Modelling for the Behaviour Modelling Exercise

15th October, 2017,
16th Behavior Modeling Workshop in Transportation Networks,
The University of Tokyo

IIT Bombay

Centre for Urban Science and Engineering

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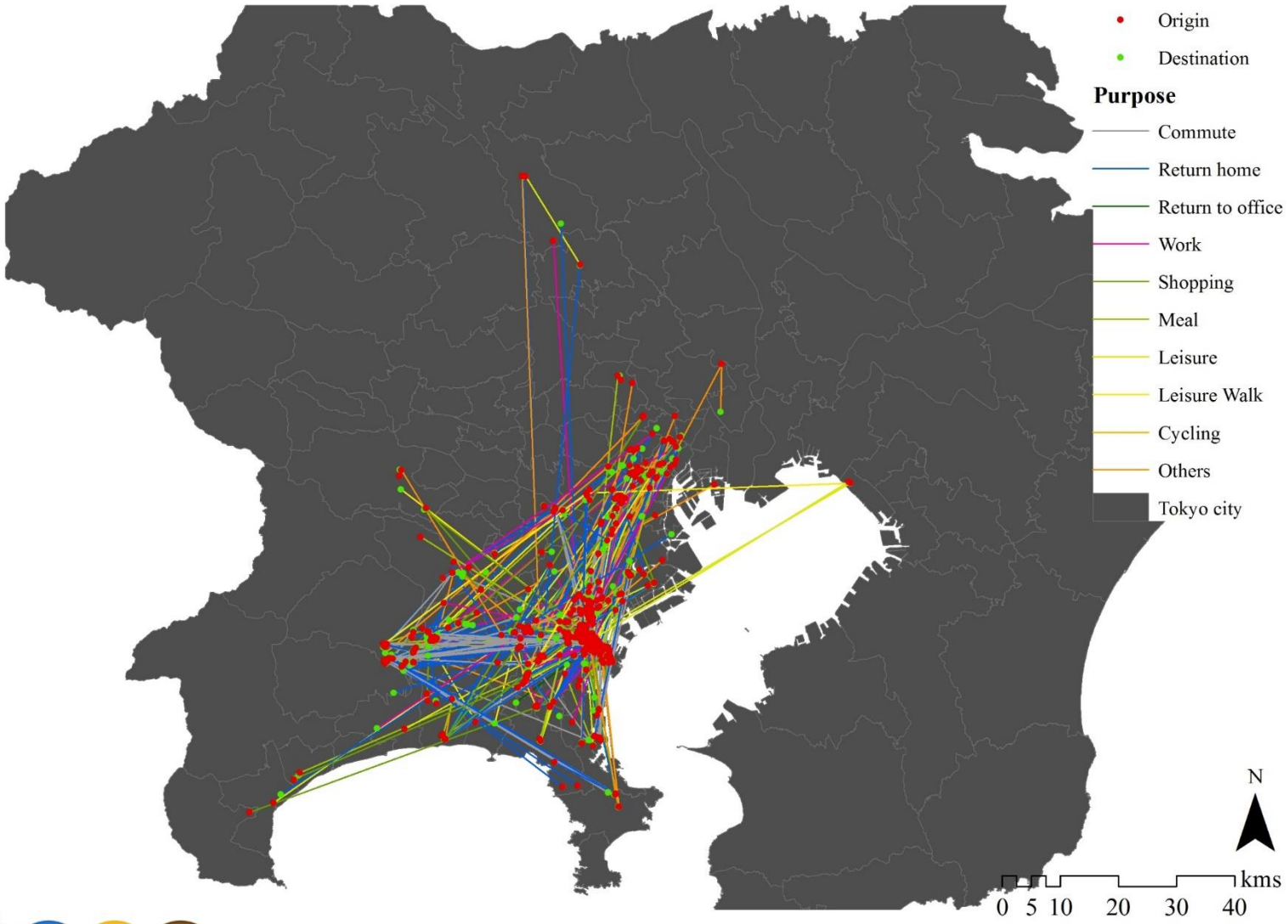
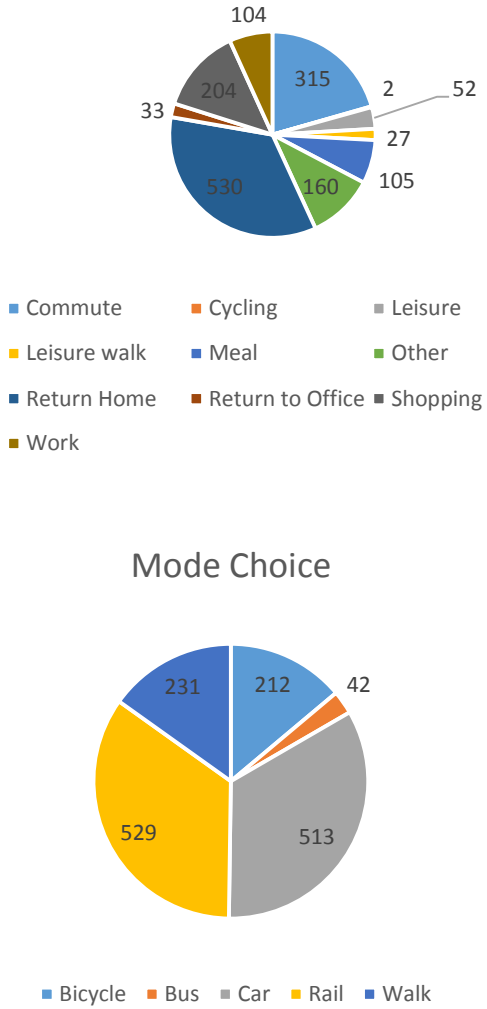
東京大学
THE UNIVERSITY OF TOKYO

Yokohama City

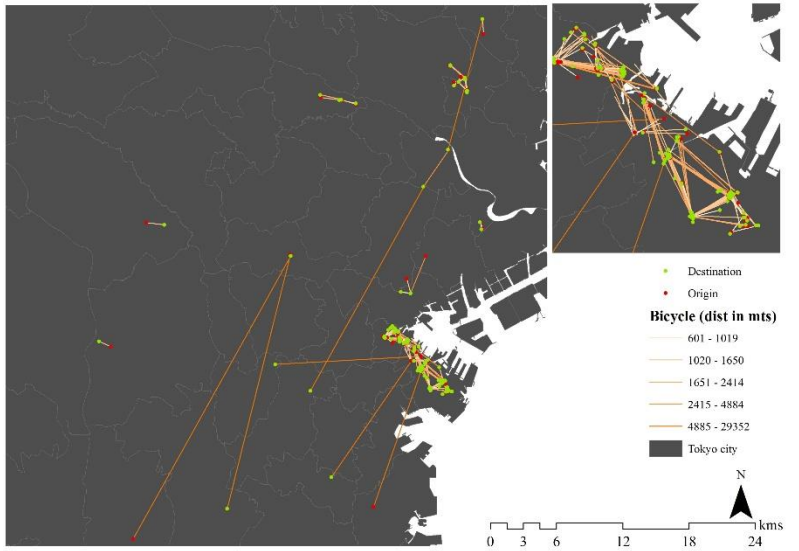


Share of Travel Purpose

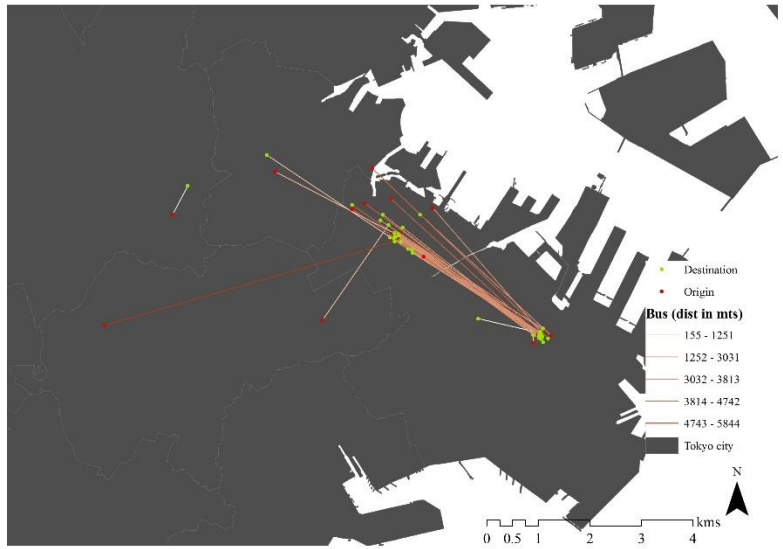


Mode Choice

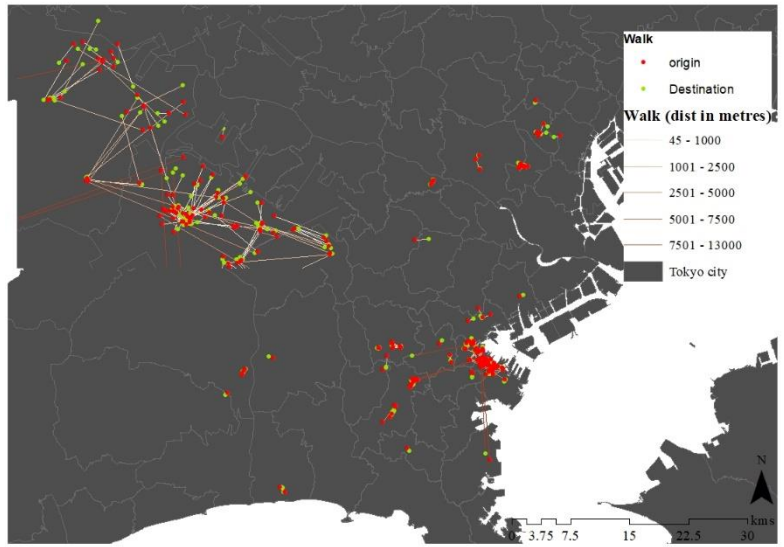
Time taken by different Modes: (O-D Spider map)



