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Reimagining Farms as Managed Ecosystems

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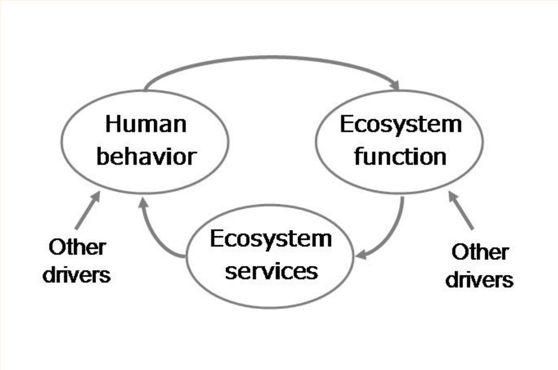
How scientists perceive people and nature to interact is changing. These changes will likely transform how we perceive farming. Along the way, they are reshaping the research agenda for agricultural and environmental economists. In short order, farmers will be faced with dramatically different management opportunities.

Farming began as a means to produce food more reliably than hunting and gathering. Over time, the scope of farming expanded to fiber and fuel crops. The historic focus on producing goods has led most farmers to view themselves as "producers." While this role will not change, new roles are becoming available as providers of more diverse ecosystem services than food, fiber and fuel.

Broadly speaking, "ecosystem services" are the valued services that people get from nature (Daily, 1997) (Figure 1). They encompass four broad areas (Millennium Ecosystem Assessment, 2005):

Figure 1. Ecosystem services link people and ecosystems



- Provisioning services include food, fiber, wood, fuel and fresh water that provide for human subsistence.
- Regulating services maintain the balance of the Earth's systems at levels that enable human survival. These services include climate, flood, water quality and disease regulation. Examples include vegetation that buffers the effects of natural flooding, or predator–prey systems that limit the spread of pathogens.
- Cultural services include the spiritual, inspirational, aesthetic, heritage, recreational and tourism benefits.
- Supporting services include the myriad natural systems that enable the three tiers above. For example, organic matter cycling contributes to soil creation, which makes food provisioning possible. Photosynthesis transforms solar energy into plant matter, enabling provisioning services, carbon cycling, and various other services.

The idea of ecosystem services transforms the way we think about nature in three ways. First, when viewed as a web of ecosystems, nature is no longer a background resource, but rather a system that can malfunction. Second, the idea of service flows implies a need to maintain the capital base that produces those services. Last, and most important, "ecosystem service" expresses a link between people and ecosystems whereby people enjoy benefits from ecosystems—but also influence their functioning.

Agriculture as Managed Ecosystem

From an ecological perspective, agriculture is an ecosystem that is frequently disturbed to favor desired products. Tillage and herbicides prevent competition from undesired weeds. Veterinary care and housing protect livestock from pathogens and predators. What ecologists call "human disturbance" agriculturalists call "management." But farmers who manage those ecosystems influence flows of many ecosystem services, whether they think about it or not. Herein lie opportunities for farmers and society at large, by perceiving the larger role of agricultural ecosystems. The opportunities are many, for crops and pasture already occupy roughly half the Earth's land area that is not barren rock, desert or permafrost (Millennium Ecosystem Assessment, 2005), and farmland is expanding.

New opportunities for farmers to manage for ecosystem services are emerging from recent research (Swinton, Lupi, Robertson and Landis, 2006). Two specific examples come from pest regulation and climate regulation.

Managing habitat for pollinators and the natural enemies of agricultural pests can enhance farm food, fiber and fuel production. Pollination and the regulation of pests and diseases are two natural ecosystem services. Like food production, they can be enhanced by management. While many farmers rely on the European honey bee for commercial pollination, native bees and other pollinators also play important roles (National Research Council, 2006). Habitat essentials typically involve a nearby landscape with suitable nesting sites and a sequence of flowering plants for food to keep the pollinators from migrating elsewhere. The natural enemies of agricultural pests have shown the ability to suppress potentially damaging populations of such invasive pests as soybean aphid. Their habitat needs are similar, though their food requirements are not.

Farming can play a major role in climate regulation, both by limiting emissions of greenhouse gases and by sequestering carbon in plants and soil (Robertson, 2004). Agriculture generates two particularly potent greenhouse gases. Methane, from rice paddies, manure and livestock digestion, has a global warming potential of 21 CO2 carbon equivalents. Nitrous oxide has over 300 times the global warming potential of CO2. It is generated by excess mineral nitrogen, particularly from heavily fertilized crop fields. More livestock waste management, fertilizer application and efficient machinery use can mitigate these ecosystem disservices. Sequestration of carbon into agricultural soils through no–till farming and production of biofuel crops that remove CO2 from the atmosphere as they grow can directly reduce global warming potential.

