

# Spotted Fever Rickettsiosis Dynamics in the United States

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## Abstract

Spotted Fever Rickettsiosis (SFR) refers to a group of tick-borne diseases caused by Rickettsia bacteria. Over the past two decades, there has been a significant surge in SFR cases, rising from 495 reported cases in 2000 to a peak of 6,248 in 2017. A significant concentration of SFR is observed in the southeastern United States, with five states contributing to more than 50% of reported instances. The high prevalence of SFR in these states has led to a scarcity of research on cases occurring in other regions of the United States as well as the spatio-temporal pattern of the burden. To bridge this gap, this study leveraged comprehensive social vulnerability index, healthcare shortage, and environmental data from all U.S. counties between 2016 and 2019. Utilizing advanced spatial analysis techniques, this project characterized SFR geographical patterns and identified contributing factors. This research also identified and analyzed high-incidence SFR areas, offering crucial insights for public health officials. These findings have potential to inform targeted interventions in high-risk areas, aiding in the effective mitigation of SFR transmission.

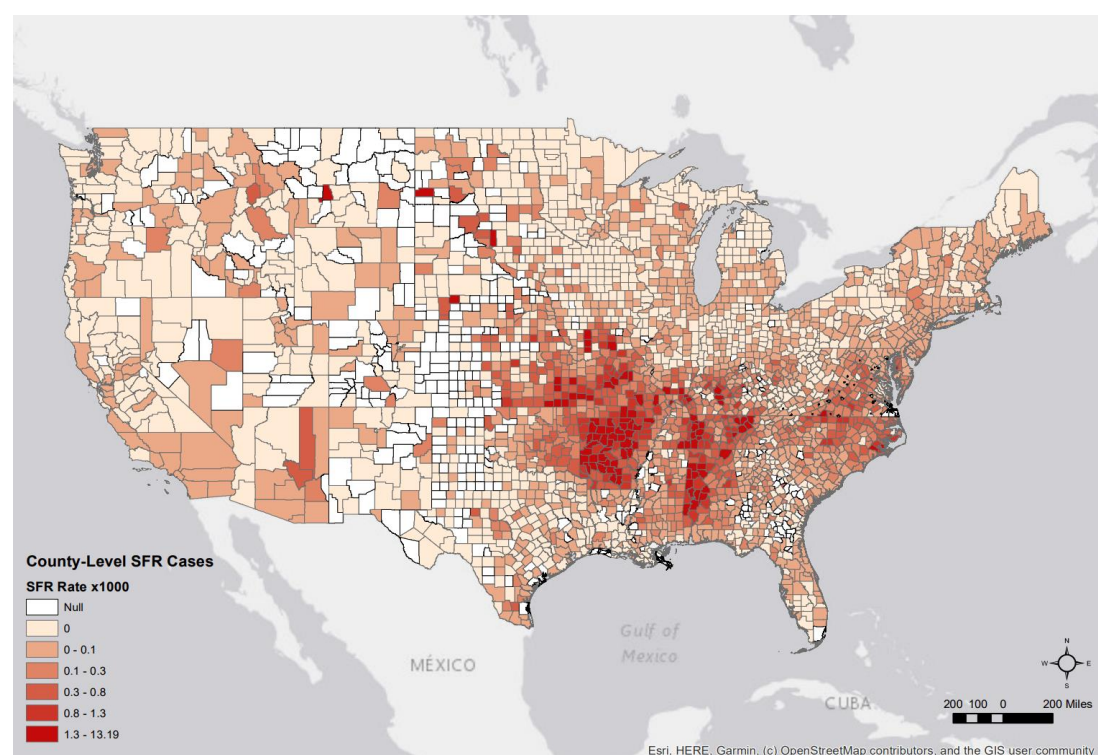
## Research Scope

Characterize geographical patterns and contributing factors of Spotted Fever Rickettsiosis in the contiguous United States.

