The Color of Water

A Report on the Human Right to Water in the City of Boston

Massachusetts Global Action
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Introduction - The Color of Water in Boston

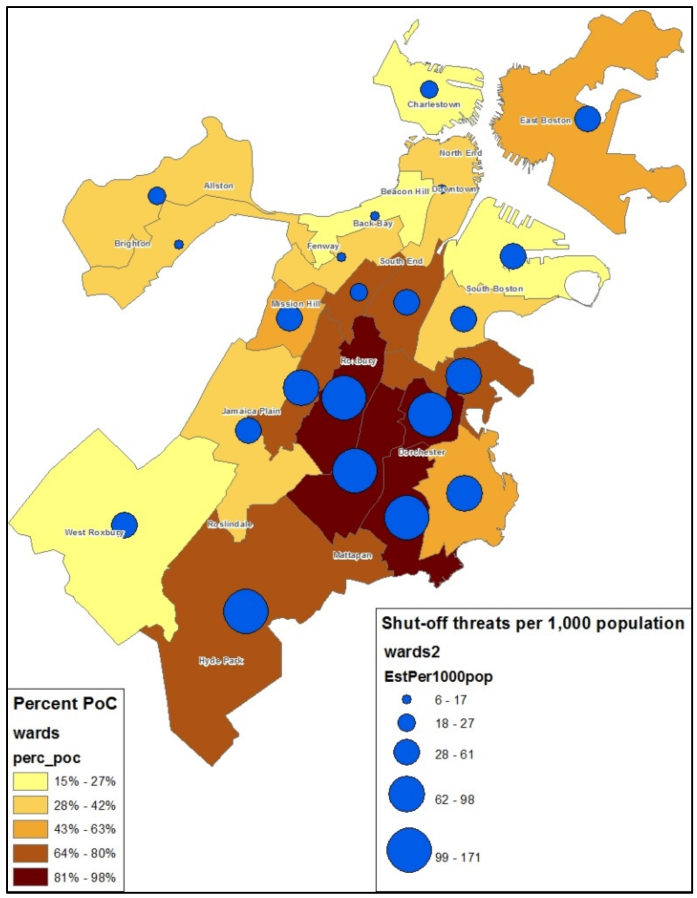
Access to a sufficient, safe and affordable supply of water is fundamental to the health and well-being of a community. However, thousands of people are threatened with shutoffs of residential water service each year in Boston. These are usually a consequence of account delinquency; lower-income neighborhoods – home to large concentrations of people of color – are more likely to experience the water insecurity that comes with shutoffs. This is magnified in neighborhoods with a greater share of multi-family dwellings – also co-incident with lower income neighborhoods. Disruptions to water service can result in serious hardships and prevent the enjoyment of a fundamental human right.

Our project explores the relationship between income, race and threatened water shutoffs. We began our research with the hypothesis that the threat of water shutoffs rises as neighborhood income decreases or percentage of people of color increases. The findings presented below show the disparities in water shutoffs across Boston and reveal an especially striking relationship between water shutoffs and race: for every 2% increase in people of color by ward, there is a 3% increase in shutoff notices.

The Data

We obtained data on threatened water shut-offs from the Boston Water and Sewer Commission (BWSC). We received one batch of data in 2007, and another in 2012 covering the years 2008-2011. The data was summarized in two ways: threatened shutoffs by land-use code, and threatened shutoffs by ward. Before running our analysis, we estimated how many of the shutoffs in each ward were for *residential* parcels, as commercial and industrial water access are presumed to present much less of a direct hardship on residents. Threatened water shutoffs represent notices the BWSC must send to customers before ceasing to provide water and are not the same as actual utility water shutoffs.

We downloaded GIS shapefiles, which allowed for geographical analysis and mapping, from MIT GeoWeb, the Boston Redevelopment Authority (BRA), and the US Census website. Demographic, land use, and housing data comes from the 2010 Decennial Census, the American Community Survey, the Boston Assessing Department, and the BRA.



Map 1 – Race and Shut-offs by Ward

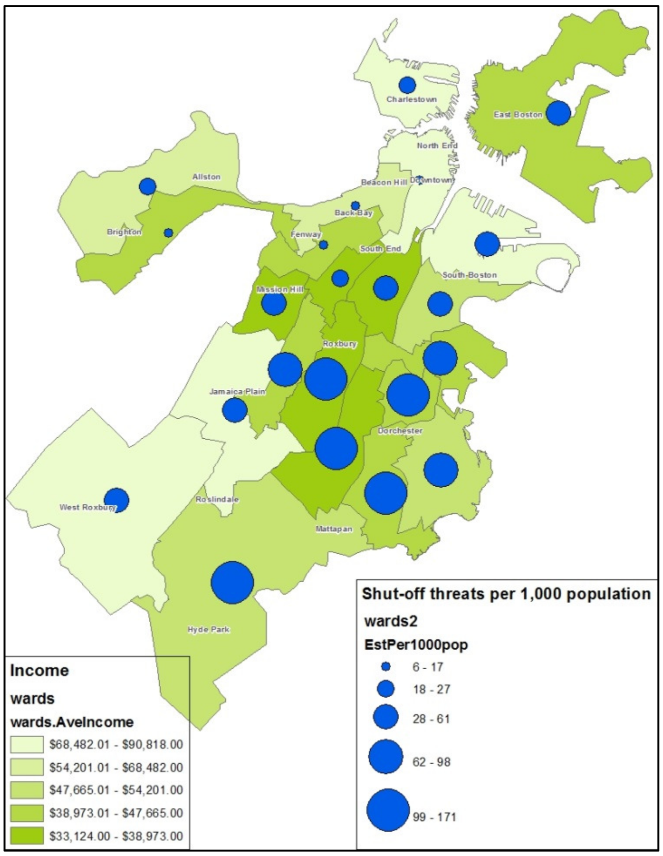
Statistical Analysis

Descriptive Statistics

Table 1 (see Appendix) shows descriptive statistics for several variables, as well as the raw data from each of Boston's twenty-two wards. There is considerable variation across Boston's wards for all of these variables. For example, on average 55% of the residents in a ward are people of color, but the full spectrum ranges from just 15%

