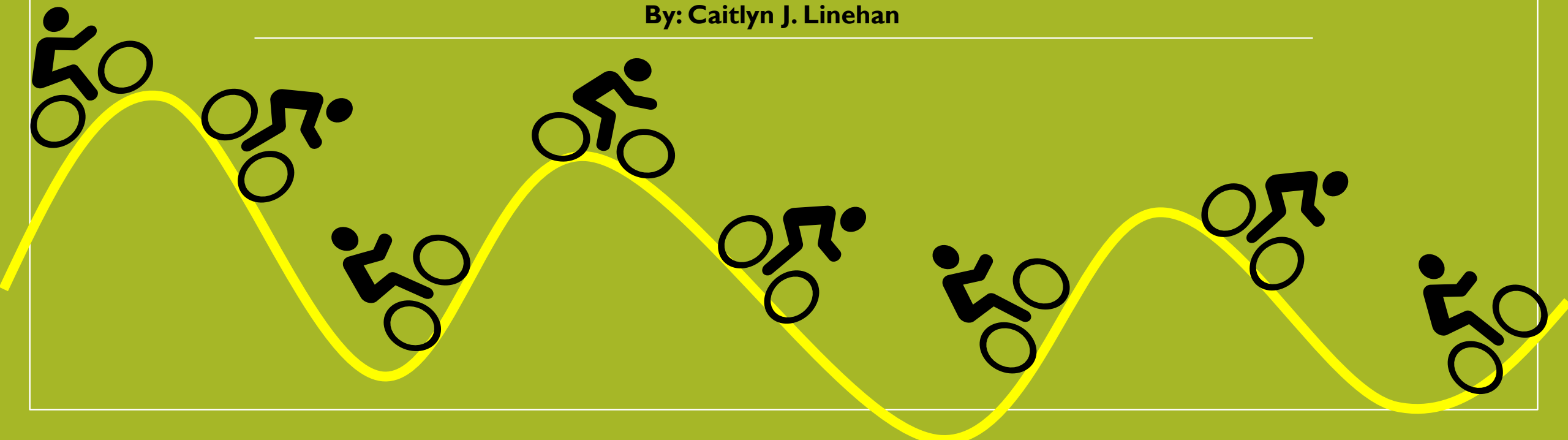
Accessibility and Connectivity of Bike Paths to Select Facilities for Bronx, NY Residents

Spring 2020: Geostatistics; Professor Musa

By: Caitlyn J. Linehan

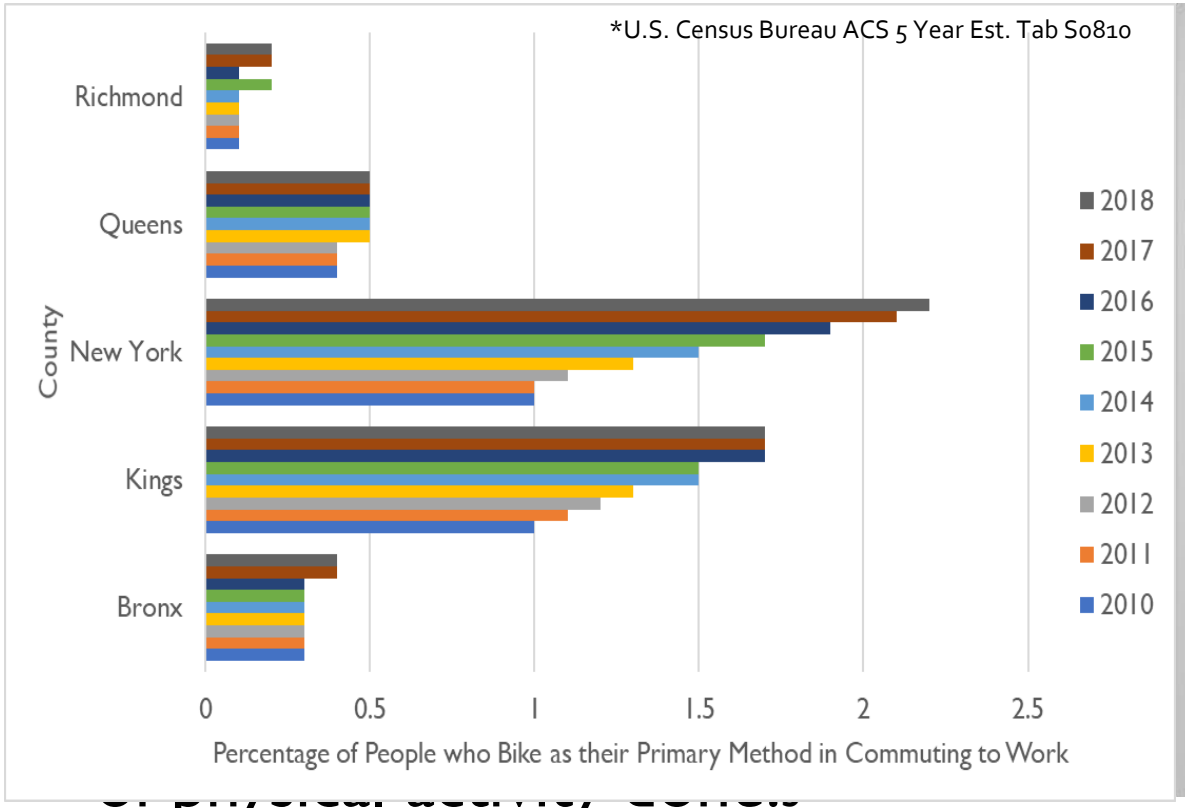


Background and Introduction

- People that engage in physical activity can greatly reduce the risk of different diseases as well as reducing stress and anxiety.[1]
- Biking is a great form of physical activity that provides these benefits.[2]
- A deterrent to urban biking is a lack of a connected bike path.
- This case study will use network analysis on the accessibility of a low stress bike network in the Bronx to access select facilities (parks, recreation centers, and libraries) that promote well being.
- When access to areas where physical activities are promoted are increased as well as educational outreach there is a significant increase in the occurrence of physical activity done.[3]

1. (Gies 2006)
2. (Götschi et.Al 2016)
3. (Kahn et.Al 2002)

Background and Introduction



1. *(Gies 2006)*
2. *(Götschi et.Al 2016)*
3. *(Kahn et.Al 2002)*

Research Questions

1. Determine stress imposed on cyclist due to a street link based on street type, speed limit, number of travel lanes, slope, and bicycle accommodation.

2a. What is the access of park entrances to Bronx, NY cyclists using a low stress bicycle network?

2b. What is the access of libraries to Bronx, NY cyclists using a low stress bicycle network?

2c. What is the access of recreation centers to Bronx, NY cyclists using a low stress bicycle network?

Methods

- 1. Cleaning the Street Data
- 2. Defining the Low Stress Network
- 3. Integrating Slope in the Low Stress Network

- 4. Making the Network in ArcMap
- 5. OD Cost Matrix: Defining the origins
- 6. OD Cost Matrix: Defining the destinations
- 7. OD Cost Matrix: Calculating the OD Matrix
- 8. OD Cost Matrix: Assessing the Results

Answers question 1. Determine stress imposed on cyclist

Answers question 2. Access of park entrances, libraries, and recreation centers

***Methodology based on a paper by Lowry et. al 2016*

1. Cleaning the Street Network and Edge Effect

- Found that the average distance that a resident in Sweden would travel to recreational forested parks is 3.5 km or approximately 2 miles. [1]

- LION Street Dataset
- Westchester Roads (from the Census)

- Clip to the 2 mile buffer border
- Remove Generic and Faux Segments
- Remove all Feature types except Streets
- Remove bridges that don't have bike accommodations
- Remove highways because bikes are not allowed on them.
- Remove roads in areas such as: Rikers Island, Bronx Zoo, and Botanical Gardens

1. (Hörnsten et Fredman 2000)

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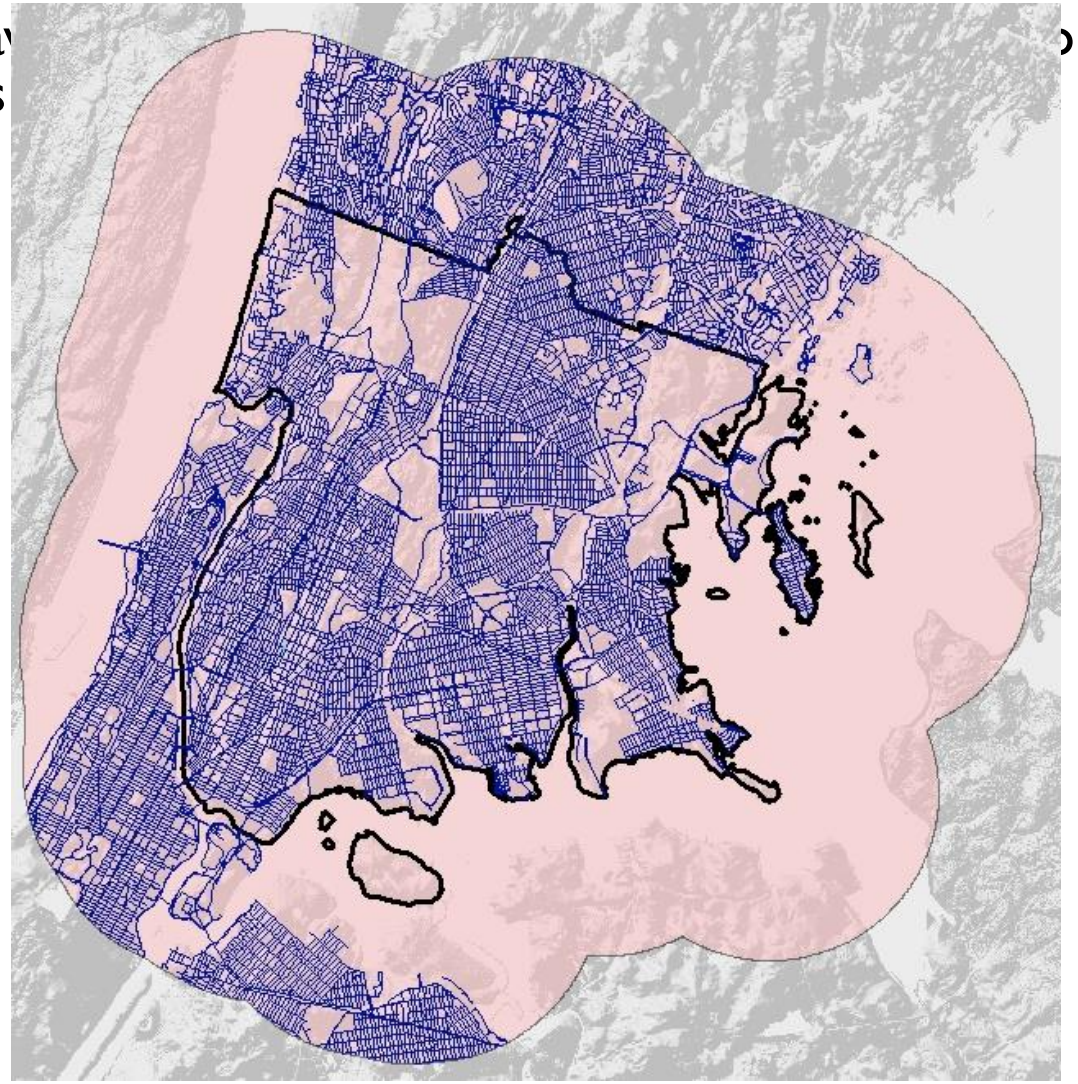

