Keeping Our Cool:
Extreme Heat in the Twin Cities Region

This story was made with Esri's Story Map Journal.
Read the interactive version on the web at https://arcg.is/4CfTK.

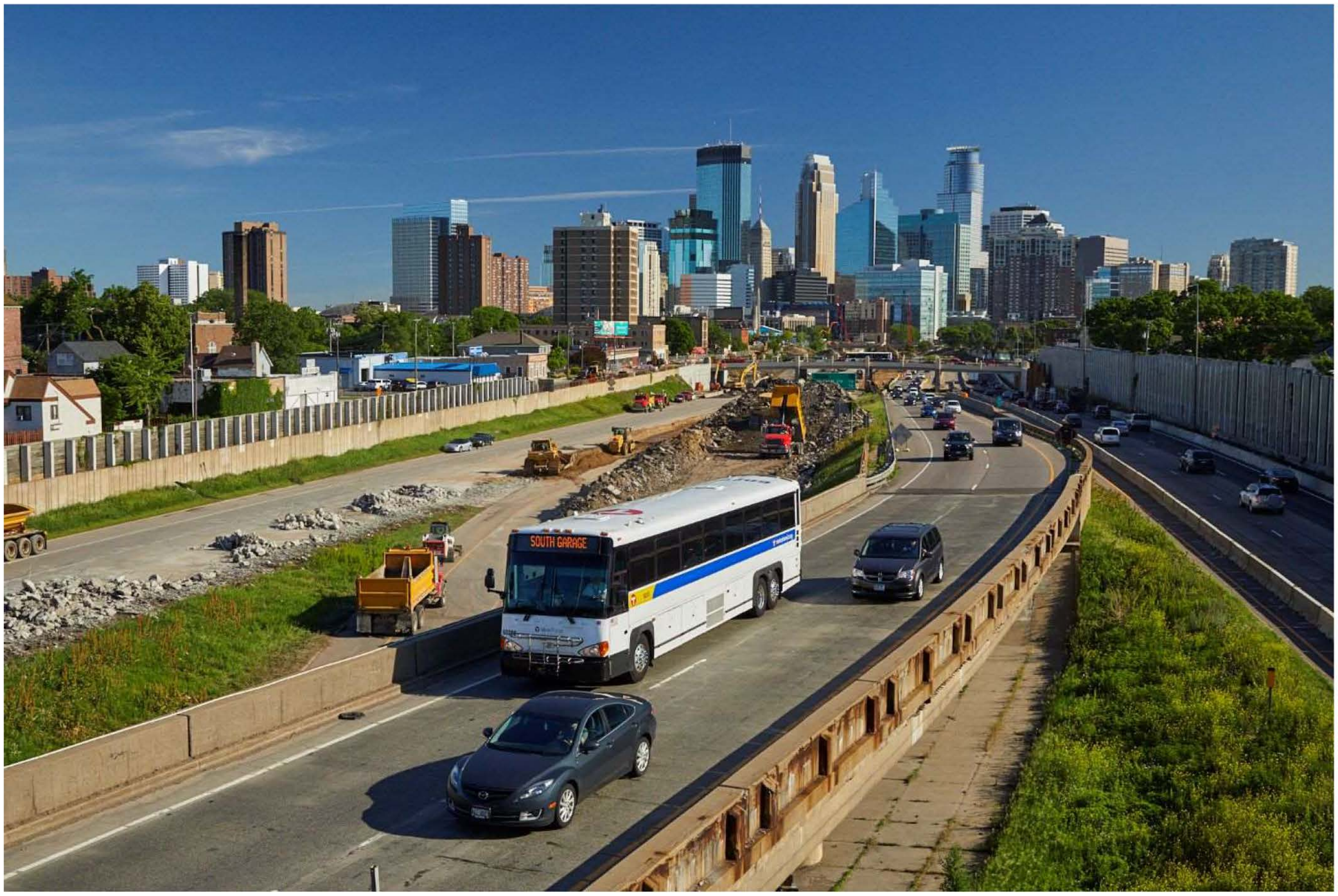


Table of Contents

1. What is this? (link available only in online story)
2. Introduction to Extreme Heat (link available only in online story)
3. Urban Heat Island Effect (UHI) (link available only in online story)
4. Pieces of UHI (link available only in online story)
5. UHI in the City of St. Anthony (link available only in online story)
6. A Fast-moving Storm (link available only in online story)
7. A Slow-moving Insect (link available only in online story)
8. Mitigation Actions (link available only in online story)
9. The Extreme Heat Map Tool (link available only in online story)
10. Extreme Heat & Human Vulnerability (link available only in online story)
11. What's Next? (link available only in online story)

What is this?

What is a Story Map?

ESRI Story Map combines interactive maps with narrative text and images to tell a story and inform audiences.

What is this Story Map?

This Story Map details how extreme heat affects the Twin Cities Metropolitan Area. It defines the issue, provides examples, and generates solutions to extreme heat, both locally and within the region. The Extreme Heat Story Map is part of the Metropolitan Council's regional **Climate Vulnerability Assessment** (all highlighted text is clickable).

What is the purpose?

The Metropolitan Council has a role in providing technical assistance to communities as they plan for future growth, sustainability, and economic success. The region faces challenges and opportunities due to climate change, and we can mitigate and reduce extreme heat impacts through thoughtful, collaborative, and proactive planning efforts.

Communities have a role in mitigating the effects of extreme heat through first identifying potential 'hot spots', then employing land use and zoning controls, as well as consideration of tree canopy, site design, and vulnerable populations. Our region stands to benefit from communities that work to identify and limit the factors that increase extreme heat.

