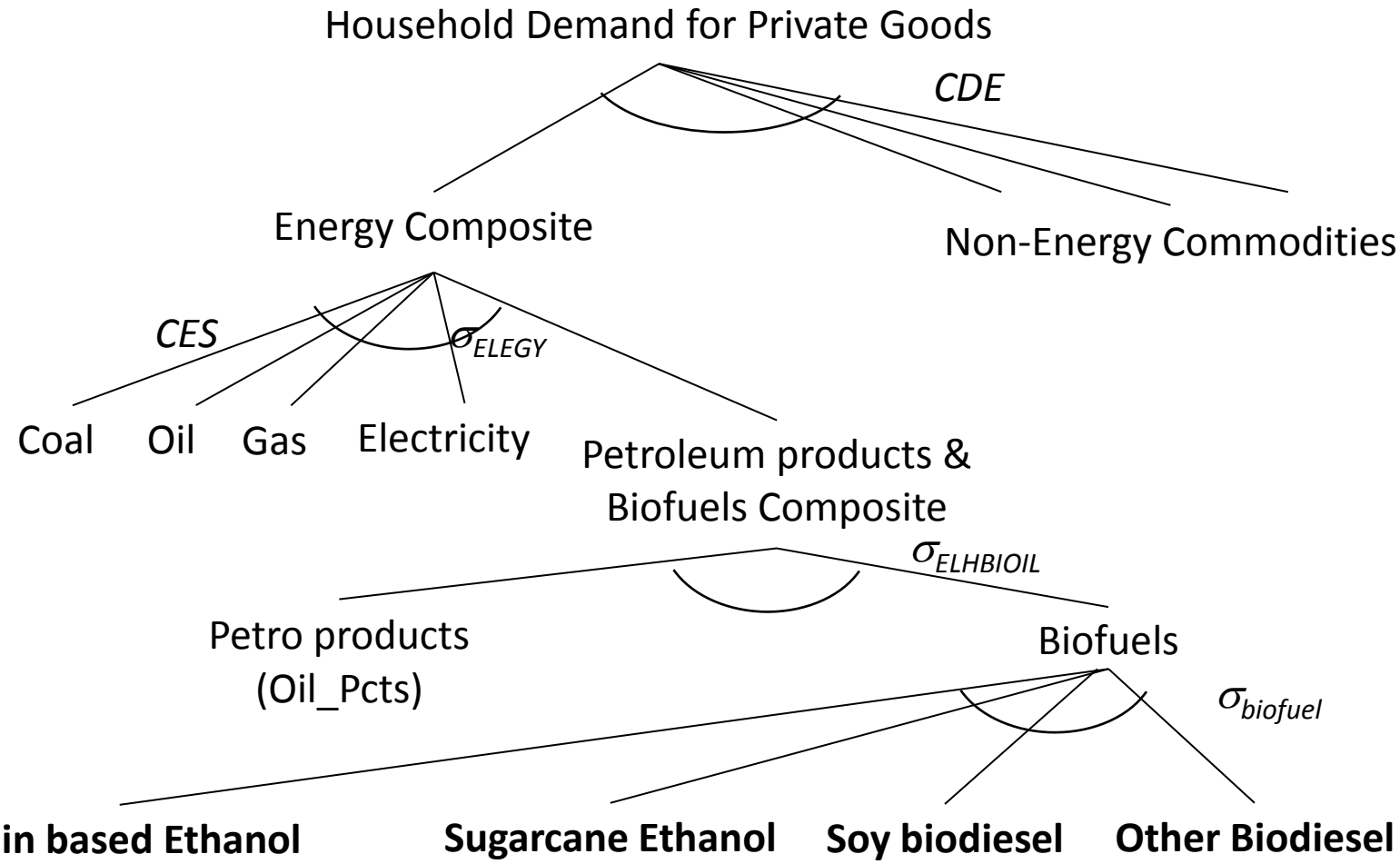
Model Modifications

- Updated energy elasticities,
- Improved treatment of DDGS and oilseed meals and oils,
  - Separation of soybean from other oilseeds,
  - Separation of soybean oil from other vegetable oils and fats,
- Separation of soybean biodiesel from other types of biodiesel.

