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

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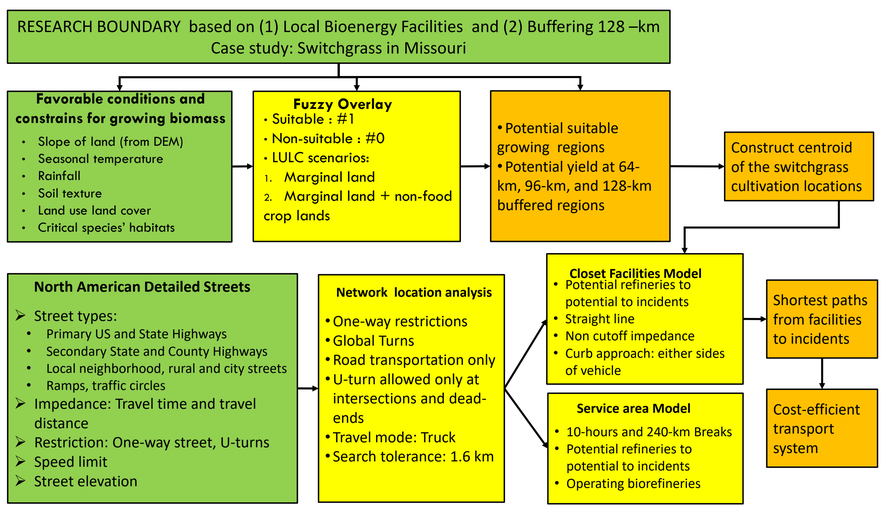
Background

- 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 L. virgatum) is regarded as a high potential bioenergy, mitigating the food vs. fuel controversy while providing a range of ecosystem services benefits (Wright et al., 2017; Irmak 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

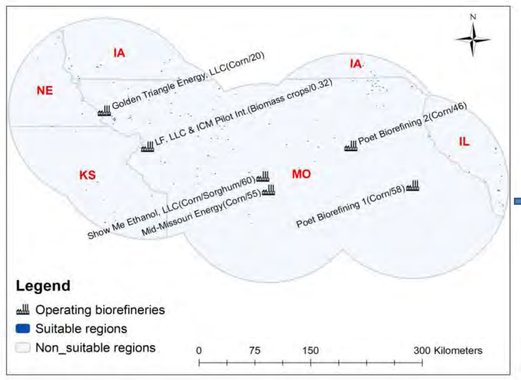


Total cost (TC) = Distance fixed cost (DFC) + Distance variable cost (DVC)

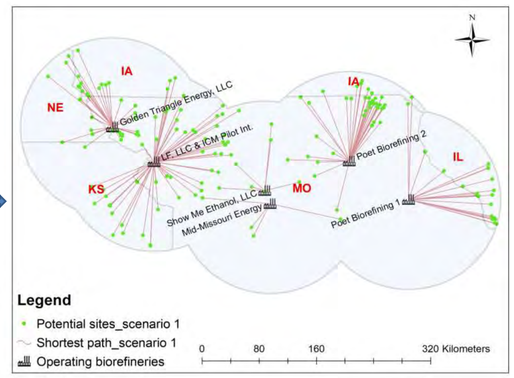
DVC = travel distance (TD) X [distance cost, empty (DCe) + distance cost, load (DCl)

Cost	U.S. Unit	Metric unit	Converted rate
Logistic cost (LC)	$3.24 ton^{-1}	$3.57 Mg^{-1}	0.907
Distance cost, empty (DCe)	$0.027 ton^{-1}mile^{-1}	$0.0476 Mg^{-1}km^{-1}	0.567
Distance cost, loaded (DCl)	$0.038 ton^{-1}mile^{-1}	$0.067 Mg^{-1}km^{-1}	0.567