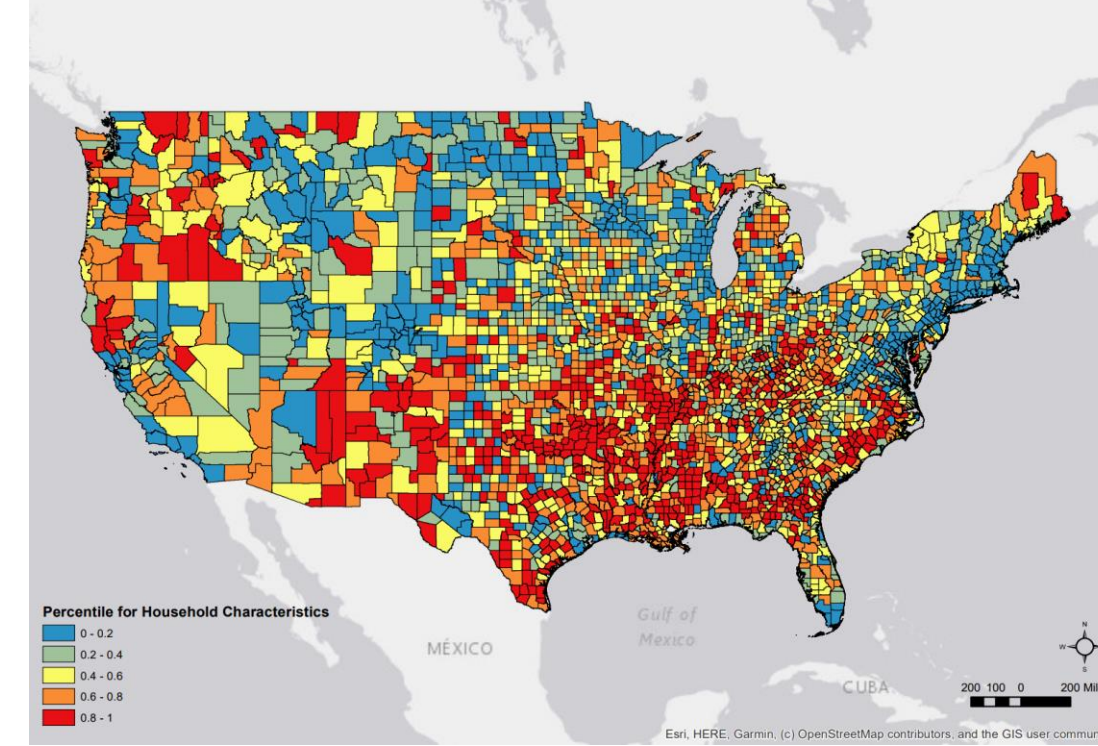
Identify and analyze locations with high incidence rates of Spotted Fever Rickettsiosis.

## Data

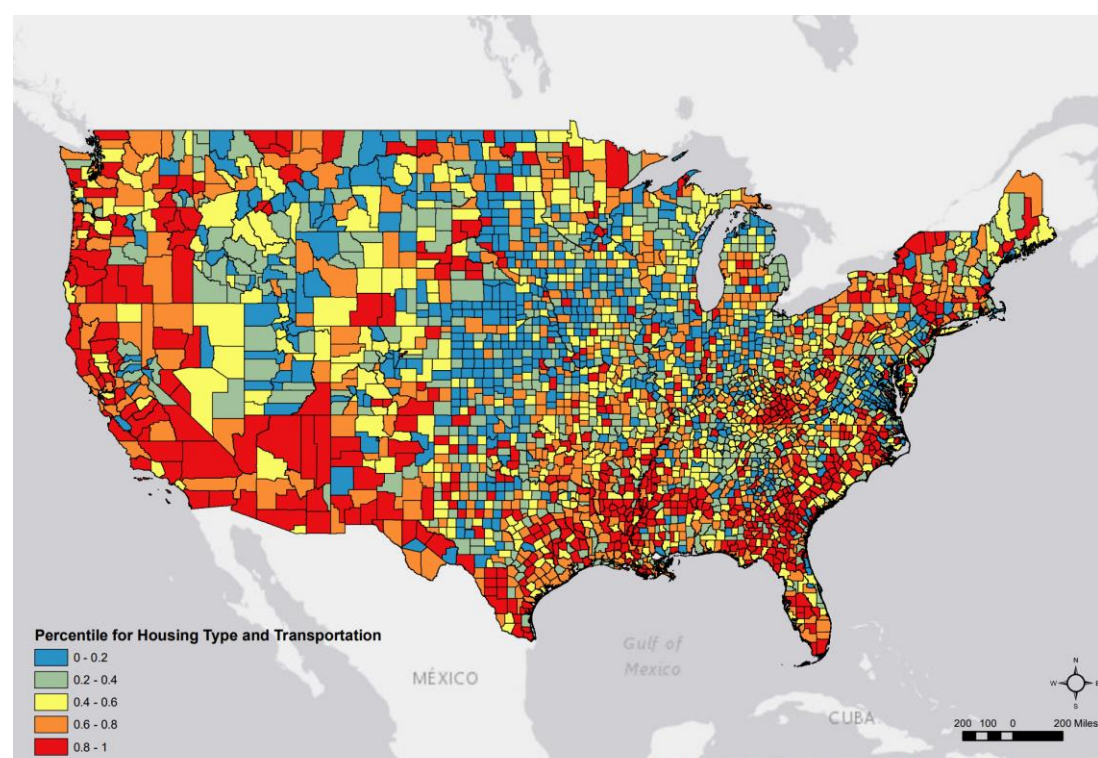
- SFR Rates (2016-2019)



