Walkability Analysis of Food Distribution Sites

Produce at The Market in Salem MA

Department of Geography and Sustainability

GPH942: Advanced Geographic Quantitative Methods using R

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Food Equity and Distribution

Massachusetts has dedicated resources to addressing food insecurity and equitable access in recent years (Anderson 2023).

Access to food for vulnerable populations without cars can be critical for food equity.

Food distribution sites include grocery stores, convenience stores, farmers markets, and food pantries. It was determined that food distribution sites must sell fresh fruits and vegetables in addition to other foods.

Walmart in Salem, MA

Farmers Market in Salem, MA

Anderson, R. B. (2023). Analysis of links between food accessibility and walkability in Boston, Massachusetts and three surrounding suburbs (Master's thesis, Georgia State University). https://doi.org/10.577f09/35323859

What is Walkability?

Walkability measurements vary based on the model being applied, though all include some measure of the distance of households from a resource (Perez-Pereda et al 2024, Anderson 2023). We will be examining the distance from food distribution sites.

1. **Demand: Walkability could be defined based on peoples' walking habits - using walking data in addition to other context and socioeconomic factors to examine where is walkable.**

2. Supply: Walkability could also be defined based on the infrastructure and elevation that would making walking easier and safer such as sidewalks, lights, crosswalks, busy traffic, vegetation, as well as slope.

Research Questions

1. What are the most walkable areas in each of the 5 towns?
2. What socioeconomic variables are the most important for high walkability?
3. What is the influence of MBTA stations for walkability to food distribution locations?
4. Which are the most walkable and least walkable food distribution sites?

Analysis was done as part of GPH942: Advanced Geographic Quantitative Methods using R

Data Layers

1. Walkability information taken from MassDOTs walkability documentation. This layer is created from demand data based on actual real-time travel using Streetlight anonymized cell phone data Streetlight data. The walkability layer includes all trips under 3 miles.

    Potential for everyday walking = (0.7 * Potential Demand + 0.2 * Transportation Access) + (1 + Social Equity)

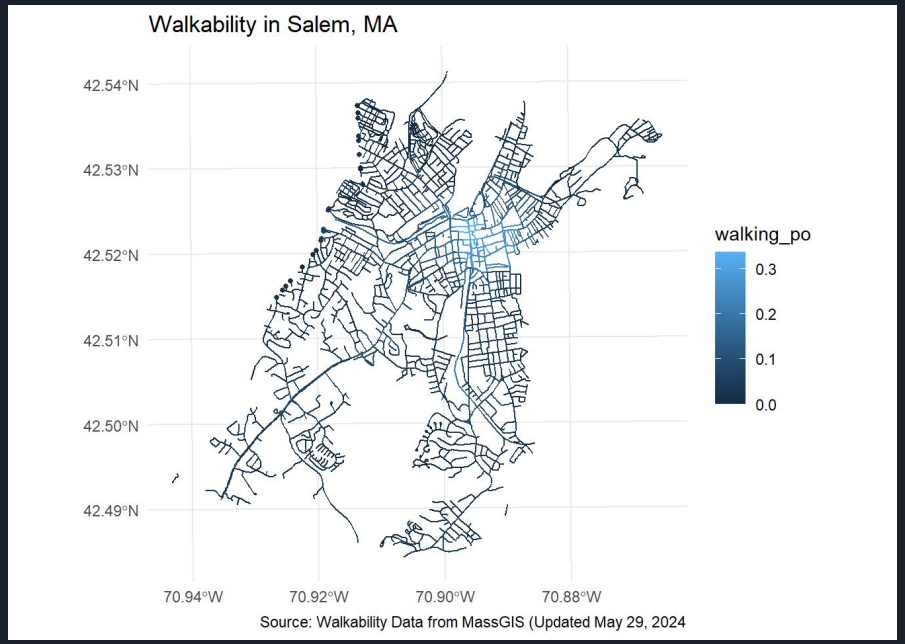
    Demand: Potential walking demand (Local Access Score) ▪ Trips less than 2.5 miles

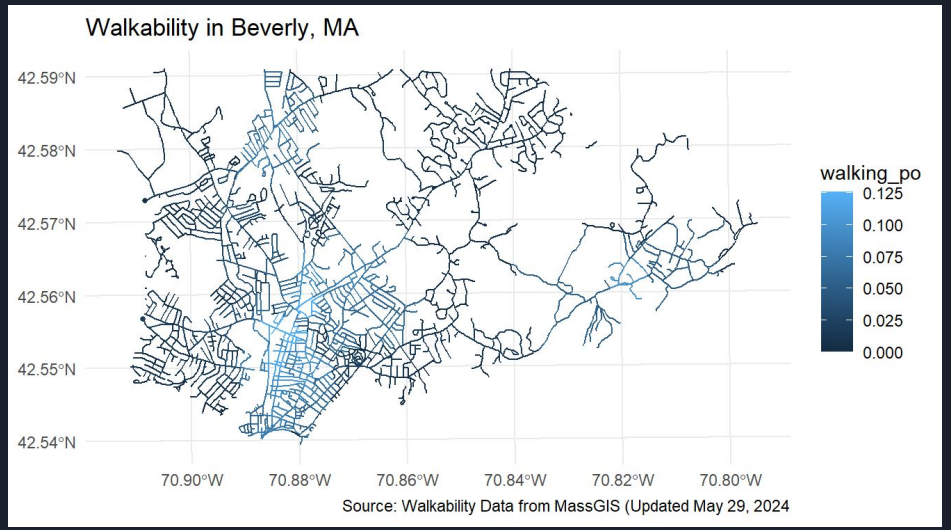
    Transportation Access: areas within a 10 minute walk from any transit hub

    Social equity: Limited to minority and low-income variables from Streetlight demographics data

2. American Community Survey (ACS) 2020, US Census
3. MassGIS Data: Trains
4. Food Distribution Sites via Greenbelt from MassGIS LCLU, MassGIS Farmers Markets, USDA Local Food Directories, Open Street Map, Parcel Data, USDA SNAP Retailer Locator, Food Pantries/Food Banks Google Maps

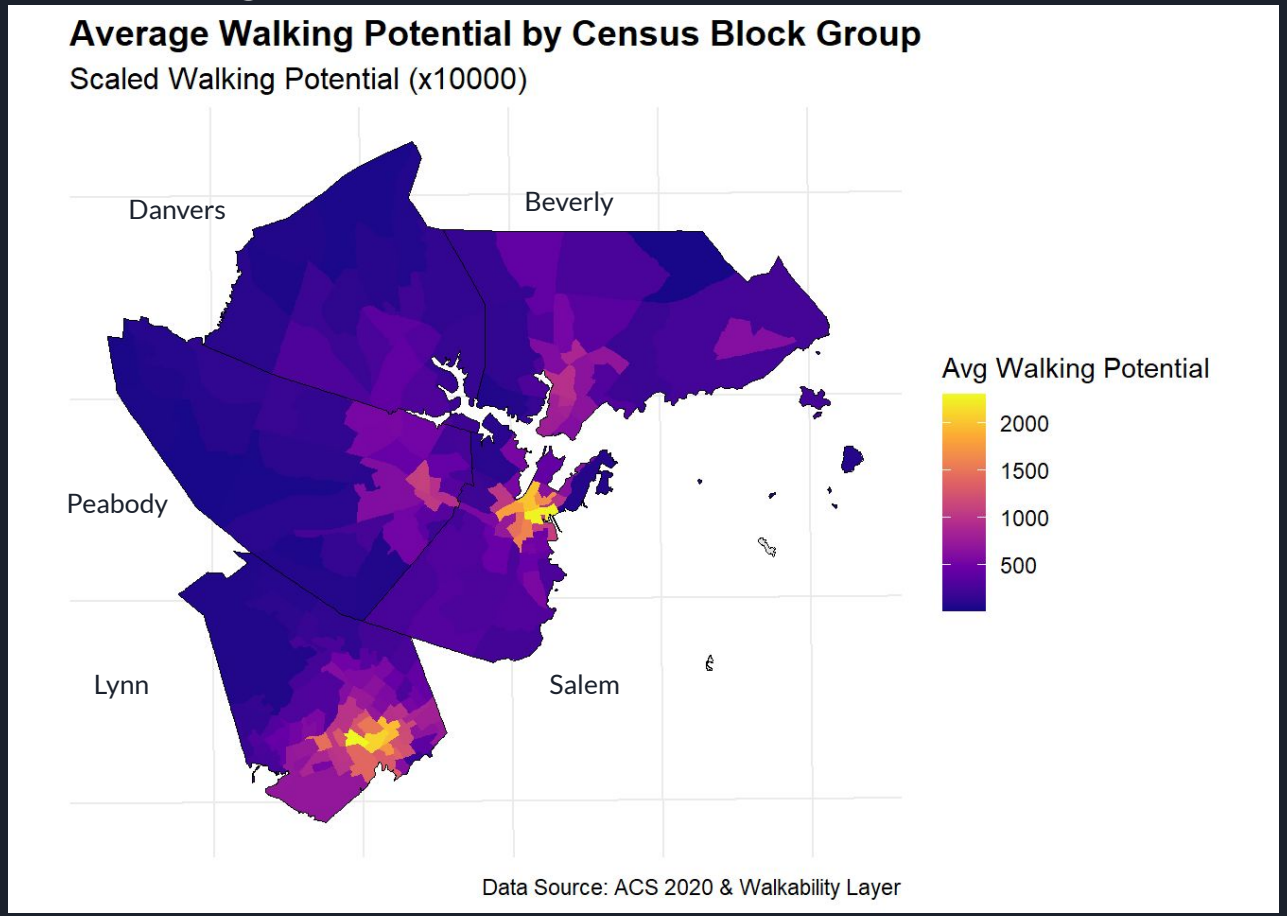
Walkability in Salem and Beverly





Raw potential walkability data. Note the bike path in Salem is visible.

Study Area


Average Walking Potential by Census Block Group
Scaled Walking Potential (x10000)
Danvers
Beverly
Peabody
Lynn
Salem
Avg Walking Potential
2000
1500
1000
500
Data Source: ACS 2020 & Walkability Layer

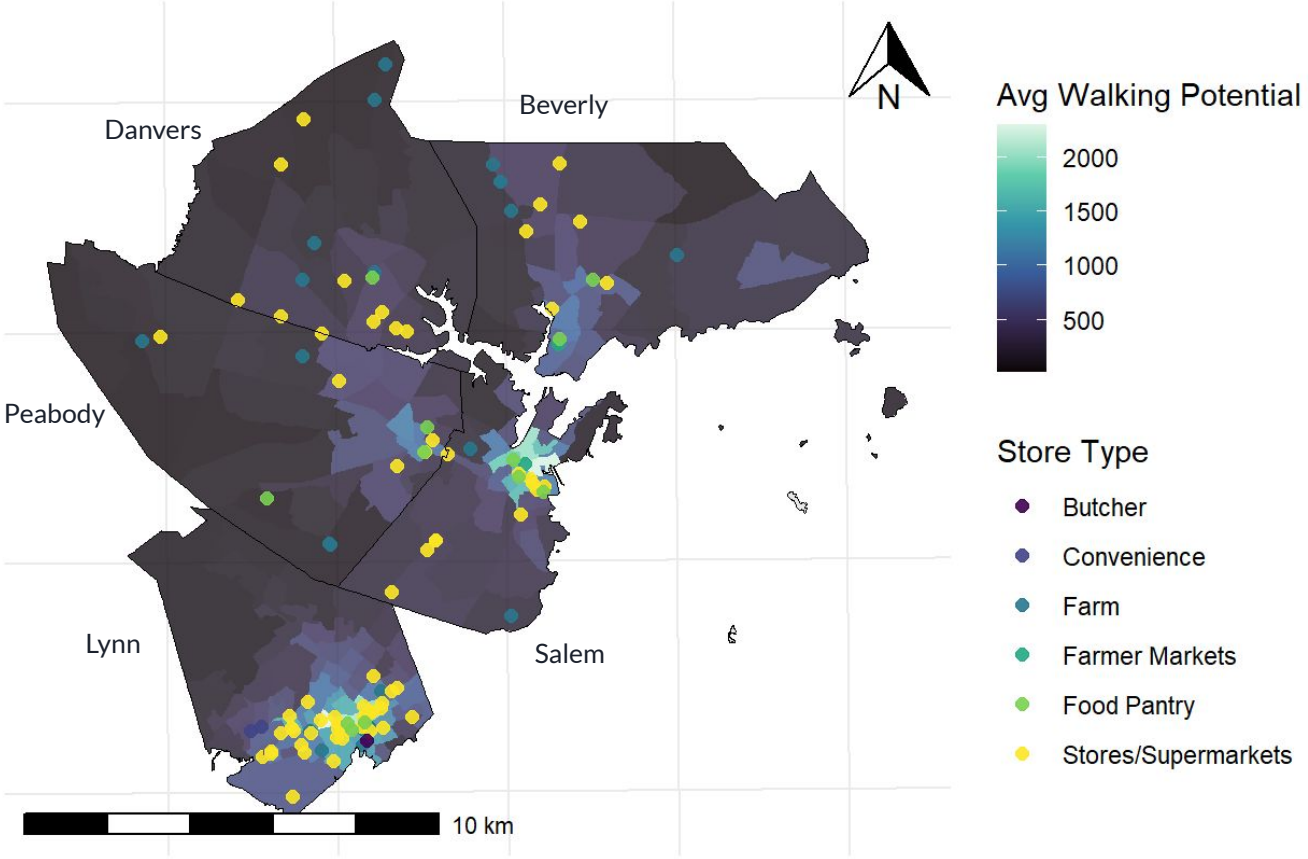
Methods and Data Processing

1. Clip Walkability, Train and ACS data to the town boundaries
2. Merge and transform food distribution sites into one dataset
3. Create 800m buffers around the food distribute sites*
4. Categorize food distribution sites in 6 categories: Butcher, Convenience, Farm, Farmer Markets, Food Pantry, Grocery Store/Supermarkets
5. Transform Potential Walkability by 10000 from a decimal to an integer
6. Spatial Join Potential Walkability to ACS data and 800m food distribution site buffer to calculate average walkability by census block group and 800m buffer
7. RandomForest analysis of socioeconomic data and average walkability to find most important socioeconomic data for average walkability
8. Linear regression to determine the impact of independent and dependent variables on average walkability
9. Scatter plots to determine relationships between individual variables
10. Evaluate MBTA Commuter Rail stations by number of food distribution sites and average walkability
11. Evaluate food distribution sites average walkability within 800m buffer

