Potential Supply of Midwest Cropland for Conversion to In-Field Prairie Strips

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ABSTRACT *Prairie strips planted into crop fields offer multiple environmental benefits. This study estimates the willingness of U.S. farmers to convert 5% of their largest corn-soybean field to prairie strips in exchange for payment. Using stated preference results to estimate land supply, we find that 20% of farmers are willing to adopt prairie strips at payments equivalent to average Conservation Reserve Program rental rates, corresponding to potential conversion of 90,000 acres on 1.8 million acres of cropland. Farmers are likelier to adopt in smaller fields and when they perceive that prairie strips will benefit environmental quality or agricultural productivity.* (JEL Q15, Q57)

1. Introduction

Prairie strips planted into crop fields are a novel conservation practice that can provide a wide array of ecosystem services. Strips planted along an elevation contour and occupying as little as 5% of farm fields have been shown to dramatically reduce soil erosion and nutrient runoff, providing a private soil conservation benefit and a public water quality benefit (Zhou, Al-Kaisi, and Helmers 2009; Helmers et al. 2012; Hernandez-Santana et al. 2013). The practice can also provide habitat for beneficial species such as birds, pollinators, and the natural enemies of agricultural pests (Schulte et al. 2016, 2017). Prairie strips are functionally similar to perennial grass crops and in-field buffer strips, which have been shown to improve arthropod abundance and biodiversity (Haaland, Naisbit, and Bersier 2011; Gill, Cox, and O'Neal 2014; Werling et al. 2014; Lane et al. 2020) as well as carbon sequestration (Bouchard et al. 2013).

These environmental benefits prompt inquiry into the potential appeal of prairie strips as a conservation practice. In spite of the favorable academic reviews of their performance, by 2017 prairie strips had been adopted by fewer than 100 U.S. farmers (Love 2017). Following the 2018 Farm Bill (U.S. Congress 2018), the practice became eligible for federal support in 2019 under the Conservation Reserve Program (CRP) Clean Lakes, Estuaries and Rivers (CLEAR) initiative. As of February 2021, nearly 10,000 acres of prairie strips had been installed under the CRP-CLEAR contracts, with particularly high adoption in Illinois and Iowa (USDA Farm Service Agency 2021). Although these numbers indicate growing interest in prairie strips, there exists scant economic research on the drivers and potential scale of prairie strip adoption.

Farmer adoption of prairie strips will depend on the private and public benefits realized and on how farmers perceive those benefits and what costs farmers must incur to plant and maintain prairie strips. Although Tyndall et al. (2013) produced a fine cost budgeting study for a representative Iowa farm, to date there exists no study of the potential supply of prairie strips that captures the heterogeneity of farmer preferences, farm resources, or other potential drivers of conservation practice adoption behavior. In this article, we use a stated preference approach to examine both monetary and nonmonetary determinants of

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prospective prairie strip adoption in the Eastern Corn Belt of the United States. By capturing farm and farmer heterogeneity, we can predict the potential supply of cropland for prairie strip adoption at increasing incentive payment levels. The supply function approach underpinning our research builds on the costs of prairie strip adoption, adjusted for farmer preferences.

To adopt prairie strips, farmers incur direct and indirect costs. The direct costs follow the sequence of tasks to install the strips. A farmer adopting prairie strips must first prepare the planting site through intensive tillage and removal of vegetation (Schulte Moore, Youngquist, and Helmers 2017). In doing so, the farmer incurs costs for labor and equipment and sometimes financing costs. Second, the farmer must plant the prairie strips, incurring costs for native seed and seeding by hand or mechanically (Schulte Moore, Youngquist, and Helmers 2017). Third, the farmer must maintain the prairie strips through grazing, mowing, or controlled burning (Schulte Moore, Youngquist, and Helmers 2017). During this maintenance phase, material and labor costs continue, although annual expenditures are lower than during the site preparation and establishment phases (Tyndall et al. 2013).

Beyond direct costs, farmers incur indirect opportunity costs from shifting prairie strip land out of crop production. Tyndall et al. (2013) found that at least 50% of the total costs that farmers incurred from planting prairie strips stemmed from lost crop revenue. Such opportunity costs are hard to measure because they vary with crop yield and price.

Apart from direct and indirect monetary costs, farmer decisions on whether to adopt prairie strips may depend on how they perceive the ecosystem services and disservices that the strips provide to adjacent cropland and the broader environment. Perennial buffer strips of prairie species have been shown to increase plant biodiversity in agricultural catchments without increasing weed populations on adjacent cropland (Hirsh et al. 2013). Whereas vegetated strips have the potential to compete with adjacent row crops (Guto et al. 2011), prairie strips have been shown not to decrease crop yields beyond the area taken out of crop production (Schulte et al. 2017). However, the effects of some ecosystem services from prairie strips on local agricultural productivity are still unclear. For example, while prairie strips can increase the abundance and diversity of pest predators on adjacent cropland, these improved populations do not necessarily lead to increased rates of local pest predation on that cropland (Cox et al. 2014).

If incorporating prairie strips into crop fields offers positive net benefits to society but not to farmers, farmers may need incentives via a payment-for-ecosystem-services (PES) program (Ma et al. 2012; Swinton et al. 2015). Incentives to enhance financial appeal and redress resource constraints are among the economic factors that affect the adoption of agricultural conservation practices in the United States (Prokopy et al. 2019; Luther, Swinton, and Van Deynze 2020). By using a survey-based experiment to elicit willingness to participate in a hypothetical conservation program in exchange for a PES payment (Mooney, Barham, and Lian 2015; Skevas et al. 2016), we are able to trace out the potential supply of prairie strip land. Such an experiment can also elucidate nonpecuniary factors that affect farmer decisions, ranging from personal preferences to farm resource capacity.

This article aims to make three major contributions to the existing economic literature. First, we go beyond representative budgeting of direct and indirect monetary costs (Tyndall et al. 2013) to investigate the willingness of real farmers to incorporate prairie strips into their fields. Heterogeneity in farm location and resource capacities has been shown to affect the costs and likelihood of adoption of other conservation practices (Prokopy et al. 2019), so we expect to see a range of willingness. Second, we explore the expected benefits that farmers perceive from adopting prairie strips. Past research shows that farmers are likelier to adopt conservation practices if they exhibit high environmental awareness (Pannell et al. 2006; Luther, Swinton, and Van Deynze 2020) or if they perceive that a practice will yield greater private benefits (Chouinard et al. 2008). Third, we explore how farm and farmer heterogeneity influence not only the determinants of prairie strip adoption but also the potential aggregate supply of prairie strip land.

