Using a randomized controlled trial to develop conservation strategies on rented farmlands

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Abstract
Addressing the environmental impacts of large-scale agriculture requires innovative approaches to conservation program design and evaluation. We used a randomized controlled trial and a sample of 2225 landowners in the Mississippi River Basin to test a new conservation program that targets a growing but overlooked population—nonoperating landowners (NOLs). To spur adoption of conservation practices on farmland rented out by NOLs, the program provided NOLs with ready-to-use lease language and a financial incentive. The program’s design was informed by field work, the behavioral science literature, and the social science literature on barriers to conservation on farmland. We cannot detect an effect on conservation practices from the lease language or the incentive. The take-up rate for the incentive was one-tenth the expected rate based on NOL responses to a hypothetical offer in a survey. The results underscore the importance of assessing program performance by rigorously testing programs in real conservation settings.

KEYWORDS
agricultural policy, behavioral economics, financial incentive, nonoperating landowners, payments for environmental services, program evaluation, randomized controlled trial, remote sensing, soil health, technology adoption

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1 | INTRODUCTION

Reducing agricultural pollution is a global environmental challenge (Food & Agriculture Organisation of the United Nations, 2018). To reduce nutrient pollution, governments in high-income nations rely on voluntary incentive programs to encourage farmers to adopt conservation practices. Farmers enrolled in these programs receive information, technical and financial assistance to adopt conservation practices that benefit both the long-term value of the farmland and waters downstream. In the United States, the Department of Agriculture (USDA) spends more than US$6 billion annually on such programs (Salzman et al., 2018; USDA, 2019). A large share of money goes to priority areas like the Mississippi River Basin (MRB), where agricultural runoff is a major contributor to a dead zone spanning thousands of kilometers in the Gulf of Mexico (Rabotyagov et al., 2014).

The continued failure of voluntary programs to sufficiently reduce nutrient pollution in the United States has given rise to calls for direct regulation (Kling, 2019). Yet regulating agriculture is politically difficult in the United States, as it is elsewhere (Aneja et al., 2008; Novotny, 1999). An alternative would be to improve the appeal and reach of voluntary programs through new strategies, such as targeting new populations or using behavior change approaches based on psychology. These or any new strategies, however, should be critically evaluated for success in achieving conservation goals to avoid wasting resources on programs that do not work.

One limitation of voluntary programs offered by USDA is that they miss an important conservation actor, nonoperating landowners (NOLs). Currently, the programs target owner operators—farmers who own the land they farm—leaving out much of the most critical farmland. Nearly 60% of farmland in key MRB states is rented and most of the owners of these rented lands are NOLs (Bigelow et al., 2016; Sawadgo et al., 2019; Zhang et al., 2018). Despite their importance on the landscape, voluntary programs are generally not designed for NOLs. Women NOLs especially are “off the radar” of the USDA and its partners (Petzelka et al., 2018; Wells & Eells, 2011). NOLs control an increasingly large portion of the most productive agricultural land in the United States, yet farmers on rented farmland are less likely to adopt conservation practices like cover crops—a crop grown between cash crops that can reduce nutrient pollution and build soil health (Hoorman, 2009; Sawadgo et al., 2019; Sharpley & Smith, 1991). Developing conservation programs that include NOLs is therefore critical.

Voluntary programs for NOLs must not only address the typical barriers to adoption of conservation practices, but they also must address barriers specific to rented lands. NOLs seldom require conservation practices, compounding the challenge of motivating practices with up-front costs and long-term benefits (Bigelow et al., 2016; Plastina et al., 2018; Ranjan et al., 2019). In field work conducted to inform the design of our field trial (Ranjan, et al., 2019), stakeholders reported barriers related to the financial costs of conservation practices and a lack of experience incorporating conservation goals into rental leases. To address the latter barrier, the authors recommended tools to help NOLs communicate with their operators and write a lease.

A review of behavior change approaches suggested that conservation programs are most successful when using at least two of three approaches—promoting awareness, incentives, and nudges—tailored to specific barriers (Reddy et al., 2017). Our study uses both a financial incentive to address costs of conservation practices and a nudge to require conservation practices in leases. Nudges promote behavior not through incentives or regulation but through small changes to the decision-making environment (Thaler & Sunstein, 2008). Incorporating nudges into voluntary programs could be cost-effective and make programs more effective. The UK’s Behavioral Insights Team demonstrate nudges in government programs with substantial impacts despite their low cost. In 2019, behavioral scientists and conservationists created a toolkit of behavioral nudges for use in conservation, and academics have called for their in practice (Byerly et al., 2018; Fisher et al., 2019; Rare & the Behavioural Insights Team, 2019). As nudges become more popular in the agricultural context, there is growing evidence that they can affect conservation behaviors. In China, Chen et al. (2009) found that information about neighbors’ enrollment in an environmental program increased stated intention to enroll. In the United States, Wallander et al. (2017) found that reminders cost-effectively increased enrollment in a USDA conservation program. The challenges of agricultural pollution will not be overcome with nudges alone, but they could be part of the solution.

