DECODING IOWA FARMERS' UNDERSTANDING OF EDGE-OF-FIELD CONSERVATION PRACTICES:

EVIDENCE FROM TWO SURVEYS IN 2022 AND 2023

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ABSTRACT

Edge-of-field (EOF) practices are designed to slow, filter, and process subsurface drainage water from farm fields. Such practices play a vital role in achieving the goal of 45% nutrient reduction outlined in the Iowa Nutrient Reduction Strategy, and in helping the U.S. agricultural system to attain long-term sustainability. The key practices, such as saturated buffers, bioreactors, and wetlands, can significantly improve water quality, store more carbon in the soil, and enhance wildlife habitat in working landscapes. However, EOF practices have been remarkably underutilized even though they can effectively reduce nutrient delivery. The purpose of this study is to understand how landowners and farmers view EOF practices and the barriers to scaling up these practices to significantly reduce nutrient loss. Using two rounds of survey responses among over 1,000 landowners and farmers residing in five watersheds in Iowa, conducted in summer 2022 and 2023, respectively, this study provides informative updates for EOF practices on current adoption rates and adoption willingness, perceived environmental benefits, and barriers to adoption, and puts forward suggestions on effective education strategies embraced by landowners and farmers. This study will help to scale up adoption and make progress toward Iowa Nutrient Reduction Strategy goals and help stakeholders attune and refine strategies for outreach and engagement activities promoting EOF practices.

KEYWORDS

Edge-of-field practices, Nutrient reduction, Barriers to adoption, Perceived benefits, Educational strategies

JEL CODES

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EXECUTIVE SUMMARY

Conservation practices play a vital role in sustainable agricultural production and maintaining a healthy ecosystem by fundamentally improving soil health, enhancing water quality, preserving biodiversity, and reducing greenhouse gas emissions. Edge-of-field (EOF) practices—such as saturated buffers, bioreactors, and water quality enhancement wetlands—can significantly improve water quality by reducing nutrient loads and enhancing wildlife habitat.

However, these key EOF practices have been remarkably underutilized even though they can effectively reduce nutrient delivery (Iowa Learning Farms 2022). The low adoption rate can be attributed to a lack of understanding of these new practices and a history with draining wetlands. As these structural practices are often novel and rooted in recent scientific advancements, a lack of familiarity and clear comprehension of how they function can create uncertainty and reluctance to implement them. This study aims to gain insights into landowners' and farmers' perceptions of EOF practices, assess the environmental benefits they perceive these practices offer, pinpoint obstacles hindering the adoption of these practices, and help stakeholders attune and refine educational strategies in extension and outreach activities to facilitate broader adoption.

In collaboration with ISU's Center for Survey Statistics and Methodology, we conducted two rounds of surveys among Iowa landowners and farmers across five different HUC-8 watersheds in the Des Moines Lobe. We initiated an online survey in August 2022 (Round 1), and a follow-up mixed-mode survey (online and paper) the following summer, in July 2023 (Round 2). Round 2 of the survey was primarily administered through the mail, but also offered an online option. We received a total of 668 completed surveys in Round 1, generating a response rate of 16%. In Round 2, we received 360 completed surveys, resulting in a response rate of 25%. The main difference is that Round 2 included both online and mail surveys, which allowed for a wider range of participants, thus leading to a higher response rate.

Our main findings from the survey are as follows:

- The results indicate that many of our surveyed farmers and landowners are very unfamiliar with EOF practices, even what each practice entails, suggesting a disconnect between academic and practical, on-the-ground knowledge. This gap highlights the necessity for increased awareness and education to bridge understanding and application of these practices.

- A significant number of farmers expressed uncertainty regarding the comprehensive environmental benefits of EOF practices. There is confusion about the multifaceted benefits of saturated buffers and water quality enhancement wetlands compared to the singular water quality benefit attributed to bioreactors, which may affect wider implementation.

- Concerns regarding the governmental regulations or administrative complexities of implementing EOF practices were prominent—over one-third of farmers are apprehensive about the bureaucratic procedures involved. This suggests a need to streamline processes and provide additional support to encourage broader farmer engagement in conservation programs.

- Preference for educational materials leans toward graphical fact sheets (i.e., infographics) rather than narrative videos, revealing that farmers value clear, visual, and succinct resources. Such materials were particularly effective in raising adoption rates among non-Conservation Reserve Program (CRP) farmers, emphasizing the need for well-designed educational tools to promote EOF practices adoption.

- The infographic outperforming narrative videos as an information treatment mechanism reveals an interesting insight into farmer learning preferences, suggesting that visual, easily digestible content is more effective at conveying information than more time-consuming narrative formats.

- Educational programs or information treatments are found to be most effective with farmers who are not already enrolled in government conservation programs.

INTRODUCTION

The Midwestern landscape is among the most highly altered and intensively managed ecosystems in the country. As such, the region faces significant water quality problems attributable to nutrient pollution from annual row crop agriculture. Transport of soil, fertilizer, and manure into Iowa's streams, rivers, and lakes increases nitrogen and phosphorus loads to potentially harmful levels and impacts drinking water sources for every citizen in the state (Rabotyagov et al. 2014).

The Iowa Nutrient Reduction Strategy (INRS), introduced in 2012, calls for 45% total load reductions in both nitrogen and phosphorus. Most of the excess nutrients come from agricultural nonpoint sources—INRS specifically outlines potential reductions in nitrogen and phosphorus loads achievable through a wide range of in-field and edge-of-field (EOF) conservation practices (Lawrence and Benning 2019; IDALS 2021). Among the more understudied aspects of the INRS is how landowners and farmers view EOF practices and the barriers to scaling up these practices to significantly reduce nutrient loss. This issue is particularly important—Iowa Governor Kim Reynolds' first major legislation allocated $282 million over the next 12 years to support EOF practices such as wetlands, bioreactors, saturated buffers, and terraces (Pfannenstiel 2018).

Scaling up the INRS could increase acres treated with nutrient-reducing wetlands from about 200,000 acres currently to a potential 12.8 million acres, and increase acres treated with bioreactors and saturated buffers from about 3,500 acres to a potential 9.9 million acres. Such implementation would take a significant investment of both private and public dollars (Helmers 2017) and wide-scale buy-in from Iowa's various decision-makers. Our project provides a comprehensive assessment of Iowa landowners' and farmers' views on and barriers to adopting key EOF practices to further accelerate progress toward INRS nutrient reduction goals.

We have extensive knowledge regarding the incentives and barriers for working-land conservation practices (Lee et al. 2019; Sawadgo, Zhang and Plastina 2021). However, we have much less understanding of what induces or inhibits landowners' and farmers' adoption of EOF practices.

The Edge-of-Field Conservation Practices Survey aims to fill this knowledge gap. The survey asks landowners and farmers about their approach and attitudes toward adopting key EOF practices. We focus on the perceived benefits of these practices as they relate to nitrate and general environmental benefits.

SURVEY IMPLEMENTATION

To explore the primary challenges that deter landowners and farmers from adopting key EOF practices, and to identify which educational strategies and incentives most encourage farmers and landowners to adopt these practices, we conducted two rounds of surveys among Iowa landowners and farmers across five different HUC-8 watersheds in the Des Moines Lobe. We initiated an online survey in August 2022 (Round 1), and a follow-up mixed-mode survey (online and paper) the following summer, in July 2023 (Round 2).

We sent questionnaires to a sample of crop farmers who reside and farm in five different Iowa watersheds: the North Raccoon River watershed, the Boone River watershed, the Middle Cedar River watershed, the Turkey River watershed, and the Winnebago River watershed. These watersheds are primarily located in the Des Moines Lobe and have varying levels of EOF practice adoption. In each watershed, we chose one or two counties with substantial crop acreage and documented adoption of EOF practices. Wright and Kossuth Counties in the Boone River watershed, Buena Vista and Sac Counties in the North Raccoon River watershed, and Black Hawk County in the Middle Cedar River watershed have higher numbers of early adopters; Howard County in the Turkey River watershed and Winnebago County in the Winnebago River watershed have fewer adopters. Figure 1 presents a map with the five watersheds highlighted and the selected counties outlined.

