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Research article

Lessons learned from using a decision-support tool for precision placement of conservation practices in six agricultural watersheds in the US midwest

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ABSTRACT

While conservation of natural resources on agricultural landscapes has been a priority for public agencies for more than 80 years, the ability of conservation planners to place conservation practices for enhanced environmental benefits remains elusive. To increase both adoption of conservation practices and efficient use of conservation funding, conservation planners are turning to decision support tools (DSTs), such as the Agricultural Conservation Planning Framework (ACPF). However, less is known about how DSTs facilitate a whole-landscape approach to conservation planning, and the strategies that are employed by conservation planners to engage with producers using new GIS-enabled planning technologies. With the goal of contributing to both the policy and practice of precision conservation, we present findings from semi-structured in-depth interviews conducted with 21 conservation professionals in six watersheds in the US Midwest. Results suggest that the ACPF encourages conservation professionals to think at a watershed scale, supports their approach to conservation planning, and helps them in watershed planning and stakeholder engagement. Results also highlight the importance of conservation professionals employing a suite of strategies, such as being mindful of the scale of producer engagement (i.e., single farm vs community based) and accounting for producers' personalities, to create 'enabling conditions' for producer engagement when adopting a precision approach to conservation. Policy recommendations for precision conservation technologies include the need to streamline and expedite the process of conservation delivery, and that DSTs are a means to an end, but not a universal remedy, because conservation planning is most effective when localized interactions of rural landscapes and social dynamics are considered in an adaptive approach.

1. Introduction and rationale

Agricultural landscapes have disproportionate environmental impacts, i.e., certain sections of the landscape disproportionately cause a large amount of environmental degradation (Nowak et al., 2006). This disproportionality necessitates identification of areas of the watershed, commonly known as critical source areas (CSAs) to enable conservation practices to be placed in locations where they will have the biggest impact (Jordan et al., 2015). This precision-placement of conservation practices can be aided by the use of spatial technologies (Arbuckle, 2013; Berry et al., 2005; Kalcic et al., 2014; Nowak et al., 2006). Whereas farmers support precision-placement of conservation practices or conservation targeting (Arbuckle, 2013; Kalcic et al., 2014; Kalcic et al., 2015), the predominant agricultural conservation policy in the United States is the "conservation policy of aggregation" (Nowak, 2009, 174A).

The policy of aggregation relies on the assumption that conservation programs, by incentivizing voluntary adoption of conservation practices by farmers, will induce enough adoption of conservation practices across the landscape to achieve an overall state of conservation (Nowak, 2009). However, agriculture driven environmental externalities such as water-quality problems are widespread and different lands contribute disproportionately towards these issues. The "conservation policy of aggregation," combined with the practicalities of resource availability, or lack thereof, with the local conservation office, promotes what is commonly known as "random acts of conservation" (Knight, 2005, 137A). As a result, conservation practices are implemented, using limited conservation funds, in locations where they may not produce the highest potential for conservation improvement. Moreover, CSAs within a watershed may not have any conservation

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practices, despite extensive and long-term conservation program participation by many farmers (Tomer et al., 2008).

In order to bridge the gap between farm scale conservation implementation and watershed scale water quality impact, and subsequently increase the effectiveness of conservation programs, scholars have identified the need for decision support tools (DSTs) that can facilitate conservation planning in a watershed context (Tomer et al., 2015a). New DSTs are emerging which can help conservation planners prioritize placement of conservation practices to CSAs, maximizing conservation benefits (McLellan et al., 2018). For example, The Nature Conservancy, a leading environmental non-governmental organization, is collaborating with numerous partners in the Saginaw Bay watershed in Michigan to achieve "Strategic Agricultural Conservation," an approach that seeks to "get the right conservation practices to the right places in the right amount, as efficiently as possible, to reach shared desired outcomes" (Fales et al. 2016). This collaboration resulted in the development of a DST, called the Great Lakes Watershed Management System (GLWMS), to facilitate conservation targeting. Similarly, the Conservation Effects Assessment Project (CEAP), a 2003 joint initiative of the USDA-NRCS and USDA-ARS, in collaboration with several other partners, stimulated the development of several DSTs that facilitate precision conservation (Duriancik et al., 2008).

Whereas scholarship on the development and design of DSTs has grown rapidly, less is known about how DSTs facilitate a strategic approach to conservation planning, and the approaches employed by conservation planners to engage with producers and encourage them to voluntarily implement new conservation practices. With the goal of filling these knowledge gaps, we present findings from interviews conducted with conservation professionals, including planners, coordinators, and technicians, who used one such DST – the Agricultural Conservation Planning Framework (ACPF). The overarching questions of this study are: (1) Whether and how does the ACPF support a precision approach to conservation planning? (2) How do conservation planners engage with producers when using decision support tools that facilitate precision conservation? By addressing these knowledge gaps, our goal is to contribute to both the policy and practice of utilizing new precision technologies in conservation planning.

2. A primer on precision conservation

The concept of a precise and well-targeted approach to conservation is not new. Recommendations for prioritizing conservation program assistance "to achieve the highest net program benefits" trace back to the early 1980s (Ervin and Ervin, 1982, 290). Targeting was identified as a shift from a passive to active approach towards conservation, which was consistent with The Soil and Water Resources Conservation Act of 1977, that called for improved targeting of conservation program to critical areas (Batie, 1985). In 1981, with the launch of a national program to prioritize conservation efforts in critical areas, "targeting emerged as a central thrust in the national conservation program" (Nielson, 1986, 70). An evaluation of the conservation targeting program led to several recommendations for improving conservation programs, including 1) encourage counties to zero in on problem farms; 2) improve on-farm planning and advising of farmers and; 3) continue and expand the role of targeting (Nielson, 1986, 76).

Conservation programs are often directed towards lands that will have the highest environmental benefits at the least cost. For example, the Conservation Reserve Enhancement Program (CREP) targets high-priority conservation concerns identified by a state (Yang et al., 2005). Targeting is also an important principle and criteria for evaluating the effectiveness of conservation programs (Kerr et al., 2016). Specifically, the evaluation criteria includes cost-effectiveness, i.e. the environmental gains versus the incurred costs, and additionality, i.e. the extent to which the program yields conservation outcomes beyond what would have occurred without the program (Kerr et al., 2016).

