ACHIEVING EFFECTIVE LANDSCAPE CONSERVATION: EVOLVING DEMANDS, ADAPTIVE METRICS

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To address the conservation of landscapes, one must first define success in terms that are measurable and relevant to impacts and results rather than simply accounting for participants. Effective conservation requires development of conservation goals that are place-appropriate. Definitions of success will necessarily depend upon location and community, but those definitions are linked to larger and nonlocal issues over a range of space and time. Knowing when, where, and under what circumstances conservation efforts are having the desired impacts is critical. Moreover, implementing goals on a landscape scale requires addressing the increasingly dynamic land use changes occurring on and off farms.

Challenges for the effective design, implementation, and measurement of conservation efforts at the landscape scale arise from shifts in knowledge, societal values and expectations, and accumulation of impacts. As fewer people in the United States are directly involved in agriculture and its supporting industries, the understanding of natural and managed systems and the conservation needs and values of natural resources have changed to a more urban perspective. What society expects from conservation has changed with this demographic shift and with increasing resource scarcity, off-farm impact awareness, and environmental degradation. Agriculture continues to be a major use of land in the United States, and the role of agriculture in conserving natural resources is recognized. U.S. Department of Agriculture (USDA) spending on conservation programs was roughly $5 billion in 2008 (Economic Research Service 2008), but results have not sufficiently addressed all environmental problems. In addition, increased urbanization and, more significantly, shifts in societal attitudes must be addressed in development of future conservation plans. Conservation goals will increasingly be required to address multiuse landscapes rather than a single-purpose land use, such as agronomic production. A second challenge of conservation efforts is the breadth of ecosystems and agricultural production systems within the United States. An overarching conservation agenda may be appropriate at the national scale, but effective conservation in a country this heterogeneous and historically different must be developed locally using knowledge of ecosystems and addressing place-specific environmental concerns (National Research Council 2008). This local knowledge comes from producers, scientists, and residents. Benefits from conservation should accrue to the local community in an obvious fashion as much as possible to elicit lasting voluntary participation. And finally, research priorities have to change to reflect the changing societal values; techniques such as participatory processes and improved

modeling can allow us to integrate these disparate goals and viewpoints and bring all participants to the table.

The agricultural landscape

Human use of land alters both structures and processes in the environment (Mander and Uuemaa 2010). The value one places on land and its natural resources determines the anticipated function of the landscape and the acceptable structure of the physical landscape (Bergstrom 1998). For those economically dependent upon the productive capacity of the land, maintenance of that productive capacity is foremost in designing conservation efforts. Alternatively, those not closely tied to production often consider landscape functions that enhance aesthetic or recreational values more desirable. In 1995, Lewis (1995) remarked that the rural landscape had become a locational amenity, "... less important for its farm produce than as a residential stage set." The viewpoints of production agriculturalists and nonproducers have become increasingly divergent with demographic shifts to a predominantly urban population.

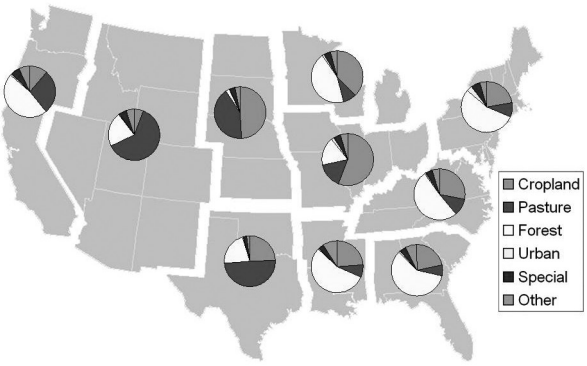
The landscape is complex and diverse, encompassing natural and cultivated land, rangeland, crops, and forests. In the contiguous 48 U.S. states, nearly 1.4 billion acres are classified as rural (Heimlich and Anderson 2001), with more than half of the total U.S. land area used for agricultural purposes (Lubowski et al. 2006). But the traditional rural-urban split is no longer useful for several reasons (Castle 1995). First, the impact of agriculture reaches beyond its direct footprint. Agricultural practices and the structure of agricultural landscapes can enhance or reduce the ability of ecosystems to provide goods and services (Tscharntke et al. 2005). Second, these landscapes are no longer dominated as they once were by agricultural activities and uses. The spread of rural residential development and the shapes and extent of suburbanization, peri-urban development, and the continuum of high to low development defy easy characterization. Moreover, demographic, economic, and political shifts have brought new kinds of on- and off-site conservation issues into the rapidly changing mix of land uses.

The structure of the landscape has changed on farm as a result of intensification of production toward monoculture and spatially distributed agricultural systems (Dimitri et al. 2005; Drabenstott 2000), which has reduced species richness and genetic diversity (Swift et al. 2004). This is particularly evident in the U.S. corn belt where the number of crop species has been declining since 1982 (Gramig and Forcella 2008). Changes in production practices, including specialized and monocultural production, declining farm numbers with increasing farm size, and conversion of perennial habitat, result in a more intensive agriculture at the landscape level (Tscharntke et al. 2005). While increased regional specificity of production may benefit marketing channels (Martinez and Stewart 2003), the lack of integration within the agricultural production system and on farms limits resource sharing between enterprises (Hendrickson et al. 2008). On-farm diversification enhances resource sharing, reducing the dependence on imported production inputs and lowering expenses and waste (Halloran et al. 2010). Disadvantages of this increased specialization are seen particularly in animal systems, where the need to manage animal waste and by-products of production exceeds the carrying capacity of crop production in the area, resulting in additional expenses to handle the waste and potential contamination of soil and water (Sassenrath et al. 2010). It may also contribute to public health problems (Pu et al. 2009; Kristof 2009). Intensive, highly specialized agriculture results in a radically simplified landscape, with much of the natural habitat eliminated, fragmented or compromised (Dale et al. 2005; Drabenstott 2000).

