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Exploring Stakeholder Consensus for Multiple Outcomes in Agriculture: An Iowa Case Study

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Extensive row-crop agricultural production systems dominant in the United States Corn Belt are designed to produce high yields of a small number of commodities at low production costs. While remarkably valuable, this model of agriculture is directly and indirectly associated with significant externalized public costs and questions about its long-term viability. Agro-environmental conservation policy in the United States has failed to deliver desired environmental outcomes at broad scales, in part, because policy is supply-oriented with scaled financial and technical incentives aimed at the interests of individual farm managers. Understanding broader stakeholder demand relative to agro-ecosystem outcomes is fundamental to modifying policy toward outcomes. Failed collective policy and management, often indicates failed consensus among stakeholders whose responsibilities are to provide guidance for achieving outcomes. We used a Delphi approach with representatives from Iowa-based agricultural and/or environmental policy, outreach, and industry organizations to explore whether or not consensus may exist regarding desired agricultural outcomes and if so, modes of provision. Through three iterative surveys, we found consensus regarding the array of ecosystem outcomes believed possible within the Iowa agricultural economy. However, when agricultural interests were sorted, a divide emerged between stakeholders who emphasize production agriculture and those who favor a more multi-outcome oriented agriculture that emphasizes multiple ecosystem services. Nevertheless, study participants identified several key ecosystem outcomes, and methods for providing them that are strongly compatible with and support private commodity driven land use while mitigating costly public externalities. A broad and simple six-point framework emerged from our data to contextualize questions and discussions of agricultural land-use management among stakeholders. This framework includes people, their expectations and values, land, management, and ecosystem processes in addition to ecosystem services. Broadening and bounding discourse in these ways may facilitate a shared appreciation of human-nature interconnections and more progressive policy reform that facilitates understanding of land-use decision making within agricultural contexts in ways that benefit all stakeholders.

Keywords: Delphi, stakeholders, ecosystem outcomes, conservation, policy

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INTRODUCTION

Extensive row-crop agricultural production systems dominant in the United States Corn Belt are designed to produce high yields of a small number of commodities at low production costs. This model of agriculture produces remarkable value for farmers, landowners, and agribusiness yet observers have long questioned its long-term viability (Tilman et al., 2002; Robertson et al., 2014; Snapp, 2017). Climate change, increased pest and pathogen pressures, weed and pest resistance, and resource limits, all variously combine to increase the costs of production and threaten future yields (e.g., Tilman et al., 2002; Xu et al., 2013; Cordell and White, 2014; Lobell et al., 2014). As such, agricultural stakeholders (e.g., farmers, non-farming citizens, policy makers) are seeking expanded outcomes from agricultural landscapes that complement high volumes of low cost food, fiber, feed, and fuel; that is, an agriculture that deliberately brings about multiple ecosystem service outcomes along with relatively low cost commodities (Boody et al., 2005; Jordan and Warner, 2010; Enloe et al., 2017; Jordan et al., 2018).

A more multifunctional agriculture can increase the flow of crucial ecosystem services through deliberate farm-level conservation management. The crucial ecosystem services include those experienced directly by farmers, such as enhanced soil health, biological control of pests, improved, or and sustained pollination, and better moisture management, as well as by society, such as enhanced habitat for game and non-game species, agrarian aesthetics, and recreational opportunities (Jordan and Warner, 2010; Robertson et al., 2014). In row-crop dominated agriculture, the often-low fixed costs of multi-outcome land use (e.g., Tyndall et al., 2013; Muth, 2014) can contribute to the joint production of a number of dynamically generated production and environmental benefits at field and landscape scales with minimal short term trade-offs and long term synergies (Robertson et al., 2014; Schulte et al., 2017). Multi-outcome land use can also reduce variable production costs in the long run and lead to higher field-scale net value (Lovell and Johnston, 2009; Muth, 2014). To address the opportunities that these conditions present for managing multi-outcome agricultural landscapes, the agricultural community broadly speaking is promoting innovative conservation knowledge, information, and expertise to restore valuable ecological functions on agricultural landscapes while supporting vibrant farmer and rural livelihoods (Jordan et al., 2018).

