

National Aeronautics and
Space Administration



2018 Summer | Arizona – Tempe

WASHOE COUNTY URBAN DEVELOPMENT

Utilizing NASA Earth Observations to Assess
Urban Heat Island Reduction Strategies in
Washoe County, Nevada

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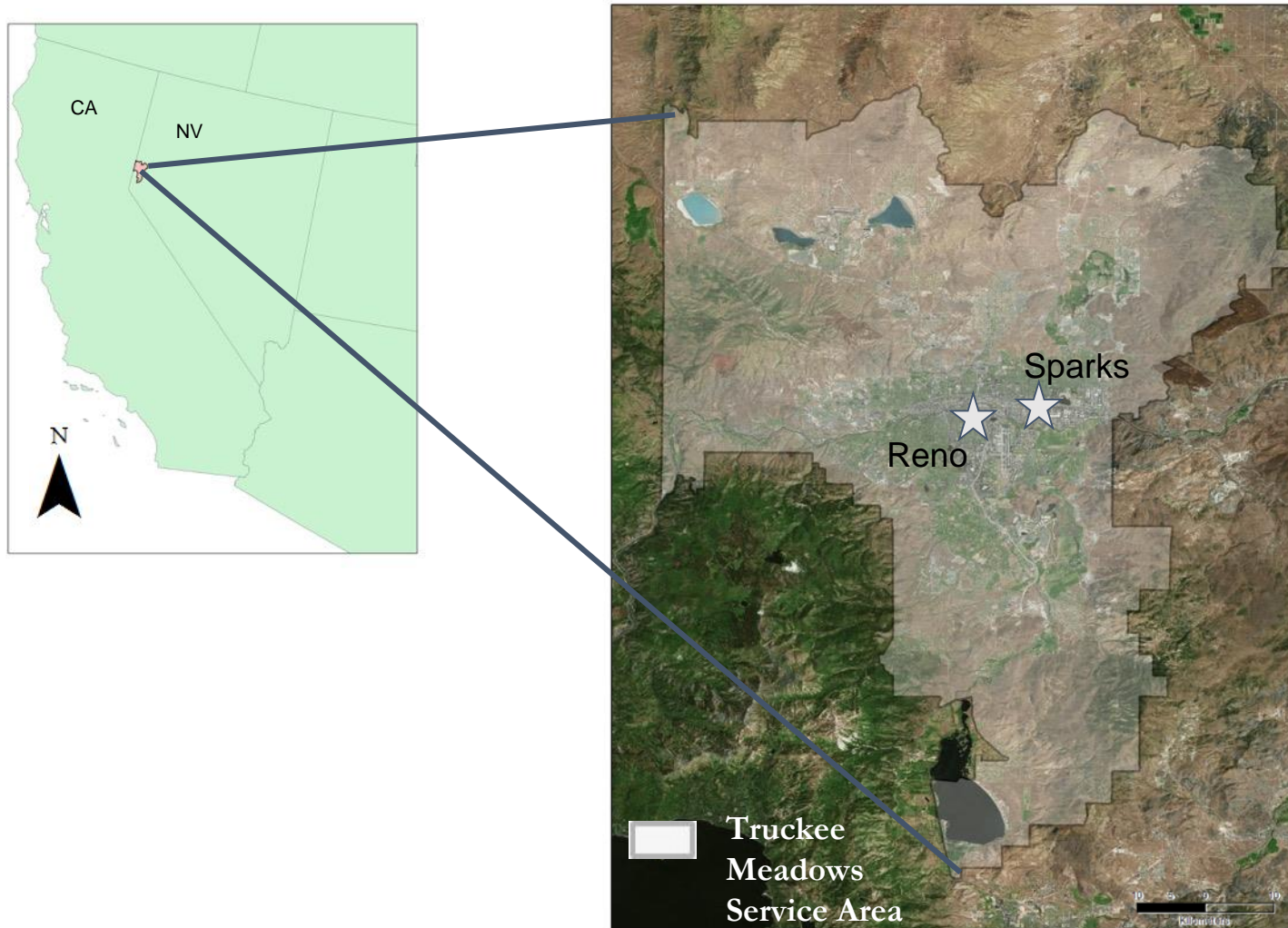




Project Overview



Study Area, 2010-2017



Population characteristics:

- ▶ Population: 241,100 (Reno), 478,000 (Metro)
- ▶ Annual growth rate: 1.3% (23,000 people between 2010-2017)