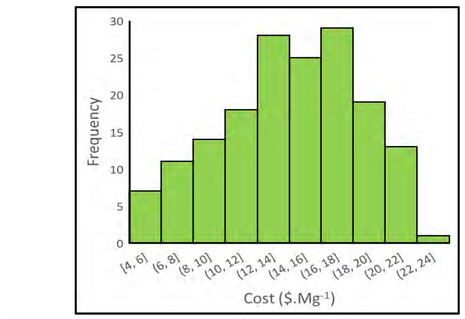
Result



Potential cultivating regions of switchgrass in Missouri with marginal land scenario (scenario 1)

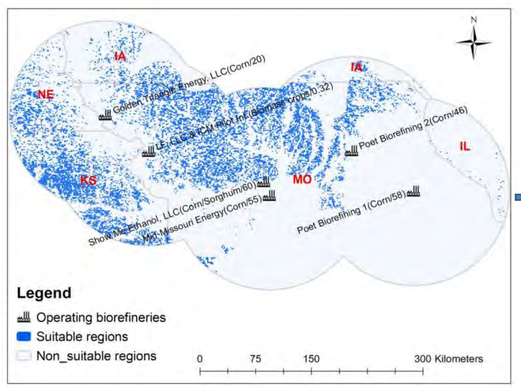


The shortest paths from the six biorefineries in Missouri to potential regions in scenario 1

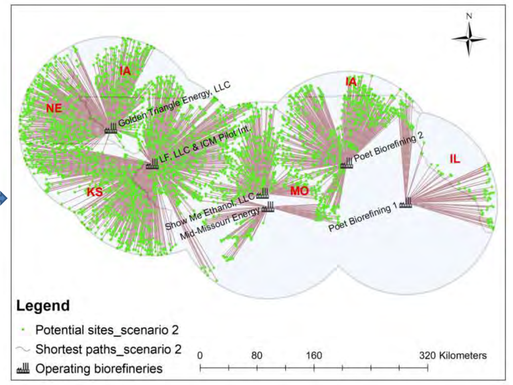


Biorefinery	Golden Triangle Energy, LLC	LF, LLC & ICM Pilot Int. Cell	Show Me Ethanol, LLC.	Mid-Missouri Energy	Poet Biorefining 1	Poet Biorefining 2
N° of potential sites	38	56	7	4	21	39
Potential area (ha)	5,182	7,188	1,029	417	2,776	4,374
Potential supply (Mg)	69,694	96,678	13,837	5,616	37,345	58,827
Percentage	24.71%	34.28%	4.91%	1.99%	13.24%	20.86%

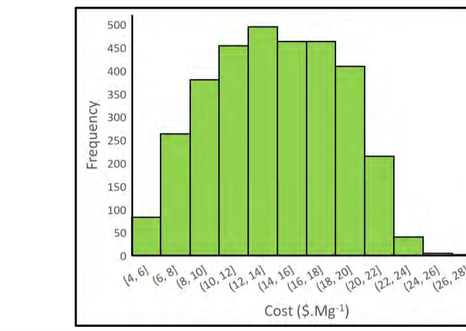
Potential yield of switchgrass and cost of transportation in scenario 1



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



Biorefinery	Golden Triangle Energy LLC	LF, LLC & ICM Pilot Int. Cell	Show Me Ethanol, LLC	Mid-Missouri Energy	Poet Biorefining1	Poet Biorefining2
No of potential sites	766	1,340	357	108	116	583
Potential area (ha)	258,426	1,646,244	298,746	37,296	14,121	383,850
Potential supply (Mg)	3,475,830	22,141,982	4,018,134	501,631	189,927	5,162,782
Percentage	9.79%	62.39%	11.32%	1.41%	0.54%	14.55%

Potential yield of switchgrass and cost of transportation in scenario 2

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 hypothesizes on land use land cover
- We found in Missouri and neighbor states
  - 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 $18 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

Mitchell et al., 2016

Acknowledgments

We gratefully acknowledge support for this work from the National Science Foundation CAREER Award 1555123 and CESAC.

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