Land Use Impacts of the Conservation Reserve Program: An Analysis of Rejected CRP Offers

Andrew B. Rosenberg
Economist
USDA, Economic Research Service
andrew.rosenberg@usda.gov

Bryan Pratt
Economist
USDA, Economic Research Service
bryan.pratt@usda.gov

David Arnold
Geographer
USDA, Economic Research Service
david.arnold@usda.gov

Abstract
The Conservation Reserve Program (CRP) is the largest agricultural land retirement program in the United States, with the General Signup competitive auction accounting for about one-half of enrolled acreage. In this study, we assess the land use impacts of the CRP, identifying the land uses that could have been retired had rejected offers in the 2016 General Signup instead been accepted. We also compare information from proposed offers with land use decisions after offers were rejected to determine the costs that the program would have to pay to avoid these land uses. In the immediate years after the Signup that we examine, 47 percent of acreage in fields with a rejected offer was planted in crops for grain, while 14 percent was planted in crops for forage, and 10 percent was used for grazing. We find that the fraction of land in each use is relatively consistent across a range of Environmental Benefits Index (EBI) scores. Further, we find that the cost effectiveness of retiring grain and other productive agricultural uses is relatively constant across a large range of EBI scores but is lower for the lowest scoring offers. Finally, we find that program land use impacts vary significantly across states and depend on prior enrollment status.

Invited Paper prepared for presentation at the 2022 AEA/ASSA Annual Meeting VIRTUAL, January 7-9, 2022.

The authors would like to acknowledge Ryan Williams's (USDA, Economic Research Service) important contributions to the development of data fundamental to this research, as well as excellent feedback from David Donaldson, Daniel Hellerstein, Krishna Paudel, Daniel Szmurlo and Steven Wallander. The findings and conclusions in this publication are those of the authors and should not be construed to represent any official USDA or U.S. Government determination or policy. This research was supported by the U.S. Department of Agriculture, Economic Research Service.

The USDA spends about 2 billion dollars each year on the Conservation Reserve Program (CRP), paying farmers to temporarily retire cropland (Hellerstein et al. 2019). The program aims to reduce soil erosion, increase wildlife habitat, improve water and air quality, and sequester carbon. Recent proposals to expand the CRP could potentially increase the acreage cap from 27 million acres to 40 million acres.[1] Within this context, it is important to understand the degree to which the program influences land use in the agricultural sector and how these impacts may change as the program expands. In this study, we assess the overall impacts and cost effectiveness of the CRP for land use, comparing land use outcomes and offer details for offers rejected from the 2016 CRP General Signup.

Previous studies have taken different approaches to estimating land use impacts of the CRP. Studies conducted around the introduction of the CRP have examined CRP land use impacts using information about land uses before the program existed. For example, while estimating water quality impacts of the CRP, Ribaudo (1989) assumes that erosion levels, and land use, would remain the same in the absence of the CRP. More recent studies examine CRP land use outcomes of expiring contracts (e.g., Roberts and Lubowski 2007; Hendricks and Er 2018; Bigelow et al. 2020). For example, examining expiring CRP contracts, Roberts and Lubowski (2007) use a two-part selection model to estimate the proportion of CRP acres that would return to cropland if the program suddenly expired. Recent studies reinforce the need to account for selection effects from CRP participants with expiring contracts that choose to re-enroll. Barnes et al. (2019) ask farmers previously enrolled in CRP about their land use choices

[1] Current legislation provides for an acreage cap of 24 million acres in fiscal year 2019 growing to 27 million acres for fiscal year 2023 (16 U.S. Code § 3831, d, 1). Proposed alternative legislation by Senators Cory Booker and Kirsten Gillibrand and Congresswoman Abigail Spanberger would provide for an acreage cap as high as 40 million acres. https://www.booker.senate.gov/news/press/with-fdrs-new-deal-as-blueprint-sen-booker-and-rep-spanberger-re-introduce-climate-change-bill-focused-on-investing-in-farm-conservation-programs-reforestation-and-wetlands-restoration

after their contracts expired. The authors find that rejected program applicants are substantially less likely to grow crops after exiting the CRP than those that choose not to re-enroll.

The current study offers a more detailed examination of the land use impacts of the CRP than has been previously possible. We observe field-level land use decisions of farmers whose offers are rejected from a General Signup, the CRP's competitive auction enrollment mechanism, and compare them with the proposed CRP contract details from their rejected offers. Because land with rejected offers would be contractually obligated to plant the cover specified in the offer for the proposed rental rate, we know what the land use pathway would have been had they enrolled in the program, as well as the cost to the program of retiring the associated land. We assess the land use choices of farmers after their offers are rejected, what we refer to as avoided land uses, and compare those with the land uses that would have occurred if they were instead accepted. This comparison can be interpreted as an average treatment effect on the untreated population of potential participants, i.e., the ATUT. Because we assess land use outcomes of rejected offers from a particularly stringent auction, General Signup 49 conducted in 2016, many of the rejected offers analyzed in the study would have been accepted with similar offers in most other Signups.[2] Thus, for a large portion of offers, the ATUT for Signup 49 would be similar to the average treatment effect on the treated (ATT) in most other Signups.

Further, this study examines certain features of CRP land use impacts left unanswered in previous analyses. We evaluate the cost effectiveness of enrolling land in CRP, linking proposed CRP contract features, including proposed rental rates and conservation covers, with land use

[2] The Agricultural Improvement Act of 2014 reduced the size of the CRP as a whole from 32 million acres to 24 million acres (USDA, 2021c). Given that CRP contracts are generally for at least 10 years, this reduction in the size of the program had to be achieved primarily by not enrolling new contracts. As a consequence, the 2016 General Signup accepted 411,000 of 1.8 million offered acres. By contract, the 2010, 2011, 2012, and 2013 General Signups accepted 4.2 million acres, 2.8 million acres, 3.9 million acres, and 1.6 million acres, respectively (USDA, 2021c).

decisions. We also link land use outcomes of rejected offers with their performance in the Environmental Benefits Index (EBI), the program's main mechanism for ranking and selecting contracts, which is based on the predicted environmental impacts and cost effectiveness of each contract. Thus, we can examine how the EBI rewards or penalizes more intensive land uses and how it balances the need to enroll intensive land uses cost effectively. Further, we determine land use impacts across important subpopulations that are sometimes unobservable using other estimation approaches. We are able to include and distinguish between both land use outcomes of those exiting the CRP voluntarily – those not attempting to reenroll upon contract expiration – and involuntarily – those attempting to reenroll but that are rejected. In addition, the sample includes both parcels with a history in the CRP and those without a history of enrollment. Finally, we examine whether there are significant selection effects associated with CRP enrollment after controlling for land use prior to applying. We do this to examine whether those that apply to be in CRP would move into less intensive land uses if CRP was unavailable.

The study leads to several main findings. First, we find that if the 2016 CRP were to accept all rejected offers in the study area, this additional acreage retired would have been composed of 47 percent cropland grown for grain, 14 percent cropland grown for forage, 10 percent in grazing use, 11 percent in other agricultural land uses, and 18 percent enrolled in Continuous Signup CRP. Further, we find that this composition of land uses does not substantially change as the EBI scores of offers decrease. We find that, if the CRP had accepted the highest quartile of rejected offers in 2016 by EBI score, about 1.2 to 1.3 acres of cropland grown for grain or forage would be retired for every $100 spent. The land uses avoided per $100 spent are relatively stable across the three highest-ranked quartiles of rejected offers in terms of the EBI.

We also find considerable differences across various subpopulations. There are large differences across states, both for the land use choices made by farmers with rejected offers as well as potential cost-effectiveness of enrolling their rejected offers. We find that land use impacts and cost-effectiveness are not closely related across states, as land in states with higher proportions of cropland retired is also more costly to enroll. Further, we find that rejected offers that previously had land enrolled in CRP were much more likely to leave unharvested land covers on their fields, supporting recent findings from the literature. Finally, we find that fields offered to CRP follow similar land use patterns after failing to enroll, as compared to fields with similar land use histories, soil productivity, and erodibility.

Background on the CRP

The CRP is the largest land retirement program in the world in terms of acres enrolled and is comprised of several distinct components. This manuscript primarily examines the General Signup component, which is a multi-unit reverse auction in which eligible landowners and producers submit offers to enroll in the program. While this research is focused on the General Signup, Continuous Signup is also notable, because fields may opt to enroll in Continuous or Grasslands Signup after being rejected from General Signup, and a single parcel may have portions enrolled in Continuous Signup while another portion is offered in the General Signup. With few exceptions, enrollment in the Continuous Signup is first-come, first-served but more restricted in eligibility, relative to General Signup.