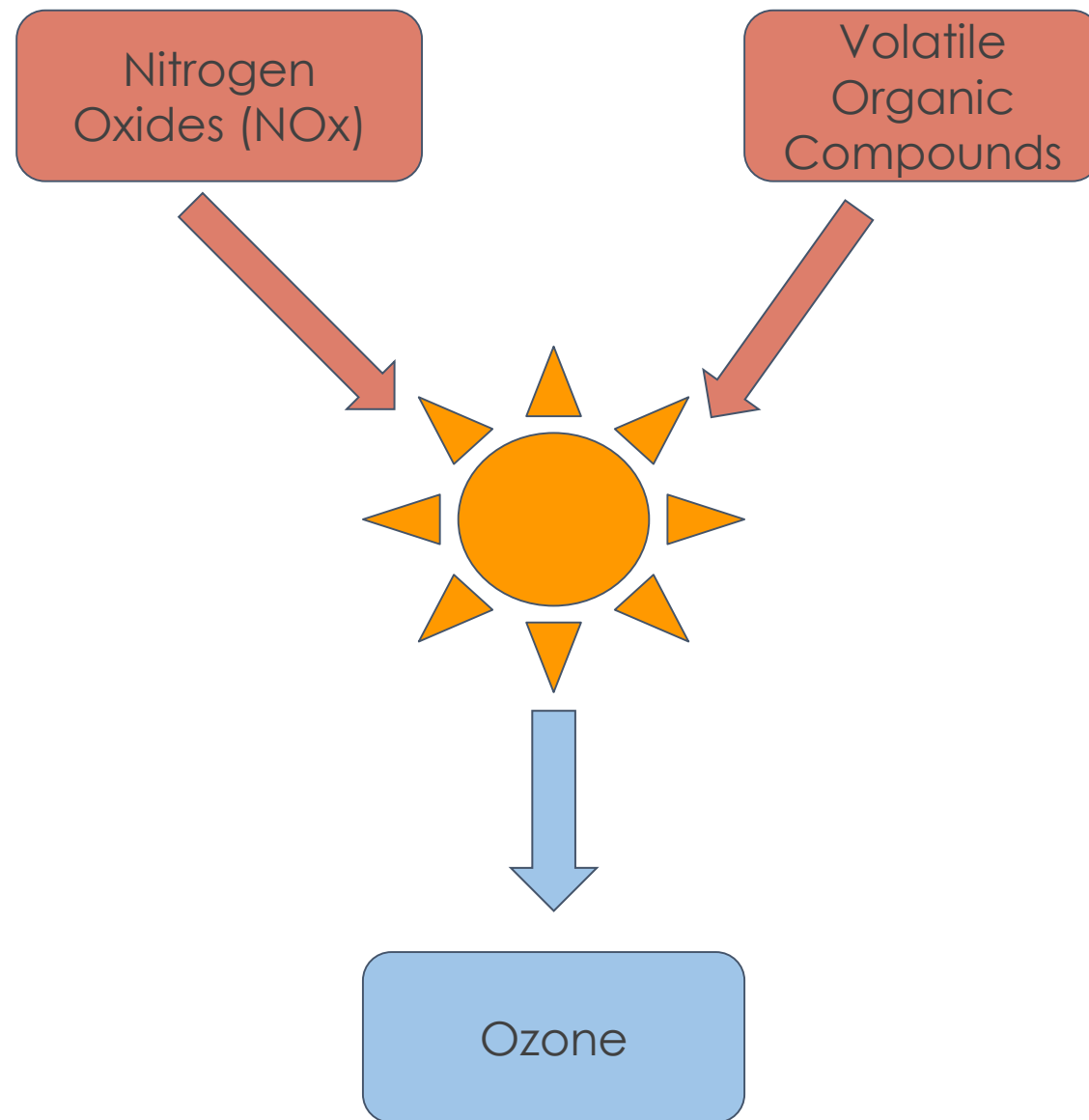
Natural environment:

- ▶ Steppe climate (Köppen: BSk)
- ▶ 4500 ft above sea level
- ▶ 7.48 in annual rainfall



Community Concerns

- ▶ Poor air quality
- ▶ Active transportation discouraged
- ▶ Increased energy demand for cooling
- ▶ Increased risk of heat-related illness and mortality
- ▶ Vulnerable populations at greater risk of negative consequences
- ▶ It's just too dang hot



Partners & Objectives

- ▶ Washoe County Health District, Air Quality Management Division (AQMD)
- ▶ Stantec Consulting Services Inc.
- ▶ **Measure** the extent and magnitude of the UHI
- ▶ **Assess** biophysical factors & **identify** the greatest contributors
- ▶ **Construct** a HVI
- ▶ **Create** a web map



Image Credit: ThisIsReno



Methodology

Data
Acquisition

Data
Processing

Data
Analysis



Methodology

Data
Acquisition

Data
Processing

Data
Analysis

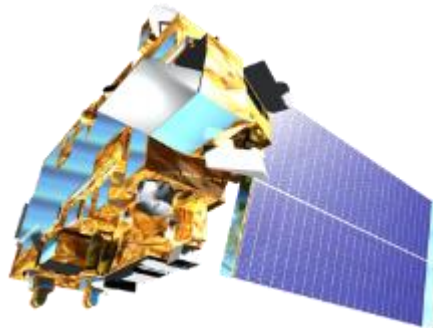


Image Credit: NASA illustration courtesy of Jenny Mottar

NASA Earth Observations



Landsat 5 TM
(2010)



Terra ASTER
(2010)



Landsat 8 OLI/TIRS
(2017)

