Manuscript accepted by *Society and Natural Resources*

Title: Understanding the Past and Present and Predicting the Future: Farmers' Use of Multiple Nutrient BMPs in the Upper Midwest

Riva C. H. Denny*
Department of Sociology
Michigan State University
509 East Circle Drive, Room 317,
East Lansing, MI, 48824, USA
rchdenny@msu.edu
*corresponding author

Sandra T. Marquart-Pyatt
Department of Sociology
Environmental Science and Policy Program
Michigan State University
East Lansing, MI, USA
marqua41@msu.edu

Matthew Houser
Department of Sociology
Michigan State University
East Lansing, MI 48824, USA
houserm9@msu.edu

Keywords: Best Management Practices; Corn; Farmers; Fertilizer; Nitrogen; Nutrients; Midwest; Practice Adoption

Abstract: Understanding what drives farmers' voluntary adoption of nutrient and soil best management practices has important consequences for many environmental outcomes including water quality. We build on research revealing the need for simultaneous use of multiple nitrogen best management practices to achieve water quality improvement goals. Using social, economic and attitudinal variables we predict the use of multiple nitrogen best management practices at three time points: current use (2013), past use (before 2013), and likelihood of use on their largest field in the next three years. Our empirical analysis uses structural equation modeling with latent variables and 2014 farmer survey data from three Midwestern US states. Most farmers in our sample used at least one of the six best management practices. Our results reveal that farmers' attitudes, use of information sources, and conservation program participation affect the number of nitrogen best management practices concurrently in use at multiple time points.

Acknowledgements: The authors would like to thank Dr. Diana Stuart for her leadership on this project, and Dr. Adam Reimer for his work in support of data collection.

Introduction

Nonpoint source pollution from agriculture, in the form of nutrient and soil loss, is a persistent problem world-wide, and the United States (US) is no exception. In the US, agricultural nonpoint source pollution is a key contributor to water quality impairments and the primary source of degraded water quality (EPA 2017). Although federal soil and water conservation programs are intended to encourage farmers to voluntarily adopt nutrient and soil best management practices (BMPs), adoption rates of these BMPs are insufficient to accomplish water quality goals (Ribaudo 2015). These practices include various activities related to nutrient application methods, tillage, the use of decision-aids, crop rotation and use of winter cover crops. A considerable body of research on this issue has focused on understanding what leads farmers to adopt BMPs (see Baumgart-Getz, Prokopy, and Floress 2012; Knowler and Bradshaw 2007; Prokopy et al. 2008; Wauters and Mathijs 2014 for reviews).

A growing number of studies suggest, however, that the simultaneous use of multiple nutrient BMPs is needed to achieve water quality improvement goals through reductions in nutrient loss (Holmes, Armanini, and Yates 2016; Lam, Schmalz, and Fohrer 2011; Liu et al. 2016; Sowa et al. 2016) and suggest focusing on this concurrent use of multiple nitrogen BMPs (Bosch et al. 2013; Makarewicz et al. 2009; Motsinger, Kalita, and Bhattarai 2016; Teshager et al. 2017). To date, little social science research has studied the drivers of farmers' simultaneous adoption of multiple BMPs, though recent work suggests the importance of considering novel measures of BMP adoption (Ulrich-Schad et al. 2017). The gains in environmental quality improvement through implementation of multiple BMPs indicate a need to better understand what motivates farmers to concurrently adopt multiple practices.

To contribute to this understanding, we build on past research exploring adoption of multiple BMPs by focusing on how social, economic and attitudinal variables influence farmers' current and past adoption of multiple BMPs and the likelihood of future use. In this study we use survey data from Iowa, Indiana, and Michigan to examine these processes within the context of Upper Midwestern row-crop agricultural producers whose nitrogen fertilizer and soil management practices impact aquatic ecosystems and water quality throughout the Mississippi River Basin, Gulf of Mexico, and Great Lakes Basin (Diaz and Rosenberg 2008; EPA 2017). Our study reflects recent research in its variable construction and analysis and responds to calls to consider farmers' nutrient practices from an interdisciplinary perspective (Stuart et al. 2015). Further, since measurable environmental improvements can be better accounted for in biophysical analyses of multiple BMP adoption, our research engages with the growing literature striving to incorporate biophysical attributes into social-scientific research (e.g., Houser, Stuart, and Carolan 2017; Stuart et al. 2015). We begin by reviewing the literature on the use of multiple BMPs.

Using Multiple Nutrient Best Management Practices

From subsurface nutrient application methods to the use of cover crops, the adoption of BMPs can provide wide-ranging environmental benefits both on- and off-farm, and many of these practices are complementary and integrated. BMPs related to nitrogen fertilizer, including technologically and biologically based practices, are the topic of this study. Agricultural nitrogen fertilizer is the primary source of nutrients contributing to hypoxia in the Gulf of Mexico (Ribaudo 2006) and a key source of degraded water quality throughout the Midwest (Howarth et al. 2002; Ribaudo et al. 2011). A multi-faceted management approach for nitrogen fertilizer use called the '4Rs' is widely promoted (Flis 2017). This approach advocates for reduction of nitrogen loss via best management in four inter-related aspects of nutrient application: (1) application rate, (2) placement, (3) timing and (4) product type (Snyder 2017).

Specific practices to achieve best management for the right rate, site, time, and product include technologically-based practices such as the use of decision aids (e.g. nitrogen leaf tests, use of optical sensors or other imagery technologies), precision technologies such as injectors that place the nitrogen close to the plant or seed, side dressing or split/multiple applications of nitrogen, and stabilized and slow release nutrient product formulations (Robertson and Vitousek 2009; Weber and McCann 2015). There are biologically-based practices such as crop rotations including legumes, the use of cover crops, and the use of conservation/reduced tillage or no-till that support and enhance the composition of, and biological functions in, the soil to increase nutrient availability and simultaneously reduce nutrient losses (Blesh and Drinkwater 2013; Drinkwater and Snapp 2007; Robertson and Vitousek 2009).

Growing evidence of the importance of simultaneous implementation of multiple BMPs has yet to be widely reflected in the conservation practice adoption literature. For this study in particular, current literature examining BMP adoption related to nutrients and soil management in Midwestern row-crop agriculture has primarily examined adoption of single BMP practices, including precision application equipment, soil and nitrate tests, slow release N, and cover crop usage among others (e.g., Arbuckle and Roesch-McNally 2015; Lambert et al. 2007; Weber and McCann 2015; Dunn et al. 2016). To this point, there is a paucity of US focused studies that consider the simultaneous use of multiple BMPs as an outcome (Adrian, Norwood, and Mask 2005; Upadhyay et al. 2003; Napier, Tucker, and McCarter 2000; Napier and Bridges 2002; Napier and Bridges 2003; Napier and Tucker 2001).

Published studies focusing on multiple BMP adoption in this context have primarily offered descriptive, comparative analyses of state- and watershed-level differences in the number of BMPs adopted (Napier et al. 2000; Napier 2000; Napier and Bridges 2002; 2003). In this work, Napier and colleagues examine a multi-item index of BMP use, which includes 18 practices across a range of tillage and nutrient application and management practices, crop rotation, and pest control methods. Adoption was measured from never using a practice to annual use.

