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A deliberative research approach to valuing agro-ecosystem services in a worked landscape

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ABSTRACT

Sustaining agricultural environments requires explicit recognition of the services provided by landscapes, particularly cultural ecosystem services that are contested and underrepresented in previous research. We assembled and engaged a panel of experts to identify and deliberate on the relationships among ecosystem services, threats and land management practices in an agricultural watershed using a Delphi method. We also drew from focus group results to gain an in-depth understanding of how participants valued the Kaskaskia River Watershed, Illinois. Results revealed that diverse benefits were derived from provisioning (e.g., crop production), regulating (e.g., flood prevention), supporting (e.g., soil formation), and cultural (e.g., farming lifestyle) services provided by the watershed. A disproportionately higher number of cultural services were identified and rated as highly important. Multiple threats, including erosion and nutrient loading, were associated with agricultural, forest and lake and river environments, highlighting the importance of connectivity across ecosystems. To mitigate and adapt to change, particularly around the provision of agro-ecosystem services, stakeholders benefit from collective discussions about land management practices such as reduced tillage and zoning policies. Engaging local stakeholders in deliberation provides a rich basis for understanding the multiple values of worked landscapes and establishing sustainable agricultural practices.

1. Introduction

Agricultural production is dependent on multifunctional agro-ecosystems that provide an array of provisioning, regulating, supporting, and cultural ecosystem services. Tradeoffs and synergies among these competing services have become increasingly important to recognize in the face of agricultural intensification and increased pressures on natural environments (Fischer et al., 2002; Sayer et al., 2013). To guide management decisions about how to balance the multiple benefits of complex social goods, stakeholder input should be accounted for and made explicit in the research process (Chan et al., 2012; Daniel et al., 2012; Muhar et al., 2018), as articulated by a suite of frameworks that underpin conservation policy and practice at a global scale (Díaz et al., 2018, MEA, 2005; TEEB, 2010). However, the consequences of stakeholder reflections on service provision–often encompassed by the cultural ecosystem services category–are difficult to quantify and incorporate into environmental policies (Maczka et al., 2019; Milcu et al., 2013; Steger et al., 2018). Investigations of cultural ecosystem services are fundamentally important in worked landscapes because they represent both tangible and intangible qualities of these settings, including a sense of heritage and a deep-seated relationship between people and places (Tengberg et al., 2012; Strauser et al., 2019), which can be sidelined by commodity-driven markets that accompany agricultural production (Conway, 1987; Power, 2010; Zhang et al., 2007).

Previous ecosystem services research has relied on typologies and metrics that are generalizable across broad contexts (Chan et al., 2012; de Groot et al., 2002; Palomo et al., 2013). Given the competing narratives that exist in the context of agro-ecosystems, where rural landscapes are managed for production but also embody cultural services (Prokopy, 2011; Swinton et al., 2007), there is a risk of

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misrepresentation when data are reduced into discrete categories. To ensure the process of aggregation does not sidestep public participation (Power, 2010; Swinton et al., 2007), deliberative valuation can be employed to engage small groups of stakeholders in facilitated discussions throughout the research process. Through a deliberative valuation approach, the relative importance of ecosystem services can be evaluated via formal assessment and gleaned from in-depth discussions among experts (Kelemen et al., 2013). This process works toward understanding the complete range of benefits that may not be elicited using pre-existing frameworks (Kenter et al., 2015, Kenter et al., 2016), increases effectiveness and perceived legitimacy in decisions (Howarth and Wilson, 2006), and considers benefits accrued at different scales of societal organization (van Riper et al., 2018). Developing an agro-ecosystem services typology through deliberative valuation is more likely to account for benefits specific to agricultural environments across all categories of the MEA (2005), which need to be considered and equitably distributed across interest groups.

In this study we investigated the provision of agro-ecosystem services within a rural agricultural context using an expert-driven deliberative research approach. Specifically, we engaged a knowledge alliance of 27 experts throughout a four-round, iterative Delphi survey about agro-ecosystem services across four land cover types. Participants identified benefits and threats to the provision of agro-ecosystem services, as well as evaluated best management practices. Focus group data were also leveraged to deepen the extent of engagement with stakeholders, validate study findings and incorporate rich qualitative insights into our interpretation of results (Prokopy, 2011). This research approach enabled us to learn from the local knowledge of experts (van Berkel and Verburg, 2014), develop an agro-ecosystem services typology informed by in-depth discussions with stakeholders (de Groot et al., 2002) and showcase a method for generating consensus around the values of an agricultural landscape in ways that could link to management decisions.

2. Background

2.1. An overview of agro-ecosystem services

An array of benefits flow to individuals and communities from agro-ecosystems that are often modified to maximize the production of goods and services (Conway, 1987). Several examples of these services include food and raw materials (i.e., provisioning), soil organic carbon and pollinator diversity (i.e., regulating), soil fertility/formation and nutrient recycling (i.e., supporting), and landscape aesthetics and cultural heritage (i.e., cultural) (Swinton et al., 2007; Zhang et al., 2007). Over the past 50 years, global crop production has increased three-fold, amounting to a $2.6 trillion industry in 2016 (IPBES, 2019), while other services that regulate these environments have declined (Díaz et al., 2018). Given the multiple values derived from agro-ecosystems that benefit communities from local to global scales (Power, 2010; Swinton et al., 2007; Zhang et al., 2007), decisions made by producers and policy-makers are widely recognized as important for balancing the future provision of goods and services in worked landscapes (Wei et al., 2009).

While agro-ecosystems provide multiple services, at times the provision of some services may impede the productivity and sustainability of others (Power, 2010; Zhang et al., 2007). Changes in climate, urbanization and increasing demand puts pressure on agricultural production and promotes intensification through mechanisms including the application of fertilizers and herbicides (Power, 2010). Tradeoffs between agriculture and conservation can emerge under circumstances such as the removal of edge habitat and establishment of agricultural monocultures. Decisions to prioritize one service over another can also reduce biodiversity (Kleijn et al., 2009), soil fertility (Matson et al., 1997), and water quality (Berka et al., 2001). However, it is possible to adopt practices that advance conservation initiatives while also sustaining production (Power, 2010). No-till practices, crop rotation, and cover crops are all techniques that reduce ecological impacts from agriculture and maintain conventional production rates (Hobbs, 2007). In this sense, adopting practices that enhance soil quality can also improve other ecosystem functions such as water quality and carbon sequestration. To achieve these 'win-win' scenarios whereby multiple agro-ecosystem services are taken into consideration, synergies between competing land management practices need to be prioritized.

2.2. Deliberative valuation and its measurement

Research approaches for assessing the multiple values of nature must take into consideration the range of ecosystem services provided by environments (Balmford et al., 2002; Costanza et al., 1997) and representation of diverse stakeholders engaged in valuation (Howarth and Wilson, 2006; Kenter et al., 2019). Monetary valuation has effectively quantified the economic values of many provisioning, regulating, supporting, and cultural services (e.g., food, fiber, crop pollination, soil formation, recreation, and tourism), and provided a useful basis for landowners and policy makers to make management decisions (Bateman et al., 2013; Fisher et al., 2009). While equally important, cultural (e.g., aesthetic values, religious values, identity) and supporting services (e.g., biological diversity, wildlife habitat) have proven more difficult to monetize (Satz et al., 2013; Steger et al., 2018) and therefore have been underrepresented in previous research (Chan et al., 2012; Daniel et al., 2012). Because ecosystems are managed to provide a wide range of services that span monetary and non-monetary values (Christie et al., 2012), deliberation in the research process is needed to ensure diverse voices are considered and legitimized in decision-making and policy outcomes (Kelemen et al., 2013; Kenter et al., 2016).

