The net global effects of alternative U.S. biofuel mandates - Fossil fuel displacement, Indirect Land Use Change and the role of productivity growth-

Aline Mosnier, Petr Havlík, Hugo Valin, Justin S. Baker, Brian C. Murray, Siyi Feng, Michael Obersteiner, Bruce A. McCarl, Steven K. Rose, Uwe A. Schneider

Introduction

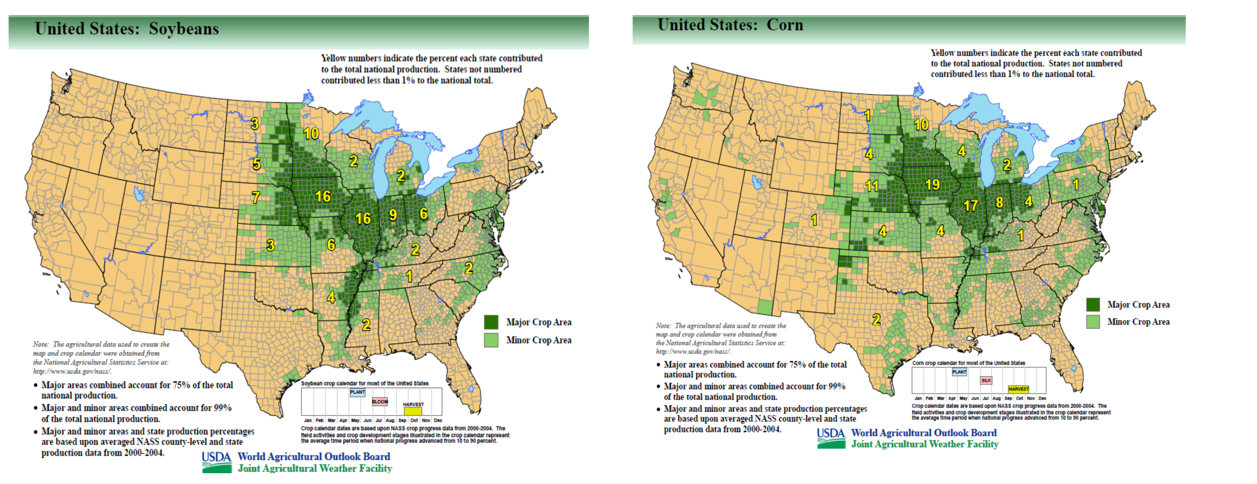
- The U.S. biofuel production has been multiplied by 7 between 2000 and 2010
- From the Energy Independence and Security Act of 2007 (EISA), the use of renewable fuels must reach 36 billion gallons (2.88 EJ) by 2022 in the U.S.
- One of the declared objectives of biofuel policies is the reduction in greenhouse gases (GHG) emissions from fossil fuel combustion but:
  - Biomass production is also responsible for some GHG emissions. Even cropland intensification could lead to additional emissions due to soil N2O and fertilizer production.
  - U.S. is a main agricultural exporter, consequently the indirect Land Use Change (iLUC) i.e. the additional GHG emissions due to the relocation of food production in other countries could be significant.

An integrated approach with a detailed description of agricultural production processes and a global coverage is needed

