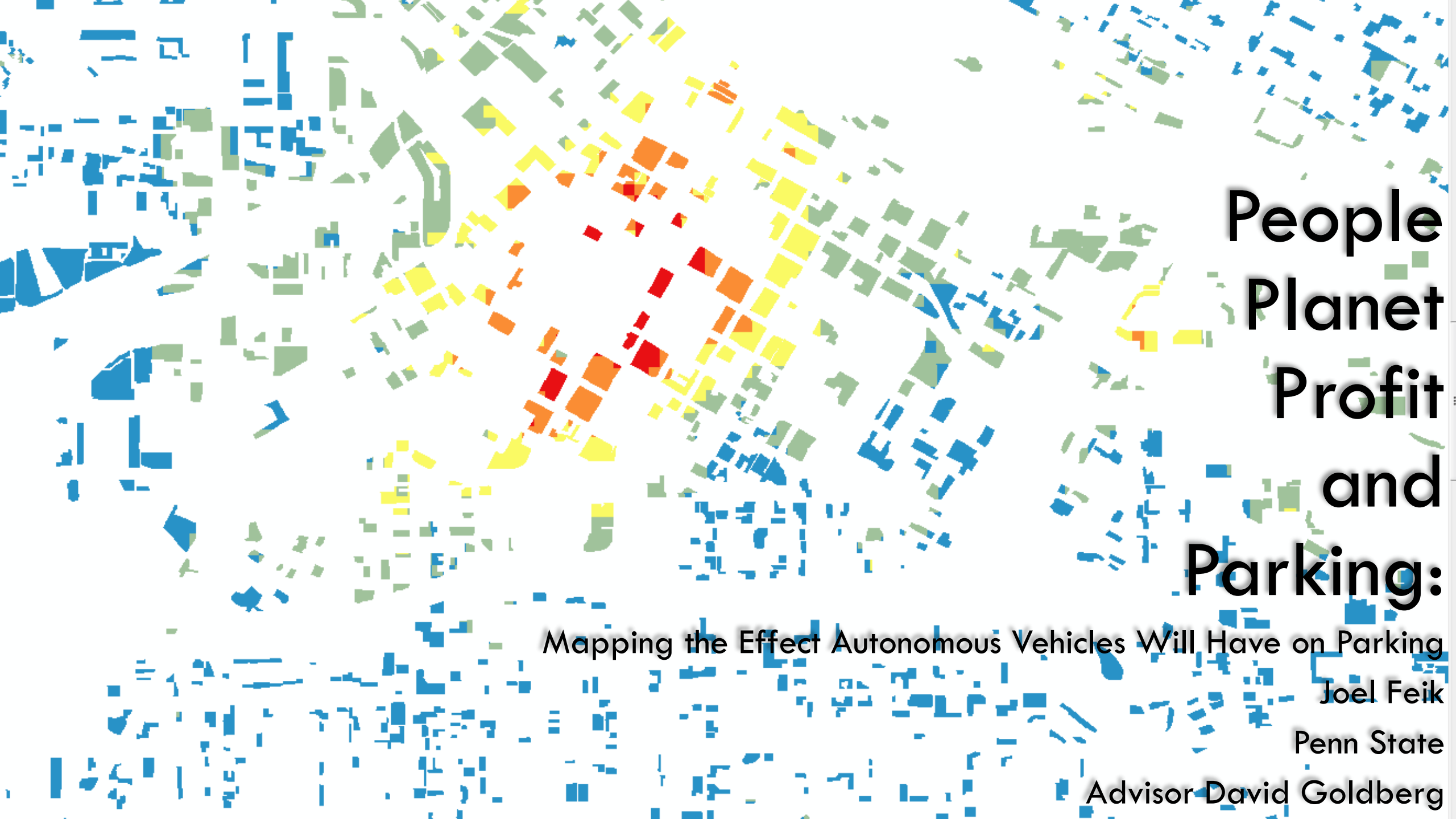


People Planet Profit and Parking:

Mapping the Effect Autonomous Vehicles Will Have on Parking

Joel Feik

Penn State

Advisor David Goldberg

Case Study: Minneapolis, Minnesota

Background—Autonomous Vehicles

- Google, Tesla, etc., developing self driving cars.
  - Fully autonomous
  - Incrementally autonomous
- Cars are on the roads now being tested
- May be commercially available in the next few years
- Could drastically change many aspects of life
- Potential impacts on:
  - Safety
  - Convenience
  - Business
  - Insurance
  - Accessibility

Background—Car-sharing, Autonomous Taxis

- Car-sharing model, Autonomous Taxis
  - Convenience
  - Cost
  - Reliability
- Reduction in parking, road width
- VMT (Vehicle Miles Traveled) may go up

Background—Cities and Parking Supply

3 Sectors: Economic, Environmental, Social

How will the projected reduction of parking from autonomous vehicles impact the American city?

Economic: Property Value and Building Value

Environmental: Urban Heat Island Effect/ Surface Temperature

Social: Automobile Mode Share and Transit Mode Share

commons.wikimedia.org
permissionmachine.com
www.businessinsider.com

Existing Conditions Metric

Sector	Attribute	Units	Current	Projected
Existing Conditions	Parking Area/Spaces	Acres of Parking Storage / # of spaces/ spaces per acre	Baseline	• 25/50/75/100 less parking

- Total Parking
- Total Acreage
- Spaces per Person

Economic Metrics

Sector	Attribute	Units	Current	Projected
Economic	Property/Building Value	Property/Building value ($) per acre	Baseline	• 25/50/75/100 less parking • Replaced with Parks/Buildings

- Total Property Value
- Property Value per person
- Average Property/Building Value

Environmental Metrics

Sector	Attribute	Units	Current	Projected
Environmental	Urban Heat Island	Surface Temperature per Acre	Baseline	• 25/50/75/100 less parking • Replaced with Parks

- # of Acres at each temperature
- % of Acres at each temperature
- Average Surface Temperature

Social Metrics

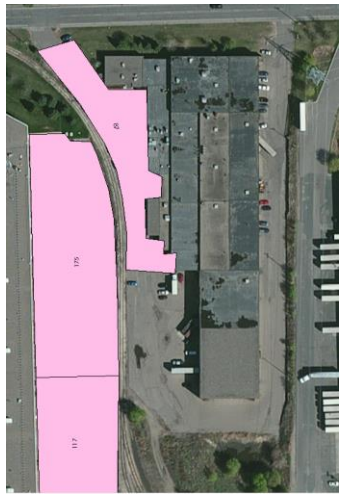
Sector	Attribute	Units	Current	Projected
Social	Automobile Mode Share/ Transit Mode Share	Commuters by Mode/acre	Baseline	• 25/50/75/100 less

- % of Commuters per Census Block Group
- Number of Commuters by Mode

Method: Existing Conditions

Parking Digitization

- Scale 1:2400
- > 3-4 stalls at 1:2400
- Systematic method to cover entire city
- Cars are present or parking stalls visible
- using ESRI Aerial (2013 30-cm)
- Not digitizing:
  - Freight/Truck Parking (esp. in Industrial areas)
  - On Street Parking
  - Parking Lot entries, islands
  - Junkyards
- Parking Ramp Inventory
  - Public websites
  - Google street view



Method: Existing Conditions

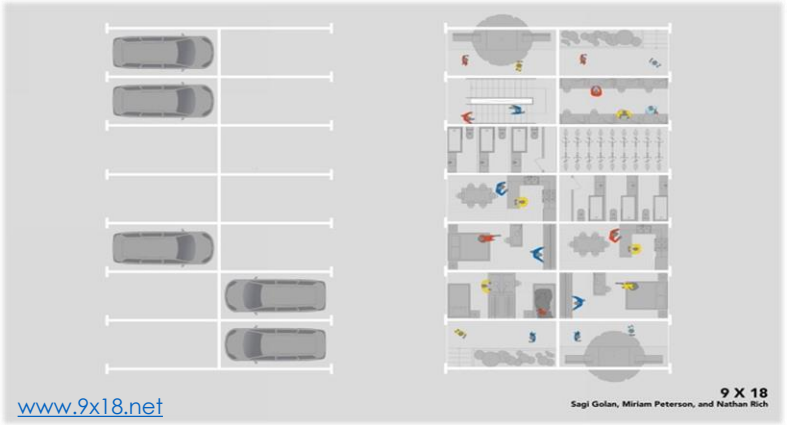
Parking Space Calculation: ([SHAPE_Area]-([SHAPE_Area]*.5))/162

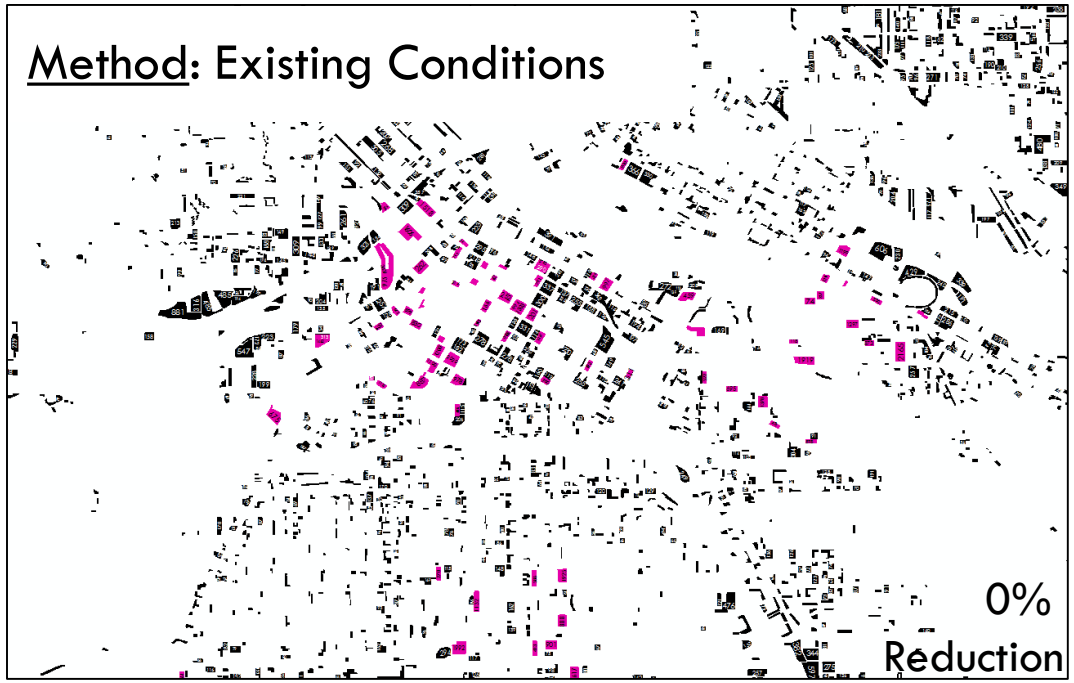
Assumes a 9’ x 18’ (=162’ stall) with 50% devoted to ingress, egress, islands

