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

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Abstract

Land policies, especially those related to land restoration, take significant time to reveal any detectable effect on environmental quality. This paper evaluates farmland conservation programs from their introduction to capture the short- and long-term effects on the environment. I demonstrate that current differences in environmental outcomes within the Great Plains can be traced to the introduction of farmland conservation activities in the 1930s. Using spatial and temporal variation in the policy, I identify that the policy has a considerable immediate effect on the agricultural landscape. Spatial heterogeneity depends on agrarian land tenancy, access to irrigation, institutional, political, and demographic factors. Also, using spatial variation in initial funding and incentive structure for land conversion, I present that the initial conversion of land through many institutional changes had persistent effects on soil erosion in the long term. Using the policy's discontinuity in some years, I reveal that the likelihood of landowners' deciding to restore grassland significantly decreases if the federal subsidy is removed.

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1 Introduction

Many governments and international agencies have become active in executing local and global policies to reduce land degradation in recent years (Elbehri et al., 2017; Hellerstein, 2017, Stevens, 2018).[1] The benefit of land conservation has been established in the scientific literature (Lele, 2017; Sweikert and Gigliotti, 2019). However, 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 landscape (Sims and Alix-Garcia, 2017; Howlader and Ando, 2020; Robalino, 2007; Deininger, 2003). Due to a lack of adequate policy settings and the limitations of data infrastructure, long-term studies remain unavailable. To understand the benefit of land conservation policies in the long-term, and to study the mechanisms by which these programs may affect different groups, I assemble a unique data set and evaluate the agricultural land conservation policies in the USA from it's introduction.

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).[2] In this paper, I document the short- and long-term impacts of land conservation policies on county-level environmental quality by following county landscape and economy over a period of seventy years from the commencement of farmland conservation policies in the United States. I evaluate the effect of land conservation programs by combining differences across counties in the targeted conservation areas with differences in the annual budget induced by the federal decision. The ideal experiment to estimate the effects of land conservation would be to allocate conservation areas randomly

[1] Land conservation policies help to increase the resilience of the ecosystem (Lal, 2004; Thuiller, 2007; Webb et al., 2017). 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.

[2] A new term "Environmental Economic History" has been proposed by scholars to facilitate our understanding of the persistent impacts of early shocks and policies (Fenske and Kala, 2017).

to some communities and not to others, and then to compare environmental benefits and distribution across communities. In the absence from such an experiment, it is necessary to rely on exogenous natural variation in combination with empirical method.

To do so, this paper exploits a dramatic change in conservation policy in USA to evaluate the effect of land conservation on grassland area and rate of soil erosion. I take advantage of the introduction of farmland conservation policies in the post-Dust Bowl USA counties in the 1930's, compile a database from multiple sources and track the effects of those policies by focusing on a period of more than seventy years. Native grassland destruction and the failure to adopt dryland agricultural practices in the Great Plains during the late nineteenth century caused the Dust Bowl, in which almost 75% of the topsoil in the Great Plains was blown away (Hornbeck, 2012, Wenger, 1941). As a policy response to the continuous drought and soil erosion of the 1930s, the federal government implemented extensive fiscal policies right away as part of the New Deal (Schlesinger, 2003).[3] The first farmland conservation attempt was integrated in 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.[4]

In a series of papers, Price Fishback and coauthors established the implications of the Agricultural Adjustment Act (AAA) on the local economy through public finance policies (Fishback, 2016). Some blamed the New Deal's land conversion 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).[5] I explore a new dimension of AAA to understand the long-term impacts that environmental restoration activities have on the economy. This paper responds to existing gaps in scholarship by providing empirical evidence to facilitate an understanding of the

[3]The New Deal was a series of assistance programs, public work projects, financial reforms, and regulations enacted by President Franklin D. Roosevelt in the United States between 1933 and 1939. It responded to needs for relief, reform, and recovery from the Great Depression.

[4]The target of Voluntary Acreage Reduction was twofold: the reduction of soil erosion and an increase in crop prices (Bennett, 1928)

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

persistent and immediate impacts of New Deal programs on the restoration of grassland and pasture land. In addition, it pertains to soil erosion levels in the Great Plains. Moreover, I study different potential mechanisms and heterogeneous effects across space to understand the effectiveness of policy.

Figure 1 provides underlying information. The graph shows that there was a sharp increase to 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.[6] 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 levels of intensity and success across the years. Annual fluctuation of the budget may have prompted immediate annual effects on environmental quality and welfare and may vary across locations.

This paper contributes to extant scholarship as I create a new dataset. The empirical strategy depends on 10 states of the Great Plains and merges county-level data from archival databases with that of agricultural and population censuses. For my primary analysis of the immediate effect of the program, I estimate the effects of the program 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 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 payment. Next, 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 fact that exposure to the land conservation program varied by region of market crop production. 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 needed in each county,

[6]The other portion of the farmland conservation was related to technical assistance that came from a new local institution: Soil Conservation District (Howlader, 2019)

the county agents used the pre-Dust Bowl years' acreage of the eligible commercial crops.[7] To identify the causal effect of non-randomly assigned farmland conservation programs on grassland restoration activities, I use information that has been acquired in this observational setting. Specifically, it pertains to information from where an exogenous increase of farmland conservation has occurred because the federal acreage allotment was based on six commercial crops. Using this initial crop intensity in the Great Plains as well as the timing of policy variations at the federal 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. This data is 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 areas of targeted crops would have experienced similar patterns of grassland restoration.

Next, I continue the empirical analysis by demonstrating the persistent effect of county-level AAA budgets on changes in 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 that is measured consistently over time. I construct data by using the Conservation Needs Inventory (CNI) collected in the 1940s. Then, the Natural Resource Inventory (NRI) database on county-level soil erosion provides data that ranges from 1982 onwards. I use this county-level soil erosion data from CNI and NRI to identify the long-term persistent impacts of the New Deal farmland conservation programs on levels of soil erosion. Further, to deal with the omitted variable bias from unobserved farmers' characteristics, I create exogenous crop-specific spatial variation in an instrumental variable strategy by using pre-policy crop intensity at the county level.

My analysis has yielded three main sets of results. First, increase in the budget for soil conservation increases areas under grassland. With two different independently-

[7] 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. 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).

constructed datasets, I show the effects of federal farmland conservation policies on grassland. On average, I found that a 1 unit increase in conservation exposure on average may explain a 3% to 8% increase in the area under grassland. This result is consistent across two datasets and remained unchanged when subjected to robust viability checks.

Second, I explore heterogeneity in the context of conservation outcomes and potential explanatory mechanisms (Wenger, 1941). Relatively 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, alternative occupations—can explain variation 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 the fact that farmers do not search for new marginal land to plant their crops; reorganization of farmland is not an unintended consequence of the conservation program.

Next, I investigate the interaction between conservation policies and both ancestral knowledge and cultural norms around soil conservation. It is said that farmers who originally immigrated from Mexico knew the soil and climate of the Great Plains better than the eastern farmers. I find that the effects of conservation policies are greater if farmers have migrated from Mexico. Next, after the second New Deal of 1937, there were new local institutions referred to as Soil Conservation Districts (SCDs). A SCD was formed through the collective action of farmers, who were responsible for creating farm conservation plans. SCDs were formed at a variety of times across regions. I use the data from Howlader (2019b) to demonstrate that SCDs foster grassland restoration projects and activities (Howlader, 2019). This observation suggests that knowledge of soil conservation is an important factor in policy success.

Third, and lastly, using the county-level total payment for AAA, I demonstrate the persistent effects of institutional changes on soil conservation programs. In the beginning, the federal government bought some marginal land, permanently, as their budget permitted. By using the initial cropping pattern 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 payment still have lower soil erosion levels and that the effect is persistent over time.

These findings present important policy implications for both the United States and developing countries. For example, soil conservation policies help at both the extensive and intensive margins. Spatial variations in the levels of production capacity and initial knowledge partially explain the variations in the results. 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 utilize the benefits of soil conservation if they depend on federal subsidies. Understanding the dynamics of early land conservation policies may help us to create and to highlight better incentives for current USA farmers to conserve land. These dynamics may also be of interest to many developing countries who are in the process of establishing comprehensive land conservation policies.

This paper contributes to three strata of literature. Firstly, it contributes to the growing body of economic history literature that address natural resource management and environmental problems. Recent economic history papers develop insights about 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, 2017a; 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, 2015). 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. Short-run impacts are mitigated by long-run adjustments, and the speed and magnitude of long-run adjustments depend on the context. In this paper, I provide 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 the availability of detailed county-level data 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).

Studies found that public works and relief spending increased consumption activity, attracted internal migration, reduced crime rates, and lowered several types of mortality. Farm programs typically aided large farm owners but reduced opportunities for sharecroppers, tenants, and farmworkers. The Home Owners' Loan Corporation's purchases and refinancing of troubled mortgages served to resist drops in housing prices and homeownership rates at a relatively low ex-post cost to taxpayers. The Reconstruction Finance Corporation's loans to banks and railroads appear to have had a limited positive impact, although the banks were aided when the RFC took ownership stakes (Fishback, 2017). Accordingly, I compile and digitize new data sources and explore a new dimension of AAA. I constructed a new database, digitizing land utilization and conversion maps from the National Archives. I have also created a soil erosion variable from Conservation Needs Inventory reports. I created policy timing and export databases from different United States Department of Agriculture (USDA) marketing statistics data books.

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. There is a growing body of conservation economics research about both developed and developing countries that 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 both the environment and human welfare, it is important 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.

The paper is organized as follows. Section 2 describes the historical background of the policy before Section 3 describes the underlying conceptual model. Then, Section 4 describes the construction of the data as well as the exploratory statistics. Section 5 outlines my empirical strategy, and Section 6 reports the results. Finally, Section 7 provides concluding comments.

2 Historical Background

2.1 Nature of The Great Plains

The Great Plains, as defined in this paper, 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 identifiers of 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. According to JW Powell, it is the 100th meridian or 20-inch rainfall line that defines the climatic variation in the Great Plains (Stegner, 1992). Land in such areas cannot be approached by using the same farming methods that are employed on the East coast or in the 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 soil on the ground.

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 created increased levels of 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 out 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 components of the soil. The result was one of the biggest human-made natural disasters, commonly known as the "Dust Bowl" (Schubert et al., 2004). Drought and wind erosion are key parts of nature at 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 the continuous drought and sandstorms. These continued through 1938 and ended after 1940 when rainfall returned. By 1938, the peak year of erosion, 10 million acres had lost at least the upper five inches of topsoil; another 13.5 million acres had lost at least two and a half inches. On average, 408 tons of dirt were blown away from an average acre; this was, in some cases, to the next state or even beyond (Worster, 2004).[8]

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 supplies of commodities and soil erosion could simultaneously be addressed by taking marginal land out of production (Bennett, 1928). In 1931, the first Land Utilization conference occurred in Chicago; the key policy suggestion from this conference was to buy 75 million acres of marginal farmland and to convert to better land use (e.g., forest or grassland). 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

[8]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.

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"). To implement reductions in harvested lands, the Department of Agriculture undertook an extensive soil survey in 1933 known as the Reconnaissance Soil Survey.[9] Land Utilization policies (purchasing sub-marginal eroded farmland) were big components of the Agricultural Adjustment Act of the New Deal in 1933. The initial program was designed to permanently buy all sub-marginal lands. However, budget constraints and opposition from farmers prevented that plan from being implemented. The federal government, though, still purchased a portion of the sub-marginal land, and the Forest Service was responsible for converting that to grassland (Hurt, 1985). Other than that, farmers were encouraged to put grasses back in their farmlands. For example, a Kansas agricultural experimental station released a bulletin to re-establish grasses by 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).

To implement this, adhering to a major 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. The payments were conditional on the conversion of farmland to soil-conserving grassland and crops in the Great Plains under the 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 purchasing power of farm population in 1909-1913, and millers and processors would pay for much of the cost of the program. Importantly, Voluntary Acreage Reduction was applied to only some commercial crops – those for which prices were low:

[9] "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.

wheat, corn, cotton, peanuts, rice, and tobacco. The Farm Security Administration at the USDA designed an aerial survey to detect the land where they should focus upon reducing cropland (Weems, 2004).

National marketing quotas and acreage allotments had been established for corn, cotton, wheat, tobacco, rice, and peanuts. Because of the Supreme Court decision on the AAA as being unconstitutional, and because of the Second World War and the referendum against them, allotments were not continuously in operation for each of the major crops. When these laws were in effect, the national acreage allotments were divided among the states that were 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 who were 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 between 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 state that was most affected by the Dust Bowl (RG 114). [12]

There is early theoretical literature on the implications of the AAA concerning the reduction of risk associated with crop price volatility. These studies try to identify relevant agricultural subsidies, optimal crop storage policies and the federal distribution of conservation funding across potential instruments (Floyd, 1965; Garst and Miller, 1975;

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

[11]The 1936 policy was used to control the supply of some specific crops 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 were working with farmers to take the desired amount of cropland out of production. The local 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. The desired base year crop acreage reduction was decided based on previous years' data on acreage (from 1929 to 1932).

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

Lidman and Bawden, 1974; Ericksen and Collins, 1985). Due to the lack of available microdata sets, these papers are mostly theoretical and lack empirical investigations to support their theoretical conclusions (Lidman and Bawden, 1974). Some studies have been undertaken from a historical perspective on how government programs affect crop acreage and actual crop yield (Houck et al., 1976; Garst and Miller, 1975). Effective support prices are used as a means of estimating the impacts of government programs on planted acreages of major crops. Such agricultural economics literature does not, though, focus on the environmental impacts of the program.

