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Developing farmer typologies to inform conservation outreach in agricultural landscapes

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ABSTRACT

Understanding factors that motivate conservation behavior among farmers is crucial to addressing societal, soil, water, and wildlife conservation goals. Farmers employ soil conservation practices to maintain agricultural productivity while minimizing impacts to water and wildlife in the long-term. The majority of conservation programs are voluntary in nature and some farmers are more willing and/or able to implement conservation practices than others. To inform the development of more effective conservation outreach and incentive programs, we created a farmer typology using data from three waves (2015, 2016, 2018) of a longitudinal survey of 358 farmers from Iowa, a highly productive agricultural state in the U.S. Midwest. Using multivariate analysis (Principal Component Analysis, and Cluster Analysis), we employed 26 summated scale variables measuring largely unobservable and latent constructs related to conservation, including awareness, attitudes, beliefs, and perceived motivations and barriers to practice adoption. Through this analysis, we identified four types of farmers-Conservationist, Deliberative, Productivist, and Traditionalist—based on the salient characteristics of each group. “Conservationist” farmers scored highest on measures of stewardship motivations and identity. “Deliberative” farmers appeared to be favorably disposed toward conservation, but also seem to consider agronomic and economic impediments more than other groups. “Productivist” farmers had the highest scores on profit motivation and emphasis on input use. “Traditionalist” farmers reported being heavily influenced by family members and scored highest on social and regulatory influence on conservation motivations. Detailed understanding of between-groups differences on key conservation-related factors can contribute to developing targeted messages for specific subgroups of a given population, potentially resulting in higher adoption of voluntary conservation programs in Iowa and beyond.

1. Introduction

Agriculture is the Earth’s dominant land use and will continue to be as global population and food demand remains steady or increases with human population growth and changing diets (Tamburino et al., 2020; Tilman et al., 2011). Yet, many significant environmental challenges that manifest themselves locally, regionally, and globally stem from the management of agricultural systems, including impacts to soil health, water quality, and biodiversity (Alagele et al., 2019; Rockström et al., 2009; Smith et al., 2019). Conversion of other land uses to agriculture and its intensification could provide the crop production increases required to meet global demand. However, efforts toward agricultural expansion and intensification need to be combined with widespread implementation of soil, water, and biodiversity conservation measures to maintain long-term functioning and reduce environmental impacts and tradeoffs (Power, 2010; Royal Society, 2009).

Agriculture in the U.S. Midwest is known for both its productivity and its significant negative impacts due to the application of fertilizers, herbicides, and tillage practices (Kim et al., 2014; Lee et al., 2020; Rabotyagov et al., 2014). Although the region is highly productive in terms of grain and livestock-based commodities, the widespread extent of agriculture creates unintended consequences for the environment, including degradation of ecosystem services and functions, biodiversity, damaged local aquatic resources, and soil and water quality (Brooks et al., 2016; Burney et al., 2010; Dirzo and Raven, 2003; E.P.A., 2017; Rabotyagov et al., 2014; Turner et al., 2012; Ward et al., 2005).

To minimize environmental degradation in the U.S. Midwest, numerous governmental and non-governmental organizations have

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been working on different strategies to promote conservation practices. The 2012 Nutrient Reduction Strategy (NRS) for the state of Iowa is one of such efforts (IDALS et al., 2017). This strategy is centered upon the promotion of voluntary adoption of diverse conservation practices such as no-till farming, cover crops, buffers, and constructed wetlands to reduce the nutrient losses that lead to water quality impairments across the Upper Midwest and hypoxic conditions in the Gulf of Mexico (Lee et al., 2018). Although sustaining agricultural productivity at high levels while minimizing nutrient loss is a significant challenge for modern agriculture, the adoption of conservation practices by farmers can help mitigate soil and water quality impairment. However, over decades both governmental and non-governmental agencies aimed at promoting conservation practices have faced difficulties in getting private landowners to adopt conservation practices (Prokopy et al., 2019), despite major outreach, extension and conservation program endeavors (National Research Council, 2010).

Farmers' individual non-economic and unobservable characteristics (e.g., motivations, attitudes) affect their behaviors (Chhetri et al., 2018; Liu et al., 2018; Prokopy et al., 2019; Ranjan et al., 2019), and different strategies and policy interventions for promoting conservation practices may appeal to different farmer types. For example, farmers' decision making about the adoption of particular conservation practices is influenced by complex individual attitudes, beliefs, and motivation/barriers in addition to other socio-economic characteristics (Prokopy et al., 2019, 2008). A better understanding of these characteristics, and knowledge of farmers' perspectives on the salient challenges, is necessary for developing more effective policies and strategies (Leeuwis, 2004; National Research Council, 2010). However, "farmers" are not a monolithic group: like most other groups of people, they are heterogeneous in their attitudes and perceptions (Gorton et al., 2008), and adoption of conservation practices can be dynamic across agricultural landscapes and over time (Brodt et al., 2006; Daloğlu et al., 2014; Davies and Hodge, 2007; Zimmerman et al., 2019). Although most conservation practice adoption studies examine individual farmer's attitudes and values towards particular topics, the development of typologies is increasingly seen as a promising approach for informing the design of outreach or incentive programs. Typologies can be used to design programs that appeal to distinct groups or segments of farmers, potentially increasing the adoption of conservation practices (Barnes and Toma, 2011).

Farmers can be categorized into different types according to their characteristics. Classifying farmers as "types" can facilitate analysis of how particular sets of characteristics such as perceptions and motivations relate with behaviors towards a specific issue (Collier et al., 2010). Each type may refer to a group of farmers who share similar attitudes, motivations, and behaviors (Foguesatto et al., 2019). The classification of farmers into different types can improve the understanding of characteristics that influence conservation adoption (Daloğlu et al., 2014; Kostrowicki, 1977; Valbuena et al., 2008). Classification can effectively address heterogeneity of farmers by finding commonalities that are related to particular behaviors (Valbuena et al., 2008), allowing targeted delivery of conservation messages based on the audience.