(Ward 6, South Boston) to 98% (Ward 14, parts of Roxbury, Dorchester, and Mattapan). Similarly, the number of shutoff notices served between 2008 and 2011 show wide disparities. While Ward 4 received notices at a rate of 6 per 1,000 residents, Ward 17 received 171 notices for every 1,000 residents over the four years. We estimate that Ward 14 has received more residential shut-off notices than there are residential parcels in that ward, reflected in the Total Notices per 100 Residential Parcels column. This suggests that numerous residential parcels received multiple shut-off notices over the study period.

The descriptive statistics already begin to suggest that diversity in race and income across the city is related to disparities in access to water. Mapping this data further adds to these suspicions. In the four maps, the blue circles represent the total shutoff notices per 1,000 residents received by each ward from 2008 to 2011. The varying colors reflect demographic data as of 2010. Map 1 shows percent people of color, Map 2 shows income, Map 3 shows median property values, while Map 4 shows the rate of vacant housing units. Confirming a relationship between these different variables requires regression analysis[1].



Map 2 – Income and Shutoffs by Ward

2007 Statistical Analysis

We decided to combine analyze shutoff notices as two different rates – shutoffs per thousand people and shutoffs per 100 parcels. This would allow us to incorporate those variables into two different dependent variables, and see which of the other variables showed the most notable relationship with either of these two new calculations.

To get a sense of what would be most meaningful to explore further, we produced a lattice plot (Illustration 1). From the lattice plot, it appeared that race did have some correlation; the number of threats seems to increase as the percentage people of color rises. In addition, it looked like median home value had a negative correlation with threats, though the line appears to arc. We calculated the natural log of the median home value, therefore, and imported that into our data table. We ran a regression first between threats ln(medvalue), and then between threats and median value. The natural log indeed helped show a stronger relationship, so from that point on we utilized ln(median home value) as the income proxy. We then ran two new lattice plots, first using shutoffs per thousand people and then using shutoffs per 100 parcels. See illustrations 2 and 3.

[1] A cheat sheet may be helpful for those unfamiliar (or rusty) with regression. The measure R describes the strength of the relationship between two variables as graphed on a scatterplot (see *Illustration 4*). B is the slope of the line in the scatterplot, while Beta is a standardized measure of B used in multiple regression. R-squared describes the amount of variation in the dependent variable that can be explained by the independent variable as a percentage. A relationship is statistically significant – that is, not likely the product of chance – if its significance score is less than or equal to .050.

This latter plot, using the shutoffs per 100 parcels showed a striking correlation both between race and between median home value. We decided to pursue these further with regressions. The resulting R2 value was a somewhat disappointing 0.3412, so we decided to see if the relationship was clearer without the natural log (rebutting our earlier assumption). While that produced a coefficient of somewhat greater significance, the R2 value was only 0.1601, accounting for much less of the variation that the relationship using the natural log. We then plotted a graph of the first of these two regressions (see illustration 4).

The final bivariate regression we ran was between threatened shutoffs per 100 parcels and percentage multifamily houses. We wanted to explore whether threatened shutoffs increased with larger house sizes – the water bill for a multifamily house would tend to be much higher than for a single-family house. In addition, because apartments in multi-unit buildings are often not metered separately, an account cut off in a multi-family house tends to affect greater numbers of people. A relationship between these two variables would therefore be notable. The resulting R2 value of 0.1064, however, indicates that the share of multifamily homes can only account for 10% of the variation between water cutoff values.

To evaluate if the independent variables together have a relationship, or influence each other in the interaction with water cutoffs, we conducted a series of multivariate regressions. We started by adding multifamily houses onto the Threats vs. People of Color regression model, then one-by-one added first median value and then population. None of these had a notable effect; the R2 value stayed about the same, while the coefficients of the slopes lost in significance.

2012 Statistical Analysis

We followed a similar procedure in our 2012 analysis. First we produced our variables, which included several not included in 2007. Using median household income data from Census block group data, along with the number of households per Census block, we were able to create an estimate of Average Income per ward. The BRA recently published data on the number of housing units across wards, along with how many units were vacant in 2010, which allowed us to create a Vacancy Rate variable. Since we had data from 2008 to 2011, we combined these numbers to produce a variable for Total Residential Notices, as well as Total Notices per 1,000 Residents. Finally, we also explored generating the natural log of median housing prices, though this did not seem to produce a significantly different analysis.

We again produced a Lattice Plot (*Illustration 5*) to get a sense of what relationships were worth further exploration. A visual inspection of the lattice plot immediately suggests correlations between several pairs of variables, such as Percent Multifamily Units and Shutoffs per 1,000 Residents (TotalRate), Vacancy Rate and Total Rate, Percent People of Color and Total Rate, Average Income and Total Rate, Median Property Value and Total Rate, Percent People of Color and Average Income, and Percent People of Color and Property Value. We ran numerous regressions, with some of the most interesting summarized in *Table 2* below. Note that in order to produce larger and more meaningful B (slope) values, some variables with dollars for units were divided by 1,000 before computation, and are indicated with "/1,000."

