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Agribusiness & Applied Economics Report 722 March 2014

Factors Influencing Conservation Practice Adoption in Agriculture: A Review of the Literature

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The authors are grateful to Delta Waterfowl Foundation, Bismarck, ND, for providing financial support for this project. They wish to thank Mr. John Devney for his assistance throughout. They would also like to extend appreciateion to Jim Gale and Dean Bangsund for their constructive comments and suggestions.

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Abstract

Recent high commodity prices and other factors have resulted in a reduction in farmland acres devoted to conservation. This report provides discussion and synthesis of literature considering factors affecting adoption of conservation practices on working lands and in land retirement programs. Literature reviewed originates from research including producer and landowner input as elicited through surveys, interviews, and instruments obtaining their reactions to hypothetical choice sets including conservation practices. Literature reporting on research using secondary data was also reviewed. The literature supports use of the utility model, including both monetary and non-monetary factors, to predict producer attitudes, intentions, and behavior regarding conservation practices and enrollment in conservation programs.

Factors Influencing Conservation Practice Adoption in Agriculture: A Review of the Literature

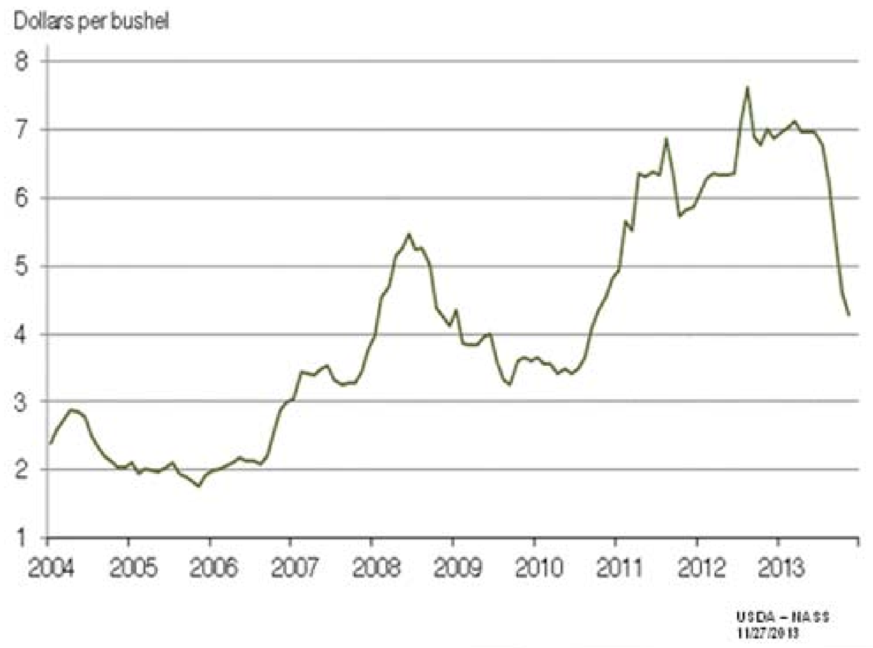
Introduction

Decisions concerning agricultural landscapes are influenced by a range of factors originating from landowners and producers, the land's physical characteristics, markets and the policy environment[1]. Modeling these decisions, a decidedly multi-variable problem, should take into account not only the landowners' economic objectives, but these many social- and physical-predicates.

This review considers a conflux of factors facing landowners, perhaps the most notable being the rapid rise in commodity prices and its resultant effect on opportunity cost of land devoted to conservation. Stubbs (2012) and Rashford, Walker and Bastian (2010), among others, note changes in enrollment in the USDA Conservation Reserve Program (CRP) in response to increasing commodity prices (Figure 1). Non-re-enrollment of marginal, as well as otherwise productive, tillable lands currently planted to grasses under the terms of the CRP is being attributed to their growing value in production. Also contributing to the reduction in conservation acres are the greater availability of production technologies (e.g., short season hybrids), farm program payments and subsidies, including those for crop insurance inviting row-cropping of soybeans and corn in areas previously excessively risky, and demand for agricultural land as a safe haven for stable, although modest returns by non-agricultural owner-investors. Loss of conservation acres in turn has resulted in losses to plant and animal habitat, increases in external costs expressed as lost carbon sequestration, reduced water quality, increased erosion, and loss of other environmental benefits offered to many consistencies, both local and downstream (Wright and Wimberly 2013; Reynolds et al. 2007; Niemuth et al 2007).

[1] It is recognized that, when separate individuals or entities, landowners and the farmers and ranchers operating the land may make different decisions regarding employment of conservation practices and program enrollment. In the absence of a lease or other agreement specifying such, land-use decisions are ultimately those of the landowner. The term landowners will be used throughout the document to represent landowners and the farmers and ranchers operating their land.

Figure 1. U.S. Prices Received for Corn by Month



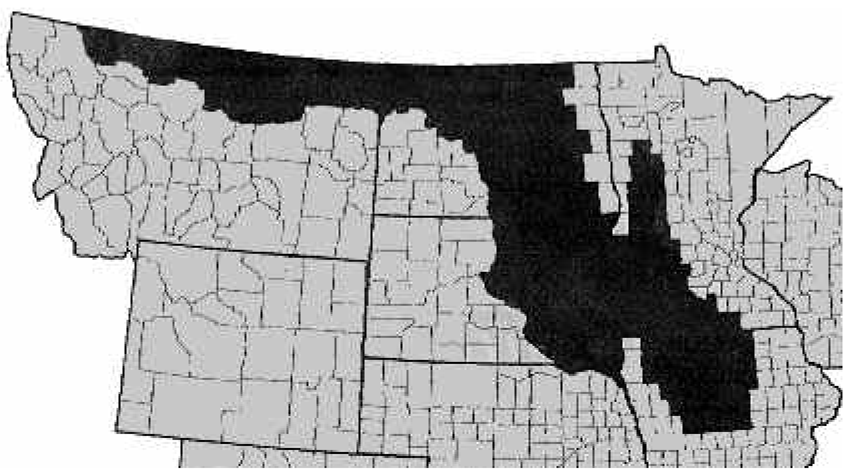
Source: United States Department of Agriculture National Agricultural Statistics Service, November 2013, http://www.nass.usda.gov/Charts_and_Maps/Agricultural_Prices/pricecn.asp.

In recent history, government conservation programs involved express coupling of reduction in production and increased land conservation practices with all attendant benefits, direct and indirect, affording stability in the landscape. In other words, balancing the financial motivations of landowners under the traditional rational, profit-maximizing model of farm/ranch management with macro-level goals off-farm was accomplished through programming inviting trade-offs. These tradeoffs generally involved landowners implementing conservation programming that reduced production and / or increased production cost in exchange for financial support. This trade-off between financial returns and non-profit-maximizing activities has, for many faced with landscape management decisions, reached a point of divergence. The resulting landscape shifts will be felt for many years since the cost of conversion may require years to recover, affording a disincentive for reversal.

