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The Opportunity Cost of the Conservation Reserve Program:

A Kansas Land Example

The Conservation Reserve Program (CRP) was implemented by Congress as part of the Food Security Act of 1985, with the goal of setting aside environmentally sensitive farmland from agricultural production. Between 1990 and 2010, the CRP idled about 30-35 million acres, which represents about 9% of the cropland area in the United States. Enrollment in the CRP reached a peak of 36.8 million acres in 2007, with an annual budget of $1.8 billion. Enrollment decreased substantially to only 23.8 million acres in 2016 due to a combination of high commodity prices and a decreasing enrollment cap imposed by the 2014 Farm Bill (Hendricks and Er 2018). Under the 2018 Farm Bill, acreage was increased to 27 million. Given that the CRP is the largest land retirement program in the United States and that farmland is the most fundamental asset to the agricultural sector, determining how farmland values are affected by the CRP remains an important empirical question and is the primary objective of this study

There is a rich literature investigating the various economic and environmental benefits of the CRP (e.g. Babcock et al. 1996; Feather et al. 1999, Wu 2000; Kirwan et al. 2005, Hellerstein 2017). Previous work has considered slippage in the CRP (Wu 2000)[1], the optimal targeting of CRP enrollment (e.g., Babcock et al. 1997; Khanna et al. 2003; Wallander, Ferraro, and Higgins 2017), the cost-effectiveness of the CRP's bidding method for enrollment (e.g., Smith 1995; Kirwan, Lubowski, and Roberts 2005), the decision of farmers to enroll in the CRP (e.g., Isik and Yang 2004; Lubowski, Plantinga, and Stavins 2008; Caldas et al. 2016), and land use decisions when farmers exit the program (Roberts and Lubowski 2007). A similar branch of literature has investigated the effects of government payment programs on agricultural land values (Just and Miranowsky 1993, Barnard et al. 1997, Goodwin et al. 2003, Roberts et al.

2003, Kirwan 2009). More recently, a study by Brown, Lambert, and Wojan (2019) found that the CRP does not have negative effects on rural job growth.

There are limited studies on the effects of the CRP on farmland values, however. In this paper, we estimate how enrollment in the CRP is capitalized into land values using a unique set of parcel-level transaction data obtained from the Kansas Society of Farm Managers and Rural Appraisers (KSFMRA) for the years 1998 to 2014. Additionally, we characterize how the effects of the CRP on land values has changed over time and how the effects vary across space.

If the expected benefits of enrolling in the CRP—through a fixed rental payment—exceed the benefits from crop production, then the additional benefits may be capitalized into the land values. For example, Kirwan, Lubowski, and Roberts (2005) found that CRP bids exceed the willingness to accept to enroll the land in the CRP program, which would lead to higher land values. On the other hand, there are several reasons why enrollment in the CRP might decrease land values. The choice to enroll in the CRP commits landowners to a 10 or 15-year contract. Breaking the contract incurs a substantial penalty. The length of the CRP contracts and restrictions on land use introduces an opportunity cost equal to the highest alternative use of the land (e.g. foregone returns from crop production or non-agricultural development). For example, if land was enrolled in the CRP during a period of low commodity prices, then the farmer may have been willing to accept a low CRP rental payment. If commodity prices increase during the contract period, then nearby farmland available for crop production is likely to fetch increased rental rates. The opportunity cost is thus the (higher) foregone rental rate from having the land idle rather than in crop production. Furthermore, farmers must incur significant costs to convert CRP back to crop production after the contract expires (Roberts and Lubowski 2007).

It is also possible that some farmers who enrolled in the CRP accepted a rental payment below the competitive rental rate for crop production if those farmers found the fixed payment especially appealing. For instance, Sullivan et al. (2004) found that the majority of CRP acres in 2001 were owned by retired farmers or those whose primary occupation was not farming. An alternative possibility is that some farmers who enter CRP contracts would have retired land from crop production by converting it to haying or grazing in the absence of CRP and so are willing to accept sub-competitive cropland rental rates (Lubowski et al. 2008).[2] However, if the land enrolled in CRP is sold, then it will be discounted compared to other land that does not face use restrictions.

For the reasons outlined above, it is difficult to predict how enrollment of land in CRP affects the value of the land. Furthermore, there is limited existing literature on the effects of the CRP on farmland values and the conclusions of these studies are largely ambiguous. Shoemaker (1989) compared bid values in the first sign-up to bid values in the fourth sign-up and found substantial windfall benefits to farmers, but only minor impacts of CRP on land values. Using county-level data from 1997, Wu and Lin (2010) estimated a structural model of CRP enrollment decisions, farmland values, and developed land values and found a positive impact on farmland values that varied regionally. Developed land was also positively impacted, but at a much lower magnitude.

Other studies have found zero or negative impacts of the CRP on land values. Lence and Mishra (2003) found statistically insignificant impacts of CRP payments on county-level cash rental rates in Iowa. Goodwin et al. (2003) found negative impacts of CRP payments on farmer-perceived land values. Taff and Weisberg (2007) and Schmitz and Shultz (2008) found a negative impact of CRP on land value and are the only studies that we are aware of that used parcel-level land transaction data. However, their data are limited to only a few years in the early 2000s and only to the states of Minnesota and North Dakota.