Our study has three objectives: (1) determine the adoptability of prairie strips by farmers in the Eastern Corn Belt, (2) measure the nonmonetary factors that affect Eastern Corn Belt farmer decisions about prairie strip adoption, and (3) predict the potential supply of land in the Eastern Corn Belt that could be devoted to this unique practice that blends elements of working lands conservation practices with land set aside.

We address these research objectives using a cross-sectional data set from a 2018 mail survey of farmers in Illinois, Indiana, Michigan, and Ohio. These Eastern Corn Belt states represented 30.4% of corn and soybean land in the entire U.S. Corn Belt in 2017 (USDA National Agricultural Statistics Service 2021). The Corn Belt acts as a major contributor to agricultural output, as well as to agricultural water pollution, notably algal blooms in Lake Erie and hypoxia in the Gulf of Mexico (Daloğlu et al. 2014). Using results from a stated preference experiment that offers compensation for converting 5% of a crop field into prairie strips, we predict a supply function for cropland convertible to prairie strips. We find that 20% of farmers are willing to adopt prairie strips in exchange for payments equivalent to average CRP rental rates in their states. Farmers are more likely to adopt on smaller fields, when they already participate in conservation programs, and if they perceive that prairie strips will have favorable effects on environmental quality or agricultural productivity. We project that farmers in the Eastern Corn Belt would be willing to plant about 90,000 cropland acres of prairie strips inside their largest fields if paid $159 per acre, the average current CRP payment in the region.

2. Conceptual Model

As a conceptual framework, we build on Dupraz et al.'s (2003) environmental supply model to describe a representative farmer's decision on whether to enroll one crop field on their farm in a conservation program, accounting for private benefits and costs and their response to government payments that compensate public benefits.

We assume that farmers choose the proportion of one field to convert to prairie strips ($\alpha \in [0,1)$) to maximize their utility. The utility function in equation [1] is separable in consumption of market goods (C) and nonmarket environmental amenities (E). We further assume that E encompasses both privately consumed environmental amenities and satisfaction from provision of public environmental amenities to others. We posit that environmental amenities are nondecreasing in α, so $E'(\alpha) \geq 0$:

$$\max_{\alpha} U[C, E(\alpha) \mid F] \quad [1]$$

$$\text{s.t. } C \leq \pi + \text{NFI} \quad [2]$$

$$\pi = A\{(1-\alpha)[p_y Y(X,\alpha) - p_x X] + (\alpha)[r - p_{xc} X_c]\} - \text{FC}. \quad [3]$$

Heterogeneous characteristics of the farm and farmer (F) have been shown to affect farmer behavior regarding the adoption of best management practices (Pannell et al. 2006; Prokopy et al. 2008; Baumgart-Getz, Prokopy, and Floress 2012). Consequently, we condition a farmer's utility on an array of idiosyncratic traits that include farm resource capacities, previous contact with the conservation practice, farmer age, and education (Prokopy et al. 2019).

Farmers face a budget constraint, equation [2], such that their cost of consumption cannot exceed their revenues from nonfield income (NFI) plus profit from their field's output (π). Field-level profit (equation [3]) depends on the revenue from selling agricultural goods produced from their field (Y) at a price (p_y). Field output (Y) is a function of field inputs (X), such as water, crop seed, and pesticides, as well as potential effects from nearby prairie strip area (α). Field-level variable costs come from crop production (inputs (X) purchased at a prices (p_x)). For adopting prairie strips, the farmer may receive a PES in the form of an annualized per acre rental rate (r) for setting aside the proportion (α) of total field area (A) for conservation use while incurring variable costs for the inputs used in managing this conservation land (X_c) at prices (p_{xc}). We formally define the farmer's profit function (π) in equation [3] as the sum of crop revenue net of variable costs from output $(p_y Y(X) - p_x X)$ for the proportion of total cropland (A) that is in production ($1 - \alpha$), and the net revenue from managing conservation land $(r - p_{xc} X_c)$ for the proportion of total field cropland (A) that is set aside for conservation use (α), minus fixed farming costs (FC). We assume that utility increases in C and E at a decreasing rate: $U'(C)>0$, $U'(E)>0$, $U''(C)<0$, and $U''(E)<0$.

To derive a field-scale, prairie strip area supply function, we take the first-order conditions to solve for α^*, the utility-maximizing allocation of land that satisfies the following condition:

$$\underbrace{r - \frac{1}{\lambda}\frac{1}{A}\left[\frac{dU}{dE}\frac{dE(\alpha^*)}{d\alpha}\right]}_{\Delta U_E} = \underbrace{p_{xc}X_c}_{\substack{\text{Direct Cost of}\\ \text{Conservation Land}}} + \underbrace{(p_y Y(X) - p_x X)}_{\substack{\text{Monetary}\\ \text{Opportunity Cost}}} - \underbrace{(1-\alpha^*)p_y \frac{dY(\alpha^*)}{d\alpha}}_{\substack{\text{Productivity}\\ \text{Change in Remaining Cropland}}}. \qquad [4]$$

At this optimal proportion of a field allocated to prairie strips, α^*, the payment for environmental services (r) minus the money metric value of the farmer's marginal utility of environmental amenities, E, with respect to changes in the proportion of land set aside, α, just equals the sum of the direct cost of conservation inputs and the monetary opportunity cost of lost net revenue from cropland shifted to conservation, minus the monetary value of any (positive) productivity change on the remaining cropland in the field.

The result in equation [4] establishes expectations to underpin hypothesis tests for the driving variables in a reduced-form, empirical model of field-level supply of land in prairie strips. Specifically, the land area supply function implied by equation [4] sets four expectations for coefficient estimates from the empirical analysis of factors determining the choice prairie strip area. First, the area in prairie strips (α^*) should be increasing in the per acre rental rate (r). Second, α^* should also be increasing in the perceived environmental benefits from prairie strips, which depend on the farmer's environmental attitudes and prior participation in conservation programs. Farmers who have positive perceptions that prairie strips will increase environmental quality (E) or agricultural productivity (Y) and farmers who already participate in conservation programs should have a higher value of α^*. Third, α^* should be decreasing in field area (A). Fourth, α^* should also be decreasing in direct costs $(p_{xc} X_c)$ and opportunity costs $(p_y Y(X) - p_x X)$ of land shifted into prairie strips.

