Environmental Recovery after the Dust Bowl: Implication of Land Policies in the Great Plains*

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June 2, 2023

Abstract

Land conservation policies, especially land restoration, take significant time to reveal any detectable effects on environmental quality. This paper evaluates farmland conservation programs in the USA from their introduction in the 1930s to recent years and captures the short- and long-term effects on environmental outcomes, such as grassland restoration and soil erosion. Using spatial and temporal variation in the policy, I use a difference-in-difference model and identify that the conservation policy exposure has increased county-level grassland restoration annually on average by 2%-8%. The treatment effect varies with initial farm size, tenancy rate, and access to irrigation. Next, I use county-level spatial variation in initial funding to examine the long-term persistent effect on cropland erosion. Using the political economy behind the funding allocation as an instrumental variable, I show that the initial conversion of land had persistent effects on county-level soil erosion in the Great Plains, even in the long term.

Keywords: Land Conservation, Agricultural Policy, Environmental Economics, Dust Bowl
JEL Codes: N52, N92, Q15, Q18, Q57, Q54

*I am incredibly grateful to Amy W. Ando for her continuous support and feedback on this project. I thank Mindy Mallory, Scott Irwin, Hope Michelson, Dominick Parker, Todd Hubbs, Rick Hornbeck, Zoe Plakias, Boleslaw Kabala, and Paul Rhode for many helpful comments. This paper has benefited from participants' comments at the Cliometric Conference, the Economics History Association Annual Conference, the SEA Annual Conference, Agricultural Policy Conference, and the AERE Annual Conference. I thank the National Archives and Record Administration at College Park, Maryland, and the National Agricultural Library for all administrative support to gain access to the archival database of the Natural Resources Conservation Service. I am also grateful to Patrick Flanagan from the United States Department of Agriculture for creating a county-level erosion database from the Natural Resource Inventory (NRI). I acknowledge financial support from the Economic History Association. All remaining errors are my own.

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1 Introduction

Many governments and international agencies have successfully executed local and global land conservation policies to reduce land degradation in recent decades (Elbehri et al., 2017; Hellerstein, 2017; Stevens, 2018).[1] The benefit of land conservation has been established in the scientific literature using various controlled experiments (Lele, 2017; Sweikert and Gigliotti, 2019). However, economic studies on the short-term effects of land conservation policies have shown mixed results concerning environmental and human welfare; and conclude that long-term studies are essential as conservation efforts may take time to demonstrate any impact on the environment (Sims and Alix-Garcia, 2017; Howlader and Ando, 2020; Robalino, 2007; Deininger, 2003). Due to a lack of adequate policy settings and relevant data to explore the policy, long-term studies remain unavailable in conservation economics. To understand the benefit of land conservation policies and to study the mechanisms by which these policies may affect different socioeconomic groups, in this paper, I assemble a unique data set from primary data sources and evaluate the USA's agricultural land conservation policies from its introduction over both the short and long term.

The long-term consequences of historical events have been analyzed by using the settings from other strands of the literature in natural resource economics and have shown that historical conditions have persistent and immediate effects on the economy (Boustan et al., 2017; Quinn, 2017; Fenske and Kala, 2017). In this paper, I document the short- and long-term impacts of land conservation policies on county-level environmental quality by following the county landscape and economy over seventy years from the introduction of farmland conservation policies in the United States. I evaluate the effects of land conservation programs by combining spatial differences across counties in the targeted conservation areas with temporal differences in the annual budget induced by the federal policy. The ideal experiment to estimate the effects of land conservation policy would be to allocate conservation areas randomly to some communities and not to others and then to compare environmental benefits and distribution across communities. In the absence of such an experiment, relying on exogenous policy variation combined with an empirical method is necessary.

This paper utilizes a dramatic change in conservation policy in the United States. I take advantage of the introduction of farmland conservation policies in the post-Dust Bowl USA counties in the 1930s. Native grassland destruction and the failure to adopt

[1] Soils store more carbon than the planet's biomass and atmosphere combined. An increase of just 1% of the carbon stocks in the top meter of soils would be higher than the amount corresponding to the annual CO_2 emissions from all fossil fuel burning (Smith et al., 2016; Turner et al., 2016; Scholes et al., 2018; Eswaran, Lal, and Reich, 2001). According to the most comprehensive analysis of global biodiversity data to date (Newbold et al., 2016; Dasgupta, 2020), biodiversity has dropped below the safe limit across 58 percent of the earth's surface due to land degradation. As a solution, land conservation policies help increase the resilience of the ecosystem (Lal, 2004; Thuiller, 2007; Webb et al., 2017).

dryland agricultural practices in the Great Plains during the late nineteenth century caused long drought and soil erosion in the 1930s, popularly known as the Dust Bowl. Almost 75% of the topsoil in some places of the Great Plains was blown away (Hornbeck, 2012; Wenger, 1941). By 1938, the peak year of the Dust Bowl, 10 million acres had lost at least the five inches of topsoil; another 13.5 million had lost at least two and a half inches. On average, 408 tons of dirt were blown away from an average acre of farmland to the next state or even beyond (Worster, 2004). As a policy response, the federal government immediately implemented comprehensive fiscal policies as part of the New Deal (Schlesinger, 2003). The first farmland conservation attempt was integrated into the Agricultural Adjustment Act of 1933 (AAA) under the New Deal. This policy served to induce aggressive farmland conversion activities together with grassland restoration in the Great Plains.

Price Fishback and coauthors established the Agricultural Adjustment Act's (AAA) implications on the local economy (Fishback, 2016). Some blamed the New Deal's land conversion and grassland restoration programs for having an ostensibly negative impact on tenant farmers in the South and leading to the eviction of low-income people from farmland areas (Depew, Fishback, and Rhode, 2013).[2] I explore a new dimension of the AAA policies to understand the short and long-term impacts on environmental restoration activities. This paper responds to existing gaps in scholarship by providing empirical evidence of the immediate effects of New Deal programs on the restoration of grassland and pastureland, as well as persistent effects on cropland erosion. Moreover, I study different potential mechanisms and heterogeneous effects across space to understand the policy's effectiveness.

Figure 1 provides underlying information. The graph shows a sharp increase in the federal farmland conservation budget in the 1930s; throughout the last century, the annual financial budget for farmland conservation has never exceeded this initial allocation. Two points to note from this figure. First, the spike at the beginning of the policy may have a persistent effect over time. The current environmental quality may well correlate with the spatial distribution of this early, initial spike. Second, the policy has always been sustained over time, albeit with different intensity and success levels across the years. The budget's annual fluctuation may have prompted immediate annual effects on environmental quality and welfare and may vary across locations. In this paper, I study these two consequences of conservation policies in the USA counties: (1) what is the persistent effect of the early conservation budget on cropland erosion? and, (2) what is the immediate annual effect of the conservation policies on grassland restoration?

The empirical strategy of this paper depends on ten states of the Great Plains and

[2] Land conservation policies in the USA have been closely tied to market pressures since the birth of the program. For more details on Farm Bills' evolution and political economy, see Coppess, 2018.

merges county-level data from archival databases with agricultural and population censuses. For my primary analysis of the program's immediate effect, I estimate the effects of the policy on the areas under different grasses for which farmers received payment in the Great Plains. Specifically, I construct grassland data from two independent sources of information. First, I use detailed raster data from the U.S. Geological Survey (USGS) to construct annual land cover databases. Second, I use agricultural census data to identify grass areas for which farmers received rental payments. Next, to study the persistent effects, I extract soil erosion variables from all available sources, including the Conservation Needs Inventory (1940's) and the Natural Resource Inventory (1982-2012).

The identification strategy in this paper uses the county-level intensity of conservation policy exposure to the land conservation programs. This land conversion policy was limited to only six commercial market crops: cotton, wheat, corn, tobacco, rice, and peanuts. To calculate the acreage of cropland reduction and conversion to grassland needed in each county, the county agents used the pre-Dust Bowl years' acreage of the eligible commercial crops.[3] To identify the causal effect of non-randomly assigned farmland conservation programs on grassland restoration activities, I follow this targeting criterion. Specifically, increased farmland conservation has occurred because the federal acreage allotment was based on six commercial crops. Using this pre-policy county-level crop intensity in the Great Plains from 1930 and the timing of policy variations at the national level, I study the average annual impacts of this conservation policy using a difference-in-difference model. I exploit this exogenous variation in historical agricultural production patterns, as captured by the 1930 agricultural census. Only the combination of the two variations is treated as exogenous. The intensity data is from pre-Dust Bowl acreage information. Thereby, its viability is not contingent on the land-use changes that occurred after the policy was introduced. The identifying assumption is that, without the policy, counties with different targeted crops would have experienced similar grassland restoration trends.

Next, I continue the empirical analysis by demonstrating the persistent effect of county-level AAA budgets on changes in the future rate of soil erosion. The post-Dust Bowl program was designed, in part, to reduce soil erosion. Notably, there is no direct proxy for soil erosion measured consistently over time. I construct data by using two available county-level information. First, the Conservation Needs Inventory (CNI) was collected in the 1940s and provides county-level data on the proportion of land needed to be conserved. Second, the Natural Resource Inventory (NRI) database on county-level soil erosion provides data that ranges from 1982 onwards. I use these county-level datasets from CNI and NRI to identify the long-term persistent impacts of the New Deal

[3] A farm's acreage allotment, under provisions of permanent commodity price support law, is its share, based on its previous production, of the national acreage needed to produce sufficient supplies of that particular crop. The United States Department of Agriculture (USDA) claimed that over 90% of the landowners agreed to reduce their farmland at the time (Depew, Fishback, and Rhode, 2013).

farmland conservation programs on soil erosion levels. However, the effect of AAA on long-term erosion levels may be endogenous due to omitted variable bias. I create exogenous crop-specific spatial variation in an instrumental variable strategy using a political economy variable to deal with the omitted variable bias from unobserved farmers' characteristics. The conservation funding was allocated to fund swing voters to nudge them into the Democratic Party for the next election (Fishback, Kantor, and Sorensen, 2005). I follow this previous literature and use the standard deviation of Democratic voters in the 1896 to 1932 elections as an instrumental variable to instrument county-level total funding under the AAA policies.

My analysis has yielded three main sets of results. First, an increase in the budget for land conservation increases areas under grassland and pastureland. With two independently- constructed datasets, I show the effects of federal farmland conservation policies on grassland and pastureland conversion. On average, I found that a 1% increase in conservation policy exposure annually explains a 2% to 8% increase in the area under grassland, depending on the spatial variation of the initial characteristics. This result is consistent across two datasets and remained qualitatively unchanged when subjected to robust viability checks.

Second, I explore heterogeneity in the context of conservation outcomes and potential explanatory mechanisms (Wenger, 1941). Little is known about the nature of the relationship between conservation outcomes and initial spatial heterogeneity: how the effect varies with background levels. I show that factors—such as agricultural tenancy, farm size, water access, and alternative occupations—can explain the variations to some degree. Also, I show that farmers respond to financial incentives and conserve less land when no financial incentives are provided. Moreover, I highlight that farmers may search for new marginal land to plant their crops; reorganization of farmland may also become an unintended consequence of the conservation program.

Third, and lastly, using the county-level total payment for AAA, I demonstrate the persistent effects of institutional changes on soil erosion. Initially, the federal government bought some marginal land, permanently, as their budget permitted. Using the initial political economy behind funding allocation as an instrument for treated counties under the New Deal, I show how the initial movement toward conversion and permanent institutional arrangements has changed the landscape forever. I found that counties with higher initial payments in the 1930s still have persistent effects on cropland erosion levels even in the 2000s.

This paper contributes to three strata of literature. Firstly, it contributes to the growing economic history literature that addresses natural resource management and environmental problems. Recent economic history papers develop insights into how current conditions are path-dependent on early historical events (Hornbeck and Keskin, 2011; Hornbeck, 2012; Libecap and Wiggins, 1984; Hansen and Libecap, 2004; Fiszbein, 2017; Banerjee and Iyer, 2005). Empirical studies have been conducted on policies related to air pollution (Cohen et al., 2017), floods (Hornbeck and Naidu, 2014), drought (Freire-González, Decker, and Hall, 2017), water management (Hornbeck and Keskin, 2014), and waste management (Alsan and Goldin, 2019). Most importantly, Hornbeck (2012) explains the long-run and short-run adjustments to environmental catastrophe – and the impacts of the Dust Bowl – by using economic data. Long-run adjustments mitigate short-run effects, and the speed and magnitude of long-run adjustments depend on the context. I contribute to this literature by providing the first evidence of how early land management and conservation decisions have changed environmental outcomes in the long term.

This paper also contributes to the growing literature on compiling new data sources and understanding the New Deal. Recently, empirical economists studied many facets of the New Deal because of detailed county-level data availability over a long period (Fishback, 2017). The main sources of identification in these papers derive from changes across time within the same geographic location after controlling for national shocks to the economy. Many studies also use instrumental variable methods to control for endogeneity. These studies explore the short- and long-term enduring impacts of the Dust Bowl on farmland and population (Hornbeck, 2012), homeownership policies (Courtemanche and Snowden, 2011), technological improvements at farms (Fishback, Kantor, and Sorensen, 2005), fiscal federalism (Wallis, 1991; Wright, 1974), unemployment (Wallis, 1991), migration (Fishback, Horrace, and Kantor, 2006), and health (Barreca, Fishback, and Kantor, 2012; Arthi, 2018). I compile and digitize new data sources and explore a new dimension of AAA.

This paper also contributes to the existing scholarship in environmental economics about land conservation that seeks to understand the impact of land conservation on environmental quality in the short term. A growing body of conservation economics research about developed and developing countries endeavors to disentangle policy impacts (Sims and Alix-Garcia, 2017; Howlader and Ando, 2020; Andam et al., 2010). These papers conclude that, while protected areas or conservation areas have had immediate effects on the environment and human welfare, it is essential to undertake long-term studies to fully understand the impacts (Baylis et al., 2016; Miteva, Pattanayak, and Ferraro, 2012). I use a historical context in this paper to understand how farmland conservation policies have affected agricultural economies over time, and explore the mechanisms by which financial incentives may create distributional consequences.

2 Historical Background

2.1 Nature of The Great Plains

As defined in this paper, the Great Plains comprise ten states: Montana, North Dakota, South Dakota, Wyoming, Colorado, Nebraska, Kansas, New Mexico, Oklahoma, and Texas (see Figure 2 for the study regions). The Great Plains consist of three physical bases for this area: almost level surfaces, treeless lands, and insufficient levels of rainfall (Webb, 1959). The High Plains may be taken as the point of departure from these characteristics; otherwise, the Great Plains are almost always semi-humid or semi-arid counties.[4]

In the late nineteenth century, population and agricultural expansion on the Western frontier started to cause the rapid destruction of native grassland in the Great Plains (Webb, 1959). On top of that, World War 1 increased the demand for wheat in Europe. In the face of heightened demand for crops and encouraged by the Homestead Act, farmers continued to uproot native grassland from the Great Plains regions and sought marginal land in the plains to plant wheat. Grassland is an essential component of the Great Plains ecosystem, and this commercial farming method disturbed the organic ingredients of the soil. This grassland destruction led to one of the biggest human-made natural disasters, commonly known as the "Dust Bowl" (Schubert et al., 2004).[5] Drought and wind erosion are vital parts of nature in the Great Plains, but continuous drought in the 1930s – coupled with grassland destruction – converted the landscape into a desert. In 1934 and 1936, there were massive crop failures due to continuous drought and sandstorms. This continued throughout 1938 and ended after 1940 when rainfall returned.[6]

2.2 Federal Conservation Programs

In the 1920s, after the First World War, discussions about methods of farmland conservation started to take place at the federal level. Soil scientist Hugh Hammond Bennett suggested possible solutions to reduce the levels of soil erosion, and the context of the economic depression of the 1920s helped him to argue that the issues of excessive

[4] According to JW Powell, the 100th meridian or 20-inch rainfall line defines the climatic variation in the Great Plains (Stegner, 1992). Land in such areas cannot be approached using the same farming methods employed on the East coast or European countries from which homestead farmers had departed for the Plains. The native short grasses in this area naturally hold water in the soil and control wind erosion by keeping the soil on the ground.