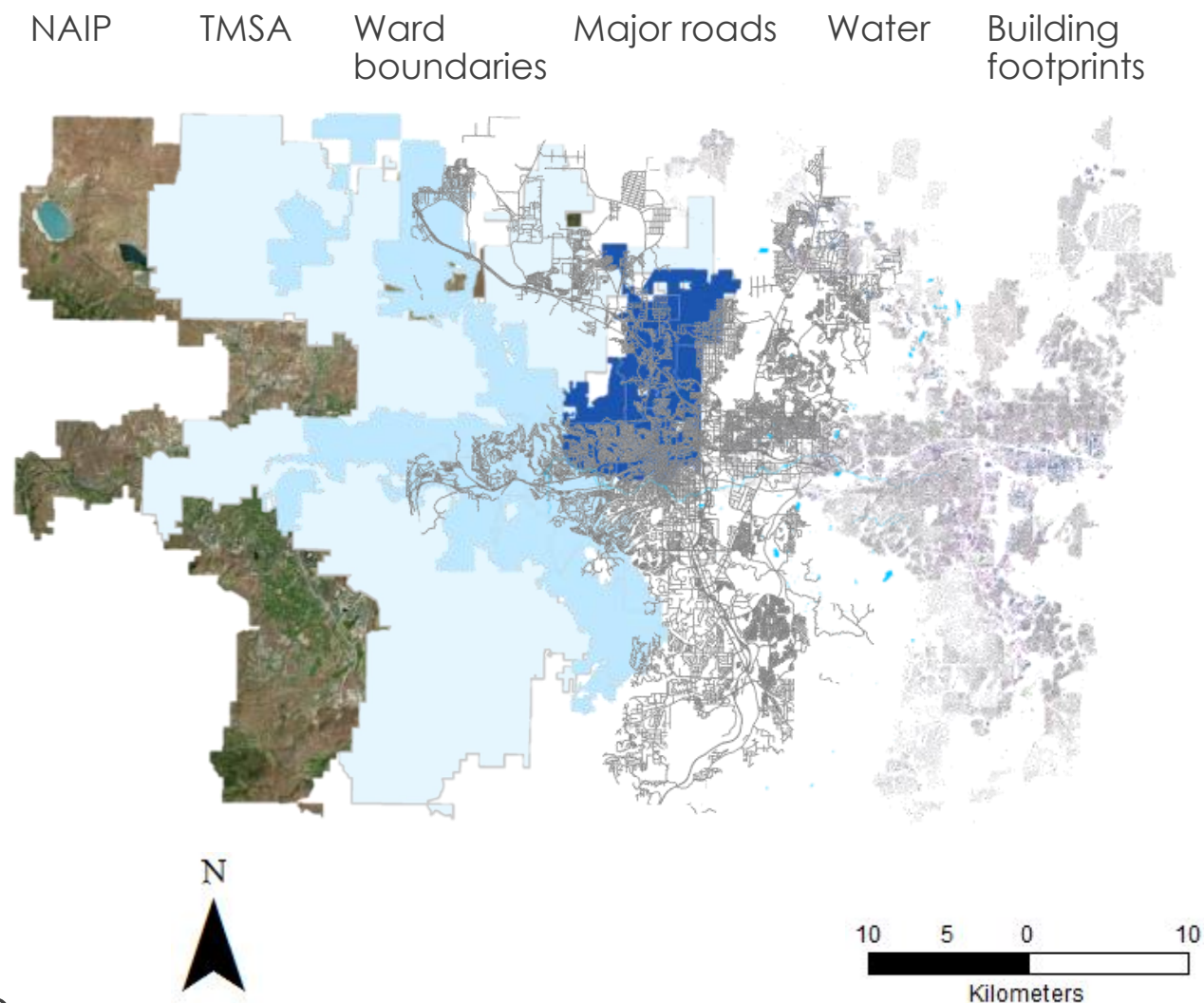


Partner Data

- ▶ Truckee Meadows Service Area (TMSA) boundary
- ▶ Reno-Sparks ward boundaries
- ▶ Building footprints
- ▶ Other municipal data

Ancillary Datasets

- ▶ National Agriculture Imagery Program (NAIP) imagery
- ▶ American Community Survey (ACS), US Census
- ▶ 500 Cities Project, CDC
- ▶ National Land Cover Database (NLCD)





