

## ESRP PROJECT AREA DESCRIPTOR

### Title of Project Area: Future Midwestern Landscapes Study

**Description of the Project:** ESRP's Future Midwestern Landscapes (FML) Study is quantifying ecosystem services (i.e., benefits that humans receive from ecosystems) in 12 states that comprise the Midwestern US (see Figure 1.), an area responsible for a significant proportion of the world's grain production. The Midwest also is home to unique ecological resources such as the wetland-dotted landscape of the Prairie Pothole Region and important avian migration routes such as the Mississippi and Central Flyways. However, excess agricultural nutrients from this region are the primary contributor to the seasonal, hypoxic "dead zones" in the Gulf of Mexico and Lake Erie. Herbicides are commonly detected in Midwestern streams and shallow groundwater, and modification of Midwestern flood plains has increased the heights and frequencies of floods in the Upper Mississippi River basin. These problems may be exacerbated, and new stresses on wildlife created, as grain prices rise in response to the demand for biofuels. Conversely, improvements in agricultural management through the adoption of conservation practices (for example, improvements in tillage practices and fertilizer management, wetland restoration, and targeted land retirements to provide wildlife habitat) have been demonstrated to improve the delivery of many ecosystem services. These services include water purification, provision of nature-based recreation, flood attenuation, and climate stabilization, as well as the production of food, fuel and fiber. Thus, these conservation practices could help address environmental problems while benefiting farm economies and society. As stated in 2005 by U.S. Department of Agriculture Secretary Mike Johanns, "I see a future where credits for clean water, greenhouse gases, or wetlands can be traded as easily as corn or soybeans."

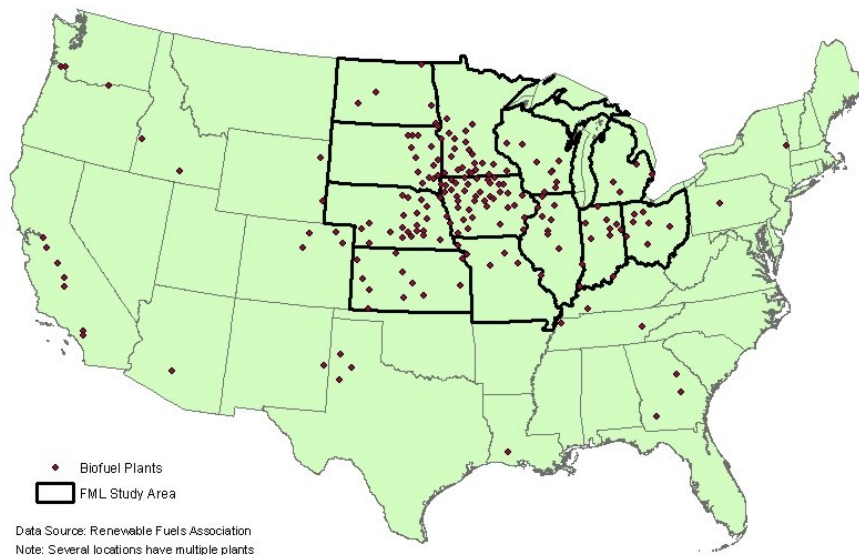


Figure 1. Map showing study area for the Future Midwestern Landscapes project. Locations of biofuel refineries are indicated by the dots.

By coupling existing databases on land cover and land use with economic projection methods, the FML Study is generating alternative future landscapes reflecting two drivers of landscape change – biofuels and conservation practices. The Biofuel Targets Landscape is approximating the landscape expected in the year 2022 given current policies which set targets for increases in biofuel production through the Energy Independence and Security Act of 2007 (EISA). This landscape is being characterized by substantial increases in corn acreage at the expense of soybeans, other crops and Conservation Reserve Program acreage. Removal of corn stover also will increase significantly. By contrast, the Multiple Services Landscape is one in which hypothetical increases in agricultural conservation practice incentives significantly increase farmer adoption of a variety of conservation practices. These future landscapes will be compared to a 2002 Base Year Landscape.

We are estimating ecosystem services for these alternative future landscapes by modeling projected changes in soil carbon, runoff, sediment and nutrient loadings, aquatic biological communities, wildlife habitat and air quality. The landscape analysis methods developed for the FML Study are being implemented as a web-based environmental decision toolkit (FML-EDT), similar to other toolkits previously created under EPA's Regional Vulnerability Assessment Program (ReVA). The FML-EDT will allow users to visualize alternative Midwestern futures and to compare them by examining tradeoffs – that is, changes in the complement of a wide variety of ecosystem services – at both local and regional scales.

