

# PARTNERS IN COMMUNITY FORESTRY

2024 CONFERENCE

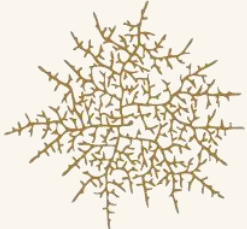


# EVIDENCE-BASED DESIGN FOR URBAN FORESTRY

PRESENTED BY:

**Brent Bucknum**

Founder and Principal  
Hyphae Design Labs



**Lannie McClelen**

SWMD Director  
Texas Trees Foundation





# AGENDA

## Evidence-Based Design for Urban Forestry



**1.**  
BACKGROUND

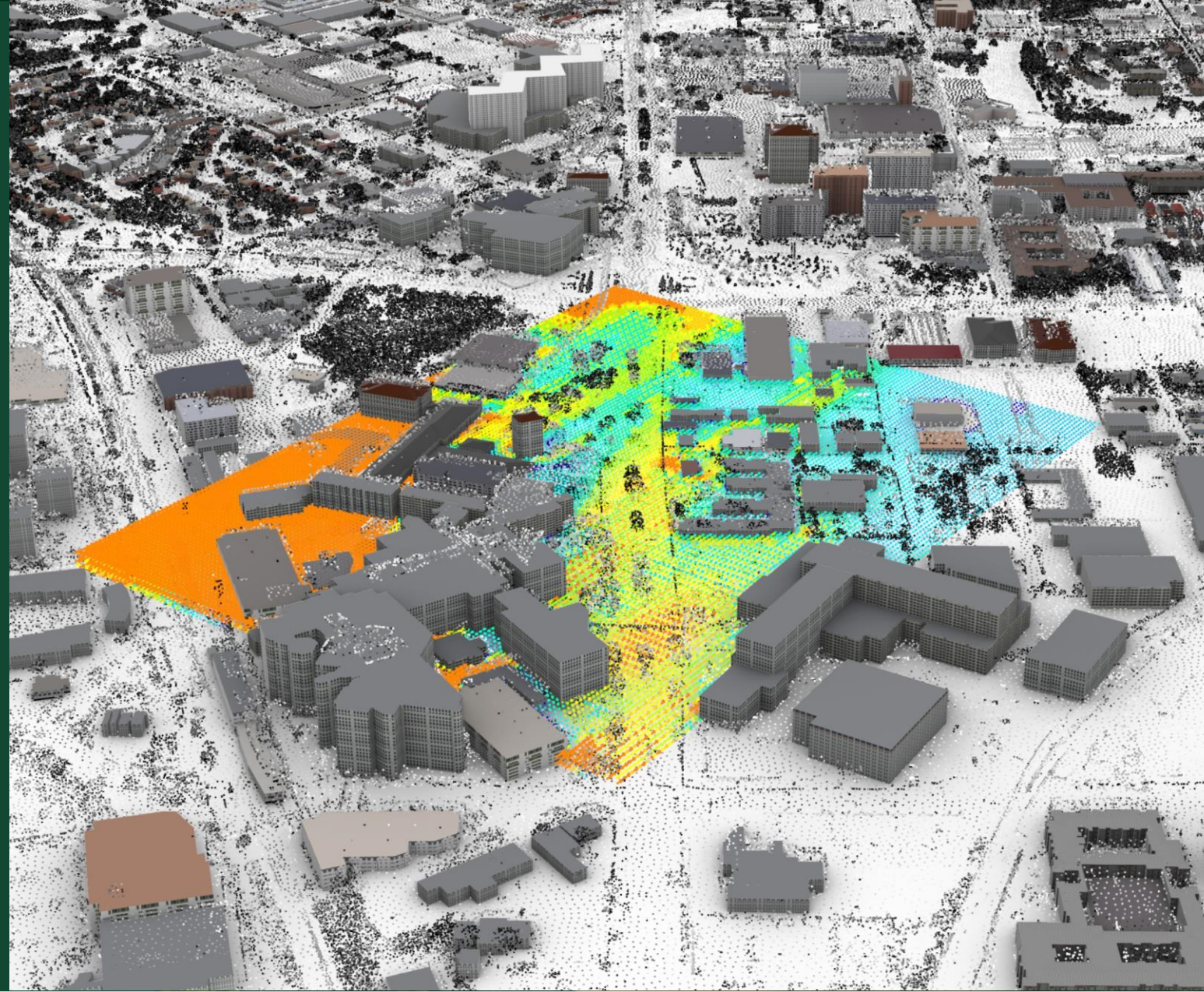


**2.**  
PROCESS

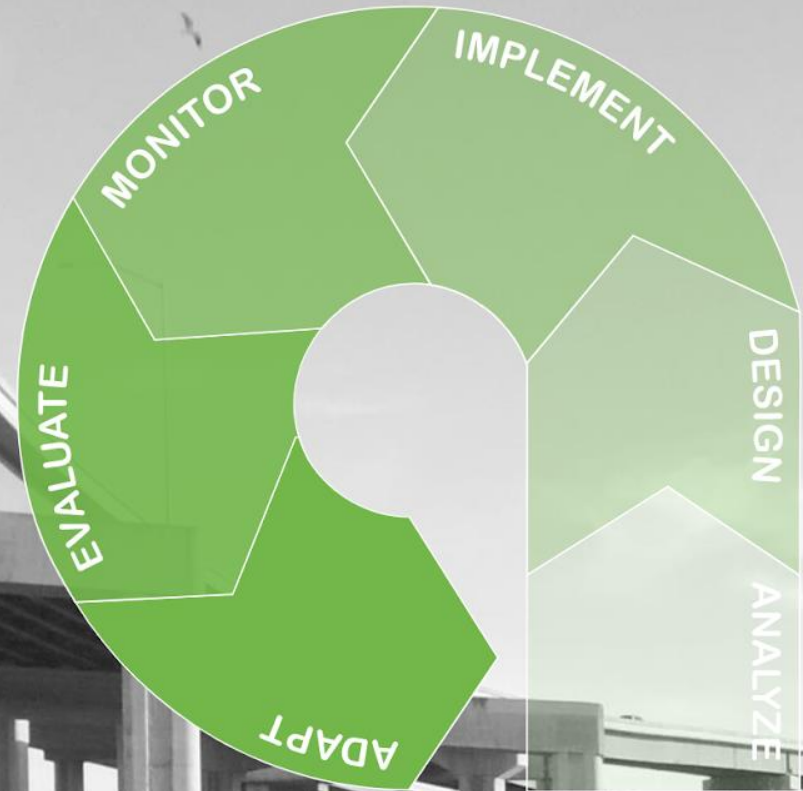


**3.**  
APPLY

# BACKGROUND



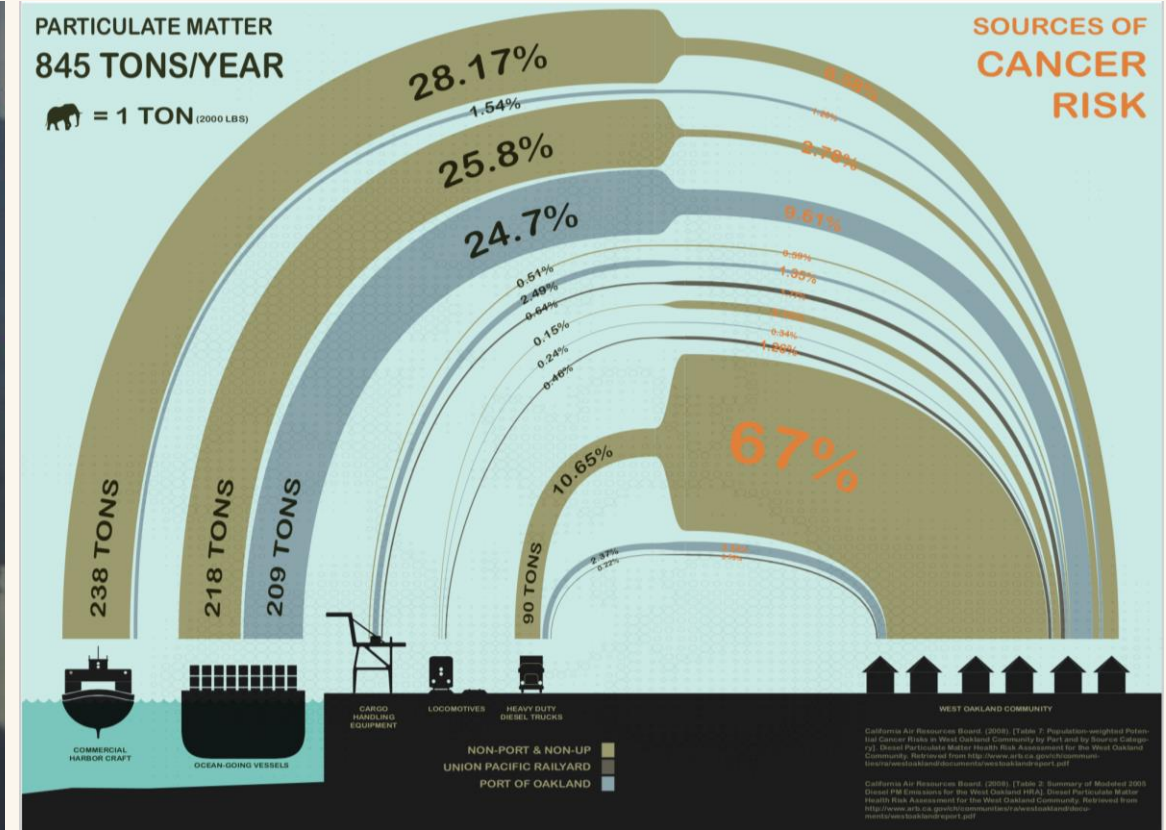




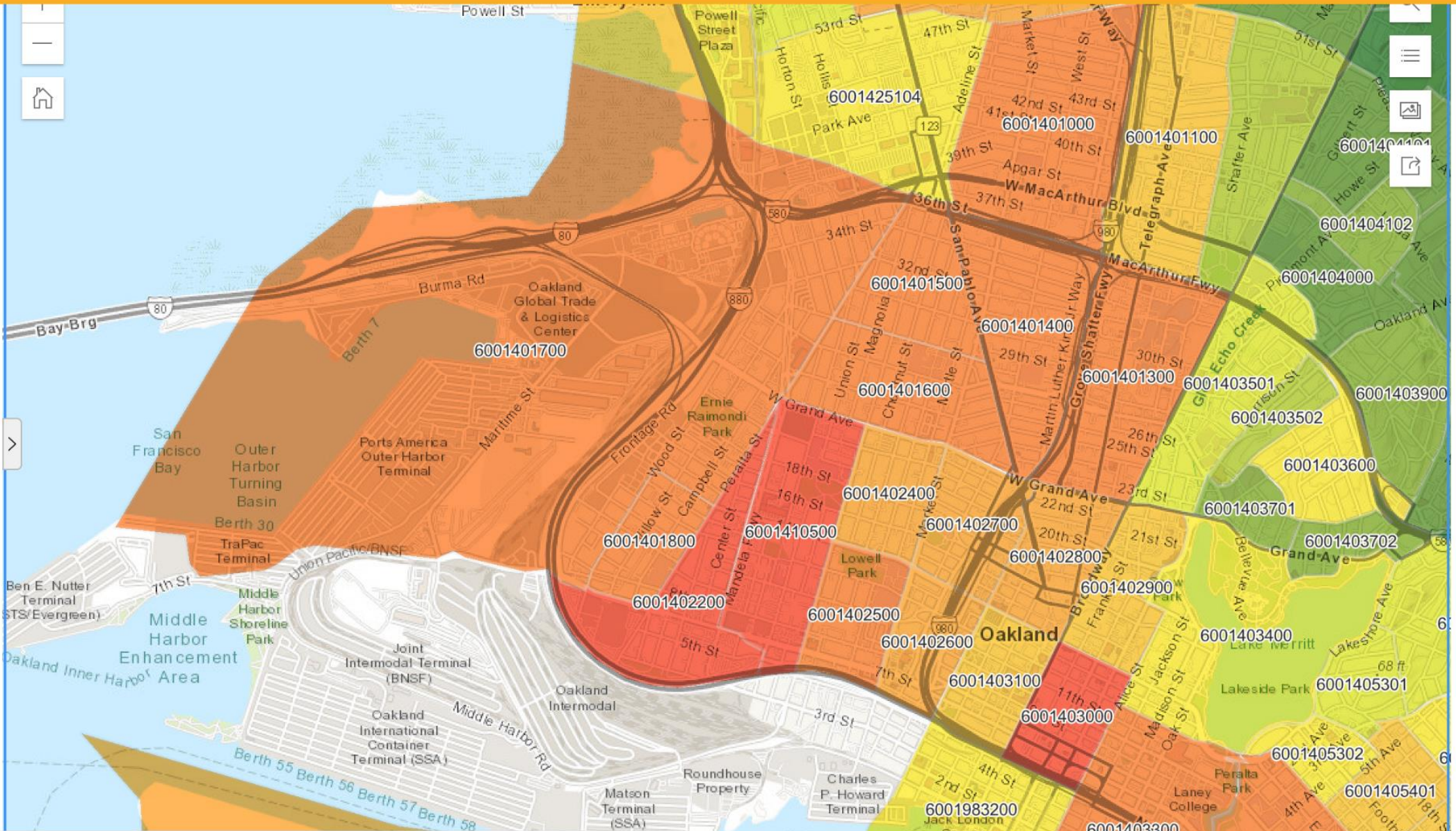
# ADAPT



# Adapt Oakland









Please note: Territory data (except Puerto Rico) is not available as comparable to the US. It is only comparable to the territory itself by using the 'Compare to State' functionality. Likewise, some of the indicators may not be available for



○ Compare to US ● Compare to State

Environmental Burden Indicators

Socioeconomic Indicators

Environmental Justice Indexes

Particulate Matter 2.5

Ozone

Nitrogen Dioxide (NO<sub>2</sub>)

Diesel Particulate Matter

Toxic Releases to Air

Traffic Proximity

Lead Paint

Superfund Proximity

RMP Facility Proximity

Hazardous Waste Proximity

Underground Storage Tanks

Wastewater Discharge

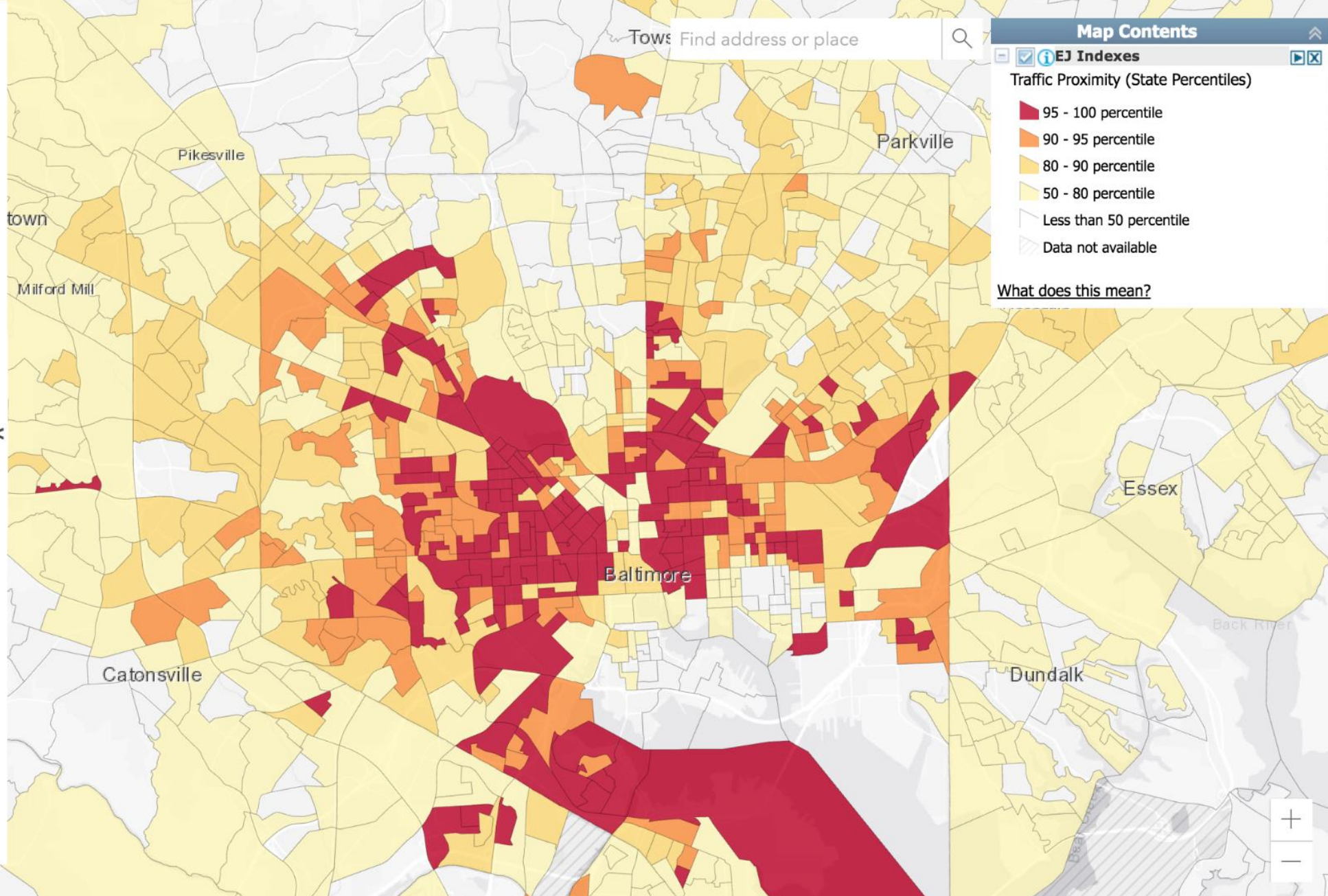
Drinking Water Non-Compliance

Supplemental Indexes

Climate Change

Health Disparities

Critical Service Gaps

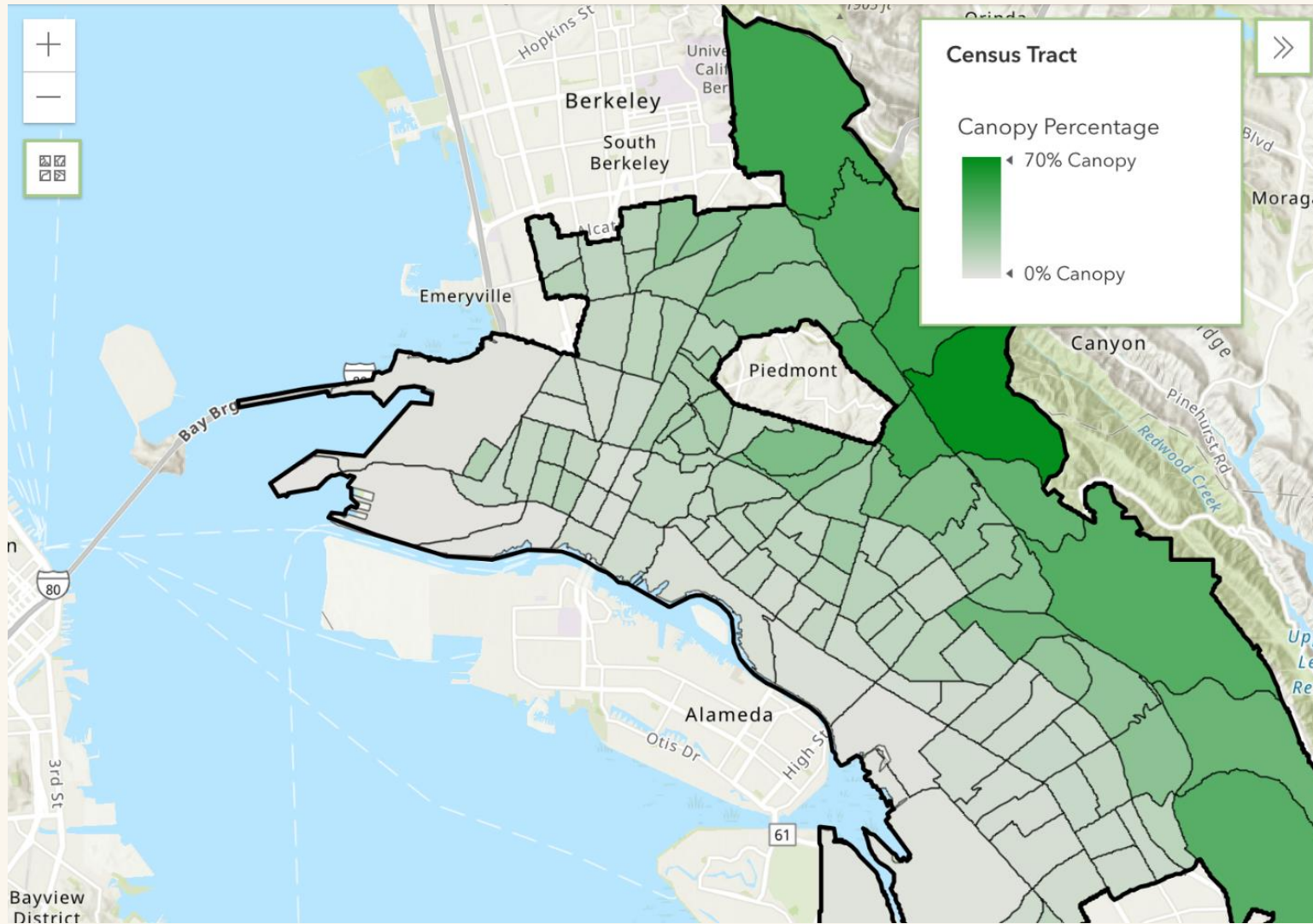


Map Contents
EJ Indexes
Traffic Proximity (State Percentiles)
95 - 100 percentile
90 - 95 percentile
80 - 90 percentile
50 - 80 percentile
Less than 50 percentile
Data not available

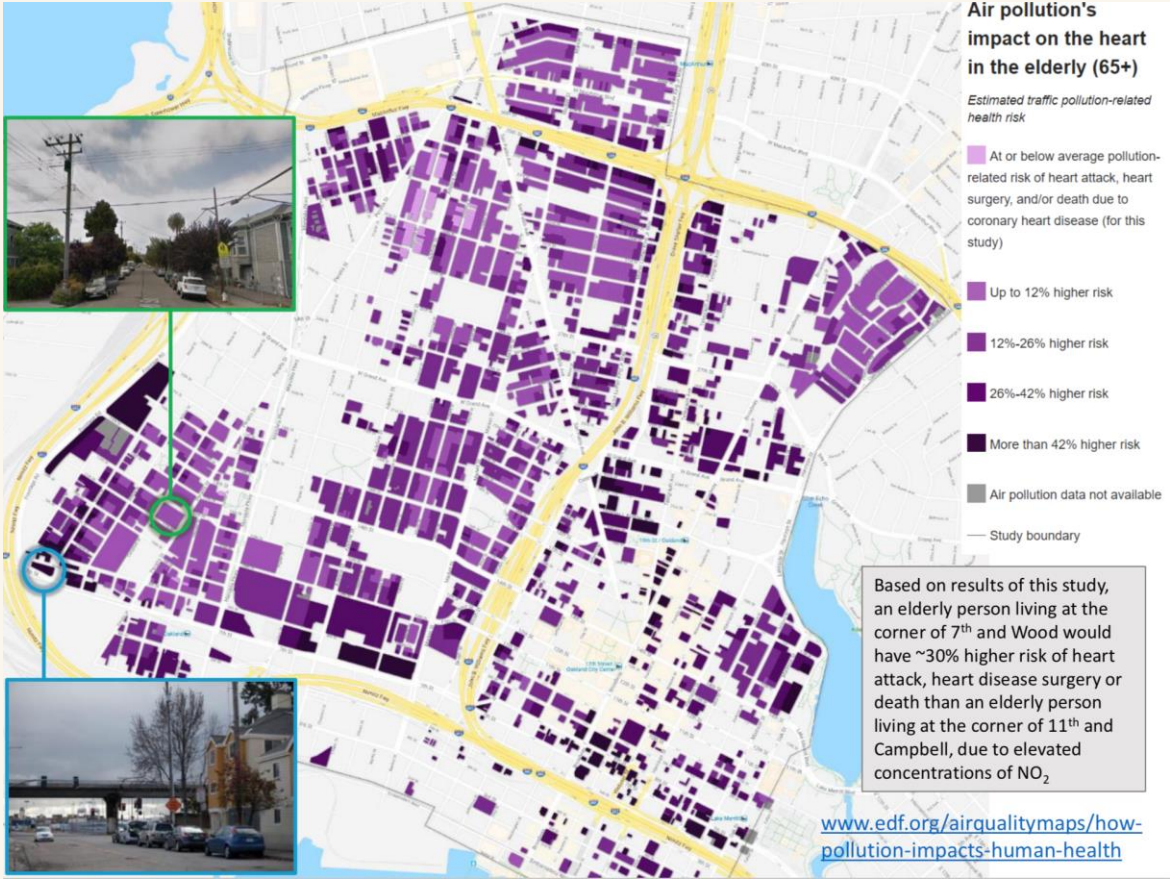
What does this mean?



# Adapt Oakland

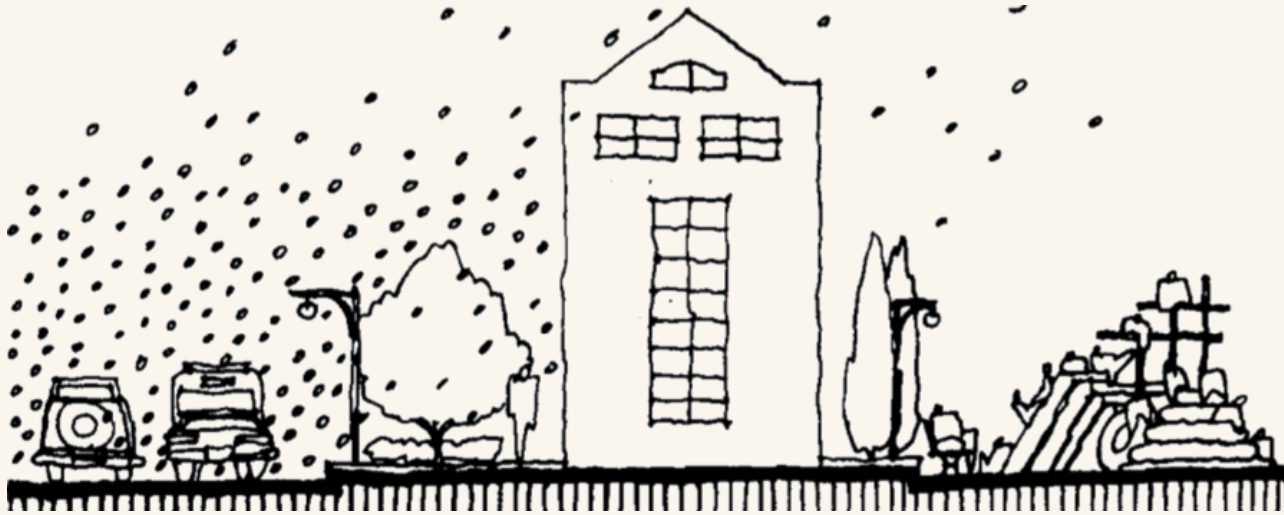


# Adapt Oakland

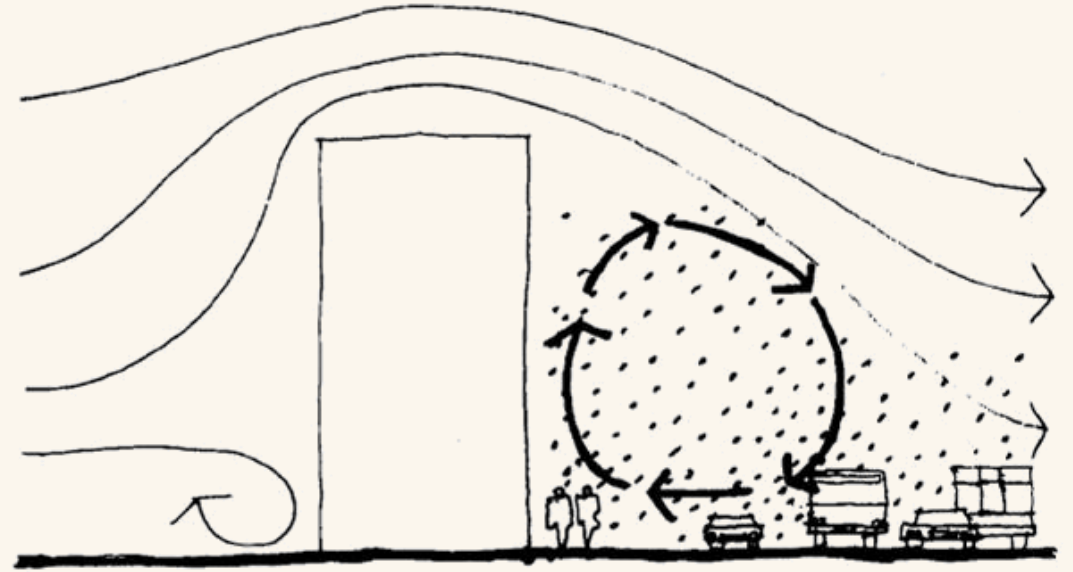




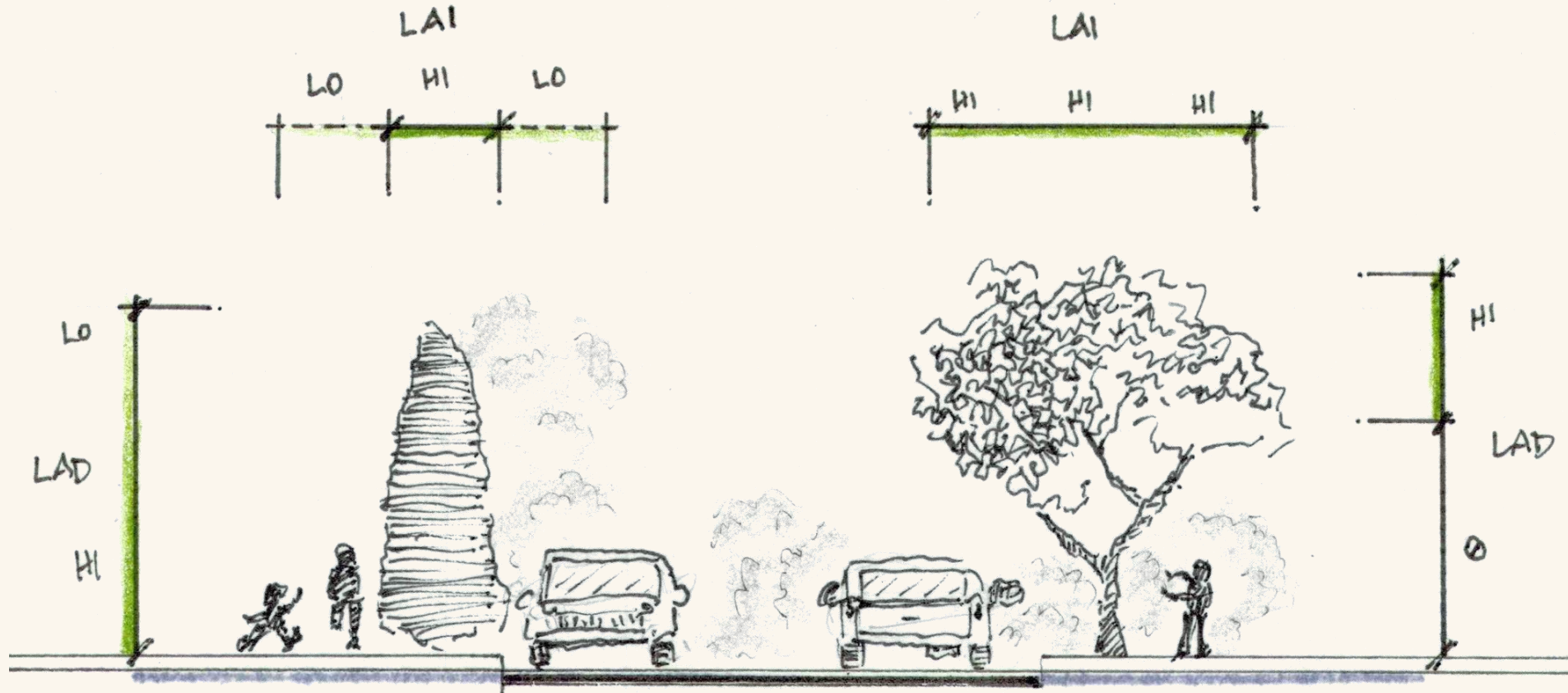
# Adapt Oakland



Anne Whiston Spirn 1986



# Adapt Oakland



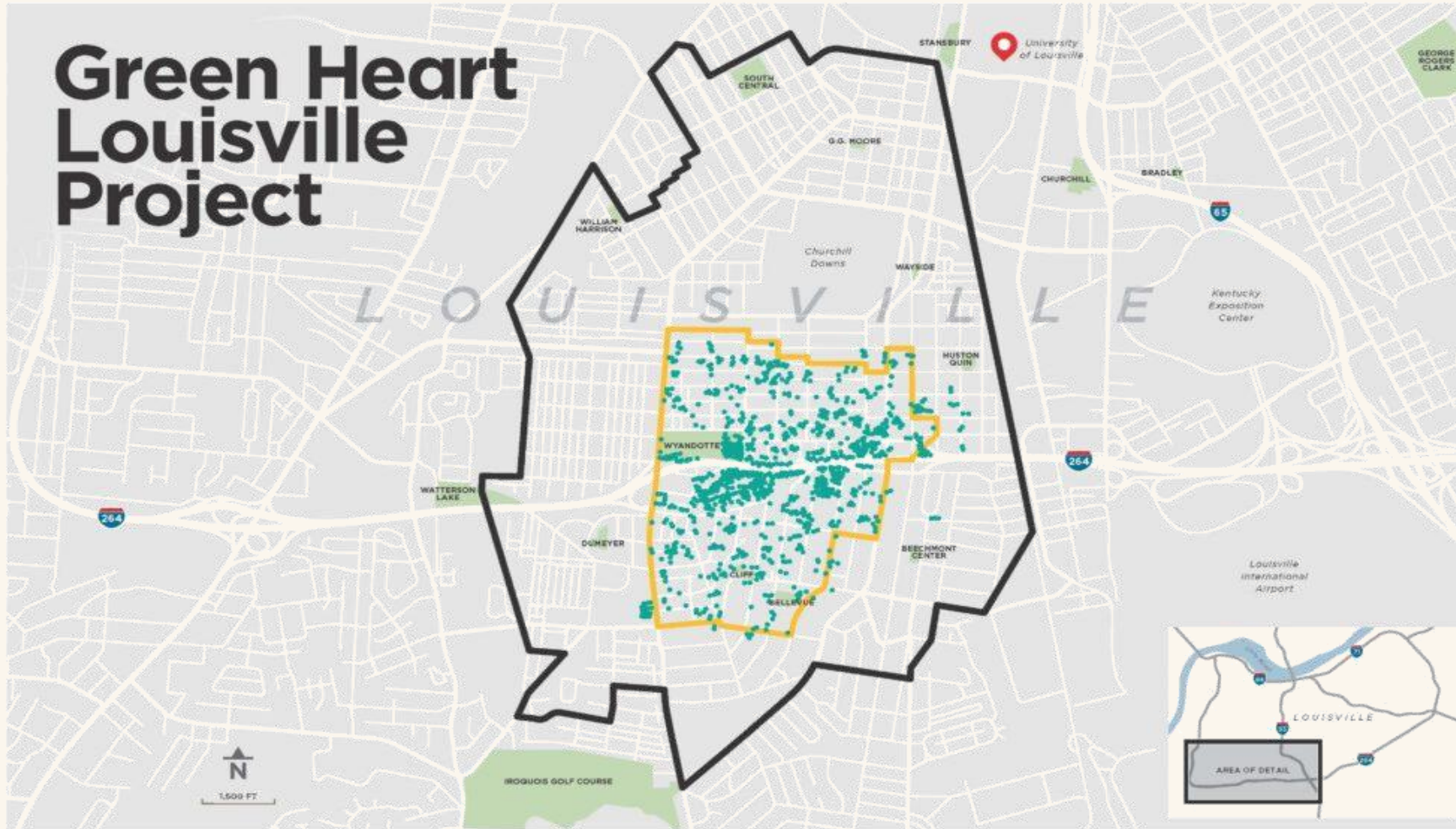
LAI - LEAF AREA INDEX

LAD - LEAF AREA DENSITY





# Green Heart Louisville Project



People living in the intervention areas had 13% lower levels of high-sensitivity C-reactive protein,

a blood marker associated with heart disease, including stroke, coronary artery disease and heart attack.

The drop was similar to starting a regular exercise routine.



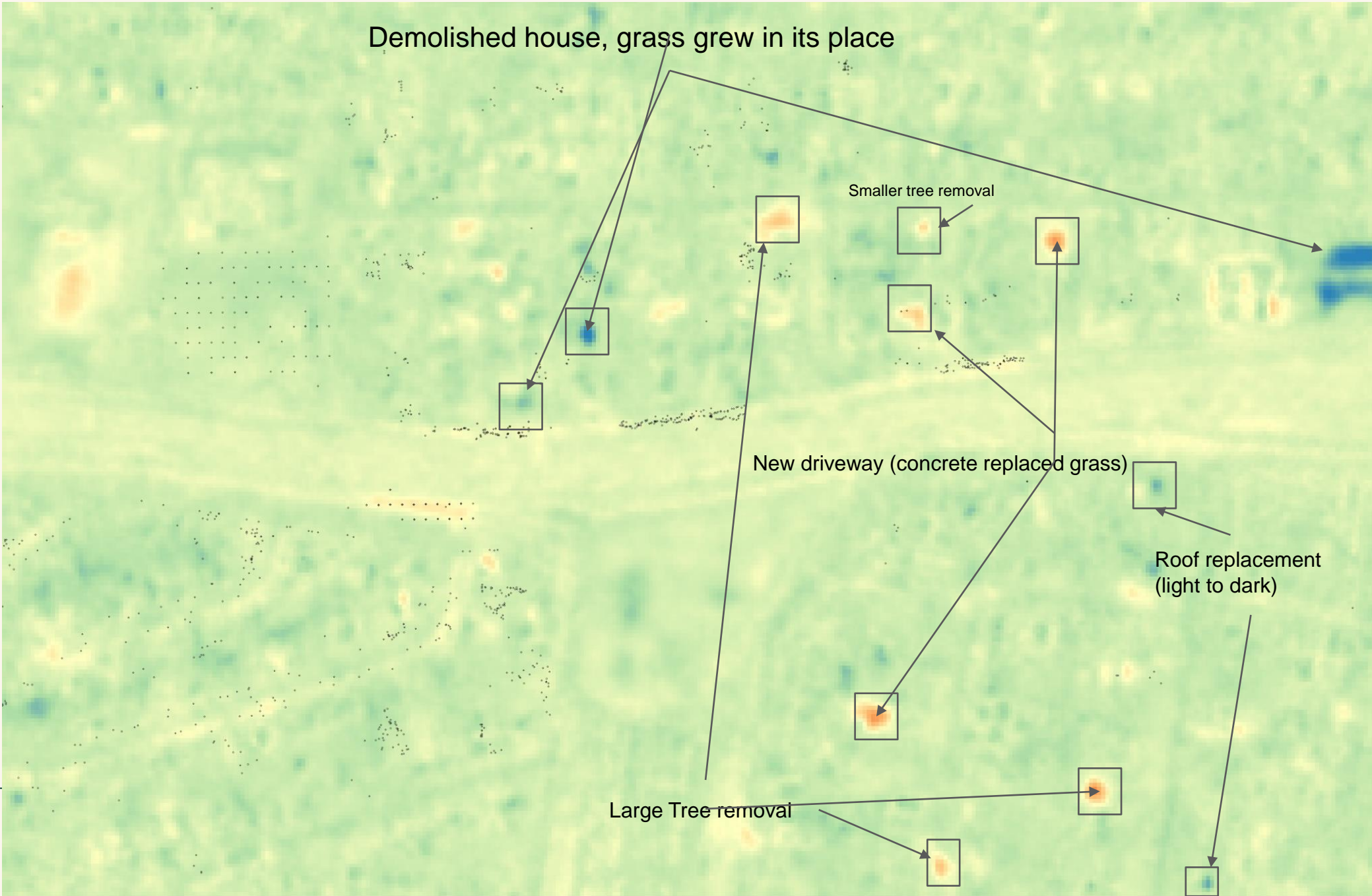
Demolished house, grass grew in its place

Smaller tree removal

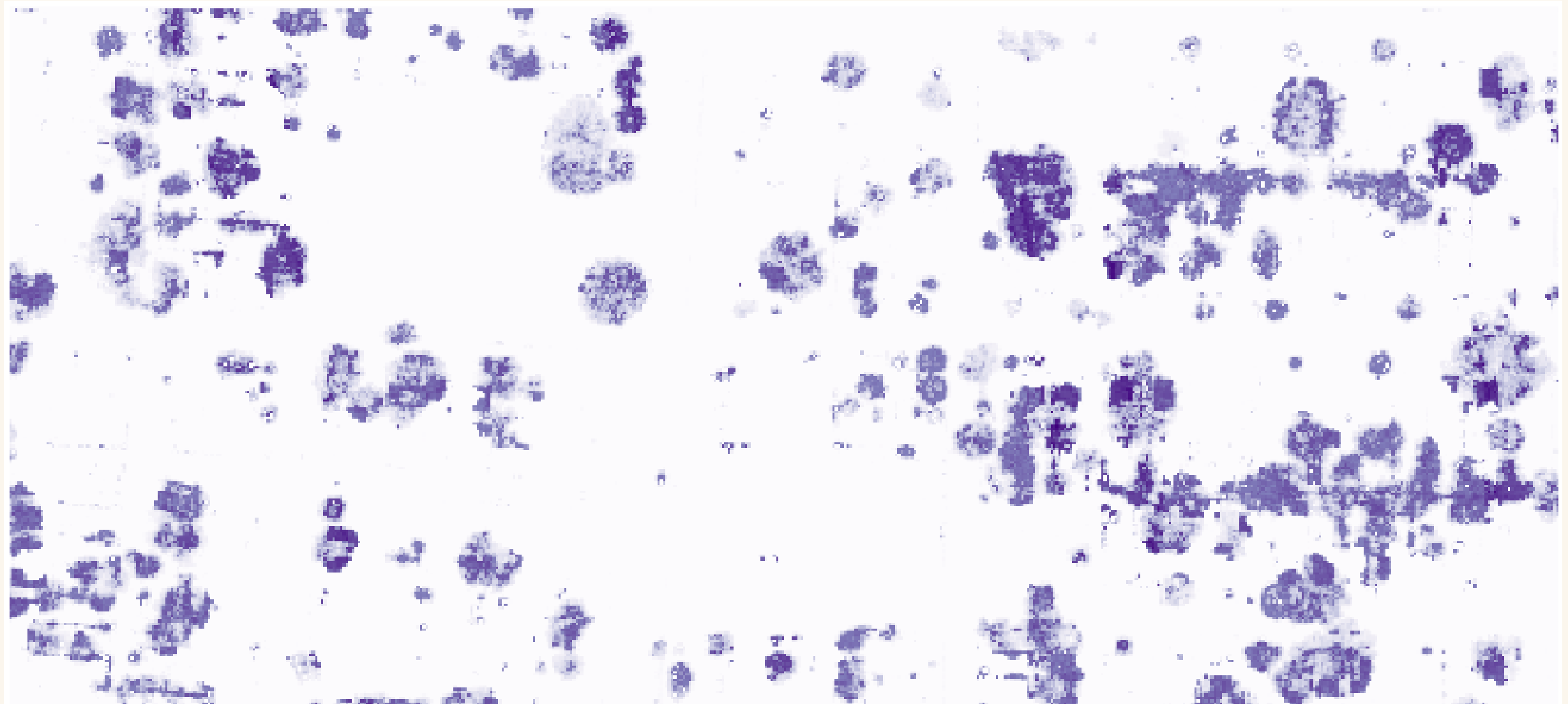
New driveway (concrete replaced grass)

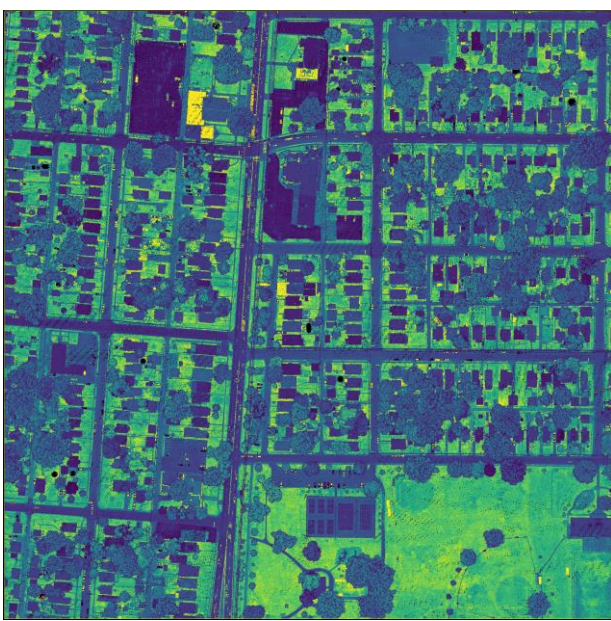
Roof replacement  
(light to dark)

Large Tree removal





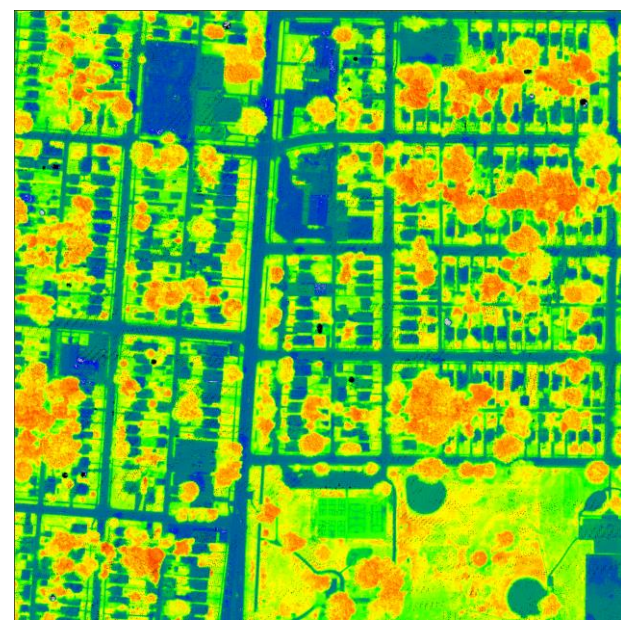




+



=

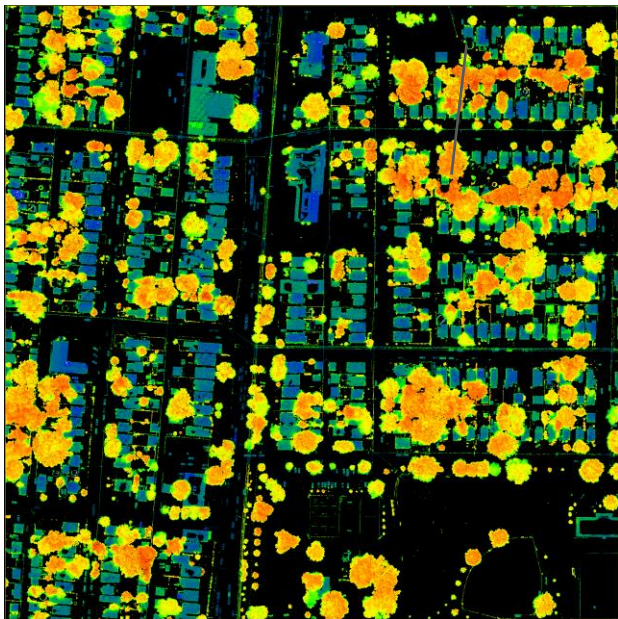


**Leaf Area Index (LAI) estimation from aerial LIDAR scans**

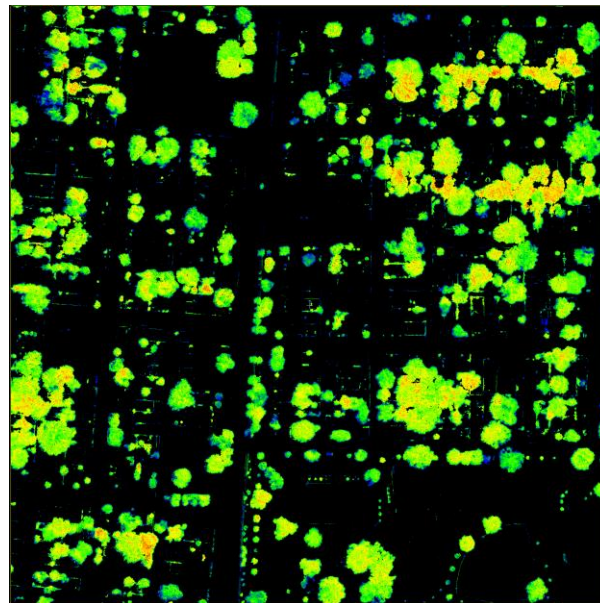
Take the aerial LIDAR point cloud from GH partners.

colorize it with concomitantly gathered NDVI raster

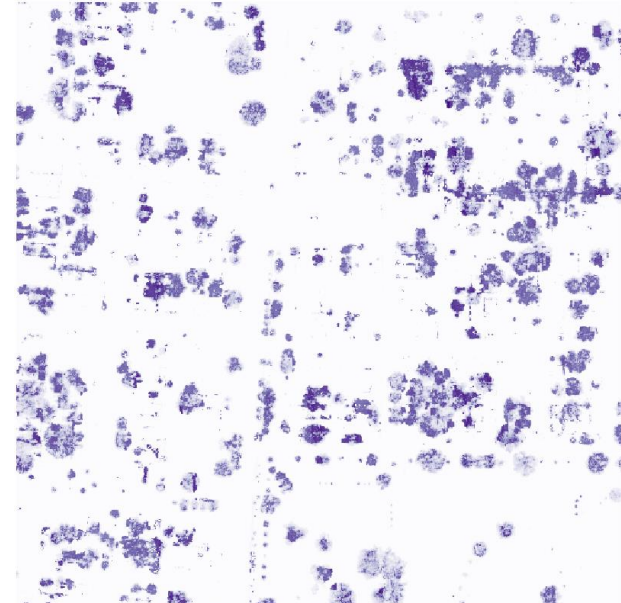
to get point cloud with NDVI as a scalar field for each point...



