Multimetric Spatial Optimization

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Goal

Sustainable production of bioenergy crops for liquid transportation fuel will require a comprehensive understanding of environmental and socioeconomic factors and interactions between those factors at the regional scale. The goal of this study was to develop and apply a tool for simultaneous environmental and economic analysis and policy research that helps users understand the interaction between multiple aspects of sustainability.

Optimization model

The Biomass Location for Optimal Sustainability Model (BLOSM http://blosm.ornl.gov) identifies where to locate plantings of bioenergy crops in a particular region given explicit feedstock goals. It considers (1) farmer's profit estimates by county and subbasin as derived from Policy Analysis System (POLYSYS), (2) crop yields from a national grid of switchgrass yield potential based on yield observations from field trials conducted across the US, and (3) effects on water quality and quantity as developed by Soil and Water Assessment Tool (SWAT) parameterized for switchgrass.

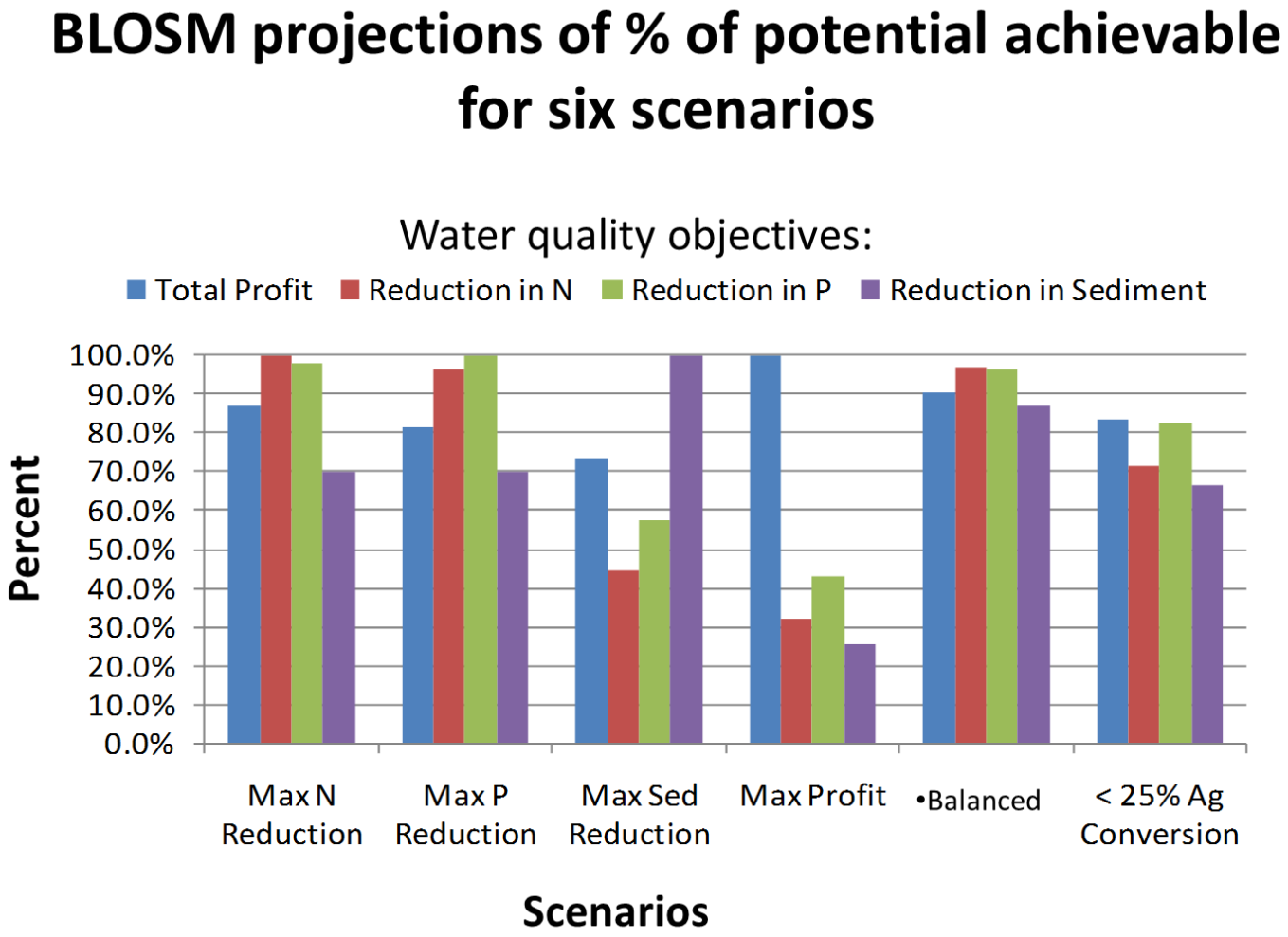
BLOSM was run to identify maximum achievable target in the Lower Little Tennessee watershed and then optimizations are compared to targets. The targets for water quality were set based on potential thresholds of stream eutrophication that resulted from these nutrients. Several scenarios were considered:

- Baseline: business as usual (no target)
- Minimize nitrogen: used to determine whether nitrogen concentration levels of ≤1 mg/L could be achieved by planting the target tonnage of switchgrass throughout the study area
- Minimize phosphorus: used to determine whether phosphorus concentration levels of ≤ 0.1 mg/L could be achieved by planting the target tonnage
- Minimize sediment: examined the possibility of achieving sediment concentrations of ≤ 50 mg/L through planting the target tonnage
- Maximize profit: solved for the greatest net returns achievable
- Balanced: All three water quality goals and economic profit were equally weighted

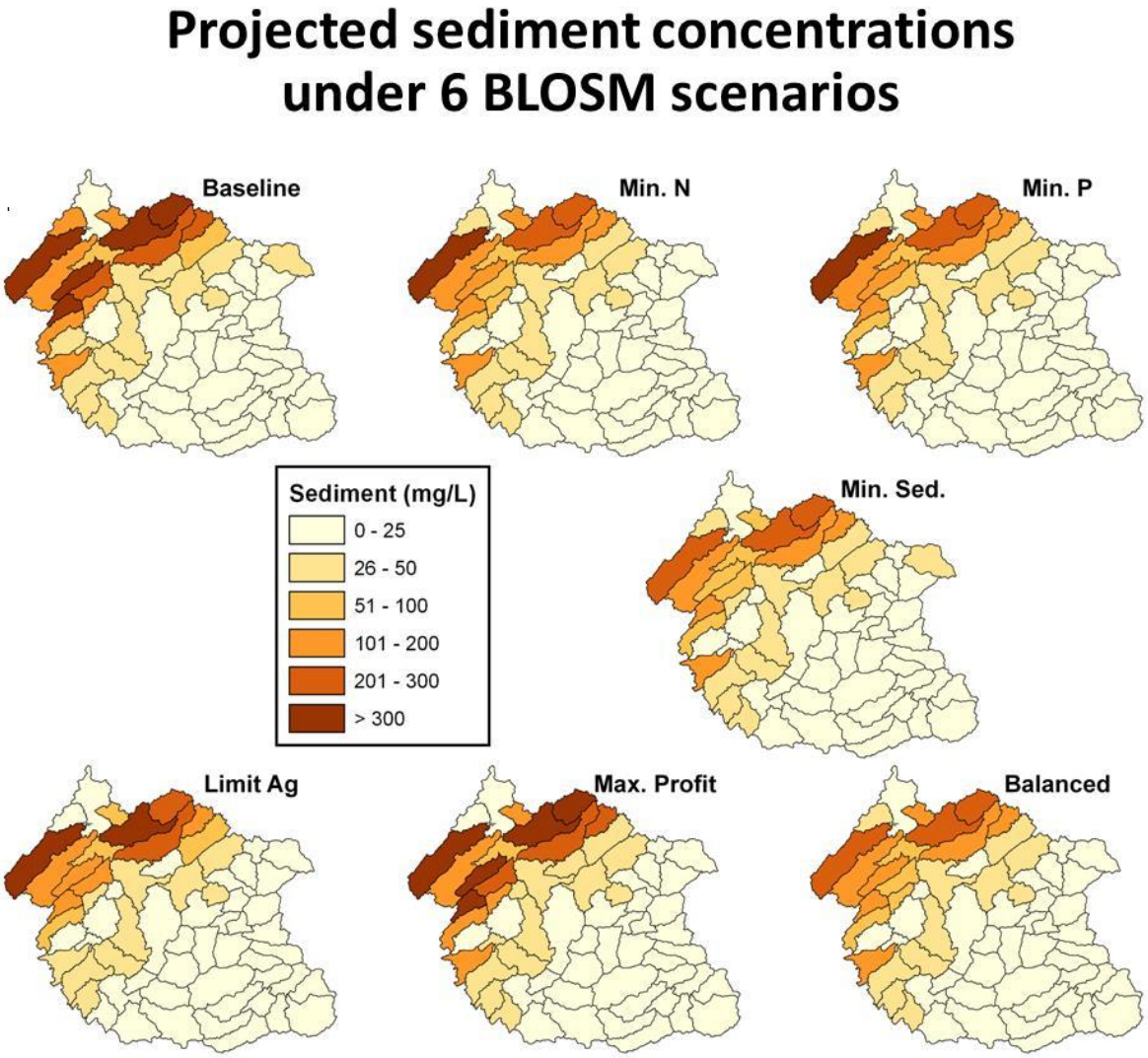
- But the balanced solution changed such a large proportion of agricultural land (compared to hay/pasture land) to switchgrass that an additional limit of less than 25% conversion of agricultural land was also run.

Results

BLOSM results indicate that a combined economic and environmental optimization approach can achieve multiple objectives simultaneously when a small proportion of the watershed is planted with perennial switchgrass.



Maps of projected BLOSM changes in subbasin-level water-quality metrics resulting from the six switchgrass planting scenarios applied to the Lower Little Tennessee watershed depict changes in total suspended sediment concentrations.



References

Parish, ES, M Hilliard, LM Baskaran, VH Dale, NA Griffiths, PJ Mulholland, A Sorokine, NA Thomas, ME Downing, R Middleton. 2012. Multimetric spatial optimization of switchgrass plantings across a watershed. Biofuels, Bioprod. Bioref. 6(1):58-72.