Shifts in land use from natural to developed and semi-developed uses have increased (Figure 1). Urban areas in the United States have increased dramatically since 1945, to about 3 percent of total land area, with a 13 percent increase between 1990 and 2000 (Lubowski et al. 2006). The largest proportions of urban land are in the eastern regions of the United States, including the Northeast, Southeast, and Appalachian regions. Even greater changes have occurred at the rural-urban fringe. Rural residential area (acres of land and associated lots in rural areas used for housing) increased 12 million acres between 1997 and 2002 (Lubowski et al. 2006). Residential development (i.e., low-density housing development) on the urban fringe or in more remote locations affects an estimated 10 (Theobald 2003) to 15 (Brown et al. 2005) times the acreage that has been settled at urban densities. One of the major impacts of exurban development is on habitat fragmentation—the subdivision of a specific habitat into smaller and smaller fragments (McGarigal and Cushman 2002). Fragmentation of the landscape from conversion of rural land to urban and other developed areas affects the mix of commodities and services produced (Alig et al. 2004). The natural amenities that attract development to an area are often the same factors that enhance biodiversity (Hansen et al. 2005). Development of those areas disrupts the natural amenities and often reduces biodiversity; areas that were once biological refugia decline because of human habitation (Huston 2005). Development can potentially degrade habitat by reducing native species richness and increasing exotic species (Hansen et al. 2005).

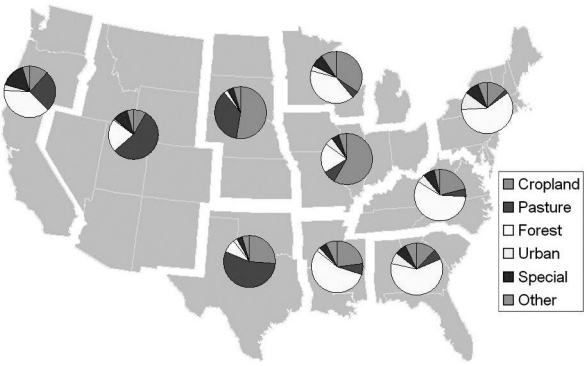
Both urban/exurban development and the simplification of agricultural systems have implications for the effectiveness of conservation. Within agriculture, one challenge is to maintain productivity at an acceptable environmental cost (Robertson and Swinton 2005). Increased fragmentation of the rural landscape hinders the efforts of production agriculturalists to make positive environmental changes.

(a) Land use by region, 1945.



Source: ERS-USDA Major Land Uses (http://www.ers.usda.gov/Data/MajorLandUses/).

(b) Land use by region, 2002.



Source: ERS-USDA Major Land Uses (http://www.ers.usda.gov/Data/MajorLandUses/).

Figure 1. Changes in land use by region from (a) 1945 to (b) 2002. The order of the pie chart wedges is as follows, starting at the top and going clockwise: cropland, pasture, forest, urban, special, and other.

Moreover, conservation programs targeted only to agricultural systems fail to include the nonagricultural landowners residing on a substantial acreage of rural land. Most importantly, the demographic shifts within the United States limit support for conservation programs by those urban dwellers who see no real benefits for themselves. Society impacts agriculture through implementation of policy (Hendrickson et al. 2008). Support for agricultural programs and agriculture-directed conservation programs will change with shifts in demographics toward a greater urban populace.

Many argue that scale is important in land use planning both for determining the proper scale to maximize ecological services (Swift et al. 2004) and also to match different spatial and temporal scales between ecological processes and land use planning (Gunderson and Holling 2001; Theobald et al. 2003). Although much of our conservation planning has been done at the field level, it may be more productive to plan at the landscape level (Swift et al. 2004). This will require conservation planning to include urban, exurban, and agricultural landscapes and integrate ecological and socioeconomic research (Robertson and Swinton 2005; Dale et al. 2005) and an understanding of the proper spatial and temporal scales needed (Swift et al. 2004).

Current conservation efforts

Several approaches have been taken to implement conservation programs in agriculture, at both the state and federal levels. The first approach is regulatory, establishing conservation goals in law, such as the Endangered Species Act (ESA) or Clean Water Act, that focuses on achieving conservation by setting a specific, mandatory level of some critical and measureable quantity.

Regulatory programs impose standards to reverse damage or prevent additional negative impacts. Where standards are not met, there is some type of adverse effect, such as a fine, legal action to force compliance, or the withdrawal of authority to regulate. Some success has been achieved with regulatory programs, such as the ESA. Serious policy and scientific issues have led to controversy, however, in part because the ESA imposes limits but only after conditions have become sufficiently threatening that action must be severe to be effective. Moreover, inequities in implementation and impacts of enacted conservation standards at times engender significant resistance to future conservation efforts in the affected communities. The political aftereffects, in terms of resistance to subsequent conservation efforts, may be an expensive if unintended consequence.

A second approach has been incentive-based programs that provide economic payments or financial support in exchange for implementing beneficial management programs. Examples of these programs include Environmental Quality Incentives Program (EQIP) payments for soil conditioning index (SCI) improvements, irrigation programs, and the Conservation Reserve Program (CRP). These programs have had mixed results as approaches to address broad-scale conservation goals over a long term.

Incentive-based conservation programs offer landowners and users a financial return for implementing conservation measures. These raise other issues, however, most importantly, fragility of commitment, reversibility of actions, and, therefore, cost-effectiveness. Successful and long-term implementation of conservation measures may be reversed if the full context of the regulatory or incentive efforts and land use pressures is not considered. The fragility of commitment was seen with the recent withdrawal of land and nonrenewal of contracts in the CRP in an attempt to capture anticipated profits from biofuel production (Lubowski et al. 2006; Bennett 2008). The CRP program leased land, and when the lease ended, the benefits ended, allowing marginal and highly erodible land to be returned to production. The

cost-effectiveness of program investments can be reduced if benefits are short-lived or terminated. Other investments under EQIP, the Wildlife Habitat Incentives Program (WHIP), and programs investing in facilities or structural improvements may have less reversibility and avoid commitment problems, with one critical exception. Subsequent land conversion to urban development is only currently prevented through use of a conservation easement. Suboptimal agricultural practices may result in poor conservation of natural resources, but a housing development is the final rotation—permanently impacting the natural resources and removing the land from conservation efforts.

