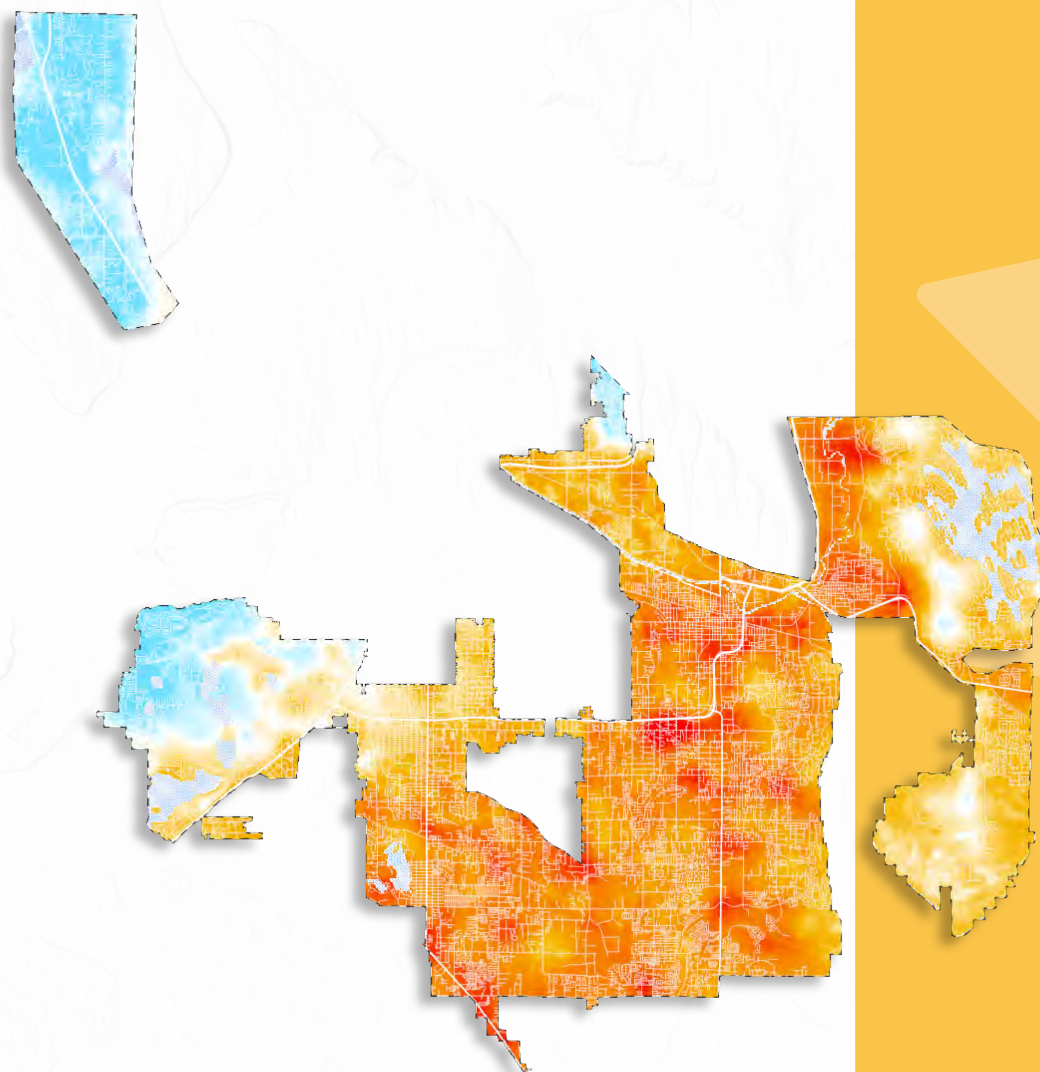
Pierce County
Washington



CAPA strategies

HEAT WATCH Report

Acknowledgements

The CAPA Heat Watch program, equipment, and all related procedures referenced herein are developed through a decade of research and testing with support from national agencies and several universities. Most importantly, these include our partners at the National Integrated Heat Health Information System, the National Oceanic and Atmospheric Administration's (NOAA's) Climate Program Office, and National Weather Service, including local weather forecast offices at each of the campaign sites, The Science Museum of Virginia, and U.S. Forest Service (USDA). Past support has come from Portland State University, the Climate Resilience Fund, and the National Science Foundation. We are deeply grateful to these organizations for their continuing support.

Heat Watch Pierce County was conducted as part of the CAPA-NIHHIS 2024 Heat Mapping Campaign. Learn more about the campaign and this public-private partnership here.

This report was prepared by CAPA Strategies, LLC

September 2024

Table of Contents

Executive Summary

We know that extreme heat is the most deadly of all natural disasters and that its impacts are not evenly distributed across people and places. Location matters. Those who live in historically disinvested neighborhoods, with limited access to resources and greenspace, and those struggling with additional health concerns are all at greater risk when it comes to the impacts of extreme heat. Our infrastructure systems (e.g. energy, transportation) are also at risk, which can further compromise a region's capacity to provide essential cooling resources. Heat Watch provides a new level of detail about where heat is most concentrated across cities, improving on coarse satellite-derived descriptions and better describing the human experience of heat.

Accomplishing this high level of detail and spatial coverage is only made possible by the efforts of campaign organizers and local volunteer data collectors, who co-designed a mobile monitoring study with CAPA to measure heat across the diverse land uses and geographical features of your region. Heat-focused partnerships emerged between local stakeholders like residents, municipal staff, health officials, emergency responders, researchers, and non-profit organizations. Throughout the process, teams learned about the Urban Heat Island (UHI) effect in their area and raised awareness of the issue through training, discussions, and media coverage.

Volunteers at Tacoma Tree Foundation table.

Heat Watch is one step in the journey towards adaptation to extreme heat. By bridging innovations in community climate action, sensor technology, and spatial analytics, together we have achieved two main objectives:

1. Developed high resolution descriptions of the distribution of ambient (air) temperature and humidity (heat index) across your region; and
2. Engaged local communities to create partnerships to better understand and address the inequitable risks posed by extreme heat

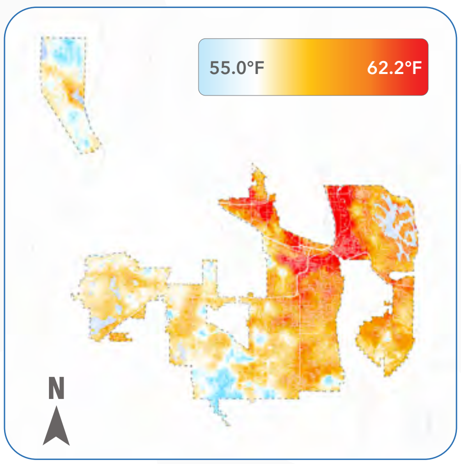
The results provide a snapshot in time of how urban heat varies across neighborhoods and how local landscape features affect temperature and humidity. In this report we present the process, mapping outputs, media coverage and photographs from Heat Watch, as well as next steps for how to build on the results.

Executive Summary

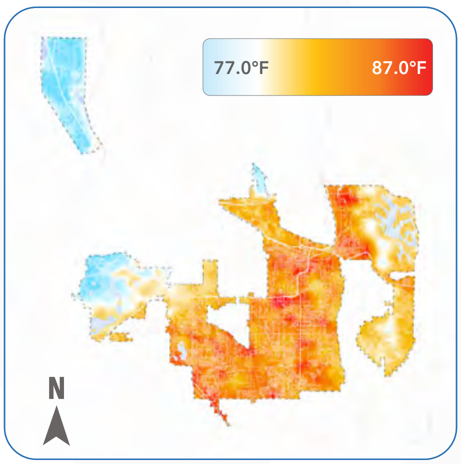
The results presented in this report are the traverse point data – the heat measurements collected by participants – and 'area-wide models' which are generated through analysis of the traverse points and their surrounding landscape features. We focus primarily here on temperature to establish a baseline of the results, while relative humidity and heat index results are available separately.

In reviewing the results, please note that while absolute temperatures (e.g. 94.1°F) are provided, we recommend focusing on the distribution of temperatures (e.g. top 20% hottest areas) within each time period. As temperatures rise, the hottest places are likely to remain the hottest. The report also includes a Frequently Asked Questions section with further detail on the data, models and visuals produced.

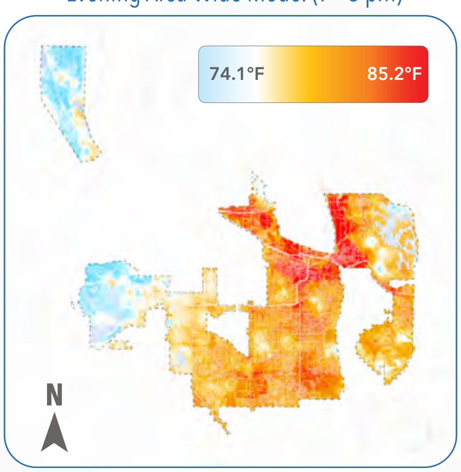
Morning Area-Wide Model (6 - 7 am)



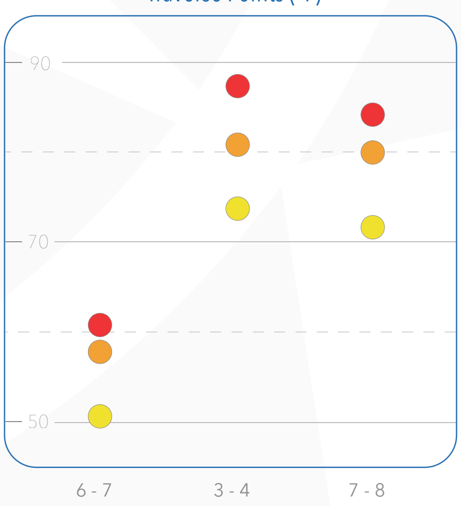
Afternoon Area-Wide Model (3 - 4 pm)



Evening Area-Wide Model (7 - 8 pm)



Traverse Points (°F)



Study Date

August 4th, 2024

157.0 mi²
Study Area

42
Volunteers

16
Routes

123,691
Measurements

88.8°F
Max Traverse Temperature

14.1°F
Max Temperature Differential

HEAT WATCH

Welcome

Congratulations and thank you to all of the organizers and participants of Heat Watch Pierce County! After weeks of planning and coordination, local partners successfully completed their heat mapping campaign by collecting thousands of temperature and humidity data points in the morning, afternoon and evening of a long, hot day on August 4th, 2024. Using this information, CAPA analysts were able to generate highly detailed models of urban heat across the study region and throughout the day.

With this new information, local decision makers will be better equipped to safeguard human life against the growing impacts of extreme heat. Heat Watch serves as an essential part of a broader 'heat planning' framework that provides a comprehensive approach for adaptation to heat. When situated with local contextual information that describes social, physical and economic conditions, Heat Watch data can help to identify people and places at highest risk to extreme heat and drive appropriate intervention strategies and policies.

CAPA Strategies is a team of analysts, planners and social scientists who recognize the need for holistic, data-driven, and equity-focused approaches to climate action. Heat Watch is one tool in a systematic process for identifying risks and advancing actions for local adaptation to our warming planet. Through collaborative and community-based approaches such as this, we envision a more connected, informed and climate resilient region.

Process

CAPA Strategies has developed the Heat Watch campaign process over several iterations, with methods well established through peer-reviewed publications[1], testing, and refinement.

The current campaign model requires leadership by local organizers, who engage community groups, new and existing partner organizations, and the media in generating a dialog about effective solutions for understanding and addressing extreme heat.

CAPA provides training, equipment, and support to the recruited community groups as they endeavor to collect primary temperature and humidity data across a metropolitan region.

The seven main steps of the campaign process are summarized to the right. An overview of the analytical modeling methodology is presented later in this report and described at full length in peer-reviewed publications.

1. Goal Setting

Campaign organizers determine the extent of their mapping effort, prioritizing areas experiencing environmental and social justice inequities. CAPA then divides this study area into routes, each containing a diverse set of land uses and land covers.

2. Engagement

Organizers recruit volunteers, often via non-profits, universities, municipal staff, youth groups, friends, family, and peers. Meanwhile, CAPA designs the data collection routes by incorporating important points of interest such as schools, parks, and community centers.

3. Training

Volunteers attend a training session to learn the why and how of the project, their roles as data collectors, and to share their personal interest in the project. Participants sign a liability and safety waiver, and organizers assign teams to each polygon and route.

4. Activation

With the help of local forecasters, organizers identify a high-heat, clear day (or as near to one as possible) and coordinate with their volunteer teams. Once confirmed, CAPA ships the sensor equipment and bumper magnets to be distributed to campaign participants.

5. Execution

Volunteer teams conduct the heat campaign by driving sensor equipment along pre-planned traverse routes at coordinated hour intervals. Each second the sensors collect a measurement of ambient temperature, humidity, longitude, latitude, speed and course.

6. Analysis

Organizers collect and return the equipment, and CAPA analysts begin cleaning the data, as described in the Mapping Method section below, and utilize machine learning algorithms to create predictive area-wide models of temperature and heat index for each traverse.

7. Implementation

Campaign organizers and participants review the Heat Watch outputs (datasets, maps, and report), and campaign teams meet with CAPA to discuss the results and next steps for addressing the distribution of extreme heat in their community.

[1] The most relevant and recent publications to the Heat Watch campaign process include:

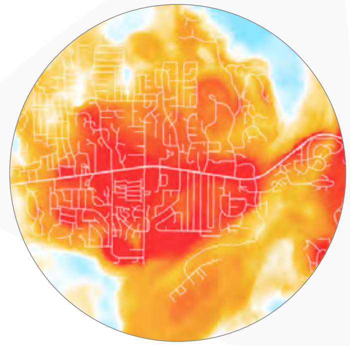
Shandas, V., Voelkel, J., Williams, J., & Hoffman, J., (2019). Integrating Satellite and Ground Measurements for Predicting Locations of Extreme Urban Heat. Climate, 7(1), 5. https://doi.org/10.3390/cli7010005

Voelkel, J., & Shandas, V. (2017). Towards Systematic Prediction of Urban Heat Islands: Grounding Measurements, Assessing Modeling Techniques. Climate, 5(2), 41. https://doi.org/10.3390/cli5020041

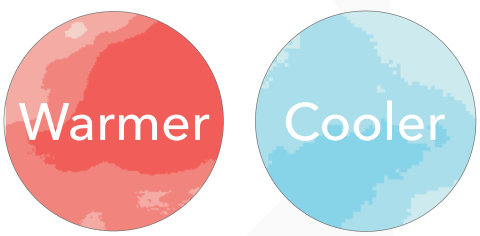
About The Maps

The following sections present results from the campaign: traverse point measurements and area-wide models at morning, afternoon and evening. Below are several key details to keep in mind as you view the results.

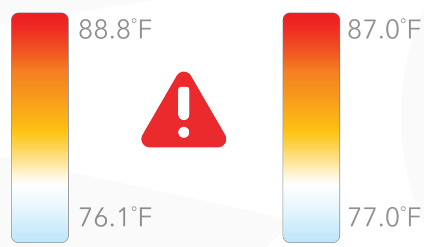
Traverse point maps present the near-surface air temperature measurements gathered during the campaign, filtered to usable data for modeling.



Area-wide maps present high resolution models of temperature across the study area based on the traverse points and Sentinel-2 spectral imagery.



The data are classified by natural breaks in order to clearly illustrate the variation between warmer (red) and cooler (blue) areas across the map.



Note that the scales are different between the traverse point and area-wide maps due to the predictive modeling process.

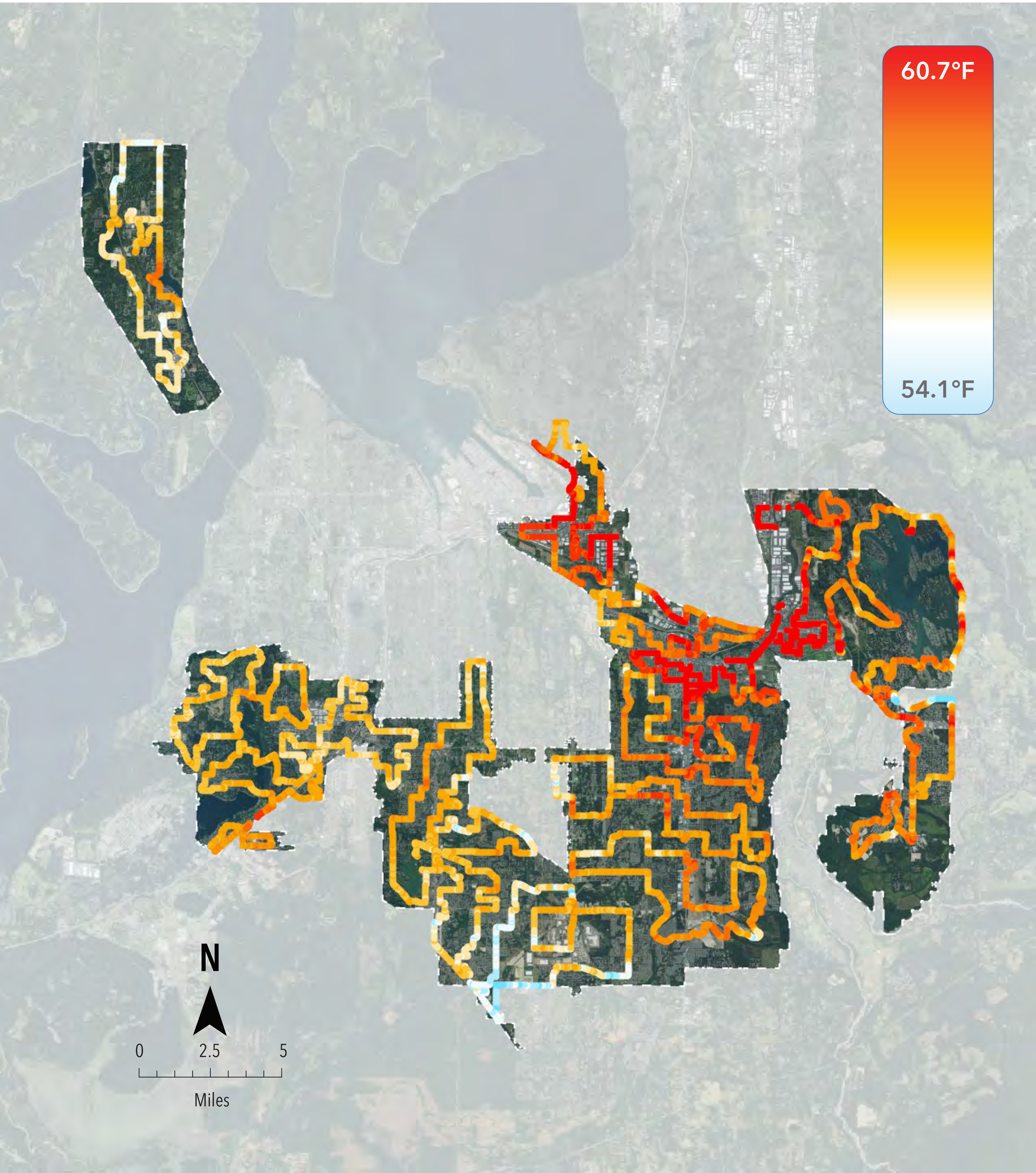
How does your own experience with heat in these areas align with the map?

Find your home, place of work, or favorite park on the maps and compare the heat throughout the day to your personal experience.

What about the landscape (trees, concrete buildings, riverside walkway) do you think might be influencing the heat in this area?

