DOES TEMPORARY LAND RETIREMENT PROMOTE ORGANIC ADOPTION? EVIDENCE FROM EXPIRING CONSERVATION RESERVE PROGRAM CONTRACTS

by

Hannah Rose Wing

A thesis submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Applied Economics

MONTANA STATE UNIVERSITY
Bozeman, Montana

May 2022

ACKNOWLEDGEMENTS

I would like to express my most sincere gratitude to my committee chairs, Dr. Dan Bigelow and Dr. Kate Fuller, for their mentorship and guidance throughout this project. I would also like to extend my thanks to Dr. Nick Hagerty for his invaluable feedback and support. It has been a great pleasure and privilege to work with each of you. Finally, many thanks to Anthony, Conner, Ian, Quinn, Ridge, and Will for greatly enriching this experience.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES – CONTINUED

Table Page

LIST OF FIGURES

ABSTRACT

The Conservation Reserve Program (CRP) is a temporary land retirement program that allows producers to remove environmentally sensitive farmland from agricultural production in exchange for a yearly rental payment. While enrolled in the CRP, land is, by definition, not being used for production and therefore typically complies with standards for organic certification. In order for an operation to become certified organic, producers must comply with organic practices for 36 months prior to when production can be labeled organic. Among other requirements, operators transitioning to organic production cannot apply synthetic pesticides or fertilizers to the land. However, some of the costly three-year transition period can be avoided through participation in the CRP as land enrolled in the program may be eligible to become certified organic in the year that it exits the program. In this paper, we study the extent to which CRP enrollment promotes organic certification. We find that CRP contract expiration leads to increases in organic adoption, and estimate a 0.157 percent increase in new organic operations in response to a 10 percent increase in expiring CRP contracts.

CHAPTER ONE

INTRODUCTION

In 2021, 5.3 million acres of agricultural land were taken out of production to enroll in the Conservation Reserve Program, bringing the total amount of land retired though the program at the start of 2022 up to 22.9 million acres, an area slightly larger than the state of Maine (USDA, 2021a). The Conservation Reserve Program (CRP) was established in 1985 in an effort to reduce agricultural production on highly erodible and otherwise environmentally sensitive farmland, and today is the largest temporary land retirement program in the United States. Through the CRP, producers are contracted to temporarily retire land from production for a contract period of 10 to 15 years in exchange for a yearly rental payment. At peak participation in 2007, enrollment in the CRP exceeded 35 million acres but has since steadily declined. A program the size of the CRP, which represented approximately 6.7 percent of all cropland in the US in 2021, has the potential to substantially impact not only a large number of individual producers, but also the greater agricultural economy (Irwin, 2021).

During the same time period in which CRP participation has declined, organic agriculture has seen tremendous growth, specifically in the absolute value of organic products and the proportion of organic to total food retail sales. However, certified organic acreage has not kept pace with growth in sales and number of operations (Oberholtzer, Dimitri, and Greene, 2005; McBride et al., 2015). Some studies cite the organic transition process as a barrier to entry into the organic market, and thus a reason for the apparent slow growth in newly certified organic operations (Delbridge and King, 2016; Delbridge et al., 2017). In order for an operation to become certified organic, producers must comply with organic practices for three years prior to when output can be labeled organic. These practices prohibit applying synthetic fertilizers, pesticides, and other inputs commonly applied to land in conventional production. During this three-year transition period, producers incur the lower yields associated with organic production without receiving a concurrent organic product price premium (McBride and Greene, 2009 and de Ponti et al., 2012).

The United States Department of Agriculture Farm Service Agency (USDA FSA) has a large number of programs, and spends a significant amount of money, in efforts to incentivize transition to organic agriculture for the purpose of sustaining the growth in certified organic commodities. These initiatives include $20 million through the Organic and Transitional Education and Certification Program in 2020, $30 million through the National Institute of Food and Agriculture's Organic Agriculture Program in 2021, the Organic Certification Cost Share Program which covers up to $500 of certification costs for any operation, as well as a large number of other smaller-scale projects (USDA 2022b). While these projects may be productive at promoting organic transition, other, more cost effective, mechanisms could aid in achieving this goal. One such mechanism is the CRP, which provides a unique opportunity for producers to forego the costly organic transition process. Land in the CRP is, by definition, not being used for production and therefore may incidentally comply with organic transition standards, allowing land enrolled in the CRP to become certified organic in the year that it exits the program. In this way, the CRP may indirectly aid in achieving the USDA's goals of incentivizing organic transition through a well-established program while allowing the large quantities of land exiting from the program to be put to beneficial use in organic agriculture.

In this paper, we study the extent to which CRP enrollment promotes organic certification. Primary econometric results come from a set of finite distributed lag models which identify the effect of the number of expiring CRP contracts on the number of new certified organic operations conditional on county fixed effects, time fixed effects, state-specific linear trends, and county covariates. This analysis is based on a unique county-level panel dataset consisting of contract-level data obtained from the FSA Conservation Contract Maintenance System and operation-level data from the USDA's Organic Integrity Database, as well as supplemental county-level data from the Census of Agriculture. Given the 10-15-year lag between the decision to enroll in the CRP and the contract's expiration, we exploit the plausibly exogenous timing of CRP contract expiration to estimate its impact on organic certification.

This paper will contribute to the literature in three ways. First, we further the discussion of the fate of land that expires from the CRP. Previous studies find that land exiting the CRP goes back into crop production (Bigelow et al. 2020 and Morefield et. al., 2016) and is even more likely to be in production relative to land that never participated in the CRP (Jacobson, 2014), but little is known about the specific types of production practices used on former CRP land. Second, we aid in understanding the transition process to organic agriculture and its obstacles. While others have identified the organic transition process as a barrier for producers, we test the hypothesis that reducing that obstruction increases rates of organic transition. Third, our specific contribution is as the first study to examine the connection between the CRP and organic agriculture to determine if participation in the CRP has led to increases in organic adoption.

Results from our empirical section indicate that CRP contract expiration leads to increases in organic certification at a rate of 0.157 percent for every 10 percent increase in expiring contracts. This effect is more significant for contracts enrolled through the CRP continuous sign-up, rather than the general sign-up, with a 10 percent increase in expiring contracts leading to a 0.138 percent increase in certified organic operations. We also find the impact of expiring contracts to be strongest in the western region of the US, where a 10 percent increase in contracts is associated with a 0.346 percent increase in new certifications. We find no meaningful heterogeneity by CRP prevalence, organic prevalence, or CRP practice type. These results suggest that easing the transition period constraints faced by landowners can promote greater uptake of organic production practices, highlighting an important consequence of the CRP.

The remainder of this thesis is divided into eight chapters. Chapter 2 provides background and history on both the CRP and organic agriculture. The following chapter reviews the relevant literature. Chapter 4 lays out a theoretical framework for transitioning from conventional to organic agriculture through enrollment in the CRP. The data used for this analysis is then described in Chapter 5. The following two chapters detail the empirical methodology used to identify the relationship between expiring CRP contracts and organic certification and its results. Chapter 8 discusses interpretations of the key findings and predictions of the anticipated effects of the next decade of expiring CRP contracts on the future of organic agriculture. The final chapter concludes with avenues for future work and policy implications.

CHAPTER TWO

BACKGROUND

2.1 Conservation Reserve Program

The Conservation Reserve Program (CRP) was established by the Food Security Act of 1985 in an effort to reduce soil erosion on environmentally sensitive agricultural land and limit the production of select agricultural products. The goals of the program quickly expanded to include wildlife habitat and wetland protection, improved water quality, and a variety of other environmental objectives. To achieve these ends, the CRP, administered by the USDA Farm Service Agency, contracts with private landowners to retire environmentally sensitive land for a period of 10-15 years.[1] The CRP is a temporary land retirement program, meaning that while land is enrolled it is completely removed from production and upon exit from the program it can return to any use the landowner chooses. Farmers are paid an annual rental rate to forego crop production and instead implement a conservation practice on all acres enrolled. The specific conservation practice is described by each contract and determined, in part, by the producer. While allowable practices have changed throughout the years, today they include native and non-native grasses, softwood and hardwood trees, wildlife habitat mixes, field windbreaks, grassed waterways, filter strips, and riparian buffers, among others (USDA, 2022).[2]

There are two main enrollment mechanisms for the CRP: the general sign-up and the continuous sign-up.[3] The general sign-up typically occurs once a year and provides the

[1]Contract perpetuation is relatively inescapable once agreed upon; producers who wish to terminate their contract early are required to repay all previous payments with interest. However, a policy change in 2017 introduced the Transition Incentives Program, which waived the repayment if land is transferred to a beginning farmer or rancher (National Grain and Feed Association, 2017).

[2]See Appendix B for a complete list of all allowable practices as of January 2020.

[3]There is also a grassland CRP sign-up that operates identically to the general sign-up, but focuses particularly on grasslands.

opportunity for landowners to submit an offer for a specific parcel of land with a proposed cover practice and rental rate. Rent requests are capped by a parcel's soil rental rate (SRR) which is calculated using parcel-specific soil productivity measures as well as county-level average non-irrigated cropland rental rates. Offers are then ranked using an Environmental Benefits Index (EBI) that incorporates the potential environmental benefits of the parcel and the cost based on the landowner's asking price. The EBI provides a cost-adjusted measure of the potential environmental impact of a parcel by scoring it based on environmental characteristics and location. Offers with the highest EBI scores are accepted, subject to the acreage cap on the program set by Congress in the most recent Farm Bill and a county-level cap that generally prohibits more than 25 percent of a county's cropland acreage from being enrolled in the CRP at any given time (Hellerstein, 2017).

The continuous sign-up, as the name implies, accepts bids continuously throughout the year and focuses on parcels and practices that have a particularly high environmental impact. In contrast to the general sign-up, acceptance into the continuous sign-up is automatic in that offers for eligible parcels are automatically accepted. However, eligibility requirements tend to be stricter compared to the general sign-up because the continuous sign-up focuses on parcels that are highly erodible, with emphasis placed on particular conservation practices. Consequently, continuous CRP payment rates tend to be higher than those offered through the general sign-up (USDA, 2021b).

Eligibility for the program is restricted to land that has been cropped four out of the six years preceding enrollment (USDA, 2021b). However, upon contract expiration, land is permitted to be re-enrolled in the program if the producer's offer is accepted. The CRP is authorized by Congress and is subject to re-authorization through the farm bill, typically every 5 years. Most recently, the Agriculture Improvement Act of 2018 extended CRP enrollment through September 20, 2023 and increased the enrollment cap from 24 million acres to 27 million acres (USDA, 2020).

Figure 2.1 shows yearly average acres enrolled by state from 2009 to 2020.[4] The central region of the county has the highest number of enrolled acres with Texas, Kansas, and Colorado each averaging close to or above 2,000,000 acres per year. Figure 2.2 shows the number of expiring contracts by county, averaged yearly from 2009 to 2020.[5] Here, we see that contract expiration is concentrated in the upper Midwest, specifically in Iowa, Illinois, and Wisconsin. Overall participation and contract expiration is sparse in the Southwest and Florida. CRP enrollment over time is shown in Figure 2.3. At its peak in 2007, enrollment in the CRP exceeded 35 million acres but has since been declining, along with the enrollment cap.

[4]Figure 2.1 omits states that average less than 1000 enrolled acres annually.
[5]Figure 2.2 omits Alaska and Hawaii.

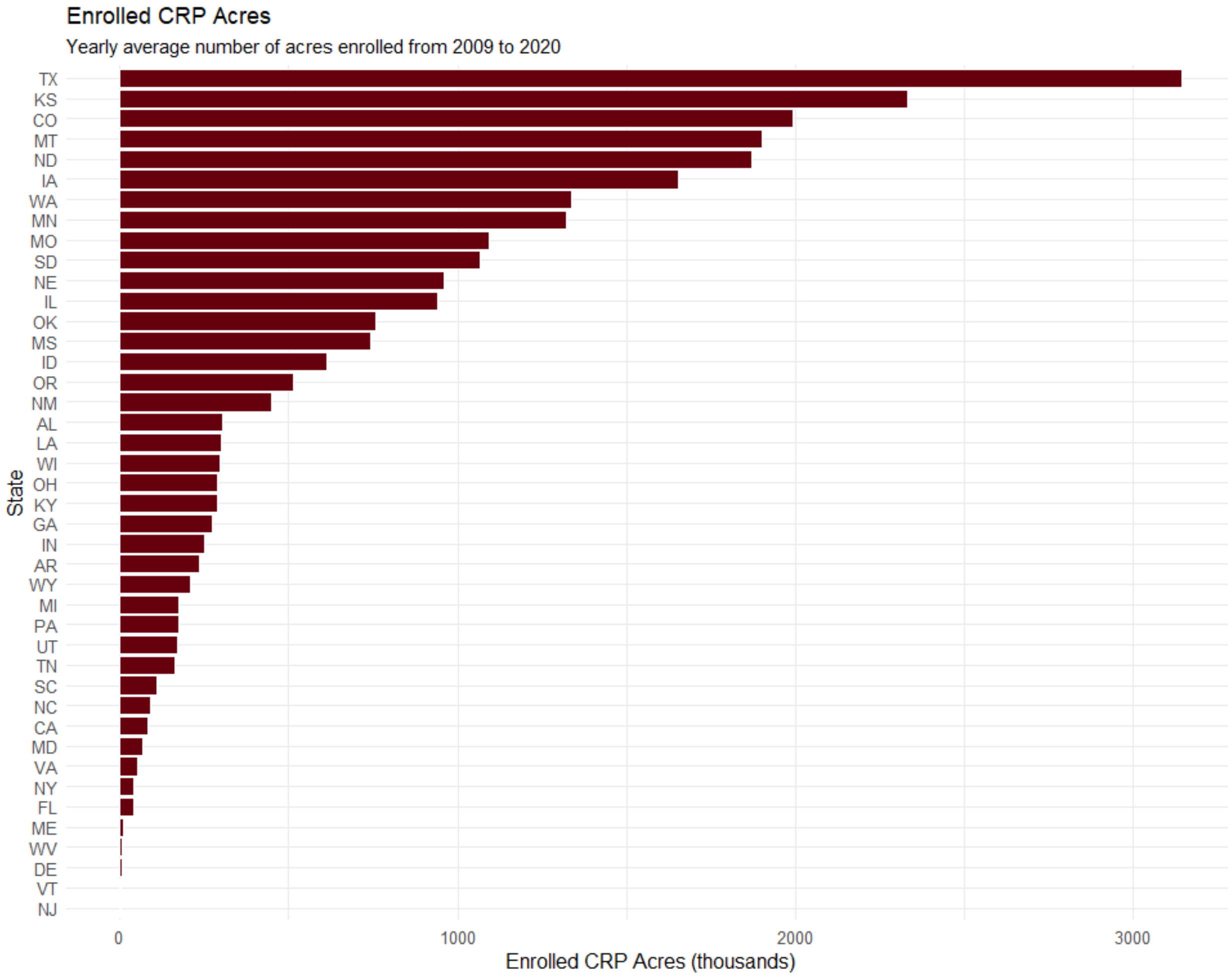

Figure 2.1: CRP Enrollment by State

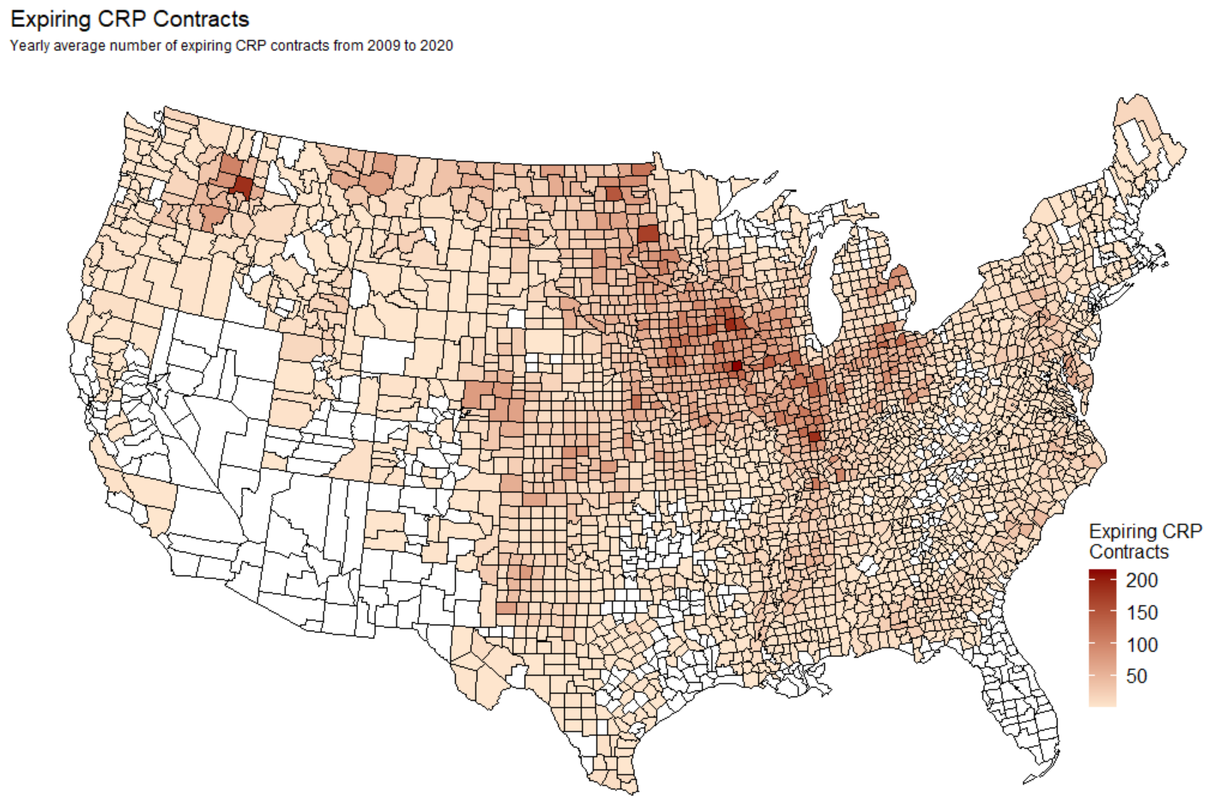

Figure 2.2: Expiring CRP Contracts by County

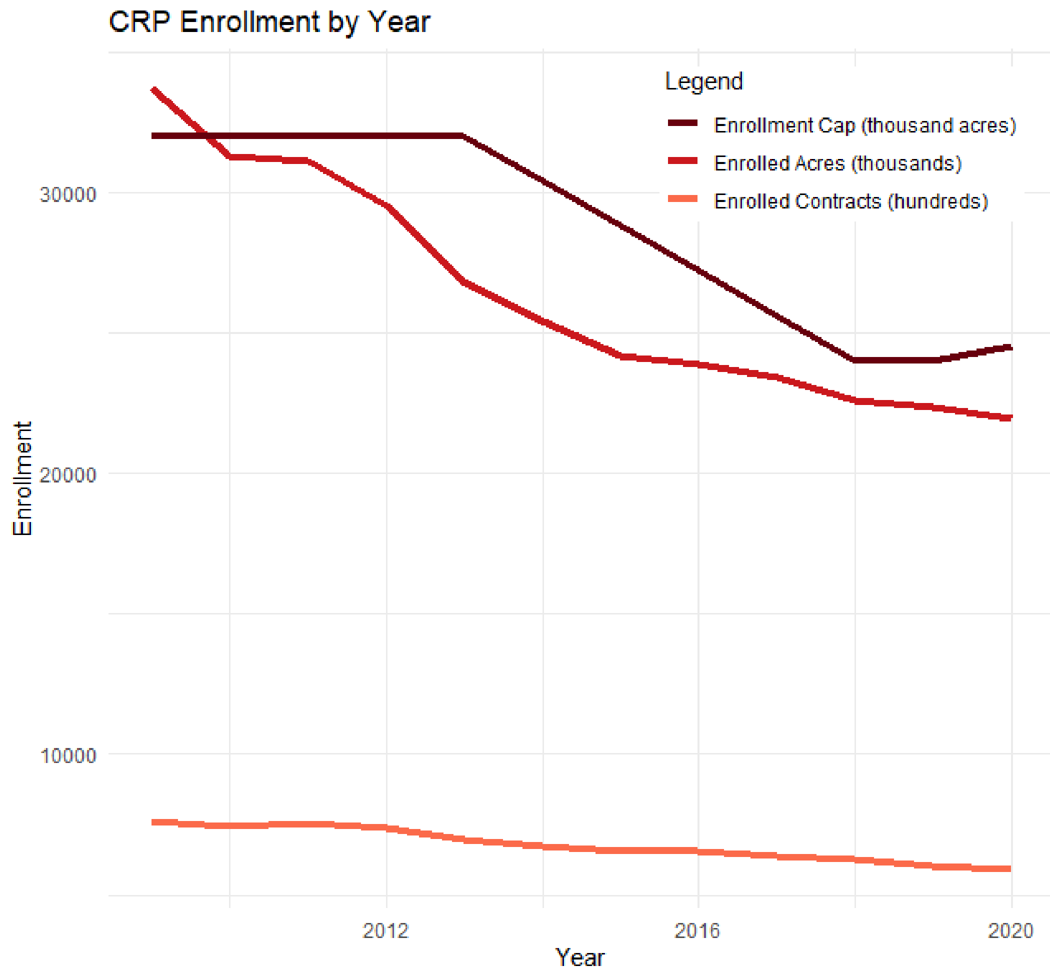

Figure 2.3: CRP Enrollment by Year

2.2 Organic Agriculture

In 1990, Congress passed the Organic Foods Production Act, which required that the USDA develop national standards for organic products. Prior to this Act, the process for organic certification had been decentralized, with each state or agency having different organic standards. This led to a general lack of clarity regarding what "organic" meant. To address this, the Act called for the establishment of a National Organic Program (NOP) to oversee the certification of organically grown agricultural products (USDA, 2007). While the Act was initially passed in 1990, Congress faced budgetary hurdles so the final law establishing the NOP was not published in the Federal Register until 2000 and not until 2002 did the program establish and enact organic standards.