3. Data and Design

Survey Sample

To measure how amenable farmers are to planting prairie strips inside crop fields, we use the 2018 Crop Management and Stewardship Practices survey, a mail survey of U.S. Eastern Corn Belt corn and soybean farmers developed at Michigan State University and cosponsored by Purdue University and Ohio State University. The sampling frame included farmers who planted more than 100 acres of cropland in corn or soybean in 2017 and resided in a county with at least 15% of total land devoted to agriculture in Illinois, Indiana, Michigan, or Ohio. Farmers with 500 acres or more were purposively oversampled to capture a wide range of farm sizes, given that the median acre of corn and soybean harvested on U.S. farms in 2017 came from farms of 685–700 acres (MacDonald 2020). Of 3,353 addresses contacted, the survey received 981 responses, for a 29.3% response rate. Of these responses, 487 were suitable for our analyses after accounting for item nonresponse.[1]

[1] Comparison of the 2017 U.S. Agricultural Census Oilseed and Grain Farms (NAICC category 1111) for the four surveyed states reveals that because of intentional oversampling of larger farms, the mean percentages of corn-soybean farms < 500 acres were 5%–20% smaller in the CMSP final analysis sample than in the agricultural census (Appendix Table A1). Linked to oversampling large farms, the percentage of respondents with off-farm work was 20% lower for the CMSP final analysis sample. Values of other key variables were within 5%–10% of census values for operator age, corn and soybean yields, and participation in conservation programs (except Ohio, where conservation program participation was 30% higher in CMSP). We see no evidence of item nonresponse bias when comparing the CMSP response sample values with the CMSP analysis sample values.

Table 1
Payment Offer Treatments (US$/Acre/Year) by State

Treatment (% of State-Wide Avg. CRP Rate, Sept. 2017)	Illinois (No. of Obs.)	Indiana (No. of Obs.)	Michigan (No. of Obs.)	Ohio (No. of Obs.)	Three-State Average of IL, IN, OH (No. of Obs.)
50	90	84	64	80	87
	(30)	(22)	(25)	(20)	(22)
100	180	167	127	161	175
	(33)	(22)	(21)	(32)	(19)
200	360	334	254	322	350
	(33)	(16)	(18)	(31)	(23)
300	540	501	381	483	525
	(29)	(28)	(13)	(30)	(20)
Total observations	(125)	(88)	(77)	(113)	(84)

Note: $N = 487$.

Survey Format

The survey used a stated preference experiment (Phaneuf and Requate 2016) designed to measure the willingness of Eastern Corn Belt farmers to integrate prairie strips into their corn or soybean fields in exchange for a payment. The experimental text asked respondents if they would enroll in a hypothetical contract in which prairie strips would occupy 5% of the respondent's largest field for a period of 10 years in exchange for a predetermined, annual, per acre payment offer.

The stated preference portion of the survey instrument (Appendix Figure A1) began with a description of prairie strips and the ecosystem services they provide. After this introduction and a question about previous contact with the practice, respondents reviewed a hypothetical 10-year prairie strip contract. By accepting the contract, respondents would be agreeing to plant and manage prairie strips that would occupy 5% of their largest corn-soybean field in exchange for a fixed annual payment for 10 years. Respondents responded to a set of Likert-scaled statements about the expected effects of planting prairie strips on environmental quality and agricultural productivity in their largest field. Finally, farmers responded to a single-bounded, dichotomous choice prompt asking if they would or would not enroll in the contract for a predetermined payment ($XX): "Would you enroll your field in the prairie strip program at $XX per acre per year?"

Bid Selection

To properly capture stated preferences in contingent valuation experiments, payment treatments must be chosen with care (Duffield and Patterson 1991). In our study, contract payment rates were anchored around rental payment rates from CRP. This anchoring was motivated by pretests with farmers, who often treated the CRP as their frame of reference. Grounding the range of PES rates in state average CRP payments not only fit the worldview of representative respondents but also provided a framework that is readily compared with the existing CRP.

All survey questionnaires were identical in every respect but one—the payment offer in the contingent valuation section. Twenty different payment treatments anchored around state-average CRP payments were randomly assigned to respondents (Appendix Table A2). For the four states, contract payment rates were set at 50%, 100%, 200%, and 300% of the state-average CRP rate for 2017 (rounded to the nearest dollar) for a total of 16 treatments. One-fifth of the surveys for Illinois, Indiana, and Ohio were randomly assigned to one of four additional treatments. These treatments consisted of 50%, 100%, 200%, and 300% of a $175 per acre treatment, rounded to the nearest dollar (Table 1).

4. Empirical Methods

Due to the accept-reject format of the stated preference experiment, the responses do not directly reveal respondents' optimal prairie strip proportion, α*, from the conceptual model. Instead, responses indicate only whether the latent variable α* was at least 5% at a given payment level, *r*. Consequently, we estimate a binary dependent variable model where the dependent variable is the indicator,

$$\tilde{\alpha} = \begin{Bmatrix} 1 & if\, \alpha^* \geq .05 \\ 0 & otherwise \end{Bmatrix}.$$

To estimate the effects of monetary and nonmonetary drivers on prairie strip adoption in the Eastern Corn Belt, we regress the binary adoption variable on a vector of explanatory variables motivated by the conceptual model. We estimate logit and probit models to (1) predict the proportion of farmers who would enroll in the prairie strip contract in response to varying incentive payment offers and (2) evaluate the importance of the factors driving the adoption decision. In a subsequent step, we extrapolate these results to predict the corn and soybean acreage in the Eastern Corn Belt that would be planted in prairie strips under different payment scenarios.

