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Testing the Affect of Modified Sense of Place, Conservation Ethic, and Good Farmer Identity Measures on Predicting the Adoption of Cover Crops in Working Landscapes in Iowa

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ABSTRACT

While sense of place (SOP) has been used in amenity landscapes to understand pro-environmental behavior, in working landscapes, SOP has not been a valid or reliable predictor for explaining conservation behavior. In this paper, we advance theory on SOP in working landscapes by assessing the relationship between several new and modified sense of place measures and farmer adoption of cover crops in Iowa. We used data from a 2018 survey of Iowa farmers and a Bayesian logistic regression, finding that physical dependence and economic dependence are distinct dimensions of SOP in working landscapes and the addition of a measure beyond SOP of who farmers feel responsible to when making land management decisions provides insights on how social groups are influential in farmers' decision-making. Our results suggest the SOP conceptual framework has the potential to help explain conservation behavior in working landscapes, and identifies opportunities for further reconceptualization and testing.

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Agricultural land; economic dependence; conservation behavior; cover crops; good farmer identity; sense of place

Introduction

In this paper we advance theory on sense of place (SOP) in working landscapes by testing the relationship between new and modified measures of SOP, as well as good farmer identity and conservation ethic, and farm conservation practice adoption in Iowa. Understanding why farmers adopt conservation practices or not is essential because

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conventional farm management practices have significant impacts on the environment, including soil erosion and water quality impairment (Floress et al. 2018), and in the United States (U.S.) adoption of conservation practices is to a large extent voluntary (Ranjan et al. 2019). Because of the voluntary nature of conservation practices, a large multi-disciplinary body of literature has examined the influence of motivations, barriers, and other factors on farmer conservation decision-making in an effort to help design programs and policies to promote conservation practice adoption (Wilson, Hu, and Rahman 2018). Despite this extensive research, two recent comprehensive reviews of U.S. farmer conservation decision-making literature found there have been few theoretical frameworks or individual factors which consistently explain farmer adoption of conservation behaviors (Prokopy et al. 2019; Ranjan et al. 2019).

Given the inconsistent results of past research (Prokopy et al. 2008; Prokopy et al. 2019; Ranjan et al. 2019), some researchers have turned to the SOP conceptual framework—defined as the affective, cognitive, and functional relationships and bonds people have with places (Jorgensen and Stedman 2001; Low and Altman 1992; Masterson et al. 2017; Rajala et al. 2020)—to provide insight into factors shaping farmer voluntary adoption of conservation practices. As such, place encompasses both a physical setting as well as human experiences of and interpretation of that physical setting (Jorgensen and Stedman 2011). Research in amenity landscapes has shown individuals with high levels of SOP have higher levels of environmental concern and engage in more pro-environmental behavior (Brehm, Eisenhauer, and Stedman 2013; Cross et al. 2011; Eaton et al. 2018). However, studies applying SOP in working landscapes, or spaces where ranchers, farmers, and other land managers produce economic goods and services while providing environmental benefits in a synergistic fashion, have been less consistent in demonstrating this relationship (Cross et al. 2011; Eaton et al. 2018; Eaton et al. 2019; Mullendore, Ulrich-Schad, and Prokopy 2015; Plieninger et al. 2012).

To overcome the challenges researchers have encountered operationalizing the SOP concept in working landscapes, Eaton et al. (2019) proposed new and modified SOP survey items designed to better measure the emotional and cognitive bonds and functional dependencies farmers have with the land where they live and work. They also suggested incorporating additional related but distinct concepts to studies that test SOP as SOP alone seems insufficient for explaining farmer behavior. Specifically, Eaton et al. (2019) identified three opportunities for modifying SOP. First, they suggest reconceptualizing and modifying SOP measures to better capture the unique relationship between working landscape actors and working landscapes by differentiating between physical and economic dependence and centering these modified measures within the functional relationship farmers have with working landscapes. Second, they suggest adding questions designed to capture the conservation ethic of farmers as a complementary concept to SOP, because early research on pairing a conservation ethic measure with SOP measures has been positive (Eaton et al. 2019; Roesch-McNally et al. 2018). Finally, Eaton et al. (2019) suggest adding a scalar dimension as a complement to SOP research, as previous research was spatially flat and did not consider how conservation behavior varies across scale. Specifically, they argued that this scalar dimension should focus on the scalar aspects of farmer conservation ethics by examining who they feel responsible to when making decisions.

The goal of this paper is to empirically test whether these modified measures of SOP and the additional, complementary concepts proposed in Eaton et al. (2019), provide theoretical advances for both measuring the SOP concept and better predicting conservation behavior than do previous measures. To do this, we use data from the 2018 Iowa Farm & Rural Life Poll and a Bayesian logistic regression to answer the following question: How do multiple dimensions of SOP and complementary concepts in working landscapes shape the adoption of conservation behavior? We employ cover crops as our outcome variable, cover crops are a conservation practice increasingly encouraged and socially acceptable as a means to build soil health and environmental and economic benefits (Bressler et al. 2021; Clay et al. 2020; Roesch-McNally, Arbuckle, and Tyndall 2017).