A lingering challenge to applying this knowledge base, however, is overcoming a biophysical divide between current and past conservation actions and outcomes realized at watershed scales. Since the mid 1980s, U.S. Federal conservation programs have invested billions of dollars in farm conservation land practices with funds largely emphasizing water quality initives via land retirement programs; e.g., USDA Conservation Reserve Program (CRP). Yet, there has been very limited environmental quality improvement at watershed scales (Osmond et al., 2012; Reimer et al., 2012; Claassen and Ribaudo, 2016). This historical disconnect appears to have (at least) two causes; one related to economic policy (Secchi et al., 2008) and the other being a matter of ineffective conservation planning particularly from a scale standpoint (McGranahan et al., 2015; Zimmerman et al., 2019).

Agro-environmental conservation policy in the United States typically fails to deliver desired environmental outcomes at broad scales because the perspective of policy is supply-oriented at the farm scale with financial and technical incentives aimed at the interests of individual farm managers (Secchi et al., 2008; Osmond et al., 2012; Wardropper et al., 2015; Lichtenberg, 2019). The alternative is for a policy orientation that targets public preferences or demand for specific land use and environmental outcomes (Smith, 2006). Agro-environmental incentive programs are designed to efficiently distribute a fixed conservation budget regionally and/or enroll a target acreage in various land conservation programs among interested farm operators whose land has bio-physical characteristics that ostensibly contribute to enhanced ecosystem functionality (Smith, 2006; Secchi et al., 2008). For example, the most influential USDA program in terms of geographic and financial impact is CRP. The eligibility process for CRP evaluates the capacity of a single field or farm conservation plan to broadly contribute to ecosystem enhancement via weighted scoring mechanisms such as the Environmental Benefits Index (EBI). The EBI thus prioritizes financial resources at field and farm scales that in the aggregate only *implicitly* contribute to regional program goals though weight is given to conservation plans that account for assumed landscape and/or hydrologic connectively (Claassen et al., 2008; Batie, 2009). Additionally, landowners use auction-like bids to best position their application for acceptance in competitive enrollment situations, as such allocations are suited to individual land owner preferences (Hellerstein, 2017). Conservation programs are largely applied in ways disconnected to critical spatial scales, as well as temporal scales particularly when landowners opt out of conservation plans at the end of contracted periods. Secchi et al. (2008) observed that government programs tend to be efficient in conservation budget management but not optimal relative to outcomes. The result of this type of policy orientation is that there is a lack of watershed-scale hydrologic consideration relative to conservation planning. The application of practices in given watersheds is not targeted toward critical sources and or hydrologic pathways of contaminants (e.g., nutrients, sediment) (Tomer and Locke, 2011; Tomer et al., 2013) or across relevant time periods (Meals et al., 2010). Furthermore, strategies often focus on singular contaminants, such as nitrogen or phosphorous, and ignore trade-offs among contaminants as well as synergies toward multiple outcomes at broader scales such as enhancing both localized and regional water quality and habitat (Tomer and Locke, 2011).

Ineffective collective policy and by extension, management, is frequently driven by flawed decision making by stakeholders who have responsibilities to guide and design systems to motivate participation, such as incentive programs (Leach et al., 2002; Ansell and Gash, 2008).

This study clarifies the extent to which agricultural stakeholders associate ecosytems services from crop land and other farming systems with agricultural and conservation management. Our study is characterized by a mixed method approach, the Delphi method, in which stakeholders first defined key ecosystem services and management practices, then surveyed respondents to determine their prioritization of services and practices from the larger pool defined by all respondents.

Prior US Cornbelt region studies (Santelmann et al., 2004; Boody et al., 2005) have innovatively examined possible crop production futures via stakeholder-determined land use scenarios that combined both production and environmental objectives. Others studies used stakeholder collaboratives to better understand the multi-scale agricultural decision making processes (Bills and Gross, 2005; Dreelin and Rose, 2008). For this study we sought a different platform for discussing these issues with stakeholders. As such, in our Delphi survey we assessed stakeholder consensus for both production and environmental outcomes from agriculture. We defined "consensus" as a high degree of agreement among stakeholders regarding importance of specific outcomes to regional agriculture. Agreement is measured by Kendall's coefficient of concordance. We focused on consensus because it is an important precursor to collective and equitable guidance within social, economic, policy, and cultural systems. Based on our analysis, we articulate how stakeholder views on ecosystem services manifest as salient argument for new approaches and policy regarding agricultural outcomes and propose a framework to aid future conversations about the ecosystem service concept for Midwest agriculture. All with the goal of facilitating deeper understanding of and appreciation for human-nature interconnections, modeling a process for progressive discourse on land-use decision-making related to agricultural contexts.

