PLAN AHEAD: Mapping Transportation Disadvantage & Extreme Weather Risk in Boston

Introduction

As the effects of climate change are exacerbated, the frequency of extreme weather events will increase. Many of these events will necessitate the evacuation of large populations. For those populations with access to personal vehicles and the funds or ability to relocate for an undetermined period of time, the evacuation process may be rather simple. But for those who do not own cars, or who are otherwise transportation disadvantaged, evacuation procedures could be much more complicated.

Transportation disadvantage (TD) is a metric that combines socioeconomic, environmental, and behavioral factors, including populations who are carless (whether by choice or not), minority, low income, elderly, disabled, those with limited mobility or health problems, homeless, children without adults present, or those with limited English proficiency (USGAO 2006, 15; Renne et al. 2011, 420).

The primary challenge in planning for the evacuation of TD populations is simply identifying where they are located. The multitude of factors that contribute to TD, coupled with the difficulty of pinpointing populations at scales more granular than typical census geographies, make it very difficult to know exactly where these populations may be living.

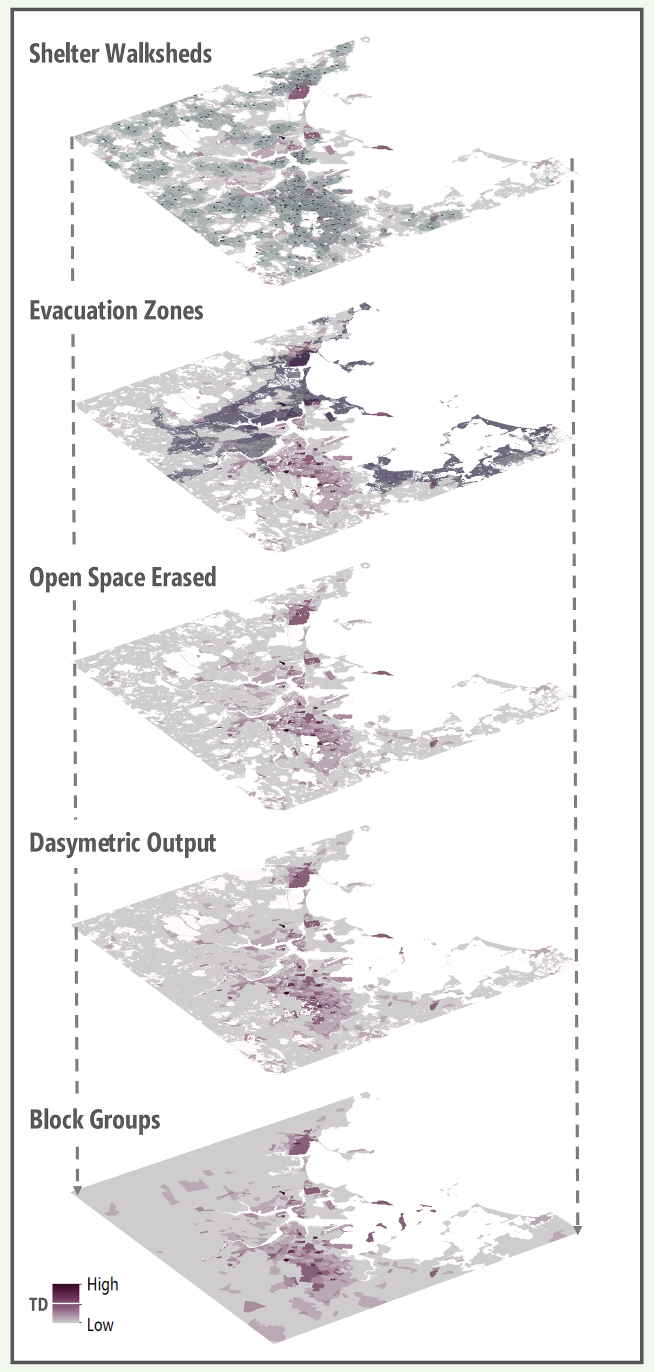
This project addresses the following research question: **where are TD populations with respect to extreme weather risk in the Boston metropolitan area?** In an effort to address this question, this project explores TD populations' access to shelters and the proportion of TD populations located in evacuation zones, which are derived from flooding estimates.