Ecosystem services research often relies on typologies to systematically describe, classify, and standardize the ecological and socio-cultural values of nature that sustain relationships between people and places (Chan et al., 2012; de Groot et al., 2002). For example, Raymond et al. (2009) engaged natural resource managers and community members in a process of identifying the provisioning, regulating, cultural, and supporting ecosystem services across a river basin in Australia. Findings from this study were translated into a typology that reflected community values. A study by Brown and Reed (2000) also elicited stakeholder input through a participatory mapping exercise that resulted in a typology of competing social values within a national forest. Although previous research has classified a range of ecosystem services that flow from public land management contexts to local communities (Palomo et al., 2013), fewer classification systems exist for agricultural contexts. There is a strong need for future research to build a classification system for agro-ecosystem services that emerge from in-depth discussions with local experts to broaden democratic principles through facilitated public participation (Reed, 2008; Spash, 2007) and increase the likelihood that results are implemented (Chan et al., 2012; Kenter et al., 2016).

2.3. Delphi method

The Delphi method is a structured, iterative, and typically anonymous process for collating the judgements and projections of expert stakeholders (Linstone and Turoff, 1975). Delphi studies typically consist of multiple 'waves' of a questionnaire that first includes open-ended questions and then in subsequent evaluations ask survey respondents to assign numeric values to items that were previously identified by the group (Curtis, 2004; Mukherjee et al., 2015). The iterative nature of Delphi research is efficient because it does not require that participants are brought together in the same place, yet it can promote the co-creation of knowledge across different sectors and minimize potential bias from "groupthink." This research approach is particularly useful for evaluating complex phenomena whereby the outcome depends on a diverse range of expert opinions rather than a large sample of respondents. Since its development, Delphi processes have been applied in a variety of natural resource settings to build scenarios for assessing biological invasions (Lauber et al., 2016), predict impacts from climate change (Mukherjee et al., 2015), and inform decisions about ecological restoration (Orsi et al., 2011).

Previous research has identified several areas for improvement in the Delphi method because its emphasis on building consensus without in-depth interactions or information sharing among participants. Given that the process of reducing open-ended responses to identify uniform judgments can simplify meaning, Delphi research may also lack the specificity necessary for implementing recommendations (Powell, 2003). However, this technique can be enhanced by more in-depth knowledge derived from exchanges between study participants, mixed methods research that combines iterative Delphi surveys with focus groups are rare (for exception see Lauber et al., 2016). Indeed, incorporating opportunities for research participants to explain their viewpoints permits opportunities for deliberation (Prokopy, 2011) and shows promise for improving the interpretation of how agro-ecosystem services are valued (Curtis, 2004).

2.4. Objectives

We engaged expert stakeholders in a mixed methods Delphi study to identify, categorize and evaluate agro-ecosystem services that spanned four types of landscapes: (1) agricultural, (2) built environments, (3) forests, and (4) lakes and rivers within the Kaskaskia River Watershed of southern Illinois. We engaged representatives from the local community in an iterative survey process and then facilitated an in-person discussion about how to protect agro-ecosystem services using land management practices that were identified during the Delphi process. With this information, we developed a typology of provisioning, regulating, supporting, and cultural agro-ecosystem services that aligned with previous research and represented local interests. Our objectives were two-fold: (1) identify and evaluate agro-ecosystem services, threats and land management practices associated with four landscapes through a Delphi process; and (2) validate and deepen our survey results through a deliberative focus group discussion with key stakeholders.

3. Methods

3.1. Study location and participants

This research was conducted in the Kaskaskia River Watershed that spans the central and southern regions of Illinois, US. The watershed, which feeds directly into the Mississippi River, drains approximately 1,506,800 ha of land and is composed of four U.S. Geological Hydrologic Unit Code (HUC) 8 sub-basins (Upper Kaskaskia [07140201], Middle Kaskaskia [07140202], Lower Kaskaskia [07140204], and Shoal [07140203]). This area represents ten percent of the land in Illinois and is the state's second largest watershed (Fig. 1).

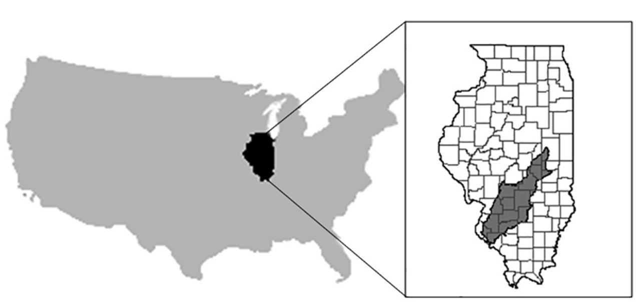

Fig. 1. Boundary of the Kaskaskia River Watershed in Illinois, United States.

There is roughly a 150-foot change in elevation throughout the watershed (Fig. 2a) with predominately low infiltration soil groups (Fig. 2b). Over 70 percent of the land area in the Kaskaskia is devoted to agriculture, alongside small forested areas (16 percent), urban land cover (nine percent), wetlands (two percent), and grassland (less than one percent) (Metzke and Hinz, 2017; Fig. 2c). The majority of agricultural practices in the watershed consist of cultivated corn and soybean crop (57 percent of agricultural land) while some is agricultural and used as pasture and hay (13 percent) (Homer et al., 2015). Livestock within the watershed is largely composed of pigs/hogs/swine (74 percent of total headcount; $n = 344,602$), followed by beef/dairy cows (12 percent; $n = 56,981$) and chickens (9 percent; $n = 42,817$) (Stroud Water Research Center, 2017; U.S. Department of Agriculture, 2018).

The Kaskaskia River is the primary river within the watershed and is approximately 523 km in length (Fig. 2d). There are two large United States Army Corps of Engineers (USACE) reservoirs along the main stem of the Kaskaskia River – Carlyle Lake and Lake Shelbyville. These two bodies of water were authorized for the purpose of flood risk management, navigation, water supply, water quality, fish and wildlife habitat, and recreation (U.S. Army Corps of Engineers, 2016). In the lower reach of the Kaskaskia River, the USACE's Jerry F. Costello Lock and Dam and associated Kaskaskia River Navigation Project have promoted cargo transport of resources such as grain, steel, and farming chemicals. There is a citizen-organized watershed association, the Kaskaskia Watershed Association (KWA), which represents community interests such as agriculture, conservation, and recreation in this region (Leahy and Anderson, 2010).

The expert stakeholders engaged in this research ($n = 38$) represented a range of interests in the Kaskaskia River Watershed. Approximately half were invited to participate in the study during an annual summit of the KWA in early 2018. The remainder of the sample was selected from a list of leaders who had been previously recommended by other stakeholders following a snowball sampling technique (Noy, 2008). To capture a diversity of perspectives, we strategically invited both males and females from different organizations with different levels of experience. The final sample consisted of leaders from key agricultural and conservation organizations across the Kaskaskia River Watershed, including tourism, economic development, and planning. Several of the key organizations represented in the sample were the United States Army Corps of Engineers (Carlyle Lake and Lake Shelbyville), Illinois Department of Natural Resources, Illinois Farm Bureau, American Farmland Trust, Heartlands Conservancy, Illinois Natural Resources Conservation Service, Montgomery County Soil and Water Conservation District, and the KWA.

The development of our study design was guided by several principles that worked to minimize double-counting, which is a methodological issue in ecosystem service research given potential for unreliability in valuation (Fu et al., 2011). First, given the widely shared regional identity in the watershed, our participants were primed to reflect on ecosystem services at the same scale of the watershed in contrast to other scales such as global or state (Hein et al., 2006). Second, our questionnaires contained explicit definitions of each ecosystem service, and distinguished services from ecosystem functions (Fu et al., 2011). Third, our purpose in this assessment was a relative valuation of ecosystem services tied to well-being within the watershed (Evans, 2019), rather than an absolute valuation, economic utility or a valuation at some other geographic scale (Fisher et al., 2009). In this sense, our inquiry was directed at participants' lived experience in their everyday routines rather than a hypothetical or idealized abstraction. Although it was difficult to disentangle the complexity in factors that influenced our study, the above principles were adopted to reduce the problem of double-counting.