Greater commitment has resulted from establishment of conservation goals and incentive programs developed in collaboration with landowners and farmers. A group working in Iowa and Vermont has achieved buy-in and participation of integrated water resource management through collaboratively developed incentives (Ingels et al. 2008; Winsten 2009). Market-opposing incentive programs must be carefully designed to succeed, and regulatory approaches that unevenly impose costs without benefits will both be disliked or resisted, and may have disappointing results. But market-driven results without serious public-interest representation result in resource degradation, which is why conservation efforts are necessary. Affecting the outcomes is increasingly important, but real conservation progress appears to require more than top-down agency programs aimed primarily at agricultural land (Fraser et al. 2006). Rather, conservation should focus on developing linkages between different users of the landscape (Knight 2007) and also between food producers and consumers (Gliessman 2010).

Conservation metrics

Interest in quantifying the impacts of conservation efforts has led to the development of conservation metrics, most commonly centered on key indicators. Some indices focus on a single environmental factor, such as a nitrogen (N) or phosphorus (P) index. Others are composites of multiple environmental factors, such as SCI. Other indices are developed around the notion of measuring the potential sustainability of agriculture and incorporate different aspects of sustainability into a common index (Quinn et al. 2010). Whether goals arise from the conservation ethic of preserving natural resources, agronomic interest in developing sustainable agricultural systems, or the provision of ecosystem services in support of society, a convergence of perspectives is giving rise to three central aspects that must be addressed: environmental, economic, and social.

A number of studies have developed various indicators of agricultural performance, environmental systems, conservation practices, and sustainability (for examples, see Wiebe and Gollehon 2006; The Heinz Center; Millennium Ecosystem Assessment; OECD; The Keystone Center). The goal of indicator development is the production of a concrete measure of the physical reality of the environment that can ultimately be used to direct policy. As with conservation programs, procedural challenges arise in scaling from changes in indicators from altered management practices implemented at the individual farm level to changes in environmental factors at the landscape scale. Indicator selection may be considered a subset of conservation targeting, with special focus on how land use and agricultural activity affect local and regional conditions and how alternative management practices impact the environment. The essential similarity is that conservation targeting research has wrestled with a host of indicators and their application at different scales, problems of geographic specificity, and the entire spatial and social context of decision-making; yet, consensus has proved elusive. Each tool developed has features and advantages beneficial for different purposes, with great variation

in the data intensity required (Sarkar et al. 2006). While each may be beneficial, development of a realistic on-farm management plan requires coordination of the individual indices, accounting for influences on all natural resources that support the on-farm economic return.

The essential element in developing indicators is determining the key components of the landscape that are valued, and the factors contributing to that valuation. Without first properly identifying the conservation goals "of what, for whom," the indicators degenerate into something, or anything, that can be measured, resulting in a pile of measurements that produce little or no insight (Salzer and Salafsky 2006). Additional frustrations arise when indicators are based on a national agenda—regional and local conditions are not only geographically and ecologically variable, but also varied by local land use history and current economic and social trajectories. SCI, for example, has been valuable in assessing improvements in soil quality with modifications in management practices for some soils, but performs poorly for other soil types and environmental conditions, limiting its usefulness as the basis for conservation payment programs in certain areas (DeFelice et al. 2006; Sassenrath et al. 2008). National standards and criteria may reflect limited research, resulting from a legal mandate to act ahead of adequate science (DeFelice et al. 2006). This may require action without necessary tailoring, resulting in conflicts rather than useful impacts.

A greater challenge to assess conservation efficiency arises from the need to integrate quantitative measures, such as SCI, with qualitative measures, such as social values. A variety of drivers shape agricultural production systems through interactions and feedbacks (Hendrickson et al. 2008). Examination of production systems demonstrates how these social, political, technological, economic, and environmental drivers interact and impact the development of agricultural production systems and management choices. The primary driving forces that lead people to choose farming are internal social factors that value agriculture as a lifestyle choice and the obligation to provide economically for their families (Sassenrath et al. 2010). Those choices are moderated by other drivers that operate internal and external to the production system (Hendrickson et al. 2008) and alter production systems and management choices. The impact of external drivers was seen dramatically during the recent increase in fuel prices that led farmers to convert land from the CRP to biofuel production (Stubbs 2007). The anticipated increase in economic return overrode the potential environmental improvements.

Translating economic health, social values, and behaviors into policy requires capturing qualitative parameters in addition to the firm metrics of the physical environment. Exploring interactions within ecological systems is challenging because those interactions are comprised of many diverse components that interact nonlinearly, resulting in response delays and feedback loops, and are heterogeneous in both space and time (Wu and Marceau 2002). Integrating those internal and external quantitative and qualitative factors that impact conservation metrics can be achieved through dynamic integrated models (Low et al. 1999; Wei et al. 2009). Integrative approaches to environmental assessment allow a more comprehensive and dynamic approach to conservation program and policy development (Piorr 2003). The integrated models also allow an examination of how production choices impact quantitative goals of conservation improvements as well as qualitative determinants of conservation efficacy (Quinn et al. 2010; Sassenrath et al. 2009).

