Historic Hookworm Prevalence Rates and Distribution in the Southeastern United States: Selected Findings of the Rockefeller Sanitary Commission for the Eradication of Hookworm

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The ideas and opinions expressed in this report are those of the author and are not intended to represent the Rockefeller Archive Center.

The following report covers the author's efforts to capture the records of the Rockefeller Sanitary Commission for the Eradication of Hookworm Disease (RSC) in GIS (Geographic Information System) format.

Hookworm, while once a major concern for parts of this country was, by and large, eliminated as a public health concern by the 1960s. Hookworm was eradicated in most wealthy, industrialized countries, but eradication occurred at a time when public health record-keeping was still a young and developing concern. As a result, data on the prevalence on hookworm is sparse and incomplete. The Sanitary Commission's findings in the Rockefeller Archive Center represent the best existing record on the historic prevalence of hookworm within the United States.

For the past fifteen years, a field of study aimed at discerning pathogenic/autoimmune interaction has developed and coalesced under the umbrella concept of the "Hygiene Hypothesis." As described by Graham Rook (2009), the hygiene hypothesis theorizes that the

changed and reduced patterns of exposure to microorganisms that have accompanied our rise from hunter gatherer to industrialization and wealth, have led to disordered regulation of the immune system, and hence to increases in certain inflammatory disorders, or autoimmune disease. Of particular note in Rook's description is the fact that he invokes the deep past, theorizing that parasitic infection and the human immune system have coevolved to a point somewhere between inevitability and necessity.

The American Autoimmune Related Disease Association (AARDA) and the National Institute of Health (NIH) estimate that these conditions are the underlying cause of more than 100 serious, chronic illnesses. The statistics that accompany these autoimmune diseases are sobering. According to the AARDA and NIH, an estimated 23.5 million Americans suffer from autoimmune disease, and the prevalence is rising (Autoimmune Statistics, 2009). Three in four afflicted are women and female children, and the diseases tend to be chronic, and sometimes life threatening. Despite these statistics, autoimmune disease remains poorly understood, for a variety of reasons.

Interestingly, according to Ron Chernow (1998), John D. Rockefeller, the man who funded the Sanitary Commission for the Eradication of Hookworm, suffered from a form of alopecia areata (alopecia totalis), which is now recognized as an autoimmune disorder (Alopecia Areata, 2009). Also thought provoking is the fact that both Rockefeller and his wife Laura, in the latter half of their lives, suffered from a host of ailments that were by nature persistent, hard-to-diagnose and treat. Granted, this was the late 1800s, but autoimmune disease is frequently described in this way.

In July 2008, the New York Times published the article "The Worms Crawl In" by Elizabeth Svoboda, concerning the work of Dr. David Pritchard, an immunologist-biologist from the University of Nottingham. Dr. Pritchard observed in Papua New Guinea, and later confirmed through experimentation in a laboratory setting, that hookworm infection had a muting effect on

hay fever and asthma, considered to be autoimmune-related illnesses. Dr. Pritchard's work represents one of the significant components of the above-mentioned emerging field of pathogenic/autoimmune interaction. One of the interesting questions that his work raises is whether there is an inverse correlation between the prevalence of hookworms and the incidence of autoimmune-related illnesses.

However, the fact that Dr. Pritchard had to go to Papua New Guinea to make his initial observations underscores one of the primary challenges in better understanding the underlying relationships of the Hygiene Hypothesis. Entrenched parasitic infections, unfortunately, are primarily a characteristic of poorer countries. Wealthy industrialized countries, on the other hand, are proudly without. Furthermore, wealthy industrialized countries tend to have well-established public health systems, while in poorer countries, if public health systems exist at all, they are often overwhelmed and underfunded. This creates an unfortunate paradox; countries with autoimmune disease that need information on parasitic infections must rely on countries that often do not have the resources to collect the needed information. Or, as Jean-Francois Bach puts it in his compendium on autoimmune and allergic diseases (2002, p. 917), "there is certainly irony in the fact that we must now search for new ways to reproduce the infectious diseases against which we have been fighting with great success."

The Hygiene Hypothesis is thus more of an abstraction or a set of abstractions than a measurable entity, which expresses itself as anecdotal evidence, or through statistical measures teased out of complex public health data sets. Bach, in the same article, touches upon the developing, large-scale geographic patterns associated with the pathogenic/autoimmune interactions of the Hygiene Hypothesis as one of the statistical measures gleaned from multiple public health data sets. Bach's comment on geographic patterns underscores the underlying importance of GIS to this particular public health quandary. Significant patterns have been shown to exist on smaller-scale levels, such as identified by Megan Blewett in her GIS analysis

of Lyme disease and Multiple Sclerosis mortality rates by counties within the United States (Harp, 2007).

The bottom line remains that autoimmune disease and its causes demand attention and study. An increasing body of evidence suggests that a counterintuitive relationship exists between parasites/pathogenic loads and autoimmune system regulation. Under these circumstances, information such as that contained in the RSC records only increases in importance, particularly where it can ameliorate the existing information gap on historic parasite infection rates.

The RSC operated between 1909 and 1915 through the direct support of John D. Rockefeller, with the express mandate "for the cure and prevention of this disease" (hookworm) in selected states of the southeastern United States (Rockefeller, 1909). In the process, the RSC first canvassed the majority of U.S. states and territories for existing health records, and then, after honing its focus to eleven states (Alabama, Arkansas, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Virginia), sampled nine of those states for existing hookworm infection levels. The RSC then mustered a massive public relations campaign (by 1910 standards) to support an equally large effort by traveling dispensaries, manned by groups of doctors, as well as lab and microscope technicians, to diagnose and treat as many cases of hookworm as was physically possible. Throughout the campaign, records and statistics of varying detail were kept by each participating state. Data appeared in regular correspondences between offices, along with overlapping reports, as well as a variety of tally sheets and accounting forms. Quarterly reports of an evolving format were submitted to the main office from 1910 through 1915, and for each year, the main office published an annual report.

At the close of the RSC efforts in 1915, all records were consolidated and are now housed at the Rockefeller Archive Center in Sleepy Hollow, New York. This collection, for the

most part, resides on eleven reels of microfilm, covering all RSC administrative, field office, minutes and reports, and financial records. Numerous bound volumes of records accompany these reels, as well as volumes of research conducted on the records. While the history, activities and personalities that drove this unique public health campaign are well covered in the works of Greer Williams (*The Plague Killers*) and John Ettling (*The Germ of Laziness*), to date, no other form of the actual data contained within the archived records has been compiled.

Metadata

Through the generous support of the Rockefeller Archive Center, a total of five days were spent at the Archives analyzing these records in the spring of 2009. Roughly one thousand pages of records focusing on infection rates were reduced to spreadsheets representing the individual states, broken down by county. These records, in turn, were joined to general population 1910 census data provided by the University of Virginia, Geospatial and Statistical Data Center (2004). State and county boundary shape files for 2007 were downloaded from The Census Bureau's (2008) **T**opologically **I**ntegrated **G**eographic **E**ncoding and **R**eferencing system (Tiger) files and merged with the 1910 census and RSC data. The resulting Shape Files and data summarizations are presented in figures following this report.