Upadhyay et al. (2003) compare the characteristics of Washington dryland farmers who adopt no erosion control practices, those who adopt one practice, and those who adopt multiple practices. The authors find level of education and farm size to be significant between farmers who adopted no erosion control practices, and those who adopted multiple practices. The authors point out the importance of considering practice adoption in relation to the adoption of other practices, as farmers may choose between practices that have the same or similar purpose.

Adrian et al. (2005) consider farmers' perceptions of the usefulness, ease of use, and net benefits of use of precision technology, along with farmers' confidence in their ability to learn how to use them, as predictors of the number of precision technologies that the farmer planned to adopt the following year. From their structural equation model (SEM), the authors' found that perceived ease of use, perceived net benefits, farmer confidence, farmer education, and farm size significantly influenced the number of precision technologies farmers reported intending to adopt. Though limited in that the outcome is intended use rather than actual practice use, this study shows how the expression of perceived practice characteristics and farmer attitudes affects the number of practices a farmer uses.

Price and Leviston (2014) use SEM to model pro-environmental land management practices in southeastern Australia, using a latent land management variable that is weighted by each practice's degree of environmental benefit. The authors find trust in agronomic information sources, locus of control, education, and biospheric concern to positively influence pro-environmental land management, while regional drought conditions reduced pro-environmental land management.

In reviewing this literature, two major points stand out: 1) few studies consider the use of multiple BMPS, and 2) the focus and approach varies across studies. Our analysis focuses on nutrient management practices, making it more specific than prior work. We use an additive index measure of actual practice use along with likelihood of future use (Adrian et al. 2005; Price and Leviston 2014), with our analyses seeking to describe the characteristics predicting the use of an increasing number of practices (Upadhyay et al. 2003).

Given the dearth of research on the use of multiple BMPs, we now briefly turn to discuss the literature on the drivers of the use of individual BMPs. Recent review articles have collected common predictors, conceptual frameworks, and anticipated effects of farmer characteristics on individual agricultural BMP adoption (Baumgart-Getz et al.2012; Knowler and Bradshaw 2007; Prokopy et al. 2008; Wauters and Mathijs 2014). Knowler and Bradshaw (2007) outline four categories of predictor variables: farmer and farm household characteristics, farm attributes (biophysical), farm financial/management factors, and exogenous factors including prices, information, and program participation. Wauters and Mathijs (2014) include four more: diffusion factors like information, social learning and past experiences; attributes of soil conservation practices; farmers' social psychological characteristics such as conservation attitudes or environmental concern; and geographic variables including region. Baumgart-Getz et al. (2012)

and Propkopy et al. (2008) include capacity, attitudes, awareness, and farm characteristics as categories to frame their meta-analysis and literature review, respectively.

In the following analyses we build on past work by using structural equation modeling with latent variables to examine the drivers of multiple nutrient specific BMP use, using measures of past, current, and likelihood of future practice use. Given expectations from previous research (Baumgart-Getz et al. 2012; Reimer, Thompson, and Prokopy 2012; Ulrich-Schad et al. 2017), we use four attitudinal measures (environmental concern, overuse of agrichemicals, farm stewardship attitude, productivist attitude), use of information sources and views of information barriers, program participation and individual demographic characteristics as variables affecting practice adoption. With the exception of age, we anticipate positive effects of these variables on our three outcome variables: the number of BMPs used in the past and present, and the likelihood of future practice use. Our findings may offer important insights for policy efforts attempting to reduce agricultural non-point source pollution in the Midwest through the increased adoption of multiple BMPs per farm.

Data and Methods

In 2014, we conducted a survey of commercial corn producers in three Midwestern U.S. states—Indiana, Iowa, and Michigan—to gather information regarding the use of nitrogen fertilizers and associated management practices. We selected these three states to represent the range of physiographic and socioeconomic settings within the "Corn Belt" states, the geographic region of the U.S. growing the majority of corn and soybean (Arbuckle et al. 2014). In 2015, the Corn Belt states grew nearly 60% of the U.S.'s 13.6 billion bushels of corn and 55% of the U.S.'s 3.9 billion bushels of soybeans (USDA 2015). Thirty-seven percent of the region's total land area was planted in these crops in 2015 (USDA 2015), ranging from 12% in Michigan to 65% in Iowa.

Our survey sample was drawn from the U.S. Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS) Census of Agriculture sample frame in consultation with the NASS Regional Office in Michigan. Given our interest in larger-scale corn farmers, the sample frame consisted of non-organic corn growers with more than 100 acres of cropland in 2012, the most recent Census of Agriculture year (USDA 2012). To ensure adequate representation of large farms, we stratified our sample into three categories by farm size: under 500 acres, 500-999 acres, and greater than 1000 acres of cropland.

We followed a four-wave mailing process using a modified Tailored Design Method that included a survey-survey-postcard-survey protocol (Dillman, Smyth, and Christian 2014). Farmers in our sampling frame were mailed a survey questionnaire in March and early April 2014 with Michigan State University letterhead and NASS return addresses. In the first contact, farmers were mailed a survey questionnaire with a cover letter explaining the study's purpose. The second contact, approximately 2 weeks later, included a second copy of the questionnaire. The third and fourth contacts consisted of a color reminder postcard and a third copy of the questionnaire, respectively, and were mailed seven days following previous contacts.

Our response rate of 17% (n=260), although low, approximates recent surveys using similar designs (Arbuckle et al. 2014; Reimer and Prokopy 2014; Stuart, Schewe, and McDermott 2014). We over-sampled operators with large numbers of acres in corn production, resulting in a sample with 75% of our respondents farming less than 500 acres, which is smaller than the three-state average of 86% of farms with less than 500 acres that grow corn for grain. Accordingly, we use survey weights in our analyses using NASS-recommended farm size class information for each state. Compared to the sample non-respondents, the respondents were older on-average (59.5 years versus 56.8 years).

The survey questionnaire included 35 questions covering a range of topics including farm operation characteristics, fertilizer management decisions, use of application technologies, views related to production strategies, farming goals, and the environment, and grower characteristics including demographics and socio-economics. In this paper we present findings from questions related to conservation practice adoption and seek to explain what factors shape past, current and likely future adoption of multiple practices. Our model (Figure 1) is a seemingly unrelated regression (SUR)[1] model, where multiple regression equations are related to each other in a single model through equation error terms between the three outcome variables—practice adoption in the present, past and likelihood in the future.

We use structural equation modeling with latent variables (SEMLV) to estimate our SUR model (Bollen 1989; Hoyle 2012). SEMLV is a multi-equation regression technique that accommodates multiple relationships between multiple exogenous and endogenous variables simultaneously and includes both latent and observed variables. A latent construct, also called a latent variable, is an unobserved variable that captures the relations between the multiple observed variables being used to measure it (Bollen 1989; 2002). As is standard practice in SEMLV, we evaluated the fit of each of the five latent variables used as predictors in our model via confirmatory factor analysis (CFA) or measurement models. We use SAS 9.3 and AMOS 24 for our analyses.

[1] SUR models use generalized least squares (GLS) estimation given information about the off-diagonal correlations between equation disturbances in the model.

