Using Agent–Based Modeling to Predict the Effects of Biorefinery Location on Land Use Change

By: Brad Love, Edwin Martinez & Sean Woznicki
GEO 890
May 4, 2010
Professor: Arika Ligmann-Zielinska
Michigan State University
Outline

- Introduction
- Objectives
- Study Area
- Methods
- Results and Discussion
- Conclusion
- Recommendations
Introduction

- A biorefinery is a facility that integrates biomass conversion processes and equipment to produce fuels, power, and value-added chemicals from biomass.

- Relationship of cell distance from a biorefinery and commodity prices with the likelihood to raise bioenergy crops for corn ethanol.

- A new Agent-Based Model (ABM) was developed to address the effect of spatial variation from a biorefinery on the production characteristics of bioenergy crops.
Objectives

- Use ABM to predict the effects of biorefinery location on land use change
- Demonstrate how ABM can be applied to analyze and describe relevant agricultural issues
Ingham County, Michigan
Study Area: 382.6 km²
Predominant land uses are urban and agriculture
Common crop rotations are corn, soybeans and wheat
ABM using Python

Model Description:
- Decision making system
  - Location of biorefinery
  - Distance of land parcel to biorefinery
  - Crop type
  - Commodity price
  - Farmer willingness to change current system out of rotation

ABM model input data:
- Crop Data Layer 2008 land use map
- Commodity price ranges for the past 10 years
Methods

Agents
- Each cell is occupied by a current landuse type
- Biorefinery placed randomly and occupies one cell

Behavior
- Next year land use determined by utility function
- Agent changes to future scenario based on land value and distance from biorefinery
- If the agent cell fails to meet the threshold requirement, the landuse falls into a crop rotation
- All other agricultural land follows crop rotation
- Forested and urban land is never occupied
Utility Function

\[ u = p \cdot w_p + (1 - d) \cdot w_d \]

- \( u \) = utility function
- \( p \) = normalized price
- \( w_p \) = price weight = 0.5
- \( d \) = normalized distance
- \( w_d \) = distance weight = 0.5
Threshold = 0.6
Legend

Utility Values

0
0.2
0.4
0.6
0.8
1

Landuse

Wheat
Soybean
Corn
Hay
Urban
Urban Low
Threshold = 0.7
Threshold = 0.8
Threshold = 0.9
Results and Discussion

- Fluctuation of prices has a large influence on distribution of land use
- Effect of threshold value on land use change and “radius of influence”
  - Small threshold = small radius
  - Large threshold = large radius
- Path dependence
  - Crop rotations and previous year’s land use
Conclusion

- Increased demand in energy sources has introduced need for biorefineries
- Biorefinery locations could potentially influence land use and crop rotations
- ABM is a useful tool in predicting land use change and feasibility of biorefinery location
Recommendations

- Use transportation distance instead of Euclidean distance
- Include farm input costs for each crop
  - Fertilizer, pesticide, harvesting, seed, equipment, labor
- Include fluctuating fuel prices
- Transportation costs based on commodity shipped
- Expand study area to encompass multiple regions