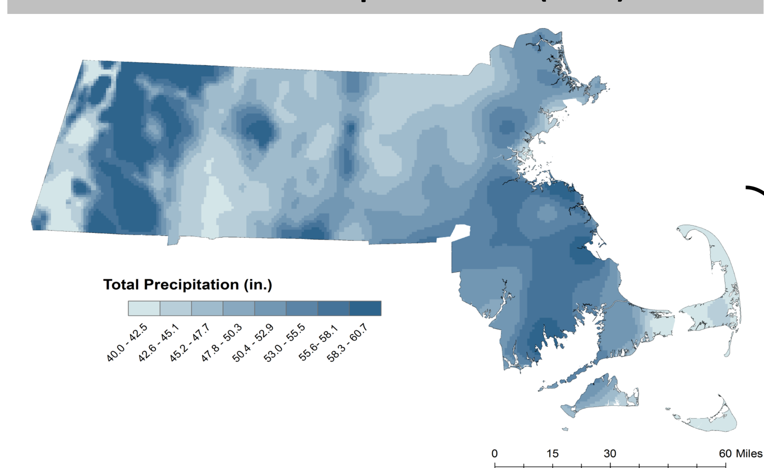
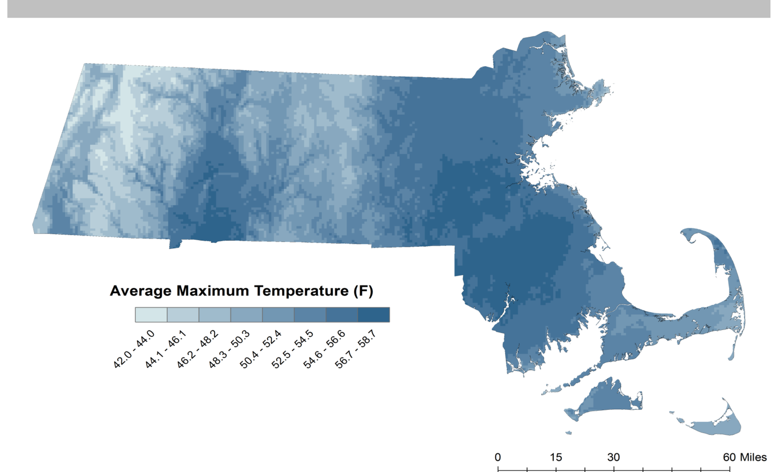
The Buzz on West Nile Virus: A Vulnerability Analysis

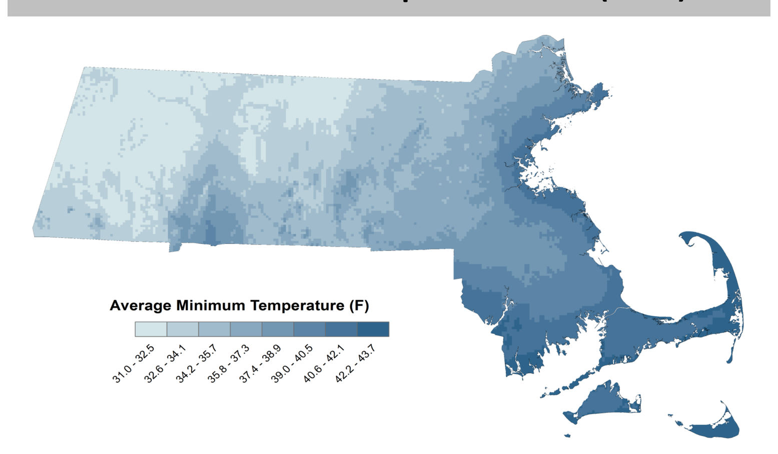
Total Precipitation (0.2)



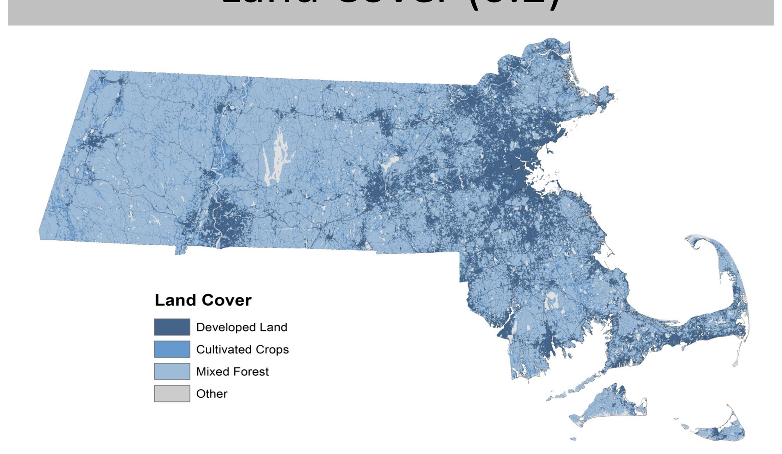
Minimum Temperature (0.2)