Benefits of precision conservation include, but are not limited to, prioritizing conservation in the CSAs, enhancing the efficiency and effectiveness of conservation efforts, and siting conservation practices to locations with the highest potential for improvement (Kalcic et al., 2014). Despite the benefits of a precision approach to conservation, as documented by Arbuckle (2013), there are several likely institutional and political barriers to implementing such an approach. For example, in order to avoid acting or appearing to act in a regulatory manner, conservation agencies may be unwilling to break away from current conservation policy and programs that often rely upon farmers' voluntary conservation initiatives. In fact, political contentiousness of a precision approach to conservation, as Kalcic et al. (2014) argue, has contributed to the prioritization of watersheds, rather than farms, for conservation efforts. Other barriers to precision conservation include lack of financial and technical resources and the complexity of a process requiring DSTs. In addition to the perceived and real barriers to precision conservation, its effectiveness is also undermined by the difficulty to document the connection between on-field conservation efforts and the resulting watershed scale environmental outcomes (Kalcic et al., 2014; Tomer and Locke, 2011).

Conceptual advancements on the topic of precision conservation include understanding the role of adaptive management as a theoretical structure to improve prioritization of conservation programs (Sims et al., 2014), and actively engaging producers and landowners in the planning process (Kalcic et al. 2015). Another crucial advancement, owing to the widespread availability of LiDAR-based elevation data, is the small watershed approach (Konopacky and Ristino, 2017). Under this approach, instead of analyzing each farm separately and comparing conservation risks, the hydrology of the watershed can be analyzed as a whole to identify and prioritize hydrologic flow paths and CSAs. Precision conservation is also considered a potential, and much needed, paradigm shift in conservation planning that is a departure from the dominant paradigm of the conservation policy of aggregation (Arbuckle, 2013). Calls for a paradigmatic shift in conservation planning by adopting a precision approach to conservation are widespread. A critical barrier to adopting such an approach is that it requires DSTs that are often difficult to use (Fales et al. 2016). To that end, this study provides a timely synthesis of conservation professionals' experiences of using one such DST – the ACPF.

3. The decision support tool – Agricultural Conservation Planning Framework (ACPF)

The ACPF is a decision support tool that is comprised of a planning concept, a database to facilitate field-level and watershed-scale analyses, and an ArcGIS toolbox with Python scripts to semi-automate the identification of field-specific opportunities for placement of conservation practices. The ACPF toolbox is designed for use at the Hydrologic Unit Code 12 (HUC 12) sub-watershed scale (typically 15,000–40,000 acres; or 6070–16,187 ha), combining high-resolution LiDAR-based elevation data, soils data, and land use data (Porter et al., 2015; Tomer et al., 2015b,c, 2015, 2013).

The ACPF tools facilitate a) hydro-conditioning of high-resolution topographic data, b) terrain analysis to identify fields and CSAs which may contribute disproportionate amounts of nutrients, sediment, or runoff water to a water body, c) identification of sites that meet criteria to site specific conservation practices such as grassed waterways, filter strips, terraces, controlled drainage, wetlands, detention basins, and buffers, and d) defining opportunities for riparian management. The ACPF tools help identify opportunities to place practices along flow pathways in order detain water and enable processes of settling, adsorption, and biological uptake/conversion to reduce nutrient and sediment loads. Results from the ACPF provide a menu of conservation planning options, which can be ranked in different ways to highlight high-priority sites. It is not considered a prioritization tool because it does not incorporate social and economic factors, and it does not directly estimate pollution reduction impacts, although the ACPF

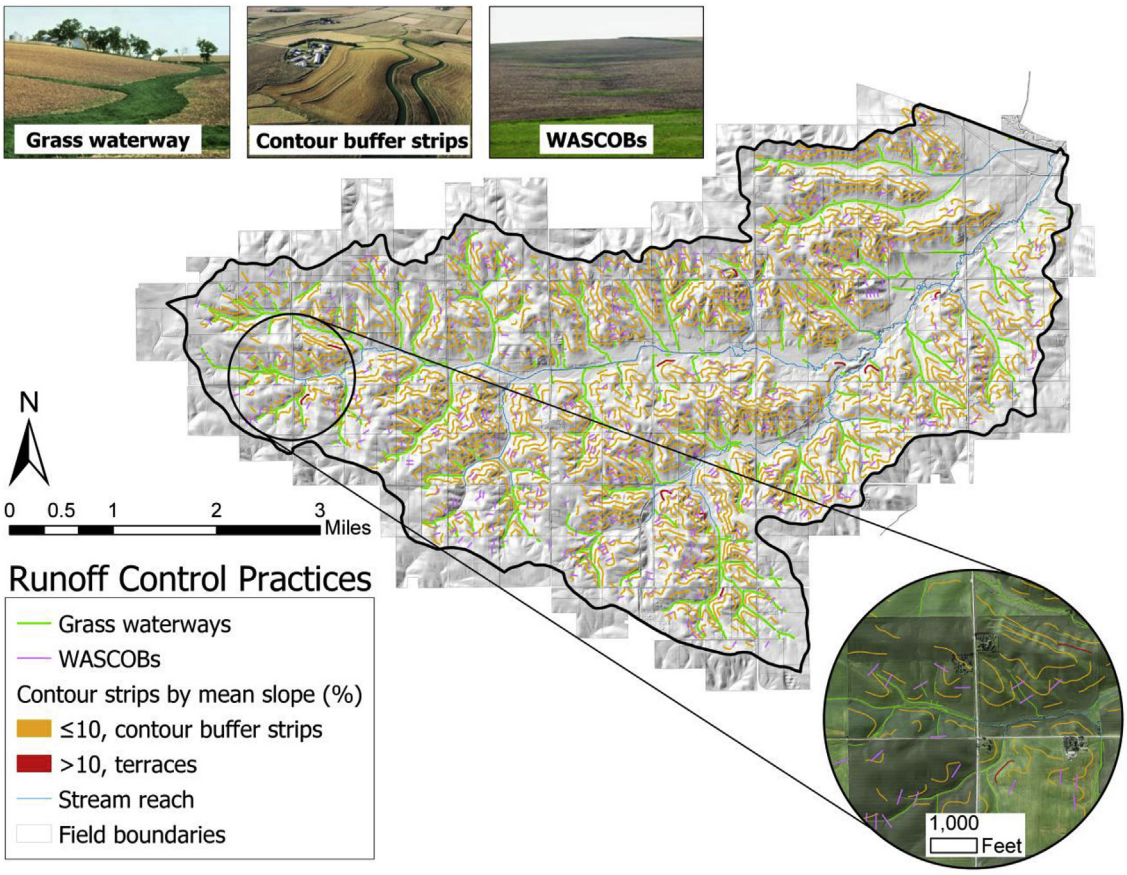

Fig. 1. An example watershed map, generated with the Agricultural Conservation Planning Framework (ACPF), showing precision placement options for three conservation practices used to control runoff and erosion. Grassed waterways and water and sediment control basins (WASCOBs) are designed to control gully formation where runoff concentrates, while contour strips/terraces intercept sheet and rill runoff along slopes where runoff is generated. Inset circle shows one option for depicting high resolution results at a scale that could be used for farm planning. Inset photos provide examples of the installed practices (credit: USDA/NRCS). Note: Visual example only, does not depict a watershed used in this study.

developers have described a method for estimating the likelihood that a given distribution of practices (planning scenario) could be used to meet nutrient reduction goals (Tomer et al., 2015a).