→



→

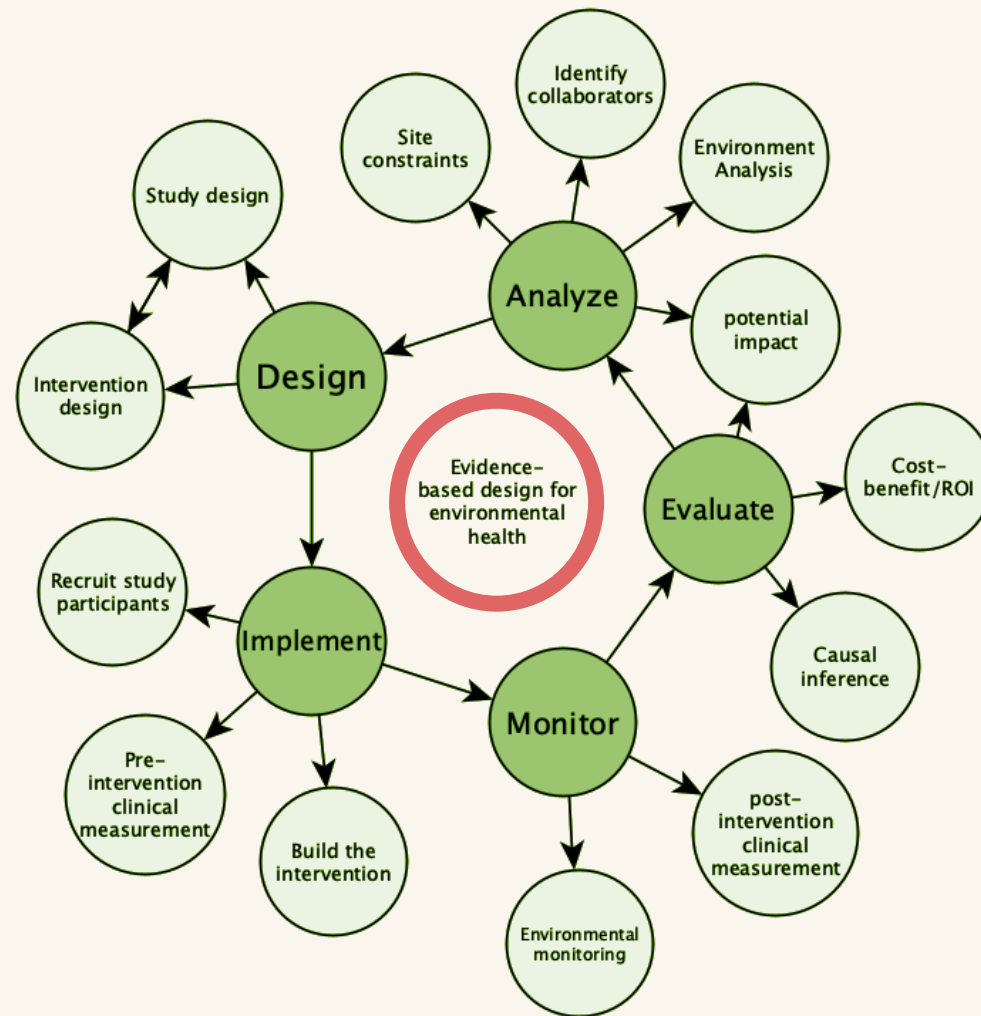
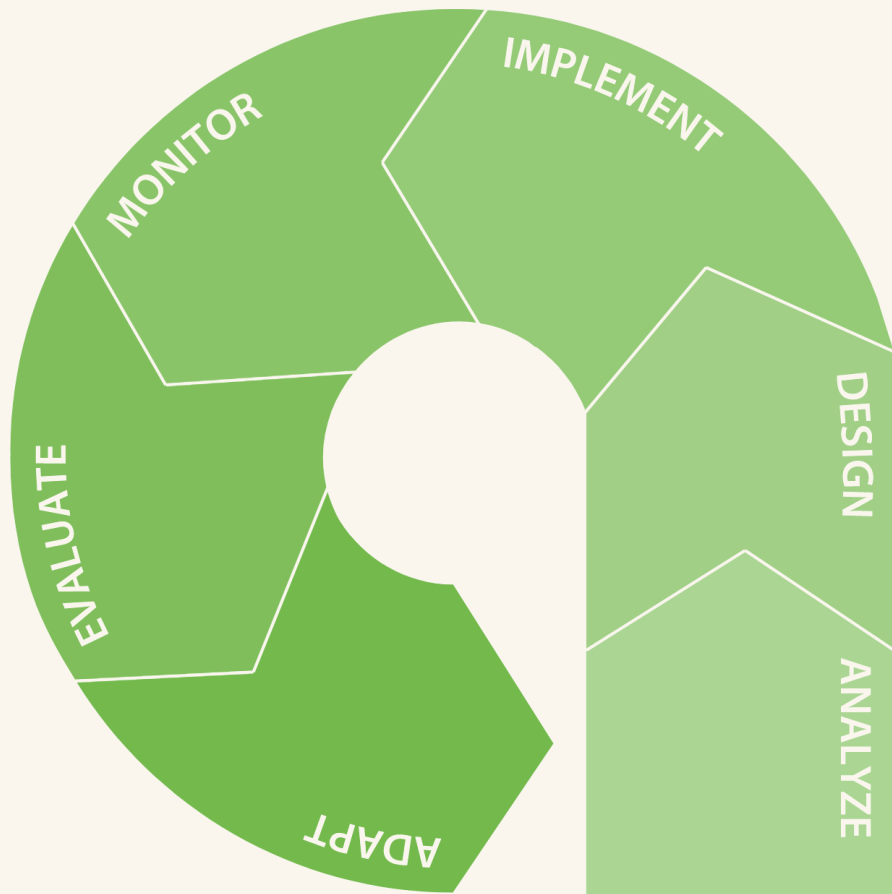


Separate ground points with cloth simulation filter....

All above-ground points with NDVI >0.23 are vegetation points (also remove roofs under trees with coplanarity filter!)

Divide point clouds into 1m XY squares, and calculate LAI using Beer-Lambert equation with ground points as sensor to get 1m LAI raster



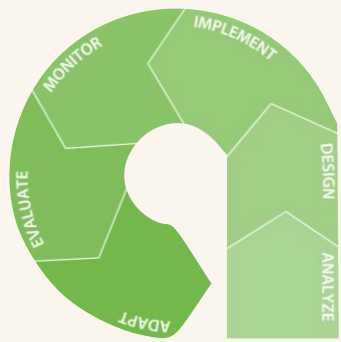


**America's  
SEED FUND**



National Institute of Environmental Health Sciences  
*Your Environment. Your Health.*





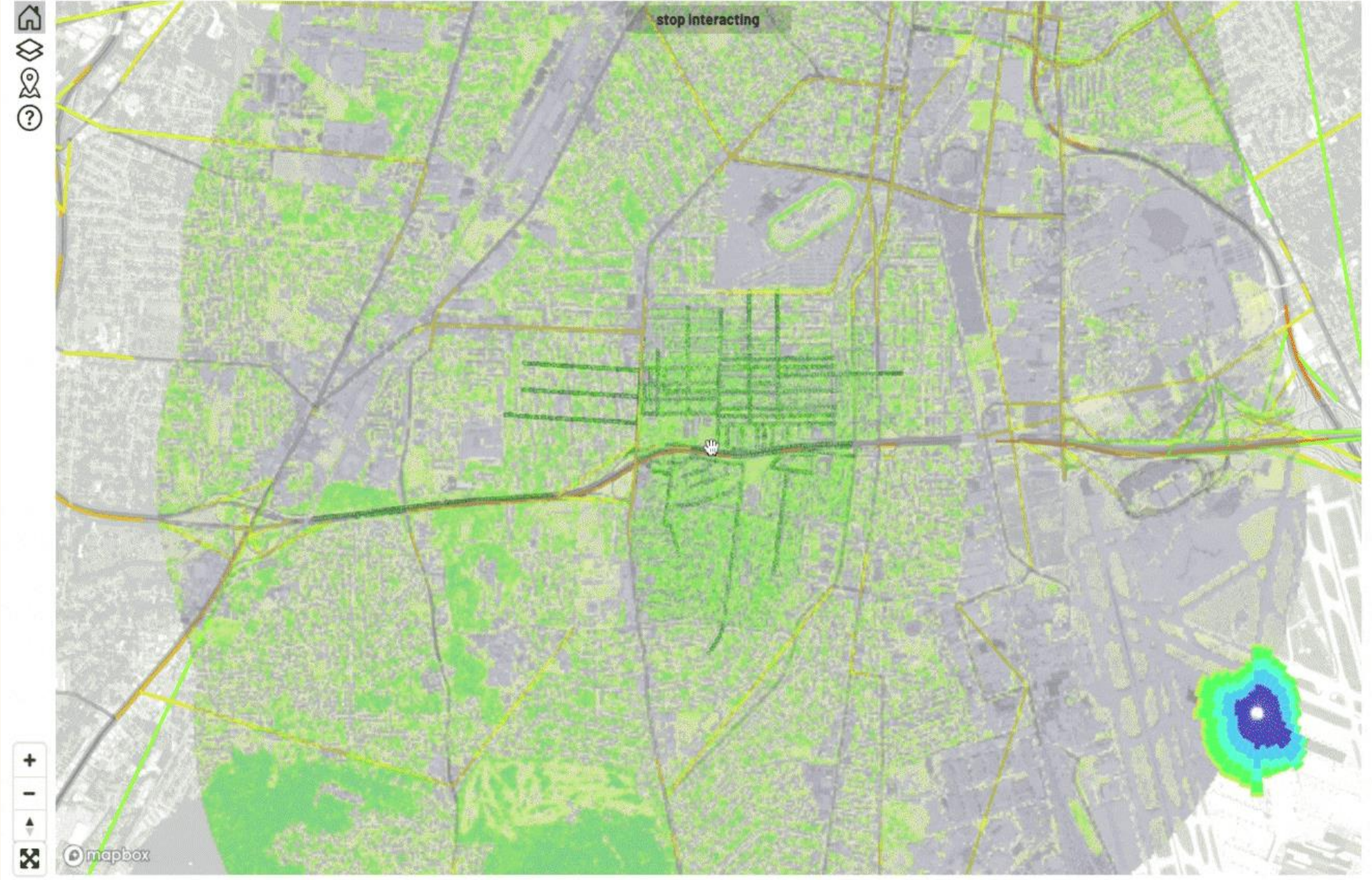
# adapt **PLATFORM**

## For Ecosystem Healthcare

*We're building tools to empower communities impacted by environmental injustice and climate change to take control and determine their own future, a new approach to community-led, evidence-based urban revitalization. What previously required teams of engineers, epidemiologists, academics, government agencies and consultants can now be done by and for communities themselves, creating resilience, while re-localizing power, knowledge and capital in the communities.*









## Measure Pollution



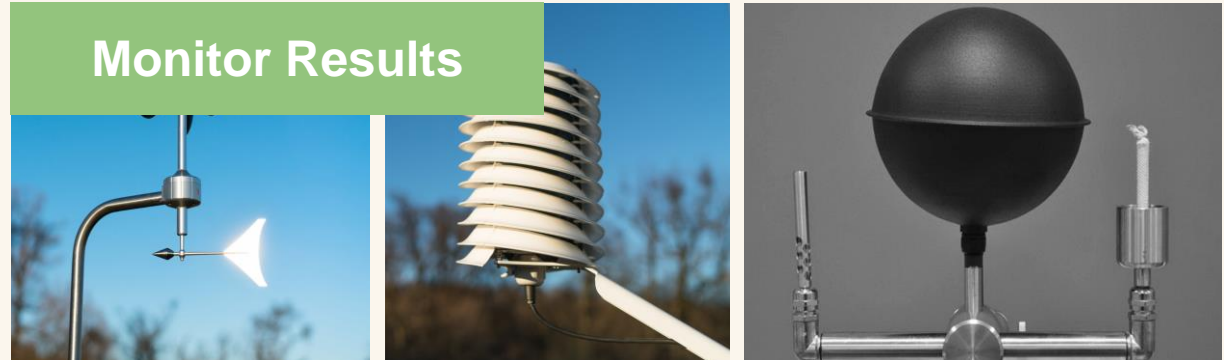
## Build Interventions



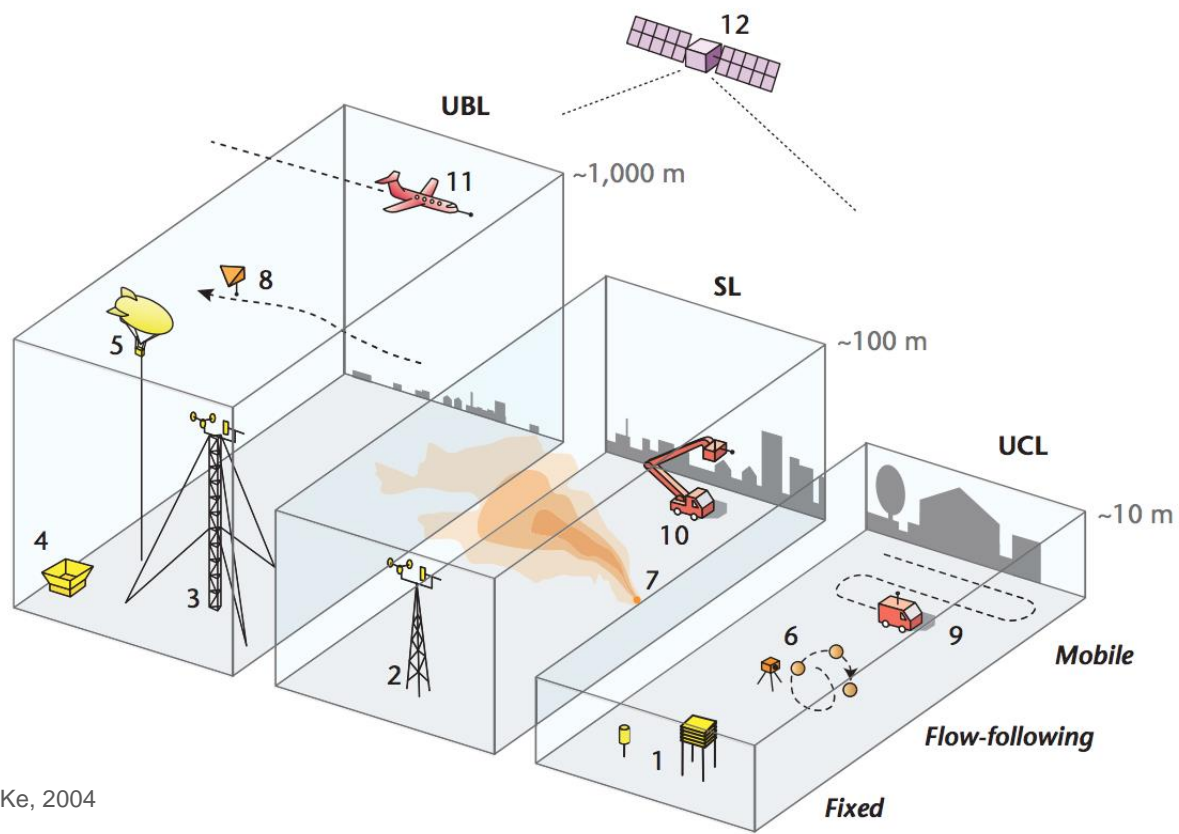
## Design Solutions



## Monitor Results

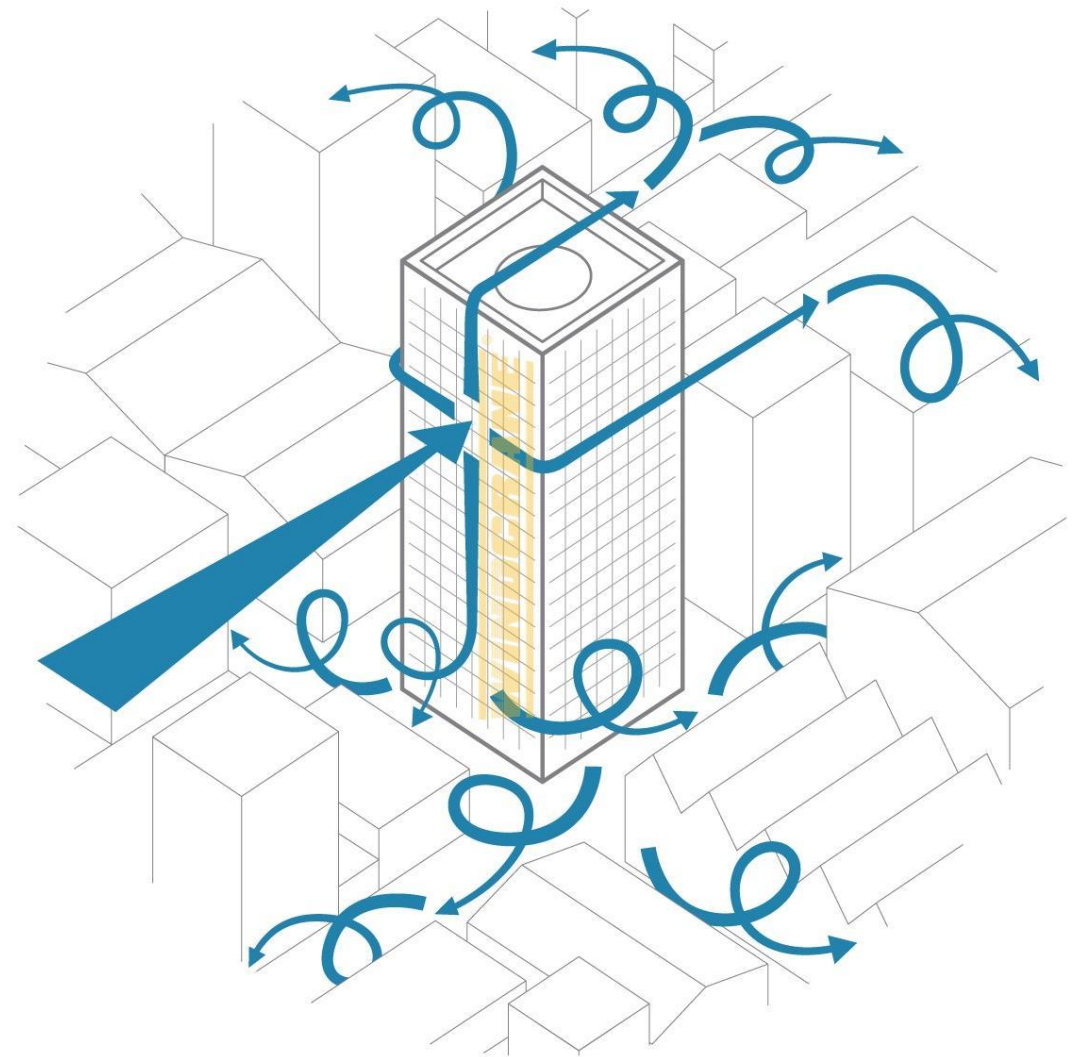






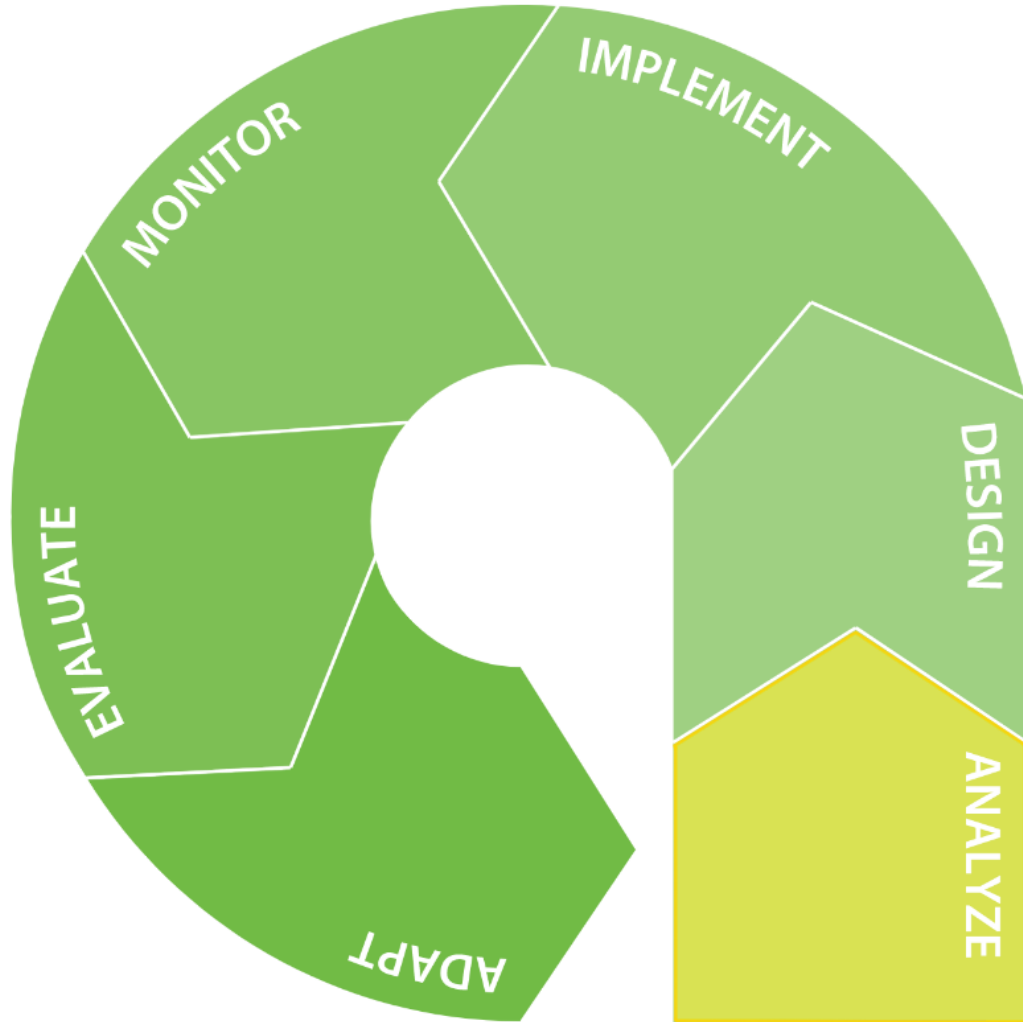
Oke, 2004

Monitoring



Model

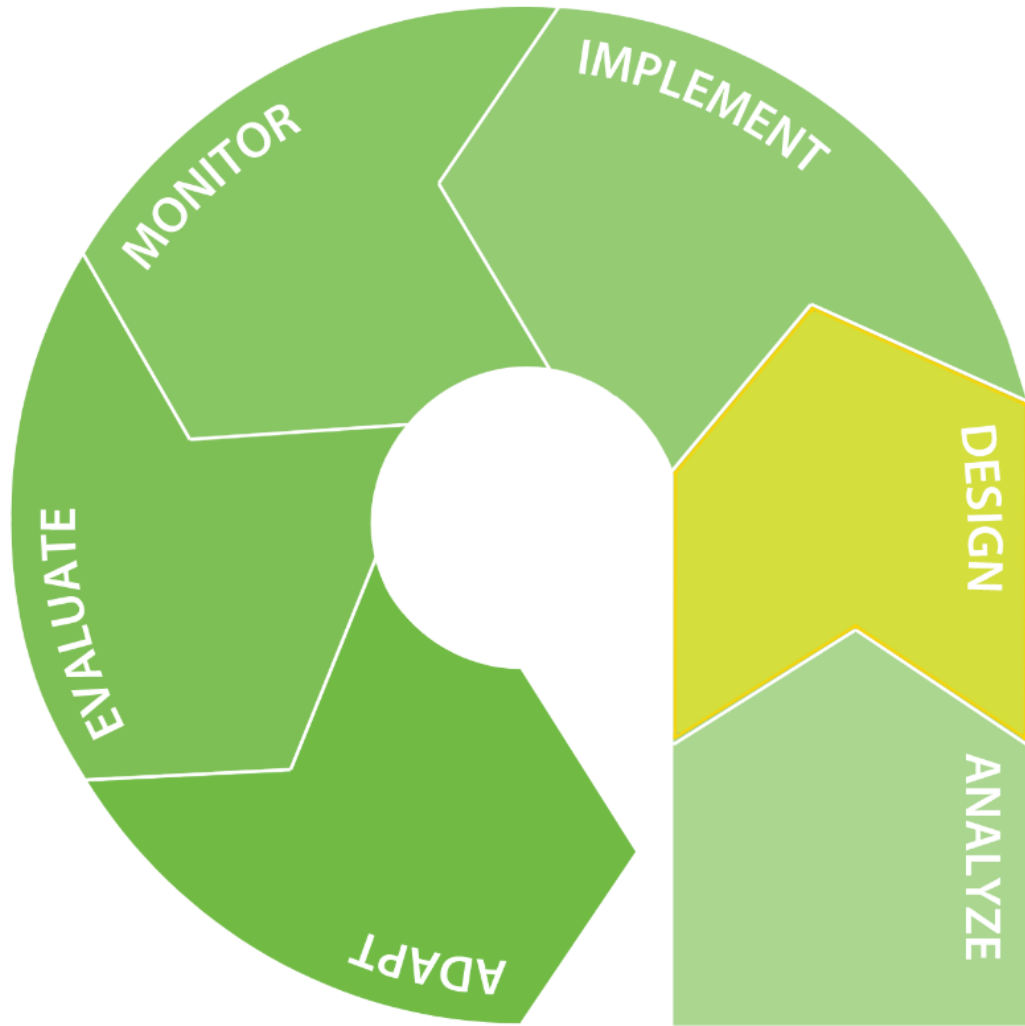
# EVIDENCE BASED DESIGN



Analyze where pollution is the worst



# EVIDENCE BASED DESIGN

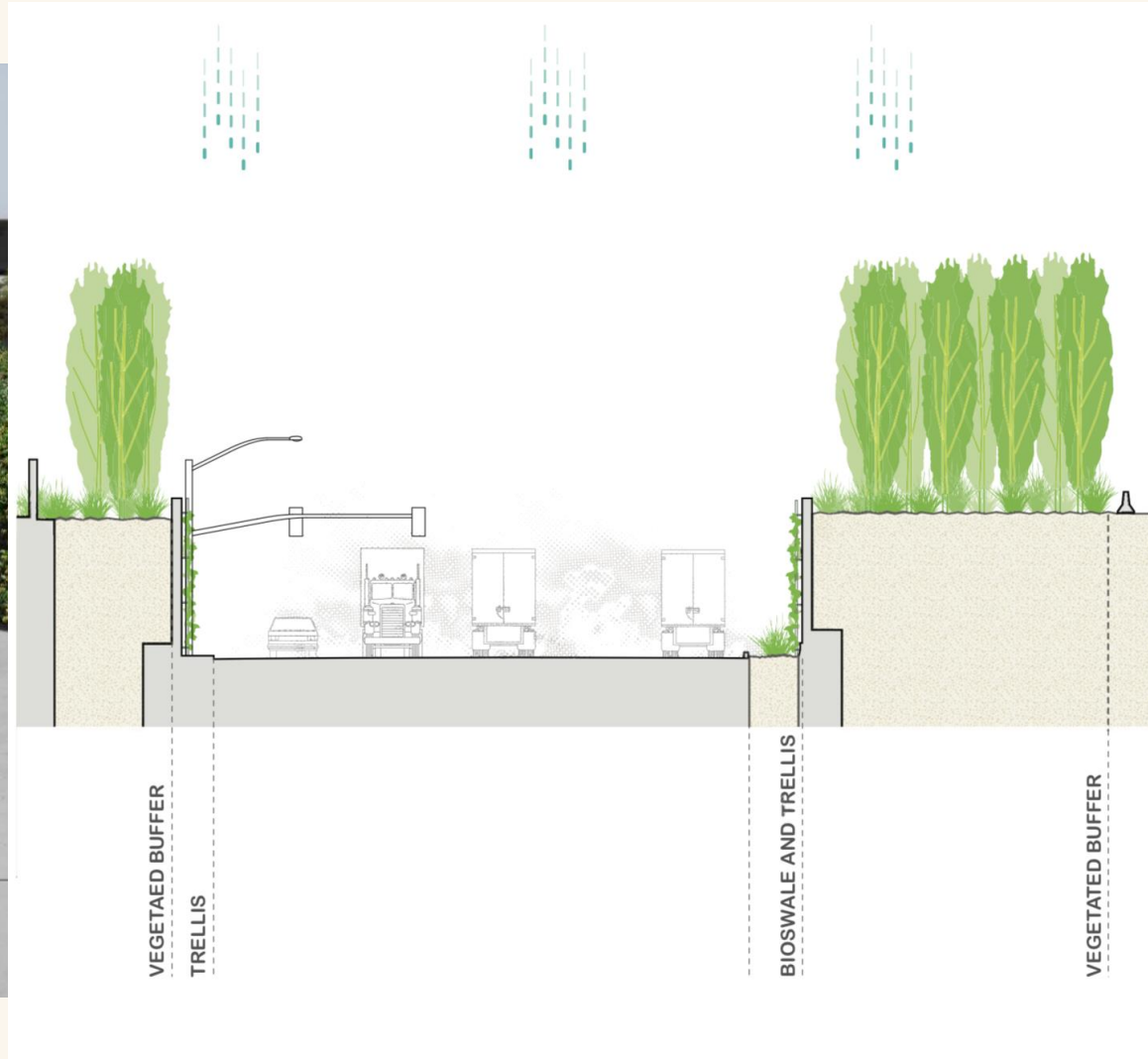


Design interventions

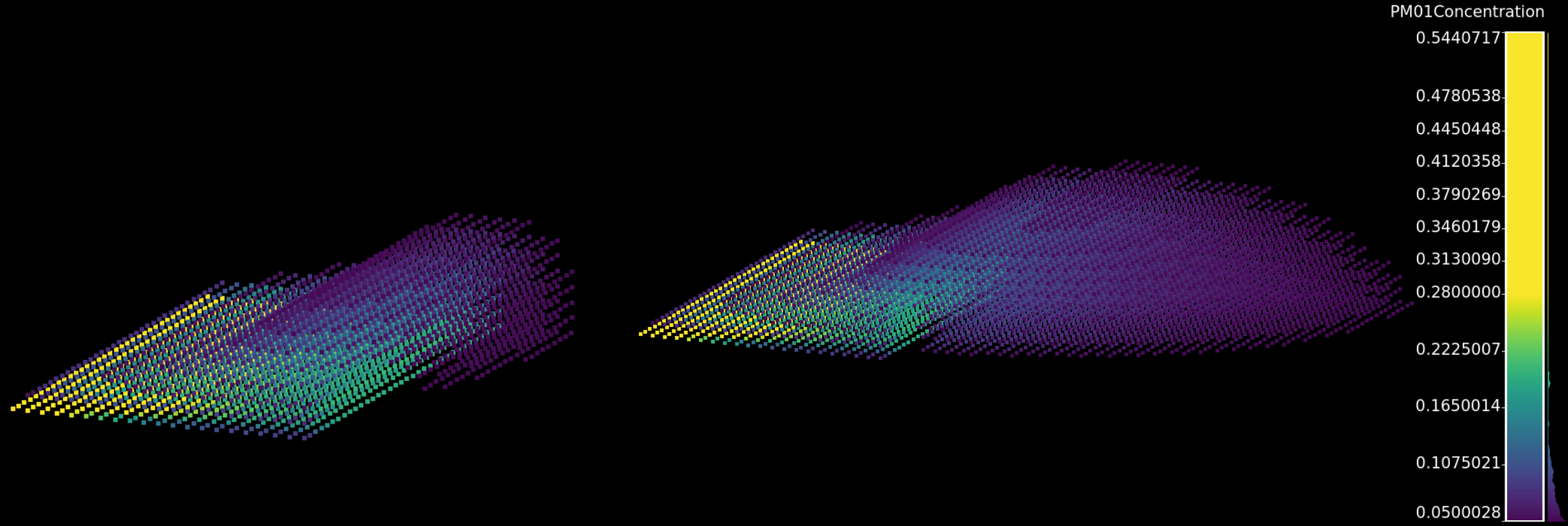




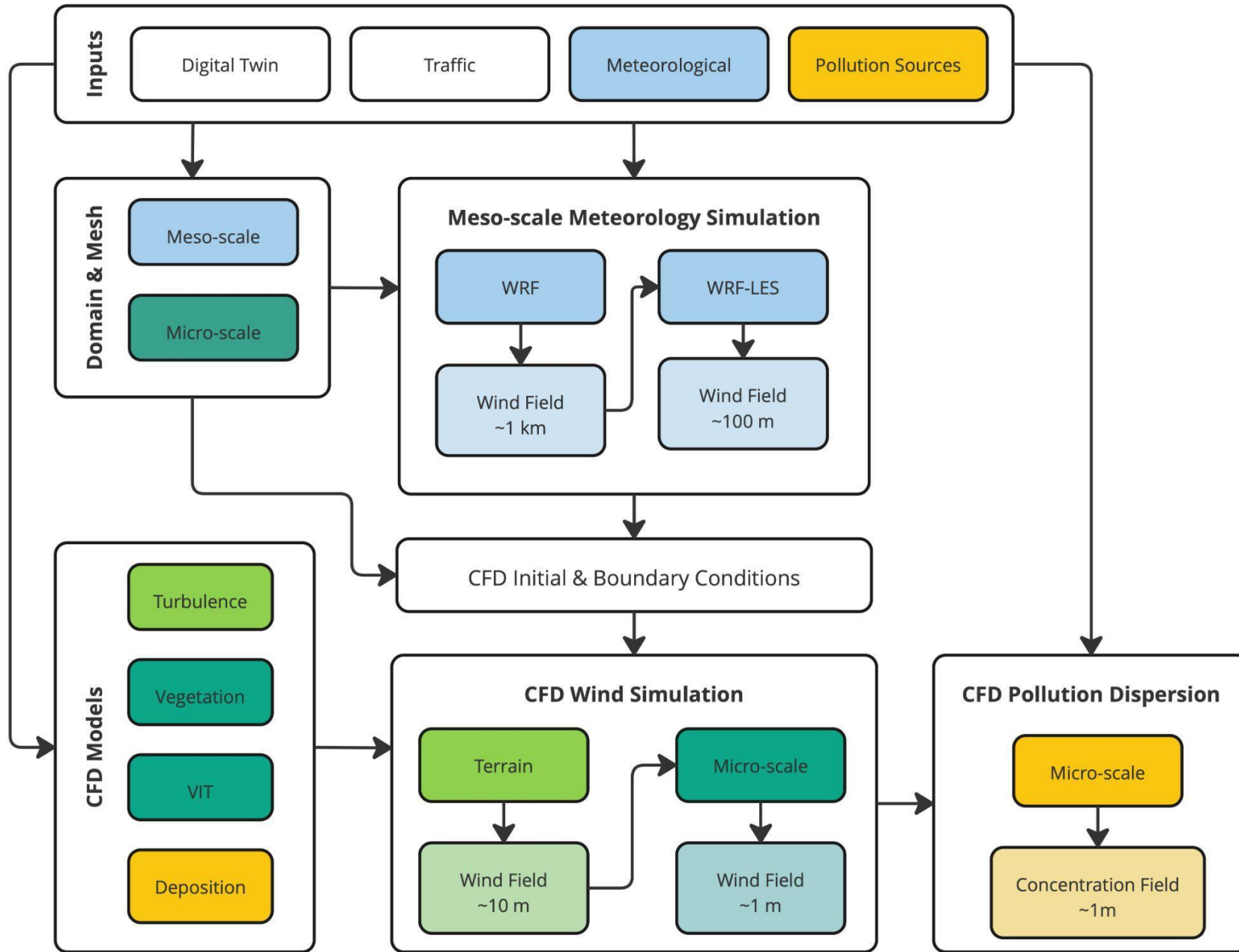




# Modeling

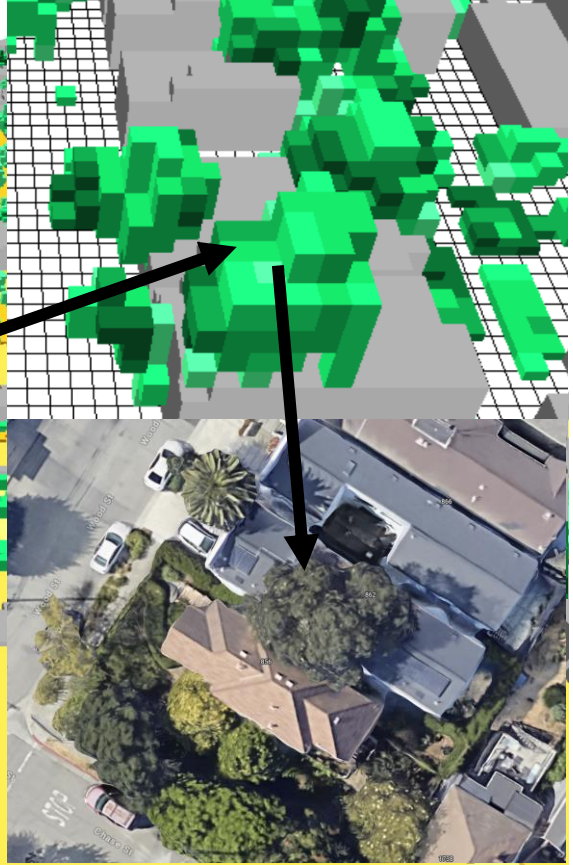
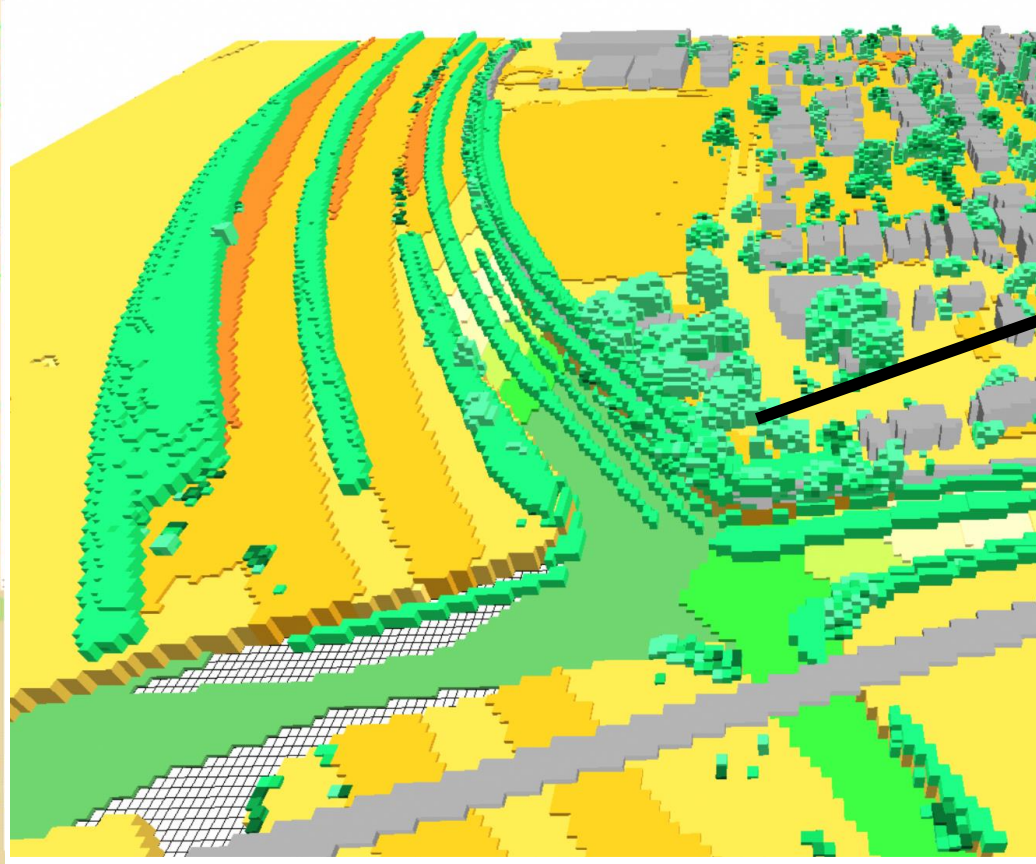
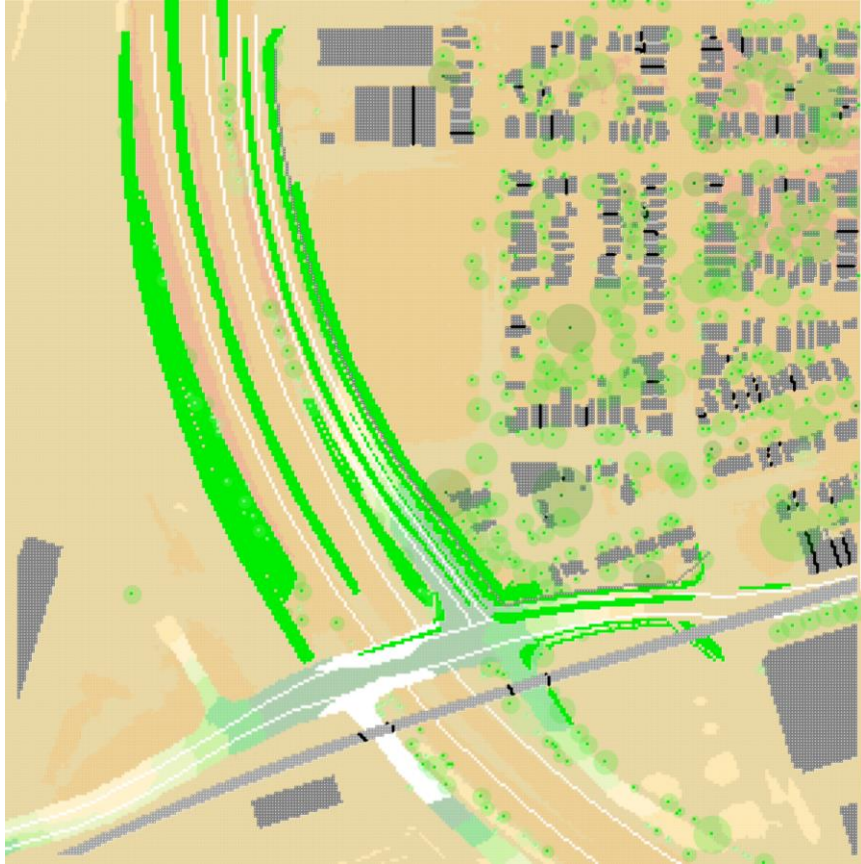