[5] I extracted information on the erosion intensity from Hornbeck, 2012, and presented the maps in the Appendix (Fig B6- Fig B8)/

[6] A newspaper reporter gave the Dust Bowl its name. Associated Press reporter Robert Geiger opened his April 15, 1935, dispatch with this line: "Three little words achingly familiar on a Western farmer's tongue, rule life in the dust bowl of the continent—if it rains." With a couple of weeks, the term had entered the national newspapers.

supplies of commodities and soil erosion could simultaneously be addressed by taking marginal land out of production (Bennett, 1928).[7] However, no actual policies were adopted until the next election in 1933. When several droughts hit the USA in the 1930s, and no ground cover was left to stop wind erosion, most regions lost more than 75% of their topsoil.

Franklin D. Roosevelt was elected in 1933 and, in the first 100 days of his presidency, he established the Agricultural Adjustment Act (AAA, popularly known as the "First New Deal"). The Department of Agriculture undertook an extensive soil survey in 1933 known as the Reconnaissance Soil Survey to implement reductions in harvested lands.[8] Land Utilization policies (purchasing sub-marginal eroded farmland) were significant components of the Agricultural Adjustment Act of the New Deal in 1933. The initial program was designed to buy all sub-marginal lands permanently. However, budget constraints and opposition from farmers prevented that plan from being implemented. Though the federal government still purchased a portion of the sub-marginal land, the Forest Service converted that to grassland (Hurt, 1985). Other than that, farmers were encouraged to put grasses back in their farmlands.[9]

To implement this, adhering to a significant provision of the New Deal, the federal government entered into short-term contracts with landowners to limit production. "Voluntary Acreage Reduction" was a complicated policy but may broadly be understood as a mechanism by which farm owners were paid in return for pledging not to produce or to remove acreage from materials and production. National marketing quotas and acreage allotments had been established for corn, cotton, wheat, tobacco, rice, and peanuts. The Supreme Court decided the AAA as unconstitutional in 1936. Congress passed new agricultural legislation, and the payments were still conditional on farmland conversion to soil-conserving grassland and crops in the Great Plains under the new Soil Conservation and Domestic Allotment Act, 1936. The federal government set an annual national target for the total maximum cropland of these crops. Farm prices were to be pegged to the farm population's purchasing power in 1909-1913, and millers and processors would pay for much of the program's cost. Importantly, Voluntary Acreage Reduction was applied to only some commercial crops – those for which prices were low: wheat, corn, cotton, peanuts, rice, and tobacco. At the USDA, the Farm Security Administration designed an aerial survey to detect the land to reduce

[7] In 1931, the first Land Utilization conference occurred in Chicago; the conference's key policy suggestion was to buy 75 million acres of marginal farmland and convert to better land use (e.g., forest or grassland).

[8] "The history of every Nation is eventually written in the way in which it cares for its soil." - Franklin D. Roosevelt on signing the Soil Conservation and Domestic Allotment Act, 1936.

[9] For example, a Kansas agricultural experimental station released a bulletin to re-establish grasses using the hay method (Hornbeck, 2012). The hay method was developed in 1937 to increase pasture in croplands. It was widely accepted that pastureland is better than cropland for the ecosystem of the Great Plains. Agricultural experiment stations and the Soil Conservation Service (SCS) encouraged farmers to shift land from wheat into hay and pasture (SCS).

cropland (Weems, 2004).

Allotments were not continuously operating for each major crop. When these laws were in effect, the national acreage allotments were divided among the states producing the commodities. The state allotments were then divided among the counties, and local committees apportioned the county allotments to individual producers.[10] County extension agents were responsible for implementing the local allocation of farmland reductions. The payments to farmers involved in the program depended on the expected yield from that land, which county agents calculated based on past yield.[11] Acreage reductions ranged from 25% to 50% of the previous year's acreage. Under the AAA, farmers could refuse to accept payments, but most farmers agreed to reduce cropland. I collected data from the National Archives on county-level payments from the most affected state by the Dust Bowl (RG 114). [12]

The conservation policy in the 1930s was the beginning of many later conservation policies. Subsequent policies were also implemented to reduce cropland and increase soil conservation bases (Bruton, 1933; Depew, Fishback, and Rhode, 2013). This initial budget allocation facilitates institutional change by creating Farm Bills, hiring extension agents, and creating Soil Conservation services. The subsequent Farm Bills also included similar laws that sought to further the idea of reducing commercial crops. The following couple of popular Farm Bills were the Set-Aside program in 1957, the Farm Bill in 1985, and the Farm Bill in 1996. The Farm Bill of 1985 introduced the next massive farmland conservation program, the Conservation Reserve Program.

The Soil Bank Act of 1956 authorized short- and long-term removal of land from production with annual rental payments to participants with the Acreage Reserve Program and Conservation Reserve Program (Coppess, 2018). This act was similar to earlier AAA policies. The Acreage Reserve Program was implemented again for wheat, corn, rice, cotton, peanuts, and several types of tobacco. The Conservation Reserve Program allowed producers to retire croplands. The Soil Bank Act was canceled by Section 601 of the Food and Agriculture Act of 1965 (P.L. 89-321). The Conservation Reserve portion of the Soil Bank was a model for the subsequent Conservation Reserve Program (CRP), enacted in 1985. To study the effects of the AAA, this paper focuses on

[10]Figure 7 plots the discontinuity of the annual program.

[11]The 1936 policy was used to control some specific crops' supply to put upward pressure on the price. The Secretary of Agriculture had the power to specify the price targets and the crops to control and how much acreage to set aside; those crop-specific decisions depended on many factors including, foreign demand, domestic consumption, and domestic stock. The USDA needed to have a significant employee base to implement the acreage limitation. More than 3,000 county agents and 100,000 local people from farming counties worked with farmers to take the desired amount of cropland out of production. The land retirement decisions depended on the local county agents who calculated the retirement payment rate from past cropland productivities. Local county agents were responsible for determining the base year yields for farmers with the help of historical county-level average yield data.

[12]Figure 12 shows the correlation between payment per acre and crop intensity in 1930. This indicates that the initial crop intensity strongly determined payment.

the pre-1985 years.

3 Conceptual Framework

The Dust Bowl changed the federal budget in a discontinuous fashion. After the initial jump in the budget allocation, the policy's intensity significantly decreased throughout the century (Fig-1). The initial spike in the budget in the 1930s included the initial push in funding for better topsoil bases after the Dust Bowl's disastrous effect. Later, farmland conservation policies continued to pay farmers for topsoil conservation activities, but the payment rate was lower. In this paper, my main objective is to track the persistent effect of this initial structure and see the immediate results of the policies using an annual budget variation. In this section, I use a conceptual model for an individual farmer's investment in environmental quality to understand the differences between the persistent and continuous effects of the federal policies and identify the sources of such variation.

For a farmer, the objective is to maximize the discounted stream of attainable profits with an input package, Z and grassland, G. The production function is denoted by f. The unit cost of production is C. We assume that the post-Dust Bowl policy shifts happened from the time t_0 to t_1. We expect a shift in the production function because of this shock, and we denote this production function as f^1. This production function is a function of the initial spike; the policy's spatial variation determines the effect. After t_1, the policy slowed down, and there may still be annual effects from the policy. This creates an optimal change in the production function during the period t_1 to t_f. We change the production function from f^1 to f^2 to denote these changes in the annual budget and opportunity cost of grassland restoration. Farmers will participate if the discounted expected profit is higher than the discounted expected profit from non-participation. In characterizing the relative adjustment with time, assume that a farmer chooses input decisions in every period to maximize the present value of profit.

f^1 and f^2 are two possibly different objective functions at two different periods, and ϕ is the cost of changing the state equation from f^1 to f^2 at t_1. There is a cost affiliated with per unit production, and farmers receive a rental payment based on the acreage under soil conserving grasses. The initial push for a soil base also limits the available land for the second period.[13]

We expect a persistent change in the grassland areas because of this timing: that is to say, policy-induced significant changes in the institutional framework, t_0 to t_1. After t_1, the policy slowed down, and there may still be contemporaneous effects from the yearly variation in the policy. After the Dust Bowl, at any point in time, t, acreage under soil

[13]The detailed mathematical model with a dynamic optimization framework is in Appendix A.

conserving grasses is a combination of persistent effects from the 1930s and the annual impact of that year's budget. The farmer's investment decision is time-dependent; there are four possibilities as described in Figure 2.

Firstly, the event's initial impact does not degrade; later annual funding also has a non-durable impact. At any given point in time, environmental variables will comprise both the persistent and the immediate effects of the soil conservation budget (Panel (a)). The result primarily depends on the policy implementation criteria, such as initial crop intensity. Secondly, with no persistent impact from the event, grassland is only maintained by flows of annual funding. At any given point in time, we can only see the immediate yearly effect of the conservation budget (Panel (b)). This may happen if the initial allocation does not change the landscape. Thirdly, if farmers do not conserve the land anyway, there will be no impact from the farmland conservation policies (Panel (c)). Fourthly, the initial spike had a persistent effect, but later, funds were ineffective (Panel (d)). In time, the Dust Bowl experience may fade away, and farmers will no longer respond to the policy incentives.

Section 5 empirically examines how farmers decide soil-conserving grass restoration over time and how these persistent and annual effects of the initial institutional changes and continuous subsidies affect the landscape. After the initial shock, at any time, land allocation changes only at the intensive margin, depending on the annual variation in the federal budget. The critical insight from this framework is that, prompted by the initial allocation, there may be a persistent impact on the landscape. The first-order condition and optimal annual grass restoration depend on how the farmer's yield function changes with land restoration and how the federal budget affects land restoration. The results vary over space depending on the spatial variation of the initial crop intensity, the farmer's capacity to adjust the land to optimize production (farm size, tenancy), and other geophysical constraints (availability of irrigation). A farmer's knowledge of soil conservation also plays a vital role in the production function. Furthermore, federal funding allocations may depend on spatial variations in political variables.

4 Data Construction and Baseline Characteristics

4.1 Data Construction

I have constructed a panel of 824 counties of the Great Plains by using 70 years'-worth of data on environmental outcomes, average farm characteristics, average farmers' characteristics, and county and geographic control variables. I have constructed this data primarily from the Natural Resource Conservation Service data archives at the National Archives at College Park (NRCS, RG 114). I also use data from the USDA agricultural census, the population census, and the USDA marketing statistical books.

Historical county-level datasets have been drawn from the United States Census of Agriculture and the Census of Population (Haines, 2005). I use counties in the ten states of the Great Plains: Montana, North Dakota, South Dakota, Wyoming, Colorado, Nebraska, Kansas, New Mexico, Oklahoma, and Texas (study area is shown in Fig-2). The empirical analysis uses a balanced panel of plain counties from 1925 to 2000. For the annual effects, I have restricted the study period to the introduction of the Conservation Reserve Program in 1985. [14] Data Appendix presents the variable names and corresponding data sources.

To ensure that we have consistent units of observation over time despite the changes to county boundaries, I have adjusted all data according to the ICPSR standard boundary from 1910 (Haines, 2005). I have drawn historical county-level population data, including racial composition, from the Census of Population (Haines, 2005). The population census is conducted every ten years. I have redacted information on Indian Reserves and Yellowstone National Park from the county-level data for consistency.

I have used two sources of information for environmental outcome variables. First, I have used data from the agricultural census, which gives me a complete picture of county-level agricultural evolution in the USA. The USDA agricultural census asks for information on different soil-conserving grass acres at the county level. The grasses include hay; tame, cultivated grasses; timothy; clover; alfalfa; and wild, salt, and prairie grasses. I include the soil-retaining grasses for which the USDA paid the farmers from each agricultural census. Second, the other source of information is provided by the U.S. Geological Survey, named the "Enhanced Historical Land-Use and Land-Cover Data Sets (1938 – 1992)" (Sohl et al., 2016). Historical LULC is a polygon-format raster database that gives annual information on grassland and cropland. I have constructed an annual area under grassland/pasture from this raster database.[15]

To gauge the persistent impact of the policy, I use erosion data from two sources of information. For the pre-1982 period, I use the Conservation Needs Inventory (CNI) data at the county level from the CNI reports collected in the 1940s (Harlow and T, 1994). I manually extract this information from state Conservation Needs Inventory reports published by USDA. The reports have information on county-level needs for conservation areas and have been collected in the 1940s and 1950s for some states. The reports are available only for five states in the Great Plains: Kansas, Nebraska, Oklahoma, New Mexico, and South Dakota.

[14] The Farm Bill, 1985, created the Conservation Reserve Program, which permanently retires land for conservation purposes. I have limited the study period to the time before 1985 to gauge other early conservation programs' effects.

[15] Researchers at the US Geological Survey have used a wide range of historical data sources and a spatially explicit modeling framework to model spatially explicit historical LULC change in the conterminous United States from 1992 to 1938. Annual LULC maps were produced at the 250-m resolution, with 14 LULC classes. Assessment of model results showed good agreement with trends and spatial patterns in historical data sources such as the Census of Agriculture and historical housing density data.

Next, for the post-1982 era, I use county-level cropland and pastureland erosion data from National Resource Inventory (NRI). NRI is a panel data for the period 1982 to the current years (Schnepf, 2008). The USDA Natural Resource Conservation Service has collected this erosion data on the same geographic location for the whole country. This data provides information on wind-induced soil erosion for both cropland and pastureland. I use this data for recent years to show the persistent effect of AAA on cropland erosion. This data is methodologically consistent after 2000, so I use data from multiple years after 2000. To compare with CNI, I focus on the same five states: Kansas, Nebraska, Oklahoma, New Mexico, and South Dakota. To see AAA's impact on future land conversion levels, I also use county-level acres under the Conservation Reserve Program (CRP) in 1990 and 1995. County-level database on CRP has been extracted from the Farm Service Agency reports. This is a county-level data of cumulative enrollment of CRP by fiscal year.

My main source of variation is coming from policy timing and spatial heterogeneity in the policy. To understand the federal conservation policy intensity and timing, I have collected historical USDA annual statistical books to obtain data on the annual acreage allotment of crop production.[16] I have manually collected this data by year and crop (Figure 7). Furthermore, I have collected and digitized Land Utilization and Conversion maps from the National Archives to construct a targeted conversion index for the Great Plains counties. Jacks (2013) is the source of world commodity price data. The Soil Conservation budget from 1935 to 1985 comes from the USDA. I have drawn on the county-level total expenditure for the AAA from Fishback, Kantor, and Wallis (2003). This dataset has information on the federal spending by the New Deal programs, aggregated over the years from 1933 to 1940, and was collected from the Congressional Budget Office. This data gives information on various projects under the New Deal (e.g., relief plan, home loan, etc.).

Furthermore, I have collected information from federal documents on the annual soil-conservation budget of the USDA. I have collected maps that show the land conversion plans for 1935 from the National Archives. Moreover, I have collected yearly federal marketing quotas by crops from marketing statistics data books. I have also collected county-level rental payment data from the agricultural reports from the National Archives at College Park.

Information on crops, farms, and farmer characteristics have been extracted from the USDA agricultural census (Haines, 2005). This county-level information is provided every five years and is designed to be representative. The main variables of interest include total farmland, total harvested acreage, average farm size, number of tractors, size of the farm population, and the share of land planted for targeted program crops: rice, peanuts, corn, cotton, tobacco, and wheat, the proportion of non-farm owner-

[16] I manually extracted this data from the HathiTrust.

operators, the percentage of sharecroppers and cash tenants, black farm population, non-farm jobs, and farm labor expenditures. I also use the population census to extract county-level data on total population and racial decomposition. I have constructed a measure of crop intensity from the agricultural census using crop area and total farmland. Figure 6 displays the spatial variation in crop intensity before the Dust Bowl (in 1930).