The explanatory variables from the conceptual model included the payment offer, the opportunity cost of forgone yield (measured via area of land contracted and perceived yield gains), direct costs (measured as perceived farm management and pest management costs), environmental disservices (measured as perceived weed and pest pressure), and environmental benefits (measured as perceived soil retention and prior participation in conservation programs). We developed the farmer perception variables in two steps. The questionnaire included Likert-scaled statements regarding farmer expectations of the costs and benefits from planting prairie strips. To reduce the number of similar variables and avoid potential collinearity, we conducted confirmatory factor analysis (Thompson 2004) to generate six factors that measure farmers' latent perceptions of the environmental and agricultural productivity effects of prairie strips. The standardized factor loadings (scaled to one unitary loading per factor) appear in Table 2.[2]

Table 2

Factor Loadings from Confirmatory Factor Analysis for Six Latent Perception Variables

Perceived Outcome	Value Statement	Factor Loading
Environmental	Perceived soil retention	
	Soil erosion	1.00
	Nutrient runoff	1.12
	Perceived weed and pest pressure	
	Weed populations	1.00
	Insect populations	0.75
	Perceived biodiversity benefit	
	Populations of natural enemies of pests	1.00
	Pollinator populations	1.66
	Wildflower populations	1.42
Agricultural productivity	Perceived yields	
	Crop yields per cropped acre	1.00
	Crop yields for entire field	1.64
	Perceived pest management costs	
	Weed control costs per cropped acre	1.00
	Pest control costs per cropped acre	0.77
	Perceived farm management costs	
	Tillage costs per cropped acre	1.00
	Planting costs per cropped acre	1.28
	Total costs for entire field	1.16
	Time spent working field	1.09
	Harvest costs per cropped acre	1.12

The estimated factor loadings for each mapped relationship are positive. We find that the factors for perceived soil retention, perceived biodiversity benefit, perceived yields, and perceived farm management costs exhibit loadings of particularly high magnitude, with each factor loading for the four factors being greater than or equal to unity. The factor loadings for the latent factors perceived weed and pest pressure and perceived pest management costs are smaller in magnitude yet still positive, suggesting a slightly weaker relationship between the observed variables that measure farmers' expectations of the effects of prairie strips and the latent variables that measure farmers' perceptions.

[2] Results from exploratory factor analyses are available Appendix Tables A3 and A4 and are similar to those from the confirmatory analysis.

Table 3
Descriptive Statistics for Key Variables

Conceptual Model Component	Empirical Variable	Units	Mean	Std. Dev.	Min.	Max.	Hypothesized Impact on Adoption
—	Contract enrollment	(0/1)	0.38	0.49	0	1	N/A
R	Payment offer	US$/acre/year	266.7	161.8	64	540	(+)
*α*A*	Prairie strip land	Acres	5.11	3.87	0.5	30.3	(–)
E	Perceived yield gains	—	0.00	0.26	–0.93	1.02	(+)
E	Perceived pest management costs	—	0.00	0.48	–1.95	1.66	(–)
E	Perceived farm management costs	—	0.00	0.42	–1.68	1.51	(–)
E	Perceived soil retention	—	0.00	0.62	–2.37	1.16	(+)
E	Perceived weed and pest pressure	—	0.00	0.57	–2.14	1.47	(–)
E	Perceived biodiversity benefit	—	0.00	0.35	–1.51	0.76	(+)
E	Conservation program participant	0/1	0.37	0.48	0	1	(+)
F	Age	Years	61.2	12.0	20	101	(–)
F	Education	Categorical	2.82	0.86	1 (<high school)	4 (Bachelor's or higher)	(+)
NFI	Nonfarm work	Categorical	2.14	1.59	1 (no days)	5 (200+ days)	N/A
F	Previous prairie strip contact	0/1	0.43	0.49	0	1	(+)
*α*A/A'*	Ratio: acreage in largest field to all corn-soybean acreage on farm[a]	Proportion	0.20	0.16	0.01	1	N/A

Note: $N = 487$. All variables are explanatory variables unless otherwise noted. Signs of expected effects: (+) denotes positive, (–) denotes negative. N/A, not applicable (i.e., no expected effect).
[a]Land-share variable is used for acreage supply projections. $N = 442$ for this variable only.

Table 3 shows descriptive statistics of the empirical variables used in our analyses, along with their connection to the conceptual model and a set of testable hypotheses.

The survey intentionally oversampled large-scale farmers (i.e., farmers with at least 500 acres of cropland) to capture a wide range of farm sizes to introduce sample variability in resource capacities and the adoption behavior of farmers who manage large swaths of land. Given that large-scale farmers manage a majority of U.S. cropland (MacDonald 2020), the outcomes of these farmers' management decisions have a disproportionate effect on the land. Consequently, unweighted empirical analyses capture the contract enrollment and land supply behavior of farmers who manage most land in the Eastern Corn Belt, whereas analyses that include survey weights to account for the survey's oversampling capture the enrollment behavior of a typical (but smaller scale) farmer (Solon, Haider, and Wooldridge 2015). We present the unweighted and survey-weighted approaches to understand any differences in prairie strip adoption across the landscape (unweighted) versus by a representative member of the Eastern Corn Belt farmer population (weighted).

We constructed ex post probability weights for the survey-weighted analyses based on the stratified sampling design.[3] For the four states in the study, we sampled two size strata, one for farms with owned and rented-in cropland of 100–500 acres and the other for farms of at least 500 acres of cropland. To calculate weights for each state by size stratum, we used data on the population of farms below and above 500 acres in each state from the NASS 2012 agriculture census:

[3]Probability weights are available in Appendix Table A5.

$$Probability\ Weight_i = \frac{1}{\frac{\#\ of\ survey\ responses\ from\ Stratum_i}{Population\ of\ Stratum_i}}. \quad [5]$$

For interested readers, the Appendix contains detailed information on bid acceptances, including means and standard deviations of explanatory variables for the four CRP-proportional bid levels (Appendix Tables A6–A9) and bid acceptance rates by state at each level (Appendix Tables A10–A14).

We conducted choice-of-model tests to compare alternative specifications of empirical variables that conform with the conceptual model. The specifications include (1) bid-level variable only; (2) baseline variables minus CRP/EQIP/CSP dummy; (3) baseline variables presented here; (4) baseline variables plus farm yield as a proportion of county average yield (yield proportion); (5) variables in (4) plus total farmland, rented land, labor supply, livestock presence, and time horizon; and (6) variables in (4) with total farmland and rented land replaced with a variable for the proportion of owned cropland in all cropland operated. We estimated logit and probit procedures on unweighted and survey-weighted data. Owing to item nonresponse on certain continuous variables, tests were adjusted by restricting the sample to the smallest subsample with usable values for all variables across all estimations.

