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Additionality in Grassland Easements to Provide Migratory Bird Habitat in the Northern Plains

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Native grassland in the Prairie Pothole Region (PPR) is important habitat for migratory birds, particularly ducks. Much of this grassland is at risk for conversion to cropland. Permanent easements, managed by the U.S. Fish and Wildlife Service, protect high-quality habitat but do not currently consider vulnerability to cropland conversion. We find that (i) grassland easements are protecting native grassland from conversion, although the level of protection is modest; (ii) it may be possible to increase habitat protection by targeting grassland that is vulnerable to cropland conversion; and (iii) conversion estimates that fail to account for easements are biased downward.

Key words: additionality, grassland easement, grassland habitat, Prairie Pothole Region, propensity score matching

Introduction

Grassland habitat in the Prairie Pothole Region (PPR) of the Northern Plains is an important but potentially vulnerable natural resource (Doherty et al., 2013). Grasslands interspersed with small "pothole" wetlands provide critical habitat for many migratory birds, including nesting ducks (Reynolds et al., 2001; Stephens et al., 2005). Native grassland (or native sod) that has never been tilled for crop production is particularly valuable habitat because it provides: (i) cover for upland nesting waterfowl, which is especially attractive when undisturbed (Reynolds et al., 2001); (ii) a mosaic of habitat options—important for grassland songbirds—resulting from plant diversity and xeric-mesic-hydric conditions; and (iii) a diversity of flora beneficial to pollinators (Black, Shepherd, and Vaughan, 2011) (although research for pollinators is scarce for the prairies). Research also suggests that landscapes with higher proportions of grass cover are more productive for breeding migratory birds than those with lower proportions (Cunningham and Johnson, 2006; Greenwood et al., 1995), and there is evidence of a threshold effect (i.e., a minimum percentage cover needed for various migratory birds to be productive) (Reynolds et al., 2001; Herkert et al., 2003; Ribic et al., 2009). Finally, protecting existing grass is more cost effective than restoring grass or reconstructing prairie after it has been lost (Loesch, Reynolds, and Hansen, 2012).

The U.S. Fish and Wildlife Service (FWS) and conservation partners purchase habitat easements to permanently protect grassland habitat, focusing on native sod in the PPR (Loesch, Reynolds, and Hansen, 2012). Landowners who sell easements retain ownership of the land and the rights to grazing, haying, and recreational activities but are prohibited from converting the land to non-

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grass uses. Between 1998 and 2012, FWS and partners spent $149 million to preserve 850,000 acres of grassland at an average cost of $173/acre (Walker et al., 2013). Nonetheless, 8 million acres of high-priority grassland for breeding waterfowl remained unprotected at the end of 2012 (Prairie Pothole Joint Venture, 2005). Between 2008 and 2013, higher land values resulted in higher easement costs and subsequently slower rates of annual habitat conservation (Doherty et al., 2013). Average easement costs reached $440/acre in South Dakota in 2010 and $227/acre in North Dakota in 2012 (Walker et al., 2013).[1]

The cost of easements and the large area of high-priority grassland yet to be protected have increased the importance of carefully assessing proposed easements for both habitat value and vulnerability to conversion. At present, habitat value is carefully assessed, but the vulnerability of the land to conversion, particularly for crop production, is not. Nor has there been any analysis of the extent to which existing easements protect grasslands that are vulnerable to conversion. "Additionality" is a measure of the extent to which a policy or program (e.g., grassland easements) is effective in achieving desired outcomes (e.g., preventing loss of grassland habitat). Habitat protection is "additional" only if the grassland under easement would be converted to another use in the absence of the easement; easements on grassland that would not be converted consume program resources without preventing habitat loss. Once an easement has been purchased, it is not possible to observe whether eased land would have been converted without the easement.

We (i) estimate the level of additionality in the FWS grassland easements program and (ii) assess the extent to which targeting easements using a proven, readily available indicator of cropland potential could increase additionality. While a number of techniques have been used to estimate additionality, matching models are preferred in the recent literature on programs designed to reduce deforestation (Andam et al., 2008; Robalino and Pfaff, 2013), protect agricultural land from urban development (Liu and Lynch, 2011; Lynch, Gray, and Geoghegan, 2007), and encourage adoption of conservation practices in agricultural production (Chabé-Ferret and Subervie, 2013; Mezzatesta, Newburn, and Woodward, 2013; Pufahl and Weiss, 2009). Finally, we show how an easement program affects the estimated rate of grassland conversion.

We hypothesize that the use of land-quality indicators could improve additionality in a grassland easement program. Past research suggests that forest protection programs yielded relatively small reductions in deforestation because protected areas tend to be on less-accessible, lower-productivity land that is inherently less susceptible to deforestation (Andam et al., 2008; Robalino and Pfaff, 2013). While grassland conversion cannot be predicted with certainty, Walker et al. (2013) suggested that the Land Capability Classification (LCC) could be used to assess the vulnerability of grassland for conversion to crop production. The LCC combines aspects of soil productivity, climate, and topography into a single indicator of land suitability for crop production (Klingebiel and Montgomery, 1961). We focus on cropland potential because the PPR is heavily agricultural and cropland conversion is the primary threat to grassland.

Finally, failing to account for existing habitat easements will result in an overestimate of the amount of grassland available for conversion and an underestimate of the rate of grassland conversion. By linking land use and easement data, we estimate the potential size of this bias for grassland conversion rates in PPR counties where the FWS grassland easement program is active.

Grassland Easement Program

Grassland easements considered in our study (figure 1) were purchased by the FWS through the Small Wetlands Acquisition Program, Land and Water Conservation Funds, North American Wetlands Conservation Act Funds, or donated to the FWS by conservation partners (e.g., Ducks

[1] Easement costs have continued to rise. In 2016, average easements prices were $552/acre in North Dakota and $813/acre in South Dakota (Personal Communication, FWS Realty Offices in North and South Dakota).

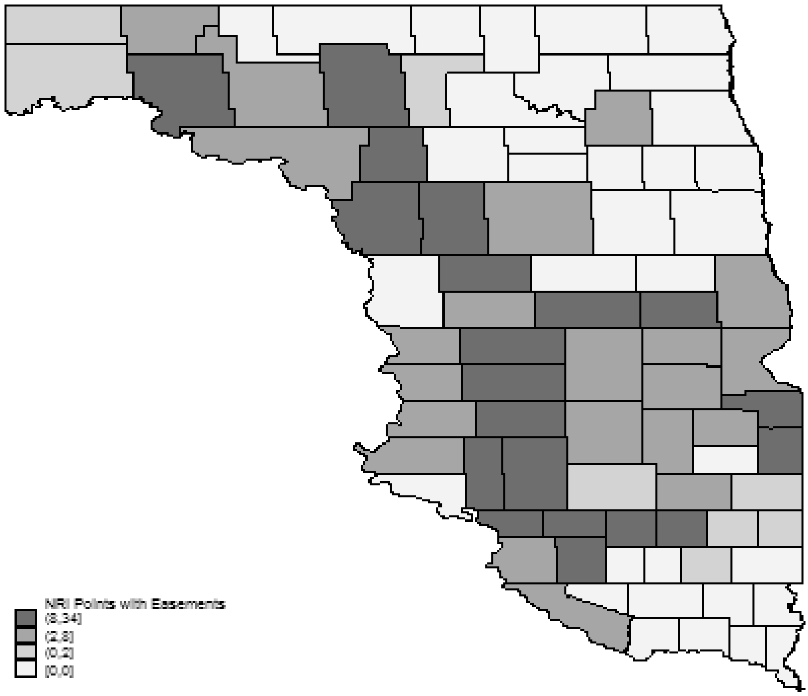

Figure 1. North and South Dakota Prairie Pothole Region Study Area

Unlimited). Landowners who are willing to consider an easement offer may identify themselves or may be approached by the FWS or conservation partners.

The FWS purchases easements on tracts of native prairie located within approved conservation areas that are not encumbered by another perpetual easement. Native prairie is defined as grassland that (i) has no history of crop production and (ii) supports native herbaceous vegetation, sometimes with a shrub component. All PPR counties are in approved conservation areas, although some eligible counties do not yet have any grassland easements. Participation varies across counties because land values (and the cost of purchasing easements) vary, as does the availability of native prairie. FWS effort is higher where relatively large areas of native prairie remain.

Once landowner interest is established, the decision to offer an easement is based on three biological measures:[2] (i) upland nesting waterfowl value: the predicted number of duck pairs (i.e., mallard [*Anas platyrhynchos*], blue-winged teal [*A. discors*], gadwall [*A. strepera*], northern pintail [*A. acuta*], or northern shoveler [*A. clypeata*]) that can "access" the tract for the purpose of nesting; (ii) grassland bird value: the proximity of the tract relative to Grassland Bird Conservation Areas (GBCA) (Niemuth, Estey, and Loesch, 2005; Johnson et al., 2010); and (iii) the presence of endangered species.[3] Duck pair access to a grassland site is determined by the carrying capacity of wetlands within 1–2 miles, depending on the species (Reynolds et al., 2006; Loesch, Reynolds, and Hansen, 2012). Zone 1 areas can be accessed by 60 or more duck pairs, zone 2 sites by 40–60 pairs, and zone 3 by 25–40 pairs. Currently, the risk of conversion, as indicated by the USDA Non-Irrigated Land Capability Class, is considered only on a very limited basis.

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[2] Although these criteria have been used only since 2005, Walker et al. (2013) found little difference in the characteristics of eased grassland acquired before and after 2005, suggesting that current methods were approximated by expert judgment used to identify easements before 2005.

[3] While endangered species are included in the FWS decision tree for easement acquisition and tracts with endangered species are considered over those without, other funding sources typically are used to address the conservation of these species.

For tracts that meet biological criteria, FWS real estate specialists estimate the value of the easement to generate an offer amount. Before 2005, values were based on a standard real estate appraisal. Since 2005, values have been based on tax assessments, adjusted for any change in land value since the most recent assessment. Easement offers are less than the full land value because the landowner retains the right to grazing, haying (with some restrictions), and recreational use. Offers are managed adaptively to maintain acceptance rates of 40–70%. If the acceptance rate is above 70%, offers are adjusted downward; an upward adjustment is made if the acceptance rate falls below 40%. Easement offer prices are not negotiable, but landowners who reject an offer may receive additional offers in subsequent years as land value changes.

Methods

Our measure of additionality is the "average treatment effect on the treated" (ATT). In our context, the "treatment" is the grassland easement and the "effect on the treated" is the grassland loss prevented by the easement program:

$$ATT = E[(Y_{1t} - Y_{1t'}) - (Y_{0t} - Y_{0t'})|D = 1], \tag{1}$$

where Y_{it} is land use (outcome), i indexes easement status ($i = 1$ when an easement is in place, $i = 0$ when there is no easement), t is a post-easement time, t' is a pre-easement time, and $D = 1$ for eased land. For example, Y_{it}=1 if land under easement continues in grass, $= 0$ otherwise. Likewise, $Y_{it'}$ is the pre-easement land use for land under easement at time t. The ATT is the expected difference between (i) the change in land use between times t' and t on land that is under easement $E[(Y_{1t} - Y_{1t'})|D = 1]$ and (ii) the change in land use between times t' and t that would have occurred on the same land had the easements not been in place: $E[(Y_{0t} - Y_{0t'})|D = 1]$.

Because easements are purchased only on land that is in grass before the easement ($Y_{1t'} = Y_{0t'} = 1$) and land under easement must remain in grass ($Y_{1t} = 1$), the ATT reduces to

$$ATT = E[1 - Y_{0t}|Y_{0t'} = 1, D = 1] = 1 - E[Y_{0t}|Y_{0t'} = 1, D = 1]. \tag{2}$$

In the absence of the easement, land could have remained in grass ($Y_{0t} = 1$) or converted to another use ($Y_{0t} = 0$) at t, so the ATT is the rate of grassland conversion that would have occurred on eased land in the absence of the easement. Because grassland easements are permanent but can be assessed only over a finite time period, we note that estimates are necessarily partial and conditional on the conversion incentives during the assessment period.