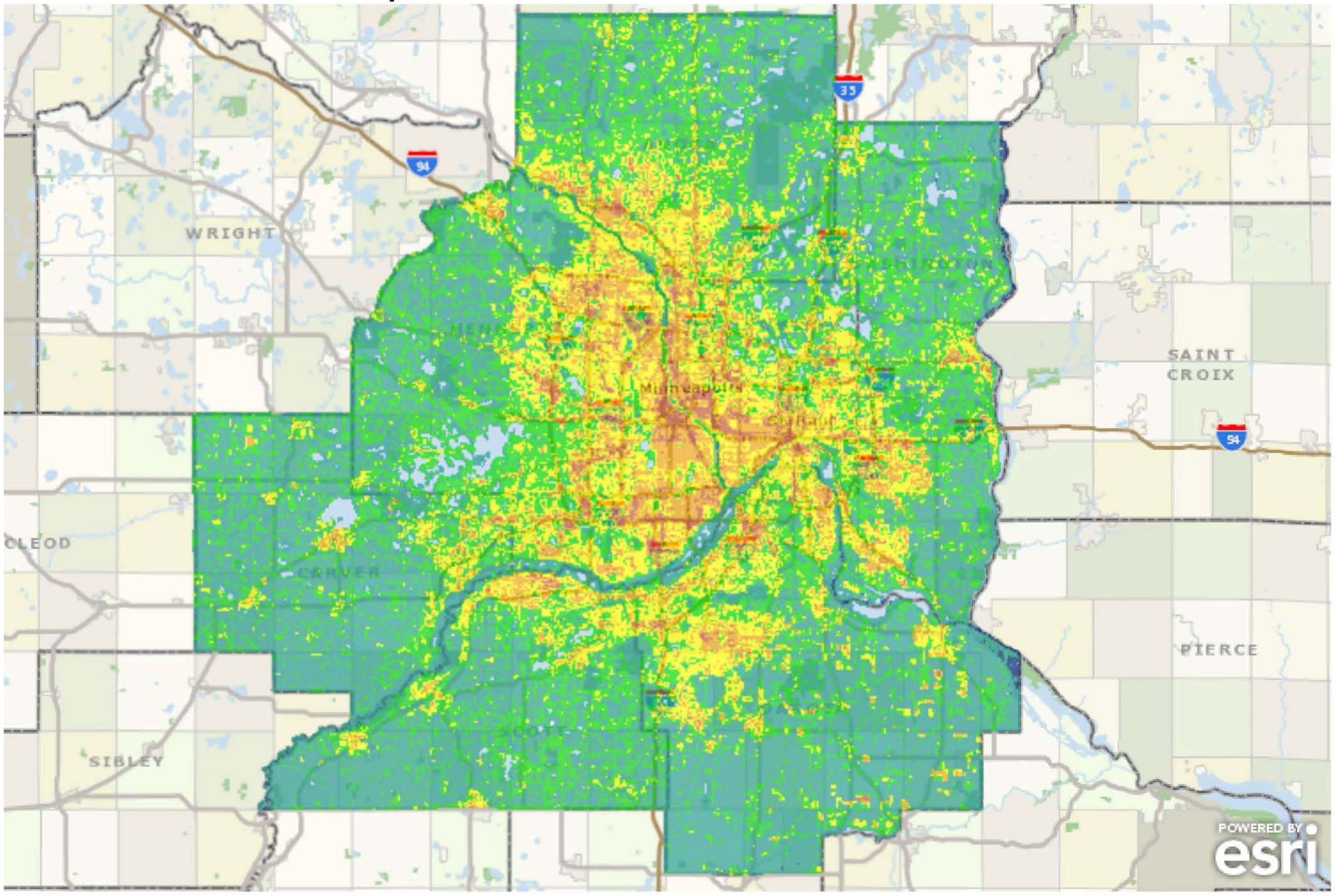
Introduction

Air temperature has been rising in Minnesota for over a century. This rise in air temperature has accelerated in the past several decades. Although climate conditions will vary from year to year, these temperature increases are expected to continue through the 21st century.

The rising **temperatures are intensified in developed areas** due to a lack of vegetation and more roads, rooftops, and parking lots. Extreme heat can increase **health risks** in **vulnerable populations** that often live in densely populated urban areas.

In the face of more frequent and intense heatwaves in years to come, it is increasingly important for communities to **understand the factors** that can intensify extreme heat and how best to employ strategies to mitigate these factors. Identifying potential 'hot spots' within a community can help **target strategies** where they are most needed.

Land Surface Temperature



LandSurfaceTemperature

Mapped by Standard Deviation

- 99.57 - 125.21 (> 2.5 Std. Dev.)
- 94.11 - 99.57 (1.5 - 2.5 Std. Dev.)
- 88.65 - 94.11 (0.5 - 1.5 Std. Dev.)
- 83.20 - 88.65 (-0.5 - 0.5 Std. Dev.)
- 77.74 - 83.20 (-1.5 - -0.5 Std. Dev.)
- 74.17 - 77.74 (< -1.5 Std. Dev.)

This map displays land surface temperatures throughout the Twin Cities metro region. Areas with higher temperatures tend to center on highly-populated, urban areas while significantly lower temperatures are captured near water and vegetation. The map displays a **strong relationship** between extreme heat and impervious (concrete, asphalt, rooftops) land cover in the Twin Cities metro region.

What is it?

The Land Surface Temperature map is an important measure in evaluating Extreme Heat. The map is derived from satellite infrared imagery.

When is it?

The map represents a snapshot of the metro area land surface temperature on July 22, 2016 at 12 PM, on the third day of a regional heat wave. On that day, the air temperature was 90°F at the Minneapolis-St. Paul International

Airport.

How is it mapped?