*Commonwealth of Massachusetts. (n.d.). Multi-family zoning requirement for MBTA communities. Massachusetts Government. Retrieved December 19, 2024, from https://www.mass.gov/info-details/multi-family-zoning-requirement-for-mbta-communities

Average Walking Potential and Food Distribution Sites

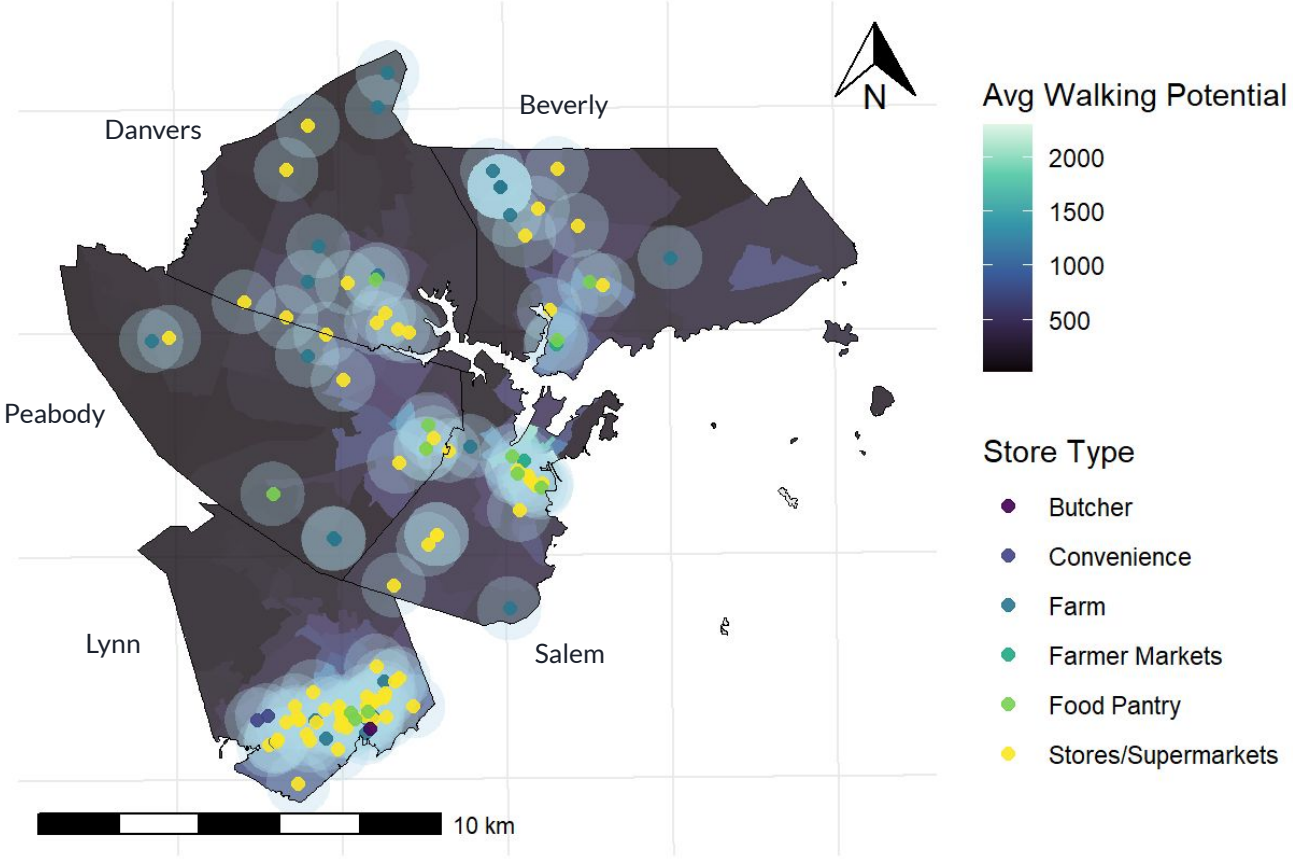
Census Block Groups and Various Food Sites in Essex Greenbelt Area



Data Source: ACS 2020, Walkability Layer, NSFFC Food Access

Average Walking Potential and Food Distribution Sites with 800m Buffer

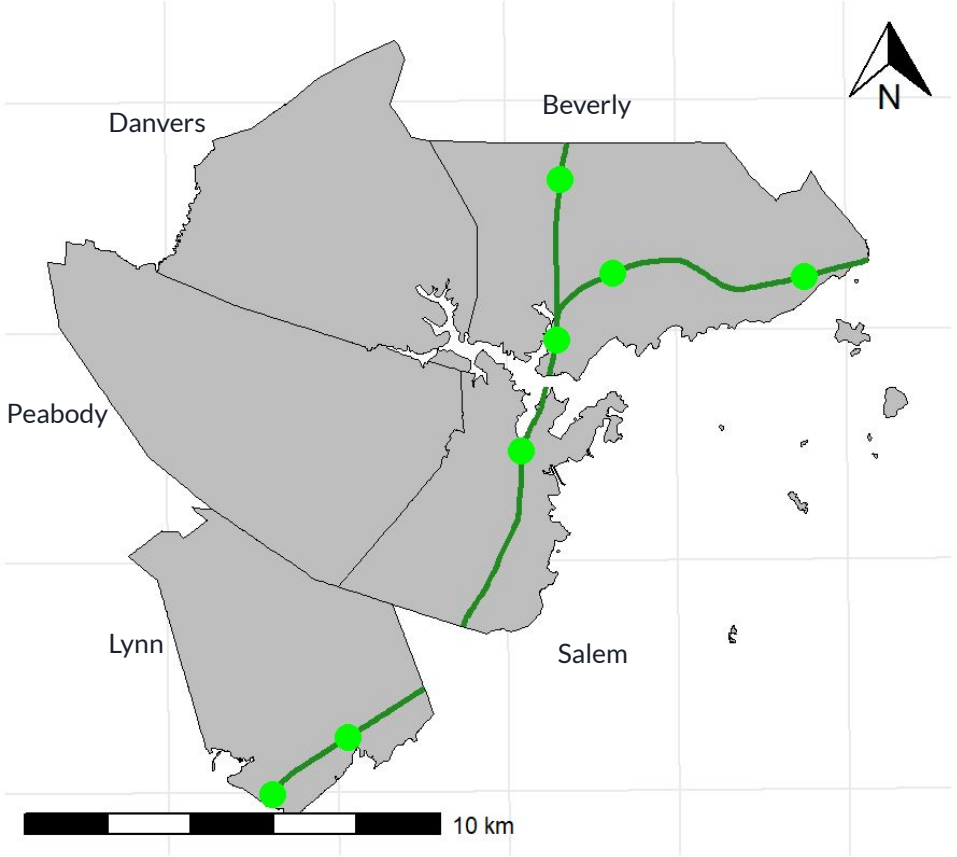
Condensed Classifications of Food Sites in Essex Greenbelt Area



Data Source: ACS 2020, Walkability Layer, NSFFC Food Access

Commuter Rail Stations and Lines in Essex County

Focusing on Peabody, Salem, Beverly, Danvers, and Lynn



Legend

- Commuter Rail Lines
- Commuter Rail Points

Data Source: MBTA

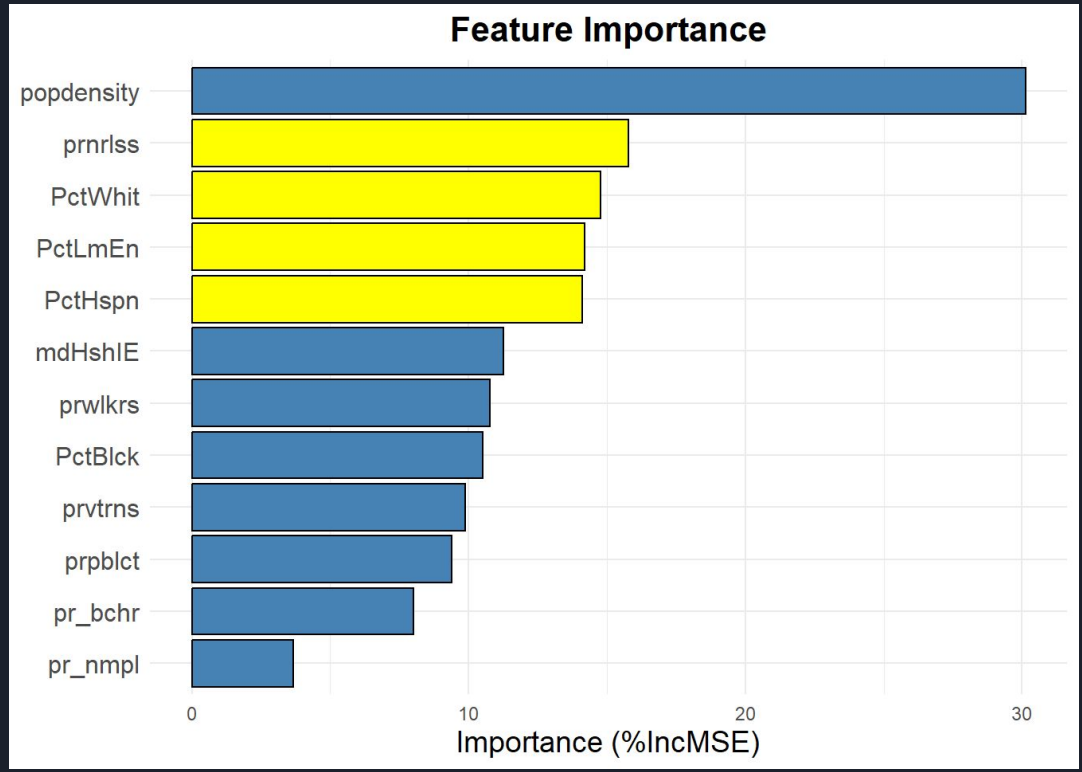
RandomForest Model Results

Population density was the most important variable

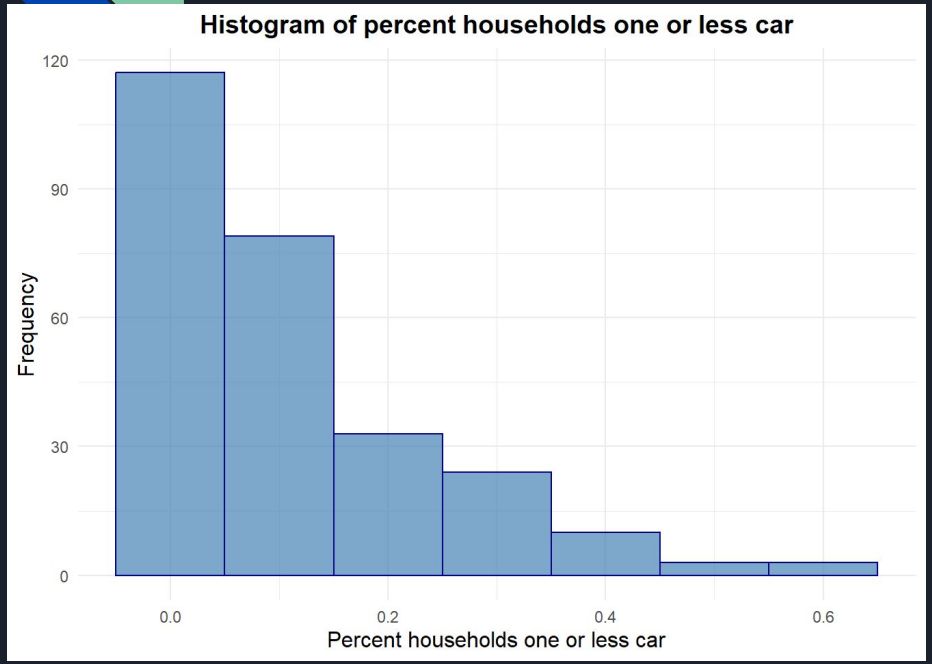
Percent households with one care or less, Percent white, Percent households with English Language Isolation, Percent hispanic were all of similar importance

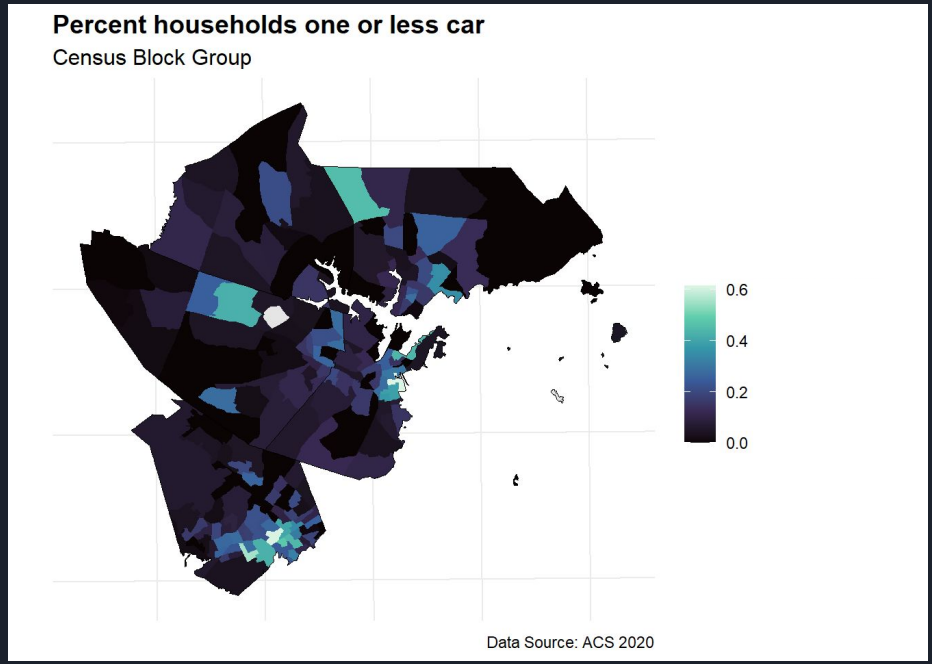
R2 = 0.57 (57% of variance explained by model)