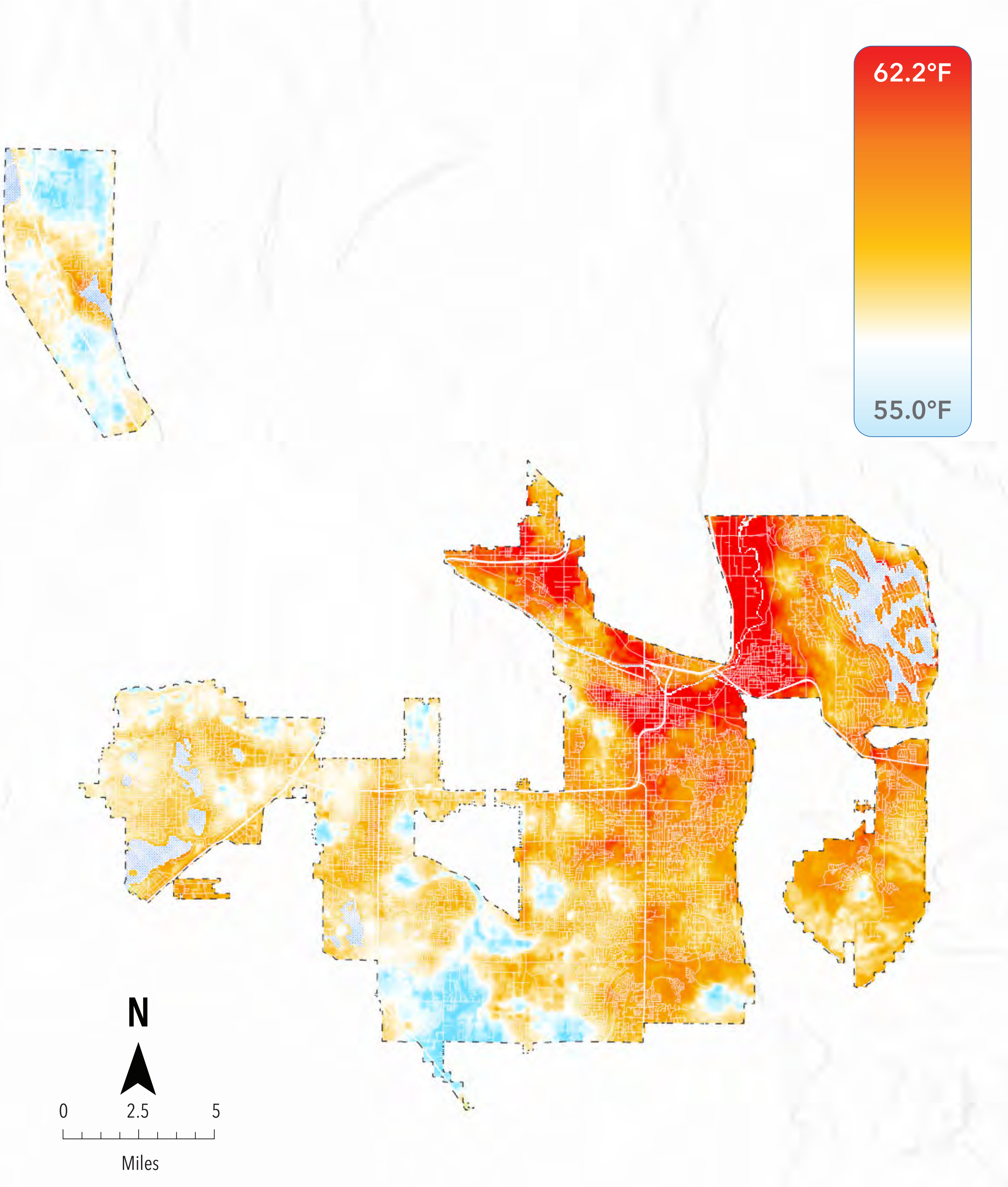
Morning Traverse Points

Temperature (6 - 7 am)



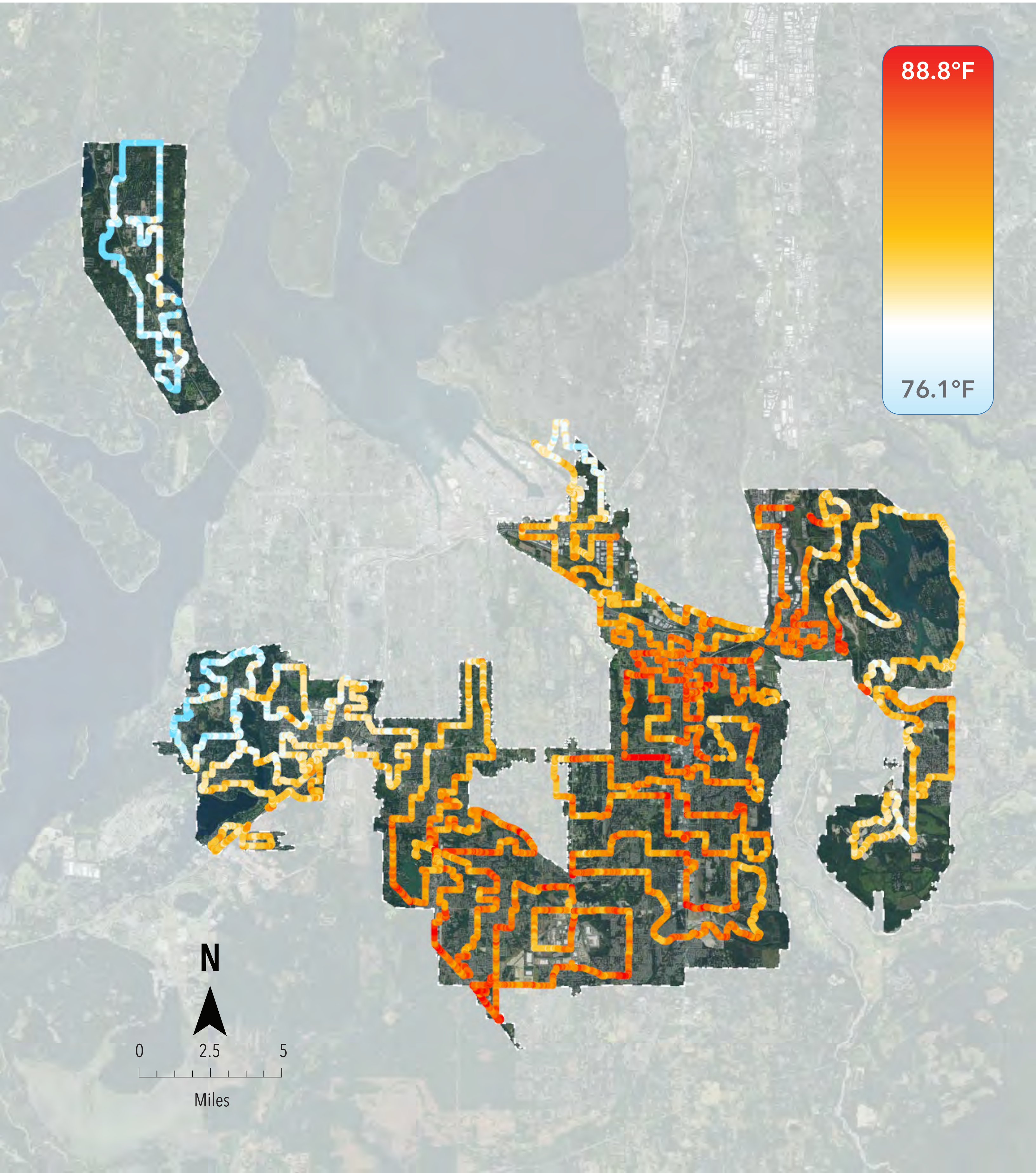
Morning Area-Wide Model

Temperature (6 - 7 am)



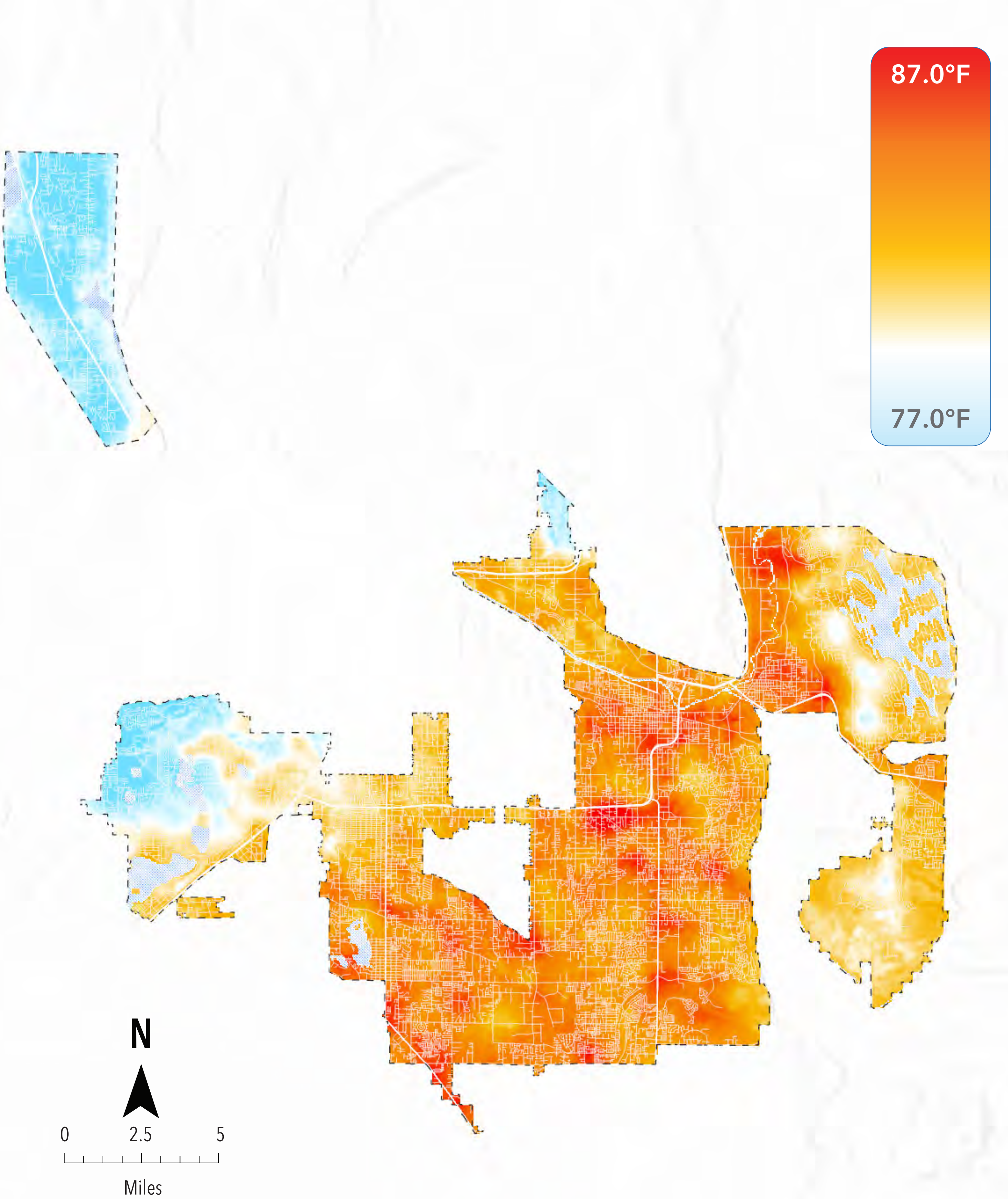
Afternoon Traverse Points

Temperature (3 - 4 pm)



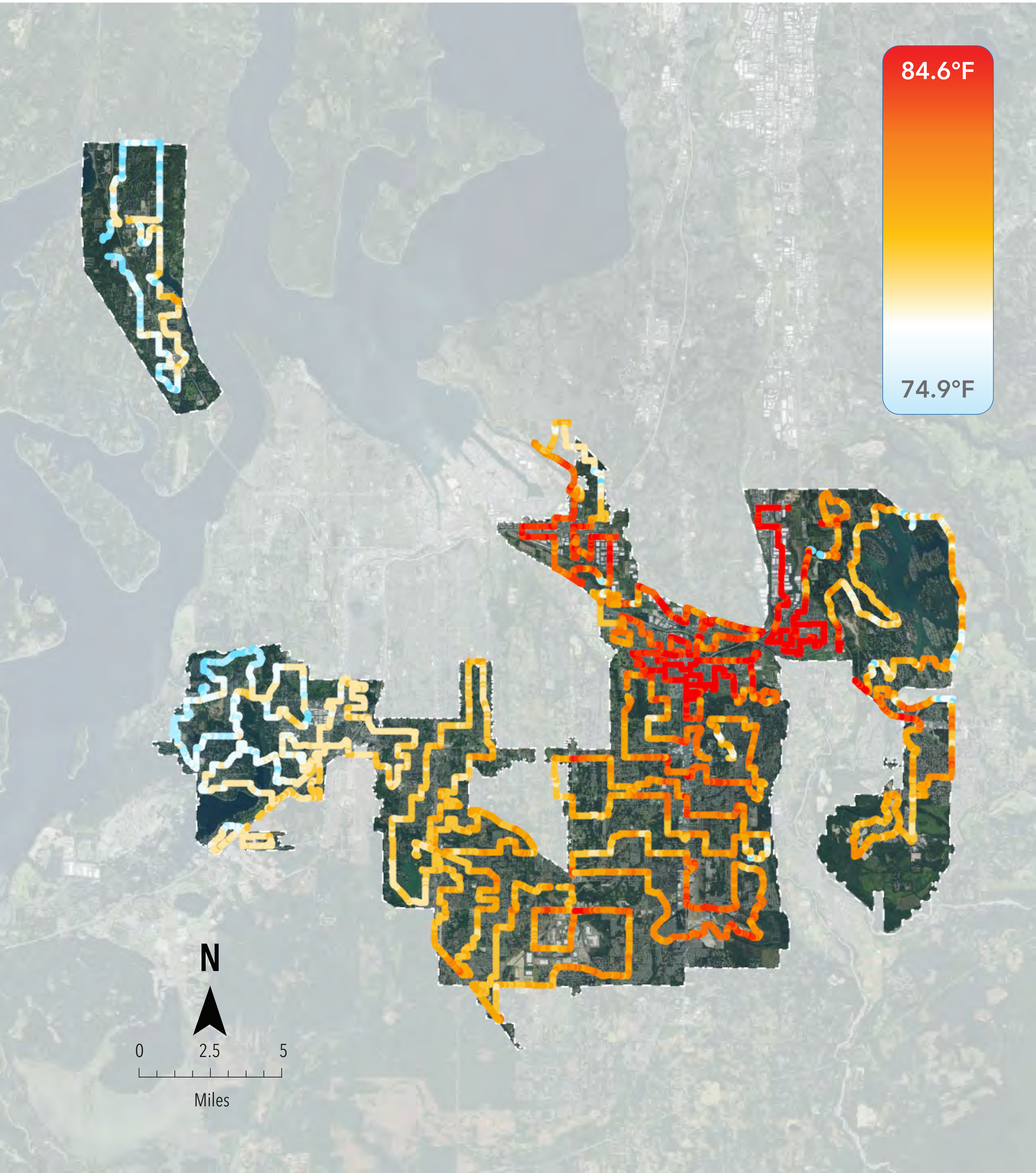
Afternoon Area-Wide Model

Temperature (3 - 4 pm)



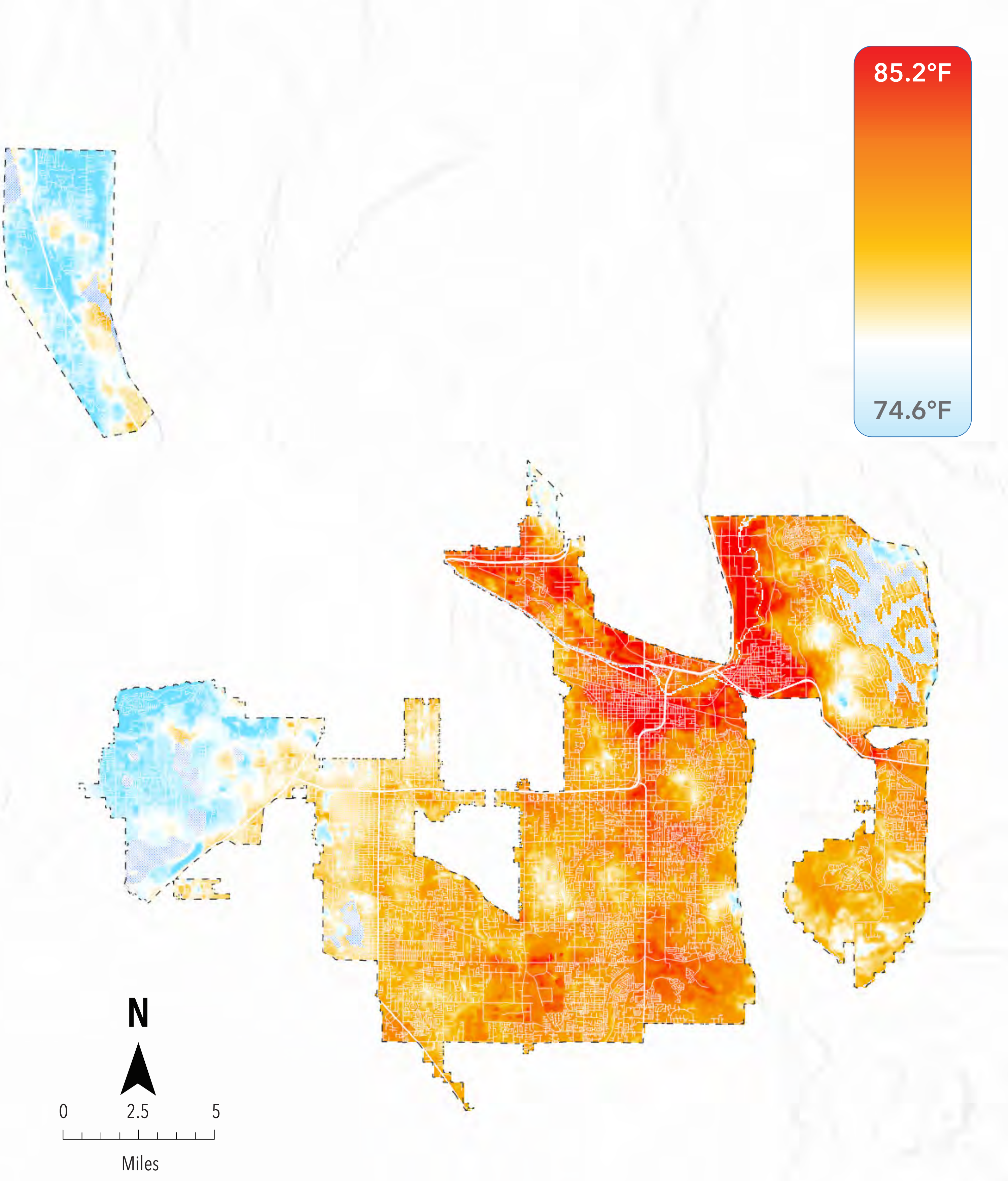
Evening Traverse Points

Temperature (7 - 8 pm)



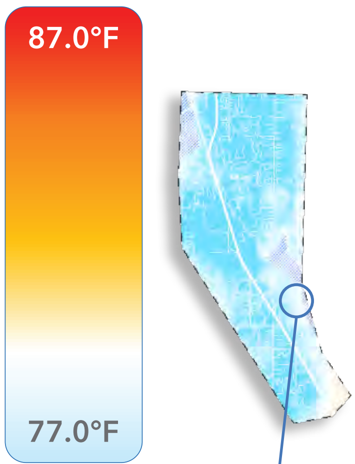
Evening Area-Wide Model

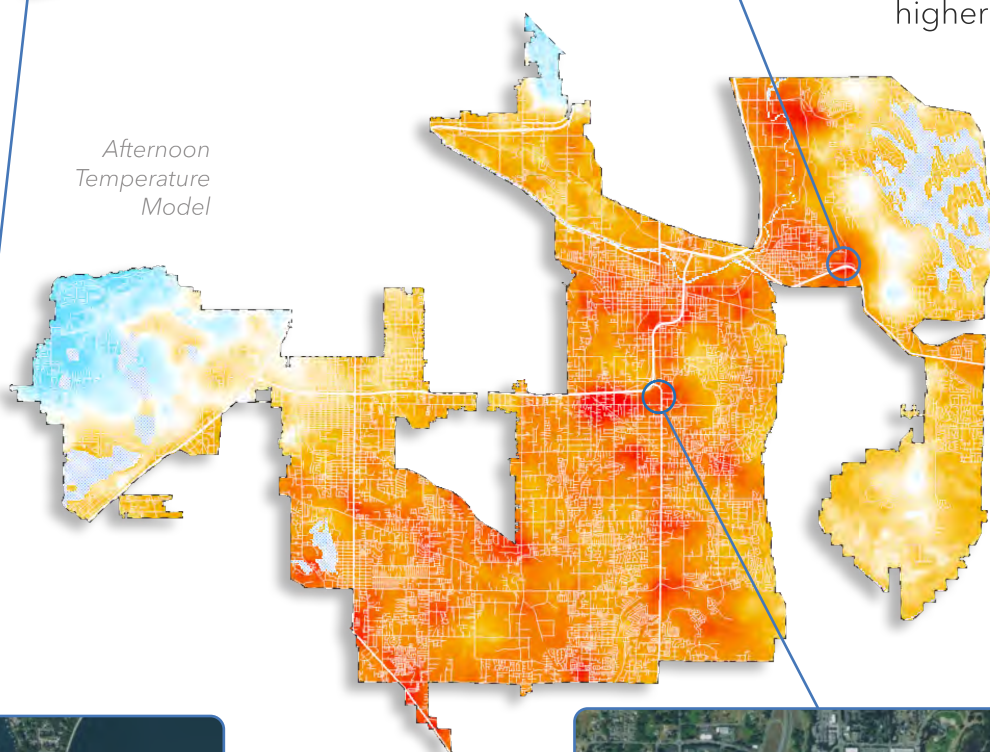
Temperature (7 - 8 pm)



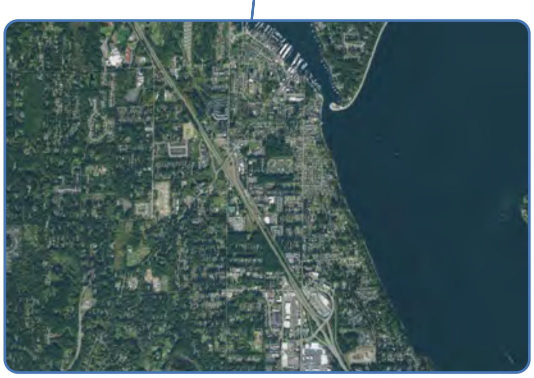
Initial Observations

The distribution of heat across a region often varies by qualities of the land and its use. Here are several observations of how this phenomenon may be occurring in your region.





Areas with industrial land uses seem to create pockets of higher temperatures.



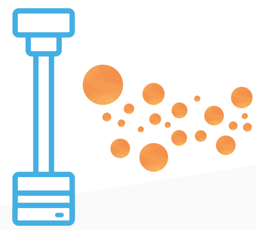
The presence of street trees and proximity to water can serve to alleviate heat in dense urban areas.

Built-up urban areas appear to concentrate heat throughout the day and evening time.

Modeling Method

The three key steps and geospatial processes that allow CAPA analysts to transform traverse point data into area-wide models of temperature.

1 Download & Filter

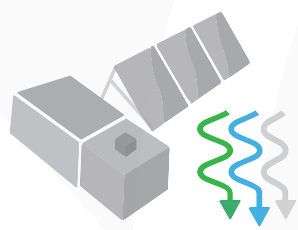


Download raw heat data from cloud storage

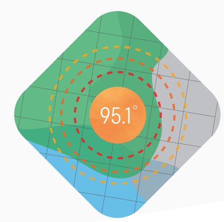
Compare data with field notes and debrief interview

Trim data to proper time window, speed, and study area

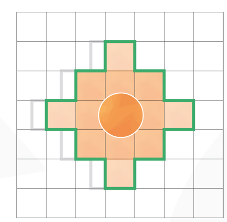
2 Integrate & Analyze



Download multi-band land cover rasters from Sentinel-2 satellite

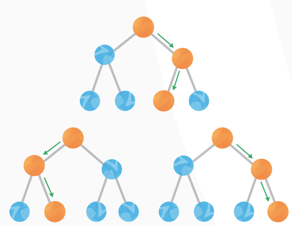


Calculate spectral indices reflecting land cover features

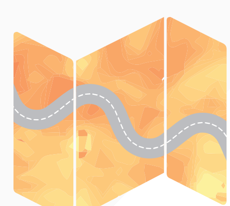


Transform land cover rasters using a moving window analysis

3 Predict & Validate



Combine heat and land cover data in geostatistical model



Create predictive raster surface models of each period

Perform cross validation using k-fold holdout method

The most relevant and recent publications include:

Shandas, V., Voelkel, J., Williams, J., & Hoffman, J., (2019). Integrating Satellite and Ground Measurements for Predicting Locations of Extreme Urban Heat. Climate, 7(1), 5. https://doi.org/10.3390/cli7010005

Voelkel, J., & Shandas, V. (2017). Towards Systematic Prediction of Urban Heat Islands: Grounding Measurements, Assessing Modeling Techniques. Climate, 5(2), 41. https://doi.org/10.3390/cli5020041

Technical Notes

Comments on the process, outputs and evaluation of the modeling process

Accuracy Assessment*	
Model Period	Adjusted R-Squared
6 - 7 am	0.95
3 - 4 pm	0.86
7 - 8 pm	0.94

Accuracy Assessment

To assess the strength of our predictive temperature models, we employ a 70:30 "holdout cross-validation method," which consists of predicting 30% of the data with the remaining 70%, selected randomly. An 'Adjusted R-Squared' value of 1.0 is perfect predictability, and 0 is total lack of prediction. Additional information on this technique can be found at the following reference: Voelkel, J., and V Shandas, 2017. Towards Systematic Prediction of Urban Heat Islands: Grounding measurements, assessing modeling techniques. Climate 5(2): 41.

