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How to build multifunctional agricultural landscapes in the U.S. Corn Belt: Add perennials and partnerships

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Abstract

Conservation of ecosystem services in agricultural regions worldwide is foundational to, but often perceived to be in competition with, other societal outcomes, including food and energy production and thriving rural communities. To address this tension, we engaged regional leaders in agriculture, conservation, and policy from the state of Iowa (USA) in a participatory workshop and follow-up interviews. Our goal was to determine constraints to, and leverage points for, broad-scale implementation of practices that use perennial vegetation to bolster ecosystem services in agricultural landscapes. Qualitative analysis of workshop and interview data highlighted the complexity involved in achieving multi-objective societal outcomes across privately owned, working landscapes—especially as the Corn Belt region enters a period of rapid reorganization driven by the demand for bioenergy crops. These leaders indicated that initiatives focusing on perennials have the potential to span differences between conservation and agricultural interests by blurring the distinction between working lands and protected areas. Landscape change that transcends private property boundaries to accomplish this goal is dependent upon: (1) facilitation of vertical and horizontal forms of social capital between social actors from different scales and perspectives, and (2) scale appropriate mechanisms that increase the value of perennial practices for farm owners and operators. Our data highlight the adaptive capacity of regional actors to act as intermediaries to shape macro-scale markets, technologies, and policies in ways that are compatible with the needs, the capabilities, and the conservation of local human and natural resources.

Keywords

complexity, ecosystem services, participatory, policy, social capital, scale

Disciplines

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Comments

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How to build multifunctional agricultural landscapes in the U.S. Corn Belt: Add perennials and partnerships

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A B S T R A C T

Conservation of ecosystem services in agricultural regions worldwide is foundational to, but often perceived to be in competition with, other societal outcomes, including food and energy production and thriving rural communities. To address this tension, we engaged regional leaders in agriculture, conservation, and policy from the state of Iowa (USA) in a participatory workshop and follow-up interviews. Our goal was to determine constraints to, and leverage points for, broad-scale implementation of practices that use perennial vegetation to bolster ecosystem services in agricultural landscapes. Qualitative analysis of workshop and interview data highlighted the complexity involved in achieving multi-objective societal outcomes across privately owned, working landscapes—especially as the Corn Belt region enters a period of rapid reorganization driven by the demand for bioenergy crops. These leaders indicated that initiatives focusing on perennials have the potential to span differences between conservation and agricultural interests by blurring the distinction between working lands and protected areas. Landscape change that transcends private property boundaries to accomplish this goal is dependent upon: (1) facilitation of vertical and horizontal forms of social capital between social actors from different scales and perspectives, and (2) scale appropriate mechanisms that increase the value of perennial practices for farm owners and operators. Our data highlight the adaptive capacity of regional actors to act as intermediaries to shape macro-scale markets, technologies, and policies in ways that are compatible with the needs, the capabilities, and the conservation of local human and natural resources.

Introduction

New crop markets associated with the production of biofuel stocks are driving land use change in agro ecosystems worldwide (Fargione et al., 2008; Field et al., 2008). These changes raise social and environmental concerns about how the appropriation of agricultural resources for biofuel production will effect food supplies, land clearing, loss of biodiversity, and carbon debt (Jordan et al., 2007; Groom et al., 2008; Robertson et al., 2008). Maintenance of ecosystem services and societal goods in the midst of this period of reorganization is dependent upon responsive policies that mediate the drivers and outcomes of land use at broad landscape scales. Because arable agricultural landscapes are often privately owned and operated, landscape-scale change is the product of an amalgamation of decisions by individual actors, which are in turn influenced by local social norms and networks, and macro-level markets, technologies, and policies (McCown, 2005; Atwell et al., 2009b). These policies will be driven not only by economic efficiency and ecological science, but also by social, technological, and political trajectories that are providing strong positive reinforcement of reinforcing production pathways and markets for biofuels presently made from monoculture crops such as corn-based ethanol (Carolan, 2009). Development of policies that bridge micro- and macro-level forces, and alter socio-techno-political trajectories, to protect landscape-scale outcomes is a recognized challenge in agricultural regions (Mattison and Norris, 2005; McCown, 2005).

Resilience science is an emerging approach to understanding and influencing processes of change in complex, multi-scale natural resource management systems (Gunderson and Holling, 2002; Folke et al., 2004; Walker et al., 2006). While it can be expedient to define and analyze ecological and social systems separately, resilience scientists use the term "social-ecological system" to emphasize that they are in fact linked and that such delineation is artificial and arbitrary (Berkes et al., 2003). Resilience science has received widespread attention and application among scientists and practitioners from diverse fields (Carpenter and Folke, 2006;

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Liu et al., 2007), but has not been widely implemented in regions dominated by intensive agricultural production and autonomous private property rights, such as the U.S. Corn Belt.

The term "resilience" was applied to ecological systems by Holling (1973) and refers to the ability of dynamic systems to respond to perturbations and maintain their essential configuration. Resilience is not a normative term; system configurations characterized as resilient may be either desirable or undesirable. In particular, resilience theorists are interested in understanding where resilience, adaptive capacity, and the potential for innovation reside in linked social-ecological systems and how these attributes can be gained, lost, or preserved (Walker et al., 2002). Because human values, perspectives, and collective decisions are fundamental in determining the structure, function, and desirability of social-ecological systems, resilience analyses emphasize the integration of stakeholders and policy makers in scientific and decision-making processes (Gunderson and Holling, 2002; Walker et al., 2002; Berkes et al., 2003; Allison and Hobbes, 2004, 2006).