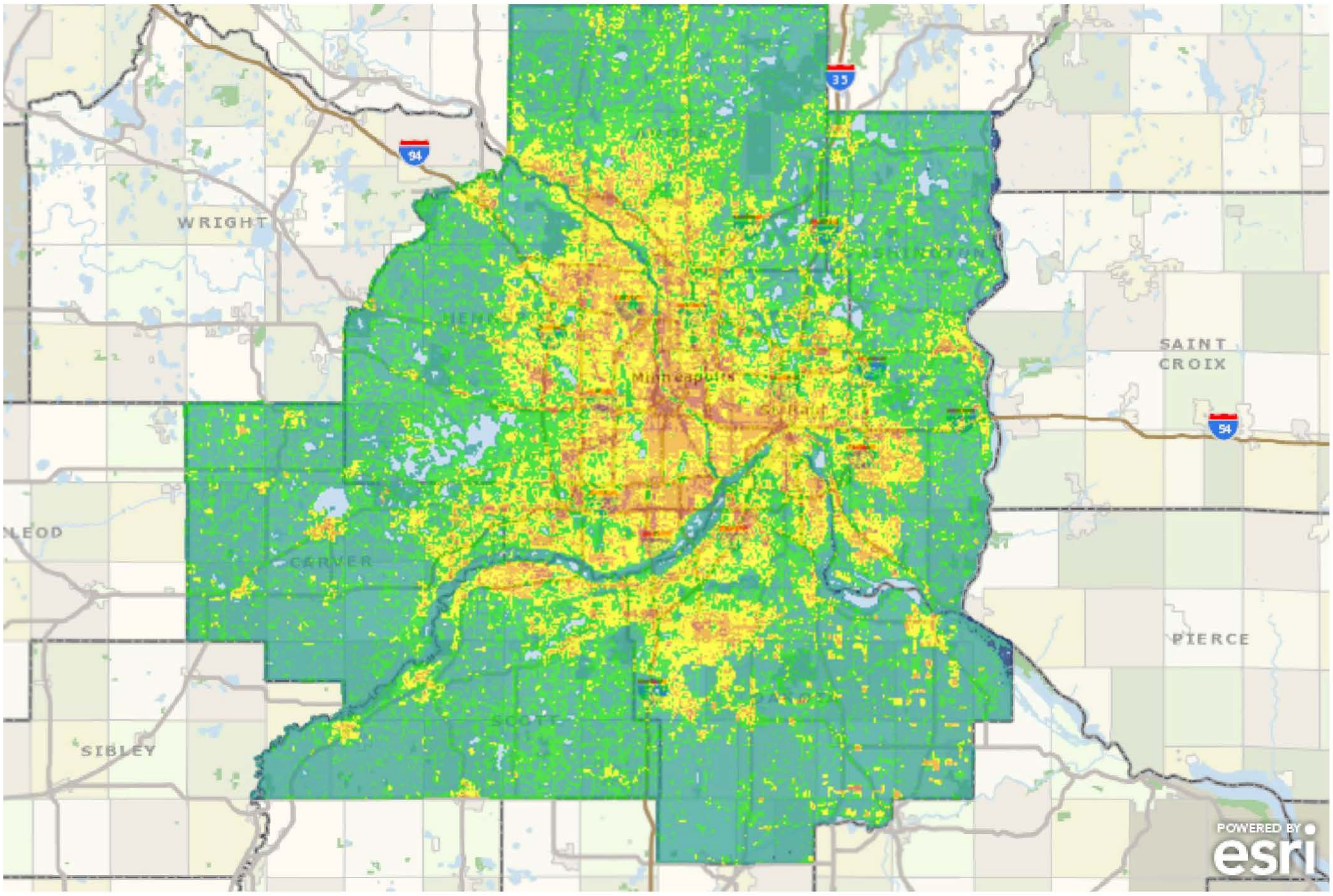
The land surface temperature data has been categorized based on the temperature's standard deviation from the mean temperature. The data is displayed on a color scale from low temperatures in blue (74°-77°F) to high temperatures in red (99°-125°F).

How does this heat analysis differ from others?

The University of Minnesota performed an extreme heat analysis within the Minneapolis - Saint Paul area using **air temperature as a measure for extreme heat**. Sensors were placed throughout the region to collect data. The temperature between air sensors is an interpolation rather than an exact measurement. The study was performed over a 3 year period, focusing on longer term trends.

The Metropolitan Council study uses land surface temperatures, **captured at a single moment in time**, in an attempt to provide a **precise picture** of Urban Heat Island effects in the region. This study allows for a detailed look, especially at smaller urban heat islands, rather than a long term trend analysis as seen in the University of MN study.

Urban Heat Island Effect



LandSurfaceTemperature

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- 99.57 - 125.21 (> 2.5 Std. Dev.)
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What is it?

Urban Heat Islands, or UHIs, occur as a result of the built environment associated with cities (buildings, parking lots, roads, rooftops), which can **trap solar radiation in the form of heat**. In addition, waste heat from combustion engines and heating/cooling can also raise temperatures in urbanized areas.

Urban heat can become trapped because there is little tree canopy or vegetation to provide shade and mitigate heat through evapotranspiration. In addition, there is often a general lack of convection (heat rising up and making space for cooler air to flow in below) in cities because of building mass and form. UHI expresses the **difference in temperature between built-up, urbanized areas and more rural, vegetated areas**.

What are the effects of UHI?

Heat islands affect communities by increasing energy demand costs, air pollution and greenhouse gas emissions, heat-related illness and mortality, and by reducing water quality.

Where does it occur?

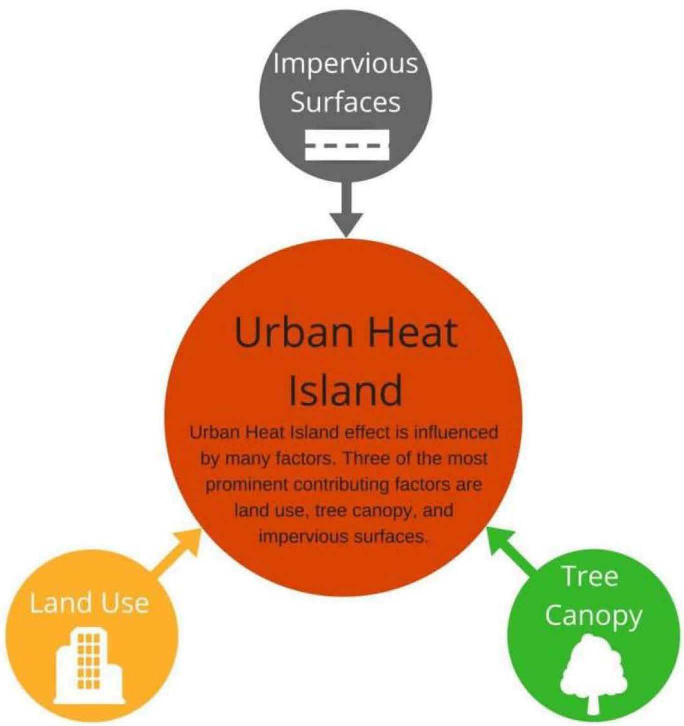
Zoom to Downtown UHI (link available only in online story)

Downtown areas, like Minneapolis and Saint Paul, that have large areas of impervious surface and relatively few trees experience higher temperatures than outlying areas. As seen on the map, these areas have high land surface temperature.

Zoom to Small Area UHI (link available only in online story)

Although areas outside of major downtowns tend to be cooler, UHI is still present and can impact the community. Downtowns, of any size, are usually high in impervious surfaces and have fewer trees than the surrounding area. This results in pockets of higher temperatures, even in less urbanized areas of the region. The City of Waconia has high land surface temperatures despite being surrounded by natural areas and Waconia Lake.

