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Farming for ecosystem services: A case study of multifunctional agriculture in Iowa, U.S.A

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Farming for ecosystem services: A case study

of multifunctional agriculture in Iowa, U.S.A

by

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Program of Study Committee:

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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ABSTRACT

Agriculture in the United States faces major challenges for the 21st Century; it is at a pivotal stage in terms of integrating societal demands for sustainability and enhanced quality of life from agricultural lands. A growing understanding that farms play key roles in provisioning a wide range of ecosystem services is converging with a surge in public interest in the sustainability of farming and food systems. Farmers in the US Corn Belt are being solicited to manage for an increasingly complex and expanding suite of production and environmental benefits. However, managing landscapes for multiple objectives presents a major challenge and inherently increases management complexity. A critical challenge lies in defining an appropriate set of agriculture and environmental objectives for management across spatial scales. The goal of this research was to analyze the degree to which there is a capacity to manage agricultural landscapes for multiple ecosystem services with existing and emerging agricultural management practices. I addressed this goal by conducting a case study with stakeholders representing agricultural and environmental interests in Iowa, U.S.A., through a mixed methods approach utilizing the Delphi survey technique and in-person interviews with photo elicitation. This thesis presents the case study results regarding the relationship between ecosystem services and agricultural land management; identifies farm scale management practices that are most promising for achieving ecosystem service objectives across scales; and, additionally, presents a portfolio of landscape visualizations depicting scenarios of land management alternatives.

CHAPTER 1
OVERVIEW

1. Introduction

Agriculture in the United States Corn Belt faces major challenges for the 21st Century. Growing human populations, increasing per capita food consumption, and a burgeoning market for biofuels are driving farmers to intensify production (MEA 2005; ICSU 2008; NRC 2010). At the same time, persistent ecological vulnerabilities, global climate change, and natural resource limitations threaten the continued productivity of many contemporary agricultural systems (Tilman et al. 2001; Metzger et al. 2006; Takle 2011). Scientific understanding that agroecosystems play key roles in provisioning a wide range of ecosystem services is coming together with a surge in public interest in the sustainability of farming and food systems (OECD 2001; MEA 2005). This phenomenon—driven by an increasing awareness of the unintended environmental, human health, and food security problems associated with industrial agriculture and spurred in popular culture by movies, e.g., *King Corn* (2007) and books, e.g., *The Omnivore's Dilemma* (2006)—is embodied in an increase in the number of farmers markets and near-exponential growth in organic food sales in recent decades (Phillips 2007, USDA NASS 2008). The 2010 National Research Council report, *Toward Sustainable Agricultural Systems in the 21st Century*, suggests agriculture is at a pivotal stage in terms of integrating societal demands for sustainability and enhanced quality of life from agricultural landscapes. Corn Belt farmers are being solicited (through market and regulatory signals) to manage for an increasingly complex and expanding suite of production and environmental benefits (Ruhl et al. 2007). Swinton and others (2006) conclude that "the scientific and political planets are aligning" for innovation in policy, research, and management of ecosystem services in agriculture.

Increasing public awareness, galvanized by seemingly intractable negative externalities of conventional agriculture, is creating new expectations that land managers (i.e., farmers, producers, ranchers) simultaneously fulfill increasing de-

mands for food and fuel, sustain the productivity of agricultural landscapes in perpetuity, and maintain or enhance the ecosystem functions that make other ecosystem benefits possible (Daily 1997; Kirschenmann 2000; Tilman et al. 2002; Robertson and Swinton 2005). As societal demand for ecosystem services intensifies, there is a need for private landowners, producers, policy makers, scientists and the public to effectively collaborate toward a common vision for agricultural landscapes (Palmer et al. 2004; Jackson 2008; NRC 2010). The concept of ecosystem services has been suggested to provide a platform for consensus building to speed progress in arriving at pragmatic solutions and a common vision to address the challenges currently facing agriculture (Daily 1997; Hein et al. 2006; NRC 2010). Already, the concept has become increasingly important in agricultural and environmental policy issues (OECD 2001; Bills and Gross 2005; Ruhl et al. 2007; USDA 2008).

Studies investigating transformative approaches to agricultural policy and practice have found that a diversity of Corn Belt stakeholders—including farmers, policy makers, and the public—favor agricultural futures other than "business as usual". Broadly speaking, citizens desire agricultural landscapes that alleviate well-known negative externalities of conventional approaches and further enhance ecosystem services (Nassauer et al. 2002; Nassauer et al. 2011; Boody et al. 2005; Atwell et al. 2010). Yet, an industrial paradigm persists (Thompson 2010), reinforced by external inputs such as government commodity programs, investment by agribusiness, and cheap energy in the form of fossil fuel. Given that the preference for an alternative future has been established, the overarching question of this thesis was: how do we transition from contemporary agricultural landscapes to future ones that look and function differently?

This research is intended to advance understanding of how the Corn Belt social-ecological systems are likely to respond to change by integrating knowledge from stakeholders who view this system from different scales and perspectives. The goal of this research was to analyze the degree to which there is a capacity to

manage agricultural landscapes for multiple ecosystem services with existing and emerging agricultural management practices. I addressed this goal by conducting a case study with key actors in the system—agricultural and environmental stakeholders in Iowa, U.S.A.—through a mixed methods approach utilizing the Delphi survey technique and in-person interviews accompanied by photo elicitation.

2. Thesis organization

My thesis is comprised of this general overview chapter, two chapters targeted for publication in academic journals, a portfolio of photorealistic visualizations, and a chapter reflecting on the findings of my research. Chapter 1 contains an introduction to the challenges and opportunities facing 21st Century agriculture, providing both broad context and general impetus for this research. Chapter 2 details the case study—conducted as the major research component for this thesis— examining the possibilities for greater ecosystem services and land management in Iowa, U.S.A, an important agricultural state in the U.S. Corn Belt. Chapter 3 synthesizes the insight of stakeholders and regional leaders into a framework to further facilitate the practical application of agro-ecosystem service management. Chapter 4 highlights photorealistic visualizations I created for six projects over the course of graduate studies, and includes an illustrated protocol using screen shots to explain the basic steps used to create visualizations. Chapter 5 summarizes the conclusions and management implications of my research.

Research design, data collection, analysis, and the preparation of this manuscript were the responsibility of the candidate, a student of the Graduate Program in Sustainable Agriculture at Iowa State University, Ames, Iowa; Drs. Lisa A. Schulte Moore and John C. Tyndall of the Department of Natural Resource Ecology and Management, a landscape ecologist and natural resource economist, respectively, provided guidance and editorial feedback on all aspects of this research. In addition, Dr. Nancy Grudens-Schuck, program of study committee member and a research social scientist in the Department of Horticulture and Agricultural Education, provided a combination of project guidance, assistance with data analysis, and

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3. Literature Cited

Atwell R.C., Schulte L.A., and Westphal L.M. 2010. How to build multifunctional agricultural landscapes in the U.S. Corn Belt: Add perennials and partnerships. Land Use Policy **27**:1082-1090.

Bills, N. and D. Gross. 2005. Sustaining multifunctional agricultural landscapes: comparing stakeholder perspectives in New York (US) and England (UK). Land Use Policy **22**:313-21.

Boody, G., B. Vondracek, D.A. Andow, M. Krinke, J. Westra, J. Zimmerman, and P. Welle. 2005. Multifunctional agriculture in the United States. Bioscience **55**:27-38.

Daily, G. 1997. *Nature's services: Societal dependence on natural ecosystems*. Washington, DC: Island Press.

Hein, L., K. van Koppen, R.S. de Groot, and E.C van Ierland. 2006. Spatial scales, stakeholders and the valuation of ecosystem services. Ecological Economics **57**:209–228.

International Council for Science. 2008. Ecosystem change and human well-being: Research and monitoring priorities based on the Millennium Ecosystem Assessment. Paris, France: ICSU-UNESCO-UNU.

Jackson, L.L. 2008. Who designs the agricultural landscape? Landscape Journal **27**:23-40.

Kirschenmann, F. 2000. Questions we aren't asking about agriculture: Beginning a new journey towards sustainable agriculture. Leopold Center for Sustainable Agriculture, Iowa State University. Retrieved from: http://www.biotech-info.net/new_vision.html on 13 May 2011

Metzger, M.J., M.D.A Rounsevell, L. Acosta-Michlik, R. Leemans, and D. Schroter. 2006. The vulnerability of ecosystem services to land use change. Agriculture, Ecosystems & Environment **114**:69–85.

Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-being: Synthesis. Washington, DC: Island Press. Retrieved from: http://www.millenniumassessment.org/documents/document.356.aspx.pdf on 19 December 2010

Nassauer, J.I., R.C. Corry, and R.M. Cruse. 2002. The landscape in 2025: Alternative landscape future scenarios as a means to consider agricultural policy. Journal of Soil and Water Conservation **57**:44A-53.

Nassauer, J. I., J.A. Dowdell, Z. Wang, D. McKahn, B. Chilcott, C.L. Kling, and S. Secchi. 2011. Iowa farmers' responses to transformative scenarios for Corn Belt agriculture. Journal of Soil and Water Conservation **66**:18A-24A.

National Research Council. 2010. *Committee on twenty-first century systems agriculture: Towards sustainable agricultural systems in the 21st century*. Washington, DC: National Academies Press.

Organisation for Economic Co-operation and Development (OECD). 2001. Environmental strategy for the first decade of the 21st century. Paris, France: Organisation for Economic Co-operation and Development, Environment Directorate.

Palmer M., E. Bernhardt, E. Chornesky, S. Collins, A. Dobson, C. Duke, B. Gold, R. Jacobson, S. Kingsland, R. Kranz, M. Mappin, M.L. Martinez, F. Micheli, J. Morse, M. Pace, M. Pascual, S. Palumbi, O.J. Reichman, A. Simons, A. Townsend, and M. Turner. 2005. Ecology for a crowded planet. Science **304**:1251-1252.

Phillips, E. 2007. Case Study #6-10, The growing trend of farmers' markets in the United States. In: P. Pinstrup-Andersen and F. Cheng (eds), *Food policy for developing countries: Case studies* (pp 13). Retrieved from: http://cip.cornell.edu/dns.gfs/1200428180 on 10 June 2011

Pollan, M. 2006. *The omnivore's dilemma: A natural history of four meals*. New York, NY: Penguin.

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**:38–46.

Ruhl, J.B., S.E Kraft, and C.L Lant. 2007. *The law and policy of ecosystem services*. Washington, DC: Island Press.

Swinton, S.M., F. Lupi, G.P. Robertson, and D.A. Landis. 2006. Ecosystem services from agriculture: Looking beyond the usual suspects. American Journal Agricultural Economics **88**:1160-1166.

Takle, E.S. 2011. Climate changes in Iowa. In: *Iowa climate change impacts committee, climate change impacts on Iowa 2010*. Des Moines, IA: Office of Energy Independence.

Tilman, D., J. Fargione, B. Wolff, C. D'Antonio, A. Dobson, R. Howarth, D. Schindler, W.H. Schlesinger, D. Simberloff, and D. Swackhamer. 2001. Forecasting agriculturally driven global environmental change. Science **292**:281-284.

Tilman, D., K.G. Cassman, P.A. Matson, R. Naylor, and S. Polasky. 2002. Agricultural sustainability and intensive production practices. Nature **418**:671-677.

Thompson, P.B. 2010. *The agrarian vision: Sustainability and environmental ethics.* Lexington, KY: University of Kentucky Press.

USDA National Agricultural Statistics Service. 2008. Organic production survey. Retrieved from: http://www.agcensus.usda.gov/Publications/2007/Online_Highlights/Organics/ on 10 June 2010

CHAPTER 2
USING ECOSYSTEM SERVICES AS A PLATFORM FOR CONSENSUS
BUILDING: A CASE STUDY OF IOWA AGRICULTURE

A manuscript to be submitted to *Agriculture and Human Values*

Abstract

The concept of ecosystem services has become increasingly important in agricultural and environmental issues in the United States. Given the multiscalar and multi-stakeholder nature of ecosystem services, it is imperative that successful planning engage producers, policymakers, scientists, commodity and agribusiness groups, and the public. This paper presents a case study conducted with agricultural and environmental leaders in Iowa, U.S.A. We studied the relationship between ecosystem services and land management through: (1) a three-round Delphi survey that assessed ecosystem service priorities, and (2) individual interviews utilizing landscape images to elicit participants' perspectives on the benefits of perennial vegetation. Ecosystem services related to water, soil, and food were found to be the most important overall. Analysis of the Delphi data supported the cultural notion of a deep divergence between stakeholders with production-oriented expectations and those with environment-oriented expectations. Recognized and acceptable management practices—including riparian buffers, strategic integration of prairie, and wetland restoration—offer potential points of consensus across these viewpoints. Interview results suggested a major roadblock to practical application of ecosystem service management is a lack of support for landscape-level planning and coordination of management. We conclude that ecosystem services may provide a potential platform for consensus building within the group. However, clear perceptual and language differences exist among participants, which may lead to breakdowns in communication and hinder decision-making processes. Such groups must work towards explicit communication to move forward. To this end, we provide a framework for the discussion of ecosystem services.

Keywords: Conservation practices, Decision making, Delphi, Midwest, Photo elicitation, Stakeholder participation, Prairie filter strips, Water quality

1. Introduction

The idea of managing agricultural landscapes to provide society with multiple ecosystem services has surfaced as a novel and potentially powerful way to frame agricultural and conservation policy and research in the U.S.A. (Cochran 2003; Bills and Gross 2005, Ruhl et al. 2007). The practical application of ecosystem service provision, however, has been hampered by a lack of coordinated, on the ground approaches. A critical challenge for ecosystem service management in parcelized agricultural landscapes is that many ecosystem service outcomes are best realized at regional scales; the aggregate result of myriad management practices used at the field and farm scale (Taylor-Lovell and Johnston 2009). Accordingly, management decision-making must effectively address the interactions and net impacts of combinations of practices at the farm and field scale and assist in coordinating the actions of multiple farms on the landscape scale (ICSU et al. 2008; NRC 2010). A critical, and often failed, step lies in defining an appropriate set of agricultural and environmental objectives for management across multiple spatial scales (Hein et al. 2006; de Groot et al. 2007; de Groot et al. 2010). In short, there is a need for multiscalar management strategies that span property and political boundaries (Hein et al. 2006; de Groot et al. 2010; Rickenbach et al. 2011).

While individual farmers, farmer operators, or corporations may be the "unit" that directly implements agricultural and conservation practices, the options for management are influenced by external agricultural and conservation programs and policy, markets, an individual's values and resources, and land-tenure and contract production arrangements; these, in turn, are influenced by a range of stakeholders, special interests, and market forces (Palmer et al. 2004; Jackson 2008; NRC 2010). The formulation of agricultural and conservation policy is heavily influenced by agribusiness, research institutions, and farmer and environmental advocacy groups (Imhoff 2007). Correspondingly, the implementation of new and existing policies into effective on the ground management is typically shaped by government institutions, such as the Natural Resources Conservation Service and Soil and Water Conservation Districts. The public has a broad stake in agricultural eco-

systems because agricultural management impacts climate, floods, and disease transmission; provides food, fuel, clean air and water, recreational and spiritual opportunities, as well as food, feed, fiber, and energy (Daily 1997). Although the public's role in land management is often limited to being a consumer of agricultural products, they can serve as a powerful force in policy creation and redesign (Jackson 2008).

Managing landscapes for an expanding set of ecosystem service objectives presents a major challenge for all players in agriculture. Attempts to incorporate multiple objectives inherently increase management complexity; land managers are faced trying to optimize for multiple, sometimes conflicting, objectives (de Groot et al. 2010; Atwell et al. 2010). Consequently, management actions, shaped by stakeholder values and attitudes (Cheng et al. 2003; Ajzen 2005), must focus equally with biophysical and political forces, when considering the context of a broad socio-ecological landscape (Kurttila et al. 2002; Goldman et al. 2007; Atwell et al. 2010). Given these complexities, our research is grounded in the premise that decision making—with regard to the many facets of agriculture and the environment, including research initiatives, policy creation, and on the ground implementation of practices—must engage a broad group of stakeholders; among them, landowners and land managers, policymakers, biophysical and social scientists, agribusiness and commodity groups, and environmental and conservation groups (Palmer et al. 2004; Jackson 2008). To partially address the complexities associated with the practical application of ecosystem service management, we examined ideas and priority areas of leaders in agricultural and environmental arenas through an Iowa-centered case study that examined the utility of the concept of ecosystem services for agriculture.

2. The Case Study

Iowa is a fitting place to examine the complexities of ecosystem services delivered by agricultural lands, as there are few places where ecosystem services and agriculture are more inextricably linked. Iowa has a history of unprecedented crop

production coupled with unparalleled environmental degradation. With 85% of the land base (>26 million acres) dedicated to agriculture, Iowa leads the US in production of corn, soybeans, hogs, ethanol, and eggs, generating nearly $25 billion in annual revenue (NASS 2009). The total agriculture-related economy exceeds $72 billion annually, or 27% of the state's economy (2007 Census of Agriculture). Concomitantly, Iowa ranks last among 50 U.S. states in the amount of remaining natural vegetation and first in the loss of diversity and richness of the native flora and fauna (Dinsmore 1994; Samson and Knopf 1994; Mac et al. 1998; Iowa Wildlife Action Plan 2006). Currently, more than 400 of the state's water bodies are impaired by agricultural pollutants (fertilizers, feces, pesticides, and sediment) and the state is considered to be a major contributor to the hypoxic zone, i.e., the "Dead Zone", in the Gulf of Mexico, via the Mississippi River (Rabalais and Turner 2002; Gilliom et al. 2006; Alexander et al. 2008). Greater than 50% of Iowa's fertile topsoil has been lost during its 150-year tenure as an agricultural state and annual soil losses can exceed 50 tons per acre in some townships (Iowa Daily Erosion Project 2010; Veenstra 2010). Global climate change and its impacts are already discernible in the state, typified by unusually high rainfall events and greater and more frequent flash flooding (US GCRP 2000; Takle 2011).

The case study presented here, a Master-level graduate studies project, was conducted in collaboration with an Integrated Long-Term Research (ILTR) project: Science-based trials of row-crop integrated with prairie (STRIPs) at Neal Smith National Wildlife Refuge (NWR), see: http://www.nrem.iastate.edu/research/STRIPs/. The ILTR, established in 2004, is investigating the ecosystem services associated with small amounts of prairie strategically integrated into row-crop fields. Through an integrated, watershed-scale approach, project investigators are testing the overarching hypothesis that disproportionate benefits arise from incorporating small amounts of native prairie into row-crop fields, such that the response is greater than would be assumed based on the area converted (Schulte et al. 2006; Secchi et al. 2008; Liebman et al 2011). Major components of the project address agronomic productivity, hydrologic functioning, biodiversity habitat value, and socioeconomic

outcomes. A summary of the biophysical findings to date can be found in Liebman, Helmers, and Schulte (2011).

The ILTR project is guided by a preeminent group of stakeholders representing agricultural and environmental interests across Iowa and the Midwest. The stakeholder group has been active for six years and the level of active participation has exceeded the expectations of the principle investigators (Grudens-Schuck personal communication). There were 17 organizations affiliated with the project at the time of our case study (Table 2.1), and interest and participation has expanded in the time since. The group, at any given time, consists of approximately 50 individuals and includes a core advisory board of approximately 24 members who are considered to be leaders in their respective fields. Most of these members have been affiliated with the STRIPs project since its beginnings. Many have been heavily involved in agriculture and conservation at the regional and national level since the Food Security Act of 1985, i.e., the first Farm Bill, and have power and influence in the arenas of sustainable agriculture. These stakeholders participate in semi-annual meetings and field days, provide input on research direction and methodology, and deliberate on seminal decisions regarding the ILTR.

Ecosystem services are realized across spatial and temporal scales—varying from the short-term, site level, such as a recreational opportunity, to the long-term, global-level, such as climate regulation—and therefore are valued differently by stakeholders; and attitudes toward ecosystem services varies according to context (Peterson et al. 1998; Cumming et al. 2006; Hein et al. 2006). Accordingly, it was documented through extensive note taking during STRIPs stakeholder meetings and field days that individuals spoke about issues related to ecosystem services differently, particularly at different scales and from different perspectives, and that some did not use the term at all (Grudens-Schuck unpublished data). In project meetings, the concept of ecosystem services often produced discussion at a general level. For example, the term ecosystem services was routinely juxtaposed with general terms like "natural resources" or "conservation" of soil, water, or biodi-

versity. The ILTR research team determined that in order to move forward with the concept of ecosystem services, both within and outside the constructs of the STRIPs project, there was a need to more attentively focus on the concept of ecosystem services, particularly in defining priority areas, boundaries, and a common knowledge base.

A framework of ecosystem services has been suggested to provide a platform for consensus building (Hein et al. 2006; NRC 2010). "Consensus" is a term that speaks to the level of agreement among individuals or groups, and is a favored state of affairs for finding pragmatic solutions to existing problems. "Consensus" on a common vision is anticipated to spur on future planning for ecosystem service management (NRC 2010). Because many members of the STRIPs stakeholder group interact elsewhere in management and policy arenas, the group provided an excellent set of experts to involve in investigating the concept of ecosystem services in agriculture. A case study with the group was decided to be an effective way to examine the capacity for the concept to serve as a platform for discussion and decision making at the organizational level. In our case study, we address the research questions:

1) Given that ecosystem services are valued differently by stakeholders, to what extent can important ecosystem services provide points of agreement regarding future agricultural land management?

2) Given that ecosystem services are valued differently by stakeholders, to what extent can land management practices provide points of agreement regarding future agricultural land management?

3) What synergies and barriers do stakeholders forecast that may help or impede the development of a comprehensive agenda for ecosystem services management?

3. Methodology

The case study was initiated at a STRIPs stakeholder meeting in June 2009. A mixed methods approached allowed us to observe the recognized relationships between ecosystem services and agricultural land management from two unique angles (Yin 1994). We utilized: (1) a Delphi survey to address the concept of ecosystem services, and (2) in-depth, image-based interviews, to investigate preferences for strategic integration of perennial-based conservation practices. Because many of the individuals involved have a long history of complex personal and professional relationships, we selected methods that preserved confidentiality and avoided potential social, personal, or political conflicts. In addition, Dalkey and Helmer (1963) suggest that by interacting with members individually, these methods offer a constructive alternative to group interactions, as is typical of most STRIPs meetings.

The Delphi survey was conducted with the STRIPs advisory board in order to aggregate the diverse views of these experts, and to analyze the degree of consensus that may exist regarding ecosystem services and management practices important for Iowa. Development of the Delphi technique is attributed to Olaf Helmer at the RAND Corporation in the 1950's (Dalkey and Helmer 1963). Delphi allows a researcher to amalgamate the ideas expressed, privately and individually, by a panel of experts into a collective "worldview". Delphi studies produce data that predict future decision making and provide unique insights into complex issues (Pill 1971; Helmer 1975; Linstone 1978; Patton 1987; Rowe and Wright 1999). The technique consists of a series of iterative questionnaires, whereby frequently mentioned or highly ranked items in a questionnaire are used to formulate the next questionnaire (Richy et al. 1985). Since its inception, the Delphi technique has been widely used, including environmental planning, social policy, marketing, and medicine (for examples see, respectively, Angus et al. 2003; Curtiss 2004; Jolson and Rossow 1971; Williams and Webb 1994). Wide use has led to much variation in the protocol of the technique (Sackman 1975). In addition to the classical Delphi

analysis, we employed an alternative analytical approach to further describe a contextualized typology of ecosystem services for Iowa (Schmidt 1997; Legendre 2005).

We paired the Delphi survey with structured, in-depth interviews, supported by photo elicitation, to further examine the relationship between ecosystem services and perennial management practices. Our use of photo elicitation—inserting a picture or pictures into a research interview—is based on research that has demonstrated that images evoke deeper elements of human consciousness than do words alone (Harper 2002). Newton and others (2007) also suggest that computer visual landscape images specifically are useful for making complex information comprehensible. Nassauer (2002) and Nassauer and Corry (2004) demonstrated that visualization of agricultural land-use scenarios allowed a diverse group of stakeholders to critically evaluate the consequences of different combinations of policy goals and agricultural practices. Additionally, given that the landscape processes behind ecosystem service provisioning are explicitly context specific (time and place), we assert that the use of images was valuable in simultaneously "anchoring the conversation in a place" while avoiding the need for a large degree of influence or preface from the research team. Interview photo elicitation was based on a series of scenarios projecting different agricultural land uses, and was presented to participants as photorealistic images, at the farm-scale (see appendix D).

3.1 Delphi Methodology

A three round Delphi survey was conducted from November 2009 through October 2010, modified from Skulmoski and others (2007) (Figure 2.1, left side). It was decided in the course of the Delphi survey that three rounds provided a sufficient balance between thorough probing of the issues and maintaining participant interest (Erffmeyer et al.1986; Taylor et al. 1990). Through successive rounds, participants: (1) formed a list of "ecosystem services" and items that comprised relevant changes in agriculture needed to achieve them, (2) pared these items through

forced-choice ranking of the most important items, and then (3) identified relationships between important ecosystem services and land management practices.

Typical of Delphi, the first round of the survey asked participants to define study themes without a large degree of influence or preface from the research team (Appendix A). We posed an opened-ended question asking participants to:

> Make a list of key ecosystem services that you envision can be obtained from agricultural lands in Central Iowa, and then list any changes that may be needed to achieve them.

Successive survey rounds were based on a ranking-type approach (Schmidt 1997). See Appendix B and Appendix C for copies of instruments used in Delphi surveys round two and round three. Following Delphi protocol, design of the second round of the survey was based on analysis of first round results; the responses were coded and categorized based on theme development by the lead author and reviewed by all authors who are involved (Neuman 2003). Given our stated research interests, themes carried into round two and three were restricted to items related to ecosystem services and management practices. Round two of Delphi required participants to rank lists of each based on importance "with Central Iowa in mind". Participants were constrained to ranking only the top six of the possible 17 items in each list, such that participants were forced to exclude some choices and prioritize the remaining. For round three, the list of prospective ecosystem service items was further condensed by the lead author by excluding items that received no tallies in round two and by the combination of related themes. The list of management practices was similarly reduced. In round three, participants were asked to again rank the importance of proposed ecosystem services and also to identify the relationships between services and agricultural land management practices.

Following classical Delphi analytical methodology (Helmer 1975; Linstone 1978), the terms and phrases that remained at the end of the survey, "ecosystem services" and management practices, are those that are most likely envisioned for Iowa agriculture. While every item included in the Delphi survey is of importance,

we ordered items by combining the percent-who-mentioned and mean rank. Rank values were transformed such that the top ranked item (most important) was given the highest numerical value for a set. A final rank was assigned by multiplying the percent-who-mention by the mean rank; standard deviation was used (in one instance) as a tiebreaker, following Cougar (1988).

We tested for agreement, a pre-cursor to consensus, within the Delphi data using the nonparametric analysis Kendall's coefficient of concordance (W). We used data from round two for this analysis because there participants described a larger and more specific set of ecosystem services and management practices than in round three. Ward's (1963) agglomerative clustering was used to define groups of correlated participants based on a Spearman correlation matrix of the ranking of ecosystem services. A posteriori concordance analysis was conducted on the resulting clusters, using the measurement of agreement (Kendall's W) for the whole as a baseline, following Legendre (2005). This analysis departs from classical use of Delphi, but is in the spirit of examining the dynamics of future decision making.