Given that $E[Y_{0t}|Y_{0t'} = 1, D = 1]$ is not observed for eased land, it must be estimated by observing land that is not eased. If easements were randomly assigned, then $E[Y_{0t}|Y_{0t'} = 1, D = 1] = E[Y_{0t}|Y_{0t'} = 1, D = 0]$, where $E[Y_{0t}|Y_{0t'} = 1, D = 0]$ is the (observed) share of uneased land that is in grass at t' and continues in grass at t, which implies that $1 - E[Y_{0t}|Y_{0t'} = 1, D = 0]$ is an unbiased estimate of the ATT. Of course, easements are not randomly assigned, as they depend on both habitat value and the landowners' willingness to sell an easement. If factors (e.g., crop suitability) exist that affect both the landowners' willingness to accept an easement offer and the likelihood of grassland conversion, the probability of easements may be correlated with the probability of conversion across tracts. Correlation could induce systematic differences between the average probability of conversion for land not under easement and the average probability of conversion for land under easement: $E[Y_{0t}|Y_{0t'} = 1, D = 1] \neq E[Y_{0t}|Y_{0t'} = 1, D = 0]$. For example, if the correlation between offer acceptance and grassland conversion is negative (land that is more likely to be eased will be less likely to be converted), the conversion rate on uneased land would be greater than the conversion rate that would have occurred on eased land in the absence of the easement. If so, $1 - E[Y_{0t}|Y_{0t'} = 1, D = 0]$ would be biased upward in relation to actual ATT.

The inference problem can be addressed by "conditioning on observables" (Rubin, 1974). If the conditional independence assumption (CIA) is satisfied by observable characteristics, **X**, then the easement and grassland conversion are independent when conditioned on **X**, $E[Y_{0t}|\mathbf{X}, Y_{0t'} = 1, D = 1] = E[Y_{0t}|\mathbf{X}, Y_{0t'} = 1, D = 0]$, and additionality can be measured as the observable quantity:

$$E[Y_{0t}|\mathbf{X}, Y_{0t'} = 1, D = 0]. \tag{3}$$

Comparisons are valid if eased tracts are compared only to uneased tracts with the same (or nearly the same) **X**. To satisfy the CIA, **X** must include all variables that could influence the easement offer, the landowner's acceptance of that offer, and grassland conversion.

While conditioning on observables can be achieved through parametric regression, Andam et al. (2008) note that matching (i) requires fewer assumptions about the underlying structural model of easement offer and acceptance and (ii) allows observations that do not satisfy common support conditions to be removed. Stuart (2010, p. 2) also emphasizes that matching methods "highlight areas of the covariate distribution where there is not sufficient overlap between the treatment and control groups, such that the resulting treatment effect would rely heavily on extrapolation." Black and Smith (2004) provide an empirical example of how to proceed when some treated observations meet common support requirements but are in a range where relatively few control observations are available.

Matching can be described as a way to weight control observations based on similarity to the treated observations (e.g., Liu and Lynch, 2011). Based on equation (3), the ATT can be estimated from survey data as

$$ATT = \sum_{k \in \{D=1\}} v_k \left(1 - \sum_{k' \in \{D=0\}} v_{k'} w_{kk'} (Y_{0tk'}|Y_{0t'k'} = 1, D = 0)\right), \tag{4}$$

where k indexes tracts under easement, k' indexes tracts that are initially in grass but not under easement, v_k is the weight used for averaging over eased observations, $v_{k'}$ is the weight used for averaging over uneased observations, $w_{kk'}$ is the matching weight, $Y_{0tk'}$ is the outcome for uneased grassland, $v_k = z_k / \sum_{l \in \{D=1\}} z_l$, and $v_{k'} = z_{k'} / \sum_{m \in \{D=0\}} z_m$, where z_k ($z_{k'}$) is the survey weight for observation k (k').

In an ideal matching model, treated and control observations would be exactly matched on every element of **X**. Control observations that are perfect matches would carry a positive weight while other controls would be assigned zero weight. In many cases, particularly when the number of covariates in **X** is large, exact matching is not possible. Matching weights are typically based on a measure of similarity (or "distance") between any given pair of treated and control observations and a matching method that determines the actual weight based on the measure of similarity.

Matching is often based on propensity scores (a measure of distance) that are typically the probability of treatment (Rosenbaum and Rubin, 1983; Heckman, Ichimura, and Todd, 1997, 1998):

$$P(D = 1|\mathbf{X}). \tag{5}$$

Propensity Score Matching (PSM) is valid only if the common support condition is satisfied. Common support ensures that all observations with the same **X** values have a probability of treatment (easement, in our case) that is not 0 or 1: $0 < P(D = 1|\mathbf{X}) < 1$. This ensures that eased land will not be compared to uneased land that is inherently different. For example, if $P(D = 1|\mathbf{X}) = 1$ for a specific set of **X** values, it will be impossible to find an appropriate set of uneased matching observations. To implement common support, we ensure that propensity scores for the treatment and non-treatment groups fall within a common range. We enforce common support by excluding observations with scores that are larger (smaller) than the largest (smallest) score in the group that has the lower maximum (higher minimum) score.

The matching weight matrix can be determined in many ways (e.g., Smith and Todd, 2005; Caliendo and Kopeinig, 2008; Stuart, 2010). For our primary estimates, weights are obtained using a kernel-based estimator. All uneased tracts are used in the counterfactual estimate for each eased tract, but matching weights decline as the absolute difference in propensity scores for the eased and uneased tracts rises. Using all of the uneased tracts to construct each counterfactual leads to greater statistical efficiency compared to other types of matching estimates (Heckman, Ichimura, and Todd, 1997, 1998; Heckman et al., 1998). For any given pair of eased and uneased tracts within a given time period, the weight is

$$w_{kk'} = \frac{f\left((\hat{P}_{k'} - \hat{P}_k)/\lambda\right)}{\sum\limits_{j \in \{D=0\}} f\left((\hat{P}_j - \hat{P}_k)/\lambda\right)}, \tag{6}$$

where $f(.)$ is the normal density function and λ is the bandwidth. The bandwidth determines the rate of decline in weights as the difference between the propensity scores increases. Bandwidth selection is discussed in the context of model estimation. Survey weights are not needed in the propensity score model (5) or in constructing the kernel-based matching weight (6) because the matching weights are not used to make inferences about the underlying population—only to determine the similarity of eased and uneased tracts within the sample.

We test the sensitivity of our approach to alternate distance measures and matching methods. Recent land conservation studies used propensity scores to select nearest neighbor(s) (Pufahl and Weiss, 2009; Robalino and Pfaff, 2013) or devise weights based on various kernel density functions (Liu and Lynch, 2011) or local linear regression (Chabé-Ferret and Subervie, 2013). Some use the Mahalanobis distance to select nearest neighbors (e.g., Andam et al., 2008; Robalino and Pfaff, 2013). To characterize and compare matching methods, we rely on standardized differences and variance ratios. The standardized difference is a normalized difference in the mean of each covariate for the treated observations and matched controls.[4] Variance ratios are the ratio of the variance of each covariate for the treated observations and matched controls. Matches are considered acceptable if the standardized difference for each covariate is less than 0.2 (20%) and the variance ratio for each covariate is between 0.5 and 2.0 (Stuart, 2010).

Data

Our unit of observation is a National Resource Inventory (NRI) point (U.S. Department of Agriculture, Natural Resource Conservation Service and Iowa State University Center for Survey Statistics and Methodology, 2015). The 2012 NRI data release includes data on broad land use (e.g., cropland, CRP, pasture, and rangeland) and Land Capability Class (LCC), among many other variables, for more than 800,000 points of non-federal rural land at five-year intervals from 1982 through 2012. For each NRI point and each survey year, land is classified by a single use, so our point-level indicator of grassland conversion is binary.

NRI is a stratified (area frame) sample survey. Nusser and Goebel (1997) describe the stratum, primary sampling unit (PSU), and point design in detail. Data are collected through site visits, interpretation of aerial photography, and information collected from USDA administrative records and farmer/landowner interviews (U.S. Department of Agriculture, Natural Resource Conservation Service and Iowa State University Center for Survey Statistics and Methodology, 2009). For example, land use (land cover) information can be obtained through site visits or photo interpretation, but information on participation in government programs (e.g., the Conservation Reserve Program) is obtained directly from the farmer/landowner or from administrative records.

[4] The standardized difference after matching (reproduced from Caliendo and Kopeinig, 2008) is

$$SB = 100\frac{\bar{X}_{1M} - \bar{X}_{0M}}{\sqrt{0.5 * (V_{1M}(X) + V_{0M}(X))}},$$

where $\bar{X}_{1M}$ (V_{1M}) is the mean (variance) in the treatment group and $\bar{X}_{0M}$ (V_{0M}) are the mean (variance) for the control group. For comparison, we also estimate the standardized bias for the unmatched sample.

Table 1. Number of Observations, Easements, and Potential Controls

	1997–2002	2002–2007	2007–2012	Total
PPR land in range or pasture 1982–1997	10,339	10,339	10,339	
In counties with one or more easements	5,516	5,516	5,516	16,548
Observations removed:				
Previously eased	183	416	551	1,150
Previously converted	0	178	266	444
Enrolled in:				
Conservation Reserve	8	11	11	30
Grassland Reserve	6	6	6	18
Wetland Reserve	0	0	0	0
Entered federal ownership	3	5	5	13
Missing covariates	63	54	48	165
Total	263	670	887	1,820
Number of observations	5,253	4,846	4,629	14,728
Eased during period	230	135	101	466
Possible controls	5,023	4,711	4,528	14,262

Because the probability of selection varies, each point has a weight that is roughly equal to the inverse probability of selection.

Given that FWS easements focus on land that (i) supports native vegetation and (ii) has no history of crop production, we restrict our dataset to NRI points that are classified as rangeland or pasture continuously from 1982 (the earliest NRI data) to 1997 (when our study begins), excluding lands cropped during 1982–1997. Native vegetation is not identified in NRI but is most likely to occur on rangeland, which is defined (in part) as "a land cover/use category on which the climax or potential plant cover is composed principally of native grasses, grass like plants, forbs, or shrubs suitable for grazing and browsing, and introduced forage species that are managed like rangeland" (U.S. Department of Agriculture, Natural Resource Conservation Service and Iowa State University Center for Survey Statistics and Methodology, 2015). We also include pasture because some easements are located on land classified as pasture in NRI: "a land cover/use category of land managed primarily for the production of introduced forage plants for livestock grazing. Pastureland cover may consist of a single species in a pure stand, a grass mixture, or a grass-legume mixture" (U.S. Department of Agriculture, Natural Resource Conservation Service and Iowa State University Center for Survey Statistics and Methodology, 2015). A total of 10,339 NRI points meet these criteria in the Prairie Pothole Region (PPR). We include 5,516 NRI points in North Dakota and South Dakota counties where easements were purchased after 1997 but before the end of 2012.

The NRI provides data on broad land-use categories for 1997, 2002, 2007, and 2012. Using these data, we define three time periods: 1997–2002, 2002–2007, and 2007–2012. So, $Y_{0t'}$=1 for land that is in grass and not under easement at the early date for one of these time periods. Likewise, $Y_{0t} = 1$ for land that is in grass at the late date for one of these time periods. An NRI point is considered "treated" for a particular period when the point falls within easement boundaries[5] and the easement enrollment date (t_e) falls within the period ($t' < t_e \leq t$), where t' is the early date (1997, 2002, or 2007) and t is the later date (2002, 2007, or 2012). For example, an NRI point that falls within the boundaries of an easement that was enrolled in 2000 would be considered treated for the 1997–2002 period. Our data include 466 NRI points with an easement purchased after 1997 but before the end of 2012 (table 1).

[5] The FWS Habitat and Population Evaluation Team (HAPET) office develops easement boundaries based on the map developed for the legal easement agreement. HAPET uses a rigorous standardized process that is reviewed by multiple FWS personnel, including field personnel who play a role in identifying tracts for easement purchase. The information is also used annually for easement enforcement activities and, as a result, has been verified for accuracy. Any errors identified are corrected.

In any one of our three time periods, an NRI point is considered a potential control observation if it is (i) not under easement at any time during the period, (ii) still in grass at the beginning of the period, and (iii) not enrolled in another program that might preclude conversion to another use (table 1). Over all three periods, our data include 14,262 control observations.