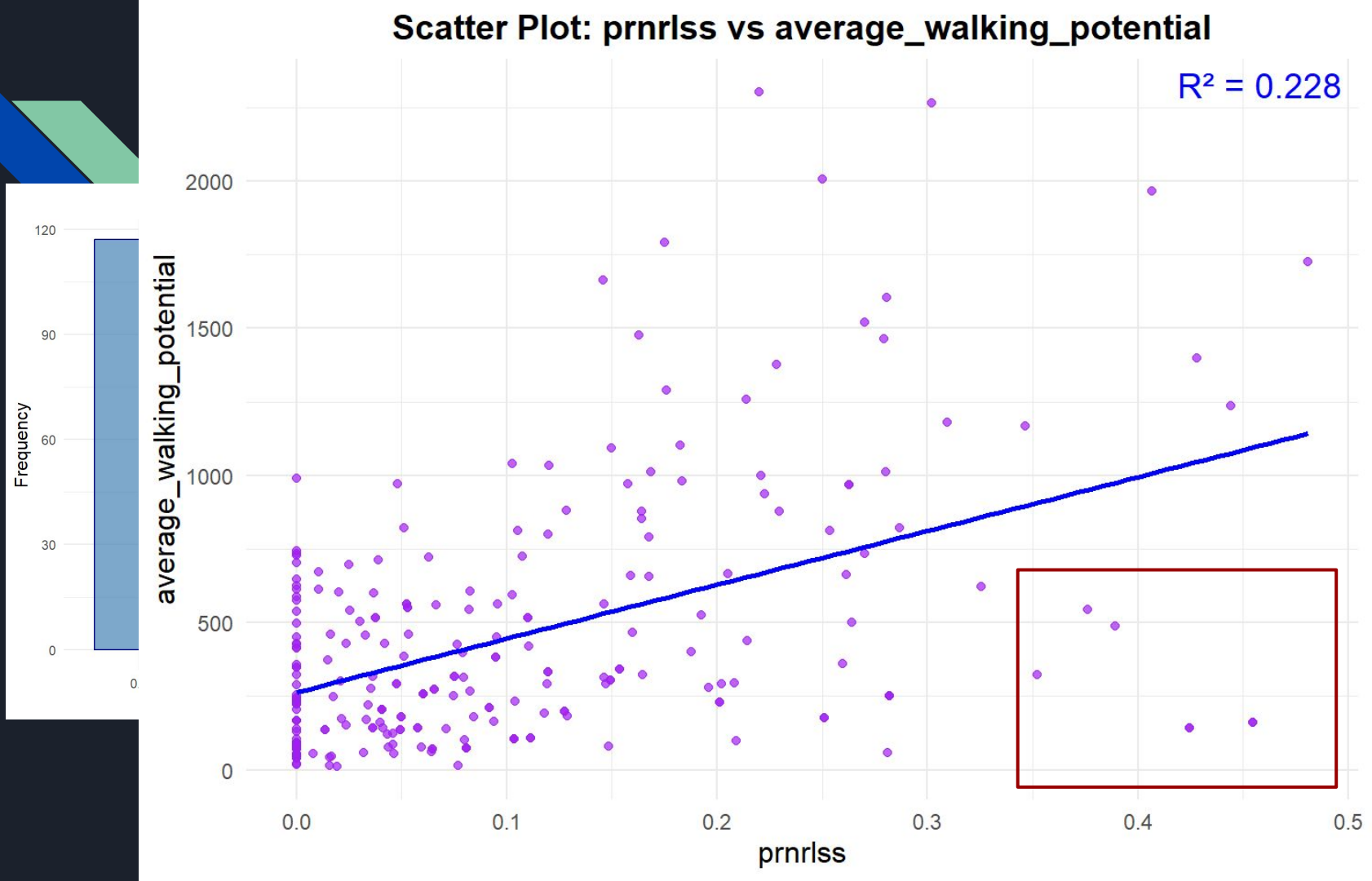
800 trees with 4 variables at each split



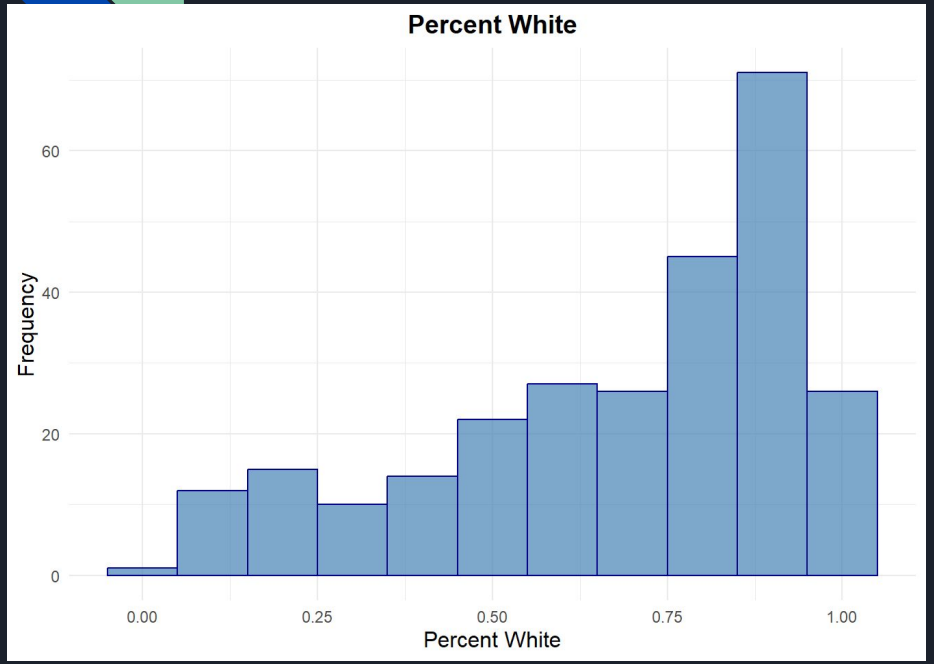
Important Variables: One Car or Less

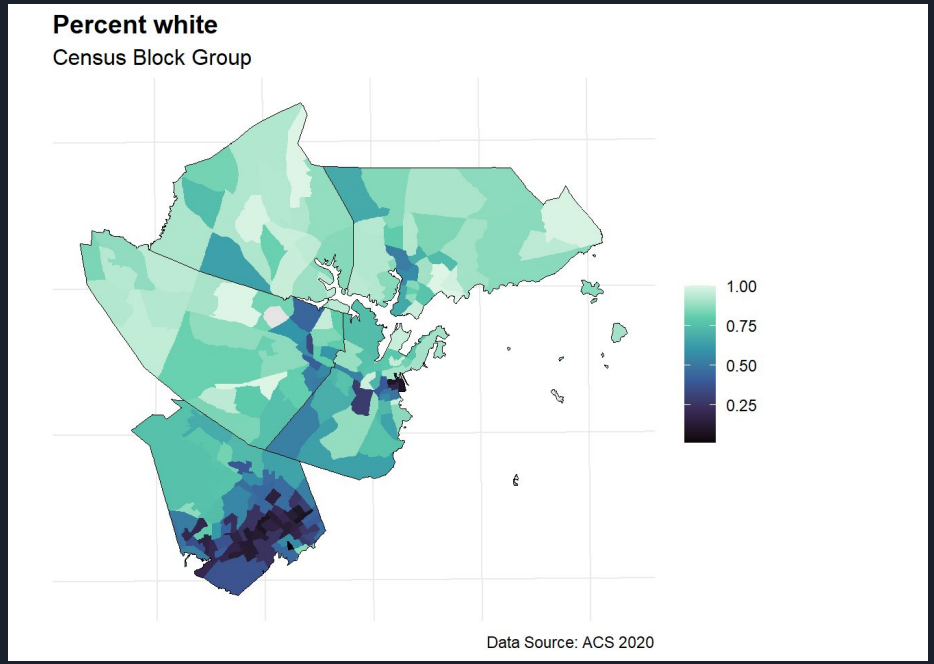


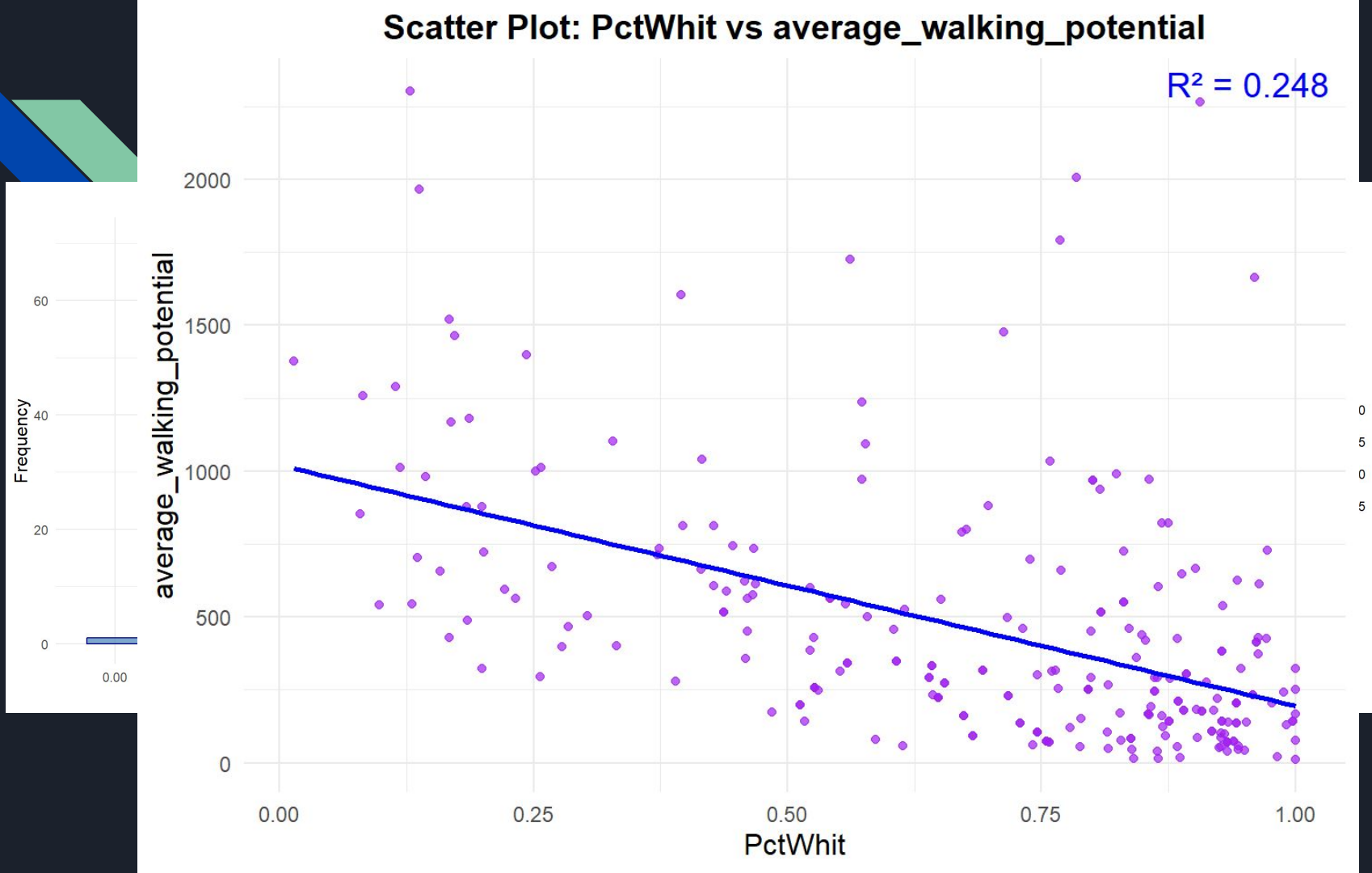



Scatter Plot: prnrlss vs average_walking_potential
R² = 0.228
average_walking_potential
prnrlss
0
500
1000
1500
2000
0.0
0.1
0.2
0.3
0.4
0.5
Frequency
120
90
60
30
0
0

