Conservation Practice Adoption and On-Field Resource Concerns

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Abstract

Soil health practices – such as no-till planting and cover crops – have different benefits and costs for farmers depending upon whether fields have specific resource concerns. Voluntary conservation programs that provide financial assistance are often designed to target specific resource concerns as a way of providing incentives to farmers to adopt practices that are likely to provide public benefits. However, data on the extent of certain resource concerns – such as soil compaction and low organic matter – are not often available without costly in-person and on-field evaluation, which is part of the formal USDA technical assistance program. In this study, we use several years of field-level data on farmers' self-assessed resource concerns from the Agricultural Resource Management Survey of the U.S. Department of Agriculture to estimate the drivers of adoption of cover crops and conservation tillage. We find that resource concerns have a significant positive influence on adoption of these practices and that having multiple resource concerns has a particularly strong impact. Wind-driven erosion and soil compaction have the strongest influence on cover crop adoption and low organic matter has the strongest influence on conservation tillage adoption. The results are similar for regression models that only include individuals receiving no financial assistance, suggesting that resource concerns also drive adoption of conservation practices for their private economic benefits in the absence of targeting by conservation programs.

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Resource concerns are common issues or conditions occurring on farms that can decrease soil productivity and plant growth, or that pollute the air, water, or other resources. They include on-farm soil issues such as erosion, compaction, poor drainage, and low organic matter, as well as off-farm issues such as high nutrient contributions. Resource concerns can result from a combination of geographic factors such as local climate and geology, as well as past and ongoing management and land use decisions (NRCS 2008). For example, soil erosion can reflect high slopes or years of intensive management such as tillage. Concerns often occur together or can interact and influence each other. For example, soil erosion may reduce topsoil, leading to low organic matter and other potential issues. Resource concerns can often be addressed through use of some combination of management practices, but the difficulty in addressing them or standards for addressing them may differ for any individual field or concern. Thus, some farmers may change the crop they grow rather than implement a practice. For example, if soil is compacted it may not allow for roots to grow below a certain depth. The farmer may then choose to cope with this issue by growing a crop with stronger or shorter roots. Alternatively, the farmer could make management decisions to help address the concern. For example, to reduce soil compaction a farmer may take steps to increase his field's soil organic content or may limit driving of heavy machinery to days when fields are dry (NRCS 1996c). For practices that are costly or that pose risks to crop production, financial assistance can be useful to encourage adoption.

Resource concerns are not only relevant for farmers, but also for managers of working lands programs such as the Environmental Quality Incentives Program (EQIP) of the U.S. Department of Agriculture (USDA). First, working lands programs use a fixed set of resource concerns to help create a regular diagnostic process for evaluating and addressing various kinds of issues on fields. A soil conservationist examines candidate fields for resource concerns and assesses their severity. This in turn helps to guide the best suite of practices needed to improve environmental quality. Thus, resource concerns serve as a basis for conservation plans that can be used by farmers interested in improving the soil health or environmental quality of their farms, or those interested in participating in financial incentives programs such as EQIP. Second, financial assistance programs use resource concerns to prioritize funding. Resource concerns can help determine which projects have the most merit and identify fields likely to help most in addressing specific environmental issues. For example, to prioritize projects when program funding is limited, EQIP uses a point system partially based on priority resource concerns to rank proposed projects (Wallander et al. 2019).

Due to their influence on the returns to practices as well as their role in program targeting, the presence of on-field resource concerns is an important determinant of practice adoption. This study focuses on the influence of resource concerns on adoption of two specific practices: conservation tillage and cover crops. Conservation tillage practices involve reducing the impact of tillage on soil erosion by leaving crop residues and reducing disturbance beneath the soil surface (NRCS 1996b). A field with a conservation tillage system can be categorized as either no-till, where farmers plant directly into the residue of the previous crop, or any reduced tillage systems such as strip till, where farmers only minimally till the soil to allow for planting. Conservation tillage can serve to build organic matter in topsoil and provide soil stability, leaving it less susceptible to issues like erosion and compaction, as well as improving its productivity (NRCS 1996b). A winter cover crop is a crop planted in the fall that is not intended for harvest. Cover crops can help to reduce loss of topsoil during the winter months, when bare and frozen soils can easily be eroded. A cover crop can also serve to remove nutrients from the soil that would otherwise be lost through runoff or leaching (NRCS 1996a). We focus on these two practices both because of their importance in promoting soil health, for which most of the resource concerns we focus on are relevant, as well as their importance in working lands programs. These two practices comprise a major portion of program outlays in federal working lands programs (Hellerstein et al. 2019). However, in recent years, funding for financial assistance of cover crop adoption has increased while funding for conservation tillage adoption has decreased (Hellerstein et al. 2019).

Despite its importance, relatively little attention has been given to the relationship between resource concerns and practice adoption, likely due to a lack of data availability. Some studies have used survey data to examine how perceived on-field benefits drive practice adoption, but usually with only a limited set of characteristics (Bergtold et al. 2012; Arbuckle and Roesch-McNally 2015; Dunn et al. 2015). Thus, in this article, we focus more attention on how a broad set of resource concerns influence the adoption of the specific practices of winter cover crops and conservation tillage. To examine the relationship of resource concerns on practice adoption we rely on data from the crop-specific, field-level version of the Agricultural Resource Management Survey (ARMS) from the USDA. In our analysis, we estimate logit models of annual field-level adoption of winter cover crops and conservation tillage. Specifically, we focus on the impacts of having on-farm soil health concerns on adoption of these two practices. With this analysis we aim to determine whether the private benefits from adoption of these soil health practices are higher on fields with resource concerns. We also seek to determine which specific resource concerns stand to gain the most from these practices, using private adoption decisions as evidence. Further, to explore whether our results reflect higher private returns from practices and not simply efforts in program targeting, we estimate models of practice adoption with a sample of fields that did not receive financial assistance for any management practice in the survey year.