We use five latent variables as predictors in our model. CFA results provide fit statistics for each measure included in a latent variable and the overall fit of the latent construct, both of which need to be examined to comprehensively assess the fit of the latent constructs and evaluate their appropriateness for use in the analysis. An acceptable latent variable has strong inter-item consistency (Raykov 1997), with standardized and unstandardized factor loadings that are of consistent size and direction (the former above 0.4 and the latter around 1). Overall model fit statistics for such a latent variable include a non-significant chi-square value (indicating that the estimated model is not significantly different from the data), values for the Incremental Fit Index (IFI), Comparative Fit Index (CFI), and Tucker-Lewis Index (TLI) that are above 0.95, and a Root Mean Square Error of Approximation (RMSEA) below 0.05 (Brown and Moore 2012; West, Taylor, and Wu 2012). Information about the component and overall model fit for each latent variable is provided in Table 2.

[FIGURE 1. CONCEPTUAL DIAGRAM]

Outcome Variables: Use of On-Farm Nitrogen Best Management Practices

We asked about the use of six nitrogen BMPs in the survey: side-dress nitrogen application, winter cover crops, soil or plant nitrate testing, variable rate nitrogen application, slow-release fertilizer products, and imagery. The three outcome variables in our model are additive indices of using these six conservation practices at three different times: used in the past (before 2013), using in 2013 (the focus year of the survey), and likelihood of using the practice on their largest field in the next three years. These measures range in value from 0 to 6.[2]

Independent Variables

Given expectations from previous research (Baumgart-Getz et al. 2012; Reimer et al. 2012; Ulrich-Schad et al. 2017), we use measures of farm stewardship and productivist attitudes (McGuire, Morton, and Cast 2013; Thompson, Reimer, and Prokopy 2015), environmental awareness and concern (Baumgart-Getz et al. 2012; Prokopy et al. 2008), agrichemical overuse (Stuart et al. 2012; 2014), and information sources (Stuart et al. 2018), and individual demographic characteristics as independent variables affecting the adoption of multiple BMPs. We constructed the latent variables in our model using measures of generally expressed attitudes and beliefs as indicators (Fishbein and Ajzen 2015)[3]. However, given our outcome variables and available data, our attitude measures are not practice-specific, but rather are of more general attitudes that reflect how the farmer approaches their operation and their perceived need for using multiple BMPs and challenges to doing so.

'*Farm stewardship attitude'* is a latent construct including four variables regarding how important the items were to being a farmer and managing their operation. These survey items include looking after the environment, passing on the land in good condition, minimizing

[2] The likelihood of future practice use was asked on a 10-point scale and then rescaled to a 6-point scale matching the past and current use indices.

[3] Given this generality-specificity issue, we use the terms attitudes and perceptions rather than beliefs, the latter of which would be more in line with the reasoned action approach (Best and Mayerl 2013; Fishbein and Ajzen 2015).

environmental impacts, and improving the land's condition (scale from 1=not at all important to 10=extremely important). CFA results and fit statistics (Table 2) indicate very good fit of this latent construct to the data.

'*Productivist attitude*' is a latent construct that includes six variables capturing the importance of being a highly productive and successful farmer, particularly in economic terms, and includes being among the best in the industry, building up land and wealth assets, and profit maximization (from 1=not at all important to 10=extremely important). Fit statistics (see Table 2) indicate very good fit of this latent construct. The latent construct 'e*nvironmental concern*' includes four variables asking survey respondents how much of a problem they perceive these environmental issues to be locally (from 1=not a problem to 5=critical problem). The four survey items include nutrients in groundwater, and nutrients, algal blooms, and hypoxia (dead zones) in surface waters. Fit statistics (Table 2) indicate excellent fit. The latent construct '*overuse of agrichemicals*' includes three variables about farmers' opinions regarding the overuse and dependence on fertilizer and pesticides in modern farming (from 1=strongly disagree to 5=strongly agree). The variables have been re-scaled so that higher values indicate disagreement with the individual items. Fit statistics show acceptable fit (Table 2).

'Information barriers' is a latent variable including four measures related to how a lack of information regarding new practices that respondents reported served as challenges to their adoption on their operation. These included questions regarding the uncertainty of benefits and not being able to see a practice in action (from 1=not a barrier to 5=strong barrier). CFA results indicate a reasonable fit (Table 2). *Information sources* is a scale that summarizes the number of sources from which survey respondents reported having received information about nitrogen management. This variable includes seven information sources—fertilizer supplier, other

farmers, friends, and neighbors, county extension/university specialist, independent crop consultant, farm magazines/media, seed suppliers, and online calculators—combined into an additive scale that ranges from 0 to 7, with higher values indicating that respondents receive materials from more information sources.

As in prior studies (e.g., Baumgart-Getz et al. 2012; Ulrich-Schad et al. 2017), we include measures of education, farming experience, age categories, and farm size. *Education* is a dichotomous measure of whether farmers have an associate's, bachelor's or graduate degree (college=1). *Farming experience* is the number of years the respondent reported having been in farming. We created four *age categories*: 49 years and younger (reference), between 50 and 59 years, between 60 and 69 years of age, and 70 years or older. *Farm size* includes three categories: 499 acres or less (reference), 500 to 999 acres, and 1000 acres or more.

We include measures of farmer characteristics, a subset of which are specific to each outcome variable (i.e. only relevant to practice adoption at certain times). *Is a risk-taker* is a binary measure of being a self-reported risk-taker compared to other farmers regarding the introduction of new practices. Binary variables of *past participation* (participate=1) *in the Environmental Quality Incentive Program (EQIP),* and *past participation in the Conservation Stewardship Program (CSP)* are included as predictors of past conservation practice use. Binary variables of *current participation in EQIP and CSP* are included as predictors of current practice use and likely future use (participate=1). The percent of a farmers' operation that is *rented* (in acres) is in the model of current practice use. *Days worked off-farm* is a predictor of current and future practice use, measured in four categories: 0 days worked off-farm (reference category), 1 to 49 days, 50 to 199 days, and 200 days or more worked off-farm.

[TABLE 1: DESCRIPTIVE STATISTICS]

[TABLE 2: LATENT VARIABLE FIT]

Results

Descriptive statistics for the variables used in the analyses (Table 1) show that on average farmers in our sample reported currently (i.e. 2013) using 2 of the 6 BMPs. Retrospectively, farmers reported using on average 1.54 BMPs on their operation. Looking forward, farmers reported moderate likelihood of using multiple BMPs on their largest field in the next 3 years—either being very likely to adopt 3 of the 6 practices (less than 10% of the sample), moderately likely to adopt all 6 practices (approximately 40% of the sample), or somewhere in between. The top three practices currently in use are side-dress nitrogen application, use of slow-release fertilizer products, and soil or plant nitrate testing, with 4 in 10 farmers in our sample reporting using each of them. On average farmers in our sample received information about nitrogen application from about 3 sources (out of 7).