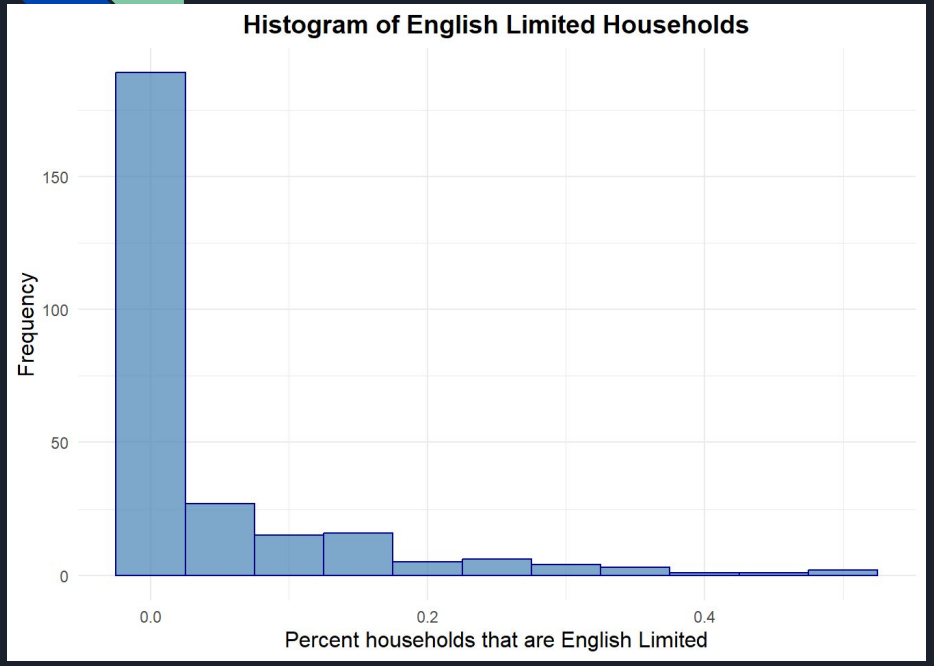
Important Variables: White Population

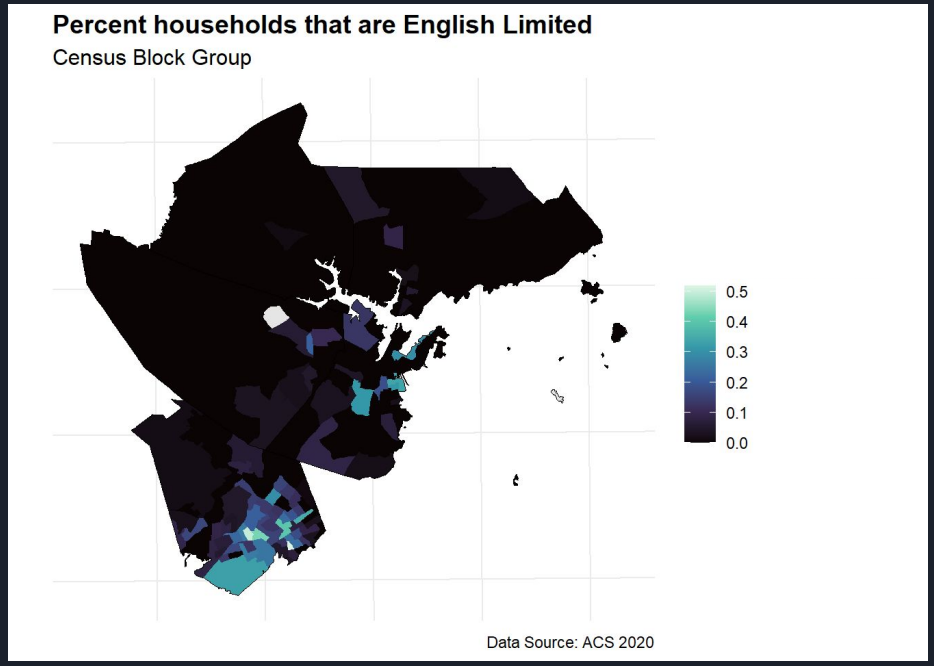


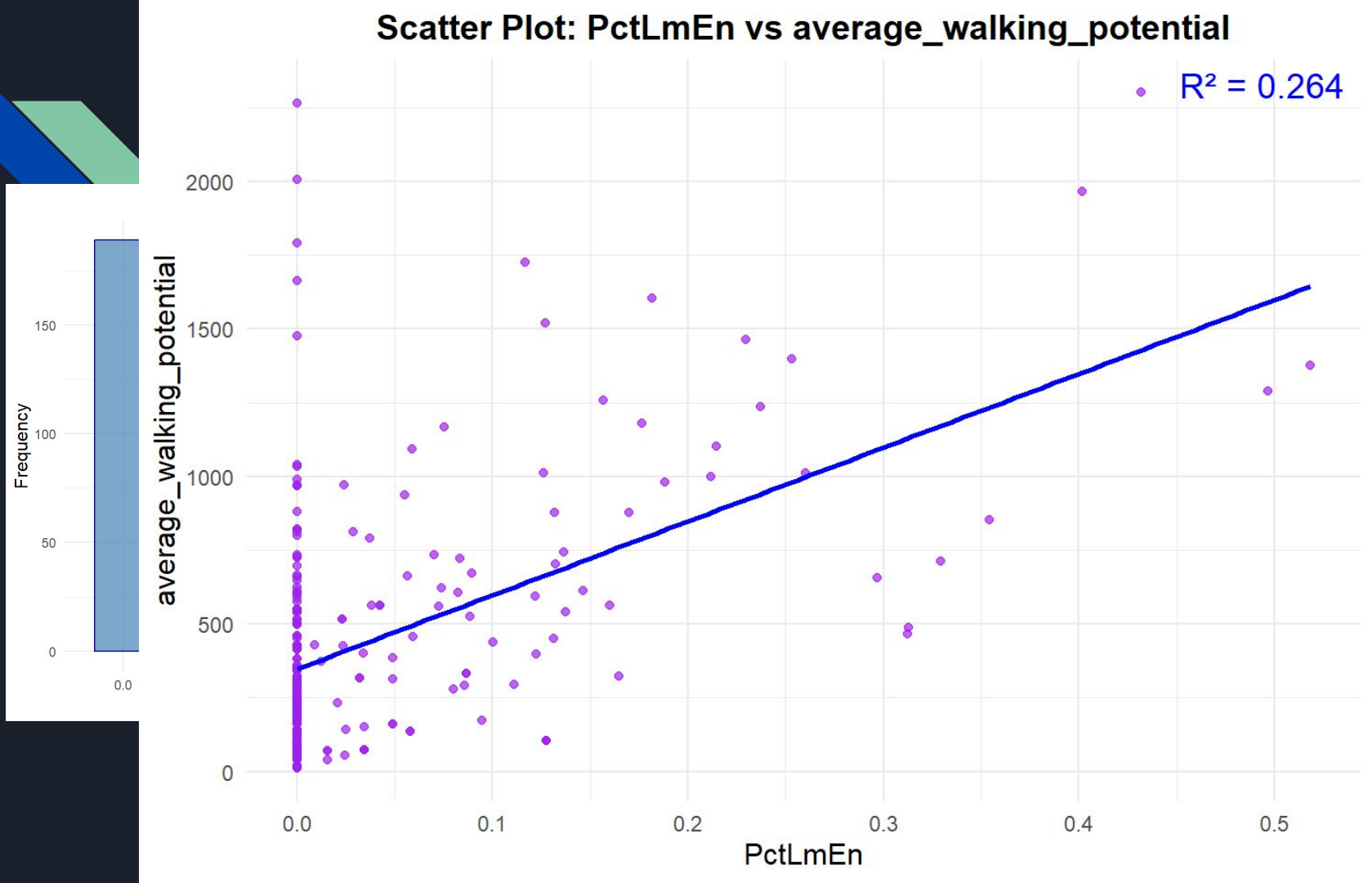



Scatter Plot: PctWhit vs average_walking_potential
R² = 0.248
average_walking_potential
2000
1500
1000
500
0
0.00
0.25
0.50
0.75
1.00
PctWhit
Frequency
60
40
20
0
0.00

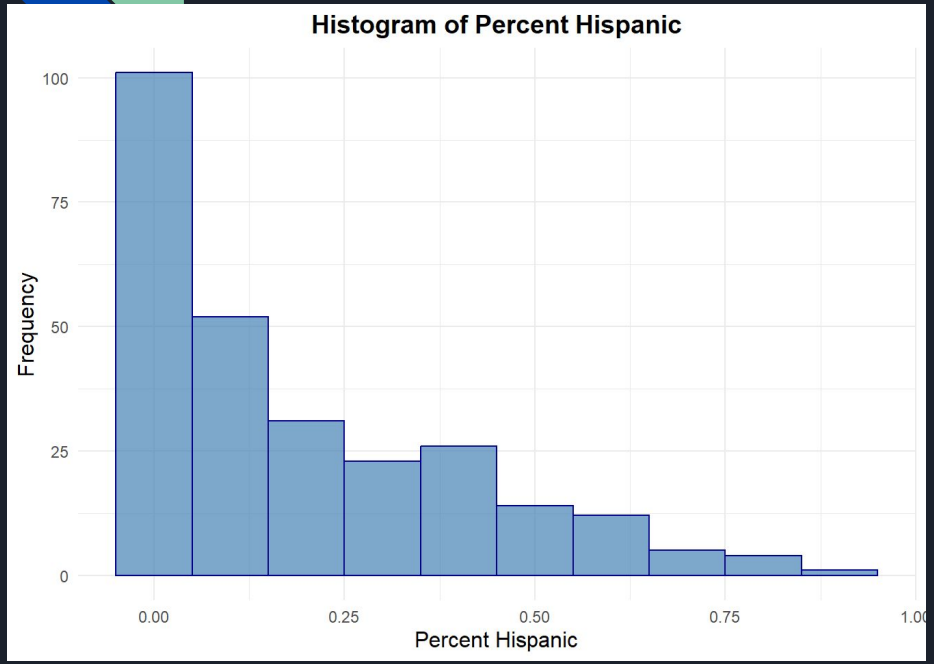
Important Variables: English Limited

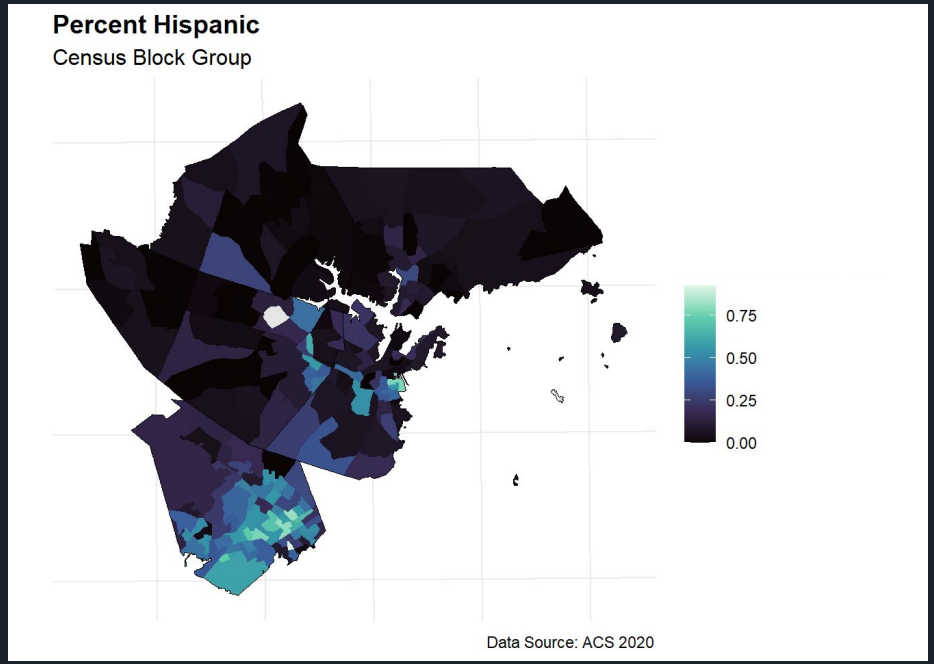


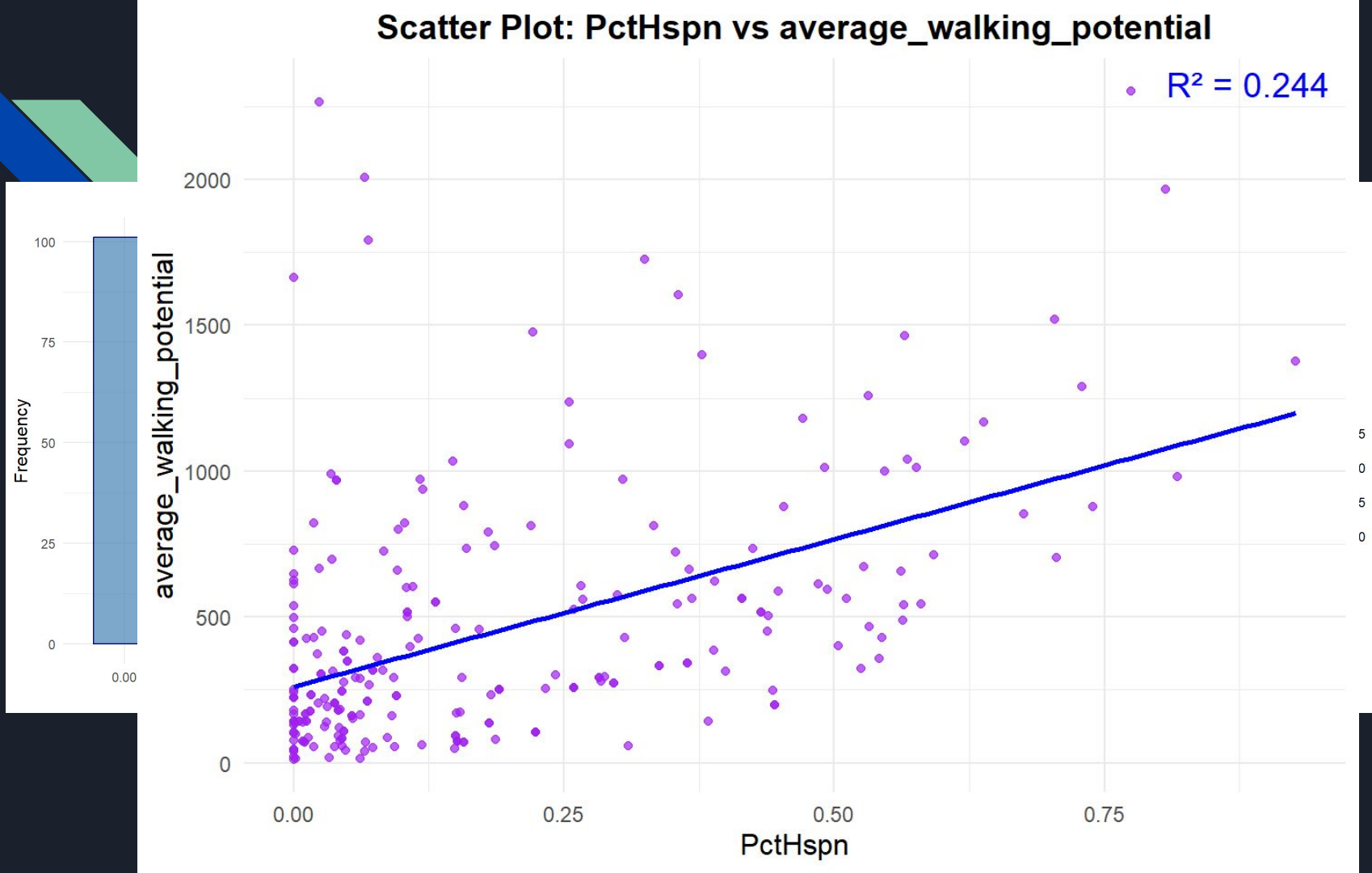



Scatter Plot: PctLmEn vs average_walking_potential
R² = 0.264
average_walking_potential
PctLmEn
0
500
1000
1500
2000
0.0
0.1
0.2
0.3
0.4
0.5
Frequency
150
100
50
0
0.0

Important Variables: Hispanic Population






Scatter Plot: PctHspn vs average_walking_potential
R² = 0.244
average_walking_potential
2000
1500
1000
500
0
0.00
0.25
0.50
0.75
PctHspn
Frequency
100
75
50
25
0
0.00