Other opportunities abound for farmers to manage for ecosystem services, from wildlife habitat to water quality to aesthetic landscapes.

Value of Ecosystem Services

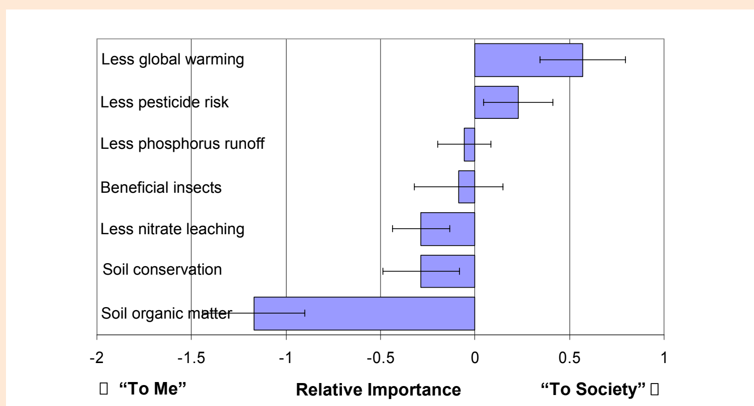
Why would farmers bother to provide ecosystem services that lack markets? To be sure, certain ecosystem services contribute to private profitability, but others do not. In 2007 focus group interviews, Michigan crop farmers identified increased soil organic matter as offering private benefits to their farms, but found reduced global warming to chiefly benefit society at large (Figure 2).

Of course, if there are clear benefits to society at large from ecosystem services that lack markets, then policymakers have justification to create incentives that stimulate more supply. In order to make such incentives operational, four steps are needed, 1) understand how humans can affect the production process for ecosystem services, 2) find cost–effective ways to measure those services, 3) estimate the value of ecosystem services to humans, and 4) design policies that fit both the environmental setting and existing legal institutions.

Agricultural ecosystems offer special opportunities to generate other ecosystem services as joint products along with food, fiber or fuel production (Wossink and Swinton, 2007). Hence, costs of providing joint ecosystem services can be much lower than if they were produced alone. Understanding how agricultural practices affect ecosystem functioning and generate ecosystem services is highly complex. For management purposes, performance indicators are needed that track high–priority ecosystem service in a cost–effective way across space and time (Dale and Polasky, 2007).

The valuation of ecosystem services that lack markets can be viewed from two perspectives: what consumers would be willing to pay for it, or what producers would be willing to accept to supply it. Many techniques exist to estimate consumer willingness to pay, including responses to questions about hypothetical purchases and calculations based on what consumers already spend. In the latter category, for example, expenses made to travel to a distant site for fishing or hiking can be used to estimate the value of the

Figure 2. Farmer ratings of the relative importance of the environmental benefits "to me" (negative) versus "to society" (positive), 34 Michigan farmers, 2007. (Likert scale paired difference t–test error bars = 1 std error).



fishery or the aesthetic ecosystem services. Land prices can be analyzed to infer the values of ecosystem services in the vicinity. Producers' willingness to accept payment in exchange for providing ecosystem services can be estimated from the implied costs due to changes in farming costs and foregone crop revenues. Because farm locations vary in potential commercial productivity and potential abundance of ecosystem services, farmers' willingness to supply ecosystem services will vary from place to place (Antle and Valdivia, 2006). These methods are discussed in greater detail in a recent special section of the journal, Ecological Economics, devoted to the topic, "Ecosystem Services and Agriculture" (Swinton, Lupi, Robertson and Hamilton, 2007).

Incentives for Farmers to Provide Ecosystem Services

If we understand how ecosystem services are produced, how to measure them, and what they are worth to consumers and producers, then incentives for their provision can be designed. Incentive programs can be divided between government programs and private sector ones. U.S. farm policy has a history of cost–share support for clearly observable practices, such as soil conservation investments, and land retirement policies, such as the Conservation Reserve Program. In the 2002 farm bill, the Conservation Security Program created payments for environmental stewardship.

Private sector activities include business–to–business payments and markets for pollution credits (Kroeger and Casey, 2007). One rapidly developing example of a market for pollution credits is the global carbon market. The Chicago Climate Exchange has developed rules for buying "carbon management offsets" from U.S. farmers whose use of reduced tillage practices can sequester atmospheric carbon in soil (Chicago Climate Exchange (CCX), 2007). Payment levels are very modest at present ($2–3/acre/year for 5–year commitments on the most productive lands). Related offset payments are available for livestock farmers who collect and burn methane, so that it is not released into the atmosphere. If international agreements to limit global warming become more binding—especially if the United States joins in—then opportunities for farmers to profit by providing climate regulation services are likely to grow in number and value.

