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# Bugged Out: Migratory and Agricultural Responses to the 1874 Rocky Mountain Locust Plague*

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**Abstract**

This paper examines the impact of the 1874 Rocky Mountain locust invasion of the US Great Plains on internal migration and agricultural adaptive strategies. Our findings highlight the various adaptive responses of early settlers in a challenging environmental setting to a large shock. We show that individuals living in locust-affected counties were, on average, 7.2 percentage points more likely to leave their home counties between 1870 and 1880 compared to those in unaffected areas. Furthermore, farmers who relocated experienced a greater increase in their occupational income scores than those who remained. As a response to the plague, the agricultural sector in affected counties saw an increase in livestock productivity, a decline in total farmland acres and the number of mid-sized farms, while there was little change in crop composition.

**Keywords:** 1874 Rocky Mountain Locust Plague, Great Plains, Internal Migration, Agricultural Adaptation
**JEL Codes:** N51, O13, O15, Q10

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# 1 Introduction

In the first half of the $19^{th}$ century the Great Plains (GP), i.e., the vast flat region of grasslands of the conterminous United States (US) stretching from the Rocky Mountains to the $98^{th}$ meridian (Powell, 1890; Webb, 2022), was commonly perceived as the *Great American Desert* and largely uninhabitable due to its harsh climate and hostile native American tribes (Webb, 2022). This changed starting in 1861 once eleven of the slave states left the Union and congressional Republicans introduced a number of pieces of legislation that encouraged an extraordinary population influx and agricultural expansion into the region over the next three decades, eventually bridging the eastern and western frontiers of the American West (Danbom, 2014). The semi-arid and un-wooded nature of the GP was, however, unsuitable for the conventional methods of cultivation that the foreign and native born settlers of the time would have been accustomed to, if they had any farming experience at all (Danbom, 2014; Fite, 1977; Webb, 2022). Thus, the earlier migrants often struggled to make ends meet and faced a highly uncertain future subject to potentially large environmental shocks threatening their livelihood (Danbom, 2014). Such a shock arrived in 1874 when there was a massive infestation of locusts that continued until 1877 (Lockwood, 2004), estimated to have caused damage of USD 200 million in 14 states (Atkins, 1984). Despite its historical importance, there is as of date no quantitative study of the impacts of the Rocky Mountain Locust Plague of the 1870s. This paper sets out to explore the extent of two of the most commonly noted channels of adaptation to the disastrous event, namely migration and a change in agricultural practices (Atkins, 1984; Briggs, 1934).

There is already a small but growing literature on the impact of environmental shocks in historical contexts. For instance, in terms of migration Long and Siu (2018) show that outflows increased in US counties affected by the Dust Bowl of the 1930s, where farmers were the least likely to move. Similarly for the Dust Bowl, of which the GP was also the center, Hornbeck (2023a) provides evidence that migration increased in medium erosion and even more so in high erosion counties, and that migrants from the latter moved further away and to more geographically scattered destinations. Moreover, there was negative selection among migrants in that they had lower incomes than natives of their destinations. The Great American Drought of the 1930s, a primary driver of the Dust Bowl, has also been shown to have an impact on migration, both incoming and outgoing, in counties affected (Sichko, 2025). Investigating the impact of Boll Weevil outbreaks in the US, a beetle that feeds on cotton buds and flowers, Ager et al. (2017a) find that their infestation in late $19^{th}$ and early $20^{th}$ century caused outward migration in affected counties with high cotton intensity. Boustan et al. (2012) show that migration increased after tornadoes but fell after floods in the US in the early 20th century. In contrast, looking specifically at the Great Mississippi Flood of 1927, Hornbeck and Naidu (2014) discover more outward migration, but only for rural blacks (Hornbeck and Naidu, 2014). With regard to the effect on the agricultural sector of regions hit by an environmental disaster, Hornbeck (2012) provides evidence that the Dust Bowl reduced agricultural land values and revenues in affected localities. Ager et al. (2017b) document the significant disruptions in the agricultural sector caused by the Boll Weevil Plague, including declining land values, tenure farm closures, and shifts toward less vulnerable crops, findings echoed by Clay et al. (2020).

To explore the impact of the 1874 Rocky Mountain Locust Plague we avail of a number of different data sources. Firstly, we geo-reference a map of the affected areas as taken from the comprehensive report written on the event by one of the leading entomologists in the US at the time (Riley, 1877a), and identify the counties affected by the plague. To estimate the impact on migration, we utilize the individual linked census data for 1870 to 1880 from Price et al. (2023). This enables us to investigate how locust infestations influenced the migration decisions of working-age men living in the affected counties. In order to capture any effects on the local agricultural sector itself, we further link information from the agricultural census at the county level to the map of the affected area.

Since standard OLS estimation on cross-sectional data, as we have for both our individual migration and county level agricultural data sets, may be biased due to both omitted variables and the likely measurement error inherent in our affected area map, we employ an instrumental variables approach where we avail of the fact that movements of the locusts across the GP was largely driven by wind.

Our empirical analysis reveals that the locust invasions influenced migration patterns. Specifically, our results show that individuals in locust-affected counties were 7.2 percentage points more likely to migrate compared to their counterparts in unaffected regions, where this is driven by native rather than foreign born persons. These migration decisions had notable implications for economic outcomes. Farmers relocating to unaffected areas experienced significant occupational earnings increases, averaging 12.6%, compared to their counterparts who stayed in locust-affected counties. Conversely, non-farmers generally faced declines in occupational income. Our findings also indicate that while there is no effect on farm output, the value of farms, or the value of inputs, total farm acreage, the total number of farms and the number of mid-sized farms (100 to 499 acres) fell as a result of locust outbreak. There is little evidence of a change in the diversity of agricultural or crop products produced, except an increase in oats and greater livestock productivity.

Our paper contributes to the existing literature on a number of fronts. For one, as noted above, there is as of date no quantitative study of the impact of the Rocky Mountain Locust Plague of the 1870s despite its arguable importance in US history (Lockwood, 2004). Moreover, the historical and regional context of the invasion also provides a number of other insights into adaptation. Firstly, at the time there was essentially no public relief available (Atkins, 1984), which, for instance, has been shown to have substantially mitigated the impact of the Dust Bowl (Arthi, 2018; Hornbeck, 2023b). Relatedly, the plague did not coincide with other events, such as a general drought or agricultural mechanization, which as argued by Hornbeck (2023b) would make empirically identifying any effect challenging. Additionally, given the inexperience of the early settlers the invasion was largely unanticipated both in its initial outbreak and its spread, so that farmers did not know what to expect nor had access to any effective preventive methods (Atkins, 1984). In contrast, Lange et al. (2009) showed that as the Boll Weevil spread, farmers in anticipation increased cotton production. More generally, the case of the 1874 locust outbreak provides insight into how early settlers, i.e., those that arrived before the large wave of migrants to the GP in the 1880s (Luebke, 1977), adapted to a large environmental shock in a largely unfamiliar environment.

The remainder of the paper is structured as follows. Section 2 offers historical context on the Great Plains and westward expansion, the Rocky Mountain Locust and the 1874-1877 invasions, including their economic consequences, local adaptation efforts and relief responses. Section 3 details the data sources and presents descriptive statistics. Section 4 outlines the empirical strategy, followed by Section 5, which presents and discusses the results. Section 6 concludes.

# 2 Historical Background

## 2.1 The Great Plains and Westward Expansion

### 2.1.1 The Great Plains

The GP is an almost treeless and flat region characterized by relatively homogeneous vegetation in the form of grasslands, and stretches across North America from the eastern slope of the Rocky Mountains to approximately the 98th meridian, dissecting 10 of current states, although none are contained wholly within it (Webb, 2022). Its climate is of a semi-arid nature, where water can be sparse both in terms of precipitation and surface water. Most of the few rivers that run through it are non-navigable, and streams are generally not year round (Danbom, 2014). The GP is also a region of high wind velocity (notably owing to the flat landscape), where winds usually are southwesterly or southerly, but occasionally blow from the southeast and even from the north (Webb, 2022). These winds can range in width from a few yards to several miles.

Farming in the Great Plains faced several challenges compared to conventional methods used elsewhere in the US and Europe (Cunfer and Krausmann, 2015). Water scarcity was a major constraint, and the lack of wood for houses, fences, and tools further limited land use. Although the soil was nutrient-rich, breaking virgin grassland, known as "sod-busting", was arduous and costly. Innovations such as the reaper (1834) and the steel plow (1837) made this process far more feasible, increasing sod-busting tenfold and reducing the need for a second plowing (Danbom, 2014; J. Schlebecker, 1977). By the 1880s, additional technologies, including barbed wire, grain-grinding windmills, and dry-farming techniques, further improved farming productivity and helped address water shortages (Danbom, 2014; J. Schlebecker, 1977; Webb, 2022).

### 2.1.2 Westward Expansion

*Territorial Expansion*. A number of important events substantially increased the amount of federal land potentially available for settlement in the GP in the $19^{th}$ century. Firstly, there was the Louisiana Purchase in 1803 from France, where the United States acquired around 828,000 square miles of territory, constituting the states of Louisiana, Arkansas, Missouri, Iowa, Oklahoma, Kansas, Nebraska, North Dakota, South Dakota, and parts of Minnesota, New Mexico, Montana, Wyoming, and Colorado, and thereby nearly doubling the nation's size. The annexation of Texas from Mexico in 1845 added additional federal territory to the GP.

With the substantial increase in land size at hand, in 1854 the government passed the Kansas-Nebraska Act, creating two states in the GP open for settlement. Additionally, in 1861 Congress admitted Kansas to the Union as a free state and organized Dakota Territory as a free territory available for settlement (Danbom, 2014). After the end of the civil war the remaining portions of the GP in these also provided some federal lands.

Finally, Oklohama Territory became open for settlement in 1889, although there was a significant number of settlers, known as 'sooners', much earlier (Hewes, 1996).

One should note that while large parts of the GP until the 1850s were considered Indian territories, the US government began the process of converting these officially to federal land that it could sell by extinguishing land titles and writing new treaties (Danbom, 2014). Moreover, a number of wars between the US Army and GP Indian tribes resulted in the relinquishment of many tribal land claims and the confinement of these tribes to reservations so that by 1880 essentially all native American tribes were living on these reservations.

### 2.1.3 Policies to Encourage Expansion

Three pieces of federal legislation that laid down the framework enabling and encouraging the subsequent substantial westward expansion of settlement were passed in 1862, followed by another in 1873 (Danbom, 2014). Most famously, the Homestead Act (HSA) of 1862 allowed any head of a family (including single persons), male or female, to claim up to 160 acres of federal land unsettled for a small registration fee of 18 USD.[1] However, in order to gain title the homesteader had to show five years of continuous residence on the land, built a home on it, farm the land and make improvements, i.e., 'prove up', upon which he/she could purchase the title at 1.25 USD per acre. Union veterans or their widows were allowed to apply their years of service to the five year requirement. Importantly, both US citizens as well as foreign aliens could acquire land under the HSA, where the latter had to state their intention to gain citizenship in writing as a prerequisite.

The Morrill Land Grant Act of 1862 gifted states federal lands on the condition that they use the proceeds of the sale to fund agricultural colleges, intended to create scientific and technical institutions to address the agricultural challenges of the GP. Each state

[1] As a predecessor to the HSA, the Pre-Emption Act of 1841 granted squatters of federal land of at least 14 months, who made improvements, the right to purchase up to 160 acres for 1.25 USD, although this appears to have been quite ineffective (Danbom, 2014).

received 30,000 acres for each of its senators and representatives in US Congress. Most of these lands were sold to private buyers (Danbom, 2014).

Perhaps most importantly, the 1862 Pacific Railway Act instigated a series of legislative enactments providing loans and land grans to railways traversing the GP. Integral to the settlement process these lands were used in a number of ways (Danbom, 2014). Firstly, the federal land simply served to provide land to build the railway lines, where the first cross-GP route was the transcontinental Pacific Railroad, built between 1863 and 1869 and stretching over 3,000 km. This, and the following build-up of the railway network extending across the GP by 1890, were crucial to settlement, enabling a practical way of moving high volume, low value commodities cheaply. Secondly, the railroads tended to buy up substantial amounts of federal lands along the route where they saw potential future profits through future settlement. Thirdly, railroads increased the sale of these lands by intensively marketing the appeal of GP for settlement both nationally and internationally. In this regard, they tended to partially subsidize transport to the plots, seldom required outright payment for the land and were lenient with borrowers falling behind in their payments. One may also want to note that, as argued by Danbom (2014), the limitation of 160 acres under homestead title claims was arguably to encourage homesteaders to also buy land from the railroads if they wanted to expand or add to their property. Finally, in 1873 the federal government also introduced the Timber Culture Act, which allowed settlers to claim 160 acres of land to receive title if they planted trees on 40 acres. This was later changed in 1878 to a minimum of 675 living trees on each of at least 10 acres (Danbom, 2014).