This paper provides several innovations to the existing literature on land value effects of CRP specifically and the effects of government payment programs more broadly. First, we are able to exploit a unique set of parcel-level transaction data for land sales in Kansas (as opposed to county-level aggregated data or assessment data). Second, our data range from 1998 to 2014. The long temporal span of our data covers a food commodity price boom that likely affected the returns to crop production and therefore the opportunity costs of CRP enrollment. The parcel-level sales data are used to estimate a hedonic model of land values following previous farmland value research (e.g. Palmquist 1989, Feng et al. 1993, Gardner and Barrows 1985, Schlenker et al. 2005, Taylor and Brester 2005, Sampson, Hendricks, and Taylor 2018). The model allows for the opportunity cost of CRP enrollment to vary across space and time. Factors impacting the opportunity costs include the relative productivity of land, returns to farming, and the time remaining under the CRP contracts.

Results provide evidence that the opportunity cost of committing to a CRP contract is non-zero. We find that the average discount associated with having land under CRP contract is 7.0% (about $71/ acre). By comparison, CRP rental payments under the new farm bill are currently $41/acre, which amounts to a capitalized value of about $333/acre assuming a 10-year contract and 5% discount rate. However, we also find that the land discount associated with CRP has been generally decreasing over time and that in some years the opportunity cost is not statistically different from zero. Additionally, the spatial pattern of CRP effects on land values is consistent with regional differences in land productivity (i.e., larger discounts in more productive regions).

Conceptual Model

The value of a parcel depends on the expected stream of net returns. When deciding to purchase land that is fully or partially enrolled in CRP, potential buyers weigh the present value of payments to be received over the remaining life of the contract against the expected returns from farming the land over the same period. Note that the impact of CRP on the land value only depends on the comparison of net benefits over the remaining contract length because after the contract ends the parcel can return to crop production and receive the same stream of benefits as a parcel not enrolled in CRP.

The present value of returns from CRP enrollment are defined as

(1) $$V_0^C = \sum_{t=1}^{k} C_t/(1+r_t)^t + w,$$

where V_0^C is the capitalized value of land at the end of period 0; C_t is the rent received from the CRP program at the end of period *t*; *k* is equal to the remaining life of the contract (up to 10 or 15 years); r_t is the real discount rate for year *t* and w are non-pecuniary benefits that may accrue to the landowner from enrolling the land in CRP (Lynch and Lovell 2003, Duke 2004). Similarly, the present value of expected returns from farming the land can be represented as follows

(2) $$V_0^F = E\left[\sum_{t=1}^{k} \frac{F_t}{(1+r_t)^t} - \frac{a}{(1+r_1)}\right],$$

where V_0^F is the value of the land at the end of period 0; F_t is the annual cash rent received from the land being farmed; a are a set of fixed adjustment costs of returning idle land to production and incurred in the first year of farming; and all other variables are as defined previously. If the present value of returns from CRP, V_0^C, is greater than the present value of expected cash rents received from farming the land, V_0^F, over the same time horizon, then the landowner will prefer a CRP contract. In this context, the opportunity cost is defined as

(3) $$V_0^C - V_0^F.$$

Another factor that affects the present value comparison is the impact on productivity of the land parcel when it exits the CRP contract and farming is resumed. Land which has not been tilled, fertilized, or managed in a farming capacity for at least a decade may require an adjustment period to again reach its full yield potential. This adjustment cost is represented by a in equation (2). The existence of these adjustment costs means that entering into a CRP contract can potentially impact returns to farming beyond the span of the contract itself. However, these impacts are not easily observable and are likely to differ by soil characteristics and farm management practices.

While the payments received from a CRP contract do not vary over the life of the contract, returns from farming will fluctuate with the profitability of the crop sector. The reduction in variability of annual returns from entering into a CRP contract may be very valuable to producers, especially those depending on a constant cash flow for financial management purposes. When deciding whether to purchase a parcel of land with an existing CRP contract, a landowner only knows recent profit levels for farming and cannot foresee the micro- and macroeconomic drivers that will affect the returns to farming a parcel of land over a multiple-year horizon.

A proxy for this tradeoff for the state of Kansas would be a comparison of the annual state average CRP rental rate to the annual state average cash rent from non-irrigated farming (USDA-FSA, USDA-NASS). To normalize these rents relative to land values, a rent-to-value ratio is calculated and displayed in figure 1 for the years 1997 to 2014. This ratio reflects the average returns to ownership of land when it is either enrolled in CRP or farmed. From 1995 to 2009, the average returns to land under CRP contract were higher than the average returns to farming. Starting in 2010, and consistent with increased net farm income due to high commodity prices, the returns to farming (measured by the cash rent-to-value ratio) exceeded the returns from enrollment in the CRP.

