A Dam Problem: TVA's Fight Against Malaria 1926-1951

by

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Abstract

The TVA has long been held in high esteem for its programs designed to reduce malaria mortality and morbidity rates in the Southeast following its establishment in 1933. One reason why the TVA developed the anti-malaria programs was that they created large bodies of standing water by damming up the Tennessee River and its tributaries. Given the recent increase in river system management projects around the globe and recurring problems with malaria, the TVA provides insight to the problems associated with large scale dams and water management. Using county level panel data from the Southeast United States, I find that the net effect of the TVA was to increase malaria morbidity and mortality rates following its construction. Using standard statistical life value estimates, I find that between 1933 and 1951 that the malaria cost was large enough to offset 24 percent of the fiscal stimulus multiplier generated by the TVA.

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1. Introduction

Recently developing nations have constructed dams for the purposes of water management, electrification, water storage, and irrigation. These dams have significantly improved agricultural production, often at the expense of the removed population (Duflo and Pande 2007). One of the major environmental concerns when dams are constructed is that they impound a large body of water. In mild and tropical climates, this impoundment may lead to large outbreaks of waterborne and vector borne disease. Duflo and Pande provided an excellent study of dams and their effects on agricultural development and rural poverty and raise the question of what impacts these dams have on malaria. This paper attempts to more closely examine the relationship between large dams and malaria.

Today, malaria is a significant public health problem in the developing world. . Between one and three million people die annually from malaria or malaria related illnesses. Over 300 million are infected annually (Sachs 2002). The World Health Organization reports that people living in highly malarious regions have incomes that are significantly lower than those living in low intensity areas. These claims have been substantiated by research on the life cycle effects of malaria and malaria eradication. Malaria can lead to reductions in physical stature, and eradication has led to significantly better labor market outcomes for individuals as well as increases in spending (Bleakley 2007, Cutler et al 2010, Hong 2007).

In this paper, I explicitly examine the malaria problem associated with the construction of large scale dams using an exogenous change in the disease environment caused by the formation of the Tennessee Valley Authority (TVA). The TVA was one of many New Deal agencies, formed with the intent of spurring economic activity during the Great Depression. Its primary objective was to control flooding that occurred on the Tennessee River and its major tributaries as well as provide a source of cheap electricity in the South. The TVA is often viewed as one of the first large regionally targeted big push projects. To fully understand the net benefits of such a massive project, it is important to study both the intended and unintended consequences of the development. Recently the standard treatment of the TVA as an engine of growth has been called into question by Kitchens (2012a) and Kline and Moretti (2012). In these papers, the authors have shown evidence that the TVA did not deliver lower power prices and that any benefits, if they did exist, occurred over a short time window. If the TVA proves to be costly in terms of malaria, it is possible that any benefits generated by the TVA could be entirely offset.

To identify the causal effect of a TVA dams on malaria rates, I have collected disease specific mortality and morbidity rates at the county level for two southeastern states, Alabama and Tennessee, where the TVA was primarily located. I use within county variation over time controlling for year specific state level shocks to identify the effect using panel data methods.

The results show that the net effect of the TVA was to increase both morbidity and mortality rates in the counties surrounding the dams. These results are robust to a variety of specifications, accounting for correlation over time and across space. While the net effect of the TVA is positive, I also find evidence that the TVA efforts to combat malaria did reduce malaria rates from the higher baseline. As more dams opened upstream from a county, allowing the TVA to raise and lower water levels in downstream reservoirs, in ways that killed mosquito populations, the malaria rate was reduced. This provides some evidence for the success of one vector control method that will be discussed below.

Point estimates from the differences-in-differences estimation are then used to construct a back of the envelope cost calculation for the cost of mortality and the cost of morbidity. I use outside estimates for the morbidity cost and Value of a Statistical Life (VSL) to estimate the cost of malaria mortality associated with the TVA dam construction. I estimate that the TVA had a hidden malaria cost of $340 million,[1] which is 24% of the fiscal multiplier generated by the TVA.

2. Malaria and the TVA

2.1 Plasmodium Vivax

The parasite Plasmodium, which is the cause of malaria was first discovered in 1880. Malaria is transmitted when the parasite Plasmodium

"… is injected into the human blood stream by the bite of an infected mosquito. Shortly thereafter the parasite enters a red blood cell and begins to grow and multiply until from 16 to 24 new parasites are formed. The red cell then bursts, freeing the parasites which soon enter other red cells to undergo similar development." [2]

This process can have devastating effects on health. Anemia results from the parasite's destruction of red blood cells. In mild or uncomplicated cases of malaria, cold chills are followed by fever and nausea, and eventually the breaking of the fever. In more complicated cases, blood may appear in one's urine. Pulmonary edema, reduction in blood platelets, and more severe complications may lead to death. Plasmodim Vivax, the variety most prevalent in the United

[1] Note all dollar values are in year 2009 constant dollars.
[2] Malaria and its Control in the Tennessee Valley

States may remain dormant in the blood for several years, causing complications well after the initial transmission.

2.2 Breeding Grounds and Eradication Efforts

The Anopheles mosquito is responsible for the transmission of plasmodium vivax in the United States. These mosquitoes lay their eggs on sitting fresh water, so any idle pool is a potential breeding ground. Sitting water is commonly found along inlets, sink ponds, and swamps. When rivers are flooded to create reservoirs it is unclear whether or not sitting water will increase or decrease. Previous breeding grounds adjacent to the river become flooded and leave larvae susceptible to natural prey. On the other hand, increases in shoreline may create larger breeding grounds, particularly if vegetation is abundant. If shorelines are cleared prior to flooding, suitable breeding grounds may become scarce, reducing the mosquito population and the transmission of malaria.

Several of the initial mosquito/malaria eradication plans operated with drainage in mind. Following its successful hookworm campaigns, the Rockefeller Foundation and the United States Public Health Service (USPHS) began campaigns to eradicate malaria by forming anti malaria groups within local and state health agencies. Beginning in 1919, the Alabama State Board of Health began inspections within counties to determine the source of the malaria problem. By 1921, over 20 counties participated in inspections and the U.S. Public Health Service provided the state a malarial engineer. Very quickly, programs were established in urban areas. In 1923 the first rural malarial campaigns began and five engineers began working on malaria relief projects. In 1930 the state established a home screening and sealing program. These programs expanded further into the 1930’s. In Tennessee, similar efforts were made through the state health agency and the American Red Cross.

Drainage programs received a boost during the Great Depression. The Federal Relief Administration (FERA), the Civilian Works Administration (CWA), and Works Progress Administration (WPA) all assigned relief employees to state health agencies, which had the relief workers build ditches, drain swamps, and spray insecticides. Federal and state control efforts continued through the 1940s through the Malaria Control in War Area's (MCWA) program, which formed the basis of the Centers for Disease Control (CDC). In 1945, local and state agencies received a boost to their eradication efforts when DDT was released from government control during World War II. States, in conjunction with the USPHS mounted a large scale spraying program to kill any anopheles mosquitoes in residential areas. By 1950, eradication was essentially achieved. All of these programs were very local in nature, as the flight range of the anopheles mosquito is approximately one mile.

2.3 The Tennessee Valley Authority

In May of 1933, President Franklin Delano Roosevelt created a new federal agency aimed at developing a lagging Southern economy. The Tennessee Valley Authority was chartered as a federal corporation that would assume control of the Tennessee River and its tributaries.

The primary goals outlined in the charter included a general provision to improve the economy in the Tennessee Valley. The first director of the TVA, Arthur Morgan, quickly established plans for a series of dams and reservoirs to line the Tennessee River and its major tributaries. The plans were to expand upon an existing US Army Corps of Engineering (USACE) project, Wilson Dam in Muscle Shoals, Alabama and existing Army plans for dams at Cove Creek (Norris Dam) and Wheeler Reservoir. In the first six years of existence, the TVA expanded rapidly. By 1939, the TVA had received over $3.68 billion in federal appropriations. By 1951 cumulative appropriations exceeded $14.2 billion. Most of the money was spent for dam construction and related expenses including land purchases, transmission lines, and electric generation plants located at the dams.

As these projects were proposed and construction began, concerns grew over the impoundment of large bodies of water. It was estimated that the system of lakes and reservoirs created by the dams would lead to a shoreline 10,000 miles in length covering 600,000 acres of water, creating a large breeding ground for mosquitoes (Derryberry and Gartrell 1952). From the beginning the TVA tried to address concerns about malaria without heavy use of insecticides. The TVA used a variety of techniques ranging from introducing natural predators of mosquito larvae, destruction of habitat through drainage and periodic water fluctuations, brush clearing, larvacides, oiling, and eventually DDT (Gartrell and Ludvik 1954, TVA Annual Report 1945).

Perhaps the TVA's largest effort came through the nearly costless plan to vary the water levels in the reservoirs, as shown in Figure 1. During the winter and early spring months, the TVA would store winter rain water at dams located along upstream tributaries. As the mosquito breeding season approached, the TVA would begin releasing the stored water into downstream reservoirs, raising the water level a few inches. This would flood potential breeding grounds for mosquitoes. The following week, flooding would occur in the next reservoir downstream in the system. This led to a drying along the shoreline in the upstream dam, exposing the mosquito larvae to natural predators. This process of fluctuating the water levels in the reservoirs continued throughout the entire system until the end of the breeding season .