3.2. Research design

A mixed methods Delphi study that included a final focus group for

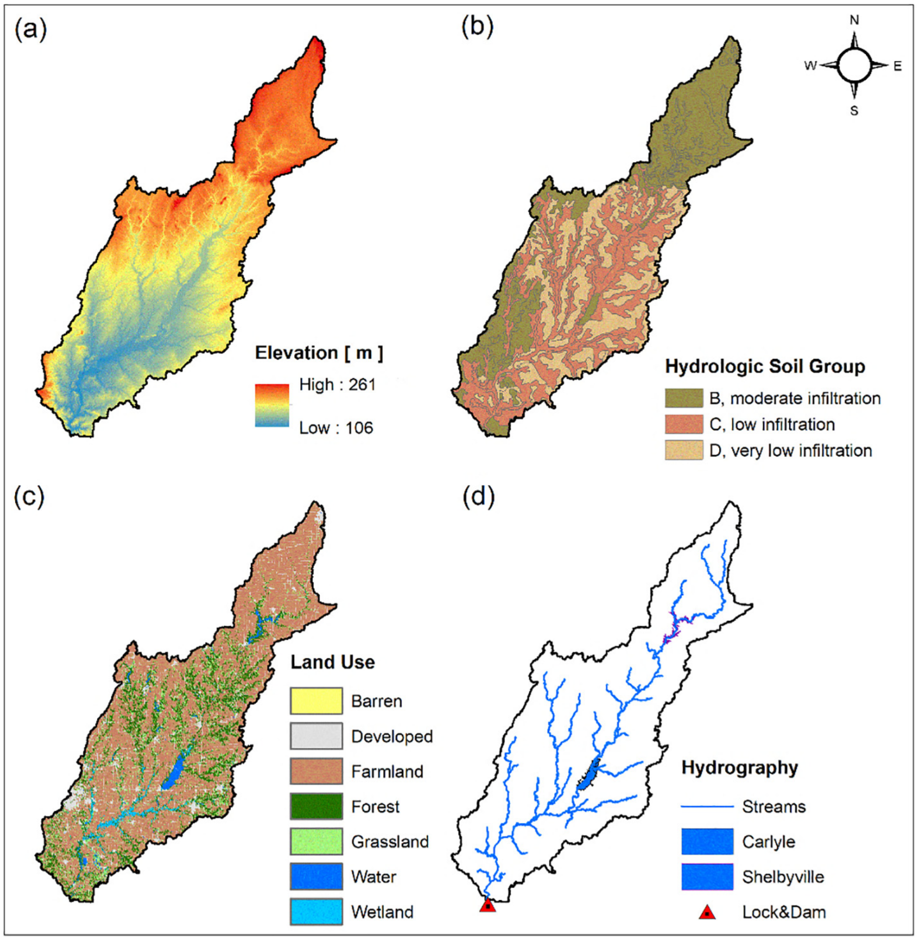

Fig. 2. Physical features of the Kaskaskia River Watershed: (a) elevation change, (b) hydrological soil groups by infiltration rate, (c) land use, and (d) main rivers and reservoirs in the watershed.

Table 1
The number of retained participants in each phase of the research process across their reported professions.

	Round 1	Round 2	Round 3	Round 4	Focus Group
Farming	11	9	8	7	4
Conservation	7	6	5	5	4
Tourism	2	2	2	2	1
Economic Development	2	2	2	2	1
Biology	1	1	1	1	1
Academia	1	1	1	1	0
Engineering	1	1	1	1	0
Media	1	1	1	1	0
Teacher	1	1	1	0	0

face-to-face deliberation was implemented in Spring 2018. Data collection occurred over the course of four rounds of surveys, each of which was administered in the beginning of the workweek and one full week was provided for a response (see Table 1). Data were analyzed and collated during the subsequent week. Given that two weeks were dedicated to each survey round, data collection spanned eight weeks. All participants were initially asked to evaluate three dominant landscape types in the Kaskaskia River Watershed, including agricultural (i.e., cultivated landscapes such as cropland or pastures), built environments (i.e., cites, towns and communities), and lakes and/or rivers (i.e., surface water such as reservoirs, rivers and streams). During the first survey round, participants were asked open-ended questions about the benefits from agro-ecosystems from each landscape type provided to themselves and their family, the local community, and the entire watershed. During analysis of the first survey results, nine participants indicated that forest landscapes were important to the watershed, therefore, forest (i.e., areas predominately covered with trees) was added as a fourth landscape type and presented in all subsequent survey rounds. Additional items in our first questionnaire evaluated the number of years participants had lived and worked in the watershed, number of years in their current profession, self-reported knowledge about the landscape types, and socio-demographic characteristics.

Three subsequent rounds of surveys were administered. During the second round, participants were asked to evaluate the importance of benefits for each landscape identified during the first survey using seven-point Likert scales (DeVellis, 2016). After evaluating the importance of benefits, participants were asked to identify threats associated with each of the four landscape types in an open-ended question format. The prompt was framed around future change in the region and the factors impacting the landscape's ability to provide benefits. During the third round, participants were asked to reconsider their evaluation of benefits, evaluate the risks posed by each threat identified in the previous round, and generate a list of land management practices that could be implemented to mitigate threats for each landscape type. To re-evaluate benefits, participants were shown their previous evaluation alongside the group median values and asked how (if at all) they would modify their previous assessment. Following Hallowell and Gambatese (2009), previous evaluations were presented using median rather than mean values because median values reduced the effects of outliers. This approach also ensured participant saw whole numbers that did not contain decimal points because their re-evaluations were requested to be in the same format. Next, participants were asked to evaluate the significance of the threat posed to each landscape identified in the second survey. Then, participants identified land management practices that could reduce threats to each of the four landscape types in an open-ended question. During the fourth and final round, participants were asked to re-evaluate the significance of threats following the same technique for re-evaluating benefits in the third survey, as well as evaluate the effectiveness of land management practices for minimizing threats to the Kaskaskia River Watershed.

Following completion of the four surveys, all participants were invited to attend a two-hour focus group to discuss the findings. The purpose of the focus group was to deliberate on the rankings of ecosystem services in ways that underscored their public value and revealed their relative importance across the watershed (Hansjurgens et al., 2017). The focus group consisted of three phases. First, members of the research team gave a brief presentation that summarized the project objectives and findings to initiate the flow of ideas (Morgan and Krueger, 1998). Next, participants (n = 11) were split into three small groups to discuss agro-ecosystem services, threats, and land management practices for one of the four landscape types. That is, one group discussed agriculture and built environments, another group discussed forests, and the final group discussed lakes and rivers to ensure equal representation across groups. Discussion questions prompted deliberation on the extent to which the results rendered an accurate portrayal of ecosystem services within the Kaskaskia River watershed, and in doing so, evaluated if any of the ecosystem services, threats, or land management practices should be changed, removed, or added (Grainger and Stoeckl, 2019). Finally, a group discussion ensued whereby the three subgroups reported back to the entire group on the issues discussed and relied on flip charts to document key observations. This final phase emphasized the broad topics and management challenges tied to agro-ecosystem services in the watershed (Bloor et al., 2001). The focus group discussion was audio recorded and transcribed verbatim.