It is important to note that, while homesteading is the most well known form of settlement on federal lands, private acquisition of these properties was likely more important (Danbom, 2014). Firstly, of the 500 million acres of federal land transferred to private ownership, only around 80 million were available for homesteading or through the Timber Culture Act, whereas 300 million were granted to the states and the railways.

Moreover, many who made homesteading claims quickly 'sold' the property by going with the buyer to the claims office and renouncing it so that the buyer could then immediately purchase it. Similarly, many Union veterans sold their reduced residence title claims, limited to a price of 1.25 USD per acre. There was also a preference for purchasing railroad lands since these tended to be, either through grant or preemptive purchase, nearer to railway lines. Finally, as the HSA stipulated that no mortgage could be taken out on the property until the title was received, many settlers preferred purchasing federal land directly despite the approximate 10-30% subsidy that homesteading represented (Allen and Leonard, 2021). As argued by Danbom (2014), the relinquishment of homesteading claims contributed to an atmosphere of impermanence and flux of population in the homesteading areas.

#### 2.1.4 Settlement of the GP

Prior to the 1840s, most settlers in the GP were fur traders or cattle ranchers, substantially outnumbered by the native Indian tribes (Webb, 2022). Even the vast amount of travelers crossing the GP bound for Oregon, Utah, California, and later Colorado, viewed the region as a vast hostile territory, both environmentally and because of the threat of native American attacks, that needed to be passed through as quickly as possible. Moreover, with the start of the civil war any increase in settlement quickly dissipated (J. Schlebecker, 1977). The policies implemented by the government in the 1860s, however, had a substantial impact on the number of settlers, where these grew almost immediately and the first boom occurred in the late 1870s (Fite, 1977). Between 1870 and 1880, the population of the GP more than doubled, increasing from approximately 1 million to about two and a half million people, demonstrating the substantial effect of the government initiatives in attracting large numbers of settlers to the region (Wishart, 2004). As noted by Salisbury (2014), internal migrants during the latter half of the $19^{th}$ century tended to be both economically and geographically mobile, where those moving to the frontier would have been relatively poor, landless and illiterate, but ultimately faired well (Stewart, 2006). Importantly, most American born internal migrants knew little about the patterns of rainfall, the qualities of the soil, or the best crops to grow in a semi-arid climate like the GP, and thus conventional farming was not appropriate (Fite, 1977).

Until 1825 few Europeans immigrated to the GP, and although this increased in the 1840s, there was a clear lull during the Civil War (Luebke, 1977). As a result of the extensive campaigning of the railway companies and the lack of requirement of citizenship for homesteading, a large number of Europeans moved to the US in order to settle in the GP (Cunfer and Krausmann, 2015). As with the internal migrants, most of these were not familiar with the kind of farming required to grow crops in the region (Fite, 1977; Luebke, 1977). The immigrants from Europe formed a major element in the population that settled in the GP. For example, in Nebraska they constituted a much larger proportion of the total population than they did in the rest of the state (Luebke, 1977).[2] Interestingly, Luebke (1977) argues that compared to native born Americans, European immigrants in the GP were much less likely to move since they valued land ownership more.

## 2.2 The Rocky Mountain Locust and the 1874-1877 Invasions

### 2.2.1 The Rocky Mountain Locust

The Rocky Mountain locust (scientifically known as *Melanoplus spretus*) was native to the Rocky Mountains of the western and northwestern United States.[3] The species was considered omnivorous, consuming nearly every type of vegetation (Riley, 1877b). Its population dynamics were driven by the weather, in particular when a period of rain was followed by a long drought. Typically, locusts began hatching in mid-March, and continued to hatch numerously a few days later. Over several weeks the nymphs molted

[2]The largest nationality represented among these were Germans, although there were dominating enclaves of other nationalities throughout the GP.

[3]Taxonomically speaking, locusts are grasshoppers, although locusts differ from other grasshoppers in their ability to change from a non-swarming, low-density, dispersed population to a high-density, migratory, swarming phase (Song, 2011).

multiple times before reaching adulthood, and after around six weeks developed wings and were able to fly (Packard Jr, 1877). One should note that even before taking flight the hatchlings themselves could travel anywhere between 20 and 50 miles, feeding on local plantation along the way.

While the permanent breeding grounds of this species were mostly restricted to an area between 3 and 3,000 square miles of sandy soils near streams and rivers in the Rockies (Lockwood, 2004), under ideal breeding conditions—i.e., warm and dry weather, but a local shortage of food—the population density could become sufficiently high to trigger a physiological transformation from the solitary to the gregarious phase. In this gregarious phase, locusts exhibited changes in coloration, form, physiology, and behavior, becoming restless, irritable, and highly migratory. Sufficient and sustained crowding caused nymphs to develop into gregarious adults, leading to the spontaneous formation of vast swarms that were capable of flying extensively on warm, dry days when body temperatures were high. Migration did not typically occur from favorable regions, but rather from marginal areas where food became scarce and environmental conditions deteriorated, further encouraging aggregation and triggering mass flight. When these conditions prevailed, Rocky Mountain locusts could migrate potentially extensive distances, in swarms covering up to 200,000 square miles (Packard Jr, 1877; Riley, 1877a). Although swarms often moved eastward from their natural breeding grounds, they could also head westward, as seen in the invasions of California in the 1830s and 1850s and in Oregon and Washington in the 1820s, 1830s, and 1850s (Packard Jr, 1877). Similarly, at times even eastward migrations could reach beyond the borders of the GP (Riley, 1879). Importantly, the direction and extent of these swarms were primarily determined by the prevailing winds (Packard Jr, 1877).

Locust swarms, once airborne, were largely passive with respect to navigation, being carried along by the winds rather than directing their flight autonomously (Lockwood, 2004). Warm, dry, and consistent winds could transport swarms hundreds of miles in a matter of days, and it was specifically the prevailing eastward airflow across the Rockies and into the GP that facilitated the vast spread of the Rocky Mountain locust (Packard Jr, 1877; Riley, 1877a). During favorable conditions, swarms could rise several hundred meters into the atmosphere, where stronger upper-level winds accelerated their movement (Lockwood, 2004). Consequently, years with stronger or more persistent eastward winds corresponded to broader and more devastating locust invasions into the prairie states. While a great number of eggs tended to be laid during such migrations, compared to those laid in the permanent breeding grounds the individuals hatched did not appear to thrive, with the size of each generation shrinking substantially so that migrations only lasted a few years at most (Scudder, 1897; Thomas, 1878).

#### 2.2.2 The 1874-1877 Invasions

In the years leading up to 1874 there had been few locust outbreaks in the GP and these did not produce extensive damages on a wide scale (Briggs, 1934; Packard Jr, 1877), thus making the 1874 invasion unexpected even for the few settlers that had already been in the area longer. The 1874 locust infestation first started in early July, most likely due to optimal breeding conditions but a local shortage of food in their natural breeding grounds (Dudley et al., 2014), and continued throughout the summer (Lockwood, 2004). The path of the swarm over the outbreak's course, estimated to have consisted of about 1.5 trillion insects flying over an area of 1,980,000 square miles, spanned from the eastern slopes of the Rocky Mountains to western Iowa, Minnesota, and Missouri, and from the Canadian prairie provinces to central Texas, just north of Austin. Figure 1, adapted from Riley (1877a), illustrates the extent of the infestation. The areas most severely affected were Kansas, Nebraska, Dakota Territory, western Iowa, Minnesota, Missouri, Indian Territory, eastern Colorado Territory, and the southeastern corner of Wyoming Territory. In contrast, while Texas, Montana Territory, and the Prairie provinces of Canada experienced infestations, these were not as impactfull as other areas. Locally the swarms appeared suddenly and without warning (Atkins, 1984). As one farmer noted:

> *"...a large black cloud suddenly appeared high in the west from which came an ominous sound. The apparition moved directly toward us, its dark appearance became more and more terrifying and the sound changed to a deep hum...We heard the buzzying; we saw the shining wings, the long bodies the legs. The grasshoppers - the scourge of the prairie - were upon us."* (Atkins, 1984, p. 17)

and another:

> *"In a clear, hot July day a haze came over the sun. The haze deepened into a gray cloud. Suddenly the cloud resolved itself into billions of gray grasshoppers sweeping down upon the earth. The vibration of their wings filled the ear with a roaring sound like a rushing storm. As far as the eye could reach in every direction the air was filled with them. Where they alighted, they covered the ground like a heavy crawling carpet."* (Sheldon, 1931, p. 494)

Once the locusts descended and feasted on the fields, the females laid eggs in the grounds about an inch below surface, where each female could deposit 4 to 6 pods of 28 eggs each (Atkins, 1984). Plowed cropland was particularly suitable for the breeding of the locusts (Danbom, 2014). The eggs remained dormant until the following spring in 1875, where they hatched and caused further damage by eating the crops that had just begun to sprout. After about 6 weeks they were able to fly and move on, but unfavorable winds kept them from developing into a swarm (Atkins, 1984). One should also note that many locusts were killed off by a cold snap in parts of the GP in that year. Another swarm formed in 1876, most likely from eggs laid in 1875 in Minnesota, Colorado, Wyoming, Dakota, and Montana (Riley, 1877a). While most of these insects did manage to head northward, they were driven back by unfavorable winds. For instance, Riley (1877a) notes that the insects that hatched in Minnesota early in the year and endeavored to move northwest as they acquired wings, were repulsed and borne back south and southwest by the prevailing winds, as was the case in Dakota. As this swarm formed in late July and August, and thus fairly late in the harvest season, limited damage was done (Riley, 1877a), except for perhaps in Minnesota (Atkins, 1984). Finally, the locusts of 1877 arising from the eggs laid during the smaller 1876 infestation in the GP, while taking flight, did not appear to have migrated much and by the end of July of 1877 were considered 'perfectly harmless' (Atkins, 1984).

After the 1874 to 1877 invasions there were no subsequent outbreaks to note of, and the Rocky Mountain locust likely became extinct around the turn of the century (Lockwood, 2004). A number of reasons have been put forth as to what caused its extinction, where the most likely includes the destruction of their habitat through residential, commercial, and agricultural development (Lockwood and Debrey, 1990).


**Figure 1:** Map depicting locust presence in 1874

*Notes:* (i) the historical map was prepared by C.V. Riley (Riley, 1879); (ii) the beige coloured area shows the area overrun by the locusts; the pink coloured area shows the areas invaded but which suffered less on account of being sparsely settled; (iii) the green coloured area shows which suffered the most.

One should note that at the time of the invasion there were no pesticides available to kill or hold off the locusts or the eggs they laid, leaving affected farmers with no line of defense. Nevertheless, a number of methods were experimented with, including covering fields with sheets, burning fires to smoke away the insects, building ditches around the fields and filling these with oil or water to drown them, and catching locusts by hand bucket or shovel, as well as the invention of a number of extermination devices (Atkins, 1984; Dudley et al., 2014). Unfortunately, none of these proved effective (Lockwood, 2004). Even trying to destroy the eggs before they hatched, a strategy that in some states was financially rewarded and in others required by law, was a futile task given their numbers (Dudley et al., 2014; Lockwood, 2004).

## 2.3 Economic Impact, Adaptation, & Relief

### 2.3.1 Economic Impact

The primary damage of the locusts was done to agricultural crops, in particular wheat, corn, and oats, but also to other smaller crops grown by farmers for their own consumption (Atkins, 1984; Lockwood, 2004). Additionally, poultry, an important source of protein for many farmers, tended to feast on the locusts, rendering their meat and eggs inedible (Dudley et al., 2014; Lockwood, 2004). Moreover, locusts tended to pollute water supplies, making these unsuitable for both human or livestock consumption.

While no detailed damage data was collected after the plague, The US Entomological Commission (1879) estimated it to have been around 200 million USD. For Minnesota, Atkins (1984) notes that after the 1874 invasion 11 and 16% of state wheat and oat crops were lost, respectively, while in its 28 most affected counties over half of the cultivated acreage was damaged, resulting in losses of 16% of wheat and 50% of oats.