Much of the research applying resilience theory to natural resource dilemmas has investigated how institutions and policies can bolster desired characteristics in regions with focal common pool resources and/or less autonomous private property rights than those found in the Corn Belt (e.g., developing nations; Lejano et al., 2007), fisheries (Olsson et al., 2004; Armitage et al., 2007), and regions with high proportions of government-owned land or collectively managed resources (Berkes et al., 2003; Lebel et al., 2006). One study which analyzed resilience in the Western Australian Wheat Belt, a region dominated by private land ownership and high agricultural production, found that the land use decisions of farmers were collectively driven by macro-scale markets, technologies, and institutions—forces which influenced, but were not influenced by, regionally specific factors such as population decline, environmental pollution, and resource depletion (Allison and Hobbes, 2004, 2006). This resulted in a resilient, but undesirable, system configuration (referred to as the lock-in trap) maintained by highly connected institutions and policies focused on facilitating commodity production.

Few mechanisms existed in the Western Australian agricultural system that could leverage change in response to regional social and ecological decline. For instance, rising water tables and salinization driven by land clearing for agriculture led to irreversible resource degradation, including lack of crop production, on upwards of 16% of the region's cropland. This loss of cropland coupled with decreased crop prices, higher input costs, and lower farmer profit margin, lead to increased demand for production on other lands. But because of the high degree of "sunk costs" invested in the current system trajectory, Allison and Hobbes (2004, 2006) found this system to be stuck in a trap with little potential for change. Based on their perception that regional social actors had little control over the macro-scale drivers of this system, Allison and Hobbes (2004, 2006) did not include stakeholder input in the process of resilience analysis.

In comparison to the Western Australian Wheat Belt, agricultural production systems in the U.S. Corn Belt are shaped by similar macro-level markets, technologies, and policies aimed at boosting commodity production, and are experiencing similarly complex social and ecological challenges (EWG, 2006; Keeney and Kemp, 2002). From 1950 to 2002, the portion of agricultural revenue returned to farmers decreased from 37% to 19%, while farm input costs increased sevenfold and the real price of corn (adjusted for inflation) decreased fivefold (Duffy, 2006). During this same time period land holdings have been consolidated into fewer larger farms, more land has been devoted to row crop production, average farmer age has increased, and rural population, numbers of young farmers, and social vitality have steadily decreased (USDA_NASS, 2002; Duffy, 2006). Regional increase in row crop production and loss of land in perennial cover has been associated with declines in biodiversity and flood control (Schulte et al., 2006, 2008), and has been implicated as the primary driver of nitrate export from the region's rivers (Hatfield et al., 2008), which is in turn a key driver of the growing hypoxic dead zone in the Gulf of Mexico (EPA_Science_Advisory_Board, 2007).

Despite these social and ecological deficits, and in contrast to the commodity production system in Western Australia, Corn Belt agroecosystems remain highly efficient at producing commodity crops and their derivatives. Corn and soybean yields have continued to increase over the last 50 years despite market consolidation and reorganization, dramatic changes in land tenure, pest outbreaks, and climactic variation (Duffy, 2006). This resilience in regional commodity production is a result of the Corn Belt's amenable natural resources, which include a temperate climate and deep glacial soils. The region also possesses a highly connected socioeconomic system, bolstered by large-scale equipment and practices, hybrid and genetically modified seed technologies, and external inputs of fertilizers, pesticides, herbicides, and government subsidies. The U.S. Corn Belt appears to be stuck in a trap different than that found in the Western Australian Wheat Belt. In this type of trap, which has been referred to as the rigidity trap by resilience theorists (Gunderson and Holling, 2002; Allison and Hobbes, 2004; Atwell et al., 2009b), the high adaptive potential and connectedness of social actors makes it possible to continue to invest in the current way of doing agriculture, in spite of the mounting social and ecological deficits and economic inefficiencies (Harvey, 2004), associated with this trajectory. Another body of research associated with this trajectory.

Currently, the amount of land taken out of production for conservation purposes (e.g., land enrolled in the Conservation Reserve Program) in the Corn Belt is decreasing and land in row crops is increasing in response to markets for corn-based ethanol (Secchi et al., 2008). Despite continued regional investment in high-yield commodity production, recent research highlights a growing concern among Corn Belt residents about the impacts of the emerging bioenergy economy on the environment, natural resources, and the long-term sustainability of rural landscapes (Hinkamp et al., 2007). One strategy to bolster social and ecological resilience of the Corn Belt system while maintaining agricultural profitability involves implementing networks of perennial vegetation across key portions of the landscape. Initial research suggests that strategically positioned perennial land cover (e.g., diverse crop rotations, pasture, riparian buffers, restored wetlands) on relatively small areas of the Corn Belt landscape has the potential to bolster regional water quality, biodiversity, and aesthetics (Schulte et al., 2006; Nassauer et al., 2007; Schulte et al., 2008). While studies of certain watersheds have shown that rural Corn Belt stakeholders voice tentative approval of some perennial conservation practices (Nassauer et al., 2007; Atwell et al., 2009a), these practices are neither well-integrated into rural culture (Atwell et al., 2009a), nor supported by regional policies or production systems (Atwell et al., 2009b), and rural people voiced little sense of efficacy to bring about broad-based change in their landscapes or institutions (Atwell et al., 2009a).