Literature review

Previous research seeking to understand farmer conservation behavior has mostly relied upon rational actor models (Peterson and Isenhour 2014) focused on individual level factors (Prokopy et al. 2019) or the theory of reasoned action (Fishbein and Azjen 2011; Floress et al. 2018; Prokopy et al. 2019). This means the theories and frameworks used to predict farmer conservation decisions may fail to adequately account for the complex interaction of scale, markets, institutions, identity, and policy that influence farmer behavior (Carlisle 2016; Reimer and Prokopy 2014; Prokopy et al. 2019). Additionally, individual-level factors inadequately capture the social, political, and economic context decisions are made in (Reimer amd Prokopy 2014).

The limitations of previously used theories and frameworks are demonstrated by the inability of previous research to identify individual variables or frameworks that consistently predict conservation behavior across studies. The SOP conceptual framework is one potential tool, in addition to previously predictive frameworks, for better understanding farmers' conservation attitudes and behaviors. SOP is typically conceptualized as including three sub-components: place identity, place attachment, and place dependence (Eaton et al. 2018; Jorgensen and Stedman 2001; Low and Altman 1992). Place identity describes how much a place, and the associated physical environment, is part of how a person sees themselves or wants others to see them (Eaton et al. 2019; Jorgensen and Stedman 2001; Proshansky 1983; Williams and Vaske 2003). Place attachment is the positive affective bond between a person, or group, and a place (Amsden, Stedman, and Luloff 2011; Eaton et al. 2019; Jorgensen and Stedman 2001). Place dependence describes a functional relationship between an individual and place and reflects how well a place provides a person with the ability to achieve goals or desired outcomes compared to other locations (Eaton et al. 2019; Jorgensen and Stedman 2001).

However, the SOP framework was originally developed and used to explore the affective, cognitive, and attitudinal relationship between humans and amenity landscapes—landscapes valued and used for the esthetic and recreation opportunities the land provides (Brehm, Eisenhauer, and Krannich 2004; Gosnell and Abrams 2011; Trentelman 2009). Thus far, its application on working landscapes, where an individual's livelihood is tied closely with land use, has met little success. Researchers have struggled to (1) validly and reliably operationalize the SOP measures developed in amenity landscapes in working landscape settings; and (2) provide evidence that traditional SOP measures have a clear relationship with conservation behaviors (Eaton et al. 2019). This is perhaps not surprising given that farmers' relationships with and use of their land are functionally and affectively different from the relationships people living in amenity landscapes have with their land (Eaton et al. 2019; Plieninger et al. 2012).

Efforts to operationalize the SOP constituents described above on working landscapes have encountered several primary challenges. First, place dependence, as defined in amenity landscapes, has repeatedly failed to capture the functional dependencies farmers have with working landscapes (Cross et al. 2011; Masterson et al. 2017; Mullendore, Ulrich-Schad, and Prokopy 2015; Rajala et al. 2020). Functional dependence measures how the characteristics of a landscape allow a person to pursue their livelihood and economic intentions (Eaton et al. 2019). Eaton et al. (2019) suggested adding a measure of economic dependence to the place dependence construct to capture functional dependencies on working landscapes. However, economic dependence on working landscapes has been difficult to capture in previous research, despite attempts to measure it across working landscapes and conservation behaviors (Cross et al. 2011; Mullendore, Ulrich-Schad, and Prokopy 2015).

Nor does economic dependence capture the entirety of a farmer's dependence on working landscapes. Place dependence provides a measurement of how well a physical landscape allows a person to achieve their goals and do what they enjoy most (Jorgensen and Stedman 2006). Previous studies did not find a relationship between place dependence and conservation behavior (Mullendore, Ulrich-Schad, and Prokopy 2015). However, previous research used measurements of place dependence that did not effectively capture the intertwined role of livelihoods with farmer lifestyles. Eaton et al. (2019) proposed several measures to capture the unique physical dependence in working landscapes in which a landscape provides the most biophysical advantages for farmers to meet non-economic goals.

Eaton et al. (2019) also suggest adding a series of conservation ethic questions, separate from the SOP measures, designed to measure the spatial and temporal components of social groups a farmer feels responsible to when making management decisions. They recommend operationalizing conservation ethic across two dimensions, a person's sense of social responsibility to other people, including their norms and intentions, and a person's sense of responsibility to nature, including their beliefs and intentions, with survey items assessing how strongly farmers agree with a range of social reference groups and places across scales. Most previous research using SOP on working landscapes has only considered one scale (e.g., farm, community, or region) (Eaton et al. 2019; Lewicka 2011), with most focus on the farm-scale (Reimer and Prokopy 2014). This single-scale view fails to capture the multifunctional and multi-scalar aspects of farms and farming, as well as how individual farmer identities are embedded in and shaped by wider structural contexts and the collective identities of other agricultural producers and consumers (Naylor et al. 2018). The decisions and behavior of farmers on working landscapes are connected to a broad suite of larger social, economic, environmental contexts (Prokopy et al. 2008; Reimer and Prokopy 2014). Accordingly, farmer identity and behavior are affected by whom they feel responsibility toward and believe will benefit from their actions, as well as the social groups individuals identify with and the scale at which those groups operate (Eaton et al. 2019; Wilson, Hu, and Rahman 2018). By adding questions about the spatiality of farmer's conservation ethic, we address these multi-scalar influences on farmer decision-making. While Eaton et al. (2019) suggest considering two dimensions of conservation ethic along with SOP, we focus only on social responsibility, or the social norms that farmers feel expectations to follow in relation to different social groups.