Subsequent policies were also implemented to achieve the same thing by reducing cropland and increasing 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 Service. The next Farm Bills also included similar laws that sought to further the idea of reducing commercial crops. The next couple of popular Farm Bills were to be the Set-Aside program in 1957, the Farm Bill, 1985, and the Farm Bill, 1996. The Farm Bill of 1985 introduced the next massive farmland conservation program, the Conservation Reserve Program. To study the effects of the AAA, this paper focuses on 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 intensity of the policy greatly 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 disastrous effect of the Dust Bowl, and also included all institutional and legal changes that were made in the first Farm Bills. Later on, farmland conservation policies continued to pay farmers for topsoil conservation activities but the rate of payment was much lower. My main objective, in this paper, is to track the persistent effect of this initial structure, and also to see the contemporaneous effects of the policies using an annual budget variation. In this section we model an individual farmer's investment in environmental quality to understand the differences between the persistent and continuous effects of the federal policies, and to identify the sources of such variation.

For a farmer, the objective is to maximize the discounted stream of profits that are attainable 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 persistent change 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 spatial variation of the policy 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 this changes in the annual budget and opportunity cost of grassland restoration. Farmers will participate as long as 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 also receive a rental payment based on the acreage under soil conserving grasses. The initial push for 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 large 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 conserving grasses is a summation 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.

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

Firstly, the initial impact from the event does not degrade; later annual funding also has a non-durable impact. At any given point in time, environmental variables will comprise of both the persistent and the immediate effects of the soil conservation budget (Panel (a)). The effect is especially dependent 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 annual immediate effect of the conservation budget (Panel (b)). This may happen if the initial budget does not serve to 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 has a persistent impact, but later funds are ineffective (Panel (d)). In time, the Dust Bowl experience may fade away, and farmers will consequently not respond to the policy incentives anymore.

Section 5 empirically examines how farmers make decisions about 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 important insight from this framework is that, prompted by the initial budget, there may be a persistent impact on the landscape. Also, the first-order condition and optimal annual grass restoration would 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 an important 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

Historical county-level datasets have been drawn from the United States Census of Agriculture and the Census of Population (Haines, 2005). I use 824 contiguous Great Plains counties in Montana, North Dakota, South Dakota, Wyoming, Colorado, Nebraska, Kansas, New Mexico, Oklahoma, and Texas (study area is shown in Fig-3). 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 from the USDA agricultural census, the Natural Resource Conservation Service data archives at the National Archives at College Park (NRCS, RG 114), the population census and the USDA marketing statistical books. I construct export data by country and crops from USA agricultural export databooks. The empirical analysis uses a balanced panel of plain counties, from 1925 to 1985. For the annual effects, I have restricted the study period to the introduction of the Conservation Reserve Program in 1985. [14] Table 1 presents the variable names and corresponding data sources.

To ensure that we have consistent units of observation over time in spite of 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. For consistency, I have redacted information on Indian Reserves and Yellowstone National Park from the county-level data.

For the empirical analysis of the contemporaneous impact of the annual conservation budget, I have used two sources of information for environmental variables. 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

[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 the effects of other early conservation programs.

on different soil-conserving grass acres at the county level. The grasses include mainly: 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. 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] Furthermore, I have collected information from federal documents on the annual soil-conservation budget of 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 databooks. I have also collected county-level rental payment data from the agricultural reports from the National Archives at College Park.

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 crops (Figure 7). Furthermore, I have collected and digitized Land Utilization and Conversion maps from the National Archives to construct a targeted conversion index for counties in the Great Plains. 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 expenditure 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.).

[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 back 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.

[16] Manually extracted from the Haithitrust

Information on crops, farms and farmer characteristics have been extracted from the USDA agricultural census. 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, the share of land planted for targeted program crops: rice, peanuts, corn, cotton, tobacco and wheat, the proportion of non-farm owner-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 by using crop area and total farmland. Figure 6 displays the spatial variation in crop intensity before the Dust Bowl (in 1930).

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 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 1940's and 1950's. The reports are available only for five states: Kansas, Nebraska, Oklahoma, New Mexico, and South Dakota. Then, for 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 current years. This erosion data has been collected by the USDA Natural Resource Conservation Service 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 erosion. To see the effect of AAA on future conversion level, I also use county-level acres under Conservation Reserve Program in 1990 and 1995. For the empirical analysis, I also extract information on county-level rate of payment from reports of the Agricultural Adjustment Act. These reports are also deposited in the National Archives at College Park.

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

4.2 Baseline Characteristics and Aggregate Trends

Table 1 reports the name of the variables and data sources. Table 2 reports the county-level summary statistics from the agricultural census. The total harvest area drops down significantly after 1940. The average farm size rises after 1940. This happened because of the consolidation process of farms after the Dust Bowl. 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 sharp loss in total harvested areas between 1940 and 1950 partly illustrates that which we are trying to study. The percentages of cotton, corn, wheat – all three main crops – drop down in 1930 and 1950. The target of this paper is to understand the implications of this crop acreage loss from the perspective of environmental outcomes.[17]

Figure 4 is a map showing the farmland that has been designated as being unsuitable for crop production, as based on the soil survey, and has been used as proposed land to convert to soil-conserving areas. This map helps us to understand spatial patterns in the actual need for conservation. 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. The map suggests places that would be appropriate for conversion from farmland to grazing (grassland), forest, and a mixture of grassland and forest. Figure 5 shows the farmland that was permanently bought and converted to national grassland by the USDA before the policy shifted to temporary land retirement incentives. Figure 6 shows the spatial variation in crop intensities in the 1930s; we can see the strong correlation between wheat areas and proposed conversion areas in Figure 4.

Figure 7 presents the annual crop acreage allotment by crop (in thousand acres). I manually collected this information from the USDA-provided market acreage allotment

[17] For more information of summary statistics by years, see Appendices.

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 be provided to encourage farmers to take excess acres out of production and convert to more environmental friendly grasses. The data also show that the program was not active during some years, mostly due to war. I use this information to see how the discontinuity of the program affect land conservation.

I have also created figures with aggregated trends of important variables that are used in my analysis. Figure 8 shows the aggregate changes in total farmland (acres) in the Great Plains. Figure 9 disaggregates total farmland by crops. We can see that the Great Plains had three main crops: cotton, corn, and wheat. It can be seen that all of the crops have experienced a sharp reduction in acreage from 1930 to 1940, and then slowly increase again. Figure 10 and Figure 11 show the evolution of grassland and hayland in the Great Plains. Our primary objective is to see how federal policies have affected this evolution.

Table 17 presents the summary statistics of the rental payment. We can see that the average rental payment to convert cropland is highest in Nebraska, and then in Colorado. The spatial distribution of the rental payment by county is presented in Figure 13. Figure 15 shows the world price movement by crop over years.

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 contemporaneous impacts of annual land conservation budgets on local environmental quality? Secondly, what are the persistent effects of the initial budget on land conservation?

5.1 Contemporaneous Impact of the Policies

I estimate the annual immediate effects of farmland conservation policies. Referring back to the conceptual framework, this corresponds to the effects on the intensive margins (Figure 2). For a causal identification of the immediate annual effects of the policy, the empirical analysis closely follows some previous papers that also study the continuous impacts of historical events. Firstly, Hornbeck(2012) studies 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), uses a difference-in-difference setting to understand the impact of war-induced male labor supplies on levels of women labor employment (Acemoglu, Autor, and Lyle, 2004). My identification strategy closely follows this last paper where I use pre-Dust Bowl crop intensity as the continuous treatment variable to see the effects of the federal policy.

As Section 2 explains, the policy exhibits spatial variation depending on the targeted market crop intensity.[18] 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 as extracted from the 1930 agricultural census. Federal decisions about whether to implement land conversion payments to keep acreage below a national allotment closely follow national factors such as the timing of wars; the timing of the land-retirement program is likely to be exogenous to county-level decisions on grassland acreages. For the continuity of the time variation, I use a continuous variable of the annual federal-level soil conservation budget. 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:

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, α_c is the county-specific fixed effect, B_t is the annual federal budget for soil conservation, X_{ct} is a set of county-level control variables, and ϵ_{ct} is the error term. The coefficient of interest is γ, which corresponds 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

[18] 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.

exposure rate". 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 land conversion budget years.

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 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 that are correlated with states and include pre-1930 characteristics.

5.2 Persistent Impact

Next, the empirical analysis explores the persistent impact of early conservation policies on environmental outcomes for the future. Referring back to the conceptual framework, this corresponds to Scenario A (panel (a)) in Figure 2, 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 impacts of historical events. Firstly, Fiszbein (2017) studies 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 tend to lead to persistent differences in economic outcomes Banerjee and Iyer, 2005.

I have used county-level area under "treatment needed" data that I extracted from Conservation Needs Inventory reports. This is my outcome variable from 1940's. Then, I use county-level cropland, pastureland and total land wind erosion rate data as the outcome variable. This data is available from 1982 from Natural Resource Inventory. Following research by Depew, Fishback, and Rhode, 2013, I use county-level total AAA payment as the independent variable from 1933-1940. This is the money landowners receive from the government to convert their land to soil conserving grasses.

As Fishback, Horrace, and Kantor, 2006 mentioned, this regression may have omitted variable bias as AAA payment maybe correlated with the future erosion level with other channels. These analyses can be biased by the unobservables related to the political process and farmers' attitude toward soil and land conservation. For example, there can be bias from reverse causality if farmers are making decisions jointly on cropland conversion and soil management activities based on their ability. For that purpose, I use an instrumental variable similar to Depew, Fishback, and Rhode, 2013. I have used a county-level spatial variation of crop intensity in pre-policy period as the instrumental variable. This IV is correlated with AAA payment, as government decided the amount of money depending on the area under these market crops. This IV is not correlated with anything that happened after the Dust Bowl. I also control for targeted land adjustment areas, rate of payment, total population, average farmsize in the 1930's.

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 wind erosion, and all are at different future points of time ($t > 1940$). My IV for "Total AAA Payment" is the pre-policy county-level treated crop intensity. This is a variable that I have created from the pre-AAA Agricultural Census of the 1930. It is a county-level variable showing the proportion of area in any county under the crops in the program. 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 total population, average farm size, and rate of payment.

The coefficient α_1 captures the effect of early conservation policies on later erosion level. Given the skewed distribution of total AAA payment, 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.

6 Results

6.1 Contemporaneous Effects on the Grassland and Pasture Areas

6.1.1 Main Results

I begin by estimating a simple difference-in-difference model for total soil conserving grassland following regression equation 1. Table 3, Table 4, and Table 5 present the main results. I derived total grassland by using the USGS Historical Land Cover and Land Use Data (Table 3 and Table 4) and the Census of Agriculture (Table 5). Data used in Table 3 is a continuous annual data. Data used in Table 5 is extracted from the agricultural census, and collected after every 5 years. I matched the data with annual USDA budget for temporal variation. The coefficients measure whether counties with higher market crop intensity before the Dust Bowl (in 1930) experienced a greater increase in grassland under the post-Dust Bowl conservation budget from 1935.

We see that there is a positive significant effect from the land conservation programs on the average annual size of the area under grassland. I use a dynamic panel model to produce estimations because the past year's grassland may also affect this year's grassland. Model 1 in Table 3 presents Dynamic Panel Model where I controlled lagged grassland acre, and Model 2 presents Arellano-Bond estimator. For wheat-intense areas, Dynamic Panel Model shows that the average effect of the exposure increase is around 3%. If we use the Arellano–Bond estimator, we see that the effect rises to 5%. For corn-intense areas, the effect varies between 2% to 8% for Model 1 and Model 2. For cotton-intense areas, the effect is comparatively small.

Table 4 presents the results after dividing the dataset into the pre- and post-irrigation periods. Research in crop science states that access to irrigation is an important substitute to 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, and so irrigation mostly decreases the effects of the grassland restoration policies.[19]

[19]Appendix Table A3 presents the results using a 20-inch rainfall line (100th Meridian). As expected,

To get a robust result, I use another data set and estimate the same regression equation. I present results from the total soil-conserving grass areas that I created from the agricultural census. Table 5 presents this result. We see that the effect is similar. The effect is mostly concentrated in wheat and corn areas. Column 1 shows the results of estimating equation 1 with Dynamic Panel Model. The result shows that a 1 unit increase in exposure in wheat areas, consequently increases the total grassland by an annual average of 152 acres. Moreover, if we use the Arellano–Bond estimator, the effects are similar.

6.1.2 Potential Mechanisms and Interpretation of the Results

We show 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, and we examine the cases with initial farm size, initial percentage of tenancy, initial racial decomposition, initial access to irrigation, and initial non-farm jobs. The effects are mostly concentrated in wheat-growing areas. This section also collates some assumptions related to the allocation of limited land and empirically shows that early farmland conservation policies have fostered environmental quality.

Contemporary anecdotal 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 2 is modified to examine heterogeneity in the response. The analysis focuses on variation in the baseline characteristics in 1930. Table 6 to Table 12 present these results. I use USGS-provided historical land use and land cover data for these tables.

Column 1 of Table 6 shows the effect through initial farm size. The coefficients show that, if the average farm size is bigger, the counties adopt more grassland. 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

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.

production capital and, thus, may not be able to 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 farms to shift land to grasses. Small farms do not have enough capacity to put land aside from crops. This corroborates the findings of Hansen and Libecap, 2004. This result has policy implication on how policy makers may need to provide differential incentives to small farmers to adopt land conservation policies.

Column 2 of Table 6 shows that a higher ratio of tenants may slow the rate of uptake of land conservation programs. Property rights may play a role, here, in decisions about long-term conservation activities. Tenants have been a strong barrier to decisions to adopt conservation programs in the Great Plains because the duration of tenancy contracts is mostly short term. Any land conservation decision takes time to show up on the soil, and tenants have lower incentives to take the conservation programs. Absentee landlords were another problem in the Great Plains in taking 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.