Thus, recent years have seen a number of segmentation studies that have considered farmers' perceptions, motivations and behaviors globally (Barnes and Toma, 2011; Bidogeza et al., 2009; Daloğlu et al., 2014; Foguesatto et al., 2019; Hyland et al., 2016; Morgan et al., 2015; Schwarz et al., 2009; Upadhaya and Dwivedi, 2019), including within the U.S. Corn Belt. Arbuckle et al. (2014) created a farmer typology to understand Corn Belt farmers' perspectives on climate change. Daloğlu et al. (2014) combined the typology and SWAT model to explore coupled soil and biophysical processes within Corn Belt agricultural systems. Generally, these studies have been conducted through farmer surveys, and the data analyzed by multivariate methods, including Principal Component Analysis (PCA) and cluster analysis.

In this study, we aimed to categorize Iowa farmers into different types based on commonalities in attitudes, perceived motivations and barriers to change, sources of information, value orientations, and other characteristics related to conservation practices. Our overall objective was to evaluate whether heterogeneous individual farmers might be sorted into groups and whether within-group commonalities (i.e., in terms of attitudes, values, etc.) could be determined for use in development of segmented or differentiated outreach strategies and policies tailored to the characteristics of each group.

2. Methods

2.1. Study area

We conducted this study using survey data collected from farmers in Iowa, an agricultural state in the Midwestern U.S. Iowa comprises 145,785.25 km^2 of primarily cultivated land located in the middle latitudes between the Mississippi and Missouri Rivers (Fig. 1). The average annual temperature ranges from 7.2 °C in the north to 12 °C in the southeast. The annual average precipitation is around 863 mm. Due to favorable climatic conditions and rich soil resources, Iowa is one of the main agricultural and grain production states in the U.S. Cultivated crops of mainly corn (*Zea mays* L.) and soybeans (*Glycine max* [L]) dominate the landscape (Fig. 1). The state is also a top producer of poultry, pork, and eggs (USDA NASS, 2019).

2.2. Survey data

We constructed the sample for this analysis using the 2015, 2016, and 2018 waves of the Iowa Farm and Rural Life Poll (IFRLP). The IFRLP is an annual panel survey conducted through a partnership between Iowa State University Extension, the Iowa Agricultural Statistics Service, and the Iowa Department of Agriculture and Land Stewardship (Arbuckle, 2013). The IFRLP has been conducted every year since its establishment in 1982 through 2018, and is the longest-running survey of its kind in the U.S. (Arbuckle, 2016). We merged datasets from 2015, 2016, and 2018, resulting in a three-year panel of 358 farmers. The 2015 survey was sent to 2093 farmers and returned by 1159 for a response rate of 55 % (Arbuckle, 2016). The 2016 survey was sent to 2089 farmers and returned by 1039 farmers for a response rate of 50 % (Arbuckle, 2017). The 2018 survey was sent to 2151 farmers and returned by 50 % or 1061 (Arbuckle, 2019). The overall sample was smaller than the annual samples due to sample attrition over time and variation in the response rate for selected questions within each year.

2.3. Indicator variable construction

The first step in our typology development process entailed construction of 26 different scales from 109 IFRLP questions and items measuring attitudes, perceived motivations and barriers to change, sources of information, value orientations, and other characteristics. We constructed these scales based of a review of the major factors influencing the adoption of conservation practices, especially the meta-analytic review articles Prokopy et al. (2008) and Prokopy et al. (2019). We employ summated scales that combine multiple items because they can improve both the reliability and precision of measurement of attitudinal constructs (DeVellis, 2003; McIver and Carmines, 1981; Spector, 1992). Over recent years, the IFRLP has contained many questions focused on farmer perspectives on soil and water conservation, primarily in the form of multiple-item question sets that measure underlying latent constructs such as attitudes and values (Arbuckle, 2019, 2017, 2016). Based on the literature review and our experience, we selected 109 items from the surveys to enter into a series of factor analyses that guided creation of 26 summated scales. The output of the factor analyses using PCA with varimax rotation is provided in tables S1−5. To evaluate the internal consistency of the constructed scales, we used a standard measure of the scale of reliability, Cronbach's alpha reliability coefficient (CARC) (Field, 2009) for each