METHODS

Study Location

Central Iowa is a fitting location to examine complexity involved with the delivery of ecosystem services from agricultural lands: there are few places in the United States where landscapes are more heavily altered to promote crop production and where ecosystem services and management activities are more inextricably linked. With 85% of the land base (>10.5 million hectares [ha]) dedicated to agriculture, Iowa regularly leads the US in production of corn, hogs, eggs, and ethanol, and is ranked first or second in soybean production (USDA NASS, 2019).

Iowa is also characterized by persistent environmental challenges. 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 112,000 kg/ha (50 short tons per acre) in some townships (Veenstra, 2010). The state ranks last among the 50 U.S. states in the amount of remaining natural ecosystems and first in the loss of diversity and richness of the native flora and fauna (Iowa Department of Natural Resources, 2015). Iowa's 2016 list of impaired rivers and lakes includes 57.5 percent of assessed water bodies (52 percent of rivers and 61 percent of lakes and reservoirs were assessed), numbering 608 waterbodies with a total of 768 impairments (Iowa Department of Natural Resources, 2018). Primary pollutants include nutrients, bacteria, pesticides, and sediment (Iowa Department of Natural Resources, 2018). Beyond the state-level, Iowa is considered to be a major contributor to Gulf hypoxia (Alexander et al., 2008). Global climate change and its impacts are already apparent in the state, typified by periodic drought, unusually intense rainfall events, and greater and more frequent flash flooding (Hatfield et al., 2018).

Overview of the Delphi Methodology

A Delphi study is characterized by repeated cycles of surveys responded to by the same set of experts, termed a "panel." The Delphi expert panel for this study was composed of individuals who shaped policy and practice in crucial aspects of the agriculture and the environment in Iowa. A major source of names for the panel was from the Advisory Board of STRIPS (Science-based Trials of Row-Crop Integrated with Prairie Strips), a collaborative and integrated long-term research and outreach project focusing on development of a conservation best management practice (Schulte et al., 2017). Twenty three participants represented 16 organizations (**Table 1**). Delphi studies are typically structured to first prompt divergent views by eliciting qualitative data, and then to aggregate the ideas through successive rounds, in a variety of ways. 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). Polush et al. (2016) used Delphi method in an agricultural organization setting to characterize and facilitate potential future opportunities related to on-farm research. Their team followed-up two rounds with a third round in a focus group-like setting with respondents.

The Delphi method typically includes multiple rounds of inquiry with panel members, but wide variation in processes, including number of rounds, has been accepted in Delphi methodology since its inception (Sackman, 1975). Testing degrees of expert consensus—or agreement—is an analytical strength of the Delphi technique (Linstone and Turoff, 1975).

Delphi Methods for the Iowa Case

Based on our previous research in this region (e.g., Atwell et al., 2011), we knew that knowledge, interpretation, and discussion of ecosystem outcomes among stakeholders working at the interface of agricultural and environmental policy and practice in Iowa would be nuanced and multifaceted. We thus employed the Delphi method as an alternative analytical approach to further describe a contextualized typology of ecosystem services for Iowa, with the goal of working toward consensus (Schmidt, 1997; Legendre, 2005). The Delphi expert panel for this study was composed of advisors associated with STRIPS (Science-based Trials of Row-Crops Integrated with Prairie Strips), a collaborative and integrated long-term research and outreach project focusing on development of a conservation best management practice (Schulte et al., 2017). We used a three-round Delphi for this study, based on iterative cycles of inquiry and preliminary analysis.

Twenty-three individuals representing 16 organizations participated in the study (**Table 1**). Twenty of these individuals variously participated in three rounds of the survey, resulting in an 87% overall participation rate. Between November 2009 and October 2010 we conducted a three round Delphi survey,

TABLE 1 | Organizations represented in the Delphi case study.

Organization
Iowa Corn Growers Association[a]
Iowa Department of Agriculture and Land Stewardship[e]
Iowa Department of Natural Resources[e]
Iowa Environmental Council[b]
Iowa Farm Bureau Foundation[a]
Iowa Natural Heritage Foundation[b]
Iowa Prairie Network[b]
Iowa Soybean Association[a]
Iowa State University[d]
Leopold Center for Sustainable Agriculture[d,e]
Practical Farmers of Iowa[a]
Prairie Rivers of Iowa Resource Conservation and Development Council[c]
The Nature Conservancy[b]
Trees Forever[b]
United States Department of Agriculture, Agricultural Research Service[d]
United States Department of Agriculture, Natural Resources Conservation Service[c]
United States Department of Agriculture,United States Forest Service[c]
White Rock Conservancy[a,b]