Based on likelihood ratio tests for the unweighted models and Wald tests for the weighted ones, supplemented by the Akaike information criterion for each, we find that the baseline specification reported here is preferred, in that we reject the hypothesis that the model was simply the bid-level variables, but we fail to reject the hypothesis that the baseline specification was improved with additional variables in nearly all cases. The only variable that fails to be significant under certain specifications is the conservation program participation variable, which we retain for the sake of theoretical consistency. Results for logit and probit estimation approaches were nearly identical in *p*-values of coefficient estimates. Because neither approach was preferred statistically, we report logit results. Choice-of-model tests appear in Appendix Tables A15–A19.

Table 4
Logit Regression Results for Respondents' Acceptance of Prairie Strip Contracts

Variable (Unit)	Unweighted Logit	Weighted Logit
Payment offer (US$/acre/year)	0.00611***	0.00735***
	(0.000747)	(0.00109)
Prairie strip land (acres)	−0.122***	−0.146**
	(0.0395)	(0.0600)
Perceived yield gains (latent)	2.307***	1.534*
	(0.516)	(0.800)
Perceived pest management costs (latent)	0.540	0.406
	(0.391)	(0.645)
Perceived farm management costs (latent)	−1.120***	−1.149
	(0.434)	(0.762)
Perceived soil retention (latent)	0.799***	1.038***
	(0.209)	(0.329)
Perceived weed and pest pressure (latent)	−0.0967	−0.0761
	(0.271)	(0.363)
Perceived biodiversity benefit (latent)	0.423	0.738
	(0.373)	(0.597)
Age (years)	−0.00122	−0.00539
	(0.0100)	(0.0181)
Education (categorical)	0.00472	−0.157
	(0.140)	(0.238)
Nonfarm work (categorical)	−0.0150	0.0259
	(0.0760)	(0.127)
Previous contact (0/1)	0.254	0.569
	(0.234)	(0.356)
CRP or EQIP/CSP	0.511**	0.613
Participation (0/1)	(0.242)	(0.419)
Constant	−1.916**	−1.618
	(0.843)	(1.409)
Pseudo R-squared	0.249	0.311

Note: $N = 487$. Standard errors are in parentheses. Probit results are in the Appendix.
* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

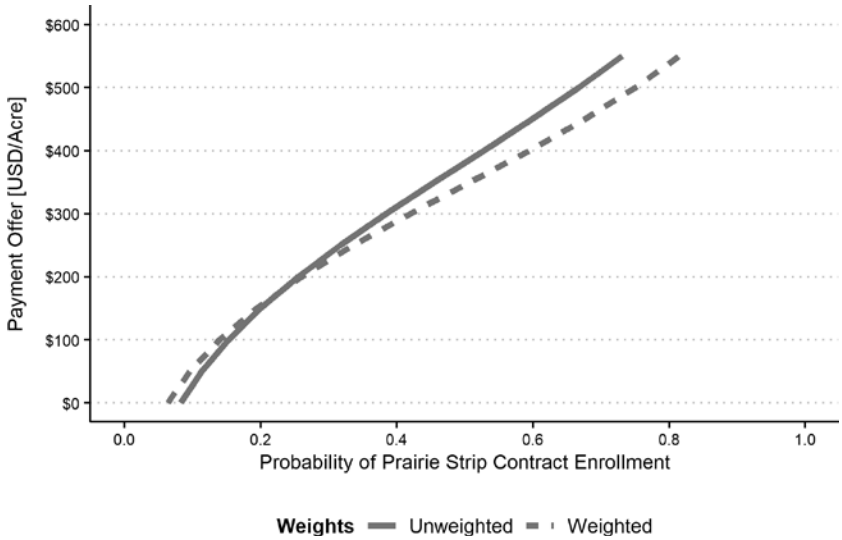
5. Findings

Logit Results

Logit results for the factors affecting farmer willingness to plant prairie strips appear in Table 4.[4] In the unweighted and survey-weighted estimates, we find that the probability of farmer enrollment in the prairie strip contract increases with payment offer, as expected. Small-scale farmers are more responsive to changes in payments than are

[4]Probit counterparts to all logit-based tables and figures can be found in Appendix Table A20. Probit results are very similar to the logit results.

Figure 1
Predicted Probability of Contract Enrollment by a Representative Eastern Corn Belt Farmer, by Payment Offer and Unweighted and Weighted Estimates



large-scale farmers, as revealed by the larger coefficient magnitude for payment offer in the survey-weighted analysis.

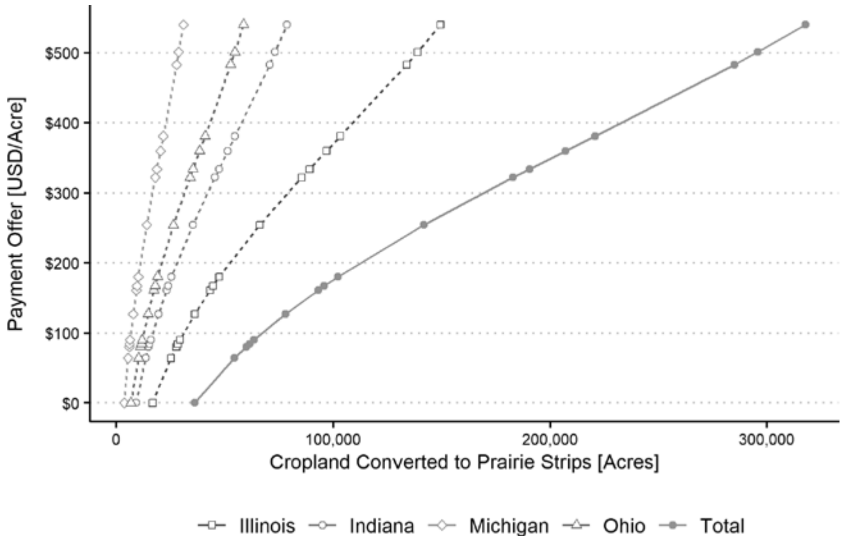
Farmers who are required to allocate less cropland toward prairie strips per the contract's 5% conversion criterion are more likely to enroll (i.e., farmers whose largest field is relatively smaller). Again, small-scale farmers are slightly more responsive to changes in land requirements than large-scale farmers are, as evidenced by the larger coefficient magnitude in the survey-weighted analysis.