The NOP develops and enforces consistent national standards for organic agricultural products within the United States. Its purpose is to "protect the integrity of the USDA organic seal" by ensuring that all products bearing that label are made with at least 95 percent organic ingredients (USDA, 2018). In addition to creating and maintaining organic standards, the NOP accredits third-party institutions to certify farms that meet the standards.

There are three standards that govern various aspects of organic production: crop standards, livestock standards, and handling standards. For the purposes of this analysis, we focus on crop production standards. There are many distinct laws in the Code of Federal Regulations relating to the production, handling, and certification of organic products, which can be encompassed by the following principles. Organic crop production standards prohibit certain substances from being applied to the land for at least 36 months prior to the harvest of an organic crop. Prohibited substances primarily consist of synthetic fertilizers or pesticides. Soil fertility and crop nutrients must be managed primarily through tillage and cultivation practices, crop rotations, and cover crops. Pests and weeds must be controlled primarily through physical, mechanical, and biological controls and genetic engineering and ionizing radiation are prohibited. Finally, operations must use organic seeds (USDA, 2011).

Every operation that applies for organic certification must be inspected by a USDA-accredited certifying agent. For crop certification, this process includes the inspection of fields, soil conditions, crop health, seeds, and approaches to management of weeds and other crop pests (USDA, 2012). Only after being granted approval by a certifying agent can a producer sell their products with an organic label. Figure 2.4 shows the total number of certified organic crop operations by state, averaged from 2009 to 2020. California has more than double the number of operations of any other state, averaging greater than 4,500 operations in a year. The number of new organic crop operations by county is displayed in Figure 2.5, which shows certification is concentrated along the west coast, the upper Midwest, and the Northeast. Figure 2.6 shows organic certification over time. The line represents the cumulative total number of certifications in a given year, which is the number of certifications in the previous year plus the number of new certifications minus the number of revoked certifications. The bars show the number of operations that become certified and the number of operations that lose their certification status in a given year.

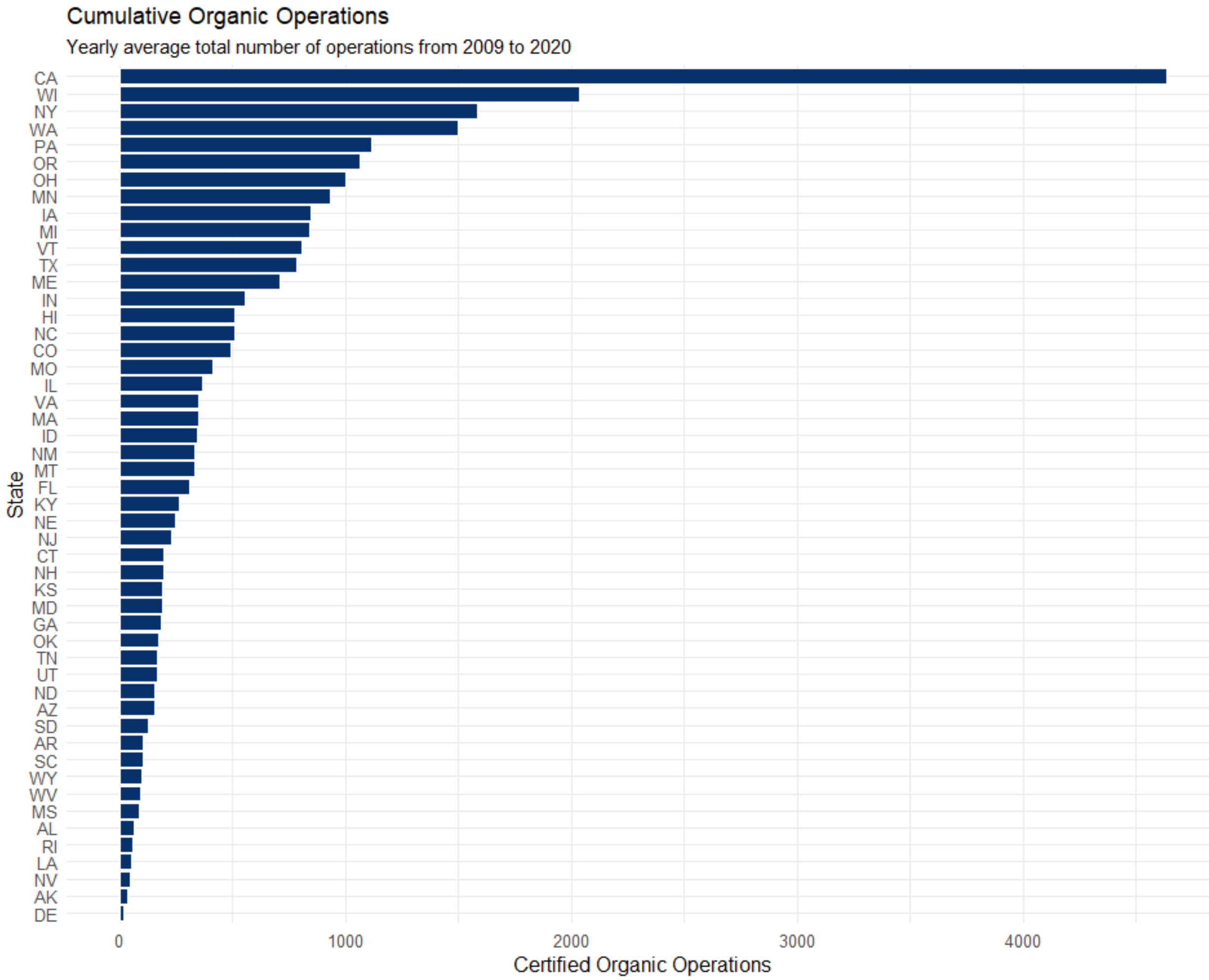

Figure 2.4: Certified Organic Operations by State

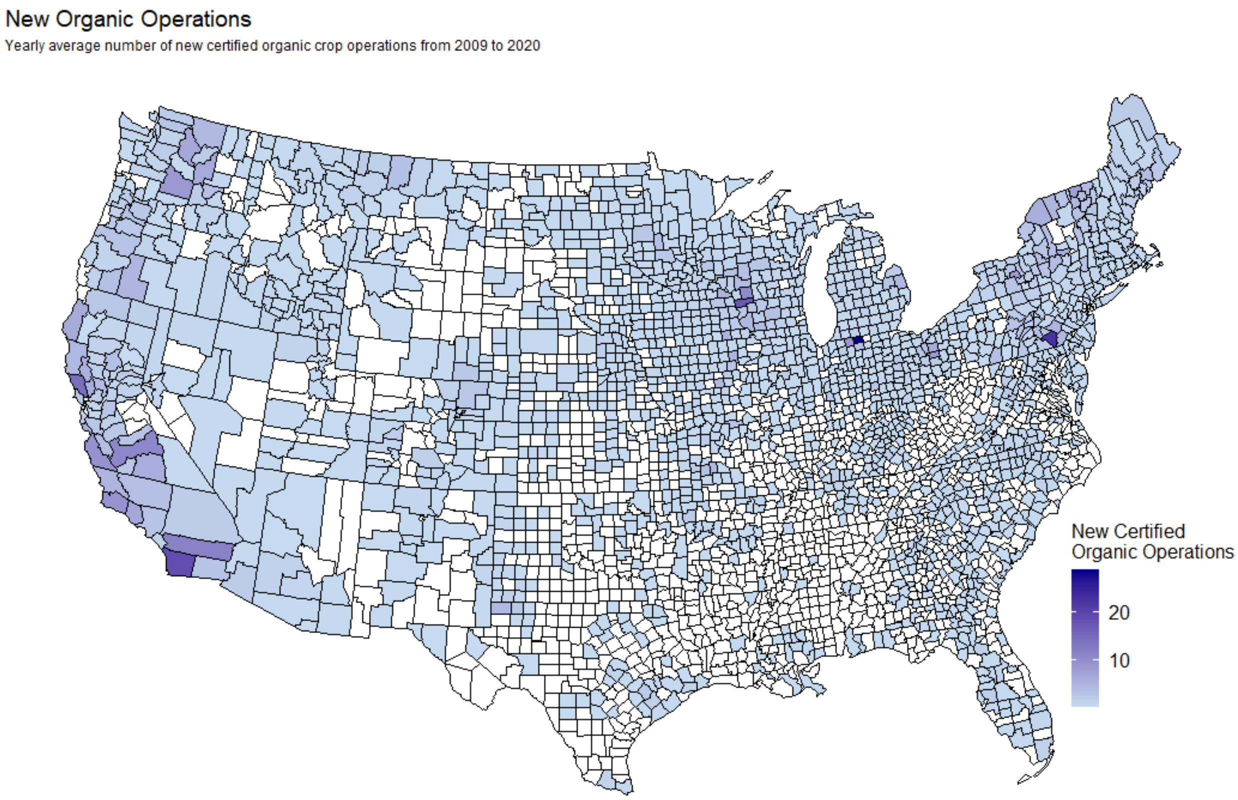

Figure 2.5: Certified Organic Operations by County

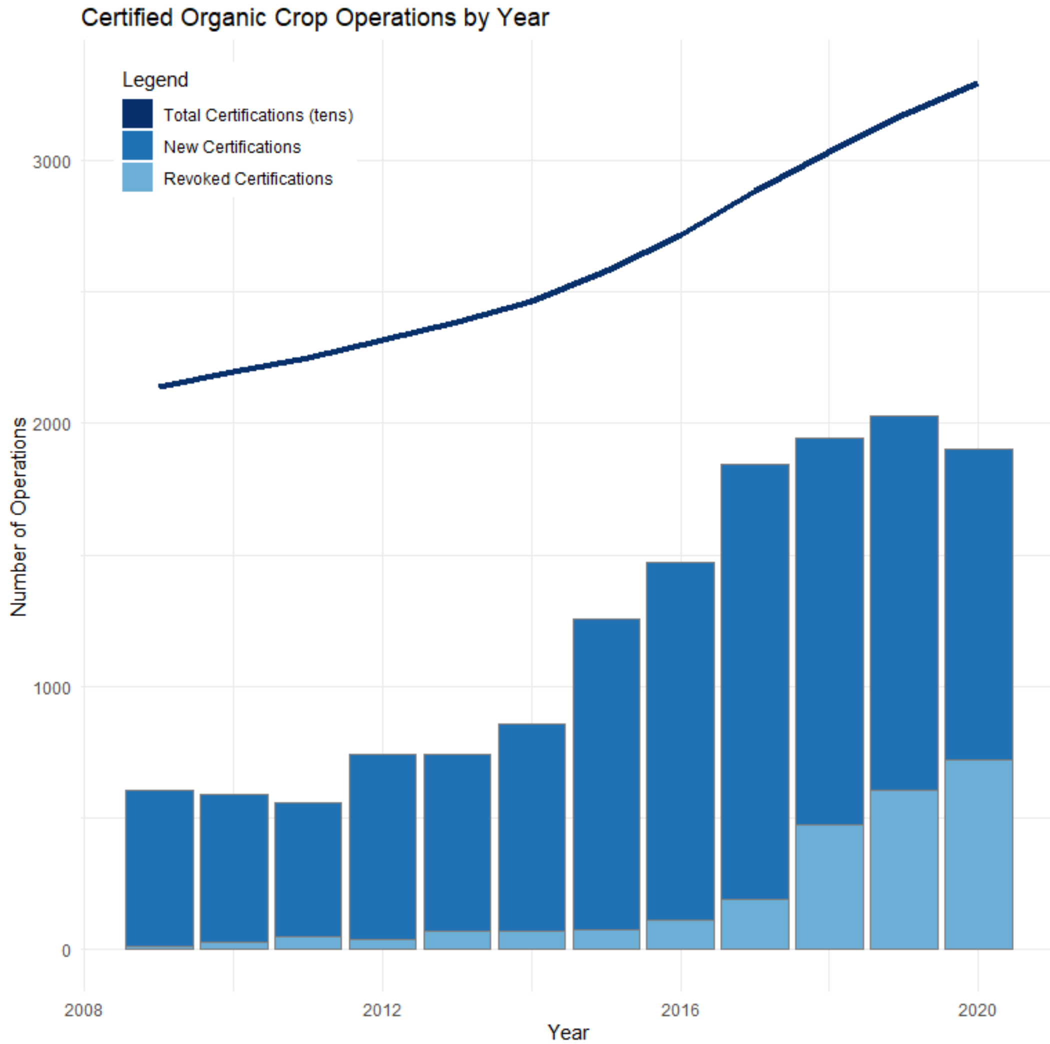

Figure 2.6: Certified Organic Operations by Year

2.3 Intersection of the CRP and Organic Agriculture

While the CRP has seen declining participation over the past decade, organic agriculture has continued to grow in popularity, as shown in Figure 2.7. Since 2014, there have been more than 1,000 new operations certified as organic each year, and, on average, more than 50,000 expiring CRP contracts per year. In the following chapters, we explore the plausible relationship between these two phenomenons.

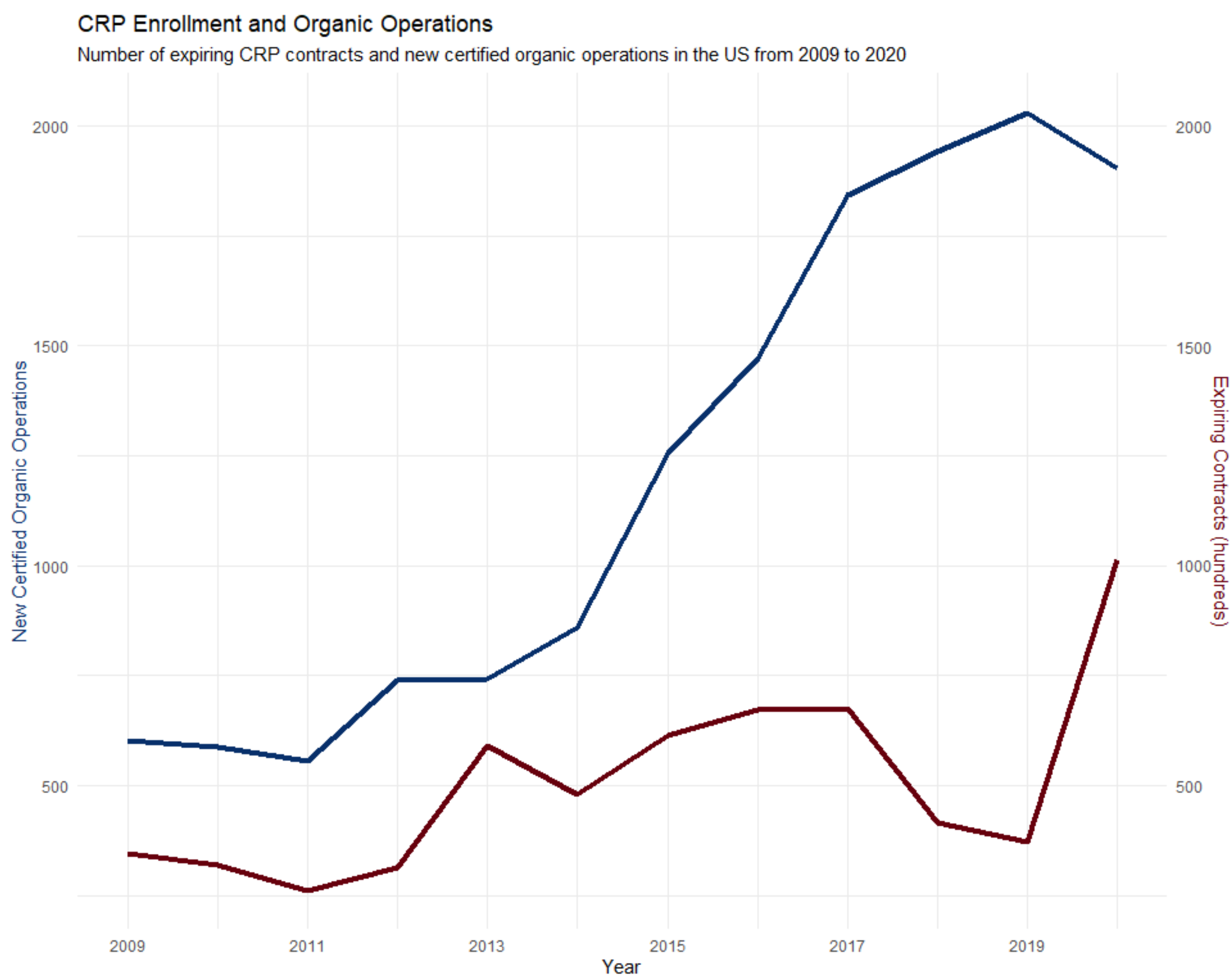

Figure 2.7: CRP Enrollment and Organic Operations Over Time

This study seeks to test the hypothesis that land that has been enrolled in the CRP is more likely to be transitioned to organic agriculture relative to land that did not participate in the CRP. The mechanism through which this would occur is through the reduction of transition costs into organic agriculture brought about by participation in the CRP.[6] Recall one of the requirements for an agricultural product to become certified organic is that the land used to grow the product must have no prohibited substances applied to it for at least three years prior to the planting of an organic crop. This three-year transitional period poses a barrier to producers to enter organic agriculture because they face lower yields from organic practices relative to conventional practices, yet are unable to sell their product with the USDA organic label and thereby receive the price premium associated with organic goods. The CRP provides a unique opportunity for producers to forego this costly organic transition period.