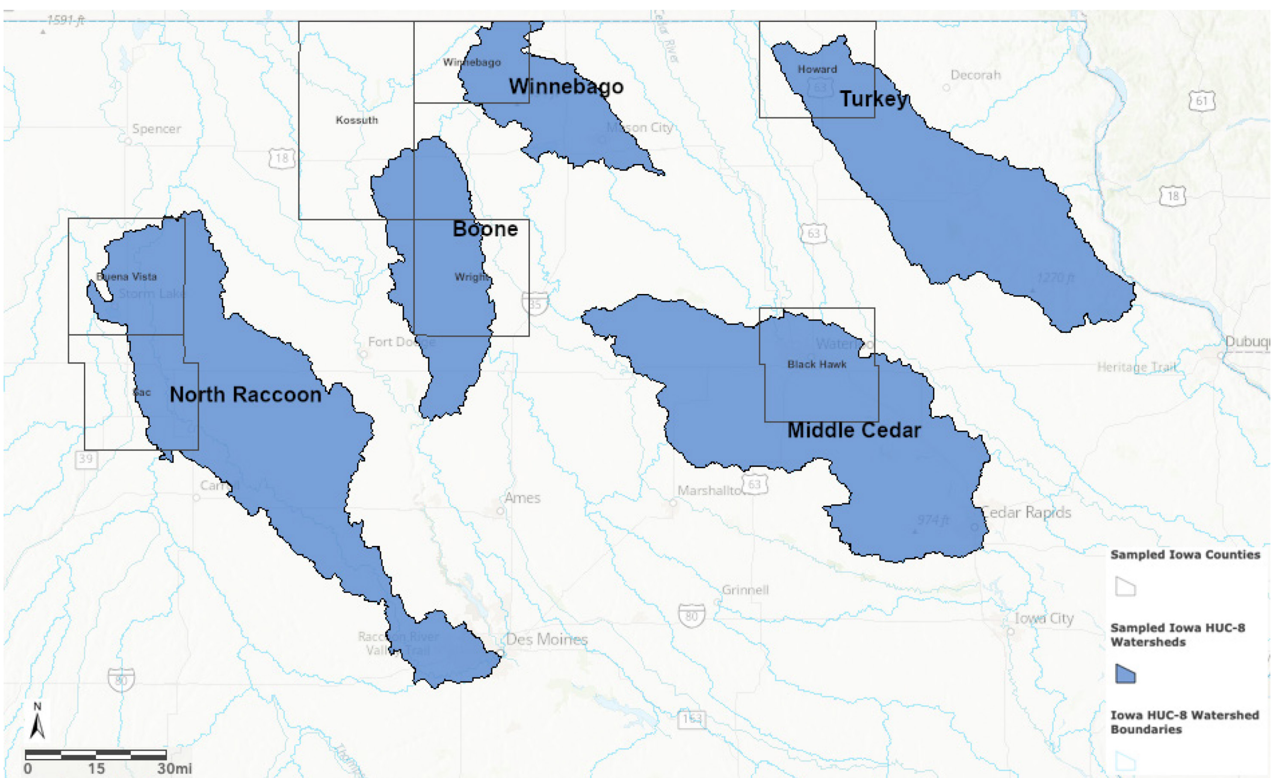

Figure 1. The sampled HUC-8 watersheds and counties in Iowa.

The initial, online data collection sampled 4,360 farmers, which we divided into seven groups of roughly 623 farmers or landowners each. The seven groups each received a different version of the survey, containing either: (*a*) a fact sheet about nutrient reduction; (*b*) a fact sheet about nutrient reduction and wildlife benefits; (*c*) a video featuring an ISU Extension and Outreach professional discussing nutrient reduction; (*d*) a video featuring an ISU Extension and Outreach professional discussing nutrient reduction and wildlife benefits; (*e*) a video featuring landowner/farmer adopters discussing nutrient reduction; (*f*) a video featuring landowner/farmer adopters discussing nutrient reduction and wildlife benefits; or (*g*) only the questionnaire without supplemental information (the control group).

The second, mixed-mode data collection sampled 1,486 Iowa farmers, which we divided into three groups of roughly 500 farmers or landowners apiece. Similarly, the three groups received different information treatments with the survey: (*a*) a baseline, traditional extension fact sheet; (*b*) an infographic-style fact sheet featuring a female farmer; or (*c*) an infographic-style fact sheet featuring a male farmer.

We can summarize the key differences between the two rounds of the survey as follows:

(1) Survey mode: Round 1 of the survey was implemented entirely online, which may have limited participation to farmers with internet access and digital devices. This could have potentially skewed the results toward a demographic that is more tech-savvy. Round 2, however, introduced a mixed-mode format that included both online and mail surveys. This approach allowed for a wider range of participants, including those who may not have easy online access or who prefer traditional mail responses. This shift is important as it may capture a more comprehensive snapshot of farmers' perspectives and experiences.

(2) Clarifications on and wording of EOF practices: In Round 1, the survey results showed higher reported adoption rates for EOF practices than what was actually present in the state. The discrepancy led the researchers to believe that respondents might have been reporting the existence of any type of buffer or wetland on their land, rather than the specific practices the survey was intended to measure. To address this, in Round 2, notations were added to the questionnaire to provide descriptions of what constitutes saturated buffers, water quality enhancement wetlands, and controlled drainage. These clarifications were aimed to alleviate misunderstandings among respondents, thus leading to more accurate reporting of adoption rates.

(3) Information treatment emphasis: In Round 1, seven different forms of information treatments were examined, revealing that communications from farmer messengers resonated more effectively than those from professional messengers, and that graphical fact sheets had a greater impact than video presentations. Building upon these findings, Round 2 streamlined the approach to focus on just three groups: a traditional fact sheet, a graphical fact sheet featuring a female farmer, and a graphical fact sheet featuring a male farmer. This phase concentrated on assessing the gender effect by comparing the effectiveness of female versus male messengers in the information treatments.

WHAT'S IN A NAME?
CURRENT ADOPTION RATES FOR EDGE-OF-FIELD PRACTICES

The first question asked on the survey concerned adoption of specific EOF practices on the farmland owned or operated by the respondent. In Round 1, we noticed that the reported adoption rates of saturated buffers and water quality enhancement wetlands were higher than the number of those practices in the state. We speculated that some of the respondents in Round 1 were reporting any buffer or any wetland they might have on their land.

We added clarifying notations in the Round 2 questionnaire to help alleviate any misunderstandings about saturated buffers, water quality enhancement wetlands, and controlled drainage as seen below:

ROUND 1:
Do you currently use the following conservation practices on any Iowa farmland you own or operate?

Saturated buffers
Water quality enhancement wetlands
Controlled drainage/drainage water management

ROUND 2:
Do you currently use the following conservation practices on any Iowa farmland you own or operate?

Saturated buffers *(i.e., water is diverted into a perforated distribution pipe, where it slowly flows through the soil of a vegetated buffer)*
Water quality enhancement wetlands *(i.e., constructed shallow water area with gently sloping banks, an average water depth of about 3ft, and was designed specifically to improve water quality)*
Controlled drainage/drainage water management *(i.e., outlet from a conventional drainage system is intercepted by a water control structure for control of water levels and flow)*

Table 1 shows the differences in responses between Round 1 and Round 2 results. The Round 2 responses seem to represent a more accurate view of the number of respondents who have adopted saturated buffers, water quality enhancement wetlands, and controlled drainage. In addition, in-field practices like cover crops, no-till, reduced tillage, grassed waterways, buffer strips, and rotational grazing showed an increase in the percentage of respondents who reported having used the practices from Round 1 to Round 2. Later survey results support the idea that respondents are not that familiar with EOF practices and their benefits and that could be a limiting factor when trying to increase their adoption across Iowa.

Table 1. Percentage of Edge-of-Field and In-field Practice Adoption

	Round 1		Round 2	
Variables	Percent	*N*	Percent	*N*
Saturated buffers*	13.1	618	5.1	335
Bioreactors	2.8	607	2.1	334
Water quality enhancement wetlands*	12.8	616	5.7	336
Grassed waterway	80.8	655	82.5	348
Buffer strips	47.2	627	51.5	340
Controlled drainage*	22.7	617	12.2	337
Rotational grazing	10.2	605	17.3	336
Cover crops	27.7	631	31.4	341
No-till	43.8	625	49.6	339
Reduced tillage	75.1	635	75.4	333

**In Round 2, we added short notations to explain saturated buffers, water quality enhancement wetlands, and controlled drainage (see descriptions above).*

PERCEIVED BENEFITS OF EDGE-OF-FIELD PRACTICES

The next five questions assess how farmers and landowners perceive the benefits of EOF practices for the environment overall, for improving soil health, for reducing nitrogen and sediment transport to water bodies, and for enhancing wildlife habitat. Water quality enhancement wetlands are the consistent favorite across the board, but there are varying degrees of confidence in and knowledge of the three EOF practices (saturated buffers, bioreactors, and water quality enhancement wetlands) and their benefits throughout Round 1. Round 2 responses show more definitive positive or negative opinions about the practice benefits than those in Round 1. One possible reason is the exclusive treatment of the fact sheet. Based on the insights from the Round 1 survey, the fact sheet has proven to be a particularly effective educational tool. In a mail survey, recipients have the liberty to read the fact sheet at their convenience, as opposed to the online format where the fact sheet is only presented at specific points in the survey.