Methodology

Data
Acquisition

Data
Processing

Data
Analysis



Delineating Study Area

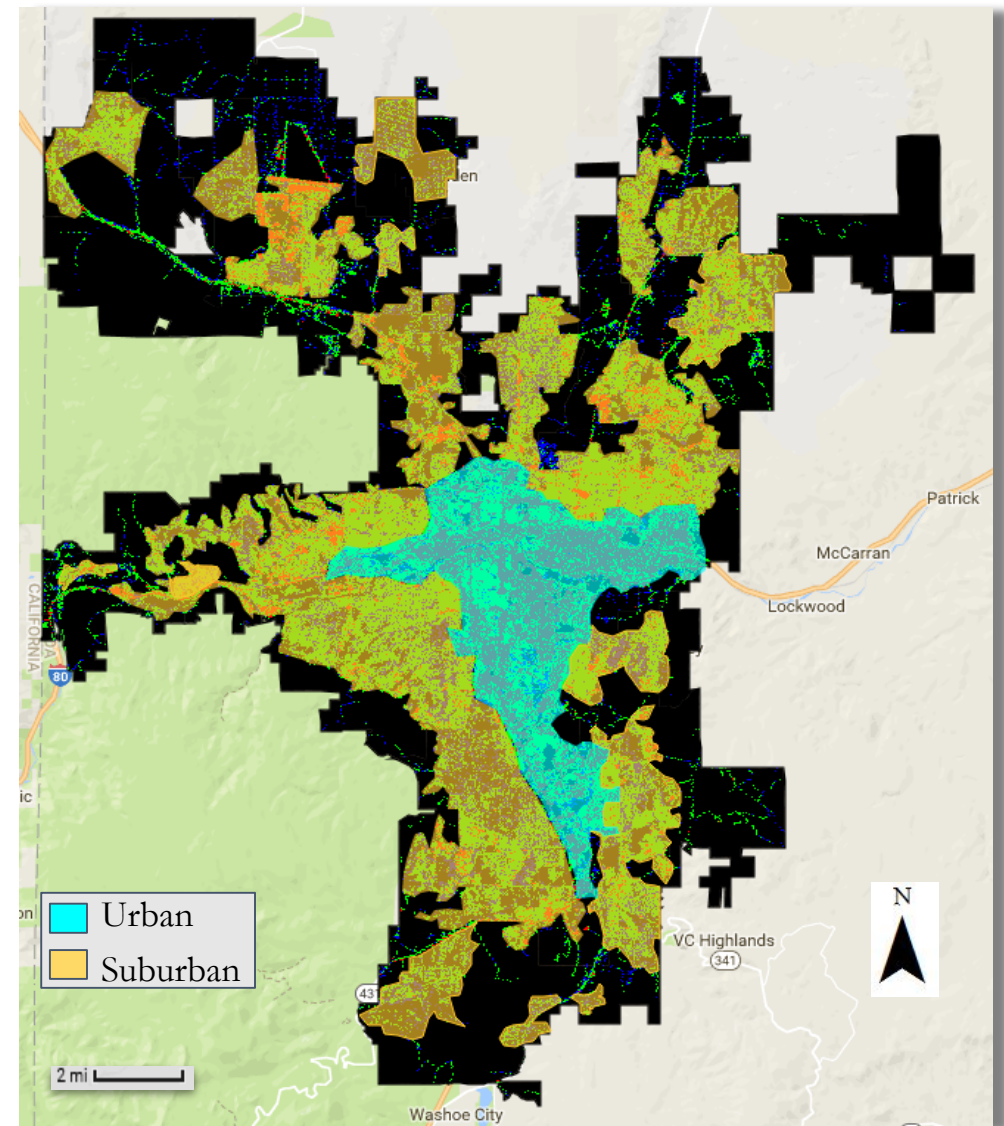
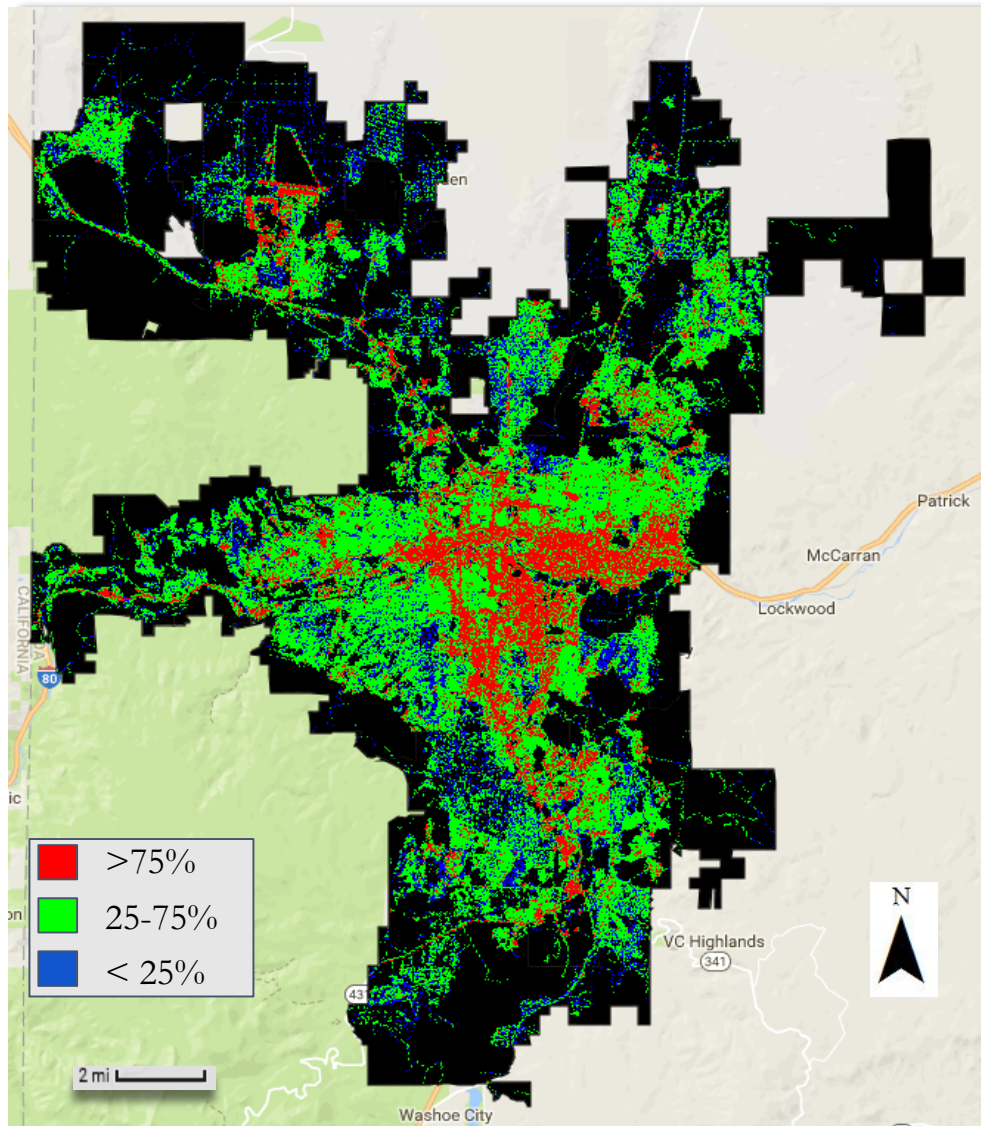
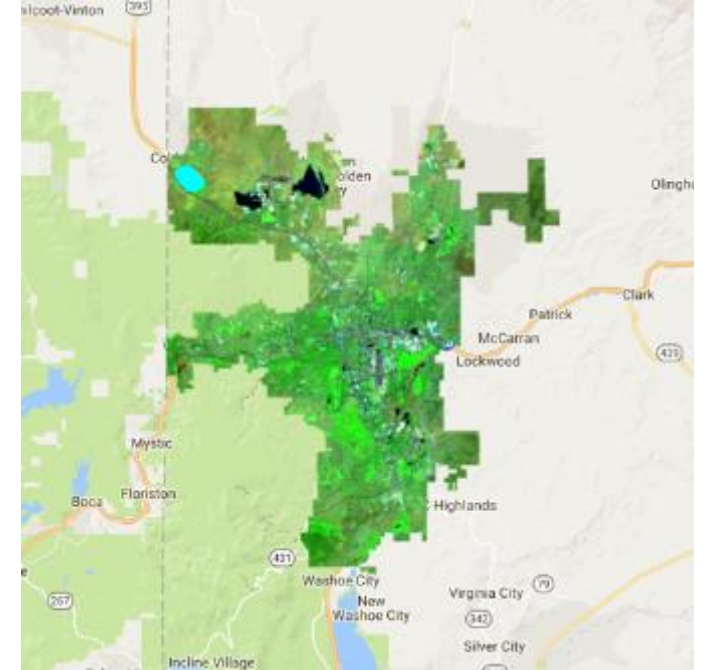