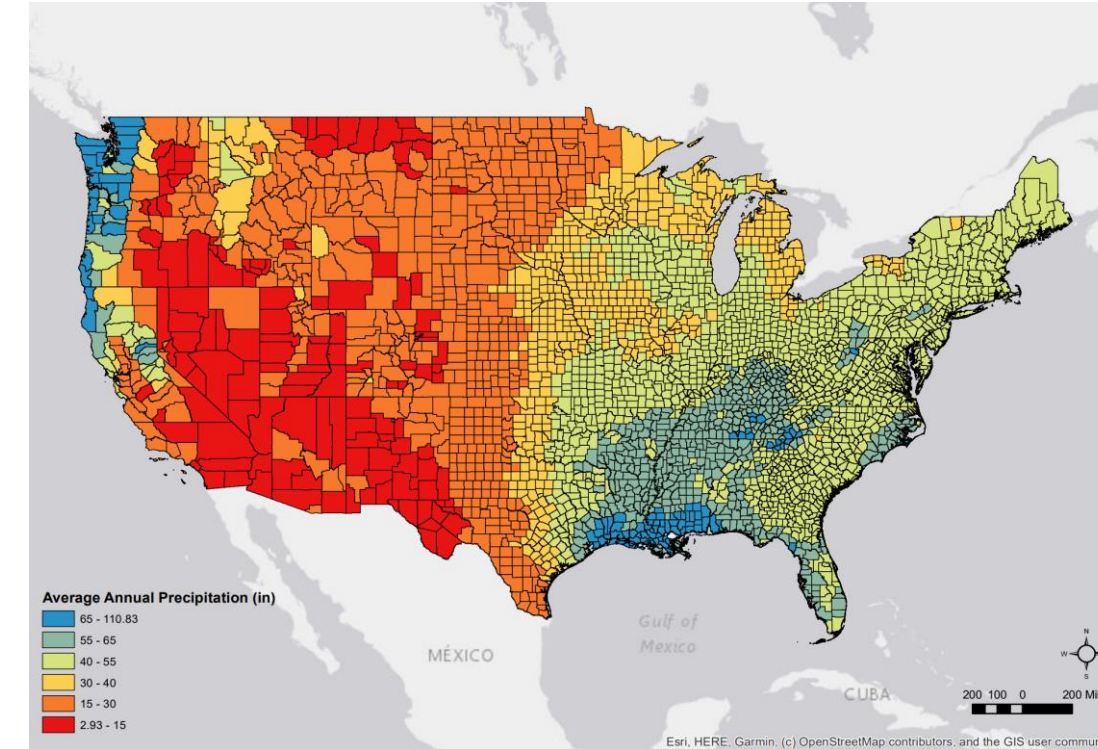
- Social Vulnerability Index: Household Characteristics (2020)



