CITY OF MINNEAPOLIS

Places at Risk: Minneapolis Climate Change Vulnerability Assessment

Prepared for Minneapolis Sustainability Office & Health Department

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Minneapolis
City of Lakes

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What is this project?

October 2015:
City of Minneapolis received grant from Public Health Institute Center for Climate Change and Health

Phase I:
Climate Change Vulnerability Assessment
(Spring 2016)

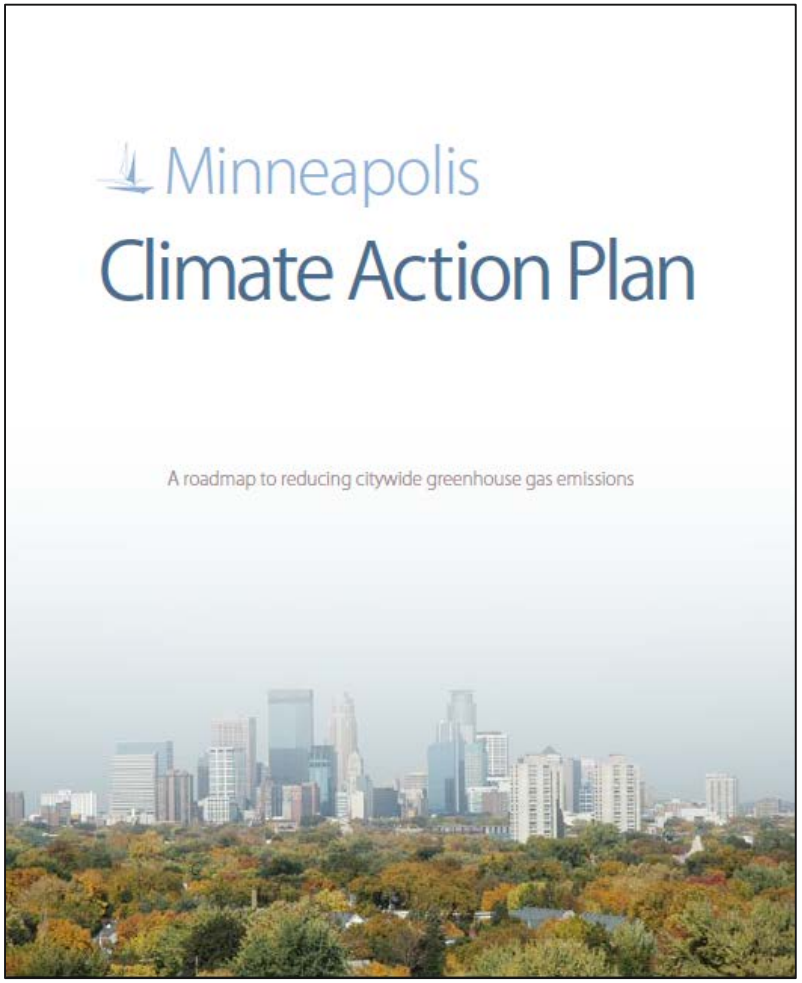
Phase II:
Community Engagement
(2016-2017)

Phase III:
Identify next steps for implementation

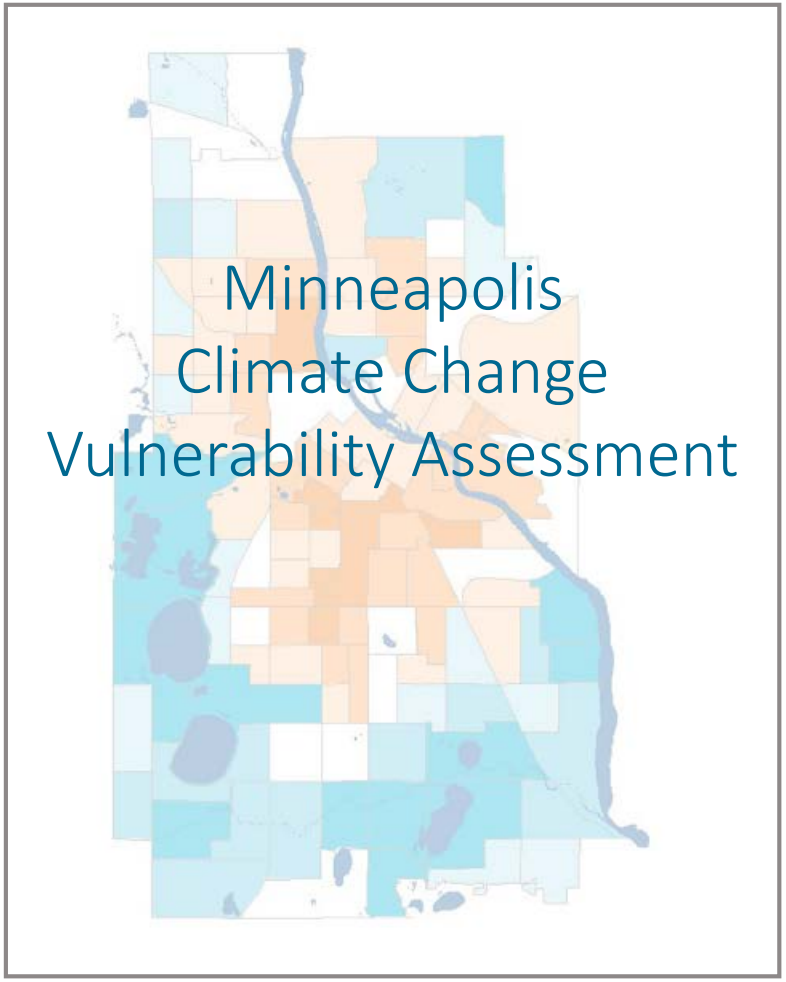
What is climate change vulnerability?

- The degree to which people and places are likely to experience harm due to exposure to disturbance or stress

The first step in adapting for climate change is understanding which places are *most at risk* to climate change vulnerability.

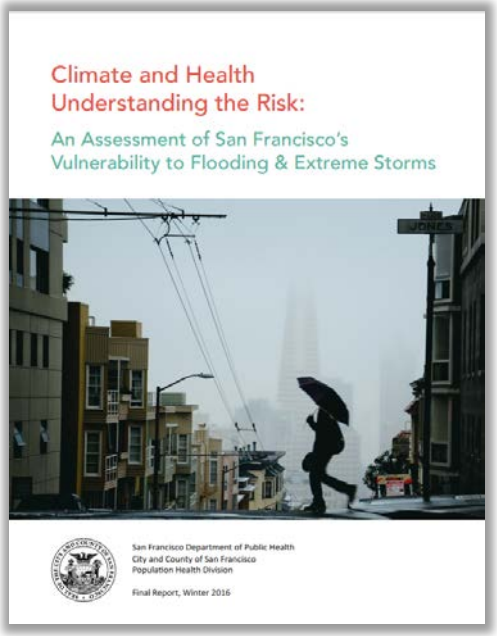


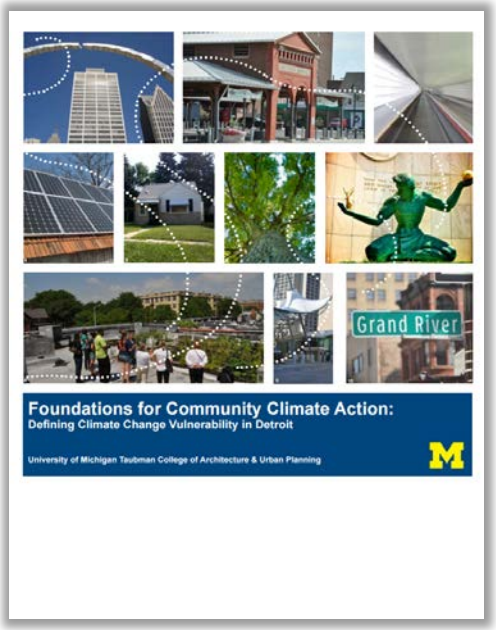
Identifies strategies for mitigation



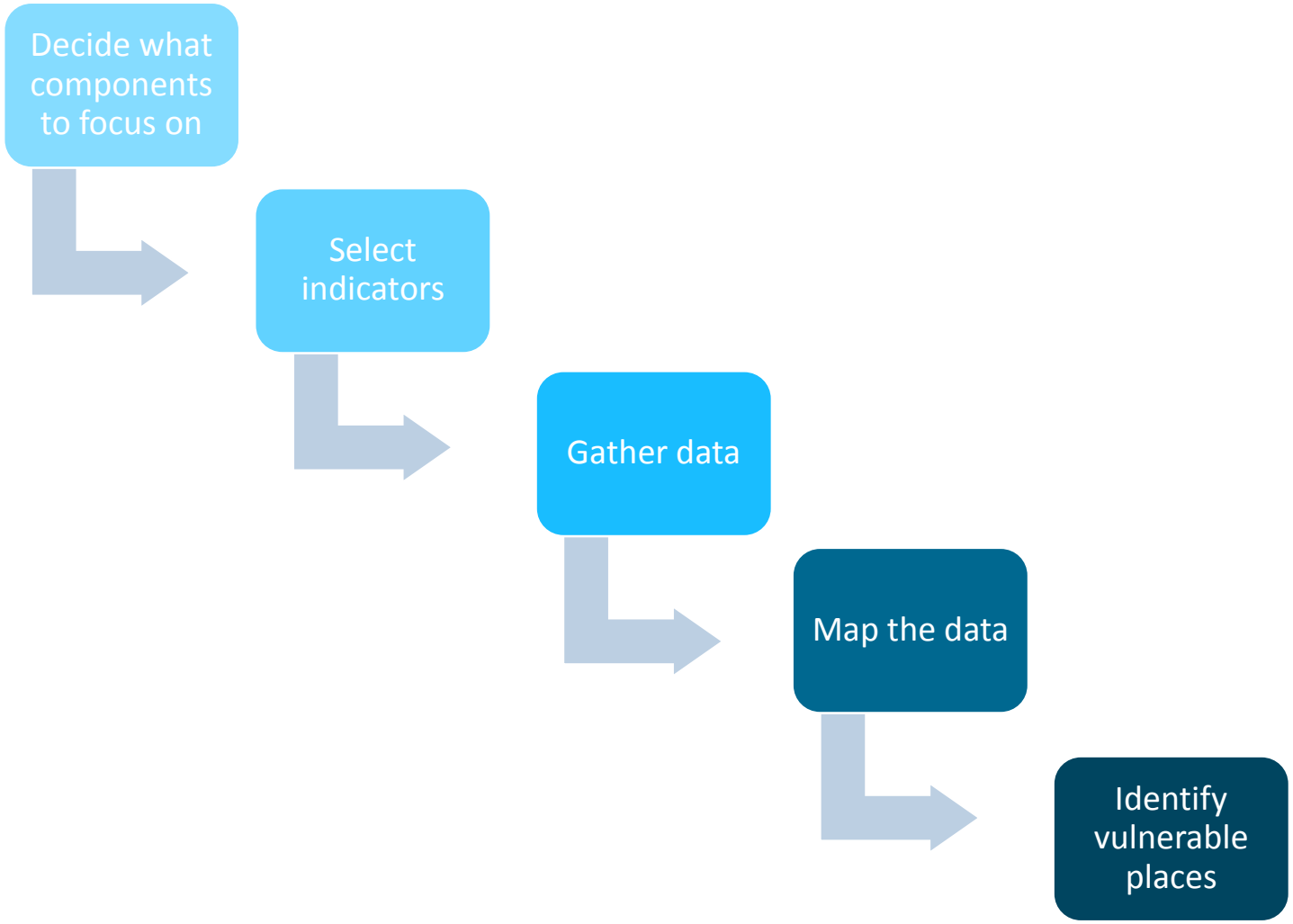
Identifies places at risk

Climate change vulnerability assessments have been done in other places.