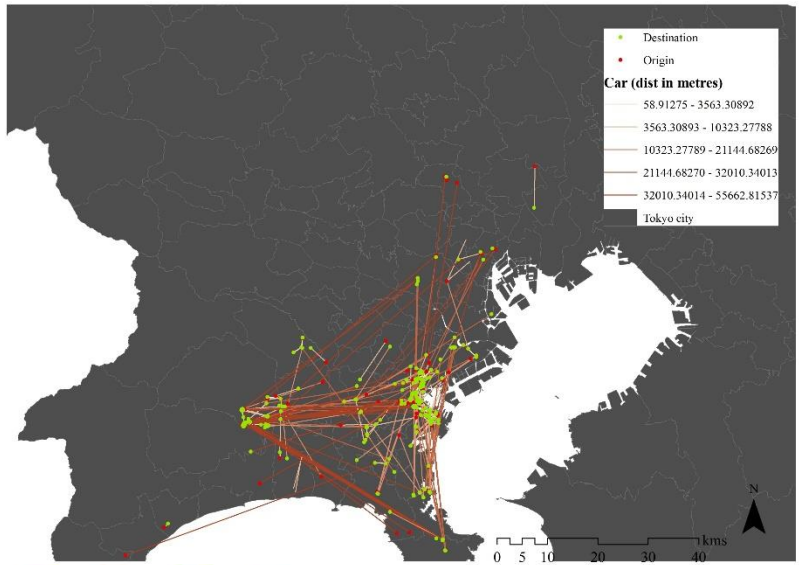
Bicycle



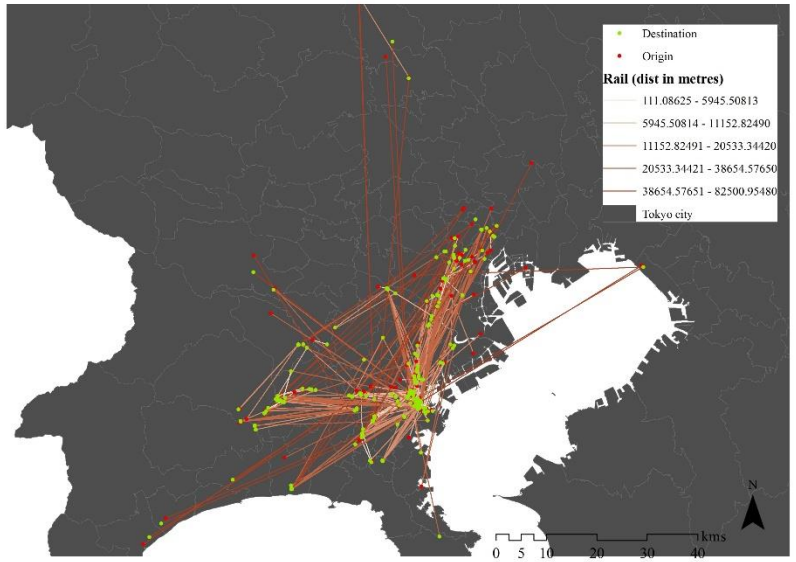
Bus



Walk

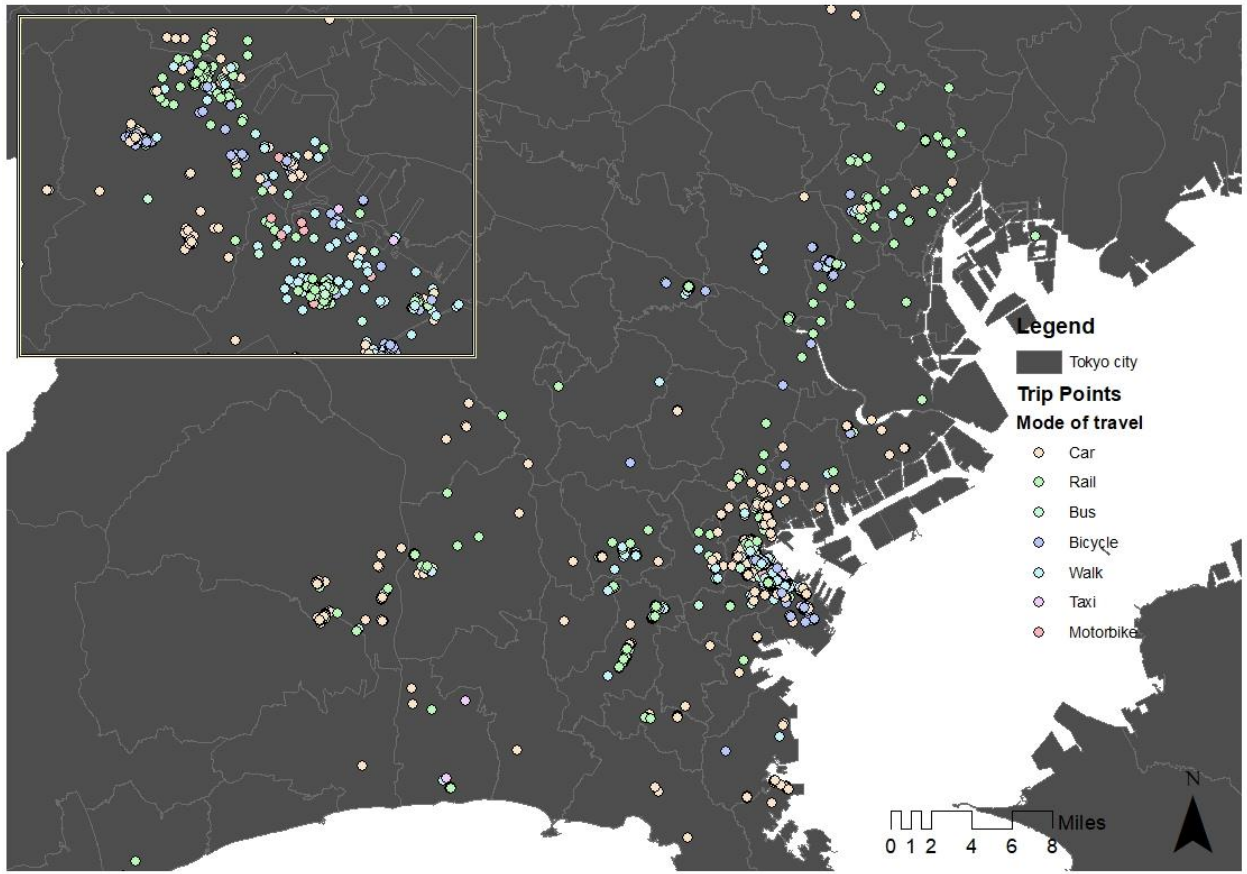


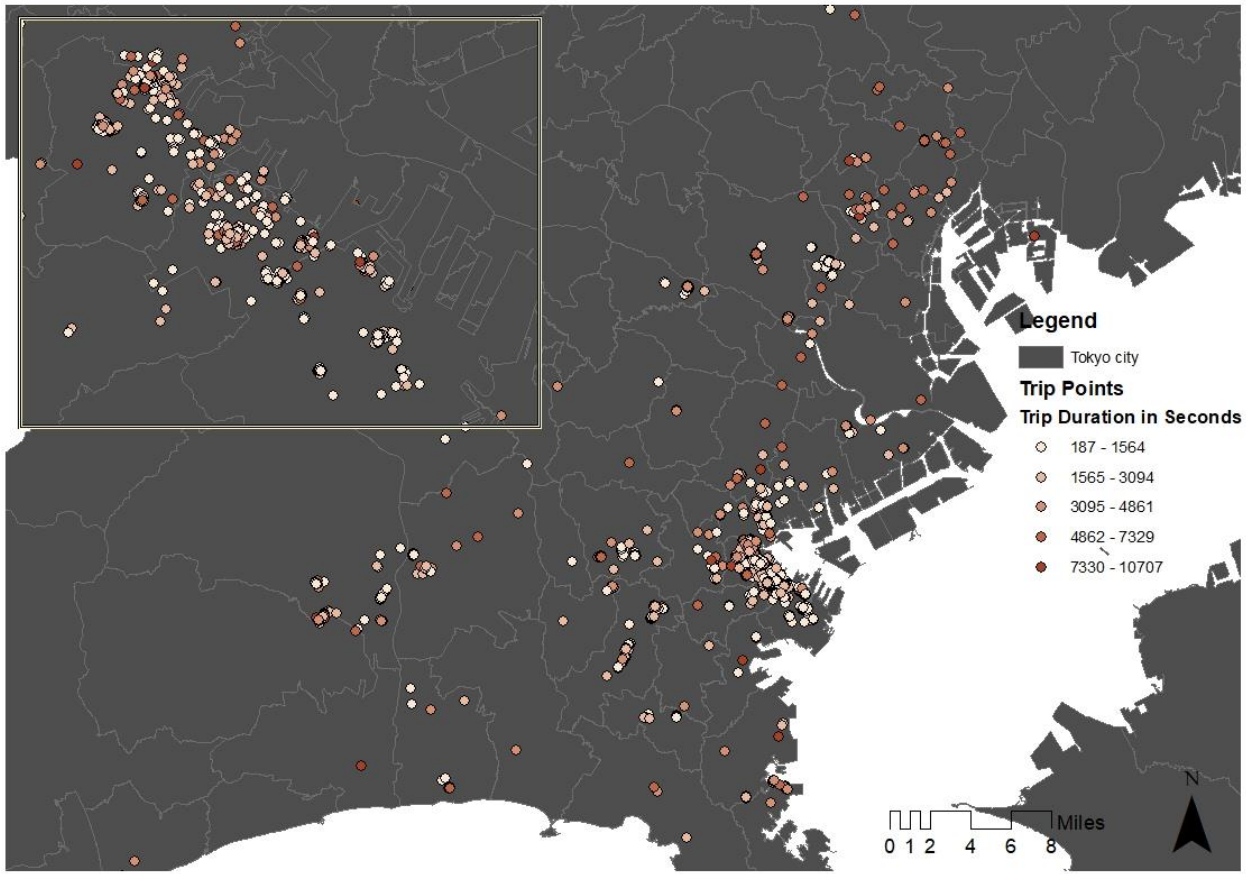
Car



Rail

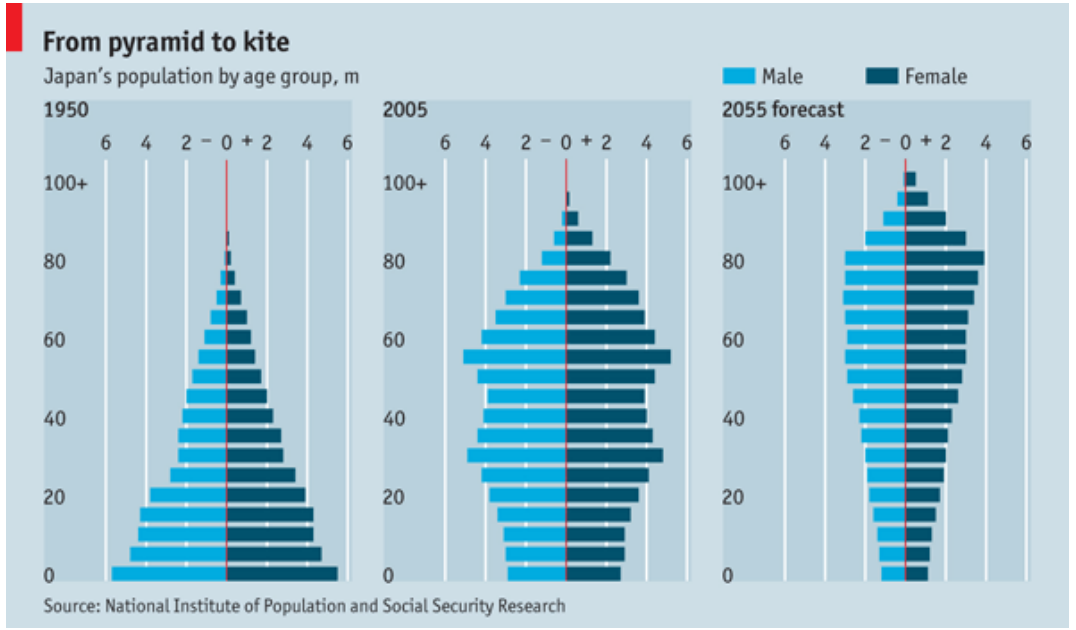
Mode of travel



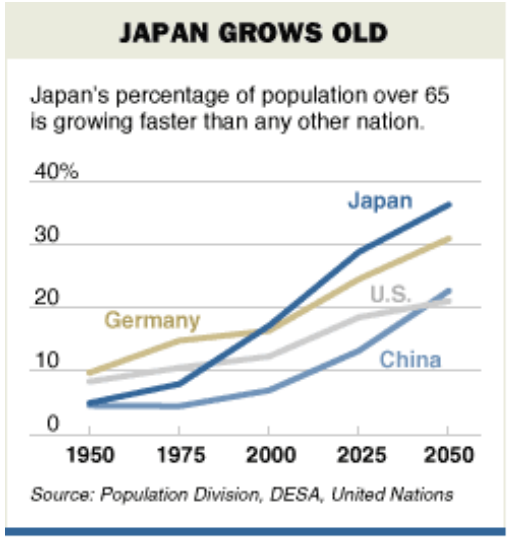


Problem Statement

Increase in Japan's ageing population

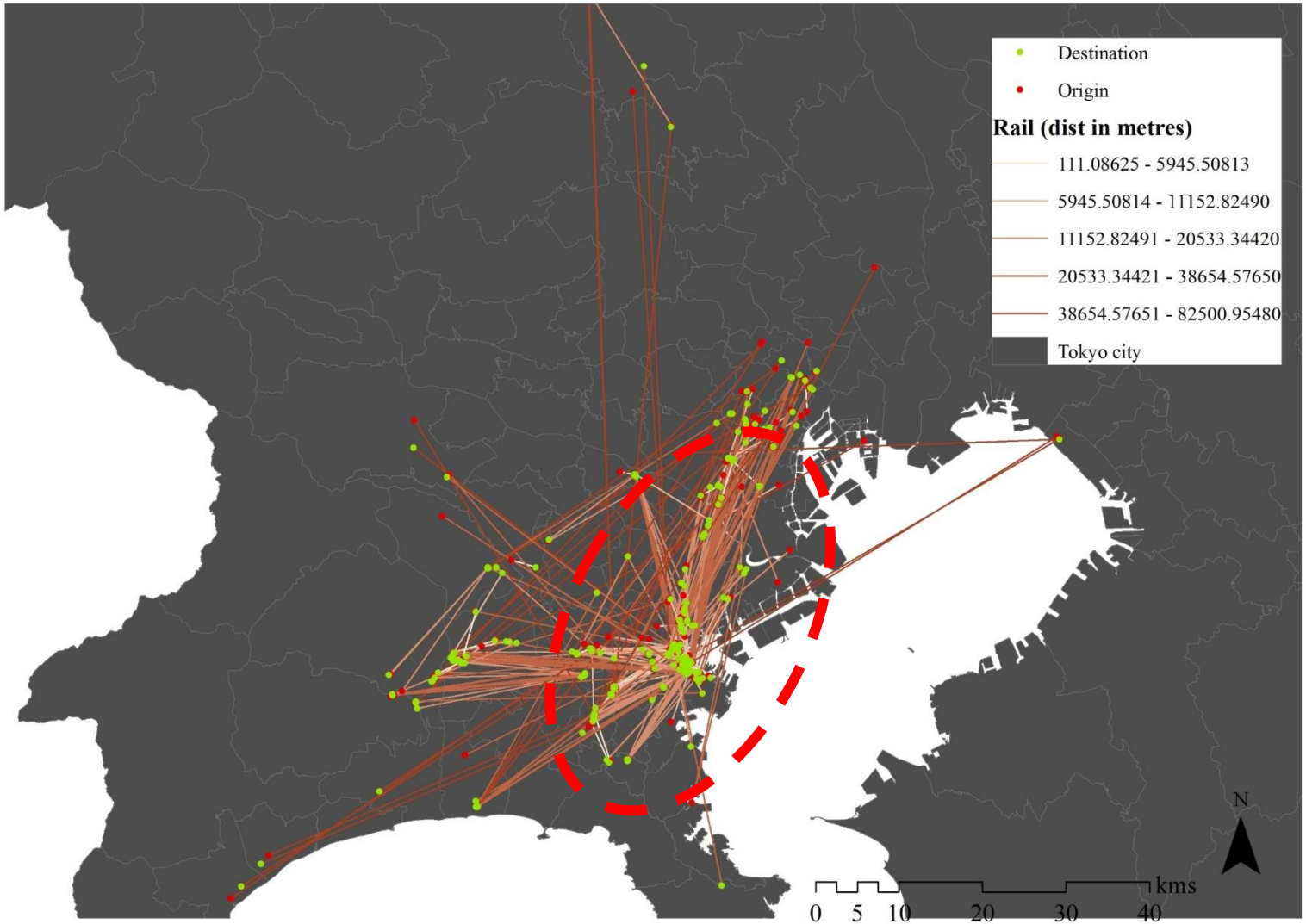


- POPULATION TO SHRINK 1/3RD BY 2050..
- The number of people is predicted to tumble from just over 127 million in 2015 to 88 million in 2065, dropping further to **51 million by 2115**.
- From 1950 to 2015, the share of population age 65+ grew from just under **5% to over 25%.**
- The population aged 80+ has risen even faster, from 0.4% in 1950 to 7.3% in 2013 (OECD average = 4.1%).
- Japan's median age was 45.9 years in 2013, compared to a world average of 29 years and an OECD median age of 38.7 for the same year. Based on current projections, the Japanese government expects Japan's population to decrease by ***22-23% between 2010 and 2050, with the elderly (65+ years) accounting for 40% of the population***.



Problem Statement

Overcrowding of metro



This overcrowded transportation system carries **8.7 million riders daily**, making it the busiest metro in the world.

Objectives

1. To investigate the **interaction of age of users with respect to mode choice**. This attempt will help in incorporating comfort and convenience specially for elderly during travel.

2. To understand the **mode choice behavior during peak hours** (both morning and evening timings have been considered).

3. Both **MXL and MNL** have been used in this case to understand the efficiency of model.

Research Flow/ Methodology

1

Reconnaissance:
Understanding the transportation of overcrowding in major metro areas in Japan. Understanding the aging population of Japan and their travel behavior, by analyzing statistics for **descriptors** and **spatial correlation** on person probe data.

2

Identification of Objectives:

- To investigate the **interaction of age of users with respect to mode choice**. This attempt will help in incorporating comfort and convenience specially for working class travellers during travel.
- To understand the **mode choice behavior during peak hours** (both morning and evening timings have been considered).
- Both MXL and MNL have been used in this case to understand the efficiency of model.

3

Identification of appropriate variables
Identify the **variables / interaction variables** for age based and peak hour based **policy analysis**. Identifying appropriate modelling technique for better prediction and taste variation.

4

Modelling

- Understanding the results of different models and comparing the results to find the **superior model**.
- Preparing **Prediction Success** Matrix
- Plotting of **elasticities across space**.

5

Using random parameter model **understand the taste variation** in the study area.

Utility Equations

```
## calculate the utility function: ;introduce the desired explanatory variables in the function

                                        # time              # Fare              # constant

Train  <- Data$ModeAvailableTrain*exp(d1*Data$TotalTimeTrain/100  + b1*matrix(1,nrow
=hh,ncol=1) + b5*Data$PeakHour +b6*Data$Age )

Bus    <- Data$ModeAvailableBus  *exp(d1*Data$TotalTimeBus/100  + b2*matrix(1,nrow
=hh,ncol=1) )

 Car    <- Data$ModeAvailableCar  *exp(d1*Data$TimeCar/100        + b3*matrix(1,nrow
=hh,ncol=1) )

Bike   <- Data$ModeAvailableBike *exp(d1*Data$TimeBike/100       + b4*matrix(1,nrow
=hh,ncol=1) )

Walk   <- Data$ModeAvailableWalk *exp(d1*Data$TimeWalk/100    + b7*Data$Age
)
```

Results (Test outputs Comparison)

MXL output

```
> ## L(0)
> print(L0)
[1] -2135.675
> ## LL
> print(LL)
[1] -1306.495
> ##rho-square
> print((L0-LL)/L0)
[1] 0.388252
> ## adjusted rho-square
> print((L0-(LL-length(b)))/L0)
[1] 0.3840379
> ##estimated parameter values
> print(b)
[1]  2.325458380  0.570460411  0.595285320  0.789269474 -9.581692389  0.873855179  0.307935134
[8]  0.003106622  0.049827158
> ## t-statistic
> print(tval)
[1]   7.9176205   1.9498257   2.2642065   3.0429503 -20.2102279   2.7916645   2.0760127   0.7337743
[9]   7.8924131
>
```

MNL output

```
> ## L(0)
> print(L0)
[1] -2135.675
> ## LL
> print(LL)
[1] -1302.748
> ##rho-square
> print((L0-LL)/L0)
[1] 0.3900065
> ## adjusted rho-square
> print((L0-(LL-length(b)))/L0)
[1] 0.3862606
> ##estimated parameter values
> print(b)
[1]   2.120489807   0.601190973   0.662505748   0.704667250 -10.250375159   0.605573358   0.007110351
0.052801164
> ## t-statistic
> print(tval)
[1]   7.117928   2.043361   2.506119   2.689903 -20.265380   3.968759   1.641621   8.299826
```

Results (Test outputs Comparison)

```
> ## L(0)
> print(L0)
[1] -2135.675
> ## LL
> print(LL)
[1] -1292.804
> ##rho-square
> print((L0-LL)/L0)
[1] 0.3946622
> ## adjusted rho-square
> print((L0-(LL-length(b)))/L0)
[1] 0.3904481
> ##estimated parameter values
> print(b)
[1]  1.962058836  0.175461223  0.357921092  0.421493803 -9.569383923  0.666301942  0.275511957  0.004911614
0.044752790
> ## t-statistic
> print(tval)
[1]   7.2696035   0.6456395   1.5173468   1.8077461 -20.1510796   2.1096568   1.8612071   1.1555494   7.8094935
```

MXL improved output

Stats:

1 – LL(B) / LL(0) = 0.39466

1 – LL(B)/ LL(C) = 0.40155

```
> #aggregate elasticitiesTrain
> p=colSums(PTrain*elasticityTrain)
> q=colSums(PTrain)
> r=p/q
> r
[1] -1.653169
>
> #aggregate elasticitiesbus
> t=colSums(PBus*elasticityBus)
> u=colSums(PBus)
> s=t/u
> s
[1] -1.195407
>
> #aggregate elasticitiesBike
> v=colSums(PBike*elasticityBike)
> w=colSums(PBike)
> y=v/w
> y
[1] -0.8447646
>
> #aggregate elasticitiesCar
> e=colSums(PCar*elasticityCar)
> f=colSums(PCar)
> g=e/f
> g
[1] -1.216221
>
> #aggregate elasticitiesWalk
> h=colSums(PWalk*elasticityWalk)
> i=colSums(PWalk)
> j=h/i
> j
[1] -0.9213409
```

Aggregate Elasticity

Results (Prediction Success Comparison)

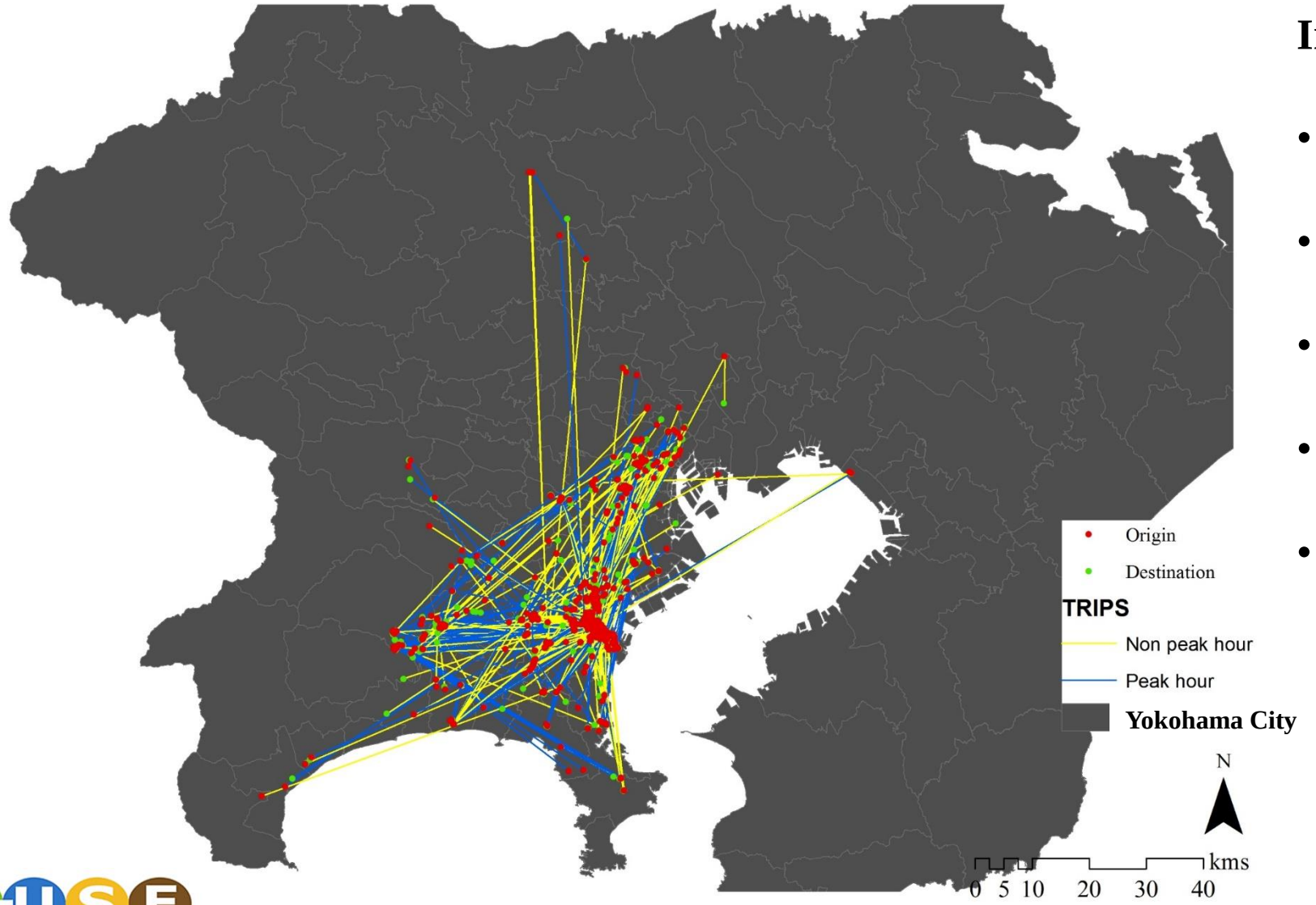
MNL

Obs. Group	Predicted Group: Rail	Bicycle	Bus	Car	Walk	Row Total	Observed Share
Rail	446	2	6	68	6	528	34.69%
Bicycle	53	64	0	43	51	211	13.86%
Bus	0	1	0	36	4	41	2.69%
Car	67	31	0	346	68	512	33.64%
Walk	19	35	0	7	169	230	15.11%
Column Total	585	133	6	500	298	1522	100.00%
Predicted Share	38.44%	8.74%	0.39%	32.85%	19.58%	Overall	**67.35%**
% Correctly Predicted	84.47%	30.33%	0.00%	67.58%	73.48%	Success	

MXL

Obs. Group	Predicted Group: Rail	Bicycle	Bus	Car	Walk	Row Total	Observed Share
Rail	454	3	7	58	6	528	34.69%
Bicycle	56	83	0	21	51	211	13.86%
Bus	1	2	0	34	4	41	2.69%
Car	80	49	0	318	65	512	33.64%
Walk	22	39	0	4	165	230	15.11%
Column Total	613	176	7	435	291	1522	100.00%
Predicted Share	40.28%	11.56%	0.46%	28.58%	19.12%	Overall	**67.02%**
% Correctly Predicted	85.98%	39.34%	0.00%	62.11%	71.74%	Success	

Results



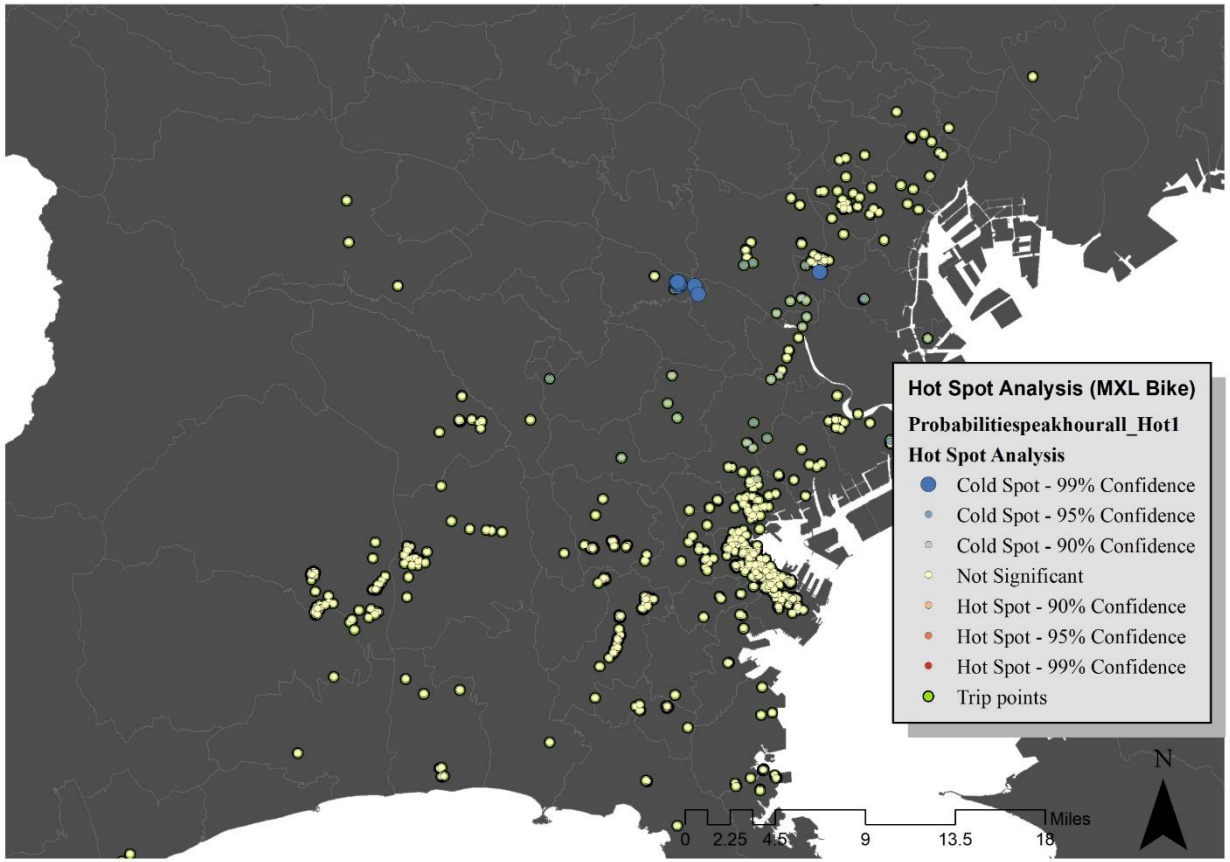
Inferences:

- Total trips: 1522
- Peak hour trips: 820
- Non peak hour trips: 702
- Morning peak hour: 7AM to 10AM
- Evening peak hour: 5PM to 9PM

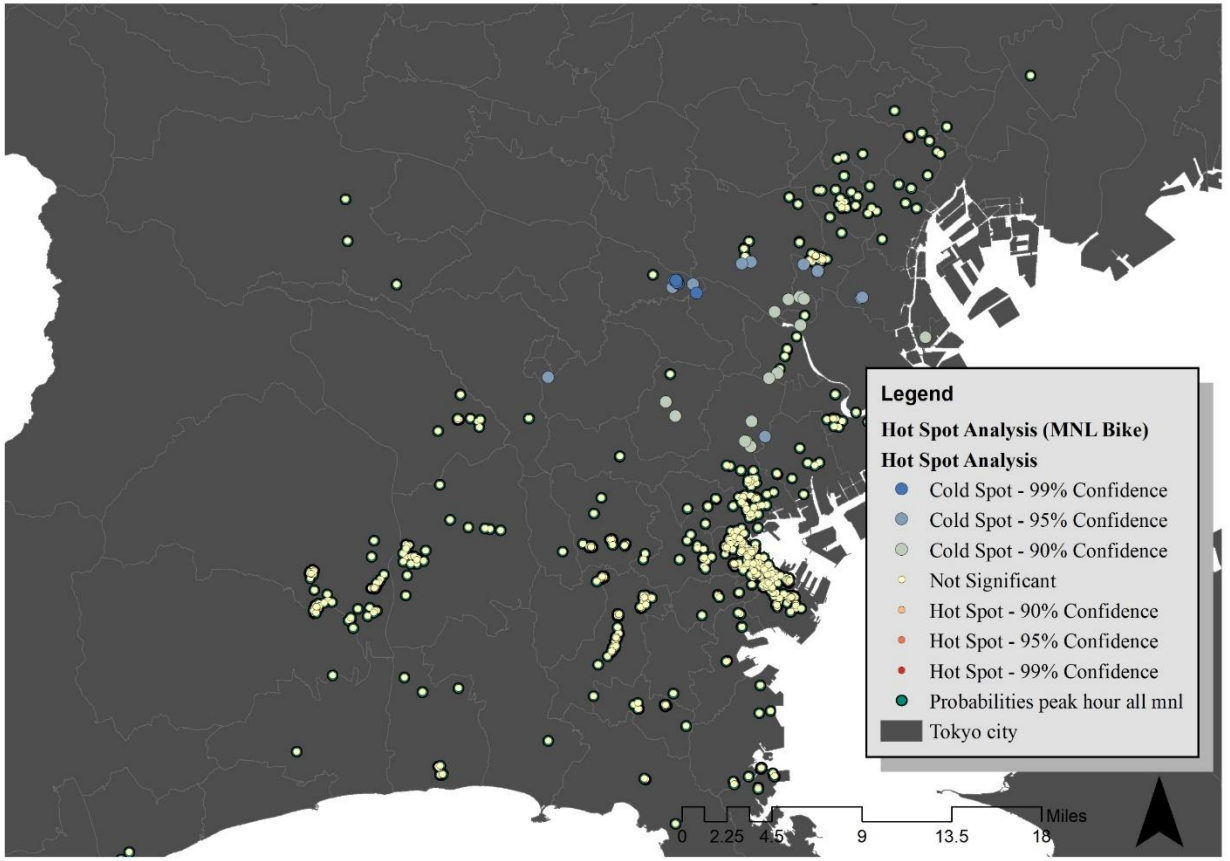
Spatial Analysis (MXL and MNL Comparison)

Bike: Probabilities peak hour

MXL



MNL

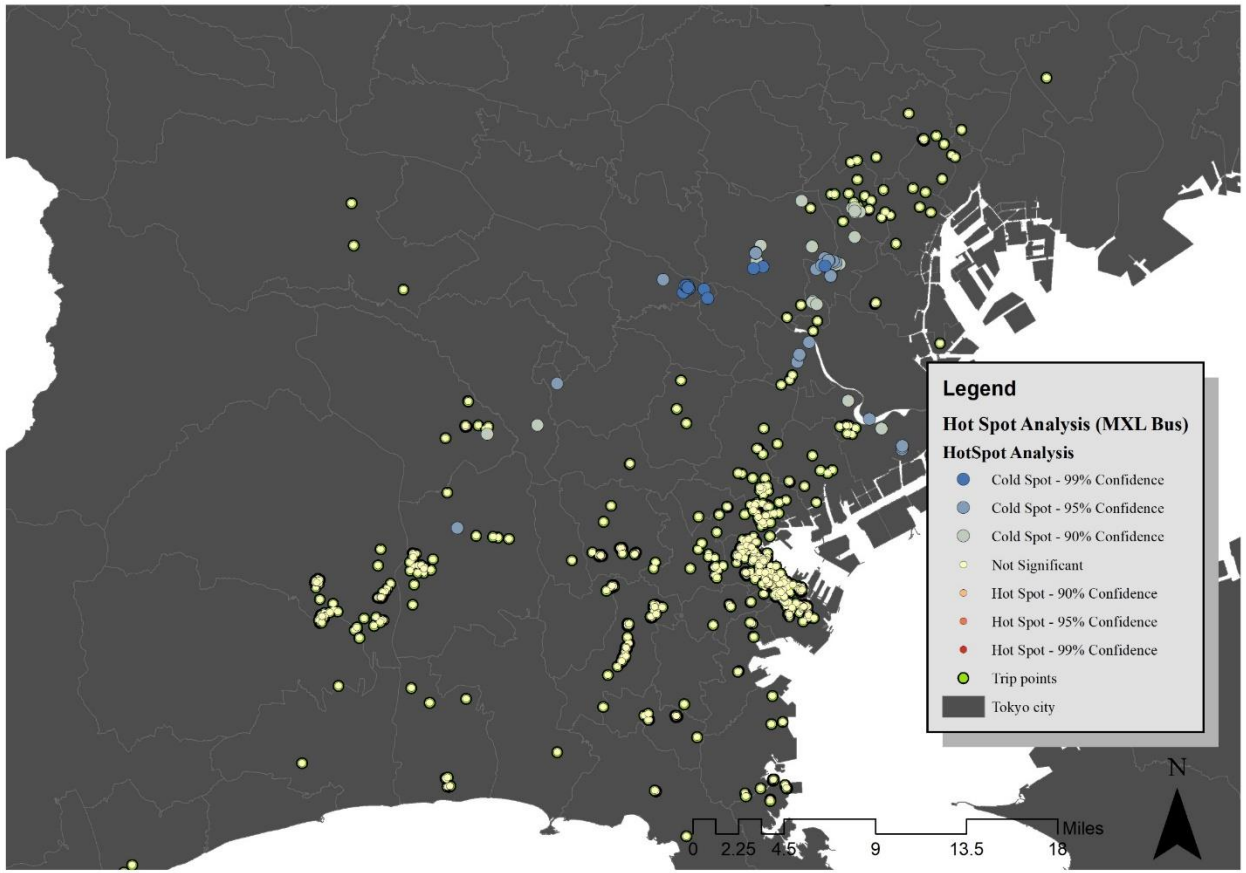


Inferences:

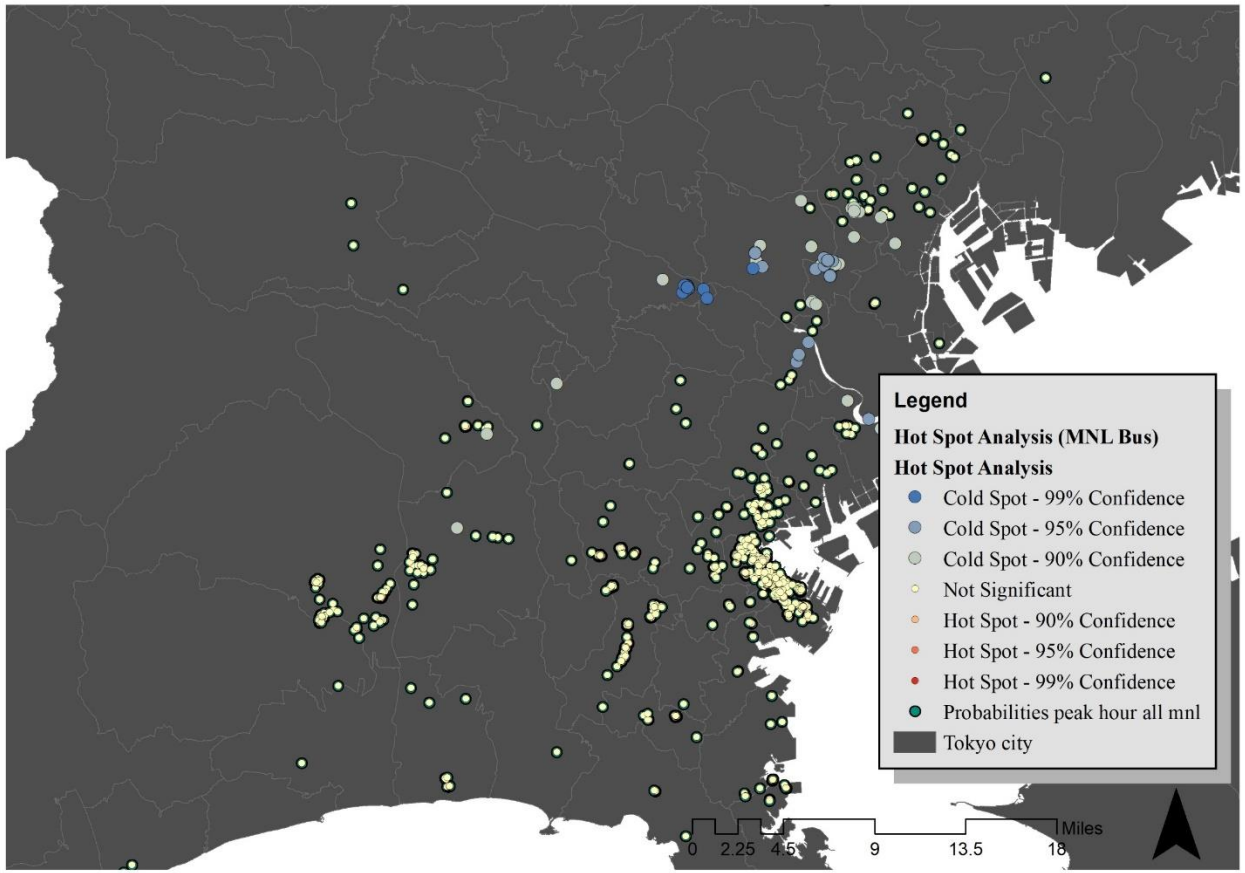
Spatial Analysis

Bus: Probabilities peak hour

MXL



MNL

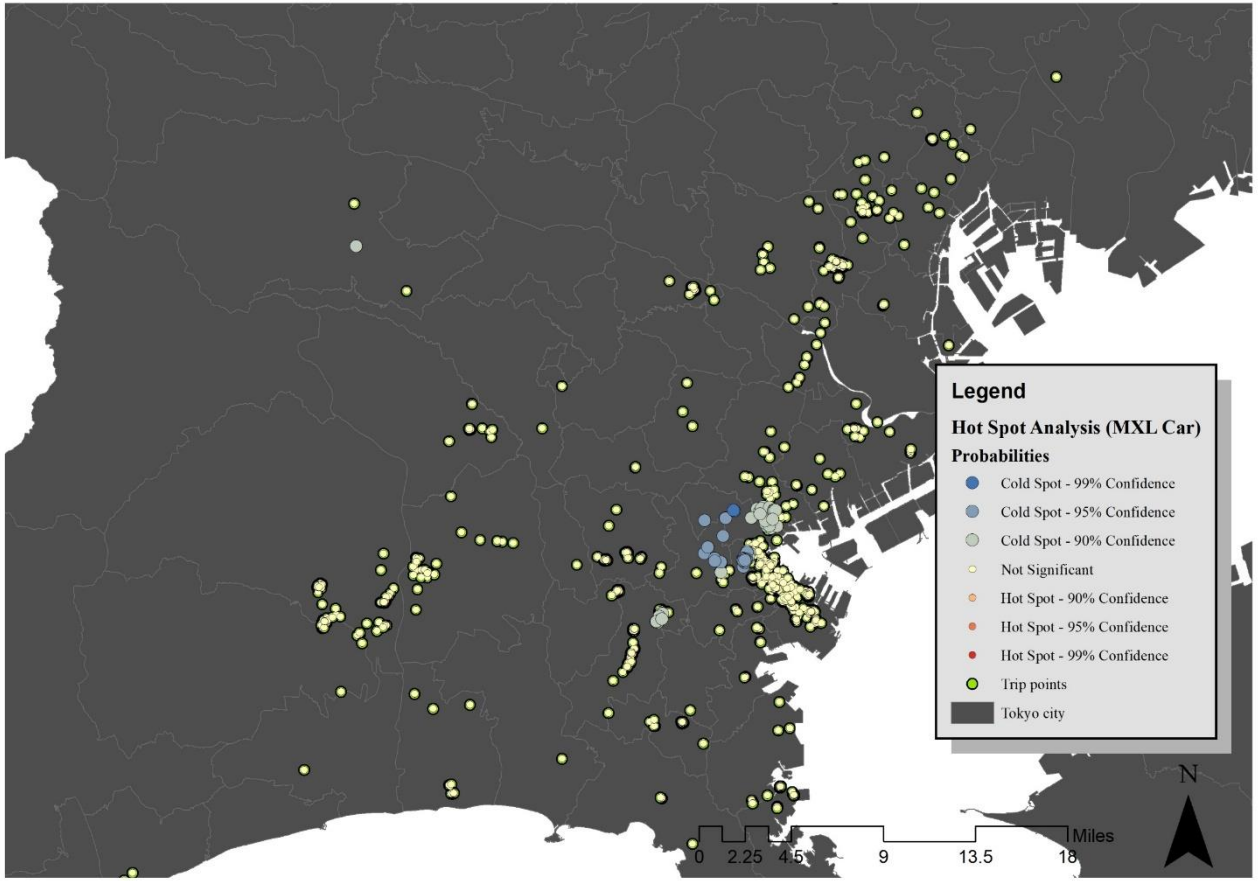


Inferences:

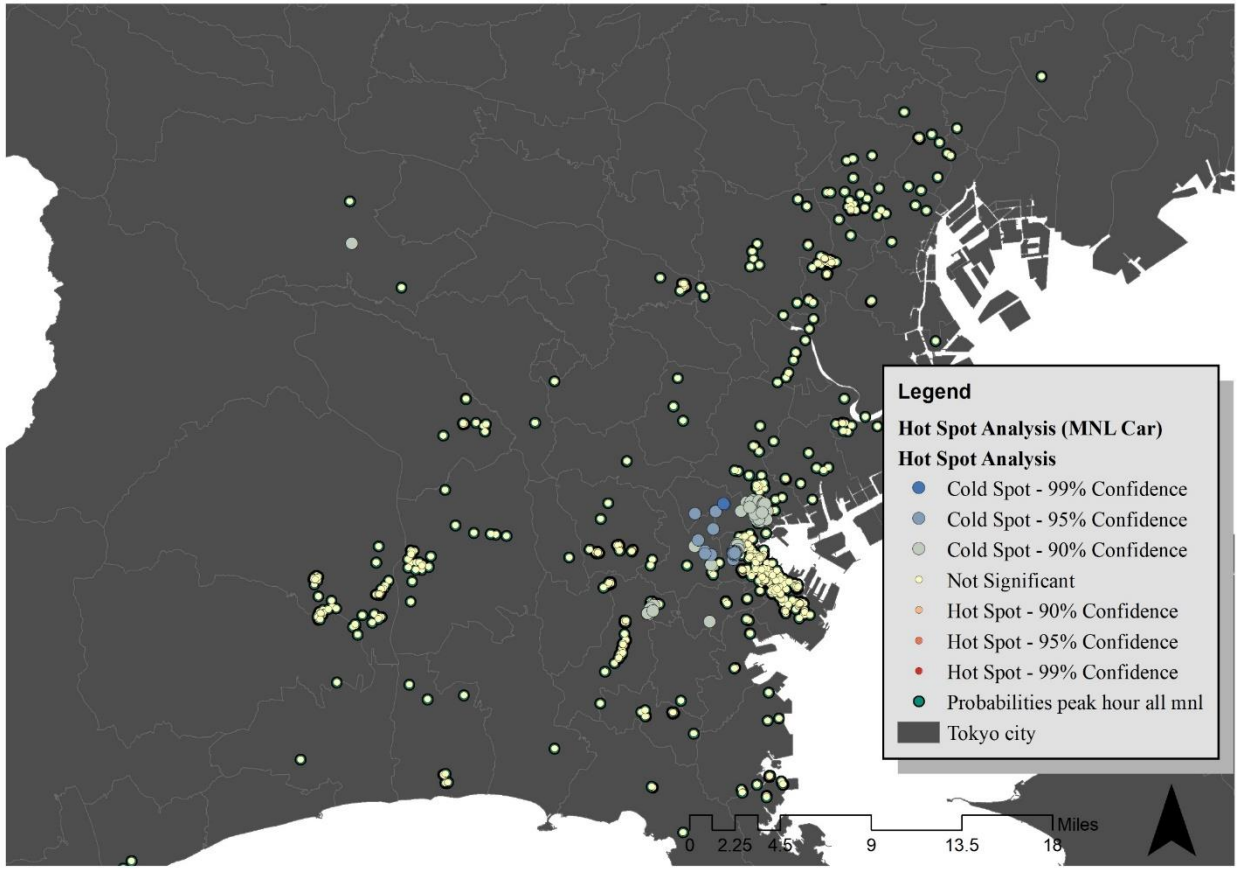
Spatial Analysis

Car: Probabilities peak hour

MXL



MNL

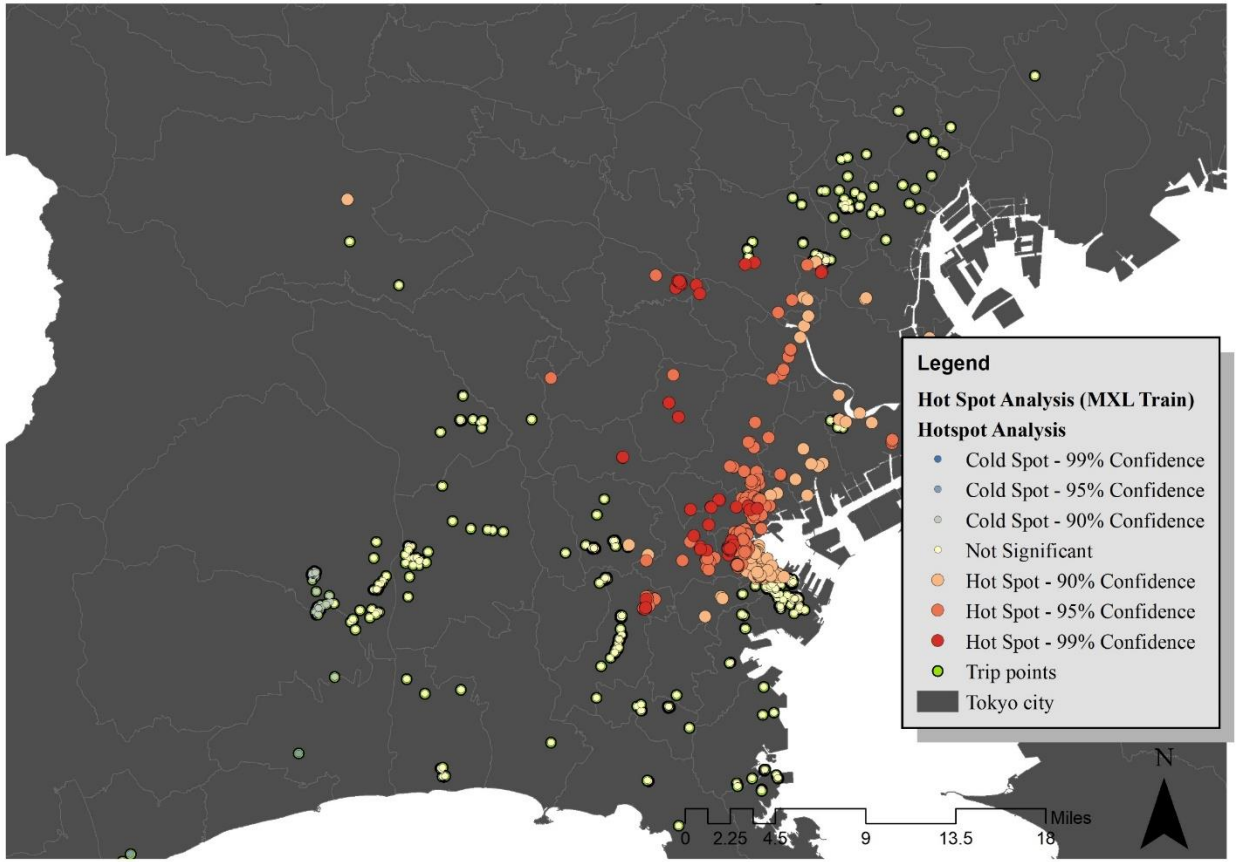


Inferences:

Spatial Analysis

Train: Probabilities peak hour

MXL



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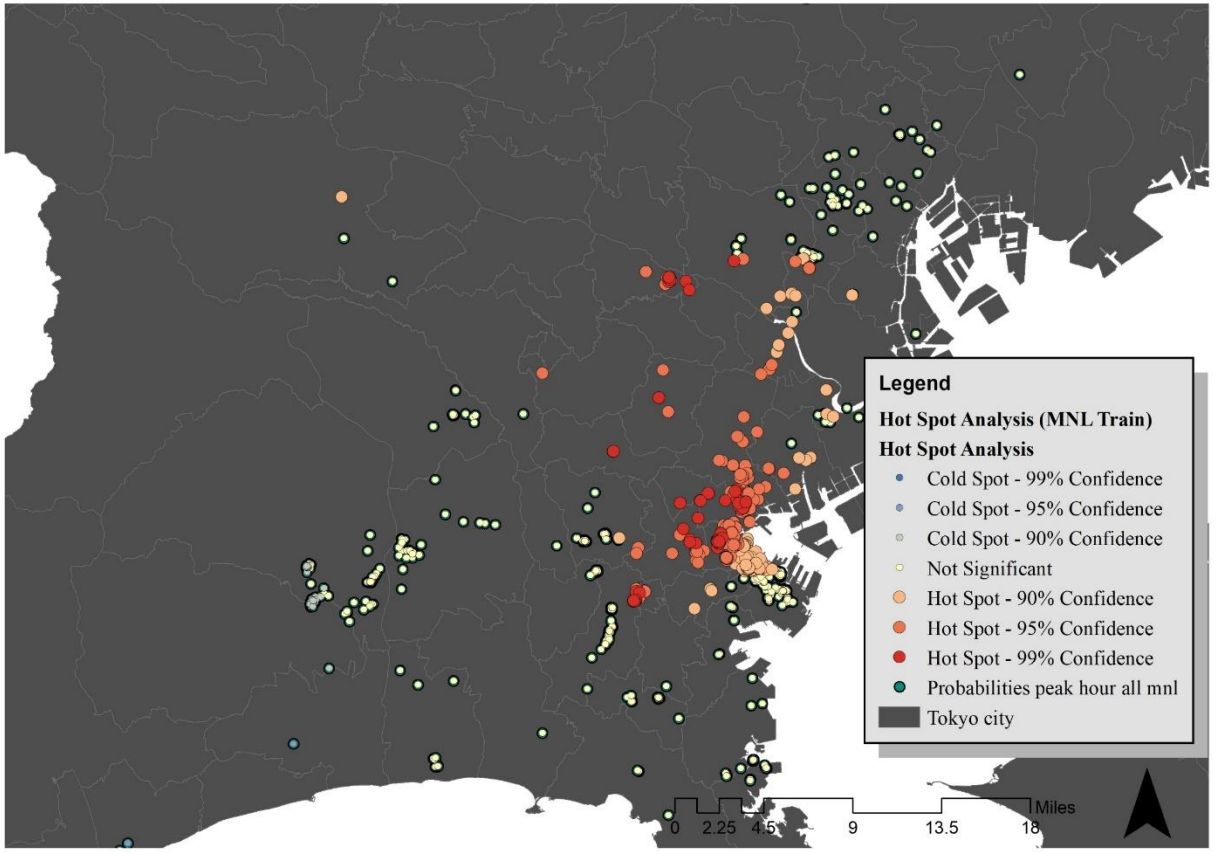
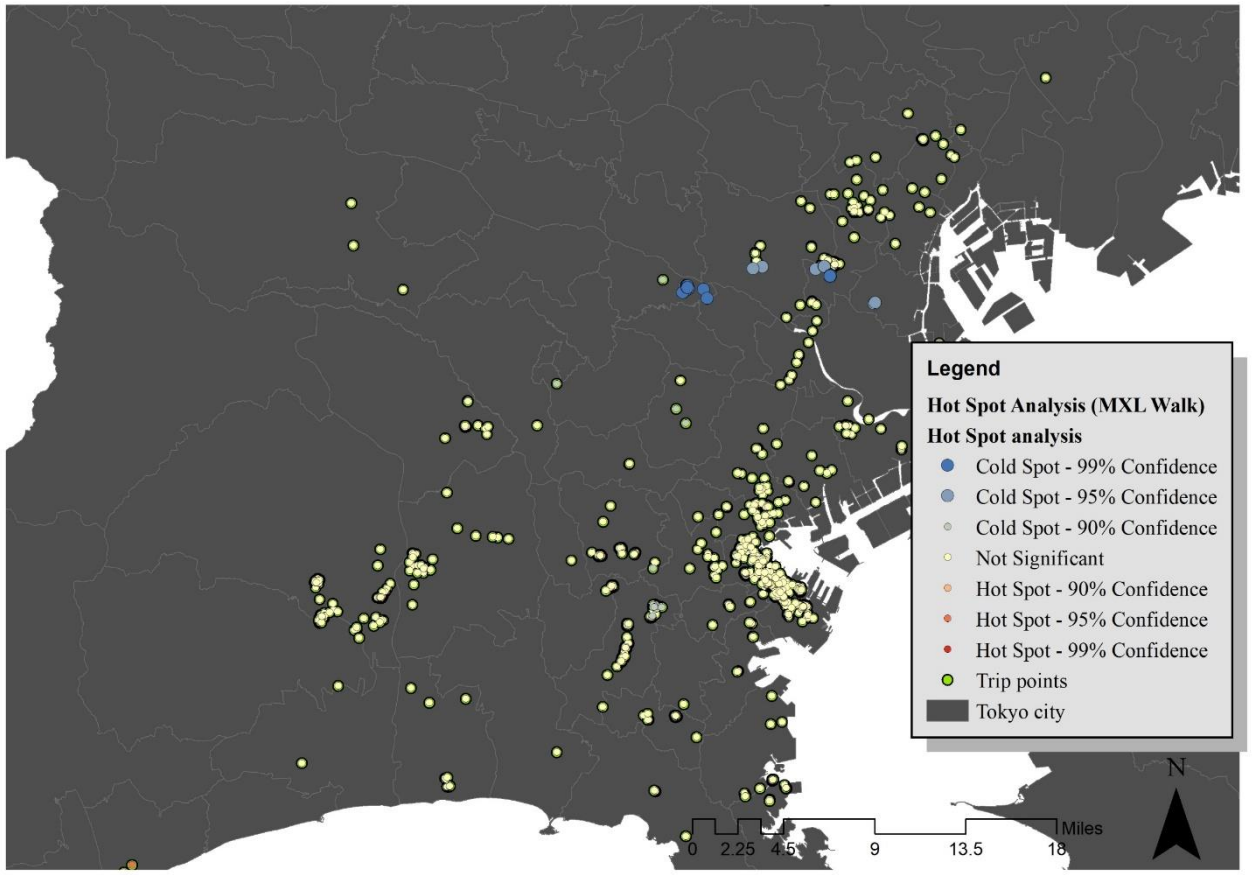


Inferences:

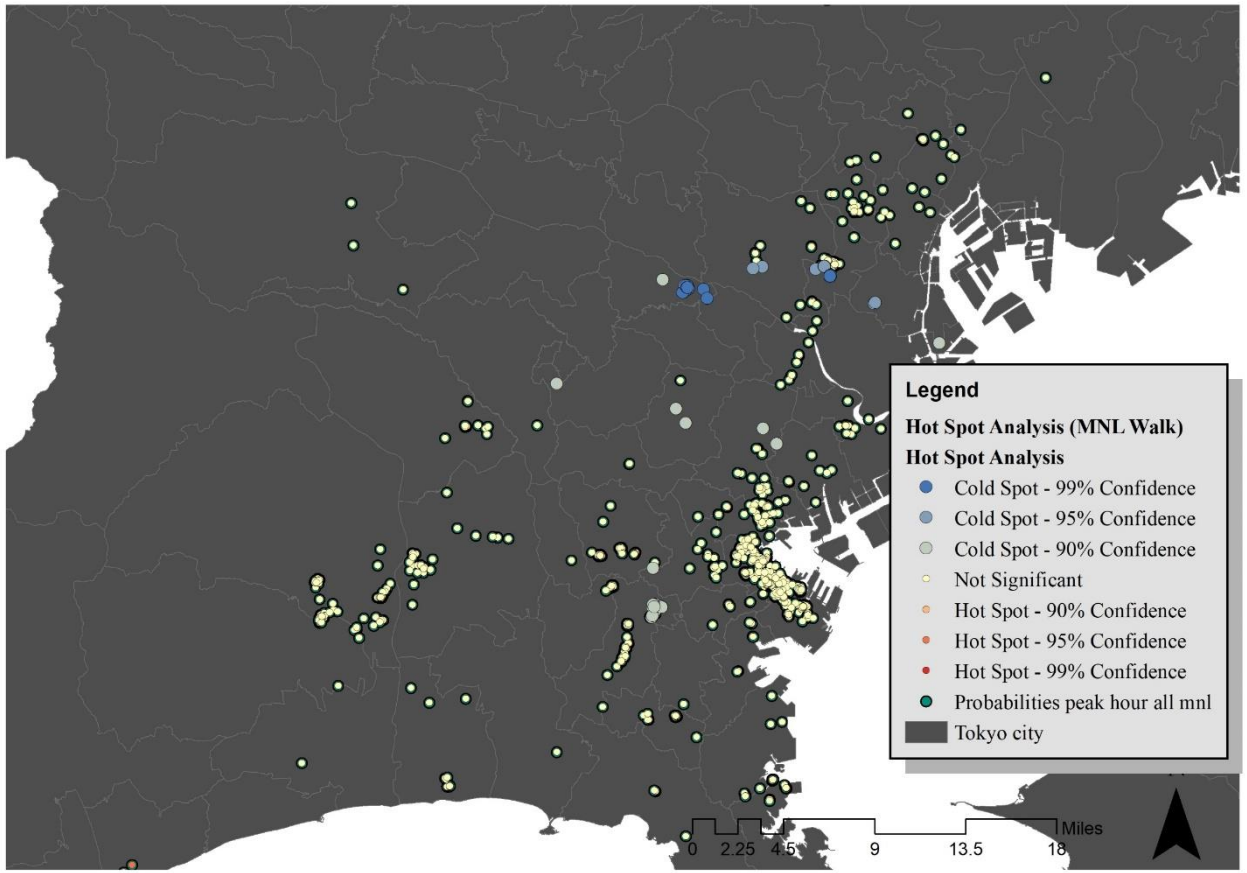
Spatial Analysis

Walk: Probabilities peak hour

MXL



MNL

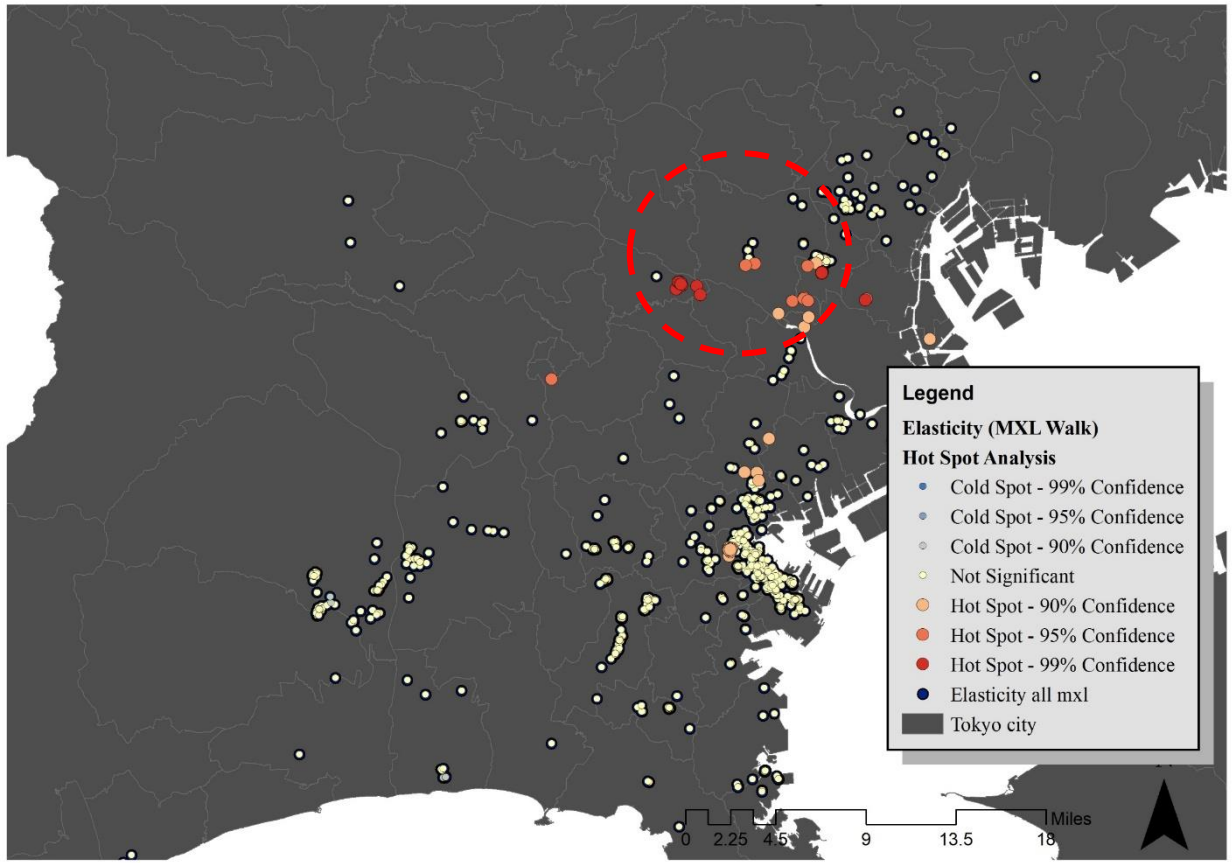


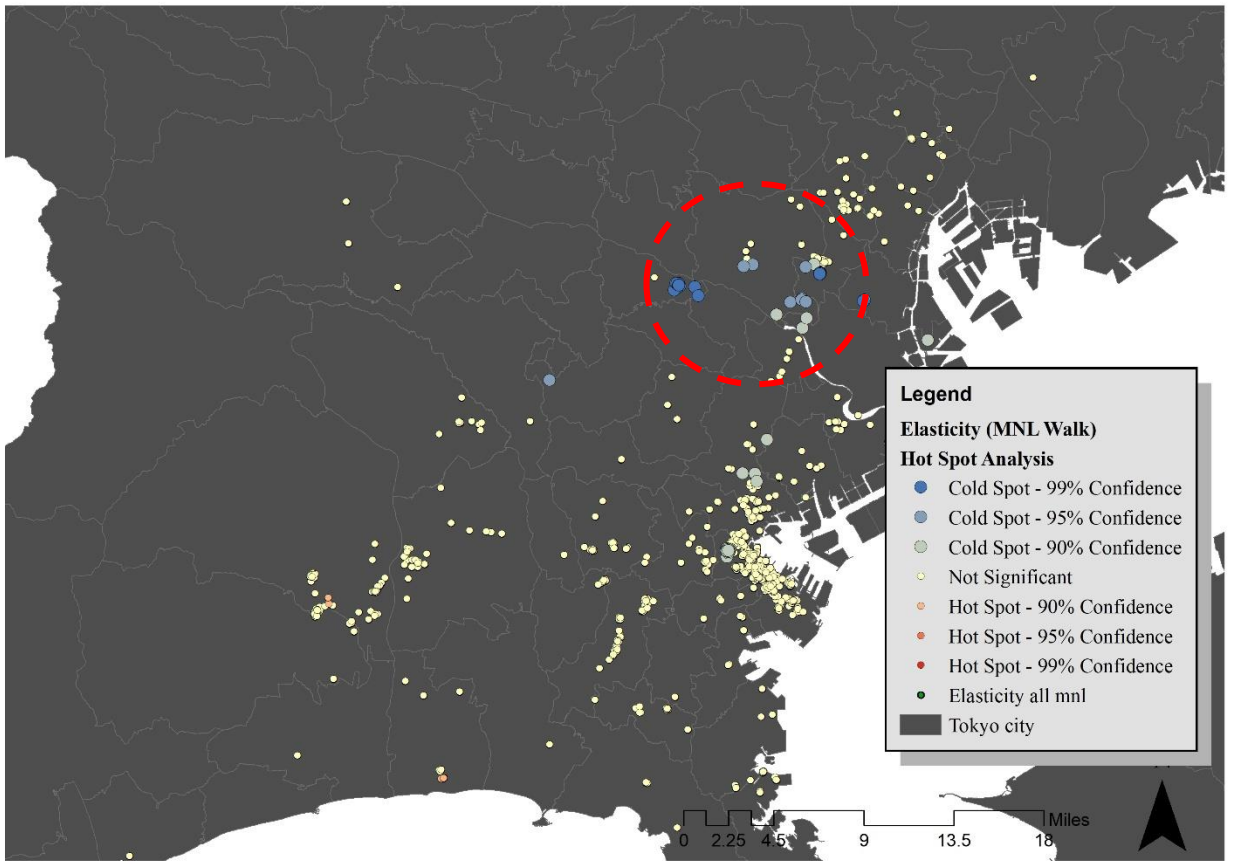
Inferences:

Spatial Analysis

Walk: Elasticities peak hour

MXL MNL



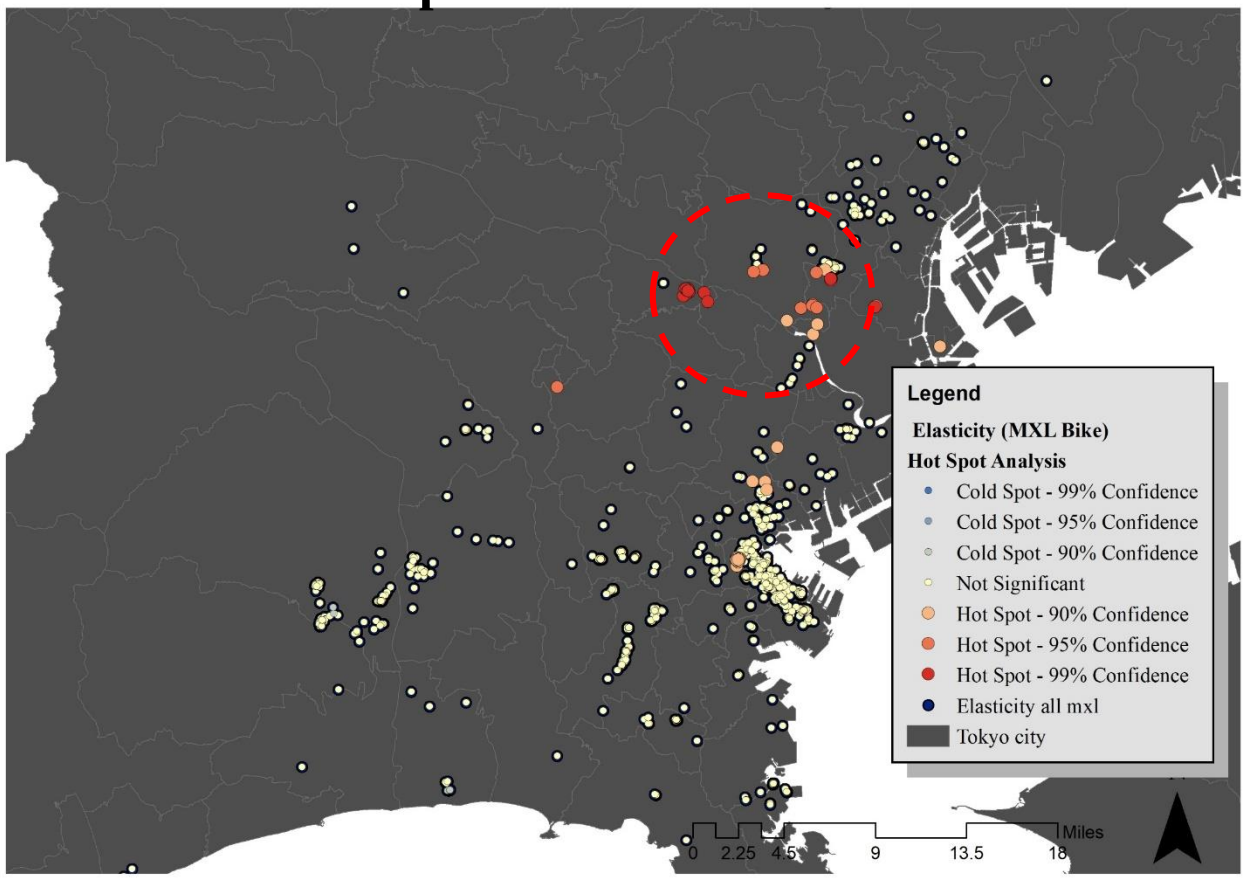


Inferences:

Spatial Analysis

Bike: Elasticities peak hour

MXL



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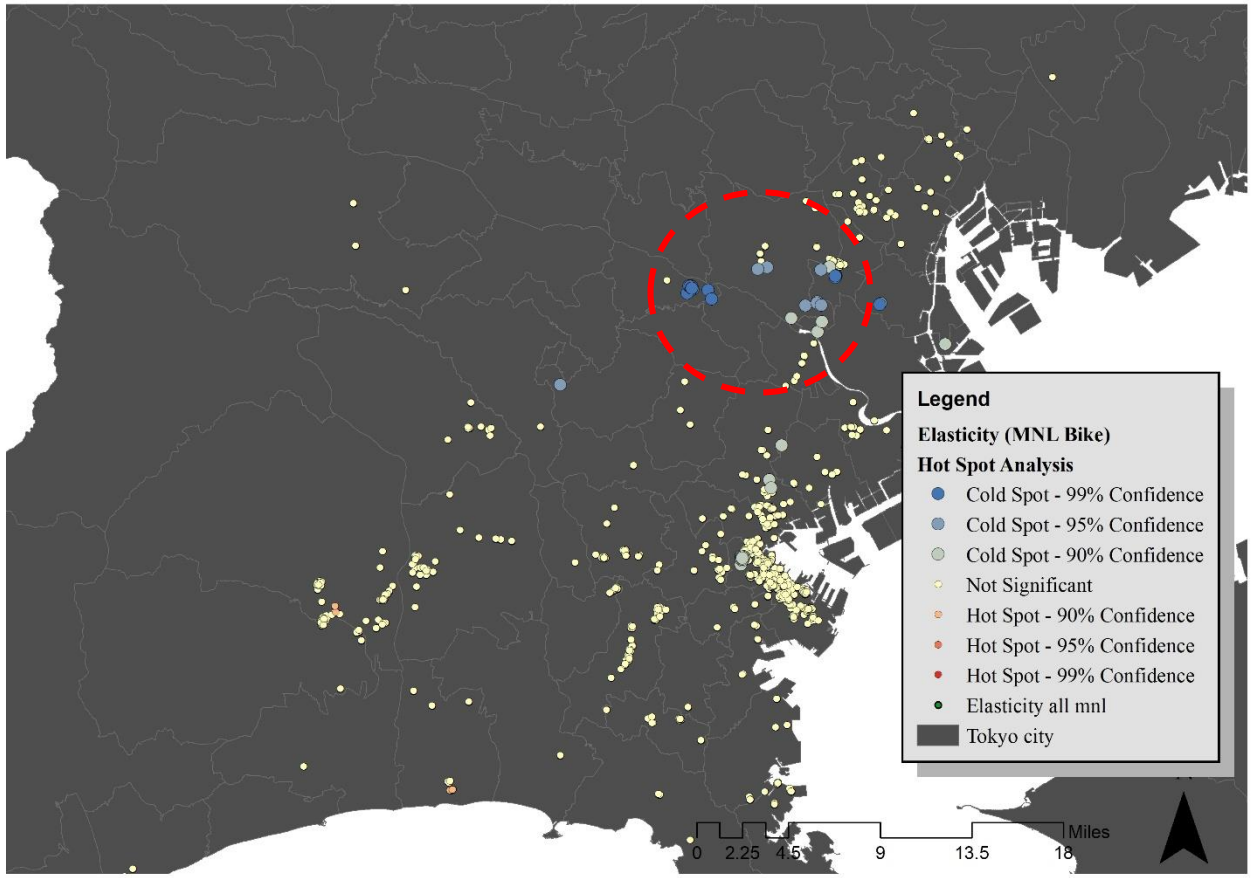
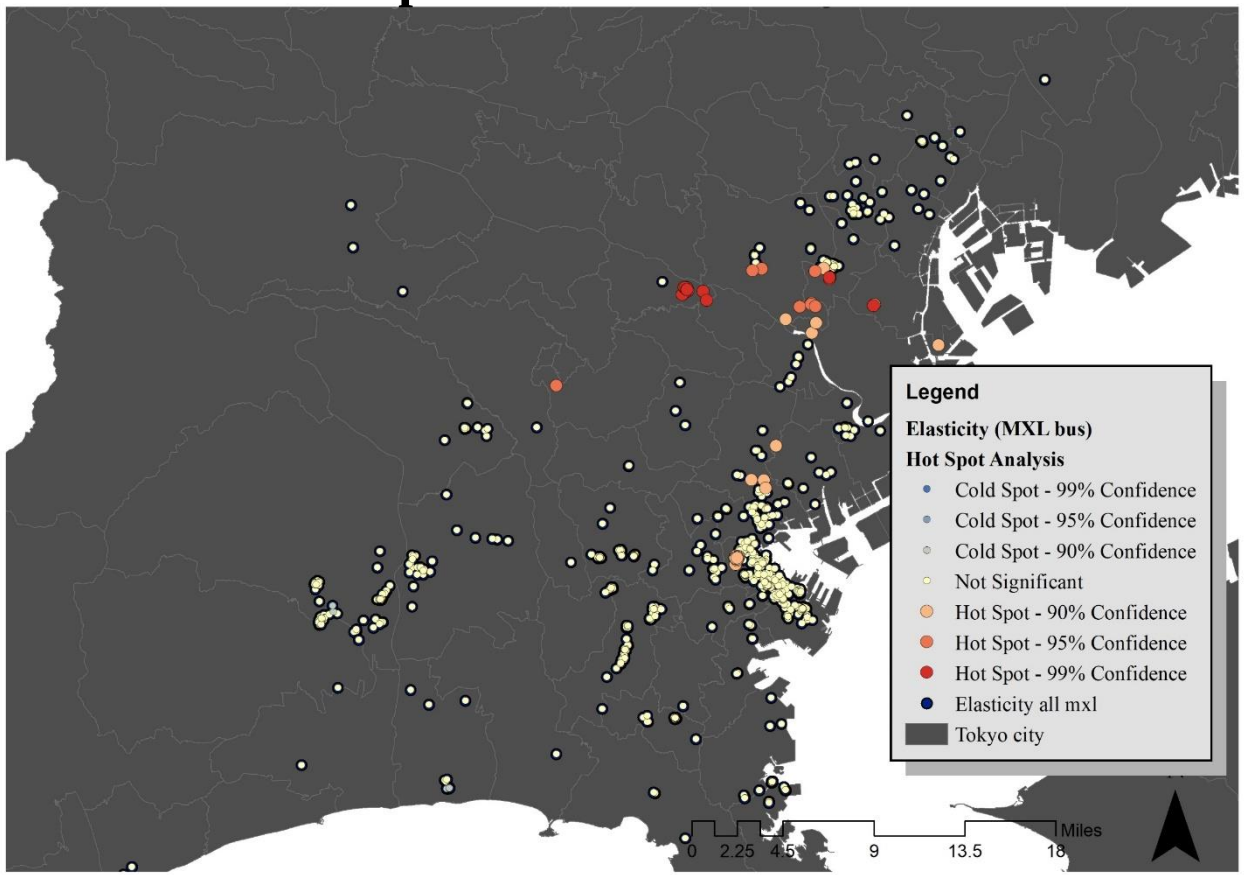


Inferences:

Spatial Analysis

Bus: Elasticities peak hour

MXL



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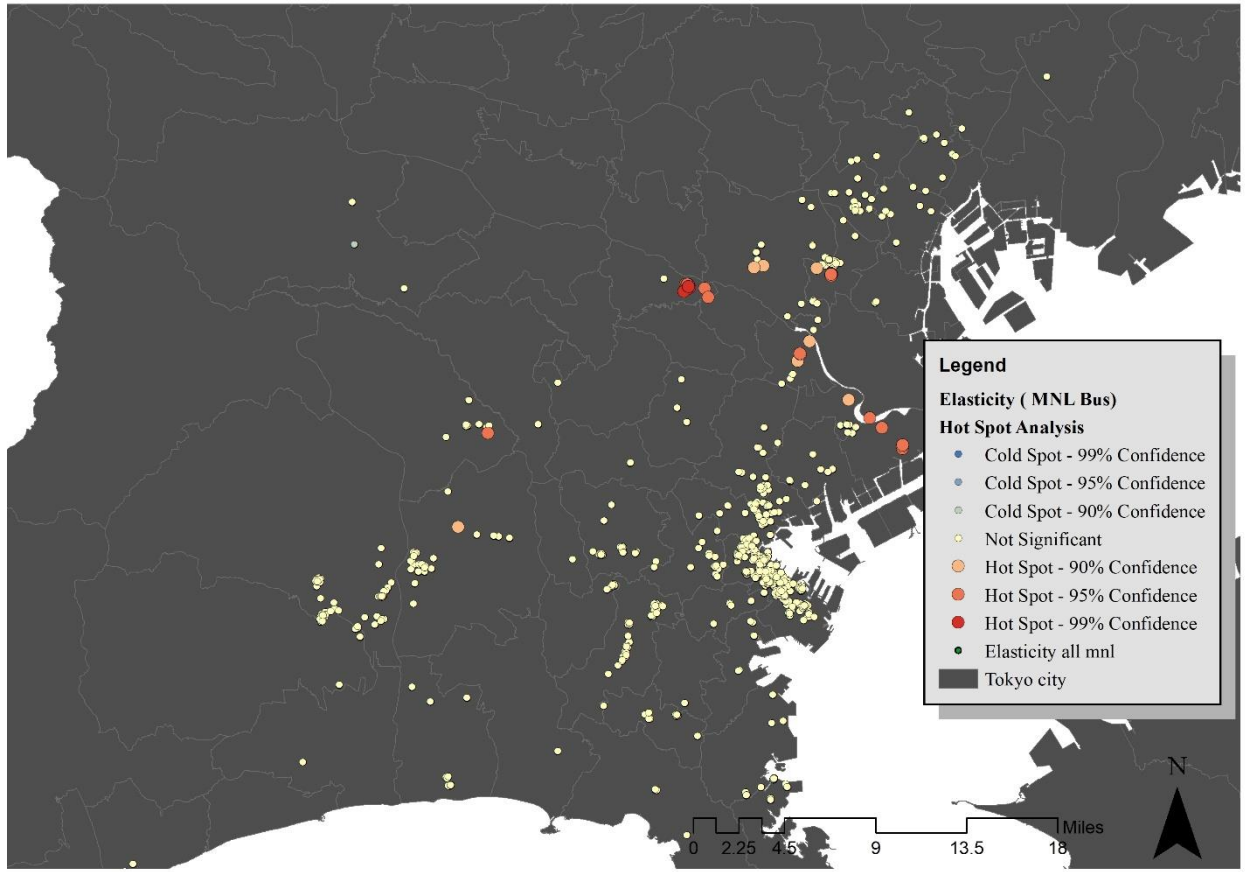
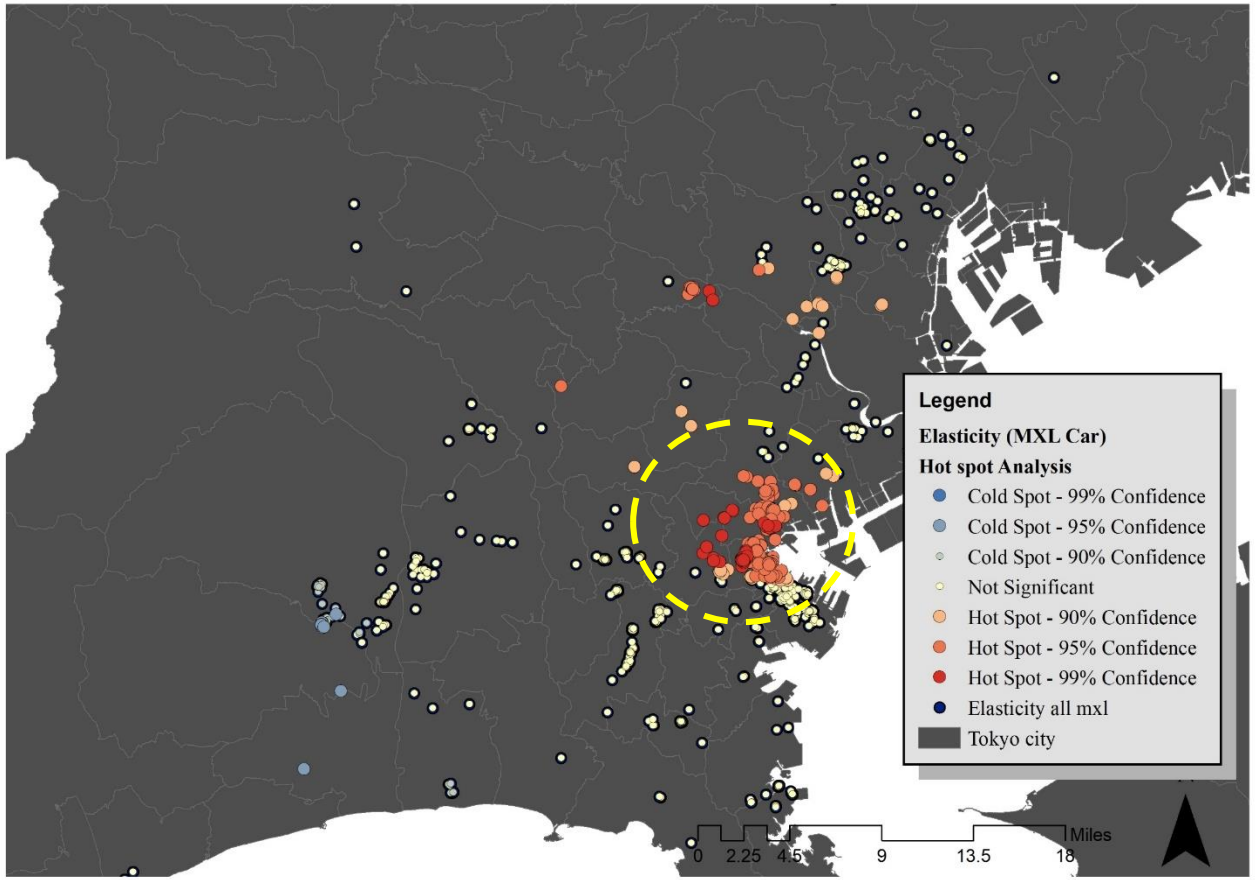