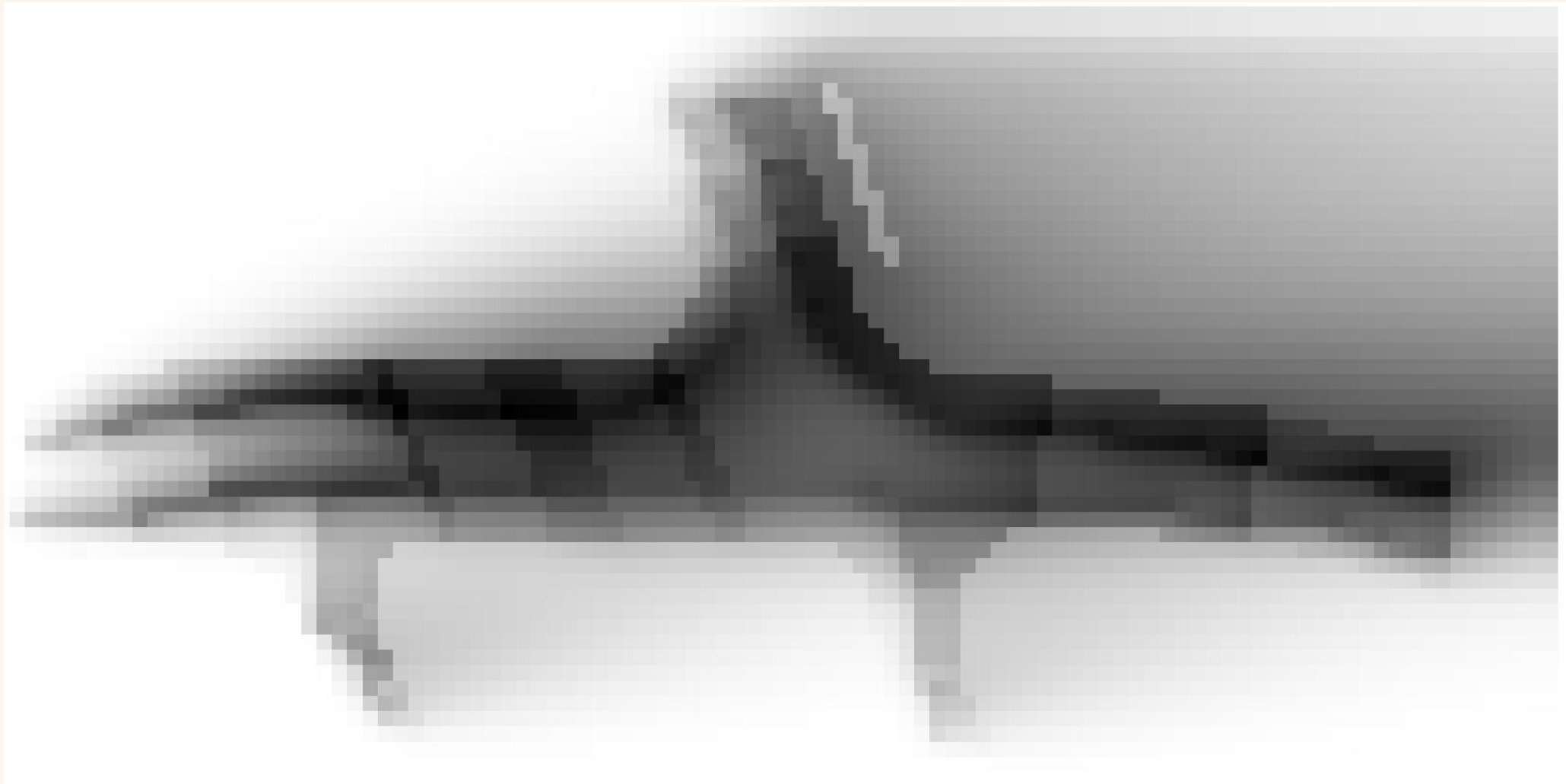








Baseline composite image of PM 2.5 at all Z values





# Leaf Area Density

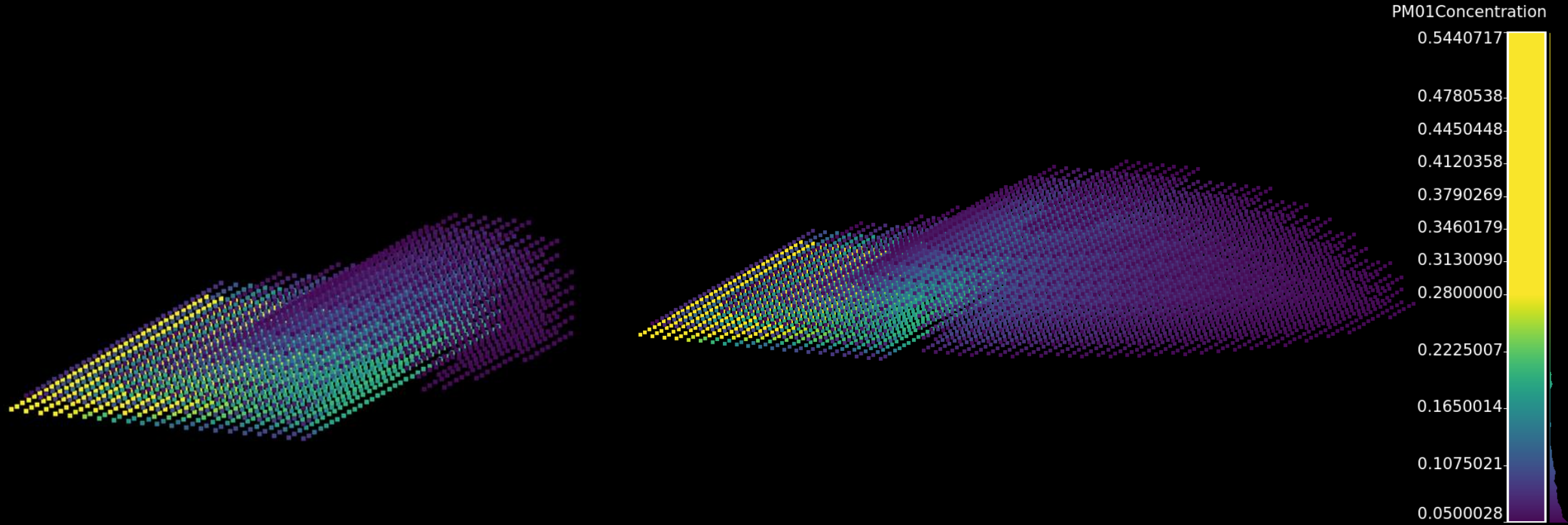


HIGHER LEAF AREA



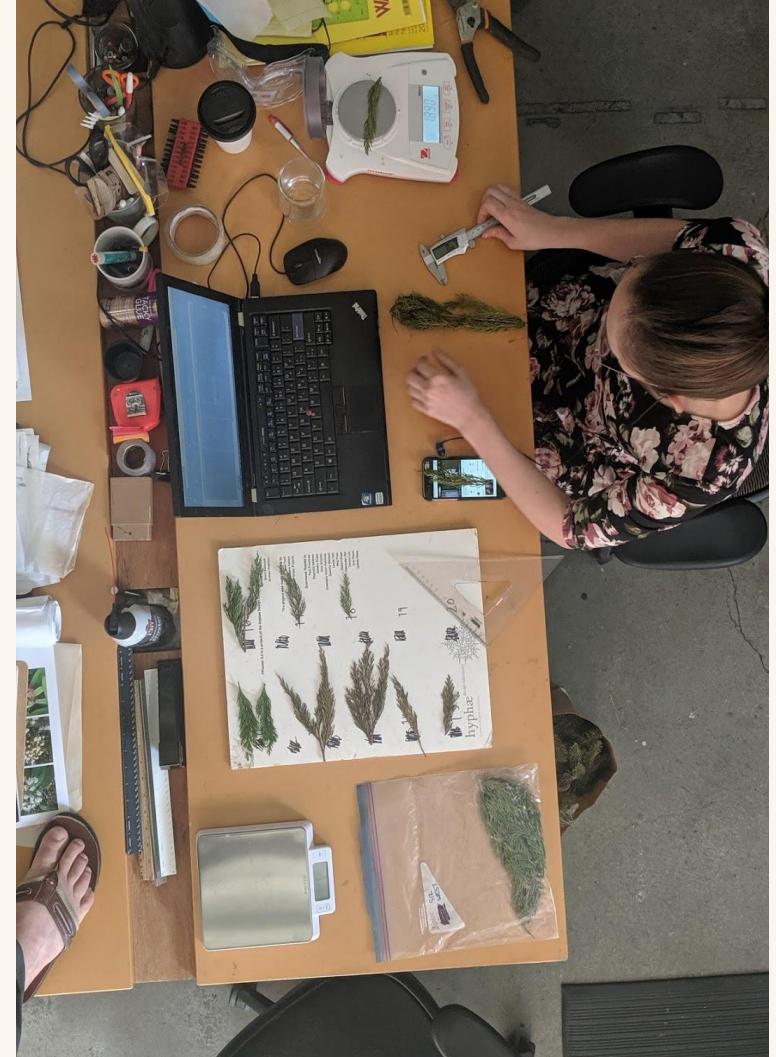
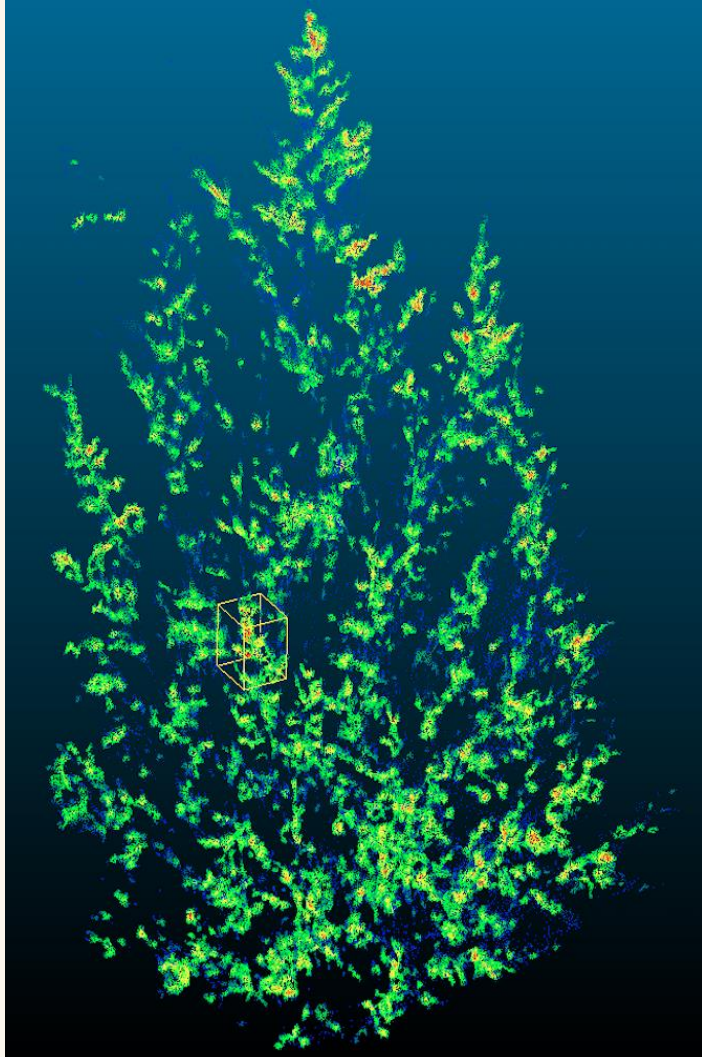
LOWER LEAF AREA

# Leaf Area Density





# Tree Modelling

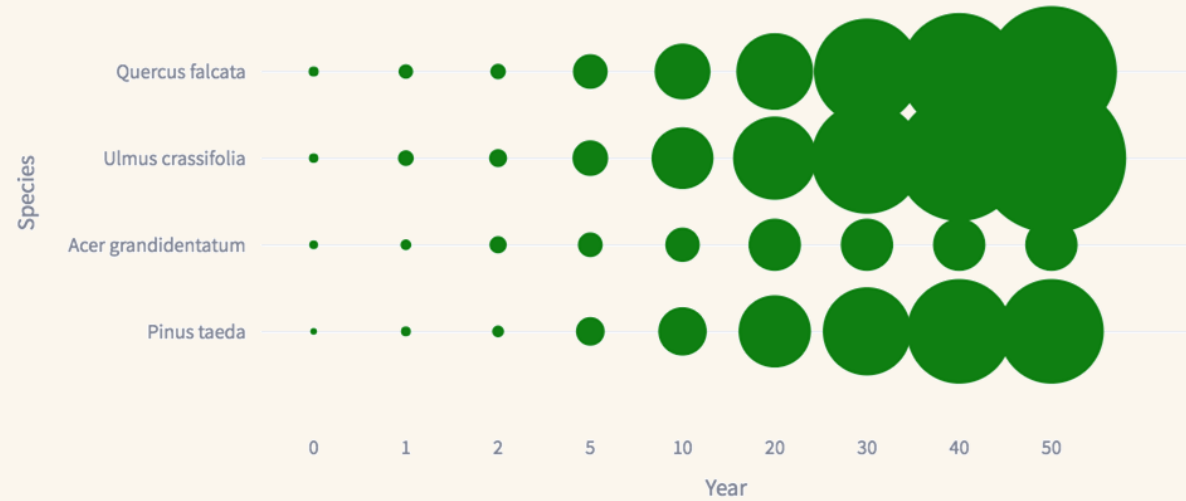
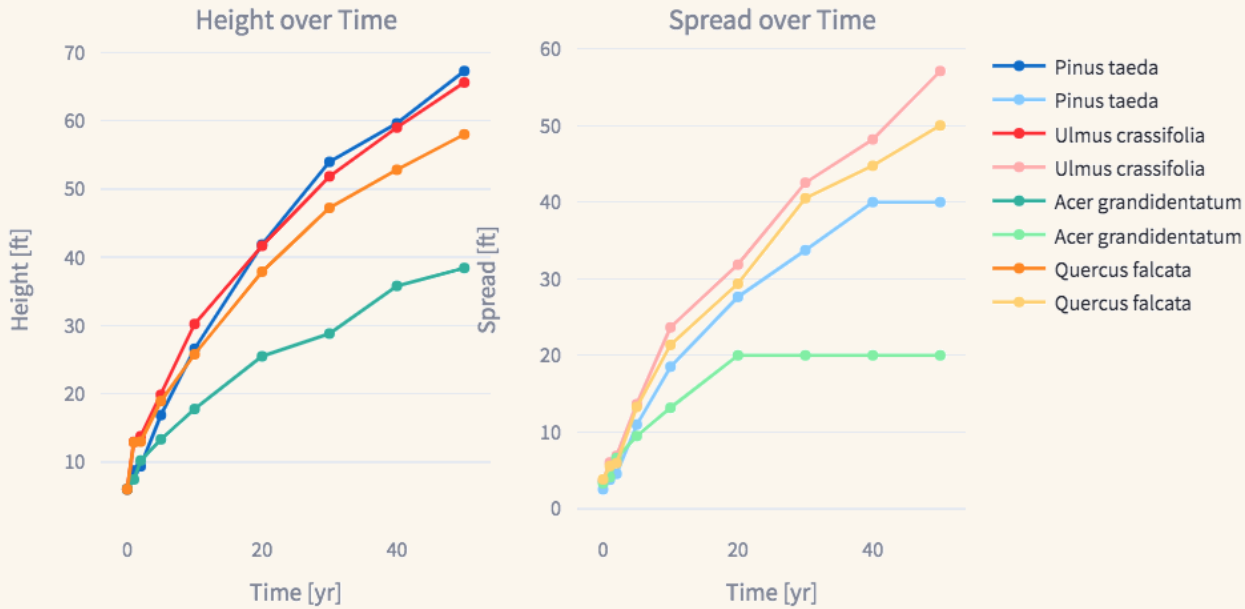


# Tree Modelling

Select Species:

- Pinus taeda ×
- Acer grandident... ×
- Ulmus crassifolia ×
- Quercus falcata ×
- × ▾

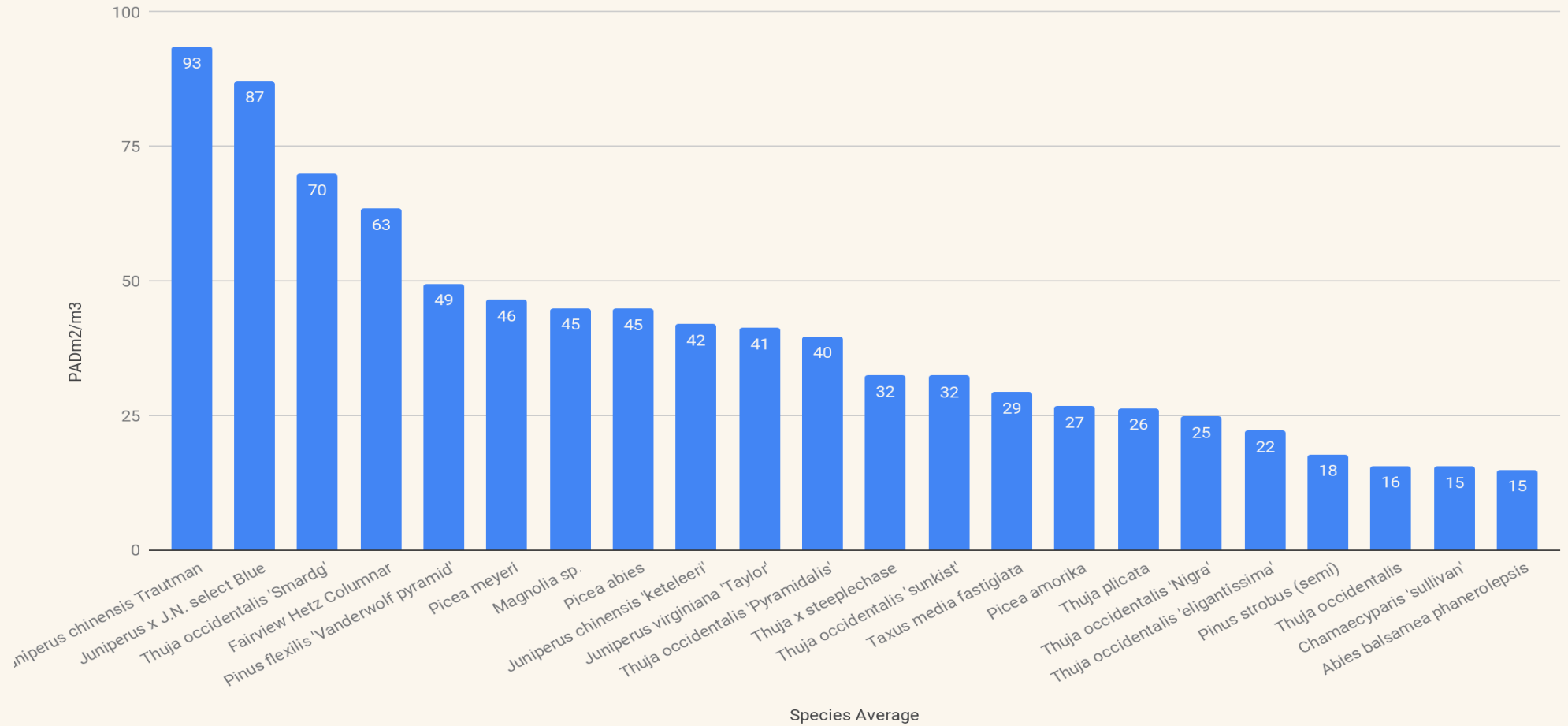
## Tree Spread Representation





# Tree Modelling

PADm2/m3 vs. Species/cultivar Average





Analyze

Design

Implement

Monitor

Evaluate

Adapt



# Test\_july29



Packed Planting Plan:

42 polygons actual mode25444\_2024-09-04



Planting Polygon Map:

42 polygons actual mode



Design Layers



packed\_66d8c6137abed23710173abb\_circles



packed\_66d8c6137abed23710173abb\_points



prescott\_geoms\_w\_sizes\_fletch\_475814

Growth Estimated in Years Passed Since Nursery Sizes

0

5 - Growth Year Used in Packing

20

Simulate Planting Plan Growth

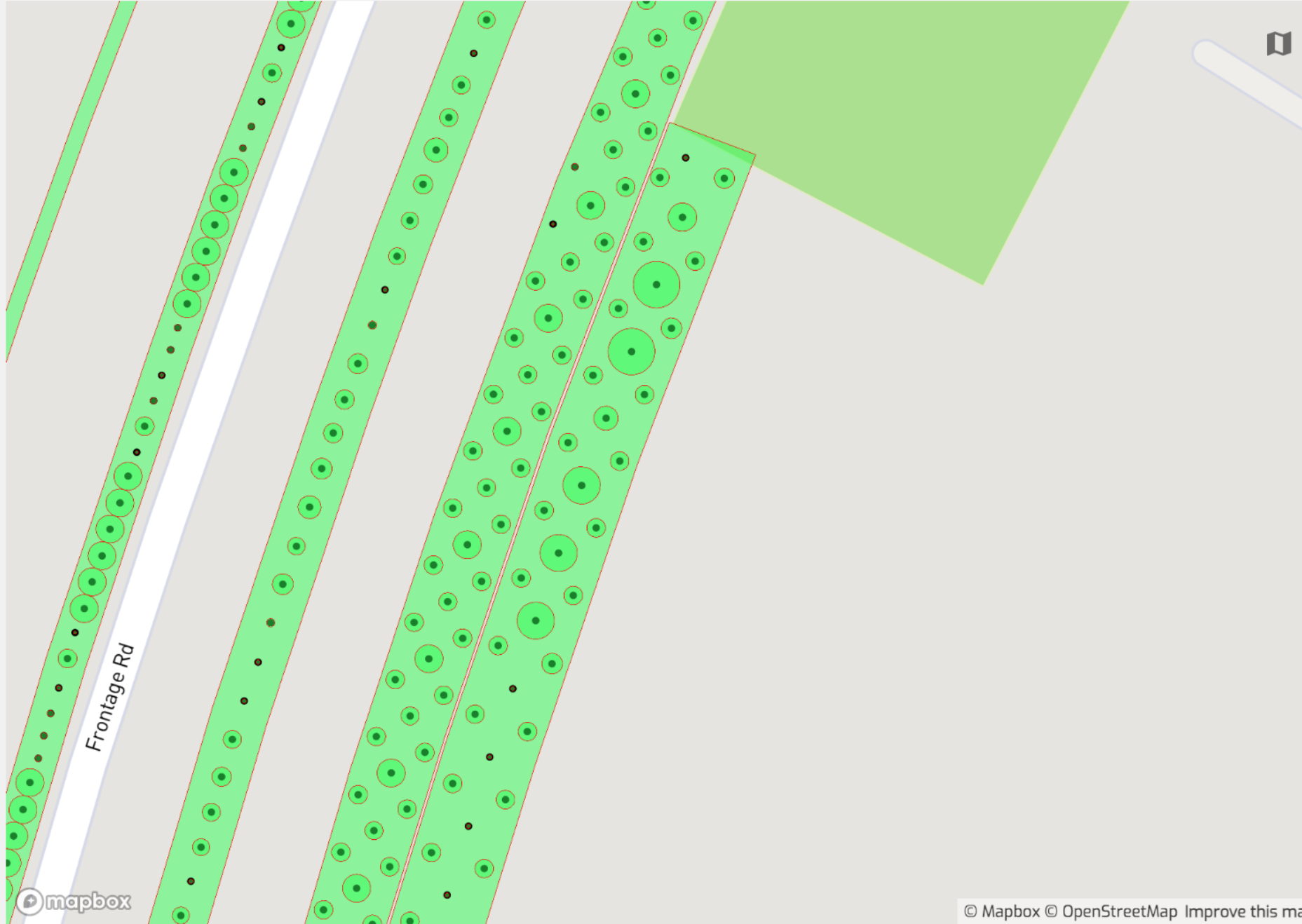
Total Years

20

Year Increment

20

SIMULATE TREE GROWTH







Analyze

Design

Implement

Monitor

Evaluate

Adapt



# Test\_july29



Packed Planting Plan:

42 polygons actual mode25444\_2024-09-04



Planting Polygon Map:

42 polygons actual mode



Design Layers



packed\_66d8c6137abed23710173abb\_circles



packed\_66d8c6137abed23710173abb\_points



prescott\_geoms\_w\_sizes\_fletch\_475814

Growth Estimated in Years Passed Since Nursery Sizes

0

5 - Growth Year Used in Packing

20

Simulate Planting Plan Growth

Total Years

20

Year Increment

20

SIMULATE TREE GROWTH





Analyze

Design

Implement

Monitor

Evaluate

Adapt



# Test\_july29



Packed Planting Plan:

42 polygons actual mode25444\_2024-09-04



Planting Polygon Map:

42 polygons actual mode



Design Layers



packed\_66d8c6137abed23710173abb\_circles



packed\_66d8c6137abed23710173abb\_points



prescott\_geoms\_w\_sizes\_fletch\_475814

Growth Estimated in Years Passed Since Nursery Sizes

0

5 - Growth Year Used in Packing

20

Simulate Planting Plan Growth

Total Years

20

Year Increment

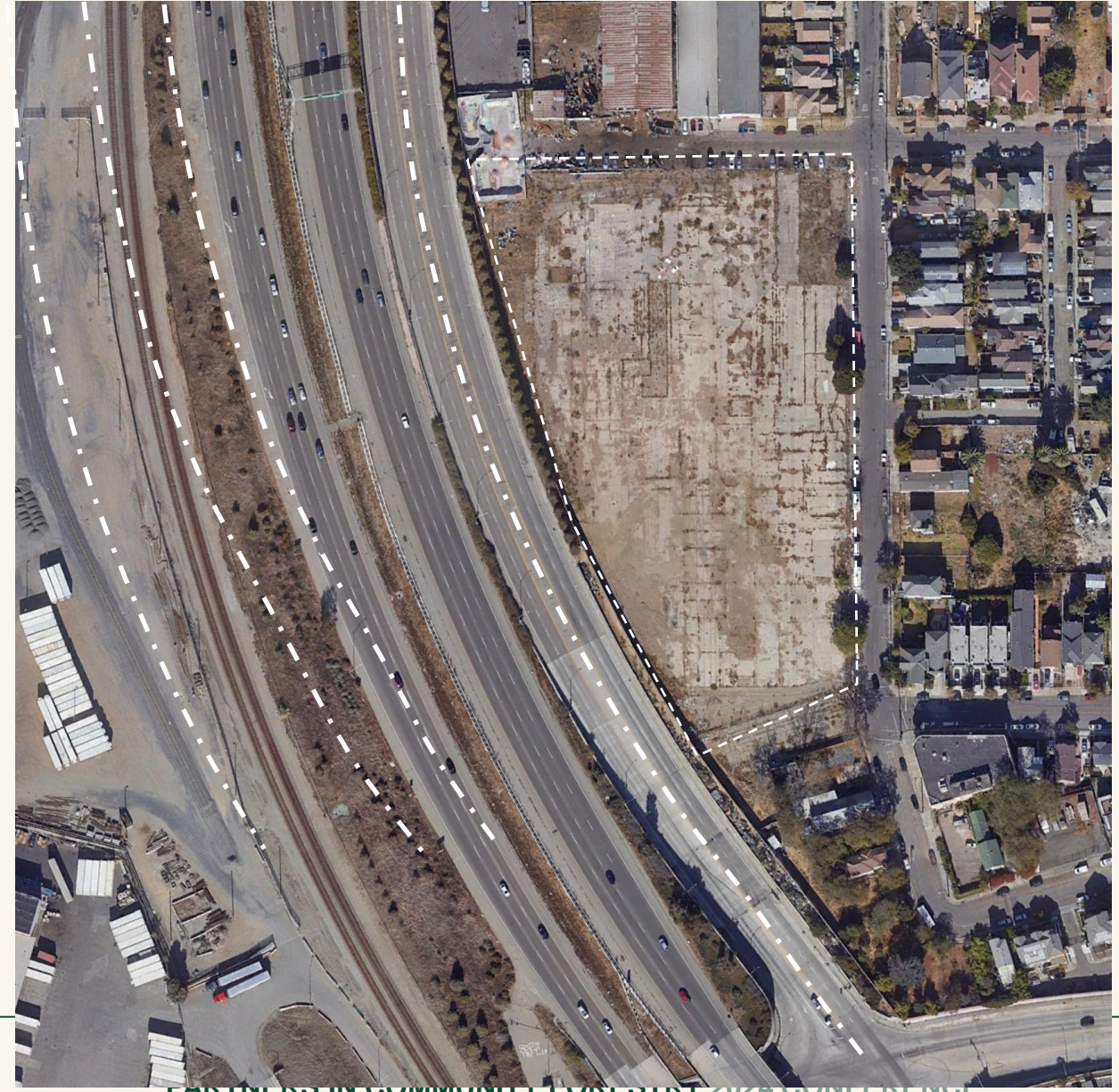
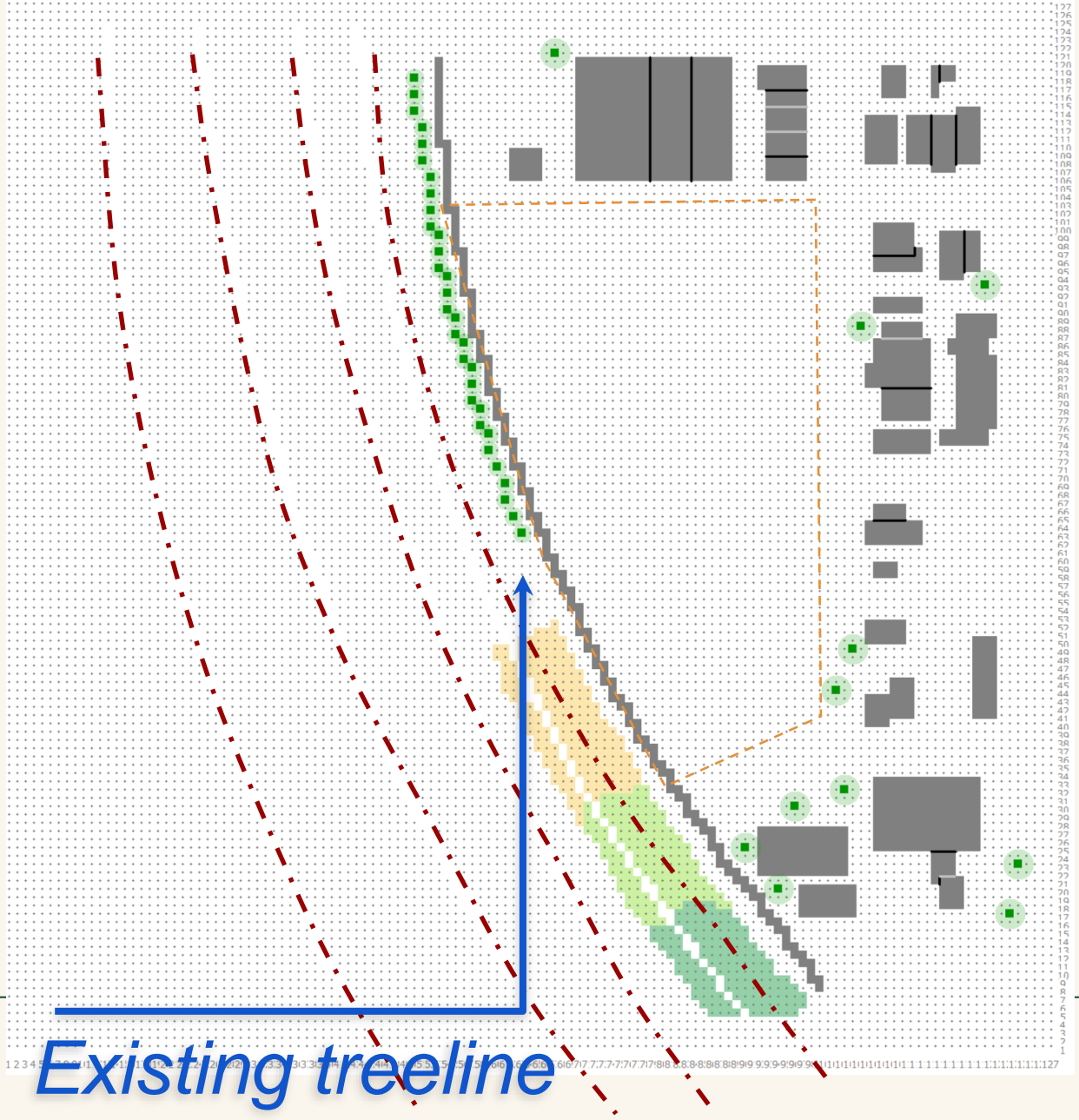
20

SIMULATE TREE GROWTH





# BASELINE MODEL

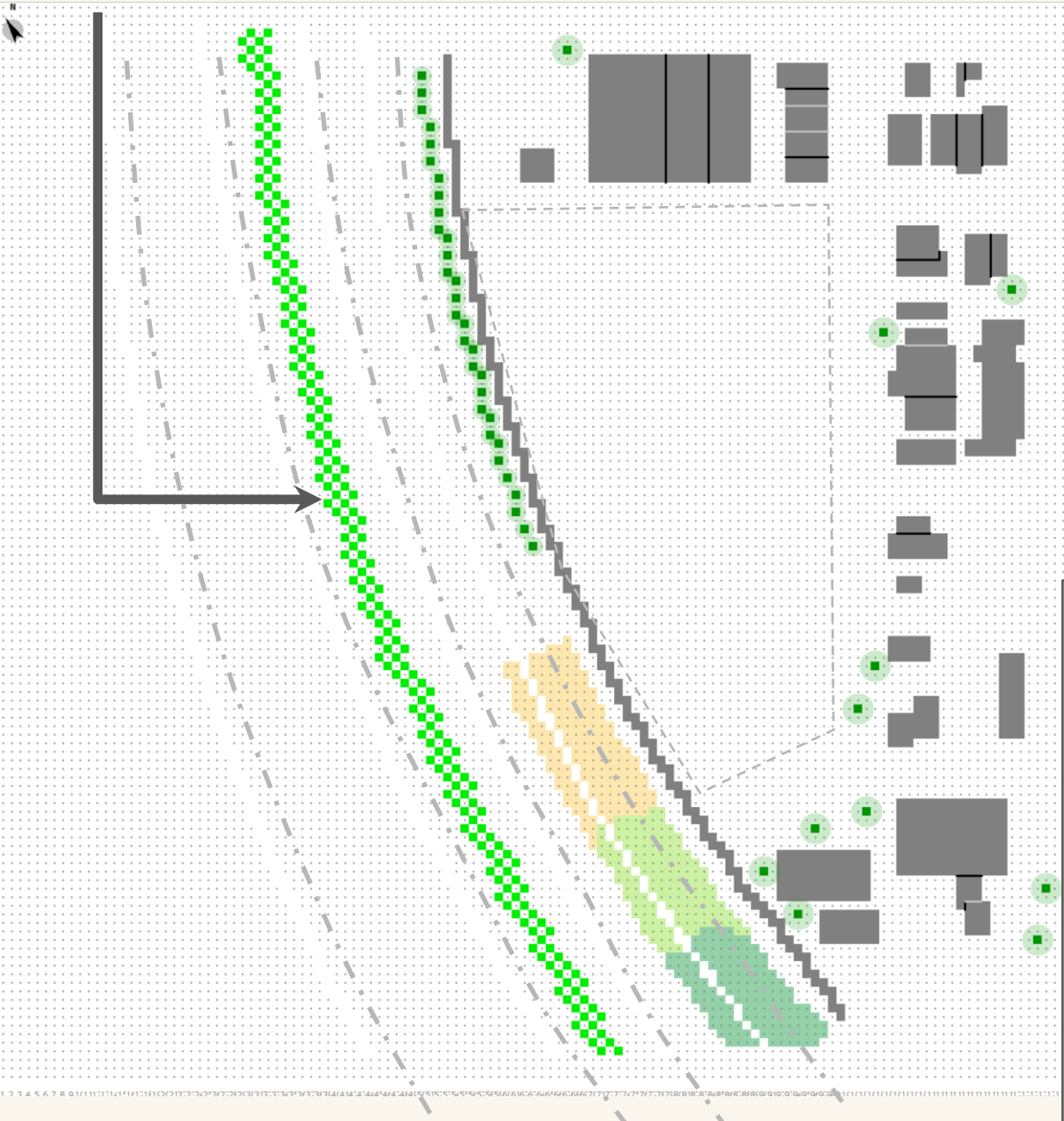




# INTERVENTION

# DIFFERENCE

z = 5m (~16ft)



**absolute difference PM-2.5 Concentration**

Dark Green	below -0.03 µg/m <sup>3</sup>
Medium Green	-0.03 to -0.02 µg/m <sup>3</sup>
Light Green	-0.02 to -0.00 µg/m <sup>3</sup>
Yellow-Green	-0.00 to 0.01 µg/m <sup>3</sup>
Yellow	0.01 to 0.02 µg/m <sup>3</sup>
Orange	0.02 to 0.04 µg/m <sup>3</sup>
Brown	0.04 to 0.05 µg/m <sup>3</sup>
Dark Brown	0.05 to 0.06 µg/m <sup>3</sup>
Dark Brown	above 0.06 µg/m <sup>3</sup>

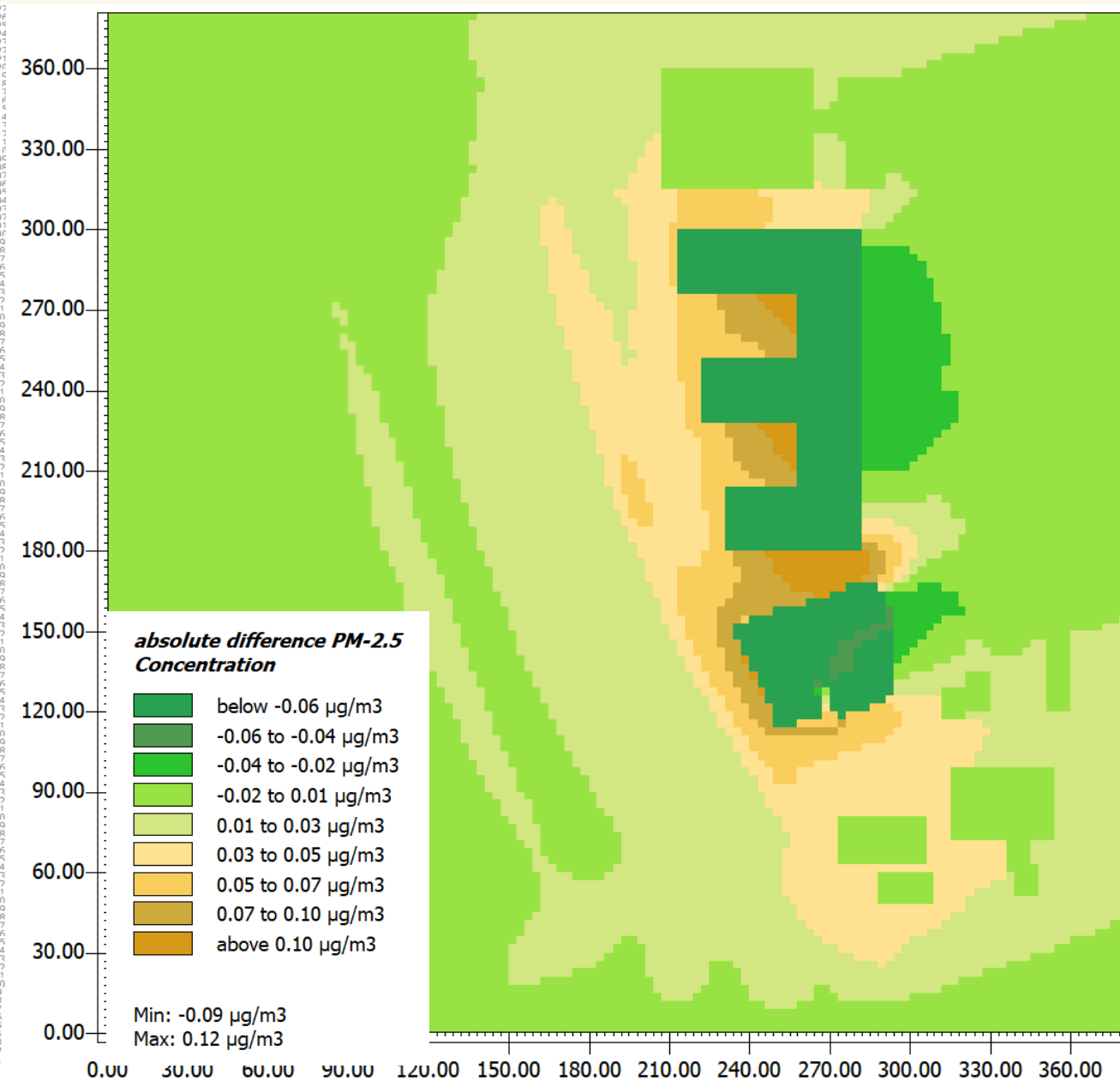
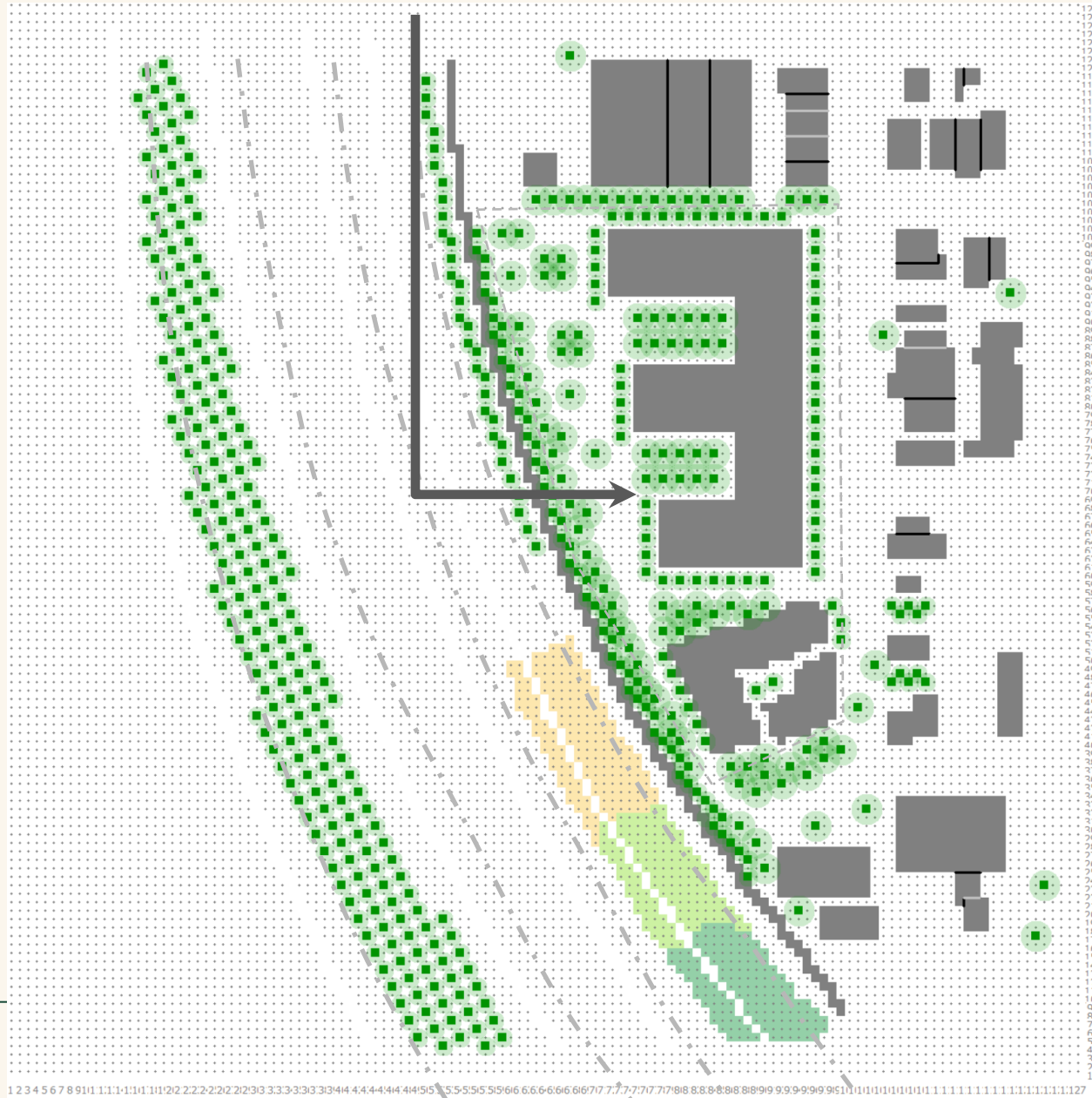
Min: -0.05 µg/m<sup>3</sup>  
Max: 0.08 µg/m<sup>3</sup>