[a]Agricultural (NG); [b]Environmental Non-Governmental Organization (NGO); [c]Federal Agency; [d]Research Organization; [e]State Agency.

modified from Skulmoski et al. (2007) whereby frequently mentioned or highly ranked items in a questionnaire were used to formulate the next questionnaire in a series. Round 1 formed a list of "benefits from Iowa's agricultural landscapes" and items that comprised relevant management changes in agriculture needed to achieve them. Similar to most Delphi surveys, this round was characterized by an open-ended question: *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.* The term "ecosystem services" was in common usage among panelists at this time, and was present in publications familiar to staff and members of organizations to which they belonged. In Round 2, panelists pared items from a consolidated presentation of the groups' lists through forced-choice ranking. Participants were required to rank their top six ecosystem services from a list of 17 services that were mentioned in round one. Panelists additionally ranked ecosystem services within groups of related ecosystems services (i.e., production outcomes, clean water, soil, wildlife and biodiversity) defined by the authors based on initial analysis of round 1 results. Panelists also identified relationships between important ecosystem services and land management practices. For Round 3, panelists were asked to further refine proposed ecosystem service outcomes and the relationships between services and agricultural land management practices, i.e., what practices delivered particular benefits, through forced-choice ranking. See **Supplemental Material** for copies of the study's survey instruments.

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. Final rank was calculated by multiplying percent-who-mention by the inverse of the mean rank among participants; 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 non-parametric 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 in round two 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). To further understand how identified ecosystem outcomes were considered and prioritized among the different categories of stakeholders, responses from the Delphi survey were sorted to determine points of divergence in the degree of importance panelists put on certain outcomes. We define "stakeholder" as any individual or group of individuals who can influence via policy or outreach, ecosystem service outcomes associated with agricultural land use.

RESULTS

Twenty members of the STRIPS project advisers participated in the Delphi survey, an 87% participation rate overall. Participants represented 16 organizations (**Tables 1**, **2**). Panelists 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. Some panelists did not respond to all survey rounds; 12, 14, and 13 individuals participated in rounds one, two, and three, respectively (**Table 2**). Initial non-respondents to round one were prompted twice via email and then by phone following Dillman (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.

Round 1 Findings

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 to ecological functions and mechanisms (for example, descriptions of the phenomenon of eutrophication

TABLE 2 | Affiliations represented and number of participants per round in the Delphi survey[a].

		Affiliation				
		Agricultural NGO[b]	**Environmental NGO[b]**	**Federal agency**	**Research entity**	**State agency**
Number of panelists per round	All	4	7	4	2	3
	R1	2	4	2	1	2
	R2	3	4	2	2	3
	R3	2	5	3	2	2[c]

[a]Participants were characterized into five groups based on their professional affiliations to provide context regarding identity while preserving individual confidentiality.
[b]Non-governmental organization (NGO).
[c]Attrition due to retirement.

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. Changes related to governmental policies included: argument both for and against the establishment of mandatory management practices that mitigate negative externalities (e.g., mandatory 30 m 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.

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 (**Table 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 clean water, or water purification; several participants focused their responses almost solely on topics of water quality.

As ranked by the Delphi participants during round two, "water filtration and purification" received the second highest mean rank in round two, but had the highest percent of round two participants (79%) who included this item in their ranking when faced with the forced-choice decision (**Table 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. Beyond water quality but related to water, flood attenuation ranked fifth being mentioned by 50% of the participants.

Ecosystem service referring directly to soil—"prevention of erosion and sedimentation" ranked second with 71% of the participants mentioning, and "maintenance of soil fertility and nutrient cycling" ranked fourth with 57% mentioning in round two. However, several participants in open ended comments that erosion, sedimentation, and issues of nutrient retention were described as being interrelated with issues of water quality. This round of the Delphi survey established that safeguarding soil fertility to sustain future farming were considered more important than carbon sequestration to mitigate climate change. Taken together, water and soil benefits were the ecosystem services of greatest importance to the panelists.

TABLE 3 | Ecosystem services important to and obtainable from Iowa's agricultural landscapes developed from participant ranking in the final round of a Delphi survey.

Ecosystem service	Final rank	Inverse 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
Crop pest control	17	0.1	0.07

Final rank was calculated by multiplying percent-who-mention by the inverse of the mean rank among participants. Ecosystem services in bold text were identified as being most important in the third round of Delphi.

Food production was the third ranked ecosystem service that garnered strong support throughout the Delphi survey. There appeared to be some ambiguity regarding this term, however, 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.