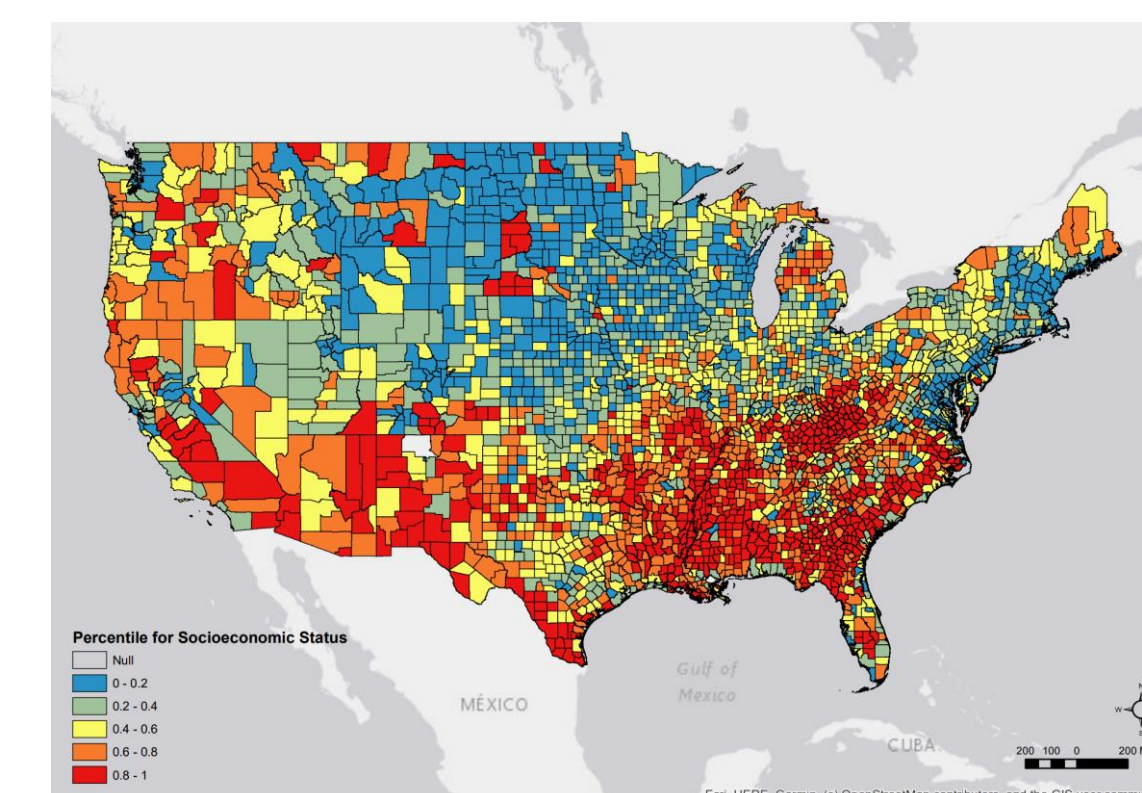
- Social Vulnerability Index: Housing Type and Transportation (2020)



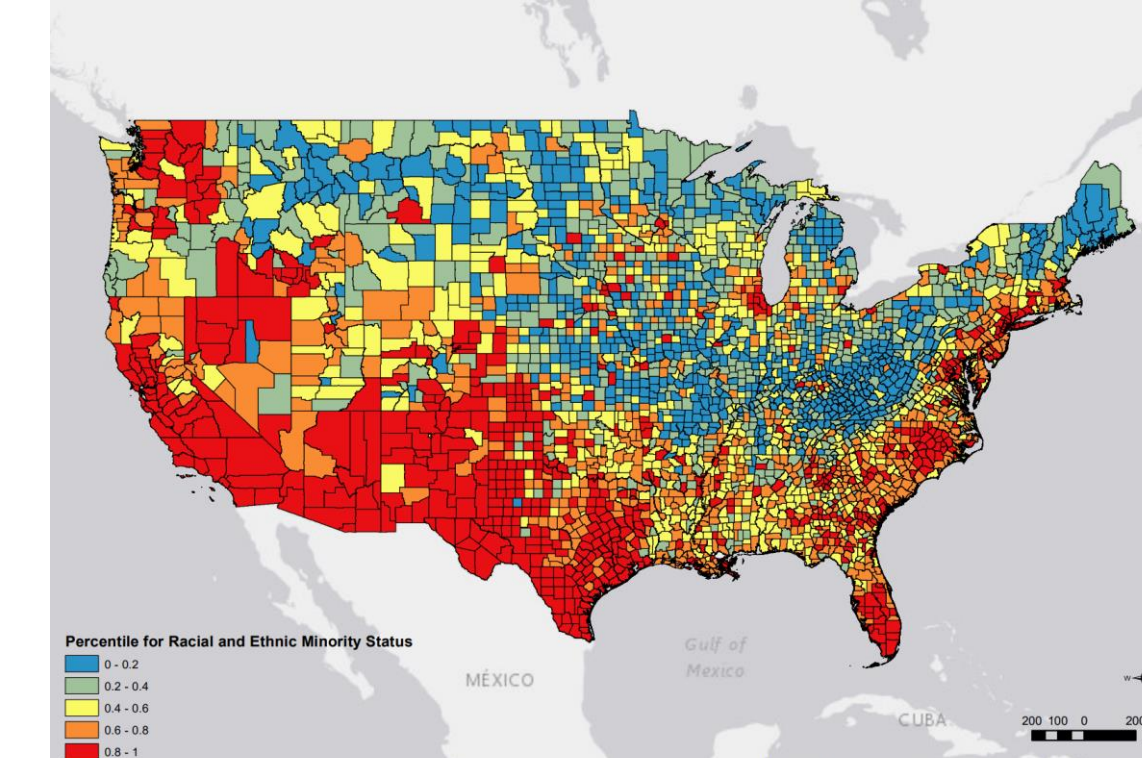
- Average Annual Precipitation (2016-2019)