With this detailed information on land use, federal policy, and economic variables, we are henceforth able to estimate the conservation policy's effect on land-use changes and environmental outcomes.

4.2 Baseline Characteristics and Spatial Patterns

Table 1 reports the county-level summary statistics from the agricultural census. The total harvest area drops significantly after 1940. The average farm size rises after 1940. This happened because of the consolidation process of farms after the Dust Bowl, and the result section discusses more on this adjustment. As the racial composition suggests, the Great Plains have always been white-dominated areas. Though popularly known as a continuous population decline in the Great Plains, on average, the population is not drastically fluctuating. The percentages of cotton, corn, and wheat – all three main crops – dropped in 1930 and 1950.[17]

Figure 4 maps farmland designated unsuitable for crop production, based on the soil survey in 1934 and has been used as proposed land to convert to soil-conservation areas. I obtained this map from the National Archives at College Park (RG 114) and digitized it to detect the areas for conversion in the Great Plains. This map helps us understand spatial patterns in the actual need for conservation. The shaded area represents the USDA estimated area that would be appropriate for conversion from farmland to grazing (grassland), forest, and a mixture of grassland and forest. We see that these areas are concentrated in some High and Low Great Plains states. The spatial pattern also exists for places that have been permanently bought in the early conservation years in the 1930s. Figure 5 maps the permanently bought areas that USDA converted to national grassland before shifting to temporary land retirement incentives.

To understand the source of spatial pattern in these targeted areas, we can see Figure 6. Figure 6 maps the spatial variation in cash crop intensities in the 1930s. I constructed this crop intensity data from the Census of Agriculture collected in the 1930s. USDA targeted six market crops to convert cropland to grassland, and the spatial variation shows this pattern. As expected, cotton areas were concentrated in Texas. Wheat areas were spread over all the states in the Great Plains, including some of the marginal areas. We can see the strong correlation between wheat areas and proposed

[17] For more information on summary statistics by year, see Appendices.

conversion areas in Figure 4. I digitized this map to extract information on county-level area under "unsuitable". The correlation coefficient between wheat intensity in Figure 6 and county-level area in Figure 4 is .1103. We may expect that the grassland conversion was mainly driven by wheat cultivation. Empirical strategy deals with the crop variation to explore this.

To understand the policy, we also need information on the acreage allotment. Figure 7 presents the annual crop acreage allotment by crops (in thousand acres). I manually collected this information from the USDA-provided market acreage allotment and agricultural statistical books. The graph shows the highest amount of land that the USDA wanted to have planted in each of the six program crops each year; payments would encourage farmers to take excess acres out of production and convert them to more environmentally friendly grasses. The data also show that the program was not active during some years, primarily due to war. I use this information to see how the discontinuity of the program affects land conservation activities.

I have also created figures with aggregated trends of essential variables used in my analysis. Figure 8 shows the aggregate changes in the Great Plains' total farmland (acres). Figure 9 disaggregates total harvested land by crops. We can see that the Great Plains had three main crops: cotton, corn, and wheat. All crops have experienced a sharp reduction in acreage from 1930 to 1940 and then slowly increased.[18] The purpose of this paper is to understand the implication of conservation policies on the area under grassland, pastureland, and other soil conserving grass areas.[19]

5 Empirical Framework

This section develops econometric strategies to estimate the parameters of interest in the conceptual framework in section 3. Firstly, what are the annual effects of farmland conservation policies on grassland restoration, measured by area under grassland and pastureland? Secondly, what are the persistent results of the initial conservation budget on future soil erosion, measured by cropland erosion and cropland under conservation treatment needs?[20]

[18] I also extracted information on planted acreage by crops from the National Agricultural Statistics Service (NASS). Figures with aggregated changes in planted crops are available in the appendix (B3 and B4). NASS data is available only for selected counties.

[19] Figure B1 and Figure B2 in the appendix show the evolution of grassland and hay land in the Great Plains.

[20] Agricultural census provides data only at county level. We cannot explore the spatial variations below county with this data limitation.

5.1 Contemporaneous Impact of the Farmland Conservation Policies

For a causal identification of the policy's immediate annual effects, the empirical analysis closely follows some previous papers that also study the continuous impacts of historical events.[21] Firstly, Hornbeck(2012) examines the long-term economic effects of the Dust Bowl and uses a difference-in-difference analysis using initial soil erosion levels, and finds that Dust Bowl had a long-term impact on the Great Plains' economy. Secondly, Acemoglu, Autor, and Lyle (2004) use a difference-in-difference setting to understand the effects of war-induced male labor supplies on levels of female labor employment (Acemoglu, Autor, and Lyle, 2004). My identification strategy closely follows this last paper. I use pre-Dust Bowl crop intensity with the annual federal conservation budget as the continuous treatment variable to see the national policy's effects on local-level grassland restoration.

As Section 2 explains, the policy exhibits spatial variation depending on the targeted market crop intensity.[22] I identify the causal effects of conservation policies on the size of the grass areas by exploiting the timing of budget and the spatial variation in the initial county-level targeted crop intensity. Federal decisions about implementing land conversion payments to keep acreage below a national allotment closely follow national factors such as the timing of wars or world market prices. The timing of the policies is likely to be exogenous to county-level decisions on grassland acreages. I use a continuous variable of the annual federal-level soil conservation budget to match with the continuity of the time variation. The idea behind this estimation is to interact federal budget decisions with initial county-level crop intensities to obtain a proxy of county-level proportions to the budget flows. The equation to be estimated is:

$$ln(G_{ct}) = \alpha_c + \beta B_t + \gamma(\text{Treated Crop Intensity})_{c,1930} * B_t + \rho X_{ct} + \epsilon_{ct} \quad (1)$$

where c indexes county, t indexes year, G_{ct} is the grassland proportion of total land in any county in year, t, α_c is the county-specific fixed effect, B_t is the federal budget for soil conservation (Figure-1) in a year, t. X_{ct} is a set of county-level control variables, and ϵ_{ct} is the error term. The coefficient of interest is γ, corresponding to the interaction term between the annual conservation budget and county-level crop intensity in 1930. To save on terminology, I refer to this interaction term as "county conservation exposure rate" or "exposure" in short. The coefficient captures whether counties with higher crop acreage in wheat, corn, cotton, tobacco, peanut, and rice in 1930 experienced a higher increase in grassland acreage during high land conservation budget years.

[21] Referring back to the conceptual framework, this corresponds to the impact on the intensive margins (Figure 2).

[22] I have used the county-specific rental payment data to show the correlation between rental rate per acre and crop intensity. Fig-12 shows that rent and crop intensity positively correlate, as expected.

The identifying assumption is that counties with different baseline levels of program crops would have changed the same after the 1930s if not for the Voluntary Acreage Allotment (grassland conversion) policies. The annual budget variation and the county crop intensity jointly determine a county's exposure to the conservation program. This is the parallel trend assumption. In the regression estimating equation, this must hold after controlling for differential changes over each period correlated with states and include pre-1930 characteristics. Evidence of the existence of parallel trend is presented in Figure 12 and Table 3.

Figure 12 shows the pre-differences in county grassland areas by different levels of crop intensity. I use 1930s agricultural census data to divide crop intensity into high, medium, and lower crop intensity counties. We see that high, medium, and low-intensity areas have a different but parallel level of grassland areas before 1935. However, we also see that after 1935, there were different levels of growth in grassland areas over these areas. [23]

This result is also presented in Table 2 within a regression framework. I regressed total grassland areas on crop intensity in 1930 before the policy using the pre-1935 Agricultural Census data. We see that before 1935, the medium and low-intensity crop acres were not different from high-intensity areas with grassland restoration over time.

5.2 Persistent Impact

Next, the empirical analysis explores the persistent impact of early conservation policies on future soil erosion. Referring to the conceptual framework, this corresponds to Scenario A (panel (a)) in Figure 3, where we expect early policies to have a non-degrading impact over time because of permanent institutional changes that have been made after the Dust Bowl. The empirical framework closely follows previous papers that also study the persistent effects of historical events. Firstly, Fiszbein (2017) examines the persistent effects of early agricultural diversity on later economic growth by using initial crop potential yield as the instrumental variable (Fiszbein, 2017b). Secondly, Banerjee and Iyer (2005) find that historical property rights institutions lead to persistent differences in economic outcomes (Banerjee and Iyer, 2005).

I have used the county-level area under "conservation treatment needed" data that I extracted from Conservation Needs Inventory (CNI) reports.[24] This is my outcome variable from the 1940s. Next, I use county-level cropland erosion rate data as the outcome variable for recent years. This data is available from 1982 from Natural Resource

[23]In the regression model, I use continuous treatment variable to pay attention to the actual funding allocation. However, I used binned data to divide intensity into medium, high, and low crop intensity areas for visual inspection of parallel trend.

[24]CNI reports were collected in the mid-40s to capture the conservation needs by county. This is the only available conservation data before the 1980s. I collected these reports for states and used them as an outcome variable.

Inventory. I use county-level total AAA payment as the independent variable and this payment is a county-level summation of funding from 1933-1940 (Depew, Fishback, and Rhode, 2013). This is the money landowners receive from the government to convert their land to soil conserving grasses.

To see the persistent environmental impacts of conservation policies, I estimate OLS equations,

$$ln(E_c) = \alpha_0 + \alpha_1 (\text{Total AAA Payment})_{c,1930} + \alpha_3 M_{c,1930} + \epsilon_c \tag{2}$$

where c denotes county, s denotes state, E is county-level CNI and cropland erosion, and all are at different future points of time $(t > 1940)$. I include several control variables; (M_c),1930 is a vector of initial conditions. ϵ_c is the error term. $(M)_{c,1930}$ includes the log of total population, permanent conversion area size, and total crop intensity.

The coefficient α_1 captures the effect of early conservation policies on later erosion levels. Given the skewed distribution of total AAA payments, I use the natural log of this variable. This estimation is cross-sectional, so monotonic transformation to logarithm does not represent growth in the variables. The sample is balanced in every regression.

As Fishback, Horrace, and Kantor (2006) mentioned, this regression may have been omitted variable bias as AAA payment may be correlated with the future erosion level with other channels. These analyses can be biased by the unobservable related to farmers' attitudes toward soil and land conservation. For example, there can be bias from reverse causality if farmers jointly decide on cropland conversion and soil management activities based on their ability. For that purpose, I use an instrumental variable (IV) presented in Kantor, Fishback, and Wallis (2013), and used in many political science papers related to the government relief. I have used a county-level spatial variation of democratic swing voters measured by the standard deviation of democratic voters in elections from 1896 to 1932. I extracted this data from Kantor, Fishback, and Wallis (2013).

This pre-policy political variable partially determines how much AAA funding will be allocated in a county. This IV is correlated with AAA payment, as the government decided the amount of money depending on the voters' characteristics. Figure-13 presents this correlation between swing voters and allocation of funding through AAA policies. This IV is not correlated with farming characteristics or environmental factors.

6 Results

6.1 Effects on the Grassland and Pasture Areas

I begin by estimating a simple difference-in-difference model for total soil conserving grassland following regression equation 1. Table 3 - Table 6 present the main results. I derive total grassland using the USGS Historical Land Cover and Land Use Data (Table 3 - Table 4) and the Census of Agriculture (Table 5).[25] Data used in Table 3, and Table 4 are continuous annual data. Data used in Table 5 is extracted from the agricultural census and collected every 5 years. I match the data with the annual USDA budget lagged by one year for temporal variation. The coefficients measure whether counties with higher exposure to conservation budget on average experienced a more significant increase in grassland area.

6.1.1 Main Results

Table 3, Column 1, reports the estimated average impact of the annual farmland policies on grassland area per county. Column 1 uses full data spanning over 50 years from 1935 to 1985. We see that for the wheat exposure counties, the growth rate of the grassland area was significant and 3.96% higher for 1% higher exposure to conservation budget. For cotton intensive counties, the grassland area is statistically insignificant but still 1.45% higher for 1% higher exposure to conservation budget. For corn-intensive counties, the growth rate of grassland areas is statistically significant and 3.06% high for a 1% higher conservation budget. Grassland areas were significantly growing for wheat and cotton areas in the Great Plains considering full data, as shown in column 1.

However, the farmland conservation budget varies significantly over decades. To understand the effect of this policy variation, I present the results for every decade. Column 2 to Column 5 report the estimated impacts of the AAA on grassland acres in each decade. Column 2 shows that in the first decade before 1950, the grassland area growth rate for counties with high wheat intensity was 6.61% higher for 1% conservation budget exposure. Column 3 shows the effect is significant 8.32% higher for 1% conservation budget exposure before 1960. However, in the 1970s and 1980s, the result is lower than before and 5.61% and 4.1% growth rate for 1% increase in conservation exposure.

In the first row, the effect of wheat counties over decades follows directly from the graph in Figure 1. We can see that the budget for conservation was high in the 1940s and the 1960s. However, after the 1960s, the budget dropped until the 1980s. The effect of this drop in funding is visible on the grassland area in Column 2 to Column 5.

[25]To save space, other graphs using Census of Agriculture are in the Appendix (Table A(1)).

Now, in counties with cotton exposure, the effect of the conservation budget is insignificant but positive in this regression model. The estimates are highest in the 1960s and a nominal 9.69% growth rate. However, in the 1970s and 1980s, the result is again low as 1.45%. Cotton counties are mainly only in Texas, and not a main crop for the whole Great Plains.

Alternatively, we see that the growth of grassland areas in the corn-intensive counties is 5.38% for a 1% increase in conservation budget exposure in 1950. However, the effect drops to .08% by the 1960s and is insignificant. The result is significant for the 1970s and 1980s, and the growth rate is 1.5% - 3.07% for a 1% increase in the conservation budget exposure. Corn was the second most important crop in the Great Plains for this period, and the conversion rate was also higher than cotton, and closer to wheat. In general, we can see that the effects were concentrated in the first decades when the conservation budget suddenly increased. Memories of the Dust Bowl also helped farmers to decide for conservation areas. Later, there were alternatives to grassland for soil moisture with the technical changes through irrigation activities. We will come to this discussion later.

Table 3 reports estimates with a generalized difference in difference model using panel data. However, this is a static panel data model. However, past year's grassland restoration areas may affect future growth of grassland restoration. I present estimates using a dynamic panel data model by the Arellano-Bond estimator in Table 5. I use the Arellano-Bond method instead of including a lagged dependent variable as a regressor in the model as that violates strict exogeneity. In this method, the first differences of the regression equation are taken, and lags of the dependent variable are used for differenced lags of the dependent variables.

This result is presented in Table 4. The estimated effects in Table 4 are qualitatively similar to Table 3. For the full dataset, the grassland growth rate is significantly high for wheat intensity areas, and the effect is 6.3%. Over decades, there have been significant changes, and the result is higher than the pre-1960s. We also see similar impacts on corn counties that vary over decades. For corn counties, the effect is 10.4% for the full data. However, we see a negative growth rate for cotton counties, around 4.3%.

In Table 5, I present results using grass areas data from the USDA agricultural census. Again, we see that the effective growth rate is highest for wheat counties, and the effect is highest before the 1960s. The growth rate is significant, and for the complete data, it is 2.22%. We can only see farmers' activities from the agricultural census and cannot follow counties where the federal government permanently bought the land. This creates some differences in the results in Table 3 and Table 5. I also present results with decadal panel data in the Appendix Table A1.

From all these regressions, in general, we can conclude that the wheat counties saw a significant growth rate of grassland restoration and the effects varied with the financial incentives from the federal government. Corn counties also went through a similar grassland restoration trend.

6.2 Robustness Checks

I also use two ways to do two placebo tests to present evidence for the identification strategy. First, I use a non-targeted crop in the 1930s AAA policies, oat, to estimate the growth rate of grassland acres for oat-intensive counties. We see that other than the targeted crops, oat does not show any positive effect on grassland. The results in Column 1 of Table 6 show that grassland area is actually decreasing for oat-intensive areas. There were places where farmers planted other crops against targeted cropland conversion. Later, the federal government started including some of these crops in the conversion list.