The eligibility requirements for General Signup consist of the following two main components. First, land must be either highly erodible (greater than or equal to a set threshold) or located within a Conservation Priority Area (CPA). Second, land must have a sufficient cropping

history. Specifically, the candidate parcel must have been cropped during four of six specified years prior to enrollment.[3] For the 2016 General Signup, they must have cropped four of the years from 2008 through 2013. Alternatively, land in the final year of a CRP contract is also eligible to reenroll (16 U.S. Code § 3831, d, 1).[4]

Offers in the General Signup CRP consist of two main components. First is a requested rental rate and second is a proposed land cover that the landowner agrees to put in place for the duration of the contract if accepted. If an offer is accepted into General Signup, the producers and landowners will institute the proposed land cover for the duration of the contract, and in return receives their proposed annual rental rate and a cost share for the implemented land cover. With few exceptions, CRP contracts have a 10-year duration.[5]

Acceptance into the General Signup auction is determined using the Environmental Benefits Index (EBI), a ranking score which seeks to approximate the environmental benefits of an offer and reward offers for incurring lower program costs. The EBI awards points based on the environmental sensitivity of the land, the environmental benefits of the cover proposed, and the rental rate requested. USDA then accepts only those offers with an EBI above a threshold, with all other offers being rejected for that enrollment period.[6] The most cost-effective way for most prospective participants to increase their EBI score is to offer a cover practice with greater benefits. This is related to the fact that the majority of offers include a cover practice other than the most basic practice available, while a minority of offers include a discounted rental rate.

[3] For the purposes of eligibility, a field is considered to have been cropped if a prevented planting claim was made.
[4] During this time certain temporary provisions were created to prevent involuntary exits in light of contracts expiring in years with gaps until the next general signup opportunity. These provisions required CRP land to remained in its CRP cover.
[5] Some CREP programs are primarily 14 to 15-year contracts, and there are 30-year contracts in the CLEAR30 program.
[6] Offers may also be rejected due to a requirement that no more than 25 percent of county cropland be enrolled in CRP. Offers in such counties are also accepted based on EBI score, with the threshold of acceptance set such that the county does not exceed its enrollment cap.

Offers in the General Signup are constrained by a maximum rental rate that can be requested. This field-specific maximum is calculated using the county average cash rental rate for non-irrigated cropland multiplied by a modifier for the relative productivity of the soils present on the field, and inflation adjusted. The current program includes different multipliers of 0.85 and 0.9 for General and Continuous Signup, respectively, but these were not present for the Signup studied here. The Farm Service Agency (FSA), which is responsible for implementing the CRP, also instituted practice-specific climate-smart multipliers in 2021 (USDA 2021b). While Continuous Signup contracts receive a flat rental rate based on this calculation, General Signup offers may submit lower rental rates in exchange for greater probability of acceptance. Continuous Signups involve stricter eligibility requirements, including either location within a Continuous program's area or the implementation of a specific Continuous practice.[7]

Prior Literature on CRP and Land Use

The current study adds to a substantive literature examining land use impacts of the CRP. Hansen (2007) identifies three main approaches that have been used in the literature to estimate land use impacts of the CRP. Two of the approaches use actual observed land use outcomes and the final approach uses survey data on landowners' intended uses if the CRP didn't exist.

The first approach that uses actual land use outcomes assumes that CRP lands would do what they did prior to enrolling in the CRP. In estimating water quality impacts of CRP, Ribaudo (1989) assumes that soil erosion levels would remain constant had the CRP not existed, implicitly assuming that land use would have remained constant as well. In general, estimating

[7] To incentivize participation, Continuous contracts may be awarded signup incentive payments (SIPs), practice incentive payments (PIPs), or both, which are one-time payments for enrollment (SIP) or use of a specific practice (PIP).

an average treatment effect on the treated population (ATT) for those that enroll into CRP using prior land uses requires that past land use decisions can similarly predict future land uses for those that apply and do not apply to CRP. This approach may fail if those that apply would be more likely to switch to less intensive land uses in the years after they apply if the program were unavailable. Further, this first approach is infeasible for re-enrollments from expiring CRP contracts, making this approach less relevant applicable outside of earlier studies on CRP.

The second major approach that uses observed land use outcomes, outlined in Hansen (2007), assesses CRP land use impacts with expiring contracts (e.g., Roberts and Lubowski 2007; Hendricks and Er 2018; Bigelow et al. 2020; Moorefield et al. 2016). Some studies take this approach primarily to examine land use transitions. For example, Bigelow et al. (2020) look at land use decisions of farmers exiting the CRP in detail. The authors find that 57 percent of expiring CRP acreage that does not re-enroll into the program goes into annual crops, in addition to 12 percent of acres going into perennial forage, with the percent of land going into annual crops much higher in many midwestern states. Using data from the National Resources Inventory, Hendricks and Er (2018) analyze transitions into and exiting the CRP, finding that from 2007 to 2012, about 60 percent of acres exiting the CRP transition to cropland, and 80 percent of new land entering CRP was previously in cropland.

Others have used expiring CRP contracts to estimate the effects of the CRP for the full population of CRP participants. Roberts and Lubowski (2007) find that 58 percent of this population would return to cropland use after exiting the CRP if the program suddenly ended. The authors find that those farmers that exited the CRP were slightly more likely to return to cropland after their exit, 61 percent, motivating the need to account for selection. Barnes et al. (2019) use survey data to detect selection effects among farmers previously enrolled in CRP in

the western plains. The authors ask farmers with land previously in CRP how they were currently using their land. They compare responses from those that applied to re-enroll but were rejected with those that did not apply for re-enrollment. Those who applied to re-enroll were about 14 percentage points less likely to convert their land to crops after their contracts expired. The authors find a similar difference for people currently in CRP that expect to re-enroll or not. In the current study, we speak further to the difference in land use outcomes for voluntary and involuntary CRP exits.

The final approach outlined in Hansen (2007) uses survey data on landowners' intended uses if the CRP didn't exist. For example, in 1993 the Soil and Water Conservation Society conducted a national survey of farmers with land enrolled in CRP. They find that farmers would return about 63 percent of their land to cropland if contracts were not renewed (Dodson et al. 1994). This approach has the advantage that it gains information on land use from a representative sample of enrollees, potentially for rejected offers. Thus, surveys could be the most appropriate approach for some questions, such as the counterfactual land use of the entire population of currently enrolled fields. However, to date, we are unaware of any surveys that have incorporated detailed CRP offer information into a survey data of CRP participants. Further due to low sample sizes surveys are less able to closely examine factors such as heterogeneity in cost effectiveness across space.

Others have used counterfactual simulations to estimate land use impacts. For example, Lubowski, Plantinga and Stavins (2008) estimate an average treatment effect on the treated using an econometric-based land use model. The authors simulate a situation where the CRP did not exist in order to estimate the land use effects of CRP. They find that 91 percent of land enrolled in CRP in 1997 would have been in cropland in the absence of the program.

Across these studies, a difference between land uses for parcels entering and exiting CRP emerges, even after accounting for selection effects. As found in Hendricks and Er (2018), a land that enters the CRP is more likely to have come from cropland than land exiting the CRP is likely to return to cropland. The authors explain that the difference may be due to persistence effects, resulting from high costs of conversion and uncertainty, or due to non-additionality, occurring if farmers would have put their land into less productive uses in the absence of the program. Roberts and Lubowski (2007) argue that the fact that less land exiting the CRP returns to cropland is more likely to come from persistence than non-additionality. In the current study, we find further evidence that non-additionality is unlikely to play a major role in the difference.

Data and Methods for Analysis of Rejected CRP Offers

Data

We focus our empirical analysis on rejected offers from the 2016 General Signup. While most General Signups feature acceptance rates above 80 percent, fewer than 20 percent of offers were accepted in 2016. This provides a large sample of rejected offers to analyze. Further, while General Signups have typically occurred annually or more frequently, the 2016 General Signup was followed by three years without another General Signup. Consequently, most land associated with rejected offers subsequently went into non-CRP land uses, unless they were able to enroll through Continuous Signup. Given the landowners' intentions to join the CRP through General Signup in 2016, they may have entered the program through Continuous Signup as soon as 2017. We also limit our analysis to multiple states located in the United States Midwest and Great Plains regions – Indiana, Illinois, Iowa, Kansas, Michigan, Minnesota, Missouri, Montana,

Nebraska, North Dakota, Ohio, South Dakota, Wisconsin, and Wyoming – which collectively account for the majority of enrolled CRP acreage.