**Potential Impacts and Accomplishments:** The primary impacts of the FML Study on decision-making will occur as users of the FML-EDT apply FML findings to various kinds of environmental management problems. ReVA clients have used past EDT versions (which did not include estimates of ecosystem services) to prioritize watershed projects, to compare alternative approaches for regional development, to study human and ecosystem vulnerability, to report on the status of ecological resources, and to prioritize conservation spending. Partners in the FML effort, including USDA's Farm Services Agency (FSA), the US Department of Interior's Fish and Wildlife Service (FWS) and EPA's Regions 5 & 7, will be among the primary clients for the new FML-EDT.

Through a Memorandum of Understanding (MOU), FSA is working directly with EPA on design of the FML-EDT, to enable the assessment of trade-offs among landscape scenarios. This collaboration will improve the Environmental Benefits Index (EBI) which FSA uses to make decisions on proposed Conservation Reserve Program (CRP) enrollments. The EBI currently focuses on water quality and local wildlife habitat, and will be broadened into an Ecosystem Services Index that will effectively evaluate potential improvements in a suite of ecosystem services including air quality, broad-scale habitat configuration, among others.

The US FWS is a collaborator on wildlife habitat modeling for the FML project and intends to use these results to inform future decisions regarding locations of potential migratory bird conservation areas. FWS is currently using the enhanced land use/land cover map developed for the Base Year landscape (including crop management) to develop maps of conservation priorities.

Under a 2010 Biofuels Research Initiative, the FML study has been awarded additional funding to improve model results for water quality and supply, air quality, soil productivity and greenhouse gas production. These additions will improve the usefulness of FML

results for EPA's air and water program offices. Regional scale water quality model results (including nutrient export to the Gulf of Mexico) will be improved. In addition the ability to evaluate effects of land management (including changes in fertilizer inputs) on air quality, as well as corresponding changes in human mortality and morbidity will be improved. The enhanced models will be transferrable, so the work should also inform decisions outside the study region.

FML results will contribute to EPA's triennial Reports to Congress (RtC) on the environmental impacts of biofuels, authorized under EISA. While our contributions to the first RtC (to be completed in 2010) will likely be qualitative, preliminary results of analyses comparing our 2002 Base Year and 2022 Biofuel Targets landscapes will be available for the 2013 RtC.

Development of the FML-EDT webtool is proceeding well. Although only limited ecosystem service estimates are included at this time, the prototype version currently provides a wide range of landscape-derived metrics for viewing and comparing the Base Year and Biofuel Targets landscapes. We have added a new guided-assessment capability to assist nontechnical users, and a mash-up between the original statistical engine (SPlus) and an online GIS capability (ArcServer) to provide enhanced visualization and expanded analytical capabilities. As a result of a recent demonstration to EPA and non-EPA clients, several additional regional offices are interested in providing data for similar tools, and the Division of Fisheries and Oceans Canada would like to use a ReVA webtool to prioritize management activities on Canada's east coast.

### **Current Status:**

Landscape Development: We have developed detailed coverages representing the Base Year and Biofuel Targets landscapes, and incorporated preliminary metrics for these into the prototype FML-EDT. The Multiple Services Landscape is under development using a hypothetical conservation incentives policy and a model of farmer decision-making (completion date: 2011). Collaboration with FSA and FWS and a new data-sharing MOU (currently in process) with USDA's Economic Research Service are supporting these efforts.

Scoping of expected ecosystem service changes: We have developed a systematic method for use of best professional judgment to estimate sign, magnitude and relative certainty of expected changes in ecosystem services for each landscape; results are currently undergoing quality assurance and analysis.

Modeling and Ecosystem Service Estimation: We are working to establish an interagency agreement with USDA's Agricultural Research Service to improve water quality model calibration at multiple scales. Available monitoring data has been prepared for a set of 41, regionally representative Midwestern watersheds (12-digit HUC scale), and the FML team is working with developers of EPA's model integration system (FRAMES) to link water quality outputs for these 41 watersheds with hydrodynamic and aquatic habitat models.

In collaboration with ESRP's national ecosystem service mapping effort, data mining and literature reviews are underway to support modeling of recreational activities (associated with a number of services) and risks associated with flooding. We are working with FWS

to develop ways to assess the relative effects of these three landscapes on wildlife habitat, including effects of landscape configuration at the broad scale.

The Community Multi-scale Air Quality (CMAQ) model has been upgraded to incorporate detailed land use/ land cover/ land management influences, particularly for N. A bi-directional version of CMAQ will be used, in combination with an USDA-based Fertilizer Emission Scenario Tool for CMAQ (FEST-C), to estimate N flux to the atmosphere in response to land use and land management changes. A beta-version of FEST-C is expected in Sept. 2010.

Through a collaboration with Cesar Izaurralde at the University of Maryland, we are exploring the use of the DAYCENT model to estimate soil carbon storage, denitrification, N<sub>2</sub>O and CO<sub>2</sub>.

Decision Support Tool: A prototype is available for clients and was demonstrated through a webinar in February. We expect to work directly with clients to improve the accessibility of our research results and will be doing additional demonstrations and training on the use of the tool.

