Can conservation complement agriculture?

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Introduction

Agriculture will need to produce at least 70% more food by 2050 to ensure global food security (FAO 2009). However, increased productivity has historically come with on-farm and societal costs such as increased soil erosion and nutrient run-off. While conservation is often considered separate from the needs of agriculture, recent research at ISU suggests that targeted conservation practices can positively impact management of farm land, especially for preventing soil erosion and nutrient run-off. Long-term productivity and stability are already being realized through the implementation of conservation management techniques. Many farmers currently implement no-till and conservation tillage practices that help control erosion and run-off. These practices have been found to provide enhanced soil fertility and crop productivity (Lafond et al. 2008).

In order to have a conversation about the impacts of conservation practices on crop productivity and farmer and societal benefits, we need to establish a common language for the discussion. As is the usual case, this means the use of jargon that farmers, industry specialists, and academics are equally comfortable using. Two of the most important terms and their associated concepts are ecosystem services and multifunctional landscapes. Ecosystem services are goods and services provided to society by any landscape (www.csrees.usda.gov). For example, a first approximation of current farmland ecosystem services might be farm income; which in 2011 was $103.6 billion (ers.usda.gov). As large as this number is, there is room for improvement of the total value of ecosystem services provided.

Multifunctional landscapes are landscapes which are managed to provide multiple, distinct goods and services. For a multifunctional landscape, its total value is best described by the summation of all ecosystem services provided. In 1997, economists estimated the US$/ha/yr value of all land cover types (Costanza et al. 1997). Global cropland was estimated, on average, to provide $92/ha/yr. This included $52 for food production, $24 for biological control, and $14 for pollination services. Within this evaluation, several services were not evaluated, but could be provided by agricultural lands: gas regulation, erosion control, nutrient cycling, habitat, and recreation. Additional focus on these services has the potential to maintain or improve income, while enhancing other services such as preventing soil erosion and nutrient run-off.

Goals of conservation techniques

Increased productivity can result from on-farm service provisioning. Providing landscape elements that reduce runoff and erosion will protect topsoil and reduce future costs. Intensive rainstorms are especially detrimental to in-field soil and adjacent waterways, but researchers at ISU have found that narrow strips of prairie can prevent most soil loss even during intense rainstorms (STRIPs at Neal Smith). With just 10% of crop area converted to native prairie filter strips (PFS), surface runoff was reduced by as much as 50%, sediment export was reduced by more than 90% (e.g. from 22.5 down to 1 T ha^{-1} with 10% PFS). Nitrogen and phosphorous run-off were reduced by about 90% in years of heavy rains in fields using PFS.

Increased pollination is another service provided by small amounts of non-crop habitat. In the Costanza and colleagues (1997) paper, pollination services of croplands were estimated to be $14/ha/yr, and grassland/rangeland were approximately double that. Following this logic, of increased pollinator services in grassland plantings, researchers are examining the pollinator communities of prairie plantings and designing non-crop habitat to support native pollinators. Native bees are especially important, as they have been shown to be much more efficient than European honeybees for some crops (e.g. 80 times more efficient in apple orchards) (Vaughan et al. 2007, p. 8). The high floral diversity of a prairie strip provides resources and nesting habitat for these efficient pollinators. For any crop that benefits from pollination, planting small amounts of diverse prairie is likely to increase pollinator abundance, richness, and services.

Another target of conservation techniques is increased biocontrol, which can reduce input costs and ultimately improve local water quality. Researchers at ISU have found that field mice and crickets are proficient weed seed consumers, but do not attack planted crop seed. A study evaluating removal of weed seeds by these species found as much as

20% of seeds removed per day (Hartzler et al. 2007). Combined with additional crop rotation, and an associated boost to insect and mouse seed predators, farmers have in fact seen weed seedbank declines (Houghton 2005). This is supported by models, which predict weed seedbank decline with a 4-year rotation, 25% seed predation, and 80% less herbicide inputs (Hartzler et al. 2007). Current research at ISU is further evaluating how field mice respond to waste grain after harvest and the interaction with weed seed consumption (Danielson Lab). The mouse's potential for regulating invertebrate pests such as corn borer are also being evaluated.

Well-managed, non-crop habitat has the potential to provide multiple services. The STRIPs at Neal Smith Project has found that a single managed habitat type, small but strategic plantings of diverse prairies, can provide many of the most desirable ecosystem services. For example, in a highly erodible field, prairie plantings slow water flow, reducing soil erosion and soil loss. At the same time, reduced erosion and flow reduces nutrient runoff to streams. The diverse planting provides year-round habitat for beneficial insects; improving recolonization time by natural enemies when pest insects begin to attack crops, enhancing habitat for invertebrate weed seed predators, and improving the diversity and abundance of pollinators. The prairie strip is also habitat for native wildlife, which could be managed to provide recreational hunting or viewing opportunities. Accordingly, an agricultural field can be managed as a multifunctional landscape, providing diverse ecosystem services throughout the field. We refer to the multiple benefits from a single management practice as "stacking" of ecosystem services, analogous to stacking desirable traits in crop varieties. Recent evaluations suggest that farmers should be allowed to stack conservation credits, rewarding them for managing these diverse habitats (WRI 2009).

Summary

Multifunctional agricultural landscapes provide multiple ecosystem services to crop productivity and society. Managing for multiple ecosystem services throughout the field and in targeted non-crop habitat can provide greater independence, reduced costs, and enhanced productivity.

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