The TVA's efforts involved the largest collection of engineers and experts working to fight malaria in the United States. As malaria rates began to decline, the TVA began to receive praise for its strong efforts. The CDC lists the TVA's accomplishments on its malaria history website.

> "An organized and effective malaria control program stemmed from this new authority in the Tennessee River valley. Malaria affected 30 percent of the population in the region when the TVA was incorporated in 1933... and by 1947, the disease was essentially eliminated. Mosquito breeding sites were reduced by controlling water levels and insecticide applications."

While rates were declining, it is unclear if the TVA was a causal factor, or merely experiencing part of a secular trend, driven in part by the USPHS, WPA, and MCWA. Theoretically it is also difficult to predict if the TVA would lead to increases or decreases in malaria because of the tension between increased breeding grounds through increases in sitting water and increased vector control efforts. These factors help to motivate an empirical model to carefully estimate the net effects of a TVA dams on malaria rates.

3. Change in Disease Rates

To identify the causal effect of the TVA on malaria rates in the Southeast United States, I construct a panel data set from county level disease specific data. I first outline the baseline specifications to identify the effect of TVA dams on malaria rates assuming that the dams were exogenously located. I then show that the placement of the dams was exogenous to malaria by regressing the eventual dam locations on pre-treatment characteristics. I also discuss historical reasons why the dam's locations are likely exogenously located with respect to malaria. After showing that the dam locations are plausibly exogenous to malaria I proceed with fixed effects regressions which use within county variation across time, controlling for state wide shocks occurring in specific years to identify the effect of dams on malaria. Given the panel nature of the data employed, I am able to control for a variety of features such as county specific shocks, year specific shocks, auto correlation, and correlation across geographic space. *3.1 Baseline Empirical Model of Malaria Rate*

To identify the causal effect of the TVA on the affected counties, the following baseline empirical model is specified.

$$M_{it} = C_i + Y_t + \beta_1 TVA_{it} + \beta X_{it} + \beta Climate_{it} + \varepsilon_{it}$$

Where M_{it} is either the mortality rate per 100,000 people or the morbidity rate per 10,000 people in county i in year t. The vector C_i represents a set of county fixed effects to control for unobservable characteristics that are specific to county *i* that did not vary over time. For example, features such as mountains, altitude, latitude, and longitude are captured by this fixed effect. Y_t is a vector of year fixed effects. The year fixed effects control for nation-wide epidemics and widespread shocks affecting the malaria rate.[3] TVA_{it} is an indicator that equals 1 if county *i* in year *t* is located on a completed TVA reservoir. $Climate_{it}$ is a vector of variables constructed from historical climate data and includes monthly average temperatures, monthly precipitation, and an interaction term of the two variables. X_{it} is a vector of time varying county level features, that include the presence of a County Health Organization (CHO) to control for changes in access to health care, as well as other demographic co-variates that help control for key variables, such as population density and percent black in the population.

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[3] Andrews, Quinby, and Langmuir in 1950 report a nationwide malaria epidemic between the years 1933-1937.

This estimation strategy assumes that dams are plausibly exogenous to malaria, which will be discussed in detail below. The model also assumes that the disease rates in counties that received dams were not on differential trends from counties that did not receive dams. Figure 2 evaluates this claim by showing the average mortality rate in Alabama from 1916 - 1933 by eventual TVA dam status.[4] Counties in blue represent counties in Alabama that never received a TVA dam and counties in red are those that eventually obtained a TVA dam. Between 1916 and 1933, prior to the creation of the TVA, there is no apparent difference in the mortality rate between the two types of counties.

The impact of a dam can be seen in Figure 3, which presents a time series of the malaria morbidity rate for two adjacent counties, Limestone County, located on Wheeler Reservoir and Madison County, which is not on the reservoir. The first vertical line in Figure 3 denotes when construction began at the reservoir, the second denotes the completion of construction. Prior to construction, the morbidity rates in the two counties had similar trends. However, following the beginning of construction, Limestone County, experienced a major increase in the malaria morbidity rate, while Madison County did not. The increase in Limestone County persists through the completion of construction and remains higher than the initial rate for several years to follow. This comparison is just one example of the kind of differences between counties that help identify the effect of the TVA.[5] While there is a spike following initial construction, in most counties receiving a TVA dam it is not possible to identify what year during construction reservoir flooding began. Therefore the TVA variable is restricted to counties being located on completed reservoirs.

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[4] The analysis is limited to counties in Alabama due to data constraints.
[5] Figures from other reservoirs are available upon request.

If counties experience a spike in the malaria rates when construction begins, rather than when the reservoir is completed, the point estimate of $\beta_1$is downward biased. Other effects will also present potential biases on the coefficient of β_1 Dams potentially lead to increases in that wealth which in turn could lead to a decrease in the probability of contracting malaria. Dams also change the distribution of the population within the county by removing an at risk population that was living in close proximity to the water. Both the income and population removal affects would lead to downward bias of β_1. One further complication in the empirical specification is that humans are mobile, possibly leading to spillovers in neighboring regions. This spatial aspect will be examined directly in the robustness checks with the use of spatially weighted regressions.[6]

3.2 Is the TVA Exogenous to Malaria?

The underlying assumption of the empirical model outlined above is that the dams are exogenously located with respect to malaria conditional on a variety of co-variates. It is possible that dams are placed in areas that are prone to malaria. However, multiple pieces of evidence suggest that malaria was not a concern in the location of TVA reservoirs. First, following the great flood of the Mississippi River in 1926-27, the USACE was commissioned to develop a strategy to prevent further major floods on the Mississippi River. This strategy included a plan to dam up the Tennessee River which would result in a 1 foot reduction of flood stage waters on the Mississippi River. This report detailed where dams need to be constructed, as well as the ordering of the dams to complete a 9-foot navigation channel from the source of the river near Knoxville, TN to the mouth at Paducah, KY. Both flood control and navigation were important

[6] Mosquitoes are limites in their flight range to 1 mile. Any spatial spillovers are then most likely to be caused by human mobility across county lines or regional shocks such as weather events.

considerations so that the plan would comply with the Federal Rivers and Harbors Act of 1899.[7] The 1930 USACE report included the engineering drawings for Norris Dam and Wheeler Dam, which TVA engineers used to construct those dams. Future dams constructed by the TVA relied on the locations outlined in that report.

Regression analysis also shows that the dams were not located with respect to pre TVA malaria rates. Table 2 Column 1 shows the results of a linear probability model that estimates the probability of obtaining a TVA reservoir by 1951 on, the presence of various sized rivers, elevation changes within the county, interactions between rivers and land gradients, and the malaria rate in 1930. These results show that dams were placed in areas with medium to large sized rivers and a steep land gradient. These results are consistent with the placement of hydro and storage dams, which require steep changes in elevation to generate electricity, or a natural basin formed by the narrowing of the river through mountainous terrain. The results also show that the malaria rate in 1930 is not correlated with the placement of TVA dams. This suggests that the inclusion of county fixed effects in the main empirical specification should make the placement of dams plausibly exogenous to malaria.

While the placement of TVA dams is not correlated with malaria, it may be the case that features of the topography where dams are placed are conducive to more malaria. To address this concern, I regress the 1930 malaria rate on geographic characteristics, such as elevation changes, river flow, rainfall, and a full set of interactions between geographic characteristics. The results, presented in Table 2 Column 2, suggest that malaria is correlated with areas that are flat in elevation, do not have moving water from medium to large sized rivers, and receive large

[7] Tennessee River and Tributaries- North Carolina, Tennessee, Alabama, and Kentucky. House Document #328 1930.

amounts of rainfall. These results suggest that malaria is most prone in areas that are least suitable for large hydroelectric and storage reservoirs. The primary empirical model includes county level fixed effects to take into account geographic features which do not change over time. However, if there is any correlation remaining, there the point estimate would be downward biased.

One further concern with the placement of dams is that the USACE selected which counties had the correct topographic characteristics and would be easiest to assemble the land needed to construct the reservoir. If farmers abandoned their land following purchase by the TVA, then there would be a large increase of idle agricultural land, which would likely contribute to increases in malaria as suggested by Humphreys (2001). Kitchens (2011) evaluates the TVA's use of eminent domain to assemble the properties for the reservoirs and finds survey evidence that the TVA allowed farmers to stay on the land after the deed transferred to the TVA. The TVA's typical policy allowed farmers to stay on the land until their piece of property was going to be flooded. This policy limited the amount of time that land was idle and undeveloped prior to flooding which would prevent increases in malaria associated with idle agricultural land.

