Temperature and Precipitation as Lyme Disease Indicators in Massachusetts

Introduction

Lyme disease is the most common vector-borne disease in the United States, most frequently found in the Northeastern and mid-Atlantic U.S (Subak, 2002). It is caused by the spirochete, *Borrelia burgdorferi*, and is transmitted in New England and the mid-Atlantic by *Ixodes scapularis*, commonly known as the black-legged tick (Shapiro and Gerber, 2000).

I. scapularis has a two year life cycle consisting of 3 different stages: larvae, nymph, and adult. Larvae, predominant during the summer months, feed almost exclusively on the white-footed mouse, *Peromyscus leucopus*, a natural reservoir of *B. burgdorferi* (Shapiro and Gerber, 2000). Larvae are most likely to become infected with *B. burgdorferi* after feeding on *P. leucopus*. Nymphs emerge the following spring and continue to feed throughout the summer. Humans are most likely to get Lyme disease from nymph ticks because of their small size, making it difficult to identify and remove the tick before it transmits *B. burgdorferi* (Tilly et al, 2008). Adult ticks emerge in the fall, feed on white-tailed deer and lay their eggs in the spring thus re-starting the 2 year life cycle.

Given the multiple vector, reservoir, host and environment interactions needed for Lyme disease to occur, several environmental factors have been examined in relation to regional or annual Lyme disease variability. Weather variability, such as fluctuations in precipitation and temperature, is one proposed factor affecting Lyme disease incidence. Deer tick survival is particularly influenced by humidity, requiring a relative humidity of 90% or higher (Ostfeld and Brunner, 2015). A study conducted in Illinois found that tick density and infection rates were associated with total precipitation (Jones, 2000). In addition to precipitation being a possible factor, several studies have suggested that temperature might also have an effect on Lyme disease. Cold winters can decrease the white-footed mouse population, which could reduce the number of tick larvae that become infected. Subak's study in several Lyme endemic states found that summer moisture two years prior and winter temperature one year prior were significantly correlated with Lyme disease incidence.

Based on the evidence from prior studies of temperature and precipitation as possible indicators for Lyme disease variability between states, this spatial analysis was designed to examine these factors as a possible explanation for town-level variability in Lyme disease incidence across Massachusetts, a Lyme-endemic state. This analysis examined temperature and precipitation from summer and winter of 2012 and 2013 in relation to 2014 Lyme disease incidence by town in Massachusetts.