Our analysis yields several interesting findings. First, we find that resource concerns have a significant impact on adoption of both cover crops and conservation tillage. Second, we find that fields with multiple resource concerns are particularly likely to adopt conservation practices. Among the specific resource concerns included in the analysis, we find that wind-driven erosion and soil compaction have the largest impacts on cover crop adoption. For conservation tillage, low organic matter is the best predictor among all resource concerns. Finally, we find for fields not receiving any program funding in the years in which they are surveyed, the influence of resource concerns on practice adoption is similar. This finding suggests that the strong influence of resource concerns on practice adoption largely reflects higher private returns, and not simply a higher likelihood of receiving financial assistance.

Literature Review

Some of the existing literature focuses on how the perceived private benefits of soil health practices influences farmer adoption decisions. Arbuckle and Roesch-McNally (2015) focus on factors that influence cover crop adoption using survey data from Iowa. Their results suggest that farmer expectations about the risks and soil health benefits associated with cover crops are important predictors of adoption decisions. To gauge farmer perceptions, the authors ask farmers for their beliefs about specific benefits and risks of cover crops, such as reduced nutrient losses or impacts on spring planting time. However, their regression analysis focuses on the influence of indices of benefits and risks on adoption decisions rather than these specific factors. Bergtold et al. (2012) also examine factors that influence cover crop adoption as well as their perceived yield impacts. They find that soybean farmers are most likely to perceive a positive yield benefit from cover crops. The authors suggest that this may be due to higher soil nitrogen in soybean fields, and thus more cover crop biomass and ultimate yield benefits. The authors also conclude that the degree of perceived yield benefits will depend on other management factors that make cover crops most advantageous. Finally, Dunn et al. (2015) conduct a survey of cover crop adaptors that provides further support that perceived soil health benefits play a significant role in cover crop adoption. They emphasize the importance of beliefs about benefits from practices over the long term. They find that experience with cover crops and a proclivity for self-learning are particularly important in long term adoption of cover crops.

Others in the literature focus on the role of site-specific biophysical characteristics that may influence the impacts of soil health practices on productivity. Several studies have emphasized the importance of erodibility in influencing conservation practice adoption (Soule, Tegene and Wiebe, 2000; Schoengold, Ding and Headlee 2015, Wade, Kurkalova, and Secchi 2016). For example, Soule, Tegene and Wiebe (2000) find that a highly erodible land (HEL) designation as well as wet soils are predictors of conservation tillage adoption. Wade and Claassen (2017) find that an HEL designation is among the most important predictors of no-till adoption. However, they suggest that this could at least be in part due to program design. The authors also find that well drained soils lead to higher adoption rates for both continuous and alternating no-till adoption patterns. Another highly important factor is soil productivity. Studies of practice adoption often measure the influence of indices of soil productivity such as the National Commodity Crop Productivity Index (NCCPI) on practice adoption. Wade and Claassen (2017) find that highly productive soils are less likely to benefit from soil health practices.

Even if the perceived soil health benefits are high, there still may be several barriers to farmers in making decisions to improve soil health. First, many steps to improve soil health can be costly. Even diagnosing some soil health issues may require costly soil tests, which can deter farmers from even recognizing some soil health issues (Stevens 2018). Second, because investments in soil health may take years to show returns, farmers must be somewhat forward looking to act to improve soil quality. If farmers discount the future considerably, they may not take measures to improve soil health even if they recognize its benefits (Stevens 2018). To make these investments, farmers must not only find that measures will improve their farm's soil productivity, they must be willing to overcome uncertainty over the returns to management practices as well as financial constraints (Bowman, Wallander and Lynch 2016). Finally, degradation can occur well before there are visible signs like soil erosion. Although having more severe resource concerns may mean the direct benefits of practices are higher, the indirect benefits from avoiding major issues like erosion may mean the benefits are just as high at an earlier stage. Practices at later stages of degradation may require more drastic and costly interventions (Bowman, Wallander and Lynch 2016).

At least in part due to these barriers, cost-share incentives have been implemented to incentivize higher adoption levels. Thus, some have recognized the need to account for the role of cost-sharing on practice adoption. If factors other than financial assistance are of most interest, it may be appropriate to model self-funded adoption decisions, as in Dunn et al. (2015) and in the current article. However, others have focused more explicitly on the performance of cost share programs. For example, several studies focus on the issue of additionality, or the extent to which farmers would not have implemented practices in the absence of assistance (Mezzatesta, Newburn and Woodward 2013; Claassen et al. 2014; Fleming 2017). For example, Claassen et al. (2014) find that selected conservation practices receiving funding in working lands programs are between 50 and 80 percent additional, implying that between 20 and 50 percent of the farmers receiving funding would have adopted the practices even without cost share payments. Fleming (2017) takes this a step further, first modeling program participation decisions in a first stage, then accounting for selection in programs when modeling decisions about acreage shares in practices.

Data

To examine the influence of resource concerns on conservation practice adoption, this study relies on data from the crop-specific, field-level version of the Agricultural Resource Management Survey (ARMS), an annual survey sponsored jointly by USDA's Economic Research Service and National Agricultural Statistics Service. This version of the survey samples a different crop each year, so that for most years only one crop is surveyed. It is a national survey sampling from states covering at least 90% of the production of each surveyed crop. Survey questions ask farmers about a randomly chosen field they operate. This version of the ARMS survey is conducted in the fall of each survey year, typically after the crop has been harvested. We use several different years of the survey: Oats and Cotton (2015), Wheat (2017), and Soybeans (2018). These survey versions contribute 6,284 survey responses for use in the analysis. In each of the survey versions used in the analysis, farmers are asked whether they have several on-field resource concerns. Figure A1 in the appendix includes an example of these questions from the 2018 survey. Note that this set of questions was also included in Corn (2016). However, the wording for this version restricted the response to those fields that received technical or financial assistance, so a larger share of survey respondents indicated that they did not have the concerns. Thus, we have left this survey year out of the analysis. Other questions in

ARMS ask farmers about which conservation practices they have used on the field in question. Conservation practice data are grouped into categories. We focus on the categories of conservation tillage and cover crops. We also include several field-level variables in the analysis, described below.

