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Research article

A meta-analysis of agricultural conservation intentions, behaviors, and practices: Insights from 35 years of quantitative literature in the United States

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A R T I C L E I N F O

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A B S T R A C T

Conservation practices (CPs) are integral to maintaining the long-term viability of agro-ecological systems. Because farming systems and farmers' values and attitudes are heterogeneous, factors that consistently predict conservation behaviors remain elusive. Moreover, heterogeneity is present among studies regarding the type of CPs examined, and whether behavioral intentions or actual behaviors were measured. This study considers the characteristics of each CP, and whether a given study measured behavioral intention or actual behavior, to better understand farmers' adoption of CPs. We reviewed and analyzed 35 years (1982–2017) of quantitative conservation adoption literature in the United States. We categorized CPs based on their primary purpose, the type of benefit they provide, and whether they are operational or structural. We also examined the following five CPs: conservation tillage, buffers or borders, soil testing, grassed waterways, and cover crops. In our behavioral intention and actual behavior analysis, we found that attitudinal factors predicted both conservation intention and action (actual behavior), whereas current or previous use of practices only influenced actions, not stated conservation intentions. In our analysis focusing on CP characteristics, we found that having specific knowledge about and positive attitudes toward the CP, adoption of other CPs, seeking and using information, larger farm size, and vulnerable land predicted actual adoption across nearly all CP categorizations. Nuances emerge when comparing predictors of CPs that share a particular characteristic. For example, we found farm characteristics to be comparatively more important in predicting adoption of soil management CPs than nutrient and livestock management CPs, and farmers' stewardship identity to be more important for permanent practices than operational practices.

1. Introduction

Conservation practices are an integral component of agroecosystem adaptation strategies that can help farmers adapt to a changing climate, reduce nutrient losses, and improve water quality while meeting global food security needs (Singh et al., 2020; Uri, 2000; Lal, 2015). Identifying factors explaining farmers' conservation behaviors has been a multi-decadal scholarly enterprise, which has resulted in reviews and meta-analyses (Baumgart-Getz et al., 2012; Knowler and Bradshaw, 2007; Lastra-Bravo et al., 2015; Pannell et al., 2006; Prokopy et al.,

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2008, 2019), and models that can help predict adoption (see, e.g., Kuehne et al., 2017). Whereas the aforementioned studies have attempted to explain farmers' adoption of CPs, scholars have also described and explored the process of farmers' conservation decision-making (Dessart et al., 2019; Carlisle, 2016; Ranjan et al., 2019). Irrespective of the research design and approach employed, the underlying goal of these studies has been to synthesize conservation adoption research to identify factors (Independent Variables or IVs) that help explain farmers' adoption of CPs (Dependent Variables or DVs). However, such reviews have identified few consistent predictors of CP adoption (Prokopy et al., 2019). As Prokopy et al. (2019) note, the complexity of farming systems and farmer decision-making complicates consistently predicting conservation behavior. Moreover, it is important to acknowledge that CPs differ with respect to their key characteristics, including purpose (e.g., soil management, water management) and the type of benefit (e.g., off-farm versus on-farm benefit) that they provide, among others. This raises the question: *do factors that influence adoption differ by practice characteristics?* Relatedly, recent calls for distinguishing between farmers' willingness to adopt CPs (hereafter, behavioral intention or intention) vs. actual adoption (Floress et al., 2018; Ranjan et al., 2019), raises the question: *do factors that influence actual adoption differ from factors that influence intention to adopt?*

To address these knowledge gaps, in this study we build upon earlier papers (Prokopy et al., 2019; Ranjan et al. 2019, 2022) that used a published database (Floress et al., 2019) to review over three decades of quantitative literature (1982–2017) examining conservation adoption in the United States (US). Unlike previous papers using the same database, in this study, we examine factors predicting intention to adopt versus actual adoption, as well as factors predicting actual adoption of CPs that share certain characteristics. Specifically, we categorized CPs by their primary purpose, the type of benefit they provide, and whether they are operational or structural to determine whether factors predicting adoption differ by practice characteristics. Additionally, we examine predictors of the following CPs: conservation tillage, buffers or borders, soil testing and sampling, grassed waterways, and cover crops.

2. Approaches towards understanding conservation behavior – a brief synthesis

Meta-analytic approaches synthesizing decades of conservation behavior literature have contributed to a rich and evolving domain of research around conservation behavior (see Baumgart-Getz et al. (2012) and Prokopy et al. (2019, 2008) for US focused reviews; see Arslan et al. (2022) for an Africa focused review; see Tey et al. (2017) for a review focused on developing countries; see Dessart et al. (2019) for a policy-oriented review focused on developed countries; see Foguesatto et al. (2020), Knowler and Bradshaw (2007), Liu et al. (2018), and Foguesatto et al. (2020) for reviews with a global focus; see Delaroche (2020) for theory-oriented review; and see Pannell et al. (2006) for an integrated review of the conservation adoption literature from several disciplines). Scholars have called for the need to move beyond a predominantly individual-level understanding of conservation behavior by focusing on both individual-level and structural factors (Prokopy et al., 2019), the institutional and governance context of conservation decision-making (Yoder et al., 2019; Ranjan et al., 2019), and understanding social media usage among farmers (Witzling et al., 2021).

Scholars interested in understanding farmers' conservation behavior have also paid growing, but limited, attention to the practice itself. For example, recent studies have focused on understanding adoption of CPs as part of a farm system wherein farmers adopt combinations or portfolios of practices (Rudnick et al., 2021). Church et al. (2020) also employed a systems approach to study conservation adoption wherein farmers may perceive CPs to have synergistic (e.g., cover crop complementing no-till) and subsidiary (e.g., cover crop reducing the need for pesticides) effects. Others have focused on binning CPs under categories such as soil health and nutrient management practices. For example, Carlisle (2016) focused on soil health practices – cover crops, crop rotation, and conservation tillage; Doran et al. (2020) focused on adoption of nine nutrient management practices; and Luther et al. (2020) examined adoption of cover crops and seven other precision agriculture technologies that reduce nutrient loss.

Although these studies highlight scholarly attention to certain attributes of CPs (e.g., practices that help improve soil health, or reduce nutrient loss), there has been a general lack of attention to practice characteristics, especially with respect to whether or not adopting a CP is relatively advantageous for the farmer (de Oca Munguia and Llewellyn, 2020; Reimer et al., 2012; Rogers, 1995), and no clear distinction between behavioral intention and actual behavior. This study systematically categorized CPs by using characteristics of each practice, and compared predictors of intention and actual behavior, to better understand farmers' adoption of CPs.

