Lyme Disease in Massachusetts, 2000-2015:

Case density dynamics, land use, and land cover

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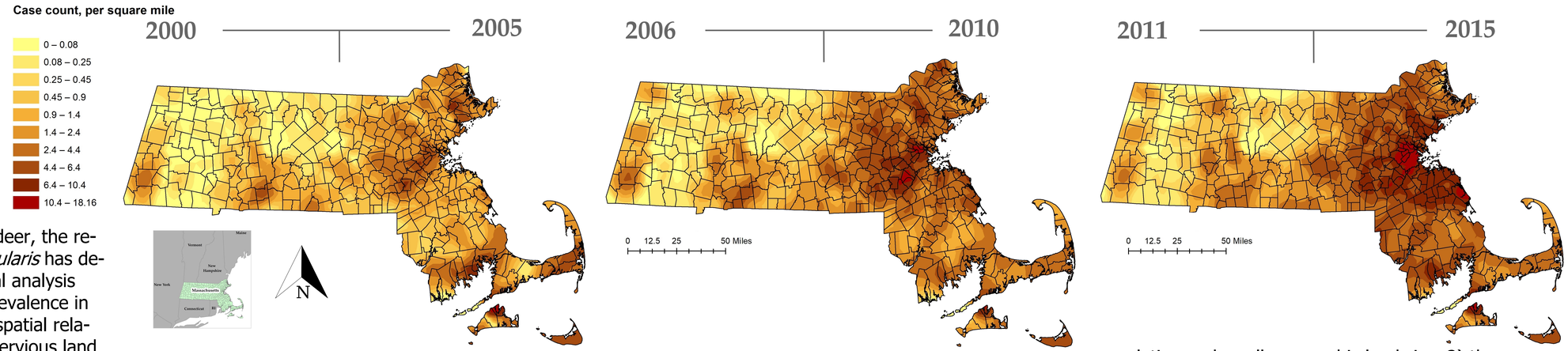
Introduction

First discovered in a group of children in Lyme, Connecticut in the mid-1970s, Lyme disease has spread rapidly across New England. In particular, Massachusetts has experienced a rapid and unrelenting epidemic, with case incidence in humans growing each year. While there are several hypotheses regarding factors that have facilitated the spread of Lyme disease in Massachusetts, there is no definitive consensus among scientists.[1] A prevailing theory posits that human encroachment on the natural habitat of white tailed deer, the reproductive host of Lyme's tick vector, *Ixodes scapularis* has definitively contributed to the epidemic.[2,3] This spatial analysis presents the most recent data on Lyme disease prevalence in the State between the years 2000 and 2015. The spatial relationship between deciduous forest land cover, impervious land use, and human case incidence if explored.

Methodology

Lyme disease case prevalence data, by municipality were acquired from the Massachusetts Department of Public Health (MDPH). Due to MDPH data suppression rules, cities and towns with populations <50,000 have case counts <5 reported as such for confidentiality purposes. An *a priori* decision was made to estimate case prevalence for cities and towns in the latter category as 2.5. First, a case prevalence table, by town, was joined to a MassGIS shapefile of all towns in Massachusetts. Next, case density was calculated for each town based on the square mileage of each municipality. In order to reduce the artificiality of municipal borders given a free-roaming disease vector, geostatistical areal interpolation was used to extend kriging theory to case density data aggregated over polygons. To determine change in case density across time, differences in case counts per square mile were calculated for all municipalities for two time periods (2000-2005 to 2006-2010, and 2006-2010 to 2011-2015).[4] Finally, deciduous forest cover and developed land usage raster files from 2011 were overlaid onto a choropleth map of Lyme disease case prevalence by town for the same year.

Figure 1: Case density (case count, per square mile)



Results

Case density data by municipality demonstrate increased prevalence per square mile between 2000 and 2015, particularly in peri-urban areas around the cities of Boston, Worcester, and Springfield between 2000-2015 (Fig. 1). Case densities between 2000-2005 to 2006-2010 and 2006-2010 to 2011-2015 showed marked changes over time (Fig. 2). In the first time period, towns with increased density of >3 cases (displayed in orange and red) were clustered around Boston and the south shore. In the second time period, increases in case density >3 cases remained spatially clustered, but migrated westerly and northerly. Additionally, all towns which had decreased case densities (displayed in dark green) in the first period, disappeared in the second period. Finally, for the year 2011, descriptive spatial overlays demonstrate a possible linear relationship between developed land and high disease prevalence, and deciduous forest cover and low disease prevalence (Fig. 3).

Discussion

These findings shed light on Lyme disease case density dynamics, land use, and land cover in Massachusetts. These data build on current knowledge (esp. Fig. 1) given that interpolation allows a deeper understanding of boundaries of risk that extend beyond municipal borders. Limitations of this analysis include: 1) case density in Boston may be skewed due to its high population and small geographic land size, 2) the overlap in year groupings (2006-2010) in Fig. 2 may attenuate change over time versus using discrete groupings, and 3) Fig.3 is for visualization purposes only, as no correlations have been calculated based on density of land use and land cover and disease rates by municipality, though this is a recommended area for future research.

