Estimating the Effect of Easements on Agricultural Production

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1 Introduction

Our agricultural systems and food production are heavily dependent on temperature, rainfall, and weather extremes. Many US crops are likely to see declines as growing season temperatures rise and destructive disasters become more commonplace (IPCC, 2012; NOAA, 2020). Studies show lower crop yields and higher losses attributed to a changing climate (Schlenker & Roberts, 2009b; Deschênes & Greenstone, 2012; Rosenzweig et al., 2014; Perry et al., 2020).

There is also a burgeoning literature on how producers adapt to manage the heightened agronomic yield risk. Adaptation is the process of adjustment by people to climate impact and risk in order to moderate harm or exploit beneficial opportunities (IPCC, 2014). Burke and Emerick (2016) find evidence suggesting that long-run adaptation has been limited and insignificant. However, more recent work suggests that panel models may not be reflective of climate adaptation in the long-term and alternate specifications do find evidence of long-run climate adaptation for crop yields (Mérel & Gammans, 2021). Other researchers take a different approach and instead focus on the effects of specific adaptation measures; there is evidence that various adaptation practices can be effective at increasing resiliency. Producers can manage risk through insurance (Annan & Schlenker, 2015), technology (Goodwin & Piggott, 2020), planting date adjustments (Zipper et al., 2016; Kucharik, 2008), cultivar selection (Hagerty, 2021; Sloat et al., 2020), irrigation (Hornbeck & Keskin, 2014; Taylor, 2021), and conservation practices (Schulte et al., 2017; Fleckenstein et al., 2020).

One potential conservation-related adaptation strategy is to withdraw frequently inundated cropland from production and restore it to its original condition. The Natural Resources Conservation Services (NRCS) of the United States Department of Agriculture (USDA) offers voluntary buyouts through the Emergency Watershed Protection Program (floodplain easements) and Wetlands Reserve Program (wetland easements). An easement contract restores the land to its natural floodplain state or enhances its wetland functions. The farmer retains ownership of the land and receives a lump-sum transfer to forgo the right to plant crops on

that field permanently. Floodplains and wetlands have the potential to serve as flood protection by storing water and acting as natural buffers. These easement programs eliminate the moral hazard associated with farmers planting on marginal fields, decrease crop insurance subsidies for taxpayers, and offer other ecological advantages.

According to the Census of Agriculture, approximately 40% land in the United States is used for agricultural purposes. NRCS floodplain and easements on the other hand, make up 0.01% of the land in the US. From 2002-2020, the NRCS spent $4.9 billion and $690 million USD on the floodplain and wetland programs respectively[1]. Although the acreage of land under easement seems minimal, easement effects are quantifiable and significant. These easement programs eliminate the moral hazard associated with farmers planting on marginal fields, decrease crop insurance spending for taxpayers, and offer other ecological advantages, such as improving yields on neighboring cropland.

A predominant vein of the conservation literature examines easement value by studying the land value impacts, foregone agricultural profits, and opportunity costs. Many studies on wetland easements and conservation efforts focus on measuring the impact of easements on land sales prices (R. J. Brown, 1976; Kousky & Walls, 2014; Lawley & Towe, 2014; Nickerson & Lynch, 2001; Shoemaker, 1989; Shultz & Taff, 2004). This line of research consistently estimates a land discount on eased land that in most cases adequately captures the foregone agricultural profits. A complementary literature uses auction modeling techniques to estimate the reservation value of retiring land from agricultural production (Boxall et al., 2017; L. K. Brown et al., 2011; Ferraro, 2008; Hellerstein et al., 2015; Kirwan et al., 2005; Narloch et al., 2013). There has been a wealth of literature focused on comparing the costs and benefits of conservation efforts. The cost benefit papers have been focused on identifying the optimal parcels and best targeting strategies to meet desired conservation goals (Costello & Polasky, 2004; Fleming et al., 2018; Gelso et al., 2008; Heimlich, 1994; Newburn et al., 2006; Wu et al., 2001). Some researchers quantify benefits by estimating how additional wetland and floodplain acreage impact property damages from flooding (Taylor & Druckenmiller, 2021; Gourevitch et al., 2020; Watson et al., 2016). Despite the wealth of studies on the impacts of easement and conservation programs, there is a gap in our understanding of the externalities of these easement programs on agricultural outcomes. Quantifying the effect of easements on agricultural systems can have ripple effects on land value estimates, conservation cost-benefit analyses, and targeting strategies for policymakers.

This research explores how easements impact agricultural systems at the county-level. Specifically, I ask: 1. Do easements increase county-level average yields? 2. Do easements decrease county-level yield risk? 3. What are the mechanisms through which easements impact agricultural production? I posit that easements impact agricultural production in two ways: 1) directly by reducing planting, prevented planting, and failed planting on marginal land, and 2) indirectly by acting as buffers that increase yields and decrease risk on

[1] https://www.nrcs.usda.gov

agricultural parcels within the watershed.

I pair a national easement database with county-level USDA data from the Risk Management Agency (RMA), Farm Service Agency (FSA), and National Agricultural Statistics Services (NASS) to build a panel of data from 1989-2020. I limit my focus to 1,700 counties east of the 100th meridian to focus on rainfed and non-irrigated counties. The main commodities focused on in this study include corn, soybeans, and wheat. The observations in my sample size range from 35,000 to 50,000 depending on the commodity and outcome variable of interest.

The NRCS houses a database on all completed easements. In 2020, there were approximately 3 million acres of eased wetlands and 185,000 acres of floodplain easements in the US. The Risk Management Agency (RMA) Cause of Loss Data and Summary of Business data provide details on agricultural insurance and risk. Crop yield and acreage stock data stem from the National Agricultural Statistics Services (NASS). The Farm Service Agency (FSA) has data on acres prevented planted and failed. Finally, PRISM data source the weather controls such as precipitation, temperature, and degree days.

I use a panel model with two-way fixed effects (TWFE) to estimate how easements impact agricultural production. I identify how an additional acre of easement (normalized by land area) impacts crop yields (bushels/acre), loss-cost ratios (the proportion of indemnities to liabilities), and loss ratios (the proportion of indemnities to premiums). I take the inverse hyperbolic sine of my independent and dependent variables to better understand the elasticity response. The parameters are identified from county-specific changes in easement enrollment after adjusting for trends common to all counties. My identifying assumption is that treatment (easement enrollment) is random conditional on county and year trends.

I also aim to identify the potential channels through which easements impact agricultural outcomes. I investigate the loss cost ratios and loss ratios for specific causes of loss to evaluate the channels that see reduced losses. I estimate the effect of easements on acres prevented planted, acres failed, and acres failed to harvest to understand the underlying mechanisms. I also interact the number of easement acres with measures of precipitation and temperature to understand the weather pathways through which easements provide adaptive benefits. Finally, I explore the heterogeneity of effects by asking whether floodplains or wetlands are more effective at reducing agricultural risk.

In the first set of preliminary results, I find evidence that easements, especially wetland easements, increase agricultural yields and reduce agricultural risk. I find that a 1% increase in land under wetland easement increases county yields by 2.11%, 4.75%, and 2.84% for corn, soybeans and wheat. I also find that easements have a negative and significant impact on the loss cost ratio and loss ratio for soybeans–especially when considering losses due to excess moisture.

These improved agricultural outcomes are due to a decrease in acres planted, prevented planted, and failed.

Producers decrease planting on marginal land. This leads to less incidences of prevented planting and failed planting. This captures the direct effects of easements. To understand the indirect effect, I estimate how an additional parcel that was not previously cropland impacts the agricultural outcomes when put under easements. There are cases that the indirect effect of easements on neighboring parcels outweigh the direct effect of mechanically removing marginal cropland from the systems.

It is worth noting the limitations of using a panel model with two-way fixed effects. Many issues with this methodology have recently been brought to the forefront of the econometric literature (Goodman-Bacon, 2021; Callaway & Sant'Anna, 2021, 2020; De Chaisemartin, D'haultfoeuille, & Haultfoeuille, 2019). As of now, dealing with the cases of staggered and continuous treatment is still being investigated. I hope to update my results when a better understanding of how to do so is reached.

The major contribution of this paper is a thorough policy analysis of an understudied program. This paper documents the externalities of the easement programs on agricultural systems. It adds to the literature on the relationship between agricultural systems and climate change. I provide evidence that these conservation policies allow farmers to adapt in ways that have a concrete and meaningful impact on the resilience of our agricultural systems. Second, this paper also complements the ecosystem benefits literature that quantifies the impact of conservation and different habitats. My paper provides an economic estimate of some of the non-market values that wetlands and floodplains provide. My work adds to our understanding of the adaptation benefits of easements in an agricultural setting. This can have policy implications on the future funding and targeting strategies of the NRCS easement programs.

The remainder of the paper proceeds as follows: Section 2 provides a background on the relationship between climate and agriculture, as well as the role of insurance and easements. Section 3 and 4 present the data and empirical models respectively. Section 5 covers empirical results and discusses their implications.

2 Background

How does climate/weather impact crop production?

