ECOSYSTEM SERVICES AND INDIANA AGRICULTURE: FARMERS' AND CONSERVATIONISTS' PERCEPTIONS[1]

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ABSTRACT

The fate of ecosystem services (ESS) in the United States (U.S.) depends on the actions of private landowners and operators ("farmers"). This work uses a mixed qualitative and quantitative method to understand farmer knowledge of ESS and willingness to manage lands from an ESS perspective. Fourteen interviews were conducted to analyze farmer understanding of ESS within the context of conservation management. Two hundred surveys of Indiana farmers and 33 surveys of Indiana U.S. Department of Agriculture Natural Resource Conservation Service (NRCS) conservationists ("conservationists") were analyzed in order to assess ESS knowledge derived from varied land types. Though most farmers and conservationists were unfamiliar with ESS, both groups consistently recognized environmental benefits from land types and conservation practices. They were also able to identify trade-offs in ESS when managing lands for maximum food production. Farmers and conservationists differed in their views of the beneficiaries and stewards of ESS, which also varied by land type. Overall, this study shows that while Indiana farmers and conservationists are aware of ESS concepts, some ecosystem services are more easily recognized and understood than others. By understanding how farmers view and describe ESS, we can start applying the ESS concept to agricultural management in the U.S.

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1 INTRODUCTION

Ecosystem services (ESS) are defined as benefits the natural environment provides to humans, and are divided into four categories: provisional, regulatory, cultural, and supporting (MEA 2005). The ESS concept provides a holistic framework for understanding links between human actions on the natural environment and human well-being, which makes it practical for land management decision-making. Human-altered landscapes have existed for thousands of years; however, in the past century, rates of land conversion have accelerated (Foley et al. 2005). Specifically, natural landscapes have been increasingly converted to agriculture; over 40% of the world's terrestrial ecosystems are now agriculturally managed (Foley et al. 2005). In this type of land conversion, ESS are often diminished or lost in order to increase food provision (Foley et al. 2005; Rodriguez et al. 2006; Wratten et al. 2013). However, this loss can create a negative feedback loop that may unintentionally undermine food provisioning (Rodriguez et al. 2006). The ESS concept can aid in evaluation of these trade-offs and development of sustainable management strategies.

Although the ESS concept is not new, it's popularity as a management tool is growing (Seppelt et al. 2011; Von Haaren and Albert 2011; Sandhu et al. 2012; Logsdon and Chaubey 2013). The U.S. Department of Agriculture (USDA) established an Office

of Environmental Markets (OEM) in 2008 (USDA 2010), and in 2011, the Presidents' Council of Advisors on Science and Technology released a report on ESS for protecting society and the economy (Holdren and Lander 2011). This coincides with the fact that approximately 60% of land in the U.S. is owned by private landowners, the majority of which is cropland or pasture/rangeland (USDA-ERS 2006). In the U.S. Corn Belt, which includes Indiana, 95% of the land is privately owned (USDA-ERS 2006). This suggests that if U.S. lands are to be managed for multiple ESS, cooperation from private land managers is needed.

USDA Natural Resource Conservation Service (NRCS) programming and accompanying state agricultural conservation programs have long established a culture and system of delivery for agricultural conservation (referred to simply as "conservation" throughout). While original design of structural and management-based conservation practices in agriculture was intended to target specific improvements in environmental quality, practice implementation inherently enhances multiple ESS.

Private landowners, farm owners, and farm operators can be considered key stakeholders in managing ESS, and their knowledge and perceptions of ESS are relevant (Purushothaman et al. 2013). Farmers generally view themselves as good stewards and land managers (Ahnstrom et al. 2008; McGuire et al. 2013). Despite this sentiment, managing lands for restoration of multiple ESS could be more complicated and require significant farmer training and involvement (Benayas and Bullock 2012).

Multiple studies have examined the effect of farmers' perceptions on conservation efforts (Ryan et al. 2003; Pannell et al. 2006; Ahnstrom et al. 2008; Prokopy et al. 2008; Greiner et al. 2009; Greiner and Gregg 2011; Reimer et al. 2011; Arbuckle 2012; Arbuckle 2013), how payments for ESS to farmers could be implemented (Powlson et al. 2011; Hayes 2012), and ESS

assessment in agriculture (Wratten et al. 2013). More recently, studies outside the U.S. have focused on understanding farmers' perceptions of ESS (Sandhu et al. 2007; Sandhu et al. 2012; Smith and Sullivan 2014). This study, however, is a first step in exploring the extent of U.S. farmer knowledge of the terms and meanings within the MEA ESS framework. We also aim to demonstrate the opportunity to engage U.S. farmers to improve and restore ESS.

The overall goal of this work was to evaluate awareness and perceptions of ESS among Indiana farmers (owners and operators) and NRCS conservationists. Four research questions motivated this work:

(1) Have farmers (or conservationists) heard of the term "ecosystem services," and do they know its MEA meaning?
(2) Do farmers (or conservationists) recognize the ESS provided by landscapes, and do they value these services?
(3) Who do farmers (or conservationists) consider to benefit directly from ecosystem services, and who do they believe is responsible for maintaining ESS?
(4) If U.S. farmers are decision-makers for restoring and improving ESS in their lands, what are effective methods of engaging them in policy discussions?

This research aimed to gain a baseline perception of ESS through in-depth interviews and statewide surveying of Indiana farmers and conservationists. Interviews provided qualitative data needed to contextualized farmers' perceptions of ESS (Kaplowitz and Hoehn 2001; Prokopy 2011). Farmers' responses, language they used, and concepts they were familiar with in the interviews aided creation of the survey.

2 MATERIALS AND METHODS

2.1 Study Area

Indiana was chosen as the study area because it is located in the Corn Belt ecoregion of the Midwestern United States (Figure 2.1 Location of Indiana in the U.S., along with number of farmer responses per county (indicated by number in county) and number of NRCS responses by district (indicated by color of district).). This region of the U.S. produces over 40% of the global corn and soybean crops and is one of the most productive regions in the world (Guanter et al. 2014). Indiana can serve as a microcosm for Midwestern agriculture and help to better understand the views of private owners and operators who control a large portion of U.S. agriculture.

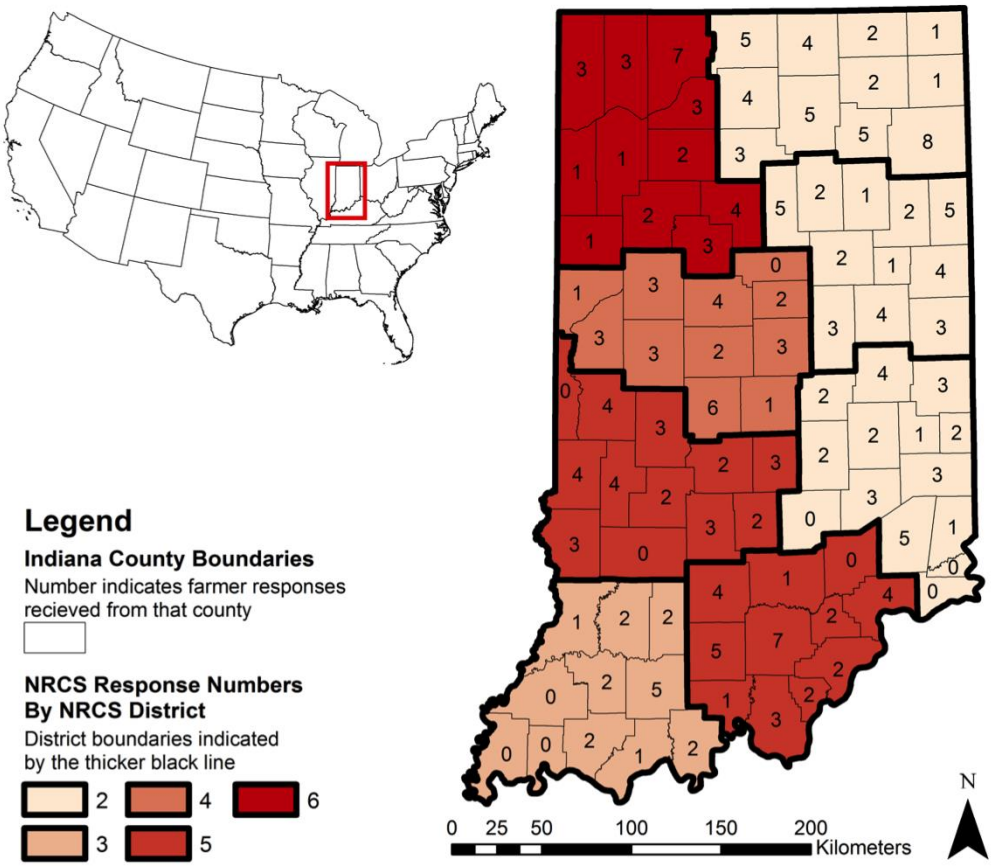


Figure 2.1 Location of Indiana in the U.S., along with number of farmer responses per county (indicated by number in county) and number of NRCS responses by district (indicated by color of district).

2.2 Sampling Tools and Methods

2.2.1 In-depth Interviews

Individual interviews with Indiana farmers were conducted to explore knowledge and perceptions surrounding ESS within the context of agricultural conservation practices. Two questions were included to define and describe ESS: (1) "Are you familiar with the term 'ecosystem services?" and (2) "How would you describe ecosystem services?" In addition, farmers were asked to describe benefits of eleven conservation practices. These questions were included in a longer interview script as part of a broader study designed to evaluate an adaptive targeting approach to conservation (Kalcic et al. 2013).

Interview participants were targeted in two small watersheds in Tippecanoe County, Indiana. Fourteen farmers were interviewed, containing twelve actively farming and two retired farmers. Participating farmers were identified using publicly available parcel ownership data, and while total land area farmed by interviewees accounted for approximately 33% of study watershed land area, the response rate was nearly 100% from farmers contacted by mail and phone. Farmers who operated in the remaining 67% of the watershed land couldn't be identified.

2.2.2 Farmer Survey

Indiana farm owners and operators were the target study group. A sample of this population was obtained using the USDA Farm Service Agency (FSA) payment records, accessed using a Freedom of Information Act request. After removing duplicates and entries with non-Indiana mailing addresses, there were 66,051 producers who received a USDA FSA payment in 2011. This modified database was then sub-sampled using a randomized algorithm, weighted by county farmland percentage. One of the three hardcopy surveys was then randomly

distributed to the resulting 1,000-person mailing list. Three rounds of hard-copy surveys were sent based on a modified Dillman method (Dillman 2000).