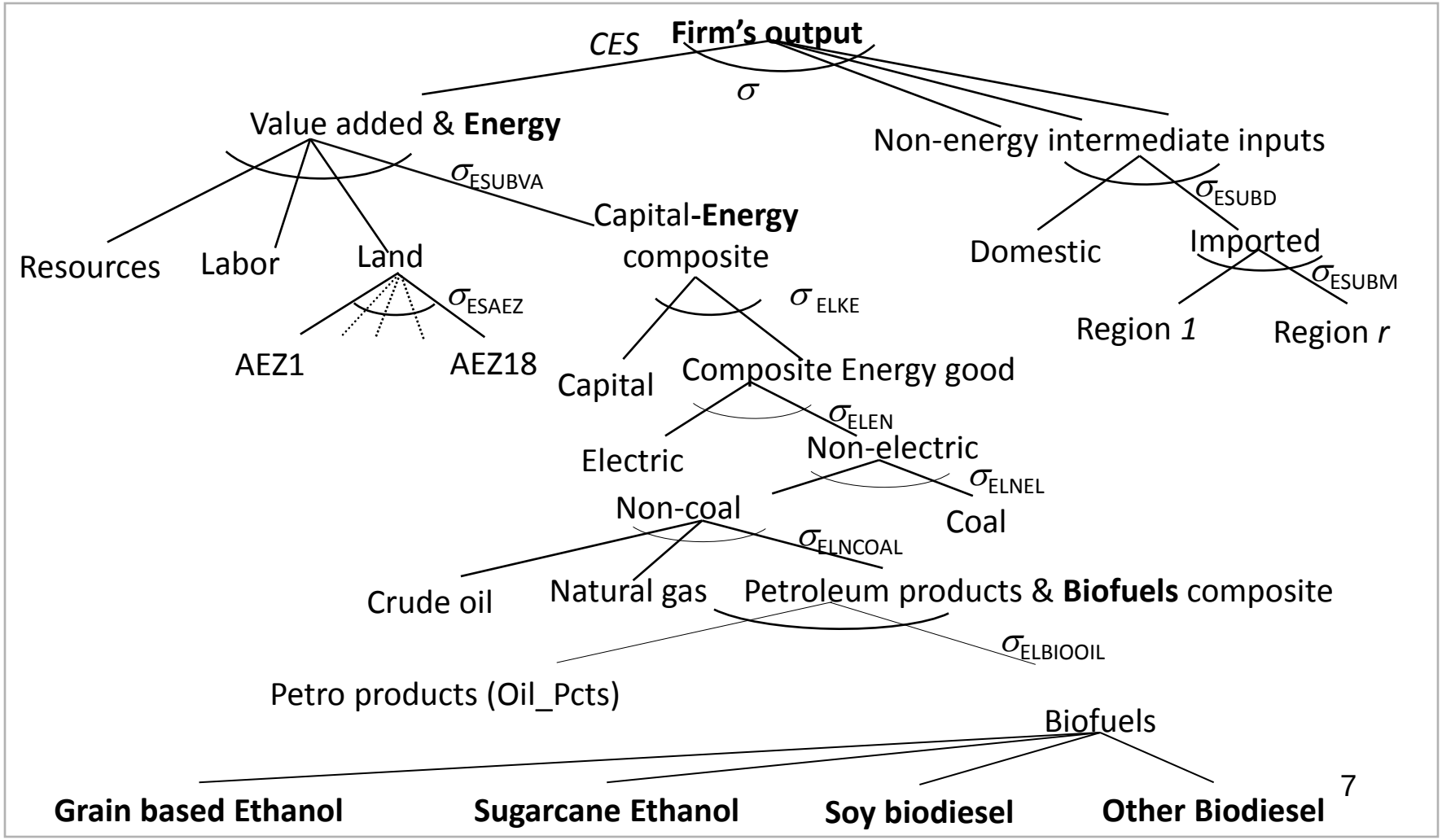
Model Modifications

- Modified model structure for livestock sector,
- Revised land conversion factor for new cropland,
- Incorporate cropland pasture for US and Brazil and CRP for US,
- Endogenous yield adjustment for cropland pasture,
- Greater flexibility in cropland switching.