Understanding the nature of decision making by landowners considering the tradeoffs is important to those interested in reduced externalities and enhanced wildlife habitat, both threatened by recent changes. The purpose of this report is to review and document those factors contributing to landowners' decisions to engage in conservation practices and enroll in conservation programs. Broadly speaking, USDA categorizes conservation practices into three groups: a) farm practices-management, b) use of site working-land structures, and c) land retirement (Lambert and Sullivan 2006). Farm-practices management describes efforts that have environmental benefits and improve profitability such as no-till planting. Working land structures represent a more permanent change in the landscape and benefit the environment and generally, through program payments, the landowner. Projects funded by Environmental Quality Incentive Program (EQIP) are examples. Land retirement programs take land out of production permanently or over an extended period of time. Landowners receive one-time and / or annual payments in return.

This review of literature focuses on decision-making in the areas of land use and conservation. Narrowly, the intent included identification of research specifically addressing the whole of the Prairie Pothole Region (PPR) (Figure 2). Although none was identified which addressed the entirety of this portion of the U.S. production area, several studies encompassed portions thereof in ways relevant to this review and were included.

Figure 2. Prairie Pothole Region of the United States



From: Jacobs, Thurman and Marra (2011).

While also extending into three Canadian provinces, the PPR spans parts of Montana, North Dakota, South Dakota, Minnesota and Iowa in the US. Estimates put over half of North American migratory waterfowl as nesting within the PPR (Environmental Protection Agency, n.d.). The Conservation Reserve Program and the Wetlands Reserve Program (WRP) have restored approximately 5.4 million acres of wetland and grassland habitats within the PPR (Gleason et al. 2008).

Model

Early research on farm economics represented landowners as rational decision-makers. In this traditional model, choice of land use depends on identifying the alternative that maximizes net present value (NPV) having taken into account comparative uses, benefits and costs (e.g., Featherstone and Goodwin 1993), while including conversion cost is not always straight-forward (Lawley, 2013). Udagawa et al. (2013) point out, e.g., that it is sometimes difficult to accurately estimate even costs associated with establishing, monitoring and maintaining land in conservation. Uncertainty in agricultural input and output markets and yields add still more uncertainty to estimation.

In spite of the complexity of considering decision-making within the narrow confines of financial considerations, over time, non-economic factors were added to the explanatory basket, contributing enhanced domain- as well as predictive-validity. This second paradigm for the evaluation of conservation decisions is that of "utility," i.e., the perceived value of a *basket* of factors including those non-monetary. This is illustrated in an early study by Traore, Landry and Amara (1998) which considered three dimensions, only one of which is economic based. They added to consideration of economic factors that (some) conservation practices may be capitalized into land values recoverable at the time of sale (their review suggested that evidence of this process among farmers was mixed). They also presented two non-economic factors, environmental consciousness and perceived harms from use of chemicals. Their literature review showed farmers' development of environmental consciousness to be linked with level of education, age, farm- and off-farm income, farm size, erosion potential on the farm and farming experience. Producer risk orientation and group norms, i.e., influence of other-farmers' attitudes, were also found to be important. Consideration of the reduction of harms or perceived harms to operators arising from the use of chemicals represented personal health as a factor which may mitigate economic considerations.

Additional thinking on environmental consciousness was advanced by Chouinard et al. (2008). They argued that the literature was far from settled on the range of non-financial factors contributing to conservation decisions, but supported the utility model and the inclusion of both land and environmental stewardship along with a host of additional factors (personal, economic, institutional, and land-based) as contributing. Wachenheim and Lesch (2014) cover state-, producer- or region-specific studies of enrollment decisions and other issues relating specifically to one land retirement program, the Conservation Reserve Program.

These articles and others included in this review concede that no single paradigm has been embraced to explain or predict conservation behavior, which itself includes numerous outcomes and varied definitions. Further, methods used to identify factors affecting conservation decisions vary. They have included producer survey (primary), qualitative study (in-depth interview and focus groups) and secondary analyses of survey data. Researchers have also presented farmers with hypothetical scenarios or conditions to model the decision-making process.

Review of the Literature

Literature was examined to improve understanding of factors influencing consideration of practices and programs favorable to conservation. These include working lands initiatives, some of which may require land retirement (e.g., filter strips, contour farming) and all of which contribute in varying ways to the productive use of land while addressing important externalities (e.g., air, water quality). Land retirement programs non-specific to CRP also are considered. Three meta-analysis of literature about adoption of conservation practices and program enrollment are first reviewed, followed by consideration of research conducted using secondary data. Reviews of research about conservation decisions related to adoption of tillage practices, riparian buffers and forest, and enrollment in the Conservation Reserve Enhancement Program and the Environmental Quality Incentives Program follow. The review concludes with a look at literature reporting on barriers to adoption of buffers.

Meta-analyses

Three meta-analyses of literature on adoption of conservation practices were reviewed (Knowler and Bradshaw 2007; Prokopy et al. 2008; and Baumgart-Getz, Prokopy, and Floress 2012). A meta-analysis is one in which the findings of a large number of research projects are summarized to reflect the current status of knowledge in the field. Knowler and Bradshaw performed a comprehensive review of factors relating to farmers' adoption of conservation agriculture. Acknowledging no universal definition, they operationalized the concept as a "label for a number of related soil management practices" (p. 26). They reviewed 31 separate analyses covering 23 published studies from a variety of developed and developing countries and a range of sample sizes (less than 50 to over 1,400), and including variable types and levels of sophistication of data analyses. Technologies /practices that were examined included those focusing on control of soil erosion, use of organic inputs, conservation tillage techniques, composting, and use of cover crops, among others.

Knowler and Bradshaw analyzed the nature and consistency among studies with respect to the predictive power of some 46 variables reflecting four classes of predictors: farmer and farm household characteristics; farm biophysical characteristics; farm financial / management characteristics; and exogenous factors. Few if any variables *generally, across studies*, explained adoption of conservation practices. In the absence of generalizability, they recommended promotion efforts be specifically tailored by locale (e.g., the effect of education in North America tends towards positive, but this is not true in non-North American studies). They also recommended targeting conservation monies (e.g., to individuals, groups) although they cautioned that the lack of significance of some factors could be due to the analytical methods used by researchers, locale, or the specific technology considered, rather than that they are not important determinants. Further, they found that considering conservation practices in general rather than specific practices can hide effects. For example, education had a positive effect on the likelihood of adopting conservation tillage, but was either negative or non-significant in influence on no-till and other practices.