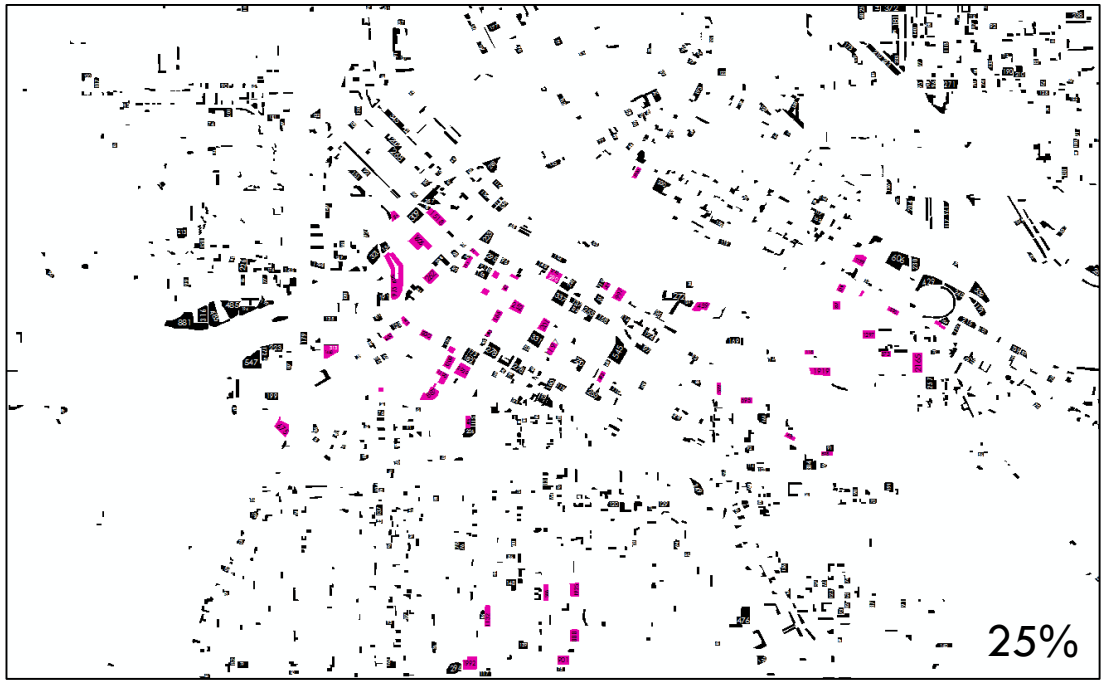
Performed verification with calculated spaces against sampled counted spaces to make adjustments to formula

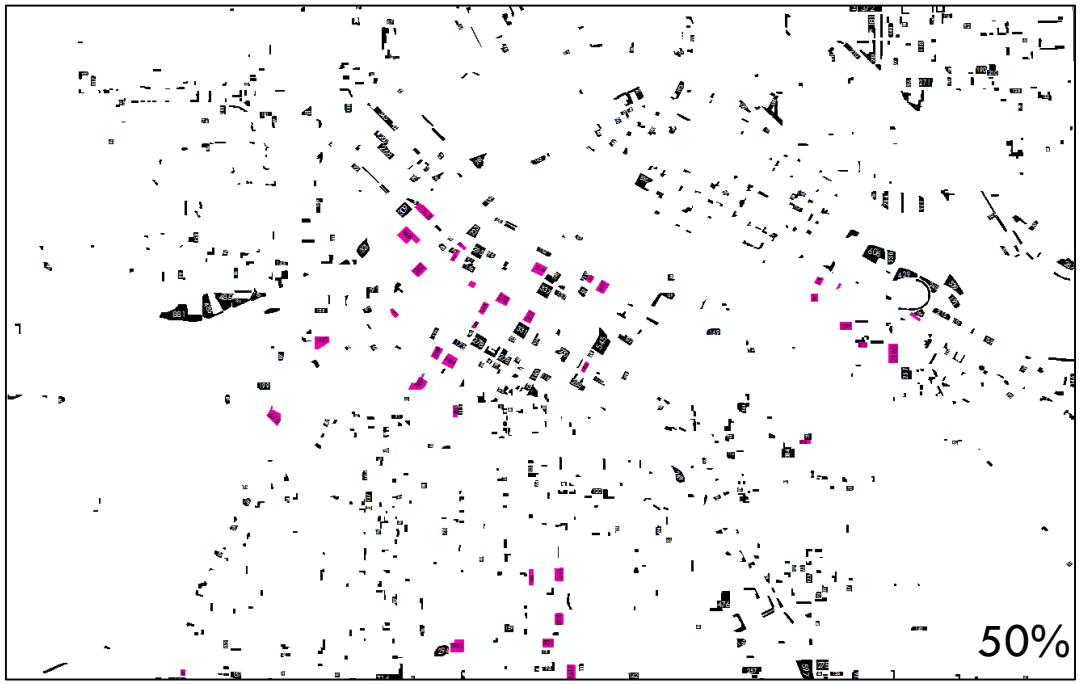
Randomization

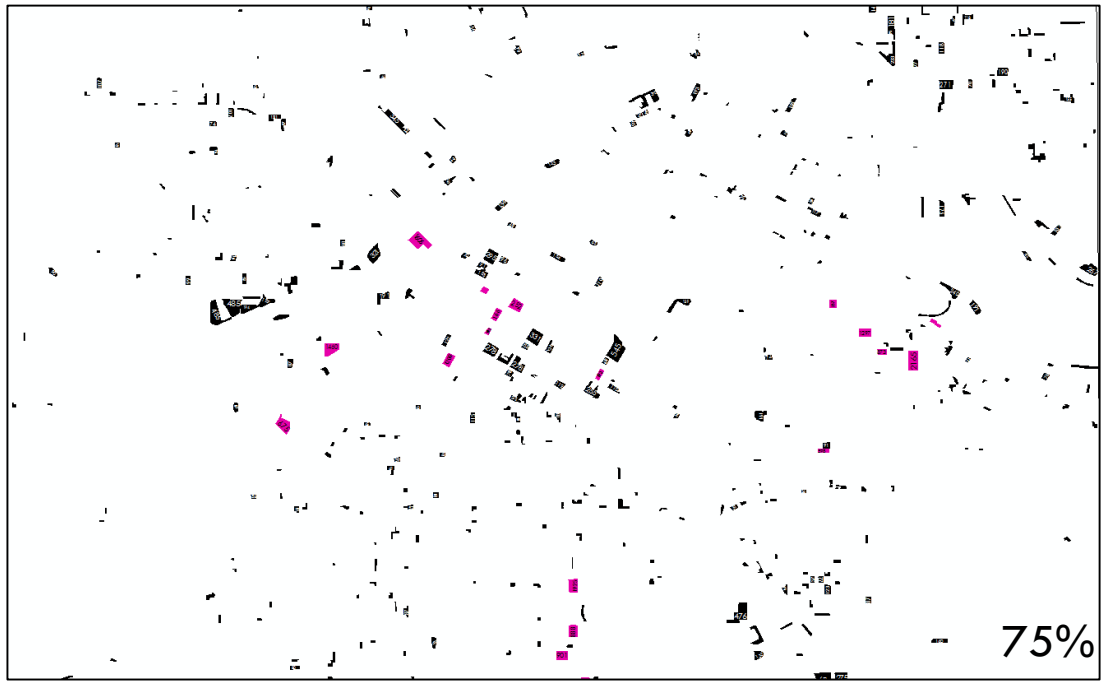
```
import random
def rand():
  return random.random()

rand()
```