Column 3 of Table 6 shows that the racial identities of farmers does not play a significant role. This results are understandable given the Great Plains have always been a white-dominated farming area. Column 4 of Table 6 shows that initial irrigation also plays no role in determining the area under grassland. Here, again, the results may only indicate that the area under irrigation was pretty small in 1930s.

Column 5 of Table 6 shows counties with higher non-farm jobs adopt more grass areas. Counties with more non-farm jobs can afford more land for non-farming works, and this results may come from that opportunity cost.

Table 7 shows similar results derived from the other grass data from agricultural census. The results are similar. For Table 7, I also provide results with farmers of Spanish origin from Mexico. These farmers were more familiar with climatic ecoregions in the Great Plains (Webb, 1959. This is because Mexico and other Spanish countries have similar weather and climate conditions 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 East and other European countries. We see from column 5 of Table 7 that farmers from Mexico conserve more land than others. Thinking about the long-term behavioral response from farmers depending on their ancestral knowledge might be important for policy makers.

We see a consistent variation in the results depending on the initial crops.The commercial market affects production and market decisions. Levels of price fluctuation are higher in the wheat regions; this may explain why wheat regions have more grass areas compared to corn and cotton. We see that wheat regions were more converted and also more planned. The reason may lie in the fact that wheat has been more export-oriented than other crops.

6.1.3 Demographic and other Changes

The benefit of the grasses may be overstated because of the channels that may influence farmers to make decisions about environmental quality. Given the period of the policy, I also check if other variables have been affected by the policy that may hinder the effects of the policy on environmental outcomes. Table 8 presents this result.

We see that the policy areas have lower population changes and lower tenancy rates over time. These have happened with USDA policies where USDA encouraged farmland consolidation and population migration. Landowners were recipient of the farm incentives, so this policy negatively affected tenants. There may also be long-term inter-generational effects from this policy as land ownership structure changes over time.

I also use average farm size as an outcome variable. We do not see any changes in the farm sizes as a result of this specific policy. Another important way to conserve land and environment was through use of fertilizer. I use fertilizer use also to see if this policy has any influence on farmers' use of fertilizer. But, we do not see any changes in the fertilizer uses as a result of this specific policy.

There is also a possibility that farmers may try to find more unsuitable land to cultivate crops under this policy. I create a data for total farmland and use that to see if there were new searches for farmland. The results show that total farmland is decreasing with the policy exposure. Farmers may not be able to find new marginal land to cultivate the crops. Table 9 presents this result.

Next, New Deal-related literature shows how democratic supporters may have a better chance of obtaining funding (Fishback, Kantor, and Sorensen, 2005). I examine this by checking the implication of the size of democratic voters on adoption of grasses. Table 10 presents this result. The results show that there is no significant effect of the democratic voters on getting more land under conservation.

6.1.4 Placebo Tests

Figure 7 shows the timing of the USDA budget. I have used marketing statistics to identify the timings of the policies and have found the years for which there was no soil conservation budget.

I show how the timing cutoff points affect the ways that landowners respond to the program. Table 11 shows that treated years have much higher effects on adoption of the programs. In the years for which farmers got financial incentives from the government, farmers convert significantly more land to grass areas. This result indicates that the soil conservation budget is important to nudge farmers to convert cropland to grassland.

6.1.5 Potential Role of Local Institutions

The federal government passed the Second New Deal in 1937, and created new local institutions, the Soil Conservation Districts (SCDs). Farmers had the power to create their own local institutions to increase conservation and land management. I use the timing of the formation of SCDs to see if local institutions help farmers to adopt more grassland.

The formation of SCDs may help to generate more hay and pasture because SCDs help to design conservation plans and ascertain if conversions are helpful for the soil. SCDs provide technical helps to farmers. To explore the benefits of these new institutions, I use data on the timings of SCD formations to see if their formation has helped to generate more conservation (Howlader, 2019). I created this data from the annual reports of the soil conservation districts that I collected from the National Archives.

Table 12 presents this result. We see that the formation of SCDs has significantly helped to generate more grassland, especially in the wheat areas. The results may have strong policy implication regarding the necessity of local institutions to help farmers in land and soil conservation.

6.2 Persistent Effects on Soil Erosion

6.2.1 Short-term persistent effect on soil erosion

Table 13 presents the state-level average of variables we use to understand short-term effect of the program on erosion. Main outcome variable is presented as proportion of cropland under conservation needs in any county, *PropNeedCNI*. Other variables include: Dust Bowl erosion variables at three levels, medium, high and low erosion; land use adjustment areas under the proposed USDA planning, $LUsize$, per acre payment for any county, *Payment*, and total AAA payment in any county, AAA. From this spatial variation across states, we see the more eroded areas in the Dust Bowl period were still under more conservation need areas in late 1940s. This data is, however, only available for five states.

Table 14 presents the OLS regression where my outcome variable is *PropNeedCNI*, and my main independent variable is the log of total AAA payment in any county, AAA. We see that if there is an 1% change in total AAA payment, there will be around .0004 increase in proportion of area under conservation need.

Table 15 presents the result where I instrument AAA payment with the pre-Dust Bowl targeted crop intensity. First-stage regression shows a strong correlation between AAA payment and pre-Dust Bowl crop intensity. The second-stage regression uses initial crop intensity as the instrument variable. We see that the effect is still positive, and is around .0007 after using the instrumental variable.

This may reflect the fact that we only have a very short period in between the policy and outcome variable collection date. It may be too early to see the effect of land use change policies on erosion and conservation needs in counties. The short-term effect of this policy does not show any reduction in soil erosion.

6.2.2 Long-term persistent effect on soil erosion

Table 16 presents average of variables we use to understand long-term effect of the program on wind erosion rate. Main outcome variable is presented as cropland, pastureland and total wind erosion rate per county. I use data from NRI for 2012, the latest year for which I have the data at county level. I did the same analysis for 2002 and 2007, the results are robust across time.

Table 17 report the estimated direct effects of the conservation programs on later environmental variables, county-level soil erosion on the pastureland and county-level soil erosion on the cropland. The results present that the Log(AAA) payment in 1930s have a negative effect on erosion in 2012. We see that for 1% change in Log(AAA) total payment in 1930s decreases wind erosion rate by .00672 in the total land, by .00675 in the pasture land, and by .00683 in the cropland. The erosion rate decreases at similar rate in cropland and pastureland at the county level in 2012. However, as explained before, this result may have omitted variable bias.

Table 18, Table 19, and Table 20 present the result where I instrument Log(AAA) payment with the pre-Dust Bowl targeted crop intensity. First-stage regression shows a strong correlation between Log(AAA) payment and pre-Dust Bowl crop intensity. The second-stage regression uses initial crop intensity as the instrument variable. The results still show there is a negative effect of the policy on erosion. Table-18 presents that 1% change in Log(AAA) total payment in 1930s decreases wind erosion rate in any county by .01631. Table-19 presents that 1% change in Log(AAA) total payment in 1930s decreases wind erosion rate in the pastureland by .01543. Table-20 presents that 1% change in Log(AAA) total payment in 1930s decreases wind erosion rate in the cropland by .01886. This result corresponds to our intuitive understanding that the converted areas have been benefited by the conversion and land use change (Hornbeck, 2012).

6.3 Uptake of Conservation Reserve Program

Conservation literature suggests that there may exist spatial and temporal spillovers of early conservation programs on later conservation uptake. To check this, I use a county-level Conservation Reserve Program (CRP) uptake data from 1985, and see if this early land conservation programs have any influence. CRP is a similar program established in 1985, and still continues as the primary working land conversion program in the USA.

Table 21 and Table 22 presents the results. Results show is early land conversion places still have strong impact on how landowners took decisions on the uptake of this later adoption of grassland under CRP. We do not see any significant change in the uptake of CRP because of the previous programs.

7 Ecological Consequences of Market-based Site Selection

I present the county-level spatial variation in rate of payment in 1930's. Figure 13 presents this map. The map suggests that higher erosion areas always did not get higher amount of payment from the government. Also, Figure-4 and Figure-6 show that targeted areas are concentrated in the wheat counties.

From the results, on average, we see that the policy was specially helpful on wheat regions. Now question comes if the site selection was based on market crops. To understand it, I explore the relationship between rate of payment, market crops, and environmental erosion index. I fit the data with a probabilistic model. Table 18 presents this result. We see that the impact of market-based crops is much higher than the erosion index. Ecological benefits concentrates on the counties where farmers were producing market crops.

This finding has policy implications. To fight with the Dust Bowl and similar ecological disaster, we needed to place conservation areas on places that have highest erosion and conservation needs, not where only market crops are overproduced. The policy has persistent impact on environmental outcomes, but the areas that needed highest conservation exposure were always not under highest priority.

8 Discussion and Conclusion

> *"Houses were shut tight, and cloth wedged around doors and windows, but the dust came in so thin that it could not be seen in the air, and it settled like pollen on the chairs and tables, on the dishes."*- John Ernst Steinbeck Jr in The Grapes of Wrath

Subsequent to the disastrous situation after the Dust Bowl, the return to a normal environment took numerous policy changes, including the conversion of farmland to 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 both the short- and long terms. I demonstrate that current differences in environmental outcomes within the Great Plains can be traced to the introduction of 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 agrarian land tenancy, access to irrigation, institutional, political, and demographic factors. Land restoration is an important policy tool under situations similar to the Dust Bowl in 1930's.

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 important and popular conservation instrument and constitutes a significant portion of the farmland conservation budget in the United States (Hellerstein, 2017 and 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. The primary purpose of farmland retirement is to increase the endowment of natural resources for future benefit. However, market pressure and the use of conservation policy as a supply control instrument makes the context complicated.[20]

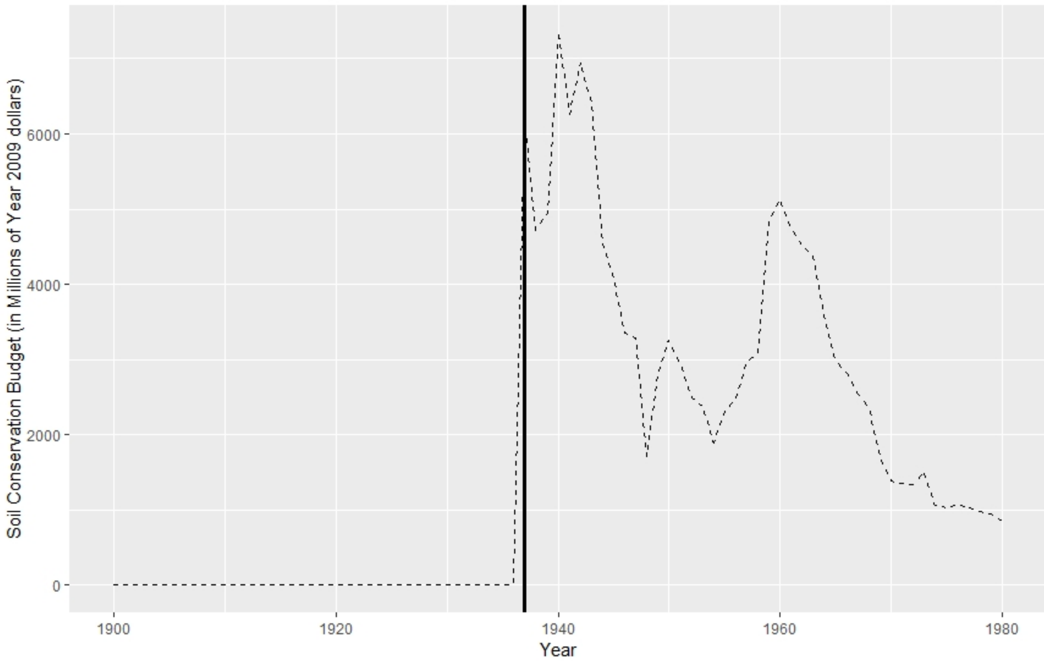
Designing farmland conservation policies is a significant component in fiscal policies in developing countries too (Jayachandran et al., 2017; Andam et al., 2010; Howlader and Ando, 2020). Some recent studies compare USA experiences of land retirement with Chinese experiences (Xiao et al., 2017; Heimlich, 2002; Lohmar et al., 2007). The main concern is that land conservation may not persist after the removal of 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 and may help to design better contracts with landowners. Also, the tendency towards short-term understandings of land conservation policies, mostly in developing countries, receives attention in environmental economics (Howlader and Ando, 2020; Sims and Alix-Garcia, 2017; Andam et al., 2010). Although, results from these studies may hinder benefits because of the limited time duration from the policy event. Land-use change takes time to be visible in landscapes. By analyzing the long-term impacts, this paper ultimately helps policymakers to 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 that there is a possibility of Dust Bowl-type events in the Great Plains in recent future (Cowan et al., 2020). This paper on the early experience with the Dust Bowl in 1930's may help to face future conditions like that. To design new conservation policies, we need to understand what has worked well in the past. Farmers with different cropping structures and methods experience different levels of exposure to conservation policy; such disparity may create long-term ecological differences. The voluntary nature of the program, and subsidy dependency, may create ecological effects, and policy makers need to keep this in mind while designing federal-level conservation policies.