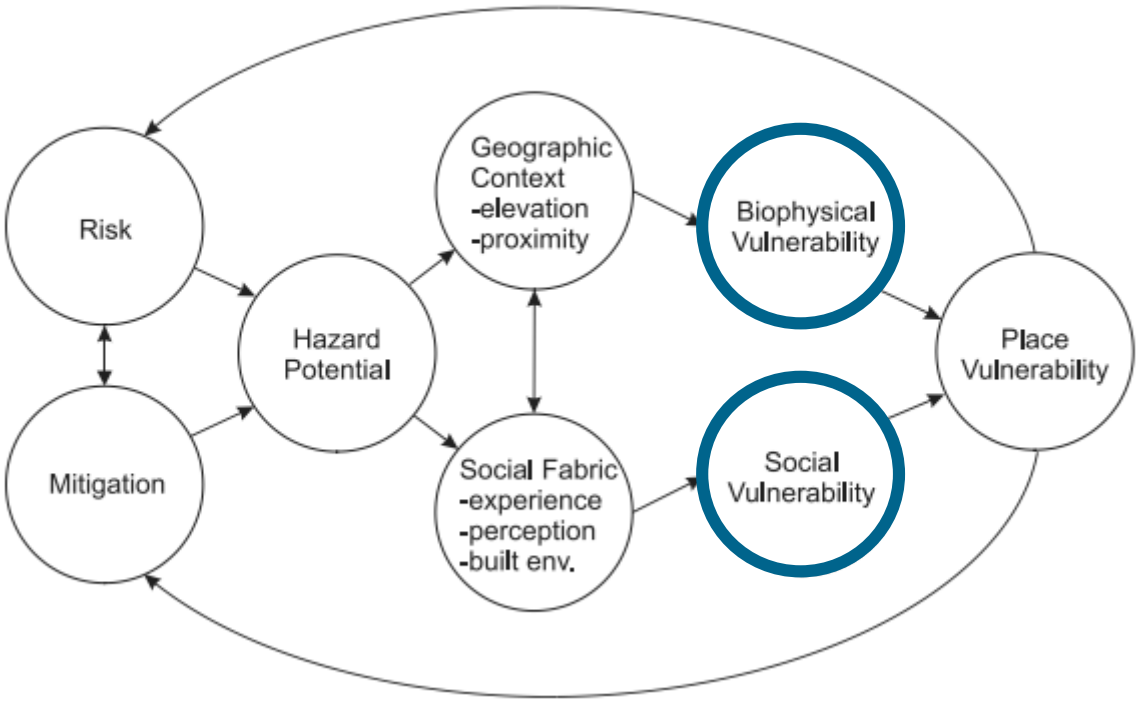


General process of a place-based vulnerability assessment



Our assessment centers around "place vulnerability"

The Hazards-of-Place Model of Vulnerability (Modified from Cutter, 1996)



What did Phase I accomplish?

1

Social vulnerability

- Mapped populations that are inherently more vulnerable
- Mapped cumulative social vulnerability

2

Landscape vulnerability to heat

- Mapped urban heat island effect
- Identified opportunity areas: high impervious surface and low vegetation

3

Landscape vulnerability to flooding

- Mapped factors that contribute to flooding
- Mapped low-elevation areas prone to flooding

Social vulnerability to climate change

Key messages:

→ Certain populations are more vulnerable to climate change than others.

→ Mapping allows us to visualize where highly vulnerable populations live in Minneapolis.

Some people are more vulnerable to climate change than others.

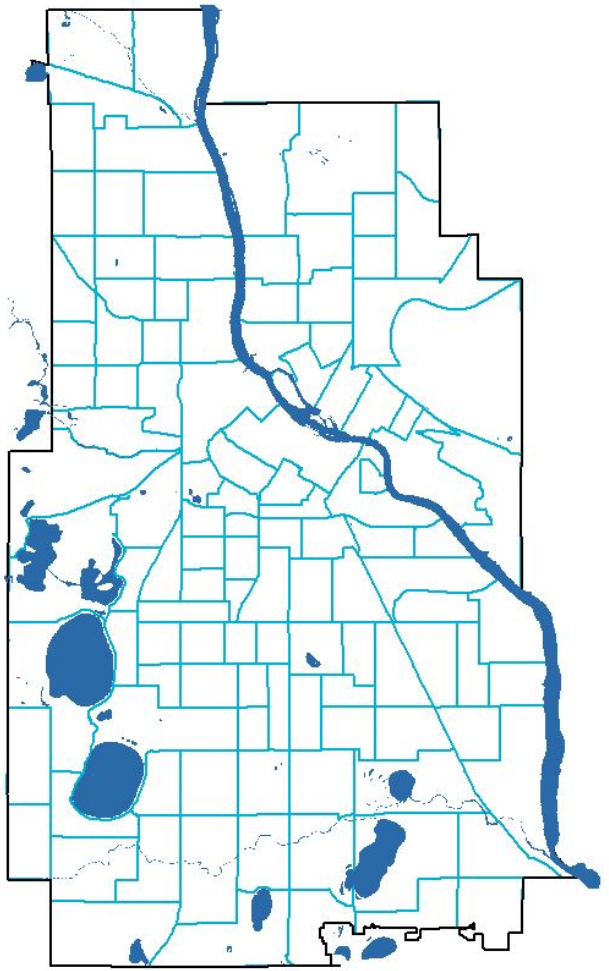
social vulnerability:

the social characteristics that influence a community's ability to respond to, cope with, recover from, and adapt to environmental hazards

Multiple factors contribute to overall social vulnerability.

Social Vulnerability Index
No access to a vehicle
Lack of central air
Renters
Households in poverty
Limited English proficiency
Elderly (over 65)
Young children (under 5)
People of color
Persons with a disability

Census tracts (total: 116)

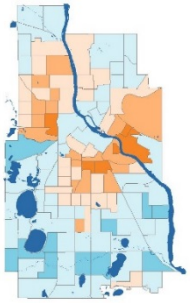


Every indicator can be linked to increased susceptibility to natural hazards.

	Measure →	Rationale
Flexible	No access to a vehicle	Lack of mobility certainty
	Lack of central air	Differential access to cooling
	Renters	No control over building environment/condition
	Households in poverty	Limited access to resources
	Limited English proficiency	Limited access to information, communication challenges
Fixed	Elderly (over 65)	Inherent health risks, limited mobility
	Young children (under 5)	Inherent health risks, dependence upon adults
	People of color	Structural & historical racism, discrimination
	Persons with a disability	Environment not conducive to physical/mental constraints

The overall social vulnerability map combines all nine factors together.

Poverty



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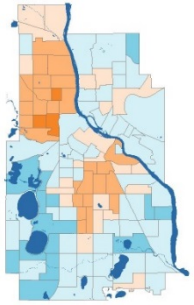
People of Color



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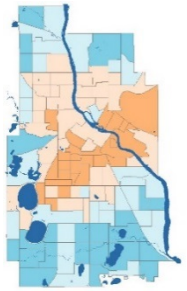
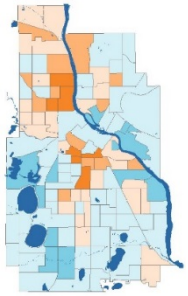
Renters



Disability



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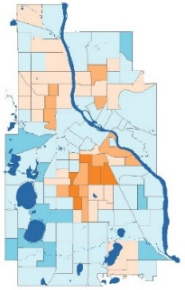
Limited English



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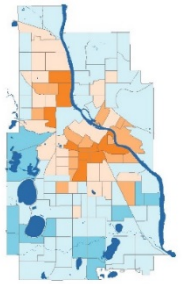
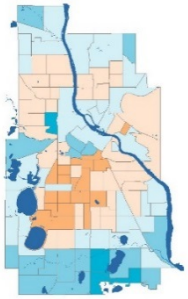
No vehicle



No central AC



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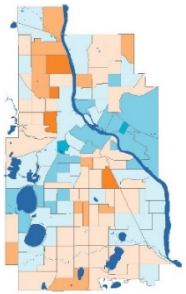
Under 5



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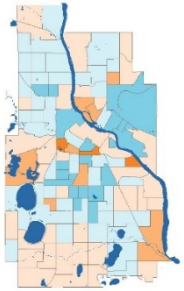
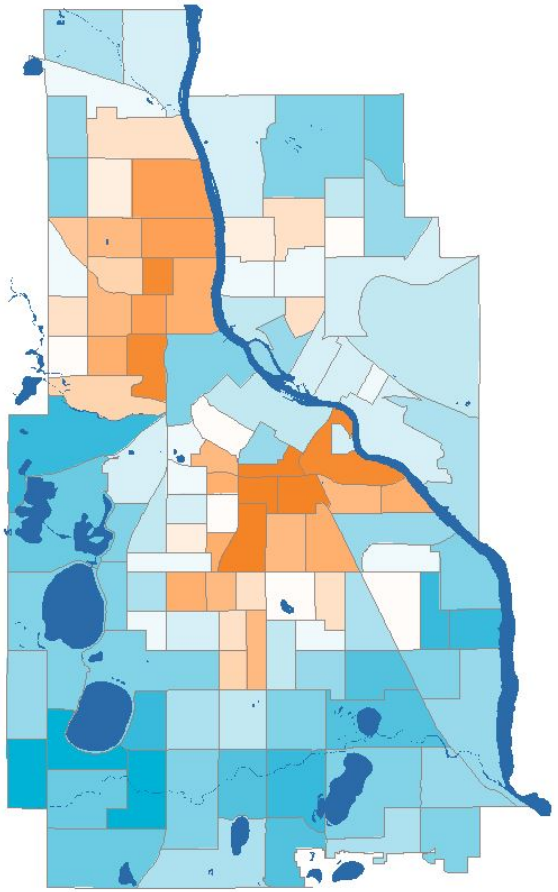
Elderly



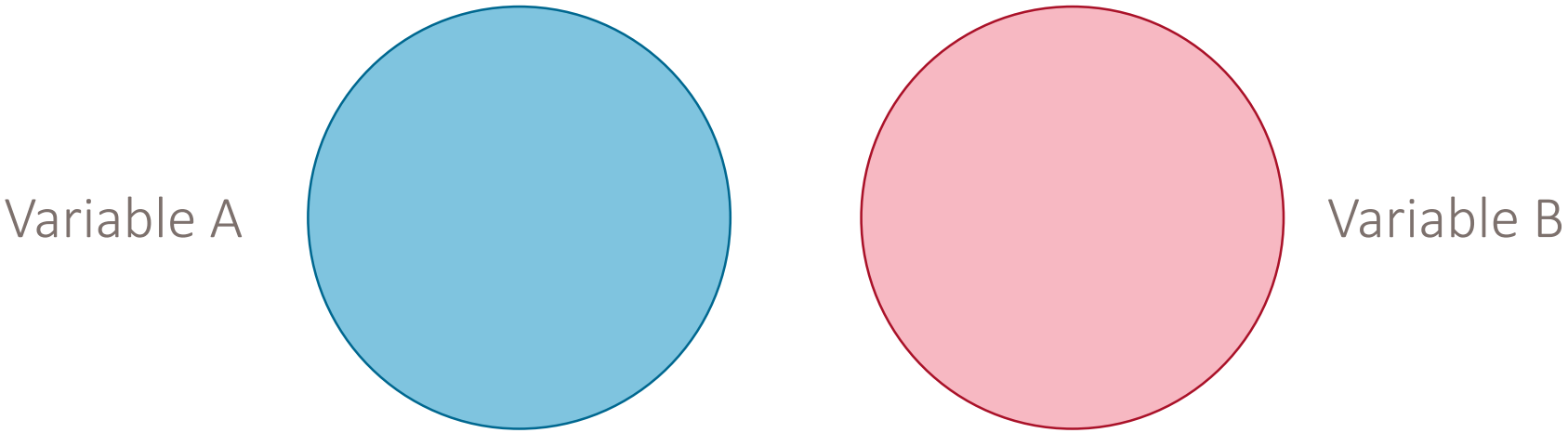
Overall social vulnerability scores



Lowest vulnerability

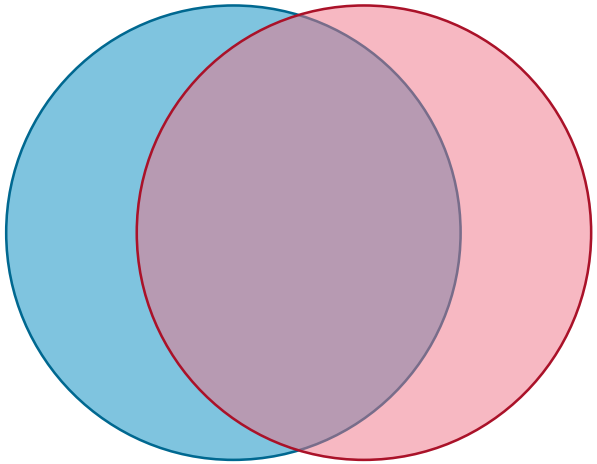
Highest vulnerability

Some of these social factors are highly correlated.