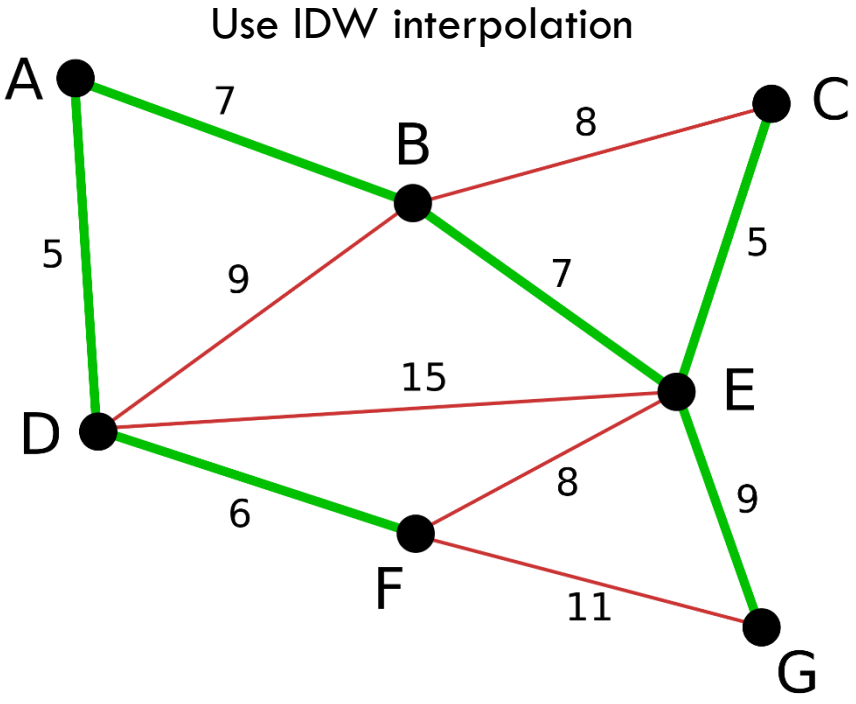


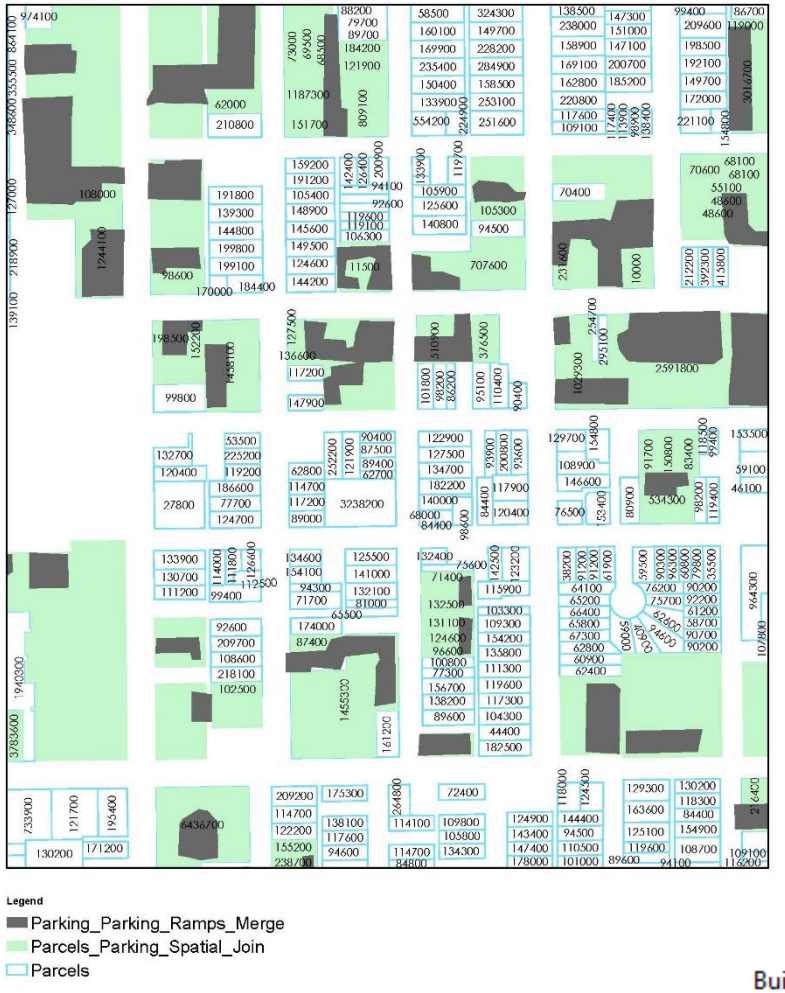


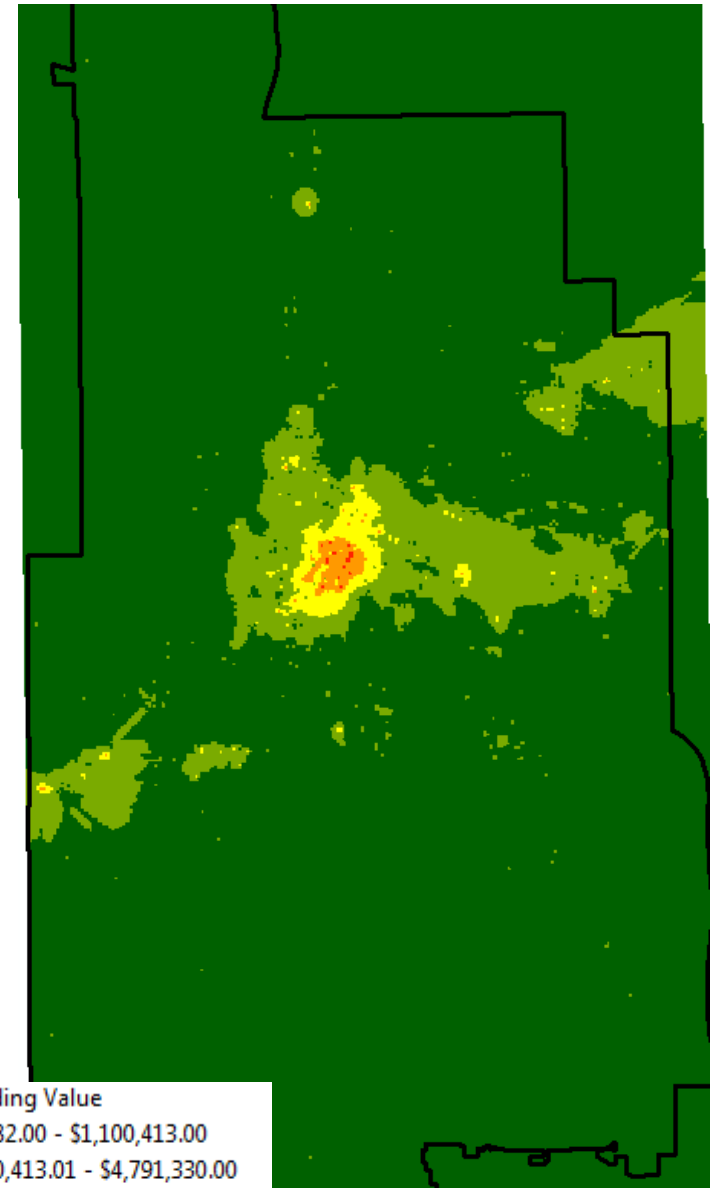


100%

Method: Economic—Parking Replaced by Buildings







Parcels Data
IDW with Geostatistical Analyst
Convert to Polygon
Spatial Join (Parcels + IDW)

Method: Economic—Parking
Replaced by Parks

Analysis from research:

- 20% increase for properties abutting or fronting park
- decrease from 500’ – 3000’ away

“The Impact of Parks on Property Values” Crompton, John L., 2001

My own analysis:

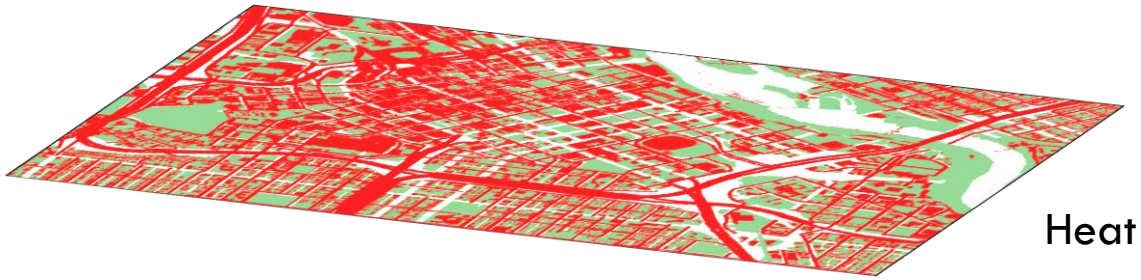
- Average Land Value by Park (< 500’): 82,641
- Average Land Value away from Park (>500’): 64,857

27.4 % higher

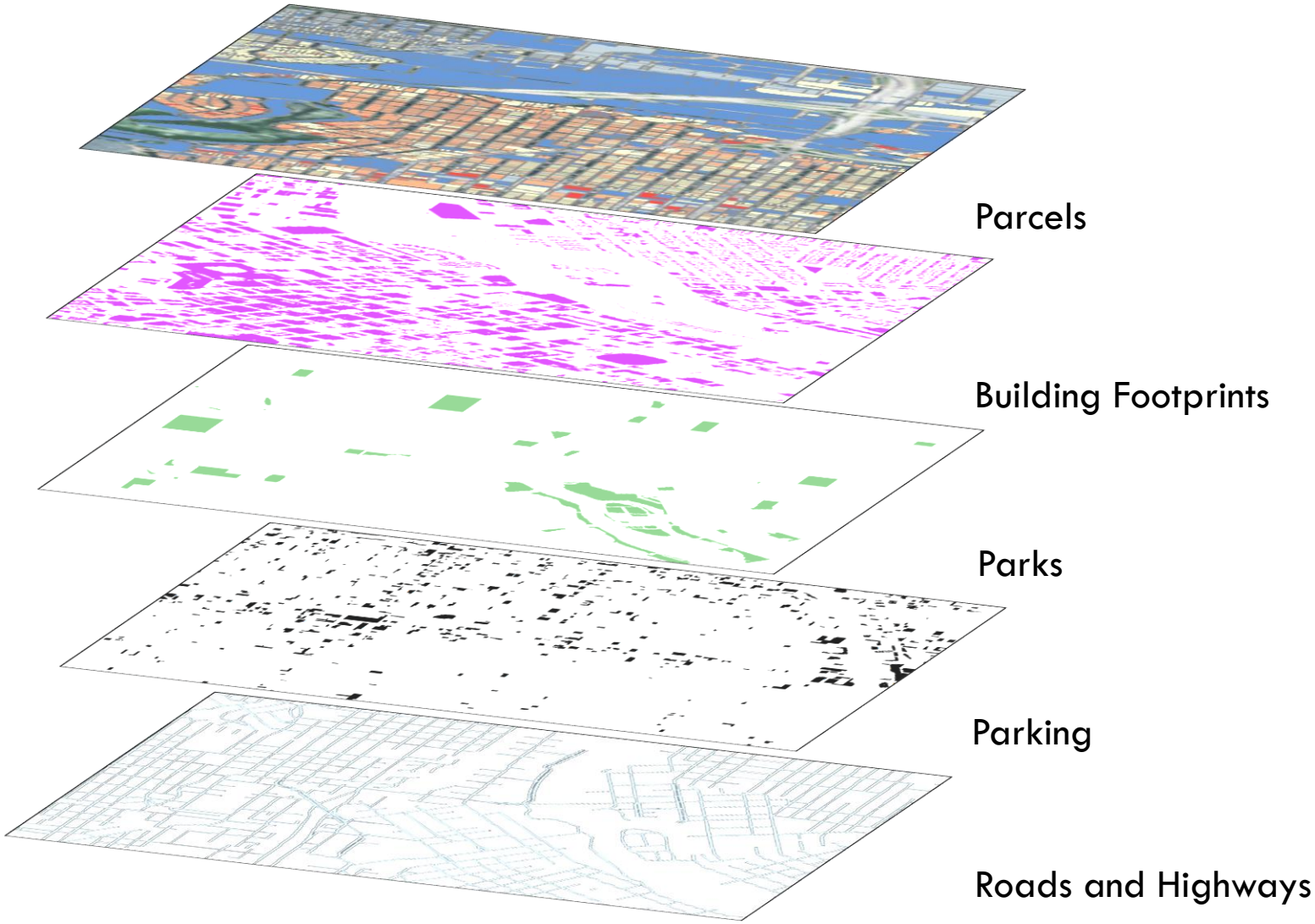
Adjusted parcels within 500’ of converted parking to be 27.4% higher land value

Method: Environmental

+ Parcels = 25°C (77°F)
  - Buildings
  - Parking (Remaining)
+ Parks = 25°C
+ Buildings = 65°C (149°F)
+ Parking (Remaining) = 65°C
+ Roads and Highways = 65°C
+ Parking Converted to Park = 25°C