Pieces of UHI



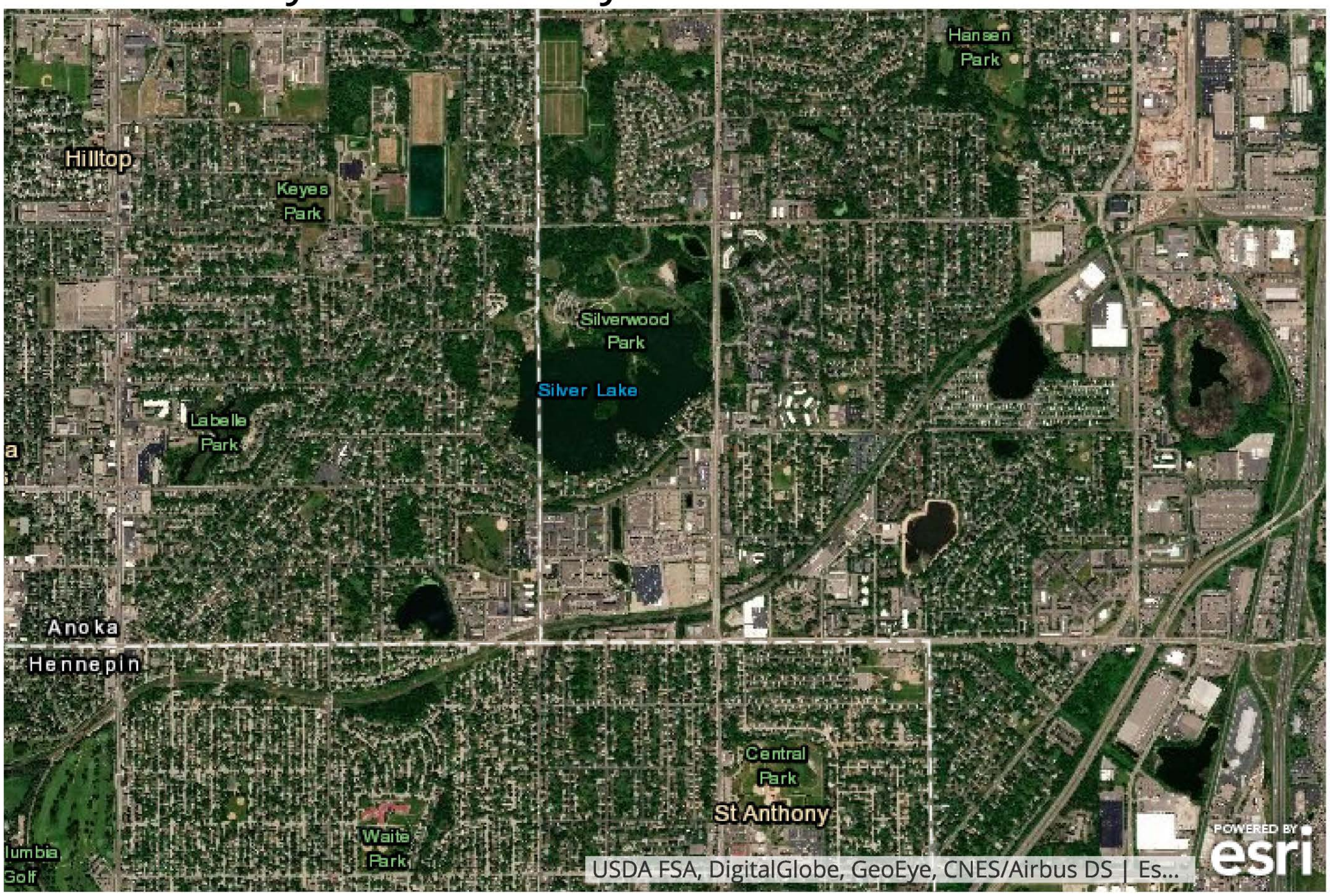
What contributes to UHI?

Urban Heat Island effect is influenced by many factors. Three of the most prominent contributing factors are **land use, tree canopy, and impervious surfaces**. All three factors are linked. For example, a mall or commercial land use, will have few trees and higher levels of asphalt or concrete. Other factors that contribute to UHI include residual heat from heating and air conditioning units, and from combustion engines.

Impervious surfaces prevent water from filtering into the ground and trap heat near the ground. Dark impervious surfaces, like asphalt, tend to absorb more heat than lighter colored ones do. As a result, they trap the most heat.

Reports have shown that impervious surfaces correlate strongly with an increase in UHI, oftentimes **more than any other single factor**. Removing impervious surfaces like asphalt and concrete is the most effective way to reduce UHI. Tree canopy helps to mitigate UHI by providing shade. A high density of trees within an area creates a mitigating effect on Urban Heat Island by keeping the land surfaces cool.

UHI in the City of St. Anthony

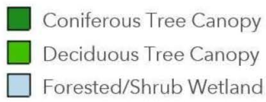


The City of St. Anthony has areas with extensive tree canopy, which mitigate UHI, and areas with high levels of impervious surfaces, which increase UHI. Each factor of UHI is displayed here in a separate map. The variations in tree canopy, land use, and levels of impervious surfaces result in **different land surface temperatures throughout the city**.

After clicking on the highlighted text below, tree canopy, impervious surfaces, and land use, the **gray bar in the center of the screen** can be moved back and forth to explore the relationship between heat and each factor of UHI.

Tree Canopy (link available only in online story)

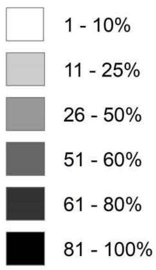
In parts of the city with extensive tree canopy, like in Silverwood Park, land surface temperature is low. Meanwhile, in areas with little to no tree canopy to provide shade, like in the Silver Lake Village area, land surface temperature is far higher and UHI is more intense. In residential areas with even moderate tree canopy, UHI is significantly reduced.



Impervious Surface (link available only in online story)

In areas with highly impervious surfaces, such as shopping center parking lots, land surface temperature tends to be higher than in surrounding areas with more vegetation.

Impervious surfaces (parking lots, roads, rooftops, etc.) are shown from light gray to black. The range represents how impervious the surface is, from low to high percent impervious.