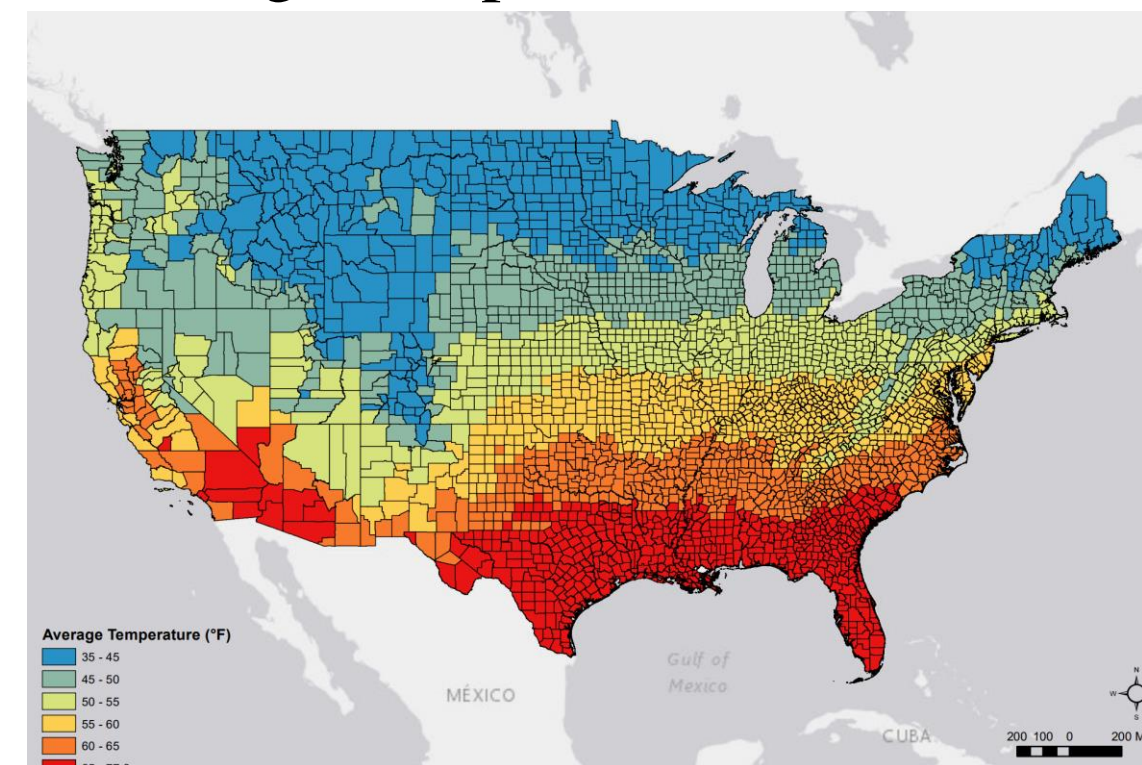
- Social Vulnerability Index: Socioeconomic Status (2020)