Difficulty generalizing is not unexpected given the broad scope of literature included. They did find some consistency among studies. Findings regarding specific variables are covered here within the four categories. First, variables that were found to be *inconsistent*, i.e., varying from significant to insignificant, and/or where the sign was sometimes positive, and other times negative in modeling conservation agricultural practices, are arranged below by predictor class (Table 1).

Table 1. Variables with Inconsistent Contribution to Conservation Adoption

Category	
Farmer/ farm household	Age, education
Farm biophysical	Farm size, rainfall, area planted, slope
Farm financial management	Tenure (ownership/lease), income, off-farm activities or income, importance of crop revenues in income
Exogenous	Technical assistance, ease/availability of information

Table 2 shows variables in each predictor category found to be *consisten*t in direction of influence when significant.

Table 2. Variables with Consistent Contribution to Conservation Adoption

Category	Positive	Negative
Farmer/ farm household	Experience, attitude towards conservation, management knowledge, concern for erosion, family partners	Perceived health threat associated with chemical use
Farm biophysical	Well-drained soils, temperature, farm/field type, highly erodible, length of growing season	Soil erosion rate, distance to paved road
Farm financial management	Family labor, gross farm income, farm profitability, emphasis on grain farming, availability of machinery, pesticides applied	Debt level/ratio, proportion irrigated, conventional tillage equipment/animals
Exogenous	Information source, program participation, membership in organizations	Output price

Those variables found to be *insignificant* in predicting conservation adoption across studies included wealth indicators and concern for groundwater pollution (farmer/farm household variables) and hired labor, cropping system/crop rotation, and impact on farm production costs (farm financial management). The latter is particularly surprising given the importance of financial factors reported by others, but is the result of conflicting findings rather than that individual studies did not find financial factors significant. Those variables consistently *significant* across studies and of the same sign (direction of influence) included awareness of environmental threats (positive) and high productivity soils (negative).

A similar review of factors contributing to the adoption of Best Management Practices (BMP) influencing *water quality* was advanced by Prokopy et al. (2008) using the vote count method. Characteristics of the studies reviewed were not unlike those examined by Knowler and Bradshaw, e.g., varying sample sizes, differences in data and statistical analyses and including a range of dependent variables (e.g., no plow tillage, variable rate technologies, animal waste management, and sustainable practices).

The primary differences from the meta-analysis by Knowler and Bradshaw are that Prokopy et al. limited their meta-analysis to the United States and considered only those conservation practices that affected water quality. Referencing some 25 years and 55 separate studies, Prokopy et al. focused on four classes of variables similar to those examined by Knowler and Bradshaw: capacity, awareness, attitudes, and farm characteristics. The dependent variable was actual adoption of one or more of the practices. In this, and the follow-on study by Baumgart-

Getz et al. (2012), research not using adoption as the dependent variable (e.g., that reflecting attitudes or intentions) was not included. Results were mixed.

Capacity included variables that affected the ability of the production system to perform at a specific level as it undergoes change. They included age, income, education, farm size and investment level, as well as networking, the latter addressing the nature of information access. A "local" network referenced farmer-to-farmer information exchange, "agency" referred to interaction with persons and organizations different from their own, and "business" networks reflected the economic integration of the producer. Other factors such as nature and level of farm labor, ownership structure, and on-off farm income were also included under capacity.

In the *capacity* category, even given the relative ease of matching variables across studies (e.g., an acre is an acre), very little consistency in findings between studies was observed. Education was found overall to relate positively to adoption, while age tended to be negative in association, but this varied by BMP. [Both age and education were reported as inconsistent in effect in Knowler and Bradshaw.] Acres were mostly positive in influence (and always for models using linear regression). Most of the investigations of information favored its role in adoption, but not consistently. Capital and income were found to be directly related to adoption more often than not, but the influence was frequently insignificant. Farms with more operational diversity, as well as those with larger labor-bases, tended to favor adoption. Influence of farmer experience and tenure were mixed.

The categories of *attitudes and environmental awareness* addressed affective as well as cognitive factors relating to pro-environmental behaviors. Beyond attitude/ feelings toward environmental outcomes, this class also included the adoption of incentive payments (indicating awareness and willingness to adopt), and other measures such as risk, the passage of the operation due to familial considerations, perceived profitability of BMP, and attitude toward water quality. Awareness included those items across the studies that could be categorized as related to knowledge of impact on the environment and of the impact of those environmental changes, and program knowledge.

Favorable attitudes towards risk, heritage, profitability, and receipt of payments generally, but not always, had a positive relationship with adoption. Prokopy et al. found that those studies including a level of environmental awareness were more likely to show a positive (than negative) influence on likeliness of adoption of BMPs, except for awareness of consequence, which was insignificant in influence. Sensitivity analysis revealed that willingness to take risks may not be a consistent factor in influencing adoption.

Farm characteristics included items not unlike Knowler and Bradshaw's biophysical qualities. Prokopy et al. specifically defined farm characteristics to include only those not sensitive to policy changes (proximity to rivers, soil types, slope, and grain/animal focus of the operation).

Results on river proximity were mixed, as was operator gender. Soil quality and slope were found to favor adoption, but not in all cases.

Despite mixed results, Prokopy et al. drew a number of important conclusions. First, the literature showed that factors including education, income, acres, capital, diversity, labor and access to information generally led to higher adoption of BMPs influencing water quality, there was enough inconsistency to warrant more focused consideration (e.g., more specific BMPs; farm types), as was also recommended by Knowler and Bradshaw. Factors affecting adoption of some BMPs might be different or exert a differential impact than those for adopting other agricultural technologies. Second, social networks hold promise for educating farmers and increasing BMP adoption, but they are complicated and difficult to utilize. . The authors suggested focusing on increasing farmer access to social networks and information and increasing farmer knowledge and awareness. This conclusion is supported also by Lemke et al. (2010) who investigated effect of outreach efforts over a four-year period on knowledge and implementation of BMPs in a Central Illinois watershed. The primary incentives driving adoption were technical and financial. Disincentives included inconveniences associated with program changes, timing and complexity of application, and potential loss of revenues. Outreach efforts increased awareness of the Conservation Reserve Enhancement Program (CREP) and the Wetlands Reserve Program (WRP) among watershed farms substantially. Lemke et al. found that county-level NRCS staff were the primary source of information about cost-share programs, but questioned whether additional outreach by USDA employees could be cost-effective. They noted alternative forms of outreach to include social networks and teams comprised of local agencies and stakeholders may improve effectiveness.