Regarding farmer characteristics, the majority of respondents (61%) operate less than 500 acres, are full-time farmers (66% worked 0 days off-farm in the last year) and are between 50 and 69 years of age (66%). Forty percent of our sample has attended college or has a college degree. Farmers in our sample have been farming for approximately 35 years on average. Past and current participation in EQIP among our sample has been steady at 17%. CSP participation in our sample is 6% in the past and 19% currently, reflecting recent expansion of the program.

Table 3 includes the results of our SUR model, showing the results of the portions of the analysis predicting the index of current BMP use, past BMP use, and likely future BMP use, respectively. We find that expressing stewardship attitudes is the largest standardized predictor of current BMP use, with a 1 standard deviation increase in stewardship attitudes being associated with a 0.309 standard deviation increase in the number of BMPs in use. Believing that agrichemicals are used appropriately had a positive effect on current BMP use, with a standardized coefficient of 0.150. Farmers who reported being risk-takers in relation to new practices and those with a college education both used more BMPs on average than farmers who did not, with standardized coefficients of 0.177 and 0.167 respectively. Being a current EQIP participant increased the number of BMPs in use, while farmers who reported working off-farm for 50 to 199 days adopted fewer practices, on average, than full-time farmers. Our model explains 33% of the variation in current BMP use.

[TABLE 3: RESULTS]

The second column of Table 3 shows the results for the portion of the model that predicts the index of past BMP use. Results reveal that farmers who use more information sources used more BMPs in the past, with a standardized coefficient of 0.151. The stewardship attitudes variable is marginally significant, with a positive effect on the number of practices used in the past and a standardized coefficient of 0.150. This model explains over 10% of the variation in past use of BMPs.

The final column of Table 3 shows the results predicting likelihood of future BMP use. Our results show that perceptions of agrichemical use and stewardship attitudes positively affect likelihood of future BMP adoption—two variables with large, positive standardized coefficients. A 1 standard deviation increase in stewardship attitude increases farmers intention to adopt BMPs in the future by 0.366 standard deviations, while a 1 standard deviation increase in perceptions of appropriate agrichemical use increases intended future BMPs use by 0.155 standard deviations. Use of more information sources had a positive effect on intention to adopt BMPs, with a 0.135 standardized coefficient. Being a current EQIP participant increased the number of BMPs likely to be used in the future, as did being a current CSP participant. Our model explains approximately 27% of the variation in likelihood of future use of BMPs.

Overall, our results reveal support for the model (Figure 1). For farmers in our sample, the number of BMPs adopted in the present and past and intended to be adopted in the future are driven by attitudes, information, and individual characteristics. Practice adoption at present, past, and future are correlated with one another temporally. More specifically, the BMP use equations are correlated at 0.50 between past and current, 0.59 between past and future, and 0.69 between current use and likelihood of future use indices[4]. Overall model fit is reasonable (see fit measures at bottom of Table 3).

Discussion

Taken overall, our results suggest several interesting patterns. One key finding is the consistent positive effect of *farm stewardship attitudes* on past and current BMP adoption and on likelihood of future adoption (Prokopy et al. 2008; Thompson et al. 2015). This variable is an important predictor in our model, having the largest standardized effects on present use and likelihood of future adoption. The number of BMPs a farmer used in the past, uses now, and intends to use in the future increases as their stewardship attitudes do. This effect is as expected

[4] The Breusch-Pagan test indicates that using this technique is warranted, suggesting there is correlation between the equation disturbances.

given how our measure of stewardship attitudes includes looking after the environment, minimizing environmental impacts, and improving the land's condition, and the practices included in the outcome variables have both farm operation and environmental benefits.

The *overuse of agrichemicals* variable has a positive effect on current use of BMPs and likelihood of future use. This result suggests that farmers who see little problem with the agrichemical status quo are more likely to use more BMPs at present and report that they are more likely to adopt them in the future, compared to farmers who might see problems with modern agrichemical practices. In other words, farmers' adoption of more BMPs is not tightly coupled with a critique of current agricultural practices regarding the intensity of chemical and fertilizer use. This finding supports emerging work arguing that farmers' perceptions and attitudes are heterogeneous, and that they may simultaneously hold complementary and competing views related to stewardship goals and agrichemical input use (Morton, McGuire, and Cast 2017; Thompson et al. 2015). This suggests that it may be more effective to promote BMPs as agricultural improvements or advances to modern farming practices rather than as "solutions" to agricultural problems or for environmental reasons. This interpretation is consistent with the positive effect of *farm stewardship attitude* on present and future BMP use, and the lack of significant effects of *environmental concern* and *productivist attitude* variables, the latter of which complements recent work (Arbuckle and Roesch-McNally 2015; Baumgart-Getz et al. 2012; Ulrich-Schad et al. 2017).

Several individual traits and characteristics were shown to affect multiple BMP use, particularly for current practice use. Interestingly, we found that using more information sources had a positive effect on the past number of BMPs used and intention to use them in the future, but not on the number of current BMPs in use. Although using more information sources suggests a farmer actively seeking new information and practices, there is likely much to be gained from considering the importance of different information sources on practice adoption (Stuart et al. 2018). Being a self-described risk-taker when it comes to introducing new practices was a positive indicator of number of currently used BMPs but was not significant for past and future practice use. Risk is rarely found to be significant in models of individual practice use (Baumgart-Getz et al. 2012; Prokopy et al. 2008).

College education had a positive effect on the number of BMPs currently in use, as anticipated, but was not significant for future likelihood of adoption. This finding aligns with recent work revealing education affecting some (e.g. use of precision technologies) but not all practices (Baumgart-Getz et al. 2012; Ulrich-Schad et al. 2017; Upadhyay et al. 2003; Adrian et al. 2005). A positive effect of EQIP participation on current use of multiple BMPs was as anticipated, as were positive effects of current EQIP and CSP participation on likely future use of multiple BMPs. For part-time farmers, the amount of time they work off farm can shape their BMP adoption. Fully part-time farmers (those working 50-199 days off-farm per year) were less likely to use more BMPs compared to full-time farmers who did not work off-farm; however, the number of BMPs currently in use was not significantly different among farmers who worked off-farm less than part-time and “hobby farmers” who worked off-farm more than half the year.

At least three general conclusions may be drawn from these results. First, there are important similarities in predictors of present BMP use and intention of future adoption. Notably, farmers’ attitudes related to agrichemical use and farm stewardship promote the simultaneous use of a greater number of BMPs in the present and intended in the future. Second, some individual attributes, such as college education and being a risk-taker, affect how many BMPs were adopted. Compared with non-college educated counterparts, those with a college education adopted more practices in the present. Being a risk-taker promoted greater practice use in the present, compared with risk-averse counterparts. Third, some unexpected differences in the temporal dimensions were revealed. For instance, using more information sources positively affected the number of BMPs used in the past and intended to be used in the future, but not used in the present.

Key gaps in our understanding of farmers' simultaneous adoption of BMPs remain. Our analysis used the body of prior literature on BMP adoption to inform variable construction and develop hypothesized relations shown in Figure 1. Future work may benefit from applying a more formalized theoretical framework of behavior, like the reasoned action approach (Fishbein and Ajzen 2015). Also, our empirical model explains a modest amount of variance in behavior (past, current and intended). Theories of attitude-behavior correspondence suggest that the predictive power of attitudes increase with specificity of the attitude object in time and space (Best and Mayerl 2013).[5] Extending this, further analysis should include belief and attitudinal measures that are more specific to the timing (current or future) and specific BMPs considered. These suggestions indicate how future research can build on this study's introductory insight into farmers' simultaneous adoption of multiple BMPs.