3.2 Interview Methodology

Structured, in-depth interviews with project stakeholders were conducted by the lead author from June 2010 through December 2010 (Table 2.1). Invited participants included all individuals who had attended STRIPs annual stakeholder meetings in 2008, 2009, and 2010. The interview process was facilitated by a series of six, visually contextualized agricultural land use scenarios portraying a gradient in the amount of perennial land cover following a base-2 logarithmic scale (2, 4, 8, 16, 32, 64% perennial vegetative cover, as opposed to continuous production of annual row crops). The scenarios were placed in a hypothetical 66.4 hectare watershed in Iowa. Scenarios were presented to participants as photorealistic images created by the lead author using Visual Nature Studio 3 (Nature 3D, LLC).

For each scenario, three images were rendered (Appendix D): a vertical view (from directly above), a high-angle, bird's-eye view (from 500m above ground level), and a low-angle view, human-eye view (from ground level). The baseline

scenario landscape (land area, topography, position of a watercourse, and slope and soil characteristics) was parameterized using a landscape model called People in Ecosystems/Watershed Integration (PE/WI), an Excel-based model used to explore trade-offs in agricultural land cover management (Schulte et al. 2010), found here: http://www.nrem.iastate.edu/landscape. The PE/WI watershed is an amalgamation of two of Iowa's major landforms, the Des Moines Lobe (characterized by flat topography and poorly-drained soils) and the Southern Iowa Drift Plain (characterized by rolling hills and well-drained soils). See Chapter 4 for more detail on scenario development.

All interviews were conducted by the lead author. Interviews followed a semi-structured format, whereby each participant was asked a set of standard questions (Appendix E). Open-ended follow-up questioning allowed for probing subject matter unique to an interview. The interview process involved four stages. After provided time to examine the scenario images, participants were (1) asked to sort the scenarios in order from "the landscape that would provide the fewest to the greatest benefits." The term "benefits" was intentionally undefined to allow participant the freedom to define topics without a large degree of influence or preface from the interviewer. Participants were then asked to (2) list and describe the benefits they had in mind when performing the sort; (3) subsequently they were asked to describe specific land cover features in the images that led them to believe these benefits were (or were not) being provided. Finally, (4) the interview concluded with two questions about "balancing" land-use outcomes: which scenario would provide a balance between public benefits and high agricultural output and what specific numerical percentage of perennials would be necessary to provide for this balance.

A data sheet was developed for the interviewer to record items specific to the structured questions for the duration of the interview. Additionally, all interviews were electronically recorded and the audio recording was later transcribed verbatim. Following each interview (within 48 hours), the lead author reviewed the audio

19

recording in conjunction with the data sheet to ensure accuracy and completeness of written notes.

Initial qualitative data associated with land use management features and benefits, as well as follow-up questions were combined for analysis because responses were not delivered discreetly, but rather as a continuous flow of conversation (Yin 1994). These data were coded into descriptive, topic themes by the lead author with support from all coauthors (Neuman 2003). When evaluating the strength or emphasis of a theme, we accounted for the percent-who-mention a given theme, how often a theme was revisited during discussion; and when possible, non-verbal cues such as the use of vocal inflection, gestures (such as pointing to a photo) and emotion. Interviews were conducted in a variety of locations including private offices and conference rooms, in participants' homes, at the Neal Smith NWR, and on the Iowa State University campus. At all locations, interviews were conducted with interviewee and interviewer sitting opposite each other across an open table with ample room so that all images could be spread out and viewed concurrently.

4. Results

4.1 Delphi

Twenty members of the STRIPs project advisory board participated in the Delphi survey, an 87% participation rate overall. Participants represented 16 organizations (Table 2.1). Participants were categorized into five groups (agricultural non-governmental organization [NGO], environmental NGO, federal agency, research organization, state agency) based on their professional affiliations to provide context regarding identity while preserving individual confidentiality. Not all individuals responded to all survey rounds; 12, 14, and 13 individuals participated in rounds one, two, and three, respectively (Table 2.2). Initial non-respondents to round one were prompted twice via email and then by phone following Dilman (2007). Initial non-respondents to rounds two and three were prompted twice via email, re-sent the survey via mail, and finally prompted by phone. For each round,

approximately one-half of the participating individuals responded to the first contact. Each prompt thereafter recruited one or two more individuals.

4.1.1 Round 1

The open-ended format typical of Delphi elicited a wide range of items; in round one, respondents mentioned 60 different ecosystem services and 130 changes that would be needed to produce the ecosystem services. Responses also included 18 references of ecological functions and mechanisms (for example, descriptions of the phenomenon of eutrophication and stream bank erosion processes) that influence ecosystem service provisioning. Of the changes mentioned, 64% related to land management, 24% related to governmental policies, and 13% related to societal changes. Land management changes are discussed in detail below (see section 4.1.3).

Changes related to governmental policies included: argument both for and against the establishment of mandatory management practices that mitigate negative externalities (e.g., mandatory 90 ft. riparian buffers statewide), restructuring the payment scheme associated with the federal farm bill (e.g., crop subsidies and conservation compliance payments) to reward management for ecosystem services, and policies that safeguard "The Commons". Societal changes were categorized in two themes: engaging the broader public in land use and food policy and societal adoption of "A Land Ethic". Twenty-five percent of respondents invoked Aldo Leopold to illustrate this latter change.

4.1.2 Ecosystem Services

Water, soil, and food emerged as the most important ecosystem services themes for Iowa and were mentioned by a majority of the participants in each round of the Delphi survey (Table 2.3). Ecosystem services related to tourism, outdoor recreation, aesthetic and spiritual benefits, pollination, and pest control were ranked highly by some participants; however, support was more variable and none received mention by a majority.

All of Delphi round one responses included at least one mention of clean water, access to fresh water, or water purification; several participants focused their responses almost solely on topics of water quality. "Water filtration and purification" received the highest mean rank in round two, with 79% of round two participants including this item in their ranking when faced with the forced-choice decision (Table 2.3). Also in round two, participants were asked to clarify the definition of "clean water" by ranking four clean water benefits specified in round one. Objectives associated with clean water were, in order of importance: drinking water, water bodies for recreation, water for crops and livestock, and mitigation of gulf hypoxia.

Round two of the Delphi survey established that soil resources were overwhelmingly being considered at a local and regional scale in relation to fertility and production, as opposed to globally in relation to carbon sequestration. In round two, the ecosystem service choices referring directly to soil—"prevention of erosion and sedimentation" and "maintenance of soil fertility and nutrient cycling"— surpassed water, specifically, as being most important; receiving the highest and second-highest mean rank, respectively, and with each garnering 100% mention. However, erosion, sedimentation, and issues of nutrient retention were described as being interrelated with issues of water quality in open comments. Taken together, soil and water benefits were overwhelmingly the ecosystem services of greatest importance to the stakeholder group.

Food production was the final ecosystem service that garnered strong support throughout the Delphi survey. However, there appeared to be some ambiguity regarding this term and divergence in the conditions that constitute food production. "Wholesome" and "healthy" were the words most frequently used to describe food-related ecosystem services in round one. In several instances, these descriptors were used to explain food in the context of fruits, vegetables, and livestock, and as being overtly different from commodity crops, such as corn and soybeans. This disagreement is further explored in the non-classical Delphi analysis below (see section 4.1.4). In round two, participants were asked to clarify the definition of

"agricultural production" by ranking production benefits specified in round one of the Delphi survey. Objectives associated with agricultural production were, in order of importance, primary income for family farmers; regionally produced foods (i.e., fruits, vegetables, meats, poultry); commodity grains for global markets; and biomass for biofuel feedstocks.

Wildlife and biodiversity received waning and divided support throughout the Delphi survey. The theme was second only to water in round one, where only one participant failed to mention wildlife explicitly and several participants revisited it multiple times. In round two, however, when faced with the forced choice, wildlife was only included by 36% of participants. Moreover, wildlife was found to be a source of divergence, as described below (see section 4.1.4). This divergence may be due in part to the ambiguity of the term and the variety of wildlife related ecosystem services. In round two, participants noted the following objectives associated with wildlife, in order of importance: wildlife for recreational opportunities, wildlife for spiritual and aesthetic significance, native pollinators and integrated pest management, and intrinsic value of wildlife.

Flood mitigation and attenuation was also a source of disagreement in the Delphi. Although the region was experiencing flooding at the time the Delphi survey was deployed and regional flooding is heavily attributable to agricultural land management (Mutel 2008; Burras personal communication); only 25% of participants mentioned flood mitigation, hydrological regulation, or similar ecosystem services in round one. In round two, it was chosen by 50% of participants and was a source of disagreement, as described below (see section 4.1.4).

4.1.3 Land Management Practices

Overall support for management practices was more diffuse than for ecosystem services; only four of 17 practices garnered majority support, these were landscape-level planning, riparian buffers, diverse crop rotations, and restored wetlands; yet none of the practices received greater than 60% mention (Table 2.4). Most management practices were identified by respondents as contributing to mul-

tiple ecosystem services. Over half of the surveyed management practices were perceived to be associated with 10 or more ecosystem services. Ten of the practices were associated with at least half of the important ecosystem services and positively regarded across groups (see section 4.1.4); this set of practices was considered to be of primary importance to the future ecosystem service management in Iowa (Table 2.4).

4.1.4 Testing for agreement

Further utilizing the data from the Delphi survey to more specifically target points of agreement, we conducted concordance analysis of individuals' preference for ecosystem services based on rank-type survey responses. Analysis showed weak agreement in preferences for ecosystem services overall (W=0.15, F=2.33, p=0.003). At least some agreement was expected given that the list in the survey was constructed wholly from the group's input in the first round. This statistic provided a baseline for a posteriori comparison below.

Agglomerative clustering based on spearman correlation of preference for ecosystem services revealed four clusters of individuals who share similar preferences for ecosystem services. Four clusters provided the highest level of within cluster agreement, with no participants excluded. A posteriori analysis revealed a significantly greater level of within group agreement for all four clusters compared to the baseline (Cluster 1: W=0.43, F=2.94, p=0.001; Cluster 2: W=0.85, F=11.82, p<0.001; Cluster 3: W=0.70, F=2.32, p=0.05; Cluster 4: W=0.56, F=3.78, p<0.001). The resulting clusters consisted of five, two, three, and four members, with the deepest disagreement existing between cluster one and all others (Figure 2.2)

To identify the sources of disagreement among groups, responses from the Delphi survey were sorted for each cluster (Table 2.5). Clear delineations emerged from qualitative comparisons of ecosystem service priorities between clusters. Regarding the deepest disagreement, participants in cluster one were classified as having primarily production-oriented, farm- and field-scale expectations, while all

others had expectations for broader suite of ecosystem services (Figure 2.3). For example, feed and livestock production topped the list for cluster one, but neither were included by any other individuals.

A second point of disagreement was related to flood attenuation: no individuals in cluster one or cluster two mentioned flood attenuation when faced with a forced-choice prioritization. A third point of disagreement was related to wildlife, where wildlife was ranked as being important by all participants in cluster three and by no participants in cluster four. Likewise, wildlife received 100% mention in cluster two and no mention in cluster one. A dendrogram of cluster results also illustrates that an individual's affiliation is not absolutely predictive of their expectations for agriculture (Figure 2.2). For example, one individual with an agricultural NGO affiliation was classified outside of the production-oriented cluster. Likewise, federal and state agency affiliates were found across all clusters.

4.1.5 Participant observation

Outside the official context of the case study, participating members disclosed internal "tension" regarding the procedure of forced-choice decisions during the latter Delphi survey rounds. This reaction suggested that at least some of the people held different, perhaps conflicting, expectations in their own minds. So, while the forced-choice method and subsequent analysis projected the most likely disagreements (i.e. production expectations versus other ecosystem services) as being cast between individuals, there was evidence that this same "disagreement" happened internally as well.

4.2 In-depth Interviews

We conducted 37 in-depth, in-person interviews. Interviewees were representative of 15 organizations and affiliations, including farmers associated with the ILTR and a more general assembly of STRIPs stakeholders than in the Delphi survey (Table 2.1). Interviews lasted between 32 and 75 minutes. The interviews yielded a bounty of information regarding values and attitudes towards perennial conservation practices. In this paper, we focused our analysis on themes that di-

rectly address our case study questions stated above. To this end, we present results in three sets: (1) benefits associated with agriculture, (2) land management, and (3) communication issues.

4.2.1 Benefits associated with agriculture

A list of ecosystem services was generated from interview data and found to be similar to the lists associated with the Delphi survey (Table 2.3). All services mentioned in the Delphi survey were mentioned during interviews. However, the interviews generated more vivid and specific descriptions, likely due in large part to the photo elicitation. Many individuals accepted the scenario images as a *real place*, and accordingly the responses became more personal in nature. This attachment suggests that the images allowed participants to start interviews "on the same page" and provided them a better understanding of some of the spatial and biophysical aspects of the scenarios, which would be difficult to convey in a text-based depiction alone.

As in the Delphi survey, ecosystem service items related to water and soil were the most frequently mentioned and were highly favored by a wide range of stakeholders; with water-related services considered the most important overall. Important ecosystem services related to water and soil included fresh drinking water, water bodies for recreation, habitat for aquatic wildlife, regulation of hydrology for flood mitigation, reduced water runoff, prevention of infield water erosion, maintenance of nutrient cycles, long-term maintenance of soil fertility, and carbon sequestration.

Water was viewed as being most important for three reasons: (1) water was described as being essential for life, (2) water quality was described as being an indicator of greater agroecosystem "health", and (3) clean water was seen as a critical component to many other ecosystem services (e.g., aesthetic and spiritual benefits, tourism and recreation, and livestock production). Tying this altogether, a representative from an agricultural NGO described how water acts as an umbrella ecosystem service:

In my mind, ... if you can address things to improve the water quality, then you know your soil's covered and things like the habitat will come along. [Moreover], water quality might have a more general appeal to the public... It just comes down to which one comes first to someone I guess, it's all connected.

The benefits from agriculture were commonly divided by participants into two general categories, environmental and economic, with many participants asking for clarification when prompted to provide benefits; "are you asking for environmental or economic benefits?" While the answer to that inquiry was consistently "any and all benefits to you," given this distinction, the theme of economics took on a much greater role in the interviews than in the Delphi survey. We further characterized responses regarding economics into two themes: (1) financial issues, those pertaining to enterprise scale issues such as net return and risk, and (2) economic issues, those pertaining to landscape- and broader-scale issues of aggregate land use such as regional development and global markets. These themes were not mutually exclusive; rather, participants were discussing economic benefits across a range of spatial and temporal scales.

Financial issues were most frequently referenced as roadblocks to management options other than row crop production, specifically the integration of perennial conservation practices, and especially where taking land out of production was concerned. One person affiliated with an agricultural NGO summed up the juxtaposition as follows:

I don't know that farmers really care one way or the other [about a given management practice]. It is [about] an economic return. Row-crop farmers have to pay cash rent ...the farmer has to pay rent for so many acres and it includes farming up to the edge of the stream. And the owner has to pay the mortgage for the property. It comes down to who is going to extract the cost of not having the economic return. Who is going to pay? People are going to pay cash rent because

> *there is a limited amount of land to farm. That is the crux of the issue, whose hide is it going to come out of.*

The economic issues revealed in interviews can be further divided in two ways based on the connection to perennial land cover. First, increased perennial land cover was generally associated with an increase in regional economic benefits such as increased job opportunities and additional markets such as agrotourism along with additional production-oriented markets. Second, existing economic conditions were seen as constraints to strategically integrated perennial land cover. For example, lack of viable markets for alternative crops and small lots of livestock inherently limit the potential for non-conventional food production.

Benefits of aesthetics and recreation were also more frequently mentioned in interviews than in the Delphi survey. Aesthetics, visual appeal, and/or scenic beauty were mentioned as a potential benefit from agricultural landscapes by the majority of participants (29 of 37). In several instances, the focus on aesthetics was directly attributed to the photo elicitation. One individual associated with an environmental NGO explained their reaction to one scenario:

> *[The] first thing is, since having the pictures, is just the appeal of the landscape as someone who would be passing through on a road or on a bike path. Diversity, animals in the landscape,... trees, ... the water in the landscape, brings out wildlife and provides for other animals,... and all the associated microhabitats and the connections of things, it's all very appealing to the eye. If I was going to paint a picture...*

It became apparent through follow up questioning concerning aesthetics that, for a majority of participants, landscapes that were perceived to provide many benefits were those that were seen as being aesthetically pleasing. As a consequence, the aesthetic value of a place was dependent on an individual's expectations for a landscape.

Aesthetics frequently provided a segue to discussion about recreation and tourism opportunities. The benefits associated with recreation opportunities from agroecosystems were twofold and spanned environmental and economic benefits. Recreation was described, on one hand, as a vector for individual psychological wellbeing; where stakeholders personally desired a landscape in which to go hiking, biking, bird watching, hunting and fishing, etcetera. On the other hand, these activities can also translate to other economic benefits, such as income for local businesses and leasing of hunting rights as a farm enterprise. Moreover, access to aesthetically pleasing landscapes that provide recreation and tourism opportunities was frequently described as being an essential part of thriving rural communities and recruitment of citizens to Iowa.

As in the Delphi survey, participants exhibited mixed valuation and attitudes towards wildlife; with 28 of 37 participants explicitly mentioning wildlife. Wildlife was described most frequently as being a critical component of recreation in Iowa, providing opportunities for hunting, fishing, and bird watching, among other benefits. Wildlife was also mentioned in the context of pollination and integrated pest management, albeit by only a few participants. However, as in the Delphi, many stakeholders did not uphold wildlife as an important criterion for their decision making regarding a balanced landscape, especially when faced with trade-offs in finding a balance between environmental and economic benefits. Wildlife was described by one third of participants as having intrinsic value, although many voiced uncertainty in how to express this benefit relative to other benefits. Several participants stated that their decision-making regarding balance were restricted to benefits that could be measured or monetized. From this stance, they suggested, wildlife-associated benefits could not be strongly considered.

Flooding and flood attenuation was a potential source of disagreement; it was mentioned as being important by half of the interview sample. While this idea was not fully explored in follow-up questions, it became apparent that at least some of the divergence may be rooted in misinformation or misunderstanding regarding

the contribution of agriculture to flooding. Several participants maintained that conventional agriculture has only a minor impact on flooding; moreover, it was described by multiple participants that in some places the extensive subsurface drainage network is expected to increases the water-holding capacity of a landscape and therefore reduce downstream flooding. Conversely, another set of several participants contended that agriculture was highly impactful, citing subsurface drainage networks and reduction in perennial land cover as major contributors to recent flooding in the Midwest U.S.A. Considering all responses, flooding and flood attenuation was also seen to be operating on multiple scales: at the farm and field level, where crop loss and crop insurance are of concern; and at the landscape and regional level, where catastrophic flooding of populated areas was the concern.

Overall, ecosystem services and their associated value were always seen as being dependent on the specific ecological and socioeconomic context at hand. Many responses were followed with caveats such as, "it all depends on," and, "but I would need to know more about the area in order to say for sure." Additionally, benefits were described as dynamic phenomena, whereby values change in response to changes in these contexts. For example, during the sorting exercise, one farmer described:

> This is a little tough, since I've farmed for so many years, the last two or three years have been extremely wet, and there has been a lot of soil erosion which actually means that strips like this [pointing to contour strips in one image], in those sorts of years would have really been a good thing. [On the other hand,] I also find in good or dry years there is very little soil erosion and the point to the strips are of no value at all. It is just taking away some farm ground that could be making you some money because you don't have a soil erosion problem.

Moreover, many participants described benefits as being dispersed across multiple spatial and temporal scales.

4.2.2 Land management

The amount of perennial land cover depicted in a scenario was highly corre-lated with the amount of perceived benefits associated with the scenario (Figure 2.3). When asked to sort the scenarios based on the sum of the perceived benefits associated with each, 76% of participants sorted scenarios precisely following the gradient in perennial cover; two other participants varied only by reversing one pair of numbers (2-1 and 4-3) and may have done so inadvertently. However, the posi-tive trend line associated with mean rank increases at a decreasing rate, suggest-ing a plateau, or in some cases decline, in the accrual of benefits at higher propor-tions of perennials. Nineteen percent (7 participants) responded that too much pe-rennial land cover ultimately compromised the level of perceived benefits and did not associate the scenario with the greatest perennial cover with the greatest per-ceived benefits.

Variance in mean rank can be used as an indicator of agreement and, inter-preted as such, we find strong agreement that the scenario depicting two percent perennial cover was perceived to provide the fewest benefits (Figure 2.3); this holds for the scenario depicting four percent perennial cover as well. It is noteworthy that these two scenarios were not only appraised as providing the fewest benefits, they were also described frequently as, "this looks like what Iowa has now." Conversely, variance was greatest, and therefore agreement was lacking, for the scenario de-picting a majority proportion of perennial cover. The scenario depicting 16% pe-rennial cover was considered most favorable regarding perceived benefits and broad agreement (Figure 2.3).

This trend was also supported qualitatively. In numerous instances, after the sort exercise was introduced to a participant, individuals that eventually sorted the scenarios along the perennial gradient would dismiss the scenarios depicting max-imum row-crop production—2% and 4% percent perennial land cover—sometimes followed with a critical statement; for instance, one state-agency affiliate stated:

These two [scenarios] offer very little beyond production value. And in fact, it is so far skewed towards production that the production benefits are likely compromised - at least they will be in the long-term.

Similarly, of the participants whose sort response did not follow the gradient in perennial cover, five participants critically dismissed the scenario depicting a majority of perennial cover (64% perennial) and three individuals included the 32% scenario in this dismissal. For example, one farmer resoundingly rejected a majority of perennials, stating:

Nothing for me there. Definitely last,

which the individual repeated throughout the interview anytime attention was brought to the scenario with a majority of perennial cover

Two main themes emerged regarding land management practices: (1) landscape-level planning—especially the ability to strategically position agriculture and conservation practices at the landscape scale—is essential and currently lacking, and (2) diversity, in many different contexts, is seen as a key component to ecosystem service management. An agricultural NGO representative summed it up:

I think whenever you are applying practices to account for topography you have a better likelihood of capturing those benefits. Targeting practices to the critical areas will also accumulate benefits better. When you are using natural systems you are creating a diversity of approaches.

All interviewees demonstrated a keen awareness of the role that landscape and regional context can play in ecosystem function. Frequently, participants asked many questions regarding the underlying biogeochemistry of the scenarios, the previous management history, and the surrounding landscape and region, in terms of both ecological and socioeconomic contexts.

Many familiar with on the ground practices suggested that the practices currently "in our tool box" are likely sufficient to increase and enhance ecosystem services compared to the present; however, they attest that approaches for coordinat-

ing management activities at the appropriate scale are currently lacking. Participants asserted that it is futile to expect changes in landscape-scale outcomes without landscape-level planning. Moreover, landscape-level planning was described as necessary to harness the potential for "economies of configuration" (a la Gottfried et al. 1996; Ruhl et al. 2007) in order to optimize between conflicting benefits. From this perspective, landscape-scale planning was recognized as an essential component to ecosystem service management and described variously as a "roadblock", an "opportunity", and a "necessity". While analysis of interview transcripts does not reveal the keys to successful landscape-level planning, it was apparent stakeholders know that landscape-level planning is a critical component of ecosystem service management and many argued that it should be a priority in future research, policy, and practice.

4.2.3 Communication issues

Throughout the duration of interviews, it became apparent that participants were not consistently using a common lexicon. Moreover, as was observed in STRIPs meetings, communication regarding ecosystem services was often relegated to a general level, whereby ambiguous or non-descriptive terminology was used without further clarification. In interviews, when participants were initially asked what benefits they supposed to come from scenario landscape, the most frequent initial response was "ecosystem services," with nothing else offered prior to follow up questioning.

The term diversity is another example of ambiguous communication. Diversity was the most commonly mentioned theme related to land management practices. After participants had listed benefits perceived from the scenarios the next question was, "what land management do you see on the ground that makes you think these benefits are being provided?" The most frequent answer was "diversity." When pressed for clarification, participants variably described diversity as: diversity of land cover types, agricultural diversity (including integrated crops and livestock and diversity of crop type), ecological diversity, biodiversity, habitat diversi-

ty, alternative land uses, multiple farm enterprises, mixed land uses, plant diversity, structural heterogeneity, and more opportunities for people.

Other words or ideas important to the ILTR that appeared to be commonly used with a variety of definitions include: perennial cover, stakeholders, landscape, scale, benefits, ecosystem processes and ecosystem services. Regarding the term ecosystem services, there are differences on both the conceptual level, i.e., what constitutes a benefit in general, and concerning details regarding specific ecosystem services. Interviews illustrate a high probability of miscommunication considering the collective lexicon used by stakeholders.

Misinformation was also apparent regarding the relationships between some ecosystem services and management practices. An example of this was mentioned above in the context of flooding; whereby there appears to be a fundamental disagreement as to the impacts of agricultural land use on flooding.

In summary, interview participants positively associated some level of increase in perennial land cover with an increase in the benefits available. They expressed more emotional responses towards scenarios at the extremes of the gradient, and were overall more accepting of the scenarios in the middle. The imperative need for landscape-level planning was demonstrated both explicitly by direct mention and implicitly through questions regarding landscape-scale elements. However, any successful multi-stakeholder planning will need to overcome apparent communication issues.

5. Discussion

The concept of ecosystem services is suggested to provide a platform for consensus building (Hein et al. 2006; NRC 2010), as is necessary for pragmatic solutions and for establishing the common vision needed for future planning (Ostrom et al. 1999; Kirschenmann 2000; de Groot et al. 2009). While the idea of managing agricultural landscapes for multiple ecosystem services has become increasingly important in policy and research (Cochran 2003; Bills and Gross 2005; Ruhl et al.

2007), the practical application of ecosystem service management has been hampered by a general lack of coordinated on the ground approaches. So we must ask, is the concept satisfying the purpose as a platform? And, if not, what can be done to facilitate success?

This case study offers insight into the trials and tribulations of applying ecosystem services as a platform for agricultural land-use decision making. Our work is distinctive in that we were able to approach the problem from two unique lenses given our mixed-methods approach. We were able to incorporate a wide range of attitudes and viewpoints through participation with a stakeholder group comprised of preeminent agricultural and environmental leaders. The Delphi technique, with its capacity for amalgamating the ideas of local experts, coupled with the photo elicitation by means of a hypothetical Iowa landscape allowed us to capture a place-based perspective on the concept of ecosystem service.

Our results reveal a deep disagreement between stakeholders with production-oriented expectations and ecosystem service-oriented expectations. This result is not a surprise as this disagreement is supported by a well recognized cultural notion cast between agriculture and the environment. As an example of this, Thompson (2010) presents contrasting philosophies for agriculture that are divided in the ways that agricultural management is seen to impact ecosystems services, and how management is viewed in a broader socio-ecological landscape. The results of our quantitative analysis, however, do reinforce our assertion that the people participating in our case study were representative of a diversity of perspectives. Moreover, this divide provides a solid basis from which to search for potential points of consensus; recognition of this divergence is useful in answering the first essential question regarding consensus: consensus among whom?