Legend
Massachusetts Towns
No Lyme Data
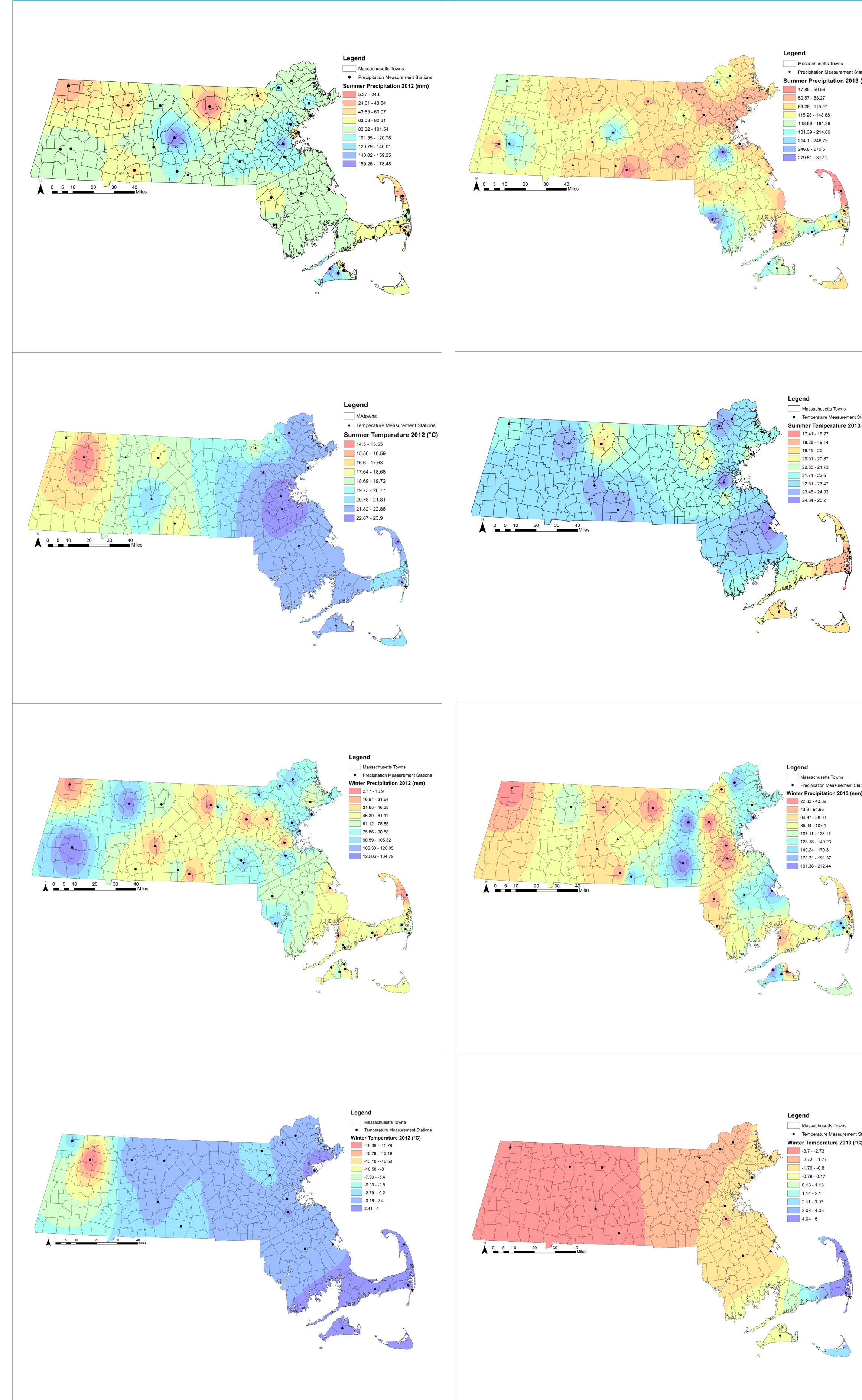2014 Lyme Disease Incidence
(cases per 100,000 residents)
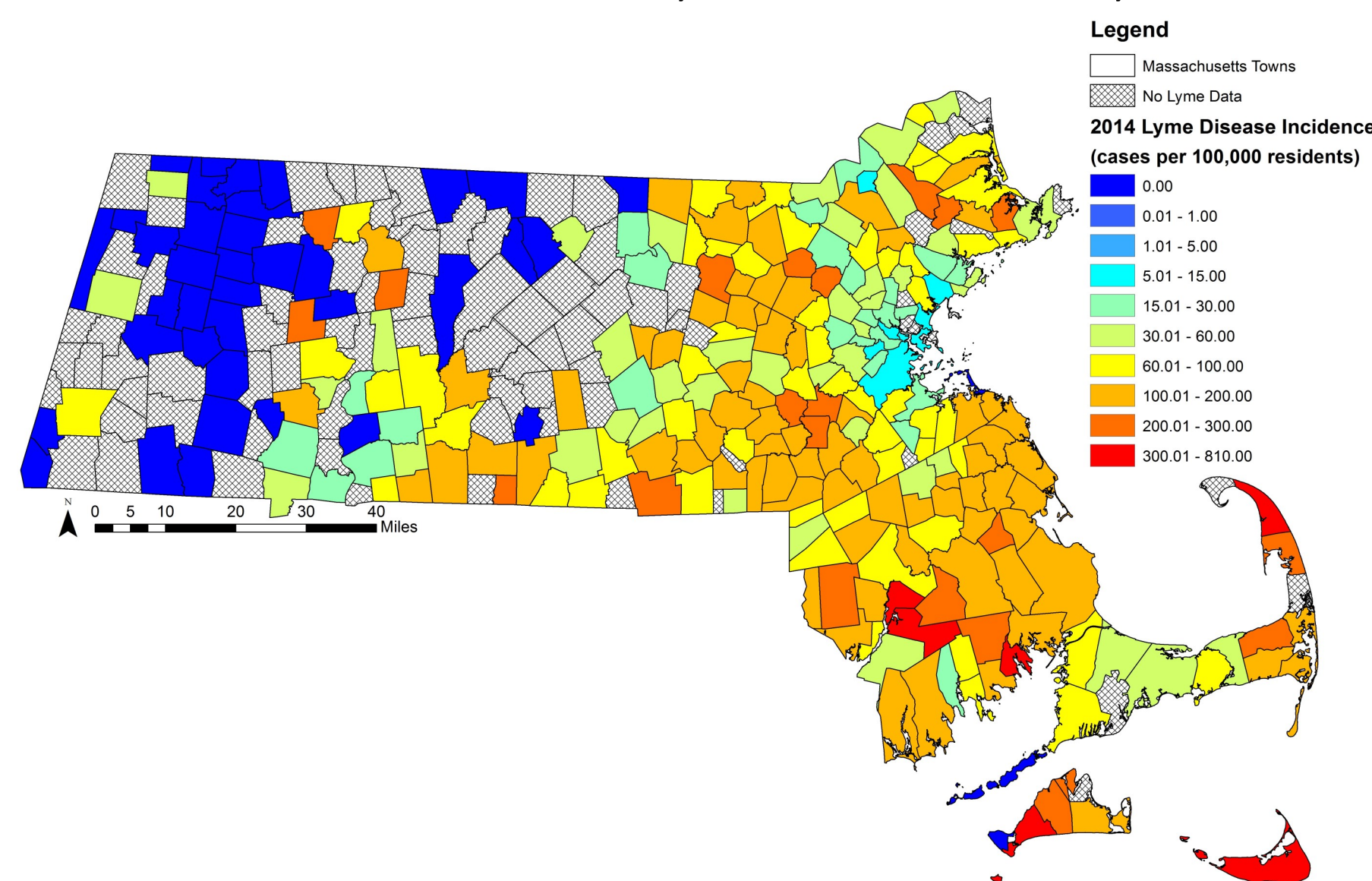
Methods