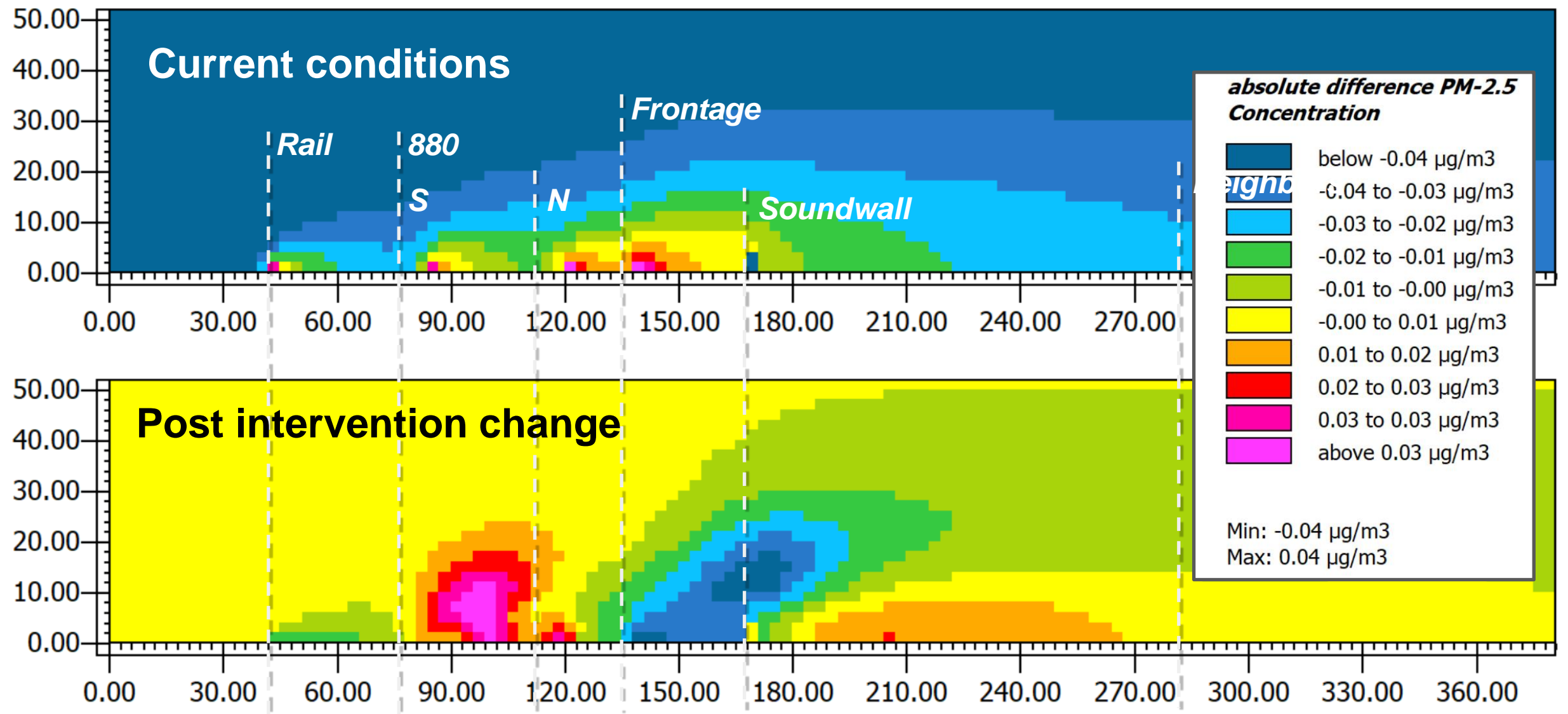


# INTERVENTION

# DIFFERENCE

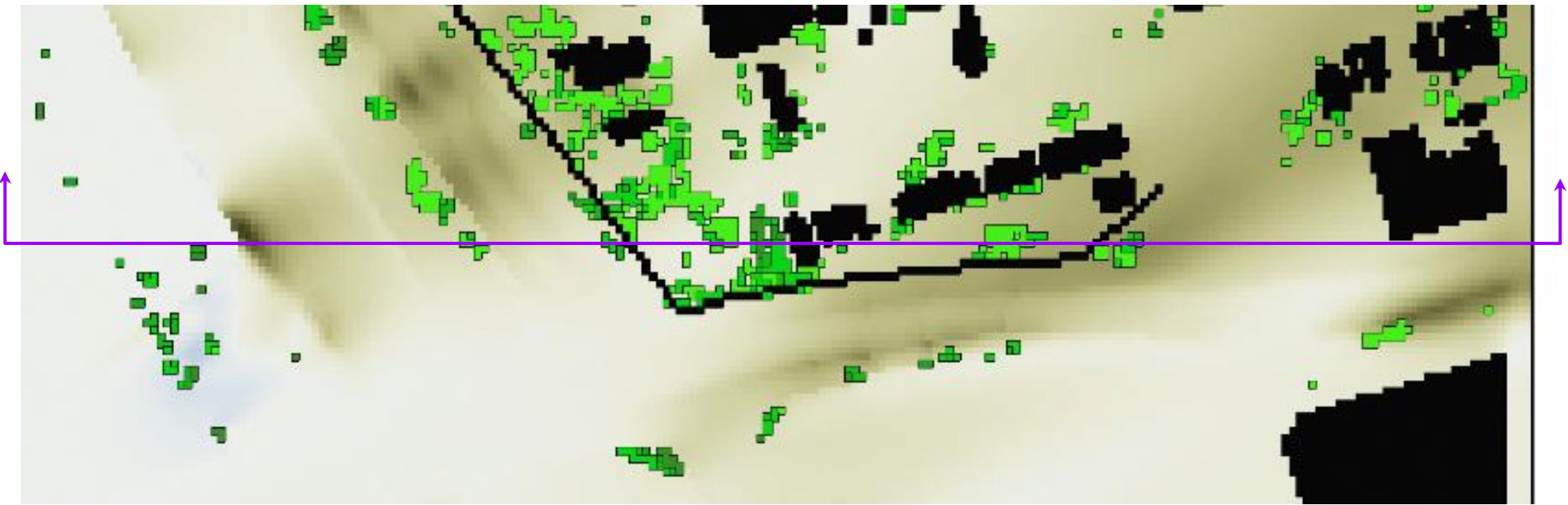
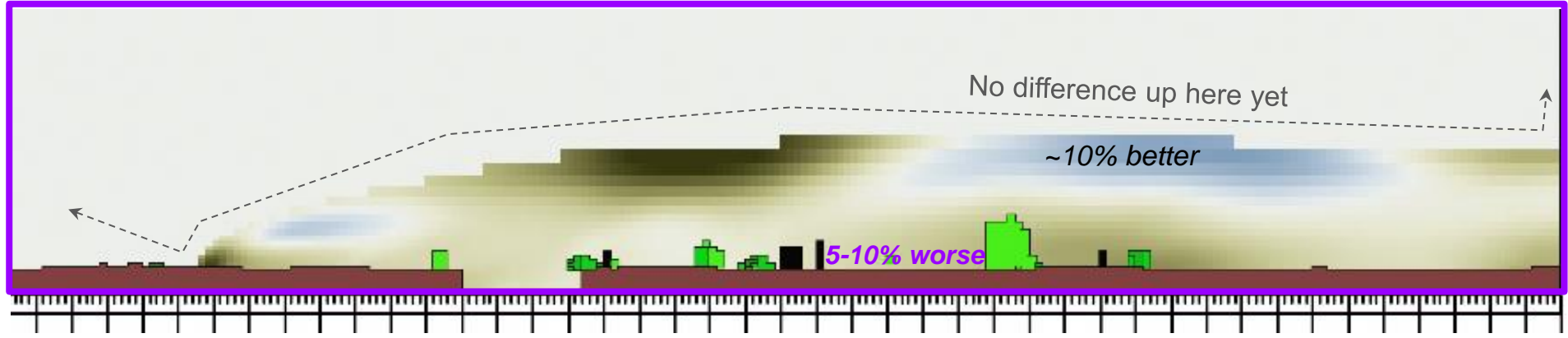
z = 5m (~16ft)



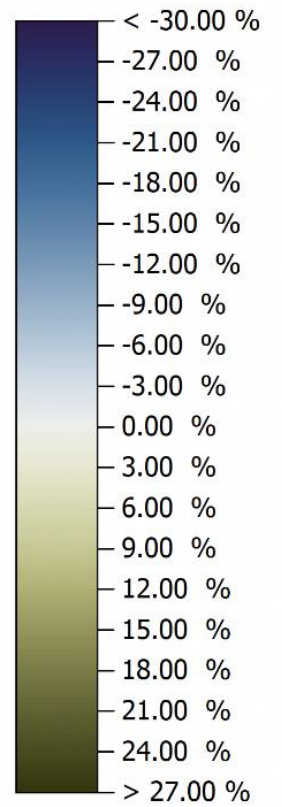




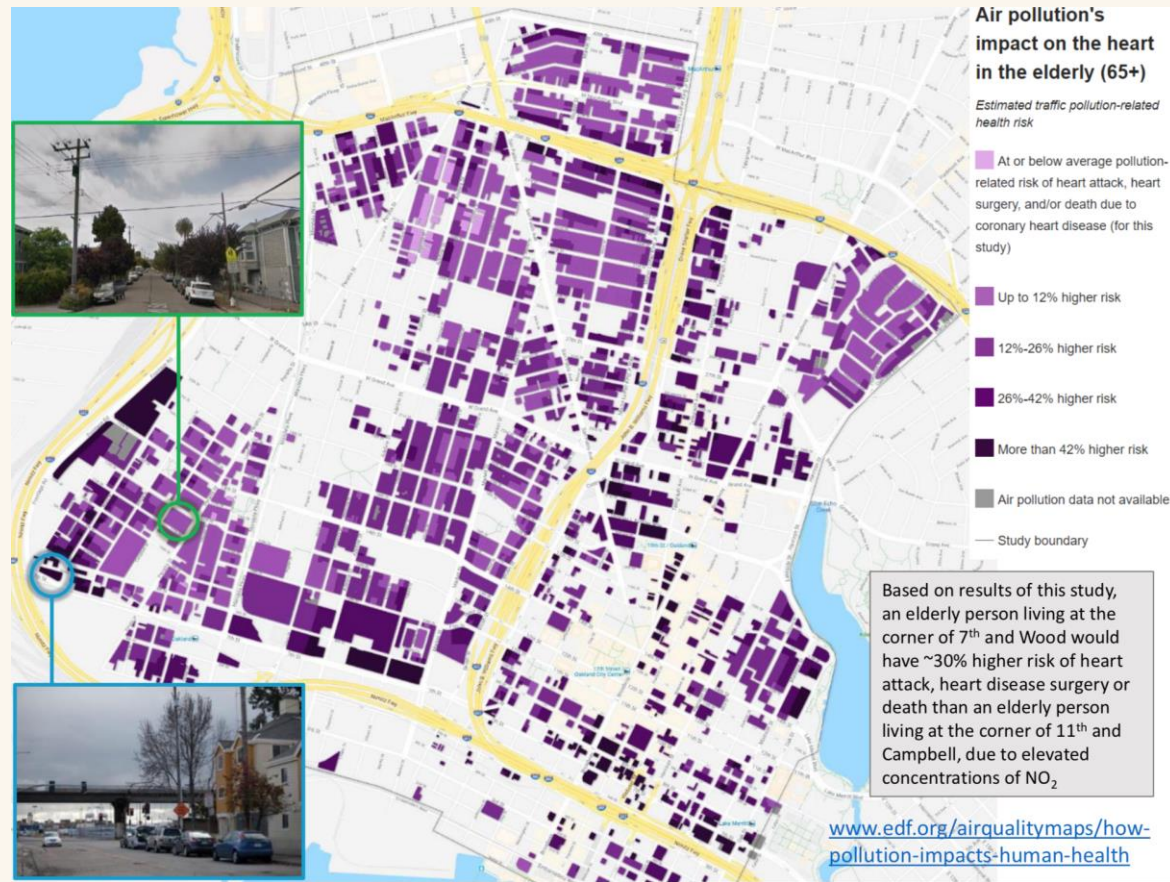
# EXISTING TREE POPULATION VS. NO VEGETATION



**relative difference PM1 Concentration**

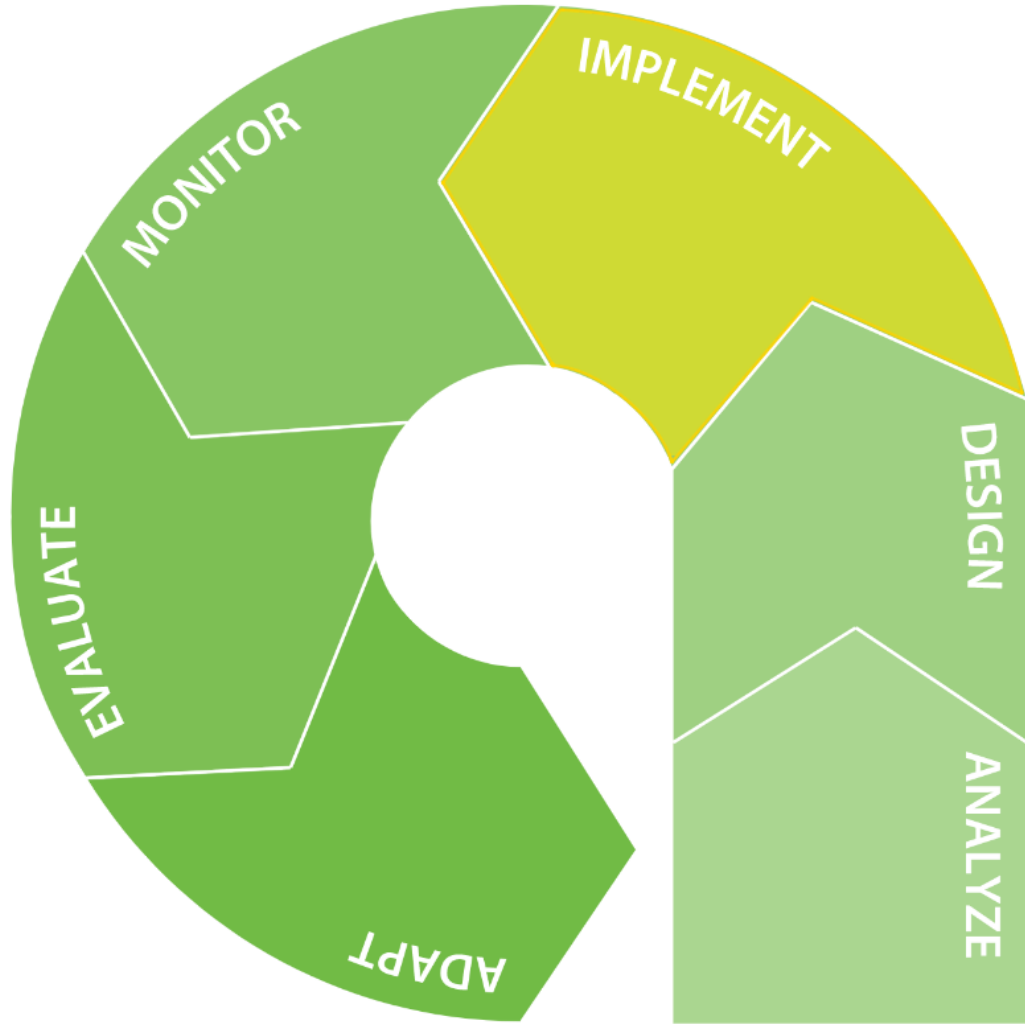


Min: -11.21 %  
Max: 30.39 %



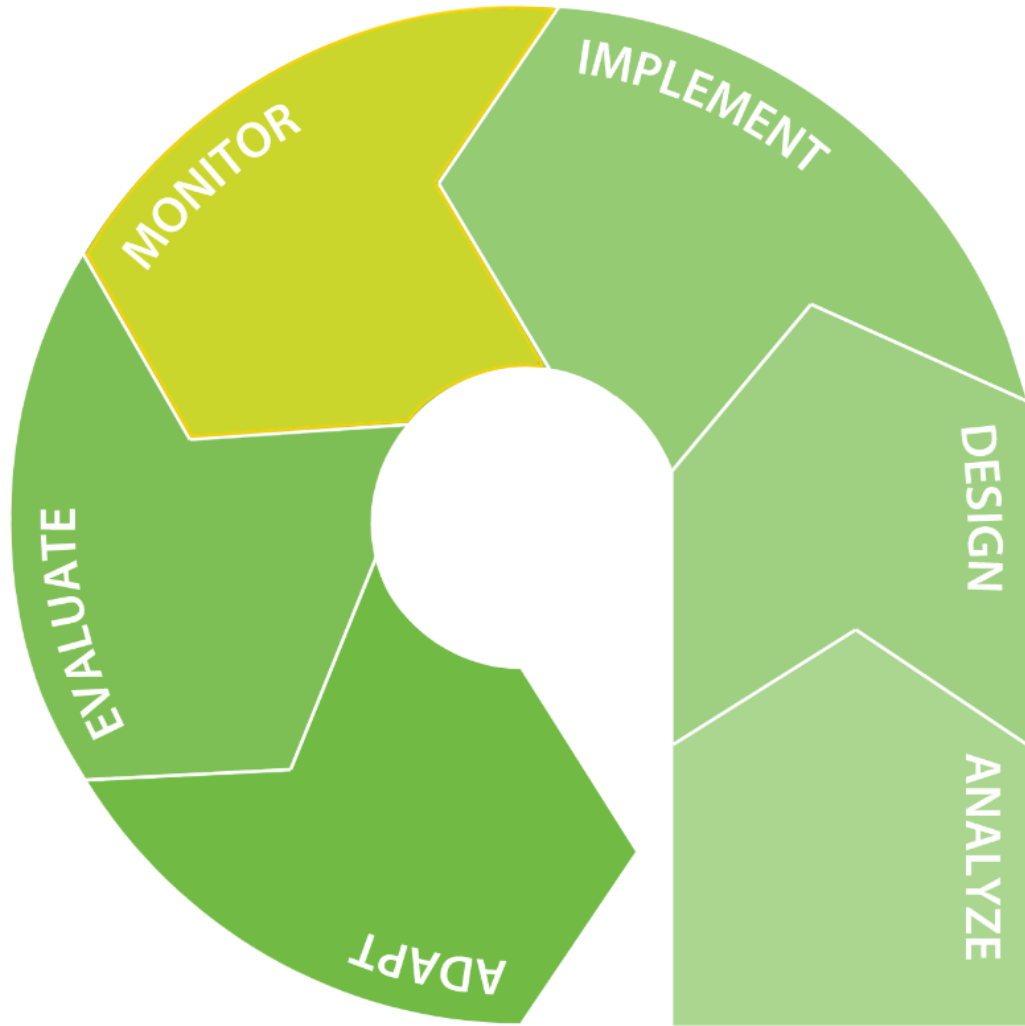


# EVIDENCE BASED DESIGN



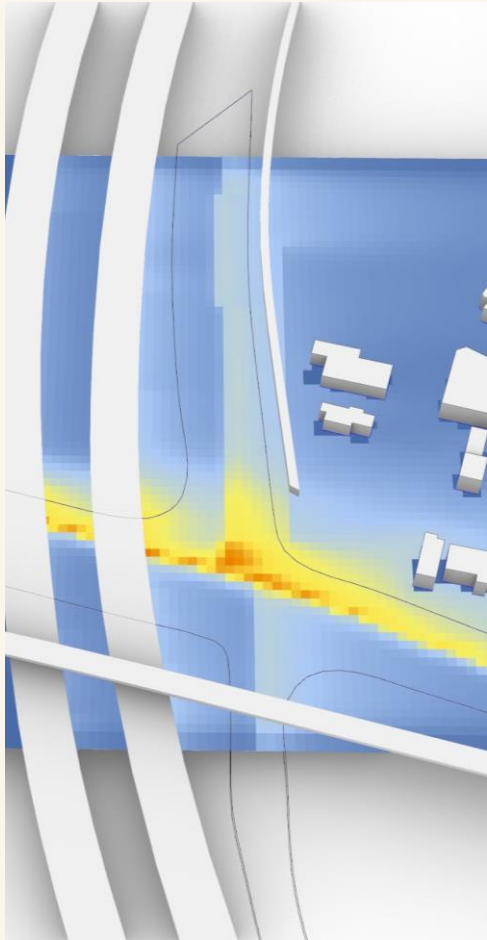
Implement

# EVIDENCE BASED DESIGN

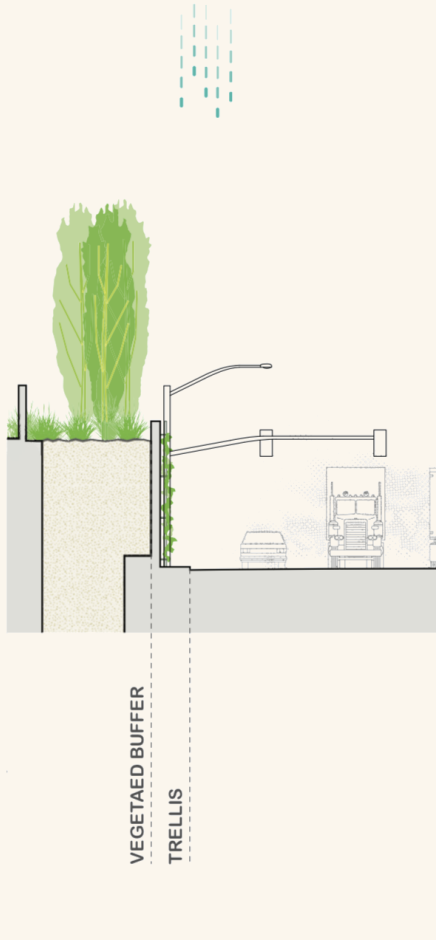


Monitor the results

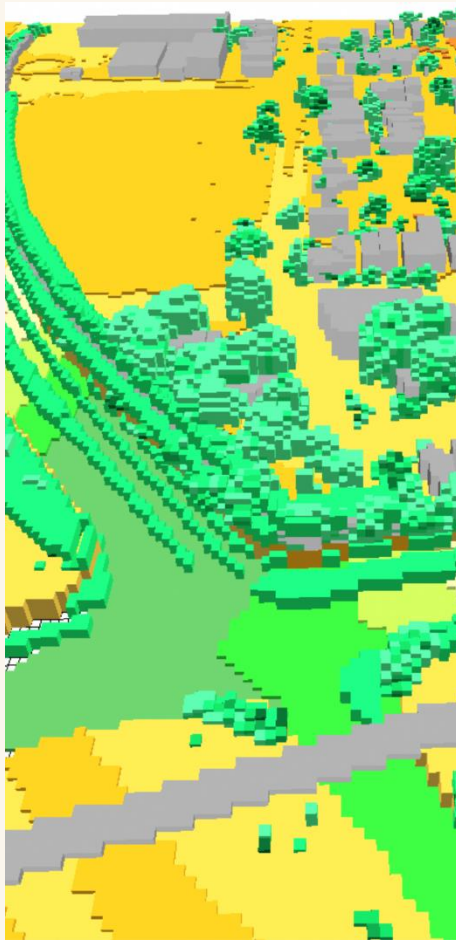




Model Pollution



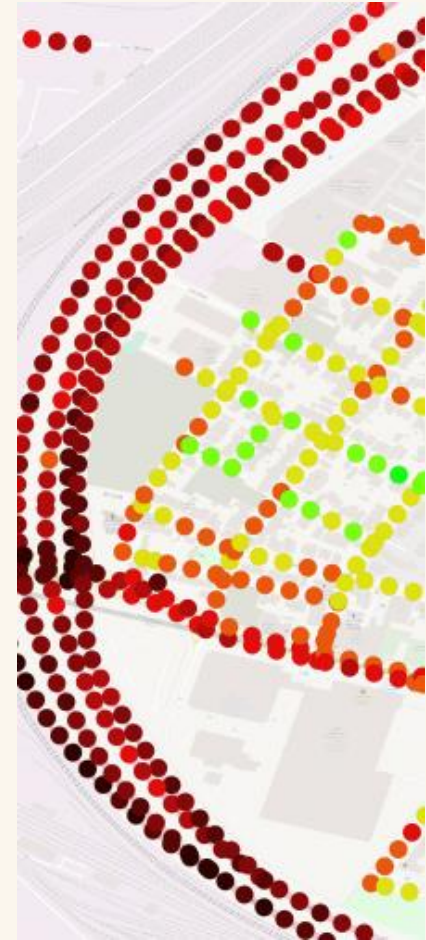
Design Solutions



Model Solutions



Build Interventions



Monitor Results



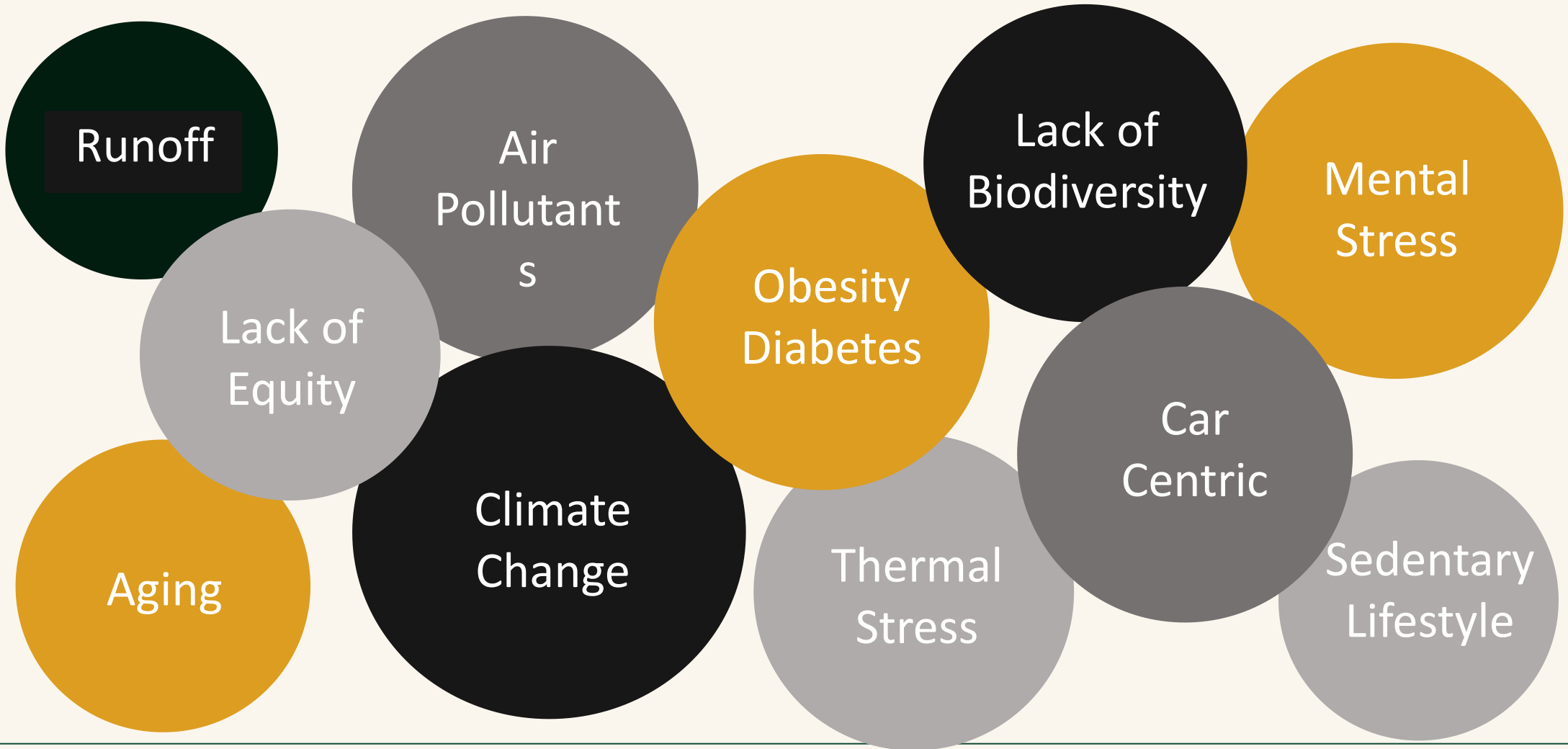


# PROCESS





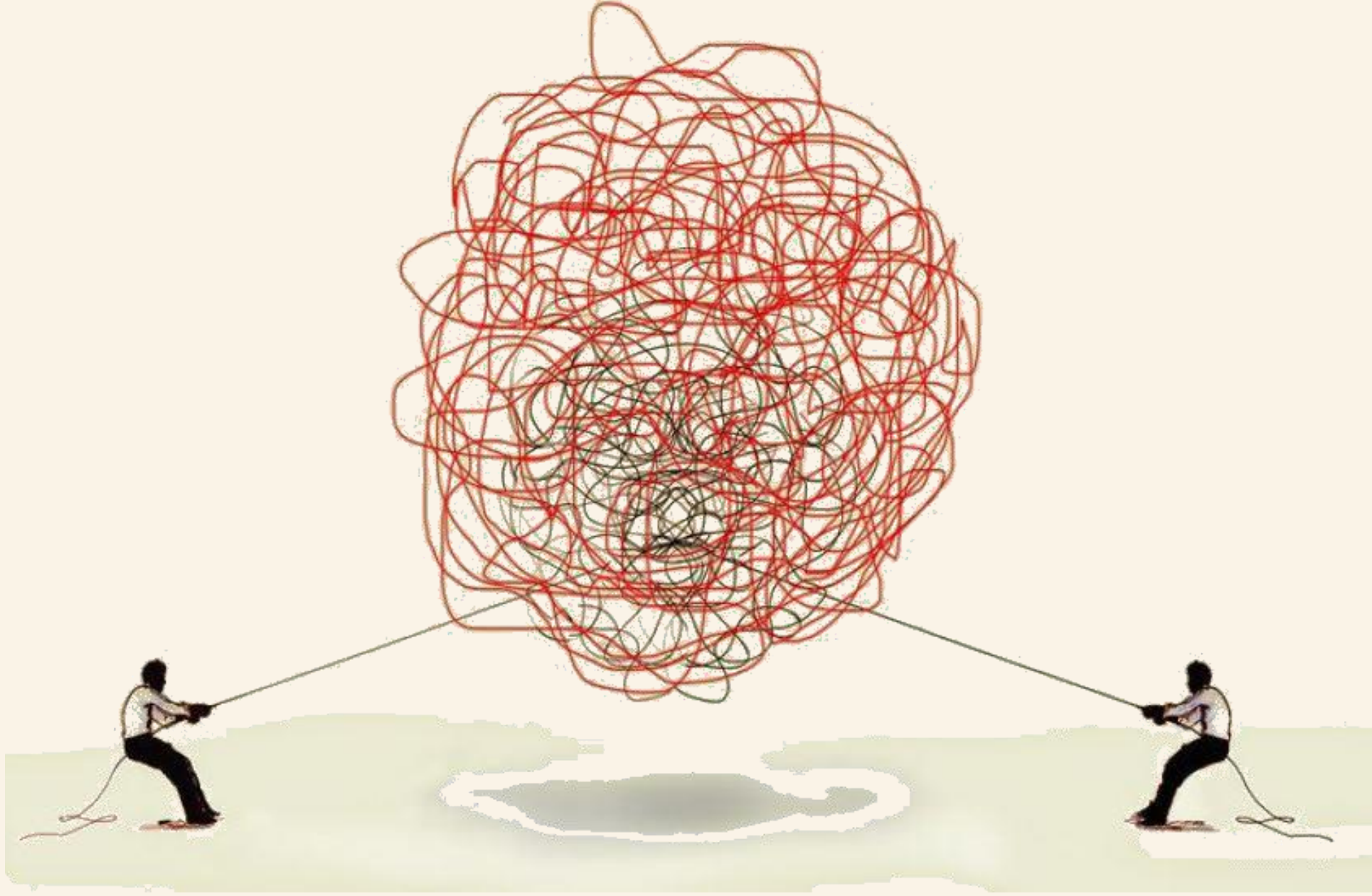
# For Every Urban Degradation.....



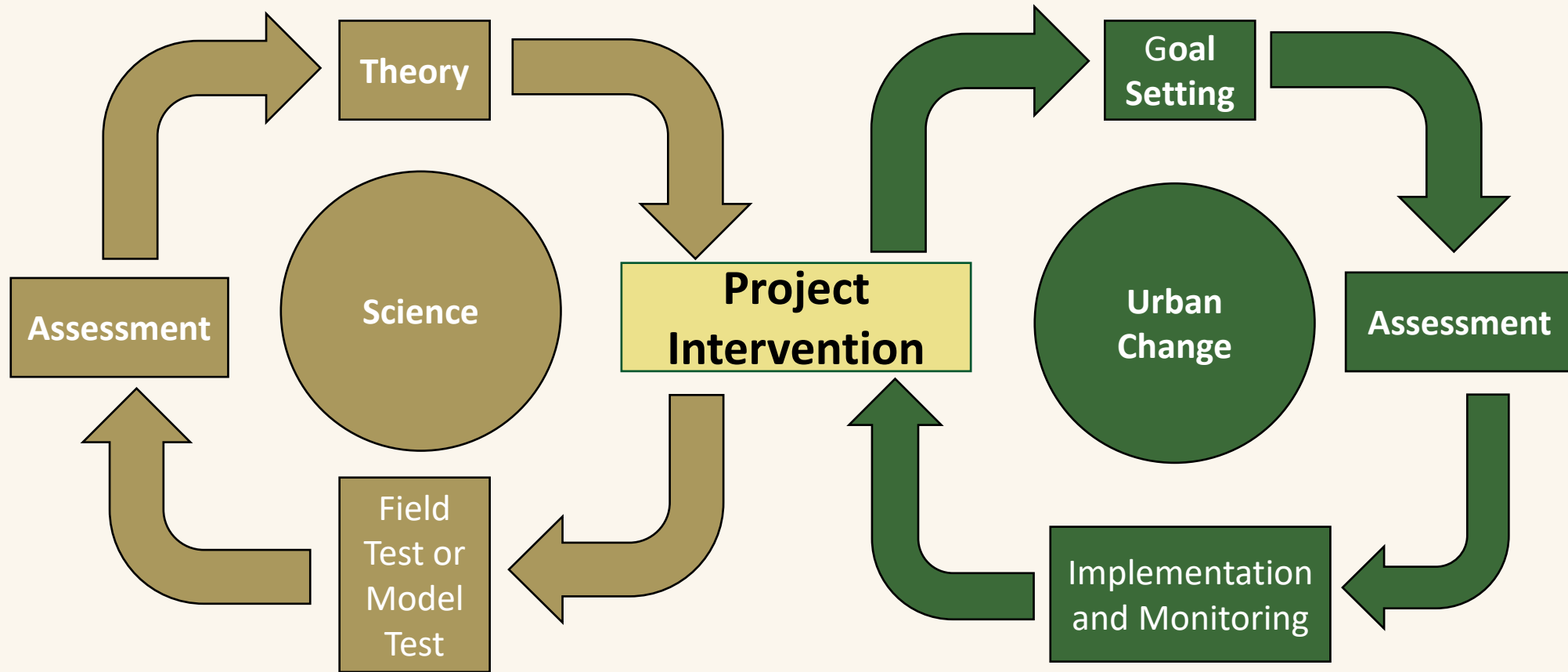
# ...Positive Intervention That Supports Health







# Evidence-Based Process



Nassauer and Opdam. Design in Science: Extending the Landscape Ecology Paradigm (2008)



**APPLY**

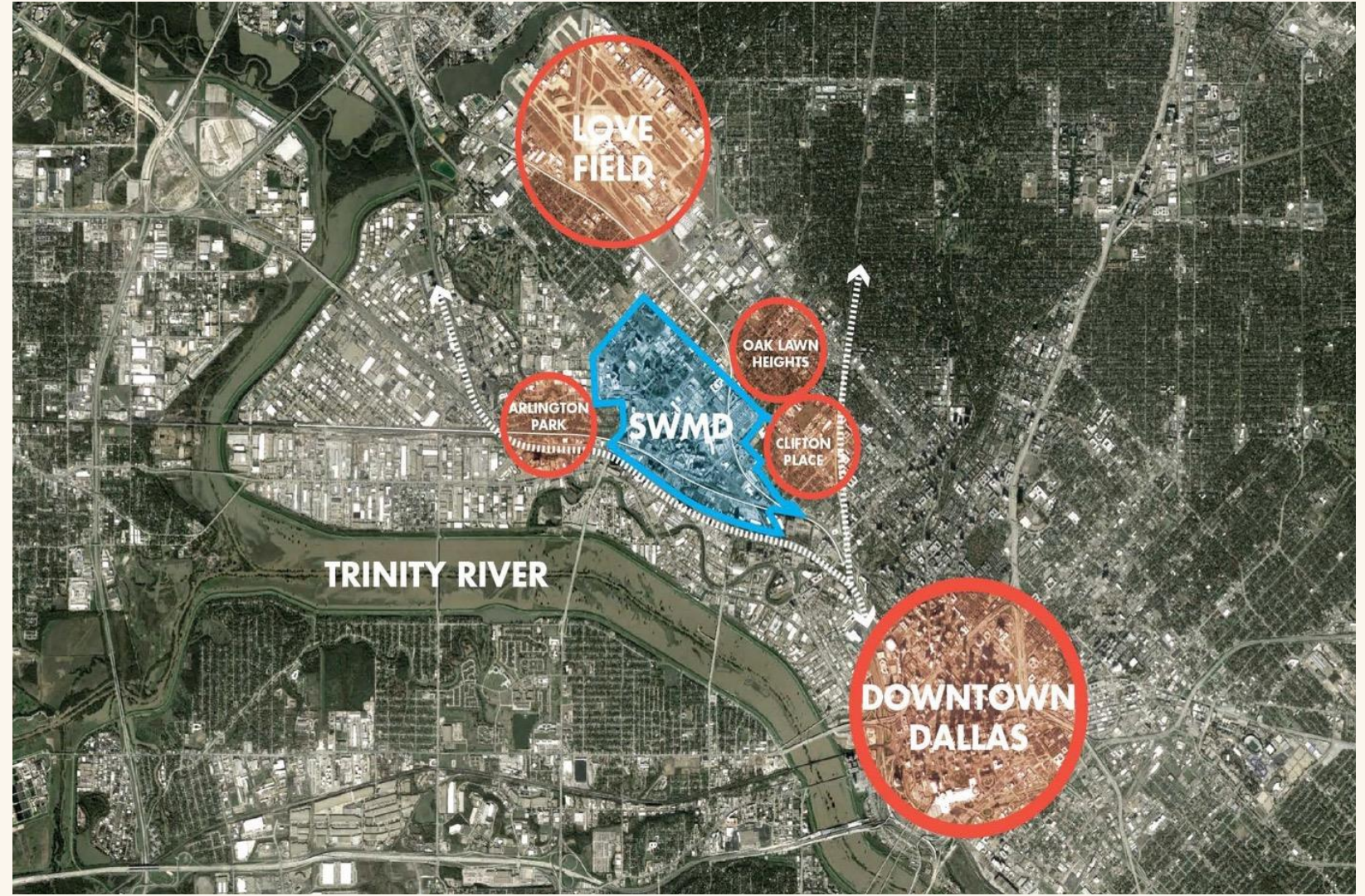


**PARTNERS IN COMMUNITY FORESTRY 2024 CONFERENCE**



# Getting to Know the Southwestern Medical District

- 3 anchor institutions
- 42,000 employees
- 3.4 million annual visits to clinics & ERs
- 3,791 students/residents/fellows
- 23,000 neighbors living in and around the District
- 1000 acres with 16+ miles of transportation corridors





# Southwestern Medical District Transformation Project

## The Green Spine

1.75 Miles



## The Green Heart

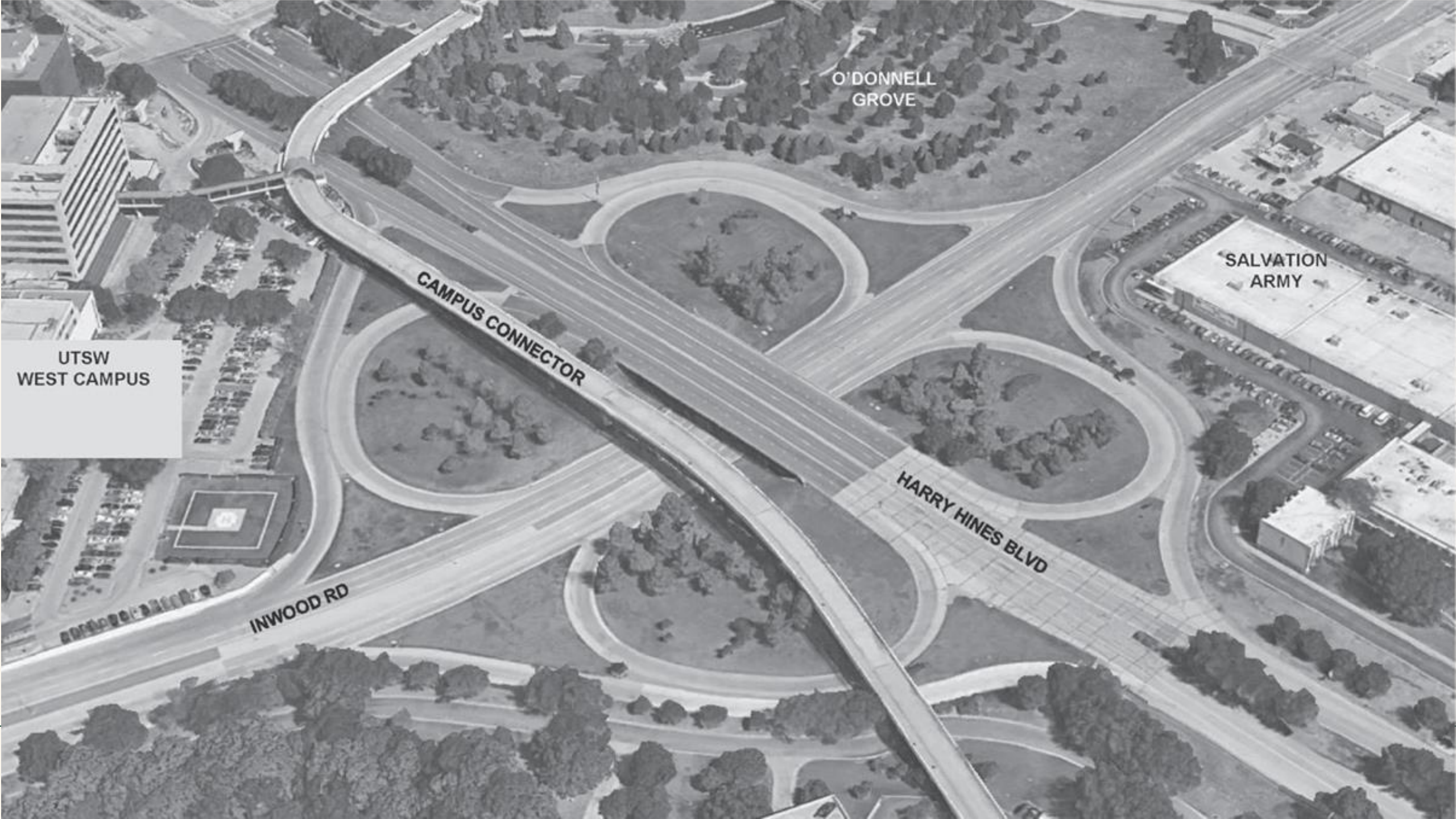
10 Acres





Harry Hines Blvd.