A typology of agro-ecosystem services was developed to synthesize findings from the Delphi survey and focus group. That is, all qualitative and quantitative data were simultaneously considered by the research team when making decisions about how to condense, collapse, and modify categories. In addition to deliberating on results from the Delphi survey, focus group participants offered suggestions for how to refine an initial draft of our typology so it better reflected local conditions. Transcripts from the focus group were analyzed to identify the particularly important and broadly supported recommendations from participants on how to create a more robust typology of agro-ecosystem services that maintained social relevancy. Our classification system was also modified and re-organized to align with the provisioning, regulating, supporting, and cultural service categories of the MEA (2005) and maintain compatibility with previous research (Brown and Reed, 2000; Chan et al., 2012; de Groot et al., 2002; Raymond et al., 2009).

3.3. Data analysis

Participant responses to open-ended questions used to identify agro-ecosystem services, threats, and land management practices were qualitatively coded to develop survey items for subsequent rounds of the Delphi survey. Responses were first open-coded and then subsequently reduced into broader categories to represent unique agro-ecosystem services (Creswell and Creswell, 2017; Strauss and Corbin, 1990). Threats and land use practices were coded in a similar manner. Coding was conducted independently by two researchers on the research team that achieved high inter-rater reliabilities (Creswell and Creswell, 2017) of 88.7 percent for agro-ecosystem services, 90.5 percent for threats, and 91.7 percent for land use practices. All disagreements were deliberated and resolved.

Responses to Likert scale survey items that evaluated the importance of agro-ecosystem services, significance of threats to landscapes, and effectiveness of land use practices were all descriptively assessed using measures of central tendency. Mean values of evaluations were used to rank order individual benefits, threats, and land use practices to assess the relative importance of each item. Mean values, rather than median values, were chosen for reporting results to reveal the variation that would otherwise go undetected by median values (Hallowell and Gambatese, 2009).

Focus group discussions were moderated by members of the research team to ensure that all voices were reflected in the discussion, keep the conversation flowing, and minimize groupthink by ensuring broad representation rather than coercion for the sake of consensus. The transcripts were coded to identify the type of ecosystem service, threat, or land use practice being discussed by the participants. For each ecosystem service benefit, threat, or land use practice, the narrative context around each code was analyzed using open coding to understand the broader context of participants' remarks (Creswell and Creswell, 2017). Codes indicated whether participants believed an ecosystem service, threat, or land use practice should be added, removed or re-ordered. An inter-rater reliability of 87.3 percent was achieved during the coding process.

4. Results

4.1. Overview of study participants

The first and last surveys in the Delphi process were completed by 27 and 20 participants, respectively, resulting in a 74 percent retention rate. The final sample (n = 20) was predominantly White (85 percent), educated (83 percent holding a Bachelor's degree or higher), relatively wealthy (53 percent reported an annual household income above $100,000), and mostly male (85 percent). Participants reported ages ranging from 25 to 79 (M = 57.2, SD = 16.05) and between one and 50 years of experience in their current profession (M = 22.7, SD = 15.46). Professions of participants across each round of the Delphi study and focus group can be found in Table 1.

4.2. Identification and evaluation of agro-ecosystem services

Participants identified 24 agro-ecosystem services from the Kaskaskia River Watershed. Of all identified services, nine were associated with agricultural landscapes, ten with built environments, six with forest landscapes, and nine with lakes and rivers. *Crop production* was the most commonly identified service from agricultural landscapes, indicated by 15 of 27 participants identifying "highly productive cropping systems" and "food" as benefits. The agro-ecosystem services predominantly associated with other landscapes were a *hub for goods and service* for built environments, *wildlife conservation* for forest landscapes and *recreation* for lakes and rivers.

Multiple services were deemed important across different landscapes. *Crop production* was important for agricultural landscapes, whereas other services including *recreation* and *wildlife habitat* were universally valued across landscapes. Although most ecosystem services were considered important, their relative value was viewed differently between and within the four landscapes. The services that received the highest rating for agricultural environments were *crop production*, *income generator,* and *farming lifestyle* (Fig. 3). Other important agro-ecosystem services of the Kaskaskia River Watershed were *education*, *income generator*, and *community history* for built environments, *water supply*, and *wildlife habitat* for forest landscapes, and *environmental stewardship*, *flood control*, and *wildlife conservation* for lakes and rivers. Both *ethanol production* of agricultural landscapes and *income generator* of forests were noted by participants but were less important.

All agro-ecosystem services were organized into categories following the MEA (2005) (Fig. 4). In instances where a service spanned multiple landscapes, a mean value score was created to represent the perceived importance of the service across the entire watershed. Results indicated that participants identified a disproportionately high number

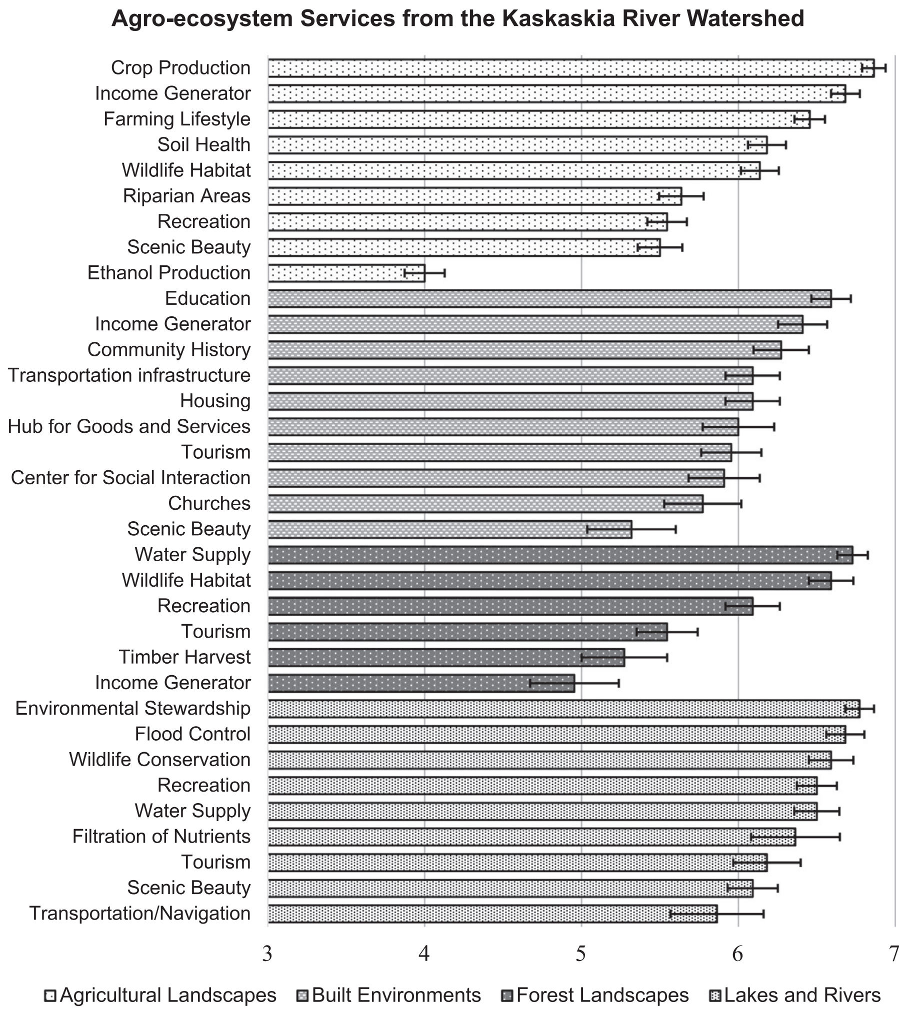

Fig. 3. Mean values and standard errors for the perceived importance of agro-ecosystem services across four landscape types in the Kaskaskia River Watershed. All services were evaluated on a seven-point Likert scale ranging from 1 “Extremely Unimportant” to 7 “Extremely Important.” (n = 24).

of cultural ecosystem services compared to provisioning, regulating and supporting services. Across all MEA categories, the most highly rated services were *crop production* (M = 6.86, SD = 0.35), *flood control* (M = 6.68, SD = 0.57), and *environmental stewardship* (M = 6.77, SD = 0.4).