Data Sources

Block group geographies were obtained from the US Census website. Demographic and socioeconomic data was gathered from American Fact Finder and Social Explorer, with the majority of data sourced from the 2017 American Community Survey 5-year estimates. Seven vulnerability attributes were selected: vehicle access, children, elderly, minority, English proficiency, disability, and poverty.

Several layers were downloaded from MassGIS, including Towns, Schools, and Protected and Recreational OpenSpace. All public schools outside of evacuation zones were assumed to be emergency shelters. Street data from StreetMap and the 2016 National Land Cover Database (NLCD) raster layer were obtained from the Tufts M:Drive. Hurricane Evacuation Zones were retrieved from the US Army Corps of Engineers, New England District. Lastly, the Environmental Protection Agency's (EPA) Intelligent Dasymetric Mapping (IDM) Toolbox was obtained from the EPA website.

The Mapping Process



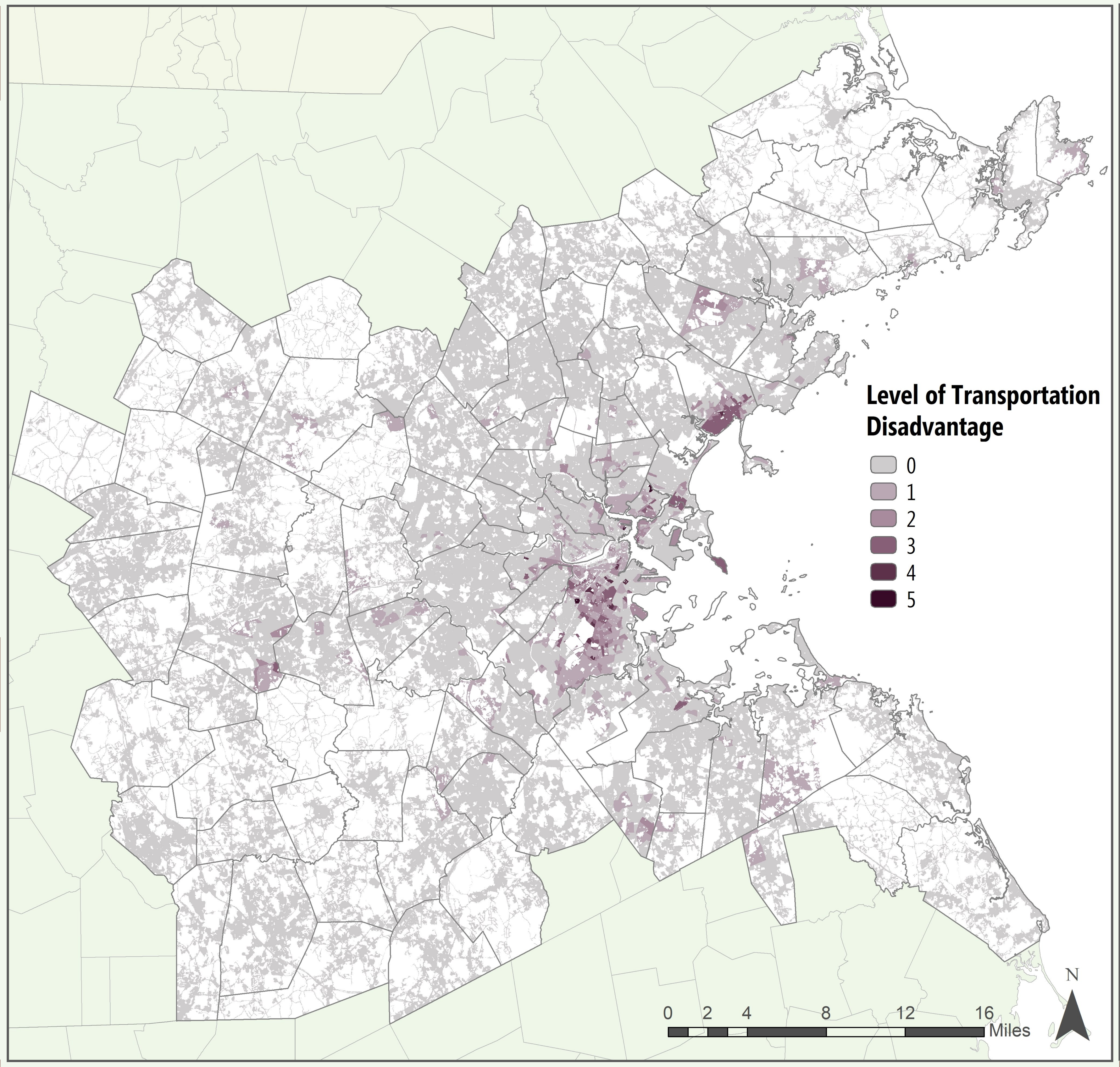
Methods

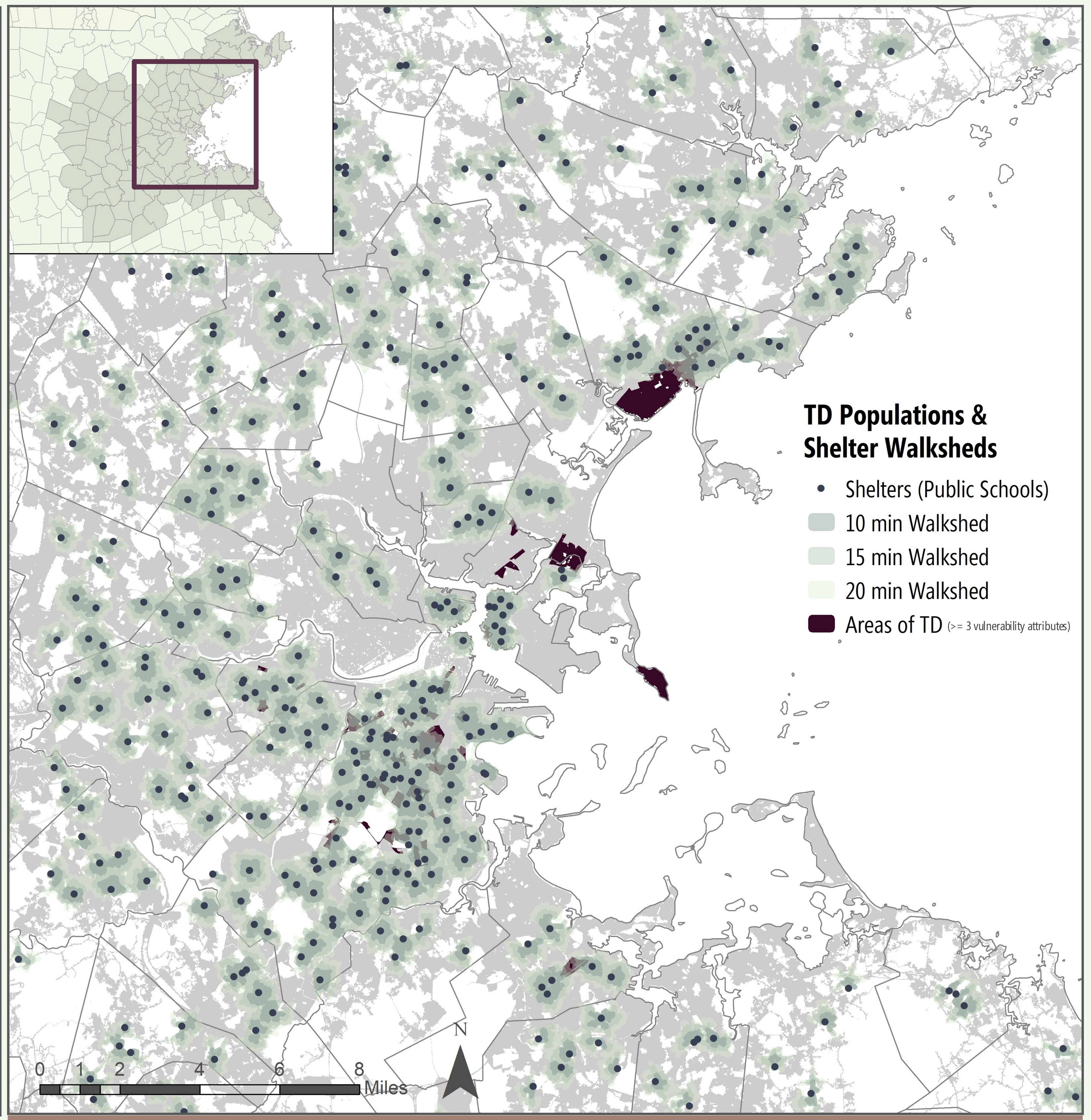
The study area was defined as the 97 cities and towns under the Boston Regional Metropolitan Planning Organization.