We find that the ecosystem services related to water filtration and purification, maintenance of soil fertility including erosion control, and food production are the most important ecosystem services for Iowa. Therefore, we suggest that these will continue to be prioritized in agricultural research and policy. Soil and water are

seminal issues key to the preservation of agriculture itself. Moreover, there is a long and strong tradition of soil and water conservation education in the state (Bruening and Martin 1998). As such, conservation efforts that focus on existing practices to address on water and soil related ecosystem service may be able to capitalize on economies of pragmatism (Christenson and Tyndall in press), whereby there are efficiencies associated with using, or tweaking, practices that are already recognized and well accepted. Conversely, management efforts that focus on ecosystem services with divergent support, such as wildlife and flooding, may need to overcome a lack of interest by a majority of stakeholders in order to move forward. Here, further consensus-building may be necessary.

Another way to approach management objectives with divided support may be to address them indirectly with management practices that are intended to enhance other ecosystem services that are well regarded. We found many of the important management practices to be related to multiple ecosystem services, such that many practices serve multiple production objectives or environmental objectives or both. In Chapter 3, we use the data from this case study to more formally spotlight multifunctional management practices. The results presented here, however, are enough to support another phenomenon that may facilitate ecosystem service management: economies of scope (Teece 1980), whereby implementing management practices that enhance two or more ecosystem services at once effectively lowers the average costs of the enhancements.

Landscape-level planning was acknowledged by the participants in our case study as being a critical strategy for the development of multiscalar management objectives. It is understood that in privately-owned and intensively managed landscapes, like those throughout much of Iowa, multifunctionality must emerge from assemblages of management practices implemented by myriad farm owners and operators (Hein et al. 2006, de Groot et al. 2009; Rickenbach et al. 2011). When compared to the management of common pool resources, change initiatives in landscapes composed of numerous, autonomous farms are especially challenged

by a distinct lack of central control. Past conservation initiatives in Iowa and else-where in the U.S.A. have been primarily focused at the scale of individual farms, fields, and patches, and on single-objective outcomes such as removing highly erodible land from production, building soil by reducing tillage, or resting land to re-duce supply and increase crop prices (Secchi et al. 2008).

Multi-objective initiatives that overcome private property boundaries and build landscape networks of agricultural land management practices represent a new paradigm in conservation practice and, as such, pose unique challenges that must be overcome (Kraft 2008; Atwell et al. 2010). In order to achieve landscape-level management within privately held landscapes, property owners and farmers must coordinate across property lines and political boundaries (Hein et al. 2006; de Groot et al. 2007; de Groot et al. 2009; Rickenbach et al. 2011). These relation-ships can form organically, from the bottom up, such as is happening for regional watershed initiatives; for example, five citizens in Ames, Iowa established the Squaw Creek Watershed Coalition, a local watershed initiative, submitted a suc-cessful grant from the local Resource Conservation and Development District, and developed an outreach program to educate local citizens about water quality and to help farmers secure financial assistance for implementing conservation practices. However, thus far, such approaches are limited in scope and accomplishment. Conversely, these relationships can be forged from top-down forces such as policy mandates. Although, in earlier work in this study area by Atwell and others (2009), agricultural and environmental policy makers indicated that there are, at this time, no regionally comprehensive policy fixes that can mandate or coerce perennial landscape change on broad scales.

Nonetheless, the call for landscape-scale approaches reveals a third econ-omy that may facilitate ecosystem service management, economies of configura-tion, where the array of practices on the landscape can be arranged such to pro-vide the optimal delivery of ecosystem services (Gottfried et al. 1996; Ruhl et al. 2007). While individual ownership of land parcel makes perfect optimization nearly

impossible, the idea of an optimal landscape and economies of configuration can be used to guide land-use decision making.

Our research supports the idea that an increase in interpersonal contact between federal and state management agents and potential adopters of conservation practices may be of critical importance in transitioning from a mainly production-oriented agriculture paradigm to an ecosystem service oriented paradigm (Atwell et al. 2009; Larsen unpublished meeting notes). We suggest the spatial scale of landscape-level management in Iowa is aligned most suitably with the operational level of several state and federal agencies, including the Natural Resource Conservation Service, the Soil and Water Conservation Districts, the Iowa Department of Natural Resources and the Iowa Department of Agriculture and Land Stewardship, and regional agricultural and environmental NGOs. Field agents of these agencies are "boundary spanners" working across spatial scales and providing "interactual expertise", by playing the dual roles of translating top-down policy into on the ground management action and providing the conduit for on the ground realities to impact future policy creation (Cash et. al. 2003; Carolan 2006; Atwell et al. 2009). We suggest that in a future of ecosystem service management, these actors will be key brokers of information across scales, bridging differences in understanding and facilitating the use of a common lexicon.

To this point, however, persistent communication barriers hinder the exchange of critical information among stakeholders (Barker 2006; this case study). Similarly, Heal and others (2001) found that the complex, often difficult to communicate, information about ecological patterns and processes hampered the potential to develop site-specific ecosystem service districts. In our study, we found potential communication barriers due to definitions of words and ideas and misinformation regarding the relationships between land management and some ecosystem services. To overcome these barriers, we offer a framework for discussions regarding ecosystem services in an agricultural context (Figure 2.3). This framework was shaped in response to questions frequently posed by participants of the case study.

The framework illustrates six key themes essential to effective communication regarding ecosystem services:

- People - clearly define all stakeholders involved;

- Land - discussions must be place-based;

- Ecosystem services - a full set of relevant ecosystem services must be generated and explicitly defined to identify and optimize trade-offs;

- Management - the avenue through which people can directly impact ecosystem service delivery;

- Ecosystem processes - clarity regarding ecosystem processes that provision specific ecosystem services is necessary for successful management; and

- Expectations and values - must be understood for the range of stakeholders as these impact stakeholder attitudes and behaviors.

Discussions using the framework must be bounded in time and space. The line is dashed to illustrate that all of these themes operate across multiple spatial and temporal scales.

While there is no shortage of frameworks for various considerations of ecosystem services (Hein et al. 2006; de Groot et al. 2007; de Groot et al. 2009; and many others), none were referenced by any of the case study participants, suggesting they may be unavailable or inaccessible to non-academic stakeholders. We suggest this simple, six point, framework maybe useful in framing ecosystem service discussions in a variety of settings, including formulation of research questions and interdisciplinary research endeavors; policy creation, especially where the integration of multiple benefits is concerned; and on the ground land management decision making. While different applications of the framework may focus more or less on a given theme, we assert that all themes must be considered to move any ecosystem service-related discussion forward. The more explicitly each factor is addressed, the more likely ideas will be communicated effectively.

In closing, given that the stakeholders of the STRIPs ILTR are considered a preeminent assemblage of stakeholders representing regional agricultural and environmental interests, we suggest the ILTR is poised to facilitate the development and expansion of the concept of landscape-level planning and as it pertains to Iowa agricultural land management. The STRIPS stakeholders interact professionally in a variety of circumstances, and concepts fortified through the STRIPs ILTR are likely to carry over into real-world decision making. Our results have reinforced the idea that there is a vast sphere of knowledge and experience embodied in the STRIPs group. However, more explicit communication is needed within the group to pave the way for the taking advantage of economies of pragmatism, scope, and configuration.

6. Summary

Our work provides useful insights on potential consensus for transitioning from contemporary agricultural landscapes to multifunctional ones. We suggest that, for Iowa, ecosystem services related to water, soil, and food will continue to be the most important ecosystem services going into the future. This research advances understanding of how the Corn Belt social-ecological systems may respond to change by integrating knowledge from stakeholders who view this system from different scales and perspectives. We reveal an overall agreement in the degree to which there is a perceived capacity to transition conventional agricultural landscapes with recognized and accepted management practices. We find the concept of ecosystem services continues to develop and become a concrete element of agricultural and environmental land management; ecosystem services can serve as a useful platform for land management decision making, with careful considerations.

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8. Literature Cited

Ajzen, I. 2005. *Attitudes, Personality and Behavior*, 2nd edition. New York, NY: Open University Press.

Alexander, R.B., R.A. Smith, G.E. Schwarz, E.W. Boyer, J.V. Nolan, and J.W. Brakebill. 2008. Differences in phosphorus and nitrogen delivery to the Gulf of Mexico from the Mississippi River Basin. Environmental Science & Technology **42** 3:822-830.

Angus, A.J, I.D. Hodge, S. McNally, and M.A. Sutton. 2003. The setting of standards for agricultural nitrogen emissions: a case study of the Delphi technique. Journal of Environmental Management **69**:323–337.

Atwell, R.C., L.A. Schulte, and L.M. Westphal. 2009. Landscape, community, and countryside: linking biophysical and social scales in U.S.A. Corn Belt conservation initiatives. Landscape Ecology **24**:791-806.

Atwell, R.C., L.A. Schulte, and L.M. Westphal. 2010. How to build multifunctional agricultural landscapes in the U.S. Corn Belt: add perennials and partnerships. Land Use Policy **27**:1082-1090.

Barker, S. 2006. Environmental communication in context. Frontiers in Ecology and Environment **4**:328-29.

Bills, N. and D. Gross. 2005. Sustaining multifunctional agricultural landscapes: comparing stakeholder perspectives in New York (US) and England (UK). Land Use Policy **22**:313-21.

Bruening, Thomas and R.A. Martin 1998. Farmer perceptions of soil and water conservation issues: Implications to agricultural and extension education. Journal of Agricultural Education **33**:48-54.

Carolan, M.S. 2006. Science, expertise, and the democratization of the decision-making process. Society and Natural Resources **19**:661-668.

Cash, D.W., W.C. Clark, F. Alcock, N.M. Dickson, N. Eckley, D.H. Guston, J. Jager, and R.B. Mitchell. 2003. Knowledge systems for sustainable development. Proceedings of the National Academy of Sciences of the United States of America **100**:8086–8091.

Cheng, A.T., L.E. Kruger, and S.E. Daniels. 2003. "Place" as an integrating concept in natural resource politics: Propositions for a social science research agenda. Society and Natural Resources **16**:87-104.

Christianson L. and J.C. Tyndall. 2011, *forthcoming*. Seeking a dialog: Targeted technologies for sustainable agricultural systems in the US Corn Belt. Sustainability: Science, Policy & Practice, Submitted November 2010 .

Cochrane, W.W. 2003. *Curse of American Agricultural Abundance: A Sustainable Solution*. Lincoln, NE: University of Nebraska Press.

Cougar, J. 1988. Key Human Resource Issues in IS in the 1990s: Views of IS Executives versus human resource executives. Information and Management **14**: 161-174.

Cumming, G.S., D.H.M. Cumming, and C.L. Redman. 2006. Scale mismatches in social-ecological systems: causes, consequences, and solutions. Ecology and Society **11**: 14. [online] URL: http://www.ecologyandsociety.org/vol11/iss1/art14/

Curtis, I.A. 2004. Valuing ecosystem goods and services: a new approach using a surrogate market and the combination of a multiple criteria analysis and a Delphi panel to assign weights to the attributes, Ecological Economics **50**:163-194.

Daily, G., editor. 1997. *Nature's services: Societal dependence on natural ecosystems*. Washington, DC: Island Press.

Dalkey, N. and O. Helmer. 1963. An experimental application of the Delphi method to the use of experts. Management Science **9**:458-467.

de Groot, J., C.J., Walter, A.H. Rossing, A. Jellema, D. Jan Stobbelaar, H. Renting, and M.K. Van Ittersum. 2007. Exploring multi-scale trade-offs between nature conservation, agricultural profits and landscape quality: A methodology to support discussions on land-use perspectives. Agriculture, Ecosystems, and Environment **120**: 58-69.

de Groot, R.S., R. Alkemade, L. Braat, L. Hein, and L. Willemen. 2010. Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. Ecological Complexity **7**:260-272.

Dillman, D.A. 2007. *Mail and internet surveys: The tailored design method*. 2nd ed. New York: Wiley.

Dinsmore, J.J. 1994. *A country so full of game: The story of wildlife in Iowa*. Iowa City, Iowa: University of Iowa Press

Erffmeyer, R.C., E.S. Erffmeyer, and I.M. Lane. 1986. The Delphi technique: An empirical evaluation of the optimal number of rounds. Group and Organization Studies **11**:120-128.

Gilliom, R.J., J.E. Barbash, C.G. Crawford, P.A. Hamilton, J.D. Martin, N. Na kaga k i, L.H. Nowell, J.C. Scott, P.E, Stackelberg, G.P. Thelin, and D.M. Wolock. 2006, The quality of our Nation's waters—Pesticides in the Nation's streams and ground water, 1992–2001: U.S. Geological Survey Circular 1291: 172.

Gottfried, R., D. Wear, and R. Lee. 1996. Institutional solutions to market failure on the landscape scale. Ecological Economics **18**:133-140.

Harper, D. 2002. Talking about pictures: a case for photo elicitation. Visual Studies **17**:13-26.

Heal, G.M., G. Daily, P. Ehrlich, J. E. Salzman, C. Boggs, J. Hellman, J. Hughes, C. Kremen, and T. Ricketts. 2001. Protecting natural capital through ecosystem service Districts. Retrieved from: http://ssrn.com/abstract=279114 or doi:10.2139/ssrn.279114.

Hein, L., K. van Koppen, R.S. De Groot, , E.C. van Ierland. 2006. Spatial scales, stakeholders and the valuation of ecosystem services. Ecological Economics **57**:209–228.

Helmer, O. 1975. Foreward. In: Linstone, H., & Turoff, M. (eds.), *The Delphi method: techniques and applications*. London, UK: Addison-Wesley.

International Council for Science (ICSU). 2008. *Ecosystem change and human wellbeing*. Research and Monitoring Report.

Imhoff, D. 2007. *Food fight: A citizen's guide to the farm bill*. Healdsburg, CA: Watershed Media.

Iowa Daily Erosion Project. 2010. Iowa State University Environmental Mesonet. Retrieved from: http://wepp.mesonet.agron. iastate.edu/.

Iowa Department of Natural Resources. 2007. The Iowa Wildlife Action Plan Iowa Department of Natural Resources. Retrieved from: http://www.iowadnr.com/wildlife/diversity/plan.html.

Jackson, L.L. 2008. Who designs the agricultural landscape? Landscape Journal **27**:23-40.

Jolson, M. A., and G. Rossow. 1971. The Delphi process in marketing decision making. Journal of Marketing Research **8**:443–448.

Kirschenmann, F. 2000. Questions we aren't asking about agriculture: Beginning a new journey towards sustainable agriculture. Leopold Center for Sustainable Agriculture, Iowa State University. Retrieved from http://www.biotech-info.net/new_vision.html.

Kraft, S. E. 2008. Ecosystem services: A 21st century policy challenge. Choices **23**:26-27.

Liebman M., M.J. Helmers, L.A. Schulte Moore. In press. Integrating conservation with biofuel feedstock production. In: M. Schnepf (ed.), *Managing Agricultural Landscapes for Environmental Quality*. Ankeny, IA: Soil and Water Conservation Society of America.

Legendre P. 2005. Species associations: the Kendall coefficient of concordance revisited. Journal of Agricultural, Biological, and Environmental Statistics **10**:226-245.

Linstone, H. A. 1978. The Delphi technique. In: Fowles, *Handbook of futures re-search.* Westport, CT: Greenwood Press.

Mac, M.J., P.A. Opler, C.E. Puckett Haecker, and P.D. Doran. 1998. Status and trends of the nation's biological resources. 2 vols. U.S. Department of the Interior, U.S. Geological Survey, Reston, Va.

Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-being: Synthesis. Washington, DC: Island Press. Retrieved from: http://www.millenniumassessment.org/documents/document.356.aspx.pdf.

Mutel, C.F., editor. 2008. *A watershed year: Anatomy of the Iowa floods of 2008.* Iowa City, Iowa: University of Iowa Press

Nassauer, J.I., R.C. Corry, and R.M. Cruse. 2002. The landscape in 2025: Alterna-tive landscape future scenarios as a means to consider agricultural policy. Journal of Soil and Water Conservation **57**:44A-53.

Nassauer, J.I., and R.C. Corry. 2004. Using normative scenarios in landscape ecology. Landscape Ecology **19**:343-356.

National Agricultural Statistics Service. 2009. 2009 Iowa agricultural statistics. Re-trieved from:http://www.nass.usda.gov/Statistics_by_State/Iowa/Publications/Annual_Statis tical_Bulletin/2009/index.asp#Crops.

Neuman, W. L. 2003. *Social research*. Washington, D.C.: Resources for the Future Press

Newton, J.L., E.T. Freyfogle, and W.C. Sullivan. 2007 Land, ecology, and democracy: A twenty-first century view. Politics and the Life Sciences **25**:42-56

National Research Council. 2010. *Committee on twenty-first century systems agriculture: Towards sustainable agricultural systems in the 21st century*. Washington, DC: National Academies Press.

Ostrom, E., J. Burger, C. Field, R. Norgaaed, and D. Policansky. 1999. Revisiting the commons: Local lessons, global challenges. Science **284**:278-282.

Palmer M., E. Bernhardt, E. Chornesky, S. Collins, A. Dobson, C. Duke, B. Gold, R. Jacobson, S. Kingsland, R. Kranz, M. Mappin, M.L. Martinez, F. Micheli, J. Morse, M. Pace, M. Pascual, S. Palumbi, O.J. Reichman, A. Simons, A. Townsend, and M. Turner. 2005. Ecology for a crowded planet. Science **304**:1251-1252.

Patton, MQ. 1987. *Qualitative Evaluation and Research Methods*. 2nd edn. Beverley Hills, California: Sage

Peterson, G., C. R. Allen, and C. S. Holling. 1998. Ecological resilience, biodiversity, and scale. Ecosystems **1**:6-18.

Pill, J. 1971. The Delphi method: substance, context, a critique and an annotated bibliography. Socio-economic Planning Science **5**:57-71.

Rabalais, N. N., R.E. Turner, and D. Scavia. 2002. Beyond science into policy: Gulf of Mexico hypoxia and the Mississippi River. Bioscience **52**:129-142.

Rickenbach, M., L.A. Schulte, D. Kittredge, W.G. Labich, and D. Shinneman. In press. Cross-boundary cooperation: a mechanism for sustaining ecosystem goods and services from private lands. Journal of Soil and Water Conservation.

Richey, J.S., B.W. Mar, and R.R. Horner. 1985. The Delphi technique in environmental assessment I. Implementation and effectiveness. Journal of Environmental Management **21**:135-146.

Rogovska, N., and R.M. Cruse. 2011. *Climate change consequences for agriculture in Iowa.* In: Iowa climate change impacts committee, Climate Change Impacts on Iowa 2010. Des Moines, IA: Office of Energy Independence.

Roux, D.J., P.J. Ashston, J.L. Nel, and H.M. MacKay. 2008. Improving cross-sector policy integration and cooperation in support of freshwater conservation. Conservation Biology **22**:1382–1387.

Rowe, G. and G. Wright. 1999. The Delphi technique as a forecasting tool: Issues and analysis. International Journal of Forecasting **15**(4):353-375.

Ruhl J.B., S.E. Kraft, and C.L. Lant. 2007. *The law and policy of ecosystem services.* Washington, DC: Island Press.

Sackman, H., 1975. Delphi Critique. Lexington books, Lanham Maryland, pp. 5

Samson, F.B., F.L. Knopf, and W.R. Ostlie. 1998. Grasslands. In: M. J. Mac, P. A. Opler, C. E. Puckett Haecker, and P. D. Doran (eds.), *Status and trends of the nation's biological resources* Vol. 2. U.S. Department of the Interior, U.S. Geological Survey.

Schmidt, R. 1997. Managing Delphi surveys using nonparametric statistical techniques, Decision Sciences **28**:763–774.

Schulte, L. A., M. Liebman, H. Asbjornsen, and T.R. Crow. 2006. Agroecosystem restoration through strategic integration of perennials. Journal of Soil and Water Conservation **61**:164A-169A.

Schulte, L.A., J, Donahey, L. Gran, T. Isenhart, and J. Tyndall. 2010. People in ecosystems/watershed integration: A dynamic watershed tool for linking agroeco-

system outputs to land use and land cover. Journal of Soil and Water Conservation **65**:33-36.

Secchi, S., J. Tyndall, L. A. Schulte, and H. Asbjornsen. 2008. Raising the stakes: High crop prices and conservation. Journal of Soil and Water Conservation **63**:68-73.

Skulmoski G.J., F.T. Hartman, J. Krahn. 2007. The Delphi method for graduate research. Journal Information Technologies Education **6**:1-21.

Takle, E.S. 2011. Climate Changes in Iowa. In: *Iowa Climate Change Impacts Committee, Climate Change Impacts on Iowa 2010*. Des Moines, IA: Office of Energy Independence.

Taylor, R.G., Pease, J., and W.M. Reid. 1990. A study of survivability and abandonment of contributions in a chain of Delphi rounds. Psychology: A Journal of Human Behavior **27**:1-6.

Taylor-Lovell S., and D.M. Johnston. 2009. Creating multifunctional landscapes: How can the field of ecology inform the design of the landscape? Frontiers in Ecology and the Environment **7**:212-220.

Teece, D.J. 1980. Economies of scope and the scope of the enterprise. Journal of Economic Behavior and Organization,1:3. p. 223.

Thompson, P.B. 2010. *The agrarian vision: Sustainability and environmental ethics.* Lexington, KY: University of Kentucky Press.

USDA NASS. 2007. 2007 Census of Agriculture: United States Summary and State Data, vol 1. Retrieved from: http://www.agcensus.usda.gov/Publications/2007/Full_Report/index.asp.

Veenstra, J.J. 2010. Fifty years of agricultural soil change in Iowa. Dissertation, Iowa State University. Ann Arbor: ProQuest/UMI (Publication No. AAT 3417963)

Walter T., M. Dosskey, M. Khanna, J. Miller, M. Tomer, and J. Wiens. 2007. The science of targeting within landscapes and watersheds to improve conservation effectiveness. In: M. Schnepf and C. Cox (eds), *Managing Agricultural Landscapes for Environmental Quality: Strengthening the Science Base* (pp 63-89). Ankeny, IA: Soil and Water Conservation Society.

Ward, J. H. 1963. Hierarchical groupings to optimize an objective function. Journal of the American Statistical Association. **58**: 234–244.

Williams P. and C. Webb. 1994. The Delphi technique: a methodological discussion. Journal of Advanced Nursing **19**:180-186.

Wilson, B. 1995. Metaphors for instruction: Why we talk about learning environments? Educational Technology **35**:25-30.

Yin, R. 1994. *Case study research: Design and methods*, 2nd ed. Beverly Hills, CA: Sage Publishing.

9. Tables

Table 2.1

Organizations represented in the case study.

Organization	Delphi	Interview
Iowa Corn Growers Association[1]	X	
Iowa Department of Agriculture and Land Stewardship[5]	X	X
Iowa Department of Natural Resources[5]	X	X
Iowa Environmental Council[2]	X	X
Iowa Farm Bureau Foundation[1]	X	X
Iowa Natural Heritage Foundation[2]	X	X
Iowa Prairie Network[2]	X	
Iowa Soybean Association[1]	X	X
Iowa State University[4]	X	X
Leopold Center for Sustainable Agriculture[4,5]		X
Practical Farmers of Iowa[1]	X	X
Prairie Rivers of Iowa Resource Conservation and Development Council[3]	X	
The Nature Conservancy[2]	X	X
Trees Forever[2]	X	
United States Department of Agriculture - Agricultural Research Service[4]	X	X
United States Department of Agriculture - Forest Service[3]	X	
USDA- Natural Resources Conservation Service[3]	X	X
White Rock Conservancy[1,2]		X
Other - including full-time farmers		X

1 - Agricultural NGO; 2 - Environmental NGO; 3 - Federal Agency; 4 - Research Organization; 5 - State Agency

Table 2.2

Affiliations represented in the Delphi survey.

		Agriculture NGO	Environmen-tal NGO	Federal Agency	Research Entity	State Agency
			Affiliation			
Number of participants	All	4	7	4	2	3
	R1	2	4	2	1	2
	R2	3	4	2	2	3
	R3	2	5	3	2	2*

*attrition due to retirement

Table 2.3

Ecosystem services important to and obtainable from Iowa's agricultural land-scapes, presented as ranked by participants in round two of the Delphi survey. All items on this list are important; however, final rank was calculated by multiplying percent-who-mention by mean rank for a clearly ordered presentation. Ecosystem services in bold text were identified as being most important in the third round of Delphi.

Ecosystem Service	Final Rank	Mean Rank	Percent Who Mention
Water filtration and purification	**1**	3.4	0.79
Erosion control	**2**	3.6	0.71
Healthy/wholesome food production	**3**	2.6	0.64
Maintain soil fertility	**4**	2.2	0.57
Flood attenuation	5	1.1	0.50
Wildlife	6	1.3	0.36
Nutrient cycling	7	1.3	0.29
Feed production	9	1.1	0.29
Aesthetic and/or spiritual benefits	8	0.9	0.36
Carbon sequestration	10	1.0	0.29
Livestock production	11	0.6	0.36
Tourism & recreation opportunities	12	0.4	0.21
Biomass feedstock for biofuel	13	0.5	0.21
Pollination	14	0.4	0.21
Waste treatment	15	0.4	0.07
Fiber production	16	0.2	0.07
Pest control	17	0.1	0.07

Table 2.4

Land management practices important for maintaining and enhancing ecosystem services from agricultural lands in Iowa, presented as ranked by survey participants in Delphi round two. Practices in bold text were identified in the third round of Delphi as being both linked to a broad range of ecosystem services and accepted by a range of stakeholders.

Ecosystem Service	Final Rank	Mean Rank	Percent Who Mention
Landscape level planning	1	2.7	0.64
Riparian buffers	2	2.4	0.64
Diverse crop rotations	3	2.7	0.57
Restored wetlands	4	1.6	0.57
Perennial cropping systems	5	2.0	0.43
Strips of perennials	6	1.4	0.57
Increase livestock numbers on the land	7	1.8	0.43
Cover crops	8	1.4	0.50
No-till or minimal tillage	9	1.7	0.36
Restored native grasslands	10	1.3	0.36
Best management practices for manure and water mgmt	11	0.6	0.29
Stream restoration	12	0.5	0.36
Bioreactors	13	0.4	0.14
Traditional terraces and grassed waterways	14	0.4	0.14
Biomass crops raised as biofuel feedstock		0.0	0.00
Sensitive lands buffer		0.0	0.00
Standard organic agricultural methods		0.0	0.00

Table 2.5

Ecosystem service items sorted into four clusters as identified in agglomerative cluster analysis.