Programs that could place a limit on the conversion of grassland to another use include the Conservation Reserve Program (CRP), Grassland Reserve Program (GRP), and the Wetland Reserve Program (WRP). NRI points on land enrolled in these programs are excluded from the pool of control observations. CRP enrollment is identified in NRI. We excluded thirty observations where land that entered CRP before or during a given period (without first being converted to crops). GRP (2003–2013)[6] and WRP (1996–2013) are not identified in the NRI data. We linked NRI points to Farm Service Agency (FSA) acreage reporting data, which include field-level information on program participation. Given that reported acreages were for 2013, any GRP or WRP contract entered into between 2004 and 2013, with a minimum length of ten years, would have been identified in the FSA data. We exclude eighteen observations enrolled in GRP; none of the observations in our data was enrolled in WRP (table 1). We also exclude thirteen observations that entered federal ownership during any one of our three periods (table 1). While federal ownership does not necessarily imply conservation or conversion, NRI does not include information on federal land.

We define grassland conversion as a change in land use classification that would not be allowed under easement. Land use classifications that signal conversion include cultivated cropland, non-cultivated cropland (e.g., hay), farmsteads, forest, mining, roads, and residential or commercial development. Other reclassifications, including marshland and small water bodies, could be explained as the expansion of wetland area (in wet years, for example) or the construction of ponds for livestock water. Neither is considered a violation of the grassland easement, and these are not counted as conversions in our analysis.

Based on the NRI points included in our study, we estimate that there were 10.078 million acres of grassland in our study region in 1997 (table 2). By the end of 2012, 861,900 acres (8.6%) were under FWS easements, 518,300 acres (5.1%) had been converted to cropland, and 569,800 acres (5.7%) had been converted to any non-grassland use (including cropland).

Covariates used for matching represent factors affecting the decision to make an easement offer, the amount of the offer, the likelihood of landowner acceptance, and the profitability of converting land to crop production (Online Supplement table A1). GIS data on duck pair priority zones and Grassland Bird Conservation Areas (GBCA) was obtained from FWS and linked to all NRI grassland points. We include a binary variable for each level of duck pair access (zone 1, 2, or 3) for tracts where the NRI points are located (not all land is in a priority zone). While there are three types of GBCAs, the FWS habitat assessment uses the type-3 GBCA, which encompasses the other two GBCA classes. Therefore, we include a single binary variable that equals 1 if the tract is in a type-3 GBCA.

Data on land characteristics affecting the likelihood of grassland to cropland conversion were drawn from a number of sources. Several previous studies have shown that Land Capability Classification (LCC) is a good indicator of the suitability of land for crop production and grassland-to-cropland conversion (e.g., Lubowski, Plantinga, and Stavins, 2008; Stephens et al., 2008; Rashford, Walker, and Bastian, 2011). The LCC system places land in one of eight classes, where class 1 is most suitable for crop production and class 8 is unsuitable for crops (Klingebiel and Montgomery, 1961). LCC is obtained directly from the NRI data. For each observation, we include a binary indicator that is equal to 1 when land is in LCC 1 or 2 and a second binary indicator that is equal to 1 when land is in LCC 6, 7, or 8. Given that relatively few easements have been purchased on land classified as pasture (see table 2 for acreage estimates), we also include a binary indicator for pasture.

[6] GRP and WRP were consolidated into the Agricultural Conservation Easement Program (ACEP) as part of the Agricultural Act of 2014.

Table 2. Grassland, Easements, and Converted Acreage

Time Period	N	Uneased in Early Year	Eased by Late Year	Converted (Crops) by Late Year	Converted (All) by Late Year
			Rangeland Acres (000s)		
1997–2002	4,715	9,093.5	393.5	123.6	129.9
		(290.9)	(61.3)	(14.5)	(17.6)
2002–2007	4,388	8,558.6	264.2	82.9	98.6
		(274.2)	(51.2)	(20.2)	(14.3)
2007–2012	4,192	8,195.8	158.7	91.4	113.0
		(261.6)	(35.9)	(52.1)	(51.8)
			Pasture Acres (000s)		
1997–2002	538	985.3	20.8	148.0	150.4
		(83.5)	(14.2)	(27.8)	(27.7)
2002–2007	458	814.1	8.9	18.4	21.3
		(83.0)	(15.7)	(17.1)	(6.3)
2007–2012	437	783.9	15.8	54.0	56.6
		(83.8)	(29.1)	(6.1)	(21.6)
			All Grassland Acres (000s)		
1997–2002	5,253	10,078.8	414.3	271.6	280.3
		(302.6)	(61.6)	(38.8)	(39.6)
2002–2007	4,846	9,372.7	273.1	101.3	119.9
		(284.0)	(57.3)	(14.2)	(15.1)
2007–2012	4,629	8,979.7	174.5	145.4	169.6
		(265.2)	(44.8)	(54.2)	(53.9)
1997–2012	5,253	10,078.8	861.9	518.3	569.8
		(302.6)	(104.8)	(68.6)	(72.0)
			All Grassland with LCC 1-3		
1997–2012	2,422	4,660.2	384.6	406.8	425.0
		(226.5)	(62.4)	(52.9)	(62.2)
			All Grassland with LCC 4–8		
1997–2012	2,831	5418.6	477.3	111.5	144.8
		(240.2)	(77.4)	(26.8)	(37.7)

Notes: Numbers in parentheses are standard errors.

Other land characteristics found to be important in previous studies include slope, the standard deviation of slope (Stephens et al., 2008), and the area and dispersion of wetlands (Gelso, Fox, and Peterson, 2008; Stephens et al., 2008). These measures were constructed for the easement area (where easements are in place) and the Farm Service Agency (FSA) tract (where easements are not in place).[7] Measures of average slope and the standard deviation of slope were constructed for each FSA tract or easement area using 90-meter-resolution digital elevation models. Digital data on wetland boundaries, wetland type, and hydro-period were obtained from the FWS National Wetlands Inventory (NWI). For each tract or easement, we created an index incorporating wetland area and dispersion: $I_w = A_{kw}C_{kw}/A_k$, where A_{kw} is wetland area at location k, C_{kw} is the wetland count, and A_k is tract or easement size. Tracts and easements with more wetlands or more widely dispersed wetlands have larger index values.

[7] An FSA tract is a contiguous area that is under a single ownership and within a single farming operation.

Covariates also include the difference in county-average expected net returns to crop production and grazing for the first year in each time period (1997, 2002, and 2007). The first year is used to ensure that only pre-easement data are included. Expected cropland revenue is based on corn, soybeans, winter wheat, and spring wheat. Following USDA Risk Management Agency (RMA) practice, the expected price for each crop is the average closing price for a harvest-month futures contract during a one-month period just before planting time. For example, the expected price of corn is the average closing price for the October CME Group contract during March. Expected yields are average yields during the most recent five-year period with the high and low yields removed. Crop-specific costs are based on operating costs published by the USDA Economic Research Service (USDA-ERS). Overall expected return to crop production is an acre-weighted average of crop-specific net returns using shares based on three-year moving average acreages for each crop (e.g., the 1997 estimate is based on crop acreage for 1994–96) .

Grassland returns are based on grazing in a cow-calf operation. Estimated forage yields were obtained from soil survey data maintained by the USDA Natural Resources Conservation Service. Forage yields are expressed as stocking rates (animal units per acre) using conversion factors developed from guidelines in Metz (2007). Data on revenue and (non-land) cost per animal unit were drawn from the cost and returns data published by the U.S. Department of Agriculture, Economic Research Service (2010). For any given year, expected revenue per animal unit (AU) is represented by the average revenue per AU for the previous three years. Net return is expected revenue less operating cost per AU for cow-calf operations in the Northern Plains, multiplied by the tract-specific yield (AU/acre).

The Population Interaction Index (PII) is included to account for the possibility that grassland will be used for development, roads, or other infrastructure. The PII provides a measure of accessibility to urban populations within a fifty-mile radius.[8] Likewise, distance to the nearest interstate highway (in meters) is a measure of the accessibility of land to the transportation network, which can also be important determinant of development potential.

Several factors that could affect easement offer acceptance cannot be linked to our data. For example, producer demographic characteristics (age, education); farm type or farm outputs; and attitudes about environmental protection, government programs, or permanent easements are not available in a form that can be related to NRI data. Of course, some of these characteristics could affect the decision to sell an easement and/or convert grassland to cropland or another use. For example, landowners who hold positive attitudes about environmental protection, are willing to participate in government conservation programs, or are committed to livestock production (which utilizes grazing land) may be more likely than other landowners to sell easements and less likely to convert grassland to other uses. Conversely, producers who focus mostly on crop production or have neutral or negative attitudes about the environment or government conservation programs may be less likely to sell an easement and more likely to convert grassland to another use. The effect of these issues on our estimate of the ATT depends on the distribution of these characteristics among landowners represented in the control group relative to the treatment group. If control observations include a larger share of landowners who are reluctant to sell easements for whatever reason, additionality estimates could be biased upward. While we cannot control for these differences in our model, we acknowledge that they could affect our results.

Model Estimation

Propensity Score Model

We estimated propensity scores by logit method using easement status as the dependent variable. Data from all three time periods (1997–2002, 2002–2007, and 2007–2012) are pooled and a fixed

[8] For details on the construction of the PII, see https://www.ers.usda.gov/data-products/population-interaction-zones-for-agriculture-piza/documentation/

effect is included to capture time period effects not captured by other covariates (Online Supplement table A2). The parameters for the period-specific indicators show that easements were more likely in 1997–2002 (230 easements) than in 2007–2012 (101 easements) and more likely in 2002–2007 (135 easements) than in 2007–2012. The parameter estimate for the pasture indicator is negative and significantly different from zero, reflecting the FWS preference for previously uncropped grassland that is typically classified as rangeland in NRI. The waterfowl habitat value priority zone parameters and the GBCA parameter are all positive and significantly different from zero, reflecting the preference for land with high habitat value. The wetland index parameter is positive and significant (including the effect of the squared term), indicating that land with a relatively large wetland area comprised of numerous wetlands dispersed throughout the tract is more likely to be eased. This result likely reflects the importance of small, dispersed wetlands to duck-pair access measures (Loesch, Reynolds, and Hansen, 2012) or the fact that land with widely dispersed wetland is perceived to be less valuable as cropland (Gelso, Fox, and Peterson, 2008).

The only other variables with statistically significant parameter estimates are the population interaction index (PII) and the PII squared. The marginal effect of the PII on the probability of easement is increasing when PII values are relatively low (less than 3,373 meters) but declines as values increase past that point and is greater than zero for all but the 178 observations with PIIs greater than 6,747. This result suggests that easements are more likely in areas with a medium PII, suggesting that easements are less likely in sparsely populated areas of the PPR but are also less likely where population density is high in and around larger cities. This may reflect the unwillingness of landowners near large cities to enter into easements on land that could eventually have value for residential or commercial development.

Parameter estimates associated with LCC and slope, which capture physical characteristics of land that make it suitable for crop production, are not statistically different from zero. This result is consistent with the fact that the potential for cropland conversion is considered only minimally, if at all, in easement acquisition. Parameter estimates for distance to interstate highways are not significantly different from zero, which may also indicate that proximity to transportation networks is not a consideration for either FWS or landowners.

Matching

As already noted, our primary estimates are obtained using a kernel-based estimator, although we also check covariate balance for a number of other matching techniques. For each technique, we impose exact matching on time period to ensure that our results are not biased due to differences in economic conditions not captured by model covariates. Exact matching is achieved by estimating matching weights using treated and control observations within each time period. As a robustness check, we also estimate entirely independent models for each time period. This and other robustness checks are discussed in the next section.

Bandwidth Selection

A popular method of selecting bandwidth in kernel density estimators is leave-out-one cross-validation (Black and Smith, 2004). In a Monte Carlo simulation study, however, Huber, Lechner, and Wunsch (2013) concluded that wider bandwidths, on average, offered a better balance between bias and variance in ATT estimates. Rather than rely on the leave-out-one cross-validation method, we evaluated a series of bandwidths for each matching method and selected a bandwidth based on covariate balance statistics typically used to validate matching. Our procedure is more transparent than the cross-validation technique, provides some insight on the sensitivity of bias to bandwidth selection, and relies on statistics that are widely used to validate matching models.