There is a large body of knowledge explaining how weather patterns impact crop production. The focus usually stems on occurrences of extreme temperature. There is less of an emphasis on how excess moisture impacts agricultural production. I focus on excess moisture and precipitation in this paper since there exists evidence suggesting that wetlands and floodplains reduce indemnities related to excess moisture.

Extreme precipitation is projected to be more frequent across the United States and cause additional disruption in agricultural production through flooding, which in turn leads to soil erosion and nutrient removal.

Flooding impacts agriculture by delaying or preventing planting, damaging standing crops, and carrying away topsoil and nutrients. When flooding occurs during planting season in the spring, farmers may be delayed or prevented from planting since their machines are unable to work on the inundated soil. Farmers may need to switch to a seed variety with a shorter season and lower yields or be unable to plant anything at all. Flooding in the early season is costly to farmers since they are unable to plant at the optimal time and will most likely see reduced yield and profit for that season. Flooding and excess rain/moisture can also be harmful later in the season when the crops are growing. If there is an abundance of water, flooding can destroy crops by washing them away, decreasing oxygen intake and respiration, building up toxic compounds in the soil, inhibiting plant growth, and making plants prone to disease, insects, or mold. This type of flood damage increase uncertainty, and reduces farmer yields and profits. Flooding can also have more long-term impacts by reducing the soil quality over time by draining nutrients out of the soil or washing away the top soil altogether.

How do floodplains and wetlands impact the land?

Wetlands and floodplains—both natural and manmade—are associated with many ecological and hydrological benefits that have been studied by economists, ecologists, hydrologists, and conservationists. Floodplains and wetlands have the potential to serve as flood protection by storing water and acting as natural buffers in the event of extreme flooding. Wetlands reduce damage from floods by lowering flood heights and reducing the water's destructive potential (Gleason et al., 2008). Restored floodplains and wetlands are also associated with improved water quality, ground water reservoir replacement vital for irrigation systems, carbon sequestration, reduced greenhouse gases, and wildlife habitat (Bostian & Herlihy, 2014; De Steven & Lowrance, 2011; Roley et al., 2016; Sonnier et al., 2018; Speir et al., 2020).

Wetlands serve a role in improving watershed health, adding to the vitality of agricultural land, and enhancing the aesthetic value of the surrounding community (NRCS, 2012). There have been a few studies of NRCS wetland restoration projects, such as regional studies from the USDA's Conservation Effects Assessment Project (CEAP). These studies provide a foundation on the easement success and study a broad set of outcomes, including habitat and biodiversity, pollution management, surface water and floodwater containment, greenhouse gas emission management, and water sustainability (NRCS, 2011; Mushet & Roth, 2020). A piece that is missing, however, is a better understanding of the relationship between easement habitat and agricultural land.

What is the role of insurance?

Crop insurance can be purchased to protect agricultural producers against the loss of crops from natural disasters such as excess heat, flooding, fire, drought, disease, insect damage, and destructive weather. Multiple peril crop insurance (MPCI) protects producers against lower than expected yields and revenues. MPCI is serviced by private sector insurance companies which the USDA subsidizes, regulates, and re-insures. The government typically subsidizes 60% of a producer's premiums in addition to offering assistance after natural disasters (Congressional Budget Office (CBO), 2019). There are more than 290 million acres insured in the US, which account for more than 80% of acres planted. In 2020, MPCI insured nearly $110 billion in liability and cost taxpayers $6.4 billion in premium subsidies and $1.5 in delivery costs (Goodwin & Piggott, 2020).

Producers can choose from a variety of policies and coverage options. Yield-based policies insure producers against crop-specific yield losses. Revenue-based policies protect against volatility in yields and also prices and are more expensive since they protect against an additional risk. Yield-based policies are the most accessible and have existed the longest. A producer pays a premium to the insurance company in order to purchase coverage on their commodities. Yield-based policies are based on the actual production history (APH) of a parcel and pay an indemnity for low yields. The APH is an average of the past four to ten years of yields on a parcel and represents the expected yields of that parcel. The APH is used to determine the liability. The liability represents the expected value of a commodity and the maximum value that is insured by a policy. In the event of a loss, the indemnity payment is determined by taking the difference between the liability and the actual value of production.

The liability and any potential indemnity values depends on the coverage level selected by a producer. Coverage levels vary from 50-85% in 5% increments. A minimal amount of acreage in the USA is covered at the 50% level.[2] A majority of producers choose to pay a premium and purchase additional coverage, called Buy-up coverage. A producer is able to choose the percentage of the commodity value to insure. The coverage level can be thought of like a deductible. For example, a policy with an 80% coverage level insures against yield losses greater than 20% of the liability but does not provide indemnities for losses that total less than 20% of the liability.

To set insurance rates and premiums, the RMA uses a loss cost ratio (LCR) approach. The history and details of how rates and premiums are devised are laid out in detail in the Federal Crop Insurance Primer (Congressional Reseach Service, 2021) and other academic papers (Schnapp et al., 2000; Woodard et al., 2019). Basically, the RMA uses historical data on individual producers and calculates LCRs for each year

[2]On the low end of coverage, there exists a specific policy called catastrophic crop insurance (CAT). CAT reimburses farmers for severe crop losses exceeding 50% of average historical yields at a payment rate of 55% of the established commodity price. No premium is required for this type of coverage except for an administrative fee–which has increased from $60 to $655 per crop per county in the past twenty years.

and each producer. They do this by dividing a producer's indemnities by their liabilities. Then, the RMA averages the LCRs across the the county-level and over time. This resulting county-level average LCR is the base rate the RMA charges producers for coverage in that area.[3] The LCR represents the yield risk of a commodity in that county. The RMA sets the premium rate equal to the rate of expected losses over the total value of commodities. The loss ratio represents the actuarial fairness of the insurance policy. The loss ratio is the proportion of indemnities to the premiums paid by a producer. When the indemnities equate the premium paid (and the loss ratio is equal to one), expected losses are equal to the payment of the coverage for that specified risk.

Most previous work primarily links climate to crop yields. This is something that is done in this paper as well but I believe that limiting the analysis to this approach has shortfalls. Looking strictly at yields does not capture whether production is becoming more or less risky. This may underestimate the impact of climate and any potential adaptation measures on yield sensitivity. For this reason, I also estimate the effect of easements on the loss cost ratio and loss ratio. Some researchers have used the variance of yields but this measure is deficient since the distribution of yields is ever evolving and changes in this coefficient are hard to interpret. Using the LCR and LR has been gaining popularity because these measures capture the risks of individual producers. For example, (Perry et al., 2020) uses the LCR when estimating how warming impact the agricultural risk of corn and soybeans. Goodwin and Piggott (2020) use the loss cost ratio and loss ratio in their analysis of how seed innovations impact agricultural risk and insurance rate-making behavior.

What is an easement?

The NRCS floodplain easement and wetland restoration programs allow agricultural producers to retire frequently flooded land from agricultural use. This alleviates the stress of operating in a high-risk flood area while still retaining ownership of the land. It eliminates the need for futile future farmer spending and insurance spending on that acreage. Information about these programs is distributed to communities through local USDA Service Centers, which I summarize here.

The NRCS states that the main purpose of the wetland restoration program is to "achieve the greatest wetland function and values, along with optimum wildlife habitat, on every acre enrolled in the program"(NRCS, 2021d). The NRCS goal of the floodplain easement program is to "restore, protect, maintain and enhance the functions of floodplains while conserving their natural values such as serving fish and wildlife habitat, improving water quality, retaining flood water, and recharging groundwater(NRCS, 2021a)". The inception of these restoration program dates back to the early 1990s. Almost half of the natural wetlands in the US had been drained and filled for agricultural and development purposes by 1984 (NRCS, 2021c). To slow the

[3]There are also other adjustments made for the base rate. Usually, the RMA also applies a spatially smoothing procedure, caps and cups rate changes, and applies a state excess load.

destruction of wetlands, Congress added wetland and conservation protection to the 1985 and 1990 Farm Bill. In 1985, the Swampbuster provision prohibited farmers from draining wetlands while participating in USDA programs and receiving any type of aid. This offered some of the first protections to wetlands. Then in 1990, the first wetland restoration program was authorized as an option for farmers to retire land that had been drained and to conserve eligible wetlands. Wetland restoration led to a reversal of wetland losses and often led to net increases in wetland coverage. The Emergency WRP was established in 1993 and became today's floodplain easement program (Hebblethwaite & Somody, 2008). The Emergency WRP Program was funded after receiving emergency appropriations following severe flooding in the Midwest in the 1990s.