While SOP provides a potential framework to understand farmer adoption of conservation behavior, its narrow conceptualization of identity fails to consider how farmers perceive their role in society and how their ideas about what makes a person a good farmer may lead to particular management orientations. Considering this, we included the concept of good farmer identity, a concept that is distinct from SOP and the identity that the modified measures of SOP aim to capture. Farmer identities are tied to broader social ideas of what constitutes a good farmer, and farmers want to both self-identify as and be viewed by others as good farmers (McGuire et al. 2015). Our inclusion of the good farmer concept recognizes that farmer identities are not only tied to places and the land (as the place identity concept theorizes identity) but are also tied to broader cultural ideas about farmers' role in society and what their social responsibilities are, thus recognizing that identity is both an individual and collective marker. The collective aspects of identity are crucial to consider when looking at farmer conservation behavior and other collective action enterprises because, much like our scalar conservation ethic measures, they capture both how social norms and who farmers feel responsible toward and for what shape their behavior (Naylor et al. 2018). We included measurements of good farmer identity as a complement to SOP to better account for these multiple types of identity that shape farmer conservation attitudes and behavior beyond how the physical and symbolic attributes of places are linked to a person's sense of self (Devine-Wright 2009).

Two major good farmer identity constructs—productivist and conservationist—both have been shown to be important predictors (negative and positive, respectively) of pro-environmental perspectives and behaviors (Arbuckle 2013; Burton 2004; Lequin, Grolleau, and Mzoughi 2019; Schwab, Wilson, and Kalcic 2021; Sulemana and James 2014; Vaske et al. 2018). The productivist good farmer identity construct emphasizes production-oriented concepts such as maximizing yields and profit. In contrast, the conservationist good farmer identity construct privileges environmental stewardship and the long-term health of the land (McGuire, Morton, and Cast 2013; McGuire et al. 2015).

In sum, to address the challenges described above, Eaton et al. (2019) proposed changes to modify existing SOP dimensions, including: (1) adding economic dependence to capture aspects of functional dependence not present in the place dependence concept; (2) modifying measurements of place dependence to be more applicable to the working lands context; and (3) incorporating the concept of conservation ethic to account for the spatiality of social groups a person identifies with and feels responsible to when making management decisions. The goal of this paper is to empirically test whether the new and modified measures of SOP proposed in Eaton et al. (2019), along with existing good farmer identity measures (McGuire et al. 2015) and measures of conservation ethic, better capture the multiple dimensions of SOP in working landscapes and their relationship with conservation behavior than previous studies.

Methods

Study site

The data we use in this study were collected in the U.S. state of Iowa. Iowa and the broader upper-Midwest are known for fertile soils that support large-scale corn and soybean production (Arbuckle 2013; Roesch-McNally, Arbuckle, and Tyndall 2017). Eighty-four percent of the land base in Iowa is classified as agricultural by the United States Department of Agriculture (USDA), and the agricultural industry there employs 216,700 people (NASS 2017). Additionally, Iowa is a leading U.S. producer of corn, soybeans, hogs, and other commodities (NASS 2017). However, soybean and corn production practices contribute to soil erosion through the removal of organic material, erosion due to tilling practices, soil nutrients leaching (King, Williams, and Fausey 2016), and nitrogen and phosphorus runoff detrimental to watershed health. For example, nutrient loss from Iowa is a major contributor to hypoxia in the Gulf of Mexico (Jones et al. 2018; Roesch-McNally, Arbuckle, and Tyndall 2017). In addition, recent changes in weather patterns and extreme weather events partly caused by climate change in Iowa compound the negative environmental effects of soil and corn production on soil health (Arbuckle 2013). As such, the state has been the focus of major efforts to reduce nutrient losses, and cover crops has been heavily promoted as an effective practice to lessen the negative effects of corn and soybean agriculture on the environment (INRS 2020).

Survey and response rate

We used data from the 2018 Iowa Farm and Rural Life Poll (IFRLP) survey, a longitudinal panel survey conducted since 1982 by the Iowa State University Sociology Extension program through a partnership with the USDA National Agricultural Statistics Service (NASS). The original sample was drawn from the Census of Agriculture master list of farms. Over time, as farmers retired or left the panel for other reasons, NASS has drawn new random samples from the Census master list to maintain sufficient sample size. The annual survey employs a modified Tailored Design Method (Dillman, Smyth, and Christian 2014) approach that follows a survey-postcard-survey mailing protocol. The first mailing, in mid-February 2018, was accompanied by an introductory letter that explained the purpose of the survey. A reminder postcard was sent to non-respondents approximately two weeks later, and a final survey was mailed to remaining non-respondents in late March. The 2018 survey was mailed to 2,227 Iowa farmers. Of these, 137 were determined to be ineligible because the recipients no longer farmed, were deceased or retired, or were otherwise ineligible, leaving an eligible sample of 2,115. In total, 1,061 usable surveys were returned for a 50% response rate. Because cover crops are promoted primarily among farmers who produce corn and soybean, we only include farmers who reported growing corn or soybean in the previous year in our analyses, resulting in a final sample of 726.