Heat Map



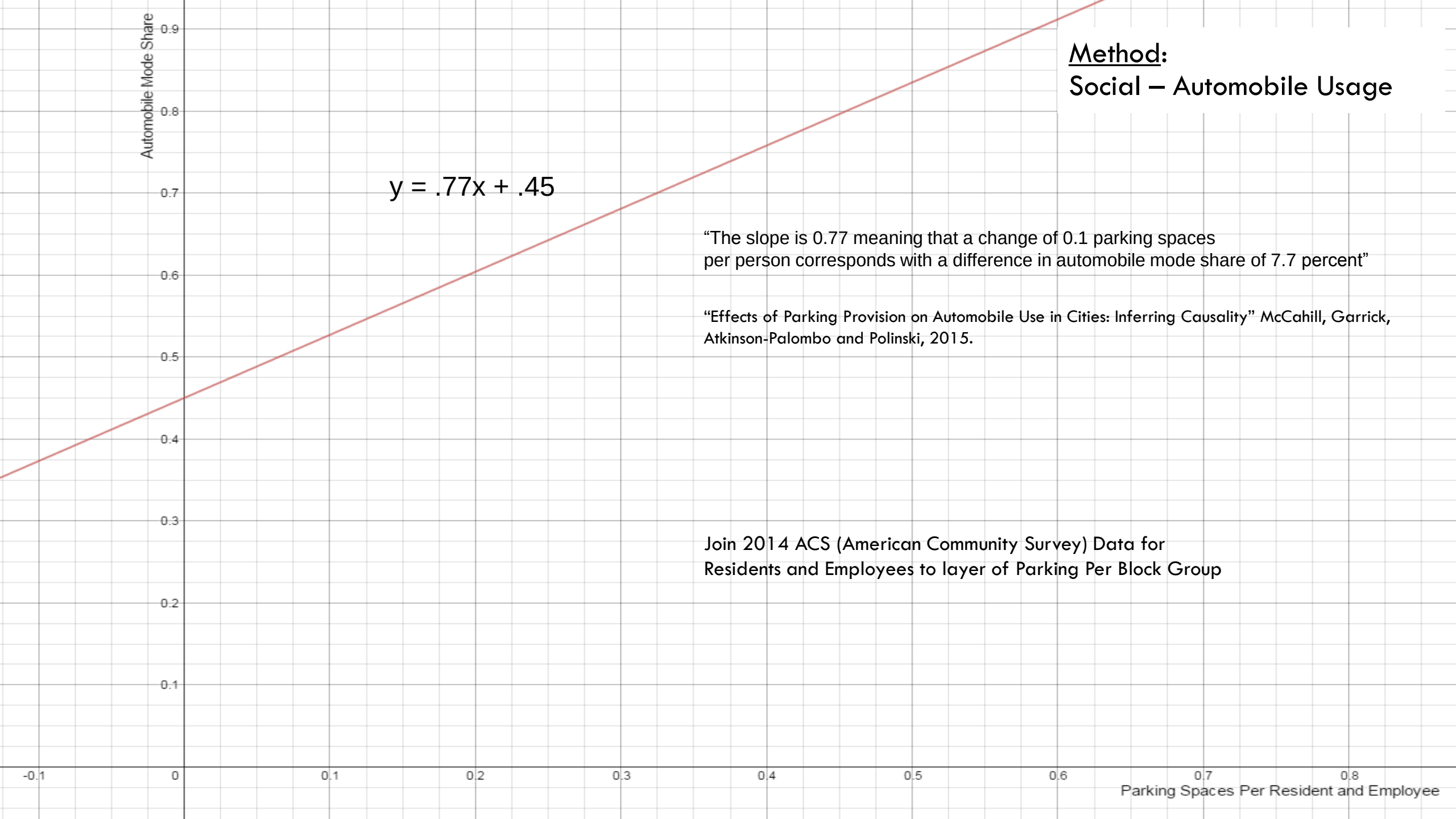
Parcels

Building Footprints

Parks

Parking

Roads and Highways

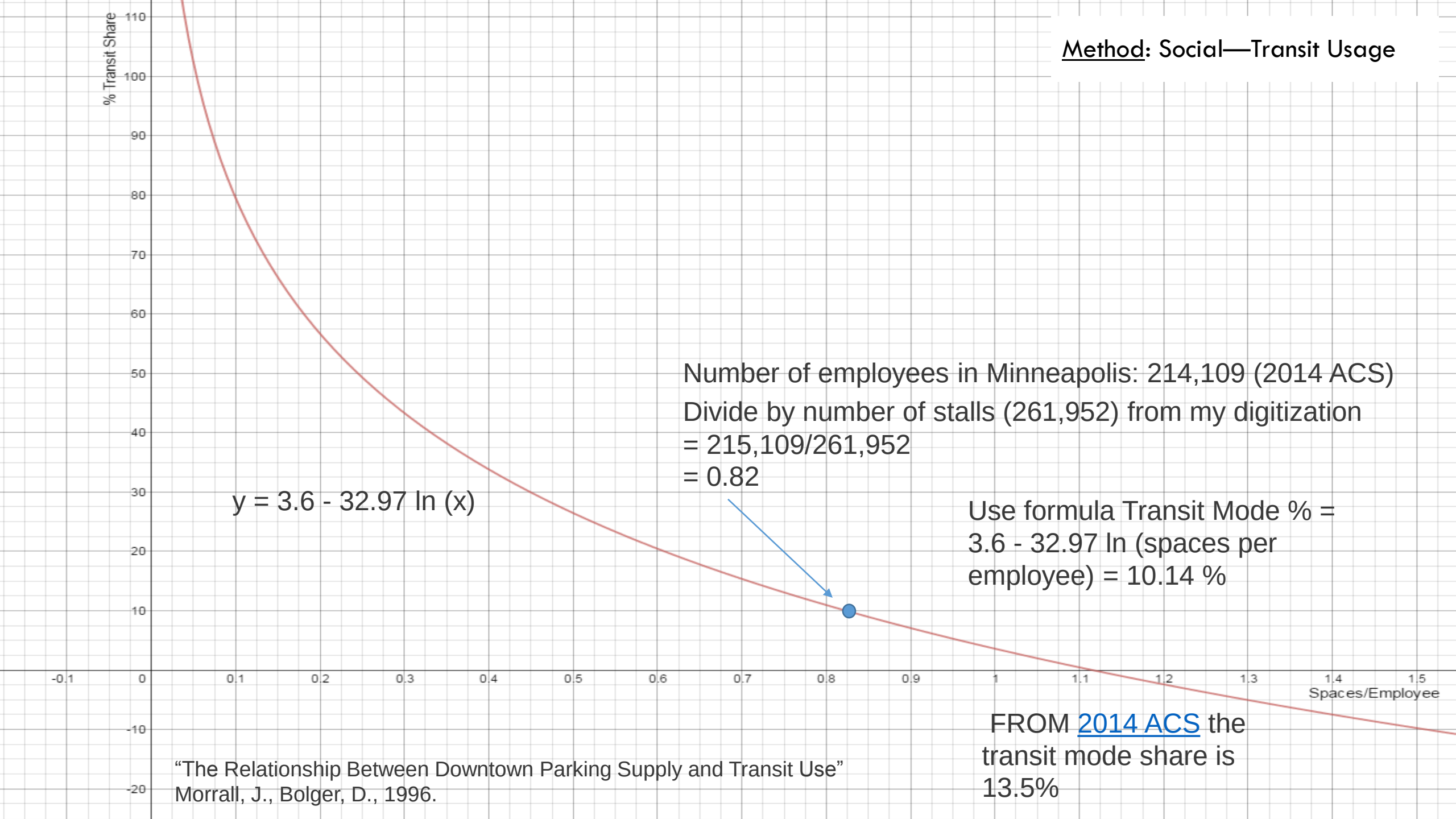


Method:
Social – Automobile Usage

"The slope is 0.77 meaning that a change of 0.1 parking spaces per person corresponds with a difference in automobile mode share of 7.7 percent"

"Effects of Parking Provision on Automobile Use in Cities: Inferring Causality" McCahill, Garrick, Atkinson-Palombo and Polinski, 2015.

Join 2014 ACS (American Community Survey) Data for Residents and Employees to layer of Parking Per Block Group



Method: Social—Transit Usage

Number of employees in Minneapolis: 214,109 (2014 ACS)

Divide by number of stalls (261,952) from my digitization

= 215,109/261,952

= 0.82

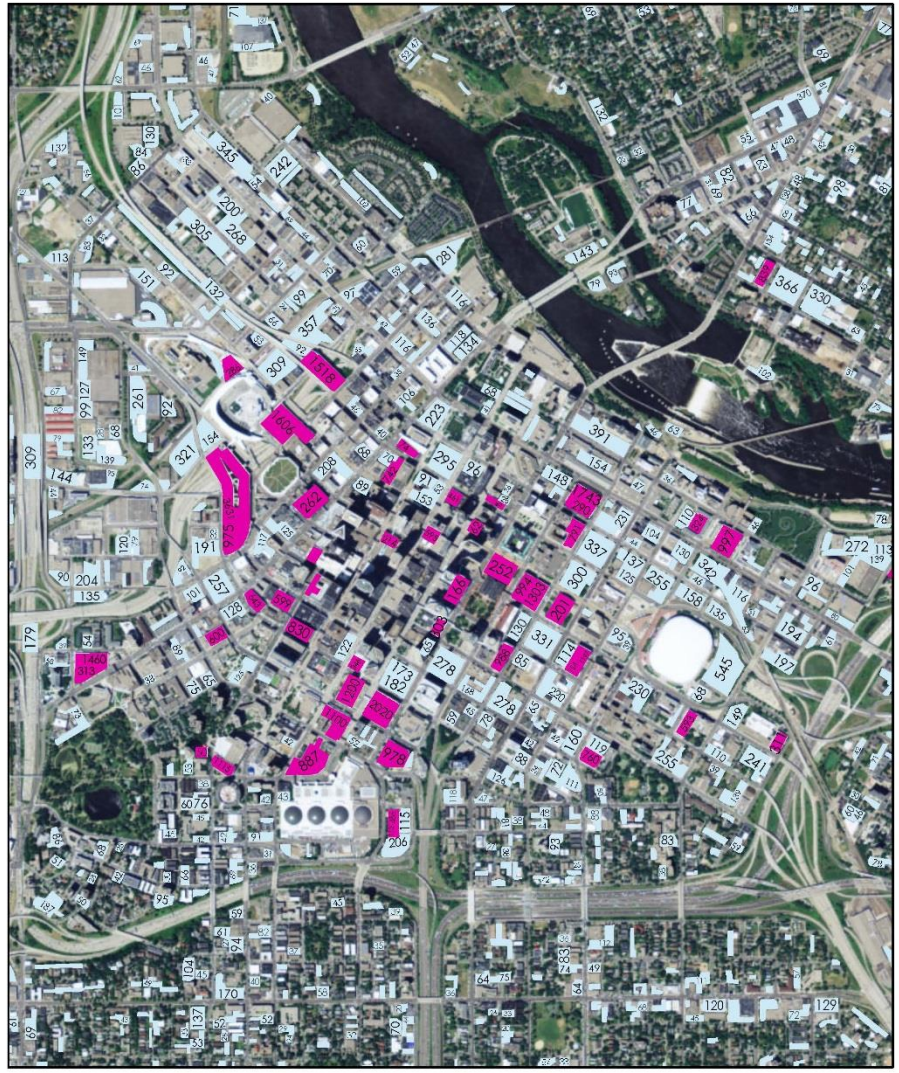
y = 3.6 - 32.97 ln (x)

Use formula Transit Mode % = 3.6 - 32.97 ln (spaces per employee) = 10.14 %

FROM 2014 ACS the transit mode share is 13.5%

"The Relationship Between Downtown Parking Supply and Transit Use" Morrall, J., Bolger, D., 1996.