By modifying programs to address the challenges faced by NOLs and by incorporating insights from behavioral science, voluntary programs could reach millions of acres of farmland that have been underserved by conservation programs. We seek to test this hypothesis. While new programs can be informed by surveys, interviews, and literature, it is impossible to know in advance how well they will perform. Managers and policymakers depend on retrospective evaluations to determine whether a program should be continued or altered. Tools for evaluation, such as matching and regression discontinuities, exploit features of naturally occurring data to understand a program’s effect. The agricultural context, with a large number of similar farmers and landowners, is an excellent fit for the randomized controlled trial (RCT) (Baylis et al., 2016).
An RCT requires upfront effort and coordination between scholars and practitioners but is useful for program evaluation. The strength of the RCT design is the ability to rule out confounding factors—factors other than the program that would cause two groups to have different outcomes. Following a call by Ferraro and Pattanayak (2006) for more RCTs in conservation, RCTs have been used to assess water consumption programs for farms and consumers (Chabé-Ferret et al., 2019; Ferraro & Price, 2013) and deforestation (Wiik et al., 2019).

In this study, we use an RCT design to test the effectiveness of an innovative program to increase conservation on lands rented by NOLs. The trial is intended to inform The Nature Conservancy’s new strategy for rented lands and, ultimately, government programs. Our results demonstrate the difficulty of moving the needle on conservation behaviors and the importance of testing new program designs—measuring real-world conservation actions before programs are scaled.

2 METHODS

2.1 Population

Our sampling frame includes NOLs that own but do not operate land in Iowa, Illinois, and Indiana. We use FarmMarketiD’s database on NOLs, which is compiled from administrative records. NOLs were recruited in the summer and fall of 2017; a total of 36,937 NOLs were sent invitations to join a soil health program offered by The Nature Conservancy and Purdue University (see the Supporting Information [S.I.] for mailer; see Reddy et al. (2020) for results from the mailing RCT). Qualifying NOLs had at least 40 acres of corn or soybean farmland and had not used cover crops in the past 3 years. 3425 NOLs responded to the invitation. In total, 2225 met the qualifying criteria to be enrolled in the main study. The NOLs control 560,000 acres in Iowa, Indiana, and Illinois, are 56% male, 29% female, and 15% companies, and have a median age of 70.

2.2 Treatments

Participating NOLs were randomly assigned to one of three treatments in the winter of 2017 or spring of 2018. Randomization reduces potential confounds from characteristics including interest in cover crops, soil type, and location (see Figure 1). The treatments build on knowledge gained from interviews (Ranjan et al., 2019) and, following the behavior change framework of Reddy et al. (2017), the treatment packets address barriers using a combination of information, nudges, and incentives.

Packets contained information on conservation, a NOL-operator discussion guide for conservation practices, and local resources including university extension and USDA offices. The group that received a packet with only this information is the control group in the RCT, which we call T1. Another group, T2, received the same packet along with a nudge, which was example lease language which could be used directly as a lease addendum requiring the operator to use cover crops and specify who would pay the costs (see the S.I.).

The third group, T3, was sent a packet with the information, the example lease language, and a financial incentive of $1500 for adding a lease requirement to plant at least 40 acres of cover crops in the fall of 2018. At $37.50 per acre, the financial incentive is similar to payment rates offered by government programs for cover crops in Indiana, Iowa, and Illinois, which are $28.18, $33.83, and $51.32 per acre, respectively. The financial incentive was easy to apply for, had minimal requirements (no seed mix restriction), was paid in advance of seed purchase, required no verification or receipts, and could be used in addition to USDA programs. Focus groups (see the S.I) that informed this study stated the amount was sufficient, and past surveys suggest that even a small increase in the financial incentive for USDA programs would lead to a large increase in cover crop adoption (Esseks & Kraft, 1988). Due to cost and the anticipated large effect size, a smaller portion of NOLs were assigned to T3 (see Table 1).

Following the adaptive approach model, we conducted a small trial to investigate the “upper bound” of increasing incentives for cover crop adoption on 40 acres. The trial selected 100 NOLs at random from T1 and T2, who had not previously been offered a financial incentive, and offered an incentive of $5000.