An integrated model developed by the Integrated Agricultural Systems workgroup is being used to explore the primary drivers influencing producers' management choices and the impact of management choices on social and environmental aspects of sustainability

(Sassenrath et al. 2009). The model has six sectors (crop production, herd size, animal diet, economics, environmental quality, and social quality) that simulate predominant production systems (row crop, extensive livestock, and integrated crop/livestock). Integration between the sectors can be manipulated to explore various production scenarios and management choices. Dynamic responses are generated by allowing yearly shifts in crop yield and herd size. Feedback factors from social acceptance can limit herd size or crop production due to negative environmental impacts. Output indices include measures of environmental health (N and P indices and SCI), economic return, and social return (total protein) with qualitative indices of social acceptance and time. Results from predominant agricultural production systems demonstrate the improved environmental and economic benefits of integrated production systems (Figure 2). Values for environmental health (N and P indices and SCI), economic return (wealth), and internal and external social drivers (time, manure stockpiled, and total protein produced) were normalized from a baseline of zero to a positive (+1) and negative (-1) range. Integrated systems that included both crops and animals in the agricultural system showed improved N and P indices and SCI, with increased wealth. Social acceptance of the integrated system also improved through the reduced stockpiling of animal wastes. This information is instructive to researchers and producers for testing potential scenarios and exploring the impact of management choices on environment, productivity, and society.

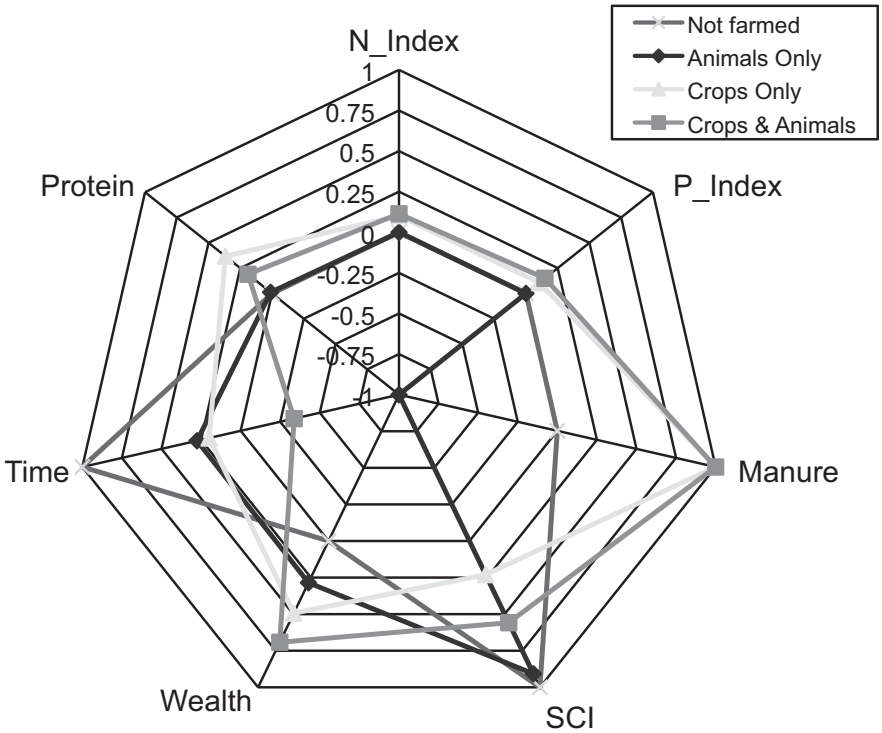


Figure 2. Plot of normalized indices of a dynamic, hybrid model of agricultural production on 1,200 acres parameterized for the Northern Great Plains region of the United States. Animal production is a cow/calf system, grazed and supplemented; crops include corn, soybeans, and spring wheat.

Defining conservation goals

Efforts to maintain natural resources have focused on the idea that getting the science right would give responsible authorities sufficient information to manage resources correctly. Behind this was the implicit premise that science was persuasive and that policy based on it would be accepted and implemented (Gunderson and Holling 2001; Norgaard 1994). The ongoing failure to correctly and completely implement conservation practices we know scientifically to be beneficial, however, points to the necessity for a new approach to conservation. Particular issues to address in any new approach include: (1) while indices are useful tools to measure conservation success, they do not help set goals, define success, or get the job done; (2) changing agricultural systems, societal views, demographics, and changes in land use create challenges to the current conservation paradigm; and (3) natural systems are dynamic—our conservation efforts will always require adjustments to account for changes in the system.

The conservation goals and associated metrics developed for any specific area will depend upon the function for which we are trying to conserve the land and the valuation of the land by the people defining the goal (Bergstrom 1998). Traditionally, a primary goal of conservation efforts on agricultural land has been to maintain the productive capacity, as measured by agricultural outputs, of the natural resource base. These efforts have been targeted to the farm scale. As discussed above, however, this is no longer a feasible scale at which to work, as changes in the farm landscape, increased nonfarm landscape use, and accelerating development has fragmented the agricultural landscape and introduced other uses that occupy significant portions of that landscape. Additional changes in demographics and societal values and goals further complicate development, especially support of traditional conservation approaches. To develop realistic conservation goals, one must recognize the full context of conservation issues arising from the different physical, ecological, cultural, economical, historical, and political settings (Knight et al. 2006). All of these affect the land, uses of that land, and human goals and values.

The way forward

The proper context for effective conservation planning is a place-specific socioecological system (Liu et al. 2007; Ostrom 2007; Turner et al. 2007). The entire process of definition of conservation goals, creation and administration of incentives, measures of effectiveness (success), and refining and/or redirecting incentives must be adaptable, locally focused and controlled, integrative (addressing multiple problems across a range of temporal, spatial, and impact scales), and continuous. Conservation efforts developed around bottom-up, locally and regionally supported targeting in collaborative processes appear more likely to succeed than top-down development and imposition of programs. Moreover, to achieve effective conservation we must have sustainable agricultural systems (Gliessman 2010). Truly sustainable agricultural systems require the integration of production and consumption. Trying to balance half of the equation by achieving sustainable production systems is not feasible—the consumption side of the food system must be brought into balance (Sustainable Consumption Roundtable 2006 Sassenrath et al. 2010).