My sample includes all the easements conducted under different iterations of the wetland easement program. Wetland restorations offered by the NRCS have evolved over time and been offered under the Emergency Wetlands Reserve Program and Wetlands Reserve Program. As of 2014, wetland restorations are offered by the Agricultural Conservation Easement Program for Wetlands Reserve Easements. Most of the basics underlying the floodplain and wetland programs remain the same, but wetland projects tend to require higher investment and more management. To be eligible for a wetland easement, land needs to be farmed wetland or converted wetland with the potential to be restored in a cost-effective manner; priorities are put on easements with high potential for protecting and enhancing the habitat. For wetland restorations, applicants are ranked based on cost, drainage conditions, amount of tiling, and restorable habitat types. For instance, in Wisconsin, restorations can be emergent wetland, uplands, forested wetland, open water, or riparian. Wetland easements can be permanent, 30-year easements, 30-year contracts or 10-year cost-share agreements. The most common type of wetland restoration are permanent. Over three million acres of wetlands have been enrolled so far.

The floodplain easement process varies slightly from the wetland restoration process. In order to be eligible for a floodplain easement, the proposed acreage must be in a floodplain that has been damaged by a flood once in the calendar year or flooded at least twice in the past decade. Land that is in danger of being adversely impacted by a dam breach is also eligible. Other parcels may also be eligible if they enhance the floodplain system, improve erosion control, or promote easement management. Floodplain easement applicants are ranked and data include both selected projects and those ranked lower. Criteria include flooding history, proximity to other protected land or public access points, adjacency to existing easements, acreage of proposed easement in the flood zone and associated flood hazard, percentage of acreage in different land use classes, estimated restoration costs, other parties' contribution of the cost, and existence of rare species within a certain buffer. All floodplain easements are permanent. There has been 185,000 acres of land enrolled in the floodplain easement program.

The amount of projects and acres that are selected depends on the individual state budget for each program. The program is funded federally but each state NRCS department oversees its implementation. The wetland

restoration program receives regular funding from Farm Bill appropriation. Funding for floodplain easements is provided by a Congressional Act, often after large-scale flooding in the US. The NRCS also funds the restoration process including removing structures that impede water flow, building topographic features such as ridges and swales, and planting native vegetation. The transaction is permanent and grants the NRCS surface rights and the right to restore the floodplain. The landowners retain ownership and pay property taxes on the land. They are also granted the rights to control public access, quiet enjoyment, and recreational use such as hunting and fishing. There is also a possibility of authorizing compatible use activities such as timber harvest, grazing or periodic haying when consistent with long-term enhancement of the floodplain functions and values.

Multiple meetings with various NRCS directors informed me of the details of the application process. Landowners submit applications for specific parcels to be considered for easement projects to their nearest farm service agency. Farmers may enroll for multiple different reasons: they are tired of constant flooding on their fields, they find themselves in debt, they hope to retire, or they find that the adaptation measure to continue cropping on consistently flooding fields is expensive (for instance, buying new tiling on a field to reduce flooding can be very costly). Typically, each state NRCS department receives 50-200 applications each year.The NRCS then scores and ranks applicant parcels on a variety of attributes. States were in charge of their own ranking systems up to 2020. The ranking sheet was pre-approved by a state technical committee that includes farmers, nonprofits, and public forums. After ranking, the state NRCS department chooses the highest ranked applicant parcels to participate in the easement program. Some projects are rejected since they do not meet the program intent or goals; often these parcels are on forested land rather than cropland in a floodplain or wetland area. Other projects are rejected since enrolled farmers need to be below a certain income threshold. The NRCS chooses applicants that are most highly ranked and continue down the list until funding for projects runs out. Sometimes, they may skip a certain project and move to the next one depending on the project costs and their budgets.

The NRCS then presents the farmer with the price that they will pay for the easement, most often this price is determined by a market survey of crop land in the area. Easement compensation is based on the lowest of three values: fair market appraisal, geographic area rate cap, and a voluntary offer by a landowner. Most often, compensation is based on the geographic area rate. Rarely does a landowner posit a voluntary offer. The farmer has three options after receiving notice of acceptance in the program: (1) they can enroll in the easement program, (2) they can cancel and withdraw from the process, or (3) they can defer their application to a future period and re-apply. Some parcels cancel because the payment is too low. Other times, there is a cancellation after the parcel changes ownership or the land is protected by other easement policies. There are also cases where the land is deemed ineligible after the farmer accepts the offer. Reasons for being deemed ineligible vary from not having access rights to the easement due to pre-existing utility or rail road contracts on the land.

Applicants that are not selected roll over to the next application period and can then be selected in the future. Applicants that are not selected in a certain year often keep their application active and continue to roll it over in future sign-ups. Based on interviews with policy directors, it is most often the case that farmers that are not selected continue to crop on the land. From this I learn that enrolling these parcels in easement programs directly reduces future crop losses since farmers would have continued farming otherwise.

3 Data

I compile from a wide array of sources to build a comprehensive data set to address my research questions. Administrative data is collected from various branches at the USDA: the NRCS, RMA, FSA, and NASS. The remote sensing Parameter-elevation Regressions on Independent Slopes Model (PRISM) data is the source of the weather and climate controls. Each observation is aggregated to the county-year level. The data spans from 1989-2020 and includes over 2,000 farming counties. The commodities of focus are corn, soybeans, and wheat. This section outlines each data set used in this research and points out important variables and trends.

1. NRCS Easements

The NRCS has a database for all the information on floodplain easements and wetland restorations completed in the United States (NRCS, 2021b). These data are collected by NRCS agents across the country. The data spans from program inception in 1992 to 2020. There are 1,613 completed floodplain easement and 17,751 completed wetland restorations in the data. Variables include program type, total acres enrolled, cropland acres enrolled, key dates in the process, condition of easements, HUC number, corresponding national initiative, and geospatial data identifying where the easement exists. The main explanatory variables of interest include the cumulative acres enrolled in the floodplain and wetland easements programs divided by the county land area. I also differentiate between the cropland and non-cropland easement acres in order to parse out the direct and indirect effects.

In 2020, there were approximately 3 million acres of eased wetlands and 185,000 acres of floodplain easements in the continental US. Figure 1 depicts the cumulative acres enrolled in wetland and floodplain easements over time. Wetland enrollment increased very slowly at first and then spiked in the late 1990s and into the early 2000s. The growth rate plateaued until the passage of the American Recovery and Reinsurance Act in 2008 which provided the NRCS with additional funding. I saw wetland enrollment increasing for a few years after ARRA before flattening again. Floodplain easement enrollment has been much milder. Floodplain easements, unlike wetland easements which are supported by Farm Bills that occur every five

years, are funded though Congressional Acts that are infrequent. Funding for floodplains spiked after severe agricultural flooding events such as in the late 1990s and 2008. This additional funding corresponds to floodplain enrollment.

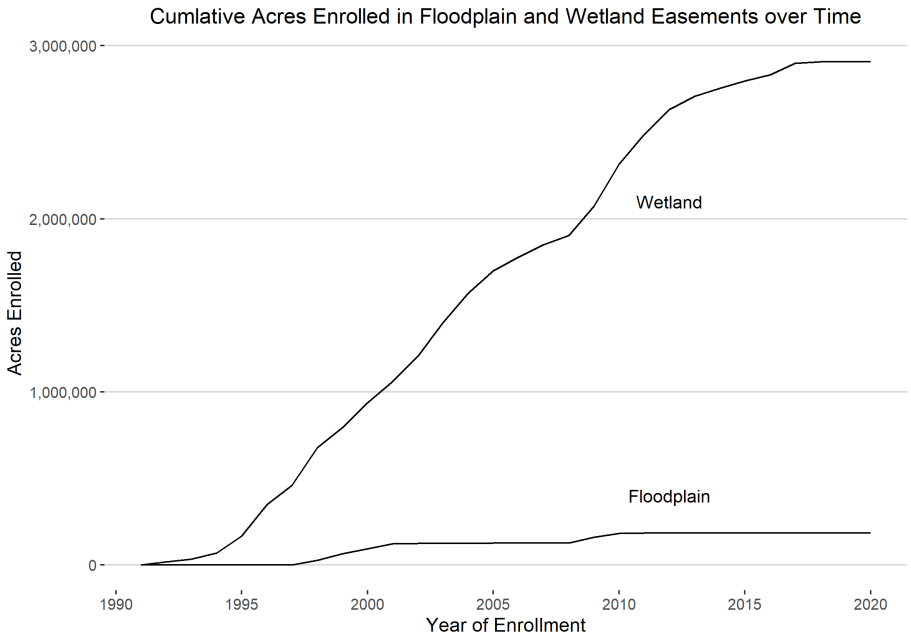


Figure 1: Acres enrolled in wetland and floodplain program

It is also important to consider the timing of easements. The NRCS Easement data records dates of importance such as application date, agreement start date, enrollment date, closing date, recorded date, and restoration completion dates. Each event in the process is defined in detail in the proceeding table. Whether a producer can crop on the land or insure the land with the USDA is also noted. Producers are actually encouraged to crop on the land until the NRCS is ready to actively restore the land. From application to restoration completion, a floodplain can take an average of 2.8 years to be finished. The wetland restoration process tends to be more intensive and takes 4.1 years on average to complete. A breakdown of each step's duration is presented in the following box plot. There is a large range in terms of how long it takes to finish the easement process—there are cases in which it takes less than a year and others than span closer to 10 years to be considered officially complete.

