Identifying Lyme Disease Risk in Maine, Massachusetts, New Hampshire, and Vermont

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Introduction

Lyme disease is a tick-borne zoonosis that infects upwards of 26,000 people annually, making it the most common vector-borne disease in the United States (CDC 2017). The etiologic agent of Lyme disease is *Borrelia burgdorferi*, which relies on the deer tick, *Ixodes scapularis*, to complete its complex life cycle (CDC 2015). An increasing global temperature may have implications for incidence of Lyme disease (Ogden 2014). We examined ecological and epidemiological factors that influence *Ixodes scapularis* to create a model of Lyme disease risk in Maine, Massachusetts, New Hampshire, and Vermont. We included the average number of days above freezing and average monthly precipitation in our model (Leighton 2012, McPherson et al. 2017).

Research Question: Is the change in Lyme disease incidence related to changes in local precipitation and local temperature?

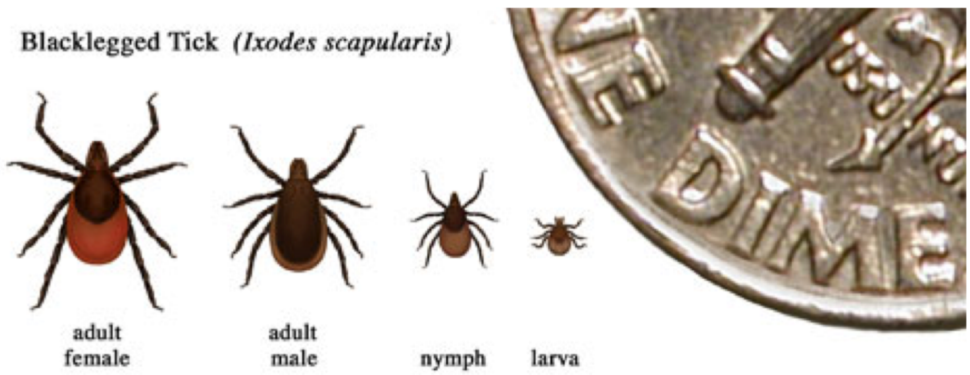

Figure 1. Life stages of the blacklegged tick (*Ixodes scapularis*) (CDC 2015).

Methods

The Lyme disease cases data by U.S. county were obtained from a CDC dataset repository (CDC 2015). Lyme disease cases data were from 54 counties in ME, MA, NH, and VT. Precipitation and temperature data were obtained from the National Oceanic and Atmospheric Administration (NOAA 2018). Elevation data were obtained from the National Elevation Dataset (NED) from the United States Geological Survey (USGS). The coordinate system used was NAD1983 in ArcGIS 10.4.1. The data were projected using USA Contiguous Albers Equal Area Conic. Significant variables were determined using pairwise t-tests. Using R, a multiple linear regression model was created to show the effects of climate factors on Lyme disease incidence from 1992-2011 in order to relate the Lyme disease incidence per county, mean daily precipitation, and the mean number of days above freezing to risk of contracting Lyme disease.

Results

There was a significant difference in Lyme disease cases in the 54 selected counties from 1992-2011 ($p<0.001$). There was no significant difference between the Lyme disease cases in the first and second year ranges ($p=0.804$) and the second and third ($p=0.280$) year ranges, but there was a significant difference between the fourth range and all previous ranges ($p<0.05$). A multiple linear regression model using Lyme disease incidence as an independent variable and mean daily temperature and precipitation as dependent variables showed that days above freezing had the largest influence on the risk of Lyme (p-value < 0.001), but precipitation still had a significant effect (p=0.001) (Table 1). The model includes mean daily precipitation and mean number of days above freezing, not the percent change, as shown in Figures 2 and 3.