Table 1 provides field level statistics used as controls in the analysis for each specific survey version and then pooled across all versions. Not all survey respondents responded to each individual question. When only including fields that responded to all questions used as controls in the regression analysis, 6,092 fields remain in the sample across surveys. Pooled across all surveys, about 45% of fields identify as having at least one resource concern. Further, conservation tillage is much more prevalent than cover crops. About 58% of fields in the full sample adopted some form of conservation tillage in the survey year. On the other hand, only about 10% of fields in the full sample planted a cover crop in the survey year. Finally, about 13% of the sample received funding for some practice implemented on the field. Specifically, each version of ARMS included in our analysis asks operators if the surveyed field is currently in a contract for financial assistance through either a federal or state program for any practice. Note that this does not necessarily mean that the operator received funding for implementing either a cover crop or conservation tillage. Table 1 also shows some variation in the prevalence of resource concerns and practice adoption behavior across surveys. Cotton farmers and durum wheat farmers are least likely to have at least one resource concern, and spring wheat and winter wheat farmers are most likely to have at least one concern. Practice adoption also varies considerably. Over 75% of fields that grow durum wheat use some form of conservation tillage, whereas fewer than 40% of oat farmers do. On the other hand, cotton farmers and oat farmers are most likely to grow a cover crop.

Table 1 also provides a summary of several other relevant factors by survey version and then pooled across surveys. Across all surveys, we find that a little over 17% of the fields in our sample have some form of drainage installed. Second, nearly 14% of the fields in the full sample have had a highly erodible land designation. Further, loamy and mixed soils are the most common soil types in our sample, at 31% and 45%, respectively. Although many fields in the sample are relatively level at 0-2 degrees, over 50% of fields have a slope of over 3 degrees on their fields. The average size of fields in the sample is 83 acres, though the sample has a very large amount of variation in field size. Only about 3% of fields in our sample have a wetland. We find that across survey versions, some factors vary more than others. Field acreage and the use of drainage have considerable variation across survey version. On the other hand, soil type and slope are relatively similar across versions.

Figure 1 then provides more detail about the proportions of fields with each specific resource concern, pooled across all survey versions used in the analysis. The two most common resource concerns are water-driven erosion and soil compaction. About 20% of fields in the sample having a self-identified issue with water-driven erosion and about 18% of fields have a self-identified issue with soil compaction. Poor drainage, wind-driven erosion and low organic matter are also common concerns in our sample of fields. We find water quality to be much less common, with only about 4% of the sample of fields having this concern. The lack of prevalence of this concern in our sample likely reflects the fact that these are self-assessed concerns. Water quality concerns are less likely than soil health issues to have an impact on farm productivity, thus fewer farmers are likely to identify these as concerns. Finally, we ask farmers whether they have any remaining unspecified concerns. We find that very few farmers self-identify as having any other concerns.

Theory

The following section briefly outlines a farm operator's decision to adopt a conservation practice. The farmer is considering practice j on field i in a given year *t*. In this analysis, the practice could be either a cover crop or conservation tillage. The farmer has an expected return of π_{i0} from not doing any practice on field i, and π_{ij} for doing practice j. The returns for doing no practice on the field are shown in equation (1). Note that time subscripts are removed here:

$$\pi_{i0} = RC_i\alpha_0 + x_i'\beta_0 + \gamma_0 + \epsilon_{i0}. \quad (1)$$

The returns for doing practice j are shown in equation (2):

$$\pi_{ij} = RC_i\alpha_j + x_i'\beta_j + \gamma_j + \epsilon_{ij}. \quad (2)$$

Returns for either choice can depend on several factors. Of particular interest to this analysis is whether or not the field in question has a resource concern, denoted by RC_i. This can be represented by a more flexible specification of resource concerns as well. For example, we will look separately at fields with one versus multiple concerns. We will also look at the impact of specific resource concerns on practice adoption. The returns to either choice may also depend on other field-specific factors x_i that may influence the returns to practice adoption. Finally, each potential choice has a choice specific intercept, γ_0 and γ_j, and an idiosyncratic error, ϵ_{i0} and ϵ_{ij}.

The farmer will decide to implement practice j if the expected returns to doing so exceed those of doing nothing. In other words, the farmer will adopt the practice if equation (3) is true:

$$\pi_{ij} - \pi_{i0} = RC_i(\alpha_j - \alpha_0) + x_i'(\beta_j - \beta_0) + \gamma_j - \gamma_0 + \epsilon_{ij} - \epsilon_{i0} > 0. \quad (3)$$

To estimate the parameters to this decision model, a binary choice model such as a logit regression model can be used. After redefining the differences in coefficients as shown in equation (3), equation (4) can be estimated:

$$(4) \qquad \Pr(\pi_{ij} > \pi_{i0}) = \Pr(RC_i\delta_j + x_i'\zeta_j + \psi_j + \mu_{ij}).$$

Some assumptions are needed for the estimate of the coefficient δ to reflect only the influence of resource concerns on the private returns of practice adoption. Specifically, we must assume that the additional expected value from the option of receiving funding is uncorrelated with having a resource concern. However, because programs prioritize fields with resource concerns, this may not be a reasonable assumption. Rather, if the chance of receiving financial assistance differs for those with and without assistance, then for a binary choice regression that does not account for the probability of getting funding, the estimated coefficient for δ will at least partially reflect these differences. As a preliminary test of whether the differential chance of getting funding leads to a significant difference in the likelihood of receiving financial assistance, we include regressions for just the subsample of fields that do not receive any funding in the year in which they were surveyed. These regressions intrinsically assume that the sample of those not receiving funding have similar underlying coefficients to the entire sample. Further, they assume that the differential incentives for receiving funding for those with and without resource concerns only act in an immediate sense. If individuals that did not get funding this year, but received funding in a previous year have less uncertainty about the benefits of a practice, for example, this approach may be insufficient.