Table 2 - 2012 Bivariate Regressions

Independent Variable	Dependent Variable	R	R-Squared	B (slope)	Constant	Significance
%POC	Average Income	0.742	0.550	-492.280	80531.57	0.000
Vacancy Rate		0.008	0.000	-64.565	54017	0.973
%POC	Median Property Value	0.677	0.458	-1926.127	413237.1	0.001
Average Income		0.563	0.317	2.415	178354.2	0.006
Vacancy Rate		0.108	0.012	3873.657	279375	0.632
Median Property value / 1,000	Shutoffs per 100 Res. Parcels	0.672	0.452	-0.264	114.463	0.001
%PoC		0.867	0.804	1.003	-21	0.000
Vacancy Rate		0.459	0.210	6.459	-13.973	0.032
%PoC	Shutoffs per 1,000 Residents	0.791	0.625	1.489	-15.152	0.000
Median Property Value / 1,000		0.652	0.425	-0.432	199.263	0.001
Ln(Median Property Value)		0.653	0.426	-140.637	1840	0.001
Vacancy Rate		0.415	0.172	9.828	-5.259	0.055
% Multifamily Parcels		0.723	0.522	2.388	-13.521	0.000
Average Income/1,000		0.362	0.131	-1.028	121.549	0.097

The most striking results from this table are that Percent People of Color is significantly related to Average Income, Median Property Value, Shutoffs per 100 Residential Parcels, and Shutoffs per 1,000 Residents. All of these are strong relationships as indicated by R and R-Squared. The B value suggests that for every 1 percentage point increase in people of color, the rate of Shutoffs per 1,000 Residents increases by 1.5. R-Squared indicates that 63% of the variation in Shutoffs per 1,000 Residents[2] is explained by percent people of color.

Average Income, surprisingly, is not significantly related to Shutoffs per 1,000 Residents, though it is strongly related to Median Property Value. Property Value is strongly associated with Shutoffs, as is the prevalence of multifamily parcels. Vacancy Rate just barely fails to cross the threshold of significance for Shutoffs Per 1,000 Residents, but is significant for Shutoffs per 100 Residential Parcels.

With these results in mind, we finally ran mutlivariate regressions. In Table 3 below the dependent variable is Shutoffs per 1,000 Residents, while Table 4 shows Shutoffs per 100 Residential Parcels. The R and R-Squared values from both regressions show a strong relationship, and a very high percentage of the variation in the dependent variables explained by the independent variables. Both tests are significance. In both cases, Percent People of Color is a significant variable and has the largest Beta value. Property Value and Percent Multifamily Parcels are not significant in either test. The significance of Average Income, Percent Residential Parcels, and Vacancy Rate conflict between the two tests.

[2] You will note that the R-Squared values do not add up to 100%. Bivariate regression only considers the relationship between *two* variables, but obviously many different factors are at play in the real world. Multivariate regression, the next step, takes into account these interaction effects.

Table 3 - Multivariate Regression: Shutoffs per 1,000 Residents

R	R-Squared	Adjusted R-squared	Std Error	Constant	Significance
0.931	0.867	0.814	21.23	-256.799	0.000
Independent Variable	**B (slope)**	**Standard Error**	**Beta**	**Significance**	
%POC	1.672	0.391	0.888	0.001	
Average Income / 1,000	1.075	0.427	0.379	0.024	
Median Property value / 1,000	-0.196	0.106	-0.296	0.086	
% Multifamily	0.07	0.53	0.021	0.896	
% Residential	2.182	0.958	0.255	0.038	
Vacancy Rate	5.346	2.857	0.226	0.081	

Table 4 - Multivariate Regression: Shutoffs per 100 Res. Parcels

R	R-Squared	Adjusted R-squared	Std Error	Constant	Significance
0.965	0.931	0.903	9.110	-112.513	0.000
Independent Variable	**B (slope)**	**Standard Error**	**Beta**	**Significance**	
%POC	0.906	0.168	0.809	0.000	
Average Income / 1,000	0.258	0.183	0.153	0.180	
Median Property value / 1,000	-0.076	0.046	-0.193	0.117	
% Multifamily	0.17	0.227	0.086	0.467	
% Residential	0.843	0.411	0.166	0.058	
Vacancy Rate	3.478	1.226	0.247	0.012	

Key Findings and Recommendations

The most striking finding of our research is the *strong, persistent relationship between race and water access*. Those wards with large populations of people of color receive a statistically significant higher number of water shutoff notifications. It is likely that the nature of our data explains some of this result. While our numbers on the race of residents across the city are precise (based on the 2010 Census, in our 2012 collection period), other values such as Average Income are estimates. Even with this caveat in mind, it bears emphasis that there are two likely reasons the BWSC would have to cut the water to a given parcel: either the account is not being paid because the tenant or landlord cannot afford to pay their bills, or the unit is vacant and no one is paying any bills. We have data on both such possibilities, Average Income and Vacancy Rate, but our data on race was the more consistent predictor of outcomes.

Recommendations

We believe that a *guaranteed uninterrupted water supply for all residents* is a basic necessity and human right, and an achievable policy goal for the city, the Commonwealth, and the United States. There are several solutions to ensuring water access for all, some of which have been applied in the US or around the world, including:

guaranteeing a minimum water supply for all households or individuals, regardless of ability to pay; creating charitable foundations to pay for water access for people who cannot afford to pay their bills; and instituting a discounted, “lifeline” rate for people who cannot afford the regular rate. We ask that city residents, community-based organizations, the BWSC and policymakers consider the following recommendations:

1. Understand the causes and impacts of water shut offs

The BWSC and interested parties should engage community residents and policy makers to carefully explore the reasons for the water shutoffs. This is likely to raise concerns about affordability, landlord responsibilities, and low-income protections. Releasing more complete data than that provided for this report would lead to a better understanding of the problem.