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

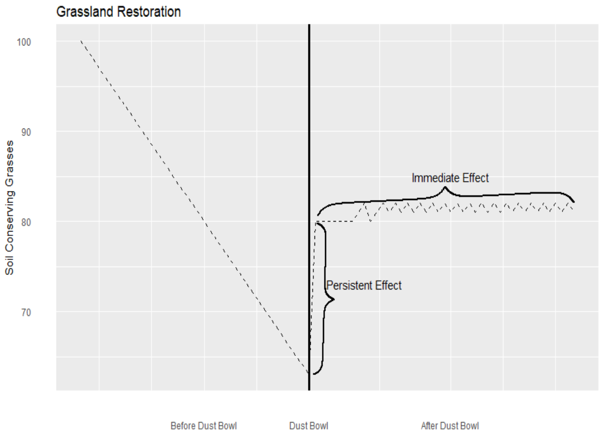
9 Figures

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

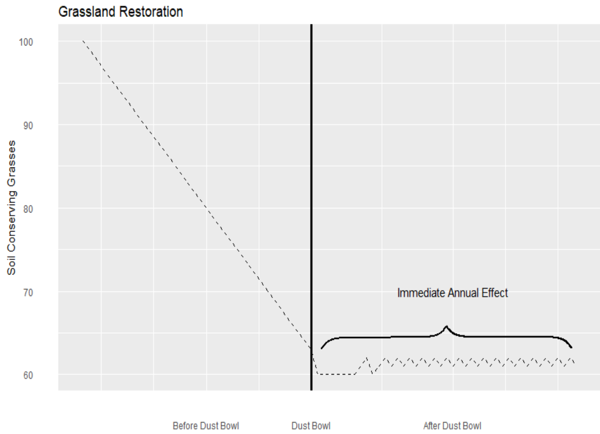


Note: This graph denotes the total financial expenditure on soil conservation by USDA Soil Conservation Service (currently named as Natural Resource and Conservation Service).

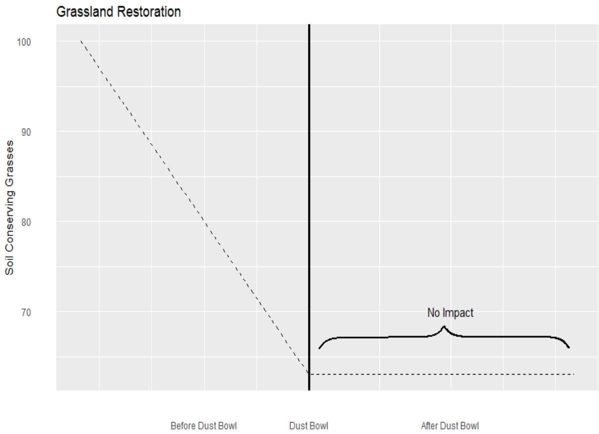
Figure (2) Conceptual Framework



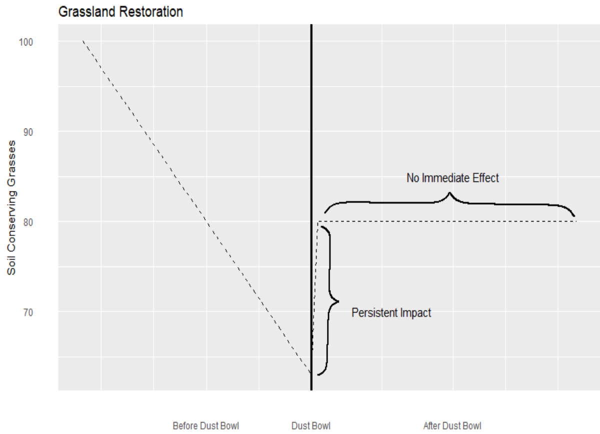
(a) Persistent and Immediate Effect



(b) Only Immediate Effect



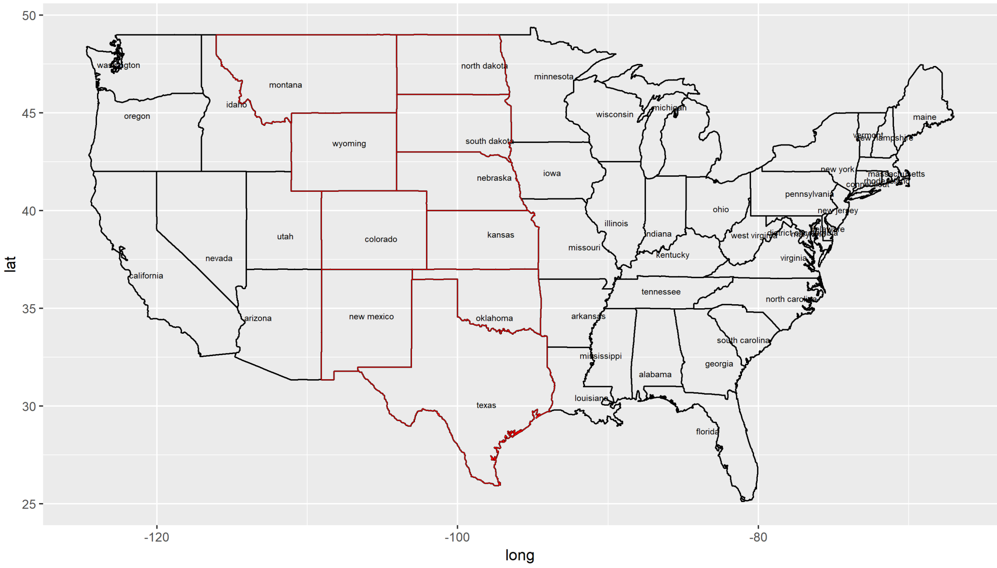
(c) No Impact



(d) Persistent but No Immediate Effect

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

Figure (3)   **Study Area - The Great Plains**

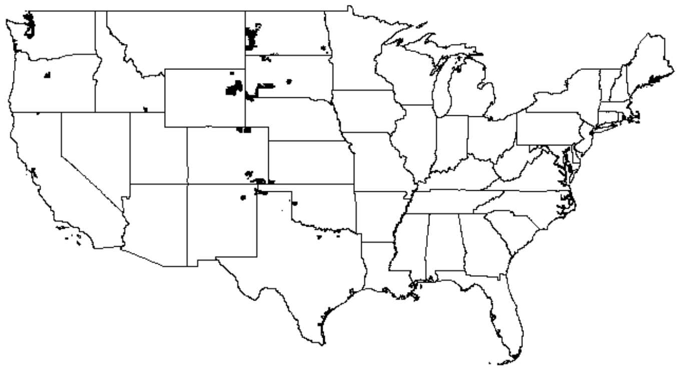


Note - States in the Great Plains: Texas, Oklahoma, Kansas, Nebraska, South Dakota, North Dakota, Wyoming, Montana, Colorado, New Mexico.

Figure (4) Proposed Land Restoration Map (1936)

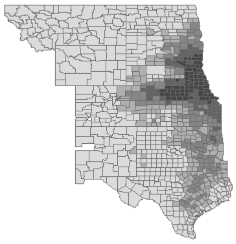
Note: Map collected from the National Archives (RG 114). Map shows the areas proposed to convert to the grasses. I digitized this map from the original map in the Appendix (B2).

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

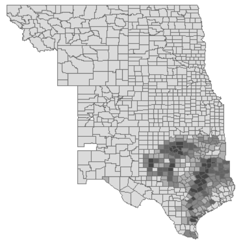


Data are from the USFS. Figure shows lands permanently purchased and restored to grassland by USFS in 1930s. National Grassland units designated by the Secretary of Agriculture and permanently held by the Department of Agriculture under Title III of the Bankhead-Jones Farm Act.

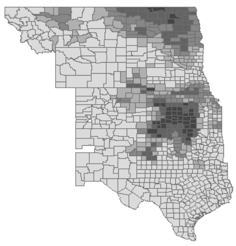
Figure (6) Spatial Variation of Crop Intensity



(a) Corn Intensity



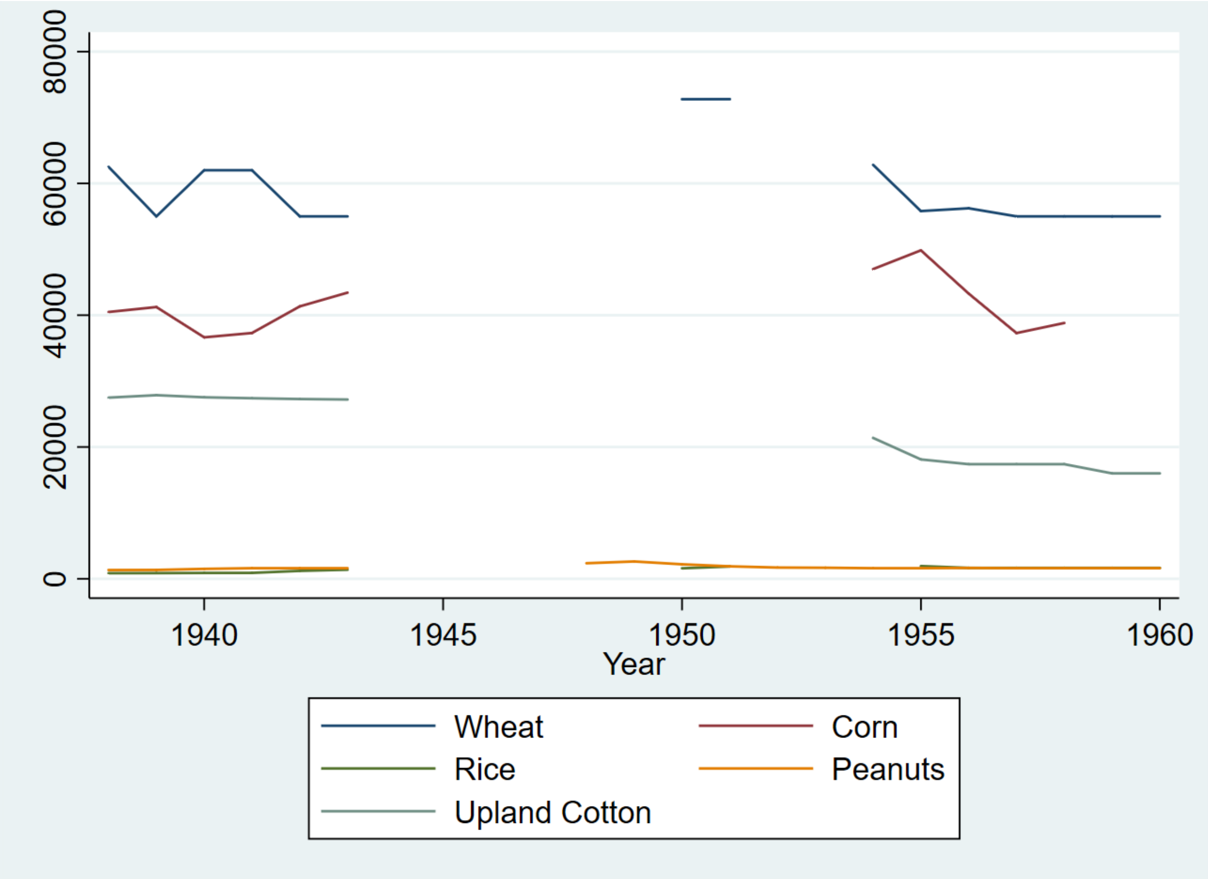
(b) Cotton Intensity



(c) Wheat Intensity

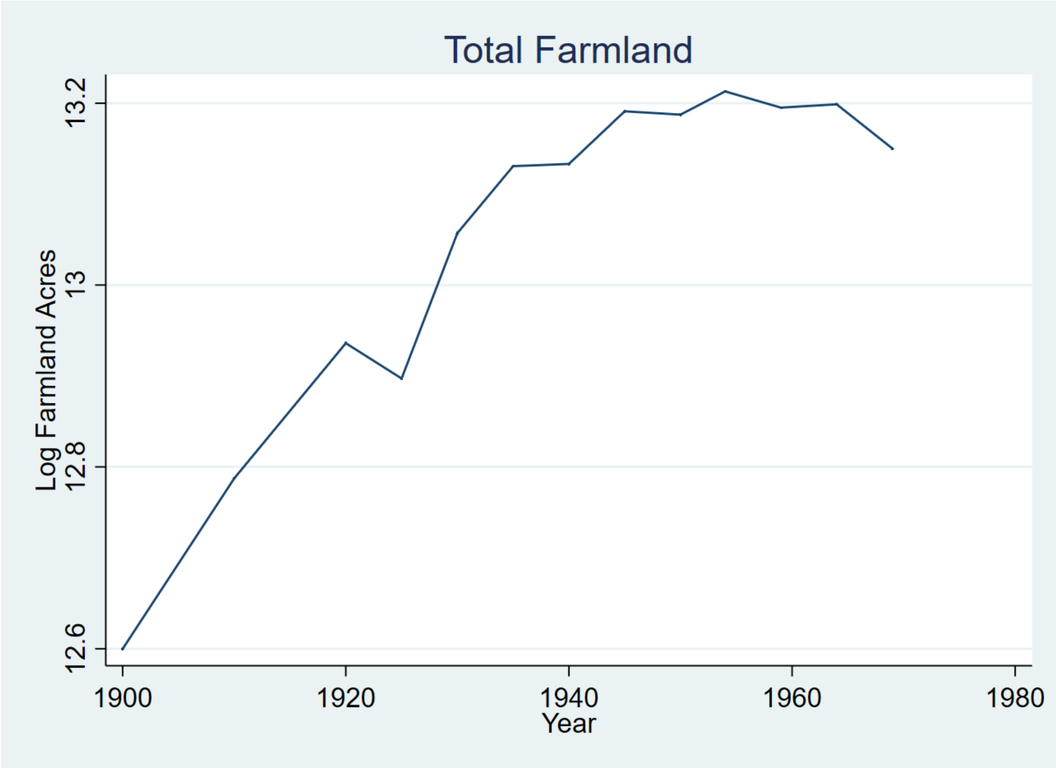
Note: County-level crop intensity data extracted from the US Census of Agriculture (1930), Crop area fraction of total farm area.