2.3 Outcomes

Our primary outcome of interest is cover crop adoption, for which we have two measures. The first measures adoption using satellite image-derived estimates of cover crops (remote sensing) from the fall of 2018 through the spring of 2019 combined with geographic information system (GIS) data on farmland ownership. This method can independently measure outcomes for all participants. A disadvantage, however, is that measurement may be imperfect if NOLs have land that is not in our GIS dataset provided by FarmMarketiD, or if detection algorithms incorrectly identify cover crops. Weeds and winter cash
Figure 1  Map of treatment assignment. Each dot represents the approximate location of a field, color-coded by treatment

Table 1  Treatment components and number of NOLs. Treatments T2 and T3 include the information in T1, and T3 includes the lease language of T2. The final column shows the number of NOLs assigned to each treatment

| Treatment | Information | Lease Language | Financial Incentive | NOLs |
|-----------|-------------|----------------|---------------------|------|
| T1        | X           |                |                     | 879  |
| T2        | X           | X              |                     | 864  |
| T3        | X           | X              | X                   | 482  |

crops could be mistaken for a cover crop, and a cover crop that is planted but fails to grow sufficiently may not be detected (see Morris & Barnes, 2019). We assume these shortfalls in detection are unrelated to landowner response to the treatment; therefore, they reduce statistical power but do not bias the estimated treatment effect.

Our second measure, a mail-in survey, complements the remote sensing. The survey asked if an operator planted cover crops due to the treatment packet. NOLs received the survey after cover crop season began so that they could report behavior rather than intention to act. As with all surveys, there is the possibility of selection bias of responders and false reporting that could bias the results.

Finally, we use administrative data on take-up of the financial incentive to corroborate the remote sensing and survey results. If we estimate a large treatment effect for T3, we would also expect to see a high take-up rate of the financial incentive.

2.4  Analysis plan

Our analysis follows a registered preanalysis plan (osf.io/hb3zc/) which stated the model and hypotheses before the outcome data were available. We use a linear probability model (Duflo & Saez, 2003) for ease of inter-
Table 2  Cover crop adoption. The remote sensing outcome indicates the portion of NOLs that adopted at least 30 acres of cover crops, shown with the percentage of adopters in the treatment and the number of adopters in brackets. The survey outcome indicates the portion of responding NOLs claiming to have adopted cover crops due to the packet they received. The administrative data report the portion of eligible NOLs that applied for the financial incentive.

| Treatment | Outcomes       | Survey       | Administrative data |
|-----------|----------------|--------------|---------------------|
|           | Remote sensing |              |                     |
| T1        | 6.1% (54)      | 5.8% (27)    | NA                  |
| T2        | 6.3% (54)      | 3.7% (15)    | NA                  |
| T3        | 6.2% (30)      | 6.5% (14)    | 1.5% (7)            |

pretability, and confirm robustness of the results with a logistic regression, to estimate

$$y_i = \beta_0 + \beta_1 T^2_i + \beta_2 T^3_i + \gamma X_i + \delta A_i + \varepsilon_i,$$

where $y_i$ is an indicator for adoption, $T^2_i$ and $T^3_i$ are indicators for treatments (2) and (3) with treatment (1) omitted as the control group, $X_i$ is a vector of individual characteristics which are gender and whether the NOL reported previously speaking to their operator about conservation, $A_i$ is a vector of state and recruitment dummies for NOL $i$, and $\varepsilon_i$ is the error term.

We test the hypotheses:

$$H1 : T^1 = T^2$$

$$H2 : T^2 = T^3.$$ We estimate statistical power assuming the T1 adoption rate is 2%, and that T2 and T3 increase adoption rates to 4.5% and 9%, respectively. We achieve 62% and 95% statistical power to reject H1 and H2, respectively, using the Bonferroni correction for multiple hypotheses. Given our large sample size, low number of treatments, and anticipated large effect size of T3, the experiment is relatively well-powered (Ioannidis et al., 2017).

3  RESULTS

Remote sensing results (Table 2) show adoption rates are similar across treatments with no statistically significant differences. The point estimates for both T2 and T3 are near zero with the width of the 95% confidence intervals less than 3 percentage points (see Table 3), indicating that adoption rates for T2 and T3 are very close to that of T1. Following our protocol, we test T2 versus T3 and find no significant difference ($p = 0.95$). Nearly 50% of NOLs, 1091 in total, responded to the survey, and responses likewise show no significant difference in the proportion of each treatment claiming to have planted cover crops due to the treatment packet and the confidence intervals are small ($p > 0.12$). The administrative data corroborate the finding that T3, the financial incentive, did not have high take-up. Only 1.5% of NOLs, seven individuals, accepted the $1500 financial incentive. The estimated adoption rates for T3 in the survey and remote sensing data suggest that NOLs adopted cover crops without taking the financial incentive. This research cannot determine whether that is the case, or if surveys are remote sensing overestimated the number of NOLs adopting cover crops, but the administrative data clearly show that the take-up rate was low.