To address these challenges, we engaged Corn Belt leaders in agriculture, environment, and policy in a participatory workshop with the following objectives: (1) understand sources of adaptive capacity, innovation, and resilience in Corn Belt social-ecological systems, including the policy potential for perennial conservation practices, and (2) identify key roadblocks and leverage points (Meadows, 1999) to maintaining biodiversity, ecosystem services, and societal goods in the midst of the emerging bioeconomy. Because of its participatory nature, this research has the potential

Table 1
Workshop participants included the following entities.

Agricultural non-profit groups
Iowa Farm Bureau: Commodity Director
Iowa Farm Bureau: Director of Environmental Affairs
Iowa Soybean Association: Director of Environmental Programs
Practical Farmers of Iowa: Crop Consultant and Program Specialist
Business
Hertz Farm Management: Accredited Farm Manager and Agricultural Consultant
Conservation non-profit groups
Iowa Natural Heritage Foundation: Director
Iowa Natural Heritage Foundation: Public Policy Consultant
The Nature Conservancy: Agricultural Watershed Director, Upper Mississippi River Basin Initiative
Government
Iowa Department of Natural Resources: Director
Iowa Department of Agriculture and Land Stewardship: Iowa Secretary of Agriculture
Iowa Office of Energy Independence: Director
Natural Resource Conservation Service, U.S. Department of Agriculture: Assistant State Conservationist for Water Resources
Hamilton County Conservation Board: Former Director
Iowa office of U.S. Senator Tom Harkin; Agricultural Advisor,

Table 2
Workshop questions included the following.

(1)	Based on your experience, consider what policies, practices, and programs are working particularly well right now in the Corn Belt to bolster (a) water quality, (b) biodiversity, and (c) rural community vitality?
(2)	What are the greatest roadblocks that may hinder (a) water quality, (b) biodiversity, and (c) rural community vitality?
(3)	In the midst of the emerging biofuel economy, what do you see as some of the key opportunities for (a) water quality, (b) biodiversity, and (c) rural community vitality?

to impact regional policy and provide insights into the unique challenges faced by conservation initiatives that work across privately owned, agricultural landscapes.

Methods

Our research was conducted in Iowa, a state situated in the center of the U.S. Corn Belt and the only state that lies entirely within this agroecoregion. While Iowa contains several distinct geological formations supporting diverse native habitats (e.g., prairies, wetlands, savannahs, and woodlands), upwards of 90% of its land area is farmed, with 63% of its land planted in row crop corn and soybeans (USDA_NASS, 2002). Agricultural practices in Iowa are representative of those across the Corn Belt as a whole.

Using strategic sampling (Neuman, 2003) with assistance from agency and non-profit partners, we selected key leaders in agriculture, conservation, and policy in the state of Iowa as workshop participants. These leaders encompassed the breadth of perspectives that influence state-level land use decisions, and they each held top positions in groups that play pivotal roles in these decisions (Table 1). Participants were also selected because each had demonstrated a personal ability to engage in thoughtful, creative, and constructive dialogue. Sixteen of the 17 leaders invited agreed to participate, but two state senators were unable to attend the workshop due to an extended committee meeting. The remaining 14 invitees participated in the workshop.

Two of these leaders were women; 12 were men. Participants ranged in age from 28 to 62, with an average age of 50. Thirteen had graduated from four-year universities and seven held graduate degrees. On average, workshop invitees had been working on agricultural or conservation policy issues for 24 years. Ten of these leaders had spent time farming and six currently owned and operated farmland. Eleven had lived in rural areas for at least 18 years.

Upon arrival, participants filled out a questionnaire that probed individual perspectives on agricultural land use change. A brief presentation was given to provide background and a common starting point. This presentation highlighted the results of a companion study investigating the perspectives of rural Iowa stakeholders on land use change and perennial conservation strategies (Atwell et al., 2009a,b). Following this presentation, we facilitated a dialogue centered on three questions related to current and future land use, institutions, and policies in Iowa (Table 2). The discussion lasted for two and a half hours, during which we routinely encouraged participants toward creativity, vision, frankness, and the inclusion of diverse perspectives. The workshop closed with an opportunity for each participant to share final comments and observations.

The discussion was recorded using audio and visual media, but anonymity of participants' comments in research reports was guaranteed to foster a candid dialogue. A transcript of workshop proceedings was imported into the NVivo7 data management and analysis software package (QSR, 2006). This transcript, along with participant questionnaires and notes taken during the workshop by our research team, became our primary data. The lead author coded these data into descriptive and analytic categories using a qualitative approach (Miles and Huberman, 1994; Neuman, 2003). Coded portions of interview data were used to determine the main workshop themes (Ryan and Bernard, 2003). While nearly all emerging themes were characterized by recurring agreement or disagreement among workshop participants, themes were also identified by comparing similarities and dissimilarities in the data, by looking at the use of key phrases, metaphors, and stories, and by organizing coded data into different categorical and hierarchical groupings (nodes) and analyzing the relationship between these groupings (node tree).