O'DONNELL GROVE

SALVATION ARMY

UTSW WEST CAMPUS

CAMPUS CONNECTOR

HARRY HINES BLVD

INWOOD RD

**Using Evidenced-Based Design in the Southwestern  
Medical District to:**

**Lower Temperature  
Improve Air Quality**



98.7 - 101.0 °F



98.4 - 98.7 °F



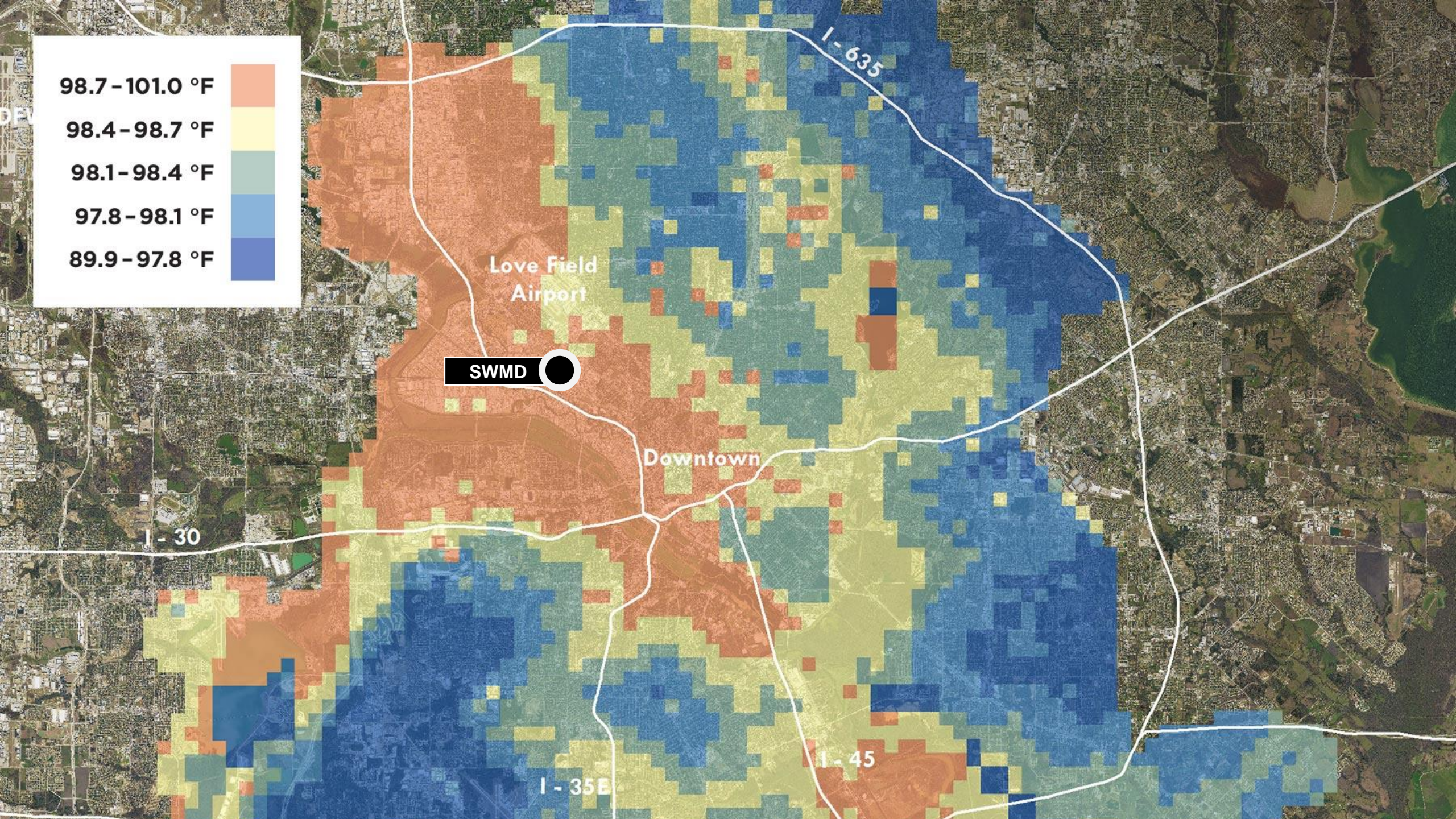
98.1 - 98.4 °F



97.8 - 98.1 °F



89.9 - 97.8 °F



Love Field  
Airport

SWMD

Downtown

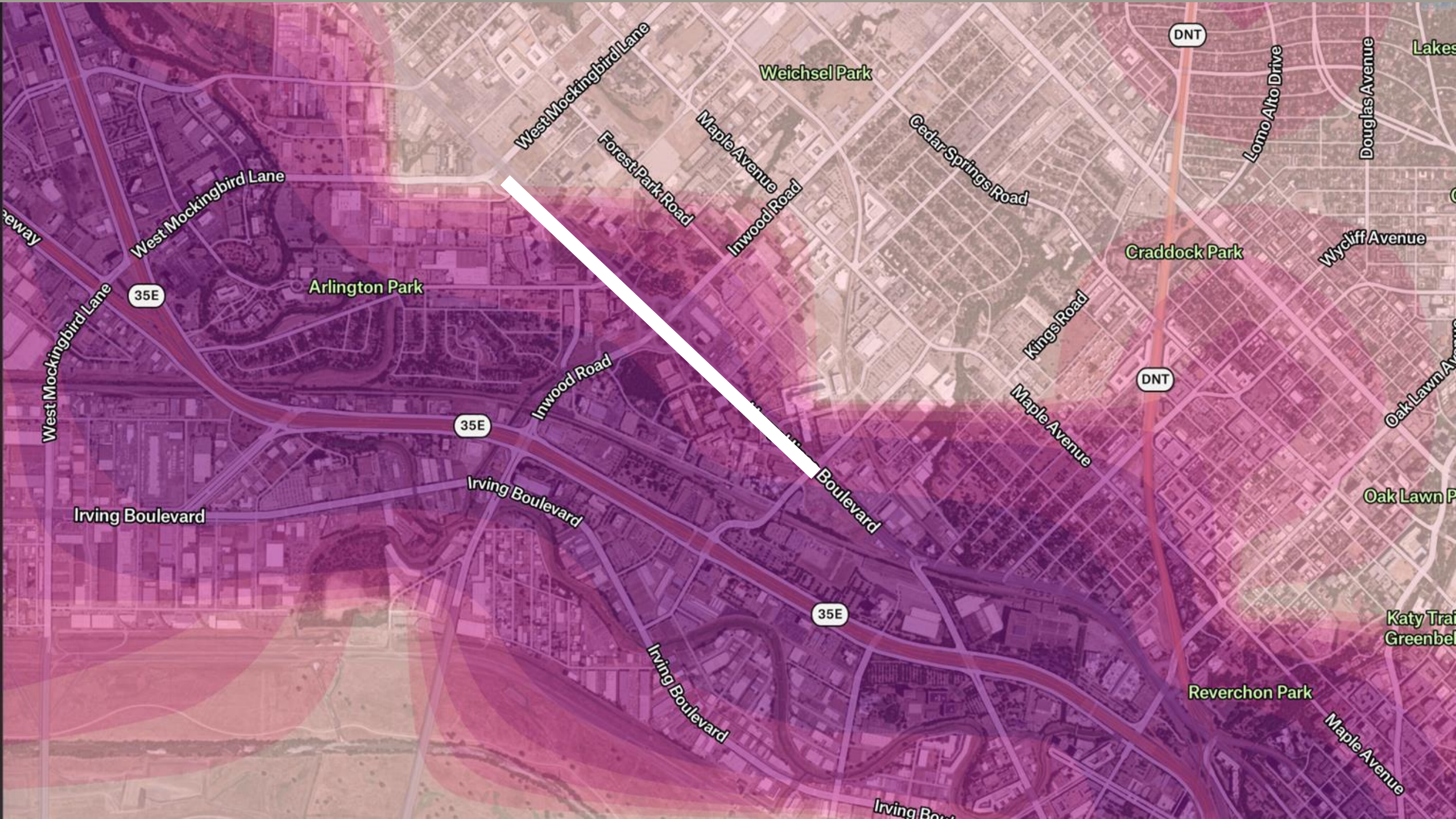
I - 30

I - 45

I - 35E

I - 635





Weichsel Park

West Mockingbird Lane

Forest Park Road

Maple Avenue

Inwood Road

Cedar Springs Road

DNT

Lomo Alto Drive

Douglas Avenue

Lakes

West Mockingbird Lane

Arlington Park

35E

Craddock Park

Wycliff Avenue

Inwood Road

Kings Road

DNT

Oak Lawn Avenue

West Mockingbird Lane

35E

Maple Avenue

Oak Lawn Park

Irving Boulevard

Irving Boulevard

35E

Boulevard

Katy Trail  
Greenbelt

Irving Boulevard

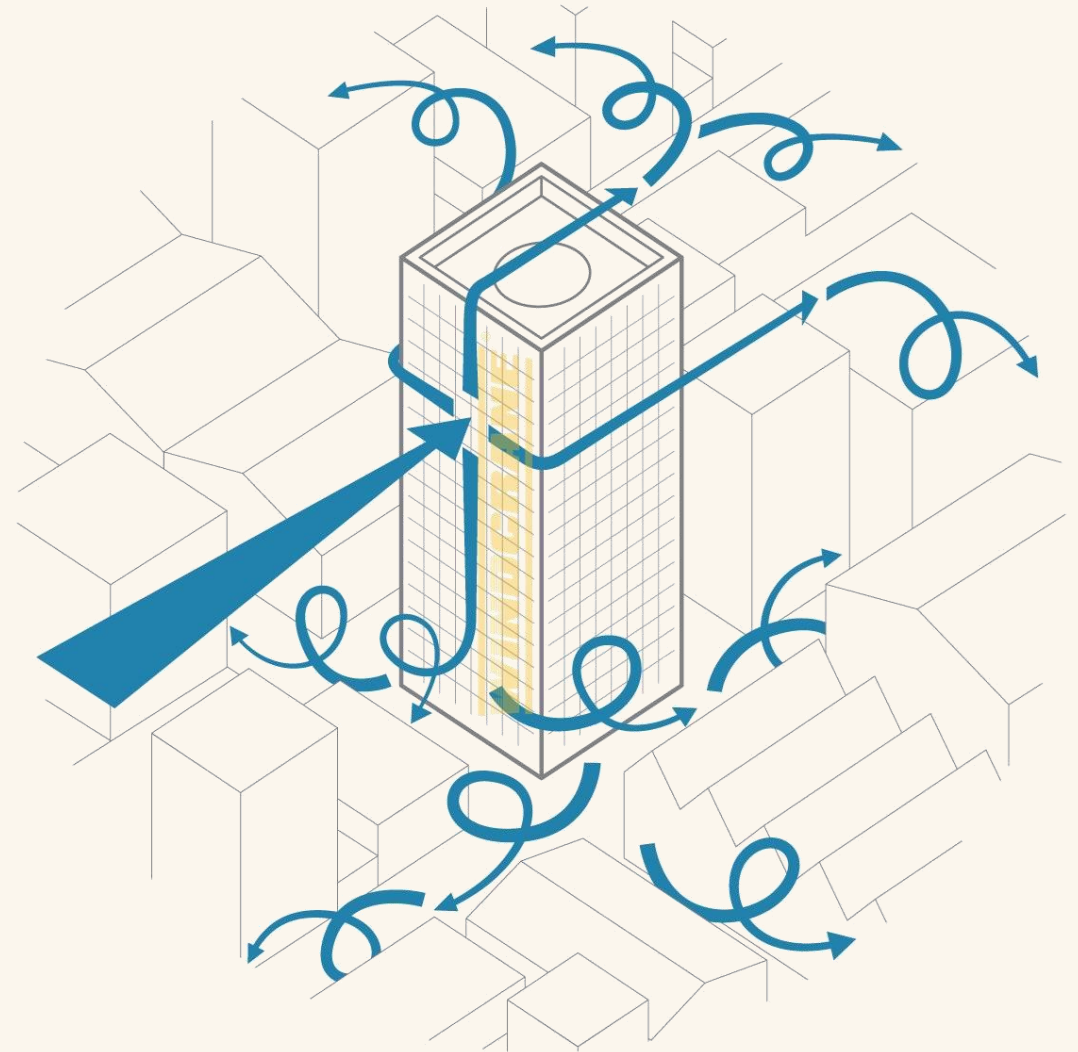
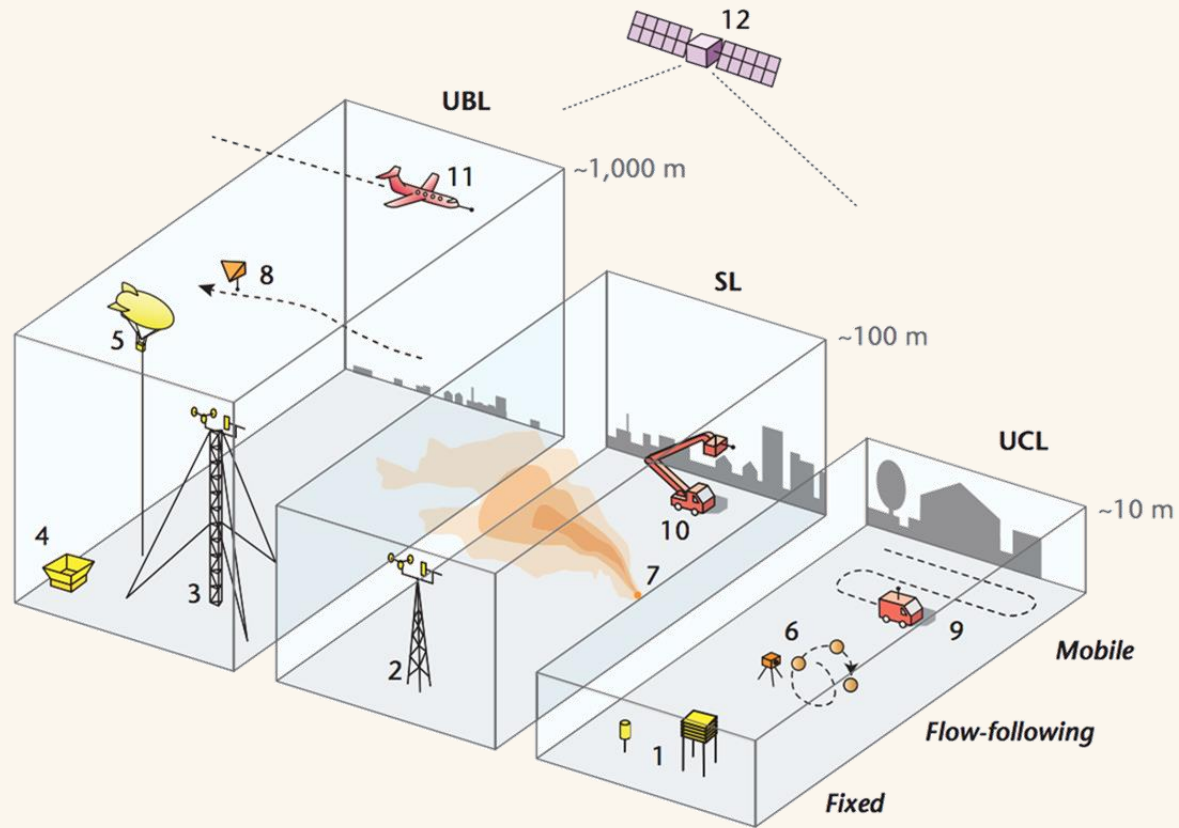
Reverchon Park

Maple Avenue

Irving Boulevard



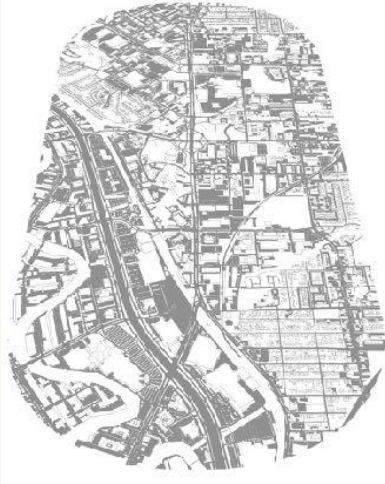
# Measurement & Modelling



# Variety of Data Sources



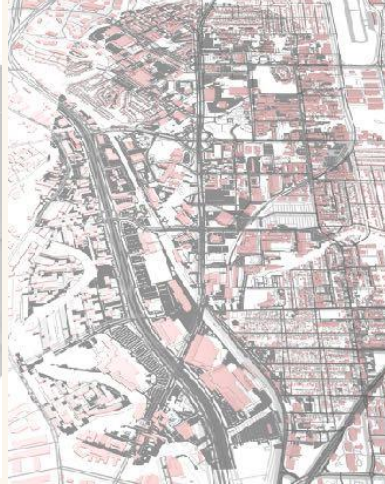
Public GIS



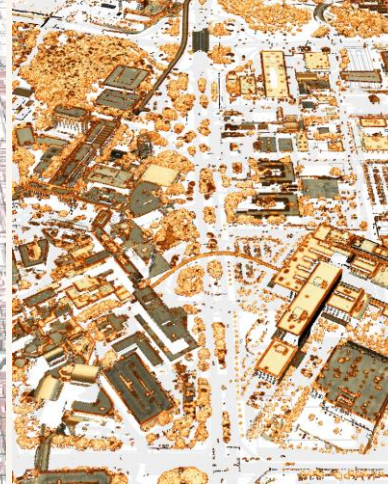
City GIS



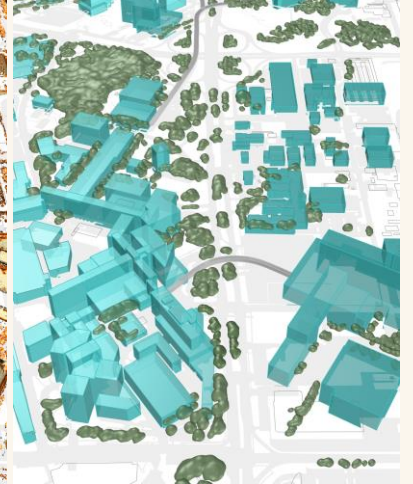
USGS Elevation



OpenStreetMap / Microsoft



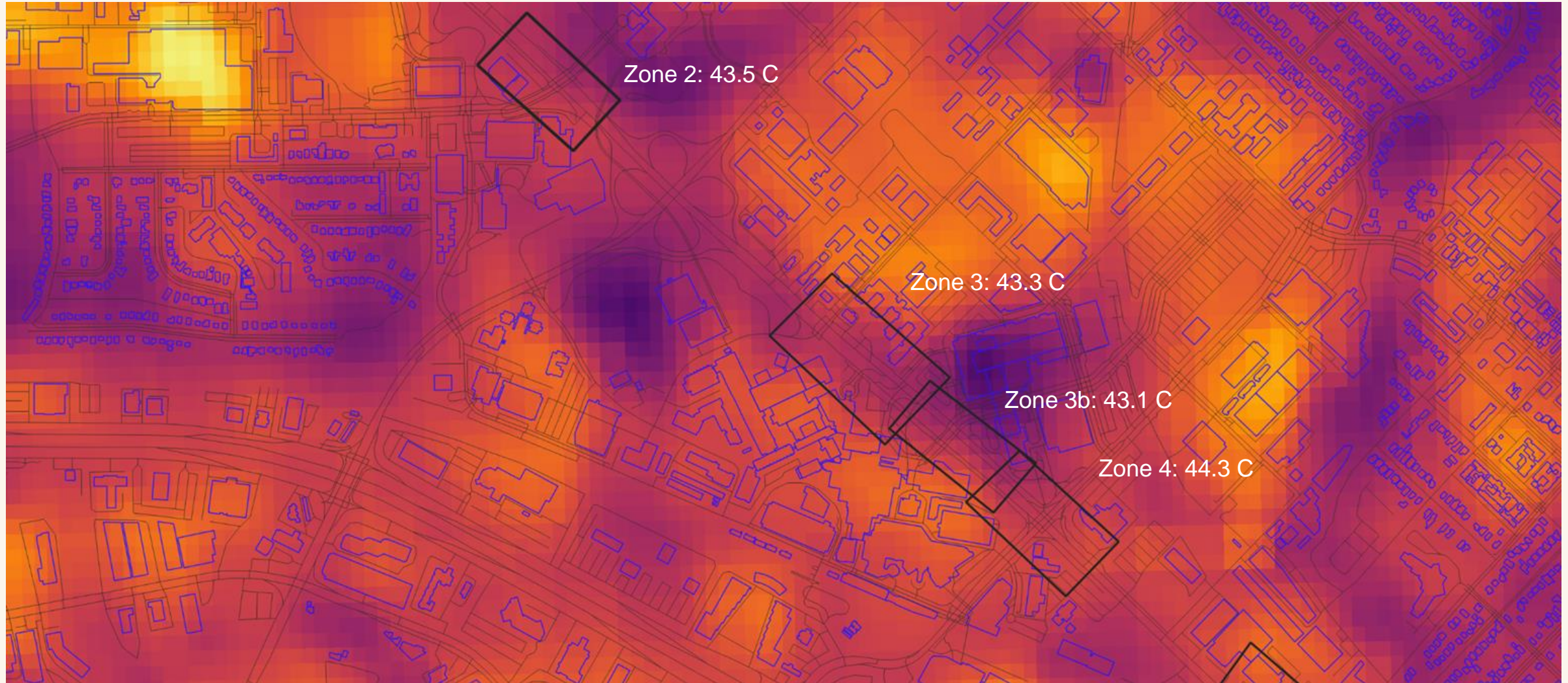
LiDAR



Watertight Tree Canopy

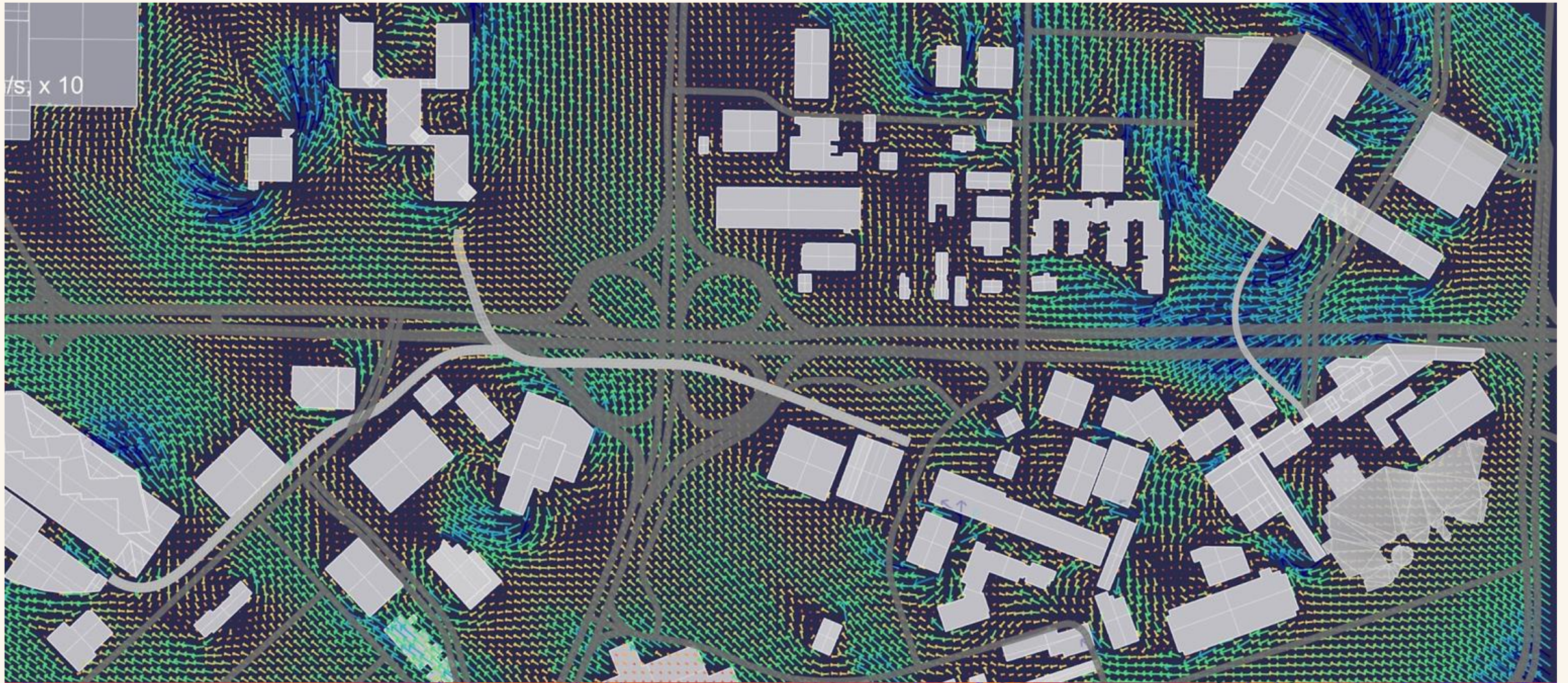


# Landsat 100M



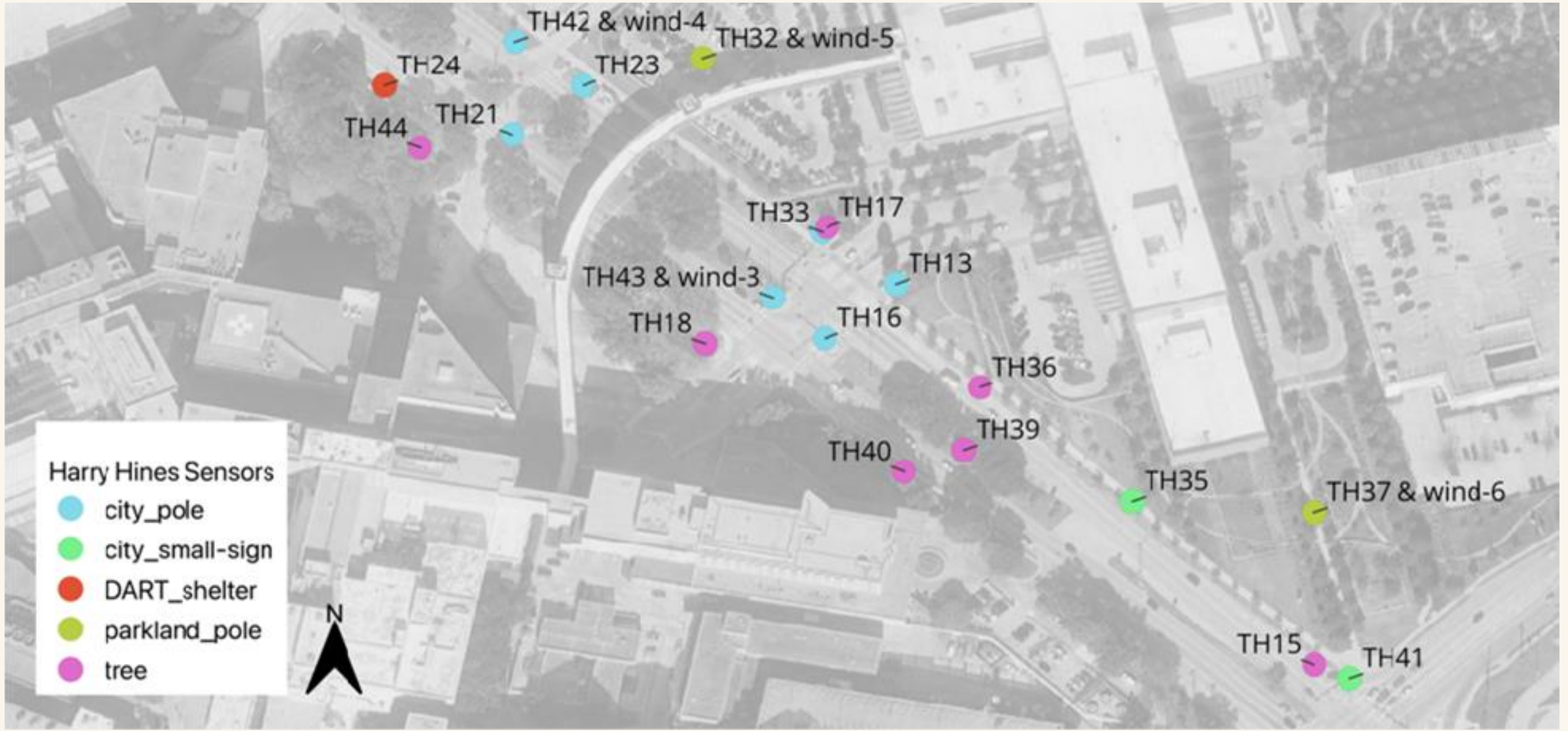


# Landsat 100M





# Microclimate Sensors



# Microclimate Sensors



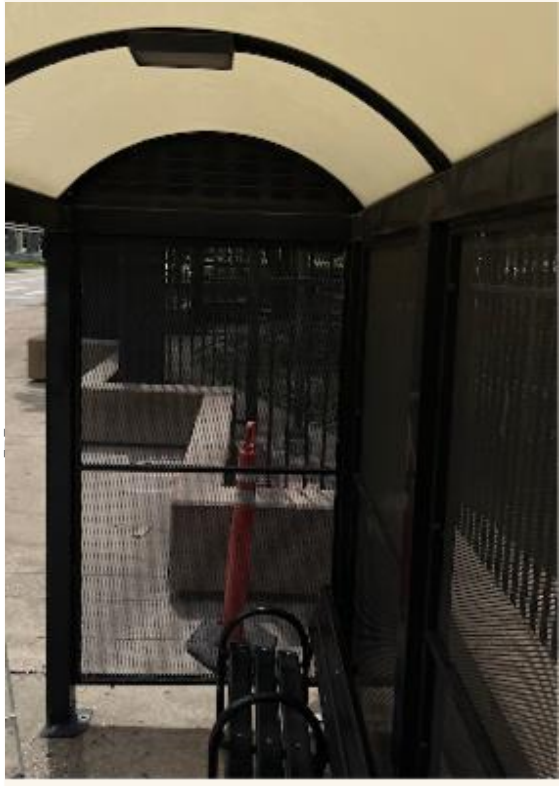
Exposed sunny areas



Deep shade of mature trees



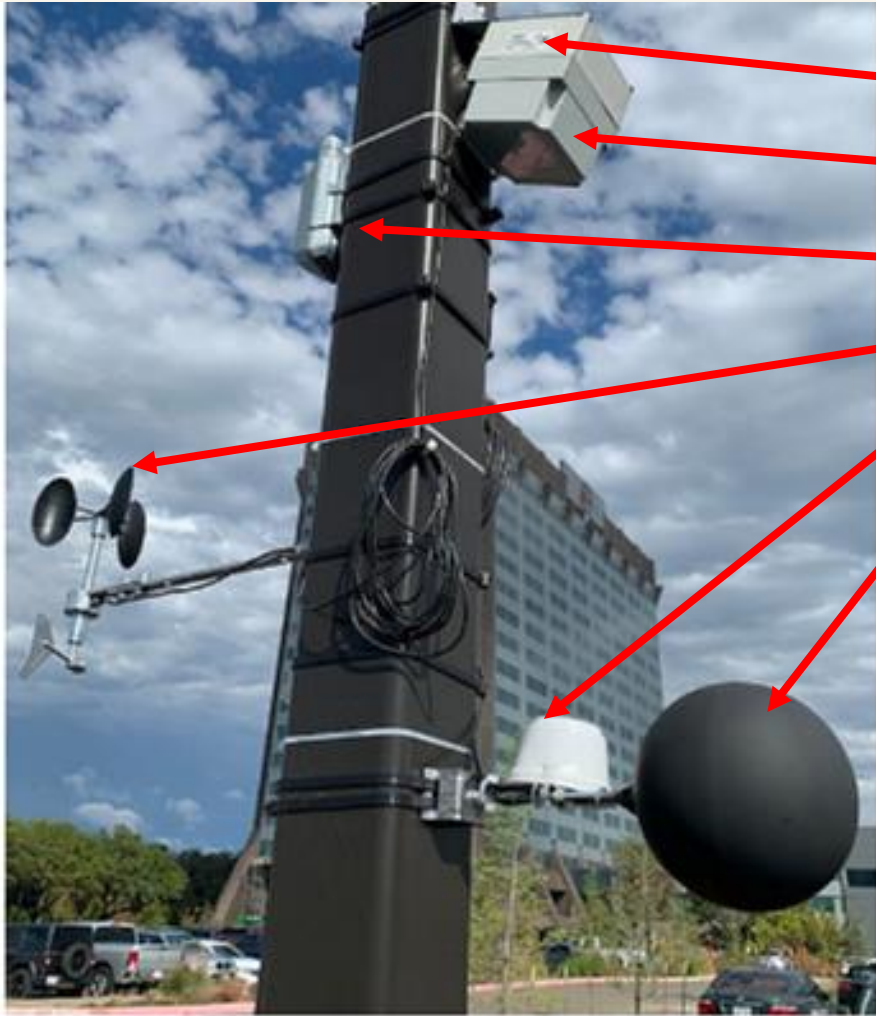
Mild shade of young trees



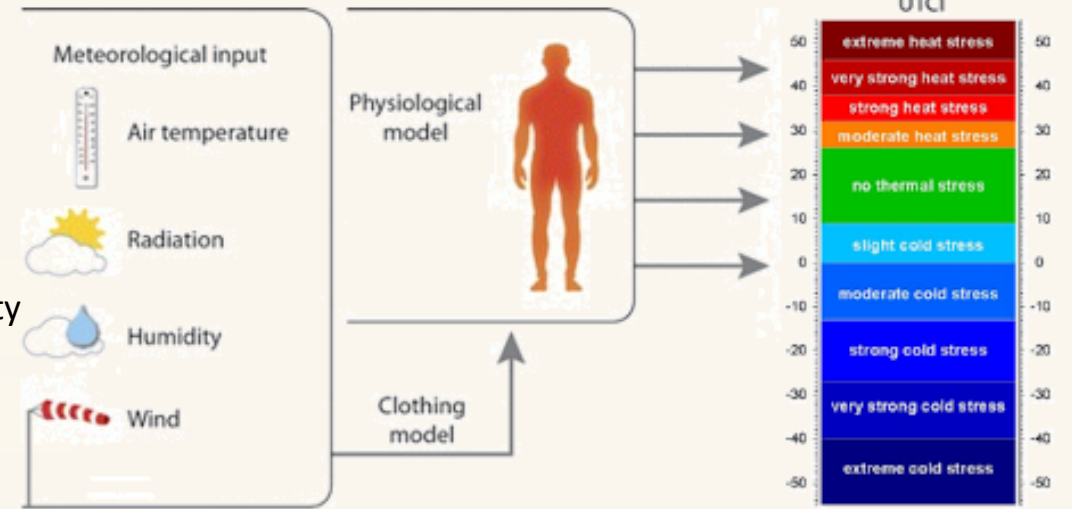
In bus shelters



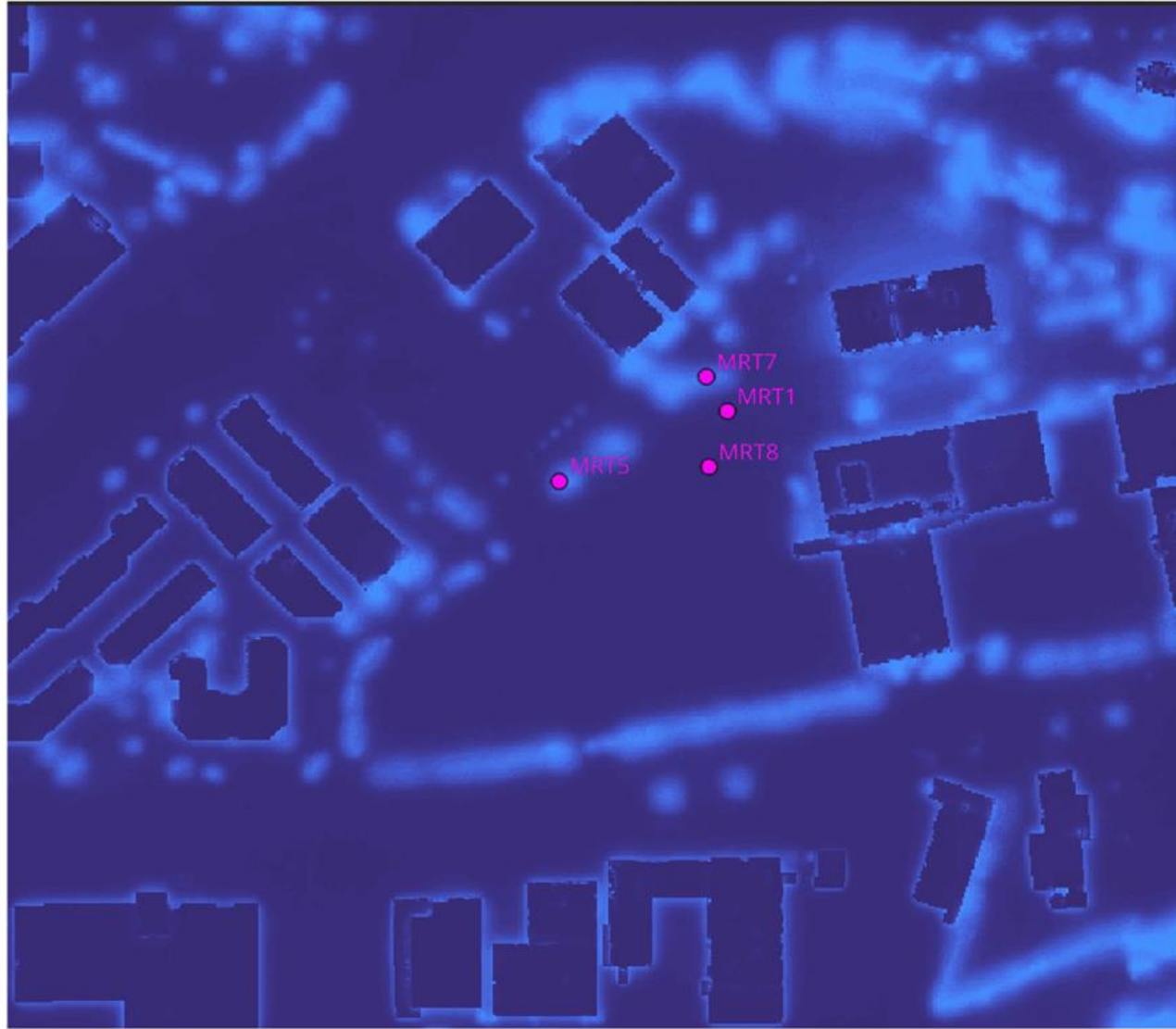
# Microclimate Sensors



- LoRaWAN radio
- Solar panel, battery
- Light sensor
- Wind speed & direction
- Air temperature & humidity
- Black Globe Temp



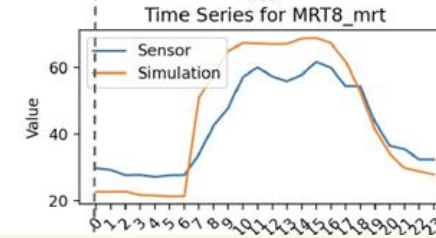
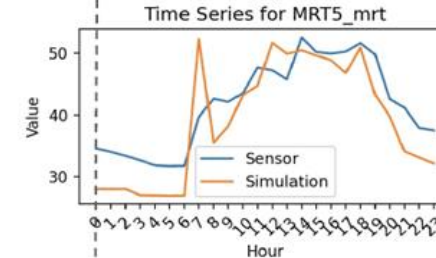
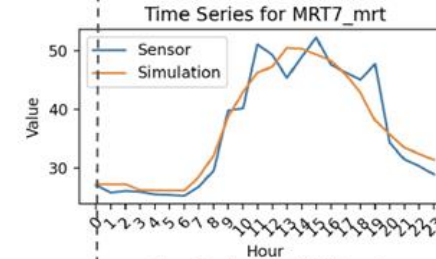
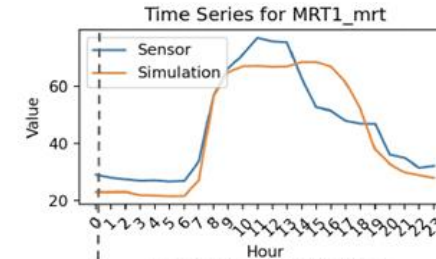
# Microclimate Sensors & Model



SOLWEIG tMRT 0:53

Pegasus Park  
July 12th 2023

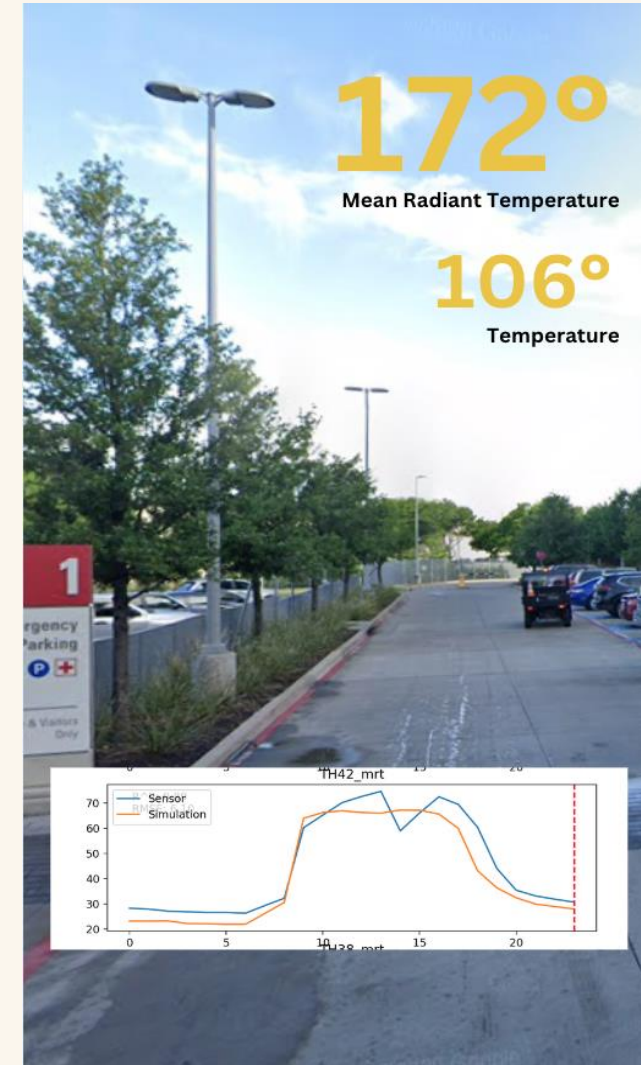
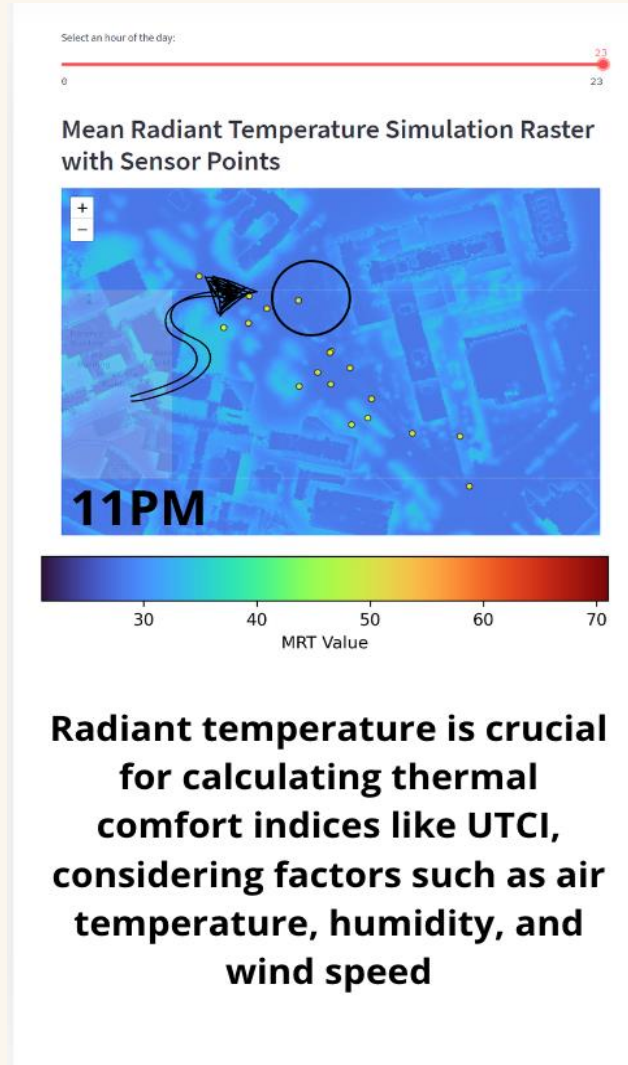
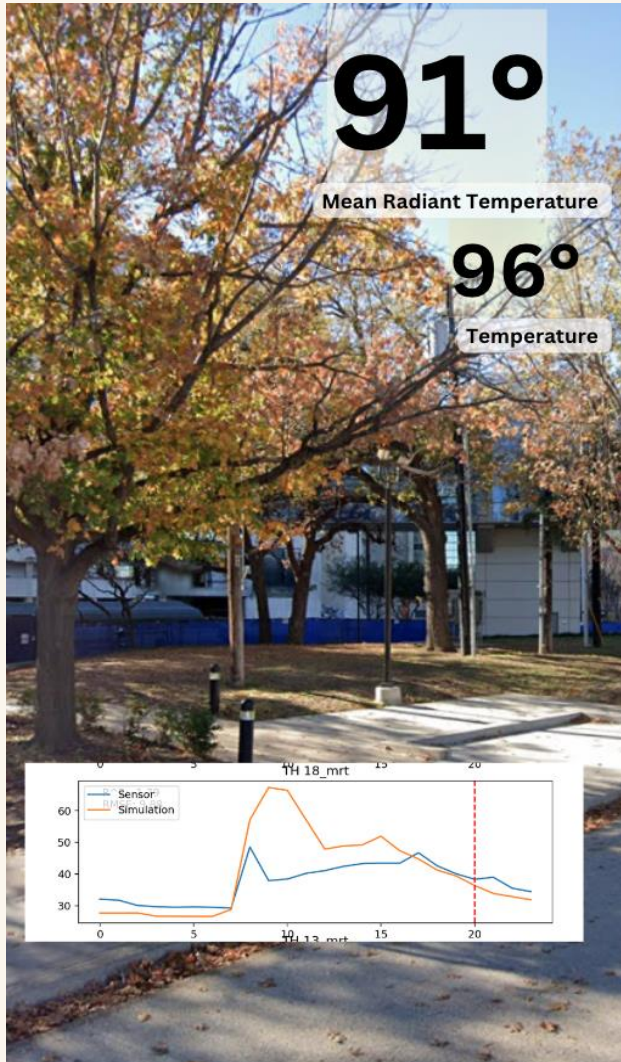
70C