The survey was developed and reviewed in multiple stages to ensure it would address the objectives of this study through a method that was quick and easy for participants to complete. Initial questions were developed using qualitative results from the interviews. The survey was pretested in focus groups with undergraduate students with agricultural backgrounds. These focus groups helped examine and improve wording and formatting that might be confusing, misleading, or off-putting for participants. The final survey is provided in the Appendix. The survey consisted of question types described in Table 2.1.

Table 2.1 Specific questions and categories of questions asked on the farmer survey.

Category	Questions Asked
Ecosystem Service Questions	• Do you know what an "ecosystem" is? • Have you heard of the term "ecosystem services"? • What would you guess that "ecosystem services" means?
Conservation Questions	• What conservation practices do you implement on your farm? • What federal or state conservation programs have you participated in? • Do you consider yourself to be conservation-minded in your views of agricultural production?
Information and Willingness to Change Farm Practices	• Where do you get information when making farm management decisions? • Would you be more willing to implement conservation practices if you knew how they benefited your farm's ecosystems? • What resources would you consult for information about the environmental benefits on your farm?
Value, Beneficiaries, and Stewards of Environmental Benefits	• How often do *[land type]* provide the following benefits to society? *benefits provided in* Table 2.3 • If you checked that one of the benefits was provided by *[land type]*, how valuable is this benefit to you? • Who benefits from *[land type]*? • Who should be responsible for maintaining *[land type]* benefits? • Of those responsible, who do you believe is most responsible for maintaining benefits form *[land type]*?
Personal and Farm Demographics	• What counties do you farm in Indiana? • How many acres do you farm? • What types of crops do you produce? • What livestock do you have on your farm? • How many years have you farmed in the area? • Did you grow up on a farm? • What is your gender? • What is your age? • What best describes your work? • Do you identify as a racial minority?

Each participant received one of three versions of the survey, each focusing on a different ecosystem or "land type": croplands, forestlands, and reservoirs, to assess whether or not farmers would recognize differences in ESS provided by different ecosystems. Questions about the given land type included the environmental benefits it provided, associated value of those benefits to society, and who they think are the primary beneficiaries and stewards of those benefits. This was not intended to be a valuation study; therefore, the valuation questions focused broadly on what ESS were most important for society. Based on the interviews, we did not anticipate farmers would know the term "ecosystem services," and determined that using this term in the survey would likely cause confusion, so in most cases we used the term "environmental benefits" instead. Some MEA definitions were reworded to aid comprehension (Table 2.2). In addition, we found that farmers shied away from the term regulation during interviews, so we asked about erosion regulation twice in different ways in the environmental benefits section: using MEA-based language "regulate erosion" as well as "reduce soil loss" so we could test the influence of the word "regulation" in ESS language, though no significant difference was determined.

Table 2.2 Wording changes to convey ecosystem service as a benefit provided by ecosystems.

Category	**Ecosystem Service (Type of Service)**	**Survey Wording – Environmental Benefits**
Provisioning	fiber provision	provide plant fibers
	food provision	provide food
	fresh water provision	provide fresh water
	fuel provision	provide fuel
	genetic resource provision	provide genetic resources
	medicine provision	provide medicines
Regulatory	air quality regulation	provide clean air
	climate regulation	regulate local climate
	erosion regulation	regulate erosion/reduce soil loss
	flood regulation	reduce flooding
Cultural	aesthetic values	are aesthetically pleasing
	recreation	provide opportunities for recreation
	sense of place	provide a sense of place
	spiritual and religious values	inspire spiritual connection
Supporting	biodiversity	maintain species diversity

2.2.3 Conservationist Survey

An almost identical survey was sent to Indiana NRCS conservationists via email by the Indiana State NRCS Office using Qualtrics; participation in the survey was voluntary. Conservationists were randomly assigned a survey land type. The three ESS questions were identical to the farmer survey, with an added question of, "Have ecosystem services ever come up in discussions with farmers?" The "Information and willingness to change practices" category of questions were asked about farmers instead of themselves. Instead of asking farming demographic questions, we asked how long they have been with NRCS, the district they serve, and the type of work they do for NRCS.

2.3 Data Analysis

2.3.1 In-depth Interviews

Interviews were transcribed verbatim and coded using a grounded theory approach as detailed in Miles and Huberman (1994) for a number of themes related to ESS and conservation. The final set of codes (Table 2.3) was developed based on commonly used ESS definitions (MEA 2005). Coding was performed by one researcher and cross-checked for reliability by other members of the research team.

Table 2.3 Final set of 19 codes used to categorize statements related to ecosystem services.

Codes	Description
Aesthetics	Farmer mentions aesthetic benefits of conservation. For example, enjoying the sight of quail or watching hawks nesting in fencerows.
Biodiversity(s)	Farmer mentions biodiversity benefits of conservation. Must specifically comment on diversity beyond statements related only to creation of wildlife habitat.
Climate regulation	Farmer mentions climate regulation benefits of conservation.
Crop pollination(s)	Farmer mentions the importance of crop pollination.
Disaster regulation	Farmer mentions the importance of natural disaster regulation. This would include drought mitigation/regulation, but not flooding regulation, as it has its own category.
Disease regulation	Farmer mentions disease regulation benefits of conservation.
Education	Farmer mentions the education value of ecosystems or cropping systems. For example, noting that Purdue University has test plots that will show how cover crops can be used to improve farmland.
Erosion regulation	Farmer mentions soil erosion benefits of conservation. The farmer may mention both soil and surface water flow related to soil erosion, or wind erosion.
Flood regulation	Farmer mentions the importance of flood regulation. For example, commenting on how a practice might mitigate flooding, or talking about how flooding is a problem in the landscape.
Food provisioning	Farmer mentions the importance of food provisioning.
Fresh water provisioning	Farmer mentions the importance of fresh water provisioning, and any water quality benefits of conservation.
Genetic resources	Farmer mentions the importance of genetic resources on the farm or elsewhere. For example, a farmer emphasizes the difficulties that come with a lack of genetic diversity in the crops he grows.
Habitat(s)	Farmer mentions wildlife habitat benefits of conservation. Coded any time a farmer mentions that a practice provides wildlife habitat, or statements that reveal a more general value of wildlife.

Table 2.3 (Continued) Final set of 19 codes used to categorize statements related to ecosystem services.

Nutrient cycling[(s)]	Farmer mentions nutrient cycling benefits of conservation. For example, water quality concerns in the streams could be addressed by a practice (e.g. nutrient "filtering" by wetlands or grassed waterways), and soil nutrient cycling (e.g. cover crops or legumes improving nutrient composition of the soil).
Pest regulation	Farmer mentions pest regulation, and benefits of conservation.
Recreation	Farmer mentions recreational activities, and the benefits of conservation, such as hunting, fishing, trapping and walking trails.
Sense of place	Farmer mentions a "sense of place" felt when in a natural or conserved area. This can be hard to determine, but examples include simply loving to visit the restored wetland on his property.
Soil formation[(s)]	Farmer mentions soil formation benefits to conservation. Soil tilth, reducing soil compaction, and improving infiltration/drainage are included. Could be in the context of better plant growth, and since soil tilth is in the eye of the beholder, and our beholders are farmers, they're considering soil health for the purpose of growing crops.
Spiritual connection	Farmer mentions a spiritual connection to nature or the land. For example, any time a farmer mentions God in relation to preserving the environment, such as "That's how the good Lord intended it to be" when talking about a more pristine landscape.
[(f)] *denotes a supporting ecosystem service.*	

2.3.2 Farmer Surveys

Early in the survey participants were asked to define ESS. In order to better understand what the term could mean to producers upon first hearing it, responses to this question were grouped according to a number of common themes that emerged, similar to those identified in the in-depth farmer interviews.

The majority of data collected, other than demographics, were categorical. In order to analyse differences in farmer responses to the three survey types, chi-squared tests were used. Chi-squared tests were used to examine the differences in responses among the survey types for (1) what benefits participants felt that land type provided, (2) of the benefits that land provides, how valuable the benefits were to society, and (3) who participants felt was most responsible for maintaining those benefits.

2.3.3 Conservationists Surveys

The same chi-squared analyses were completed for the NRCS data as for the farmer data. However, for some tests with low sample sizes, the chi-squared tests results were compared with Fisher's Exact Test as well as Chi-squared tests using Monte Carlo simulation to estimate p-values to confirm the interpretation. Conservationist results were also compared with farmer survey results using similar techniques to examine similarities and differences between the two stakeholders.

3 RESULTS AND DISCUSSION

3.1 In-depth Interviews

Of the 14 farmers interviewed, none produced the MEA definition of "ecosystem services", and only two had heard of the term. However, they identified a variety of ESS in the context of agricultural conservation, and particularly the benefits received from conservation

practices explicitly discussed (Figure 3.1). Some farmers focused almost exclusively on one or two ESS (e.g. erosion regulation), while others discussed an assortment of ESS. All farmers recognized freshwater provisioning and erosion regulation. Most ESS were only recognized by some of the farmers, although failing to mention a service does not indicate that the farmer does not recognize that service on their lands – instead, it may indicate that they don't believe the specific conservation practices discussed provide that particular service.

Provisioning and regulating services were emphasized more frequently than cultural services. Soil erosion regulation was the most discussed service at over 100 references in fourteen interviews, with food provisioning and freshwater provisioning ranking second and third. It's possible that farmers referred to services they thought the researcher wanted to hear, as the context of the interview was on targeting conservation practices to locations where they would do the most good, and NRCS conservation practice standards were shown to the farmers on sheets of paper during the conversation. In most cases, however, farmers answered the question with their own opinion, as evidenced by frequently neglecting to provide answers available on the NRCS practice standard sheets.