Second, there are many years without any allotment funding (because of wars and other financial shock). I use these budget cutoff years to see if farmers continue to plant grasses in years without federal subsidies. For the years with no funding for farmland conservation, we see that the effects on the grassland area are always adverse. These results are presented in Column 2 of Table 6. These results show that farmers depend on federal subsidies to conserve their land. The ecological heterogeneity may come from this subsidy dependence.[26]

6.3 Mechanisms and Heterogeneity

The conceptual framework and past theoretical models identify several other factors that could create heterogeneity in the outcome variables over space and initial conditions. I explore heterogeneity in the treatment effects by using the initial characteristics that may affect farmers' production decisions and investments in environmental quality methods, activities, and projects. Heterogeneity may arise from multiple sources. I examine the heterogeneous treatment effect from initial farm size, initial percentage of tenancy, initial racial decomposition, initial access to irrigation, and initial non-farm jobs. I also explore several other spatial differences in the estimates.

Historical literature suggests that land-use adjustment barriers include excessive tenancy rates, credit access, access to irrigation, and farm size (Wenger, 1941). To estimate the impact of the factors that may affect land use adjustment, equation 1 is modified to examine heterogeneity in the response. I use a triple difference regression model and interact these variables with the treatment variable, conservation policy exposure. The analysis focuses on variation in the baseline characteristics extracted

[26]Budget cutoff years are presented in Figure 1 in the Appendix. I present results with different other regression specifications in the Appendix. The results are qualitatively similar.

from the Agricultural and Population Census in 1930. Table 7 presents these results.[27]

Column 1 of Table 7 reports the estimated effects of growth in grassland through initial farm size. I define "small farms" as 0 acres to 1000 acres, "Medium farms" as 1000 acres to 5000, and "Large Farms" as 5000 acres and above. With a heterogeneous treatment effect model where I interact initial farm size with the treatment variable, Column 1 reports that medium farms have a significant 16.9% higher growth rate of grassland areas for wheat-intensive counties than small farm sizes. Alternatively, large farm sizes show an insignificant but positive growth rate compared to small farm sizes. Also, medium farms have a significantly higher grassland area growth rate for corn and wheat counties. We do not see significant differences between medium and large farm sizes for cotton counties. [28]

This is aligned with our theoretical production model. Farmers with bigger farms have better chances to set aside some land for grassland restoration. Small farms have lower access to production capital and, thus, may not fully utilize the incentives to convert cropland to grassland. Farm size is a proxy of a farm's capacity, and this relationship may shed light on the flexibility of farmers to shift land to grasses. Small farms do not have enough capacity to put land aside from crops. This also corroborates the findings of Hansen and Libecap (2004). This result has policy implications on how policymakers may need to provide differential incentives to small farmers to adopt land conservation policies.

Next, we explore the implication of agrarian institutions, such as the proportion of farmers under tenancy contracts. Column 2 of Table 7 presents results for the tenancy barrier. We see that high tenant counties have a lower grassland growth rate than low tenant counties; however, this is insignificant. Property rights may play a role in decisions about long-term conservation activities. Tenants have been a solid barrier to decisions to adopt conservation programs in the Great Plains because the duration of tenancy contracts is primarily short-term. Any land conservation decision takes time to show up on the soil, and tenants have lower incentives to take the conservation programs. In the Great Plains, absentee landlords were another problem in making decisions for better land quality in the long term. This effect is highest in cotton areas, as cotton areas had the highest rate of tenants. However, the estimates are always insignificant.

Column 3 presents results for black owner farms, and we see that the black-owned farms have a higher percentage of growth rate in wheat counties. Column 4 presents results for initial irrigation areas, and Column 5 presents results for initial non-farm workers. For these 2 columns, we do not see any significant changes. Irrigation in

[27] Some results are in Appendix to save space.

[28] Largest farms in the Great Plains were mostly managed by third parties and had absentee landowners. That may affect the results.

the 1930s was a smaller fraction of total farm area; however, this situation changed over years because of the access to groundwater. The next section studies the access to groundwater.

Similar results are shown in Appendix Table A2 using Agricultural census data, and the results are qualitatively identical. However, some results have significant changes with this data. For example, access to non-farm jobs in wheat counties shows a significantly higher growth in grassland areas in this table.

6.4 Adjustments

The benefit of the grasses may be overstated because of the channels that may influence farmers to make decisions about environmental quality. Given the policy period, I also check if other variables have been affected by the policy that may hinder the effects of the policy on ecological outcomes. Table 8 presents this result. Along with AAA policies for conservation, there was active pressure from the USDA to change demography and farm size in the Great Plains. For example, farm consolidation over the years increased farm size. Also, there was pressure to decrease the number of tenants. There could also be a change in harvest area if people convert crop plants to grassland and find new land to harvest.

Column 1 reports that population growth is lower in wheat and corn intensive counties, but the estimates are insignificant. This is similar to Hornbeck (2012) where he has shown that people move out from places in the Great Plains, but rehabilitation was mainly in the same states. There is also a possibility that farmers may try to find more unsuitable land to cultivate crops under this policy. I create data for total farmland and use that to see new searches for farmland. Column 2 and Column 3 report the estimates for total farm area and total harvest area. Even if there is a growth rate in grass acres, we can see that the pressure has been modified by increasing farmland and harvested land. Farmers may not find new marginal land to cultivate the crops.

In Column 4, we see a sharp decrease in the percentage of tenants in corn and cotton counties. Mostly this happened in cotton and corn counties where the tenancy rate was highest. The Southern Tenant Farmers Union also worked in these areas. Landowners were recipients of the farm incentives, and this discrimination negatively affected tenants. This policy may also have long-term intergenerational effects as land ownership structure changes over time.

Lastly, in these areas, one other significant technological change happened in the Great Plains was through the exploration of the Ogallala Aquifer. Discovery of the groundwater in the aquifer started to change the water base in the 1960s. Access to groundwater may also decrease the necessity to depend on grassland for soil moisture. To see the heterogeneity, I collect aquifer data from Hornbeck Keskin (2014) and use the heterogeneous treatment effect model to see the effects of access to aquifers.

Table 9 presents these results. As we can see, aquifer access adversely affects grassland growth rate in the wheat areas. This effect is significant at the beginning of the aquifer access. The effects are also mainly concentrated in intense wheat counties, supporting results from Hornbeck & Keskin (2014). Research in crop science states that access to irrigation is an essential substitute for land conservation (Hudson, 1995). We see that irrigation changes the dynamics of the effect. Irrigation is a substitute for grassland to increase access to soil moisture, so irrigation mainly decreases the impact of the grassland restoration policies. The estimates show that in some decade's aquifers had positive effects on grassland growth for corn counties.[29]

However, the conversion to grass areas was not at all unprofitable. Most producers use livestock growth to substitute cropland. One of the adjustment mechanisms has been detected through livestock production.

Table 10 reports estimated impacts on livestock growth in the plains after the introduction of the New Deal. We see that the growth rate of value from livestock has increased by 2.32% for wheat-intensive counties for the complete data. The growth rate for corn areas is also significant, 4.84%. However, as before, the growth rate in cotton areas is an insignificant 5.81%. With decadal data, the effect starts to show up mainly after the 1950s.[30]

6.5 Effects on Soil Erosion

In this section, I present results for the effect of early farmland conservation policies on county-level data for erosion and conservation needs. I measure these outcome variables with two sources of information. First, I use Conservation Needs Inventory (CNI) data from 1945 to show the effect in the short term after the policy implementation. The hypothesis is if conservation policy already has an effect on erosion, then the need for conservation would be lower in areas with higher conservation funding. Second, I use Natural Resource Inventory (NRI) data after the 1980s to show its long-term impacts. Data on these environmental qualities are only available for some years; we cannot follow a difference-in-difference structure. Instead, I use an instrumental variable method as described in section 6.

[29] Appendix Table A2 presents the results using a 20-inch rainfall line (100th Meridian). As expected, the increase in rainfall decreases the efficacy of the policy. The policy is more effective in the regions where farmers had less access to rainfall and irrigation.

[30] I also provide results for higher percentage of farmers of Spanish origin from Mexico. These farmers were more familiar with climatic ecoregions in the Great Plains (Webb, 1959. This is because Mexico has similar weather and climate conditions as the lower Great Plains, and so they have a better idea of what to do with the soil in the Great Plains when compared with people who come from the Eastern side of the USA and other European countries. I collect information on the origin of farmers from the Population Census in 1930. We see from Table A(3) in the Appendix that farmers from Mexico do not have any significant effects on grassland compared to others.

6.5.1 Short-term persistent effect on soil erosion

Table 11 presents the short-term effect of the AAA policies on the conservation needs of any county. The primary outcome variable is presented as the proportion of cropland under conservation needs in any county, PropNeedCNI. The regression coefficient measures if the policy affects the county area that still needs high conservation treatment. I include other control variables: total targeted crop intensity in 1930, log of population, land area under permanent conversion. This data is, however, only available for five states.

Table 11, column 1, presents the OLS regression where my outcome variable is PropNeedCNI, and my primary independent variable is the log of total AAA payment in any county, AAA. We see that if there is a 1% increase in total AAA payment, there will be around a .128% increase in the proportion of area under conservation need.

Table 11 also presents the result where I instrument AAA payment with the pre-Dust swing voters for Democratic Party. This is measured by the standard deviation (SD) of democratic voters from 1896 to 1932. First-stage regression shows a strong correlation between AAA payment and pre-Dust Bowl democratic swing voters. The second-stage regression uses the SD of democratic voters as the instrument variable. We see that the effect is still positive and is around .103 after using the instrumental variable. However, this effect is not significant anymore.

The results say that in the 1940s and the early 1950s, the effect of AAA policies on conservation needs is not detectable in 1940s. This may mean that protection policies takes time to show up in the environmental quality. Also, there was a budget cut just before 1945 because of the war. This may reflect that we only have a brief period between the policy and outcome variable collection date.

6.5.2 Long-term persistent effect on soil erosion

Table 12 presents the average of variables we use to understand the long-term effect of the program on wind erosion rate. I use data from NRI for 2012, the latest year for which I have the data at the county level. I did the same analysis for 1997, 2002, 2007, and 2012. The results are robust across time.

Column 2 to column 5 present the result where I instrument Log(AAA) payment with the pre-Dust Bowl democratic swing voters. First-stage regression shows a strong correlation between Log(AAA) payment and pre-Dust Bowl swing-voting counties. The second-stage regression uses initial crop intensity as the instrument variable. The results still show a negative effect of the policy on erosion. Table-14 presents that a 1% change in Log(AAA) total payment in the 1930s decreased the wind erosion rate in any county by .218 in 1997. Table-12, column 3, presents that a 1% change in Log(AAA) total payment in the 1930s decreases wind erosion rate in the cropland by .118. Column 4 shows that a 1% change in Log(AAA) total amount in the 1930s reduced wind erosion rate in the cropland by .516, and in 2012 the decrease rate was .648. This result corresponds to our intuitive understanding that the converted areas have benefited from the conversion and land-use change (Hornbeck, 2012).

Conservation literature suggests that spatial and temporal spillovers of early conservation programs may exist on later conservation uptake. To check this, I use a county-level Conservation Reserve Program (CRP) uptake data from 1985 and see if these early land conservation programs influence. CRP is a similar program established in 1985 and continues as the USA's primary working land conversion program. Table 13 presents the results. Results show that early land conversion places still substantially impact how landowners took decisions on the uptake of this later adoption of grassland under CRP.

7 Discussion and Conclusion

After the disastrous situation after the Dust Bowl, the return to a normal environment took numerous policy changes, including transforming farmland into grassland. The process included buying farmland and providing financial and technical incentives to farmers. In this paper, I evaluated these land programs to investigate how they affected landscapes and environmental quality in the short- and long terms. I demonstrate that current differences in ecological outcomes within the Great Plains can be traced to farmland conservation activities in the 1930s. Using spatial and temporal variation in the policy, I identify that the policy has a considerable immediate and persistent effect on the agricultural landscape. Spatial heterogeneity depends on agricultural land tenancy, access to irrigation, institutional, political, and demographic factors.

These findings present important policy implications for both the United States and developing countries. For example, soil conservation policies help at the extensive and intensive margins. While farmland conservation policies helped to generate soil-conserving grassland in the Great Plains, these estimates imply that the interaction of price stabilization policies with soil conservation policies may have long-term ecological consequences. Notably, farmers may not fully realize soil conservation benefits if they depend on federal subsidies. Understanding the dynamics of early land conservation policies may help us create and highlight better incentives for current USA farmers to conserve land. These dynamics may also be of interest to many developing countries that are in the process of establishing comprehensive land conservation policies.

This paper complements recent empirical studies on the implication of early historical events, offering unique insights into how existing land uses can affect long-term environmental performances in the context of land conservation. Farmland conversion is an essential and popular conservation instrument and constitutes a significant portion of the farmland conservation budget in the United States (Hellerstein, 2017; Wu and Babcock, 1999). For example, the 2018 USA federal budget includes 2.1 billion dollars in funding for the Conservation Reserve Program (CRP) to protect 24 million acres of environmentally sensitive cropland and grassland (US Congressional Budget Office, 2018). The impact of farmland retirement on harvest acreage is well-documented in the literature (Ericksen and Collins, 1985). However, it is not clear how farmland retirement affects land degradation in the long term.[31]

Designing farmland conservation policies is a significant component in developing countries' fiscal policies (Jayachandran et al., 2017; Andam et al., 2010; Howlader and Ando, 2020). The main concern is that land conservation may not persist after removing state-level subsidies. This study on the USA's experience of subsidized conservation programs could also be applied to understanding the future effects of land retirement in developing countries. It may help to design better contracts with landowners. By analyzing the long-term impacts, this paper ultimately helps policymakers re-design policies to factor in these negative consequences that arise from the interaction of supply-control policy instruments with land conservation policy tools.

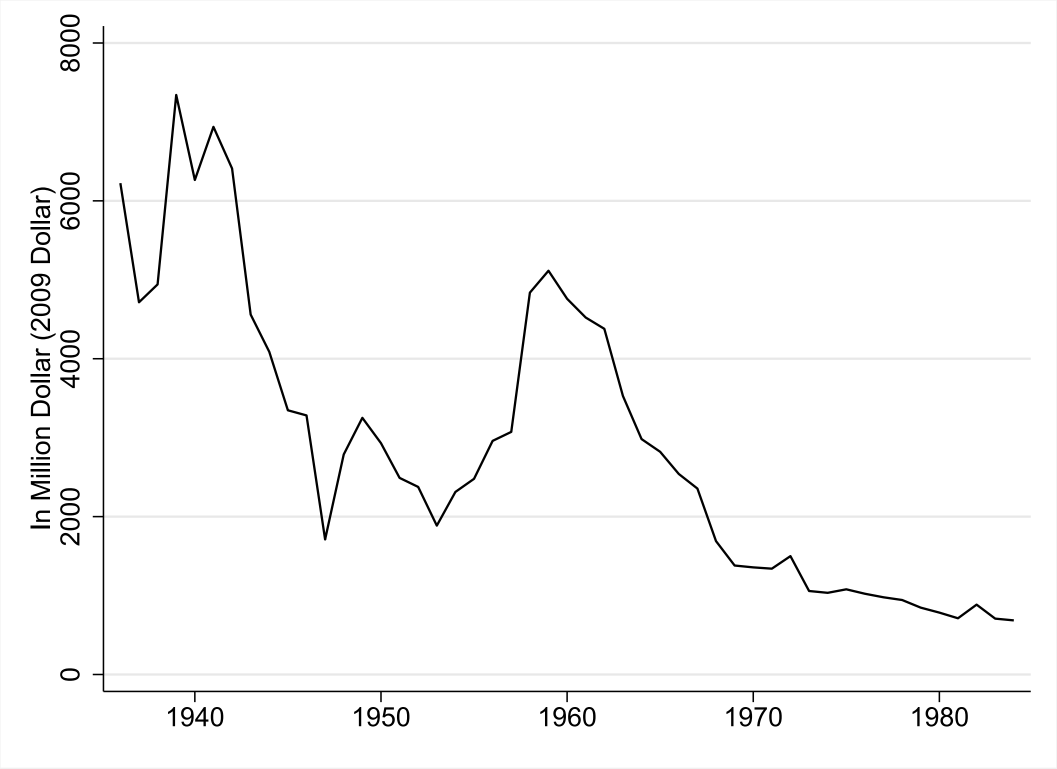
New scientific studies show a possibility of Dust Bowl-type events in the Great Plains in the future (Cowan et al., 2020). This paper on the early experience with the Dust Bowl in the 1930s may help face future conditions like that. To design new conservation policies, we need to understand what has worked well in the past. The voluntary nature of the conservation program, and subsidy dependency, may create ecological effects, and policymakers need to keep this in mind while designing federal-level conservation policies.