Table 3 provides a summary of balance statistics (based on the standardized difference and variance ratio for individual covariates) for a series of bandwidths used with the normal kernel

Table 3. Summary of Balance Statistics for Selected Bandwidths, Weights Based on Normal Kernel

	Standardized Difference (%, Absolute Value)			Variance Ratio	
Bandwidth	Mean	Median	Maximum	Minimum	Maximum
0.005	1.52	1.35	5.43	0.858	1.116
0.004	1.40	0.91	4.88	0.919	1.101
0.003	*1.39*	*0.94*	*4.39*	*0.917*	*1.086*
0.002	1.70	1.32	4.14	0.916	1.181
0.001	1.95	1.53	4.43	0.917	1.231

Notes: Italics indicate chosen bandwidth.

to devise matching weights. For every bandwidth in table 3, the kernel matching procedure yielded good balance on every variable. While no single bandwidth is best for all five balance measures, 0.003 is best or a close second in all measures, outperforming all other bandwidths. After matching, the highest standardized difference for any covariate is 4.4%, well under the maximum acceptable of standardized difference of 20%. The lowest and highest variance ratios for any covariate under any bandwidth are 0.92 and 1.09, respectively, within the acceptable bounds of 0.5 and 2.0. Standardized differences and variance ratios for each covariate in the matched and unmatched samples are given in Online Supplement table A3. For most variables, standardized differences are substantially closer to zero and variance ratios are substantially closer to one in the matched sample.

Post-Matching Regression and Survey Weighting

Post-matching regressions are often used to remove any remaining bias (Ho et al., 2007; Andam et al., 2008; Stuart, 2010; Robalino and Pfaff, 2013). Post-matching regression also provides the opportunity to incorporate survey weights in final estimates. In terms of survey weights, we follow the advice of DuGoff, Schuler, and Stuart (2014, p. 300): "... when estimating the ... [Population Average Treatment Effect on the Treated] PATT,[9] the weights are the product of the survey weight and the propensity score [matching] weight." We regress the outcome variable (the indicator of whether land is retained in grass) against the treatment variable (the easement indictor) and all variables included in the propensity score model. The regression is weighted using the product of matching weight and NRI survey weight.

Variance Estimation

For kernel matching, the bootstrap is one option for variance estimation. While Abadie and Imbens (2008, p. 1537) show that "the standard bootstrap fails to provide asymptotically valid standard errors" for nearest-neighbor matching with a fixed number of matches per treated observation, the bootstrap is appropriate for kernel-based estimates. For kernel-based matching estimators, which are asymptotically linear, Abadie and Imbens (2008, p. 1547) "anticipate that the bootstrap provides valid inference."

It is not clear, however, that a simple bootstrap can accurately account for the NRI survey design. The NRI data include twenty-nine sets of replicate weights designed for use with the delete-a-group jackknife (DAGJK) procedure (Kott, 2001). In each set of weights, a subset or "group" of observations have near-zero weights, effectively deleting them from the dataset. The DAGJK procedure is used to estimate standard errors for all estimates found in the 2012 NRI Summary Report (U.S. Department of Agriculture, Natural Resource Conservation Service and Iowa State University Center for Survey Statistics and Methodology, 2015) and has been validated for

[9] DuGoff, Schuler, and Stuart (2014) used PATT (population ATT) to distinguish estimates made using survey weights (which can be generalized to the population) from estimates made without survey weights (SATT or survey ATT) (which cannot be generalized beyond the survey sample).

estimating the variance of regression coefficients (Opsomer, Fuller, and Li, 2003). To our knowledge, however, the DAGJK has not been validated for use with any matching technique. Given that we do not use survey weights in estimating matching weights, however, variance due to estimation of matching weights cannot be accounted for with DAGJK. Nonetheless, a key question in the literature on matching is whether variance estimates need to account for the fact that matching weights are estimated (Stuart, 2010). We follow the advice of Stuart (2010) and Ho et al. (2007), who argue that variance estimates need not incorporate the fact that matching weights are estimated. We estimate variance using DAGJK with the post-matching regression using the NRI replicate weights.[10] In doing so, we err on the side of ensuring that our estimates accurately reflect the NRI survey design.

Results

Given a bandwidth of 0.003, our estimate of the ATT is 0.0142 (0.0022),[11] implying that, on average, 1.42% of eased grassland would have been converted over a five-year period, or an average annual rate of 0.28%. A naïve estimate of the ATT (the average rate of conversion on all uneased grassland) is 0.0207 (0.0025), implying that our estimate of the ATT would be significantly higher without the bias adjustment achieved by matching on observables. The post-matching regression (Online Supplement table A5) result is a small (statistically insignificant) change in the ATT estimate from 0.0147 without the post-matching regression to 0.0142 with the post-matching regression.

Estimation by Land Capability Class

As already noted, using Land Capability Class (LCC) as a measure of vulnerability to cropland conversion could improve additionality in a grassland easement program. The LCC has been shown to be an effective measure of the suitability of land for crop production (e.g., Lubowski, Plantinga, and Stavins, 2008; Stephens et al., 2008; Rashford, Walker, and Bastian, 2011). In the counties included in our study (PPR counties with grassland easements), 80% of grassland-to-cropland conversion observed between 1997 and 2012 occurred on land in LCC 1–3 (table 2).

To investigate the potential for improving additionality, we divided the data into two groups—land with LCC 1–3 and land with LCC 4–8—and estimated the ATT separately for each (see table 4 and model estimation details in Online Supplements E and F). As expected, the ATT estimate for LCC 1–3 land is higher than for our full model estimate (0.0186 vs. 0.0142), but the 95% confidence intervals for the two estimates have considerable overlap, implying that the difference between the results is not statistically significant. The estimate for LCC 4–8 land is lower than for the full model (0.0069 vs. 0.0142). The confidence intervals for the LCC 1–3 and LCC 4–8 models do not overlap, implying that additionality is significantly higher for LCC 1–3 land than for LCC 4–8 land.

These result suggest that additionality could be improved by targeting grassland that is vulnerable to cropland conversion. We note, however, that these lands may also be more costly to enroll (because they are more productive) and habitat value will vary. Therefore, program managers may want to consider LCC (or any measure of conversion vulnerability) in the context of habitat value and cost.

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[10] Specifically, the delete-a-group jackknife variance estimator for NRI data is $V_{ATT} = \sum_{m=1}^{29} \left(ATT_m - \overline{ATT}\right)^2$, where ATT_m is the ATT estimate given the mth set of replicate weights and $\overline{ATT} = \frac{1}{29} \sum_{m=1}^{29} ATT_m$ is the average of the estimate using the replicate weights.

[11] Standard errors are in parentheses. For the purpose of comparison, we also estimated the standard error using a bootstrap with 200 replications. The bootstrap estimate is 0.0018, slightly lower than our delete-a-group jackknife estimate. Bootstrap estimates for all models are reported in footnotes to Online Supplement tables A6 and A7.

Table 4. Comparison of ATT Estimates for the Full Dataset and Data by Land Capability Class

Dataset	Full	LCC 1–3	LCC 4–8
Observations	14,728	6,693	8,035
Eased observations	466	215	251
On support	465	215	247
Bandwidth	0.003	0.004	0.003
Balance statistics			
Max standardized diff	4.39	7.26	5.43
Min variance ratio	0.92	0.86	0.89
Max variance ratio	1.09	1.70	1.17
ATT			
Estimate	0.0142**	0.0186**	0.0069**
Standard error	0.0022	0.0037	0.0014
t-statistic	6.6	5.0	4.9
95% C.I. lower bound	0.0100	0.0113	0.0042
95% C.I. upper bound	0.0184	0.0259	0.0096

Notes: Single and double asterisks (*, **) indicate significance at the 5% and 1% level. For comparison, bootstrap standard errors are 0.0018 for the full model, 0.0034 for LCC 1-3, 0.0015 for LCC 4–8.

Table 5. Balance Statistics for Alternate Matching Methods

			Standardized Difference (%, Absolute Value)			Variance Ratio		
Matching Method	Bandwidth	# Match	Mean	Median	Max	Min	Max	ATT Estimate
PSM, normal kernel	0.003		1.39	0.94	4.39	0.917	1.086	0.0142
PSM, Epan kernel	0.007		1.36	0.86	4.39	0.917	1.083	0.0143
PSM, local linear	0.004		1.22	0.79	3.97	0.921	1.083	0.0143
PSM, NN		5	2.25	1.00	8.78	0.905	1.689	0.0123
Mahalanobis, NN		2	2.96	0.75	12.42	0.996	1.251	0.0112

Effect of Easements on Land Use Conversion Rate

Identifying NRI points on eased grassland also shows the effect of easements on the estimated rate of grassland conversion. In 2012, PPR counties with at least one easement had 9.51 million acres of grassland with roughly 862,000 acres under easement. Any estimated rate of grassland conversion using total grassland, rather than uneased grassland, in the denominator underestimates the conversion rate. For example, conversion of 500,000 acres from 2012 grassland area would imply a conversion rate of 5.3% when easements are not considered ($500/9,509 = 0.053$), but the conversion rate is actually 5.8% when only uneased land is considered ($500/(9,509 - 862) = 0.058$).

Robustness Checks

To check the robustness of our approach to matching, we compare covariate balance using four other methods (table 5). Each alternate method yielded an acceptable level of balance for all covariates. The Epanechnikov kernel and local linear methods produced very similar results. Nearest neighbor methods were better for some balance measures but worse in terms of other measures. More detail on balance statistics for the alternative models is given in Online Supplement table A4.

To check whether some eased tracts have very few potential matches, we graphed the distribution of propensity scores for eased and uneased tracts (Online Supplement figure A1). For propensity scores under 0.15, the number of potential matches appears to be more than sufficient. For propensity scores above 0.15, however, the number of control observations is more limited. Following Black and Smith (2004) we re-estimated the full model after removing all observations with propensity scores greater than 0.15. A total of 181 observations were removed from the dataset, including 27 observations on eased land, leaving 14,547 total observations and 439 with easements. The ATT estimated using the restricted model is well within one standard deviation of the original estimate (0.0153 vs. 0.0142, a difference of 0.0011), while the standard error of the estimate is slightly higher (0.0023 vs. 0.0022). In the restricted model, all standardized differences are 8.33% or less (in absolute value) and all variance ratios are between 0.52 and 1.02. These results confirm that the apparent lack of uneased observations with propensity scores > 0.15 does not significantly affect the estimated ATT while covariate balance remains within the acceptable range for all covariates.

As a further robustness check, we estimate the ATT independently for each of our three time periods: 1997–2002, 2002–2007, and 2007–2012 (Online Supplement table A6). When compared our primary estimate, we find that the ATT is roughly the same for the 1997–2002 (0.0145 (0.0040)) and 2007–2012 (0.0148 (0.0062)) and somewhat lower for 2002–2007 (0.0089 (0.0025)) . For each model, we graphed the propensity scores to check for significant mismatch in the number of treated and control observations (Online Supplement figures B1, C1, and D1). We re-estimated the 1997–2002 model without propensity scores > 0.15 but found that removing these observations resulted in very little change in our estimate of the ATT; all covariates remained in balance. Finally, we note that not all covariates meet the standards for good balance in the 2007–2012 model. All standardized differences are 10.3% or less, but three variables have variance ratios outside of the interval 0.5 to 2.0 (Online Supplement table D3).

Discussion and Conclusion

We find that the FWS-managed grassland easement program in North and South Dakota is preserving habitat that would otherwise be lost. Our results suggest that grasslands eased during 1997–2012 would have been lost at an average annual rate of 0.28% in the absence of the easement. At that rate, given 861,900 acres under easement, roughly 2,450 acres of grassland habitat would be lost each year in the absence of the easements. While this is a low rate of additionality, grassland easements are permanent and additionality is cumulative over time. The rate of additionality could also increase (or decrease) over time as a function of technical change and/or market prices that encourage more rapid (less rapid) expansion of crop production at some future time. If the average annual rate of habitat protection continued at 2,450 acres/year, 24,500 acres would preserved over a ten-year period and 122,500 acres over a fifty-year period. If an easement is purchased for $300/acre today (abstracting from any enforcement costs) and reduces habitat loss at our estimated rate, the cost per acre of habitat preserved over fifty years would be roughly $2,115.