Table 2 presents the degree to which respondents perceived the three EOF practices—saturated buffers, bioreactors, and water quality enhancement wetlands—as having environmental benefits. In Round 1, water quality enhancement wetlands were viewed most favorably at 71%, followed by saturated buffers at nearly 60%. Respondents were most uncertain of the environmental benefits of bioreactors. In Round 2, however, there was a marked polarization of opinions, with an increase in both skepticism and firm belief in their benefits. This suggests a shift toward more definitive stances, with fewer respondents expressing uncertainty about the practices. It is noteworthy that a considerable number of respondents in both rounds expressed uncertainty about the environmental benefits of these EOF practices. It appears that respondents are unclear about the fact that both saturated buffers and wetlands can offer multiple environmental benefits, whereas bioreactors are primarily valued for their water quality benefits alone. This lack of clarity on the comprehensive benefits of these practices could hinder their broader adoption.

Table 2. Do you think that any of the following practices can be beneficial for the environment?

Percent who answered—	*N*	Definitely no	Probably no	Neutral/ Not sure	Probably yes	Definitely yes
Round 1						
Saturated buffers	658	0.6	2.3	38.1	45.1	13.8
Bioreactors	658	1.1	4.1	51.4	33.6	9.9
Water quality enhancement wetlands	659	1.2	2.4	25.3	52.0	19.0
Round 2						
Saturated buffers	345	4.6	7.0	33.0	39.4	16.2
Bioreactors	344	5.5	7.9	41.3	33.7	11.6
Water quality enhancement wetlands	344	4.9	7.6	32.8	36.9	17.7

Table 3 reveals respondents' attitudes towards the efficacy of EOF practices in improving soil health over the two survey rounds. In Round 1, farmers and landowners showed a pronounced uncertainty in the effectiveness of all three practices, particularly bioreactors, for soil health. This is likely because many farmers do not have knowledge of or experience with bioreactors and thus selected “Not sure.” Water quality enhancement wetlands had the highest positive rankings, with the highest number of respondents agreeing they improve soil health. Although water quality enhancement wetlands were highly rated for soil health improvement, it is necessary to note that their main function is to enhance water quality and support wildlife habitat, not to directly improve the soil health of agricultural fields. Moreover, none of the EOF practices in question—saturated buffers, bioreactors, or water quality enhancement wetlands—directly improve soil health on agricultural land. The agreement with the statement on soil health improvement may reflect a lack of understanding about these practices among respondents. Correcting this misconception is vital for an accurate understanding of the distinct roles and benefits of these practices.

Table 3. To what extent do you agree or disagree that the following practices can improve soil health?

Percent who answered—	*N*	Strongly disagree	Disagree	Neutral/ Not sure	Agree	Strongly agree
Round 1						
Saturated buffers	648	1.1	6.8	59.1	28.7	4.3
Bioreactors	649	1.9	8.0	65.0	22.0	3.1
Water quality enhancement wetlands	647	1.1	6.5	52.6	32.5	7.4
Round 2						
Saturated buffers	332	2.1	4.5	56.0	33.7	3.6
Bioreactors	334	2.4	8.1	61.1	24.3	4.2
Water quality enhancement wetlands	330	1.8	7.6	55.5	29.1	6.1

Table 4 reflects the levels of agreement among survey respondents regarding the efficacy of EOF practices in reducing nitrogen in water bodies. Notably, the data indicate a concerning level of dissent or uncertainty: nearly half of the respondents were either neutral or disagreed with the effectiveness of these practices. This highlights a significant challenge for extension services and researchers, as these EOF practices—saturated buffers, bioreactors, and water quality enhancement wetlands—are promoted for their nutrient reduction capabilities for water. The expectation is that a majority would recognize and agree with these benefits. The fact that agreement is not as widespread as hoped signals a clear need for more concerted educational efforts to enhance understanding and acceptance of these practices' roles in water quality improvement.

Table 4. To what extent do you agree or disagree that the following practices can reduce the amount of nitrogen in water bodies?

Percent who answered—	*N*	Strongly disagree	Disagree	Neutral/ Not sure	Agree	Strongly agree
Round 1						
Saturated buffers	648	0.3	1.9	46.0	42.9	9.0
Bioreactors	650	0.9	1.5	43.8	42.3	11.4
Water quality enhancement wetlands	648	0.6	1.1	38.7	47.8	11.7
Round 2						
Saturated buffers	331	1.5	1.2	41.7	49.5	6.0
Bioreactors	334	1.5	1.5	46.7	41.6	8.7
Water quality enhancement wetlands	329	1.9	3.3	38.6	48.9	7.3

Table 5 presents respondents' agreement with the statement that EOF practices can prevent sediment from reaching water bodies. On average, saturated buffers had a combined 51% in agreement (agree and strongly agree), bioreactors had 46.6%, and water quality enhancement wetlands were viewed most favorably, with 61.7% agreement. The data indicate a disparity between the perceived and actual functions of these EOF practices. Many respondents mistakenly view wetlands primarily as sediment traps, which suggests a fundamental misunderstanding, since wetlands primarily improve water quality via nutrient reduction, not sediment control. The data also reflect confusion about bioreactors, which have no role in sediment management but are designed for water quality benefits. On the other hand, saturated buffers are correctly identified for their role in sediment control. These insights reveal a need for clearer educational outreach to rectify misconceptions and enhance the understanding of the specific environmental benefits of EOF practices.

Table 5. To what extent do you agree or disagree that the following practices can prevent sediment from reaching water bodies?

Percent who answered—	*N*	Strongly disagree	Disagree	Neutral/ Not sure	Agree	Strongly agree
Round 1						
Saturated buffers	647	0.6	4.0	48.5	39.9	7.0
Bioreactors	648	1.2	4.9	46.0	39.0	8.8
Water quality enhancement wetlands	650	0.6	0.8	37.1	49.1	12.5
Round 2						
Saturated buffers	332	1.8	2.7	40.4	48.2	6.9
Bioreactors	335	2.1	3.9	48.7	37.0	8.4
Water quality enhancement wetlands	329	1.2	2.4	34.7	53.5	8.2

Table 6 presents respondents' views on whether the three EOF practices enhance wildlife habitat. In Round 1, saturated buffers had a combined 38.8% in agreement (agree and strongly agree), bioreactors had 35.5%, and water quality enhancement wetlands were viewed most favorably, with 62% agreement. Disagreement levels were low for saturated buffers and water quality enhancement wetlands at 5.3% and 1.1%, respectively, but higher for bioreactors at 9.6%. In Round 2, however, where respondents could read the fact sheet at their convenience and were provided with clear definitions of each practice, there was a notable increase in both agreement and disagreement for saturated buffers and a slight rise in agreement for water quality enhancement wetlands, indicating that with better information, respondents formed stronger opinions. These findings underline the importance of educational materials in shaping public perceptions.

Table 6. To what extent do you agree or disagree that the following practices can enhance and expand wildlife habitat?

Percent who answered—	*N*	Strongly disagree	Disagree	Neutral/ Not sure	Agree	Strongly agree
Round 1						
Saturated buffers	645	0.4	4.8	56.0	31.8	7.0
Bioreactors	650	2.0	7.6	55.0	28.7	6.8
Water quality enhancement wetlands	647	0.3	0.8	36.9	45.6	16.4
Round 2						
Saturated buffers	330	1.8	3.6	48.5	39.4	6.7
Bioreactors	335	1.8	5.7	56.4	29.4	6.6
Water quality enhancement wetlands	325	1.5	1.5	33.5	51.4	12.0

BARRIERS TO ADOPTION

The next four questions assess how farmers and landowners perceive four possible barriers to adopting EOF practices—unfamiliarity with the practices, extra time and labor requirements in implementing them, difficulty in finding information on conservation programs, and requirements and restrictions of government programs. The survey results underscore a widespread unfamiliarity with these practices. This points to a potential disconnect between conservation efforts and on-the-ground knowledge among farmers, highlighting the importance of increasing awareness and providing clear, accessible information about the benefits and implementation of these practices.

Table 7 measures respondents' unfamiliarity with the three EOF practices. In the first round, respondents exhibited varying degrees of familiarity with the practices. For saturated buffers, only 20% expressed familiarity and the majority (51.9%) expressed unfamiliarity. Bioreactors had a similar pattern—27.8% indicated they were familiar with the practice, while 45.9% indicated they were not. For water quality enhancement wetlands, 26.7% were familiar and 41.7% were not familiar with the practice. The fact that only 20% of respondents were familiar with saturated buffers, with similar low familiarity rates for bioreactors and water quality enhancement wetlands, underscores a widespread unfamiliarity with these practices. In Round 2, the level of unfamiliarity decreased for all practices, while neutrality increased. This suggests that while respondents were becoming more aware, their awareness did not necessarily translate into a confident understanding of the practices.