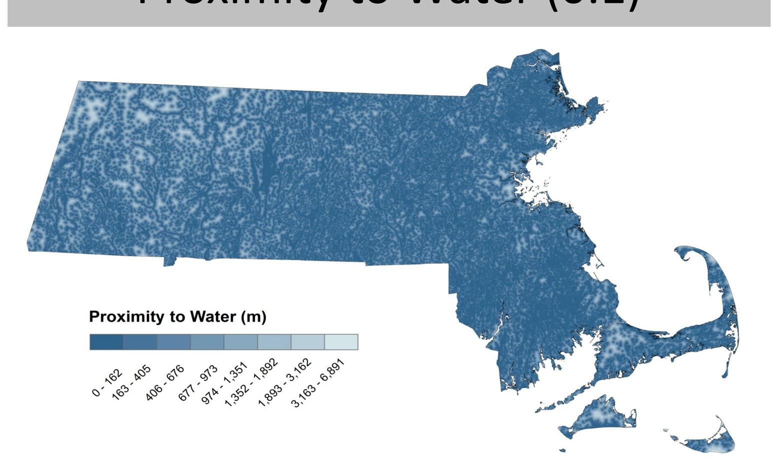
Maximum Temperature (0.2)



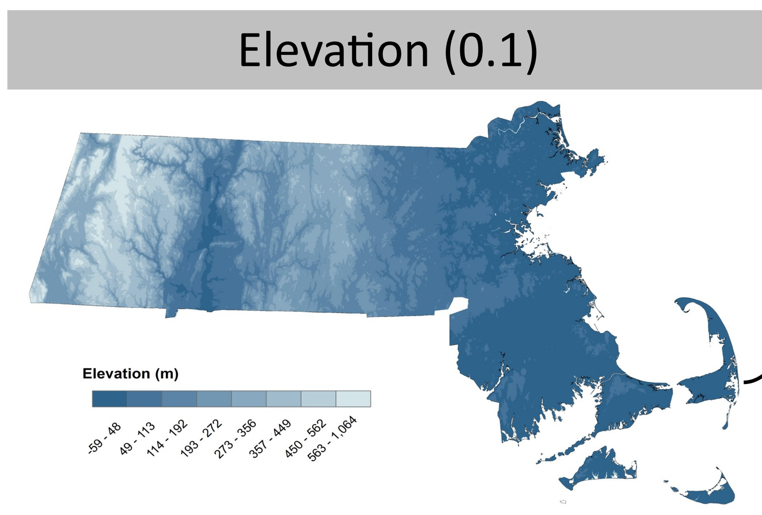
Land Cover (0.2)



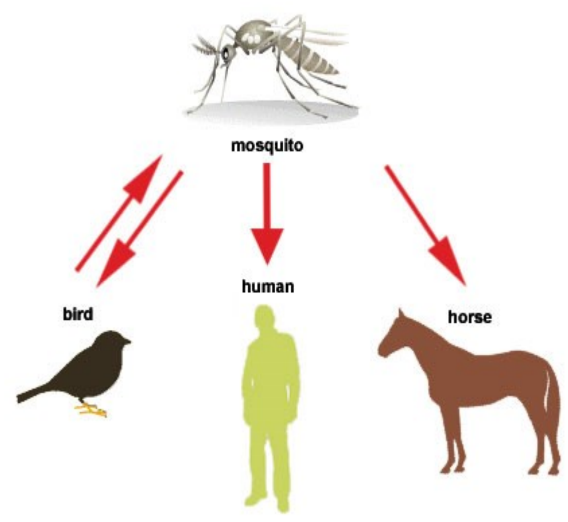
Proximity to Water (0.1)



Elevation (0.1)

