# BIOFUELS, CLIMATE POLICY, AND WATER MANAGEMENT: ASSESSING POLICY-INDUCED SHIFTS ON AGRICULTURE'S EXTENSIVE AND INTENSIVE MARGINS

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# Biofuels, Climate Policy, and Water Management: Assessing Policy Induced Shifts on Agriculture's Extensive and Intensive Margins

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## INTRODUCTION

Biofuel expansion efforts and climate mitigation policy could fundamentally alter land management trends in U.S. agriculture and forestry (AF). Previous research has shown that biofuel mandates can induce agricultural land expansion and more intensive forms of production[2,3,4,6,8]. Meanwhile, terrestrial greenhouse gas (GHG) mitigation efforts could limit agricultural expansion, reduce current cultivation, and lower management intensity by incentivizing emissions reduction and carbon sequestration within AF[1,7]. To date, little empirical work has addressed the combined implications of biofuel and GHG policies on agricultural land management at both the ***intensive*** and ***extensive*** land use margins.

## RESEARCH QUESTIONS

This study uses a comprehensive and detailed economic model of the U.S. AF sectors to simulate land management responses to biofuel expansion and GHG policies. Specifically, we seek to address the following questions:

1) To what extent will varying existing biofuel mandates (Renewable Fuels Standard, or RFS2) affect U.S. cropland movement to the ***extensive*** margin?
2) How might the addition of GHG mitigation incentives further alter cropland trajectories?
3) What are the different implications of biofuel and climate policies on land management ***intensity***?
   - Measured as changes in total nitrogen (N) and water use, and intensity per-unit area

## MODELING FRAMEWORK AND SCENARIOS

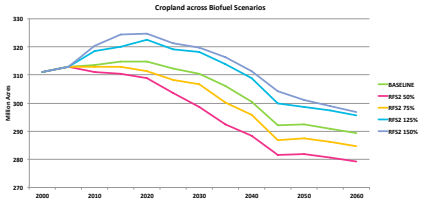
- Simulation using the U.S. Forest and Agricultural Sector Optimization Model with Greenhouse Gases (FASOMGHG)[7]
- Model enhancements reflected in this study:
  1. Updated land categorization system
  2. Updated Bioenergy transportation and storage costs
  3. Multiple N application rates, including an intensification option (Base, 85%, 70%, and 115%); yield and N2O emissions derived DAYCENT model output

**SIMULATION SCENARIOS--**

1. ***BASELINE:*** Simulation includes biofuel mandates consistent with RFS2 legislation, run for the 2000-2070 horizon using an aggregated 5-region version of FASOMGHG
2. ***BIOFUEL SCENARIOS:*** Scenarios alter the total volume of mandated biofuels in positive and negative directions, holding the proportion of conventional ethanol, cellulosic ethanol, and biodiesel constant. Includes:
   - RFS2 50% (lowest), RFS2 75%, RFS2 125%, and RFS2 150% (highest)
3. ***GHG MITIGATION SCENARIOS:*** An exogenous $CO_2$ equivalent (e) price is use to incentivize GHG reductions relative to the BASELINE. Prices include:
   - \$15/$tCO_2$e, \$30/$tCO_2$e, and \$50/$tCO_2$e

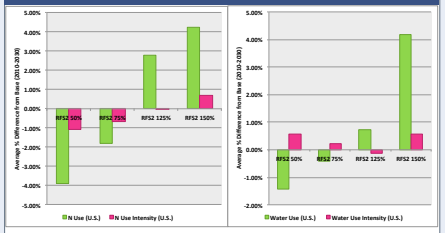
## SIMULATION RESULTS

### EXTENSIVE MARGIN (BIOFUEL SCENARIOS)




- Cropland use expands with the volume of the mandate
- Deviations from the baseline are relatively small, ranging -3.8%-2.9% by 2030 for the RFS2 50% and 150% cases, respectively

### INTENSIVE MARGIN (BIOFUEL SCENARIOS)

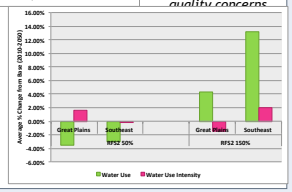



- Total U.S. N and water use expand with the volume of the mandate (at slightly higher rates that total cropland expands)
- N use intensity increases with the mandate, though only slightly

### REGIONAL INTENSIFICATION (BIOFUEL SCENARIOS)

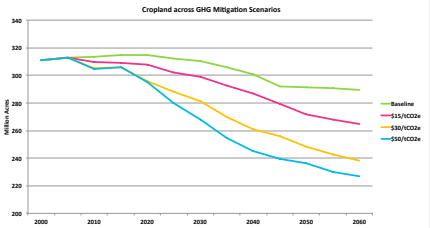
*-Evaluated at the RFS2 50% and RFS2 150% Scenarios*


- *N use and intensity increase with the value of the mandate in productive regions*
- *Elicits water quality concerns*



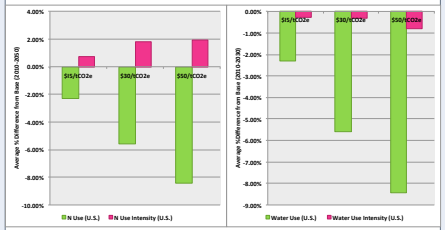

- *Water use expands in regions with existing scarcity*
- *Intensity changes are small*

### EXTENSIVE MARGIN (GHG MITIGATION SCENARIOS)




- Mitigation contracts cropland substantially
- Moves land to forestry for carbon sequestration

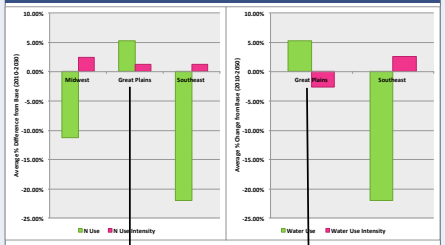
### INTENSIVE MARGIN (GHG MITIGATION SCENARIOS)




- Total N, Water use declines with the mitigation price
  - Due to higher costs, less land in production
- However ***N use intensifies*** across mitigation scenarios

### REGIONAL INTENSIFICATION (GHG MITIGATION SCENARIOS)

*-Evaluated at $30/tCO2e*




- *As land leaves agriculture in productive regions, production and input use shift to regions with little GHG mitigation opportunities (Great Plains).*
  - *Incidence of "water leakage"*

## GENERAL CONCLUSIONS.

1. Land management trends are sensitive to biofuel/climate policies at both the ***intensive*** and ***extensive*** margin.
2. Consistent with expectations, cropland use expands (contracts) as the mandate is increased (decreased), as does total input use.
3. Total cropland declines significantly with the value of the CO2 price incentive.
   - Productivity losses raises important concerns, such as international leakage and "Food vs. Carbon"[1,5]
   - While not shown, commodity price effects of a \$50/$tCO_2$e price incentive are higher than price effects of increasing the RFS2 mandate by 50%.
4. For the climate mitigation scenarios, $N_2O$ emissions reductions are directly incentivized, but N use intensifies. As some land leaves production to pursue mitigation opportunities, production expands to the ***intensive*** margin elsewhere (raising environmental concerns).
5. Regional distribution of impacts are important
   1. N/Water use and intensity expands the most in regions with existing water scarcity/quality concerns
   2. Climate mitigation can lead to "water leakage," in which water and N use are exported to regions with limited mitigation opportunities.
   3. Indirect effects of policy on water resource systems deserves further research

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