The maps resulting from ACPF analyses provide non-prescriptive information by identifying high risk areas and showing specific opportunities for conservation practices. This information can empower producers and other stakeholders to engage in developing effective solutions to locally defined conservation issues (see Fig. 1).

4. Methods

The data for this study come from semi-structured in-depth interviews with conservation professionals in six watersheds in the US Midwest. Potential watersheds for selection in this study were identified using the ACPF website of the North Central Region Water Network (https://acpf4watersheds.org). The website contains a map showing the watersheds where ACPF analyses has been conducted, along with the contact information of the person involved with running the toolbox. Our criteria for selecting watersheds for this study was whether the watershed was using or planning to use the ACPF as part of engagement with producers. To develop a list of watersheds that met our criteria we contacted potential study subjects in all watersheds via email and phone calls and asked them if and how the ACPF was rolled out in their watershed and have they used ACPF output maps to encourage producer engagement.

We received responses from conservation professionals from 11 watersheds, which were then evaluated based on our watershed selection criteria of conservation professionals using or planning to use the ACPF for engagement with producers. Six watersheds, three each in Iowa and Minnesota, fit our criteria and were selected for this study (see Fig. 2).

Semi-structured interviews were conducted with 21 conservation professionals across the six watersheds between October 2016 and June 2017. All interviews were conducted individually in person, except one which was done by phone, and another in which two co-workers were interviewed together. At the time of conducting the interviews, producer engagement was ongoing in three watersheds, it was planned in the future in two watersheds, and limited producer engagement was being conducted in one watershed. Interviewees were recruited based upon their knowledge of the ACPF toolbox and/or their experience of using its results to engage with producers in their respective watersheds. Across the six watersheds, interviewees represented a diversity of experiences with the ACPF, ranging from running the toolbox, using the results to engage with producers, or both. Interviewee designations and roles include, but are not limited to, GIS Conservationist, District Technician, District Conservationist, and Watershed Coordinator.

Snowball sampling was used with the initial interviewees to identify other conservation professionals who had used the ACPF in a given watershed (Patton, 1990). For example, initial conservation professionals were asked to identify others as potential interviewees so that we obtained a diversity of people in terms of their experience with the ACPF. Subsequently, all the ACPF users in a given watershed were interviewed. Interviews in a given watershed were conducted until no additional interviewees were identified. Interviews ranged from 40 min to 2 h, using a series of 24 questions structured around five core thematic areas: conservation professionals' approach to conservation

Fig. 2. Study watersheds in Iowa and Minnesota.

planning; experiences with running the ACPF; producer engagement using the ACPF; GIS/geospatial analysis experience; and perceptions of ACPF's usefulness (see Appendix 1). All interviews were recorded and transcribed.

Qualitative data analysis was conducted using NVivo 11. Coding was done following a grounded theory approach, which involved reading the interview transcripts and iteratively adding codes, categories and subcategories throughout the coding process (Charmaz, 2006). Once the final coding framework was established and agreed upon, an inter-coder reliability test was undertaken on a subset of four interviews, and achieved a Cohen's kappa of 0.73, indicating adequate consistency between the two researchers who coded the four interviews (Viera and Garrett, 2005). For any emerging theme to be included in the results section as a finding, at least two or more interviewees, from at least two or more watersheds, had to independently identify it.

5. Results

We first present evidence in support of whether and how does the ACPF support a precision approach to conservation planning. Second, we describe nine producer engagement strategies employed by conservation professionals to engage with producers when using the ACPF. In this section, we make a conceptual distinction between strategies that helped create 'enabling conditions' for producer engagement, and strategies that were subsequently used to directly engage with producers. In the last section, we make several recommendations for precision conservation, especially discussing them in light of agricultural conservation policy.

5.1. ACPF and a precision approach to conservation planning

The ACPF was identified by conservation professionals as a toolbox that could be run at the front-end of the conservation planning process and thus enable conservation planning to be effective and productive. Expressing this theme, a conservation professional from Minnesota mentioned, "*There's only so much money available to help get conservation on the ground and work with these landowners, and you want to make sure you're maximizing your effort … taking tools like ACPF and some of the other ones that are available, and running those on the front end to try to focus down right away and make sure we're being effective and productive …*" ACPF also supported precision conservation by showing locations of conservation opportunities on a map, and by saving time and resources, a theme often expressed by interviewees as, "*not having to wander around the watershed*", and "*taking the guesswork out of having to talk to a producer*". Highlighting several of the aforementioned themes, an interviewee from Iowa mentioned, "[ACPF result] *rapidly streamlines the process of identifying where a practice can be done, so it takes all the guesswork out of having to talk with someone, hope that they have some sort of interest in doing a practice, and then hope that it's even feasible to do it there … so it drastically reduces the amount of wasted time.*"

Conservation professionals also valued that the scale at which the ACPF toolbox is run (HUC 12) fits the scale of conservation planning needs. While statewide entities often pursue large-scale watershed goals, at HUC 8 (average size of 375,590 ha) & HUC 10 (average size of 42,600 ha) scale, having a toolbox that is run at a smaller scale enabled identification of fields where local conservation professionals could prioritize their conservation efforts. Highlighting this theme, an interviewee from Minnesota mentioned, "*… when we get asked to look at something at this scale* [HUC 12]*, I think really it's* [ACPF] *a starting point that you would want to start with.*" With ample evidence highlighting that the ACPF supports a precision approach to conservation planning, we now turn our attention to the research question, 'how does the ACPF support a precision approach to conservation planning'?