Cluster/Ecosystem Service	Final Rank	Mean Rank	Percent Who Mention
Cluster 1			
Feed production	1	3.0	0.80
Livestock production	2	1.8	1.00
Healthy/wholesome food production	3	3.0	0.60
Erosion control	4	2.6	0.60
Maintain soil fertility	5	2.6	0.60
Water filtration and purification	6	1.8	0.60
Biomass feedstock for biofuel	7	1.2	0.40
Tourism & recreation opportunities	8	0.6	0.40
Aesthetic and/or spiritual benefits	9	1.2	0.20
Nutrient cycling	10	1.0	0.20
Waste treatment	11	1.0	0.20
Carbon sequestration	12	0.6	0.20
Fiber production	13	0.6	0.20
Flood attenuation		0.0	0.00
Pest control		0.0	0.00
Pollination		0.0	0.00
Wildlife habitat		0.0	0.00
Cluster 2			
Erosion control	1	4.5	1.00
Wildlife habitat	2	4.5	1.00
Maintain soil fertility	3	4.0	1.00
Pollination	4	2.0	1.00
Nutrient cycling	5	2.5	0.50
Water filtration and purification	6	2.5	0.50
Aesthetic and/or spiritual benefits	7	0.5	0.50
Pest control	8	0.5	0.50
Biomass feedstock for biofuel		0.0	0.00
Carbon sequestration		0.0	0.00
Feed production		0.0	0.00
Fiber production		0.0	0.00
Flood attenuation		0.0	0.00
Healthy/wholesome food production		0.0	0.00
Livestock production		0.0	0.00
Tourism & recreation opportunities		0.0	0.00

Table 2.5 (continued)

Waste treatment		0.0	0.00
Cluster 3			
Water filtration and purification	1	5.3	1.00
Healthy/wholesome food production	2	3.3	1.00
Maintain soil fertility	3	3.3	1.00
Erosion control	5	3.7	0.67
Flood attenuation	6	2.0	1.00
Carbon sequestration	7	0.3	0.33
Aesthetic and/or spiritual benefits		0.0	0.00
Biomass feedstock for biofuel		0.0	0.00
Feed production		0.0	0.00
Fiber production		0.0	0.00
Livestock production		0.0	0.00
Nutrient cycling		0.0	0.00
Pest control		0.0	0.00
Pollination		0.0	0.00
Tourism & recreation opportunities		0.0	0.00
Waste treatment		0.0	0.00
Cluster 4			
Water filtration and purification	1	4.3	1.00
Erosion control	2	4.3	0.75
Flood attenuation	3	2.5	1.00
Healthy/wholesome food production	4	2.8	0.75
Carbon sequestration	5	2.5	0.50
Nutrient cycling	6	2.0	0.50
Aesthetic and/or spiritual benefits	7	1.3	0.75
Tourism & recreation opportunities	8	0.8	0.25
Pollination	9	0.5	0.25
Biomass feedstock for biofuel	10	0.3	0.25
Feed production		0.0	0.00
Fiber production		0.0	0.00
Livestock production		0.0	0.00
Maintain soil fertility		0.0	0.00
Pest control		0.0	0.00
Waste treatment		0.0	0.00
Wildlife habitat		0.0	0.00

10. Figures

STRIPs
Integrated Long-Term
Research Project

The Case Study: Ecosystem Services in Iowa

**Assessment
of Ecosystem
Services**

Delphi R1 — Analysis and Feedback

Delphi R2 — Analysis and Feedback

Delphi R3 — Analysis and Feedback

Non-classical Delphi Analysis

**Evaluation of
Agricultural
Practices**

Scenario development

Interviews

Integration of mixed-methods

Outputs

**Framework for ecosystem service management
Management priorities for Central Iowa**

Figure 2.1

Framework for case study work. Top - the case study is based in an integrated long term research project, and stakeholders of the project served as case study participants. Left - a three round Delphi study was conducted to assess the importance of ecosystem services. Following the Delphi technique, the analysis of one round was used to inform the create of the next. Between each round, results were reported back to the group. Right - interviews, utilizing photo elicitation, were used to evaluate agriculture and conservation practices. Bottom - by combining data from methods, we are able to provide a framework for ecosystem service management to the project group, and develop a set of management priorities for Iowa.
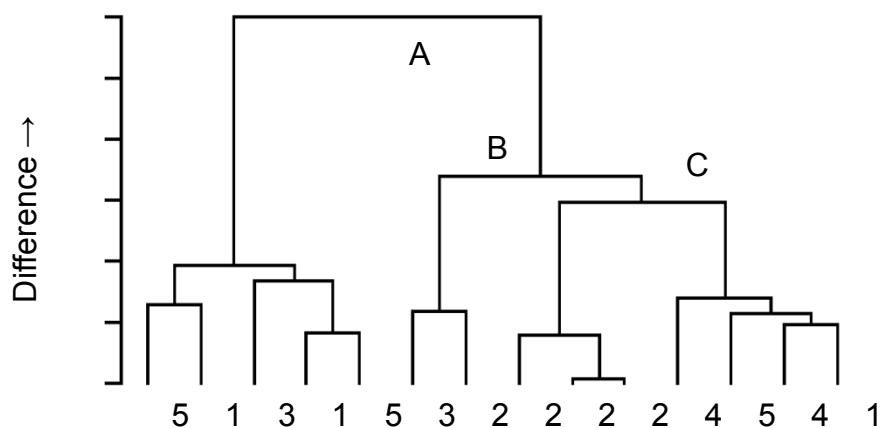
Figure 2.2

Dendrogram illustrating agglomerative clustering based on Spearman correlation of preferred ecosystem services. Individuals are labeled numerically indicating their affiliation as follows: 1 - Agricultural non-governmental organization (NGO), 2 - Environmental NGO, 3 - Federal Agency, 4 - Research Organization, and 5 - State Agency. Qualitative analysis was used to explain the major points divergence: (A) between production expectations and expectations for other ecosystem services, (B) between mention of flooding and no mention of flooding, and (C) between mention of wildlife and no mention of wildlife.

Figure 2.3

Mean rank results from the sort exercise for all interviews. The trend line supports a positive, plateauing relationship between ecosystem services and perennial land cover. Error bars represent variance as an indicator of agreement.
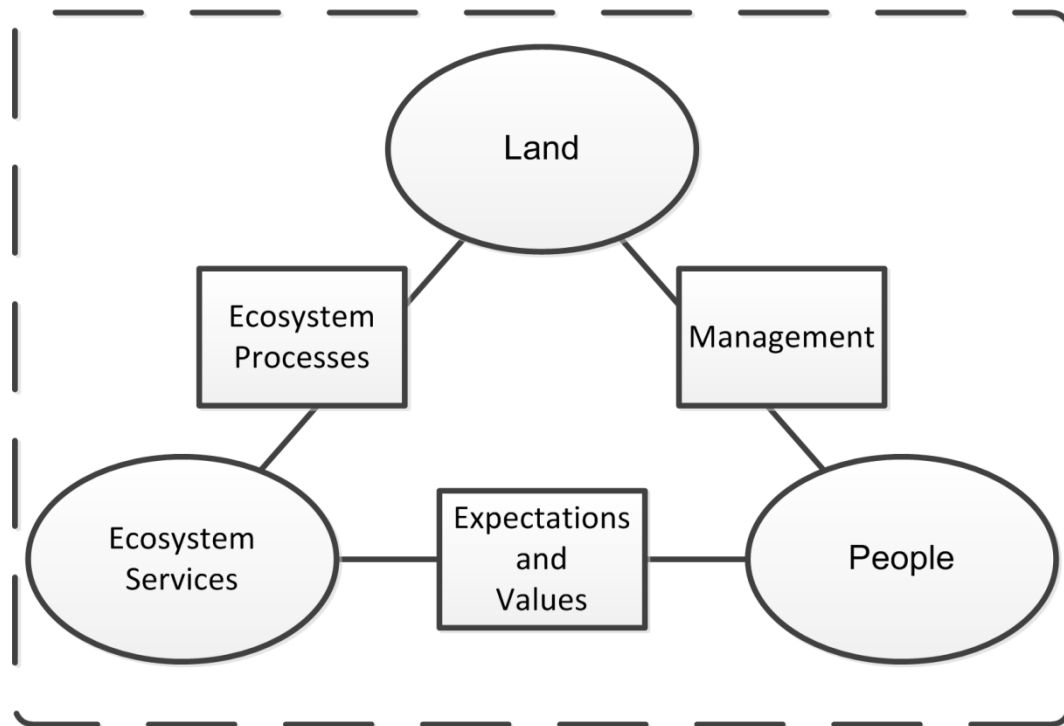
Figure 2.4

Framework for discussions regarding ecosystem services, developed from analysis of themes present in questions throughout the Delphi survey and interviews. The six major points for discussions regarding ecosystem services are: People - clearly define all sta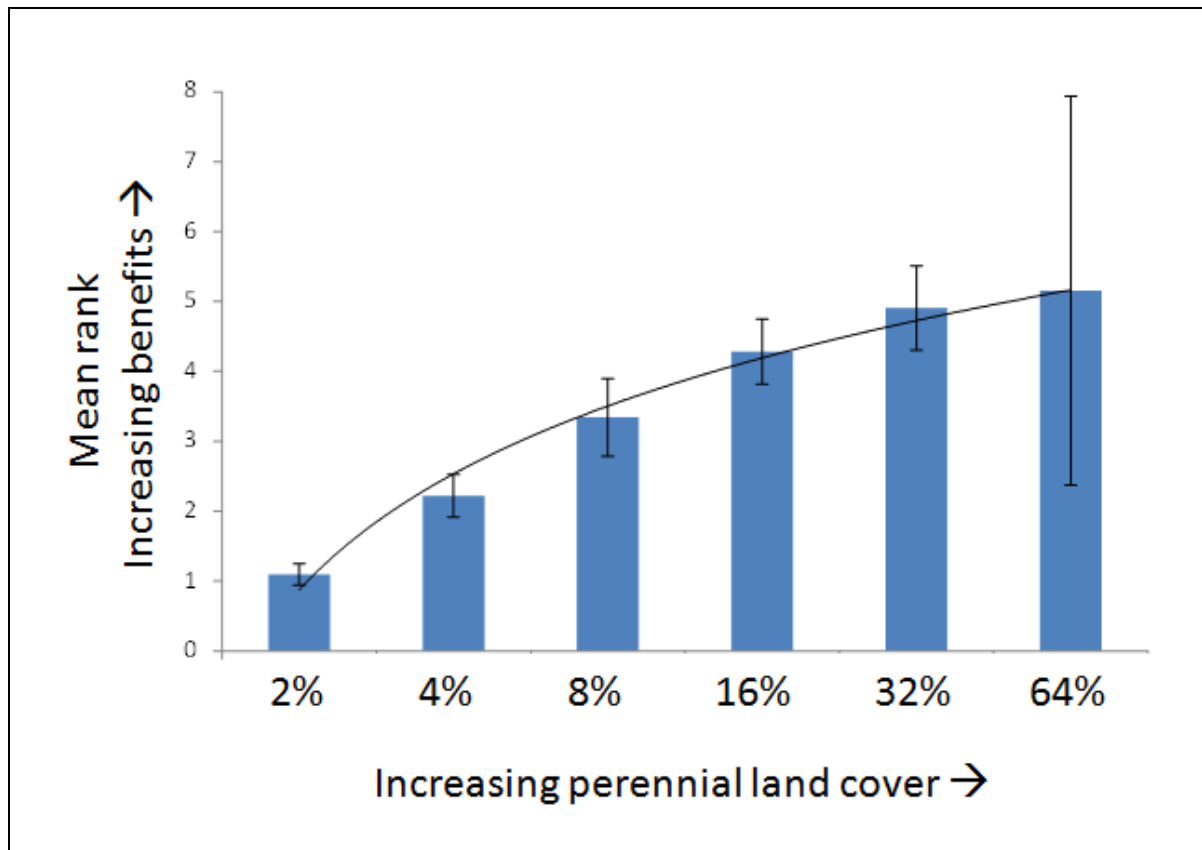keholders involved; Land - discussions must be place-based; Ecosystem services - a full set of relevant ecosystem services must be generated and explicitly defined to identify and optimize trade-offs; Management - the avenue through which people can directly impact the delivery of ecosystem services; Ecosystem processes - clarity regarding ecosystem processes that provision specific ecosystem services is necessary for successful ecosystem service management; and Expectations and values - must be understood for the range of stakeholders as these impact stakeholder attitudes and behaviors. The framework is surrounded by a box to suggest that the discussion must be bounded in time and space; though line is dashed to illustrate that all of these themes operate across multiple spatial and temporal scales.

CHAPTER 3
PRIORITIZING MANAGEMENT PRACTICES TO MEET PRODUCTION AND ECOSYSTEM SERVICE GOALS IN PARCELIZED AGRICULTURAL LANDSCAPES

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Abstract

Current recommendations for enhancing the delivery of ecosystem services from agricultural landscapes highlight the need for approaches coordinated over the landscape scale. However, the subdivision of landscapes into private ownership parcels poses a significant barrier to management efforts at this scale. The variety of objectives sought by private landowners across landscapes creates a fragmented management mosaic and operationally feasible approaches for ecosystem services management are lacking. We developed a framework for the prioritization of land management practices based on "multifunctionality" of management practices and "consensus" regarding the merits of the practice. We intend this framework to inform the development of a place-based toolbox for achieving both farm-scale and landscape-scale priorities with the same practices. As an example application of the framework, we apply data from a case study of regional leaders from agricultural and environmental arenas in Iowa, U.S.A.—a state dominated by agriculture—to determine management priorities for Iowa.

Keywords: Environmental decision making, Iowa, Multifunctional agriculture, Stakeholder participation, Targeted conservation, Management objectives, Decision making framework

1. Introduction

Faced with heightened social expectations for ecosystem services, agriculture in the 21st century is expected to not only produce food, feed, and fuel, but also to maintain and enhance the delivery of additional, largely public, environmental benefits (Pretty 2002; Cochrane 2003; MEA 2005; ICSU et al. 2008, NRC 2010). However, many of these socially-desired ecosystem services, such as fresh drinking water and flood attenuation, are coupled to ecological processes that function at scales broader than that of typical farm management (Hein et al. 2006; deGroot et al 2010). Consequently, these ecosystem services can only come about as the aggregate result of numerous, individual management practices deployed at farm scales (Hein et al. 2006; Taylor-Lovell and Johnston 2009). As such, current recommendations for enhancing the delivery of ecosystem services from agricultural lands focus on the need for coordinated approaches that engage stakeholders across scales (Ruhl et al. 2007; Newton et al. 2007; NRC 2010).

At the same time, there is a growing body of literature documenting that the spatial arrangement of management practices on the land is key to the provision of many ecosystem services (Doskey et al. 2002; Schulte et al. 2006; Walter et al. 2007; Doskey et al. 2008). For example, Doskey and others (2008) show that the width required for a riparian buffer strip to effectively trap sediment varies depending on slope, soils, and cover type of the adjacent land. Practical application of this sort of knowledge allows for the targeted placement of conservation practices, whereby practices are strategically located in order to concurrently maximize ecological benefits and minimize economic costs (Walter et al. 2007). For example, targeting conservation practices that provide wildlife habitat along wildlife migration routes have been shown to have a greater positive impact on wildlife populations than practices that have been arbitrarily placed (Groves 2003). However, despite the increasing ability to make science-based decisions regarding the strategic placement of practices, conservation policy and the payment schemes related to such practices largely remain haphazard and non-targeted (Secchi et al. 2008).

The subdivision of land into ownership parcels has, thus far, presented a significant barrier to coordinated management efforts (de Groot et al. 2010; Atwell et al. 2010). The variety of objectives that landowners hold for their properties creates a fragmented management mosaic over landscapes; whereby decision making lacks connectivity and involves a diverse array of expectations, attitudes, knowledge, skills, and approaches (Cheng et al. 2003; Ajzen 2005; Clayton and Brook 2005). Landowners' expectations for the land can vary widely depending on both the socioeconomic context and the scale and time at which benefits are being assessed (Newton et al. 2007). Often, landscape-scale objectives are viewed as being incongruent with farm-scale objectives, especially when taking land out of production is concerned (Chapter 2), and the mix of ecosystem services available from a piece of land, and their value, is ultimately dependent on the scale of analysis, and therefore efforts toward full valuation are tenuous at best (Ruhl et al. 2007; Balmford et al. 2011). Furthermore, to date, there are few property laws governing ecosystem services, and therefore they are innately vulnerable to under-provision and over-exploitation (Ruhl et al. 2007). For these reasons, operationally feasible approaches for coordinated ecosystem service management on privately owned agricultural lands are largely lacking.

Despite the lack of progress to date, the need to develop successful approaches to effectively target conservation practices over landscape and broader scales is increasingly urgent. The current economic conditions of high land values and crop prices create a tenuous future for the traditional mechanisms of achieving conservation (Secchi et al. 2008; NRC 2010). Our research is grounded in the premise that, if such coordinated management is to succeed, decision-making on the use agricultural lands must engage a broad group of stakeholders. Research and theory in the environmental social sciences show that decision making is based on a complex interaction of values, attitudes, and norms that are in turn shaped by a biophysical, social, and cultural context (Cheng et al. 2003; Ajzen 2005; Clayton and Brook 2005). Therefore, because they are important drivers of change, such socio-cultural factors must be incorporated into agricultural land management and

planning. At a minimum, stakeholder groups engaged should include farmers and farm owners, agricultural businesses, scientists, policymakers, and the public and their representatives (Jackson 2008; Palmer et al. 2004).

The goal of our research was to analyze how farm-scale management practices can be best used to achieve ecosystem service objectives across scales. We build on a case study of stakeholders' opinions regarding the relationship between ecosystem services and agricultural land management in Iowa, U.S.A. (Chapter 2). In the case study, we engaged regional leaders from agricultural and environmental organizations to characterize their expectations for the delivery of ecosystem services and the management practices effective at enhancing ecosystem services in Iowa—now and into the future.

Here we provide a framework for the prioritization of land-management practices for meeting farm and landscape goals. Adapted from a recent paper on the science of ecosystem services (Balmford et al. 2011), our framework is rooted knowledge gained in the case study, where multifunctionality and consensus were identified as important factors for coordinated management efforts. Using this framework, we analyze the suite of ecosystem services and management practices discussed in the case study to produce a toolbox for multiscalar ecosystem service management in Iowa.

2. Framework for prioritizing land management practices

Recent work by Balmford and others (2011, page 169) introduced a framework for prioritizing scientific research pertaining to ecosystem services based on two criteria: importance to human-well being and feasibility of analysis. We find this framework useful for clearly identifying and communicating ecosystem service priorities, and have adapted their approach for analysis of management practices pertaining to ecosystem services. In shifting our focus from science to management, we recast the criteria used by Balmford and others (2011) according to two themes that emerged from our case study: management practices that (1) simulta-

neously enhance multiple ecosystem services, especially ecosystem services across scales, and (2) are well regarded by diverse stakeholders, which possibly provide points of consensus among divergent perspectives (Chapter 2). As such, our framework prioritizes management practices according to the criteria:

- *Multifunctionality*: The capacity for a management practice to address multiple management objectives.
- *Consensus*: The degree to which the merits and usefulness of a practice are agreed upon.

Following Balmford and others (2011), practices were ranked on a three-point scale within each criterion. All possible combinations of these two criteria results in a five-point overall priority score (Figure 3.1); (A1) very high priority, (A2 and B1) high priority, (A3, B2, and C1) moderate priority, (B3 and C2) low priority, (C3) and very low priority. Here, the description of the three-point scales is presented generally; below we use insights from the case study to define them in greater detail (see section 3.4).

3. Methods

Our case study provided data through two methods commonly used in the social sciences: (1) a three-round Delphi survey (n=20) (Dalkey and Helmer 1963; Skulmoski et al. 2007), and (2) individual interviews (n=37), facilitated with photo elicitation (Harper 2002; Nassauer 2002; Nassauer and Corry 2004). The Delphi survey initially solicited open-ended responses and subsequently employed a series of rank-type questions to determine the perceived importance of ecosystem services, land management practices, and the relationships among these. Individual interviews used photorealistic images of a series of landscape scenarios depicting perennial conservation practices (such as restored wetlands, riparian buffers, and alternative biomass production) to elicit detailed discussion of participants' view of the relationship between ecosystem services, land cover, and land management practices (see Chapter 2 for a more complete description of case study methods).

Here, we utilize the data generated from both methods to inform the prioritization framework.

3.1 Identifying management practices

Land management practices included in this assessment were determined by first analyzing all applicable survey and interview responses for reference to such practices. Next, the list of practices mentioned was pared to include only those for which enough information existed to confidently inform the framework. Management practices were characterized across three themes of scale, identified through the case study: (1) field periphery, (2) farm scale, (3) landscape scale, or any combination of these according to the context in which they were discussed in interviews. Finally, as landscape-scale planning was established as major theme in the case study (Chapter 2), all management practices were analyzed for reference to mention of association with landscape-level planning.

As noted in the case study (Chapter 2), not all of our practices are practices in the strict sense of the word, i.e., the actual application or use of a method. Some of items in the following assessment may be better described as strategies or approaches, i.e., a plan of action or a way of dealing with something. Here we use a single term for simplicity's sake.

3.2 Linking land management to ecosystem services

The presence or absence of a relationship between a land management practice and an ecosystem services was established by analyzing all applicable survey and interview responses for reference to management practices and their relationship(s) to 14 ecosystem services of key importance to stakeholders in Iowa as revealed in the Delphi survey. Given the type and amount of data gathered, we were able to further classify existing links dichotomously as being either strong or weak. Whenever possible, the strength of a given link was determined numerically (relative to other practices) using rank-type data from the Delphi survey. Qualitative links were established by a combination of frequency-of-mention statistics, direct statements by study participants regarding the strength of the relationship, and

analysis of interview transcripts and interviewer notes on interviewee behavior, such as changes in vocal inflection, gestures, and repetition in responses indicating emphasis or emotional responses.

3.3 Identifying agreement

The first step in addressing issues of consensus is answering the question "consensus among whom?" Cluster analysis performed on Delphi survey data provided quantitative evidence for divergence in opinion between individuals with primarily expectations for farm-scale, production-oriented services and those with primarily expectations for other ecosystem services (Chapter 2). Priority ecosystem services articulated by the latter group included flood attenuation, wildlife habitat, and carbon sequestration, which are largely garnered over broad spatial scales. We analyzed for potential points of consensus among these two groups.

Secondly, to characterize the levels of agreement within and between these groups, we sorted lists of management practices according to the individuals in these groups. Levels of agreement were characterized as strong, moderate, and weak. For 14 practices articulated in the second round of the Delphi survey, we were able to make quantitative comparisons of agreement within each group using *a posteriori* concordance analysis (Kendall's W), and compared lists of practices directly across clusters.

For practices where direct comparisons were not available, interview data were used to identify the context(s) in which certain practices were being discussed. Using this information, we were able to establish, for each instance, whether a practice was considered to meet primarily production-centered or environment-centered goals. We estimated the level of agreement based on frequency of mention and context of mention; for example, whether a practice discussed in favorable terms or not.

3.4 *Parameterizing the framework*

Prior to applying our case study to the prioritization framework, we further defined the three-point rank scale of the framework using parameters identified in case study data presented above (Table 3.1). The consensus criterion was parameterized along the aforementioned divide between production-centered and an environment-centered perspectives for ecosystem services, and the agreement within and across these groups. The multifunctionality criterion was parameterized based on the cumulative number and strength of linkages between management practices and ecosystem services. Furthermore, as tradeoffs between production objectives and environmental objectives are quintessential (Chapter 2), the highest rank of multifunctionality was established as being able to meet both.

4. Results

4.1 *Typology of management practices for Iowa*

Our case study data provided an abundance of information on 31 management practices (Table 3.2). These practices were identified as operating at or across three spatial scales, with 15 practices identified as operating at multiple spatial scales (Table 3.2). Sixteen practices were described as requiring landscape-level planning in order to effectively capture the related benefits (Table 3.2).

According to our study participants, many management practices were related to multiple ecosystem services (Table 3.3). Twelve practices were linked to 10 or more ecosystem services. Those identified as being related to the greatest number of ecosystem benefits included restoration of native grasslands and wetlands, various forms of riparian buffers, utilization of livestock to meet both production and conservation objectives, increased crop diversity, and landscape-level planning. Conversely, 10 of the 31 practices were linked to five or fewer ecosystem services.

There was strong agreement from the production-centered perspective on the importance of 12 practices for enhancing ecosystem services. Similarly, there

was strong agreement from the environment-centered perspective on the importance of 13 practices (Table 3.4). Seven of these practices overlapped between perspectives, including, variable width riparian buffers, restricted livestock access to streams, cover crops, grazing animals as a conservation tool, increased crop diversity, targeted perennial conservation practices, and landscape-level planning. The two perspectives were in absolute opposition (the lowest level of consensus) over six practices. Multiple species riparian buffers and restored native grassland were strongly agreed upon as being important from an environment-centered perspective and weakly viewed from a the production side The converse was true for bioreactors, installation of drainage tile, no till and minimum tillage, and precision agriculture. Regarding the latter two practices, several case study participants representing the environmental standpoint acknowledged the practices to be useful, but described them as representing a minimum level of environmental stewardship, and did not considered them to enhance ecosystem services, per se.

4.2 Ecosystem service management priorities for Iowa, U.S.A.

The case study data were easily applied to the prioritization framework (Table 3.5). Seven of the 31 management practices assessed were found to be very high priority for Iowa (Table 3.5, dark green). These practices are: cover crops, grazing animals as a conservation tool, increased crop diversity, restored wetlands, targeted integration of perennials, increased numbers of livestock "on the land", and landscape-level planning. Conversely, seven practices were identified as low or very low priority (Table 3.4, orange and red). Cover crops—identified as operating at the farm-scale—were the only very highly prioritized management practice at a scale other than landscape. However, high, moderate, and low priorities were evenly distributed across all scales.

5. Discussion

This prioritization information is intended to inform the development of place-based toolboxes for multiscalar ecosystem service management; which, in turn may be useful for guiding research efforts and policy creation, as well as for allocating

resources devoted to the management of agricultural landscapes (Hein et al. 2006; de Groot 2010). Applying this framework in prioritizing management practices for Iowa demonstrates that there are opportunities for enhancing ecosystem services at multiple scales and across levels of management organization. Given this statement of proposed effectiveness, here we address two questions: How is the toolbox we developed different from existing ones? And, what are the next steps in its application? We conclude with some discussion on the management implications of our work.

Our approach is unique in several ways. It provides a holistic perspective on a wide array of available management practices. Our prioritization explicitly integrated input from a broad range of agricultural stakeholders. Additionally, during data collection and analysis, management practices under consideration were developed and discussed relative to one another, offering comparability across management scales, a variety of objectives, and individual expectations. Finally, depending on the data used to inform the framework (more on this later) the outcome is place-based; that is to say, founded in a specific socioeconomic and ecological context. Place is known to be a critical element for successful land planning and management (Chen et al. 2003; Leeuwis 2004). While explicitly Iowa-based, our list of priority management practices may still be too general. Nevertheless, this explicit foundation in place is a key feature that separates lists such as generated through our approach from existing practice lists.

This approach differs from other such lists for prioritizing management practices in its capacity to allow for innovation in the use of practices and a multiplicity of applications. The multifunctionality criterion overtly focuses on practices that can be used to manage for multiple objectives. This flexibility to take into account multiple objectives for a given practice is another key feature of our approach.