Field Data

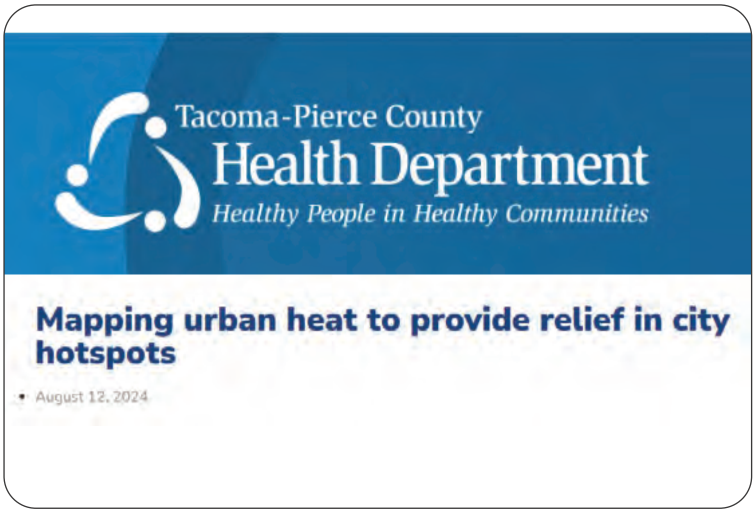
Like all field campaigns, the collection of temperature and humidity data requires adherence to a specific set of protocols and experimental controls. In the event that unreported or undetected error is introduced during the data collection process, the accuracy of the resulting datasets and models may be compromised in quality. While our team has a developed a multi-stage process for quality assurance and quality control (outlier removal), some errors can go unidentified and undetected, and thereby compromise the accuracy of the results. We suggest keeping this nature of field data collection in mind when reviewing the results.

Prediction Areas

The traverse points used to generate the areas wide models do not cover every square mile of the studied area -- rather, we take a sampling approach to gather representative measurements across the diversity of land-use, land-cover, and biophysical attributes of each study area. We suggest keeping this sampling and modeling approach in mind when reviewing the results.

Media

Participant photos and news stories covering the campaign


Tacoma-Pierce County
Health Department
Healthy People in Healthy Communities

Mapping urban heat to provide relief in city hotspots

- August 12, 2024


Tacoma Tree Foundation

This summer, Pierce County is doing a community heat-mapping project that will bring together local cities, organizations, and volunteers to produce heat maps.

PIERCE COUNTY IS SO HOT RIGHT NOW!

Media

Participant photos and news stories covering the campaign

Next Steps

Heat Watch data provides new and valuable descriptions of how heat is distributed across your city or region. With these new datasets in-hand, there are several short- and long-term next steps you can follow to build upon this work. We first suggest validating the information with local stakeholders, generating interpretations and meanings through further analysis, and/or employing the data across a myriad of applications for heat mitigation and heat preparedness. Consider how different communities and sectors are affected by these results. The collaboration between partners and volunteers who planned and conducted the campaign may also serve as a strong network for future efforts on heat.

Using GIS software you may investigate relationships between heat and the built environment using land use, canopy cover and impervious surface data; assess social vulnerability factors like age and income; and calculate impacts in specific sectors such as energy and public housing. The data may guide you in identifying priority areas for tree planting, planning resilience hubs in high-need areas, or understanding how much heat is present along transportation routes to schools. Such questions and many others can all be better addressed using the high resolution ambient descriptions provided by Heat Watch data.

These new datasets may also prompt and support further research needs into the intersection of heat with overlapping natural hazards like air quality as well as the indoor experience of residents during heat waves, and future projections of heat based on models of emissions levels and climate change. We know that increased temperatures will also lead to increased energy use and grid vulnerability. In fact, nearly all sectors of urban life are likely to be affected by rising temperatures and at inequitable rates of impact to our cities' populations.

Heat Action Plan

A significant longer-term application of Heat Watch results is building out a comprehensive and systematic approach to address the many physical, social and economic threats of extreme heat facing your communities. Developing a "Heat Action Plan" is essential for situating heat data within current conditions and stakeholder interests, defining local risk to extreme heat, and assembling actionable and place-based intervention strategies.

Next Steps

As plans can be complex documents requiring technical subject expertise, CAPA aims to support cities with an accessible Heat Action Plan product. This plan builds on Heat Watch data, synthesizes existing local plans, policies, and climate projections, collects social data from local communities, sets priorities, and offers recommendations for heat action at citywide and neighborhood levels. We capture baseline information about exposure, context, and potential risk, while revealing directions for deeper research, analysis, and strategy development. As a comprehensive document, CAPA's Heat Action Plan may serve as the central point of guidance and evaluation of progress towards local resilience to heat.

TABLE OF CONTENTS

We are thrilled to be a part of your path towards heat resilience and look forward to continuing to build a better prepared and more climate-responsive world together!

CAPA

HEAT WATCH

Frequently Asked Questions (FAQ)

A. Data and Access

A1. How can I access the data from Heat Watch?

All Heat Watch data (traverses, models and metadata) are available on the Open Science Framework (OSF). When first delivered to campaign leaders, the OSF page is provided as a view-only link; once the results are approved by the local team, CAPA will update the OSF page to be publicly accessible. All Heat Watch data, this summary report, and metadata will then be available for download and use by the public.

A2. In what format are the data provided?

The traverse point data from each time period (morning, afternoon and evening) are provided as vector shapefiles.The models from each time period are provided as geo-tiff rasters at 10-meter resolution. In order to view and manipulate these data, GIS software is needed.

A3. What is the accuracy of the traverse point temperature measurements?

The Heat Watch sensor includes a temperature probe that is accurate to ±0.5°F. The response time (the amount of time it takes for the sensor to accurately measure a change in temperature) is 1 second.

B. Relative Humidity and Heat Index

B1. Where are the relative humidity and heat index results, and why are only the temperature results displayed in this report?

The relative humidity measurements and heat index calculations are provided in the traverse shapefiles for each time period; heat index models are provided with the rasters. We focus on temperature data in the report because it is the most plainly understood variable and based more on direct measurements of the environment. Temperature then provides the basis for incorporating relative humidity to calculate heat index.

B2. What is the accuracy of the relative humidity measurements?

The accuracy of the relative humidity sensor is ±3%.

Frequently Asked Questions (FAQ)

B3. What is heat index and how is it calculated?

Heat index is an approximation of the heat felt when the presence of humidity is felt in combination with temperature. We calculate heat index by combining the measured traverse point temperature with its corresponding relative humidity measurement using the same equations as advised by the National Weather Service. Note that there are multiple ways of calculating heat index at various thresholds. To learn more, visit https://www.weather.gov/safety/heat-index.

B4. Where can the relative humidity and heat index data be accessed?

All results are available through OSF, and the relative humidity and heat index data can be viewed and manipulated using GIS software.

C. Maps and Visualization

C1. How can I visualize the data and make maps similar to the report?

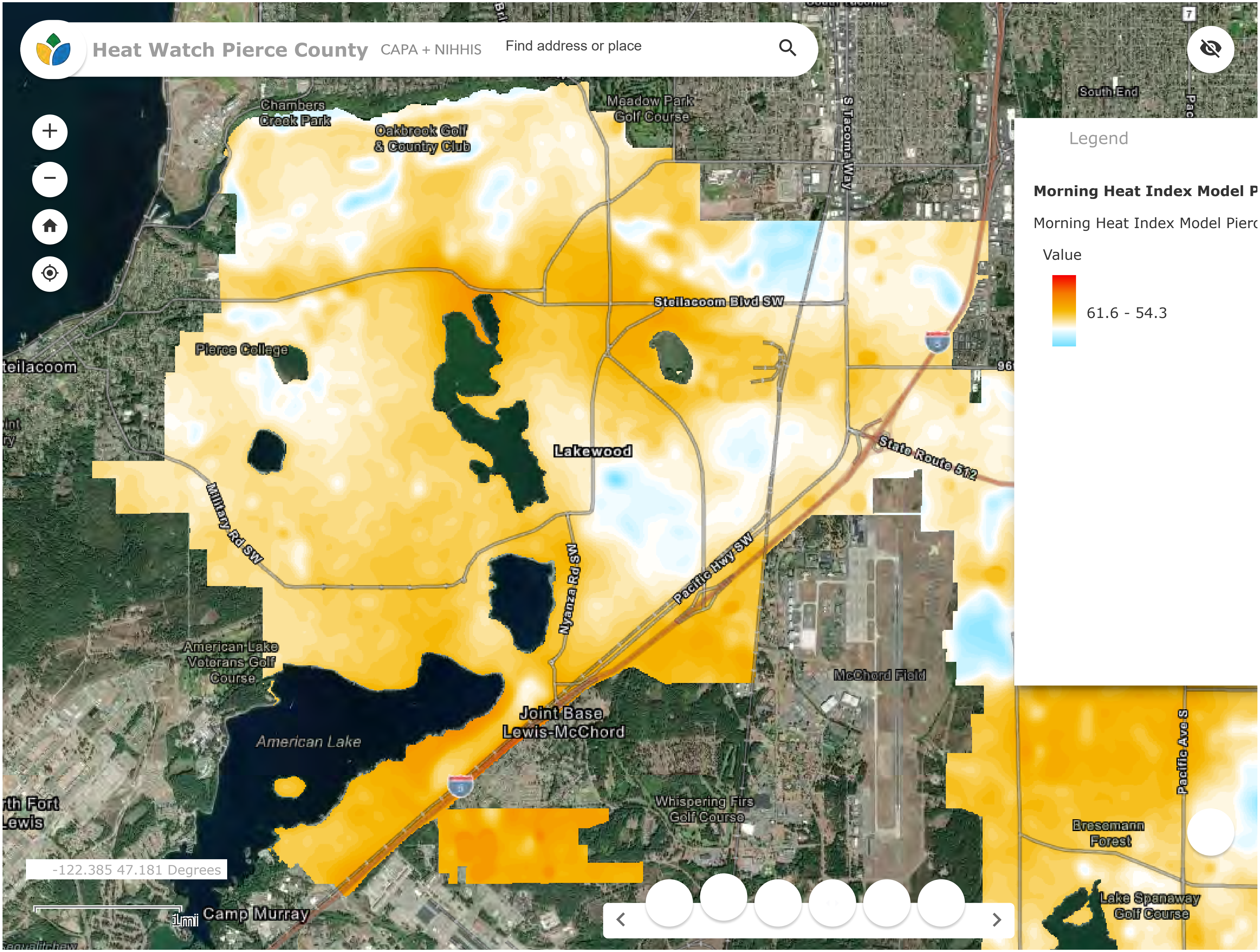
You can extract and print any map from this pdf report to use in media and other products. If you wish to visualize the data in similar style (colors, breaks, etc.) using a GIS tool, please see the CAPA Heat Watch Style Guide.

C2. Why do the maps show the temperature range of just that period (e.g. morning minimum temperature to morning maximum temperature), instead of the entire day (i.e. overall minimum to overall maximum)? Wouldn't this allow better visualization of how heat shifts throughout the day?

The temperature range of each time period is used in order to emphasize the distribution of heat within that specific time period. While the data can be visualized differently with the range from the entire day, the differences across the area then become much less apparent in the maps.

C3. Why are the ranges between traverses and models slightly different?

You may notice that for instance the maximum temperature in a traverse point dataset is 94.1°F, whereas the maximum temperature from its corresponding area-wide model is 94.5°F. The reason for this slight discrepancy is inherent to predictive modeling – all models introduce some degree of uncertainty and error. The best-fit model consists of many input variables that may produce a slightly higher or lower prediction of temperatures than measured by the traverses.


Heat Watch Pierce County
CAPA + NIHHIS
Find address or place
Legend
Morning Heat Index Model P
Morning Heat Index Model Pierc
Value
61.6 - 54.3
Chambers Creek Park
Oakbrook Golf & Country Club
Meadow Park Golf Course
S Tacoma Way
South End
Steilacoom Blvd SW
Pierce College
Lakewood
State Route 512
Military Rd SW
Nyanza Rd SW
Pacific Hwy SW
American Lake Veterans Golf Course
American Lake
Joint Base Lewis-McChord
McChord Field
Whispering Firs Golf Course
Pacific Ave S
Bresemann Forest
Lake Spanaway Golf Course
Camp Murray
-122.385 47.181 Degrees
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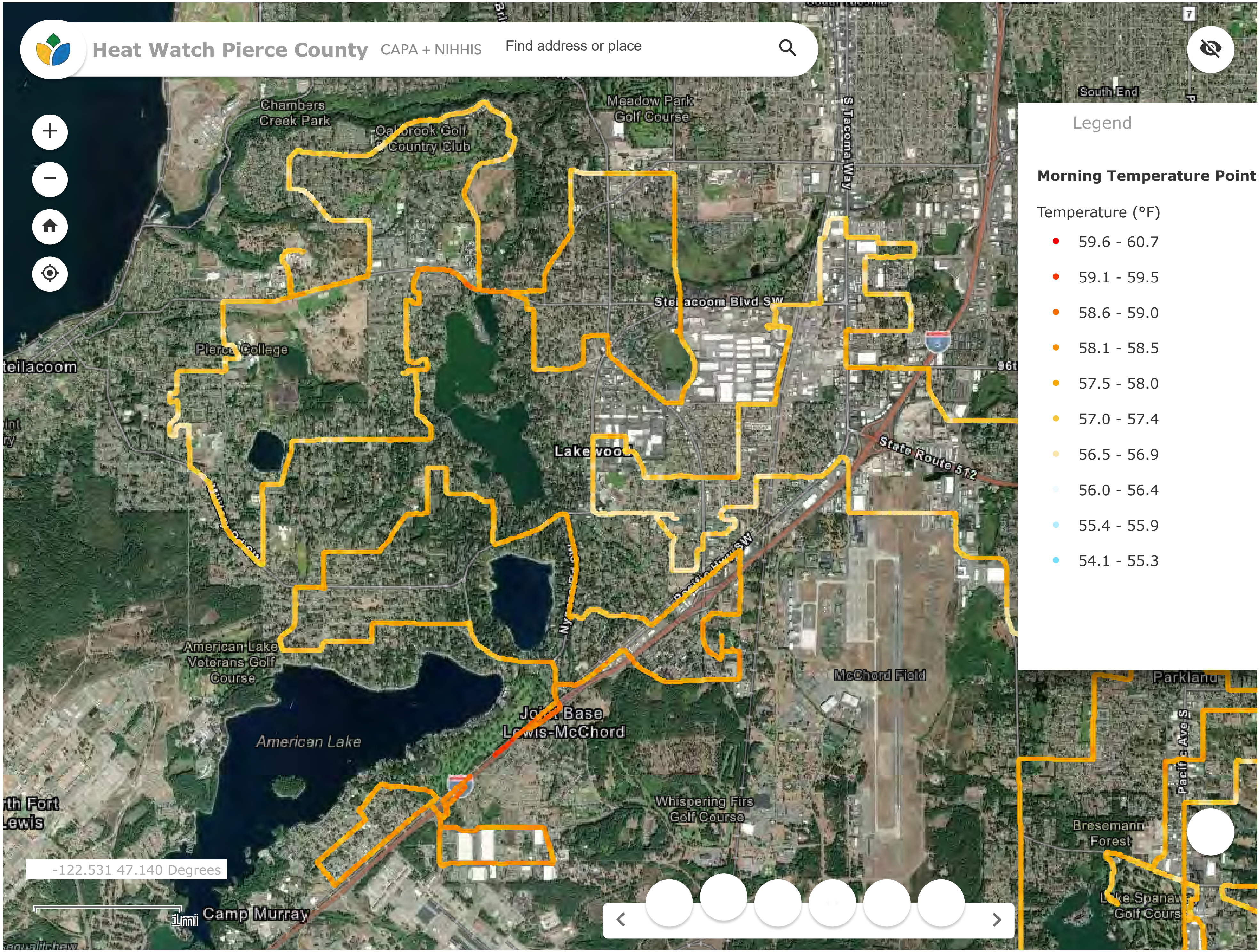
Heat Watch Pierce County
CAPA + NIHHIS
Find address or place
Legend
Morning Temperature Point
Temperature (°F)
59.6 - 60.7
59.1 - 59.5
58.6 - 59.0
58.1 - 58.5
57.5 - 58.0
57.0 - 57.4
56.5 - 56.9
56.0 - 56.4
55.4 - 55.9
54.1 - 55.3
Chambers Creek Park
Meadow Park Golf Course
Pierce College
Lakewood
Steilacoom Blvd SW
S Tacoma Way
State Route 512
American Lake Veterans Golf Course
American Lake
Joint Base Lewis-McChord
McChord Field
Whispering Firs Golf Course
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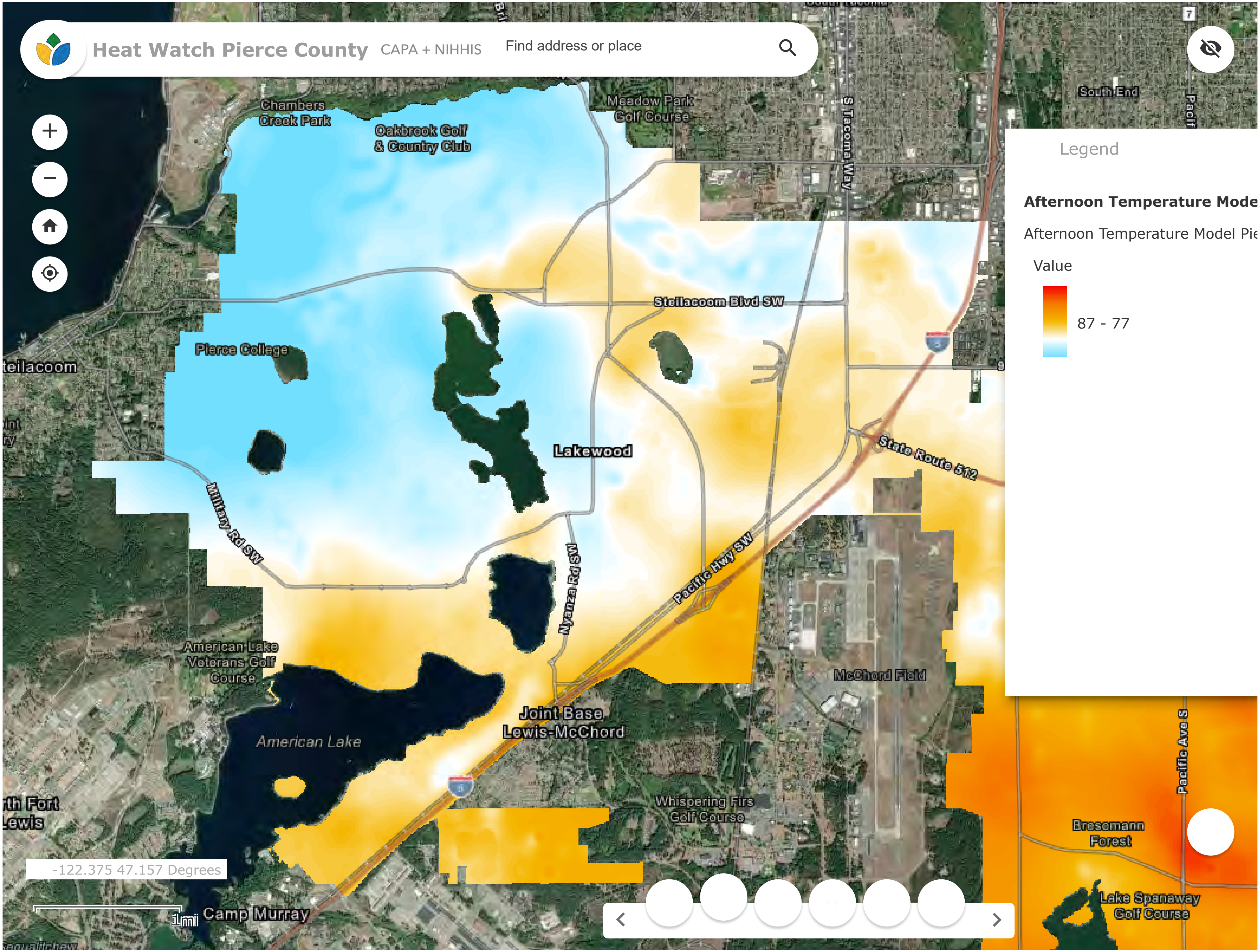
Heat Watch Pierce County
CAPA + NIHHIS
Find address or place
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Afternoon Temperature Mode
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87 - 77
Chambers Creek Park
Oakbrook Golf & Country Club
Meadow Park Golf Course
South End
S Tacoma Way
Steilacoom Blvd SW
Pierce College
teilacoom
Lakewood
State Route 512
Military Rd SW
Nyanza Rd SW
Pacific Hwy SW
American Lake Veterans Golf Course
Joint Base Lewis-McChord
McChord Field
American Lake
Whispering Firs Golf Course
Bresemann Forest
Pacific Ave S
Lake Spanaway Golf Course
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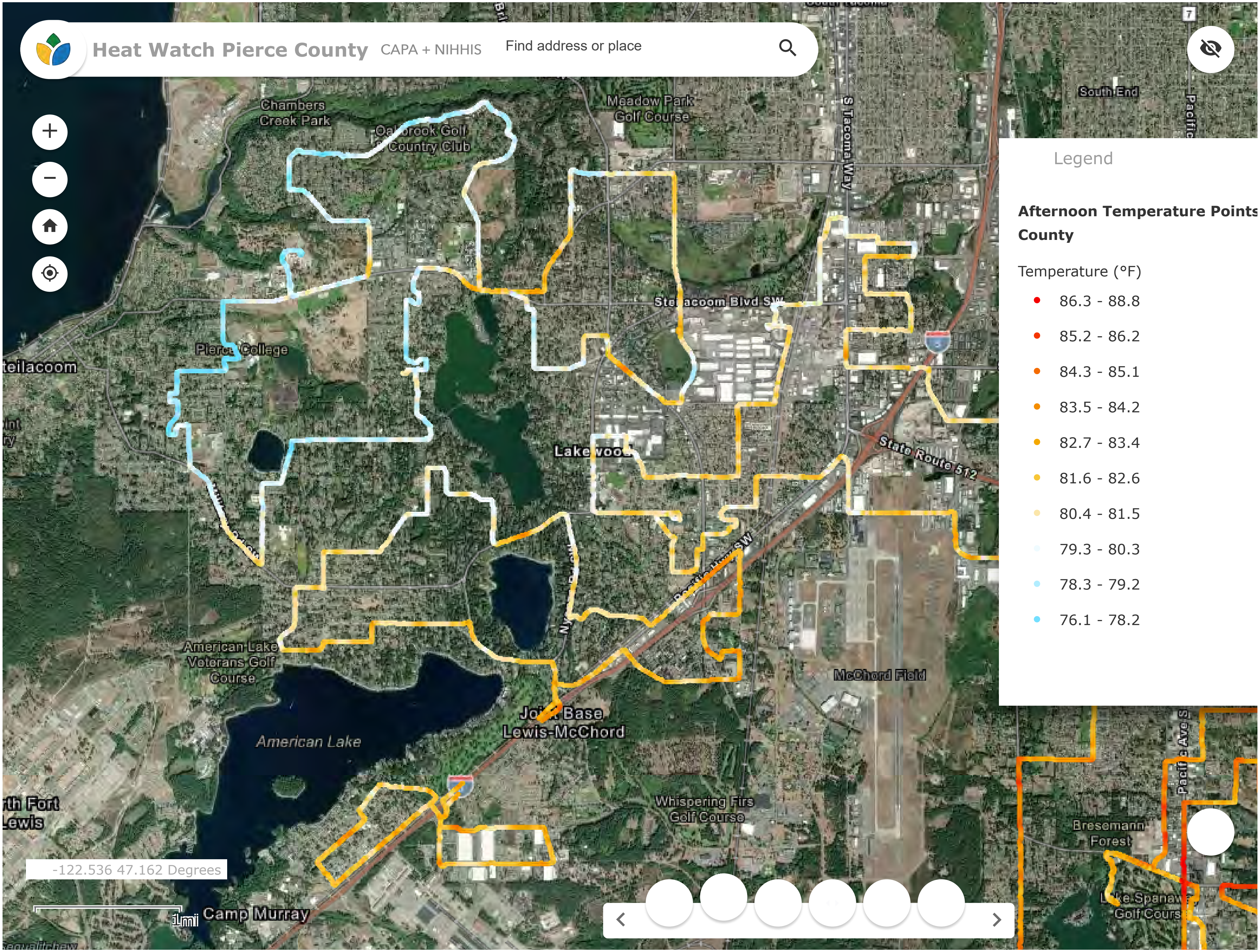
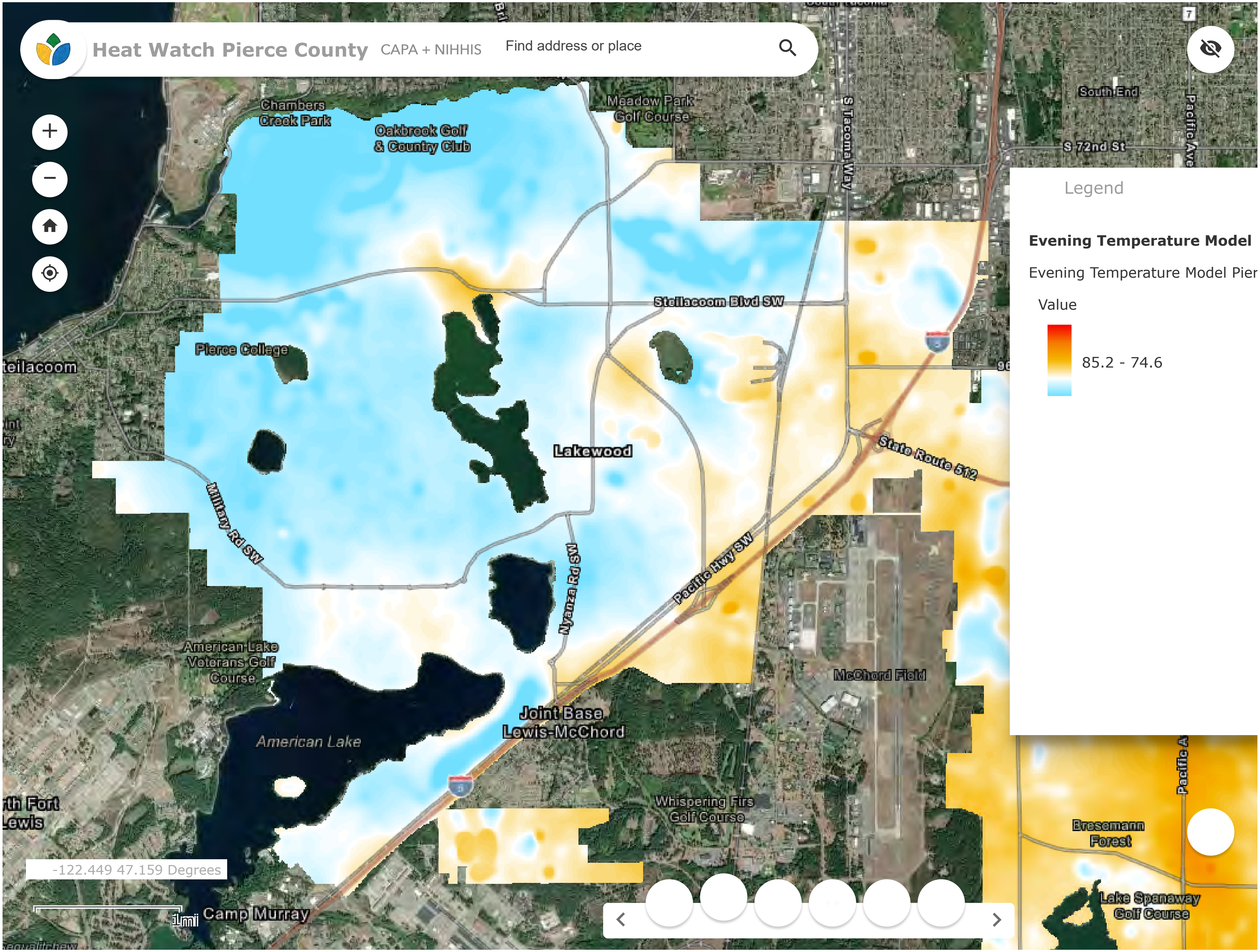
1mi
Camp Murray