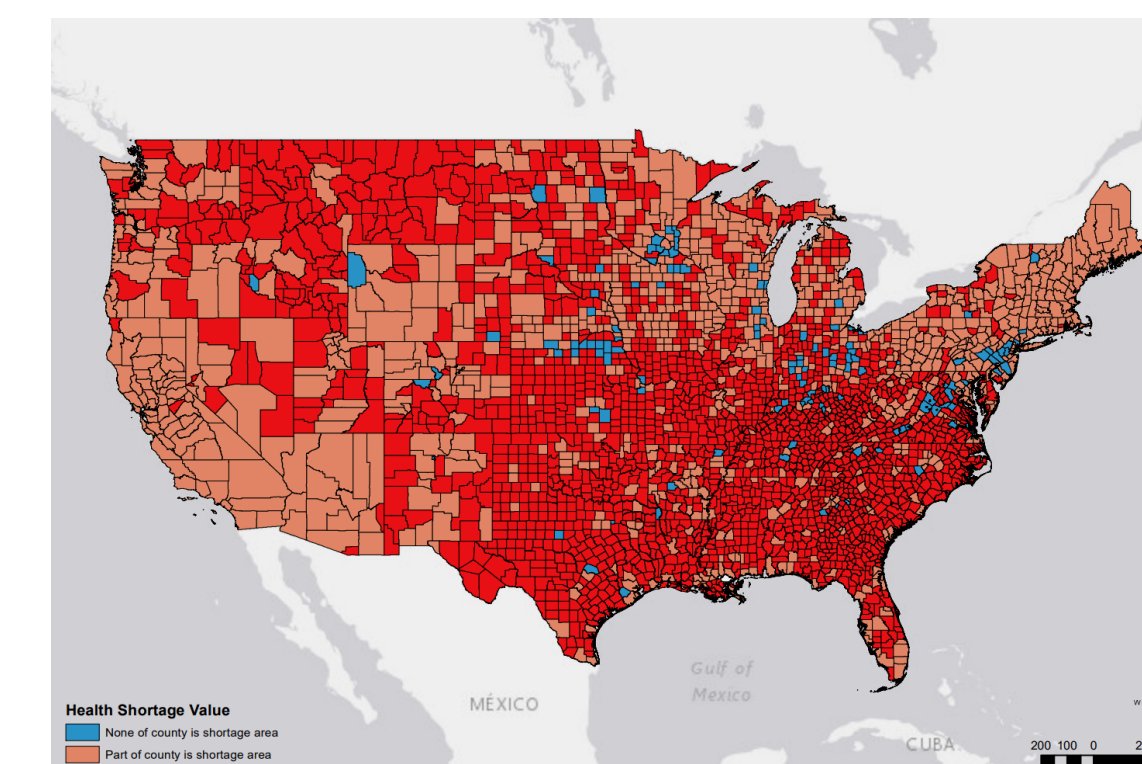
- Social Vulnerability Index: Racial and Ethnic Minority Status (2020)



- Average Temperature (2016-2019)



- Health Shortage Value (2023)