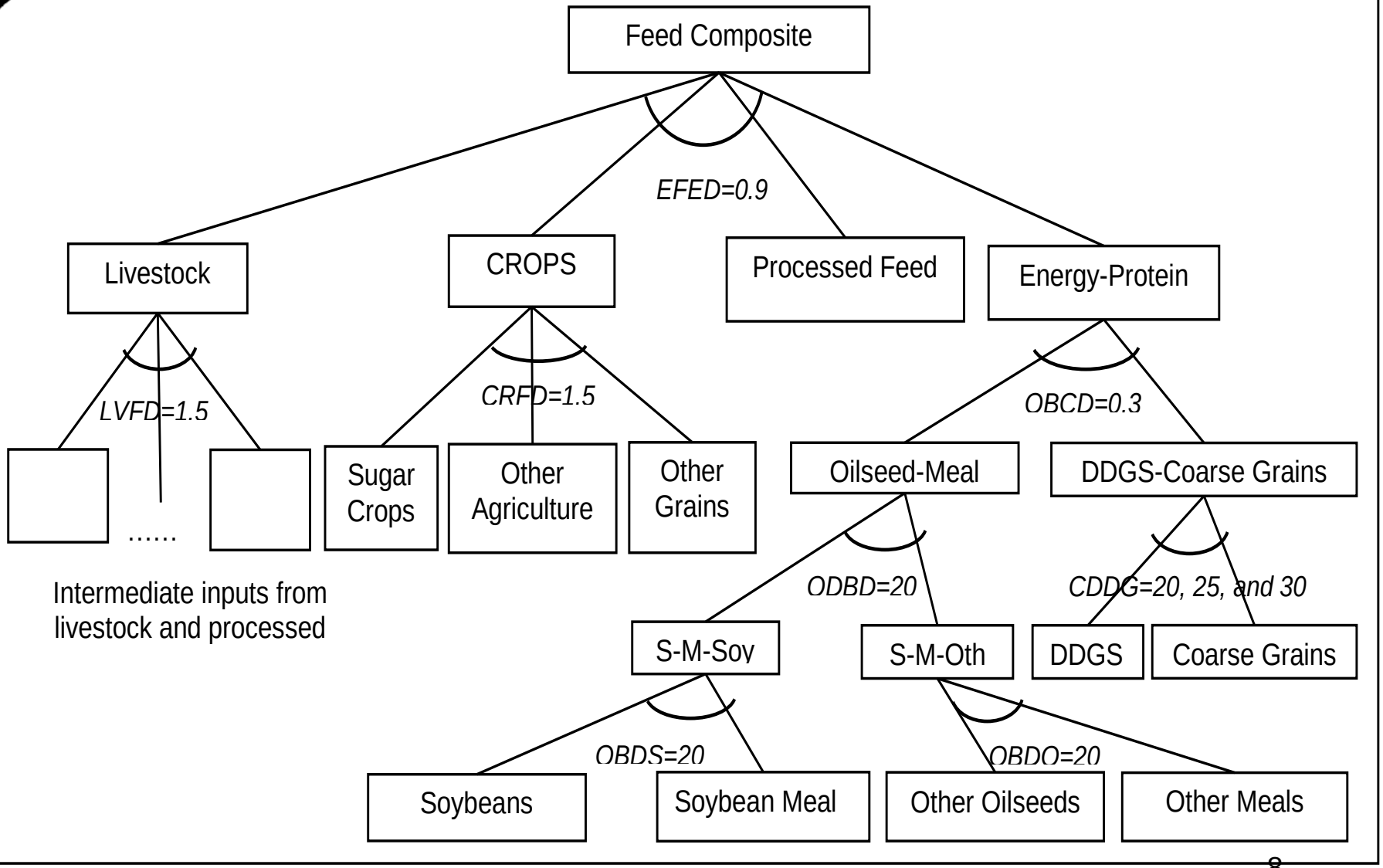
Household Demand Structure



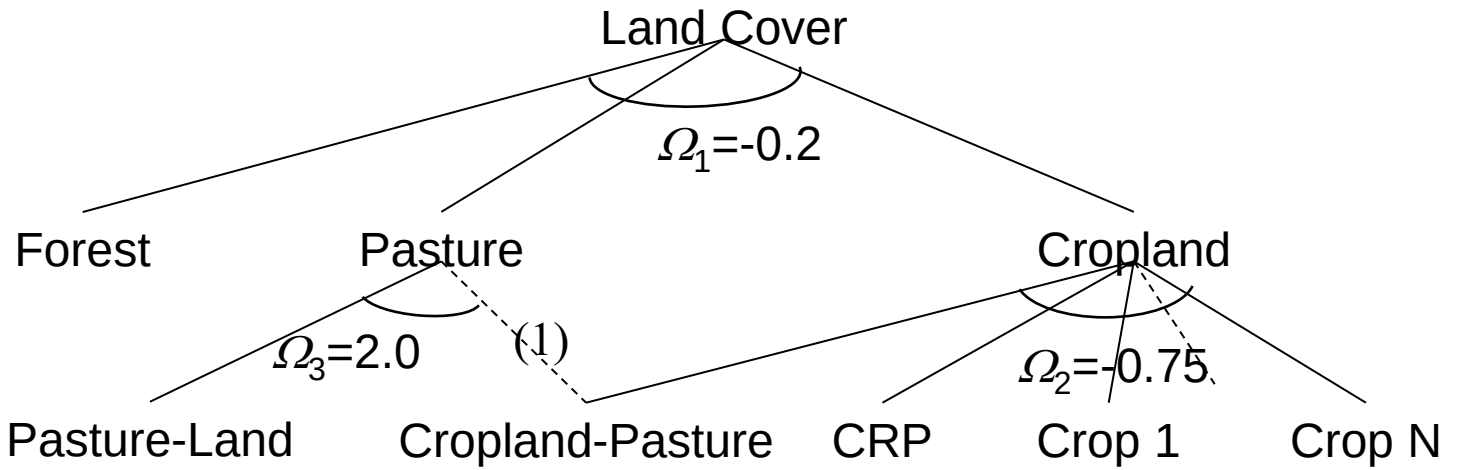
Firms Input Demand Structure



Nested Demand for Livestock Feed



Land Cover and Use Nesting



(1) In this land supply tree Ω_1 and Ω_2 are transformation elasticities and Ω_3 is the elasticity of substitution between pasture land and cropland pasture in the livestock industry

Add Greater Flexibility in Acreage Switching Among Crops

- In our previous work we and others had observed that GTAP does not seem to have as much acreage responsiveness as we experienced in the decade 2000-09.
- In this analysis, we asked the question of whether there is any difference in farmers reactions to crop price changes in the past decade and earlier periods.

Add Greater Flexibility in Acreage Switching Among Crops

- To answer this question we estimated acreage response to changes in soybean and corn returns per acre over different decades prior to 2000 and for 2000-2009.
- The following regression shows the results for the time period of 2000-2009:
  - ΔHarvested corn area (acres) = 1.388 + 0.084 ΔCorn revenue/acre(t-1) – 0.138 ΔSoybean revenue/acre(t-1),
  - The independent variable *t* values are 2.9 and 3.0 respectively, and the adjusted R^2 is 0.44.
- We did the same regressions for prior periods and found no significant relationship.