### 2.3.2 Adaptation

The impact of the agricultural losses had substantial effects on the local population, where many settlers ”faced destitution & distress” (Atkins, 1984, p. 33). For instance, in the most affected counties in Kansas about 70% of the population became impoverished

(Dudley et al., 2014). What is likely to have contributed to this is that there was a 5-year fairly lucrative period starting in 1868 that encouraged many farmers to borrow money or take out a mortgage, such as in Dakota (Briggs, 1934). Additionally, the financial panic of 1873 caused the demand for crops and their prices to drop, putting further financial strain on the farmers (Dudley et al., 2014). For instance:

> "[...] *The owners, having paid out all their money, sold everything they could get along without, and mortgaged their farms to get money to carry their stock through the winter and plant their crops, now are left with nothing to eat. Their stock have starved to death, and they have no money, and no means of raising any by loan or mortgage, to buy food or to get away from here to more favored sections of the country."* – The Globe-Democrat Correspondence from Strasburg, Cass County, June 16, 1875

One response to the damage inflicted by the plague was to simply abandon the farm or the affected area. As Paul W. Riegert noted in his 1977 newspaper article, homesteaders, who were required by the Homestead Act of 1862 to improve and reside on their land, faced difficult choices. With their crops destroyed, many sought work in unaffected villages, cities, or other farms, abandoning their land to survive (Atkins, 1984). For instance, Briggs (1934) stated that the number who left Dakota after the attacks was large relative to the population. Nevertheless, for many others their financial situation may have not left this as an affordable option, as has been noted for Dakota and Nebraska (Briggs, 1934; Dudley et al., 2014). The devastation caused by locusts may have also discouraged some settlers to come, as was the case in Dakota (Briggs, 1934). In this regard, one should note, however, that many local newspapers and government officials denied or underplayed the fact that there was anything more than limited damage, fearing that negative publicity would discourage further settlement, development and investment (Dudley et al., 2014).

Many farmers remaining in affected localities adapted their agricultural practices to the large shock of the plague. In particular, Briggs (1934) notes that afterwards farmers took greater care in preparation of the land, diversified more towards crops that they perceived to be less prone to locusts, practiced more crop rotation and mixed farming, as well as raised more livestock for meat and dairy farming. However, these reactions were often short-lived. For instance, while farmers in Jackson county (Minnesota) decreased their cultivation of wheat, which was considered more vulnerable, from 64% of acreage before the locust outbreak to 16%, while increasing that dedicated to corn, likely less susceptible, from 8 to 47%, by 1878 wheat acreage was nearly the same (63%) as in 1873 and corn acreage dropped again to 12% (Atkins, 1984).

## 2.4 Relief

Importantly, as thoroughly discussed by Atkins (1984), in the 1870s there was still no organized and mandated public relief available after agricultural disasters. For instance, at the county level there was no existing policy for handling diaster relief. Rather County Commissioners either only distributed what came from outside or, on rare occasions, drew small amounts from the county's meager financial reserves. At the state level, actors were uncertain what their obligation was, where any programs implemented in the past had been piecemeal, ad hoc, and spontaneous. In terms of federal aid it was not clear whether Congress' power to provide for the general welfare of the nation included relief for the indigent or obligated a response to natural disasters. As a matter of fact, of the only 30 relief measures for natural disasters, foreign or abroad, that were implemented over the $19^{th}$ century, 23 were after the 1870s Rocky Mountain locust invasion. This left, at least initially, privately financed relief as the only option. However, most private organizations were urban focused and at any rate would not have been able to provide support for any large amount of persons at a time. More generally, as noted by Dudley et al. (2014), the lack of relief efforts at all levels during the time was representative of the skepticism towards unfettered charity, and that when it should be provided only for those deserving, after their own financial resource had been completely exhausted.

The general lack of a strategy of providing relief was reflected in the unsubstantial amounts extended to those affected by the plague. For instance, in Nebraska private relief donations were only about 68,000 USD in cash and in-kind, while the state government used 50,000 USD to provide seeds to locust victims (Dudley et al., 2014). Moreover, any state help provided often was only on the basis of a test of 'worthiness', as, for instance, in Nebraska and Minnesota (Dudley et al., 2014). At the federal level the first response to the plague was at the end of December of 1874, where homesteaders where allowed to be temporarily absent from their land until July 1875, followed by further extensions in the following three years. However, since being granted such extensions required proving that their crops were destroyed or seriously damaged by the locusts, only a little over one hundred applications were made in total (Dudley et al., 2014). In 1876, the government also amended the Timber Culture Act of 1874 to grant farmers who had planted trees and lost them due to the insects an extra year for each infestation to prove up their claim to the land without losing their rights, and this was extended in 1878 (Dudley et al., 2014). Finally, in 1875 Congress appropriated 150,000 USD for the purchase of food for locust victims, as well as 30,000 USD for the distribution of wheat seeds (Briggs, 1934; Dudley et al., 2014). The US Army additionally provided blankets and clothing from its stockpiles in certain areas (Dudley et al., 2014).

# 3 Data

## 3.1 Data

### 3.1.1 Population Data and Crosswalks

The empirical analysis draws on full-count data for the years 1870 and 1880 provided by the Integrated Public Use Microdata Series (IPUMS) USA (Ruggles et al., 2021). To link individual observations across the two census years, we use the crosswalk developed by the Census Tree (Price et al., 2023), which relies on the New York State Identification and

Intelligence System (NYSISS) Phonetic Code. This code standardizes names based on pronunciation, allowing us to uniquely identify individuals within the same birth year. The initial linked sample includes 21,728,887 observations. Due to challenges in linking females (primarily due to name changes after marriage), we restrict our sample to males. Additionally, to limit the analysis to economically active individuals, we restrict our sample to prime-age workers at the time of the 1870 census.[4] We further clean the sample by excluding individuals identified as "head of household" but younger than 18 years old.

**Migration** The primary outcome of interest is migration. Using the linked data we track changes in an individual's county of residence between 1870 and 1880. Our main migration measure compares an individual's county of residence across the two census years. Given that our data only captures county-level locations for 1870 and 1880, we are unable to observe multiple or return migrations within the period.

**Individual-level characteristics** The 1870 census provides standard demographic information, including age, number of children, literacy, race, nativity, urban status and whether they lived in a farm household. We also consider variables indicating whether an individual was classified as a "head of family" and whether they lived in their state of birth. Additionally, the 1870 census reports the value of both real and personal estate, which we use as a proxy for wealth in our analysis.

**Work and Income** The 1870 census provides detailed occupational information, which we classify into six broad categories using occupational codes from 1880, along with labor force status. For occupational outcomes, we focus on measures of occupational standing based on reported occupations as captured by the OCCSCORE variable, which assigns the 1950 median income for each occupation to all individuals with positive income ,

[4]We only retain observations of individuals being at least 15 but less than 65 years old in the 1870 sample.

with values ranging from 1 to 80. Using our linked sample (1870-1880), we are able to calculate the difference in log occupational income scores between 1870 and 1880.

**Population Growth** We generate an indicator variable for whether a county experiences population growth, which takes the value of 1 if $TotalPopulation_{1880} - TotalPopulation_{1870} > 0$, and 0 otherwise. Population figures are sourced from the Agricultural Censuses of 1870 and 1880 (Haines et al., 2014).

**Share of homesteads** We calculate the shares of homesteads (in acres) relative to each county's total land area. The source of the original data is the Bureau of Land Management's General Land Office (BLM GLO) Records website. We use the dataset provided in Allen and Leonard's (2021) replication package.

### 3.1.2 Locust Affected Counties

In our analysis, we construct our treatment indicator capturing the locust affected counties based on the historical map from 1874 originally published by Riley (1877a), shown in Figure 1. The construction of these historical maps was based on a combination of primary sources compiled during and immediately after the swarms. In particular, the estimates of swarm size and direction relied heavily on telegraphic reports assembled by Albert Child, a meteorologist for the U.S. Signal Service based in St. Louis. Child collected locust sighting data transmitted via telegraph from over 100 reporting stations across the western United States, using this information to delineate the spatial spread and density of the swarms. Riley supplemented this with firsthand field observations, correspondence from local farmers and officials, and newspaper reports. Swarm paths were inferred by interpolating from dated, geolocated sightings, allowing the Commission to reconstruct the approximate shape and movement of the swarm. These data formed the empirical foundation for the Commission's maps, including those used in this study. One should note while Riley (1877a) provides also a map for the 1876 invasion, we only use that from 1874 as both maps heavily overlap. In the original map, he distinguishes between areas that are heavily and those less affected, based on the relative level of population settlement rather than the degree of locust invasion. Thus we do not use this distinction, but rather simply identify areas affected.

The 1874 map was digitized into shapefiles and spatially joined with 1870 U.S. county boundary shapefiles. This process enabled us to assign treatment status at the county level, which was then merged with population data to identify individuals residing in affected counties. The control group was constructed by creating a 300-kilometer buffer around the affected areas.. Counties were classified as treated or untreated depending on whether the majority of their land area fell within or outside the locust-affected area. One should note that we chose a buffer that reaches not only westward of the Rocky Mountains and eastward even outside the GP since, as noted earlier, the locust migrations was not limited to the GP. The 300-kilometer distance was chosen to ensure a balanced representation of affected and unaffected counties, while maintaining geographic comparability. The resulting treatment and control set of counties are shown in Figure **??**.

### 3.1.3 Agricultural Data

We take historical agriculture county-level Census data for 1870 and 1880 from Haines et al. (2014) and use these to create a number of county level agricultural outcome variables. Those not taking into account crop specific production include the total value of farm output, the present cash value of farms, value of livestock, the value of farm implements and machinery, number of improved acres and total farmland.[5] We also include county-level measures of the number of farms according to different sizes ($<$ 10, 10-19, 20-49, 50-99, 100-499, 500-999, and $>$ 1000 acres). To generate crop-specific proxies, we compute total cereal crop output (in bushels), which allows us to derive the relative shares of key cereal crops, i.e. wheat, corn and oats. Then we convert the reported agricultural

[5]Our variables are expressed in relation to total farmland, which is calculated as the combined area of unimproved and improved land.

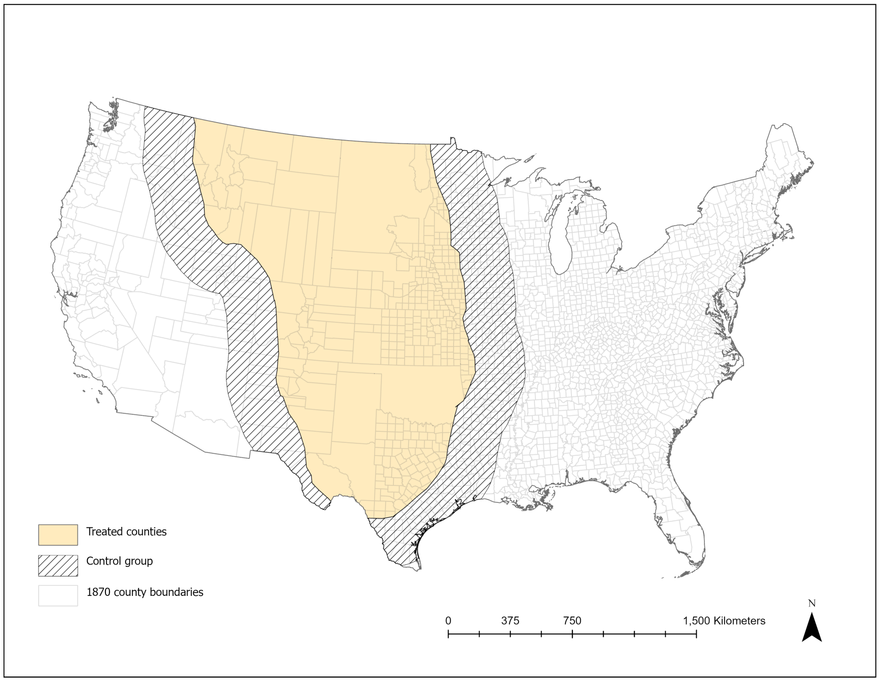


**Figure 2:** Treatment variable and control group (based on 1874 locust map)

*Notes:* The yellow areas indicate regions and counties that were infestated by the locusts in 1874. The cross-hatched area denotes the control group included in our sample, representing "non-treated" counties.

output units into a common measure using state-level 1860 prices from Manson et al., 2019. Since neither crop prices or acreage by crop is available in the 1870 or 1880 census, this approach allows us to assess agricultural production diversity. To do so, we derive the Herfindahl-Hirschman Index (HHI), which reflects how evenly agricultural output is distributed across different products. More precisely, following Fiszbein (2022), Agricultural Diversity for county $c$ is defined as $\text{Diversity}_c = 1 - \sum_i \theta_{ic}^2$, where $\theta_{ic}^2$ denotes the share of product $i$ in the total value of county $c$'s production (in value terms) based on a range of 23 agricultural outputs ($i = 1, 2, ..., 23$).[6]

One should note that to ensure consistency in geographical definitions between 1870 and 1880, we account for county boundary changes following the methodology of Hornbeck (2012). Specifically, we use the crosswalk by Ferrara et al. (2021), applying the corre-

[6]We include fewer variables in our calculation compared to Fiszbein (2022), as we restrict our analysis to variables available in both 1870 and 1880. For example, we exclude "animals slaughtered", as this information is not recorded for 1880. This ensures consistency across both decades while maintaining the comparability of diversity measures.

sponding weight from their area-based model, assuming that data is evenly distributed across county area.