All authors were present at the workshop and worked together to probe the strength, connectedness, and nuances of these themes and to ensure that analysis was consistent, valid, and confirmable. After preliminary rounds of analysis, we presented brief descriptions of emerging workshop themes and the relationships among these themes to our workshop participants in individual interviews. The aim of these interviews was both to document their feedback – including reactions, critiques, affirmations, and additions – and to give workshop participants a further sense of ownership over the workshop proceedings and the data analysis process. Data from these interviews was coded and incorporated into further thematic development. These interviews added clarifications, caveats, and rich examples to our data set. However, workshop participants generally affirmed our preliminary data analysis and the essence of major themes remained the same after analysis of interviews. Final rounds of analysis were used to scrutinize how the data reinforced or contradicted themes and with what caveats, as well as how themes were related to one another, to study questions, and to theoretical considerations. Here the text searching, sorting, and crosstab capabilities of the NVivo7 software were used to analyze how parts of interview text assigned to different codes related to one another, to emerging themes, and to various attributes of our participants' backgrounds (QSR, 2006). All of our methods were designed and conducted following IRB requirements for research with human subjects.

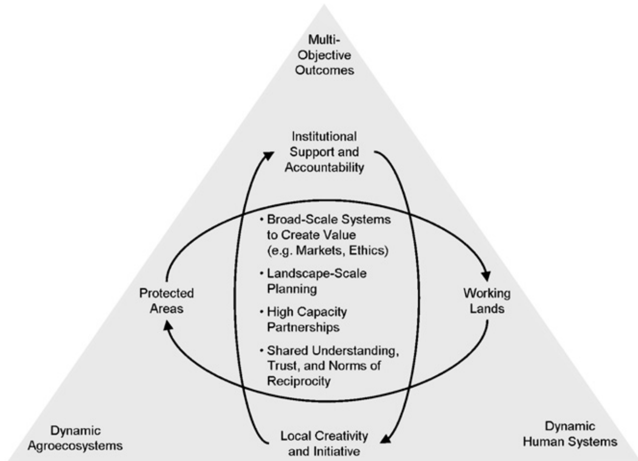

Fig. 1. Relationships among the themes that emerged through qualitative analysis of workshop and interview data. The grey triangle represents the complex social-ecological context in which agroecosystem practices are implemented and evaluated in the U.S. Corn Belt; at the triangle's corners lie three themes highlighting aspects of this complexity emphasized by regional leaders. These leaders also developed strategies to realize desired societal outcomes in the midst of this complexity: the arrows represent two bridges that must be built between or within themes to bolster long-term resilience of desired agroecosystem outcomes and the four center bullet points are focal strategies to build these bridges.

Results

Analysis of workshop data shows that regional leaders from diverse agricultural, conservation, and policy perspectives exhibited thoughtful consideration of, and enthusiasm towards, strategies that use spatially targeted perennial practices to achieve ecological and social outcomes in the midst of the emerging bioeconomy. Ten themes emerged through data analysis that summarize the most consistently and strongly voiced dimensions of this dialogue (Fig. 1). We present these themes below in two groups; three themes describe challenges to effective initiatives, while seven describe potential leverage points for reconfiguring Corn Belt systems.

Challenges: dealing with complexity

Our workshop participants agreed that the greatest challenge to the broad-scale implementation of perennial practices, and to agricultural conservation initiatives in general, lies in the complex nature of the Corn Belt system. In the words of one participant: "We have an incredibly incomplete understanding of systems. And that gets in our way all the time." The complexity described by the leaders with whom we worked can be summarized by three interrelated themes that emerged from data analysis: dynamic agroecosystems, dynamic human systems, and multi-objective outcomes.

Dynamic agroecosystems

> *On water quality and non-point source [pollution] issues, we have a lot yet to learn. These are complex interactions... We have new knowledge that has to be gained, and people have to be invested in [acquiring that knowledge].*

While research and technological development in both agriculture and ecology were seen as proceeding at a rapid pace in the Corn Belt, there was a frustration that these disciplines experience little cross-pollination within industry, academia, and society. Our participants recognized that, to bolster biodiversity and ecosystem services while meeting agricultural production goals, it was necessary to actively manage landscape pattern and hydrologic variables that transcend individual farmers' fields and private property boundaries. While several participants emphasized that understanding of how agronomic and ecological variables interact to produce general outcomes at certain scales is growing, these interactions and outcomes hinge upon many contingencies unique to particular places and scales. Current scientific understanding of watershed and species responses to landscape patterns was seen as greatly limited by lack of large-scale, long-term adaptive management projects that manipulate landscapes and monitor ecological outcomes.

