Identifying the Determinants and Availability of Marginal Land

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MOTIVATION

- Marginal land has garnered significant attention for its potential to produce bioenergy feedstocks thus restricting or minimizing diversion of productive agricultural land from food crop production.
- However, despite the frequent use of the term marginal land in the literature, there remains no consensus on its definition and, more importantly, its identification.
- Previous studies that have quantified the amount of "marginal land" available rely on biophysical thresholds for soil quality and productivity.
- The problem is that they do not quantify the economic returns of different agricultural lands and thus cannot be stated as "economically marginal land".

OBJECTIVES

- A fundamental challenge in identifying economically marginal land is the lack of economic return data at the parcel level.
- We estimate economic returns at the parcel level across different land uses in identifying economically marginal land.
- We identify "socially marginal land" by incorporating economic returns and values of environmental outcomes at the parcel level.

METHODS

- Although we lack direct observations of profits from alternative land uses for each parcel, producers presumably evaluate net returns against alternative land uses.
- We hypothesize that parcel-level net returns depend on the parcel-level land use, biophysical and climate characteristics, and county-level net returns.
- First, we econometrically estimate the fractional multinomial land use model, i.e., factors affecting parcel-level land use shares (factors affecting parcel-level land use returns).
- Second, we approximate parcel-level net returns to each land use category by setting the coefficient of own county-level net returns to unity.
- Third, we monetize the negative (positive) externalities associated with row crop (energy crop) production to compare social value.

DATA

- We implement a 4 × 4 sq. km parcel level land-use change model in the rainfed region (east of the 100th meridian) of the United States using 2016 land use shares as dependent variables.
- We use 5-year averages (2012-16) of county-level net returns (**Fig. 1**), and parcel-level 5-year averages (2012-16) of seasonal growing degree days (GDD), and precipitation (**Fig. 2**), elevation, slope, vulnerability, and productivity as explanatory variables.
- We obtain classifications available at 30 × 30 sq. m pixels for 2016 from the Cropland Data Layers (CDL) and aggregate them into 5 different 4 × 4 sq. km parcel categories corresponding to crop, pasture, forest, urban, and other land uses.

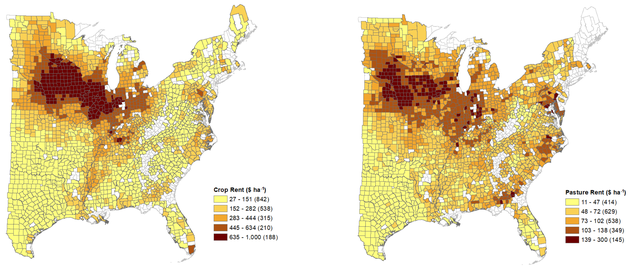

Fig. 1 Crop and Pasture Returns, 2012-16 Average (2022$)

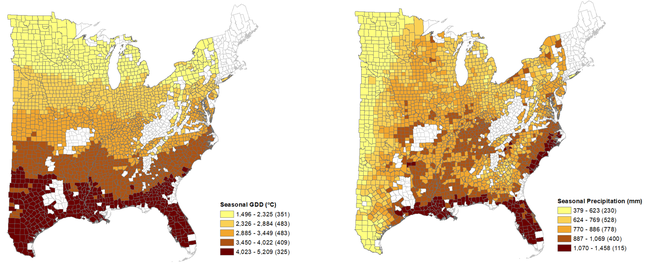

Fig. 2 Seasonal GDD and Precipitation, 2012-16 Average

RESULTS

- An increase in crop and pasture returns increases crop and pasture shares, respectively, with decreases in forest shares (**Fig.** 3).

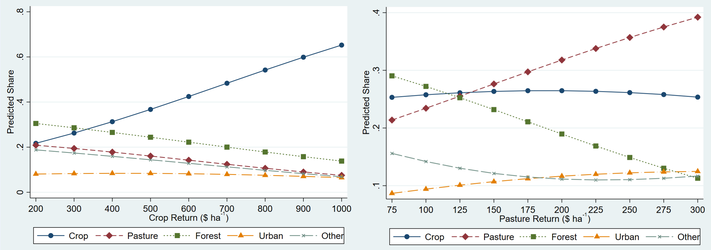

Fig. 3 Predicted Shares to Crop and Pasture Returns

RESULTS

- An increase in GDD increases crop and pasture shares whereas an increase in precipitation decreases crop and pasture shares (**Fig. 4**).
- In contrast, an increase in GDD decreases forest shares whereas an increase in precipitation increases forest shares (**Fig. 4**).