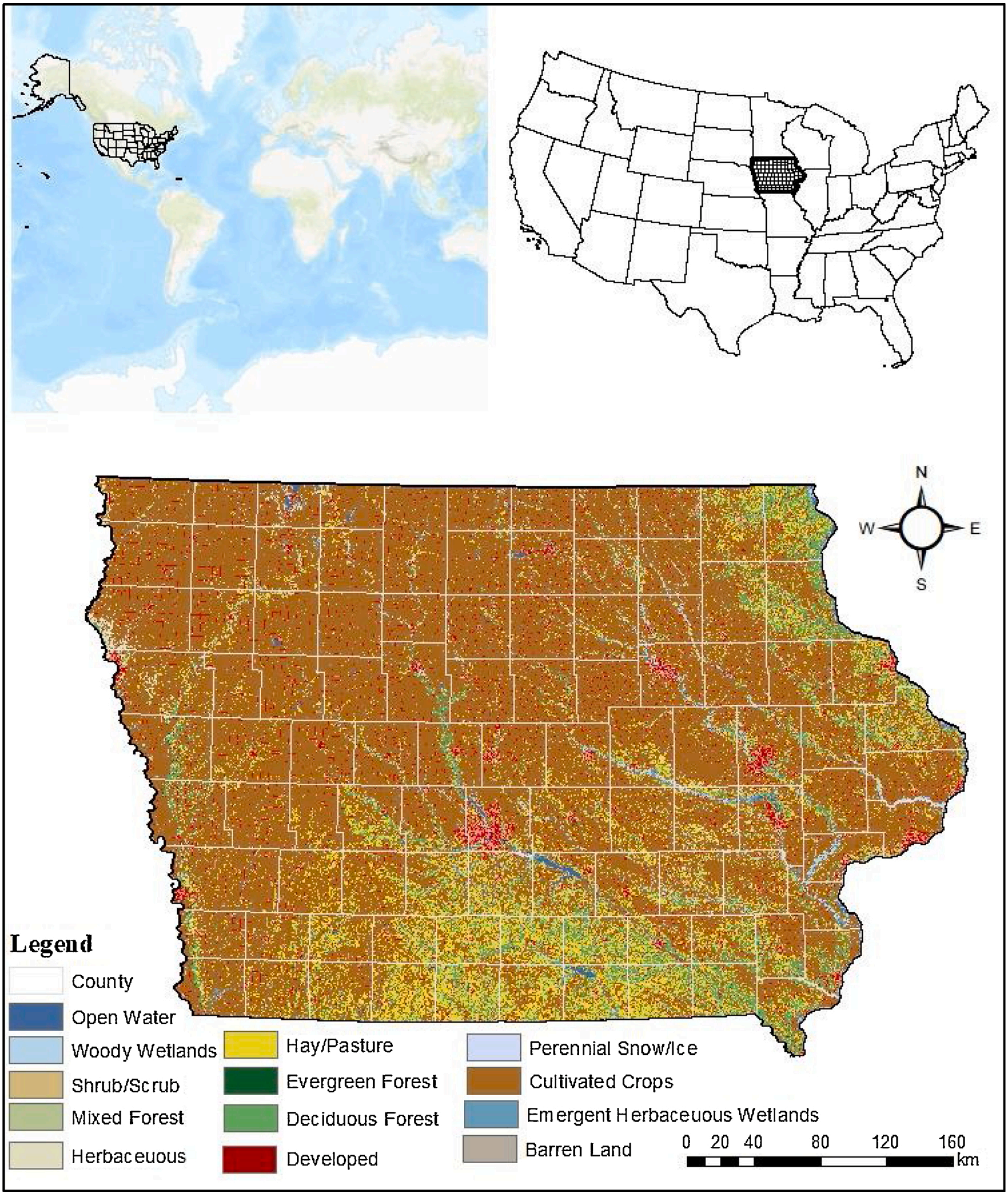

Fig. 1. The location and land use/ land cover map of the state of Iowa. (source NLCD, 2016).

scale.

We derived the variables included in the analyses from question sets containing numerous items measured on 3–6-point scales (i.e., agreement, importance; S1–5). Many of the question sets were designed to measure key latent constructs that research has associated with farmer adoption of conservation practices (Prokopy et al., 2019, 2008). The major conservation-focused variables measured awareness, attitudes, beliefs, trust in information sources, motivations/barriers, and stewardship values related to conservation. Other variables measured selected agronomic practices, perspectives on farm policy, and self-rated quality of life.

Two attitudinal scales measured farmers' agricultural identity and values orientation. These question sets were replicated from previous research that examined the "good farmer" identity, or what farmers believe are important characteristics of a "good farmer" (McGuire et al., 2013, 2015). Farmers were asked to rank 14 items on a five-point importance scale ranging from not important at all (1) to very important (5) in terms of defining what makes a good farmer. Factor analysis was conducted on these 14 items to identify two constructs, the "conservationist identity" and the "productivist identity" (S1).

A related set of items examined intergenerational influence on farm management and conservation behaviors. Farmers were asked to rate the influence that previous generations of their family had on 12 aspects of their farm operation on a five-point influence scale from no influence (1) to very strong influence (5). We constructed two scales, “family influence farm operations” and “family influence stewardship” (S1). Similarly, to understand farmers’ interest in prairie strips two scales were developed from using survey questions asking whether or not farmers were interested in learning about and planting prairie for conservation purposes on their farm (S1).

Two scales measured farmer beliefs about the spatial extent of prospective benefits that conservation practices might generate on a 4-point scale from not beneficial (1) to very beneficial (4). Four items were extensive scale (i.e., my state, planet earth). Three items were more local (i.e., my farm, my watershed) (S1).

Two major question sets assessed factors that motivate farmers to incorporate conservation practices and perceived barriers of conservation practices adoption into their operations, resulting in four motivations and two barriers scales. Farmers were asked to rank 23 motivation-related items on an importance scale ranging from not important at all (1) to very important (5) in terms of factors that were important for their decision to adopt conservation practices. We constructed four motivational scales; “stewardship motivations,” “regulation motivations,” “social motivations,” and “biodiversity motivations.” During factor analysis, only one item, “improve wildlife habitat” was loaded on “biodiversity motivations” because of which we separate this from “stewardship motivation.” Similarly, they were asked to rank seven barrier-related items on a five-point agreement scale ranging from strongly disagree (1) to strongly agree (5). The two barriers scales, “agronomic barriers” and “economic barriers,” were constructed from 10 items measured on an agreement scale from strongly disagree (1) to strongly agree (5) (S2).

Another major question set measured the degree to which farmers trust a range of agricultural stakeholder entities as sources of information to help them make conservation decisions. The survey provided a list of 18 stakeholders and asked farmers to rate them on a 5-point trust scale ranging from strongly distrust (1) to strongly trust (2). Factor analysis of the 18 items indicated four scales: “trust commodity groups,” “trust conservation (oriented) entities,” “trust agribusiness entities,” and “trust family and friends” (S3). S3 also includes three scales related to soil health. Farmers awareness about soil health was assessed through a survey question asking them to rank 10 items on a 5-point agreement scale ranging from strongly disagree (1) to strongly agree (5). The factor analysis of these 10 items resulted in three soil health awareness scales named “soil health self-efficacy,” “soil health response efficacy,” and “soil health information awareness” (S3).

A next set of questions examined key agronomic and fertility management practices and technologies. Farmers were asked to report changes in use of six items on a 5-point scale ranging from major decrease (1) to major increase (5) and combined into a "agronomic management" scale (S4). Use of five key fertility management items were rated on a three-point use scale: not used (1), might use (2), and used (3) and combined into a “fertility management practices” scale (S4).

A final series of questions focused on well-being. Farmers were asked to rate three items on a five-point scale ranging from strongly disagree (1) to strongly agree (5). The farmers were also asked to rate how they feel about the quality of life of their family in the recent past and near future. Using five-point scale ranging from much worse (1) to much better (5) two scales were constructed; “quality of life family future” and “quality of life family past” (S5). A scale “attitude towards the Farm Bill” is comprised of three items that measured farmer perspectives on the United States Department of Agriculture’s largest farm policy instrument, the Farm Bill.