3.3 Malaria Rate Data

Data has been collected from a variety of state and federal sources for every county in Alabama and Tennessee for the years 1926 through 1951 inclusive. Each year consists of 162 county observations over the 26 years which results in 4212 county year observations. Morbidity and mortality for Alabama and Tennessee come from publications of the state’s public health department and from the Vital Statistics of the United States.[8] These state level reports provide the best insight into the prevalence of disease during the period; however they also have many shortcomings. The earliest state health reports do not report malaria deaths or illnesses by race, and the only data pertaining to the age distribution of deaths is available at the state level in a limited number of years. In spite of the shortcomings, the county level statistics are the best measures available for the time period and were used by policy makers to make decisions about funding and control efforts. For example, in 1945, when DDT was released to state health agencies, the counties that received DDT were determined by their average mortality rate between 1938 and 1942.[9] While there are some instances of more accurate blood smear surveys in elementary schools, these surveys are few and far between, making the county level statistics the most reliable malaria source during the period. Directly using mortality and morbidity rates has several advantages over previously employed methods. Namely, the probability of infection does not have to be inferred from climate and geographic variables or other crude measures such as the infant mortality rate. It should also be noted that the reported rates may actually be a lower bound estimate of the true prevalence in a county. Reporting of illness only occurred if a person was attended to by a physician. Contemporary malaria experts believed that the true prevalence was between 200 and 400 percent higher than reported rates.[10]

Throughout the sample period, malaria was in secular decline approaching zero by 1950. Figure 4 (a) – Figure 4 (e) shows the spatial distribution of malaria mortality in Alabama and Tennessee in 5 year intervals starting in 1930. Deaths were heavily concentrated in the warm

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[8] When crude death rates were reported they were used as observations, however in some years only the raw number of deaths or raw number of illnesses were reported. In these years rates were constructed using population estimates from the US Census.
[9] Alabama State Board of Health Annual Report 1946 p217.
[10] Malaria Control in War Areas 1942

climates of South Alabama and in the wet regions of the Mississippi River in West Tennessee. Maps of morbidity are shown in Figure 5 (a) – Figure 5 (e). These figures reveal a similar pattern.

I use monthly weather variables to control for random weather shocks that would affect malaria rates. To control for this, I have collected the Historic Climatology Networks Monthly Weather data from 1895-2009. This data contains the monthly average, maximum, and minimum temperatures as well as precipitation data collected at each weather station throughout the country. County level observations were constructed through a triangular interpolation method.[11]

TVA Annual Reports to Congress are used to determine the locations of reservoirs. By the end of the sample period 25/162 counties have a TVA reservoir located in their county. Figure 6 (a) – Figure 6 (e) show the expansion of treated counties over time as new reservoirs were constructed by the TVA. The majority of counties are in eastern Tennessee and North Alabama, areas which traditionally had low malaria rates.

To proxy for the water level fluctuations from upstream storage reservoirs downstream through the system, I have created a variable that counts the number of reservoirs located upstream from each reservoir county. In the absence of upstream dams, the water level fluctuation would not be possible, likely creating more stagnation in the reservoir. Reservoirs further downstream are likely to gain the most due to increased control over the water level and flow rates through the reservoir.

[11] One obstacle in dealing with this data is that there are far fewer weather stations than there are counties. To create county level observations the following procedure was used. The latitude and longitude of the county seat were used to calculate the distance to the three nearest weather stations. Each weather station was then weighed by the distance and the observations at those weather stations were multiplied by the county weight.

In both Alabama and Tennessee the State Board of Health had active offices at the county level. Starting in 1919 Alabama began establishing county offices, and by 1937 had set up an office in every county in the state. These local offices were faced with a variety of diseases to fight, as well as other concerns such as infant mortality. Malaria, typhoid, syphilis, and other communicable diseases were at the forefront of importance for the local authorities. The opening of a health agency is likely endogenous, however it can be shown that the opening of a CHO and a TVA reservoir are uncorrelated, thus including the presence of a CHO will not bias the estimate for the TVA.

Other New Deal agencies also played a crucial role in the fight against malaria. Kitchens (2012b) shows that work by the WPA in Georgia led to large reductions in malaria during the 1930's. To account for ongoing work by other agencies, I include a set of three variables: New Feet, Old Feet, and Acres Excavated. New Feet refers to the number of linear feet of concrete lined drainage ditch constructed in the county-year. Old feet refers to the number of linear feet of drainage ditches which were cleaned, and Excavated refers number of acres of ponds or swamps filled with dirt or gravel. These measures were reported in Alabama's State Board of Health reported annual progress in counties where federal relief agency labor was used. Evidence in Kitchens (2012b) and Humphreys (2001) suggest that shoddy construction of drainage ditches and poor maintenance of ditches often led to increases in sitting water from sitting debris, whereas filling in swamp land with dirt or filling in ponds reduces the sitting water problem.

Population characteristics are compiled from the Census of Population and from the State Vital statistic reports. Combining the population and area data provides a measure of the population density per square mile. In the early years of the malaria campaigns, state agencies focused on urban areas, recognizing that a large portion of the population could be affected by malaria fighting efforts. Because malaria is transferred from human to human through mosquito bites, counties that have higher population densities may be more susceptible to transmission of the disease.

Census data are also be used to determine the percentage of the population that was African American. There are two arguments in the literature assessing the importance of blacks pertaining to malaria. The first relies on sickle cell anemia, which would suggest that blacks should have a lower infection rate. The second argument focuses on the poverty of southern blacks. Blacks may have to live on land closer to swamps and mosquito breeding grounds due to their low income status in the south, putting them at higher risk for contracting malaria. It is unclear if sickle cell or poverty will play the dominating role.

4. Results

The regression results in Tables 4 and 5 shows that there are statistically and economically significant increases in both the mortality and morbidity rate associated with the TVA. Depending on the specification, the TVA increases mortality rates by 2.8 to 4.4 deaths per 100,000 and increases morbidity rates between 7.1 and 13.9 cases per 10,000. This estimate is the net effect of having a TVA reservoir in the county, taking into account the campaigns financed and implemented by TVA as well as all possible channels through which dams affect malaria.

Column 1 of Table 3 presents the OLS results with the inclusion of county specific fixed effects, the estimated net effect of a TVA reservoir located in a county results in a 4.4 increase in the malaria mortality rate. Specification 2 adds year fixed effects, and specification 3 includes state by year fixed effects. State by year effects may be important to control for changes in the ways reporting occurs, or to capture changes within the structure of the state level health agency. Even after controlling for a large portion of variation with the inclusion of various fixed effects, the TVA coefficient remains positive and large. The point estimate represents a forty to fifty percent increase in malaria mortality relative to the sample mean.

As predicted, the number of dams upstream reduces the malaria burden downstream.[12] This is a direct result of the water level fluctuations which are used to expose mosquito larvae to the elements. However, as additional controls are added the statistical significance declines. Other control activities, such as draining and ditching have little effect on mortality rates which is consistent with qualitative evidence. Humphreys (2001) discusses how many of the WPA projects were poorly constructed, leading to stagnate pools of water in drainage ditches.

Table 4 presents the full set of morbidity results. Column 1 presents the results with the inclusion of county fixed effects. Column 2 adds year specific effects and Column 3 includes state by year effects. In each specification, the presence of a TVA reservoir increased morbidity by a statistically significant amount. The upstream dams played a crucial role in mitigating malaria morbidity in downstream reservoirs. While having a reservoir in the county increases rates up to 13.9 cases, having a dam located upstream leads to a 1.7-2.4 reduction in the number of cases. For some locations, this could completely offset the malaria increase caused by the TVA reservoirs. Counties located adjacent to head water dams, such as Norris, received no benefits from the water fluctuations, however, as one moves downstream, there is an increasingly positive effect. A dam such as Ft. Loudon, with only one dam upstream only experienced minor benefits from upstream dams, however, a dam like Pickwick, located in Hardin County, TN,

[12] This result is robust to a variety of functional forms of the number of dams upstream. Including quadratics, cubics, and dummy variables. The interpretation does not change with the functional form.

eventually had 11 dams located upstream from it. Its malaria rate fell from a high in 1935 (when construction began) of 122 illnesses per 10,000 to zero by 1951.

Parts of other New Deal programs also seem to have been effective at reducing the morbidity rate. The combined efforts by the CWA, FERA, and WPA to excavate dirt to fill and drain swamps led to a statistically significant reduction in the malaria morbidity rate. For every acre of dirt excavated or filled, the resulting reduction in the malaria rate is .02 per 10,000. While excavation appears to have worked, ditching is associated with increases in the malaria rate. The Tennessee Department of Public Health Biennial Reports discusses how some of the ditches constructed were of poor design and led to more debris collecting, exacerbating the problem.

4.1 Robustness Checks

Results from alternative specifications suggest that the results presented in Table 3 and 4 (Columns 1-3) are robust. The baseline specification assumes that malaria rates were not correlated over time. The plasmodium vivax parasite can live in the blood stream for up to three years, so shocks that occur in the past might have affected rates in the future. Furthermore, there are two potential ways that spatial spillovers may affect the baseline results. Some spatial correlation is induced into the model due to the interpolation of climate data. Because the data are interpolated, data in a given county will be correlated across space with other counties sharing the same weather station observation. To account for this, I adopt a method posed by Cameron, Gelbach, and Miller (2010), which clusters observation along multiple dimensions. The second spatial issue arises from the natural geography. There is a general downward slope from the eastern portion of the sample to the west as water drains towards the Mississippi River. Counties further east, or upstream, may experience improved natural drainage across counties, leading to less sitting water where mosquitoes might breed. This means that if there is a shock in one area, it could affect other cross sectional observations. To account for this, I re-estimate the model using a spatial error model, as posed in Anselin (1988) and LeSage and Pace (2009).