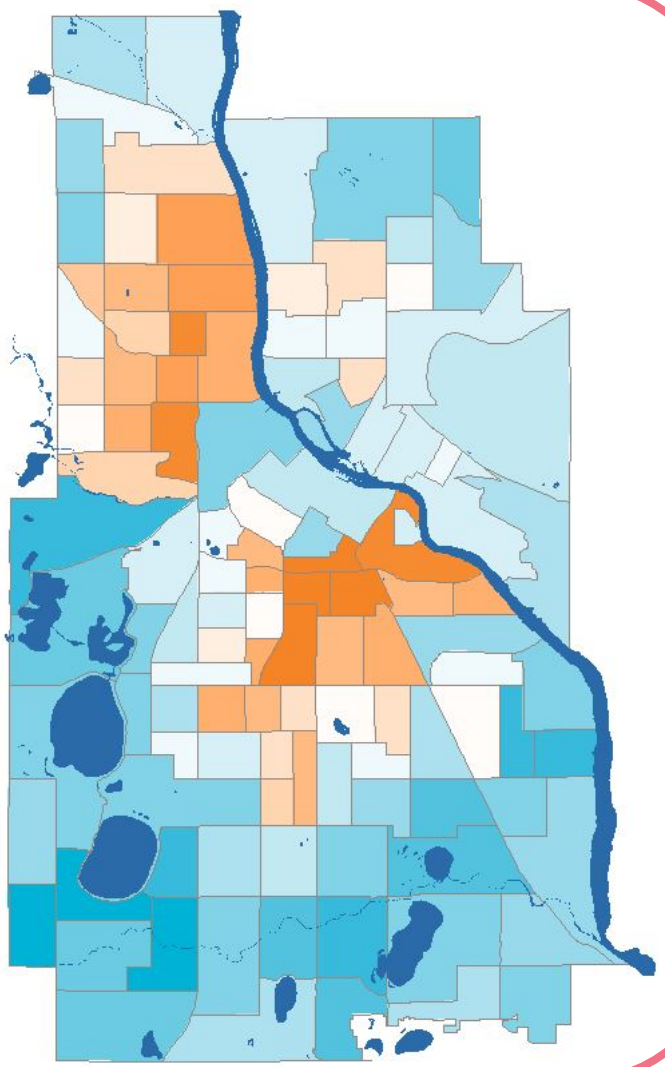


For example, our study shows that **race** and **poverty** tend to overlap in places.

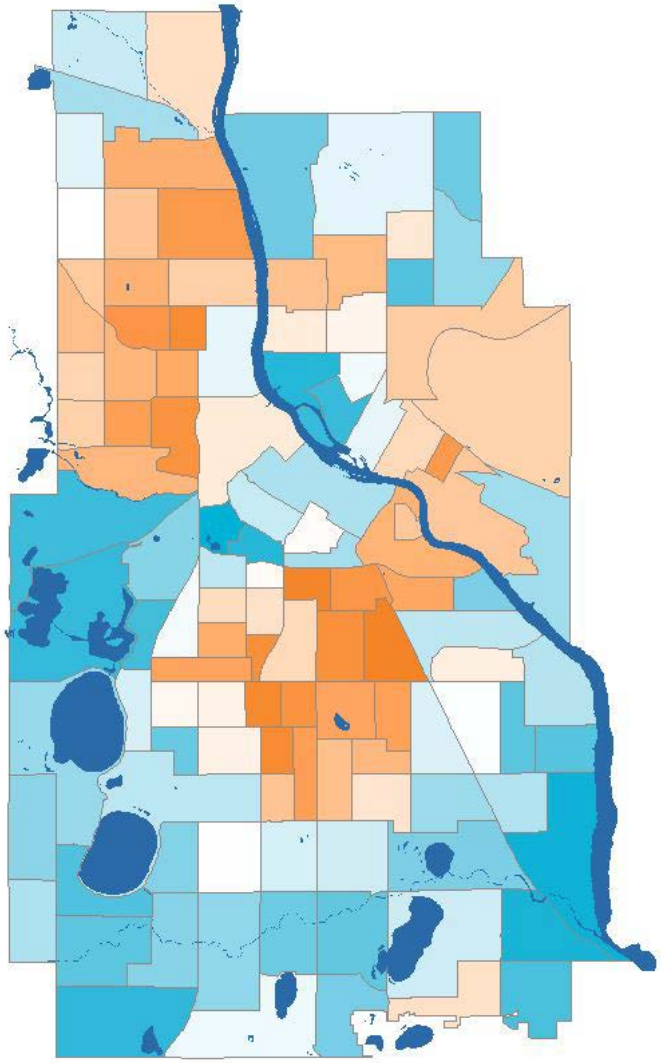
Statistical methods can control for this correlation.



Social vulnerability: Overlaying and adding individual maps



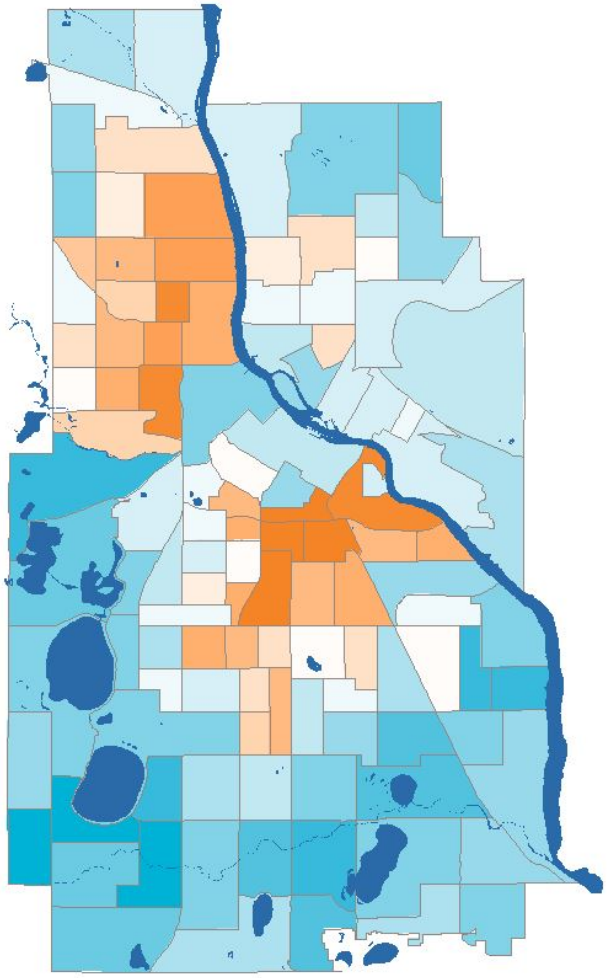
Social vulnerability: Controlling for correlation



Lowest vulnerability — **Highest** vulnerability

When thinking about next steps for action, indicator rationales can be informative.

Measure →	Rationale
No access to a vehicle	Lack of mobility certainty
Lack of central air	Differential access to cooling
Renters	No control over building environment/condition
Households in poverty	Limited access to resources
Limited English proficiency	Limited access to information, communication challenges
Elderly (over 65)	Inherent health risks, limited mobility
Young children (under 5)	Inherent health risks, dependence upon adults
People of color	Structural & historical racism, discrimination
Persons with a disability	Environment not conducive to physical/mental constraints



Overall social vulnerability scores

Landscape vulnerability to heat

1 Social vulnerability

2 Landscape vulnerability to heat

3 Landscape vulnerability to flooding

Key messages:

→ Minneapolis tends to be hotter than the surrounding metropolitan region.

→ Key places for the City to adapt to increasing temperatures can be identified using spatial analysis methods.

Some places are more vulnerable to climate change impacts than others.

landscape vulnerability:

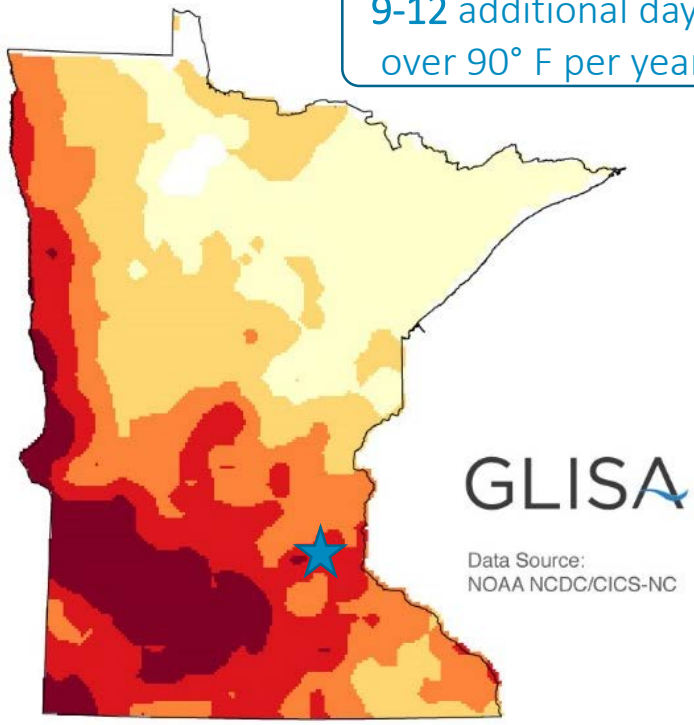
the physical characteristics that influence the capacity of a place to respond to, cope with, recover from, and adapt to environmental hazards

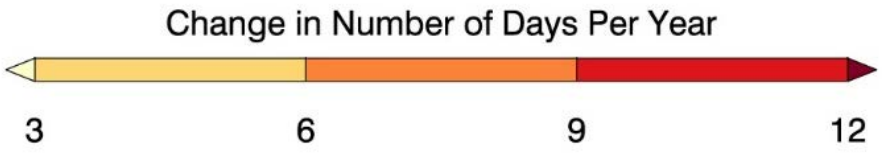
For this analysis, environmental hazards are limited to heat and flooding.

The number of days over 90° F is projected to increase over time throughout Minnesota.

Historical (1971-2000)

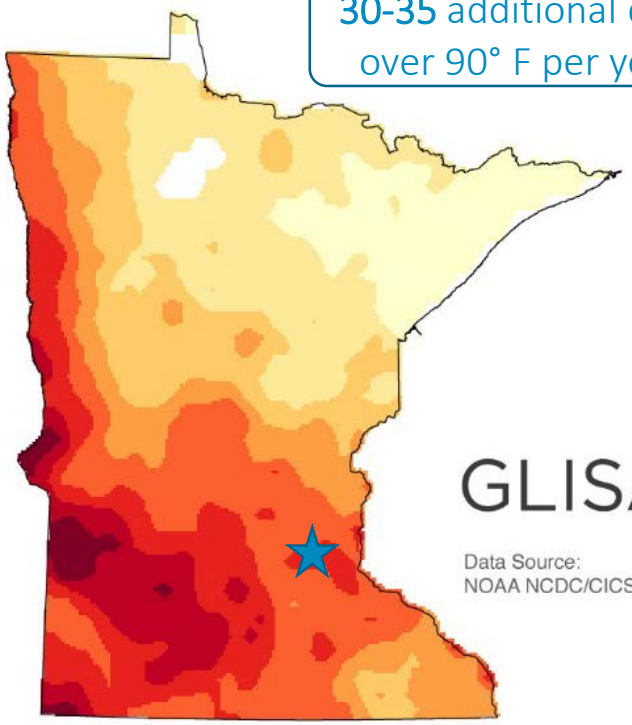
9-12 additional days over 90° F per year

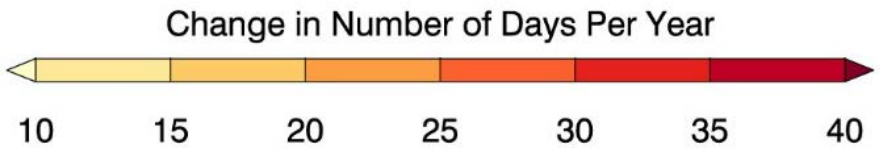




Projected (2041-2070)

30-35 additional days over 90° F per year





Data Source: Great Lakes Integrated Sciences + Assessments Center (GLISA)

The **urban heat island effect** magnifies these temperature increases in Minneapolis.