Add Greater Flexibility in Acreage Switching Among Crops

- As the literature suggests, in prior periods, government policy was a major driver, and now it is commodity prices and revenue.
- For these reasons, we increased the supply transformation elasticity among traditional crops that helps govern the response in acreage share to changes in commodity prices from -0.5 to -0.75.
- However, we are still experimenting with this parameter value to make sure it is the best representation of reality possible.

Endogenous Cropland Pasture Yield Change

- We received comments on our previous work suggesting that the increased use of land for biofuels would lead to investments in increased productivity as land rents increased.
- This led us to introduce an endogenous change in cropland pasture productivity as cropland pasture rent increases due to higher demand for the resource.
- This change in productivity is a function of the change in rent and a new elasticity parameter.

Endogenous Cropland Pasture Yield Change

$$af_{pasture} = \propto \left[1 + \beta \left(\frac{A}{A+B}\right)\right] pf$$

- $af_{pasture}$ *:* Cropland pasture augmenting technical change,
- *A:* Area under dedicated energy crop (0 in this analysis),
- B: Area remaining in cropland pasture,
- *pf* : Percent change in the cropland pasture rent,
- *α:* Scalar yield elasticity (0.4),
- *β:* Scalar yield adjustment factor (0 in this analysis),
- The yield-to-price elasticity is set to zero for cropland pasture.

New GTAP-BIO Database

- Introduced 2004 global production, consumption, and trade of the first generation of biofuels including grain ethanol, sugarcane ethanol, and biodiesel into the database following Taheripour et al. (2007).
- Modified the basic GTAP database:
  - Split GTAP food industry into food and feed industries,
  - Split GTAP vegetable oil into soybean oil and other vegetable oils and fats.
- Introduced biofuel by-products into the 2004 database.
- Updated land use, land cover, and land rent headers to 2004 following Avetisyan, Baldos, and Hertel (2010).

New Database Modifications

- Split harvested area and production of soybeans from other oilseeds,
- The *osd* sector is divided into two industries of *Soybeans* and *Other_Oilseeds*,
- The *vol* industry divided into two industries of *Vol_Soy* and *Vol_Oth* which prodcue:
  - Soybean oil and Soybean meal,
  - Other vegetable oils and non-soybean meals
- We incorporated two biodiesel industries of *Biod_Soy* and *Biod_Oth*.

Land Use Change Results

(ha/1000 gal. biofuel)

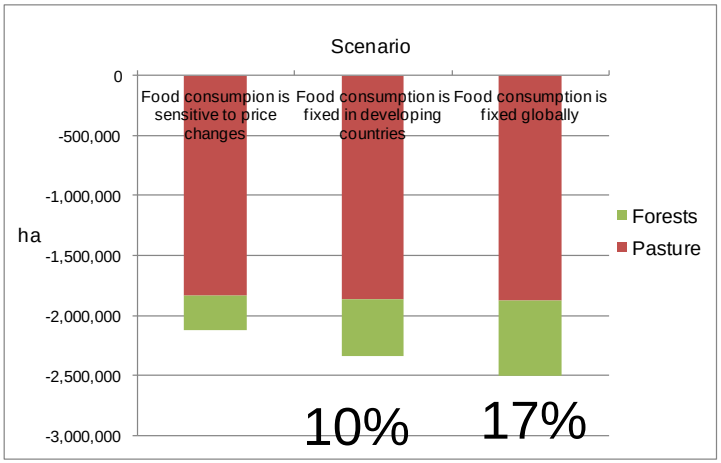
Biofuel	CARB 2009	Purdue 2010	Current Results	Results with CP
US corn ethanol	0.29	0.13 – 0.22	0.18	0.31
US soy biodiesel	0.63	0.94[a]	0.18	0.43
Brazilian sugarcane	0.55	-	0.16	0.40