Heat Watch Pierce County
CAPA + NIHHIS
Find address or place
Legend
Afternoon Temperature Points County
Temperature (°F)
86.3 - 88.8
85.2 - 86.2
84.3 - 85.1
83.5 - 84.2
82.7 - 83.4
81.6 - 82.6
80.4 - 81.5
79.3 - 80.3
78.3 - 79.2
76.1 - 78.2
Chambers Creek Park
Meadow Park Golf Course
South End
S Tacoma Way
Pierce College
Lakewood
State Route 512
American Lake Veterans Golf Course
American Lake
Joint Base Lewis-McChord
McChord Field
Whispering Firs Golf Course
Bresemann Forest
Camp Murray
-122.536 47.162 Degrees
1mi


Heat Watch Pierce County
CAPA + NIHHIS
Find address or place
Legend
Evening Temperature Model
Evening Temperature Model Pier
Value
85.2 - 74.6
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Oakbrook Golf & Country Club
Meadow Park Golf Course
S Tacoma Way
South End
S 72nd St
Pacific Ave
Steilacoom Blvd SW
Pierce College
Lakewood
State Route 512
Military Rd SW
Nyanza Rd SW
Pacific Hwy SW
American Lake Veterans Golf Course
McChord Field
Joint Base Lewis-McChord
American Lake
Whispering Firs Golf Course
Bresemann Forest
Lake Spanaway Golf Course
Camp Murray
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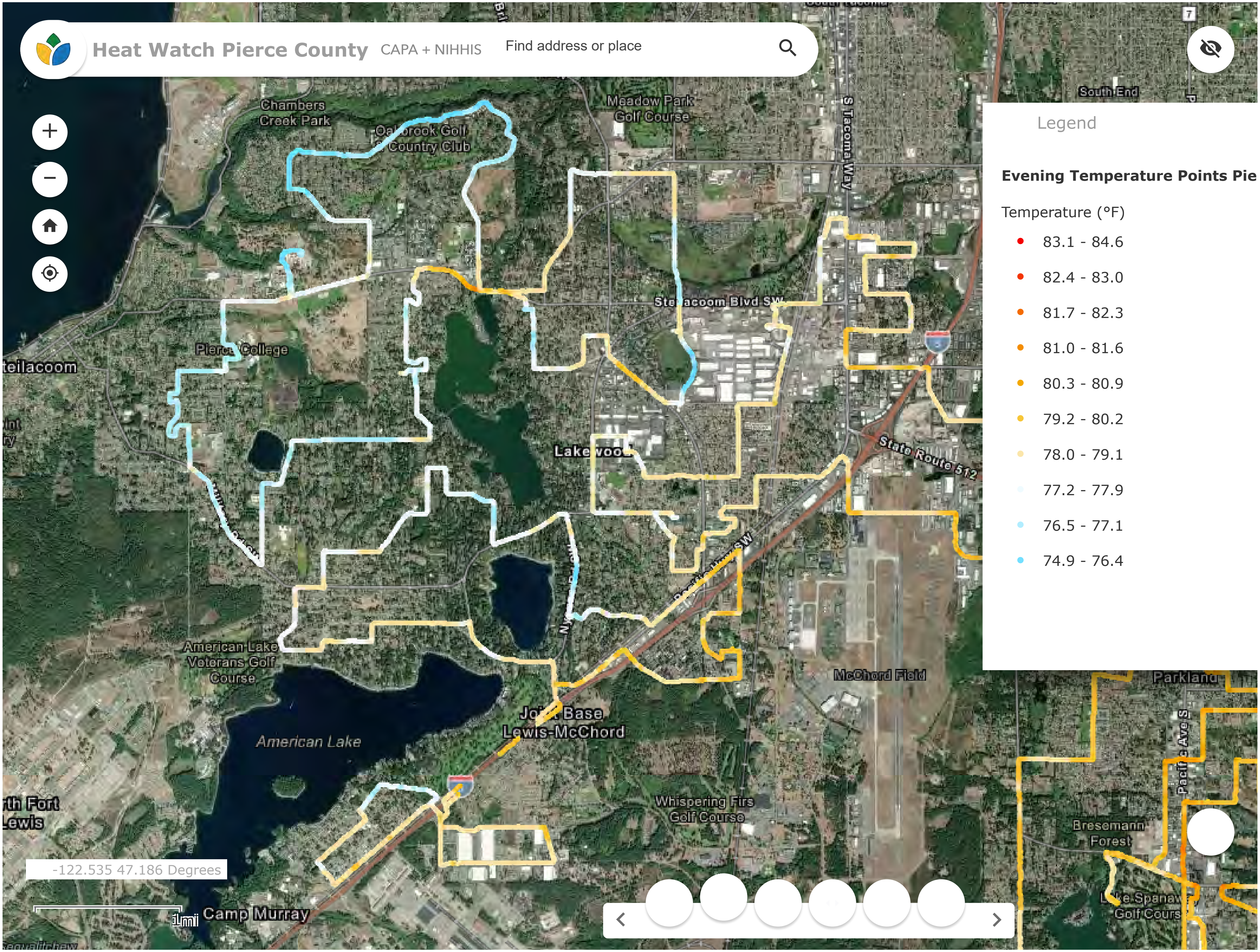
1mi


Heat Watch Pierce County
CAPA + NIHHIS
Find address or place
Legend
Evening Temperature Points Pie
Temperature (°F)
83.1 - 84.6
82.4 - 83.0
81.7 - 82.3
81.0 - 81.6
80.3 - 80.9
79.2 - 80.2
78.0 - 79.1
77.2 - 77.9
76.5 - 77.1
74.9 - 76.4
Chambers Creek Park
Meadow Park Golf Course
South End
S Tacoma Way
Steilacoom Blvd SW
Pierce College
Lakewood
State Route 512
American Lake Veterans Golf Course
American Lake
Joint Base Lewis-McChord
McChord Field
Parkland
Whispering Firs Golf Course
Bresemann Forest
Camp Murray
-122.535 47.186 Degrees
1mi

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Canopy Analysis

Summary Report

by CAPA

Table of Contents

Introduction

Over the summer of 2024, Pierce County community members collected tens of thousands of heat measurements across select areas of the County with the mobile mapping program, CAPA Heat Watch. Results from this campaign provide new hazard descriptions of air temperature and heat index across the City at high resolution, improving on coarse descriptions of land surface temperature. In this analysis, we assess the relationships between these heat data and descriptions of key land cover characteristics, specifically canopy cover and impervious surfaces, to better understand which areas are more and less exposed to extreme heat and identify relevant solutions. We examine relationships using high resolution land cover data across two scales: the area-wide Pierce County study area, and eight sub-areas identified by the Puget Sound Regional Council's Urban Regional Geographies dataset. For each scale we provide a description of methods, data visualizations, and initial interpretations of results, as well as recommendations of how to leverage each data product towards targeted heat mitigation and adaptation actions.

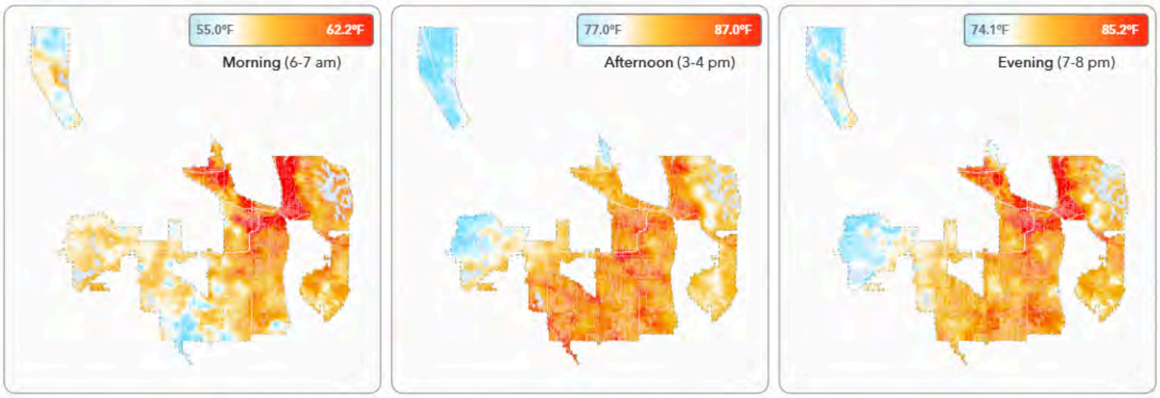
Delivered alongside this report are several spatial data products, including the localized heat data as well as corresponding datasets for area-wide and sub-area results. These data products are available **here.**

Data Sources & Methods

Localized Heat

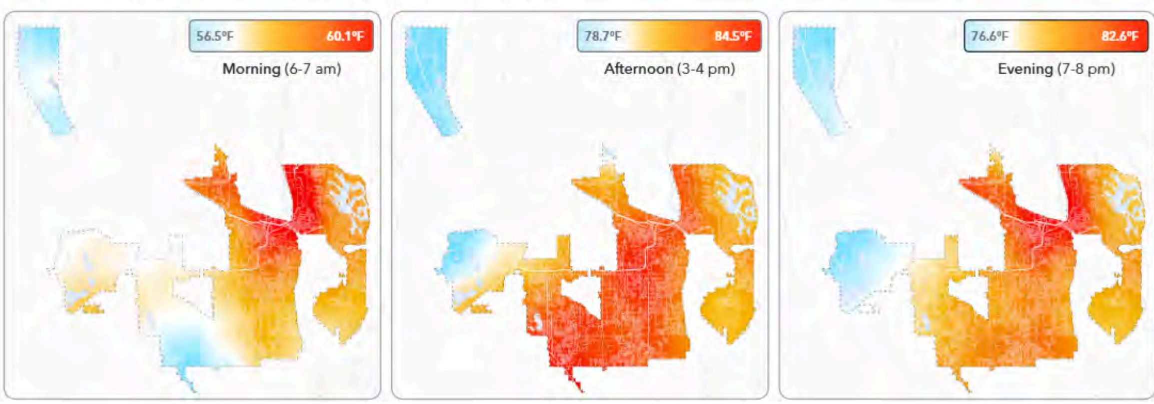
Heat Watch data describes the distribution of air temperatures at one to two meters above the ground across the Pierce County study area during typical urban heat island conditions. The data was collected by sensors mounted to passenger vehicles that traversed through a variety of land uses and land covers across the study area at simultaneous periods during the morning, afternoon and evening. Using the data, area-wide models of air temperature distribution were generated for the three time periods by integrating land cover imagery from the Sentinel-2 satellite in a machine learning process.

Figure 1. 2024 Heat Watch maps



As the Pierce County study area spans a wide region including the Puget Sound, the heat distribution patterns may be influenced by the regional geography of the area (for example, proximity to a large water body). To reduce this regional effect, a localized heat raster was developed. For each time period, a "temperature difference" raster was created by subtracting the temperature at each grid point from a coarse temperature raster (visualized below) produced by aggregating the Heat Watch data up to 25 kilometer resolution. The localized heat raster was then computed by averaging the temperature difference rasters from the three time periods. The localized heat data was used for area-wide and sub-area analyses.

Figure 2. 2024 Coarse (30-meter) Heat Watch maps



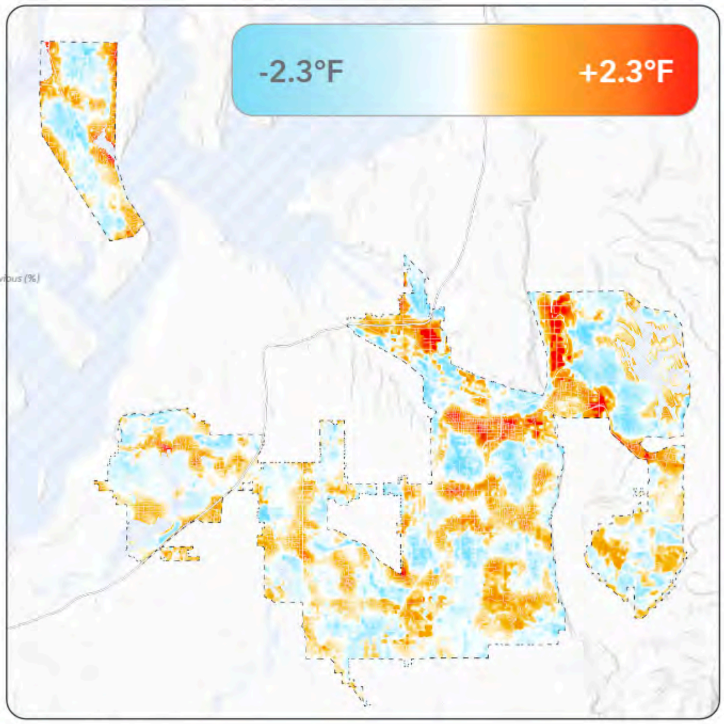
Area-Wide Results

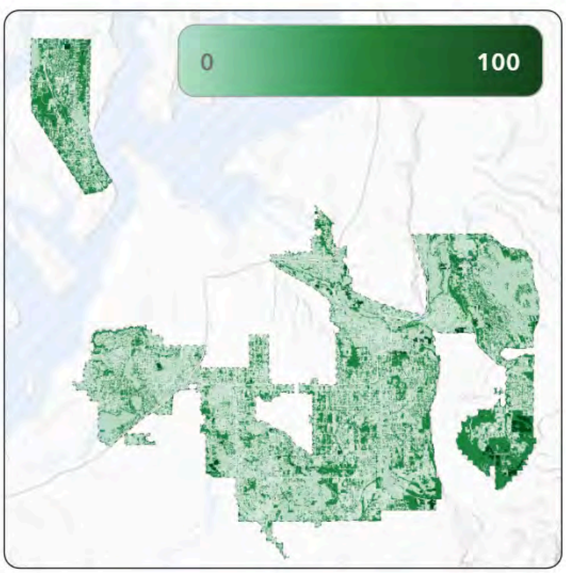
Area-Wide Summary

The localized heat raster displays heat distribution relative to the surrounding 25 km, reducing the regional effect due to differences in geography across the study area. Note that while the range of localized temperatures is roughly 5°F due to the processing steps (involving averaging of multiple time periods), temperature differences as wide as 14°F were measured during the Heat Watch campaign traverses.

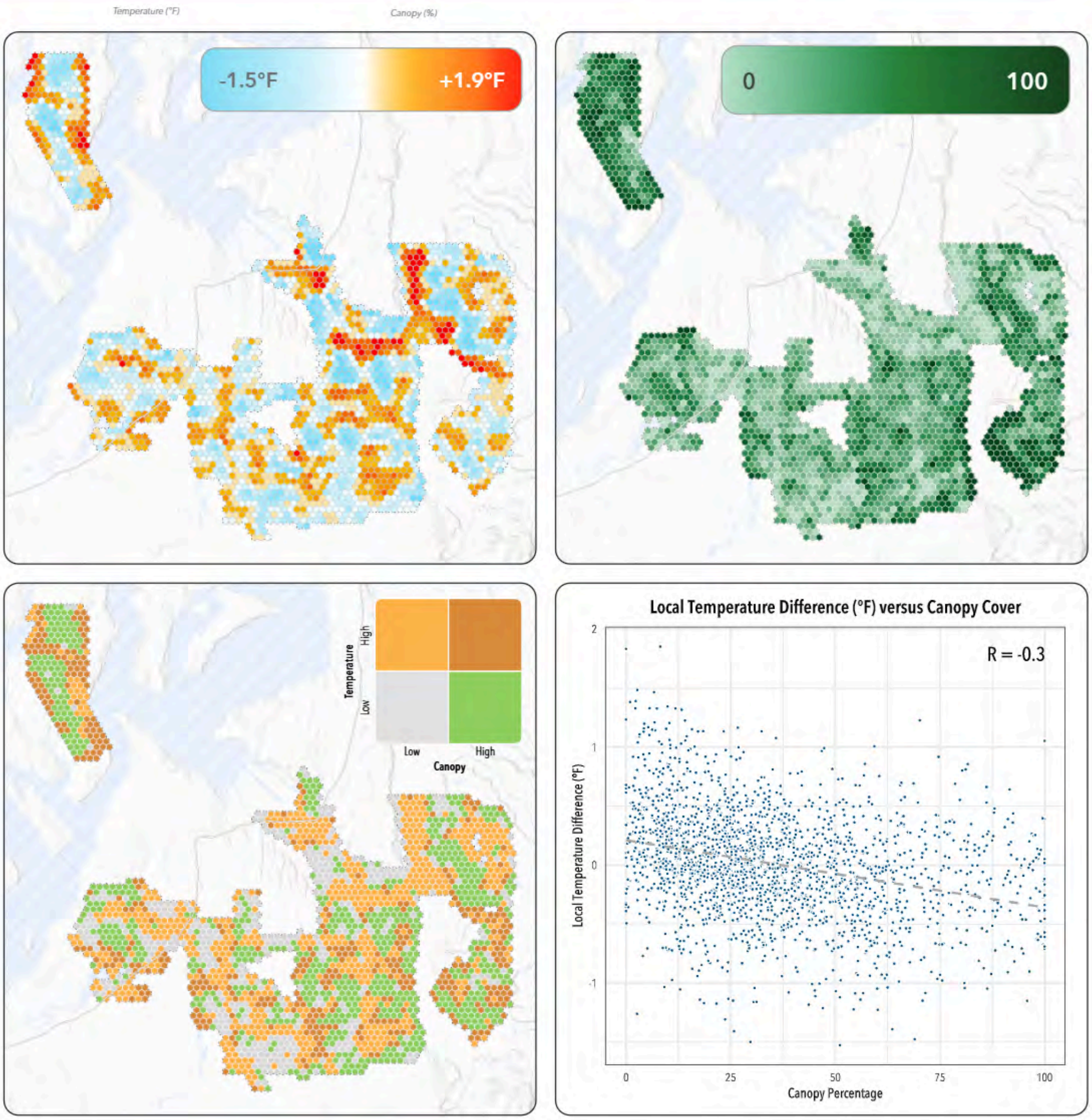
The overall percentage of canopy across the area is 34% and impervious surfaces is 30%. Patterns between heat, canopy cover and impervious surfaces can be seen at the broad scale in the maps below. Cool areas with high canopy cover are seen in Clarks Creek Park and Wildwood Park near Puyallup, and surrounding Lake Tapps; warm areas with high impervious surface amounts can be seen in the industrial area around Sumner, Fife and Puyallup.