Dynamic human systems

> *We have to create mechanisms that are flexible... We've had the same kind of scenario for the last dozens and dozens and dozens of years, and now it is all of a sudden upside down... We need things that can survive a landscape that we can't even predict what it's going to be.*

Like the agroecosystems they influence, our workshop participants emphasized that people systems in the Corn Belt – including rural demographics and culture, economic markets, technological developments, political alliances and personalities, and relationships between multi-level partners – were also changing rapidly in ways that were difficult predict ahead of time. Our participants perceived that to manage these different system components to produce congruent outcomes was extremely difficult given the discrepancies in their different modes of operation, methods of analysis, and units of measurement. Workshop participants also indicated that the playing field involved in natural resource management was constantly changing. The emerging biofuel economy was seen as ushering in a time of extreme uncertainty in which future cropping systems and landscape patterns would change a great deal in the next 5–25 years, driven by new markets and technologies. In addition, rural culture and demographics, and state and federal agricultural and environmental politics were recognized to be in a state of flux. Like ecological variables, cultural and political variables were seen as dictated by both measurable trends as well as particularities unique to the times, places, people, and partnerships involved.

Multi-objective outcomes

> *In the Boone River watershed, there are stakeholders involved in the watershed planning process and we're looking, not only at water quality, but at economic and community development, as well as biodiversity. And it's because of who's at the table that those issues remain important. You can build strategies that are compatible, but it occurs when you are doing the planning. And you have to have pretty high capacity people to be able to develop a plan that provides multi-objective outcomes.*

Workshop participants expressed differing views on the ultimate objective of perennial practices that were implemented for conservation purposes, including improvement of surface water quality, biodiversity, flood control, soil health, carbon sequestration, marketable cropping systems, recreational opportunities, and rural aesthetics, economies, and social vitality. The need to build policy to address these multi-objective outcomes was recognized. Such initiatives were seen as different from past programs that focused on only one outcome (e.g., soil conservation). It was recognized that attempts to simultaneously achieve multiple objectives will further increase the complexity of initiatives. When addressing this multiplicative complexity, robust science was viewed as a critical component of the systems approach advocated by participants, but the incorporation of multiple stakeholder perspectives (e.g., farm owners and operators, rural residents, agricultural and conservation interest groups) was seen as having equal or greater importance.

Leverage points: bridging system boundaries

Workshop participants indicated that the potential to achieve multi-objective outcomes in complex, changing systems hinged upon linking key components that are often disconnected in current system configurations. Seven themes describe leverage points (Meadows, 1999) at which regional social actors might intervene to alter the current system trajectory and to achieve desired outcomes.

Integrating working lands and protected areas

We've got a political system that relies on philanthropy to support conservation right now... And one of the problems of perennials is the primary focus has been on non-working lands; it's been on land retirement or land preservation...There is a lot of potential for working lands perennials, but you have to unleash the economic activity of perennials

In the current system, conservation was seen as being based primarily on programs that removed land from agricultural production (e.g., Conservation Reserve Program), thus greatly restricting the types of use and profit that could be derived from this land. As a result, perennial set-aside lands were rarely implemented broadly or strategically enough to achieve landscape-scale conservation objectives. It was recognized that government financial incentives to keep agricultural land out of production as part of conservation programs could not compete with the rising value of crops for bioenergy stocks. Some participants also argued that conservation set-aside programs competed with ecologically sustainable industries, such as rotational grazing, causing decline in these markets. Because of the variety of perennial practices with both agronomic and ecological benefits, conservation strategies that focused on perennial vegetation were seen as having the potential to bridge working areas and protected lands, as well as a perceived cultural divide between struggling rural agricultural communities and urban environmentalists.

Building broad-scale value

My challenge is to ask, 'how do you get value out of perennials?' If you can answer that question, everything else will fall into line. The answer, from my perspective, is scale. You must be able to increase the scale and volume of production systems in order to get value out of perennials.

To be broadly implemented, perennial practices have to be able to add value to desired societal outcomes. The form of value most strongly emphasized was economic sustainability for rural stakeholders and communities. Many participants gave examples of current or potential markets that could create value for perennial practices at broad scales. These included: increasing use of the countryside by wildlife, recreation, and tourism industries; pasture and grazing as ecological management tools; and investment in alternative biofuel stocks such as diverse prairie and woody crops. Several of the ideas proposed emphasized recognizing, utilizing, and/or transforming extant aspects of the current system to encourage multiple uses of land for both agricultural and conservation benefit. For instance, riparian buffers and highly erodible land could be planted to a diverse forage mixture that could generate economic value through rotational grazing, harvest for perennial biomass, hunting rights, or carbon credits. It was recognized that, for new markets to be available to farmers and broadly utilized, they must be catalyzed by attendant policies, technologies, and infrastructures at appropriate scales. For instance, growing a diverse prairie mixture for ethanol production would require changes in current government subsidy systems, refinement of production technologies, adoption of these technologies by regional refineries, and new infrastructure to move the crop from fields to refineries. In addition to economic sustainability, participants also suggested the potential to increase valuation of conservation practices through facilitation of socially normative ethical dialogue among different groups of resource users; churches and other civic organizations could facilitate this dialog.

Landscape planning

We've had a proliferation of incentive programs without a demand for a corresponding kind of multi-farm or watershed planning. The mandate has been to spend the money with individual farms doing individual practices... That's called "random acts of conservation."

Landscape planning was seen as essential to overcome the lack of societal benefits associated with programs and practices that focused on individually owned or operated farms. This planning involved targeting land uses and cover types to the most suitable locations, thereby achieving agronomic and ecological goals based on soil patterns, topography, and hydrology. Social landscape assessment was also viewed as a necessary complement to biophysical planning—the goals, perspectives, and value systems of the primary decision maker(s) on any given piece of land as well as the social, cultural, economic, and political dynamics within a watershed or community must be understood and considered. Dialogue among regional leaders on how to best span private property boundaries and coordinate management across landscapes highlighted the need for an important link in the system described by the next two themes: local creativity and initiative must be empowered by regional goals, support, monitoring, and accountability.