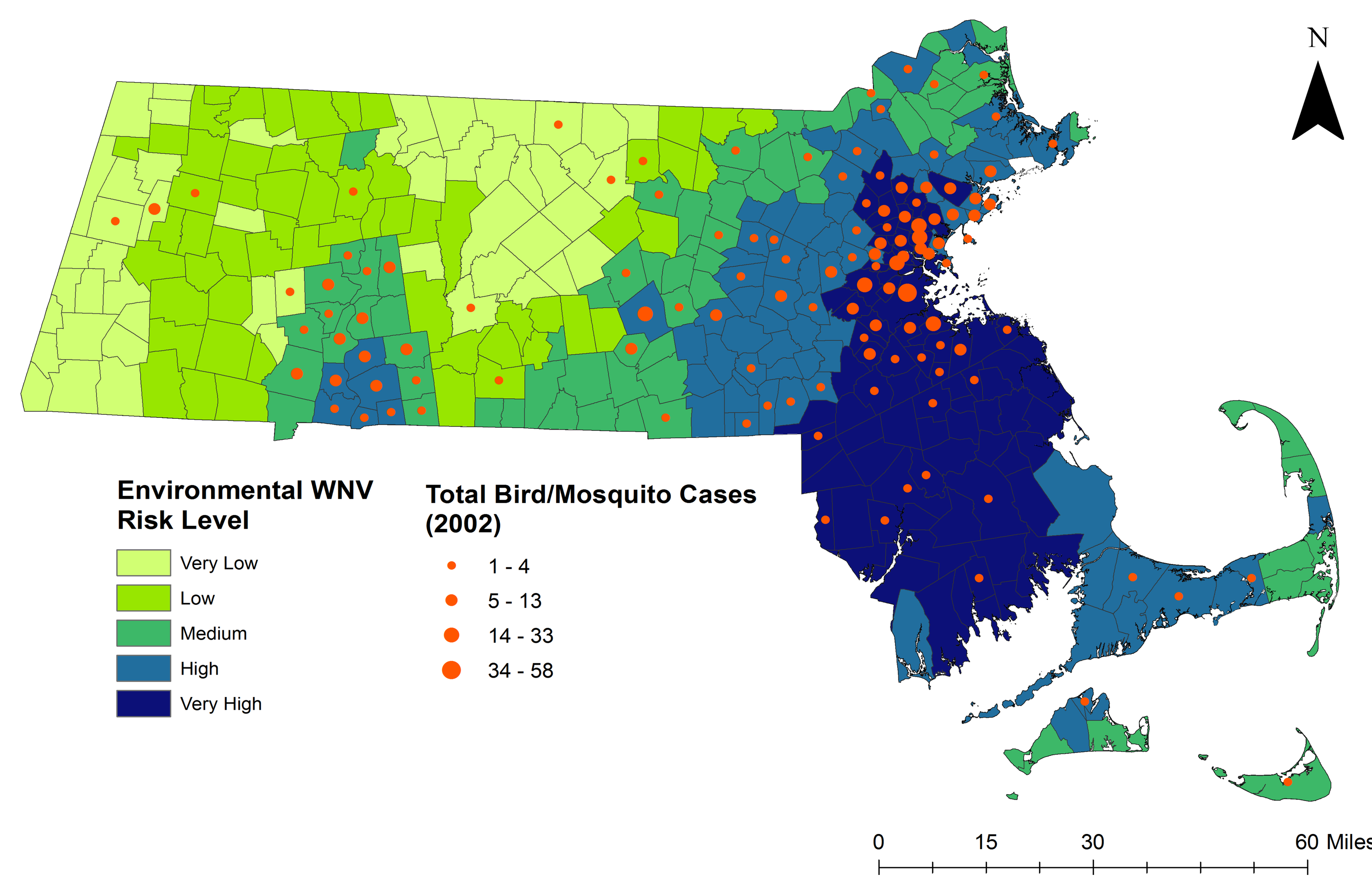


Introduction

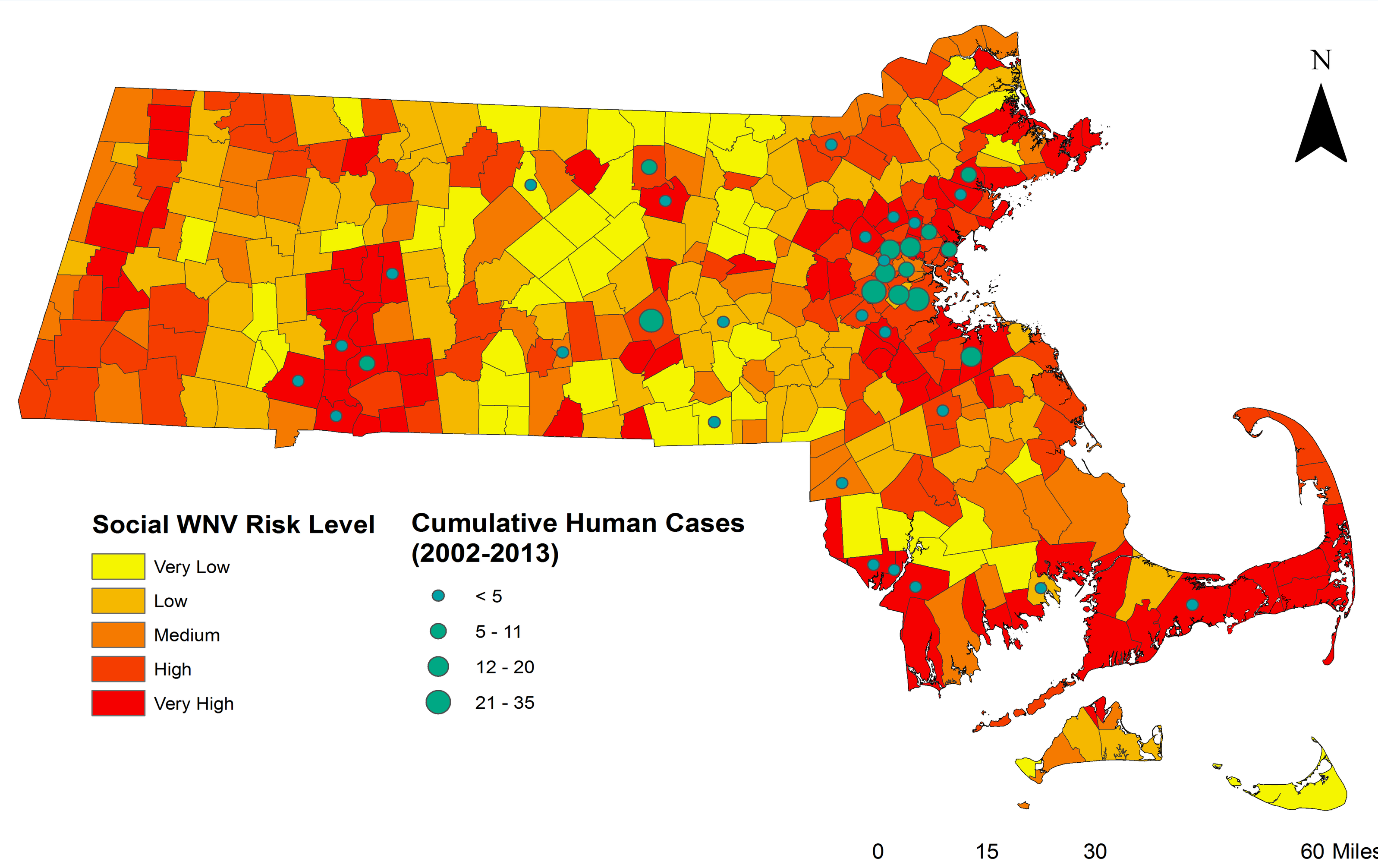


West Nile Virus (WNV) is considered one of the most clinically important arboviruses in North America today. WNV has remained a public health concern in the Northeast ever since its arrival in the United States in 1999 in New York City. The state of Massachusetts has never experienced a major outbreak but has consistently reported human cases since 2002, with increasing numbers over the past few years. Humans, birds, and horses are all at risk of infection through a mosquito vector. Because there is no vaccine, vector surveillance and control remain the most effective tools for disease prevention. Hence, the goal of this project is to utilize GIS data to evaluate the potential mosquito habitat and the ensuing spatial risk of WNV within Massachusetts. This study uses climatic, landscape, and socio-economic variables correlated with the disease in order to determine regions at highest risk for transmission of the virus. The accuracy of these high-risk areas is assessed by comparing them against positive mosquito, dead bird, and human case data on the disease.