During the 10-15 year period of enrollment, land enrolled in the CRP is completely removed from production. Instead, it is used for an approved conservation practice, such as a practice related to the conservation or establishment of grasses, trees, wetlands, or wildlife habitat mixes, which in many cases does not involve the application of synthetic fertilizers, pesticides, or other substances prohibited by the National Organic Program. While it is likely that most CRP practices comply with organic standards, it is not necessarily the case. Several different practices allow for the use of herbicides, pesticides, or fertilizers, without specifying that they cannot be synthetic. For example, the 2003 maintenance standards for a field windbreak establishment state that "perennial barriers should be fertilized as needed, and weeds controlled by cultivation or chemical spot treatments." The practice for establishment of permanent introduced grasses and legumes instructs to "control weeds in the cover crop by mowing or herbicide application." Finally, maintenance guidelines for riparian

[6] Another plausible mechanism is improved soil productivity. Land coming out of the CRP typically has improved soil quality which can lead to higher yields, representing another way that the CRP could incentivize organic transition (Karlen, et al., 1999).

buffer practices advise, "the use of any fertilizers, pesticides, or other chemicals in the riparian area should be used only when necessary" (USDA, 2003). These guidelines, established in 2003, would apply to a large portion of the contracts included in this analysis. The most recently available practice guidelines simply state that producers must "apply nutrients as needed to ensure growth" and "control noxious weeds and other undesirable plants, insects, and pests" without explicitly prohibiting synthetic fertilizers or pesticides (USDA, 2022). Practice requirements go on to say that participants will "work with a USDA-approved conservationist to develop a conservation plan." So, the specifics of each conservation plan are determined on an individual basis, and are not guaranteed to comply with organic standards. However, given the goal of the CRP as an environmentally sensitive conservation program, it is likely that practices put in place by a USDA-approved conservationist will comply with organic standards in most cases. Consequently, land that exits the CRP may be eligible to be certified for organic production the very year that it returns to crop production rather than having to go through the organic transition process. Figure 2.8 illustrates this process for a producer with a 10-year CRP contract.[7]

Consider a producer who did not participate the CRP and is faced with the choice between conventional and organic production. If they choose conventional production, products will be produced using conventional practices and sold at conventional prices in time period zero, as illustrated with Outcome A in Figure 2.8. If that producer chooses organic production, products are produced using organic practices and sold at conventional prices for the first three years before they are sold at organic prices in time period t = 3, shown by Outcome B. Conversely, consider a producer who did participate in the CRP and has exited the program and now faces the choice between conventional and organic production. If they choose conventional production, they are faced with the same outcome

[7] In some cases, transitioning land out of the CRP into organic production may require an additional year of preparation, as will be described in the methodology chapter. However, this model assumes that producers can transition to organic in the first year exiting from the CRP.

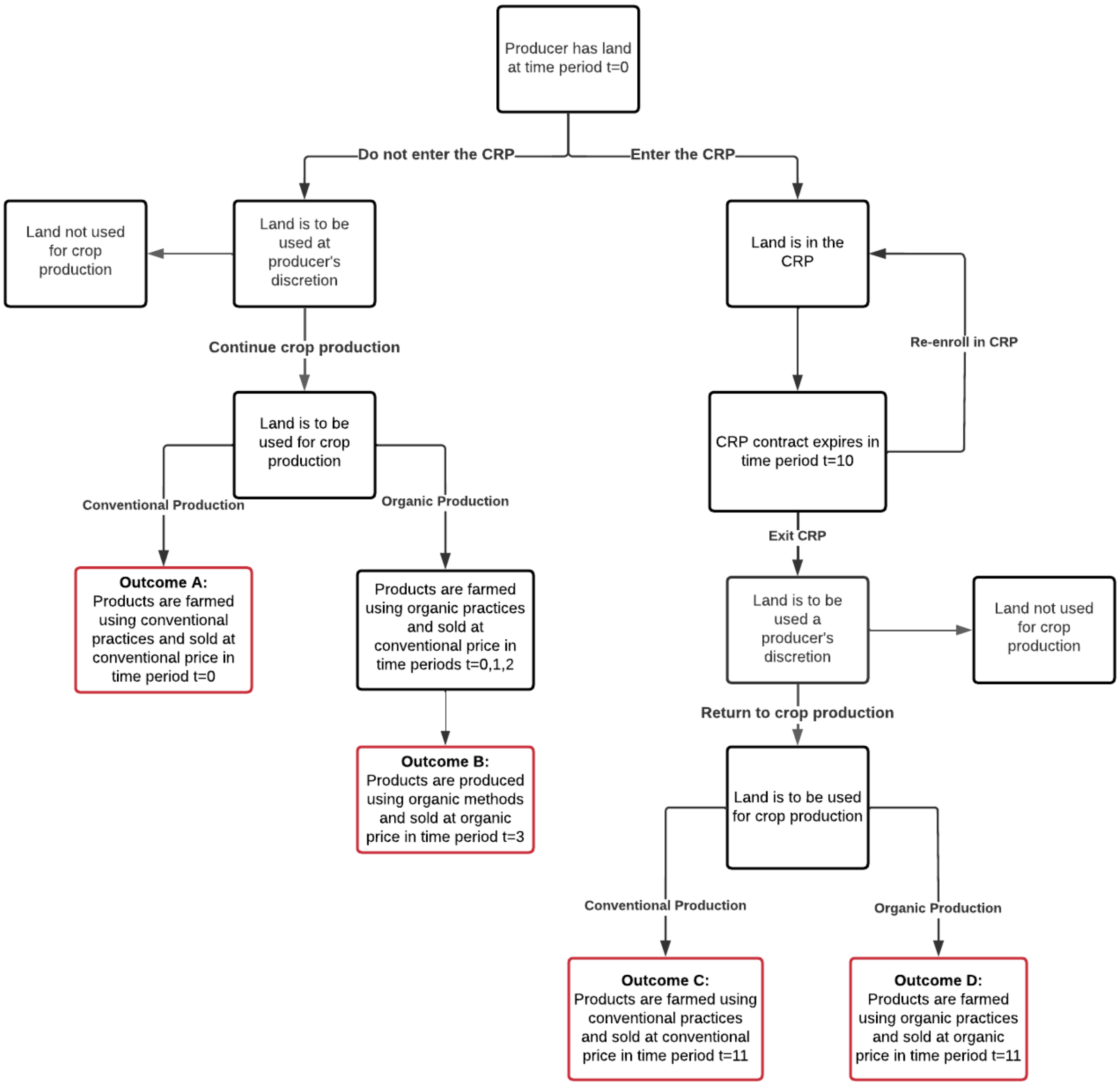

Figure 2.8: Decision Tree

Note: The above figure models the process of organic and conventional crop production through two avenues: without participation in the CRP and with participation in the CRP. It assumes a 10-year CRP contract with maintenance practices in compliance with NOP organic standards.

as the producer who did not participate in the CRP. Under Outcome C, products can be farmed using conventional practices and sold at conventional prices in time period t = 11. However, if this producer chooses organic production, products are farmed using organic practices and can be sold at organic prices in time period t = 11 rather than waiting an additional three years, as shown by Outcome D. In that way, the CRP reduces the costs associated with transitioning to organic agriculture and thereby incentivizes producers to transition to organic.

CHAPTER THREE

LITERATURE

In this analysis, we examine the connection between the CRP and organic agriculture. To date, substantial research has been conducted on each of these topics independently, but little work has been done on the interaction between the two. In the following literature review, we first describe existing work on the CRP and then turn to the relevant research on organic agriculture.

3.1 Conservation Reserve Program

In the 36 years that the CRP has been operational, many thousands of acres of environmentally sensitive land have been temporarily retired from crop production. This has led a number of researchers to quantify the environmental benefits associated with removing this land from production including reduced erosion (Lubowski et al., 2006; Goodwin and Smith, 2003), habitat protection (Quinlan et al., 2021; McCoy et al., 1999; Johnson and Schwartz, 1993), greenhouse gas reduction (Jones et al., 2013), and improved water quality (Yin et al., 2021), among others. In addition, the CRP has the potential to be used as a climate mitigation tool as soil in CRP acres sequesters carbon (Li et al., 2017); however, these benefits may be short lived as much of the soil carbon sequestered under the CRP is lost upon conversion back to agricultural production (Gelfand et al., 2011; Abraha et al., 2019). These studies have identified variety of environmental benefits associated with the CRP and suggest that the program has been successful in accomplishing its conservation goals. However, due to the variety of services provided by the CRP and the many changes of the program's goals throughout its existence, a complete evaluation of the program's benefits is difficult to obtain.

One important consideration is additionality in the CRP, which represents the environmental benefits that would not occur if the CRP did not exist. The consideration of additionality could cause divergence from other estimates of the benefits of the CRP if some land in the program would not have been used for agricultural production every year regardless of whether or not the CRP existed. Therefore, as Claassen et al. (2018) points out, environmentally friendly practices are only additional if they would not otherwise occur in the absence of the CRP. Claassen et al. (2018) finds high levels of additionality in off-field structural practices, including 98 percent additionality with filter strips, 96 percent with riparian buffers, and 95 percent with field borders, indicating that most benefits from CRP practices are additional. Other research by Hansen (2007) finds that 71 percent of CRP land would be in crop production if not for the CRP, which means that 29 percent of CRP land would not be in crop production if the CRP did not exist. This difficulty in measuring the additional benefits of the program also creates difficulty in measuring its cost effectiveness. Nevertheless, most estimates have generally found the CRP not to be cost effective (Miao et al., 2016) with one estimate of the program's benefits representing 75-80 percent of the program's cost (Hansen, 2007). Another study found that, for the same level of government expenditure, farmers benefit more from programs like Agriculture Risk Coverage (ARC) and Price Loss Coverage (PLC) than voluntary paid diversions such as the CRP (Hendricks, 2022). Regardless of the range of estimates of the benefits of the CRP, there is a general consensus that the program has made considerable headway in reaching its stated goals of environmental conservation.

While the aforementioned studies sought to measure the impact of the CRP by evaluating land in the program, while the land was in the program, others have examined the spillover effects of the CRP on adjacent and exited land. These studies have found that there are both temporal and spatial spillovers associated with the CRP. Spatial spillover occurs when land that is not in the CRP is affected due to its spatial proximity to CRP land.

When evaluating the impact of the CRP, it is important to account for spatial spillovers because they can change the total effectiveness and overall impact of the program. If conservation practices that take place on CRP land spillover onto surrounding land, then the environmental benefits of the program would be greater than indicated by the number of acres officially enrolled. Conversely, if land that is not in the CRP is farmed more intensively by a producer to "make up" for the temporarily retired land, that spillover would reduce the net environmental of the program. This is precisely what Wu (2000) finds. Wu estimates that, in the central United States, for every 100 acres of cropland that was retired under the CRP an additional 20 acres was brought into production. This substitution offsets 9 to 14 percent of the water and wind erosion reduction benefits caused by the CRP. Others have debated the credibility of these results and subsequent studies have found that every 100 acres of land enrolled in the CRP converted between 5 and 14 acres of grassland to agriculture and zero acres of wetland to agriculture (Fleming, 2010) or found no evidence of spatial slippage at all (Roberts and Bucholz, 2006).

In addition to spatial spillovers, it is also important to account for temporal spillovers, as the CRP has the potential to impact land use decisions beyond the duration of the contractual period. Studies tracking land use after expiration from the CRP find that 51 percent of CRP land expiring between 2013 and 2016 was put into some variety of crop production (Bigelow et al., 2020) and that less than three percent of expiring CRP land from 2010 to 2013 was put into some non-CRP land retirement or easement program (Morefield et al., 2016). Others have studied if land use upon exit from the program varies systematically from the use of land that never participated in the program. Roberts and Lubowski (2007) estimate that 42 percent of acres in the CRP would not have been returned to crop production within a year if the program had expired in 1997. This indicates that there are spillover effects as land that exits the CRP is less likely to return to previous conventional farming practices. In contrast, Jacobson (2014) finds that land exiting the CRP is 20 to 25 percent more likely to be farmed than land never in the CRP. However, exiting land is slightly more likely to use a conservation practice. This finding suggests that the CRP is effectively fulfilling its role as a temporary land retirement program, as upon exit from the program land is returned to production. Further, since this land reentering production is more likely to use environmentally friendly production practices, the environmental benefits brought about by the CRP are even larger than what may be indicated by the size of the program. Finally, Lin and Wu (2010) find that CRP increases farmland values, another important spillover to consider when examining the impacts of the program. This study aims to contribute to this literature by addressing the use of land that exits from the CRP, specifically focusing on the decision to produce organic products.

3.2 Organic Agriculture

In addition to contributing to the literature on the fate of land that expires from the CRP, this study also seeks to aid in understanding the drivers of the decision to transition to organic agriculture as well as the barriers that prevent that transition. Organic grain producers have been shown to have more than one motivation for transitioning to organic production including profit maximization, environmental stewardship, and lifestyle factors (Peterson et al., 2012). The literature is inconclusive in determining which of these motivations are predominant. Cranfield et al. (2010) find that health concerns and environmental issues are the primary motivations for transitioning to organic agriculture while economic motives are less significant. Regarding general environmental stewardship, some find that producers are willing to forego profit in order to engage in stewardly farm practices (Chouinard et al., 2008) while others find that economic rewards are the primary driver of the adoption of sustainable practices (Trujillo-Barrera et al., 2016). While there is considerable debate over whether organic agriculture is more or less environmentally beneficial relative to conventional agriculture, a producer's perception of organic agriculture's environmental impact is likely to influence their decision-making. Along with personal and economic motivations, a producer's risk preferences and demographics have been shown to play a large role in the decision to transition to organic production. Risk-averse producers are less likely to transition to organic production (Kallas et al., 2010) while younger producers are more likely (Khaledi et al., 2010).

A variety of factors influence a producer's decision to transition to organic production and their perception of the profitability of organic agriculture can play a significant role. Scholars continue to debate whether organic agriculture is more profitable than conventional agricultural due to the trade off between yields are price premiums. Certified organic dairy products receive a price premium over conventional dairy products that can range from 27 to 56 percent (Badruddoza et al., 2021). Organic soybeans have been shown to receive greater than $11 (2022 dollars) per bushel more than conventional soybeans (McBride and Greene, 2009). Organic production is also associated with lower yields than conventional production, which raises per-unit production costs. However, estimated yield differences are highly contextual and can vary substantially depending on the crop and production practices (de Ponti et al., 2012; Seufert et al., 2012). These opposing factors have led to disputes over the profitability of organic production compared to conventional production. Crowder and Reganold (2015), Delate et al. (2003), Delbridge, Fernholz, et al. (2013), Krause and Machek (2018), and McBride and Greene (2009) find that organic production outperforms conventional production in terms of profitability. Conversely, Froehlich et al. (2018) and Uematsu and Mishra (2012) conclude that organic production is actually less profitable than conventional production. Other results indicate that profitability is context-dependent as some organic crops are more profitable and others are less profitable than their conventional counterparts, a differential that is also dependent on region of the country (Langemeier, 2021; Fuller et al., 2021). Although this debate remains unsettled, a producer's perception of relative profitability likely plays a large role in their decision to transition to organic farming.

Producers who are considering transitioning to organic agriculture face several barriers that may inhibit them from doing so. The certification process itself can be burdensome, requiring significant paperwork, fees, and detailed record-keeping, which can cause some producers not to certify their products even though their production practices are organic (Veldstra et al., 2014). In addition, a large rental rate premium on organic farmland can present a barrier for tenants seeking to rent organic land (Fuller et al., 2021). These tenants would then have an even lower incentive to transition to organic if they are unable to secure long-term contracts. Among the most commonly cited barriers to transition are the risk and sunk cost associated with transitioning land from conventional to organic production (Delbridge and King, 2016). Due to the large, unrecoverable costs associated with transitioning, producers may benefit from delaying transition in the face of uncertainty surrounding market conditions (Kuminoff and Wossink, 2010; Delbridge et al., 2017). It is possible that the CRP can encourage organic certification by reducing some of costs associated with transitioning to organic production. Delate et al. (2002) provide evidence that organic grains can be produced on lands following enrollment in the CRP, indicating that this mechanism is plausible. This thesis seeks to contribute to the literature by furthering our understanding of the future of land after it exits from the CRP, the barriers related to transitioning to organic production, and the relationship between the CRP and organic agriculture.

CHAPTER FOUR

THEORY

We apply a profit maximization framework to demonstrate why participation in the CRP may induce producers who otherwise would choose conventional production to choose organic production. The decision to produce organic or conventional products is modeled as a one-time decision where time is normalized such that $t = 0$ is the point in time at which a producer is deciding what to produce. We assume that producers make decisions over the time horizon from $t = 0$ to $t = T$. There are four outcomes to consider in this analysis: conventional production conditional on not participating in the CRP, organic production conditional on not participating in the CRP, conventional production conditional on participating in the CRP, and organic production conditional on participating in the CRP. First, we will show that the CRP increases the difference between organic and conventional profits. Then, we will show that cost heterogeneity leads to there being some marginal producers who would otherwise choose conventional production, but are induced to transition to organic as a result of participation in the CRP.[1]

For producers who did not participate in the CRP and chose conventional production, the per-acre net present value of producer profit is:

$$\pi_{C|CRP=0} = \sum_{t=0}^{t=T} \frac{P_C Y_C - S_C}{(1+i)^t} \tag{4.1}$$

where P is product price, Y is product yield, S is the cost, and i is the discount rate. The C subscript denotes conventional products and the O subscript denotes organic products.

[1] We may also consider that producers not only maximize profits, but also utility. Utility depends on both profit as well as intrinsic, non-monetary benefits producers receive from organic agriculture. Research has shown that these personal preferences for organic production can be powerful drives of organic adoption (Peterson et al., 2012). In this model, we could consider heterogeneity in either costs, utility, or both.

While price, yield, and costs may vary over time, we suppress the time subscript for simplicity. For a producer who did not participate in the CRP and chose organic production, the per-acre net present value of producer profit is:

$$\pi_{O|CRP=0} = \sum_{t=0}^{t=2} \frac{P_C Y_O - S_O}{(1+i)^t} + \sum_{t=3}^{t=T} \frac{P_O Y_O - S_O}{(1+i)^t} \tag{4.2}$$

We assume $P_C < P_O$ and $Y_C > Y_O$. For producers who participated in the CRP and chose conventional production, the per-acre net present value of producer profit is:

$$\pi_{C|CRP=1} = \sum_{t=0}^{t=T} \frac{P_C Y_C - S_C}{(1+i)^t} \tag{4.3}$$

For producers who participated in the CRP and chose organic production, the per-acre net present value of producer profit is:

$$\pi_{O|CRP=1} = \sum_{t=0}^{t=T} \frac{P_O Y_O - S_O}{(1+i)^t} \tag{4.4}$$

Producers who did not participate in the CRP will choose organic production on any given acre if the net present value of profit from organic production is greater than the net present value of profit from conventional production, as shown in equation 4.5.

$$\sum_{t=0}^{t=2} \frac{P_C Y_O - S_O}{(1+i)^t} + \sum_{t=3}^{t=T} \frac{P_O Y_O - S_O}{(1+i)^t} > \sum_{t=0}^{t=T} \frac{P_C Y_C - S_C}{(1+i)^t} \tag{4.5}$$

Producers who participated in the CRP will choose organic production on any given acre if the net present value of profit from organic production is greater than the net present value of profit from conventional production, as shown in equation 4.6.

$$\sum_{t=0}^{t=T} \frac{P_O Y_O - S_O}{(1+i)^t} > \sum_{t=0}^{t=T} \frac{P_C Y_C - S_O}{(1+i)^t} \tag{4.6}$$

For each producer it is undetermined whether the net present value associated with organic production is greater than or less than the net present value associated with conventional production. However, we do know that the difference in profit between organic and conventional production conditional on participation in the CRP will be greater than the difference in profit between organic and conventional production without participating in the CRP. We can show:

$$(\pi_{O|CRP=1} - \pi_{C|CRP=1}) - (\pi_{O|CRP=0} - \pi_{C|CRP=0}) > 0 \tag{4.7}$$

Because $\pi_{C|CRP=1} = \pi_{C|CRP=0}$, equation 4.7 becomes:

$$(\pi_{O|CRP=1}) - (\pi_{O|CRP=0}) > 0 \tag{4.8}$$

Using the net present value of the profit functions given above, we can break up $\pi_{O|CRP=0}$ into two time periods to show:

$$\begin{aligned} &\sum_{t=0}^{t=2} \frac{P_O Y_O - S_O}{(1+i)^t} + \sum_{t=3}^{t=T} \frac{P_O Y_O - S_O}{(1+i)^t} \\ -&\sum_{t=0}^{t=2} \frac{P_C Y_O - S_O}{(1+i)^t} + \sum_{t=3}^{t=T} \frac{P_O Y_O - S_O}{(1+i)^t} > 0 \end{aligned} \tag{4.9}$$

The profit expressions starting at $t = 3$ are identical for producers who were in the CRP and producers who were not in the CRP so we drop the second and fourth terms from equation 4.9 to get:

$$\sum_{t=0}^{t=2} \frac{P_O Y_O - S_O}{(1+i)^t} - \sum_{t=0}^{t=2} \frac{P_C Y_O - S_O}{(1+i)^t} > 0 \tag{4.10}$$

Given that Y_O, Y_O, S_O, and i are identical for a given producer, we know this expression to be true because $P_C < P_O$. Therefore, participation in the CRP increases the difference in profit between organic production and conventional production.