The date of importance for our analysis is the closing date. The closing date represents the point that the contract becomes official. The conservation agent has approval to purchase the easement and the landlord is paid. After this date, farmers can no longer receive benefits on that parcel nor insure the eased parcel. They may still be able to plant crops on the parcel with a compatible use authorization. It is not until the restoration is complete that producers are prohibited from cropping on the easement. I chose the closing date as the time that an easement is counted in the county running total of acres—our main explanatory

Event	Definition	Can the producer farm the land?	Can the producer insure the land?
Application	Application received by the NRCS from producer.	Yes.	Yes.
Agreement Start	Parcel selected and producer agrees to continue in process.	Yes.	Yes
Enrollment	Parcel enrolls in program.	Yes.	Yes.
Closing	Conservation agent has approval. Attorneys sign off. Landlord paid money.	Only with Compatible Use Authorization (CUA).	No. After this date, farmer can no longer receive FSA benefits nor crop insurance.
Recorded	Transaction recorded in court. Officially NRCS easement.	Only with CUA.	No.
Restoration Complete	Parcel has been restored	No.	No.

Figure 2: Table outlining each step in easement process

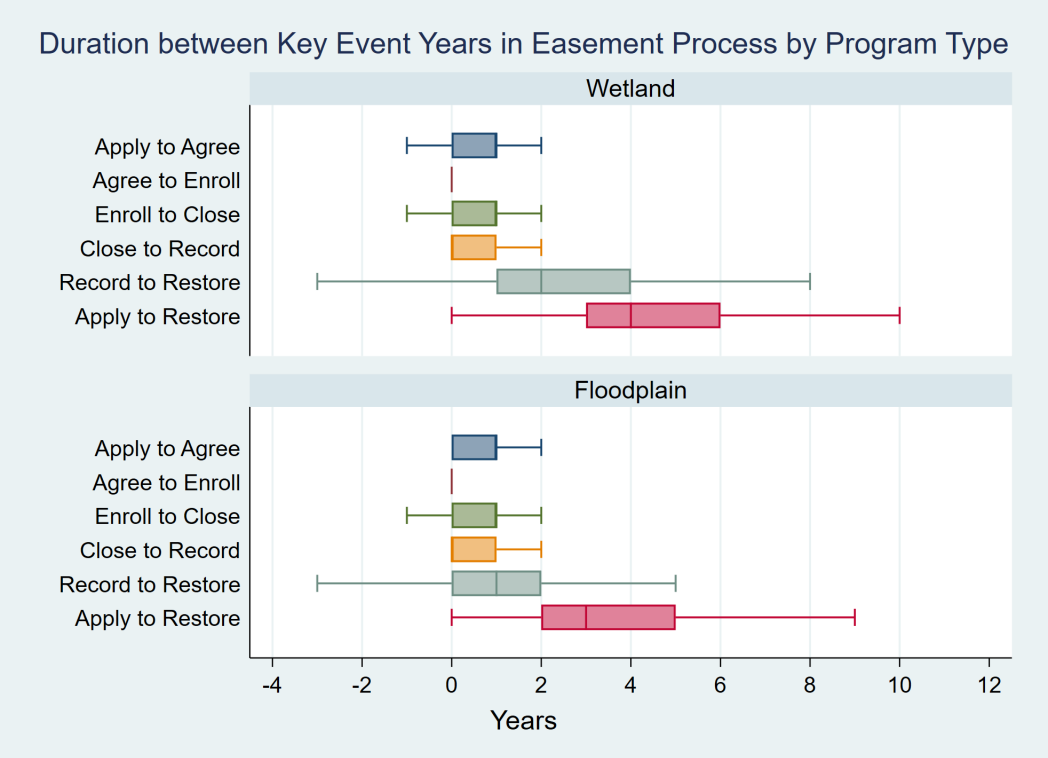


Figure 3: Duration in each phase by program type

variable of interest. I believe at this point that I will see changes in risk reflected at the county-level since the land is no longer insured at this point.I might expect to see indirect effects on neighboring parcels at this

time as well. It is also possible that at the restoration completion date the indirect effects may be amplified.

At what time in the year do easements occur? I break down the key steps in the easement process by month of occurrence. I notice that applications and restoration completions tend to occur during certain months. On the other hand, I notice that the timing is distributed evenly during the year for NRCS management specific steps such as closing and recording.

Application timing is likely to be endogenous. The decision to apply to an easement program is not random. A producer may be motivated to apply after facing agricultural losses. It appears that wetland applications are more likely to occur in heavy-flooding months, March and June. Floodplain applications are more likely to occur during the spring and summer season as well. Over thirty-six percent of floodplain applications are received in July and August. At this point in the year, producers have realized whether their yields will be less than expected. A willingness to retire marginal cropland after facing flood losses may have incited an increase in the frequency of applications during these months.

The work completed by the NRCS seems to be distributed in a uniform distribution across the year, especially for closings and court recordings. There does seem to be patterns worth mentioning for when restorations are completed. Restorations require removing tiling or planting native flora on the eased parcel. It is understandable that wetlands tend to be finished by the end of summer around September. Floodplains generally take less effort and planting to complete. Floodplain restorations tend to take place in late summer as well and also the month of December. I investigate the timing of the easement process in order to better understand when I may begin to see effects on agricultural production and risk. These exercises informs the decisions of which date to consider when studying easement effects. The main specifications presented here correspond to the closing date. Robustness checks for the other important dates are underway.

2. RMA Cause of Loss and Summary of Business

The Cause of Loss (COL) dataset from the RMA (Risk Managment Agency, 2021) provides valuable information on monthly indemnities for each county from 1989-2020. Each observation gives us county-month-commodity-cause of loss information. Outcome variables of interest include the acres lost as well as indemnity totals for specific loss types. I reorganize the causes-of-loss data and calculate the total indemnities for each category to better understand the magnitude of losses (figure 5). The biggest cause-of-loss is drought, with indemnities totaling over $35 trillion over the period 1989-2020. The second biggest cause of loss is Excess Moisture, with indemnities close to $30 trillion. The causes of loss that I am specifically interested in are for events related to flooding and excess water. I focus on these types of losses since I believe that floodplain and wetlands will have the biggest impact on agricultural risk concerning excess water. However, I also consider the overall causes of losses as well since crops may be indirectly impacted by other types of losses at



Figure 4: Monthly Breakdown of Main Easement Steps

a greater rate after suffering water damage. Crops that face water damage are also more liable to damages caused by disease, insects, and wildlife.

The Cause of Loss Data are merged with another RMA data set resource, the Summary of Business (SOB) data file. The SOB data record the acres planted, liabilities, premiums, subsidies, coverage levels, and chosen policies. The SOB data allow us to build our outcomes of focus, the Loss Ratio and Loss Cost Ratio. We aggregate the data to a yearly total for each county to create panel data. To create a balanced panel, we assume that reported indemnities and losses are zero for county-years with no reported losses. However, our analysis only consists of the subset of counties that faced losses (ie counties that had non-zero losses in that year as is standard practice). The map highlights the counties included in our sample and displays the extent of agricultural damages. We notice that damages are high in the Dakota area as well as in counties along the Mississippi river. We also note that easement are also clustered in these areas.

It is also interesting to consider the timing of these damages. To explore when indemnities occur, I graph