2.4. Analytical approach

We employed a two-stage multivariate analytical approach, using Principal Component Analysis (PCA) and cluster analysis, to construct the farmer typologies. First, PCA was used to reduce 109 different variables into a new set of components measuring key latent constructs (detailed in Section 2.3). The PCA condensed information from the original interdependent variables to a smaller set of independent variables (Bidogeza et al., 2009). The reduction of number of variables is essential in cluster analysis to retain stable and non-overlapping clusters. Before running PCA, the dataset was checked for appropriateness of this technique. If the variables are largely independent or correlate very strongly, PCA may not be appropriate. Hence, we performed the Kaiser-Maier-Olkin (KMO) and Bartlett’s Sphericity test to check the appropriateness of data included in the PCA (Field, 2006). We used Cronbach’s alpha reliability coefficient (CARC) to test the internal consistency and reliability of the factor loading. DeVellis (2017) suggested that CARC values of more than 0.6 are considered to be adequate in the social sciences.

Using PCA, selected scale variables were used to construct factors. These factors were rotated using the varimax method, whereby the process tries to load a smaller number of highly correlated variables onto each component resulting in easier interpretation (Field, 2009; Upadhaya and Dwivedi, 2019). Following Kaiser’s criterion, all factors exceeding an eigenvalue of one were retained for cluster analysis (Foguesatto et al., 2019), allowing us to concentrate a large part of the total information in a small number of uncorrelated variables. Factors retained from PCA were used in cluster analysis.

Cluster analysis groups cases (in this case, farmers) according to their (dis)similarity in terms of their attributes represented by selected variables (Everitt et al., 2011). Cases within a certain cluster should be similar to each other, and cases belonging to different clusters should be dissimilar. As no single procedure is available to determine the most suitable number of clusters (Bidogeza et al., 2009), we used two clustering methods to ensure the stability of clusters, Ward’s hierarchical procedure and K-means clustering. Ward’s method minimizes the variance within clusters and tends to find clusters of relatively equal sizes (Köbrich et al., 2003). The numbers of clusters (k) retained from Ward’s method using the agglomeration coefficient schedule were used as a starting point for K-means clustering to get a desired number of un-nested clusters. We used information from the dendrogram, agglomeration coefficients from Ward’s method, and knowledge about the study population to select an optimal number of clusters. This two-stage clustering approach yielded four distinct clusters. We performed a one-way analysis of variance test (ANOVA) to identify the variables with the largest differences between clusters (Field, 2009).

3. Results

The results of KMO test and Bartlett’s sphericity test showed that datasets of survey responses from 358 Iowa farmers could be factored. The overall KMO test was higher than 0.75 and Bartlett’s sphericity test was highly significant ($p < 0.000$). This suggested that the variables under analysis are related, justifying some form of factoring (Bidogeza et al., 2009; Field, 2009).

3.1. Principal component analysis results and component labeling

In total, 26 variables were included in the PCA, of which nine principal components with eigenvalues >1 were identified for further analysis (S6). These nine components explained 69 % of the total variability in the dataset. We then evaluated each component and developed descriptive labels that characterize them according to the variables with which they were most strongly associated.

The first component (F1), which explained 20.3 % of the total variance, was most strongly and positively correlated with non-economic conservation motivations such as biodiversity and stewardship (S6). Thus, we labeled F1 "Non-economic Conservation Motivations" (Table 1). The second (F2) component explained 9 % of the variance. This component was most closely related to sources of information that farmers trust to inform their decisions about conservation practices (S6). This component was labeled "Conservation Trust." The third component (F3, 7.7 % of variance) was related to farmer perspectives regarding the spatial extent over which benefits from conservation practices are accrued (e.g., local, global) and the conservationist identity scale, and was labeled "Conservation Perceived Benefits". The fourth component (F4, 6.5 % of variance) was strongly related to farmers' understanding of and perceived capacity to manage for soil health; hence, we labeled it "Soil Health Focus."

The fifth (F5) and sixth (F6) components explained 5.8 % and 5.4 % of the variance, respectively (S6). The salient feature of F5 component is a relatively strong loading of agronomic input-intensive management and the productivist farmer identity scale, thus we labeled this component "Productivism." The sixth component was related to how intergenerational familial factors influence farm operations and farmers' stewardship. This component was most strongly associated with factors measuring the influence of past generations of family on farm decisions, and was labeled "Family Influenced." The remaining three components each explained about 5 % of the variance. The seventh component (F7) showed a positive relationship with the farmers' quality of life, i.e., the degree of satisfaction with all aspects of life for their families. This component was referred to as "Quality of Life." The eighth component (F8) was positively correlated with farmers' interest in learning about the prairie strips conservation practice or interest in planting prairie strips in their farmland. The last component (F9) correlated with perceived barriers to use of soil and water conservation practices. Components F8 and F9 were thus labeled "Prairie Strips" and "Agronomic and Economic Barriers" respectively (S6, Table 1)).

3.2. Cluster analysis: identifying and characterizing farmer types

The nine factors retained from PCA were analyzed using K-Means clustering methods, and further reduced to four clusters (Table 1, Figs. 2, 5), following the guidance of Bidogeza et al. (2009) for developing a meaningful classification. We labeled the clusters according their defining attributes: Conservationist, Deliberative, Productivist, and Traditionalist. The following sections describe each cluster and discuss the rationale for the labels we assigned them.

3.2.1. The Conservationists

The defining attributes of the "conservationist" cluster are the highest mean scores on the prairie strips factor and the soil health focus factor (Table 1, Figs. 2, 5). This group of farmers also had the second highest score on the non-economic conservation motivations factor, and the second lowest score on the productivism factor (Figs. 2, 5).

Comparisons of mean scores on the variables that underlie the PCA factors illuminates details about the conservationist cluster relative to the other three groups. Farmers in this cluster had the highest scores on the biodiversity and stewardship motivations scales, the conservationist identity scale, and the soil health response efficacy scale (Fig. 4). They also had the highest score on the intergenerational family influence on stewardship scale and the prairie strips interest scale (Fig. 3). Importantly, the Conservationist cluster also had the highest scores on past and future quality of life, suggesting that this group tended to feel better about where they have been and their prospects for the future in terms of quality of life than their counterparts in other clusters. Thus, not only does this group appear to be the most conservation-oriented of the four clusters, they may also be happiest.