Now, we can consider heterogeneity in the costs of organic production to show how a producer who would otherwise choose conventional production would choose organic production conditional on having participated in the CRP. Producers may have heterogeneous costs of organic production due to differences in both physical and human capital. We can show that when a producer maximizes profit there are certain values of S_O for which that producer will never choose organic production, always choose organic production, or only choose organic production conditional on having participated in the CRP. Producers will never choose organic production if $\pi_{C|CRP=0} > \pi_{O|CRP=0}$ and $\pi_{C|CRP=1} > \pi_{O|CRP=1}$. So, the conditions for a producer always choosing conventional production simplify to

$$\sum_{t=0}^{t=T} S_O > \sum_{t=0}^{t=2} \frac{P_C Y_O}{(1+i)^t} + \sum_{t=3}^{t=T} \frac{P_O Y_O}{(1+i)^t} - \sum_{t=0}^{t=T} \frac{P_C Y_C - S_C}{(1+i)^t} \tag{4.11}$$

and

$$\sum_{t=0}^{t=T} S_O > \sum_{t=0}^{t=T} \frac{P_O Y_O}{(1+i)^t} - \sum_{t=0}^{t=T} \frac{P_C Y_C - S_C}{(1+i)^t} \tag{4.12}$$

We know the right hand side of equation 4.12 is larger than the right hand side of equation 4.11, so the sufficiency condition for a producer always choosing conventional agriculture is simply equation 4.12. Conversely, a producer will always choose organic agriculture if the inverse relationship is true for equation 4.11 and 4.12. Therefore, a producer will always choose organic agriculture if

$$\sum_{t=0}^{t=T} S_O < \sum_{t=0}^{t=2} \frac{P_C Y_O}{(1+i)^t} + \sum_{t=3}^{t=T} \frac{P_O Y_O}{(1+i)^t} - \sum_{t=0}^{t=T} \frac{P_C Y_C - S_C}{(1+i)^t} \tag{4.13}$$

Finally, a producer will choose conventional agriculture conditional on not participating in the CRP and organic agriculture conditional on participation in the CRP only if $\pi_{C|CRP=0} >$

$\pi_{O|CRP=0}$ and $\pi_{C|CRP=1} < \pi_{O|CRP=1}$.

$$\sum_{t=0}^{t=T} S_O > \sum_{t=0}^{t=2} \frac{P_C Y_O}{(1+i)^t} + \sum_{t=3}^{t=T} \frac{P_O Y_O}{(1+i)^t} - \sum_{t=0}^{t=T} \frac{P_C Y_C - S_C}{(1+i)^t} \tag{4.14}$$

and

$$\sum_{t=0}^{t=T} S_O < \sum_{t=0}^{t=T} \frac{P_O Y_O}{(1+i)^t} - \sum_{t=0}^{t=T} \frac{P_C Y_C - S_C}{(1+i)^t} \tag{4.15}$$

In this way, for the marginal producer whose value of S_O for a given acre of land falls between

$$\sum_{t=0}^{t=2} \frac{P_C Y_O}{(1+i)^t} + \sum_{t=3}^{t=T} \frac{P_O Y_O}{(1+i)^t} < S_O < \sum_{t=0}^{t=T} \frac{P_O Y_O}{(1+i)^t} \tag{4.16}$$

participation in the CRP would induce transition to organic agriculture on that acre that otherwise would be used for organic production.

We can therefore conclude that participation in the CRP can incentivize transition to organic agriculture by increasing the difference in profit between organic and conventional production. This theory will be empirically tested in the following chapters.

CHAPTER FIVE

DATA

This analysis primarily utilizes data from two sources. Data on organic certifications were obtained from the USDA Agricultural Marketing Service Organic Integrity Database and CRP contract data were obtained from Farm Service Agency Conservation Contract Maintenance System through a Freedom of Information Act request. This is supplemented with additional county-level producer demographic and farm characteristic data from the USDA's National Agriculture Statistics Service (NASS), Economic Research Service (ERS), and Natural Resource Conservation Service (NRCS).

5.1 USDA Organic Integrity Data

Producer-level data on organic certification status were obtained from the USDA Organic Integrity Database (USDA, 2021c). The Integrity database contains information about operations' certification status, certification date, the certifying agent, and certified products.[1] The USDA has maintained this database in an effort to deter fraud, increase transparency for buyers and sellers, and promote market visibility for certified organic operations (USDA, 2021c). Aggregating to the county level, we use these data to obtain a count of all newly certified operations in a given county and year across all 50 states from 2002 to 2020.[2] While operations may be certified for organic livestock, handling, crops, or wild crops, we only include crop operations for this analysis. We also restrict our sample to counties that have cropland acres as of 2007.

We focus on two main outcome variables of interest in this analysis. The first is organic

[1]Importantly, this database does not include comprehensive data on certified organic acreage.

[2]The Integrity database contains information on operations dating back to 1973, but prior to 2002, when the NOP was established, these data are unreliable.

crop operations, which counts the number of new certified organic operations in a given county and year. The second is cumulative organic crop operations, which counts the total number of certified organic operations in a given county and year. The status of an operation is reported in the Integrity database as either certified, revoked, or suspended. The organic crop operations variable counts each operation with a certification status of "certified" in each year as a new organic certified operation. The cumulative organic crop operations variable was calculated starting with the total number of organic operations in a given county as reported by the National Agriculture Statistics Service (NASS) in 2007. From there, in each year we added the number of new certified organic operations and subtracted the number of revoked or suspended operations to get a total count of the number of certified organic operations. As a result of combining data from two different sources we have introduced some measurement error into the cumulative dependent variable.[3] Consequently, it sometimes takes on a negative number for the total count of organic operations. This occurs for 211 county-year observations, so we drop those 67 counties from our analysis with that variable.

5.2 CRP Contract Maintenance Data

CRP contract data were collected from the Farm Service Agency Conservation Contract Maintenance System as a result of a Freedom of Information Act request. These data contain yearly contract-level information from 2009 to 2020 on expiring CRP contracts and acreage, contract type (general or continuous), practice type, average rent of expiring contracts, and average length of expiring contracts. We aggregate this up to the county level to calculate the primary independent variable of interest in this analysis, which is the number of expiring CRP contracts. While our data are available starting in 2009, our empirical strategy employs

[3]Data from the Integrity database prior to the formation of the NOP in 2002 are unreliable, so we are unable to obtain a count of the cumulative number of certified organic operations from that data alone. NASS data on organic operations comes from the Census of Agriculture, which is conducted every five years. In order to get yearly data, we must combine this data with the Integrity database.

a two-year lag of expiring contracts, so our analysis is limited to the years 2011 through 2020. The CRP contract data only allows us to examine contract expirations rather than program exits; we are unable to determine if the producer associated with each contract chooses to exit or re-enroll in the program once the contract expires. We primarily examine expiring contracts rather than expiring acreage due to availability of organic certification data. The Integrity database only provides data on the number of certified organic operations, not the number of certified organic acres. Consequently, our model focuses on decision-making that occurs on the operation-level rather than the acre-level.

Table 5.1 provides descriptive statistics for key variables of interest, with variables having 30,620 county-year observations representing 3,062 counties in each of the 10 years we observe. Nineteen percent of our counties have at least one new certified organic operation each year. The mean number of new certified organic operations in a county and year is 0.43 and the mean number of total organic operations in a county and year is 8.85. As shown in Figure 5.1, the distribution of the new certified organic operations variable is right skewed, with the majority of observations having zero new certifications.[4] Eighty-three percent of counties in our data set have at least one expiring CRP contract between 2011 and 2020, with the mean number of expiring contracts being 17.65. Figure 5.2 shows that the expiring CRP contracts variable is also right skewed with 40 percent of observations having zero expiring CRP contracts.[5]

[4]Figure 5.1 shows 30,616 observation in 40 bins, omitting four observations that have greater than 40 new certified organic operations.

[5]Figure 5.2 shows 30,609 observations in 40 bins, omitting 11 observations that have greater than 400 expiring contracts.

Table 5.1: Descriptive Statistics of Outcome and Treatment Variables

Variable	Description	Mean	St. Dev.	Min	Max
Expiring Contracts (All)	Number of expiring CRP contracts, all types	17.65	36.76	0	696
Expiring Contracts (Continuous)	Number of expiring CRP contracts, continuous	10.52	25.01	0	447
Expiring Contracts (General)	Number of expiring CRP contracts, general	7.13	21.60	0	695
County has Expiring Contracts	Equal to 1 if county has any expiring CRP contract in any year from 2009-2020	0.83	0.37	0	1
Expiring Contracts Indicator	Equal to 1 if an observation has at least one expiring CRP contract	0.60	0.49	0	1
Organic Operations	New certified organic operations	0.43	1.67	0	80
County Has Organic Operations	Equal to 1 if a county has any new certified organic operations	0.60	0.49	0	1
Organic Operations Indicator	Equal to 1 if an observation has at least one new certified organic operation	0.19	0.39	0	1
Organic Revoked or Suspended	Count of organic operations with organic certification "revoked" or "suspended"	0.08	0.41	0	19
Cumulative Organic Operations	Total number of certified organic operations	8.85	24.79	-4	673

Notes: The above table shows descriptive statistics for the outcome and treatment variables used in this analysis, obtained from the USDA Agricultural Marketing Service Organic Integrity Database and the Farm Service Agency Conservation Contract Maintenance System. Each variable has 30,620 observations, which represents 10 years from 3,062 counties we observe with any cropland acres in 2007.

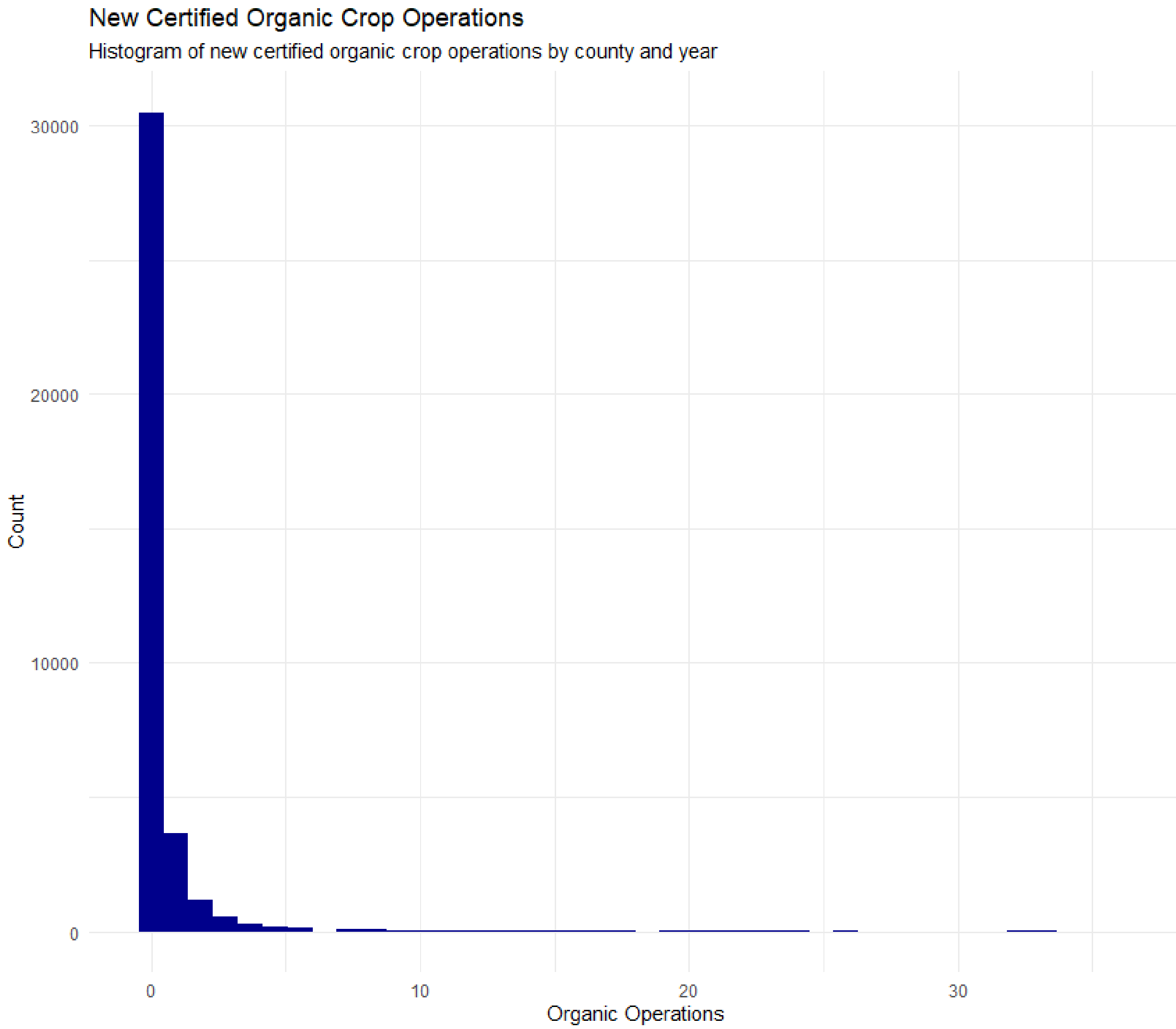

Figure 5.1: New Certified Organic Operations Histogram

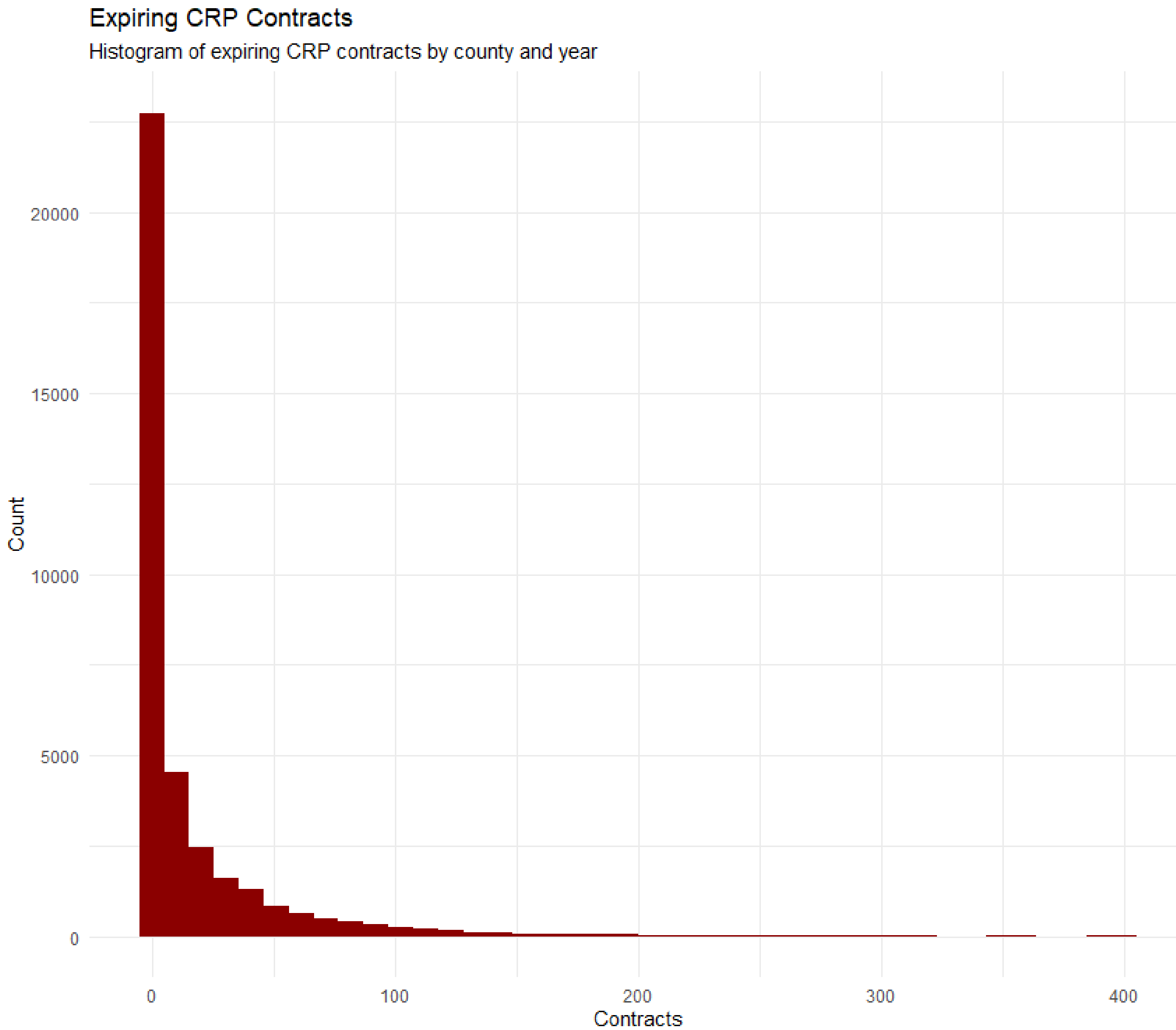

Figure 5.2: Expiring CRP Contracts Histogram

5.3 NASS, ERS, and NCRS Data

Other county-level data to be used as controls were collected from the USDA National Agricultural Statistics Service (NASS), the USDA Economic Research Service (ERS), and the USDA Natural Resource Conservation Service (NCRS). The Rural Urban Continuum Code variable was obtained from the ERS and evaluates each county on its urban proximity by assigning an integer between 1 and 9 with 9 meaning the county is a "nonmetro county completely rural or less than 2,500 urban population and not adjacent to metro area" and 1 meaning the "county is in a metro area with 1 million population or more." This index was based upon a county's status in 2003 and is included as a set of dummy variables. Raw data for the National Commodity Crop Productivity Index (NCCPI) was obtained from the NRCS, while the database directly used for this analysis is used in Hendricks (2018). This variable evaluates a county's soil productivity and assigns values ranging from .01 indicating low productivity to .99 indicating high productivity based on the highest value among corn and soybeans, small grains, and cotton.[6] This index was created based on a county's average soil characteristics as of 2015.

All other variables were obtained from NASS and are utilized only from the year 2007 with the exception of percent beginning operator and rent ratio.[7] Percent beginning operator is utilized from the year 2012 due to data availability. The rent ratio variable was created using average non-irrigated cropland rental rates from NASS and average rental rates of enrolled CRP acres from the year 2009. Variables related to producer demographics describe either principal operators or all operators, depending on data availability.[8] As defined by NASS, an operator designates a person who is involved in decision-making for their operation

[6] For a full description of this dataset, see Hendricks (2018).

[7] We only utilize control variables from 2007 to mitigate "bad controls" which are variables "that are themselves outcome variables in the notional experiment at hand" (Angrist and Pischke, 2008). This will be described further in the following chapter.

[8] All control variables describe principal operators except variables describing race and gender.

and a principal operator designates a person who makes the most decisions for the farm. The descriptive statistics for these variables are displayed in Table 5.2.

Table 5.2: Descriptive Statistics for Control Variables

Variable	**Description**	**Mean**	**St. Dev.**	**Min**	**Max**
Baseline Organic Operations	Number of organic operations in a county	6.63	17.89	0	444
Rural Urban Continuum Code	Factor variable indicating a county's urban population	5.14	2.67	1	9
NCCPI Soil Quality Index	National Commodity Crop Productivity Index. Values range from .01 (low productivity) to .99 (high productivity)	.43	.21	.01	.92
Rent Ratio	Ratio of average rent of enrolled CRP acres and average non-irrigated cropland rental rate	1.01	0.29	0.10	4.08
Cropland	Cropland acres (thousands)	132.70	149.42	.007	1,310.45
Farm Income	Farm related income, average for operations	5,255.35	5,291.98	0	62,160
Operator Age	Average age of principal operators	57.25	2.04	46.2	65.4
% Beginning Operator	Principal operators who have been on any operation less than 10 years	18.16	4.91	0	65
% No Off Farm Income	Principal operators who worked zero days off operation	36.08	6.91	0	71.43

Table 5.2 Continued

% Female	Female operators	29.69	6.05	0	58.82
% Residence Not on Operation	Principal operators whose residence is not on operation	24.75	12.03	0	79.12
% Owned	Acres owned by operators	21.47	8.97	0	60.83
% Orchards	Cropland acres devoted to orchards	1.44	6.15	0	86.40
% Nonwhite Operators	Operators who identified as Hispanic, Black, Asian American Indian or Pacific Islander	5.42	9.54	0	100
% Irrigated	Irrigated harvested acres	9.73	19.21	0	94.95

Notes: The above table shows descriptive statistics for control variables used in this analysis, obtained from the USDA National Agricultural Statistics Service, the USDA Economic Research Service, and the USDA Natural Resource Conservation Service. Each variable has 3,062 observations, which represents one year from each county we observe having cropland acres in 2007. The baseline organic operations variable includes all organic operations, not just operations certified for crops.