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, when faced with the forced choice, wildlife was only included by 36% of participants. 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 the intrinsic value of wildlife.

As a way to solidify the list of key ecosystem services relevant to Iowa's agricultural lands, in round three the list of ecosystem services was further condensed into just seven agricultural outcomes for a final ranking. As such, the top five rankings summarized in **Table 3**—water filtration and purification, erosion control, healthy/wholesome food production, maintain soil fertility, and flood attenuation—were confirmed as the final desired ecosystem service outcomes for Iowa.

Using data from round two of the Delphi survey to more specifically target points of agreement, we conducted concordance analysis on the rank-type survey responses. Analysis showed a low level of agreement in preferences for ecosystem services overall ($W = 0.15$, $F = 2.33$, $p = 0.003$). At least some agreement was expected given all panelists shared an affiliation with the STRIPS project. This statistic provided a baseline for a posteriori comparison below.

Agglomerative clustering based on spearman correlation of ecosystem service rankings revealed four clusters, with individuals within groups sharing attitudes. 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 individuals, with the least agreement existing between the first cluster and all others.

To identify the sources of disagreement among groups, responses from the second round of the Delphi survey were sorted for each cluster (**Table 4**).

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. For example, feed and livestock production

TABLE 4 | Ecosystem service items sorted into four clusters as identified in agglomerative cluster analysis. Final rank was calculated by multiplying percent-who-mention by the inverse of the mean rank among participants.

Cluster/Ecosystem service	Final rank	Inverse 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
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

(Continued)

TABLE 4 | Continued

Cluster/Ecosystem service	Final rank	Inverse mean rank	Percent who mention
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

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.

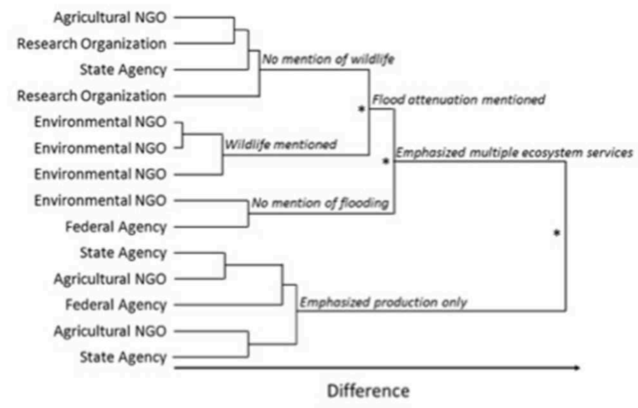

FIGURE 1 | Dendrogram illustrating agglomerative clustering based on Spearman correlation of preferred ecosystem services. NGO, non-governmental organization. Stars (*) indicate major points of divergence.

topped the list for cluster one, but neither were included by any other individuals. Within this latter cluster, there were two additional divergence points. The first was related to the role that agriculture can play in flood attenuation, with only half of the stakeholders mentioning this as part of their final benefit prioritization. The other divergence was related to agriculture's contribution to wildlife and habitat, where wildlife was final ranked as being important by only some of the participants who value the multiple outcome possibilities of agricultural land use. The dendrogram of how values cluster also illustrates that an individual's affiliation is not absolutely predictive of their expectations for agriculture (**Figure 1**). 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. All the stakeholders affiliated with environmental NGOs favored multiple ecosystem outcomes.

Strategies for Achieving Desired Ecosystem Service Outcomes

Based on the diversity of responses that panelists offered in Round 1 of the survey, Iowa agriculture is believed to have the capacity to provide numerous ecosystem outcomes. Still, when agricultural interests were sorted, there were some panelists who emphasize production agriculture and those who favor a more multi-outcome oriented agriculture that emphasizes multiple ecosystem services. This finding was clarified in the second and third round of the Delphi, which explored stakeholder expectations for land management strategies and practices to promote desired ecosystem outcomes.

We documented consensus among our stakeholders regarding landscape level planning and targeted conservation as being the critical strategy for achieving broad ecosystem service outcomes in a way that is compatible with the two main branches of ecosystem priorities (**Table 5**). Landscape planning and targeted conservation involve the use of high-resolution topographic and hydrologic data to identify specific cropped fields or areas within fields that are disproportionately contributing potential pollutants such as sediment and nutrients to surface waterways (e.g., Tomer et al., 2015). Once these areas are identified, conservation practices can be more successfully implemented at the field scale with greater impact and less risk.