Image Processing in Google Earth Engine

- ▶ Cloud filtering
- ▶ Top of Atmosphere (TOA) and surface reflectance
- ▶ Mosaic and clip






Data Processing in ArcGIS

GEOID *	Age Under 5
14000US32031000101	0
14000US32031000102	11
14000US32031000201	108
14000US32031000202	74
14000US32031000300	12
14000US32031000400	121
14000US32031000700	137
14000US32031000900	95
14000US32031001005	62
14000US32031001008	299
14000US32031001009	34
14000US32031001010	46

TRACTFIPS	GEOID_Data	Age Under 5	Asthma Prevalence
32031000101	14000US32031000101	0	9.4
32031000102	14000US32031000102	11	10.6
32031000201	14000US32031000201	108	10.7
32031000202	14000US32031000202	74	10.6
32031000300	14000US32031000300	12	9.2
32031000400	14000US32031000400	121	9.2
32031000700	14000US32031000700	137	9.4
32031000900	14000US32031000900	95	10.7
32031001005	14000US32031001005	62	8.9
32031001008	14000US32031001008	299	10.7
32031001009	14000US32031001009	34	9.4
32031001010	14000US32031001010	46	8.6

TractFIPS	Asthma Prevalence
32031000101	9.4
32031000101	9.4
32031000102	10.6
32031000102	10.6
32031000201	10.7
32031000201	10.7
32031000202	10.6
32031000202	10.6
32031000300	9.2
32031000300	9.2
32031000400	9.2
32031000400	9.2

- ▶ Selecting and deriving variables
- ▶ Joining data



Identify

Identify from: **WashoeCounty_CensusTract_Boundaries**

☐ WashoeCounty_CensusTract_Boundaries

1.01

Location: -43,711,226.353 14,420,364.011 Feet

Field	Value
TRACTFIPS	32031000101
GEOID_Data	14000US32031000101
Age Under 5	0
Asthma Prevalence	9.4