CHAPTER SIX

METHODOLOGY

We employ a set of finite distributed lag models to estimate the effect of participation in the CRP on the decision to transition to organic crop production. The primary outcome variable of interest is the number of new certified organic operations in a given county and year and the primary explanatory variable of interest is the lagged number of expiring CRP contracts in a given county and year.

In order to identify a causal relationship between participation in the CRP and transition to organic agriculture, it is necessary that the decision to participate in, and subsequently exit, the CRP is exogenous to the decision to transition to organic agriculture. The ideal experiment through which we would measure this effect would be to randomly assign participation in the CRP to a fraction of producers throughout the country and have all producers exit the CRP after a 10 year contract period. We would then compare rates of organic transition between those who participated in the CRP and those who did not to observe if participation in the CRP induced more producers to transition to organic production. In the absence of this ideal experiment, we must find an alternative plausibly exogenous treatment to identify the effect of CRP participation on organic transition. Therefore, we examine the impact of the number of CRP contracts that expire in a given county and year, with the assumption that the timing of the expiration of a CRP contract is exogenous to a producer's decision to transition to organic agriculture. Following from this, we can assume that the number of expiring CRP contracts in a given county and year is unrelated to other factors driving organic adoption in that same county and year. This assumption will be defended later in the chapter.

The baseline model used to estimate the effect of CRP participation on organic certifications is given below in equation 6.1.

$$Y_{i,t} = \beta_1 exp_{i,t-1} + \beta_2 exp_{i,t-2} + \phi_t \mathbf{X}_i + \gamma_i + \delta_t + \sigma_s t + \epsilon_{i,t} \tag{6.1}$$

In this equation, $Y_{i,t}$ represents the number of new organic crop certifications that occur in county i and year t. The independent variables of interest, $exp_{i,t-1}$ and $exp_{i,t-2}$ represent the number of expiring CRP contracts in county i in years $t-1$ and $t-2$, respectively. The variable $\mathbf{X}_i$ represents a vector of fixed baseline county characteristics related to producer demographics and other county-level attributes related to agricultural production described in Table 5.2. In addition, we include fixed effects to control for county- and year-specific heterogeneity that may be correlated with the number of expiring CRP contracts and the number of new certified organic operations. Specifically, γ_i represents county fixed effects, which control for time-invariant heterogeneity across counties, and δ_t represents year fixed effects, which control for time-varying factors that affect organic transition across all counties. Finally, $\sigma_s t$ represents state-specific time trends, which control for time-varying heterogeneity within state s. This model is then adapted to examine different forms of heterogeneity.

For causal identification, this model assumes that an individual's decision to initially participate in the CRP is not correlated with their decision to transition to organic agriculture. Simply put, we assume that producers did not choose to enter the CRP explicitly with the intention to transition that land to organic production upon expiration of the contract. If producers did choose to enter the CRP with the intention to transition that land to organic production, this would imply that those same producers may have transitioned to organic production regardless of CRP existence, or at least when faced with a similar transition cost reduction. In that case, the estimated treatment effect would not be driven by participation in the CRP. We believe this to be a valid assumption for the following reasons. First, to the extent that producers are myopic in their decision-making and there is uncertainty regarding the future, it is unlikely that they have finalized production plans for land after it exits the CRP at they time that they initially decide to enroll. Recall that CRP contracts typically last for a duration of 10 to 15 years with the option to re-enroll in the program. Producers are conscientious when making land-use decisions and would be heavily influenced by both organic and conventional crop prices as well as general economic conditions at the time of their contract expiration; it is not clear that they would make plans for their land for a minimum of 10 years in the future.

Second, even if some producers had exceptional foresight and considered what they would do with CRP land upon exit from the program before they choose to participate, it is unlikely they they would have strongly considered organic transition. Recall that the National Organic Program (NOP) did not enact organic standards until 2002. Assuming the minimum possible contract length of 10 years, producers whose contract expired in 2012 at the earliest would be aware of the rules regarding the three-year organic transition period. Furthermore, the last year of CRP contract data used in this analysis is 2019, meaning that the very latest a producer could have enrolled the CRP and appear in this data set is 2010. Consider Figure 6.1, which shows the number of new certified organic operations by year. Even if a producer in 2010 considering CRP participation had the foresight to ponder land use decisions for land after it exited the program, organic transition may not have been an obvious choice. There were slightly more than 500 new operations across the U.S. in 2010, indicating that organic production just wasn't popular or widely adopted. In addition, an average producer whose forecasting was consistent with both rational and adaptive expectations would likely not have predicted a large growth in organic certification, likely at least caused in part by expected organic profits relative to conventional, in 2010 considering organic certification didn't see large increases in popularity until 2014.[1] Therefore, it is plausible

[1] An exception to this occurred in 2002 when the NOP went into effect, which caused a brief spike in organic certifications.

that the timing of a producer's CRP contract expiring is exogenous to their decision to transition to organic agriculture.

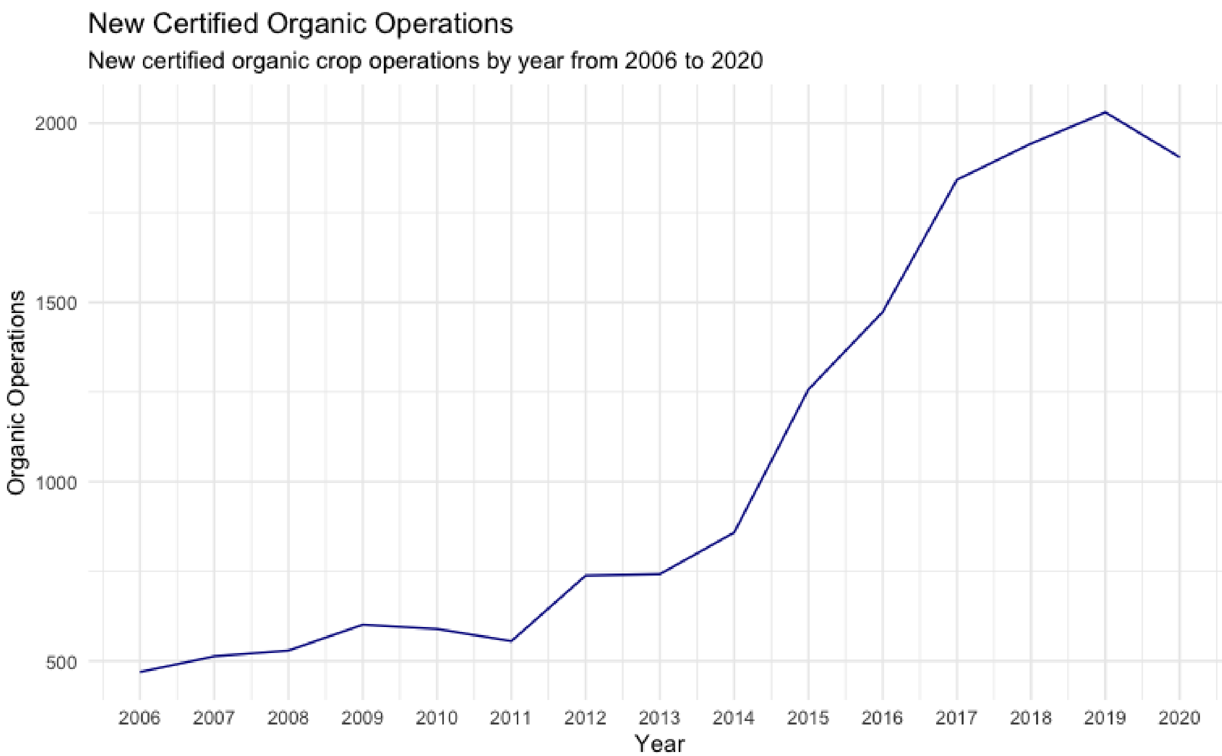

Figure 6.1: New Certified Organic Operations Over Time

Our dependent variable of interest takes on three different forms in this analysis. First, we examine the number of new certified organic operations in a given county and year using both ordinary least squares and weighted least squares and apply an inverse hyperbolic sine (IHS) transformation to the variable to do so. The IHS transformation is used to reduce the variance of the right-skewed dependent variable while accounting for the large number of zero values it takes on.[2] Second, since the dependent variable is a count variable, equation

[2]In an additional effort to mitigate the challenges with the large number of zeros on our dependent variable, we run a robustness check with a limited sample. In this limited sample, we only include operations that have some kind of organic activity prior to 2007, either indicated by NASS or the integrity data.

6.1 is also estimated using a Poisson model in which we do not apply the IHS transformation to the dependent variable. Third, as a robustness check, we estimate equation 6.1 using the IHS of the cumulative number of new certified organic operations in a given county and year using weighted least squares. While in our primary specification we examine the number of new certified operations in each county and year, in that specification we examine the total number of certified operations in each county and year.

We choose to lag the number of expiring CRP contracts by one and two years. A same-year expiring CRP contract variable is not included because CRP contracts expire on the 30th of September on any given year and the organic certification process takes a considerable amount of time. For example, California Certified Organic Farmers (CCOF), the first organic certification entity in the United States, states that certification typically requires 12 weeks and they recommend that producers begin the process at least 90 days before the harvest or launch of their organic line (California Certified Organic Farmers, 2022). Given that CRP contracts expire at the end of September, and the certification process typically takes 12 weeks, it is unlikely that any producer would be able to complete the certification process and have their cropland become certified organic in the same year that their CRP contract expired. Furthermore, most on-site organic inspections are required to take place after planting a crop, and preferably after there is visible growth of the crop, making same-year certification nearly impossible.[3]

For this reason, we would expect certifications to mostly occur in the first and second years following contract expiration. The first year lag captures producers who were able to plan, prepare fields, and complete the certification process in the year following their contract expiration. The second year lag allots for the time it may take producers to prepare fields for transition back to crop production after being out of production and the time it may

As shown in the appendix, results based on this more restrictive sample are consistent with the preferred estimates presented in the main text.

[3]This insight came from local Montana organic producer Nathaniel Powell-Palm.

take new organic producers to navigate the certification process. In addition to the typical factors that go into land-use decisions, land coming out of the CRP has additional challenges to account for including heavy residues, additional weeds, and low levels of soil moisture (Keene et al., 2021). Practices to manage these challenges could take an additional year to implement. In addition, new producers who may be unaware of the details and complexity of the certification process may require an additional year to organize their production. Therefore, our model includes a one-year and a two-year lag on expiring CRP contracts. We also use the IHS transformation on these lag variables, again to reduce the variance of the right-skewed independent variables while accounting for the large number of zeros.

We introduce two different specifications to incorporate control variables (listed in Table 5.2) into the model. First, we interact the control variables values from 2007 with a linear time trend to allow the impact of each variable to change over time without conflating changes in these variable with changes in expiring contracts. Second, in a more flexible specification, we interact the control variable from 2007 with year dummy variables to allow the impact of each variable to take on a different value for each year.

In addition to the base model given by equation 6.1, we also explore various forms of heterogeneity in our results. This takes the form of regional heterogeneity by interacting regional dummy variables with the expiring contract lagged variables.[4] It also takes the form of heterogeneity by popularity of CRP expiration and organic certification by exploring only states with a high number of expiring CRP contracts, a high number of new organic certifications, or both. In addition to regional heterogeneity, we explore results based on differences in CRP enrollment type, that being general or continuous, and CRP practice type, that being grasses, wetlands, trees, or wildlife.

In all specifications described above, standard errors are clustered at the Agricultural

[4]In one specification, regional dummy variables consist of four regions following the U.S. Census regional divisions. In another specification, regional dummy variables consist of nine "Farm Resource Regions" determined by the ERS.

Statistics Districts (ASD) level to account for spatial correlation in the error structure. ASD are defined by the USDA and group counties within a state into districts based on geography, climate, and cropping practices. There are between two and fifteen ASD per state and a total of 271 ASD clusters used in our sample. Additionally, some regressions are weighted by cropland acres in 2007. This puts greater emphasis on counties that have more agricultural production, as measured by acres of cropland.

CHAPTER SEVEN

RESULTS

Using the model described in Chapter 6, we estimate the relationship between participation in the Conservation Reserve Program (CRP) and transition to organic agriculture. Results are presented in the following way. First, we discuss a specification progression where various fixed effects are added to a baseline model with no controls. We then present our preferred model specification results, which include time dummy interactions with control variables. Next, we discuss heterogeneity in these results, starting with variation by CRP enrollment type, that being the general CRP or the continuous CRP, and CRP conservation practice type, that being grasses, trees, wildlife, or wetlands. We then examine regional heterogeneity in three forms: geographic region of the country, farm resource region (as defined by the ERS), and areas with high concentrations of CRP participation and organic operations. Results of additional specifications are included in Appendix A.

Table 7.1 reports the results of progressive specifications for estimating the relationship between expiring CRP contracts and new certified organic operations. Each result has two independent variables of interest: the number of expiring contracts lagged one year and the number of expiring contracts lagged two years. Also presented is the cumulative effect, or joint impact, of these two lags. The dependent variable is the number of new certified organic operations. In all equations, the dependent variable and the independent variables are transformed using the inverse hyperbolic sine function, so the results shown are the impact of a one percent increase in the number of expiring contracts on the percentage change in new certified operations. Column (1) of Table 7.1 contains no controls. In column (2) of Table 7.1 we control for county and year specific fixed effects. In column (3) we control for state-specific time trends. Finally, in column (4) we weight the observations by the number of cropland acres present in that county in 2007. Before including any county controls or county or year fixed effects, we estimate that ten percent increase in the number of CRP contracts that expire in a given county and year is associated with a 0.347 percent increase in the number of new certified organic operations in that county in the two years following contract expiration. This estimate falls in magnitude as we successively add county and year fixed effects (0.216 percent), and state time trends (0.117 percent), before increasing slightly with weights (0.184 percent).

Table 7.1: Effect of Expiring CRP Contracts on New Organic Operations: Model Progression

	(1)	(2)	(3)	(4)
Expiring Contracts Lag 1	0.0099**	0.0111***	0.0045	0.0110**
	(0.0047)	(0.0032)	(0.0029)	(0.0045)
Expiring Contracts Lag 2	0.0248***	0.0105***	0.0072**	0.0074
	(0.0059)	(0.0038)	(0.0035)	(0.0060)
Cumulative Effect	*0.0347****	*0.0216****	*0.0117***	*0.0184****
	(0.0093)	*(0.0054)*	*(0.0046)*	*(0.0060)*
County FE	NO	YES	YES	YES
Year FE	NO	YES	YES	YES
State time trend	NO	NO	YES	YES
Weights	NO	NO	NO	YES
Observations	30,620	30,620	30,620	30,620
Number of counties	3,062	3,062	3,062	3,062
R-squared	0.012	0.053	0.093	0.118

*** p<0.01, ** p<0.05, * p<0.1

Notes: The above table shows the results from regressions with the dependent variable being the IHS of new certified organic operations and the independent variables being the IHS of lagged CRP contracts. 30,620 observations come from 3,062 counties over 10 years. Standard errors, adjusted for clustering at the agricultural statistic district level, are in parenthesis. No additional controls beyond the indicated fixed effect enter into these models. Where indicated, regressions are weighted by cropland acres in 2007 at the county level.

In Table 7.2 we add county-specific time-varying demographic and agricultural controls and present the results of our preferred specification for estimating the relationship between expiring CRP contracts and new certified organic operations. Column (1) of Table 7.2 shows the results of regressions where additional control variables enter the model through interacting their 2007 value with a linear time trend. Column (2) show the results of regressions where additional control variables enter the model through interacting their 2007 value with year dummy variables. The specification in column (2) is preferred to that in column (1) as it better allows us to control for changes in the impact of control variables over time. Our findings indicate that a 10 percent increase in expiring CRP contracts in a given county and year is associated with an increase in the number of new certified organic operations by 0.084 percent in the first succeeding year. This result is significant at the 10 percent level. When we aggregate the two years following contract expiration together, we find that a 10 percent increase in expiring CRP contracts is associated with an increase in the number of new certified organic operations in a county by 0.157 percent in the following two years. This result is significant at the 5 percent level. These findings suggest that the CRP plays a role in incentivizing transition to organic agriculture.

The preferred specification of our model, as presented in column (2) of Table 7.2, is then adapted to explore various forms of heterogeneity in our results. First, we explore heterogeneity based on CRP enrollment type. Recall the two mechanisms for enrolling in the CRP, the general sign-up and the continuous sign-up, which each target different kinds of land and conservation practices. As land enrolled in these two ways can be fundamentally different from each other, we examine heterogeneity in our results dependent on this factor, the results of which are presented in Table 7.3. We find no significant effect of the number of expiring general CRP contracts on the number of new certified organic operations. For the continuous CRP, we find that a 10 percent increase in expiring contracts is associated with a 0.09 percent increase in the number of new certified organic operations in the second year

Table 7.2: Effect of Expiring CRP Contracts on New Certified Organic Operations: Preferred Model

	(1)	(2)
Expiring Contracts Lag 1	0.0096**	0.0084*
	(0.0042)	(0.0045)
Expiring Contracts Lag 2	0.0066	0.0073
	(0.0062)	(0.0063)
Cumulative Effect	*0.0163****	*0.0157***
	(0.0058)	*(0.0064)*
County FE	YES	YES
Year FE	YES	YES
State time trend	YES	YES
Weights	YES	YES
Observations	30,620	30,620
Number of counties	3,062	3,062
R-squared	0.133	0.155

*** p<0.01, ** p<0.05, * p<0.1

Notes: The above table shows the results from regressions with the dependent variable being the IHS of new certified organic operations and the independent variables being the IHS of lagged CRP contracts. 30,620 observations come from 3,062 counties over 10 years. Standard errors, adjusted for clustering at the agricultural statistic district level, are in parenthesis. In column (1), all variables from NASS included as controls enter the model using their base 2007 values interacted with a linear time trend. In column (2), all variables from NASS included as controls enter the model using their base 2007 values interacted with year dummy variables. Where indicated, regressions are weighted by cropland acres in 2007 at the county level.

Table 7.3: Effect of Expiring CRP Contracts on New Certified Organic Operations: Enrollment Type Heterogeneity

	(1)	(2)
Lag 1 General	0.0048	0.0060
	(0.0029)	(0.0045)
Lag 2 General	0.0001	0.0002
	(0.0030)	(0.0046)
Lag 1 Continuous	0.0024	0.0049
	(0.0037)	(0.0045)
Lag 2 Continuous	0.0058	0.0090*
	(0.0041)	(0.0049)
Cumulative Effect General	*0.0047*	*0.0058*
	(0.0040)	*(0.0056)*
Cumulative Effect Continuous	*0.0082*	*0.0138*****
	(0.0054)	*(0.0062)*
County FE	YES	YES
Year FE	YES	YES
State time trend	YES	YES
Weights	NO	YES
Observations	30,620	30,620
Number of counties	3,062	3,062
R-squared	0.118	0.155

*** p<0.01, ** p<0.05, * p<0.1

Notes: The above table shows the results from regressions with the dependent variable being the IHS of new certified organic operations and the independent variables being the IHS of lagged CRP contracts. 30,620 observations come from 3,062 counties over 10 years. Standard errors, adjusted for clustering at the agricultural statistic district level, are in parenthesis. Where indicated, regressions are weighted by cropland acres in 2007 at the county level.

following the contract expiration, or a 0.138 percent increase in the cumulative two years following contract expiration.