Beyond landscape planning and targeted conservation, stakeholders ranked an assortment of specific conservation practices as important for maintaining or enhancing multiple ecosystem services (**Table 5**). Many of these practices also help operationalize landscape planning and targeted conservation, such as cover crops, conservation grazing, increased crop diversity, restored wetlands, targeted integration of perennials, and increased numbers of livestock on the land. Nevertheless, overall support for management practices was more diffuse than for ecosystem services: only five of 17 practices garnered majority support as measured by percent mentioned, these were landscape-level planning, riparian buffers, diverse crop rotations, restored wetlands, and strips of perennials; yet none of the practices received >64% mention (**Table 5**). The rankings of land management practices or approaches determined via round two were largely confirmed by round three findings, with the top eight practices/approaches ranked the same (**Table 5**).

TABLE 5 | Land management practices important for maintaining and enhancing ecosystem services from agricultural lands in Iowa, developed from participant ranking in the second round of a Delphi survey.

Management tactic	Final rank	Inverse mean rank	Percent who mention
Landscape level planning (i.e., targeted conservation activities)	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	6	2.0	0.43
Strips of perennials	5	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 management	11	0.6	0.29
Stream restoration	12	0.5	0.36
Bioreactors	13	0.40	0.14
Traditional terraces and grassed waterways	14	0.40	0.14
Biomass crops raised as biofuel feedstock	n.a.	0.00	0.00
Sensitive lands buffer	n.a.	0.00	0.00
Standard organic agriculture practices	n.a.	0.00	0.00

Practices listed in bold text were identified in the third round of the Delphi as being both linked to a broad range of ecosystem services and accepted by a range of stakeholders. Final rank was calculated by multiplying percent-who-mention by the inverse of the mean rank among participants.

DISCUSSION

Among Iowa-based agricultural and/or environmental policy, outreach, and industry stakeholders, there is informed opinion that along with commodity production, a broader array of ecosystem outcomes is both desirable and possible within the Iowa agricultural economy. Delphi participants identified several ecosystem outcomes that they believe to be compatible with private commodity driven land use. Various landscape-scale analyses of multifunctional agriculture have demonstrated this compatibility (e.g., Boody et al., 2005; Burkart et al., 2005; Jordan and Warner, 2010; Meehan et al., 2013; Brandes et al., 2018). This finding remains salient for the state of Iowa, particularly because policy-based efforts to operationalize the multiple ecosystem outcome concept are mounting, as exemplified by regional or state level conservation programs such as the Iowa Nutrient Reduction Strategy (IA-NRS; Iowa Department of Agriculture and Land Stewardship et al., 2017), and the USDA Natural Resource Conservation Services' Monarch Butterfly Habitat Development Project (MBHDP; program focus area involves Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Ohio, Oklahoma, Texas, and Wisconsin) (Natural Resource Conservation Service United States Fish and Wildlife Service, 2016). The IA-NRS specifies ways in which farmers and landowners can reduce agricultural impacts on surface water quality through voluntary adoption of conservation oriented Best Management Practices and/or perennial commodities (e.g., such as dedicated biomass production). The MBHDP focuses on a core set of conservation practices, including many of the same practices promoted by the IA-NRS, while also promoting specific habitat needs such as milkweed planting and prescribed burning. These programs provide synthesis-based scientific backing regarding the biophysical nature of water quality and biodiversity issues in the state and the field-level efficacy of certain Best Management Practices. Both also rely on widespread voluntary adoption of these practices on largely private lands. The challenge as always, is how best to approach these goals and unfortunately, there is very little historical evidence nationally, not just in Iowa, that voluntary conservation efforts without strategic planning and appropriate incentives are enough (Secchi et al., 2008; Nowak, 2009; Tomer and Locke, 2011).

This case study, however, suggests a consensus-based way forward. Land-use planning and targeted conservation was identified as the primary way for maintaining and enhancing ecosystem outcomes from agricultural lands in Iowa. Mechanistically, a pathway to expanding the outcomes of agriculture and capitalizing on benefits of jointly produced ecosystem functions (e.g., a single land use practice and cost that results in multiple benefits) is utilizing spatially targeted conservation methods. Spatially targeted conservation is the spatial coordination of conservation practices and/or alternative land use (e.g., perennial biomass production) on specific fields identified within a watershed as being significant multi-scale contributors to nutrient loads due to combined soil, topographic, hydrological and land use conditions (Taylor-Lovell and Johnston, 2009; Tomer et al., 2013). Recent advances in publically available high-resolution data and geographic information system (GIS) based land use planning tools have significantly enhanced the capacity of conservation planners to analyze and guide spatially targeted conservation (Tomer et al., 2015; Zimmerman et al., 2019).