Farmer perceptions of how prairie strips affect their fields' environmental quality and agricultural productivity are significant drivers in their decisions to enroll in the contract. As expected, farmers are likelier to enroll in a prairie strip contract if they perceive that prairie strips will increase (1) crop yields on their fields or (2) soil retention on their fields. However, large-scale farmers appear to be more responsive to changes in perceived yield gains and less responsive to changes in perceived soil retention (based on comparing the unweighted and survey-weighted results). Surprisingly, there was no effect on prairie strip enrollment due to farmers perceiving that prairie strips will increase (1) weed and pest management costs or (2) biodiversity. However, large-scale farmers are likelier to enroll if they perceive that prairie strips will decrease farm management costs on their fields. Likewise, large-scale farmers are more likely to enroll if they already participate in one of the three leading agricultural conservation programs (CRP, EQIP, or CSP). For the demographic variables of farmer age, education, and previous contact with prairie strips, we find no evidence of an effect on enrollment. Neither do we find evidence that the level of nonfarm employment in the farmer's household affects contract enrollment.

Using the predicted probabilities generated over the range of payment offer levels, we graph the relationship between the expected probability of prairie strip contract enrollment by payment level, holding all other covariates at their sample means (Figure 1). The predicted probability of enrollment increases roughly linearly as payment offer increases, with a predicted probability of enrollment of 0.20 at the $159 payment level (the mean of the four state-average CRP treatments at the 100% rate). At this payment level, the probability of enrollment is the same for unweighted and weighted analyses, although probability of enrollment grows faster for the weighted (smaller farm)

Figure 2

Corn and Soybean Acres Supplied for Prairie Strips by Payment Offer, by State and in Aggregate for Illinois, Indiana, Michigan, and Ohio (Unweighted)



analysis at higher payment offers. For comparison, the predicted probability of enrollment at a payment level of $318 (the mean of the four state-average 200% CRP rate treatments) rises to 0.40 in the unweighted and 0.45 in the weighted analyses.

Breaking this relationship down by state and focusing on the unweighted predictions (with weighted ones in parentheses), we estimate that 21.9% (21.2%) of Illinois farmers, 21.1% (19.4%) of Indiana farmers, 17.9% (24.4%) of Michigan farmers, and 20.9% (22.3%) of Ohio farmers would enroll in the contract with payments equivalent to the CRP state-specific average.

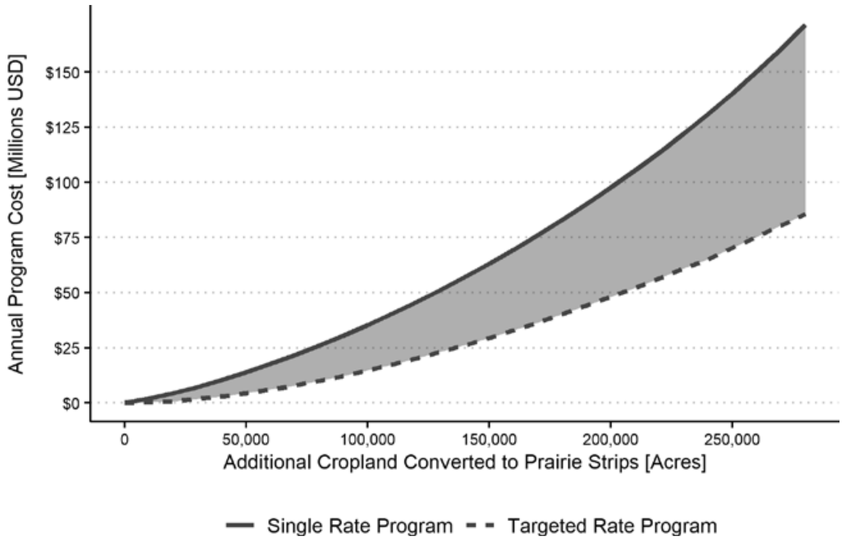
Although the experimental treatments offered to farmers all involved payments, we can cautiously extrapolate our results to provide a loose estimate of the percentage of farmers who might enroll in a prairie strip contract voluntarily. We find that in the absence of a payment incentive, farmers have a predicted probability of contract enrollment of 0.09 (0.07 using the survey-weighted approach).

Estimated Supply Curve

We can extrapolate from the results of our binary dependent variable model to estimate the supply of corn and soybean cropland in the Eastern Corn Belt that would be allocated to prairie strips under a program that occupies 5% of farmers' largest fields. To do this, we calculate the ratio of the area of the largest field to whole-farm area planted to corn or soybean (see the bottom row of Table 3). We then multiply the sample mean of the largest-field-to-total-acreage ratio by total corn-soybean planted area in the four Eastern Corn Belt states in 2017 (USDA National Agricultural Statistics Service 2017) to estimate the base area occupied by farmers' largest corn-soybean fields. We multiply the resulting base area by 5% to calculate the maximum potential land area converted to prairie strips under 100% program enrollment. To estimate the potential prairie strip acreage supplied, we multiply the maximum potential prairie strip land area by the predicted probability of contract enrollment from our logit results across the range of payment levels across the four Eastern Corn Belt states in 2017. Figure 2 shows the relationship between payment level and the predicted, unweighted acreage supply, by state and in aggregate. At the benchmark payment level of $159/acre, the average annual CRP rental payment in the four states, the projected area supply is 89,500 acres of

Figure 3

Projected Annual Payment Costs of a Prairie Strip Incentive Program at Uniform and Targeted Payments (Unweighted), by Acreage Supplied and Four Eastern Corn Belt States



cropland converted to in-field prairie strips (ignoring land that farmers might convert voluntarily).

Figure 3 displays the range of annual incentive payment costs that we estimate the federal government would incur for a program that pays farmers to plant various acreages in prairie strips. Actual government expenditures will depend on farmer willingness to accept (represented by the supply curves in Figure 2) and specific policy design. To capture the range of possible expenditures that may result from different policy decisions, we calculate projected expenditures using methods that represent two policy extremes. First, we consider a "single price" policy, where all enrolled farmers receive the same payment rate, by multiplying the targeted number of acres by the bid level required to enroll the marginal acre. Such a policy would be fair but would pay many farmers a producer surplus that exceeds what they would require to adopt prairie strips. Second, we consider a policy of perfect price targeting, where each farmer receives exactly the minimum payment they are willing to accept, by computing the positive area under the aggregate supply curve. These extremes are used to benchmark the upper and lower bounds of projected payment costs. Figure 3 (and Appendix Table A21) presents the estimated payment costs of a prairie strip conservation program on corn-soybean land in the Eastern Corn Belt at increasing acreage levels.