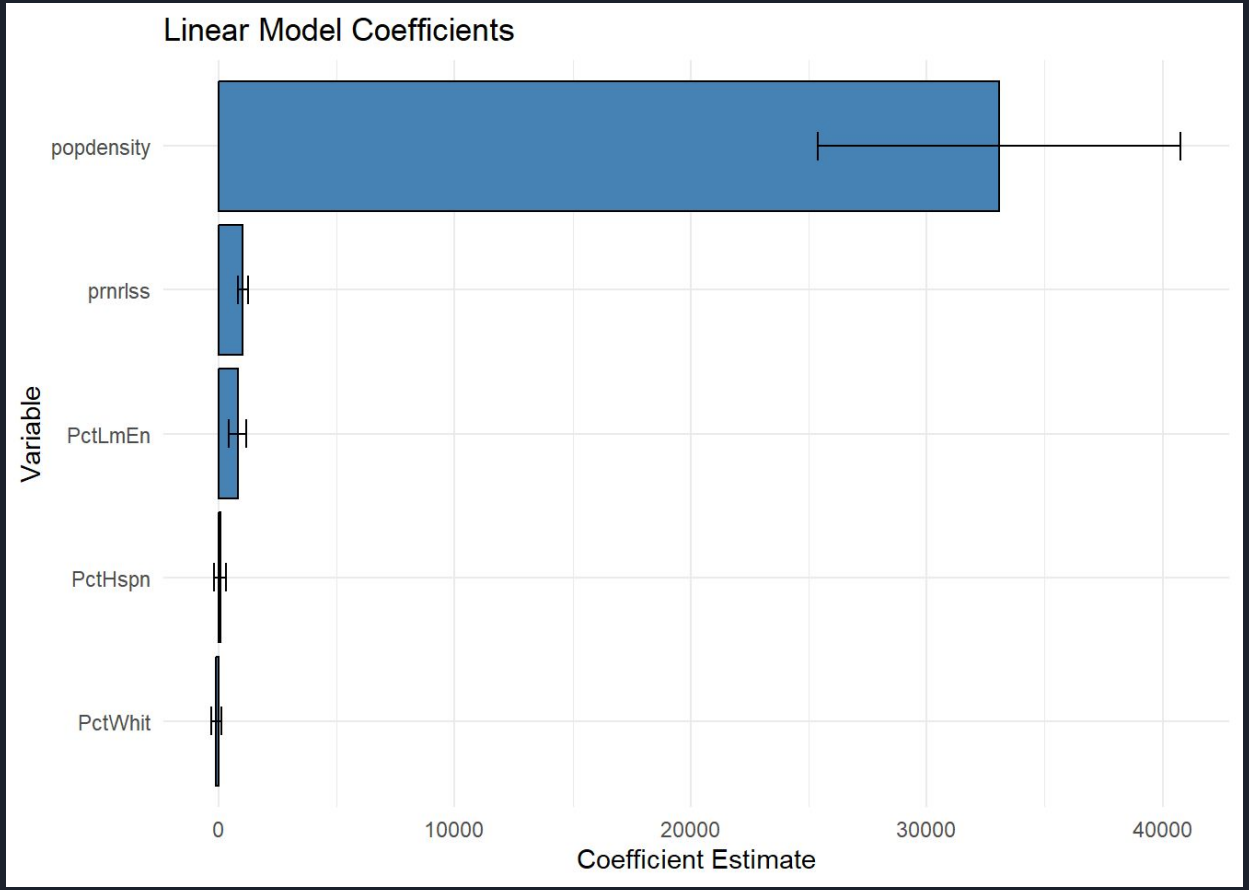
Linear Model Results

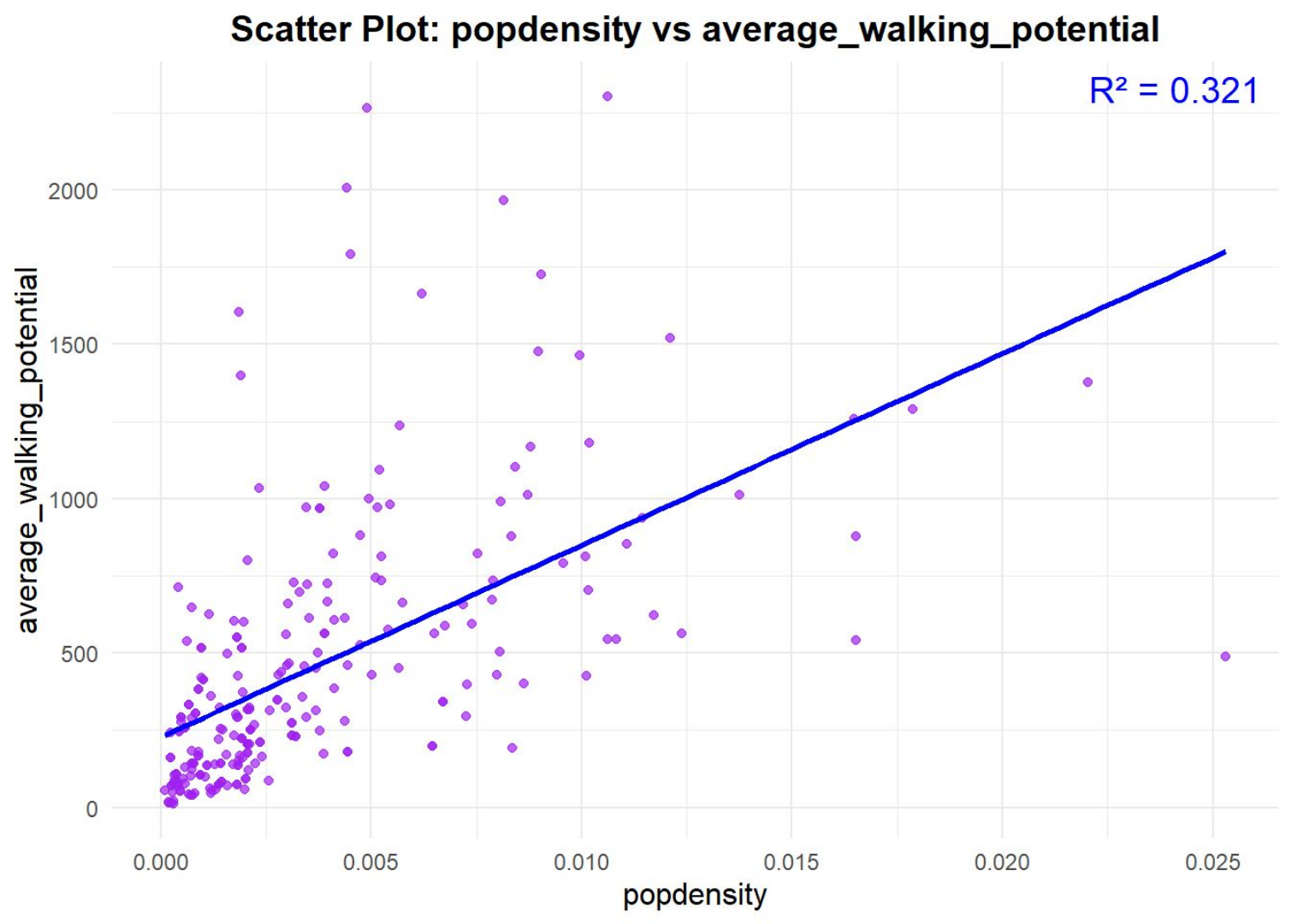
	Estimate Std.	Error	t value	Pr(>|t|)	Significance
Intercept	253.03	185.78	1.362	0.1745	
prnrlss	1028.26	206.63	4.976	1.23e-06	***
PctWhit	-105.83	200.52	-0.528	0.5981	
PctLmEn	800.09	358.21	2.234	0.0264	*
PctHspn	66.65	253.67	0.263	0.7930	
popdensit	33078.66	7689.90	4.302	2.47e-05	***

Adjusted R-squared: 0.419

p-value: < 2.2e-16

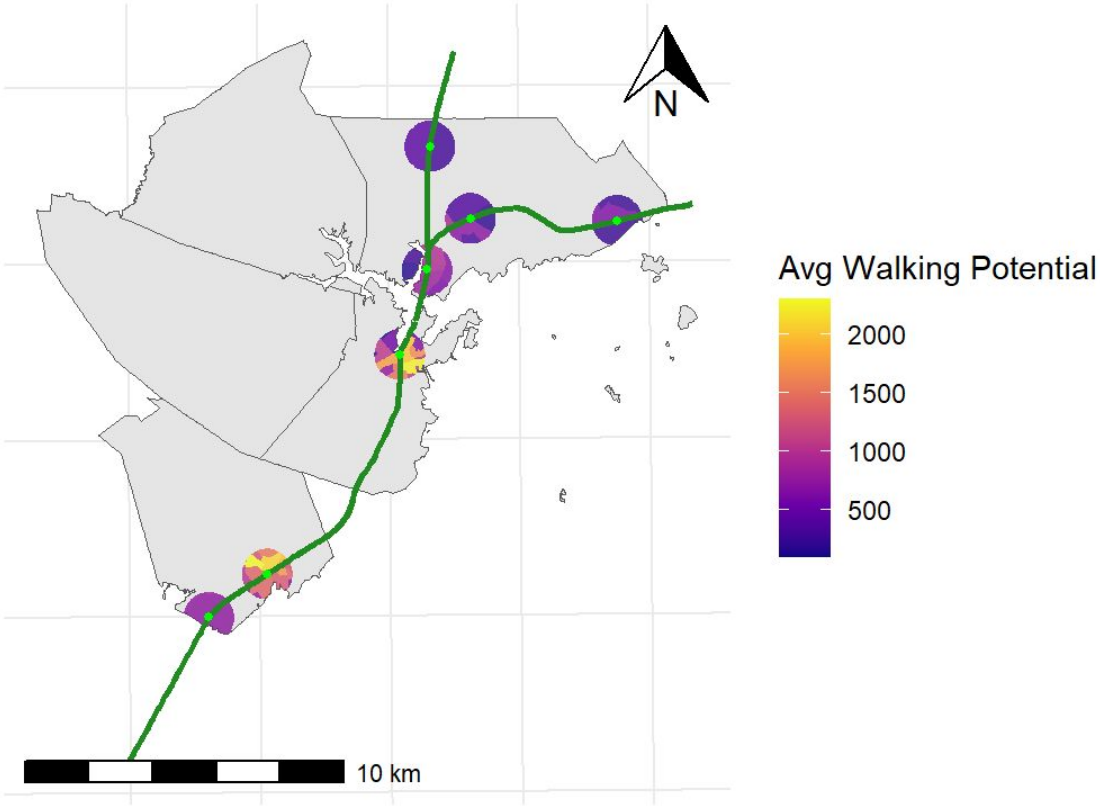
Linear Model Results




Scatter Plot: popdensity vs average_walking_potential
R² = 0.321
average_walking_potential
2000
1500
1000
500
0
0.000
0.005
0.010
0.015
0.020
0.025
popdensity

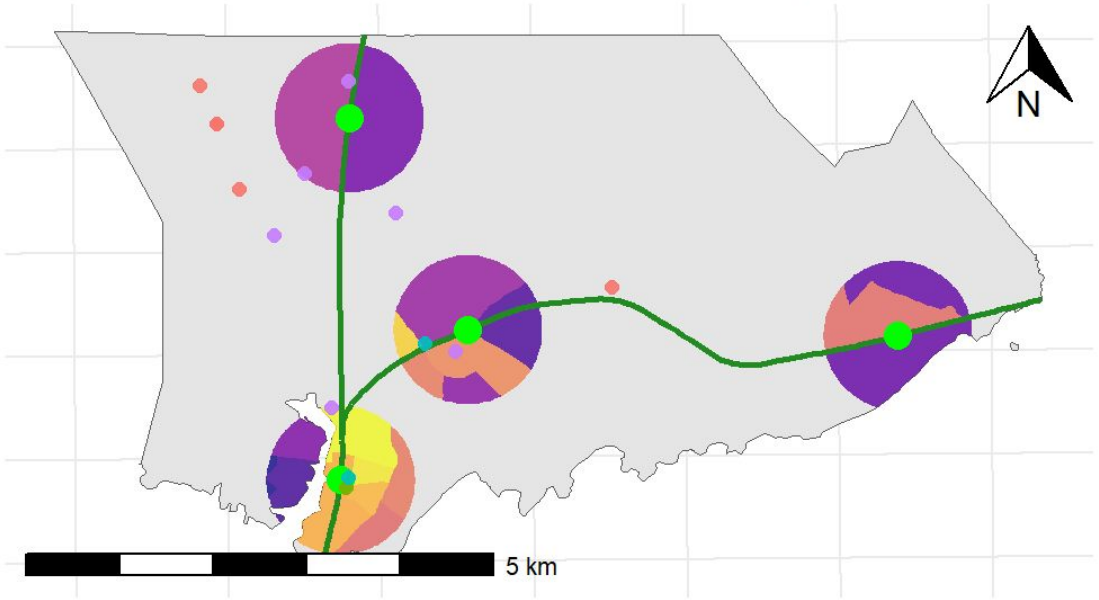
Average Walking Potential around MBTA Commuter Rail Stations in Peabody, Salem, Beverly, Danvers and Lynn

Walking Potential Clipped to 800m from MBTA Commuter Stations



Data Source: ACS 2020, Walkability Layer, MBTA

Commuter Rail Stations, Commuter Rail Lines, Average Walking Potential and Food Distribution Sites in Beverly