2. Consider the impact of water and sewage price increases on households

With residents already subject to water shut-offs, future price increases must take into account the likelihood of increased water shutoffs and/or landlords passing increased costs onto tenants.

3. Guarantee uninterrupted water supplies for all residents

As a basic necessity and human right, methods have to be found to keep the water flowing to all households, even in cases where the residents are unable to pay for water. A community conversation will share these models with all residents and encourage creative policy responses that match Boston’s reputation as an innovative and caring city.

4. Generate greater civic involvement in matters impacting this human need and the stewardship of water

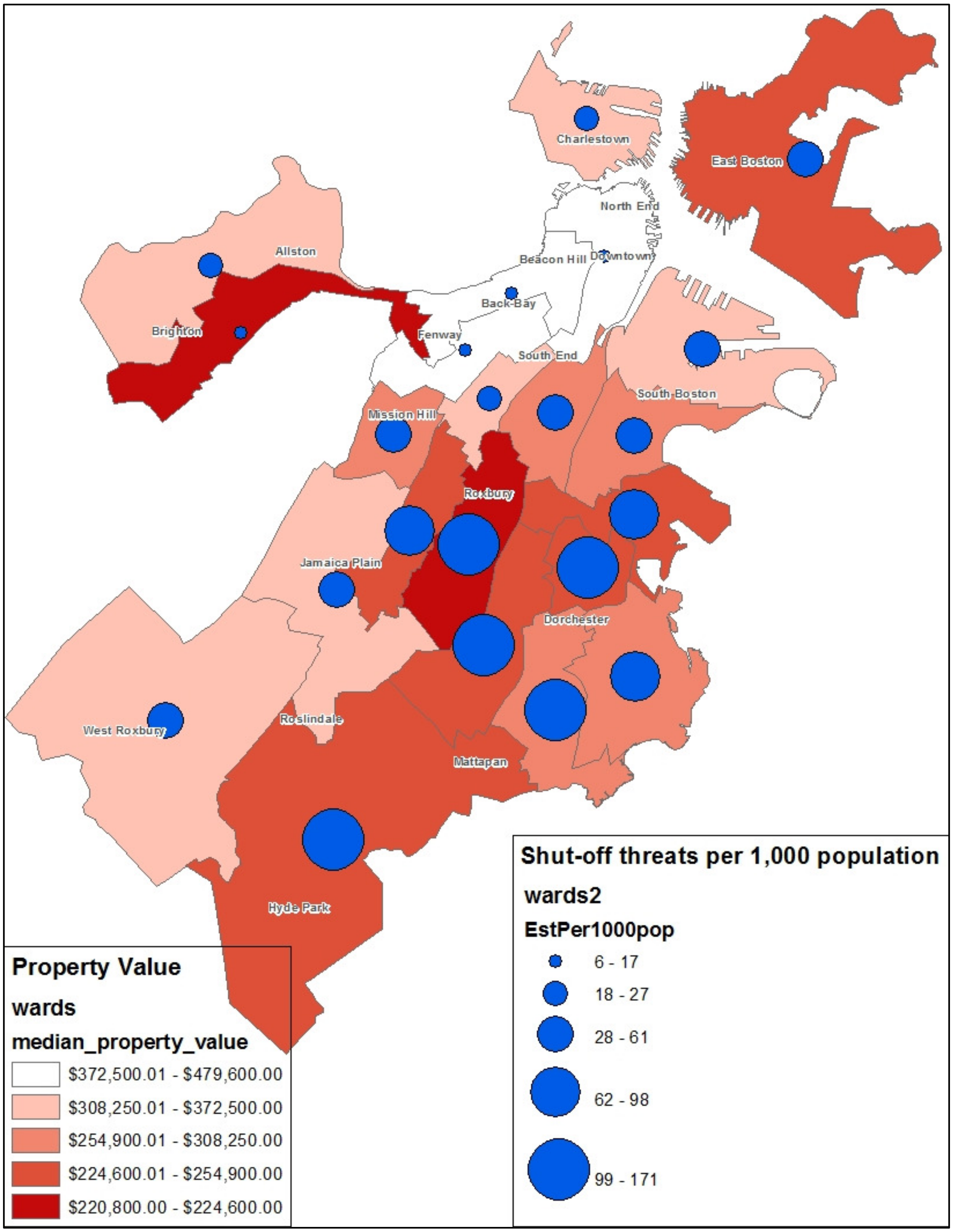
More than greater civic awareness, resident involvement in all matters affecting the provision, service, and protection of water resources is a practical necessity as the need for more investment in water and in climate change adaptation impacts our communities. An informed community can make sensible choices and better prioritize our resources.