The Conservationist cluster is also notable for its low scores on a number of variables. Farmers in this cluster scored lowest on the productivist identity scale, and they had the lowest levels of trust in commodity groups as a source of information on soil and water conservation (Figs. 3 and 4). They also scored lowest on the economic barriers to conservation scale (Fig. 3). One seemingly inconsistent result is this group's low mean on the Conservation Perceived Benefits factor (Fig. 2). This result appears to be driven by a low score on one of the three items with the strongest loadings on the factor. While this group had the second highest mean on the local conservation benefits scale item and scored highest by far on the conservationist identity scale item, it had a low score on the extra-local benefits of conservation practice that pulled the overall mean down (Fig. 4). In other words, while this group on average had the strongest conservation identity and believed that the conservation practices they use are beneficial to their farms and their local watersheds, they did not rate the extra-local benefits of those practices as highly as farmers in the other clusters (Fig. 4). That said, overall this group is defined by its robust conservation orientation.

3.2.2. The Deliberative

We labeled this group the "Deliberative" following Rogers' (2003, 284) use of this term to characterize ideal-type "early majority" adopters of innovations. His description of the early majority adopters, which tend to make up the largest proportion of adopters of a given innovation, as having a tendency to "…deliberate for some time before completely adopting a new idea," seems fitting for this group. The Deliberative had high scores on some key conservation variables but low scores on others, indicating some uncertainty or ambivalence about conservation. They scored highest of all the clusters on the non-economic motivations factor, the conservation trust factor, and the conservation perceived benefit factor, and lowest on the family influence factor (Table 1, Figs. 2, 5). Other notable results were the second highest barriers score and second lowest soil health focus score (Figs. 3 and 4). Thus, farmers in this group appeared to lean toward a conservation orientation, evidenced by their trust in different sources of information to help them make conservation decisions and their high score on the conservation perceived benefits factor. At the same time, however, their interest in the innovative prairie strips practices and the innovative concepts of soil health was relatively low, and agronomic and economic barriers to conservation practice adoption was relatively high (Table 1, Fig. 3).

Table 1
Final cluster centers (mean for each variable within each final cluster) for the four-cluster solutions (K-means method).

		Clusters				
	Factors	Conservationist	Deliberative	Productivist	Traditionalist	F
C1	Non-economic Conservation Motivations	0.131	0.217	−0.664	0.080	12.672**
C2	Conservation Trust	0.044	0.403	−0.203	−0.310	9.984**
C3	Conservation Perceived Benefits	−0.234	0.153	0.076	0.042	2.809*
C4	Soil Health Focus	0.533	0.108	0.313	−0.857	51.143**
C5	Productivism	−0.318	0.051	0.938	−0.325	32.022**
C6	Family Influenced	0.369	−1.003	0.363	0.369	69.164**
C7	Quality of Life	0.436	−0.324	−0.380	0.111	14.714**
C8	Prairie Strips	0.998	0.006	−0.561	−0.674	101.298**
C9	Agronomic and Economic Barriers	−0.045	0.102	−0.421	0.217	5.894**
	Percentage of Farmers	28.2 %	26.8 %	17.6 %	27.4 %	

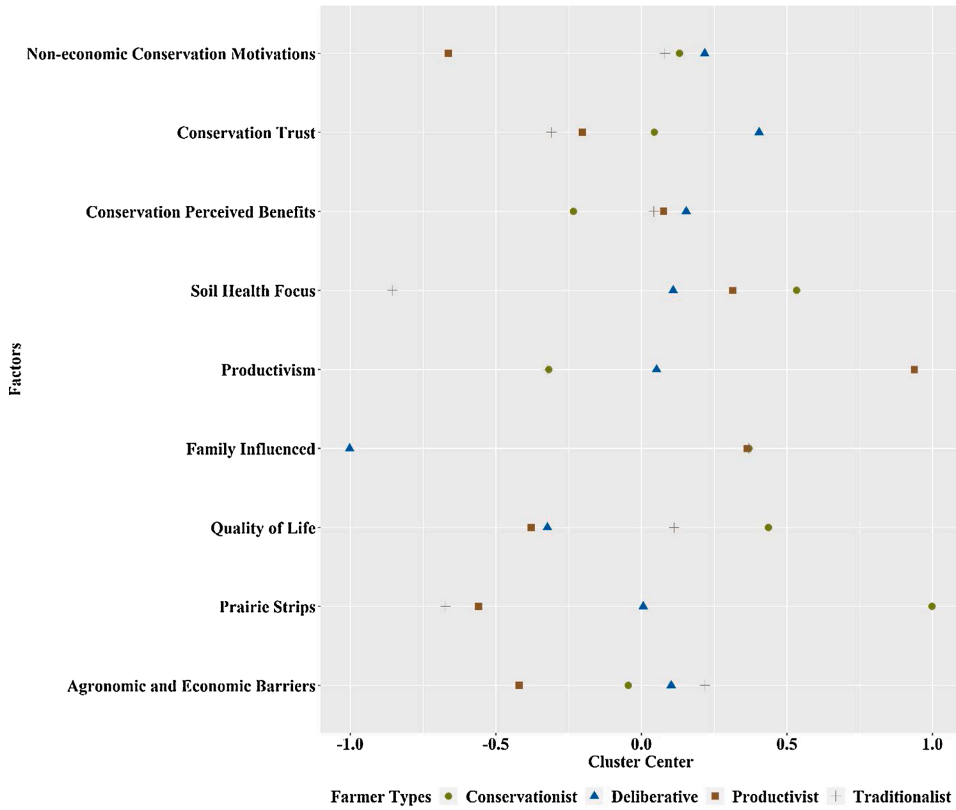

Fig. 2. Final cluster centers (mean for nine different factors within each final cluster) for the four-cluster solutions (K-means method).