#### 3.1.4 Climate Data

**Wind:** An important part of our empirical identification strategy is to capture likely locust migration through the relevant wind patterns, in particular wind direction and wind speed. To construct this we use the climate data from the 20th Century Reanalysis Project, generated by NOAA's Physical Sciences Laboratory (Slivinski et al., 2019). The 20CRv3 provides time series of 3-hourly analysis fields at a spatial resolution of $\sim 0.75^{\circ} \times 0.75^{\circ}$ longitude $\times$ latitude, which offers a globally consistent dataset suited for examining historical climate trends and variability.[7] To capture the relevant locust wind pattern during locust migration we downloaded the u- and v-wind [8] (given in meters per second) and averaged these to monthly values identified the monthly eastward wind direction when the u-wind component was positive. Monthly wind speed is calculated as the square-root of the sum of the quadrative values of the u- and v-wind components. The monthly values of these are averaged over 1870 county shapefiles to generate county-specific measures.

**Other Climatic Variables:** Using the 20CRv3 we also generated county-level annual averages of the monthly values of temperature and precipitation during the growing season (April-September) in a similar manner to the wind proxies. These are then averaged over all years between 1870 and 1880.

[7]Since these climate data are derived from model equations in conjunction with available weather station data rather than directly assimilated, some general concerns about accuracy might arise (Auffhammer et al., 2013). However, the 20CRv3 dataset ensures consistency by relying on physical laws and circulation patterns. Historical weather station data can be largely sparse and subject to changes over the long term and data gaps, which in turn may induce high, possibly systematic, measurement error. Re-analysis data mitigates these limitations by integrating historical observations with model predictions.

[8]The meteorological convention for winds is that the u component is positive for a west to east flow (eastward wind) and the v component is positive for south to north flow (northward wind)

#### 3.1.5 Geographic Controls

**Rocky Mountain range:** This is an indicator variable that takes the value of 1 if the county lies in the Rocky Mountain range, 0 otherwise, as taken from CartographyVectors.com

**Ruggedness index:** We generate a proxy of terrain ruggedness within a county, where this ranges from 0 to 10000 and is based on the 100-Meter Resolution Elevation of the Conterminous United States from Geological Survey (U.S.). (2012). Based on information of ruggedness per cell we compute county-level ruggedness using the 1870 county shapefiles.

**Crop Suitability:** A crop suitability (0 – 10000) of a county is constructed from the gridded data provided by Global Agro Ecological Zones version 4 (GAEZ v4) under rainfed conditions and low input level and without CO2 fertilization (Fischer et al., 2021). County level measures are generated with the 1870 county shapefiles.

### 3.2 Descriptive Statistics

Table 1 provides a comparison of 1870, i.e., pre-treatment, characteristics of our individual level male working age data categorized by their migration decision (between 1870 and 1880). In total our sample consists of 478,944 non-movers and 374,868 movers, revealing that around 43.9% of the sample were migrating either within or across states during the studied period. On average, movers tend to be younger (30 years) than non-movers (34 years). Additionally, 48% of movers have at least one child under five, compared to 43% of non-movers. A smaller proportion of movers (55%) are designated as heads of households relative to non-movers (69%). Both groups exhibit nearly identical literacy rates (84% vs. 83%) and racial composition (95% vs. 94%). 19% of the non-movers were still living in their birth state, compared to 17% of the movers. In terms of economic characteristics, movers and non-movers show comparable occupational income scores. However, non-movers hold significantly greater real estate wealth ($1,661.05 vs. $697.20) and personal estate value ($718.31 vs. $405.61). Labor force participation rates are similar, though non-movers are more likely to work in agriculture (67% vs. 58%) and reside in farm households (70% vs. 61%).

**Table 1:** Descriptive statistics of pre-treatment characteristics (in 1870)

| | **Non-movers** | | | | | **Movers** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | mean | sd | min | max | count | mean | sd | min | max | count |
| Age | 34.02 | 12.82 | 15 | 65 | 478944 | 29.74 | 11.42 | 15 | 65 | 374868 |
| Child under 5 | 0.43 | 0.49 | 0 | 1 | 478944 | 0.34 | 0.48 | 0 | 1 | 374868 |
| Head of household | 0.69 | 0.46 | 0 | 1 | 478944 | 0.55 | 0.50 | 0 | 1 | 374868 |
| Literacy | 0.84 | 0.37 | 0 | 1 | 478944 | 0.83 | 0.37 | 0 | 1 | 374868 |
| Race | 0.95 | 0.22 | 0 | 1 | 478944 | 0.94 | 0.23 | 0 | 1 | 374868 |
| Nativity | 0.79 | 0.41 | 0 | 1 | 478944 | 0.82 | 0.39 | 0 | 1 | 374868 |
| In birth state | 0.19 | 0.39 | 0 | 1 | 478944 | 0.17 | 0.37 | 0 | 1 | 374868 |
| Urban status | 0.08 | 0.28 | 0 | 1 | 478944 | 0.09 | 0.29 | 0 | 1 | 374868 |
| Farm household | 0.70 | 0.46 | 0 | 1 | 478944 | 0.61 | 0.49 | 0 | 1 | 374868 |
| Labor force status | 0.86 | 0.35 | 0 | 1 | 478944 | 0.83 | 0.37 | 0 | 1 | 374868 |
| Working in agriculture | 0.67 | 0.47 | 0 | 1 | 478944 | 0.58 | 0.49 | 0 | 1 | 374868 |
| Occupational income score | 14.70 | 10.71 | 0 | 80 | 478944 | 14.51 | 10.90 | 0 | 80 | 374868 |
| Value of personal estate | 718.31 | 3334.28 | 0 | 560000 | 478944 | 405.61 | 2147.33 | 0 | 380000 | 374868 |
| Real estate value | 1661.05 | 5370.88 | 0 | 800000 | 478944 | 697.20 | 3431.27 | 0 | 700380 | 374868 |
| *N* | 853812 | | | | | | | | | |

*Notes:* (i) We refer to movers (non-movers) as individuals that have left (stayed in) their home county between 1870 and 1880; (ii) Literacy is defined as the percentage of the sample being able to both read and write; (iii) Race is a dummy that takes the value of 1 if the individual is white and 0 otherwise.

Table 2 presents the results of a balance test of our sample that allows us to assess whether individuals in treated and untreated counties differed in their pre-treatment characteristics.[9] Most variables show statistically significant differences between the two groups, suggesting that individuals in affected counties were generally slightly younger (0.78 years), had slightly less children under 5, higher literacy rates (0.05), and were less likely to be foreign-born and working in agriculture, among other pre-treatment characteristics. Real estate values are significantly lower (by 119.48) in affected counties, while personal estate values show no significant difference, hence the importance to control for these characteristics.

[9]Prior to the locust invasions.

**Table 2:** Balance test by treatment status

| | Non-affected counties | Affected counties | Difference | Std. Error | N |
|---|---|---|---|---|---|
| Age | 32.36 | 31.58 | 0.78*** | (0.03) | 853812 |
| Child under 5 | 0.40 | 0.38 | 0.01*** | (0.00) | 853812 |
| Head of household | 0.63 | 0.62 | 0.01*** | (0.00) | 853812 |
| Literacy | 0.82 | 0.87 | -0.05*** | (0.00) | 853812 |
| Race | 0.94 | 0.97 | -0.02*** | (0.00) | 853812 |
| Nativity | 0.79 | 0.84 | -0.05*** | (0.00) | 853812 |
| In birth state | 0.20 | 0.13 | 0.07*** | (0.00) | 853812 |
| Urban status | 0.08 | 0.09 | -0.01*** | (0.00) | 853812 |
| Farm household | 0.67 | 0.64 | 0.02*** | (0.00) | 853812 |
| Labor force status | 0.85 | 0.85 | -0.01*** | (0.00) | 853812 |
| Working in agriculture | 0.64 | 0.61 | 0.02*** | (0.00) | 853812 |
| Occupational income score | 14.47 | 14.97 | -0.50*** | (0.03) | 853812 |
| Value of personal estate | 579.14 | 585.68 | -6.54 | (6.88) | 853812 |
| Real estate value | 1272.18 | 1152.70 | 119.48*** | (11.11) | 853812 |

*Notes*: Non-affected (affected) counties refer to counties overrun by locusts as defined by Riley (1879) (see Figures 1 and 2).

Table 3 presents a balance test for county-level characteristics in 1870, comparing affected and non-affected counties based on a range of agricultural, economic, and environmental factors. *Panel A* reports the key agricultural and economic indicators. As can be seen, non-affected counties had significantly lower total revenue, farm value, improved land, value of inputs and, total number of farms, and cropland productivity, but higher livestock productivity. The population growth variable in *Panel C* indicates locust affected counties had a significantly higher probability of experiencing population growth between 1870 and 1880, with a mean difference of 0.293. *Panel D* provides the averages of our climatic and geographic variables. Affected counties experienced less average precipitation (-0.047), which could have influenced agricultural viability. Temperature differences were not significant, but affected counties were more likely to be located in the Rocky Mountain range (0.074). In terms of crop suitability, we find that, on average, affected counties were more suitable for wheat and crop cultivation than unaffected ones.

**Table 3:** Balance test for county-level characteristics in 1870

| | Non-affected counties | | | Affected counties | | | |
|---|---|---|---|---|---|---|---|
| | n | mean | sd | n | mean | sd | Diff |
| ***Panel A.*** | | | | | | | |
| Total revenue relative to total farmland | 382 | 5.36 | 5.33 | 271 | 6.96 | 21.39 | 1.599 |
| Total farm value relative to total farmland | 382 | 12.15 | 10.54 | 271 | 10.52 | 8.37 | -1.634** |
| Total farmland (in acres) | 382 | 156634.83 | 112820.93 | 271 | 83391.29 | 82032.42 | -73,243.536*** |
| Improved land relative to total farmland | 382 | 0.35 | 0.21 | 271 | 0.30 | 0.22 | -0.052*** |
| Value of implements & machinery relative to total farmland | 382 | 0.69 | 0.55 | 271 | 0.64 | 0.51 | -0.045 |
| Livestock productivity | 382 | 4.30 | 5.50 | 271 | 16.23 | 86.33 | 11.921** |
| Cropland productivity | 382 | 7.03 | 3.69 | 271 | 6.54 | 4.11 | -0.489 |
| Agricultural diversity | 382 | 0.62 | 0.16 | 271 | 0.60 | 0.18 | -0.015 |
| Number of farms $<$ 9 acres | 382 | 72.56 | 93.39 | 271 | 44.09 | 58.47 | -28.469*** |
| Number of farms 10-19 acres | 382 | 128.22 | 148.34 | 271 | 72.91 | 84.26 | -55.312*** |
| Number of farms 20-49 acres | 382 | 338.18 | 265.20 | 271 | 193.17 | 204.89 | -145.007*** |
| Number of farms 50-99 acres | 382 | 252.05 | 273.72 | 271 | 118.00 | 148.45 | -134.056*** |
| Number of farms 100-499 acres | 382 | 167.56 | 230.08 | 271 | 66.40 | 103.15 | -101.161*** |
| Number of farms 500-999 acres | 382 | 3.69 | 8.23 | 271 | 0.96 | 2.57 | -2.728*** |
| Number of farms 1000+ acres | 382 | 0.60 | 1.49 | 271 | 0.20 | 0.70 | -0.399*** |
| ***Panel B.*** | | | | | | | |
| Share of corn in cereal grains production | 382 | 0.61 | 0.34 | 271 | 0.61 | 0.32 | 0.003 |
| Share of wheat in cereal grains production | 382 | 0.20 | 0.21 | 271 | 0.16 | 0.16 | -0.036** |
| Share of oats in cereal grains production | 382 | 0.16 | 0.16 | 271 | 0.15 | 0.16 | -0.007 |
| ***Panel C.*** | | | | | | | |
| Population growth | 381 | 0.39 | 0.49 | 265 | 0.68 | 0.47 | 0.293*** |
| Share of homesteads (acres) per county | 381 | 0.00 | 0.01 | 265 | 0.01 | 0.02 | 0.007*** |
| ***Panel D.*** | | | | | | | |
| Average precipitation 1874-1878 | 382 | 0.41 | 0.11 | 271 | 0.36 | 0.08 | -0.049*** |
| Average temperature 1874-1878 | 382 | 18.19 | 4.09 | 271 | 18.02 | 3.72 | -0.171 |
| Average wind speed 1870-1880 | 382 | 1.01 | 0.72 | 271 | 1.51 | 0.74 | 0.503*** |
| Rocky Mountain range | 382 | 0.05 | 0.21 | 271 | 0.13 | 0.34 | 0.082*** |
| Ruggedness index | 382 | 0.96 | 1.26 | 271 | 1.02 | 1.19 | 0.060 |
| Suitability for wheat cultivation | 382 | 5966.58 | 2482.14 | 271 | 6946.65 | 2524.65 | 980.076*** |
| Suitability for oat cultivation | 382 | 5739.17 | 2686.05 | 271 | 7189.75 | 2638.12 | 1,450.579*** |
| Suitability for corn cultivation | 382 | 5618.22 | 2458.02 | 271 | 5922.09 | 2665.72 | 303.872 |