[a] Preliminary Purdue result provided to CARB in January 2010

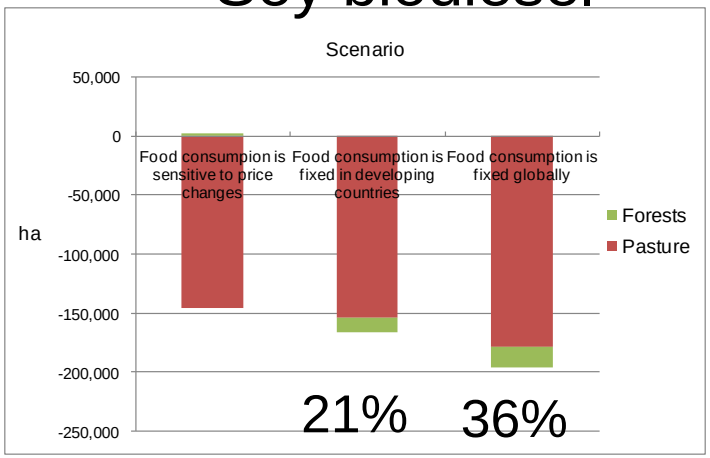
Complete details on land use change have been provided to CARB.

Food Consumption Sensitivity

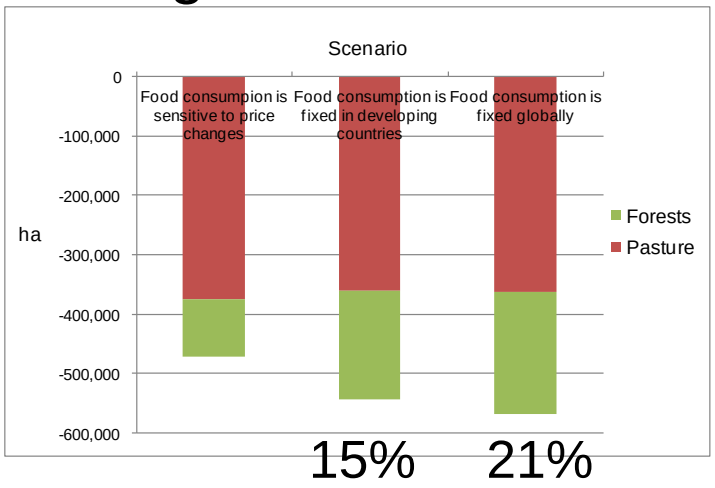
Corn ethanol



Soy biodiesel



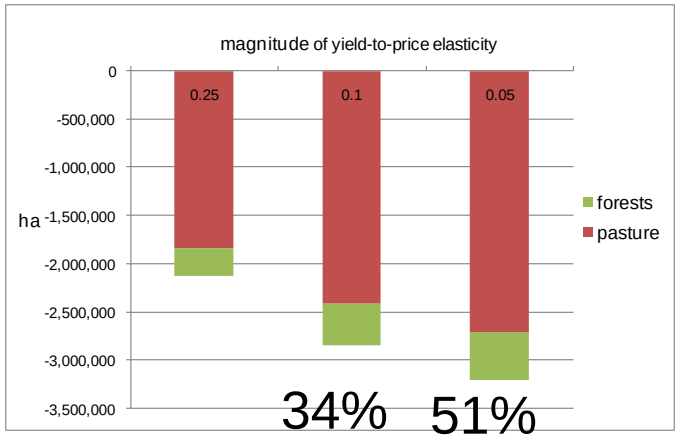
Sugarcane ethanol



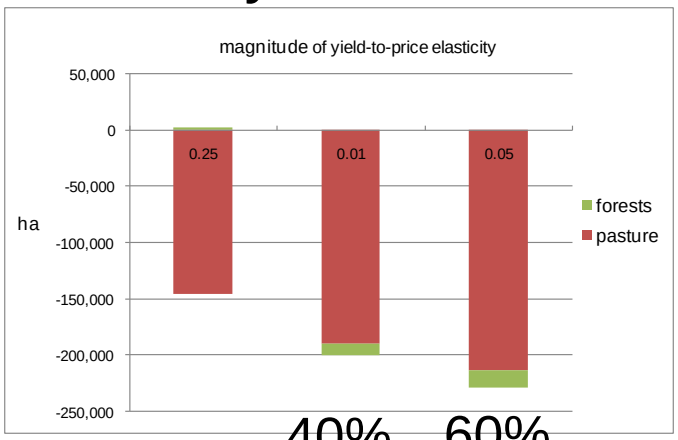
The food consumption sensitivity results indicate that the land cover change is somewhat sensitive to changes in the food consumption assumption.

Yield-to-price Elasticity Sensitivity

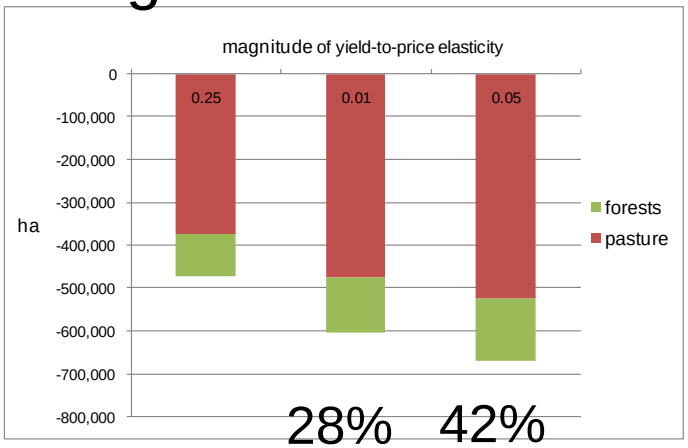
Corn ethanol



Soy biodiesel



Sugarcane ethanol



The results in all cases are sensitive to the value of the price-yield elasticity. Of the three, sugarcane is least sensitive, and soybean is the most sensitive.

Sensitivity on cropland transformation elasticity and cropland pasture endogenous technical change elasticity

Biofuel Case		Transformation Elasticity = -0.75			Transformation Elasticity = -0.5		
		forest	Cropland	pasture	forest	Cropland	Pasture