Avg Walking Potential

750

500

250

Store_Type

Farm

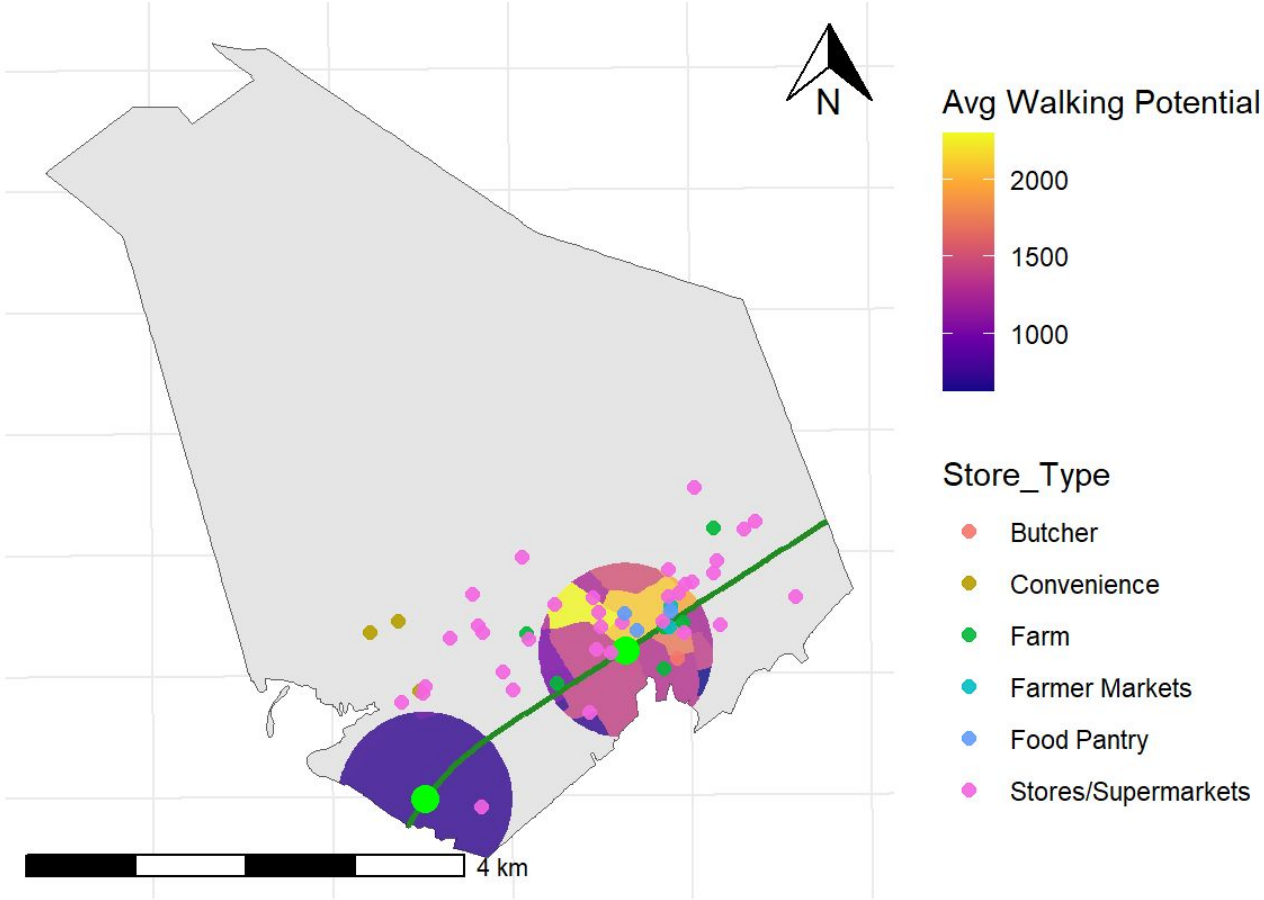
Farmer Markets

Food Pantry

Stores/Supermarkets

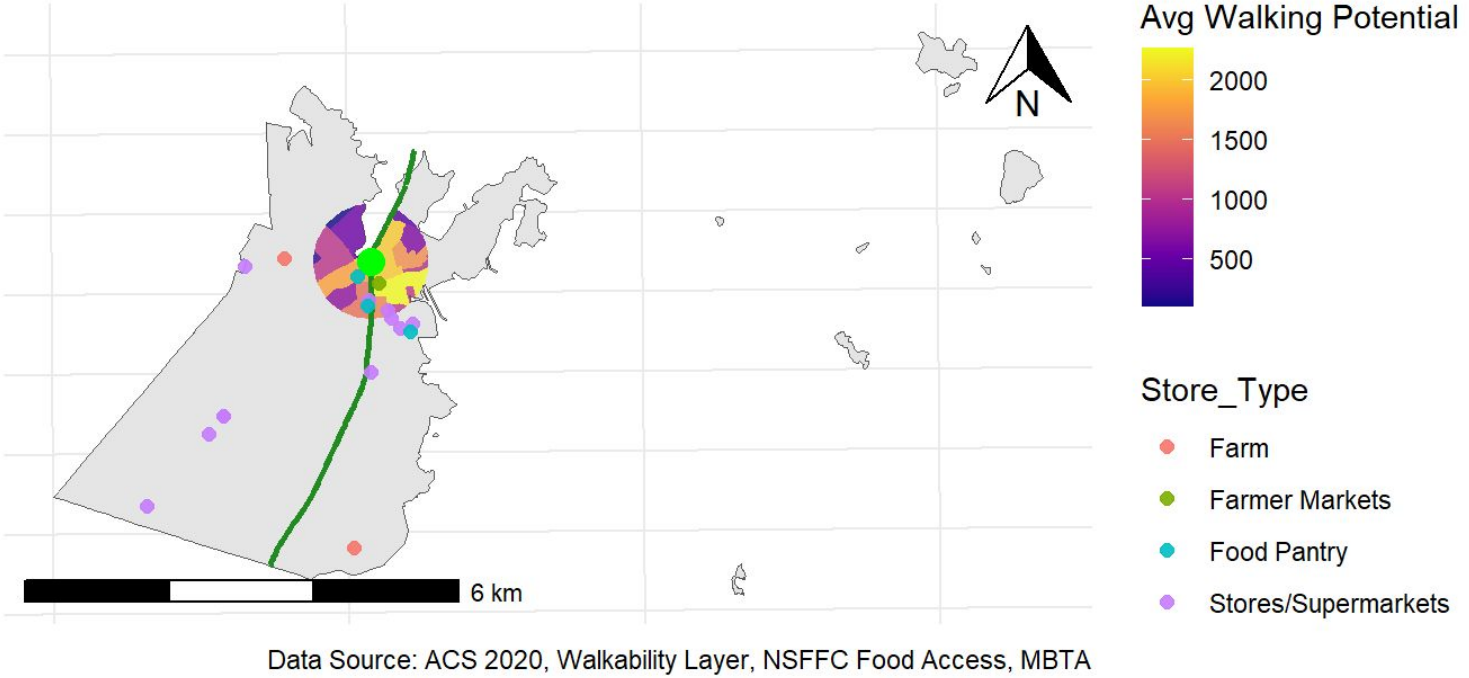
Data Source: ACS 2020, Walkability Layer, NSFFC Food Access, MBTA

Commuter Rail Stations, Commuter Rail Lines, Average Walking Potential and Food Distribution Sites in Lynn

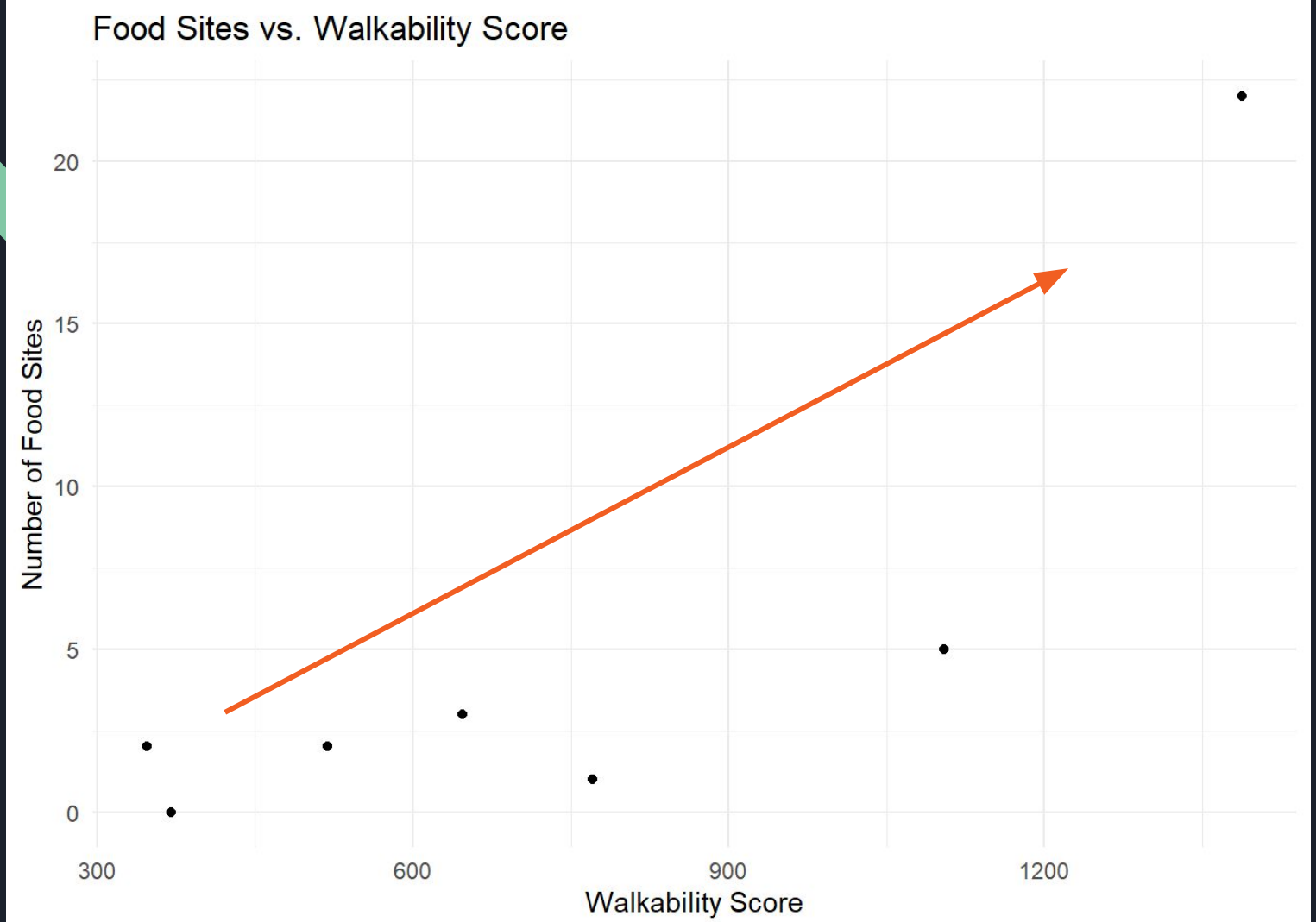


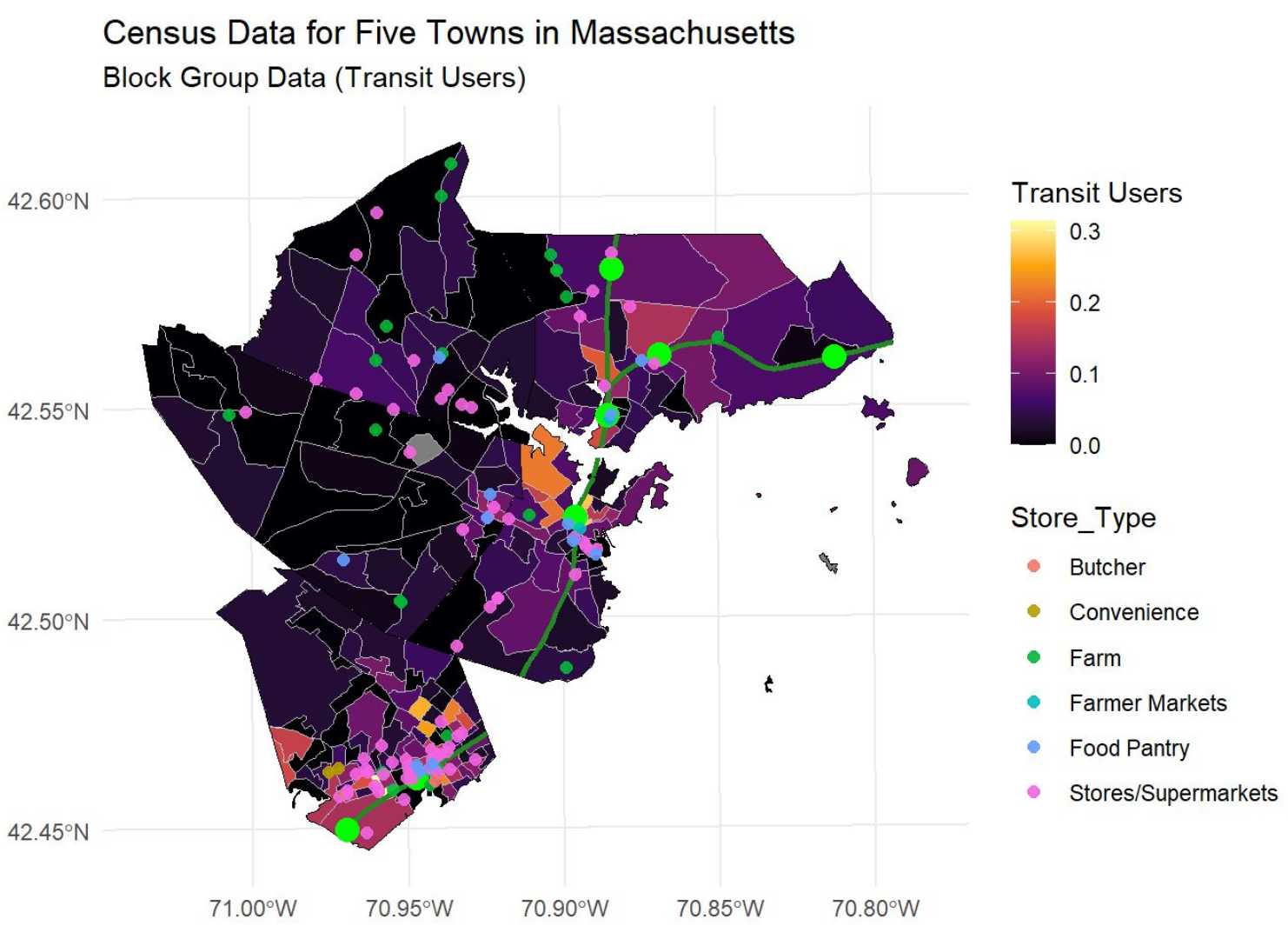
Data Source: ACS 2020, Walkability Layer, NSFFC Food Access, MBTA