Fields associated with offers made in General Signup 49 were identified using data from the FSA, which administers the CRP. The offer dataset contains information on whether each offer was accepted or rejected, the CRP land cover that was proposed, the proposed rental rate, and the EBI scores associated with the offer. This information is used to identify what fields with rejected offers would have done had they been accepted into CRP. The offer data also contains field identifiers that can be used to identify their actual land use decisions after being rejected. There were 26,279 offers made in General Signup 49. In our geographic sample, this included 18,063 offers, 16,878 of which contained field identifying information, i.e., 93% of offers in our geographic sample. This includes 24,229 fields associated with rejected offers.

We link offers to other field-level information using a panel of fields constructed using the USDA FSA's Common Land Unit (CLU) dataset.[8] A panel of fields is generated using CLU boundaries from 2013 through 2019. Our main data to identify land use decisions made by producers with rejected CRP offers come from Form 578 data from FSA. All producers are required to file a Form 578 on an annual basis in order to participate in USDA programs and receive financial support from USDA. The data generated through this process is compiled in the Crop Acreage Reporting Database (CARD), and this record serves as the official record of planted acreage for a variety of purposes. Reported plantings include a variety of useful information, including the acreage planted to a specific crop and the intended use of the planting, such as harvesting for grain (GR) or planting for forage (FG). The data from 578 forms, referred

[8] Identifiers for some fields, or CLUs, change each year, hence one must identify sub-parcels that are constant over time to create a true panel. In most cases, sub-parcels are simply the same CLU throughout time, however in some cases CLUs may split, combine or otherwise be reidentified. In such cases, new subfields are created so that the entirety of CLUs are included for each field in each year of the panel.

to as the 578 data from here, is linked to the panel of fields, and in turn matched to each offer from Signup 49. Nonetheless, a minority of offers only have 578 data from a subset of observed data from 2013 through 2019. The 578 data also identifies the acreage in each field that is enrolled in CRP, as well as the types of land covers that are associated with their CRP contracts.

Methods for Assessing Land Use of Rejected Offers

Much of the analysis in this study relies on simple descriptive statistics of the data described above. The analysis of land use outcomes provides evidence for two causal questions of interest. First, how much of the land that enters CRP would otherwise be in land uses such as crops for grain, forage, or grazing, and how does this vary across crucial program subpopulations? Second, how much of each land use per dollar spent on the CRP, i.e., how cost effective is the CRP at avoiding different land uses?

To address the question of how CRP impacts land use, we observe how land associated with rejected CRP offers is used in the years immediately following the rejected offer. If the CRP accepted more acreage in Signup 49, this land would instead have gone into CRP, performing the conservation practices proposed in the offers that were rejected. Thus, unlike in most observational studies, we have reliable information about both scenarios of interest; the actual land use that the farmer chose for the land associated with the rejected offer and the counterfactual situation, represented by the proposed offer. We begin by looking at the impact of accepting all rejected land, i.e., setting the minimum EBI accepted at 0. We then look at the land uses that would be retired if offers with gradually lower EBI scores were accepted, i.e., as more acreage was accepted into the program. We also examine how land uses avoided due to

enrollment in the CRP vary across state to get some idea of how program impacts on land use differ across the study area.

We also examine how CRP land use impacts vary by prior CRP enrollment. We do this to examine whether land use impacts show persistence (Roberts and Lubowski 2007, Hendricks and Er 2018) and whether voluntary and involuntary exits differ significantly (Barnes et al. 2020). We estimate differences in proportions of land in several land use types, by prior CRP enrollment status and application status. Before estimating differences, we match fields associated with rejected offers with unoffered fields based on bins of land use proportions from 2013 through 2015, the National Commodity Crop Productivity Index (NCCPI), and Highly Erodible Land designation. Land use proportions from 2013 through 2015 are segmented into bins for each of several land uses – cropland for grain, cropland for forage, grazing land, unharvested, CRP, and all other uses. Bins for each of these six land uses include categories for no acreage, more than zero but less than or equal to 25 percent, 25 to 50 percent, 50 to 75 percent and greater than 75 percent. Bins for NCCPI include less than or equal to 0.2, 0.2 to 0.4, 0.4 to 0.6, 0.6 to 0.8, and 0.8 to 1. Fields are assigned to one of 156,250 ($5^6 \times 5 \times 2$) unique combinations of land use, HEL status, and NCCPI value, and we refer to the collection of fields with the same values for each of these bins as match groups.[9] In total, the matched sample includes approximately 6.2 million unique fields, including fields that did and did not make offers.

This study also examines the cost of enrolling more land into the CRP. We use proposed rental rates from rejected offers in General Signup 49 to infer the marginal costs of inducing certain types of land use change. More specifically, we summarize the average acreage in each

[9] Because these bins are correlated, including land use fractions mechanically, there are only 1,300 non-empty match groups.

land use that would have been retired for an additional $100 paid in rental rates, if the program accepted more acreage into the program. We assess how the cost of avoided land uses from the program would change as the EBI cutoff point is lowered. We also look at how program cost effectiveness varies by state. In addition to rental rates, the cost of establishing cover practices is also relevant for calculating the cost to the program of retiring additional acreage. Future work will incorporate this cost, which varies substantially across cover practices but comprises a small component of the total cost to FSA per acre.[10]

Determining Selection Effects into the CRP

Another main question that we examine in this manuscript is whether individuals that choose to make an offer in the CRP are non-additional in ways unobservable via past land use decisions. As discussed in the literature (e.g., Hendricks and Er 2018), non-additionality may occur if the CRP does not avoid as much cropland, because individuals who intend to do less intensive land uses in the future may be more inclined to apply to the CRP. The data that we use in this manuscript allow us the unique opportunity to examine this form of non-additionality, which in most other cases is unobservable.

We examine this form of non-additionality using two linear regression approaches. Before using either regression approach, we restrict our sample to the match groups described above to control for observable differences between parcels making offers and those that do not make offers. We then run regressions to determine whether there is non-additionality associated with making a CRP offer, where each regression includes land use fixed effects for each matching group. First, we estimate regressions using only post-2016 land use decisions, where

[10] Note that FSA spent $36 million on cost sharing for CRP in fiscal year 2020, while total rental payments for CRP in fiscal year 2020 was $1.796 billion (USDA, 2021a).

the dependent variable is the proportion of land in grain or in grain and forage in the years following the 2016 General Signup. Second, we estimate difference in differences regressions to determine if changes in the proportion of land in grain or in grain and forage were different for those that made an offer compared to fields in the same match group that did not make an offer. For the difference in differences regressions, we focus only on fields without CRP at any point, excluding fields which might have exited the program between 2013 and 2016.

Results

Land Use Impacts of CRP

We start by providing an overview of which land uses would have been avoided if the CRP had accepted more acreage in 2016. We summarize these results in figure 1, which provides an overview of land uses of all rejected offers in the years following their rejected offer. In the figure, shares of acreages by land use categories are shown across broad CRP practice categories. The size of each rectangle is weighted by the proportion of total acreage represented. Cover practices in General Signup CRP can be categorized broadly as grass, wildlife habitat, habitat for rare and declining species, pollinator habitat, and trees.[11] As seen in figure 1, grass practices accounted for the majority of rejected offers. Among offered grass practices, nearly 45 percent of acreage went into grain, about 15 percent of acreage went into forage, about 20 percent of acreage went into grazing or some other land use, and the remaining acreage found another way

[11] The cover practice (CP) codes within the grass category include CP1 and CP2. The CP codes within the wildlife habitat category include CP4B and CP4D. Habitat for rare and declining species is categorized as CP25, and pollinator habitat is categorized as CP42. Tree practices include CP3 and CP3A and constitute less than 700,000 acres nationally and are geographically concentrated outside our sample. Pollinator habitat constitutes approximately 540,000 acres nationally. Both tree practices and pollinator habitat are excluded from the figure given their limited acreage.

into CRP, likely through Continuous Signup.[12] The proportions of land use are similar for fields that offered rare habitat practices and wildlife practices. However, fields offering rare habitat were more likely than other offers to have went into a cropland for grain use, and less likely to have grown crops for forage.

Of course, in General Signup 49, there were many rejected offers. An expanded CRP may not have accepted all rejected acreage. Thus, in figure 2 we show how land uses of rejected offers varied by quartiles of EBI scores. If the CRP accepted only a small amount of extra acreage, it would start with rejected offers with the highest EBI scores. For Signup 49 in 2016, the EBI cutoff point was 292, so that the first quartile is bound from above at 292 and from below at 259. Most rejected offers had EBI scores in a relatively tight range, so that any below 200 are in the fourth quartile of EBI points. As the EBI scores of rejected offers decrease, land is more likely to have grown crops for grain in the years after being rejected. However, the differences across EBI quartiles are small and the amount of land used for grain or forage hovers around 60 percent across EBI quartiles. As shown in figure 2, 16-18 percent of land was in Continuous Signup CRP from 2017 through 2019, where landowners could enroll at any time during this period. Land eventually going into CRP is close to constant as the EBI decreases. Land used for grazing decreases as EBI points of rejected offers decrease (see figure 3 for proportions of land going into non-CRP uses).