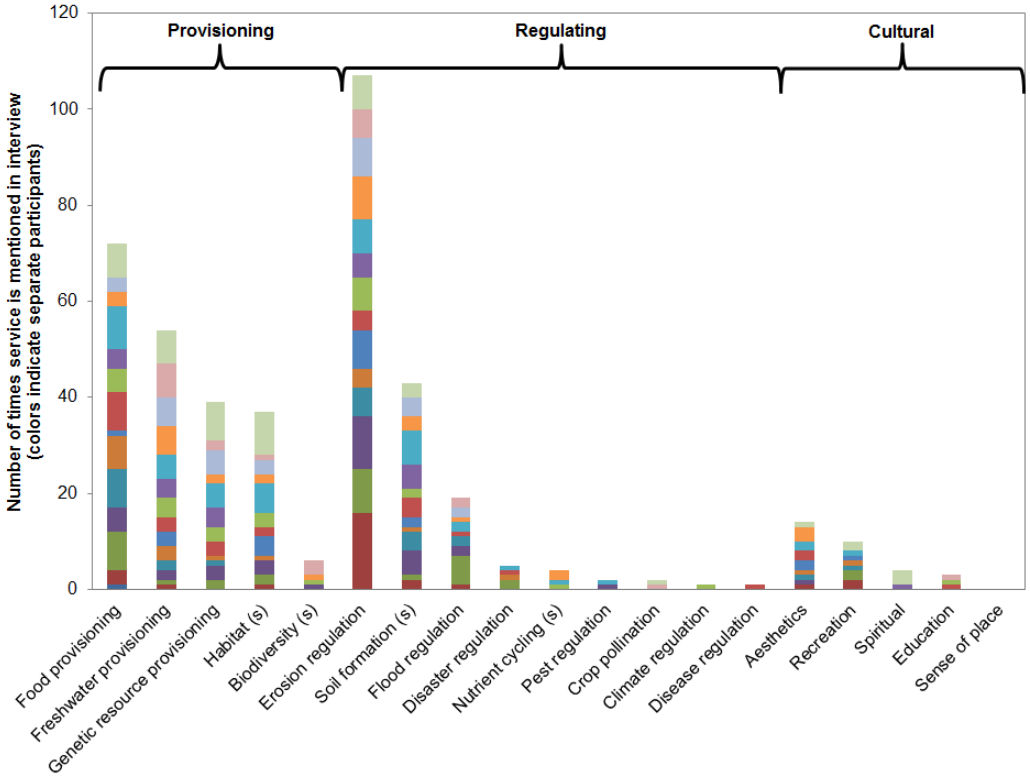


Figure 3.1 Total number of references to ecosystem services over fourteen interviews. Each interview is given a particular color across all bars. Services are arranged by prevalence within service type (provisioning, regulating, and cultural services). Supporting ecosystem services are denoted with an (s).

The emphasis on freshwater provisioning and erosion regulation may also be an outcome of long-term, targeted education and outreach activities to farmers by federal and state conservation agencies such as the NRCS "T-by-2000" campaign. Simultaneously, Indiana has also focused efforts on nonpoint source reduction campaigns, such as the Indiana Department of Environmental Management (IDEM) Section 319 Grant-Funded Watershed Management and the Indiana Department of Agriculture's Clean Water Indiana (CWI) Initiative. The water quality emphasis of these programs may have increased farmer awareness and recognition of freshwater provisioning as a key benefit. Understanding the institutions that already influence farmers can help reveal preferences for ESS provision (Spangenberg et al. 2014).

The following sections detail how farmers perceived the major provisioning, regulating, and cultural services to be relevant to their work and agricultural conservation. Actual quotations are provided in Table 3.1.

Table 3.1 Actual quotes from farmer interviews.

FP-1	"That was nature's way of taking care of us, so we've modified it, and made it, you know, more specialized and more productive. Because how many people can we feed off of these acres today, versus what we did fifty years ago? And that's what your goal is, to make this whole thing more efficient."
FP-2	"I guess it just goes back to the soil is the basis for the productivity and we are…producers of products that sustain people."
FP-3	"we're all about yield out here, so the more we can grow out here off of an acre, then hopefully that will give us more money to operate on."
FWP-1	"[Water protection] is more important to me as a secondary. Obviously economic survival is first. But [it is] secondary to not contribute my nitrogen, phosphorus and potassium to the water supply."
FWP-2	"Keeping those soluble nutrients out of drainage water is very big. We don't want them to go anyplace else, they're ours. We don't want to give them away down the creek. We don't want the guys in New Orleans and on south to have to deal with it. We want to keep them."
FWP-3	"I was always very conscientious when we pumped our pits out of our hog barns, tried not to do it where it could run off, potentially get into a stream."
FWP-4	"I think the previous year, where the big issue was basically nutrient leaching, you couldn't get rid of enough water. I hate to say it, that's why we leach nutrient. And it really wasn't a surface drain problem, it was basically going out the tile [subsurface drain]."
GRP-1	it's kind of nice, it's an ecosystem, you know, and you've got to protect ecosystems. So, [there are] some benefits of it, even though there's no practical agricultural benefit."
GRP-2	"there is some habitat there for types of birds that like to live in the grass."
GRP-3	"just for habitat, homes for wildlife."
GRP-4	"The DNR [Department of Natural Resources] guys used to come up and check this about every year, walk it with you, and every once in a while they'd say 'well there's something' that had gotten established that was lost to the area. They were tickled to death, you never see [these species], so [conservation] works. Like I said, build it and they will come."
GRP-5	"It would be helpful [to do so, but] whether I can justify taking land out of production, that's another story."
GRP-6	"This bench here is a big area for invasive species to get started in."

Table 3.1 (Continued) Actual quotes from farmer interviews.

ER-1	"I will do virtually whatever I can, to a point, to limit the amount of soil leaving our property."
ER-2	"Basically the soil is the most important thing…without soil you don't have anything else."
ER-3	"I think everybody ought to have an idea of what their soil losses are, where they occur, and how to control that."
ER-4	"there's a fine line of being able to keep the dirt where it belongs and keep everything usable,"
ER-5	"Yeah, it's just a problem. The tiles drain into this area, and they're all plugged, so it erodes the top of the ground and starts huge erosion ditches, I'm almost at wits ends. So I need to…whatever programs are available I'll line up for that one. And like I said, there's more erosion on this 78 acres of farm ground than on all the other acres I have."
ER-6	"Again, the biggest deal, it helps control water movement. It keeps the soil much more in place, controls erosion, depending again on the topography."
ER-7	"Slowing the water down, having an access for rain, runoff, to escape without carrying with it much topsoil."
ER-8	"And I can see, this one particular farm we have, it's got a lot of hills, sloping land, and if you get a big rain, there'll be areas, there will be silt, top soil, this deep, that's just washed off of these hills. It can only last so long."
ER-9	"I guess, if it was something that makes the soil, preserves it in some way, I mean I certainly look forward to taking care of the next generation. Someone took care of it for me."
FR-1	"drainage was a religion, it was very rigid – you have to drain."
FR-2	"When it rains, anything more than an inch and three quarters to two inches…if we have had some rain prior too…I lose up to 65 acres of that 150 acres. That has happened about one in three years."
A-1	"Biodiversity. And even landscape diversity. Just the way the landscape looks," or "Well, it's just kind of nice to see the wildlife, I kind of like to see it, diversity of the environment."
A-2	"I think probably we did it more for aesthetic purposes than for anything."
A-3	"It's fun, it's just a fun place to go out to if you like that kind of stuff, go out and walk. We mow the edges [of the wildlife area] and mow through it a little so I can just…when I lived on the farm I'd just go out there and spend an evening, go out after supper and just walk, and it was always fresh out there, cooler, seemed like."

3.1.1 Food Provisioning

Many farmers stated clearly that food provisioning was their primary goal. One farmer emphasized that the goal of farming in general is to increase crop yields (FP-1). Another suggested that food provisioning is at the core of the identity of his profession (FP-2). The importance of crop yields went beyond the satisfaction of sustaining human life on earth – sustaining high crop yields is necessary for farm profitability. Some made direct references to food provisioning as a factor in economic sustainability (FP-3).

Farmers' statements displayed an understanding of the interconnectedness between food provisioning and several supporting services, particularly soil formation and nutrient cycling. While direct references to food provisioning services were common, farmers frequently focused on related supporting services. Soil compaction, soil tilth, nutrient and organic matter content of soils, as well as water availability were emphasized because of their importance to crop growth.

3.1.2 Freshwater Provisioning

Freshwater provisioning was highlighted as another primary benefit of conservation practices, and was also acknowledged as a challenge for intensive agriculture. Most farmers expressed a desire not to pollute waters with fertilizer runoff for two main reasons: fertilizer loss impacts their economic bottom line and it causes harm to humans and the environment downstream. While loss of nutrients to surface waters is a cost to the farmer, some farmers believed water quality consequences of farming were assumed by neighbouring lands or society at large (FWP-1, FWP-2).

Farmers primarily emphasized the water quality aspect of freshwater provisioning rather than quantity. Many farmers used conservation practices intended to reduce the impact of nutrient leaching (FWP-3). However, one farmer highlighted the inherent difficulty of keeping

nutrients out of surface waters, especially under the Indiana climate and subsurface drainage conditions (FWP-4). Overall, most farmers cared about freshwater provisioning primarily for practical (lost fertilizer value) and ethical (not wanting to contribute to problems downstream) reasons. Some farmers showed heightened awareness of water quality concerns related to subsurface tile drainage, while others presumed that water quality protection only need occur along open waterways.

3.1.3 Genetic Resource Provisioning

Genetic resource provisioning was viewed as less synergistic with food provisioning – the main goal of most farmers – leading to discussion of ESS trade-offs. Farmers primarily discussed the benefits of species diversity in the context of habitat restoration conservation practices. Many farmers suggested that diversity is important for sentimental or ideological reasons rather than practical ones. One farmer spoke about a five acre "lake" in his field that he chose not to drain because of "other" benefits it provided, despite its lack of agricultural benefit (GRP-1). Another farmer chose not to mow grass areas on his farm until after wildlife breeding periods so that there was habitat for certain types of birds (GRP-2). One farmer converted a large piece of farmland to wetland, native prairie, and food plots for wildlife. His sole justification was habitat benefits for wildlife (GRP-3). He went on to share how endangered sparrows had inhabited the conservation land (GRP-4). This is also an example of how state and federal agency conservation outreach and encouragement can support and influence farmer priorities.

Ideological reasons, however, are not always sufficiently compelling in the face of practical constraints, such as economics, invasive species, and inconvenience. One farmer brought up the declining bird populations due to decreased habitat, but stated that he may not be comfortable creating habitat from good farmland (GRP-5). Still others brought up difficulties of

keeping invasive species out of conservation lands such as filter strips (GRP-6). Between the economic bottom line of intensive agricultural production and the inconveniences of managing diverse lands on the farm, many were not able to justify conservation measures intended to increase genetic resources.