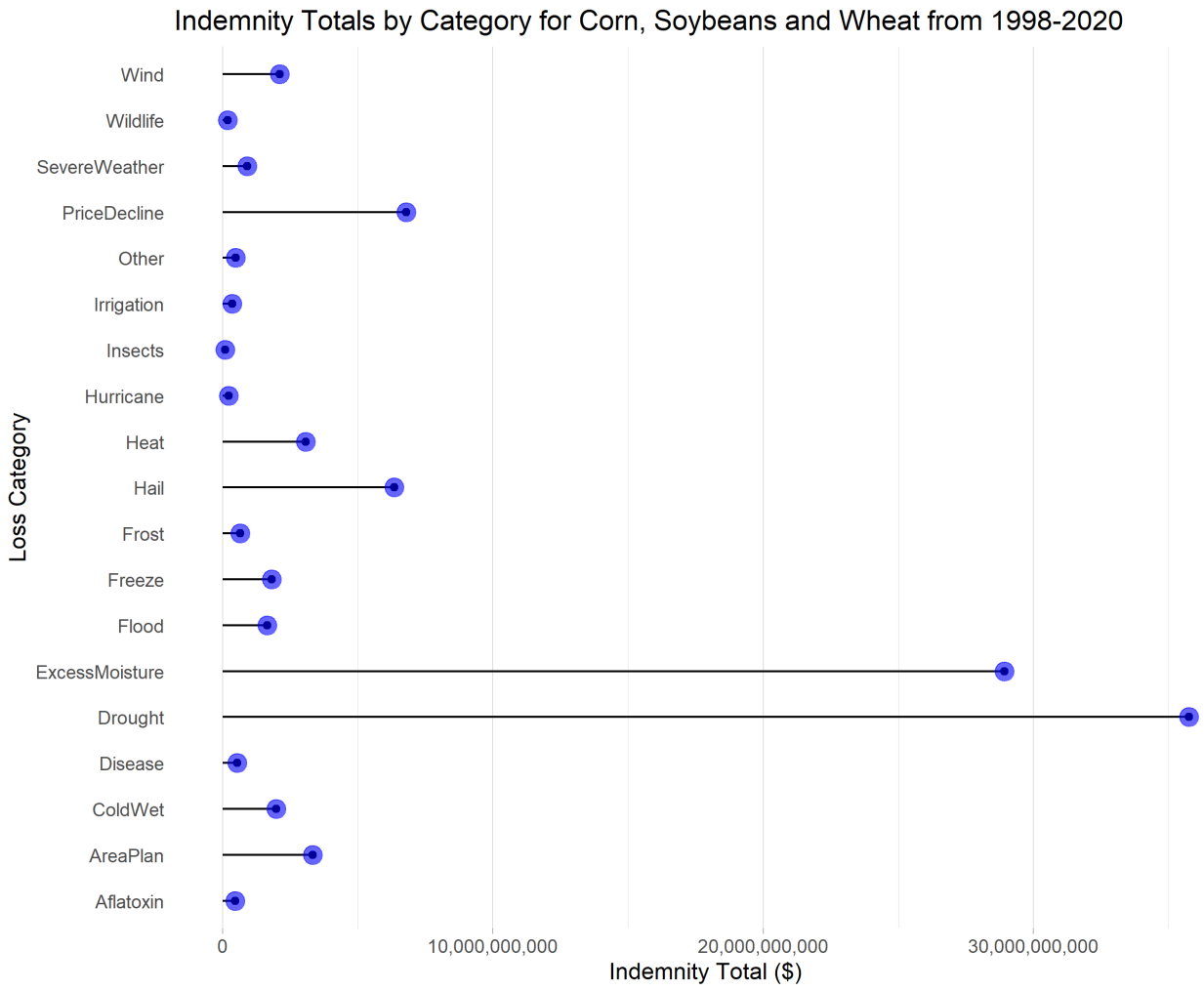


Figure 5: Indemnity Totals

changes in indemnities for corn, soybeans and wheat during our sample period. I notice that indemnities remain relatively low and stable for the first decade in our sample. I then notice more frequent upswings in losses for crops. I notice losses around $3 billion for each crop in 2008. This year is notorious for severe flooding and the associated ARRA funding uptick. I also see severe losses for corn in 2012 after another bad year of flooding that amount to almost $12 billions in indemnities paid out to farmers.

3. FSA Crop Acreage

The FSA has collected data on acreage planted, prevented planted, and failed from 2009-2020 (FSA 2020). Producers who participate in FSA programs are required to self-report on acreage outcomes each year to the FSA. Records include the sum of planted acres, volunteer acres, failed acres, prevented acres, and net planted acres. These reports are used to calculate losses for various disaster assistance programs. Observations are

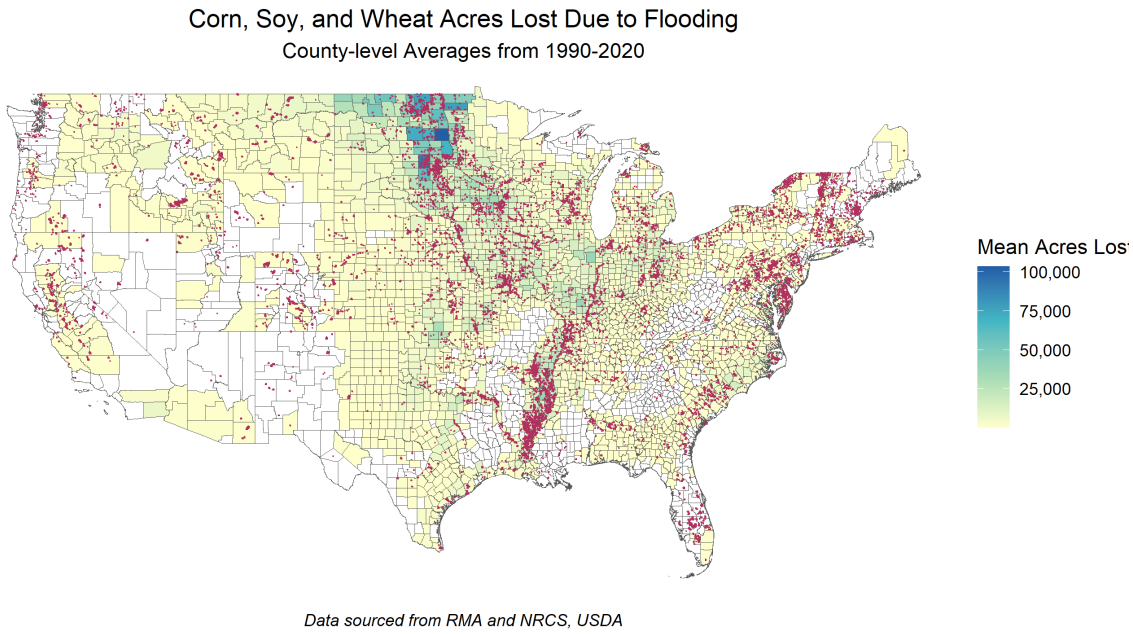


Figure 6: Acres damaged due to water-related damages and easement parcel locations

then aggregated to the county-level for each year and then made publicly available.

The main outcomes that I use from the FSA data are the prevented planting and failed planting variables. Prevented planting is the inability to plant the intended crop acreage with proper equipment by the final planting date for a specific crop type. This may occur if flooding occurs during planting season in the spring; a farmer may be delayed or prevented from planting since their machines are unable to work the inundated soil. Flooding and excess rain can also be harmful later in the season when crops are growing. If there is an abundance of water, flooding can destroy crops by washing them away, decreasing oxygen intake, building up toxins in the soil, inhibiting plant growth, and making plants prone to disease, insects, and mold. These damages may lead to failed acreage: acreage that is planted with the intent to harvest but because of disaster-related conditions are unable to be brought to harvest. The FSA data allows an investigation of the timing of easements effects. Do easements reduce agricultural risk by reducing acres prevented planted during planting season? Or is it the case that easements reduce risk later on in the season by reducing acres failed?

4. NASS Crop Yields

Another common data set used to study agricultural outcomes is the NASS. The NASS uses survey data to provide estimates of county level yields, acres planted, and acres harvested. Our data compiles these statistics for each county for corn, soybeans and wheat from 1989-2020. Yields for each crop are measured

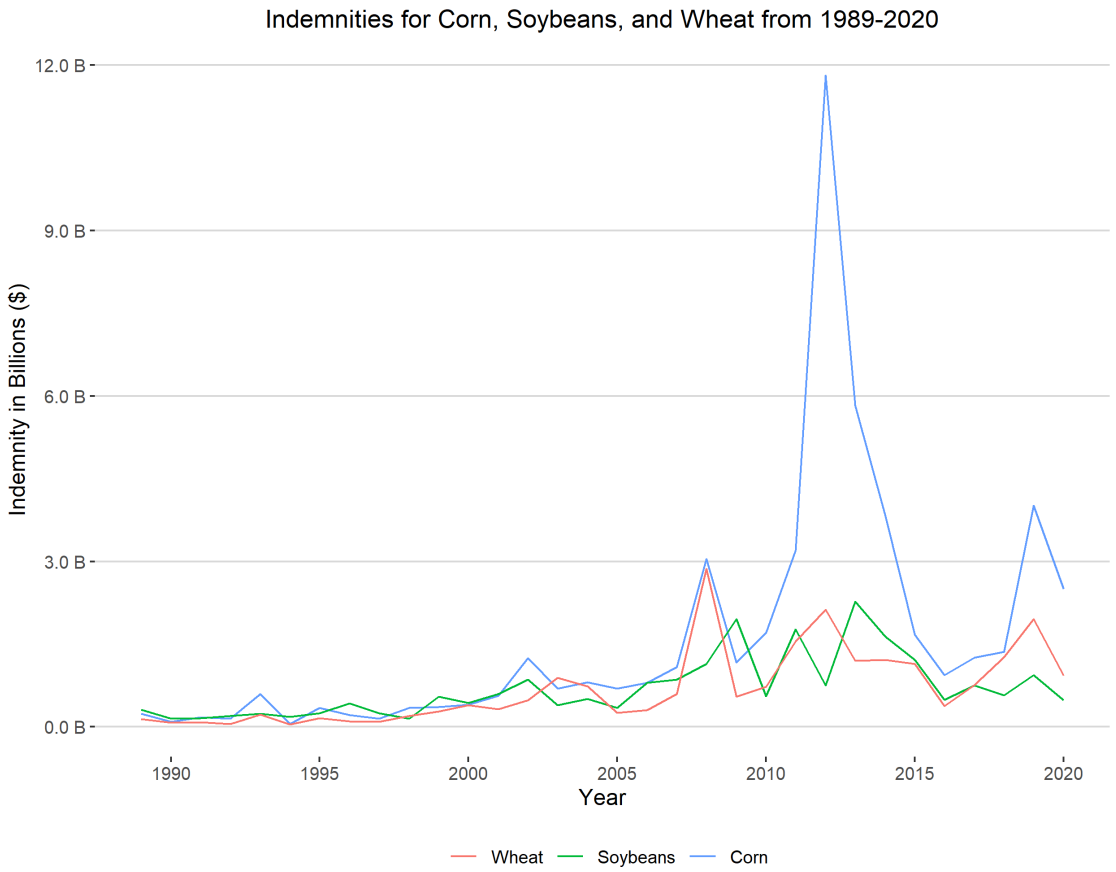


Figure 7: Indemnities over time by crop

as bushels per acre.