Figure (7) Total Acreage Allotment for Crops



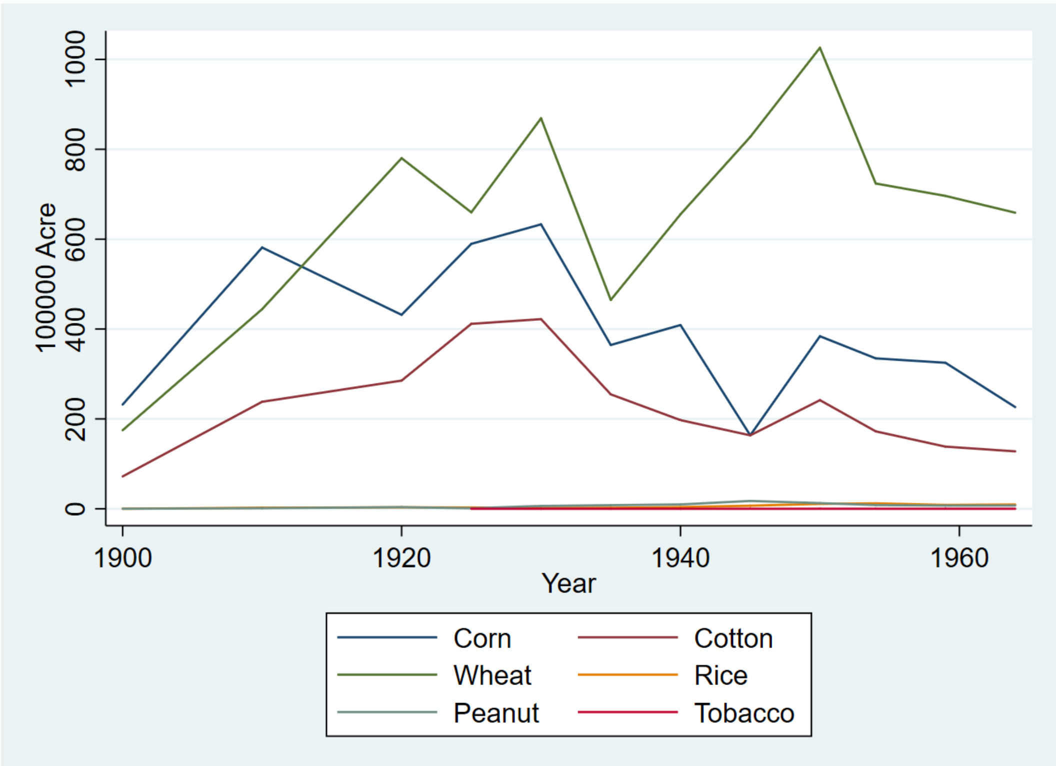
Note: Data Calculated From USDA Bulletin, "Acreage Allotment and Marketing Quota Summary" 1961. Graph denotes the annual crop acreage allotment for the USA. The variation closely follows the world price movement.

Figure (8) **Aggregate Changes on the Plains in Agriculture**



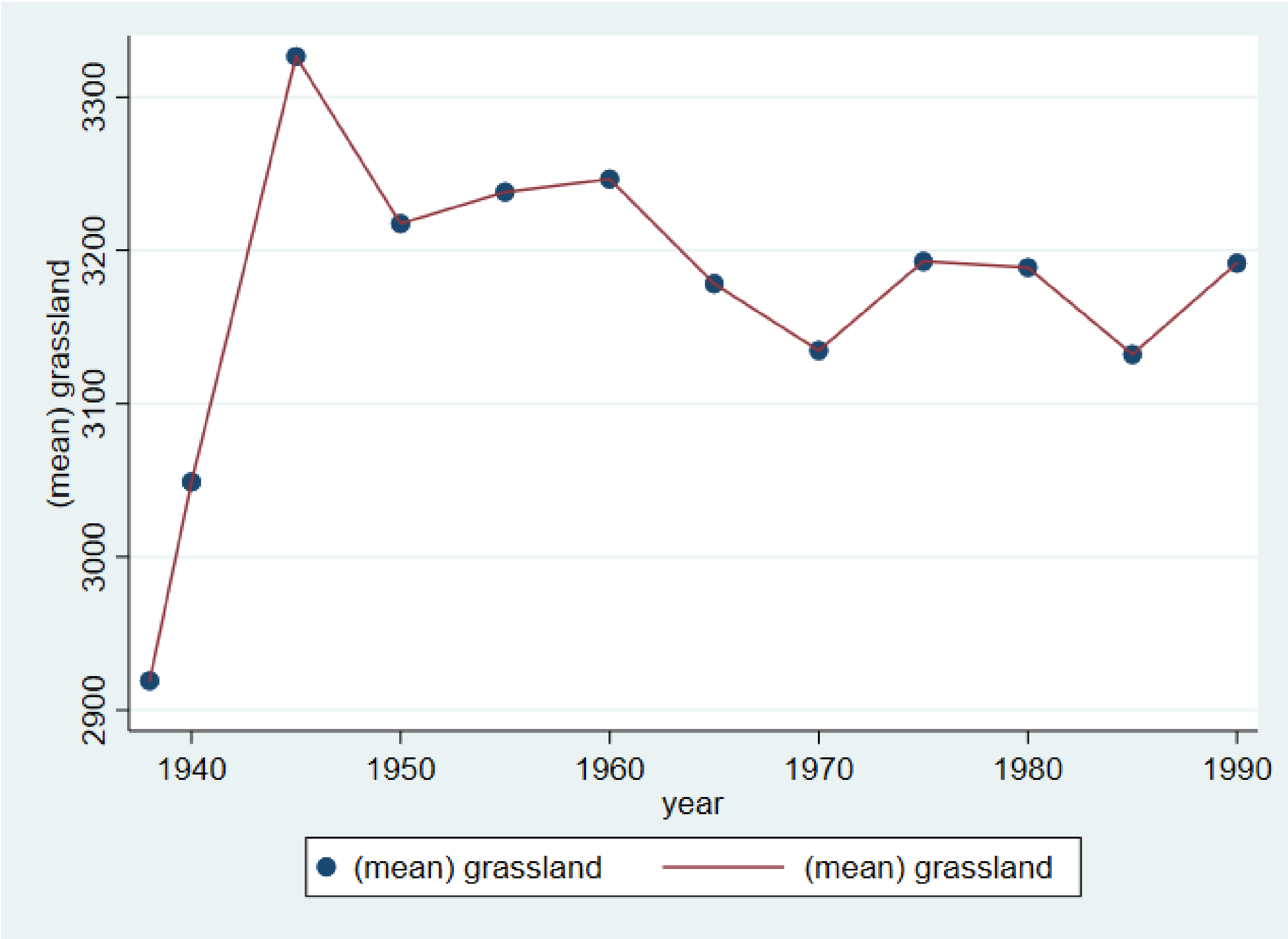
Data are from the US Census of Agriculture, and reports the log total acres of farmland.

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



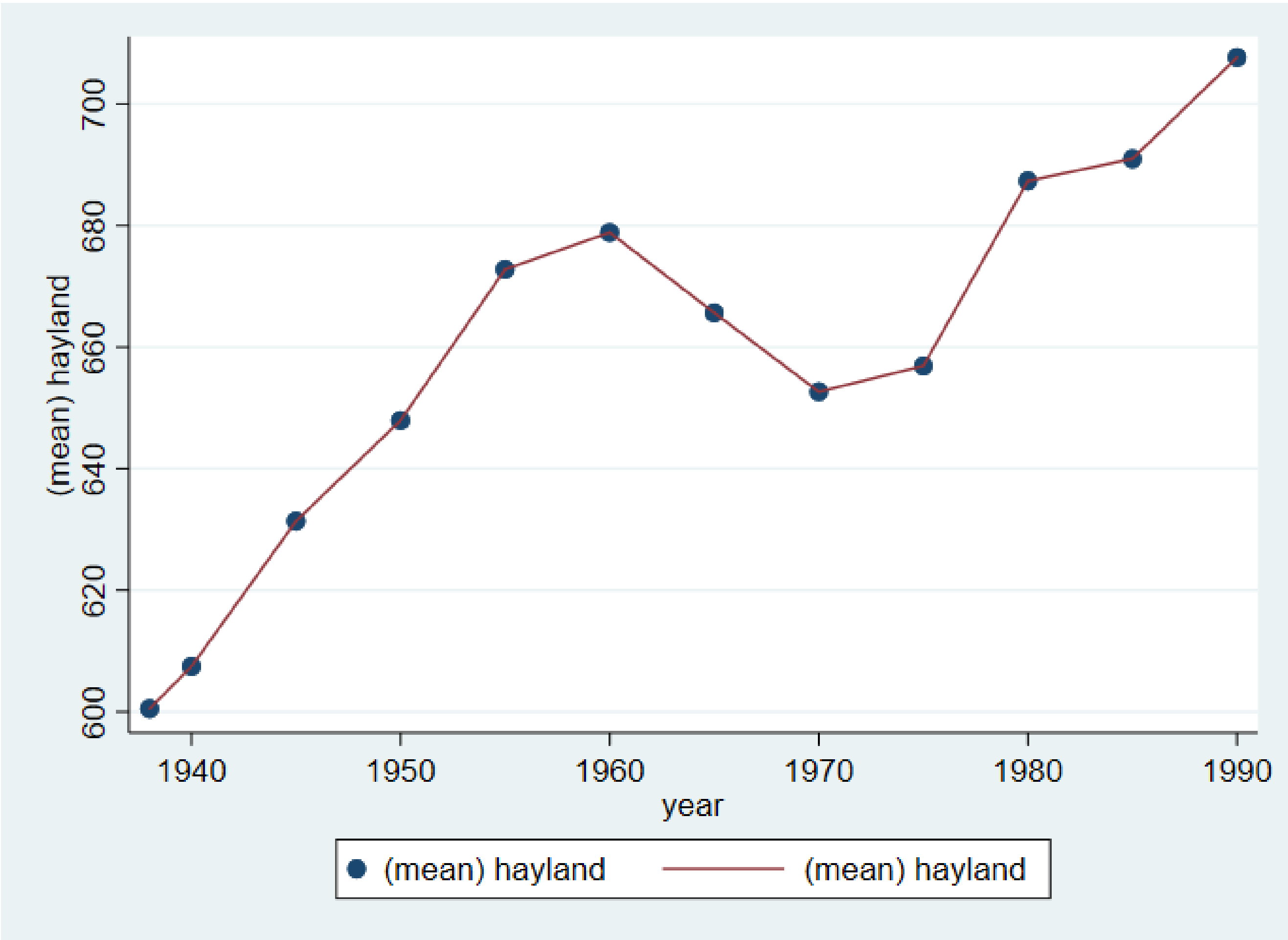
Note: Data are from the US Census of Agriculture

Figure (10) Evolution of Grassland in the Great Plains



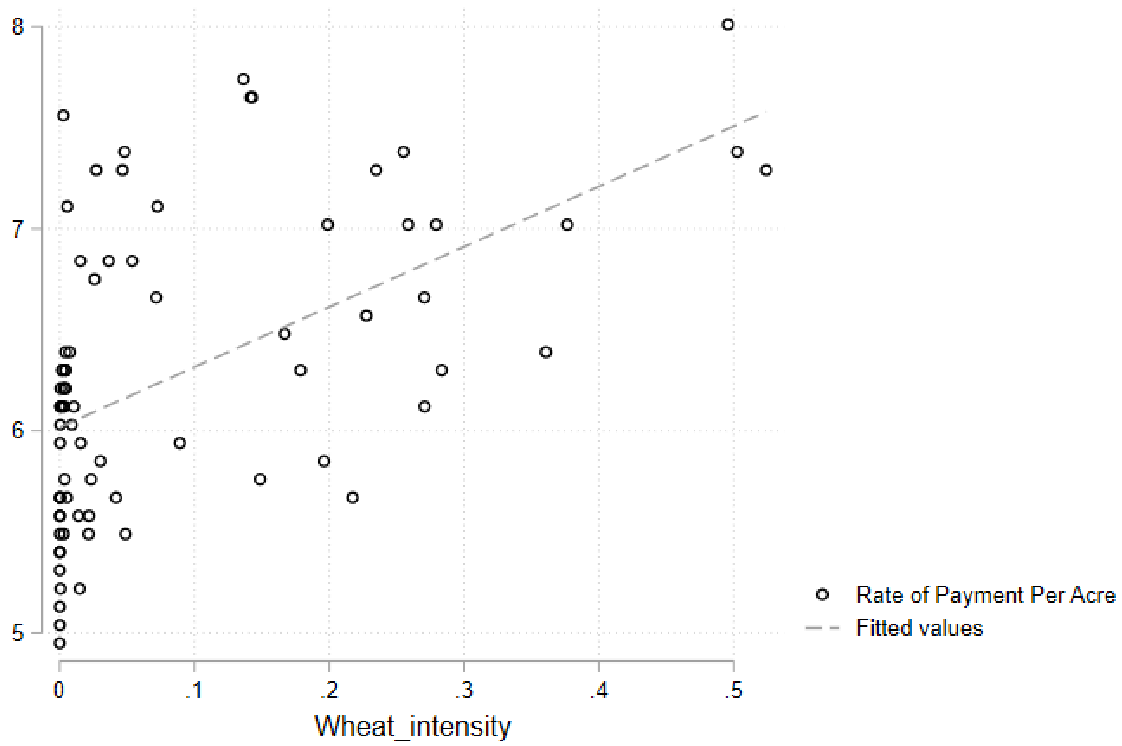
Note: Data extracted from USGS Historical Land Use and Land Cover database from 1938. This is a raster data providing information on the grassland.