To achieve successful landscape conservation requires long-term commitment and implementation (Knight et al. 2006). This commitment can come by first establishing principles that are supported across the citizenry, such as clean water, production of safe and nutritious food, preservation of landscape elements, biodiversity, flexibility, and opportunity. From these principles, we can develop the

place-specific conservation goals for landscape conservation that move beyond a single-purpose land use. Development of conservation goals that will be locally supported also requires input from all interested parties. Development of the concept of adaptive management, a process of addressing a problem and redefining the goal as the problem responds and changes, has shown a new way forward for conservation (Gunderson and Holling 2001; Knight et al. 2006; Liu et al. 2007; Turner et al. 2007; Allan et al. 2008). Though there have been some efforts to undertake adaptive management in practice, transferral to policymakers, political processes, or implementing agencies has been limited (Jacobs and Pulwarty 2003; National Research Council 2004, 2009). Incorporation of sound science is a good beginning, but the comparable incorporation of the social counterpart in the process is required as well (Mason 2008; Brunner and Lynch 2010).

A new paradigm of collaborative, community-based, participatory resource governance (Wondolleck and Yaffee 2000; Koontz et al. 2004; Sabatier et al. 2005; Mason 2008; Brunner and Lynch 2010) has emerged as a promising method to integrate traditional conservation goals and emerging social issues. Agreement based on shared understanding is expected to be more durable and effective than forced compliance. The emerging paradigm is best described as "collaborative, community-based, participatory planning." The collaboration arises as a practical response to the problems of fragmentation of authority, jurisdiction, and funding and lack of capacity to cooperate, modify programs, and respond to context within existing state and federal systems responsible for conservation (Koontz et al. 2004). The collaboration suggested also moves beyond the traditional collaboration between natural scientists and landowners or farmers to encompass diverse aspects of society (Gliessman 2010; National Research Council 2010).

The idea of community-based participation is two-fold. There are communities of interest created by spatial and physical linkages, such as those based on watersheds and the mutual interactions of resource uses, consumption, and externalities. Also, there are communities of interest linked by common concerns with a resource set (e.g., reservoirs), a problem (e.g., water scarcity), economic linkages, or other political and social linkages (Sabatier et al. 2005). Human involvement is not only reactive in the sense of cross-considerations, but also reflexive in the sense of reconsiderations, responses, and proactive strategic behavior. In other words, the communities of interest often disagree with each other about almost everything, but a stepwise convergence to a common understanding of at least critical parts of the issues and opportunities is widely considered to be one of the most important products of these processes (National Research Council 2008). Hans Bleiker, founder of the Institute for Participatory Management and Planning, shows that the minimum needed for forward progress is "grudging but informed consent," and that agreement beyond that has social transformational value. This idea is widely adopted as "social capital" (National Research Council 2008; Ostrom et al. 2007, Liu et al. 2007). It is important to note again that the shrinkage of the population directly involved in commercial agriculture means that there are limits on the extent to which that limited minority can dictate outcomes or rely on the public at large to trust externally imposed conservation programs.

The relevance of participatory planning to conservation programs in agricultural landscapes is clear: Without understanding the full context, decisions may be under-informed, misinformed, or even irrelevant to those whose consent or affirmative implementation is required; those decisions can also be potentially wrong in the sense of missing important local understandings, experience, craft, and ecological knowledge (National Research

Council 2008; Gilchrist and Mallory 2007). We include the term "planning" in collaborative, community-based, participatory planning to emphasize that these processes are not a one-time choice or an exercise in box-checking for legal compliance. With the increasing importance of willing participation, collaborative community-based participatory planning will be increasingly critical where change cannot be leased or bought on a sufficiently large or long-term basis.

The distinguishing features of the emergent paradigm are (1) inclusion and respect for context, place-specific issues, and conflicts by combining scientific knowledge with local craft and ecological knowledge; (2) the interactions of the physical environment with human activities, social structure, and individual incentives and constraints that affect the range of choice and incentives and effects of choices; and (3) to support the search for acceptable kinds and levels of tradeoffs while envisioning desirable futures, often compared with likely futures under current trajectories. The community-based aspect reflects the geographically specific case and interactions therein. The collaborative aspect reflects the involvement of federal and state agencies as well as state, regional, and local governments and a wide range of nongovernmental organizations and individuals; many of these stakeholders do not have direct authority to manage or influence management. The process itself is a product, with important social values in conflict reduction and capacity building, and in development of willing implementation or at least grudging consent for the implementation of interventions and plans. The participation potentially includes all interests, including agencies as well as all levels of government and business, nongovernmental organizations, and individuals.

Examples of this approach demonstrate its potential. Emerging local markets, food cooperatives, and other variants of Community Supported Agriculture (CSA) have been around for almost half a century (DeMuth 1993). From the inroads these alternative production systems have made, it appears we may have reached a critical mass of acceptance by society of this model of food production. Consumers are now seeking out and supporting alternative agriculture (Halloran et al. 2010). As an example, the bottom-up development of markets for organic and locally grown produce in Maine has enhanced the opportunities for farmers in that state to expand their environmentally friendly production practices (Halloran et al. 2010). Market development has come about through regional cooperation between farmers and consumers. These alternative markets are an example of collaborative decision-making that shows that lasting change must be linked to day-to-day realities of the people making decisions.

A directed approach to conservation planning that includes both agricultural and non-agricultural stakeholders has been successful in other areas. Fraser et al. (2006) found integration of stakeholder concerns into policymaking forums was particularly important to ensure adequate inclusion. They found that getting multiple stakeholders involved early in the process of indicator development empowered the community, in addition to establishing more realistic goals and indicators of progress. Knight (2007) stated that in western landscapes discussion about the future needed to include all aspects, such as recreation, grazing, and development. In the southwestern United States, the Quivira Coalition and the Malpai Borderlands Group have brought together diverse groups of shareholders, including both ranchers and conservations, to work with state and federal agencies and nonprofit groups to successfully improve natural resources. Cultural and economic issues must be included in these focused discussions, in addition to traditional ecological aspects. It is time to consistently bring this approach into our conservation efforts.

