Ecosystem function and biodiversity in watersheds with contrasting annual-perennial plant community configurations

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INTRODUCTION

Important opportunities exist to improve the overall health and diversity of landscapes dominated by agriculture in the Midwest and downstream. Restoring native vegetation and modifying agricultural production systems to incorporate greater diversity may enhance the ecologic and socioeconomic functioning of these landscapes. This project will explore this assumption through an integrated watershed-scale approach that uses spatial models, field experimentation, and tradeoff assessments to quantify changes in ecological functioning resulting from different configurations of perennial and annual plants within an agricultural landscape. Integral to the project is the effective communication of project results in order to catalyze positive change on the landscape.

PROJECT OBJECTIVES

1) Quantifying the influence of different proportions and landscape configurations of annual (e.g., corn and soybean) and perennial (e.g., prairie, savanna, agroforestry) plant communities on the storage, cycling, and output of nutrients, water, and carbon at the field and catchment scale.

2) To promote greater understanding among diverse groups of people (i.e., the public, policy makers, farmers, environmentalists, etc.) that agroecosystem production and environmental stewardship may be compatible if appropriate combinations and configurations of perennial and annual plants are established.

HYPOTHESES

1) The placement of perennial plant communities at strategic locations and of appropriate spatial extent in a watershed will produce disproportionate improvements in **ecosystem functioning (e.g., water, nutrient and carbon cycling)** without compromising the social and economic viability of agroecosystems.

2) Small increases in perennial plant cover in watersheds dominated by annual crops will result in disproportionately large increases in **species richness and diversity** of major taxa (plants, animals, insects, microbes.).

STUDY SITE

The Neal Smith National Wildlife Refuge (NSNWR) is located in Prairie City, IA, and comprises part of the Walnut Creek Watershed (Figure 1). Since its creation in 1990, the primary management objective at the Refuge has been the reestablishment and maintenance of the historical landscape—including plant communities (e.g., prairie reconstruction, oak savanna restoration) and animal communities (e.g., reintroduction of bison and elk). In addition, the Refuge seeks to restore important disturbance processes such as fire.

Of the Refuge's current area of 4,343 acres, approximately 18% have been planted to native prairie, while 579 acres are still rented to local farmers (Figure 2). New land within the Refuge boundaries, which comprise 8000 acres total, continues to be purchased by the government when consensual agreements are reached.

APPROACH

This experiment is being implemented at three sites containing a total of 12 small watersheds (Figure 2). Watersheds were initially under brome grass, and the following treatments were established from Fall 2006-Spring 2007 (Figure 3):

Conventional Agriculture (CA): Two-year corn-soybean rotation, without tillage, and with standard herbicide- and fertilizer-based weed and nutrient management practices.

Mixed Annual-Perennial system (MAP): Patches and strips of perennial vegetation (native grasses and forbs) are incorporated into the conventional corn-soybean production system, using a combination of modeling and existing knowledge to predict the optimal watershed configuration.

Reconstructed Prairie (RP): Native grass and forb seed (obtained from existing prairie plantings at and near Neal Smith) have been sown. Sites will be maintained by mowing for 2 years, followed by prescribed burning every 2-3 years.

RESPONSE VARIABLES

Water cycling	Nutrient cycling	Carbon cycling	Biodiversity
Soil moisture	Soil physical & chemical properties	Soil carbon	Plant, bird, invertebrate diversity
Groundwater flux	Soil water nutrients	Soil respiration	Structure-function relationships
Infiltration	Plant nutrient uptake	Above- & belowground net primary production	Species colonization rates over time
Plant transpiration		Litter/root decomposition	Predator-prey interactions
Rooting dynamics			
Surface runoff			

EXPECTED OUTCOMES

- A demonstration site on the ecological functioning of alternative watershed designs established at NSNWR.
- Quantitative data obtained from the experimental catchments on nutrient, water, and carbon cycling under different annual-perennial plant configurations.
- Relationship between area of perennial cover and total plant species richness and diversity in agricultural landscapes.
- Calibration and validation of models for predicting watershed and plant community response to alternative agroecosystem designs.
- Educational and outreach activities: field days oriented towards policy-makers, farmers, the public; a permanent project display at the Neal Smith Learning Center; and an extension brochure with complementary road markers at the site.
- Network for research-policy linkages established to promote communication and information exchange between the research team and the public.

Figure 1. Location of Walnut Creek Watershed.

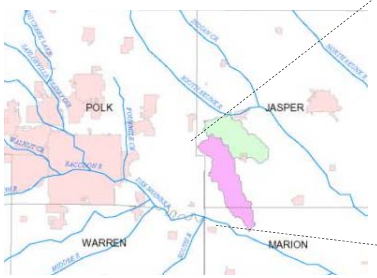
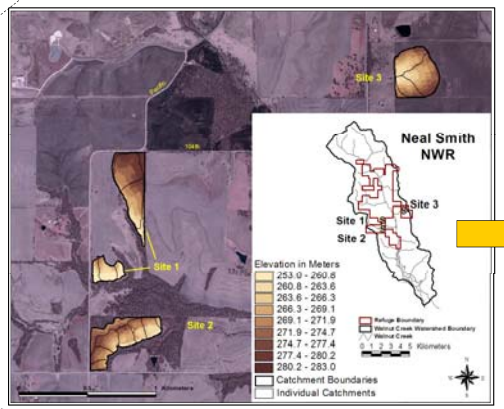


Figure 2. Neal Smith National Wildlife Refuge: Location of 12 experimental watersheds.



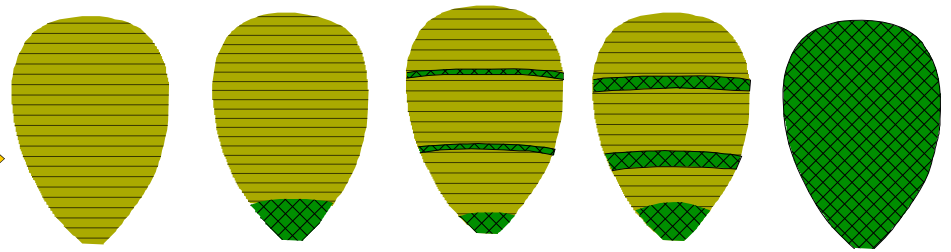


Figure 3. Design of experimental Watersheds = corn and bean row crops = perennial vegetation

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