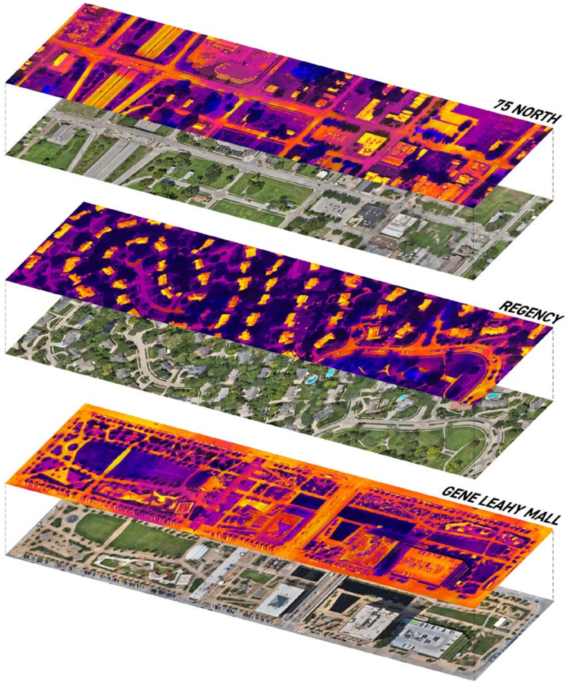
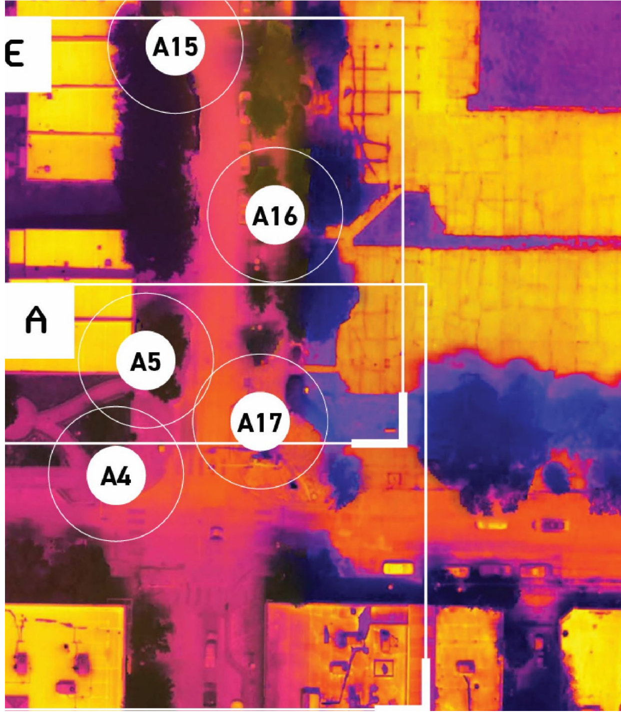




VISUALIZING EXTREME HEAT DISPARITIES

LESSONS FROM THE LAF-FUNDED "HEAT WAVES" RESEARCH PROJECT

LAF

1.0 LA CES CEU (HSW)

- Link to quiz in the chat + follow-up email
- 1.0 PDH (HSW) issued upon completion of 10-question quiz with a score of at least 75%
- Retakes allowed
- Certificate will be emailed **within 2 weeks**

INCREASE the **INFLUENCE** and **IMPACT** of landscape architects

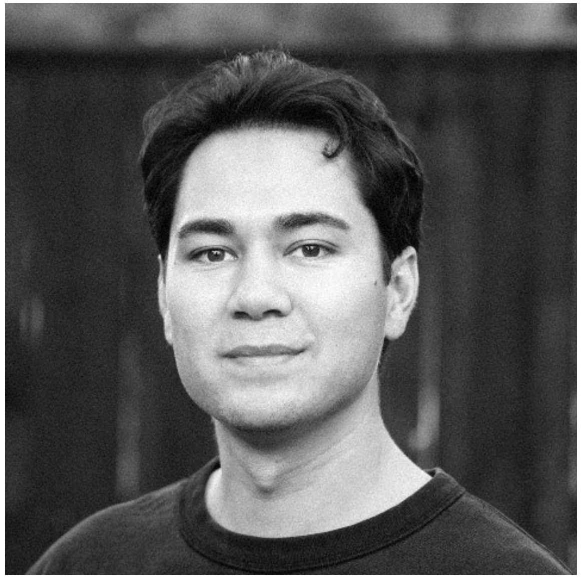
LANDSCAPE ARCHITECTURE FOUNDATION

- 501(c)(3) nonprofit based in Washington, DC
- Invested over $3 million in research since 1986
- Awarded over $2 million in scholarships to over 650 students since 1986
- Awarded $440,000 to 31 professionals to support innovation and leadership since 2017
- Cultivating the next generation of leaders by investing in landscape architects

LAF DEB MITCHELL RESEARCH GRANT

- Deb Mitchell, FASLA + SmithGroup
- Research projects that are relevant and impactful for the professional practice of landscape architecture
- 1 award of $25,000
- Principal Investigator must be trained as a landscape architect
- 12 to 18 months, beginning in summer or fall
- Pre-proposals due December 1

PRESENTERS



Salvador Lindquist
Assistant Professor
University of Nebraska

Keenan Gibbons, PLA, LEED Green
Landscape Architect, SmithGroup
Lecturer, University of Michigan

INTRODUCING THE THERMAL TOOLKIT:

TECHNOLOGIES AND TECHNIQUES FOR VISUALIZING THERMAL DISPARITIES

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Lecturer - University of Michigan
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2024 LAF WEBINAR

CELA
Council of Educators in Landscape Architecture

LAF
LANDSCAPE
ARCHITECTURE
FOUNDATION

ABSTRACT:

Extreme heat kills more people in the United States than any other natural disaster (Berko 2010). These effects are more pronounced in urban environments, where buildings, roads, and other infrastructure absorb and re-emit the sun's heat, otherwise known as urban heat island effect. The increasing frequency and intensity of extreme heat in urban environments pose significant public health risks, disproportionately impacting underserved populations. While heat action plans have gained traction as a process for mitigating the unequal distribution of intense surface temperatures, there is a need for more granular data to guide site-scale landscape planning decisions. The prevailing method of measuring Land Surface Temperature (LST) using United States Geological Survey (USGS) remote sensing data can only reach a resolution of 30m x 30m, and often overlooks the lived reality of the impacts of extreme heat. **This study uses UAV thermography and handheld thermal imagery to visualize the hyper-localized impacts of the urban heat island effect by applying these technologies through a comparative study of three urban corridors in Omaha, Nebraska: 75 North, Regency, and the Gene Leahy Mall.** Not only can thermo-visualization technologies improve landscape decision making, it can improve the transdisciplinary processes that contribute to consensus building by making the distribution of extreme heat more tangible.

00

CONTENTS

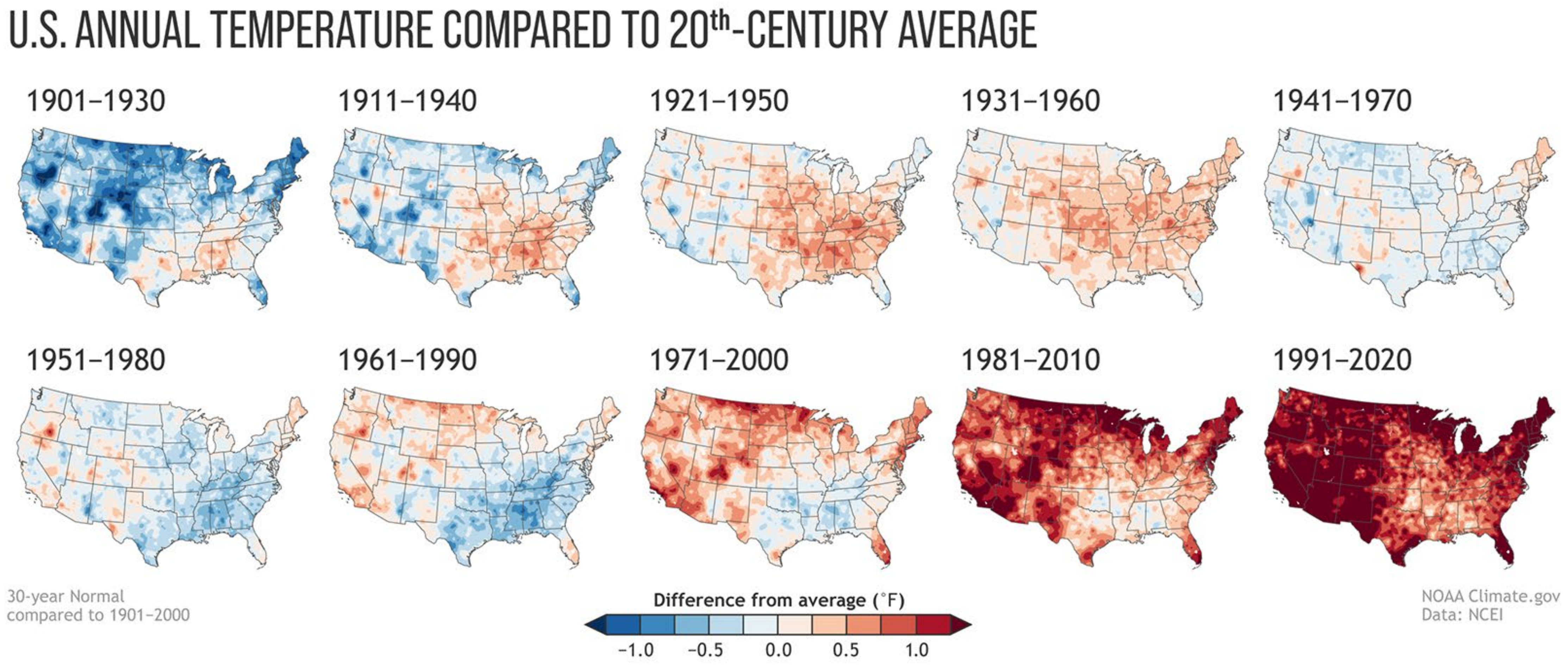
01

INTRODUCTION: HEATING UP!

Extreme heat is one of the **leading causes of natural disaster-related deaths** in the United States, and the problem is expected to worsen as the effects of climate change intensify (Berko, 2014).

IMAGE CREDIT: SAM BLOCH


This is the HOTTEST summer of my life
This is the COLDEST
summer of the rest of your life


U.S. ANNUAL TEMPERATURE COMPARED TO 20th-CENTURY AVERAGE
1901–1930
1911–1940
1921–1950
1931–1960
1941–1970
1951–1980
1961–1990
1971–2000
1981–2010
1991–2020
30-year Normal
compared to 1901–2000
Difference from average (°F)
−1.0
−0.5
0.0
0.5
1.0
NOAA Climate.gov
Data: NCEI

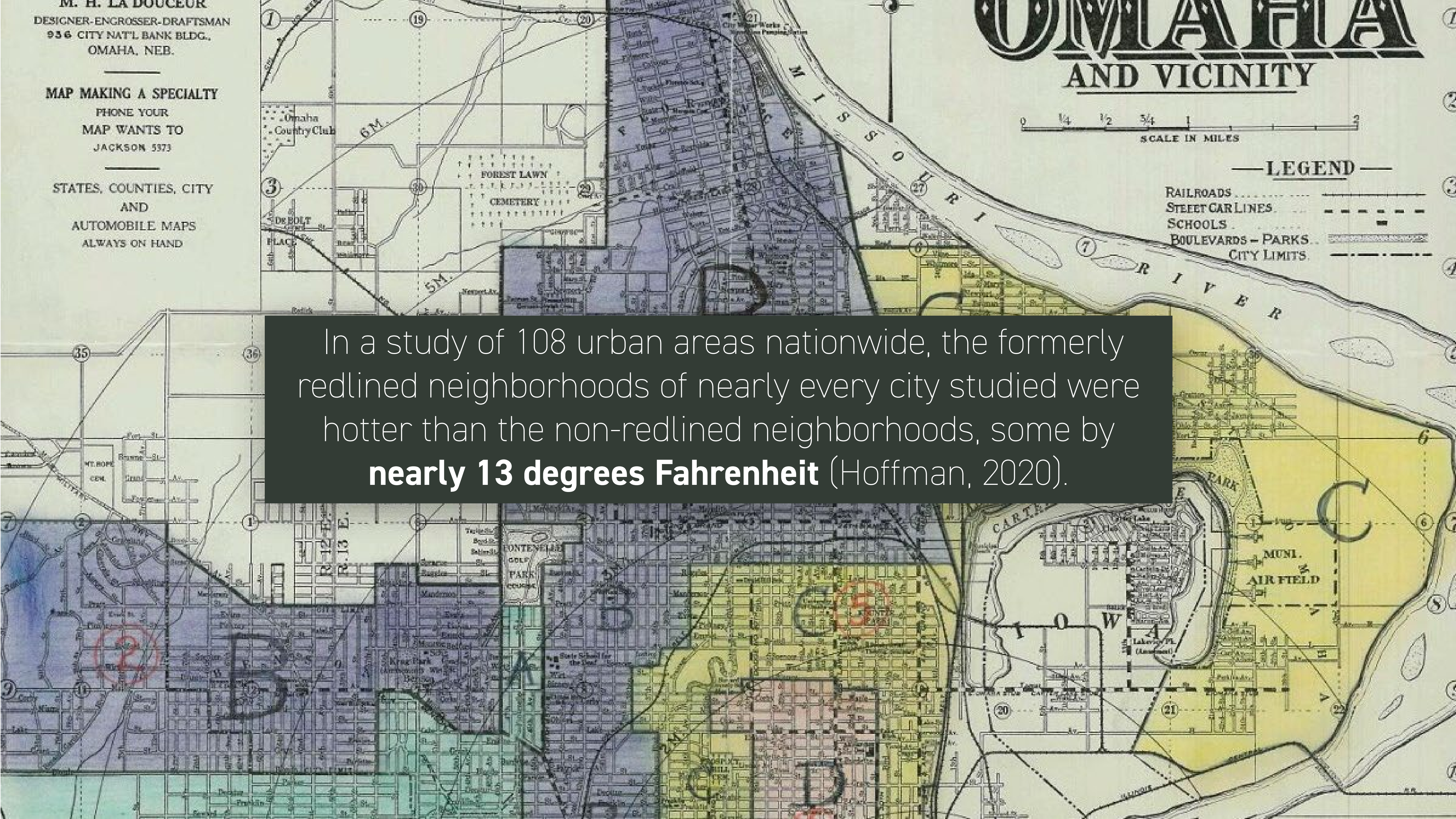
Urban environments are particularly vulnerable to the heat, with hotter temperatures in areas with higher concentrations of concrete and asphalt (EPA, 2022).

IMAGE CREDIT: SAM BLOCH

Today, researchers think of the **heat island as more of an archipelago**, where hot spots are heterogeneously distributed throughout a city in locations with higher concentrations of concrete and asphalt, whereas **cooler temperatures can be found around trees, parks, or other open space** (Borunda, 2021).

IMAGE CREDIT: NASA EARTH OBSERVATORY

IMAGE CREDIT: SAM BLOCH, "Shade in the Skid Row neighborhood, Downtown Los Angeles."



In a study of 108 urban areas nationwide, the formerly redlined neighborhoods of nearly every city studied were hotter than the non-redlined neighborhoods, some by **nearly 13 degrees Fahrenheit** (Hoffman, 2020).

TREE EQUITY SCORE | National Explorer

Search for a location

Census Block Group 310550008001

Population: 1,184

Omaha, NE

NE Congressional District 2

70

Tree Equity Score

Ranked 451st of 462 block groups in Omaha

Priority: HIGH

Current canopy cover: 16%

Canopy cover goal: 30%

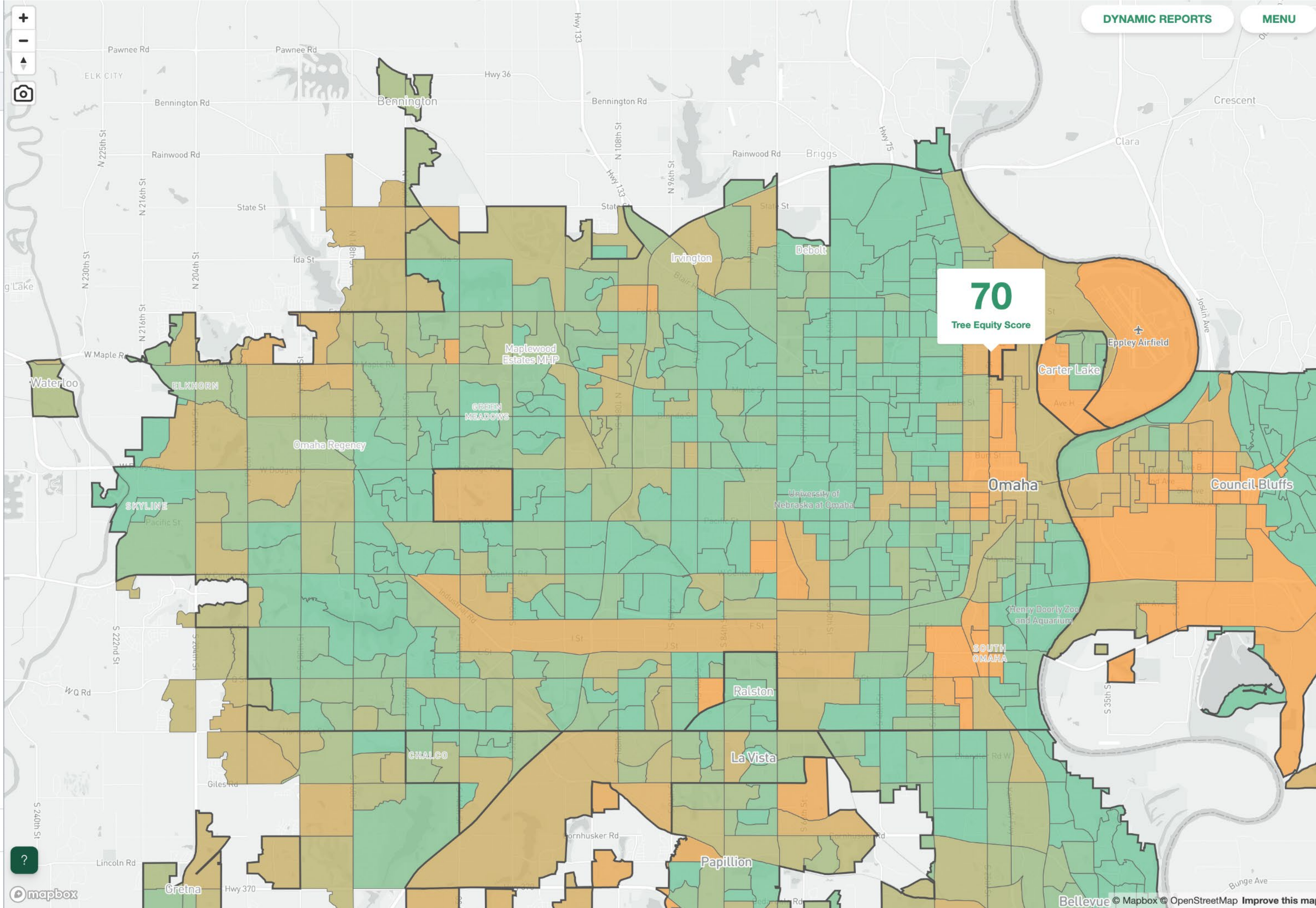
Score indicators

Priority index

Layers | Filters

<70 — 100

Tree Equity Score



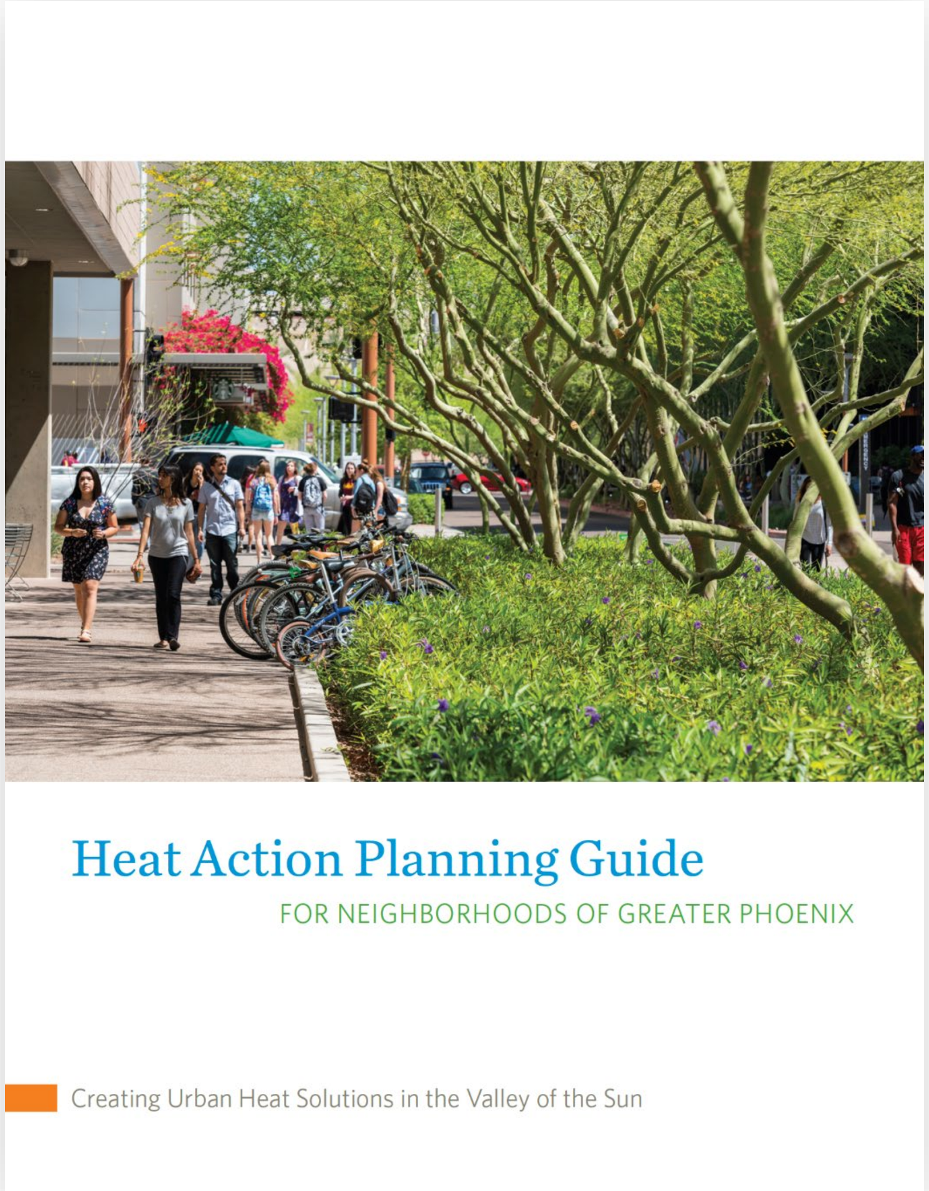

"Shade is often understood as a luxury amenity. But as deadly heatwaves become commonplace, we have to see it as **a civic resource shared by all**." (Bloch, 2019)
IMAGE CREDIT: AGENCE TER

Mitigating the unequal distribution of intense surface temperatures requires a multifaceted approach, including **policy, public health, urban planning, and nature-based solutions.**

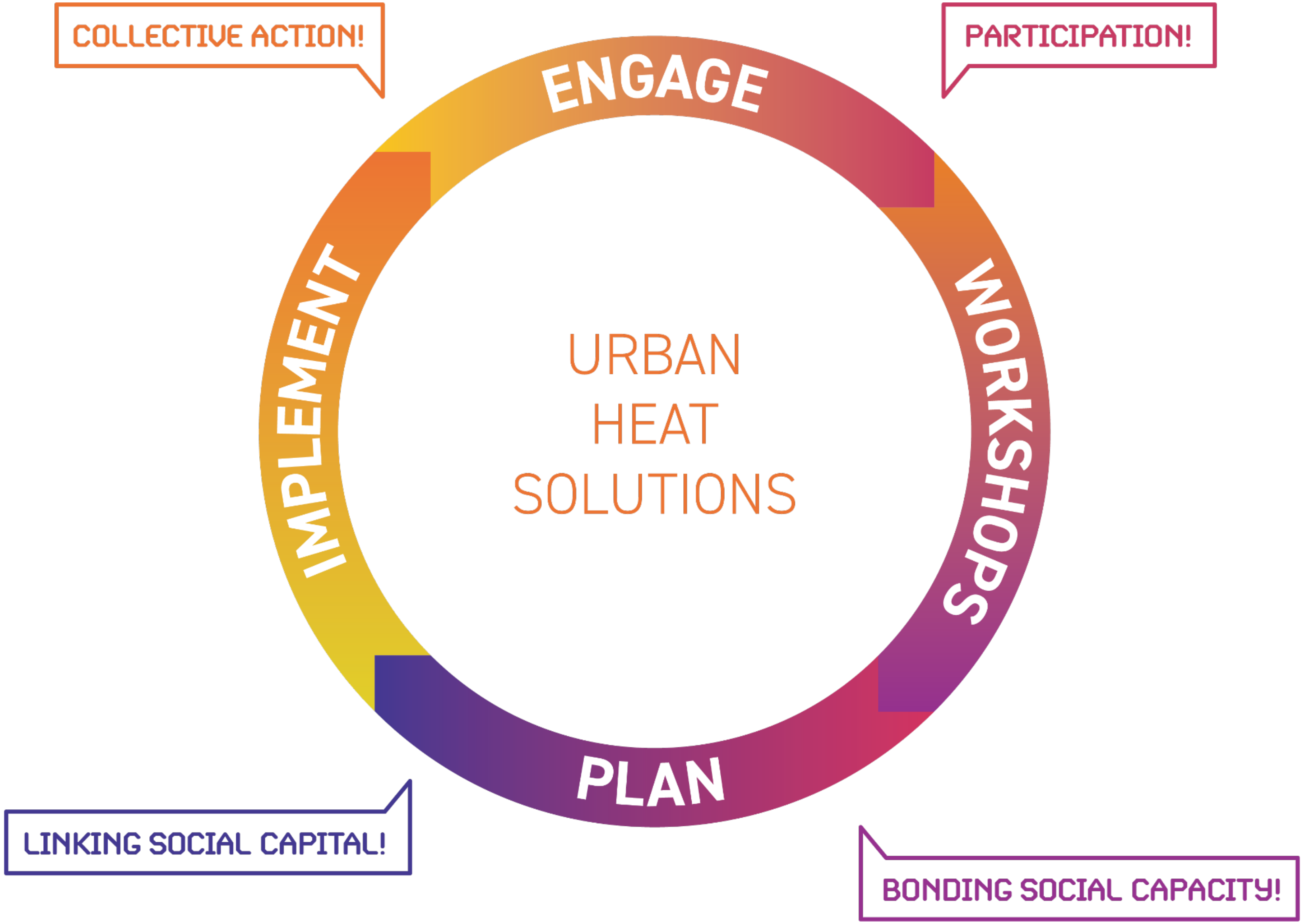
IMAGE CREDIT: THE NATURE CONSERVANCY

02

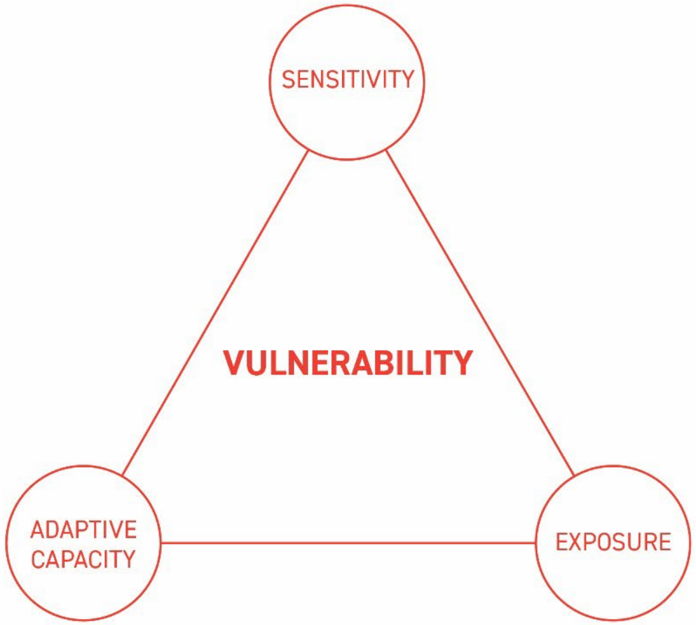
HEAT, DESIGN, ACTION!