3. Materials and methods

3.1. Data collection

We used a public database containing peer-reviewed articles, Ph.D. dissertations, M.S. theses, and technical reports focused on adoption of CPs in the US published during the period 1982 to 2017 (Floress et al., 2019). This database contained 166 articles, out of which 126 articles were quantitative and 40 were qualitative. The articles included in the database were original empirical research, i.e., not a review or meta-analysis, and their unit of analysis was at the level of farmer/farm operator. A detailed description of study inclusion criteria, search-and-screen process, and data entry guidelines for this database can be found in Floress et al. (2019). To select and categorize articles for this study, the study team followed a two-reviewer, two-level data entry approach to capture detailed information for all studies, including the exact words that study author(s) used to describe each DV and IV, analysis method (e.g., logistic regression), and analysis results (e.g., variable significance and direction, p-value, group means for adopters vs. non-adopters, regression coefficients, odds ratio, t-statistics, marginal effects, goodness-of-fit statistics, etc.). This paper focuses only on studies that used a quantitative approach ($n = 126$) to examine farmers' actual adoption or intention to adopt CPs.

3.2. Categorization of variables

In order to develop the IV and DV categorization frameworks, the study team met both in-person and remotely across several months. Initial IV categorizations were based on the four categories and associated subcategories in Prokopy et al. (2008). As coding proceeded, more categories emerged, and the categorization framework evolved, resulting in 7 main categories (attitudes, behavior, environmental awareness, information, farm characteristics, operator characteristics, and economic factors) and numerous associated subcategories. We also developed a directional hypothesis for each IV category/subcategory based on previous literature for which a hypothesis was conceptually and methodologically defensible (see Table 1). For a detailed description of the IV categorization process, please refer to Prokopy et al. (2019).

Dependent variables in the database were categorized into the following 5 categories: (1) behavioral measurement type (i.e., actual adoption or intention to adopt), (2) primary purpose, (3) type of benefit, (4) operation and permanency, and (5) extent of coverage in the literature (see Table 2; see Supplementary Material Tables S1–S3 for a detailed description of DV categorizations 2 to 4, including descriptions and examples). For the last DV categorization, we selected the following specific CPs that were included in at least 10 studies from the conservation adoption literature: conservation tillage ($n = 26$), buffers or borders ($n = 13$), soil testing and sampling ($n = 13$), grassed waterways ($n = 10$), and cover crops ($n = 10$). Each CP was assigned to one of the DV subcategories unless a quorum of the study team decided it did not fit

Table 1
Independent variable (IV) definitions and directional hypothesis.

Category	Subcategory	Definition (hypothesized effect)
Attitudes	Environmental	Positive environmental attitudes (+)
	Farmer identity other	Farmer self-identifying primarily as stewardship motivated or otherwise non-financially motivated (+)
	Other program practice	Attitude toward other program/practice than the DV (+)
	Perception climate	Perception of weather/climate (+)
	Program practice	A positive attitude toward the particular program or practice (+)
Behaviors	Other program practice	Adoption of other conservation programs/practices than the DV (+)
	Program practice	Conservation program/practice behaviors closely related to the DV of interest (+)
Economic factors	Capital	Monetary measure of assets or investment into farm; includes access to credit; includes debt-asset ratio (reverse code) (+)
	Income	Higher levels of income, including crop value, etc. (+)
	Income farm	Income from farm (+)
	Willingness to accept	Measure of willingness to accept (WTA), i.e., minimum monetary amount that a farmer is willing to accept to sell (+)
	Yield	Positive yield impact expected (+)
Environmental awareness	Program practice	Knowledge of nonpoint source programs or efforts or practices (+)
Farm characteristics	Acres	Larger farm size (+)
	Diversity	More than one crop in rotation (beyond just corn/soybeans or other crops typically grown together), more than one crop, more than one type of livestock, or livestock and crop. (+)
	Livestock number	Number of livestock (+)
	Row crop	Measures whether a farm grows row crops (+)
	Tenure	Percentage or proportion of operated land that is owned; if field level variable, field is owned; entire farm is owned. If variable is measure of rented land, it is reverse coded. Also a measure of lease security (e.g., written lease) (+)
	Vulnerable	Vulnerable land, e.g., higher levels slope, highly erodible land, pest presence, leaching (+)
	Waterbody	Farm located near a lake, stream or in a river bottom, wetland (+)
Information	Affiliation	Indicates affiliation in an agricultural organization; indicative of simply being a member of organization/s; also captures level of involvement in the organization, but that involvement does not necessarily have anything to do with information seeking/use. For example, being a chair vs. being a secretary in an organization, would both be coded as affiliation (+)
	Sought use	Seeking and/or using information (+)
Operator characteristics	Age	Farmer age (−)
	Farming experience	Years farming (−)
	Formal education	Higher levels of formal education (+)

Note: Only IVs that are of interest in this study are included; adapted from Tables 1–7 in Prokopy et al. (2019).

in any of the subcategories; in this case, CPs were put in a "do not analyze" category.

For each IV to be included in the DV categories analyses – measurement type, primary purpose, benefit type, and operation and permanency – we required the IV to have at least 2 studies and 10 observations along with the necessary data for analysis. For the specific CP analyses, since the number of observations of each CP was much smaller than DV categories, we required at least 2 studies and 5 observations for each IV. An observation referred to a single row in the dataset that contained information (e.g., significance and direction, p-value, regression coefficient, etc.) about a single IV and a single associated DV. For example, if a study contained three logistic regression models to investigate adoption of three CPs and each model has 10 IVs, this resulted in 30 observations for our analysis.

3.3. Data analysis

Data were analyzed using a sign test approach (Bushman and Wang, 2009). This approach was used to test whether or not the direction (positive or negative sign) of an estimated effect size coefficient for each IV category/subcategory was consistent with our directional hypothesis (Arslan et al., 2022; Bushman and Wang, 2009; Prokopy et al., 2019). The number of observations where estimated coefficient signs reported in individual studies agreed with our directional hypothesis were calculated and divided by the total number of observations for a given IV category/subcategory and DV category/subcategory combination. This resulted in the proportion of observations that were consistent with our directional hypothesis. We then calculated a Wilson's 95% confidence interval (CI) (Brown et al., 2001) of the binomial proportion to test whether or not the CI included the value 0.50 (i.e., the probability of a fair coin toss as would be expected by chance alone), which suggested whether or not the proportion of observations consistent with our directional hypothesis was different from 50% of the time as would be expected by chance alone.

$$\widehat{p} = \frac{n_s}{n}$$

$$Wilson's\ 95\%\ CI = \left(\frac{1}{1+\frac{z_{\alpha/2}{}^2}{n}}\right)\left(\widehat{p}+\frac{z_{\alpha/2}{}^2}{2n}\right) \pm \left(\frac{z_{\alpha/2}}{1+\frac{z_{\alpha/2}{}^2}{n}}\right)\sqrt{\frac{\widehat{p}(1-\widehat{p})}{n}+\frac{z_{\alpha/2}{}^2}{4n^2}}$$

Table 2
Dependent variable (DV) categories, subcategories, descriptions, and examples.