We then examine heterogeneity in our results dependent on the practice type utilized by producers in each CRP contract to determine if the different conservation practices implemented on land impacts its likelihood of being used for organic production. There are many different practices a producer may implement on land enrolled in the CRP, and they can generally be grouped into five categories: grasses, trees, wildlife habitat, wetlands, and other.[1] Under our preferred specification, displayed in column (2) of Table 7.4, we find that a 10 percent increase in expiring CRP contracts with a conservation practice related to tree conservation is associated with a 0.154 percent increase in the number of new certified organic operations in the first year following the contract expiration and a 0.175 percent increase in the following two years. When we consider CRP contracts related to wildlife habitat conservation and aggregate the two years following a contract's expiration, we find that a 10 percent increase in expiring wildlife habitat contracts is associated with a 0.108 percent decrease in the number of new certified organic operations. It should be noted that these practices are loosely grouped into each category and were cultivated 10-15 years prior to when we observe them in our data. Examples of wetland conservation related practices include marginal pastureland wetland buffers and filter strips while examples of wildlife habitat conservation related practices include wildlife food plots and pollinator habitats. Some tree conservation related practices include alley cropping and field wind break establishments.[2] Given this, it is possible that the significant results found for trees, wetlands, and wildlife habitat CRP contracts are instead being driven by regional heterogeneity.[3] In each county-

[1] As there were a very small number (5) of contracts grouped in the "other" category, and their practices were ambiguous in where they should be grouped, they were added to the wetland category for the purposes of this analysis.

[2] See Appendix B for a complete list of all approved CRP practices as of January 4th, 2020 and their placement into one of the four groups.

[3] See Figure B.1 for the geographic dispersion of conservation practices.

year observation, there were an average of 8.76 expiring grass contracts, 2.11 expiring tree contracts, 2.04 expiring wildlife contracts, and 6.18 expiring wetlands contracts. We find no significant impact for any other CRP practice on the number of new certified organic operations.

Table 7.4: Effect of Expiring CRP Contracts on New Certified Organic Operations: Practice Type Heterogeneity

	(1)	(2)
Lag 1 Grass	-0.0018	0.0035
	(0.0045)	(0.0051)
Lag 1 Trees	0.0092**	0.0154***
	(0.0042)	(0.0056)
Lag 1 Wildlife	-0.0055	-0.0076
	(0.0042)	(0.0052)
Lag 1 Wetlands	0.0069**	0.0065
	(0.0033)	(0.0048)
Lag 2 Grass	-0.0027	0.0039
	(0.0048)	(0.0063)
Lag 2 Trees	0.0031	0.0021
	(0.0048)	(0.0068)
Lag 2 Wildlife	-0.0036	-0.0031
	(0.0036)	(0.0044)
Lag 2 Wetlands	0.0057	0.0025
	(0.0035)	(0.0050)
Cumulative Effect Grass	*-0.0046*	*0.0074*
	(0.0076)	*(0.0076)*
Cumulative Effect Trees	*0.0122**	*0.0175**
	(0.0068)	*(0.0090)*
Cumulative Effect Wildlife	*-0.0091*	*-0.0108**
	(0.0057)	*(0.0062)*
Cumulative Effect Wetlands	*0.0126***	*0.0090*
	(0.0049)	*(0.0076)*
County FE	YES	YES
Year FE	YES	YES
State time trend	YES	YES

Table 7.4 Continued

Weights	NO	YES
Observations	30,620	30,620
Number of counties	3,062	3,062
R-squared	0.118	0.155

*** p<0.01, ** p<0.05, * p<0.1

Notes: The above table shows the results from regressions with the dependent variable being the IHS of new certified organic operations and the independent variables being the IHS of lagged CRP contracts. 30,620 observations come from 3,062 counties over 10 years. Standard errors, adjusted for clustering at the agricultural statistic district level, are in parenthesis. Where indicated, regressions are weighted by cropland acres in 2007 at the county level.

Next, we examine regional heterogeneity in three forms: heterogeneity by census region, ERS farm resource region, and CRP and organic prevalence. For each of these analyses, the groups and the number of observations in each group is displayed in Table 7.5.

Table 7.5: Number of Observations in Heterogeneity Analysis Groups

Heterogeneity Analysis	Group	Observations
Census Region	West	4,190
	Midwest	10,540
	South	13,780
	Northeast	2,110
ERS Farm Resource Region	Northern Great Plains	1,880
	Heartland	5,430
	Northern Crecent	4,170
	Prairie Gateway	3,940
	Eastern Upland	4,100
	Southern Seaboard	4,780
	Fruitful Rim	2,750
	Basin and Range	1,940
	Mississippi Portal	1,630
CRP and Organic Prevalence	Top CRP	9,050
	Top Org	7,420
	Top Both	4,380

Table 7.6 displays the results of regressions exploring regional heterogeneity in various parts of the United States, using the four regions described by the US Census Bureau. Here, we interact expiring CRP contracts with regional dummy variables, using the West dummy variable as the base category. Under our preferred specification in column (2), we find limited significant effects of contract expiration on organic certification in the Midwest, South, and Northeast regions of the United States. In the West, we estimate that a 10 percent increase in expiring CRP contracts is associated with a 0.346 percent increase in the number of new certified organic operations in the two years following contract expiration. Turning to the South, we find a significant different effect from the West, and estimate the overall effect in the South to be zero. We also estimate an overall zero effect in the Midwest and Northeast.

Table 7.6: Effect of Expiring CRP Contracts on New Certified Organic Operations: Regional Heterogeneity

	(1)	(2)
Expiring Contracts Lag 1	0.0084	0.0133
	(0.0094)	(0.0108)
Lag 1 * Midwest	-0.0088	-0.0076
	(0.0106)	(0.0120)
Lag 1 * South	-0.0083	-0.0074
	(0.0099)	(0.0138)
Lag 1 * Northeast	0.0152	0.0106
	(0.0237)	(0.0215)
Expiring Contracts Lag 2	0.0043	0.0212
	(0.0110)	(0.0148)
Lag 2 * Midwest	0.0045	-0.0140
	(0.0121)	(0.0149)
Lag 2 * South	-0.0025	-0.0230
	(0.0118)	(0.0187)
Lag 2 * Northeast	-0.0048	-0.0254
	(0.0265)	(0.0345)
Cumulative Effect	0.0128	*0.0346***
	(0.0148)	*(0.0150)*
*Cumulative Effect * Midwest*	*-0.0043*	*-0.0216*

Table 7.6 Continued

	(0.0169)	*(0.0171)*
*Cumulative Effect * South*	*-0.0108*	*-0.0303***
	(0.0154)	*(0.0154)*
*Cumulative Effect * Northeast*	*0.0104*	*-0.0148*
	(0.0380)	*(0.0444)*
County FE	YES	YES
Year FE	YES	YES
State time trend	YES	YES
Weights	NO	YES
Observations	30,620	30,620
Number of counties	3,062	3,062
R-squared	0.118	0.155

*** p<0.01, ** p<0.05, * p<0.1

Notes: The above table shows the results from regressions with the dependent variable being the IHS of new certified organic operations and the independent variables being the IHS of lagged CRP contracts. 30,620 observations come from 3,062 counties over 10 years. Regional indicator variables are interacted with the number of expiring CRP contracts to generate our independent variables of interest. Standard errors, adjusted for clustering at the agricultural statistic district level, are in parenthesis. All variables from NASS included as controls enter the model using their base 2007 values interacted with year dummy variables. Where indicated, regressions are weighted by cropland acres in 2007 at the county level.

Then, rather than examining heterogeneity dependent on census regions, we examine the ERS farm resource regions in order to better group together counties that have similar farm production patterns. The ERS constructed these regions based on farm type, commodities produced, soil traits, physio-graphic characteristics, and climate traits in order to more accurately portray the distribution of farm production (USDA 2000). A map of these regions is provided in Appendix B. We interact expiring CRP contracts with farm resource regional dummy variables, using the Northern Great Plains region as the base category. The cumulative effect of the lagged expiring contract variables interacted with regional dummy variables is displayed in Table 7.7.[4] Here, we find the strongest effect in the Heartland, where, adding the Heartland interaction term to the base category coefficient, the effect of a

[4] See Table A.6 for the individual year lag effects.

10 percent increase in expiring contracts is a 0.171 percent increase in new certified organic operations in the following two years. We also find a significant effect in the Eastern Upland region where a 10 percent increase in expiring contracts leads to a 0.253 percent increase in new organic certifications, again relative to zero.

Recall CRP participation and and organic production are both heavily concentrated in specific regions of the country. We examine regional heterogeneity in our results based on the popularity of the CRP and organic agriculture in various areas in order to understand how this concentration impacts the relationship we observe. The results of this analysis are displayed in of Table 7.8. An indicator variable for states with high levels of CRP participation is interacted with the number of expiring contracts. A "Top CRP State" is defined as a state that ranks in the top ten for the number of expiring CRP contracts between 2009 and 2018 (or, similarly, a state that ranks in the top 10 for the lagged number of expiring contracts between 2011 and 2020).[5] We find no significant differential effect of expiring contracts on organic certification between states that have a large number of expiring CRP contracts and states that do not. We repeat this process again based on the popularity of organic certification by state and display the results in column (2). Here, a "Top Organic State" is defined as a state that ranks in the top ten for the number of new certified organic operations between 2011 and 2020.[6] Again, we find no significant differing impact of expiring contracts on organic certification for states that have high levels of organic certification and states that do not. Finally, we examine the differing effects for states that have both high levels of CRP participation and high levels of organic participation (which include Iowa, Minnesota, Ohio, Indiana, and Wisconsin) and find no significant results.

[5]The states with the greatest number of expiring CRP contracts in this data set are, in order, Iowa, Illinois, Minnesota, Ohio, Indiana, Wisconsin, Nebraska, Missouri, North Dakota, and Kansas.

[6]The states with the greatest number of new certified organic crop operations are, in order, California, Wisconsin, New York, Pennsylvania, Indiana, Iowa, Ohio, Washington, Minnesota, and Michigan.

Table 7.7: Cumulative Effect of Expiring CRP Contracts on New Certified Organic Operations: Farm Resource Regions Heterogeneity

	(1)	(2)
Cumulative Effect	*0.0056*	*0.0089*
	(0.0071)	*(0.0086)*
*Cumulative Effect * Heartland*	*0.0185*	*0.0355***
	(0.0146)	*(0.0169)*
*Cumulative Effect * Northern Crescent*	*0.0096*	*0.0082*
	(0.0201)	*(0.0226)*
*Cumulative Effect * Eastern Upland*	*0.0115*	*0.0164*
	(0.0142)	*(0.0170)*
*Cumulative Effect * Southern Seaboard*	*-0.0026*	*0.0062*
	(0.0094)	*(0.0133)*
*Cumulative Effect * Fruitful Rim*	*-0.0065*	*0.0300*
	(0.0177)	*(0.0280)*
*Cumulative Effect * Basin and Range*	*-0.0394*	*-0.0391*
	(0.0256)	*(0.0254)*
*Cumulative Effect * Mississippi Portal*	*-0.0112*	*-0.0093*
	(0.0119)	*(0.0143)*
County FE	YES	YES
Year FE	YES	YES
State time trend	YES	YES
Weights	NO	YES
Observations	30,620	30,620
Number of counties	3,062	3,062
R-squared	0.118	0.155

*** p<0.01, ** p<0.05, * p<0.1

Notes: The above table shows the results from regressions with the dependent variable being the IHS of new certified organic operations and the independent variables being the IHS of lagged CRP contracts scaled by 10. 30,620 observations come from 3,062 counties over 10 years. Regional indicator variables are interacted with the number of expiring CRP contracts to generate our independent variables of interest. Standard errors, adjusted for clustering at the agricultural statistic district level, are in parenthesis. All variables from NASS included as controls enter the model using their base 2007 values interacted with year dummy variables. Where indicated, regressions are weighted by cropland acres in 2007 at the county level.

Table 7.8: Effect of Expiring CRP Contracts on New Certified Organic Operations: States with High CRP and Organic Popularity

	(1)	(2)	(3)
Lag 1	0.0085	0.0093**	0.0098*
	(0.0058)	(0.0046)	(0.0057)
Lag 1 * Top CRP State	-0.0004		-0.0011
	(0.0085)		(0.0097)
Lag 1 * Top Organic State		-0.0049	-0.0083
		(0.0115)	(0.0190)
Lag 1 * Top CRP * Top Organic			0.0071
	0.0000		(0.0229)
Lag 2	0.0081	0.0044	0.0031
	(0.0087)	(0.0071)	(0.0095)
Lag 2 * Top CRP State	-0.0025		0.0040
	(0.0098)		(0.0109)
Lag 2 * Top Organic State		0.0139	0.0326
		(0.0134)	(0.0205)
Lag 2 * Top CRP * Top Organic			-0.0368
			(0.0236)
Cumulative Effect	*0.0166***	*0.0136***	*0.0128*
	(0.0080)	*(0.0064)*	*(0.0079)*
*Cumulative Effect * Top CRP*	*-0.0029*		*0.0030*
	(0.0116)		*(0.0134)*
*Cumulative Effect * Top Organic*		*0.0089*	*0.0243*
		(0.0174)	*(0.0273)*
*Cumulative Effect * Top CRP * Top Organic*			*-0.0297*
			(0.323)
County FE	YES	YES	YES
Year FE	YES	YES	YES
State time trend	YES	YES	YES
Weights	YES	YES	YES
Observations	30,620	30,620	30,620
Number of counties	3,062	3,062	3,062
R-squared	0.155	0.155	0.155

*** p<0.01, ** p<0.05, * p<0.1

Notes: The above table shows the results from regressions with the dependent variable being the IHS of new certified organic operations and the independent variables being the IHS of lagged CRP contracts. A "Top CRP State" is defined as a state that ranks in the top ten for the number of expiring CRP contracts between 2009 and 2018. A "Top Organic State" is defined as a state that ranks in the top ten for the number of new certified organic operations between 2009 and 2020. 30,620 observations come from 3,062 counties over 10 years. Standard errors, adjusted for clustering at the agricultural statistic district level, are in parenthesis. All variables from NASS included as controls enter the model using their base 2007 values interacted with year dummy variables. Where indicated, regressions are weighted by cropland acres in 2007 at the county level.

We present three alternative models in Appendix A: a model with different independent variables of interest, a model with a different dependent variable of interest, and a model with a different estimation method. First, we estimate a model using lagged expiring CRP acres, rather than lagged expiring contracts, as the primary independent variables of interest. Table A.1 shows the effect of expiring CRP acres on the number of new certified organic operations. This model is included in the appendix rather than a main result because we do not observe the number or certified organic acres in our data, only the number of certifications. Due to this measurement mismatch, we use expiring CRP contracts rather than acres in this analysis. We find than 1,000 expiring CRP acres is associated with a 0.0534 percent increase in new certified operations in the first year following contract expiration.

Next, we examine the relationship between expiring contracts and the cumulative number of certified organic operations in a county. These results are presented in Tables A.2 and A.3, which mimic the specifications in Tables 7.1 and 7.2. The results from the preferred specification using this dependent variable are presented in column (2) of Table A.3. Here, our estimates are noisier, likely due to the measurement error related to this dependent variable discussed in the data chapter.

The final alternative model estimates the effect of expiring CRP contracts on the new number of certified organic operations using a Poisson regression rather than weighted least squares. A Poisson regression is used to account for the skewness in the dependent count variable as a substitute to the inverse hyperbolic sine transformation. Table A.4 displays these results. Before adding weights, Poisson estimates indicate that a 10 percent increase in expiring CRP contracts is associated with a 0.586 percent increase in the number of new certified organic operations in the first year following contract expiration and a 0.698 percent increase in the second year, resulting in a cumulative effect of 1.284 percent increase.

Finally, in an effort to mitigate the problems associated with having such a large proportion of observations take on a zero value for the dependent variable, we limit the sample used to only counties that have some level of organic activity prior to the start of our data. This is defined either by having a new organic certification in the Integrity database prior to 2007 or having a positive count of certified organic operations reported by the Census of Agriculture in 2007. These results are presented in Table A.5 and closely follow the results of our preferred specification in Table 7.2.

CHAPTER EIGHT

DISCUSSION

The results from this study indicate that the decision to transition from conventional to organic agriculture is impacted by expiring CRP contracts. The magnitude and practical significance of this impact has important meaning when considered in light of the scope of the CRP.

The full elasticity estimates, calculated at the averages of the dependent variable and two independent variables of interest from our preferred model specification, as described in Table 7.2 column (2) are presented in Table 8.1. Results displayed estimate the impact of expiring CRP contracts on organic operations for the mean number of expiring contracts and the mean number of new certifications in a given county and year. These results indicate that a 10 percent increase in expiring CRP contracts lead to a 0.211 percent increase in new certified organic operations in the first year following contract expiration. Further, we find that in the two years following contract expirations, a 10 percent increase in expiring CRP contracts leads to a 0.393 percent increase in new organic certifications. While upon initial inspection these magnitudes seem inconsequential, when we consider the size of the CRP their effect become apparent. The mean number of expiring CRP contracts per county and year in our data set is 17.65, which means that in the average year, there were 54,044 expiring contracts in the US.

Table 8.1: Marginal Effect of a One Percent increase in Expiring CRP Contracts on the Percent Change of New Certified Organic Operations

	(1)
Expiring Contracts Lag 1	0.0211*
	(0.0113)
Expiring Contracts Lag 2	0.0182
	(0.0158)
Cumulative Effect	0.0393**
	(0.0159)

*** p<0.01, ** p<0.05, * p<0.1

Notes: The above table shows the full elasticities from the regression described in column (2) of Table 7.2.

The results of this study have profound implications as we look forward and consider the future of the Conservation Reserve Program, as well as the future of organic agriculture. Examining the past decade, we can see longstanding trends: enrollment in the CRP has steadily declined since 2007 while the number of organic certifications has grown over that same time period. As large numbers of acres of land exit the CRP, it is important to consider how they will be used, and the impact that they may have on the future organic market.

As of 2022, the Farm Service Agency (FSA) reports 9,583,821 acres that are set to expire from the CRP between September 20, 2022 and September 30, 2031. The average contract in our data set has 37.86 acres so this equates to approximately 358,505 CRP contracts. We can use the model presented in this thesis to anticipate the effect these expiring contracts will have on the future of organic certifications. Using the estimates obtained from our model specification in Table 7.2 column (1), we perform a back-of-the-envelop calculation to estimate that between 2022 and 2031 there will be approximately 6,189 new certified organic operations in the United States if we do not consider the impact of expiring CRP contracts, and 6,913 new certified organic operations in the United States when we include the effect of 305,869 expiring contracts.

These estimates were obtained by taking the coefficient estimates from the equation used in Table 7.2 column (2) for the county fixed effects, state time trends, lagged expiring contracts variables, and all control variables interacted with year dummy variables and applying them to the out-of-sample data for the years 2022 through 2030. In doing so, we use the coefficient from the year 2020 interacted with the 2007 values for all county-level control variables as well as the year 2020 value for state time trends. Thus, the same impact we observed for each state and county control variable in the year 2020 of our initial regressions, as well as the same county fixed effects, are then applied again to the years 2022 through 2030 in our forecasting data set.

To estimate the number of new organic operations without the CRP, we use the method described above assuming zero expiring contracts from 2022 to 2030. Then, to estimate the number or new organic operations with the CRP, we re-calculate the lagged expiring contracts variables using known and expected expiring contracts from 2020 through 2028 and use the method described above again. We then apply the hyperbolic sine transformation to our dependent variable, which is given in terms of the inverse hyperbolic sine, to back out the number of organic operations we anticipate each year. We predict 6,189 new operations in the absence of any expiring CRP contracts and 6,913 new operations with the predicted number of expiring contracts. This leaves a difference of 724 new organic operations certified as a result of expiring CRP contracts. The yearly breakdown of these results is displayed in Table 8.2.

These predictions represent only a rough calculation, and should therefore be treated with a great degree of caution, keeping in mind this model was not built for the purpose of forecasting. The estimates are biased both by the limitations of the model, as discussed in the methodology section, as well as the limitations of forecasting. However, this study provides an important first step in identifying and understanding the connection between the

CRP and organic agriculture. Results indicate that producers have recognized and utilized the possibility of organic transition post-CRP participation and future predictions suggest that as large amounts of land continue to exit the CRP, we will likely see more transition into organic production as a result.