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1. (Hörnsten et Fredman 2000)

2. Defining the Low Stress Network

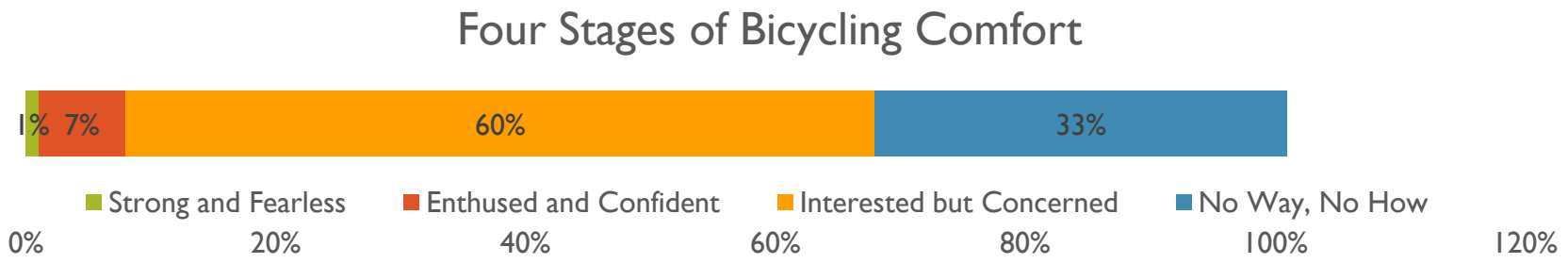
- $F_{stress,e} = F_{roadway,e} \times (1 - F_{bikeaccom,e})$
  - $F_{stress,e} = stress\ factor\ for\ link\ e$
  - $F_{roadway,e}$= roadway stress factor
  - $F_{bikeaccom,e} =$ $bicycle\ accomodation\ stress\ reduction\ factor\ for\ link\ e$

- $F_{slope,e} = slope\ factor\ for\ link$
  - 37% if slope > 2%
  - 120% if slope > 4%
  - 320% if slope > 6%

- $F_{slope,e} + F_{stress,e} = Stress\ Level$
- Stress Level Threshold is 60%

**Methodology based on a paper by Lowry et. al 2016

Bicycling Comfort and Low Traffic Stress Levels



**Source: Geller 2009*

	Low Traffic Stress Criteria Tables
LTS 1	"Strong separation from all except low speed, low volume traffic. Simple-to-use crossings. LTS 1 indicates a facility suitable for children."
LTS 2	"Except in low speed / low volume traffic situations, cyclists have their own place to ride that keeps them from having to interact with traffic except at formal crossings. Physical separation from higher speed and multilane traffic. Crossings that are easy for an adult to negotiate. Limits traffic stress to what the mainstream adult population can tolerate."
LTS 3	"Involves interaction with moderate speed or multilane traffic, or close proximity to higher speed traffic. A level of traffic stress acceptable to the 'enthused and confident'."
LTS 4	"Involves being forced to mix with moderate speed traffic or close proximity to high-speed traffic. A level of stress acceptable only to the 'strong and fearless'."

**Source: Furth 2012*

2. Defining the Low Stress Network

Roadway			Stress Reduction from Bicycle Accommodations				
Number of Lanes	Speed Limit	Roadway Stress w/out Accommodation	3: III: Signed Bicycle Route	5: Combo of II, III	6:Combo of I, III	2: II: Striped Bike Lane	4: Combo of I, II
			5.00%	23.00%	43.00%	50.00%	70.00%
1 lane	SL≤25	10.00%	9.50%	7.70%	5.70%	5.00%	3.00%
1 lane	25<SL≤35	15.00%	14.25%	11.55%	8.55%	7.50%	4.50%
2-3 lanes	SL≤25	20.00%	19.00%	15.40%	11.40%	10.00%	6.00%
4-5 lanes	SL≤25	35.00%	33.25%	26.95%	19.95%	17.50%	10.50%
2-3 lanes	25<SL≤35	40.00%	38.00%	30.80%	22.80%	20.00%	12.00%
6+ lanes	SL≤25	67.00%	63.65%	51.59%	38.19%	33.50%	20.10%
4-5 lanes	25<SL≤35	70.00%	66.50%	53.90%	39.90%	35.00%	21.00%
6+ lanes	25<SL≤35	80.00%	76.00%	61.60%	45.60%	40.00%	24.00%
2-3 lanes	SL>35	100.00%	95.00%	77.00%	57.00%	50.00%	30.00%
4-5 lanes	SL>35	120.00%	114.00%	92.40%	68.40%	60.00%	36.00%
6+ lanes	SL>35	140.00%	133.00%	107.80%	79.80%	70.00%	42.00%
Separated Path (Greenway)		0.00%					
Link	TrafDir=P	0.00%					
1 lane	25	10.00%					
2-3 lanes	25	20.00%					
4 lanes	25	35.00%					
1 lane	30	15.00%					
2-3 lanes	30	40.00%					
4 lanes	30	70.00%					
Stairs		5.00%					

LTS 1 Threshold: 10%

LTS 2 Threshold: 30%

LTS 3 Threshold: 60%

LTS 4 Threshold: No Max

***Methodology based on a paper by Lowry et. al 2016*

Calculating Slope of Street Segments

Use the Feature Vertices to Points tool (once for the end of the street segment and another for the start of the street segment)

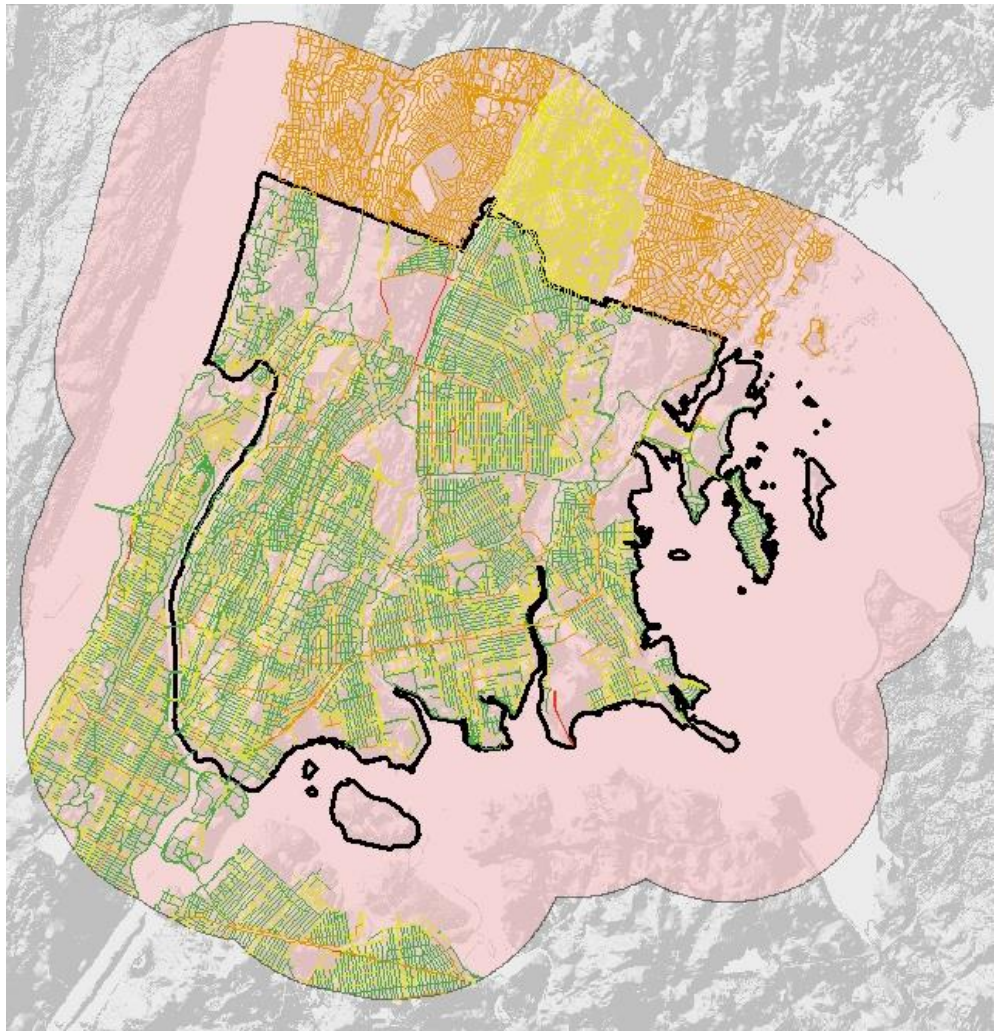
Use a DEM and use the Extract Values to Points tool to get the elevation value for the beginning and end point