Given the high returns to CRP contracts relative to the average returns to farming, one might have expected to see largescale enrollment among landowners. However, the rules of the program ensure that mass enrollments are not possible. Along with the acreage cap, the bidding process is complex and favors land that, when retired, would bring about the most positive environmental impact. Also, the trends shown in figure 1 reflect returns to farming for the average parcel of land. If the land or the farmer's management skills are better than average, then it is possible that farming the land is the preferred option (i.e., inframarginal returns).

The average returns to CRP fell below the returns to farming in 2010. High commodity prices and record farm incomes resulted in average cash rents that made farming the more profitable choice. If given the choice, it seems plausible that landowners would consider breaking their CRP contract and resume farming the land. However, this option would result in having to repay the entire amount the government has paid on the contract up to that point in time. Also, management costs associated with cash rentals tend to be higher than those associated with CRP. A landowner has to exert the effort to either find a tenant or farm the land themselves and this may require investment in machinery and other management costs. Finally, the previously mentioned nonpecuniary benefits of the program may be large enough that they are willing to accept a lower rate of return to avoid losing the environmental benefits associated with the CRP contract (e.g., Lynch and Lovell 2003, Duke 2004).

While figure 1 shows how the CRP and cash rent to value ratios changed on average statewide, it is also important to consider the heterogeneity of land productivity in Kansas. Figure 2 displays the six regions of the state used in the following analysis. The eastern and western regions of the state have distinct crop mixes that can be attributed to wide variance in rainfall and soil quality. Parcels of land in eastern Kansas tend to be better suited for corn and soybeans, while western Kansas rainfall levels are preferential for wheat and grain sorghum. Figures 3a and 3b display the relative rent-to-value ratios for CRP and cash rent for the Northwest and Northeast regions of state. These charts were constructed using a weighted average by county enrollment of CRP rate and regional land values in Kansas (USDA-FSA, 2016). In Northeast Kansas, the CRP rent-to-value is lower than the returns from cash rent for all years except 1997. However, in Northwest Kansas, acres enrolled in CRP exhibit higher rent to value ratios than farming for all years of the study period. Explicitly controlling for regional differences in agricultural productivity and region-specific temporal trends in CRP and cash rent to value ratios is therefore an important modeling consideration.

CRP contracts have a 10 or 15-year lifetime. It is therefore logical that the opportunity cost borne by a landowner entering a CRP contract may change over the length of the contract (e.g. due to changing food commodity prices). Our analysis is unique in that spatio-temporal heterogeneity in opportunity cost of CRP enrollment is captured explicitly in certain model specifications when estimating potential land buyer's willingness to pay for parcels with CRP contracts.

Empirical Model

The conceptual model shown in equations (1) and (2) are incorporated into a hedonic regression model of land values that follows Palmquist's (1989) extension of Rosen's (1974) model applied to heterogeneous land parcels. The model is specified as follows:

(4) $$\ln(Price_{it}) = \beta_0 + \beta_1 Size_i + \beta_2 Size_i^2 + \beta_3 CropPerc_i + \beta_4 Precipitation_i + \beta_5 AverageQ_i + \beta_6 GoodQ_i + \beta_7 DirtRd_i + \beta_8 GravelRd_i + \beta_9 NetRet_{d,t-1} + \lambda_0 CRP_i + \gamma_t + \alpha_c + \eta_d t + \sum_{q=1}^{3} \pi_q Z_{it}^q + \varepsilon_{it},$$

where $\ln(Price_{it})$ is the natural logarithm of the per acre sale price of parcel *i* that sold in year t; $Size_i$ and $Size_i^2$ are the linear and squared terms for size in acres of parcel *i*; $CropPerc_i$ is the percent of parcel *i* that is classified as cropland relative to pasture; $Precipitation_i$ is a 20-year average annual rainfall, measured at the section level, for parcel *i*; $AverageQ_i$ and $GoodQ_i$ are binary variables indicating average or good land quality as determined by the appraisers who compiled the data, respectively; $DirtRd_i$ and $GravelRd_i$ are binary variables that indicate the type of road that accesses parcel i; $NetRet_{d,t-1}$ measures the one-year lagged, deflated net returns to farming in Kansas on a per acre basis in region d for year t-1; and CRP_i is a binary variable indicating if a CRP contract is present on parcel i. The model is completed by specifying a set of year fixed effects (γ_t), county fixed effects (α_c), interaction terms between the region of the state (of which there are six) and a year trend variable ($\eta_d t$), a set of binary variables to indicate the quarter of the year when the parcel sold (Z_{it}^q), and robust standard errors ε_{it} (Huber 1967, While 1980). It is important to note that even though we have different parcels selling at different points in time, we do not have repeated sales data. It is also important that we control for the quality of the parcel with $AverageQ_i$ and $GoodQ_i$ and county fixed effects because land enrolled in CRP is likely to be of lower quality. Omitting land quality controls would bias the coefficient on CRP downwards.