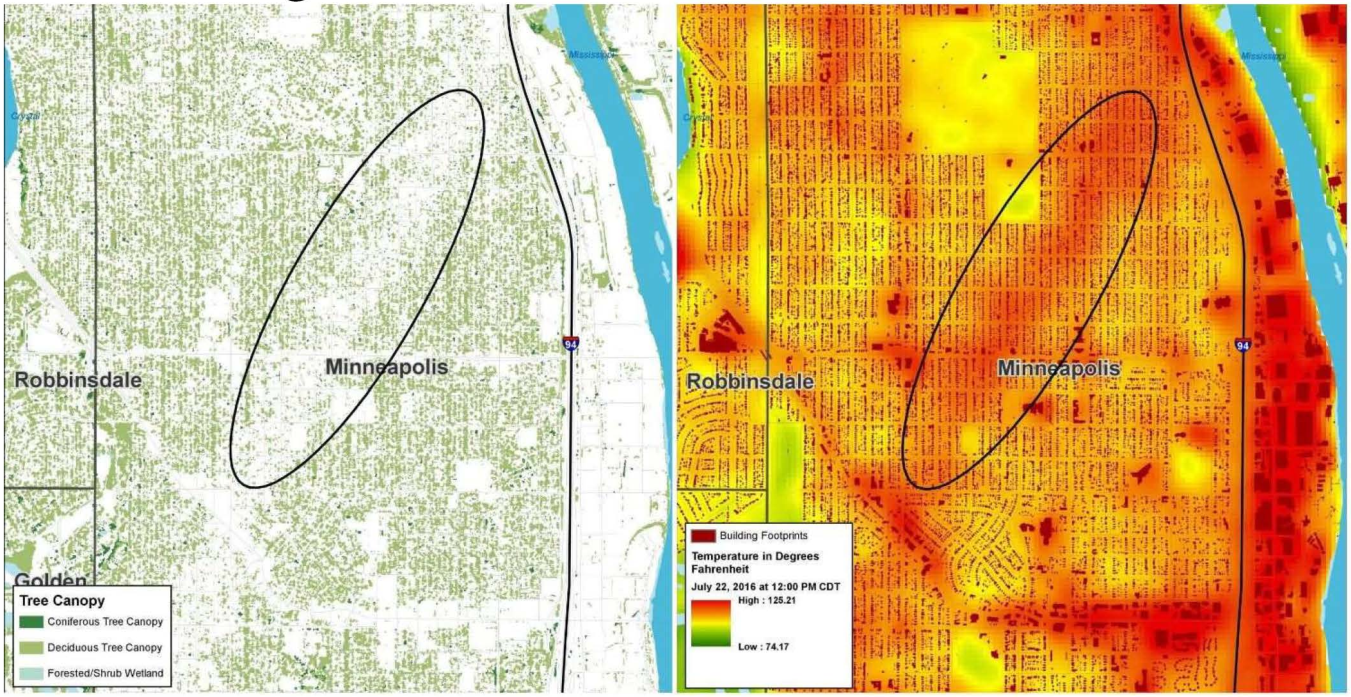


Land Use (link available only in online story)

Parts of the City where land is covered by commercial or industrial land uses have higher land surface temperatures. In these areas, surfaces tend to absorb lots of heat and there is little opportunity to plant trees. St. Anthony is considering different redevelopment options for a former 'big box' retail area at Silver Lake Village. The City may consider redevelopment opportunities that reduce UHI at the site scale, through removal of impervious surfaces and enhancing vegetative cover.

LanduseSplitLegend.png

A Fast-moving Storm



What happened?

On May 22nd, 2011, a tornado caused major destruction in North Minneapolis. Wind speeds between 86 and 110 miles per hour uprooted mature trees and caused them to fall on houses and vehicles. One man lost his life during the tornado.

How does this relate to extreme heat?

The destructive path of the tornado had a **measurable impact on land surface temperatures and UHI**. Unlike areas of higher land surface temperatures that can be explained by, for instance, industrial or commercial land use, the diagonal path of increased temperatures, shown by the black oval, is **primarily related to loss of tree canopy**. Land use along the path is largely residential like the surrounding area. Decreased tree canopy, as a result of the tornado, shown in the image to the left, is directly related to higher temperatures along the tornado's path, shown in the image on the right.

Damage to trees, or complete removal, has decreased the amount of canopy along the tornado's path. This means there is **less shade along the damaged corridor, allowing the surface temperature there to rise**. This area, and its residents, now experience increased urban heat island effect. Even many years after an event like this, local residents **may still be recovering and rebuilding from the impact.**

Areas along the tornado's path could benefit from replanting trees, and from other mitigation strategies to reduce UHI. The tornado demonstrates that UHI is complex; many factors may influence how susceptible an area is to extreme heat.

A Slow-moving Insect

What is the problem?

Today, the invasive Emerald Ash Borer (EAB) beetle **threatens the survival of 1 in 5 community trees** in Minnesota. Without strategies to mitigate this loss of tree canopy, losing these trees will increase extreme heat across our region.

Ideally, each ash tree lost to EAB will be replaced by at least one new tree. However, **replacing ash trees is an expensive and lengthy process.** Even after a replacement tree is planted, it will take decades for the new tree to reach the shade-providing expanse and carbon-capturing capacity of the mature tree that was removed. The Minnesota Shade Tree Advisory Committee (MNSTAC) has published a document on the cost of and solution to the EAB problem in Minnesota.

What should be done?

Surface temperatures in Minnesota communities may temporarily increase before new trees are planted and grow to maturity. However, if ash trees are removed and are not replaced at all, the consequences would be far graver. Permanently losing the canopy provided by these ash trees could lead to a sustained intensification of UHI.

How does EAB relate to the tornado?

Like the tornado that tore through North Minneapolis, leaving a path of higher land surface temperatures, the **loss of ash trees will increase UHI in region communities until the canopy is restored.**

What areas are most at risk from the loss of ash trees?

High risk areas are those already experiencing high land surface temperatures. These areas will continue to heat up with loss of tree canopy, and other mitigation strategies may need to be considered to decrease impervious surfaces and heat absorption.

Where can I learn more?

The City of Saint Paul and the MN Department of Natural Resources are tracking ash tree disease and removal. Interactive maps linked below provide insight into the extent of the EAB problem.

St. Paul - Boulevard Ash Tree Management Program
MN DNR - Map of Ash Trees

Other impacts of EAB will be discussed in the MN Environmental Quality Board Interagency Report on Emerald Ash Borer, which will be published in late 2018.

What Can Communities Do?

Identify existing conditions

First, Communities can use our Extreme Heat Map Tool to help identify potential community 'hot spots' to better target strategies.

Plant & maintain trees

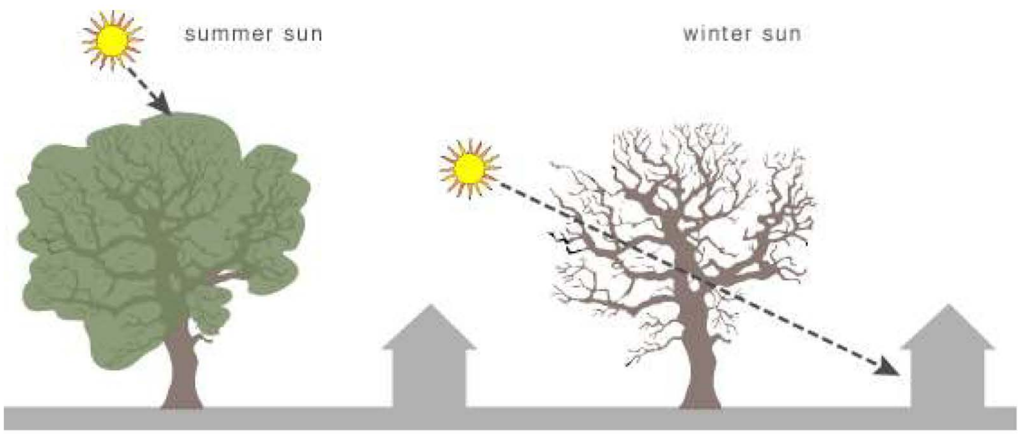
The region can benefit from increasing tree and vegetated cover in areas where heat islands are prominent. Plants can be used to lower surface temperatures in urban areas by 20-45°F through providing shade and 2-9°F through evapotranspiration.