Conclusions

Conservation efforts to date have been commendable in addressing the challenging work of preserving our natural resource base. "More of the same" in future conservation programs will not be sufficient, however. Continued intensification of agricultural production systems to address the growing world population and, more significantly, the growing demands of developing countries for more meat protein will accelerate the degradation of our natural resource base if current trends continue. Fragmentation of the rural landscape due to development, even of low intensity, will limit the impact of conservation programs directed only at agriculture. Indices, while incorporating the best science, fail to provide adequate direction for the complex, multiuse, dynamic environments present in the current landscape. A new paradigm for conservation is desirable that includes all the participants in a responsive process. Committed, long-term success in natural resource conservation will not become a reality until societal aspects, values, and goals are factored in at the beginning.

The concept of public involvement in conservation goal-setting, implementation, and accountability is not new. The sustainable food movement has suggested a shift in societal perspectives from consumer to "food citizen," where consumers take a more active part in their food choices (Wilkins 2005) and, by inference, the agricultural production system. Because Americans pay less than 7 percent of their income for food, compared to 10 to 15 percent in Western Europe and 40 to 50 percent in India and the Philippines (ERS 2005), citizens and policymakers alike have been able to ignore the natural resource base that provides that inexpensive food. Exploring the linkages between food, health, agriculture, and the environment requires a different approach to agricultural production and is becoming an increasingly important component of the social environment influencing farming (Archer et al. 2008; Hamm 2008). Reintegrating consumption and production by bringing consumers back into the equation will improve conservation efforts through more realistic production expectations and food expenditures. One outcome of this process of transitioning agricultural production systems towards sustainability will be less environmental degradation (Gliessman 2010).

A recent report by the National Research Council (2010) calls for a transformative approach to move agricultural production towards sustainability. A key component of this transformation of agriculture is the integration of diverse groups into the land use planning and goal-setting processes. Integration is required to synthesize disparate goals of unique land uses into common landscape goals. Implementing effective conservation on the landscape will require a change in mindset to a systems view and an expectation of a continuous, ongoing process rather than a "do-once emergency fix." The entire physical and human landscape, not just agricultural landscapes, must be considered. Our nation needs to move beyond allowing a limited set of land-uses to define conservation goals, policy, and authority. Given the multiple goals and interests of citizens, conservation goals should be developed with more in mind than single uses, recognizing that land-use shifts may be irreversible. An integration of the entire system, production and consumption, urban and rural, is possible through collaborative planning.

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References

Alig, R.J., J.D. Kline, and M. Lichtenstein, M. 2004. Urbanization on the US landscape: Looking ahead in the 21st century. Landscape and Urban Planning 69: 219-234.

Allan, C., G. Stankey, and B. Shindler. 2008. Adaptive management and watersheds: A social science perspective. Journal of the American Water Resources Association 44: 166-174.

Archer, D.W., J. Dawson, U.P. Kreuter, M. Hendrickson, and J.M. Halloran. 2008. Social and political influences on agricultural systems. Renewable Agriculture and Food Systems 23: 272-284.

Armsworth, P.R., G.C. Daily, P. Kareiva, and J.N. Sanchirico. 2006. Land market feedbacks can undermine biodiversity conservation. Proceedings of the National Academy of Sciences 103: 5403-5408.

Bergstrom, J.C. 1998. Exploring and expanding the landscape values terrain. Faculty Paper Series FS 98-20. Department of Agricultural and Applied Economics, University of Georgia, Athens.

Brown, D.G., K.M. Johnson, T.R. Loveland, and D. M. Theobald. 2005. Rural land-use trends in the conterminous United States, 1950-2000. Ecological Applications 15: 1851-1863.

Brunner, R.D., and A.H. Lynch. 2010. Adaptive Governance: Proposals for climate change science, policy and decision making. *In* Adaptation and Mitigation Strategies for Climate Change, eds., A. Sumi, K. Fukushi, and A. Hiramatsu. Springer: Tokyo.

Castle, E. 1995. An Overview. *In* The Changing American Countryside: Rural People and Places, ed. E. Castle. Lawrence, Kansas: University Press of Kansas.

Dale, V., S. Archer, M. Chang, and D. Ojima. 2005. Ecological impacts and mitigation strategies for rural land management. Ecological Applications. 15: 1879-1892.

DeFelice, M.S., P.R. Carter, and S.B. Mitchell. 2006. Influence of tillage on corn and soybean yield in the United States and Canada. Online. Crop Management. http://www.plantmanagementnetwork.org/pub/cm/research/2006/tillage/.

DeMuth, S. 1993. Community Supported Agriculture (CSA). An annotated bibliography and resource guide. Agritopics Series no. AT 93-02. http://www.nal.usda.gov/afsic/pubs/csa/at93-02.shtml.

Dimitri, C., A. Effland, and N. Conklin. 2005. The 20th century transformation of US agriculture and farm policy. Economic Information Bulletin. EIB-3. Economic Research Service, U.S. Department of Agriculture, Washington, DC.

Drabenstott, M. 2000. A new structure for agriculture: A revolution for rural America. Journal of Agribusiness 18: 61-70.

Economic Research Service. Multiple years. Economic Research Service, multiple years. http://www.ers.usda.gov.

Fraser, E.D.G., A.J. Dougill, W.E. Mabee, M. Reed, and P. McAlpine. 2006. Bottom up and top down: Analysis of participatory processes for sustainability indicator identification as a pathway to community empowerment and sustainable environmental management. Journal of Environmental Management. 78: 114-127.

Gilchrist, G., and M.L. Mallory. 2007. Comparing expert-based science with local ecological knowledge: What are we afraid of? Ecology and Society 12(1): r1. http://www.ecologyandsociety.org/vol12/iss1/resp1/.