5.1.1. By encouraging watershed thinking among conservation professionals

The ACPF encouraged watershed thinking among conservation professionals in several ways, including, but not limited to, by encouraging them to do area-wide planning, and by providing them the perspective of situating a field in the context of its impact on water quality in the watershed. Expressing this theme, an interviewee from Iowa mentioned, "*This* [ACPF]*, to me, gives you an opportunity to do area-wide planning. Look at the big picture. Don't just look at where you're at. Look at the big picture. This reminds us to look at the big picture.*" A salient precursor to watershed thinking is to have an awareness of the watershed itself, which was also encouraged by the ACPF. For example, as expressed by an interviewee, "*… because it* [ACPF] *produces results that are for the full watershed … I think it does help you get to know your watershed.*" In other instances, conservation professionals reflected upon their own training to think from a watershed perspective. Since the ACPF is also designed from a watershed perspective, as an interviewee mentioned, "*… that's why I think it's a good fit for us.*"

5.1.2. By supporting conservation professionals' approach to conservation planning

Several interviewees in this study expressed the theme of the ACPF supporting their approach to conservation planning. A conservation professional's approach to conservation planning could vary depending upon their organizational roles and responsibilities. For example, a watershed coordinator may need a toolbox that identifies conservation practices as well as can be used as a tool for educating farmers. Expressing how ACPF fulfills that role, a watershed coordinator from Iowa mentioned, "*It* [ACPF] *makes it so much easier to do conservation planning …* [ACPF] *works as an outreach tool in which you can target specific people to talk to … and then* [ACPF] *also provides an agronomic plan for that field too* [by] *providing* [conservation] *practices.*" A district coordinator from Iowa, further substantiating this theme, mentioned, "*I would say it* [ACPF] *changes how I approach conservation planning for the better so that it's* supported *better.*"

5.1.3. By helping conservation professionals in watershed planning and engagement with watershed stakeholders

While the ACPF supports precision conservation, several interviewees expressed how that could also facilitate watershed planning. For example, an interviewee from Iowa mentioned, "*If you think about watershed planning, it* [ACPF] *is helping us identify those locations, so I think it does a good job of giving us locations to do things."* Recognizing that the ACPF supports precision conservation, which in turn helps watershed planning, a watershed coordinator from Iowa mentioned, *"It* [ACPF] *does complement watershed planning because it's this direct approach. And we're not scattered in our planning."* Another interviewee expressed that the ACPF could be the foundation of a watershed plan. They added, "*I think they* [ACPF data/maps] *could be a very crucial step in it. I mean, it's giving you the ability to look at all the GIS data, terrain data, land use, and hydrology. Basically, they could be the foundation of a watershed plan."*

Watershed scale conservation planning, more often than not, requires working with a diverse set of stakeholders, who may have different expectations from the conservation planning process. Several interviewees in this study expressed the theme of the ACPF facilitating engagement with watershed stakeholders. A need for working across different stakeholders was especially evident in instances when upstream and downstream stakeholders were involved in the watershed planning process. For example, in one of the watersheds in Minnesota, the local drainage district organized a citizen advisory committee meeting inviting the producers (upstream stakeholders) and the lake association members (downstream stakeholders). ACPF maps were shown during the meeting, along with both groups of stakeholders engaging in small group exercises talking about the watershed issues and what they were doing to address those issues. The meeting acted as a platform to bridge upstream-downstream watershed concerns and facilitated discussions around what each of the two stakeholders were doing to address those concerns. Talking about the success of the meeting, an interviewee mentioned, *"We got great feedback on that meeting … it was kind of an eye-opening meeting."* An interviewee from a different watershed, expressing this theme, mentioned, *"We think it* [ACPF] *is a really good starting point when we're having a conversation in watershed planning meetings.* In three watersheds, ACPF results not only facilitated engagement of different watershed stakeholders, but were also incorporated into the watershed management plan.

5.2. A typology of producer engagement strategies for precision conservation

Perhaps one of the most challenging, but crucial stages in precision conservation is producer engagement. Simply put, producer engagement is a necessary precursor to the implementation of conservation practices. While producer engagement is the logical next step for a conservation professional who has either run the ACPF toolbox and/or has access to ACPF results, it is important to also have strategies in place for successfully engaging with producers. Conservation professionals employed a suite of strategies to engage with producers. These strategies can be conceptualized as strategies that helped create 'enabling' conditions for producer engagement and strategies that were subsequently used to directly engage with producers. Strategies that helped create 'enabling conditions' for producer engagement are armchair conservation, dual prioritization approach, field validation of results, coordinating producer engagement, being mindful of the scale of effective producer engagement, making resources available, and using local faces. Strategies that were subsequently used for producer engagement are sharing ACPF maps one-on-one and sharing ACPF maps in a group setting.

5.2.1. Armchair conservation

"*Armchair conservation*," a term expressed by one of the interviewees, involved a conservation professional doing their homework before visiting a producer and speaking with them about conservation opportunities on their farm. The homework involved getting all the data-sets prepared and organized beforehand. In one of the watersheds, this step involved creation of a variety of maps to assist the conservation professional in identifying critical areas in the watershed, prior to visiting the farm. Expressing this theme, an interviewee from Minnesota mentioned, *"The ACPF was critical in helping* [the conservation professional] *when he did the walkovers* [visiting the farm] *to allow him to do his homework, so to speak, before he went out in the field."* Armchair conservation was also mentioned as a producer engagement strategy in other watersheds, expressed more commonly as conservation professionals using the ACPF maps as a guiding tool prior to engaging with producers.

5.2.2. Dual prioritization approach

Whereas the ACPF identified locations of conservation practices across the watershed, conservation professionals often went beyond what the toolbox suggested in terms of channelizing their resources, and subsequently prioritizing those practices. Specifically, they accounted for producer personalities in deciding where to go and whom to talk. For example, in one of the watersheds, the first level of prioritization was based off the ACPF toolbox and other available datasets. The second level of prioritization was based off producer personalities. Expressing this dual approach of prioritization, an interviewee from Minnesota mentioned, *"The seven priorities* [conservation practices] *was first based off the potential sediment runoff from the field. And then we sat down, we talked about the landowners' personalities … Then we kind of said, ""So she may have priority number three as opposed to the toolbox, but she's a priority one because she's going to influence her neighbors more."* Thus, a prioritization approach facilitated conservation planning by accounting for available data, while also accounting for "innovators" within the watershed. In a different watershed, dual prioritization approach took the form of assigning feasibility codes to conservation practices that were ranked based on cost/ton/year of sediment reduction. These codes accounted for whether the concerned producer had a history of cooperation with the local conservation organization and did adoption entail coordination with other producers. Describing this approach, an interviewee from Minnesota mentioned, *"We had a feasibility code. So high likelihood, medium, or low likelihood that the project will actually occur. High likelihood, this might be something where you're only dealing with one landowner instead of multiple landowners that have had a history of working with us …"*