Conclusion

In an effort to further our understanding of how to reduce the environmental impacts of agriculture, a growing body of social science scholarship examines the multitude of factors shaping on-farm BMP adoption. Research with a watershed emphasis from the natural sciences suggest that the simultaneous use of multiple nutrient BMPs is needed to achieve significant

[5] We thank an anonymous reviewer for suggestions included in this section.

reductions in nutrient loss and associated improvements in water quality (Bosch et al. 2013; Teshager et al. 2017). As Teshager et al. (2017: 1195) comment, their results indicate "more expanded implementation, in area and/or number, of agricultural management practices may be required to achieve the water quality standard," a finding that "underscore(s) the need for a broader suite of management practices [to be adopted]." Thus, it is increasingly important that social science research pursue an understanding of what drives farmers to adopt multiple BMPs. Our study is an introductory effort in this task. We examined the predictors of farmers' adoptions of multiple nitrogen BMPs at three time-points: past, present, and intended future. Across these analyses, our results show that the number of nitrogen BMPs concurrently in use is driven by farmers' attitudes, use of information, and select individual characteristics.

Although this analysis is a step forward in considering the number of BMPs used, much remains to be understood. Future studies can build upon our introductory insights in a number of ways. First, future analyses should investigate the use of multiple BMPs by considering which practices are frequently used together and why. Specifically, might a given set of BMPs cluster, driven by the adoption of a 'gateway' practice enabling the adoption of subsequent related BMPs? Second, attitudes, while important, are not the only requirement to BMP adoption. Cognitive, economic, and skill barriers are potentially important intervening variables warranting greater examination. Rather than simply limit the absolute number of BMPs used, it may be that these barriers influence the type of BMPs adopted. Farmers facing economic barriers may use a high number of low-cost BMPs (e.g. field scouting) but are unable to undertake BMPs requiring large capital investments (e.g. purchasing new equipment for variable rate nitrogen application).

Although we examined technologically and biologically-based practices given the available survey data, including sidedress application, use of slow-release fertilizer, and cover crops, future work should include structural practices like vegetative buffers or grassed waterways (Robertson and Vitousek 2009). An examination of all three types of practices would provide greater breadth and depth than was possible in this study, providing an important bridge between scholarship on practice adoption from the social and natural sciences. Finally, although the temporal component of our model is interesting, without panel data we cannot be sure how accurately these reported intentions predict future behavior. While our descriptive findings suggest that the number of BMPs adopted increases over time, a longitudinal study is needed to determine if farmers accrue BMPs over time, or if they adopt novel BMPs to replace currently used practices. Future research should examine these interrelations to provide a richer description of the complexities farmers face as they make nutrient management decisions to improve our understanding of ever-changing constraints placed on farmer decision-making.

References

Adrian, Anne Mims, Shannon H. Norwood, and Paul L. Mask. 2005. "Producers' Perceptions and Attitudes toward Precision Agriculture Technologies." *Computers and Electronics in Agriculture* 48 (3): 256–71.

Arbuckle, J. G., and G. Roesch-McNally. 2015. "Cover Crop Adoption in Iowa: The Role of Perceived Practice Characteristics." *Journal of Soil and Water Conservation* 70 (6): 418–29.

Arbuckle, J G, J Hobbs, A Loy, L W Morton, L S Prokopy, and J Tyndall. 2014. "Understanding Corn Belt Farmer Perspectives on Climate Change to Inform Engagement Strategies for Adaptation and Mitigation." *Journal of Soil and Water Conservation* 69 (6): 505–16.

Baumgart-Getz, Adam, Linda Stalker Prokopy, and Kristin Floress. 2012. "Why Farmers Adopt Best Management Practice in the United States: A Meta-Analysis of the Adoption Literature." *Journal of Environmental Management* 96 (1): 17–25.

Best, H. and Mayerl, J. 2013. Values, Beliefs, Attitudes: An Empirical Study on the Structure of Environmental Concern and Recycling Participation. *Social Science Quarterly* 94 (3): 691–714.

Blesh, J., and L. E. Drinkwater. 2013. "The Impact of Nitrogen Source and Crop Rotation on Nitrogen Mass Balances in the Mississippi River Basin." *Ecological Applications* 23 (5): 1017–35.

Bollen, Kenneth A. 1989. *Structural Equations with Latent Variables*. New York, NY: Wiley.

———. 2002. "Latent Variables in Psychology and the Social Sciences." *Annual Review of Psychology* 53: 605–34.

Bosch, Nathan S., J. David Allan, James P. Selegean, and Donald Scavia. 2013. "Scenario-Testing of Agricultural Best Management Practices in Lake Erie Watersheds." *Journal of Great Lakes Research* 39 (3): 429–36.

Brown, Timohty A., and Michael T. Moore. 2012. "Confirmatory Factor Analysis." In *Handbook of Structural Equation Modeling*, edited by Rick H. Hoyle, 361–79. New York: Guilford Press.

Diaz, Robert J., and Rutger Rosenberg. 2008. "Spreading Dead Zones and Consequences for Marine Ecosystems." *Science* 321 (5891): 926–29.

Dillman, D.A., J.D. Smyth, and L.M. Christian. 2014. *Internet, Phone, Mail, and Mixed-Mode Surveys: The Tailored Design Method*. Hoboken, NJ: John Wiley & Sons.

Drinkwater, L E, and S S Snapp. 2007. "Nutrients in Agroecosystems: Rethinking the Management Paradigm." *Advances in Agronomy* 92: 163–86.

Dunn, M., J. D. Ulrich-Schad, L. S. Prokopy, R. L. Myers, C. R. Watts, and K. Scanlon. 2016. "Perceptions and Use of Cover Crops among Early Adopters: Findings from a National Survey." *Journal of Soil and Water Conservation* 71 (1): 29–40.

Environmental Protection Agency (EPA). 2017. "National Water Quality Inventory: Report to Congress." *EPA 841-R-16-011*. Washington D.C. https://www.epa.gov/sites/production/files/2017-12/documents/305brtc_finalowow_08302017.pdf.

Fishbein, Martin, and Icek Ajzen. 2015. *Predicting and Changing Behavior: The Reasoned Action Approach*. New York, NY: Routledge.

Flis, Sally. 2017. "The 4Rs in Crop Nitrogen Research." *Crops & Soils* 50 (2): 18–20.

Holmes, Roger, David G Armanini, and Adam G Yates. 2016. "Effects of Best Management Practice on Ecological Condition: Does Location Matter?" *Environmental Management* 57 (5): 1062–76.

Houser, Matthew, D. Stuart, and Michael Carolan. 2017. "Is Seeing Believing? Applying a Realist Framework to Examine Agriculture and Climate Change." *Environmental Sociology* 3 (4): 321-336.

Howarth, Robert W, Elizabeth W Boyer, Wendy J Pabich, and James N Galloway. 2002. "Nitrogen Use in the United States from 1961-2000 and Potential Future Trends." *AMBIO: A Journal of the Human Environment* 31 (2): 88–96.