Table 7. To what extent do you agree or disagree with the statement: I am not familiar with the following practices.

Percent who answered—	*N*	Strongly disagree	Disagree	Neutral/ Not sure	Agree	Strongly agree
Round 1						
Saturated buffers	642	4.7	15.3	29.1	39.7	11.2
Bioreactors	639	5.6	22.2	26.3	33.8	12.1
Water quality enhancement wetlands	640	3.4	23.3	31.6	33.3	8.4
Round 2						
Saturated buffers	332	3.3	12.0	42.5	36.7	5.4
Bioreactors	331	3.0	18.1	37.5	34.4	7.0
Water quality enhancement wetlands	330	3.3	17.6	45.2	30.3	3.6

Table 8 summarizes respondents' concerns about excess labor and time required to implement and maintain the three EOF practices. A substantial majority of respondents were neutral regarding concerns about excessive labor to maintain the practices, with 74.5% for saturated buffers, 71.9% for bioreactors, and 66.5% for water quality enhancement wetlands on average. The substantial uncertainty implies that a large portion of respondents may not have any practical experience with these practices and therefore cannot accurately gauge the labor required. Providing farmers with hands-on demonstrations, clear guidelines, and real-world examples of maintenance commitments could help demystify the processes and encourage wider adoption. More importantly, farmers need to see that the benefits of these practices outweigh the efforts required, ensuring that their operations remain efficient and sustainable.

Table 8. To what extent do you agree or disagree with the statement: It takes too much work and time to implement and maintain the following practices.

Percent who answered—	*N*	Strongly disagree	Disagree	Neutral/ Not sure	Agree	Strongly agree
Round 1						
Saturated buffers	629	1.3	10.2	75.8	11.6	1.1
Bioreactors	628	1.6	7.3	70.1	18.0	3.0
Water quality enhancement wetlands	631	1.6	13.0	68.1	15.2	2.1
Round 2						
Saturated buffers	324	3.1	6.2	73.1	15.1	2.5
Bioreactors	322	2.2	6.2	73.6	14.9	3.1
Water quality enhancement wetlands	319	0.9	14.7	64.9	17.2	2.2

Table 9 gauges how difficult respondents perceive it to be to access information about state or federal conservation programs on the EOF practices. We note that most respondents were neutral (unaware) regarding the difficulty in accessing such information: 70.4% for saturated buffers, 68.9% for bioreactors, and 65.2% for water quality enhancement wetlands on average. The high percentage of neutrality implies that farmers are not actively seeking out information, possibly due to a lack of awareness of the programs or uncertainty about their applicability to their operations. On the other hand, the relatively small percentage who found it difficult to access information points to potential barriers, such as complex program requirements or lack of targeted outreach.

Table 9. To what extent do you agree or disagree with the statement: It is difficult to find information about state or federal conservation programs.

Percent who answered—	*N*	Strongly disagree	Disagree	Neutral/ Not sure	Agree	Strongly agree
Round 1						
Saturated buffers	630	1.4	13.3	67.6	16.7	1.0
Bioreactors	627	2.2	15.0	68.3	12.6	1.9
Water quality enhancement wetlands	632	1.6	15.3	65.8	15.8	1.4
Round 2						
Saturated buffers	325	2.5	9.5	73.2	13.5	1.2
Bioreactors	320	1.6	14.7	69.4	12.5	1.9
Water quality enhancement wetlands	319	2.2	16.3	64.6	15.4	1.6

Table 10 summarizes respondents' concerns about the requirements, restrictions, and paperwork in government programs. Compared with the barriers mentioned above, over one-third of respondents are worried about the "red tape" associated with implementing practices like saturated buffers, bioreactors, and water quality enhancement wetlands. Concern about administrative hurdles is significant, as it can discourage participation in programs designed to improve environmental outcomes and suggests a need for streamlining processes and possibly providing more support or simplifying application procedures to encourage more farmers to engage with these conservation efforts.

Table 10. To what extent do you agree or disagree with the statement: There are too many requirements, restrictions, and paperwork associated with government programs.

Percent who answered—	*N*	Strongly disagree	Disagree	Neutral/ Not sure	Agree	Strongly agree
Round 1						
Saturated buffers	633	0.8	5.4	55.5	25.1	13.3
Bioreactors	626	0.8	5.9	58.1	22.8	12.3
Water quality enhancement wetlands	637	0.8	6.9	55.3	24.0	13.0
Round 2						
Saturated buffers	326	1.2	4.3	58.3	24.5	11.7
Bioreactors	320	0.3	6.3	59.4	24.1	10.0
Water quality enhancement wetlands	321	0.9	7.8	52.6	28.0	10.6

INFORMATION TREATMENT EXPERIMENTS

After assessing existing farmer attitudes toward the benefits of and barriers to adopting the three EOF treatments, the survey moved to identifying which educational strategies and incentives were most effective in encouraging farmers and landowners to adopt these practices. We also sought to determine whether participating in the Conservation Reserve Program made a difference in how farmers reacted to the various information treatments.

ROUND 1 SURVEY

Respondents received information about saturated buffers and bioreactors in one of seven format categories: (*a*) an infographic-style fact sheet including information on the benefits to nutrient reduction; (*b*) a similar fact sheet that includes information on the benefits to nutrient reduction and wildlife; (*c*) a video featuring an extension professional including nutrient reduction information; (*d*) a similar extension video that includes nutrient reduction and wildlife benefit information; (*e*) a video featuring a farmer adopter including nutrient reduction information; (*f*) a similar farmer video that includes nutrient reduction and wildlife benefits; and (*g*) a traditional, more text-oriented extension fact sheet (control group). By randomly assigning participants to different groups—each received a specific type of information treatment or only the questionnaire—we can isolate the effects of these interventions from other confounding factors. To encourage comprehensive viewing, the survey paused for two minutes for the video and respondents were instructed to watch the video attentively and wait for the "continue" button to appear before proceeding to the next question. Figures 2 and 3 show examples of three of the seven educational tools respondents saw.

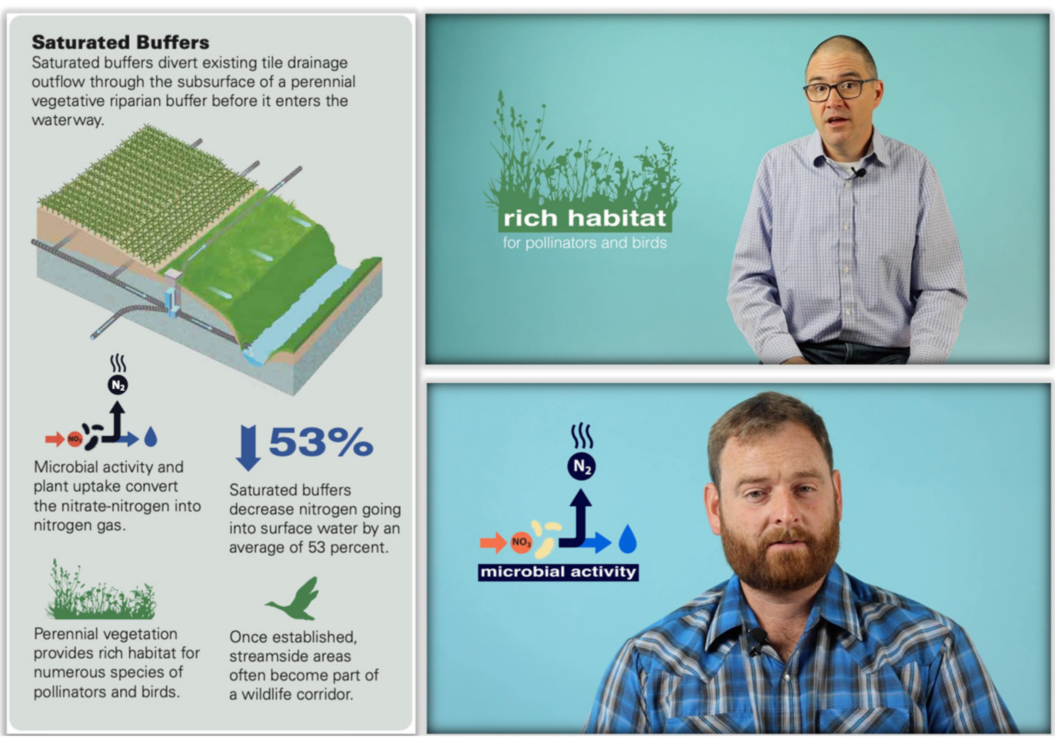

Figure 2. A snapshot of information treatments: infographic-style fact sheet (left), extension professional video (top right), and farmer video (bottom right).