5.2.3. Field validation of ACPF data

An intermediate step taken by conservation professionals between running the ACPF and subsequently generating data to engage with producers was to field validate the data, a step commonly referred as 'ground-truthing' by GIS specialists. Field validation was conducted by several means, including but not limited to, conservation professionals driving around the watershed to look at the topography, and using other data sources such as aerial photographs, google maps, etc. In one of the watersheds, field validation was conducted in consultation with a local conservation professional. Reflecting upon their experience of conducting field validation, an interviewee mentioned, *"… without getting feedback from* [the local Drainage Inspector]*, who is very familiar with it* [the watershed]*, having been working on that area and managing those ditch systems - the* [ACPF] *tool was giving me inaccurate results."* In fact, in a different watershed, presenting ACPF data, in the form of maps, that were not field validated, drew criticism from producer members of the watershed advisory council. Owing to criticism of the maps, widespread producer engagement is currently on hold in this watershed. ACPF data also provided watershed issue validation for conservation professionals. Although conservation professionals are often aware of the local watershed issues, but to have a toolbox like the ACPF also identify those areas as areas of concern and suggest conservation opportunities, provided validity to their own experiential knowledge, thus adding to their confidence when engaging with

producers. Highlighting this theme, an interviewee mentioned, *"… sometimes the* [ACPF] *tool is just basically reiterating what you already know."*

5.2.4. Coordinating producer engagement

A strategy employed by conservation professionals was to coordinate with each other when engaging with producers. While the toolbox helped conservation professionals identify producers to work with, they recognized the need to coordinate efforts so that different conservation professionals did not approach the same producers. Acknowledging the importance of doing so, an interviewee mentioned, *"When we start to engage farmers on water quality, soil loss - they don't want to be approached multiple times by multiple different agencies and people … I think when it comes down to the conservation planning process, it really makes a lot of sense to have it be very coordinated …".* Coordination of efforts, as the previous quote highlights, could take the form of both intra-agency and interagency coordination. In one of the watersheds, intra-agency coordination entailed producer engagement by a designated conservation professional, a process that helped gage producers' interest in conservation practices identified on their farm, which then led to producers working with the district technician to implement those practices. In a different watershed, interagency coordination entailed a watershed coordinator collaborating with the local NRCS (Natural Resources Conservation Service) office to offer cost-share for conservation practices not funded under the watershed plan. Describing this approach, the interviewee mentioned, *"… we had cost share available for conservation practices, but not everything that was run in the ACPF model for the watershed … so when I would go to farms, I wouldn't just show them* [Producers] *what I had to offer but what other groups* [local NRCS offices] *had to offer as well for putting practices in."* In another watershed, interagency coordination entailed cooperation between the local drainage district and the lake association to avoid a situation of blame game between the upstream (producers) and the downstream (lake association members) stakeholders. In this watershed, the lake association wanted a list of the names and addresses of producers in priority areas, as identified by the ACPF, so that they could contact them directly. Instead, the lake association members cooperated with the drainage district and agreed to serve on the Citizen Advisory Committee for the district. Overall, by employing a coordinated strategy of engaging producers, conservation professionals were able to share resources, avoid situations of blame game, and be respectful of producers' time.

5.2.5. Being mindful of the scale of effective producer engagement

Conservation professionals were often mindful of the scale of producer engagement. In one of the watersheds, HUC 12 provided a 'community-type' sub-watershed scale for producer engagement because producers knew each other. Highlighting this theme, an interviewee from Minnesota mentioned, "*We were running that* [ACPF] *on HUC 12, which is just big enough to still be a community-type sub-watershed … when you get out to the rural areas, a HUC 12, is, about the right size for everybody to still know each other. If you get a lot bigger than that, people don't know each other … and then you lose that power to make connections between neighbors."* In a different watershed, sub-watershed scale was helpful in keeping producer engagement manageable. Expressing this theme, an interviewee from Minnesota mentioned, *"That* [sub-watershed] *was really critical* [for success of our project]*, I think. It* [the project] *is at a scale that is manageable in terms of … what are the effects of existing practices that farmers are using, and if they installed additional ones, what are those effects? And, to be able to measure that in the water quality, you really have to boil it down to a small scale. So, scale was really important."*

5.2.6. Making resources available

Another strategy used by conservation professionals to facilitate producer engagement was by making human and financial resources available, in order to both enhance their organizational capacity for producer engagement and generate incentives for producers to adopt conservation practices. Human resource availability was in the form of watersheds having dedicated staff/personnel for producer engagement using ACPF maps. For example, in one of the Minnesota watersheds, having a devoted conservation professional who could have one-on-one conversation with producers and build relationships and trust was critical in facilitating producer engagement. Expressing this theme, an interviewee from the watershed mentioned, *"… this is my only job. And I think if you want to make this kind of progress in a watershed, small or big, you have to have staff that has got that project and that project only."* In a different watershed, the local lake association funded hiring of an intern who could work on the 10–12 priority areas identified by the ACPF maps. Availability of financial resources took the form of using multiple funding sources and/or providing high cost-share incentives to producers. For example, in one of the Minnesota watersheds, funding was available to producers who were willing to adopt conservation practices, via multiple sources. Expressing this theme, an interviewee from the watershed mentioned, *"I had an existing* grant *to do conservation practices. So, I had existing* funds *that were just sitting there, waiting for people* [producers] *to come in."*

5.2.7. Using local faces

Conservation professionals often relied on local faces from the community in order to engage with producers. For example, in one of the watersheds in Minnesota, a letter signed by farm leaders and a trusted crop advisor was used to encourage producers to participate. In the same watershed, once the producer engagement process concluded, a letter signed by the county commissioner was mailed to them, thanking them for their participation in the process. Whereas local faces were used prior to and after the producer engagement process in this watershed, in a watershed in Iowa, local faces were used while directly engaging with producers. For example, an interviewee from this watershed mentioned, *"Sometimes I'll have them* [district commissioners] *come out to visit the landowner with me, so that there's a local face from the community who understands my side of things and also understands the producer's side of things."*

5.2.8. Sharing ACPF maps one-on-one

ACPF maps were also shared by conservation professionals in a one-on-one setting across several watersheds. Using maps one-on-one often facilitated conversation in a risk-free setting, and was also beneficial for subsequent implementation of conservation practices. Expressing the theme of maps enabling risk free conversation in a one-on-one setting, an interviewee from Iowa mentioned, "*It* [ACPF map] *was a quick way to get a conversation started, a quick way to show information to someone, especially in a risk-free way."* In a different watershed in Minnesota, recognizing the critical role played by the ACPF maps in facilitating one-on-one engagement with producers, an interviewee mentioned, *"… every time I showed a map, it was more like, ""Here's our monitoring results that we use to put into the ACPF tools … and this is why I'm working here."" And most people understood that, that I wasn't just out there to pick on them, it* [promoting conservation opportunities] *was a lot easier sell, for sure."* Another form of one-on-one sharing of maps, but not necessarily engaging with producers, was via mail. Although this strategy was used in two watersheds in this study, conservation professionals did not recommend mailing ACPF maps because it was not effective in eliciting producer response, and subsequent interest in adopting conservation practices.