5. PRISM Weather and Climate

I follow the approach of Schlenker and Roberts (2009a) when including weather data in my models. I use PRISM data that is aggregated at the county-level. Notably, I only include the raster weather data on parcels that are classified as cropland or pastureland by the USGS National Land Cover Data Base. Since the original PRSIM dataset is at the monthly level and my data are at the year level, I also aggregate over the growing season from April to September to create a yearly panel. For example, my precipitation measure represents the total millimeters of precipitation that a county receives in a growing season. I also include a squared precipitation term since precipitation has a non-linear effect on the agricultural outcomes of interest. My data set also includes heat exposure by considering the average growing season temperature as well as the average monthly minimum and maximum temperatures. Instead of focusing on the temperature variables, I consider the exposure of varying temperature levels by binning time spent at each Celsius degree–a term

known as degree days. Similar to Annan and Schlenker (2015), my model includes moderate degree days (total exposure from 10-29 degrees Celsius) and extreme degree days (total exposure at and above 30 degrees Celsius).

4 Empirical Model

Panel model with two-way fixed effects

The main specification in this paper uses a panel model with two-way fixed effects (TWFE) to estimate how easements impact agricultural outcomes. The panel spans from 1989 to 2020, encompassing 32 years of data. My equation takes the form of

$$Y_{ict} = \beta_1 Ihs(Wetland_{it}) + \beta_2 Ihs(Floodplain_{it}) + \Gamma X_{it} + \alpha_i + \delta_t + \epsilon_{ict} \tag{1}$$

The outcome variables of interest, Y, that I examine are the crop yields, lost cost ratio, and loss ratio in county i in year t for crop c. The crops of interest in this study are corn, soybeans, and wheat. When studying potential mechanisms, I also look at the acres planted, prevented planted, failed, and failed to harvest as outcomes of interest. I take the inverse hyperbolic sine transformation (Ihs) of all the outcome variables except for the risk ratios. This transformation allows estimated effects in the outcomes to be interpreted as percent changes. The ihs is preferred to the natural log transformation since there are many cases of zero values in the data.

I include fixed effects at the county-level to account for the average differences across counties. The county-level fixed effect controls for observed and unobserved county factors that are time invariant. This allows me to use within county variation to reduce the threat of omitted variable bias. I also include year fixed effects. These control for both observable and unobservable factors changing across time that are consistent across counties. The underlying assumption that is being made is that conditional on the county and year, treatment is exogenous. I also assume that there is independence across units—there are no spillover effects across counties.

The main treatment variables, $Floodplain$ and $Wetland$, represent the floodplain and wetland eased land as a proportion of a county's total land area. The ihs of the treatment variables is taken as well for ease of interpretation and since there are many counties with zero changes in easement acreage over time. The main source of identifying variations stems from variation across time and space in the implementation of easement acres. The coefficient of interest β_1 measures the elasticity response of the chosen agricultural outcomes to a 1% increase in land under wetland easement. The coefficient β_2 represents the elasticity response after a

1% increase in land under floodplain easement.

To reduce the threat of omitted variable bias, I include relevant controls in my model. I account for planting-relevant variables that are common in the literature such as precipitation, temperature, and degree days. My main specification includes moderate and extreme degree days as well as precipitation and precipitation squared. Moderate degree days are the sum of degree days from 10-29 degrees Celsius. Extreme degree days are the sum of degree days above 30 degrees Celsius. Finally, I adjust the standard error by clustering at the state-level. I cluster at the state since the programs are funded and administered by each state NRCS department.

I use the closing year in my preferred specification since this date is the most reasonably exogenous and the point in time that is associated with reduced risk. This is also the point at which a producer can no longer insure the parcel. The application date is heavily influenced by recent flooding and previous indemnities. This means that our treatment and outcome variables are co-determined. However, once a farmer decides to apply and enroll into the program, the rest of the process is in the hands of the NRCS. Meetings with NRCS directors and agents have shed light on the fact that the NRCS steps including closing, court recording, and restoration completion are somewhat random. Many potential hurdles may delay the process. It is often the case that various legal issues make the closing and restoration process last longer. For example, a previous utility contract may be unearthed and an agreement must be worked out. Alternatively, sometimes there is trouble with accessing the parcel of land for the NRCS because of legalities with rail roads and private roadways. There are many legal documents and processes that take an quasi-random amount of time to complete. For these reasons, I believe the timing of closing is reasonably exogenous.

Limitations and Trends in TWFE and DiD Models

It is worth noting the limitations and current updates regarding panel models with two-way fixed effects. The two-way fixed effect strategy can also be interpreted as a difference-in-differences(DiD) set up but with a staggered, continuous treatment variable. There has been a lot of recent work in the DiD setting: decomposing the treatment effects, discerning how they are weighted, and understanding the underlying assumptions(Goodman-Bacon, 2018; De Chaisemartin, D'haultfoeuille, & Haultfoeuille, 2019; Callaway & Sant'Anna, 2020). Alternative estimators have been specified to create the correct counterfactual groups and accurately weigh observations to find the average treatment effect in a variety of settings, especially in the canonical two-period DiD setting. Currently, the literature is applying this logic to multi-period settings and cases when treatment is staggered and continuous(De Chaisemartin, Haultfoeuille, & Guyonvarch, 2019; Callaway et al., 2021).

How can we interpret the main treatment coefficients? There are two causal effects of interest: a treatment

effect and causal response effect (Callaway et al., 2021). The treatment (level) effect measures the difference between a unit's potential treated outcome and potential untreated outcome. The causal response (slope) effect captures the response to an incremental change in the treatment level. To identify the treatment effect, a comparison must be made between treated and untreated units with the assumption of parallel trends on untreated potential outcomes. The causal response effect comes from comparisons between units that have more treatment relative to other treated units and requires a much stronger parallel trends assumption. There can also be selection bias that is captured in the parameter since there may be non-random differences between units with different treatment intensity.

As Callaway et al. (2021) notes, the original TWFE estimator is composed of four different types of comparisons: 1) between units treated at the same time with different treatment levels, 2) between units in early-treated groups relative to later-treated groups, 3) between later-treated groups relative to already-treated groups, and 4) between early-treated and later-treated groups in common periods. To identify the treatment effect and causal response effect, the correct comparison groups must be selected.

Callaway et al. (2021) propose a specification to correctly identify the causal effects of interest in a multi-period setting with variation in treatment timing and intensity as well as the needed parallel trend assumptions. The code for this alternate specification is still being developed. In the mean time, I am working on trying to create original code to follow their alternative specification. (These results are not yet ready, so below are the estimates with the original TWFE estimator).

5 Results

This section reviews my findings from using a TWFE model. The regression tables are all collated at the bottom of this section. Each regression includes fixed effects at the county and year level. Each model also includes precipitation, precipitation squared, moderate degree days, and extreme degree days but these coefficient are not always shown. The sample is restricted to counties that are east of the 100th meridian. All standard errors are clustered at the state level.

How do easements impact crop yields?

Table 1 presents the regression output for how wetland and floodplain easements impact corn, soybean and wheat yields. A clear pattern emerges, especially for wetland easements. As hypothesized, easements positively impact yields. For wetland easements, a 1% increase in land under wetland easement is associated with 2.11%, 4.75% and 2.84% increase in yields for corn, soybeans, and wheat. The estimates on floodplain easements are also positive but no longer statistically significant for corn and soybeans. There is evidence

of significant increases in wheat yields after an increase in floodplain easements. The signs for the control variables are as expected. Moderate degree days are associated with positive yields while more extreme degree days decrease yields. Precipitation also has a positive impact on yields with decreasing returns seen in the squared precipitation term.

Table 2 differentiates by the original land use of the easement. A majority of the land put under easement is cropland. There are cases when adjacent non-cropland (land not used in production) is put under easement as well. Non-cropland is eased in order to to connect eased cropland, improve drainage outcomes, and create more robust ecosystems. Differentiating by the original land use allows us to uncover the direct and indirect effect of easements. The estimates on cropland wetland and floodplain acres help us understand the direct impacts of removing marginal cropland from production. The estimates on the non-cropland wetland and floodplain easements give us a proxy of the indirect effects of easementshow do wetlands and floodplains impact nearby cropland?