This study has several limitations. First, understanding the effects of land conservation with regard to the crop science perspective is important to measure the long-term ecological effects in agricultural system. Second, land restoration process may have hydrological relationship with irrigation. Answering these questions beyond the scope of this paper, but future research could use the historical land policies to understand these effects.

[31] Most of the studies on land conservation programs in the empirical literature study the Conservation Reserve Program established in the late 1980s (Wachenheim, Lesch, and Dhingra, 2014; Sullivan et al., 2004).

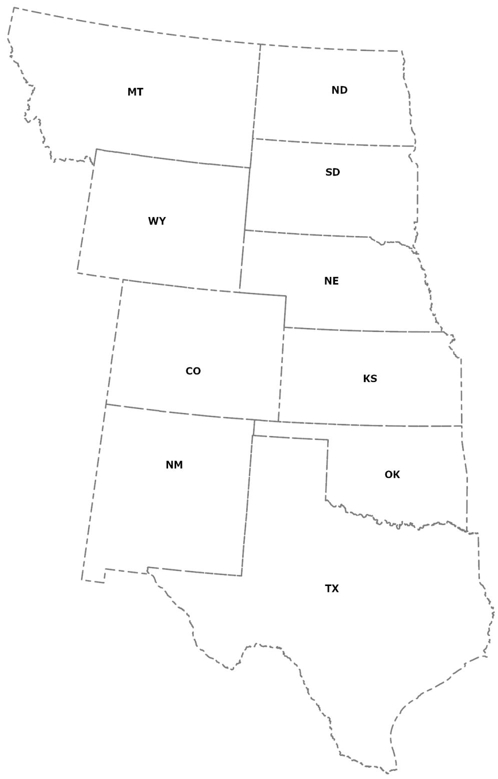
8 Figures

Figure (1) **USDA Budget for Soil Conservation**



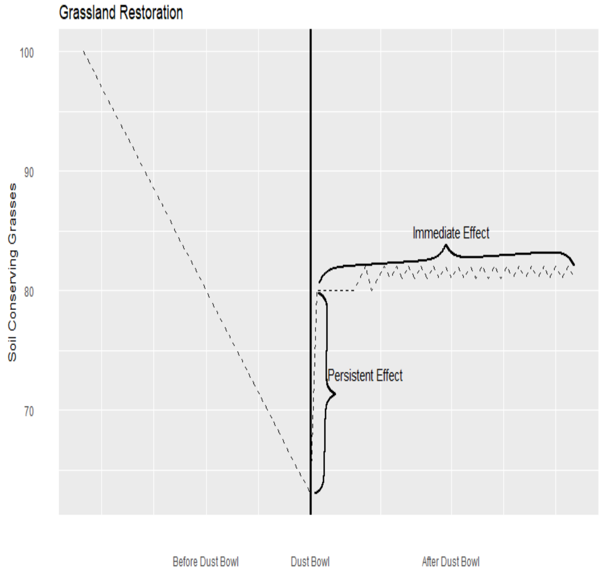
Note: This graph denotes the total financial expenditure on soil conservation by USDA Soil Conservation Service (currently named Natural Resource and Conservation Service).

Figure (2) **Study Area: The Great Plains**

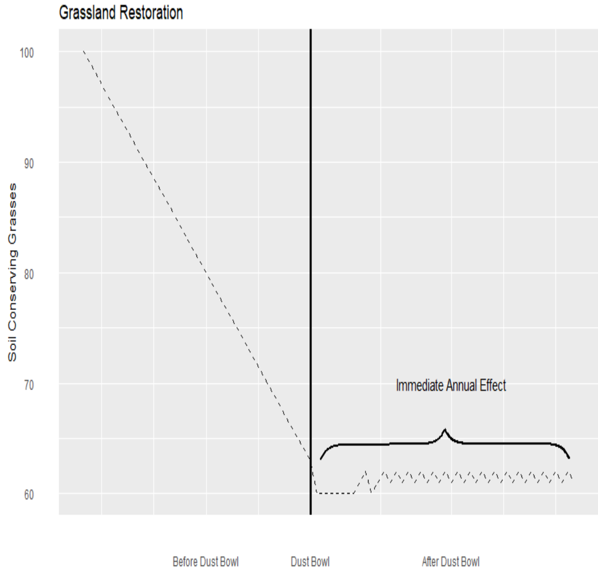


Note: Ten Great Plains states are included in the study : Nebraska, North Dakota, South Dakota, Montana, Kansas, Oklahoma, New Mexico, Wyoming, Texas and Colorado.

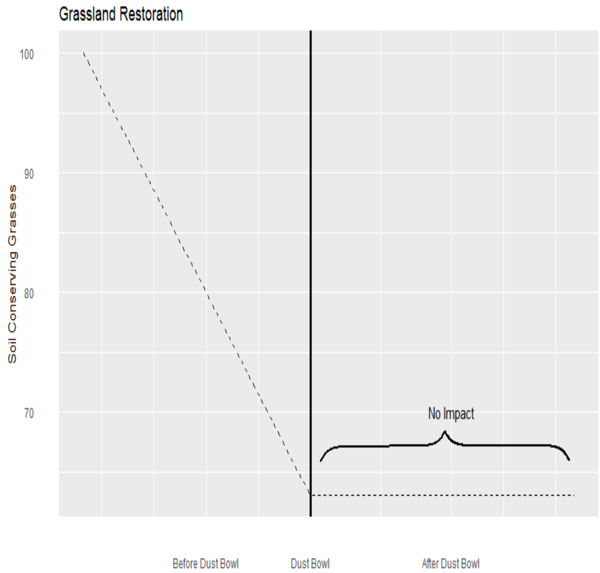
Figure (3) Conceptual Framework



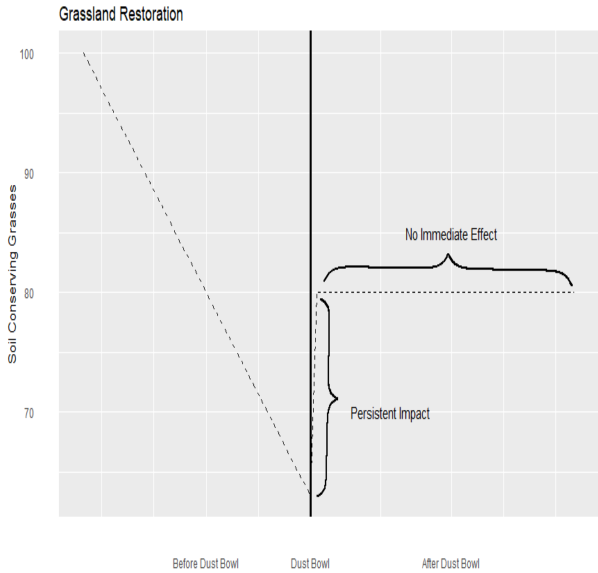
(a) Persistent and Immediate Effect



(b) Only Immediate Effect



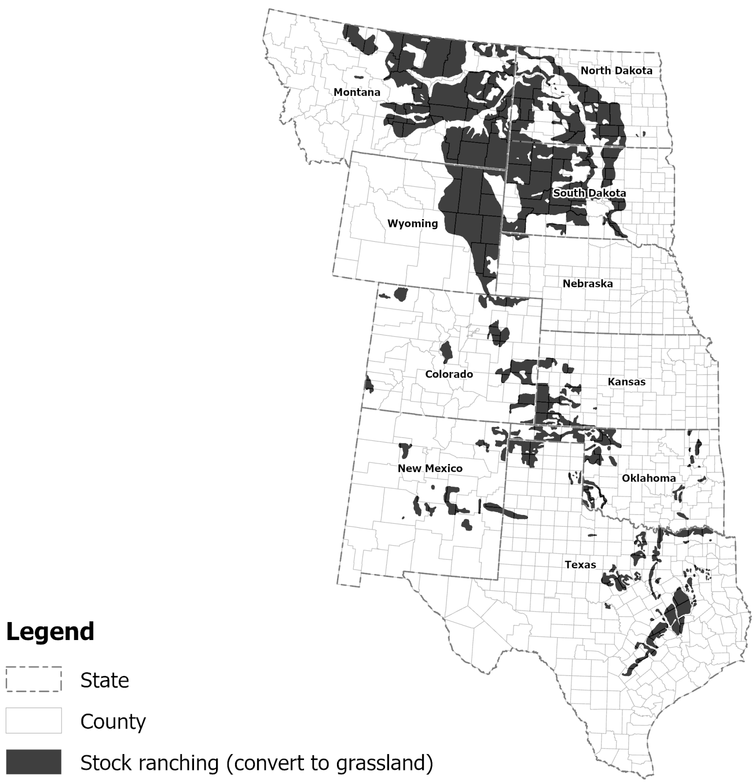
(c) No Impact



(d) Persistent but No Immediate Effect

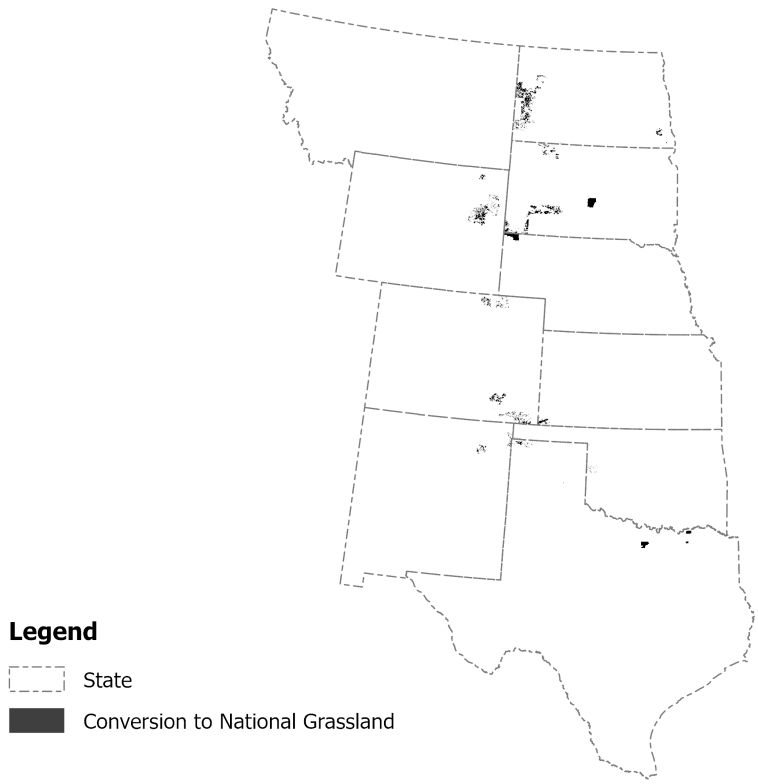
Note: This graph denotes the four potential cases that might occur because of the introduction of farmland conservation policies, as described in the conceptual framework. Dotted lines corresponds to the change in the grassland level. Panel corresponds to the case where the initial impact does not degrade, and later funding also has a non-durable effect. Panel (b) corresponds to the case where funding flows only maintain grassland. Panel (c) corresponds to the point where farmland conservation policies have no impact. Panel (d) corresponds to the case where the initial impact does not degrade, but later funding has no effect. The persistent result corresponds to α in equation 3 and equation 4 in section 5.1; the immediate impact corresponds to γ in the Appendix.

Figure (4)   Proposed Land Restoration Map (1936)



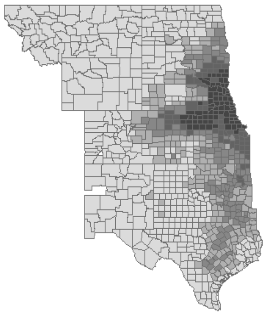
Note: I collected this land conversion map from the National Archives (RG 114). The map shows the areas proposed to convert to the grasses.

Figure (5) **Conversion to National Grassland (1933 - 1941)**

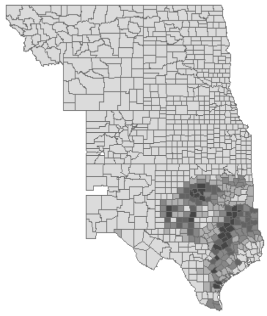


Note: Data is from the United States Forest Service (USFS). The figure shows lands permanently purchased and restored to grassland by the USFS in the 1930s. National Grassland units are designated by the Secretary of Agriculture and always held by the Department of Agriculture under Title III of the Bankhead-Jones Farm Act.

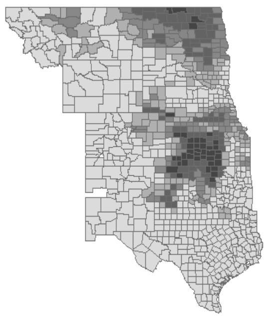
Figure (6) Spatial Variation of Crop Intensity