Inferences:

Spatial Analysis

Car: Elasticities peak hour

MXL



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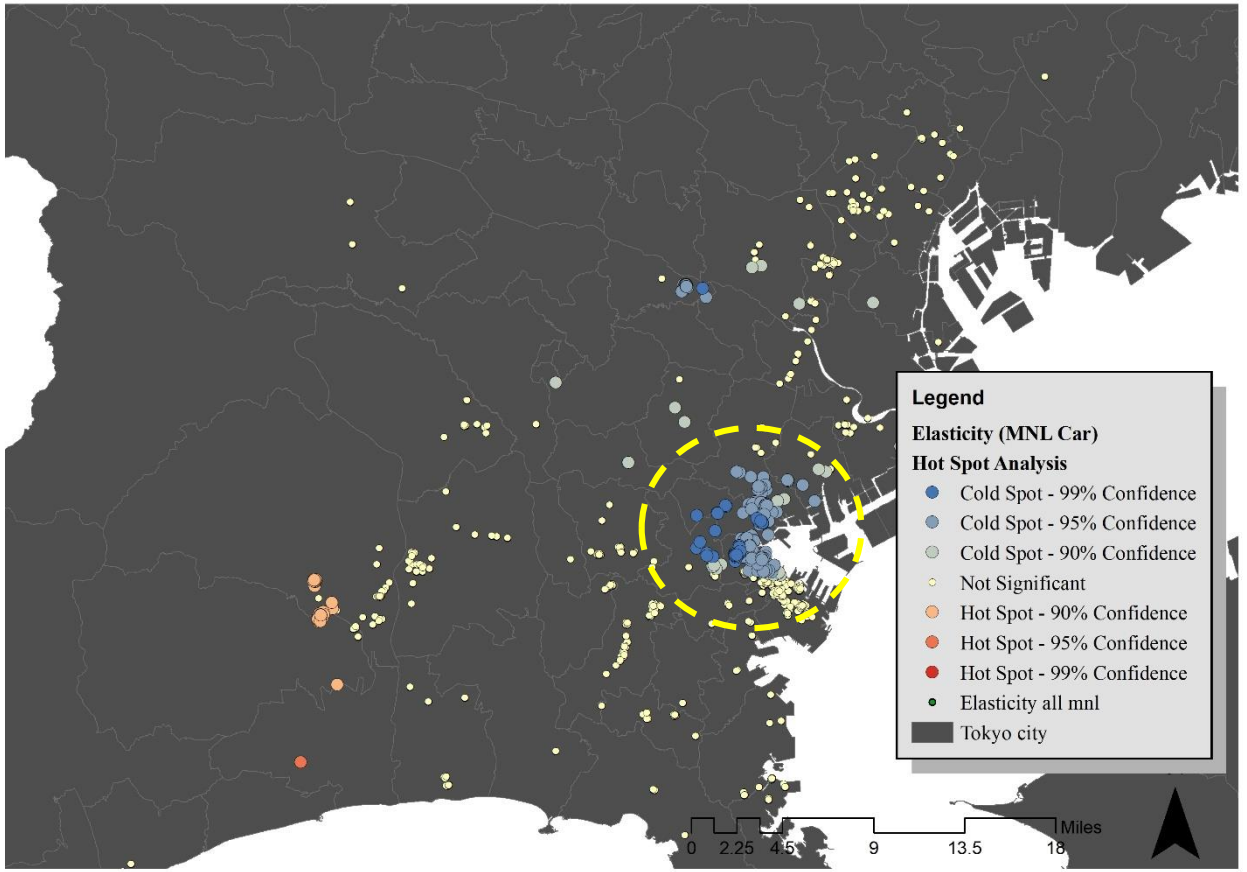
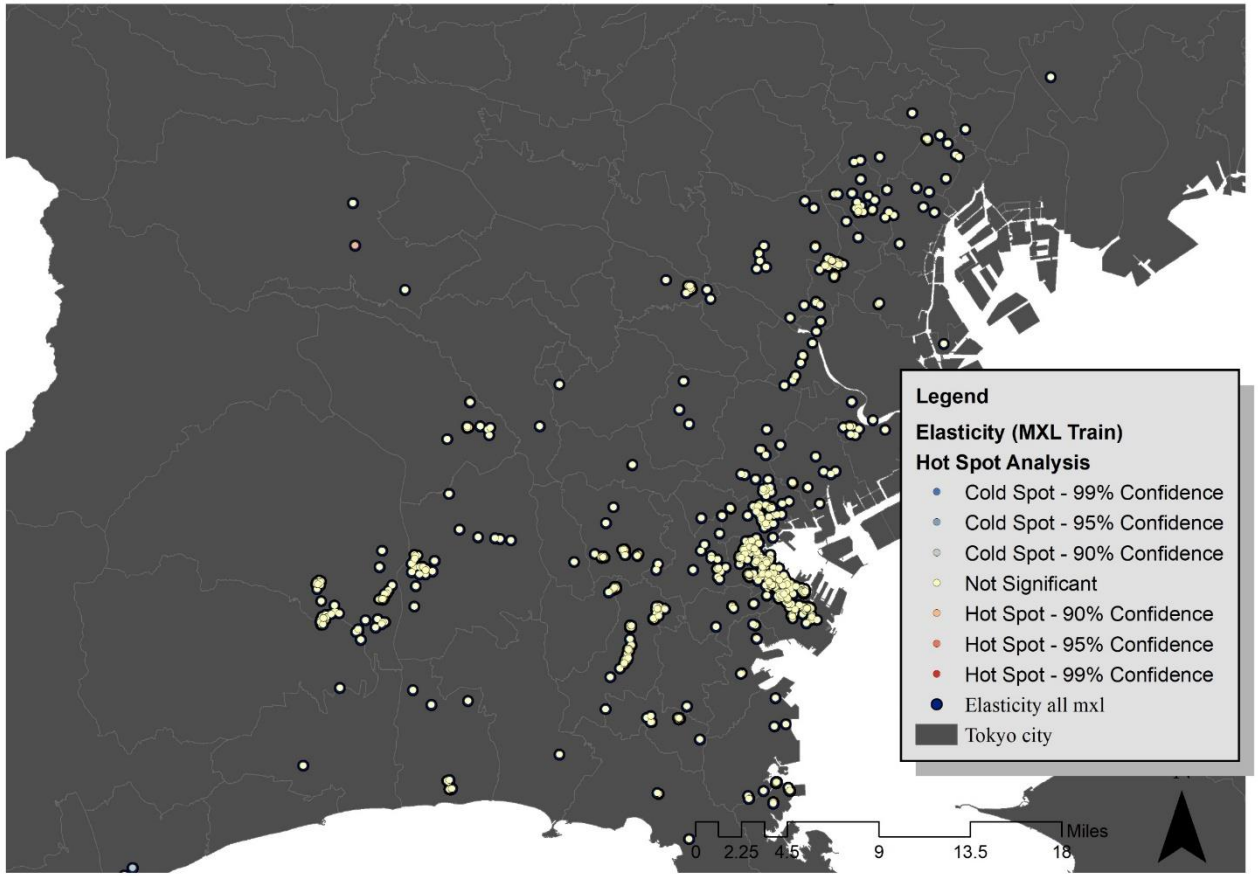


Inferences:

Spatial Analysis

Train: Elasticities peak hour

MXL



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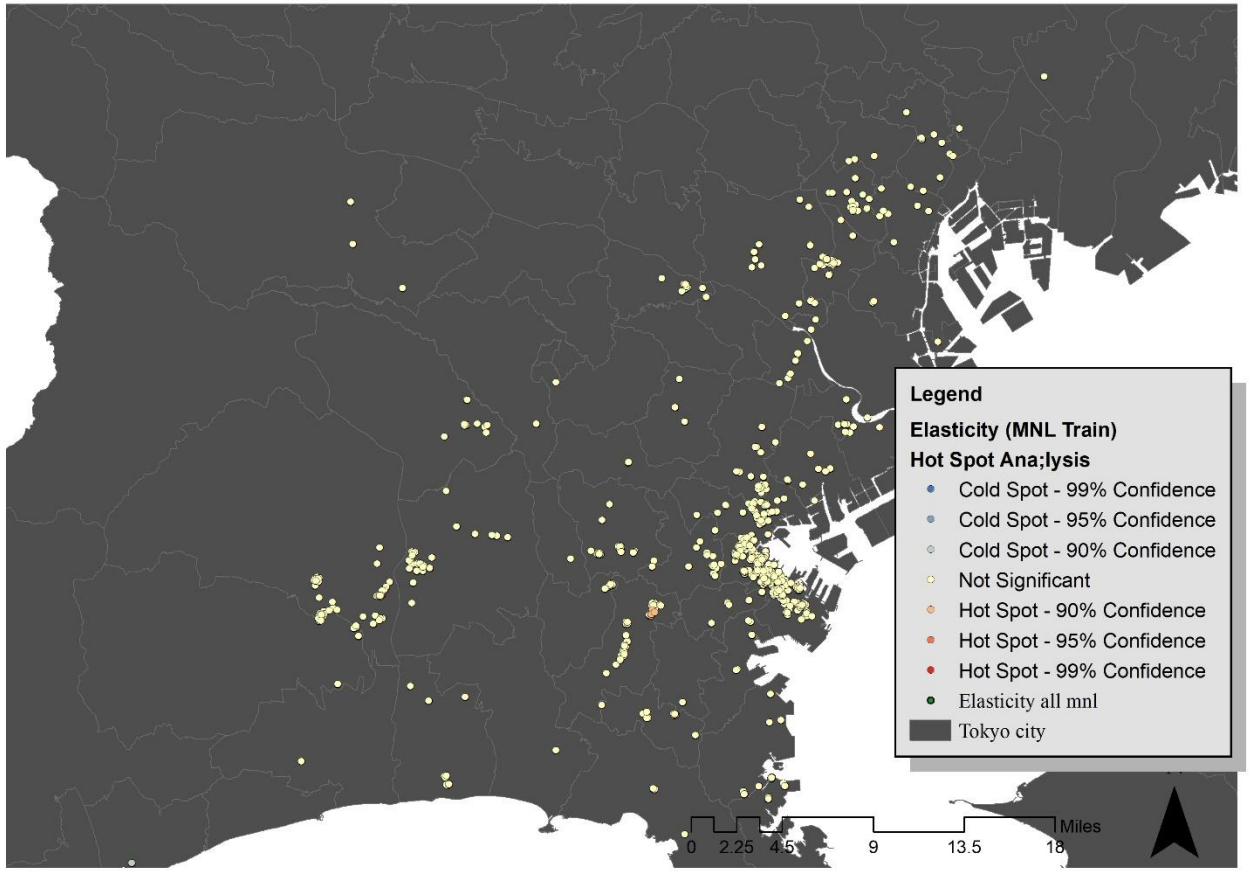

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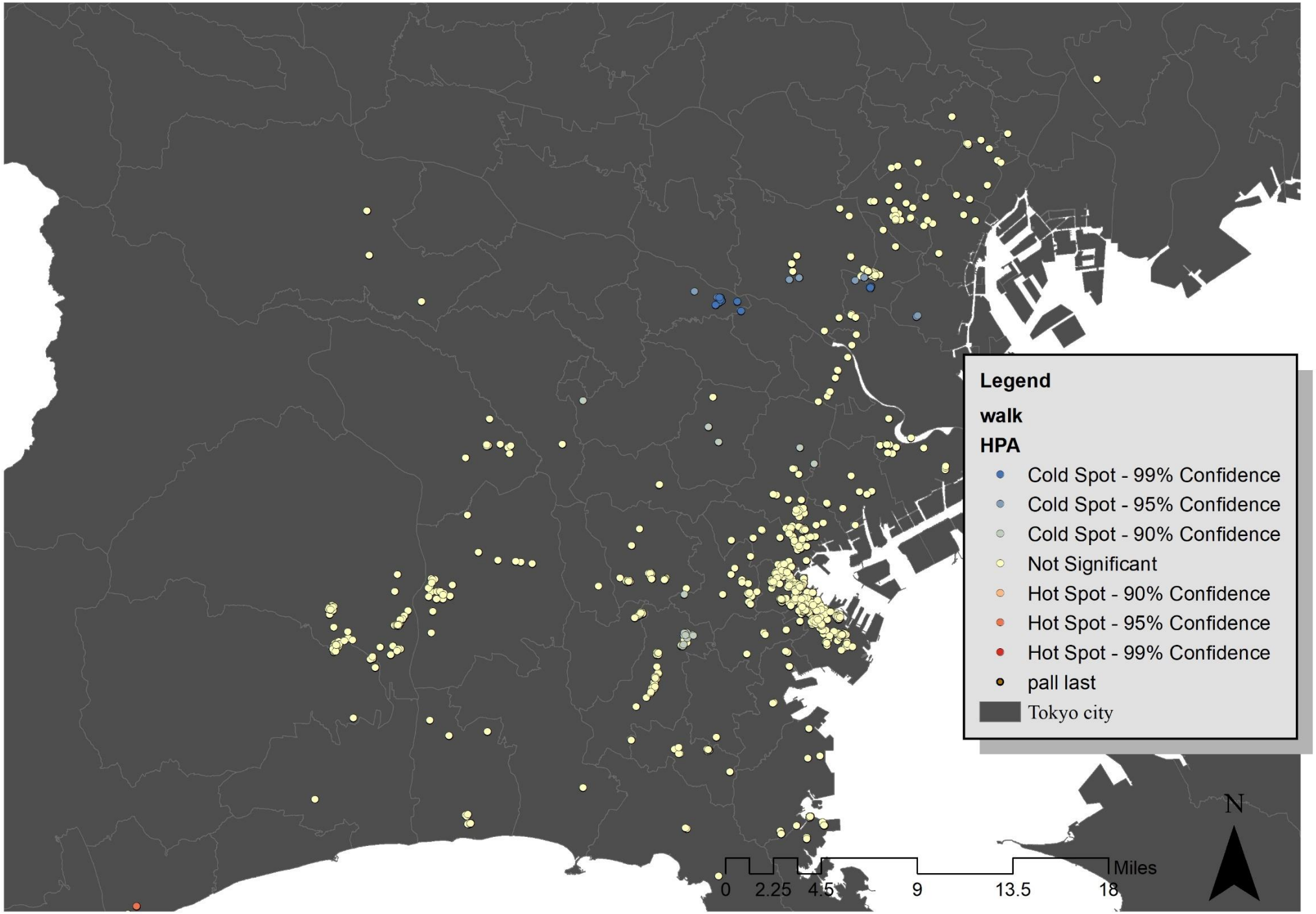
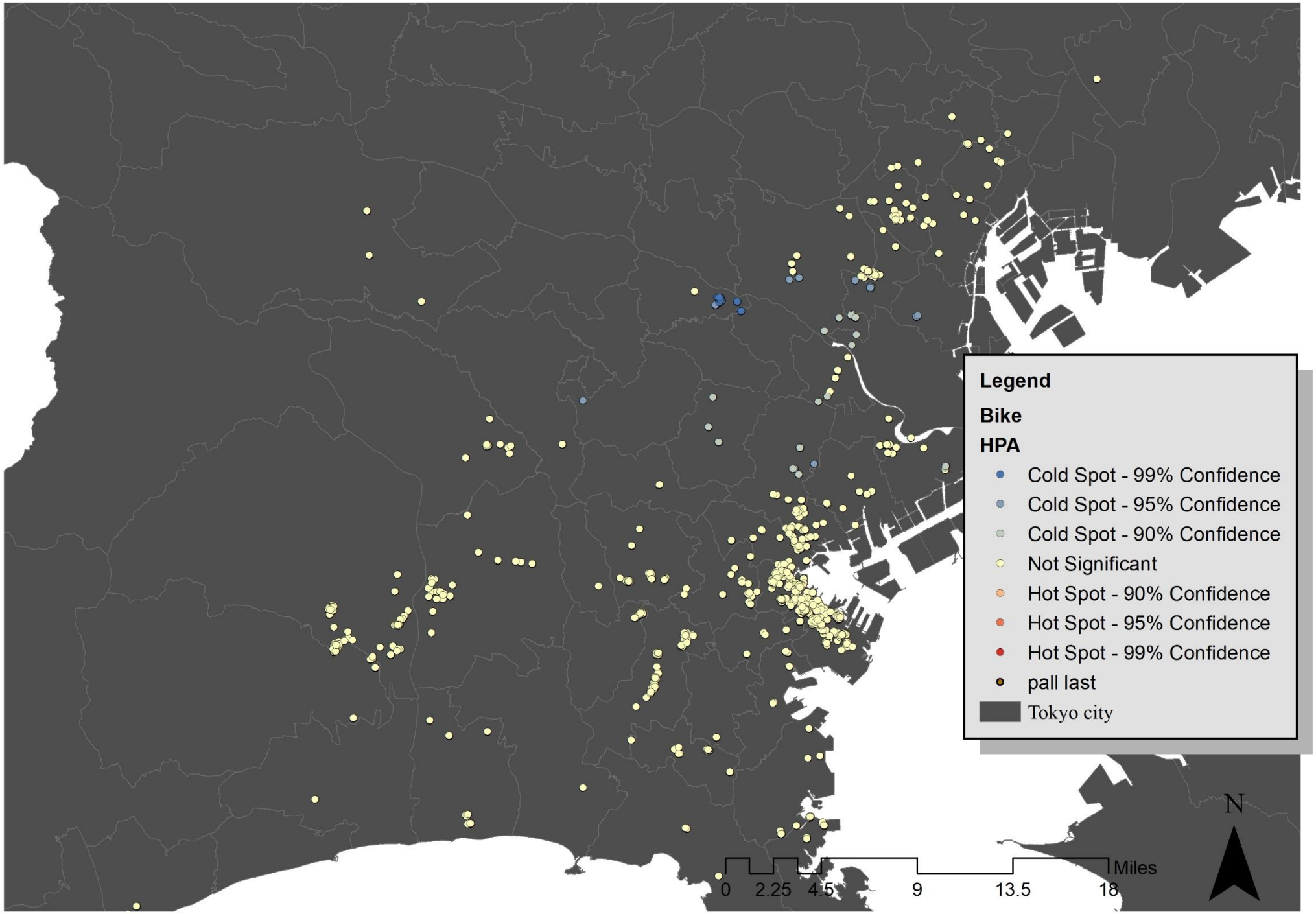