Gliessman, S.R. 2010. The framework for conversion. *In* The Conversion to Sustainable Agriculture. Principles, Processes, and Practices, eds., S.R. Gliessman and M. Rosemeyer. Boca Raton, Florida: CRC Press.

Gramig, G.G., and F. Forcella. 2008. Mapping recent temporal changes in crop species diversity for the 48 contiguous U.S. states [abstract]. Paper P14678. Ecological Society of America, Washington, D.C.

Gunderson, L., and S.C. Holling. 2001. Panarchy: Understanding Transformations in Systems of Humans and Nature. Washington, D.C.: Island Press.

Halloran, J.F., G.F. Sassenrath, D.W. Archer, J. Hendrickson, J. Hanson, and P. Vadas. How drivers shape the economic sustainability of agricultural systems: Results from farmer panels. Applied Economics Letters. Submitted.

Hamm, M.W. 2008. Linking sustainable agriculture and public health: Opportunities for realizing multiple goals. Journal of Hunger & Environmental Nutrition 3(2–3). doi: 10.1080/19320240802243241.

Hansen, A.J., R.L. Knight, J.M. Marzluff, S. Powell, K. Brown, P.H. Gude, and K. Jones. 2005. Effects of exurban development on biodiversity: Patterns, mechanisms, and research needs. Ecological Applications 15: 1893-1905.

Heimlich, R.E., and W.D. Anderson. 2001. Development at the urban fringe and beyond: Impacts on agriculture and rural land. Report 803. Economic Research Service, U.S. Department of Agriculture, Washington, D.C. http://ageconsearch.umn.edu/bitstream/33943/1/ae010803.pdf.

The Heinz Center. 2008. The State of the Nation's Ecosystems 2008. Measuring the Lands, Water, and Living Resources of the United States. Washington, D.C.: Island Press.

Hendrickson, J.R., G.F. Sassenrath, D.W. Archer, J.D. Hanson, and J.M. Halloran. 2008. Interactions in integrated agricultural systems: The past, present and future. Renewable Agriculture and Food Systems 23: 314-324.

Huston, MA. 2005. The three phases of land-use change: implications for biodiversity. Ecological Applications 15: 1864-1878.

Ingels, C., J. Rodecap, and S. Brown. 2008. Social and environmental indicators of success in performance-based agricultural management. 16th National Nonpoint Source Monitoring Workshop. September 14-18, 2008 Columbus, Ohio "Getting the Point About Nonpoint."

Jacobs, K., and R. Pulwarty. 2003. Water Resource Management: Science, Planning and Decision-Making. Water: Science, Policy and Management. Water

Resources Monograph 16. Washington, D.C.: American Geophysical Union.

The Keystone Center. 2009. Environmental Resource Indicators for Measuring Outcomes of On-Farm Agricultural Production in the United States. Field to Market: The Keystone Alliance for Sustainable Agriculture, Keystone, Colorado. http://keystone.org/spp/env-sustain_ag.html.

Knight, A.T., R.M. Cowling, and B.M. Campbell. 2006. An operational model for implementing conservation action. Conservation Biology 20: 408-419.

Knight, R.L. 2007. Ranchers as a keystone species in a West that works. Rangelands 29: 4-9.

Koontz, T.M., T.A. Steelman, J. Carmin, J.S. Korfmacher, C. Mosely, and C.W. Thomas. 2004. Collaborative Environmental Management: What Roles for Government? Washington, D.C.: Resources for the Future.

Kristof, N.D. 2009. Our pigs, our food, our health. New York Times, March 12, 2009. http://www.nytimes.com/2009/03/12/opinion/12kristof.html.

Lewis, P. 1995. The urban invasion of rural America: The emergence of the Galactic City. *In* The Changing American Countryside: Rural People and Places, ed., Castle, E.. Lawrence, Kansas: University Press of Kansas.

Liu, J., T. Dietz, S.R. Carpenter, C. Folke, M. Alberti, C.L. Redman, S.H. Schneider, E. Ostrom, A.N. Pell, J. Lubchecnco. W.W. Taylor, Z. Ouyang, P. Deadman, T. Kratz, and W. Provencher. 2007. Coupled human and natural systems. Ambio 36: 639-649.

Low, B., R. Costanza, E. Ostrom, J. Wilson, and C.P. Simon. 1999. Human-ecosystem interactions: A dynamic integrated model. Ecological Economics 31: 227-242.

Lubowski, R., S. Bucholtz, R. Claassen, M.J. Roberts, J.C. Cooper, A. Gueorguieva, and R. Johansson. 2006. Environmental effects of agricultural and land-use change: The role of economics and policy. Economic Research Report 25. Washington D.C: U.S. Department of Agriculutre, Economic Research Service. http://www.ers.usda.gov/publications/err25/err25fm.pdf.

Lubowski, R.N., M. Vesterby, S. Bucholtz, A. Baez, and M.J. Roberts. 2005. Major uses of land in the United States, 2002. Bulletin 14. Washington, D.C.: U.S. Department of Agriculture, Economic Research Service. http://www.ers.usda.gov/publications/EIB14/eib14fm.pdf.

Mander, U., and E. Uuemaa. 2010. Landscape assessment for sustainable planning. Ecological Indicators 10: 1-3.

Martinez, S., and H. Stewart. 2003. From supply push to demand pull: Agribusiness strategies for today's consumers. Amber Waves 1: 22-29.

Mason, R.J. 2008. Collaborative Land Use Management: The Quieter Revolution in Place-based Planning. Lanham, MD: Rowman and Littlefield.

McGarigal, K., and S.A. Cushman. 2002. Comparative evaluation of experimental approaches to the study of habitat fragmentation effects. Ecological Applications: 12(2): 335-345. doi: 10.1890/1051-0761(2002)012[0335:CEOEAT]2.0.CO;2.

Millennium Ecosystem Assessment. 2005. Washington, D.C.: World Resources Institute.