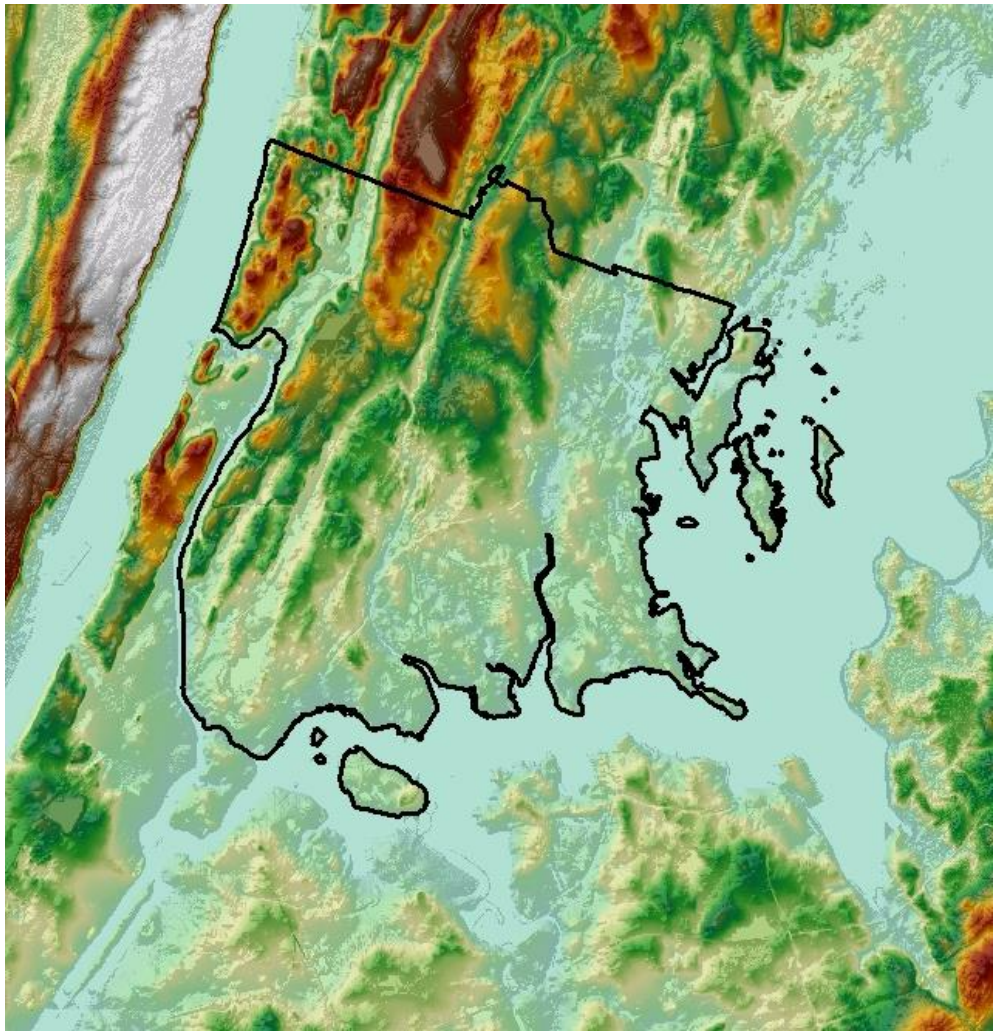
Join Point Data with Start and End Elevation to Street Network

Calculate slope percent:

$$\frac{End\ Elevation - Start\ Elevation}{Segment\ Length} \times 100$$

3. Using slope in our LTS network





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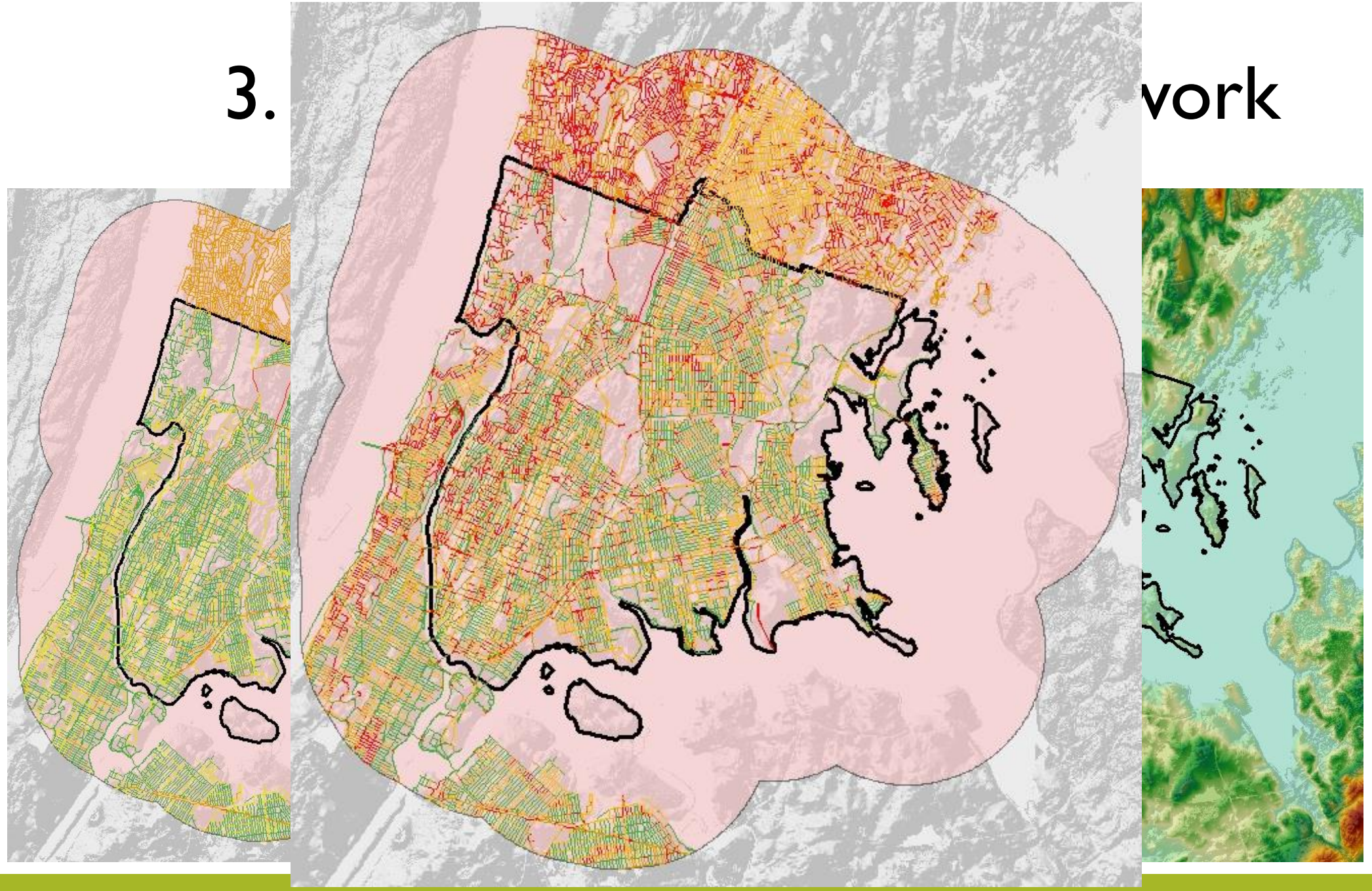
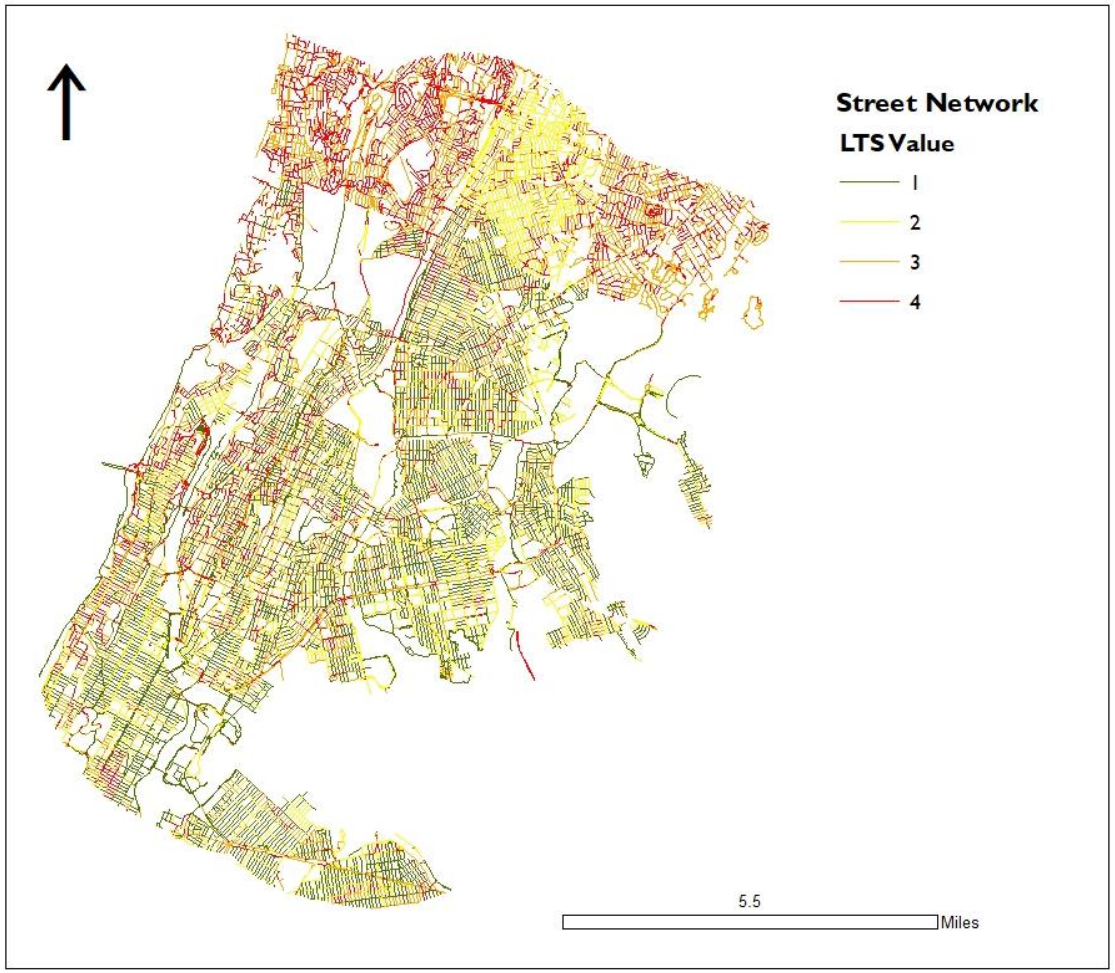
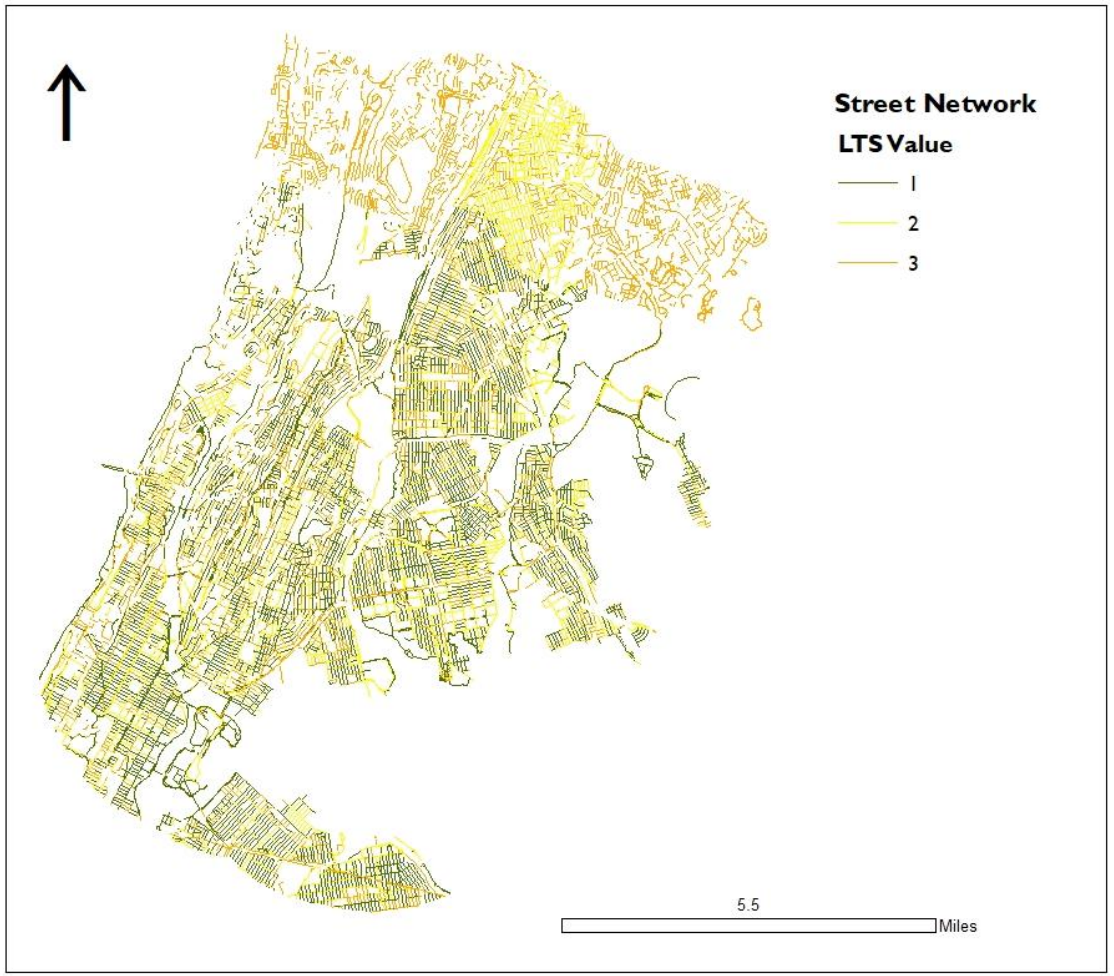