Figure (11) Evolution of Hayland in the Great Plains



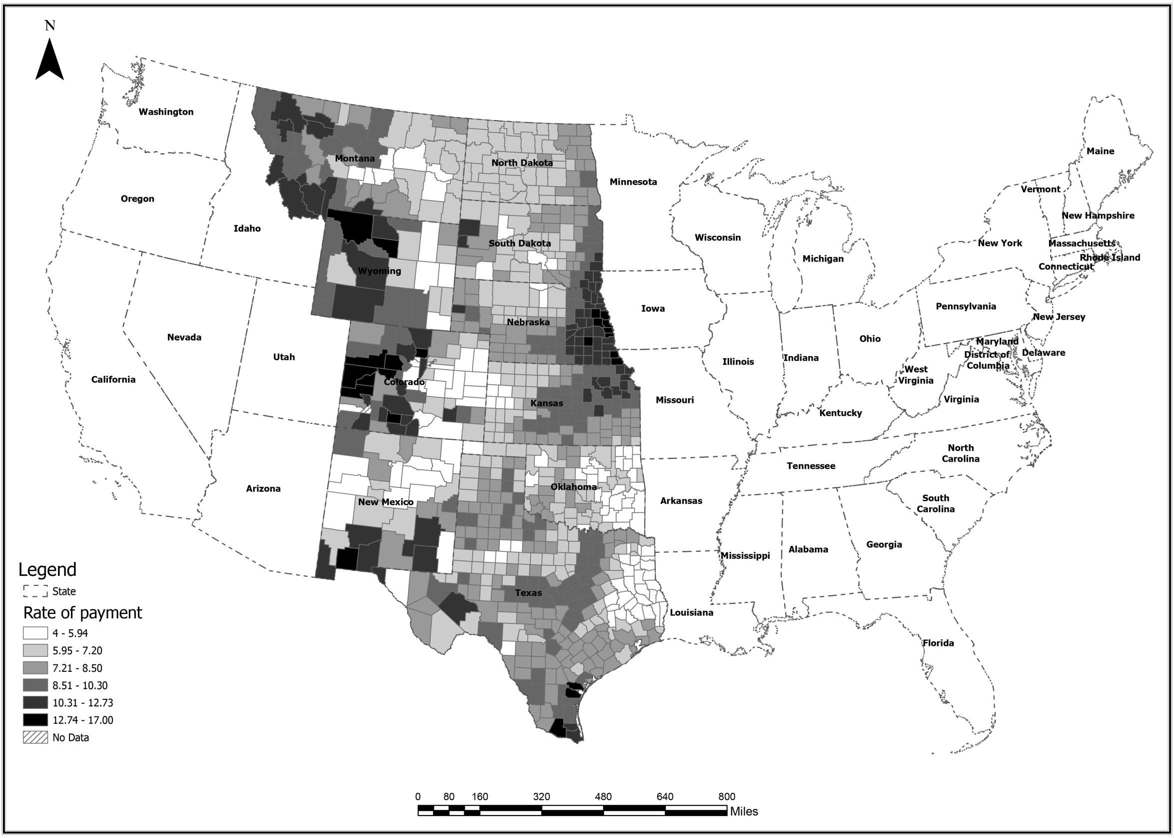
Note: Note: Data extracted from USGS Historical Land Use and Land Cover database from 1938. This is a raster data providing information on the hayland.

Figure (12) Relationship between Rate of Payment and Crop Intensity in Oklahoma



Note: Data extracted from National Archives at College Park (for more details of the data, see the appendix). Graph denotes the correlation between Oklahoma counties' rate of payment per acre and their 1930 wheat intensity. This shows the rate of payment has a strong positive correlation with pre-policy crop intensity in Oklahoma. Wheat is Oklahoma's main crop.

Figure (13) Rate of Payment



Note: Data extracted from National Archives at College Park. Graph denotes the spatial variation in rate of payment per acre.

Figure (14) Histogram: 1930's Average Crop Intensity

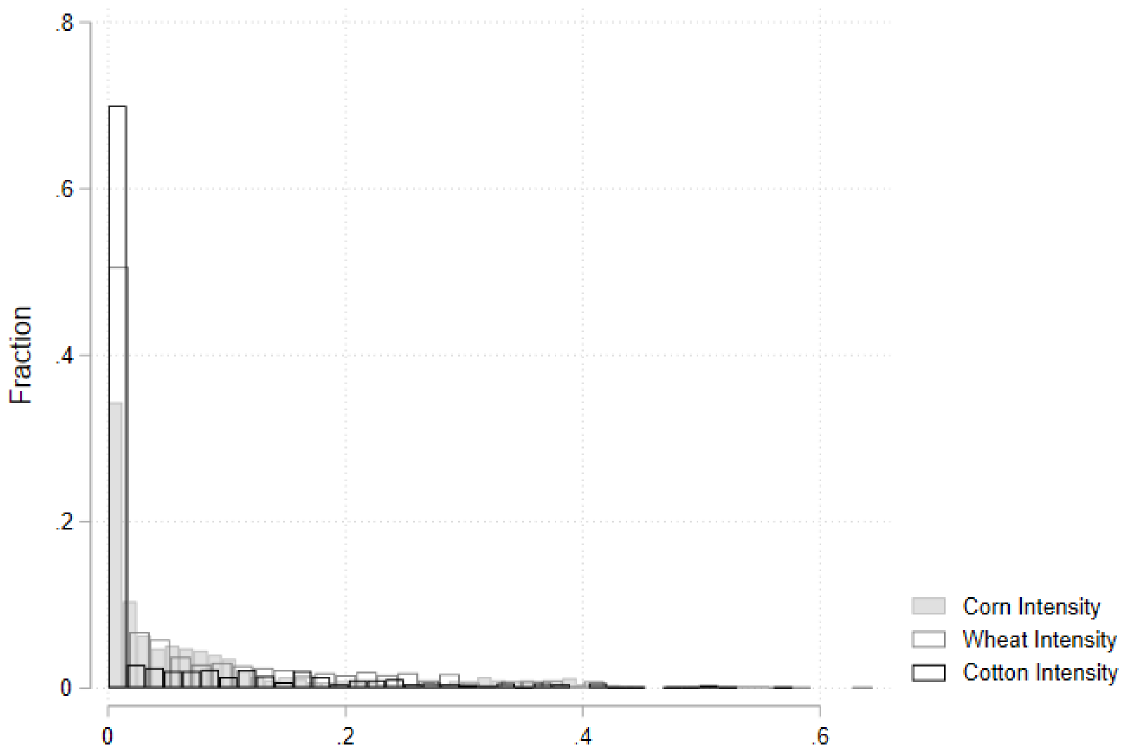
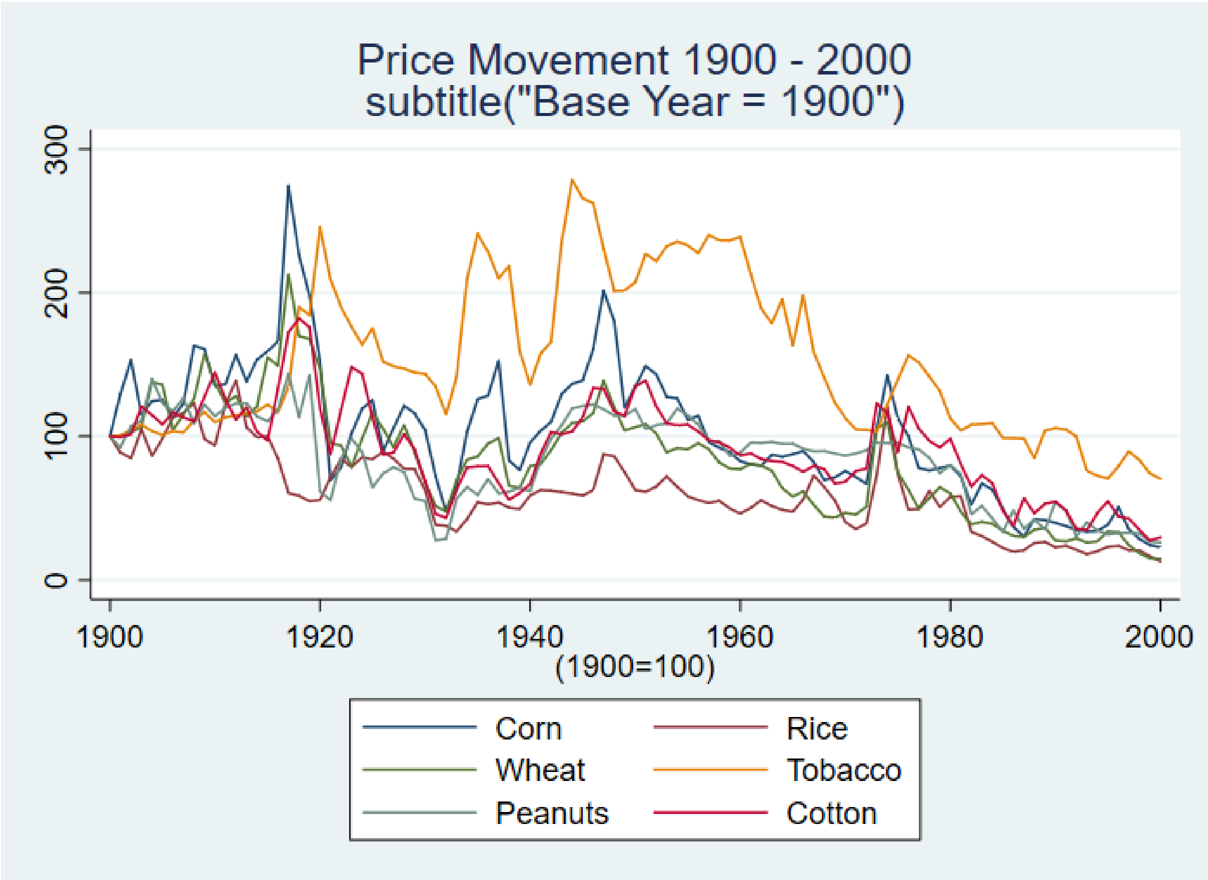


Figure (15) **World Price Variation by Commodities**



Note: World Price Variation by Commodities, Data from Jacks, D. (2013), "From Boom to Bust: A Typology of Real Commodity Prices in the Long Run", NBER Working Paper 18874; Base Year = 1900

10 Tables

Table (1) **Description of the Variables**

Variable Name	Description	Data Source
(i) Soil Conserving Grass		
Grassland, Hayland	Area	USGS Historical Land Use and Land Cover Data;
Grass	Hay, tame, alfalfa, clover, timothy, wild, salt and prairie	Census of Agriculture 1920 - 1980
(ii) Erosion Variables		
Cropland Erosion	Loss under erosion	Natural Resource Inventory (1982-2012);
Pastureland Erosion	Loss under erosion	Natural Resource Inventory (1982-2012)
Soil Erosion, 1934	Soil Erosion Index	Reconnaissance Erosion Survey (Hornbeck (2012))
Land Conversion Map, 1934	Map showing targeted conversion areas	National Archives (RG 114)
Conservation Needs Inventory, 1940s	Conservation Needs Inventory Reports	USDA Archives at the Haithitrust Digital
(iii) Agricultural Statistics		
Farmland	Total area under farms (acre)	Census of Agriculture
Crop Intensity'1930	Crop Area/Farm Area	Census of Agriculture
Tenancy	Percentage of Tenants	Census of Agriculture
Proportion Black Farms	Black Farms/Total Farms	Census of Agriculture
Proportion White Farms	White Farms/Total Farms	Census of Agriculture
Farm size	Average farm size	Census of Agriculture
Number of Farms	Total Number of Farms	Census of Agriculture
Population Density	Population/acre	Census of Agriculture
Origin of the farmers	Country name	Census of Agriculture
Cap on the production	Marketing Quota	USA Marketing Quota books
Budget	Annual Soil Conservation Budget	USDA
Soil Conservation District (SCD)	Timing	Annual Reports of the SCDs
County payment per acre	Financial Incentives for Farmers	National Archives (RG 114)
(iv)Population Statistics		
Total Population	Total number of people	Population Census
Voting Results	Proportion of voters democrat	Fishback (2006)

[a] Marketing Quota books are manually extracted from HathiTrust Digital Library.
[b] Land conversion map is collected and digitized from the National Archives.

Table (2) **Summary Statistics by Census Year**

	(1)	(2)	(3)	(4)	(5)
	1930	1940	1950	1960	1970
	mean	mean	mean	mean	mean
Total Population	36066.24	37364.42	46759.26	54496.83	59570.15
County Area	507366.9	511169.3	510570.9	511874.7	511896.9
Total Harvest Area	119377.2	233695.2	113804.6	102326.5	89504.02
Average Farmsize	339.2313	396.2733	503.2128	602.0993	659.8266
Percentage of Tenant	38.98595	37.77527	24.94758	19.17877	12.4364
Cotton Acre	14961.91	3594.977	9646.532	5135.723	3752.886
Tobacco Acre	661.6517	6404.469	643.9849	545.2521	314.4238
Corn Acre	34134.71	30577.72	29326.95	27947.96	21346.51
Wheat Acre	19750.56	27254.5	24615.48	16009.45	14498.25
Peanut Acre	489.6099	3077.987	1138.292	1309.253	512.1492
Rice Acre	230.4426	3342.478	3855.84	706.738	-
Proportion of White	.8572825	.8779208	.8847669	.8841911	.887793
Proportion of Black	.1207721	.1157882	.1086398	.1049307	.0984421
Observations	824	824	824	824	824

Table (3) **Contemporaneous Impact of Farmland Conservation on Total Grassland**

VARIABLES	(1) Model 1	(2) Model 2
Budget(Mil)*Initial wheat Intensity	0.0324***	0.0597***
	(0.00727)	(0.0137)
Budget(Mil)*Initial Corn Intensity	0.0262***	0.0879***
	(0.00807)	(0.0158)
Budget(Mil)*Initial Cotton Intensity	0.0119	-0.0356**
	(0.00890)	(0.0168)
Lag(Grassland Acre Proportion)	3.003***	
	(0.489)	
State*Year	-1.40e-06***	-1.81e-06***
	(2.46e-07)	(2.52e-07)
Lag(Log Grassland Proportion)		-0.0179***
		(0.00550)
Constant	-4.451***	-4.504***
	(0.0176)	(0.0302)
Observations	34,440	33,620
R-squared	0.004	
Number of FIPS	820	820
State-Year FE	Yes	Yes

Standard errors in parentheses

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

[a] Note: Outcome variable is calculated from USGS Historical Land Use Data for the USA. Difference-in-difference results with budget variation interacted with initial crop intensity. Model 1 uses Dynamic Panel Model and Model 2 uses Arellano-Bond estimator from STATA 16.