Overall impacts on land use also differ by state. Table 1 shows the proportions of land uses that could have been avoided for each state if CRP was expanded to accept the highest two

[12] The vast majority of cover practice (CP) codes among these fields are only available through Continuous Signup, and those CP codes that are available through General Signup are relatively rare in Continuous Signup. Grasslands Signup uses a separate set of CP codes. Because these CP codes are reported in the planting data that we use, we can identify CRP acreage on these fields as either definitely Continuous, probably General, or Grasslands. Notably, almost all of this acreage is in CP codes that are only available through Continuous Signup, suggesting either pre-existing partial-field enrollments or new enrollments in Continuous Signup. There may be pre-existing General Signup partial-field enrollments on fields with rejected offers, but the evidence would suggest this is rare.

EBI quartiles among rejected offers. Across most states, the proportion of land in crops for grain ranged from 30 to 55 percent. Missouri had the most land from rejected offers in grain, 61 percent, and Wyoming had by far the lease at 1 percent. However, it is worth noting that Wyoming had a large portion of land that went into cropland used for forage, 15 percent. Notably, some states had a large proportion of land that eventually enrolled in the CRP through Continuous Signup. Iowa had the biggest proportion going into continuous CRP, 53 percent of its rejected offers. Montana had the least amount of land going into continuous CRP.

Table 2 provides a clearer idea of how landowners with rejected offers that did not subsequently enroll into CRP used their land. Even though states like Indiana, Illinois and Iowa had high proportions of land going into continuous CRP, the proportion of land in grain or forage was very high for those landowners that did not enroll into CRP, close to 80 percent of acres in each of those states. Several more states in the region had more than 60 percent going into grain and often higher when forage is included. In general, the table implies that CRP reduces the amount of land in intensive crop use across the sample states.

Table 3 breaks down land use in 2017 through 2019 on the basis of the field's history with CRP. Specifically, each column reports coefficients from a separate regression for the fraction of acreage in a given land use on indicators for whether a field made a rejected offer, whether a field was partially or fully enrolled in CRP in 2013, 2014, or 2015, and an interaction between those two. Each regression is estimated separately, with fixed effects for each match group and standard errors clustered by match group. All coefficients represent comparisons against similar fields across categories, with the baseline category being fields with no prior CRP enrollment and that did not make an offer in 2016. Fields with prior CRP enrollment were statistically less likely to plant crops for grain or to graze, regardless of whether they submitted

an offer in 2016. On the other hand, such fields were statistically more likely to be used for forage or to be left standing, with the latter potentially describing CRP plantings that were not disturbed after the end of the contract. More explicitly, fields with prior CRP enrollment were statistically more likely to be enrolled in CRP, especially if they did not submit an offer. The results for fields with prior enrollment not offering in 2016 are most likely driven by continuing contracts.

Among fields without prior CRP enrollment, fields with rejected offers were not statistically more likely to be engaged in grain or forage use. Fields with prior enrollment and a rejected offer were statistically more likely to be used for forage, relative to fields with prior enrollment but no offer in 2016. One could consider fields with prior enrollment and a rejected offer to be "involuntary exits" from the program, where at least some of those fields with prior enrollment and no offer in 2016 would be "voluntary exits." Under this terminology, this would suggest that voluntary exits are slightly less likely to engage in forage. Fields with rejected offers and no prior enrollment were statistically less likely to engage in grazing and more likely to report left standing, relative to fields without an offer in 2016 and no prior enrollment. Finally, among fields without prior CRP enrollment, fields with rejected offers were statistically more likely to ultimately enroll in the CRP, through Continuous Signup. However, the magnitude of this effect is small relative to CRP enrollment.

Cost of Land Uses Avoided through CRP

The last section focuses primarily on what kinds of land uses the CRP could have avoided if the CRP were expanded to accept rejected offers. We find that the proportion of land uses that could have been enrolled does not change substantially as the hypothetical EBI cutoff is lowered.

However, because the CRP penalizes higher rental rates, retired land comes at a higher cost as the EBI cutoff is lowered. Figure 4 summarizes the average amount of acres in each land use avoided with $100 spent in the CRP, as the EBI cutoff is decreased. For those rejected offers with the highest quartile of EBI scores, 1.68 acres of land would have been retired for every $100 spent. The $100 would have retired 0.74 acres of cropland for grain, 0.22 acres of cropland for forage, 0.25 acres for grazing, and 0.24 acres in other uses. The remaining amount would simply have replaced enrollments in Continuous Signup CRP. These proportions do not change considerably from the first to third quartiles. However, among rejected offers in the fourth quartile, the land uses that could have been retired per $100 decreases considerably. This difference is due to higher rental rates among this group. As we discovered before, the proportion of land in grain or forage is similar across EBI quartiles.

In some ways, we get a better sense of the cost-effectiveness of the CRP at avoiding land uses by restricting our calculation to only those that did not sign up for Continuous CRP. This is shown in figure 5. Notably, the highest amount of grain avoided would have occurred for acreage in the highest EBI quartile. In this group, nearly an acre of grain could have been avoided for each $100 spent, and 1.21 acres in grain or forage could have been avoided per $100 spent. However, the second quartile of EBI scores would have retired the most amount of land across all land uses per $100 spent, as well as the highest amount of acreage retired in grain or forage per $100 spent. The least amount of acres in grain and forage would have been avoided among those with the lowest quartile of EBI scores among rejected offers.

Figure 6 provides a bit more detail about the amount of grain and forage that could have been avoided for offers in each quartile of EBI points. The figure provides the cumulative distributions for grain and forage acres potentially avoided for each of the four quartiles of EBI

points, among offers that did not go into CRP after being rejected. Reflecting what we saw in figure 5, offers in the first three quartiles of EBI points have similar distributions. However, from this figure we can see that quite a few offers would have led to 2 or more acres of grain and forage avoided for each $100 spent. Further, quite a few rejected offers would not have retired any land in grain or forage.

We provide more detail about the cost effectiveness of the CRP across states in tables 4 and 5. Table 4 provides the average acres in each land use that could be avoided per $100 for the top two EBI quartiles, by state. There is a considerable amount of variation in the acres that went into different land uses across states. Wyoming, Montana and North Dakota could have provided the most retired acres per $100 had these rejected offers been accepted. However, rejected offers in Montana and North Dakota consist of much more land in crops for grain than those in Wyoming. Rejected offers in Kansas also had a relatively high amount of acreage going into crops for grain. Table 4 also provides the average rental rates paid and the average EBI points assigned to inherent environmental benefits associated with rejected offers (referred to here as land EBI) for each state. The land EBI provides an indication of the potential environmental benefits from retiring the rejected offers in a particular state. We see that in states with fewer total acres retired per $100, both rental rates paid and land EBI values tend to be higher. Thus, although this land would be more expensive to enroll, retiring it would have avoided more grain (as we saw above) and may have brought more significant environmental benefits.

In table 5 we focus on land that did not enroll in Continuous CRP. The table shows how much acreage in each land use would have been avoided per $100, only for land that did not enroll in Continuous CRP. Rejected offers in Montana could have provided the most avoided grain or forage acreage per $100, followed by North Dakota, South Dakota and Kansas.

Wyoming could have provided the most acreage going into cropland for forage per $100, in large part due to the lower rental rates in the state.

Determining Selection Effects into the CRP

Finally, we examine whether there are significant selection impacts into the CRP, as evidenced by land use outcomes of rejected offers. Table 6 provides results for the set of regressions we explained in the previous section. All standard errors are clustered at the match group level. Column (1) provides results for a regression of the relationship between making an offer and subsequent land in grain from 2017 through 2019. The regression has a negative but insignificant impact, suggesting that those that make an offer had a similar proportion of land in grain after being rejected than did similar fields that did not make a CRP offer in the same set of years. In the second column, where the outcome is proportion in grain and forage, the impact is positive and significant. This implies that those that enrolled in CRP were likely to have a higher proportion of land in forage than similar fields in that period.

It may be the case that despite matching prior to running the regressions reported in columns (1) and (2) of table 6, there were slight differences in the levels of land in grain and forage among those that made offers in CRP compared to similar fields. For this reason, we also run two difference in differences regressions, reported in columns (3) and (4) in table 6, with similar dependent variables. These regressions indicate very small and insignificant positive impacts of applying for CRP. The effects and their standard errors are small enough such that the effect is convincingly null. Thus, we can conclude that there was not a large selection effect related to those that applied for CRP involving plans for future changes in land use. Interestingly,

this implies that land uses prior to enrolling into CRP would be a good indicator of land uses avoided from the CRP, at least for the immediate years before and after the application decision.