Heat Action Planning Guide
FOR NEIGHBORHOODS OF GREATER PHOENIX
Creating Urban Heat Solutions in the Valley of the Sun

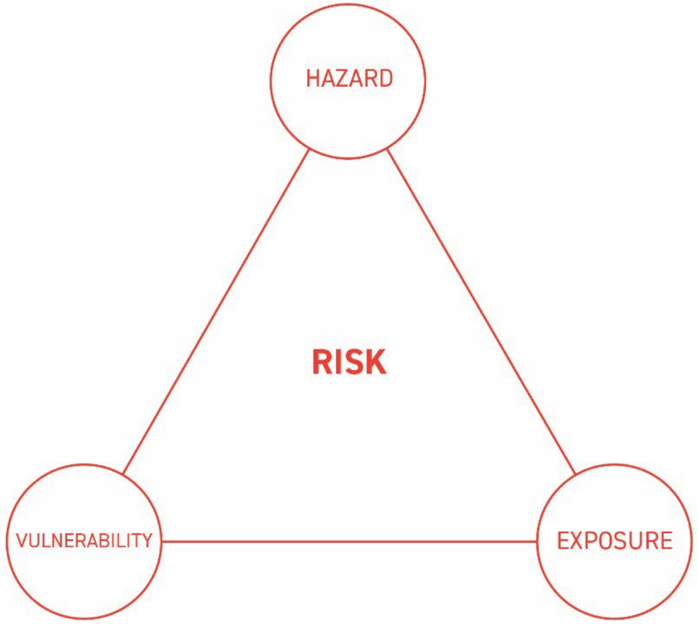

WSROC
TURN DOWN THE HEAT
TURN DOWN THE HEAT
STRATEGY AND ACTION PLAN
2018



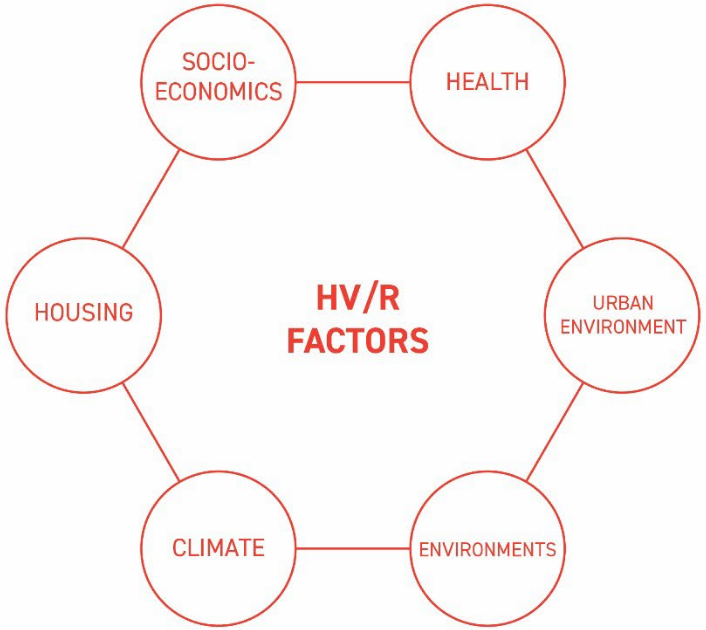
Heat Action Planning Process methodology adapted from Semenza, et al. (2007)



Cutter et al., 2003; Change, I. P. O. C, 2001



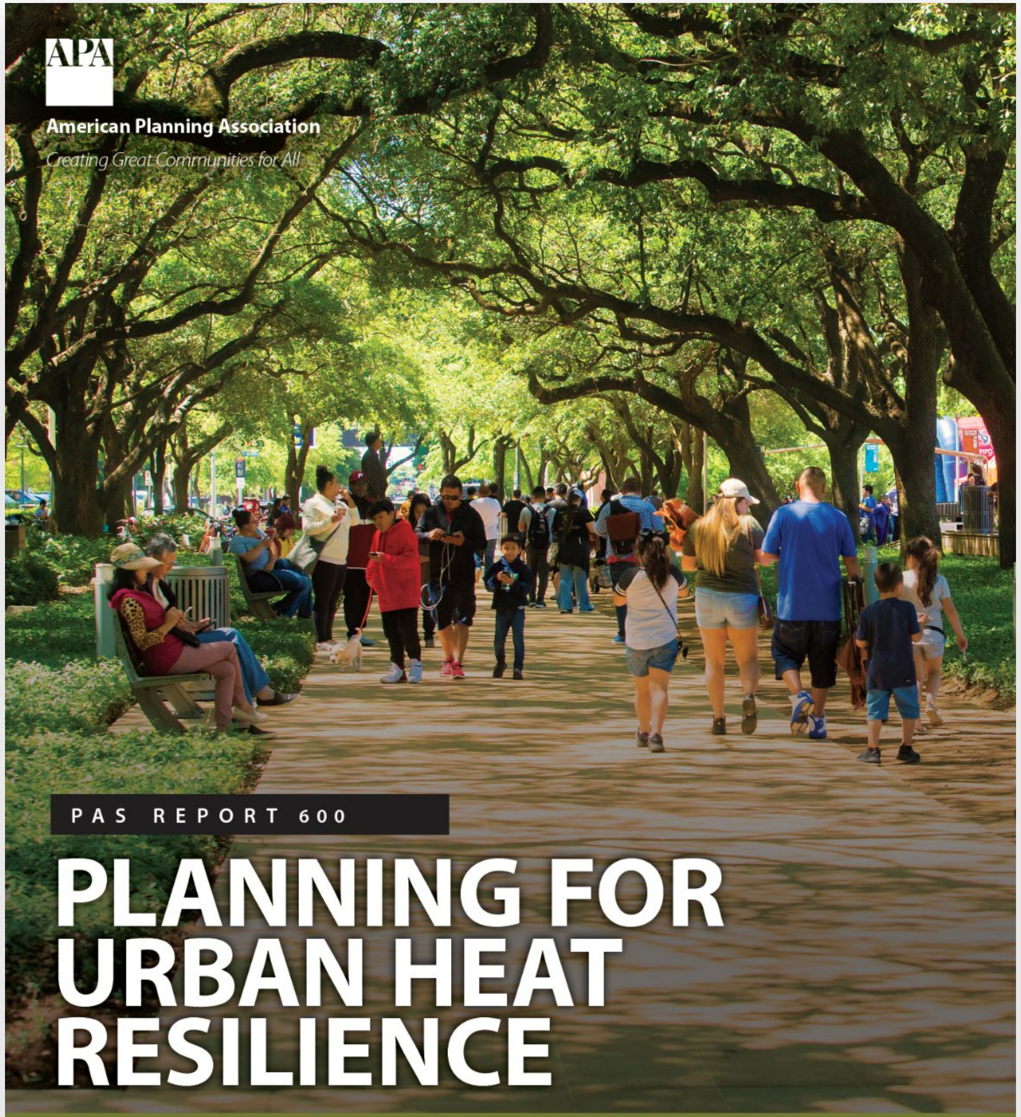
Crichton, 1999; Field and Barros, 2014



Cheng et. al., 2021

American Planning Association

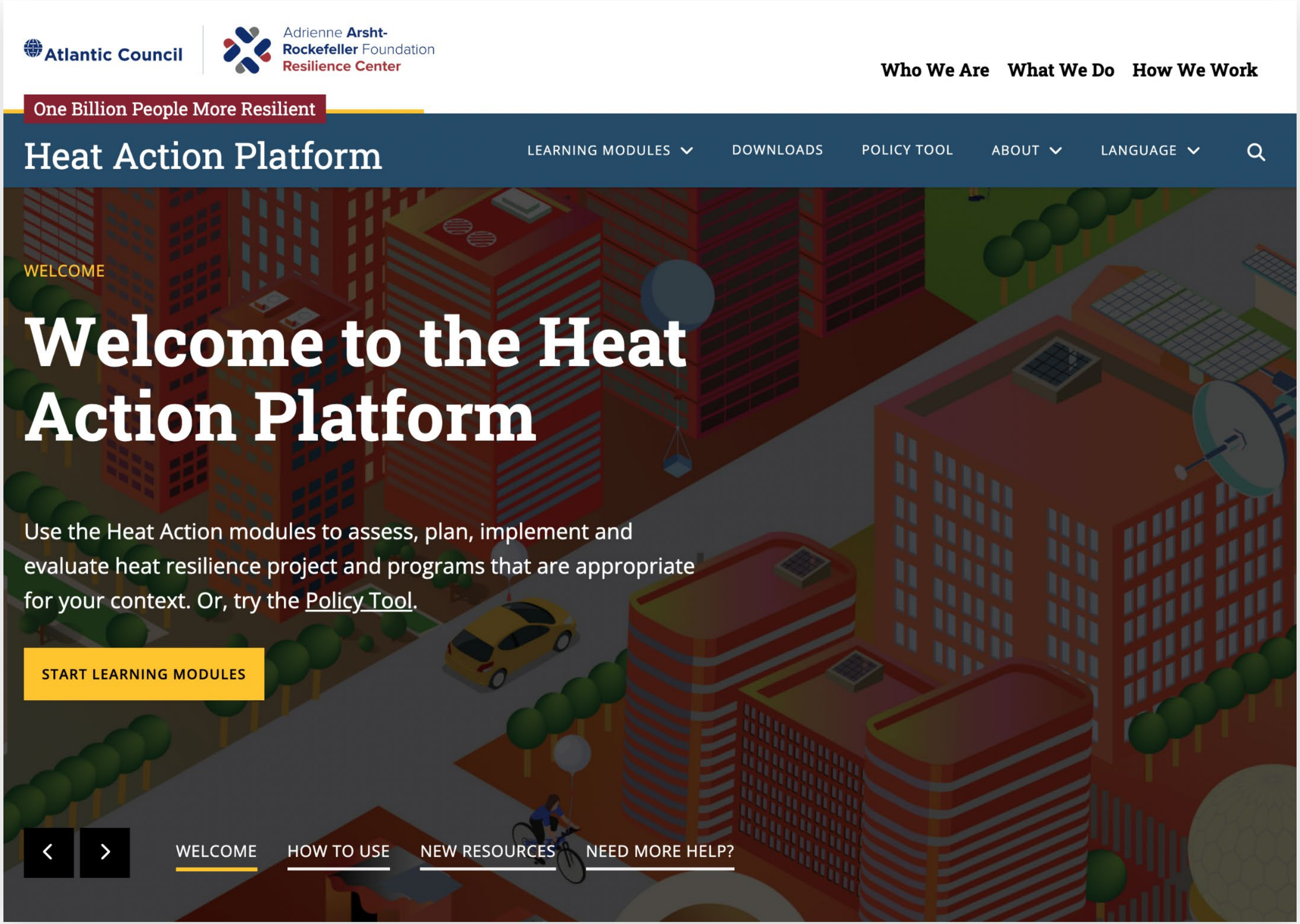
Creating Great Communities for All



PAS REPORT 600

PLANNING FOR URBAN HEAT RESILIENCE

Ladd Keith, PHD, and Sara Meerow, PHD


Atlantic Council
Adrienne Arsht-Rockefeller Foundation Resilience Center
Who We Are
What We Do
How We Work
One Billion People More Resilient
Heat Action Platform
LEARNING MODULES
DOWNLOADS
POLICY TOOL
ABOUT
LANGUAGE
WELCOME
Welcome to the Heat Action Platform
Use the Heat Action modules to assess, plan, implement and evaluate heat resilience project and programs that are appropriate for your context. Or, try the Policy Tool.
START LEARNING MODULES
WELCOME
HOW TO USE
NEW RESOURCES
NEED MORE HELP?

Assess

- Baseline Assessment
- Identify Vulnerable Communities
- Assess Awareness

Plan

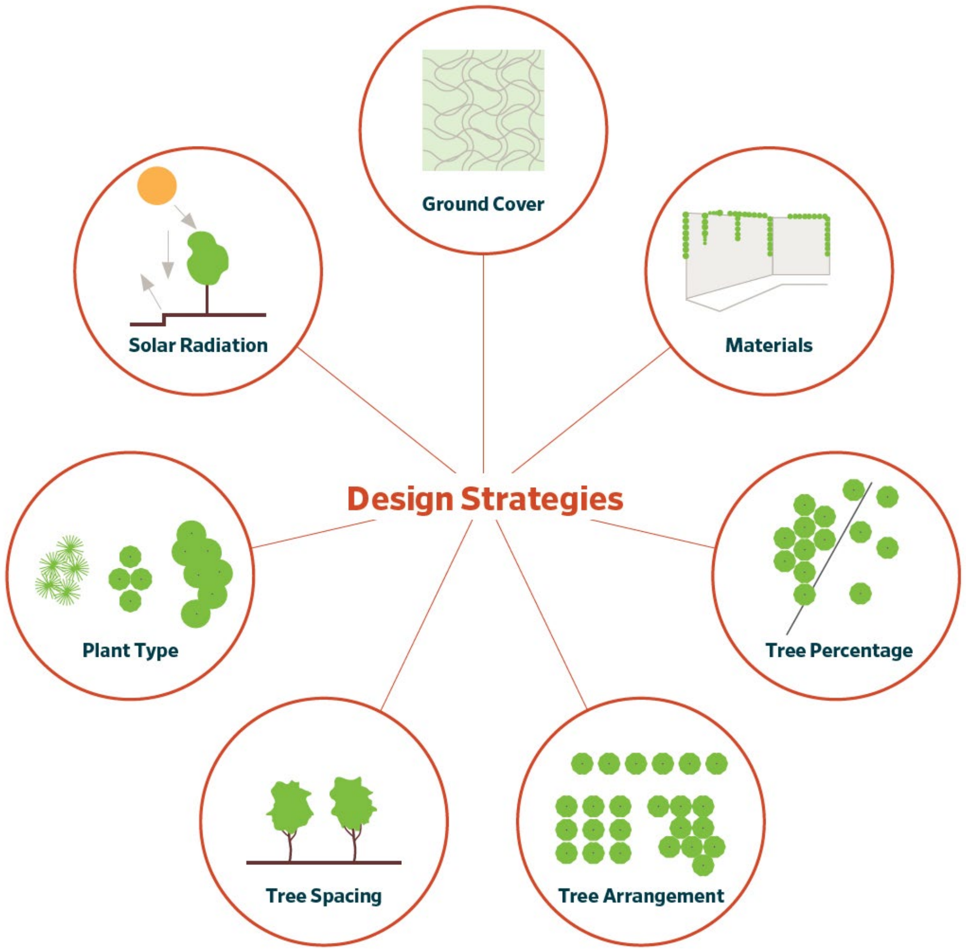
- Develop an Education Strategy
- Explore Adaptation Solutions
- Fund and Finance Projects

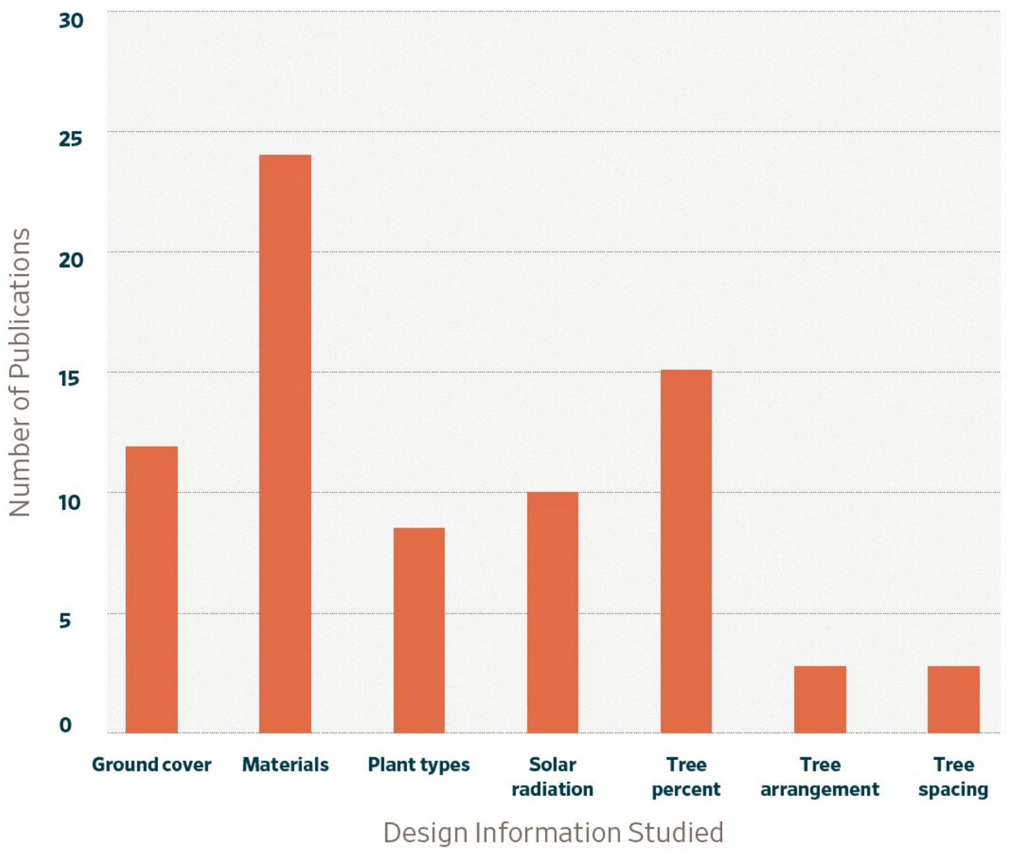
Implement

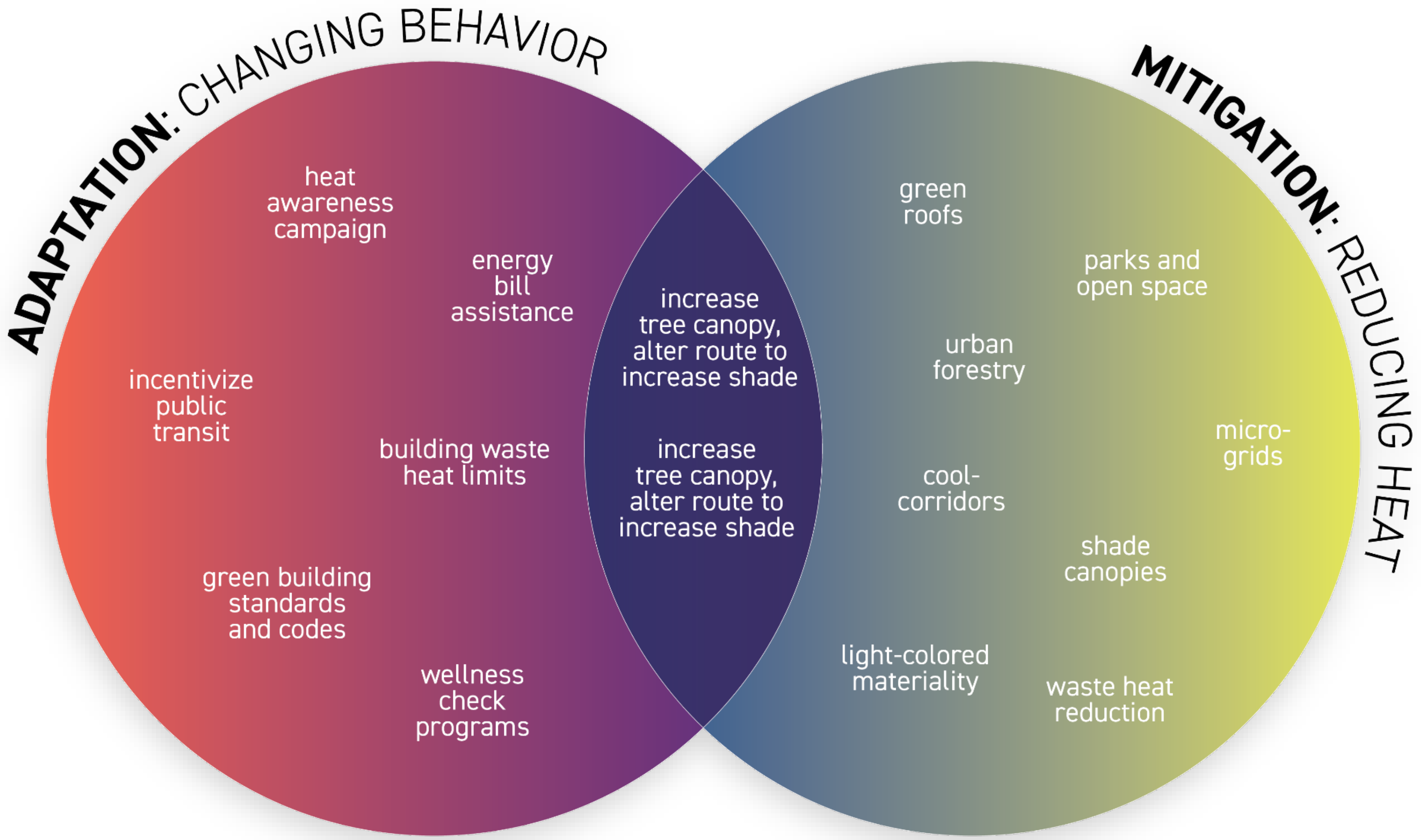
- Create a Heat Action Plan
- Implement and Scale
- Monitor and Evaluate

02

ADAPTATION AND MITIGATION TACTICS


Ground Cover
Solar Radiation
Materials
Design Strategies
Plant Type
Tree Percentage
Tree Spacing
Tree Arrangement


30
25
20
15
10
5
0
Number of Publications
Ground cover
Materials
Plant types
Solar radiation
Tree percent
Tree arrangement
Tree spacing
Design Information Studied


ADAPTATION: CHANGING BEHAVIOR
MITIGATION: REDUCING HEAT
heat awareness campaign
energy bill assistance
incentivize public transit
building waste heat limits
green building standards and codes
wellness check programs
increase tree canopy, alter route to increase shade
increase tree canopy, alter route to increase shade
green roofs
parks and open space
urban forestry
micro-grids
cool-corridors
shade canopies
light-colored materiality
waste heat reduction

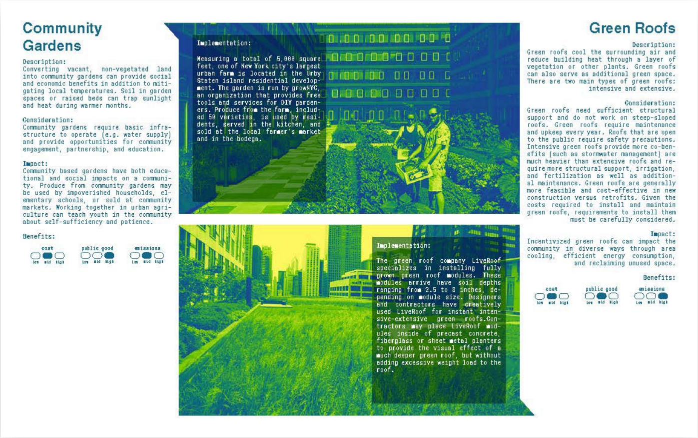
ADAPTATION

COMMUNITY	Energy bill assistance
	Establishing urban forestry, tree, and landscape program
	Heat awareness campaign
	Providing incentives and awards
	Thermal comfort policies
EMERGENCY	Chief heat officers
	Cool hospital preparedness mandate
	Heat emergency response plan
	Heat hotlines
	Public transit services during heat waves
	Wellness check programs
INFRASTRUCTURE	Building materials and standards
	Building waste heat limits
	Green building and energy efficiency standards and codes
	Heat design guidelines
ASSESSMENT	Building energy benchmarking
	Catastrophe (CAT) bond
	Conduct a heat vulnerability assessment
	Design a heat management plan
	Heat-resilient environmental impact assessments