Results

The following section provides results for several logit regressions based on the specification outlined in equation (4) in the last section. We first discuss the results of table 2, which reports the impact of resource concerns and other field-level factors on cover crop adoption in a given year, using the full sample of fields from table 1. The impacts of field-level factors are presented as odds ratios. For indicator variables, an odds ratio can be interpreted as the relative odds when the indicator is true versus when it is false. For example, column 1 shows that for those fields with at least one resource concern, the odds of planting a cover crop in a given year are about 1.6 times the odds of planting a cover crop for fields without any resource concerns. The ratio is significant at the 0.1 percent level. This finding suggests that the presence of resource concerns has a strong impact on cover crop adoption. Table 1 also shows that cover crop adoption varies by crop type, as determined by different survey versions across three years. Cotton farmers are most likely to adopt cover crops, and durum wheat farmers are least likely, controlling for other factors. This mostly echoes the results in table 1. Note that these effects must be interpreted carefully, as crop-specific impacts could reflect influences related to the survey year in addition to the crop being grown. For continuous variables, odds ratios can be interpreted proportionally. For example, we also find in column 1 that field acreage has a significant negative impact on cover crop adoption, meaning a larger field is less likely to have a cover crop planted. Specifically, increasing the size of a field by 1 acre decreases the odds of planting a cover crop by about 0.3%.

The regression shown in column 2 of table 2 splits those with resource concerns into two categories. First are those fields that identify as only having one resource concern. Second are those that identify as having multiple resource concerns. Fields where farmers identify as having only one resource concern have 1.41 times the odds of those without a resource concern. Those fields with multiple concerns have 1.85 times the odds of planting a cover crop as those with no resource concerns. This implies that the returns to adopting practices are higher for fields with multiple concerns. Finally, in column 3 we look at each resource concern individually to see how individual resource concerns impact cover crop adoption. We find that several different resource concerns have a significant impact on cover crop adoption. Interestingly, wind-driven erosion and soil compaction have the largest impacts, with odds of adoption of 1.42 and 1.39 times those of fields without those specific concerns, respectively. Low organic matter also has a significant positive impact on cover crop adoption. Notably, some factors that are often found to be important for cover crop adoption fail to have a significant impact in table 2. For example, fields designated as highly erodible have a positive but statistically insignificant impact on cover crop adoption. The results in this table suggest that an HEL designation is not as good of a predictor of cover crop adoption as self-assessed indicators of erosion.

Next we discuss table 3, which provides the impacts of field-level factors on conservation tillage, also using the full sample from table 1. Column 1 of table 3 suggests that for those with at least one resource concern, the odds of using some form of conservation tillage are about 1.53 times as high as those without any resource concerns, significant at the 0.1 percent level. Column 1 also suggests that some factors other than resource concerns are also significant predictors of conservation tillage. Fields with a wetland and fields with a highly erodible land designation are significantly more likely to use conservation tillage. Slope also has a significant impact, with the flattest fields being most likely to use conservation tillage. Unlike for cover crop adoption, a highly erodible land designation has a particularly strong impact. Those with this designation have 2.1 times the odds of conservation tillage adoption as those without it. Also, in contrast with cover crop adoption, acreage does not have a significant impact on conservation tillage adoption.

As in table 2, column 2 provides odds ratios for a regression that measures the impact of resource concerns on conservation tillage adoption separately for fields that self-identify as have one or multiple resource concerns. As with cover crop adoption, the impact on adoption is larger for fields with multiple resource concerns. Fields with one concern have an odds of adoption that are 1.42 times as large as fields without any concerns. The odds of adoption for fields with multiple concerns are 1.66 times as large as fields without any concerns. Finally, column 3 provides odds ratios for the impacts of specific resource concerns on field level conservation tillage adoption. Interestingly, we find that the specific concern that has the largest impact on adoption is low organic matter. Fields with issues of low organic matter have an odds of adoption that are 1.55 times those of fields without that issue. This result provides evidence that farmers are aware of the intended effect of conservation tillage as a way to build organic matter on fields. Fields with wind-driven erosion, water-driven erosion, and soil compaction also have significantly higher odds of conservation tillage. Conservation tillage is more likely in certain survey versions. Wheat farmers are most likely to use conservation tillage and oat farmers are least likely. However, as with cover crops, this finding could in part reflect year specific factors.

Next we discuss the results of a second set of regressions that only includes individuals who do not financial assistance for practices in the year in which they are surveyed. This is intended to provide a measure of the impact of resource concerns on practice adoption without the added incentive of funding. The difference in incentives could be important, as some programs like EQIP use resource concerns in prioritizing fields for program funding, as discussed above. Column one of table 4 provides the odds ratios of different field-level factors on cover crop adoption. Having at least one resource concern increases the odds of cover crop adoption by 1.58 times compared to someone without any concern. Interestingly, this is not much different from the results in table 2, suggesting that those with resource concerns are more likely to adopt cover crops largely because of higher expected productivity impacts of practice adoption and not primarily because the potential for receiving financial assistance is higher for those with resource concerns. For the results in column 2 of table 4, the odds ratios are slightly larger for fields with one concern and slightly smaller than those in table 2. In column 3 of table 4, the odds ratio is very similar for soil compaction and slightly higher than those in table 2 for the impacts of wind-driven erosion, though the difference is small. In general, these results suggest that these two specific concerns increase the likelihood of cover crop adoption due to their impact on the perceived on-farm benefits of adoption. The general takeaways from table 5 are similar to those from table 4. For both tables 4 and 5, the results suggest that resource concerns have a significant impact on the returns to doing soil health practices.