The IFRLP survey generally contains questions about quality of life, farm and financial well-being, soil and water conservation practices use, and socio-demographics. In

2018, the survey included a series of questions developed as part of the research effort described in Eaton et al. (2019). These questions comprised modified SOP measures, the social responsibility concept, as well as questions designed to measure good farmer identity.

To assess non-response bias, we compared our respondent profiles to the target population across several farm characteristics using data from the 2017 Census of Agriculture. The comparison showed a slight bias toward older farmers in the IFRLP sample, likely due to the longitudinal survey method used (Arbuckle 2013), and a slight bias toward larger-scale farmers.

Variable measurement and modeling approach

In our below results section, we present results from a Bayesian logistic regression model to assess how SOP, good farmer identity, and conservation ethic influence farmer adoption of cover crops. All survey items used in our analysis are shown in supplementary Table 1. Answering our research question required two stages of data analysis. First, because there were high correlations between many of the individual, observed variables within each of our constructs of interest, we used the p*sych* package in R to conduct confirmatory factor analysis (CFA) on each question set to measure the hypothesized latent dimensions underlying our data (Brown and Moore 2012). We based the number of factors chosen for each CFA on Eaton et al. (2019) review of SOP on working landscapes and previous literature on good farmer identity (Arbuckle 2013; Roesch-McNally, Arbuckle, and Tyndall 2017). We used a promax rotation because it allows for high correlation among individual items and maximizes dispersion, meaning a small number of observed variables load strongly on each factor (Brown 2009). To measure the internal consistency of each identified factor, we used Cronbach's alpha, for which scores of >.70 are considered to be reliable (Nunnally and Bernstein 1994). Following the CFA, we computed Bartlett factor scores to determine the location of each survey respondent on the factor. Before describing the second stage of data analysis, we describe how our predictor and outcome variables were measured and generated. As part of this, we present the results of our CFA (see Table 1) here rather than in our results section, because the generated factors are predictor variables in our model.

Sense of place

To measure SOP, we asked respondents to indicate their level of agreement with 15 statements developed in Eaton et al. (2019) designed to measure five dimensions of SOP, place attachment, place identity, social identity, economic dependence, and place dependence. Each question used a four-point agreement scale, ranging from 1 = strongly disagree to 4 = strongly agree. We hypothesized that the SOP survey items would factor into five latent variables that correspond with the five dimensions outlined above. Based on our factor analysis and previous literature, we identified three distinct dimensions of SOP, though they did not correspond perfectly to our hypothesized factors (Table 1).

Table 1. Factor analysis results.

		Factor							
	Survey item	1	2	3	4	5	6	7	8
Sense of Place	When I think of home, I think of the land I farm.	.53							
	I feel happiest when I am on the land I farm.	.53							
	The land I farm is my favorite place to be.	.53							
	If I could farm anywhere in the world, it would be the land I farm now.		.50						
	Even though there might be better places to farm, I would rather farm in the area where I farm right now.		.61						
	Farmers in the area where I farm generally have beliefs and values similar to mine.			.50					
	I have a trusted network of people I talk with about farming in the area where I farm.			.50					
Social Responsibility	I feel responsible to … myself … when conserving the soil and water resources on the land I farm.				.54				
	… my immediate family …				.60				
	… my neighbors …					.50			
	… people in the area where I farm …					.54			
	… everyone on planet earth …						.55		
	… future generations …						.60		
Good Farmer Identity	A good farmer is one who … puts long-term conservation of farm resources before short-term profits							.63	
	… scouts before spraying for pests/weeds/disease							.55	
	… minimizes soil erosion							.62	
	… considers the health of streams that run through or along their land to be their responsibility							.72	
	… minimizes nutrient runoff into waterways							.74	
	… maintains or increases soil organic matter							.61	
	… has the highest yields per acre								.61
	… gets their crops planted first								.59
	… has the highest profit per acre								.56
	… uses the latest seed and chemical technology								.60
	… the most up-to-date equipment								.64
	Cronbach's Alpha	.90	.90	.90	.90	.89	.90	.85	.86

[a]1: Attachment and identity, 2: Physical place dependence, 3: Social networks, 4: Family, 5: Local, 6: Global, 7: Conservationist, 8: Productivist. [b]Oblique promax rotation.

Social responsibility

To measure social responsibility, we asked respondents to indicate their level of agreement with eight statements designed to measure social responsibility. Each question used a four-point responsibility scale, ranging from 1 = not at all responsible to 4 = very responsible. We hypothesized the social responsibility survey items would factor into three latent variables at family, local, and global scales, which was supported by our CFA (Table 1).

Good Farmer identity

To measure good farmer identity, we employed 15 statements taken from the good farmer literature (McGuire, Morton, and Cast 2013, McGuire et al. 2015). Each item was rated on a five-point importance scale ranging from 1 = not important at all to 5 = very important. We hypothesized the good farmer identity items would factor into two latent variables corresponding to the concepts of productivist identity and conservationist identity (Arbuckle 2013), which was supported by our CFA (Table 1).