MITIGATION

MATERIAL	Shade structures
	Permeable pavement
	Heat resilient building envelopes
	Light pavement/material
ARCHITECTURE	Cool roofs/walls
	Building orientation
	Exterior building shade
	Green building
GREEN INFRASTRUCTURE	Urban forestry
	Tree protection
	Parks and open space
	Water features
	Community gardens
	Green roofs
	Cool corridors
ENERGY	Microgrids
	Electric vehicle infrastructure
	District cooling
	Waste heat reduction
	Solar panels


Energy Bill Assistance
Establishing Urban-Forest Programs
Cool Hospital Preparedness Mandate
Heat Emergency Response Plan
Building Waste Heat Limits
Green Building Standards & Codes
Heat Awareness Campaign
Providing Incentives and Awards
Heat Hotlines
Public Transit During Heat Waves
Heat Design Guidelines
Building Energy Benchmarking
Thermal Com- fort Policies
Chief Heat Officer
Wellness Check Programs
Building Material Standards
Catastrophe (CAT) Bonds
Conduct a Heat Vulnerability Assessment

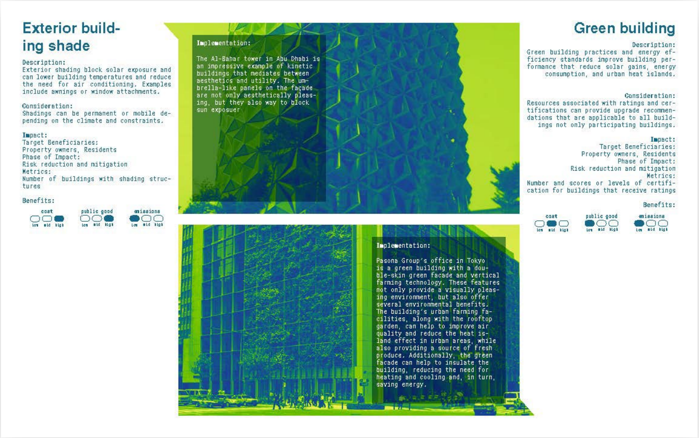

Community Gardens
Green Roofs


Electric Vehicle Infrastructure
Microgrids


Cool roofs & walls
District cooling


Parks and Open Space
Tree Protection


Walkability and Cool Corridors
Waste Heat Reduction

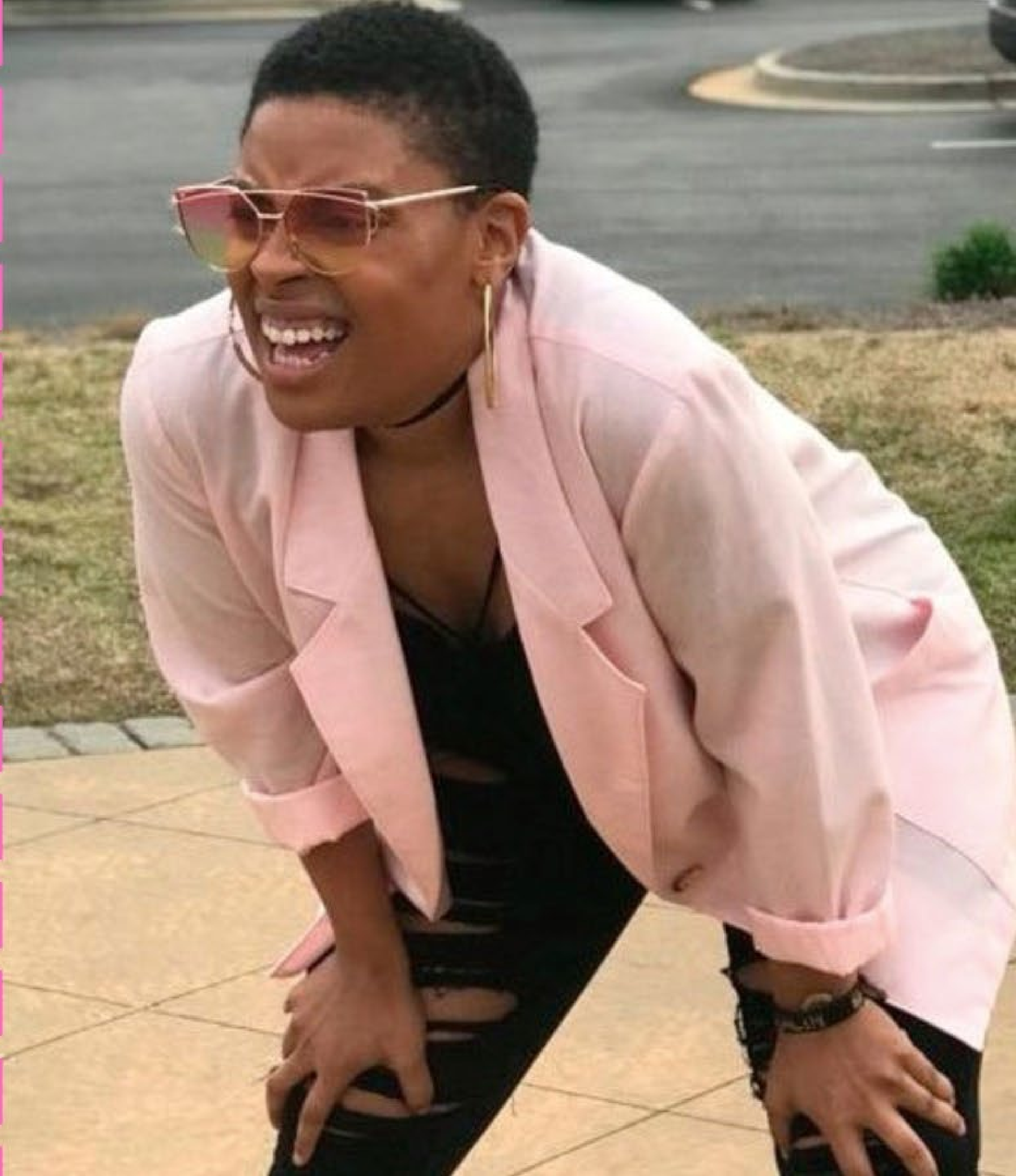

Exterior build-ing shade
Green building


Urban Forestry
Public Water Features


Building envelopes
Building orientation


Light-colored material
Permeable pavement

IMAGE CREDIT: Carolina A. Miranda / Los Angeles Times


PLAZA
DASH


Short on Shade

Research on Equity and Exposure in Los Angeles

swa

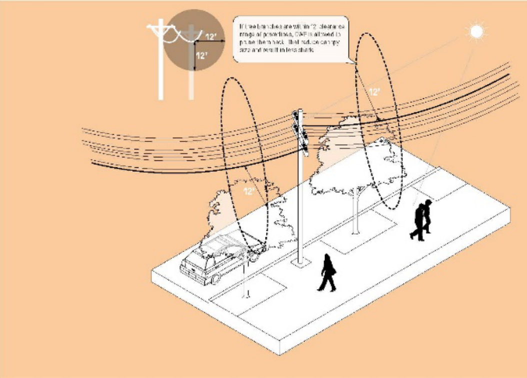
01

Utility Clearance

California State's standard for clearance around power lines has increased from 4 feet to 12 feet since 2017.

POLICY AND CODE

State of California
California Public Utilities Commission
Order 95, Rule 35, Table 1:
Case 14 for High Fire-Risk Areas



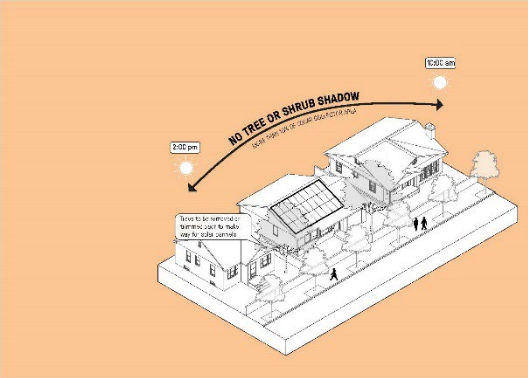
02

Solar Rights

Solar Shade Control Act: Trees, shrubs or other shade forms give way to solar collectors.

POLICY AND CODE

State of California
California Public Resources Code
Division 15, Chapter 12: Solar Shade Control
(25980 - 25986)



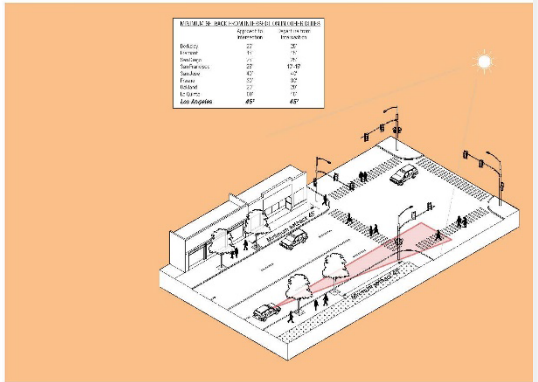
03

Intersection Setbacks

City guidelines require a 45-foot setback from intersections for tee planting.

POLICY AND CODE

State of California
Tree Spacing Guidelines
Bureau of Street Services
City of Los Angeles



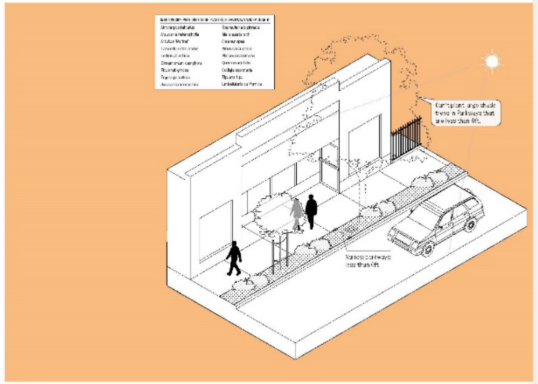
04

Narrow "Hellstrips"

The City prohibits planting of large trees in parkways less than 6 feet wide in order to protect sidewalks and underground utilities.

POLICY AND CODE

City of Los Angeles
Approved Street Tree List
City of Los Angeles



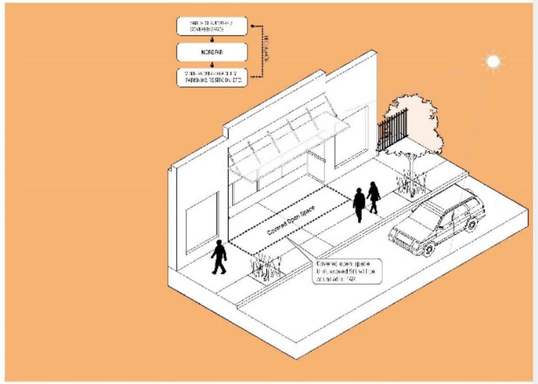
05

Floor Area Ratio

Covered open space that exceeds 5 feet, or that is supported by columns, is counted as floor space in FAR code, discouraging developers from building shade structures in the public realm.

POLICY AND CODE

City of Los Angeles
Los Angeles Municipal Code
Section 12.03: Balconies Projection
for Height and Floor Area.
City of Los Angeles



06

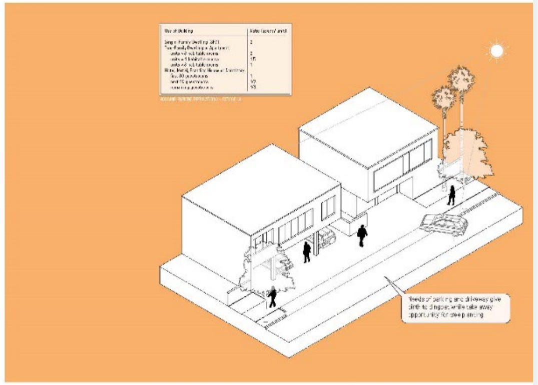
Parking Requirements

Dingbats, a housing type that originating in a car-centric era, provide generous parking space but limit planting areas.

Parking and driveway needs supercede opportunities for tree shade.

POLICY AND CODE

City of Los Angeles



07

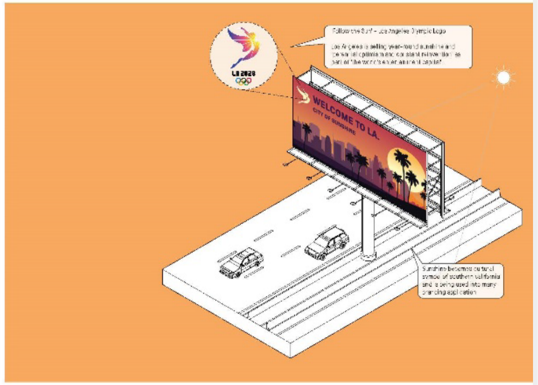
Sun Symbolism

Sunshine is culturally prized by Los Angelenos as a symbol of their city.

Angelenos' altitude towards sunshine complicate the provision of shade.

CULTURAL IDENTITY

City of Los Angeles



08

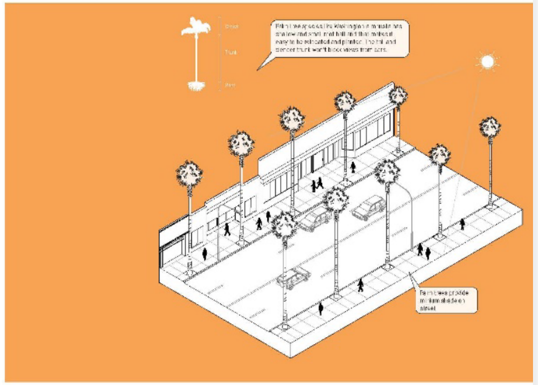
Palms Mean Paradise

Palm trees became one of the dominant Los Angeles street tree species, due in part to characteristics that were ideal for an era dominated by cars.

The ubiquity of these trees has resulted in less overall street shade.

CULTURAL IDENTITY

City of Los Angeles



09

Cars Trump Trees

Car-oriented road-widening development practices resulted in diminished parkways that are not wide enough for shade trees.

CAR-CENTRIC URBANISM

City of Los Angeles

10

Policing and Surveillance

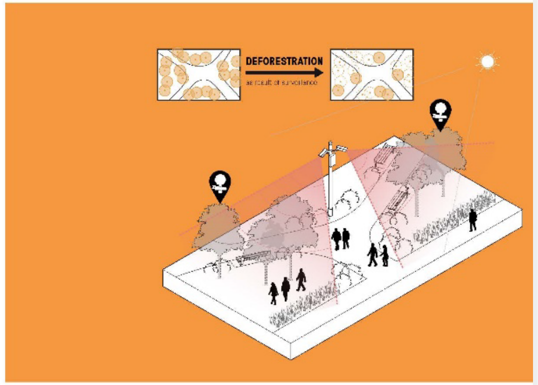
Shade is considered as an impediment to surveillance and safety, resulting in a preference for unshaded public spaces by law enforcement agencies. Sunlight was weaponized to deter “deviants and criminals” in Los Angeles.

SHADE STEWARDSHIP

City of Los Angeles

In 1964, business owners sponsored a redesign intended to clear out “deviants and criminals.” The City removed perimeter benches and culled shade trees and even palms so that office workers and shoppers could move through the park without being “accosted by derelicts and ‘bums.’” Sunlight was purposely weaponized with the intent that “before long, pedestrians (could) be walking through, instead of avoiding, Pershing Square.”

—Sam Bloch, “Shade,” *Places Journal*, April 2019. (Accessed 11 Dec 2019.)



11

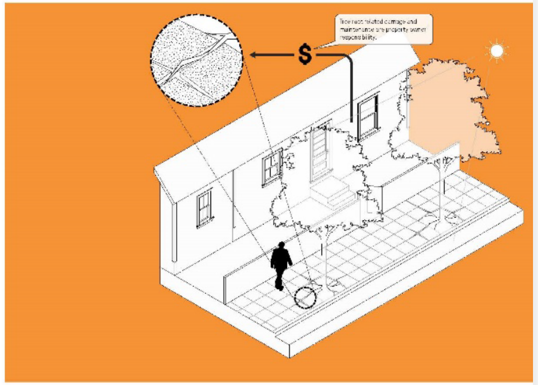
Tree Maintenance

Adjacent owners are responsible for the maintenance of parkway trees, resulting in their becoming a private financial burden.

Tree watering and maintenance were historically the obligation of property owners until 1932, when the City began to take more responsibility for managing street trees. However, root-related damage and maintenance remain property owners' responsibility today.

SHADE STEWARDSHIP

City of Los Angeles



12

Advertising Dollars

The City of Los Angeles signed contracts with private vendors to install and maintain bus shelters in exchange for advertising space on the shelters themselves.

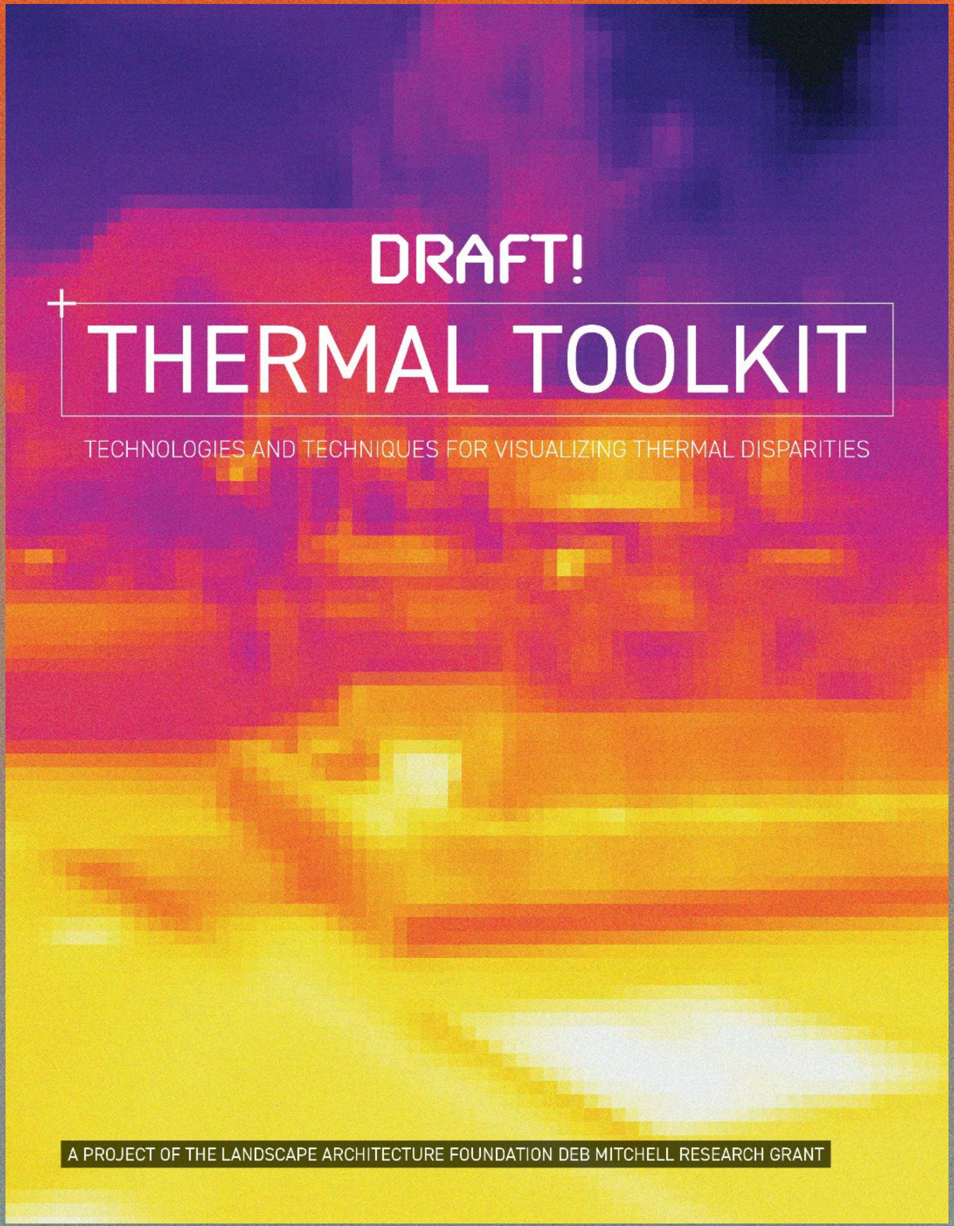
Advertising revenue became a driving factor in determining bus shelter locations, with the result that “high-value” neighborhoods benefit from more bus shelter shade.

SHADE STEWARDSHIP

City of Los Angeles

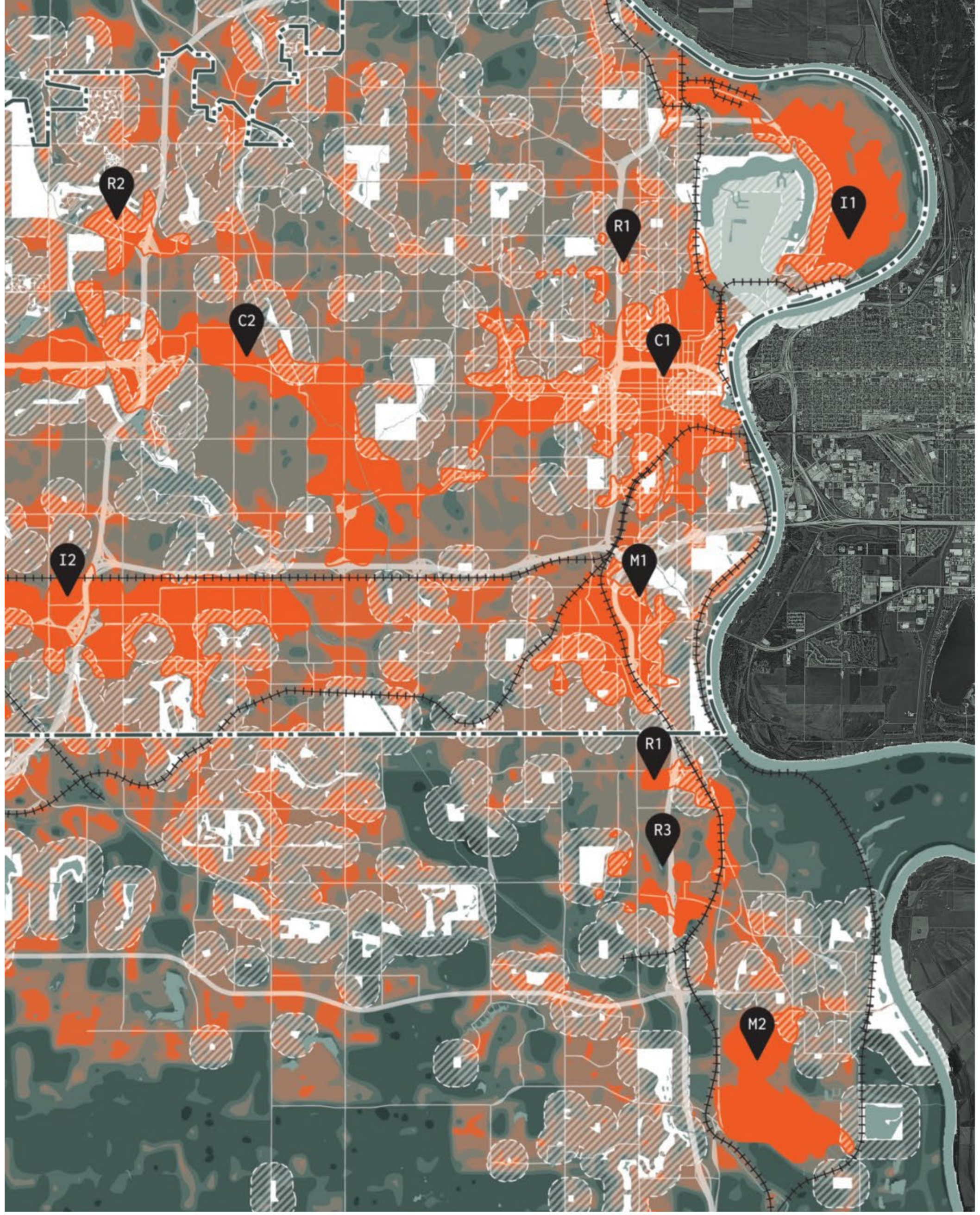
03

METHODS FOR VISUALIZING HEAT



A	Landsat/GIS
B	UAV Infrared Thermography
C	Handheld Thermography
E	Mobile Biometeorological Instrument Platform
F	Vehicle-Mounted Thermocouple Sensors
G	Environmental Simulation
H	Community-led Assessment

VISUALIZATION TOOL	DESCRIPTION	ASSESSMENT	TOOLS	SCALE			PROJECT PHASE		
				REGIONAL	NEIGHBORHOOD	SITE	PRE-DESIGN	DESIGN	POST-DESIGN
LANDSAT IMAGERY/GIS DATA	Satellite imagery used to map surface temperature and land cover.	Land surface temperature, Land cover classification	GIS software (e.g., ArcGIS, QGIS), Landsat imagery, Tree Equity Score (TES)	●	●		○		
UAV INFRARED THERMOGRAPHY	Use of drones equipped with infrared cameras to capture high-resolution thermal images.	Material surface temperature, infrared radiation (IR)	UAVs, infrared cameras (e.g., FLIR)		●	●	○		○
HANDHELD THERMOGRAPHY	Portable infrared cameras to measure temperature variations on the ground level.	Material surface temperature, infrared radiation (IR)	Handheld infrared cameras (e.g., FLIR)		●	●	○		○
MOBILE BIOMETEOROLOGICAL INSTRUMENT PLAT-FORM	Mobile units equipped with sensors to measure various environmental parameters that comprise mean radiant temperature.	Air temperature (°C), humidity (%), wind speed (m/s). Mean Radiant Temperature, 6-directional method for obtaining average temperature of all surfaces surrounding a person, including walls, floors, and objects.	Mobile meteorological stations (e.g. MaRTy)			●	○		
VEHICLE-MOUNTED THERMOCOUPLE SENSORS	Thermocouples mounted on vehicles to measure temperature while driving through different areas.	Air temperature	Vehicles, thermocouple sensors		●	●	○		
ENVIRONMENTAL SIMULATION (e.g. ENVI-met)	Simulation software to model and predict microclimatic conditions in urban environments.	Temperature (°C), wind flow (m/s), humidity (%)	ENVI-met software		●	●	○	○	
COMMUNITY ENGAGEMENT/HEAT WALKS	Engaging with the community to collect temperature data and identify heat-affected areas.	Perceived temperature, community feedback, qualitative data	Surveys, mobile apps, handheld thermometers		●	●	○	○	○



Heat Islands and proximity to green space in Omaha, NE. Landsat 8 and GIS data. Map by Salvador Lindquist.