Infection rates for sampled populations were compiled using present-day county boundaries. In some cases, where more than one population sample was examined per county, a range of prevalence values can occur. In these cases, if the record was clear that more than one distinct population sample was examined for an individual county, those samples were combined for the raw prevalence values. In the event that it was not clear if presented values represent separate sampling events, because samples were often reported in correspondences prior to completion of the sampling event, preference is given first to the infection value for the larger sample, then to the higher infection value.

The RSC data does not come without its own faults and cautionary tales. John Ettling (1982, p. 152) points to the early frustration of Wickford Rose in his efforts to compile reports and records for the RSC. "Lack of uniformity in the maintenance of records made it virtually impossible for Rose to gauge the actual number of people examined and treated in the first year of the Commission's work." That and the years that follow relied on an evolving process of examination and treatment that was highly dynamic, fluid and increasingly more efficient, with an examination and data collection process running at breakneck speed. In contrast, the treatment portion of the program was semi-voluntary. Once diagnosed with infection, a person could be treated up to four times. Treatment consisted of being given medication and instructions, which were demanding to say the least (two days of little or no eating and repeated induced evacuations of one's bowels), and then being sent home to self-administer. How many people went home and did as instructed is one of several points of speculation that muddies the numbers presented in these records.

The RSC was the first step in the public health systems for many states, and as a result, as mentioned, record-keeping was a young and developing concern. Many of the unique challenges of keeping public health data on such a large scale were in the process of being discovered. The same could be said for data interpretation. The prevailing attitude of the RSC appears to have been that of success being a foregone conclusion. As a result, the emphasis was on number of people served, and cost of service. However, the outcome was not as effective as the RSC led one to believe (Stiles, 1939 and Williams, 1969). Hookworm infection, though not as acute as it had been, persisted well into the 1950s and 60s (Ettling, 1981).

The population samples examined by the RSC, while likely statistically valid in terms of numbers relative to the total county and state populations, would be an interesting medical-anthropological study by themselves. The RSC initiated its hookworm campaign with a survey to confirm infection and infection levels in most participating states on a county-by-county basis.

The method for the initial survey was relatively straightforward. Approximately two-hundred of the most likely candidates for hookworm infection, by known clinical expressions of the disease, were initially sought out and examined. In essence, this survey went after the lowest hanging fruit. These initial surveys, as one might expect, produced higher infection rate values than the more extensive traveling dispensary campaigns that followed.

When the campaign, "the big show," arrived, the RSC tried to make the hookworm examination process as fashionable as possible. As Ettling describes (1981), the fact that women's clubs across the South lent considerable support to the work of the Commission was of critical importance. Those efforts were accompanied by regular announcements run in newspapers. In addition, employers persuaded their workers to attend, and preachers exhorted their congregations. However, beyond this, methodology often approached coercion. For example, the RSC in some cases was able to impose mandatory examinations for many schools. From there, records indicate that the dispensaries accepted all comers, which apparently included people who had traveled considerable distances from beyond the county where the dispensary was located. And methodology or not, all numbers were then folded together into dispensary and quarterly reports.

Importantly, some states kept records on subset populations. The most common subset was school-aged children, followed by the resident African-American populations. Some states further broke some of their findings down by a variety of factors such as age groups and sex, rural verses urban, and by community within counties. At first glance, despite initial claims of some working for the RSC about differing rates of infection in certain groups, hookworms appear to have been highly egalitarian opportunists.

GIS formatting can use a variety of direct and indirect methods to relate data to physical locations (counties in this case) for mapping purposes. Because the selected RSC records used to create the GIS Shape Files, started as data recorded by county, the translation is direct and

straight-forward; there are few if any assumptions imposed on the data, nor is their value lost in any type of translation. The data retains its face value in GIS format. Future work will involve an effort to normalize the existing data for intended comparisons to known incidence or prevalence rates of autoimmune conditions for spatial pattern analysis and geographic relationships.

However, these newly constructed GIS files remain data sets representing acute infection conditions found between 1909 through 1915. Between that time and the 1960s, obviously, conditions changed. Though it is fair to say that change for this particular region can be characterized as a progressive movement over a 45-year period (Breeden, 1989), many of the factors that led to the circumstances of chronic infection remained entrenched, though in diminished capacities.

The conditions under which an acute and chronic infection occurs are reasonably well understood (Roberts & Janovy, 2005). These conditions can be broken down into a variety of environmental and social components. Of these, it was more the change in the social component which has led to the eradication of most hookworm disease by the 1960s (construction code laws and the new tendency of the general population to wear shoes, which prevents the main mode of infection). However, the environmental component for these areas, which relies strongly on geologic and meteorological conditions, remains predominantly unchanged.

Further preserving a population with a distinct history of the hookworm infection accompanied by characteristics that lead to greater tendency for infection to begin with, was a population shift from rural southern areas to urban ones. The rural areas did not enjoy an influx of new population, only a drain on existing population, and for this reason, poverty (the single best conveyer of hookworm disease) persisted in these rural areas (Breeden, 1989), and the resident population is dominated by descendents of those participating in the RSC study.

When autoimmune disease gained a foothold in the general population remains poorly understood. However, within the framework of the Hygiene Hypothesis, there is an implied

sequence of events that gathers from a point in time, part of which is represented by the eradication of hookworm disease, from which, theoretically, increased autoimmune disease follows. For this reason, those places identified by the RSC with acute chronic infections and likely remained places with the most likely chance of continued infection after the RSC ceased operations, represent exceptional places to test some of the precepts of the Hygiene Hypothesis. Therefore, the GIS formatted records of the RSC, if used in a relativistic fashion, can be used comparatively in targeted areas with the more current records on autoimmune disease prevalence.