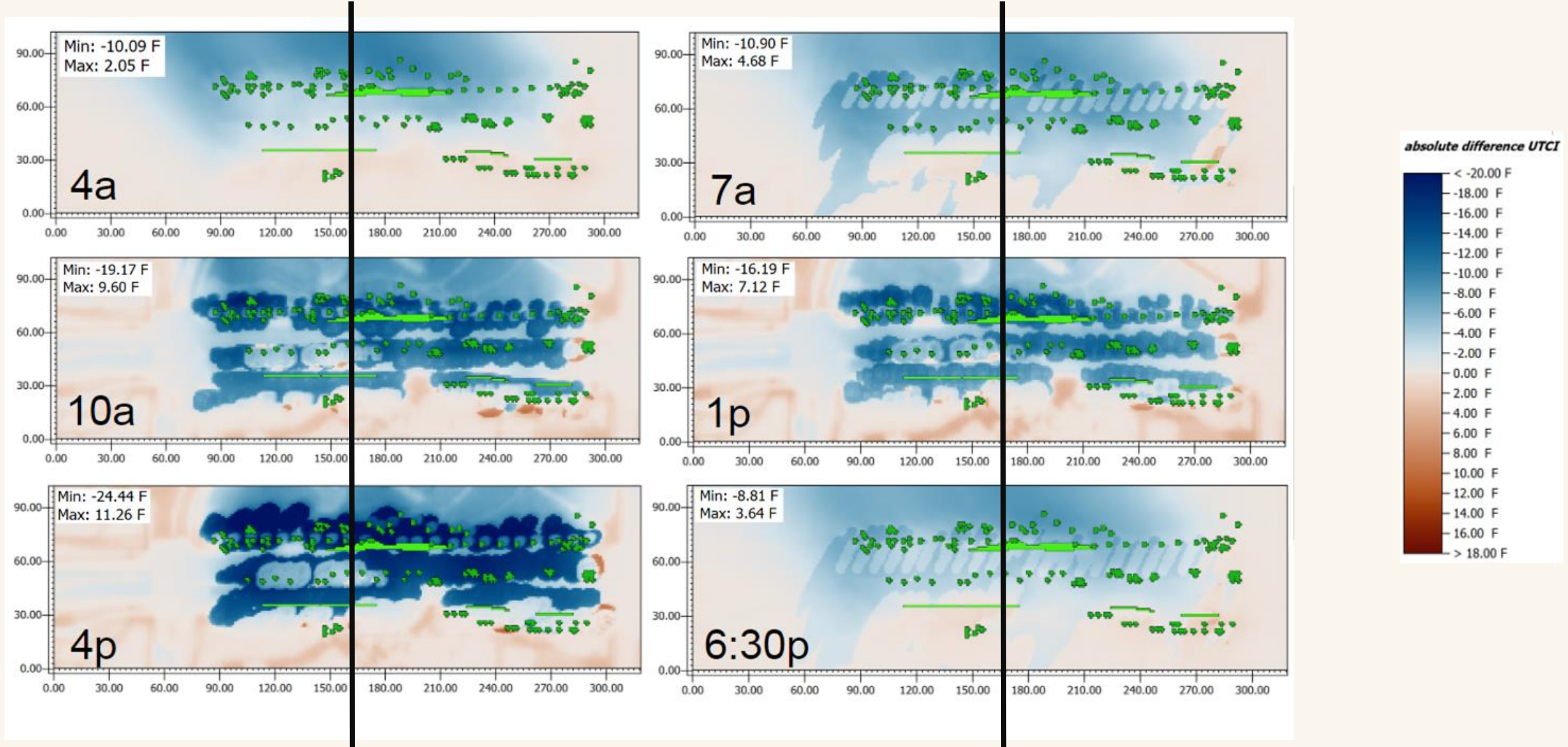
21C



# Microclimate Sensors

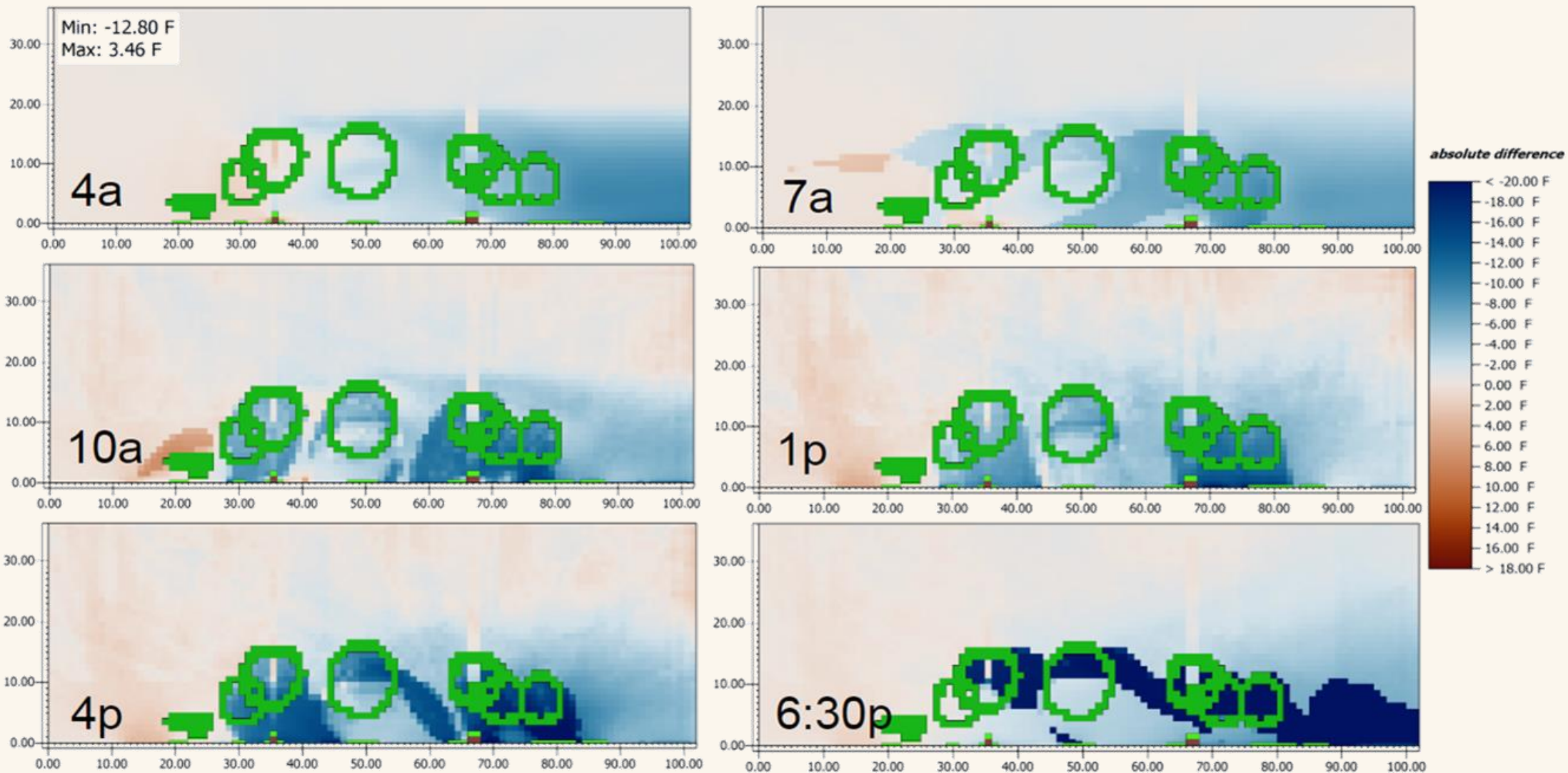


# Corridor Planting Performance Analysis

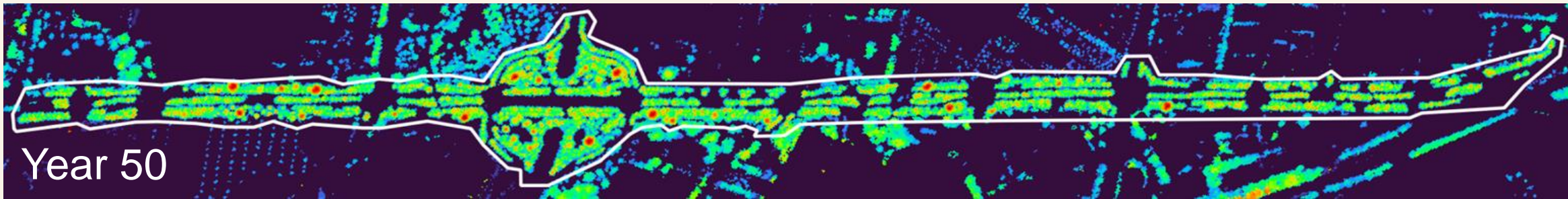
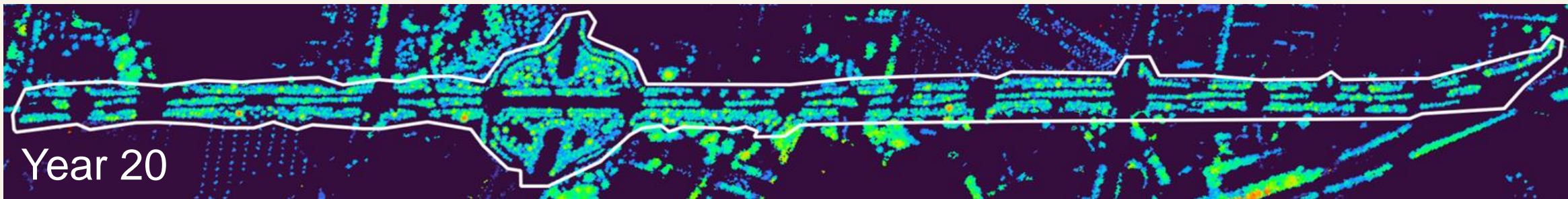
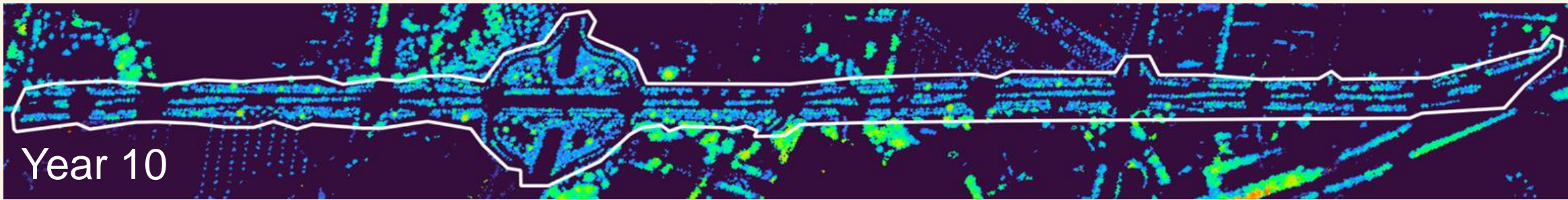
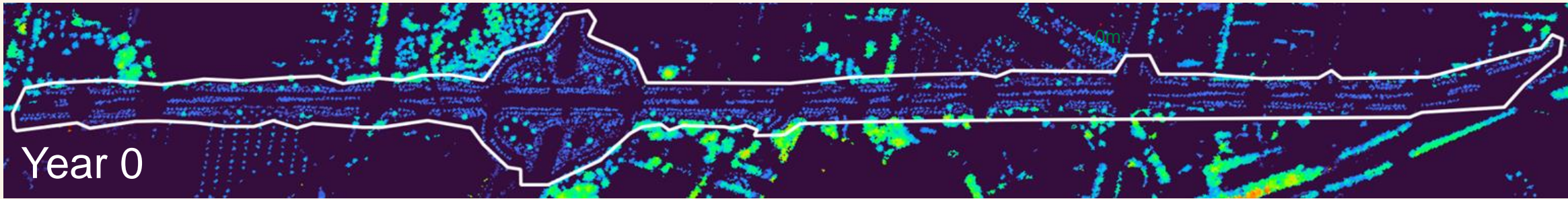




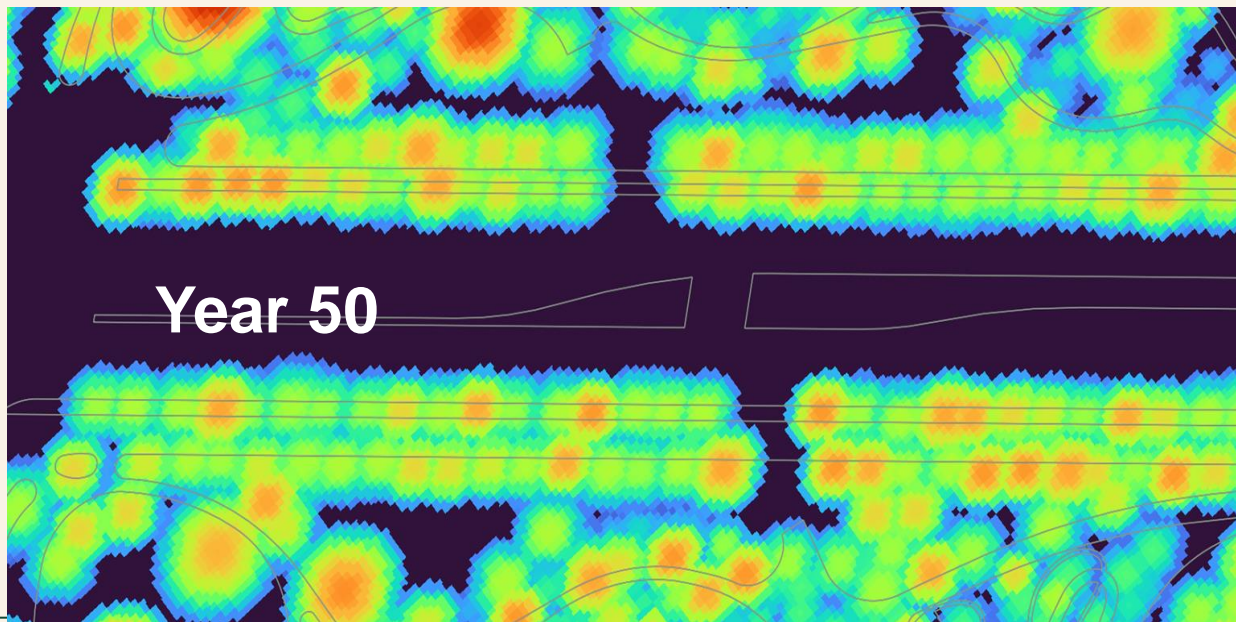
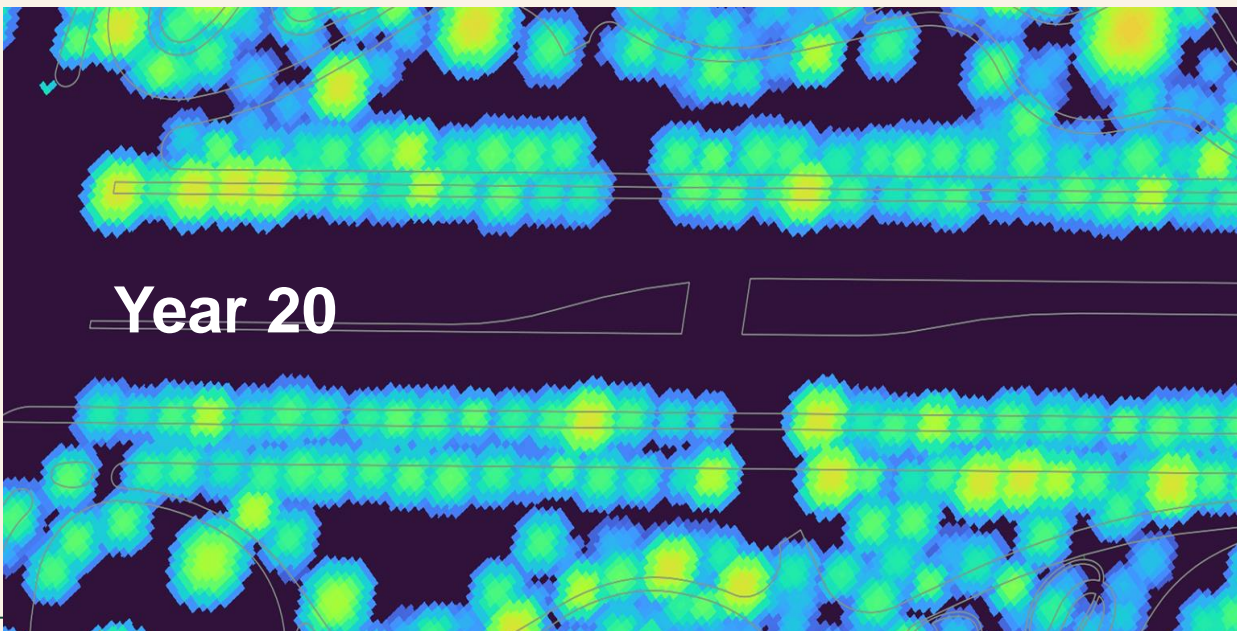
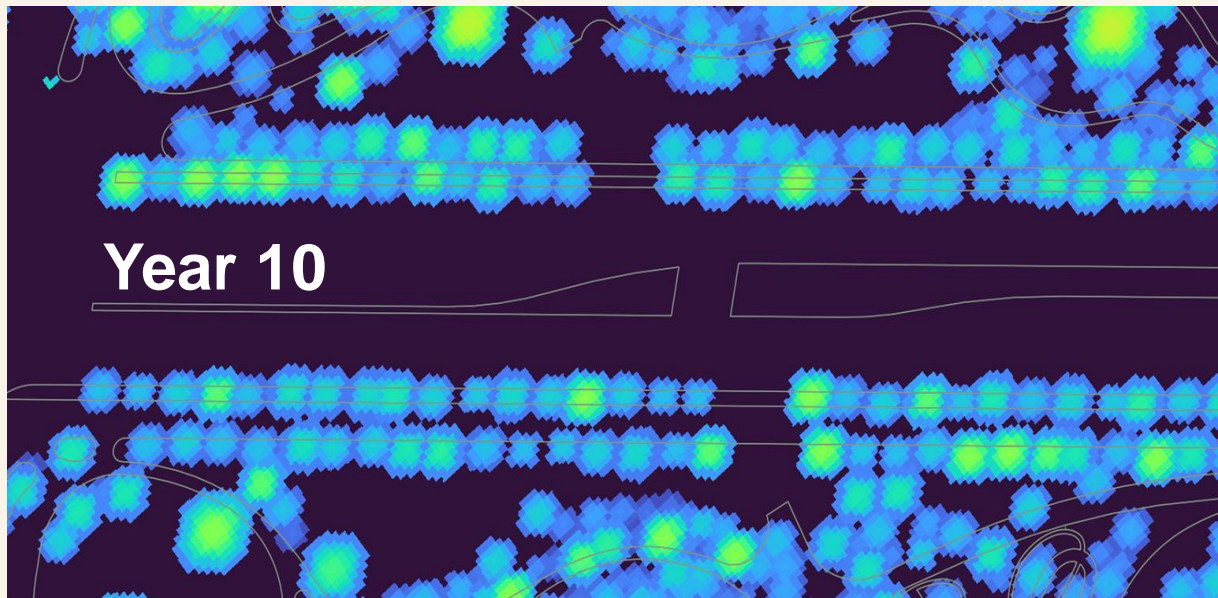
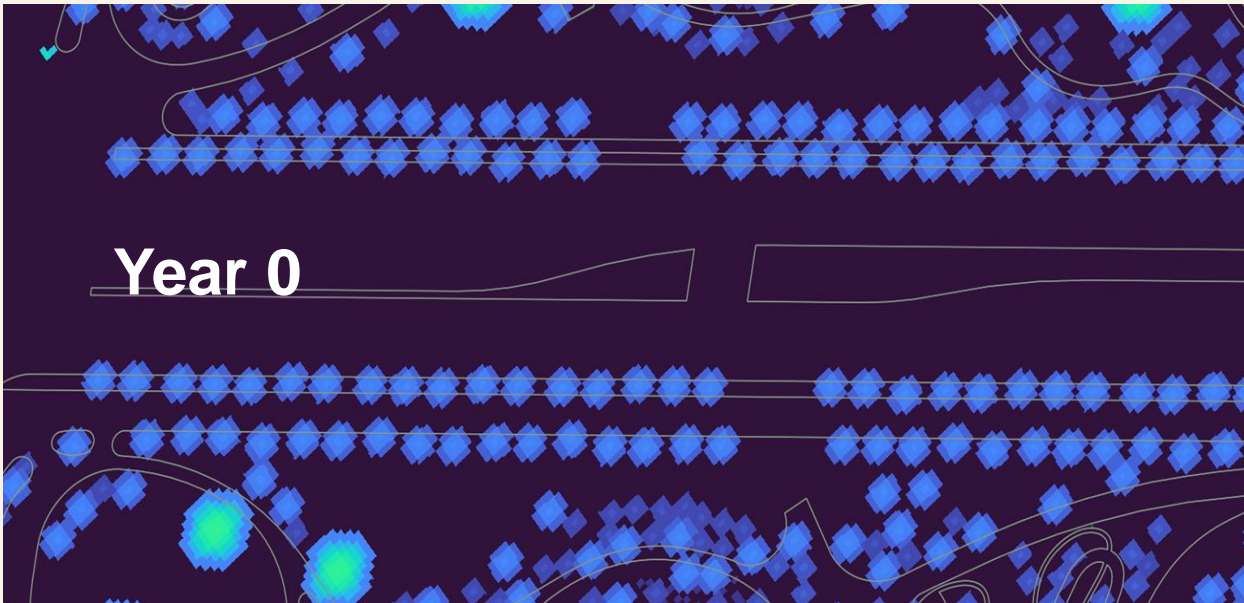
# Performance Analysis: Boulevard Tree Planting







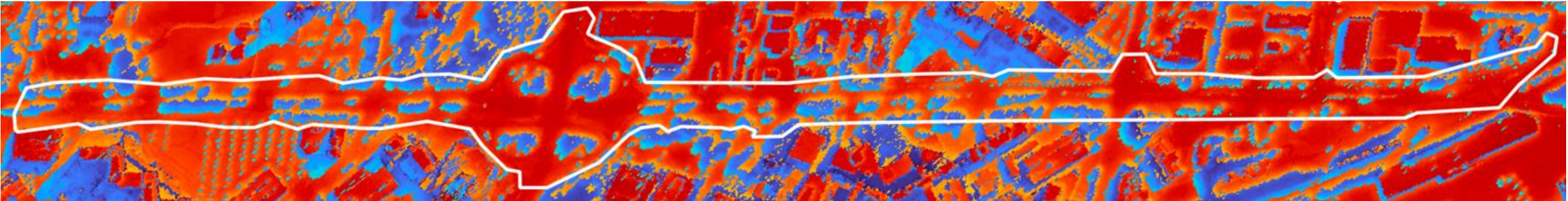






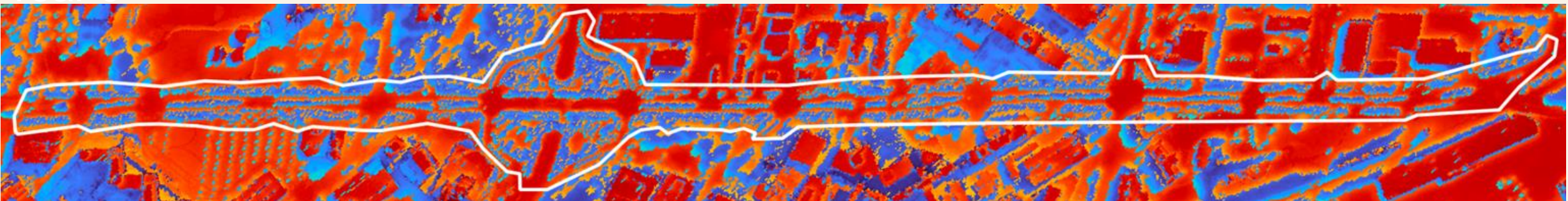
# Existing Conditions

Average MRT = 66.76 C



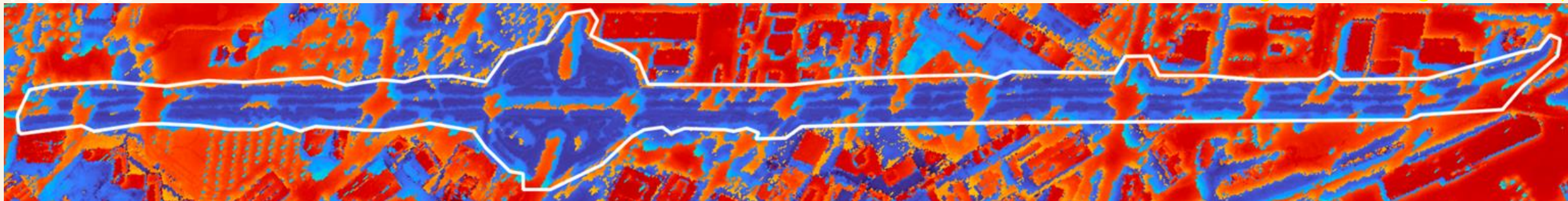
# Year 0

Average MRT = 62.8 C (4C cooling over existing conditions)



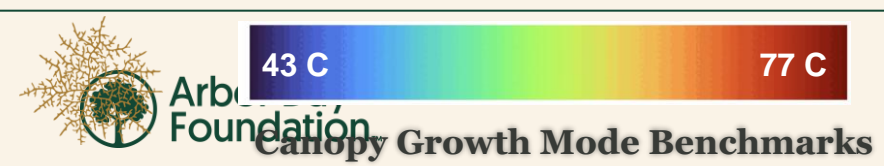
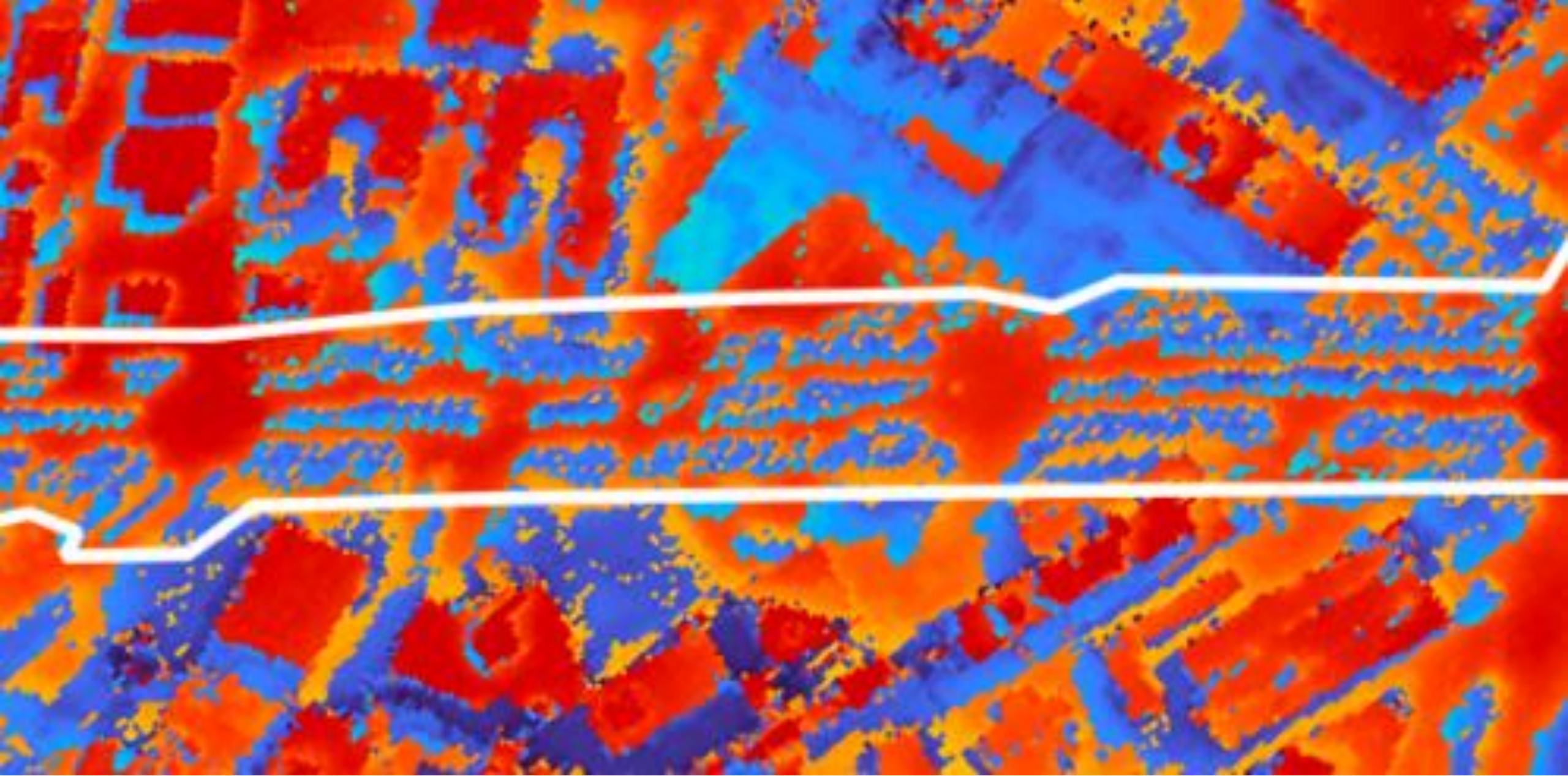
# Year 50

MRT = 52.38 C (14C cooling over existing conditions)



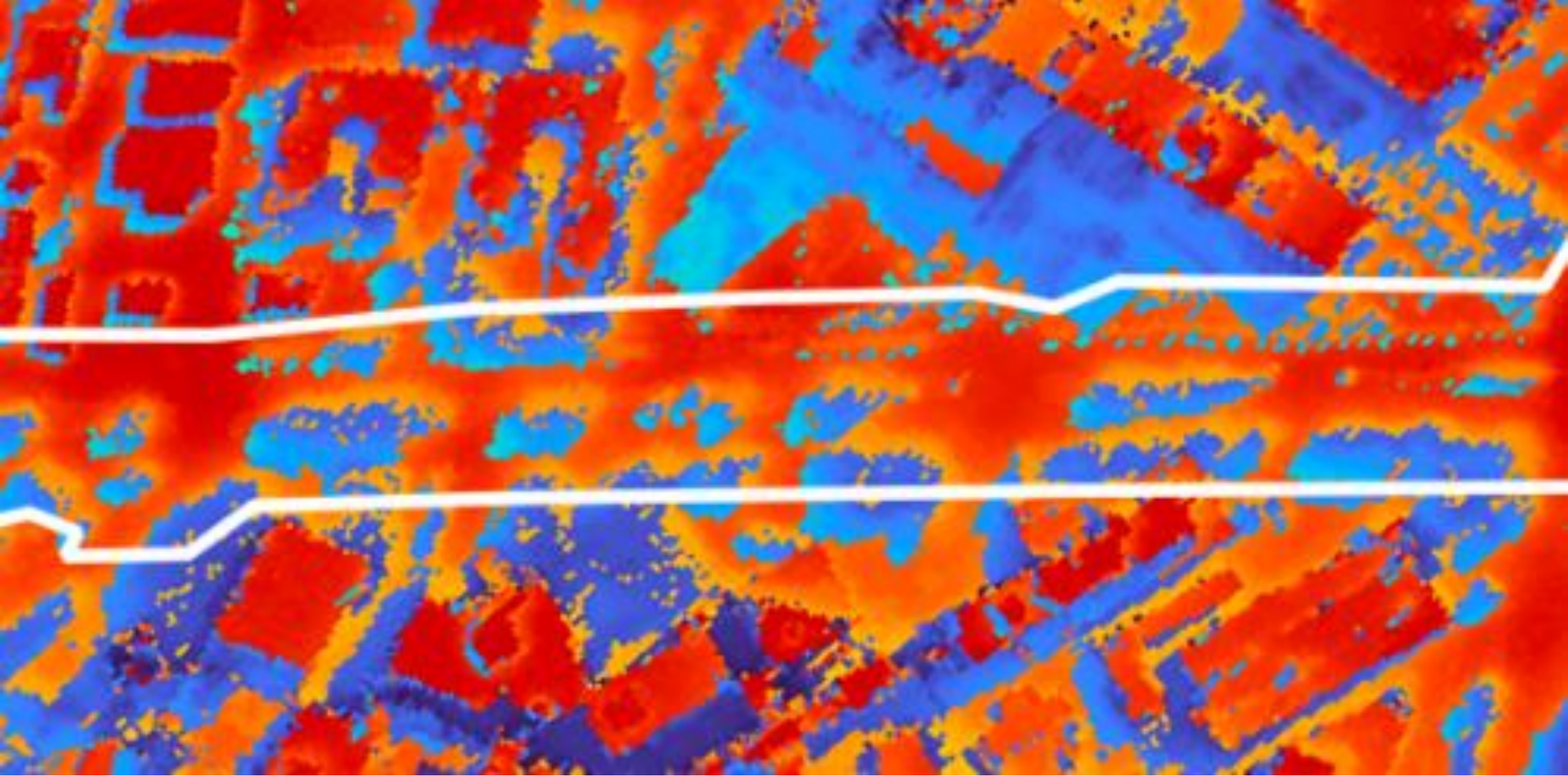
Canopy Growth Mode Benchmarks





PARTNERS IN COMMUNITY FORESTRY 2024 CONFERENCE

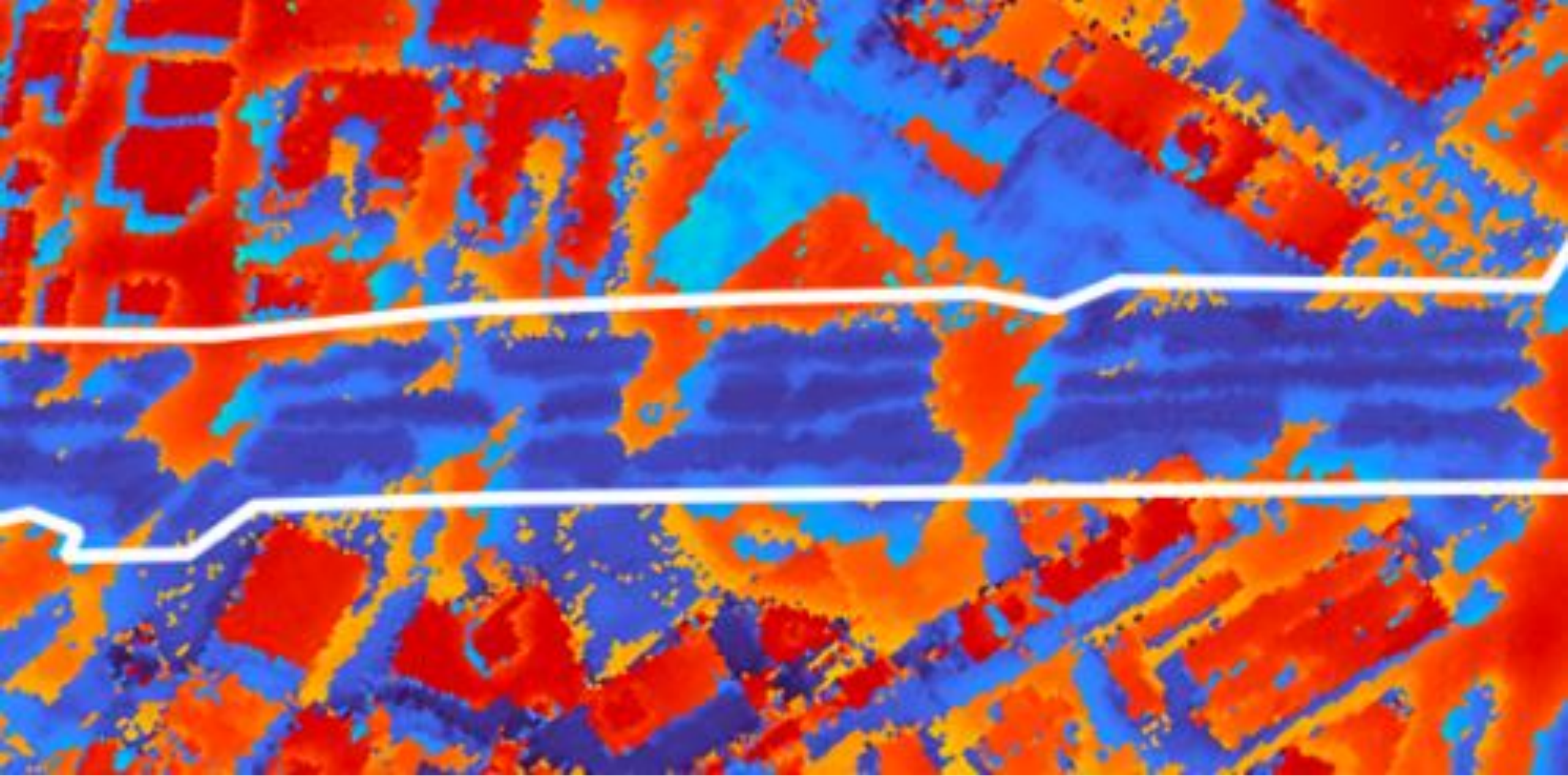




**Canopy Growth Mode Benchmarks**

**PARTNERS IN COMMUNITY FORESTRY 2024 CONFERENCE**





**Canopy Growth Mode Benchmarks**

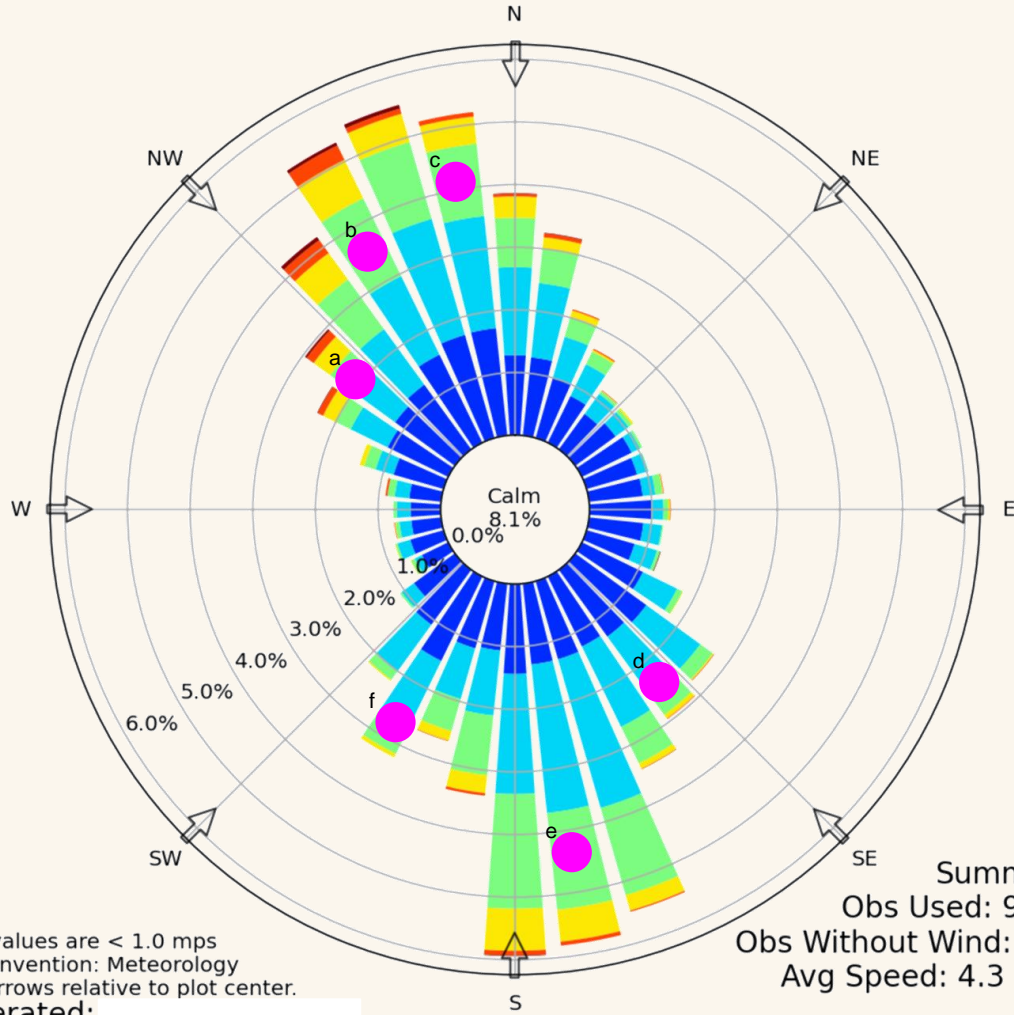
**PARTNERS IN COMMUNITY FORESTRY 2024 CONFERENCE**



# Wind Model

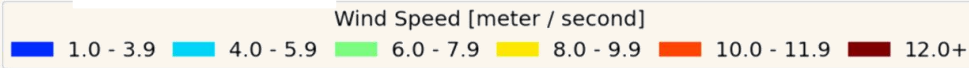
(a)