Increasing tree canopy is one of the most cost-effective mitigation strategies because the initial costs of trees and maintenance are outweighed by the benefits. A recent **partnership between the University of MN and the City of Ramsey demonstrates the real value of urban trees.** Increasing tree and vegetation planting also improves air quality, prevents flooding, and improves water quality

Integrate trees into design

Integrating trees and vegetation into parking lot design, like **this example from the Minnesota Landscape Arboretum**, decreases urban heat island effect by creating shade. Trees provide other co-benefits which include storm water treatment and improved air quality.

Deciduous trees provide shade in the summer and allow sun to enter buildings in the winter. This allows for more efficient cooling and heating of a building or home.



Source: Greenspec

Other Mitigation Strategies

In addition to planting trees, how else can UHI be mitigated?

Communities can implement various mitigation strategies, from heat-conscious land use planning to cooling design innovations and retrofits. The goal of all strategies is to decrease the temperature in the given area. Possible strategies include the following:

Green Roofs

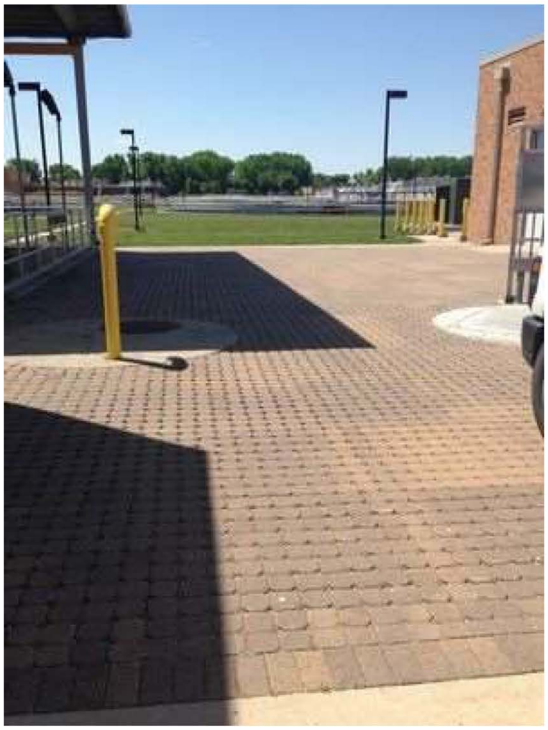
Around 10-30% of solar energy is able to penetrate through vegetation, which in turn, **blocks sunlight from heating up a roof**. Leaves and foliage absorb the remaining energy, with only a small remainder reflecting back into the atmosphere. Local governments can take measures to **incentivize** the construction of green roofs. The City of Minneapolis, for instance, incentivizes green-roofing indirectly by offering utility fee reductions for managing stormwater quality or quantity. The photo to the right shows the green roof at the Empire Wastewater Treatment Plant.

Cool Roofs

A cool roof is one that has been designed to **reflect more sunlight and absorb less heat** than a standard roof. Traditional roofs can reach temperatures of 150-185°F, while cool roofs are typically 50-60°F cooler in the summer. Local governments can take measures to promote the construction of cool roofs. This strategy need not cost a fortune; New York City has embarked on an effort to **paint all its roofs white through the work of volunteers.**

Cool Pavement

Conventional asphalt and concrete absorb a vast amount of solar energy. As a result, they can reach surface temperatures of 120-150°F in the summer. Cool pavements like permeable pavers or solid grass parking areas can **decrease surface temperature by decreasing the amount of energy absorbed**. Cool pavement utilizes lighter colors, permeable surfaces, vegetation, and other strategies to mitigate urban heat island effect.