DV categorization	DV subcategories	Brief description and examples	N
By measurement type	Actual adoption	Dependent variables that measure actual adoption.	4116 (81)
	Intention to adopt	Dependent variables that measure intention (willingness) to adopt.	309 (15)
By primary purpose	Livestock management	Practices that are mainly related to managing livestock, e.g., prescribed grazing or rotational grazing, fence, water facility (trough or tank), etc.	488 (7)
	Nutrient management	Practices that are mainly related to managing nutrient, e.g., nutrient management plan, commercial fertilizer plan, waste management system, split application, soil testing, etc.	1135 (28)
	Soil management	Practices that are mainly related to managing soil, e.g., terraces, contour farming, conservation tillage, cover crops, grassed waterway, buffer, etc.	1452 (37)
By type of benefit	Primarily off farm benefit	Practices that are primarily related to off-farm environmental benefits, such as edge-of-field practices protecting water quality by trapping sediment, chemical and other pollutants and providing wildlife habitat, e.g., riparian buffers, field borders, streambank stabilization, grassed waterways, irrigation fish screen, etc.	762 (17)
	Both on- and off-farm benefit	Practices that have both on-farm and off-farm benefits (primarily on farm benefit), which could include both economic benefits and environmental benefits. The practices that have on farm benefits, but do not fall into the "Primarily off farm benefit" category are classified into this category.	2500 (64)
By operation and permanency	Operational or management	Practices that entail short-run decisions that are implemented on a year-by-year basis, or related to farming management, e.g., working lands conservation program enrollment, prescribed grazing, soil testing and sampling, conservation tillage, cover crop, etc.	2214 (61)
	Permanent or structural	Practices that entail long-run decisions with minimum annual management requirement that will be in place once implemented until removed or altered, or related to structural implementation of a practice requiring engineering designs and surveying, or related to use of a facility, e.g., buffer, sediment basin, field borders, streambank or shoreline stabilization, waste treatment lagoon/system, land smoothing and precision leveling, terraces, etc.	1214 (18)
By extent of coverage in adoption literature (specific CPs)	Conservation tillage	Practice that includes minimum tillage, no till, ridge till, and mulch till	561 (26)
	Buffers/borders	Practice that includes riparian buffers (areas of trees, shrubs, or grasses located adjacent to a body of water), field borders or filter strips (strips of perennial vegetation or grasses established at the edge or around the perimeter of a field)	331 (13)
	Soil testing and sampling	Practice that includes soil testing or sampling	287 (13)
	Grassed waterways	Practice that is grassed waterway	202 (10)
	Cover crop	Practice that is cover crop	205 (10)

Note: N indicates total # of observations (total # of studies) for the sign tests.

where n_s indicated the number of observations where estimated coefficient signs agreed with the directional hypothesis for a given IV category/subcategory and DV category/subcategory combination; n indicated the total number of observations for a given IV category/subcategory and DV category/subcategory combination; $z_{\alpha/2}$ indicated the standard normal quantile with right-tail probability equal to $\alpha/2$; α is 0.05; $\hat{p}$ was the estimated binomial proportion representing the proportion of observations that were consistent with our directional hypothesis. If the Wilson's 95% CI did not include the value 0.50, we rejected the null hypothesis that the proportion of observations consistent with our directional hypothesis was equal to 0.50 at a significance level of 0.05, i.e., the proportion was not expected by chance alone, while if the Wilson's 95% CI included the value 0.50, we did not reject the null hypothesis at a significance level of 0.05, i.e., the proportion was expected by chance alone.

A complementary vote count analysis (i.e., counting number of times that an IV was reported to be not statistically significant, positively significant, or negatively significant at a significance level of 0.05) was also conducted, and selected findings are reported under the results section. For detailed vote count results, please see supplementary materials (Tables S4–S8).

Before we present the results, we would like to acknowledge the following: (1) the same studies may be included in multiple separate DV category analyses which may conflate the global findings. For example, a study that examined the adoption of cover crops would be included under the category of soil management, non-technology practice, and operational practice; (2) except when we compared predictors of actual adoption and intention to adopt (see section 4.1), our study focused on predictors of actual adoption; (3) section 4.1 includes all IVs that had enough observations of intention to adopt a CP, but there were fewer intention studies (n = 15) compared to actual adoption (n = 81) for the sign test and therefore the intention analysis did not include the number and variety of predictors that have been assessed in actual adoption studies; (4) willingness and intention are related but distinct concepts in the literature (Floress et al., 2018), but in our analysis we grouped them together because both are fundamentally different from a farmer having already adopted a conservation behavior or practice. This assumption in our study accords with microeconomic theory and the difference between stated versus revealed preferences. Willingness and intention are inherently stated preferences or intended actions that have not (yet) been acted upon; this is distinct from revealed preferences that have already been acted upon; and (5) the results presented in this study provide new insights from the literature database (Floress et al., 2019) not previously investigated in other studies using the same database (Prokopy et al., 2019; Ranjan et al. 2019, 2022).

4. Results and discussion

In section 4.1, we present a comparison between predictors of actual adoption and intention to adopt. In sections 4.2, 4.3, and 4.4, we discuss predictors of DVs that share particular characteristics. In section 4.5, we discuss predictors of specific CPs. In section 4.6, we present an overview of findings from our analyses focusing on factors predicting actual adoption of different categories of CPs.

4.1. Actual adoption vs. intention to adopt

The *reasoned action approach* (previously theory of planned behavior) makes an important theoretical distinction between "behavioral

Table 3
Factors predicting actual adoption versus intention to adopt.