January



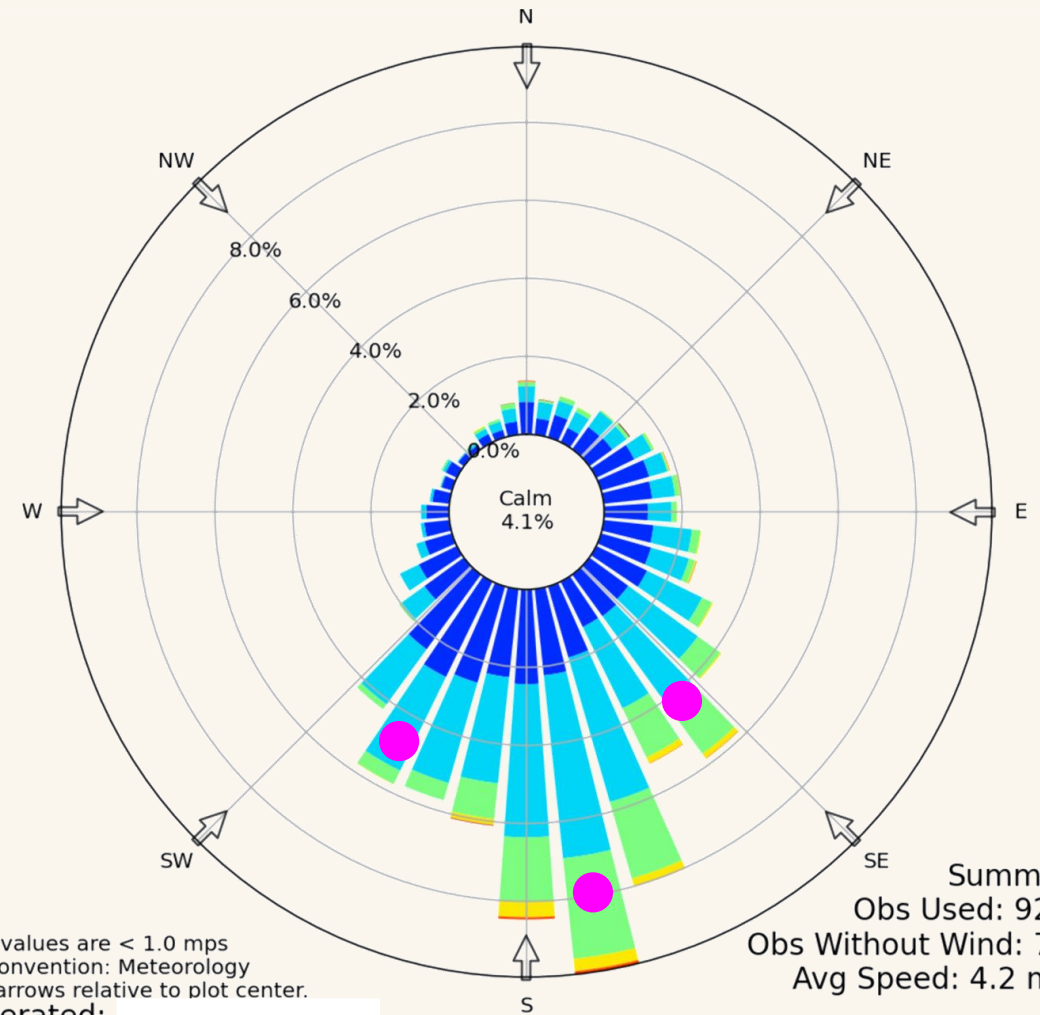
Calm values are < 1.0 mps  
Bar Convention: Meteorology  
Flow arrows relative to plot center.  
Generated:

Summary  
Obs Used: 9746  
Obs Without Wind: 353  
Avg Speed: 4.3 mps



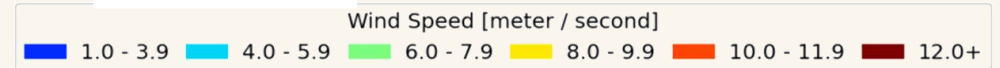
(b)

July



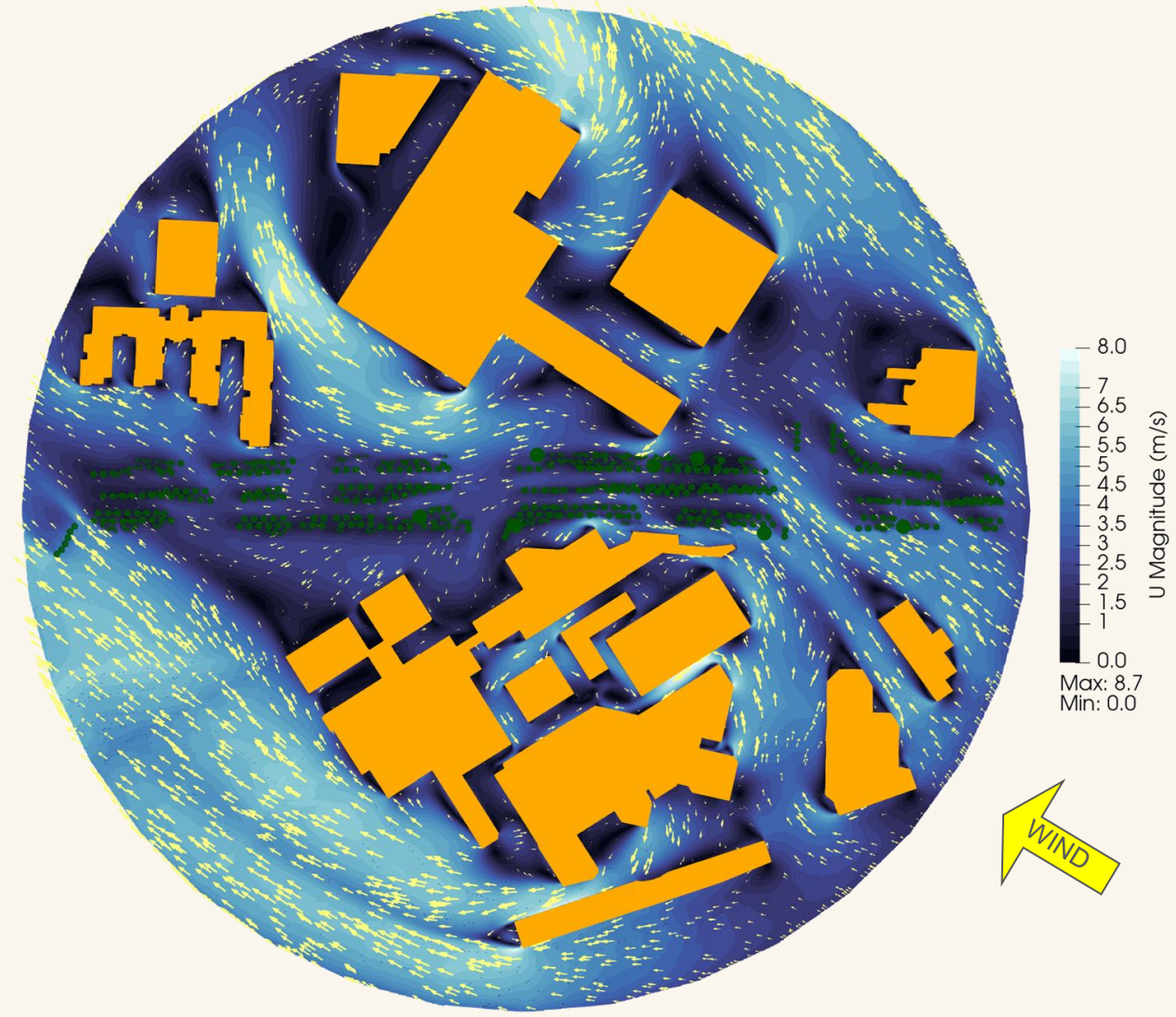
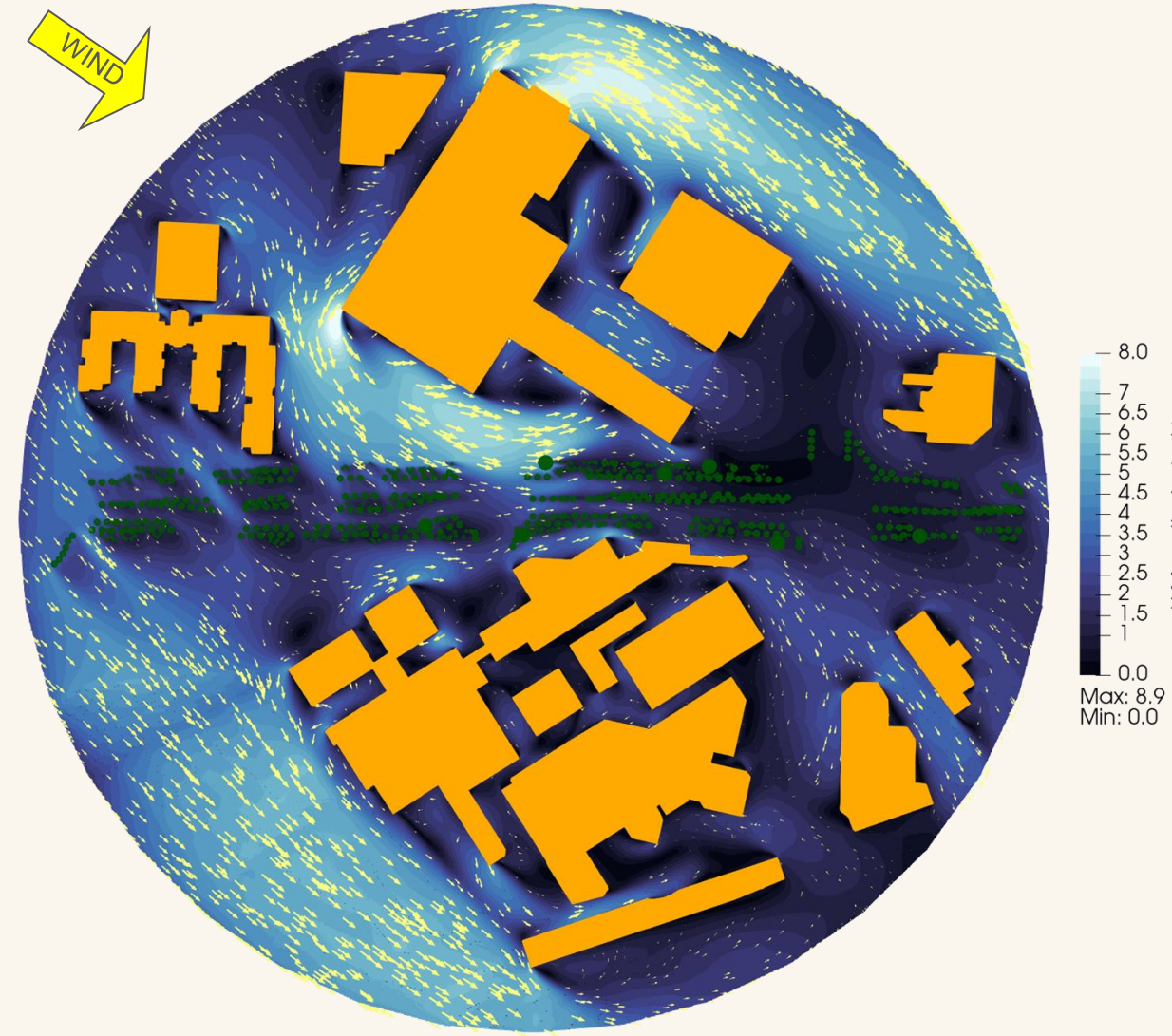
Calm values are < 1.0 mps  
Bar Convention: Meteorology  
Flow arrows relative to plot center.  
Generated:

Summary  
Obs Used: 9232  
Obs Without Wind: 751  
Avg Speed: 4.2 mps



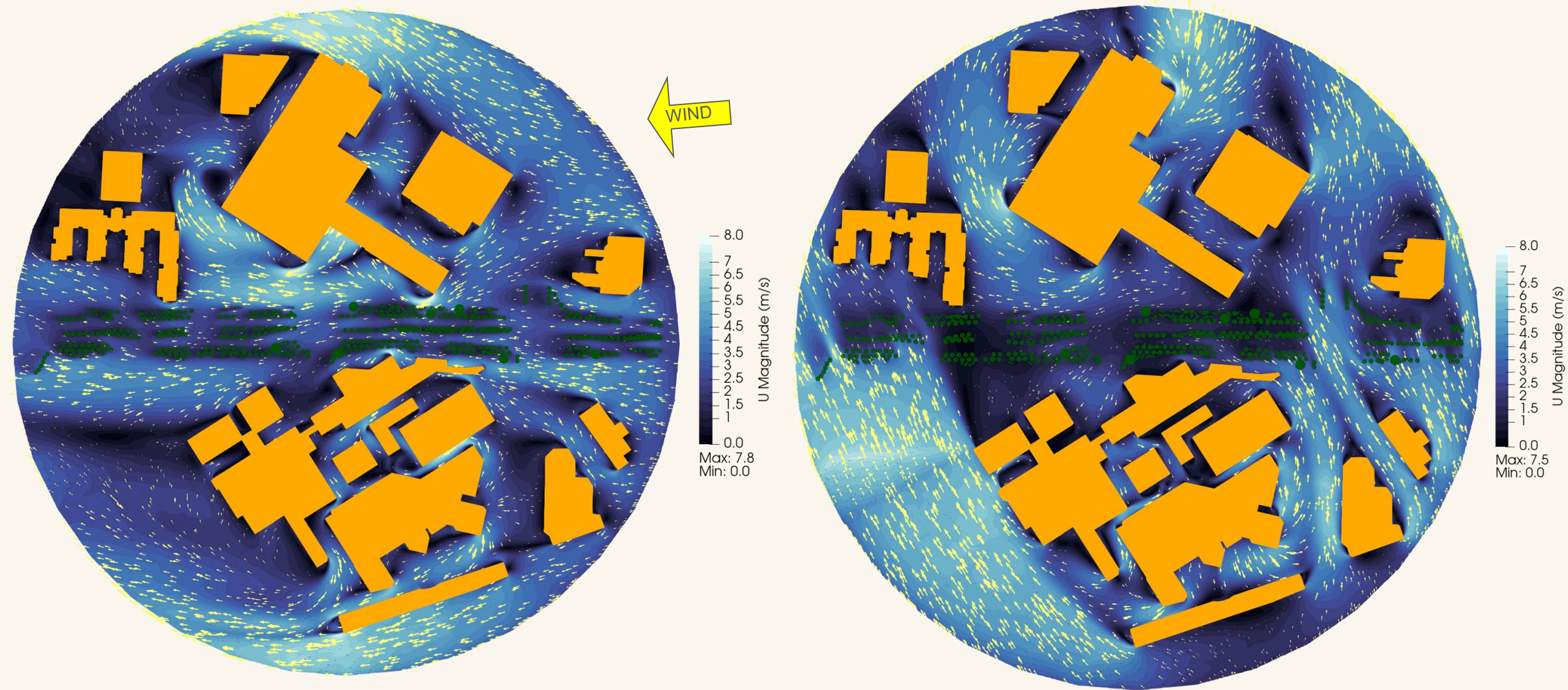


# Corridor Wind & Pollution Studies





# Corridor Wind & Pollution Studies





# Corridor Wind & Pollution Studies



$\mu\text{g}/\text{m}^3$   
1.0  
0.9  
0.8  
0.7  
0.6  
0.5  
0.4  
0.3  
0.2  
0.1  
0.0  
PM Concentration  
Max: 1.0  
Min: 0.0



$\mu\text{g}/\text{m}^3$   
1.0  
0.9  
0.8  
0.7  
0.6  
0.5  
0.4  
0.3  
0.2  
0.1  
0.0  
PM Concentration  
Max: 1.2  
Min: 0.0

# Corridor Wind & Pollution Studies



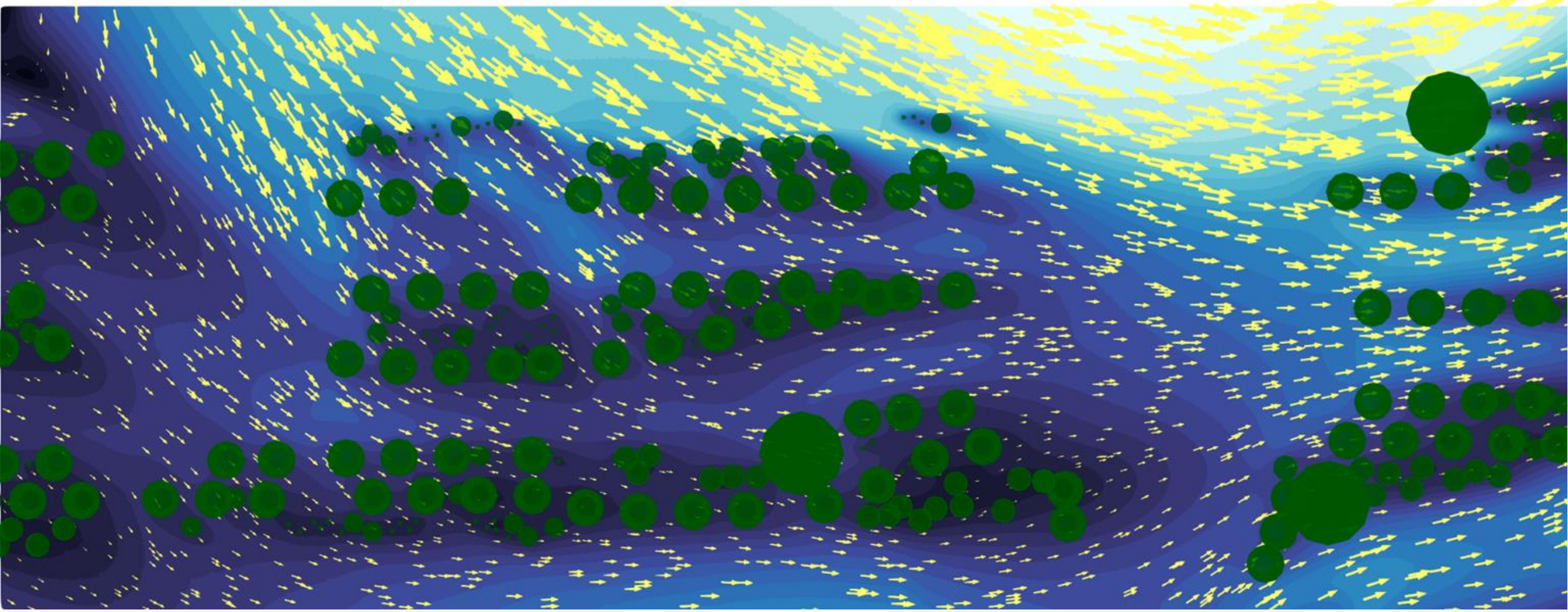
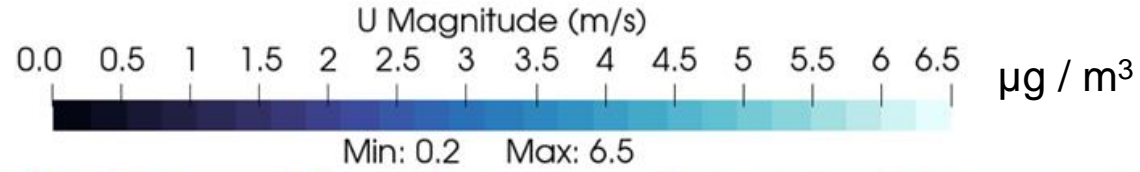
$\mu\text{g} / \text{m}^3$   
1.0  
0.9  
0.8  
0.7  
0.6  
0.5  
0.4  
0.3  
0.2  
0.1  
0.0  
Max: 1.2  
Min: 0.0  
PM Concentration



$\mu\text{g} / \text{m}^3$   
1.0  
0.9  
0.8  
0.7  
0.6  
0.5  
0.4  
0.3  
0.2  
0.1  
0.0  
Max: 1.0  
Min: 0.0  
PM Concentration



# Corridor Wind & Pollution Studies



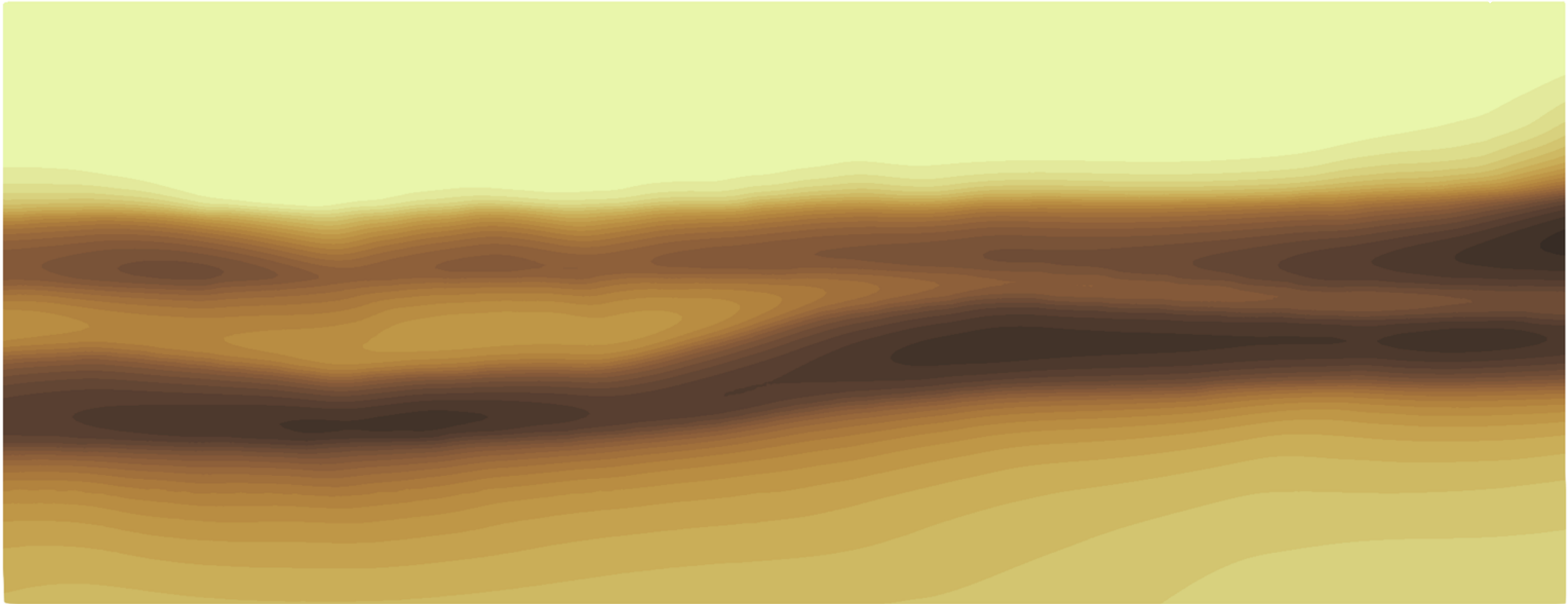
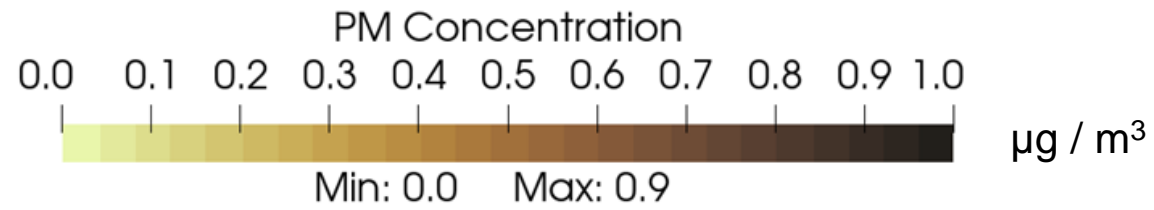
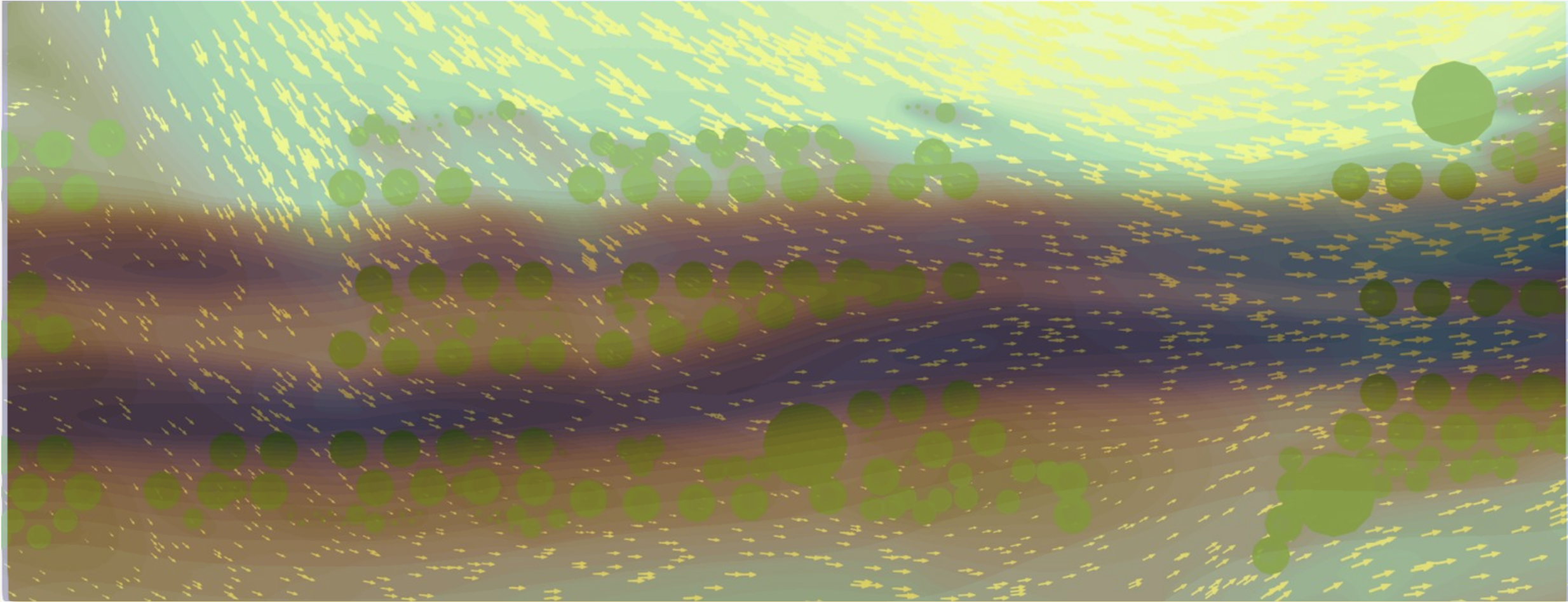
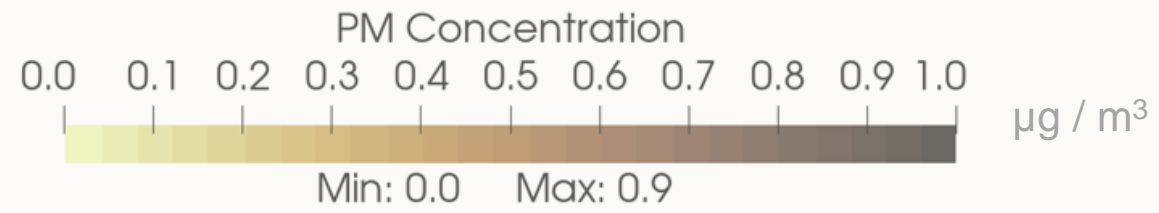
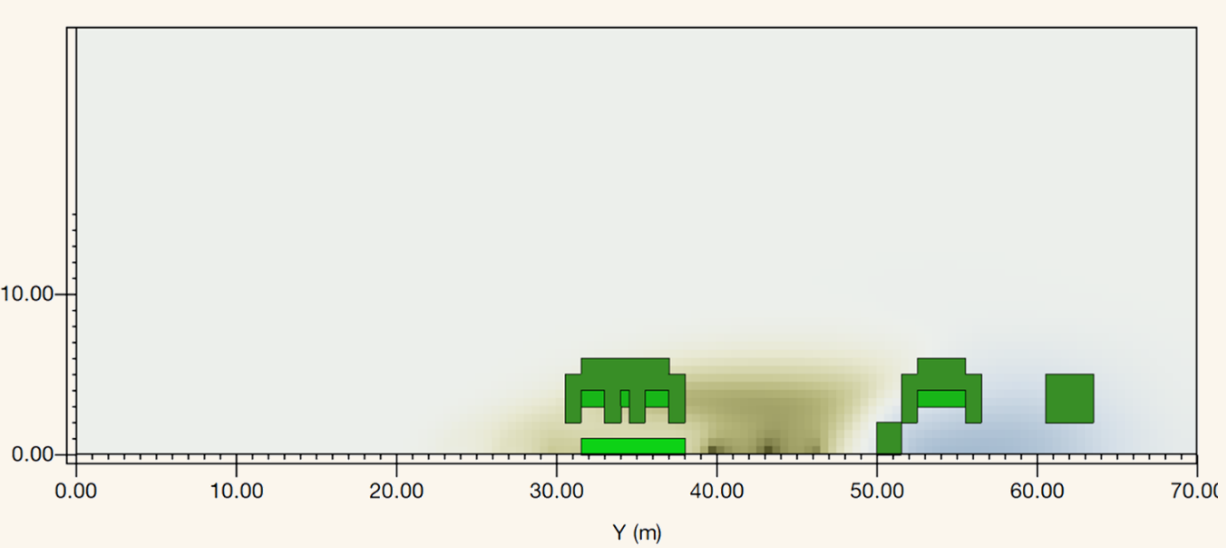
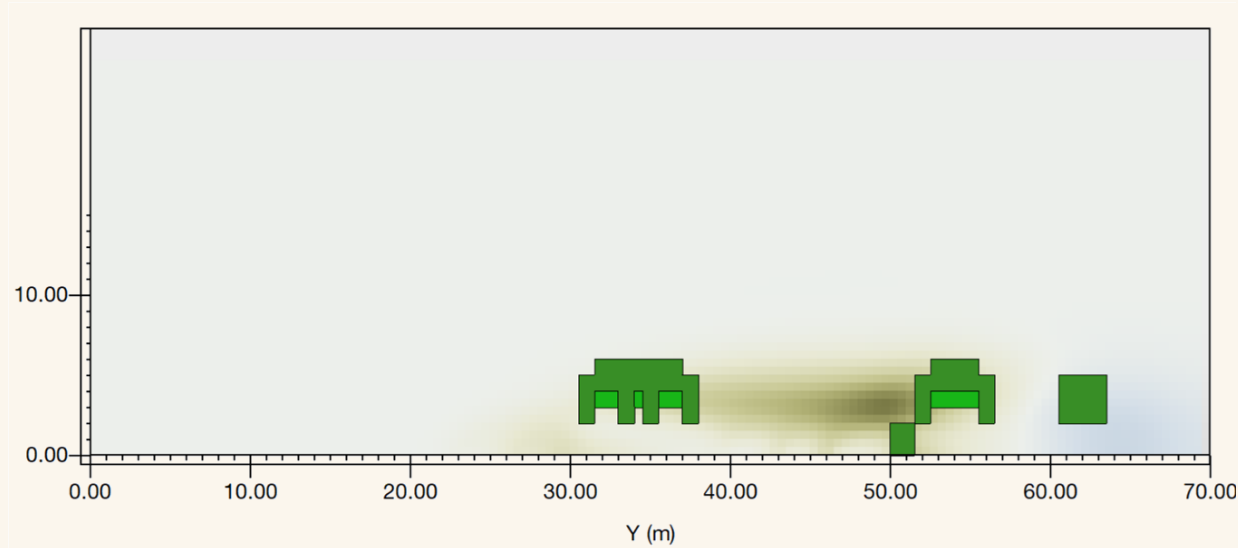
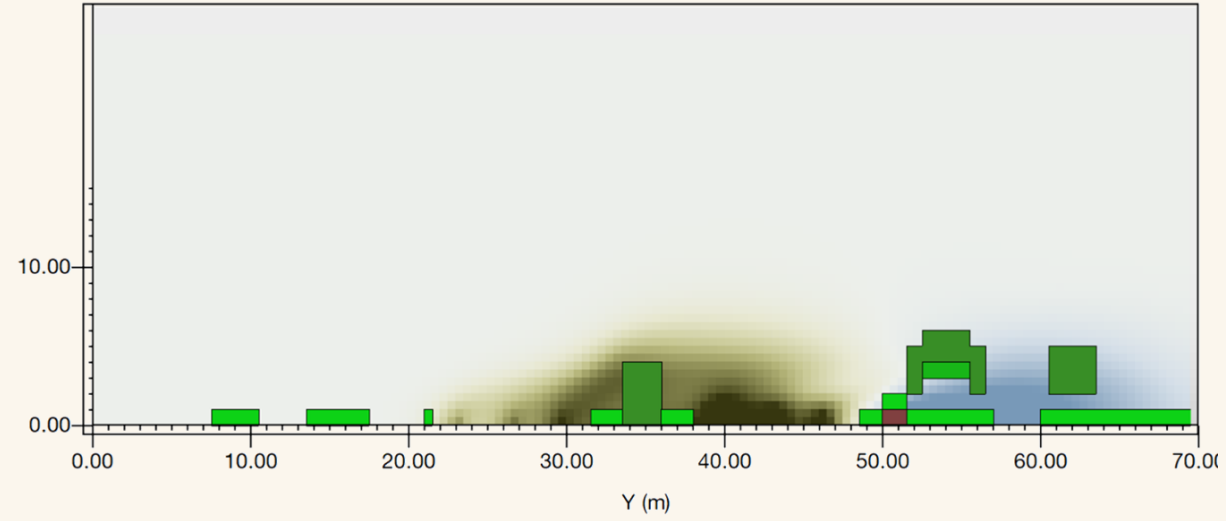
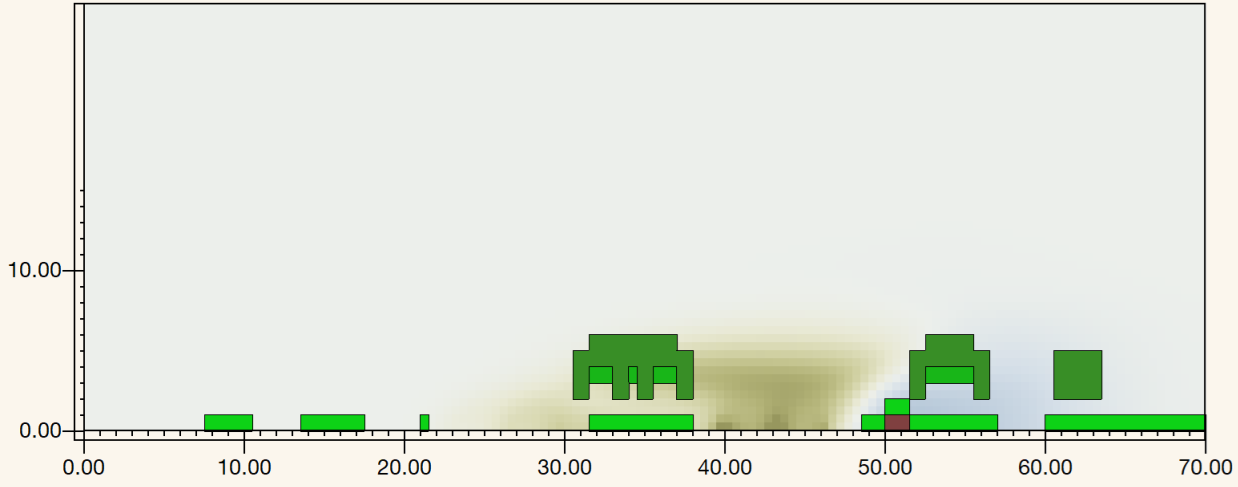


Figure. PM concentration on a terrain-following surface 1.5 m above ground at the Harry Hines corridor. (a)-(f) PM<sub>2.5</sub> concentration at pedestrian level (1.5 m above ground) for the selected wind directions. Note that the region shown extends 225 x 85 m.





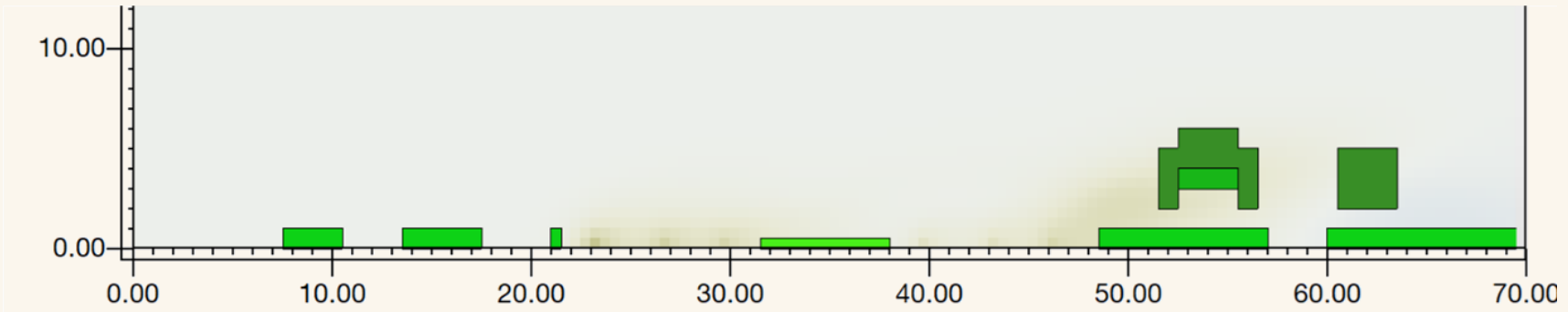
# Alternative Analysis



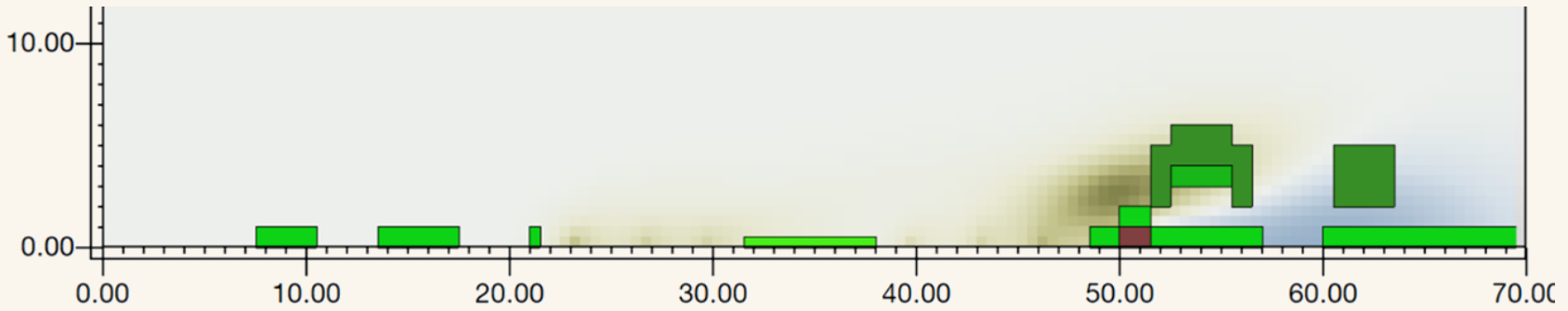


# Air Quality Simulation Studies

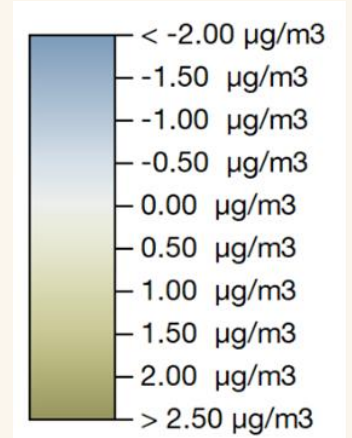
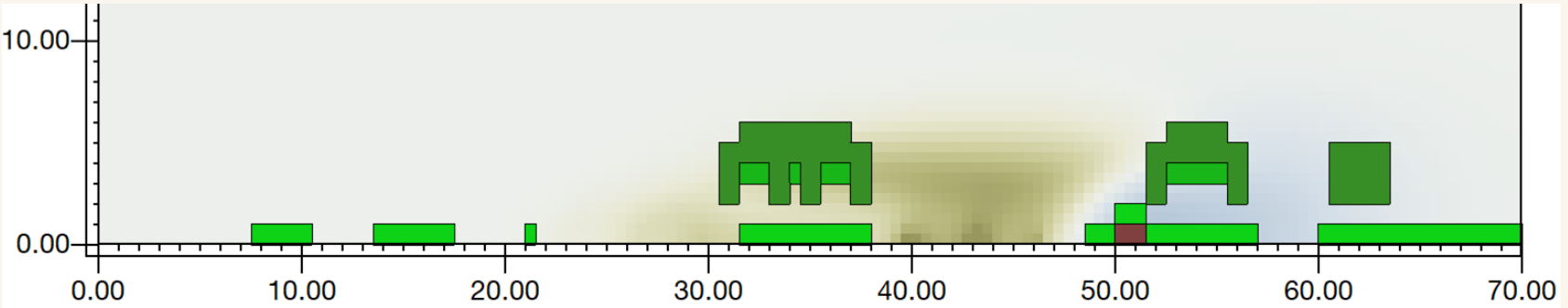
1M GRASS



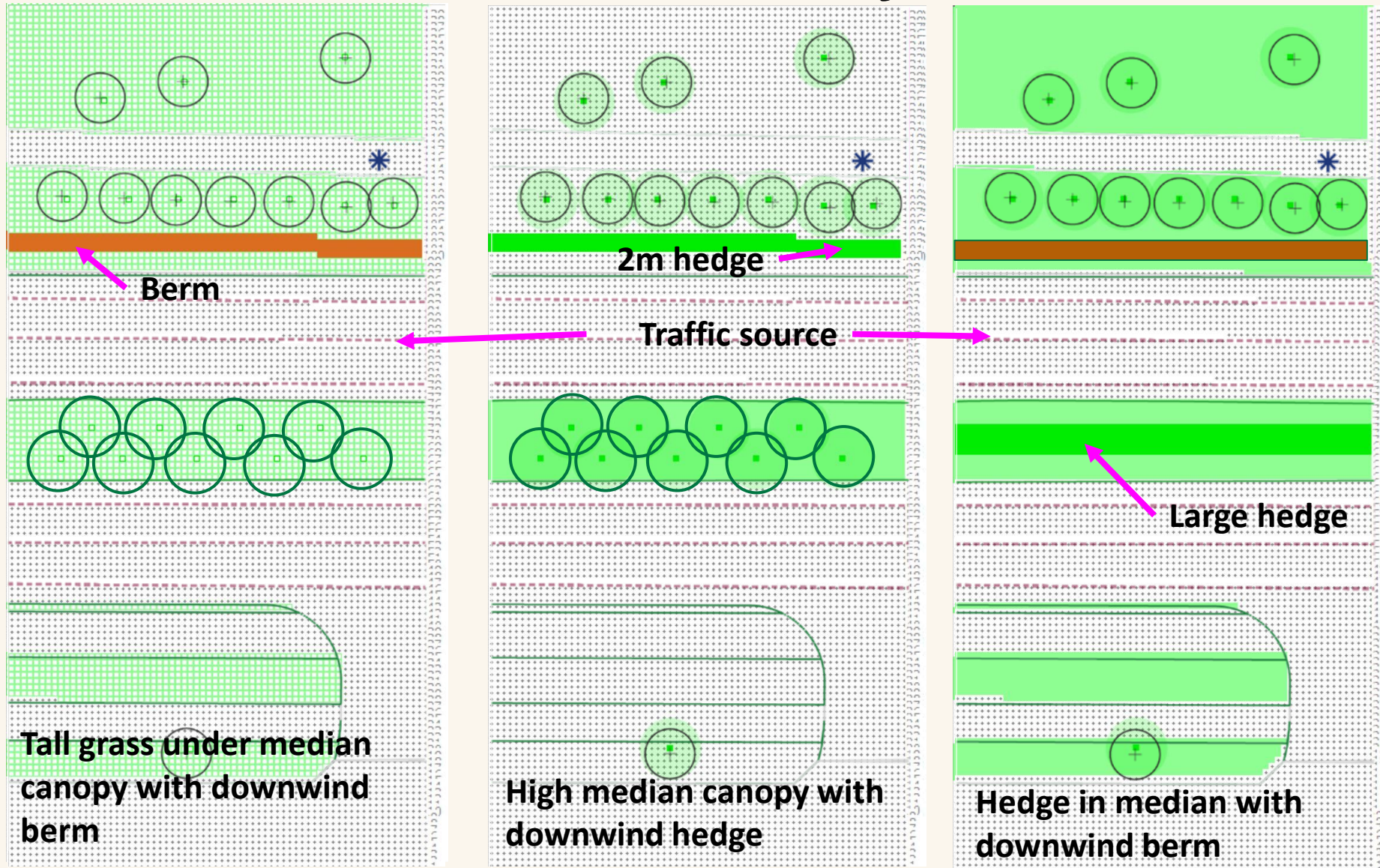
1M GRASS + 1M BERM



1M GRASS + 1M BERM W/ MEDIAN PLANTING

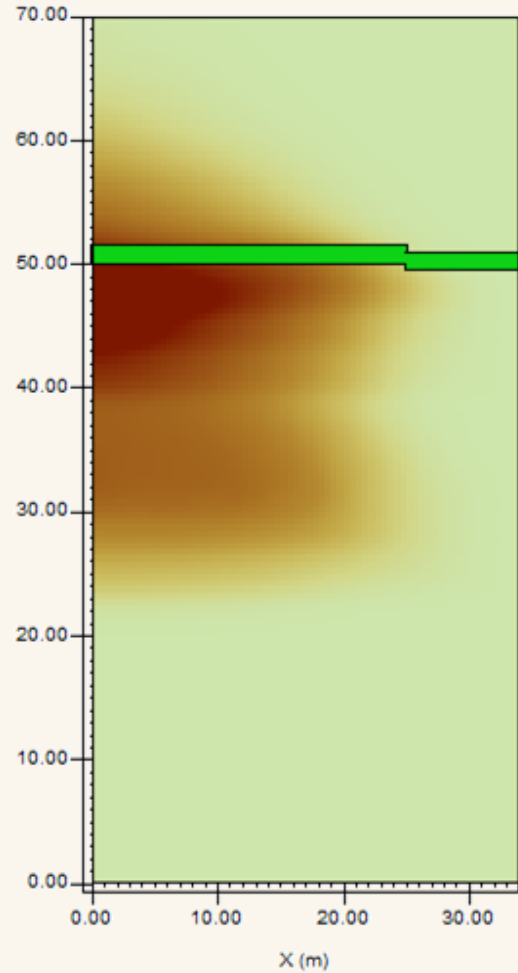
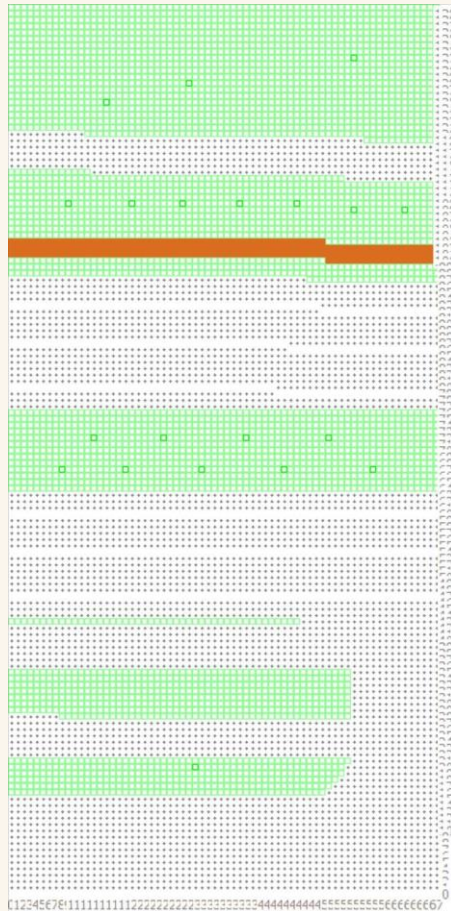