Conclusions

This manuscript assesses the land use impacts of the CRP. Specifically, we estimate land use impacts by assessing which land uses would be retired if the 2016 General Signup had accepted more acreage into the program. Across a wide range of EBI levels of rejected offers, we find that nearly 60 percent of unretired land not going into continuous CRP went into cropland grown for grain, and greater than 15 percent went into cropland for forage. We find that the proportion of land uses that could have been retired remains relatively steady as the EBI decreases. We also find that a relatively high proportion of land goes into Continuous CRP soon after being rejected. We also examine how cost-effectively the CRP retires land. We find that the cost of retiring different land uses remains relatively steady as the EBI cutoff is decreased, until the lowest quartile of EBI scores among rejected offers, where cost effectiveness is lower. Among rejected offers that do not subsequently enroll in continuous CRP, 1.2-1.3 acres of forage and grain are retired for each $100 paid across the highest three quartiles of EBI points among rejected offers.

We also find large variation across subpopulations. Variation is large across states in both the proportions of land uses avoided and cost-effectiveness of land avoided through CRP. We find that land use is substantially different for parcels exiting the CRP, both voluntarily and involuntarily, compared to offers not previously in the CRP. Specifically, those previously in CRP show evidence of persistent land use impacts of the CRP. We also examine whether there is significant non-additionality among those that make CRP offers, examining whether those that make offers subsequently decrease land use intensity in the years after making an offer. We do

not find significant evidence that this phenomenon occurs, implying that land uses prior to applying to CRP are a good predictor of land uses after enrolling, at least in the near term.

In this study, we focus on the land use that would have been avoided by the CRP had General Signup 49 accepted more acreage. Notably, the Signup followed legislation that significantly reduced the total acreage allowed into the CRP and was thus more stringent than previous auctions. Thus, this auction included a large set of fields that would have been accepted into CRP in other Signups with similar offers, meaning the ATUT estimated in this article may represent the treatment effects of a large portion of enrolled land from other auctions, lending our results external relevance.

However, we acknowledge that the actual set of offers in each auction may depend on the stringency of the auction. In a less competitive year, offers may have been less competitive, with proposed rental rates closer to their maxima and/or lower EBI land covers offered. Further, more landowners may make CRP offers in less competitive years. We argue that our results extend to other General Signup conditions. Less competitive offers across the board would increase the costs of enrolling land in CRP through higher cost shares and rental rates paid, but such a scenario would not change the land uses avoided for the same offered fields. Further, we know from variation in offers across several General Signups that the primary way that landowners make their offers more competitive is through practice choices. We do not consider the costs of practice choices in this analysis but note that cost shares play a relatively small role in the overall program costs of enrollments. To account for higher rental rates, one could estimate an upper bound for the cost of enrolling land, assuming that landowners would offer their maximum rental rates. Further, although a less competitive auction may entice more landowners to offer land, these would be expected to have EBI scores within the range of less competitive offers observed

in this study. We find that the distribution of land uses avoided through the CRP changes little as the EBI score is decreased. If an auction was significantly less competitive than Signup 49, these new offers would be expected to follow this trend to some level. Finally, we find that fields that make offers do not behave differently after the 2016 Signup than fields that do not make offers, after controlling for land use decisions prior to the Signup. Thus, we do not find evidence of any unobservable driver of making an offer to the General Signup that is also correlated with subsequent land use decisions.

References

Barnes, J.C., M. Sketch, A.R. Gramza, M.G. Sorice, R. Iovanna, and A.A. Dayer. 2020. "Land Use Decisions After the Conservation Reserve Program: Re-Enrollment, Reversion, and Persistence in the Southern Great Plains." *Conservation Science and Practice* 2(9): e254.

Bigelow, D., R. Claassen, D. Hellerstein, V. Breneman, R. Williams, and C. You. 2020. "The Fate of Land in Expiring Conservation Reserve Program Contracts, 2013-16." U.S. Department of Agriculture, Economic Research Service EIB-215.

Conservation Reserve, 16 U.S. Code § 3831. 1985. Retrieved from: https://www.law.cornell.edu/uscode/text/16/3831

Dodson, C., R. McElroy, F. Gale, K. Hanson, and T. Carlin. 1994. "Gauging Economic Impacts as CRP Contracts Expire." Washington, DC: U.S. Department of Agriculture Economic Research Service, Agricultural Outlook-211.

Hansen, L. "Conservation Reserve Program: Environmental Benefits Update." 2007. *Agricultural and Resource Economics Review* 36(2): 267-280.

Hellerstein, D., D. Vilorio, and M. Ribaudo, eds. 2019. *Agricultural Resources and Environmental Indicators, 2019*. Washington DC: U.S. Department of Agriculture, Economic Research Service, Economic Information Bulletin-208, May.

Hendricks, N.P., and E. Er. 2018. "Changes in Cropland Area in the United States and the Role of CRP." *Food Policy* 75: 15-23.

Kirwan, Barrett, R.N. Lubowski and M.J. Roberts. 2005. "How Cost-Effective are Land Retirement Auctions? Estimating the Difference between Payments and Willingness to Accept in the Conservation Reserve Program." *American Journal of Agricultural Economics 87*(5): 1239-1247.

Lubowski, R.N., A.J. Plantinga, and R.N. Stavins. 2008. "What Drives Land-Use Change in the United States? A National Analysis of Landowner Decisions." *Land Economics* 84(4): 529-550.

Morefield, P.E., S.D. LeDuc, C.M. Clark, and R. Iovanna. 2016. "Grasslands, Wetlands, and Agriculture: The Fate of Land Expiring from the Conservation Reserve Program in the Midwestern United States." *Environmental Research Letters* 11(9): 094005.

Ribaudo, M. 1989. *Water Quality Benefits from the Conservation Reserve Program.* Washington, DC: U.S. Department of Agriculture, Economic Research Service, Agricultural Economic Report-606

Roberts, M.J., and R.N. Lubowski. 2007. "Enduring Impacts of Land Retirement Policies: Evidence from the Conservation Reserve Program." *Land Economics* 83(4): 516-538.

United States Department of Agriculture: Farm Service Agency. 2021a. Conservation Reserve Program, Status – End of September 2021. Retrieved from https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/Conservation/PDF/OnePager%20September%202021%20CRPOnePager.pdf

United States Department of Agriculture: Farm Service Agency. 2021b. Fact Sheet: 56th General Enrollment Period Environmental Benefits Index (EBI). Retrieved from https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/FactSheets/2020/crp-56th-ebi-fact-sheet-12-31-2020.pdf

United States Department of Agriculture: Farm Service Agency. 2021c. The Conservation Reserve Program: A 35-Year History. Retrieved from

https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/Conservation/PDF/35_YEARS_CRP_B.pdf