Tests of the fixed effects residuals indicate that auto correlation only persisted for one period. The auto correlation parameter is estimated using the Prais-Winsten procedure with an AR(1) error process. Results from this regression are presented in Table 3 Column 4 for Mortality, and Table 4, Column 4 for morbidity. The estimated net effect of a TVA reservoir, accounting for auto correlation, remains positive and statistically significant.[13] The correlation coefficient across time periods is .295 for mortality and .344 for morbidity.

Results from the Cameron, Gelbach, and Miller (2010) multidimensional clustering are presented in Column 5 of Tables 3 and 4. These regressions are clustered to account for shocks occurring at each of the three weather stations used in the interpolation of the climate variables. After accounting for this error structure, the standard errors change, however, the significance levels of the variables are unchanged, leaving the qualitative interpretation of the TVA projects the same.

Spatial spillover may also influence the rate of malaria transmission. Moran I tests reveal the potential for spatial correlation in the error structure. To account for spatial spillover, I estimate the model with the inclusion of spatially correlated errors. Column 6 of Tables 3 and 4 presents the results of a spatial error model (SEM). In this model, errors occurring in neighboring

[13] The Durbin Watson Statistics is 1.37 (1.8 transformed) for mortality and 1,29 (1.9 transformed) for morbidity, which indicates there is little if any auto correlation.

cross sectional units are weighted by proximity to the i^{th} observation.[14] Once this spatial dependence in the errors is taken into account, the results remain unchanged. In all specifications the net effect of the TVA was a large increase in malaria mortality and morbidity.

In the current empirical specifications, it is assumed that reservoir construction does not differentially impact counties. However, epidemiological research suggests that areas that had relatively low malaria rates prior to treatment should experience larger increases in malaria rates than counties that had historically high malaria rates. To determine if there were differential effects of receiving a dam, I modify the empirical specification in two ways. I first specify a regression where I interact the presence of a reservoir with lagged malaria rates. This may not the most desirable specification as it introduces serial dependence in the error structure which could bias the estimated effect. To address this issue, I also specify a regression where I interact the presence of a TVA reservoir with the Hong Malaria Index for 1920 (Hong 2007). This index predicts the probability of contracting malaria based on geographic, topographic, and climatic conditions.   The results from these regressions are presented in Table 5Columns 1 and 2 present the results when the previous period malaria rate is interacted with the TVA indicator variable. In this specification the TVA reservoir point estimate falls, yet remains positive and statistically significant. The results also show that there were differential effects for counties that had high or low levels of malaria prior to the dams arrivals. If a county had a one point lower death rate, it experienced a .267 increase in the number of deaths per 100,000 individuals when it received a reservoir.[15] The effect is similar using morbidity as the outcome variable of interest, however it

[14] To construct this weighting matrix I estimate the distance between county seats in kilometers and use the normalized inverse distance to weight the errors of neighboring counties.

[15] These results are robust to a number of different lags interacted with the TVA reservoir and help mitigate the potential serial correlation induced by using a single period lag of the malaria rate.

is statistically insignificant. In each additional specification the results remain positive and statistically significant. Columns 3 and 4 of Table 5 display the results when the Hong Index is interacted with the TVA reservoir variable. In this specification, the results also show that areas with a higher likelihood of malaria experienced smaller increases in the malaria mortality and morbidity rate following the completion of a TVA reservoir.

4.2 Effects During Dam Construction

The baseline empirical model assumes that the effect of the dam does not occur until construction is finished, however, dams typically take several years to construct and are partially filled at various points in time. Figure 3 hints that construction may also be a treatment, as there is an increase in the malaria rate following the start of construction in 1933 at Wheeler Dam. If there is a construction effect, the baseline estimates presented above would be biased downward due to an inflated pretreatment malaria rate.

To test the extent which the construction period biases the estimate, I re-estimate the baseline model to include an indicator variable equal to 1 if the project is under construction, but not yet completed. The effect that the construction period has on malaria is not clear a priori. The influx of construction workers to the job site may increase the number of people available to transmit malaria, temporary disruptions in the river and partial flooding may increase sitting water; however income shocks associated with wages to construction workers may allow workers to take more precautions to avoid malaria.

Results from this regression are presented in Table 6 and show that construction led to increases in the malaria rate. During the average dam's construction, the mortality rate increased by 1.8 deaths per 100,000, which is a 18 percent increase in the malaria mortality rate. After taking into account the effects during construction, I find that the point estimate of a completed TVA reservoir has a larger effect than when the construction period is ignored. Without including the effects of construction, the mortality rate increased by 2.8 deaths per 100,000 people,[16] with construction effects included, the mortality rate increased by 3.7 deaths per 100,000, which is a 37 percent increase over the average mortality rate for the period. The morbidity rate also increased in this specification from 7.13 cases per 10,000 to 12 cases per 10,000.

4.3 The Evolution of Malaria Over Time

The baseline analysis also assumes that when a reservoir is completed, the effect of increased malaria is instant and it persists over time, however, it is possible that the effect of the reservoir on the malaria rate evolves over time, as suggested by Figure 3. I generalize the baseline model to allow for time varying effects as follows:

$$M_{it} = \sum_{k=-1}^{k=4} \beta_1^t \, TVA_{it} \times 1(\tau = t) + \beta X_{it} + \beta Climate_{it} + C_i + Y_t + \varepsilon_{it}$$

Where $M_{it}$is defined as above, and *k* is the number of years before or after dam arrival. Because the length of construction varies for each dam, *k=-1* is defined as the year prior to construction , *k=0* is defined as the construction period, and *k>0* is defined as the number of years after construction is completed.[17]

[16] This specification reports results using State-Year Fixed Effects.
[17] Additional specifications extend the time horizon to 2 years prior to construction and 10 years after completion. However, given that several dams were completed in the 1940's and the sample ends in 1951, there is a large loss of data in these specifications.

The results of these regressions are best shown in Figures 7 and 8. Figure 7 plots the β_1^t coefficients, normalized by setting the pre-construction period equal to zero, using mortality as the outcome of interest. Relative to the pretreatment period, there is an increase in the mortality rate during construction and an even larger spike following completion of the reservoir which persists for 3 years, after which the malaria rate returns to pre-construction levels. Given that the average dam took 3 years to construct prior to filling, malaria rates were elevated for 6 years, leading to a total increase in the mortality rate of 13.4 deaths per 100,000. Similarly, Figure 8 plots the results using morbidity as the outcome of interest. Over the same 6 year period, morbidity increased by a total of 38.4 cases per 10,000.

4.4 Placebo Regressions

While the results suggest that the introduction of TVA reservoirs increased malaria rates, it may be possible that the entire disease profile is endogenously changing in the counties where the TVA is located. An entire shift in the disease profile might make it appear as though the TVA was the cause of a malaria rate increase when the change in rates was due to an exogenous factor. To examine this hypothesis, I re-estimate the model using data pertaining to a different disease.

Measles has several nice properties for the purpose of this exercise. First and foremost, it is not a waterborne disease. Changes in the water environment should not affect the transmission of measles. Furthermore, it is an airborne virus that infects a large portion of the population. Data for measles morbidity rates come from the Alabama State Board of Health Annual Reports and Tennessee Morbidity Report.

In this setting, I substitute the measles morbidity rate in place of the malaria morbidity rate in the baseline empirical model and and re-estimate the estimating equation. Regression results show that there is no statistically significant link between the TVA reservoirs and measles. The full set of results is presented in Table 7. This suggests that when the TVA entered the region, it only raised malaria rates and not morbidity for other major diseases.

5. The Cost of the TVA

In this section I develop a back of the envelope calculation to estimate the cost of lost life from malaria attributable to the TVA using Value of a Statistical Life (VSL) estimates from the literature. To do this I assume that the value of a life is the same in all counties with a TVA reservoir and that the VSL does not change over the sample period. To calculate the malaria cost of the TVA, I use the following formula

$$Malaria\ Cost\ of\ TVA = \sum_t \sum_i VSL \times \frac{Pop_{it}}{100{,}000} \times TVA_{it}(\beta_1 + \delta Upstream_{it}).$$

VSL is an external estimate of the value of a life. The second term adjusts the county population in year *t* to correspond to the mortality rates. TVA is defined as previously, β_1 is the estimated change in malaria resulting from a TVA reservoir, δ is the estimated impact of upstream reservoirs and Upstream is the number of reservoirs upstream from the given county-year. By doing this, I calculate the number of malaria deaths per TVA county in a given year and then multiply this by the VSL. I use similar methods to calculate the cost attributable to malaria morbidity.

Using the most preferred estimates that include state by year fixed effects; morbidity increased by 7.1 cases per 10,000 individuals. Using external estimates reported by the Atlanta

Journal Constitution at the time, a case of malaria cost $45 in lost wages, or approximately 2 weeks of labor.[18] After adjusting the estimates to 2009 dollars and using the formula above, I find that the TVA morbidity cost was $7.4 million in lost income over the sample period when upstream effects are ignored. When upstream effects are included the cost falls to $1.7 million.