*Notes:* (i) Total farmland is computed by taking the sum of improved and unimproved acres of farmland. (ii) Population change is a dummy variable that takes the value of 1 if the population has increased between 1870 and 1880; ; (iii) Average wind speed 1870-1880 refers to the average wind speed in June and July calculated over the years 1870 to 1880, excluding the year of the major locust invasion (1874); (iv) The variable Rocky Mountain range is a dummy variable that takes the value of one when a county is located within the latter range.

# 4 Empirical Strategy

## 4.1 Internal Migration

We first estimate the following linear probability model of the choice to migrate using OLS:

$$Y_{i,c} = \alpha + \beta \times LOCUST_{c,1874} + X'_{i,c}\gamma + Z'_{c}\delta + \epsilon_i \qquad (1)$$

where $Y_{i,c}$ represents the internal migration outcome at the individual level in 1880,

$LOCUST_{c,1874}$ is an indicator if the county of residence in 1870 was affected by locusts, $X_{i,c}$ is a vector of individual-level controls, as listed in Table 1, and $Z_c$ is a vector of county-level controls, as shown in Table 3. One should note that all time varying individual and county level control variables are measured in 1870, except population growth and the climatic controls, which are over the 1870 to 1880 period. In all of our empirical specifications we cluster the standard errors at the county level, to account for local shocks on outcomes correlated on individuals within counties.

## 4.2 Occupational Outcome of Migrants

We also study the occupational outcomes of individuals migrating in response to the locust invasions. In doing so we narrow our analysis to individuals originally from locust-affected counties, excluding all "untreated" individuals, i.e., those that resided in counties in 1870 that were not affected by the locust plague. More specifically, we compare the occupational outcomes of those who migrated to non-affected counties with those who either stayed or migrated to another locust-affected county. To investigate the relationship between the migration decision and the subsequent economic outcome in terms of occupational income scores, we follow Long and Siu (2018) and estimate the change in individual occupational earnings using OLS:

$$y_i = \beta_0 + \beta_1 locust\_to\_locust + \beta_2 locust\_to\_nonlocust + \alpha_c + X_i^{'}\delta + \epsilon_i \quad (2)$$

where $X_i$ includes all our individual-level controls , and $\beta_1$, $\beta_2$ are the coefficients of interest. The dependent variable, $y_i = y_{i,1880} - y_{i,1870}$ is the difference between *log* occupational income scores in 1870 and 1880. Additionally, we include a full set of origin county dummies $\alpha$ to take account of origin county differences. Our regressors of interest are *locust_to_locust* and *locust_to_nonlocust*, which take on a value of 1 if between 1870 and 1880 individual $i$ moved from a locust-affected county to another locust-affected or to a non-locust-affected county, respectively, both measured relative to those that stayed. The standard errors are clustered by origin county.

## 4.3 Agricultural Outcome

We also explore how the locust invasion impacted agricultural outcomes in the counties affected using the following OLS specification:

$$Y_c = \alpha + \beta \times LOCUST_{c,1874} + Z_c^{'}\delta + \epsilon_c \tag{3}$$

where $Y_c$ represents the change in a $log$-transformed agricultural outcome for county $c$ from 1870 to 1880, $LOCUST$ is our treatment variable, and $Z$ is our full set of county level controls listed in Table 3. Standard errors are clustered at the county level.

## 4.4 Instrumental Variable

There are a number of worries regarding the interpretation of $\beta$ of our treatment variable $LOCUST_{c,1874}$ in Equations 1 and 3 as the causal effect on the outcome $Y$. Firstly, while we control for a large number of individual and county specific factors, there may still be other omitted variables that affect the probability of locust invading a county and adaptation in terms of migration or agricultural practices. Moreover, while the map of affected counties created by Riley (1877a) is likely to have been based on as much information as was available to the authors at the time of the report, there may still be some mis-classification of counties, thus creating measurement error and potentially attenuation bias in the estimate of $\beta$. To address these concerns we employ an instrumental variable (IV) strategy. Specifically, we construct a plausibly exogenous variable that captures exogenous variation in locust movement based on local wind patterns. More specifically, as noted in Sections 2.2.1 and 2.2.2, the Rocky Mountain Locust had limited flight capability. When swarms grew too large for the available food, their migrations depended heavily on wind strength and direction. In the case of the 1874 outbreak in particular, strong eastward winds during June and July allowed a large swarm of locusts to form and migrate into the GP. In view of this, we construct an instrument by interacting a binary variable indicating eastward wind direction and the average wind speed in a county during the June and July months of 1874:

$$Windpattern_c = \mathbb{1}\{D_c = East\} \times WS_c \tag{4}$$

where $D_c$ is a county level indicator variable that takes the value of 1 if average wind direction was eastward, and $WS$ the average wind speed, both measures from their June and July 1874 averages. The exclusion restriction is thus that the wind impacts migration only through its effect on locust invasions and not through another mechanism (such as direct climatic effects on livelihoods). In this regard, one should note that in our county level controls we already include the average temperature and rainfall during the growing seasons of the 1870 to 1880 decade. Additionally, when we instrument we also include the average wind speed and direction during June and July over 1870 to 1880, excluding the year 1874. This controls for the possibility that some counties have persistent wind patterns, such as stronger or more eastward winds, that may influence agricultural outcomes directly, independent of locust presence.[10]

# 5 Empirical Results

## 5.1 Internal Migration

The results of estimating Equation 1 are presented in Table 4, where we first show the OLS results systematically including our set of controls in the first four columns. As can be seen, when we include no other controls there is a significant 7.1 per cent increase

[10] As shown in Table 3, in the years outside of 1874 locust invasions, locust-affected counties experienced, on average, higher wind speeds during these months.

in the linear probability of migration in locust affected counties. However, as we add our set of different controls the impact drops to 4 per cent, but is still significant. The last column (5) presents the estimates from our instrumental variable strategy, where we allow the specific wind direction and speed conditions in June and July of 1874 to proxy likely locust presence in a county. The first stage results confirm that the instrument is statistically significant and strongly correlated (0.499) with locust presence, with an F-statistic above the standard rule of thumb value of 10. The second stage confirms the statistically significant impact on migration within counties. The coefficient estimate is nearly double that of the OLS specification with the richest set of controls. This suggests an downward bias under OLS, consistent with an attenuation bias or other omitted factors that increase migration and are positively correlated with locust presence. Overall, the IV results indicate that locust presence in a county increased the probability of migrating to another county between 1870 and 1880 on average by 7.2 percentage points. Thus the effect is substantially larger than that found for rural blacks after the Great American drought of the 1930s (Sichko, 2025).

In the final column of Table 4 we also interacted the instrumented locust variable with the share of area in a county under the Homestead Act. The coefficient on this interaction term is negative, but statistically insignificant, indicating no meaningful difference in the locusts' impact between counties with higher and lower shares of homesteaded land.

The IV specification is estimated separately for native-born and foreign-born working age males, as presented in Table 5. As can be seen, native-born individuals were 7.2 percentage points more likely to migrate when residing in affected counties compared to their unaffected counterparts. In contrast, among foreign-born individuals, we observe a smaller effect of 6.7 percentage points, which is statistically significant at the 5% level. This supports the argument made by Luebke (1977) that foreign-born settlers were less mobile.

We also used our IV approach to estimate the impact using aggregated county-level

**Table 4:** Effect of locust invasions on internal migration

| | OLS | | | | IV | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\text{Locust}_{1874}$ | 0.071*** | 0.049*** | 0.046*** | 0.040*** | | |
| | (0.009) | (0.008) | (0.009) | (0.008) | | |
| $\widehat{\text{Locust}}_{1874}$ | | | | | 0.072*** | 0.077*** |
| | | | | | (0.026) | (0.028) |
| × Share of homesteads (per county, in acres) | | | | | | -0.981 |
| | | | | | | (0.944) |
| Constant | 0.419*** | 0.675*** | 0.884*** | 0.789*** | 0.827*** | 0.822*** |
| | (0.004) | (0.013) | (0.058) | (0.100) | (0.106) | (0.124) |
| Individual-specific controls | - | Yes | Yes | Yes | Yes | Yes |
| Agricultural-specific controls | - | - | Yes | Yes | Yes | Yes |
| Geo-climatic controls | - | - | - | Yes | Yes | Yes |
| *Wind pattern* ($1^{st}$ stage) | | | | | 0.499*** | |
| | | | | | (0.063) | |
| F-statistic (Kleibergen-Paap) | | | | | 64.763 | |
| Observations | 853812 | 853812 | 853812 | 853812 | 853812 | 853812 |
| Adjusted $R^2$ | 0.004 | 0.061 | 0.066 | 0.068 | 0.067 | 0.067 |

*Notes:* Standard errors are clustered at the county level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Individual-specific controls include all variables in table 1. Agricultural-specific controls (at the county-level) include all variables in Panel A-D of table 3, whereas geo-climatic controls (at the county-level) include all variables in Panel E of table 3.

migration data. More specifically, we calculated for each county in our sample the outward migration rate relative to the county's population in 1870. Table A1 suggests no statistically significant effect of locusts on county level outflows. One may want to note in this regard, that this is in line with Sichko (2025), who finds much smaller and statistically weaker results when comparing aggregate to individual level migration estimations, and is possibly due to aggregate bias (Jargowsky, 2005).

While it would have been unfeasible to empirically model inward migration at the individual level, given the over 3,000 relocation county level choices of potential inward migrants, we nevertheless calculated the county level inflow rates into our sample counties relative to the 1870 county population. Results in Table A1 show that the locusts reduced inward migration in affected counties by 162 per cent, which is nearly four times the effect that Sichko (2025) finds for severe heat during the Great American drought. One may also want to note that, this large impact is plausible despite the effort of local individuals to downplay the locust invasion, as outlined earlier.

**Table 5:** Effect of locust invasions on internal migration: native vs. foreign born

| | Native-born | Foreign-born |
|---|---|---|
| $\widehat{\text{Locust}}_{1874}$ | 0.072*** | 0.067** |
| | (0.028) | (0.030) |
| Constant | 0.796*** | 1.353*** |
| | (0.108) | (0.126) |
| Individual-specific controls | Yes | Yes |
| Agricultural-specific controls | Yes | Yes |
| Geo-climatic controls | Yes | Yes |
| Observations | 686205 | 167607 |
| Adjusted $R^2$ | 0.054 | 0.144 |

*Notes:* Standard errors are clustered at the county level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Controls are the same as in table 4.