Local creativity and initiative

If you could cut through it all and say, "this watershed, we're giving a block grant to... And we're going to hold you accountable to some kind of outcome, but we're not going to hold you to a specific program," and let the creative juices flow. Let people solve this problem. We're not allowing them to solve the problem because we're saying you have to fit the tools that we've got; we have a limited tool box and some of them are broken.

When asked what strategies were currently working to meet multi-objective conservation goals in Iowa agroecosystems, the first leader to respond characterized much of the subsequent discussion: "I think some of the best examples of things that are working well are pretty localized." That successful strategies were driven to a large extent by local initiative was a theme voiced by several workshop participants with no disagreement (but with the caveats of accountability and partnership discussed below). The participant quoted above went on to explain a widely agreed upon assertion: that conservation initiatives were successful when local "stake," or ownership, was coupled with careful planning by a consortium of key interests.

Empowering local initiatives was voiced as important for several reasons. Creative and novel solutions were seen as arising from grassroots efforts because local people had an intimate knowledge of the systems in which they lived and worked. It was also pointed out that societal objectives were often resisted when groups felt that external entities were pressuring private individuals to provide public goods, while not providing adequate compensation for them to do so. External control was associated with bureaucratic inefficiencies, lack of attendant local benefits, and little understanding of, and appreciation for, the values and realities that underlie local livelihoods.

Institutional support and accountability

> *[Performance-based incentives] are a good and a viable principle. I think the key of making performance-based incentives work, though, is good science and good metrics. Because to say, "let the local group decide what they want to do," well that's fine, but if it's simply cosmetic or if it's simply, "they're kidding themselves," then you really haven't gained anything.*

Local control was not viewed as a panacea; strong institutions were seen as its necessary complement. Our workshop participants emphasized that local control must include careful planning, organization, empowerment, and feedback across and among multiple organizational levels. Many participants emphasized the need for regional institutions to augment local initiatives in several ways including scientific monitoring, financial support, technical support, and collective goals and vision. Participants agreed that increased investigation of how land use practices affected ecological outcomes was needed. Progress implementing this type of monitoring was impeded by debate between conservation interests that favored regulation and agricultural entities that resisted regulation and emphasized market-based incentives. Proposed alternatives to get beyond this impasse included (1) implementing a water quality and pollution trading system that linked upstream producers and downstream consumers and allowed trading between those bolstering and those detracting from ecosystem services, and (2) block grants to local watershed groups of farm owners and operators to meet measurable outcomes in water quality in a manner of their own choosing.

High capacity partnerships

> *We're talking about working across institutional levels, scales. Well, that system is already in place, with the [National Resource Conservation Service] and the [county level] Soil and Water [Conservation] Districts... There's 400 and some county offices across the Mississippi River Basin, and I think we could do more to harness that system which is both locally led and a cooperation between the US citizens, taxpayers, and farmers.*

Many workshop participants described successful partnerships among diverse entities such as land owners, farm operators, neighbors, community and watershed groups, non-profit organizations, agriculture and conservation coalitions, scientists, industries, government agencies, and policy makers. These partnerships were both horizontal (among entities operating at similar scales and power structures) and vertical (among entities at different scales or different levels of power) in character. An example given of a horizontal partnership included a watershed coalition of farmers and landowners surrounding a lake that used social norms to encourage other land owners and operators to change practices. Vertical dimensions were added to this localized effort when a non-profit organization and a federal agency empowered this local effort with technical assistance and when the group applied for, and was awarded, state and federal grants. In another instance, an agricultural group, a conservation group, and an academic research center partnered and pooled their resources and connections to initiate and equip a watershed conservation planning effort. These partners, in turn, built connections with local land owners and farm operators as well as with federal and state agencies.

Shared understanding, trust, and norms of reciprocity

> *When I hear "let's talk about [turning a conservation set aside program into a working land program]," I'm terrorized, because I'm envisioning corn on all of it. [But yet] I know that's not going to happen, [because] as we get down to the state I know you and you and you, and I trust you, and we can talk together and find multiple objectives. As you get down to the watershed it's even better.*

Although admittedly difficult to measure or systematically reproduce, our participants emphasized that successful conservation initiatives were marked by a sense of shared understanding, stake, experience, and rapport between diverse partners at multiple levels of the system. It was recognized that both agricultural and conservation groups from many sectors of society were all working on initiatives at a variety of different scales to achieve overlapping goals. While the most successful initiatives were seen as involving cooperation among these groups, competition for limited resources, as well as cultural, political, or ideological differences among groups, were recognized as leading to initiatives that did not share resources or build upon and reference one another.