Note that our empirical model implies that some farmers would adopt prairie strips without payment. Across the four Eastern Corn Belt states, we predict that approximately 40,000 acres could be planted in prairie strips without incentives. Therefore, our program cost projections only consider the additional acres beyond those we predict farmers would provide for free.

Per Figure 3, we estimate that the annual cost of payments to induce Eastern Corn Belt farmers to shift 100,000 acres of corn and soybean to prairie strips would range from $6 to $18 million. This area rounds up from the 89,500 acres that would cost $14.2 million at a uniform payment of $159 per acre. Such a 100,000-acre program would convert 4.4% of corn and soybean cropland in the region to a management system where prairie strips occupy 5% of farmers' corn and soybean fields. The lower bound estimate represents the integrated area under the land supply curve, corresponding to a program that pays farmers the minimum payment they are willing to accept, and the upper bound estimate represents the cost of a program where all farmers are paid the amount required to induce participation by the farmer with the highest minimum willingness to accept.

6. Discussion

We find that at payment rates similar to the current CRP, one-fifth of the farmers surveyed are willing to plant prairie strips into corn and soybean fields. This magnitude of interest signals the potential to transform a meaningful share of cropland in the Eastern Corn Belt. Although farmers are wary of opportunity costs and direct costs, such a program is consistent with the stewardship values that many of them hold. The results dovetail well with the existing literature related to all three of our research objectives.

Objective 1: Overall Willingness of Farmers to Adopt Prairie Strips

Farmers are quite amenable to adopting prairie strips under payment scenarios similar to those used in the CRP. Approximately 20% of Eastern Corn Belt farmers would willingly enroll in a prairie strip contract if offered CRP-equivalent payments. Such a payment level would apparently offset prairie strip adoption costs—both direct and indirect opportunity costs (Tyndall et al. 2013). A cautious extrapolation below the minimum payment offer indicates that some farmers might adopt prairie strips without payment. Our interpretation is that these farmers perceive the expected private benefits and environmental stewardship value they would experience from prairie strips outweighs the expected costs of adoption. This finding is consistent with prior evidence that farmers with environmentally oriented attitudes are more prone to adopt conservation practices, even without incentive payments (Pannell et al. 2006; Luther, Swinton, and Van Deynze 2020).

Objective 2: Determinants of Willingness to Adopt Prairie Strips

Incentive payment offers clearly boost the likelihood that farmers adopt prairie strips. Holding other variables at their sample means, the marginal effect of a $100 increase in payment level is to increase the likelihood of adoption by 14%. Our results are consistent with findings elsewhere that financial compensation encourages farmer adoption of conservation practices (Bremer, Farley, and Lopez-Carr 2014; Arbuckle 2015; Yeboah, Lupi, and Kaplowitz 2015). Payments turn the conservation practice into a revenue generator that contributes to profitability, offsetting opportunity costs from taking land out of production (Cary and Wilkinson 1997; Pannell et al. 2006; Liu, Bruins, and Heberling 2018).

The finding that farmers are more willing to adopt prairie strips on smaller fields fits with reducing monetary opportunity costs and the risk of depressing adjacent agricultural production. Past literature has documented how opportunity costs (Liu, Bruins, and Heberling 2018) and land use restrictions (Wachenheim et al. 2018) can deter adoption of conservation practices. The preference to adopt prairie strips on smaller fields is also consistent with the conceptual model assumption that farmers experience diminishing marginal utility from environmental stewardship. However, there is evidence that the environmental benefits from prairie strips increase with field area and contiguity (Schulte et al. 2016). Accordingly, policy makers who aim to optimize net benefits may wish to identify ways to compensate farmers at per acre rates that increase with field size.

Perceived profitability has been shown repeatedly to drive farmer adoption of best management practices (Cary and Wilkinson 1997; Pannell et al. 2006; Liu, Bruins, and Heberling 2018). Consistent with prior studies that find expected private profitability effects to be especially compelling (Chouinard et al. 2008), the perceived yield gain factor from prairie strips has the strongest positive effect among the attitudinal factors. As a cautionary note, agronomic research has not found prairie strips to benefit yields on remaining cropland (Schulte et al. 2017). Farmer perceptions that prairie strips reduce farm management costs also encourage adoption to a smaller extent and only in the unweighted analysis (truer on larger farms). The magnitude of the coefficient on this cost reduction factor was less than half that of the yield gain factor.

Soil retention blends environmental stewardship with agricultural productivity benefits. Farmers who perceive that prairie strips help with soil retention tend to favor prairie strip adoption. In this case, the effect size is less than a quarter the magnitude of the perceived yield gain effect in the unweighted analysis. Because prairie strips have been successfully shown to improve soil retention (Zhou, Al-Kaisi, and Helmers 2009; Helmers et al. 2012; Schulte et al. 2017), disseminating information to farmers on the extent of the private soil quality benefits from prairie strips could modestly encourage adoption (Yeboah, Lupi, and Kaplowitz 2015), particularly among farmers who experience regular or heavy soil loss.

Objective 3: Potential Supply of Land for Prairie Strips

Our results indicate that payments to Eastern Corn Belt farmers comparable to existing CRP payments could support widespread prairie strip adoption. We estimate that a program that paid farmers the regional average CRP land rental payment of $159/acre would attract 89,500 acres of cropland into prairie strips, an area corresponding to 1.8 million acres of cropland where 5% was allocated to prairie strips.

Our program cost analysis predicts that a prairie strip program in the Eastern Corn Belt that aims to convert 100,000 corn-soybean acres to prairie strips would have payment costs in the range of $6–$18 million annually, depending on how the payment scheme is structured. In 2017, farmers in the four Eastern Corn Belt states received $258,372,000 in CRP rental payments to enroll 1,511,385 acres into CRP (Barbarika 2017). Our findings suggest that acreage equivalent to 6.6% of CRP-enrolled acres could be planted in prairie strips at costs ranging from 2.3% to 6.8% of CRP expenditures across these four states in 2017. A program that seeks to allocate 200,000 acres toward prairie strips (13.2% of CRP-enrolled acres) would do so at costs ranging from $33 to $70 million (12.6%–27.1% of CRP expenditures). The drop in program efficiency relative to CRP at higher enrollment goals results from the rising marginal cost of attracting more participants.