A third recommendation from Prokopy et al. related to profitability. Since profitability influences adoption, there is a need for additional research on the effect of BMP adoption on long-term profitability of the farm. This is supported by the work of Brant (2002), which is covered later in the review. Fourth, there is a reasonable chance some of the literature reviewed suffered from self-selection bias, with responses weighted towards those willing to adopt. Therefore research should be evaluated for non-response bias. Fifth, interaction effects are largely unexplored, but may be important. And, finally, most of the research has focused on initial adoption and the literature would benefit from decisions regarding retention/continuation of existing BMPs.

Baumgart-Getz, Prokopy, and Floress (2012) considered many of the same studies in their meta-analysis, but added unpublished studies to overcome potential bias associated with researchers who did not publish their work (e.g., when studies did not reveal significant relationships). They criticized the earlier study by Prokopy, et al. because the vote count method they used does not allow influence variables to be distinguished from insignificant variables and because most variables were found to be insignificant. Another difference was that Baumgart-Getz, Prokopy, and Floress broke previously combined variable categories into separate variables (e.g., education was split into formal and extension education). They also considered access to and participation in four types of networks (agency, business, local and university). Finally, they worked to overcome the limitation that measurement level can bring to bear on the predictive efficacy of modelling adoption. For example, they found that use of a continuous variable to represent years of education resulted in a negative influence while use of an ordinal categorization resulted in a positive but insignificant influence.

Results of this later work were more conclusive. Baumgart-Getz, Prokopy, and Floress found that under the capacity category, farm size, informal (extension) education, capital, information, the percentage of income from farming, and both agency and local networking had a positive influence on adoption, while the influence of age was negative. They found high heterogeneity and low degrees of freedom resulted in the inability to speak to the role of business networking and tenure on adoption. The attitudes category was insignificant overall (including attitudes towards risk, adoption of payments, and perceived quality of the local ecosystem). The authors noted that the latter may have been significant if not for the low sample size. They tested the impact of level of risk aversion over time and found that it has decreased; concurring with Prokopy et al. in suggesting it may no longer be a useful variable for inclusion in studies aimed at predicting adoption of conservation practices.

The subcategories representing farmer awareness of how non-point-source pollution influences water quality (cause) and the consequences of impaired water quality were not significant. Knowledge about environmental quality and specifically about non-point-source pollution (program) were significant. The authors concluded that the latter points to the importance of educating farmers about specifics rather than the more general impact of conservation efforts on the environment, consistent with Knowler and Bradshaw and Prokopy et al. Baumgart and Getz et al. also encouraged the use of networks to increase the influence of extension education efforts and recommended policymakers follow a two-step approach including targeting those farmers most likely to adopt and educating them on the specific benefits of adoption of BMPs, using social networks to extend reach.

Secondary Data

Perhaps the most comprehensive examination of landowners' actual use of working land structures linked to conservation arises in a series of studies authored by USDA personnel. Lambert et al. (2006a, 2006b, 2007), Lambert, Sullivan, and Claassen (2007), and Lambert and Sullivan (2006) examined participation in both working- and retirement-land programs through use of secondary data sets drawn by USDA personnel in 2001 (the USDA Agricultural Resources Management Survey). Only family farms were considered (i.e., the data-set did not include corporate or cooperative farms, very small in number). Because landowners were not surveyed or interviewed, the set of explanatory variables was limited (e.g., it excluded awareness and attitudinal measures). About 25% of all farms had one or more conservation structures in place, with roughly one half of those practices in the form of whole field plantings (grasses, trees, and shrubs).

Practicing farms included those with structures or practices defined as conservation oriented. Lambert et al. (2006a; 2006b) reported on associations between farm and farm household characteristics and 1) participation in land retirement and working land programs, and 2) percentage of acreage enrolled in land retirement programs and the number of working-land structures installed. Farm ownership and highly erodible land were positively related to likelihood of participation in a land retirement program; the share of production including high-value crops was negatively related. Contrasting were factors associated with likelihood of participation in working-land programs. Farm income and location of the farm near water were positively related. Off-farm income as a percentage of total income was negatively related (i.e., those earning a larger portion of income from the farm were more likely to participate in working-lands programs). Percentage of land enrolled in a land retirement program was positively associated with farm ownership, government payments as a percentage of the value of production, and female gender, and negatively related to a focus on grain crops. The number of conservation structures employed was positively related to farm ownership, household size, operator raised on a farm, the highly erodible land index, and the farm being located next to a water source, and negatively related to a focus on high-value crops. These findings underscore the importance of how conservation participation is defined to understand influencing factors.

In contrast to the meta-analyses and the work by Lambert and others, the remaining literature reviewed concerns more narrowly defined conservation practices, generally over a relatively small geographic area. We start with a look at adoption of tillage practices and of conservation technology and use of riparian buffers and forest. Later, decisions to enroll in CREP and EQIP and barriers to adoption of buffers are discussed.

Adoption of Tillage Practices

Three articles considered adoption of conservation tillage practices. Deployment of conventional (CT), reduced (RT), and conservation (CST) tillage practices were examined among a sample of wheat producers in Oklahoma (Vitale et al. 2011). *Farm characteristics* of significance that had a positive influence on likelihood of adoption of CST included farm size, and percentage of sales from crops, and grain only operation. The latter and the fact that those raising only forage had a lower likelihood of adopting CT suggested to the authors that livestock landowners making both grain and forage use of crops were less likely to use conservation tillage. Grazing of crop fields may result in compaction calling for greater use of CT. Use of rotation also had a positive influence on adoption of CST. The authors suggest this may be because weed, disease and insect pressure are lower under rotation, requiring less tillage, and that farmers using rotations may be more progressive. *Producer characteristics* linked with conservation practices included age, level of understanding of conservation practices (direct), and share of income earned off-farm (direct with RT).   Age was directly related to likelihood of adopting RT and inversely related to adoption of CST. [The literature on the effect of age also is mixed.] Level of education and off- farm employment were not significant.

Regarding economic impact, and as expected, positive perceptions about profitability and reduction in labor costs associated with conservation practices were directly related to likelihood of adopting CST. However, perceptions that CST results in increased machinery costs and that there is a lack of rental equipment available for CST decreased likelihood. On the agronomic side, beliefs about reduced erosion (positive) and the type of soil and compaction (perhaps due to the heavy clay soils common in Oklahoma), residue, stand, and insects as barriers (negative) were significant. Erosion was significant in all three equations. Perceptions about differences in weed management, disease, soil fertility, soil moisture and yield were not significant. Lack of state–level research and livestock grazing (negative), and the belief that use required additional managerial expertise (positive) were also linked with conservation practices.