IV Category: Subcategory (Hypothesized effect)	Actual adoption		Intention to adopt	
	N	Prop	N	Prop
Attitude: environmental (+)	89 (8)	0.61*	18 (3)	1.00*
Attitude: perception climate (+)	21 (3)	0.62	16 (2)	0.69
Attitude: program practice (+)	262 (27)	0.63*	36 (7)	0.92*
Attitude: other program practice (+)	–	–	22 (2)	0.82*
Bhavior: other program practice (+)	243 (30)	0.68*	42 (6)	0.48
Economic factors: income farm (+)	164 (22)	0.53	31 (7)	0.61
Farm characteristics: acres (+)	194 (49)	0.64*	10 (4)	0.2
Farm characteristics: row crop (+)	46 (13)	0.72*	10 (2)	0.6
Farm characteristics: tenure (+)	201 (36)	0.5	16 (3)	0.75*
Information: sought use (+)	265 (28)	0.69*	39 (6)	0.87*
Operator characteristics: age (−)	192 (43)	0.53	16 (6)	0.69
Operator characteristics: farming experience (−)	126 (29)	0.42	16 (2)	0.44
Operator characteristics: formal education (+)	253 (52)	0.64*	19 (8)	0.79*

Note: N indicates total # of observations (total # of studies); Prop indicates proportion of analyses w/findings consistent with hypothesis; * indicates Sign Test statistical significance at 0.05 level; the results of actual adoption were retrieved from Prokopy et al. (2019).

intention" and "behavior"[2] itself (Fishbein and Icek, 2011). Conceptually, this distinction translates into the conservation adoption literature as farmers' intention to adopt CPs vs. actual adoption – an important distinction to be made when studying farmers' conservation behaviors (Floress et al., 2018) given the intention-behavior gap in related fields of study [e.g., sustainable consumption (Fink et al., 2021); sustainable diets (Chekima et al., 2017). Therefore, we were interested in examining whether or not factors that influence actual adoption differ from factors that influence intention to adopt (Table 3).

The vote count analysis (Table S4) revealed important distinctions between actual adoption and intention to adopt. For actual adoption, overall, 76% of observations were not statistically significant, 7% were significant and negatively correlated with the DVs, and 17% were positively correlated (Prokopy et al., 2019). However, for intention to adopt, 57% of variables were not statistically significant, 7% were significant and negatively correlated, and 35% were positively correlated. Overall, we found that IVs were more likely to be significantly positively correlated with intention to adopt than actual adoption.

The following factors were found to be positively associated with both intention to adopt and actual adoption: having a positive environmental attitude (*attitude: environmental*), having a positive attitude towards a similar program/practice (*attitude: program practice*), higher levels of *formal education*, and seeking and using information (*sought use*). We also found additional predictors that are uniquely significant to each category. For example, behaviors such as previous or current adoption of other CPs (*other program/practice*), the number of acres farmed (*acres*), and whether the farm grew *row crops* were positively associated with actual adoption; whereas percentage or proportion of operated land that was owned (*tenure*) was only significantly associated with intention to adopt.

Important patterns emerged when we compared factors predicting actual adoption vs. intention to adopt. Although a few factors were found to predict both actual adoption and intention to adopt, factors that were unique to one of the two categories highlight the importance of making this conceptual distinction when studying farmers' conservation behavior. For example, attitudinal factors were found to predict both actual adoption and intention to adopt, but behaviors such as previous or current adoption of other CPs (*behavior: other program practice*) were more important for predicting actual adoption than intention to adopt. Indeed, intention to adopt a specific CP, for instance, as a result of having a positive attitude towards it, does not mean farmers actually have control over their behaviors. Several factors – costs, farm characteristics, lack of information/technology/equipment, (un)availability of cost share, status-quo bias, weather variability, fluctuating market prices, etc. could hinder actual adoption. Our findings suggest that farmers who have successfully overcome barriers to adoption, as a result of previous or current adoption of other CPs, were more likely to adopt a particular CP of interest.

Different farm characteristics, such as *acres* and *row crop* were found to be positively associated with actual adoption, but not with intention to adopt. This suggests that farm characteristics were more important in predicting actual adoption than intention to adopt. For example, larger farm size could be indicative of capacity and therefore encourage *trialability*, i.e., experimenting with a CP on smaller number of acres before making the decision to adopt (Rogers, 1995). Similarly, growing row crops could encourage adoption of CPs that are *compatible* with farmers' farm management needs (Rogers, 1995). Conceptually distinguishing between intention and actual adoption also sheds light on the effect of land *tenure* which was positively associated with intention to adopt, but not actual adoption. Although this was somewhat contradictory to our expectation that ownership of land would predict actual adoption, this nevertheless underscored the difficulty in predicting actual adoption. As mentioned earlier, several factors beyond a farmer's control could hinder actual adoption.

4.2. Categorization by purpose: livestock, nutrient, and soil management

Conservation practices can serve several purposes, including the management of livestock, nutrients, and soil, which were the three primary practice purposes with the greatest number of observations in the study database, and were therefore included in this study (see Table S1). Two IVs out of 20, seeking and using information (*information: sought use*) and having knowledge specific to the programs/practices (*environmental awareness: program practice*), were significant predictors of adoption for all three practice purpose categories (Table 4). Several IVs predicted adoption of at least two practice categories. Economic factors such as higher levels of overall *income* and income specifically from the farm (*income farm*), and farm characteristics such as having more than one type of crop or livestock (*diversity*) and having *vulnerable* land (highly erodible land, higher levels of slope, etc.) predicted adoption of both livestock and soil management CPs. Similarly, farm size (*acres*) predicted adoption of both nutrient and soil management CPs.

When comparing different categories of CPs and their predictors, results show a few important patterns. Given how integral livestock, nutrient, and soil management are to an effective farming operation, it is not surprising that several farm characteristics predicted adoption when we categorized CPs by their purpose. However, a different number of

[2] This distinction is very closely related to the distinction between "stated preferences", i.e., how agents respond when making hypothetical choices or faced with a contingent choice in a survey-based experiment, and "revealed preferences", i.e., actions taken, or choices made by agents.

Table 4
Factors predicting actual adoption of conservation practices: categorization by purpose.

IV Category: Subcategory (Hypothesized effect)	Livestock management		Nutrient management		Soil management	
	N	Prop	N	Prop	N	Prop
Attitude: environmental (+)	21 (2)	0.62	15 (4)	0.67	33 (5)	0.55
Attitude: farmer identity other (+)	–	–	17 (3)	0.71	43 (7)	0.58
Attitude: program practice (+)	–	–	151 (9)	0.63*	61 (8)	0.62
Behavior: other program practice (+)	40 (4)	0.65	62 (16)	0.77*	92 (16)	0.6
Behavior: program practice (+)	–	–	10 (4)	0.90*	21 (4)	0.62
Economic factors: capital (+)	17 (4)	0.41	31 (6)	0.90*	38 (10)	0.42
Economic factors: income (+)	26 (3)	0.92*	15 (8)	0.73	39 (10)	0.67*
Economic factors: income farm (+)	18 (4)	0.89*	36 (10)	0.28	62 (14)	0.63*
Economic factors: willingness to accept (+)	–	–	11 (3)	0.91*	–	–
Economic factors: yield (+)	–	–	–	–	11 (2)	1.00*
Environmental awareness: program practice (+)	19 (2)	0.74*	12 (3)	0.83*	14 (3)	0.79*
Farm characteristics: acres (+)	14 (3)	0.5	47 (19)	0.74*	71 (24)	0.65*
Farm characteristics: diversity (+)	23 (2)	0.91*	24 (6)	0.54	22 (4)	0.82*
Farm characteristics: livestock number (+)	–	–	10 (4)	0.5	15 (3)	0.80*
Farm characteristics: row crop (+)	–	–	–	–	21 (7)	0.67
Farm characteristics: vulnerable (+)	15 (3)	0.80*	21 (7)	0.52	79 (19)	0.89*
Farm characteristics: waterbody (+)	16 (4)	0.69	13 (6)	0.62	32 (8)	0.72*
Information: affiliation (+)	16 (3)	0.5	23 (4)	0.74*	42 (5)	0.4
Information: sought use (+)	39 (5)	0.72*	78 (10)	0.62*	77 (13)	0.74*
Operator characteristics: formal education (+)	18 (5)	0.61	90 (26)	0.66*	74 (21)	0.57

