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WINNER COMPETITION FOR NATURAL RESOURCES CATEGORY

Iowa Drainage and Wetlands Landscape Systems Initiative

By Dean Lemke and Shawn Richmond

***ABSTRACT*:** Nutrient export from agricultural land is an increasing environmental and societal concern, while there is increasing demand for agriculture to supply food, fiber and fuel. A new Iowa initiative is proposed utilizing integrated drainage and wetland landscape systems to achieve environmental, ecological services and agricultural benefits. Most of the 6 million acres of the Des Moines Lobe of Iowa targeted for nitrate reduction to Iowa streams and the Gulf of Mexico are artificially drained with subsurface drainage systems that were installed in the early 1900's. Over the next few decades, drainage systems and drainage mains throughout Iowa's Drainage Districts will be replaced, and with this comes an opportunity to enhance the infrastructure to meet environmental and ecological objectives. While the subsurface drainage systems that have been installed throughout the Des Moines Lobe result in crop production benefits, future designs can optimize watershed function to reduce nitrate and phosphorus export to downstream waters, increase wetland function, and optimize crop production. Overall redesign of the drainage network with integration of wetlands will allow for improved downstream water quality by reduced surface water runoff, soil erosion and sediment and phosphorus transport to streams. Redesigned drainage systems will be coupled with strategically-targeted wetlands to treat subsurface drainage water to remove nitrate, while optimizing crop production. This proposal hinges on the institutional capacity to implement, manage, and maintain these integrated systems through Iowa's 3,000 existing Drainage Districts. Nutrient removal wetlands and replacement drains will be developed through existing locally-led drainage districts. Up to 25 sites will be developed as pilot demonstrations. Initial sites will be assessed by Iowa State University wetland-drainage systems researchers and others to confirm water quality impacts, wetland functions and values, and crop yield responses.
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Nutrients transported to water resources from the row-cropped lands of Iowa and the remainder of the U.S. corn belt contribute to local water quality concerns, as well as to hypoxia in the Gulf of Mexico. The goal for addressing Gulf hypoxia by year 2015 sets nutrient reduction targets of 45% for both nitrogen and phosphorus in Mississippi River waters delivered to the Gulf.

The U.S. corn belt has rich soils and climate suitable for producing grains for food and bioenergy, primarily corn and soybeans. Even with the best in-field management of crop nutrients, these cropped landscapes are leaky systems requiring significant amounts of nutrients to be present for optimum plant growth, yet susceptible to nutrient loss whenever excess water drains from the land due to uncontrolled rainfall.

The more than 3,000 Drainage District common outlet systems across the six million acres of Iowa's Des Moines Lobe were installed 70 to 90 years ago. These systems were designed for a very different agricultural production system—one in which 50% of the watershed areas were in pasture, hay and small grains production instead of the nearly 100% row-crop use today. This drainage infrastructure is very large; representing an investment by Iowa landowners for the drainage district outlets in the early 20th century is nearly equivalent to the entire U.S. investment in the Panama Canal (New York Times, 1910).

In the coming years, these drainage systems will be redesigned and replaced. The question is whether they will be designed and replaced using outdated standards or if a more innovative approach will be taken to incorporate environmental benefits while also benefiting agriculture? Previous studies and assessments have concluded that, in addition to optimal in-field management, structural solutions are needed to stem the transport of nutrients from cropped lands. In Iowa, the primary landscape targeted for reducing nitrate transport totals six million acres estimated to source 60% of the nitrate exported from the state. Located within 3,000 existing watershed management districts, this area has extensive subsurface drainage infrastructure installed in the early 20th century. This aging infrastructure will be replaced in the next three to four decades, providing an opportunity to re-design systems to address nutrient reduction, environmental goals, and ecological services.

Iowa Drainage and Wetland Landscape Systems Initiative

The Iowa Department of Agriculture and Land Stewardship (IDALS), through a multi-disciplinary science team from Iowa State University (ISU) College of Agriculture and Iowa Drainage District Association, in collaboration with the Iowa Farm Bureau Federation, have developed the Iowa Drainage and Wetland Landscape Systems Initiative for environmental improvement and ecological services enhancement in cropped landscapes with subsurface drainage. This private/public initiative builds on the innovative technology developed by ISU for nitrogen-removal wetlands in cropped landscapes and implemented through the Iowa Conservation Reserve Enhancement Program (CREP), recipient of the 2008 Gulf Guardian Award for addressing hypoxia in the Gulf of Mexico.

The landscape systems initiative integrates new technologies of whole-scale watershed optimization for environmental, ecological and agricultural benefits. It is projected to provide:

- A 40% to 70% reduction in nitrate transport to water resources;
- A 50% reduction in phosphorus transport;
- A 50% reduction in surface runoff that contributes to downstream flooding;
- A decrease in nitrous oxide greenhouse gas emissions;
- Significant enhancements of wetland functions, values, wildlife habitat, landscape diversity and recreational opportunities; and
- A 7% to 20% increase in crop yields, which will serve as a market-driver for implementation

Initial deployment of the initiative through 25 pilot demonstrations will serve as study sites to confirm expected environmental/ecological benefits and economic impacts. Once those pilot demonstrations are successfully completed and expected benefits are confirmed, the initiative could be deployed across the six million acre Iowa target area. It is estimated the initiative could reduce by 40% the nitrate transport from Iowa croplands, and spur infrastructure development investment exceeding $4 billion, primarily funded by private landowner funds investing in the initiative's potential to increase crop yields and net income.