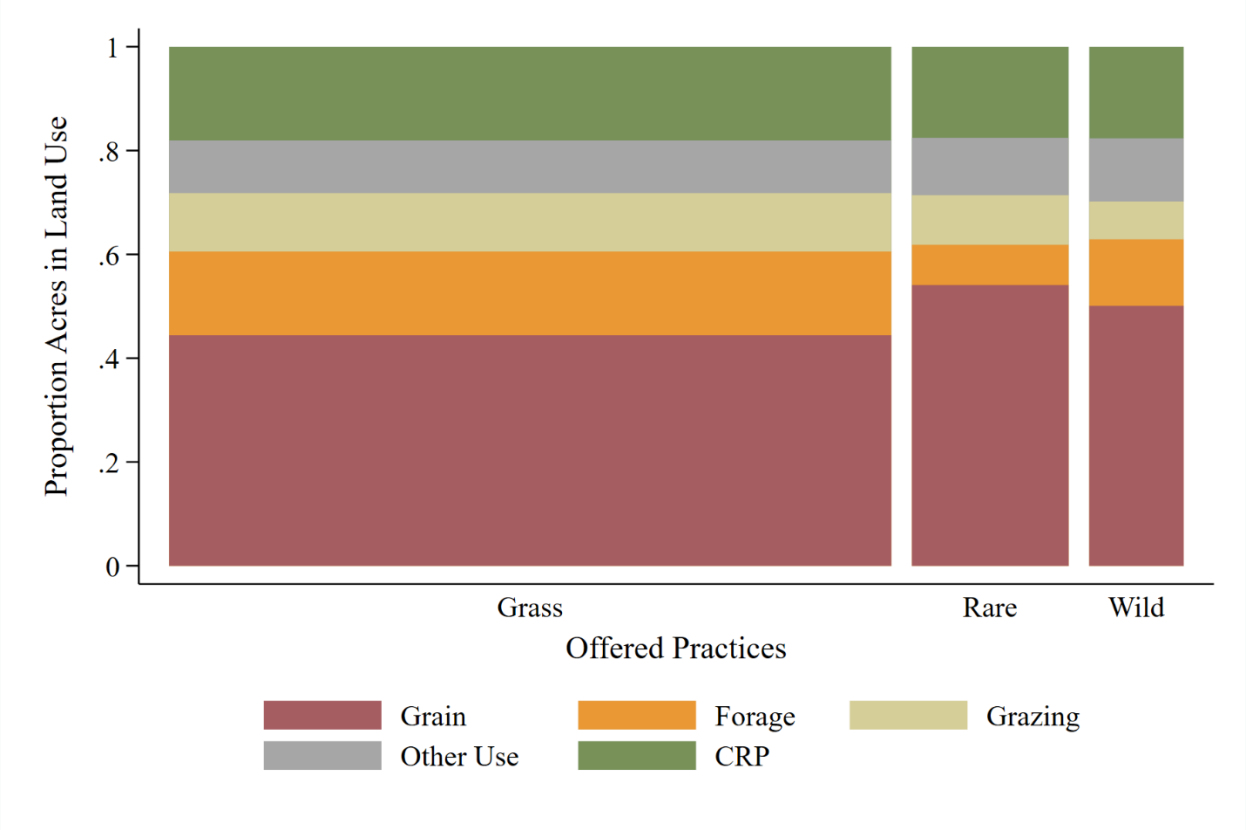

Figure 1: Most common land uses of rejected offers in the years after Signup 49, by practice category

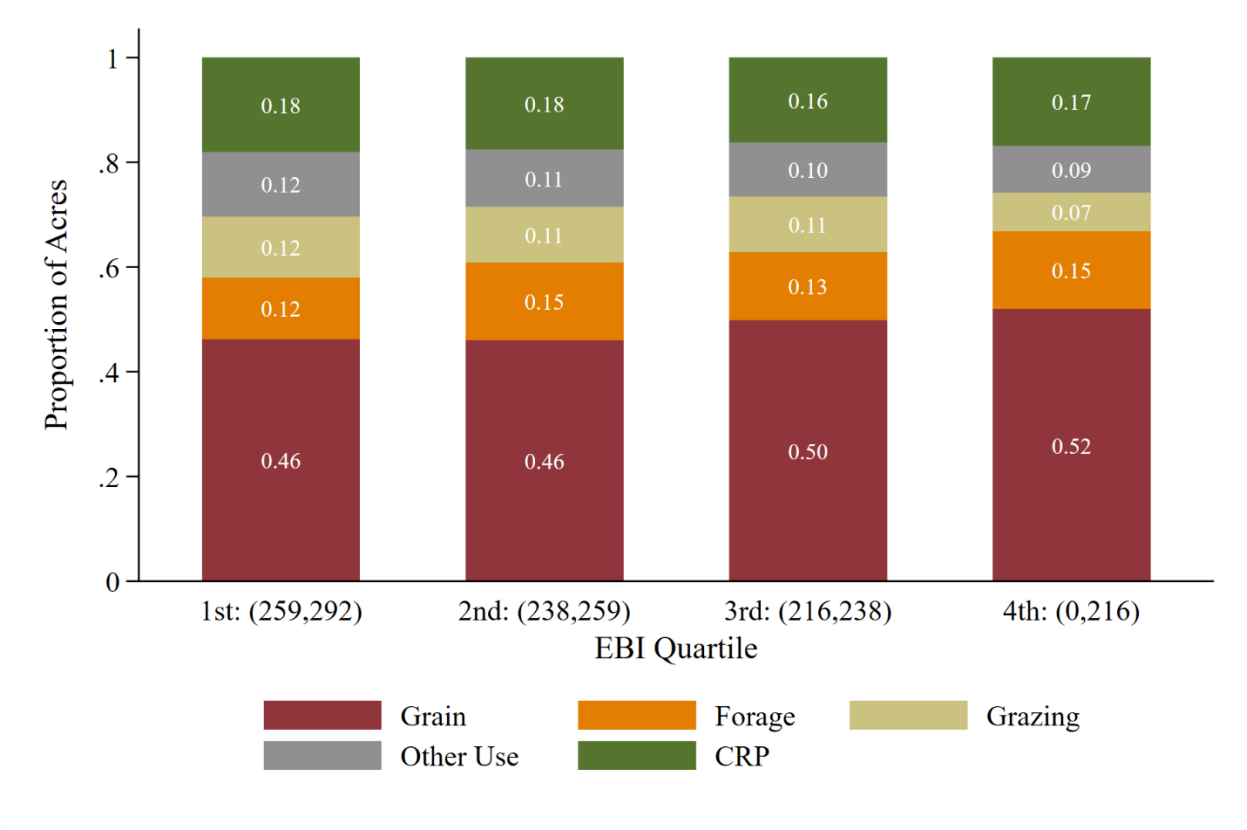

Figure 2: Proportion of acres avoided for rejected CRP offers, by land use and EBI quartile (including CRP)

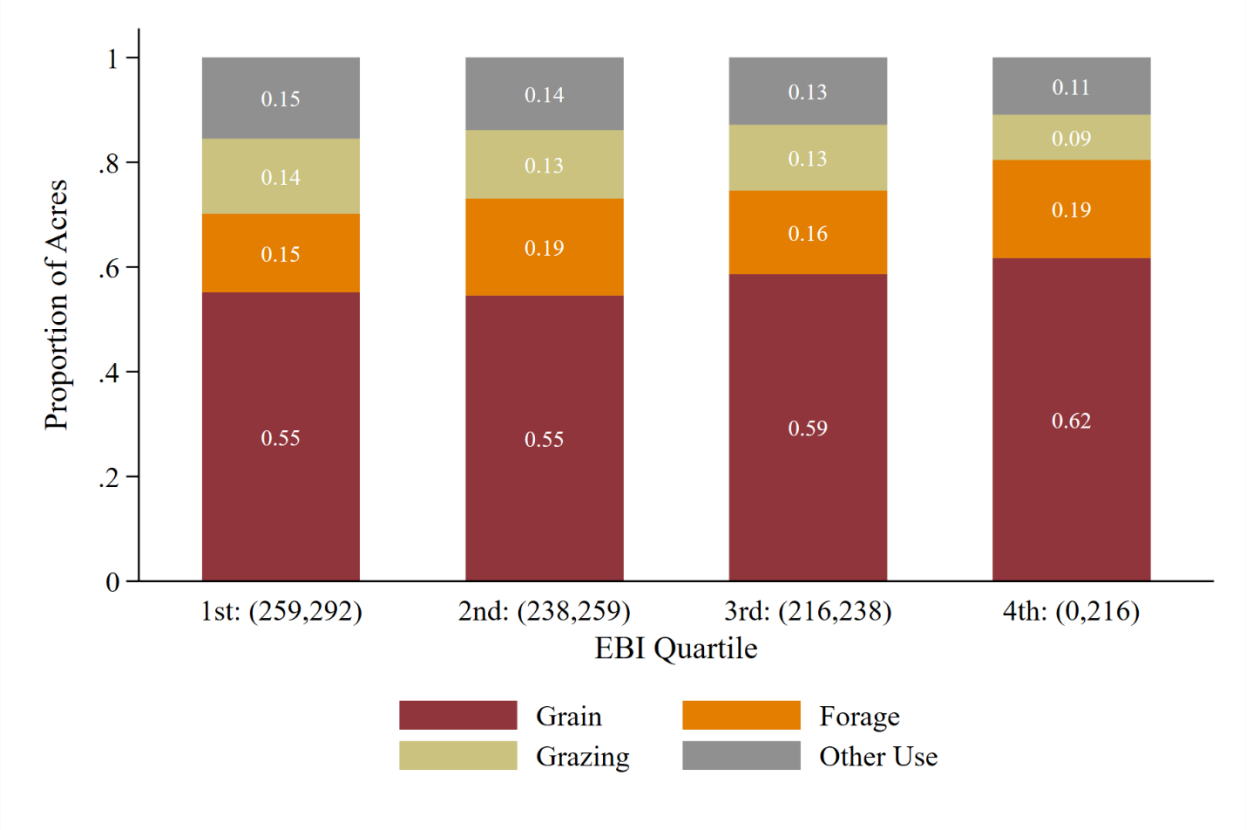

Figure 3: Proportion of acres avoided for rejected CRP offers, by land use and EBI quartile (no CRP)