Figure 1

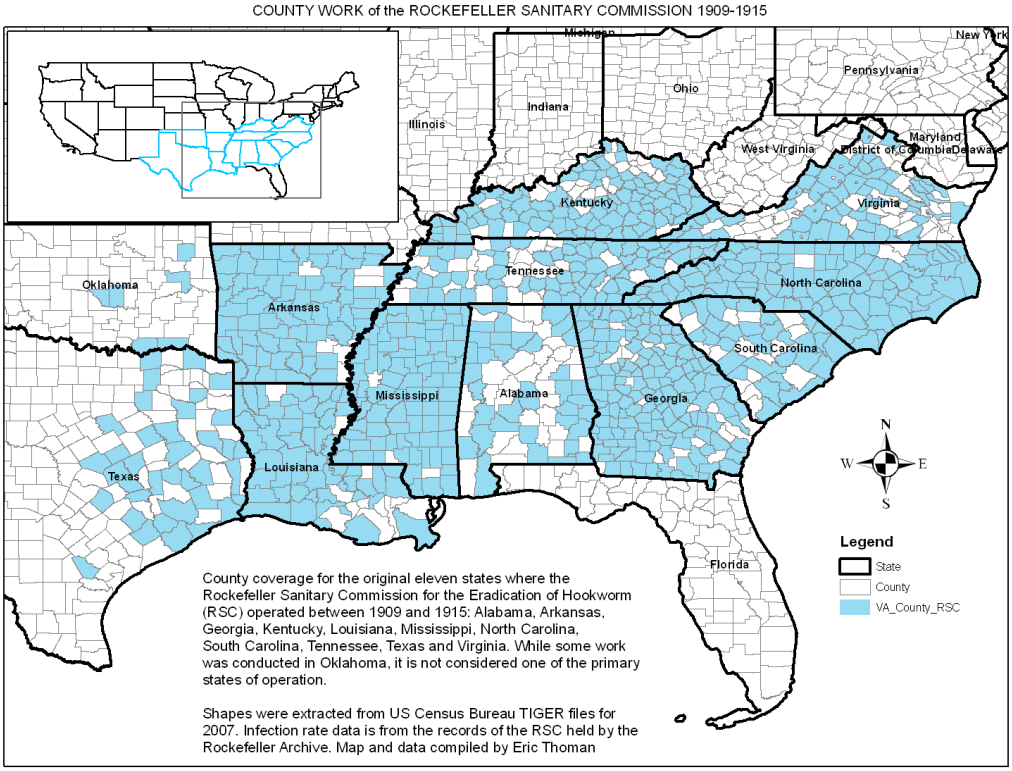

COUNTY WORK of the ROCKEFELLER SANITARY COMMISSION 1909-1915
Michigan
New York
Pennsylvania
Ohio
Indiana
Illinois
West Virginia
Maryland
District of Columbia
Delaware
Kentucky
Virginia
Tennessee
North Carolina
Oklahoma
Arkansas
South Carolina
Mississippi
Alabama
Georgia
Louisiana
Texas
Florida
N
W
E
S
Legend
State
County
VA_County_RSC
County coverage for the original eleven states where the Rockefeller Sanitary Commission for the Eradication of Hookworm (RSC) operated between 1909 and 1915: Alabama, Arkansas, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas and Virginia. While some work was conducted in Oklahoma, it is not considered one of the primary states of operation.
Shapes were extracted from US Census Bureau TIGER files for 2007. Infection rate data is from the records of the RSC held by the Rockefeller Archive. Map and data compiled by Eric Thoman

Figure 2
Alabama infection rates by county. (Note: No records were collected by the RSC for counties with white fill).