4.3. Identification and evaluation of threats to landscapes

Participants identified 21 threats facing the Kaskaskia River Watershed. Of the identified threats, 13 were associated with agricultural landscapes, nine with built environments, seven with forest landscapes, and eight with lakes and rivers. *Erosion* and *run-off* were the most commonly identified threats to agricultural services, indicated by 10 participants with responses such as “soil loss from erosion.” Other commonly reported threats were *lack of economic support and infrastructure* for built environments, *invasive species* for forest landscapes, and *siltation/sedimentation* for lakes and rivers.

Most threats were believed to be detrimental to the provision of agro-ecosystem services, but the rating of these threats varied between and within different landscapes. For example, *erosion* was problematic for agricultural landscapes, while also posing danger to forests, lakes, and rivers. Threats evaluated as most harmful for agricultural landscapes included *unstable fertilizer and herbicide application*, *lack of conservation practices*, and *removal of environmental buffers*. The other threats facing the Kaskaskia River Watershed according to study participants were *resistance to change*, *poor governance*, and *run-off/pollution* for built environments, *habitat fragmentation* and *invasive species* for forest landscapes and *siltation/sedimentation*, *run-off,* and *invasive species* for lakes and rivers (Fig. 5). Threats that were rated as least detrimental included *industrial demand* for agricultural landscapes and *erosion* for built environments.

4.4. Identification and evaluation of land use practices

Participants identified 29 land use practices that had the capacity to minimize future threats facing the Kaskaskia River Watershed. Of all identified land use practices, 12 were associated with agricultural landscapes, nine with built environments, ten with forests, and ten with lakes and rivers. *Reduced tillage* was the most commonly identified land use practice for agricultural landscapes, indicated by six participants with responses such as “encourage no-till farming.” The land use practices identified for other landscapes included *zoning plans* for built environments, *invasive species control* for forest landscapes and *riparian buffers* for lakes and rivers.

While landscapes in the Kaskaskia River Watershed faced many of the same threats, the land use practices that could be applied to combat these threats differed across the four landscapes. For example, *cover crops*, *reduced tillage*, and *crop rotations* were unique to agricultural landscapes and also effective practices for reducing threats. Land use practices unique to forest landscapes focused on *removing invasive*

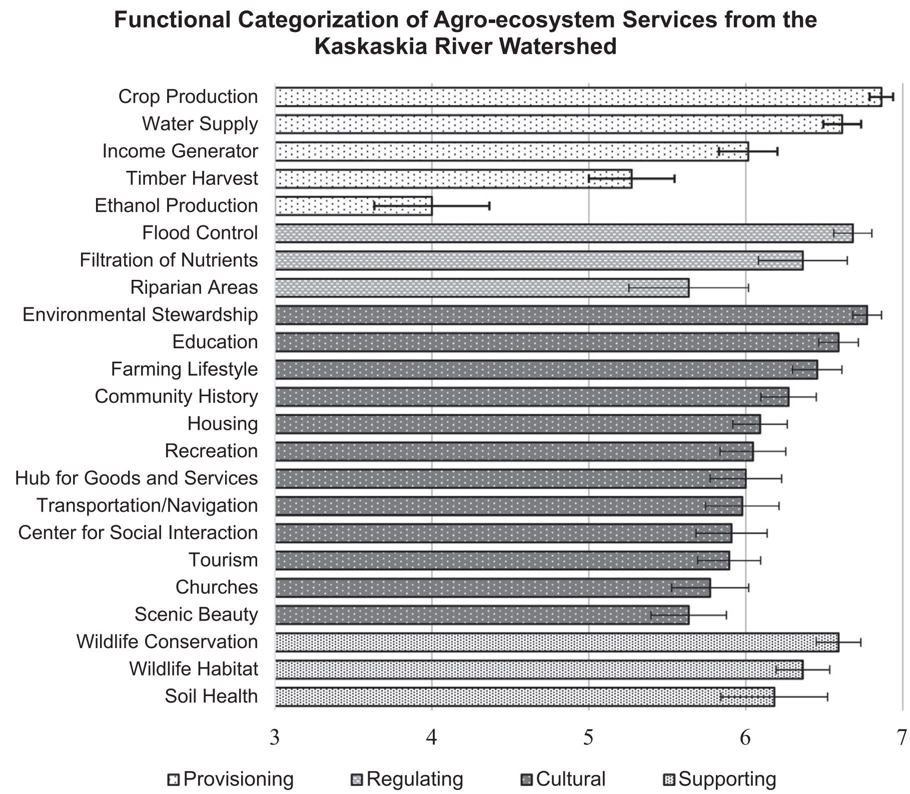

Fig. 4. Mean values and standard errors of the perceived importance of agro-ecosystem services categorized by function across the provisioning, regulating, supporting, and cultural services identified in the MEA (2005). All services were evaluated on a seven-point Likert scale ranging from 1 "Extremely Unimportant" to 7 "Extremely Important." (n = 24).

species and *timber stand improvements* (Fig. 6). Most practices for the built environment involved improving rather than implementing practices, such as developing *zoning plans*, *improving infrastructure*, and *increasing penalties for negative practices*. Connectivity between land-use practices was important, given that participants evaluated effective strategies for reducing threats to lakes and rivers that involved changing agricultural practices through *filter strips/grass waterways* and *riparian buffers*. Enacting *best management practices for nutrient application* and improving *education on conservation planning* were also key threats identified for lakes and rivers.

Prioritizing management actions to enhance human well-being requires an understanding of the relationships between land use practices and threats from the perspective of local experts in the Kaskaskia River Watershed. We categorized land use practices into non-structural practices, structural practices, and monitoring and regulation (Fig. 7). We also synthesized results that emerged from our assessment of threats by organizing these issues into the categories of lack of conservation, pollution, and socio-economic pressure. We observed that many non-structural practices including *reduced tillage*, *cover crops*, and *sustainable harvesting* can be implemented in agricultural and forest landscapes to reduce conservation and pollution threats, including *lack of biodiversity*, *erosion*, and *increased flooding*. There were few non-structural practices identified that could be implemented in built environments or lakes and rivers. These findings suggest that more intensive structural or regulating practices including the creation of *retention ponds*, *riparian buffers*, and *conservation programs* are needed to reduce threats such as the *loss of wildlife habitat*.

4.5. Focus group evaluation of agro-ecosystem services

Focus group discussions provided an opportunity for participants to learn about the study findings and provide feedback on how our team was interpreting the results generated during the Delphi survey process. Our prompts directed discussion away from personal or individual-level benefits to focus on watershed and public interests. A rich dialogue among participants ensued and provided insight on how to identify, remove, and re-order our classification of agro-ecosystem services that emerged from the expert-based surveys. For example, one participant emphasized the importance of adding *international bird habitat* to our list of key services: "*I say all the time that it is the largest contiguous bottomland hardwood forest in Illinois and it has all the strengths of habitat for birds*" [Participant 9]. Another participant disagreed and suggested "*wildlife conservation could encapsulate international bird habitat*" [Participant 11]. In one of the small group discussions, a participant indicated that carbon sequestration was an agro-ecosystem service that we had overlooked in our interpretation of the Delphi findings, mentioning that "*one [service] that we thought was missing potentially, carbon sequestration, as a benefit*" [Participant 6]. Other participants underscored the importance of distinguishing between tourism and recreation when considering income generation "*we debated whether or not to separate or to group those together…tourism we said has financial implications…income generation can be from tourism, but it can also be from other things*" [Participant 11].