Complementing land-use planning and targeted conservation in critical ways, our study's stakeholders associated many available conservation management practices with multiple ecosystem services. The practices noted by our participants have multifunctional biophysical capacity and jointly produce a host of effects that support more than one ecosystem outcome, such as enhanced water quality, flood attenuation, biodiversity, recreation, aesthetics, and economic development (e.g., Schultz et al., 2004; BenDor et al., 2015; Schulte et al., 2017).

Importantly, it is not just our stakeholders who support the use of landscape planning, targeted conservation, and the use of multi-functional best management practices: farmers and the general public have variously weighed in on these approaches as well. A statewide representative survey of Iowa farmers noted that they by and large have favorable attitudes about and broadly support targeted conservation approaches (Arbuckle, 2012). These farmers believe that conservation funding should be increased, favor its use to incentivize implementation of conservation practices on targeted farm fields, and are open to working with governmental technical support entities in conservation planning. In the context managing agricultural lands for the maintenance and enhancement of ecosystem services from agricultural lands in Iowa, there is clear technological capacity as well as evidence of farmer willingness. Notably, similar findings of farmers being amenable to spatially targeted conservation and supporting conservation policy have been noted in other US Cornbelt states (Kalcic et al., 2014).

From a demand stand point, in November 2010, the people of Iowa voted by a 63% majority to amend Iowa's Constitution (Senate File, 2310, Iowa Code Chapter 461) to dedicate three-eighths of one percent of any future sales tax increase to create the Natural Resources and Outdoor Recreation Trust Fund (Arbuckle et al., 2015). This fund in turn was expected to contribute between $150 and $180 million annually to support conservation and recreation efforts throughout the state (Dorman, 2018). A 2012 survey of Iowa citizens, found that two-thirds of Iowans indicated they would support a policy shift from the current uncoordinated approach to conservation, to specifically a "targeted agricultural conservation approach [that] uses technologies such as satellite imagery and mapping technology to identify areas likely to have problems, such as erosion and impaired water quality. Funding [would] then be targeted to those areas that are particularly in need of assistance" (Arbuckle et al., 2015, p. 7). In addition to voicing support for such a policy shift, Iowa citizens indicate a willingness to pay a significant amount on an individual level to help cover the transaction costs of such a policy shift; collectively, Iowans would be willing to pay well over $400 million over a 10-year policy transition period (Arbuckle et al., 2015). Among various land use priorities provided in the survey, Iowans ranked the following agro-ecosystem outcomes (respectively): water quality for human consumption, water quality for aquatic life, rural economic development, flood attenuation, water quality for recreation, and game wildlife habitat (Schulte et al., 2017). As of 2019, the Iowa Natural Resources and Outdoor Recreation Trust Fund trust remains unfunded largely because of political opposition toward tax-based approaches to enhancing public resources (Cohen, 2019).

Taken as a whole, the results of this study, when coupled with other studies (Arbuckle, 2012; Arbuckle et al., 2015), suggest fulfillment of the three important preconditions for shifting domestic farm policies to directly support and actively promote agriculture that features broader ecosystem outcomes beyond just commodity production (as described in Moon and Griffith, 2011): (i) qualifying and quantifying the existence of social demand for the array of ecosystem service outcomes in question; (ii) determining that the desired array of ecosystem service outcomes are jointly produced with farm commodities; and (iii) assessing and accounting for the transaction costs associated with required policy shifts. A demand orientation is important so that policy and outreach targets stakeholder preferences for specific land use and environmental outcomes thus defining a more appropriate context for actual, on-the-ground land management performance improvement. Joint production of multiple ecosystem outcomes is important to minimize tradeoffs and maximize land use efficiency. Recognizing the transaction costs of implementing a new policy such as watershed scale landscape planning and targeted conservation is pragmatically critical for articulating and in time properly financing the required policy guidelines and incentives for coordinated environmental management to garner multiple ecosystem service outcomes (Naidoo et al., 2006).