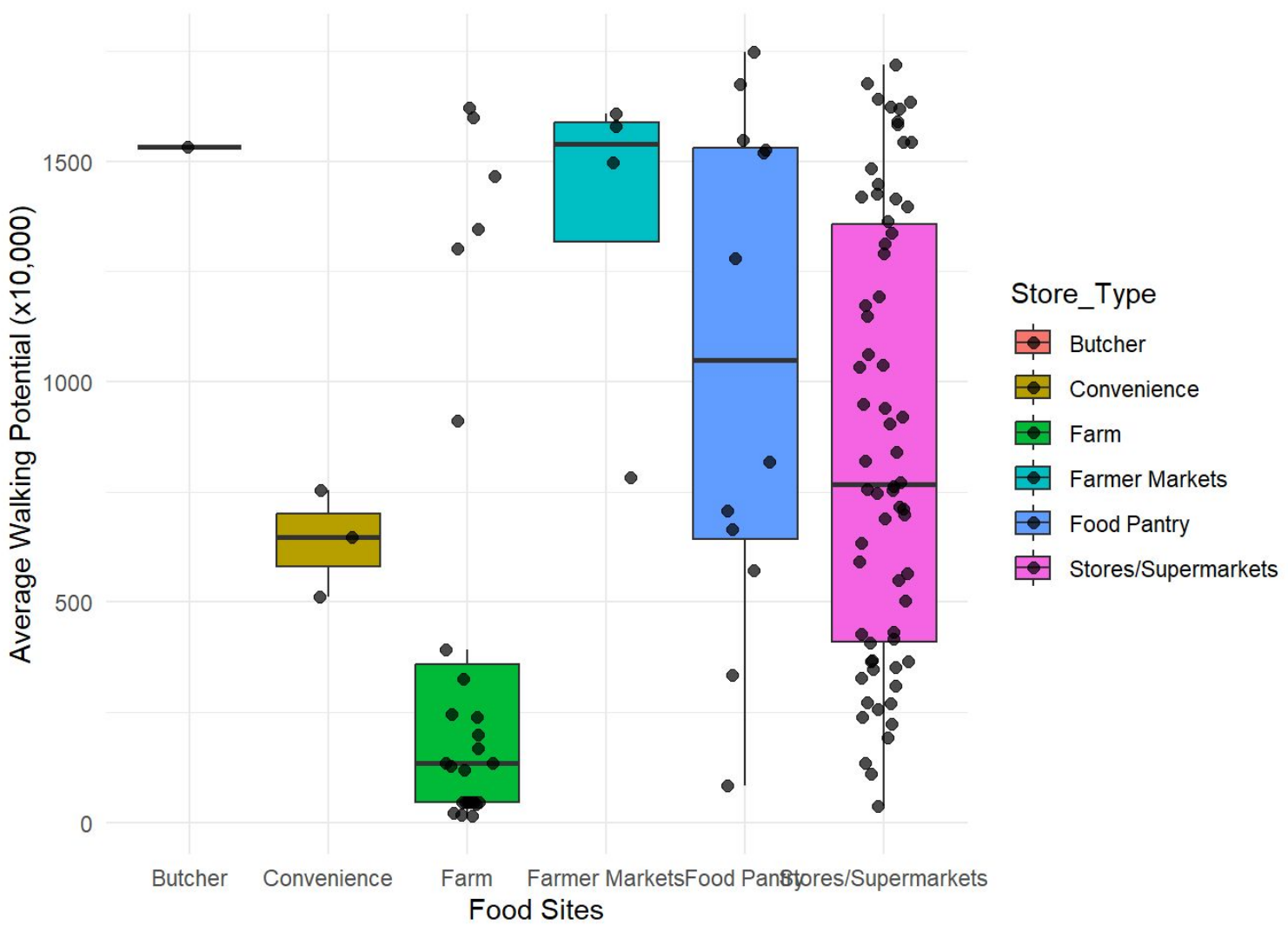
Commuter Rail Stations, Commuter Rail Lines, Average Walking Potential and Food Distribution Sites in Salem



Data Source: ACS 2020, Walkability Layer, NSFFC Food Access, MBTA

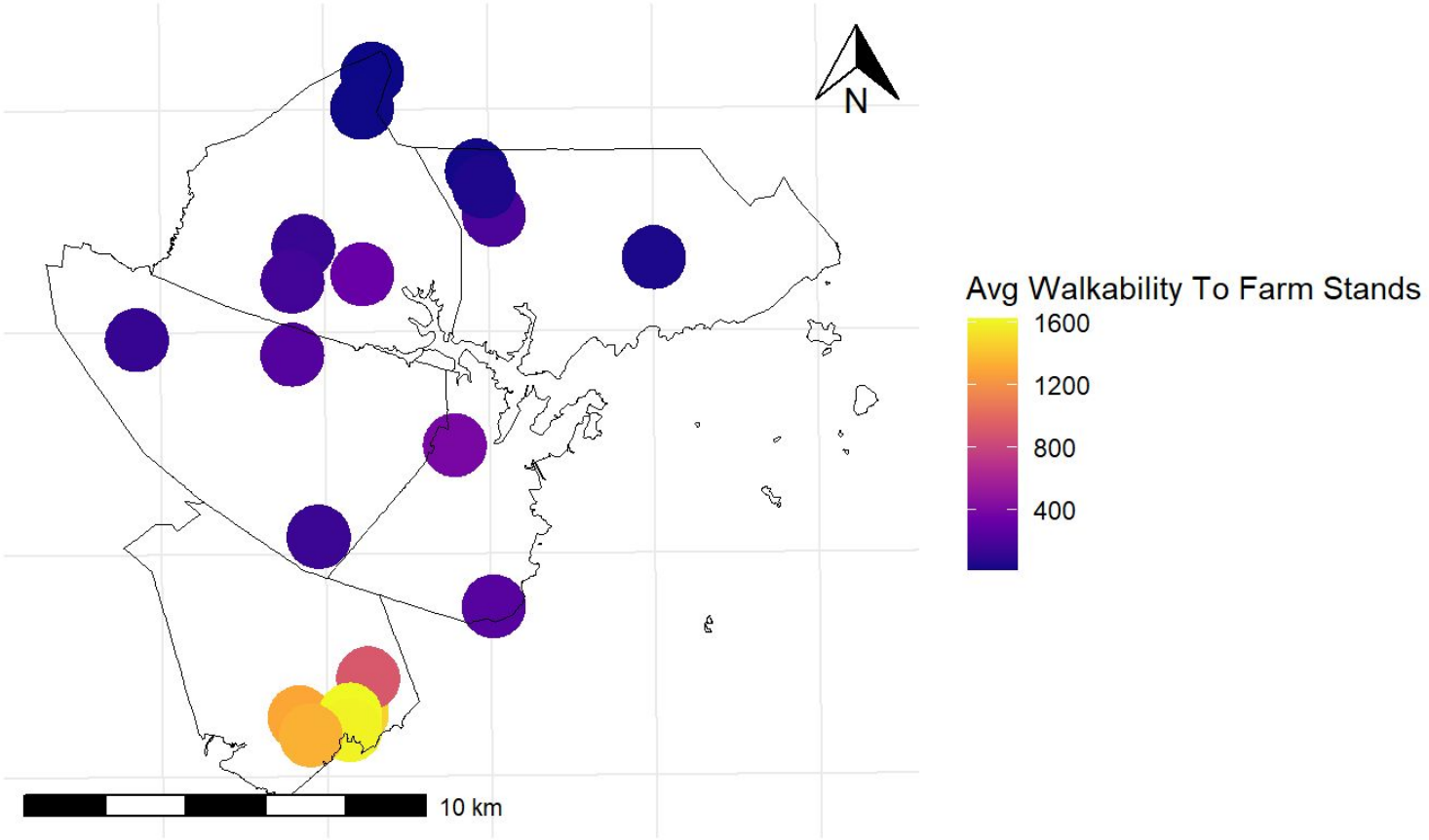

Food Sites vs. Walkability Score
Number of Food Sites
0
5
10
15
20
300
600
900
1200
Walkability Score


Census Data for Five Towns in Massachusetts
Block Group Data (Transit Users)
42.60°N
42.55°N
42.50°N
42.45°N
71.00°W
70.95°W
70.90°W
70.85°W
70.80°W
Transit Users
0.3
0.2
0.1
0.0
Store_Type
Butcher
Convenience
Farm
Farmer Markets
Food Pantry
Stores/Supermarkets


Average Walking Potential (x10,000)
1500
1000
500
0
Butcher
Convenience
Farm
Farmer Markets
Food Pantry
Stores/Supermarkets
Food Sites
Store_Type
Butcher
Convenience
Farm
Farmer Markets
Food Pantry
Stores/Supermarkets

Average Walking Potential to Farm Stands

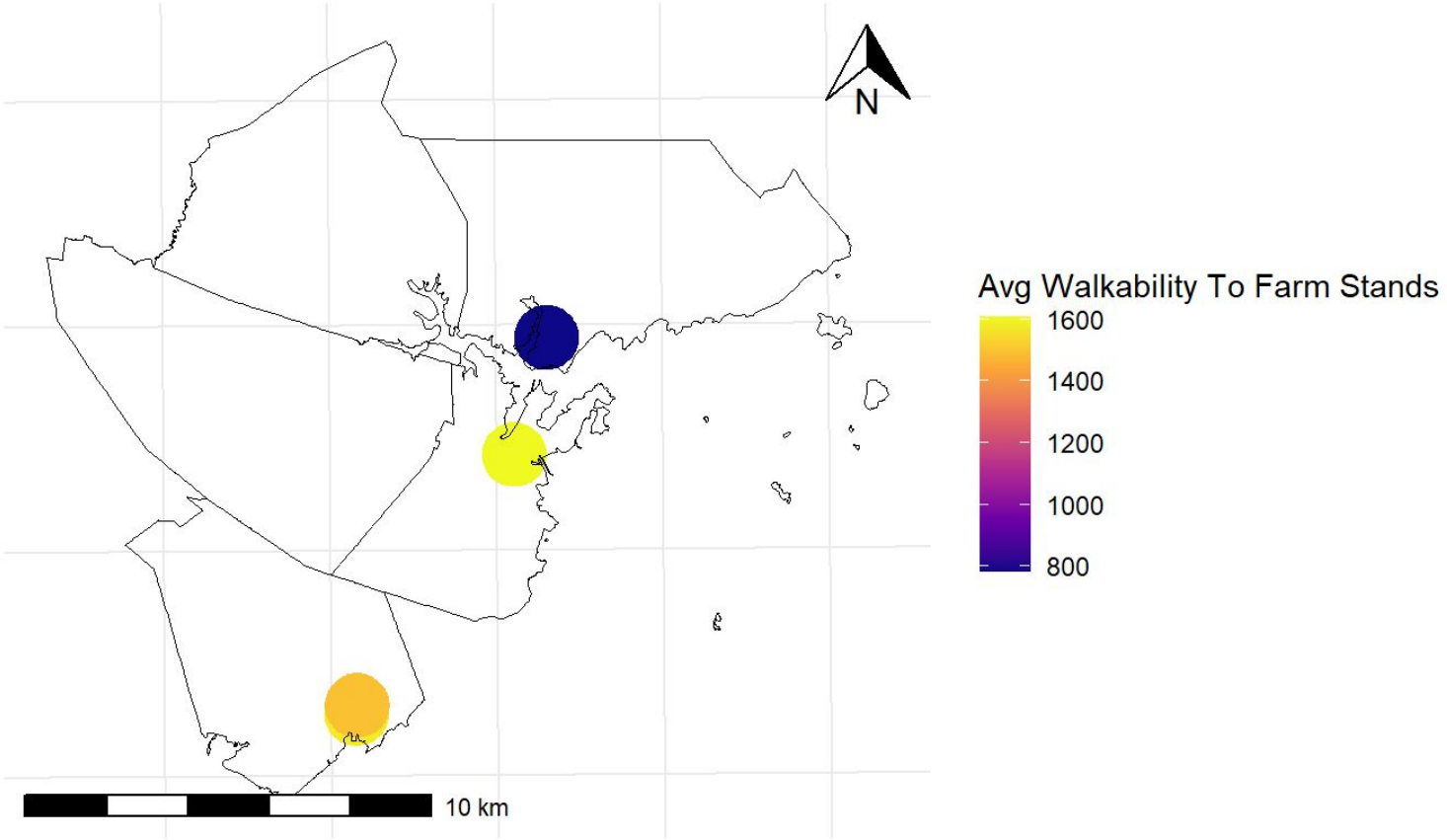
Within 800M of Site



Source: ACS 2020, Walkability Layer, NSFFC Food Access (Updated May 29, 2024)