## 5.2 Robustness Checks

### 5.2.1 County Boundary Changes

One limitation of our population dataset is that it only provides information on the county of residence, without more specific location details. Since we rely on this location information to construct our migration outcome variable, a potential issue is that county boundary changes between 1870 and 1880 could result in individuals being misclassified as migrants, when, in reality, it is only the boundaries that have shifted during the studied period. To address this, we estimate equation 1 using a more conservative measure for migration that accounts for these county boundary changes. To construct the latter variable, we begin by spatially joining 1870 and 1880 county shapefiles, which enables us to identify counties with boundary changes. This approach allows us to determine whether individuals should be classified as true migrants. In cases where there is uncertainty about an individual's migration status due to these county boundary changes, we flag the observation. In this more conservative approach, flagged individuals are classified as non-movers to minimize the risk of incorrectly identifying them as migrants[11].

[11] In total, 1.47% of our observations are flagged due to the uncertainty about their migration status.

The results in Table A2 shows no changes in the signs of the coefficients, with magnitudes remaining stable, indicating that the main findings remain robust even when flagged individuals are conservatively classified as non-movers.

#### 5.2.2 Alternative Linkage Method

To further ensure the robustness of our results, we also examine whether our main findings are sensitive to changes in the linkage method. For this purpose, we replicate our analysis using the crosswalk based on the exact conservative ABE algorithm from the Census Linking project (Abramitzky et al., 2022), which relies on exact names matches and requires individuals be unique within a five-year age band. This alternative linking approach yields a sample of 229,444 individuals (including 198,888 natives and 30,556 foreign-born individuals). Table A3 reports the results for the migration outcome variable, showing higher IV estimates. Individuals from locust-affected counties were 8.1 percentage points more likely to migrate compared to individuals from unaffected ones and similarly natives had higher effects (8.4), whereas the lack of impact on foreign born working age males remains.

### 5.3 Occupational Outcome of Migrants

As a first step in exploring the occupational outcomes of migrants we follow Long and Siu (2018) and calculated transition matrices across broad occupational groups for migrants, distinguishing between those who relocated within locust areas, those who left the locust-area, and non-migrants. As can be seen in Table 6 farmers who relocated to a non-affected area were more likely to experience downward occupational moves, becoming laborers, than those who stayed in affected areas or persisted (17.91 percent vs 8.66 and 3.81 respectively). However, this tendency for greater downward occupational mobility for farmers was more than offset by their greater likelihood of experiencing upward moves toward semi-skilled or high skilled occupations. The negative migration effect for non-farmers is driven primarily by the greater tendency of high-skilled to transition into semi-skilled or farmer occupations, relative to persisters, who primarily stayed in their high-skilled occupation.

**Table 6:** Occupational Transition Matrices: Migrants vs. Persisters (non-movers)

| **Migrants who relocate to a non-affected area** | | | | | |
|---|---|---|---|---|---|
| | *Occupation Group, 1870* | | | | |
| *Occupation Group, 1880* | High-Skilled | Semi-Skilled | Farmer | Laborer | Observations |
| High-Skilled | **46.24** | 15.32 | 10.33 | 10.48 | 6,295 |
| Semi-Skilled | 19.77 | **42.82** | 16.29 | 22.00 | 9,932 |
| Farmer | 21.77 | 22.84 | **55.47** | 38.22 | 16,259 |
| Laborer | 12.22 | 19.02 | 17.91 | **29.30** | 8,745 |
| Observations | 4,410 | 8,675 | 14,846 | 13,300 | |

| **Migrants who stay in a locust-affected area** | | | | | |
|---|---|---|---|---|---|
| | *Occupation Group, 1870* | | | | |
| *Occupation Group, 1880* | High-Skilled | Semi-Skilled | Farmer | Laborer | Observations |
| High-Skilled | **57.41** | 12.64 | 7.38 | 6.90 | 7,435 |
| Semi-Skilled | 11.81 | **44.26** | 9.21 | 11.99 | 9,157 |
| Farmer | 25.92 | 35.42 | **74.74** | 58.54 | 36,088 |
| Laborer | 4.85 | 7.67 | 8.66 | **22.57** | 7,259 |
| Observations | 5,273 | 8,639 | 29,109 | 16,918 | |

| **Persisters** | | | | | |
|---|---|---|---|---|---|
| | *Occupation Group, 1870* | | | | |
| *Occupation Group, 1880* | High-Skilled | Semi-Skilled | Farmer | Laborer | Observations |
| High-Skilled | **71.12** | 12.37 | 4.12 | 5.38 | 11,337 |
| Semi-Skilled | 7.01 | **53.18** | 3.05 | 7.06 | 9,730 |
| Farmer | 18.30 | 27.63 | **89.02** | 60.89 | 75,864 |
| Laborer | 3.57 | 6.82 | 3.81 | **26.67** | 9,333 |
| Observations | 8,677 | 10,516 | 65,247 | 21,824 | |

*Notes:* Values in rows indicate the probability that individuals from one occupation group in 1870 (arranged by column) transits to each occupation group in 1880. High-skilled = managers, officials, and proprietors etc.; semi-skilled = sales workers, craftsmen, operatives etc.; laborer = general laborer and farm laborer.

The results of estimating Equation 2 are shown in Table 7. One should note that since we have two treatment variables but only one available instrument that we were unable to use our instrumental strategy for this regression, and thus the results should be treated with some caution. Accordingly, there is a statistically significant, but economically small, increase in occupational earnings for migrants, regardless of whether they moved to another affected county or relocated to a non-affected area. Those who relocated within a locust-affected area experienced occupational changes that translated to a 2.7 percent increase in earnings on average, while individuals who left the locust-affected area experienced a percent increase of 5.1 compared to those who persisted to relocate. Given that 52.7% of our sample consists of farmers, we conduct separate regressions for both non-farmers and farmers. The results in column (2) indicate that non-farmers experienced an average decrease in occupational earnings of 4.2 percent when moving to another affected county with a slightly smaller decline of 3.4 percent when relocating to a non-affected county, compared to those who persisted. In contrast, farmers (column 3) who migrated tended to fare better then their counterparts who did not, experiencing a 6.8 percent increase in occupational earnings when relocating within the locust-affected area and a 12.6 percent increase when moving to a non-affected county. These findings align with those of Long and Siu (2018), who noted small aggregate gains for Dust-Bowl migrants, masking significant benefits for farmers and moderate losses for non-farmers. If one examines the farmer vs. non-farmer distinction separately for foreign and native born individuals, they remain qualitatively the same, except for much larger effects for foreign settlers. Thus, although foreign migrants were less likely to move away after the locust outbreak, those that do gained or lost more than native migrants, depending on whether they were farmers or not.

**Table 7:** Effect of migration paths on occupational income scores: OLS results

| | | | | Native-born | | Foreign-born | |
|---|---|---|---|---|---|---|---|
| | (1) Whole sample | (2) Non-Farmers | (3) Farmers | (4) Non-Farmers | (5) Farmers | (6) Non-Farmers | (7) Farmers |
| *Moved from a...* | | | | | | | |
| ...locust-affected to another affected county | 0.027*** | -0.042*** | 0.068*** | -0.033*** | 0.063*** | -0.084*** | 0.095*** |
| | (0.002) | (0.003) | (0.002) | (0.004) | (0.002) | (0.008) | (0.006) |
| ...locust-affected to a non-affected county | 0.051*** | -0.034*** | 0.126*** | -0.041*** | 0.103*** | -0.015** | 0.255*** |
| | (0.002) | (0.004) | (0.003) | (0.004) | (0.003) | (0.007) | (0.006) |
| Constant | 0.551*** | 0.641*** | 0.070*** | 0.646*** | 0.074*** | 0.587*** | -0.032 |
| | (0.005) | (0.008) | (0.007) | (0.009) | (0.007) | (0.038) | (0.054) |
| Individual-level controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 207328 | 98150 | 109161 | 77670 | 93373 | 20470 | 15767 |
| $R^2$ | 0.257 | 0.353 | 0.052 | 0.360 | 0.048 | 0.339 | 0.140 |

*Notes:* Robust standard in parentheses. Individual-level controls include the following pre-treatment characteristics: age, literacy, head of household status, dummy for race (=1 if white, 0 otherwise) and 1870 occupational income score.
$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$.

## 5.4 Agricultural Outcome

Figures 3, 4, and 5 depict the estimated coefficients on the locust treatment indicator under our IV strategy for our various agricultural outcomes, as described in *Panels A & B* of Table 3. Examining Figure 3 reveals that locust infestations did not affect the farm output, the cash value of farms, or the value of inputs. In constrast, Hornbeck (2012) shows that counties eroded from the Dust Bowl in 1930s by 1940 experienced losses in the value of output and farm value, of which the latter result was echoed in the study by Ager et al. (2017b) in response to the Boll Weevil outbreak. We also find that areas affected by locusts decreased total farmland considerably, as was discovered in the context of Ager et al. (2017b), where our estimate (0.83) is about 40% lower. The fall in farm acreage was, however, not due to a change of relative share of improved versus unimproved land. One should note that although Hornbeck (2012) did not explore the Dust Bowl effect on total farmland, the author similarly showed that there was no increase in the share of improved land. While cropland productivity was not affected, there was a substantial increase in livestock productivity (52.6%). This differs from the Dust Bowl in that there was a fall in both cropland and livestock productivity (Hornbeck, 2012), although one needs to caution we were not able to measure our productivity measures relative to the relevant acreage in cropland and pasture, respectively, but only in terms of total improved land since the Agricultural Census had not yet distinguished between the uses of the improved land. This may also be the reason why our result in terms of livestock is not in line with of the historical accounts that farmers switched to livestock after experiencing locust damage (Briggs, 1934; Lockwood, 2004; J. T. Schlebecker, 1953).

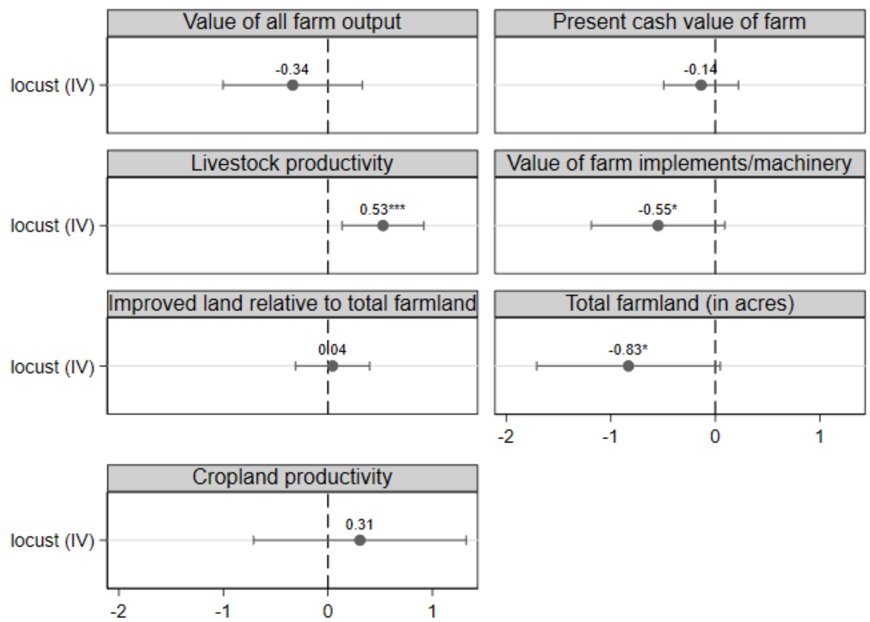


**Figure 3:** IV estimates for farm specific outcomes

*Note:* (i) Value of all farm output, present cash value of farm and value of farm implements/machinery are expressed relative to total farmland. (ii) Livestock productivity, measured as the value of all livestock per acre of total farmland, shows a stronger effect (coefficient 0.795 significant at the 1% level) when calculated using only unimproved land as the denominator. Controls include all variables listed in Table 3 (Panels *A&D*).
$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$.