Environmental Vulnerability to WNV

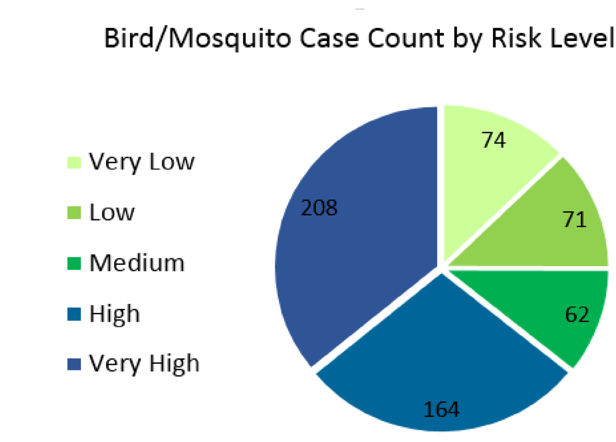


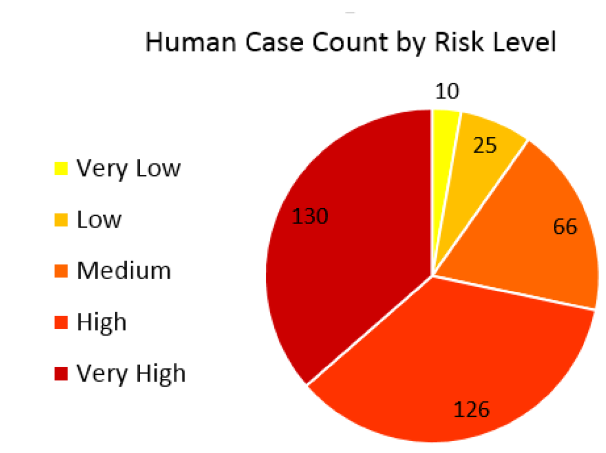
Social Vulnerability to WNV



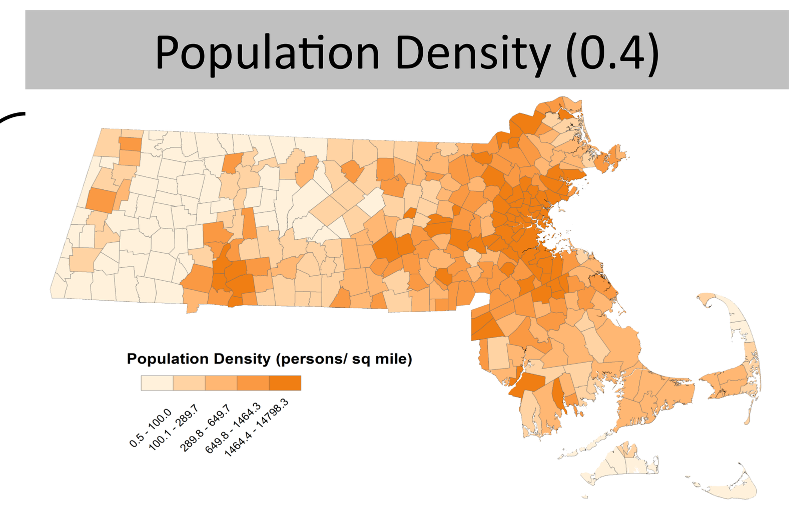
Methodology: Environmental

Environmental vulnerability refers to the likelihood of mosquito establishment in an area, based on the climatic and landscape factors displayed to the left. Prime mosquito habitat is positively associated with higher minimum/maximum temperatures, higher rainfall, closer proximity to water, and more developed land; mosquito habitat is negatively associated with elevation. Each of these variables were reranked from low risk (unsuitable habitat) to high risk (suitable habitat) and then all layers were added together in terms of their relative weights, as shown in parentheses next to each variable. Rainfall, temperature, and developed land were assigned higher weights because of their strong correlation with mosquito populations. In the resulting map, the mean risk value was calculated for each town in Massachusetts.