The model presented in equation (4) will provide an estimate of the average effect of having a CRP contract on a tract of land. It does not, however, allow for that effect to change over space and time. Therefore, we estimate a second model that allows for the impact of CRP to vary across years and across the six regions in Figure 2. The model is as follows:

(5) $$\ln(Price_{it}) = \beta_0 + \beta_1 Size_i + \beta_2 Size_i^2 + \beta_3 CropPerc_i + \beta_4 Precipitation_i + \beta_5 AverageQ_i + \beta_6 GoodQ_i + \beta_7 DirtRd_i + \beta_8 GravelRd_i + \beta_9 NetRet_{d,t-1} + \lambda_0 CRP_i + \sum_{t=1}^{17} \lambda_t (CRP_i * Y_t) + \sum_{d=1}^{6} \theta_d (CRP_i * R_d) + \gamma_t + \alpha_c + \eta_d t + \sum_{q=1}^{3} \pi_q Z_{it}^q + \varepsilon_{it},$$

where λ_t is the year-specific effect of CRP on land values and θ_d denotes a region-specific effect of CRP on land values. The variables of interest in this model are CRP_i, $CRP_i * Y_t$, and $CRP_i * R_d$. The coefficient of CRP_i measures the impact on price per acre of a parcel of land with a CRP contract present on some or all of the parcel, evaluated at the base year (1998) and for the base region (Southeastern KS). The interaction term, $CRP_i * Y_t$, measures how the impact of a CRP contract affects land value over time, relative to the base year. The third term, $CRP_i * R_d$, measures the impact of CRP contracts across different regions of the state relative to the base region (Southeastern KS). This specification thus allows for the possibility that the opportunity cost CRP enrollment adjusts over time (e.g., due to commodity price changes affecting farm profitability) and space.

The coefficient on $Size_i$ is expected to be negative, while the squared term is expected to be positive. This reflects a higher per acre sale price for smaller tracts of land, but with this effect declining at a declining rate as parcels increase in size (Taylor and Brester 2005). This effect is driven primarily by the demand for larger versus smaller tracts of land. For example, buyers must have access to large amounts of capital to purchase a large tract, making the overall number of bidders less than those with sufficient capital to bid on a small tract.

The composition of the parcel, in terms of cropland and pasture, affects its usage and profit potential. Non-irrigated cropland is expected to sell at a premium to pasture based on expected profitability. Similarly, land rated as Good quality is expected to sell at a premium relative to Average quality, which is likely to sell at a premium to Poor quality land.[3] Access to the parcel, which affects both transportation logistics and costs, is expected to affect land value. Parcels with a hard paved road are expected to sell at a premium relative to gravel and dirt roads. The use of an annual precipitation variable accounts for spatial heterogeneity in rainfall, which is the primary source of water for nonirrigated crops and pasture. Annual net returns from farming per region, calculated as pre-tax total revenue minus total costs are included in the hedonic model to control for the profitability of agricultural production in the year in which a parcel sold, possibly affecting a buyer's willingness to pay for land.

A rich set of year, quarter, and county fixed effects along with region-specific linear trend interactions are included to control for unobserved temporal and spatial heterogeneity that might affect sales prices. County factors could include any number of variations including variation in access to urban areas and the marketing patterns of regional crop producers. Year fixed effects should capture any macroeconomic differences between years that affect all parcels (e.g., interest rates, expectations regarding farm policy, and shifts in international trade). Quarterly fixed effects are included to account for the seasonality of harvests and the availability of funds to bid on land. Regional linear trends capture systematic changes to land values over time that may differ across space. Thus, the identifying variation in the effect of CRP on land values will come from cross-sectional variation in enrollment within counties and time series variation in enrollment within counties that is not common to all counties in a year and net of long-run trends.

A common concern in hedonic models is omitted variables. There are a number of factors that may affect the amount a person is willing to bid on land that cannot be observed by the researcher. For example, a bidder with property bordering a tract that is for sale may be willing to bid slightly more than market price simply for the value close proximity brings. This is only a concern for our empirical approach if agglomeration is also correlated with CRP enrollment. Similarly, we do not observe if a tract has more than one CRP contract on it, or if those multiple contracts expire at the same time. This variability may cause a discount in the willingness of buyers to bid aggressively on a piece of land if the tract is broken up in a way that would affect farmability of the land.

Data

The data used in this study are parcel-level transaction data obtained from the Kansas Society of Farm Managers and Rural Appraisers (KSFMRA) for the years 1998 to 2014. The KSFMRA collected agricultural land sales over this period to assist members with appraisal work. To be included in the dataset, the land must be deemed by KSFMRA to be representative of the land sales in their region. The KSFMRA data include all the parcel characteristics, sale date, type of sale, sale price, and a rating of the overall quality of the parcel based on the member's professional opinion. Additional data on the average net returns per acre from farming were obtained from the Kansas Farm Management Association database for six regions of the state. Parcels without complete records or having fewer than 35 total parcel acres were dropped from the dataset. Precipitation is the 30-year average precipitation at the section level obtained from PRISM. The remaining number of usable observations totals 9,489 transactions. Of the total number of observations, 614 had current CRP contracts on some portion of the parcel. Summary statistics and definitions of the variables used in the analysis are shown in table 1.