Note: N indicates total # of observations (total # of studies); Prop indicates proportion of analyses w/findings consistent with hypothesis; * indicates Sign Test statistical significance at 0.05 level.

farm characteristics significantly predicted adoption depending upon the primary purpose of the practice; more farm characteristics predicted adoption of soil management CPs than livestock or nutrient management CPs. Different economic factors were found to be important for different CP categories or pairs of categories; both *income* and *income from farm* predicted adoption of livestock and soil management CPs, positive *yield* expectation predicted adoption of soil management CPs, and having access to *capital* predicted adoption of nutrient management CPs.

4.3. Categorization by the type of benefit: on- or off-farm

Benefits associated with CP adoption have been identified as a driver of conservation behavior (Ranjan et al., 2019). However, an important distinction when categorizing CPs was whether they provided benefits that were primarily off-farm (e.g., water quality benefits downstream), or they provided both on- and off-farm benefits, i.e., both private and public benefits. This distinction was important because farmers' adoption of practices that primarily provided off-farm benefits could be indicative of their stewardship identity and preference towards provisioning of environmental amenities (Luther et al., 2020). From a theoretical perspective (e.g., collective action theory), farmers' adoption of CPs with primarily off-farm benefits could be associated with higher levels of environmental concern and perceived collective efficacy (Pradhananga and Davenport, 2017; Ostrom, 2007). However, from a practical perspective, it was likely that private on-farm benefits were the primary driver of adoption, while off-farm benefits, even for farmers who were relatively public-spirited, were a secondary driver of adoption.

Seven of the 20 IVs were predictors of both categories of CPs (Table 5): having a positive attitude towards the particular practice (*attitude: program practice*), previous or current adoption of other CPs (*behavior: other program/practice*), having knowledge specific to the programs/practices (*environmental awareness: program practice*), number of *acres* farmed, having *vulnerable land*, having more than one type of crop or livestock (*diversity*), and seeking and using information (*sought use*).

A higher level of *formal education* was found to be positively associated with adoption of CPs that provide both on- and off-farm benefits. In contrast, higher levels of *income*, *livestock number*, and adjacency to a *waterbody* were found to predict adoption of CPs that provide primarily off-farm benefits. Predictors that were found to be unique to a specific category shed some light on farmers' underlying motivations for engaging in conservation behavior. For example, adjacency to a *waterbody* could be indicative of a farming operation's need for water quality-related practices that are typically edge-of-field practices such as grassed waterways, two-stage ditches, controlled drainage, etc., and therefore increase the effectiveness of providing off-farm benefits. As a result of

Table 5
Factors predicting actual adoption of conservation practices: categorization by the type of benefit.

IV Category: Subcategory (Hypothesized effect)	Both on- and off-farm		Primarily off-farm	
	N	Prop	N	Prop
Attitude: environmental (+)	35 (7)	0.66	30 (5)	0.53
Attitude: farmer identity other (+)	72 (6)	0.61	–	–
Attitude: program practice (+)	164 (19)	0.66*	67 (6)	0.63*
Behavior: other program practice (+)	158 (26)	0.65*	19 (6)	0.84*
Behavior: program practice (+)	36 (8)	0.75*	–	–
Economic factors: capital (+)	58 (15)	0.64*	27 (5)	0.37
Economic factors: income (+)	52 (14)	0.56	25 (5)	0.80*
Economic factors: income farm (+)	107 (18)	0.46	27 (7)	0.67
Economic factors: willingness to accept (+)	21 (3)	0.86*	–	–
Economic factors: yield (+)	11 (4)	0.91*	–	–
Environmental awareness: program practice (+)	24 (6)	0.83*	15 (2)	0.80*
Farm characteristics: acres (+)	133 (41)	0.67*	20 (8)	0.75*
Farm characteristics: diversity (+)	48 (9)	0.69*	21 (2)	0.86*
Farm characteristics: livestock number (+)	14 (6)	0.43	15 (3)	0.87*
Farm characteristics: row crop (+)	34 (11)	0.74*	–	–
Farm characteristics: vulnerable (+)	77 (24)	0.78*	34 (6)	0.88*
Farm characteristics: waterbody (+)	24 (9)	0.54	29 (8)	0.76*
Information: affiliation (+)	77 (6)	0.58	16 (2)	0.06
Information: sought use (+)	161 (23)	0.66*	55 (7)	0.73*
Operator characteristics: formal education (+)	176 (44)	0.65*	29 (9)	0.52

Note: N indicates total # of observations (total # of studies); Prop indicates proportion of analyses w/findings consistent with hypothesis; * indicates Sign Test statistical significance at 0.05 level.

this synergy, a farmer might feel self-efficacy in achieving off-farm benefits from improved water quality.

4.4. Categorization by operation and permanency

From a farm management perspective, a key categorization of CPs was whether they were operational in nature, and therefore typically required decision-making on an annual basis (e.g., cover crops, no-till), or they were structural, and therefore were of permanent nature with relatively fewer decisions to make on an annual basis (e.g., sediment basins, contours, etc.). This categorization not only captured the extent and frequency of farm management efforts (e.g., labor) but also the cost these practices entailed. Operational practices could entail a somewhat moderate recurring annual cost (e.g., buying and seeding costs associated with cover crops), while structural practices could entail a large upfront cost of adoption (e.g., two-stage drainage ditches).

Five IVs were predictors for both the operational and permanent CP categories: having *vulnerable land*, having more than one type of crop or livestock (*diversity*), seeking and using information (*sought use*), having knowledge specific to the programs/practices (*environmental awareness: program practice*), and adoption of other CPs (Table 6). Five IVs were found to predict adoption of operational practices: having a positive *attitude* towards the particular *program practice*, having assets or investment options (*capital*), the number of acres farmed (*acres*), organizational *affiliation*, and higher levels of *formal education*. Five different IVs were found to predict adoption of permanent practices: farmers self-identifying as altruistic or stewardship motivated as opposed to financially motivated (*farmer identity: other*), economic factors such as higher levels of overall *income* and income specifically from farm (*income farm*), *livestock number*, and adjacency to a *waterbody*.