4.Making the Network in ArcMap

Select and Export Links with LTS Values of 1,2, or 3

This is the new defined network





4.Making the Network in ArcMap

Add and calculate the redefined length field

$$NewW_eLength = L_e(1 + F_{slope,e} + F_{stress,e})$$

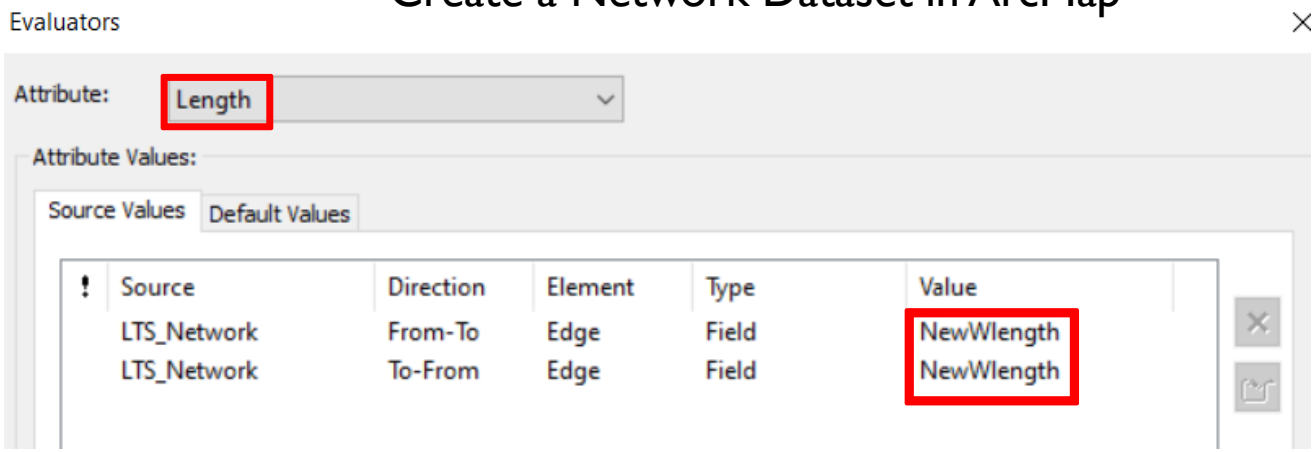
$NewW_eLength = Impedence\ length\ factor\ of\ link\ e$

$L_e = length\ of\ link\ e$

$F_{stress,e} = stress\ factor\ for\ link\ e$

$F_{slope,e} = slope\ factor\ for\ link\ e$

Create a Network Dataset in ArcMap



**Methodology based on a paper by Lowry et. al 2016

5. Defining the areas of origins (Tax Lot Data)

Performed Cadastral Based Expert Dasymetric System (CEDS) to estimate the Population at the Tax Lot level

Data Inputs

- Residential Units at the Lot Level
- Residential Area at the Lot Level
- Population at the Census Tract Level
- Population at the Block Group Level

***Methodology based on a paper by Maantay et. al 2007*

5.5 CEDS Method (Tax Lot Data)

Census Tract

Population= 40 people
Total RU= 10
Total RA= 17,000 ft

Tax Lot 1
RU=1
RA= 1,000 ft

Tax Lot 2
RU=2
RA= 2,000 ft

Tax Lot 3
RU=7
RA= 14,000 ft

Estimating Population at the Tract Level

- $POP_l = POP_c \times \frac{U_l}{U_c}$
- $POP_l = Estimated\ Population\ at\ the\ Lot\ Level$
- $POP_c = Population\ at\ the\ Census\ Tract\ Level$
- $\frac{U_l}{U_c} = Ratio\ of\ the\ Residential\ Units\ at\ the\ Lot\ Level\ to\ the\ Residential\ Units\ of\ the\ Censust\ Tract\ Level$

