Induced Land Use Change Component of Aviation Biofuel GHG Emissions

Project 13-C-AJFE-PU

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ASCENT
AVIATION SUSTAINABILITY CENTER

Motivation

- Induced land use change emissions likely will be a part of the aviation biofuel emission estimates for the ICAO/CAEP/AFTF process, so we need the best possible estimated values.
- ILUC emissions are commonly estimated using computable general equilibrium models such as GTAP.
  - In recent years, a lot of work has been done improving the way GTAP works on the **extensive margin**.
  - However, little work has been done on the **intensive margin** (double cropping, irrigation, or other productivity investments). This research will take advantage of newly available data to better calibrate changes on the **intensive margin**.

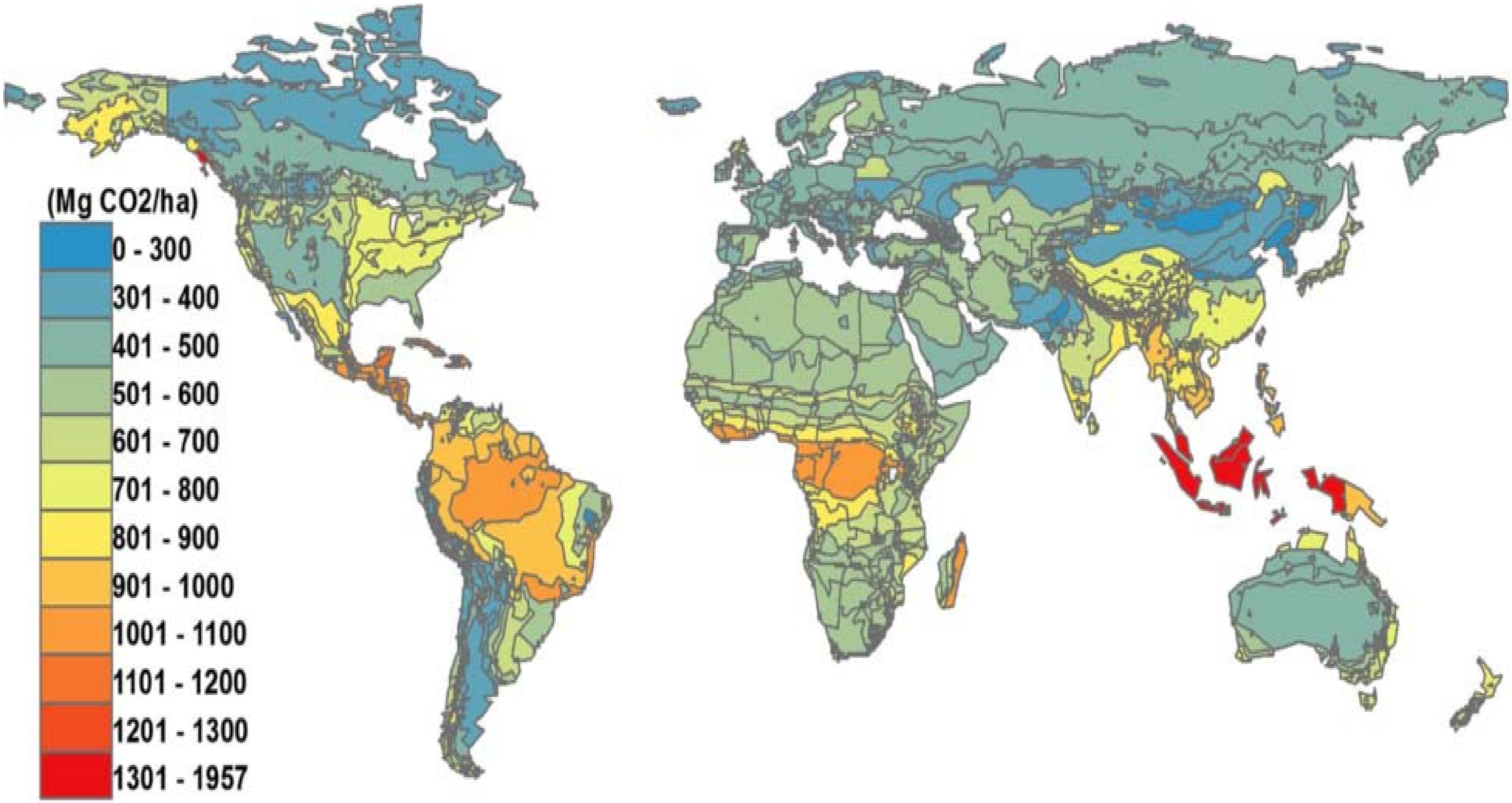
Objectives

- Our work under ASCENT covers stochastic TEA and induced land use change emissions for aviation biofuels. Today I am reporting only on the ILUC work.
- Our long term objectives will focus on producing ILUC estimates for different types of aviation biofuels produced in any region of the world.
- Our near term objectives are to improve the GTAP handling of changes at the intensive margin and to do some illustrative sample runs for two pathways for different regions of the world.
- We expect more complete results from this work in March 2016.