SCALE/RESOLUTION
regional | neighborhood | site

PROJECT PHASE
pre-design | design | post-design

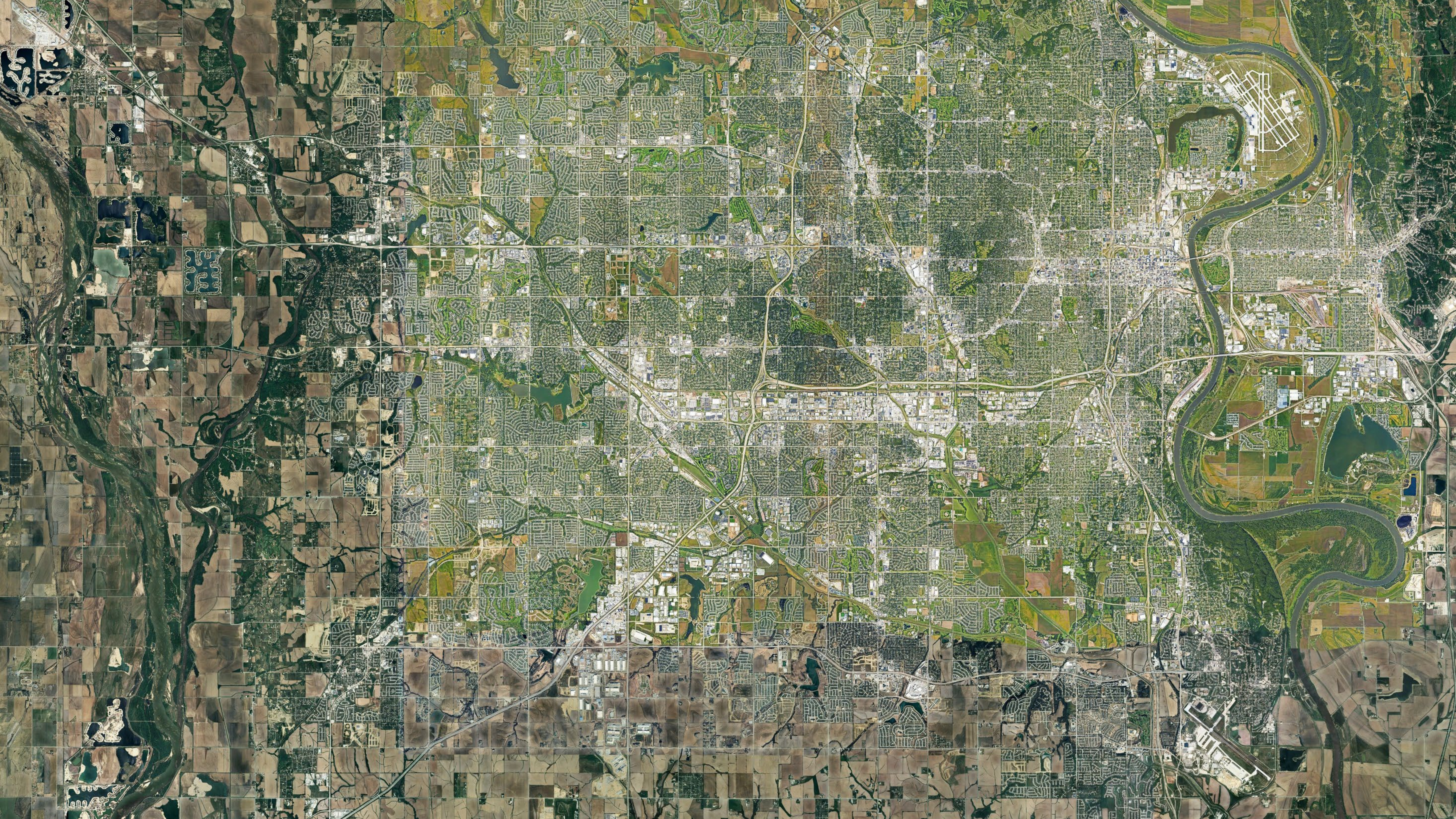
LANDSAT / GIS

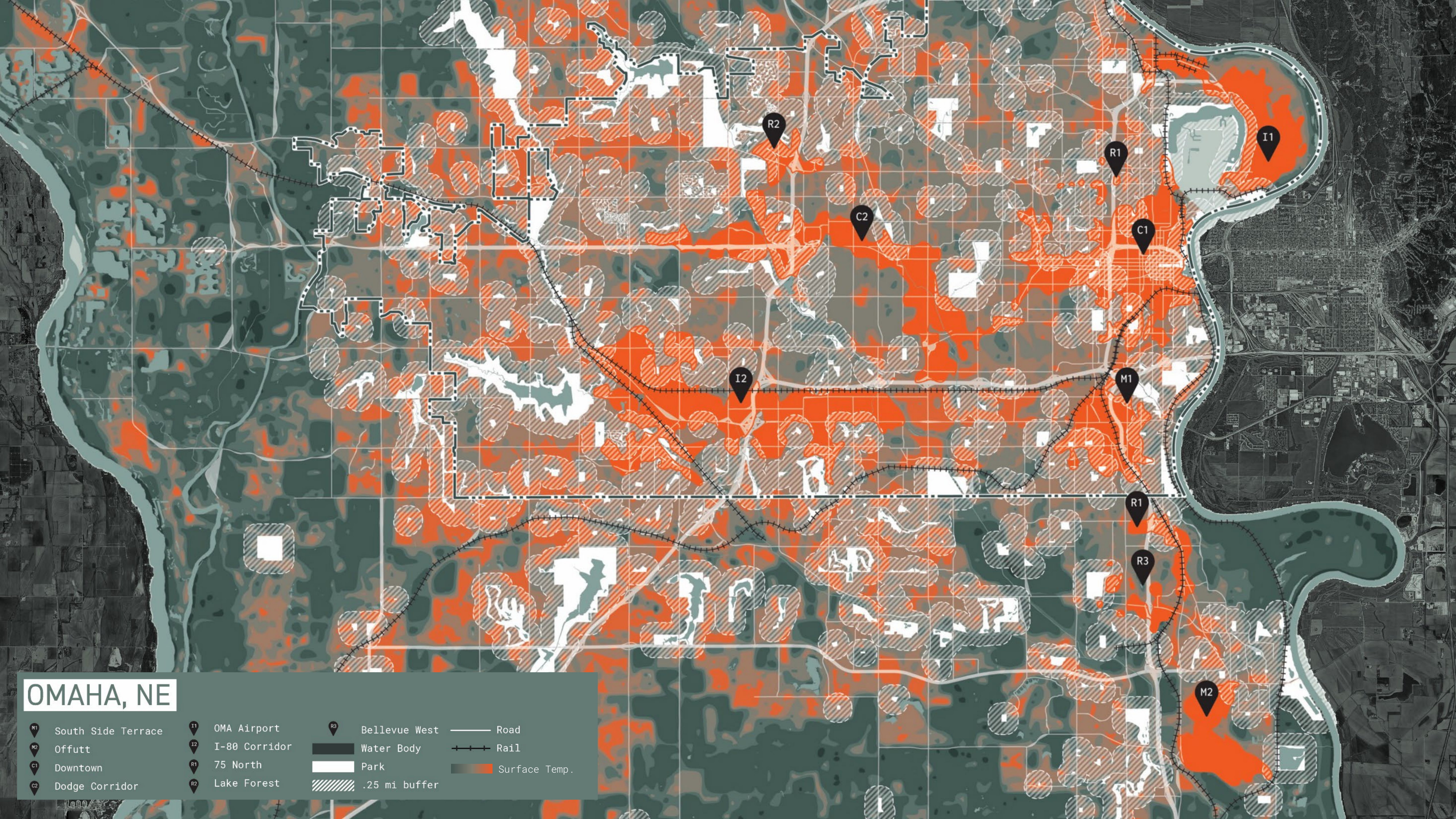
BRIEF DESCRIPTION:

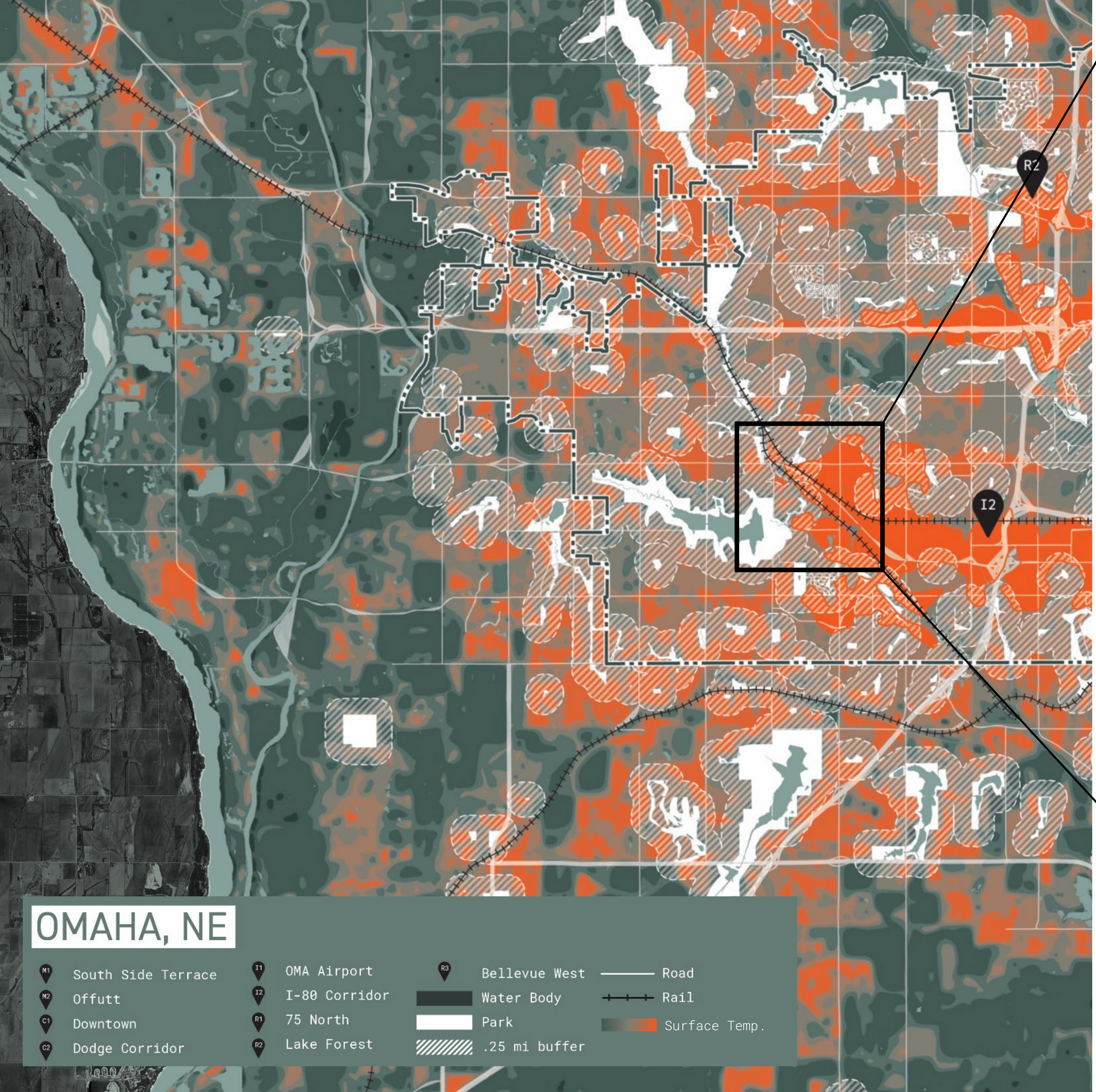
Landsat is a series of Earth-observing satellite missions jointly managed by NASA and the U.S. Geological Survey (USGS). Launched initially in 1972, the Landsat program has provided a continuous record of Earth's surface, making it one of the longest-running satellite imagery programs in existence. The satellites are equipped with various sensors which capture data across multiple spectral bands, from visible light to thermal infrared. This diverse range of data allows for detailed analysis of land cover, vegetation health, and, crucially, surface temperature, making Landsat an invaluable tool for studying urban heat islands and other climate-related phenomena.

Geographic Information Systems (GIS) coordinate with Landsat data to provide a powerful platform for analyzing and visualizing the spatial distribution of heat. By integrating the spectral data from Landsat with other geographical data layers, GIS enables researchers and urban planners to map temperature variations across different regions, identify hotspots, and correlate these findings with factors such as land use, population density, and socioeconomic variables. For example, by overlaying temperature data with land cover maps, GIS can reveal how different surfaces (like concrete, vegetation, and water bodies) contribute to urban heat islands, offering insights into where mitigation efforts are most needed.

The applications of Landsat and GIS in understanding heat distribution are extensive. On a regional scale, these tools can be used to monitor changes in surface temperatures over time, helping to track the effectiveness of interventions like tree planting or reflective roofing. They also play a critical role in assessing the impact of urbanization on local climates, guiding policy decisions aimed at improving urban resilience to extreme heat. Additionally, by combining Landsat data with demographic information in GIS, planners can identify vulnerable communities disproportionately affected by heat, ensuring that adaptation and mitigation strategies are equitably distributed.




R2
R1
I1
C2
C1
I2
M1
R1
R3
M2
OMAHA, NE
South Side Terrace
Offutt
Downtown
Dodge Corridor
OMA Airport
I-80 Corridor
75 North
Lake Forest
Bellevue West
Water Body
Park
.25 mi buffer
Road
Rail
Surface Temp.



The U.S. Geological Survey (USGS) provides georeferenced Landsat surface temperature maps available at a 30m x 30m spatial resolution. These data work well at a large scale (county or state), but lack the fidelity and resolution required to make targeted site-based landscape interventions.

Abdoulaziz Abdoulaye of UNMC demonstrates a sensor used in the heat study (Photo by Fred Knapp, Nebraska Public Media News)

SCALE/RESOLUTION
regional neighborhood site

PROJECT PHASE
pre-design design post-design

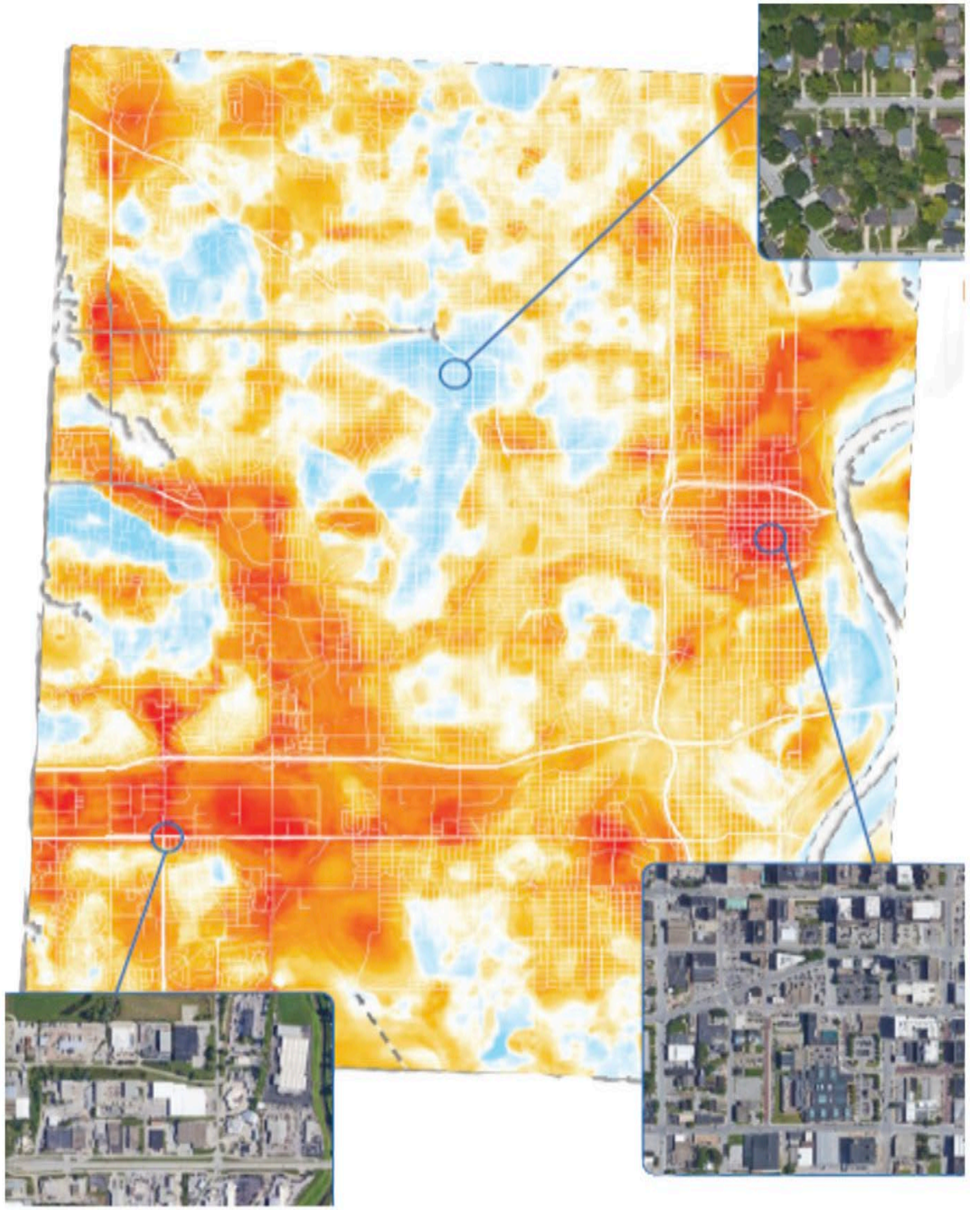
VEHICLE-TRAVERSE COLLECTION

BRIEF DESCRIPTION

Vehicle-traverse collection is a dynamic method used to assess the urban heat island (UHI) effect by equipping vehicles with thermal imaging technology to capture surface temperature data across different urban areas. This approach involves driving a vehicle fitted with thermal sensors, such as infrared cameras or temperature probes, which continuously record temperatures as the vehicle traverses various streets and neighborhoods.

This method provides a comprehensive, real-time view of temperature variations across a city, capturing data across a wide range of locations in a single trip. This continuous data collection enables detailed analysis of temperature gradients and hotspots over large areas, offering insights into how urban design, land use, and infrastructure contribute to the UHI effect. Unlike stationary measurements, which are limited to fixed points, vehicle-traverse collection can reveal varying street-level conditions and identify areas with significant heat disparities.

Vehicle-traverse collection stands out from other heat visualization methods such as UAV, handheld thermography, and Landsat imagery. While UAVs capture data from fixed altitudes and may miss ground-level variations, and handheld thermography provides localized measurements, vehicle-traverse collection combines the mobility of vehicles with high-resolution thermal sensing to cover extensive urban areas. It produces detailed heat maps that reflect granular, dynamic temperature changes. Unlike Landsat imagery, which offers broad, satellite-based data at a lower resolution and less frequent updates, vehicle-traverse collection can capture more specific and timely temperature variations. This method offers unique insights into localized heat patterns that can directly inform targeted design and planning interventions in landscape architecture.



MaRTy is a "mobile biometeorological instrument platform that measures air temperature, humidity, wind speed and direction, GPS coordinates, and MRT (Mean Radiant Temperature) using the 6-directional method." Photo courtesy of SHaDE Lab, Arizona State University.

SCALE/RESOLUTION

regional | neighborhood | site

PROJECT PHASE

pre-design | design | post-design

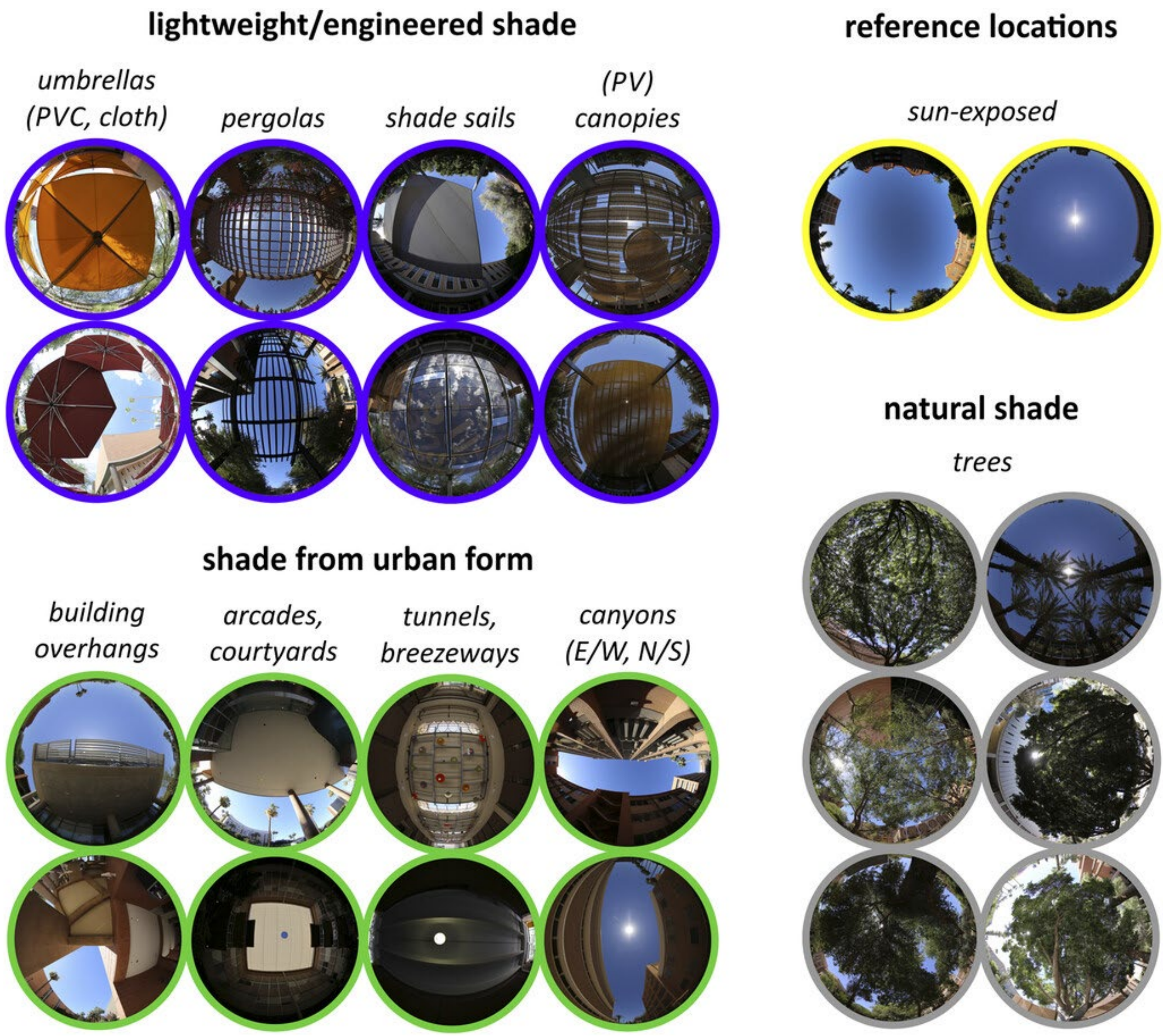
MOBILE BIOMETEOROLOGICAL INSTRUMENT PLATFORM

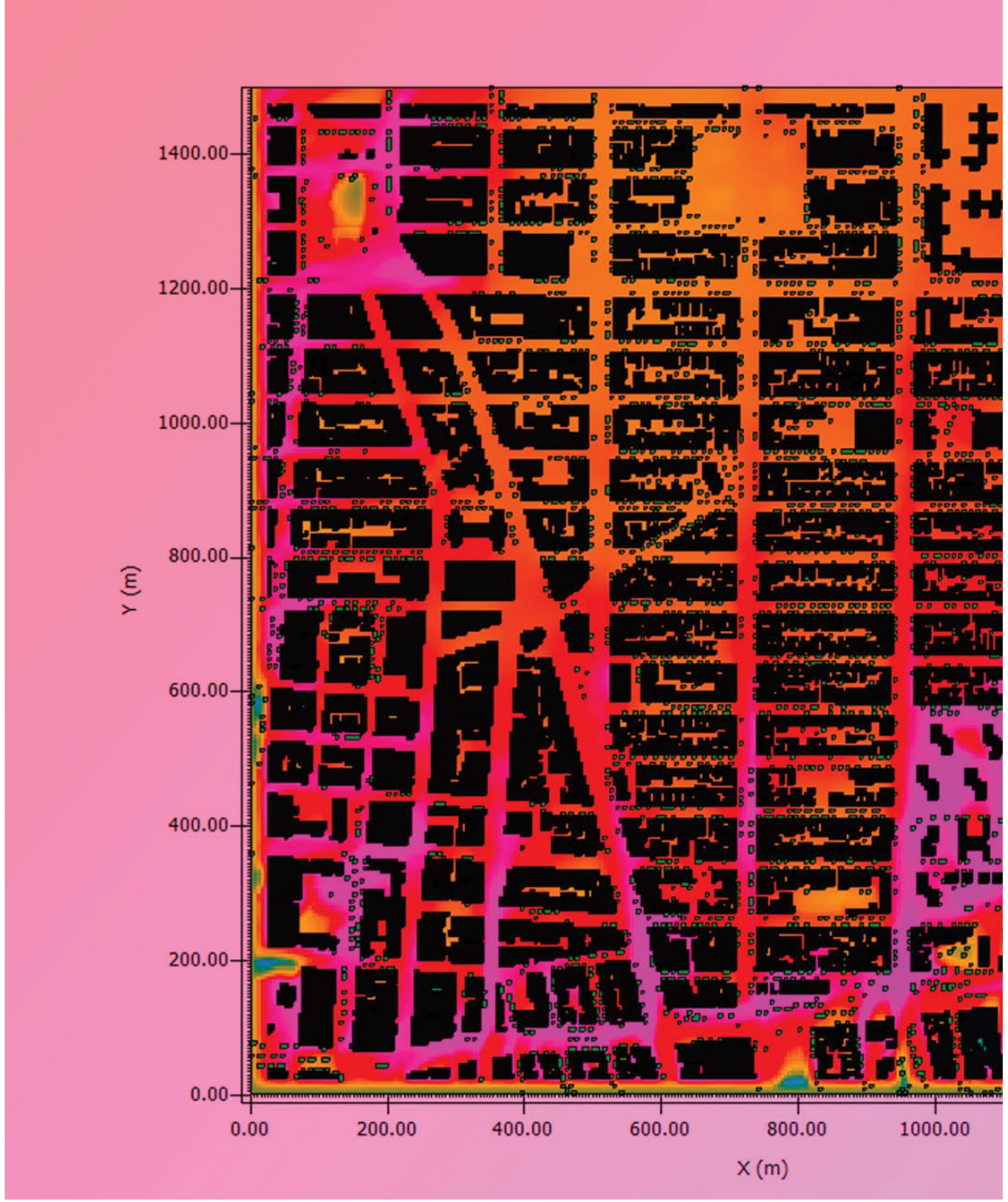
BRIEF DESCRIPTION

The Mobile Biometeorological Instrument Platform, known as MaRTy, is a mobile research station developed by Arizona State University (ASU). It is designed to measure and analyze various aspects of thermal comfort and heat exposure in urban environments, making it a valuable tool in the study of urban microclimates. MaRTy has the capacity to assess mean radiant temperature (MRT), which is crucial for understanding how humans experience heat in real-world conditions.