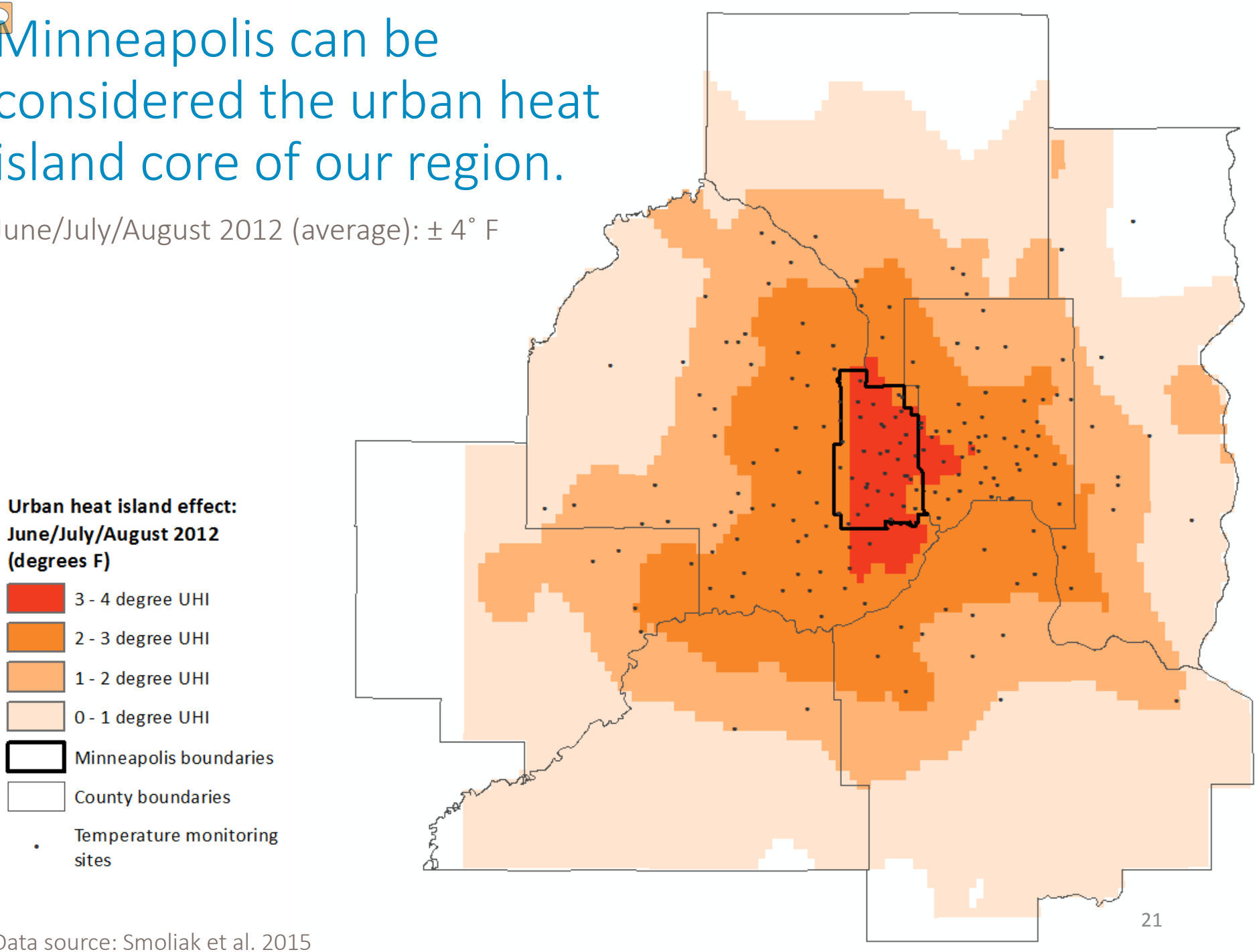
Consequences of UHI:

- Increased energy consumption *(Santamouris et al. 2001)*
- Urban ecosystem stresses *(Baker et al. 2002)*
- Decreased air quality *(Stone 2005)*
- Increased heat stress *(Kovats and Hajat 2008)*

Source: Smoliak et al. 2015

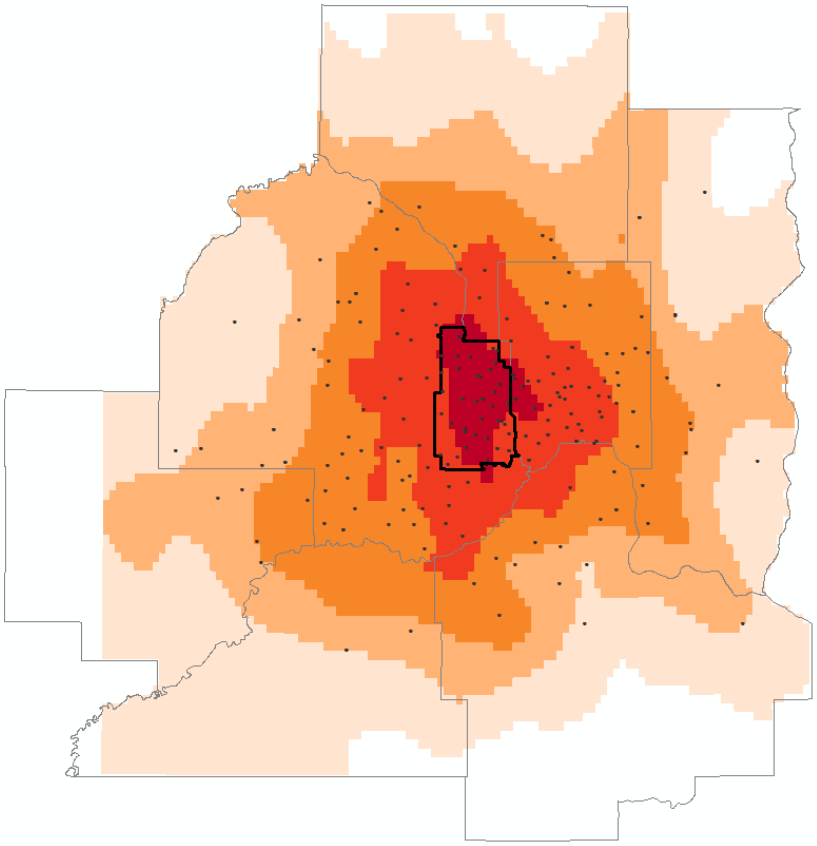
Minneapolis can be considered the urban heat island core of our region.

June/July/August 2012 (average): ± 4˚ F

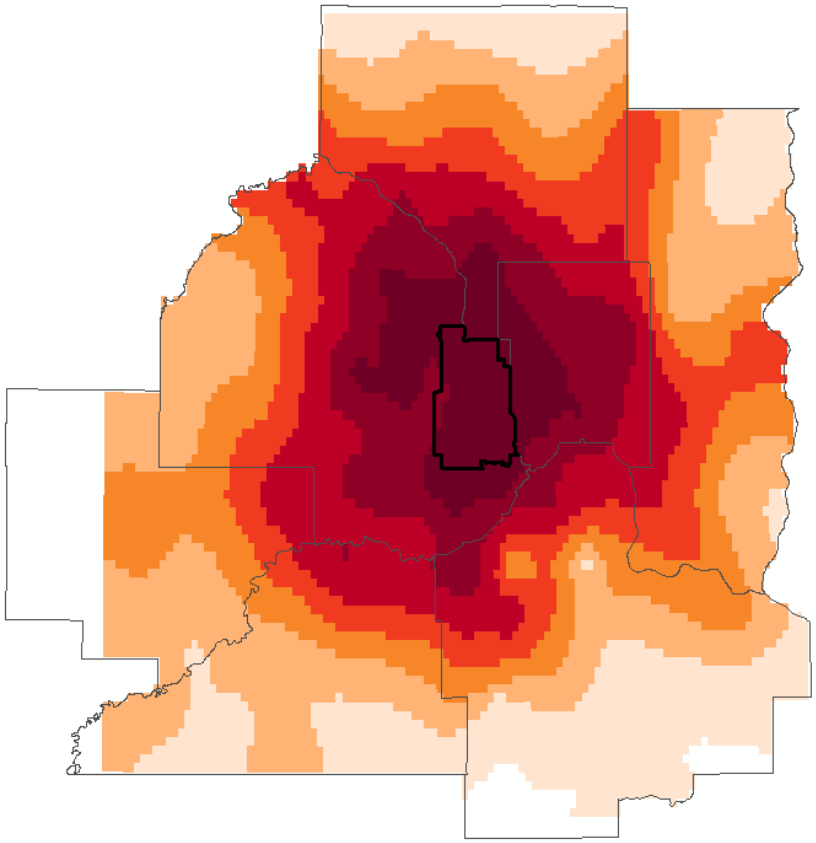


Data source: Smoliak et al. 2015

The urban heat island effect is magnified on very hot days, and even more so at night.



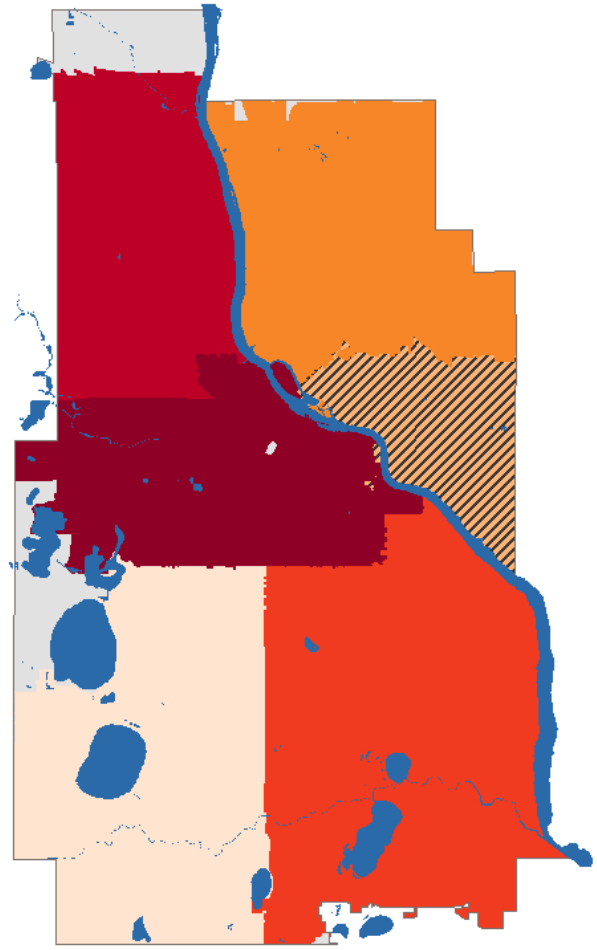
July 4, 2012 (average): ± 5˚ F



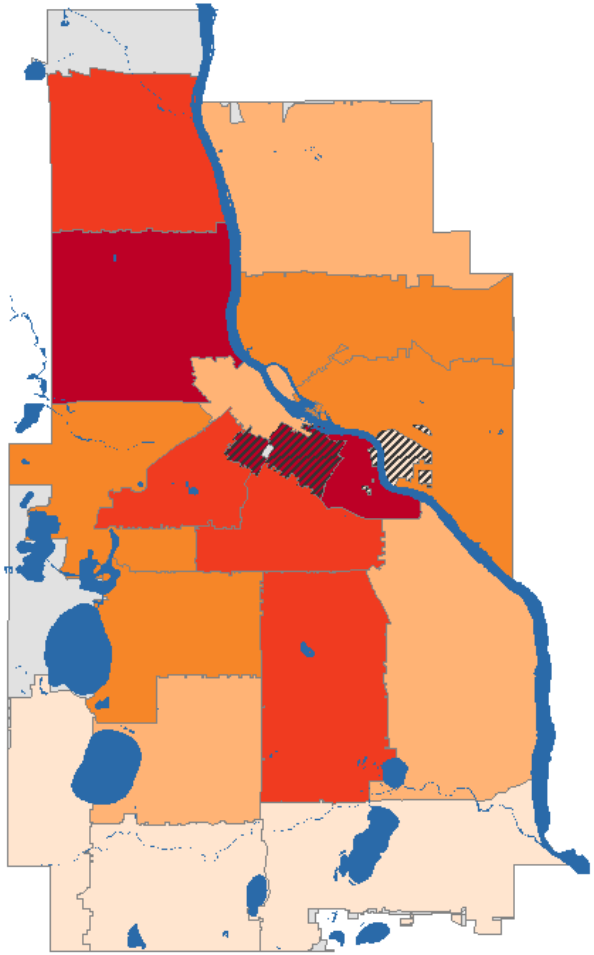
July 4, 2012 (9-10pm): ± 7˚ F

Data source: Smoliak et al. 2015

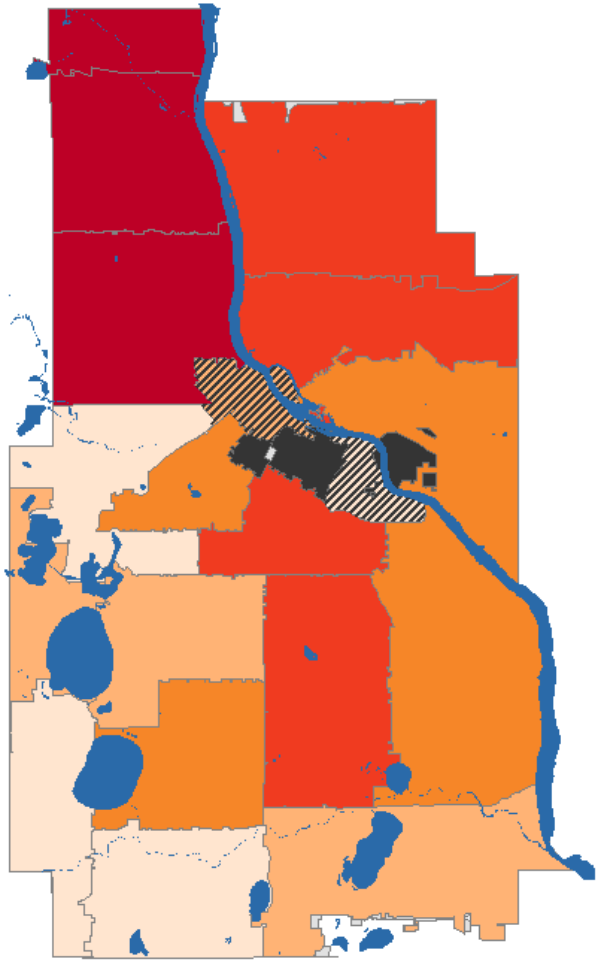
Increases in temperature influence health outcomes, and these outcomes vary by place.