The following pages display the data summarized by 500-meter hexagon and present plots describing the overall pattern between canopy cover and impervious surfaces with localized heat across the study area.





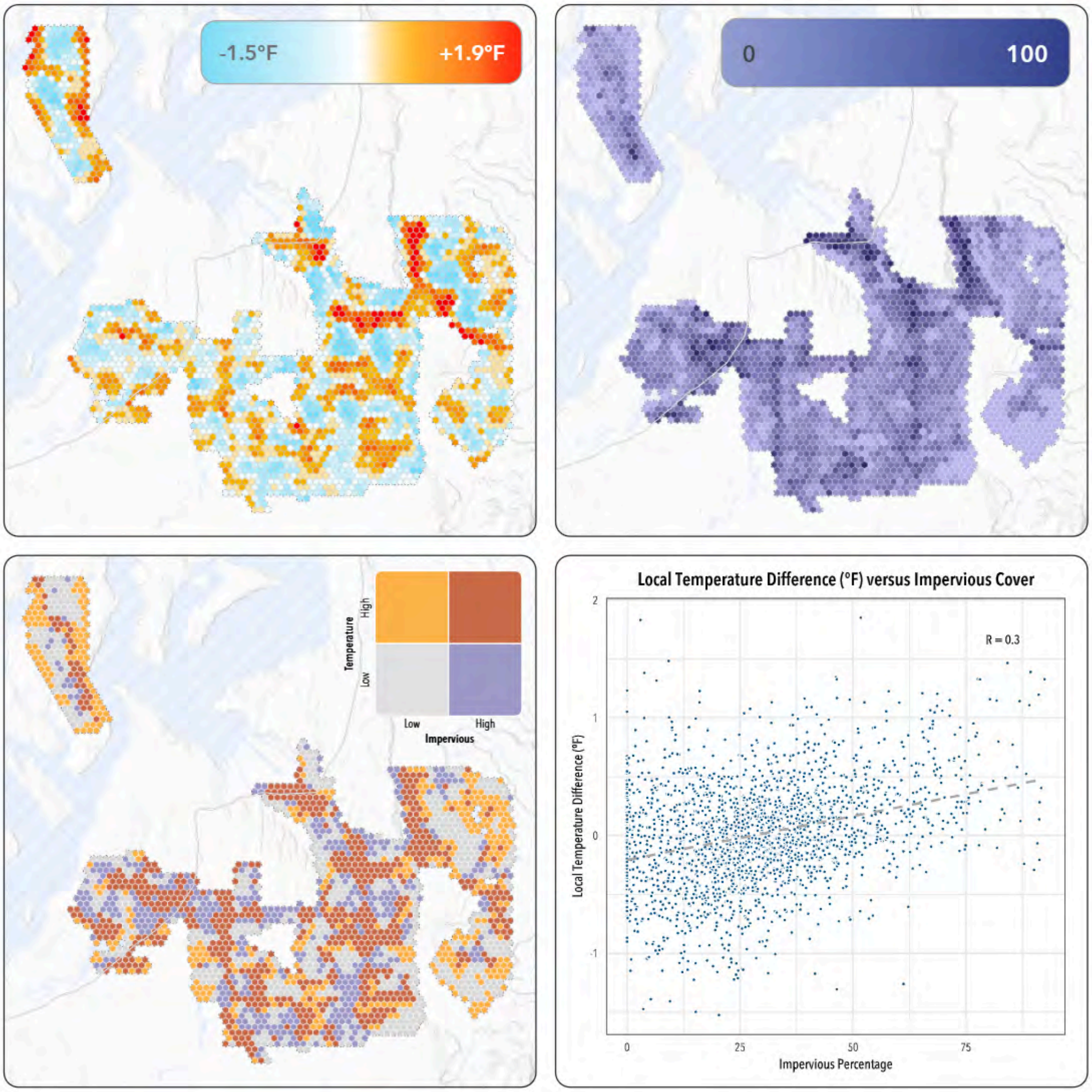
Area-Wide Canopy Cover



Area-Wide Impervious

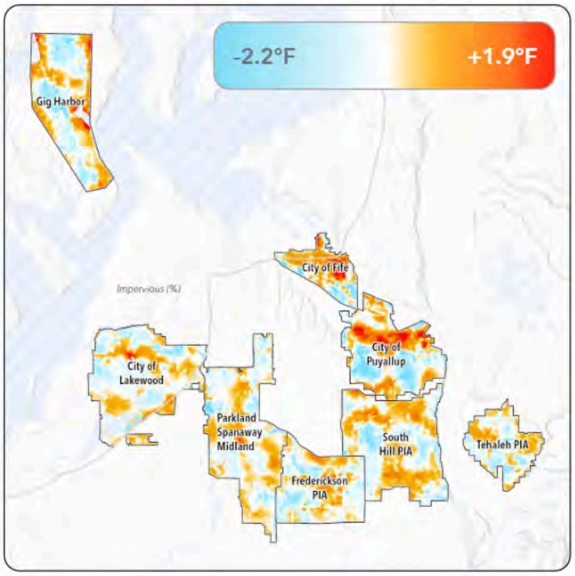
Temperature (°F)

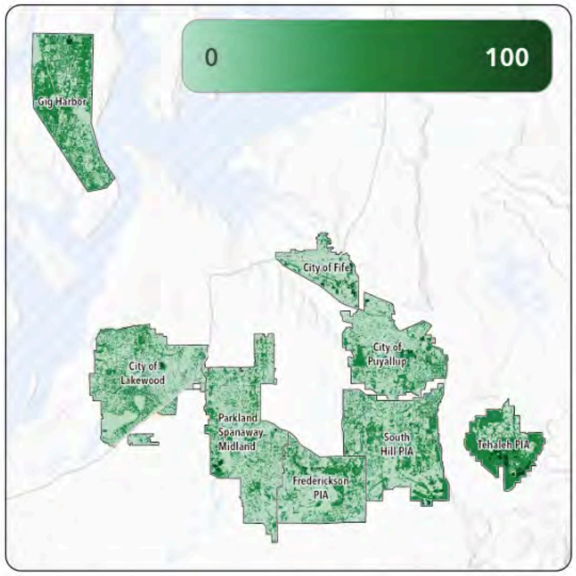
Impervious (%)

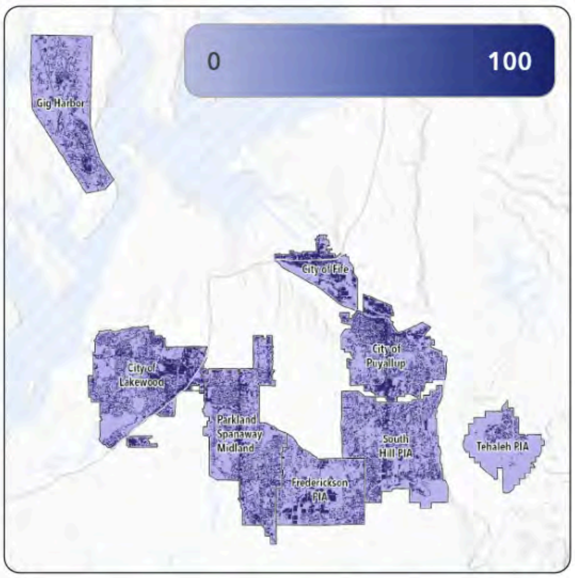


Sub-Area Results

Sub-Area Summary





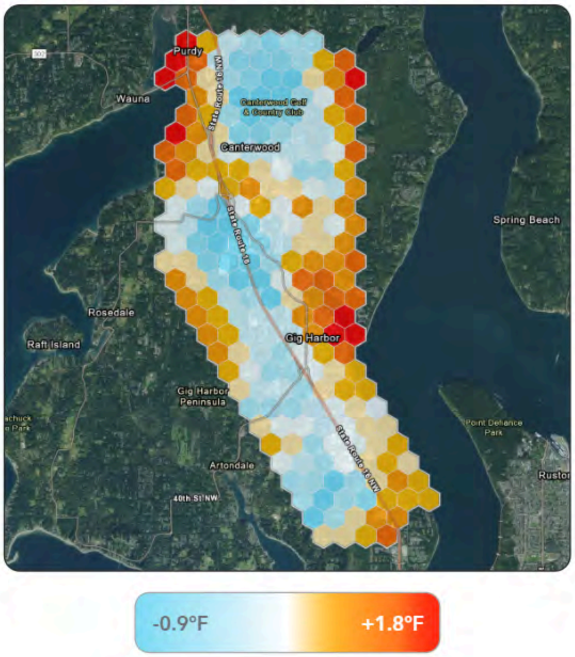


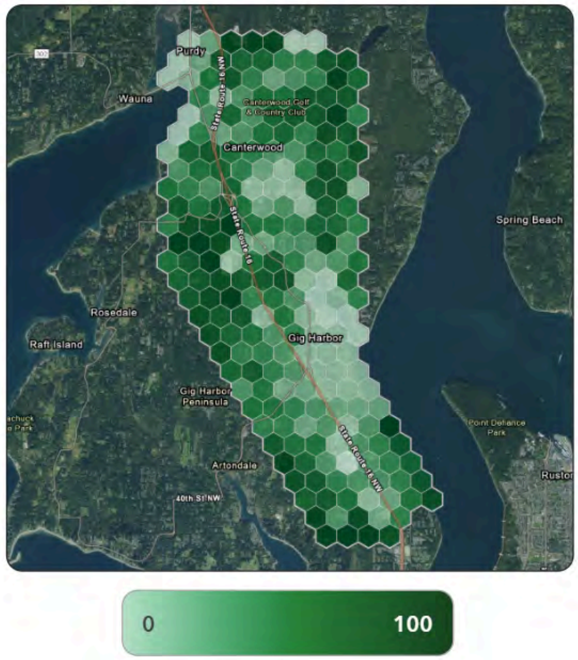
Summarized below, the percentage of canopy cover of sub-areas ranges from 16.8% in the City of Fife to 65.5% across Tehaleh PIA; conversely, the percentage of impervious surfaces coverage ranges from 9.3% in Tehaleh PIA to 44.4% in the City of Fife. Differences in sub-area average temperature from the global average range from -2.2°F in Gig Harbor to +1.3°F in Puyallup.

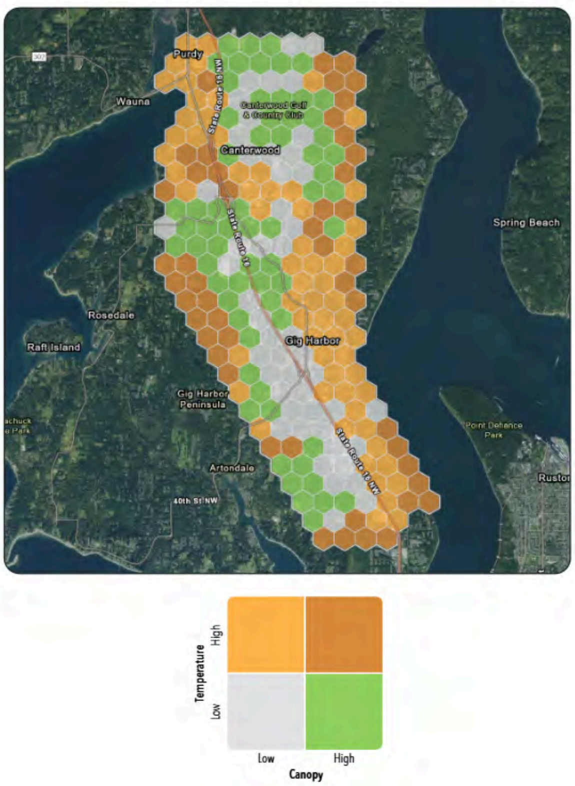
The following pages display the canopy and impervious surface raster data for each sub-area along with bivariate maps comparing the variables with localized heat using 500-meter hexagons as sampling units. Also presented are plots describing the relationship between localized heat, canopy cover and impervious surfaces within each sub-area.

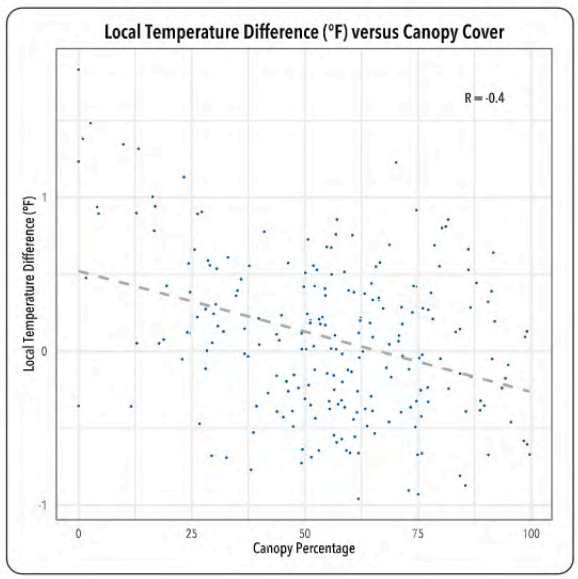
Sub-Area	Canopy (%)	Impervious (%)	Avg Temp (°F)	Global Temp (°F)	Avg Temp Diff (°F)
Parkland Spanaway Midland	26.6	33.9	73.4	73.5	-0.1
Gig Harbor	53.9	22	71.3	73.5	-2.2
Frederickson PIA	29.7	30.3	73.9	73.5	0.4
Tehaleh PIA	65.5	9.3	73.2	73.5	-0.3
City of Fife	16.8	44.4	74.5	73.5	1.0
City of Puyallup	29.3	39.5	74.8	73.5	1.3
City of Lakewood	27.1	36.3	72	73.5	-1.5
South Hill PIA	36.4	30.1	74.2	73.5	0.7

Gig Harbor Canopy Cover

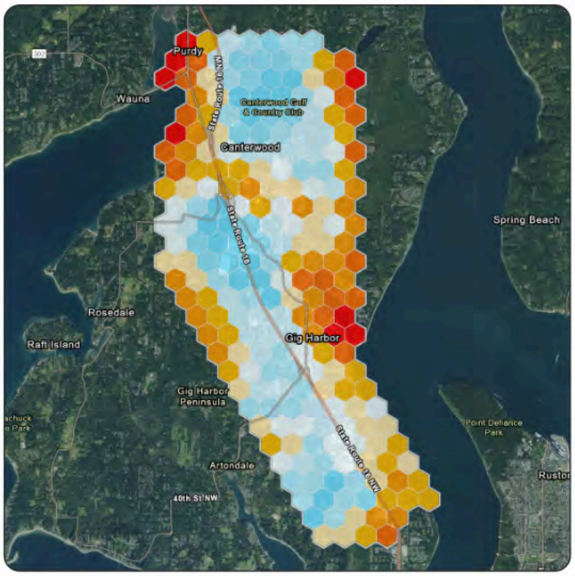


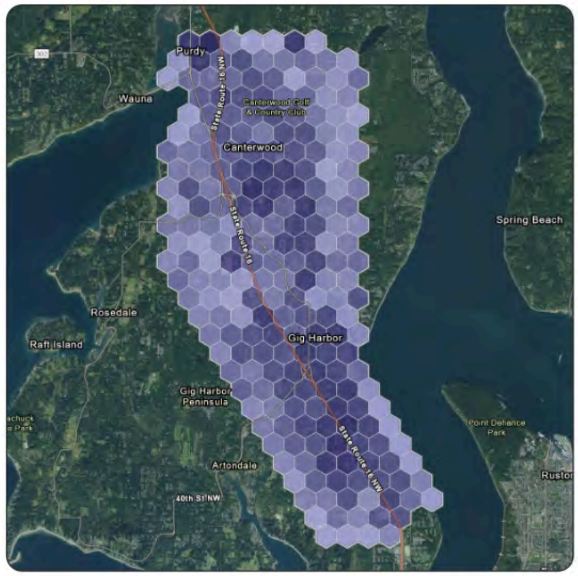






Gig Harbor Impervious Surfaces





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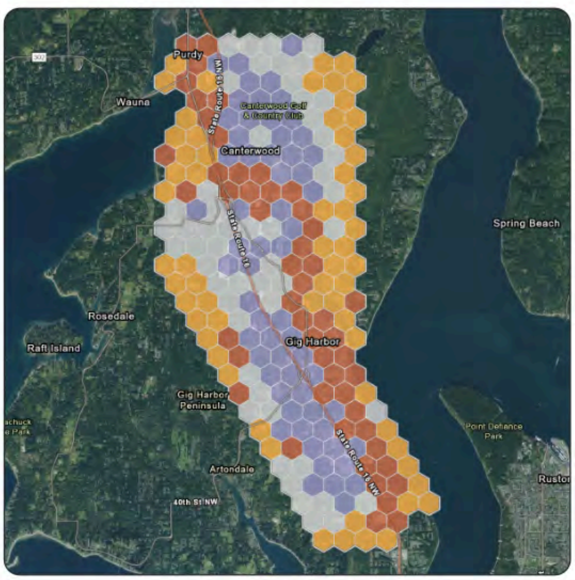
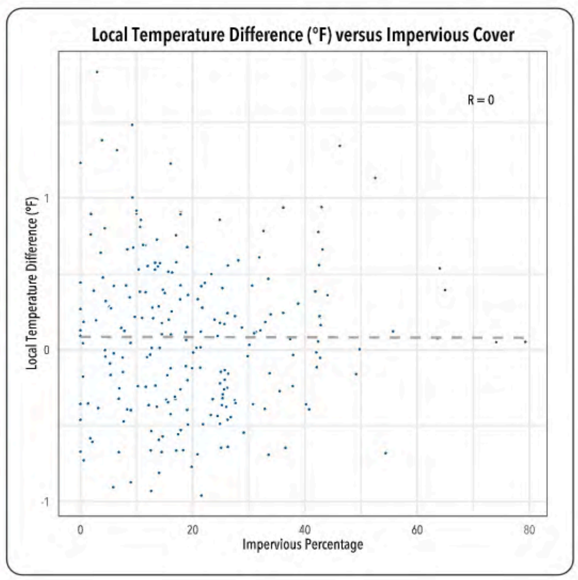
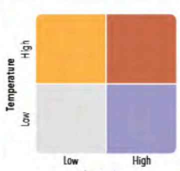
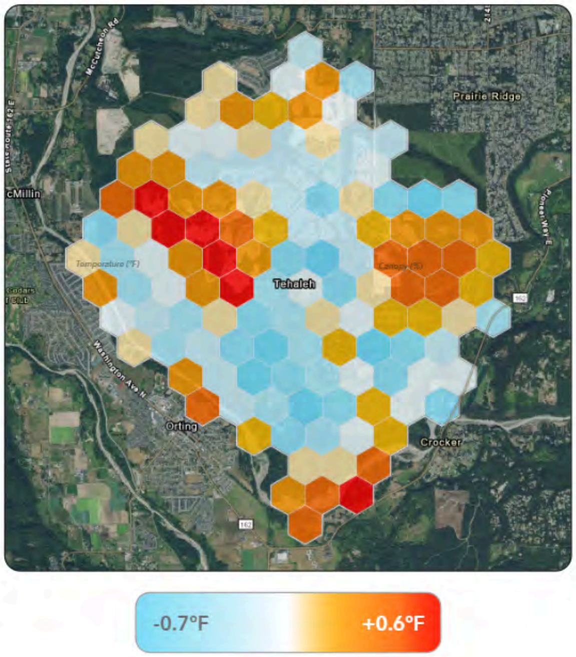
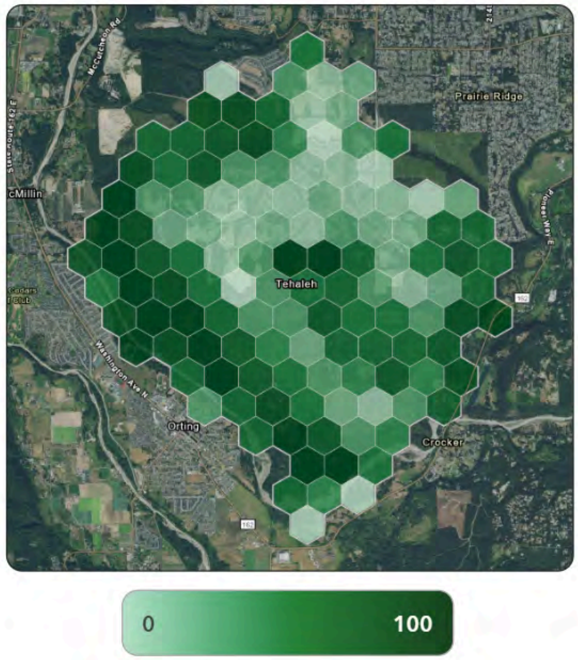