In Figure 4 we depict the results for the number of farms, as well as by size group. As can be seen, there was a negative impact on the number of farms. The same was discovered for the Boll Weevil by Ager et al. (2017b), although the size of the estimate is substantially larger in case of locusts (-1.04 versus 0.176). In view of the loss in total farmland we find, this is possibly due to migrating farmers abandoning their farms altogether

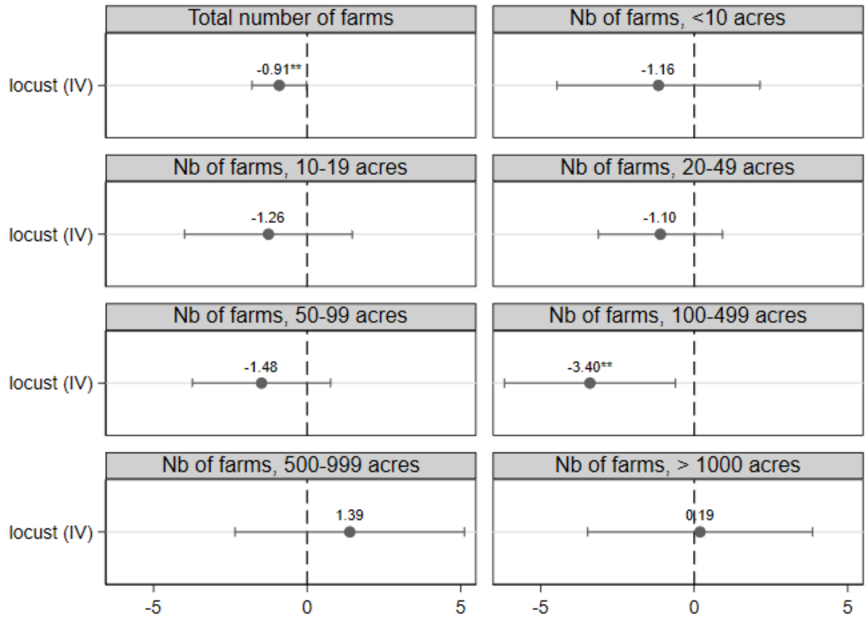


**Figure 4:** IV estimates for the number of farms

*Note:* Controls include all variables listed in Table 3 (Panels *A&D*).
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

and/or the selling off farms to other existing farmers. Examining the coefficients for the various size groups shows that there was a large fall in medium sized farms (100-499 acres). One may want to note that this is also the category in which most federal and state owned parcels were sold (at 160 acres), although our result in terms of migration suggests that these were not predominantly farms that were still under the Homestead Act.

In Figure 5 we explore dimensions of agricultural diversity. In particular, our findings show that there was no effect on agricultural diversity. In terms of the main crops in the GP at the time, only the share of oats was reduced after the locust invasion, where it is noteworthy that this only constituted 16% of total crops at the time. The absence of long-term adjustment in the main crops—wheat and corn—after locust damage is consistent with evidence from Minnesota. There, any diversification away from these staples was only temporary, as noted by Atkins (1984).

Finally, to ensure the robustness of our results, we computed Conley standard errors

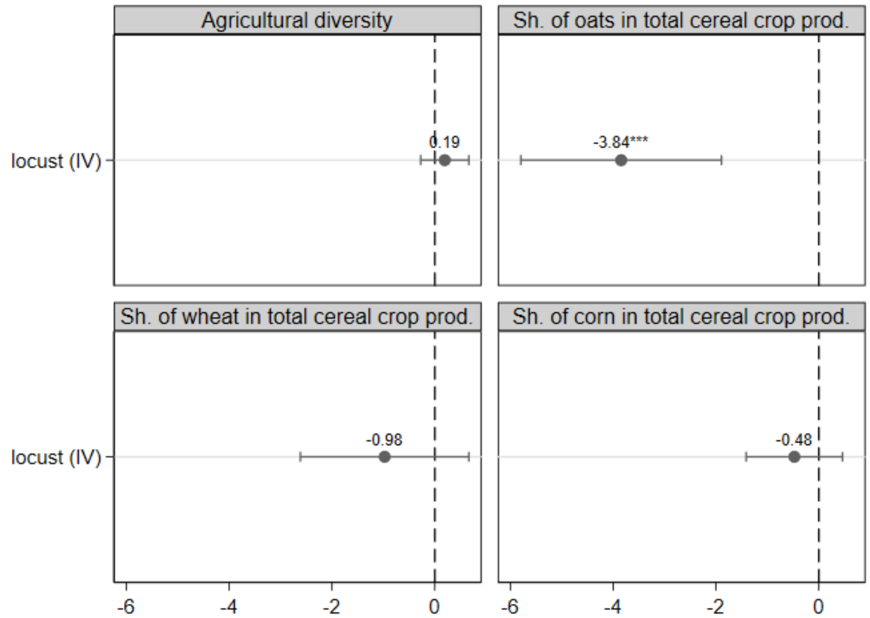


**Figure 5:** IV estimates for crop specific outcomes

*Note:* Controls include all variables listed in Table 3, Panels A&D. Standard errors are clustered at the county level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

(Conley, 1999) for all our agricultural specifications, applying threshold distances of 35 and 50 kilometers. After accounting for spatial correlation, the coefficients of total farm output, the present cash value of farms and the number of improved acres remain statistically significant at the 5% level (Table A4 in the appendix). Additionally, we applied propensity score matching (PSM) weights to further validate our findings. The results, which can be found in Tables A4 through A8, align with our baseline results.

## 6 Conclusion

This study explored the migratory and agricultural adaptive responses to the 1874 Rocky Mountain Locust plague, which caused extensive damages to farms in the US Great Plains. We show that this large negative shock increased the likelihood of working age males moving elsewhere, on average by 7.2 percentage points. While migrating farmers from locust-affected counties experienced modest economic gains, non-farmers often faced occupational setbacks, highlighting the uneven economic consequences of migration, and this is true for both native and foreign born migrants, although the relative impacts are much larger for the latter.

In terms of the locust outbreak's implications for agriculture, our findings showed that the total number of farms and acreage they occupied fell, with the former due to a fall in medium sized farms. Neither output, inputs, nor the value of farms seems to have been affected. There was also no detectable change in crop composition, except for a drop in the relative growing of oats. However, there was a subsequent increase in livestock production, in line with historical narrative accounts. It is noteworthy that this shift towards animal production occurred despite there being little fencing material available in the Great Plains at the time, and thus risked further crop damage from grazing farm animals (Danbom, 2014; J. Schlebecker, 1977; Webb, 2022).

More generally, our study provides an historical example of what the effects of an unanticipated large environmental shock were in an agricultural setting where there was little experience and technology suitable for the local land and climate, and thus most settlers were just struggling to make ends meet. Their response to the crisis was multifaceted in that their tendency was to move away, but little change was made in terms of local farming. While this 1874 locust plague was the last significant outbreak that farmers in the Great Plains experienced before the pest's extinction, America's 'breadbasket' continued and continues to be a region where devastating environmental disasters are not uncommon, but are intrinsically linked to economic choices (Cunfer, 2005; Gregg, 2015; Sanderson and Frey, 2014).

# References


Abramitzky, R., Boustan, L., Eriksson, K., Rashid, M., & Pérez, S. (2022). Census Linking Project: 1870-1880 Crosswalk. https://doi.org/10.7910/DVN/OCWCFR

Ager, P., Brueckner, M., & Herz, B. (2017a). The boll weevil plague and its effect on the southern agricultural sector, 1889–1929. *Explorations in Economic History*, *65*, 94–105.

Ager, P., Brueckner, M., & Herz, B. (2017b). The boll weevil plague and its effect on the southern agricultural sector, 1889–1929. *Explorations in Economic History*, *65*, 94–105. https://doi.org/10.1016/j.eeh.2016.07.005

Allen, D. W., & Leonard, B. (2021). Property right acquisition and path dependence: Nineteenth-century land policy and modern economic outcomes. *The Economic Journal*, *131*(640), 3073–3102.

Arthi, V. (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), 196–230.

Atkins, A. (1984). *Harvest of grief: Grasshopper plagues and public assistance in minnesota, 1873-78*. Minnesota Historical Society Press.

Auffhammer, M., Hsiang, S. M., Schlenker, W., & Sobel, A. (2013). Using weather data and climate model output in economic analyses of climate change. *Review of Environmental Economics and Policy*, *7*(2), 181–198. https://doi.org/10.1093/reep/ret016

Boustan, L. P., Kahn, M. E., & Rhode, P. W. (2012). Moving to higher ground: Migration response to natural disasters in the early twentieth century. *American Economic Review*, *102*(3), 238–244. https://doi.org/10.1257/aer.102.3.238

Briggs, H. E. (1934). Grasshopper plagues and early dakota agriculture, 1864-1876. *Agricultural History*, *8*(2), 51–63.

Clay, K., Schmick, E. J., & Troesken, W. (2020). *The boll weevil's impact on racial income gaps in the early twentieth century*. National Bureau of Economic Research.

Conley, T. (1999). GMM estimation with cross sectional dependence. *Journal of Econometrics*, *92*(1), 1–45. https://doi.org/10.1016/S0304-4076(98)00084-0

Cunfer, G. (2005). *On the great plains: Agriculture and environment*. Texas A&M University Press.

Cunfer, G., & Krausmann, F. (2015). Adaptation on an agricultural frontier: Socio-ecological profiles of great plains settlement, 1870–1940. *Journal of Interdisciplinary History*, *46*(3), 355–392.

Danbom, D. B. (2014). *Sod busting: How families made farms on the nineteenth-century plains*. JHU Press.

Dudley, J. L., Pillsbury, J. S., & Pennington, J. L. (2014). Article title: Grasshoppered: America's response to the 1874 rocky mountain locust invasion.

Fischer, G., Nachtergaele, F. O., van Velthuizen, H., Chiozza, F., Franceschini, G., Henry, M., Muchoney, D., & Tramberend, S. (2021). *Global Agro-Ecological Zones (GAEZ v4) - Model Documentation* (Model documentation / Data portal). International Institute for Applied Systems Analysis (IIASA), Food, and Agriculture Organization of the United Nations (FAO). Laxenburg, Austria; Rome, Italy. https://doi.org/10.4060/cb4744en

Fiszbein, M. (2022). Agricultural Diversity, Structural Change, and Long-Run Development: Evidence from the United States. *American Economic Journal: Macroeconomics*, *14*(2), 1–43. https://doi.org/10.1257/mac.20190285

Fite, G. C. (1977). Great plains farming: A century of change and adjustment. *Agricultural History*, *51*(1), 244–256.

Gregg, S. M. (2015). From breadbasket to dust bowl: Rural credit, the world war i plow-up, and the transformation of american agriculture. *Great Plains Quarterly*, 129–166.

Haines, M., Fishback, P., & Rhode, P. (2014). United States Agriculture Data, 1840 - 2012: Version 4. https://doi.org/10.3886/ICPSR35206.V4

Hewes, L. (1996). Making a pioneer landscape in the oklahoma territory. *Geographical Review*, 588–603.

Hornbeck, R. (2012). The Enduring Impact of the American Dust Bowl: Short- and Long-Run Adjustments to Environmental Catastrophe. *American Economic Review*, *102*(4), 1477–1507. https://doi.org/10.1257/aer.102.4.1477

Hornbeck, R. (2023a). Dust bowl migrants: Environmental refugees and economic adaptation. *The Journal of Economic History*, *83*(3), 645–675.

Hornbeck, R. (2023b). Dust Bowl Migrants: Environmental Refugees and Economic Adaptation. *The Journal of Economic History*, *83*(3), 645–675. https://doi.org/10.1017/S0022050723000244

Hornbeck, R., & Naidu, S. (2014). When the Levee Breaks: Black Migration and Economic Development in the American South. *American Economic Review*, *104*(3), 963–990. https://doi.org/10.1257/aer.104.3.963

Jargowsky, P. A. (2005). The ecological fallacy. *Encyclopedia of social measurement*, *1*, 715–722.

Lange, F., Olmstead, A. L., & Rhode, P. W. (2009). The impact of the boll weevil, 1892–1932. *The Journal of Economic History*, *69*(3), 685–718.

Lockwood, J. A., & Debrey, L. D. (1990). A solution for the sudden and unexplained extinction of the rocky mountain grasshopper (orthoptera: Acrididae). *Environmental Entomology*, *19*(5), 1194–1205.

Lockwood, J. A. (2004). *Locust: The Devastating Rise and Mysterious Disappearance of the Insect that Shaped the American Frontier* (1. ed). Basic Books.

Long, J., & Siu, H. (2018). Refugees from Dust and Shrinking Land: Tracking the Dust Bowl Migrants. *The Journal of Economic History*, *78*(4), 1001–1033. https://doi.org/10.1017/S0022050718000591

Luebke, F. C. (1977). Ethnic group settlement on the great plains. *The Western Historical Quarterly*, *8*(4), 405–430.

Manson, S., Schroeder, J., Van Riper, D., & Ruggles, S. (2019). National Historical Geographic Information System: Version 14.0. https://doi.org/10.18128/D050.V14.0

Packard Jr, A. (1877). The migrations of the destructive locust of the west. *The American Naturalist*, *11*(1), 22–29.