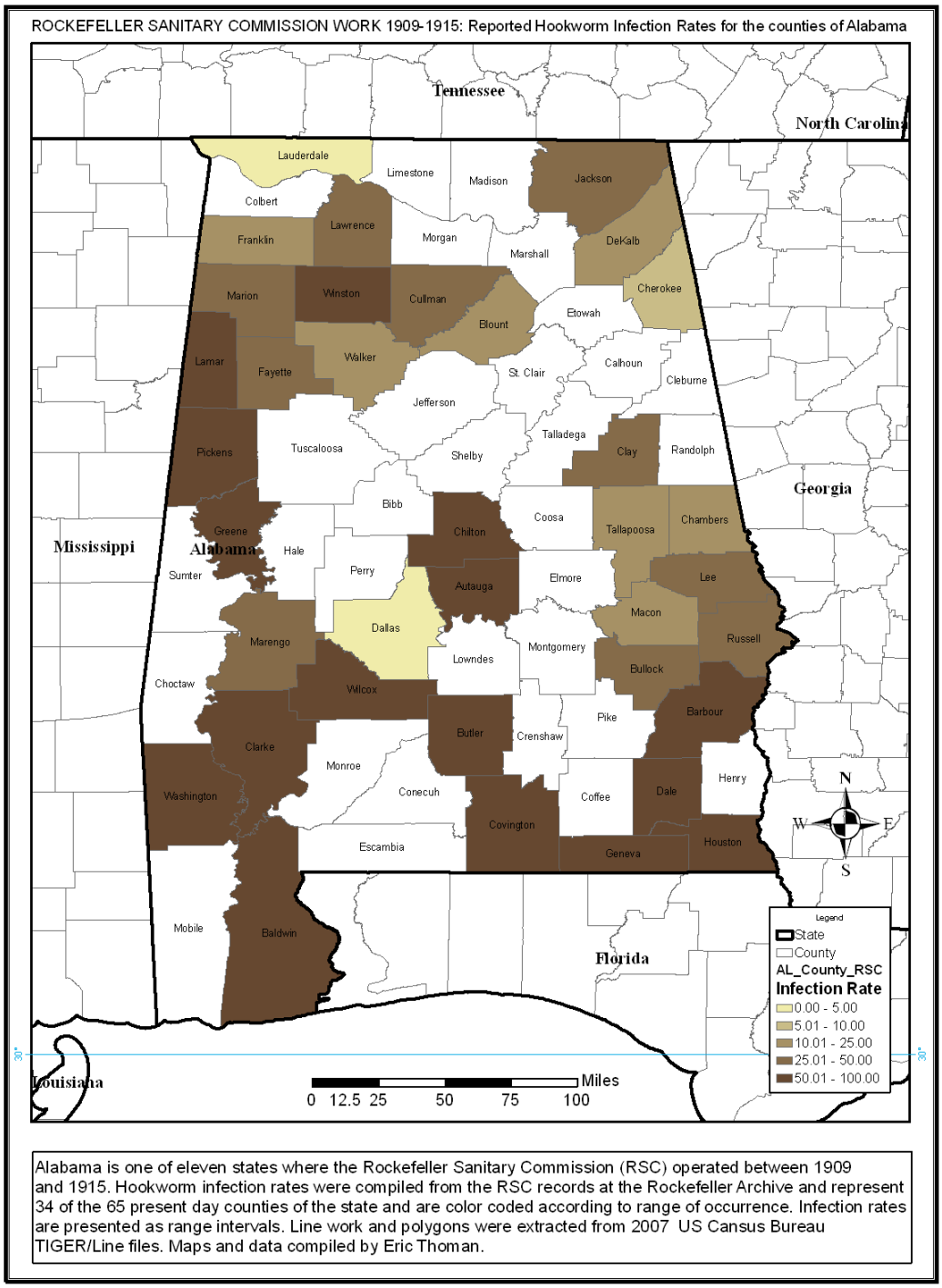
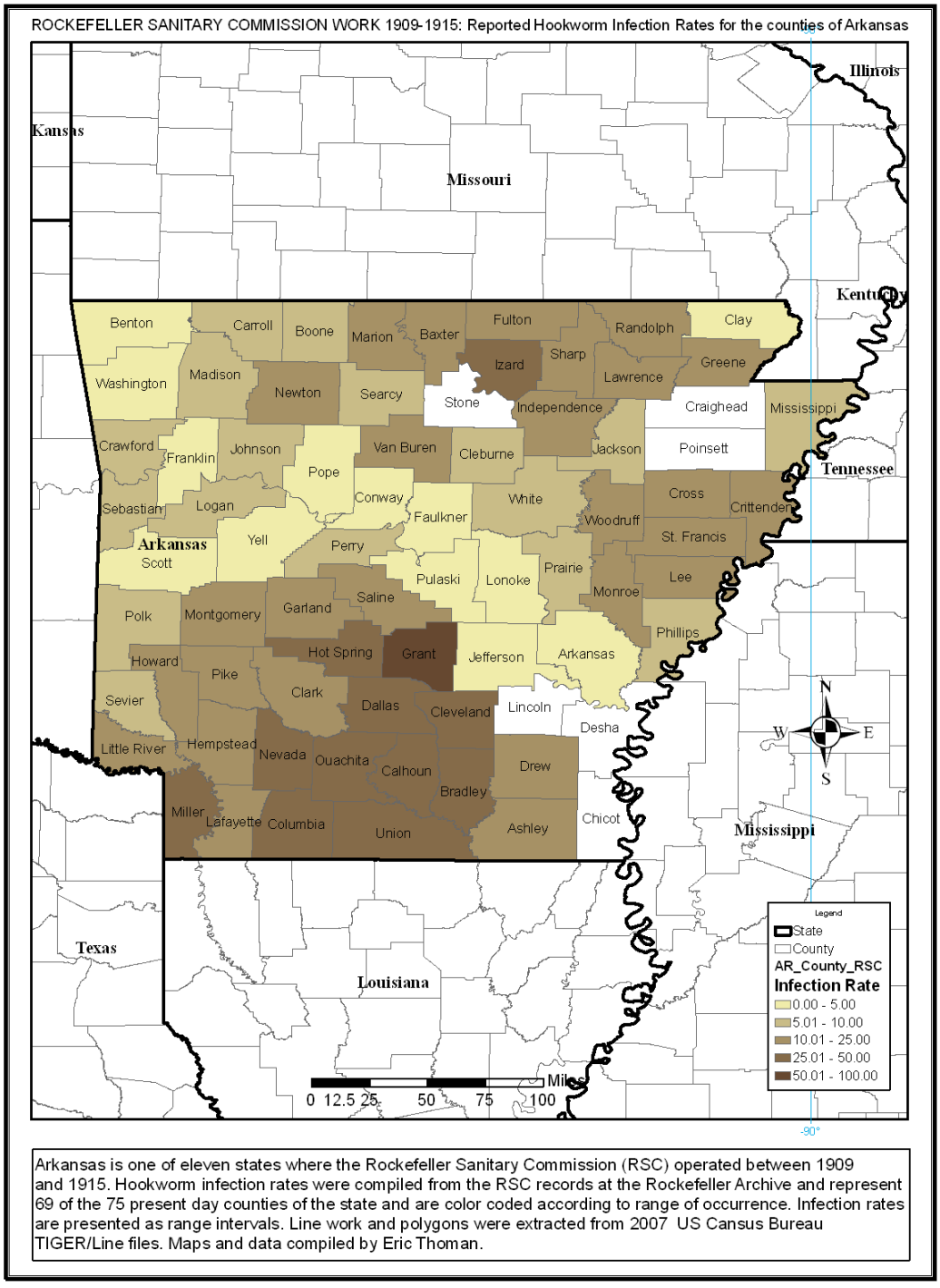
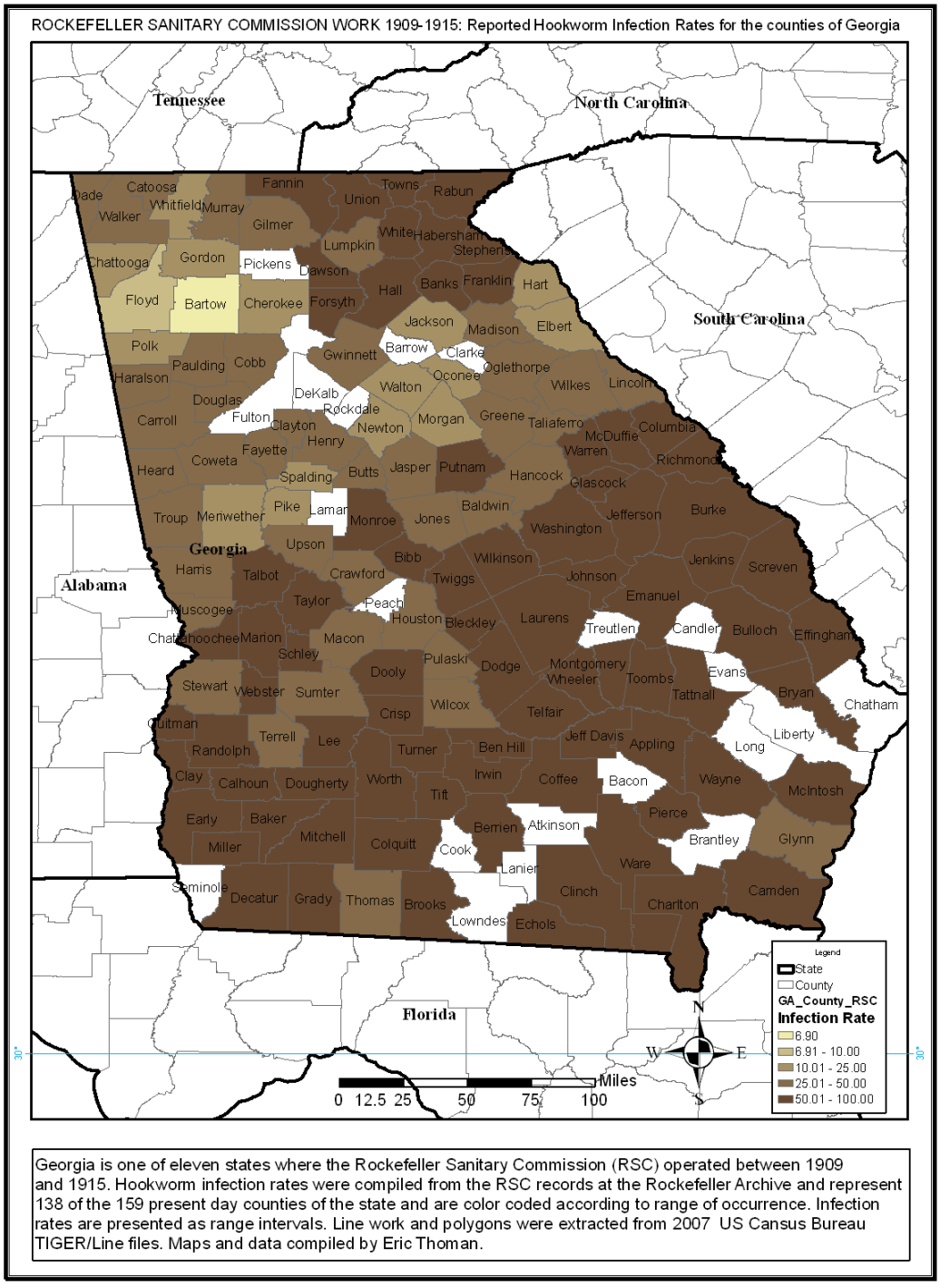


Figure 3
Arkansas infection rates by county. (Note: No records were collected by the RSC for counties with white fill).