Hoyle, Rick H. 2012. "Model Specification in Structural Equation Modeling." In *Handbook of Structural Equation Modeling*, edited by Rick H Hoyle, 126–44. New York: The Guilford Press.

Knowler, Duncan, and Ben Bradshaw. 2007. "Farmers' Adoption of Conservation Agriculture: A Review and Synthesis of Recent Research." *Food Policy* 32 (1): 25–48.

Lam, Q. D., B. Schmalz, and H. Fohrer. 2011. "The Impact of Agricultural Best Management Practices on Water Quality in a North German Lowland Catchment." *Environmental Monitoring and Assessment* 183 (1–4): 351–79.

Lambert, Dayton M, Patrick Sullivan, Roger Claassen, and Linda Foreman. 2007. "Profiles of US Farm Households Adopting Conservation-Compatible Practices." *Land Use Policy* 24 (1): 72–88.

Liu, Yongbo, Wanhong Yang, Luis Leon, Isaac Wong, Craig McCrimmon, Alice Dove, and Phil Fong. 2016. "Hydrologic Modeling and Evaluation of Best Management Practice Scenarios for the Grand River Watershed in Southern Ontario." *Journal of Great Lakes Research* 42 (6): 1289–1301.

Makarewicz, Joseph C., Theodore W. Lewis, Isidro Bosch, Mark R. Noll, Nathan Herendeen, Robert D. Simon, James Zollweg, and Anthony Vodacek. 2009. "The Impact of

Agricultural Best Management Practices on Downstream Systems: Soil Loss and Nutrient Chemistry and Flux to Conesus Lake, New York, USA." *Journal of Great Lakes Research* 35 (SUPPL. 1): 23–36.

McGuire, Jean, Lois Wright Morton, and Alicia D Cast. 2013. "Reconstructing the Good Farmer Identity: Shifts in Farmer Identities and Farm Management Practices to Improve Water Quality." *Agriculture & Human Values* 30: 57–69.

Morton, Lois Wright, Jean M. McGuire, and Alicia D. Cast. 2017. "A Good Farmer Pays Attention to the Weather." *Climate Risk Management* 15: 18–31.

Motsinger, Jason, Prasanta Kalita, and Rabin Bhattarai. 2016. "Analysis of Best Management Practices Implementation on Water Quality Using." *Water* 8 (4): 145.

Napier, Ted L., and T. Bridges. 2002. "Adoption of Conservation Production Systems in Two Ohio Watersheds: A Comparative Study." *Journal of Soil and Water Conservation* 57 (4): 229–35.

Napier, Ted L., and Tracy Bridges. 2003. "Adoption of Conservation Production Systems within the Upper Region of the Scioto River Watershed in Ohio." *Journal of Food, Agriculture & Environment* 1 (2): 287–94.

Napier, Ted L., M. Tucker, and S. McCarter. 2000. "Adoption of Conservation Production Systems in Three Midwest Watersheds." *Journal of Soil and Water Conservation* 55: 123–34.

Napier, Ted L., and Mark Tucker. 2001. "Use of Soil and Water Protection Practices among Farmers in Three Midwest Watersheds." *Environmental Management* 27 (2): 269–79.

Price, Jennifer C, and Zoe Leviston. 2014. "Predicting Pro-Environmental Agricultural Practices: The Social, Psychological and Contextual Influences on Land Management." *Journal of Rural Studies* 34 (0): 65–78.

Prokopy, L S, K Floress, D Klotthor-Weinkauf, and A Baumgart-Getz. 2008. "Determinants of Agricultural BMP Adoption: Evidence from the Literature." *Journal of Soil and Water Conservation* 63 (5): 300–311.

Raykov, Tenko. 1997. "Estimation of Composite Reliability for Congeneric Measures." *Applied Psychological Measurement* 21 (2): 173–84.

Reimer, Adam P., and Linda S. Prokopy. 2014. "One Federal Policy, Four Different Policy Contexts: An Examination of Agri-Environmental Policy Implementation in the Midwestern United States." *Land Use Policy* 38: 605–14.

Reimer, Adam P., Aaron W. Thompson, and Linda S. Prokopy. 2012. "The Multi-Dimensional Nature of Environmental Attitudes among Farmers in Indiana: Implications for Conservation Adoption." *Agriculture and Human Values* 29 (1): 29–40.

Ribaudo, Marc. 2006. “Hypoxia in the Gulf: Addressing Agriculture’s Contribution.” *Amber Waves* 4: 37.

———. 2015. “The Limits of Voluntary Conservation Programs.” *Choices: The Magazine of Food, Farm & Resource Issues* 30 (2): 1–5.

Ribaudo, Marc, Jorge Delgado, Leroy Hansen, Michael Livingston, Roberto Mosheim, and James Williamson. 2011. “Nitrogen In Agricultural Systems: Implications For Conservation Policy.” Washington DC. http://www.chesapeake.org/stac/presentations/63_Ribaudo M et al_2011_Nitrogen in agricultural systems_implications for conservation policy.pdf.

Robertson, G. Philip, and Peter M. Vitousek. 2009. “Nitrogen in Agriculture: Balancing the Cost of an Essential Resource.” *Annual Review of Environment and Resources* 34 (1): 97–125.

Snyder, Clifford S. 2017. “Enhanced Nitrogen Fertiliser Technologies Support the ‘ 4R ’ Concept to Optimise Crop Production and Minimise Environmental Losses.” *Soil Research* 55 (6): 463–72.

Sowa, Scott P., Matthew Herbert, Sagar Mysorekar, Gust M Annis, Kimberly Hall, A. Pouyan Nejadhashemi, Sean A. Woznicki, Lizhu Wang, and Patrick J. Doran. 2016. “How Much Conservation Is Enough? Defining Implementation Goals for Healthy Fish Communities in Agricultural Rivers.” *Journal of Great Lakes Research* 42 (6): 1302–21.

Stuart, D., B. Basso, S. Marquart-Pyatt, A. Reimer, G. P. Robertson, and J. Zhao. 2015. “The Need for a Coupled Human and Natural Systems Understanding of Agricultural Nitrogen Loss.” *BioScience* 65 (6): 571–78.

Stuart, D., R. C. H. Denny, M. Houser, A. P. Reimer, and S. Marquart-Pyatt. 2018. “Farmer Selection of Sources of Information for Nitrogen Management in the US Midwest: Implications for Environmental Programs.” *Land Use Policy* 70: 289–97.

Stuart, D., R. L. Schewe, and M. McDermott. 2012. “Responding to Climate Change: Barriers to Reflexive Modernization in U.S. Agriculture.” *Organization & Environment* 25 (3): 308–27.

———. 2014. “Reducing Nitrogen Fertilizer Application as a Climate Change Mitigation Strategy: Understanding Farmer Decision-Making and Potential Barriers to Change in the US.” *Land Use Policy* 36: 210–18.

Teshager, Awoke Dagnew, Philip W. Gassman, Silvia Secchi, and Justin T. Schoof. 2017. “Simulation of Targeted Pollutant-Mitigation-Strategies to Reduce Nitrate and Sediment Hotspots in Agricultural Watershed.” *Science of The Total Environment* 607–608: 1188–1200.