(a) Corn intensity



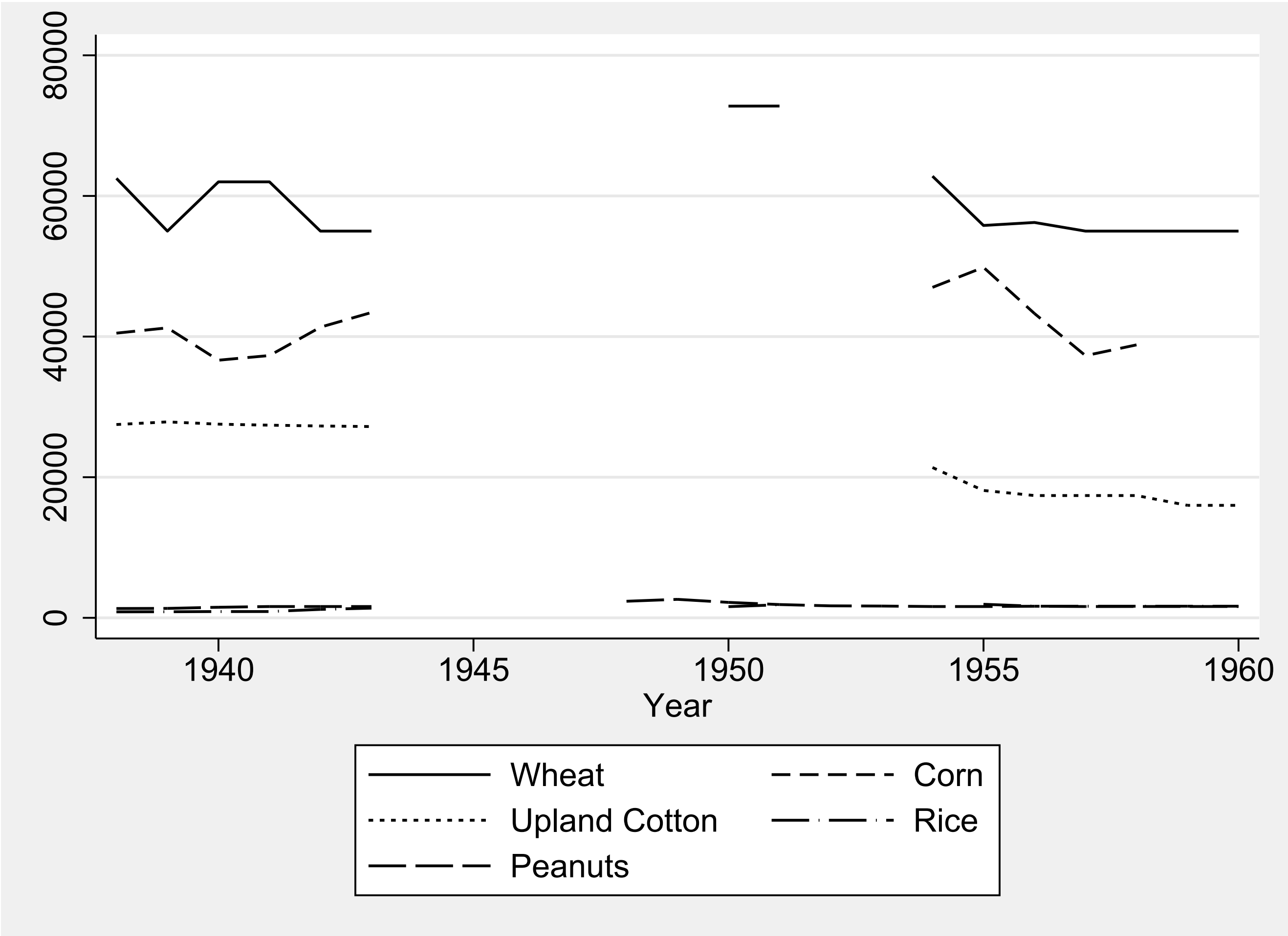
(b) Cotton intensity



(c) Wheat Intensity

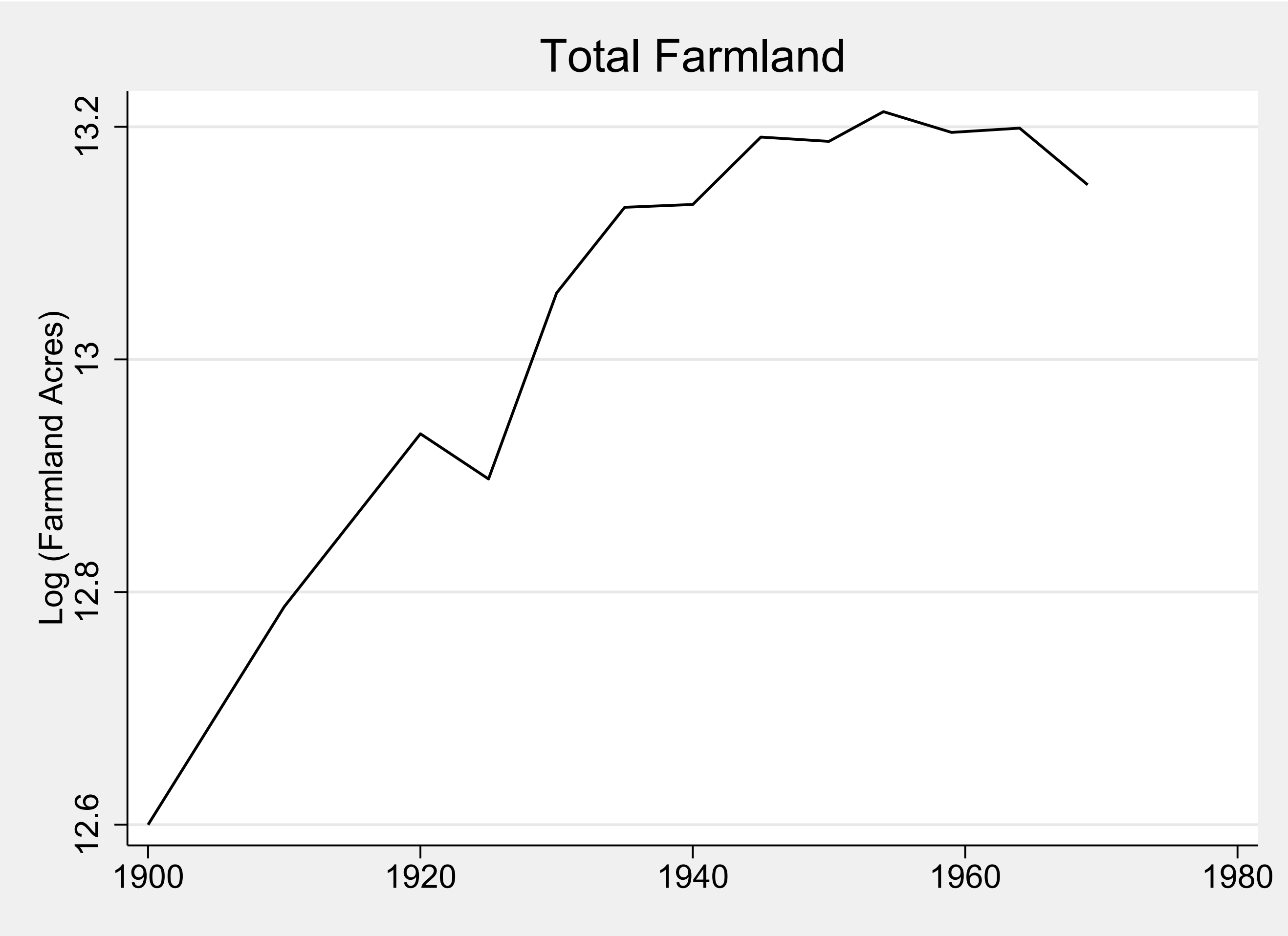
Note: County-level crop intensity data extracted from the US Census of Agriculture (1930). Figures present the Crop area fraction of total farm area by county. Panel a presents high corn intensity areas, panel b presents high cotton intensity areas, and panel c presents high wheat intensity areas.

Figure (7) **Total Acreage Allotment for Crops**



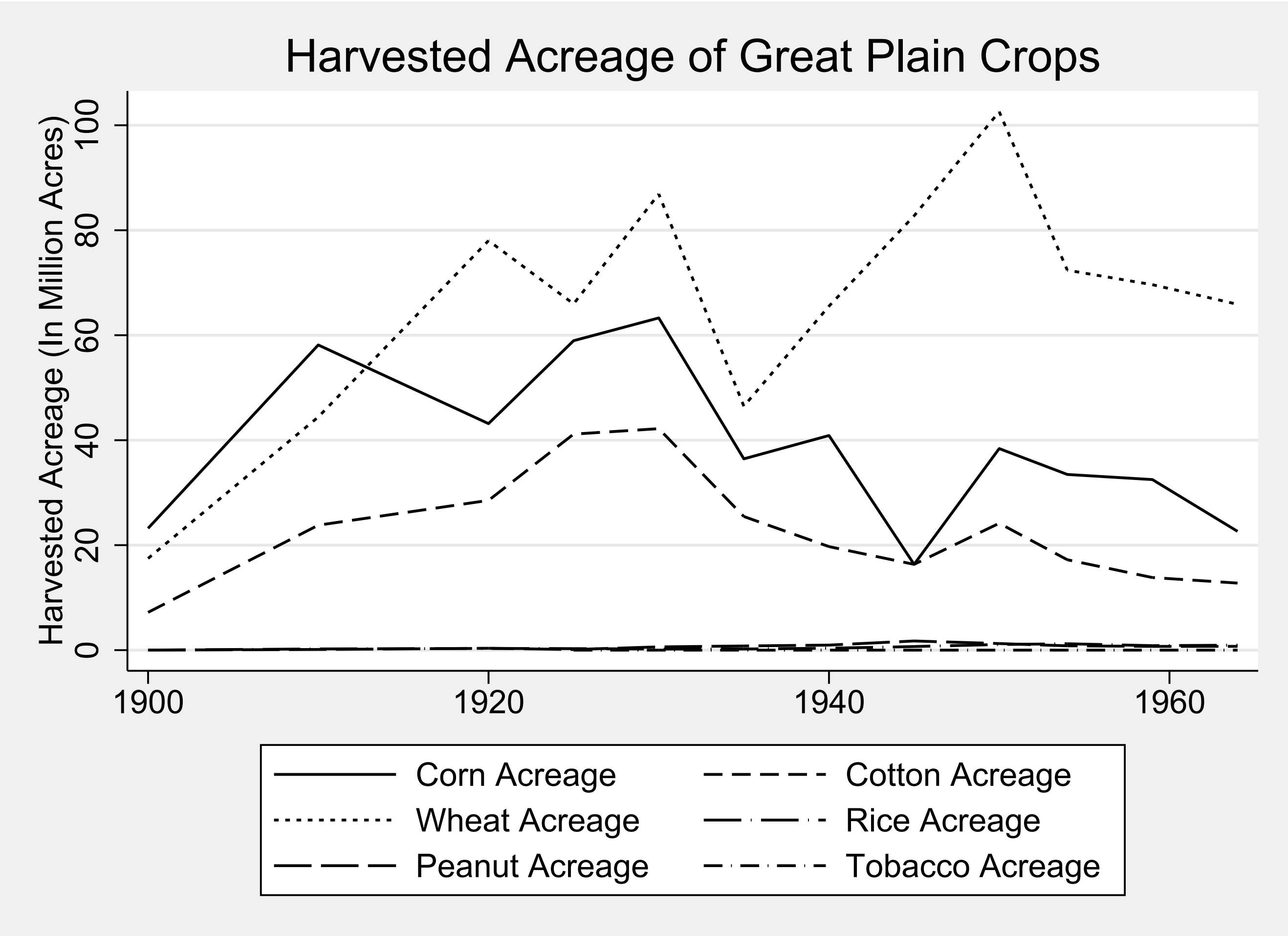
Note: Data calculated from USDA Bulletin, "Acreage Allotment and Marketing Quota Summary", 1961. Graph denotes the annual crop acreage allotment for the USA. The variation closely follows the world price movement. The values are in thousand acres. The graph also show that the program was not active during some years, primarily due to war. I use this information to see how the discontinuity of the program affects land conservation activities.

Figure (8) Aggregate Changes on the Plains in Agriculture: Farmland



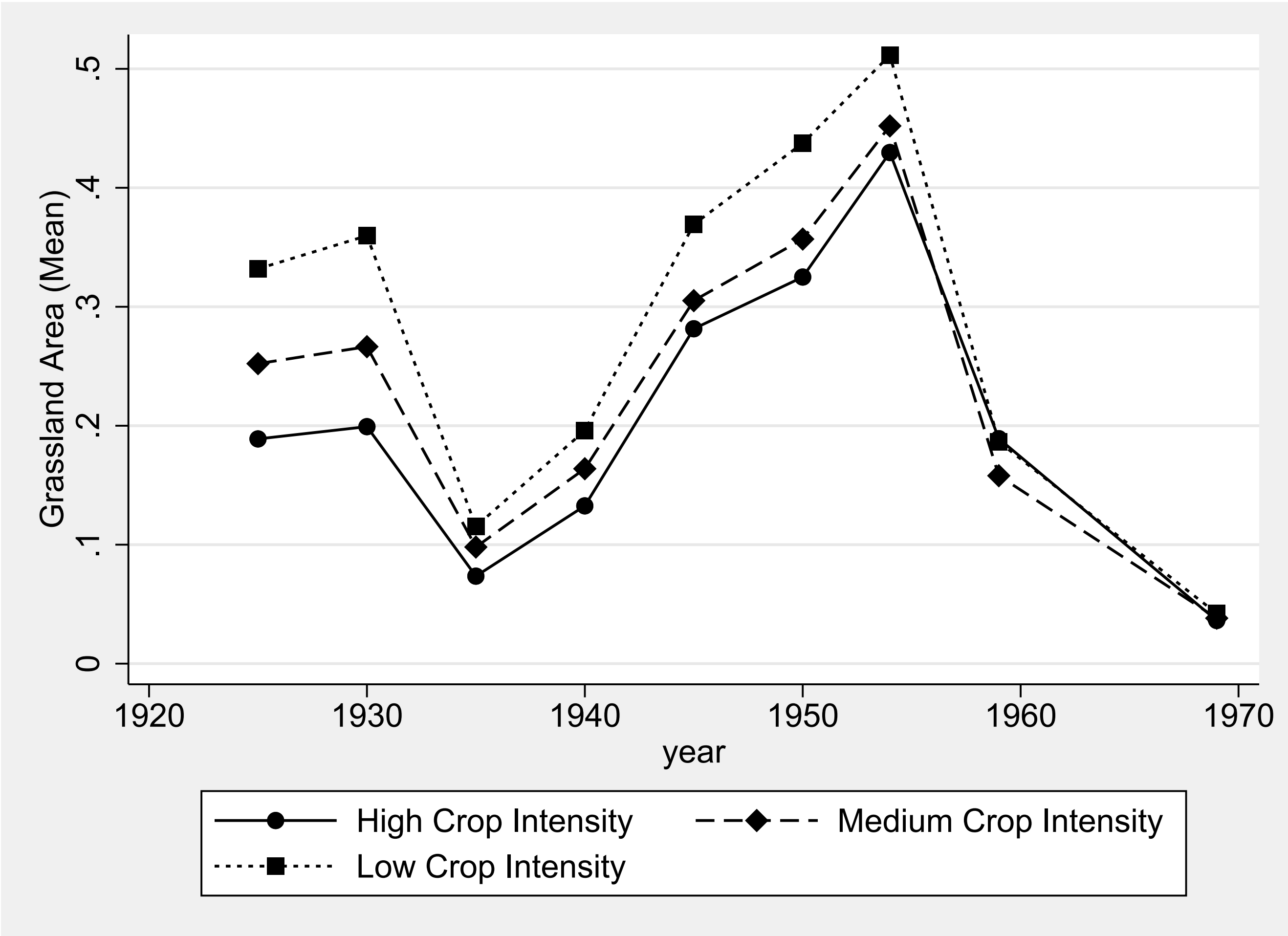
Note: Data are from the US Census of Agriculture and reports the total log acres of farmland. Agricultural expansion in 1900-1935 has been slowed down after the Dust Bowl.

Figure (9) Total Great Plains Harvested Acreage by Crop (1920 - 1960)



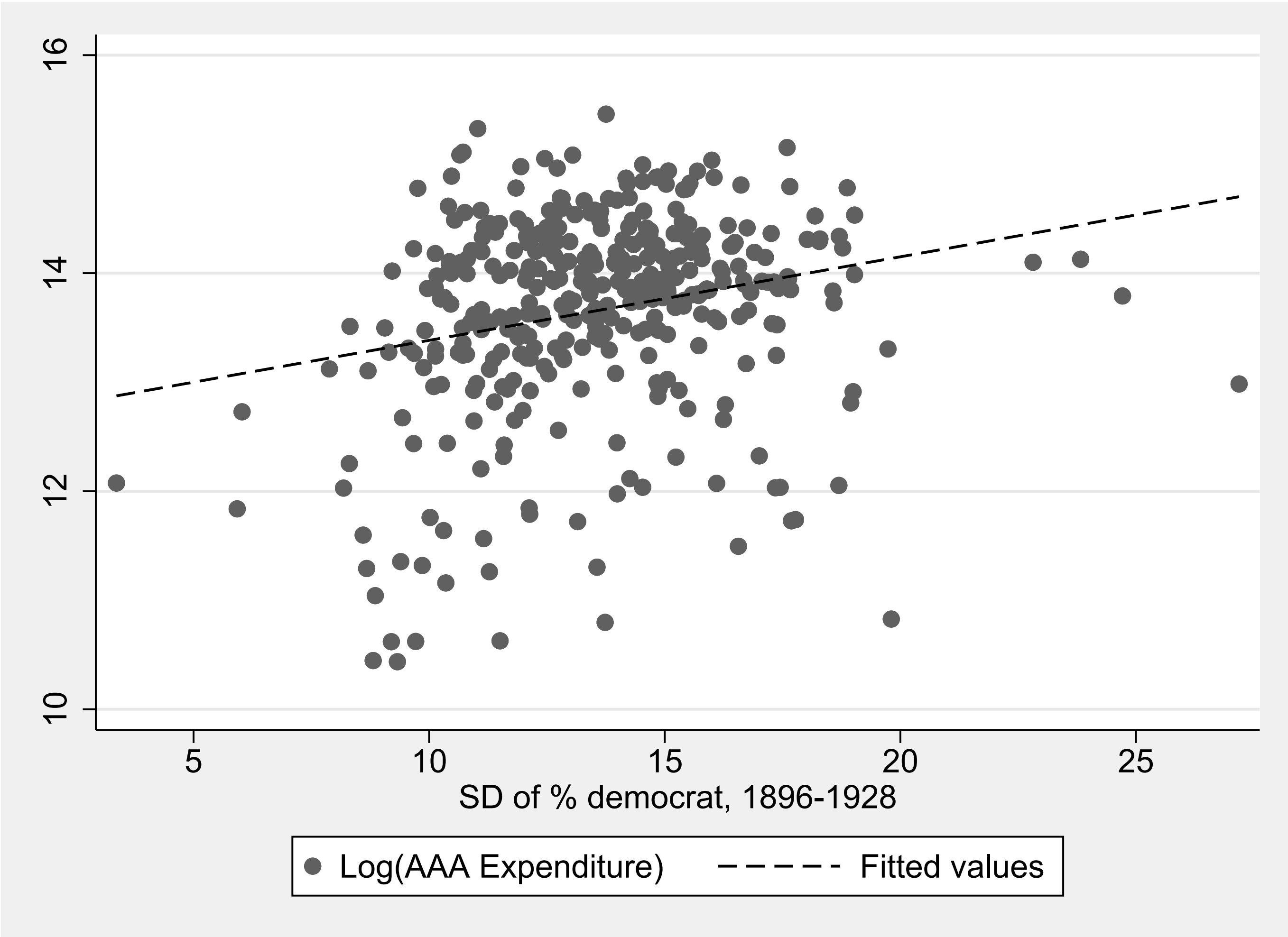
Note: Data are from the US Census of Agriculture. Figures present that corn, cotton and wheat were the main crops in the Great Plains in the 1930s. Corn, cotton, wheat are the three main crops grown in the Great Plains.