Predictors unique to one or the other of the two CP categories reveal possible explanations for why farmers adopt operational or structural practices. For example, larger farm size could allow farmers to experiment with a new practice on a few acres prior to adopting across their farm – therefore encouraging *trialability* (Rogers, 1995). Larger farm size could also help farmers achieve the desired economies of scale suitable for their farming operation – therefore positively influencing farmers' perceptions of *compatibility* of the operational practice (Rogers, 1995). In contrast, farmers can have livestock on smaller acres adjacent to a waterbody; factors important in predicting adoption of structural practices (see Table 6). Having a positive attitude towards the practice (*attitude: program practice*), and being affiliated with or involved in an agricultural organization (*affiliation*) were found to be more important for the adoption of operational practices than structural practices, because managing operational CPs typically requires an annual implementation and decision-making cycle. Structural practices typically entail a large upfront cost of adoption, therefore making the economic factors of higher levels of overall *income* and income from farm (*income farm*) important for adoption. In contrast, higher level of *capital* was important for farmers' adoption of operational practices since access to credit or investment into farms facilitate annual farm operations.

Table 6
Factors predicting actual adoption of conservation practices: categorization by operation and permanency.

IV Category: Subcategory (Hypothesized effect)	Operational/ management practice		Permanent/ structural practice	
	N	Prop	N	Prop
Attitude: environmental (+)	29 (6)	0.62	49 (5)	0.55
Attitude: farmer identity other (+)	70 (7)	0.61	12 (4)	0.92*
Attitude: program practice (+)	170 (18)	0.65*	44 (4)	0.57
Behavior: other program practice (+)	144 (23)	0.63*	54 (8)	0.74*
Behavior: program practice (+)	36 (8)	0.75*	–	–
Economic factors: capital (+)	49 (11)	0.65*	44 (6)	0.45
Economic factors: income (+)	49 (13)	0.63	41 (5)	0.83*
Economic factors: income farm (+)	93 (17)	0.47	43 (8)	0.72*
Economic factors: willingness to accept (+)	16 (2)	0.94*	–	–
Economic factors: yield (+)	–	–	–	–
Environmental awareness: program practice (+)	21 (5)	0.81*	25 (2)	0.76*
Farm characteristics: acres (+)	111 (39)	0.66*	40 (11)	0.55
Farm characteristics: diversity (+)	37 (7)	0.81*	33 (3)	0.91*
Farm characteristics: livestock number (+)	17 (6)	0.47	22 (3)	0.86*
Farm characteristics: row crop (+)	30 (10)	0.77*	–	–
Farm characteristics: vulnerable (+)	71 (24)	0.73*	53 (6)	0.91*
Farm characteristics: waterbody (+)	28 (10)	0.61	41 (6)	0.71*
Information: affiliation (+)	70 (6)	0.66*	31 (3)	0.19
Information: sought use (+)	139 (21)	0.68*	85 (8)	0.72*
Operator characteristics: formal education (+)	160 (41)	0.62*	44 (11)	0.59

Note: N indicates total # of observations (total # of studies); Prop indicates proportion of analyses w/findings consistent with hypothesis; * indicates Sign Test statistical significance at 0.05 level.

4.5. Factors predicting adoption of conservation tillage, buffers or borders, soil testing and sampling, grassed waterways, and cover crops

Our final set of analyses explored factors that predict adoption of five specific CPs that were included in at least 10 studies from the conservation adoption literature (Table 7).

Having *vulnerable* land predicted adoption for three of the five CPs: conservation tillage, buffers or borders, and grassed waterways. Previous or current adoption of other CPs (*behavior: other program/practice*) predicted adoption of buffers or borders, and soil testing and sampling, whereas seeking and using information (*sought use*) predicted adoption of conservation tillage and buffers or borders. We also found predictors unique to specific CPs. Larger farm size (*acres*) and whether a farm grows *row crops* predicted adoption of conservation tillage. Higher levels of *income* predicted adoption of buffers or borders. Having a positive attitude towards soil testing and sampling, behaviors such as previous or current adoption of a practice related to soil testing and sampling (*behavior: program/practice*), having knowledge specific to the programs/practices (*environmental awareness: program practice*), being affiliated with or involved in an agricultural organization (*affiliation*), and higher levels of *formal education*, predicted adoption of soil testing and sampling. Income specifically from farm (*income farm*) predicted adoption of cover crops.

When we look across specific CPs and their predictors, a few important patterns emerge. Several characteristics of the farm predicted adoption of conservation tillage highlighting the importance of farmers' perception of *compatibility* of conservation tillage with their farming operations to be an important consideration when adopting this practice (Rogers, 1995), while soil testing and sampling seem to be driven more by behavioral, attitudinal, and awareness factors (see Table 7). Vulnerability of land predicted adoption of conservation tillage (an operational practice) as well as buffers and grassed waterways (structural practices), highlighting the importance of farm vulnerability in driving adoption of both operational and structural practices.

4.6. Factors predicting actual adoption of different categories of conservation practices: an overview

A key question we examined in this study was whether factors that influence adoption differ when CPs were systematically categorized based on their characteristics. As we described at length in sections 4.2 to 4.5, we found that different IVs predicted adoption of CPs that share a particular characteristic, as well as specific CPs. However, we found that nearly all of the variables that were significant predictors of specific types of CPs or CPs that share particular characteristics (see Table 8) also predicted CP adoption when CPs were not categorized based on their

Table 7
Factors predicting actual adoption of specific conservation practices.