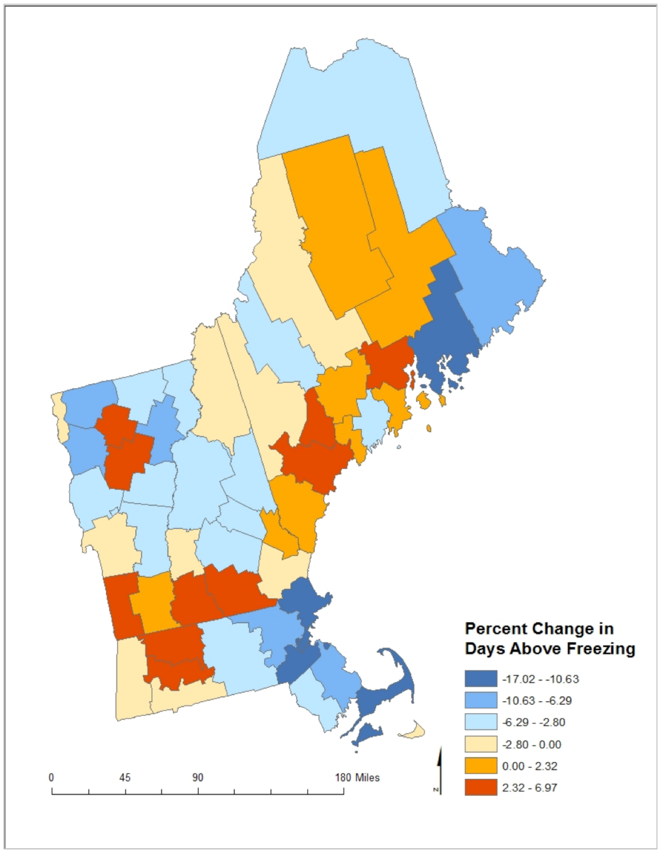

Figure 2. Percent change in days above freezing from 1990 - 2006. This variable was a significant predictor of Lyme disease cases (p < 0.001).

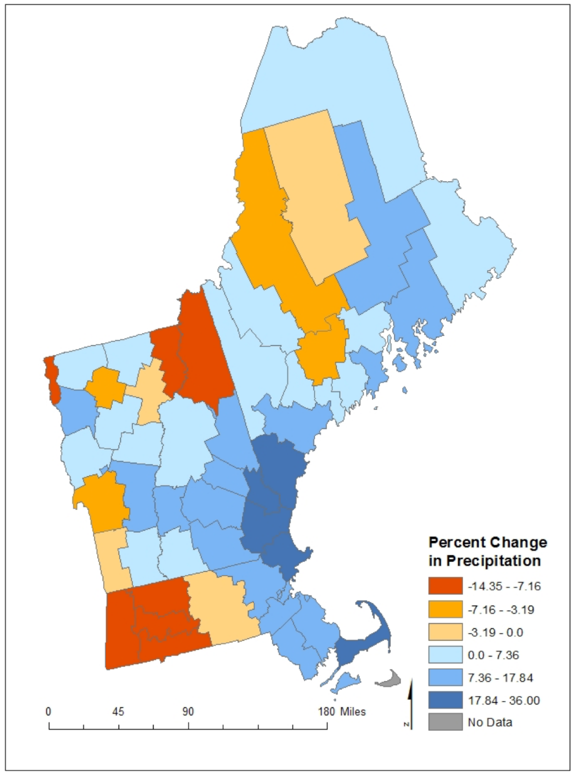

Figure 3. Percent change in precipitation from 1990 - 2006. This variable was a significant predictor of Lyme disease cases ($p = 0.0163$).