US corn ethanol	Area	-290,637	2,126,261	-1,835,267	-244,643	2,242,346	-1,997,737
	ha/1000 gall	-0.03	0.18	-0.16	-0.02	0.19	-0.17
US soy biodiesel	Area	2,179	143,189	-145,369	11,936	145,775	-157,664
	ha/1000 gall	0.00	0.18	-0.18	0.01	0.18	-0.19
Brazilian Sugarcane ethanol	Area	-96,897	471,693	-374,589	-37,167	549,994	-512,993
	ha/1000 gall	-0.03	0.16	-0.12	-0.01	0.18	-0.17

Biofuel Case		US=0.4 and Brazil=0.2			US=0.0 and Brazil=0.0		
		forest	Cropland	pasture	forest	Cropland	Pasture
US corn ethanol	Area	-290,637	2,126,261	-1,835,267	-552,610	2,019,458	-1,466,719
	ha/1000 gall	-0.03	0.18	-0.16	-0.05	0.17	-0.13
US soy biodiesel	Area	2,179	143,189	-145,369	-32,236	130,157	-97,844
	ha/1000 gall	0.00	0.18	-0.18	-0.04	0.16	-0.12
Brazilian Sugarcane ethanol	Area	-96,897	471,693	-374,589	-190,255	455,906	-265,832
	ha/1000 gall	-0.03	0.16	-0.12	-0.06	0.15	-0.09

Thank you!

Questions and Comments

For more information:

http://www.ces.purdue.edu/bioenergy

http://www.agecon.purdue.edu/directory/details.asp?username=wtyner