5. Ensure the appropriate resourcing for our water and sewage infrastructure

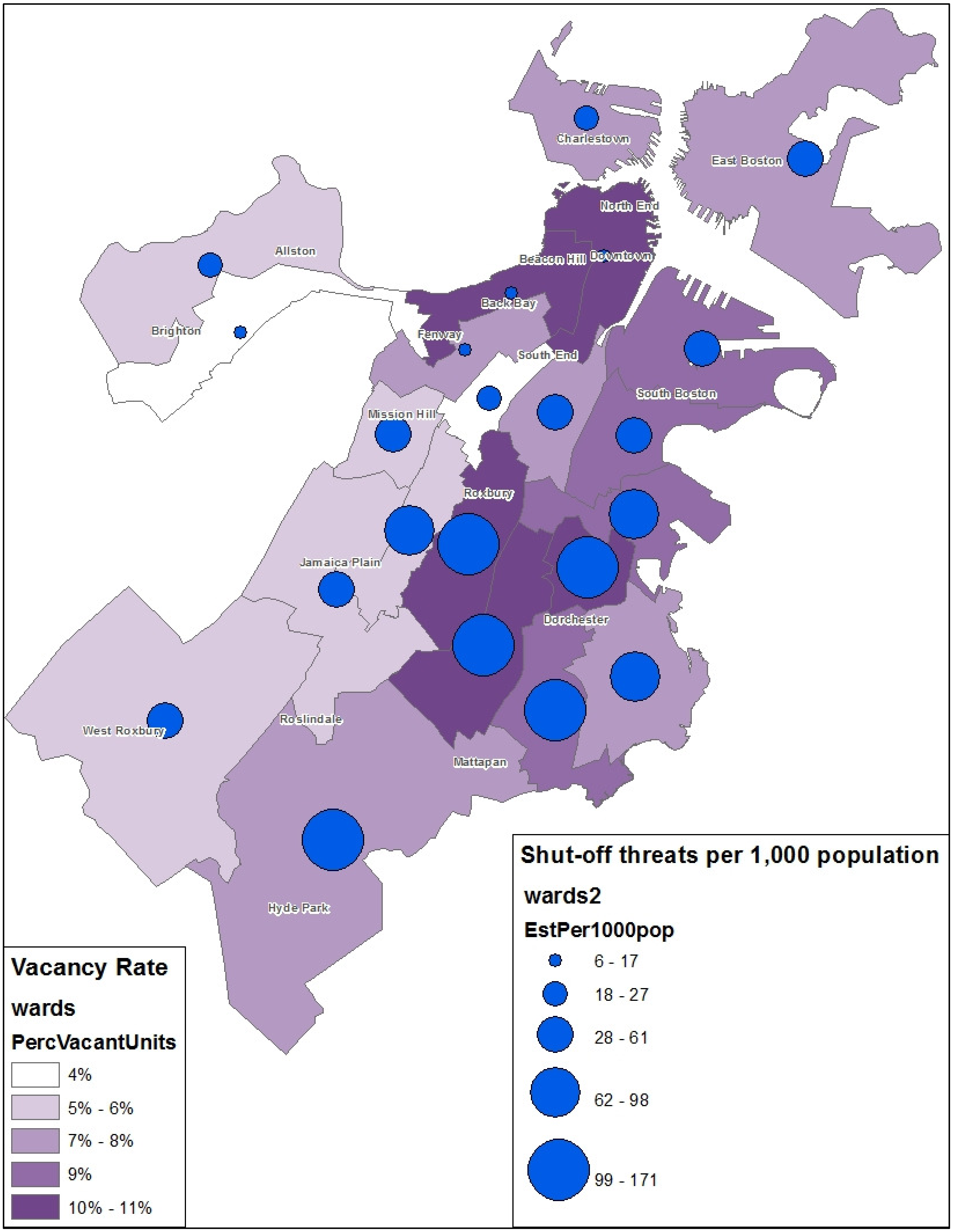
As civic awareness grows about challenges in providing water and in developing the appropriate infrastructure for our community to meet its obligations to all residents, to the environment, and to future generations, we expect a commensurate growth in resourcing for our infrastructure.

Appendix: Maps, Tables, and Illustrations

Map 3



Map 4



Charlestown
East Boston
North End
Allston
Beacon Hill
Downtown
Back Bay
Brighton
Fenway
South End
South Boston
Mission Hill
Roxbury
Jamaica Plain
Dorchester
West Roxbury
Roslindale
Mattapan
Hyde Park
Shut-off threats per 1,000 population
wards2
EstPer1000pop
6 - 17
18 - 27
28 - 61
62 - 98
99 - 171
Vacancy Rate
wards
PercVacantUnits
4%
5% - 6%
7% - 8%
9%
10% - 11%