Table 8.2: Future Expiring CRP Contracts and Their Predicted Impact on Organic Operations

		Organic Operations		
Year	Expiring Contracts	Without CRP	With CRP	Attributable to CRP
2022	105,770	285	399	114
2023	52,706	374	480	106
2024	12,998	466	566	100
2025	25,787	563	632	69
2026	40,498	665	727	62
2027	35,811	774	854	80
2028	10,238	891	973	82
2029	10,588	1,017	1,080	63
2030	11,474	1,154	1,202	48
Total	305,870	6,189	6,913	724

Notes: The above table shows the number of expiring CRP contracts estimated from FSA data on expiring acres, the predicted number of new certified organic operations before accounting for expiring contracts, the predicted number of new certified organic operations after accounting for expiring contracts, and the difference which shows the number of certifications attributable to expiring CRP contracts for the years 2022 to 2030.

CHAPTER NINE

CONCLUSION

This study analyzes the relationship between the Conservation Reserve Program (CRP) and organic agriculture. Specifically, we examine whether participation in the CRP induces producers to transition from conventional to organic agriculture upon exit from the program. The proposed mechanism through which this may occur is a result of the National Organic Program's (NOP) standards for organic certification, which require that prohibited substances, included synthetic fertilizers and pesticides, not be applied to land used to produce organic products for three years prior to when the product can be marketed and sold as organic. The CRP can reduce some of the costs of transitioning to organic production by eliminating this costly three-year transitional period as land exiting the CRP typically complies with the NOP's organic certification standards. Results from our empirical investigation suggest that that CRP participation does encourage producers to transition from conventional to organic agriculture.

We use a weighted least squares model to exploit exogeneity in CRP contract expirations to estimate the impact that expiring CRP contracts have on new organic certifications. We find that a 10 percent increase in expiring CRP contracts is associated with a 0.157 percent increase in the number of new certified organic operations. This effect is most significant for contracts enrolled in the continuous CRP, rather than the general sign-up, with an 10 percent increase in expiring continuous CRP contracts leading to a 0.138 percent increase in organic operations. Furthermore, this effect is greatest in the western region of the country where a 10 percent increase in expiring contracts is associated with a 0.346 percent increase in certified operations. These results are consistent and robust to a variety of specifications (included in Appendix A) and indicate that there exists a transition pathway to organic agriculture through CRP participation that producers have recognized and exploited.

The foremost take-away from this study is that temporary land retirement programs, such as the CRP, can promote transition from conventional to organic production. Past literature has cited the organic transition process as a barrier to organic certification through theoretical modelling, but we are the first to test if eliminating some of that barrier results in more certification. In addition, while previous work has studied land-use upon exit from the CRP in terms of general production patterns, with some limited focus on conservation practices in particular, we provide analysis specifically related to organic production.

Although our analysis presents evidence on the impact of reducing transition costs on organic certification through the lens of the CRP, there are several important questions it does not address. First, its results do not necessarily translate to other land conservation programs, such as the Grasslands Reserve Program or various state and local programs, which have different management practices that may or may not allow for easier transition to organic production. Second, it does not address how reducing costs of organic transition through other avenues, such as incentives offered by the USDA Organic Certification Cost Share Program, impacts certification. Avenues for future work therefore include exploring how other reductions in the costs of organic transitioning promote certification. In addition, this study addresses the immediate consequence of expiring contracts, looking at two years past expiration. Research exploring if these decisions persist over time and rates of organic dis-adoption in the following years would shed additional light on this phenomenon.

The results of this study have profound implications as we look forward and consider the future of the Conservation Reserve Program, as well as the future of organic agriculture. First, land transitioning from the CRP back to organic, or any other type of crop production, means that the environmental benefits associated with the temporary retirement are short-lived. The extent to which the environmental benefits accrued during contract duration are off-set upon exit from the program are determined by the specific use of the land. Relative to returning to conventional crop production, organic production may be able to retain more of these environmental benefits through the reduced pollution from synthetic fertilizers and pesticides. However, due to lower yields associated with organic production, more land is required to produce the same volume of crops relative to conventional production. If additional land is brought into crop production to account for this, then the climate impact of organic production may be higher than conventional due to increased greenhouse gas emissions. In this way, the specific environmental benefits from the CRP retained upon return to crop production depend on the type of crop or other agricultural production, as well as the counterfactual scenario being compared.

Second, our findings suggest that the transition process to organic certification faced by producers can be a costly barrier, and easing these constraints can promote greater uptake of organic practices. Policymakers have made significant efforts to incentivize organic transition through a variety of new grants and other funding opportunities, while the CRP may have been overlooked as a means of accomplishing these same ends. As policymakers consider the future of the CRP as a tool for climate mitigation and improving overall environmental health and quality, they may also consider the potential consequence of increased organic adoption.

REFERENCES CITED

Angrist, J.D. and Jorn-Steffen Pischke. 2008. *Mostly Harmless Econometrics.* Princeton, NJ: Princeton University Press.

Abraha, Michael, Ilya Gelfand, Stephen K. Hamilton, Jiquan Chen, and G. Philip Robertson. 2019. "Carbon debt of field-scale conservation reserve program grasslands converted to annual and perennial bio-energy crops." *Environmental Research Letters* 14 024019. https://doi.org/10/1088/1748-9326/aafc10.

Badruddoza, Syed, Andrea C. Carlson, and Jill J. McCluskey. 2021. "Long-term dynamics of US organic milk, eggs, and yogurt premiums." *Agribusiness* 38: 45– 72. https://doi.org/10.1002/agr.21723.

Bigelow, Daniel, Robert Claassen, Daniel Hellerstein, Vince Breneman, Ryan Williams, and Chengxia You. 2020. *The Fate of Land in Expiring Conservation Reserve Program Contracts, 2013-16.* USDA ERS Economic Information Bulletin No. EIB 215.

California Certified Organic Farmers. 2022, *Frequently Asked Questions.* https://www.ccof.org/faqs.

Chouinard, Hayley H., Tobias Paterson, Philip R. Wandschneider, and Adrienne M. Ohler. 2008. "Will Farmers Trade Profits for Stewardship? Heterogeneous Motivations for Farm Practice Selection." *Land Economics* 84(1): 66-82. https://doi.org/10.3368/le.84.1.66.

Claassen, Roger, Eric N. Duquette, David J. Smith. 2018. "Additionality in U.S. Agricultural Conservation Programs." *Land Economics* 94(1): 19-35. https://doi: 10.3368/le.94.1.19.

Cranfield, John, Spencer Henson, and James Holliday. 2010. "The motives, benefits, and problems of conversion to organic production." *Agriculture and Human Values* 24: 291-306. https://doi.org/10.1007/s10460-009-9222-9.

Crowder, David W., and John P. Reganold. 2015. "Financial competitiveness of organic agriculture on a global scale." *Proceedings of the National Academy of Sciences* 112(24): 7611-7616. https://doi.org/10.1073/pnas.1423674112.

Delate, Kathleen, Cynthia A. Cambardella, Douglas L. Karlen. 2002. "Transition Strategies for Post-CRP Certified Organic Grain Production." *Crop Management* 1(1): 1-9. https://doi.org/10.1094/CM-2002-0828-01-RS.

Delate, Kathleen, Michael Duffy, Craig Chase, Ann Holste, Heather Friedrich, and Noreen Wantate. 2003. "An economic comparison of organic and conventional grain crops in a long-term agroecological research (LTAR) site in Iowa." *American Journal of*

Alternative Agriculture 18(2): 59-69. https://doi:10.1079/AJAA200235.

Delbridge, Timothy A., Carmen Fernholz, Robert P. King, William Lazarus. 2013. "A whole-farm profitability analysis of organic and conventional cropping systems." *Agricultural Systems* 122: 1-10. https://doi.org/10.1016/j.agsy.2013.07.007.

Delbridge, Timothy A. and Robert P. King. 2016. "Transitioning to Organic Crop Production: A Dynamic Programming Approach." *Journal of Agricultural and Resource Economics* 41(3): 481-498. https://www.jstor.org/stable/44131351.

Delbridge, Timothy A., Robert P. King, Gianna Short, and Kellee James. 2017. "Risk and Red Tape: Barriers to Organic Transition for U.S. Farmers." *Choices* 32(4) 1-10. https://www.jstor.org/stable/26487423.

de Ponti, Tomek. Bert Rijk, and Martin K. van Ittersum. 2012. "The crop yield gap between organic and conventional agriculture." *Agricultural Systems* 108: 1-9. https://doi.org/10.1016/j.agsy.2011.12.004.

Fleming, David A. 2010. "Slippage Effects of the Conservation Reserve Program: New Evidence from Satellite Imagery." *Presented at the Annual Meeting of the Agricultural and Applied Economics Association, Denver, CO.* https://10.22004/ag.econ.61394.

Froehlich, Anderson G., Andrea S.S.A. Melo, and Breno Sampaio. 2018. "Comparing the Profitability of Organic and Conventional Production in Family Farming: Empirical Evidence From Brazil." *Ecological Economics* 150: 307-314. https://doi.org/10.1016/j.ecolecon.2018.04.022.

Fuller, Kate Binzen, Joseph P. Janzen, B. Munkhnasan. 2021. "Farmland Rental Rates: Does Organic Certification Matter?" *Land Economics* 97(1): 80-106. https://doi:10.3368/wple.97.1.030119-0032R2.

Gelfand, Ilya, Terenxio Zenone, Poonam Jasrotia, Jiquan Chen, Stephen K. Hamilton, and G. Philip Robertson. 2011. "Carbon debt of Conservation Reserve Program (CRP) grasslands converted to bioenergy production." *Proceedings of the National Academy of Sciences* 108(33) 13864-13869. https://doi.org/10.1073/pnas.1017277108.

Goodwin, Barry K. and Vincent H. Smith. 2003. "An Ex Post Evaluation of the Conservation Reserve, Federal Crop Insurance, and Other Government Programs: Program Participation and Soil Erosion." *Journal of Agricultural and Resource Economics* 28(2): 201-216. https://www.jstor.org/stable/40987182.

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

doi:10.1017/S1068280500007085.

Hellerstein, Daniel M. 2017. “The US Conservation Reserve Program: The evolution of an enrollment mechanism.” *Land Use Policy* 63: 601-610.

Hendricks, Nathan P. 2018. “Potential Benefits from innovations to Reduce Heat and Water Stress in Agriculture.” *Journal of the Association of Environmental and Resource Economists* 5(3): 545-76. https://doi.org/10.1086/697305.

Hendricks, Nathan P. 2022. “Would farmers benefit from removing more land from production in the next farm bill? *Applied Economics Perspective and Policy* 1-19. https://doi.org/10.1002/aepp.13242.

Irwin, Scott. 2021. “Estimating Total Crop Acres in the U.S.” *farmdoc daily* (11):91. Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign. https://farmdocdaily.illinois.edu/2021/06/estimating-total-crop-acres-in-the-us.html

Jacobson, Sarah. 2014. “Temporal spillovers in land conservation.” *Journal of Economic Behavior and Organization* 107(A): 366-379. https://doi.org/10.1016/j.jebo.2014.04.013.

Johnson, Douglas H. and Michael D. Schwartz. 1993. “The Conservation Reserve Program an Gassland Birds.” *Conservation Biology* 7(4): 934-937. https://www.jstor.org/stable/2386828.

Jones, Carol Adaire, Cynthia J. Nickerson, and Paul W. Heisey. 2013. “New Uses of Old Tools? Greenhouse Gas Mitigation with Agriculture Sector Policies.” *Applied Economic Perspectives and Policy* 35(3): 398-434. https://doi.org/10.1093/aepp/ppt020.

Kallas, Zein, Teresa Serra, and José Maria Gil. 2010. “Farmers’ objectives as determinants of organic farming adoption: the case of Catalonian vineyard production.” *Agricultural Economics* 41: 409-423. https://doi.org/10.1111/j.1574-0862.2010.00454.x.

Karlen, D. L., M. J. Rosek, J. C. Gardner, D. L. Allan, M. J. Alms, D. F. Bexdicek, M. Flock, D. R. Huggins, B. S. Miller, and M. L. Staben. 1999 “Conservation Reserve Program effects on soil quality indicators.” *Journal of Soil and Water Conservation* 54(1): 439-444.

Keene, Clair, Hans Kandel, Ron Haugen, Dave Franzen, Janet Knodel, Zac Carlson, Kevin Sedivec, and Joe Ikley. *Bringing Land in the Conservation Reserve Program Back Into Crop Production or Grazing.* North Dakota State University Extension A1364.

Khaledi, Mohammad, Simon Weseen, Erin Sawyer, Shon Ferguson, and Richard Gray. 2010. "Factors Influencing Partial and Complete Adoption of Organic Farming Practices in Saskatchewan, Canada." *Canadian Journal of Agricultural Economics* 58(1): 37-56. https://doi.org/10.1111/j.1744-7976.2009.01172.x.

Krause, Josef, and Ondřej Machek. 2018. "A comparative analysis of organic and conventional farmers in the Czech Republic." *Agricultural Economics* 64: 1-8. https://doi.org/10.17221/161/2016-AGRICECON.

Kuminoff, Nicolai V. and Ada Wossink. 2010. "Why Isn't More US Farmland Organic?" *Journal of Agricultural Economics* 61(2): 240-258. https://doi.org/10.1111/j.1477-9552.2009.00235.x.

Langemeier, Michael. 2021. "Conventional and Organic Enterprise Net Returns." *farmdoc daily* 11: 140. Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign.

Li, Chenhui, Lisa M. Fultz, Jennifer Moore-Kucera, Veronica Acosta-Martínez, Juske Horita, Richard Strauss, John Zak, Francisco Calderón, and David Weindorf. 2017. "Soil carbon sequestration potential in semi-arid grasslands in the Conservation Reserve Program." *Geoderma* 294: 80-90. https://doi.org/10.1016/j.geoderma.2017.01.032.

Lin, Haixia, and JunJie Wu. 2010. "The Effect of the Conservation Reserve Program on Land Values." *Land Economics* 86(1): 1-21. doi: 10.3368/le.86.1.1.

Lubowski, Ruben N., Shawn Bucholtz, Roger Claassen, Michael J. Roberts, Joseph C. Cooper, Anna Gueorguieva, and Robert C. Johansson. 2006. *Environmental Effects of Agricultural Land-Use Change: The Role of Economics and Policy.* USDA ERS Economic Research Report No 25.

McBride, William D. and Catherine Greene. 2009. "The profitability of organic soybean production." *Renewable Agriculture and Food Systems* 24(4): 276-284. doi:10.1017/S1742170509990147.

McBride, William D., Catherine Greene, Linda Foreman, and Mir Ali. 2015. *The Profit Potential of Certified Organic Field Crop Production.* USDA ERS Economic Research Report No. 188.

McCoy, Timothy D. Mark R. Ryan, Eric W. Kurzejeski, and Loren W. Burger, Jr. 1999. "Conservation Reserve Program: Source or Sink Habitat for Grassland Birds in Missouri?" *The Journal of Wildlife Management* 63(2): 530-538. https://doi.org/10.2307/3802639.

Miao, Ruiqing, Hongli Fend, David A. Hennessy, and Xiaodong Du. 2016. "Assessing Cost-effectiveness of the Conservation Reserve Program (CRP) and Interaction between the CRP and Crop Insurance." *Land Economics* 92(4): 593-617. doi: 10.3368/le.92.4.593.

Morefield, Philip E., Stephen D. LeDuc, Christopher M. Clark, and Richard 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. https://doi.org/10.1088/1748/9326/11/9/094005.

National Grain and Feed Association. 2017. "USDA offers early termination policy for CRP." *Agriculture Policy, Newsletter.* https://www.ngfa.org/newsletter/usda-offers-early-termination-policy-crp/

Peterson, Hikaru Hanawa, Andrew Barkley, Adriana Chacón-Cascante, and Terry L. Kastens. 2012. "The Motivation for Organic Grain Farming in the United States: Profits, Lifestyle, or the Environment?" *Journal of Agricultural and Applied Economics* 44(2): 137-155. https://doi.org/10.1017/S1074070800000237.

Oberholtzer, Lydia, Carolyn Dimitri, and Catherine Greene. 2005. *Price Premiums Hold on as U.S. Organic Produce Market Expands.* USDA ERS Electronic Outlook Report No. VGS-308-01.

Quinlan, Gabriela M., Meghan O. Milbrath, Clint R. V. Otto, and Rufus Isaacs. 2021. "Farmland in the U.S. Conservation Reserve Program has unique floral composition that promotes bee summer foraging." *Basic and Applied Ecology* 56: 358-368. https://doi.org/10.1016/j.baae.2021.08.011.

Roberts, Michael J., Shawn Bucholz. 2006. "Slippage in the Conservation Reserve Program or Spurious Correlation? A Rejoinder." *American Journal of Agricultural Economics* 88(2): 512-514. https://doi.org/10.1111/j.1467-8276.2006.00875.x.

Roberts, Michael J. and Ruben N. Lubowski. 2007. "Enduring Impacts of Land Retirement Policies: Evidence from the Conservation Reserve Program." *Land Economics* 83(4): 516-538. doi: 10.3368/le.83.4.516.

Seufert, Verena, Navid Ramankutty, and Jonathan A. Foley. 2012. "Comparing the yields of organic and conventional agriculture." *Nature* 485: 229-232. https://doi.org/10.1038/nature11069.

Trujillo-Barrera, Andres, Joost M. E. Pennings, and Dianne Hofenk. 2016. "Understanding producers' motives for adopting sustainable practices: the role of expected rewards, risk perception and risk tolerance." *European Review of Agicultural Economics* 43(3):

359-382. https://doi.org/10.1093/erae/jbv038.

Uematsu, Hiroki and Ashok K. Mishra. 2012. "Organic farmers or conventional farmers: Where's the money?" *Ecological Economics* 78: 55-62. https://doi.org/10.1016/j.ecolecon.2012.03.013.

USDA Economic Research Service. 2000. *Farm Resource Regions.* USDA ERS Agricultural Information Bulletin No. 760. https://www.ers.usda.gov/webdocs/publications/42298/ $32489_a ib - 760_0 02.pdf$.

USDA Farm Service Agency. 2003. "CRP Associated Conservation Practices." *FSA Conservation Reserve Program Final Programmatic Environmental Impact Statement.* https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/Environ-Cultural/ appendixb.pdf.

USDA Sustainable Agriculture Research and Education. 2007. "Transitioning to Organic Production." https://www.sare.org/wp-content/uploads/Transitioning-to-Organic-Production.pdf.

USDA Agricultural Marketing Service. 2011. "Organic Production and Handling Standards." https://www.ams.usda.gov/sites/default/files/media/Organic%20Production-Handling%20Standards.pdf.

USDA Agricultural Marketing Service. 2012. "Guide for Organic Crop Producers." https://www.ams.usda.gov/sites/default/files/media/CropProducersGuide.pdf.

USDA Agricultural Marketing Service. 2018. "What's Behind the Organic Seal? Organic Labels Explained" https://www.ams.usda.gov/publications/content/whats-behind-organic-seal-organic-labels-explained.

USDA Farm Service Agency. 2020. "The Conservation Reserve Program: A 35-Year History." https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/Conservation/ PDF/$35_Y EARS_C RP_B.pdf$.

USDA Farm Service Agency. 2021a. "USDA Accepts More than 2.5 Million Acres in Grassland CRP Signup, Double Last Year's Signup." https://www.fsa.usda.gov/news-room/news-releases/2021/usda-accepts-more-than-2-5-million-acres-in-grassland-crp-signup-double-last-years-signup.

USDA Farm Service Agency. 2021b. "Conservation Reserve Program – Continuous Enrollment Period." *Fact Sheet June 2021.* https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/FactSheets/crp-continuous-enrollment-period-factsheet.pdf.

USDA Agricultural Marketing Service. 2021c. *Organic Integrity Database.* https://organic.ams.usda.gov/integrity/default.aspx.

USDA Farm Service Agency. 2022. *CRP Practices Library.* https://www.fsa.usda.gov/programs-and-services/conservation-programs/crp-practices-library/index.

USDA National Institute of Food and Agriculture. 2022b. *Organic Agriculture Program.* https://nifa.usda.gov/grants/programs/organic-agriculture-program.

Veldstra, Michael D., Corinne E. Alexander, Maria I. Marshall. 2014. "To certify or not to certify? Separating the organic production and certification decisions." *Food Policy* 49(2): 429-436. https://doi.org/10.1016/j.foodpol.2014.05.010.

Wu, Junjie. 2000. "Slippage Effects of the Conservation Reserve Program." *American Journal of Agricultural Economics* 82(4): 979-992. https://doi.org/10.1111/0002-9092.00096.