Results indicated that engaging participants in discussions provided new insight for interpreting findings from the Delphi surveys. For agricultural landscapes, most participants indicated that *ethanol production* should be removed as a service from agricultural landscapes because it overlapped with crop production, as articulated by Participant 8: "*they are different uses I guess technically, but, I mean, you don't get ethanol unless you have crop production.*" Participants were also concerned that some services were not derived from agriculture but were merely associated with the landscape. One participant noted, "*I don't really think soil health would be a benefit of an agricultural landscape,*" "*I wouldn't really consider wildlife conservation an agricultural thing,*" and "*I don't know how much recreation you are doing in the middle of your corn field*" [Participant 7]. In a similar fashion, another participant was bewildered that scenic beauty was a benefit of agricultural landscapes, indicating "*If you think, you know, monoculture crop fields are pretty? Okay*" [Participant 8]. Participants had differing opinions about timber harvesting being an ecosystem service of forest landscapes, as

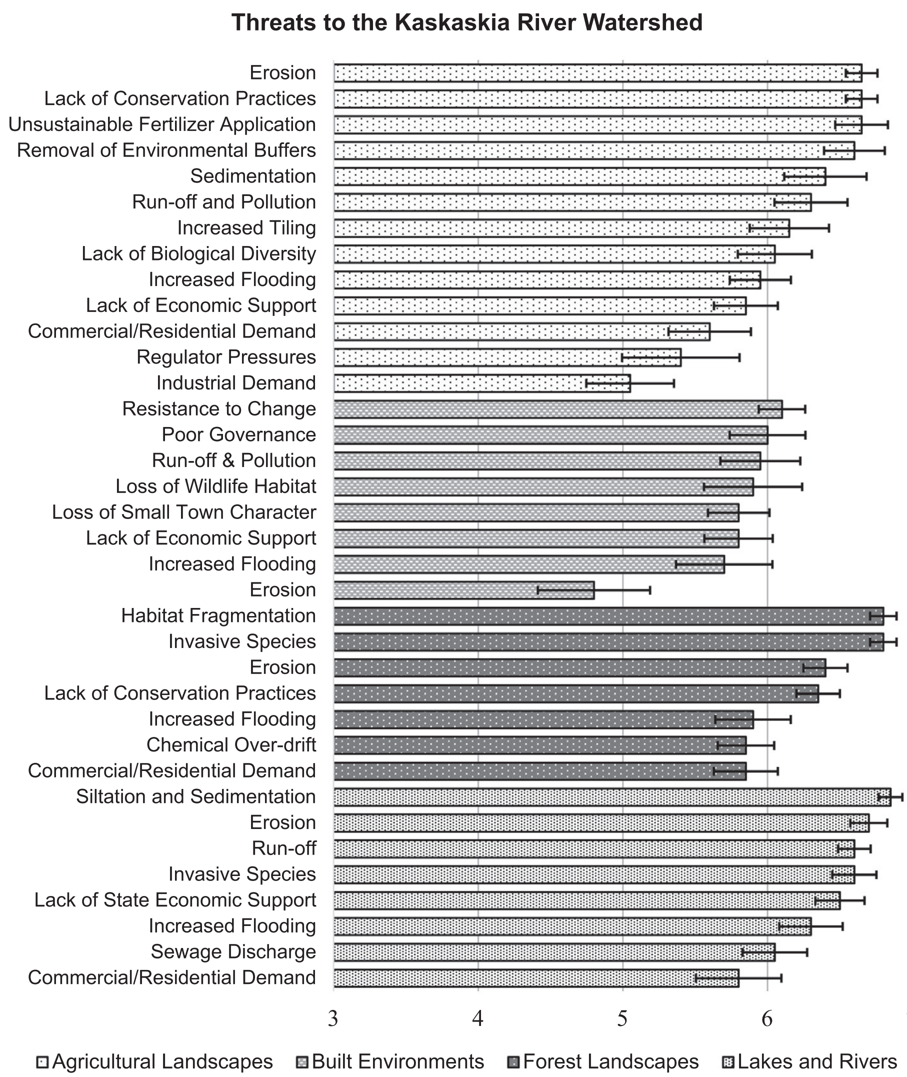

Fig. 5. Mean values and standard errors of the perceived significance posed by threats across four landscape types in the Kaskaskia River Watershed. All threats were evaluated on a seven-point Likert scale ranging from 1 “Extremely Insignificant” to 7 “Extremely Significant.” (n = 22).

evidenced by Participant 10 “*maybe timber harvest could fall under income generator,*” while Participant 9 suggested that the “*difference between timber harvesting and income generating, lease your property for hunting rights or clubs having membership fees. Where timber harvesting would be taking timber off your property.*”

Participants suggested that some agro-ecosystem services varied in importance across the watershed and emphasized the place-based qualities of specific areas. Water supply was one agro-ecosystem service that participants believed should have been rated as more important given that their town depended on reservoirs, expressing that “*I thought since this is my water, I thought water supply would have been higher for whatever reason*” [Participant 3]. Another agro-ecosystem service that participants thought was undervalued was *navigation*, because the lower section of the Kaskaskia River was channelized, and transportation of materials was such a strong economic driver of the region. Others were attuned to geographic differences in the importance of navigation for the Kaskaskia River. For example, Participant 3 “*I would rate it higher down there*” [Participant 3], while Participant 4 observed “*we don’t really have that up here at the lake, so it’s not that important. However, we know that it’s important to the whole river system*”.

4.6. Developing a typology of agro-ecosystem services in the Kaskaskia River Watershed

A typology of agro-ecosystem services for the Kaskaskia River Watershed was created to synthesize results from the Delphi study and subsequent focus group (Fig. 8). Our original conceptualization of provisioning services included *crop production, ethanol production*, *timber harvesting*, and *income generator* as separate services. However, participant’s narratives blended the later categories, so we developed two services labeled *crop production* and *income from non-agricultural products.* Participants also indicated that *transportation via navigation* varied in importance across the watershed and was not sufficiently different than *transportation infrastructure*, therefore, both services were combined into a new service of *transportation*. Focus group participants agreed with all regulating and supporting services identified in the Delphi study but added *carbon sequestration* and suggested *riparian areas* be re-labeled to *erosion protection/regulation*. *Housing* was removed because it was considered synonymous with the built environment. To account for the economic impact of *housing* on the region, the *goods and services* category was changed to *commerce*.

Several other nuances in our interpretation of the study findings emerged from focus group discussions. *Environmental stewardship,*