### **Coordination with Other ESRP Projects:**

Mapping: We are collaborating on assessment of broad-scale habitat configuration (using the Morphological Spatial Pattern Recognition software, GUIDOS), on approaches to model recreation demand, and on identification of rare habitat types for biodiversity sustainability. We are exploring linkage of the interactive atlas (that will be produced by Mapping) directly from the FML-EDT, and possibly use of the EDT framework to produce statistical summaries at the national scale.

Nitrogen: We will be coordinating on the comparative modeling of N-loading response to a set of conservation practices.

Albemarle-Pamlico Watershed System: Our use of the FRAMES model integration system is being patterned on, and coordinated with, ongoing work in the APWS.

### **Collaborators:**

EPA Region 7 is a research collaborator and has provided RARE funding to support the development of future scenarios.

We have a formal MOU with FSA to access data on the Conservation Reserve Program. Additionally FSA is contributing to landscape development and providing input to the EDT.

We are in the process of developing a data-sharing MOU with USDA's Economic Research Service to provide access to the Agricultural Resource Management Survey (ARMS) data.

The FWS is providing habitat modeling and input into landscape development and the EDT.

We are exploring the possibility of a cost-shared IAG with USDA ARS to improve water quality modeling at multiple scales.

We are working informally with Oak Ridge National Laboratory on the effects of the actions related to the biofuels supply chain on ecosystem services.

We are collaborating with the U of MD to estimate changes in soil productivity and greenhouse gas production.

We are collaborating informally with The Nature Conservancy Ecosystem Services group to identify rare and unique ecosystems and habitats that are valued because of their attributes. TNC is providing access to relevant data layers they have and has agreed to provide information for special queries we may have on these rare/unique systems. (Note this collaboration includes the National Mapping effort.)

### **Available Products/Publications:**

#### Products:

A detailed land cover/land use map is available that integrates data from the USDA NASS on cropland management and the Landfire database developed by USDA and TNC to map vegetation types. This map layer defines 200 land cover types compared to 14 land cover types provided by the NLCD.

A prototype web-based decision tool is available for review and preliminary analysis.

#### Publications:

Bash, J.O., J.T. Walker, G.G. Katul, M.R. Jones, E.Nemitz and W.P. Robarge, 2010. "Estimation of in-canopy ammonia sources and sinks in a fertilized *Zea mays* field," *Environ. Sci. Technol.*, 44:1683-1689.

Bruins, R.J.F., S.E. Franson, W. E. Foster, F.B. Daniel, P.B. Woodbury. 2009. A methodology for the preliminary scoping of future changes in ecosystem services: with an illustration from the Future Midwestern Landscapes Study. EPA/600/R-09/134. Office of Research and Development, U.S. Environmental Protection Agency. Washington, DC.

### **Upcoming Products/Publications:**

#### Products:

A detailed hypothetical multiple services landscape that includes an optimization of land management actions to sustain a suite of ecosystem services will be completed in 2011.

#### Publications:

Cooter, E.J., J.O. Bash, J.T. Walker, M.R. Jones and W. Robarge, (2010) "Estimation of NH<sub>3</sub> bi-directional flux from managed agricultural soils." *Accepted for publication in Atmospheric Environment.*

Gore, M., V. Aneja, R. Dennis, E. Cooter, J. Pleim (2010, planned.) Evaluation of the pilot implementation of bi-directional flux CMAQ for the Eastern U.S. during 2002.

Pleim, J., J. Bash, J. Walker and E. Cooter. (2010 planned.) Preliminary implementation of a bi-directional ammonia flux estimation approach in CMAQ.

Schwede, D. (2010, planned.) Impact of a mosaic approach to sub-grid variability estimation of dry deposition on ecosystem exposure.

Cooter, E.J., L. Ran and V. Benson. (2011, planned.) Description and demonstration of the Fertilizer Emission Scenario Tool for CMAQ (FEST-C).

Mehaffey, M., R. VanRemortal, E.R. Smith and R.J.F. Bruins (2011, submitted to IJGIS, currently in revision) Developing a dataset to assess ecosystem services in the Midwest, United States.

Mehaffey, M, E.R. Smith and R.J. F Bruins (2011 planned). A Landscape change scenario for 2020 biofuels demand in the Midwest, United States.

Rebecca S. Dodder, Amani Elobeid, Timothy L. Johnson, P. Ozge Kaplan, Lyubov A. Kurkalova, Silvia Secchi, Simla Tokgoz. Environmental impacts of emerging biomass feedstock markets: Energy, agriculture, and the farmer. Accepted for review at Environmental Science & Technology.

Smith and Bruins along with scientists from ORNL. The effects of biofuel production and distribution on ecosystem services (2011, planned). This review article will be featured in a special issue of Environmental Management.

Following a workshop in April 2010 in Madison, Wisconsin we will produce an article on Landscapes for conservation for the Midwest. Authorship will include Smith and Sander along with colleagues from the FWS and local universities. (2011, planned)