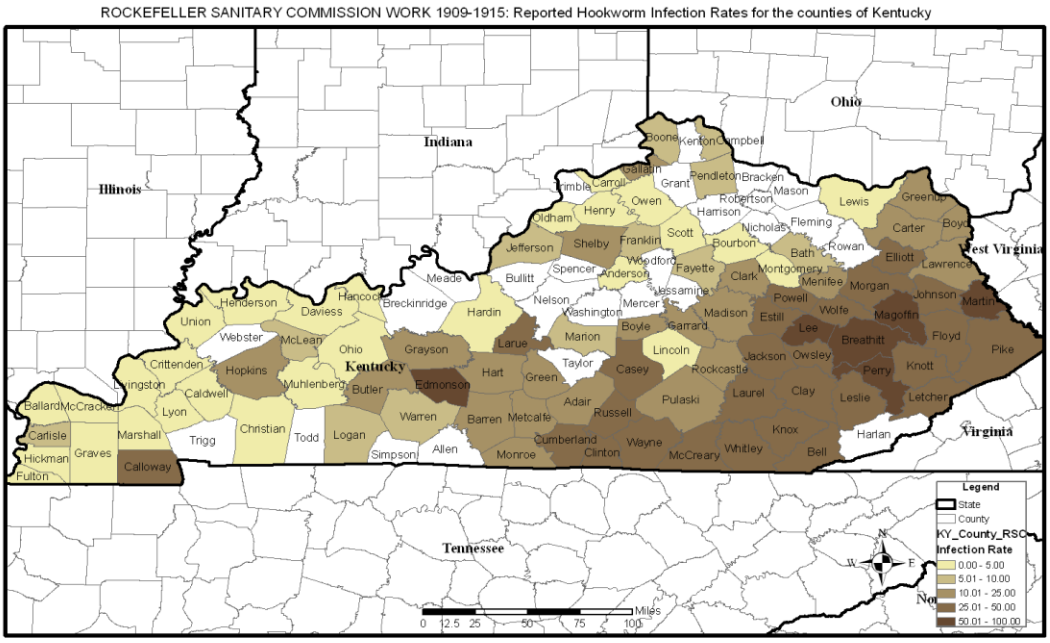


Arkansas is one of eleven states where the Rockefeller Sanitary Commission (RSC) operated between 1909 and 1915. Hookworm infection rates were compiled from the RSC records at the Rockefeller Archive and represent 69 of the 75 present day counties of the state and are color coded according to range of occurrence. Infection rates are presented as range intervals. Line work and polygons were extracted from 2007 US Cansus Bureau TIGER/Line files. Maps and data compiled by Eric Thoman.

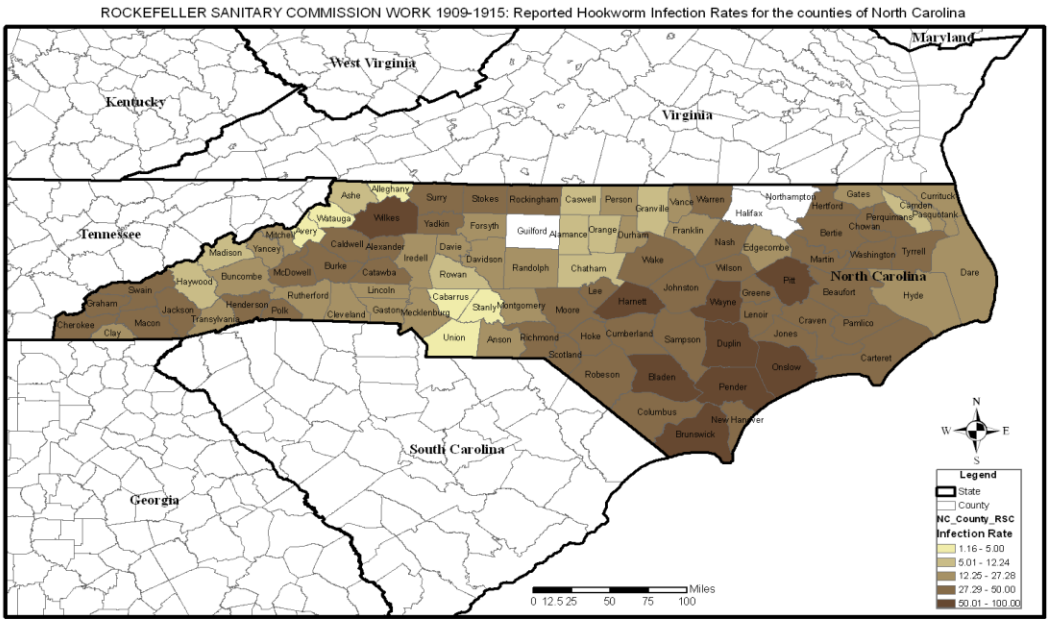
Figure 4
Georgia infection rates by county. (Note: No records were collected by the RSC for counties with white fill).



Figures 5 & 6
Kentucky and North Carolina infection rates by county. Note no records were collected by the RSC for counties with white fill.



Kentucky is one of eleven states where the Rockefeller Sanitary Commission (RSC) operated between 1909 and 1915. Hookworm infection rates were compiled from the RSC records at the Rockefeller Archive and represent 93 of the 119 present day counties of the state and are color coded according to range of occurrence. Infection rates are presented as range intervals. Line work and polygons were extracted from 2007 US Cansus Bureau TIGER/Line files. Maps and data compiled by Eric Thoman.



North Carolina is one of eleven states where the Rockefeller Sanitary Commission (RSC) operated between 1909 and 1915. Hookworm infection rates were compiled from the RSC records at the Rockefeller Archive and represent 97 of the 100 present day counties of the state and are color coded according to range of occurrence. Infection rates are presented as range intervals. Line work and polygons were extracted from 2007 US Cansus Bureau TIGER/Line files. Maps and data compiled by Eric Thoman.

Figure 7
Louisiana infection rates by county. (Note: No records were collected by the RSC for counties with white fill).