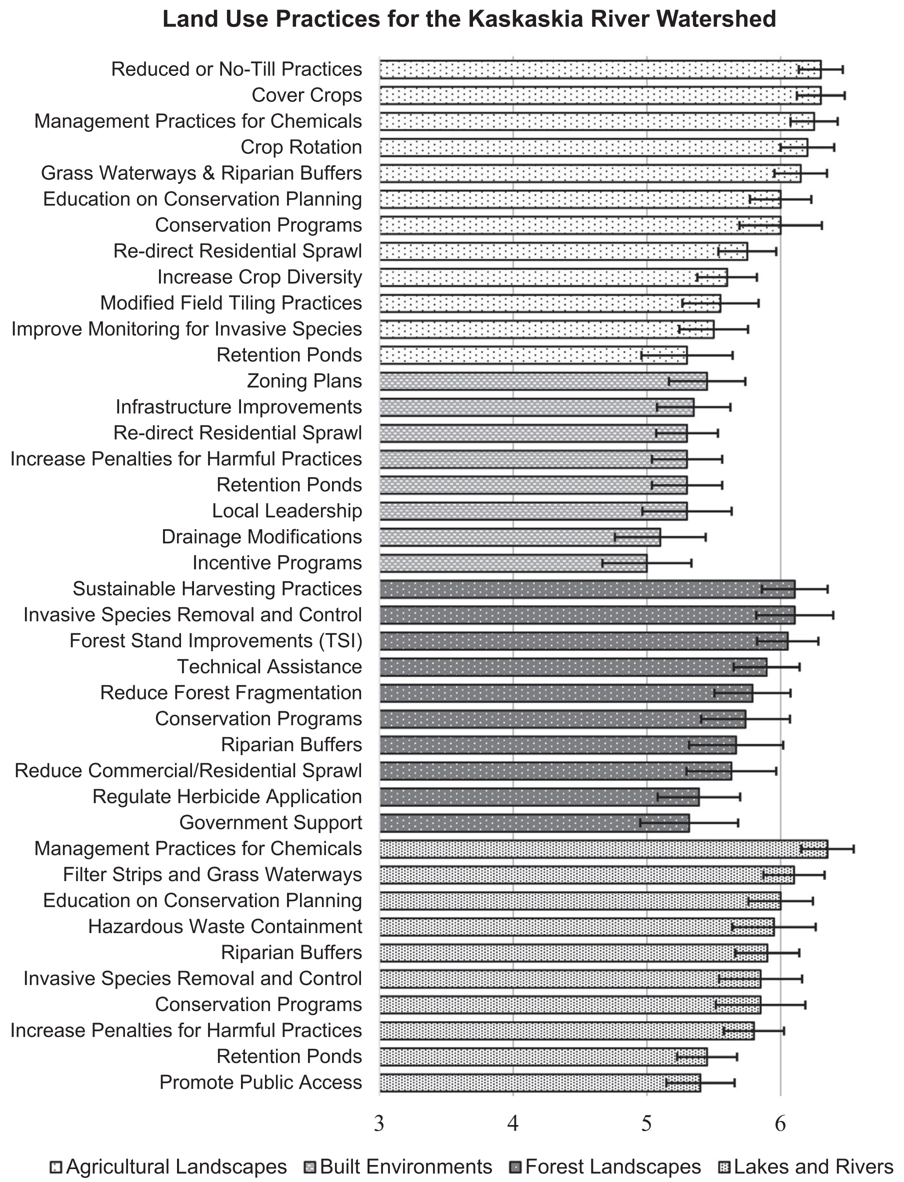

Fig. 6. Mean values and standard errors for the perceived effectiveness of land use practices across four landscape types in the Kaskaskia River Watershed. All practices were evaluated on a seven-point Likert scale ranging from 1 “Extremely Ineffective” to 7 “Extremely Effective.” (n = 20).

community history, and *farming lifestyle* were rated as important services, yet each represented a collection of values and overlapping heritage narratives. Therefore, these services were collapsed into *farming lifestyle and heritage*, in line with research indicating the importance of passing down traditions and ways of life in rural contexts (Strauser et al., 2019). To promote further compatibility between our agro-ecosystem service typology and previous research, we re-labeled *churches* into *religious values* and changed *social interaction* into *social relations* (de Groot et al., 2002). Also, *water quality/regulation* was added given the prominence of water resources in the region and the common occurrence of this service in ecosystem service typologies.

5. Discussion

5.1. Agro-ecosystem services in the Kaskaskia River Watershed

Through a deliberative process, local expert stakeholders provided insight into the perceived importance of a variety of agro-ecosystem services, threats, and land use practices within the Kaskaskia River Watershed. In line with previous research (Power 2010; Zhang et al., 2007), the provisioning services of agricultural landscapes were highly rated by participants. Specifically, *crop production* was an important agro-ecosystem service across all landscape types, which complements previous research showing food production is the primary function of these environments (Swinton et al., 2007) and reinforces the finding that much of the arable land in the watershed (over 70 percent) is harvested. Our study involved participation of local stakeholders and therefore enabled us to identify agro-ecosystem services that reflected a diversity of benefits articulated by stakeholders (Swinton et al., 2007; Tengberg et al., 2012). In line with previous research (de Groot et al., 2002; Raymond et al., 2009), we developed a typology that nuanced the interpretation of landscape conditions to give justice to the particularities of place and valuation of complex social goods (Grainger and Stoeckl, 2019) within an agricultural watershed. That is, some services in our typology were universal (e.g., *recreation*, *water supply*; Palomo et al., 2013) whereas others (e.g., *transportation via waterways*) were specific to the Kaskaskia. These findings underscored the importance of engaging individuals and groups throughout the research process to align results with public interests (Kenter et al., 2016) and discover the full range of services that emerge from competing narratives about the

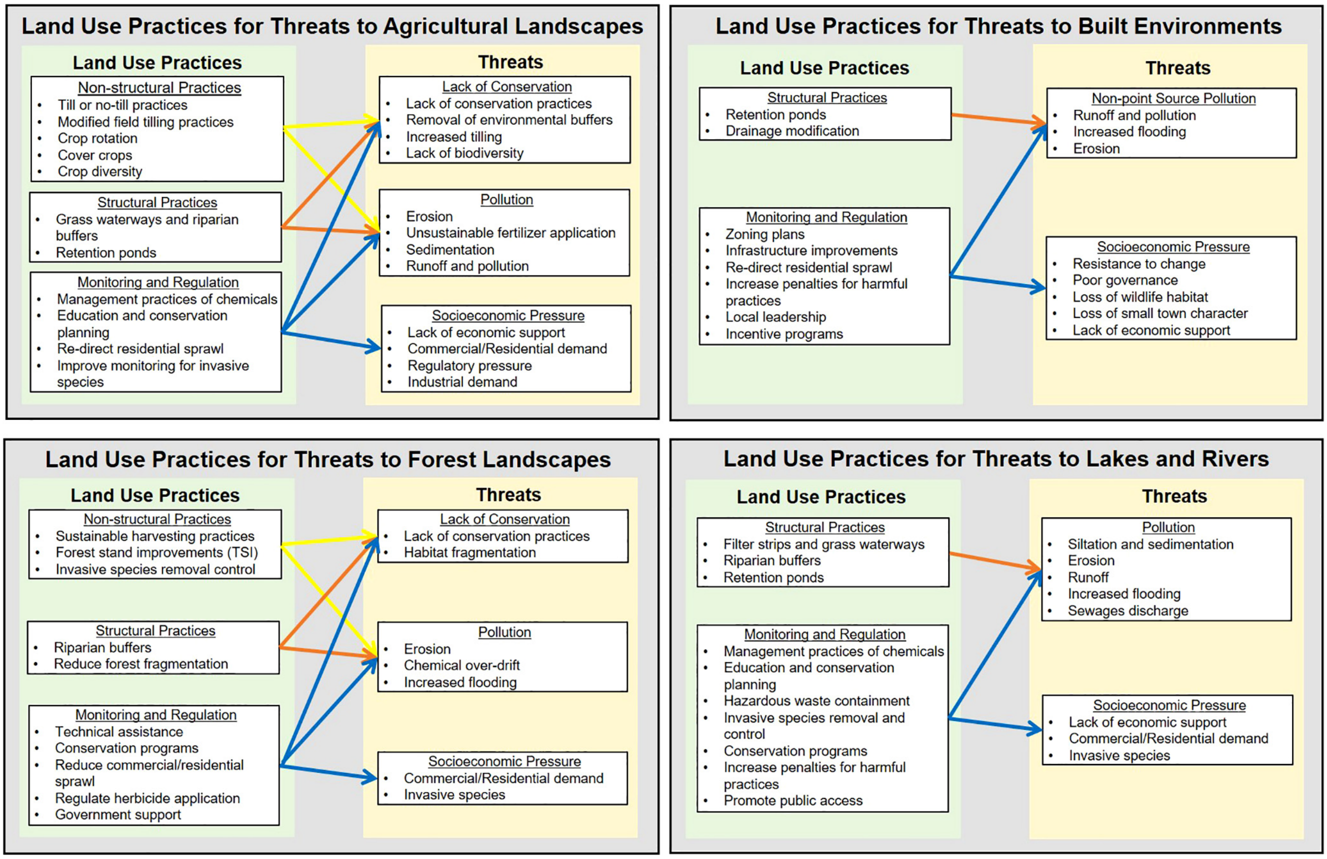

Fig. 7. Relationships between land use practices and threats across the Kaskaskia River Watershed.