The primary malaria cost comes through lost life. The mortality estimates that account for state-year fixed effects show that malaria increased by 2.8 deaths per 100,000 individuals per year. Costa and Kahn (2004) construct estimates for the value of a statistical life during the 1940's. They find that during the period a life was valued between $1.1 and $1.6 million in 2009 dollars. Using a VSL of $1.1 million, and a rise in mortality of 2.8 deaths per 100,000, the resulting cost, ignoring the effects of upstream dams is $508 million- When upstream effects are included in the calculation, the cost falls to $340million in lost life.

Several issues arise from the use of VSL's. The estimates in the literature range from $1-$11 million depending on industry, occupation, and age of the work force in the samples. Using the range of estimates in the literature, the estimated effect of the TVA could be larger than $3.7 billion. This figure could also fluctuate depending on the age structure in the county. The back of the envelope calculation could severely over or underestimate the lost value of life depending on where the deaths occur in the age distribution. Unfortunately, the data is not rich enough to explore impacts of malaria deaths within the age distribution. However, it does provide a point of reference.

[18] An earlier draft of this paper estimated that morbidity cost approximately $45 per case in a family from a sample of families living in the Guntersville Reservoir. Data for that sample were derived from TVA Form 970.

How large is the loss of life from malaria relative to the size of the TVA? The typical TVA story is one in which a regionally targeted development agency spurs growth through low electricity prices leading to spillovers in other industries. By 1951, about $14.2 billion had been spent in the Tennessee Valley by the TVA. Recent work by Kitchens (2012a) shows that the TVA did not lead to faster growth relative to areas not electrified by the TVA and did not lead to lower electric rates than comparable private firms. Kline and Moretti (2012) show that in the short run the TVA did little to stimulate local economies and more likely led to shifts in employment from agriculture to manufacturing, Kline and Moretti (2012) also note that any gains from the TVA are likely short run phenomena and will diminish in the long run.

This suggests that the federal spending on the TVA may be the reference point for the benefits that are derived from the TVA. Fishback and Kachanovskaya (2012) note that during the New Deal, the fiscal spending multiplier was 1.1, so the roughly $14.2 billion spent on the TVA would yield $15.6 billion in total benefits, or $1.4 billion in additional benefits beyond the direct spending. Using the most conservative cost calculations of $340 million, the malaria cost would represent 2.1 percent of all TVA appropriations and multiplied benefits. If the TVA generated $1.4 billion in benefits through fiscal stimulus, the malaria cost reduces the benefit by 24 percent. If the correct VSL is on the higher end of the literature, the malaria cost would represent 23.7 percent of total TVA benefits, and would more than offset the fiscal multiplier effect. In this scenario, the region would be better off receiving direct cash transfers rather than constructing the infrastructure.

6. Conclusions

Given the recent focus of providing infrastructure in developing nations is it important to understand the unintended consequences of development. When large scale dams are constructed to provide electricity they change the local environment which may affect the local disease profile. In assessing the net benefits of the project these unintended consequences must be factored into the analysis. This paper examines the unintended consequences of large scale reservoir construction on local disease rates by looking at the experience of the TVA, which was one of the largest regionally focused development projects in U.S. history. Using malaria rates constructed from state level health publications and the plausible exogeneity of dam location and timing decisions I find that reservoirs constructed by the TVA led to large increases in the malaria morbidity and mortality rates. This increase in malaria rates implies a large hidden cost, 24 percent of the fiscal stimulus, due to illness and the loss of life.

The TVA provides insight into a growing problem around the world today. As more developing nations begin to construct large water management programs, increased sitting water is liable to create increased rates of infectious disease. The TVA, which was long held in esteem for tackling the malaria problem in the Southeast, had to take action because of the increases in sitting water in the reservoirs. These increases in sitting water increased the breeding ground for mosquitoes, which ultimately led to an increase in malaria despite the largest anti- malaria efforts to date on the behalf of the TVA. Almost certainly the problem would have been more severe had the TVA not made an attempt to control the disease by spraying, ditching, and fluctuation of the water level in the reservoirs.

Specific attention should be given to the method of raising and lowering the water levels from reservoir to reservoir. There is support that this method reduced the malaria problem. This method can be used at low cost and is easily implemented. A note of caution, the TVA storage reservoirs upstream were typically located in mountainous areas, which are less susceptible to malaria due to their higher elevations and cooler climates. Attempting upstream water storage for mosquito prevention may not work as well in areas with warmer and wetter climates or lower elevations.

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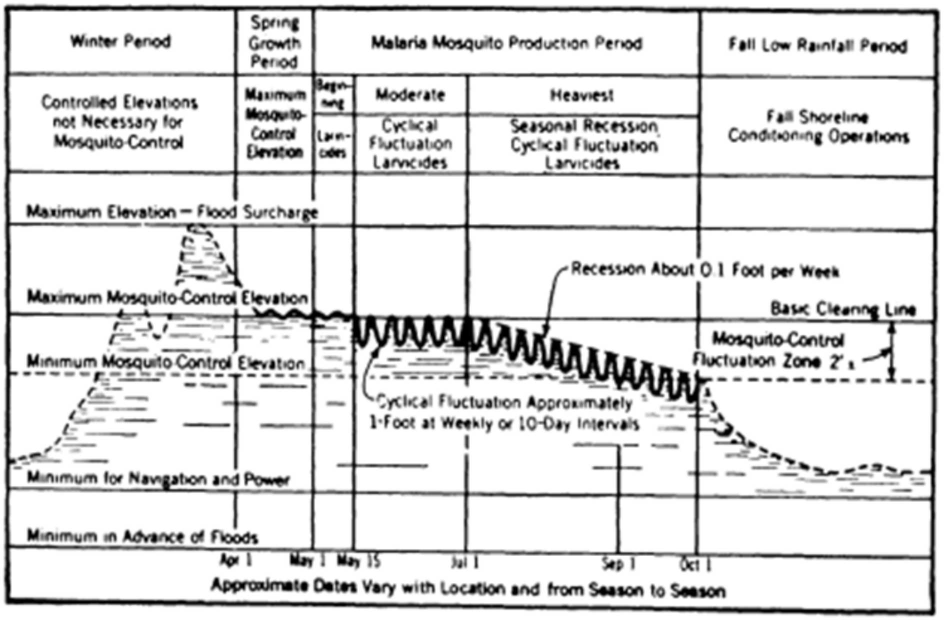
Tables and Figures