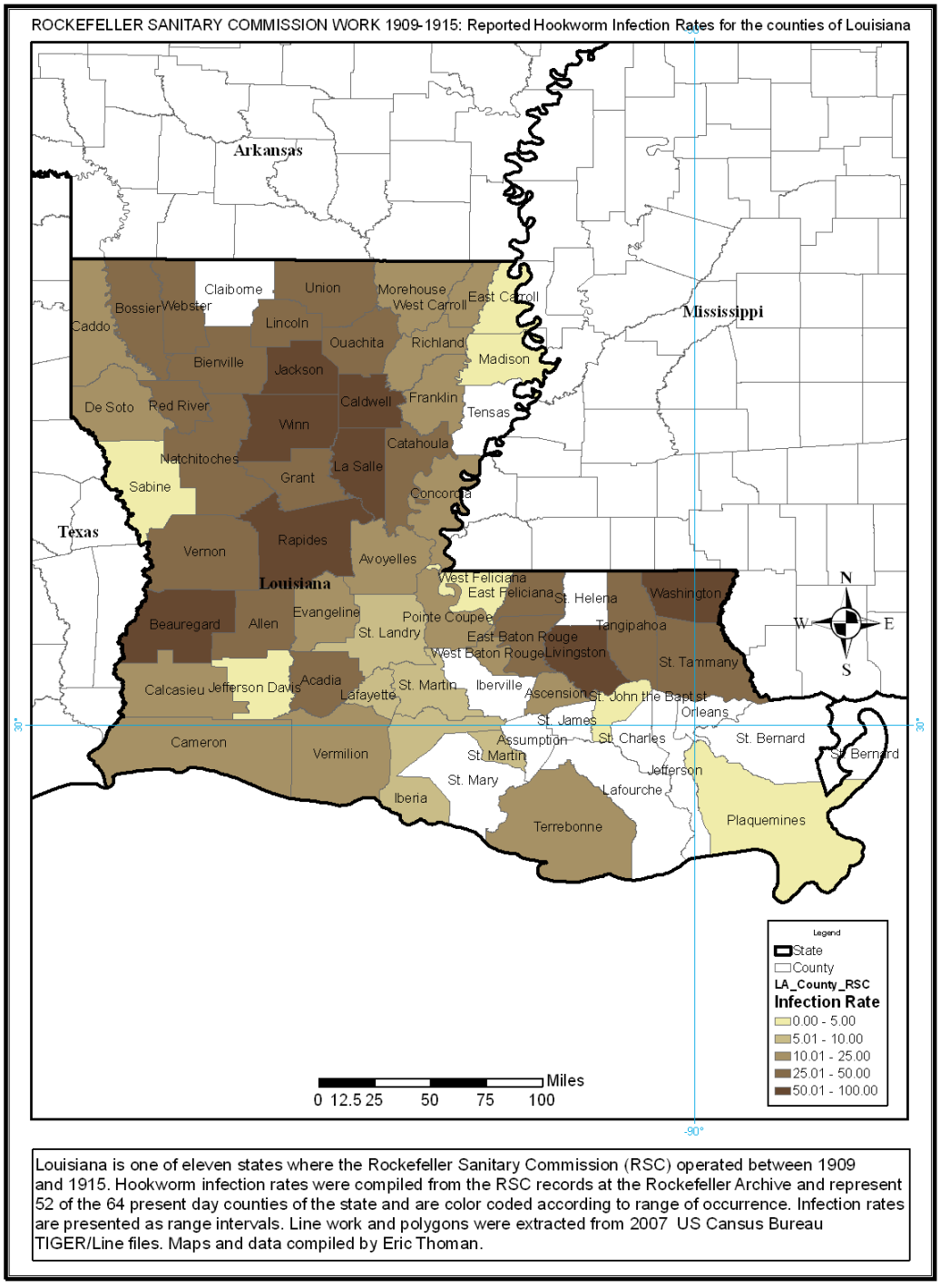


Figure 8
Mississippi infection rates by county. (Note: No records were collected by the RSC for counties with white fill).