Powell, J. W. (1890). The irrigable lands of the arid region. *Cent. Mag*, *39*, 766–776.

Price, J., Buckles, K., Haws, A., & Wilbert, H. (2023). The Census Tree, 1870-1880. https://doi.org/10.3886/E193246V1

Riegert, P. W. (1977). A century of locusts and mortgages. *Prairie Forum*, 121–126.

Riley, C. V. (1877a). *The locust plague in the United States: Being more particularly a treatise on the Rocky Mountain locust or so-called grasshopper, as it occurs east of the Rocky Mountains, with practical recommendations for its destruction*. Rand, McNally & Co. https://doi.org/10.5962/bhl.title.70400

Riley, C. V. (1877b). The Rocky Mountain locust. *The American Naturalist*, *11*(11), 663–673.

Riley, C. V. (1879). First Annual Report of the United States' Entomological Commission. *Nature*, *19*(484), 309–311. https://doi.org/10.1038/019309a0

Ruggles, S., Flood, S., Foster, S., Goeken, R., Pacas, J., Schouweiler, M., & Sobek, M. (2021). IPUMS USA: Version 11.0. https://doi.org/10.18128/D010.V11.0

Salisbury, L. (2014). Selective migration, wages, and occupational mobility in nineteenth century america. *Explorations in Economic History*, *53*, 40–63.

Sanderson, M. R., & Frey, R. S. (2014). From desert to breadbasket… to desert again? a metabolic rift in the high plains aquifer. *Journal of Political Ecology*, *21*(1), 516–532.

Schlebecker, J. (1977). Tillage and crops on prairies and plains: America 1830-1960. *Journal d'agriculture traditionnelle et de botanique appliquée*, *24*(2), 171–184.

Schlebecker, J. T. (1953). Grasshoppers in American Agricultural History. *American Agricultural History*, *27*(3), 85–93. http://www.jstor.org/stable/3739844

Scudder, S. H. (1897). *Revision of the orthopteran group melanopli (acridiidae): With special reference to north american forms* (Vol. 20). US Government Printing Office.

Sheldon, A. E. (1931). *Nebraska: The land and the people* (Vol. 1). Lewis Publishing Co.

Sichko, C. (2025). Environmental migration during the great american drought. *Journal of Economic Geography*, lbaf006.

Slivinski, L. C., Compo, G. P., Whitaker, J. S., Sardeshmukh, P. D., Giese, B. S., McColl, C., Brohan, P., Allan, R., Yin, X., Vose, R., Titchner, H., Kennedy, J., Spencer, L. J., Ashcroft, L., Bronnimann, S., Brunet, M., Camuffo, D., Cornes, R., Cram, T. A., … Wyszynski, P. (2019). Noaa-cires-doe twentieth century reanalysis version 3. https://doi.org/10.5065/H93G-WS83

Song, H. (2011). Density-Dependent Phase Polyphenism in Nonmodel Locusts: A Minireview. *Psyche: A Journal of Entomology*, *2011*, 1–16. https://doi.org/10.1155/2011/741769

Stewart, J. I. (2006). Migration to the agricultural frontier and wealth accumulation, 1860–1870. *Explorations in Economic History*, *43*(4), 547–577.

Thomas, C. (1878). *On the orthoptera collected by dr. elliott coues, usa, in dakota and montana, during 1873-74*. US Government Printing Office.

Webb, W. P. (2022). *The great plains*. U of Nebraska Press.

Wishart, D. J. (Ed.). (2004). *Encyclopedia of the great plains*. University of Nebraska Press.

**Table A1:** Effect of locust invasions on internal migration: IV results

| | (1) Out-migration | (2) In-migration |
|---|---|---|
| $\widehat{\text{Locust}}_{1874}$ | -0.002 | -1.622** |
| | (0.013) | (0.710) |
| Constant | 0.105*** | 1.806 |
| | (0.028) | (1.478) |
| Observations | 653 | 656 |
| $R^2$ | 0.374 | 0.150 |
| Agricultural-specific controls | Yes | Yes |
| Geo-climatic controls | Yes | Yes |

*Notes:* Standard errors are clustered at the county level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. County-level controls are the same as in table 4.

**Table A2:** Effect of locust invasions on internal migration: IV results using the conservative migration measure

| | Whole sample (1) | Native-born (2) | Foreign-born (3) |
|---|---|---|---|
| $\widehat{\text{Locust}}_{1874}$ | 0.062** | 0.063** | 0.054* |
| | (0.029) | (0.032) | (0.030) |
| Constant | 0.809*** | 0.770*** | 1.301*** |
| | (0.107) | (0.113) | (0.118) |
| Individual-specific controls | Yes | Yes | Yes |
| Agricultural-specific controls | Yes | Yes | Yes |
| Geo-climatic controls | Yes | Yes | Yes |
| Observations | 853812 | 686205 | 167607 |
| Adjusted $R^2$ | 0.064 | 0.051 | 0.140 |

*Notes:* Standard errors clustered at county level are reported in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

**Table A3:** Effect of locust invasions on internal migration: IV results using the linked sample based on the exact conservative ABE algorithm

| | (1) Whole sample | (2) Native-born | (3) Foreign-born |
|---|---|---|---|
| $\widehat{\text{Locust}}_{1874}$ | 0.082*** | 0.083*** | 0.064 |
| | (0.030) | (0.032) | (0.045) |
| Constant | 0.906*** | 0.883*** | 1.181*** |
| | (0.117) | (0.115) | (0.164) |
| Individual-specific controls | Yes | Yes | Yes |
| Agricultural-specific controls | Yes | Yes | Yes |
| Geo-climatic controls | Yes | Yes | Yes |
| Observations | 229444 | 198888 | 30556 |
| $R^2$ | 0.054 | 0.051 | 0.092 |

*Notes:* Standard errors are clustered at the county level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

**Table A4:** The effect of locust presence on farm-specific outcomes: IV estimates using Conley SE

| | Value of all farm output | Present cash value of farm | Value of farm implements/machinery | Livestock productivity | Cropland productivity | Improved lands relative to total farmland | Total farmland (in acres) |
|---|---|---|---|---|---|---|---|
| $\widehat{\text{Locust}}_{1874}$ | -0.337 | -0.136 | -0.548* | 0.526*** | 0.306 | 0.044 | -0.831* |
| | (0.340) | (0.182) | (0.326) | (0.199) | (0.519) | (0.181) | (0.448) |
| Conley SE (dist=35) | (0.353) | (0.191) | (0.361) | (0.203)*** | (0.525) | (0.181) | (0.456)* |
| Conley SE (dist=50) | (0.406) | (0.228) | (0.390) | (0.226)** | (0.565) | (0.196) | (0.471)* |
| Constant | 0.305 | 1.234*** | 0.978 | 1.600*** | 6.234*** | 1.879*** | 1.851* |
| | (0.582) | (0.359) | (0.607) | (0.599) | (1.278) | (0.355) | (0.956) |
| Observations | 653 | 653 | 653 | 653 | 653 | 653 | 653 |
| Farm-specific controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Geo-climatic controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

**Table A5:** The effect of locust presence on farm-specific outcomes: IV estimates using PSM weights

| | Value of all farm output | Present cash value of farm | Value of farm implements/machinery | Livestock productivity | Cropland productivity | Improved lands relative to total farmland | Total farmland (in acres) |
|---|---|---|---|---|---|---|---|
| $\widehat{\text{Locust}}_{1874}$ | 0.098 | 0.012 | -0.219 | 0.903*** | 0.889** | -0.050 | -1.064*** |
| | (0.169) | (0.171) | (0.246) | (0.178) | (0.407) | (0.171) | (0.296) |
| Constant | 1.910*** | 2.789*** | 1.604*** | 1.996** | 7.972*** | 1.590*** | 0.720 |
| | (0.577) | (0.393) | (0.564) | (0.870) | (1.410) | (0.505) | (1.407) |
| Observations | 653 | 653 | 653 | 653 | 653 | 653 | 653 |
| Farm-specific controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Geo-climatic controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

**Table A6:** The effect of locust presence on farm structures: IV estimates using Conley SE

| | Total nb of farms | Nb of farms (< 9 acres) | Nb of farms (10-19 acres) | Nb of farms (20-49 acres) | Nb of farms (50-99 acres) | Nb of farms (100-499 acres) | Nb of farms (500-999 acres) | Nb of farms (> 1000 acres) |
|---|---|---|---|---|---|---|---|---|
| $\widehat{\text{Locust}}_{1874}$ | -0.907* | -1.164 | -1.258 | -1.101 | -1.484 | -3.397*** | 1.390 | 0.190 |
| | (0.471) | (2.285) | (1.207) | (1.041) | (1.198) | (1.280) | (1.840) | (1.576) |
| Conley SE (dist=35) | (0.478)* | (2.254) | (1.224) | (1.047) | (1.221) | (1.342)** | (1.941) | (1.651) |
| Conley SE (dist=50) | (0.519)* | (2.587) | (1.334) | (1.153) | (1.289) | (1.579)** | (2.152) | (1.862) |
| Constant | 0.787 | -10.653*** | -6.247** | 0.765 | 9.130*** | 15.593*** | 6.847*** | -1.597 |
| | (0.884) | (3.305) | (2.930) | (2.722) | (2.123) | (2.404) | (2.116) | (2.289) |
| Observations | 653 | 653 | 653 | 653 | 653 | 653 | 653 | 653 |
| Farm-specific controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Geo-climatic controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

**Table A7:** The effect of locust presence on farm structures: IV estimates using PSM weights

| | Total nb of farms | Nb of farms (< 9 acres) | Nb of farms (10-19 acres) | Nb of farms (20-49 acres) | Nb of farms (50-99 acres) | Nb of farms (100-499 acres) | Nb of farms (500-999 acres) | Nb of farms (> 1000 acres) |
|---|---|---|---|---|---|---|---|---|
| $\widehat{\text{Locust}}_{1874}$ | -0.878*** | 1.109 | -0.394 | -0.913 | -1.482** | -2.362*** | 1.093 | 0.320 |
| | (0.308) | (1.728) | (0.826) | (0.725) | (0.693) | (0.728) | (1.307) | (1.038) |
| Constant | 0.612 | -10.221** | -1.161 | 1.202 | 11.320*** | 13.101*** | 10.865*** | 1.524 |
| | (1.324) | (4.110) | (4.172) | (4.865) | (3.316) | (3.024) | (2.748) | (2.750) |
| Observations | 653 | 653 | 653 | 653 | 653 | 653 | 653 | 653 |
| Farm-specific controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Geo-climatic controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

**Table A8:** The effect of locust presence on farm structures: IV estimates using Conley SE

| | Agricultural diversity | Sh. of oats in total cereal crop prod. | Sh. of wheat in total cereal crop prod. | Sh. of corn in total cereal crop prod. |
|---|---|---|---|---|
| $\widehat{\text{Locust}}_{1874}$ | 0.194 | -3.845*** | -0.976 | -0.476 |
| | (0.239) | (0.796) | (0.628) | (0.569) |
| Conley SE (dist=35) | (0.248) | (0.822)*** | (0.679) | (0.574) |
| Conley SE (dist=50) | (0.297) | (1.012)*** | (0.876) | (0.588) |
| Constant | 4.326*** | 11.225*** | 8.570*** | 0.912 |
| | (0.862) | (1.672) | (1.803) | (1.042) |
| Observations | 653 | 653 | 653 | 653 |
| Farm-specific controls | Yes | Yes | Yes | Yes |
| Geo-climatic controls | Yes | Yes | Yes | Yes |

Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

**Table A9:** The effect of locust presence on crop-specific outcomes: IV estimates using PSM weights

| | Agricultural diversity | Sh. of oats in total cereal crop prod. | Sh. of wheat in total cereal crop prod. | Sh. of corn in total cereal crop prod. |
|---|---|---|---|---|
| $\widehat{\text{Locust}}_{1874}$ | 0.029 | -3.144*** | -0.777 | 0.092 |
| | (0.138) | (0.591) | (0.477) | (0.366) |
| Constant | 4.505*** | 13.546*** | 9.423*** | 2.326** |
| | (0.757) | (1.785) | (2.380) | (1.168) |
| Observations | 653 | 653 | 653 | 653 |
| Farm-specific controls | Yes | Yes | Yes | Yes |
| Geo-climatic controls | Yes | Yes | Yes | Yes |

Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$