Yin, Dameng, Le Wang, Zhenduo Zhu, Susan Spierre Clark, Ying Cao, Jordan Besek, Ning Dai. 2021. "Water quality related to Conservation Reserve Program (CRP) and cropland areas: Evidence from multi-temporal remote sensing." *International Journal of Applied Earth Observation and Geoinformation* 96: 102272. https://doi.org/10.1016/j.jag.2020.102272.

APPENDICES

APPENDIX A

ADDITIONAL REGRESSION RESULTS

Table A.1: Effect of Expiring CRP Acres on New Certified Organic Operations

	(1)	(2)
Expiring Acres Lag 1	0.0391	0.0534**
	(0.0240)	(0.0261)
Expiring Acres Lag 2	0.0194	0.0155
	(0.0278)	(0.0320)
Cumulative Effect	*0.0584*	*0.0689*
	(0.0399)	*(0.0477)*
County FE	YES	YES
Year FE	YES	YES
State time trend	YES	YES
Weights	NO	YES
Observations	30,620	30,620
Number of counties	3,062	3,062
R-squared	0.118	0.155

*** p<0.01, ** p<0.05, * p<0.1

Notes: The above table shows the results from regressions with the dependent variable being the IHS of new certified organic operations and the independent variables being the IHS of lagged values of thousands of expiring CRP acres. 30,620 observations come from 3,620 counties over 10 years. Standard errors, adjusted for clustering at the agricultural statistic district level, are in parenthesis. All variables from NASS included as controls enter the model using their base 2007 values interacted with a linear time trend. Where indicated, regressions are weighted by cropland acres in 2007 at the county level.

Table A.2: Effect of Expiring CRP Contracts on Cumulative Number of Certified Organic Operations: Model Progression

	(1)	(2)	(3)	(4)
Expiring Contracts Lag 1	0.0163	0.0053**	0.0014	0.0034
	(0.0148)	(0.0025)	(0.0024)	(0.0030)
Expiring Contracts Lag 2	0.0422**	0.0101***	0.0072***	0.0066**
	(0.0164)	(0.0025)	(0.0023)	(0.0025)
Cumulative Effect	*0.0584**	*0.0154****	*0.0086***	*0.0100***
	(0.0299)	(0.0046)	(0.0043)	(0.0048)
County FE	NO	YES	YES	YES
Year FE	NO	YES	YES	YES
State time trend	NO	NO	YES	YES
Weights	NO	NO	NO	YES
Observations	29,950	29,950	29,950	29,950
Number of counties	2,995	2,995	2,995	2,995
R-squared	0.005	0.175	0.218	0.292

*** p<0.01, ** p<0.05, * p<0.1

Notes: The above table shows the results from regressions with the dependent variable being the IHS of the cumulative number of certified organic operations and the independent variables being the IHS of lagged CRP contracts. 29,950 observations come from 2,995 counties over 10 years. 211 county-year observations had a value for the cumulative number of organic crop operations less than zero, so 67 counties were dropped from this analysis. Standard errors, adjusted for clustering at the agricultural statistic district level, are in parenthesis. No additional controls beyond the indicated fixed effect enter into these models. Where indicated, regressions are weighted by cropland acres in 2007 at the county level.

Table A.3: Effect of Expiring CRP Contracts on Cumulative Number of Certified Organic Operations

	(1)	(2)
Expiring Contracts Lag 1	0.0019	0.0024
	(0.0028)	(0.0028)
Expiring Contracts Lag 2	0.0049*	0.0049*
	(0.0025)	(0.0026)
Cumulative Effect	*0.0067*	*0.0072*
	(0.0046)	*(0.0047)*
County FE	YES	YES
Year FE	YES	YES
State time trend	YES	YES
Weights	YES	YES
Observations	29,950	29,950
Number of counties	2,995	2,995
R-squared	0.324	0.329

*** p<0.01, ** p<0.05, * p<0.1

Notes: The above table shows the results from regressions with the dependent variable being the IHS of the cumulative number of certified organic operations and the independent variables being the IHS of lagged CRP contracts. 29,950 observations come from 2,995 counties over 10 years. 211 county-year observations had a value for the cumulative number of organic crop operations less than zero, so 67 counties were dropped from this analysis. Standard errors, adjusted for clustering at the agricultural statistic district level, are in parenthesis. In column (1), all variables from NASS included as controls enter the model using their base 2007 values interacted with a linear time trend. In column (2), all variables from NASS included as controls enter the model using their base 2007 values interacted with year dummy variables. Where indicated, regressions are weighted by cropland acres in 2007 at the county level.

Table A.4: Effect of Expiring CRP Contracts on New Certified Organic Operations: Poisson Regression

	(1)	(2)
Expiring Contracts Lag 1	0.0586***	0.0000
	(0.0183)	(0.0000)
Expiring Contracts Lag 2	0.0698***	-0.0001**
	(0.0168)	(0.0000)
Cumulative Effect	*0.1284**	*-0.0001**
	(0.0259)	*(0.0001)*
County FE	YES	YES
Year FE	YES	YES
State time trend	YES	YES
Weights	NO	YES
Observations	29,570	29,570
Number of counties	2,957	2,957

*** p<0.01, ** p<0.05, * p<0.1

Notes: The above table shows the results from Poisson regressions with the dependent variable being the number of new certified organic operations and the independent variables being the IHS of lagged CRP contracts. 29,575 observations come from 2,957 counties over 10 years. 105 counties were dropped for having all zero dependent variable values. Standard errors, adjusted for clustering at the agricultural statistic district level, are in parenthesis. All variables from NASS included as controls enter the model using their base 2007 values interacted with a linear time trend. Where indicated, regressions are weighted by cropland acres in 2007 at the county level. However, due to limitations of the weighted Poisson regression, these estimates should be examined with a high degree of caution.

Table A.5: Effect of Expiring CRP Contracts on New Certified Organic Operations: Limited Sample

	(1)	(2)
Expiring Contracts Lag 1	0.0136**	0.0124*
	(0.0063)	(0.0069)
Expiring Contracts Lag 2	0.0052	0.0069
	(0.0083)	(0.0081)
Cumulative Effect	*0.0187***	*0.0193***
	(0.0075)	*(0.0084)*
County FE	YES	YES
Year FE	YES	YES
State time trend	YES	YES
Weights	YES	YES
Observations	21,560	21,560
R-squared	0.145	0.172
Number of counties	2,156	2,156

*** p<0.01, ** p<0.05, * p<0.1

Notes: The above table shows the results from regressions with the dependent variable being the IHS of new certified organic operations and the independent variables being the IHS of lagged CRP contracts. 21,560 observations come from 2,156 counties over 10 years. All counties that do not have any organic certifications prior to 2007 are not included in this sample. Standard errors, adjusted for clustering at the agricultural statistic district level, are in parenthesis. In column (1), all variables from NASS included as controls enter the model using their base 2007 values interacted with a linear time trend. In column (2), all variables from NASS included as controls enter the model using their base 2007 values interacted with year dummy variables. Where indicated, regressions are weighted by cropland acres in 2007 at the county level.

Table A.6: Effect of Expiring CRP Contracts on New Certified Organic Operations: Farm Resource Regions Heterogeneity

	(1)	(2)
Expiring Contracts Lag 1	0.0044	0.0067
	(0.0049)	(0.0065)
Lag 1 * Heartland	0.0085	0.0241**
	(0.0089)	(0.0111)
Lag 1 * Northern Crescent	0.0017	-0.0082
	(0.0122)	(0.0118)
Lag 1 * Eastern Upland	-0.0015	0.0054
	(0.0106)	(0.0129)
Lag 1 * Southern Seaboard	-0.0044	0.0007
	(0.0062)	(0.0091)
Lag 1 * Fruitful Rim	-0.0100	0.0013
	(0.0122)	(0.0229)
Lag 1 * Basin and Range	-0.0106	-0.0172
	(0.0153)	(0.0172)
Lag 1 * Mississippi Portal	-0.0117	-0.0093
	(0.0077)	(0.0096)
Expiring Contracts Lag 2	0.0012	0.0022
	(0.0066)	(0.0100)
Lag 2 * Heartland	0.0101	0.0114
	(0.0114)	(0.0146)
Lag 2 * Northern Crescent	0.0080	0.0164
	(0.0155)	(0.0189)
Lag 2 * Eastern Upland	0.0130	0.0110
	(0.0091)	(0.0128)
Lag 2 * Southern Seaboard	0.0018	0.0055
	(0.0083)	(0.0122)
Lag 2 * Fruitful Rim	0.0035	0.0286
	(0.0156)	(0.0227)
Lag 2 * Basin and Range	-0.0289	-0.0220
	(0.0191)	(0.0254)
Lag 2 * Mississippi Portal	0.0005	-0.0001
	(0.0086)	(0.0112)
County FE	YES	YES
Year FE	YES	YES
State time trend	YES	YES
Weights	NO	YES

Table A.6 Continued

Observations	30,620	30,620
Number of counties	3,062	3,062
R-squared	0.118	0.155

*** p<0.01, ** p<0.05, * p<0.1

Notes: The above table shows the results from regressions with the dependent variable being the IHS of new certified organic operations and the independent variables being the IHS of lagged CRP contracts. 30,620 observations come from 3,062 counties over 10 years. Regional indicator variables are interacted with the number of expiring CRP contracts to generate our independent variables of interest. Standard errors, adjusted for clustering at the agricultural statistic district level, are in parenthesis. All variables from NASS included as controls enter the model using their base 2007 values interacted with year dummy variables. Where indicated, regressions are weighted by cropland acres in 2007 at the county level.

APPENDIX B

ADDITIONAL TABLES AND FIGURES

Table B.1: CRP Practices

Category	Practice Code	Description
Grass	CP1	Establishment of permanent introduced grasses & legumes
	CP2	Establishment of permanent native grasses
	CP7	Erosion control structure
	CP8	Grassed waterways
	CP8A	Grassed waterways – Non Easement
	CP10	Vegetative cover, grass already established
	CP13A	Vegetative filter strips (grass)
	CP13C	Vegetative filter strips (grass) – Non Easement
	CP15	Establishment of permanent vegetative cover (contour grass strips)
	CP15B	Establishment per vegetative cover (cont grass strips), terraces
	CP18	Establishment of perm vegetative to reduce salinity
	CP18A	Establishment of perm salt tolerant vegetative cover
	CP18B	Establishment of perm vegetative to reduce salinity – Non Easement
	CP18C	Establishment of perm salt tolerant vegetative cover – Non Easement
	CP24	Crosswind trap strips
	CP38E	State Acres for Wildlife Enhancement – Grass
	CP87	Permanent Introduced Grasses and Legumes
	CP87A	Permanent Introduced Grasses and Legumes - Livestock
	CP88	Permanent Native Grasses, Forbes, or Legumes
	CP88A	Permanent Native Grases, Forbes, or Legumes - Livestock
	CP3	Tree planting
	CP3A	Hardwood tree planting
	CP5	Field wind break establishment
	CP5A	Field wind break establishment – Non Easement
	CP5C	Field wind break establishment – Non Easement
	CP5N	Field wind break establishment – Non Easement
	CP11	Vegetative cover, trees already established

Continued on next page

Table B.1 – continued from previous page

Category	Practice Code	Description
	CP13B	Vegetative filter strips (trees)
	CP13D	Vegetative filter strips trees) – Non Easement
	CP14	Bottomland timber establish on wetlands
	CP14C	Bottomland timber establish on wetlands
	CP14N	Bottomland timber establish on wetlands
	CP16	Shelterbelt establishment
	CP16A	Shelterbelt establishment – Non Easement
	CP17	Living snow fence
	CP17A	Living snow fence – Non Easement
Trees	CP19	Alley cropping
	CP32	Expired CRP Hardwood Tree Planting on Marginal Pastureland
	CP35A	Emergency Forestry-Longleaf Pine-New
	CP35B	Emergency Forestry-Longleaf Pine-Existing
	CP35C	Emergency Forestry-Bottomland Hardwood-New
	CP35D	Emergency Forestry-Bottomland Hardwood-Existing
	CP35E	Emergency Forestry-Softwood-New
	CP35F	Emergency Forestry-Softwood-Existing
	CP35G	Emergency Forestry-Upland Hardwood-New
	CP35H	Emergency Forestry-Upland Hardwood-Existing
	CP35I	Emergency Forestry-Mixed Trees-Existing
	CP35J	Emergency Forestry-Lump Sum Rental
	CP36	Continuous longleaf pine
	CP38C	State Acres for Wildlife Enhancement – Trees
	CP38D	State Acres for Wildlife Enhancement – Longleaf Pine
	CP4	Permanent wildlife habitat
	CP4A	Permanent wildlife habitat, corridors
	CP4B	Permanent wildlife habitat, corridors – Non Easement
	CP4C	Permanent wildlife habitat

Continued on next page

Table B.1 – continued from previous page

Category	Practice Code	Description
Wildlife	CP4D	Permanent wildlife habitat – Non Easement
	CP4N	Permanent wildlife habitat
	CP12	Wildlife food plot
	CP25	Rare and declining habitat
	CP29	Marginal pastureland wildlife habitat buffer
	CP33	Habitat Buffer For Upland Birds
	CP37	Duck nesting habitat
	CP38	State Acres for Wildlife
	CP42	Pollinator Habitat
Wetlands	CP9	Shallow water areas for wildlife
	CP9C	Shallow water areas for wildlife
	CP9N	Shallow water areas for wildlife
	CP21	Filter strips
	CP21B	Denitrifying Bioreactor on Riparian Buffers
	CP21S	Saturated Filter Strips
	CP22	Riparian buffers
	CP22B	Denitrifying Bioreactor on Riparian Buffers
	CP22S	Saturated Riparian Buffers
	CP23	Wetland restoration
	CP23A	Wetland Restoration, Non-Flood Plain
	CP27	Farmable wetlands pilot wetland
	CP28	Farmable wetlands pilot buffer
	CP30	Marginal pastureland wetland buffer
	CP31	Bottomland hardwood establishment on wetlands
	CP38B	State Acres for Wildlife Enhancement – Wetlands
	CP39	FWP Constructed Wetland
	CP40	FWP Aquaculture Wetland Restoration

Continued on next page

Table B.1 – continued from previous page

Category	**Practice Code**	**Description**
	CP41	FWP Flooded Prairie Wetland
Other	CP6	Diversions
	CP13	Filter strips
	CP20	Alternate perennial
	CP26	Sediment retention control structure
	CP34	Flood Control System
	CP38A	State Acres for Wildlife Enhancement – Buffers

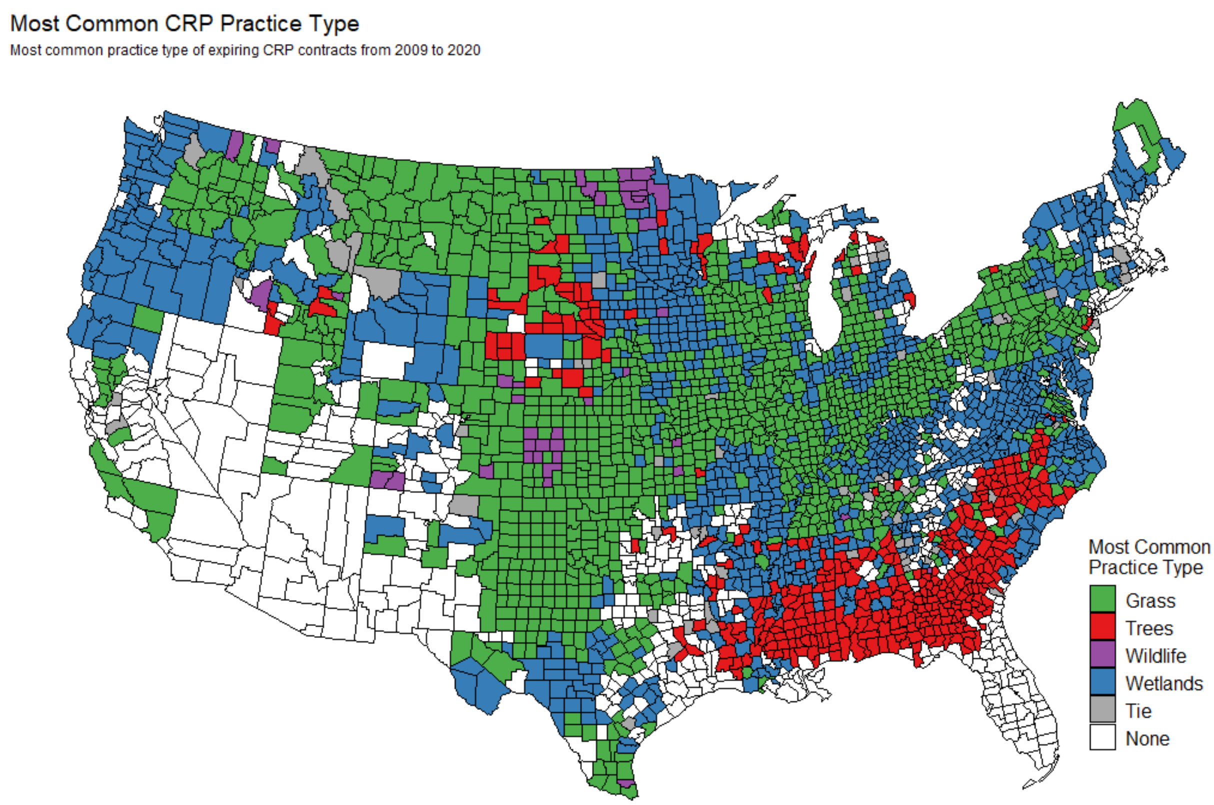

Figure B.1: CRP Practice Type by County

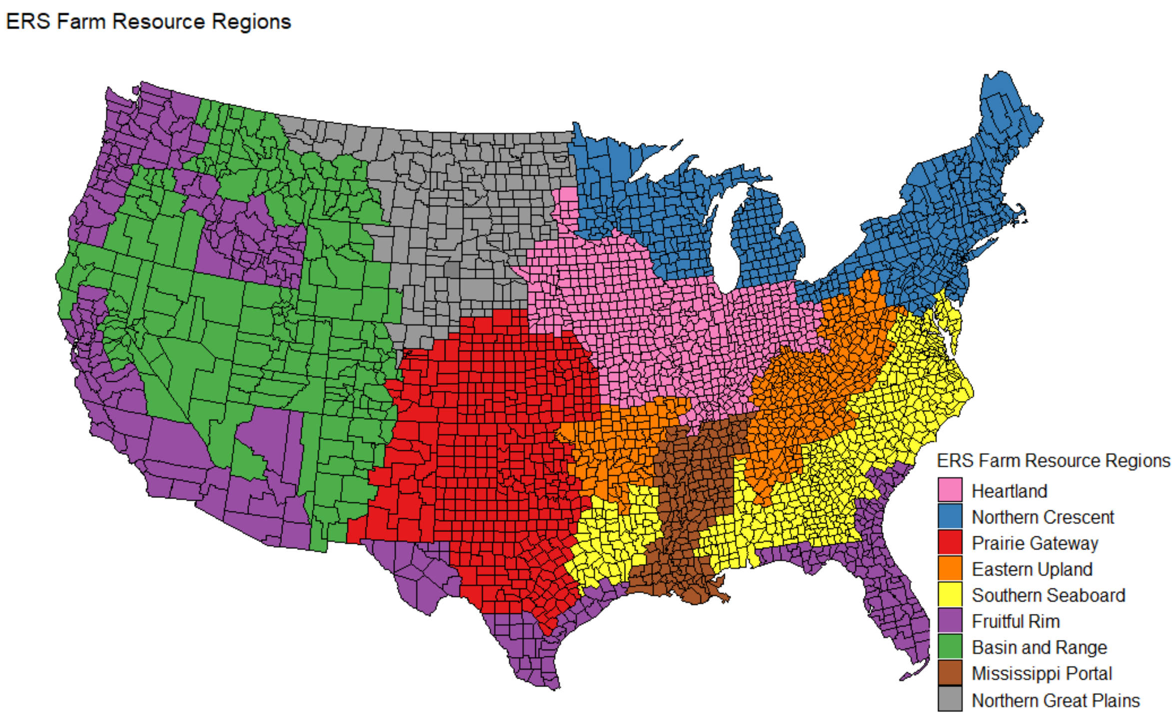

Figure B.2: ERS Farm Resource Regions