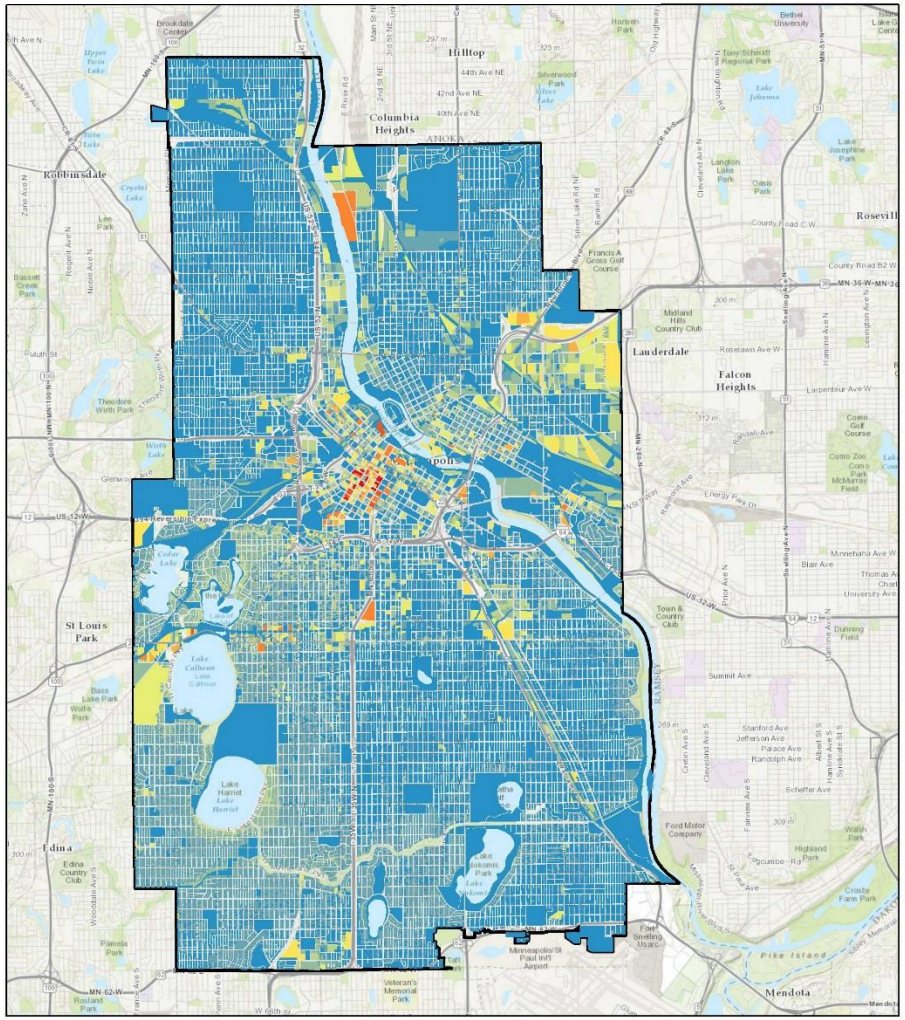
Results: Existing Conditions Maps



Legend

- Minneapolis_City_Limits
- Parking Ramps
- Parking

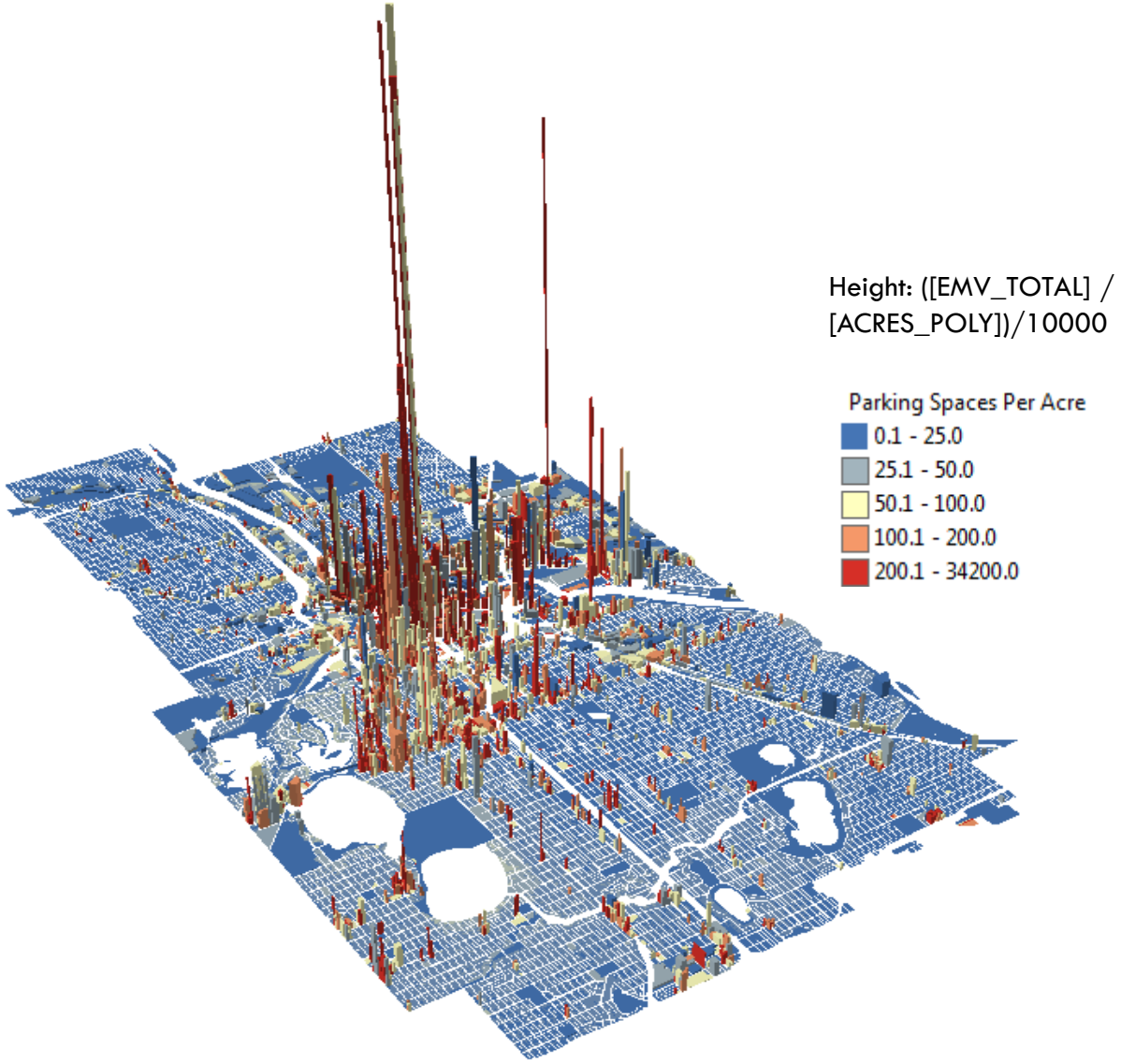
Results: Existing Conditions Maps



Minneapolis Property Value Map

Property Value

- 0 - 226,000
- 226,001 - 614,500
- 614,501 - 1,610,000
- 1,610,001 - 3,956,000
- 3,956,001 - 8,342,500
- 8,342,501 - 15,510,000
- 15,510,001 - 28,401,000
- 28,401,001 - 48,000,000
- 48,000,001 - 99,710,000
- 99,710,001 - 209,970,000
- Minneapolis City Limits



Property Value per Acre and Parking Spaces per Acre

Results: Existing Conditions Stats and Random Reductions in Parking

0% Reduction	Spaces	Acreage
Parking Ramps Total	61,502	99.3
Parking	200,415	1,490.6
Total	261,917	1,560.0

Spaces per acre (36,756.5 acres)	7.1
Spaces per person (400,070 in 2013)	0.6

25% Reduction	Spaces	Acreage
Parking Ramps Total	53,264	82.0
Parking	147,117	1,094.2
Total	200,381	1176.2

Spaces per acre (36,756.5 acres)	5.5
Spaces per person (400,070 in 2013)	0.5

50% Reduction	Spaces	Acreage
Parking Ramps Total	33,816	54.1
Parking	99,751	742.0
Total	133,567	796.1

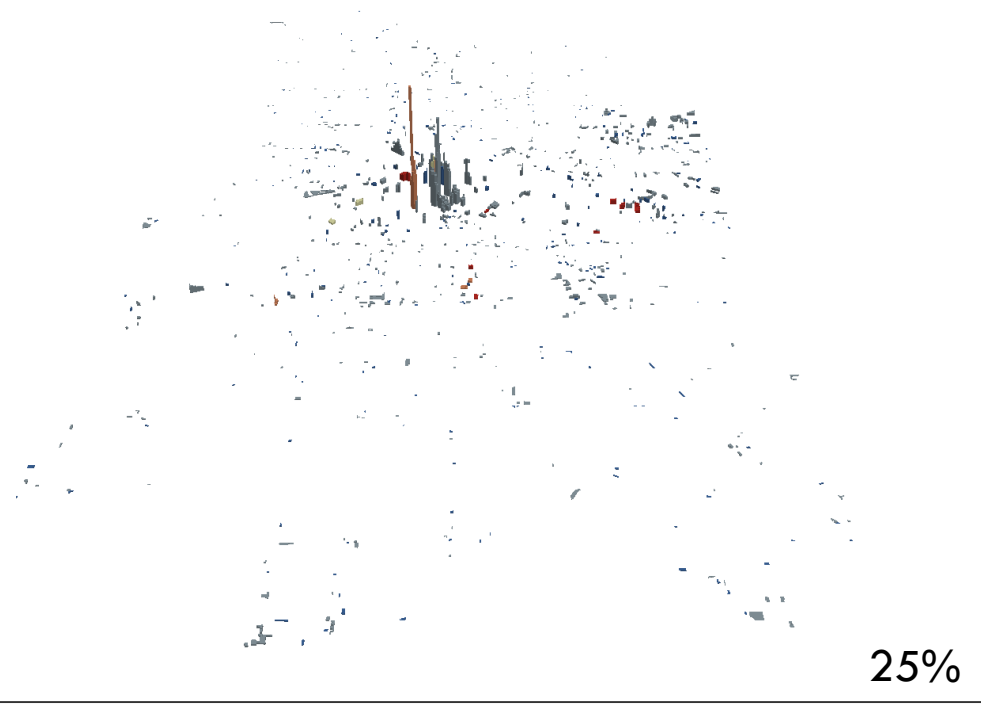
Spaces per acre (36,756.5 acres)	3.6
Spaces per person (400,070 in 2013)	0.3

75% Reduction	Spaces	Acreage
Parking Ramps Total	19,063	30.7
Parking	49,994	371.8
Total	69,057	402.5

Spaces per acre (36,756.5 acres)	1.9
Spaces per person (400,070 in 2013)	0.2

Results: Economic Maps – Parking Replaced by Buildings

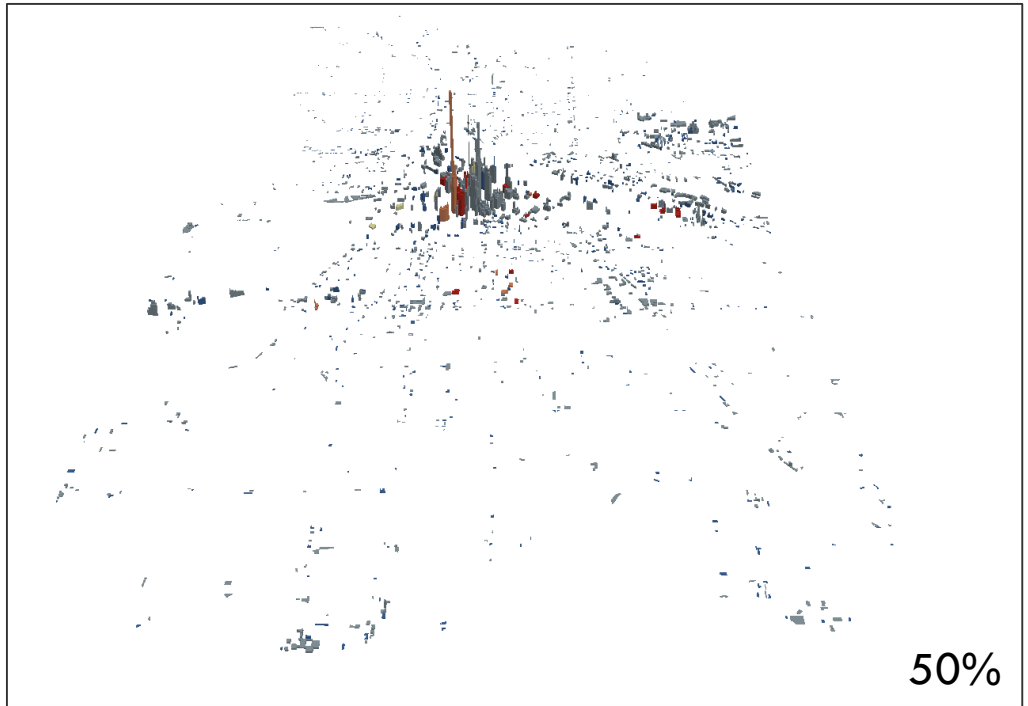
0% Reduction



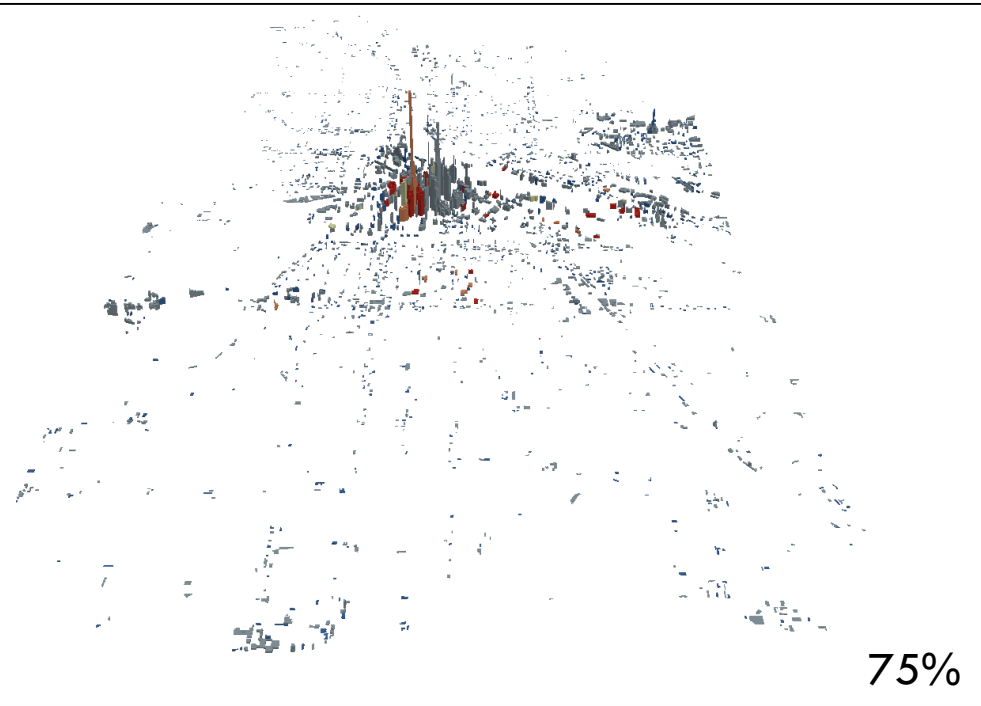
25%

Polygon Height = [Building Value]/10000

Calculated_Spaces / Acreage
- 109.5 - 134.0
- 134.1 - 144.3
- 144.4 - 403.4
- 403.5 - 672.5
- 672.6 - 1479