Business–to–business payments for environmental services are also developing, particularly linked to water markets (Pagiola, Bishop and Landell–Mills, 2002). In most successful programs, such payments have compensated farmers or foresters for maintaining vegetative cover so as to protect drinking water supplies. More recent efforts are underway to pay for more diverse ecosystem services, such as biodiversity and soil conservation.

Biodiversity conservation is particularly challenging for policy design, because it often calls for coordinated action among multiple landowners. Many large mammals and migratory species require contiguous habitat over large areas. Recent research involving experimental games has shown that land owners can rapidly learn to cooperate if offered policy incentives that favor cooperating by agglomerating contiguous habitat (Parkhurst and Shogren, 2007).

Demand for Research on Economics of Ecosystem Services

Because so many ecosystem services have intrinsic value yet lack markets, scientists and policy makers are keen to see economic measures of their value. The twin challenges of lucid communication and sound economic methodology are formidable. Scientists and policy makers would like clear numbers, while economists want to explain that "it depends" on various parameters. Can economists meet these twin challenges? Ecosystem services pose broad, complex valuation problems, but the benefit transfer literature has progressed impressively in recent years (Wilson and Hoehn, 2006).

Research opportunities on the economics of ecosystem services are proliferating. A growing consensus among science research administrators seeks to fill a perceived void in research efforts on multidisciplinary problems, notably those associated with global change. The National Science Foundation has just converted a temporary initiative into a permanent program in Coupled Natural and Human Systems—its first such multidisciplinary program. It is currently evaluating follow–on ideas for its successful initiative in Human and Social Dynamics. New opportunities in these areas involve multidisciplinary teams, especially focused on socioecological research.

Rethinking farming as ecosystem management offers fresh and promising ways to imagine contributions from agriculture. Agriculture's history as a managed ecosystem and its scale, coupled with society's growing needs for a broad mix of ecosystem services, create a formidable research and policy agenda. That agenda calls for multidisciplinary research into how farmers can produce a wider range of ecosystem services, what those services are worth, and what policy designs could effectively induce more such services to be provided. Successful answers will capitalize on the unique productive potentials of diverse ecosystems using incentives tailored to fit farmers' objectives, resources and property rights. The challenge is great, the rewards as well.

For More Information

Antle, J.M., & Valdivia, R. (2006). Modeling the supply of ecosystem services from agriculture: a minimum data approach. Australian Journal of Agricultural and Resource Economics 50(1),1–15.

Chicago Climate Exchange (CCX). (2007). Soil carbon management offsets. Available online: http://www.chicagoclimatex.com/docs/offsets/CCX_Soil_Carbon_Offsets.pdf.

Daily, G., ed. 1997. Nature's services. Washington, DC: Island Press.

Dale, V.H., & Polasky, S. (2007). Measures of the effects of agricultural practices on ecosystem services. Ecological Economics 64(2), 286–296.

Kroeger, T., & Casey, F. (2007). An assessment of market–based approaches to providing ecosystem services on agricultural lands. Ecological Economics 64(2), 321–332.

Millennium Ecosystem Assessment. (2005). Ecosystems and human well–being: synthesis. Washington, DC: Island Press.

National Research Council. (2006). Status of pollinators in North America. Washington, DC: National Academies Press.

Pagiola, S., Bishop, J. & Landell–Mills, N., eds. (2002). Selling forest environmental services: marked–based mechanisms for conservation and development. London: Earthscan.

Parkhurst, G.M., & Shogren, J.F. (2007). Spatial incentives to coordinate contiguous habitat. Ecological Economics 64(2), 344–355.

Robertson, G.P. (2004). Abatement of nitrous oxide, methane and other non–CO2 greenhouse gases: the need for a systems approach." In Field, C.B. & Rapauch, M.R., eds., The global carbon cycle. Washington, DC: Island Press, pp. 493–506.

Swinton, S.M., Lupi, F., Robertson, G.P. & Hamilton, S.K. (2007). Ecosystem services and agriculture: cultivating agricultural ecosystems for diverse benefits. Ecological Economics 64(2), 245–252.

Swinton, S.M., Lupi, F., Robertson, G.P. & Landis, D.A. (2006). Ecosystem services from agriculture: looking beyond the usual suspects. American Journal of Agricultural Economics 88(5), 1160–1166.

Wilson, M.A., & Hoehn, J. P. (2006). Valuing environmental goods and services using benefit transfer: the state–of–the art and science. Ecological Economics 60(2), 335–342.

Wossink, A., & Swinton, S.M. (2007). Jointness in production and farmers' willingness to supply non–marketed ecosystem services. Ecological Economics 64(2), 297–304.

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