Economic dependence

Because economic dependence did not load onto our derived SOP factors, we included it in our model as a standalone variable to enable testing hypothesis 4 in Table 2. To measure economic dependence, we asked respondents to rate their agreement, 1 = strongly disagree to 4 = strongly agree, with the following statement: the land I farm is important to my economic well-being.

Control variables

To account for the influence of variation in land use, land ownership, and sociodemographic characteristics on our response variable, we included several control variables based on findings from previous literature (Prokopy et al. 2019). The variables were age, income from farming, type of crops grown, whether respondents produced livestock, and whether respondents rented farmland. Descriptive statistics for our control variables are displayed in supplementary Table 2.

Table 2. Hypothesized relationships.

	Variable	Relationship to cover crop adoption	Citations
	Sense of place		
1)	Place attachment & identity	Positive	Mullendore, Ulrich-Schad, and Prokopy (2015); Cross et al. (2011)
2)	Physical place dependence	Negative	Mullendore, Ulrich-Schad, and Prokopy (2015); Eaton et al. (2019)
3)	Social Network	Positive	Church and Prokopy 2017
4)	**Economic Dependence**	Negative	Cross et al. (2011)
	Social Responsibility		
5)	Family	Negative	Eaton et al. (2018)
6)	Local	Positive	Eaton et al. (2018)
7)	Global	Positive	Eaton et al. (2018)
	Good farmer identity		
8)	Conservationist	Positive	Roesch-McNally et al. (2018)
9)	Productivist	Negative	Roesch-McNally et al. (2018)

Outcome variable

Our outcome variable for the Bayesian logistic regression model was a binary measure of cover crop use. Respondents were assigned a value of one if they had grown cover crops in 2017 and a value of zero if they had not. The relationships we hypothesized between latent and other predictor variables and our outcome variable are displayed in Table 2.

Statistical modeling

Bayesian logistic regression

Following the factor analysis, the relationship between the identified latent variables and cover crop adoption was analyzed using a Bayesian hierarchical logistic regression model. This allows for robust estimation of both the regression coefficients and the controls even in cases where there are few observations (i.e., partial pooling), characterization of the uncertainty associated with those partially pooled results by sampling the entire posterior distribution rather than estimating single point estimates, and prior information to prevent implausible results. We used a Bayesian logistic regression with Hamiltonian\Monte Carlo (HMC) sampling to estimate the influence of our SOP, good farmer, and social responsibility latent variables, as well as economic dependence, on cover crop adoption while controlling for socio-demographic categories that may affect the likelihood of cover crop adoption. The model was fit using Stan, a Bayesian computational language accessed via the R package *rstanarm* (Goodrich et al. 2020). We ran four chains for 2000 iterations (1000 warmup) each. We used weakly informative priors (i.e., Normal ($\mu = 0$; $\sigma = 2.5$) for both the intercepts and regression coefficients (0, 2.5), which is a conservative, but flexible, approach that allows for exploratory analysis (Fraser et al. 2010; Lemoine 2019).

Model fit

We visually assessed trace plots for convergence of the Markov chains. Converged trace plots will show multiple chains scattering around a mean value, or mixing (Jackman 2009). All trace plots were well-mixed and stable, indicating that the Markov chains had converged. We assessed goodness of fit of the binary logistic regression model by examining and evaluating the area under the receiver-operating curve (AUC) (Robin et al. 2011). AUC is a model fit measurement that indicates how well a model is at distinguishing between outcomes, with higher AUC scores indicating better discrimination between classes (Zipkin et al. 2012). An AUC >0.75 is generally regarded as a good model fit as this indicates that 75% of the time a model will predict an outcome correctly (Williamson et al. 2020). Our model had an AUC of .70, which indicates that 70% of the time our model will accurately predict whether a farmer adopted cover crops.

Strength of association of individual predictors

To assess the strength of evidence that a predictor in our model was strongly associated with cover crop adoption, we calculated the proportion of the posterior probability mass that exceeded zero for each of the model's predictor variables. We considered the strength of a predictor to be a function of its magnitude and the uncertainty associated with that magnitude. Rather than using traditional frequentist confidence intervals which assume symmetrically distributed uncertainty, we rely on the posterior predictive mass which leverages the full posterior distribution of our models. This approach allows us to ask not just whether the tail of the estimate crosses zero, but rather how much of the posterior distribution overlaps zero. When $>$ either 0.90 or $<$0.10 of the posterior predictive mass for the regression coefficient ≥ 0, we considered that predictor to be strongly positively or strongly negatively associated with the response variable, respectively. With weakly informed priors, posterior proportions $>$0.9 equate to odds ratios of $>$10, which are evidence of strong positive associations, and posterior proportions $<$0.10 are equal to odds ratios of $<$.10, which are indicative of strong negative associations (Jeffreys 1961; Williamson et al. 2020). When the posterior predictive mass for a regression coefficient was close to but did not quite meet these parameters, we described the relationship as strong but uncertain. We also provide marginal effects plots to illustrate how changes in each predictor impacts the outcome variable to further characterize the role of each predictor in cover crop adoption.