3.1.4 Erosion Regulation

Soil erosion regulation was the ESS stressed most by farmers regarding conservation, sustainability, and personal farm management goals. One farmer expressed the importance of soil conservation as a priority for his management strategies (ER-1). Another suggested that soil conservation is the most basic need of farming (ER-2). Another farmer suggested that soil conservation is a responsibility all farmers share (ER-3). Yet many farmers mentioned the difficulty of balancing soil erosion and other farm goals. One noted that it is difficult to maintain topsoil, in the context of the practicality and inconvenience of using conservation practices in his farm management (ER-4). Another lamented the difficulty of controlling soil erosion when other management practices fail (ER-5).

Soil erosion regulation was often connected to freshwater provisioning, and farmers generally expressed greater concern over erosion by surface runoff than wind erosion (ER-6). Another farmer suggested that the goal of conservation was to slow runoff so that it could not carry away topsoil (ER-7). Soil erosion was tied to long-term sustainability of farming more than any other service in the interviews. One farmer even expressed a sense of urgency over soil erosion occurring on one sloped farm field (ER-8). Another more directly expressed a desire to sustain the farm for future generations, and that doing so requires soil preservation (ER-9).

3.1.5 Flood Regulation

The importance of flood regulation emerged repeatedly in the need for subsurface drainage in the fairly flat, poorly-drained agricultural fields that are characteristic of west central Indiana. Farmers generally did not discuss the environment as providing flood regulation, but rather as being the cause of the problem. While tile drainage may not be a natural ESS provided by the land, a preoccupation with drainage revealed farmer knowledge of its importance to their operations. All farmers had extensive tile drainage on at least some of their fields, and many had plans to increase the number of tile drains in the wettest fields they worked. One farmer spoke of a mentality where drainage was equivalent to religion (FR-1). Another farmer's story demonstrated how maintaining farm productivity depends on tile drainage, and poor drainage can result in considerable yield losses. In his case, a main tile drain had broken, leaving his land susceptible to ponding (FR-2).

It is notable that while farmers viewed freshwater provisioning and nutrient cycling services as beneficial to humans and the environment downstream, they did not connect the problem of downstream flooding to their tile drainage management. Were the landscape to return to pre-settlement conditions, where extensive poorly-drained soils were wetlands, downstream lands would benefit from reduced flooding in the Wabash River and its tributaries. Yet in this condition, un-drained farmlands would not be nearly as productive for crops.

3.1.6 Aesthetics

Aesthetics was the cultural ESS most frequently mentioned, and was generally introduced in the context of wildlife and restoring diverse landscapes. When asked the benefits of conservation intended to create wildlife habitat, farmers might say how "nice" it was view the diversity and wildlife of the landscape (A-1). When asked why they used these practices, one

commented that aesthetics was a main influence (A-2). When farmers had installed a conservation practice for wildlife, they often told stories of the cultural services provided, such as spending an evening walking around and enjoying the landscape (A-3).

3.2 Farmer and Conservationist Surveys

3.2.1 Sample Characteristics

The response rate for the farmer survey was 20% (N = 200), including 71 cropland surveys, 61 forestland surveys, and 68 reservoir surveys. The responses were spatially distributed across Indiana, with 82 of the 92 counties having at least one response (Figure 2.1). The majority of respondents were male (75%), 55 or older (75%) and either the farm owner (45%) or farm owner and operator (42%). These demographics correspond to National Agricultural Statistics Service (NASS) statistics from Indiana in 2007 which report that Indiana farmers are 90% male and the average age is 55 (USDA 2011). Corn, soybean, hay, and wheat were farmed by 80%, 83%, 34%, and 26%, respectively, with 16% of the respondents growing something other than these crops, and 4% growing no crops (most indicated they were retired). Respondents generally implemented conservation practices, participated in conservation programs, and farmed hundreds to thousands of acres (Table 3.2).

The response rate for the conservationists survey was 16% (N=33) with 10 cropland responses, 8 forestland responses, and 15 reservoir responses. There were at least two responses from each of the NRCS conservation districts in Indiana (Figure 2.1). The majority of respondents who chose to indicate their gender were male (64%) and most respondents were under the age of 55. This is significantly different from the farmer responses, as the majority of respondents were over the age of 55 ($p<0.05$). The most common positions held by participants were District Conservationists (35%), Soil Conservationists (18%) and Engineers (12%).

Table 3.2 Minimum, maximum and mean conservation participation and farm size of farmers.

Farm Demographics	**Min**	**Mean**	**Max**
Conservation practices (no.)	0	2.8	7
Conservation programs (no.)	0	1.2	4
Land farmed (acres)	0*	405	3,000

*Reasons farmers marked "no" land as farmed included they were renting their land, they retired recently, or they had fruit or nut trees, not farmland.

3.2.2 Baseline Knowledge of Ecosystem Services

Most of the farmer participants (72%) were unfamiliar with "ecosystem services." Of the 55% of surveys that provided a definition, only 11 respondents (6%) gave definitions consistent with MEA (Table 3.3). Farmers who had heard of the term were not significantly more likely to provide the correct definition than farmers who hadn't heard of the term. The most common (and incorrect) definition provided by respondents was a category of responses we refer to as "conservation consultant," where participants defined ESS as services provided by an outside group to assess and improve their farm's ecosystem (Table 3.4). This definition is similar to the idea of crop or soil and water conservation service consultants, and the similarity of language is likely one reason they commonly provided this definition. Other categories included "land management," where participants gave a definition which involved humans generally managing the landscape for the benefit of the ecosystem (not humans), "general environment," where participants provided a general statement about protecting the environment, and "ecosystem," where participants gave the definition of an ecosystem (Table 3.4).

Although the percent of conservationists who had heard of the term "ecosystem services" did not differ significantly than the percent of farmers who had heard of the term, a significantly larger percentage (30%, α=0.05) of conservationists were able to provide the MEA definition. The conservationist responses were readily grouped in the same categories as the farmers' responses (Table 3.4). Three conservationists who provided a correct definition of ESS also said the term had come up in conversations with farmers.

Table 3.3 Results of baseline assessment of participant ecosystem service knowledge

	Heard of Term	Not Heard of Term
Definition Right	6	5
Definition Wrong	24	65

Table 3.4 Qualitative coding of farmer and landowner responses to the question "What would you guess that 'ecosystem services' means?" Descriptions of each code, along with representative definitions in that code group, are provided.

ES definition group	**Group description**
No response	The definition is left blank.
Vague	Cannot be grouped because it is too vague.
Irrelevant	Response is irrelevant to the question.
Not sure	Participant states they are not sure what the definition is and does not guess a definition.
Ecosystem	Definition is that of "ecosystem"
General environment	Only a general understanding that ecosystem services relate to the environment in some way.
Land management	Focus is on humans managing the land in ecologically relevant ways, without the mention of an external consultant educating or helping the farmer or landowner. Humans are providing a service to the land.
Conservation consultant	Emphasis is on an outside consultant from government, private industry, academia, etc. helping farmers and landowners manage land in "environmentally friendly" ways. Focuses on external consultants providing a service to the land or landowner.
Correct definition	Definition is in line with the ecosystem service concept. Focus is on the environment providing benefits to humans.

Table 3.4 (Continued) Qualitative coding of farmer and landowner responses to the question "What would you guess that 'ecosystem services' means?" Descriptions of each code, along with representative definitions in that code group, are provided.

ES definition group	Response % (number)		
	Farmers	NRCS	Representative definitions
No response	45% (90)	18% (6)	*N/A*
Vague	1% (1)	0% (0)	*"Management, information"*
Irrelevant	4% (8)	3% (1)	*"You want to control what I do on my land. Tax me or penalize me for not doing it your way."*
Not sure	5% (9)	3% (1)	*"Don't know"* *"?"*
Ecosystem	3% (5)	3% (1)	*"A system formed by the interaction of a community of organisms with its environment"* *"full habitat system"*
General environment	4% (8)	0% (0)	*"Something to do with conservation practices"* *"Balance of soil and nature"* *"Method of protecting the environment"*
Land management	10% (20)	26% (9)	*"A plan that would create a positive, productive ecosystem"* *"How to maintain farm land and protect the environment"*
Conservation consultant	24% (47)	15% (5)	*"Somebody who helps design ecosystems"* *"Help from a Government agency or Group to assist farmer to improve their farm and in turn improve the ecosystem"* *"Consulting to help people maintain the ecology of their lands"*
Correct definition	6% (11)	30% (10)	*"The benefits we get from an ecosystem"* *"Services provided by nature that would otherwise be necessary for humans to perform"*

3.2.3 Recognition and Value of Ecosystem Services

3.2.3.1 Farmers

Although many farmers had not heard of "ecosystem services" and even fewer could correctly define it, it was clear that farmers recognized benefits that different kinds of landscapes provided (Figure 3.2). By indicating the presence (always, sometimes, or never) of a "benefit to society" provided by a land type, the farmers demonstrated their recognition of ESS – even though they may not use the term ESS. Based on the responses from the three different survey types, it was also clear that farmers recognized that different landscapes provide different benefits (or ESS) with some trade-offs (Figure 3.2).

When comparing responses of the forestland and cropland surveys, there was a significant difference in recognized benefits for all services except fiber provision. Moreover, all ESS except food provision were chosen as being provided significantly more often by forestlands than croplands. This shows a trade-off of ESS between these two land types consistent with ESS literature (Groffman et al. 2007) and notably depicted in conceptual trade-offs identified by Foley et al. (2005), where an intensively managed agroecosystem has increased food provision at the expense of other ESS.