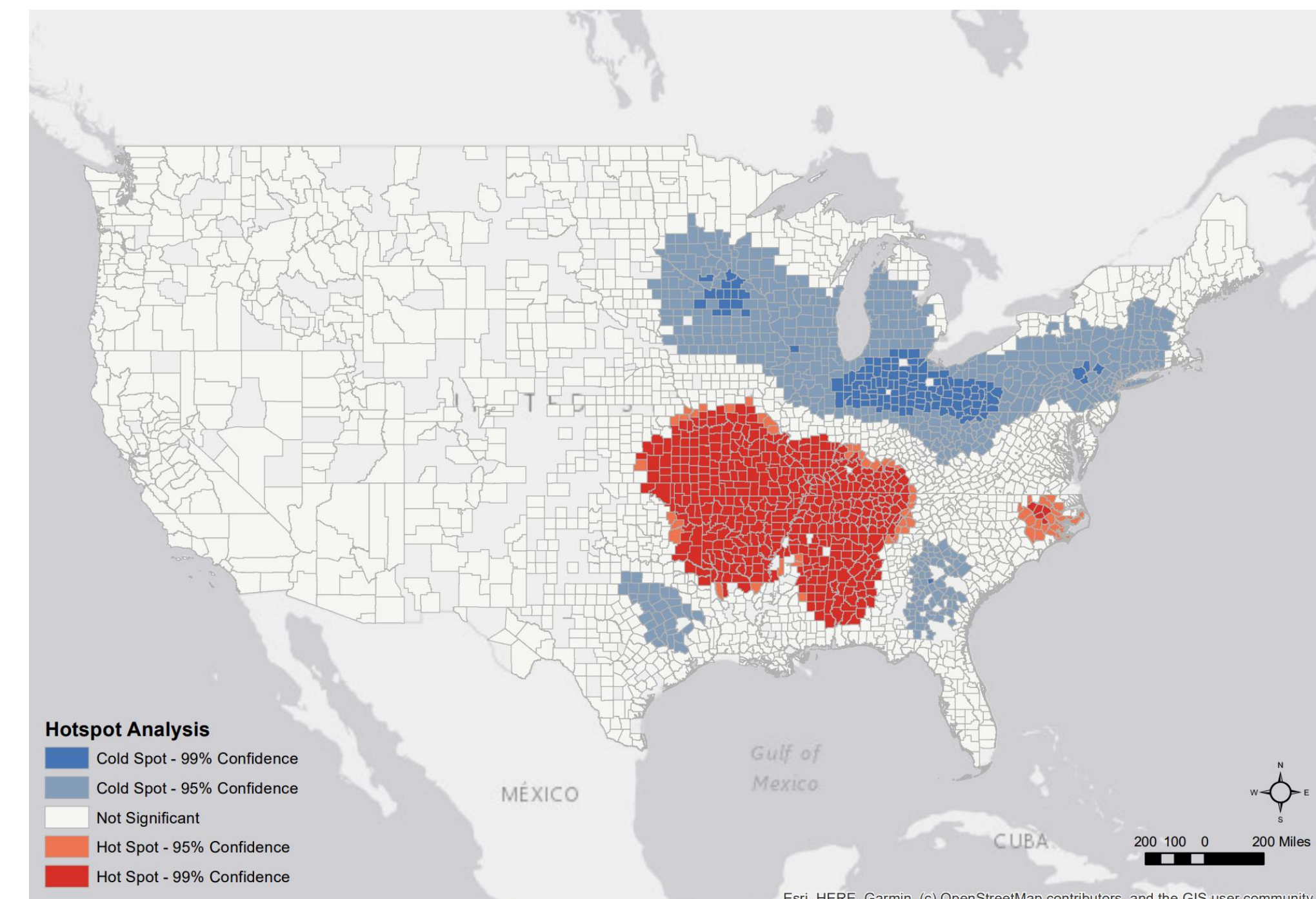


## Nation-Wide Linear Regression

- The SFR Rates were multiplied by 1000 and a linear regression was fit to the data.

	Coefficients	Standard Error	t Statistic	P-Value	Lower 95%	Upper 95%
Intercept	<b>-0.5078</b>	0.082	-6.183	0.000	-0.669	-0.347
HousingChar	<b>0.2245</b>	0.046	4.919	0.000	0.135	0.314
MinorityStat	<b>-0.4000</b>	0.051	-7.916	0.000	-0.499	-0.301
AvgTemp	<b>0.0095</b>	0.002	4.733	0.000	0.006	0.013
AvgPrecip	<b>0.0042</b>	0.001	4.256	0.000	0.002	0.006
HealthShortVal	<b>0.0513</b>	0.023	2.262	0.024	0.007	0.096

## Hot Spot Analysis



### Hot Spot Descriptive Statistics

	Mean	Minimum	Median	Maximum	Standard Deviation
Socioeconomic	0.6511	0.0061	0.7021	0.9978	0.2311
HousingChar	0.6517	0.0057	0.7386	0.9987	0.2930
MinorityStat	0.3972	0.0105	0.3715	0.9659	0.2483
HousingAndTransp	0.5176	0.0121	0.5100	0.9866	0.2466
AvgTemp	59.964	52.700	59.400	68.700	3.2394
AvgPrecip	53.559	36.870	54.975	68.090	7.0317
HealthShortVal	1.779	0	2	3	0.4847
SFRRate	0.8296	0.0000	0.4435	9.76786	1.2255