Notes were made by KSFMRA members regarding the nature of the CRP contract for a subset of the parcels. These notes were coded by hand in the analysis dataset and are used to create a binary variable equal to 1 if a current CRP contract exists on that parcel of land. There was not sufficient information in the appraisal notes to create other CRP variables such as contract size (in acres) or time remaining under contract. However, for those observations with that data, the average number of acres under CRP contract is 83 acres, while average parcel size is 190 acres. The average time remaining on a CRP contract at the time of sale is 4.5 years and the average rental rate from CRP contracts in the dataset is $41.48 per acre. These data give some idea of the relative size and value of the CRP contracts at the parcel level.

Results

The use of the natural logarithm of price per acre as the dependent variable requires Kennedy's (1981) adjustment to all binary variables to correct for bias. The equation for the Kennedy adjustment is as follows:

(6) $$g = \exp\left(\hat{\beta} - 0.5\hat{V}\left(\hat{\beta}\right)\right) - 1$$

where $\hat{\beta}$ is the unadjusted coefficient resulting from the regressions in equations (4) and (5), and $\hat{V}$ is that coefficient's variance. The transformed coefficients, g, are presented in tables 2 and 3 for all binary variables.

The results of equation (4) are presented in table 2. The estimate of *CRP* from this model gives the average effect of the presence of a CRP contract on a piece of land. An existing CRP contract reduces the value of agricultural land by 7.0% on average. However, it is possible that this effect varies by region and year, so the results of equation (5), containing interactions between annual and regional fixed effects and the *CRP* variable, are presented in table 3.

The variable of most interest, *CRP*, is statistically significant and has a negative sign. This suggests that, in the base year of 1998 and in the Southeast region of the state, parcels having existing CRP contracts were worth 24.3% less than comparable land without a CRP contract. By comparison, parcels with existing CRP contracts in the Northwestern and Northcentral regions faced a relatively smaller land value discount in the base year; consistent with these regions having lower land productivity on average. It is also interesting to note the variability in the impact of a CRP contract on land value as it changes over time. As previously mentioned, changes in commodity prices affect the profitability of farming and thus affect the opportunity cost of having land under CRP contract. Additionally, it is expected that the opportunity cost of CRP changes over the life of the contract. In particular, it would be expected that the value of land enrolled in CRP would increase as the contract approaches its termination year. Figure 4 shows the linear combination of coefficients, of the marginal impact of a CRP contract on land value by year for the state.[4] Based on an F-test, the estimated linear combinations of *CRP* plus *CRP_Y* marked with a circle are negative and statistically significant at a p-value of 0.05 or better. Years marked by a square are not statistically different from zero. Taken together, the results indicate a pattern of relatively large land value discounts associated with CRP enrollment early in the sample period (i.e., discounts of 15-29%). In particular, the land value discount went from about -29% in 1999 to about -15% in 2005. For the subsequent years, except 2013, there is no evidence of a statistically significant land value discount associated with CRP enrollment.

The estimated coefficients trend up to a peak in 2008, where the value of land with a CRP contract is not statistically different from land without a CRP contract. This particular point estimate is unusually positive relative to the other estimated coefficients, warranting further interpretation. The first year of CRP enrollment was 1986 with a cumulative enrollment of 2.0 million acres. That number increased by 13.4 million acres in 1987, while another 10.6 million acres were added in 2008 (USDA-FSA 2009). From 1988 until 1998, additional acres were added at a much lower rate, with a decrease of 2.6 million enrolled acres in 1998. Enrollments also decreased in 2008 by 2.2 million acres. Given that contracts are either 10 or 15 years in length, it is possible that a large number of the parcels sold from 2006 to 2009 had CRP contracts that were either ready for renewal or would soon be expiring.[5] Figure 5 shows the statewide average number of years remaining on CRP contracts was lowest in 2007 at 3.49 years.[6] This pattern of years remaining in the contract corresponds to the pattern shown by the estimated coefficients—CRP land values were relatively larger when the length of contracts was smaller. A situation where a contract would soon be expiring would allow a new owner to either opt into another contract of CRP or begin farming the land, giving them the most flexibility of choosing the option with the highest expected payout. This result suggests that accounting for the remaining life of the contract is likely to affect the estimated effect of an existing CRP contract on land value.

The impact of CRP on land values not only differs temporally, but also differs spatially. As a comparison between two extreme farm production regions, the impacts of CRP on land prices for the Northwest Kansas region and the Northeast Kansas region are discussed.[7] The key observation is that CRP land values are relatively smaller in the Northeast region than the Northwest region. This result is expected because relative returns to CRP are smaller than for farming in the Northeast and conversely in the Northwest (figures 3a and 3b). For land in the Northeastern region of the state, CRP decreases the value of land in all years except 2008. For land in the Northwestern region of the state, in all but four years CRP contracts either does not significantly affect the value or increases the value of agricultural land.

For both equation (4) and equation (5) models, the estimated coefficients of the variables *Size*, $Size^2$, *CropPerc*, *AverageQ*, *GoodQ*, *DirtRd*, *GravelRd*, *Precipitation*, and *NetRet* are all statistically significant and have the expected sign. The interaction terms between the year trend and the North Central and Northeast regions also suggest an approximate growth in land values of 1.3% and 1.7% per year, respectively.