Conceptualizing a conservation-orientation around the notion of empathy for others as well as a focus on self in the prediction of no-till practices, Sheeder and Lynne (2011) surveyed producers in a watershed involving counties in Nebraska and Kansas. Their model included measures of empathy, sympathy, and influence by others and engagement with downstream users, income, and additional factors linked to operation control, habits, and slope. Farmers seeking more control over their operations did not favor conservation tillage, while income benefits were favorable to adoption. Interactions were noted between what was operationalized as empathy toward others (farm entities and families) and orientation to more selfish interests. Altruism and habit influenced tillage decision. Authors concluded that policy needs to account for farmer diversity, to include that defining their level of self-interest, focus on leading farmers to new habits regarding conservation, and build incentive structures around level of self-interest.

In earlier work, Camboni and Napier (1993) estimated adoption of alternative tillage methods to include two conventional tillage (deep plow and conventional plow with 1/3 ground cover at planting), two conservation tillage practices (no-till and chisel plow with 1/3 ground cover at planting), and three additional conservation measures (percentage of fields protected by filter strips, waterways protected by grass cover, and gullies protected by gully plugs) for a sample of farmers in east central Ohio. They found that variables related to farm structure were the best predictors of adoption and that the personal characteristics of farmers were not very useful predictors[2]. They suggested a shift in focus to changes in farm structure rather than changes in farmers may help progress conservation practice adoption. Participating in a government program, the percentage of gross farm income derived from grains, and awareness of agricultural pollution were all positively linked to no-till and to (except awareness of agricultural pollution) chisel plowing with 1/3 ground cover at planting. For the latter, more acres under cultivation and higher gross farm income were also positive influencers. The number of acres farmed and level of farming experience were negatively associated with no-till. Interesting was that the percentage of fields protected by filter strips and of waterways protected by grass cover were associated with less frequent participation in government programs. Those more willing to use coercion to force farmers to protect land had a higher percentage of their gullies protected by gully plugs.

Adoption of Riparian Buffers and Forest

Five additional studies looked at interest in and willingness to participate in conservation practices including riparian buffers or trees. Lant, Kraft and Gillman (1995) examined producer intentions among ten corn-belt counties in five Midwestern states where participants met eligibility for enrollment into CRP relative to the use of filter strips, recharge areas or farmed wetlands or were subject to terms of the Swampbuster provision. Enrollments in the various programs were shown to be substantially elastic as a function of annual payments. Exploring the range of reasons for non-enrollment, the researchers found higher income from production, loss of flexibility to adjust use, and the 'hassle' of government programs were reported among a majority of respondents, concurring with disincentives identified by Lemke et al (2010), among others. Lant, Kraft and Gillman also reported loss of commodity base acres, restrictions on heirs' use, reduced sale value of the land, the small number of acres eligible, and infringement by the government on property rights as expressed obstacles by between one-third and one-half of respondents. As also reported in McCann and Easter (1999), a certain amount of antagonism was observed among landowners toward the metropolitan area.

Ryan, Erickson and De Young (2003) studied the adoption of conservation practices in riparian areas within a watershed in southeastern Michigan. They identified six categories of motivations including a) intrinsic/attachments to the land, b) reduction of soil erosion, c) visual quality of the conservation practices adopted, d) downstream costs (negative effects of soil erosion and stream pollution on neighbors), e) removal of marginally productive fields from

[2] Likewise, Tosakana et al. (2010) found that many socio-demographic variables (education, management experience, full-time farming status, heritage commitment) were not useful in predicting adoption of conservation practices (i.e., gully plugs and buffer zones) among a sample of farmers in northern Idaho and eastern Washington. The primary predictor of use was perception of effectiveness, with cost (perhaps due to cost sharing programs) not an obstacle. However, regulation and maintenance were seen as disincentives.

production, and f) an economic motivation (compensation for adoption of a practice). The percentage of income received from farming, and farm size were found to be predictive of riparian conservation practices, although full-time farmers, it was noted, tended to also have larger farms. They were also more likely than part-time farmers to adopt no-till farming, use grass buffer strips alongside streams and drains, and use a range of more permanent structural tactics (e.g., drain tiles, retention basins). Part-timers preferred the use of woody vegetative cover.

Habron (2004) surveyed landowners in three watersheds within the Umpqua River Basin of southwestern Oregon in 1998 to develop profiles of landowners who were utilizing a variety of conservation practices. The author estimated participation in five conservation practices to include use of off-stream watering facilities, rotational grazing, riparian exclusionary fencing, riparian tree planting, and irrigation fish screens. Riparian tree planting was influenced by a belief that stream bank erosion is problematic, level of knowledge about watershed conservation, support for voluntary, scientific watershed experiments on private lands, success in outreach to others to influence them to practice conservation measures, and a desire for survey results. Use of riparian fencing was affected by spousal influence, the desire for survey results, and the use of farm irrigation.

Key conclusions included 1) the need to specify the conservation practice under consideration, since influencing factors differ by practice (especially between practices that differ by benefactor as landowner only versus landowner and the environment) agrees with conclusions from the previously discussed meta-analyses; 2) that a desire for survey results is an important factor, but likely represents something not measured such as an interest in the thoughts of and outcomes for others who have adopted like practices; and 3) that it is important to understand the decision-making process and who influences the decision. Regarding the latter, the importance of spousal influence suggests that efforts to increase conservation practices should consider the family unit. Further, use of a peer- approach to disseminate information may be effective because of the trust-level between landowners, and the potential reduction in fear associated with government involvement. This venue is considered underutilized by the authors. These recommendations were later in part echoed by Lemke et al. (2010) who recommended creative means for increased outreach.

Valdivia and Poulos (2009) looked at interest in riparian buffers and forest farming in Missouri. The most powerful predictors of riparian buffer interest included knowledge of riparian buffers, experience with bank erosion, and the value of trees to future generations. Older farmers expressed less interest than younger farmers. On the side of forest farming, knowledge of forest farming and the value of trees for future generations were most predictive of interest in the practice. The amount of variance explained by the block of predictors was small, about 18% and 19% for riparian buffers and forest farming, respectively.

Yu and Belcher (2011) investigated farmers' willingness to accept (WTA) payments to preserve wetlands and riparian zones in the Prairie Pothole Region of Saskatchewan under a 10-year payment program. A binomial probit model revealed that payment, experience with wetlands management (drainage, maintenance of riparian surrounds) and the demographic factor of transition to heir, were all positively related to WTA. Among wetland attitudes, only the harboring of pests was revealed as significant and positive. Negative signs were observed for perceived aesthetic value, and number of years farming.