Heat-related emergency room visits
(age-adjusted rate per 100,000 people)



Asthma emergency room visits
(age-adjusted rate per 10,000 people)

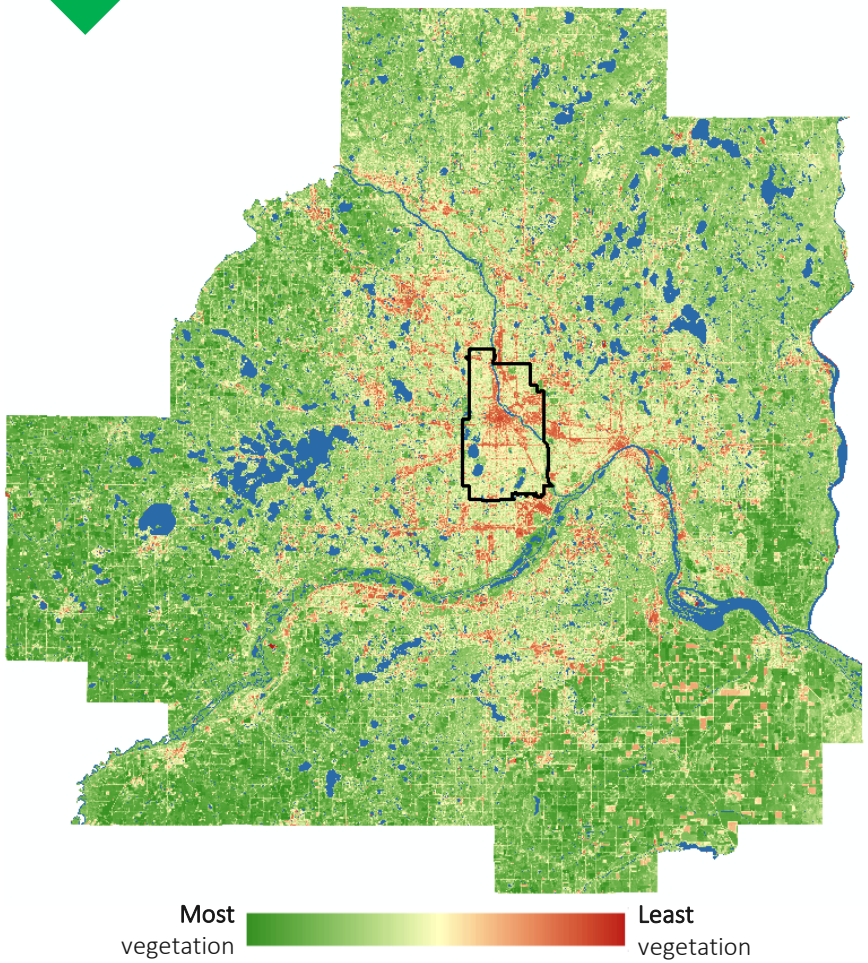


Heart attack hospitalizations
(age-adjusted rate per 10,000 people)

Lowest rate — Highest rate | Unstable rate | Data suppressed | No data available

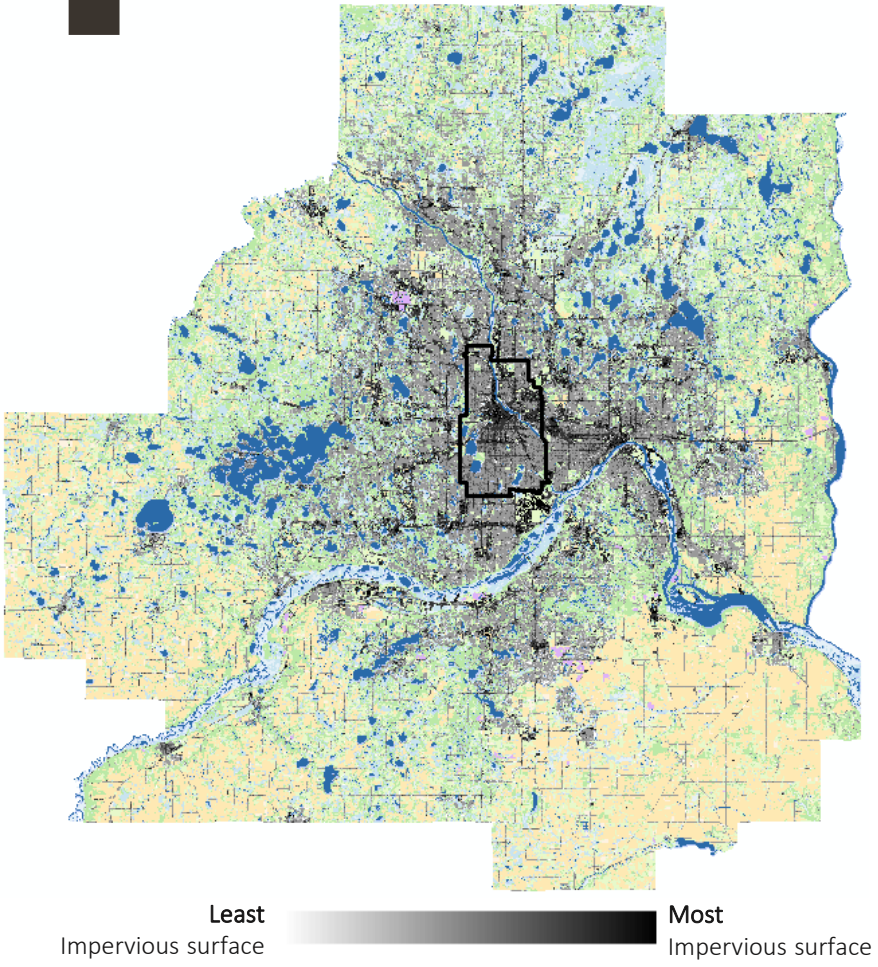
Two major factors influence the urban heat island effect.

Vegetation



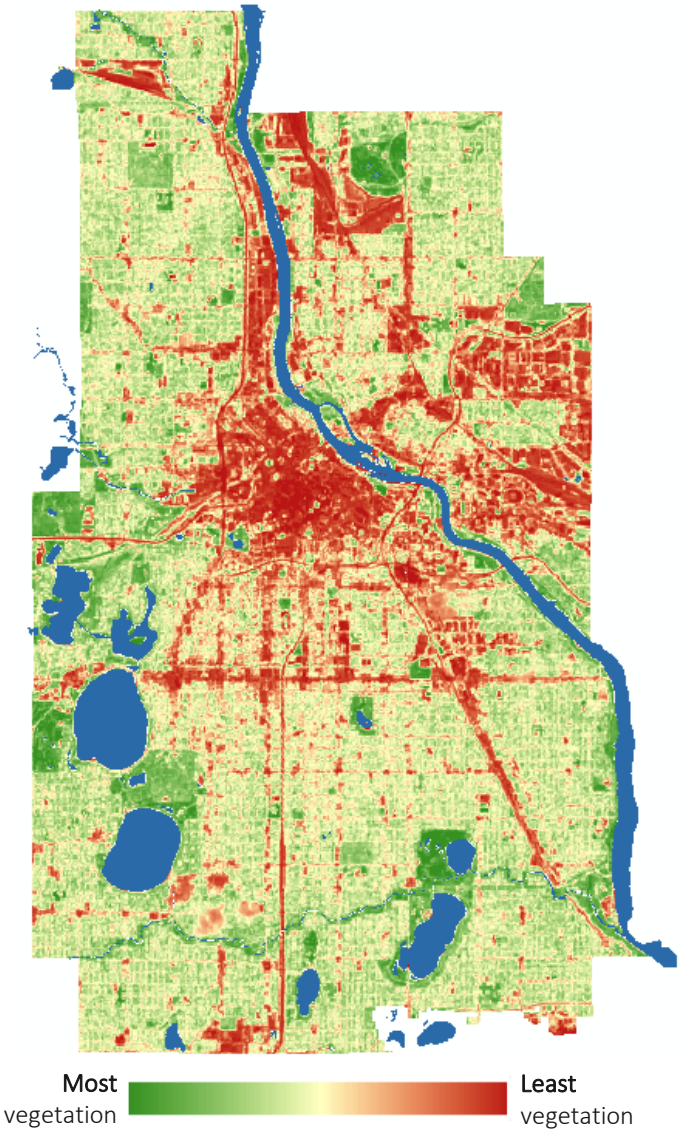
Measure: Normalized Difference Vegetation Index
Data source: United States Geological Survey (2015)

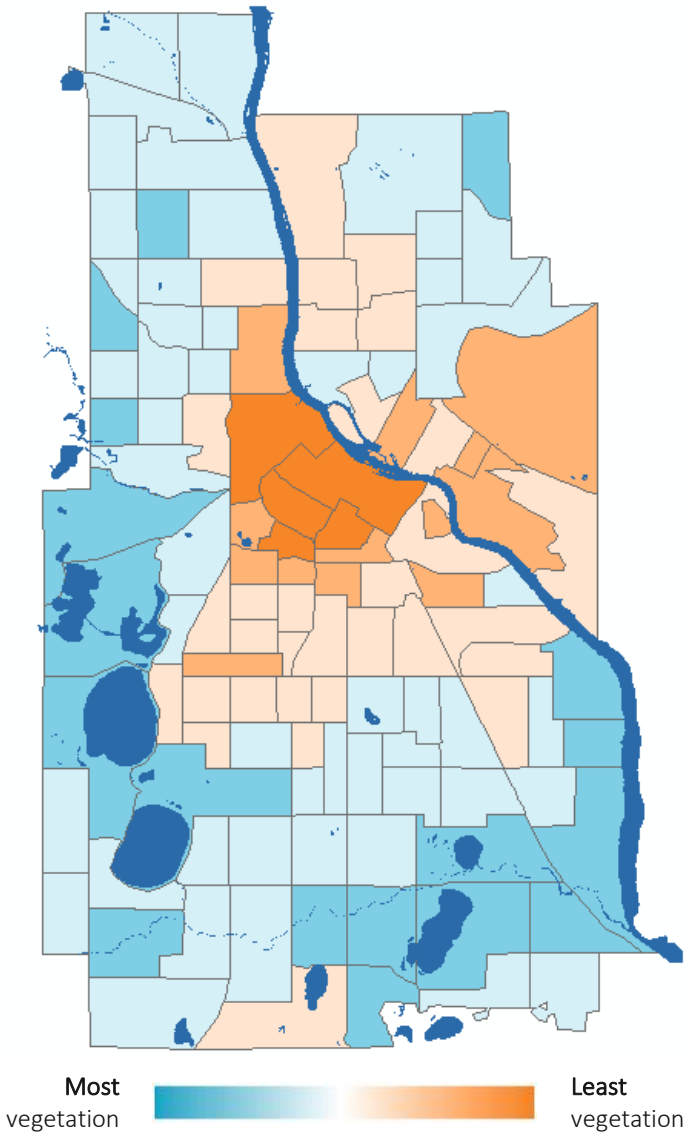
Impervious surface



Measure: Percent impervious surface cover
Data source: University of Minnesota (2013)

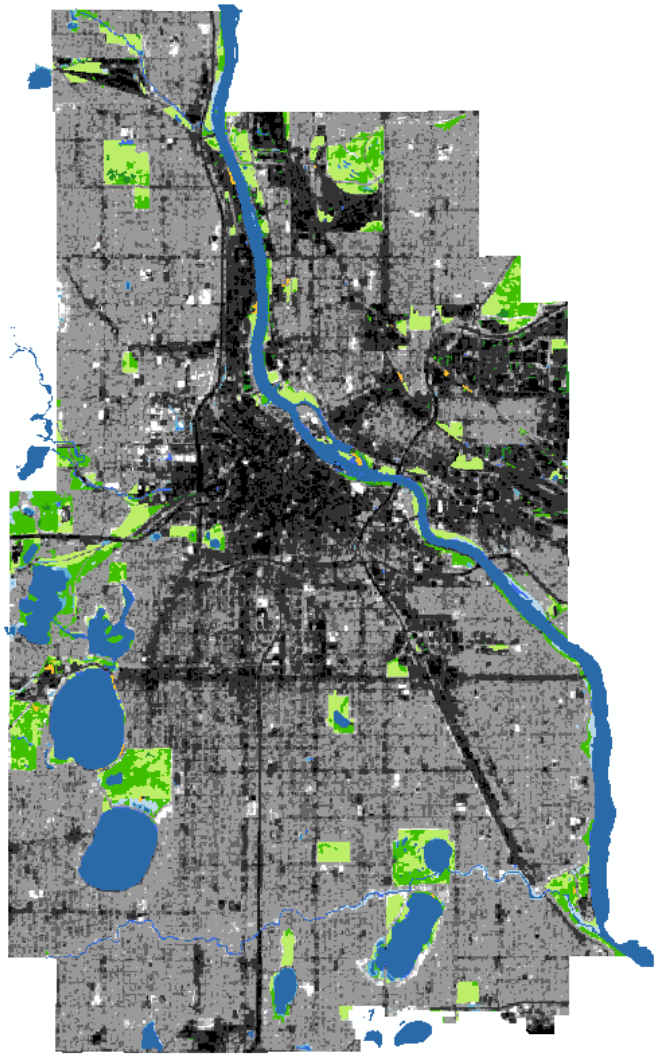
Healthy vegetation reduces the urban heat island effect by providing shade and cooling through evapotranspiration.