As an example of how our prioritization framework differs from current prioritization applications, consider the Environmental Quality Incentives Program (EQIP) practice list(s), provided through the Natural Resource Conservation Service

(NRCS). While these lists are county-based, they often overlook the full ecological and socioeconomic context to be considered place-based; specificity is often limited to incorporating general information regarding the dominant soil types and topography of an area. Furthermore, practices are restricted to serving only a narrow range of objectives. Case in point, consider prairie buffer strips on the contour (a la the STRIPs project outlined in Chapter 2), referred to as vegetative treatment strips by the NRCS (practice number 635). These strips are the main research object of the stakeholder group represented in this our case study. However, the practice is not a viable EQIP practice in Story County Iowa (NRCS EQIP 2011), the home of Iowa State University and the lead investigators of the research project. This is not for lack of topographic relief, erosion, or utility of perennial vegetation. The reason the practices is not supported in Story County is because practice 635 is limited to use in manure management applications, and Story County isn't considered a livestock producing county. Despite a multitude of ecosystem service outcomes related to prairie buffer strips, these merits are not acknowledged in the current paradigm of resource allocation.

As the demand for multiple ecosystem services increases, extant agricultural and conservation programs must be able to incorporate and expanding and evolving suite of objectives. We find our approach to be complimentary and not contradictory to other methods of prioritization. Given that our approach successfully incorporates the necessary aspects of people, place, and multiple objectives into prioritization of management practices, we suggest our approach could be useful in adding flexibility to current programs, such as EQIP, and the associated practice list(s).

A crucial aspect of the application of this framework is the identification of relevant ecosystem services and land management practices important to an area. This can be achieved in numerous ways; for example, through individual brainstorming, focus groups, or literature review. The flexibility of the framework allows for catering the priority criteria to a given system; for instance, alternative divergent

perspectives could be considered to define the consensus criterion. For example, where grass-based and row-crop-based agriculture coexist, as in Petrehn (2011), tension sometime exists between these two agricultural perspectives. In that case, the priority framework could be used to find commonalities between them. Chapter 2 (Figure 2.4) offers a general framework for discussions regarding ecosystem services and land management, and that may be useful for generating lists of ecosystem services and management practices for an area.

What are the next steps in the application of this toolbox? In our case study, several individuals in the role of coordinating management efforts across scales, including agents of the NRCS and commodity groups, made clear that there is a need for landscape-level initiatives that have "something to offer everyone", even those managing land that is not targeted for conservation practices. In this circumstance, considering the scale of practices may important to ensure that any coordinated efforts offer practices for all by including practices at the field periphery, farm scale, and landscape scale. For example, consider a hypothetical landscape-level clean water initiative aimed at implementing a series of prairie buffer strips across property boundaries. For a farmer with highly productive flat ground it may not make sense to install prairie buffer strips designed for hill slope protection. The farm scale implementation of cover crops and precision agriculture, however, are also related to clean water goals, and therefore may offer the farmer to a means of participating in the initiative. Offering something for everyone is also crucial for promoting active civil engagement in issues related to ecosystem services (Sullivan 2007; NRC 2010). Moreover, while many farmers share the same goals and motivations, different farmers may choose different technological or management approaches (Vanclay and Lawrence 1994; Bell 2004), and therefore, multiple practices are likely needed on order to offer something for everyone.

The prioritization approach can also be used to identify areas where consensus building may be needed to foster pragmatic solutions. For example, precision agriculture was determined to be low priority according to our assessment, due in

large part to lack of mention by non-production oriented stakeholders. However, in a recent stakeholder meeting of the case study group, farmers and commodity group representatives lauded the technologies related to precision agriculture and the fine scale at which managers can now monitor yields, soil conditions, nutrient application rates, and etcetera. As the discussion continued, one individual noted that precision agriculture technologies may serve as an important tool for implementing targeted/precision conservation. All that was needed to uncover this latent agreement was a dynamic conversation. The same might be true encouraging broad support for bioreactors and restored native grasslands.

This example, however, exposes a caveat of the framework. Prioritization based on our proposed framework is idealistic and plastic rather than definitive. In reality, management priorities will vary based on the best available knowledge, resources at hand, constraints within the contemporary system, socio-cultural norms, and the behavior and attitudes of the people involved (Cheng et al. 2003; Clayton and Brook 2005; Newton et al. 2007). In addition, like ecosystem services, priorities are not static but dynamic across time and space.

Moving forward, we need to compare these priority practices to land cover data regarding what exists on the ground. Additionally, priorities should be compared to existing conservation incentive programs to identify paths or roadblocks to accessing incentives. Comparing these priorities to existing land cover and incentives would allow us to identify mismatches between: what we want, what we have got, and how we get there. Mismatches would suggest the need for restructure of policy, research, and management decision making. One example of such a mismatch was alluded to in the case study; participants criticized that the aforementioned EQIP practice list was skewed towards engineered practices over ecological ones. In contrast, in our case study only two of the 31 most important practices, bioreactors and artificial wetlands, include a purely engineered approach.

Prioritization exercises such as these may help to foster discussion and implementation of a broader suite of multiscalar management approaches that span

property boundaries (Kurttila et al. 2002; Goldman et al. 2007; Rickenbach et al. 2011). The development of place-based toolboxes is a critical element for such approaches. While the existence of a list, alone, may not trigger wide-spread ecosystem service management, it may be useful for guiding research efforts, policy creation, and the allocation of resources, and prompting discussion and dialog.

6. Conclusions

Farmers in the 21st century are faced with pressures to manage for an expanding suite of goods and ecosystems services. This presents a major challenge for management and decision makers. The goal of our research was to analyze how existing farm-scale management practices can be best used to achieve ecosystem service objectives across scales. We present a framework for prioritizing management practices based on a given practice's multifunctionality and group consensus regarding the usefulness of the practice. In principle, this framework can be applied to land management practices across regions and across spatial scales and necessarily integrates knowledge from stakeholders who view these systems from different scales and perspectives. We apply this framework to Iowa agriculture, utilizing data from a case study of stakeholders' opinions regarding the relationship between ecosystem services and agricultural land management. We identify that nearly half of the 31 practices assessed were considered to operate across spatial scales. Moreover, many practices were related to multiple ecosystem services. Landscape-level planning was seen as being required for 16 of 31 practices. Seven and nine practices were found to be very high and high priority, respectively. We suggest that prioritizing management practices is useful for guiding research initiatives, policy creation, and on the ground implementation of practices.

7. Literature Cited

Atwell R.C., Schulte L.A., and Westphal L.M. 2010. How to build multifunctional agricultural landscapes in the U.S. Corn Belt: Add perennials and partnerships. Land Use Policy **27**:1082-1090.

Ajzen, I. 2005. *Attitudes, Personality and Behavior*, 2nd edition. New York, NY: Open University Press.

Balmford, A., B. Fisher, R.E. Green, R. Naidoo, B. Strassburg, R.K. Turner, and A.L. Rodrigues. 2011. Bringing ecosystem services to the real world: An operational framework for assessing the economic consequences of losing wild nature. Environmental Resource Economics **48**:161–175.

Bell, M.M. 2004 *Farming for us all: Practical agriculture and the cultivation of sustainability.* University Park: The Pennsylvania State University Press.

Cheng, A.T., L.E. Kruger, and S.E. Daniels. 2003. "Place" as an integrating concept in natural resource politics: Propositions for a social science research agenda. Society and Natural Resources **16**:87-104.

Clayton S. and A. Brook 2005. Can psychology help save the world? A model for conservation psychology. Analysis of Social Issues and Public Policy **5**:87-102.

Cochrane W.W. 2003. *Curse of American Agricultural Abundance: A Sustainable Solution*. Lincoln, NE: University of Nebraska Press.

de Groot R.S., J.R.M. Alkemade, and L. Braat. 2010. Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. Ecological Complexity **7**:260-272.

Dosskey M.G., M.J. Helmers, D.E. Eisenhauer, T.G. Franti, and K.D. Hoagland. 2002. Assessment of concentrated flow through riparian buffers. Journal of Soil and Water Conservation **57**:336-343.

Dosskey M.G., M.J. Helmers, and D.E. Eisenhauer. 2008. A design aid for determining width of filter strips. Journal of Soil and Water Conservation **63**:232-241.

Goldman R.L., B.H. Thompson, G.C. Daily. 2007. Institutional incentives for managing the landscape: Inducing cooperation for the production of ecosystem services. Ecological Economics **64**:333-343.

Gould W.B., W.E. Saupe, and R.M. Klemme. 1989. Conservation tillage: the role of farm and operator characteristics and perception of soil erosion. Land Economics **65**:167-181.

Hein, L., K. van Koppen, R.S. De Groot, and E.C van Ierland. 2006. Spatial scales, stakeholders and the valuation of ecosystem services. Ecological Economics **57**:209–228.

Jackson, L.L. 2008. Who designs the agricultural landscape? Landscape Journal **27**:23-40.

Jensen, M.E. and P.S. Bourgeron. 1994. An overview of ecological principles for ecosystem management. In: M.E. Jensen and P.S. Bourgeron, (eds). *Volume II: Ecosystem Management: Principles and Applications. Gen. Tech. Rep. PNW-GTR-318* (pp 45-57). Portland, OR, USDA Forest Service, Pacific Northwest Research Station.

Knowler D., and Bradshaw B. 2007. Farmers' adoption of conservation agriculture: A review and synthesis of recent research. Food Policy **32**:25-48.

Kurttilaa M., J. Uutterab, and S. Mykra. 2002. Decreasing the fragmentation of old forests in landscapes involving multiple ownership in Finland: economic, social and Leeuwis, C. 2004. *Communication for rural innovation: Rethinking agricultural extension*. 3rd edition. Oxford, UK: Blackwell Publishing

Liebman, M., M.J. Helmers, and L.A. Schulte. 2010. Integrating conservation with biofuel feedstock production. Pages 131-142 in: P. Nowak and M. Schnepf (eds.),

Managing Agricultural Landscapes for Environmental Quality II: Achieving More Effective Conservation. Soil and Water Conservation Society, Ankeny, Iowa.

Lubowski R.N., A.J. Plantinga, and R.N. Stavins. 2008. What drives land-use change in the United States? A national analysis of landowner decisions. Land Economics **84**:529-550.

Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-being: Synthesis. Washington, DC: Island Press. Retrieved from: http://www.millenniumassessment.org/documents/document.356.aspx.pdf.

Nassauer J.I., C.L. Kling. 2007. Changing societal expectations for environmental benefits from agricultural policy. In: J.I. Nassauer, M.V. Santelmann, D. Scavia (eds), *From the Corn Belt to the Gulf*. Washington, DC: Resources for the Future Press.

Natural Resources Conservation Service - Environmental Quality Incentives Program. Story County practice list: Retrieved from: ftp://ftp-fc.sc.egov.usda.gov/IA/eqip/Story11WebPracticeList.pdf

Newton, J.L., E.T. Freyfogle, and W.C. Sullivan. 2007 Land, ecology, and democracy: A twenty-first century view. Politics and the Life Sciences **25**:42-56

National Research Council. 2010. *Committee on twenty-first century systems agriculture: Towards sustainable agricultural systems in the 21st century.* Washington, DC: National Academies Press.

Öhman K, and T. Lämås. 2003. Clustering of harvest activities in multi-objective long-term forest planning. Forest Ecology and Management **176**:161-171.

Palmer M., E. Bernhardt, E. Chornesky, S. Collins, A. Dobson, C. Duke, B. Gold, R. Jacobson, S. Kingsland, R. Kranz, M. Mappin, M.L. Martinez, F. Micheli, J. Morse, M. Pace, M. Pascual, S. Palumbi, O.J. Reichman, A. Simons, A. Townsend, and M. Turner. 2004. Ecology for a crowded planet. Science **304**: 1251–1252.

Petrehn, M.R. 2011. Mapping the social landscape of grazing management in the Corn Belt: A review of research and stakeholder perceptions of the multifunctionality of Iowa grazing systems**.** Thesis, Iowa State University. Ann Arbor: ProQuest/UMI

Petrzelka P., T. Buman, and J. Ridgely. 2009. Engaging absentee landowners in conservation practice decisions: A descriptive study of an understudied group. Journal of Soil and Water Conservation **64**:94A-99A.

Pretty, J.N. 2002. *Agriculture: Reconnecting People, Land, and Nature*. London, UK: Earthscan Publications.

Rickenbach, M., L.A. Schulte, D. Kittredge, W.G. Labich, and D. Shinneman. In press. Cross-boundary cooperation: a mechanism for sustaining ecosystem goods and services from private lands. Journal of Soil and Water Conservation.

Ruhl J.B., S.E. Kraft, and C.L. Lant. 2007. *The Law and Policy of Ecosystem Services*. Washington, DC: Island Press.

Secchi, S., J. Tyndall, L. A. Schulte, and H. Asbjornsen. 2008. Raising the stakes: High crop prices and conservation. Journal of Soil and Water Conservation **63**:68-73.

Taylor, R.G., J. Pease, and W.M. Reid. 1990. A study of survivability and abandonment of contributions in a chain of Delphi rounds. Psychology: A Journal of Human Behavior **27**:1-6.

Thompson, P.B. 2010. The agrarian vision: Sustainability and environmental ethics. Lexington, KY: University of Kentucky Press.

Vanclay, F., and G. Lawrence. 1994. Farmer rationality and the adoption of environmetnally sound practices: a critique of the assumptions of traditional agricultural extension. European Journal of Agricultural Education and Extension 1:59-90

Walter T., M. Dosskey, M. Khanna, J. Miller, M. Tomer, and J. Wiens. 2007. The science of targeting within landscapes and watersheds to improve conservation effectiveness. In: M. Schnepf and C. Cox (eds), *Managing Agricultural Landscapes for Environmental Quality: Strengthening the Science Base* (pp 63-89). Ankeny, IA: Soil and Water Conservation Society.

8. Tables

Table 3.1

The prioritization framework is based on two criteria: consensus and multifunctionality. Practices are ranked on a three-point scale; A, B, C and 1, 2, 3 for consensus and multifunctionality criterion, respectively. Divergence in this case is production- versus environment-centered perspectives.

Status	Description
Consensus $_A$	Strong/strong; strong/moderate agreement across divergent perspectives
Consensus $_B$	Strong/weak; moderate/moderate agreement across divergent perspectives
Consensus $_C$	Weak/weak; or no agreement across divergent perspectives
Multifunctionality $_1$	Linked to economic and environmental benefits
Multifunctionality $_2$	Linked to multiple benefits; either economic or environmental, but not strongly both
Multifunctionality $_3$	Linked to a small number of benefits

Table 3.2

Land management practices important for enhancing the delivery of ecosystem services in Iowa, U.S.A as determined by regional leaders in agriculture and conservation in Iowa. The scale at which various practices were perceived to operate is indicated in gray. Relevant scales recognized by stakeholders were defined as (1) field periphery, (2) farm scale, and (3) landscape scale. Stakeholders indicated many practices require landscape-level planning to garner benefits. Numbers indicate rank of importance for practices identified with the Delphi survey. Items are arranged according to spatial scale, and alphabetically within groups of practices with the same spatial scale characteristics. This same order follows throughout tables in this manuscript. [Next page]

Table 3.2 (cont.)

Management practice	Field Periphery	Farm and Field	Landscape	Landcape level planning required
Grass field borders				
Minimal width riparian buffers				
Multi-species buffers (including trees and/or shrubs)				X
Providing fence row habitat				
Riparian buffers	2			X
Stream bank restoration			12	X
Variable width buffers				X
Artificial treatment wetlands				X
Biomass crops rasied as 2nd gen. biofuel feedstock				X
Bioreactors - subsurface drainage treatment		13		
Restrict livestock access to streams				
Best management practices for manure and water		11		X
Cover crops		8		
Diverse crop rotations		3		
Installation of tile drainage				X
No-till or minimal tillage		9		
Precision agriculture				
Rotational grazing				
Standard organic agricultural methods				
Strips of prairie grassland on the contour		6		X
Agroforestry				
Drainage management				
Grazing animals as a conservation tool				X
Increase crop variety and species diversity				
Providing winter habitat for wildlife				
Restored native grasslands			10	X
Restored wetlands			4	X
Targeted integration of perennial practices				X
Increase livestock numbers "on the land"			7	X
Landscape level planning			1	X
Large reserves of native grasslands				X

Table 3.3

Perceived linkages between ecosystem service and land management practices for Iowa, U.S.A. as establish through our case study. Triple star (***) indicates important links and star (*) indicates relatively less important links.

Management Practice	Water filtration and purification	Erosion control	Maintain soil fertility	Flood attenuation	Nutrient cycling	Aesthetic and/or spiritual benefits	Tourism & recreation opportunities	Pollination	Healthy/ wholesome food production	Wildlife habitat	Feed production	Carbon sequestration	Livestock production	Biomass feedstock for biofuel
Grass field borders		***		*		***	***	*		***	*	*		*
Minimal width riparian buffers	*	*												*
Multi-species buffers (including trees and/or shrubs)	***	***	*	***	***	***	***	***		***	*	*		***
Providing fence row habitat						*	*	*		*				
Riparian buffers	***	***	*	*	*	***	***	***		***				*
Stream bank restoration	***	***		*		*	*			***				
Variable width buffers	***	***	*	*	*	***	***	***		***				*
Artificial treatment wetlands	***			*	***	*	*			*		*		
Biomass crops raised as biofuel feedstock	*	***	***	*	*	*	*			*		***	*	***
Bioreactors - subsurface drainage treatment	***				***									
Restrict livestock access to streams	***	***											***	
Best management practices for manure and water	*				*			*					*	
Cover crops	*	***	***	*	***			*	*			***		
Diverse crop rotations	*	***	***	*	***	***	***	***	***	*	*	*		*
Installation of tile drainage		***	*						*		***			
No-till or minimal tillage	*	***	***	***	*	*	*	*				*		
Precision agriculture	***		***		*							***		
Rotational grazing	***	***	***	*	***	***	*		*	*	***	*	***	
Standard organic agricultural methods			*					*	***	*			*	
Strips of prairie grassland on the contour	*	***		*		***	***	***		*				*
Agroforestry	*	*	*			*	*			*		*		*
Drainage management	***	*	***	***	*									
Grazing animals as a conservation tool	*	***	***	*	***	*	*		*	*	*	*	***	
Increase crop variety and species diversity		***	***		*	*	*	*	***		*		*	
Providing winter habitat for wildlife		*				***	***			***				*
Restored native grasslands	*	***	***	*	*	***	***	*		***	*	***	*	***
Restored wetlands	***	*	*	***	***	***	***	*		***		*		
Targetted integration of perennial practices	***	***	***	*	*	***	***	*				*		
Increase livestock numbers "on the land"	*	*	***	*	***	***	***	*	*	***			***	
Landscape level planning	***	***	***	***	***	***	***	***		***		*	*	*
Large reserves of native grasslands	*	***	***	***		***	***	*		***		***	***	*

Table 3.4

Level of support (*** = strong, ** = moderate, and * = weak) for management practices from production- and environment-centered perspectives as detailed through our case study.

	Agreement	
Management practice	Production standpoint	Environmental standpoint
Grass field borders	**	**
Minimal width riparian buffers	**	*
Multi-species buffers (including trees and/or shrubs)	*	***
Providing fence row habitat	**	**
Riparian buffers	**	***
Stream restoration and stabilization	**	**
Variable width buffers	***	***
Artificial treatment wetlands	***	**
Biomass crops rasied as 2nd generation biofuel feedstock	**	**
Bioreactors - subsurface drainage treatment	***	*
Restrict livestock access to streams	***	***
Best management practices for manure and water management	*	**
Cover crops	***	***
Diverse crop rotations	**	**
Installation of tile drainage	***	*
No-till or minimal tillage	***	*
Precision agriculture	***	*
Rotational grazing	**	***
Standard organic agricultural methods	*	**
Strips of prairie grassland on the contour	**	**
Agroforestry	*	**
Drainage management	**	**
Grazing animals as a conservation tool	***	***
Increase crop variety and species diversity	***	***
Providing winter habitat for wildlife	**	**
Restored native grasslands	*	***
Restored wetlands	**	***
Targetted integration of perennial practices	***	***
Increase livestock numbers "on the land"	**	***
Landscape level planning	***	***
Large reserves of native grasslands	*	**

Table 3.5

Prioritization of land management practices based on two criteria: (1) consensus between divergent production- and environment-centered perspectives and (2) multifunctionality of the practice (i.e., the capacity for the practice to simultaneously enhance the delivery of multiple ecosystem services).

	Priority	
Management Practice	Consensus	Multi-functionality
Grass field borders	B 2	
Minimal width riparian buffers	C 3	
Multi-species buffers (including trees and/or shrubs)	B 1	
Providing fence row habitat	B 2	
Riparian buffers	A 2	
Stream restoration and stabilization	C 2	
Variable width buffers	A 2	
Artificial treatment wetlands	B 1	
Biomass crops rasied as 2nd generation biofuel feedstock	B 1	
Bioreactors - subsurface drainage treatment	C 1	
Restrict livestock access to streams	A 2	
Best management practices for manure and water management	B 2	
Cover crops	A 1	
Diverse crop rotations	B 1	
Installation of tile drainage	C 3	
No-till or minimal tillage	C 2	
Precision agriculture- practical use of modern equipment	C 3	
Rotational grazing	B 1	
Standard organic agricultural methods	C 1	
Strips of prairie grassland on the contour	B 2	
Agroforestry	C 1	
Drainage management	B 1	
Grazing animals as a conservation tool	A 1	
Increase crop variety and species diversity	A 1	
Providing winter habitat for wildlife	B 2	
Restored native grasslands	C 2	
Restored wetlands	A 1	
Targetted integration of perennial practices	A 1	
Increase livestock numbers "on the land"	A 1	
Landscape level planning	A 1	
Large reserves of native grasslands	C 2	

9. Figures

Figure 3.1

Framework for prioritization of land management practices based on consensus and multifunctionality. Priorities are defined by five color-coded categories (dark green, light green, yellow, orange, and red), which range in priority rating from very high (A1 - dark green) to very low (C3 - red).

CHAPTER 4
VISUALIZATION OF ALTERNATIVE AGROECOSYSTEMS:
A PORTFOLIO OF PHOTOREALISTIC LANDSCAPE MODELS

Abstract

Photorealistic landscape images—otherwise known as terrain visualizations—are recognized as useful tools for enhancing communication among diverse stakeholder groups regarding complex resource management issues, including the topic of ecosystem service provision. Visualizations may be useful for setting a "level playing field" for discussion, whereby miscommunications due to jargon or concepts with meanings that differ among different individuals, can be potentially avoided or minimized. Additionally, images are expected to evoke deeper elements of human consciousness than do words alone. Images of agricultural scenarios have been successfully used in the U.S. Corn Belt and elsewhere to facilitate dialogue with farmers, land managers, policy makers, and others regarding land-use change. Here I present a portfolio of landscape visualizations created as part of my graduate research assistantship and program of study. In total, I completed seven visualization projects, each of which included the creation of between one and 18 images. I provide a short description of each project and high resolution versions of the images produced. Finally, I describe a brief, generalized description of the process used to create such high-quality, detailed, and spatially explicit visualizations.

1. Introduction

Photorealistic landscape images, also referred to as terrain visualizations, are recognized as a useful for tool for enhancing the communication among diverse stakeholder groups regarding complex land management issues (Sheppard 1989), including ecosystem service management. Visual depictions of proposed management actions or alternative landscape designs have been shown to be a decisive factor for decision-making in environmental planning and management (Nassauer 1984; Oh 1994). They are useful for translating complex quantitative information into an accessible format (Sheppard 1989) and provide a "level playing field" for dialog, whereby miscommunications due to unfamiliar jargon or concepts are minimized. The use of photos is expected to evoke deeper elements of human consciousness than do words alone (Harper 2002), and I presume this holds true for photorealistic images as well.

Visualization of land management scenarios has been used extensively in forestry to demonstrate impacts and elicit public perception of forest management (Oh 1994; McCarter et al. 1998; McGaughey 1998; Stoltman et al. 2004; Stoltman et al. 2007). For example, Stoltman and others (2007) visualized pre-Euro-American settlement and current forest conditions in Wisconsin to visually compare the differences in forest stand complexity and density. Similarly, photorealistic images of agricultural scenarios have been successfully used to facilitate interactions with farmers, regional land managers, policy makers, and the public regarding land use change. Nassauer and colleagues have prominently demonstrated that visualizations of agricultural scenarios (created largely by Robert Corry) allow for diverse stakeholders to critically evaluate the consequences of different combinations of policy goals and agricultural practices in the US Corn Belt (Nassauer et al. 2002; Nassauer and Corry 2004; Santelman et al. 2004).

Furthermore, photo elicitation using photorealistic landscape images was a key component of the interviews conducted as part of the case study detailed in Chapter 2 of this thesis. There I concluded that the use of images was indispensa-

ble in simultaneously "anchoring the conversation in a place" while avoiding the need for a large degree of influence or preface from the research team. During these structured interviews, the use of photorealistic visualizations generated more vivid and specific descriptions. For example, many participants indicated where in their preferred scenario they would desire to build a house.

Here I present a portfolio of seven photorealistic landscape visualizations projects I completed as part of my graduate research assistantship and program of study. Each of these projects included the creation of between one and 18 photo-realistic images, for a total of 40 images. I provide a short description of each project and high-resolution versions of the images produced. These photorealistic visualizations were created using the Visual Nature Studio 3 (VNS3; 3d Nature, LLC) software package. I did not receive any formal training or instruction to develop these visualizations, though learning was greatly assisted through online tutorials available from Visual Nature Studio and help received through the online community. Finally, I describe a brief, generalized description of the process used to create such high-quality, detailed, and spatially explicit visualizations.