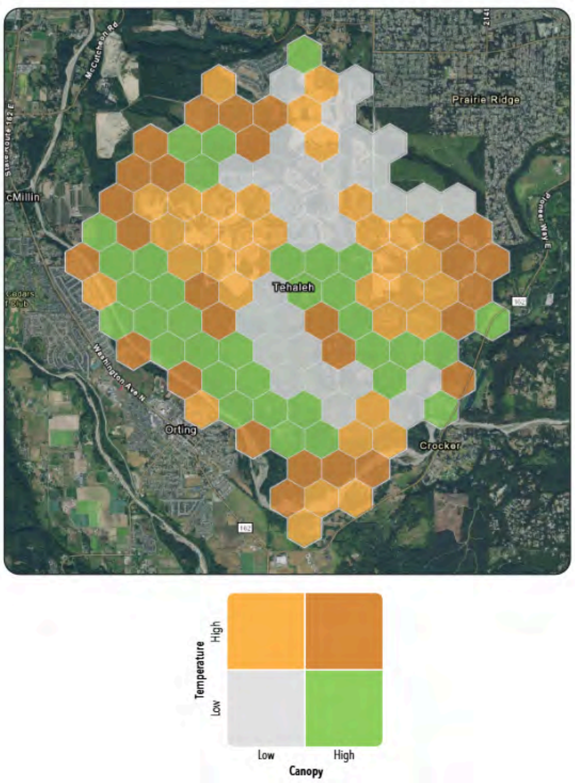


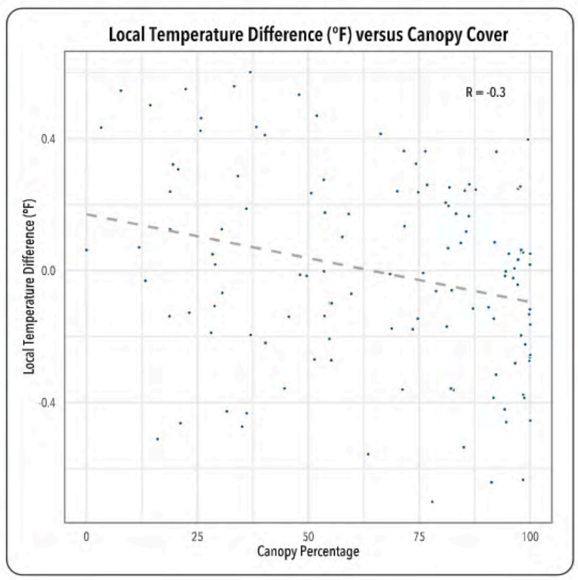


Tehaleh Canopy Cover

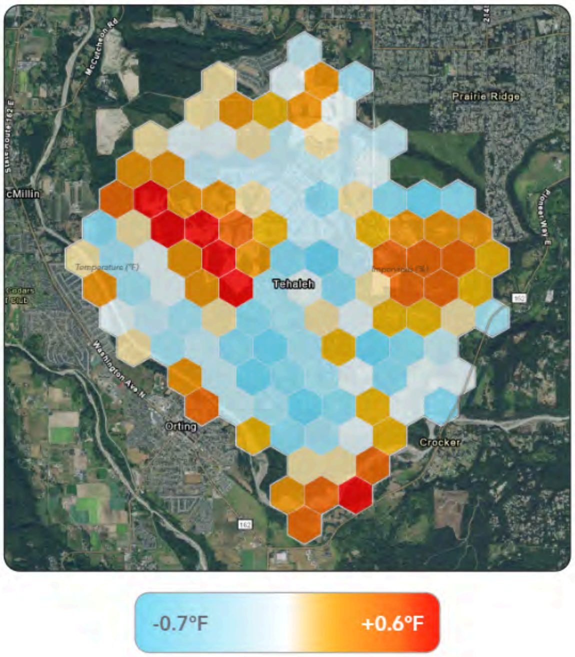


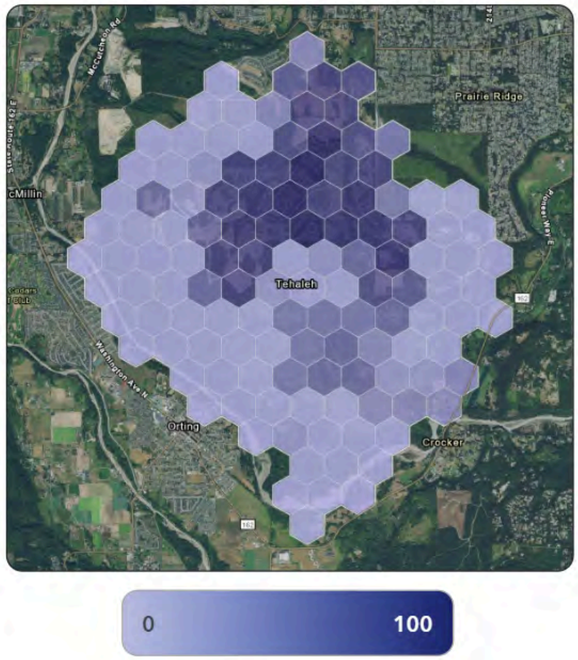






Tehaleh Impervious Surfaces





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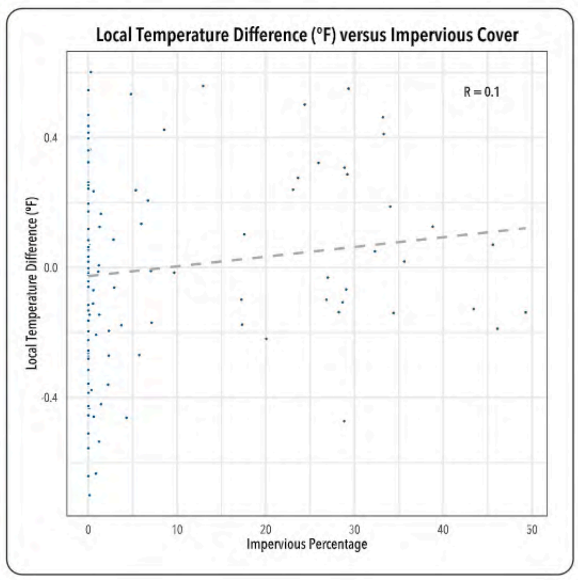
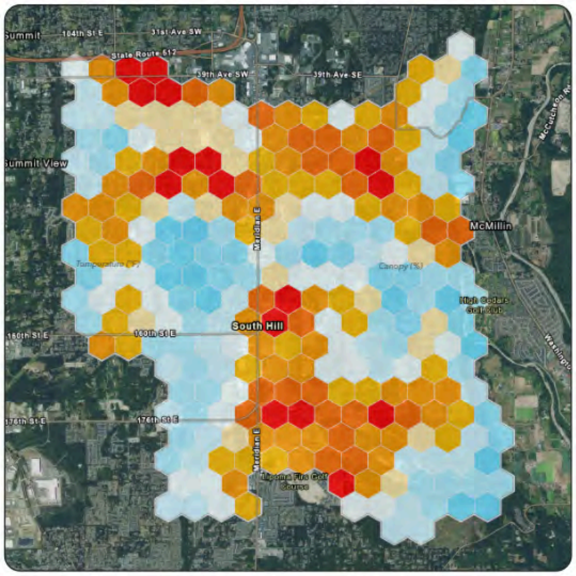
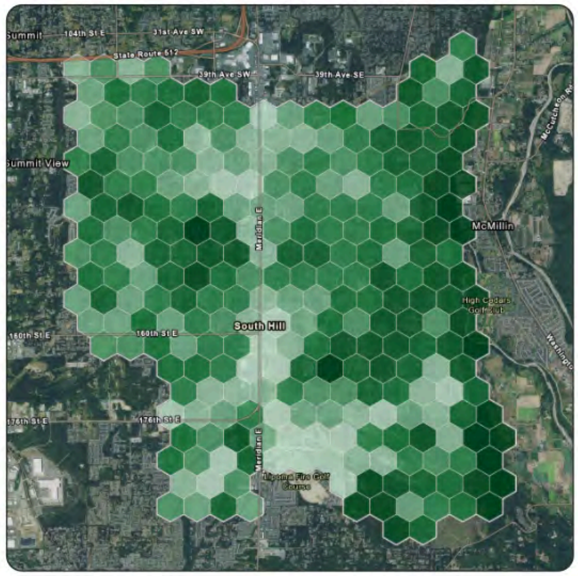
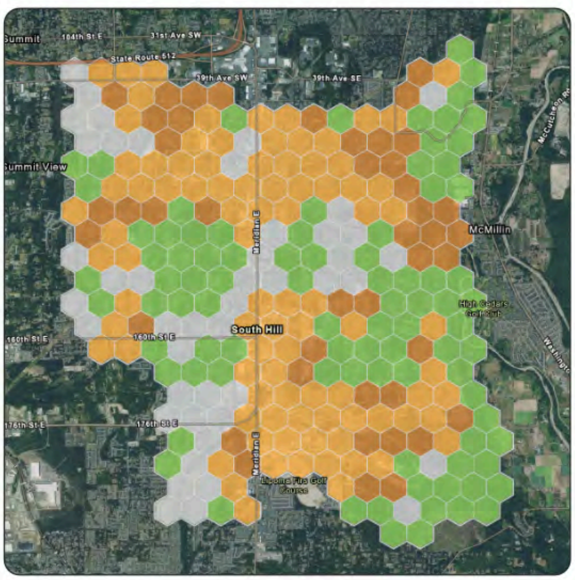
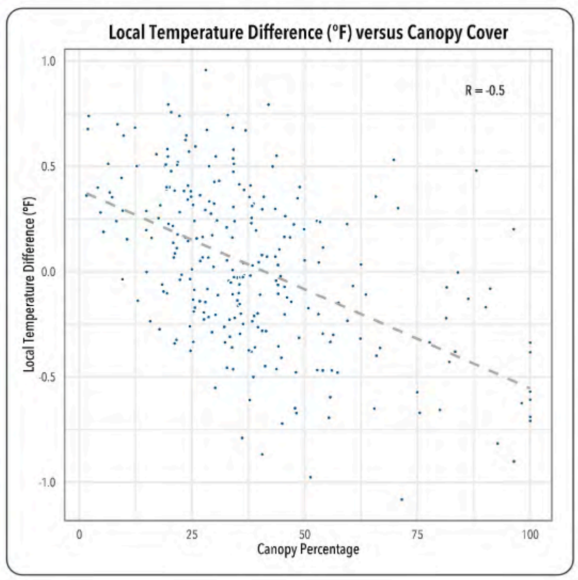