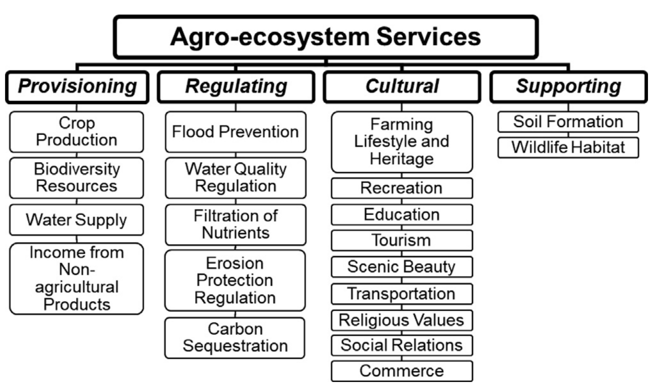

Fig. 8. Typology of agro-ecosystem services for the Kaskaskia River Watershed developed from Delphi survey results and focus group discussions.

values of worked landscapes (Prokopy, 2011).

We drew on the MEA (2005) as a guiding framework to distinguish among provisioning, regulating, supporting, and cultural services that were expressed by study participants. We observed that cultural services (e.g., *recreation*, *farming lifestyle*) were more abundant but equally important as provisioning services (e.g., *crop production*). Other cultural services specific to the Kaskaskia River Watershed such as *heritage* and *identity* served as indicators of well-being (Tengberg et al., 2012). These findings highlight that while cultural services have historically been limited in their representation and prioritization (Chan et al., 2012; Daniel et al., 2012; Milcu et al., 2013; Satz et al., 2013), they warrant attention due to their salience and potential for harboring points of social discord if not discussed (Maczka et al., 2019). By accounting for the relative importance of cultural services alongside other agro-ecosystem services, a pluralistic approach to value articulation is more likely to be considered in research involving human-environment interactions (van Riper et al., 2017).

5.2. Threats to agro-ecosystem services and solutions for the Kaskaskia River Watershed

Through the Delphi process we inductively identified multiple threats to the provision of agro-ecosystem services in the Kaskaskia River Watershed and a series of land use practices adopted to mitigate threats. One key finding was that while agricultural landscapes were valued for production, stakeholders indicated agricultural intensification was problematic and the cause of threats to an array of landscape features. Although agricultural intensification enhances the provision of *crop production* (Power, 2010), it can also result in significant environmental impacts such as reductions in water and soil quality (Berka et al., 2001; Matson et al., 1997). In our study, environmental threats such as *erosion* and *run-off* were believed to pose harm to agricultural, built, forest, and lake and river landscapes, underscoring the importance of considering connectivity when making land use decisions (Pringle, 2003). The degree to which agro-ecosystem services work in conjunction with threats and land use practices is crucially important in areas like the Kaskaskia where there are many small habitat patches (Tischendorf and Fahrig, 2000). Given that 97.5 percent of the watershed is private land (Illinois Department of Natural Resources), the decisions made by landowners have substantive impacts on spatial connections within the watershed and the extent to which organisms can move across the landscape.

It is important to recognize that land use practices can be adopted to mitigate and adapt to threats, identify synergies between services such as *crop production* and *recreation*, and raise visibility of land use practices across landscape types (Hobbs, 2007). For example, two practices that residents deemed beneficial were *cover crops* and *reduced tillage* *practices*, because they enhanced soil health, which reduces the impacts of *erosion* (Matson et al., 1997), *run-off* and *siltation/sedimentation* (Berka et al., 2001). Local knowledge can elucidate the relationships among these interconnected practices and therefore identify drivers of change that influence multiple services simultaneously (Bennett et al., 2009). This study brought together diverse forms of knowledge to better understand these relationships and improve service provision by strategically engaging participants that represented different sectors and socio-demographic profiles. Consequently, our research approach created a foundation for future research to explicitly consider the negotiations between different interest groups and establish a more robust governance regime for acting on these negotiations in a just and equitable manner (Brondizio et al., 2009).

5.3. Enhancing ecosystem services through deliberative valuation

We engaged stakeholders in an iterative Delphi process over the course of four surveys to produce a refined list of agro-ecosystem services, threats, and land use practices for the Kaskaskia River Watershed, while promoting opportunities for stakeholders to deliberate and nuance the interpretation of study findings. Integrating local community opinions into various phases of the research process enabled us to co-create and validate findings through facilitated public participation (Reed, 2008) while working toward consensus on the relative evaluations of services, threats and land use practices (Christie et al., 2012; Curtis, 2004; Mukherjee et al., 2015). Building on previous research, we included multiple rounds of surveys that facilitated the sharing of knowledge (Grainger and Stoeckl, 2019) and the inclusion of potentially divergent opinions through an open exchange of ideas during our focus group (Mukherjee et al., 2015; Spash, 2007). Moreover, our inductive approach was sensitive to community-driven desires that extending beyond simple individual interests (Stoeckl et al., 2018) that otherwise may not have been represented in policy outcomes (Chan et al., 2012).

Incorporating a focus group into our iterative Delphi survey provided numerous benefits. We came to better understand why different agro-ecosystem services were valued through an open exchange with study participants and had an additional point of contact to disseminate our results and discuss possibilities for adopting best management practices. This process also facilitated social learning and raised awareness of concerns shared across diverse stakeholder groups (Grainger and Stoeckl, 2019; Eriksson et al., 2019). The multiple methods adopted in this study generated a deep understanding of the meanings behind our deliberative valuation and enabled us to more confidently represent diverse interests while aggregating results into an agro-ecosystem service typology (Howarth and Wilson, 2006). Our study therefore underlines the importance of remaining sensitive to different worldviews in research and practice (van Riper et al., 2019), and recognizing diverse landscape types that can be found across worked landscapes in the Midwest (Leahy and Anderson, 2010; Strauser et al., 2019).

6. Conclusion

Our research raises visibility of the range of ecosystem goods and services that can be derived from agricultural landscapes. We contend that watersheds such as the Kaskaskia are important for a diversity of reasons that are reflected in provisioning, regulating, supporting, and cultural ecosystem services. Cultural ecosystem services, in particular, are discussed by participants in ways that are distinctive from other ecosystem services and warrant special attention given trends in previous research and practice to sideline the intangible qualities of places. Farming lifestyles, heritage, environmental stewardship, and community history are key services from worked landscapes that are important yet potentially contested. Forming a diverse knowledge alliance of experts in an agricultural watershed and engaging these individuals in deliberative valuation carries potential to enrich the quality of findings and deepen understanding of how to broaden representation in policy outcomes. Moreover, these groups can direct attention to the scale of the watershed rather than personal or family-based benefits to inform regional decision-making (Hansjurgens et al., 2017; Fu et al., 2011; Grainger and Stoeckl, 2019).

Threats facing agricultural, built, forest, and lake and river landscapes within the Kaskaskia River Watershed are complex and interconnected with the perceived benefits of places. We suggest the land use practices inductively identified through our Delphi study, especially those that mitigate agricultural intensification, are critically important to implement given their potential to influence ecosystems at a regional scale. Tradeoffs inevitably exist among competing ecosystem services, so the goals articulated by stakeholder groups need to be carefully weighed and negotiated, particularly in the context of multifunctional landscapes. Typologies such as the one developed in this study can be useful tools for managers to prioritize their actions and protect key ecosystem services. Through our mixed methods research approach that included a survey and deliberative focus group, we generated a valuable dataset and demonstrated how future studies can bring rural stakeholders together in discussions about how to preserve the desired character and benefits of places.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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