The low take-up of the financial incentive could signal that the amount was insufficient. The survey sheds light on this question by asking NOLs in T1 and T2 if they would have accepted the $1500 offer and finds that 45% of the 640 responding NOLs reported they would take the offer. If offered $3000, the acceptance rate rises to 57%. Selection bias cannot account for the discrepancy between survey responses for the $1500 offer and acceptance in the RCT. Using the most conservative assumption, that all NOLs who did not answer or did not return the survey would have rejected the offer, the acceptance rate is 16%—an order of magnitude greater than the acceptance rate in the RCT.

Following the “test, learn, adapt” principle that is a cornerstone of adaptive management (Walters & Hilborn, 1978), we ran a follow-up study with a sample of 100 NOLs from T1 and T2—the NOLs not offered the financial incentive. We offered a financial incentive of $5000 for the fall of 2020, yet only 5% took the offer (see the S.I.).

Table 3  Estimated treatment effects. Estimated treatment effect relative to the information treatment (T1) for adoption rates (Remote Sensing) and reported adoption due to the packet among responders (Survey) using linear regression with covariates as stated in the methods section. See S.I. for full regression results.

| Treatment | Estimates (95% CI) | Survey       |
|-----------|-------------------|--------------|
|           | Remote sensing    |              |
| T2        | 0.02% (−2.3%, 2.3%) | −2.3% (−5.2%, 0.7%) |
| T3        | 0.09% (−2.6%, 2.8%) | 0.6% (−3%, 4.2%) |
4 | DISCUSSION

By implementing a field trial testing a behavioral nudge and financial incentives with NOLs, we demonstrate how an RCT can be used to evaluate a new strategy on rented lands. Our results showing no effect of the interventions on conservation behavior provide further evidence that changing behavior through voluntary programs is difficult, especially in agriculture where the stakes are high. Yet, our success engaging this hard-to-reach population shows it is possible to offer NOLs new programs tailored to their needs.

The new NOLs conservation program was designed with both conservation and evaluation as goals. Importantly, careful evaluation of real behaviors in a real-world conservation setting was necessary to identify whether the interventions offered through the program were effective in helping reach the conservation goal. Conservation programs evaluated with experimental designs often find that programs have little effect on outcomes. For example, Ferraro and Price (2013) found that information to reduce water consumption during a drought had a small effect on behavior, but the addition of a behavioral nudge had a larger effect. Chabé-Ferret et al. (2019) did not detect a reduction in water consumption among a small set of French farmers.

Lessons learned from testing new strategies are important for adaptive management and future research, even if the results show no effect. Although the financial incentive offered was not sufficient to drive adoption of conservation practices, larger or differently designed incentives may be part of the solution for voluntary programs. Maryland, for example, has achieved high cover crop rates through a combination of high incentives, up to $65 per acre, and nutrient management requirements (Beegle et al., 2000). Our trial with increased incentives of $125 per acre, but no regulatory mandate, was unable to achieve substantial adoption, indicating a need for program complements to incentives (Selinske et al., 2017).

Evaluation is only as good as the outcomes measured. We find a substantial difference between actual and hypothetical (survey) take-up of the financial incentive, even though the survey had a high response rate and was of the target population. If the program were evaluated based on survey results, which inflated take-up by 10–30 times, the program would appear to be a massive success. Our survey results are not anomalous, a survey conducted by Singer et al. (2007) showed that 56% of Midwestern farmers would adopt cover crops with similar financial assistance.

The difference between real and hypothetical acceptance rates may be due to the intention-behavior gap (Kollmuss & Agyeman, 2002; Sheeran, 2002), which acknowledges that respondents indicate they will take action at an overly optimistic rate. The discrepancy we find supports two pillars of our approach. The first is the importance of measuring real outcomes with innovations like remote sensing. The second is that changing farmer and landowner behavior is challenging: attaining the desired levels of adoption may require looking to other fields such as behavioral science and ensuring that conservation programs reach NOLs and other underserved populations.

5 | CONCLUSION

Addressing environmental threats from large-scale agriculture requires innovative solutions. This study demonstrates a test of potential solutions through a scholar-practitioner partnership with evaluation as a cornerstone. This emphasis on evaluation and real-world outcomes allows us to determine our program changes did not result in significant adoption of conservation practices—in contrast to a survey of the same population with hypothetical offers. Our study does not rule out the effectiveness of all nudges or financial incentives. Programs should test different messengers, multiyear programs, and the trade-offs between financial and technical assistance. We encourage future studies to have high statistical power, a preanalysis plan, a comparison or control group, and actual conservation behaviors. With better evidence for what works in voluntary programs, policymakers, and program administrators can more efficiently allocate resources and improve environmental outcomes.

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**SUPPORTING INFORMATION**

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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