Temperature and precipitation data were divided into tables according to season and year (ex. summer precipitation 2012). The stations where these measurements were taken were plotted using XY coordinates onto a base map of Massachusetts towns using GCS NAD 1983 and projected to NAD 1983 Massachusetts StatePlane.

Stations missing temperature or precipitation measurements were removed. The resulting stratified temperature and precipitation data were then interpolated using IDW to display temperature and precipitation across Massachusetts for each selected time period. Zonal statistics were run on the resulting rasters using the "TOWNS" field from the Massachusetts Towns layer to calculate the mean raster value for each town (temperature or precipitation).

The extracted zonal statistics were exported into SPSS with 2014 Lyme disease incidence rate for each town. Towns with no Lyme disease data were removed. Spearman's correlation tests were run for each of the 8 categories comparing the weather variables 2014 Lyme disease incidence to see if any of them were correlated with Lyme disease incidence across Massachusetts.
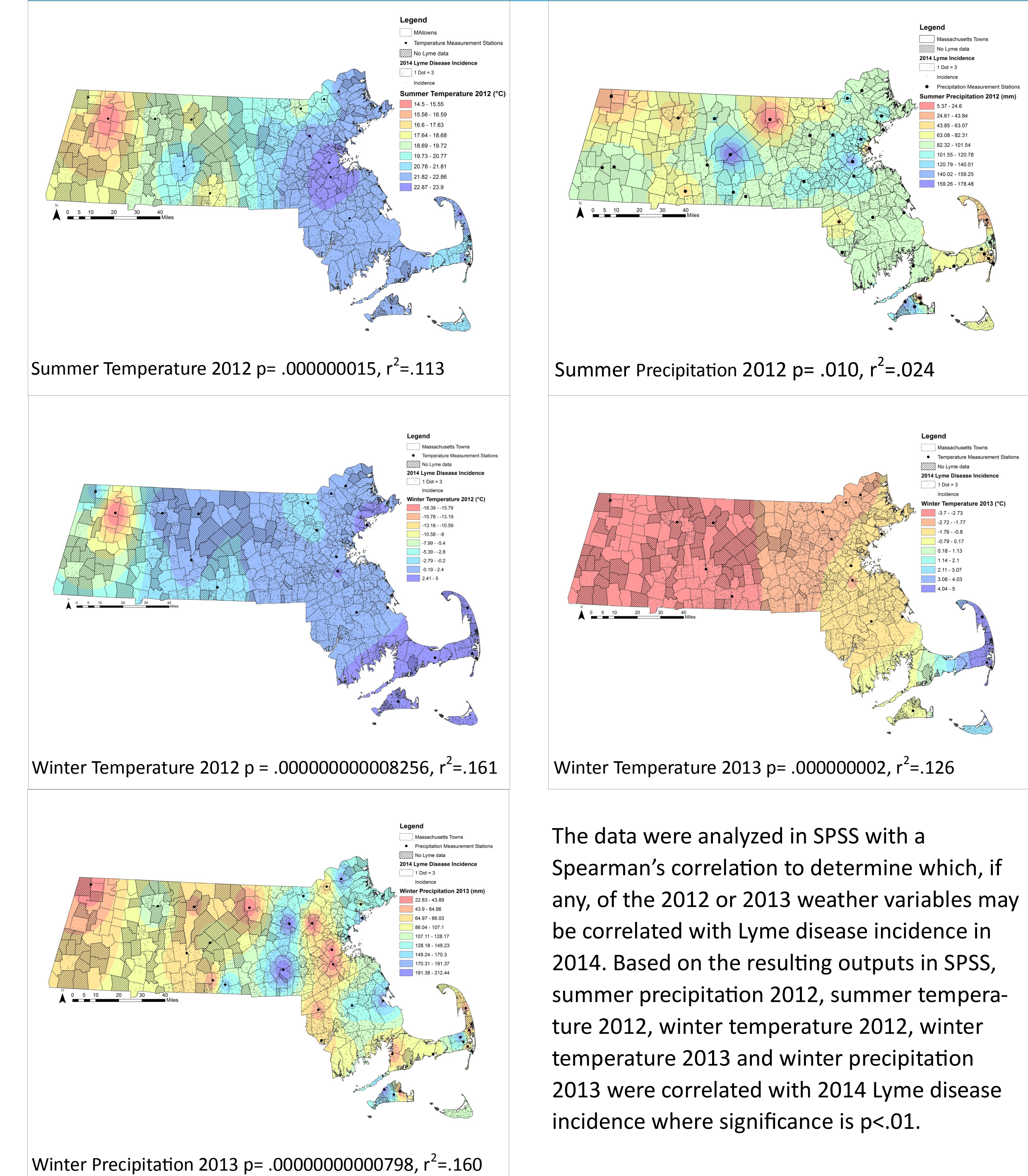
Temperature and Precipitation Data