Table 1 - Characteristics of Boston's Wards

	Population	Total Housing Units	Residential Parcels	Multifamily Parcels	Vacancy Rate	People of Color	Average Income	Median Property Value	Total Notices ('08-'11)	Total notices per 1,000 people	Total Notices per 100 Residential Parcels
Minimum	14,154	5,703	68%	11%	4%	15%	$33,124	$220,800	203	6	3
Maximum	57,789	23,115	94%	58%	11%	98%	$90,818	$479,600	7,550	171	101
Mean	27,986	12,386	88%	33%	7%	55%	$53,546	$307,653	1,809	66	33
Median	23,823	10,227	90%	34%	7%	55%	$46,943	$279,650	1,304	56	26
STD Deviation	11,631	5,279	6%	15%	2%	26%	$17,359	$74,448	1,758	49	29
Wards											
Ward 01	40,026	15,854	88%	54%	8%	63%	$44,167	$236,800	2,448	61	35
Ward 02	15,950	8,648	92%	21%	7%	22%	$90,818	$371,100	366	23	6
Ward 03	33,927	20,309	81%	11%	11%	31%	$75,143	$442,115	570	17	5
Ward 04	35,039	14,495	91%	17%	8%	34%	$44,391	$430,600	203	6	3
Ward 05	37,106	21,185	92%	11%	10%	27%	$68,482	$479,600	477	13	4
Ward 06	19,089	10,265	88%	26%	8%	15%	$78,459	$327,600	1,045	55	14
Ward 07	20,476	9,879	91%	40%	8%	37%	$49,768	$308,250	1,258	61	23
Ward 08	14,154	5,703	68%	30%	7%	80%	$34,882	$268,300	739	52	33
Ward 09	18,272	7,903	82%	23%	4%	68%	$33,124	$353,850	488	27	18
Ward 10	21,984	9,392	88%	38%	5%	58%	$38,973	$278,900	899	41	29
Ward 11	19,159	8,573	88%	37%	6%	67%	$47,665	$254,900	1,523	80	34
Ward 12	17,985	7,819	87%	49%	10%	97%	$34,421	$220,800	2,334	130	89
Ward 13	21,041	8,421	89%	45%	8%	68%	$46,222	$252,200	1,506	72	39
Ward 14	32,016	12,143	86%	58%	10%	98%	$36,328	$244,000	4,859	152	101
Ward 15	18,285	6,640	88%	58%	11%	92%	$42,043	$240,000	2,458	134	78
Ward 16	24,292	10,188	91%	40%	7%	52%	$52,494	$280,400	2,386	98	37
Ward 17	24,593	9,807	91%	46%	9%	86%	$45,527	$269,800	4,208	171	79
Ward 18	57,789	23,115	91%	27%	7%	77%	$54,201	$250,300	7,550	131	53
Ward 19	23,353	10,311	94%	31%	5%	42%	$81,265	$330,850	1,349	58	18
Ward 20	38,781	17,188	93%	17%	5%	24%	$77,053	$330,900	1,737	45	12
Ward 21	50,908	21,964	94%	14%	4%	33%	$41,677	$224,600	562	11	7
Ward 22	31,457	12,679	92%	44%	5%	36%	$60,915	$372,500	826	26	12
Boston Total	615,682	272,481	89%	29%	7%	53%	$55,345	$295,200	39,795	65	27

Sources: US Census, BWSC

Illustration 1: Lattice Plot 1: Total threatened residential cutoffs, population, % of residential units that are 3+ units, median home value, % people of color, and # of parcels

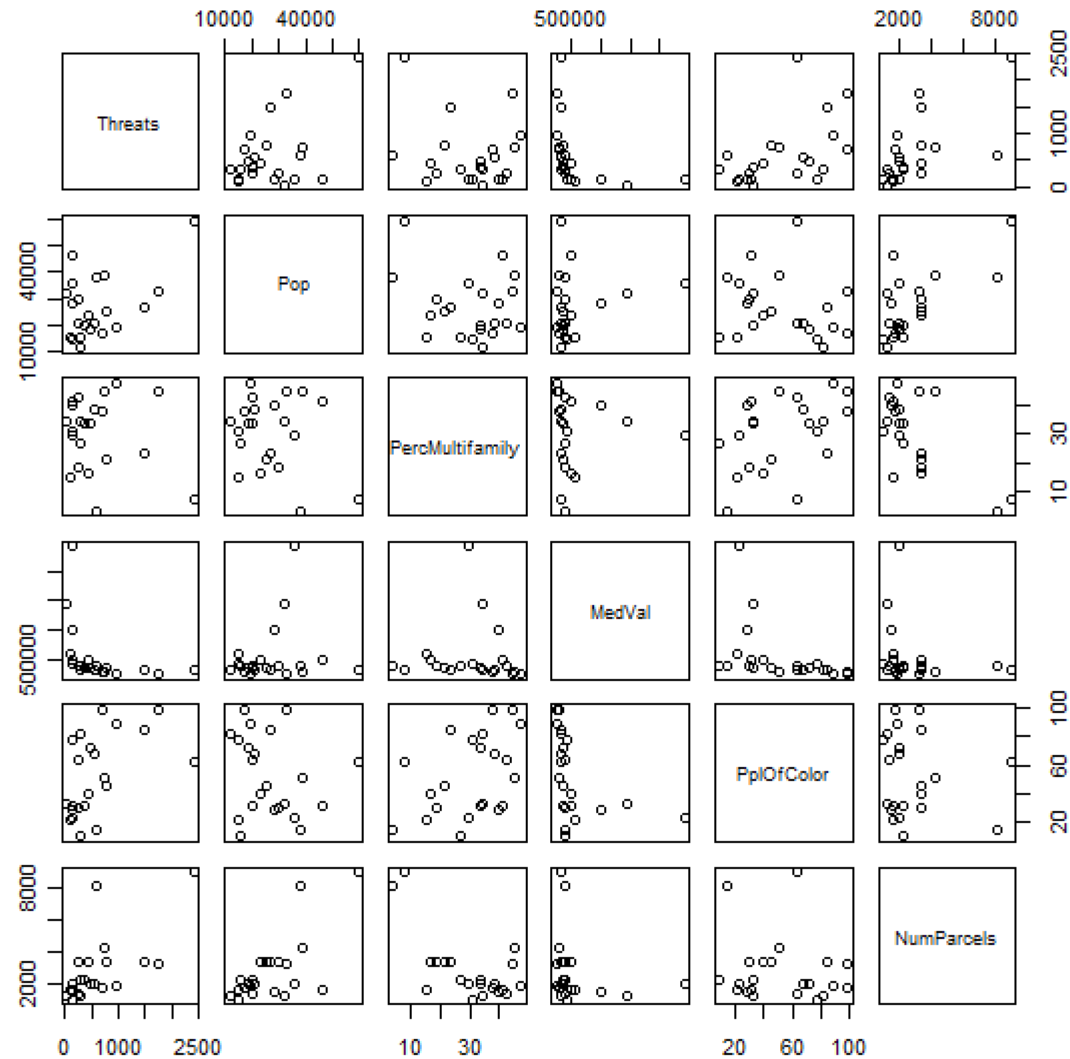


Illustration 2: Lattice plot with Threats per Thousand People, Population, PercMultifamily, LnMedian Home Values, and %People of Color