Conclusion

The CRP offers landowners the opportunity to retire environmentally sensitive farmland for periods of 10 or 15 years and pays a fixed rental rate each year of those contracts. The opportunity cost of this program is the foregone returns from farming the land and earning rents from agricultural production. When purchasing a tract of land with an existing CRP contract, the new landowner is limited in their ability to farm the land because of the high cost of terminating a CRP contract. It is therefore expected that if the foregone returns from farming are greater than the CRP contract, the sales price of a parcel with CRP will be lower than a comparable parcel without a CRP contract.

This study estimates the impacts of existing CRP contracts on land values using parcel-level sales data from Kansas. Parcels with CRP sell for 7.0% less than otherwise equivalent parcels, on average. However, the discount that CRP has on land values varies over both time and space. During years when it is likely a contract is up for renewal, parcels with CRP will sell with either no discount or a slight premium. For land with relatively low productivity, as demonstrated by land sales in Northwestern and Northcentral Kansas, parcels with CRP sell with little to no discount. However, highly productive land, such as that found in Northeastern Kansas, is discounted when sold with an existing CRP contract.

These results extend the CRP literature by quantifying the opportunity cost of CRP contracts as well as showing the variability of opportunity cost across land with different productivity and time remaining under contract. Additionally, management of the CRP by USDA may use these results to anticipate the amount of CRP rental rate needed to entice contract renewal during periods of very high or very low profitability in the crop sector. For example, in the 2018 Farm Bill, the rental rate of CRP contracts has been lowered relative to the previous Farm Bill. This decrease is supported by our results, which suggests that a lower opportunity cost of enrolling land in CRP, due to low profitability in the agricultural sector currently, warrants a lower rental rate to entice people to enroll their land.

[1] Slippage is an unintended consequence where non-cropland is brought into production due to either output price feedback effects resulting from reduced production on CRP land or land substitution effects. See Wu (2000) for a detailed theoretical and empirical analysis.

[2] Some landowners may also enjoy the non-pecuniary benefits of developing habitat for wildlife and doing their part to enhance the environmental sustainability of their farmland, but these non-pecuniary benefits are not likely to be captured in land values.

[3] The rating of Good, Average, and Poor are opinions of the professional appraisers and farm managers who provided the data for research purposes.

[4] The state value is generated by averaging across the regional coefficients.

[5] Unfortunately, our data do not allow us to directly observe the number of years left on the CRP contract for approximately 97.4% of our observations.

[6] The average remaining length of contracts is based on data on acres with new enrollments and re-enrollments each year and assuming a 10-year contract. These calculations will not be exactly correct to the extent that some contracts were 15-year contracts or some received a contract extension. This should be a small proportion of contracts, especially prior to 2008. Data on new enrollments prior to 1998 are from the Farm Service Agency website on total acres enrolled. Data on new enrollment and re-enrollment from 1998 and afterwards are from the Farm Service Agency obtained through a Freedom of Information Act request.

[7] Northwest Kansas is a relatively dry climate with lower farm production, while Northeastern Kansas has higher precipitation and higher crop production.

References

Babcock, B. A., P.G. Lakshminarayan, J. Wu, and D. Zilberman. (1996). "The Economics of a Public Fund for Environmental Amenities: A Study of CRP Contracts." *American Journal of Agricultural Economics* 78(4): 961-971.

Babcock, B.A., P.G. Lakshminarayan, J. Wu, and D. Zilberman. 1997. "Targeting Tools for the Purchase of Environmental Amenities." *Land Economics* 73(3): 325–339.

Barnard, C. H., G. Whittaker, D. Westenberger, M. Ahearn. (1997). "Evidence of Capitalization of Direct Government Payments into U.S. Cropland Values." *American Journal of Agricultural Economics* 79(5): 1642-1650.

Brown, J.P., Lambert, D.M. and Wojan, T. "The Effect of the Conservation Reserve Program on Rural Economies: Deriving a Statistical Verdict from a Null Finding." *American Journal of Agricultural Economics* 101(2): 528-540.

Caldas, M.M., J.S. Bergtold, J.M. Peterson, and D.H. Earnhart. 2016. "Land-Use Choices: The Case of Conservation Reserve Program (CRP) Re-Enrollment in Kansas, USA" Land Use Science 11(5): 579-594.

Duke, J.M. 2004. "Participation in Agricultural Land Preservation Programs: Parcel Quality and a Complex Policy Environment." *Agricultural and Resource Economics Review* 33(1): 34-49.

Feather, P., et al. (1999). Economic valuation of environmental benefits and the targeting of conservation programs: the case of the CRP. Agricultural Economics Report 778. Washington, DC: U.S. Department of Agriculture, Economic Research Service.

Feng,X., R.C. Mittelhammer, and P.W. Barkley. 1993. "Measuring the Contributions of Site Characteristics to the Value of Agricultural Land." *Land Economics* 75(August):440-452.

Gardner, K., and R. Barrows. 1985. “The Impact of Soil Conservation Investments on Land Prices.” *American Journal of Agricultural Economics* 67(December):943-47.