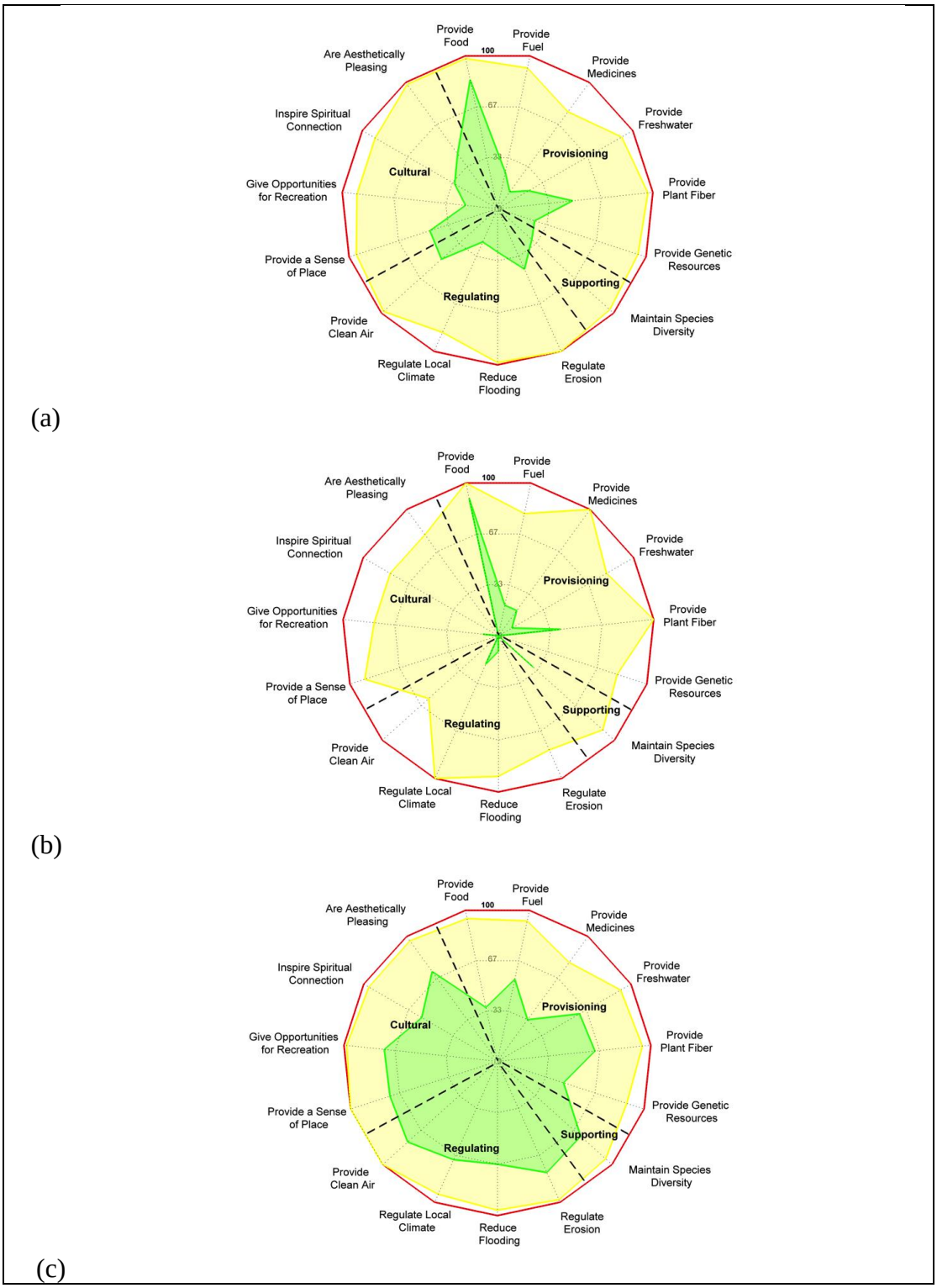


Figure 3.2 Farmer (a) and conservationist (b) recognition of Indiana cropland benefits. Farmer (c) and conservationist (d) recognition of Indiana forestland benefits. Farmer (e) and conservationist (f) recognition of Indiana reservoir benefits.

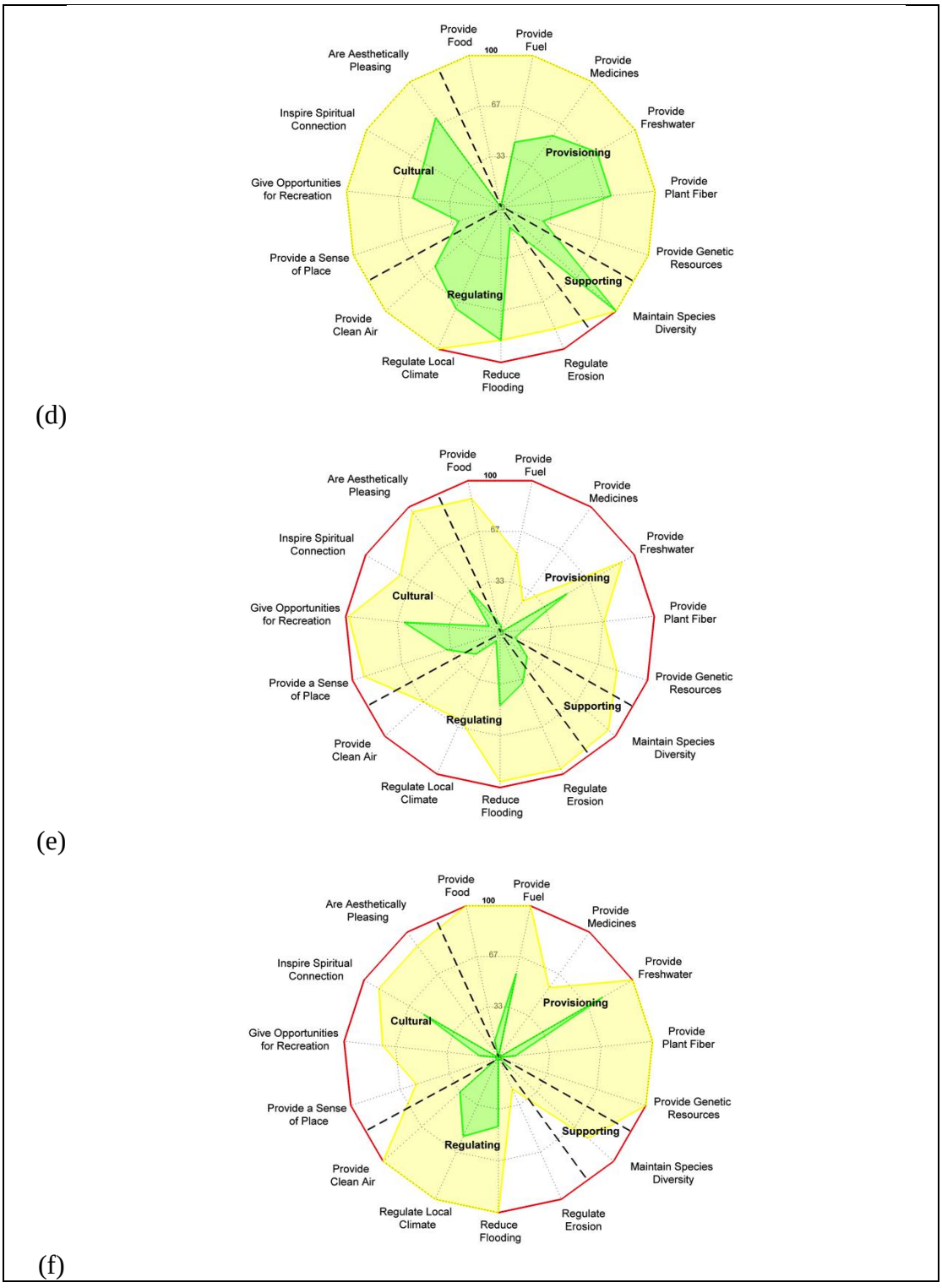


Figure 3.2 (Continued) Farmer (a) and conservationist (b) recognition of Indiana cropland benefits. Farmer (c) and conservationist (d) recognition of Indiana forestland benefits. Farmer (e) and conservationist (f) recognition of Indiana reservoir benefits.

In comparing the cropland and forestland survey responses to the reservoir responses (Figure 3.2), it is clear that farmers felt reservoirs provided significantly less ESS. Between forestlands and reservoirs, only freshwater provision, flood regulation and recreation services provided by both land types were not significantly different. Between croplands and reservoirs, only erosion regulation, sense of place, aesthetics, and habitat for species were not significantly different. The fact that farmers felt reservoirs provide significantly less benefits than forests and croplands could be due to a perception of reservoirs as man-made rather than natural systems.

Farmers were also asked to choose whether ESS they selected as "always" or "sometimes" being provided were "always", "sometimes", or "never" valuable to society (Figure 3.3). Between the cropland and forestland survey responses, the valuation of the benefits recognized by farmers was not significantly different for the majority of services listed. Only valuations of food provision, climate regulation, recreation, and aesthetics were significantly different (α=0.05). Food provisioning from croplands was valued higher than food provisioning from forestlands, whereas recreation, climate regulation, and aesthetics benefits from forestlands were valued higher than croplands. The higher valuation of food from croplands by farmers is expected as those lands are typically managed primarily for providing food.