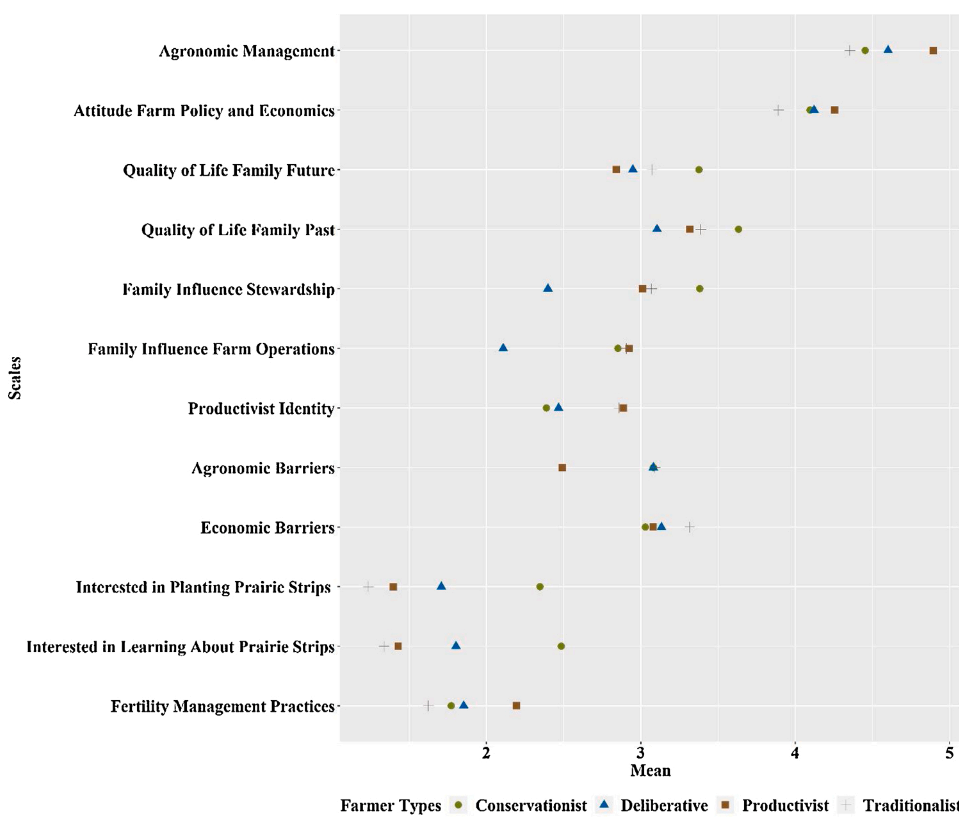

Fig. 3. Mean scores for Conservationist, Deliberative, Productivist, and Traditionalist farmer types on the 12/26 scales entered into PCA, including input-intensive agronomic management scales, attitudinal and beliefs scales other characteristics related to conservation practices.

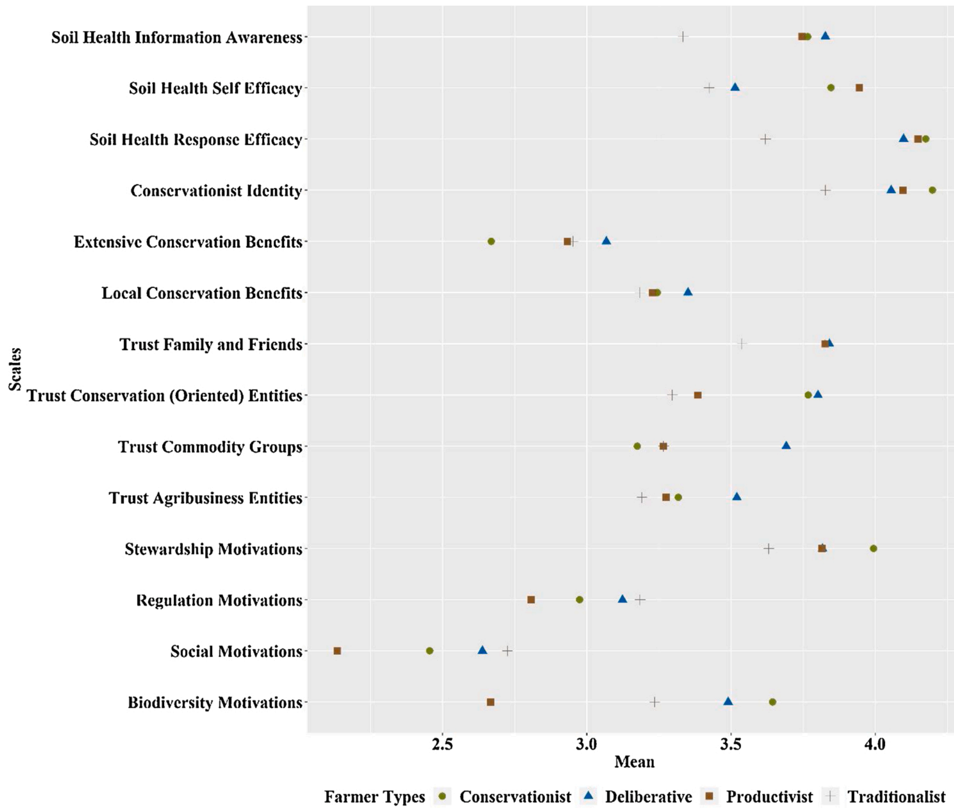

Fig. 4. Mean scores for four farmer types: Conservationist, Deliberative, Productivist, and Traditionalist on the 14/26 scales entered into PCA including soil and water conservation motivations, trusts in formation sources, soil health perspectives other characteristics related to conservation practices.

In-depth examination of mean scores on the variables that underlie each of the factors (Figs. 3 and 4) provides further clarifying information. This group scored second highest on all of the motivation scales, suggesting that their conservation motivations are diverse (Fig. 4). They scored highest on all of the conservation trust items, indicating that they trust agribusiness entities, commodity groups, and conservation groups, and family and friends alike for information about soil and water conservation (Fig. 4). They also had the highest self-rating of both benefits of conservation practices scales, meaning that they tend to believe more strongly in both the local and extra-local conservation benefits of the practices they employ on the land they farm than the other groups. On the other hand, although they had the highest score on the soil health information awareness item, they had the second lowest scores on both of the soil health efficacy variables and on the conservationist identity scale, and second highest on the economic and agronomic barriers scales (Figs. 3 and 4). Considering all of these results together, this group appears to be favorably disposed toward conservation, but also "deliberative," perhaps weighing perceived agronomic and economic impediments against conservation benefits more than other groups. Their scores on past and future quality of life were the lowest and second lowest, respectively.