Fig. 2: Change in case density (case count, per square mile), 2000-2005 to 2006-2010 and 2006-2010 to 2011-2015

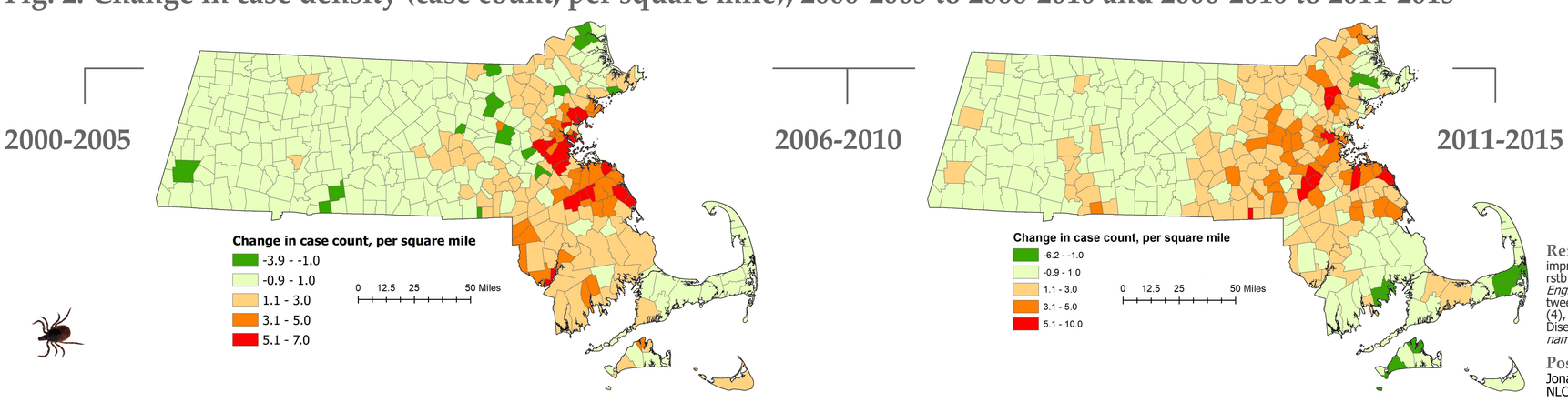
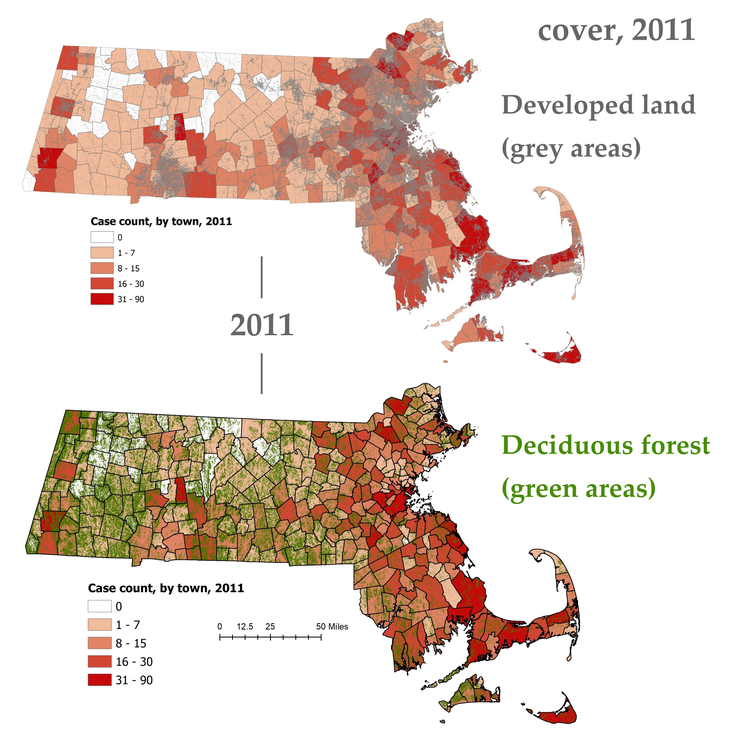


Figure 3: Lyme disease prevalence, land use & land cover, 2011



References: (1) Kilpatrick, A. M., et al. (2017). Lyme disease ecology in a changing world: Consensus, uncertainty and critical gaps for improving control. *Philosophical Transactions of the Royal Society B: Biological Sciences,372*(1722), 20160117. doi:10.1098/rstb.2016.0117. (2) Lastavica, C. C., et al. (1989). Rapid Emergence of a Focal Epidemic of Lyme Disease in Coastal Massachusetts. *New England Journal of Medicine,320*(3), 133-137. doi:10.1056/nejm198901193200301. (3) Kilpatrick, H. J., et al. (2014). The Relationship Between Deer Density, Tick Abundance, and Human Cases of Lyme Disease in a Residential Community. *Journal of Medical Entomology,51*(4), 777-784. doi:10.1603/me13232. (4) Haddad, H., et al. (2015). Web Mapping and Behavior Pattern Extraction Tools to Assess Lyme Disease Risk for Humans in Peri-Urban Forests. *Wiley Series in Probability and Statistics Analyzing and Modeling Spatial and Temporal Dynamics of Infectious Diseases*,371-402. doi:10.1002/9781118630013.ch18.

Poster attributes:
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