It may be possible to improve additionality. The propensity score models suggest that easement selection criteria are effective in directing enrollment toward high-quality habitat for waterfowl. Our estimate of the ATT, however, is below the "naïve" estimate (0.0207), implying that grassland under easement would have been less likely to be converted to another use (in the absence of the easement) than all remaining (uneased) grassland. Eased lands appear to have a wide range of conversion potential, as evidenced by a wide range of LCCs (table 2). Given that land conversion rates vary widely across LCCs, prioritizing easements on land with higher potential for conversion to cropland (low LCC) could improve additionality. Our estimates of the ATT do, in fact, suggest that higher ATT could be attained by focusing easement acquisition on low-LCC land. For LCC 1–3 land eased during 1997–2012, our results suggest that grassland would have been lost at an average annual rate of 0.37%. While this rate of additionality is still low, it implies habitat protection of roughly 3,200 acres/year rather than the 2,460 acres for the current program as implied by our analysis. For an easement purchased for \$300/acre today, the cost per acre of habitat preserved over fifty years would be roughly \$1,615, \$500 (30%) less than the cost per acre (\$2,115) estimated using our ATT estimate for the existing easement program. Our estimates imply that easements on LCC 4–8 would cost more than \$4,350 per preserved acre.

Of course, the possibility of higher additionality must be considered along with the availability, cost, and habitat value of land that is more vulnerable to conversion. Additionality may be limited because at least two-thirds of the funds available for purchasing easements must be expended each year and options may not be available on land with high conversion risk during that year. While quality waterfowl habitat has been eased, opportunities to purchase easements on grassland with a higher probability of conversion may have been limited. While 3.85 million acres of grassland with LCC 1–3 were still uneased in 2012 in counties that already have easements, further restricting the scope of easement acquisition activities may or may not be feasible depending on the willingness of landowners to accept easements on land with relatively high conversion potential. Nonetheless, our analysis suggests that habitat preserved under easement on LCC 1–3 land is more than twice as likely to be additional when compared to easements on LCC 4–8 land ($0.0184/0.0069 = 2.7$). To the extent that tracts of similar habitat quality are being considered, our results suggest that incorporating LCC into easement acquisition decisions could increase additionality. For equivalent habitat, LCC 1–3 may be more costly to ease but could yield higher habitat preservation.

Finally, estimates of the rate of grassland conversion using the NRI data (or any other land-use data) are influenced by the presence of FWS habitat easements. When estimating rates of rangeland loss, either annual or cumulative, excluding private lands protected by perpetual easements from estimates of total rangeland available for conversion will avoid downward bias in estimates of conversion rate.

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Online Supplement A: Supplemental Tables

Table A1. Descriptive Statistics

	Eased (N=466)		Controls (N=14,262)	
	Mean	Standard Deviation	Mean	Standard Deviation
Land Capability Class 1–2	0.29	0.45	0.28	0.45
Land Capability Class 3–5	0.33	0.47	0.34	0.47
Land Capability Class 6–8	0.37	0.48	0.38	0.48
Pasture	0.05	0.22	0.09	0.29
Priority Zone 1	0.77	0.42	0.47	0.50
Priority Zone 2	0.14	0.35	0.20	0.40
Priority Zone 3	0.07	0.25	0.15	0.36
Grassland Bird Cons. Area	0.83	0.38	0.66	0.47
Population Interaction Index	1,346	855	1,485	1,295
Distance to Interstate Hwy	77,741	52,423	82,988	54,451
Wetland Index	2.53	3.65	1.02	2.10
Average Slope	1.93	1.13	2.52	1.92
Standard Deviation of Slope	0.87	0.49	1.05	0.77
Relative Return to Cropland	103.33	87.38	124.67	97.86

Table A2. Propensity Score Model Parameter Estimates

	Estimate	Standard Error	t-statistic
Indicator 1997–2002 Period	1.0343**	0.2799	3.69
Indicator 2002–2007 Period	0.5980*	0.2998	1.99
Land Capability Class 1–2	0.1199	0.1191	1.01
Land Capability Class 6–8	0.0788	0.1211	0.65
Pasture	−0.6093**	0.2095	−2.91
Priority Zone 1	2.0266**	0.3105	6.53
Priority Zone 2	1.4738**	0.3210	4.59
Priority Zone 3	1.1315**	0.3403	3.32
Grassland Bird Cons. Area	1.0064**	0.1293	7.78
Population Interaction Index	0.0003*	0.0001	2.33
Population Interaction Index, Squared	0.0000*	0.0000	−2.11
Distance to Interstate Hwy.	0.0000	0.0000	−0.52
Distance to Interstate Hwy., Squared	0.0000	0.0000	−0.62
Wetland Index	0.1808**	0.0345	5.25
Wetland Index, Squared	−0.0057**	0.0021	−2.69
Average Slope	−0.1751	0.1954	−0.90
Average Slope, Squared	−0.0019	0.0269	−0.07
Standard Deviation of Slope	0.8316	0.4884	1.70
Standard Deviation of Slope, Squared	−0.2774	0.1670	−1.66
Relative Return to Cropland	0.0019	0.0026	0.75
Relative Return to Cropland, Squared	0.0000	0.0000	−0.06
Constant	−7.0152**	0.5484	−12.79
Number of Observations	14,728		
Number of Easements	466		
Log-Likelihood	-1,852.62		
Likelihood ratio	430.35		

Notes: Single and double asterisks (*, **) indicate significance at the 5% and 1% level.

Table A3. Balance Statistics for Propensity Score, Normal Kernel

	Standardized Difference (%)		Variance Ratio	
	Unmatched	**Matched**	**Unmatched**	**Matched**
Land Capability Class 1–2	5.9	−0.2	1.05	1.00
Land Capability Class 6–8	−5.5	0.5	0.97	1.00
Pasture	−16.1	−0.1	0.59	1.00
Priority Zone 1	64.1	−2.0	0.76	1.02
Priority Zone 2	−11.8	1.5	0.81	1.03
Priority Zone 3	−26.3	−0.9	0.51	0.97
Grassland Bird Cons. Area	39.0	1.2	0.63	0.98
Population Interaction Index	−10.1	3.3	0.44	1.04
Population Interaction Index, Squared	−15.8	2.4	0.17	1.06
Distance to Interstate Hwy.	−8.9	−2.5	0.92	0.99
Distance to Interstate Hwy., Squared	−10.1	−2.3	0.80	0.92
Wetland Index	49.3	4.4	3.22	1.09
Wetland Index, Squared	30.5	3.0	4.79	0.98
Average Slope	−38.9	0.5	0.34	1.02
Average Slope, Squared	−36.4	0.6	0.14	1.07
Standard Deviation of Slope	−31.5	0.0	0.40	1.00
Standard Deviation of Slope, Squared	−29.2	0.0	0.15	1.08
Relative Return to Cropland	−19.6	−0.3	0.83	0.98
Relative Return to Cropland, Squared	−17.7	−0.8	0.80	1.02

Table A4. Balance Statistics for Selected Bandwidths, Number of Matches

		Standardized Difference (%, Absolute Value)			Variance Ratio	
Bandwidth	**# Matches**	**Mean**	**Median**	**Maximum**	**Minimum**	**Maximum**
Propensity Score; Normal Kernel						
0.005		1.52	1.35	5.43	0.858	1.116
0.004		1.40	0.91	4.88	0.919	1.101
0.003		*1.39*	*0.94*	*4.39*	*0.917*	*1.086*
0.002		1.70	1.32	4.14	0.916	1.181
0.001		1.95	1.53	4.43	0.917	1.231
Propensity Score; Epanechnikov Kernel						
0.009		1.45	1.14	4.93	0.920	1.104
0.008		1.39	0.82	4.69	0.918	1.097
0.007		*1.36*	*0.86*	*4.39*	*0.917*	*1.083*
0.006		1.40	0.94	4.06	0.915	1.114
0.005		1.57	1.10	4.08	0.915	1.162
Propensity Score, Local Linear, Normal Kernel						
0.006		1.38	1.40	4.38	0.799	1.113
0.005		1.29	1.03	4.21	0.887	1.100
0.004		*1.22*	*0.79*	*3.97*	*0.921*	*1.083*
0.003		1.38	0.97	3.68	0.919	1.104
0.002		1.64	1.27	3.98	0.917	1.194
Propensity Score, Nearest Neighbor						
	5	2.25	1.00	8.78	0.905	1.689
	6	2.15	1.64	7.45	0.928	1.570
	7	*2.50*	*1.57*	*6.72*	*0.910*	*1.472*
	8	2.34	1.63	6.11	0.917	1.423
	9	2.46	2.01	6.35	0.914	1.446
Mahalanobis Distance, Nearest Neighbor						
	1	2.82	1.42	12.33	0.994	1.242
	2	*2.96*	*0.75*	*12.42*	*0.996*	*1.251*
	3	3.30	0.79	12.95	0.999	1.258
	4	3.69	1.42	13.87	0.982	1.263
	5	3.49	0.94	12.53	0.986	1.251

Notes: Italics indicate chosen bandwidth or number of matches.

Table A5. Post-Matching Regression Results

	Estimate	Standard Error	t-Statistic
Easement Indicator	0.0142**	0.0014	10.01
Indicator 1997–2002 Period	0.0026	0.0041	0.63
Indicator 2002–2007 Period	0.0059	0.0045	1.32
Land Capability Class 1–2	−0.0062**	0.0018	−3.41
Land Capability Class 6–8	0.0019	0.0018	1.06
Pasture	−0.0347**	0.0032	−10.83
Priority Zone 1	−0.0051	0.0056	−0.91
Priority Zone 2	−0.0080	0.0057	−1.40
Priority Zone 3	−0.0070	0.0060	−1.17
Grassland Bird Cons. Area	0.0155**	0.0019	8.08
Population Interaction Index	0.0000	0.0000	−0.91
Population Interaction Index, Squared	0.0000	0.0000	0.63
Distance to Interstate Hwy.	0.0000	0.0000	−0.64
Distance to Interstate Hwy., Squared	0.0000	0.0000	0.31
Wetland Index	0.0016**	0.0005	3.25
Wetland Index, Squared	−0.0001*	0.0000	−2.48
Average Slope	0.0020	0.0029	0.70
Average Slope, Squared	−0.0002	0.0004	−0.42
Standard Deviation of Slope	0.0038	0.0066	0.58
Standard Deviation of Slope, Squared	−0.0010	0.0021	−0.50
Relative Return to Cropland	0.0001	0.0000	1.38
Relative Return to Cropland, Squared	0.0000	0.0000	−1.08
Constant	0.9705	0.0089	108.86
Number of Observations	14,725		
Number of Easements	465		
F	17.43		
Adjusted R^2	0.02		

Notes: Single and double asterisks (*, **) indicate significance at the 5% and 1% level.

Table A6. Comparison of ATT Estimates for the Full Dataset and by Time Period

Dataset:	Full	1997–2002	2002–2007	2007–2012
N Observations	14,728	5,253	4,846	4,629
Eased Observations	466	230	135	101
On Support	465	230	135	97
Bandwidth	0.003	0.006	0.004	0.002
Balance Statistics				
Max Standardized Diff	4.39	4.04	3.30	10.31
Min Variance Ratio	0.92	0.92	0.76	0.27
Max Variance Ratio	1.09	1.28	1.09	1.06
ATT				
Estimate	0.0142**	0.0145**	0.0089**	0.0148**
Standard Error	0.0022	0.0040	0.0020	0.0062
t-statistic	6.6	3.6	4.5	2.4
95% C.I. Lower Bound	0.0100	0.0067	0.0050	0.0026
95% C.I. Upper Bound	0.0184	0.0223	0.0128	0.0270

Notes: Single and double asterisks (*, **) indicate significance at the 5% and 1% level. For comparison, bootstrap standard errors are 0.0018 for the full model, 0.0028 for 1997–2002, 0.0024 for 2002–2007, and 0.0053 for 2007–2012.