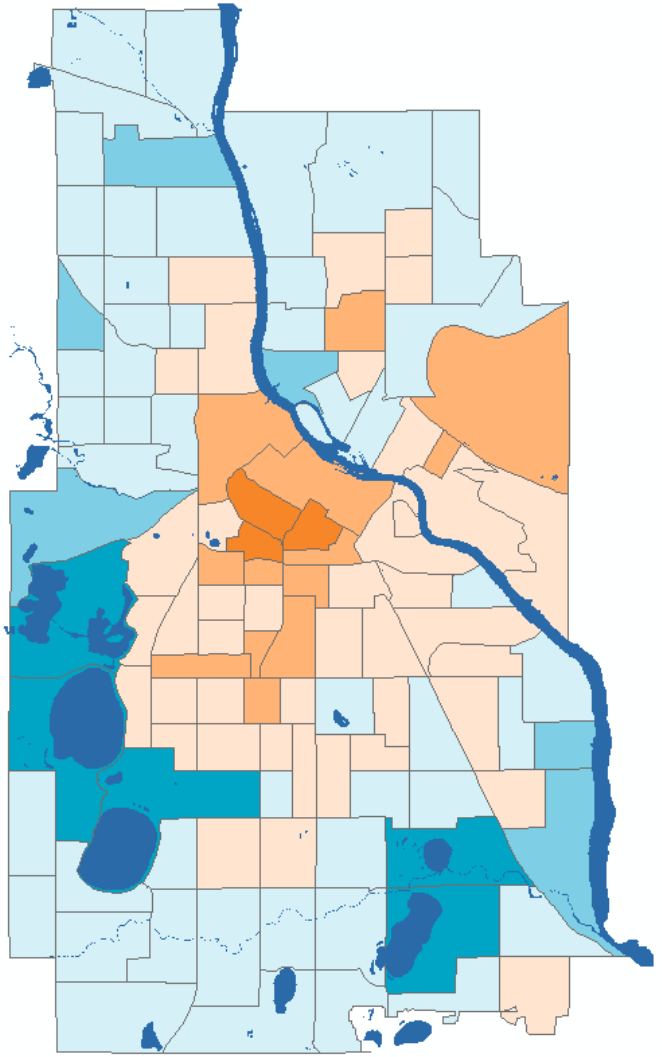


Measure: Normalized Difference Vegetation Index. Data source: United States Geological Survey (2015)

Impervious surfaces absorb heat during the day and release heat at night.



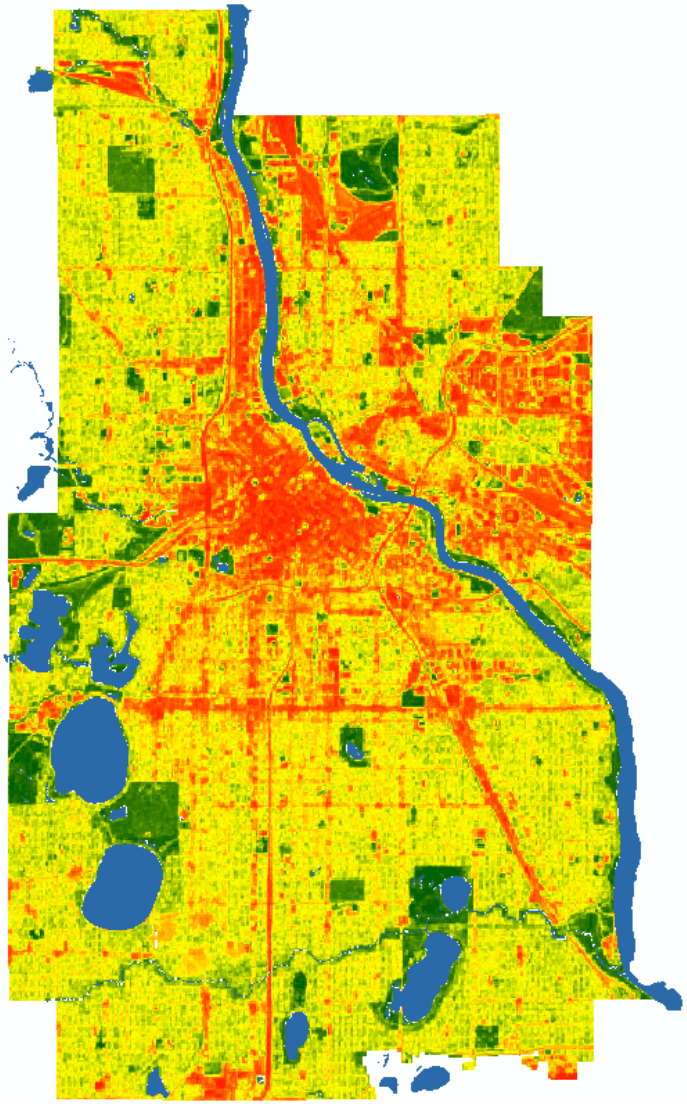
Least Impervious surface — Most Impervious surface



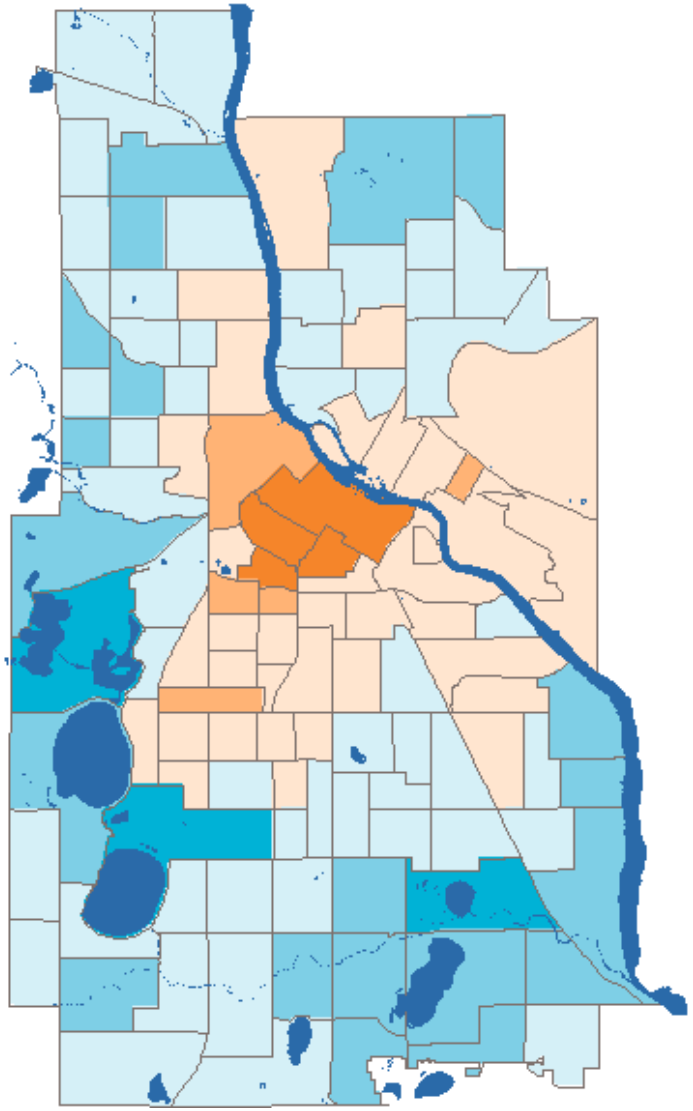
Least impervious surface — Most impervious surface

Measure: Percent impervious surface cover. Data source: University of Minnesota (2013)

Locations with **low vegetation** and **high impervious surface** are key places to focus urban heat island adaptation efforts.



Lowest landscape vulnerability to heat — **Highest** landscape vulnerability to heat



Lowest landscape vulnerability to heat — **Highest** landscape vulnerability to heat

Flooding vulnerability

1
Social vulnerability

2
Landscape Vulnerability to Heat

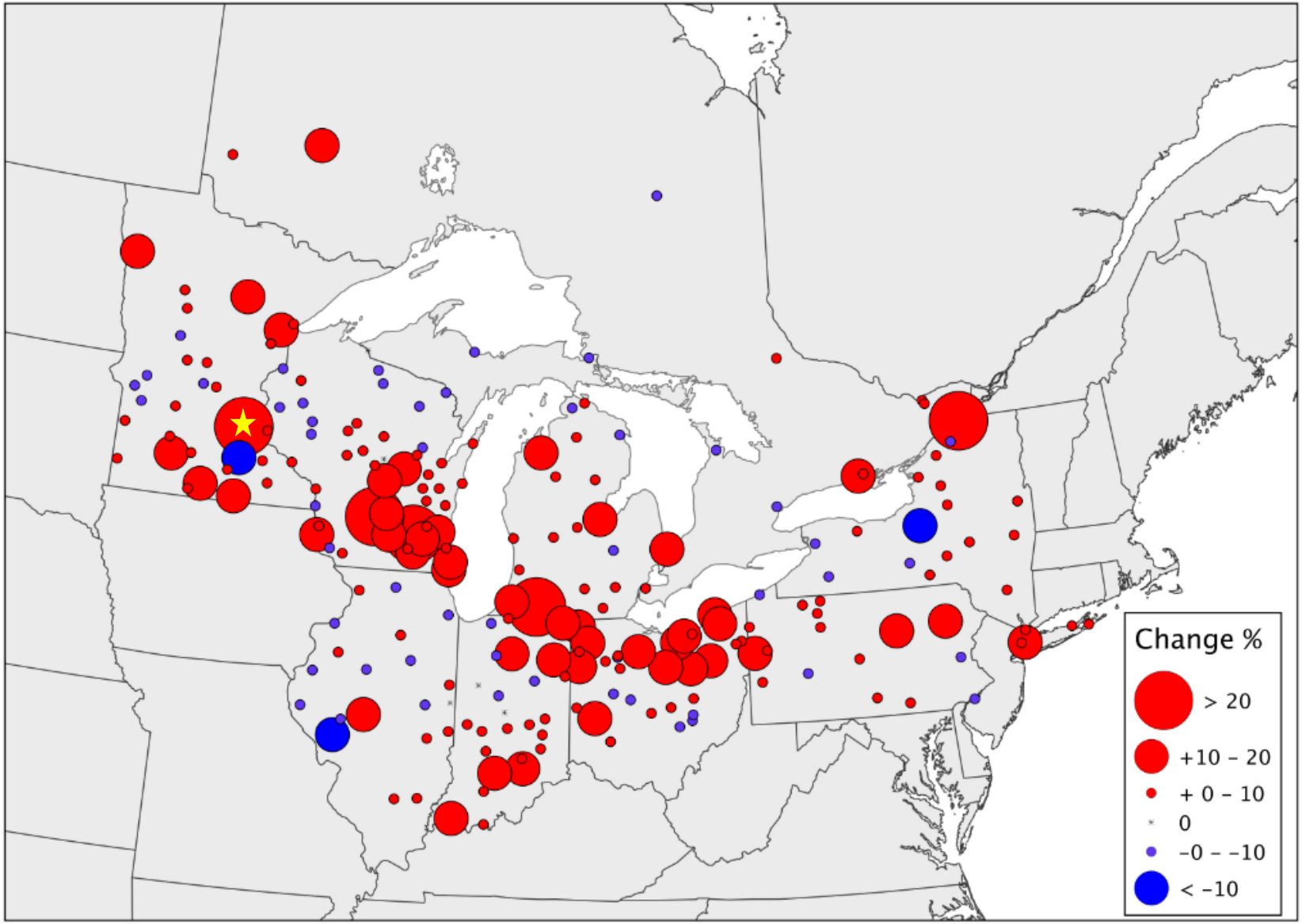
3
Landscape vulnerability to flooding

Key messages:

→ Climate Change Projections suggest more intensive and more frequent heavy precipitation events.

→ We need a better understanding of our stormwater system as a whole.