Matt Helmers: *"...Iowa farmers have several edge-of-field options. Among those with the highest potential are saturated buffers, bioreactors, and water quality enhancement wetlands and oxbows. A saturated buffer diverts existing tile drainage outflow through the subsurface of a riparian buffer before it enters the waterway. Microbial activity and plant uptake reduce the amount of nitrogen going into the surface water by an average of 53% and the perennial vegetation provides rich habitat for numerous species of pollinators and birds and these stream side areas often become part of a wildlife corridor..."*

Wade Dooley: *"...I had suitable land along the river what was never very productive, and I was willing to commit the land of this because of the water quality benefits and because it would provide more wildlife habitat. IDALS came in and worked with me on everything. They made it easy. Now my tile drainage drops down to a shallow U-shaped water pool with vegetation around the edge. Microbial activity and plant uptake convert the nitrogen. I'm already drawing in a lot of waterflow down there, butterflies, bees, turtles and lots of frogs..."*

Figure 3. Key narratives in video treatments: extension professional (top) and farmer adopter (bottom).

We presented a contingent valuation question immediately after the information treatments to gauge respondents' adoption willingness for an EOF practice. For example, in one instance, the contingent valuation question was preceded by the text: "Now assuming that IDALS will offer a one-time cost share payment of 100% of the installation cost for your field, would you sign up for an IDALS cost-share program and install a saturated buffer on your field?" This is the standard way to ask a contingent valuation question, known as dichotomous choice format, which is less prone to inaccurate preference estimates than directly asking farmers to state their desired payment level.

Table 11 presents the take-up rates of a hypothetical saturated buffer and a hypothetical bioreactor in the Round 1 survey.

Table 11. Round 1 Take-up Rates of Edge-of-Field Practices

	Saturated buffers		Bioreactors	
Treatment	*N*	Percentage	*N*	Percentage
Fact sheet	38	37.6	24	24.0
Fact sheet w/wildlife info	35	40.2	23	26.1
Extension professional video	30	33.7	21	23.3
Extension video w/wildlife info	24	24.5	22	22.4
Farmer video	35	39.3	24	26.4
Farmer video w/ wildlife info	22	29.0	17	22.4
Control	31	35.2	25	28.1

In Round 1, the fact sheet was the most effective treatment for encouraging practice adoption. Adding wildlife information to the fact sheet increased the take-up rates for saturated buffers to 40.2%, showing a positive effect. However, for bioreactors, the increase was more modest, to 26.1%. This was followed closely by the group that received the farmer video, with a take-up rate of 39.3% for saturated buffers and 26.4% for bioreactors. The extension professional video, alone or with wildlife information, had the lowest take-up rates, at 33.7% and 24.5%, respectively.

In summary, the farmer video was generally more effective than the extension video in increasing the take-up rates of EOF practices. Adding wildlife information to the fact sheet improved the effectiveness for saturated buffers but had a less pronounced effect for bioreactors. Interestingly, adding wildlife information to the farmer and professional videos reduced their effectiveness. This suggests that while supplemental wildlife information can enhance the appeal of some informational treatments, it may potentially dilute the message or reduce the impact of others, depending on the information delivery medium.

In addition to information format, farmer participation in CRP also makes a difference. Figure 4 presents the adoption rates across treatments for two farmer groups with distinctive training backgrounds. For analysis purposes, we recategorized treatments into four groups by pooling with and without wildlife information.

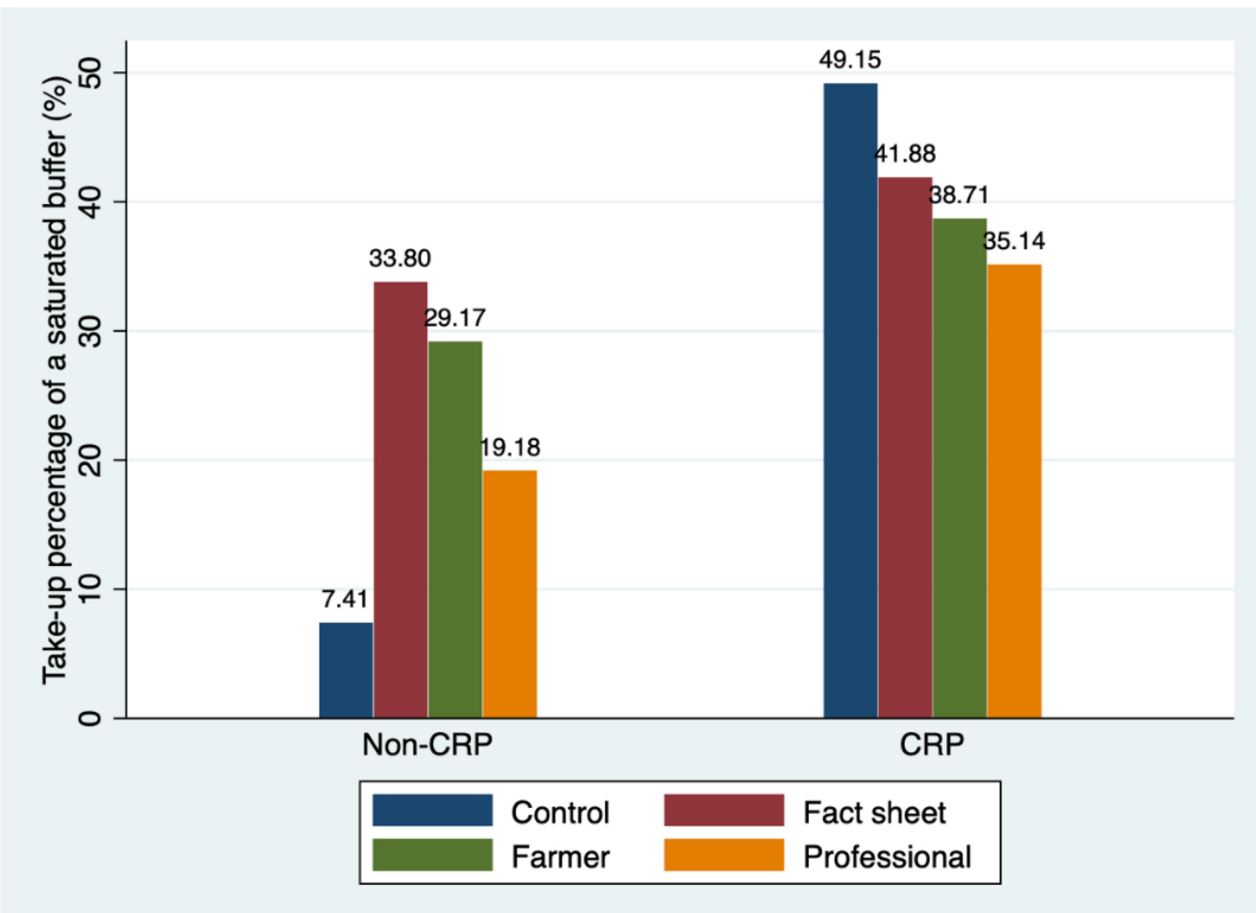

Figure 4. Take-up percentage of saturated buffers by information treatments and CRP participation.

Those who have participated in CRP are generally more comfortable using government programs to implement conservation practices, and show higher opt-in rates for hypothetical saturated buffers, regardless of information format. More importantly, treatment effects are dependent on the farmers' prior training. The treatment is particularly effective for farmers who lacked relevant conservation experience and knowledge outside of CRP. For non-CRP respondents, we observe the raw adoption rate increased by 27%, 22%, and 12% in the fact sheet, farmer narrative, and extension professional narrative treatment groups, respectively, relative to the control group. In contrast, the treatment effects are not promising for CRP respondents. Interestingly, graphical fact sheets are more effective than narrative videos for both CRP and non-CRP farmers. In particular, the non-CRP group saw the highest adoption rate in the fact sheet treatment, which is nearly five times that of the control group.

The fact that graphical fact sheets outperformed narrative videos in both CRP and non-CRP groups reveals an interesting insight into farmer learning preferences, suggesting that visual, easily digestible content is more effective at conveying information than more time-consuming narrative formats. This effectiveness is particularly pronounced in the non-CRP group, where the adoption rate with the fact sheet treatment was substantially higher compared to the control group. This could point to the importance of clear, concise, and visually engaging educational resources in promoting the adoption of conservation practices among farmers, especially those who are less familiar with such programs.