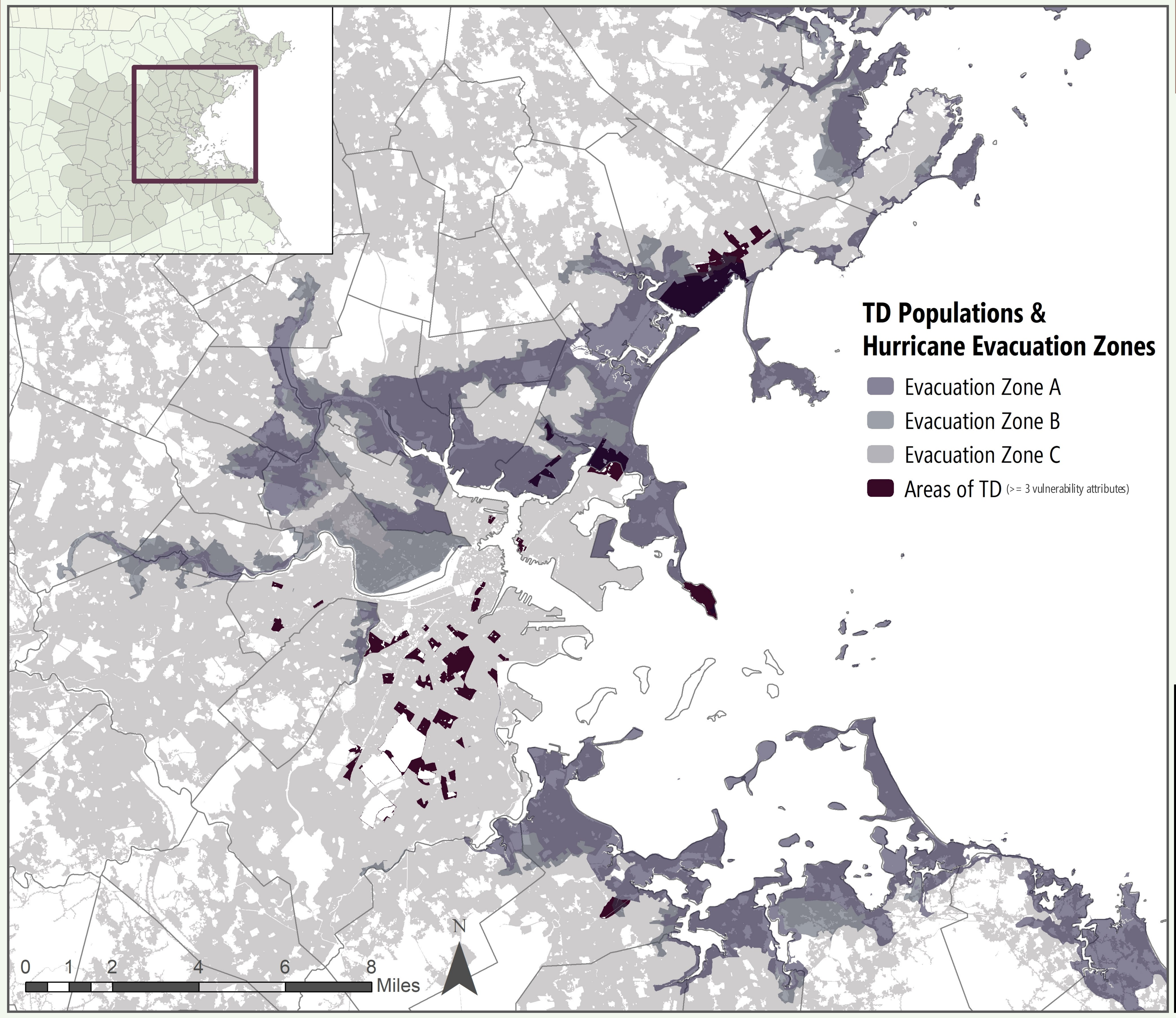
TD was first mapped by block group as a standard choropleth map. A binary system was used to code block groups as "vulnerable" or "not vulnerable" for each vulnerability attribute. The threshold for vulnerability was two standard deviations from the state mean. This method assumed uniform population distribution across census block groups.