### Hot Spot Linear Regression

	Coefficients	Standard Error	t Statistic	P-Value	Lower 95%	Upper 95%
Intercept	<b>-0.5078</b>	0.082	-6.183	0.000	-0.669	-0.347
MinorityStat	<b>-0.4000</b>	0.051	-7.916	0.000	-0.499	-0.301
AvgTemp	<b>0.0095</b>	0.002	4.733	0.000	0.006	0.013

### Cold Spot Descriptive Statistics

	Mean	Minimum	Median	Maximum	Standard Deviation
Socioeconomic	0.425	0.0003	0.4217	0.9866	0.2691
HousingChar	0.4017	0.0013	0.3773	0.9729	0.2602
MinorityStat	0.4561	0.0051	0.4046	0.9968	0.2851
HousingAndTransp	0.5026	0.006	0.5333	0.9987	0.2919
AvgTemp	52.221	40.200	51.200	69.500	6.605
AvgPrecip	44.199	26.490	43.990	57.300	5.629
HealthShortVal	1.3353	0	1	2	0.6236
SFRRate	0.0175	0.0000	0.0000	0.47636	0.0424

### Cold Spot Linear Regression

	Coefficients	Standard Error	t Statistic	P-Value	Lower 95%	Upper 95%
Intercept	<b>-0.026</b>	0.018	-1.461	0.144	-0.061	0.009
HousingChar	<b>0.0175</b>	0.008	2.176	0.03	0.002	0.033
MinorityStat	<b>-0.0174</b>	0.007	-2.348	0.019	-0.032	-0.003
HousingAndTransp	<b>0.0282</b>	0.008	3.392	0.001	0.012	0.045

## Discussion

### Nation-wide Characterization

- Positive Correlations: Housing Characteristics, Temperature, Precipitation, and Health Shortage Value
- Negative Correlation: Racial and Minority Status
- Non-Influential Factors: Socioeconomic Status, and Housing Type and Transportation Vulnerability

### Hot Spot Characterization

- Hot Spot Traits: Elevated values in Socioeconomic Status, Housing Characteristics, and Housing Type and Transportation, Temperature, Precipitation, and Health Shortage Value.
- Positive Correlation: Temperature
- Negative Correlation: Racial and Minority Status

### Cold Spot Characterization

- Cold Spot Traits: Elevated Racial and Minority Status.
- Positive Correlation: Housing Characteristics and Housing Type and Transportation
- Negative Correlation: Racial and Minority Status

## Future Work

Investigate the impact of canine hosts on SFR Rate, considering existing evidence suggesting a potential increase.

Explore further models and methods for predicting SFR occurrence in new locations.

## Acknowledgements

Funding for this project is provided by the National Science Foundation, Award Number 2019609, the University of New Mexico Arts & Sciences Support for Undergraduate Research (ASSURE), and the Frank O. and Sadie M. Lane Scholarship.

## References

- Centers for Disease Control and Prevention Agency for Toxic Substances and Disease Registry. (2023). *CDC/ATSDR Social Vulnerability Index 2020*. <https://www.atsdr.cdc.gov/placeandhealth/svi/index.html>
- Centers for Disease Control and Prevention National Center for Emerging and Zoonotic Infectious Diseases Division of Vector-Borne Diseases. (2023). *Reported Cases of Selected Tickborne Diseases 2016-2019*. <https://www.cdc.gov/ticks/data-summary/geographic-distribution.html>
- National Centers for Environmental Information. (2023). *Climate at a Glance County Mapping 2016-2019*. <https://www.ncei.noaa.gov/>
- Rural Health Information Hub. (2023). *Health Professional Shortage Areas: Primary Care, by County, 2023*. <https://www.ruralhealthinfo.org/charts/5>
- Virginia Department of Health. (2018). *Spotted Fever Rickettsiosis (including Rocky Mountain Spotted Fever)*. <https://www.vdh.virginia.gov/epidemiology/epidemiology-factsheets/spotted-fever-rickettsiosis-including-rocky-mountain-spotted-fever/>