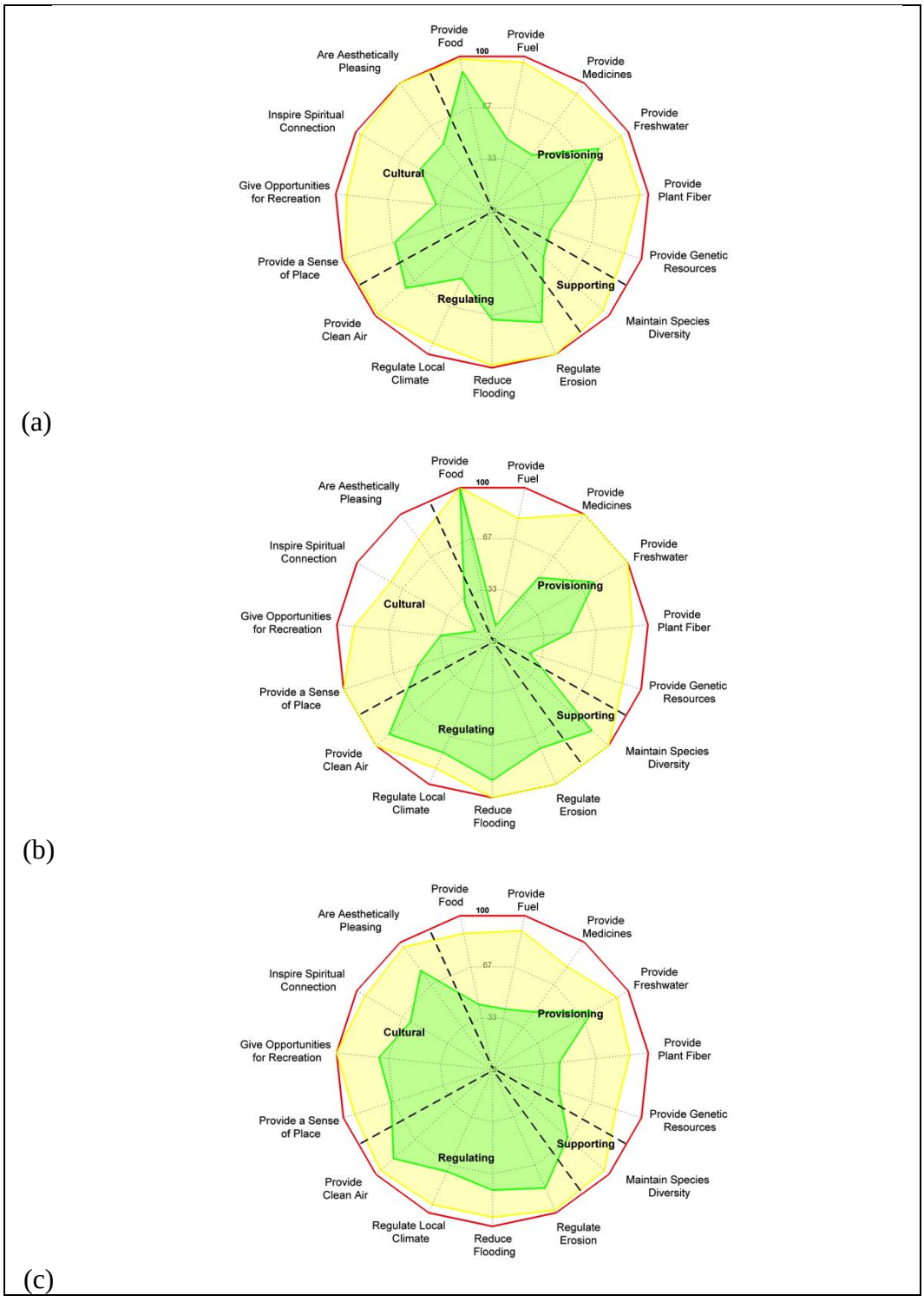
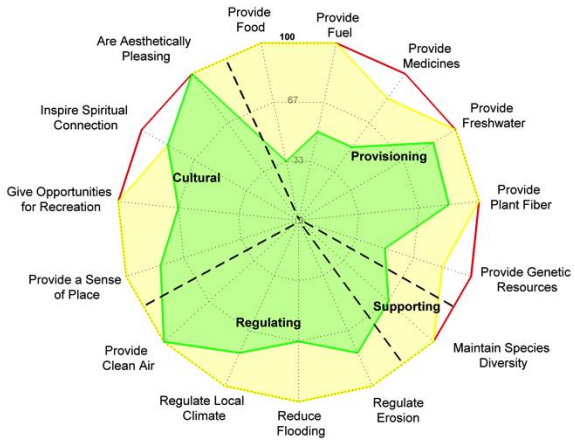
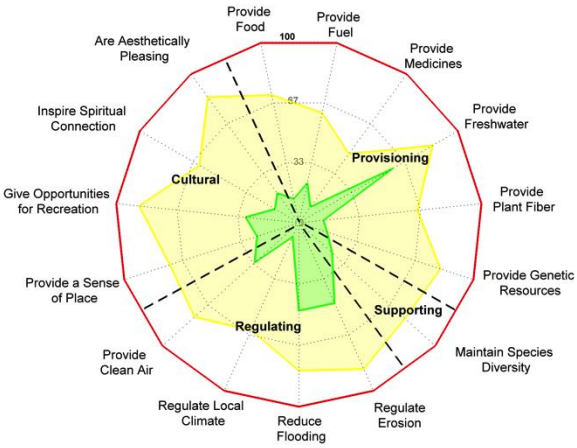


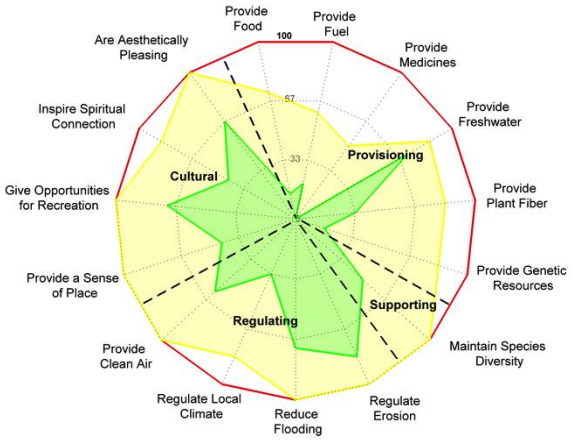
Figure 3.3 Farmer (a) and conservationist (b) valuation of recognized Indiana cropland benefits. Farmer (c) and conservationist (d) valuation of recognized of Indiana forestland benefits. Farmer (e) and conservationist (f) valuation of recognized Indiana reservoir benefits.



(d)



(e)



(f)

Figure 3.3 (Continued) Farmer (a) and conservationist (b) valuation of recognized Indiana cropland benefits. Farmer (c) and conservationist (d) valuation of recognized of Indiana forestland benefits. Farmer (e) and conservationist (f) valuation of recognized Indiana reservoir benefits.

Benefits provided by reservoirs were typically valued lower than benefits provided by forestlands and croplands. Comparing forestlands and reservoirs, only the valuation of freshwater provision was not significantly different (Figure 3.3). For all other services, the valuation of benefits provided by forestlands was higher than those provided by reservoirs. Between croplands and reservoirs only the valuation of recreation was not significantly different. For all other services, farmers valued the benefits provided by croplands higher than the benefits provided by reservoirs.

3.2.3.2 NRCS Conservationists

Similar to the farmers, conservationist responses showed the recognition of trade-offs between different land types (Figure 3.2). Comparing the forestland responses to the cropland responses showed that food provision, freshwater provision, flood regulation, air quality regulation, spirituality, aesthetics, and habitat benefits provided were significantly different. Of these benefits, only food provision was selected as being more often provided by croplands, whereas the rest were chosen as being more often provided by forestlands. The trade-off in services from a natural system to an intensively managed agricultural landscape is clearly shown in the conservationists' response.

The comparison between croplands and forests to reservoirs (Figure 3.2) shows that similar to farmers, conservationists felt reservoirs provided less benefits overall. Between forestlands and reservoirs medicine provision, fiber provision, erosion regulation, aesthetics, and habitat were the only benefits shown as being provided differently between the two land types. The responses indicated that forestlands were providing these benefits more often than reservoirs. Comparing cropland and reservoir responses showed that food provision, medicine provision, freshwater provision, erosion regulation, air quality regulation, and spirituality were

significantly different. Food provision, medicine provision, and erosion regulation were seen as being more often provided by croplands, whereas freshwater provision, air quality regulation, and spirituality were seen as being more often provided by reservoirs.

Conservationists were also asked to value the benefits they selected as being "always" or "sometimes" provided by the land (Figure 3.3). The valuations of forestlands and croplands showed that only food provision, spirituality, and aesthetics were valued differently between the two land types. Food provision was valued higher for croplands, whereas spirituality and aesthetics were valued higher for forestlands. This suggests that, like farmers, conservationists think the food grown on croplands is more valuable, perhaps because croplands are primarily managed for food. Comparing the valuation of benefits provided by forestlands and reservoirs, all benefits were valued the same. This may suggest that conservationists think that ESS, despite the land type they were provided from, have similar value. Yet, in comparing croplands and reservoirs, food provision was valued differently, indicating that conservationists valued food provisioning higher on croplands.

3.2.3.3 Comparing Farmers and NRCS Conservationists

We compared the responses of farmers and conservationists for benefits provided by each land type and the valuation of those benefits. In general we found that valuation of services did not differ considerably, but recognition of services derived from croplands and reservoirs did vary.

While farmers and conservationists thought food provisioning was the dominant service provided by croplands, they differed widely in their views of other ESS (Figure 3.2). Farmers and conservationists who took the cropland surveys differed in how often croplands provide erosion regulation, air quality regulation, sense of place, and aesthetics ($p < 0.05$). Farmers

identified these benefits as being provided more often than did conservationists. Valuation of these benefits differed only in fuel provisioning, spiritual connection, and aesthetics, and again farmers valued these higher on croplands than did conservationists. The divergence in the valuation of cultural services derived from cropland is notable. Farmers' higher valuation of aesthetics of croplands agrees with findings that Midwest farmers value an aesthetically pleasing, tidy landscape (Ryan et al. 2003; Ahnstrom et al. 2008). It is unclear from this survey why farmers would view croplands as more spiritually inspiring than conservationists, although it may pertain to attachment many farmers feel to their land (Ryan et al. 2003). The discrepancy between farmer and conservationist views of benefits provided by croplands might come from true differences or sampling bias. Farmers may have a more positive view of croplands because they own and/or work on them. Alternatively, the sample of farmers may be biased towards conservation-mindedness and these farmers may be thinking of their own specific farm, whereas conservationists may be generalizing across multiple farms.

When responses were compared for the forestland surveys, only erosion regulation and sense of place were recognized at significantly different levels ($p < 0.05$) and no services were given different values (Figure 3.2). Most farmers thought forests always regulated erosion while most conservationists thought forests sometimes regulate erosion. Again, farmers rated sense of place and erosion regulation from forestlands higher than conservationists, and the difference is considerable.

Farmers and conservationists exhibited differing views of ecosystem benefits from reservoirs yet no significant difference in valuation ($\alpha = 0.05$) (Figure 3.2 & Figure 3.3). Recognition of fuel provision, erosion regulation, climate regulation, sense of place, recreation, and spirituality benefits differed significantly between farmer and conservationist responses ($p <$

0.05). Fuel provision, climate regulation, and spirituality were chosen by conservationists as being more often provided by reservoirs, whereas erosion regulation, sense of place, and recreation were seen by farmers as being more often provided. These differences between farmer and conservationist recognition of ESS from reservoirs may be partially due to variation in the particular "reservoir" each participant was thinking of when asked to "think of the reservoirs in your town and in the state of Indiana."