Figure (10) Test of Pre-trend in the Grassland Evolution



Note: Data extracted from the USDA agricultural census. Graph presents the trend of grassland evolution with different crop intensity in 1930s. For graphical presentation, total targeted crop intensity has been divided into three groups: high (1), medium (2), and low (3). Before the policy, different crop intensity areas have seen similar trend in grassland.

Figure (11) Test of Instrument Variable



Note: Correlation between Log(AAA expenditure) and swing voters in Democratic Party, 1896-1932 (measured by standard deviation of % of democrat voters). Graph presents that the counties with higher swing voters had higher allocation of AAA funding.

9 Tables

Table (1) **Summary Statistics by Census Year**

	(1) 1925	(2) 1930	(3) 1935	(4) 1940	(5) 1945	(6) 1950	(7) 1954	(8) 1959	(9) 1969
Cotton Share of Farm Area	0.120	0.048	0.048	0.049	0.048	0.048	0.049	0.0479	0.048
	(0.125)	(0.098)	(0.098)	(0.09)	(0.098)	(0.099)	(0.099)	(0.098)	(0.098)
Corn Share of Farm Area	0.043	0.078	0.078	0.081	0.079	0.08	0.081	0.078	0.078
	(0.042)	(0.106)	(0.105)	(0.106)	(0.106)	(0.106)	(0.107)	(0.105)	(0.105)
Wheat Share of Farm Area	0.036	0.08	0.079	0.082	0.08	0.082	0.083	0.079	0.079
	(0.086)	(0.11)	(0.11)	(0.12)	(0.12)	(0.120)	(0.12)	(0.11)	(0.119)
Total Harvest Area	1.27	1.83	2.83	1.60	1.71	1.69	1.62	1.46	1.29
(in 100000 acres)	(.98)	(1.38)	(53.86)	(1.89)	(1.35)	(1.34)	(1.37)	(1.28)	(1.13)
Percent Tenant	0.535	0.438	0.45	0.438	0.328	0.269	0.252	0.220	0.170
	(0.152)	(0.165)	(0.148)	(0.132)	(0.128)	(0.109)	(0.111)	(0.105)	(0.076)
Average Farm size	1017.1	882.7	829.0	1101.70	1183.3	1243.0	1313.2	1648.3	1734.7
	(3042.3)	(3107.9)	(2554.1)	(1663.9)	(3327.9)	(2693.6)	(2840.9)	(3041.7)	(2992.2)

Notes: Data extracted from the agricultural census (Haines, 2005). "Crop intensity" has been extracted from agricultural census by dividing crop area by total farm area. Other variables are also extracted from agricultural census (Haines, 2005).

Table (2) **Estimated Change in Total Grassland Restoration pretrend**

	(1)	(2)
VARIABLES	Model 1	Model 2
Medium Crop Intensity#1930	0.000184	0.000184
	(0.148)	(0.104)
Low Crop Intensity#1930.year	0.00044	0.00044
	(0.143)	(0.0998)
Medium Crop Intensity	0.312***	0.257***
	(0.105)	(0.0737)
Low Crop Intensity	0.619***	0.558***
	(0.101)	(0.0714)
1930.year	0.0888	0.0888
	(0.137)	(0.095)
State FE	No	Yes
Observations	278	278
R-squared	0.333	0.680

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: Test of parallel trend in grassland evolution in the Great Plains. This tables uses data from two pre-1935 agricultural census: 1930 and 1925. Coefficients present that different crop intensity area saw similar trend in grassland evolution before the policy enactment under the New Deal.

Table (3) **Estimated Change in Total Grassland Restoration, by decades**

VARIABLES	(1) Full	(2) < 1950	(3) < 1960	(4) < 1970	(5) < 1980
Log(Budget#Wheat)	0.039***	0.066***	0.083***	0.056***	0.041***
	(0.0084)	(0.0049)	(0.017)	(0.0078)	(0.0084)
Log(Budget#Cotton)	0.0145	0.0028	0.0096	0.0122	0.015
	(0.0101)	(0.0059)	(0.0205)	(0.0094)	(0.0102)
Log(Budget#Corn)	0.031***	0.054***	-0.0082	0.0150*	0.0307***
	(0.0091)	(0.0055)	(0.018)	(0.0086)	(0.0092)
Constant	-4.380***	-6.194***	-4.406***	-4.580***	-4.348***
	(0.0185)	(0.0370)	(0.0574)	(0.0257)	(0.0194)
Observations	34,440	9,020	17,220	25,420	33,620
R-squared	0.010	0.269	0.010	0.008	0.011
Number of FIPS	820	820	820	820	820
County FE	Yes	Yes	Yes	Yes	Yes
State*Year	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Notes: Difference-in-difference results are presented where the outcome variable is calculated from the United States Geological Survey (USGS) Historical Land Use Data for the USA. Column 1 reports estimates from equation 1 in the text for the log value of total grassland. Column 2 - Column 5 reports the exact estimations, separated by decades. The parentheses report robust standard errors with county FE and state and year interaction effects.

Table (4) **Estimated Change in Total Grassland Restoration, dynamic panel regression model**

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Full	< 1950	< 1960	< 1970	< 1980
Log(Budget#Wheat)	0.063***	0.059***	0.120***	0.065***	0.064***
	(0.0156)	(0.001)	(0.027)	(0.014)	(0.016)
Log(Budget#Cotton)	-0.043**	-0.023***	-0.0015	0.017	-0.042**
	(0.019)	(0.0019)	(0.032)	(0.017)	(0.019)
Log(Budget#Corn)	0.104***	0.013***	0.066**	0.079***	0.103***
	(0.018)	(0.0018)	(0.030	(0.016)	(0.018)
Constant	-4.629***	-1.113***	-4.589***	-4.482***	-4.638***
	(0.025)	(0.010)	(0.036)	(0.029)	(0.025)
Observations	33,620	8,200	16,400	24,600	32,800
Number of FIPS	820	820	820	820	820

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: Difference-in-difference results are presented using the Arellano-Bond panel estimator. The outcome variable is calculated from the USA's United States Geological Survey (USGS) Historical Land Use Data. Column 1 reports estimates from equation 1 in the text for the log value of total grassland. Column 2 - Column 5 reports the exact estimations, separating by decades.

Table (5) **Estimating Change in the total soil conserving base, by decades**

VARIABLES	(1) Full	(2) < 1950	(3) < 1960	(4) < 1970
Log(Budget*Wheat)	0.022***	0.029***	0.032***	0.015***
	(0.0067)	(0.0067)	(0.0052)	(0.0056)
Log(Budget*Corn)	-0.052***	-0.0004	-0.002	-0.022***
	(0.0082)	(0.0074)	(0.006)	(0.006)
Log(Budget*Cotton)	0.008	0.025***	0.038***	0.021***
	(0.009)	(0.008)	(0.006)	(0.0078)
Constant	10.86***	12.36***	12.50***	11.62***
	(0.255)	(0.181)	(0.170)	(0.206)
Observations	8,075	4,061	6,445	7,260
Number of FIPS	819	819	819	819
State FE	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Note: Difference-in-difference results are presented where the outcome variable is calculated from the agricultural census (Haines, 2005). Column 1 reports estimates from equation 1 in the text for the log value of total soil conserving grasses. Column 2 - Column 5 reports the exact estimations, separating by decades.

Table (6) **Placebo Tests**

VARIABLES	(1) Placebo Crop	(2) Placebo Year
Log(Budget#Wheat)	0.069***	
	(0.013)	
Log(Budget#Cotton)	0.008	
	(0.016)	
Log(Budget#Corn)	0.052**	
	(0.023)	
Log(Budget#Oat)	-0.125**	
	(0.06)	
No Budget Year#wheat_prop		-0.005**
		(0.0023)
No Budget Year#corn_prop		-0.005**
		(0.0026)
No Budget Year#cotton_prop		-0.003
		(0.003)
Constant	-4.48***	-4.56***
	(0.048)	(0.044)
Observations	18,040	18,860
R-squared	0.009	0.008
Number of FIPS	820	820
County FE	Yes	Yes
State*Year Trend	Yes	Yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: The Placebo treatment crop is defined by the crop that was not targeted and not defined as soil conserving grass in 1933. The placebo year is defined as the years for which there was zero budget for grass restoration (Figure 7). Model 1 presents that grassland restoration is negative for the placebo crop, compared to the targeted crop. Model 2 presents that farmers decreases grassland restoration activities if they do not receive financial incentives.

Table 7: Estimated Change in grassland restoration after 1934, interacted with county precharacteristics

VARIABLES	(1) Farmsize	(2) Tenancy	(3) Race(Black)	(4) Irrigation	(5) Nonfarm
Log(Budget#Wheat)	0.036***	0.043***	0.039***	0.039***	0.039***
	(0.0084)	(0.0093)	(0.0084)	(0.0084)	(0.0086)
Log(Budget#Cotton)	0.014	0.054	0.016	0.014	0.013
	(0.01)	(0.068)	(0.01)	(0.01)	(0.01)
Log(Budget#Corn)	0.029***	0.04***	0.03***	0.03***	0.031***
	(0.009)	(0.011)	(0.009)	(0.009)	(0.009)
MediumFarms#Log(Budget#Wheat)	0.169**				
	(0.067)				
LargeFarms#Log(Budget#Wheat)	82.21				
	(164.7)				
MediumFarms#Log(Budget#Cotton)	0.152				
	(0.259)				
LargeFarms#Log(Budget#Cotton)	-1.152				
	(3.905)				
MediumFarms#Log(Budget#Corn)	1.167***				
	(0.186)				
LargeFarms#Log(Budget#Corn)	15.83				
	(16.80)				
HighTenants#Log(Budget#Wheat)		-0.0287			
		(0.022)			
HighTenants#Log(Budget#Cotton)		-0.0366			
		(0.069)			
HighTenants#Log(Budget#Corn)		-0.0193			
		(0.019)			
Black#Log(Budget#Wheat)			3.013***		
			(0.848)		
Black#Log(Budget#Cotton)			-0.0475		
			(0.111)		
Black#Log(Budget#Corn)			0.0657		
			(0.303)		
Irrigation#Log(Budget#Wheat)				0.149	
				(0.728)	
Irrigation#Log(Budget#Cotton)				-0.0326	
				(0.219)	
Irrigation#Log(Budget#Corn)				0.269	
				(1.20)	
Nonfarm#Log(Budget#Wheat)					0.0185
					(0.038)
Nonfarm#Log(Budget#Cotton)					0.293
					(0.256)
Nonfarms#Log(Budget#Corn)					-0.028
					(0.068)
Constant	-4.55***	-4.55***	-4.55***	-4.55***	-4.55***
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Observations	34,440	34,440	34,440	34,440	34,440
R-squared	0.004	0.002	0.002	0.002	0.002
Number of FIPS	820	820	820	820	820

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Column headers denotes the variables that have been used in the triple difference model to estimate heterogeneous effect.

Table 8: Adjustment - Estimated Change in total population, farm area, harvest area and tenants

VARIABLES	(1) Log(Population)	(2) Log(Farm area)	(3) Log(Harvest area)	(4) %Tenants
Log(Budget*Wheat)	-0.003	0.086***	0.147***	0.0007
	(0.0046)	(0.0063)	(0.0086)	(0.0007)
Log(Budget*Corn)	-0.0058	0.098***	0.088***	-0.014***
	(0.0048)	(0.0074)	(0.009)	(0.0008)
Log(Budget*Cotton)	0.014***	0.024***	-0.017*	-0.015***
	(0.0034)	(0.0072)	(0.0091)	(0.0006)
Constant	9.082***	16.22***	12.00***	-0.135***
	(0.165)	(0.150)	(0.184)	(0.0170)
Observations	7,361	9,000	7,664	8,998
Number of FIPS	819	819	819	819
State FE	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Note: Difference-in-difference results are presented where the outcome variable is calculated from the agricultural census. Column headers are the outcome variables used in the regression.

Table 9: HTE Impact of Farmland Conservation on Total Grassland by Ogallala Aquifer

VARIABLES	(1) Full	(2) < 1950	(3) < 1960	(4) < 1970	(5) < 1980
Log(Budget#Wheat)	0.054***	0.105***	0.110***	0.068***	0.056***
	(0.015)	(0.0097)	(0.032)	(0.014)	(0.015)
Log(Budget#Cotton)	0.02	-0.0002	0.026	0.035***	0.021
	(0.013)	(0.0074)	(0.025)	(0.012)	(0.013)
Log(Budget#Corn)	0.009	0.05***	-0.089**	-0.055***	0.008
	(0.02)	(0.0117)	(0.0411)	(0.0189)	(0.0209)
Aquifer#Log(Budget#Wheat)	-0.0201	-0.0519***	-0.04	-0.017	-0.02
	(0.0185)	(0.0113)	(0.0383)	(0.0173)	(0.0187)
Aquifer#Log(Budget#Cotton)	-0.007	0.01	0.0002	-0.028	-0.0073
	(0.023)	(0.012)	(0.045)	(0.021)	(0.023)
Aquifer#Log(Budget#Corn)	0.026	0.006	0.104**	0.0874***	0.0286
	(0.023)	(0.013)	(0.045)	(0.021)	(0.023)
Constant	-4.38***	-6.21***	-4.4***	-4.584***	-4.348***
	(0.018)	(0.037)	(0.057)	(0.025)	(0.019)
Observations	34,440	9,020	17,220	25,420	33,620
R-squared	0.010	0.271	0.010	0.009	0.012
Number of fips	820	820	820	820	820
County FE		Yes	Yes	Yes	Yes
State*Year Trend		Yes	Yes	Yes	Yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Triple difference model results are presented where the treatment variable has been interacted with the access to the Ogallala aquifer.