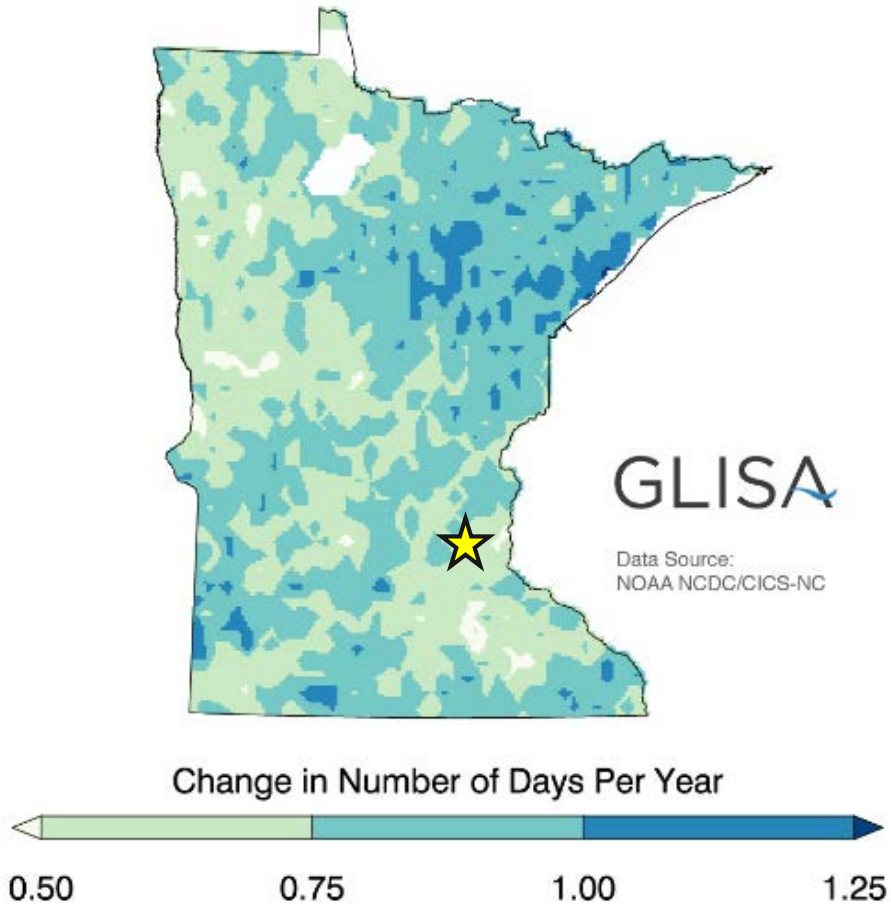
The intensity of the 1% heaviest rainy days has increased throughout the region between 1951-1980 and 1981-2010.



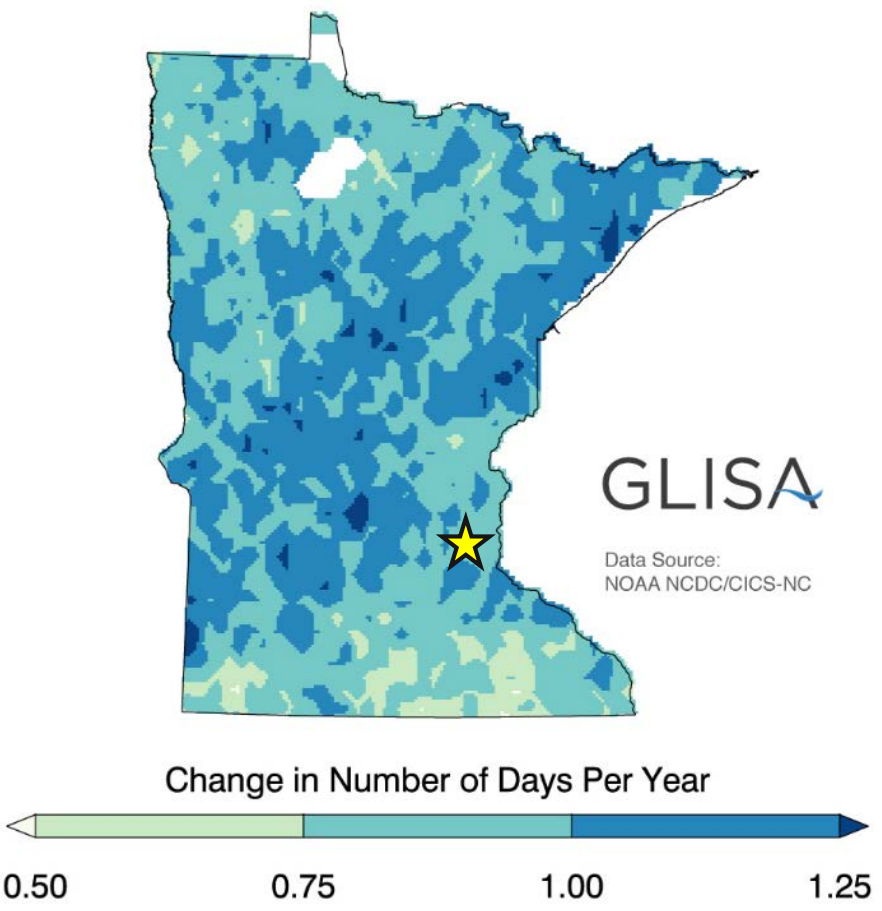
http://glisa.umich.edu/climate/extreme-precipitation

The number of the 2% heaviest precipitation events is projected to increase over time throughout Minnesota.

Lower emissions scenario (2041-2070)



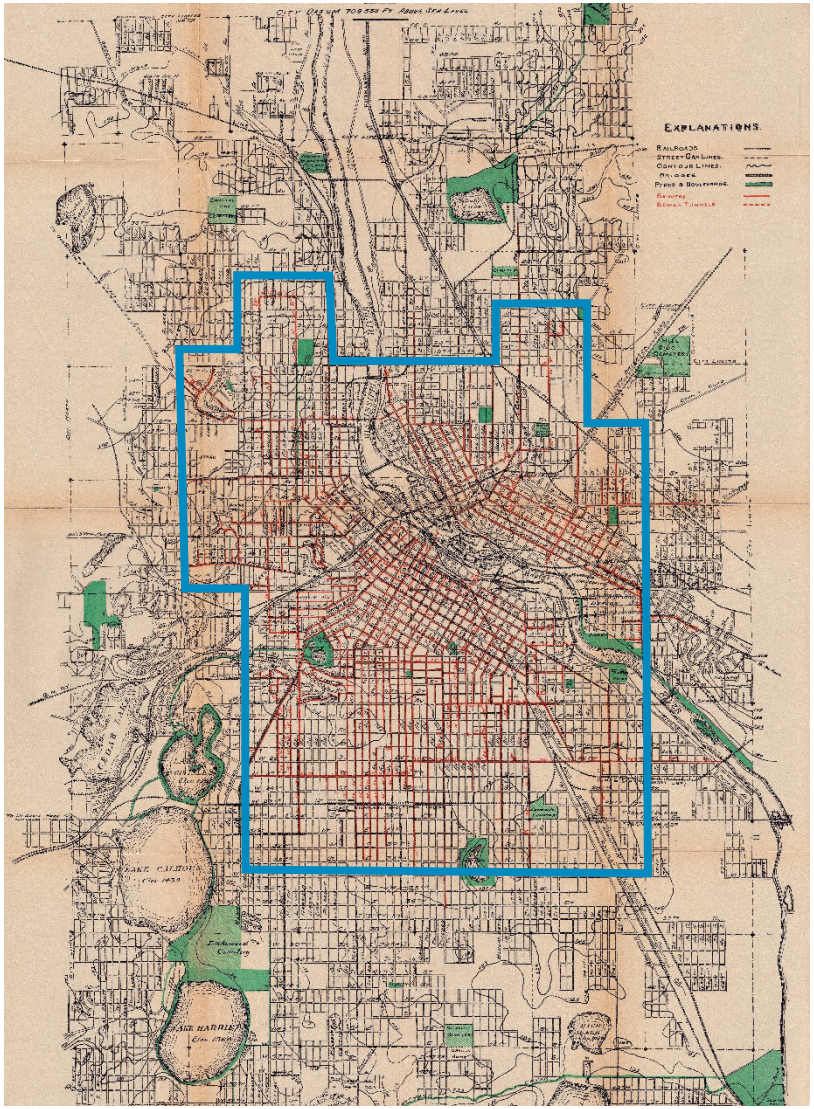
Higher emissions scenario (2041-2070)

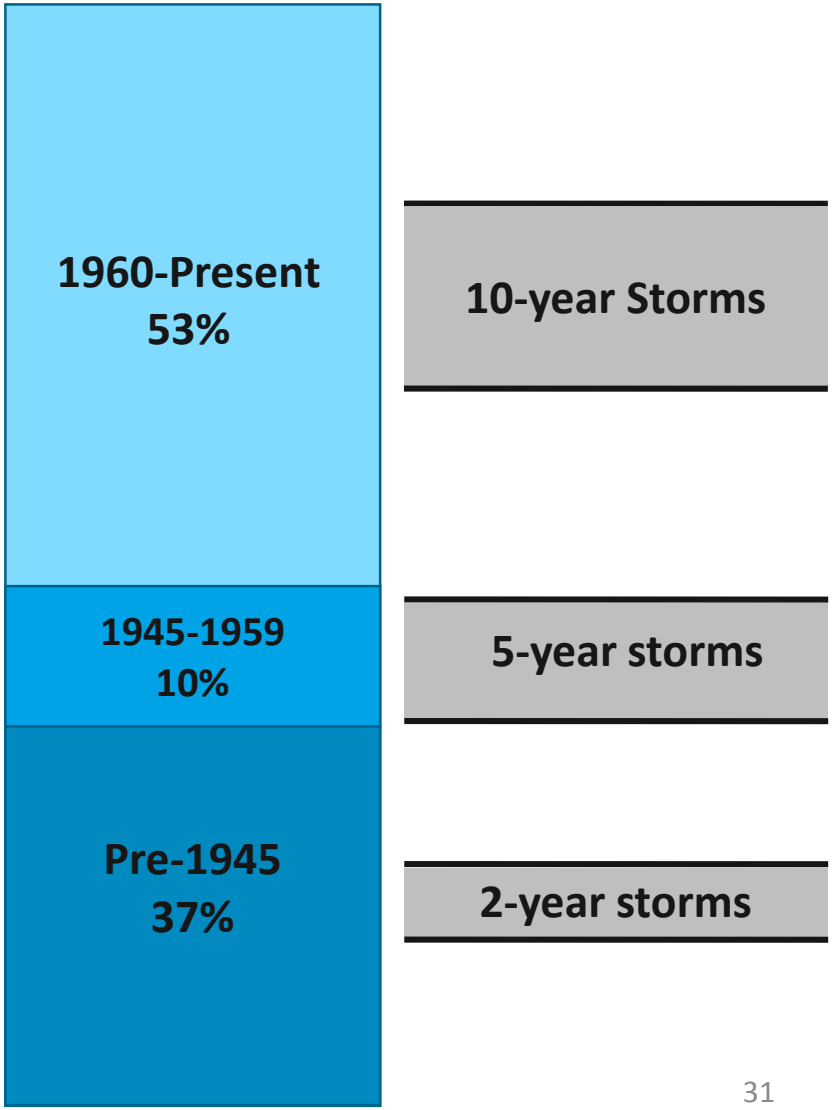


Data Source: Great Lakes Integrated Sciences + Assessments (GLISA)

The City has built larger stormwater pipes to control for more water over time.

1897 – Minneapolis Existing Sewer System



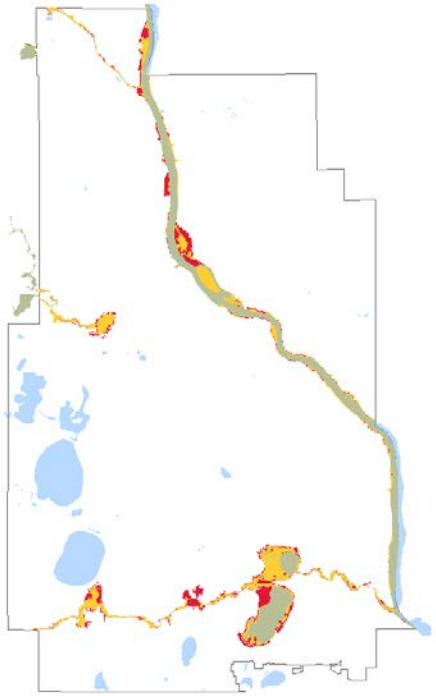


More frequent and intense heavy rain events increases the risk of the stormwater infrastructure being overwhelmed.

Stormwater infrastructure design guideline (pipes)	10 year storm event			
Probability in any year	10%			
	Without Climate Change		With Climate Change Projections	
Scenario	Past (1960-1982)	Current (1982-)	Best Case (optimistic)	Worst Case (pessimistic)
Rainfall amount	2.1 inches / hour	2.3 inches / hour	> 2.3 inches / hour	**>>> 2.3 inches / hour**

These are the main factors that contribute to overloading the stormwater drainage system.