IV Category: Subcategory (Hypothesized effect)	Conservation tillage		Buffers or borders		Soil testing and sampling		Grassed waterways		Cover crop	
	N	Prop	N	Prop	N	Prop	N	Prop	N	Prop
Attitude: environmental (+)	–	–	9 (4)	0.44	–	–	5 (4)	0.8	–	–
Attitude: farmer identity other (+)	20 (3)	0.45	–	–	–	–	–	–	–	–
Attitude: program practice (+)	9 (3)	0.67	41 (2)	0.56	9 (3)	0.89*	–	–	6 (3)	0.83
Behavior: other program practice (+)	61 (10)	0.56	11 (5)	0.82*	15 (6)	0.80*	–	–	–	–
Behavior: program practice (+)	17 (3)	0.59	–	–	6 (2)	1.00*	–	–	–	–
Economic factors: capital (+)	8 (6)	0.5	9 (5)	0.22	–	–	–	–	–	–
Economic factors: income (+)	12 (6)	0.33	8 (5)	0.88*	–	–	–	–	–	–
Economic factors: income farm (+)	23 (8)	0.43	8 (6)	0.62	–	–	5 (5)	0.6	7 (7)	1.00*
Economic factors: willingness to accept (+)	–	–	–	–	–	–	–	–	–	–
Economic factors: yield (+)	–	–	–	–	–	–	–	–	–	–
Environmental awareness: program practice (+)	–	–	5 (2)	0.8	5 (3)	1.00*	–	–	–	–
Farm characteristics: acres (+)	37 (15)	0.78*	6 (5)	0.67	10 (9)	0.8	–	–	5 (5)	0.6
Farm characteristics: diversity (+)	–	–	6 (2)	0.83	–	–	–	–	–	–
Farm characteristics: livestock number (+)	–	–	–	–	–	–	–	–	–	–
Farm characteristics: row crop (+)	8 (5)	0.88*	–	–	–	–	–	–	–	–
Farm characteristics: vulnerable (+)	32 (16)	0.81*	8 (3)	1.00*	6 (3)	0.33	6 (4)	1.00*	6 (3)	0.83
Farm characteristics: waterbody (+)	–	–	11 (6)	0.73	–	–	–	–	–	–
Information: affiliation (+)	7 (4)	0.71	5 (2)	0	5 (2)	1.00*	–	–	5 (2)	0.2
Information: sought use (+)	13 (7)	1.00*	16 (5)	0.81*	22 (6)	0.5	8 (5)	0.75	10 (6)	0.6
Operator characteristics: formal education (+)	37 (15)	0.65	8 (6)	0.62	17 (11)	0.76*	–	–	5 (4)	0.2

Note: N indicates total # of observations (total # of studies); Prop indicates proportion of analyses w/findings consistent with hypothesis; * indicates Sign Test statistical significance at 0.05 level.

Table 8
An overview of factors predicting actual adoption of different categories of conservation practices.

DV Categorizations →	#1. Primary purpose			#2. Type of benefit		#3. Operation and permanency		#4. Specific conservation practices				
	1.1	1.2	1.3	2.1	2.2	3.1	3.2	4.1	4.2	4.3	4.4	4.5
Attitudes: environmental	NS	NS	NS	NS	NS	NS	NS	–	NS	–	NS	–
Attitudes: farmer identity other	–	NS	NS	NS	–	NS	✓	NS	–	–	–	–
Attitudes: program practice	–	✓	NS	✓	✓	✓	NS	NS	NS	✓	–	NS
Behaviors: other program practice	NS	✓	NS	✓	✓	✓	✓	NS	✓	✓	–	–
Behaviors: program practice	–	✓	NS	✓	–	✓	–	NS	–	✓	–	–
Economic factors: capital	NS	✓	NS	✓	NS	✓	NS	NS	NS	–	–	–
Economic factors: income	✓	NS	✓	NS	✓	NS	✓	NS	✓	–	–	–
Economic factors: income farm	✓	NS	✓	NS	NS	NS	✓	NS	NS	–	NS	✓
Economic factors: willingness to accept	–	✓	–	✓	–	✓	–	–	–	–	–	–
Economic factors: yield	–	–	✓	✓	–	–	–	–	–	–	–	–
Environmental awareness: program practice	✓	✓	✓	✓	✓	✓	✓	–	NS	✓	–	–
Farm characteristics: acres	NS	✓	✓	✓	✓	✓	NS	✓	NS	NS	–	NS
Farm characteristics: diversity	✓	NS	✓	✓	✓	✓	✓	–	NS	–	–	–
Farm characteristics: livestock number	–	NS	✓	NS	✓	NS	✓	–	–	–	–	–
Farm characteristics: row crop	–	–	NS	✓	–	✓	–	✓	–	–	–	–
Farm characteristics: vulnerable	✓	NS	✓	✓	✓	✓	✓	✓	✓	NS	✓	NS
Farm characteristics: waterbody	NS	NS	✓	NS	✓	NS	✓	–	NS	–	–	–
Information: affiliation	NS	✓	NS	NS	NS	✓	NS	NS	NS	✓	–	NS
Information: sought use	✓	✓	✓	✓	✓	✓	✓	✓	✓	NS	NS	NS
Operator characteristics: formal education	NS	✓	NS	✓	NS	✓	NS	NS	NS	✓	–	NS

Notes.
Categorization #1: By primary purpose [1.1 Livestock management; 1.2 Nutrient management; 1.3 Soil management].
Categorization #2: By the type of benefit [2.1 Both on- and off-farm; 2.2 Primarily off-farm].
Categorization #3: By operation and permanency [3.1 Operational/management; 3.2 Permanent/structural].
Categorization #4: Specific conservation practices [4.1 Conservation tillage; 4.2 Buffers or borders; 4.3 Soil testing and sampling; 4.4 Grassed waterways; 4.5 Cover crops].
✓ → Indicates Sign Test statistical significance at 0.05 level.
NS → Not significant.
– → Not enough observations/studies.
IVs highlighted in bold are those that are statistically significant in Prokopy et al. (2019), a study that does not categorize CPs based on their characteristics.

characteristics (see Prokopy et al., 2019).

When looking across the 4 DV categorizations, several important patterns emerge. For example, having knowledge specific to the programs/practices (*environmental awareness: program practice*), having a positive attitude towards the particular program or practice (*attitudes: program practice*), and behaviors such as previous or current adoption of related or other non-related CPs (*behaviors: program practice and behaviors: other program practice*), predicted CP adoption (see Table 8). These findings are supported by the diffusion of innovations (DOI) theory (Rogers, 1995): being aware of an innovation, having knowledge about it, and understanding how it functions are salient precursors for an individual to form an attitude towards it, which can then result in the behavior of adopting or rejecting an innovation. The DOI theory also highlights the importance of several factors or conditions which can influence the diffusion process. Across the 4 DV categorizations, the following factors or conditions predicted conservation behavior: higher levels of income, formal education, larger farm size, having vulnerable land, and farmers' propensity to seek and use information. Having more than one type of crop or livestock (*diversity*) and adjacency to a *waterbody* were other important background factors (see Table 8).

Nuances in farmers' conservation decision-making emerge when comparing predictors of CP adoption that shared a particular characteristic and specific CPs. For example: 1) More farm characteristics predicted adoption of soil management CPs than nutrient management CPs and livestock management CPs, while economic factors such as *income* and *income from farm* predicted adoption of livestock and soil management CPs (see section 4.2). 2) Adjacency to *waterbody* was only positively associated with adoption of CPs that provided primarily off-farm benefit, which was because several of these CPs can be edge of field practices, and adjacency to waterbody is typically a necessary condition for implementing such practices (see section 4.3). 3) Vulnerability of land predicted adoption of conservation tillage, buffers, and grassed waterways, but not of soil testing/sampling and cover crops (see section 4.5). Therefore, our findings suggest that farmers' conservation decision-making is differently motivated based on CP type and characteristics. Several of our findings (see Table 8) are also supported by the current literature. For example, Doran et al. (2020) found that, among other factors, farmer attitudes, larger farm size, and college education predicted their intention to adopt nutrient management practices. Luther et al. (2020) focused on 8 CPs that help reduce nutrient loss, and found that among others, farmers' stewardship identity, scale of farming operations, and access to capital and information influenced adoption. Di Bene et al. (2022) found that loss of profitability was the most important barrier to adoption in their study context, which highlights the importance of economic factors.