Our results suggest that extensive adoption of prairie strips looks entirely feasible under current federal conservation budgets, particularly when policy makers use conservation auctions to tailor payments to what individual farmers are willing to accept. Two caveats are in order. First, as Palm-Forster et al. (2016) have shown, actual program costs are likely to be higher than such minimum estimates because of transaction costs and strategic behavior inherent in conservation auctions. Second, although the single binary choice used here has been shown to be incentive compatible in willingness-to-pay surveys, experimental research suggests that in a context like this one of a private good (cropland) and a new program (prairie strip payments), respondents have an incentive to exaggerate their true willingness to adopt (provision bias) in hopes that the program will be provided (Lloyd-Smith and Adamowicz 2018). We realized that "cheap talk" scripts encouraging truthful responses, follow-up questions on motivations and interpretation of consequentiality, and auction-based elicitation methods can alleviate incentive compatibility concerns, but we were unable to include these approaches here because of limited questionnaire space and concerns about survey fatigue. The caveats suggest that the actual supply of land for prairie strips would likely be lower than the one estimated here from stated preferences.

This research opens the door for important extensions. First, as implied by our conceptual model, farmers are likely to vary in the land area that they would willingly set aside for prairie strips at any given payment rate. Empirically, this study limited the land area to 5% of the farm's largest corn or soybean field. Future research could provide a more detailed picture of willingness to adopt prairie strips by varying the proportion of cropland allocable for prairie strips and the range of eligible fields. For example, prairie strips could have greater adoption potential where the opportunity costs from forgone crop revenue are lower. Farmers could mitigate their opportunity costs by choosing to plant prairie strips on lower-quality cropland (Claassen and Tegene 1999), low-profitability subplots of their fields (Brandes et al. 2016), or cropland with high yield variability (Martinez-Feria and Basso, 2020).

As with CRP in general, prairie strips will have lower opportunity costs when expected future crop prices are low, so prairie strips may see greater adoption when crop prices slump. Future research repeating similar stated preference surveys over time, through additional cross sections or a panel, should address how crop price dynamics affect prairie strip adoption behavior and how flexible contract characteristics might alleviate the effect of opportunity costs as a barrier to adoption.

Finally, it is possible that enrollment in other conservation programs may affect how much land a farm has available for adopt prairie strips. Future surveys that measure conservation program participation in greater detail could test the hypothesis that such enrollments affect prairie strip supply.

Since 2019, prairie strips have been eligible for federal payments under the CRP-CLEAR initiative. Practices covered under CRP-CLEAR are intended to improve water quality near and far from farming sites through decreased soil erosion and nutrient loadings, and through increased wildlife habitat (USDA 2019). While prairie strips are formally a set-aside practice under CRP-CLEAR, they are unique in being located inside crop fields, where they act like a working lands practice that would otherwise be eligible for support under the Environmental Quality Incentives Program (EQIP) or the Conservation Stewardship Program (Kemp 2009). Nearly 10,000 acres across the United States, including nearly 5,000 in states represented in this study, had been converted to prairie strips under the CRP-CLEAR program as of February 2021 (USDA FSA 2021). These early contracts represent a promising start for an incentive program similar to the hypothetical program studied here. Our results suggest that without budgetary and eligibility constraints and assuming that farmers are fully informed and face negligible transaction costs to participate, the CRP-CLEAR program can expect up to an 18-fold prairie strip acreage expansion in Illinois, Indiana, Michigan, and Ohio.

Prairie strips have primarily been researched in contexts where they are planted inside crop fields, but CRP-CLEAR also supports prairie plantings along field margins, in irrigation pivot corners, in terrace channels or next to waterways (USDA 2019). Although farmers can mitigate opportunity costs by choosing to plant elsewhere than across the inside of crop fields (Brandes et al. 2016), certain ecosystem services provided by prairie strips are likely enhanced when the strips are spaced regularly inside crop fields (Schulte et al. 2016). Future research should explore ecosystem services when prairie patches are located where opportunity cost is low compared with planting along topographic contours (for soil conservation) or at regular spacing (for pollination and natural pest biocontrol) in row crop fields rather than elsewhere. Identifying the spatial configuration of prairie strips to maximize the value of ecosystem services would be a valuable complement to research into ecosystem services from placing prairie strips where opportunity cost is low (Meehan et al. 2013).

Future cost-benefit analyses should link farmer models of willingness to adopt with agro-ecological models of the environmental benefits from prairie strips. Such linkage would enable studying how these ecosystem services (and farmer valuations of these services compared to their expected costs) differ under alternative prairie strip management systems. This kind of research could assist in identifying the most desirable ways to target prairie strip adoption and could extend the supply curve of prairie strips presented here to a supply curve for ultimate public ecosystem services that result from prairie strips.

7. Conclusions

Prairie strips have been shown to provide a wide array of ecosystem services to farmers and to the public. However, without incentive payments, the direct costs of installation and maintenance plus the opportunity cost of forgone crop income are entirely borne by farmers, forcing them to make a trade-off between improved environmental quality and agricultural profits.

We find that this trade-off is not a prohibitive barrier for farmers to adopt prairie strips.

Farmers surveyed in the Eastern Corn Belt show considerable willingness to shift working cropland into prairie strips in exchange for payments similar to those used in current conservation initiatives. At payment levels equal to in-state CRP averages, approximately 20% of farmers would adopt prairie strips on their largest corn or soybean field. The acreage they are willing to switch into prairie strips rises with the level of payments offered and farmer perceptions of higher yields and greater environmental benefits. By contrast, available acreage falls when farmers manage larger field areas and when adoption is perceived to increase costs.

Current farmer knowledge of prairie strips and their effects remains at a formative stage. Farmer willingness to adopt them hinges in part on perceptions of likely crop productivity and environmental effects. Those perceptions will be shaped by ongoing research that will help inform the location- and price-specific thresholds where the additional benefits from planting prairie strips inside crop fields offset the attendant opportunity costs. Of particular value will be research that expands our knowledge ecologically, beyond soil and water conservation to measure biodiversity benefits; economically, to discern the appeal of prairie plantings at low-earning sites in farm fields; and both ecologically and economically, to determine the benefits and costs of siting in-field prairie plantings where opportunity costs are low.

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