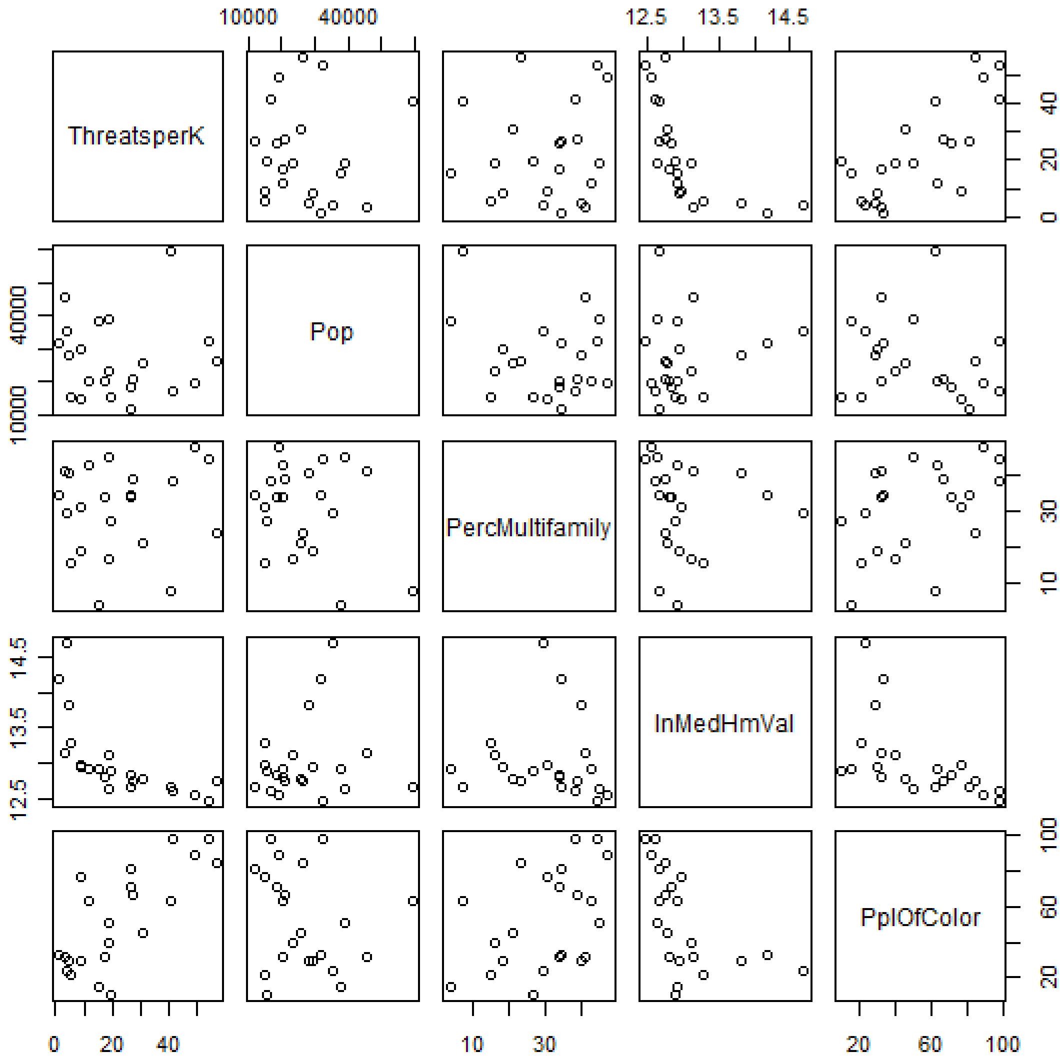


Illustration 3: Lattice Plot of Threats per 100 Parcels, Population, Percent Multifamily Homes, Ln of Median Home Values, and % People of Color