Technology Adoption

Attitudes of livestock farmers in Iowa and Missouri concerning the use of stream setbacks to reduce nutrient run-off (primarily manure) and contamination of local and downstream water sources, and three other technologies, were examined by Gedikoglu and McCann (2012). Their review of literature revealed that an increase in soil quality had a positive effect on adoption of environment-oriented technology and an increase in risk aversion had a negative effect. Unlike the case of adoption of profit-oriented technology (where directional signs were largely in agreement in the literature), effect of other factors on environment-oriented technology adoption were mixed.

Level of education was inversely related to maintenance of setbacks, with those who did not complete high school less likely to maintain setbacks. Small farms (with less than $100,000 in annual sales) were less likely to maintain setbacks than the base case of farms with annual sales of $100,000 to $250,000. Those raising poultry, beef cows or cattle, and dairy were less likely than those raising pigs to maintain setbacks. The use of a solid, or solid and liquid manure handling system (as compared to a liquid only system) and location to a nearby lake or stream were found to be positively related to the practice, as were use of EQIP funds and beliefs concerning the profitability (favorable) of setback maintenance. The authors note that the latter pair support the hypothesis that farmers are unlikely to adopt a practice that is not profitable even if they have environmental concerns. Use of EQIP funds was only important in the environment-oriented technology (setbacks), further supporting this assertion. The authors therefore suggest that educational efforts include information about expected impact on profitability, especially when this estimation is complex, and caution that this impact will vary by farm operation. Beliefs about water quality and its interaction with beliefs about efficacy of the practice on water quality (interactive terms) were also predictive of setback practices, although, unexpectedly, general beliefs about water quality or the environment alone were not.

Conservation Reserve Enhancement Program

Water-quality issues associated with non-point sources of pollution (especially agriculture) have received considerable federal attention (Farm Service Agency, 2013). USDA programs such as the Environmental Quality Incentives Program (EQIP) and the Conservation Reserve Enhancement Program (CREP), along with CRP and the Wetlands Reserve Program (WRP) have contributed to reduced erosion, containment of field chemicals and reduced run-off. Four studies were reviewed which looked specifically at factors affecting producer adoption of CREP. They are followed by two studies considering participation specifically in the EQIP.

The Conservation Enhancement Reserve Program (CREP) is a voluntary land-retirement program with a contract period that generally extends 10 to 15 years. It targets locale-specific high priority issues. Farmers remove environmentally sensitive land from production and introduce conservation practices and, in return, they are paid an annual rental rate. In order for land to be eligible for enrollment, it must be eligible for enrollment in CRP and the resident state must have a CREP agreement. USDA partners with state and tribal governments to develop local conservation objectives.

Kingsbury and Boggess (1999) studied the propensity of Oregon's dry- and irrigated-land producers in two counties to participate in CREP. Program funds were focused on preservation of native fish populations and were used to encourage forested buffers, filter strips, and the restoration of wetlands. Factors included in their model were level of payment, opportunity costs (overall acreage and that (acreage) dedicated to low and high value crops, and percentage of income from the farm operation), previous experience with state or federal programs of this nature (past participation in USDA programs and knowledge of CRP and Oregon CREP), socio-demographics (age, education, and retirement status), belief structure (e.g., value of fish and water quality and satisfaction thereof, required agency interaction, perceived acceptance by neighbors, availability of cost-share, and reductions in economic returns), and expectations (land flexibility, compliance with changing regulations, and planned operator retirement within 10 years). Application of a logit model resulted in a more than 90% level of efficacy in predicting participation in CREP for both the dry-land producers and those using irrigation.

The most important factors common to each land-type included the payment, cost share, and education. Payment was significant in both models and in the expected direction with the exception of irrigated farms in one of the two counties. The authors hypothesized that lack of significance in this one county may be due to limited bids and diversity of crops in that county and that participation in CREP is not perceived to have an important impact on overall profitability. The average willingness-to-accept value was higher than the average bid for both counties and for both dry- and irrigated-land. Somewhat surprising was the finding that the willingness-to-accept value did not differ substantially between dry- and irrigated-land farmers.

In the dry land model, acres of low-value crops (positive effect) and percentage of income from farming (negative) were the significant opportunity cost factors affecting likelihood of participation. Each of the opportunity cost factors was significant for irrigated farms (effect of acres and percentage of income from farming were positive and high and low value acres were negative). With one exception, future expectation factors were all significant in both models and, except for expected flexibility in land use, (which was positive in both models), the signs for the two models were inconsistent with one another. Each of the belief structure factors (except those associated with placed importance of and satisfaction with fish and water quality and perception of whether an environmental problem existed), was significant in the dry land model. All belief structure factors except satisfaction with fish and water quality and perception of acceptance by neighboring landowners were significant for the irrigated-land model. In both models, directions were as expected with the exception of reduced economic returns for the irrigated-land model, where the coefficient was positive.

Education had a negative effect in the dry land model, but a positive effect in the irrigated model. In the irrigated model, also significant was the variable indicating a retired farmer (positive). Past participation variables were not significant except that indicating knowledge of the CRP program (positive for the irrigated-land model) and past participation in USDA programs (positive for the dry land model).

Landowners were asked to indicate their reasons for not participating in the CREP. The most important reasons were their concern about restrictions at the end of the contract, reduced flexibility for land use, and a belief that riparian areas can be restored with the right management. The authors suggested that focus be placed on clarifying the end-of-contract regulations, that flexibility be considered as part of the program and, because those farming irrigated acres were more likely to adopt CREP if they perceived an environmental problem, better communication about environmental problems.

Lynch and Brown (2000) developed a contingency approach to understanding producer decisions on the adoption of CREP in state efforts to improve the Chesapeake Bay area's water quality. The decision to adopt was hypothesized to be influenced by land strategy, i.e., to continue to farm or to sell. If the decision was to continue to farm, decisions regarding CREP (forest or grass buffers) were then relevant. The underlying model reflected the landowners' assumed maximum utility of the land over no more than 30 years. Use of a forest buffer for 30 years held until the land value reached $5,000 per acre. Landowners only refrained from participation if there was a very high net crop price or low rental rates. Forest was a preference over grass buffers up to farm sizes of 100 acres unless resulting deer pressure was high. Larger acreage farms would plant forest buffers if not for the limiting percentage of acres allowed (which does not allow for minimizing deer damage). In the absence of deer pressure, the maximum enrollment of 10% to CREP was always binding. If there existed deer pressure, whether to plant to forest or grass depended on timber value and the cost share associated with planting trees versus grass. The authors contend that increasing cost share rates might be more effective than an equivalent increase in rental rates. And, because of the importance of deer pressure, they suggested considering higher rental rates in areas with significant deer damage. Beginning at $5,000 per acre and forward to a tested peak of $10,000 per acre, optimal utility excluded use of CREP. Higher values resulted in an optimal decision of not entering the program so as to maintain sale rights. The economic analysis suggested that farmers should always be participating in the program at land values at the time of the study, suggesting that the model is missing some important factors influencing the decision, farmers are not well educated on the value of the program, or some mix of the two.