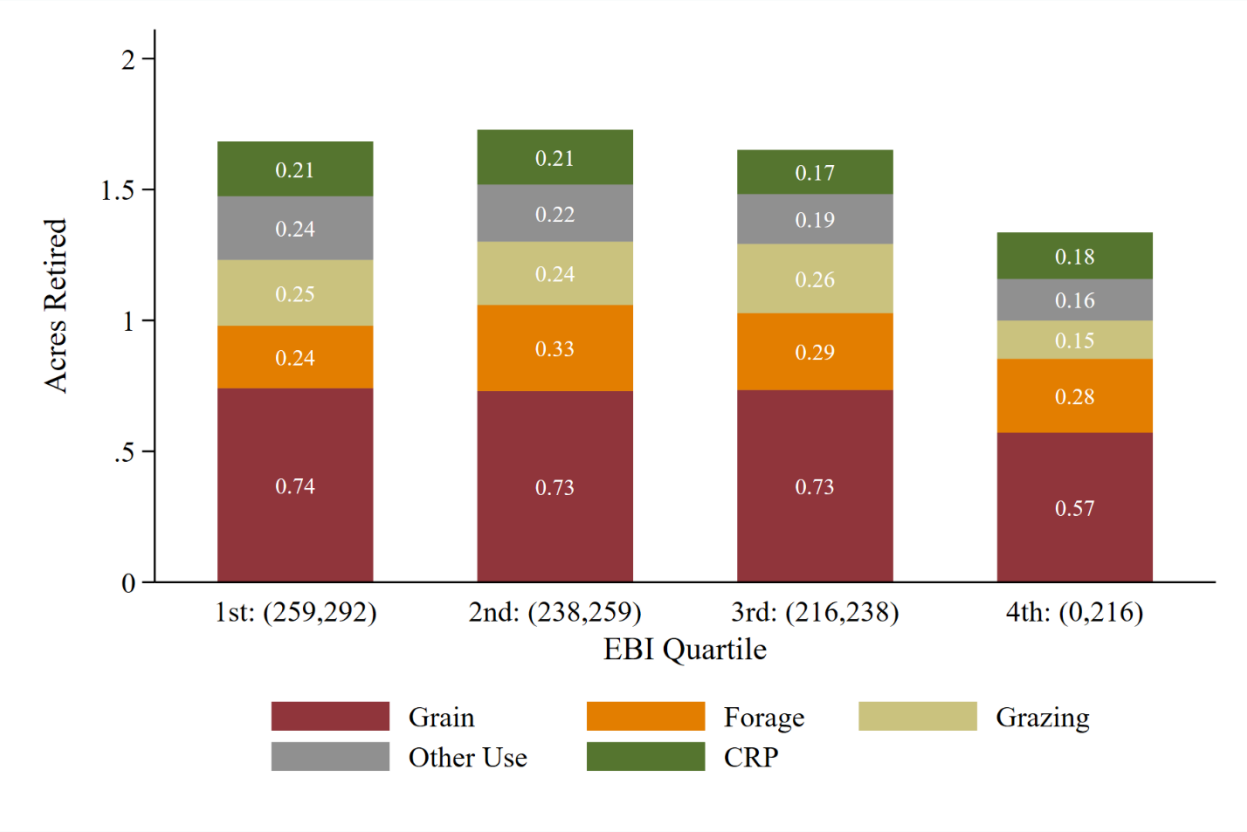

Figure 4: Acres retired per $100 spent on rejected CRP offers, by land use and EBI quartile (including CRP)

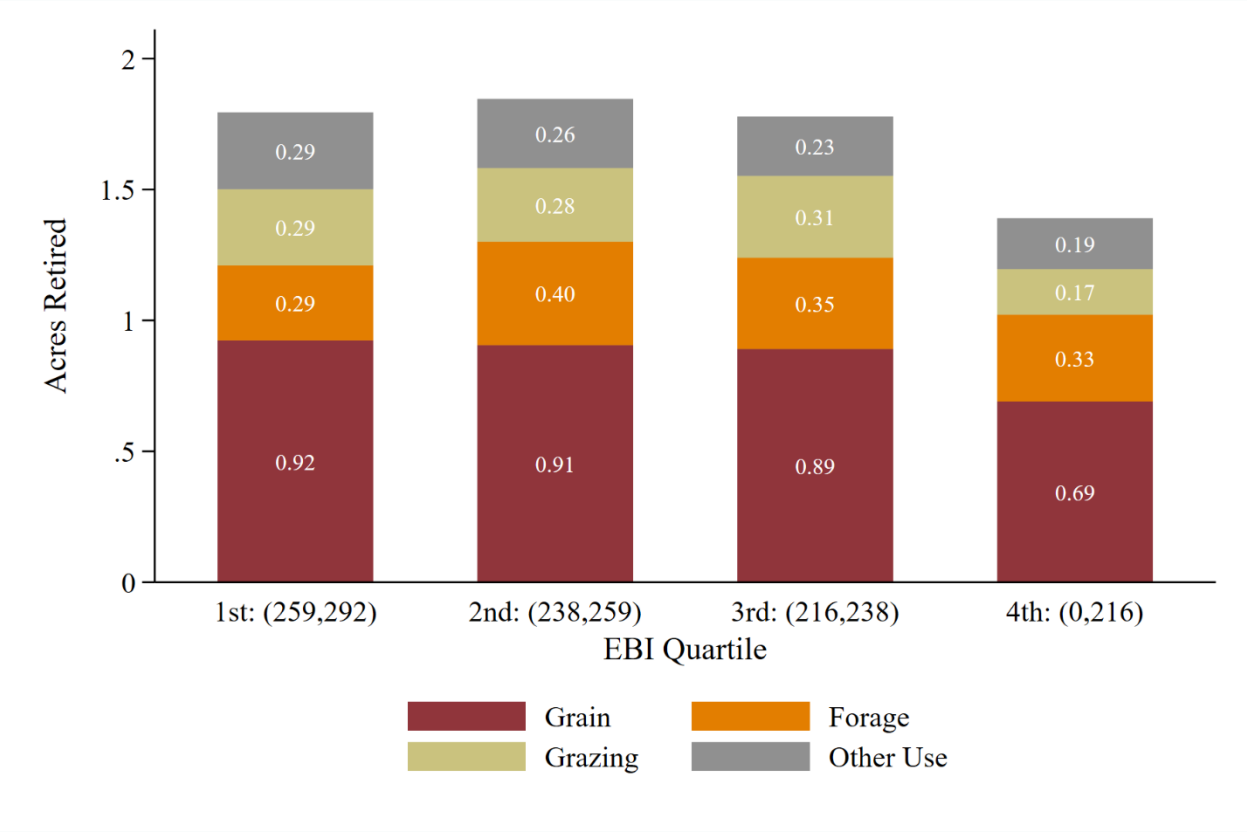

Figure 5: Acres retired per $100 spent on rejected CRP offers, by land use and EBI quartile (no CRP)