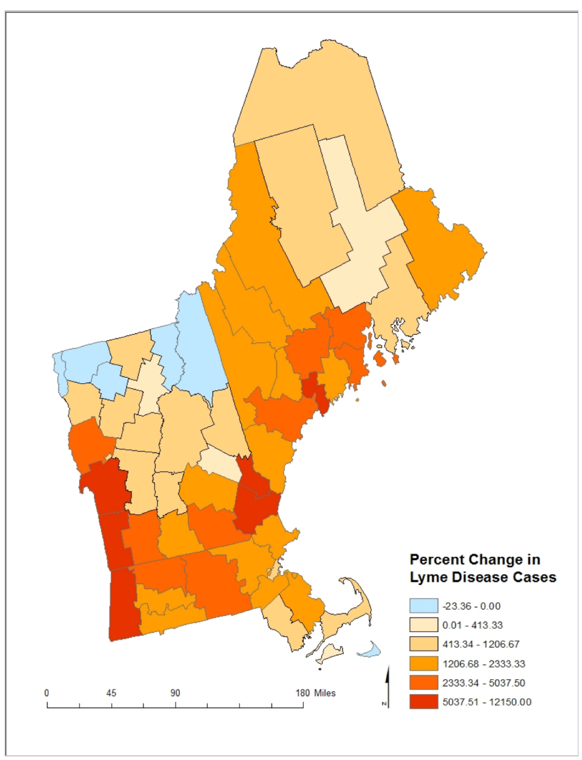

Figure 4. Percent change in Lyme disease cases from 1992 - 2011 in selected US counties ($p<0.001$).

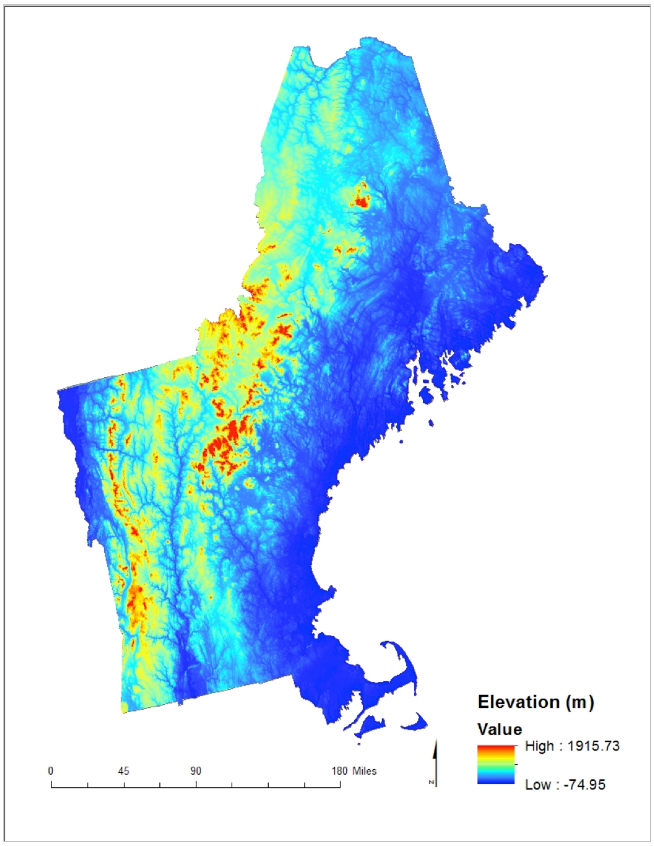

Figure 5. Elevation profile (m). No statistical analyses were performed.

Variable	p-value
Precipitation	<0.001
Days above freezing	<0.001

Table 1. Significant ecological factors with p-values for the Lyme disease regression model.

Lyme Disease Risk = -13.738 + (3.191 * Mean Daily Precipitation) + (0.036 * Number of Days Above Freezing)