A macroeconomic study by Suter, Poe and Bills (2008) examining CREP enrollments among 218 counties spread among the states of New York, North Carolina, Oregon, Virginia and Washington (1997-2002) revealed that the most important predictors included annual payment, one-time payment, and an urban influence index. Payments were positive in influence; urbanity negative. The findings that one-time up-front payments are more cost effective than increases in rental rates concur with those of Lynch and Brown. The authors note that farmer responsiveness to payments is consistent with an ability to target specific areas where the program otherwise does not enroll enough acres.

Armstrong et al. (2011) compared adopters and non-adopters of a CREP program focused on the installation of riparian buffers intended to reduce run-off into streams in a watershed northwest of New York City. Conservation Reserve Enhancement Program adopters had been farming fewer years, but also were slightly older than non-adopters. The authors note the latter finding to be inconsistent with the working land conservation literature which shows an inverse relationship between age and participation. Adopters tended to seek information from a broader range of sources (e.g., extension agents, consultants, water authority personnel) than did non-adopters, were more politically liberal, and were more likely to be affiliated with environmental organizations. Level of education did not influence participation. Farmers with hay production near to streams expressed a lower level of CREP adoption (14% v 36%); although they were more likely to use near-stream areas for flood control (10% v 2%).

The authors identified attitudinal factors present in the population of enrollees including resentment toward external stakeholders, an innovative philosophy, and attitudes regarding land costs, maintenance costs, traditionalism, and private property rights. The researchers note that the latter two are important, but not often considered in conservation adoption literature. Adopters had less resentment toward NYC and were more tolerant of land costs than non-adopters. Current or intended enrollment in the CREP program was impacted by perceived economic considerations, resentment, and the number of crop acres owned (the latter was only marginally significant). The balance of attitudes, farmer characteristics and farm characteristics did not contribute to differences. The authors concluded that attitudes of resentment towards the New York City Watershed Agricultural Program (NYCWAP) and the “face of New York City” and about land costs associated with CREP as strong predictors of adoption of CREP point to a need to work on upstream – downstream relationships. Adoption of CREP to protect water quality differs from some other water conservation adoption decisions because farmers are not the direct benefactors of the improved water quality, but benefits rather favor downstream residents and entities. The authors recommend efforts to improve relationships not take the place of current efforts to improve environmental attitudes of farmers because they found the effects to be separate.

Environmental Quality Incentives Program

Two studies considered participation specifically in the Environmental Quality Incentives Program (EQIP). Through the EQIP, landowners are provided financial and technical assistance through contracts of up to ten years. The assistance is used to plan and implement conservation practices, and to help meet federal, state, tribal, and local regulations. The Natural Resources Conservation Service (NRCS) works with landowners in plan development.

Jones (2007) advanced a four-factor model to predict producer participation in either CRP or EQIP, including demographics, land characteristics, production characteristics, and county location within an agricultural region. The author evaluated data from the ten Economic Research Service regions in a series of logit, OLS and Spatial Lagged-model equations. While differences were found across the models' abilities to predict EQIP program payment per acre of farm land in a county, the overall amount of variance explained by these factors was low. Females were more likely to participate in EQIP, and positive correlations were observed between participation and erosion, the presence of pastureland, payment per acre, and costs of production. Negative relationships were observed between participation and both the value of the farm and farming as the primary occupation.

Using secondary data, Reimer, Gramig and Prokopy (2013) examined application-rates for the EQIP program, where the application rate was defined as the "…proportion of a state's farming population applying for an EQIP contract in a given year" (p. 112) The number of high-sales farms in the state had a significant positive relationship with application rate but the size of effect was not large. Direction is consistent with the literature and supports the idea that commercial farmers are more able to afford the cost and have the time and technical skills to implement EQIP projects. Relative importance of livestock in the state and environment damage also were positive in influence and significant[3]. Share of tenant farmers was positive in influence. The authors indicate EQIP is the main conservation program available to tenant farmers. Only one sociopolitical factor, the state environmental opinion measure, was significant. It was positively related to application rate and had a large marginal effect.

[3] Sixty percent of national EQIP funding must go to livestock producers (Environmental Quality Incentives Program, National Sustainable Agriculture Commission http://sustainableagriculture.net/publications/grassrootsguide/conservation-environment/environmental-quality-incentives-program/ accessed 10 September 2013).

Although farmer's social and political attitudes were expected to be important to adoption rates, the proxies used to represent them were not significant, likely because they were not adequate representations of these attitudes and beliefs. Significance of dummy variables for region indicate that location is important, although the authors note that the regional variables may be picking up non-stated differences between landowners by region (e.g., environmental views, program participation inclinations, differences in prevalence or type of farms).

Barriers to Adoption

Brant (2002) carried out a series of personal interviews with landowners to ascertain barriers to the adoption of conservation buffers. Results were classified by type of producer. The overall pattern of responses among the 358 interviewees identified barriers including lack of information about site-specific costs and benefits and about conservation alternatives, and that the information that is presented is often too technical; short term costs may exceed short term returns or cost share incentives; some conservation practices would require significant changes to operational practices; personal goals may conflict with program goals; land removed from production takes on an element of 'idleness' that, when compared with perceptions of self, can have negative connotations; and restrictions on heirs or subsequent owners. Other articulated barriers include complexity of government programs; prior bad experiences with design of buffers; that adjacent farmers may not use buffers to protect adjacent tracts; perceived competition with nutrient needs of crops; and lack of knowledge concerning roles and structure of assisting organizations. Barriers specific to CRP included reduction of program base acres, lower income than renting the land, reduced flexibility in land use in response to market dynamics, and negative effects on the farm's financial health and with landlord-tenant relations.

Recommended strategies for consideration for the USDA included, among others:

- Train staff not only on the technical details of planting buffers, but also the social, legal and especially economic consequences.
- Economic consequences are important for producers and they would benefit from a cost – benefit analysis for their individual or a like farm or clear guidance on how to produce one.
- General benefits should be included in marketing efforts and this information should be provided at the lowest level that is cost-effective.
- Consider efforts, especially peer to peer efforts, to change perceptions about buffers, particularly highlighting that they are indeed a productive use of the land.
- Consider new marketing efforts including social networking, especially peer to peer.
- Standardize what can be standardized (e.g., diagrams of potential layouts; visuals of buffers over time; contact lists) and make it available.