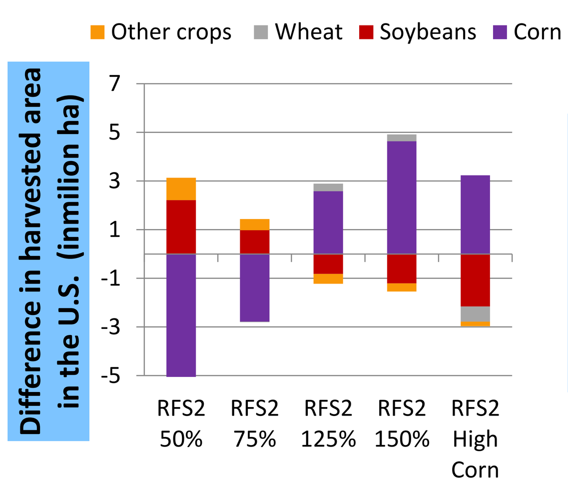
Methodology

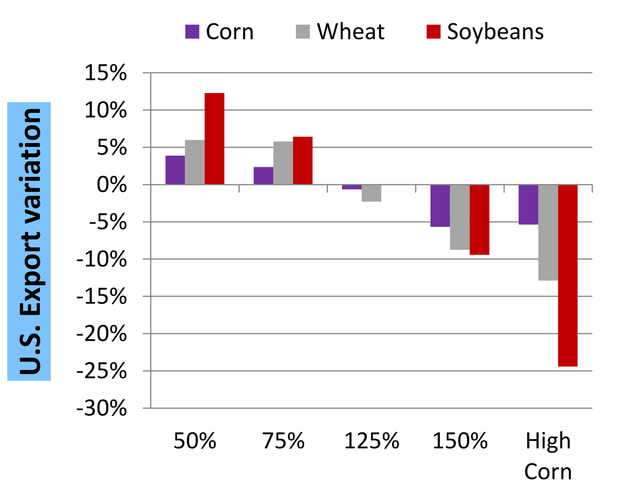
- We use ***GLOBIOM, a global, partial equilibrium model including the major land-based production sectors***: agriculture, forestry, and bioenergy (Havlik et al., 2010). It accounts for about 20 of the most globally important crops, a range of livestock production activities, major forestry commodities, and multiple bio-energy transformation pathways.
- Prices and international trade flows are endogenously determined at the level of these regions. The supply side of the model reflects a ***detailed spatial resolution*** that accounts for land heterogeneity.
- ***GHG emissions*** from agriculture, land use change and fossil fuel displacement are computed including emissions related to crop cultivation, livestock, and deforestation.
- The model is ***recursive dynamic*** i.e. changes in land use made in one period alter land availability in the various categories in the next period. The model is run by 10 year-time steps over 2000-2030.

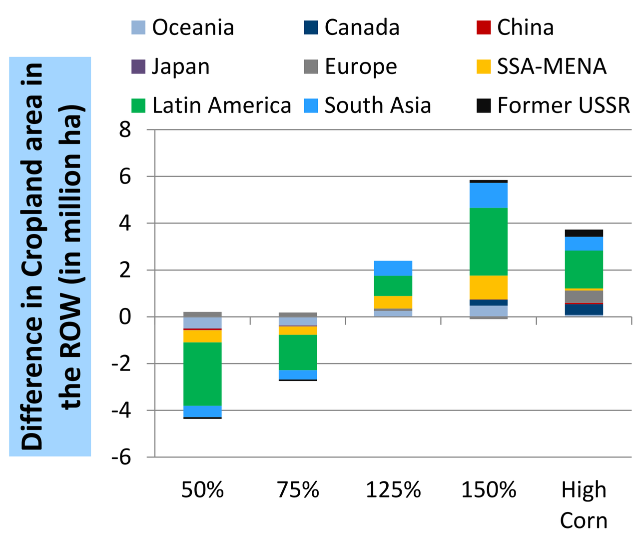
Current production area of soybeans (left) and corn (right) in the U.S.