2. Portfolio

2.1 Agroforestry scenario

The image was created for use in a grant submitted by Dr. Rick Hall to the North Central Sun Grant Initiative in 2010. The image depicts an agroforestry scenario where a hybrid aspen and cottonwood trees are being grown for use in ligno-cellulosic bioenergy feedstock. The image is unique in that it is based in the real-world field site where Dr. Hall and others are conducting research on biomass crops. Also note, this same landscape is used in the example visualization for the general workflow described below.
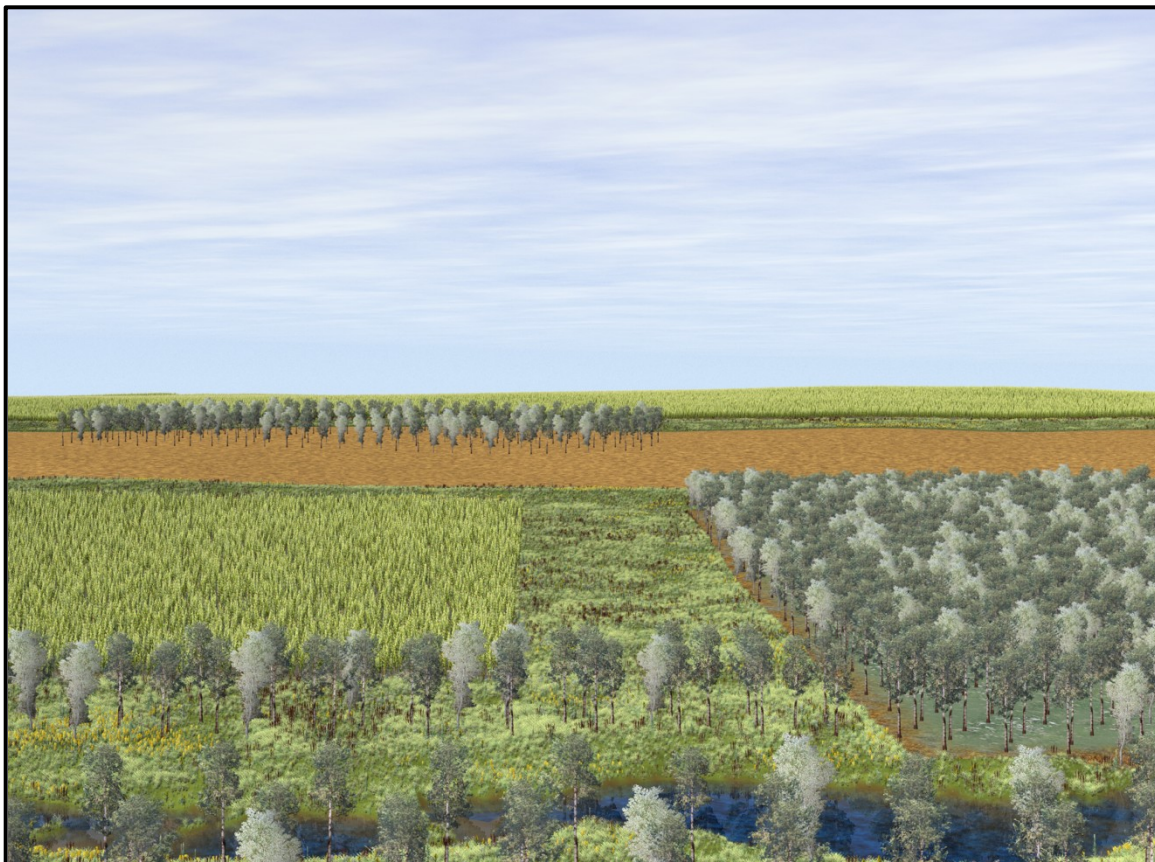
2.2 The future of agriculture and society in Iowa: Four scenarios

These images were created as a figure for inclusion in a manuscript that has been submitted for review by a peer-review scientific journal. The manuscript was written as part of a course conducted at Iowa State University in the Fall 2009 offering of Food, Agriculture and Quality of Life in Iowa (SusAg 620X). The images depict four scenarios for the future of Iowa agriculture in 2100. Scenarios schemes were developed by the students based on their combined knowledge of Iowa agriculture. A portion of this knowledge was developed through in-class experiences as we interviewed individuals involved in various aspect of Iowa agriculture.
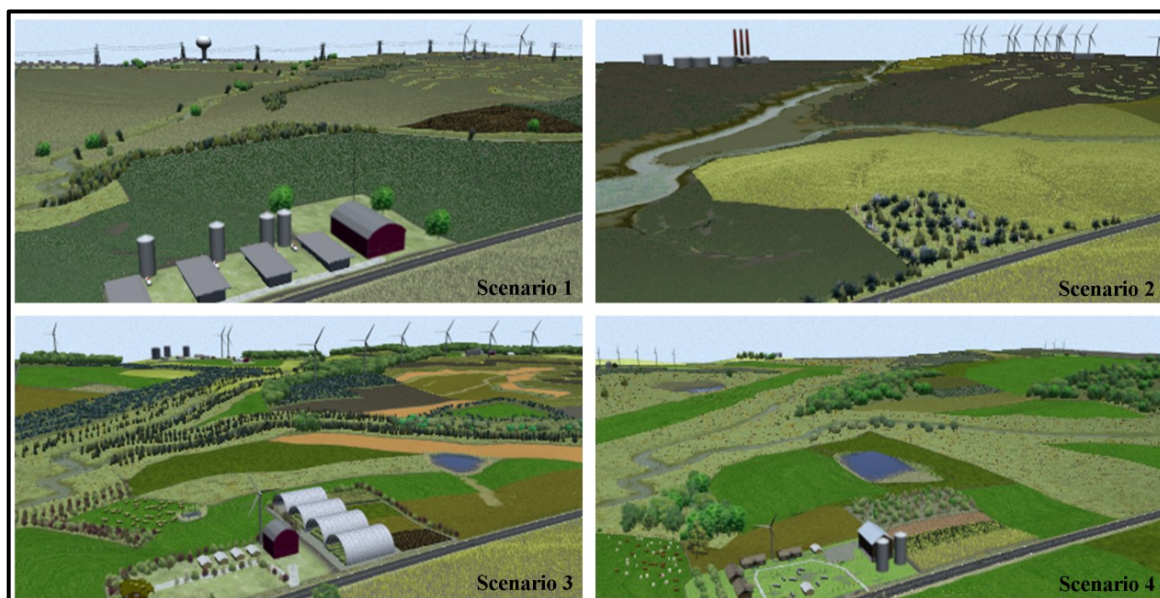
2.3 Incorporating prairies into multifunctional landscapes

This suite of images was created for use in an Iowa State University Extension publication (Jarchow and Liebman 2010).
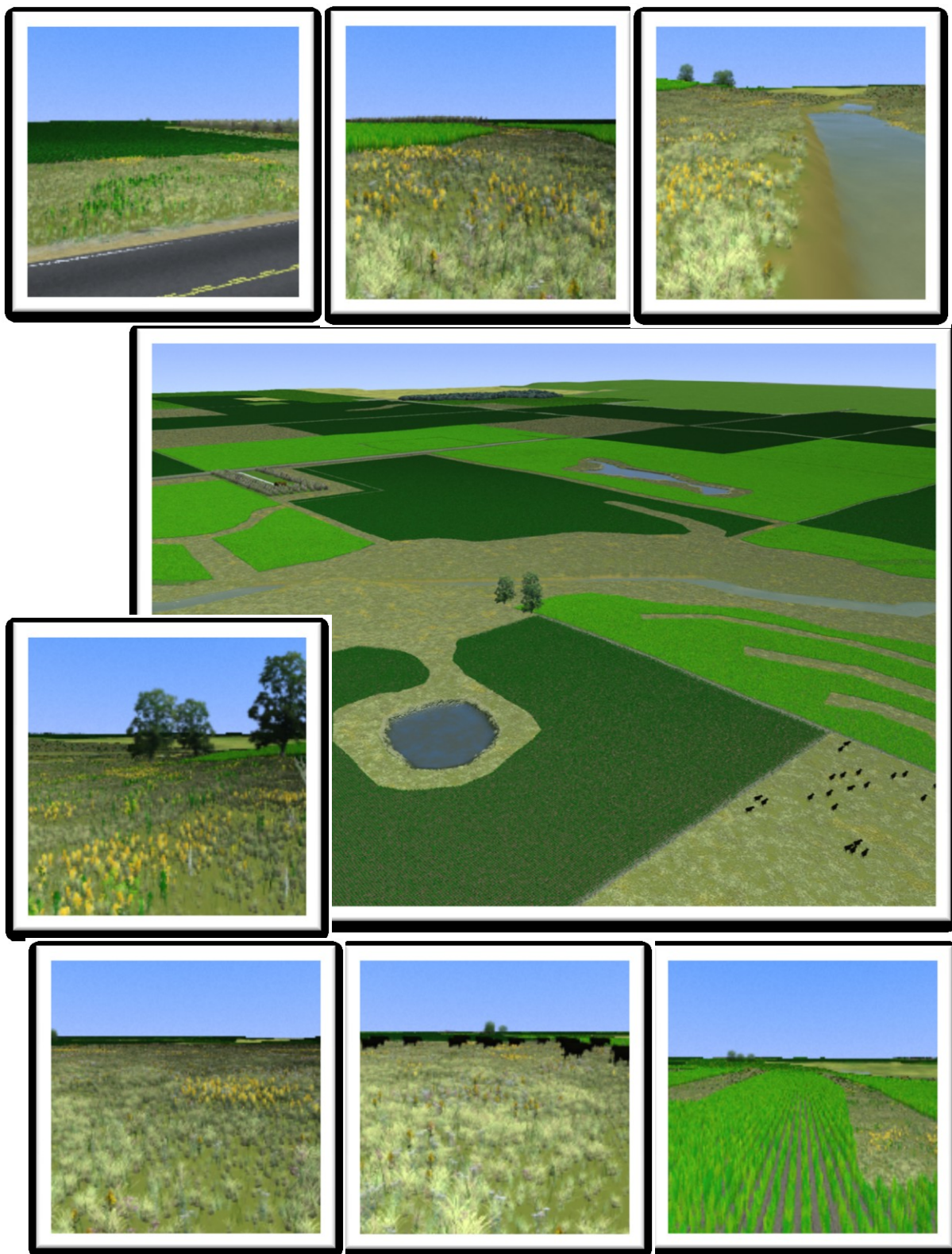
2.4 People in Ecosystems/ Watershed Integration

This suite of images was constructed in conjunction with the major research component of my graduate degree (Chapter 2). The images depict a hypothetical watershed adapted from People in Ecosystems Watershed Integrated (PE/WI), an Excel-based model used to explore trade-offs in agricultural land cover management (Schulte et al. 2010), which can be downloaded from the following internet location: http://www.nrem.iastate.edu/landscape/. The 66.4 ha PE/WI watershed is an amalgamation of two of Iowa's major landforms, the Des Moines Lobe (characterized by flat topography and poorly-drained soils) and the Southern Iowa Drift Plain (characterized by rolling hills and well-drained soils). The excel-based PE/WI watershed was transformed for photorealistic modeling in a GIS-based process. The PE/WI model controlled for land area, position of a watercourse, and slope and soil characteristics based on 900m^2 blocks. Slope values provided in PE/WI were transformed into elevation values by mean of hand-calculation (sine θ) for each block. Elevation values were used to generate a 2m-resolution digital elevation map (DEM) using the terrain generator toolkit in Visual Nature Studio 3 (Nature 3D, LLC) and exported to ArcMap 9.2 (ESRI 1999-2006).

Using this watershed, the land management strategies used in the scenarios were established by four principle investigators of the STRIPs at Neal Smith NWR project, including a landscape ecologist, an agronomist, an agriculture and biosystems engineer, and a natural resource economist in a single planning session facilitated by the lead author. The result of the planning session was a single management prescription based on Best Management Practices and targeted conservation efforts, including variable-width riparian buffers, mitigation wetlands, and strips of prairie on the contour. Using the perennial cover prescription outlined in the planning session, I generated six land cover scenarios based on the percent of perennial land cover following a base-2 logarithmic scale (i.e., 2%, 4%, 8%, 16%, 32%, and 64% perennial cover). For each scenario, three images were rendered (Appendix D): a vertical view (from directly above), a high angle, bird's-eye view (from

500m above ground level), and a low angle view, human-eye view (from ground level). See appendix D for images.

2.5 Cross-boundary Cooperation: A Mechanism for Sustaining: Ecosystem Goods and Services from Private Lands

These four images were created as a figure for a manuscript submitted to the *Journal of Soil and Water Conversation* (Rickenbach et al. 2011). The images depict plausible scenarios of status quo and cross-boundary management on four 16 ha (40 ac) parcels. In the top row: (a) Status quo management in southwestern ponderosa pine forests on private lands in which only the owners of the lower-right property have adopted firewise techniques; their home is still at a high risk for burning because of a lack of fuels treatment on adjacent properties. (b) Under cross-boundary management, the fire risk has been lowered for three of the four homes as a result of the owners of the lower-right property talking to and working with their neighbors; the owners of the lower- and upper-left properties have also instituted firewise techniques around their homes, while the owner of the upper-right property has collaborated to reduce the fire risk to adjacent owners' homes, but has chosen not to institute these practices directly around her home. In the bottom row: (c) Status-quo management of Midwestern oak forests where the owner of the lower-left property clear-cuts the majority of his property in order to have a large enough timber volume to attract a buyer. (d) A cross-boundary scenario in which the owner of the lower-left property engages his neighbors on oak forest management and the timber sale; the owners of the lower-right and upper-left properties respectively clear cut and thin a portion of their forest, allowing an overall higher volume timber sale and the maintenance of more natural ecosystem boundaries.

Image next page
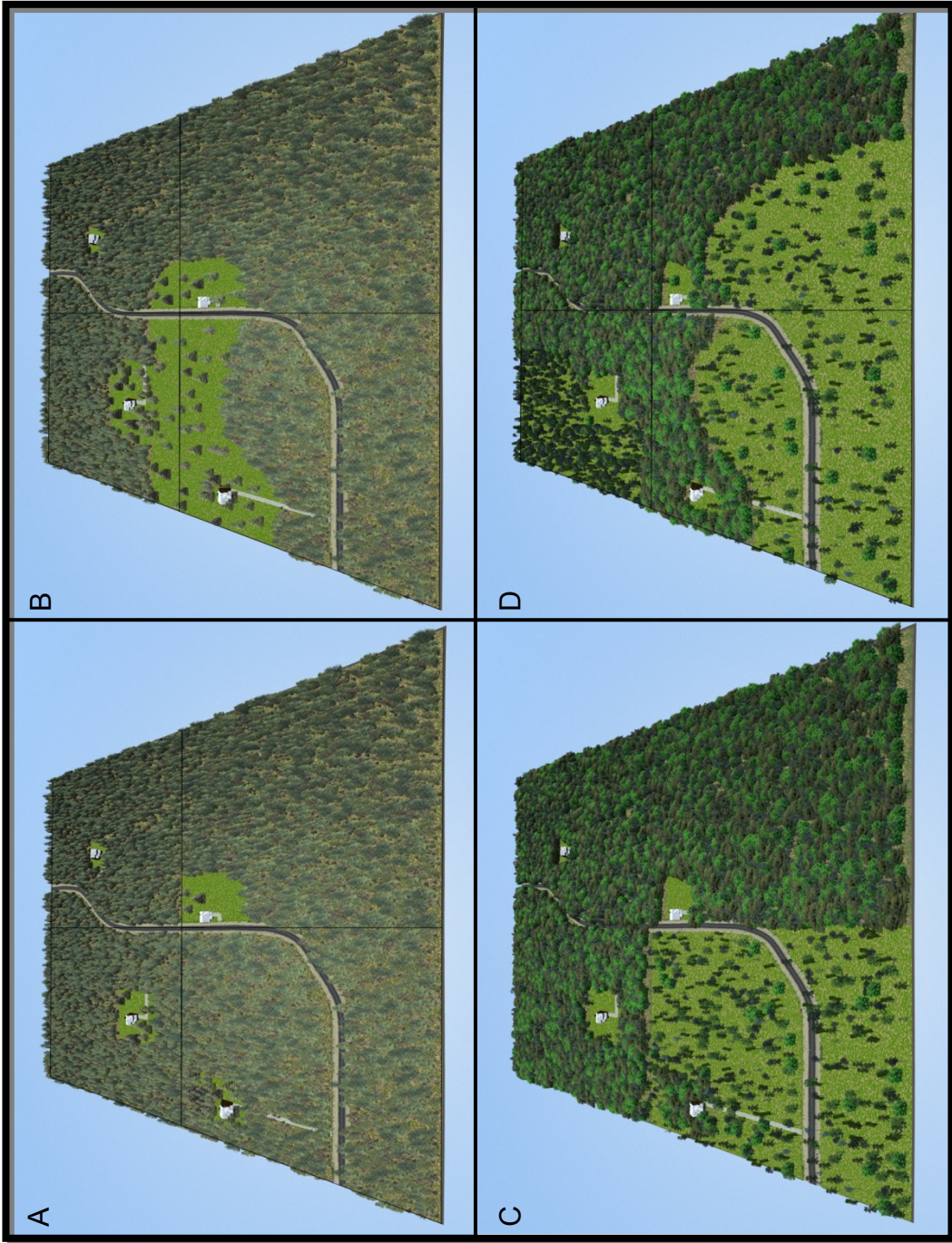
2.6 Tweak, adapt, transform

These images were created from a modified PE/WI landscape as an (unofficial) supplement to the scenarios presented in Atwell and others (2011); they depict three possible future scenarios for Iowa agroecosystems based on policy responses to emerging biofuels markets. Atwell and others (2011) produced the scenarios using data from a workshop discussion they facilitated between of leaders in agriculture and environmental policy in Iowa. More recently, two of the scenarios, adapt and transform, were submitted as a figure component in a manuscript submitted to the Encyclopedia of Biodiversity titled, *Biodiversity and Biofuels: Boon or Boondoggle* (Schulte et al. in review).

Atwell and others (2011) describe each of the scenarios in greater detail; here, I briefly describe each one. In "tweak" (top), macroscale market and policy forces are driving regional outcomes, but beyond regional control. In "adapt" (middle), policies, partnerships, and programs are based on understanding regional social-ecological complexity and are designed to achieve desired multi-objective outcomes. In "transform" (bottom) regional partnerships and programs impact powerful top-down drivers to catalyze and equip new markets that have the power to reorient the regional system to a desired configuration.

Image next page
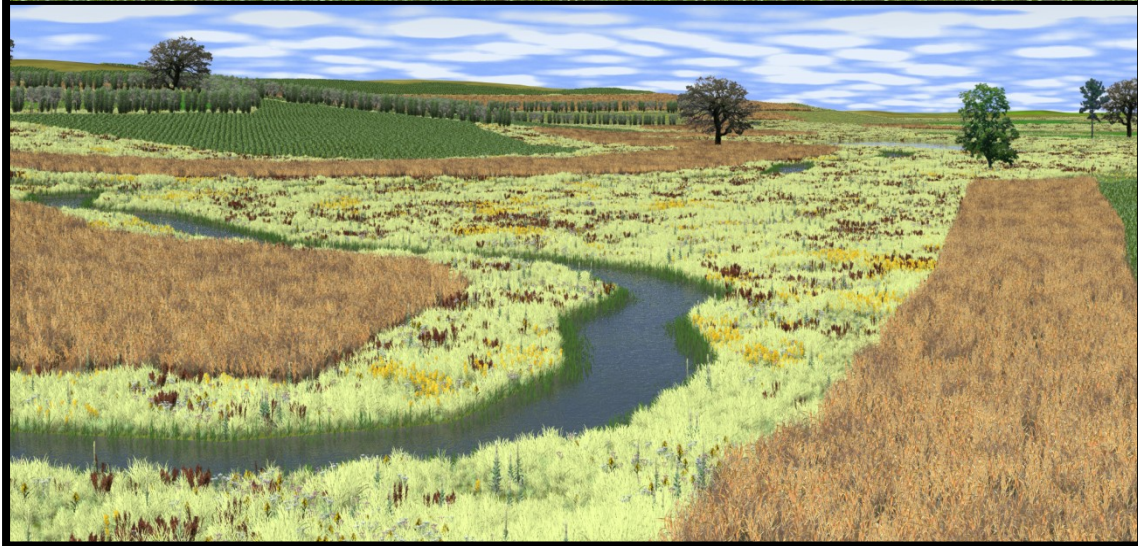
2.7 A survey of public perception of multi-objective agriculture

This image was created by tiling aerial photographs to create a symmetrical watershed, where the watershed is dissected by a stream and the land on either side is a mirror image of the other, save for targeted conservation practices that have been incorporated into the east half.

This image is included as a component of a survey of local residents in Iowa, with oversampling focused on the four counties surrounding the Neal Smith National Wildlife Refuge (Jasper, Marion, Polk and Warren) to determine their willingness-to-pay for initiatives that improve ecosystem services through targeted incorporation of perennials in agriculture. The data will be used to develop a comprehensive understanding the social and economic factors that mediate local residents' willingness-to-pay, and will also incorporate measures of a number of social and social-psychological variables.
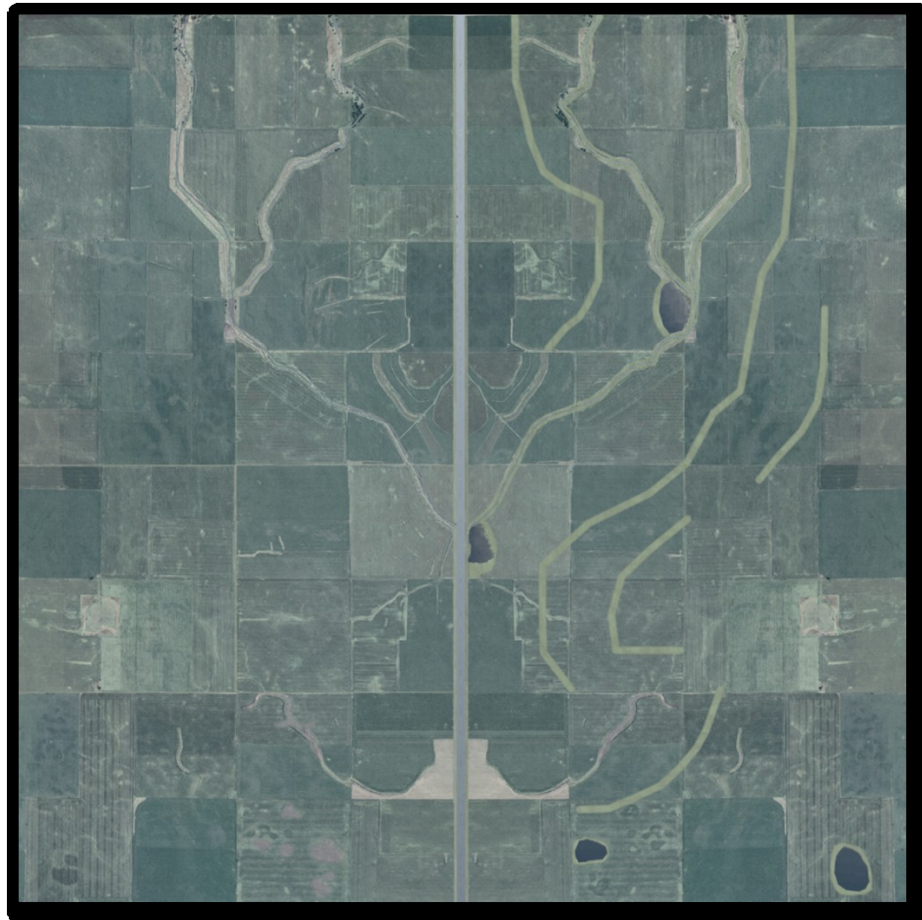
3. General work flow

The following is a simplified description of the generalized procedure used in creating photorealistic visualizations. The goal here is to provide a brief glimpse of what is an involved process. First, I offer a couple of caveats. There are multiple terrain visualization software packages available. While this description is general enough to be relevant for a range of software packages, I only have working knowledge of VNS3 (3d Nature, LLC). VNS3 is considered to be one of the most powerful and user-friendly terrain visualization software packages available. Other software packages may not be capable of everything described below and may not be accessed in the same manner. Secondly, I am only a beginning user and have received no formal training in producing terrain visualizations. My knowledge is limited thus far to what I have learned independently in 18 months of sporadically using the software. The works presented here represent the sum of my finished projects to date. All this is to explicitly declare that this is no expert guide; however, I believe that it is relevant to include here because (1) in researching terrain visualization in a natural resource context, I have not seen such a description, and (2) in showing photorealistic images to others, the most frequently asked question has been: *how did you do that?*

- Step 1: The first step in any project is to import the topographic data, which will serve as the foundation for the image, into the terrain visualization software (Figure 4.1). For real-world applications this is most easily achieved by importing a pre-existing digital elevation map (DEM), Light Detecting and Ranging Radar (LI-DAR) data, or an Arc Export Grid (file type ".e00"). A DEM can also be created manually by inputing elevation data on a cell-by-cell basis across an extensive grid, as was done for the hypothetical watershed used for PE/WI-related project detailed above. Finally, terrain data can be generated using grayscale images; whereby black and white are used to define a range of possible elevations (e.g., black represents the highest chosen elevation and white the lowest) and then actual elevation is assigned based on gray shading of an image, such as one

created in, for example, in Adobe Photoshop (Adobe Systems Incorporated 2011). This grayscale method is far easier than manually entering elevation values and is recommended for the creation of original landscapes.

- <u>Step 2</u>: Create a geographic information system (GIS) database, namely shape files for import into the terrain visualization software. In the screenshot below (Figure 4.2), I have used ArcMap 9.3.1 (ESRI 2009) to access common land-use data (USDA-FSA) (A), and create two shape files representing contour buffer strips (green) as the management practice to be visualized (B). Polygons, lines, and points can be used to place, for example, different land-cover types, roads and rivers, and individual objects such as a tree or building. Such features can also be created within the terrain visualization software, but for purposes of precision, the bulk of the shape files should be created in a GIS.

- <u>Step 3</u>: Selecting a camera view and setting camera attributes such as field of view, elevation, heading, and pitch. It is helpful to determine the point of view early on in a project, as it saves time if this is determined before the level of detail needed in different parts of the image (e.g., more detail is needed close up and less is needed far away) and the lighting. In the images below, the example landscape DEM is seen from the east side of the DEM looking west, from an elevation of 345m (40m above ground level) and a 45° field of view.

- <u>Step 4</u>: Once georeferenced shape files have been imported into the terrain visualization software they can be linked to the appropriate land-cover features (Figure 4.3). In VNS3, land-cover types are referred to as ecosystems. Ecosystems can be comprised of layering various textures, colors, and patterns combined at various spatial scales; by creating a collage of images; or both. Consider a distant view of a grassland as an example of an ecosystem based on textures, colors, and patterns. At a micro-scale, say 1m, shades of greens and brown may be streaked to give the illusion of vertical blades of grass; at a meso-scale, say

10m, a speckled pattern can be used to influence the mixing of the colors the micro-scale colors creating patchiness across the grassland; and finally, at a macro-scale, say 200m a wave pattern can be used to create the effect of wind blowing across the grassland. Similarly, to create the look of a plowed field, a hierarchy of textures and patterns could be used to create, from smallest to largest, dirt clods, plowed rows, contrasting areas of dry or wet soil, and a set of tire tracks traversing the field. As an example of an ecosystem based in a collage of images, consider a closer view of the previous grassland. A selection of five grass images and three flower images could be overlaid repeatedly, with the grass densely covering the ecosystem and the flowers placed more dispersed. In this approach, the same sorts of textures and patterns described above are used to drive differences in plant density, height, and arrangement. Complex ecosystems, such as a forest, may include dozens of images (Stoltman et al. 2007).

For the example visualization, a collage consisting of one image of small corn plant has been used to create the look of cornfield in late June. The underlying field has been created as explained above for the plowed field. The corn image is arranged in rows according to a set population (in this case 74,100 plants per hectare), and a fractal pattern is used to introduce variability in corn plant height to increase realism. The nearest contour buffer strip is made up of a collage of images while the farther consists of only colors arranged by texture and pattern (Figure 4.4a). A closer image of the cornfield (Figure 4.4b) provides a better view of the collage of corn images.

- Step 5: Finally, additional components can be applied to add further realism to a scene, including sunlight, clouds, celestial objects, and atmosphere components (such as fog or distant heat haze). Below, clouds and wind turbines have been added to the example image.

4. Conclusion

Given an ever increasing computational capacity and the growing urgency that management decision making engage a broad diversity of stakeholders, photo-realistic landscape visualizations will continue to gain approval as a valuable tool for agriculture and conservation management. Given the wholly positive response I have received in reference to these visualizations, I foresee they may be an invaluable for policy discussion and on the ground planning. I highly suggest photorealistic landscape visualizations be more widely used in the fields of natural resources and agriculture.

5. Acknowledgements

6. Literature Cited

Harper, D. 2002. Talking about pictures: A case for photo elicitation. Visual Studies **17**:13-26.

Jarchow, M.E., and M. Liebman 2010. Incorporating prairies into multifunctional landscapes: establishing and managing prairies for enhanced environmental quality, livestock grazing and hay production, bioenergy production, and carbon sequestration. University Extension PMR 1007 (pp 25). Ames, IA: Iowa State University.