Identified 1 feature



Methodology

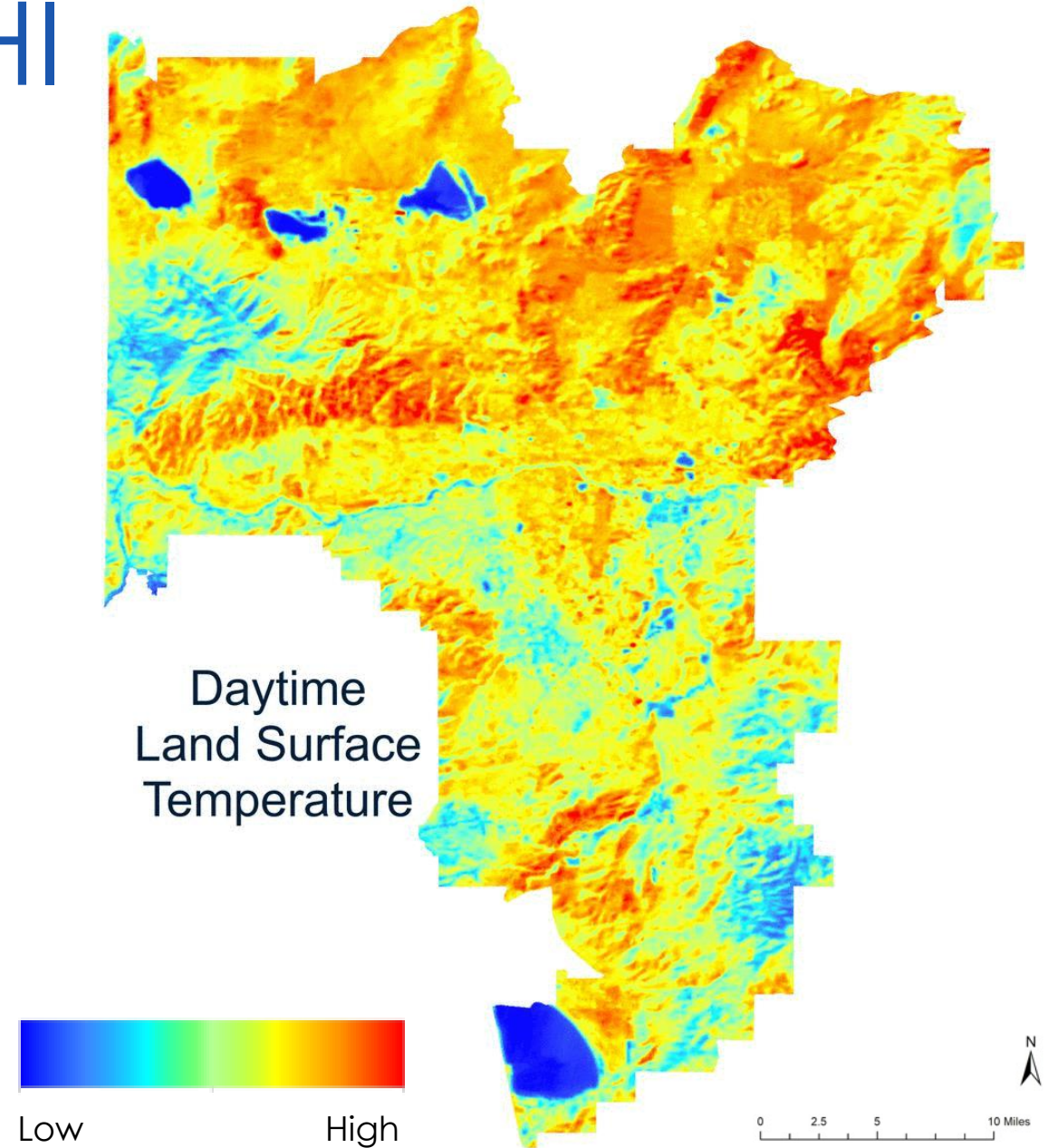
Data
Acquisition

Data
Processing

Data
Analysis

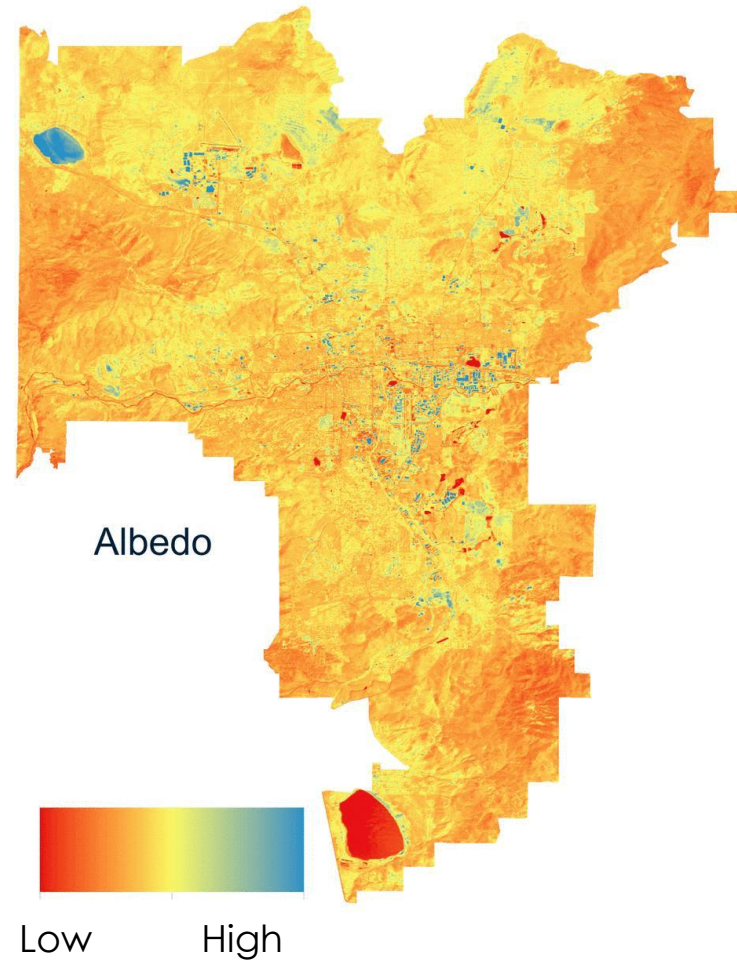
Measuring the UHI

- ▶ ASTER nighttime temperature image
- ▶ Landsat daytime and nighttime temperature image
- ▶ UHI intensity