Impact of alternative U.S. biofuel mandates compared to the baseline in 2020



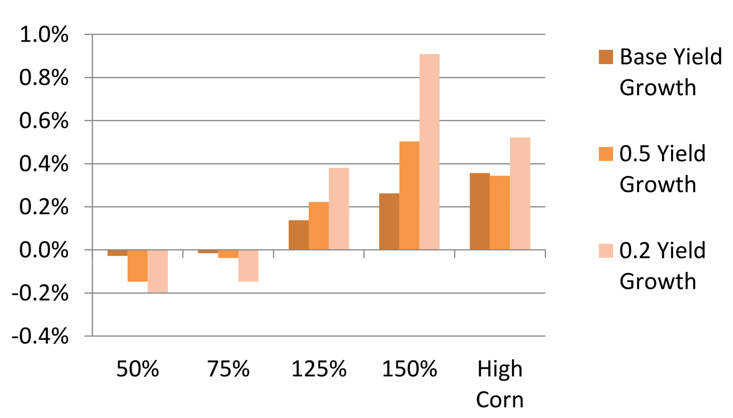




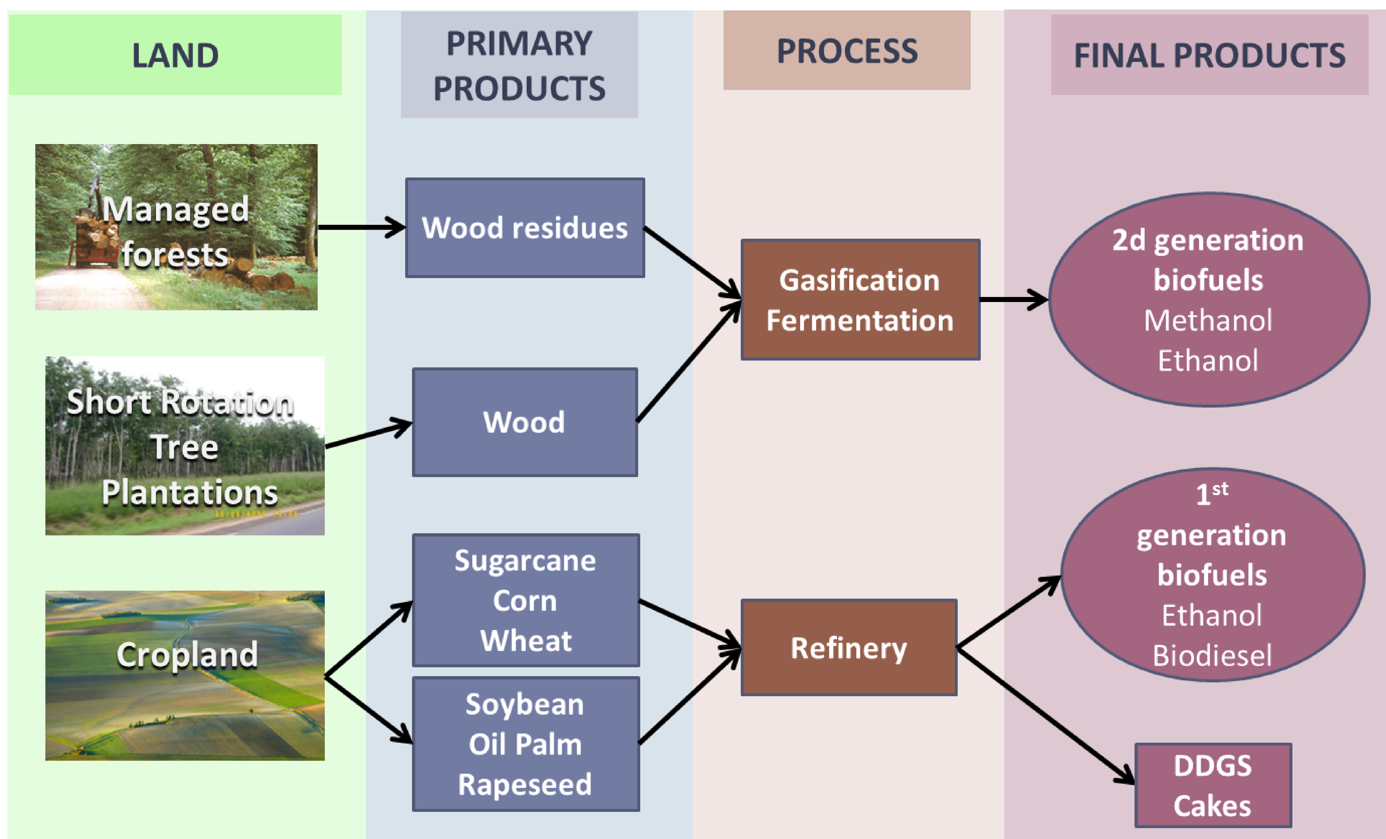
Differences in annualized GHG emissions over 2010-2030 in tCO2e

Source of GHG emissions	RFS2 50%	RFS2 75%	RFS2 125%	RFS2 150%	RFS2 High Corn
U.S.					
LUC	-2	-2	-1	1	0
Agriculture	-27	-14	17	30	10
Fossil Fuel Disp.	61	32	-33	-65	1
Total	**32**	**17**	**-16**	**-34**	**11**
REST OF THE WORLD					
LUC	-23	-10	15	35	11
Agriculture	-16	-8	15	24	6
Fossil Fuel Disp.	5	2	-2	-4	0
Total	**-35**	**-18**	**27**	**54**	**16**
WORLD					
LUC	-25	-12	15	36	11
Agriculture	-41	-22	32	55	17
Fossil Fuel Disp.	65	33	-36	-70	0
Total	**-2**	**-1**	**10**	**20**	**27**

Relative difference in global GHG emissions compared to the baseline with alternative assumptions on technological change over 2010-2030