A comparison across the 4 DV categorizations and the resulting patterns in understanding farmers' conservation behavior also has implications for outreach and education to promote CPs adoption. For example, having land that is highly erodible or has steep slopes (*vulnerable*) was a consistent predictor of conservation behavior (see Table 8). Indeed, vulnerability of farmland has been identified as a factor motivating conservation behavior in the literature (Ranjan et al., 2019). Therefore, using a targeted approach that channels technical and financial resources toward the most vulnerable lands, but also ensures that farmers have autonomy in the targeting process, could be useful in encouraging conservation behavior (Arbuckle, 2013; Ranjan et al., 2020a). Having knowledge specific to the programs/practices predicted adoption for nearly all DV categories and sub-categories. This highlights the need for conservation professionals to continue their efforts around conducting education and outreach with farmers, directing their efforts to those who are early adopters or innovators in their community, as well as those who have not yet adopted CPs or adopted minimal levels of CPs (Lu et al., 2021; Ranjan et al., 2020b). Having more than one type of crop or livestock (*diversity*) emerged as a predictor for all DV categories and sub-categories, except for nutrient management practices. Whereas our finding does not imply that diversification by itself is a causal factor of adoption, it aligns with arguments that increased diversity in the agricultural landscape may be associated with multiple social, economic, and environmental benefits (Prokopy et al., 2020). Last but not least, the effectiveness of the CP at delivering both private and public benefits is an important consideration when conducting outreach and education with farmers.

5. Conclusions

Conservation practices are an integral component of maintaining the long-term viability of agro-ecological systems. However, what adds to the complexity of understanding farmers' conservation behavior, but has received limited attention in the meta-analyses, is the heterogeneity of CPs. To address this knowledge gap, we examined whether farmers' conservation decision-making was differently motivated based on CP types and characteristics. In this study, we also responded to calls for understanding farmers' actual adoption of vs. intention to adopt CPs.

This review and analysis of 35 years of quantitative CP adoption studies in the U.S. resulted in several insights into ways that future adoption studies might be improved. First, the predominant focus of the quantitative adoption literature on IVs related to either the population of farmers (e.g., age, education) or the farming context (e.g., farm acres, income, quality of land) could result in neglect of variables related to the relative advantage of specific practices (e.g., economic and environmental returns relative to alternatives) (de Oca Munguia and Llewellyn, 2020; Pannell et al., 2006; Rogers, 1995). Moreover, the quantitative adoption literature would benefit from inclusion of IVs that more effectively account for the institutional, market, and governance context in which farmers are embedded (Ranjan et al., 2019). Second, we would like to acknowledge that inconsistency among existing adoption studies in conceptualizing and measuring IVs could result in combining IVs that actually measure different things. For example, in studies included in the public database (Floress et al., 2019), the authors found that the overall effect of land tenure on conservation behavior was inconclusive in quantitative studies, and therefore suggest that there is a need to better operationalize and measure variables in the adoption literature (Prokopy et al., 2019; Ranjan et al., 2022).

Taken together, inconsistent conceptualization and measurement, and the neglect of key IVs in the adoption literature could explain why this and other meta-analyses have found that only a few IVs have a consistent statistically significant relationship with CP adoption (Prokopy et al., 2019). Thus, potential omitted variable bias and measurement may lead to statistical models that have less explanatory power than they could have and, therefore, scholarly understanding of IVs that consistently predict CP adoption is limited. That said, by following a rigorous and systematic approach in our meta-analysis, we found that among others, predictors such as farmers' propensity to seek and use information, size and vulnerability of their land, and higher levels of income and formal education consistently predicted adoption.

In addition to paying attention to IVs, a conceptual contribution of our study is the use of meta-analysis to bring to fore the importance of paying attention to the DV, or the behavioral measurement type, i.e., distinguishing between farmers' intention to adopt vs. actual adoption. Indeed, as recent literature suggests, scholars have started paying attention to behavioral measurements (see Luther et al., 2020; Doran et al., 2020; Floress et al., 2018). Our results suggested that while attitudes towards practices/programs were important for both actual adoption and intention to adopt, behaviors such as previous or current adoption of other CPs were more important for predicting actual adoption (see Table 3). Moreover, this study also suggested that farm characteristics (e.g., *acres* and *row crops*) were more important for predicting actual adoption than intention, which indicates that farm characteristics might facilitate farmers' adoption of CPs. Lastly, contrasting intention to adopt vs. actual adoption revealed important findings for land *tenure*. Farmers who have secure land *tenure* are often expected to be better stewards in preserving natural resources and adopting CPs (Caswell et al., 2001; Soule et al., 2000; Ranjan et al., 2019), but no positive association was found in Prokopy et al. (2019) for actual adoption. Nevertheless, this study found that land *tenure* predicted intention to adopt perhaps because many other factors might intercede to influence actual adoption as we mentioned above. Although our findings highlighted the importance of precision in behavioral measurement, we would like to acknowledge the following limitations: (1) the studies focusing on 'willingness' and 'intention' to adopt were combined; and (2) the number of studies in the willingness/intention to adopt category were few in comparison with the actual adoption category (see Table 3).

By employing a meta-analytic approach, we found that the overall predictors of conservation behavior were important regardless of CP type and characteristics. However, as we described at length in this study, the effect of these factors in influencing adoption of CPs that shared a particular characteristic or specific CPs, was nuanced. We also found that several, if not all, factors that influenced actual adoption differed from those that influence intention to adopt. Therefore, it is important to not only understand the context of farmer-decision making (Ranjan et al., 2019), and account for both heterogeneity of farming system and farmers (Carlisle, 2016), but also pay attention to CP type and characteristics (see Table 8), when designing research to understand farmers' conservation behavior, and conducting education and outreach with farmers.

Author contribution statement

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Author agreement/declaration

We, the authors, certify that all authors have seen and approved the final version of the manuscript being submitted. The article is the authors' original work, hasn't received prior publication and isn't under consideration for publication elsewhere.

Disclaimer Statement

The findings and conclusions in this publication are those of the authors and should not be construed to represent any official USDA or U. S. Government determination or policy.

Declaration of competing interest

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

Data availability

All of the data used in this study are available in the public database (Floress, et al. 2019).

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Appendix A. Supplementary data

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