# Alternative Analysis

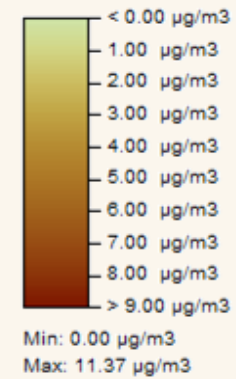




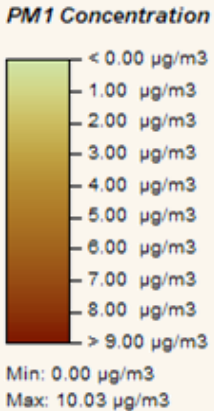
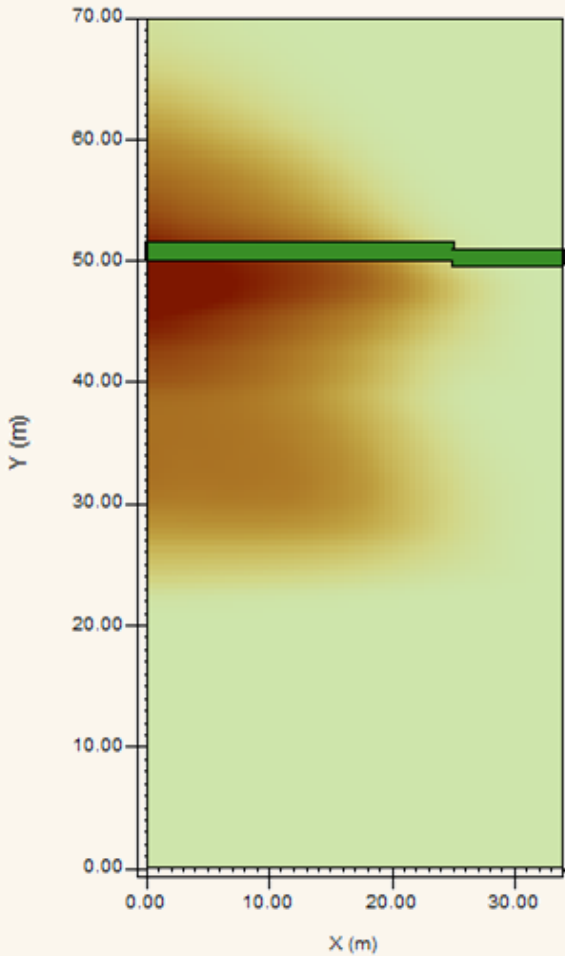
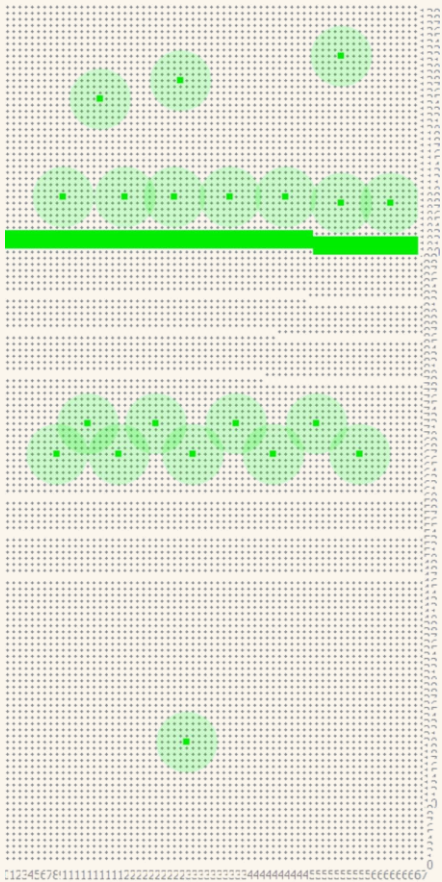
# Tall Grass Under Median Canopy With Downwind Berm



*PM1 Concentration*

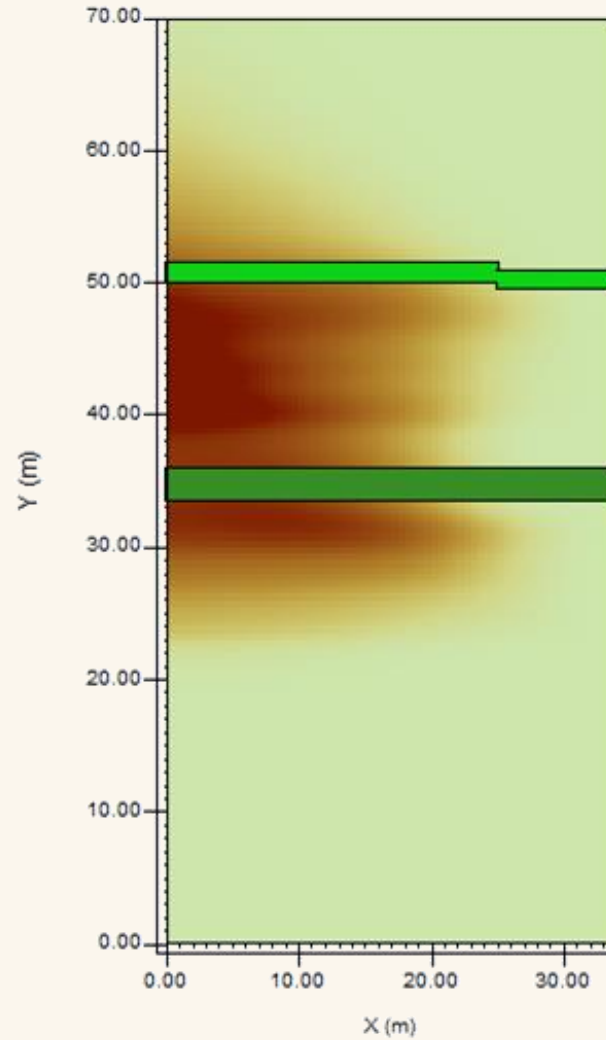


# Tall Grass Under High Median Canopy With Downwind Hedge

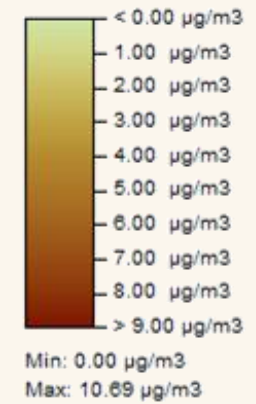




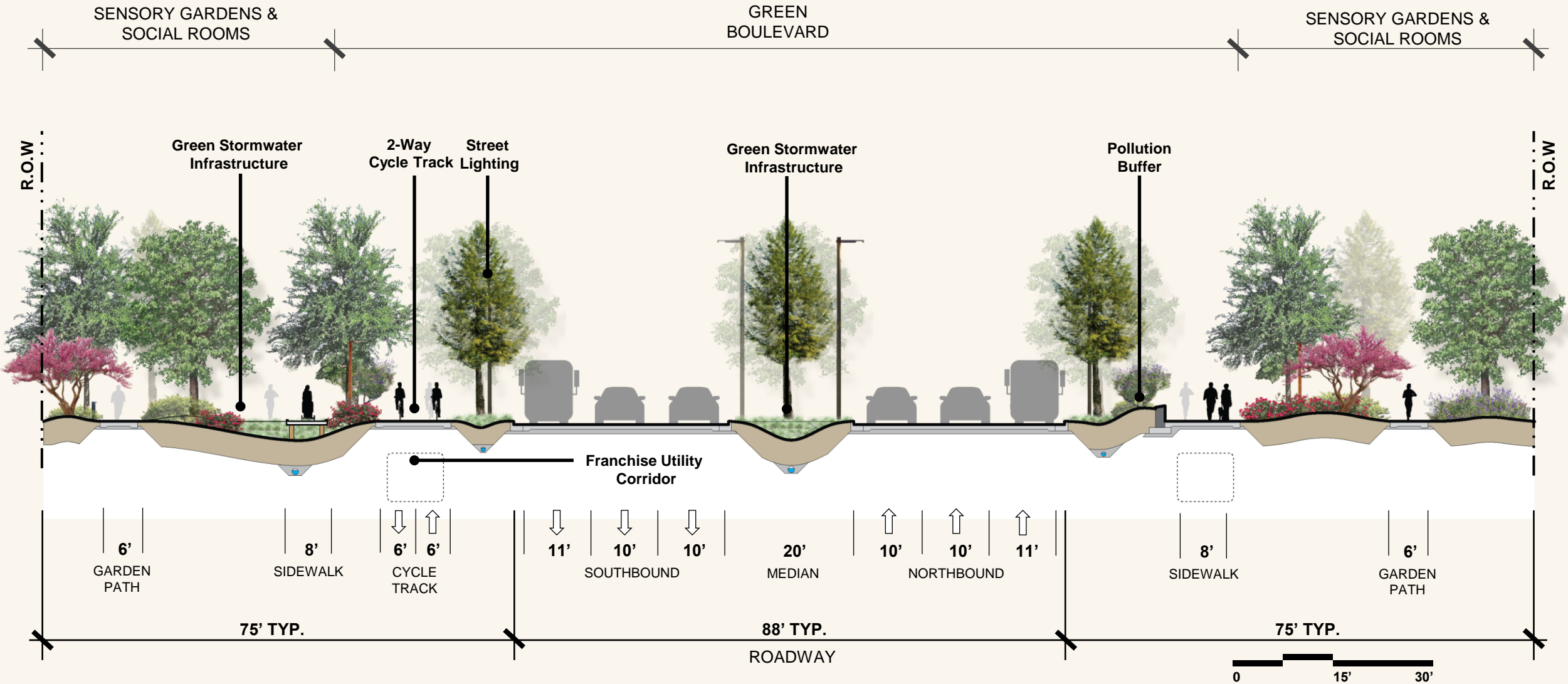
# Hedge In Median With Downwind Berm



*PM1 Concentration*



# The Green Spine: Typical Section

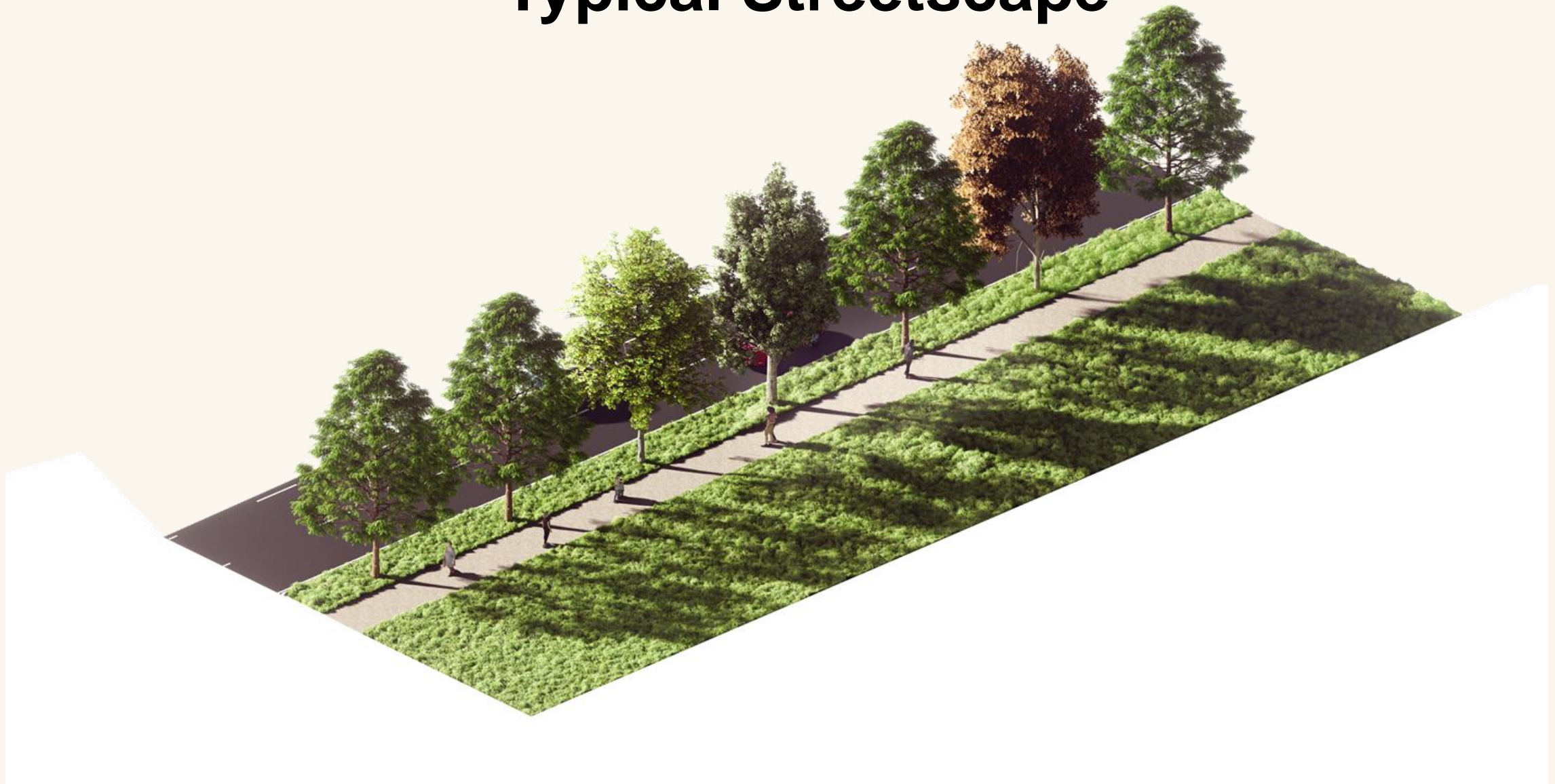






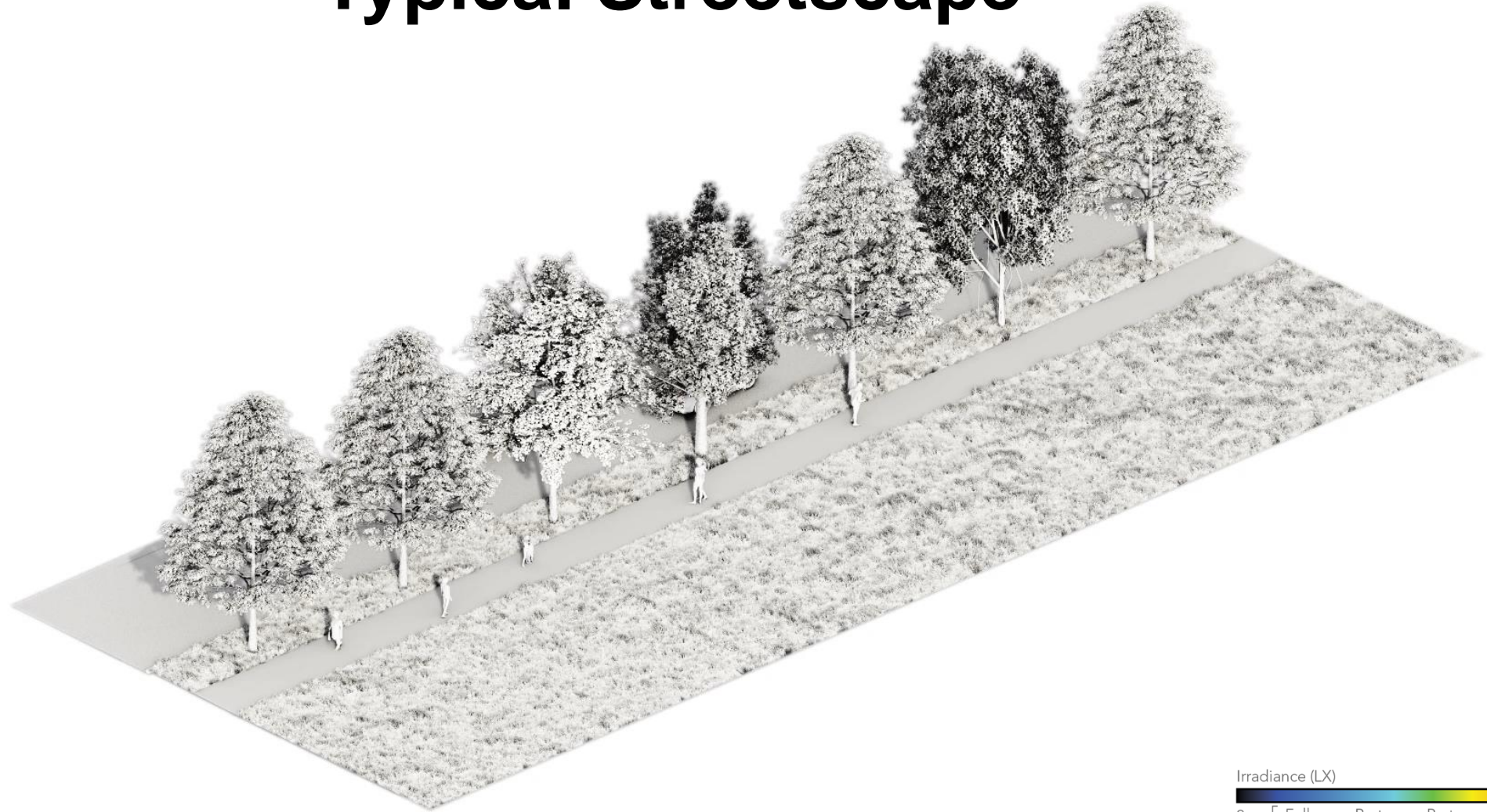


# Typical Streetscape

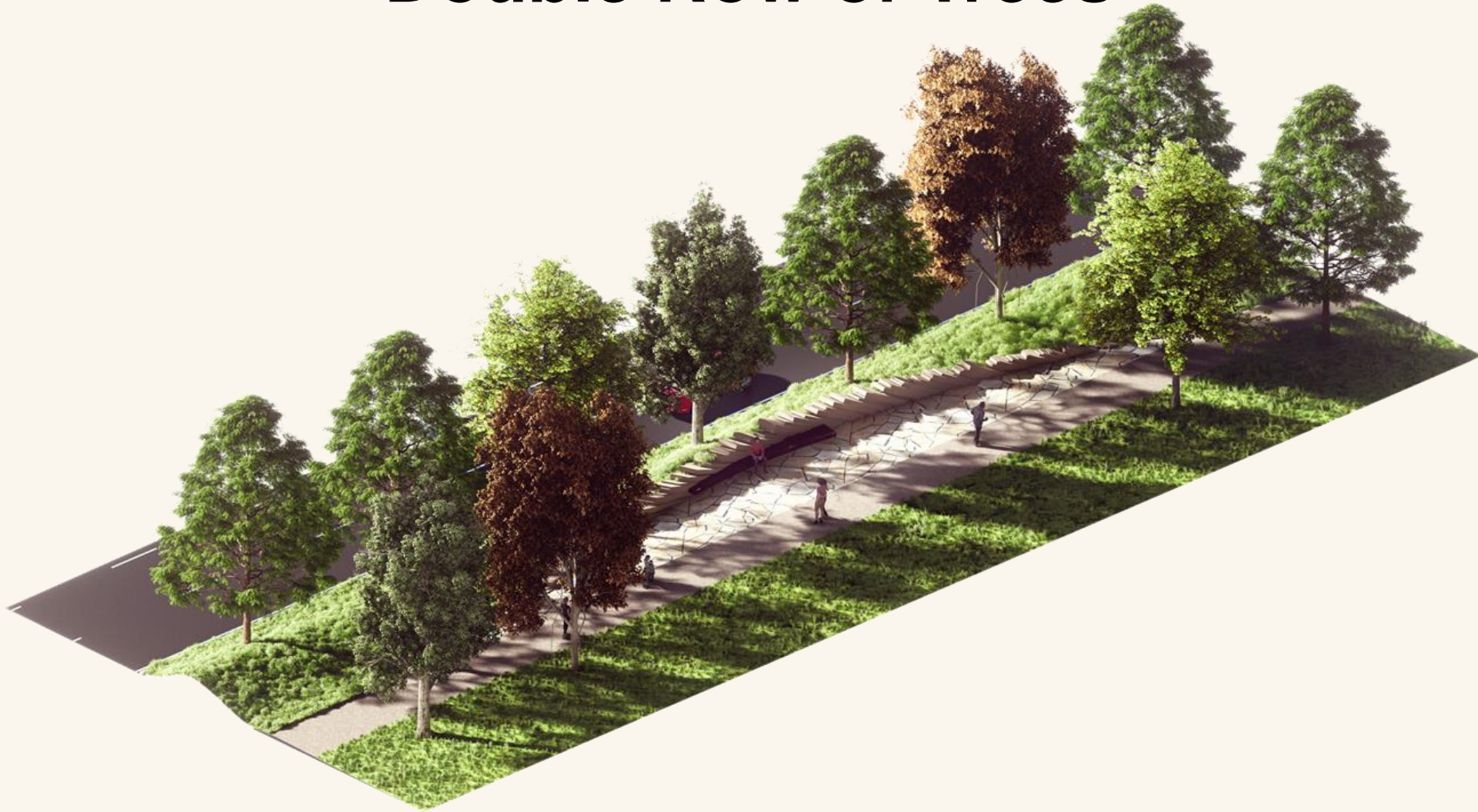




# Typical Streetscape



# Double Row of Trees





# Double Row of Trees

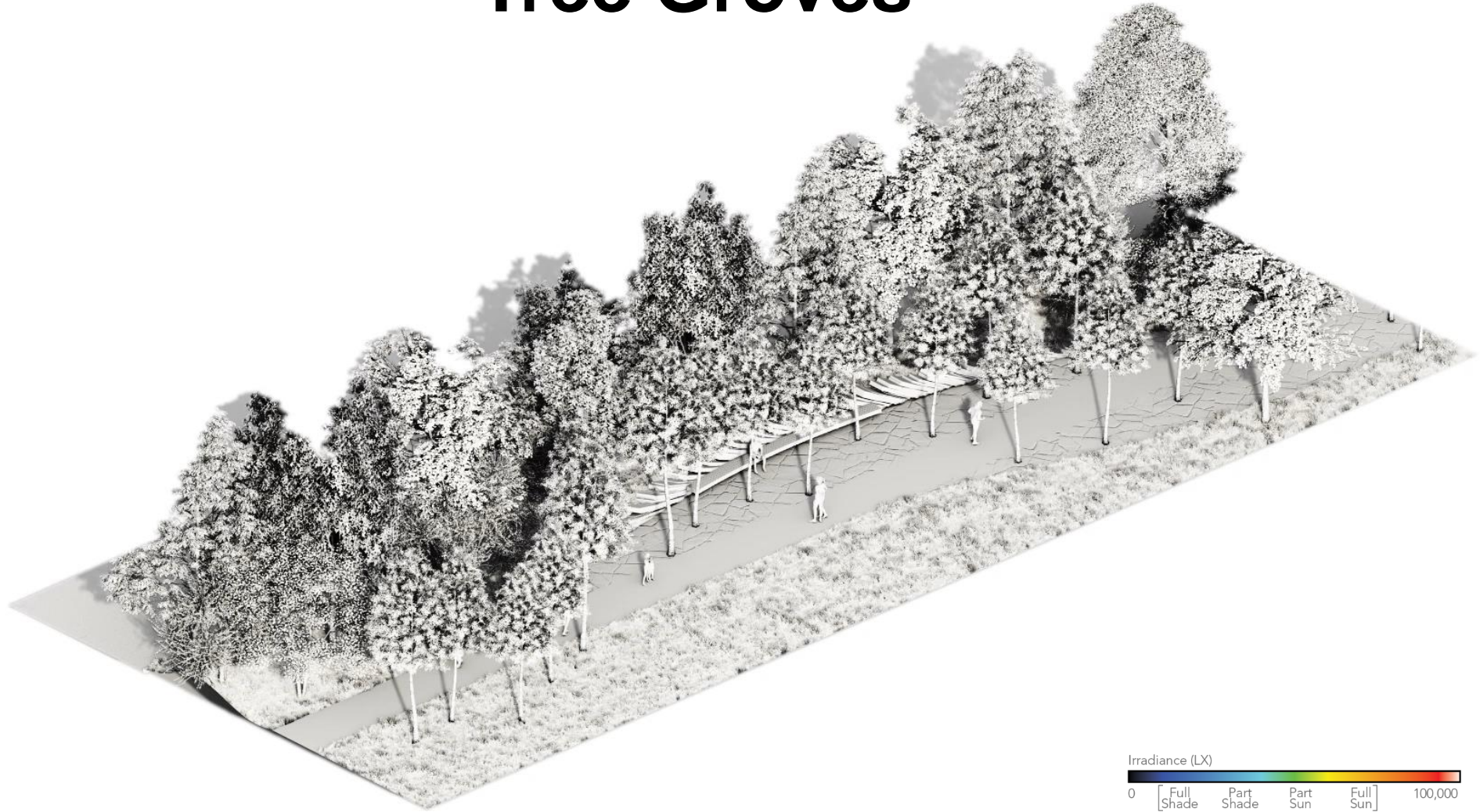


# Tree Groves

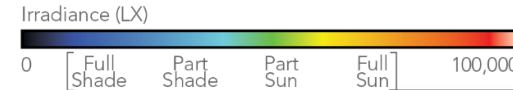
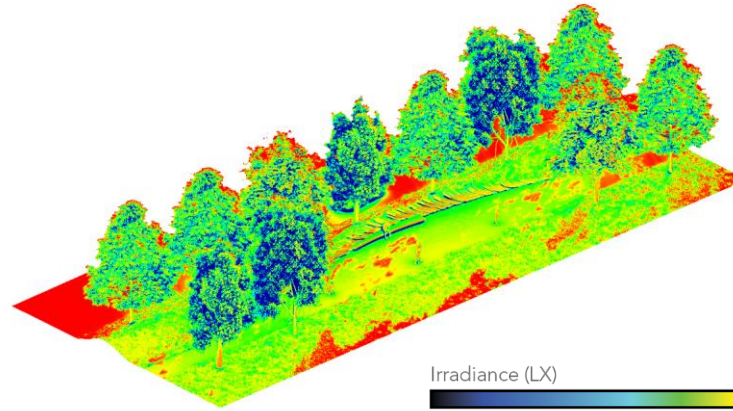
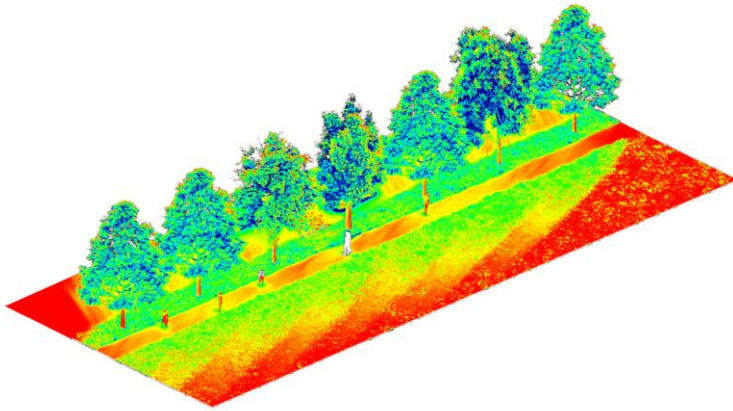




# Tree Groves



# Design Studies: Boulevard Tree Planting



## Typical Streetscape (Single Row)

- Follows Complete Streets Planting Guidelines
- Increases Tree Sizes (from 2"-6" caliper)

## Double Row of Trees

- Adds Second Row of Trees
- Increases Quantities of Trees
- Maintains Tree Size and Spacing of Option 1

## Tree Groves

- Adds Trees of Various Sizes and Spacing along sidewalk





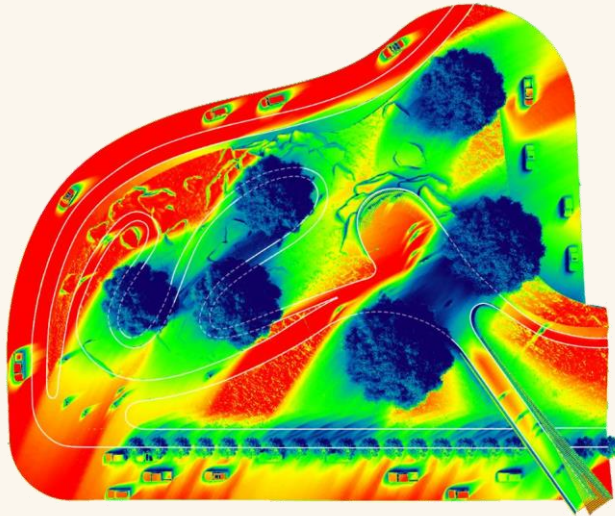




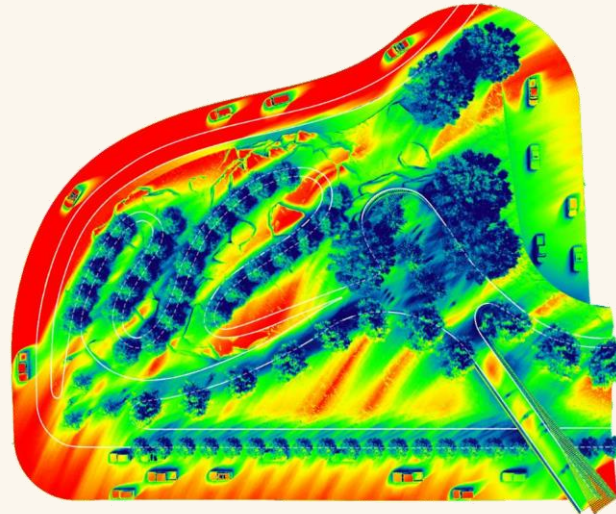
- KEY**
- 1 The Grove and Water Feature
  - 2 Food Truck Parking
  - 3 Campus Walk
  - 4 2-way Cycle Track
  - 5 Footbridge
  - 6 Hillside Meadow
  - 7 O'Donnell Overlook
  - 8 Escarpment Walk
  - 9 Gardens
  - 10 Hilltop Lawns
  - 11 The Balcony
  - 12 Connection to UTSW Connector
  - 13 Connection to UTSW Roof Garden



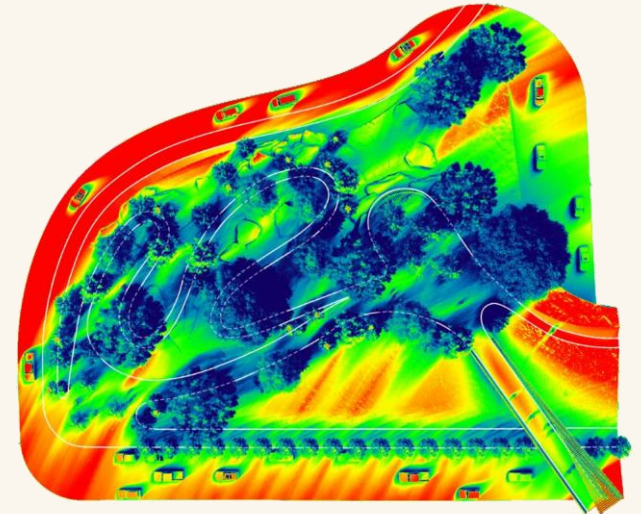
# Design Studies: Park Tree Planting



**Canopy Trees**  
Scattered Across a Lawn



**Tree Rows**  
Medium-sized Trees Lining Paths

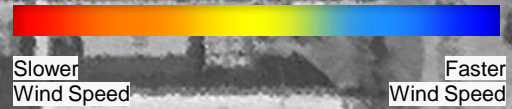


**Tree Clusters**  
Varying Sizes and Spacing





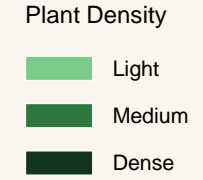
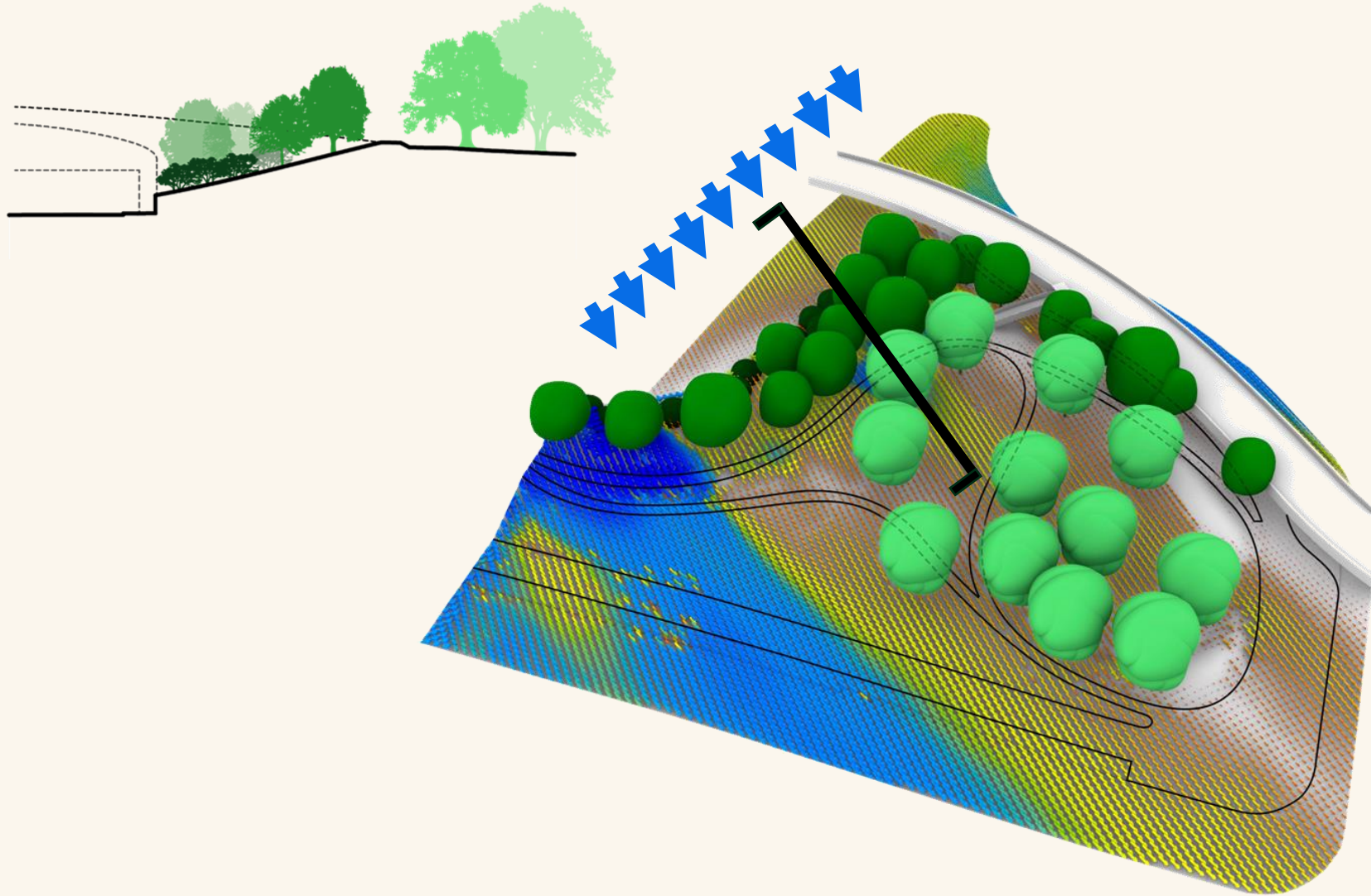




# WIND FLOW ANALYSIS

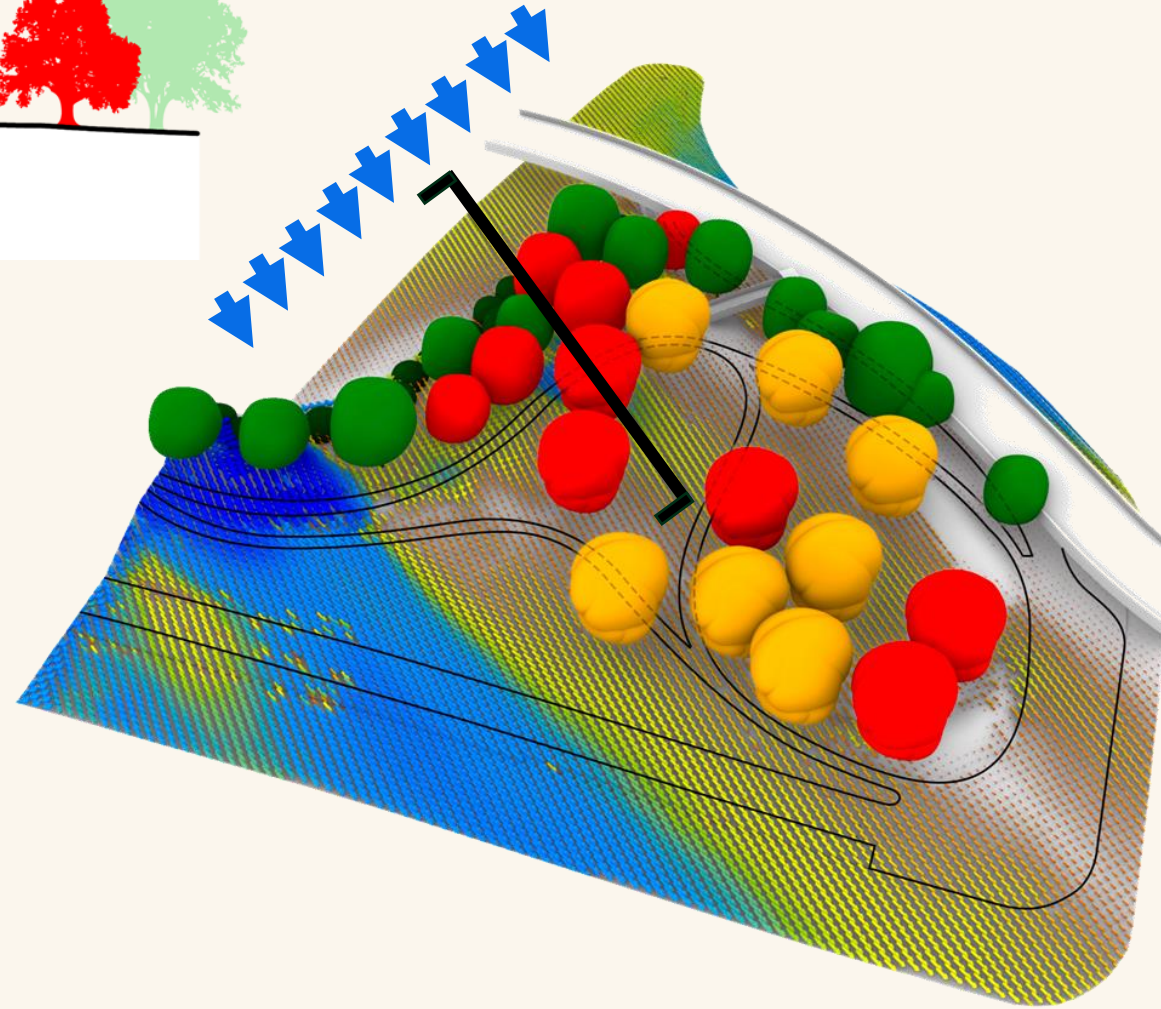


# Maximized Shade





# THERMAL ADJUSTMENT



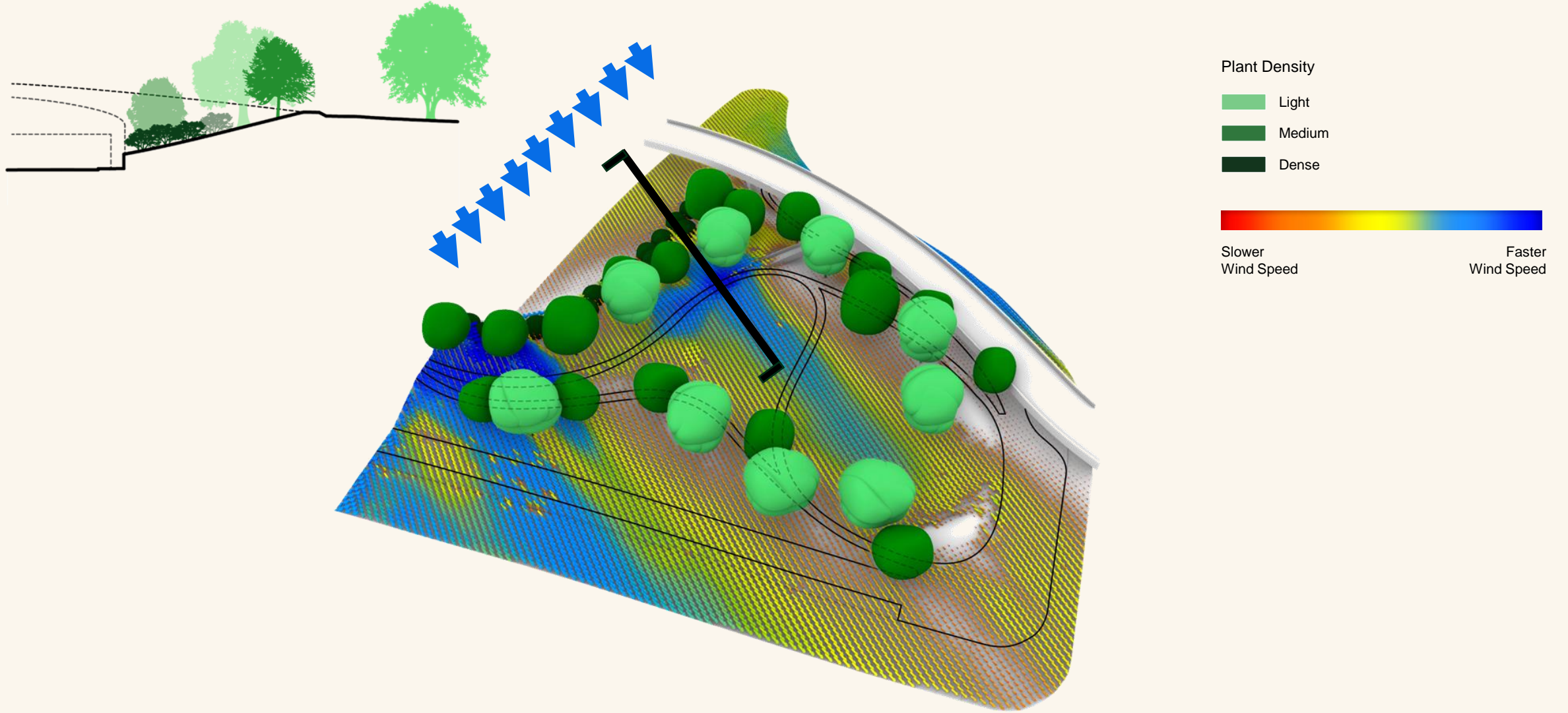
Tree Adjustments

Removed

Relocated



# Mixed Density + Trees At Edges







Hilltop Lawn



# Thank you.

**Hyphae Design Labs:** [Brent@hyphae.net](mailto:Brent@hyphae.net)

**Texas Trees Foundation:** [Lannie@texastrees.org](mailto:Lannie@texastrees.org)



# CEUs

For ISA CEUs, record the code to the right for each session.

Post conference, you can submit all Your CEU codes within the Conference app.

Sign-in sheets for Society of American Foresters (SAF) CFE credits are available at the registration desk post conference.

## Evidence-Based Design for Urban Forestry

Speakers:

Brent Bucknum & Lannie McClelen



**PP-24-923**  
**.5 A, BCMA-S, MS**