Thompson, Aaron W., Adam Reimer, and Linda S. Prokopy. 2015. “Farmers’ Views of the Environment: The Influence of Competing Attitude Frames on Landscape Conservation Efforts.” *Agriculture and Human Values* 32 (3): 385–99. doi:10.1007/s10460-014-9555-x.

Ulrich-Schad, J.D., S. García de Jalón, N. Babin, A. Pape, and L.S. Prokopy. 2017. "Measuring and Understanding Agricultural Producers' Adoption of Nutrient Best Management Practices." *Journal of Soil and Water Conservation* 72 (5): 506–18.

United States Department of Agriculture (USDA). 2012. *Census of Agriculture*. Washington, DC: United States Department of Agriculture, National Agricultural Statistical Service. https://www.agcensus.usda.gov/Publications/2012/.

———. 2015. *Crop Production 2014 Summary*. Washington, DC: United States Department of Agriculture, National Agricultural Statistical Service. www.usda.gov/nass/PUBS/TODAYRPT/cropan15.pdf.

Upadhyay, Bharat M., Douglas L. Young, Holly H. Wang, and Philip Wandschneider. 2003. "How Do Farmers Who Adopt Multiple Conservation Practices Differ from Their Neighbors?" *American Journal of Alternative Agriculture* 18 (1): 27–36.

Wauters, Erwin, and Erik Mathijs. 2014. "The Adoption of Farm Level Soil Conservation Practices in Developed Countries: A Meta-Analytic Review." *International Journal of Agricultural Resources, Governance and Ecology* 10 (1): 78–102.

Weber, Catharine, and Laura McCann. 2015. "Adoption of Nitrogen-Efficient Technologies by U.S. Corn Farmers." *Journal of Environment Quality* 44 (2): 391–401.

West, Stephen G., Aaron B. Taylor, and Wei Wu. 2012. "Model Fit and Model Selection in Structural Equation Modeling." In *Handbook of Structural Equation Modeling*, edited by Rick H. Hoyle, 209–31. New York: Guilford Press.

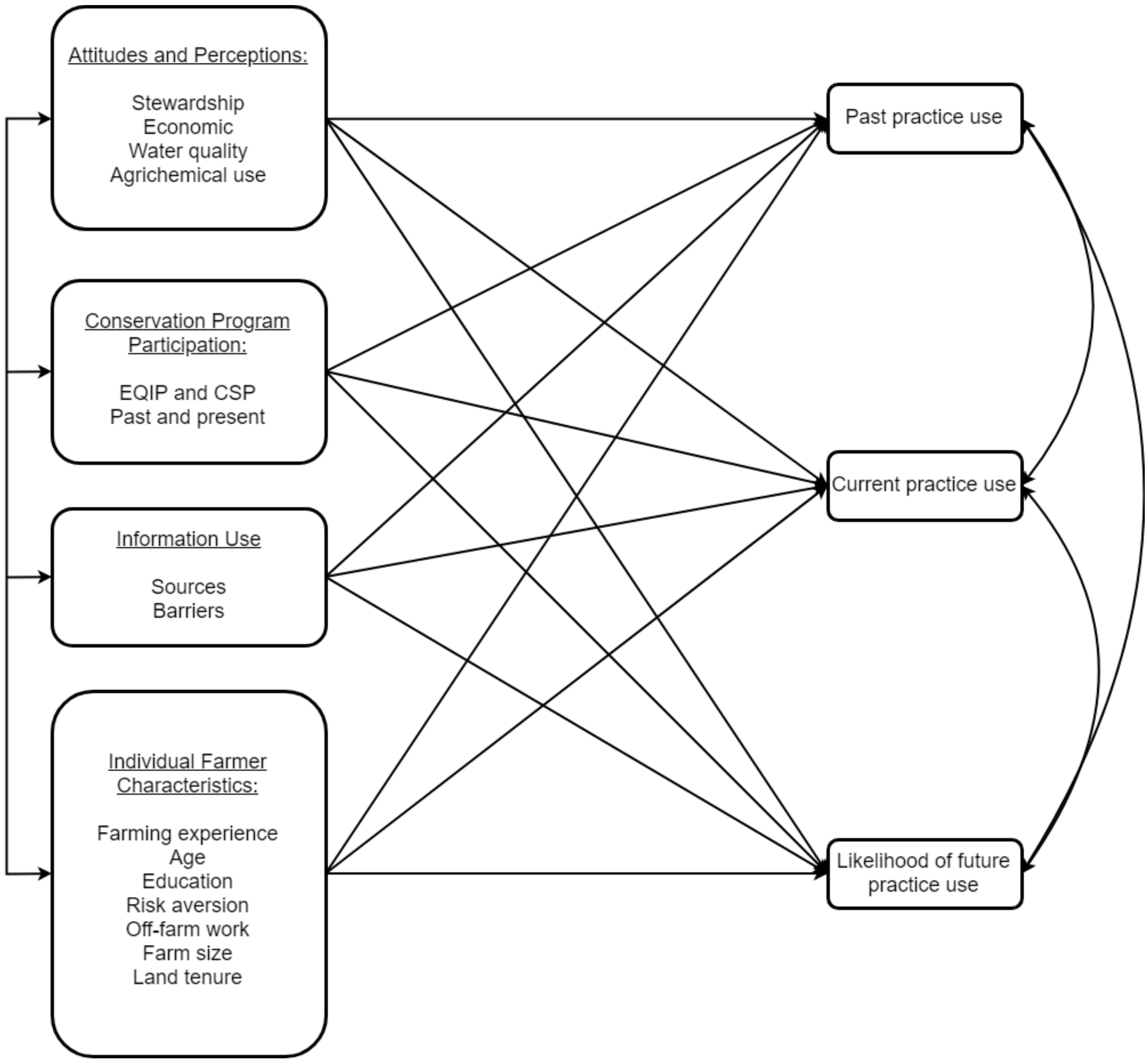

Figure 1. Conceptual model diagram.