Results

Of the 726 respondents who answered the question asking them to indicate if they grow or planned to grow cover crops, 21% reported having planted cover crops on at least some of the land they farmed. Figure 1 presents the Bayesian logistic regression results and model fit statistics and visually represents the marginal effects of each of our predictor variables on cover crop adoption.

For the three sense of place latent variables, we found support for our hypothesized positive association between attachment and identity and cover crop adoption, with our models showing a strong but uncertain relationship between the two (Figure 1). Our hypothesized negative association between physical dependence and cover crop adoption was also supported with a strong but uncertain negative association. As shown in Figure 1, as physical place dependence scores increase the probability of a farmer adopting cover crops decreases. In contrast to our hypothesized positive association between social networks and cover crop adoption, we did not find an association between these two variables. Finally, in contrast to our expectation that farmers who indicated they were more economically dependent on farming would be less likely to grow cover crops, we found a strong but uncertain positive association between economic dependence and cover crop adoption.

For our three social responsibility latent variables, as we hypothesized, we found that a sense of social responsibility to one's family had a strong but uncertain positive association with cover crops and that a sense of social responsibility to the global scale had a strong positive association with cover crop adoption. In contrast to our hypothesis, we found a sense of social responsibility to local people had a strong negative association with the adoption of cover crops.

For our good farmer latent variables, we hypothesized a negative association between productivist farmer identity and cover crop adoption and a positive association between

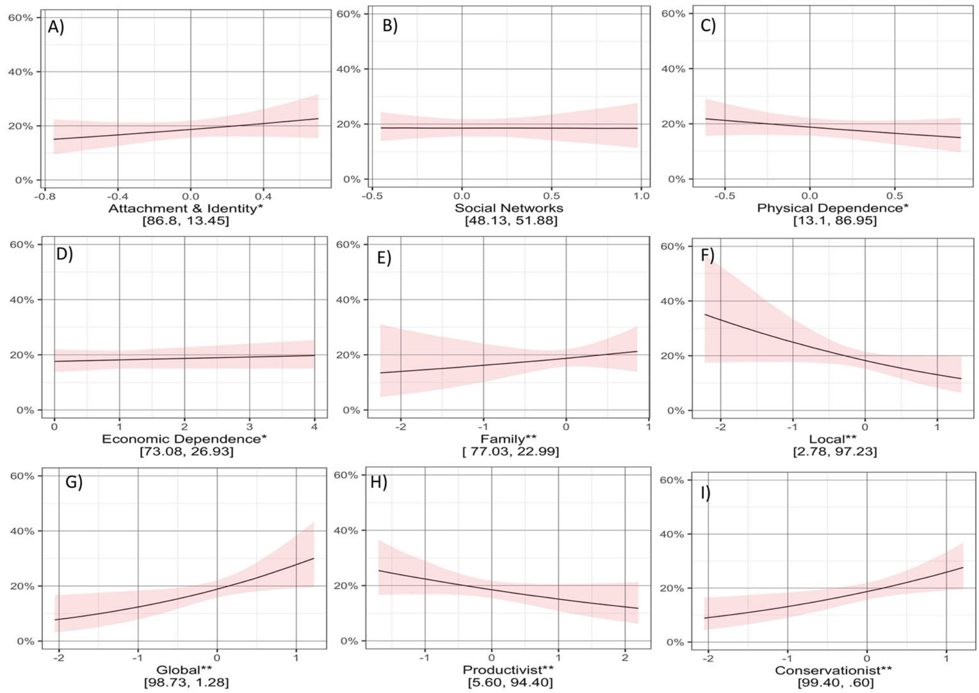

Figure 1. Marginal effect plots with posterior proportions displayed below. Posterior proportions >0.9 equate to odds ratios of >10, which are evidence of strong positive associations, and posterior proportions <0.10 are equal to odds ratios of <0.10, which are indicative of strong negative associations. **Strong association, *Strong but uncertain association.

conservationist farmer identity and cover crop adoption. Both of these hypotheses were supported with a strong negative association between productivist farmer identity and the probability of a farmer adopting cover crops and a strong positive association between conservationist farmer identity and the adoption of cover crops.

Discussion

Overall, our results validate Eaton et al. (2019) call for the development and use of SOP measures tailored to working landscapes, while also suggesting that the continued refinement of the measures is needed to validly and reliably measure SOP on working landscapes. In the following discussion, we highlight findings that speak to how well these new and reconceptualized dimensions of SOP on working landscapes and related concepts worked and where there is opportunity for improvement. We start by focusing on the findings we see as improving theory.

Physical dependence

In our study, we found two distinct types of place dependence amongst our respondents: physical and economic dependence. Like Eaton et al. (2019), we found items related to livelihood (e.g., “If I could farm anywhere right now, it would be the land I farm") factored into a distinct physical dependence dimension of SOP. Physical dependence measures how a physical landscape allows a person to achieve their goals and do what they enjoy most (Jorgensen and Stedman 2001). Unlike in previous research that showed that physical dependence had association with conservation behavior in working landscapes (Eaton et al. 2018; Mullendore, Ulrich-Schad, and Prokopy 2015), we found a strong (but uncertain) negative relationship between our physical dependence factor and the adoption of cover crops. We suggest the difference is that we used questions, designed to capture the non-economic functional dependence of farmers on their land, that were specific to farming, whereas past studies asked broader questions about dependence on land taken from studies focused on recreation in amenity landscapes. This supports Eaton et al. (2019) suggestion that physical dependence is an independent dimension of SOP on working landscapes that includes both a livelihood and lifestyle component, rather than just the typical lifestyle component used in research in amenity landscapes.