Calculation of ILUC emissions

- The first step is to simulate the model shock being considered (size of the biofuel program).
- The result of this simulation will be changes in land cover and harvested area by country and AEZ.
  - Changes in land cover including forest, pasture, cropland,
  - Changes in cropland pasture,
  - Changes in harvested areas by crop.
- The next step is to feed the LUC into an EF model to estimate induced LUC emissions.
- We have worked with CARB in this process.

CARB forest emissions factors



Emissions factors vary significantly across regions and AEZs

Current CARB emissions values
(illustrative of what we will do)

Fuel	Direct CI g/MJ	ILUC g/MJ	Total CI g/MJ	Percent Reduction
Gasoline (CARBOB)	100.53		100.53	
Sugar cane base	41.43	11.8	53.23	47.1%
Sugarcane mechanized harvest	32.17	11.8	43.97	56.3%
Grain sorghum ethanol	67.29	19.4	86.69	13.8%
Corn ethanol	60.29	19.8	80.09	20.3%
Ultra-low sulfur diesel	102.76		102.76	
Soybean biodiesel	22.73	29.1	51.83	49.6%
Tallow biodiesel	32.83		32.83	68.1%
Canola biodiesel	35.73	14.5	50.23	51.1%
Corn oil biodiesel	28.68		28.68	72.1%

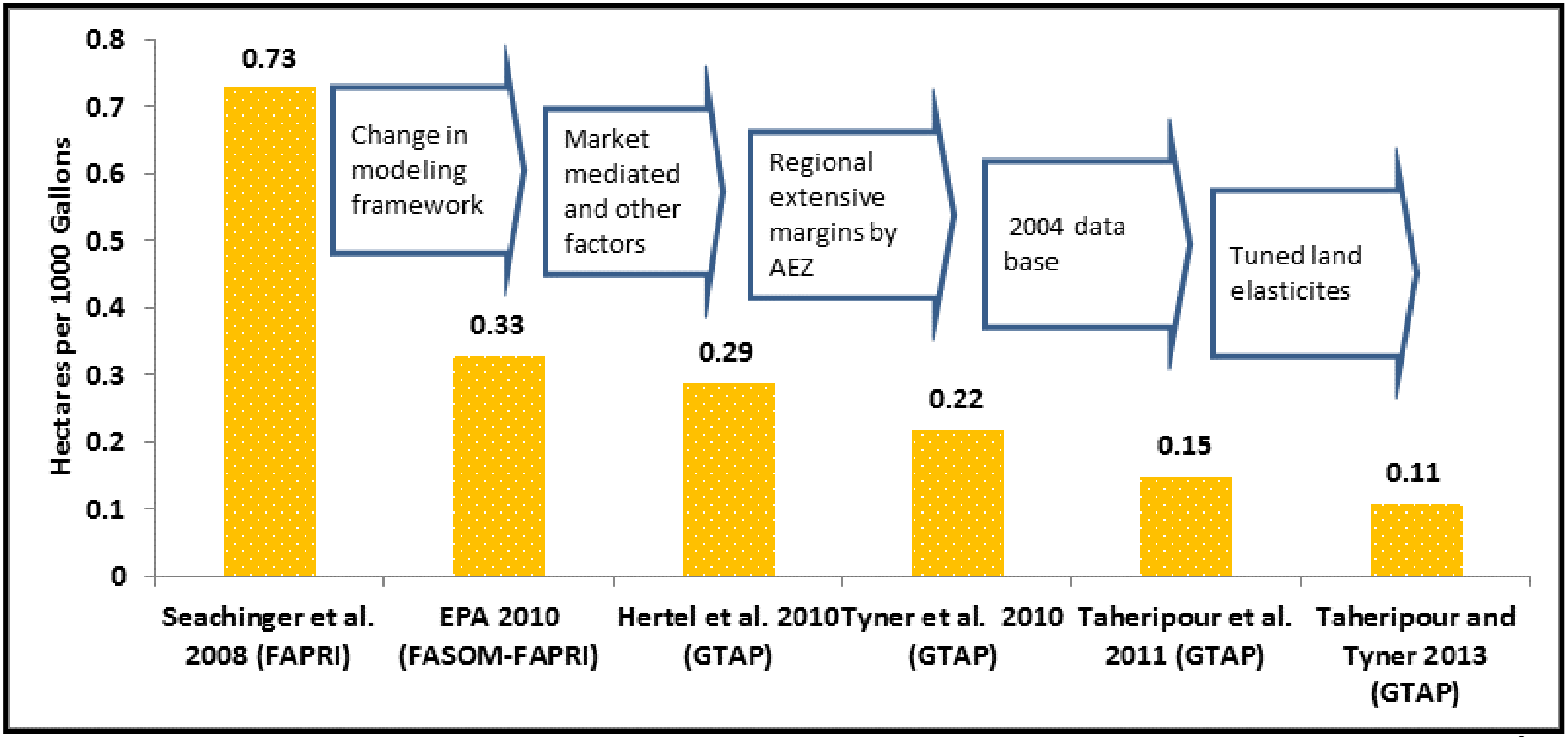
Illustrative test simulations with 2004 GTAP-BIO model