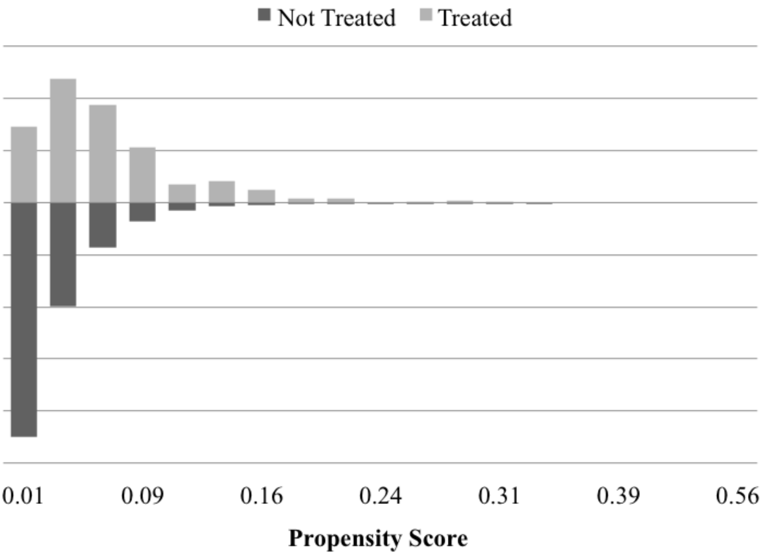

Figure A1. Distribution of Propensity Scores for Treated (Eased) and Untreated (Control) Observations

Online Supplement B: Estimation Results for 1997–2002

Table B1. Propensity Score Model Parameter Estimates, 1997–2002

	Estimate	Standard Error	t-statistic
Land Capability Class 1–2	0.3450*	0.1746	1.98
Land Capability Class 6–8	0.2648	0.1779	1.49
Pasture	−0.6405*	0.3003	−2.13
Priority Zone 1	1.2269**	0.3747	3.27
Priority Zone 2	1.3059**	0.3795	3.44
Priority Zone 3	0.9636*	0.4059	2.37
Grassland Bird Cons. Area	1.2428**	0.1985	6.26
Population Interaction Index	0.0005*	0.0002	2.21
Population Interaction Index, Squared	0.0000*	0.0000	−2.39
Distance to Interstate Hwy.	0.0000	0.0000	−0.88
Distance to Interstate Hwy., Squared	0.0000	0.0000	0.61
Wetland Index	0.1868**	0.0497	3.76
Wetland Index, Squared	−0.0034	0.0028	−1.23
Average Slope	−0.4378	0.2419	−1.81
Average Slope, Squared	0.0321	0.0291	1.1
Standard Deviation of Slope	1.7360*	0.7288	2.38
Standard Deviation of Slope, Squared	−0.6425*	0.2661	−2.41
Relative Return to Cropland	0.0011	0.0127	0.09
Relative Return to Cropland, Squared	0.0000	0.0001	0.31
Constant	−6.0897**	0.7050	−8.64
Number of Observations	5,253		
Number of Easements	230		
Log-Likelihood	−847.32		
Likelihood ratio	194.24		

Notes: Single and double asterisks (*, **) indicate significance at the 5% and 1% level.

Table B2. Balance Statistics for Selected Bandwidths, Normal Kernel Matching, 1997–2002

	Standardized Difference (%, Absolute Value)			Variance Ratio	
Bandwidth	Mean	Median	Maximum	Minimum	Maximum
0.009	2.29	2.00	4.87	0.739	1.316
0.008	2.11	1.92	4.60	0.809	1.302
0.007	2.00	1.94	4.32	0.881	1.284
0.006	*2.09*	*2.04*	*4.04*	*0.915*	*1.280*
0.005	2.18	2.27	3.77	0.916	1.356
0.004	2.30	2.43	3.48	0.917	1.401
0.003	2.41	2.39	3.76	0.916	1.416

Notes: Italics indicate chosen bandwidth.

Table B3. Balance Statistics for Propensity Score, Normal Kernel Matching, 1997–2002

	Standardized Difference (%)		Variance Ratio	
	Unmatched	**Matched**	**Unmatched**	**Matched**
Land Capability Class 1–2	8.6	1.8	1.07	1.01
Land Capability Class 6–8	1.7	2.0	1.01	1.01
Pasture	−17.7	−1.8	0.57	0.93
Priority Zone 1	40.2	1.7	0.91	0.99
Priority Zone 2	3.4	−2.1	1.05	0.97
Priority Zone 3	−17.7	−3.3	0.66	0.91
Grassland Bird Cons. Area	48.5	−0.5	0.53	1.01
Population Interaction Index	−12.9	2.9	0.37	1.02
Population Interaction Index, Squared	−18.8	2.0	0.12	1.28
Distance to Interstate Hwy.	0.4	2.2	1.04	1.04
Distance to Interstate Hwy., Squared	1.6	3.1	0.97	0.93
Wetland Index	50.3	4.0	4.83	1.07
Wetland Index, Squared	37.6	3.0	8.91	1.26
Average Slope	−36.1	−0.7	0.38	1.06
Average Slope, Squared	−33.8	0.6	0.16	1.01
Standard Deviation of Slope	−30.5	0.7	0.37	1.05
Standard Deviation of Slope, Squared	−29.8	1.4	0.10	0.95
Relative Return to Cropland	−3.4	2.9	0.80	1.03
Relative Return to Cropland, Squared	−6.4	3.0	0.59	0.96

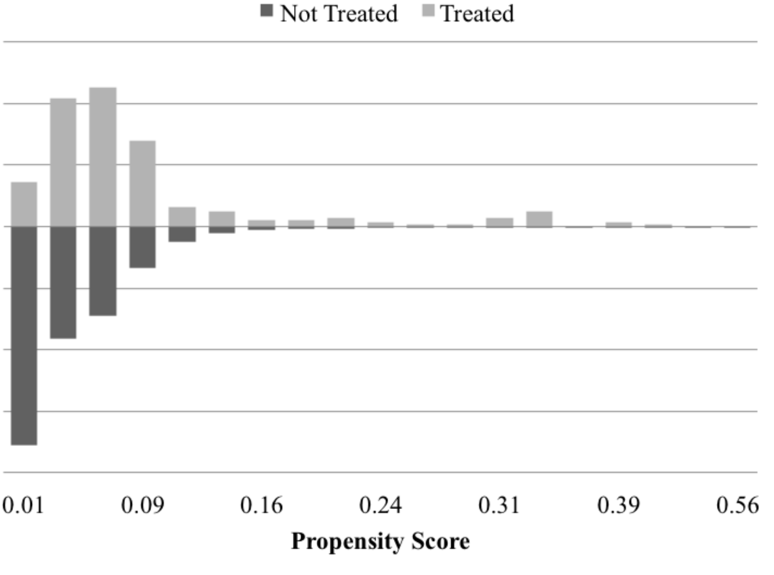

Figure B1. Distribution of Propensity Scores for Treated (Eased) and Untreated (Control) Observations, 1997–2002

Table B4. Post-Matching Regression Results, 1997–2002

	Estimate	Standard Error	t-statistic
Easement indicator	0.0145**	0.0024	5.93
Land Capability Class 1–2	−0.0089**	0.0032	−2.81
Land Capability Class 6–8	−0.0008	0.0031	−0.25
Pasture	−0.0580**	0.0054	−10.74
Priority Zone 1	−0.0036	0.0083	−0.44
Priority Zone 2	−0.0125	0.0083	−1.51
Priority Zone 3	−0.0038	0.0087	−0.43
Grassland Bird Cons. Area	0.0241**	0.0037	6.52
Population Interaction Index	0.0000	0.0000	1.00
Population Interaction Index, Squared	0.0000	0.0000	−0.76
Distance to Interstate Hwy.	0.0000	0.0000	0.06
Distance to Interstate Hwy., Squared	0.0000	0.0000	0.01
Wetland Index	0.0020*	0.0009	2.17
Wetland Index, Squared	−0.0001*	0.0001	−1.97
Average Slope	0.0062	0.0046	1.34
Average Slope, Squared	−0.0004	0.0006	−0.65
Standard Deviation of Slope	−0.0116	0.0130	−0.89
Standard Deviation of Slope, Squared	0.0039	0.0047	0.83
Relative Return to Cropland	0.0001	0.0002	0.41
Relative Return to Cropland, Squared	0.0000	0.0000	−0.43
Constant	0.9614**	0.0142	67.56
Number of Observations	14,725		
Number of Easements	230		
F	17.43		
Adjusted R^2	0.02		

Notes: Single and double asterisks (*, **) indicate significance at the 5% and 1% level.

Online Supplement C: Estimation Results for 2002–2007

Table C1. Propensity Score Model Parameter Estimates, 2002–2007

	Estimate	Standard Error	t-statistic
Land Capability Class 1–2	0.0666	0.2250	0.3
Land Capability Class 6–8	0.0888	0.2242	0.4
Pasture	−0.7622	0.4296	−1.77
Priority Zone 1	15.5579	774.1398	0.02
Priority Zone 2	14.1578	774.1398	0.02
Priority Zone 3	14.2125	774.1398	0.02
Grassland Bird Cons. Area	0.8582**	0.2330	3.68
Population Interaction Index	0.0002	0.0002	1.14
Population Interaction Index, Squared	0.0000	0.0000	−0.44
Distance to Interstate Hwy.	0.0000	0.0000	1.46
Distance to Interstate Hwy., Squared	0.0000*	0.0000	−2.09
Wetland Index	0.2928**	0.0970	3.02
Wetland Index, Squared	−0.0229*	0.0102	−2.26
Average Slope	0.2923	0.3691	0.79
Average Slope, Squared	−0.0530	0.0505	−1.05
Standard Deviation of Slope	−0.1380	0.7903	−0.17
Standard Deviation of Slope, Squared	0.1178	0.2315	0.51
Relative Return to Cropland	−0.0013	0.0127	−0.1
Relative Return to Cropland, Squared	0.0000	0.0001	0.24
Constant	−20.1336	774.1400	−0.03
Number of Observations	4,846		
Number of Easements	131		
Log-Likelihood	−536.32		
Likelihood ratio	160.33		

Notes: Single and double asterisks (*, **) indicate significance at the 5% and 1% level.

Table C2. Balance Statistics for Selected Bandwidths, Normal Kernel Matching, 2002–2007

	Standardized Difference (%, Absolute Value)			Variance Ratio	
Bandwidth	Mean	Median	Maximum	Minimum	Maximum
0.007	1.56	1.26	5.80	0.701	1.043
0.006	1.36	1.15	4.58	0.720	1.057
0.005	1.28	1.02	3.41	0.740	1.073
0.004	*1.23*	*0.94*	*3.30*	*0.761*	*1.091*
0.003	1.18	1.30	3.21	0.786	1.109
0.002	1.07	1.13	3.03	0.829	1.132
0.001	1.29	1.21	3.64	0.920	1.164

Notes: Italics indicate chosen bandwidth.