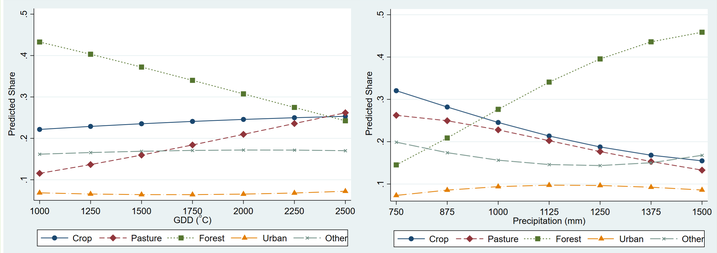

Fig. 4 Predicted Shares to GDD and Precipitation

- An increase in productivity increases crop and pasture shares with a corresponding decrease in forest and urban shares.
- Higher elevation increases crops, pasture, and urban shares whereas decreases forest shares.
- The slope negatively impacts crop shares but has a positive impact on pasture, forest, and urban shares.

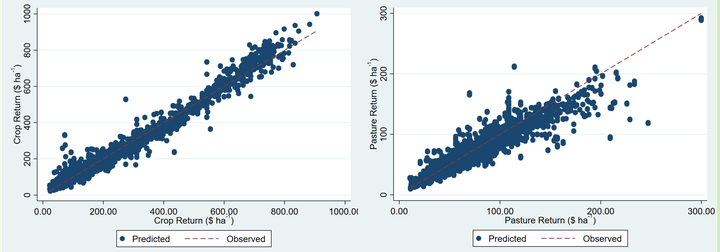

Fig. 5 Observed County-Level Vs Predicted Parcel-Level Returns

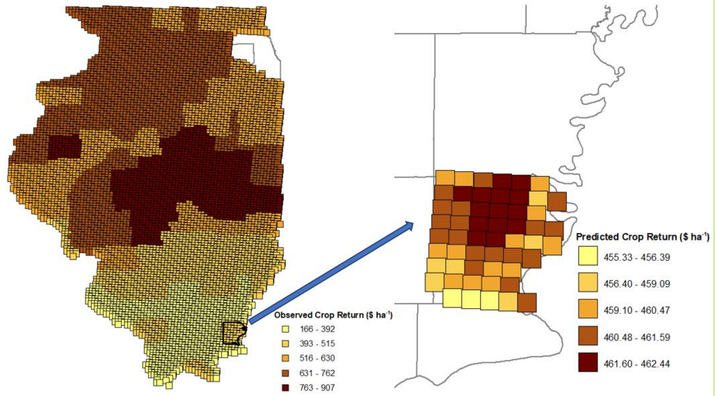

Fig. 6 Predicted Parcel-Level Crop Returns in Gallatin County, IL

RESULTS (Cont'd)

- The predicted parcel-level crop and pasture returns range between $22 to $1003 ha^{-1} and $10 to $300 ha^{-1}, respectively (**Fig. 5**).
- For example, the predicted parcel-level crop returns in Gallatin County, IL range between $455 to $462 ha^{-1} corresponding to the observed county-level returns of $482 ha^{-1} (**Fig. 6**).

CONCLUSIONS

- Overlaying the monetary values of ecosystem services on top of the economic returns at the parcel level will help us determine the socially marginal (beneficial) land for food (energy) crop production.
- Monetizing the costs and benefits of negative and positive environmental externalities through taxes and payments, respectively, should incentivize the conversion of socially marginal land for food crops into socially beneficial bioenergy crops.
- There is no denying that the shifts in climate have resulted in land use changes specifically as an adaptation strategy against adverse effects of climate change in agricultural production.
- Combining the anticipated changes in future climatic and economic conditions, we can further explore the incentives required to promote specific land uses as a climate change mitigation strategy.

DIRECTION

- We are generating forest net returns using stumpage prices, and total forest standing volume and forested area from the Forest Inventory and Analysis (FIA) database.
- We are computing urban net returns using sales prices of single-family homes and the improved lot including the lot sizes from the American Community Survey (ACS) and Survey of Construction (SOC) reports.
- CABBI researchers are quantifying soil carbon sequestration and nutrient losses under conventional and bioenergy crops.
- We will soon update the model with forest and urban returns and include monetized values of environmental services.

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