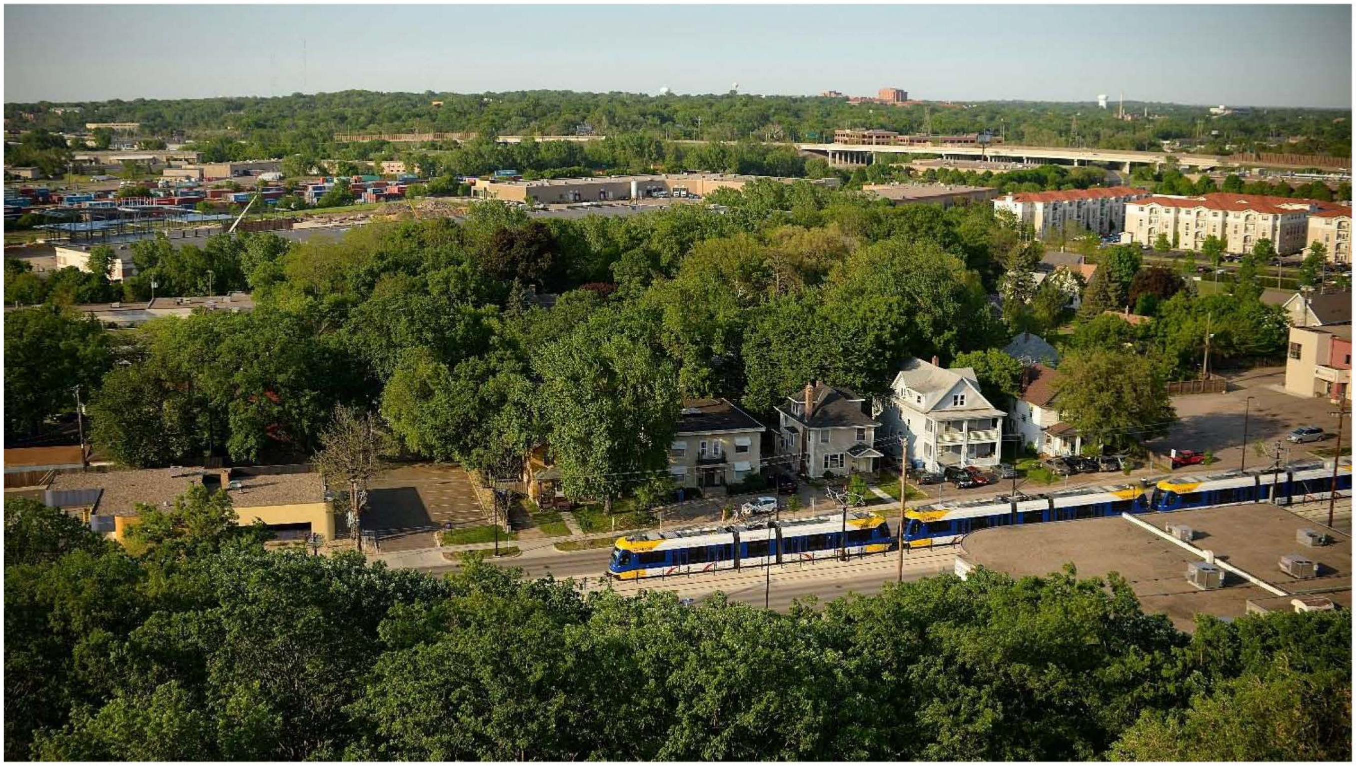
Permeable Pavers at Empire WWTP

Street Design
Street design encompasses everything from sidewalks and bike lanes to turn lanes and transit stops. These design elements present **opportunities to increase tree canopy and vegetation along streets**. Widening sidewalks or narrowing vehicle lanes can create more room for street trees and plants. This increases shade along streets and decreases the amount of impervious surface to help mitigate UHI. There are many other ways to use street design as a tool to mitigate UHI. More information about street design can be found at the National Association of City Transportation Officials.

Made with Streetmix

Land Use & Zoning

Heat mitigation strategies can be **written right into local zoning codes**. Requiring certain standards for tree planting and limiting surface parking are two strategies for increasing tree canopy and reducing impervious surface coverage through local zoning. By establishing a flexible building code that allows for mixed-used residential developments, local jurisdictions can require higher standards for tree and vegetation planting within and adjacent to commercial and industrial land uses.



Zoning to allow mixed commercial, residential and industrial uses promotes an increase of tree canopy throughout the area, mitigating UHI.

Parks and Open Space

Creating even a small community garden or pocket park can have measurable impacts on lowering local UHI, and can provide **numerous co-benefits for the local community**.

St. Paul's **Frogtown Farm** is a 13 acre urban farm established in 2013. Densely populated with vegetation, the farm contributes to lowering local UHI. Frogtown Farm provides a space for community gathering, improves soil and water quality, and increases local bird and pollinator presence.

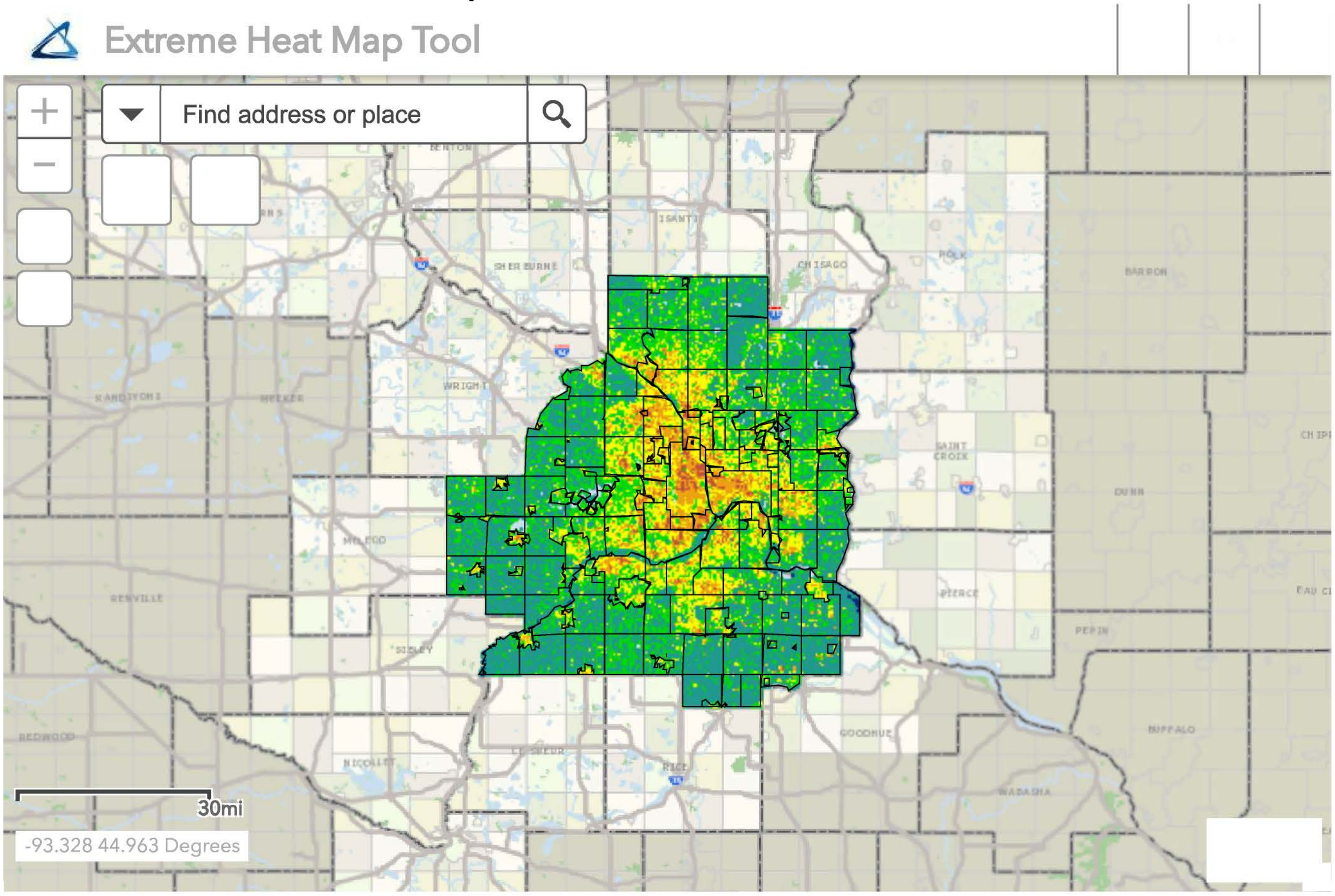
Public Education

Community staff and elected officials can promote cooling strategies for private developers and on private residential lots. This can take the form of incentivizing tree planting on private land and outreach related to climate change hazards, such as the Ready & Resilient document produced by the City of St. Louis Park. The City of Golden Valley identified populations vulnerable to extreme heat in the Resilience & Sustainability Chapter of its 2040 Comprehensive Plan. Golden Valley's efforts are a great way to set a course towards further work on heat reduction strategies.