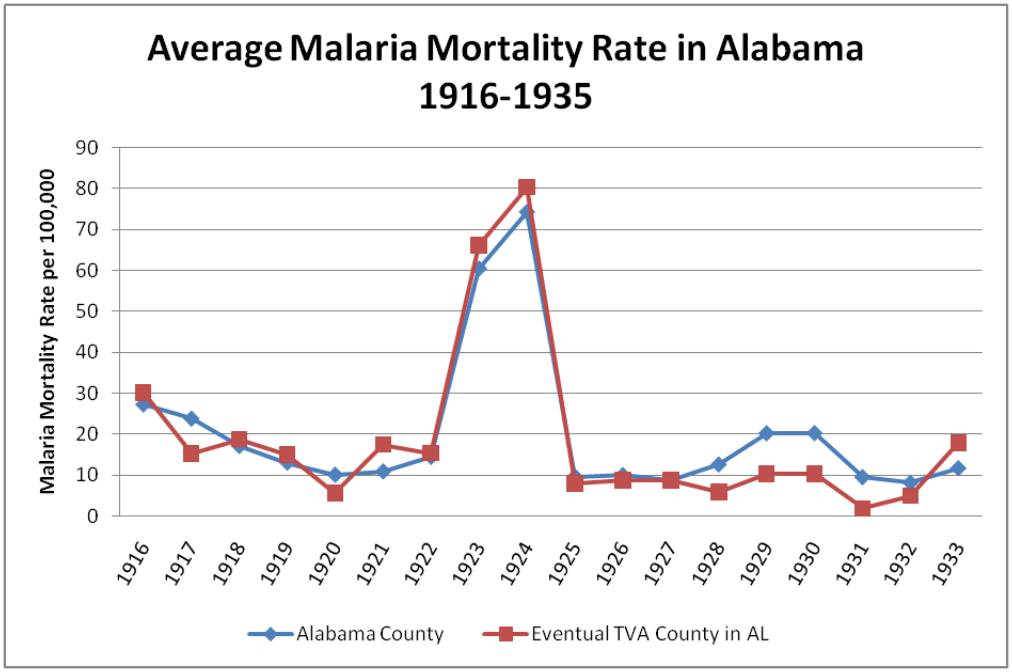
Figures

Figure 1: Water Level Fluctuations



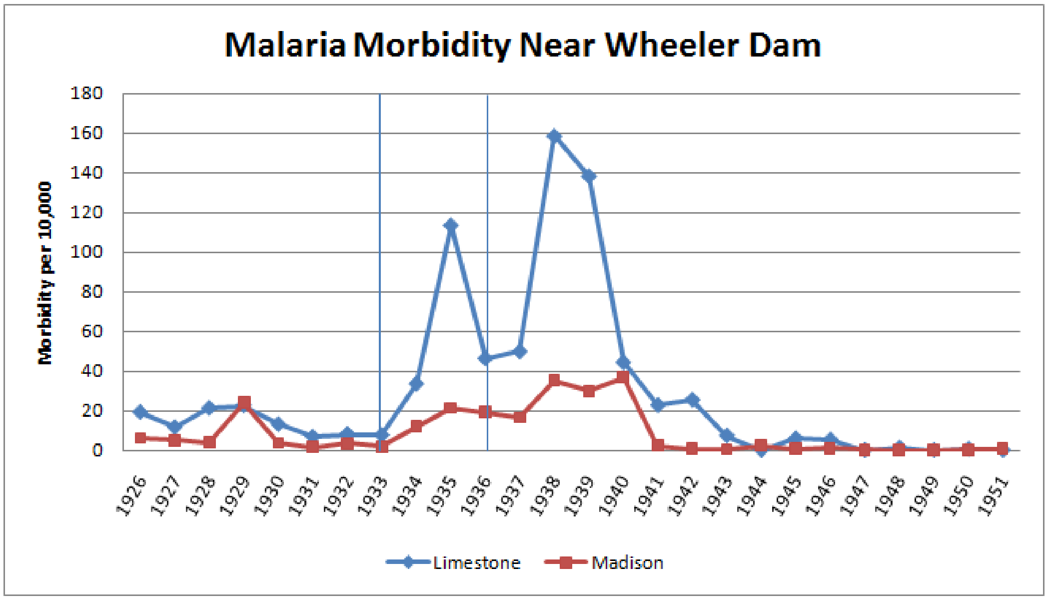
Source: Kitron and Spielman (1989)

Figure 2: Malaria Mortality in Alabama 1916-1935



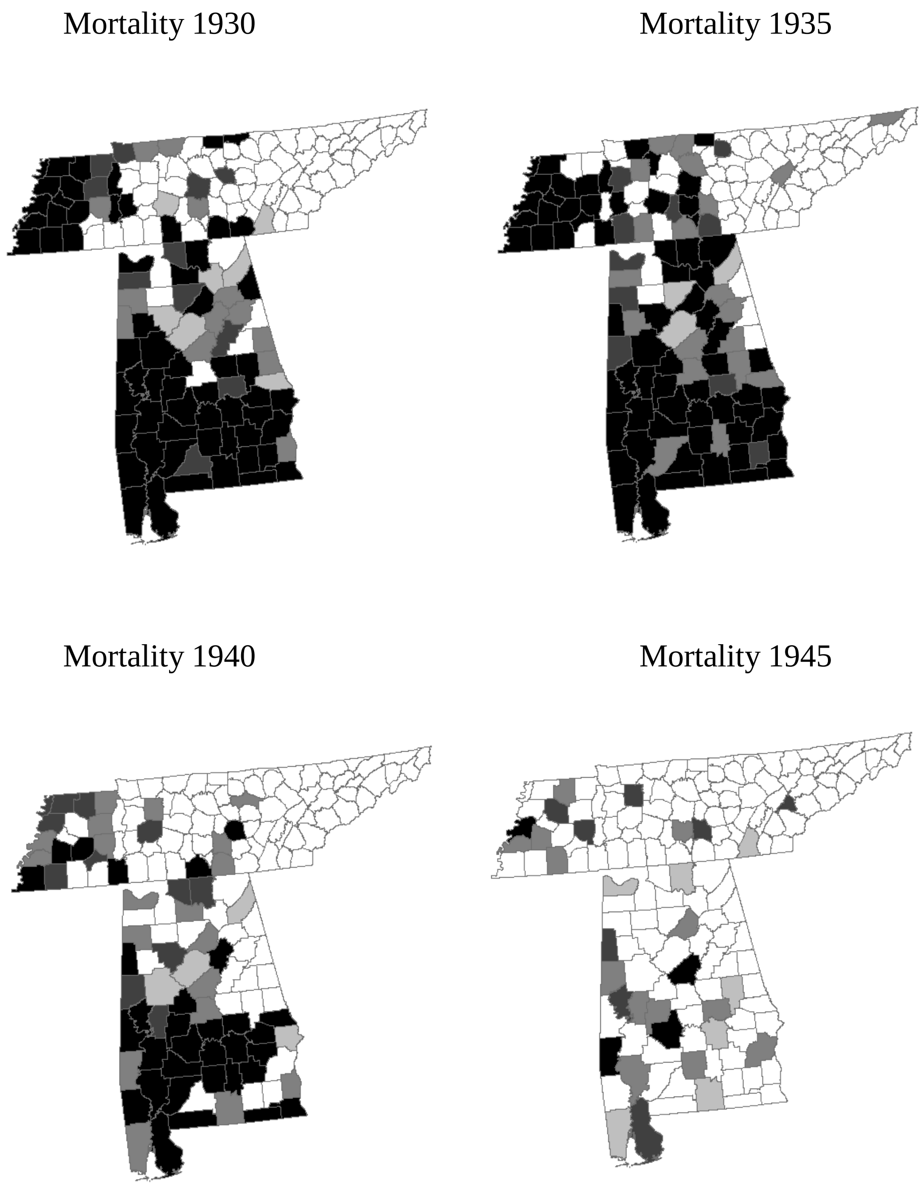
Source: Alabama State Board of Health Annual Reports 1916-1933

Figure 3: Malaria Morbidity Near Wheeler Reservoir

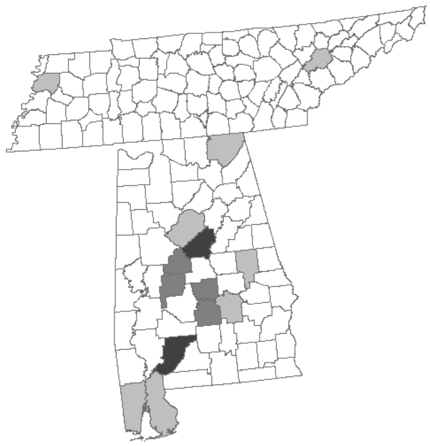


Source: Alabama State Board of Health Annual Reports 1925-1951

Figure 4 – Spatial Pattern of Malaria Mortality

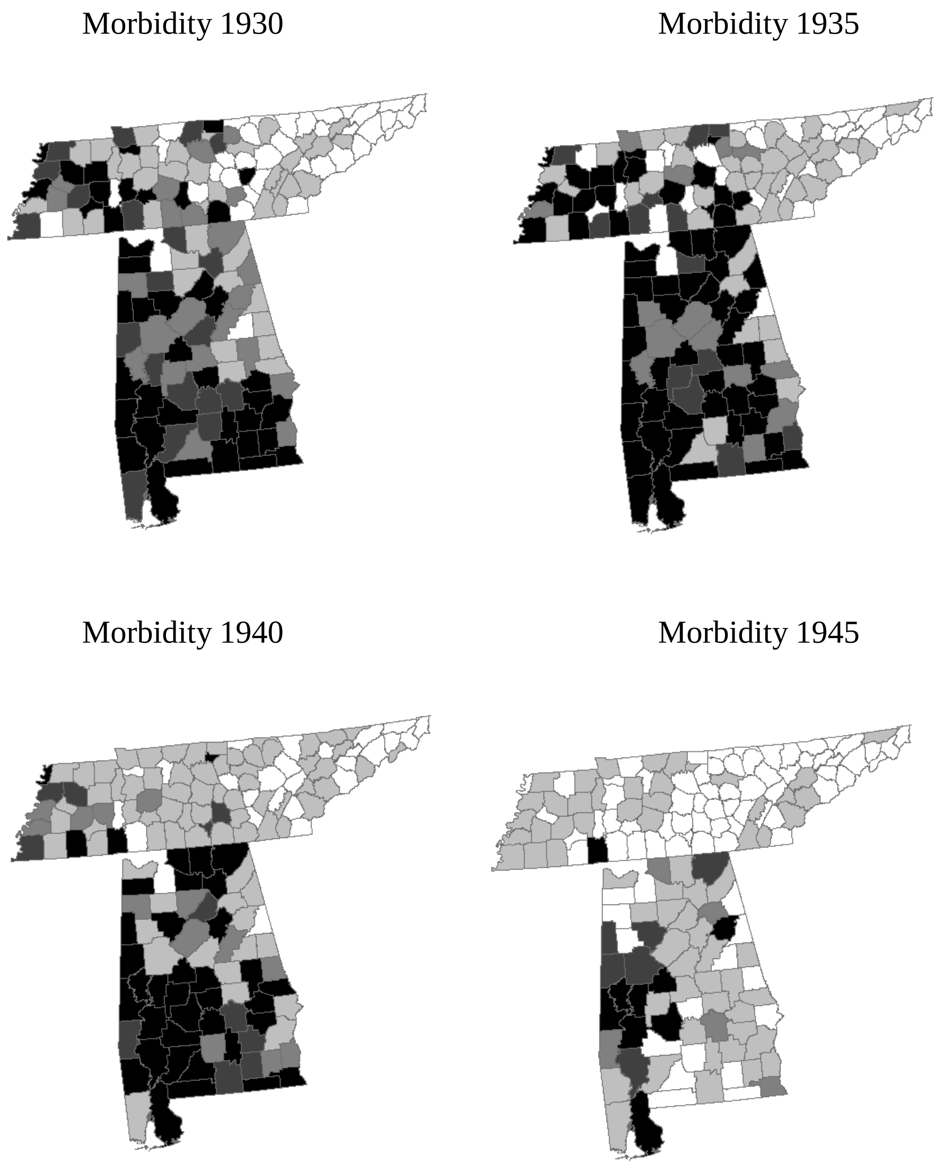


Mortality 1950

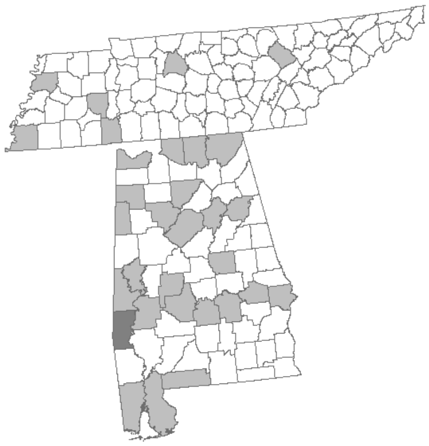


Note: Counties shaded in white represent 0 deaths in the county. Counties in solid black represent over 12 deaths per 100,000.