Table (4) **Continuous Impact on Total Grassland: Pre- and Post Irrigation**

VARIABLES	(1) Pre-Irrigation	(2) Post-Irrigation
Budget(Mil)*Initial Wheat Intensity	0.0589***	0.00536
	(0.0144)	(0.0103)
Budget(Mil)*Initial Corn Intensity	-0.00256	0.0379***
	(0.0159)	(0.0115)
Budget(Mil)*Initial Cotton Intensity	-0.0173	-0.0449***
	(0.0179)	(0.0134)
Lag(Grassland Acre Proportion)	1.545**	-3.735***
	(0.696)	(0.722)
State*Year	-1.88e-06**	-7.89e-06***
	(7.54e-07)	(9.42e-07)
Constant	-4.416***	-3.981***
	(0.0537)	(0.0679)
Observations	17,220	16,400
R-squared	0.002	0.010
Number of FIPS	820	820
State-Year FE	Yes	Yes

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

[a] Note: Outcome variable is calculated from USGS Historical Land Use Data for the USA. Difference-in-difference results with budget variation interacted with initial crop intensity. Large-scale Irrigation started after 1960s, so we do a temporal analysis with irrigation period. We see conservation programs have lower impact after irrigation period, at least in wheat regions.

Table (5) **Continuous Impact of Farmland Conservation on Total Soil Conserving Land**

VARIABLES	(1) Model	(2) Model
Budget(Mil)*Initial Wheat Intensity	152.1***	154.7***
	(13.84)	(26.51)
Budget(Mil)*Initial Corn Intensity	288.2***	406.1***
	(26.43)	(64.21)
Budget(Mil)*Initial Cotton Intensity	91.51***	87.58**
	(21.34)	(43.05)
Lag(Soil Base)	-0.0735***	-0.102***
	(0.0126)	(0.0310)
state_year	-0.000148***	
	(3.23e-06)	
Lag(Soil Base)		0.0697*
		(0.0364)
Constant	13.83***	0.118***
	(0.298)	(0.0124)
Observations	3,847	937
R-squared	0.471	
Number of FIPS	834	558
State-Year FE	Yes	Yes

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

[a] Note: Outcome variable is calculated from USDA agricultural census (summation of all land under soil conserving grasses for which USDA paid farmers). USDA annual financial assistance conservation budget has been interacted with 1930's initial crop intensity in the difference-in-difference model. Variables have been converted to logarithm for skewness. Results are similar to Table 3.

Table (6) **Heterogeneious Treatment Effect on Total Grassland**

VARIABLES	(1) Farmsize	(2) Tenancy	(3) Race(Black)	(4) Irrigated	(5) NonFarm
Budget(M)*Wheat	-0.0370**	0.0679***	0.0309***	0.0294***	0.0749***
	(0.0160)	(0.0142)	(0.00752)	(0.00744)	(0.0138)
Budget(M)*Corn	-0.0870***	0.0466**	0.0257***	0.0238***	-0.0104
	(0.0173)	(0.0208)	(0.00821)	(0.00823)	(0.0109)
Budget(M)*Cotton	0.0160	0.0305	0.0186*	0.0124	0.0256
	(0.0150)	(0.0187)	(0.0112)	(0.00893)	(0.0157)
Budget(M)*Corn*Farmsize	0.000546***				
	(6.51e-05)				
Budget(M)*Cotton*Farmsize	7.10e-05				
	(7.67e-05)				
Budget(M)*Wheat*Farmsize	0.000108***				
	(3.16e-05)				
Lag(Grassland Acre Prop)	2.592***	3.021***	3.077***	3.043***	3.017***
	(0.493)	(0.492)	(0.492)	(0.492)	(0.492)
Budget(M)*Corn*Tenancy		-1.90e-05			
		(2.24e-05)			
Budget(M)*Cotton*Tenancy		-2.77e-06			
		(8.60e-06)			
Budget(M)*Wheat*Tenancy		-5.70e-05***			
		(1.84e-05)			
Budget(M)*Corn*Black			4.80e-05		
			(6.48e-05)		
Budget(M)*Cotton*Black			-2.64e-05		
			(2.16e-05)		
Budget(M)*Wheat*Black			6.00e-05		
			(0.000140)		
Budget(M)*Corn*Irrigation				1.659	
				(1.474)	
Budget(M)*Cotton*Irrigation				-0.205	
				(0.866)	
Budget(M)*Wheat*Irrigation				1.866	
				(1.427)	
Budget(M)*Corn*NonFarm					1.09e-05***
					(2.11e-06)
Budget(M)*Cotton*NonFarm					-3.03e-06
					(2.34e-06)
Budget(M)*Wheat*NonFarm					-1.18e-05***
					(3.27e-06)
Constant	-4.451***	-4.451***	-4.451***	-4.451***	-4.452***
	(0.0176)	(0.0176)	(0.0176)	(0.0176)	(0.0176)
Observations	34,020	34,020	34,020	34,020	34,020
R-squared	0.007	0.005	0.004	0.004	0.005
Number of FIPS	810	810	810	810	810
State*Year FE	Yes	Yes	Yes	Yes	Yes

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

[a] Note: Outcome variable is calculated from USGS Historical Land Use Data for the USA. Triple Difference results with budget variation interacted with initial crop intensity and initial spatial heterogeneity.

Table (7) **Heterogeneious Treatment Effect Soil Conserving Grassland**

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Farmsize	Tenancy	Black	Irrigated	Origin
Budget(M)*Wheat	54.97***	342.0***	103.2	-3,027***	157.8***
	(20.20)	(46.71)	(64.11)	(774.5)	(27.60)
Budget(M)*Corn	280.3***	397.2***	72.78	-6,031***	282.6***
	(40.73)	(69.97)	(73.79)	(915.6)	(57.88)
Budget(M)*Cotton	-142.4***	426.5***	-429.9***	82.89	96.23***
	(31.64)	(79.24)	(69.11)	(1,282)	(34.16)
Budget(M)*Corn*Size	0.295**				
	(0.120)				
Budget(M)*Cotton*Size	1.122***				
	(0.0978)				
Budget(M)*Wheat*Size	0.114***				
	(0.0218)				
Lag(Soil Base)	-0.0723***	-0.0497***	-0.0549**	-0.0190**	-0.0930***
	(0.0122)	(0.0136)	(0.0249)	(0.00848)	(0.0222)
State*Year	Y	Y	Y	Y	Y
Budget(M)*Corn*Tenancy		-3.182*			
		(1.788)			
Budget(M)*Cotton*Tenancy		-6.716***			
		(1.576)			
Budget(M)*Wheat*Tenancy		-6.524***			
		(1.381)			
Budget(M)*Corn*Black			-0.192*		
			(0.110)		
Budget(M)*Cotton*Black			0.0284		
			(0.0301)		
Budget(M)*Wheat*Black			0.106		
			(0.0655)		
Budget(M)*Corn*Irri				-7.87e-07	
				(5.07e-06)	
Budget(M)*Cotton*Irri				0.00605	
				(0.00945)	
Budget(M)*Wheat*Irri				-5.48e-08	
				(6.10e-07)	
Budegt(M)*Corn*Mexican					-0.114
					(0.304)
Budegt(M)*Cotton*Mexican					0.332
					(0.231)
Budegt(M)*Wheat*Mexican					-0.0611
					(0.415)
Constant	14.21***	16.18***	18.06***	4.692***	14.73***
	(0.295)	(0.318)	(0.378)	(0.266)	(0.603)

Standard errors in parentheses

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

[a] Note: Outcome variable is calculated from USDA agricultural census (summation of all land under soil conserving grasses for which USDA paid farmers). Tripple difference models have been estimated to explore how initial spatial heterogeneity explains the results.

Table (8) **Potential Mechanism Hindering Environmental Quality**

VARIABLES	(1) Total Population	(2) Tenancy	(3) Farmsize	(4) Fertilizer
Budget(M)*Wheat	-101.6***	-1,901***	-2.911e+08	-2.139e+07
	(21.20)	(626.1)	(2.934e+08)	(9.416e+08)
Budget(M)*Corn	-68.31***	1,508**	-1.770e+08	1.023e+07
	(21.25)	(646.5)	(3.031e+08)	(2.173e+09)
Budget(M)*Cotton	223.8***	-1,043	4.052e+08	-8.265e+07
	(35.48)	(1,050)	(4.916e+08)	(1.527e+09)
state_year	3.74e-05***	-0.0128***	-112.0*	443.3***
	(6.33e-06)	(0.000140)	(63.80)	(146.7)
Constant	5.878***	1,220***	1.060e+07*	-4.077e+07***
	(0.585)	(12.95)	(5.905e+06)	(1.356e+07)
Observations	6,677	7,500	8,323	5,117
R-squared	0.017	0.572	0.001	0.002
Number of FIPS	833	834	834	834
State-Year FE	Yes	Yes	Yes	Yes

Standard errors in parentheses

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

[a] Note: Outcome variable is calculated from USDA agricultural census. USDA annual finacial assistance conservation budget has been interacted with 1930's initial crop intensity.

Table (9) **Unintended Consequence on Land Use**

	(1)
VARIABLES	Search For New Land
Treat Year*Corn	-6.542***
	(0.281)
Treat Year*Wheat	-8.619***
	(0.243)
Treat Year*Cotton	-4.019***
	(0.400)
Lag(Soil Conserving Grasses)	0.0586
	(0.109)
State*Year	0.000756***
	(3.25e-05)
Constant	-54.42***
	(3.007)
Observations	5,520
Number of FIPS	834
R-squared	0.393
State-Year FE	Yes

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

[a] Note: Outcome variable is calculated from USDA agricultural census. Regression estimates if farmers search for new cropland in the marginal areas in the treated years.

Table (10) **Impact Democratic Voter**

VARIABLES	(1) Voter Democrat
Budget(M)*Wheat	189.9***
	(67.25)
Budget(M)*Corn	408.2***
	(110.6)
Budget(M)*Cotton	206.1
	(237.7)
Budget(M)*Vote*Corn	-1.675
	(1.431)
Budget(M)*Vote*Cotton	-0.985
	(2.624)
Budget(M)*Vote*Wheat	-0.537
	(0.875)
State*Year	Yes
Constant	13.95***
	(0.227)
Observations	5,979
Number of FIPS	820
R-squared	0.470
State-Year FE	Yes

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

[a] Note: Democratic voter variable is calculated from Fishback (2017). Results show if democratic counties got more funding.

Table (11) **Restoration Without Incentives?**

VARIABLES	(1) Incentive Years
Treat Year*Corn	0.339***
	(0.0376)
Treat Year*Wheat	0.265***
	(0.0288)
Treat Year*Cotton	-0.0808*
	(0.0469)
Lag(soil conserving grasses)	-0.0834***
	(0.0130)
State*Year	-0.000149***
	(3.59e-06)
Constant	13.91***
	(0.331)
Observations	3,848
Number of FIPS	834
R-squared	0.434
State-Year FE	Yes

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

[a] Note: Outcome variable is calculated from USDA agricultural census (summation of all land under soil conserving grasses for which USDA paid farmers). USDA annual marketing statistics has been used to create incentive years. Treat is defined as the years for which landowners get incentives.

Table (12) **SCD Formation**

VARIABLES	(1) Political Economy: SCD Formation
Formation Year*Corn	0.280***
	(0.0778)
Formation Year*Wheat	0.450***
	(0.0674)
Formation Year*Cotton	1.489***
	(0.409)
Lag(Soil Conserving Grasses)	-0.0677***
	(0.0190)
State*Year	-0.000163***
	(5.08e-06)
Constant	14.21***
	(0.437)
Observations	1,562
Number of FIPS	353
R-squared	0.484
State-Year FE	Yes

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

[a] Note: Outcome variable is calculated from USDA agricultural census. Treat is defined as the years for which landowners formed a soil conservation district.

Table (13) **Summary Statistics: Conservation Needs Inventory, 1945**

	KA mean	NE mean	NM mean	OK mean	SD mean
Prop_NeedCNI	0.68	0.47	0.24	0.39	0.30
LU_size	7.58	8.72	79.27	24.88	64.35
Medium Erosion	0.50	0.38	0.61	0.52	0.14
High Erosion	0.32	0.32	0.16	0.35	0.02
Low Erosion	0.18	0.30	0.23	0.13	0.83
Payment	8.32	9.54	6.89	6.28	8.02
AAA	1466175.26	1099130.41	409655.25	1198965.09	1056741.91

[a] Note: I extract information on Conservation Needs Inventory(CNI) from CNI reports. Prop˙NeedCNI denotes the proportion of cropland that need conservation treatment. I collected this information for five states: Kansas, Nebraska, New Mexico, Oklahoma, South Dakota. Other states are not available. This data has been collected in mid-1940s. I digitized Land Utilization map (Fig 4), and extracted county-level area under targeted land use adjustment, denote it by LU˙size. Payment denotes the per acre rate of payment to the landowners to convert their land to grassland. I manually collected this county-level information from the Agricultural Adjustment Act reports. I also have county-level total AAA payment from Fishback, 2017. I collected Medium, High and Low erosion data from Hornbeck, 2012.