Where can a community find more information about reducing extreme heat?

EPA - Heat Island Mitigation
EPA - Heat Island Community Actions Database

The Extreme Heat Map Tool



What is this mapping tool?

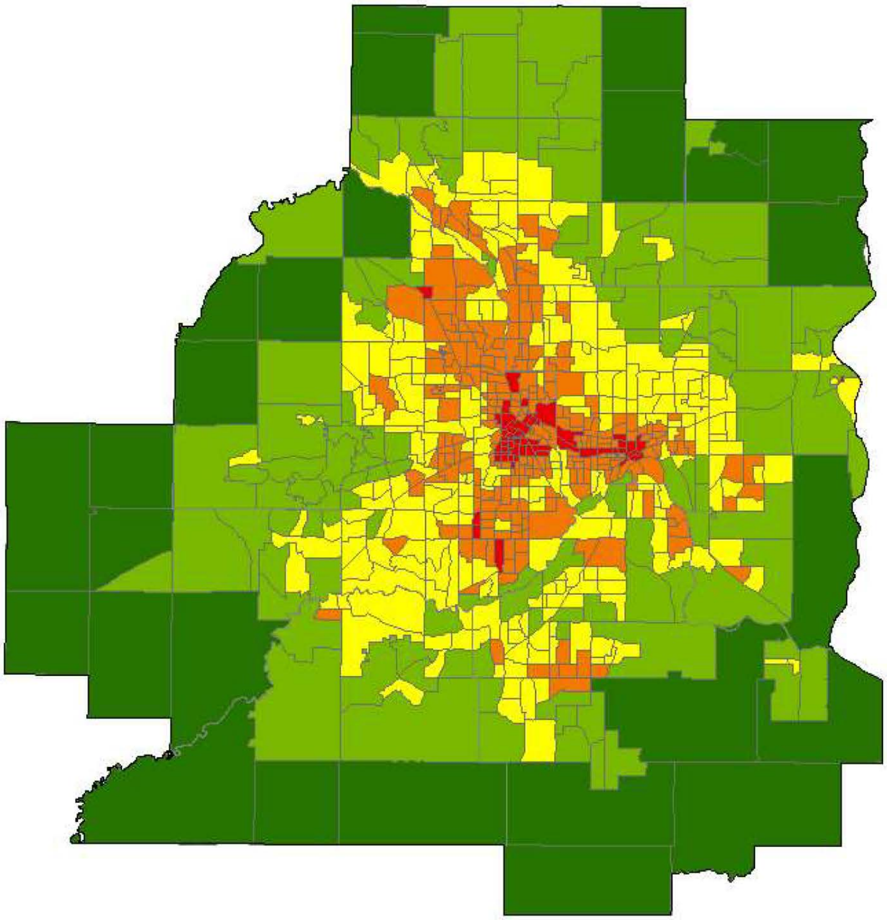
Communities can use the [Extreme Heat Map Tool] to explore impacts of UHI and its relationship to land use and tree canopy. This tool compiles the land surface temperature map, the land use map, and the tree canopy map for the metro area. Using this tool, **you can zoom to your community** and view each of the layers either separately or layered on top of each other. You can adjust the transparency of each layer.

Why is this tool useful?

Examining the unique relationship between land use, canopy, and UHI in your community can help **identify areas that would most benefit** from implementing heat mitigation strategies.

For more detailed information about how to use the Extreme Heat Map tool, view [this how-to guide.]

Extreme Heat & Human Vulnerability



What is this map?

The Heat Hazard Index depicts the land surface temperature from July 22, 2016 normalized to the census tract level. Measuring land surface temperature across census tracts allows for integration of socio-economic data into the analysis, as this data is often collected at the census tract level and can provide some measure of human of human vulnerability to impacts associated with climate change.

Heat Hazard Index

- Very Low
- Low
- Medium
- High
- Very High

Who does extreme heat most affect?

According to the Minnesota Department of Health, certain populations, such as children, the elderly, people with medical conditions, and low income households may be **more vulnerable to the impacts of extreme heat than other populations**. Mitigation strategies can be implemented to offer targeted identification and assistance to members of these populations against UHI effects.

What can be done to protect vulnerable residents?

Cooling Centers

Establishing Cooling Centers can provide vulnerable residents **temporary relief** from extreme heat. Hennepin County has a Cooling Options Map, though some of the locations listed incur an entrance fee. A region-wide map and accepted definition of 'Cooling Center' would assist in providing shelter information to vulnerable populations.

Social Cohesion

Social networks and informal relationships are strengths a community can utilize to combat the impact of extreme heat. Connections between residents can be supported and enhanced by local government assistance. This can ensure that vulnerable residents are contacted, safe, and have what they need **during a heatwave**.

Land Use & Zoning

Permanent changes to the built environment to mitigate extreme heat in the hottest areas will **provide long-term safety to at-risk residents**. Communities can require higher standards for landscaping, tree cover, and cooling materials in industrial and commercial areas that are near residential housing. These actions can help reduce extreme heat and improve air quality for local residents.

What's Next?

Where do communities go from here?

Extreme heat is a grave and often overlooked threat to the health of our region and its residents. **Communities have the power to protect their residents from this threat** by directly addressing the three main contributors to Urban Heat Islands: land use, impervious surface coverage, and tree canopy. Communities can include heat-reducing land use policies in their comprehensive plans and build heat-reduction materials into the built environment. Protecting the region from extreme heat requires proactive planning.

How can extreme heat be better understood?

The **Extreme Heat Map Tool** is a great first step in educating stakeholders and establishing a baseline for the regional context of extreme heat.

Extreme Heat & Human Vulnerability

More research is needed to understand how extreme heat specifically affects our region, what populations are most directly impacted by extreme heat, and how residents may ultimately be affected in the longer term.

Further research could investigate how extreme heat patterns change over several years and during different times of the year. Research could also assess how extreme heat affects population groups throughout the metro area in different ways. By examining how extreme heat relates to demographic factors including income, race, and age, measures can be taken to provide targeted mitigation strategies in the areas where they are most needed.

Scenario Planning

Ideally, our region would benefit from research that assesses how different multijurisdictional strategies can reduce the Twin Cities metro region's UHI. For instance, research could assess future UHI scenarios based on different combinations of strategies. Such research would help streamline efforts to adapt to future extreme heat impacts associated with climate change.