Argonne NATIONAL LABORATORY

Environmental Science Division

Holistic, sustainable bioenergy landscapes: where productivity meets sustainability.

Integrated field demonstration and watershed scale blueprints for sustainable bioenergy production

The problem

Meeting the world's needs for food, feed, fiber, energy and conservation in the face of population growth and climate change pressures will require a new agricultural mindset that effectively balances concerns about economic viability with an ambitious focus on sustainability. Use of the limited water and land resources will have to be carefully planned at a regional and local scale for a sustainable intensification of our agricultural production systems. Land use change, greenhouse gas emissions, water use, and water quality are the chief environmental sustainability indicators against which intensified production metrics are judged. Socioeconomic sustainability metrics include regional and international concerns such as farm profitability, jobs, maintaining the social fabric, acceptance and perception, and more globally food security and geopolitics.

We research ways to integrate the Midwestern food and bioenergy production systems so that sustainability is built in from the start and we properly address the food/energy/water nexus. Agricultural soil management practices accounted for approximately 75% of the greenhouse gas nitrous oxide U.S. emissions in 2012. Runoff from fertilization of row crops is a significant source of non-point source water pollution. What if we could convert those losses into recoverable resources for biomass feedstock production? Bioenergy crops have the potential for providing ecosystem services with their deep root system, perennial growth, attractiveness to wildlife and lower fertilizer requirements. For example, what if we could take areas that are vulnerable for nitrate leaching, underproductive acreage such as crop edges, marginal field portions and riparian/roadway buffers and increase their potential productivity and environmental performance by dedicating them to bioenergy? While simple in principle, this is just one example of a future sustainable bioenergy landscape: bioenergy crops growing side by side with main row crops, providing the energy required for our nation's growth, and a suite of ecosystems services *by design*.

Our work explores the challenges, the tools and the sustainability end points of this future landscape, and engages stakeholders to collectively design such a holistic approach to sustainable biomass production so that the final product meets the needs of all.

Our approach

Through field testing and modeling, Argonne proposes new productive landscape concepts to determine how it is possible to balance productivity and sustainability at the watershed scale.

A strip of short rotation bioenergy willows scavenges nutrients lost by corn at Argonne's field research station in Fairbury IL.

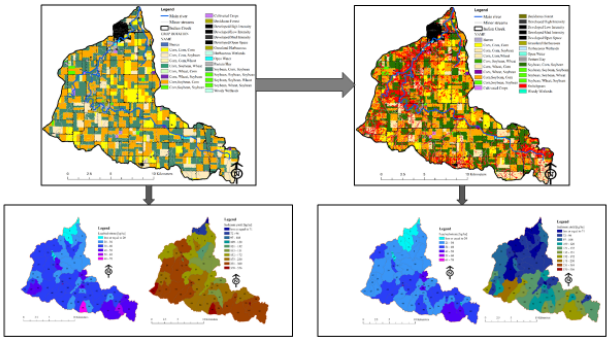
Our research shows that a holistic approach can result in production intensification, better nitrogen use efficiency at the farm scale, restoration of contaminated water supplies, and mitigation of greenhouse gas emissions from both biomass and row crops.

Bioenergy crops have deep root systems that can intercept subsurface nutrient flows and reuse leached fertilizer to increase growth.

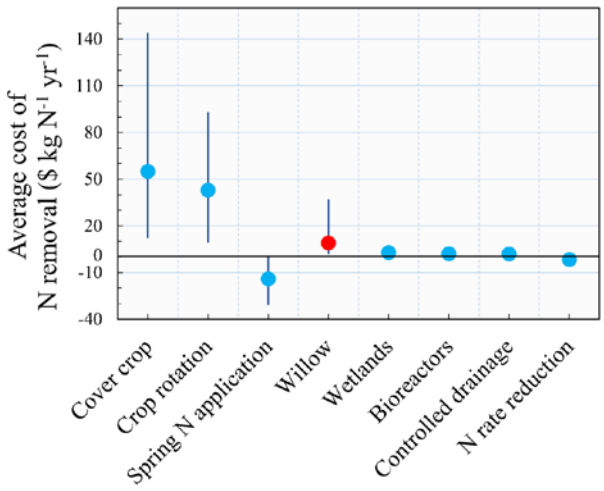
From field to watershed communities: designing a new agricultural landscape

Our work is now developing the blueprint and partnerships for the design of a new landscape for a watershed in Central Illinois. Using mathematical modeling and design tools combined with partnerships with local conservation initiatives and feedback from stakeholders we are answering these questions:

- What land can be prioritized for bioenergy crops in the landscape so that row crops and farmer revenues are not penalized, and we generate the most ecosystem services?
- What designs can be developed at the watershed and landscape scale that reflect this approach?
- What economic opportunities could be derived from this approach?



From our analysis, switchgrass grown on vulnerable land in an Illinois watershed could reduce nitrate loadings by 25% and sediment by 33%.



When normalized on the basis of nitrogen removal efficiency, bioenergy buffers can be more cost-effective than commonly adopted conservation practices such as cover crops and crop rotations.

Recent Literature

- H. Ssegane, C. Zumpf, M. C. Negri, P. Campbell, J. Heavey, and T.A. Volk (2016) -*The Economics of Growing Shrub Willow as a Bioenergy Buffer on Agricultural Fields. A case study in the Midwest Corn Belt*. In press, Biofuels, Bioproducts and Biorefining. DOI: 10:1002/bbb.1679.
- Hamada, Y., H. Ssegane, and M. C. Negri (2015) *Mapping Intra-Field Yield Variation Using High Resolution Satellite Imagery to Integrate Bioenergy and Environmental Stewardship in an Agricultural Watershed*. Remote Sensing, 2015, 7, 9753-9768; doi:10.3390/rs70809753.
- Ssegane, H., M.C. Negri, J. Quinn, M. Urgun Demirtas (2015) *Field scale Design of multifunctional landscapes for food, bioenergy and ecosystem services.* Biomass and Bioenergy 80, 179-190.

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