Goodwin, B.K, A.K. Mishra, and F.N, Ortalo-Magné. 2003. “What’s Wrong with Our Models of Agricultural Land Values?” *American Journal of Agricultural Economics* 85 (3): 744–752.

Hellerstein, D. M. 2017. “The U.S. Conservation Reserve Program: The Evolution of an Enrollment Mechanism.” *Land Use Policy* 63: 601-610.

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.

Huber, P. J. 1967. “The behavior of maximum likelihood estimates under nonstandard conditions.” In Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability. Berkeley, CA: University of California Press, vol. 1, 221–233.

Isik, M., and W. Yang. 2004. “An Analysis of the Effects of Uncertainty and Irreversibility on Farmer Participation in the Conservation Reserve Program.” *Journal of Agricultural and Resource Economics* 29(2): 242–259.

Just, R. E. and J. A. Miranowski (1993). "Understanding Farmland Price Changes." *American Journal of Agricultural Economics* 75(1): 156-168.

Khanna, M., W. Yang, R. Farnsworth, and H. Önal. 2003. “Cost-Effective Targeting of Land Retirement to Improve Water Quality with Endogenous Sediment Deposition Coefficients.” *American Journal of Agricultural Economics* 85(3): 538-553.

Kirwan, B., 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.

Kirwan, B. (2009). "The Incidence of U.S. Agricultural Subsidies on Farmland Rental Rates." *Journal of Political Economy* 117(1): 138-164.

Lence, S. H., and A.K. Mishra. 2003. "The Impacts of Different Farm Programs on Cash Rents." American Journal of Agricultural Economics 85(3): 753-761.

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). University of Wisconsin Press: 529–550.

Lynch, L. and S.J. Lovell. 2003. "Combining Spatial and Survey Data to Explain Participation in Agricultural Land Preservation Programs." *Land Economics* 79(2): 259-276.

Palmquist, R.B. 1989. "Land as a Differential Factor of Production; A Hedonic Model and Its Implications for Welfare Measurements." *Land Economics* 65(February): 23-28.

Roberts, M. J., B. Kirwan, J. Hopkins. (2003). "The Incidence of Government Program Payments on Agricultural Land Rents: The Challenges of Identification." *American Journal of Agricultural Economics* 85(3): 762-769.

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.

Rosen, S. (1974). "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition." Journal of Political Economy 82(1): 34-55.

Sampson, GS., N.P. Hendricks, M.R. Taylor. 2018. Land Market Valuation of Groundwater. Paper presented at the Agricultural and Applied Economics Association Annual Meeting, Washington, D.C.

Schlenker, W., W.M. Hanemann, A.C. Fisher. (2005). "Will US agriculture really benefit from global warming? Accounting for irrigation in the hedonic approach." *American Economic Review* 95(1): 395-406.

Schmitz, N., and S. Shultz. 2008. “The Impact of the Conservation Reserve Program on the Sale Price of Agricultural Land.” *Journal of American Society of Farm Mangers and Rural Appraisers* (2008): 51-59.

Shoemaker, R. 1989. “Agricultural Land Values and Rents Under the Conservation Reserve Program.” *Land Economics* 65(2): 131-137.

Smith, R.B.W. 1995. “The Conservation Reserve Program as a Least-Cost Land Retirement Mechanism.” *American Journal of Agricultural Economics* 77 (1): 93–105.

Sullivan, P., D. Hellerstein, L. Hansen, R. Johansson, S. Koenig, R. Lubowski, W. McBride, D. McGranahan, M. Roberts, S. Vogel, and S. Bucholtz. 2004. “The Conservation Reserve Program: Economic Implications for Rural America.” Economic Research Service, USDA. Agricultural Economic Report No. 834.

Taff, S.J., and S. Weisberg. 2007. “Compensated Short-Term Conservation Restrictions May Reduce Sale Prices.” *The Appraisal Journal* (Winter): 45-55.

Taylor, M.R., and G.W. Brester. 2005. “Noncash Income Transfers and Agricultural Land Values.” *Review of Agricultural Economics* 27(4): 526-541.

Wallander, S., P. Ferraro, and N. Higgins. 2017. “Addressing Participant Inattention in Federal Programs: A Field Experiment with the Conservation Reserve Program.” *American Journal of Agricultural Economics* 99(4): 914-931.

White, H. 1980. “A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity.” Econometrica 48: 817–830.

Wu, J. 2000. “Slippage Effects of the Conservation Reserve Programs.” *American Journal of Agricultural Economics* 82(4): 979-92.

Wu, J., and H. Lin. 2010. “The Effect of the Conservation Reserve Program on Land Values.” *Land Economics* 86(1): 1-21.