Column 1 shows positive but minimally significant impacts of crop and non-cropland wetland acres on corn yields. The estimate of cropland floodplain acres is negative but insignificant while non-cropland floodplain acres have a large and significant effect on corn yields of 19.81%. These findings suggest that the indirect effects of easements are of a larger magnitude than the direct effects. The story for soybean yields in column 2 is similar. Cropland and non-cropland wetland acres have a positive and significant effect on soybean yields of 5% and 4% respectively. Similar to corn, there is a negative effect of cropland floodplain acres but a positive impact of non-cropland floodplain acres on soybean yields. Column 3 shows a consistent positive effect of wetland acres on wheat yields. For wheat, I do not find a negative effect of cropland floodplain acres such as for corn and soybeans; however, I do find that non-cropland floodplain acres have a large positive effect on yields.

This evidence lends support to the hypothesis that easements have an overall positive effect on agricultural production by increasing the average yields within the county. We find positive effects of easements for corn, soybeans, and wheat. There appears to be different effects of easements depending on the original land use of the eased parcel. Easing non-cropland acres has positive and sizeable impacts on agricultural yields.

How do easements impact crop yield risk?

Our next set of regression tables look at how easements impact agricultural risk. I measure yield risk as the ratio of indemnities to liabilities as well as the ratio of indemnities to premiums paid. The subset of data here include only county observations that have a non-zero indemnity in that year [4] Table 3 shows how

[4]If a county has zero indemnities in a year, the loss cost ratio and loss ratio are undefined. Moreover, sticking to the subset of observations that regularly face losses will give a better idea of the true effect of easements since we will have a more accurate

floodplain easements and wetland easements impact the lost cost ratio. Unlike with yields, I do not find a strong relationship between easement closing and reduced risk. I find no significant effects of wetland and floodplain acres on corn and wheat loss cost ratios. However, I do find that an increase in wetland acres reduces the loss cost ratio for soybeans. I explore this relationship more in Table 5 by again differentiating by original land use of the easements. Column 2 shows that cropland wetland acres and non-cropland floodplain acres decrease yield risk of soybeans. Meanwhile, cropland floodplain acres are associated with a higher lost cost ratio. The other estimates in Table 4 are not statistically different from zero. These tables suggest that there is not as robust of a relationship between easements and crop yield risk. There is some evidence showing that soybean production is less risky post easement implementation.

To try to understand the types of agricultural losses that may be prevented by easements, I calculate the loss cost ratio for different subsets of loss types. For example, I create a separate lost cost ratio for drought losses, for excess moisture losses, and for hail losses. Table 5 explores how the lost cost ratio dealing with excess moisture indemnities changes after an increase in easements. Similar to previous results, there is an insignificant effect of easements on the corn and wheat excess moisture LCR. But again, I find that an increase in easements reduces the loss cost ratio for soybeans. This suggests that easements prevent losses due to excess moisture for soybeans. Easements may be increasing agricultural resiliency by preventing losses due to excess water and severe water-related weather events.

To investigate how producer risk are impacted by easements, I regress the loss ratio on wetland and floodplain acres in Table 6. All the coefficients are insignificant. This may suggest that producers are not experiencing any changes in risk post easement closings in their area.

What are the potential mechanisms?

This section explores the potential mechanisms through which easements may be impacting agricultural production. I use the FSA and NASS data on acreage stock to try and understand how planting behavior and incidences of acreage losses respond to an increase in easements. I look at how an increase in wetland and floodplain easement acres impact soybean acres planted, prevented planted, failed, harvested, and failed to harvest. I focus this analysis on soybeans since easements seem to have the largest impact on soybean production based on the previous tables. Table 7 and 8 show similar findings even though the data sets are different which lend evidence to the robustness of results.

Table 7 uses FSA acreage data and has a shorter panel of data stemming from 2009-2020. As expected, easing land leads to a decrease in the percentage of soybean acres planted. A 1% increase in wetland acreage leads to 9% reduction in the acres of soybeans planted. Remember that the 1% increase in easement is

counterfactual group.

relative to the county land area not the acreage of cropland. It makes sense that we see a more elastic response. The coefficients in column 2 show that more easements lead to less acres prevented planted. For floodplain, I find a 1% in floodplain acreage leads to a reduction of prevented planting by almost 400%. Acres prevented planted often occur because of extreme flooding and excess moisture in the soil. This highlights that easements may be decreasing losses stemming from water-related issues. There is also evidence showing that easements are associated with less soybean acres lost due to failed planting, particularly for wetland acres.

The NASS data do not have data on acres prevented and failed from planting. However, the NASS data let me test how easements impact acres planted and harvested. Similar to the FSA data, wetland acres lead to less acres planted and in turn less acres harvested. The magnitude of the effect is larger for planted soybeans acres: a 1% increase in wetland acres reduces soybean acres planted by about 13%. The coefficient is the same for acres harvested. I create a measure of acres failed to be brought to harvest by subtracting the acres harvested from acres planted for each county-year. Wetlands do not seem to impact acres failed to harvest. Concerningly, increases in floodplain acres are associated with a increase in acres failed to harvest for soybeans. Further investigation into this finding is needed.

Finally, I explore the potential weather pathways by taking an approach similar to Annan and Schlenker (2015) in which they look at how the portion of land that is insured impact the effect of precipitation and degree days on crop yields. I interact the share of easements with moderate degree days, extreme degree days, precipitation. and precipitation squared. This allows me to see through which type of weather pathways easements impact crop yields. In Table 9, I look again at how easements impact the crop yields of corn, soybeans, and wheat but this time with these interaction terms included. I find interesting effects on corn and soybean yields.

In column 1, I find that easements decrease the effect that moderate degree days have on corn yields. This makes sensemore moderate degree days lead to better yields and easing land will mitigate this positive effect since less land is in production. The coefficient on the interaction between easement acres and precipitation is negative and significant as well (a similar story can be told here of how precipitation improves yields and more easements dull this effect). However, the interaction with the squared precipitation term shows that easements can be beneficial when precipitation deviates from the optimal level. For soybeans, I see that yields are improved by easements by mitigating the effect of extreme degree days. This may suggest that losses due to extreme degree days are reduced in counties with a higher proportion of eased land. None of the interaction terms are significant for wheat.

Table 1

Effect of Easements on Yields

VARIABLES	(1) Corn yield (bushels/acre)	(2) Soybean yield (bushels/acre)	(3) Wheat yield (bushels/acre)
Wetland Acres	2.111***	4.749***	2.835***
	(0.671)	(1.184)	(0.705)
Floodplain Acres	9.441	1.026	10.46**
	(7.224)	(4.621)	(3.871)
Moderate degree days	0.000267***	0.000244***	0.000118
	(5.38e-05)	(6.96e-05)	(0.000101)
Extreme degree days	-0.000598***	-0.000539***	-2.21e-05
	(9.59e-05)	(0.000105)	(0.000137)
Precipitation	0.000871***	0.00112***	0.000399***
	(0.000166)	(0.000178)	(0.000144)
Precipitation squared	-6.44e-07***	-7.13e-07***	-5.00e-07***
	(1.17e-07)	(1.05e-07)	(1.09e-07)
Outcome Mean	5.439	4.269	4.531
Observations	50,343	45,877	34,867
R-squared	0.449	0.486	0.315
Number of counties	1,878	1,768	1,722
County FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Robust standard errors clustered at the State-level in parentheses
*** p<0.01; ** p<0.05; * p<0.10

Table 2

Effect of Cropland and Noncropland Wetland and Floodplain Easements on Yields

VARIABLES	(1) Corn yield (bushels/acre)	(2) Soybean yield (bushels/acre)	(3) Wheat yield (bushels/acre)
Cropland Wetland Acres	1.492	5.107***	3.526***
	(1.198)	(1.397)	(1.044)
Non-cropland Wetland Acres	3.283*	4.303**	1.717
	(1.768)	(1.749)	(1.669)
Cropland Floodplain Acres	-9.595	-12.43**	4.933
	(6.535)	(5.094)	(10.57)
Non-cropland Floodplain Acres	19.81**	8.365**	12.24**
	(8.759)	(3.828)	(4.937)
Outcome Mean	5.439	4.269	4.531
Observations	50,343	45,877	34,867
R-squared	0.450	0.486	0.315
Number of counties	1,878	1,768	1,722
County FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Weather controls	Yes	Yes	Yes

Robust standard errors clustered at the State-level in parentheses
*** p<0.01; ** p<0.05; * p<0.10

Table 3

Effect of Easements on Loss Cost Ratio

VARIABLES	(1) Corn Loss Cost Ratio	(2) Soybean Loss Cost Ratio	(3) Wheat Loss Cost Ratio
Wetland Acres	-0.262	-1.302**	0.258
	(0.717)	(0.586)	(0.541)
Floodplain Acres	0.0212	-0.0139	-1.853
	(1.752)	(1.083)	(2.124)
Moderate degree days	-0.000160***	-8.64e-05**	-0.000155**
	(5.34e-05)	(4.16e-05)	(5.62e-05)
Extreme degree days	0.000324***	0.000228***	-2.60e-05
	(7.73e-05)	(5.86e-05)	(7.33e-05)
Precipitation	-0.000396***	-0.000629***	-0.000144
	(8.03e-05)	(9.94e-05)	(8.81e-05)
Precipitation squared	3.34e-07***	4.59e-07***	2.43e-07***
	(5.61e-08)	(5.76e-08)	(6.27e-08)
Outcome Mean	0.0996	0.0927	0.123
Observations	44,950	42,906	37,859
R-squared	0.202	0.172	0.131
Number of counties	1,777	1,667	1,604
County FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Robust standard errors clustered at the State-level in parentheses