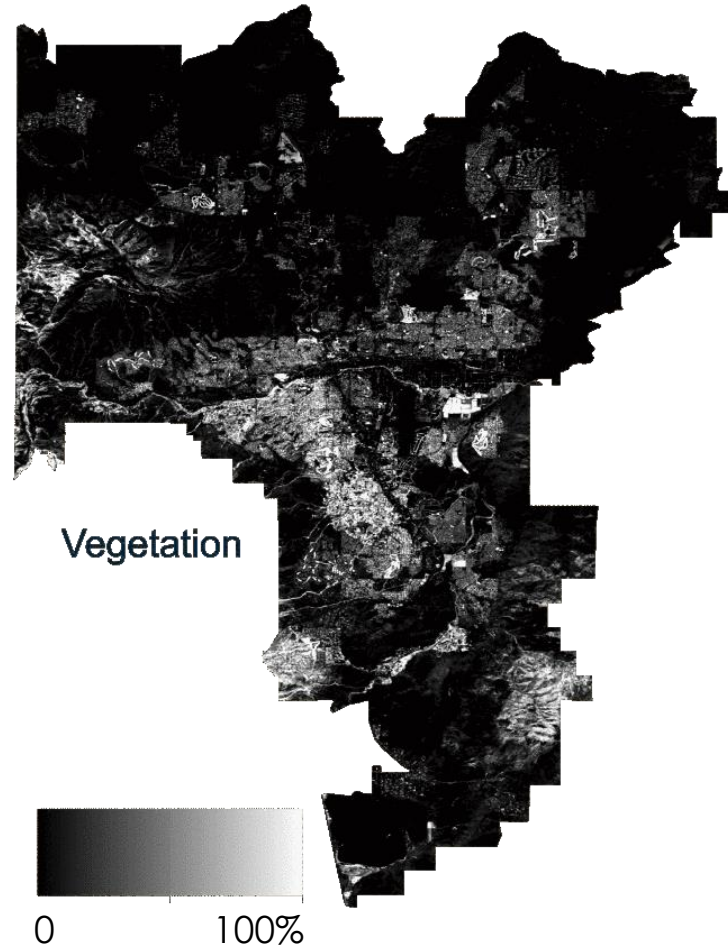


Assessing Biophysical Parameters

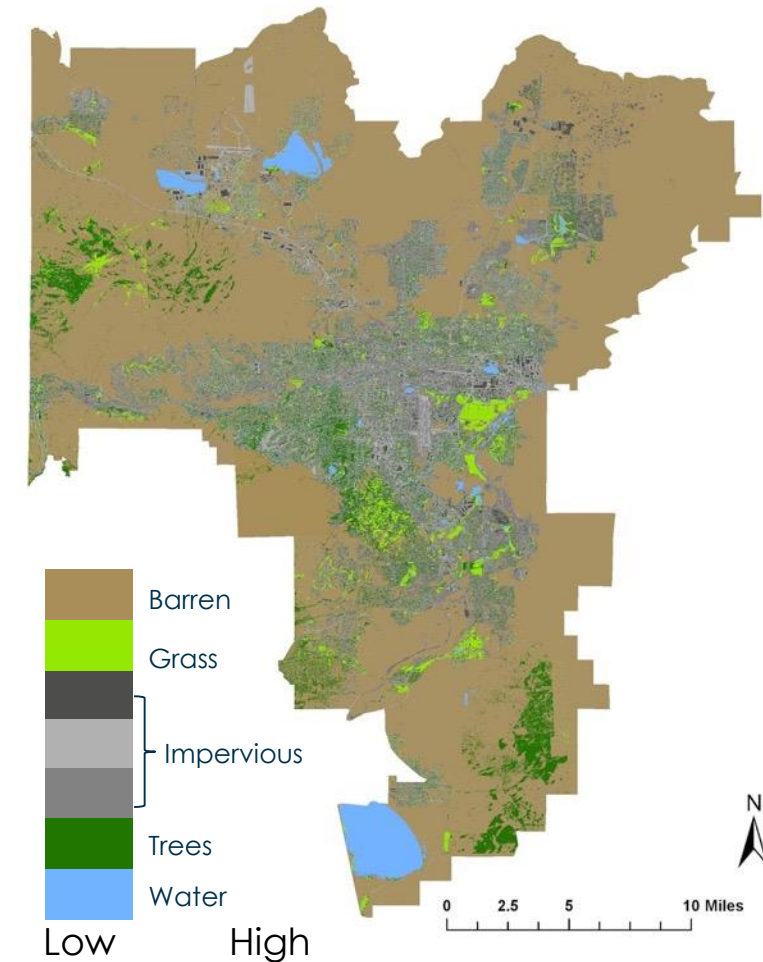
- ▶ Coarse resolution image derivative



- ▶ Coarse resolution subpixel analysis



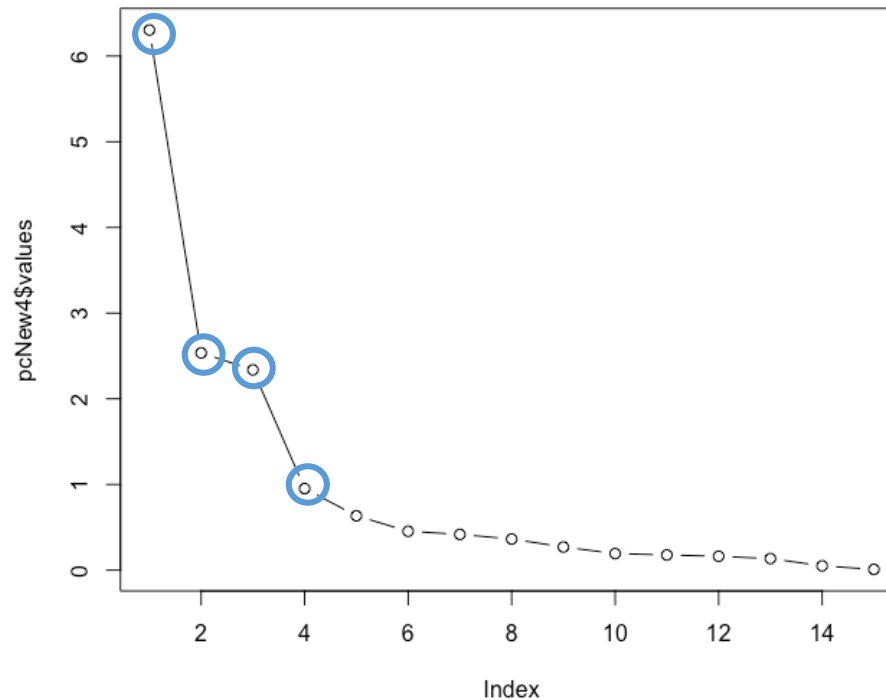
- ▶ High resolution object-based classification





Constructing the HVI

VARIABLES
Age
Race
Income
Household characteristics
Neighborhood Stability
Education
Disability status
Chronic disease
Health access and behavior