* Repeat for the Residential Area

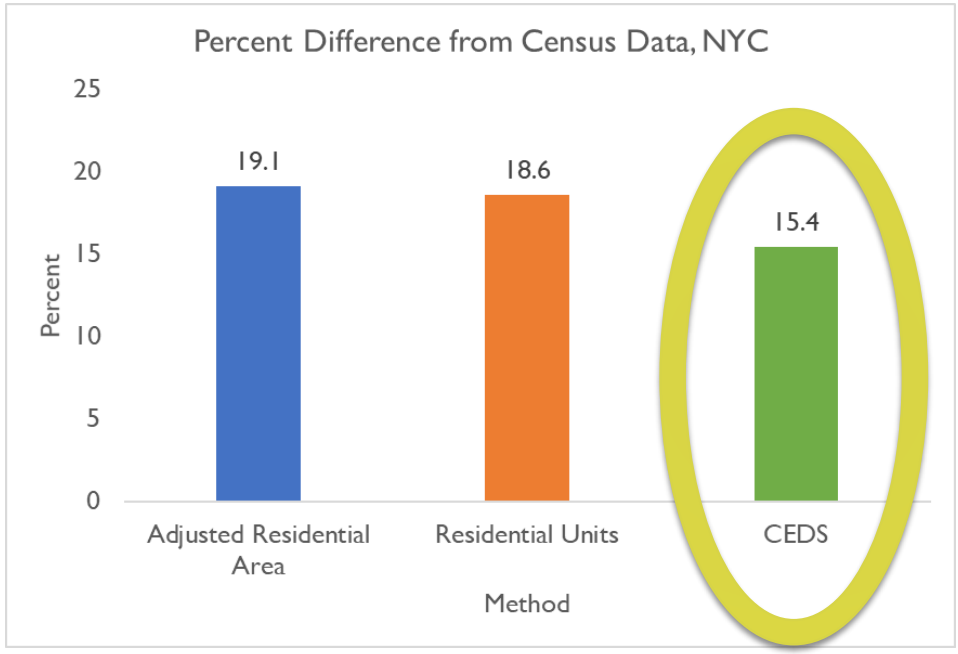
Assessing Errors

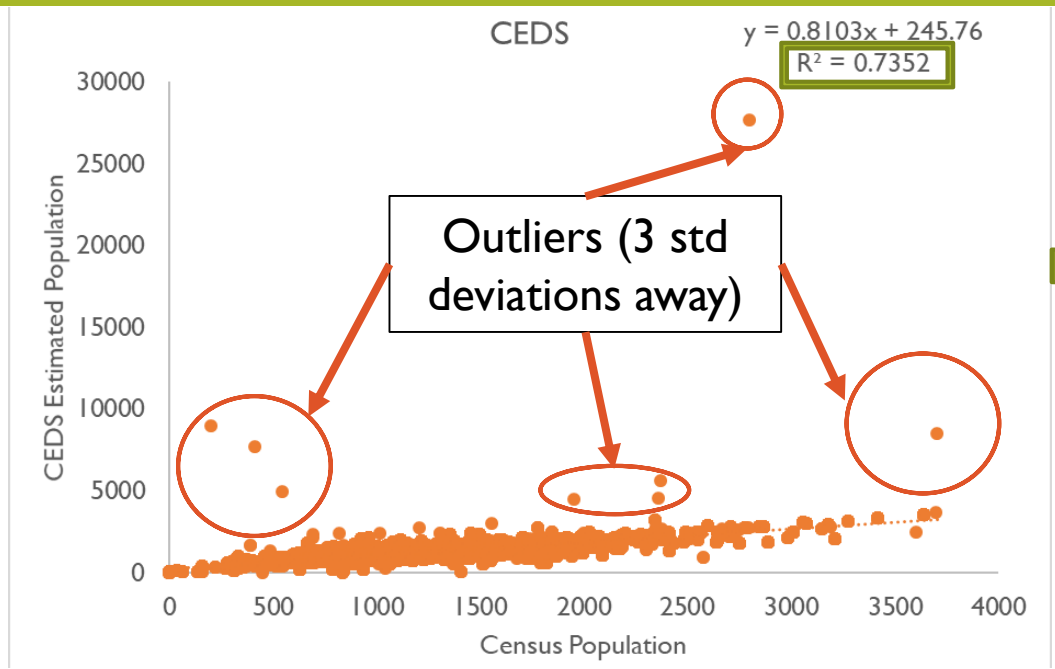
- $RU\_POP_{diff} = |POP_{BG} - POP_{est}|$
- $RU\_POP_{diff} = Absolute\ Difference\ between\ Census\ Block\ Group\ Population\ and\ the\ estimated\ tax\ lot\ population\ based\ on\ Residential\ Units\ aggregated\ to\ the\ Block\ Group$

CEDS

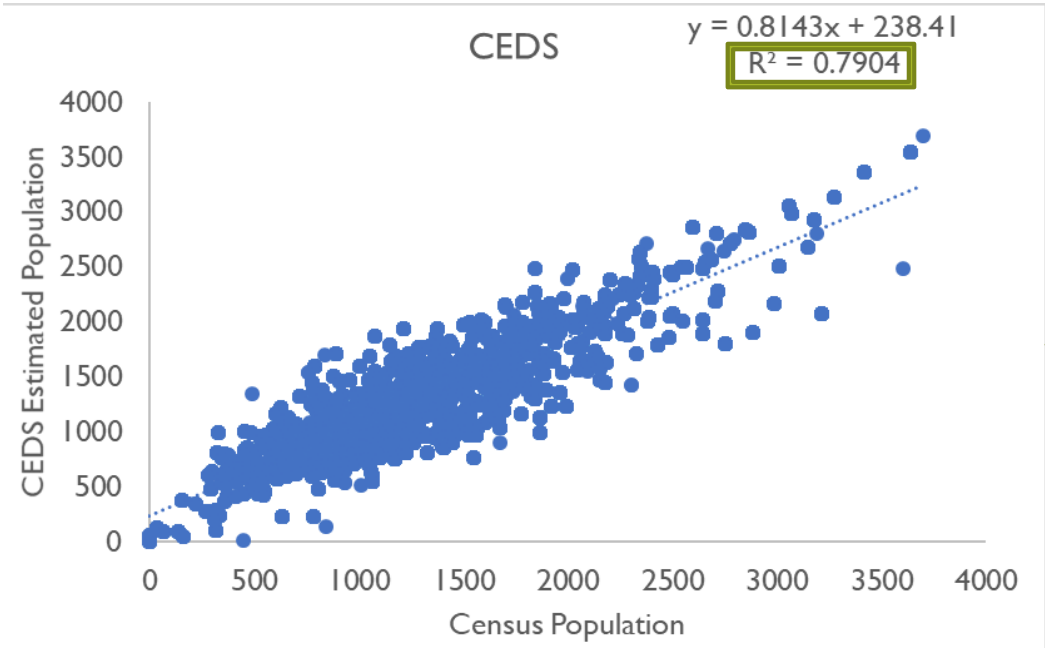
- $If\ RU\_POP_{diff} \leq ARA_{POP_{diff}}, Then\ POP_{lot} = POP_{RU\_CT}, Else\ POP_{lot} = POP_{ARA\_CT}$