MRT is distinct from air temperature in that it accounts for all radiant heat sources a person is exposed to, including direct sunlight, reflected radiation from surrounding surfaces, and thermal radiation emitted by objects and structures in the environment. Unlike air temperature, which only measures the temperature of the air, MRT provides a more comprehensive assessment of the thermal environment as it is perceived by humans. This makes it the closest measure we have to a true understanding of thermal comfort, as it reflects the combined effects of air temperature, solar radiation, and infrared radiation on the human body. As a result, MRT is a critical variable in evaluating the potential health risks posed by extreme heat, particularly in densely built urban areas where radiant heat can be intensified by materials like concrete and asphalt.

In the context of landscape architecture, MaRTy's ability to measure MRT allows professionals to gain deeper insights into the thermal comfort of outdoor spaces. Instead of merely identifying hotspots, MaRTy can pinpoint areas where the overall thermal experience might be uncomfortable or hazardous for people. This data enables landscape architects to design interventions that enhance thermal comfort, such as optimizing shade coverage, selecting appropriate materials, and strategically placing vegetation to reduce radiant heat exposure.


lightweight/engineered shade
umbrellas (PVC, cloth)
pergolas
shade sails
(PV) canopies
reference locations
sun-exposed
natural shade
trees
shade from urban form
building overhangs
arcades, courtyards
tunnels, breezeways
canyons (E/W, N/S)



Sample of urban heat island mapping using ENVI-met, an environmental simulation software.[1]

SCALE/RESOLUTION

regional neighborhood site

PROJECT PHASE

pre-design design post-design

ENVIRONMENTAL SIMULATION

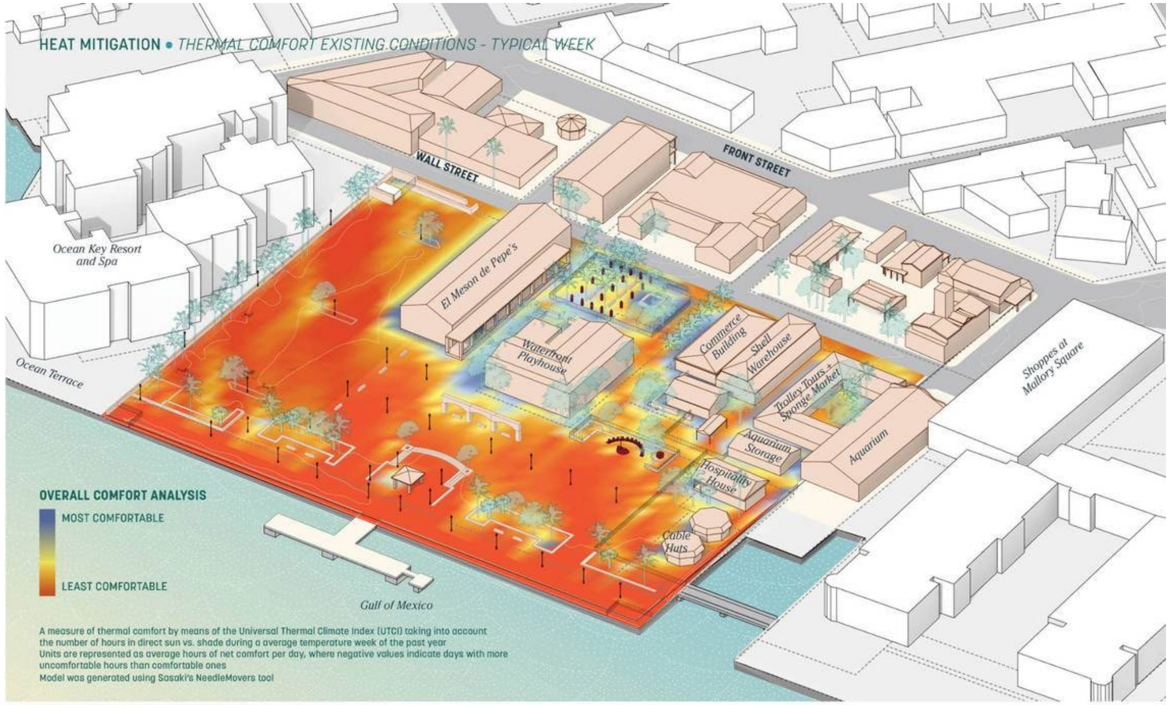
BRIEF DESCRIPTION

Environmental simulation is a critical process in understanding and predicting the behavior of environmental factors within built and natural environments. This practice involves using advanced computational tools to model various conditions such as temperature, humidity, wind flow, solar radiation, and their effects on buildings, landscapes, and urban spaces. By simulating these environmental conditions, designers and planners can make informed decisions that enhance sustainability, energy efficiency, and thermal comfort in their projects. Several software tools exist for environmental simulation, each offering capabilities tailored to specific aspects of environmental analysis:

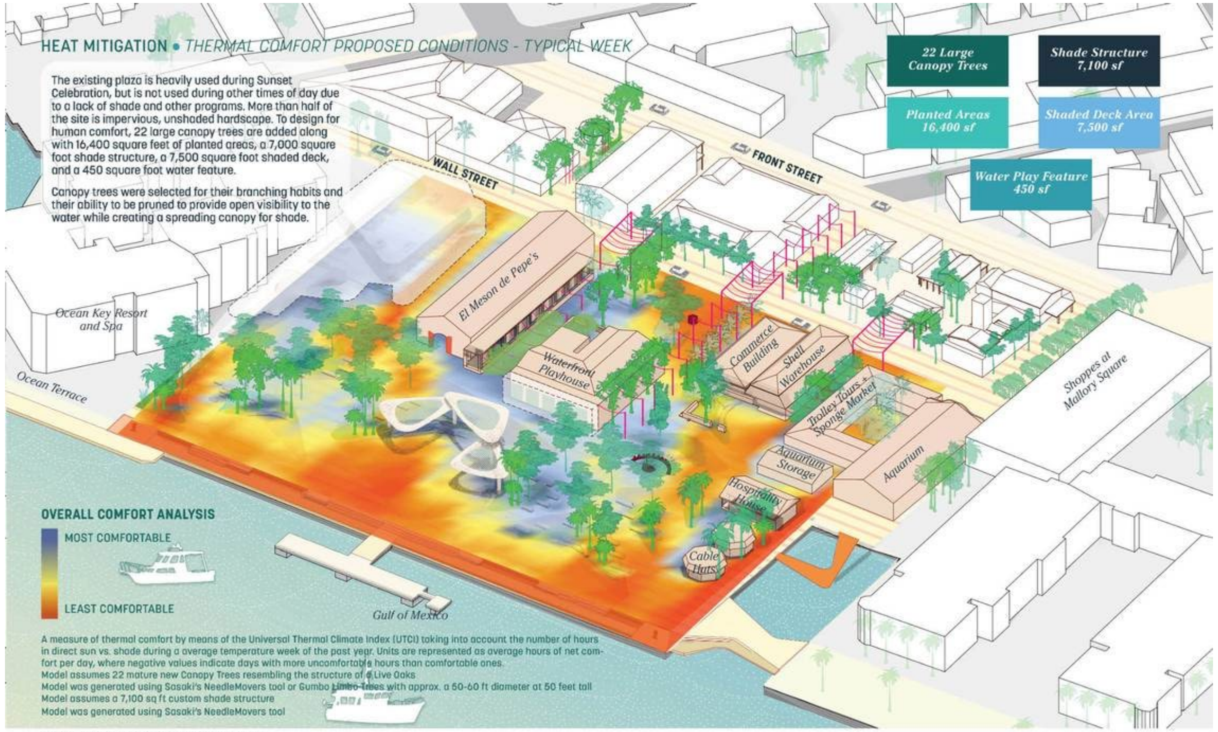
ENVI-met is a popular tool, specifically designed for simulating microclimates in urban areas. It can model the interactions between buildings, vegetation, and atmospheric conditions, allowing designers to assess the impact of green spaces, materials, and urban layouts on local temperatures and comfort levels. There are many other softwares that assist in conducting environmental assessments, but ENVI-met is one of the more commonly utilized tools, although not without its limitations, which we will describe later in this section.[3]

Ladybug Tools, which integrates with Rhino and Grasshopper, offers a suite of environmental analysis tools that allow for detailed simulations of sunlight, wind, and thermal comfort. These tools are particularly valuable in early design stages, enabling iterative testing of design strategies.

These software tools are instrumental in simulating thermal comfort by allowing users to predict how different design elements—such as shading, orientation, and material choices—affect the temperature and humidity experienced by occupants early in the design stage.



MALLORY SQUARE SUNSET CELEBRATION



MALLORY SQUARE SUNSET CELEBRATION

"Engaging Heat" community engagement exercise with residents of the South Omaha neighborhood. Photo by Salvador Lindquist.

SCALE/RESOLUTION

regional | neighborhood | site

PROJECT PHASE

pre-design | design | post-design

COMMUNITY-LED HEAT ASSESSMENT

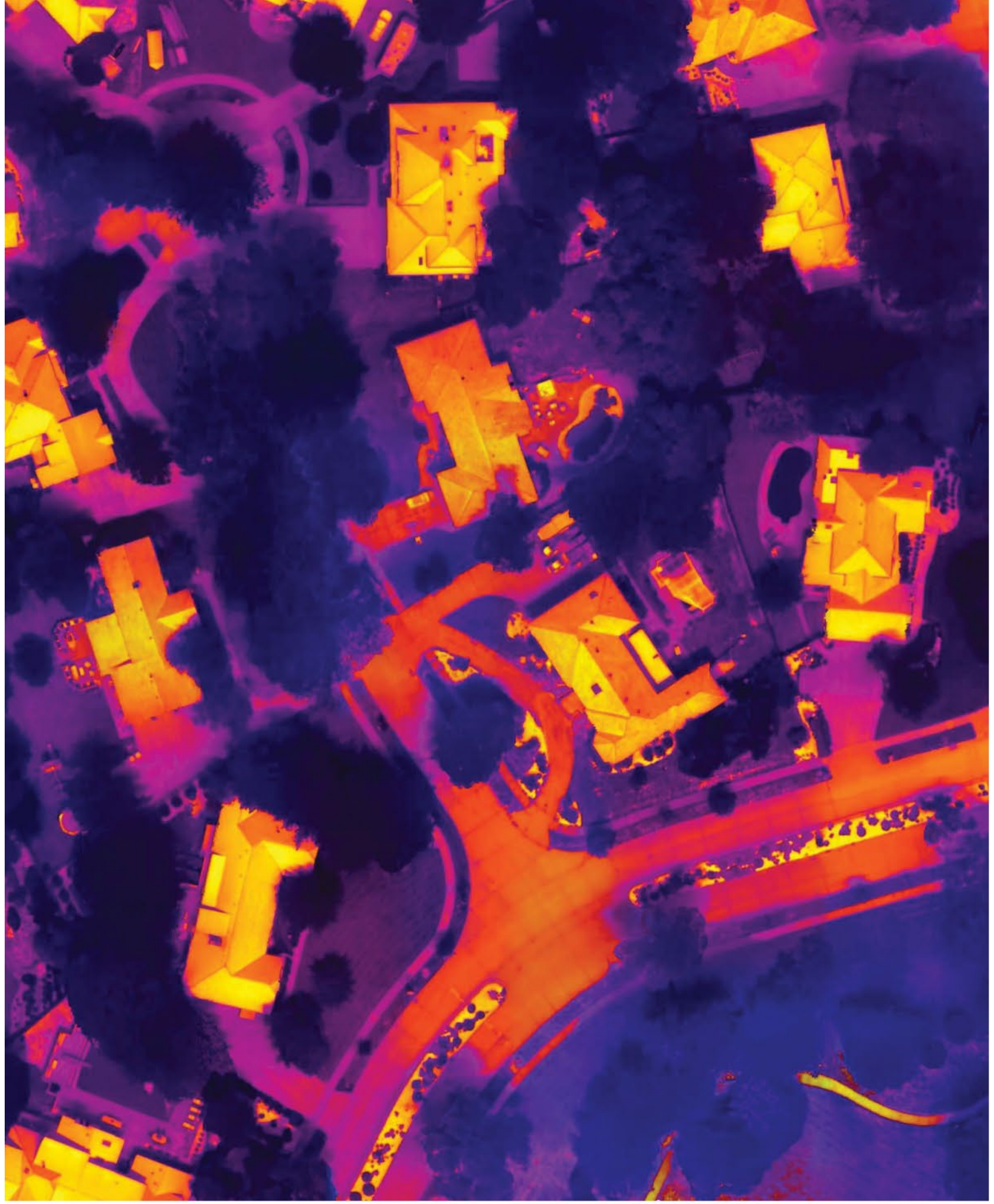
BRIEF DESCRIPTION

Community-led heat assessments are a participatory approach to evaluating the impacts of extreme heat within urban environments. Unlike traditional heat measurement tools, such as Landsat imagery, UAV thermography, and handheld thermal sensors, these assessments involve local residents in the data collection and analysis process. This grassroots methodology offers unique insights into heat exposure that may be missed by more conventional methods.

Community-led assessments typically involve training residents to use simple tools, like temperature loggers or mobile apps, to record heat conditions in their neighborhoods. Participants might also conduct surveys to gather qualitative data on their experiences with heat, including health impacts and access to cooling resources. This approach allows for the collection of data from a variety of micro-environments that might not be captured by broader, less granular methods.

One of the primary advantages of community-led assessments is their ability to capture localized heat experiences that are often overlooked by traditional tools. While Landsat imagery provides broad, satellite-based data, and UAV and handheld thermography offer high-resolution temperature readings, these methods often miss nuanced variations at the street level. Community-led assessments can identify specific hotspots and vulnerable areas based on direct, lived experiences of residents, revealing how different demographics are affected by extreme heat.

Furthermore, community involvement fosters greater engagement and empowerment, ensuring that the solutions and recommendations are directly informed by those most impacted. This participatory approach can lead to more effective and equitable heat adaptation strategies, as it considers the unique needs and challenges of various communities.



Streetscape thermal enlargement of the Regency corridor scan. Thermal scan by Keenan Gibbons.

SCALE/RESOLUTION
regional neighborhood site
PROJECT PHASE
pre-design design post-design

UAV THERMOGRAPHY

BRIEF DESCRIPTION

UAV Thermography refers to the use of Unmanned Aerial Vehicles (UAVs), commonly known as drones, equipped with thermal imaging cameras to capture and analyze heat patterns from an aerial perspective. These specialized cameras detect infrared radiation emitted by objects and surfaces, converting this data into visual images that represent temperature variations. By analyzing the thermal data, UAV thermography can reveal how heat is distributed across different areas, highlighting hot and cool zones with high precision.

The process of UAV thermography involves flying the drone over a specified area, where it captures thermal images that are processed into detailed maps. These maps use color gradients to indicate temperature differences, with warmer areas typically represented by reds and oranges, and cooler areas by blues and greens. This visual representation of heat distribution helps in identifying hotspots or areas of interest that may require further investigation or intervention. In the field of landscape architecture, UAV thermography is a powerful tool for understanding microclimates within urban environments. Professionals can use this technology to identify areas where heat is disproportionately concentrated, such as on concrete surfaces, rooftops, or sparsely vegetated zones. This information is crucial when designing or retrofitting urban spaces to improve thermal comfort and reduce the urban heat island effect.

For instance, landscape architects can use UAV thermography to assess the effectiveness of green infrastructure, such as green roofs, tree canopies, and parks, in cooling urban environments. By comparing thermal maps taken before and after the implementation of such features, they can quantitatively evaluate their impact on reducing surface temperatures. Additionally, this tool can be used to monitor the performance of existing landscapes over time, ensuring that they continue to provide the intended cooling benefits.

Handheld thermal image of an ADA ramp at the Gene Leahy Mall.

SCALE/RESOLUTION

regional | neighborhood | site

PROJECT PHASE

pre-design | design | post-design

HANDHELD THERMOGRAPHY

BRIEF DESCRIPTION

Handheld Thermography involves using portable thermal imaging cameras to capture infrared radiation emitted by surfaces, converting this data into visual heat maps. Unlike UAV thermography, which provides broader aerial views, handheld thermography allows for a more detailed and granular examination of specific surfaces and materials at close range. This close-up capability enables landscape architects to assess thermal variations on surfaces like pavements, building facades, or vegetation, which are often missed in broader UAV scans.

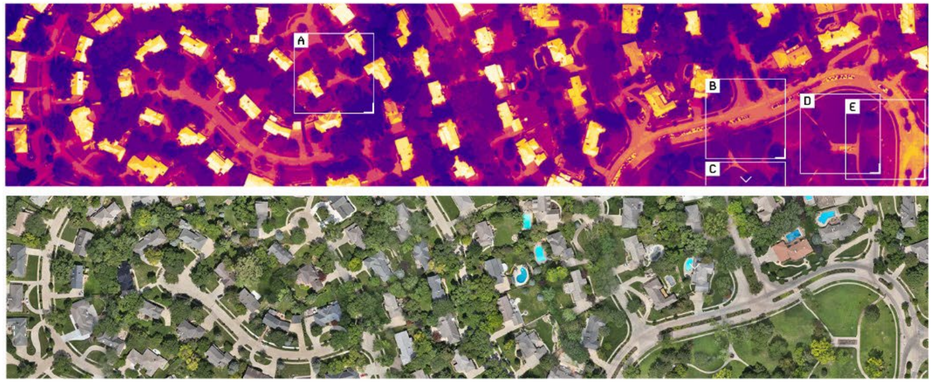
One of the key advantages of handheld thermography is its ability to pinpoint specific thermal anomalies or variations in real time. While UAVs provide an expansive overview, handheld devices allow practitioners to dive deeper into particular areas of interest, such as identifying heat retention in different materials or the cooling effects of specific vegetation. This level of detail is crucial for understanding the nuances of thermal comfort in outdoor spaces and the performance of different landscape elements under heat stress.

In landscape architecture practice, handheld thermography enhances the way heat is visualized by allowing for an on-the-ground perspective. It enables designers to gather data from hard-to-reach areas or locations that require more detailed analysis, such as shaded versus unshaded areas or the thermal performance of specific plant species. This tool helps in creating more precise heat maps, which can inform the placement of shade structures, vegetation, and other cooling strategies.

Furthermore, handheld thermography's portability makes it an ideal tool for iterative design processes, where designers can test and visualize the thermal impacts of various interventions on-site, making adjustments in real-time. This approach fosters a more responsive and adaptive design process, leading to more effective and targeted heat mitigation strategies in urban landscapes.

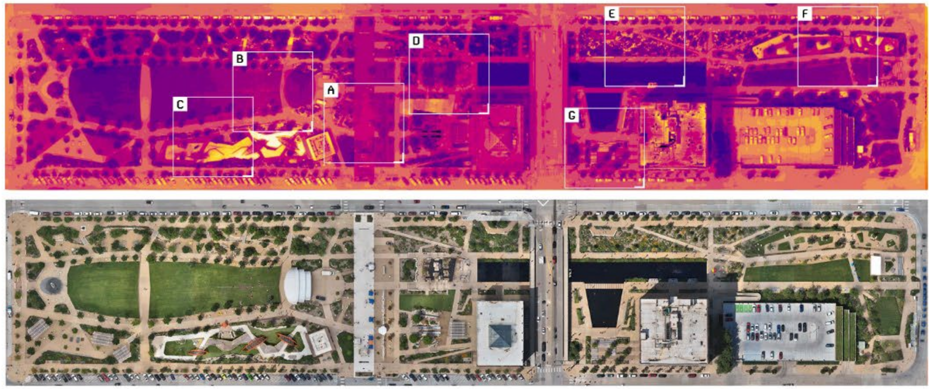
A STREET INTERSECTION
B INTERSTATE OVERPASS
C PARKING LOT
D COMMUNITY GARDEN
E STREETSCAPE