Data Sources

Lyme disease data was obtained from the Massachusetts Department of Public Health per a personal communication with Dr. Al DeMaria of the Bureau of Infectious Diseases. The data displayed is Massachusetts Lyme disease incidence for 2014 by town/city. Incidence is calculated as new cases per 100,000 residents. Temperature and precipitation data were retrieved from the National Climatic Data Center (NOAA) from the Global Historical Climatology Network. Summer is defined as June, July and August and winter is defined as December, January and February. Total monthly precipitation is displayed in mm and monthly mean temperature is displayed in degrees Celsius.

Results

Summer Temperature 2012 p= .000000015, r^2=.113

Summer Precipitation 2012 p= .010, r^2=.024

Winter Temperature 2012 p = .000000000008256, r^2=.161

Winter Temperature 2013 p= .000000002, r^2=.126

Winter Precipitation 2013 p= .00000000000798, r^2=.160

The data were analyzed in SPSS with a Spearman's correlation to determine which, if any, of the 2012 or 2013 weather variables may be correlated with Lyme disease incidence in 2014. Based on the resulting outputs in SPSS, summer precipitation 2012, summer temperature 2012, winter temperature 2012, winter temperature 2013 and winter precipitation 2013 were correlated with 2014 Lyme disease incidence where significance is p<.01.

Conclusions and Limitations

While the p values for all 5 of these weather variables are highly significant (where significance is p<.01), the r^2 values, the coefficients of determination, are quite small meaning only 2% (summer precipitation 2012) to 16.1% (winter precipitation 2013) of the variance in Lyme disease incidence is explained by its relationship with the above weather variables. These small r^2 values indicate weak correlation of these weather variables as indicators for Lyme disease incidence.

This study has several limitations. One of the major limitations of this analysis is the small and uneven number of measurement points from which temperature and precipitation data were interpolated. More measurement stations more evenly distributed would increase the accuracy of the interpolation across the state. It is also possible that total precipitation is not the best measure for moisture in this case and perhaps the Palmer Hydrological Drought Index might be a more specific measurement for future studies. This study examined annual incidence for Lyme disease rather than looking specifically at summer onset cases. It is possible that there might be more of a correlation between these weather factors and summer onset cases specifically.

Cartographer: Aislinn Cook
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CEE187: Geographical Information System
Geographic Coordinate System:
GCS_North_American_1983
Projected Coordinate System:
NAD_1983_StatePlane_Massachusetts_Mainland_FIPS_2001

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