Average Walking Potential to Farmers Markets

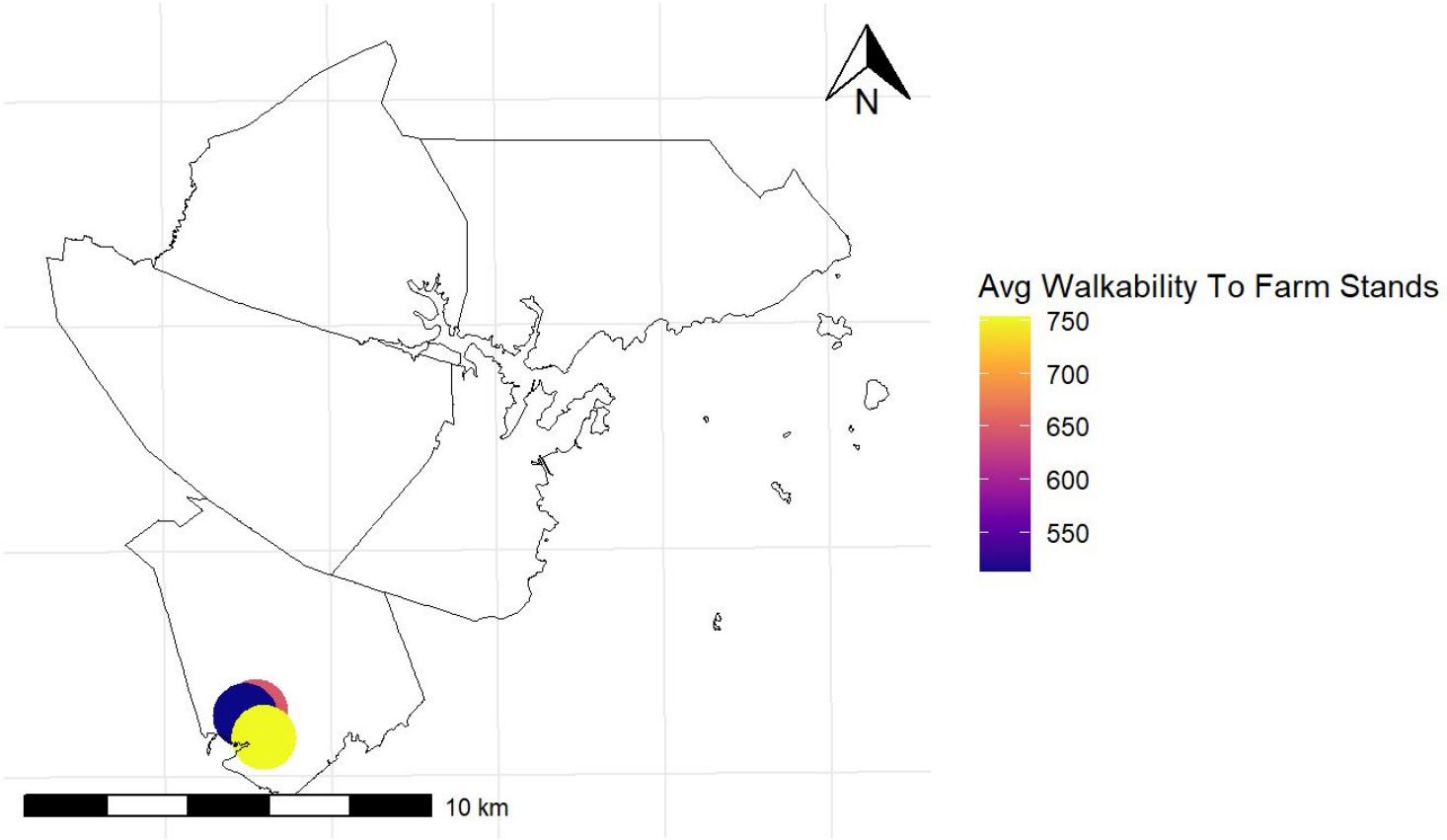
Within 800M of Site



Source: ACS 2020, Walkability Layer, NSFFC Food Access (Updated May 29, 2024)

Average Walking Potential to Convenience Stores

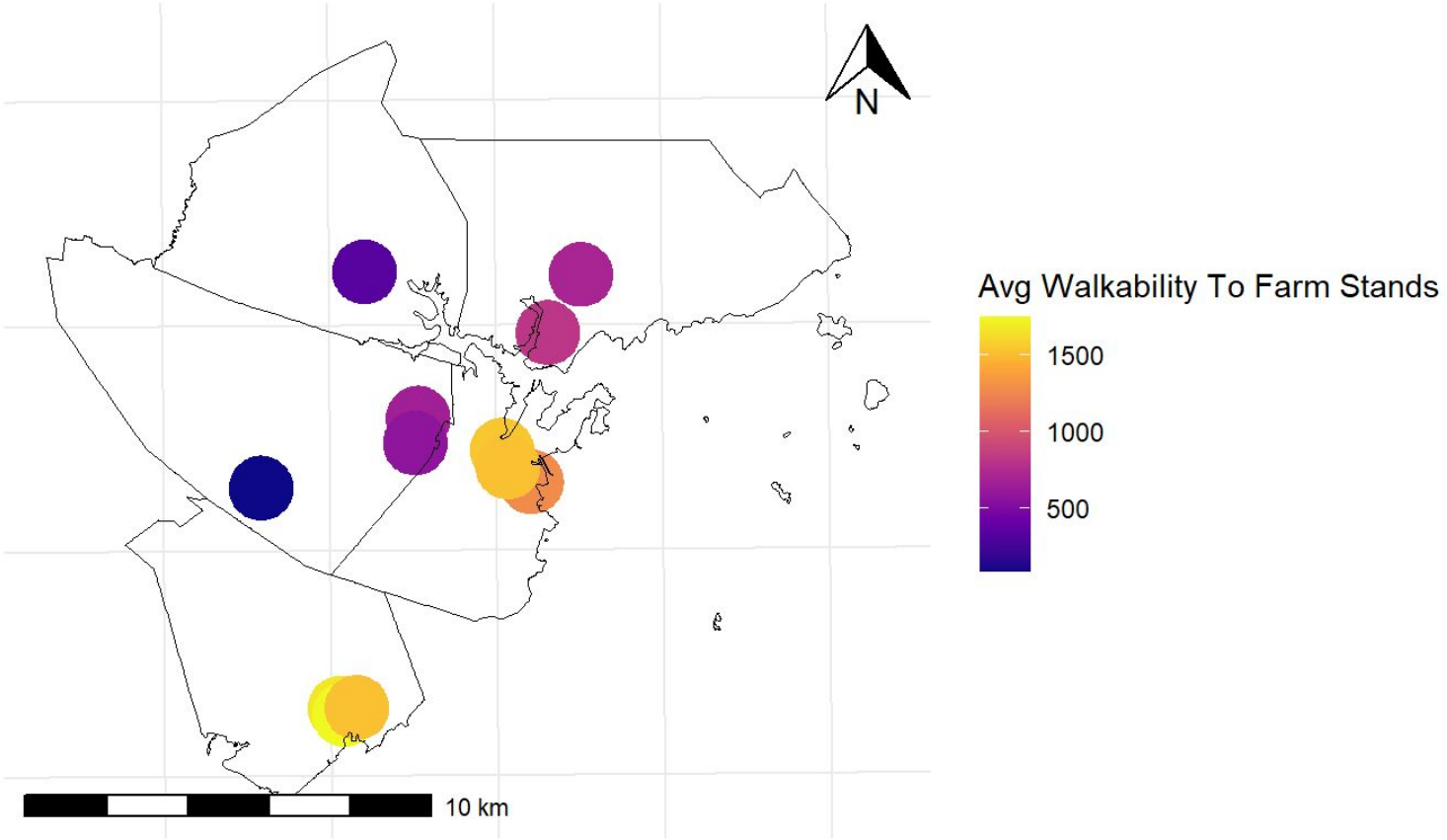
Within 800M of Site



Source: ACS 2020, Walkability Layer, NSFFC Food Access (Updated May 29, 2024)

Average Walking Potential to Food Pantries

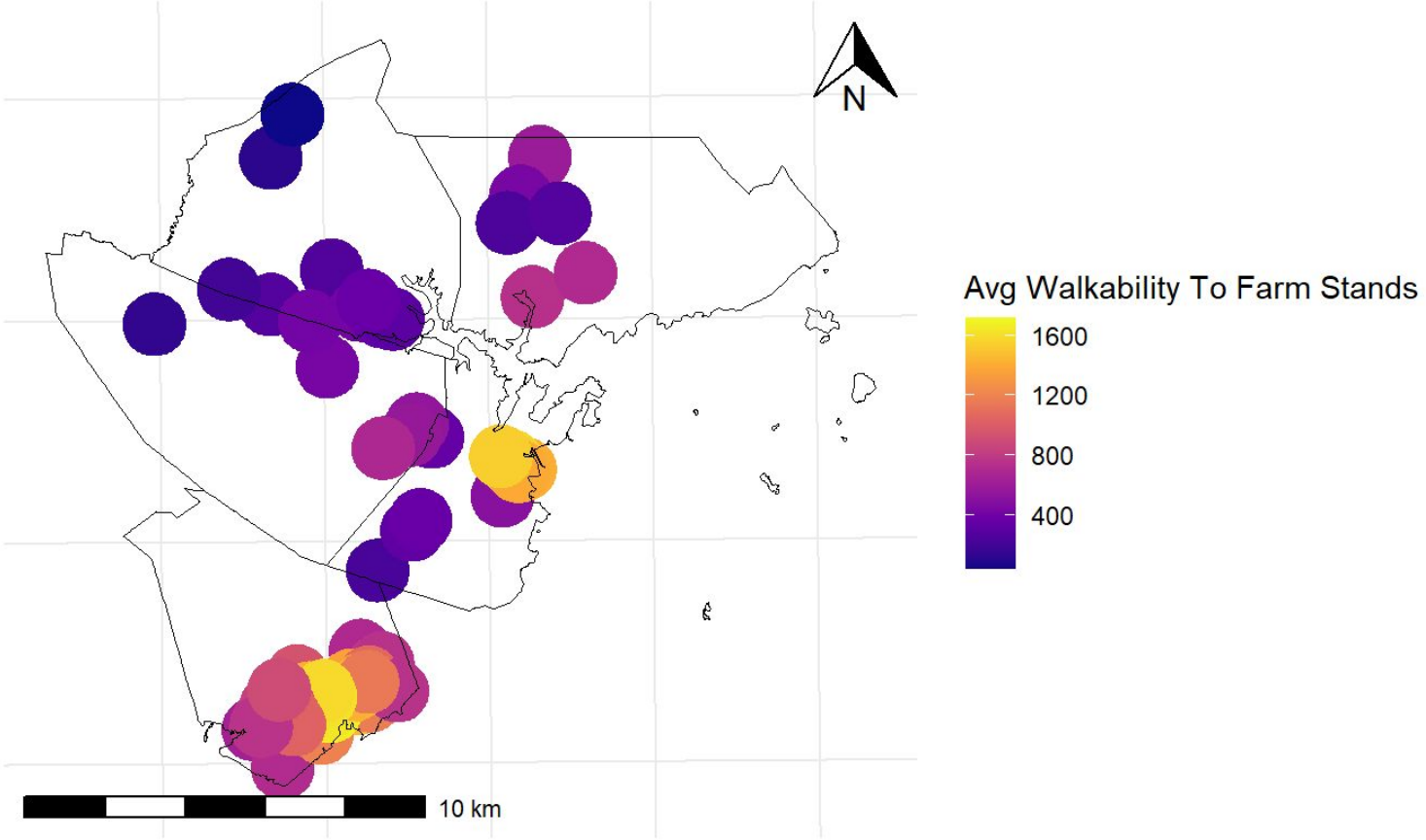
Within 800M of Site



Source: ACS 2020, Walkability Layer, NSFFC Food Access (Updated May 29, 2024)

Average Walking Potential to Grocery Stores

Within 800M of Site



Source: ACS 2020, Walkability Layer, NSFFC Food Access (Updated May 29, 2024)

Discussion

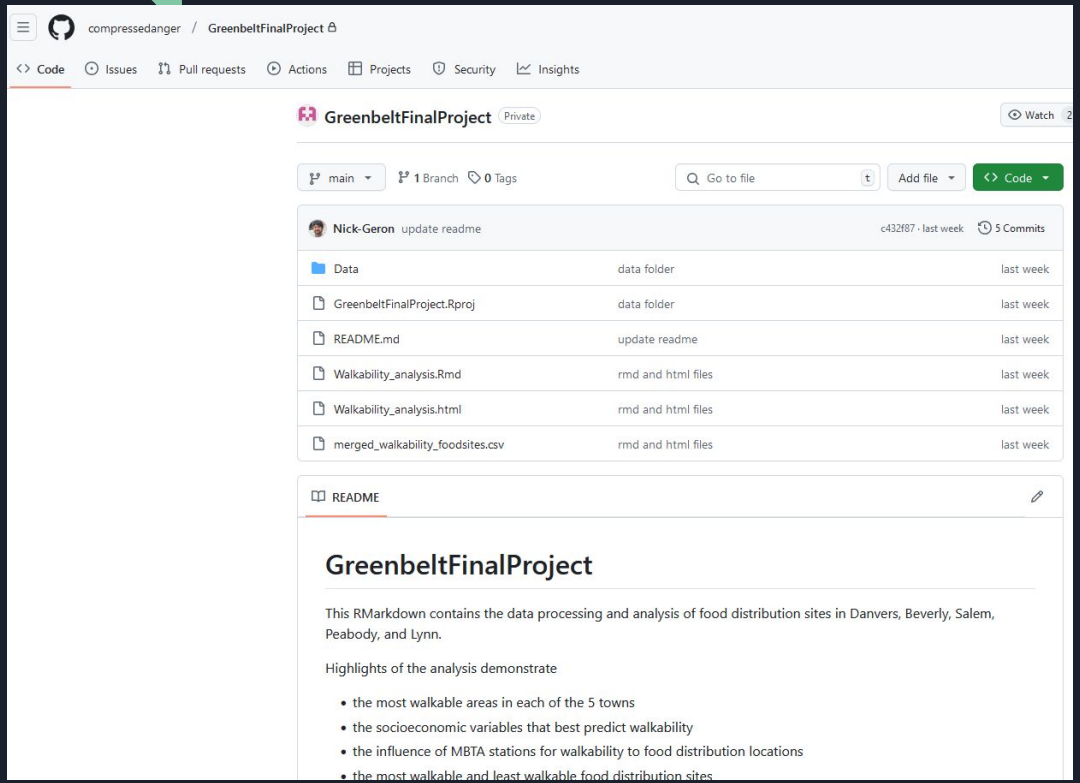
1. Walkability is higher in high density, non-white, english limited, larger hispanic, and households with one or less cars. Population density, car ownership and english limited households were found to be significant. Future food distribution and food equity planning should incorporate these US Census variables into planning.

2. Lynn is the most walkable MBTA station while the least walkable is Beverly Farms. Lynn also had 22 food distribution sites within 800m while none were within 800m in Beverly Farms.

3. Large variance in average walkability at food distribution sites but farmers markets, farm stands and grocery stores had the highest values.

   Convenience stores had the lowest walkability scores but there were very few

Next Steps



1. Project data and code is available in GitHub (currently private but would like to make public)
2. Identify food deserts
3. Investigate food distribution sites to include non-perishable food as well
4. Examine clusters of food distribution sites
5. Expand analysis beyond these 5 towns

Thank you!

Thank you to Abby Hardy-Moss, Rebecca Smalley, and Jason Risberg from Greenbelt Essex County's Land Trust for their support and feedback

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Greenbelt
Essex County's Land Trust

Salem
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