Figure 5 shows that lack of understanding of the practice is a key barrier to adopting saturated buffers—and that information in any format is helpful. Nearly half of control group respondents said they did not understand the function of a saturated buffer. The lack of understanding dropped significantly among those who received information about the practice. The treatments had a lesser effect on improving awareness of the water quality benefits of saturated buffers. Again, the infographic-style fact sheet had the most substantial impact on increasing awareness of the water quality benefits of the practice.

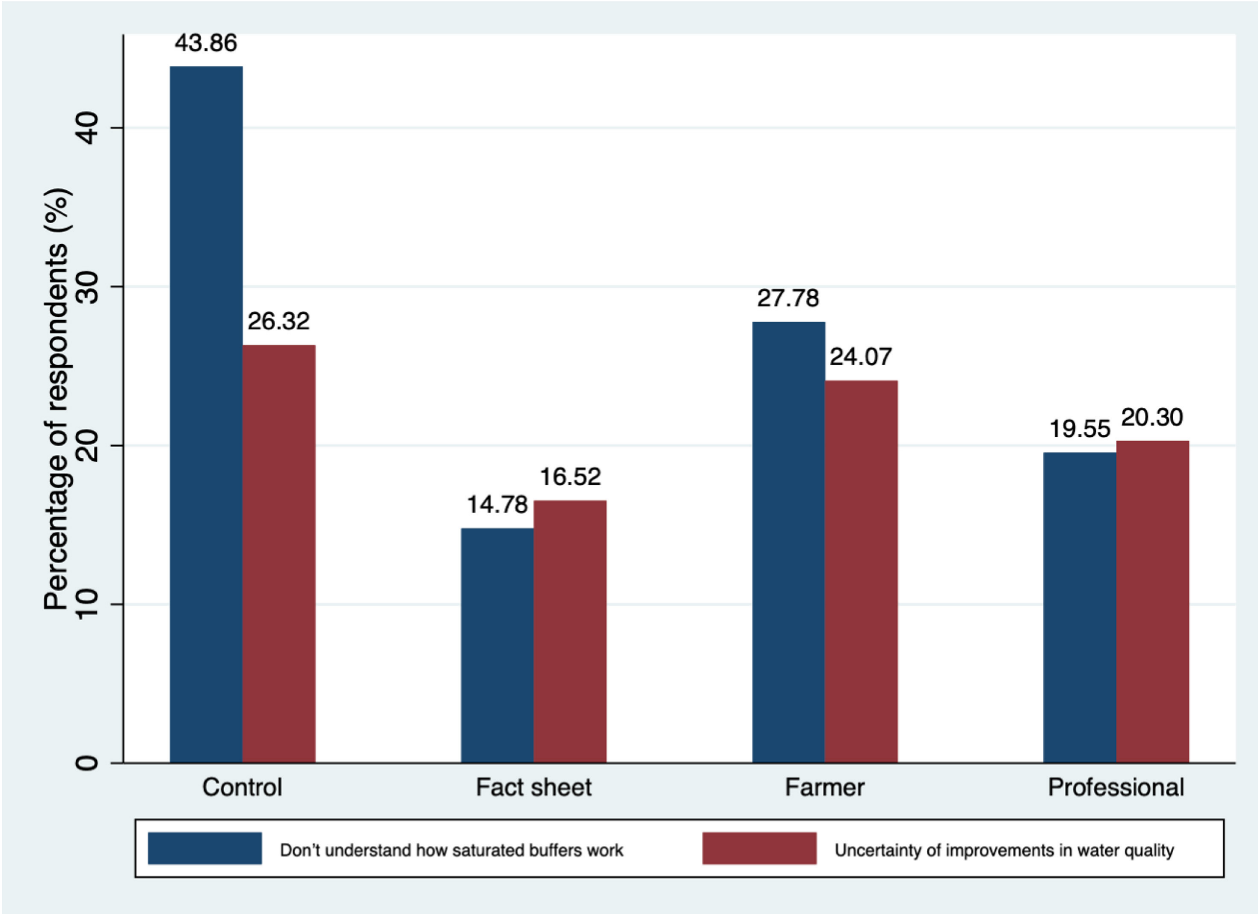

Figure 5. Top reasons for rejecting a saturated buffer program.

Figure 6 presents the predictive adoption probability over treatment groups across different levels of prior perceived environmental benefits of saturated buffers between CRP and non-CRP participants. For non-CRP respondents, the predicted adoption probabilities in the treatment groups exceed those in the control group across all levels of perceived benefits, and the graphical fact sheet drives the highest adoption rates. When respondents strongly disagree about the environmental benefits of saturated buffers, almost none are willing to install one on their farm in the control group; however, this percentage rises to 1.6% after reading the fact sheet. Conversely, when respondents fully recognize the environmental advantages, 17.5% are willing to adopt the practice in the control group, which jumps to 57.1% if viewing the fact sheet.

For CRP participants, the treatments are not effective, given that the adoption probabilities in treatment groups are largely similar to those in the control group. Comparing the two graphs, we notice that CRP farmers are more open to adopting saturated buffers than are non-CRP farmers. These data underscore the importance of tailored educational efforts. Specifically, they highlight the effectiveness of clear, visually engaging materials in shifting perceptions and promoting EOF practices among farmers less familiar with such programs. Conversely, they also indicate that different strategies may be necessary to engage those already involved in conservation efforts through programs like CRP.

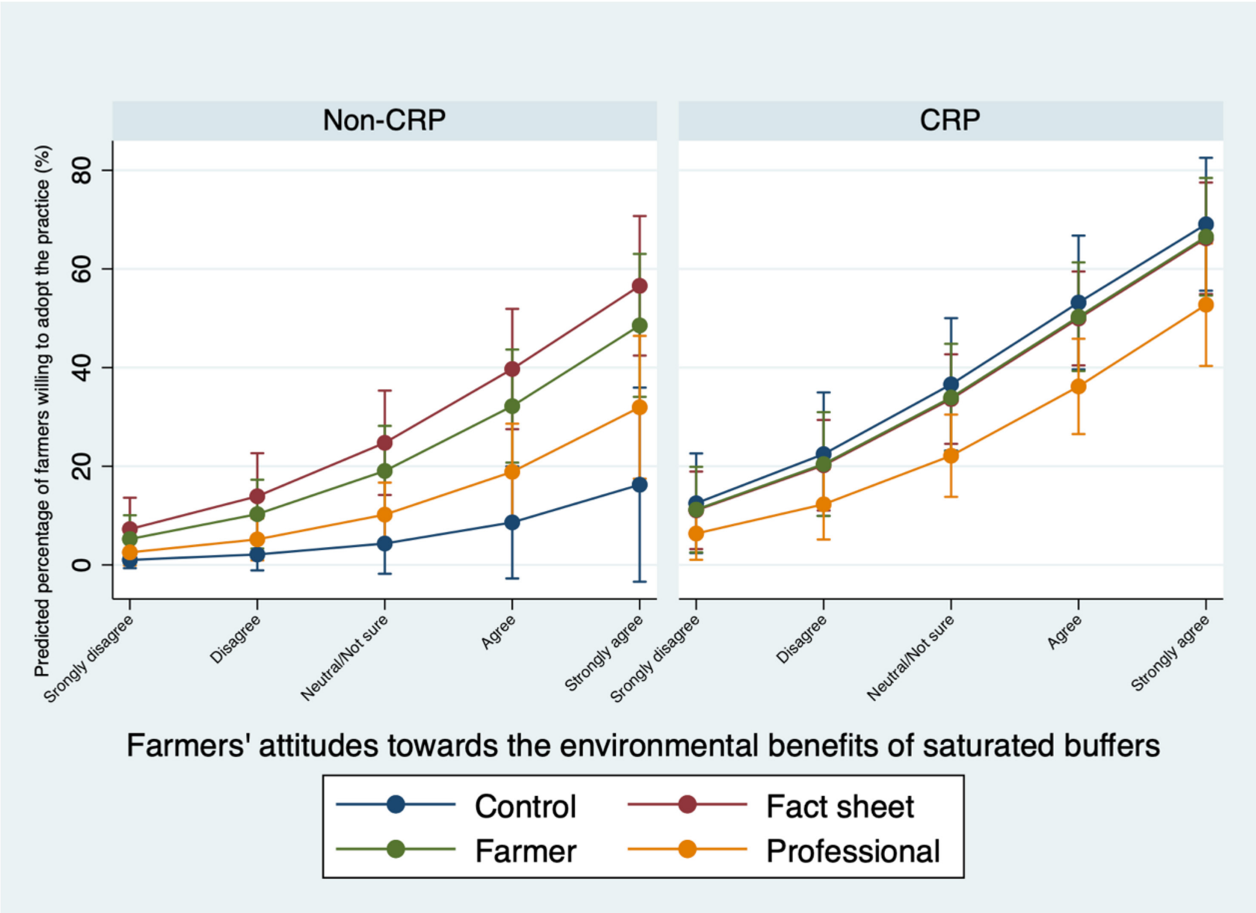

Figure 6. Predicted percentage of farmers willing to adopt a saturated buffer over perceived environmental benefits.