Table C3. Balance Statistics for Propensity Score, Normal Kernel Matching, 2002–2007

	Standardized Difference (%)		Variance Ratio	
	Unmatched	**Matched**	**Unmatched**	**Matched**
Land Capability Class 1–2	1.0	0.7	1.01	1.01
Land Capability Class 6–8	−2.9	0.1	0.98	1.00
Pasture	−20.3	1.1	0.49	1.05
Priority Zone 1	92.8	2.3	0.51	0.96
Priority Zone 2	−33.3	−0.9	0.48	0.97
Priority Zone 3	−28.6	−0.6	0.47	0.98
Grassland Bird Cons. Area	33.7	−0.7	0.68	1.01
Population Interaction Index	−8.5	0.8	0.56	0.98
Population Interaction Index, Squared	−12.2	0.0	0.28	0.76
Distance to Interstate Hwy.	−9.7	1.2	0.77	1.00
Distance to Interstate Hwy., Squared	−15.8	0.9	0.59	0.91
Wetland Index	49.8	3.3	1.45	1.02
Wetland Index, Squared	20.7	1.8	0.79	1.09
Average Slope	−29.2	−0.9	0.40	0.98
Average Slope, Squared	−30.4	−0.9	0.18	1.00
Standard Deviation of Slope	−19.4	−1.6	0.57	0.96
Standard Deviation of Slope, Squared	−19.2	−1.7	0.30	1.07
Relative Return to Cropland	−9.3	−1.9	1.00	0.99
Relative Return to Cropland, Squared	−7.4	−1.8	0.89	0.99

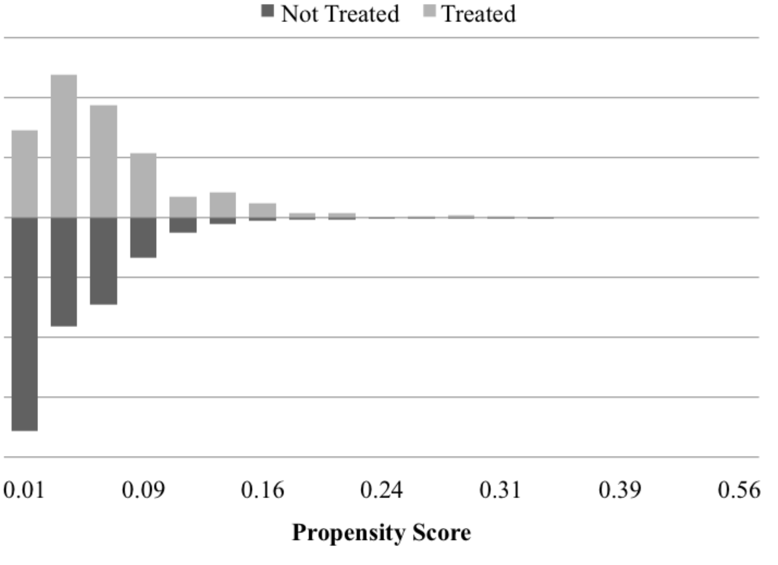

Figure C1. Distribution of Propensity Scores for Treated (Eased) and Untreated (Control) Observations, 2002–2007

Table C4. Post Matching Regression Results, 2002–2007

	Estimate	Standard Error	t-statistic
Easement indicator	0.0089**	0.0019	4.67
Land Capability Class 1–2	0.0032	0.0025	1.29
Land Capability Class 6–8	0.0051**	0.0024	2.17
Pasture	−0.0016	0.0051	−0.32
Priority Zone 1	−0.0013	0.0219	−0.06
Priority Zone 2	−0.0078	0.0220	−0.35
Priority Zone 3	−0.0068	0.0221	−0.31
Grassland Bird Cons. Area	0.0073**	0.0025	2.88
Population Interaction Index	0.0000	0.0000	−0.40
Population Interaction Index, Squared	0.0000	0.0000	1.00
Distance to Interstate Hwy.	0.0000	0.0000	0.83
Distance to Interstate Hwy., Squared	0.0000	0.0000	−1.09
Wetland Index	0.0010	0.0011	0.95
Wetland Index, Squared	−0.0001	0.0001	−0.61
Average Slope	0.0005	0.0037	0.12
Average Slope, Squared	−0.0001	0.0005	−0.13
Standard Deviation of Slope	0.0098	0.0077	1.27
Standard Deviation of Slope, Squared	−0.0024	0.0021	−1.11
Relative Return to Cropland	0.0002	0.0001	1.27
Relative Return to Cropland, Squared	0.0000	0.0000	−0.91
Constant	0.9703**	0.0229	42.39
Number of Observations	4,619		
Number of Easements	135		
F	5.68		
Adjusted R^2	0.02		

Notes: Single and double asterisks (*, **) indicate significance at the 5% and 1% level.

Online Supplement D: Estimation Results for 2007–2012

Table D1. Propensity Score Model Parameter Estimates, 2007–2012

	Estimate	Standard Error	t-statistic
Land Capability Class 1–2	−0.2743	0.2464	−1.11
Land Capability Class 6–8	−0.2490	0.2644	−0.94
Pasture	−0.4308	0.4097	−1.05
Priority Zone 1	2.0554**	0.6410	3.21
Priority Zone 2	0.9479	0.6788	1.4
Priority Zone 3	−0.0072	0.8272	−0.01
Grassland Bird Cons. Area	0.8092**	0.2596	3.12
Population Interaction Index	0.0004	0.0003	1.37
Population Interaction Index, Squared	0.0000	0.0000	−1.36
Distance to Interstate Hwy.	0.0000	0.0000	−0.14
Distance to Interstate Hwy., Squared	0.0000	0.0000	−0.81
Wetland Index	0.2663**	0.0954	2.79
Wetland Index, Squared	−0.0157	0.0083	−1.9
Average Slope	0.4036	0.6599	0.61
Average Slope, Squared	−0.1430	0.1302	−1.1
Standard Deviation of Slope	1.3209	1.4374	0.92
Standard Deviation of Slope, Squared	−0.6374	0.6315	−1.01
Relative Return to Cropland	−0.0319*	0.0128	−2.48
Relative Return to Cropland, Squared	0.0001*	0.0000	2.53
Constant	−2.8591	1.5639	−1.83
Number of Observations	4,629		
Number of Easements	101		
Log-Likelihood	−417.11		
Likelihood ratio	138.20		

Notes: Single and double asterisks (*, **) indicate significance at the 5% and 1% level.

Table D2. Balance Statistics for Selected Bandwidths, Normal Kernel Matching, 2007–2012

	Standardized Difference (%, Absolute Value)			Variance Ratio	
Bandwidth	**Mean**	**Median**	**Maximum**	**Minimum**	**Maximum**
0.007	5.25	5.93	14.44	0.193	1.035
0.006	4.88	4.47	13.23	0.211	1.043
0.005	4.58	3.59	12.08	0.231	1.049
0.004	4.34	4.02	11.12	0.249	1.054
0.003	4.16	4.48	10.51	0.263	1.058
0.002	*4.15*	*3.82*	*10.31*	*0.271*	*1.061*
0.001	4.22	3.17	10.43	0.267	1.063

Notes: Italics indicate chosen bandwidth.

Table D3. Balance Statistics for Propensity Score, Normal Kernel Matching, 2007–2012

	Standardized Difference (%)		Variance Ratio	
	Unmatched	**Matched**	**Unmatched**	**Matched**
Land Capability Class 1–2	6.2	4.2	1.06	1.04
Land Capability Class 6–8	−22.8	0.7	0.84	1.01
Pasture	−8.2	0.1	0.78	1.00
Priority Zone 1	86.5	−0.7	0.59	1.01
Priority Zone 2	−22.9	2.4	0.64	1.06
Priority Zone 3	−44.7	−0.4	0.22	0.98
Grassland Bird Cons. Area	25.4	−1.9	0.77	1.03
Population Interaction Index	−11.4	−3.7	0.42	0.89
Population Interaction Index, Squared	−16.9	−3.8	0.12	0.47
Distance to Interstate Hwy.	−27.3	−0.3	0.79	0.98
Distance to Interstate Hwy., Squared	−28.9	−0.7	0.65	1.04
Wetland Index	45.8	−5.1	1.56	0.87
Wetland Index, Squared	21.1	−5.4	0.70	0.56
Average Slope	−57.8	−8.5	0.17	0.67
Average Slope, Squared	−49.4	−10.3	0.04	0.27
Standard Deviation of Slope	−49.2	−5.0	0.23	0.74
Standard Deviation of Slope, Squared	−41.1	−7.2	0.05	0.35
Relative Return to Cropland	2.1	−9.4	1.05	1.01
Relative Return to Cropland, Squared	2.6	−9.2	0.96	0.96

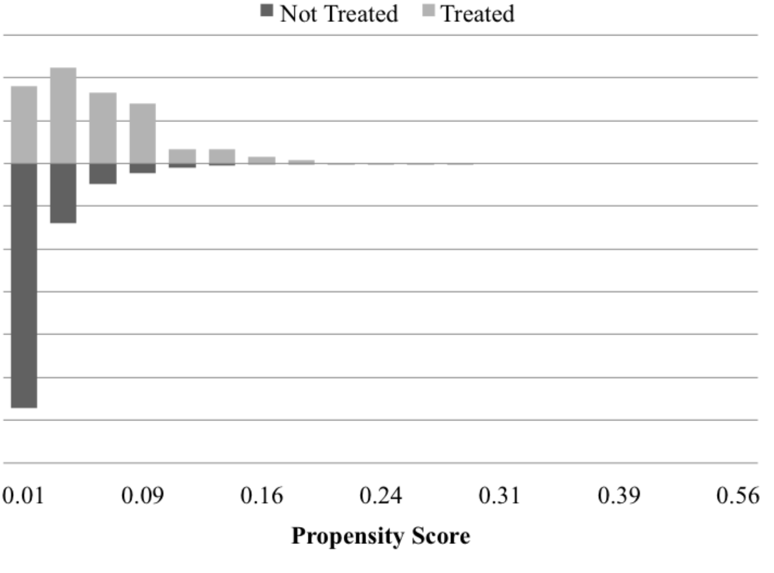

Figure D1. Distribution of Propensity Scores for Treated (Eased) and Untreated (Control) Observations, 2007–2012

Table D4. Post Matching Regression Results, 2007–2012

	Estimate	Standard Error	t-statistic
Easement indicator	0.0148**	0.0025	5.86
Land Capability Class 1–2	−0.0136**	0.0031	−4.34
Land Capability Class 6–8	−0.0014	0.0032	−0.43
Pasture	−0.0289**	0.0049	−5.90
Priority Zone 1	−0.0053	0.0084	−0.63
Priority Zone 2	0.0015	0.0089	0.17
Priority Zone 3	−0.0056	0.0110	−0.51
Grassland Bird Cons. Area	−0.0013	0.0031	−0.41
Population Interaction Index	0.0000	0.0000	−1.87
Population Interaction Index, Squared	0.0000	0.0000	1.32
Distance to Interstate Hwy.	0.0000**	0.0000	−2.48
Distance to Interstate Hwy., Squared	0.0000	0.0000	1.67
Wetland Index	0.0033**	0.0012	2.74
Wetland Index, Squared	−0.0003*	0.0001	−2.37
Average Slope	0.0045	0.0051	0.89
Average Slope, Squared	−0.0003	0.0007	−0.37
Standard Deviation of Slope	−0.0012	0.0112	−0.10
Standard Deviation of Slope, Squared	−0.0005	0.0038	−0.12
Relative Return to Cropland	−0.0003	0.0002	−1.49
Relative Return to Cropland, Squared	0.0000	0.0000	1.33
Constant	1.0415**	0.0214	48.70
Number of Observations	4,617		
Number of Easements	97		
F	6.24		
Adjusted R^2	0.02		

Notes: Single and double asterisks (*, **) indicate significance at the 5% and 1% level.

Online Supplement E: Estimation Results for Land Capability Class 1–3

Table E1. Propensity Score Model Parameter Estimates, Land Capability Class 1–3

	Estimate	Standard Error	t-statistic
Indicator 1997–2002 Period	0.6330	0.3792	1.67
Indicator 2002–2007 Period	0.1872	0.4008	0.47
Pasture	−0.4954	0.2576	−1.92
Priority Zone 1	1.9616**	0.4403	4.46
Priority Zone 2	1.2074**	0.4580	2.64
Priority Zone 3	1.0391*	0.4739	2.19
Grassland Bird Cons. Area	1.2753**	0.2062	6.19
Population Interaction Index	0.0004	0.0003	1.33
Population Interaction Index, Squared	0.0000	0.0000	−1.41
Distance to Interstate Hwy.	0.0000	0.0000	−1.38
Distance to Interstate Hwy., Squared	0.0000	0.0000	0.55
Wetland Index	0.1438**	0.0609	2.36
Wetland Index, Squared	−0.0023	0.0043	−0.54
Average Slope	0.3342	0.3843	0.87
Average Slope, Squared	−0.0831	0.0691	−1.2
Standard Deviation of Slope	0.1227	0.7000	0.18
Standard Deviation of Slope, Squared	0.0087	0.2360	0.04
Relative Return to Cropland	0.0064	0.0041	1.57
Relative Return to Cropland, Squared	0.0000	0.0000	−1.81
Constant	−6.9206**	0.8018	−8.63
Number of Observations	6,693		
Number of Easements	215		
Log-Likelihood	−854.85		
Likelihood ratio	191.74		

Notes: Single and double asterisks (*, **) indicate significance at the 5% and 1% level.