75 NORTH



A STREETSCAPE
B BOULEVARD
C PLAYGROUND
D PARK/GREEN SPACE
E NEIGHBORHOOD GATEWAY

REGENCY



A PLAZA
B CENTRAL LAWN
C PLAYGROUND
D SPLASH PAD
E STREETSCAPE
F DOG PARK
G AMPHITHEATER

GENE LEAHY MALL

G

SG UAV

2018


AJ Noto


Tommy Reyna


Matthew Medley


Keenan Gibbons

SG UAV

2018

DJI Phantom 4 RTK

DJI Matrice 210 RTK

SG UAV

2024


Lindsey Mathus


Lichao Liu


Laura Holman


AJ Noto


Keenan Gibbons


Luis Bribiesca


Rob Kish


Bill Roznik


Tim VanOudenhoven


Katherine DeKrey


Dustin Simmons


Juan Arias


Mrunmayee Atre


Ryan Dashkevicz


Ginny Rice


Julius Taniguchi

SG UAV

DJI Mavic 3E

DJI Mavic 3T

DJI Mavic 3T

DJI Mavic 3T

DJI Mavic 3T

DJI Mavic 3T

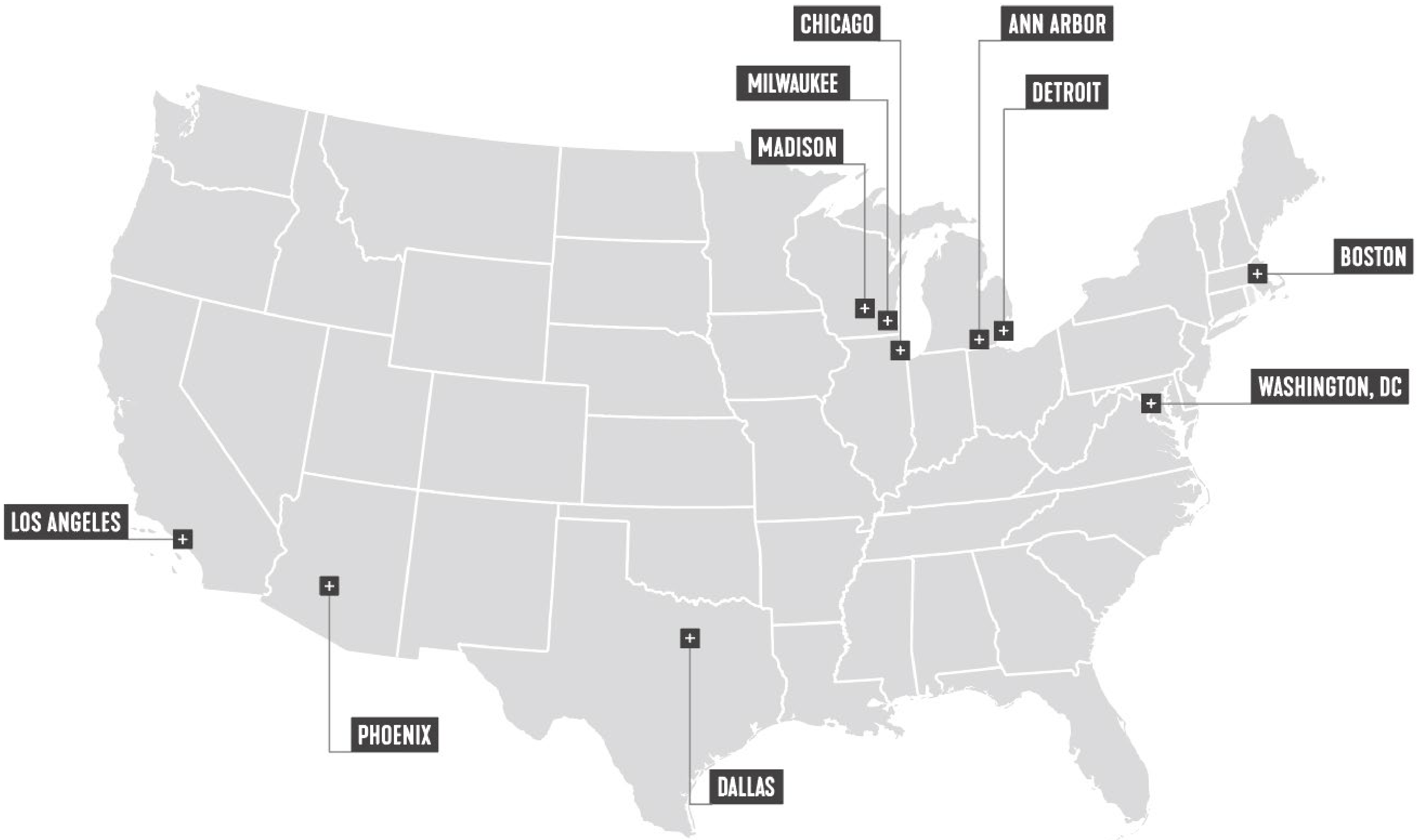
DJI Mavic 3T

DJI Mavic 3T

DJI Phantom 4 RTK

DJI Matrice 210 RTK

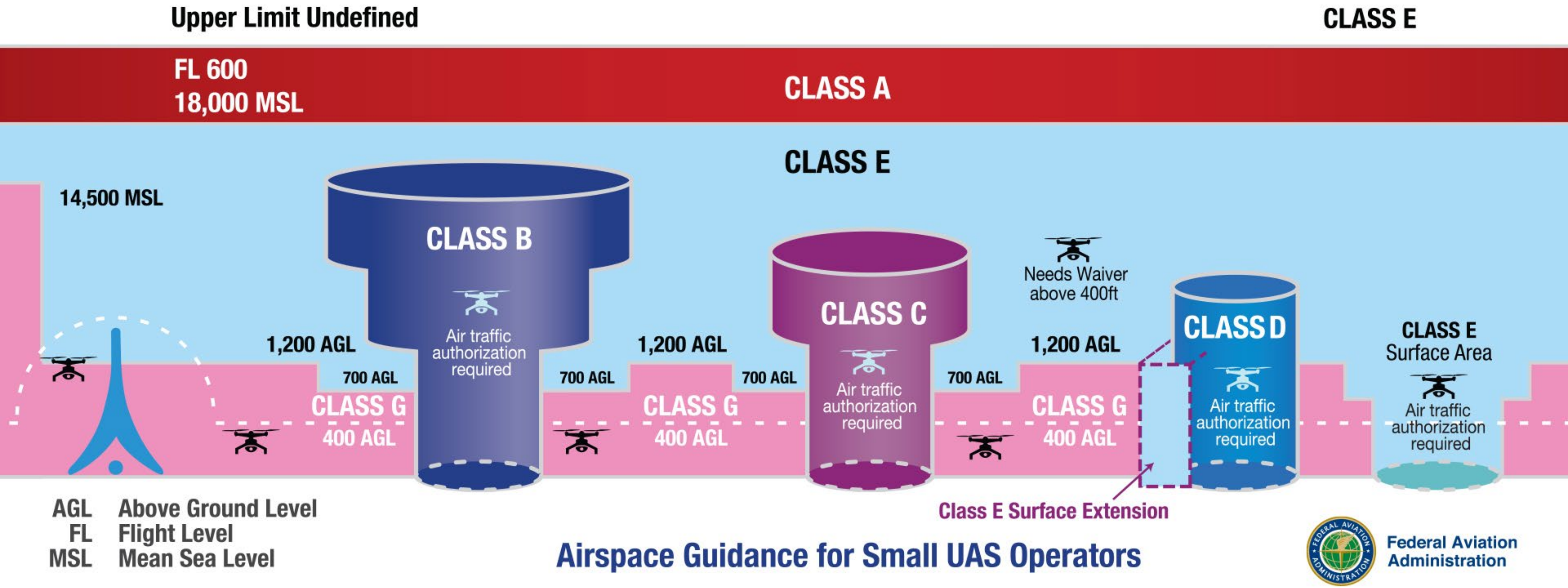
SG UAV


CHICAGO
ANN ARBOR
MILWAUKEE
DETROIT
MADISON
BOSTON
WASHINGTON, DC
LOS ANGELES
PHOENIX
DALLAS

UAV NOMENCLATURE

- ***UAV:*** (drones) are also referred to as UAS or sUAS. They basically mean the same thing.
- ***3D photogrammetry***: overlapping 2D imagery to process surface models and orthos.
- ***Orthomosaic / orthoimagery:*** the 'stitching together' of georeferenced 2D images.
- ***RTK (Real Time Kinematic)***: GPS capability to produce replicate saved flightpaths within 1cm on X,Y,Z.
- ***FAA Remote Pilot, Part 107 Regulations:*** this "drone license" is required to conduct flights as a professional service for compensation.
- ***Controlled Airspace:*** What is it? Why does it matter?

FAA AIRSPACE



Source: FAA

DJI Matrice 210 RTK

Zenmuse XT2 Thermal Camera

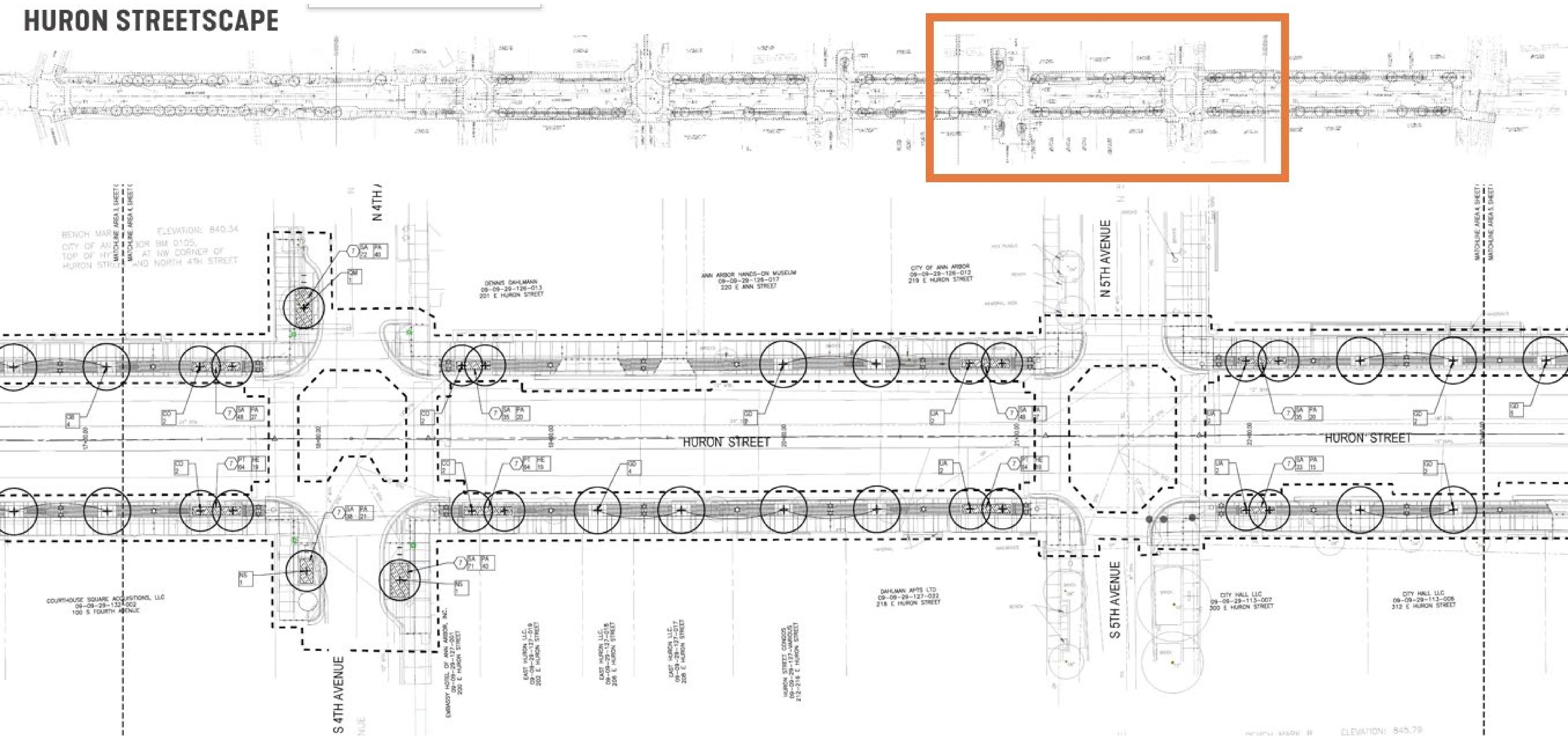
NOVEL RESEARCH + PILOT PROJECT

PROJECT: HURON STREETSCAPE
LOCATION: ANN ARBOR, MICHIGAN
COST: $4.5M = OVERALL
$400K = TREES + PLANTING [130 SHADE TREES]
CONSTRUCTION: SUMMER 2019 – WINTER 2019

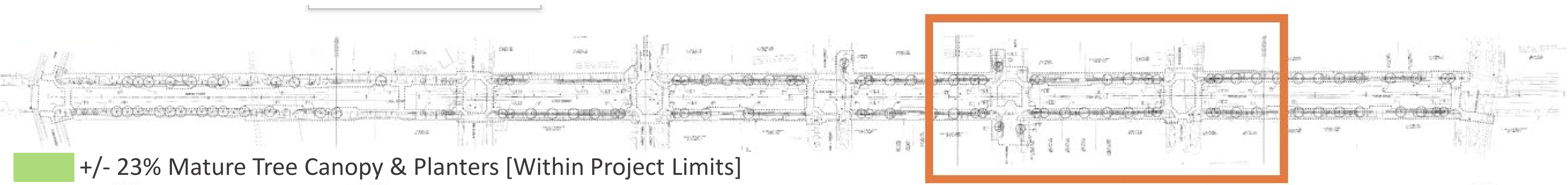
1ST FLIGHT / SCAN: JUNE/JULY 2019
2ND FLIGHT / SCAN: JUNE/JULY 2020
3RD FLIGHT / SCAN: JUNE/JULY 2024?

NOVEL RESEARCH + PILOT PROJECT

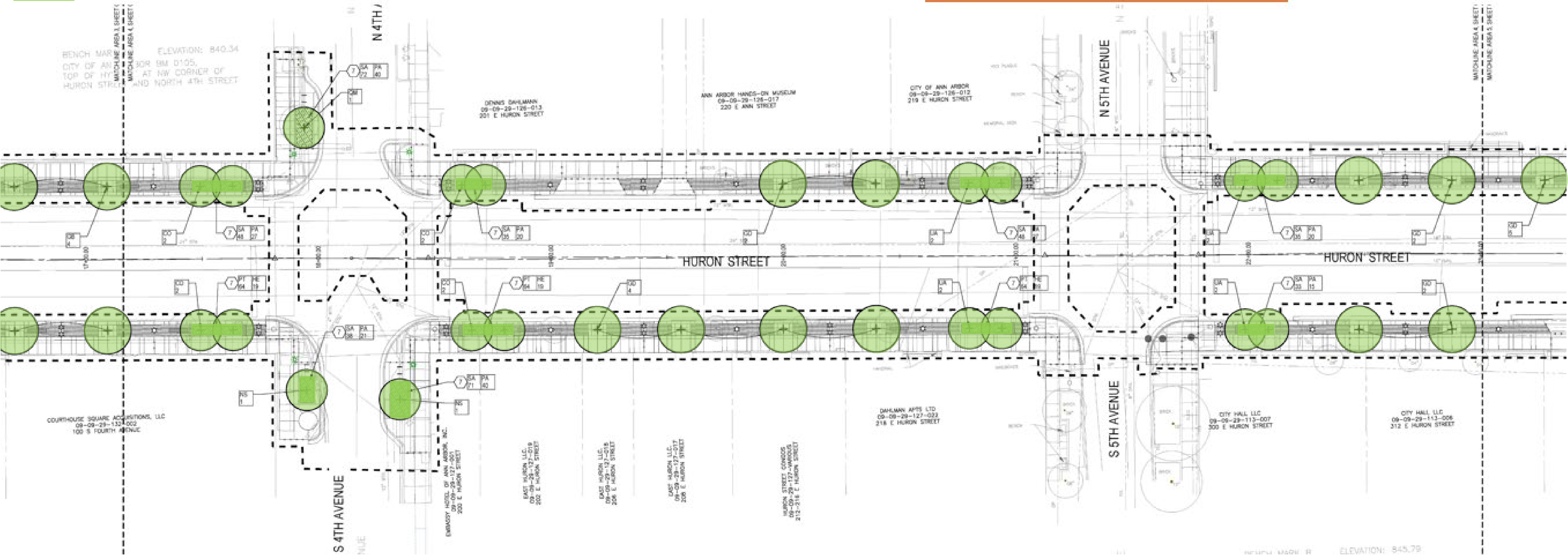
HURON STREETSCAPE



NOVEL RESEARCH + PILOT PROJECT



+/- 23% Mature Tree Canopy & Planters [Within Project Limits]



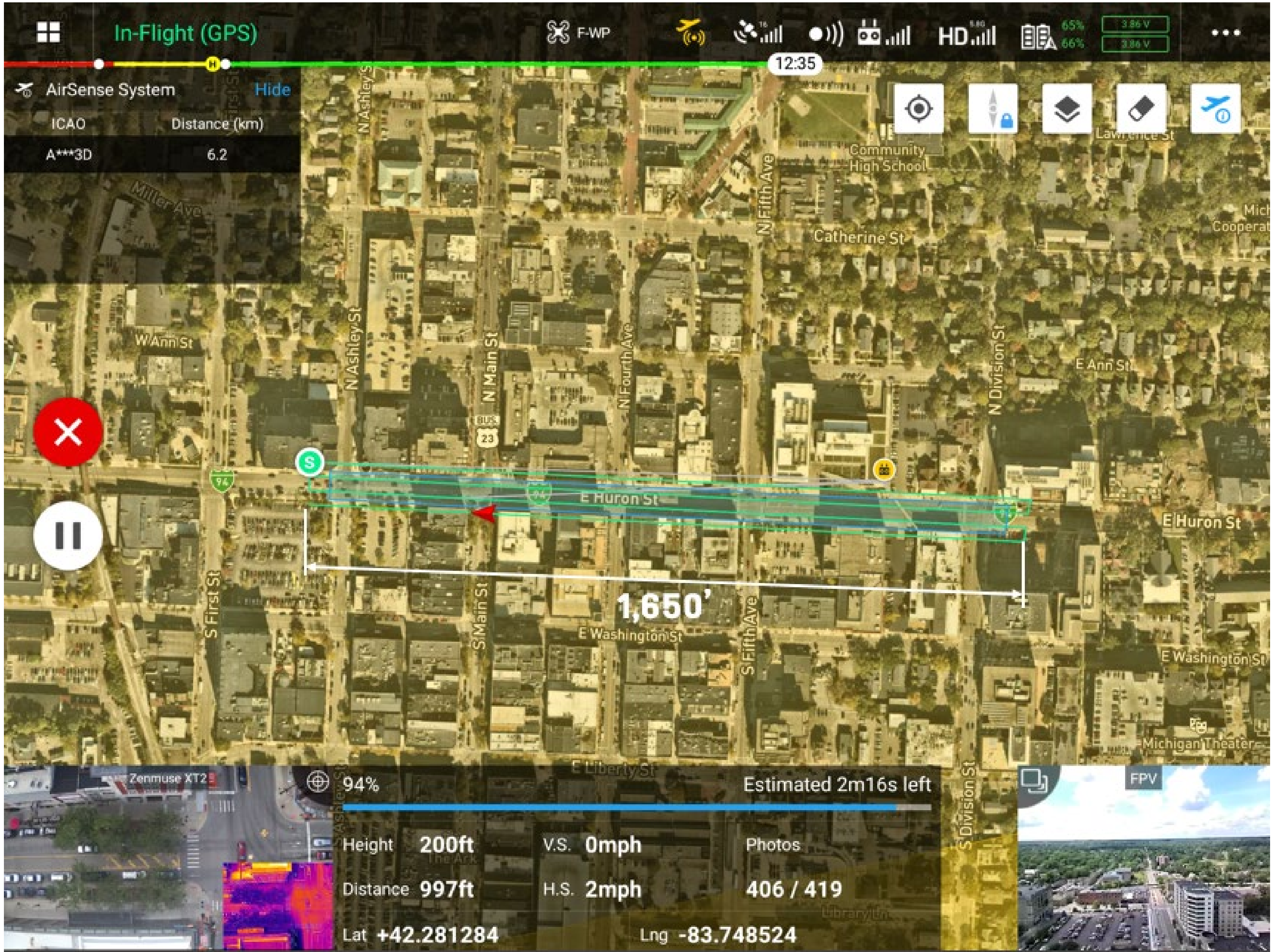
NOVEL RESEARCH + PILOT PROJECT

NOVEL RESEARCH + PILOT PROJECT

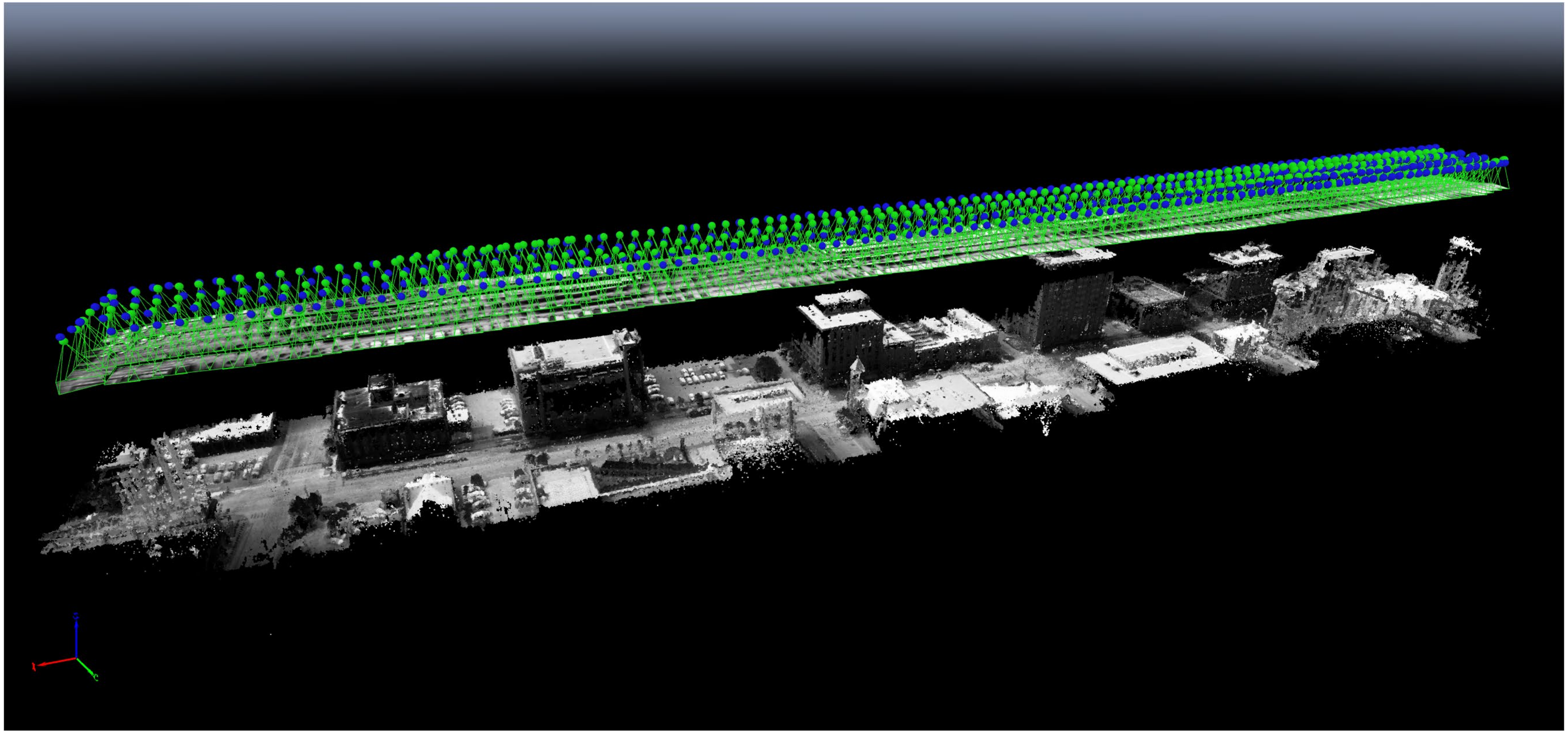
METAR text:	**KARB 211653Z 29009KT 10SM SCT039 29/20 A2993 RMK AO2 SLP129 T02890200**
Conditions at:	KARB (ANN ARBOR , MI, US) observed 1653 UTC 21 August 2019
Temperature:	28.9°C (84°F)
Dewpoint:	20.0°C (68°F) [RH = 59%]
Pressure (altimeter):	29.93 inches Hg (1013.6 mb) [Sea-level pressure: 1012.9 mb]
Winds:	from the WNW (290 degrees) at 10 MPH (9 knots; 4.6 m/s)
Visibility:	10 or more miles (16+ km)
Ceiling:	at least 12,000 feet AGL
Clouds:	scattered clouds at 3900 feet AGL
Weather:	no significant weather observed at this time


CAUTION
CAUTION

NOVEL RESEARCH + PILOT PROJECT



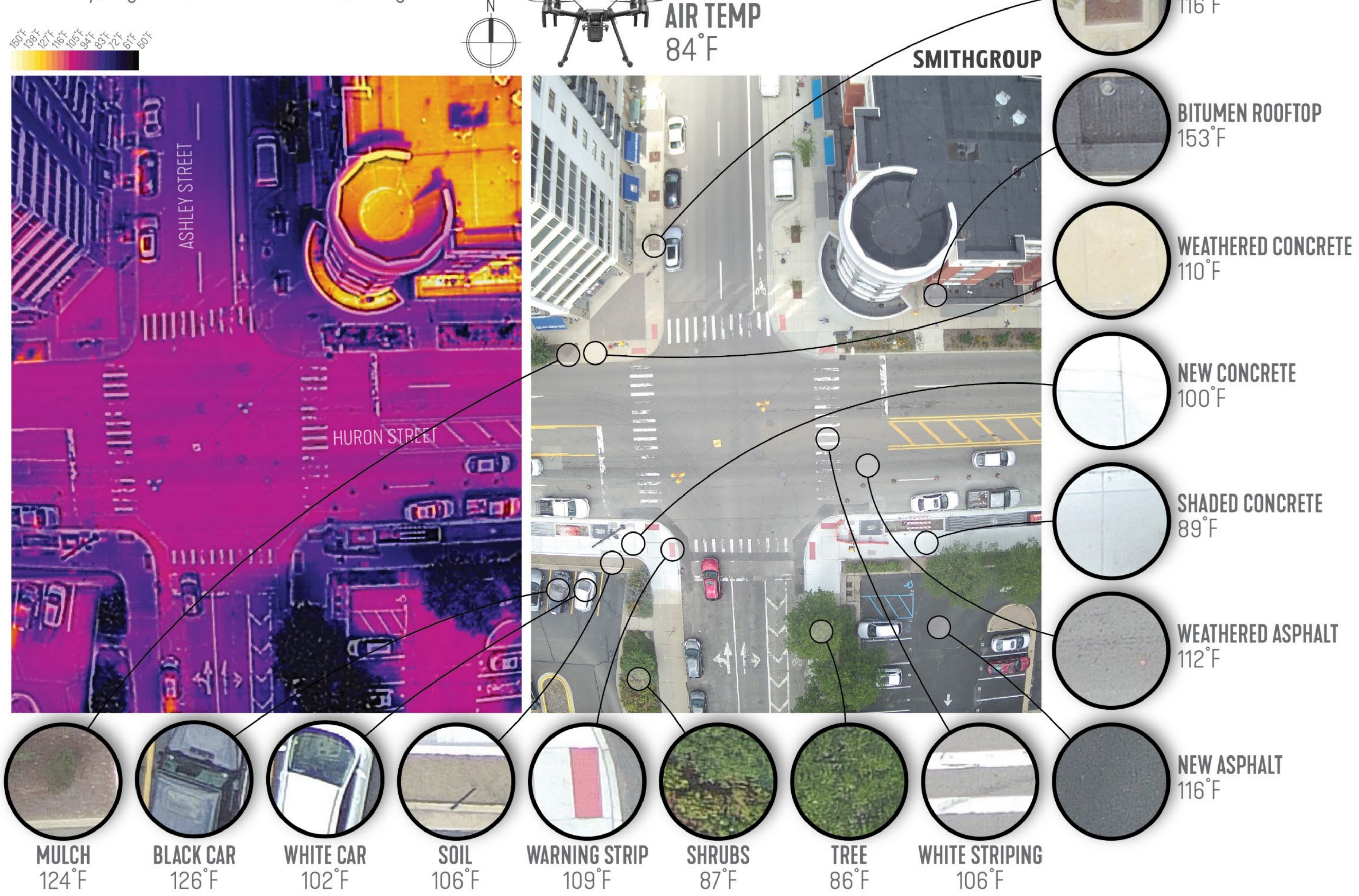
POST-PROCESSING UAV THERMAL IMAGING & PHOTOGRAMMETRY



POST-PROCESSING UAV THERMAL IMAGING & PHOTOGRAMMETRY

THE URBAN HEAT ISLAND EFFECT MATERIAL PALETTE

Wednesday, August 21, 2019 • Ann Arbor, Michigan



SOLAR NOON IN THE **URBAN HEAT ISLAND**

Huron Streetscape Project, Existing Conditions • Ann Arbor, Michigan • Wednesday, August 21, 2019

1:24PM FLIGHT

84˚F AIR TEMP

SURFACE TYPE:	BUILDING	4.04 AC [35% AREA]
	SIDEWALK	2.14 AC [19% AREA]
	ASPHALT	4.69 AC [40% AREA]
	VEGETATION	.64 AC [6%AREA]
AREA:		11.51 AC [100% AREA]