5.2.9. Sharing ACPF maps in a group setting

ACPF maps were shared by conservation professionals in a group setting across several watersheds. A group setting often took the form of regional meetings, organized either as a conference or an open house, where ACPF maps for HUC 12 watersheds were displayed. A group setting also took the form of sharing maps with advisory board members of the local conservation district. Sharing maps in a group setting,

as expressed by interviewees in this study, helped gauge the overall interest of the community. For example, in one of the watersheds in Iowa, watershed maps were shared at a regional meeting where the watershed coordinator used these maps to strike conversation with producers and subsequently invited them for one-on-one follow-up. Expressing their experience of sharing maps at the regional meeting, the interviewee mentioned, "*I would show* [farmers] *those* [HUC 12] *maps and talk about the ACPF and how we were implementing practices based off of strategic placement, using the ACPF, as opposed to just a scatter shot approach to conservation. So, I'd have farmers approach me and sign up on a sheet for follow-ups for me to talk about their farm ground specifically."* An open house was organized in another watershed in Iowa where producers in the watershed were invited to look at the watershed maps. An important consideration when sharing maps in a group setting was the issue of invasion of privacy. Expressing their experience of sharing maps at the open house, an interviewee mentioned, *"I didn't get anyone who was hostile towards the map … we have some concerns about that as whether or not it would be an invasion of privacy, but* [we received] *a lot of good feedback, a lot of positive feedback."*

The nine producer engagement strategies described above often worked in conjunction with each other. For example, armchair conservation was followed by one-on-one interaction with a producer. In one of the watersheds, the conservation planner after doing their homework, visited a producer's farm, and subsequently compiled a report for their farm. This report included a section on applauding the producer for the conservation practices they were doing, a section informing them about conservation opportunities on their farm, and a simple graph showing how many additional conservation practices they can consider, how much it will cost, and which one of those additional practices were high priority practices. The strategies of sharing maps in a group and one-on-one setting were also often used in conjunction. Reflecting upon their experience of sharing maps in a group setting followed by sharing them in a one-on-one setting, an interviewee mentioned, *"I'd say they* [producers] *were a little more receptive in a one-on-one meeting to talk about things. And in the group, they were all kind of standing back and quicker to shoot something down as to why it wouldn't work."*

5.3. Policy recommendations for precision conservation

Conservation professionals often drew upon their experiences of engaging with producers in respective watersheds and made several recommendations for precision conservation. In this section, we reflect upon these recommendations, especially discussing them in light of agricultural conservation policy.

Conservation professionals often cautioned against considering the ACPF as a *"solve-all, holy grail, silver bullet."* Although the ACPF supports a precision approach to conservation planning, interviewees advised that it does not take out the human element from the conservation planning process. Expressing this theme, an interviewee from Minnesota mentioned, *"… it's just a tool and it takes that person* [conservation professional] *and that connection* [with producers] *to actually get something accomplished."* Substantiating the importance of human element in conservation planning, another interviewee expressed that DSTs, such as the ACPF, are not a substitute for conservation professionals' experiential knowledge. The interviewee mentioned, *"… ACPF gives you an objective look, but also, it's really important that there's a subjective portion of it … other nuances of information that you can use to help you decide which area maybe you should really focus on … that's where the subjectivity comes in, and the experience* [of the conservation professional]*."* These recommendations make an obvious but critical point for policymakers – DSTs that support precision conservation are the means to an end, but not a universal remedy for conservation planning.

Conservation professionals also highlighted the importance of building trust and relationships with producers in the conservation planning process. Because the process entails a proactive approach from a conservation planner, an interviewee cautioned, *"When I ask to come on their farm* [during precision conservation]*, this is like asking if I can come into your home and find the dirt …"* The proactive nature of the precision conservation process thus makes it imperative that the process is grounded in building trust and relationship with the so-called "targeted" producers. In one of the watersheds, this was accomplished via several ways, such as, by being respectful of producers' time, assuring privacy of the data collected from their farm, applauding them for their current conservation efforts, using trusted information channels, and showing appreciation for their participation in the process, to name a few. Interviewees also highlighted the importance of being transparent and honest with producers when sharing maps/data. For example, an interviewee mentioned, *"You* [conservation professional] *have a map of their* [producer's] *property and if you're talking to them, you're probably out on their site. There's this idea of trust. If I'm* [producer] *going to tell you things, where's that going to go, and be honest with that …"* Interviewees also suggested that precision approach to conservation should impart a sense of producer ownership into the conservation planning process. Reflecting upon their experiences of using the ACPF, an interviewee mentioned, *"I think the key with conservation planning is, how do you convey and present the information in a way that the producer ultimately figures that out for themselves, that they think it's good for them and that you give them options?"* Imparting a sense of process ownership, as expressed by an interviewee, could also be accomplished by letting producers know why a map of their farm and/or the watershed was created. Based on the aforementioned recommendations, we suggest creating institutionalized avenues for a dialogue with producers at the beginning of a precision conservation process. Doing so, we argue, would not only lay down the foundations of building trust and relationship, but also impart a sense of producer ownership of the conservation planning process.

Last but not least, and perhaps a recommendation most proximal to current agricultural conservation policy, was the need to streamline and expedite the process of conservation delivery. Expressing their frustration with conservation programs, an interviewee mentioned, *"We* [local conservation agency] *got told one time, ""You've got too many cooks in the kitchen"" It's so true. It's mind boggling when you have to try to pull all of these people together on a specific project and they've all got their little turf they protect and what they want to do … and there's a lot of friction in the room … So, that alone is a major problem."* While precision conservation expedites identification of potential conservation opportunities across the watershed, interviewees felt that the conservation delivery process under the current conservation policy also needs to be brought up to speed. Talking about the realities of resources at conservation professionals' disposal, and the need for expediting conservation delivery, an interviewee mentioned, *"… you've got your workload for people that walk through the door and you have the workload that is generated from* [precision conservation] … [the local NRCS offices] … *may not have the capacity to do this. They're built for what they're doing now, which is to deal with the workload* [producer] *that comes in … so this* [precision conservation] *is a whole another business model … with all these cost share programs, you have to follow all these steps … which is important and good … but that's a stumbling block for us … because if we do the eight steps of conservation planning and we have the balls tee'd up, we just have to hit it, and we can't seem to hit it, that's a challenge."* Discussion with conservation professionals about expediting conservation delivery often resulted in interviewees acknowledging the shifting dynamics of conservation planning. For example, an interviewee mentioned, *"… landowners don't come to us with conservation anymore. We go out and try to sell conservation. So, it's a different mentality …"* The shifting role of conservation professionals in a precision approach to conservation planning was also highlighted by another interviewee, who mentioned, *"We went out knocking on doors to get conservation on the ground …* [Conservation] *agencies wait for the landowners to come in with a problem. It's a whole different concept."* Owing to such shifting dynamics in conservation planning, it is imperative that agricultural conservation policy

funds the human (staffing) side of conservation.