3.2.4 Beneficiaries and Stewards of Ecosystem Services

Both farmer and conservationist responses show slight differences in who they perceived to benefit from ESS provided by different land types (Figure 3.4). For croplands, respondents identified owners and operators as benefiting the most, with society and local community just behind. Similarly for forestlands, both conservationists and farmers felt owner/operators and society/community benefited the most. Fewer beneficiaries were chosen for the benefits provided by reservoirs, which may be due to the lower amount and value of the benefits that farmers and conservationists felt reservoirs provided.

There was a significant difference overall ($p = 0.02$) in who respondents believed was most responsible for maintaining benefits provided by the three land types (Figure 3.5). However, comparing farmer and conservationist responses within each land type showed that for croplands and forestlands there was no significant difference in who they believed were primary stewards, but there was a significant difference ($p = 0.003$) for primary stewards of reservoir benefits. For croplands, both conservationists and farmers overwhelmingly felt farm owner and/or operators were responsible for maintaining benefits they identified as being provided to society. The majority of farmer responses that fell into the combination category chose both farm owner and operator. There were more farmer respondents that felt forestland benefits were the

responsibility of various levels of government. For reservoirs, farmer respondents felt government was the major entity that should be responsible for maintaining these benefits, whereas conservationists felt this to be primarily society's responsibility.

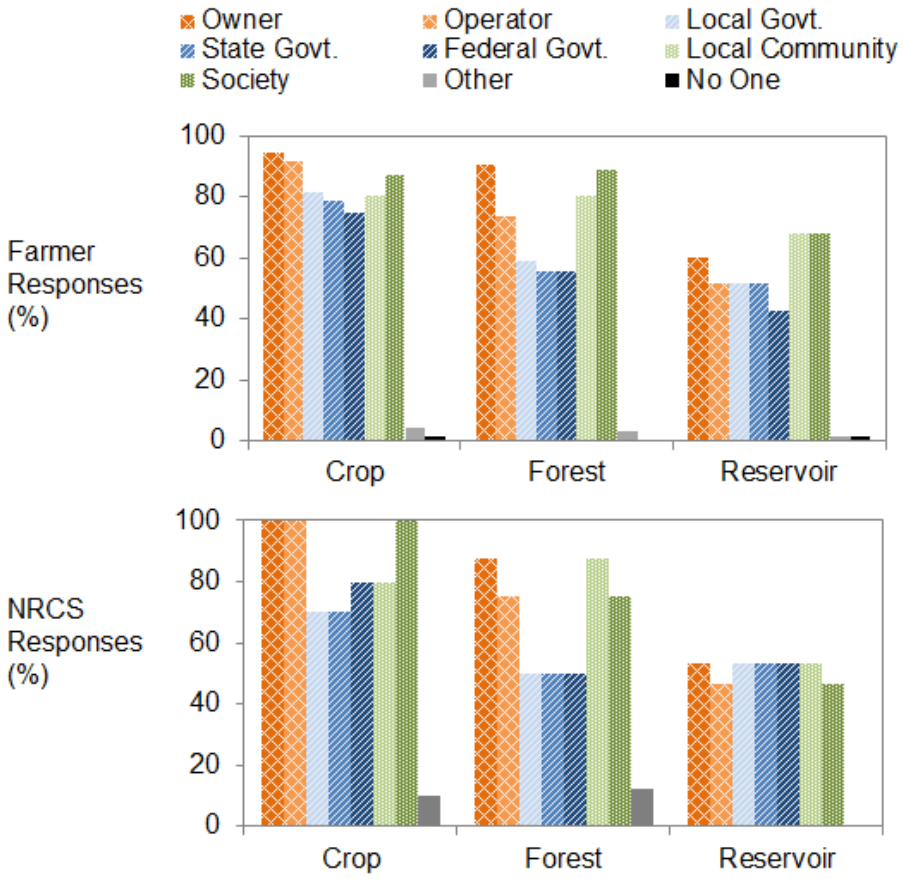


Figure 3.4 Farmers' and conservationists' perceptions of those benefiting from ecosystem services derived from each land type. Respondents were permitted to select as many beneficiaries as desired, and the unit shown is the percentage of respondents selecting a given beneficiary.

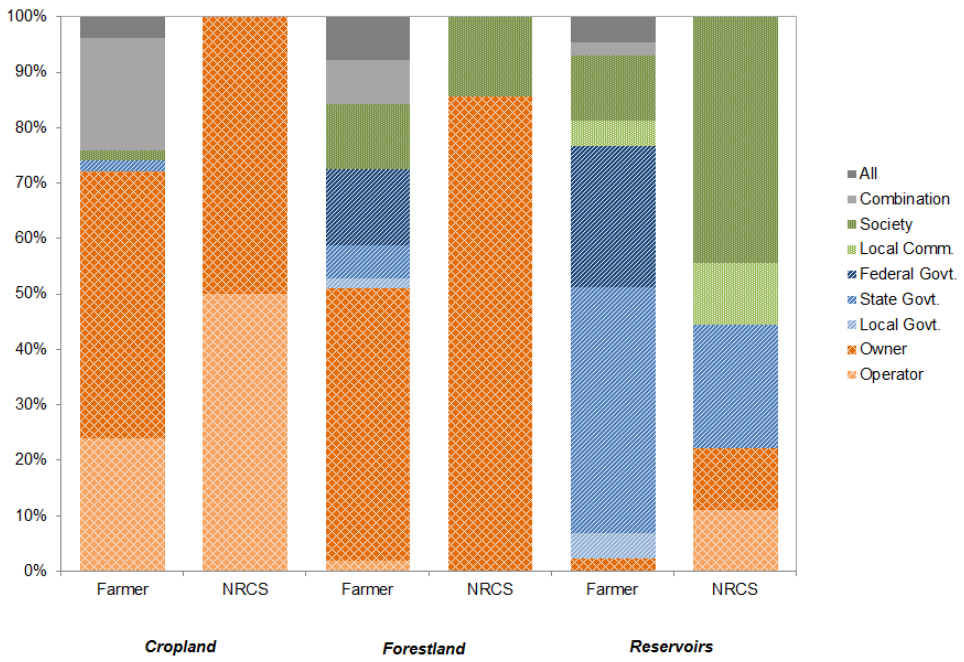


Figure 3.5 Participant response for who was most responsible for maintaining benefits provided to society by the different land types.

Overall, results show that both farmers and conservationists recognize that ecosystem benefits from these three land types are important to a wide range of stakeholders, including society at large. Understanding the breadth of beneficiaries likely corresponds with knowledge that management of these private croplands and forestlands has widespread impacts in our society, and indicates that it may not be a stretch for farmers to think about how management of their farm is relevant to society. It's interesting to note that farmers tended to view the government as having a greater responsibility than did the conservationists, although the distinction between "government" and "society" may be a matter of preferred language (since government funds come from society). These findings generally demonstrate that Indiana farmers believe they are primarily responsible for maintaining benefits (ESS) on their lands.

3.2.5 Engaging Farmers in Policy Discussions

Knowledge about issues on hand is a prerequisite to engage any stakeholder on a policy discussion. This study evaluated farmers' awareness of ecosystem services. Results from this study indicated that an overwhelming majority of the farmers participated in conservation programs or were willing to participate making them ideal participants in policy discussions related to ESS. What may be needed is increased outreach to educate them about how conservation practices relate to ESS derived from their farmland. From the 200 responses, only three indicated they didn't have any conservation practices on their farm (five left this question blank), which demonstrates that many farmers are already participating in conservation on their farm. Farmers also indicated what kinds of conservation practices they used on their farm: No-tillage (70%), grassed waterways (60%), nutrient management (43.5%), cover crops (39%), filter strips (28.5%), wetlands (20.5%), riparian buffers (12.5%), two-stage ditch (3.5%), and other (7%). Sixty-three percent of respondents participated in at least one federal conservation

program, with 21% participating in more than one. Despite this prevalence of conservation participation, there were no statistically significant connections (α=0.05) between the number or type of conservation practices implemented and farmer knowledge or valuation of ESS. This suggests that most farmers were knowledgeable about and valued ESS provided by conservation practices, but their participation in conservation practices may have been influenced by other factors such as cost.

We also asked farmers directly if they would "be more willing to implement conservation practices if [they] knew how they benefited [their] farm's ecosystems." Thirty-seven percent responded "yes" and 49% responded with "potentially". Only 4% responded "no", and the remaining 10% left the question blank. Similarly, we asked farmers to evaluate their level of conservation-mindedness to better understand their view of their own attitude towards conservation. Sixty-four percent said they were conservation-minded, 25% said they were mostly conservation-minded, and 9% said they were somewhat conservation-minded. None responded that they weren't conservation-minded and the rest (2%) left the question blank. Farmers' self-assessments indicated a general interest in conservation and a willingness to manage their lands to improve their farm's ecosystems, suggesting that they will be a cooperative and active stakeholder in ESS policy discussions.

When conservationists were asked to assess farmers' willingness to implement practices that benefit their farms' ecosystems, they gave a less optimistic assessment. They responded that "yes" farmers would be willing only 21% of the time, "no" 18% of the time, and "potentially" 53% of the time (9% left blank). This inconsistency in view of farmer willingness to change practices may be because of the survey pool – it's possible that farmers who responded were more open to change. However, it agrees with previous work showing that farmers generally

view themselves as good stewards and land managers (Ahnstrom et al. 2008; McGuire et al. 2013), and that farmers often view themselves to be conservation-minded, though conservationists may not agree (Carr and Tait 1991). This slight discrepancy between farmers and conservationists may need to be considered before initiating ESS policy discussions.

Lastly, to understand how best to begin involving farmers on discussions of managing multiple ESS, we asked where farmers preferred to get information when making management decisions on their farm, as well as what resources they would consult for information about their farm's environmental benefits. Most farmers preferred consulting other farmers or publicly funded professionals such as the FSA, Extension Officers, and NRCS. To get more information about environmental benefits on their farm, respondents indicated they would consult mostly with publicly-funded professionals or learn from articles in farm or other magazines they read. The results of these two questions show the greatest potential for engaging farmers in ESS policy discussions may involve outreach through publicly-funded professionals as well as farm magazines, as these sources seem to be more trustworthy to farmers.

3.3 Joint Discussion of All Three Studies

All study results support a central theme of current farmer knowledge of ESS and the potential for ESS-based farm management. Farmer interviews focused mainly on conservation practices within croplands, while farmer and conservationist surveys focused on cropland in general, along with forestlands and reservoirs. The qualitative work was exploratory, informing the primarily quantitative survey that followed. Interviews were also able to support findings from surveys, particularly farmer knowledge of ESS.