Legend
walk
HPA
Cold Spot - 99% Confidence
Cold Spot - 95% Confidence
Cold Spot - 90% Confidence
Not Significant
Hot Spot - 90% Confidence
Hot Spot - 95% Confidence
Hot Spot - 99% Confidence
pall last
Tokyo city
N
0
2.25
4.5
9
13.5
18
Miles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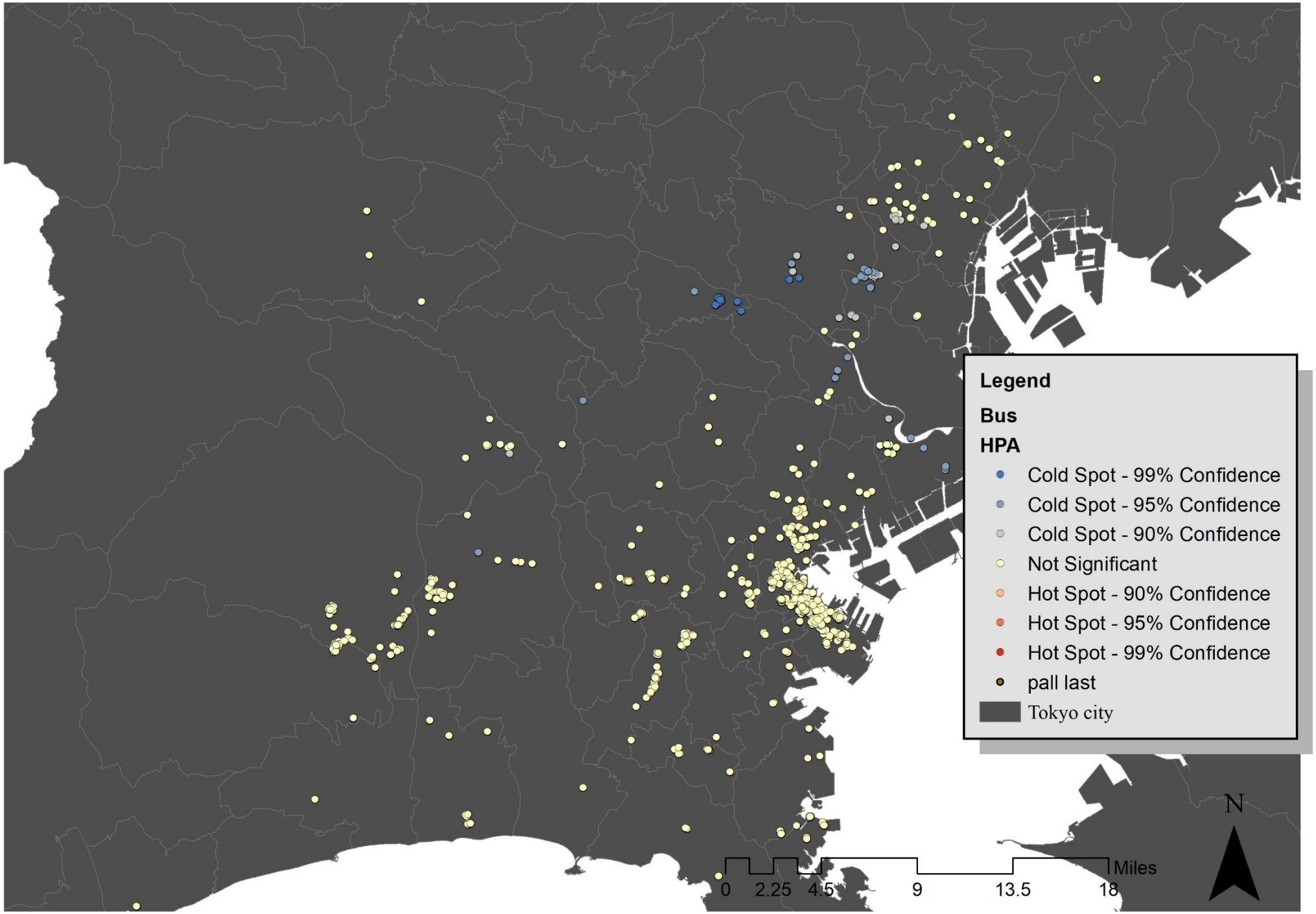
Miles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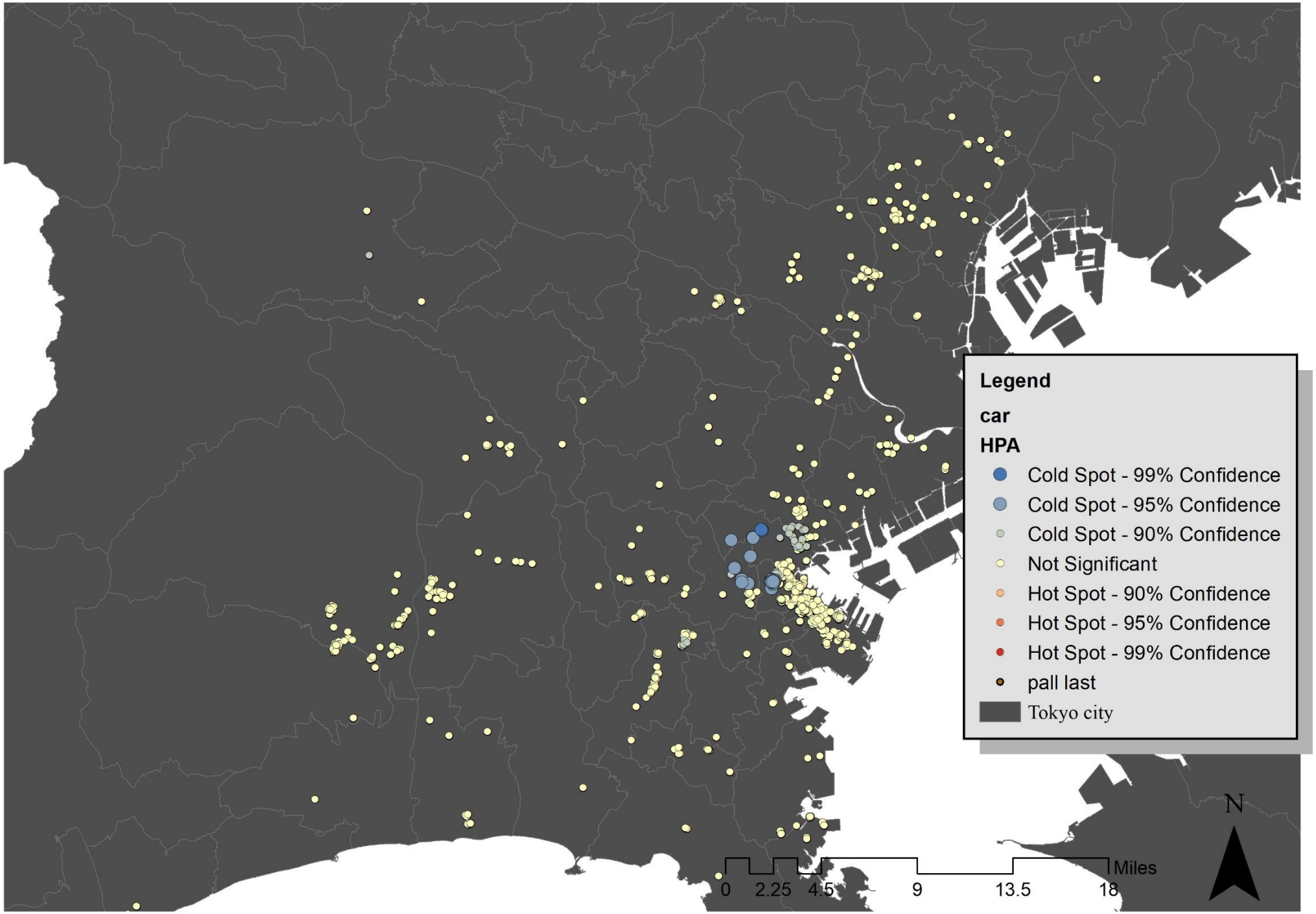
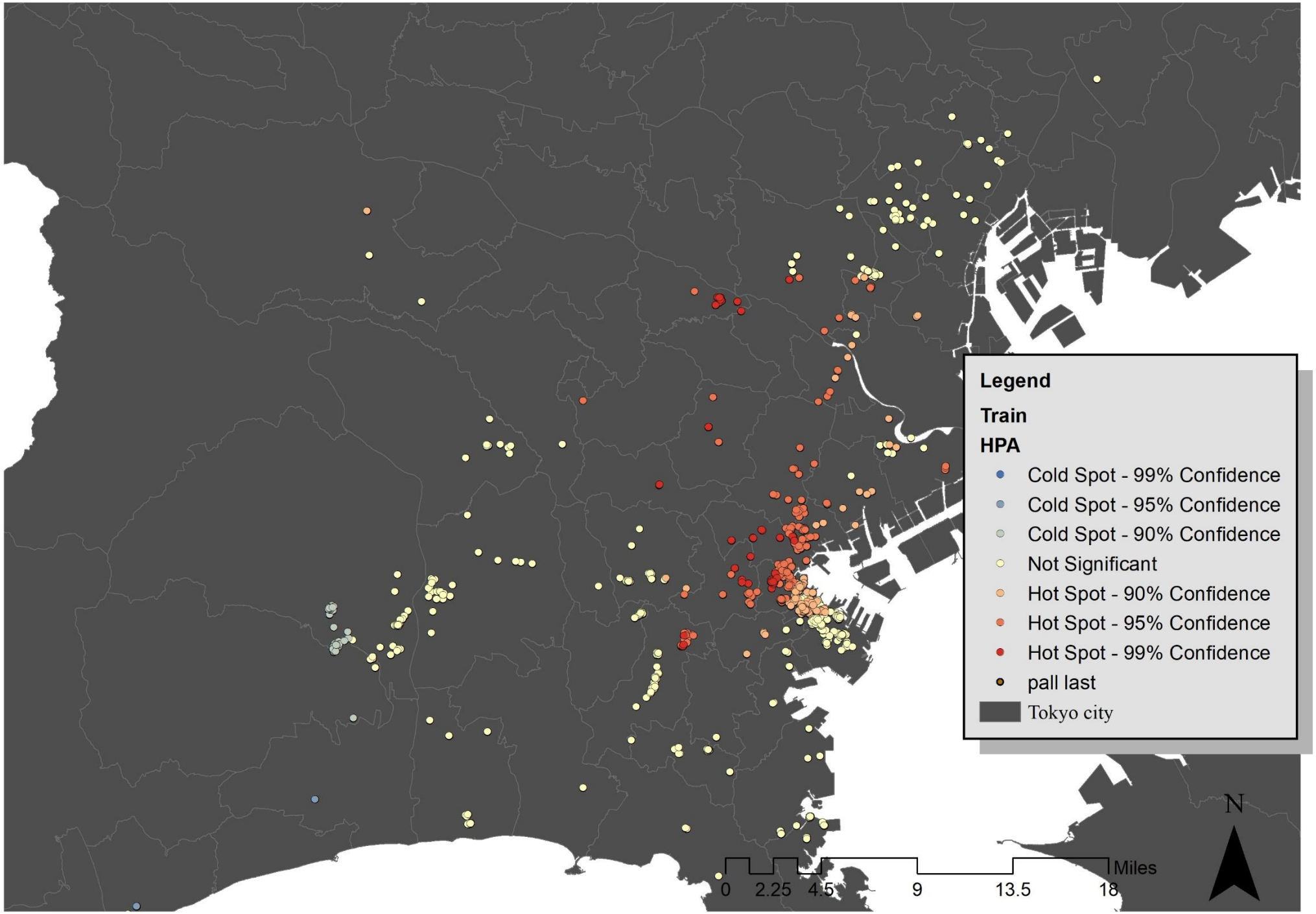
18
Miles


Legend
car
HPA
Cold Spot - 99% Confidence
Cold Spot - 95% Confidence
Cold Spot - 90% Confidence
Not Significant
Hot Spot - 90% Confidence
Hot Spot - 95% Confidence
Hot Spot - 99% Confidence
pall last
Tokyo city
N
0
2.25
4.5
9
13.5
18
Miles


Legend
Train
HPA
Cold Spot - 99% Confidence
Cold Spot - 95% Confidence
Cold Spot - 90% Confidence
Not Significant
Hot Spot - 90% Confidence
Hot Spot - 95% Confidence
Hot Spot - 99% Confidence
pall last
Tokyo city
N
0 2.25 4.5 9 13.5 18
Miles

Thank You