Jarchow M.E., GL D. Larsen, G. Zdorkowski, R. Costanza, S.R. Gailans, N. Ohde, R. Dietzel, S. Kaplan, J. Neal, M.R Petrehn, T. Gunther, S. D'Adamo, N. McCann, A. Larson, P. Damery, L. Gross, I.Kubiszewski,. M Merriman, J. Post, M. Sheradin, and M. Liebman. *In review*. The future of agriculture and society in Iowa: Four scenarios. International Journal of Agriculture Sustainability. Submitted April 2011.

McCarter, J., J. Wilson, P. Baker, J. Moffett, C. Oliver. 1998. Landscape management through integration of existing tools and emerging technologies. Journal of Forestry **96**:17-23.

McGaughey, R.J. 1998. Techniques for visualizing the appearance of forestry operations. Journal of Forestry **96**:9-1.

Nassauer, J.I . 1983. Framing the landscape in photographic simulation. Journal of Environmental Management **17**:1

Nassauer, J.I., R.C. Corry, and R.M. Cruse. 2002. The landscape in 2025: Alternative landscape future scenarios as a means to consider agricultural policy. Journal of Soil and Water Conservation **57**:44A-53A.

Nassauer, J.I., and R.C. Corry. 2004. Using normative scenarios in landscape ecology. Landscape Ecology **19**:343-356.

Oh, K. 1994. A perceptual evaluation of computer-based landscape simulations. Landscape and Urban Planning **28**:201-216

Rickenbach, M., L.A. Schulte, D. Kittredge, W.G. Labich, and D. Shinneman. In press. Cross-boundary cooperation: a mechanism for sustaining ecosystem goods and services from private lands. Journal of Soil and Water Conservation.

Santelmann, M.V., D. White, K. Freemark, J.I. Nassauer, J.M. Eilers, K.B. Vache, B.J. Danielson, R.C. Corry, M.E. Clark, S. Polasky, R.M. Cruse, J. Sinfeos, H. Rustigan, C. Coiner, J. Wu, and D. Debinski. 2004. Assessing alternative futures for agriculture in Iowa, USA. Landscape Ecology **19**:357-374.

Schulte, L.A., T.A. Ontl, GL.D. Larsen. *In review*. Biodiversity and biofuels: boon or boondoggle? Encyclopedia of Biodiversity. Princeton University, New Jersey, U.S.A.

Sheppard, S.R.J. 1989. Visual Simulation: A User's Guide for Architects, Engineers, and Planners. New York: Van Nostrand Reinhold.

Stoltman, A. M., V.C. Radeloff, and D.J. Mladenoff. 2004. Forest visualization for management and planning in Wisconsin. Journal of Forestry 102:7-13.

Stoltman, A., V.C. Radeloff, and D.J. Mladenoff. 2007. Computer visualization of pre-settlement and current forests in Wisconsin. Forest Ecology and Management **246**:135-143.
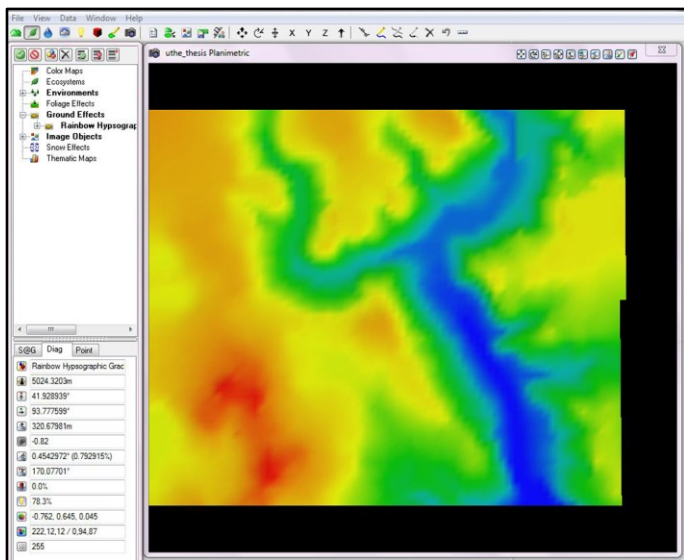
7. Figures

Figure 4.1

Visual Nature Studio 3 (3d Nature L.L.C.) screen capture of rainbow hypsography for the digital elevation model used in the example visualizations that follow.
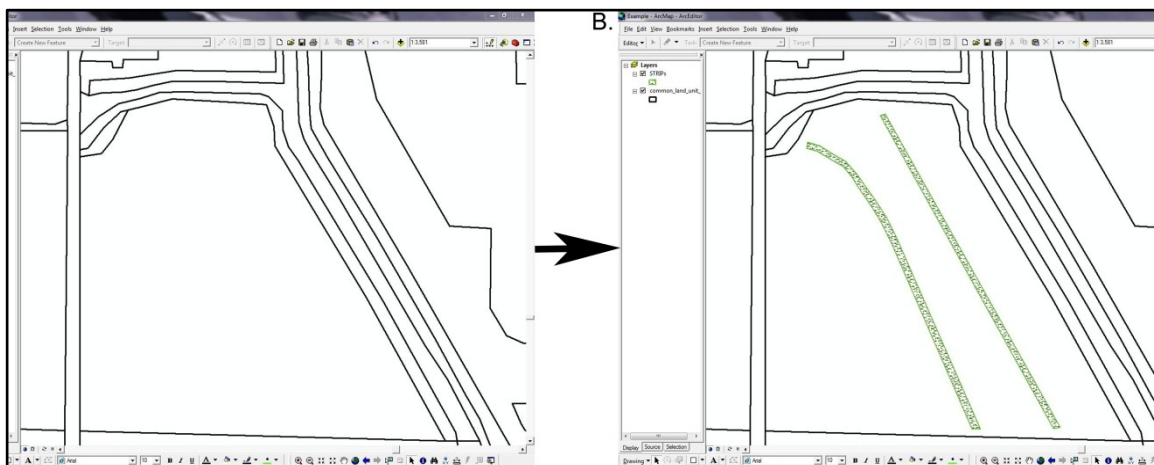

Figure 4.2

(A) ArcGIS screen capture of common land unit and (B) the addition of terraces as an example conservation practice to be visualized.
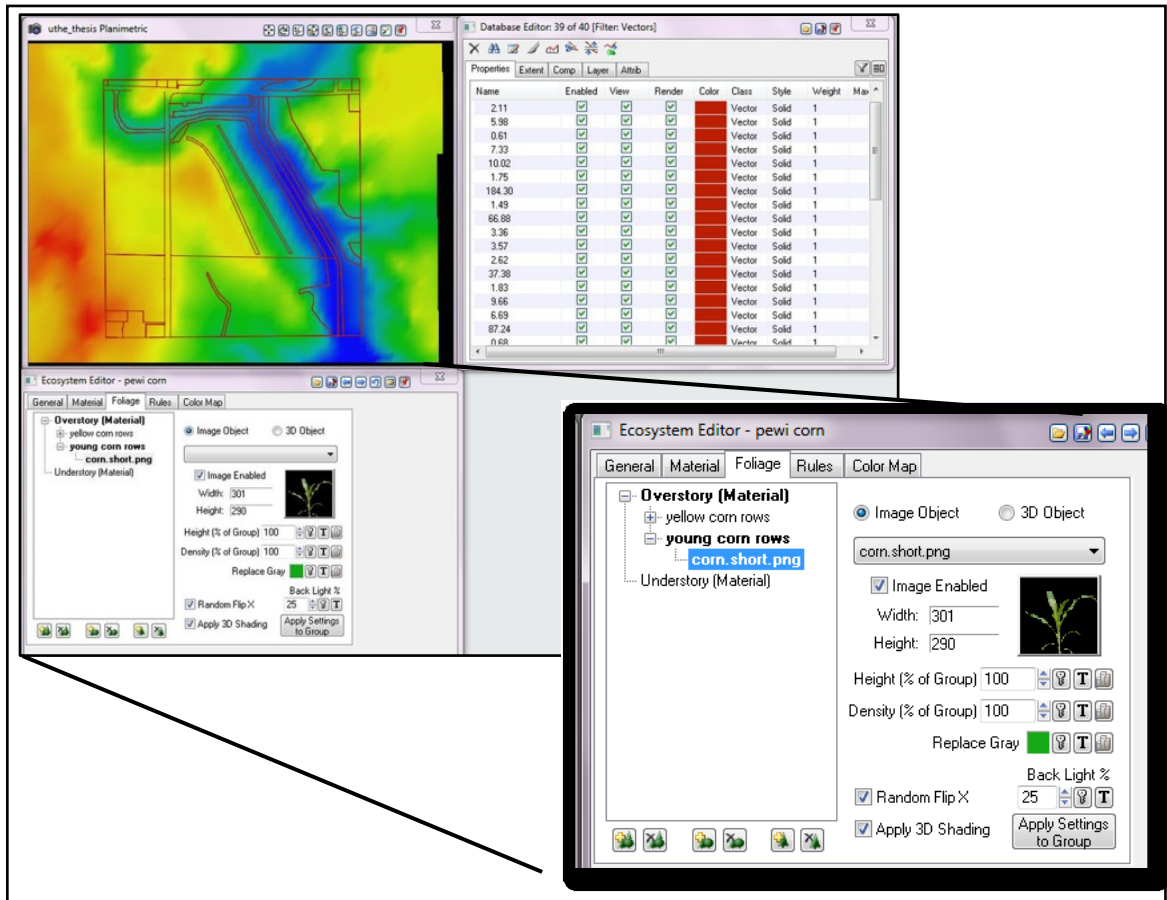
Figure 4.3

VNS3 screen capture of ecosystem manipulation. Notice the single corn plant image in the lower left panel and inset.
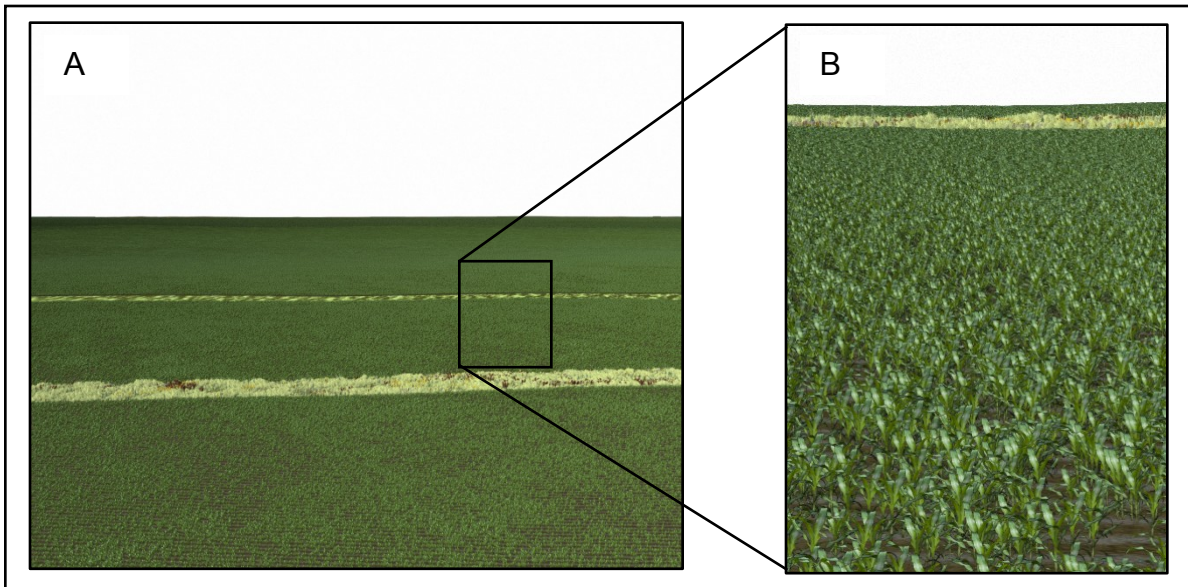
Figure 4.4

Visualization example from (A) far, and (B) near— a closer view to provide a better view of the corn plant images.

Figure 4.5

Final example visualization, including a cloud model and 3D wind turbines.

CHAPTER 5
CONCLUSION

The goal of this research was to analyze the degree to which there is a capacity to manage agricultural landscapes for multiple ecosystem services with existing and emerging agricultural management practices. I addressed this goal by conducting a case study with agriculture and conservation stakeholders in Iowa, U.S.A, using the Delphi survey technique and in-person interviews with photo elicitation. I assessed stakeholders' views on the relationships between ecosystem services and land management. The collective response, with respect to my research goal was both *yes, the capacity exists,* and *no, the capacity does not exist*. More specifically, yes, we *can* manage for multiple ecosystem services with the existing and emerging practices in our toolbox. We know enough to do far better than the current levels of environmental degradation may lead an outsider to believe. However, we lack the capacity to coordinate management efforts at the appropriate scale.

Landscape-level planning was acknowledged by the participants in the case study as being a critical strategy for the development of ecosystem services management on agricultural lands. However, landscape-level planning is a task beset with challenges. Management initiatives must overcome private property boundaries, build landscape networks of agricultural land management practices, and establish a new paradigm in conservation policy and practice. There is nothing particularly novel in this finding, as others have made compelling arguments for coordinated planning and management for years. It is exciting, however, to hear the participants in this case study speak to it, and with strong sentiment. Many of the individuals included in this case study are in positions of power and influence, in which they have the capacity to promote landscape-level planning.

This case study offered insight into the trials and tribulations of applying ecosystem services as a platform for agricultural land-use decision making (Chapter 2). While the results reveal a deep disagreement between production-centered pers-

pectives and ecosystem service-centered perspectives, benefits related to water filtration and purification, maintenance of soil fertility including erosion control, and food production were found to be the most important for Iowa. The case study revealed potential communication barriers due to differing definitions of words and ideas and misinformation regarding the relationships between land management and some ecosystem services. To overcome these barriers, I presented a framework—shaped in response to questions frequently posed by participants of the case study—for discussions regarding ecosystem services in an agricultural context. The case study finds an overall agreement in the degree to which there is a perceived capacity to transition conventional agricultural landscapes with recognized and accepted management practices. The concept of ecosystem services is found to be useful and continuing to develop towards becoming a concrete element of agricultural and environmental land management. With careful considerations, ecosystem services can serve as a useful platform for land management decision making.

I applied the case study data to a prioritization framework to generate a list of management priorities for Iowa, U.S.A., and found that there are opportunities for enhancing ecosystem services at multiple scales and across levels of management organization (Chapter 3). This priority list is intended to inform a place-based ecosystem service management tool box which offers something for all farmers and farm owners. I suggest that prioritizing management practices is useful exercise for guiding research initiatives, policy creation, and on the ground implementation of practices.

Finally, I've presented a portfolio of photorealistic landscape visualizations, which I created as part of my graduate research assistantship and program of study (Chapter 4). These and other such visualizations have been shown to be useful for communicating complex issues regarding land management. I presented projects designed for research purposes—for use in interviews, surveys, grant applications, presentations, and publications. Given the wholly positive response I have re-

ceived in reference to these visualizations, I foresee they may be an invaluable tool for policy discussion and on the ground planning. I highly suggest the tool of photo-realistic landscape visualizations be more widely used in the fields of natural re-sources and agriculture.

In closing, I find that there is great hope for advancing ecosystem service management using existing and emerging agricultural and conservation practices. While there are many roadblocks to establishing effective coordination of ecosys-tem service management at the appropriate scale, I am greatly encouraged by the knowledge and passion of agricultural and environmental stakeholders in Iowa. We know enough to do better; now we just need to do it. I hope that this work provides a pathway for capturing efficiencies associated with successfully using the concept of ecosystem services as a framework for agricultural decision making.

APPENDIX A: DOCUMENTS ASSOCIATED WITH DELPHI ROUND ONE

ISU IRB # 1	09-331
EXEMPT DATE:	10 July 2009
Initial By:	jlc

Farming for Ecosystem Services

Organizers: Drake Larsen[†], Lisa Schulte Moore[†], John Tyndall[†], and Nancy Grudens-Schuck[‡]

[†]Iowa State University, Department of Natural Resource Ecology and Management
[‡]Iowa State University, Department of Agricultural Education and Studies

The following surveys and landscape modeling exercise are part of a research project to evaluate the utility of the concept of ecosystem services. Your participation in this research project is voluntary. You may skip any questions or activities that you do not feel comfortable with.

Your individual responses will remain confidential and will only be viewed by members of the research team listed above. Any information reported from this exercise will be done in such a way that individual identities are removed.

If you have any questions about this process, please do not hesitate to contact one of us. By completing and returning this survey, you are authorizing us to use your answers in this research.

_____

Circle <u>all</u> that apply from the following categories.

I come from a [**FARM**] or [**SCIENCE**] or [**POLICY**] background.

Ecosystem Services in Iowa Agriculture

Ecosystem Services Survey: Society increasingly demands that agricultural lands serve multiple purposes. This study focuses on the provision of ecosystem services. Meeting the demand for ecosystem services may require big changes in land management, because there is a strong link between land cover, its management, and any benefits that can be derived.

Directions: Make a list of key ecosystem services that you envision can be obtained from agricultural lands in Central Iowa, and then list any changes that may be needed to achieve them. You may bullet the list; responses should be brief phrases, not full sentences.

For questions contact graduate student Drake Larsen, dlarsen@iastate.edu
-or- Dr. Lisa Schulte Moore, lschulte@iastate.edu

APPENDIX B: DOCUMENTS ASSOCIATED WITH DELPHI ROUND TWO

Delphi Survey Round 2

**Neal Smith National Wildlife Refuge Experimental Watershed Advisory Board
Ecosystem Services from Iowa Landscapes**

Part A focuses on 17 ecosystem services and associated benefits that were frequently mentioned during round one of the Delphi survey. Please prioritize these benefits based on what *you* think are important outcomes from Iowa's agricultural lands.

A With Central Iowa in mind, please rank the **top 6** important to you on a scale of 1 - 6 with 1 being the most important and 6 being of lower importance. <u>Use each number only once</u>.

Rank	Ecosystem Services & Benefits
_____	Aesthetic and/or spiritual benefits
_____	Biomass feedstock for biofuel
_____	Carbon sequestration
_____	Erosion control
_____	Feed production
_____	Fiber production
_____	Flood attenuation
_____	Healthy/wholesome food production
_____	Livestock production
_____	Maintain soil fertility
_____	Nutrient cycling
_____	Pest control
_____	Pollination
_____	Tourism & recreation opportunities
_____	Waste treatment
_____	Water filtration and purification
_____	Wildlife habitat

Feel free to make notes or comments in the margins.

Also, there is additional room for comments on the final page of the survey.

Part B focuses on 4 main categories of benefits that emerged from the first round: **1) Agricultural Outcomes, 2) Clean Water, 3) Soil, and 4) Wildlife and Biodiversity.**

B

Agricultural Outcomes

Rank the following in order from 1-4 with 1 being the most important and 4 being of lower importance. Use each number only once.

_____ Grains for conventional commodity markets i.e., feed and processed foods

_____ Regionally-produced foods, i.e., fruits, vegetables, meat, poultry

_____ Primary income for family farmers

_____ Biomass or grain feedstock for biofuel

Clean Water

Rank the following in order from 1-4 with 1 being the most important and 4 being of lower importance. Use each number only once.

_____ Drinking water for downstream populations

_____ Water for crops and livestock

_____ Water bodies for recreation such as fishing, swimming, and boating

_____ Mitigation of hypoxia, the *dead zone*, in the Gulf of Mexico

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Soil

Rank the following in order from 1-2 with 1 being the most important and 2 being of lower importance. Use each number only once.

_____ Safeguarding of soil fertility to sustain future farming

_____ Store carbon to mitigate global climate change

Wildlife and Biodiversity

Rank the following in order from 1-5 with 1 being the most important and 5 being of lower importance. Use each number only once.

_____ Wildlife for recreational opportunities such as fishing, hunting, bird watching

_____ Wildlife for spiritual and aesthetic significance

_____ Native pollinators

_____ Integrated Pest Management utilizing non-crop plants and animals

_____ Intrinsic value of wildlife

Part C focuses on land cover and land management tactics that are linked to ecosystem goods and services provisioned from Iowa's agricultural landscapes. Please prioritize these tactics based on what *you* think can be the most useful for managing Iowa's agricultural lands for multiple goods and services.

C With Central Iowa in mind, please rank the <u>top 6</u> important to you on a scale of 1 - 6 with 1 being the most important and 6 being of lower importance. <u>Use each number only once</u>.

Rank	Land cover or land management tactic
_____	Best management practices for manure and waste management
_____	Biomass crops raised as biofuel feedstock, e.g., switchgrass, perennial mixes
_____	Bioreactors, i.e., pits of wood chips at the outlets of tile lines, used to capture nitrogen from drainage water
_____	Cover crops
_____	Diverse crop rotations, e.g., including small grains and hay in rotations
_____	Increase livestock numbers on the land, i.e., more managed grazing
_____	Landscape level planning, i.e. targeted conservation activities
_____	No till or minimal tillage
_____	Perennial cropping systems
_____	Restored wetlands
_____	Restored native grasslands
_____	Riparian buffers
_____	Sensitive lands buffers
_____	Standard organic agricultural methods for row crops
_____	Stream restoration, e.g., allowing streams to meander
_____	Strips of perennial plants on the contour in row crop fields, such as the treatments at Neal Smith National Wildlife Refuge experimental watersheds
_____	Traditional terraces and grassed waterways

Feel free to make notes or comments in the margins.

Also, there is additional room for comments on the final page of the survey.

D | Circle all that apply from the following categories.
I come from a **[FARM]** or **[SCIENCE]** or **[POLICY]** background.

Comments:_____

_____

_____

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_____

This is the end of the survey. Thank you for your time. Please return using the envelope provided.

APPENDIX C: DOCUMENTS ASSOCIATED WITH DELPHI ROUND THREE

Delphi Survey Round 3

STRIPs project at Neal Smith National Wildlife Refuge
Ecosystem Services from Iowa Landscapes

A
Please prioritize the following agricultural outcomes based on what *you* think are important outcomes from Iowa's agricultural lands; rank the **top 5** on a scale of 1 - 5 with 1 being the most important and 5 being of lower importance.

Rank	Agricultural Outcomes
_____	Maintenance of soil fertility and nutrient cycling
_____	Outdoor recreational opportunities and aesthetically-pleasing landscapes
_____	Pollination and natural pest control
_____	Prevention of soil erosion and sedimentation
_____	Production of crops and livestock
_____	Purification and filtration of water
_____	Regulation of water movement, including flood prevention

B For each of the following agricultural outcomes (underlined), please prioritize the land management tactics that merit further effort in scientific research, outreach and education, or implementation in order to be achieved in Iowa. Rank on a scale of 1 - 6 with 1 being the most important and 6 being of lower importance. If any item is not appropriate for reaching the outcome, please mark it as: N/A.

Maintenance of soil fertility and nutrient cycling

_____ Using small grains and forages in multi-year crop rotations with corn and beans

_____ Livestock grazing on perennial vegetation

_____ Riparian buffers

_____ Restoration and reconstruction of wetlands

_____ No-till or minimum tillage of row crop fields

_____ Strategic placement of conservation measures and landscape level planning

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Outdoor recreational opportunities and aesthetically-pleasing landscapes

_____ Using small grains and forages in multi-year crop rotations with corn and beans

_____ Livestock grazing on perennial vegetation

_____ Riparian buffers

_____ Restoration and reconstruction of wetlands

_____ No-till or minimum tillage of row crop fields

_____ Strategic placement of conservation measures and landscape level planning

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Pollination and natural pest control

_____ Using small grains and forages in multi-year crop rotations with corn and beans

_____ Livestock grazing on perennial vegetation

_____ Riparian buffers

_____ Restoration and reconstruction of wetlands

_____ No-till or minimum tillage of row crop fields

_____ Strategic placement of conservation measures and landscape level planning

Prevention of soil erosion and sedimentation

_____ Using small grains and forages in multi-year crop rotations with corn and beans

_____ Livestock grazing on perennial vegetation

_____ Riparian buffers

_____ Restoration and reconstruction of wetlands

_____ No-till or minimum tillage of row crop fields

_____ Strategic placement of conservation measures and landscape level planning

Purification and filtration of water

_____ Using small grains and forages in multi-year crop rotations with corn and beans

_____ Livestock grazing on perennial vegetation

_____ Riparian buffers

_____ Restoration and reconstruction of wetlands

_____ No-till or minimum tillage of row crop fields

_____ Strategic placement of conservation measures and landscape level planning

Regulation of water movement, including flood prevention

_____ Using small grains and forages in multi-year crop rotations with corn and beans

_____ Livestock grazing on perennial vegetation

_____ Riparian buffers

_____ Restoration and reconstruction of wetlands

_____ No-till or minimum tillage of row crop fields

_____ Strategic placement of conservation measures and landscape level planning

Comments:_____

_____

_____

C In the past 6 months, how often have you been engaged in the following activities?
Circle the appropriate response for each activity.

Farming	OFTEN	SOMETIMES	SELDOM	NEVER
Interacting with farmers and landowners	OFTEN	SOMETIMES	SELDOM	NEVER
Interacting with policy makers concerning agriculture or natural resources	OFTEN	SOMETIMES	SELDOM	NEVER
Interacting with the public concerning agriculture or natural resources	OFTEN	SOMETIMES	SELDOM	NEVER
Scientific research pertaining to agriculture or natural resources	OFTEN	SOMETIMES	SELDOM	NEVER

Comments:_____

_____
_____
_____
_____
_____

This is the end of this survey and concludes the overall Delphi survey. Thank you for your time.