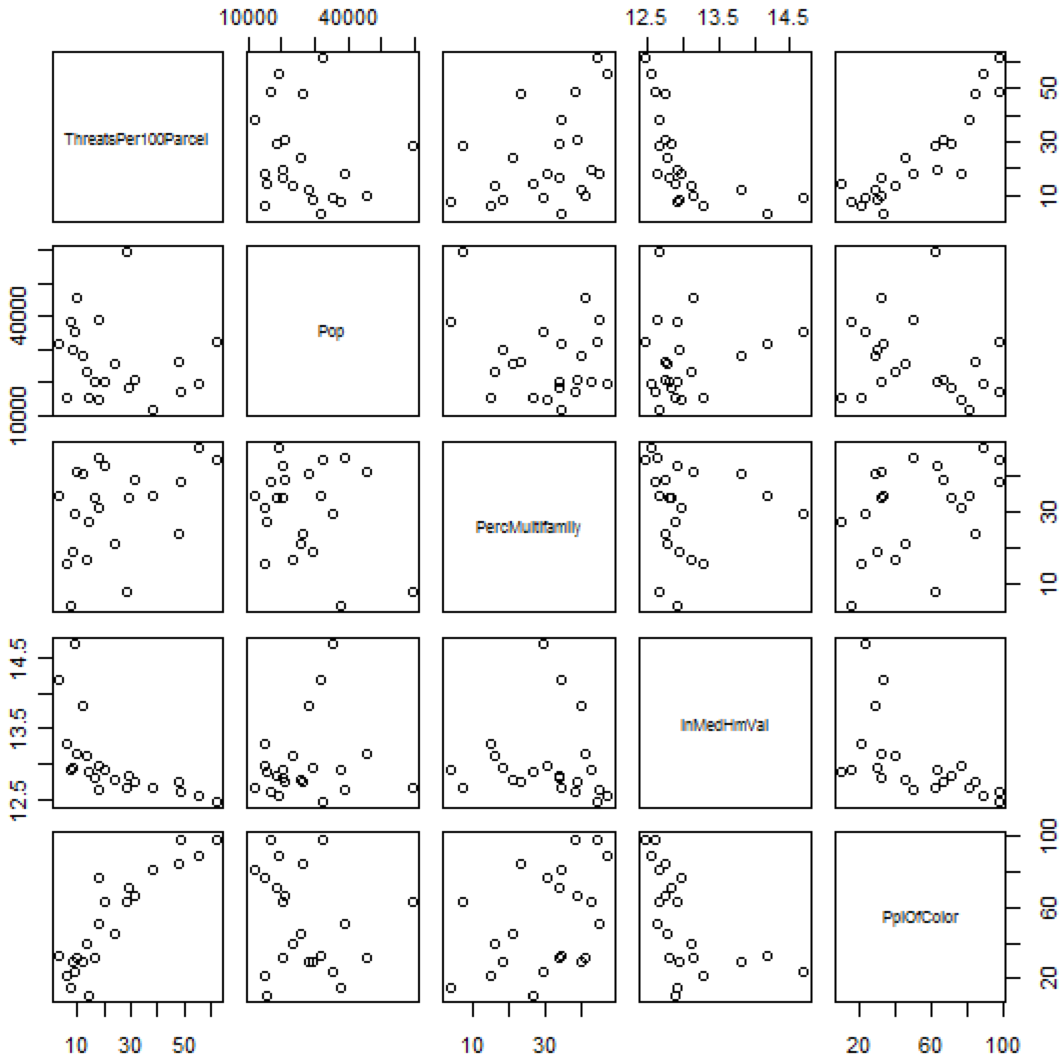


Illustration 4:

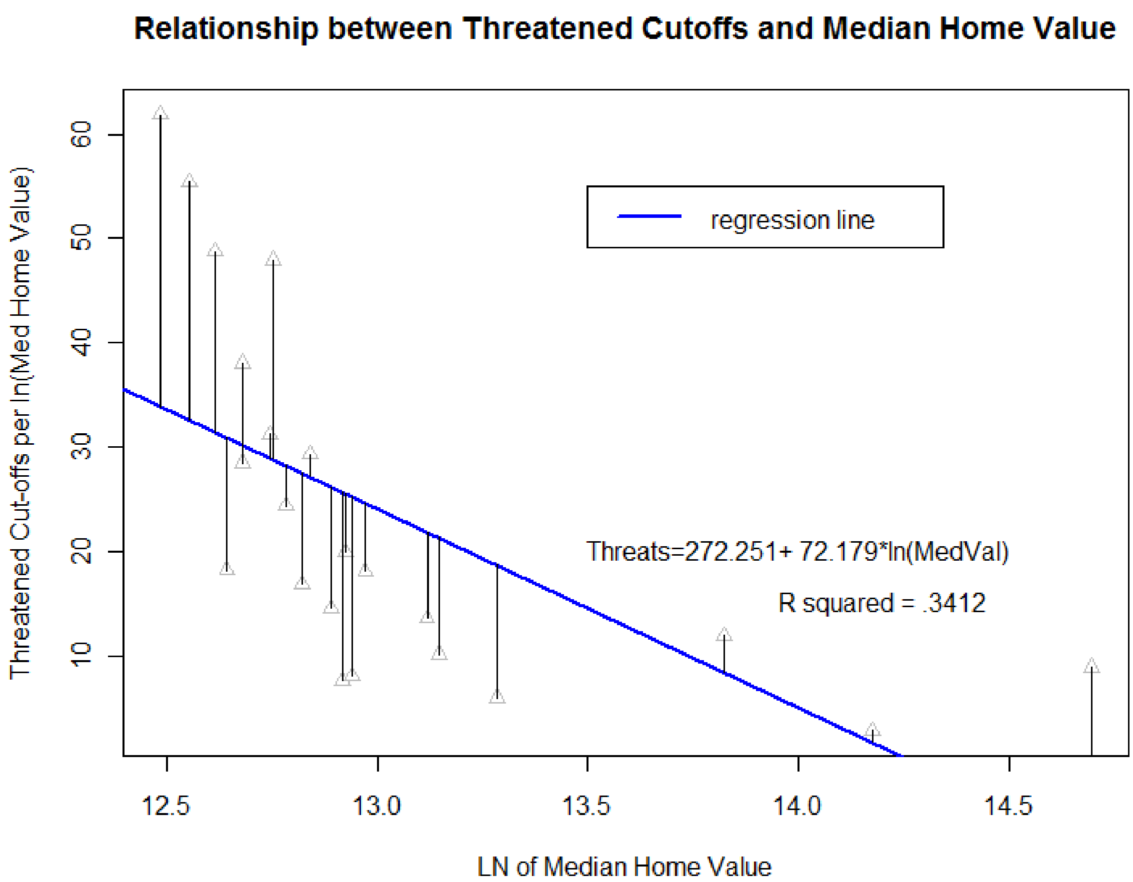


Illustration 5