6. Discussion

Whereas the roots of a precision approach to conservation planning dates back to the 1970s (Batie, 1985), conservation policy of aggregation is still the norm (Arbuckle, 2013). Recent scholarship documents support for precision conservation (Arbuckle, 2013; Kalcic et al., 2014; Kalcic et al. 2015; Fales et al. 2016), both by conservation professionals and producers, but lacks an understanding of how DSTs facilitate this approach to conservation planning. More importantly, less is known about the strategies that can facilitate producer engagement in precision conservation, as well as crafting policies that are amenable to producer needs and expectations, who are the ultimate recipients of a precision approach to conservation planning. With the goal of fulfilling the aforementioned research gaps, we interviewed 21 conservation professionals across six watersheds in the US Midwest, who had used the ACPF, a high resolution planning toolbox that provides a menu-driven approach to conservation prioritization and targeting.

The conservation planning needs of conservation professionals motivated the use of the toolbox across the six watersheds. This highlights the importance of having a clear purpose in planning to adopt an approach utilizing the ACPF. Others highlight that DSTs should take into account the information and practical needs of conservation professionals (Fales et al. 2016). Our results support these findings, but also emphasize that DSTs should reinforce some of conservation professionals' deeper cognitive needs, such as encouraging watershed thinking. Cognitive reinforcement could also take the form of watershed issue validation, where a DST provides validity to a conservation professional's experiential knowledge of the watershed.

Several of the producer engagement strategies identified in this study are supported by the existing scholarship. For example, dual prioritization approach highlights the importance of taking into account local watershed priorities and preferences, a recommendation also made by the developers of the ACPF (Tomer et al., 2013). In our study, conservation professionals accounted for producer personalities in order to prioritize their conservation efforts. Likewise, researchers have engaged producers and landowners in the conservation planning process in order to take into account their priorities and preferences (Kalcic et al. 2015). Scholars have attributed the success of a watershed project in Illinois in part to the small scale of the watershed (Church and Prokopy, 2017). As we also found, HUC 12 sub-watershed scale helped conservation professionals keep producer engagement manageable, which subsequently contributed to the success of precision conservation. Neilson (1986, 76) suggested improving on-farm planning and advising of farmers as a recommendation for precision conservation. Conservation professionals in this study were often proactive in working one-on-one with producers. Using ACPF maps, as we found, helped conservation professionals work with producers in a risk-free setting. Conservation professionals' proactive approach in engaging with producers only confirm the underlying tenets of precision conservation (Batie, 1985). We also provided several recommendations for crafting policies that are amenable to producer needs and expectations, when they are subject to precision conservation. This is particularly important, because producers' receptiveness to precision conservation recommendations has been found to be negated by distrust for the government (Kalcic et al., 2014). Reducing the complexity and time taken for assessing producers' conservation program eligibility and payments, a step that can expedite conservation delivery, is also recommended by others (Fales et al. 2016).

7. Conclusion

The goal of this study was to develop an understanding of how the ACPF facilitates conservation professionals' precision approach to conservation planning, identify producer engagement strategies for precision conservation, and to make policy recommendations for precision conservation. We found that the ACPF helped fulfill several conservation planning needs of conservation professionals, such as conducting sub-watershed analysis, identifying CSAs, creating a watershed management plan, and engaging watershed stakeholders, including producers. We also found that conservation professionals' perceptions of ACPF's usefulness was driven by the ACPF encouraging them to think at a watershed scale, by supporting their approach to conservation planning, and by meeting their practical needs of watershed planning and stakeholder engagement. We found that conservation professionals employed a suite of strategies to create 'enabling conditions' for producer engagement. From a policy perspective, our results suggest the need for streamlining and expediting the process of conservation delivery.

Unlike prior scholarship on DSTs that often focuses on their development and design, we employ an exploratory, qualitative approach in order to provide a rich description of the context within which conservation professionals employ a precision approach to conservation planning. We also draw upon the rich contextual knowledge of producer engagement to make several policy recommendations for precision conservation. By doing so, we contribute to both the policy and practice of precision conservation. Like all studies, this one has limits. While we cannot make any claims about generalizability of producer engagement strategies to other DSTs or watersheds, nevertheless, they highlight potential strategies conservation professionals using GIS-enabled planning technologies can test out in their respective watersheds. The onus is on future scholarship to test the causality, as well as the relative significance, of different producer engagement strategies in motivating producers to adopt conservation practices.

A precision approach to conservation planning, as we found in this study, requires conservation professionals to be proactive in producer engagement. These findings allude to a potential shift from the dominant paradigm of the conservation policy of aggregation (Arbuckle, 2013), however, is this a paradigm shift? At least in one of the six watersheds in this study, a shift in conservation paradigm seems palpable. Highlighting the ability of the ACPF in changing conversations around conservation planning, an interviewee from this watershed mentioned, *"I think it* [ACPF] *has totally changed the conversation, honestly, because we never really knew. We had ideas where buffers should go … but we didn't know where, and I think it's entirely changed the conversation."* Only time will tell whether these changing conversations are indicative of a paradigm shift in conservation planning. In the meanwhile, we need to toil with the pragmatic question of whether policy can support a process that humanizes precision conservation efforts.

Declarations of interest

None.

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References

Arbuckle, J.G., 2013. Farmer attitudes toward proactive targeting of agricultural conservation programs. Soc. Nat. Resour. 26, 625–641. https://doi.org/10.1080/08941920.2012.671450.

Batie, S.S., 1985. Soil conservation in the 1980s: a historical perspective. Agric. Hist. 59, 107–123.

Berry, J.K., Delgado, J.A., Pierce, F.J., Khosla, R., 2005. Applying spatial analysis for precision conservation across the landscape. J. Soil Water Conserv. 60, 363–370.