*** p<0.01; ** p<0.05; * p<0.10

Table 4

Effect of Cropland and Noncropland Floodplain and Wetland Easements on Lost Cost Ratio

VARIABLES	(1) Corn Loss Cost Ratio	(2) Soybean Loss Cost Ratio	(3) Wheat Loss Cost Ratio
Cropland Wetland Acres	0.366	-2.382***	-0.950
	(1.341)	(0.586)	(0.772)
Non-cropland Wetland Acres	-1.310	0.418	2.271**
	(0.900)	(0.970)	(1.020)
Cropland Floodplain Acres	5.474	5.879**	3.928
	(3.441)	(2.550)	(6.761)
Non-cropland Floodplain Acres	-2.998	-3.186**	-4.528
	(1.957)	(1.384)	(3.031)
Outcome Mean	0.0996	0.0927	0.123
Observations	44,950	42,906	37,859
R-squared	0.202	0.173	0.132
Number of counties	1,777	1,667	1,604
County FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Weather controls	Yes	Yes	Yes

Robust standard errors clustered at the State-level in parentheses

*** p<0.01; ** p<0.05; * p<0.10

Table 5

Effect of Easements on Excess Moisture Loss Cost Ratio

VARIABLES	(1) Corn Excess Moisture LCR	(2) Soybeans Excess Moisture LCR	(3) Wheat Excess Moisture LCR
Wetland Acres	0.176	-0.637*	0.0796
	(0.410)	(0.326)	(0.580)
Floodplain Acres	-0.221	-0.0555	-1.577
	(1.209)	(0.495)	(1.697)
Moderate degree days	-8.67e-05***	-4.92e-05***	-8.03e-05***
	(1.73e-05)	(1.73e-05)	(2.58e-05)
Extreme degree days	-8.86e-05***	-0.000103***	-7.88e-06
	(2.20e-05)	(2.51e-05)	(3.12e-05)
Precipitation	2.82e-05	-2.86e-05	-1.87e-05
	(5.28e-05)	(4.52e-05)	(6.22e-05)
Precipitation squared	7.47e-08*	1.04e-07***	1.36e-07***
	(4.05e-08)	(2.95e-08)	(4.35e-08)
Outcome Mean	0.0288	0.0286	0.0621
Observations	44,950	42,906	37,859
R-squared	0.149	0.137	0.167
Number of counties	1,777	1,667	1,604
County FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Robust standard errors clustered at the State-level in parentheses
*** p<0.01; ** p<0.05; * p<0.10

Table 6

Effect of Easements on Loss Ratio

VARIABLES	(1) Corn Loss Ratio	(2) Soybean Loss Ratio	(3) Wheat Loss Ratio
Wetland Acres	-0.848	-1.248	3.379
	(6.086)	(3.080)	(5.880)
Floodplain Acres	4.333	-17.05	-10.26
	(15.16)	(11.94)	(20.45)
Moderate degree days	-0.00162***	-0.00115***	-0.00184**
	(0.000469)	(0.000367)	(0.000668)
Extreme degree days	0.00248***	0.00135***	-0.000735
	(0.000681)	(0.000474)	(0.000674)
Precipitation	-0.00413***	-0.00530***	-0.000576
	(0.000891)	(0.000750)	(0.000821)
Precipitation squared	3.52e-06***	3.93e-06***	1.75e-06***
	(6.85e-07)	(4.39e-07)	(5.58e-07)
Outcome Mean	0.887	0.769	1.050
Observations	44,950	42,906	37,859
R-squared	0.225	0.194	0.150
Number of counties	1,777	1,667	1,604
County FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Robust standard errors clustered at the State-level in parentheses
*** p<0.01; ** p<0.05; * p<0.10

Table 7

Effect of Easements on FSA Soybean Acreage

VARIABLES	(1) Planted Soybean Acres	(2) Prevented Planted Soybean Acres	(3) Failed Soybean Acres
Wetland Acres	-9.859*	-17.12	-34.65**
	(5.211)	(21.72)	(16.78)
Floodplain Acres	-4.161	-373.9*	94.87
	(27.37)	(184.9)	(95.76)
Moderate degree days	-2.58e-05	0.000297	-0.000128
	(0.000139)	(0.00178)	(0.000480)
Extreme degree days	-5.49e-05	-0.00206	-0.000164
	(0.000155)	(0.00148)	(0.000657)
Precipitation	0.000164	0.00289	0.000422
	(0.000224)	(0.00234)	(0.000696)
Precipitation squared	-2.01e-07	1.06e-06	3.99e-07
	(1.41e-07)	(1.38e-06)	(4.86e-07)
Outcome Mean	10.40	3.088	0.758
Observations	18,303	18,303	18,303
R-squared	0.029	0.276	0.025
Number of counties	1,794	1,794	1,794
County FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Robust standard errors clustered at the State-level in parentheses
*** p<0.01; ** p<0.05; * p<0.10

Table 8

Effect of Easements on NASS Soybean Acreage

VARIABLES	(1) Planted Soybean Acres	(2) Harvested Soybean Acres	(3) Failed Harvest Soybean Acres
Wetland Acres	-12.87***	-13.07***	-7.486
	(3.133)	(3.218)	(4.845)
Floodplain Acres	35.16	34.49	80.99**
	(30.09)	(30.69)	(33.41)
Moderate degree days	0.000153	0.000204	-0.000368
	(0.000247)	(0.000251)	(0.000595)
Extreme degree days	0.000192	0.000118	0.000962
	(0.000345)	(0.000345)	(0.000876)
Precipitation	0.000242	0.000598***	-0.00453***
	(0.000155)	(0.000151)	(0.000826)
Precipitation squared	-2.69e-07**	-5.30e-07***	3.39e-06***
	(1.12e-07)	(1.05e-07)	(5.59e-07)
Outcome Mean	10.68	10.64	6.051
Observations	45,879	45,877	45,877
R-squared	0.152	0.158	0.053
Number of counties	1,768	1,768	1,768
County FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Robust standard errors clustered at the State-level in parentheses
*** p<0.01; ** p<0.05; * p<0.10

Table 9

Effect of Easements on Yields through Weather Pathways

VARIABLES	(1) Corn yield (bushels/acre)	(2) Soybean yield (bushels/acre)	(3) Wheat yield (bushels/acre)
Easement Acres	38.71**	1.807	10.05
	(14.76)	(12.39)	(18.72)
Moderate degree days	0.000277***	0.000255***	0.000120
	(5.39e-05)	(6.92e-05)	(0.000100)
Extreme degree days	-0.000602***	-0.000561***	-2.28e-05
	(9.37e-05)	(0.000103)	(0.000137)
Precipitation	0.000904***	0.00112***	0.000408**
	(0.000176)	(0.000179)	(0.000156)
Precipitation sq.	-6.59e-07***	-7.12e-07***	-5.08e-07***
	(1.24e-07)	(1.06e-07)	(1.20e-07)
Easement Acres x Moderate dd	-0.00631**	-0.000832	-0.00146
	(0.00297)	(0.00229)	(0.00350)
EasementAcres x Extreme dd	-0.000153	0.00914***	0.000124
	(0.00283)	(0.00234)	(0.00360)
Easement Acres x Precipitation	-0.0361***	-0.00416	-0.00675
	(0.0117)	(0.0120)	(0.0196)
Easement Acres x Precipitation sq	2.05e-05***	2.07e-06	5.45e-06
	(7.40e-06)	(7.28e-06)	(1.53e-05)
Outcome Mean	5.439	4.269	4.531
Observations	50,343	45,877	34,867
R-squared	0.451	0.489	0.315
Number of counties	1,878	1,768	1,722
County FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Robust standard errors clustered at the State-level in parentheses

*** p<0.01; ** p<0.05; * p<0.10

Conclusion

This paper presents novel evidence of how conservation measures have spillover effects on agricultural production. I quantify the impact of easements, both floodplain and wetland, on county level yields and risk using a TWFE model. I find that wetland and floodplain easements increase the crop yields for corn, soybeans, and wheat. I also find some evidence suggesting that easements reduce the yield risk for soybeans. I parse out the direct and indirect effect of easements by distinguishing by the original land use. I find that easing non-cropland improves agricultural outcomes. I also study the mechanisms through which easements impact production. I find evidence that easements reduce losses due to excess moisture and flooding. The lost cost ratio specific to excess moisture losses are improved in counties that see more easement enrollment. There are also less incidences of prevented and failed planting in counties with higher easement acreage. This study is a step towards a better understanding of the NRCS easement programs. Quantifying these benefits may impact how policy-makers fund future conservation efforts. Accounting for these spillover effects may also be important when considering future parcel selection into the program.

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