The Iowa initiative could be a model for deployment across similar landscapes of the subsurface-drained U.S. corn belt, helping to reduce nutrient transport and improve local water quality needs and Gulf hypoxia, while optimizing crop production. More than 30 national and Iowa environmental and agricultural organizations/agencies have expressed support to proceed with the initial pilot demonstrations. Initial pilot demonstrations are expected to begin in 2010.

Pilot Demonstrations and Studies

This innovative initiative optimizes watershed function to provide ecological services and environmental benefits, while optimizing agricultural production to provide market-driven implementation. Pilot project sites will be used to demonstrate technologies and approaches, as well as confirm the benefits of drainage and wetland landscape systems coupled with integrated in-field nutrient management.

Surface runoff volume and rate are decreased through increasing subsurface drainage, also resulting in decreased losses of sediment, ammonium-nitrogen, phosphorus, pesticides and micro-organisms. Studies have shown that improved nitrogen management practices—in the way of correct rate, timing and placement—have some potential to reduce nitrate leaching. Alternate cropping, such as small grains, alfalfa, other sod-based crops/rotations or cover crops, also have the potential to result in major reductions, but have major negative economic implications.

To address hypoxia in the Gulf of Mexico and local water quality concerns, this initiative proposes a systems approach that combines the best in-field management with drainage redesign and integration of high-value nutrient removal wetlands. These wetlands, which take up about 0.5% to 2% of the watershed area to achieve 40% to 90% nitrate removal, are a proven technology. Iowa State University monitoring of the Iowa Conservation Reserve Enhancement Program (CREP) wetlands indicates that relatively small areas of wetlands intercepting tile drainage can remove up to 90% of the nitrate-nitrogen in tile drainage water.

Increasing the capacity of subsurface drainage is expected to decrease surface runoff and associated losses of contaminants by about 50%, while increasing the loss of nitrate by about

10%. However, subsurface drainage will be treated through strategically-located nitrogen-removal wetlands, which remove an average of 40% to 90% of the nitrate. In addition, integrating design and placement of the wetlands with the redesign of the drainage systems is expected to increase the number of potential sites for topographically-limited nutrient removal wetlands over the current Iowa CREP approach of retrofitting the wetlands onto existing drained landscapes.

It may also be possible to design these wetlands to allow for more flow attenuation and reduction in peak outflows to receiving streams. The redesign of the drainage system will increase the drainage capacity, so existing continuously-cropped farmed wetlands will need to be mitigated if deemed to be better drained as a result of the redesigned drainage system. Impacts on farmed wetlands will be mitigated with high-value nutrient removal wetlands. This could substantially increase wildlife habitat and important ecological functions on the landscape over that of the current continuously-cropped farmed wetlands.

Demonstration and Study Objectives

Agriculture faces increased demands to supply food, feed, fiber and fuel, while protecting natural resources and providing environmental services. The need exists for innovative approaches to meet these demands. This initiative will create an integrated approach of redesigning the subsurface drainage network to reduce surface runoff volume, rate and runoff contaminants, while optimizing crop production to serve as a market-driver. This redesign will be combined with high-value nutrient removal wetland systems and implementation of best in-field nutrient management practices. This initiative seeks to:

- Design, demonstrate and evaluate the environmental effectiveness, specifically water quality benefits, of integrating in-field nutrient management, drainage system redesign, and high-value nutrient removal wetlands in north-central Iowa. The goals of these integrated systems are to: reduce surface runoff volume, rate, and peak flow; reduce loss of surface runoff contaminants; reduce the loss of subsurface flow contaminants; increase habitat and wetland ecological functions of the landscape; decrease greenhouse gas emissions; and improve crop yield and profitability as a market-driver for private implementation.

- Demonstrate and evaluate the impacts of drainage redesign with increased capacity on crop production. Transfer the information gained to agencies and producers for use in making future decisions using such communication tools as data summaries, educational materials, and hosted field days at demonstration sites. Project partners will each have an important key role in communicating pilot program results to stakeholders, a key factor in the long-term success of this initiative.

The anticipated environmental and economic benefits demonstrated in the initiative's pilot projects could trigger significant future investments in wetland and drainage systems throughout Iowa and the entire U.S. corn-belt. The design and construction of these systems would generate large-scale economic development and job creation opportunities.

To design, construct and evaluate this integrated strategy will require performance evaluation of the systems approach for watershed optimization. Projects will have three work elements: 1) nutrient management and crop production; 2) engineering and construction of drainage and wetland systems; and 3) assessment of water quality and ecological benefits.

Projects will be integrated with an ongoing monitoring program to document agricultural and environmental benefits. Hydrologic and nutrient mass balance monitoring of the drainage and wetland systems will be used to evaluate performance of the drainage-wetland systems with respect to nitrate and phosphorus export. Work will be done with producers to obtain GPS crop yield data to evaluate potential yield benefits, as well as estimate nutrient export through grain removal. Nutrient input and export data will be used to develop nutrient budgets to document the balance of nutrient inputs and outputs at the drainage-district scale, information that is currently lacking.

If successful, this project could be a model for how to improve environmental quality while optimizing crop production. The integration of these approaches will provide opportunities for developing market-based solutions for improving ecological services when aging drains are replaced. Beneficiaries would be producers, rural communities, and those interested and concerned about environmental quality.

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