Charmaz, K., 2006. Constructing Grounded Theory: A Practical Guide through Qualitative Analysis. Sage Publications.
Church, S., Prokopy, L.S., 2017. The influence of social criteria in mobilizing watershed conservation efforts: a case study of a successful watershed in the Midwestern U.S. Land Use Pol. 61, 353–367. https://doi.org/10.1016/j.landusepol.2016.11.030.
Duriancik, L.F., Bucks, D., Dobrowolski, J.P., Drewes, T., Eckles, S.D., Jolley, L., Kellogg, R.L., Lund, D., Makuch, J.R., O'Neill, M.P., Rewa, C.A., Walbridge, M.R., Parry, R., Weltz, M.A., 2008. The first five years of the conservation effects assessment project. J. Soil Water Conserv. 63, 185A–197A. https://doi.org/10.2489/jswc.63.6.185A.
Ervin, C.A., Ervin, D.E., 1982. Factors affecting the use of soil conservation practices: hypotheses, evidence, and policy implications. Land Econ. 58, 277. https://doi.org/10.2307/3145937.
Fales, M., Dell, R., Herbert, M.E., Sowa, S.P., Asher, J., O'Neil, G., Doran, P.J., Wickerham, B., 2016. Making the leap from science to implementation: strategic agricultural conservation in Michigan's Saginaw Bay watershed. J. Great Lakes Res. 42, 1372–1385. https://doi.org/10.1016/j.jglr.2016.09.010.
Jordan, N.R., Clower, K.M., Manson, S.M., Bonsal, D.B., Immich, J.L., 2015. Land use and land cover in critical source areas on small dairy farms in the eastern United States. J. Soil Water Conserv. 70, 257–266. https://doi.org/10.2489/jswc.70.4.257.
Kalcic, M., Prokopy, L., Frankenberger, J., Chaubey, I., 2014. An in-depth examination of farmers' perceptions of targeting conservation practices. Environ. Manag. 54, 795–813. https://doi.org/10.1007/s00267-014-0342-7.
Kalcic, M.M., Frankenberger, J., Chaubey, I., Prokopy, L., Bowling, L., 2015. Adaptive targeting: engaging farmers to improve targeting and adoption of agricultural conservation practices. J. Am. Water Resour. Assoc. 51, 973–991. https://doi.org/10.1111/1752-1688.12336.
Kerr, J.M., Meersman, M., Fuller, E., Fales, M.K., 2016. Exploring the potential role of public drain managers in motivating agricultural conservation practices. J. Great Lakes Res. 42, 1386–1394. https://doi.org/10.1016/j.jglr.2016.08.001.
Knight, B.I., 2005. Precision conservation. J. Soil Water Conserv. 60, 137A.
Konopacky, J., Ristino, L., 2017. The healthy watershed framework: revising Clean Water Act and Farm Bill conservation programming to catalyze small-scale watershed planning and implementation. Environ. Law Rev. 47, 647–693.
McLellan, E.L., Schilling, K.E., Wolter, C.F., Tomer, M.D., Porter, S.A., Magner, J.A., Smith, D.R., Prokopy, L.S., 2018. Right practice, right place: a conservation planning toolbox for meeting water quality goals in the Corn Belt. J. Soil Water Conserv. 73, 29A–34A. https://doi.org/10.2489/jswc.73.2.29A.
Nielson, J., 1986. Conservation targeting success or failure? J. Soil Water Conserv. 41, 70–76.
Nowak, P., 2009. Lessons learned: conservation, conservationists, and the 2008 flood in the US Midwest. J. Soil Water Conserv. 64, 172A–174A. https://doi.org/10.2489/jswc.64.6.172A.
Nowak, P., Bowen, S., Cabot, P.E., 2006. Disproportionality as a framework for linking social and biophysical systems. Soc. Nat. Resour. 19, 153–173. https://doi.org/10.1080/08941920500394816.
Patton, M.Q., 1990. Qualitative Evaluation and Research Methods, second ed. Sage Publications, Newbury Park, CA.
Porter, S.A., Tomer, M.D., James, D.E., Boomer, K.M.B., 2015. Agricultural Conservation Planning Framework: ArcGIS®Toolbox User's Manual. (Ames).
Sims, K.R.E., Alix-Garcia, J.M., Shapiro-Garza, E., Fine, L.R., Radeloff, V.C., Aronson, G., Castillo, S., Ramirez-Reyes, C., Yañez-Pagans, P., 2014. Improving environmental and social targeting through adaptive management in Mexico's payments for hydrological services program. Conserv. Biol. 28, 1151–1159. https://doi.org/10.1111/cobi.12318.
Tomer, M.D., James, D.E., Kostel, J.A., Bean, J., 2015a. Siting multiple conservation practices in a Tile-Drained watershed using LiDAR topographic data. In: Mueller, T., Sassenrath, G. (Eds.), GIS Applications in Agriculture, Volume Four: Conservation Planning. CRC Press.
Tomer, M.D., Porter, S.A., Boomer, K.M.B., James, D.E., Kostel, J.A., Helmers, M.J., Isenhart, T.M., McLellan, E., 2015b. Agricultural conservation planning framework: 1. Developing multipractice watershed planning scenarios and assessing nutrient reduction potential. J. Environ. Qual. 44, 754. https://doi.org/10.2134/jeq2014.09.0386.
Tomer, M.D., Boomer, K.M.B., Porter, S.A., Gelder, B.K., James, D.E., McLellan, E., 2015c. Agricultural conservation planning framework: 2. Classification of riparian buffer design types with application to assess and map stream corridors. J. Environ. Qual. 44, 768–779. https://doi.org/10.2134/jeq2014.09.0387.
Tomer, M.D., Locke, M.A., 2011. The challenge of documenting water quality benefits of conservation practices: a review of USDA-ARS's conservation effects assessment project watershed studies. Water Sci. Technol. 64, 300–310. https://doi.org/10.2166/wst.2011.555.
Tomer, M.D., Moorman, T.B., James, D.E., Hadish, G., Rossi, C.G., 2008. Assessment of the Iowa river's South Fork watershed: Part 2. Conservation practices. J. Soil Water Conserv. 63, 371–379. https://doi.org/10.2489/jswc.63.6.371.
Tomer, M.D., Porter, S.A., James, D.E., Boomer, K.M.B., Kostel, J.A., McLellan, E., 2013. Combining precision conservation technologies into a flexible framework to facilitate agricultural watershed planning. J. Soil Water Conserv. 68, 113A–120A. https://doi.org/10.2489/jswc.68.5.113A.
Viera, A.J., Garrett, J.M., 2005. Understanding interobserver agreement: the kappa statistic. Fam. Med. 37, 360–363.
Yang, W., Khanna, M., Farnsworth, R., 2005. Effectiveness of conservation programs in Illinois and gains from targeting. Am. J. Agric. Econ. 87, 1248–1255.