BREAKDOWN

COOL SPOTS — 42% SURFACE AREA

80˚F - 104˚F [Δ 24˚F] — **UP TO 20˚F > AIR TEMP**

SURFACE TYPE: VEGETATION, SHADED CONCRETE SIDEWALK & ASPHALT

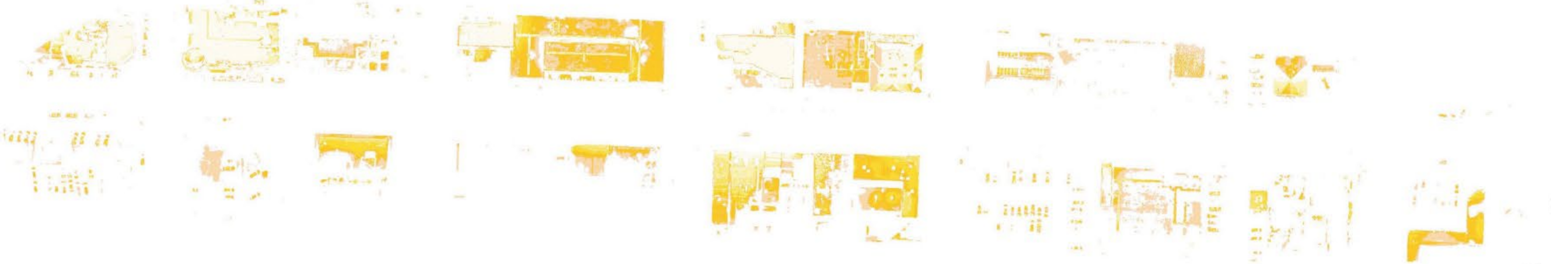
AREA: 4.48 AC [42.4% AREA]

WARM SPOTS — 42% SURFACE AREA

104˚F - 118F [Δ 14˚F] — **UP TO 34˚F > AIR TEMP**

SURFACE TYPE: PASSIVELY EXPOSED CONCRETE & ASPHALT

AREA: 4.84 AC [41.9% AREA]



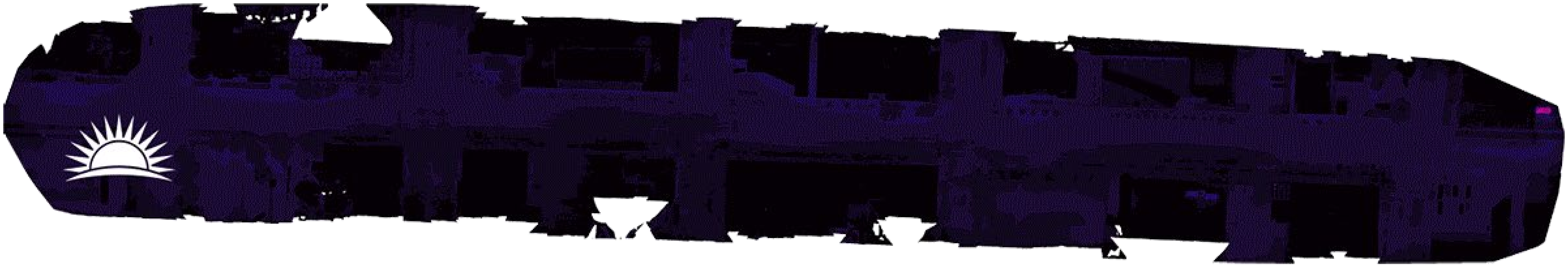
HOT SPOTS — 16% SURFACE AREA

118˚F - +150F [Δ 32˚F] — **UP TO +66˚F > AIR TEMP**

SURFACE TYPE: CONTINUOUSLY EXPOSED HIGH EMISSIVITY ROOFTOPS

AREA: 1.80 AC [15.6% AREA]

SMITHGROUP



A DAY IN THE URBAN HEAT ISLAND

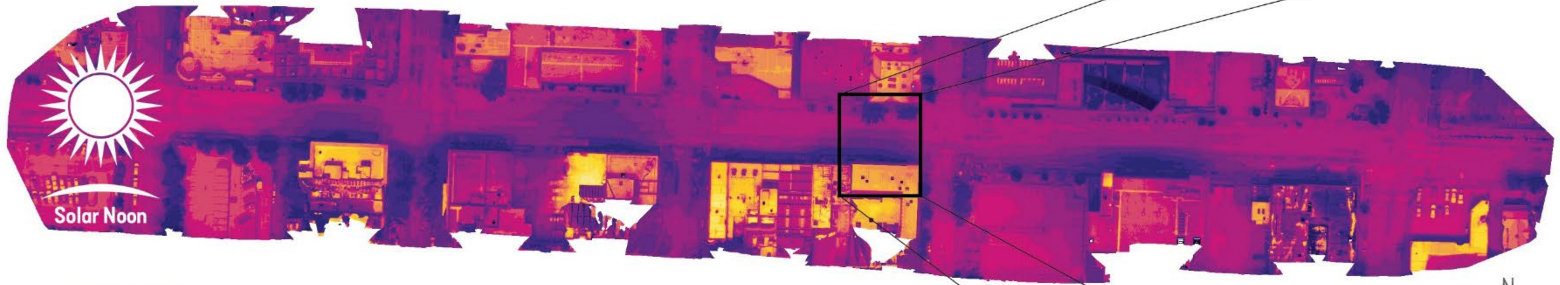
Huron Streetscape Project, Existing Conditions • Ann Arbor, Michigan • Sunday, August 25, 2019

6:34AM FLIGHT

AIR TEMP:	61°F	[16.1°C]
MAX TEMP:	76°F	[24.2°C]
MIN TEMP:	36°F	[2.2°C]
Δ MAX-MIN TEMP:	40°F	[16.1°C]
Δ MAX-AIR TEMP:	15°F	[8.1°C]

80' 0 160'

N

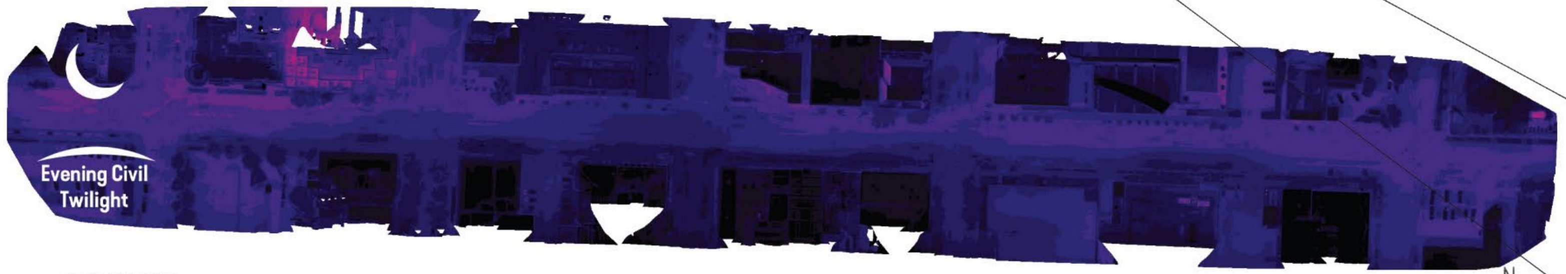


1:23PM FLIGHT

AIR TEMP:	74°F	[23.3°C]
MAX TEMP:	127°F	[52.5°C]
MIN TEMP:	62°F	[16.5°C]
Δ MAX-MIN TEMP:	65°F	[36.0°C]
Δ MAX-AIR TEMP:	53°F	[29.2°C]

80' 0 160'

N



8:11PM FLIGHT

AIR TEMP:	70°F	[21.1°C]
MAX TEMP:	96°F	[35.8°C]
MIN TEMP:	42°F	[5.8°C]
Δ MAX-MIN TEMP:	54°F	[30.0°C]
Δ MAX-AIR TEMP:	26°F	[14.7°C]

80' 0 160'

N

MATERIAL

- (A) TREE
- (B) TREE SHADE
- (C) SIDEWALK
- (D) ASPHALT
- (E) BUILDING SHADE
- (F) BUILDING ROOF

SMITHGROUP

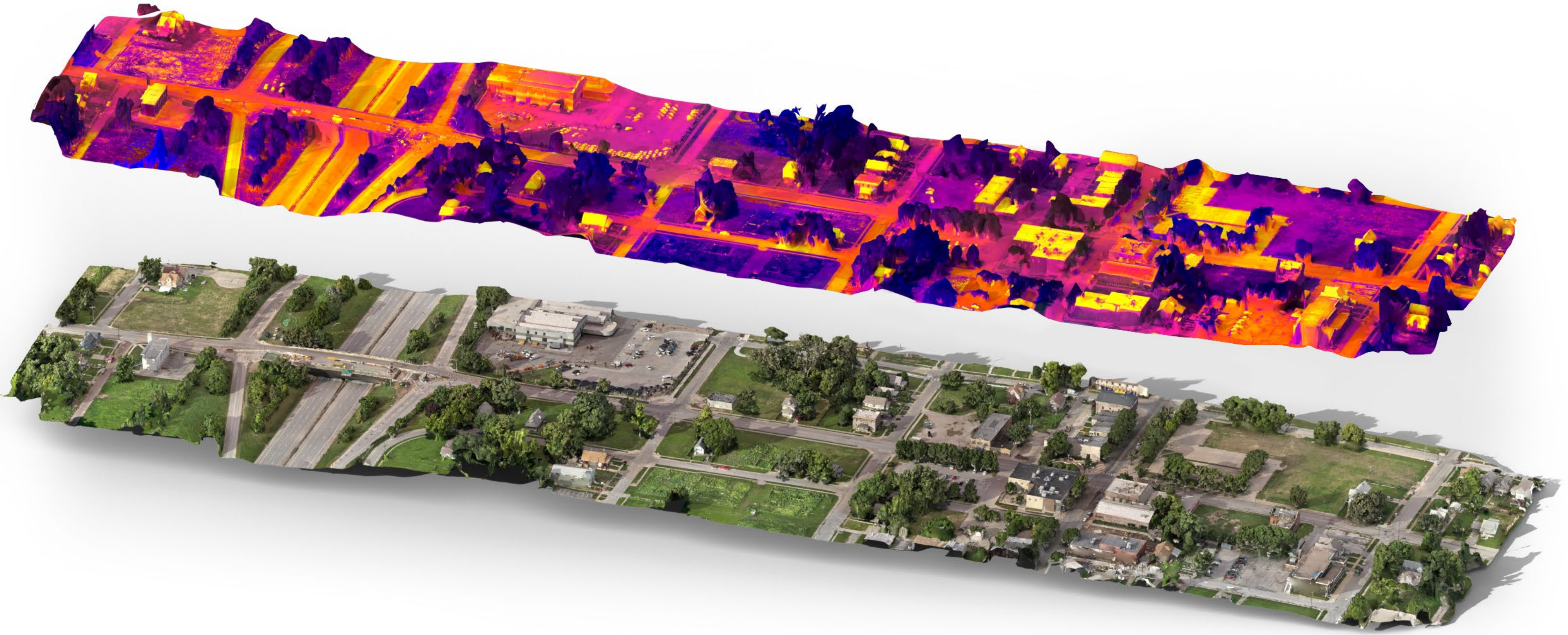
NOT ALL GREEN SPACE IS EQUAL

MOWED LAWN
108.6˚F

NATIVE PRAIRIE
85.1˚F

keenan.gibbons

AUGUST 18, 2021 • OKEMOS, MI • 82˚F




MAVIC 3 ENTERPRISE

- Extreme Danger [125°F or higher]
- Danger [103°F - 124°F]
- Extreme Caution [90°F - 102°F]
- Caution [80°F - 90°F]
- Mild Caution [79°F or lower]

NWS Heat Index

Temperature (°F)

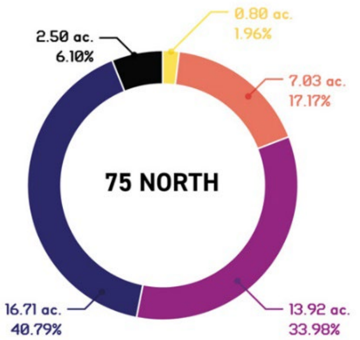
Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

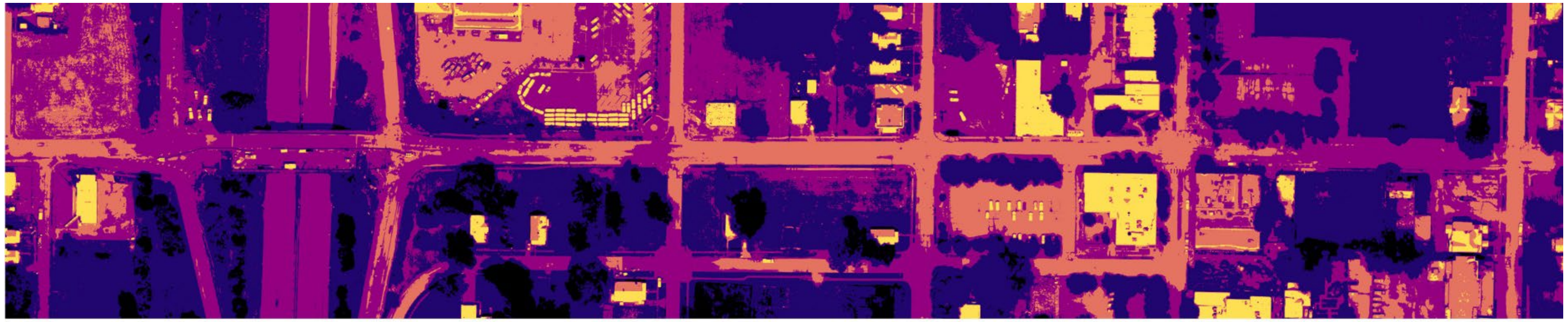
Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution / Extreme Caution / Danger / Extreme Danger

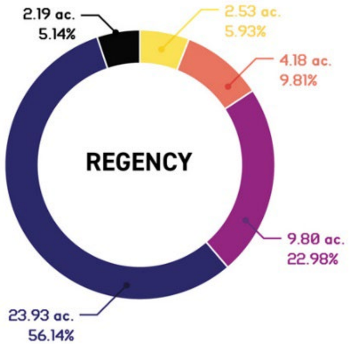
Classification	Heat Index	Effect on the body
Caution	80°F - 90°F	Fatigue possible with prolonged exposure and/or physical activity
Extreme Caution	90°F - 103°F	Heat stroke, heat cramps, or heat exhaustion possible with prolonged exposure and/or physical activity
Danger	103°F - 124°F	Heat cramps or heat exhaustion likely, and heat stroke possible with prolonged exposure and/or physical activity
Extreme Danger	125°F or higher	Heat stroke highly likely

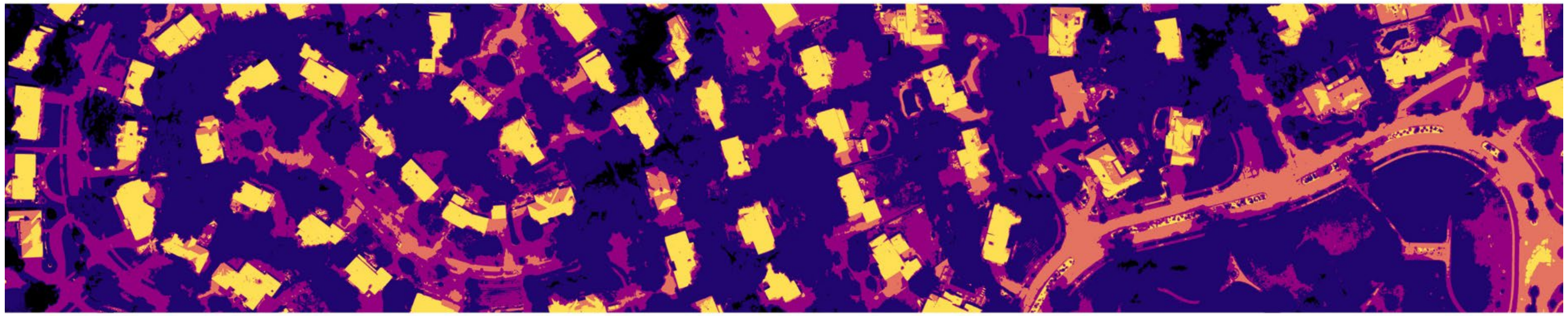
- Extreme Danger [125°F or higher]
- Danger [103°F - 124°F]
- Extreme Caution [90°F - 102°F]
- Caution [80°F - 90°F]
- Mild Caution [79°F or lower]



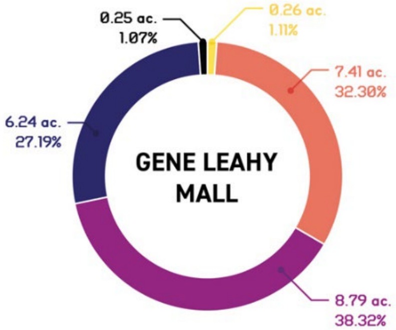


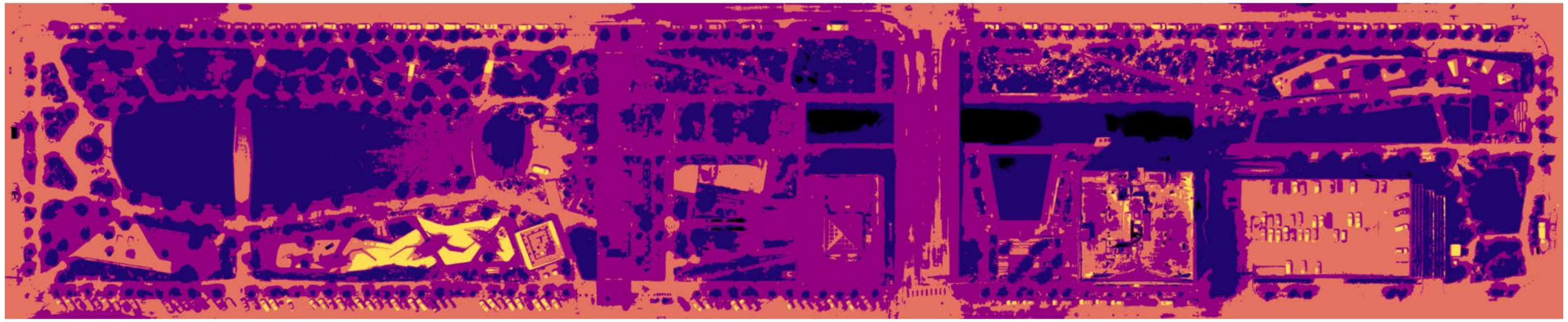
75 NORTH





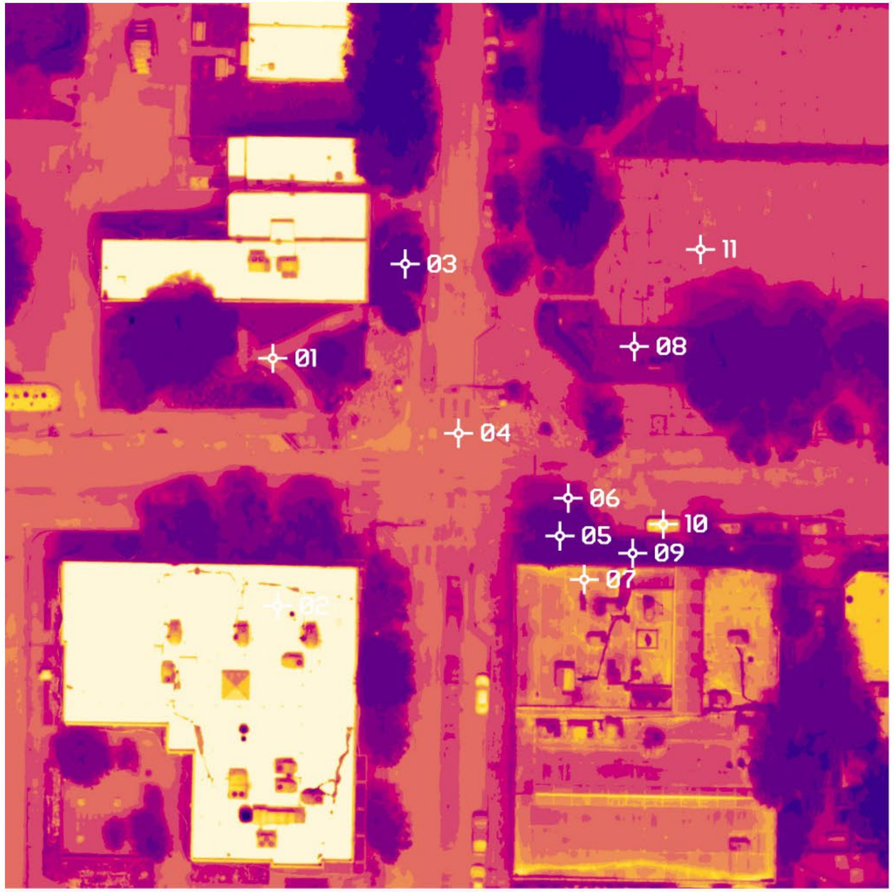
REGENCY

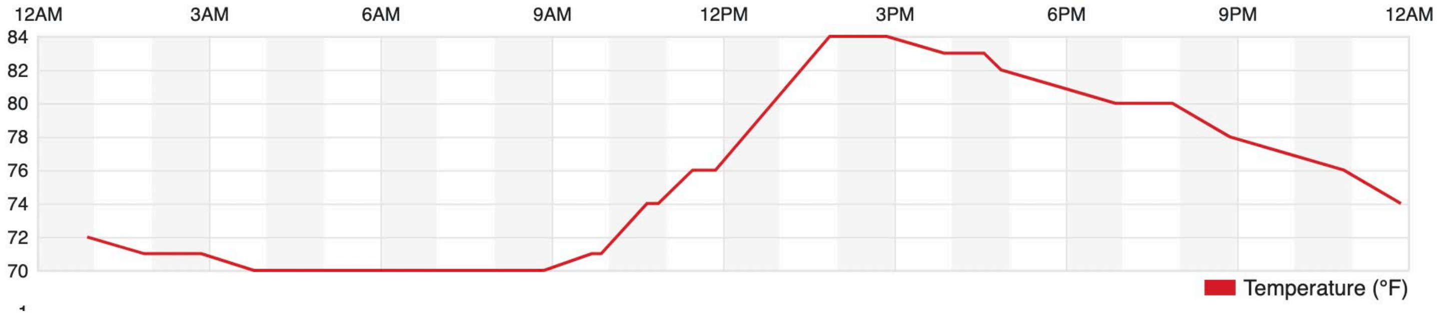




GENE LEAHY MALL

SPOT	MATERIAL	TEMP.
01	Concrete (Sidewalk; Sun)	108.0° F
02	Bituminous Roof (Black; Sun)	150.4° F
03	Tree Canopy	82.9° F
04	Concrete (Road; Sun)	113.0° F
05	Tree Canopy	82.2° F
06	Concrete (Road; Shade)	90.5° F
07	Bituminous Roof (White; Sun)	119.3° F
08	Lawn (Sun)	97.5° F
09	Concrete (Sidewalk; Shade)	85.6° F
10	Automobile (Black; Sun)	138.4° F
11	Asphalt (Sun)	107.2° F






9:04
FLIR
26.3°
19.9°
FLIR
FLIR
KIZEN
LaserPro LP300
INFRARED THERMOMETER
HOLD
25.5
Kestrel
WBGT Out °F
70.8
settings
HEAT STRESS TRACKER

SPOT	MATERIAL	TEMP.
01	Concrete (Sidewalk; Sun)	108.0° F
02	Bituminous Roof (Black; Sun)	150.4° F
03	Tree Canopy	82.9° F
04	Concrete (Road; Sun)	113.0° F
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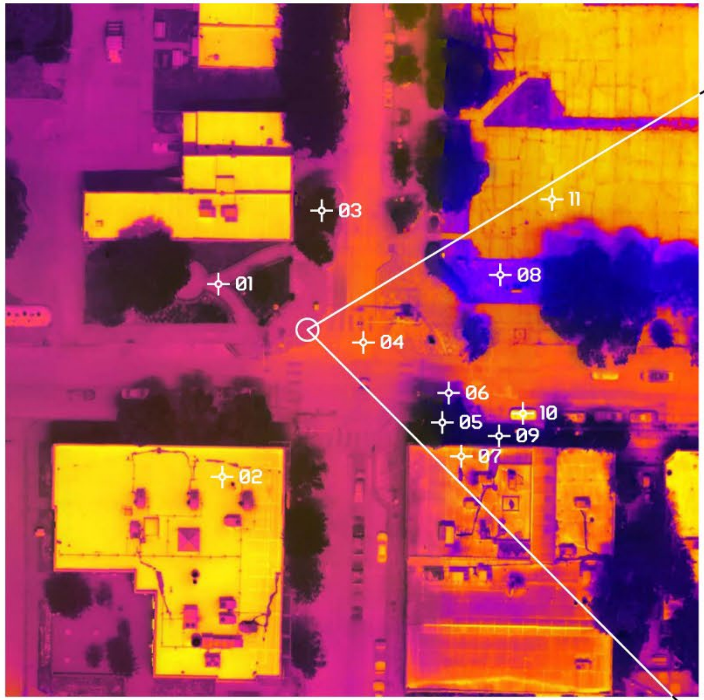
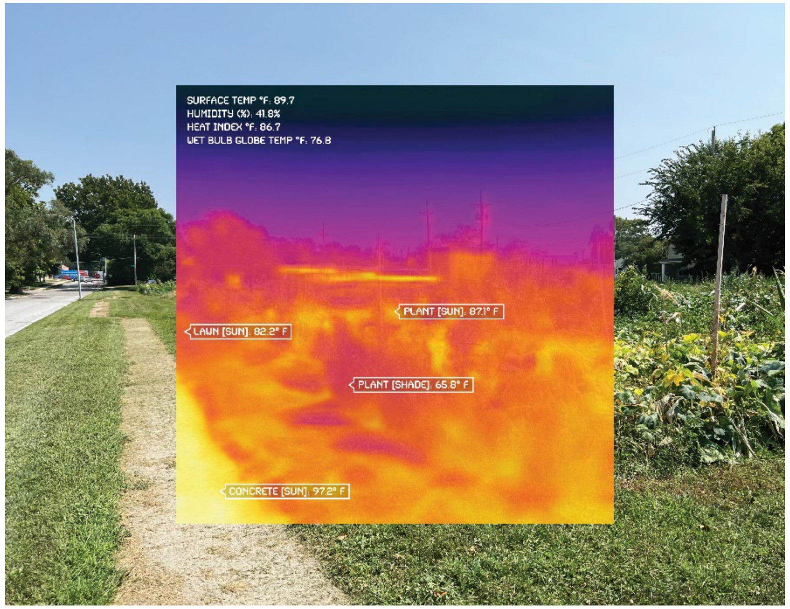
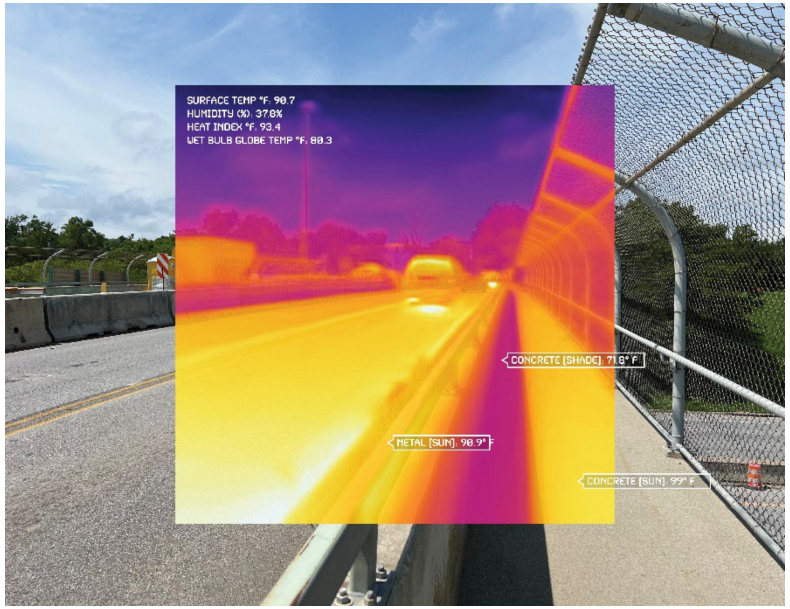