National Research Council. 2010. Toward Sustainable Agricultural Systems in the 21st Century. Washington, D.C.: National Academies Press. http://www.nap.edu.

National Research Council. Multiple years. http://sites.nationalacademies.org/NRC/index.htm.

Norgaard, R. B. 1994. Development Betrayed: The End of Progress and a Coevolutionary Revisioning of the Future. London and New York: Routledge.

Organization for Economic Co-operation and Development.. 2001. Environmental Indicators for Agriculture. Volume 3: Methods and Results. Paris, France.

Ostrom, E., M.A. Janssen, and J.M. Anderies. 2007. Going beyond panaceas. PNAS 104: 15176-15178.

Piorr, H.-P. 2003. Environmental policy, agri-environmental indicators and landscape indicators. Agriculture, Ecosystems and Environment 98: 17-33.

Pu, S., F. Han, and B. Ge. 2009. Isolation and characterization of methicillin-resistant Staphylococcus aureus strains from Louisiana retail meats. Applied Environmental Microbiology 75: 265-267.

Quinn, J.E., J.R. Brandle, and R.J. Johnson. 2010. Development of a healthy farm index to assess ecological, economic, and social function on organic and sustainable farms in Nebraska's four agroecoregions. *In* Farming With Grass: Achieving Sustainable Mixed Agricultural Landscapes, ed., A.J. Franzluebbers. Ankeny, Iowa: Soil and Water Conservation Society.

Robertson, G.P., and S.M. Swinton. 2005. Reconciling agricultural productivity and environmental integrity: a grand challenge for agriculture. Frontiers in Ecology and the Environment: 3(1): 38-46. doi: 10.1890/1540-9295(2005)003[0038:RAPAEI]2.0.CO;2..

Sabatier, P.A., W. Focht, M. Lubell, Z. Trachtenberg, A. Vedlitz, and M. Matlock, eds. 2005. Swimming Upstream: Collaborative Approaches to Watershed Management. Cambridge, MA: MIT Press.

Salzer, D, and N. Salafsky. 2006. Allocating resources between taking action, assessing status, and measuring effectiveness of conservation actions. Natural Areas Journal 26: 310-329.

Sarkar, S., R.L. Pressey, D.P. Faith, C.R. Margules, T. Fuller, D.M. Stoms, A. Moffett, K.A. Wilson, K.J. Williams, P.H. Williams, and S. Andelman. 2006. Biodiversity conservation planning tools: Present status and challenges for the future. Annual Review of Environment and Resource 31: 123-159.

Sassenrath, G.F., D.K. Fisher, and J.R. Williford. 2008. Impact of conservation production practices on soil moisture availability in alluvial soils. *In* D.M. Endale, ed., Proceedings, 30th Southern Conservation Agricultural Systems Conference and 8th Annual Georgia Conservation Production Systems Training Conference, Tifton, Georgia, July 29-31, 2008. http://www.ag.auburn.edu/auxiliary/nsdl/scasc/Proceedings/2008/Sassenrath.pdf.

Sassenrath, G.F., J.D. Hanson, D.W. Archer, J.R. Hendrickson, J.M. Halloran, and P. Vadas. 2009. Exploring

agricultural production systems and their fundamental components with dynamic modeling. Farming Systems Design Conference, Monterey, California. August 23–26, 2009.

Sassenrath, G.F., J.M. Halloran, D. Archer, R.L. Raper, J. Hendrickson, P. Vadas, and J. Hanson. 2010. Drivers impacting the adoption of sustainable agricultural management practices and production systems in the Northeast and Southeast US. Journal of Sustainable Agriculture 34: 6, 680-702.

Stubbs, M. 2007. CRS Report for Congress. Land Conversion in the Northern Plains. Order Code RL33950. http://www.ncseonline.org/NLE/CRSreports/07May/RL33950.pdf.

Sustainable Consumption Roundtable. 2006. Sustainable Consumption Roundtable, I Will if You Will: Towards Sustainable Consumption. London, United Kingdom: Sustainable Development Commission and the National Consumer Council, http://www.sd-commission.org.uk/publications/downloads/I_Will_If_You_Will.pdf.

Swift, M.J., A.-M.N. Izac, and M. van Noordwijk. 2004. Biodiversity and ecosystem services in agricultural landscapes—are we asking the right questions? Agriculture, Ecosystems and Environment 104. 113-134.

Theobald, D.M. 2003. Targeting conservation action through assessment of protection and exurban threats. Conservation Biology 17: 1624-1637.

Tscharntke, T., A. M. Klein, A. Kruess, I. Steffan-Dewenter, and C. Thies. 2005. Landscape perspectives on agricultural intensification and biodiversity—ecosystem service management. Ecology Letters 8: 857-874.

Turner, B.L., II, E.F. Lambin, and A. Reenberg. 2007. The emergence of land change science for global change and sustainability. Proceedings of the National Academy of Sciences 104: 20666-20671.

Wei, Y., B. Davidson, D. Chen, and R. White. 2009. Balancing the economic, social and environmental dimensions of agro-ecosystems: An integrated modeling approach. Agriculture, Ecosystems and Environment 131: 263-273.

Wiebe, K., and N. Gollehon. 2006. Agricultural Resources and Environmental Indicators, 2006 Edition Economic Research Service/USDA, EIB-16. http://www.ers.usda.gov/publications/arei/eib16/eib16.pdf.

Wilkins, J.L. 2005. Eating right here: Moving from consumer to food citizen. Agriculture and Human Values 22: 269-273.

Winsten, J.R. 2009. Improving the cost-effectiveness of agricultural pollution control: The use of performance-based incentives. Journal of Soil and Water Conservation 64: 88A-93A.

Wondolleck, J.M., and S.L. Yaffee. 2000. Making Collaboration Work: Lessons from Innovations in Natural Resource Management. Washington D.C.: Island Press.

Wu, J., and D. Marceau. 2002. Modeling complex ecological systems: an introduction. Ecological Modelling 153: 1-6.