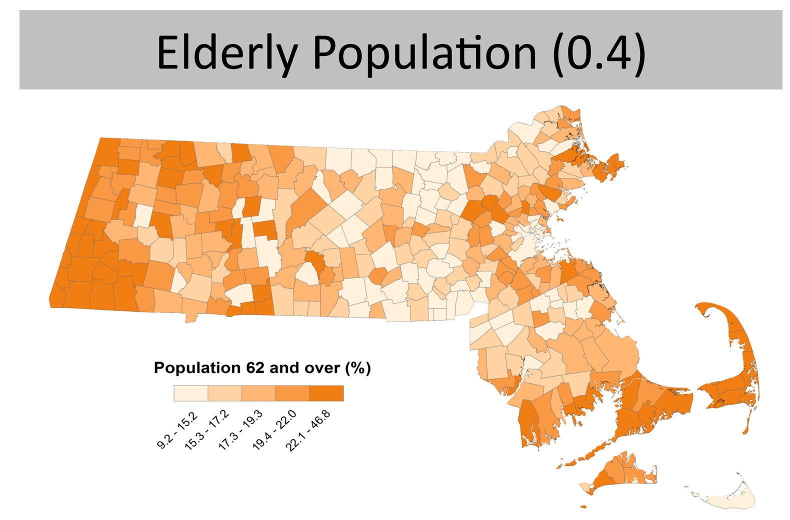




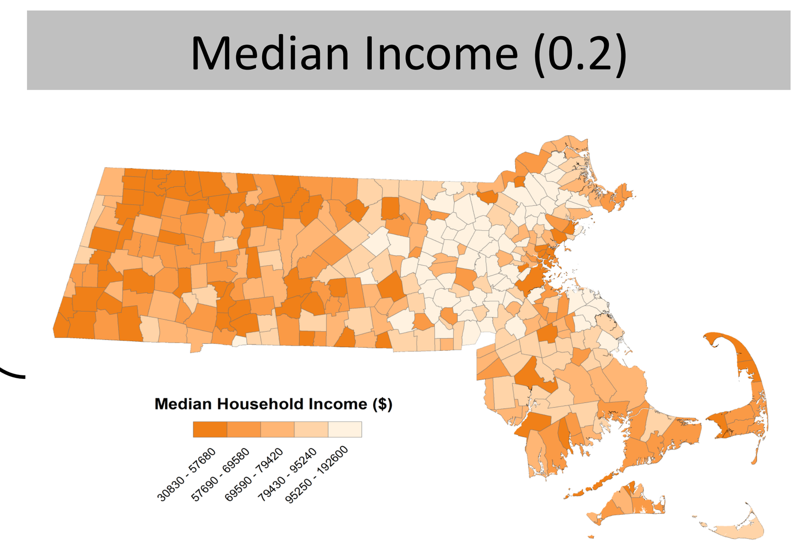
Population Density (0.4)



Elderly Population (0.4)



Median Income (0.2)



Methodology: Social

The three social factors most commonly associated with human incidence of WNV are dense populations, large elderly populations (aged 62 and over), and lower-income areas. These three variables were mapped for each municipality in Massachusetts. Again, maps were ranked from least risk to highest risk, and layers were added together in terms of their relative weights. Because the relationship between income and WNV incidence is more contested in the literature, it was assigned a lower weight than the other two social variables.

Accuracy Assessment

Case data was obtained from the Massachusetts Department of Public Health arbovirus surveillance program. The bird/mosquito case data represents all positively-tested mosquitos and dead birds found in 2002 – the year in which WNV emerged as a public health threat in the state. Because environmental factors are often most influential when a vector-borne disease first emerges and before it becomes endemic, case data from the year of WNV emergence is sufficient for this study. Human case data was obtained from the same source; however, due to limited case numbers and data suppression rules, the human case counts are cumulative between 2002 to 2013. Each set of case data was overlaid with its respective risk map.

Results and Limitations

In the risk maps above, environmental vulnerability yields a more clear spatial trend than social vulnerability. However, in both cases, it appears that high risk areas are concentrated along the coast of the state. Additionally, both sets of case data roughly follow the same risk trends as their respective vulnerability maps. In fact, as shown in the pie charts, 65% of the total bird/mosquito cases fall within the "high" and "very high" risk areas. Similarly, 72% of human cases fall within the "high" and "very high" risk areas. Theoretically, since human cases are not only dependent on social factors but also on vector behavior, human cases depend on both social and environmental factors. Hence, the high percentage of correlating risk level and case count is surprising. Yet the accuracy assessment in itself may be skewed due to biased data collection. For example, towns with more public health resources may set out more mosquito traps and consequently report greater numbers of mosquitos. Further, the human health data was not normalized based on population. Finally, because human health data is sensitive and difficult to obtain, the specific case data for a number of cities was lacking in this analysis.

Conclusions

Despite these limitations, the final vulnerability maps appear to somewhat accurately predict where animal and human cases have occurred within the last decade. Hence, these risk maps may be useful in forecasting vulnerable areas in the future, especially in light of increasing temperature and rainfall levels due to climate change. Further, because the maps display vulnerability on the city level, this information may be useful to municipalities seeking data and guidance on mosquito abatement for the purposes of disease control.

Tufts

Cartographer: Hanna Ehrlich

Date: December 12, 2014
Projection: Massachusetts State Plane
Sources: Massachusetts Department of Public Health; PRISM Climate Group 30-Year Normals; National Land Cover Database; MassGIS; American Community Survey 2013 5-year estimates