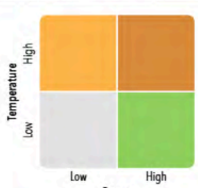
South Hill Canopy Cover



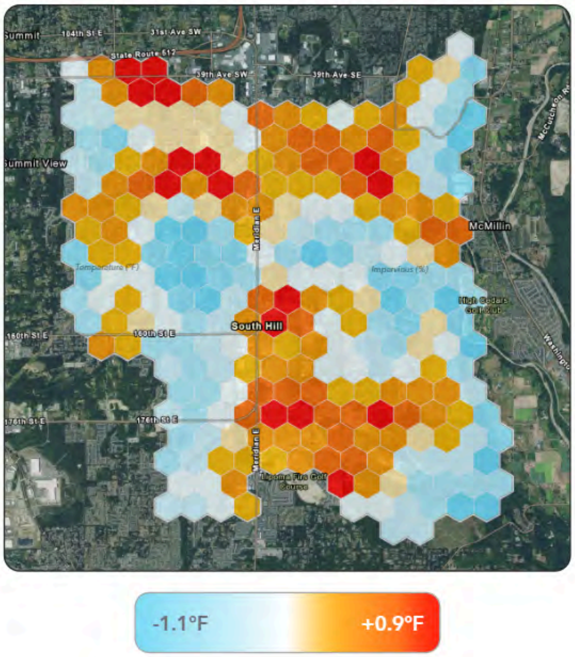


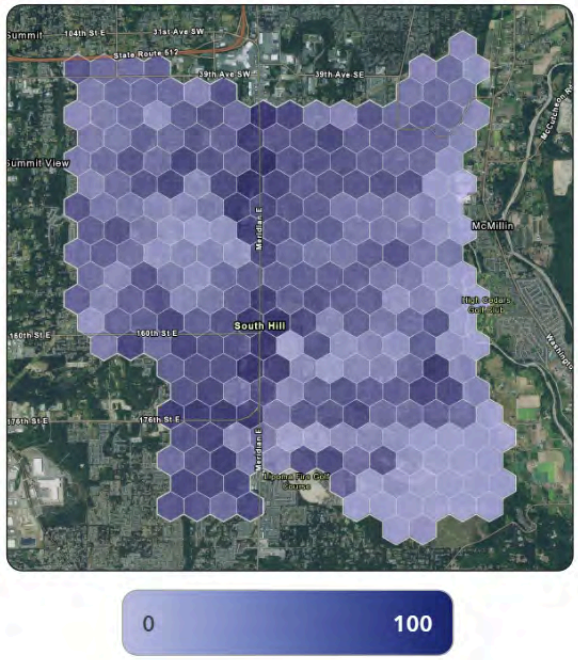


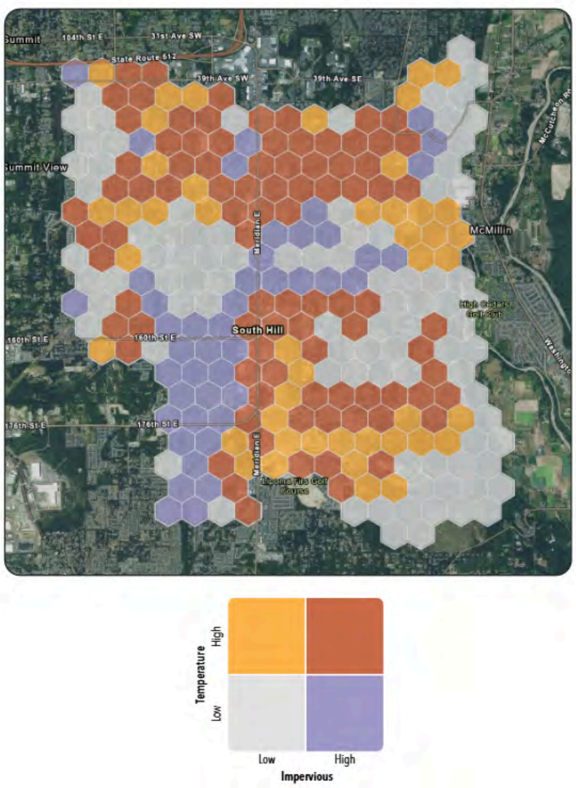


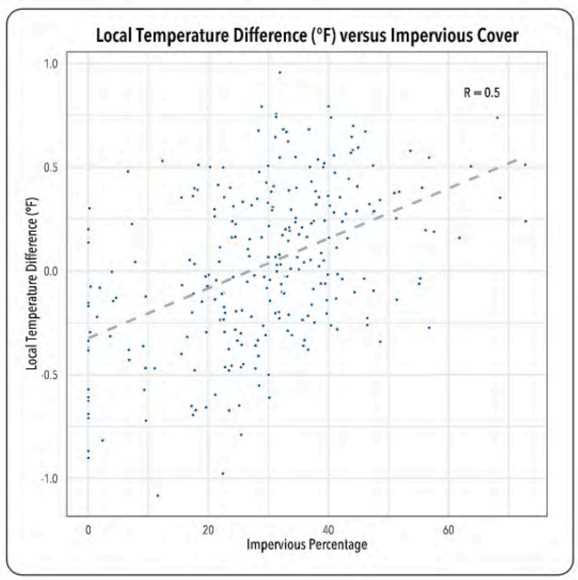


South Hill Impervious Surfaces

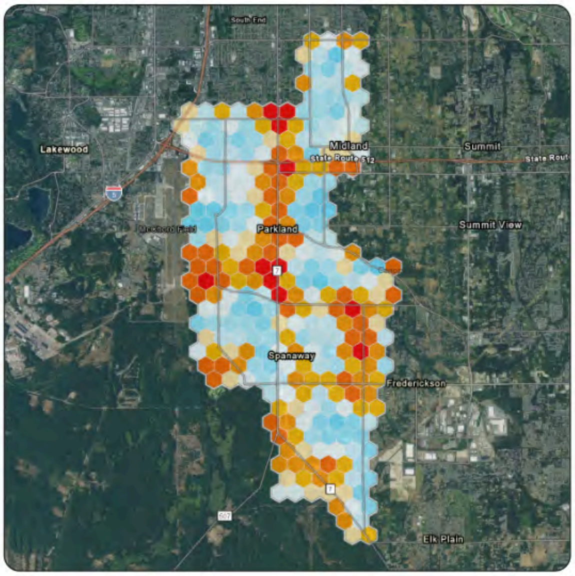


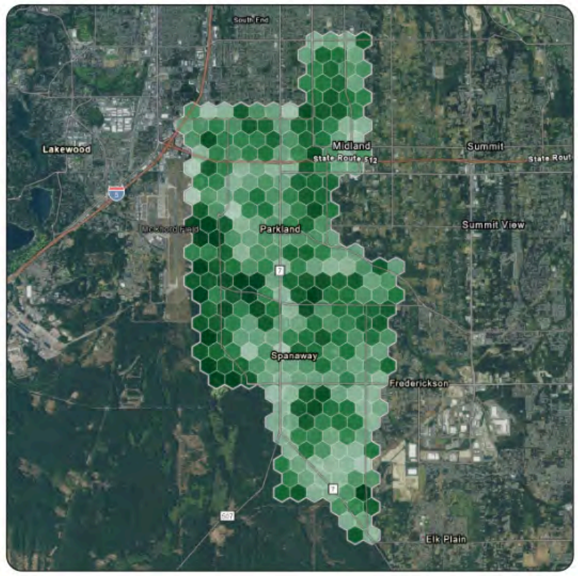


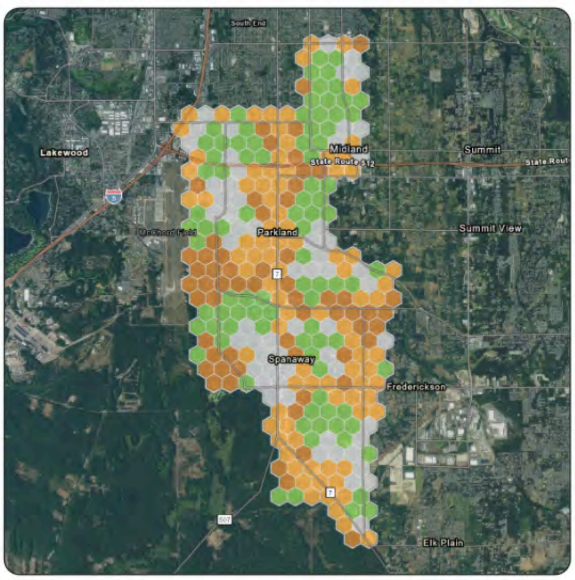


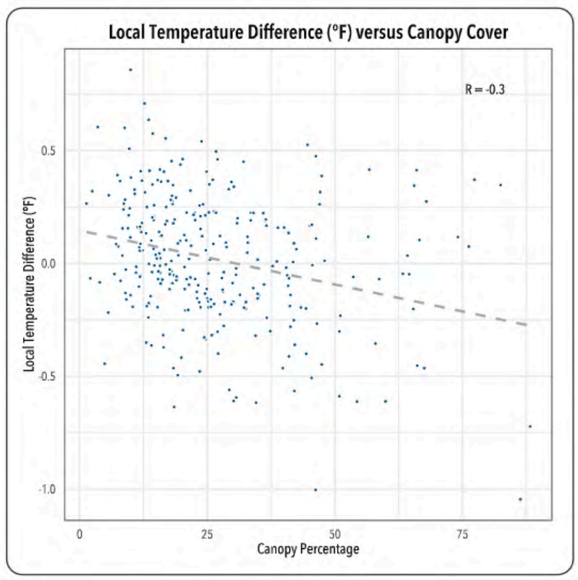


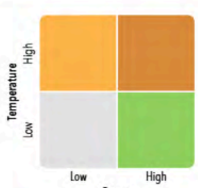
Parkland Canopy Cover



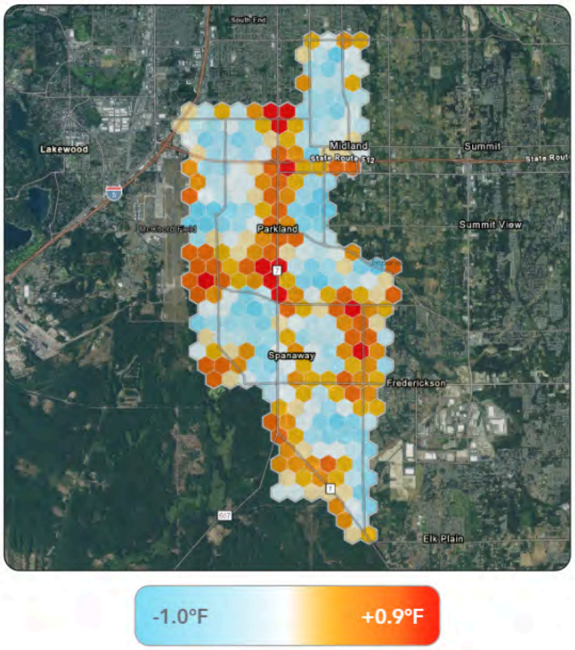


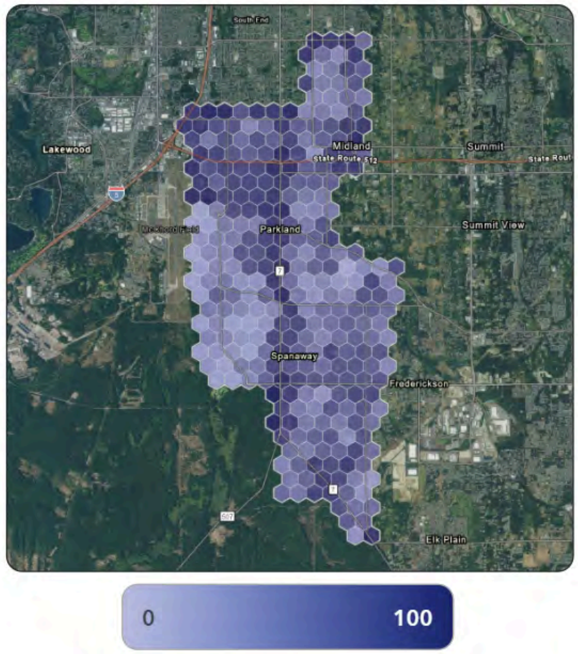


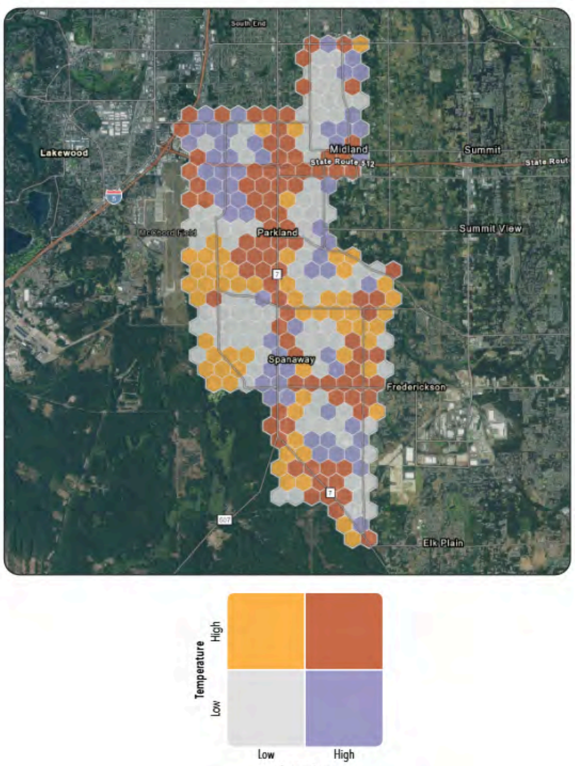


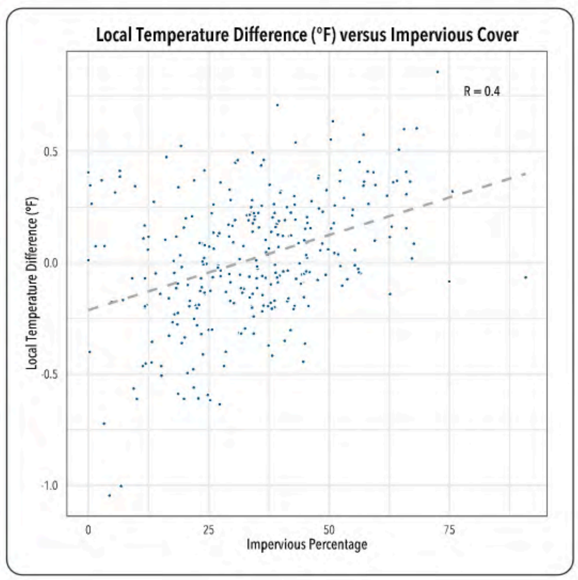


Parkland Impervious Surfaces

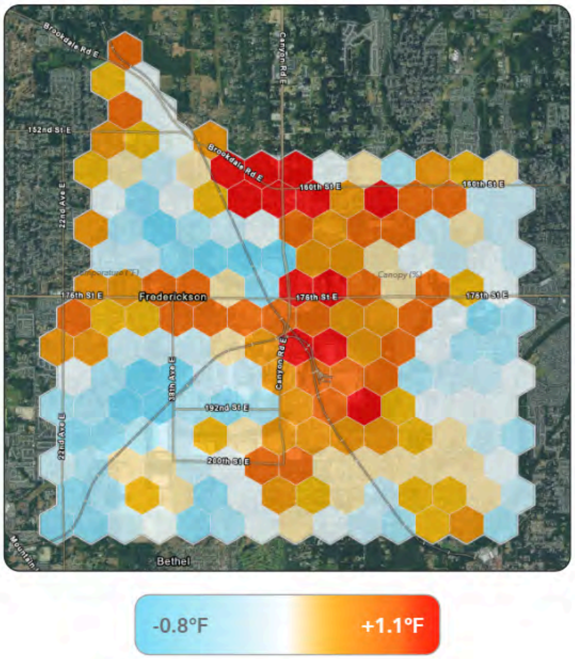


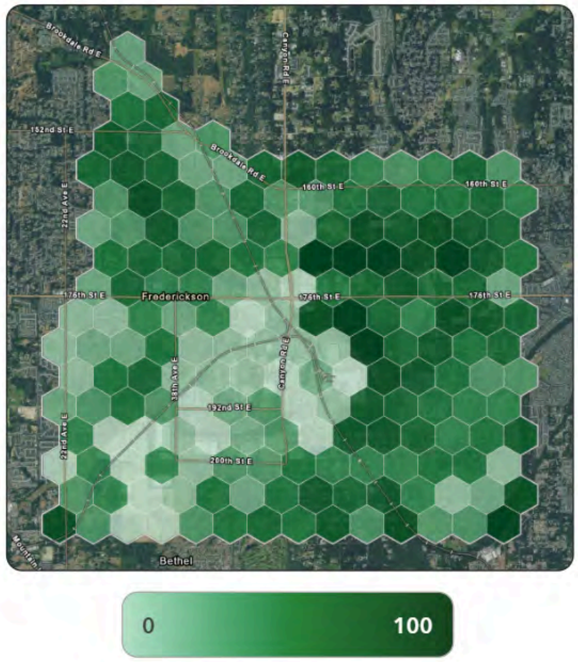


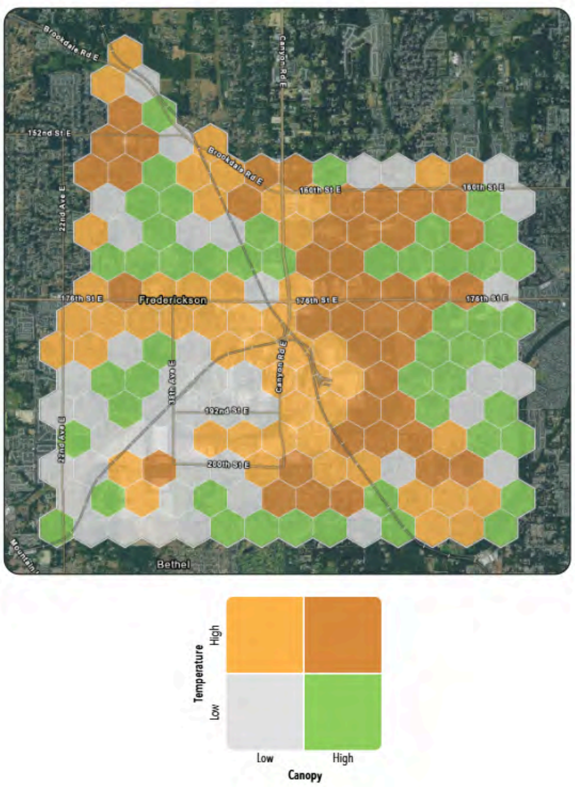


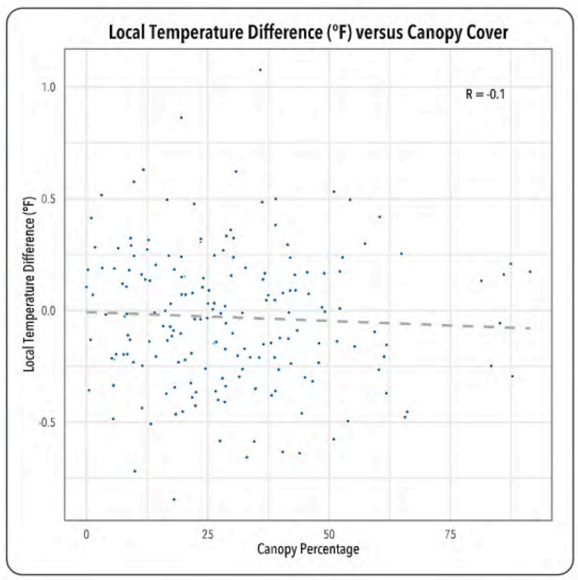


Frederickson Canopy Cover

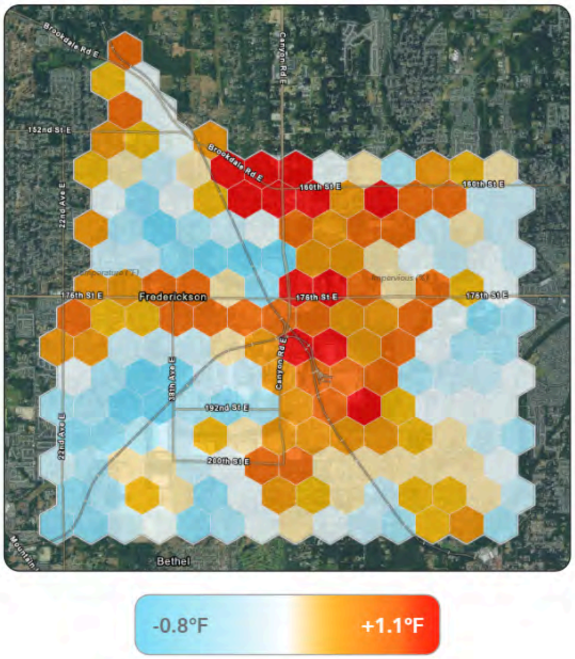


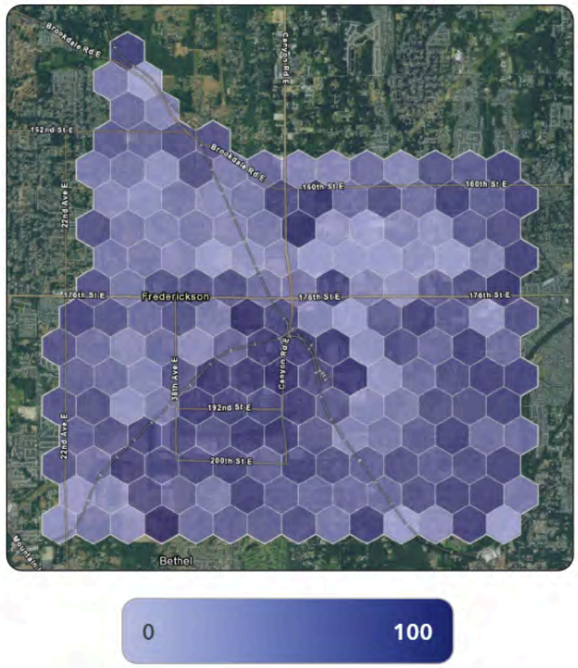


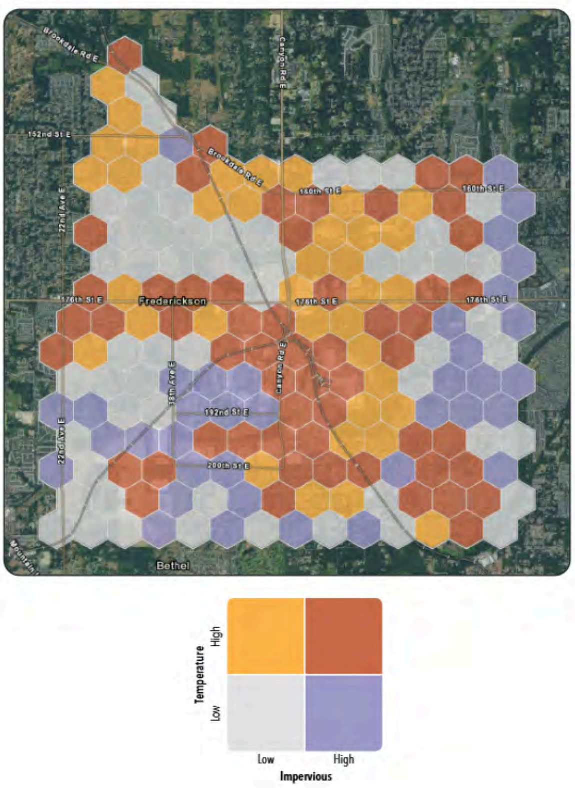


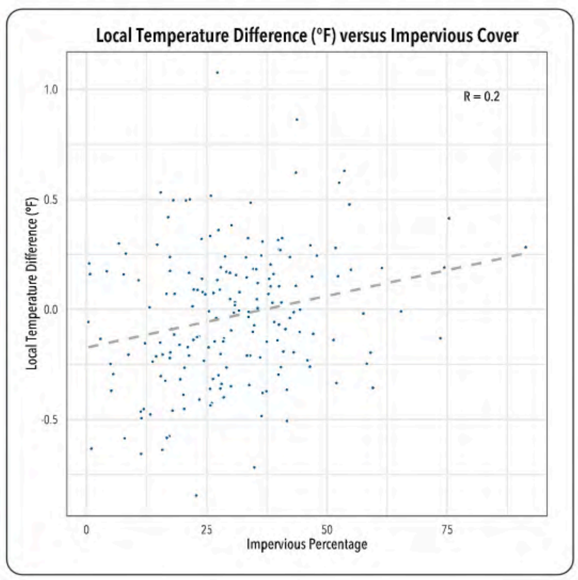


Frederickson Impervious Surfaces



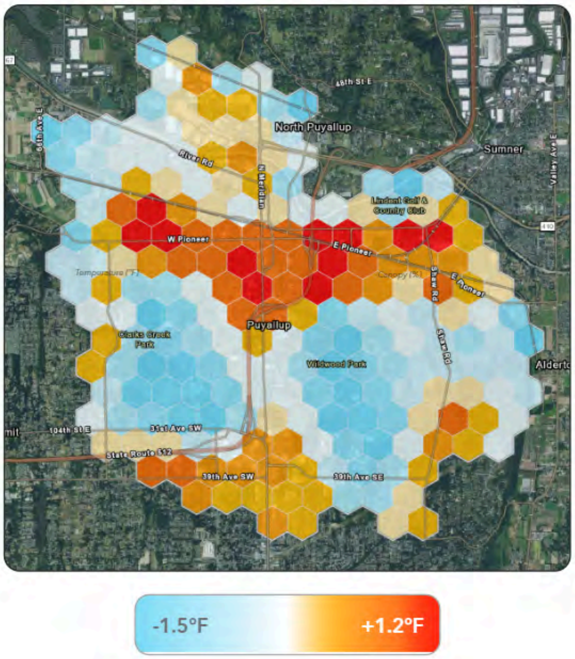


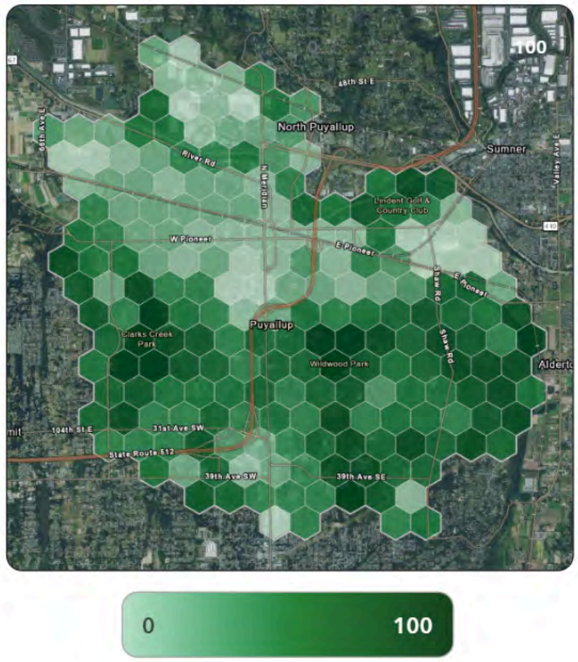




Puyallup Canopy Cover

Canopy (%)





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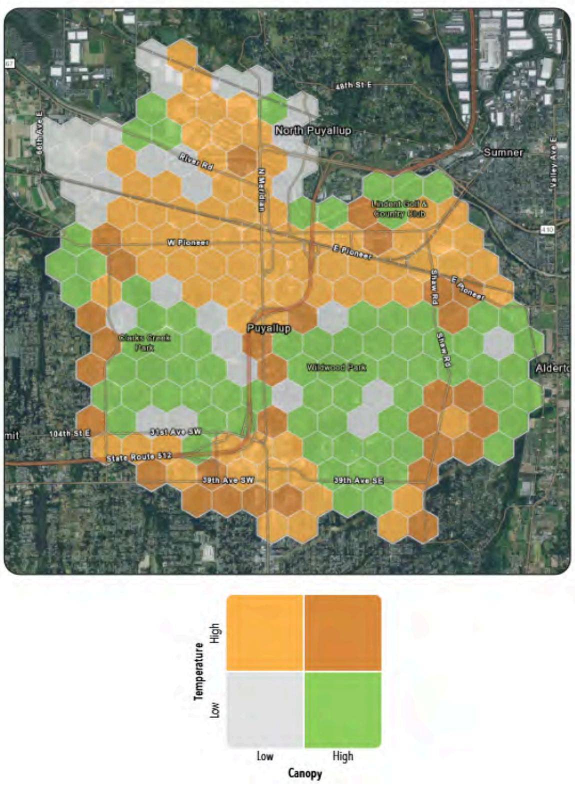
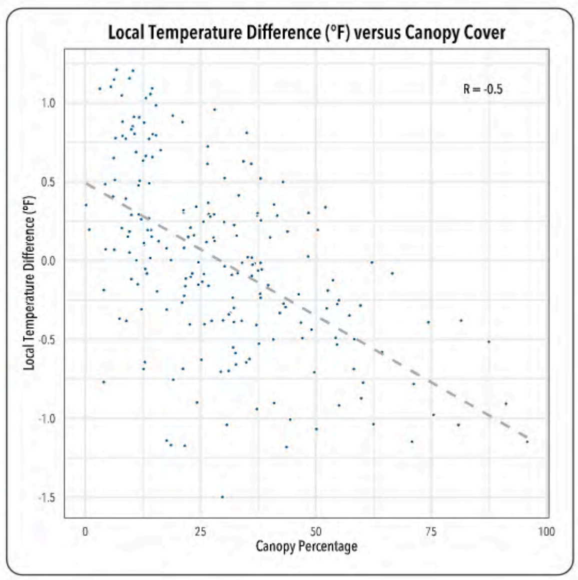
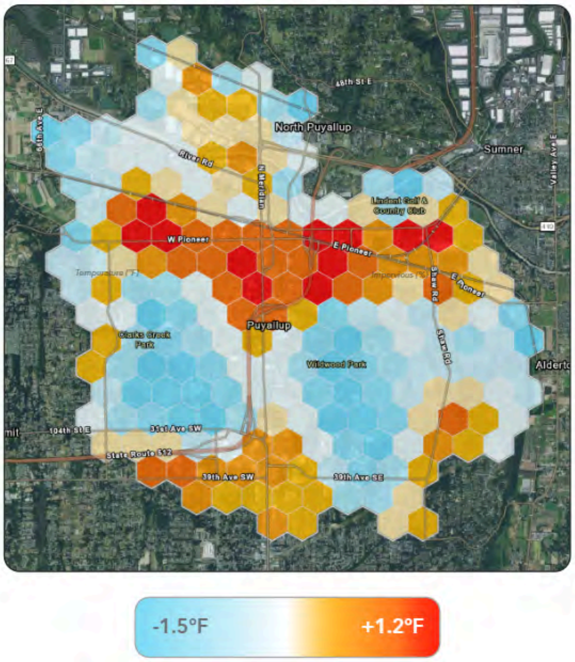
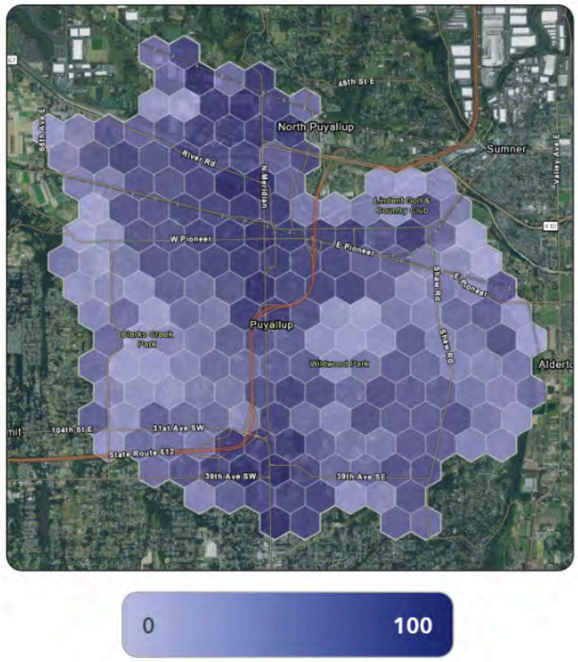
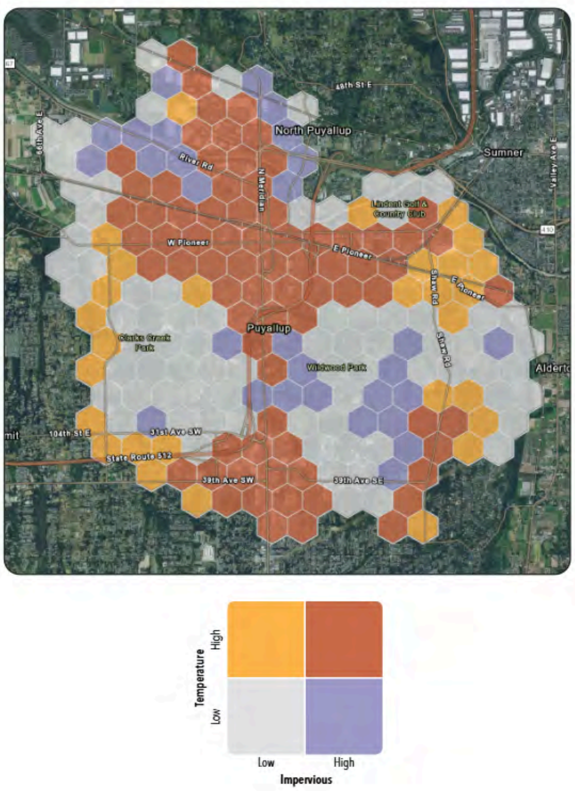