Conclusion

This study's findings have some important policy implications. First, we find that certain specific concerns have large impacts on practice adoption, but others do not. Insomuch as the effects of specific self-assessed resource concern do not align with the intended benefits of practices, programs may use this information to target their efforts. This may mean providing more information about the benefits of certain practices. Alternatively, if practice adoption does not provide sufficient private benefits to farmers in addressing specific concerns, but the environmental benefits are large, this may reflect the need for more targeted efforts in terms of incentive design. Such concerns may simply require a higher cost-share. Second, we find that regression models that only include individuals who did not receive any funding in the year surveyed yields similar results as models estimated with the full sample. This finding suggests that a large portion of the impact of resource concerns is due to their influence on the private economic returns of practice adoption. The finding also means that farmers with resource concerns are more likely to adopt practices even in the absence of cost sharing assistance. This may have significant implications for the cost effectiveness of financial assistance programs that also aim to enroll farms with high environmental impacts.

Finally, there are some important limitations to the findings of this study. First, the study reports self-assessed resource concerns. Although self-assessed concerns are most likely to lead to private adoption decisions, this may not be a perfect indicator of the degree to which fields have issues that threaten environmental quality. Future work would benefit from comparing data on self-assessed resource concerns with objective assessments of concerns to determine how self-assessments compare to priorities for environmental quality. Second, the analysis leaves some uncertainty about the degree to which higher practice adoption among those with resource concerns is due to private soil health benefits versus targeting efforts from programs. The results suggest that the private benefits are large. However, future work is needed to decipher the separate impacts of each influence.

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Table 1: Summary Statistics of Field-Level Characteristics, by Survey Version

	Cotton - 2015	Oat - 2015	Durum Wheat - 2017	Spring Wheat - 2017	Winter Wheat - 2017	Soybean - 2018	Total
At least one concern	0.412	0.403	0.367	0.526	0.490	0.458	0.448
	(0.492)	(0.491)	(0.483)	(0.500)	(0.500)	(0.498)	(0.497)
Conservation Tillage	0.474	0.396	0.754	0.699	0.721	0.604	0.583
	(0.500)	(0.489)	(0.431)	(0.459)	(0.449)	(0.489)	(0.493)
Cover Crop	0.149	0.164	0.0236	0.0513	0.0834	0.0817	0.101
	(0.356)	(0.370)	(0.152)	(0.221)	(0.277)	(0.274)	(0.301)
Funding for some practice	0.0929	0.0931	0.101	0.255	0.193	0.110	0.131
	(0.290)	(0.291)	(0.302)	(0.436)	(0.395)	(0.313)	(0.338)
Field has tile drainage	0.0459	0.165	0.0606	0.0581	0.149	0.290	0.174
	(0.209)	(0.371)	(0.239)	(0.234)	(0.356)	(0.454)	(0.379)
Highly erodible land	0.0634	0.138	0.138	0.176	0.190	0.135	0.138
	(0.244)	(0.345)	(0.346)	(0.381)	(0.392)	(0.342)	(0.345)
Soil Type							
Loam	0.308	0.247	0.283	0.342	0.306	0.333	0.308
	(0.462)	(0.431)	(0.451)	(0.475)	(0.461)	(0.471)	(0.462)
Clay	0.0962	0.168	0.104	0.133	0.143	0.163	0.145
	(0.295)	(0.374)	(0.306)	(0.340)	(0.350)	(0.369)	(0.352)
Sandy	0.139	0.0931	0.0741	0.0872	0.0715	0.0894	0.0936
	(0.346)	(0.291)	(0.262)	(0.282)	(0.258)	(0.285)	(0.291)
Mixed	0.457	0.492	0.539	0.438	0.480	0.415	0.454
	(0.498)	(0.500)	(0.499)	(0.497)	(0.500)	(0.493)	(0.498)
Slope							
0-2 Degrees	0.549	0.359	0.438	0.402	0.407	0.493	0.452
	(0.498)	(0.480)	(0.497)	(0.491)	(0.492)	(0.500)	(0.498)
3-9 Degrees	0.423	0.597	0.529	0.525	0.539	0.478	0.508
	(0.494)	(0.491)	(0.500)	(0.500)	(0.499)	(0.500)	(0.500)
10 Degrees or more	0.0284	0.0433	0.0337	0.0735	0.0536	0.0300	0.0404
	(0.166)	(0.204)	(0.181)	(0.261)	(0.225)	(0.171)	(0.197)
Field Acreage	73.07	25.62	159.6	156.6	119.7	69.70	83.34
	(91.92)	(33.66)	(131.6)	(186.3)	(157.9)	(68.17)	(114.6)
Field has a wetland	0.00328	0.0194	0.0572	0.0598	0.0149	0.0363	0.0281
	(0.0572)	(0.138)	(0.233)	(0.237)	(0.121)	(0.187)	(0.165)
Observations	915	1,085	297	585	1,007	2,203	6,092

Note: Means of each statistic are provided for each survey version, with standard deviations in parentheses. Data are from three years of the field-level Agricultural Resource Management Survey (ARMS): Oats and Cotton (2015), Wheat (2017), and Soybeans (2018).