ROUND 2 SURVEY

Participants in Round 2 received information on saturated buffers and bioreactors in one of three different formats, shown in Figure 7: (*a*) a baseline, traditional extension fact sheet; (*b*) an infographic-style fact sheet featuring a female farmer; or (*c*) an infographic-style fact sheet featuring a male farmer.

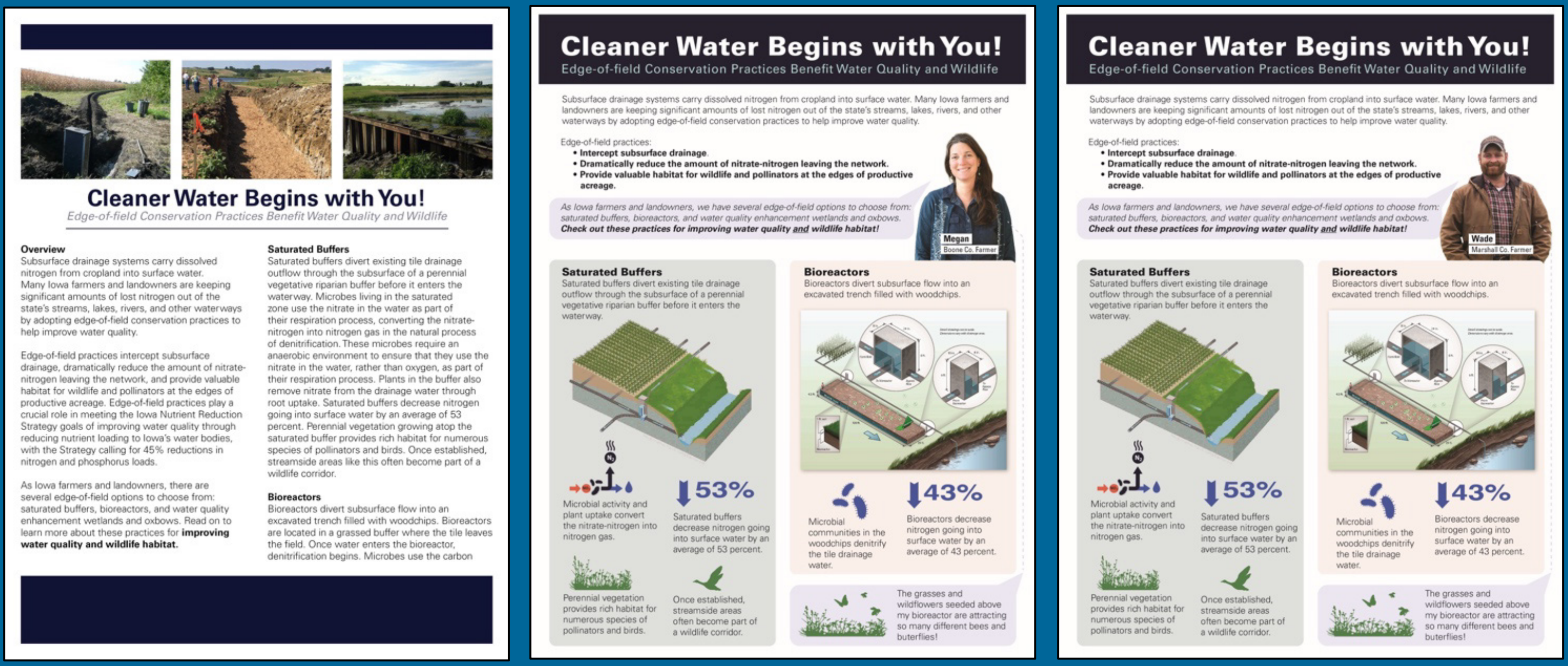

Figure 7. Three information treatments: traditional extension fact sheet (left), and infographic-style fact sheets with female farmer messenger (center), and male farmer messenger (right).

Table 12 presents the take-up rates of a hypothetical saturated buffer and a hypothetical bioreactor in the Round 2 survey. For saturated buffers, the baseline fact sheet has a take-up rate of 29.0%, which is slightly higher than the treatment groups. For bioreactors, the baseline fact sheet has a take-up rate of 19.6%, the take-up rate for the female farmer fact sheet group is marginally higher at 19.8%, and the male farmer group shows a more noticeable increase to 23.4%, which is the highest among the treatments. The potential gender effect observed in the adoption rates of bioreactors may arise from a combination of cultural norms and societal roles. For many agricultural communities, farming has historically been male-dominated, which can influence perceptions of expertise. When respondents see educational materials featuring a male farmer, it may subconsciously align with their expectations of who typically embodies a knowledgeable figure in agriculture, leading to higher engagement and trust in the information presented.

Table 12. Take-up Rates of Edge-of-Field Practices in Round 2

	Saturated buffers		Bioreactors	
Treatments	Number of farmers willing to adopt	Percentage	Number of farmers willing to adopt	Percentage
Traditional extension fact sheet	27 of 93	29.0%	18 of 92	19.6%
Female farmer fact sheet	34 of 131	26.0%	26 of 131	19.8%
Male farmer fact sheet	31 of 111	27.9%	26 of 111	23.4%

We also compared this population by participation in CRP. Figure 8 presents take-up rates for the hypothetical bioreactor for both groups. Notably, for those not participating in CRP, the introduction of a male farmer messenger on the fact sheet significantly elevates the take-up rate of bioreactors from 14% to 23%, whereas the effect of a female messenger is limited. CRP participants are generally more receptive to conservation practices, and the information treatments have limited effect on their adoption.

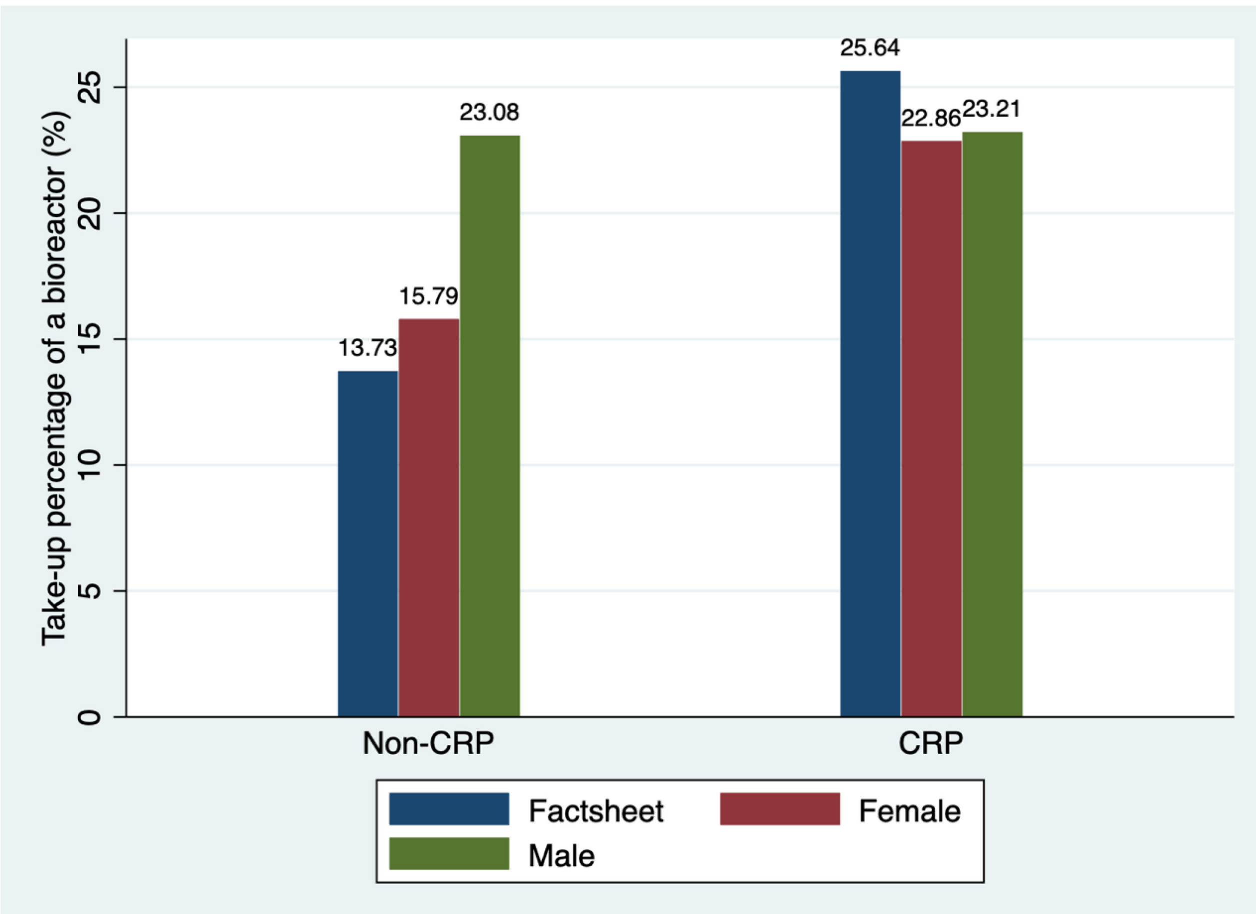

Figure 8. Take-up percentage of bioreactors by information treatments and CRP participation.