The social and technical capacity (and data) to plan for outcome-oriented conservation is seemingly in place. As such, stakeholders and policy decision makers have critical information to base earnest discussions regarding implementation of unified belief systems regarding ecosystem services important to and obtainable from Iowa's (and other US Cornbelt states') agricultural landscapes (Wardropper et al., 2015). Beyond synthesizing what we expect to be a salient argument for the adoption of approaches that better fulfill stakeholders' agricultural interests, we also offer a simple framework to inform and support continued public discourse regarding agricultural ecosystem services (**Figure 2**). The framework is based directly and indirectly on our Delphi process and follow up discussions with survey participants, but also on the author's collective research and professional experiences with agricultural stakeholders in Iowa. The framework illustrates six key themes essential to effectively contextualize policy and management regarding ecosystem service outcomes in row-crop dominated landscapes: people, land, ecosystem service outcomes, management, ecosystem processes, and expectations and values. With people, the panelists while appropriate for our study represent only a subset of key stakeholders relevant to agricultural issues, management, outcomes, and policy. Farmers, livestock producers, food processors, commodity groups, food policy entities, civic leaders and consumers (among others) all have critical voices relative to the future of agriculture throughout the world (Jordan and Warner, 2013). As such there is a need to clearly define all stakeholders involved, including characterization of their "stakes" and the different qualitative and quantitative ways that a stake is valued, measured, and accounted for in decision making processes. With land, panelists collectively noted the need to consider multiple scales. With ecosystem service outcomes, they articulated an appreciation for generating and explicitly defining a full set of priorities so that the full scope of goals and potential tradeoffs among them could be better understood. Interactions among these primary attributes are mediated through management, ecosystem processes, and expectations and values, although these secondary attributes were less clearly articulated by study participants. Management includes the avenues of land use through which people can directly impact ecosystem service delivery. Ecosystem processes are natural mechanisms by which ecosystems operate, that are only partially understood and can only be partially managed by people. Expectations and values range among stakeholders, and must be acknowledged by all

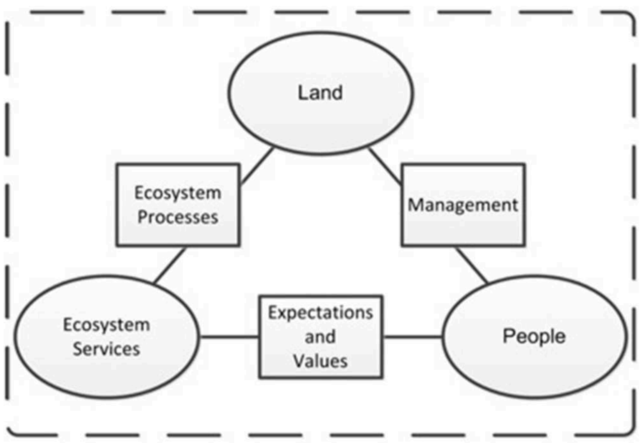

FIGURE 2 | Framework for discussions regarding ecosystem services, with six major themes developed through a Delphi survey of stakeholders working on agricultural sustainability in central Iowa. The bounding box, though dashed to recognize connections to other regions and systems, represents the need to bound discourse in time and space for effective communication among groups.

due to their impact on stakeholder attitudes and behaviors. Follow up discussions with survey participants also underscored the need to bound these concepts not just in space but also time.

We suggest this simple, six point, framework may be useful in framing agro-ecosystem 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 outcome-related discussion forward. The more explicitly each factor is addressed, the more likely ideas will be communicated effectively among stakeholders.

CONCLUSION

We found that agricultural and/or policy, outreach, and industry stakeholders in Iowa share similar priorities relative to water, soil, and food in the region. While broadly agreeing on top priorities, at a finer level stakeholders diverged into two more specific groups: one that emphasized production over other ecosystem services and another that had expectations for a broad suite of ecosystem services. We found some further divergence among the secondary priorities of conservation-oriented stakeholders, but also that the stakeholders expected to be achieve these secondary priorities through careful alignment and promotion of landscape planning and use of land-management practices capable of jointly delivering multiple benefits. This study focusing on policy and outreach stakeholders strongly complements and parallels the findings from other agricultural stakeholder assessments regarding farmers and the general public. We offer a simple six-point framework—that includes people, their expectations and values, land, management, and ecosystem processes in addition to ecosystem services—to appropriately contextualize questions and discussions among stakeholders. Our analysis and experience suggests that this framework can be useful for agricultural stakeholders to fully contextualize, explain, and ground discussions regarding consensus driven findings such as more explicit use of landscape planning such as spatially targeted conservation that leads to multiple desired outcomes, in ways that maximize synergies and minimize trade-offs.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Iowa State University Institutional Review Board. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

DL, LS, and JT collaborated to conceive different aspects of the research. DL conducted the research. DL and NG-S collaborated on the analysis with support from LS and JT. DL, JT, LS, and NG-S contributed to the writing and also edited the manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2019.00110/full#supplementary-material

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