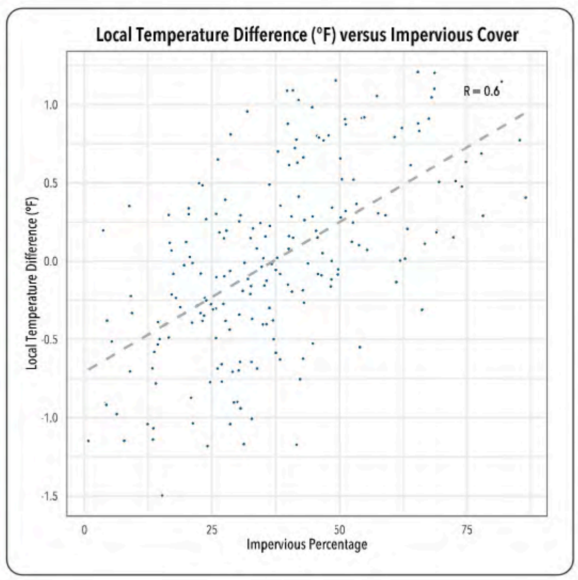


Puyallup Impervious Surfaces

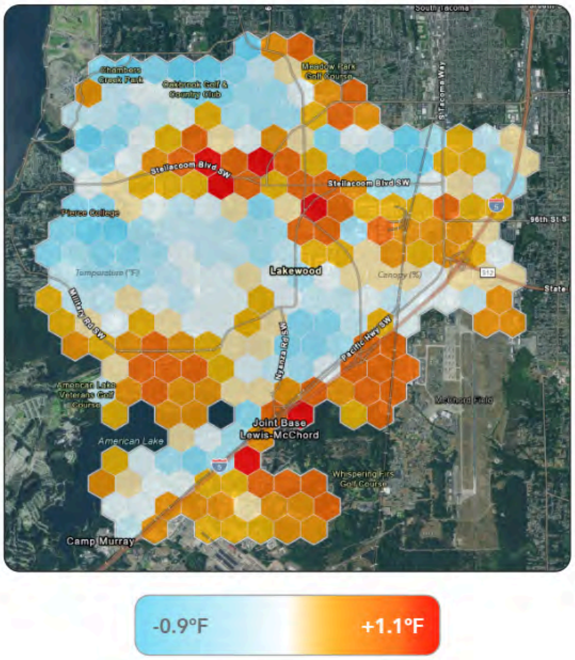


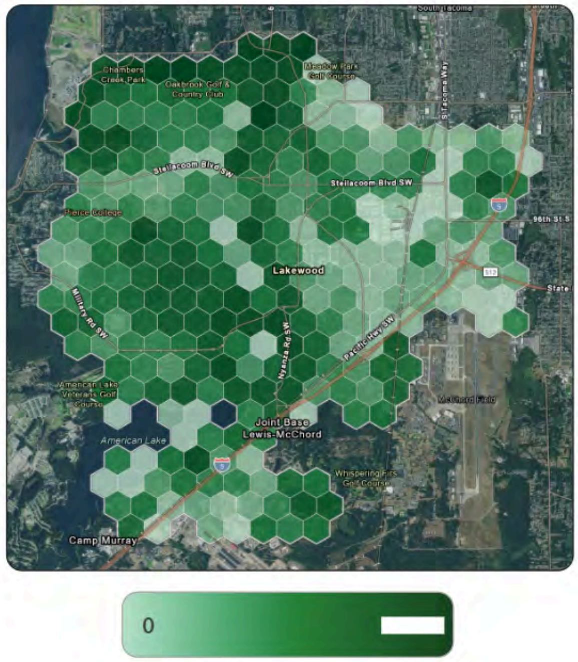


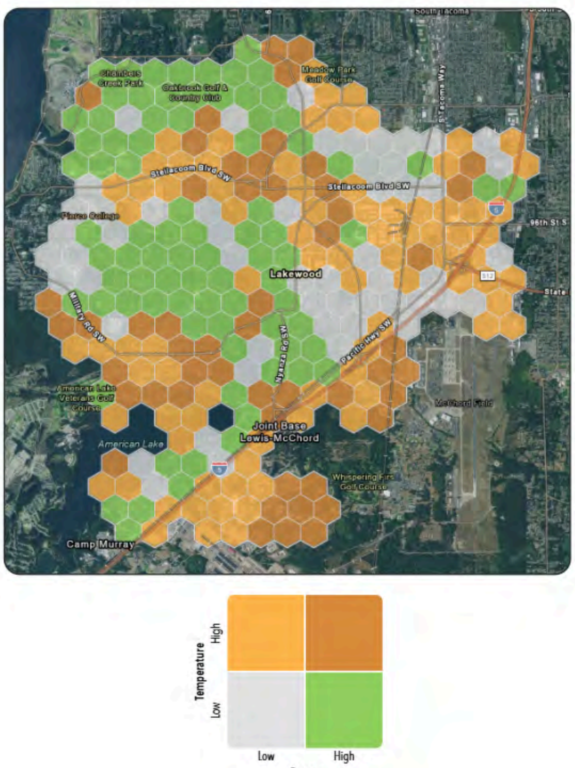


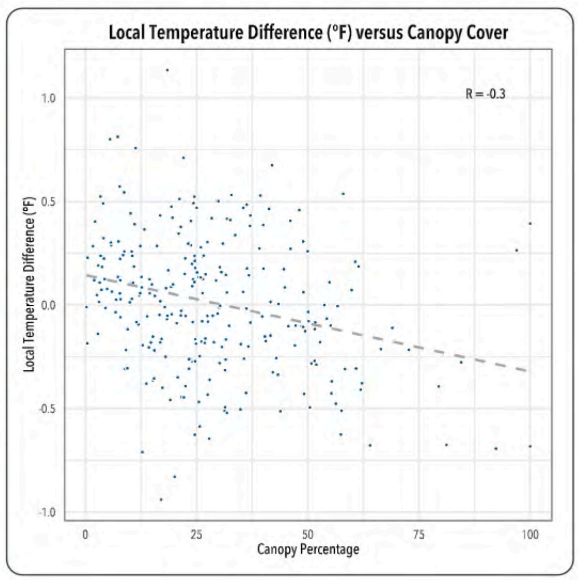


Lakewood Canopy Cover

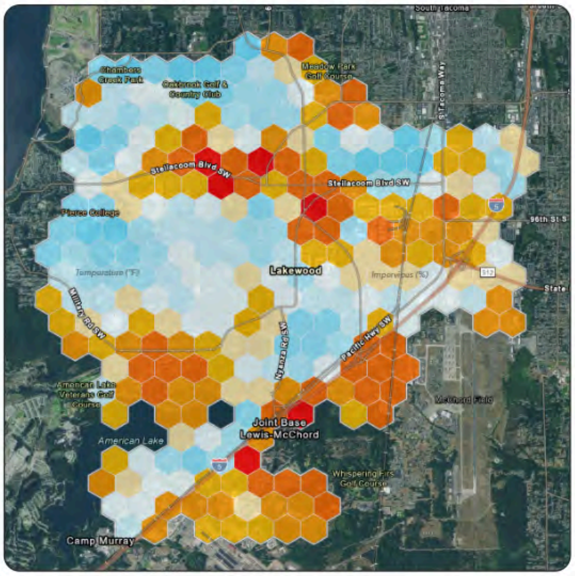


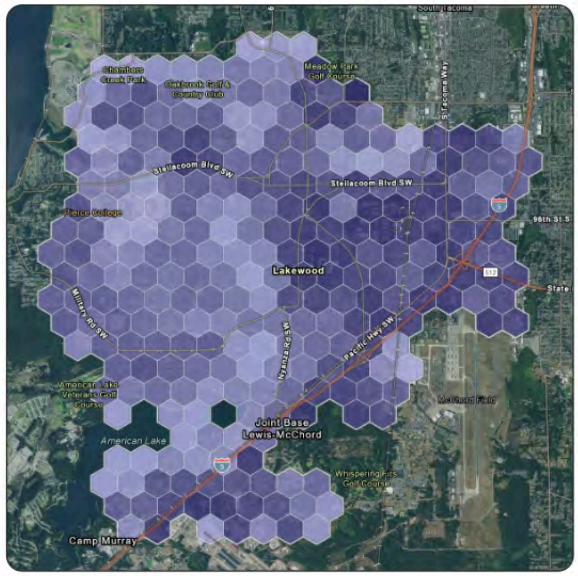






Lakewood Impervious Surfaces





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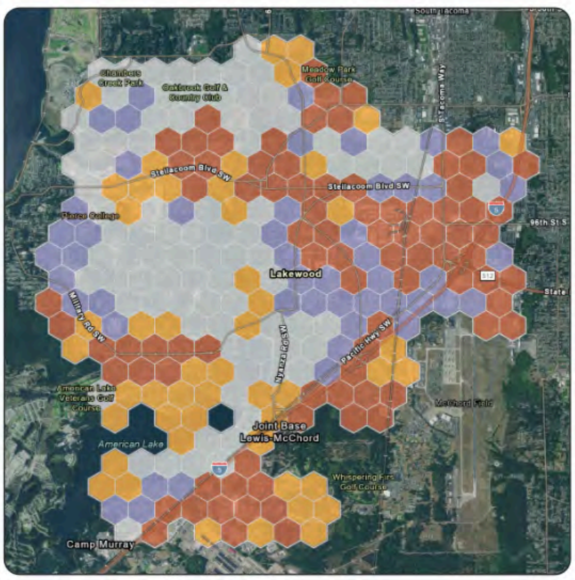
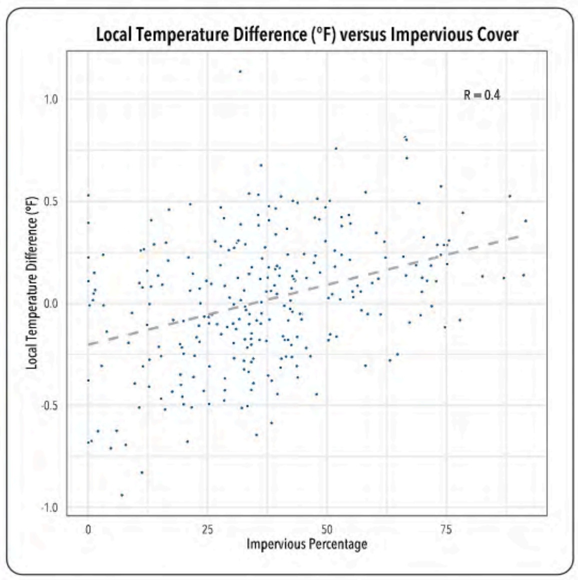
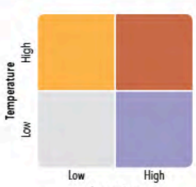
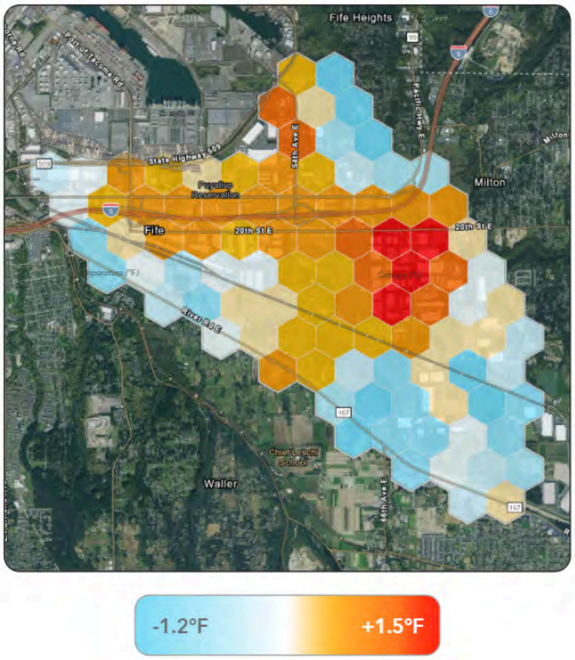
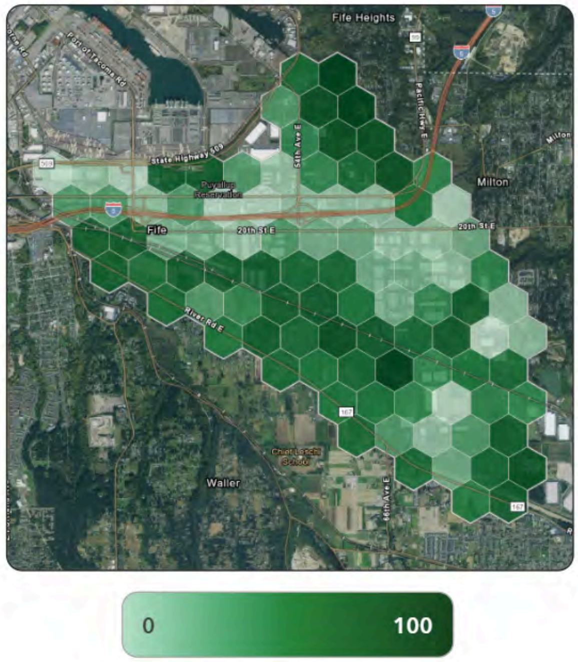


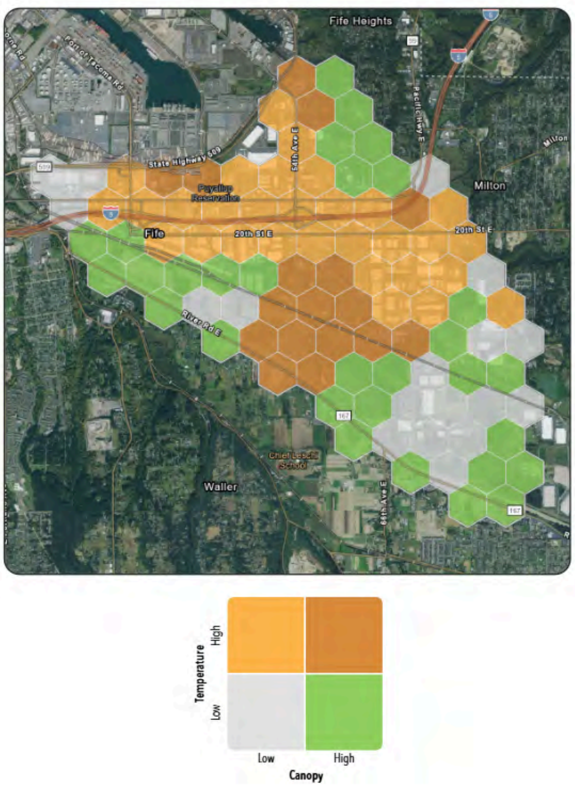


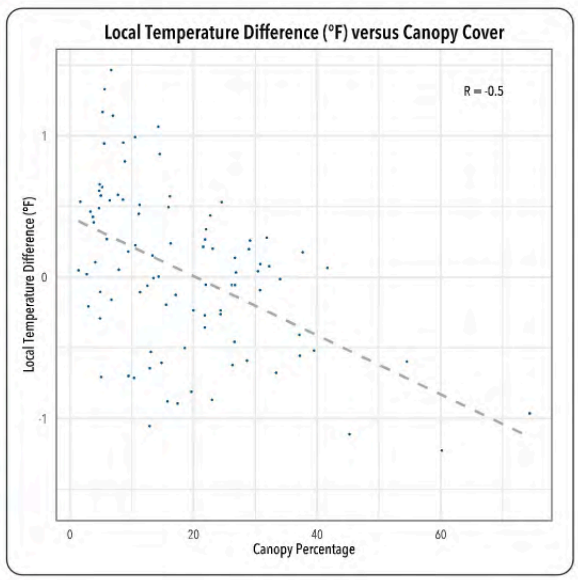


Fife Canopy Cover

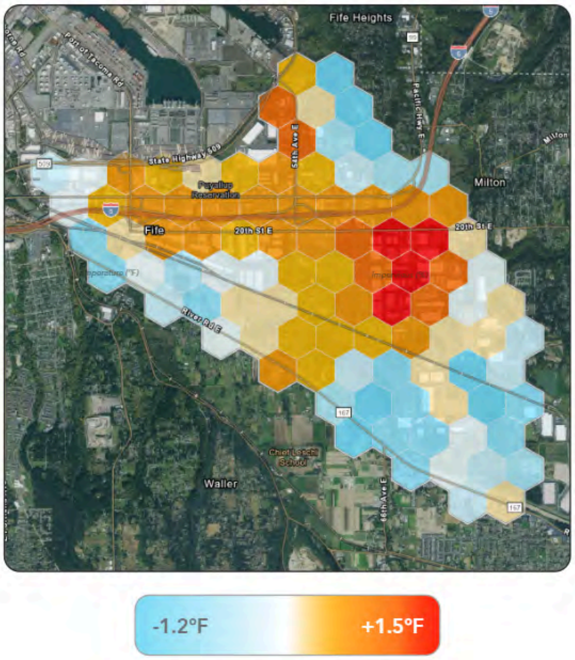


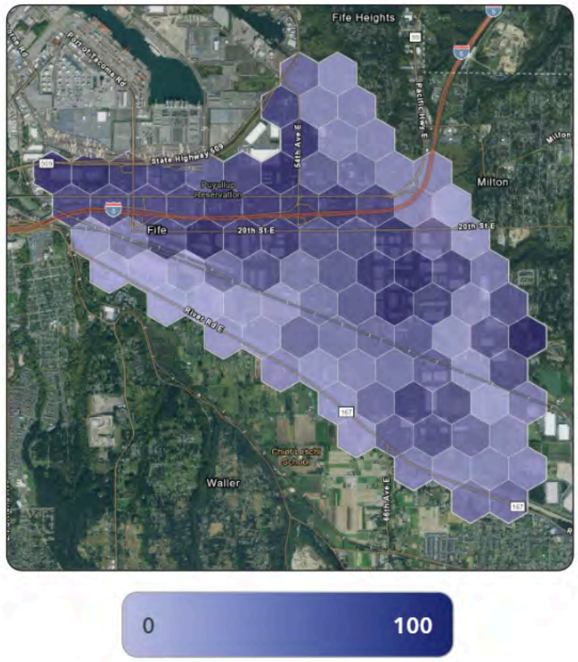






Fife Impervious Surfaces





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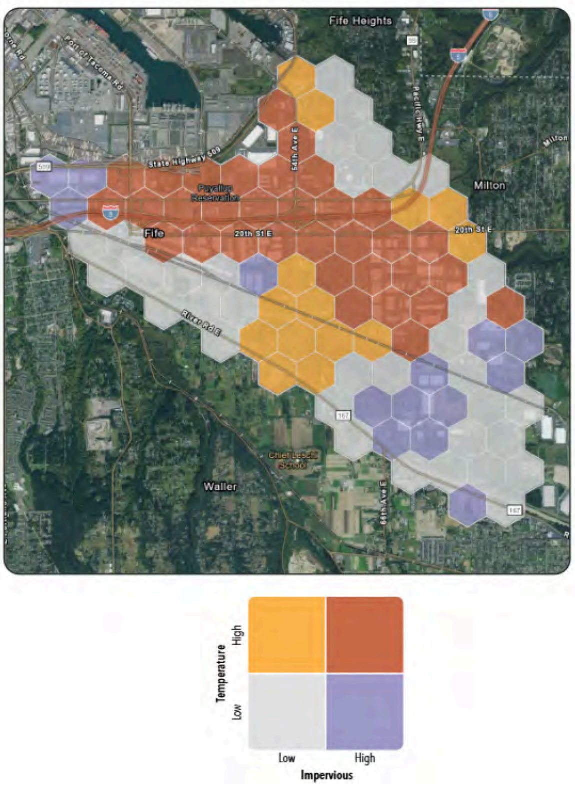

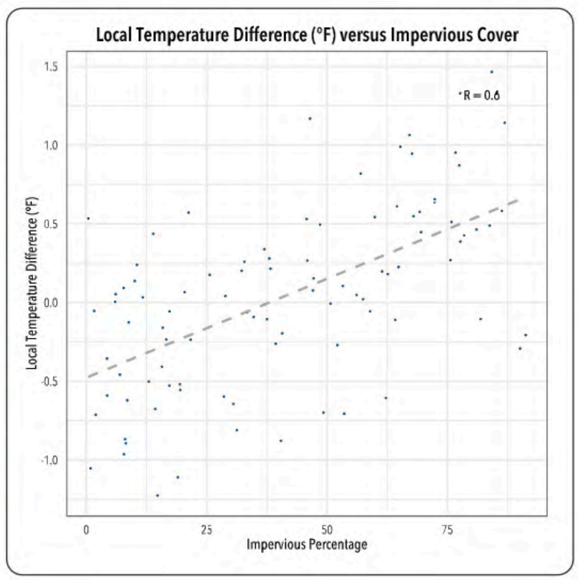

Recommendations

The data products and visualizations presented in this report provide new sets of information that can be leveraged for directing mitigation and adaptation strategies to reduce heat risk in areas of Pierce County facing high exposure and vulnerability to extreme heat. In this section we identify direct ways in which each of these products can be applied with relevant intervention strategies.

Canopy Cover

- Apply the canopy cover and heat assessment to target the expansion of canopy cover at both area-wide and sub-area scales.
    - Set targets and prioritize areas that are especially hot with low existing canopy cover. Studies have shown that the cooling benefits of trees level off when coverage reaches approximately 20-30%, while prior guidance has indicated ideal targets as high as 40%.
    - Plan for robust community engagement and localized data gathering when setting neighborhood targets to ensure that interventions will be welcomed by local residents and that interventions do not inadvertently create harm to vulnerable populations (e.g., exacerbating issues with tree debris and maintenance); use these maps and data as visual aids and communication tools when engaging with community members.
    - Prioritize native tree species when possible. Non-invasive, non-native species are also suitable for the future as native species may be unable to adapt to a warmer climate. A list of native and non-native "climate adapted species" which can survive in projected conditions should guide future planting selections.
    - Consider different planting configurations for different interests. A cluster of trees in one location (e.g., a forest) offers greater benefits in terms of air purification, stormwater control, and localized heat mitigation. The same number of trees spread equally over a large area (e.g. an entire city) will have less pronounced ecological effects, but will impact a greater number of urban residents. Placing trees within green space or near water features will maximize their cooling potential.
- Preserve existing mature tree canopy using this analysis as evidence for the cooling effect of trees. Full grown trees are up to 70 times more effective than saplings at capturing carbon, mitigating heat, and controlling stormwater.
- Target green job development in areas with lacking tree cover and high heat; youth conservation corps are especially valuable in helping to increase and maintain canopy cover.

Impervious Surfaces

- Apply the impervious cover and heat assessment to target the reduction of impervious surfaces in high heat areas identified at both the area-wide and sub-area level.
    - Utilize permeable and/or light pavements along pedestrian and bike paths to cool the path surface for people and pets.
- In areas with high impervious cover and heat, introduce non-vegetative shading solutions where feasible.
    - Locate shade structures in areas where people typically congregate or recreate for an extended period of time, such as picnic areas, playgrounds, or athletic courts.

- Shade areas where individuals will be resting or waiting, such as benches and bus stops. Pergolas and shade canopies are popular options for this purpose.
- Aim for at least 30% shade coverage along transit paths and consider how shade structures will behave at different times of day and with different sun angles.
- Note that paths or sites with east-west exposure will require more shading than those with north-south exposure.
- Incorporate public art into shade structure to improve the aesthetic. Art may include messaging related to heat safety or other heat-related topics.

Data

The corresponding datasets for this report are available here.

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