Feedstock-Region	Fuel Produced	Land Category	Global land use change in 1000 ha	Emissions g CO_2e MJ^{-1}
Miscanthus-USA	1 billion gallons	Forest	-6	12
		Pasture	-20	
		Cropland	26	
		Cropland pasture	-696	
Soybean-USA	0.5 billion gallons	Forest	-15	21
		Pasture	-49	
		Cropland	64	
		Cropland pasture	-17	
Rapeseed-USA	0.5 billion gallons	Forest	-56	22
		Pasture	-58	
		Cropland	114	
		Cropland pasture	-22	
Rapeseed-EU	0.5 billion gallons	Forest	-52	28
		Pasture	-79	
		Cropland	131	
		Cropland pasture	-18	

Schedule and Status

- We have updated the GTAP data base and model from 2004 to 2011.
- Regional land transformation elasticities (extensive margin) have been calibrated to the actual land cover changes 2006-2011.
- Projected productivity of new cropland has been estimated with a Terrestrial Ecosystems Model and varies by Agro-ecological zone and region.
- Many other improvements have been made in both the data base and model.
- We are in the process of changing the intensive margin and expect to have a preliminary version first quarter 2016.

Estimates for additional land requirement due to US ethanol production
(demonstrating progress through time)



Interfaces and Communications

- External
  - Presentation to the CRC Life Cycle Workshop, Oct. 28-30.
  - Recent Publications
  - Taheripour, Farzad, and Tyner, Wallace E. “Incorporating Recent Land Use Change Data into Simulations of Biofuels Land Use Change.” *Applied Sciences* 3 (2013) 14-38.
  - Suttles, Shellye A., Wallace E. Tyner, Gerald Shively, Ronald D. Sands, and Brent Sohngren. “Economic effects of bioenergy policy in the United States and Europe: A general equilibrium approach focusing on forest biomass.” *Renewable Energy*, 69 (2014), pp. 428-436.
  - Taheripour, Farzad, and Wallace E. Tyner. “Corn oil biofuel land use change emission impacts: Sharing emission savings between ethanol and biodiesel Biofuels,” *Biofuels* 5(4), 2014, pp. 353-364.
  - Bittner, Amanda, Xin Zhao, and Wallace E. Tyner. Field to Flight: A Techno-Economic Analysis of Corn Stover to Aviation Biofuels Supply Chain.” *Biofuels, Bioproducts & Biorefining* 9, 201-210, 2015
  - Mueller, Steffen, Stefan Unnasch, Wallace E. Tyner, Jennifer Pont, and Jane M-F Johnson. ”Handling of co-products in life cycle analysis in an evolving co-product market: A case study with corn stover removal.” *Advances in Applied Agricultural Science* 3(5) 2015, pp. 8-21.

- Within ASCENT
  - Collaboration with Robert Malina and his group at MIT

Summary

- Summary statement
  - Land use change is a market mediated response to an increased demand for agricultural commodities. We need to provide the best possible estimates of the induced land use changes and the GHG emissions associated with these changes. That is the overarching objective of this sub-project.
- Next steps?
  - We expect to have a new version of the model first quarter of 2016 that will have better calibrated responses at the intensive margin and other improvements.
- Key challenges/barriers
  - Our challenges are getting the data needed to improve the model calibration and the resources needed to make the data base and model changes and implement simulations.

Contributors

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- Xin Zhao, PhD student, Purdue University
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