Table 1. Summary Statistics

Variable	Definition	Mean	Standard Deviation	Minimum	Maximum
Price	Price per acre of parcel	1,026.62	942.2649	50	26,000
ln(Price)	Natural log of price per acre	6.55	0.58	3.89	9.95
Size	Parcel size in acres	182.90	234.03	20.00	9,735.00
$Size^2$	Parcel size squared	88,220	1,422,684	400.00	94,800,000
CropPerc	Percent of parcel in cropland	0.66	0.35	0	1
Average	Binary variable equal to 1 if parcel productivity rated as "average", 0 otherwise	0.74	0.44	0	1
Good	Binary variable equal to 1 if parcel productivity rated as "good", 0 otherwise	0.21	0.41	0	1
Dirt	Binary variable equal to 1 if road access is dirt, 0 otherwise	0.14	0.35	0	1
Gravel	Binary variable equal to 1 if road access is gravel, 0 otherwise	0.69	0.46	0	1
Precipitation	Average annual precipitation	480.43	77.79	271.21	701.27
NetInc	One-year lagged, deflated net returns to farming	51,933	34,765	17,981	120,022
CRP	Binary variable equal to 1 if parcel has current CRP contract, 0 otherwise	0.065	0.25	0	1

Number of Observations = 9,489

Table 2. Hedonic OLS Regression Results – Equation (4)

Variable	Coefficient	Robust Standard Error	P-Value	Transformed Coefficient
Dependent Variable: ln(Price)				
Size	-2.49E-04	3.05E-05	0.000	--
Size^2	2.87E-08	4.56E-09	0.000	--
CropPerc	0.394	0.012	0.000	--
AverageQ	0.183	0.019	0.000	0.201
GoodQ	0.368	0.020	0.000	0.444
DirtRd	-0.123	0.013	0.000	-0.116
GravelRd	-0.072	0.010	0.000	-0.069
Precipitation	0.002	0.000	0.000	--
NetInc	2.21E-05	1.34E-06	0.000	--
CRP	-0.073	0.013	0.000	-0.070
NW_YearTrend	0.005	0.004	0.251	
NC_YearTrend	0.013	0.004	0.000	
NE_YearTrend	0.017	0.005	0.002	
SW_YearTrend	0.000	0.000	0.238	
SC_YearTrend	0.004	0.004	0.257	
Quarter2	0.001	0.009	0.886	0.001
Quarter3	0.016	0.010	0.108	0.016
Quarter4	0.056	0.010	0.000	0.058
Constant	15.170	0.681	0.000	--
Adjusted R^2	0.692			

Notes: Year and County-level fixed effects are included in the model.

Table 3. Hedonic OLS Regression Results – Equation (5)

Variable	Coefficient	Robust Standard Error	P-Value	Transformed Coefficient
Dependent Variable: ln(Price)				
Size	-2.50E-04	3.06E-05	0.000	--
$Size^2$	2.89E-08	4.55E-09	0.000	--
CropPerc	0.398	0.012	0.000	--
AverageQ	0.180	0.019	0.000	0.197
GoodQ	0.365	0.020	0.000	0.440
DirtRd	-0.122	0.013	0.000	-0.115
GravelRd	-0.072	0.010	0.000	-0.069
Precipitation	0.002	2.37E-04	0.000	--
NetInc	2.23E-05	1.34E-06	0.000	--
CRP	-0.274	0.092	0.003	-0.243
CRP_Y1999	-0.043	0.056	0.435	-0.044
CRP_Y2000	-0.014	0.055	0.797	-0.015
CRP_Y2001	0.038	0.059	0.520	0.037
CRP_Y2002	-0.010	0.055	0.848	-0.012
CRP_Y2003	0.072	0.060	0.226	0.073
CRP_Y2004	0.088	0.062	0.158	0.090
CRP_Y2005	0.087	0.068	0.202	0.088
CRP_Y2006	0.168	0.062	0.007	0.180
CRP_Y2007	0.128	0.067	0.056	0.133
CRP_Y2008	0.276	0.084	0.001	0.313

Table 3. Hedonic OLS Regression Results – Equation (5), cont.

Variable	Coefficient	Robust Standard Error	P-Value	Transformed Coefficient
CRP_Y2009	0.126	0.097	0.194	0.129
CRP_Y2010	0.120	0.061	0.048	0.126
CRP_Y2011	0.124	0.077	0.107	0.128
CRP_Y2012	0.109	0.085	0.199	0.112
CRP_Y2013	-0.007	0.103	0.946	-0.012
CRP_Y2014	0.010	0.156	0.950	-0.002
CRP_NW	0.171	0.084	0.043	0.182
CRP_NC	0.177	0.084	0.035	0.189
CRP_NE	-0.029	0.118	0.807	-0.035
CRP_SW	0.094	0.091	0.305	0.094
CRP_SC	0.125	0.084	0.135	0.129
NW_YearTrend	0.004	0.004	0.320	--
NC_YearTrend	0.013	0.004	0.001	--
NE_YearTrend	0.017	0.005	0.001	--
SW_YearTrend	-4.68E-05	3.50E-05	0.181	--
SC_YearTrend	0.004	0.004	0.340	--
Quarter2	0.003	0.009	0.772	0.003
Quarter3	0.017	0.010	0.090	0.017
Quarter4	0.058	0.010	0.000	0.060
Constant	4.043	0.170	0.000	--
Adjusted R^2	0.683			

Notes: Year and County-level fixed effects are included in the model.