Table 1. Descriptive Statistics (n=260)

	Mean	**Std Dev**	**Minimum**	**Maximum**	**Mode**
Practice Use					
Number of practices used in past	1.54	1.51	0.00	6.00	0.00
Number of practices used in 2013	2.06	1.43	0.00	6.00	2.00
Likelihood of using practices in future	3.13	1.52	0.00	6.00	0.00
Attitudes and Perceptions					
Farm Stewardship Attitude	8.52	1.42	1.00	10.00	
Productivist Attitude	7.74	2.02	1.00	10.00	
Environmental Concern	1.80	0.81	1.00	5.00	
Overuse of Agrichemicals	2.62	0.77	1.00	5.00	
Conservation Program Participation					
Current EQIP participant	0.17	0.47	0.00	1.00	
Past EQIP participant	0.17	0.52	0.00	1.00	
Current CSP participant	0.19	0.56	0.00	1.00	
Past CSP participant	0.06	0.26	0.00	1.00	
Information Use					
Information Barriers	1.49	0.54	1.00	5.00	
Use of 7 key N information sources	3.28	3.20	0.00	7.00	1.00
Individual Farmer Characteristics					
Years in farming	34.83	12.11	2.00	69.00	
Education (college degree or some college)	0.40	0.63	0.00	1.00	
Is a risk-taker	0.45	0.71	0.00	1.00	
Less than 49 years (reference)	0.21	0.43	0.00	1.00	
Ages 50 to 59 years	0.29	0.54	0.00	1.00	
Ages 60 to 69 years	0.37	0.65	0.00	1.00	
Ages 70 or more years	0.13	0.32	0.00	1.00	
Worked off-farm 0 days (reference)	0.66	0.73	0.00	1.00	
1-49 days	0.10	0.30	0.00	1.00	
50-199 days	0.06	0.22	0.00	1.00	
200 days or more	0.16	0.36	0.00	1.00	
Rented acres percent	44.44	45.15	0.00	100.00	
Farm Size 1-499 acres	0.61	0.34	0.00	1.00	
500-999 acres (reference)	0.09	0.40	0.00	1.00	
1000 or more acres	0.30	0.74	0.00	1.00	

Table 2. Measurement Model and Component Fit Statistics for Latent Variables

Measurement Model Fit	Chi-sq (df)	Chi-sq *p*	TLI	IFI & CFI	RMSEA (CI)
Farm Stewardship Attitude	2.13 (df=1)	0.144	0.98	1.00	0.06 (0.00, 0.17)
Productivist Attitude	7.24 (df=5)	0.204	0.99	0.99	0.07 (0.02, 0.12)
Overuse of Agrichemicals	..	..	..	..	..
Environmental Concern	0.11 (df=1)	0.742	1.00	1.00	0.00 (0.00, 0.11)
Information Barriers	3.71 (df=1)	0.054	0.90	0.99	0.05 (0.02, 0.09)

Component Fit	Std factor loadings**	Unstd factor loadings**	Reliability estimates (SMC)	Composite reliability
Farm Stewardship Attitude				0.90
Improve resource/land condition	0.918	1.000	0.842	
Pass on land in good condition	0.710	0.781	0.503	
Look after the environment	0.891	0.934	0.795	
Minimize environmental impacts	0.776	0.821	0.602	
Productivist Attitude				0.90
Earn a high income	0.961	1.000	0.924	
Have lots of money to spend	0.719	0.850	0.517	
Maximize farm/company profit	0.688	0.637	0.474	
Build up the land and property assets	0.663	0.616	0.440	
Build up wealth and family assets	0.877	0.932	0.770	
Be among the best in the industry	0.724	0.884	0.524	
Environmental Concern				0.89
Nutrients in groundwater	0.900	1.217	0.809	
Nutrients in surface waters	0.807	1.000	0.651	
Algal blooms in surface waters	0.781	1.133	0.609	
Hypoxia (dead zones) in surface waters	0.794	1.143	0.631	
Overuse of Agrichemicals				0.82
Farming relies too heavily upon fertilizers	0.807	1.000	0.872	
Farming relies too heavily upon pesticides	0.789	1.007	0.823	
Farmers often apply too much fertilizer	0.737	0.706	0.406	
Information Barriers				0.68
Uncertainty of benefits	0.534	1.000	0.300	
Lack of available information…	0.640	1.082	0.410	
Not being able to see a field demo....	0.554	1.017	0.307	
No one else I know is implementing…	0.635	1.043	0.403	

Table 3. SEMLV Results for Models of Current, Past and Likely Future Use of Multiple Nutrient Best Management Practices (n = 260)

	Current Practice Use		**Past Practice Use**		**Future Practice Use**	
	Unstd coeffs (std errors)	Std coeffs	Unstd coeffs (std errors)	Std coeffs	Unstd coeffs (std errors)	Std coeffs
Attitudes and Perceptions						
Farm Stewardship Attitude	0.276***	0.309	0.140†	0.150	0.348***	0.366
	(0.067)		(0.079)		(0.085)	
Productivist Attitude	0.001	0.004	0.004	0.006	-0.042	-0.060
	(0.048)		(0.048)		(0.058)	
Environmental Concern	0.079	0.050	-0.183	-0.111	-0.023	-0.014
	(0.118)		(0.130)		(0.132)	
Oveuse of Agrichemicals	0.210†	0.150	-0.058	-0.039	0.231†	0.155
	(0.110)		(0.122)		(0.126)	
Conservation Program Participation						
Program Participant—EQIP‡	0.464**	0.152	0.107	0.037	0.468*	0.144
	(0.188)		(0.196)		(0.208)	
Program Participant—CSP‡	0.096	0.038	0.427	0.074	0.412*	0.151
	(0.161)		(0.339)		(0.183)	
Information Use						
Information Barriers	..	..	..	..	0.106	0.044
	..		..		(0.185)	
Information source use	0.050	0.078	0.103*	0.151	0.085*	0.135
	(0.035)		(0.041)		(0.039)	
Individual Farmer Characteristics						
Years in Farming	-0.005	-0.037	0.009	0.148	-0.011	-0.187
	(0.008)		(0.008)		(0.009)	
College Education	0.398***	0.167	0.115	0.048	0.161	0.066
	(0.141)		(0.163)		(0.157)	
Is a risk-taker	0.491**	0.177	0.039	0.014	0.282	0.091

	(0.164)		(0.193)		(0.183)	
Farmers aged up to 49 years (ref)	..	..	..	..	..	..
	..		..		..	
Farmers aged 50 to 59 years	-0.159	-0.061	-0.072	-0.028	-0.296	-0.096
	(0.242)		(0.276)		(0.260)	
Farmers aged 60 to 69 years	-0.010	-0.004	-0.318	-0.139	-0.068	-0.029
	(0.285)		(0.326)		(0.319)	
Farmers aged 70+ years	-0.429	-0.096	-0.660	-0.141	-0.278	-0.059
	(0.401)		(0.446)		(0.449)	
Worked off-farm 0 days (ref)	..	..	..	..	..	..
	..		..		..	
Worked off-farm 1-49 days	0.208	0.044	..		-0.101	-0.020
	(0.262)		..		(0.284)	
Worked off-farm 50-199 days	-0.679†	-0.103	..		-0.013	-0.002
	(0.348)		..		(0.393)	
Worked off-farm 200 days or more	-0.099	-0.025	..		-0.201	-0.048
	(0.219)		..		(0.239)	
Rented Acres Percent	-0.002	-0.056	..		..	..
	(0.003)		..		..	
Farm Size 499 Acres and Below	0.043	0.010	..		0.236	0.053
	(0.332)		..		(0.357)	
Farm Size 500-999 Acres (ref)	..	..	..	..	..	..
	..		..		..	
Farm Size 1000 Acres and Greater	0.090	0.047	..		0.176	0.086
	(0.204)		..		(0.280)	
Adjusted R-Squared	0.330		0.107		0.268	

Chi-square	919.078***
TLI	0.86
IFI & CFI	0.92

RMSEA (CI)	0.06 (0.05 – 0.06)

† $p < 0.1$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$ (two-tailed)

‡ Past conservation program participation predicts past practice use; current conservation program participation predicts current and future practice use.