Table E2. Balance Statistics for Selected Bandwidths, Normal Kernel Matching, Land Capability Class 1–3

	Standardized Difference (%, Absolute Value)			Variance Ratio	
Bandwidth	Mean	Median	Maximum	Minimum	Maximum
0.007	2.07	1.12	7.56	0.730	1.669
0.006	1.90	0.96	7.42	0.783	1.673
0.005	1.78	0.64	7.32	0.824	1.684
0.004	*1.74*	*0.78*	*7.26*	*0.857*	*1.699*
0.003	1.79	0.76	7.22	0.882	1.715
0.002	1.94	1.31	7.31	0.905	1.745
0.001	2.12	1.80	7.00	0.896	1.693

Notes: Italics indicate chosen bandwidth.

Table E3. Balance Statistics for Propensity Score, Normal Kernel Matching, Land Capability Class 1–3

	Standardized Difference (%)		Variance Ratio	
	Unmatched	**Matched**	**Unmatched**	**Matched**
Pasture	−19.2	−3.1	0.62	0.91
Priority Zone 1	61.1	−0.8	0.77	1.01
Priority Zone 2	−20.5	1.2	0.70	1.03
Priority Zone 3	−23.7	0.5	0.58	1.02
Grassland Bird Cons. Area	54.2	1.2	0.51	0.97
Population Interaction Index	−17.3	−0.3	0.35	0.94
Population Interaction Index, Squared	−20.9	−1.2	0.12	1.01
Distance to Interstate Hwy.	−8.2	2.8	0.95	1.02
Distance to Interstate Hwy., Squared	−8.6	2.9	0.80	0.92
Wetland Index	45.2	6.2	3.24	1.27
Wetland Index, Squared	30.8	7.3	5.57	1.70
Average Slope	−21.9	−0.1	0.51	1.01
Average Slope, Squared	−23.4	0.1	0.21	0.86
Standard Deviation of Slope	−14.6	−0.5	0.61	1.00
Standard Deviation of Slope, Squared	−15.9	−0.4	0.35	0.92
Relative Return to Cropland	−23.0	0.5	0.71	1.02
Relative Return to Cropland, Squared	−23.6	0.7	0.62	1.07
Relative Return to Cropland	−3.4	2.9	0.80	1.03
Relative Return to Cropland, Squared	−6.4	3.0	0.59	0.96

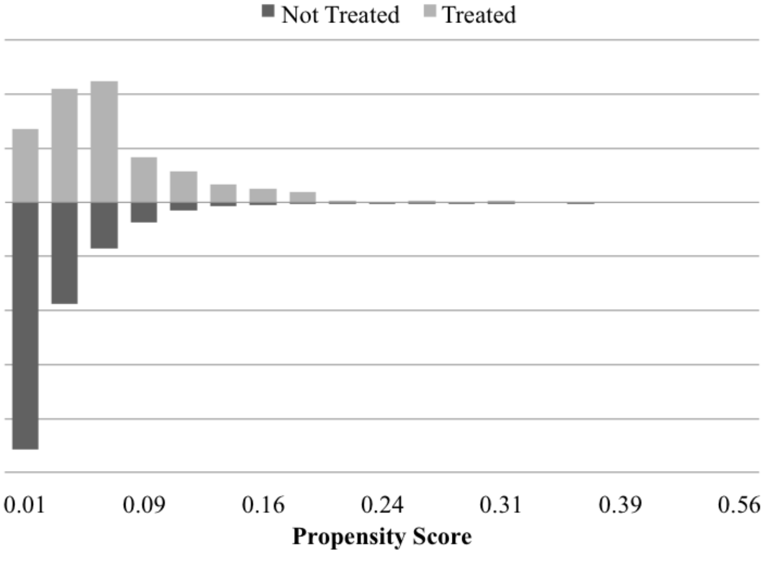

Figure E1. Distribution of Propensity Scores for Treated (Eased) and Untreated (Control) Observations, LCC 1–3

Table E4. Post Matching Regression Results, LCC 1–3

	Estimate	Standard Error	t-statistic
Easement indicator	0.0186**	0.0024	7.60
Indicator 1997–2002 Period	0.0026	0.0068	0.38
Indicator 2002–2007 Period	0.0060	0.0072	0.83
Pasture	−0.0385**	0.0045	−8.48
Priority Zone 1	−0.0089	0.0086	−1.03
Priority Zone 2	−0.0172	0.0089	−1.92
Priority Zone 3	−0.0131	0.0093	−1.42
Grassland Bird Cons. Area	0.0259**	0.0036	7.26
Population Interaction Index	0.0000	0.0000	−1.00
Population Interaction Index, Squared	0.0000	0.0000	1.07
Distance to Interstate Hwy.	0.0000	0.0000	−0.80
Distance to Interstate Hwy., Squared	0.0000	0.0000	0.46
Wetland Index	0.0029**	0.0011	2.60
Wetland Index, Squared	−0.0001	0.0001	−1.45
Average Slope	0.0072	0.0065	1.10
Average Slope, Squared	−0.0008	0.0012	−0.70
Standard Deviation of Slope	0.0036	0.0123	0.30
Standard Deviation of Slope, Squared	−0.0007	0.0041	−0.18
Relative Return to Cropland	0.0002**	0.0001	2.93
Relative Return to Cropland, Squared	0.0000**	0.0000	−3.17
Constant	0.9482**	0.0148	64.13
Number of Observations	6,686		
Number of Easements	215		
F	11.64		
Adjusted R^2	0.03		

Notes: Single and double asterisks (*, **) indicate significance at the 5% and 1% level.

Online Supplement F: Estimation Results for Land Capability Class 4–8

Table F1. Propensity Score Model Parameter Estimates, Land Capability Class 4–8

	Estimate	Standard Error	t-statistic
Indicator 1997–2002 Period	1.6154**	0.4244	3.81
Indicator 2002–2007 Period	1.1868**	0.4557	2.60
Pasture	−0.7423*	0.3689	−2.01
Priority Zone 1	2.1199**	0.4414	4.80
Priority Zone 2	1.7255**	0.4530	3.81
Priority Zone 3	1.1930*	0.4908	2.43
Grassland Bird Cons. Area	0.7938**	0.1674	4.74
Population Interaction Index	0.0004	0.0002	1.94
Population Interaction Index, Squared	0.0000	0.0000	−1.71
Distance to Interstate Hwy.	0.0000	0.0000	0.46
Distance to Interstate Hwy., Squared	0.0000	0.0000	−1.21
Wetland Index	0.2060**	0.0445	4.63
Wetland Index, Squared	−0.0070**	0.0026	−2.72
Average Slope	−0.3691	0.2233	−1.65
Average Slope, Squared	0.0242	0.0269	0.90
Standard Deviation of Slope	1.1309	0.6294	1.80
Standard Deviation of Slope, Squared	−0.3974	0.2109	−1.88
Relative Return to Cropland	−0.0006	0.0034	−0.18
Relative Return to Cropland, Squared	0.0000	0.0000	1.66
Constant	−7.4322**	0.7667	−9.69
Number of Observations	8,035		
Number of Easements	251		
Log-Likelihood	−984.94		
Likelihood ratio	264.19		

Notes: Single and double asterisks (*, **) indicate significance at the 5% and 1% level.

Table F2. Balance Statistics for Selected Bandwidths, Normal Kernel Matching, Land Capability Class 4–8

	Standardized Difference (%, Absolute Value)			Variance Ratio	
Bandwidth	**Mean**	**Median**	**Maximum**	**Minimum**	**Maximum**
0.007	2.51	1.35	7.42	0.645	1.288
0.006	2.08	1.07	6.91	0.702	1.269
0.005	1.69	0.86	6.45	0.769	1.249
0.004	1.36	0.68	5.99	0.848	1.220
0.003	*1.10*	*0.56*	*5.43*	*0.888*	*1.174*
0.002	1.25	0.85	4.70	0.917	1.169
0.001	1.59	0.99	4.63	0.901	1.256

Notes: Italics indicate chosen bandwidth.

Table F3. Balance Statistics for Propensity Score, Normal Kernel Matching, Land Capability Class 4–8

	Standardized Difference (%)		Variance Ratio	
	Unmatched	Matched	Unmatched	Matched
Pasture	−13.4	−0.6	0.55	0.97
Priority Zone 1	65.9	0.3	0.75	1.00
Priority Zone 2	−3.8	−0.1	0.93	1.00
Priority Zone 3	−28.6	−1.7	0.45	0.94
Grassland Bird Cons. Area	26.0	0.6	0.74	0.99
Population Interaction Index	−6.7	0.3	0.49	0.98
Population Interaction Index, Squared	−13.4	−0.2	0.20	0.89
Distance to Interstate Hwy.	−8.1	−0.7	0.90	1.00
Distance to Interstate Hwy., Squared	−10.1	−0.6	0.81	0.96
Wetland Index	51.2	5.4	3.18	1.16
Wetland Index, Squared	30.6	4.7	4.61	1.17
Average Slope	−50.3	−0.5	0.33	1.00
Average Slope, Squared	−45.7	−0.3	0.13	0.95
Standard Deviation of Slope	−42.3	0.3	0.35	0.97
Standard Deviation of Slope, Squared	−37.0	−0.3	0.12	1.02
Relative Return to Cropland	−20.3	−0.7	0.85	0.97
Relative Return to Cropland, Squared	−17.4	−1.3	0.86	0.95

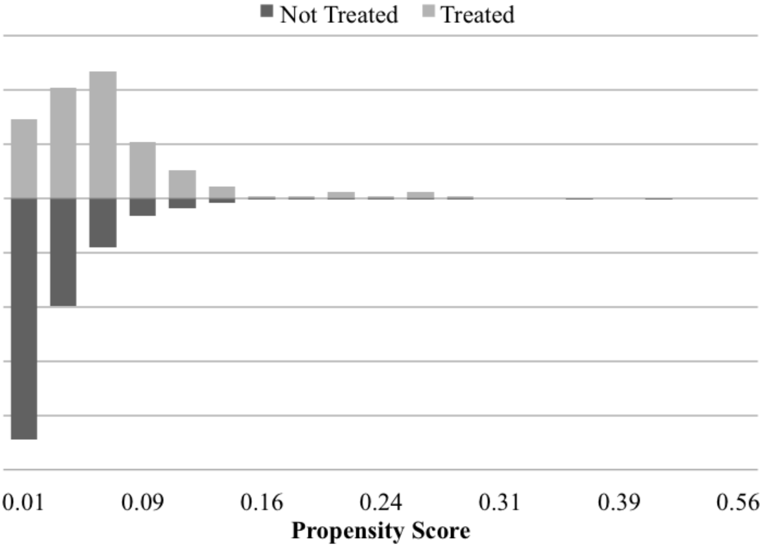

Figure F1. Distribution of Propensity Scores for Treated (Eased) and Untreated (Control) Observations, LCC 4–8

Table F4. Post-Matching Regression Results, LCC 4–8

	Estimate	Standard Error	t-statistic
Easement indicator	0.0069**	0.0013	5.23
Indicator 1997–2002 Period	0.0071	0.0042	1.69
Indicator 2002–2007 Period	0.0095*	0.0046	2.07
Pasture	−0.0105**	0.0037	−2.81
Priority Zone 1	−0.0007	0.0052	−0.14
Priority Zone 2	−0.0016	0.0053	−0.30
Priority Zone 3	−0.0058	0.0057	−1.02
Grassland Bird Cons. Area	0.0087**	0.0017	5.09
Population Interaction Index	0.0000	0.0000	−1.37
Population Interaction Index, Squared	0.0000	0.0000	1.09
Distance to Interstate Hwy.	0.0000	0.0000	0.52
Distance to Interstate Hwy., Squared	0.0000	0.0000	−0.58
Wetland Index	0.0009*	0.0004	2.14
Wetland Index, Squared	0.0000	0.0000	−1.71
Average Slope	0.0010	0.0023	0.45
Average Slope, Squared	0.0000	0.0003	0.04
Standard Deviation of Slope	−0.0003	0.0055	−0.06
Standard Deviation of Slope, Squared	−0.0003	0.0016	−0.16
Relative Return to Cropland	0.0001	0.0000	1.55
Relative Return to Cropland, Squared	0.0000	0.0000	−0.05
Constant	0.9743**	0.0082	119.24
Number of Observations	8,021		
Number of Easements	247		
F	4.57		
Adjusted R^2	0.01		

Notes: Single and double asterisks (*, **) indicate significance at the 5% and 1% level.