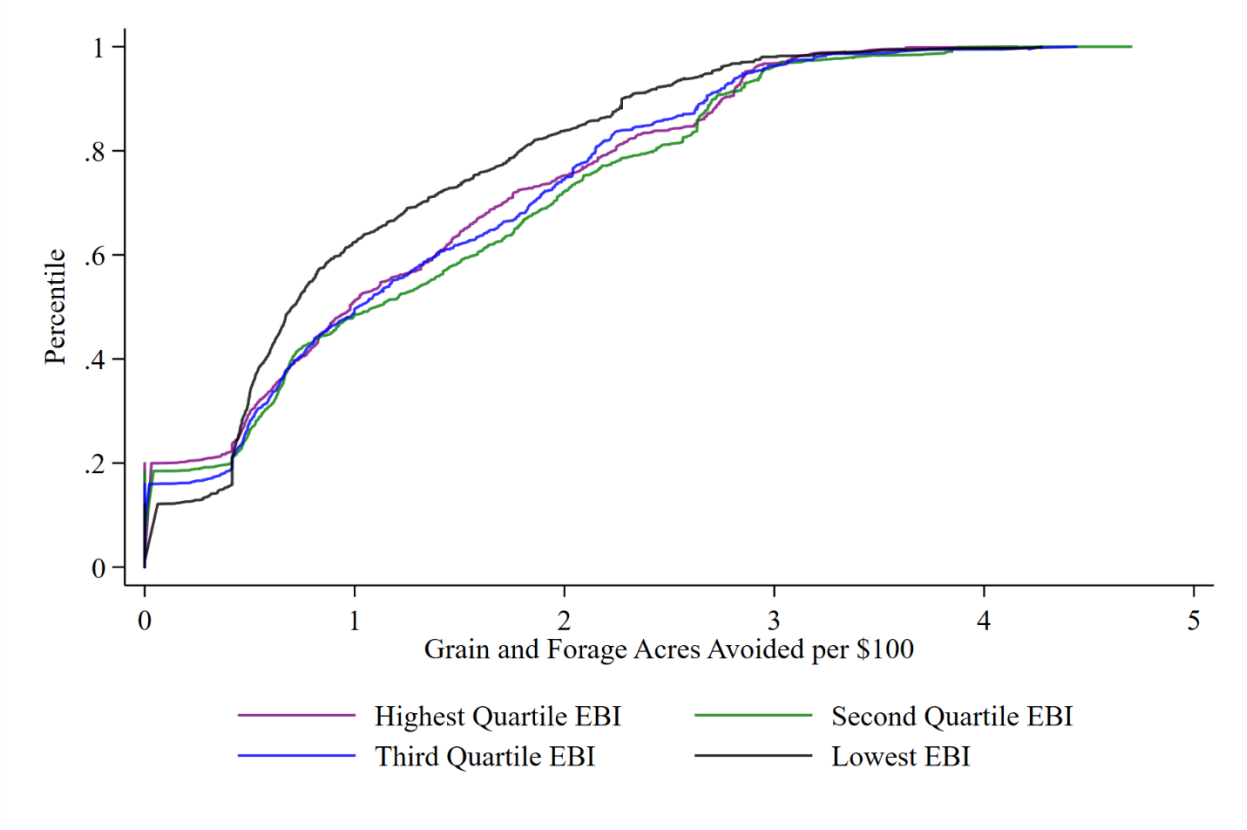

Figure 6: Distribution of grain and forage acres avoided per $100 spent on enrolling rejected offers, by EBI quartile

Table 1: Proportion acres avoided, by land use and state

State	Grain	Forage	Grazing	CRP	Other
Illinois	0.45	0.04	0.00	0.44	0.06
Indiana	0.47	0.04	0.01	0.35	0.13
Iowa	0.35	0.08	0.01	0.53	0.03
Kansas	0.45	0.11	0.18	0.10	0.15
Michigan	0.46	0.04	0.01	0.31	0.19
Minnesota	0.58	0.06	0.01	0.22	0.14
Missouri	0.61	0.07	0.03	0.23	0.06
Montana	0.45	0.23	0.13	0.04	0.14
Nebraska	0.36	0.10	0.22	0.18	0.13
North Dakota	0.53	0.20	0.00	0.15	0.11
Ohio	0.52	0.06	0.00	0.27	0.15
South Dakota	0.29	0.28	0.15	0.22	0.06
Wisconsin	0.41	0.12	0.03	0.34	0.09
Wyoming	0.01	0.15	0.68	0.15	0.00

Table 2: Proportion acres avoided, by land use and state (excluding Continuous enrollment)

State	Grain	Forage	Grazing	Other
Illinois	0.80	0.08	0.01	0.12
Indiana	0.73	0.06	0.01	0.20
Iowa	0.75	0.16	0.03	0.06
Kansas	0.50	0.13	0.20	0.17
Michigan	0.66	0.05	0.02	0.27
Minnesota	0.74	0.07	0.01	0.18
Missouri	0.79	0.09	0.04	0.08
Montana	0.47	0.24	0.14	0.15
Nebraska	0.45	0.13	0.26	0.16
North Dakota	0.63	0.23	0.00	0.13
Ohio	0.71	0.08	0.00	0.20
South Dakota	0.38	0.36	0.19	0.07
Wisconsin	0.62	0.19	0.05	0.14
Wyoming	0.02	0.18	0.80	0.00

Table 3: Differences in Land use Outcomes

	(1) Grain	(2) Forage	(3) Grazing	(4) CRP	(5) Left Standing	(6) Other
No Offer Made X Previous CRP	-0.190***	-0.00158	-0.136***	0.198***	0.137***	-0.00801***
	(0.0164)	(0.00231)	(0.0188)	(0.00464)	(0.00710)	(0.00243)
Offer Made X No Previous CRP	0.0162	0.00508	-0.0368*	0.00170***	0.0195***	-0.00568**
	(0.0213)	(0.00718)	(0.0192)	(0.000303)	(0.00533)	(0.00261)
Offer Made X Previous CRP	-0.194***	0.0847***	-0.114***	0.0613***	0.174***	-0.0117***
	(0.0184)	(0.00619)	(0.0195)	(0.0120)	(0.00906)	(0.00265)
P (Coefficient on Offer and No Offer are Equal | Previous CRP)	0.60	0.00***	0.00***	0.00***	0.00***	0.01**
Mean, No Offer, No Previous CRP	0.603***	0.144***	0.185***	-0.00118***	0.0429***	0.0264***
	(0.000261)	(0.0000414)	(0.000306)	(0.0000730)	(0.000117)	(0.0000392)
R^2	0.556	0.391	0.649	0.146	0.387	0.0764
Obs.	17,925,835	17,925,835	17,925,835	17,925,835	17,925,835	17,925,835

Standard errors in parentheses clustered by match group

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: The table compares proportions in each land use outcome by whether the parcel makes an offer and whether it was previously in CRP. Each regression is matched using match groups. The baseline category is no offer and no previous CRP enrollment.

Table 4: Total acres avoided per $100, by land use and state

State	Grain	Forage	Grazing	CRP	Other	Total Acres	Rent Paid	Land EBI
Illinois	0.29	0.02	0.00	0.27	0.04	0.63	171.13	170.78
Indiana	0.28	0.03	0.01	0.24	0.09	0.64	160.96	150.45
Iowa	0.17	0.04	0.01	0.26	0.01	0.49	207.80	178.40
Kansas	0.82	0.18	0.34	0.19	0.29	1.83	58.73	99.10
Michigan	0.43	0.03	0.01	0.27	0.18	0.93	114.70	109.01
Minnesota	0.46	0.05	0.00	0.14	0.16	0.82	148.89	124.90
Missouri	0.41	0.05	0.03	0.15	0.05	0.69	152.62	165.29
Montana	1.23	0.69	0.42	0.13	0.41	2.88	35.47	83.57
Nebraska	0.60	0.17	0.43	0.31	0.27	1.78	76.06	107.70
North Dakota	0.97	0.48	0.01	0.35	0.24	2.05	55.65	97.74
Ohio	0.57	0.05	0.00	0.22	0.12	0.97	122.05	107.02
South Dakota	0.39	0.57	0.31	0.40	0.08	1.74	69.62	96.16
Wisconsin	0.36	0.12	0.02	0.25	0.08	0.83	132.08	149.52
Wyoming	0.05	0.56	2.74	0.61	0.00	3.95	25.40	131.33

Table 5: Total acres avoided per $100, by land use and state (excluding Continuous enrollment)

State	Grain	Forage	Grazing	Other	Total Acres	Rent Paid	Land EBI
Illinois	0.52	0.04	0.00	0.07	0.63	169.41	167.23
Indiana	0.43	0.05	0.01	0.13	0.61	169.11	158.41
Iowa	0.36	0.09	0.01	0.03	0.49	208.21	178.36
Kansas	0.92	0.20	0.38	0.32	1.83	58.55	98.56
Michigan	0.63	0.04	0.02	0.26	0.95	112.75	107.30
Minnesota	0.60	0.07	0.01	0.20	0.87	139.14	120.45
Missouri	0.54	0.07	0.03	0.06	0.70	150.44	164.40
Montana	1.31	0.72	0.42	0.43	2.88	35.44	82.72
Nebraska	0.79	0.21	0.46	0.32	1.78	75.30	106.35
North Dakota	1.16	0.55	0.01	0.28	2.00	57.11	97.64
Ohio	0.80	0.07	0.00	0.15	1.02	119.41	104.04
South Dakota	0.55	0.65	0.44	0.07	1.71	70.02	93.23
Wisconsin	0.55	0.17	0.04	0.13	0.88	125.20	144.11
Wyoming	0.09	1.01	2.76	0.00	3.86	26.07	120.43

Table 6: Do individuals who make offers go into different land uses than similar fields unassociated with offers?

	Post-Offer Land Use		Difference in Differences	
	(1)	(2)	(3)	(4)
	Proportion Grain	Proportion Grain and Forage	Proportion Grain	Proportion Grain and Forage
Offer made	0.00278	0.0451***		
	(0.0100)	(0.0159)		
Offer made X post			-0.00614	-0.0492***
			(0.00993)	(0.0185)
Constant	0.600***	0.743***	0.613***	0.780***
	(0.0000241)	(0.0000383)	(0.00479)	(0.00895)
R^2	0.557	0.584	0.858	0.879
Obs.	17,925,260	17,925,260	37,013,004	37,013,004

Standard errors in parentheses clustered by match group
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$