3.2.3. The Productivists

The defining characteristics among farmers in the "Productivist" cluster are the highest mean score on the productivism component, the lowest score on the non-economic conservation motivations factor, and the lowest score on the agronomic and economic barriers factor (Table 1, Fig. 2). Other notable results are the second-lowest score on the conservation trust factor, the second-lowest score on the prairie strips factor, and the lowest score on the quality of life factor (Table 1, Fig. 2). Thus, farmers in this group tended to place more emphasis on the productivist elements of the good farmer identity scale items such as having the highest yields, the latest seed and chemical technology, and the newest equipment as signifiers of what makes a "good farmer" (McGuire et al., 2015).

Similar to the other clusters, a close look at the means for the individual variables that make up the factors provides a more nuanced characterization of the Productivist cluster. As would be expected, they had the highest mean scores on the productivist identity and the input-intensive agronomic and fertility management scales (Fig. 3). They also placed relatively little importance on non-economic conservation motivations, having the lowest scores on the biodiversity, social, and regulation motivations scales and second lowest score on the stewardship scale (Figs. 2, 4, 5). The productivists reported the second lowest levels of trust in conservation information from all entities (Fig. 4). They also expressed the second-lowest levels of interest in the innovative prairie strips practice. Taken together, these results indicate that farmers in this cluster tend to be highly focused on productivity and less conservation-oriented than other groups.

Two notable results reference quality of life and farm well-being. The Productivist farmers scored lowest on the quality of life factor (Table 1, Fig. 2), indicating lower life satisfaction than the other groups. They scored second lowest on the past quality of life scale and lowest on the future quality of life scale (Fig. 3). They also scored highest on the (negative) attitudes toward farm policy and economics scale, indicating concern about the impacts of farm policy and rising input costs on their operations. Together these results signal lower overall satisfaction with their family and work situations.

3.2.4. The Traditionalists

Farmers in the "Traditionalist" cluster stand out not so much for their high scores on the cluster factor score means, which are notable, but for their low scores (Table 1, Fig. 2). Traditionalists had the lowest scores of all groups on the soil health focus factor, the prairie strips factor, the conservation trust factor, and the productivism factor, and the highest scores on the agronomic and economic barriers and the family influence

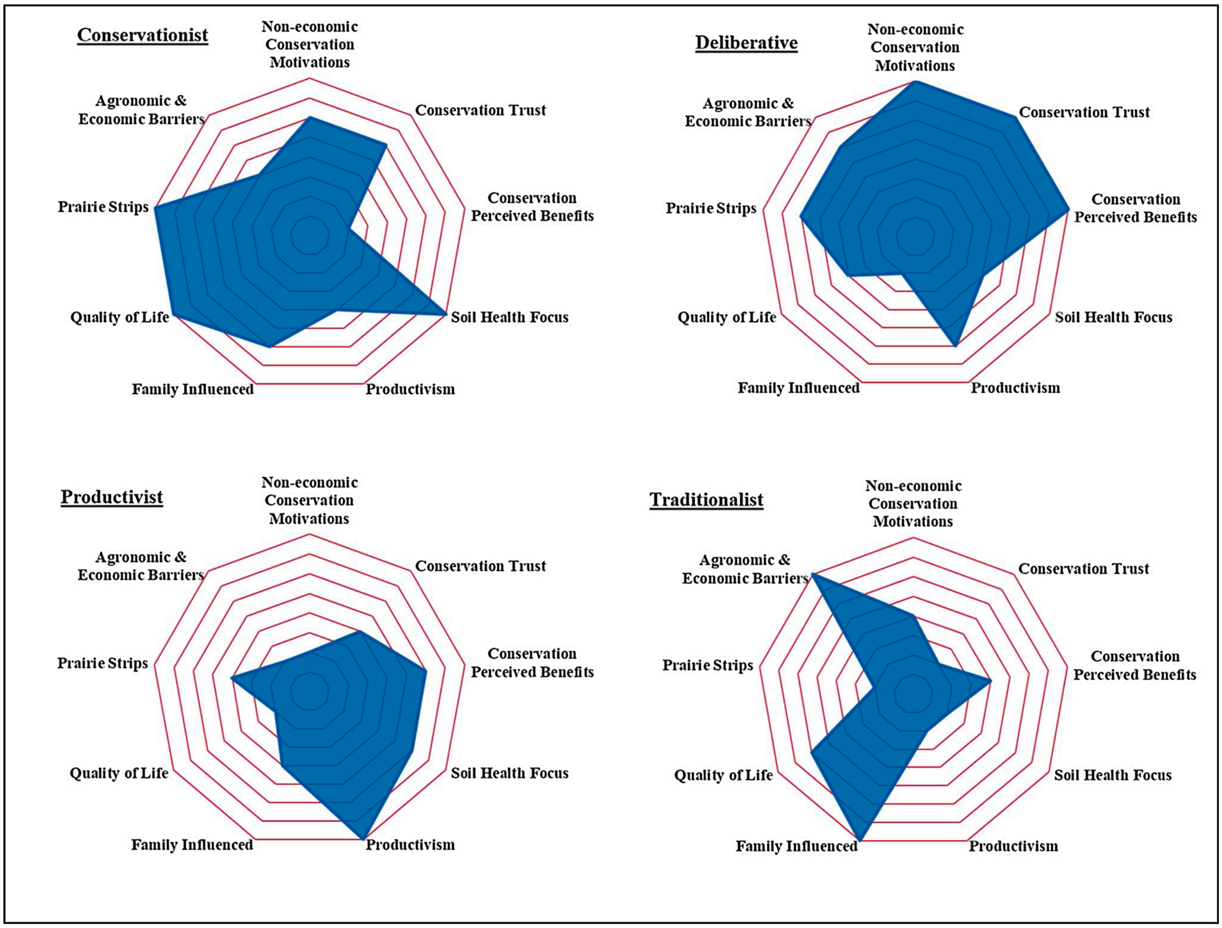

Fig. 5. Radar diagrams showing the cluster rank for each category of variables by standardized mean factor scores.

factors (Table 1, Fig. 2). Scores on the underlying variables show that the Traditionalists had the lowest scores on 14 out of the 26 scales that were analyzed with PCA (Figs. 3 and 4). They had the lowest score on the stewardship motivation and conservation identity scales, were least trusting of state agencies, agribusiness firms, and family and friends as sources of conservation information, and they perceived the highest levels of agronomic and economic barriers to conservation practice adoption (Figs. 3 and 4). They had the lowest scores on all of the soil health and prairie strips scales. They had the lowest scores on the agronomy and fertility management scales, and second lowest score on the productivist identity scales.