Table 2: Odds Ratios of Logit Regressions of Determinants of Cover Crop Adoption, Full Sample

	(1) Cover Crop		(2) Cover Crop		(3) Cover Crop	
At Least One Concern	1.628***	(0.147)				
One Concern			1.412**	(0.158)		
Multiple Concerns			1.851***	(0.195)		
Water-Driven Erosion					1.246	(0.144)
Wind-Driven Erosion					1.415**	(0.181)
Soil Compaction					1.386**	(0.162)
Poor Drainage					0.931	(0.120)
Low Organic Matter					1.347*	(0.174)
Water Quality					1.263	(0.254)
Other Concern					1.129	(0.275)
Wetland	1.156	(0.317)	1.148	(0.316)	1.242	(0.345)
Field is Drained	1.234	(0.140)	1.216	(0.138)	1.219	(0.141)
Highly Erodible	1.146	(0.146)	1.124	(0.144)	1.101	(0.144)
Soil Type[1]						
Clay	0.906	(0.129)	0.903	(0.128)	0.928	(0.133)
Sandy	1.249	(0.189)	1.242	(0.188)	1.205	(0.186)
Mixed	1.018	(0.105)	1.016	(0.105)	1.026	(0.106)
Slope[1]						
0-2 Degrees	1.083	(0.0999)	1.077	(0.0995)	1.073	(0.101)
3-9 Degrees	0.961	(0.225)	0.946	(0.222)	0.933	(0.221)
Field Acreage	0.997***	(0.000676)	0.997***	(0.000679)	0.997***	(0.000688)
Survey Version[1]						
Oat – 2015	0.977	(0.127)	0.988	(0.129)	0.998	(0.131)
Durum Wheat - 2017	0.167***	(0.0665)	0.173***	(0.0689)	0.183***	(0.0728)
Spring Wheat - 2017	0.339***	(0.0731)	0.343***	(0.0739)	0.352***	(0.0761)
Winter Wheat - 2017	0.529***	(0.0800)	0.534***	(0.0808)	0.544***	(0.0827)
Soybean - 2018	0.465***	(0.0591)	0.470***	(0.0597)	0.478***	(0.0614)
Constant	0.152***	(0.0203)	0.153***	(0.0203)	0.155***	(0.0203)
Observations	6092		6092		6092	
Pseudo R^2	0.046		0.047		0.053	

Note: Standard errors are in parenthesis. Single, double and triple asterisks (*, **, ***) denote statistical significance at the 5%, 1%, and 0.1% levels, respectively. The table provides the odds ratios for various field-level characteristics on cover crop adoption. For indicator variables, an odds ratio can be interpreted as the relative odds when the indicator is true vs. false. For example, in column 1, the average field with at least one resource concern has an odds of cover crop adoption that is 1.628 times the odds of adoption for the average field with no self-reported resource concerns. Odds ratios for continuous variables such as field acreage can be interpreted proportionally.

[1] The respective default categories for soil type, slope and survey version are loam, 10 degrees or more, and Cotton – 2015.

Table 3: Odds Ratios of Logit Regressions of Determinants of Conservation Tillage Adoption, Full Sample

	(1) Conservation Tillage		(2) Conservation Tillage		(3) Conservation Tillage	
At Least One Concern	1.533***	(0.0870)				
One Concern			1.418***	(0.0995)		
Multiple Concerns			1.661***	(0.118)		
Water-Driven Erosion					1.209*	(0.0972)
Wind-Driven Erosion					1.266*	(0.119)
Soil Compaction					1.199*	(0.0979)
Poor Drainage					1.162	(0.0969)
Low Organic Matter					1.555***	(0.152)
Water Quality					0.811	(0.127)
Other Concern					1.037	(0.179)
Wetland	1.571*	(0.293)	1.569*	(0.293)	1.597*	(0.300)
Field is Drained	0.987	(0.0735)	0.981	(0.0731)	0.988	(0.0743)
Highly Erodible	2.141***	(0.199)	2.122***	(0.198)	2.129***	(0.202)
Soil Type[1]						
Clay	1.029	(0.0900)	1.027	(0.0899)	1.030	(0.0905)
Sandy	0.968	(0.0981)	0.966	(0.0980)	0.935	(0.0964)
Mixed	1.052	(0.0675)	1.051	(0.0674)	1.045	(0.0672)
Slope[1]						
0-2 Degrees	1.203**	(0.0688)	1.200**	(0.0687)	1.199**	(0.0695)
3-9 Degrees	0.887	(0.133)	0.879	(0.132)	0.879	(0.133)
Field Acreage	1.000	(0.000292)	1.000	(0.000291)	1.000	(0.000292)
Survey Version[1]						
Oat – 2015	0.666***	(0.0632)	0.670***	(0.0636)	0.666***	(0.0636)
Durum Wheat - 2017	3.155***	(0.487)	3.203***	(0.495)	3.245***	(0.502)
Spring Wheat - 2017	2.179***	(0.253)	2.189***	(0.254)	2.210***	(0.258)
Winter Wheat - 2017	2.507***	(0.249)	2.520***	(0.251)	2.524***	(0.252)
Soybean - 2018	1.570***	(0.130)	1.577***	(0.131)	1.582***	(0.132)
Constant	0.637***	(0.0552)	0.637***	(0.0552)	0.656***	(0.0564)
Observations	6092		6092		6092	
Pseudo R^2	0.068		0.069		0.071	

Note: Standard errors are in parenthesis. Single, double and triple asterisks (*, **, ***) denote statistical significance at the 5%, 1%, and 0.1% levels, respectively. The table provides the odds ratios for various field-level characteristics on conservation tillage adoption. For indicator variables, an odds ratio can be interpreted as the relative odds when the indicator is true vs. false. For example, in column 1, the average field with at least one resource concern has an odds of conservation tillage adoption that is 1.533 times the odds of adoption for the average field with no self-reported resource concerns. Odds ratios for continuous variables such as field acreage can be interpreted proportionally.