Both farmer interviews and surveys demonstrate recognition of many ESS derived from natural and managed landscapes, and the services emphasized provide an understanding of how

farmers view ecosystems. While farmers recognized a wide variety of ESS in interviews, they emphasized services that impact them economically – food provisioning is their source of income, and soil formation and erosion regulation sustain food provisioning long-term. Freshwater provisioning and genetic resource provisioning were well known benefits to conservation efforts, yet under current management and policy directives these services have a less direct impact on them. Utilizing this knowledge of farmers' perceptions towards ESS will aid in creating policies that help improve ESS on farms.

The trade-off between food provisioning and other ESS was evident in both interviews and surveys, where farmers and conservationists consistently felt that croplands provided less ESS than forestlands, except for food provision. This is unsurprising, as others have shown such as that when agricultural lands are managed to maximize production, other ESS suffer (Groffman et al. 2007; Pilgrim et al. 2010). Our results demonstrate that Indiana croplands are currently managed mainly for food provisioning rather than for multiple ESS. Policies and programs which promote multi-objective farm management may be required to help change this specific management behaviour.

Interestingly, farmers and conservationists rated reservoirs as providing fewer benefits than forestlands, and reservoir benefits were considered less valuable to society. We have realized the term "reservoir" may have been perceived as an engineered system, rather than a natural one. Originally, we had planned to use "wetland" to represent an aquatic ecosystem, but interviews suggested the word "wetland" had negative connotations to farmers. Farmers are known to have negative attitudes toward federal regulation in the Midwest (Arbuckle 2012) and in the region where interviews took place (Reimer et al. 2011; Kalcic et al. 2014). This concern about government intrusion was confirmed to exist in the surveyed population through multiple

survey comments. If further studies were conducted we suggest using a term such as “pond” or “lake” that could be viewed as a natural ecosystem while avoiding contentious ecosystems like wetlands.

All studies indicate inherent understanding of ESS concepts for major provisioning and regulating services by farmers and conservationists. However, the ESS framework was unfamiliar to the majority of all three study groups. While conservationists were better able to define ESS, farmer views of specific ESS were often similar to conservationists’, indicating a shared understanding of environmental benefits. If farmers receive information from conservationists, education of conservation professionals may be an effective way to transfer knowledge. If conservation policy were to incorporate ESS in its goals, the framework appears to already exist to translate this knowledge into factors that may affect farm-level management. Understanding the language farmers already use to explain ESS can also provide a pathway for further ESS management education. Our results can begin to lay the foundation to develop a shared language and understanding of ESS between farmers, conservation professionals, and policy-makers, which may be a useful next step that will move the science of ESS into practice in U.S. agricultural landscapes.

4 CONCLUSIONS

This research demonstrates that Indiana farmers recognize benefits that their land (and other ecosystems) provides to people. Despite this general understanding of benefits, they were unfamiliar with the term “ecosystem services”, which suggests that more education is needed to develop policies that support ESS-based agricultural management. The majority of farmers surveyed were already implementing conservation practices or programs, and stated that they were interested in learning more about how they can improve ESS on their farm. They saw

themselves as the primary stewards of the benefits provided by their croplands to society, which suggests an opportunity to engage farmers in ESS-based policy discussions. Their recognition and valuation of ESS generally aligned with conservationists, which was not surprising since the study also showed that farmers preferred to get information from publicly-funded professionals. Expanding existing conservation programming in the U.S. is an approach that does not require a major shift in national policy, but instead, an expansion of current systems of delivery. This study supports the idea that dissemination of ESS research at the levels of administrative and program-development as well as through Extension Service partnerships could leverage current farmer interest in and knowledge of conservation management to promote ESS-based management.

One of the primary obstacles to integrating ESS in program decisions may be the ongoing gaps between data producers and data users. Since Zhang et al. (2007) called for research that quantifies the flows of ES to and from agricultural lands, the number of ESS publications has expanded (Rodriguez et al. 2006) and the ability to quantify flows continues to improve. Translating such knowledge into program-based metrics while establishing a language that is simultaneously consistent with ESS concepts and approachable for conservationists and farmers may be an important step for administrative-level implementation.

There is a specific opportunity for extension specialists, government agencies, and private companies to work with farmers to develop strategies and programs to improve and restore ESS in the U.S. This work offers some insight into which ESS are currently well understood and valued by farmers, and which may require more education and programming to manage. Wratten et al. (2013) note that because of the large land area of agricultural landscapes, these managed ecosystems offer the greatest opportunity to increase global ESS. Our research

demonstrates that Indiana farmers are knowledgeable about the ESS benefits provided by conservation practices on their farm and can be easily engaged in discussions to restore and increase ESS in the U.S. Since private stakeholders own and manage a large portion of U.S. agricultural lands, and as we have shown that they not only recognize benefits ecosystems provide but also work to conserve them and are willing to improve their farm's ecosystems, U.S. farmers are key stakeholders that should be engaged in discussions about improving and restoring ESS. If we are not engaging U.S. farmers in ESS discussions, then we cannot expect that policies created will (1) be well understood by the farmers who are making decisions at the field-level, and (2) make the kind of impact required to improve and restore ESS from intensively managed landscapes.

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Appendix 1. Farmer survey

1. Do you know what an **"ecosystem"** is? ☐ Yes ☐ No
2. Have you heard of the term **"ecosystem services"**? ☐ Yes ☐ No
3. What would you guess that **"ecosystem services"** means?

   _____

   _____

   _____

4. Please check the conservation practices on your farm: (check all that apply)
   ☐ Riparian buffer ☐ Filter strips ☐ Wetland
   ☐ Grassed waterways ☐ Two-stage ditch ☐ No-till
   ☐ Nutrient management ☐ Cover Crops ☐ None
   ☐ Others _____
5. Please check all federal or state conservation programs you have participated in: (check all that apply)
   ☐ Environmental Quality Incentives Program (EQIP)
   ☐ Conservation Reserve Program (CRP)
   ☐ Conservation Reserve Enhancement Program (CREP)
   ☐ Wetlands Reserve Program (WRP)
   ☐ Wildlife Habitat Incentives Program (WHIP)
   ☐ None of the above ☐ Others
6. Where do you get information when making farm management decisions? (check all that apply)
   ☐ Extension ☐ Other farmers ☐ Farm Service Agency
   ☐ Internet ☐ Newspapers ☐ Private crop advisor
   ☐ Radio ☐ Soil and Water Conservation District
   ☐ NRCS (Soil or District Conservationist)
   ☐ Other: _____ ☐ None of the above
7. Do you consider yourself to be conservation-minded in your views of agricultural production?
   ☐ Yes ☐ No ☐ Mostly ☐ Somewhat ☐ Unsure
8. What county/counties do you farm in Indiana?

   _____
9. Approximately how many acres do you farm? _____
10. Please check the crops you produce: (check all that apply)
    ☐ Corn ☐ Soybeans ☐ Wheat ☐ Hay ☐ No crops
    ☐ Specialty crop: _____ ☐ Other: _____
11. Do you have any livestock on your farm? (check all that apply)
    ☐ Dairy cattle ☐ Beef cattle ☐ Hogs ☐ Poultry
    ☐ Sheep ☐ Goats ☐ None
    ☐ Other _____
12. How many years have you farmed officially in the area?: _____
13. Did you grow up on a farm? ☐ Yes ☐ No ☐ Prefer not to answer
14. Would you be more willing to implement conservation practices if you knew how they benefited your farm's ecosystems?
    ☐ Yes ☐ No ☐ Potentially
15. What resources would you consult for information about the environmental benefits on your farm? (check all that apply)
    ☐ Articles in farm or other magazines that I read
    ☐ Online or farm-specific calculators
    ☐ Conversations with publicly funded professionals (e.g., Extension services, NRCS conservationists, SWCD technical staff)
    ☐ Conversations with private/industry professionals (e.g., crop advisors)
    ☐ Other: _____ ☐ None
16. Gender: ☐ M ☐ F ☐ Prefer not to answer
17. Age: ☐ < 25 ☐ 25-34 ☐ 35-44 ☐ 45-54 ☐ 55-65
    ☐ 65+ ☐ Prefer not to answer
18. Which best describes your work? ☐ Farm owner
    ☐ Farm operator ☐ Owner & operator ☐ Other: _____
19. Do you identify as a racial minority?
    ☐ Yes ☐ No ☐ Prefer not to answer

CROPLANDS – think of the croplands in your town and in the state of Indiana, and answer the following questions

CROPLANDS…	20. How often do croplands provide the following **benefits to society**? Always	Sometimes	Never	21. If you just checked always or sometimes, how **valuable** is this benefit (from croplands) to **you**? Very Valuable	Somewhat Valuable	Not Valuable
…provide food	☐	☐	☐	☐	☐	☐
…provide a "sense of place"	☐	☐	☐	☐	☐	☐
…regulate erosion	☐	☐	☐	☐	☐	☐
…provide fuel	☐	☐	☐	☐	☐	☐
…provide medicines	☐	☐	☐	☐	☐	☐
…give opportunities for recreation	☐	☐	☐	☐	☐	☐
…inspire spiritual connection	☐	☐	☐	☐	☐	☐
…provide fresh water	☐	☐	☐	☐	☐	☐
…reduce flooding	☐	☐	☐	☐	☐	☐
…are aesthetically pleasing	☐	☐	☐	☐	☐	☐
…maintain species diversity	☐	☐	☐	☐	☐	☐
…provide plant fibers	☐	☐	☐	☐	☐	☐
…reduce soil loss	☐	☐	☐	☐	☐	☐
…provide genetic resources	☐	☐	☐	☐	☐	☐
…regulate local climate	☐	☐	☐	☐	☐	☐
…provide clean air	☐	☐	☐	☐	☐	☐

	22. Check each box for those who **benefit from** croplands	23. Check each box for those who should be **responsible for** maintaining cropland benefits
Society	☐	☐
Local gov't	☐	☐
State gov't	☐	☐
Fed. gov't	☐	☐
Local community	☐	☐
Farm operator	☐	☐
No one	☐	☐
Other (fill in blank)	_____	_____

24. Of the list above, who is most responsible for maintaining benefits from croplands?

_____

Please provide us with any comments, questions, or suggestions you have in the blank space below!
THANK YOU!!