Figure 5- Spatial Pattern of Malaria Morbidity

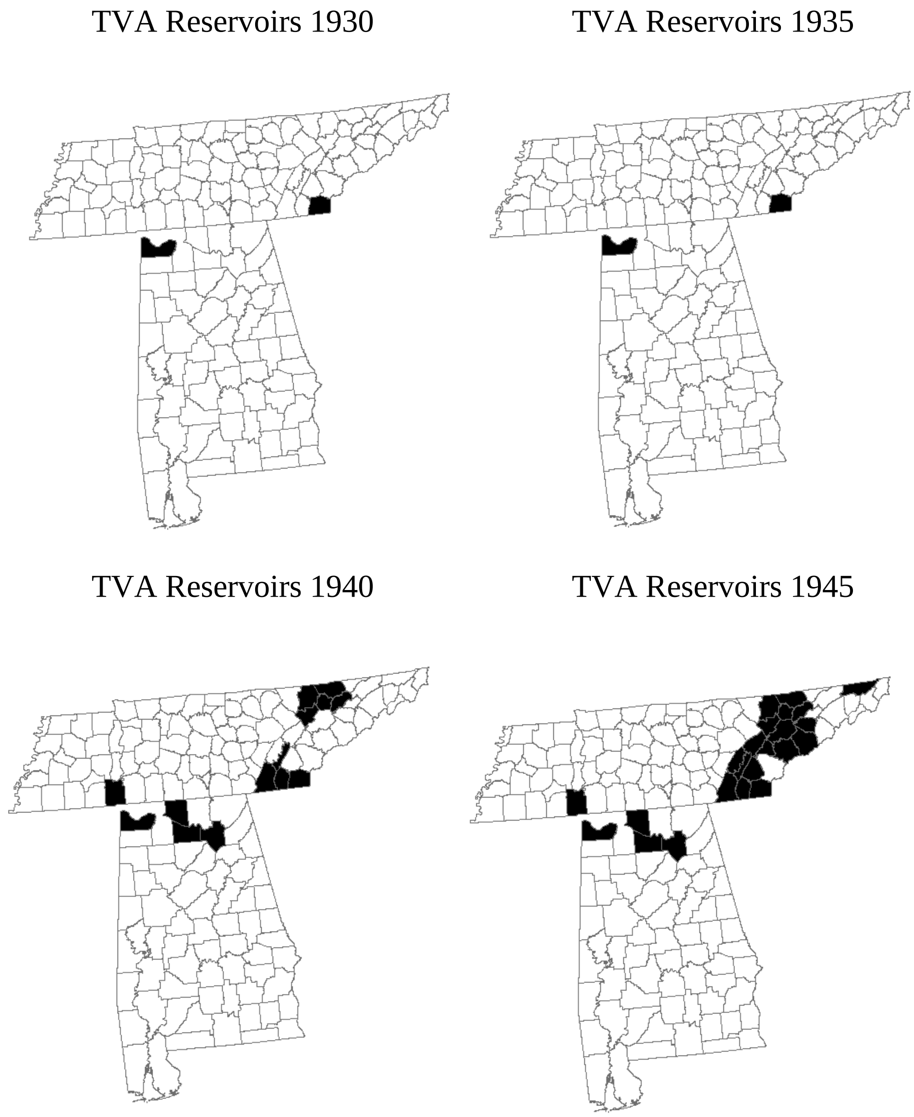


Morbidity 1950

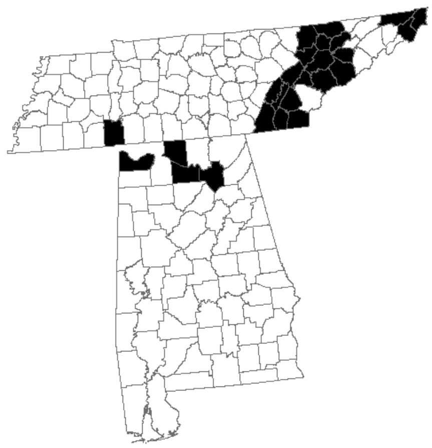


Note: Counties shaded in white correspond to zero cases of malaria reported in the counties filled with solid black represent over 15 cases per 10,000.

Figure 6 – Expansion of TVA Reservoirs



TVA Reservoirs 1950



Note: Counties shaded in black represent counties that lay on a TVA reservoir in the given year.

Figure 7: Time Varying Effect of TVA Dams on Malaria Mortality

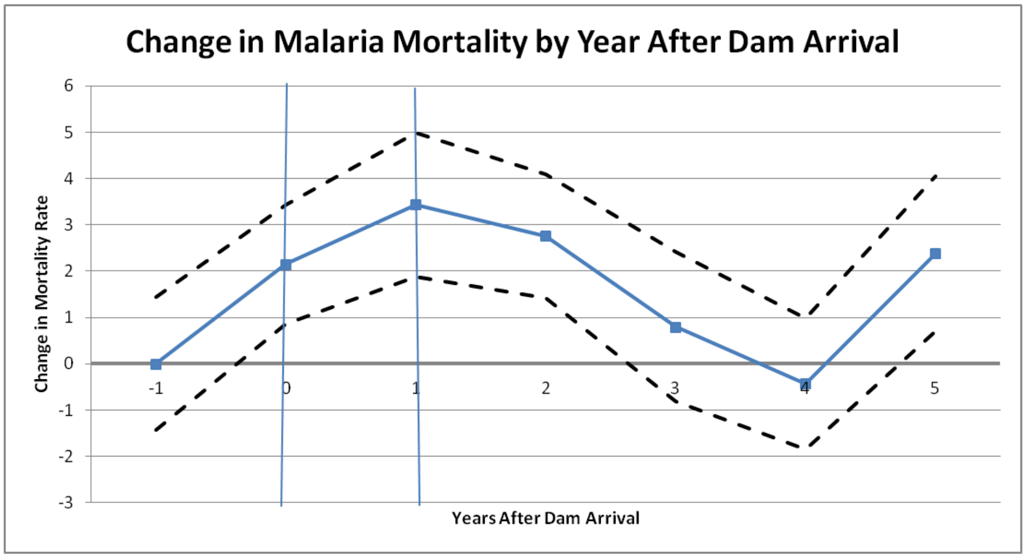
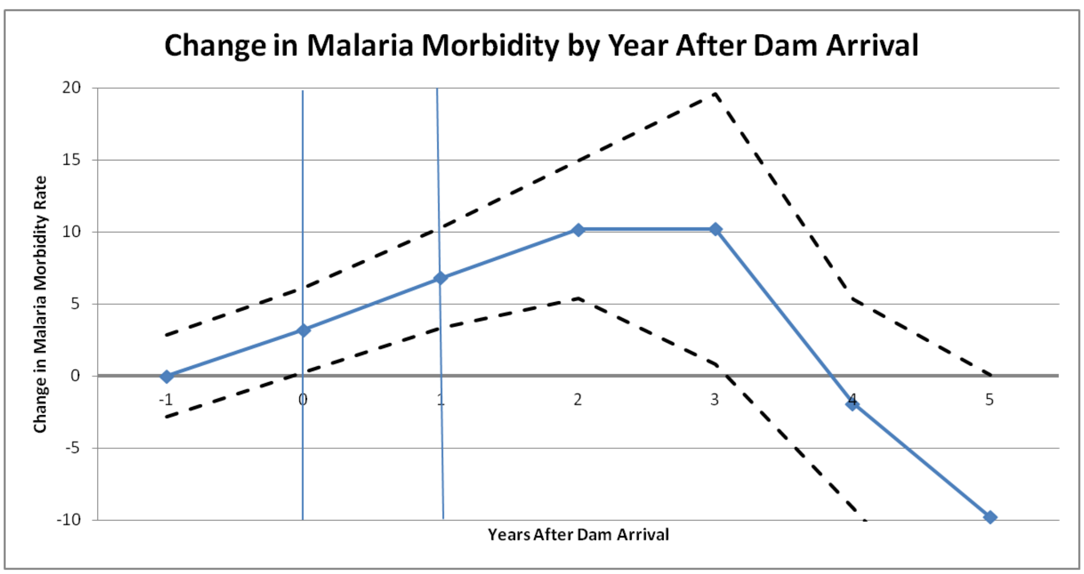