[1] The respective default categories for soil type, slope and survey version are loam, 10 degrees or more, and Cotton – 2015.

Table 4: Odds Ratios of Logit Regressions of Determinants of Cover Crop Adoption, Fields with No Funded Practices

	(1) Cover Crop		(2) Cover Crop		(3) Cover Crop	
At Least One Concern	1.588***	(0.161)				
One Concern			1.457**	(0.181)		
Multiple Concerns			1.726***	(0.208)		
Water-Driven Erosion					1.227	(0.163)
Wind-Driven Erosion					1.496**	(0.220)
Soil Compaction					1.386*	(0.186)
Poor Drainage					0.860	(0.131)
Low Organic Matter					1.155	(0.178)
Water Quality					1.138	(0.271)
Other Concern					1.431	(0.386)
Wetland	1.187	(0.389)	1.176	(0.386)	1.230	(0.408)
Field is Drained	1.158	(0.151)	1.149	(0.150)	1.160	(0.153)
Highly Erodible	1.017	(0.153)	1.006	(0.152)	0.994	(0.154)
Soil Type[1]						
Clay	0.968	(0.156)	0.964	(0.156)	0.993	(0.161)
Sandy	1.450*	(0.244)	1.448*	(0.244)	1.409*	(0.242)
Mixed	1.100	(0.130)	1.100	(0.130)	1.108	(0.131)
Slope[1]						
0-2 Degrees	1.135	(0.118)	1.132	(0.118)	1.125	(0.119)
3-9 Degrees	1.067	(0.279)	1.059	(0.277)	1.043	(0.275)
Field Acreage	0.998**	(0.000769)	0.998**	(0.000771)	0.998**	(0.000788)
Survey Version[1]						
Oat – 2015	0.920	(0.132)	0.927	(0.133)	0.931	(0.134)
Durum Wheat - 2017	0.112***	(0.0577)	0.114***	(0.0589)	0.120***	(0.0622)
Spring Wheat - 2017	0.238***	(0.0682)	0.240***	(0.0688)	0.248***	(0.0711)
Winter Wheat - 2017	0.454***	(0.0798)	0.457***	(0.0802)	0.462***	(0.0815)
Soybean - 2018	0.466***	(0.0648)	0.468***	(0.0651)	0.483***	(0.0679)
Constant	0.130***	(0.0193)	0.130***	(0.0194)	0.135***	(0.0197)
Observations	5291		5291		5291	
Pseudo R^2	0.047		0.047		0.052	

Note: Standard errors are in parenthesis. Single, double and triple asterisks (*, **, ***) denote statistical significance at the 5%, 1%, and 0.1% levels, respectively. The table provides the odds ratios for various field-level characteristics on cover crop adoption. For indicator variables, an odds ratio can be interpreted as the relative odds when the indicator is true vs. false. For example, in column 1, the average field with at least one resource concern has an odds of cover crop adoption that is 1.588 times the odds of adoption for the average field with no self-reported resource concerns. Odds ratios for continuous variables such as field acreage can be interpreted proportionally.

[1] The respective default categories for soil type, slope and survey version are loam, 10 degrees or more, and Cotton – 2015.

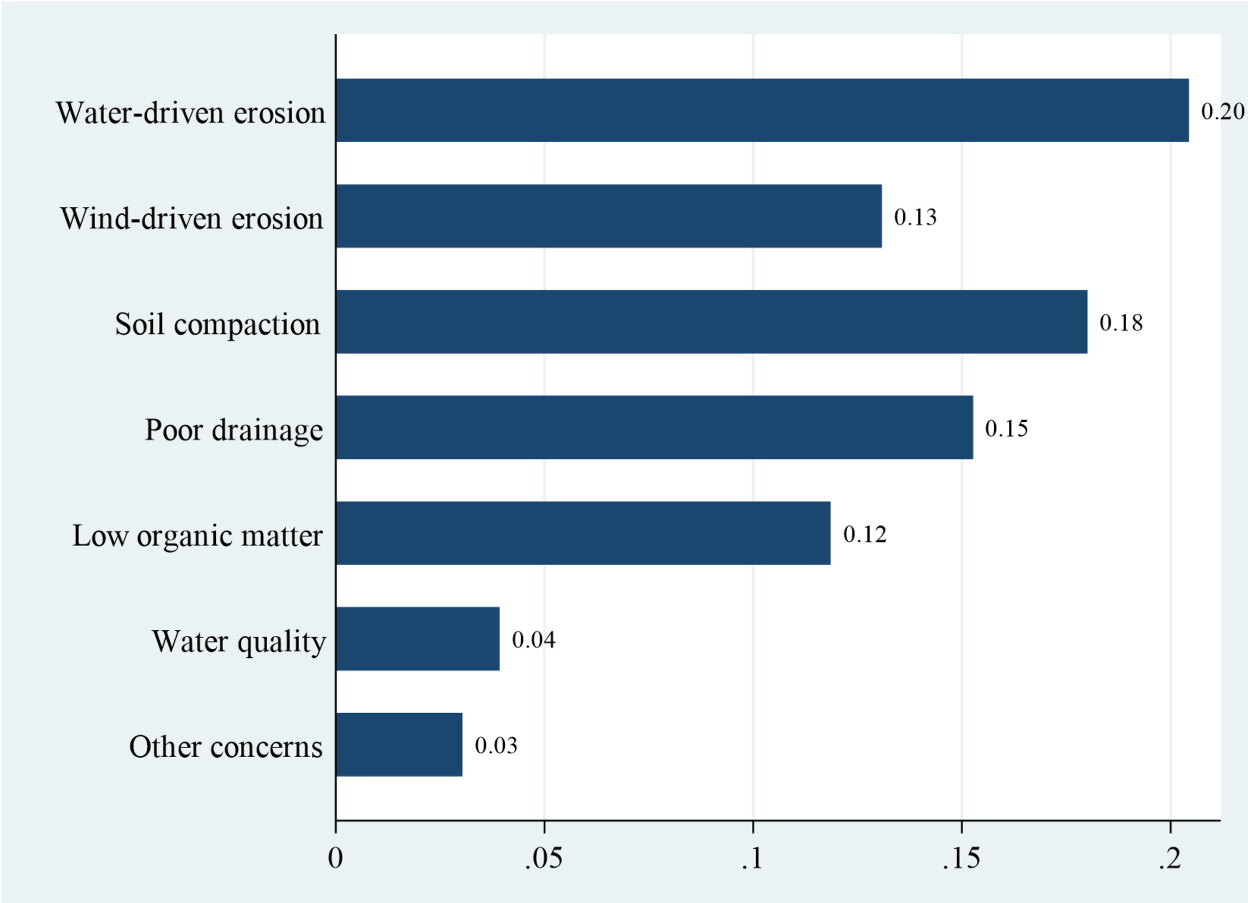
Table 5: Odds Ratios of Logit Regressions of Determinants of Conservation Tillage Adoption, Fields with No Funded Practices