50%



75%

Results: Economic Maps – Parking Replaced by Buildings

Results: Economic Stats—Parking Replaced by Buildings

25% Reduction in Parking	New Building Value
Total of New Buildings	$794,980,582.85
Per Acre (36,756.5 acres)	$21,628.29
Per Person (400,070 in 2013)	$1,987.10
Per New Building (803)	$990,013.17

50%	Building Value
Total	$1,578,738,036.45
Per Acre	$42,951.26
Per Person	$3,945.15
Per New Building (1,620)	$974,526.65

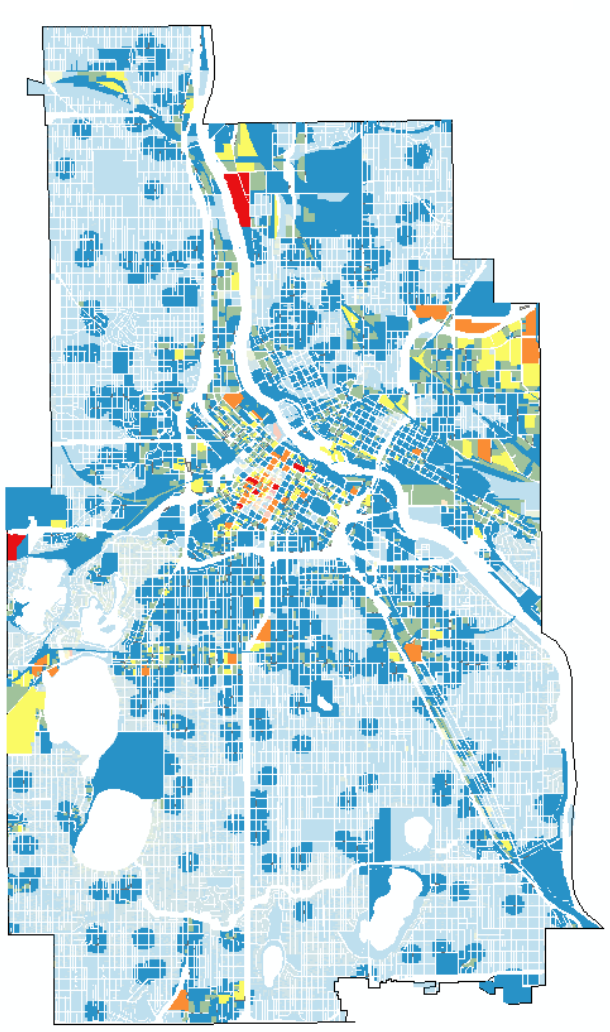
75%	Building Value
Total	$2,339,591,087.24
Per Acre	$63,651.08
Per Person	$5,847.95
Per New Building (2,465)	$949,124.17

100%	Building Value
Total	$3,110,368,405.02
Per Acre	$84,620.90
Per Person	$7,774.56
Per New Building (3,317)	$937,705.27

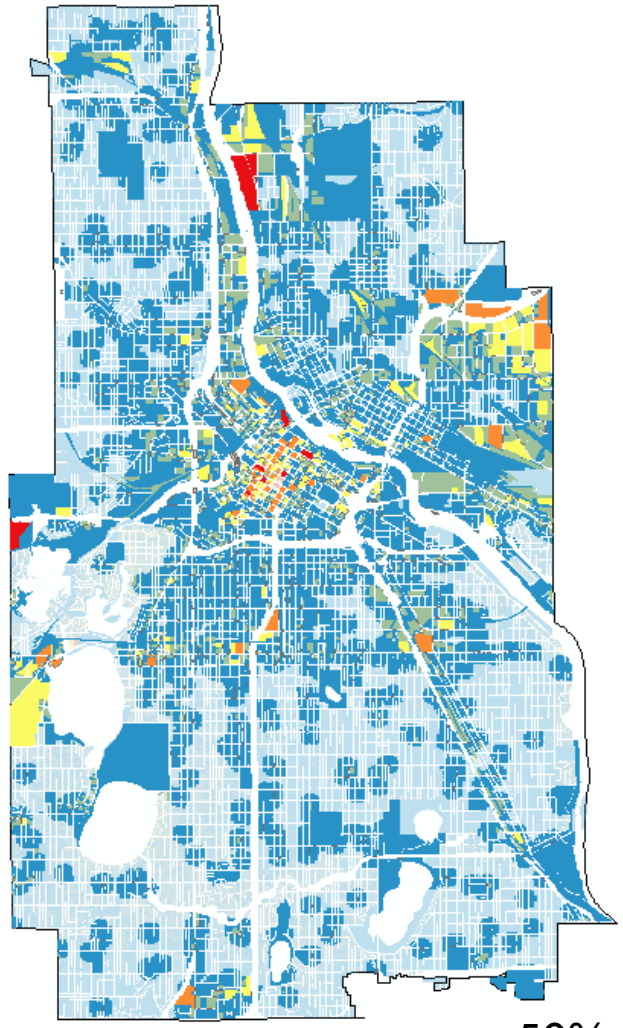
<u>Results</u>: Economic Maps – Parking Replaced by Parks

0% Reduction

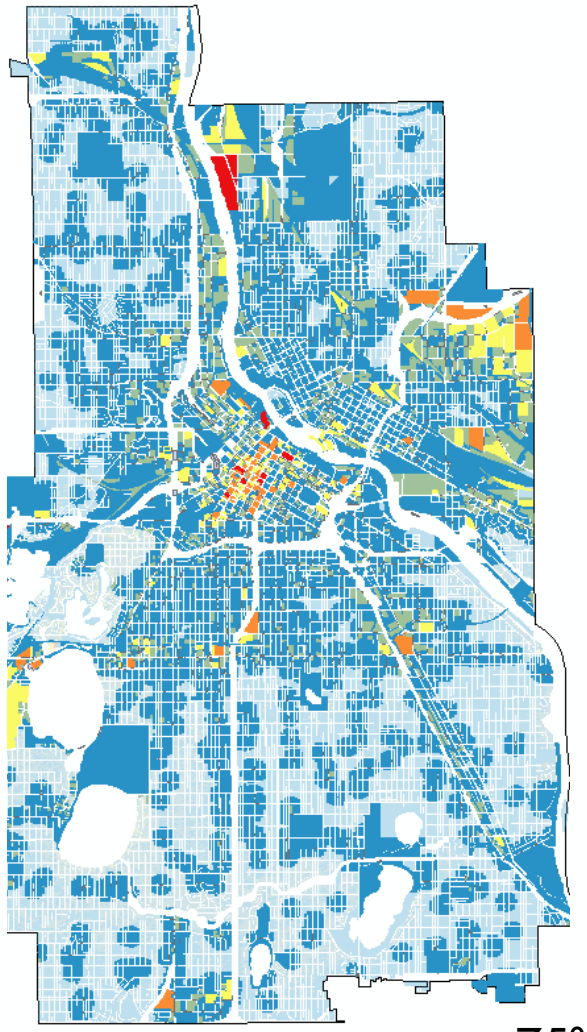
Increase in Land Value
- $0.00 - $119,957.19
- $119,957.20 - $508,598.75
- $508,598.76 - $1,333,092.00
- $1,333,092.01 - $2,840,037.00
- $2,840,037.01 - $7,985,868.00