Figure 8: Time Varying Effect of TVA Dams on Malaria Morbidity



Tables

Table 1

Table 1: Summary Statistics of Malaria Rate

Variable	Obs	Mean	Std Dev	Min	Max
Deaths/100,000	3955	10.06	34.58	0	1117.46
Morbidity/10,000	4530	11.6	31.55	0	828.5
TVA Reservoir	4787	0.06	0.23	0	1
County Health Agency	4312	0.61	0.49	0	1
Percent Black	4785	23.05	22.65	0	87.27
Pop. Density	4787	57.98	66.51	11.09	658.86
Percent Urban	4785	14.46	18.62	0	85.48
Average Temp					
January	4787	430.3	69.64	202.87	659.2
February	4787	450.83	64.46	279.76	643.74
March	4787	518.22	59.01	366.18	671.75
April	4787	601.64	40.24	501.45	713.66
May	4787	682.45	35.51	584.48	785.79
Jun	4787	759.39	31.29	663.5	834.36
July	4787	784.09	26.15	677.5	860.01
August	4787	776.44	29.5	681.61	855.99
September	4787	725.56	40.02	620.31	844.87
October	4787	622.42	44.09	513.13	779.68
November	4787	504.43	48.32	393.41	658.78
December	4787	436.65	59.23	287.24	630.51
Precipitation					
January	4787	530.4	321.33	31.78	2281.33
February	4787	482.75	246.02	22.34	1404.13
March	4787	589.13	254.58	45.01	1821.87
April	4787	449.76	225.04	50.22	1517.81
May	4787	398.51	199.71	17.65	1505.49
Jun	4787	411.98	210.52	16.77	1670.15
July	4787	509.89	232.39	63.39	2221.72
August	4787	417.96	206.03	25.02	1958.03
September	4787	312.76	195.5	3.37	1310.63
October	4787	277.8	200.4	1.49	1316.86
November	4787	384.17	251.14	1.05	1551.56
December	4787	473	242.52	68.02	1715.94

Table 2

Table: Characteristics Correlated with Dam Placement and Malaria

	TVA Dam Location		1930 Malaria Rate	
1930 Malaria Rate	-0.001			
	(0.001)			
Medium River	0.808	***	-0.787	
	(0.096)		(2.910)	
Large River	-0.005		7.358	*
	(0.014)		(3.979)	
Medium-Large River	0.167		-4.510	
	(0.120)		(8.295)	
Medium Elevation	0.011		-7.698	**
	(0.029)		(3.643)	
Steep Elevation	0.128	**	-11.137	***
	(0.058)		(3.881)	
Medium River X Steep Elevation	-0.355	*	2.963	
	(0.188)		(2.377)	
Medium-Large River X Medium Elevation	0.057		2.543	
	(0.163)		(8.205)	
Medium-Large River X Steep Elevation	0.221		5.835	
	(0.202)		(8.618)	
Rainfall	-0.005		1.132	***
	(0.005)		(0.338)	
Constant	0.242		-29.941	*
	(0.208)		(15.680)	
R^2	0.316		0.406	

* P<.10, ** p<.05, *** p<.01

Table 3

Table : Malaria Mortality Regression Results

	1	2	3	4	5	6
TVA Reservoir	4.409 ***	3.083 ***	2.835 ***	3.413 ***	3.083 ***	4.500 ***
	(0.914)	(0.795)	(0.594)	(1.262)	(1.157)	(0.857)
Number of Dams Upstream	-0.768 **	-0.274	-0.307 *	-0.217	-0.274	-0.591 ***
	(0.329)	(0.360)	(0.169)	(0.242)	(0.273)	(0.167)
WPA Ditches	0.007	-0.013	-0.022	0.013	-0.013	-0.012
	(0.034)	(0.035)	(0.024)	(0.015)	(0.043)	(0.015)
WPA Ditch Clearing	0	0.008	0.009	0.007	0.008	0.007
	(0.009)	(0.009)	(0.006)	(0.007)	(0.011)	(0.914)
WPA Acres Filled	0.001	0.001	0.002	-0.001	0.001	0.003
	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.816)
Climate Variables	Y	Y	Y	Y	Y	Y
County FE	Y	Y	Y	Y	Y	Y
Year FE	N	Y	Y	Y	Y	Y
State X Year FE	N	N	Y	N	N	N
N	3257	3257	3257	3257	3257	3257

* p<.10, **p<.05, *** p<.01

Note: Spec 4 Accounts for AR(1) error structure

Note: Spec 5 Clusters Error at Weather Station Level

Note: Spec 6 Adjusts for Spatial Correlation in Errors

Table 4

Table : Malaria Morbidity Regression Results

	1	2	3	4	5	6
TVA Reservoir	13.991 ***	11.597 ***	7.135 ***	10.358 **	11.597 ***	11.751 ***
	(4.003)	(4.237)	(2.267)	(4.347)	(2.716)	(2.620)
Number of Dams Upstream	-2.449 ***	-2.222 ***	-1.712 ***	-1.981 **	-2.222 ***	-2.182
	(0.744)	(0.746)	(0.435)	(0.778)	(0.630)	(0.479) ***
WPA Ditches	0.048	0.048	0.011	0.054	0.048	0.054
	(0.042)	(0.054)	(0.051)	(0.056)	(0.052)	(0.052)
WPA Ditch Clearing	-0.006	0.002	0.011	0.02	0.002	-0.004
	(0.011)	(0.011)	(0.014)	(0.025)	(0.015)	(0.024)
WPA Acres Filled	-0.02 ***	-0.022 ***	-0.026 ***	-0.022 **	-0.022 ***	-0.021
	(0.005)	(0.006)	(0.007)	(0.010)	(0.007)	(0.011) **
Climate Variables	Y	Y	Y	Y	Y	Y
County FE	Y	Y	Y	Y	Y	Y
Year FE	N	Y	Y	Y	Y	Y
State X Year FE	N	N	Y	N	N	N

* p<.10, **p<.05, *** p<.01

Note: Spec 4 Accounts for AR(1) error structure

Note: Spec 5 Clusters Error at Weather Station Level

Note: Spec 6 Adjusts for Spatial Correlation in Errors

Table 5

Table : Heterogeneous Effects of a TVA Reservoir

	Previous Period Malaria Rate		1920 Hong Malaria Index	
	Mortality	Morbidity	Mortality	Morbidity
TVA Reservoir	2.325 **	9.164 **	6.390 ***	2.128
	(0.916)	(3.984)	(2.130)	(4.719)
Malaria Rate $_{t-1}$	0.021	0.563 ***		
	(0.030)	(0.134)		
Malaria Rate $_{t-1}$ x TVA	-0.267 ***	-0.303		
	(0.090)	(0.388)		
Hong Index 1920 X TVA			-13.41	39.83
			(8.660)	(26.547)
Number of Dams Upstream	-0.376	-2.773	-0.311	-2.145
	(0.258)	(0.923)	(0.325)	(0.793)

* p<.10, **p<.05, *** p<.01

Table 6

Table: Change in Malaria Including Construction Effects

	Mortality	Morbidity
Under Construction	1.844 **	3.783
	(0.846)	(2.527)
TVA Reservoir	3.751 ***	12.039 ***
	(0.798)	(3.707)
Number of Dams Upstream	-0.417	-1.765 ***
	(0.397)	(0.652)
WPA Ditches	-0.023	0.009
	(0.035)	(0.054)
WPA Ditch Clearing	0.009	0.012
	(0.009)	(0.012)

* p<0.10, ** p<0.05, *** p<.01

Each Specification Includes State by Year Fixed Effects

Table 7

Table : Measles Regression Results

	1		2		3	
TVA Reservoir	3.033		1.516		1.934	
	(3.187)		(2.888)		(3.147)	
Number of Dams Upstream	-6.691	**	-5.009	*	-4.214	
	(2.583)		(2.653)		(2.695)	
New CHO	5.372	**	7.046	***	7.085	***
	(2.142)		(2.436)		(2.384)	
CHO	-1.308	***	-0.484		-0.744	
	(0.462)		(0.479)		(0.500)	
WPA Ditches	0.033		-0.073		-0.113	*
	(0.049)		(0.053)		(0.062)	
WPA Ditch Clearing	-0.041	***	-0.016		-0.007	
	(0.011)		(0.013)		(0.014)	
WPA Acres Filled	0.018		0.024	**	0.024	*
	(0.011)		(0.012)		(0.012)	
Pct Black	0.599	**	0.317		0.314	
	(0.287)		(0.300)		(0.308)	
Pop Density	-0.113		-0.097		-0.094	
	(0.072)		(0.066)		(0.066)	
Pct Urban	-0.653	***	-0.114		-0.148	
	(0.204)		(0.228)		(0.214)	
Climate Variables	Y		Y		Y	
County FE	Y		Y		Y	
Year FE	N		Y		Y	
State X Year FE	N		N		Y	

* p<0.10, ** p<0.05, *** p<.01