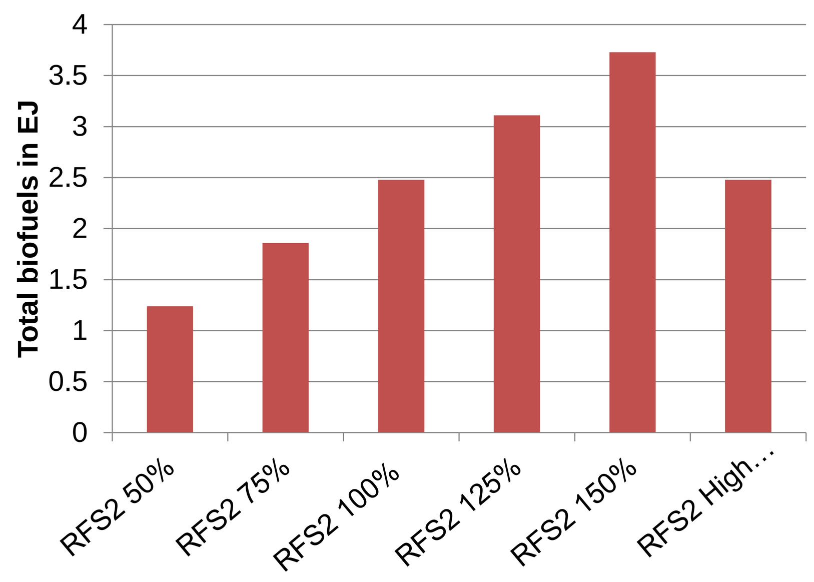


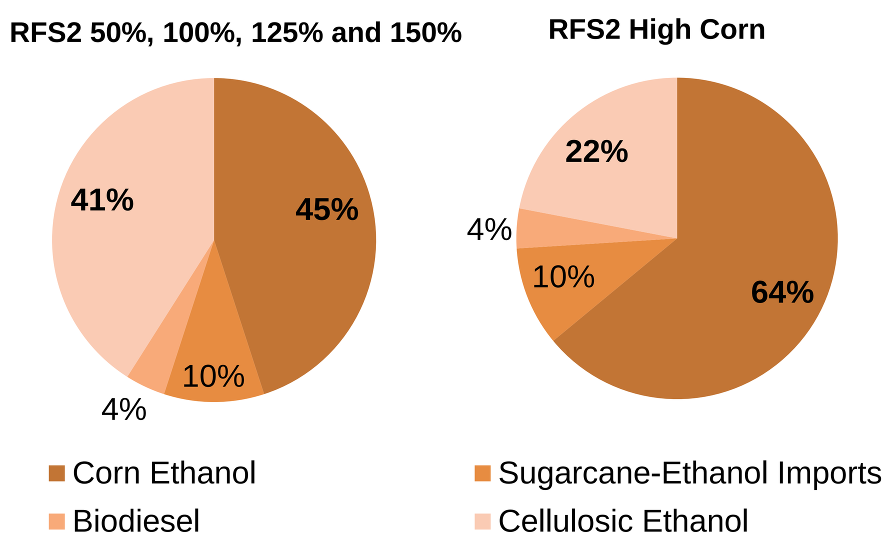
Biofuel supply chain in GLOBIOM



Scenarios

- Change in the total biofuel volume
- Change in the mandate composition





Results

- Changes in the level of the biofuel mandate lead to a proportional change in feedstock demand for processing but also to a proportional production of biofuel by-products (corn DDGS) that can be used for livestock feeding.
- ***Adjustments to alternative biofuel mandates in the U.S. are mainly made through changes in harvested area, increase of fertilizer use, and exports reduction*** due to higher domestic crop prices.
- The competition for land is strong between corn and soybeans which are grown in the same areas. Moreover, corn DDGS substitute soybean in the livestock feeding. Consequently, the highest the corn ethanol production the lowest is the soybean area.
- The cropland and short rotation tree plantations expansion leads to decrease of grassland (+0.2,-0.6 Mha) and of other natural land area (+1.42,-1.8 Mha) in the U.S. in 2020.
- ***The net impact of higher biofuel policies is a reduction of GHG emissions in the U.S***. but from our results the increase in fertilizer use in scenarios with higher biofuel mandates offset about 50% of the GHG emissions reduction due to fossil fuel displacement.
- Higher world prices and the reduction in U.S. exports leads to: a) a reduction in the demand, b) higher domestic production in the importing countries (e.g. in Africa, Europe and China), c) higher domestic production in other exporting countries (e.g. in Latin America), which result in ***cropland expansion especially in Latin America and in Africa.***
- Additional use of fertilizers and natural land conversion to agriculture lead to ***higher GHG emissions in the ROW with higher U.S. biofuel mandates and higher share of corn ethanol to fulfill the mandate***.

Conclusion

- Since the additional emissions in the ROW are higher than the net GHG emissions savings in the U.S. when the U.S. biofuel mandates increase, ***the U.S. biofuel policies do not reduce GHG emissions from fossil fuel combustion over 2010-2030***.
- If 2d generation biofuels cannot be produced on large-scale by 2020, the net impact of U.S. biofuel policies on global GHG emissions will worsen.
- The pace and diffusion of technological change in the U.S. and in the ROW are crucial to reduce the additional pressure on land due to higher biofuel demand.

*The authors acknowledge the **Packard Foundation** for the financial support.*

Reference: *Mosnier et al. (2012) The Net Global Effects of Alternative U.S. Biofuel Mandates. Fossil Fuel Displacement, Indirect Land Use Change, and the Role of Agricultural Productivity Growth. Nicholas Institute for Environmental Policy Solutions Report NI R 12-01 (under review in Energy policy)*