75 NORTH



COMMUNITY GARDEN

STREET INTERSECTION



INTERSTATE OVERPASS

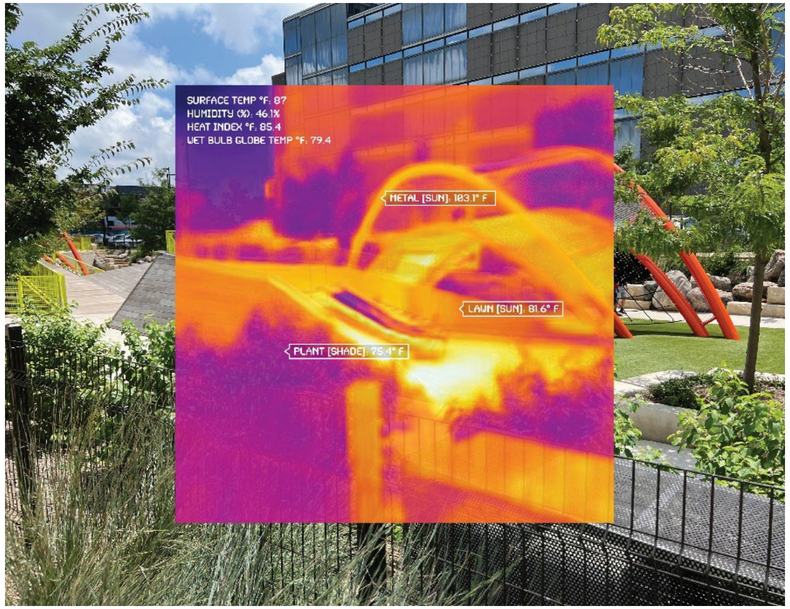
REGENCY

PLAYGROUND

BOULEVARD

STREET INTERSECTION

GENE LEAHY MALL



PLAYGROUND

PLAZA/HARDSCAPE

STREETSCAPE

04

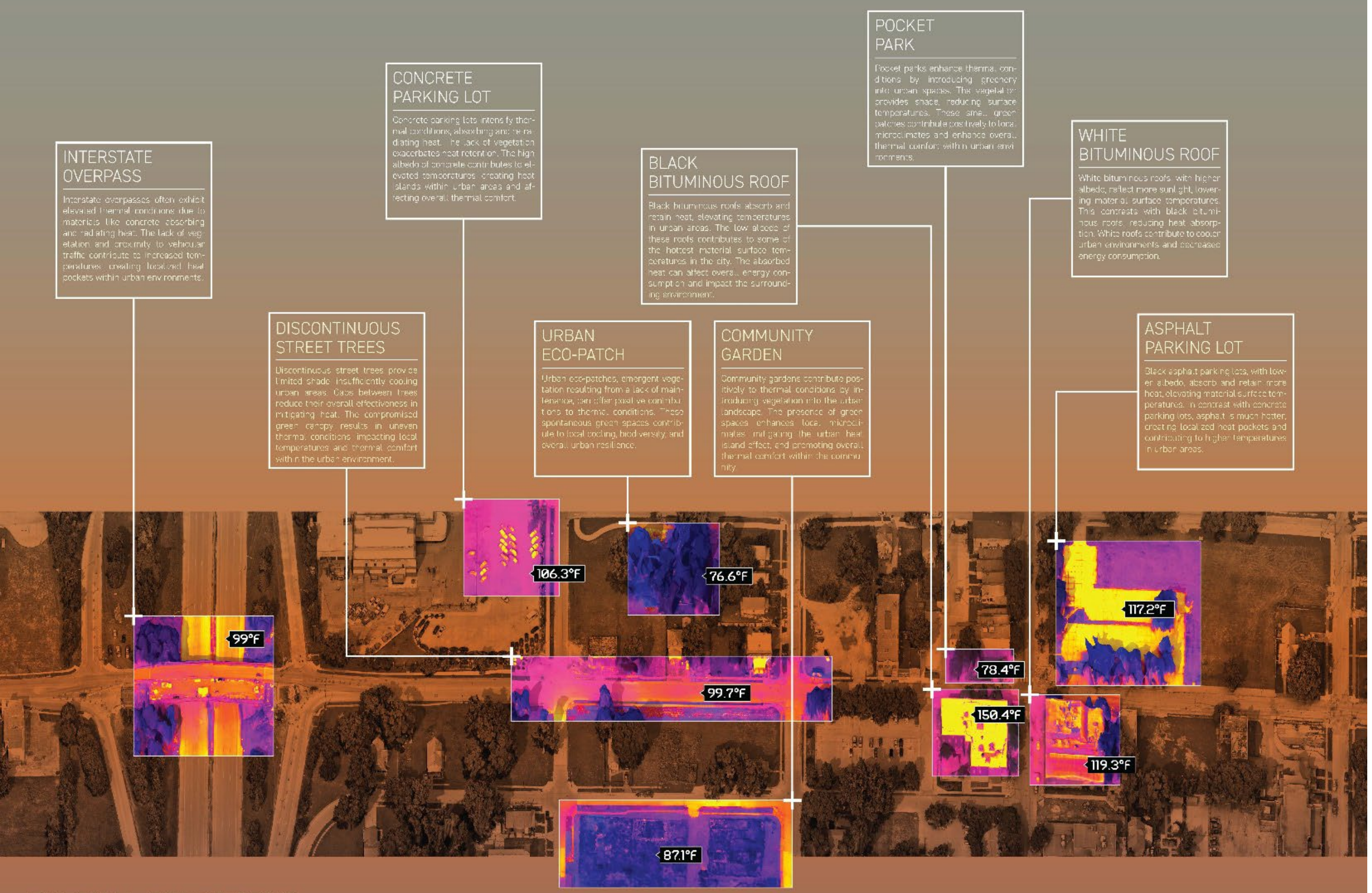
DISCUSSION AND CONCLUSION

A UAV Thermography

B Ground Thermography

75 NORTH CORRIDOR

material surface temperature XXX.X°F

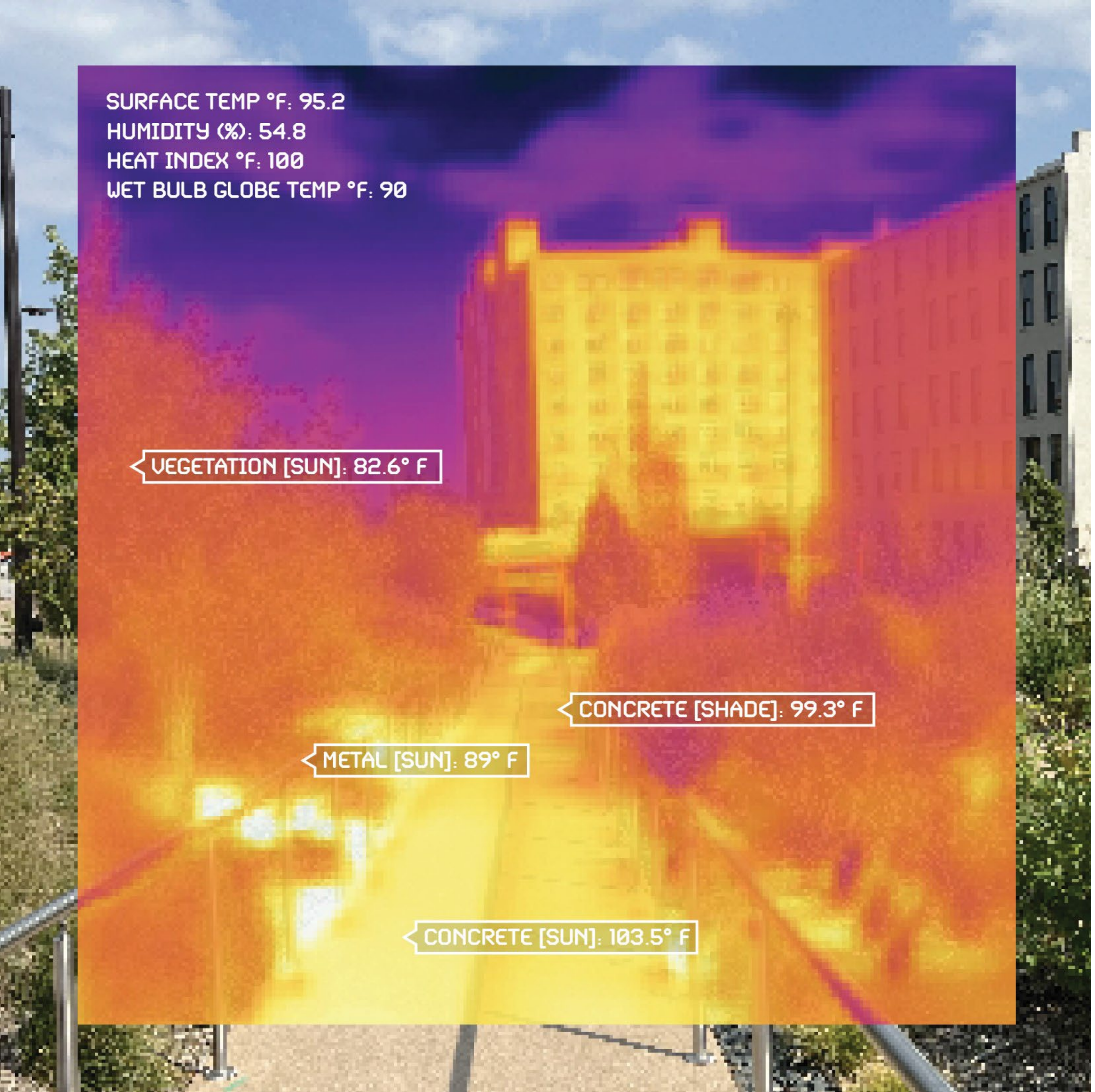


THERMAL CONDITIONS

North Omaha is a historically significant area with a unique demographic and urban condition. The neighborhood has a complex history, shaped by redlining policies that were prevalent in the mid-20th century. Redlining, a discriminatory practice by which certain neighborhoods were marked as high-risk for lending or insurance based on racial composition, has had lasting effects on North Omaha. One of the prominent demographic features of North Omaha is its higher percentage of Black population. This is a result of historical segregation and discrimination, as Black residents were often confined to specific neighborhoods due to restrictive housing policies. The challenges associated with the urban condition in North Omaha, particularly those stemming from historical redlining and economic disparities, contribute significantly to thermal disparities within the community, particularly in the context of the urban heat island (UHI) effect. One key factor is the unequal distribution of green spaces and tree cover in North Omaha. The redlining policies have led to disinvestment and limited resources in the area, resulting in fewer parks and green spaces. In neighborhoods with limited green infrastructure, as North Omaha, there is a higher likelihood of increased temperatures, creating thermal disparities within the urban landscape. Moreover, the quality of housing and infrastructure in North Omaha also plays a role in contributing to thermal disparities. The economic challenges faced by the community may lead to substandard housing conditions, with inadequate insulation and ventilation. Such housing situations can result in higher indoor temperatures, further intensifying the overall thermal conditions experienced by residents. The urban heat island effect is often exacerbated by the prevalence of impervious surfaces like asphalt and concrete in urban areas. In North Omaha, historical disinvestment may have led to limited infrastructure improvements, contributing to a higher proportion of impervious surfaces. These surfaces absorb and retain heat, intensifying the UHI effect and creating localized hotspots within the community. ▌

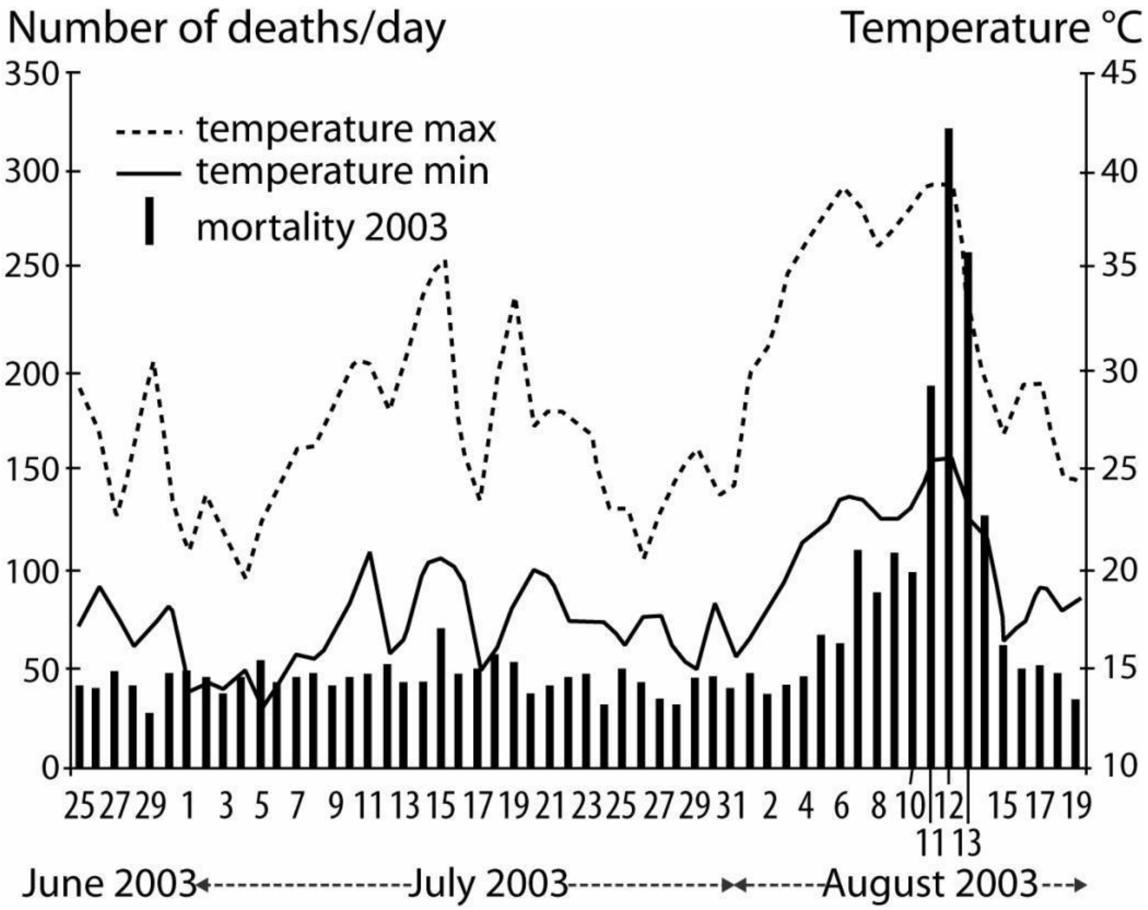
UAV THERMOGRAPHY

- UAV operations required on separate days to scan multiple corridors.
- Challenges faced due to weather variability.
- Flight days had similar but not identical temperature and UV index, potentially affecting surface temperature measurements.
- Time constraints limited scanning to a 1/2 mile by 1/8 mile corridor.
- Selected area for maximum variability in land use conditions.
- Small sample size means macro-scale data should not be generalized broadly unless land use is similarly configured.
- Area measurements by thermal classes suggest influence by surrounding urban conditions.
    - 75 North corridor: 53% of surfaces above 90°F, higher than Regency's 39%, attributed to less canopy coverage.
    - Gene Leahy Mall corridor: 72% of area above 90°F, likely due to highly urbanized context.
- UAV thermography can produce RGB and infrared digital surface models.
- Drone flights can be optimized for 3D thermography on oblique surfaces.
- Future studies should further examine the efficacy and applicability of these models.



GROUND THERMOGRAPHY

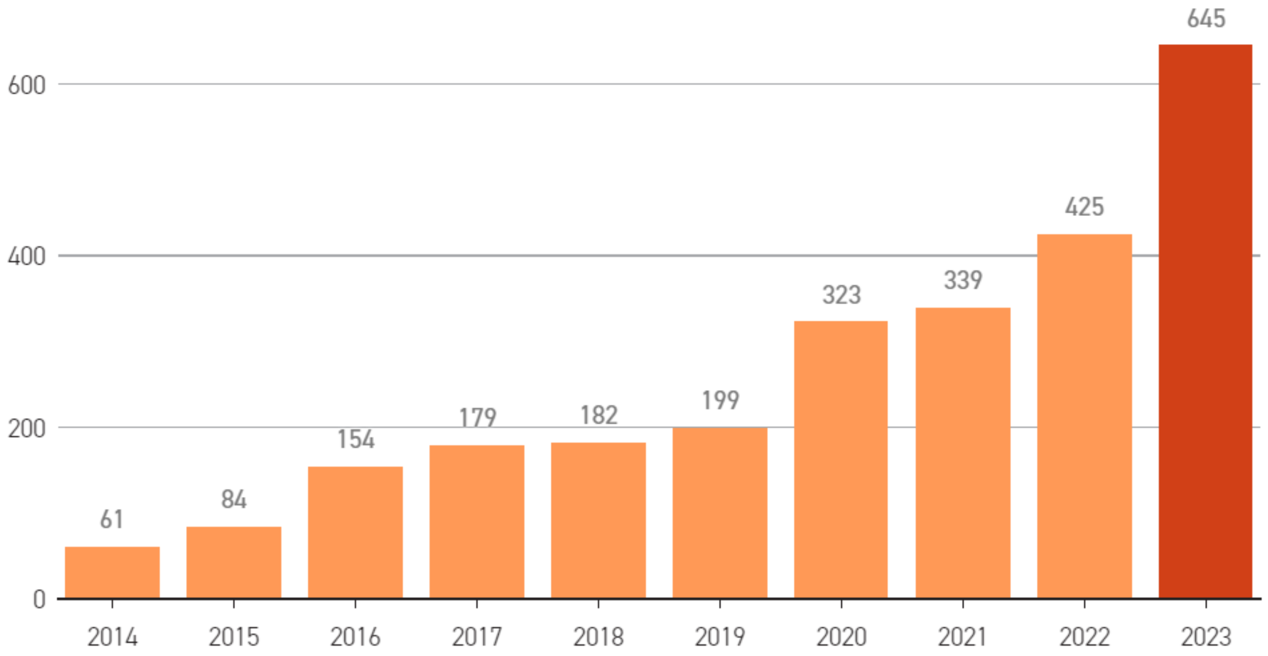
- Ground temperature fluctuations are influenced by changing weather conditions like cloud cover.
- Fluctuations stay within a reasonable standard deviation compared to infrared imagery.
- Time and weather constraints affect field work.
- A heat map from regularly spaced ground temperature measurements could validate UAV thermography data.
- Ground measurements were useful for spot checking aerial measurements.
- Future studies could benefit from more robust "ground-truthing."



Source: University of Hawaii at Manoa/Benedicte Dousset

Deaths caused by heat in Maricopa County, Arizona have increased tenfold in the last decade

Number of heat deaths in Maricopa County, Arizona



Source: Maricopa County Department of Public Health

INTRODUCING THE THERMAL TOOLKIT:

TECHNOLOGIES AND TECHNIQUES FOR VISUALIZING THERMAL DISPARITIES

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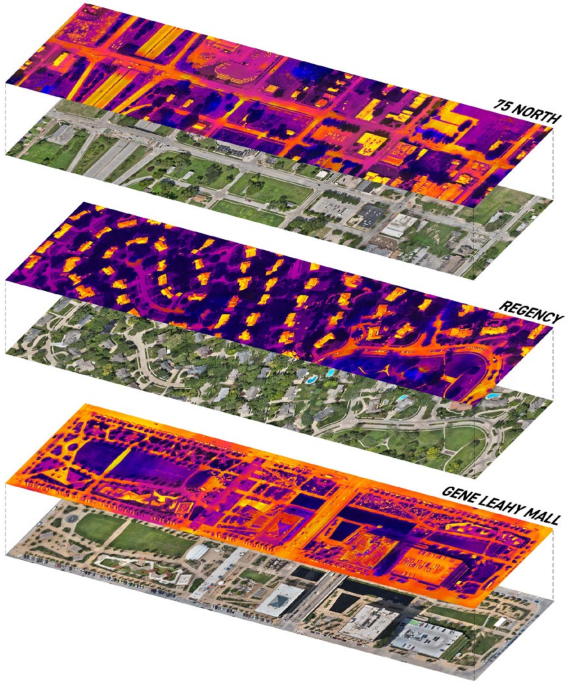
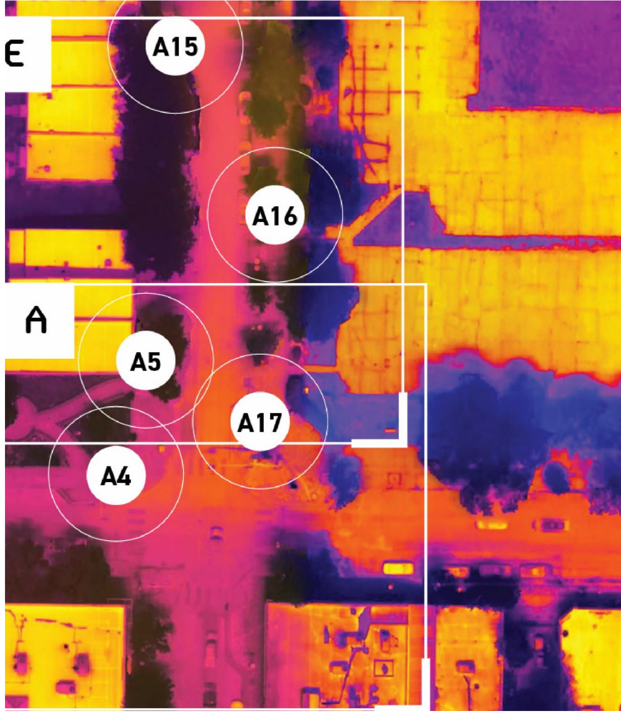
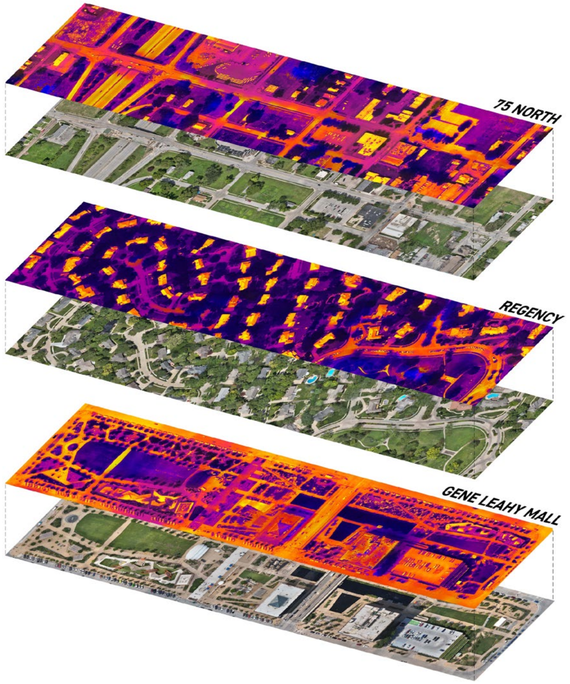
2024 LAF WEBINAR

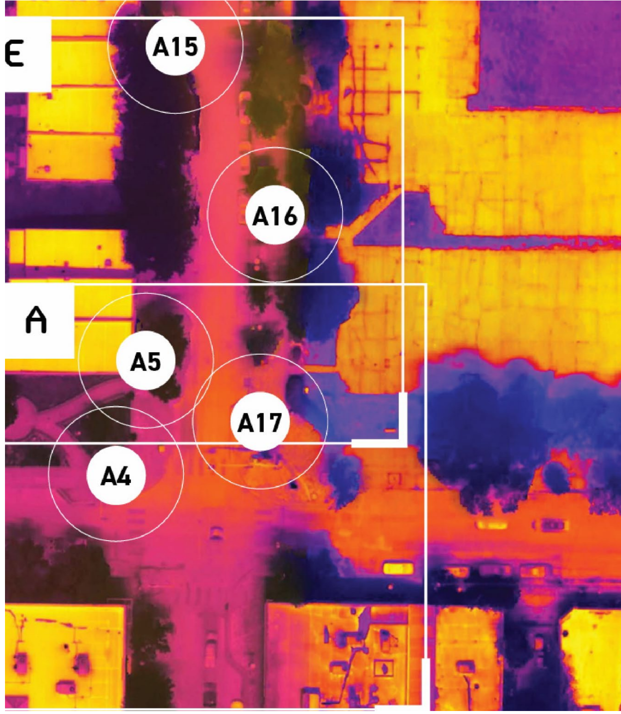




VISUALIZING EXTREME HEAT DISPARITIES

AUDIENCE Q&A





VISUALIZING EXTREME HEAT DISPARITIES

THANK YOU!