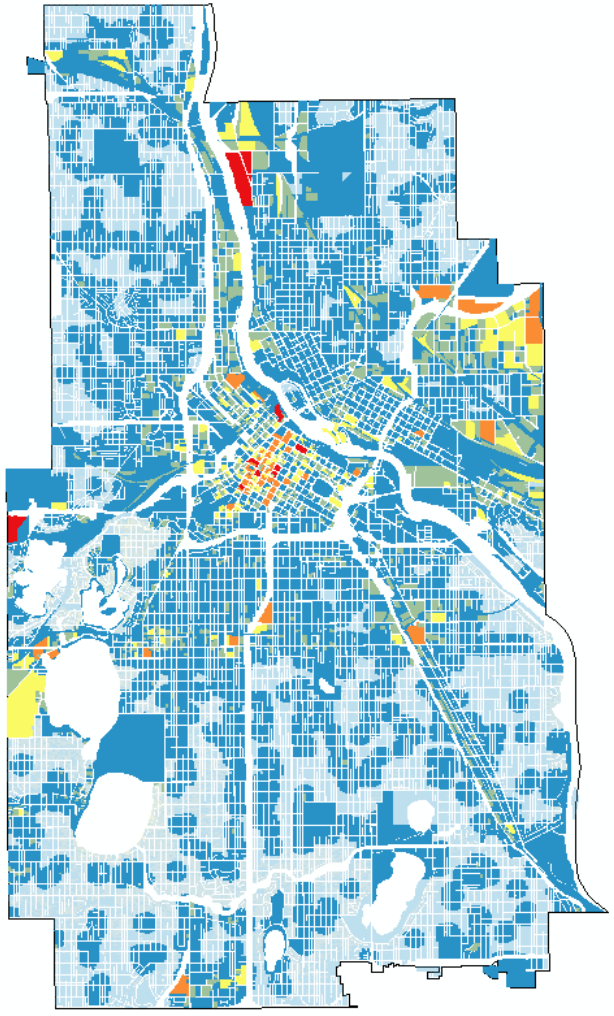
25%



50%



75%



100%

Results: Economic Stats—Parking Replaced by Parks

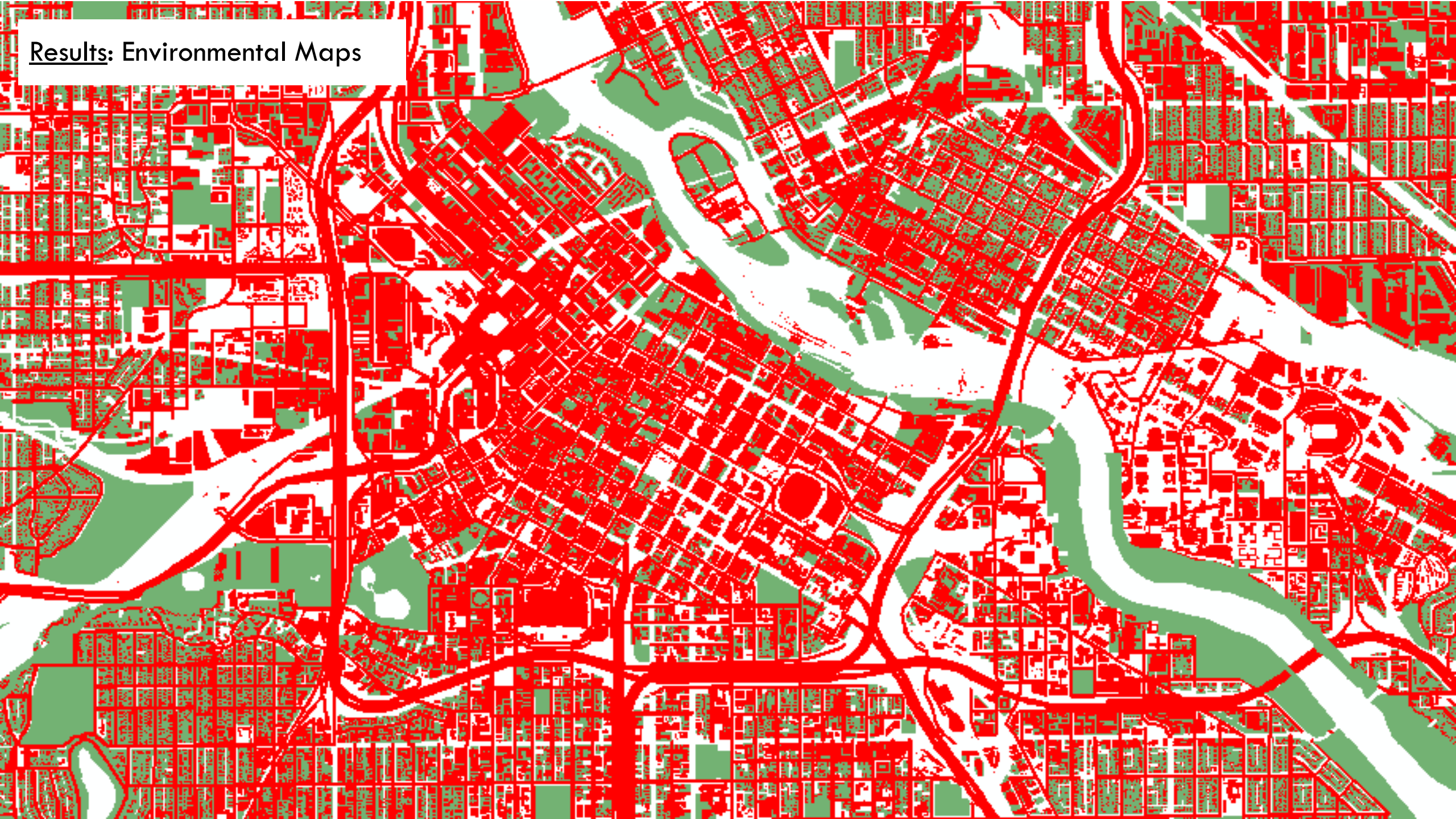
25% Reduction in Parking	Land Value	Increase (27.4%)
Total of Properties Near Parks	$4,643,824,764	$1,060,339,987
Per Acre (36,756.5 acres)	$126,340	$28,848
Per Person (400,070 in 2013)	$11,608	$2,650
Per Property (57,723)	$86,440	$19,737

50%	Land Value	Increase
Total	$6,021,889,271	$1,295,131,601
Per Acre	$163,832	$35,235
Per Person	$15,052	$3,237
Per Property (68,482)	$87,934	$18,912

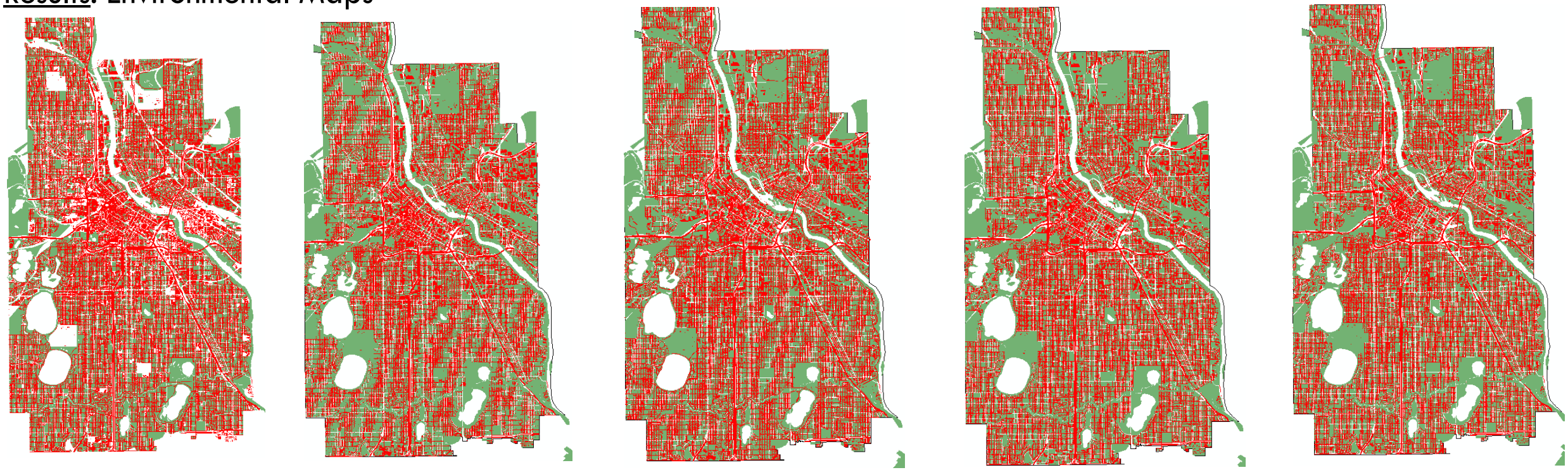
75%	Land Value	Increase
Total	$6,250,471,884	$1,427,191,079
Per Acre	$170,051	$38,828
Per Person	$15,623	$3,567
Per Property (76,487)	$81,719	$18,659

100%	Land Value	Increase
Total	$7,000,177,564	$1,505,532,694
Per Acre	$190,447	$40,960
Per Person	$17,497	$3,763
Per Property 82,585	$84,763	$18,231

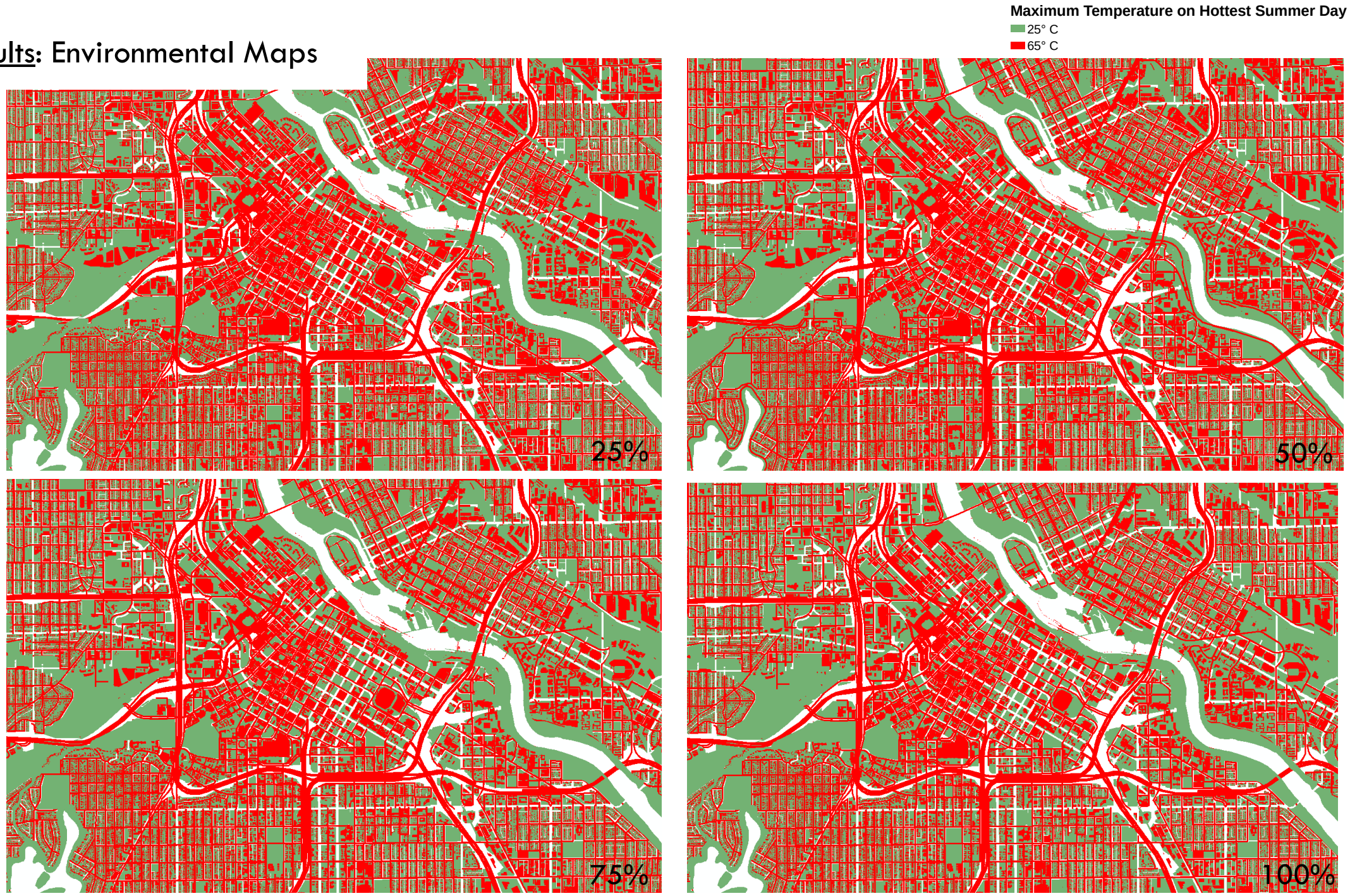
Results: Environmental Maps



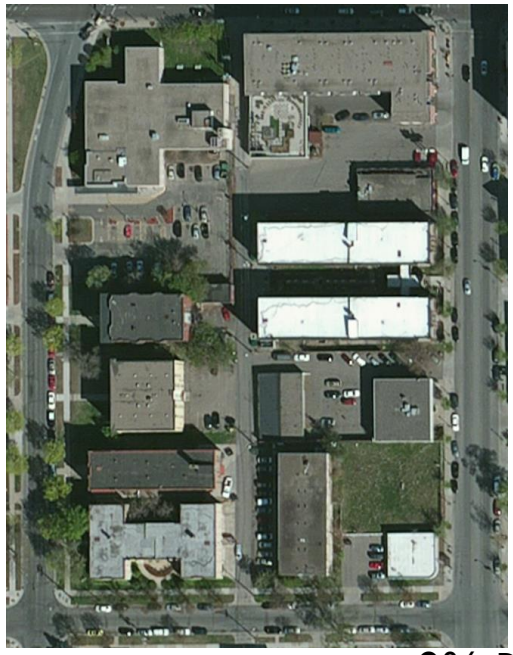
Results: Environmental Maps



Results: Environmental Maps



Results: Environmental Maps Block Level

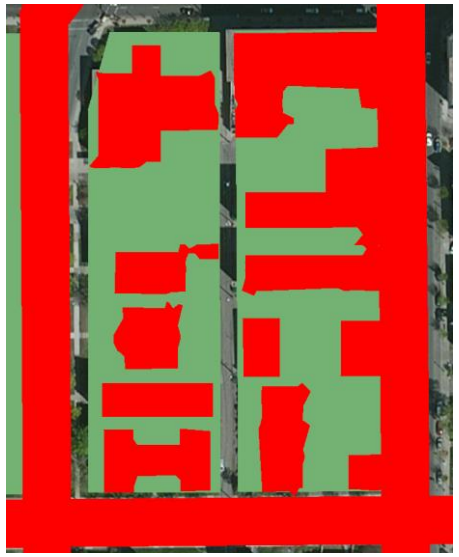


0% Reduction

25%

50%

75%



100%

Maximum Temperature on Hottest Summer Day

- 25° C
- 65° C

Results: Environmental Stats

(36,756.5 acres)

0% Reduction	# of Acres	% Acres
25°C (77°F)	16,752	45.6%
65°C (149°F)	15,523	42.2%
Average Surface Temperature per Acre		
44.8° C (122.6° F)		