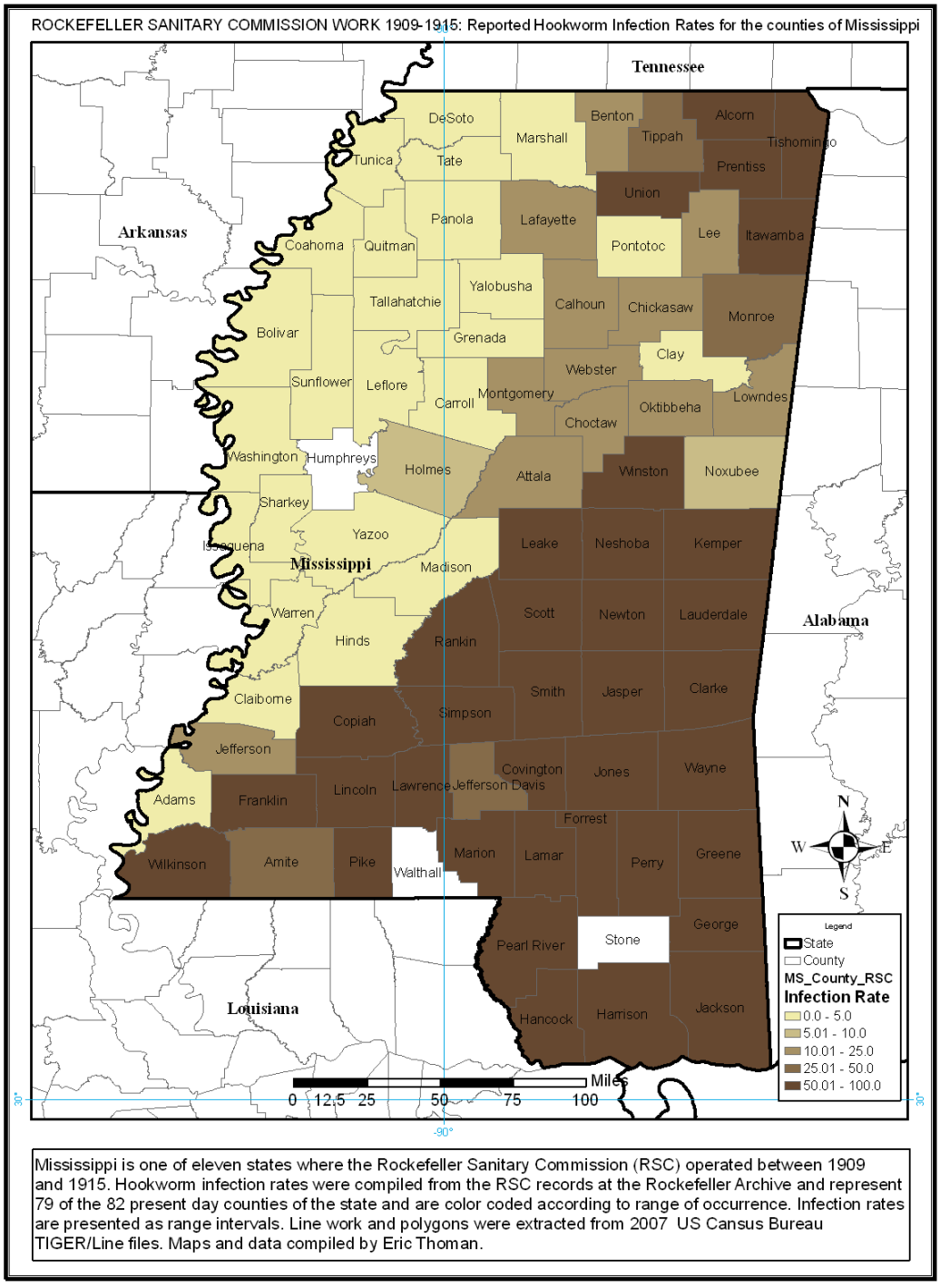
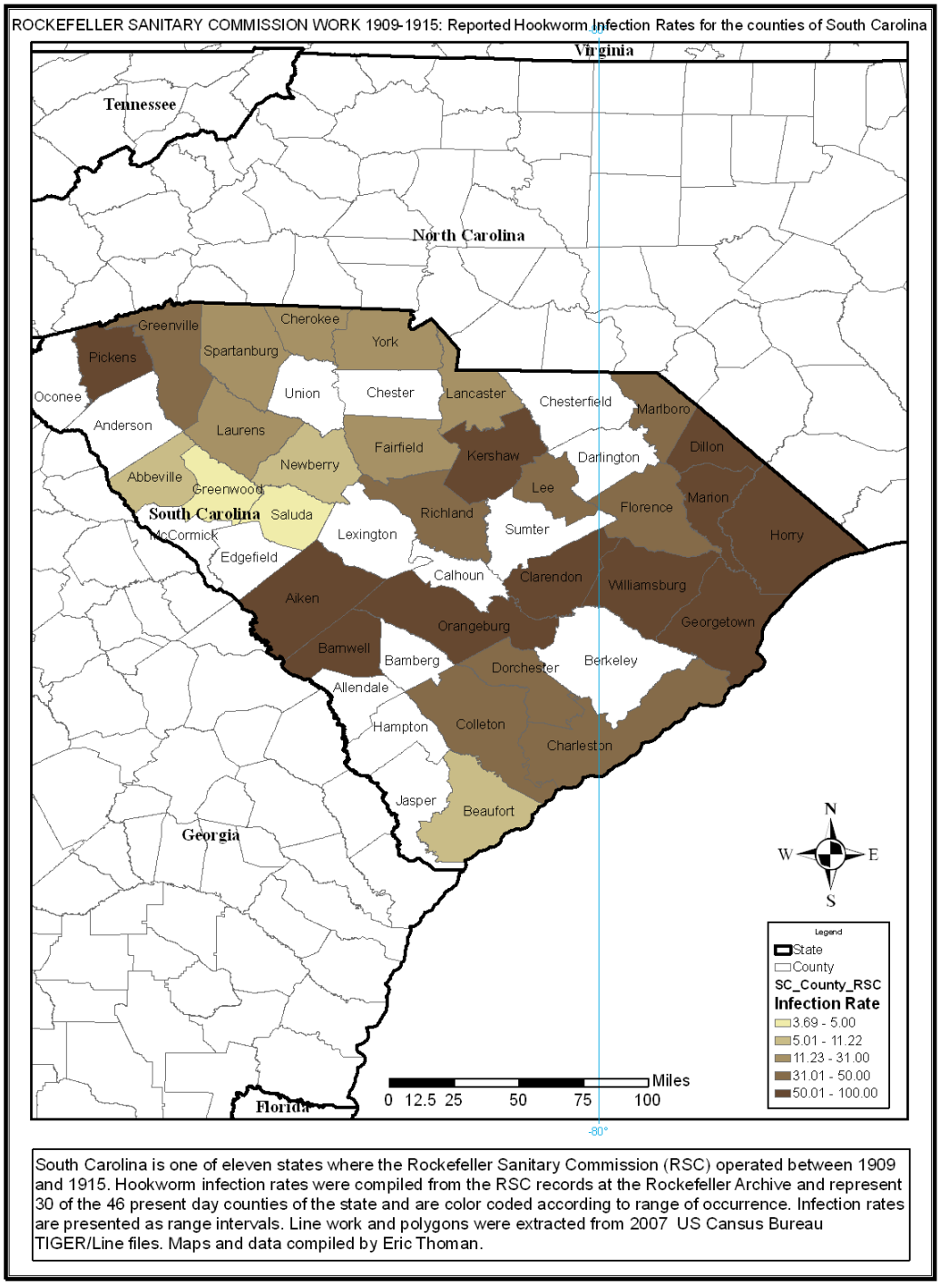
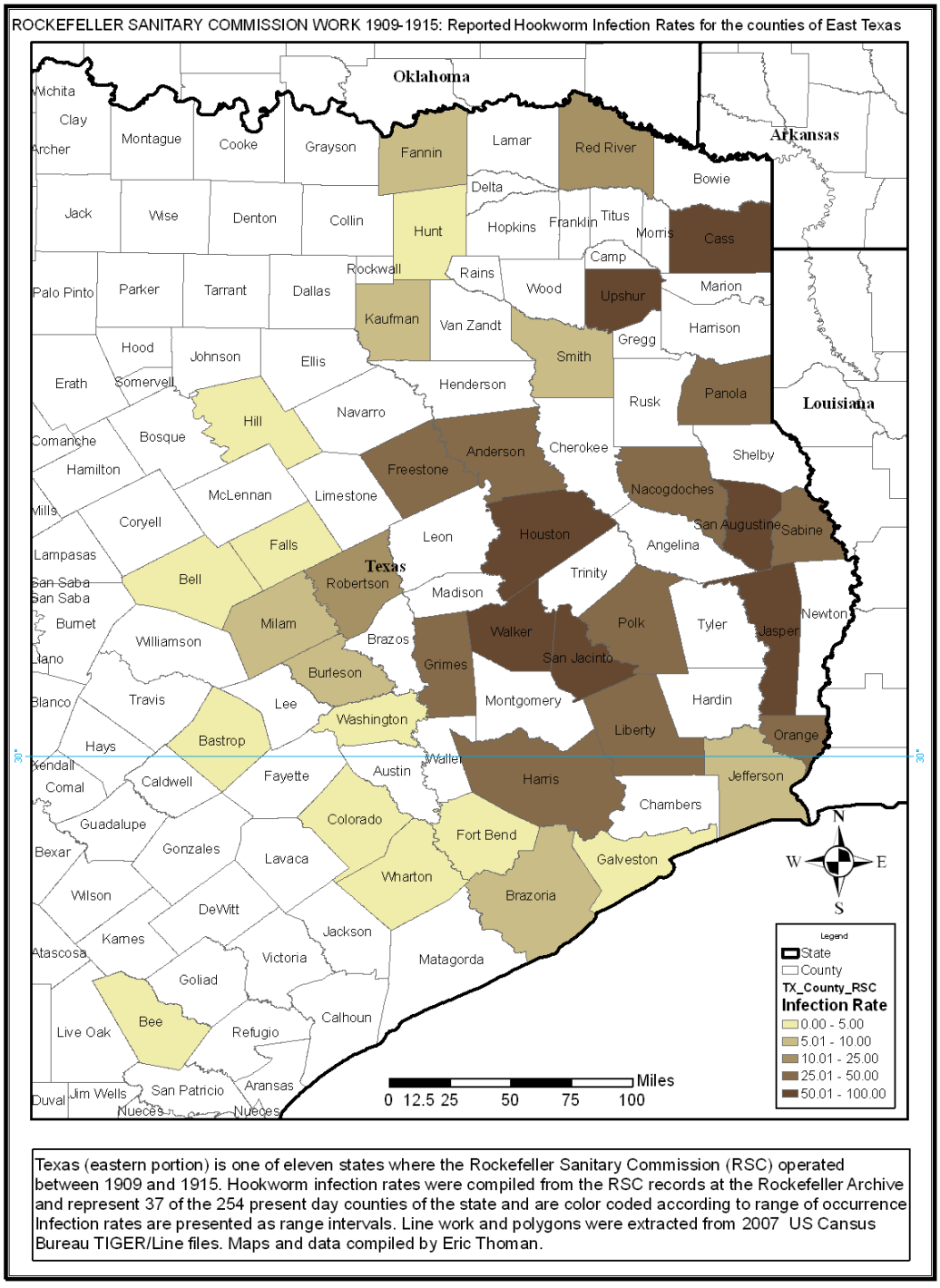