5. 75 Assessment of CEDS Methods

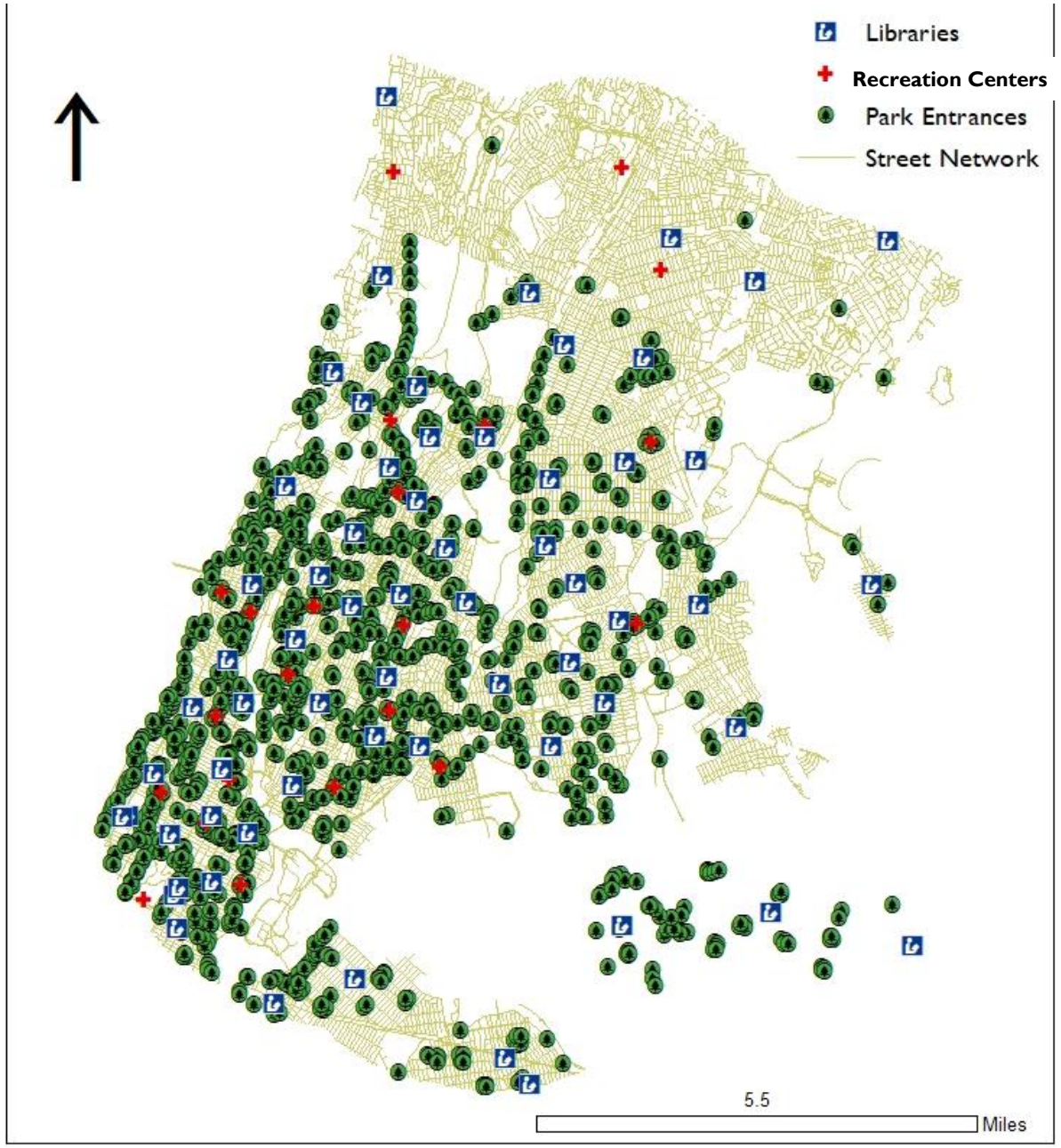


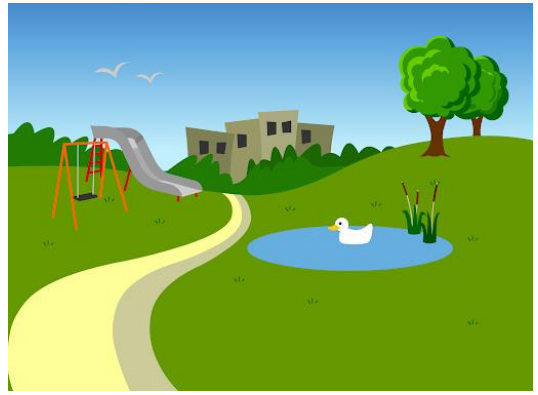


Remove Outliers

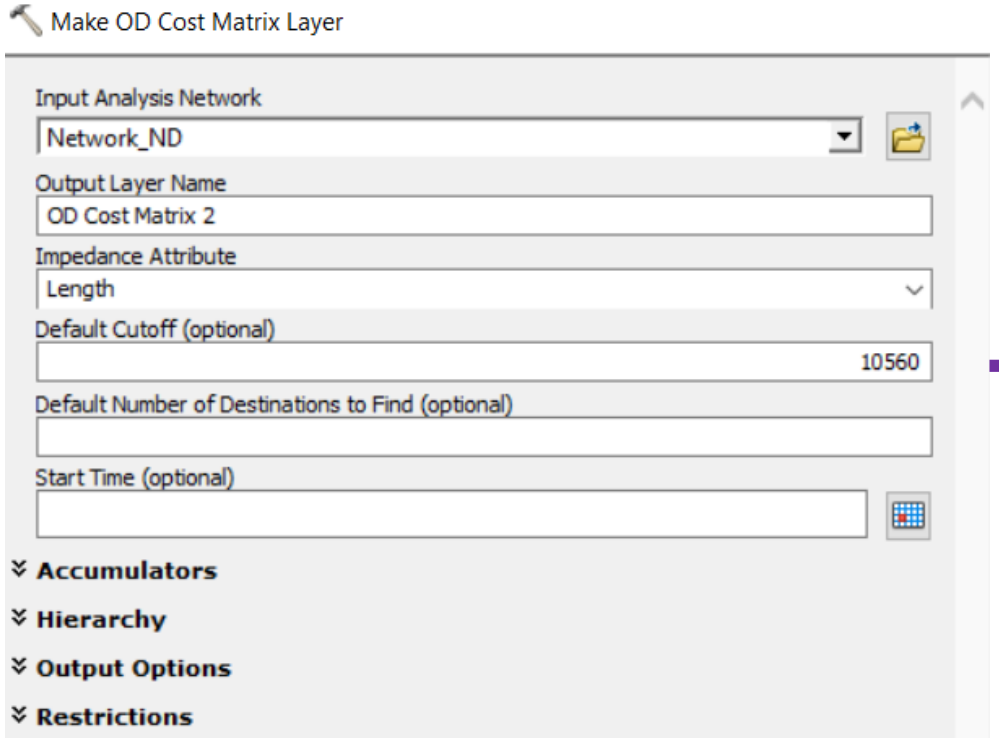


6. Defining the Areas of Interest (Destinations)





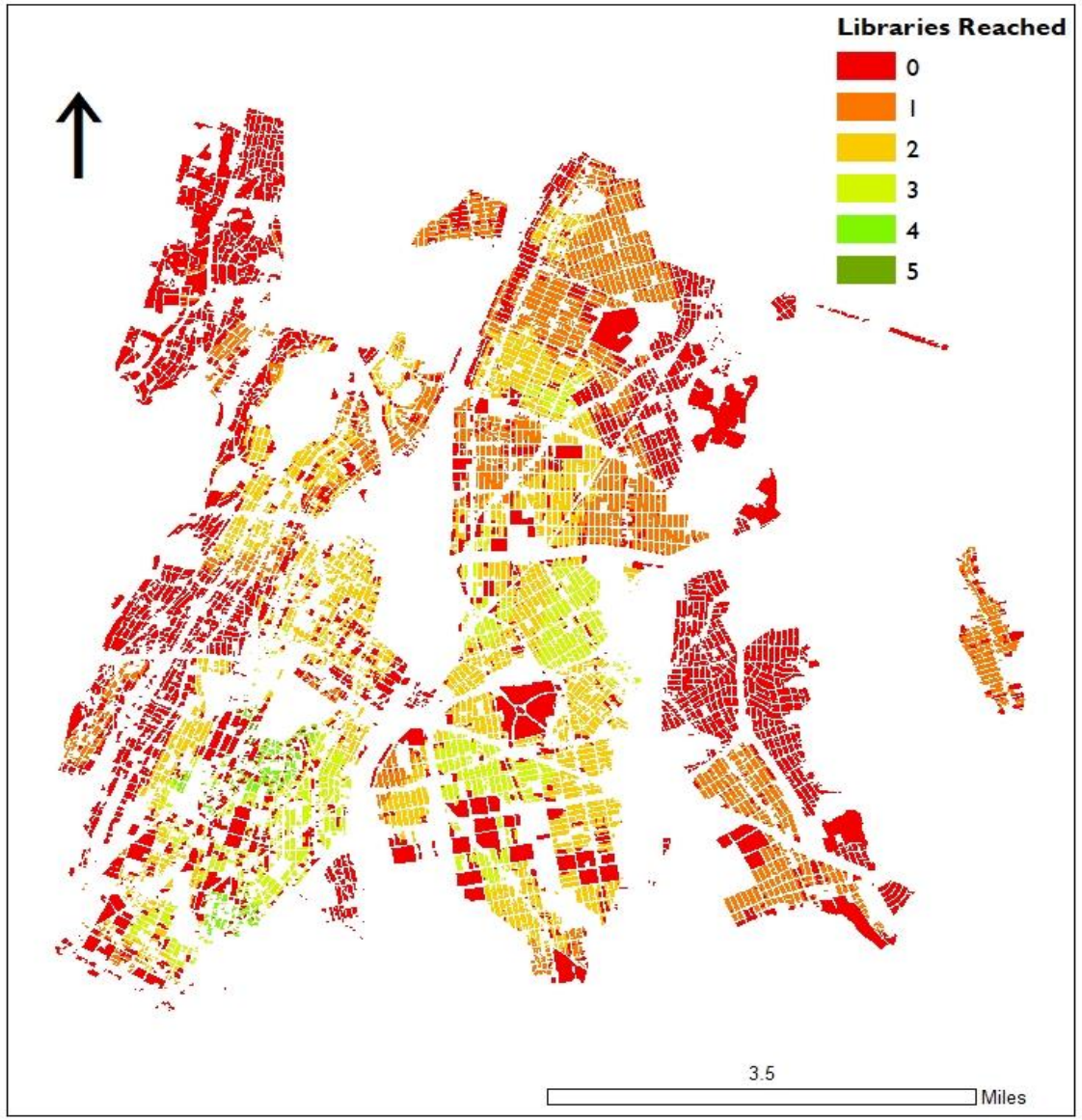
7. OD Cost Matrix: Calculating the OD Matrix

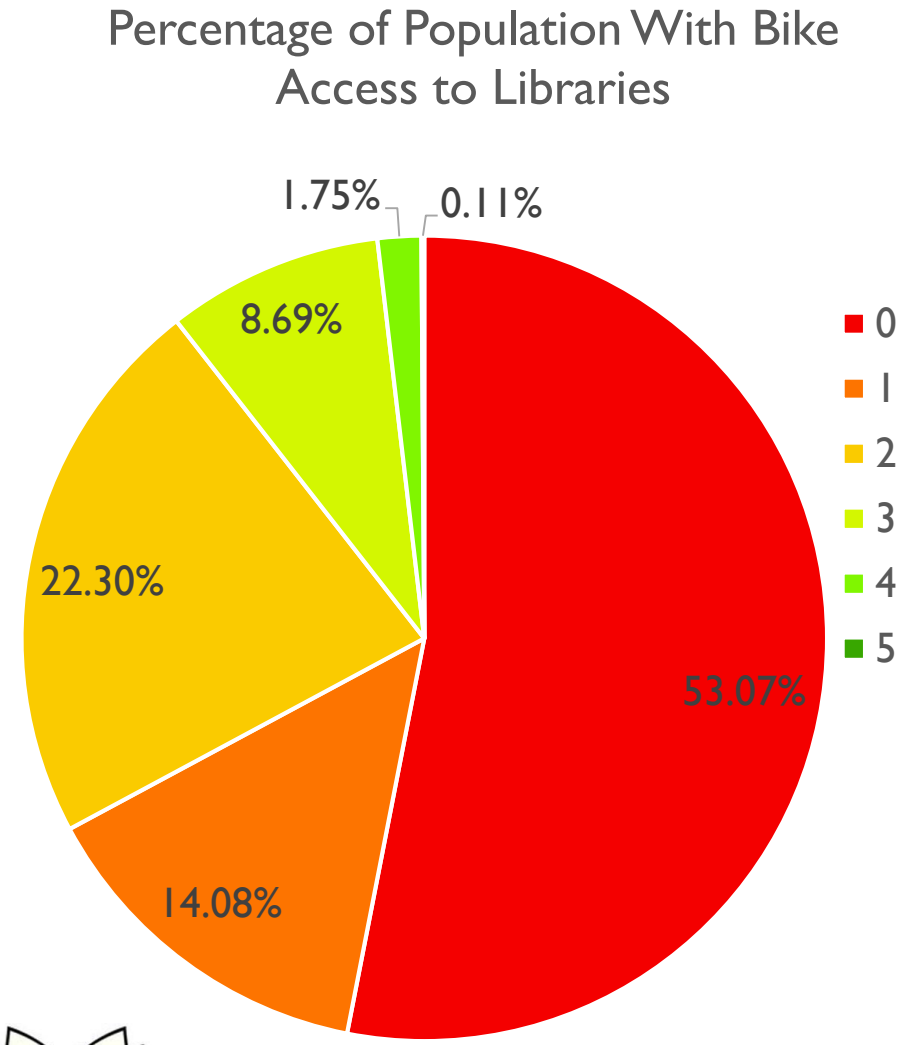


Results:

Table that stated how many destinations (libraries/ recreation centers/parks) that a certain origin (singular tax lot) has reached

8. Assessing the Results





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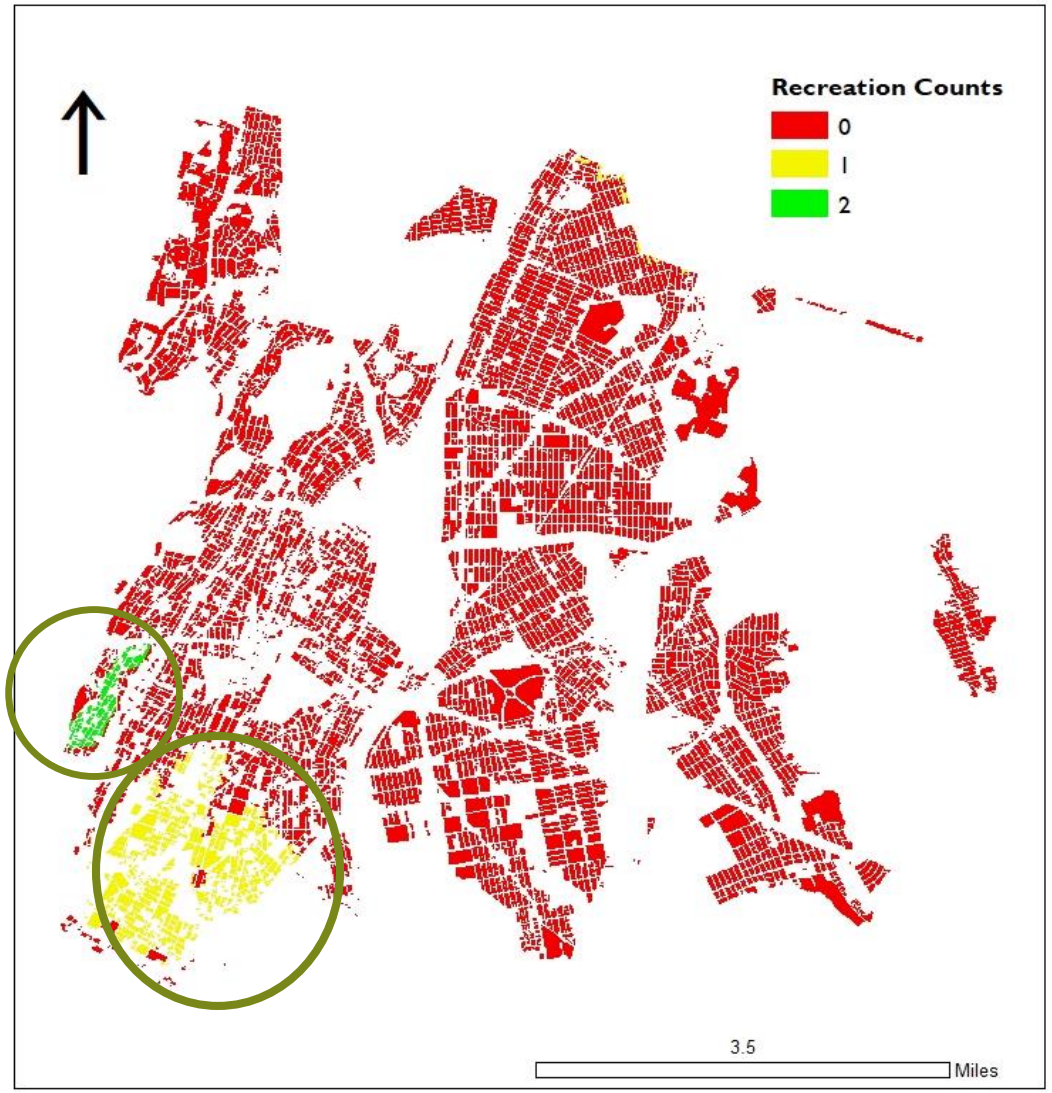