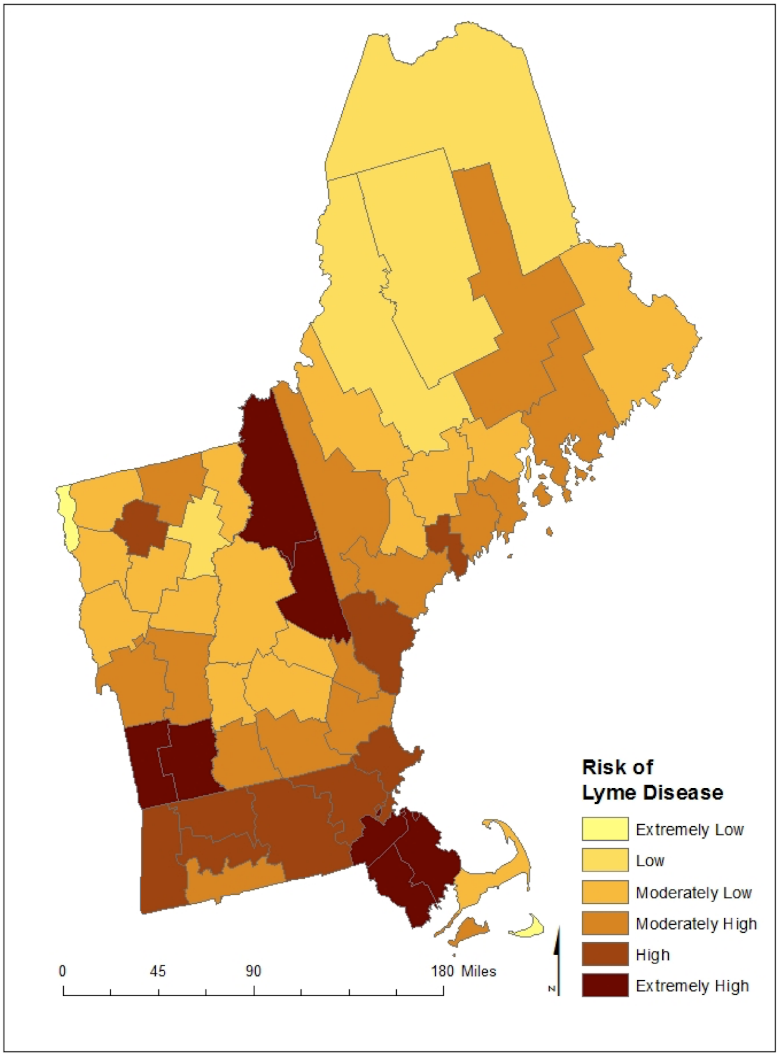

Figure 6. Results for the multiple regression model for risk of Lyme disease.

Discussion

This Lyme disease risk model was used for a project in an introduction to GIS class at Colby College and therefore, has several limitations and may not be accurate in predicting Lyme disease risk. Using mean daily precipitation and mean number of days above freezing as variables for this risk model, we predict that 3 counties in counties MA, 2 counties in VT, 2 counties in NH, and 0 counties in ME have an extremely high risk for Lyme disease (Figure 6).The six classes of Lyme disease risk were arbitrarily chosen to show Lyme disease risk in a more understandable way (Figure 6). Forest patch size has significant influence on tick populations, although we were unable to analyze forest cover data using ArcGIS 10.4.1 (Pfeiffer 2018). We were unable to find data for Lyme disease incidence on a yearly basis at the county level, so the incidence is reported in five year intervals. The temperature and precipitation data were only reported up to 2006, whereas the Lyme incidence data was reported through 2011. In future studies it would be important to consider land use and forest edge in identifying risk. Elevation is an important predictor of Lyme disease risk, but it was not included in the regression model (Ogden et al. 2014) (Figure 5). This regression model could be used to predict the risk of Lyme disease based on current and historic trends in temperature and precipitation for these states (Figure 6). We believe this is valuable information for public health and government officials to have in order to create preventative measures and educate individuals in hopes of mitigating the incidence of Lyme disease.

Acknowledgments
Thank you to Dr. Philip Nyhus, Professor of Environmental Studies, Dr. Manny Gimond, GIS and Quantitative Analysis Specialist, Wes Zebrowski, and Gavin Blake for their guidance with our data collection and GIS analysis.

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