On the high side, the Traditionalists had the highest scores on the social and regulatory conservation motivations scales, meaning that neighborhood expectations and potential regulations were most influential in conservation decisions. They had the highest scores on both the economic and agronomic barriers to conservation adoption scales. They had the second highest scores on the influence of previous generations on current actions scales. Thus, overall the traditionalist seems to be defined by what might be characterized as a distrust of and rejection of both conservationist and productivist orientations, perhaps sticking to familial traditions passed down through the generations rather than trying new conservation ideas.

4. Discussion and conclusion

Despite decades of investment in soil, water, and wildlife habitat conservation, loss of biodiversity and degradation of agroecosystem resources and services is still widespread in the U.S. Midwest (Lark et al., 2015; Spivak et al., 2011) and by some measures is getting worse (Moore et al., 2019; Secchi and Mcdonald, 2019). The state of Iowa and its highly productive agroecosystems is a leading contributor of nutrient load to Gulf of Mexico and resultant hypoxia (Rabalais et al., 2002) and is also losing soil and soil organic matter at unsustainable rates (Rabotyagov et al., 2014).

Because conservation programs in the Midwest (and Iowa) are almost wholly voluntary in nature (Secchi and Mcdonald, 2019), progress toward conservation goals depends largely on farmer actions. Consequently, development of more effective outreach and engagement strategies that motivate increased conservation behavior among farmers is critically important. Our two-stage cluster analysis approach using 109 measures of conservation-relevant attitudes, motivations, and identity constructs has allowed us to develop a meaningful conservation-orientation typology of Iowa farmers that can be employed to inform engagement strategies.

The four clusters identified—Conservationist, Deliberative, Productivist, and Traditionalist—are highly varied, complex, and distinct. Conservationists have a strong conservationist identity, are highly interested in innovative conservation approaches, and have strong non-economic conservation motivations. They also had the highest self-rated quality of life, both past and future. Productivists are highly focused on yield and profit maximization, and are confident in their capacity to manage for soil health. They are also most concerned about potential negative impacts of farm policy and the economics of commodity production, and report the lowest levels of self-rated future quality of life. The Deliberative group had high levels of trust in sources of conservation information and a high rating of potential benefits from conservation practices, yet low levels of interest in innovative conservation approaches and high levels of perceived agronomic and economic barriers to conservation practice adoption, indicating a potential leaning toward a conservation orientation, but also a reticence, perhaps due perceived lack of economic or agronomic capacity or knowledge/efficacy. Finally, Traditionalists appear to be the least conservation oriented, least trusting of conservation information sources, and perceive the highest levels of agronomic and economic barriers to conservation practice adoption.

We propose that this farmer typology, like numerous similar products of segmentation analyses conducted across the globe to inform public engagement processes (see Chryst et al., 2018), can be employed to guide targeted, nuanced communications and outreach strategies for farmers in Iowa and across the U.S. Midwest. Take, for example, the findings that the Deliberative cluster farmers were most trusting of all conservation information sources and reported relatively high awareness of soil health as a concept, yet they reported lower confidence in their capacity to manage for soil health and also had high perceived agronomic and economic barriers (Figs. 2–5). This points to a gap between awareness and capacity and suggests opportunities for trusted entities to focus outreach on increasing efficacy and addressing barriers, especially around soil health-focused practices. Traditionalists, on the other hand, while they also reported high perceived agronomic and economic barriers and low conservation efficacy, were least trusting of all entities except commodity groups. They also had the highest scores on the social (e.g., neighborhood expectations) and regulatory (e.g., comply with farm program requirements) motivations (see S2). Considering these factors together suggests that engagement strategies employing local opinion leaders, particularly those connected with commodity groups, might be effective with Traditionalist farmers.

The primary goal of audience segmentation is to inform the development and dissemination of targeted messages to specific subgroups of a given population (Hine et al., 2014). Our results provide a detailed understanding of between-group differences on key conservation-related attitudes, values, beliefs, and similar measures that point to many potential communication strategies. That said, as with most segmentation analyses, our measures are primarily unobservable characteristics, which can make identification of members of a given segment a challenge (Arbuckle et al., 2017). For example, Arbuckle et al. (2017) found that segments that showed high between-group differentiation on variables such as attitudes and perceived risks were not appreciably different on variables such as farm enterprise characteristics and land management practices. Such lack of tangible characteristics that could be used to identify potential targets for segmented communications strategies may present challenges to effective engagement. Thus, further research needs to be conducted to examine how, if at all, the clusters vary in terms of observable characteristics. In particular, hypotheses regarding conservation behavior (i.e., amount and types of conservation practices used by different clusters) should be generated and tested.

From this study, it can be concluded that multivariate statistical techniques combining PCA and cluster analysis are suitable tools for analyzing key variables measuring farmers' attitudes, motivations, and identity constructs and creating typology to inform outreach strategies. Our differentiation of farmer types is an important step toward the development of segmented extension and outreach approaches that target sub-groups of farmers to improve the effectiveness of soil and water conservation programs and increase practice adoption.

CRediT authorship contribution statement

Suraj Upadhaya: Conceptualization, Data curation, Formal analysis, Methodology, Visualization, Writing - original draft. **J. Gordon Arbuckle:** Conceptualization, Methodology, Data curation, Formal analysis, Writing - original draft, Supervision, Funding acquisition. **Lisa A. Schulte:** Conceptualization, Writing - review & editing, Supervision, Funding acquisition.

Declaration of Competing Interest

The authors report no declarations of interest.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.landusepol.2020.105157.

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