Figure 9
South Carolina infection rates by county. (Note: No records were collected by the RSC for counties with white fill).

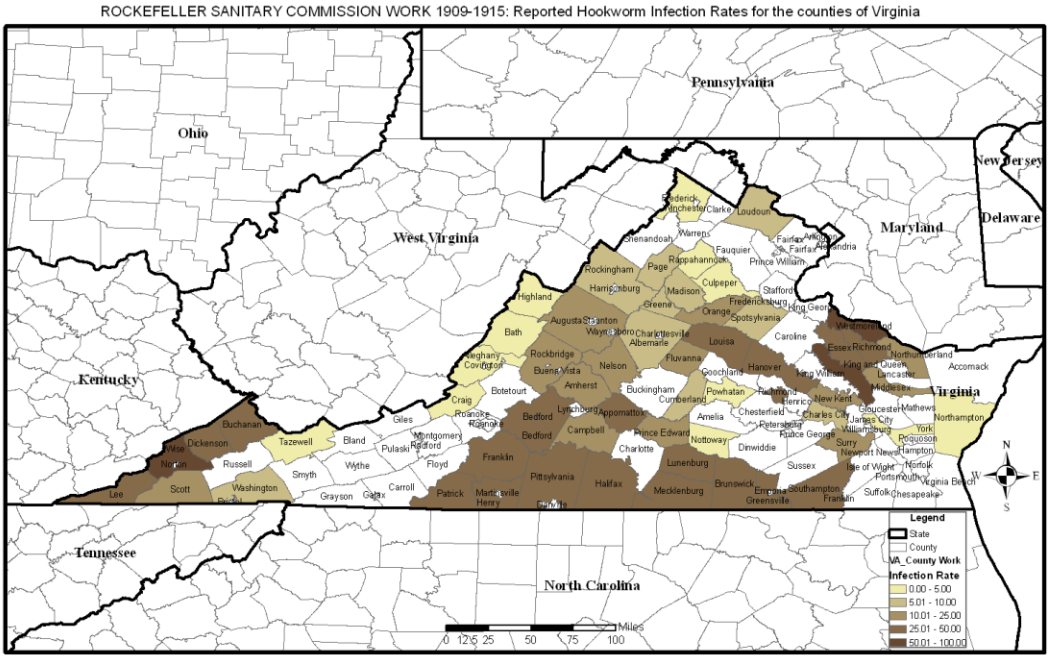


South Carolina is one of eleven states where the Rockefeller Sanitary Commission (RSC) operated between 1909 and 1915. Hookworm infection rates were compiled from the RSC records at the Rockefeller Archive and represent 30 of the 46 present day counties of the state and are color coded according to range of occurrence. Infection rates are presented as range intervals. Line work and polygons were extracted from 2007 US Cansus Bureau TIGER/Line files. Maps and data compiled by Eric Thoman.

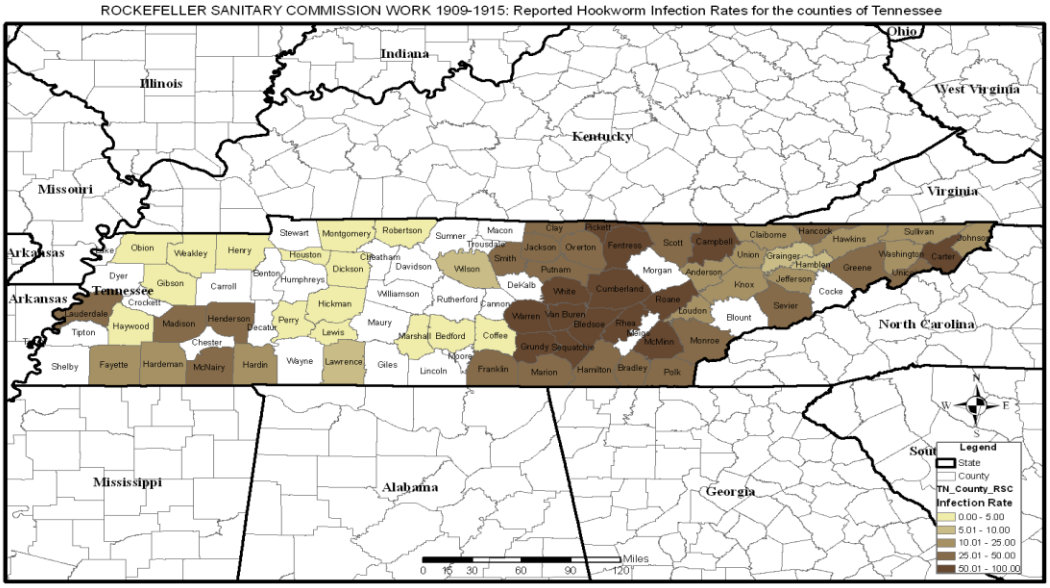
Figure 10
East Texas infection rates by county. (Note: No records were collected by the RSC for counties with white fill).



Figures 11 & 12
Tennessee and Virginia infection rates by county. (Note: No records were collected by the RSC for counties with white fill).



Virginia is one of eleven states where the Rockefeller Sanitary Commission (RSC) operated between 1909 and 1915. Hookworm infection rates were compiled from the RSC records at the Rockefeller Archive and represent 60 of the 135 present day counties of the state and are color coded according to range of occurrence. Infection rates are presented as range intervals. Line work and polygons were extracted from 2007 US Cansus Bureau TIGER/Line files. Maps and data compiled by Eric Thoman.



Tennessee is one of eleven states where the Rockefeller Sanitary Commission (RSC) operated between 1909 and 1915. Hookworm infection rates were compiled from the RSC records at the Rockefeller Archive and represent 66 of the 95 present day counties of the state and are color coded according to range of occurrence. Infection rates are presented as range intervals. Line work and polygons were extracted from 2007 US Cansus Bureau TIGER/Line files. Maps and data compiled by Eric Thoman.

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