- Keep both the landowner and the producer involved throughout the decision-making and implementation process.
- Leverage efforts of others such as volunteers, local agencies, and funding sources.

Barriers among *livestock producers* were reported to include: perceived excessive costs for installation and maintenance of fencing; reluctance to change stream bank practices, even in view of damage; historical precedence; desire to maintain livestock access to streams and other traditional sources of water; fear that woody vegetation will attract beavers resulting in increased flooding; and that use of shelterbelts, living snow fences and windbreaks will reduce grazing area. In addition to recommendations presented previously, Brant recommended livestock producers consider additional funding sources such as EQIP. A stated barrier highlighted for *low-income and minority producers* was financial ability to establish and maintain buffers. Brant recommended using one-on-one contact initially, involving the producer's social network, searching out special grants, and emphasizing low-cost technologies.

Reported barriers to *American Indian* producers included: lack of familiarity with cultural differences or operation of tribal governments; proposed buffer areas may intersect historical, cultural or sacred areas; Native American landowners and tribes may not participate in locally led conservation efforts; the establishment and maintenance of buffer structures may require assistance from the Bureau of Indian Affairs (BIA), which may not have adequate staffing or training; decision making may take longer owing to culture and organizational involvement; costs may not be manageable among Native American landowners, tribes, or for BIA managed ground; conservation may not be a top priority if the lands are leased; installation of buffers may reduce rental acreage as it comes out of production; and BIA may lack resources for enforcement of lease agreements. Brant recommended working one-on-one with American Indian producers, learning to work with tribal governments, where possible obtaining external experts to help do so and for other purposes such as identifying culturally-significant land areas, using visual rather than written representations when possible, and emphasizing the importance of conservation practices for the land and future generations.

Summary

A majority of literature reviewed in this report is based on research using producer and landowner input elicited through surveys, interviews, and instruments obtaining their reactions to hypothetical choice sets including conservation practices. Limited literature using secondary data was also considered. Two models have been used to predict or estimate intended or actual adoption of conservation practices or enrollment in conservation programs: the rational economic man model, based on profit maximization, and the utility model, which considers the perceived value of a basket of factors, including those monetary and non-monetary.

Three meta-analyses were reviewed. Knowler and Bradshaw (2007) investigated 31 separate analyses covering 23 published studies from a variety of developed and developing countries. They considered the impact of variables in four categories on adoption of conservation practices: a) farmer and farm household characteristics, b) farm biophysical characteristics, c) farm financial/management characteristics, and d) exogenous factors. Few if any variables were identified that generally, across studies, explained adoption. A similar review of factors contributing to the adoption of Best Management Practices (BMPs) was advanced by Prokopy et al. (2008). The primary differences from the meta-analysis by Knowler and Bradshaw are that Prokopy et al. limited their meta-analysis to literature originating from the United States and considered only those conservation practices that affected water quality. Referencing some 25 years and 55 studies, they focused on the influence of variables in the categories of capacity, awareness, attitudes, and farm characteristics on adoption rates. A follow-on meta-analysis by Baumgart-Getz (2012) considered many of the same studies and added unpublished work to overcome associated bias. They used more sophisticated analysis techniques and broke down previously combined variables into separate factors. They also worked to overcome the limitation that data type can influence the predictive effect of variables on adoption. Results of this later work were more conclusive.

A broad look at conservation practices in the U.S. using secondary data were reported by Lambert et al. (2006a, 2006b, 2007), Lambert, Sullivan, and Claassen (2007), and Lambert and Sullivan (2006). They investigated the use of working land structures among family farms. Literature considering more specifically defined conservation practices within more narrowly-defined locales was then considered. Three studies looked at farmer tillage practices. Five studies specifically considered the adoption of riparian buffers and forests, one focused on technology adoption. Four studies considered farmer participation in CREP and two looked at farmers' participation in EQIP. One study considered barriers to adoption of conservation practices.

The review of independent studies provides a broad look at research investigating landowner decision-making regarding conservation practice adoption and program enrollment. The level of detail provided is supported by the level of inconsistency found within the literature about the influence of market and policy environment, location, and particular practice(s) considered, among other factors. Clearly, the decision-making process cannot be generalized.

Conclusions

The influence of changes in agricultural markets on participation in conservation programs is well referenced. However, the literature reveals that not all influencing factors have been financial and some factors considered financial do not affect decision-making as one would predict under a model of maximizing net present value. A majority of the literature investigating landowner adoption of conservation practices and participation in conservation programs considers non-financial influencers as well as those financial under a utility maximization model. Most studies did not take place during the recent spikes in commodity prices and therefore, may not be generalizable to the contemporary situation faced by producers.

Two primary methods employed to explain conservation behavior include elicitation and analysis of primary data collected from landowners and others and the analysis of existing secondary data. The advantage of using primary data is that researchers can design questions to elicit information important to meet their research objectives, such as explaining why producers enroll in a particular conservation program. Important disadvantages are that the resultant data is self-reported and is incomplete and, as such, may be both inaccurate and bias in its representation of a target group.

The extensive review of literature comprising this report provides a comprehensive list of variables that do or show promise to influence decision making regarding conservation, broadly defined. That the review of three meta-analyses and other literature shows inconsistency in what influences decisions is in part due to differences between studies in conservation practices considered, existing market and policy environments, and other factors. Further, how questions are asked to include level of delineation of variables (e.g., education as both formal and informal) and how equations are estimated appears to be an important source of apparent inconsistency between studies about the significance and directionality of influence of various factors.

These outcomes support the importance of well-defined research objectives and clear acknowledgement and understanding of conditions both internal and external to the farm or ranch. Defining objectives must precede model design and data collection and analysis, figuratively defined by the well-known saying originating from carpentry “twice measured, once cut.”

The literature also underscores the importance of including the human element, i.e., human or social factors. What we have discovered regarding application of conservation practices and program enrollment does not always fit an economically-supported prediction. Two conclusions can be drawn from this. First, decision-makers are missing some important information about the opportunities available to them and should be better educated. This is an excellent hypothesis to test and will result in a useful recommendations for many, from policymakers to those that implement the policy at the farm and ranch level. A second conclusion is that models used by researchers to predict intention or behavior are not accurate. This can be mitigated by careful consideration of lessons learned from the literature and careful planning, and, where appropriate and cost-effective (possible), precluding the design of the data collection instrument with individual farmer interviews, focus groups, and beta tests.

A final finding from this report of the literature is that there is considerable uncertainty about what motivates and what inhibits conservation practice adoption and program enrollment. In addition to sound modeling and information collected, this supports sensitivity analysis and other methods to incorporate the reality of considerable risk in agriculture and levels of risk aversion that differ by factors not predicted purely by economic models.

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