Table (14) **Persistent Impact of Voluntary Acreage Reduction and Conversion Program on Conservation Needs Inventory, 1945**

VARIABLES	(1) PropNeedCNI
Log(Total AAA Payment)	0.0421**
	(0.0171)
Payment per acre	0.0130*
	(0.00719)
Population 1930	5.97e-07
	(6.27e-07)
Average Farm Size	0.000244
	(0.000150)
LU size	-9.02e-05
	(0.000126)
Constant	-0.263
	(0.213)
Observations	364
R-squared	0.060

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

[a] Note: Regression coefficients from equation 2. Extracted from regressing conservation needs inventory area in any county in 1940s on the county-level total AAA payment. Regressions are weighted by area under farmland in 1930. Targeted land utilization area, farm size, total population, per acre payment are controlled.

Table (15) **Persistent Impact of Voluntary Acreage Reduction and Conversion Program on Conservation Needs Inventory, 1945**

VARIABLES	(1) first stage Log(AAA)	(2) second stage PropNeedCNI
Targeted Crop Intensity, 1930	3.853***	
	(0.223)	
Log(AAA Payment)		0.0705***
		(0.0253)
Payment per acre	-0.000364	0.00889
	(0.0175)	(0.00765)
Population30	1.95e-06	4.75e-07
	(1.42e-06)	(6.30e-07)
Avg Farm Size	0.00235***	0.000142
	(0.000320)	(0.000164)
LU Size	0.000704**	-7.81e-05
	(0.000293)	(0.000125)
Constant	12.08***	-0.598**
	(0.152)	(0.305)
Observations	364	364
R-squared	0.587	0.053

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

[a] Note: Regression coefficients from equation 2. Extracted from regressing conservation needs inventory area in any county in 1940s on the total AAA payment, where I instrument total AAA payment with spatial variation in pre-policy targeted crop intensity. Targeted land utilization area, farm size, total population, per acre payment are controlled.

Table (16) **Summary Statistics - Natural Resource Inventory (NRI)**

	Mean
CroplandWindRateEstimate	3.47
PastureWindRateEstimate	1.36
PastureTotalRateEstimate	1.68
CroplandTotalRateEstimate	5.39
TotalAcresEstimate	247.35
TotalWindRateEstimate	2.81
TotalTotalRateEstimate	4.13
Log(AAA)	13.27
Target Crop Intensity, 1930	0.21
LU Size	56.91
Payment	7.95

[a] Note: Natural Resource Inventory (NRI) database is created by USDA, and is a county-level erosion database. NRI provides information on cropland wind erosion, pastureland wind erosion, and total land erosion. This summary is for year 2012.

Table (17) **Persistent Impact of Voluntary Acreage Reduction and Conversion Program on Future Wind Erosion, 2012**

VARIABLES	(1) TotalWindErosion	(2) PastureWindErosion	(3) CroplandWindErosion
Log(AAA)	-0.672***	-0.675***	-0.683***
	(0.178)	(0.179)	(0.208)
Payment	-0.0687	-0.00863	-0.190
	(0.0974)	(0.0936)	(0.116)
Population, 1930	-1.38e-05*	-1.30e-05*	-1.74e-05**
	(7.60e-06)	(7.29e-06)	(8.88e-06)
Average Farm Size	0.000382	-0.00338*	-0.000212
	(0.00202)	(0.00201)	(0.00239)
LU Size	-9.94e-05	5.89e-06	0.000151
	(0.000636)	(0.000608)	(0.000743)
Constant	12.50***	11.21***	14.43***
	(2.307)	(2.343)	(2.712)
Observations	802	771	786
R-squared	0.030	0.041	0.030

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

[a] Note: Regression coefficients from equation 2. Extracted from regressing rate of erosion data from NRI in any county in 2012 on the total AAA payment in 1930s. Targeted land utilization area, farm size, total population, per acre payment are controlled.

Table (18) **Persistent Impact of Voluntary Acreage Reduction and Conversion Program on Future Wind Erosion: Instrumental Variable Method**

VARIABLES	(1) first stage log_AAA	(2) second stage TotalWindErosionRate, 2012
Target Crop Intensity, 1930	4.968***	
	(0.180)	
Log(AAA Payment)		-1.631***
		(0.257)
Payment per acre	-0.0400***	-0.0326
	(0.0141)	(0.0991)
Population, 1930	6.14e-06***	-2.72e-06
	(1.06e-06)	(8.00e-06)
Average size of farms	0.00325***	0.00523**
	(0.000266)	(0.00225)
LU Size	0.000390***	-0.000115
	(9.19e-05)	(0.000645)
Constant	11.91***	23.99***
	(0.127)	(3.214)
Observations	802	802
R-squared	0.600	

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

[a] Note: Regression coefficients from equation 2. Extracted from regressing rate of wind erosion data from NRI in any county in 2012 on the total AAA payment in 1930s, where I instrument total AAA payment with initial crop intensity. Targeted land utilization area, farm size, total population, per acre payment are controlled.

Table (19) **Persistent Impact of Voluntary Acreage Reduction and Conversion on Future Pastureland Wind Erosion: Instrumental Variable Method**

	(1)	(2)
	first stage	second stage
VARIABLES	Log(AAA)	PastureWindErosionRate, 2012
Target crop intensity, 1930	4.767***	
	(0.179)	
Log(AAA Payment)		-1.543***
		(0.261)
Payment per acre	-0.0455***	0.0124
	(0.0139)	(0.0948)
Population, 1930	5.90e-06***	-3.70e-06
	(1.04e-06)	(7.64e-06)
Avg Farm Size	0.00334***	0.000951
	(0.000269)	(0.00224)
LU size	0.000349***	-3.78e-05
	(8.97e-05)	(0.000615)
Constant	12.02***	21.77***
	(0.126)	(3.294)
Observations	771	771
R-squared	0.591	0.011

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

[a] Note: Regression coefficients from equation 2. Extracted from regressing rate of pastureland wind erosion data from NRI in any county in 2012 on the total AAA payment in 1930s, where I instrument total AAA payment with initial crop intensity. Targeted land utilization area, farm size, total population, per acre payment are controlled.

Table (20) **Persistent Impact of Voluntary Acreage Reduction and Conversion on Future Cropland Wind Erosion: Instrumental Variable Method**

VARIABLES	(1) first stage Log(AAA)	(2) second stage CroplandWindErosionRate, 2012
Target crop intensity, 1930	4.974***	
	(0.181)	
Log(AAA Payment)		-1.886***
		(0.303)
Payment per acre	-0.0385***	-0.139
	(0.0145)	(0.119)
Population, 1930	6.07e-06***	-3.65e-06
	(1.07e-06)	(9.37e-06)
Average Farm Size	0.00326***	0.00592**
	(0.000271)	(0.00267)
LU Size	0.000391***	0.000134
	(9.23e-05)	(0.000756)
Constant	11.90***	28.78***
	(0.133)	(3.776)
Observations	786	786
R-squared	0.600	

Standard errors in parentheses

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

[a] Note: Regression coefficients from equation 2. Extracted from regressing rate of cropland wind erosion data from NRI in any county in 2012 on the total AAA payment in 1930s, where I instrument total AAA payment with initial crop intensity. Targeted land utilization area, farm size, total population, per acre payment are controlled.

Table (21) **Consequences on Conservation Reserve Program Uptake**

VARIABLES	(1) First stage Log(AAA)	(2) second stage CRP,1990
Target crop intensity, 1930	5.039***	
	(0.189)	
Log(AAA Total Payment)		190.7
		(1,219)
Payment per acre	-0.0391***	-1,730***
	(0.0149)	(477.7)
Population,1930	6.51e-06***	0.00761
	(1.12e-06)	(0.0387)
Average Farm Size	0.00340***	153.4***
	(0.000279)	(10.90)
LU Size	0.000400***	23.98***
	(9.71e-05)	(3.112)
Constant	11.85***	8,762
	(0.134)	(15,118)
Observations	811	811
R-squared	0.587	0.361

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

[a] Note: Outcome variable is calculated from USDA CRP database. Results show if early conservation areas do not affect later conservation areas.

Table (22) **Consequences on Conservation Reserve Program Uptake**

VARIABLES	(1) first log_AAA	(2) second CRP, 1995
Target crop intensity, 1930	5.039***	
	(0.189)	
Log(AAA)		367.6
		(1,249)
Payment per acre	-0.0391***	-1,693***
	(0.0149)	(489.2)
Population, 1930	6.51e-06***	0.00602
	(1.12e-06)	(0.0396)
Average Farm Size	0.00340***	155.1***
	(0.000279)	(11.16)
LU Size	0.000400***	23.95***
	(9.71e-05)	(3.187)
Constant	11.85***	6,696
	(0.134)	(15,484)
Observations	811	811
R-squared	0.587	0.357

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

[a] Note: Outcome variable is calculated from USDA CRP database. Results show if early conservation areas do not affect later conservation areas.

Table (23) **Rate of Payment by State**

	Mean	Standard Deviation
Colorado	8.755738	3.55488
Kansas	8.315238	1.64134
Montana	8.216071	1.857836
Nebraska	9.535269	2.34042
New Mexico	7.432258	2.540654
North Dakota	7.039623	.6493605
Oklahoma	6.275455	.7370631
South Dakota	7.965147	1.675992
Texas	7.643701	1.554675
Wyoming	8.6	2.745409
All	7.94363	2.079967
N	821	

[a] Note: Spatial variation in rate of payment per acre as incentive to farmers to restore grassland. The data is manually extracted from AAA reports.

Table (24) **Understanding variation in Rate of Payment**

VARIABLES	(1) Rate of Payment
Medium Erosion	-0.486**
	(0.241)
High Erosion	-0.622*
	(0.361)
Wheat intensity	1.468**
	(0.714)
Corn intensity	8.089***
	(0.989)
Cotton intensity	1.912**
	(0.825)
Kansas	-1.501***
	(0.350)
Montana	0.468
	(0.422)
Nebraska	-1.061***
	(0.378)
New Mexico	-1.014**
	(0.426)
North Dakota	-2.118***
	(0.381)
Oklahoma	-3.065***
	(0.339)
South Dakota	-2.067***
	(0.390)
Texas	-1.419***
	(0.282)
Wyoming	0.153
	(0.539)
Constant	8.857***
	(0.280)
Observations	754
R-squared	0.272

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

[a] Note: Impact of ecological and economic variables on rate of payment. Omitted state = Colorado, Omitted erosion level = Low. Results show what affects the probability to get higher rate of payment to convert cropland to grassland.

References

Acemoglu, Daron, David H Autor, and David Lyle (2004). "Women, war, and wages: The effect of female labor supply on the wage structure at midcentury". *Journal of political Economy* 112.3, pp. 497–551.

"Acreage Allotment and Marketing Quota Summary" (1961).

Alsan, Marcella and Claudia Goldin (2015). *Watersheds in infant mortality: The role of effective water and sewerage infrastructure, 1880 to 1915*. Tech. rep. National Bureau of Economic Research.

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.

Bruton, Paul W (1933). “Cotton Acreage Reduction and the Tenant Farmer”. *Law & Contemp. Probs.* 1, p. 275.

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.*

Ericksen, Milton H and Keith Collins (1985). “Effectiveness of acreage reduction programs”. *Agricultural Food Policy Review*, pp. 166–184.

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 (2017a). *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.

— (2017b). *Agricultural diversity, structural change and long-run development: Evidence from the us*. Tech. rep. National Bureau of Economic Research.

Floyd, John E (1965). "The effects of farm price supports on the returns to land and labor in agriculture". *Journal of Political Economy* 73.2, pp. 148–158.

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.

Garst, Gail D, Thomas A Miller, et al. (1975). "impact of the Set-Aside Program on the US Wheat Acreages". *Agr. Econ. Res* 27.2, pp. 30–37.

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.*

Heimlich, Ralph E (2002). "The US experience with land retirement for natural resource conservation". *Forest Trends-China Workshop on "Forests and Ecosystem Services in China.*

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.

Houck, James P, Martin E Abel, Mary E Ryan, Paul W Gallagher, Robert G Hoffman, JB Penn, et al. (1976). *Analyzing the impact of government programs on crop acreage.* USDA Washington DC.

Howlader, Aparna (2019). "Understanding the Formation of Local Environmental Institutions: Historical Evidence from Soil Conservation Districts".

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.

Hudson, Norman et al. (1995). *Soil conservation.* 3. ed. Bt Batsford.

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. ISSN: 0036-8075. DOI: 10.1126/science.aan0568. eprint: http://science.sciencemag.org/content/357/6348/267.full.pdf. URL: http://science.sciencemag.org/content/357/6348/267.

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.

Lidman, Russell and D Lee Bawden (1974). "The impact of government programs on wheat acreage". *Land Economics* 50.4, pp. 327–335.

Lohmar, Bryan, Cynthia Nickerson, Emi Uchida, and Xu Jintao (2007). "Land Conservation in the United States and China: A Comparison of Practices, Policies, and Data Implications for Assessment and Evaluation". *presentation at the Fourth International Conference on Agricultural Statistics, Beijing, China.*

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.

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.

Wu, JunJie and Bruce A Babcock (1999). "The relative efficiency of voluntary vs mandatory environmental regulations". *Journal of Environmental Economics and Management* 38.2, pp. 158–175.

Xiao, Yao, Xiao-Zhong Wu, Li Wang, and Jing Liang (2017). "Optimal farmland conversion in China under double restraints of economic growth and resource protection". *Journal of Cleaner Production* 142, pp. 524–537.