Social responsibility

Following the suggestion of Eaton et al. (2019), we included a measure of conservation ethic in our study to capture the spatial and temporal components that a farmer feels socially responsible to when making management decisions.

Family responsibility

In our factor analysis, we identified a family scale of social responsibility in which farmers were concerned for their own well-being and the well-being of their family. We found a family scale of responsibility had a strong but uncertain positive association with the adoption of cover crops, which contrasts previous research finding a negative relationship between a person having a strong sense of responsibility to their farm and conservation behavior. In their study of perennial bioenergy crop adoption, Eaton et al. (2018) found farmers who "believed their land should only be used to benefit themselves or their families" were less likely to adopt bioenergy crops. We suggest the difference may have resulted from the conservation practice of interest in each study. Planting bioenergy crops in the northeast U.S. is largely done to mitigate climate change and offers low return on investment, thus making their use largely directed at solving global challenges. While cover crops mitigate regional and broader scale water quality problems, they also have more on-farm benefits than bioenergy crops. As such, the different findings between the two studies are likely determined by interactions between the scalar benefits of the conservation practice investigated and the scales of responsibility reported by respondents. The inconsistency of measures of family scale of social responsibility at predicting conservation behavior suggests that while its inclusion in SOP research improves the predictive power of SOP focused studies, further research is needed to understand the relationship between an on-farm scale of responsibility and conservation behavior, and how it influences conservation behavior across different management practices.

Local responsibility

In our factor analysis, we identified a local scale of social responsibility factor we hypothesized would have a positive association with the adoption of cover crops. However, we found the local scale of responsibility was strongly negatively associated with the adoption of cover crops. Previous research has shown a local scale of social responsibility can be negatively associated with conservation practices when farmers have concerns about the environmental and community impacts of a practice (Eaton et al. 2018), although one study in Illinois showed farmers in a small watershed were motivated to implement conservation practices due to a shared goal to improve water quality (Church and Prokopy 2017). In Iowa, conservation districts at that local scale provide information and guidance to farmers regarding farm management practices, such as the adoption of cover crops, and their guidance likely influences what conservation behavior farmers do and do not adopt (Cross et al. 2011; Reimer and Prokopy 2014). Often, the guidance provided regarding farm management is shaped by input by local farmers, which points to the potential importance of social networks in shaping local scales of responsibility and associated conservation behavior (Church and Prokopy 2017; IDALS 2021; McGuire, Morton, and Cast 2013). Additionally, farm management policies can constrain or motivate conservation behavior at a local level. Following previous research, we suggest future studies consider the role of local and regional policies, social networks, and broader agricultural systems in influencing conservation behavior at a local scale (Reimer and Prokopy 2014).

Global

In our factor analysis, we identified a global scale of social responsibility in which farmers were concerned about both the global population and future generations. Consistent with previous research (Eaton et al. 2018), we found a strong positive relationship between a global scale of responsibility and the adoption of conservation practices. Unlike previous studies that analyzed the role of feelings of social responsibility to people and places across the globe in shaping conservation behavior, our measures included a temporal component of concern for future generations. We suggest the reason our temporal responsibility measure factored with the global measure of responsibility may be due to concerns about family farm succession (Eaton et al. 2018; Inwood and Sharp 2012; Keske et al. 2021). Additionally, a concern for the future of the agricultural economy could contribute to these findings (Inwood, Clark, and Bean 2013).

Overall, our results indicate Eaton et al. (2019) suggestion of adding the concept of social responsibility as a complement to SOP studies focused on farmer adoption of conservation behavior in working landscapes can help us understand broader sets of forces than the rational actor or individual-level factors extensively studied in early work that had mixed results. In our study, all three scales of social responsibility were at least fairly strongly associated with the adoption of cover crops. We suggest future SOP studies consider both the spatial and temporal scales of social responsibility that farmers consider when making management decisions.

Good farmer identity

Consistent with previous research (Roesch-McNally et al. 2018), our factor analysis identified conservationist and productivist farmer identities were both strongly predictive of conservation behavior. In particular, and as expected, we found a strong positive association between conservationist farmers and the adoption of cover crops. This finding is consistent with previous research on good farmer identity that found a positive relationship between conservationist identity and conservation behavior (Arbuckle 2013; Burton 2004; Sulemana and James 2014). Likewise, as expected, we found a strong negative relationship between productivist farmer identity and cover crop adoption. The negative relationship we found is consistent with previous studies that have examined how good farmer identity affects conservation practice adoption (McGuire et al. 2015). While these results are unsurprising, they suggest good farmer identity should be included as an additional concept in future SOP studies to expand its conceptualization of identity beyond the traditional SOP definition of how a person wants to be or sees themselves as part of the landscape to include how a person's identity is connected to how they believe a landscape should look and be managed. The following findings offer some improvement to SOP theory.