CONCLUSIONS

We conducted two rounds of surveys of Iowa farmers to measure perceived benefits, pinpoint barriers, and identify effective educational strategies related to EOF practice adoption. Our study is crucial for crafting targeted programs since it equips policymakers with evidence-based information to develop targeted programs that address specific concerns of the farming community, potentially increasing the adoption rates of EOF practices. The key findings from the surveys follow.

First, during Round 1 of the survey, reported adoption rates for EOF practices were higher than the actual prevalence of these practices in the state, suggesting respondents might have included any type of buffer or wetland present on their land. Recognizing this potential overreporting, we introduced clarifications in the Round 2 questionnaire, providing precise definitions of specific practices such as saturated buffers, water quality enhancement wetlands, and controlled drainage. This strategic adjustment aimed to rectify misconceptions among farmers and resulted in a more precise assessment of the actual adoption rates for these EOF practices.

Second, many respondents in both surveys demonstrated uncertainty regarding the environmental benefits of EOF practices. There was a notable ambiguity among farmers regarding the environmental benefits that saturated buffers, bioreactors, and water quality enhancement wetlands can provide. For example, it appears that respondents are unclear about the fact that both saturated buffers and water quality enhancement wetlands can offer multiple environmental benefits, whereas bioreactors are solely valued for their water quality benefits. This lack of clarity on the environmental benefits of these practices could hinder broader adoption.

Third, the survey results underscore a widespread unfamiliarity with EOF practices, suggesting a gap between conservation initiatives and practical knowledge among the agricultural community. This highlights the need for enhanced outreach and education about EOF practices and their benefits. For example, a substantial majority of respondents were neutral regarding concerns about excessive labor to maintain the practices, indicating that a large portion of respondents may not have any practical experience with these practices and therefore cannot accurately gauge the labor required.

Fourth, more than one-third of farmers are concerned about the bureaucratic challenges, or government regulations, associated with implementing the EOF practices. This apprehension about the administrative complexities involved could act as a deterrent to farmer participation in conservation programs. Our findings indicate the necessity for simplifying administrative processes and perhaps offering additional support, which could motivate a greater number of farmers to engage in these beneficial conservation endeavors.

Finally, our survey's findings indicate a clear preference for graphical fact sheets over narrative videos, suggesting that farmers favor visual and concise educational materials.

Additionally, educational information was especially effective among non-CRP farmers, who showed a higher adoption rate when presented with educational information compared to the questionnaire only. This underscores the effectiveness of straightforward and visually appealing educational tools in encouraging the uptake of EOF practices.

APPENDIX: SURVEY METHODOLOGY DETAILS AND DEMOGRAPHICS

In summer 2022, we contracted ISU's Center for Survey Statistics and Methodology (CSSM) Survey Research Services to conduct a two-part web/mail survey about the willingness of Iowa farmers to adopt EOF practices.

For the initial online survey data collection in August 2022, CSSM, in collaboration with the principal investigators, drafted an invitation letter, a reminder postcard, and two subsequent reminder letters. The initial invitation letters explained the purpose of the study, requested online participation, and assured complete confidentiality of all information provided. The CSSM toll-free phone number was also included so that people could call to ask questions or express concerns about the project. The invitation letter, including a $2 bill incentive, was sent in August 2022. The postcard reminder was sent three weeks later to those who did not respond to the initial appeal. Subsequent follow-up reminder letters to nonrespondents were mailed in September and December of that year.

Of the 4,360 sampled farmers, we found 132 were not eligible, primarily because they did not or did not intend to operate a farm in the years that were the focus of our survey. There were an additional 167 samples returned by the United States Postal Service, or refused. A total of 668 survey responses were received during the data collection period from August 8, 2022, through January 30, 2023. This total included 56 partial survey responses that were more than 50% complete.

The second round of surveys was primarily administered through the mail, but also offered an online option. These surveys were sent to 1,486 people in June 2023. The survey packets contained a cover letter, the paper survey, a $1 incentive, and a postage-paid return envelope. The cover letter included the link and access code for respondents to complete the survey online rather than on paper if they wished. A reminder postcard was sent to nonrespondents in the middle of July. An additional reminder, including another copy of the survey, was sent to nonrespondents two weeks later. A final reminder letter was sent to nonrespondents in September. A total of 360 completed surveys were received during the data collection period—306 completed paper surveys, and 54 completed online.

Table 13. 2022 Edge-of-Field Online Survey Response Rate

	Total	Percent of total
Initial Sample	**4360**	
Not eligible	132	3%
Eligible sample	**4228**	
Returned by USPS	144	3.4%
Refused	23	0.5%
No response	3296	78%
Completed surveys	**668**	**15.8%**
Fully complete	612	91.6% (612/668)
Partially (>50%) complete	56	8.4% (56/668)

Table 14. 2023 Edge-of-Field Mixed-mode (Online and Mail) Survey Response Rate

	Total	Percent of total
Sample	**1486**	
Not eligible	63	4.2%
Eligible sample	**1423**	
Returned by USPS	69	4.8%
Refused	13	0.9%
No response	979	68.8%
Completed surveys	**360**	**25.3%**
Online	54	15% (54/360)
Paper	306	85% (306/360)

Table 15 presents summary statistics of farmer demographics by survey round. The average age of respondents increased marginally in Round 2, indicating a slightly older participant group. Male representation remained high and stable. Notably, there was a significant drop in respondents with a college degree in Round 2, suggesting a more diverse educational background among participants. The proportion of higher-income respondents saw a slight rise, while employment rates increased marginally. There was also a small uptick in the number of retirees. Risk tolerance levels stayed consistent across both groups, indicating a steady approach to risk among participants.

Table 15. Summary Statistics of Sociodemographic Variables

	Round 1			Round 2		
Variables	Mean	Std. Dev.	*N*	Mean	Std. Dev.	*N*
Age	65.1	12.5	596	66.3	13.0	319
Male	82.5%	0.4	605	81.3%	0.4	331
% College	46.7%	0.5	608	35.1%	0.5	342
% Income > $250k	33.5%	0.5	550	35.7%	0.5	308
% Employed	57.4%	0.5	613	59.5%	0.5	343
% Retired	9.8%	0.3	613	12.5%	0.3	343
Risk tolerance*	3.8	1.5	595	3.8	1.6	332

**Risk tolerance measures a farmer's willingness to take on risks, scaling from 1 (always avoid taking risks) to 7 (always take risks).*

Table 16 presents summary statistics of farm characteristics by survey round. Respondents in Round 2 operate smaller farms, with a small decrease in the presence of creeks and tile drainage. There is a notable decrease in the participation in conservation programs, with the percentage of farmland enrolled in CRP and EQIP dropping by approximately 10% and 3.6%, respectively, from Round 1 to Round 2. The decrease indicates a change in the participant pool, with the Round 2 sample possibly including farmers who are less involved in or aware of such programs.

Table 16. Summary Statistics of Farm Characteristics

	Round 1			Round 2		
Variable	**Mean**	**Std. Dev.**	***N***	**Mean**	**Std. Dev.**	***N***
Farm size (acres)	635.4	1342.3	654	280	771.0	360
Percentage of farms with—	**Percent**		***N***	**Percent**		***N***
Creek	59.4%	0.5	662	59.3%	0.5	354
Tile drainage	94.9%	0.2	664	93.4%	0.3	349
CRP participation	61.2%	0.5	658	51.3%	0.5	347
EQIP participation	8.7%	0.3	629	5.1%	0.2	335

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