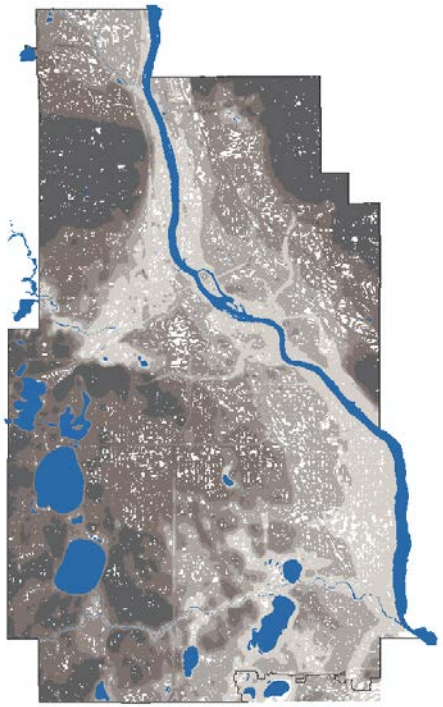
Floodplains



100-year floodplains

500-year floodplains

Elevation



Highest: 881 - 978 feet

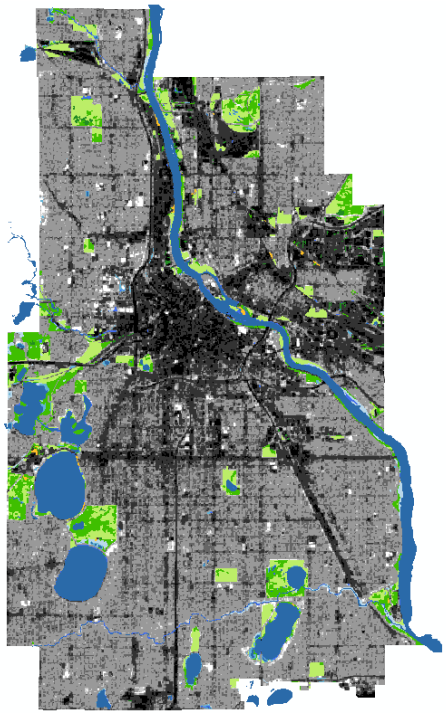
859 - 880 feet

845 - 858 feet

831 - 844 feet

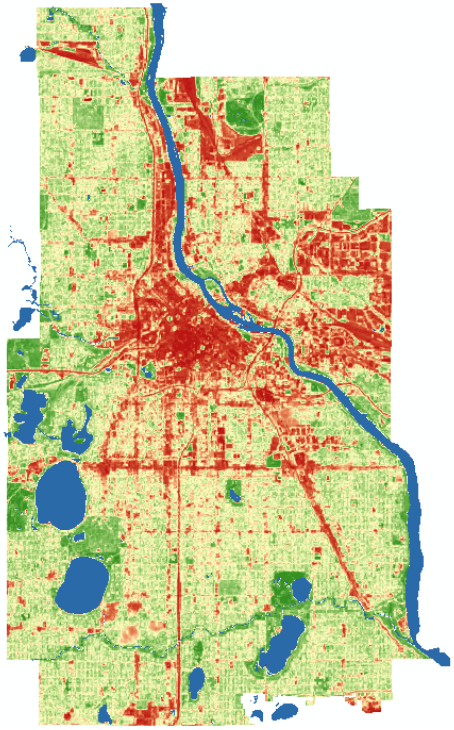
Lowest: 704 - 830 feet

Impervious Surface



Least Impervious surface — Most Impervious surface

Vegetation Coverage



Most vegetation — Least vegetation

Measure: Land area within 100-year or 500-year floodplains. Data Source: Federal Emergency Management Agency (2006)

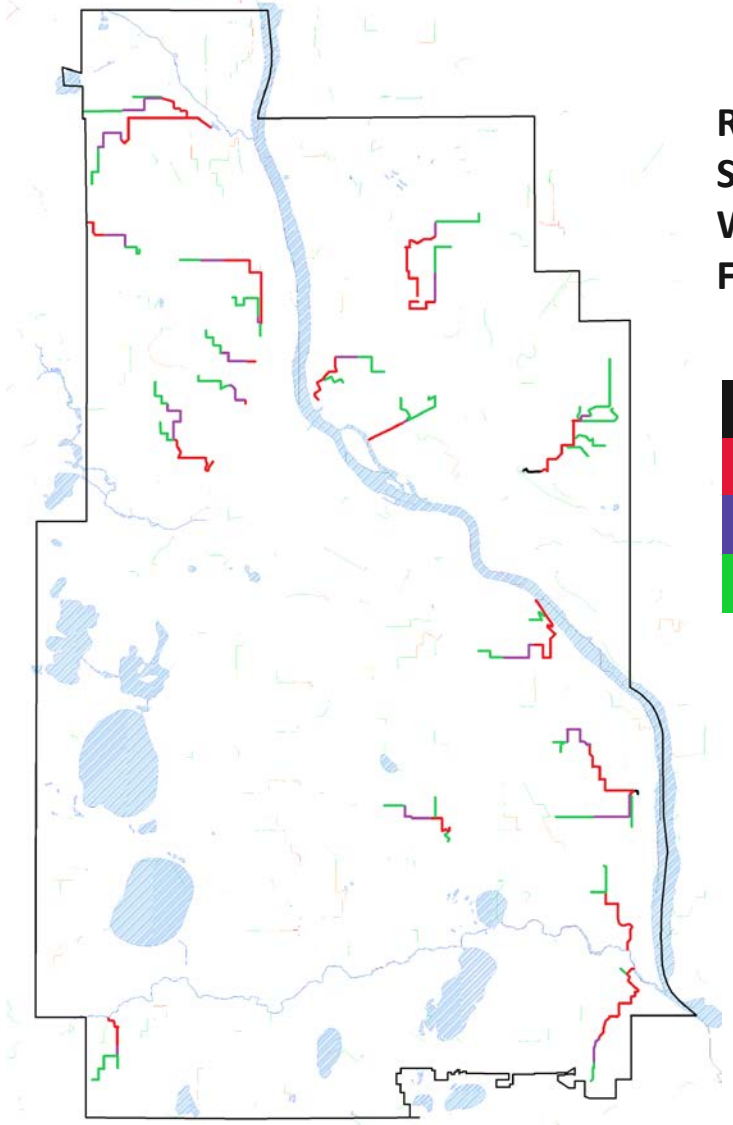
Measure: Normalized Difference Vegetation Index. Data source: United States Geological Survey (2015)

Measure: Percent impervious surface cover. Data source: University of Minnesota (2013)

Measure: Elevation above sea level. Data Source: City of Minneapolis Open Data (Date N/A)

Extremely large storms can cause stormwater infrastructure to fail. Locally low-lying areas would be more vulnerable to flooding than others.

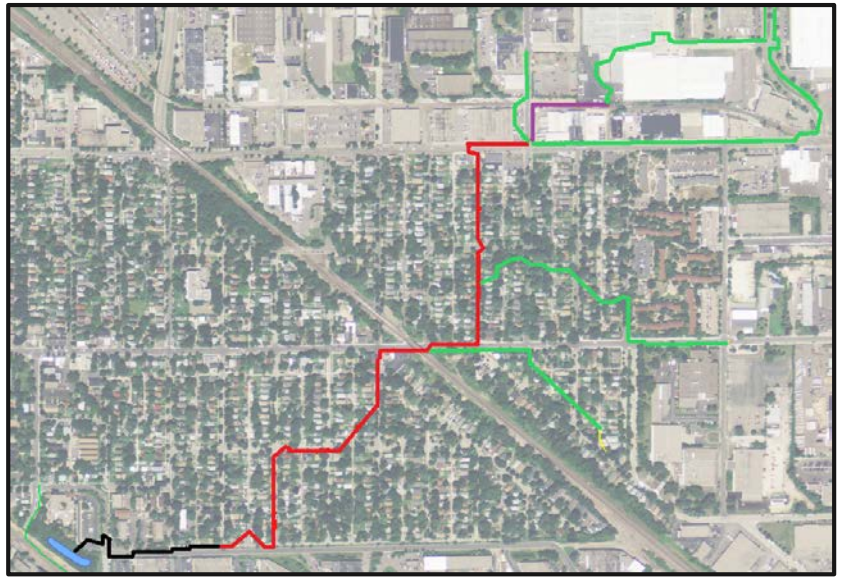
Surface Water Accumulation



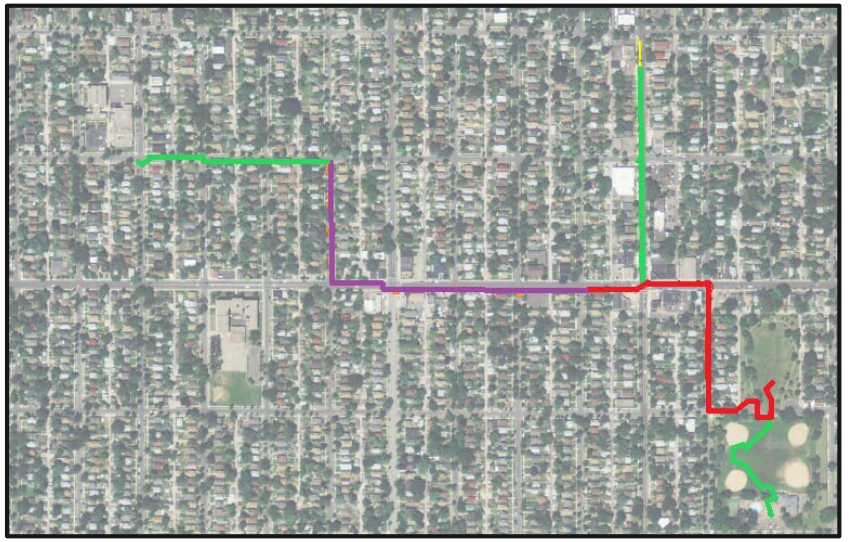
Risk of Surface Water Flooding

High

Low



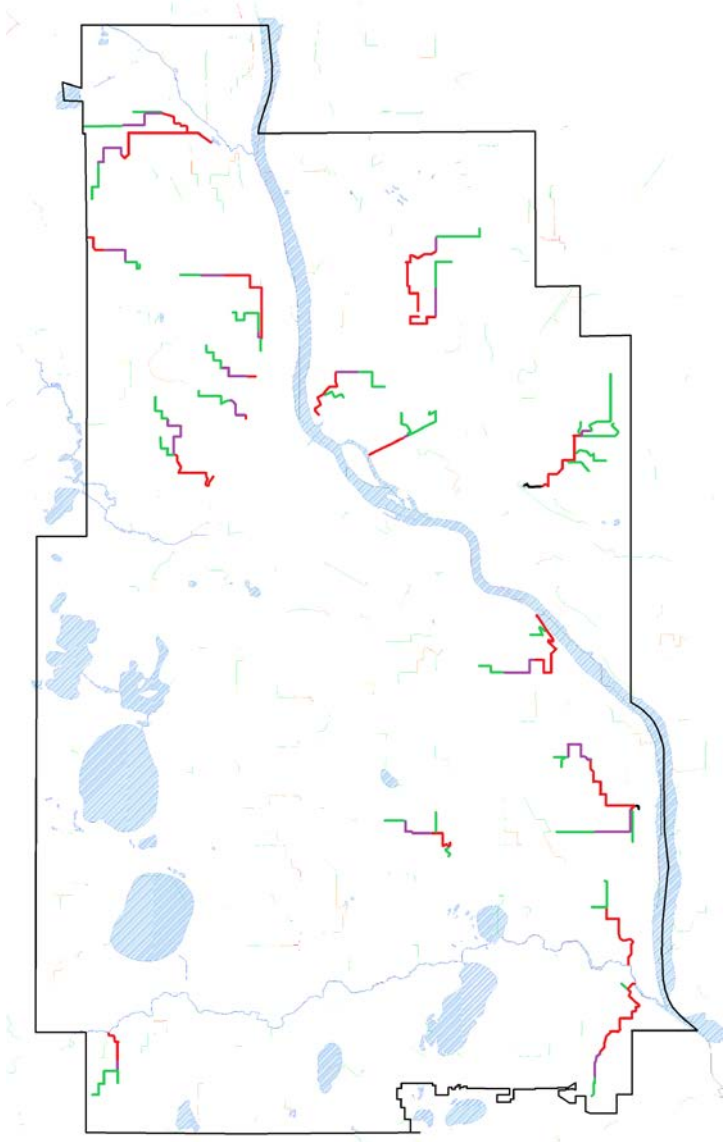
Como Neighborhood



Powderhorn Neighborhood

Source: Digital Elevation Model provided by City of Minneapolis

Mapping accurate flooding vulnerability is not currently possible due to limited understanding of the stormwater drainage system as a whole.



- A baseline comprehensive analysis of all primary flooding factors is necessary
- Heavy rain event intensity is very likely to continue trending upward
- Increased risk of flooding in areas that currently see flooding
- Increased risk of flooding in areas that don’t see flooding

Data Source: Digital Elevation Model provided by City of Minneapolis

What did Phase I accomplish?

1

Social vulnerability

2

Landscape vulnerability to heat

3

Landscape vulnerability to flooding

→Technical report

→Maps and data

Next steps for climate adaptation planning

October 2015:
City of Minneapolis received grant from Public Health Institute Center for Climate Change and Health

Phase I:
Climate Change Vulnerability Assessment
(Spring 2016)

Phase II:
Community Engagement
(2016-2017)

Phase III:
Identify next steps for implementation

Discussion