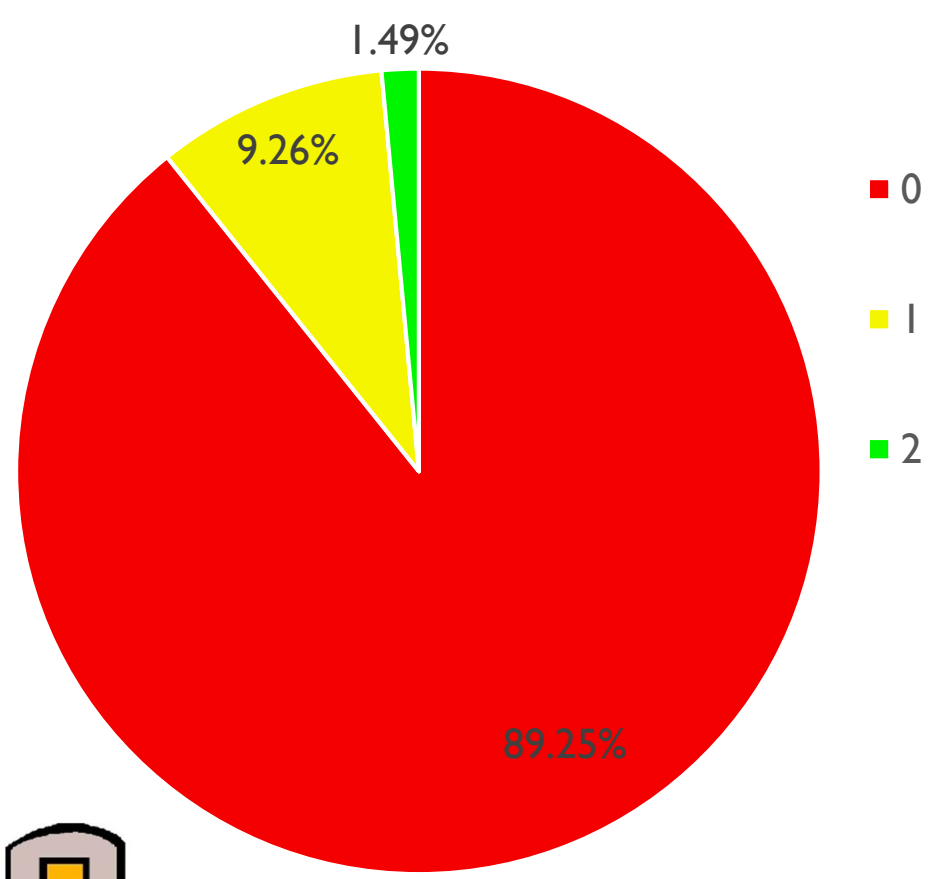

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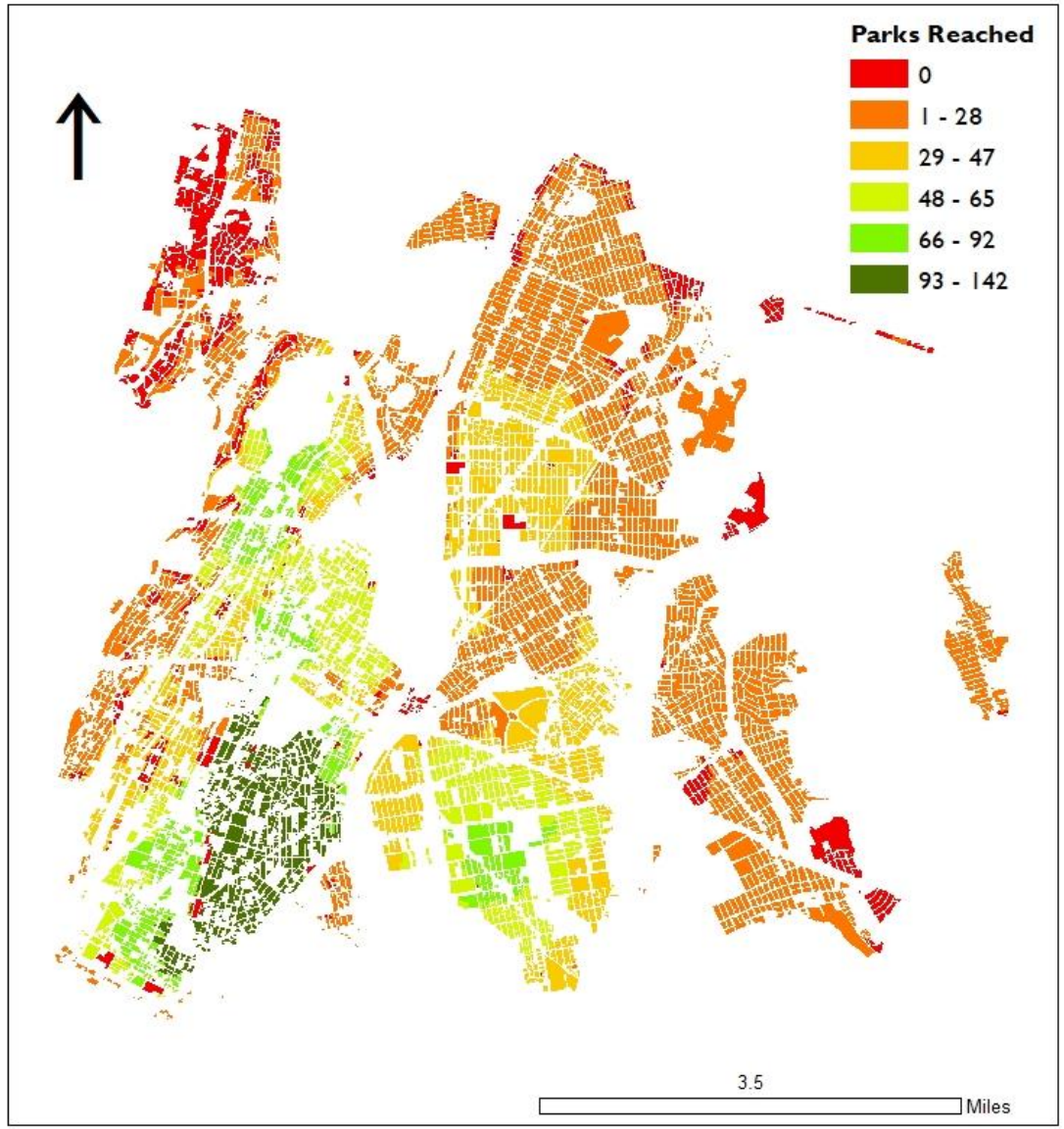
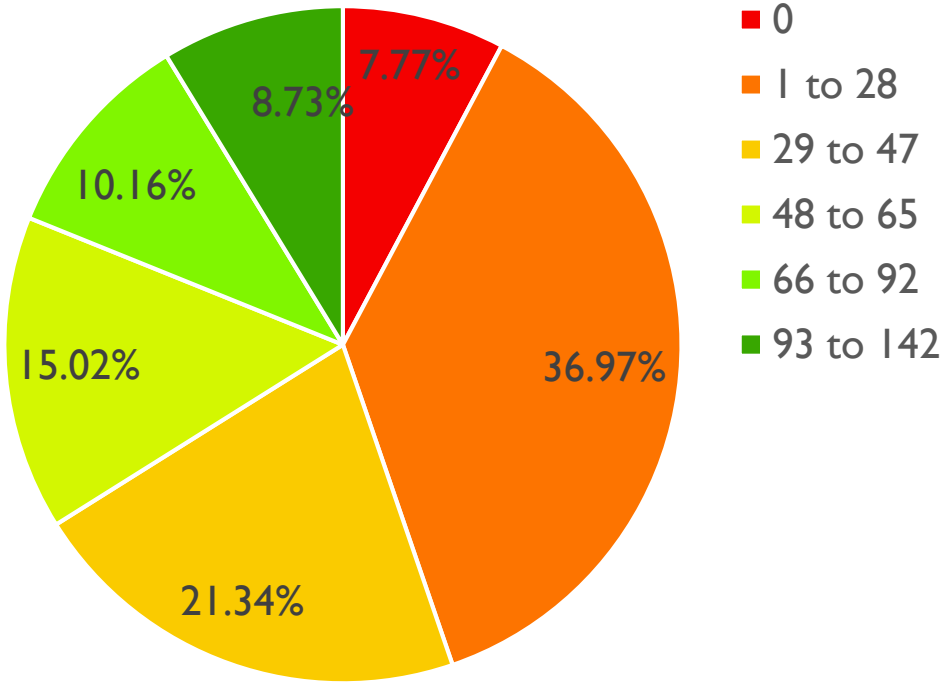
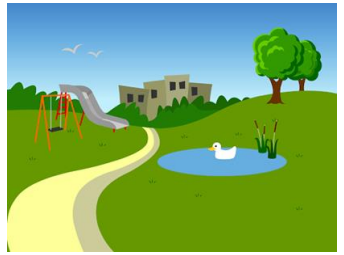
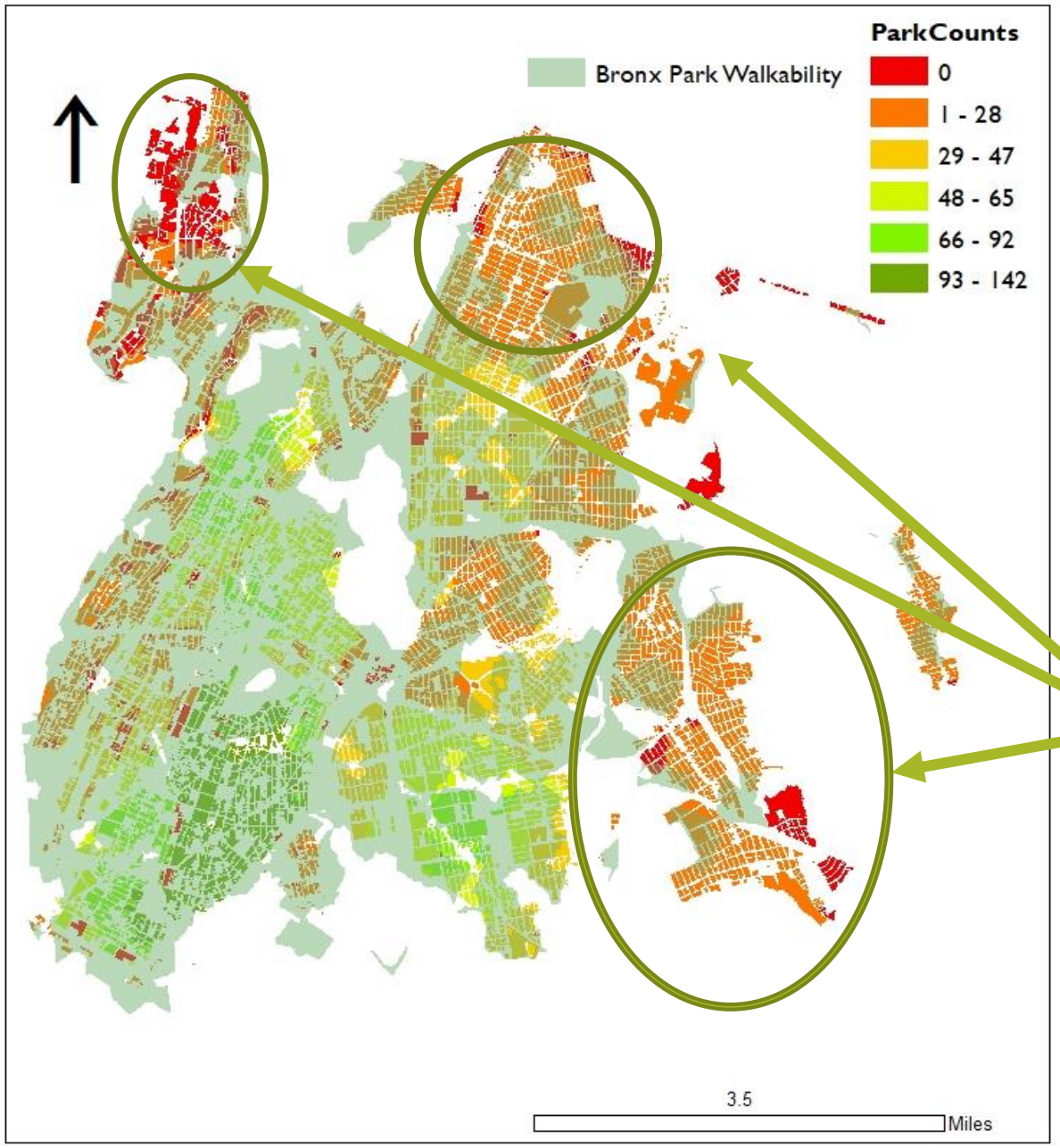


Percentage of Population With Bike Access to Park Entrances







Percentage of Population With Bike Access to Park Entrances

Performed a Network Analysis with Park Walkability:

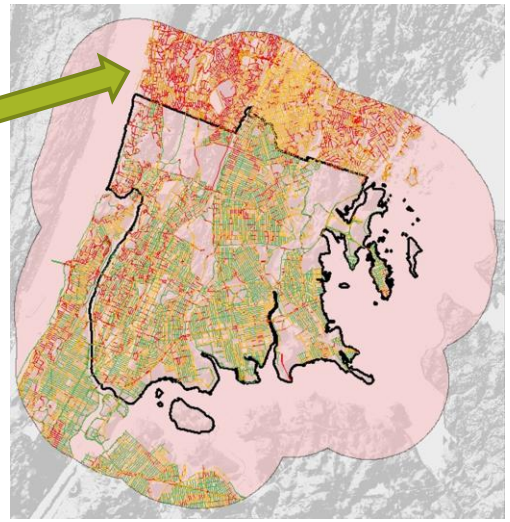
-Used Sidewalks as my network

-Defined walkability measure as ¼ of a mile

-See similar areas that have a lack of walkability and lack of bike access to parks

Issues to Consider: The Westchester Dilemma and Future Studies

- Westchester Road data didn't include speed limits or number of travel lanes.
- Number of travel lanes was declared as two
- Speed limit was generalized depending on what municipality it was in:
  - Mount Vernon: 25
  - Bronxville: 30
  - Pelham: 30
  - Yonkers: 30
  - Pelham Manor: 30
  - New Rochelle: 30



Future studies should include:

- Model Turn Restrictions
- Model Inherent Slow Downs at Intersections
- Model shifting in bike accommodations at intersections.
- Integrate traffic data into the low stress network

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Thank you and any Questions?