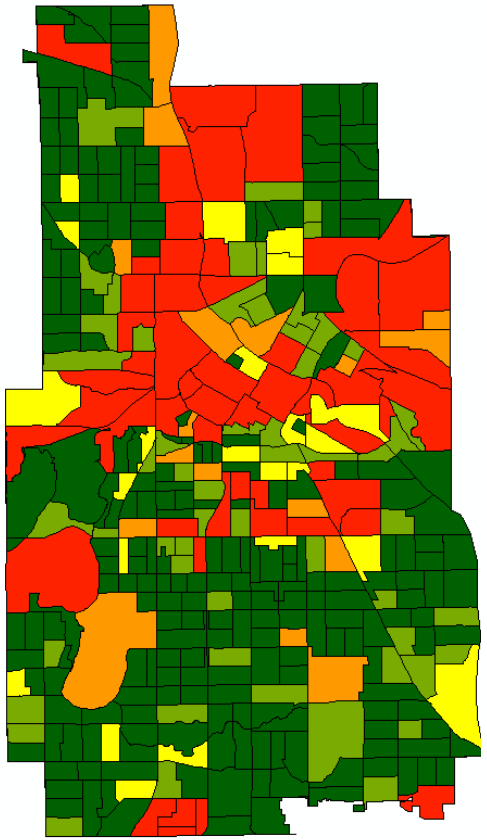
25%	# of Acres	% Acres
25° C	17,962	48.8%
65° C	14,313	39.0%
Average Temperature		
42.7° C (108.9° F)		

50%	# of Acres	% Acres
25° C	18,348	50.0%
65° C	13,927	37.8%
Average Temperature		
41.5° C (104.9°F)		

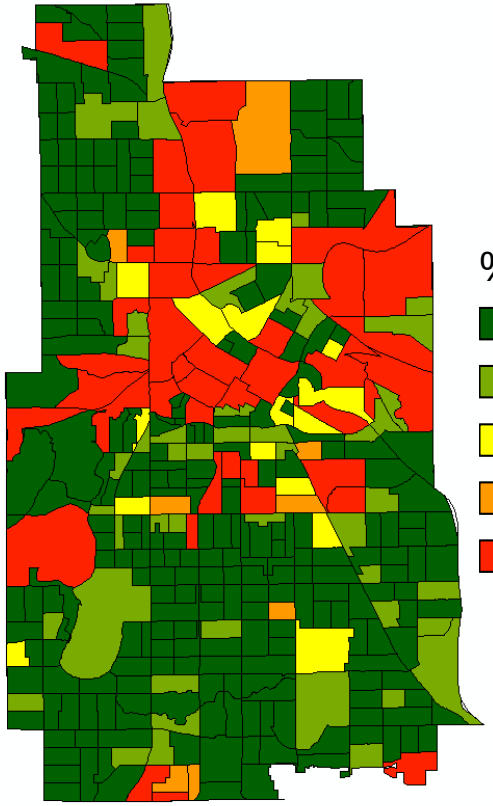
75%	# of Acres	% Acres
25° C	18,962	51.6%
65° C	12,162	33.1%
Average Temperature		
40.6° C (105° F)		

100%	# of Acres	% Acres
25° C	19,230	52.3%
65° C	11,878	32.3%
Average Temperature		
40.2° C (104.3° F)		

Results: Social Map—Automobile Mode Share

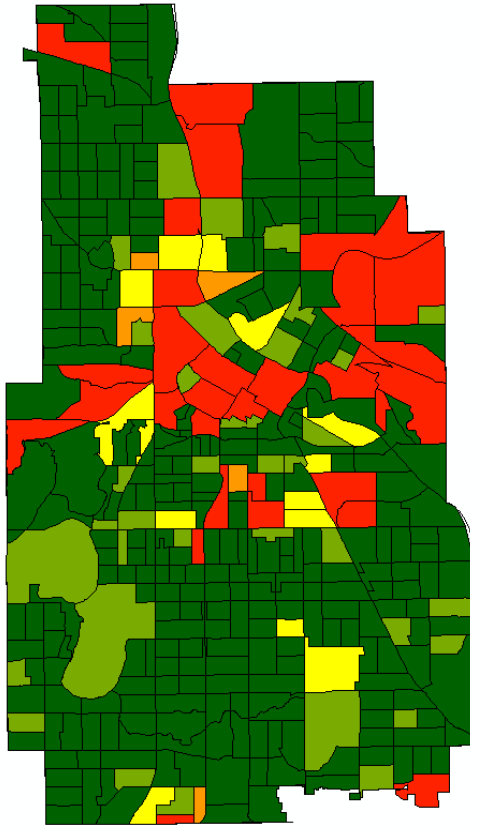


0% Reduction

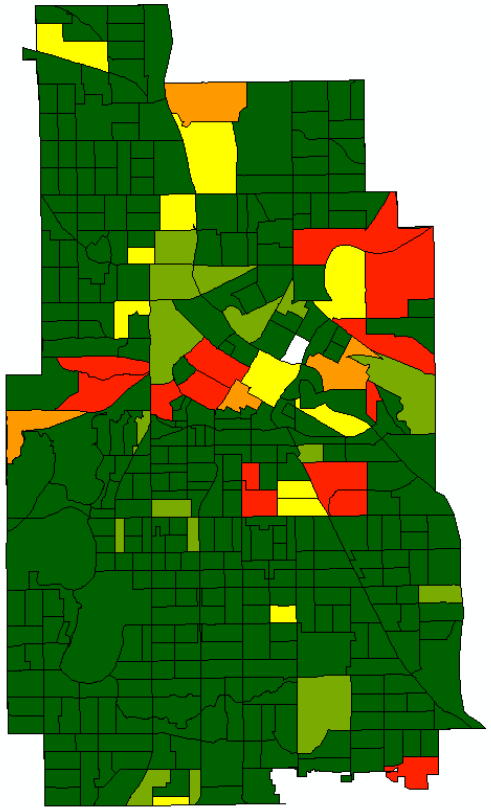


25%

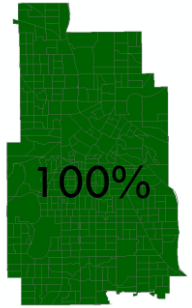
% Auto Share
45.2% - 60.0%
60.1% - 70.0%
70.1% - 80.0%
80.1% - 90.0%
90.1% - 100.0%



50%



75%



100%

Results: Social Map—Transit Mode Share

Results: Social Stats

Reduction	Average Auto Mode Share	Population (400,070)	Per Acre (36,756.5)
0%	60.6%	242,442	6.6
25%	57.7%	230,840	6.3
50%	54.7%	218,838	6.0
75%	50.9%	203,636	5.5
100%	39.5%	158,027	4.3

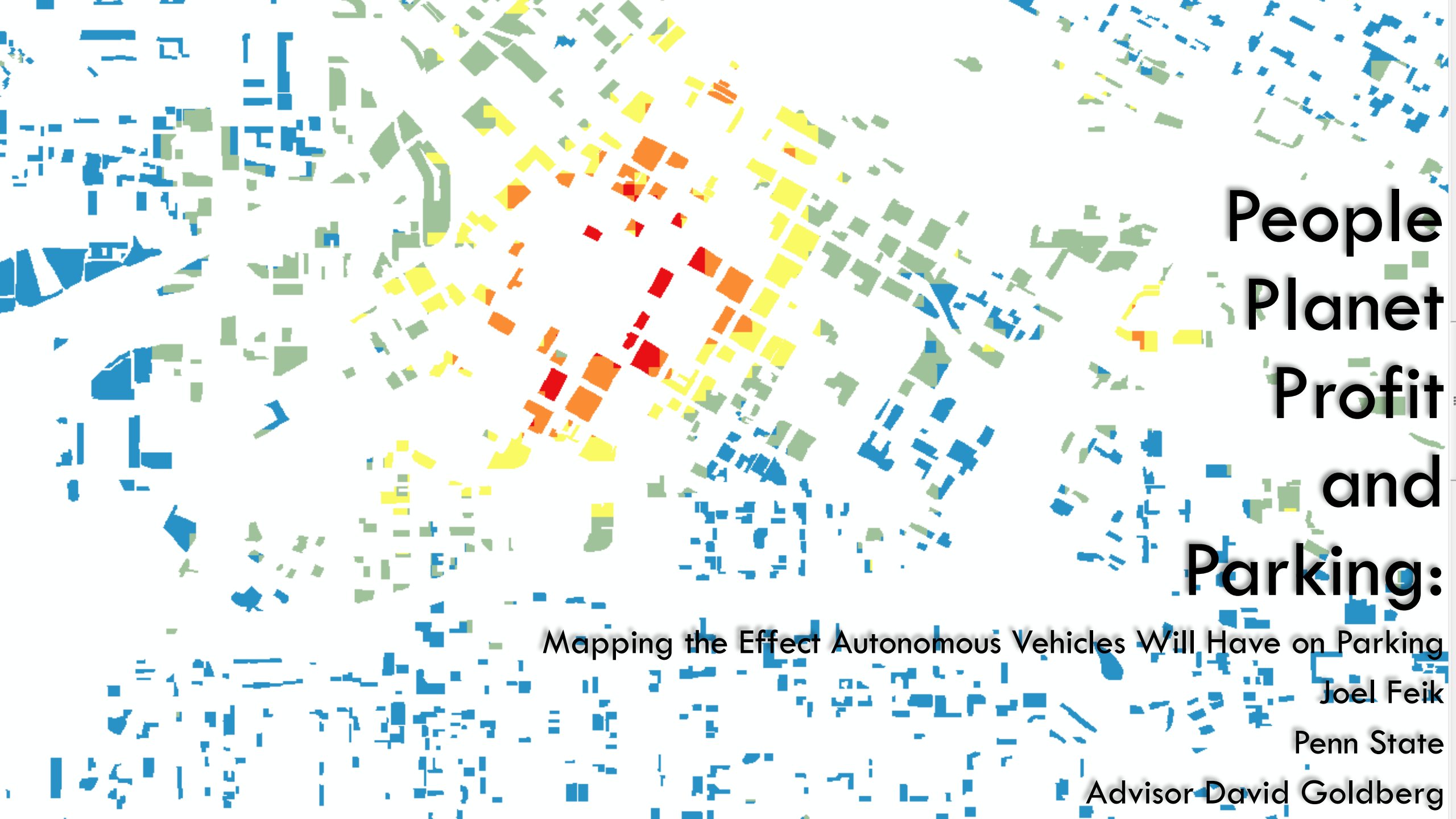
Reduction	Average Transit Mode Share	Population	Per Acre (36,756.5)
0%	53.2%	212,837	5.8
25%	59.9%	239,642	6.6
50%	68.3%	273,248	7.4
75%	80.3%	321,256	8.7
100%	100%	400,070	10.9

Challenges

- Geographical Scope
  - Minneapolis only
  - Urban environment
- Other Factors Involved, Oversimplification
  - Limited study of buildings and parks with regards to property value
  - Season, materials, Day, Night, Shadow, etc. all effect Urban Heat Island Effect
  - Other factors influence auto share and transit share beyond parking
- Estimates
  - Parking Space calculations
- The Future
  - Unknowns
- Limited ability of GIS software
- Hard to find a good relationship between parking and social issues

Major Themes/Conclusion

- Vast economic potential with the reduction of parking
- Replacing parking with parks would significantly alter property values across a large area of the city
- Reducing parking does not seem to reduce urban heat island at the city scale
- Replacing parking with parks would not significantly alter urban heat island
- Replacing parking with buildings would not alter urban heat island effect
- More parking in downtown than I realized, which affects auto mode share, transit mode share



People Planet Profit and Parking:

Mapping the Effect Autonomous Vehicles Will Have on Parking

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