The second method employed the EPA IDM Toolbox which used the NLCD raster layer to remove non-residential, or "uninhabitable," pixels from the study area and to disaggregate the census-level population to pixels based on low, medium, and high density. This resulted in a raster layer with new population counts and densities, varying by pixel within each block group. This layer was further refined by erasing known areas of open space.

Network analysis was used to create three walksheds around each school, representing areas within 10, 15, and 20 minute walks from each shelter. A series of spatial and attribute queries were used to calculate the population within each of these walksheds and to compare the proportion of TD to total population. A similar process was used to assess population within evacuation zones. The results are displayed in the tables to the right.







Conclusions

While this analysis is not able to pinpoint specific TD households in need of evacuation assistance, it does demonstrate the areas in which residents may have a greater propensity to be vulnerable in an extreme weather event. The results suggest that TD populations do not make up a large proportion of those living in evacuation zones *or* those farther than a 20 minute walk from a shelter, but when these variables are combined, we find that 13% of the total estimated TD population appears to reside both in an evacuation zone *and* farther than a 20 minute walk from a shelter. It is important to note that even those who live very close to shelters may not be able to transport themselves. This kind of mapping, paired with in-person outreach, information campaigns, or evacuation registries, could help both state-level emergency management professionals, as well as community organizations, to understand which areas to prioritize during an evacuation.

Future research on this topic will hopefully utilize finer-grained parcel data, more accurate shelter and evacuation assembly points, and a principal components analysis to produce a more precise analysis of where TD populations are located. These changes in methodology will improve the precision of identifying residential areas, utilize accurate emergency shelter information (as opposed to proxies), and reduce potential collinearity.

TD Population Within Walksheds

Walkshed	TD Population
10 min	30,920 (5.7%)
15 min	46,496 (5.0%)
20 min	53,832 (4.3%)
> 20 min	11,988 (1.0%)

TD Population Within Evacuation Zones

Evacuation Zone	TD Population
A	9,529 (4.2%)
B	1,686 (1.3%)
C	0 (0%)
Outside Zones	54,605 (2.6%)

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Sources: ACS 2017 (5-year estimates), Bian et al. 2017, Fitzpatrick et al. 2006, Fotheringham et al. 1991, Maantay et al. 2007, MassGIS, MRLC consortium, Nelson et al. 2015, NH GRANIT, Renne et al. 2011, RIGIS, Shay et al. 2016, StreetMap, US Army Corps of Engineers, US Census 2010, US EPA, USGAO

Projection and Coordinate System: Lambert Conformal Conic, NAD 1983 StatePlane Massachusetts Mainland FIPS 2001 (Meters)

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