	(1) Conservation Tillage		(2) Conservation Tillage		(3) Conservation Tillage	
At Least One Concern	1.467***	(0.0889)				
One Concern			1.380***	(0.103)		
Multiple Concerns			1.562***	(0.119)		
Water-Driven Erosion					1.211*	(0.104)
Wind-Driven Erosion					1.224*	(0.124)
Soil Compaction					1.151	(0.101)
Poor Drainage					1.149	(0.103)
Low Organic Matter					1.463***	(0.154)
Water Quality					0.810	(0.135)
Other Concern					1.094	(0.207)
Wetland	1.792**	(0.379)	1.785**	(0.378)	1.792**	(0.381)
Field is Drained	1.008	(0.0798)	1.004	(0.0795)	1.010	(0.0807)
Highly Erodible	2.056***	(0.206)	2.044***	(0.205)	2.048***	(0.210)
Soil Type[1]						
Clay	1.039	(0.0966)	1.036	(0.0964)	1.037	(0.0969)
Sandy	1.034	(0.112)	1.034	(0.112)	1.007	(0.111)
Mixed	1.037	(0.0707)	1.037	(0.0707)	1.033	(0.0705)
Slope[1]						
0-2 Degrees	1.243***	(0.0755)	1.241***	(0.0754)	1.237***	(0.0761)
3-9 Degrees	0.834	(0.133)	0.828	(0.133)	0.824	(0.133)
Field Acreage	1.000	(0.000303)	1.000	(0.000302)	1.000	(0.000303)
Survey Version[1]						
Oat – 2015	0.667***	(0.0666)	0.670***	(0.0670)	0.666***	(0.0667)
Durum Wheat - 2017	3.193***	(0.513)	3.225***	(0.518)	3.242***	(0.522)
Spring Wheat - 2017	2.115***	(0.270)	2.124***	(0.271)	2.142***	(0.274)
Winter Wheat - 2017	2.356***	(0.249)	2.364***	(0.250)	2.365***	(0.251)
Soybean - 2018	1.557***	(0.136)	1.562***	(0.137)	1.564***	(0.138)
Constant	0.624***	(0.0569)	0.624***	(0.0569)	0.644***	(0.0582)
Observations	5291		5291		5291	
Pseudo R^2	0.062		0.062		0.063	

Note: Standard errors are in parenthesis. Single, double and triple asterisks (*, **, ***) denote statistical significance at the 5%, 1%, and 0.1% levels, respectively. The table provides the odds ratios for various field-level characteristics on conservation tillage adoption. For indicator variables, an odds ratio can be interpreted as the relative odds when the indicator is true vs. false. For example, in column 1, the average field with at least one resource concern has an odds of conservation tillage adoption that is 1.467 times the odds of adoption for the average field with no self-reported resource concerns. Odds ratios for continuous variables such as field acreage can be interpreted proportionally.

[1] The respective default categories for soil type, slope and survey version are loam, 10 degrees or more, and Cotton – 2015.

Figure 1: Proportions of sample with individual resource concerns



Note: The figure provides proportions of fields with each specific resource concern for the sample in table 1. "Some concern" indicates that a field self-identifies as have at least one concern. Specific concerns are not mutually exclusive.

Appendix

24. **Next we will ask about soil and water concerns that you have on the selected field.**

In the selected field, are you concerned about any of the following?	CODE YES = 1 NO = 3	Have you received technical assistance from any of the following sources to evaluate this resource concern? (Report up to 2 sources that you received assistance from.) 1 USDA – NRCS 2 Cooperative Extension Service 3 Other USDA staff, including Forest Service 4 Other (e.g. Soil and Water Conservation District, state agency)	
		Source 1	Source 2
a. Water-driven erosion.	2407	2417	2427
b. Wind-driven erosion.	2408	2418	2428
c. Soil compaction.	2409	2419	2429
d. Poor drainage.	2410	2420	2430
e. Low organic matter.	2411	2421	2431
f. Water quality.	2412	2422	2432
g. Other concerns.	2413	2423	2433
h. *No significant concerns.	2414		

*__ENUMERATOR NOTE__: Enter Yes = 1 for item h, *No significant concerns*, **ONLY** if the respondent replies NO = 3 to all other concerns (items a – g).

Figure A1: Questions about resource concerns from 2018 ARMS survey
Note: The figure provides the series of questions included in the 2018 field-level version of ARMS asking about resource concerns.