Assessing the potential for switchgrass-based bioenergy in Missouri: A geospatial-based approach

Gia Nguyen, Pankaj Lal Ph.D., Erik Lyttek, Pralhad Burli Ph.D., Taylor Wieczerak. Montclair State University

Background

- Developing renewable energy sources has been mandated by the US government.
  - Expected 36 billion gallons of biofuels (MMGY) by 2022, of which 21 MMGY must come from non-food or cellulosic sources. (RFS, 2018)
- Increased emphasis on dedicated energy crops including herbaceous perennials such as switchgrass, other grasses, and woody species (US. Dept. of Energy, 2011).
  - The RFS expected that the portion of cellulosic biofuel would be approximately 45% of total renewable fuel in 2022. (RFS, 2018)
- Switchgrass (Panicum v. virgatum) is regarded as a high potential bioenergy, mitigating the food vs. fuel controversy while providing a range of ecosystem services benefits (Blight et al., 2017; Irmai et al., 2017)
- It is a challenge to construct cost-effective supply systems, as regions suitable for cultivating switchgrass may not be near bioenergy facilities (Langholtz et al., 2016)
- There are limitations in composing a methodology to identify suitable locations for bioenergy crops which consider multiple spatial condition layers which also minimize transportation costs.

Research Objectives

1. To develop a land suitability model for biomass-based growing cultivation development to integrate selected spatial and environmental criteria.
2. To find suitable locations with transport cost optimization and the number of biorefineries in an area considering spatially different biomass yield and the road network.

Methods and Materials

- RESEARCH BOUNDARY based on (1) Local Bioenergy Facilities and (2) Buffering 128 km
- Case study: Switchgrass in Missouri

- Favorable criteria and constraints for growing biomass:
  - Slope of land (degrees)
  - Seaside temperature
  - Rainfall
  - Soil texture
  - Land use land cover
  - Critical species/entails

- Land use planning and allocation
  - Growing cultivation development to buffered regions
  - Potential cultivating regions of switchgrass in Missouri with marginal land scenario (scenario 1)
  - The shortest paths from the six biorefineries in Missouri to potential regions in scenario 1

- Potential cultivating regions of switchgrass in Missouri with marginal land and non-food crop land scenario (scenario 2)
  - The shortest paths from the six biorefineries in Missouri to potential regions in scenario 2

- Network location analysis
  - Shortest path
  - Asymmetrical land use planning

- Service area model
  - Cost-efficient transport system

- Shortest path from facilities to incidents

- Potential suitable growing regions
  - Potential yield at 64, 68, 86, and 126 km buffered regions

- Total cost (TC) = Distance fixed cost (DFC) + Distance variable cost (DVC)

- Cognitive suitability of the switchgrass cultivation locations

Criteria for cultivating regions:
- Potential cultivating regions of switchgrass in Missouri with marginal land scenario (scenario 1)
- The shortest paths from the six biorefineries in Missouri to potential regions in scenario 1

Conclusion

Findings
- We performed a performed a geospatial analysis to assess the suitability of switchgrass-based bioenergy
- The model identifies suitable growing biomass for bioenergy based on favorable conditions, potential constraints as well as the real-world transportation network
- The model can also be applied to different hypotheses on land use land cover
- 21,000 hectares of marginal land suitable for switchgrass cultivation
- 2.6 mil. hectares of non-food cropland (incl. marginal land) ideal for switchgrass cultivation
- Minimum transportation cost for biomass is about 518 Mg–1

Limitations
- We did not examine the weight of factors affecting to the models
- We did not normalize factors in the cost calculation
- The model does not consider possible interactions between the various conditions

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References