I will share the results with you as soon as they are available.
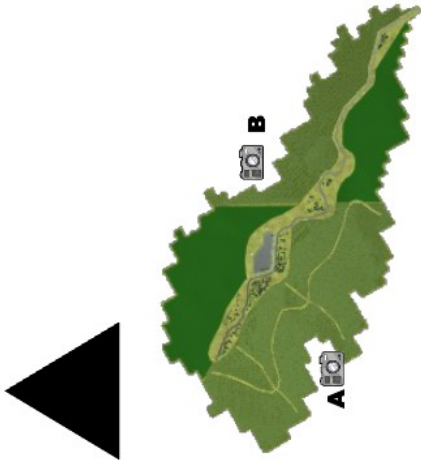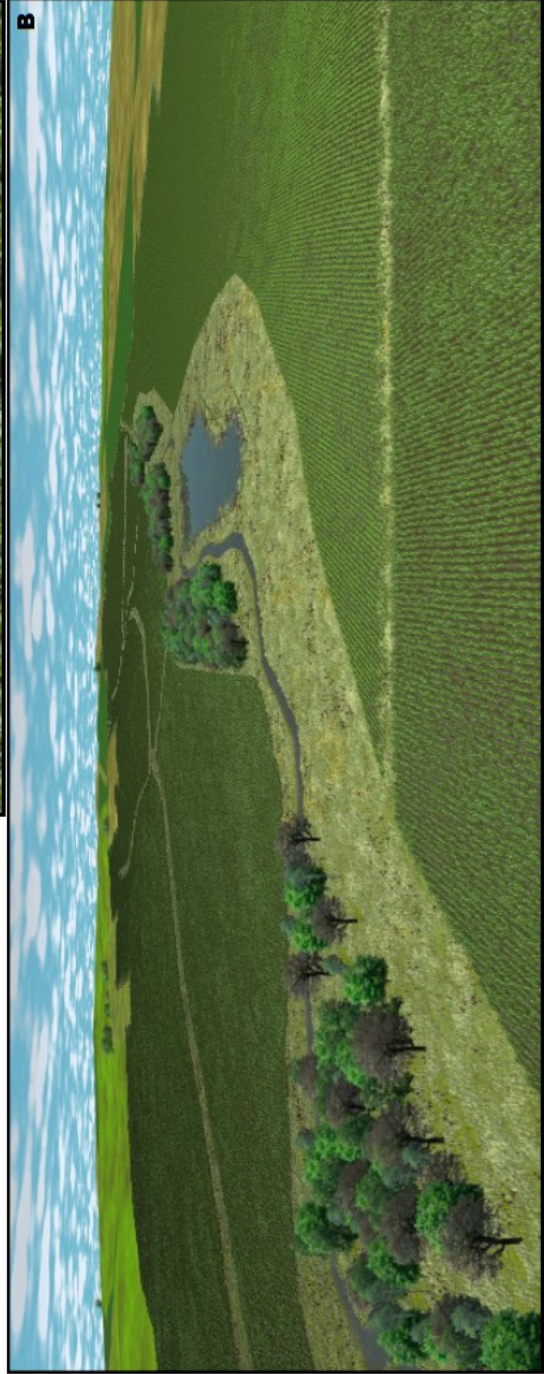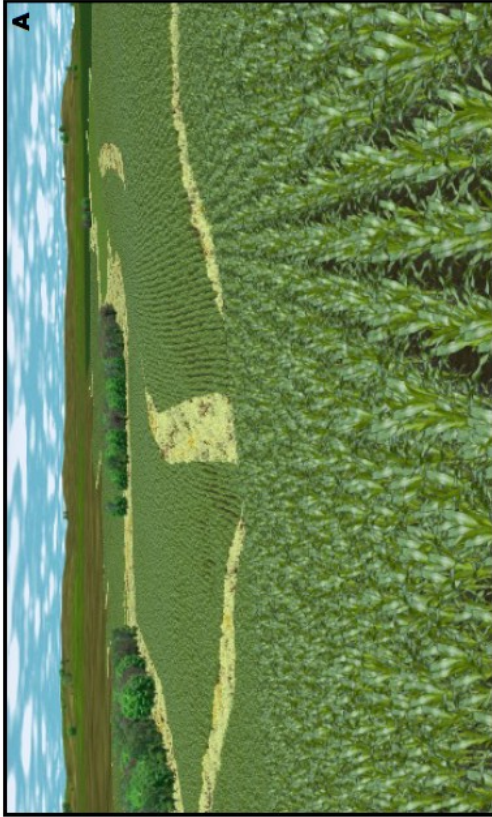
Please return using the envelope provided.

APPENDIX D: IMAGES ASSOCIATED WITH LANDSCAPE SCENARIOS PRESENTED IN CHAPTERS 2 AND 4

124
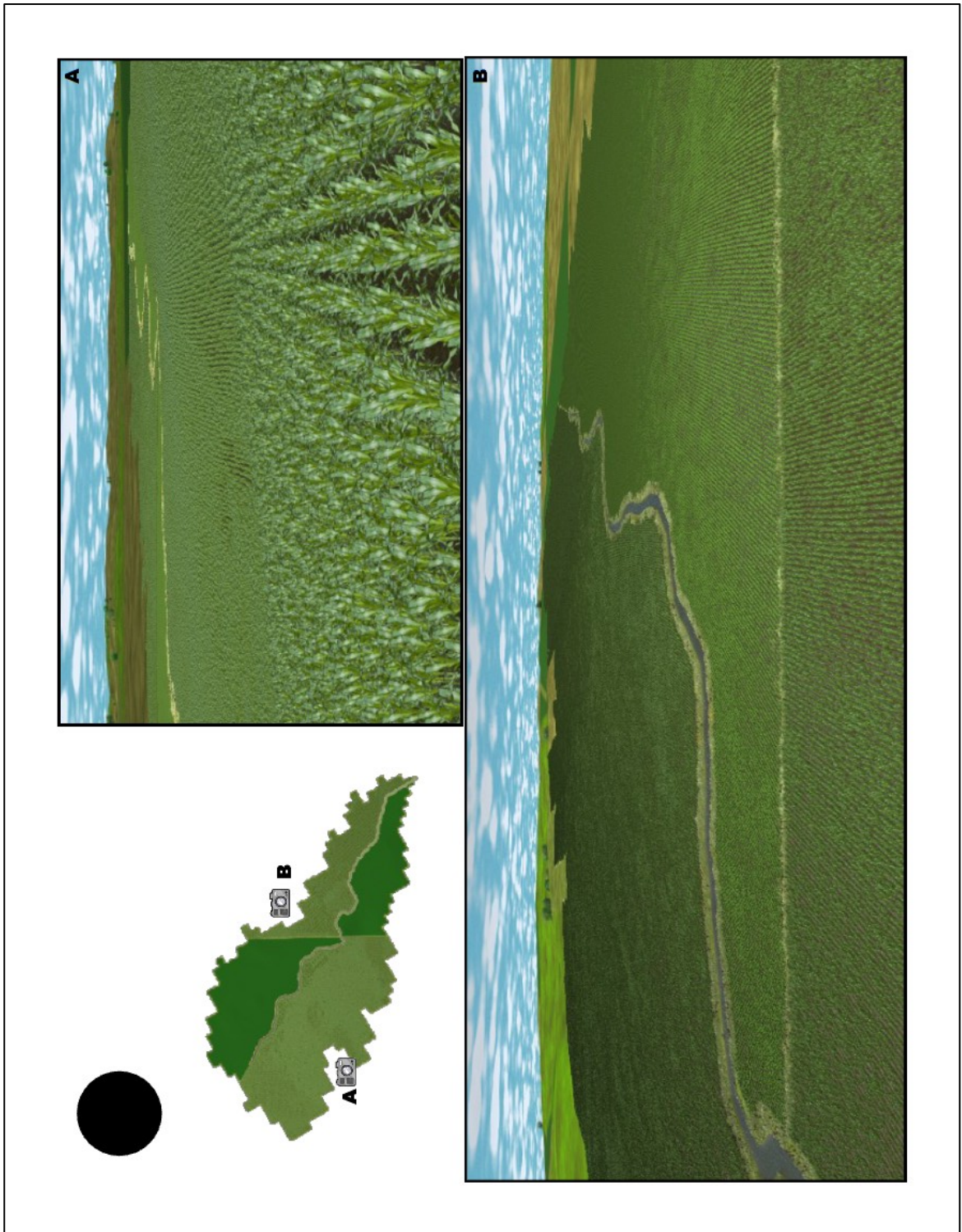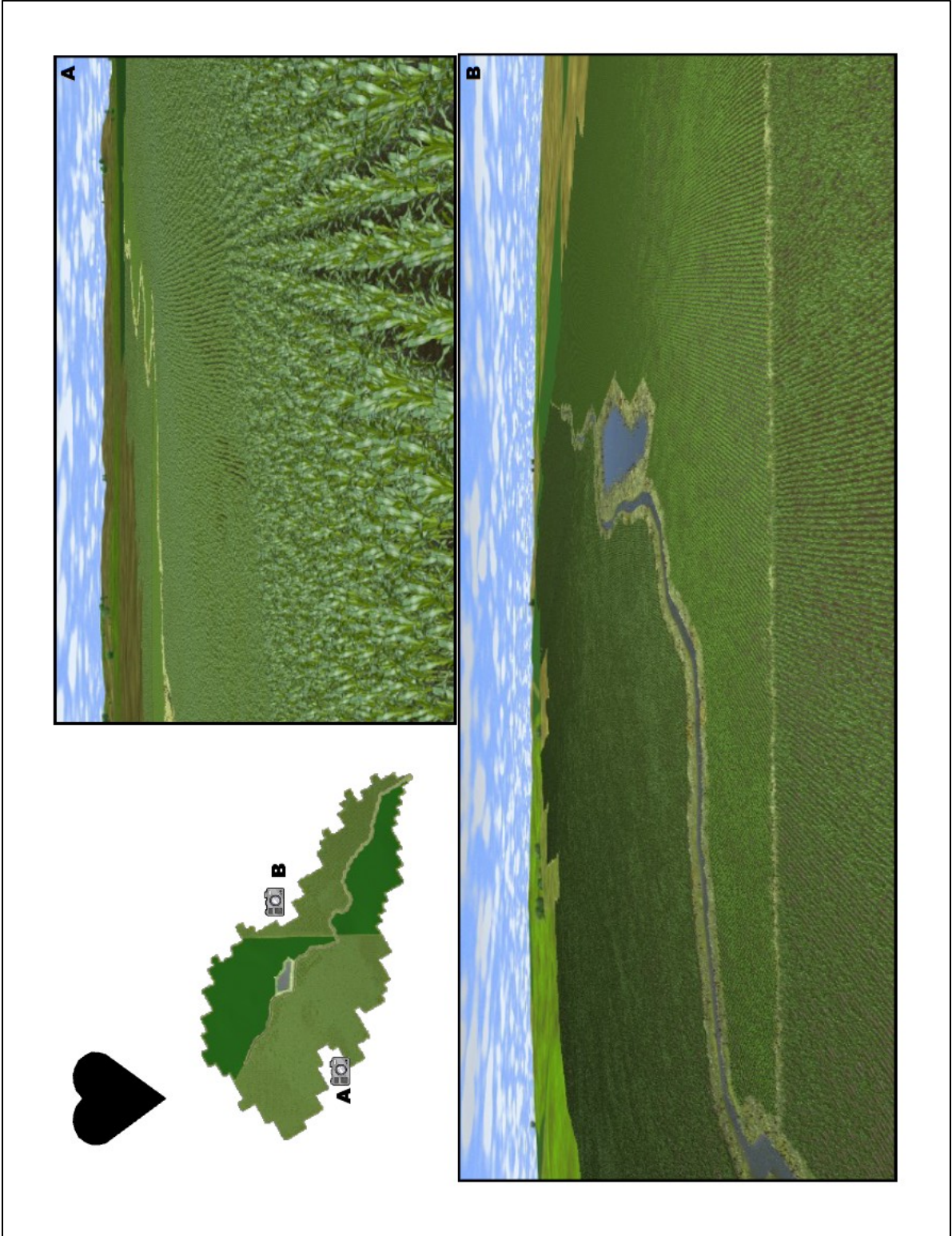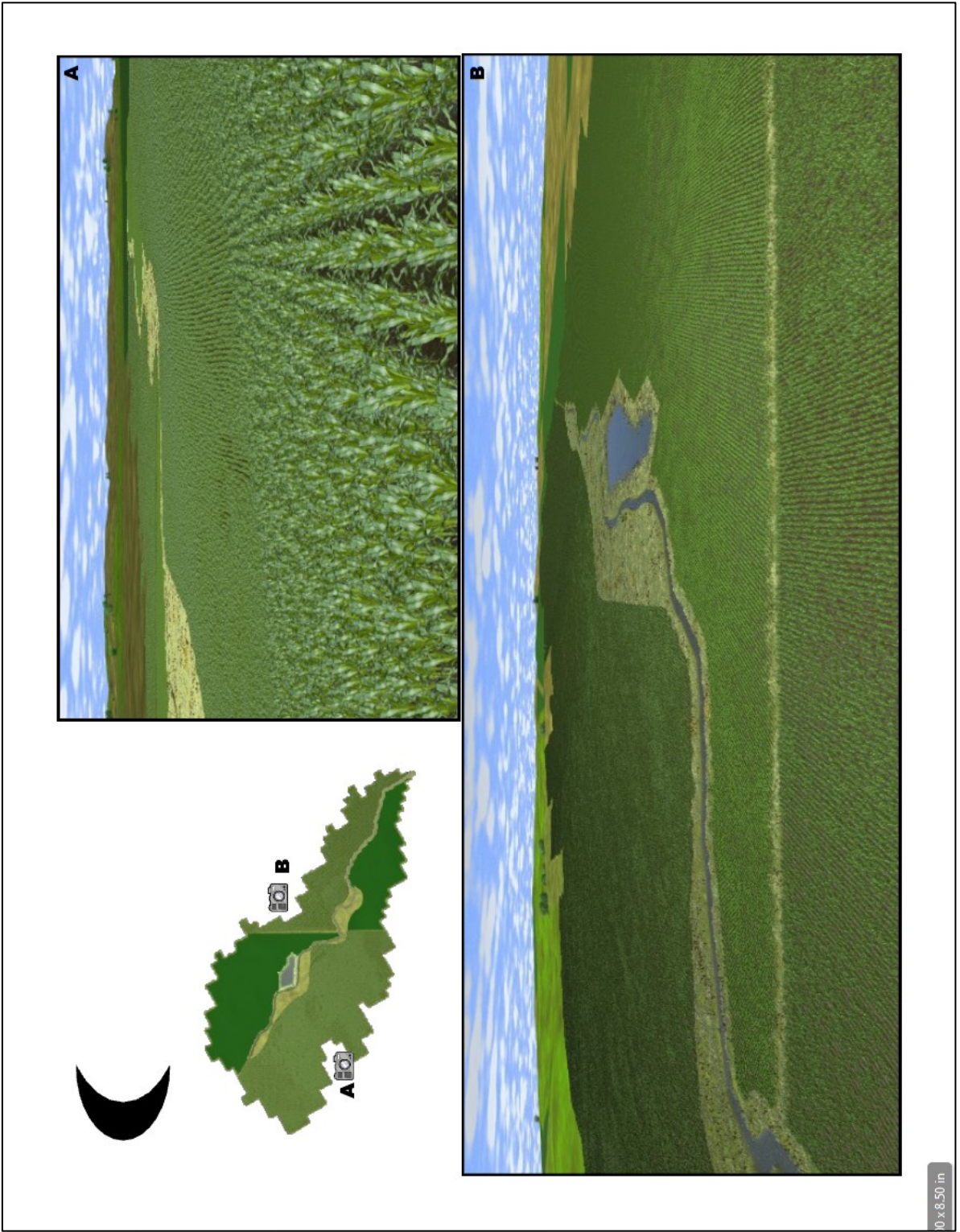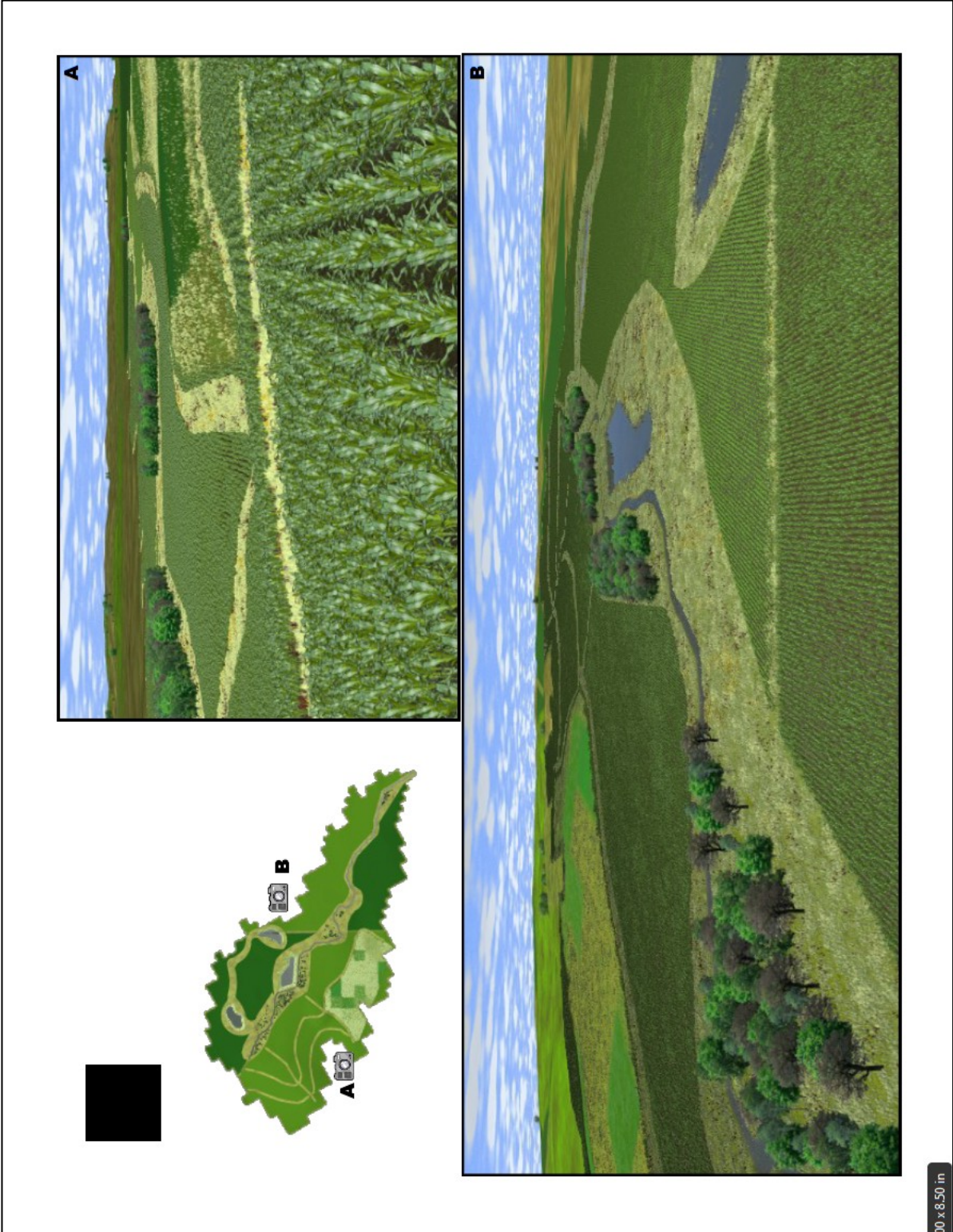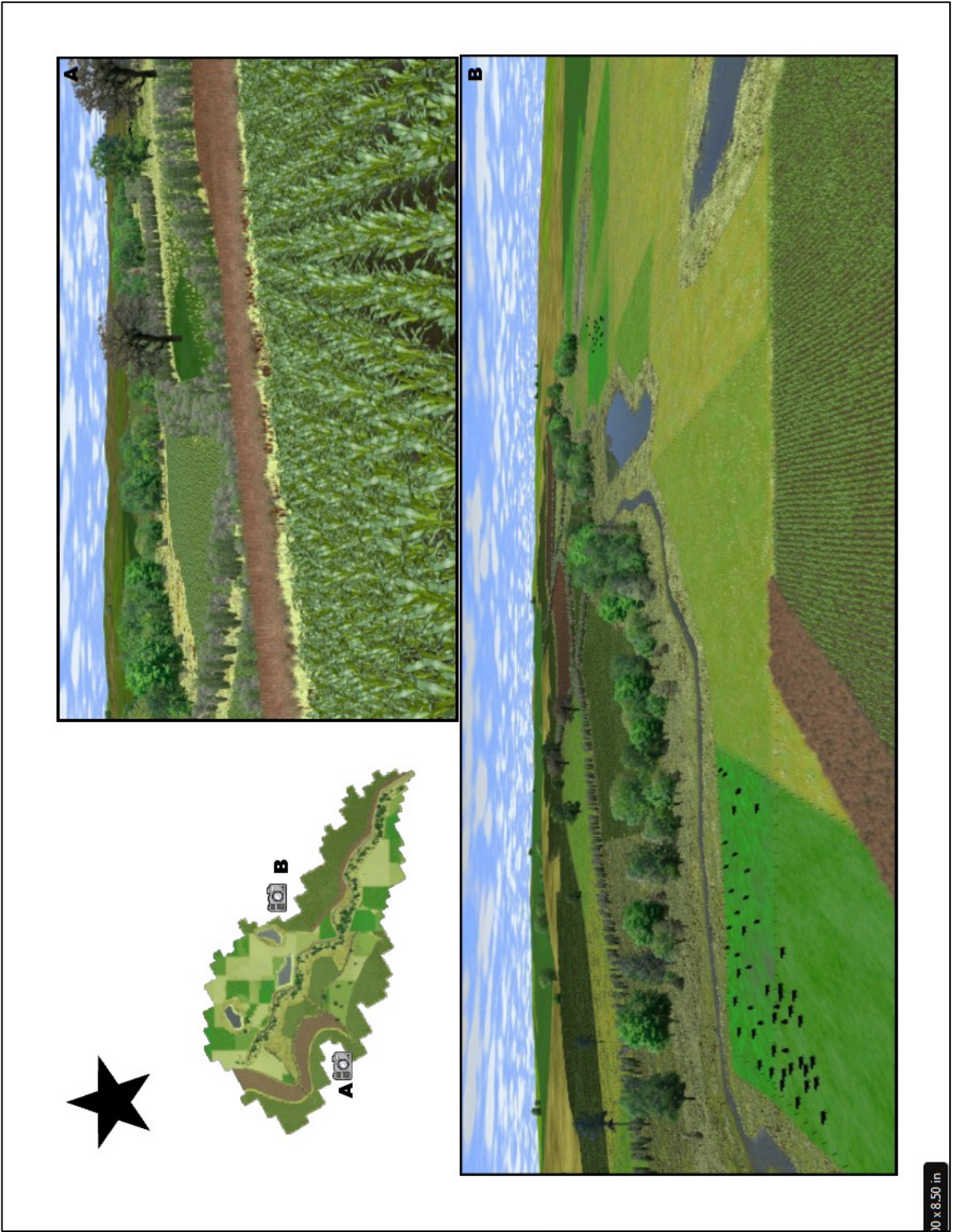
APPENDIX E: INTERVIEW PROTOCOL

A. Introduction

"Hi, I am Drake Larsen, a graduate student in the College of Agriculture at Iowa State University. I work in the Department of Natural Resource Ecology and Management and am interested in landscape ecology—which is the science of understanding how people, wildlife, and water interact on the land. My research explores the links between Iowa's agricultural landscape and the benefits it provides to the people of Iowa. Specifically, I am interested in what sorts of benefits people envision from Iowa's landscape, how changes in land management can bring about different sorts of benefits and the trade-offs between managing for a certain benefit over another.

"I am happy to be working with the stakeholders of the STRIPs project at Neal Smith because I feel this group accurately represents the diversity of backgrounds and different perspectives that are at the table in the land use decision making process; from scientists to farmers to policy makers to NGO representatives to community leaders and plain citizens.

"I would like to take the next 10 to 20 minutes to talk with you about your perspectives on the suite of benefits that Iowa's landscape can provide. To this end, I want to get your feedback on a set of pictures that depict different agricultural management tactics that might be practiced in Iowa now and in the future. Your individual responses will remain confidential and will only be viewed by members of our research team. Any information reported from this exercise will be done in such a way that your identity is removed. If you have any questions about this process or confidentiality, please ask now or interrupt me at anytime. Additionally, I would like to record the audio our conversation for the sake of accurate data collection, would this be OK? [start recording if they say OK, if not proceed without recording]

"OK, as I mentioned, I am interested in the links between land, land management, and the benefits these provide to Iowans. One of the challenges of

this sort of work is that the benefits are often disassociated from their place of origin - that is, the land is owned and managed by many different individuals and the subsequent benefits go to various peoples/ communities at large. Another challenge is that while it is understood that these links exist, the specifics are usually dependant on the time and place and the people involved. To focus our conversation today, we have created a hypothetical watershed, which is located Iowa, as our "place". The time is now and people are you and your fellow stakeholders of the STRIPs project.

"Before we get started, I would like to ask generally about your background. Would you say you come from a farm, science, policy, or NGO background (can be multiple or other)."

B. Scenario survey

"Welcome to our hypothetical watershed. [show the PE/WI slope map] Here is slope map of the watershed - the hot colors are steeper slopes while the cooler colors are flatter areas. You will notice, the watershed is divided by a small stream down the middle, in blue. This hypothetical watershed has been designed to be a hybrid of two of Iowa's major landforms. To the SW of the stream the land is typical of the Southern Iowa Drift Plain, which is characterized by rolling hills with some steep hillsides and is found (here) at Neal Smith NWR and south of (t)here. To the NE of the stream the land is typical of the Des Moines Lobe landform, which is flatter, the soil somewhat less well drained in places and is found generally north of Neal Smith NWR; this area is also known as the Prairie Pothole Region. The hypothetical watershed is 165 acres it is all farmland—there are no farmsteads or roads within the watershed. Do you have any questions so far?

"For this watershed I have designed six land management scenarios - more simply six possible management approaches. I am going to show you some land cover models for each scenario - these models are intended to depict a realistic

view - akin to a photo of the real place. I have labeled the scenarios by the names of shapes in an effort not to order them, but so that we can still easily discuss them and I can reference written or recorded comments to the correct scenario later on [secret labels are from 1-6 respectively: circle, heart, crescent, triangle, square, and star]. Here are the models [layout sheets individually on the table], I will give you as long as you'd like to look them over. If you have any questions as to what you are seeing in any of them, please feel free to ask at any time.

"Great, thanks. Ok, now I'd like you to look at the pictures/scenarios again, and I would like you to arrange them in order from left to right, based on the landscape that has potential to provide the least benefits to the potential to provide the most benefits. Please make your decisions on reasons that matters to you personally. Again, on the left are the least benefits to most benefits to the right."

[record order on data sheet]

C. Land, land management, and ecosystem services

"OK, great. First, I would like to ask what sorts of benefits you had in mind as you made your decisions."

[Follow-up questions as to rank order - specifically probing what they saw in pictures and what management practices they thought were linked to the benefit they had in mind]

[Any more follow up on links between land and benefits?]

[Follow up on common benefits that they did not mention? Probe for disinterest and "collateral" benefits, aka, benefits that simply come along with doing something for a different purpose]

D. Percent Perennial Cover

"Ok, great, now I've got one final task for you today. You may have noticed, these scenarios represent a range in the amount perennial cover. I am going to arrange them in order from least to most perennial cover" [arrange their left to right].

"Now I would like you to think to yourself for a moment about the landscape that you envision for the future of Iowa agriculture: a landscape that provides the sorts of benefits like we've discussed today balanced with upholding Iowa's rich agricultural role. Given our hypothetical watershed, think about how "your Iowa" would look for this hypothetical little piece of land.

"OK, do you have your Iowa vision in your head? Keep that vision and look at the scenarios again and think about where your vision would fit in along this gradient of percent perennial cover. Ok, now I am going to reveal the percentage of perennials for each of the scenarios [reveal scenario legend sheet]. Now, using these scenarios as a ruler, please estimate what percent perennial cover did you envision could provide a good balance of multiple benefits and balanced with high agricultural output?"

E. Conclusion

"Excellent. That concludes my formal questions for you. Do you have anything that you would like to add that has come to mind during our conversation? Anything about benefits possible from Iowa's landscape, management practices, or the scenario models that we used today?

"Alright, great. Thanks very much for your time and participation. Please contact me if you think of any comments or questions later on: dlarsen@iastate.edu. Also, as we begin to synthesize the results of this work, updates will be posted on the newly revamped STRIPs website found here: http://www.nrem.iastate.edu/research/STRIPs/