Economic dependence

In our factor analysis, our measure of economic dependence did not factor in with our other measures of place dependence, supporting the findings of Cross et al. (2011) and Mullendore, Ulrich-Schad, and Prokopy (2015) that together suggest economic dependence is a unique dimension of SOP on working landscapes. Furthermore, we found economic dependence was positively (but uncertainly) associated with cover crop adoption. In previous research, economic dependence has been a particularly troublesome SOP dimension to define and measure. In a study of agricultural landowners in Colorado and Wyoming, Cross et al. (2011) found higher levels of economic dependence were negatively associated with the adoption of conservation easements. In their study of midwestern farmers, Mullendore, Ulrich-Schad, and Prokopy (2015) found economic dependence was not a distinct component of SOP, nor was it encompassed within physical dependence. It also had no association with farmer adoption of various conservation behaviors, including conservation tillage and grassed waterways. Further lending to these inconsistent findings, we found, in contrast to our hypothesized negative association, economic dependence was positively associated with the adoption of cover crops.

We suggest that the discrepancies in the relationship between economic dependence and conservation behavior in each of the three studies that have tested it may be the outcome of the different conservation behaviors each explored and that future research should examine the role of economic dependence in conservation adoption across a wide range of conservation behaviors. Further, while strongly positive, there was a fair amount of uncertainty in the relationship between our economic dependence measure and cover crop adoption, which suggests more research is needed to better understand the role of economic dependence in the adoption of conservation behavior on working landscapes.

Overall, our results support the idea that economic dependence should be included as an additional dimension of SOP on working landscapes in future studies while simultaneously suggesting that a broader conceptualization of economic dependence is likely needed to adequately measure it on working landscapes. We echo Eaton et al. (2019) and Bastian et al. (2020) suggestion for a broader and more valid conceptualization of economic dependence that includes the addition of economic benefits, such as private amenity rents (e.g., pride in ownership), to measurements of economic dependence to capture the complexity of the benefits that working landscapes provide to working landscape actors.

Attachment & identity

We found that unlike on amenity landscapes, attachment and identity did not factor into two separate SOP dimensions (Jorgensen and Stedman 2001; Low and Altman 1992). Rather, consistent with other research on working landscapes (Cross et al. 2011; Mullendore, Ulrich-Schad, and Prokopy 2015), we found attachment and identity were closely related and varied together to comprise one attachment/identity factor that was strongly (but uncertainly) positively associated with the adoption of cover crops. This finding supports the suggestion of Eaton et al. (2019) to reconceptualize SOP dimensions on working lands. In this case, we suggest that on working landscapes attachment and identity together may comprise one independent SOP dimension. It is possible the attachment a person feels to their landscape and the role of the landscape in how they want to be seen and are seen by others are closely related. However, more research is needed across working landscapes and conservation behaviors to identify if attachment and identity consistently comprise one variable and continue to be predictive of conservation behavior.

Social network

Our factor analysis produced a unique variable, social network, that has not been identified in previous research on SOP in working landscapes. Previous research on the conservation behavior of farmers more broadly has found social networks can be associated with the adoption of cover crops (Prokopy et al. 2019). However, it is not clear if our social network latent variable measures a social network dimension of SOP suggestive of how people's relationships with other people in a place shape their relationship to that place, or if it is something different. Additionally, in this study, belonging to a local social network with high trust did not have a relationship with the adoption of cover crops. Considering this, we suggest more research is needed to determine how social networks constitute an element of SOP on working landscapes and when networks play a role in conservation behavior.

Limitations

While this study does contribute to the testing of modified measures of sense of place, there are limitations that need to be addressed. One, our results are limited by the single binary outcome variable of self-reported behavior we chose to use. Future research should test these measures with different outcome variables and compare how these modified measures of sense of place compare across conservation behaviors. Two, the binary nature of our outcome variable is a limitation that future research can address by considering intent to adopt, rather than simply if a person has adopted or not. Additionally, self-reported behaviors can be misreported by respondents, intentionally or unintentionally (Floress et al. 2018). As discussed above, economic dependence was measured with a single survey item. Future research should use more robust measurements of economic dependence.

Conclusion

Farm management practices significantly contribute to soil erosion and water quality degradation. To encourage the voluntary adoption of practices that minimize the negative environmental impacts of farm management practices, governmental and nongovernmental incentives have been used. However, despite incentives, the adoption of conservation practices is not as high as needed, and rates of adoption are difficult to predict. Because of this, researchers have turned to SOP as a framework to better understand what motivates farmer conservation behavior. Using a Bayesian logistic regression, we tested updated measures of SOP specific to working landscapes to test whether these new measures of SOP improve the predictive power for farmer's adoption of cover crops in Iowa. We found a number of modified SOP dimensions were predictive of cover crop adoption. Additionally, we found the value of SOP might be enhanced when paired with additional concepts. As our results show, social responsibility and good farmer identity were both predictive of the adoption of cover crops and indicate additional concepts that have been predictive in previous research can be meaningful additions to SOP research on working landscapes. We suggest extension employees and educators use this research and SOP to encourage farmers to adopt conservation behaviors. However, future research should continue to test the modified measures of SOP with an emphasis on applying the modified measures across conservation practices and landscapes.

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