Discussion

The appeal of perennial cover types lies in the potential of these practices to achieve multi-objective outcomes while blurring the distinction between working lands and protected areas (Fig. 1). Such an approach is ideally suited for privately owned landscapes geared towards high agricultural production. In these landscapes, large protected areas are unrealistic; ecosystem function and societal goods must emerge from networks of conservation practices implemented by myriad farm owners and operators. When compared to the management of common pool resources, change initiatives in landscapes composed of numerous, autonomous farms must deal with a distinct lack of central control. Although macro-scale markets, technologies, and policies can have strong effects on the aggregated individual decisions of Corn Belt landowners (McCown, 2005), both rural stakeholders (Hinkamp et al., 2007; Atwell et al., 2009a) and our workshop participants indicate these top-down influences often drive change in unpredictable or undesirable ways.

Past federal farm policy initiatives designated for conservation purposes have focused on single-objective outcomes (e.g., removing highly erodible land from production, building soil by reducing tillage, or resting land to reduce supply and increase crop prices) at smaller scales (e.g., individual farms, fields, and patches; Secchi et al., 2008). Our workshop participants shared examples from the Corn Belt illustrating how human actors often seek to optimize one focal outcome (such as agricultural production or soil loss) and fail to anticipate the ripple effects of this management approach on other system components (rural social vitality or water quality). They understood that multi-objective initiatives that overcome private property boundaries and build landscape networks of perennial conservation practices represent a new paradigm in conservation practice, and as such, pose unique challenges (Kraft, 2008; Lant et al., 2008).

Our participants indicated that regional coordination of scientific monitoring, adaptive management, and enforceable environmental standards are foundational to long term, multi-objective change given the complexity of the Corn Belt system. While such an approach was seen by our workshop participants as having the potential to link agricultural and conservation objectives, they also indicated that macro-scale programs intended to mandate or coerce landscape change across private property boundaries are often resisted by stakeholder groups. For instance, rural residents in an agricultural community in central Iowa value independence and are often suspicious of government regulations and programs (Atwell et al., 2009a). These stakeholders initially balked at conservation strategies that threaten to restrict infield agricultural practices, expressed land ethics focused on smaller farm and field scales, and displayed little ownership of, or feelings of efficacy to influence, regional institutions.

The leaders we talked to indicated that desired changes in the regional social-ecological system are most effectively brought about through relatively local initiatives. What makes these initiatives successful is attention to cultural, political, economic, and ecological particularities unique to their places and people. But local initiatives were also seen to have drawbacks. They are often implemented at scales too narrow to achieve desired regional outcomes, are conducted with little reference to one another, and are difficult to replicate in other settings. Taken together, the themes characterizing our workshop data suggest that, to achieve regional outcomes, strategies must be implemented that increase the connectedness and effective scale of regionally successful solutions.

Partnerships

Our workshop participants emphasized that the success of regional actors to influence multi-scale change within complex Corn Belt social-ecological systems hinged upon the quality of key human relationships within and among levels of the system. As in the privately owned Western Australian agricultural system described in the introduction, technologies, markets, and government subsidies severely limit the autonomy of local farmers in the Corn Belt. However, where macro-scale forces have locked the Western Australian system into a configuration characterized by little potential for change (Allison and Hobbes, 2004), the same types of macro-level forces are propelling Corn Belt systems into a period of change resulting in new challenges and possibilities in resource management. Incorporating the insights of Corn Belt leaders in the process of analyzing system resilience suggests that much of the regional adaptive capacity to deal with this period of change in proactive ways lies in strategic collaboration (Westley et al., 2006; Nkhata et al., 2008) among partners within and across levels of the system.

Westley et al. (2006) investigate the process by which social innovation happens in complex systems that are resistant to change. They point out the human tendency to treat complex systems like machines, but suggest that such an approach, focused on understanding a whole as the sum of its interacting parts, is limited because it ignores the living, relational aspects of these systems. Seemingly unlikely changes in complex systems often come about when social actors who are intimately involved in the system understand system relationships through first hand experience. The "lived" knowledge of these social innovators allows them to see and understand the dynamic "rules of engagement" and "strange attractors" that govern the system. Their incarnate perspective gives these actors the insight to work with and through these interactions to produce change. In a similar argument, Carolan (2006) posits that when addressing natural resource management dilemmas, the knowledge contributions of scientists and stakeholders must be augmented by "interactional expertise" to understand and facilitate the necessary interactions among contributors. The leaders we talked to indicate that this interactional expertise is an essential characteristic of successful conservation change initiatives across scales—from rural watershed groups to powerful political alliances. To achieve desired outcomes in this complex, changing, and multilayered system, our workshop participants emphasize the necessity of collaboration among diverse partners who understand the system from different scales and perspectives.

Building effective relationships across system levels is the focus of Woolcock's (1998) theory of social capital for international development. Defined by Woolcock (1998) as "information, trust, and norms of reciprocity inhering in one's social networks," social capital has been recognized as a necessary ingredient in empowering diverse actors to overcome the "tragedy of the commons" so often experienced in the management of common pool resources (Ostrom and Ahn, 2003; Pretty, 2003; Plummer and FitzGibbon, 2007). Woolcock (1998) adds consideration of scale to the concept of social capital, proposing that many challenges in international development must be addressed by building social capital both within and among community and institutional social scales. The insights of our workshop participants, and the results of a companion study of rural Corn Belt stakeholders (Atwell et al., 2009a,b), illuminate the ways in which the vertical and horizontal dimensions of social capital described by Woolcock (1998) influence relationships among diverse partners across multiple organizational scales to mediate social and ecological outcomes in the Corn Belt (Fig. 1).