Table 10: Continuous Impact of Farmland Conservation on Value of livestock

VARIABLES	(1) Full	(2) < 1950	(3) < 1960	(4) < 1970
Log(Budget#Wheat)	0.023***	-0.018***	0.004	0.023***
	(0.0049)	(0.0025)	(0.0038)	(0.004)
Log(Budget#Corn)	0.048***	-0.032***	0.019***	0.048***
	(0.0052)	(0.0027)	(0.004)	(0.005)
Log(Budget#Cotton)	0.005	0.015***	0.005*	0.005
	(0.003)	(0.002)	(0.002)	(0.003)
Constant	15.08***	13.45***	14.46***	15.08***
	(0.181)	(0.149)	(0.153)	(0.181)
Observations	4,910	1,638	3,276	4,910
Number of FIPS	819	819	819	819
State FE	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Note: Difference-in-difference results are presented where the outcome variable ”value of livestock” is calculated from the agricultural census.

Table 11: Impact of Farmland Conservation Programs on Conservation Needs

VARIABLES	(1) OLS Log(Proportion CNI)	(2) First Stage Log(AAA Expenditure)	(3) IV Log(Proportion CNI)
Log(AAA Expenditure)	0.128**		0.103
	(0.056)		(0.19)
SD of % democrat, 1896-1928	-0.008	0.074***	
	(0.015)	(0.013)	
Total Crop Intensity	-0.527*	3.7***	-0.436
	(0.308)	(0.220)	(0.755)
Log(Population, 1930)	0.006	0.061	0.008
	(0.046)	(0.044)	(0.043)
LU Size	-310.1	339.3	-301.7
	(237.9)	(229.2)	(244.7)
Constant	-2.027**	11.18***	-1.753
	(0.793)	(0.472)	(2.425)
State FE	Yes	Yes	Yes
Observations	352	352	352
R-squared	0.332	0.563	0.332

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Note: Column 1 reports estimate from equation 2 using OLS. Column 2 presents results from the first stage estimation. Column 3 shows results from IV using voting share.

Table 12: Impact of Farmland Conservation Programs on Cropland Erosion

	(1)	(2)	(3)	(4)	(5)
	first	IV	IV	IV	IV
VARIABLES	log(AAA)	TotalCrop1997	TotalCrop2002	TotalCrop2007	TotalCrop2012
SD of % democrat, 1896-1928	0.082***				
	(0.0171)				
Log(AAA Expenditure)		-0.218	-0.118	-0.516**	-0.648***
		(0.179)	(0.175)	(0.219)	(0.243)
Constant	12.48***	4.14*	2.76	8.19***	9.96***
	(0.238)	(2.433)	(2.375)	(2.985)	(3.309)
Controls		Yes	Yes	Yes	Yes
Observations	370	370	371	371	371
R-squared	0.060				

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Column 1 reports the first stage. Column 2 to Column 5 report estimates from equation 2 using cropland erosion data from the NRI. This is total cropland erosion data collected annually by the USDA.

Table 13: Impact of Farmland Conservation Programs on Conservation Reserve Program Uptake

VARIABLES	(1) first Log(AAA Expenditure)	(2) CRP,1990	(3) CRP,1995	(4) CRP,2000
SD of % democrat, 1896-1928	0.0827***			
	(0.0170)			
Log(AAA Expenditure)		4.344***	4.290***	5.146***
		(0.765)	(0.760)	(0.884)
Constant	12.47***	-50.83***	-50.04***	-62.44***
	(0.237)	(10.41)	(10.33)	(12.02)
Observations	372	372	372	372
R-squared	0.060	0.026	0.040	0.054

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: County-level database on CRP has been extracted from the Farm Service Agency reports. This is a county-level data of cumulative enrollment of CRP by fiscal year. Column 1 reports the first stage. Column 2 to Column 4 report estimates from equation 2 using data from the Conservation Reserve Program (CRP) in different years.

References

Alsan, Marcella and Claudia Goldin (2019). "Watersheds in child mortality: The role of effective water and sewerage infrastructure, 1880–1920". *Journal of Political Economy* 127.2, pp. 586–638.

Andam, Kwaw S, Paul J Ferraro, Katharine RE Sims, Andrew Healy, and Margaret B Holland (2010). "Protected areas reduced poverty in Costa Rica and Thailand". *Proceedings of the National Academy of Sciences* 107.22, pp. 9996–10001.

Arthi, Vellore (2018). ""The dust was long in settling": human capital and the lasting impact of the American Dust Bowl". *The Journal of Economic History* 78.1, pp. 196–230.

Banerjee, Abhijit and Lakshmi Iyer (2005). "History, institutions, and economic performance: The legacy of colonial land tenure systems in India". *American economic review* 95.4, pp. 1190–1213.

Barreca, Alan I, Price V Fishback, and Shawn Kantor (2012). "Agricultural policy, migration, and malaria in the United States in the 1930s". *Explorations in Economic History* 49.4, pp. 381–398.

Baylis, Kathy, Jordi Honey-Rosés, Jan Börner, Esteve Corbera, Driss Ezzine-de Blas, Paul J Ferraro, Renaud Lapeyre, U Martin Persson, Alex Pfaff, and Sven Wunder (2016). "Mainstreaming impact evaluation in nature conservation". *Conservation Letters* 9.1, pp. 58–64.

Bennett, Hugh Hammond (1928). *Soil erosion—a national menace*.

Boustan, Leah Platt, Matthew E Kahn, Paul W Rhode, and Maria Lucia Yanguas (2017). *The effect of natural disasters on economic activity in us counties: A century of data*. Tech. rep. National Bureau of Economic Research.

Cohen, Aaron J, Michael Brauer, Richard Burnett, H Ross Anderson, Joseph Frostad, Kara Estep, Kalpana Balakrishnan, Bert Brunekreef, Lalit Dandona, Rakhi Dandona, et al. (2017). "Estimates and 25-year trends of the global burden of disease attributable to ambient air pollution: an analysis of data from the Global Burden of Diseases Study 2015". *The Lancet* 389.10082, pp. 1907–1918.

Coppess, Jonathan (2018). *The Fault Lines of Farm Policy: A Legislative and Political History of the Farm Bill*. University of Nebraska Press.

Courtemanche, Charles and Kenneth Snowden (2011). "Repairing a mortgage crisis: HOLC lending and its impact on local housing markets". *The Journal of Economic History* 71.2, pp. 307–337.

Cowan, Tim, Sabine Undorf, Gabriele C Hegerl, Luke J Harrington, and Friederike EL Otto (2020). "Present-day greenhouse gases could cause more frequent and longer Dust Bowl heatwaves". *Nature Climate Change*, pp. 1–6.

Dasgupta, P (2020). “The Dasgupta Review–Independent Review on the Economics of Biodiversity Interim Report”. *Treasury, HM Retrieved from https://www. gov. uk/government/publications/interim-reportthe-dasgupta-review-independent-review-on-the-economics-of-biodiversity*.

Deininger, Klaus W et al. (2003). *Land policies for growth and poverty reduction*. World Bank Publications.

Depew, Briggs, Price V Fishback, and Paul W Rhode (2013). “New deal or no deal in the Cotton South: The effect of the AAA on the agricultural labor structure”. *Explorations in Economic History* 50.4, pp. 466–486.

Elbehri, A, A Challinor, L Verchot, A Angelsen, T Hess, A Ouled Belgacem, et al. (2017). “FAO-IPCC Expert Meeting on Climate Change, Land Use and Food Security: Final Meeting Report”. *Rome: FAO and IPCC*.

Eswaran, Hari, Rattan Lal, PF Reich, et al. (2001). “Land degradation: an overview”. *Responses to Land degradation*, pp. 20–35.

Fenske, James and Namrata Kala (2017). “Environmental economic history”. *The Long Economic and Political Shadow of History Volume I. A Global View*, p. 63.

Fishback, Price (2017). “How Successful Was the New Deal? The Microeconomic Impact of Spending and Lending Policies in the 1930s”. *Journal of Economic Literature* 55.4, pp. 1435–85.

Fishback, Price, Shawn Kantor, and Todd Sorensen (2005). “The New Deal and the Diffusion of Tractors in the 1930s”.

Fishback, Price V (2016). “New Deal”. *Banking Crises*. Springer, pp. 241–250.

Fishback, Price V, William C Horrace, and Shawn Kantor (2006). “The impact of New Deal expenditures on mobility during the Great Depression”. *Explorations in Economic History* 43.2, pp. 179–222.

Fiszbein, Martin (2017). *Agricultural Diversity, Structural Change and Long-run Development: Evidence from the U.S.* Working Paper 23183. National Bureau of Economic Research. DOI: 10.3386/w23183. URL: http://www.nber.org/papers/w23183.

Freire-González, Jaume, Christopher Decker, and Jim W Hall (2017). “The economic impacts of droughts: A framework for analysis”. *Ecological Economics* 132, pp. 196–204.

Haines, Michael R et al. (2005). *Historical, demographic, economic, and social data: The United States, 1790-2002*. Inter-university Consortium for Political and Social Research.

Hansen, Zeynep K and Gary D Libecap (2004). “Small farms, externalities, and the Dust Bowl of the 1930s”. *Journal of Political Economy* 112.3, pp. 665–694.

Harlow, Jerry T and T (1994). “History of natural resources conservation service national resources inventories”. *USDA Natural Resources Con servation Service*.

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

Hornbeck, Richard (2012). "The enduring impact of the American Dust Bowl: Short- and long-run adjustments to environmental catastrophe". *The American Economic Review* 102.4, pp. 1477–1507.

Hornbeck, Richard and Pinar Keskin (2011). *The evolving impact of the Ogallala Aquifer: Agricultural adaptation to groundwater and climate*. Tech. rep. National Bureau of Economic Research.

— (2014). "The historically evolving impact of the ogallala aquifer: Agricultural adaptation to groundwater and drought". *American Economic Journal: Applied Economics* 6.1, pp. 190–219.

Hornbeck, Richard and Suresh Naidu (2014). "When the levee breaks: black migration and economic development in the American South". *American Economic Review* 104.3, pp. 963–90.

Howlader, Aparna and Amy W Ando (2020). "Consequences of Protected Areas for Household Forest Extraction, Time Use, and Consumption: Evidence from Nepal". *Environmental and Resource Economics*, pp. 1–40.

Hurt, R Douglas (1985). "The national grasslands: origin and development in the dust bowl". *Agricultural History* 59.2, pp. 246–259.

Jayachandran, Seema, Joost De Laat, Eric F Lambin, Charlotte Y Stanton, Robin Audy, and Nancy E Thomas (2017). "Cash for carbon: A randomized trial of payments for ecosystem services to reduce deforestation". *Science* 357.6348, pp. 267–273.

Lal, Rattan (2004). "Soil carbon sequestration impacts on global climate change and food security". *science* 304.5677, pp. 1623–1627.

Lele, Uma J (2017). *Managing a Global Resource: Challenges of forest conservation and development*. Routledge.

Libecap, Gary D and Steven N Wiggins (1984). "Contractual responses to the common pool: prorationing of crude oil production". *The American Economic Review* 74.1, pp. 87–98.

Miteva, Daniela A, Subhrendu K Pattanayak, and Paul J Ferraro (2012). "Evaluation of biodiversity policy instruments: what works and what doesn't?" *Oxford Review of Economic Policy* 28.1, pp. 69–92.

Newbold, Tim, Lawrence N Hudson, Andrew P Arnell, Sara Contu, Adriana De Palma, Simon Ferrier, Samantha LL Hill, Andrew J Hoskins, Igor Lysenko, Helen RP Phillips, et al. (2016). "Has land use pushed terrestrial biodiversity beyond the planetary boundary? A global assessment". *Science* 353.6296, pp. 288–291.

Quinn, Riley (2017). *Guns, Germs & Steel: The Fate of Human Societies*. Macat Library.

Robalino, Juan A (2007). "Land conservation policies and income distribution: who bears the burden of our environmental efforts?" *Environment and development economics* 12.4, pp. 521–533.

Schlesinger, Arthur M (2003). *The Coming of the New Deal: 1933-1935, The Age of Roosevelt*. Vol. 2. Houghton Mifflin Harcourt.

Schnepf, Max (2008). *A History of Natural Resource Inventories Conducted by the USDA's Soil Conservation Service and Natural Resources Conservation Service: A Special Report by the Soil and Water Conservation Society*. Soil and Water Conservation Society.

Scholes, RJ, L Montanarella, E Brainich, N Barger, B ten Brink, M Cantele, B Erasmus, J Fisher, T Gardner, TG Holland, et al. (2018). "IPBES (2018): Summary for policymakers of the assessment report on land degradation and restoration of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services".

Schubert, Siegfried D, Max J Suarez, Philip J Pegion, Randal D Koster, and Julio T Bacmeister (2004). "On the cause of the 1930s Dust Bowl". *Science* 303.5665, pp. 1855–1859.

Sims, Katharine RE and Jennifer M Alix-Garcia (2017). "Parks versus PES: Evaluating direct and incentive-based land conservation in Mexico". *Journal of Environmental Economics and Management* 86, pp. 8–28.

Smith, Pete, Joanna I House, Mercedes Bustamante, Jaroslava Sobocká, Richard Harper, Genxing Pan, Paul C West, Joanna M Clark, Tapan Adhya, Cornelia Rumpel, et al. (2016). "Global change pressures on soils from land use and management". *Global Change Biology* 22.3, pp. 1008–1028.

Sohl, Terry, Ryan Reker, Michelle Bouchard, Kristi Sayler, Jordan Dornbierer, Steve Wika, Rob Quenzer, and Aaron Friesz (2016). "Modeled historical land use and land cover for the conterminous United States". *Journal of Land Use Science* 11.4, pp. 476–499.

Stegner, Wallace (1992). *Beyond the hundredth meridian: John Wesley Powell and the second opening of the West*. Penguin.

Stevens, Andrew W. (2018). "Review: The economics of soil health". *Food Policy* 80, pp. 1–9. ISSN: 0306-9192. DOI: https://doi.org/10.1016/j.foodpol.2018.08.005. URL: http://www.sciencedirect.com/science/article/pii/S0306919218303397.

Sullivan, Patrick, Daniel Hellerstein, Leroy Hansen, Robert Johansson, Steven Koenig, Ruben N Lubowski, William D McBride, David A McGranahan, Michael J Roberts, Stephen J Vogel, et al. (2004). "The conservation reserve program: economic implications for rural America".

Sweikert, Lily A and Larry M Gigliotti (2019). "Evaluating the role of Farm Bill conservation program participation in conserving America's grasslands". *Land Use Policy* 81, pp. 392–399.

Thuiller, Wilfried (2007). "Biodiversity: climate change and the ecologist". *Nature* 448.7153, p. 550.

Turner, Katrine Grace, Sharolyn Anderson, Mauricio Gonzales-Chang, Robert Costanza, Sasha Courville, Tommy Dalgaard, Estelle Dominati, Ida Kubiszewski, Sue Ogilvy, Luciana Porfirio, et al. (2016). "A review of methods, data, and models to assess changes in the value of ecosystem services from land degradation and restoration". *Ecological Modelling* 319, pp. 190–207.

Wachenheim, Cheryl Joy, William Clarence Lesch, Neeraj Dhingra, et al. (2014). *The conservation reserve program: A literature review*. Department of Agribusiness & Applied Economics, Agricultural Experiment Station, North Dakota State University.

Wallis, John Joseph (1991). "The political economy of New Deal fiscal federalism". *Economic Inquiry* 29.3, pp. 510–524.

Webb, Nicholas P, Nadine A Marshall, Lindsay C Stringer, Mark S Reed, Adrian Chappell, and Jeffrey E Herrick (2017). "Land degradation and climate change: building climate resilience in agriculture". *Frontiers in Ecology and the Environment* 15.8, pp. 450–459.

Webb, Walter Prescott (1959). *The great plains*. Vol. 766. U of Nebraska Press.

Weems, Jason D (2004). "Aerial views and farm security administration photography". *History of Photography* 28.3, pp. 266–282.

Wenger, Leon E (1941). "Re-establishing native grasses by the hay method".

Worster, Donald (2004). *Dust bowl: the southern plains in the 1930s*. Oxford University Press.

Wright, Gavin (1974). "The political economy of New Deal spending: An econometric analysis". *The Review of Economics and Statistics*, pp. 30–38.