Adding scale and value to perennial farm practices

Many of the problems that our participants identified in the current Corn Belt agroecosystem, and their proposed approaches for change, involved issues of scale. These leaders stated that successful landscape change initiatives must give careful consideration to ecological, economic, cultural, social, and political scales. They affirmed the need for biophysical landscape analyses implemented at relatively local levels in order to identify key locations for perennial agriculture and conservation practices. They also emphasized that biophysical analyses must be coupled with social landscape analyses to determine the primary decision maker on any given piece of land and to build rapport with, and provide technical assistance to, this farm owner or operator.

In a companion study, we found that rural stakeholders also valued stewardship and social integration at local scales (Atwell et al., 2009a), and adoption of perennial conservation practices by farmers was seen as dependent upon social norms and connectedness with institutional partners at community scales (Atwell et al., 2009b). However, these local stakeholders expressed little understanding of, or efficacy to effect change over, their regional landscapes or institutions (Atwell et al., 2009a). Regional leaders' experience of what is working well in regional conservation initiatives corroborates the insights of stakeholders, but adds understanding of, and efficacy to influence, macro-level market, technological, and political forces. Workshop participants recognized that the fast-pace of technological development and market volatility associated with the biofuel and bioproduct economies increased system uncertainty. However, their comments were also characterized by a confidence that Corn Belt special interest groups, industries, academic institutions, and government agencies have the power, influence, and capability to shape these forces to achieve desired regional outcomes. Our data highlight the adaptive capacity of regional actors to act as intermediaries who shape markets, technologies, and policies in ways that are compatible with the needs, the capabilities, and the conservation of local human and natural resources.

In particular, our participants emphasized the need for regional partners to build "value" for farmers who produce ecosystem services in order to encourage aggregate decisions that lead to outcomes desired by the regions' citizen consumers. Several strategies to develop such broadly influential value were offered. Foremost among these was the need to develop new economic markets for agricultural production strategies that utilize various types of perennial vegetation at strategic landscape positions. Markets considered realistic in the next decade included algae grown in wetlands to produce biodiesel and purify waste, diverse prairie biomass for ethanol or rotational grazing on hilly or sensitive ground, and sustainable harvest of wood for lumber in river bottoms and steep hillsides. The need to bolster extant, but undervalued, aspects of the region's economy that utilized perennial cover types was emphasized, including the cow-calf, timber, wildlife, recreation, and tourism industries.

In addition to economic markets, political and cultural mechanisms were also proposed to build broad-scale value. In many cases participants suggested that new laws or legislation were needed to make markets that rewarded perennial cover types viable. This included phasing out federal subsidies that supported row crop production and corn-based ethanol and transferring these funds to programs that encouraged innovative practices balancing production and conservation. It also included strengthening the Clean Water Act to catalyze new technologies and economic trading systems to address non-point source water quality issues. Laws were seen as necessary to protect land owners who opened their property to hunting, wildlife viewing, and other recreational activities from liability. Participants suggested that ethical dialogue, similar to that of the soil stewardship movement following the dustbowl of the 1930s, was needed to emphasize the importance of landscape scale provision of ecosystem services by agricultural areas. Soil health, water quality, wildlife and aquatic biodiversity, and sustainable rural livelihoods were all seen as normative issues that had the potential of catalyzing ethically motivated changes in practices in rural communities. Local social networks such as coffee groups, churches, and civic organizations were offered as a powerful, but underutilized, approach to influence socially normative behavior. In sum, our data highlight the adaptive capacity of well-connected regional actors to act as intermediaries who have the ability to shape market, technological, and political trajectories in ways that are compatible with the needs, the capabilities, and the conservation of local human communities and natural resources.

Conclusion

Perennial conservation initiatives, if implemented at landscape scales, were viewed by regional leaders in agriculture, the environment, and policy as having the potential to bolster agricultural production, socioeconomic sustainability, and ecosystem services. Perennials were perceived by regional leaders to be especially viable at the current juncture, as the Corn Belt system undergoes reorganization associated with the emerging bioeconomy. The success of landscape-scale initiatives was, however, seen as dependent upon careful attention to ecological, socio-cultural, economic, and political dynamics among field, community, regional, national, and international scales. To address the complexity inherent in initiatives that span private property boundaries, regional leaders suggested policy mechanisms must build partnerships that blur distinctions between working lands and protected areas and bridge gaps between local creativity and initiative and regional support and accountability.

Our workshop data emphasized the need for mechanisms that were responsive to the particularities embedded in local ecological and social factors, but also highlighted the need for regional actors to "scale up" locally successful drivers of change. Local solutions were recognized as necessitating macro-scale funding and regional training to support county-level conservation personnel who could work consistently with rural communities over decadal timeframes. Workshop participants provided examples of how regional actors could increase the value of perennial cover types for the farmers who implement them by developing markets, policies, laws, support structures, and normative dialogue that support and reinforce desired landscape change. Success of these mechanisms is dependent upon building and maintaining vertical and horizontal forms of social capital that facilitate strategic collaboration within and among social actors operating at different levels of the system. In the Corn Belt, much of the adaptive capacity to bolster ecosystem services and societal goods lies in the regional relational capital among diverse partners who understand the system from different scales and perspectives.

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