4 PCA factors

Heat
vulnerability
map

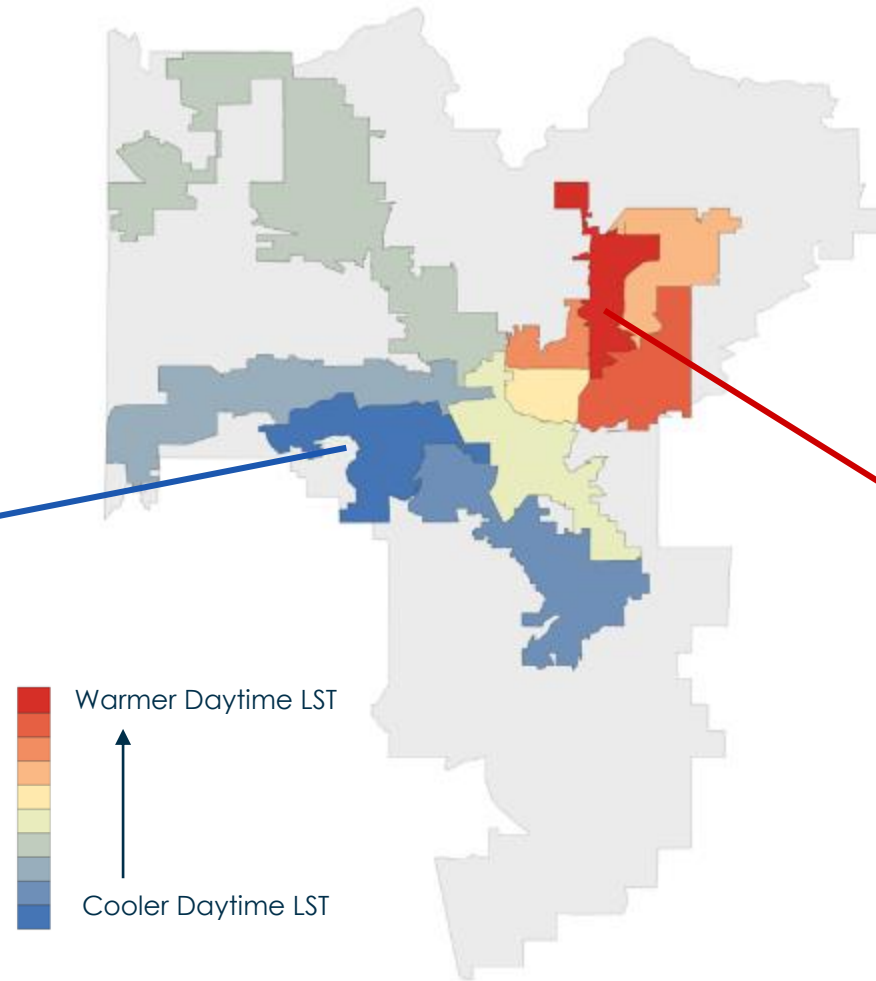


Results



UHI Assessment

Coolest Ward	
Daytime LST (°F)	101.1
Nighttime LST (°F)	66.7
% Impervious	27.8
% Vegetation	30.9
NDVI	0.25
Built-up	-0.02
Albedo	0.158

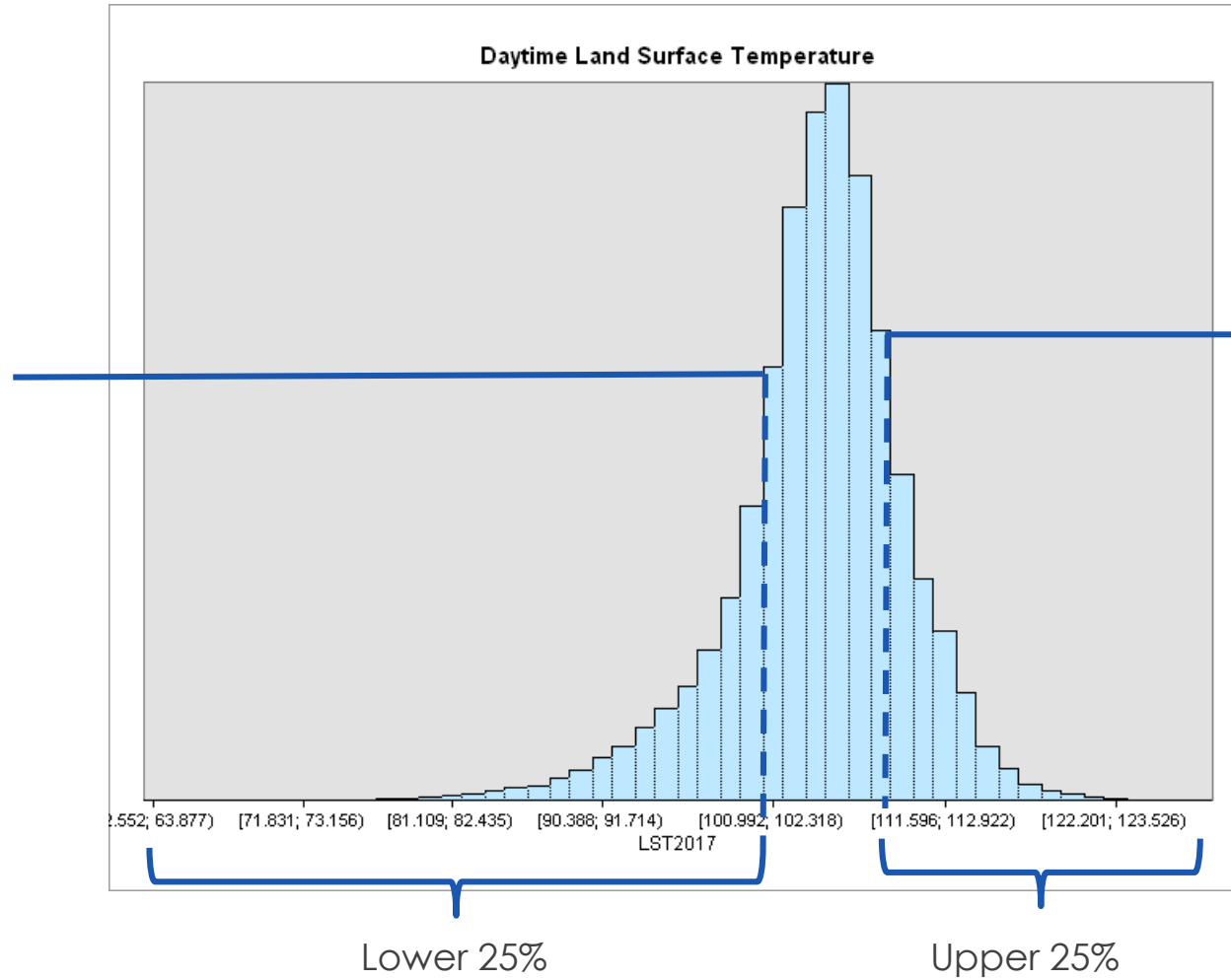


Warmest Ward	
Daytime LST (°F)	106.7
Nighttime LST (°F)	65.4
% Impervious	27.8
% Vegetation	16.1
NDVI	0.18
Built-up	-0.05
Albedo	0.171



Daytime LST – Biophysical Relationship

Lower LST	
Tree (%)	16.5
Grass (%)	9.3
Impervious (%)	38.5



Upper LST	
Tree (%)	2.9
Grass (%)	0.3
Impervious (%)	34.1

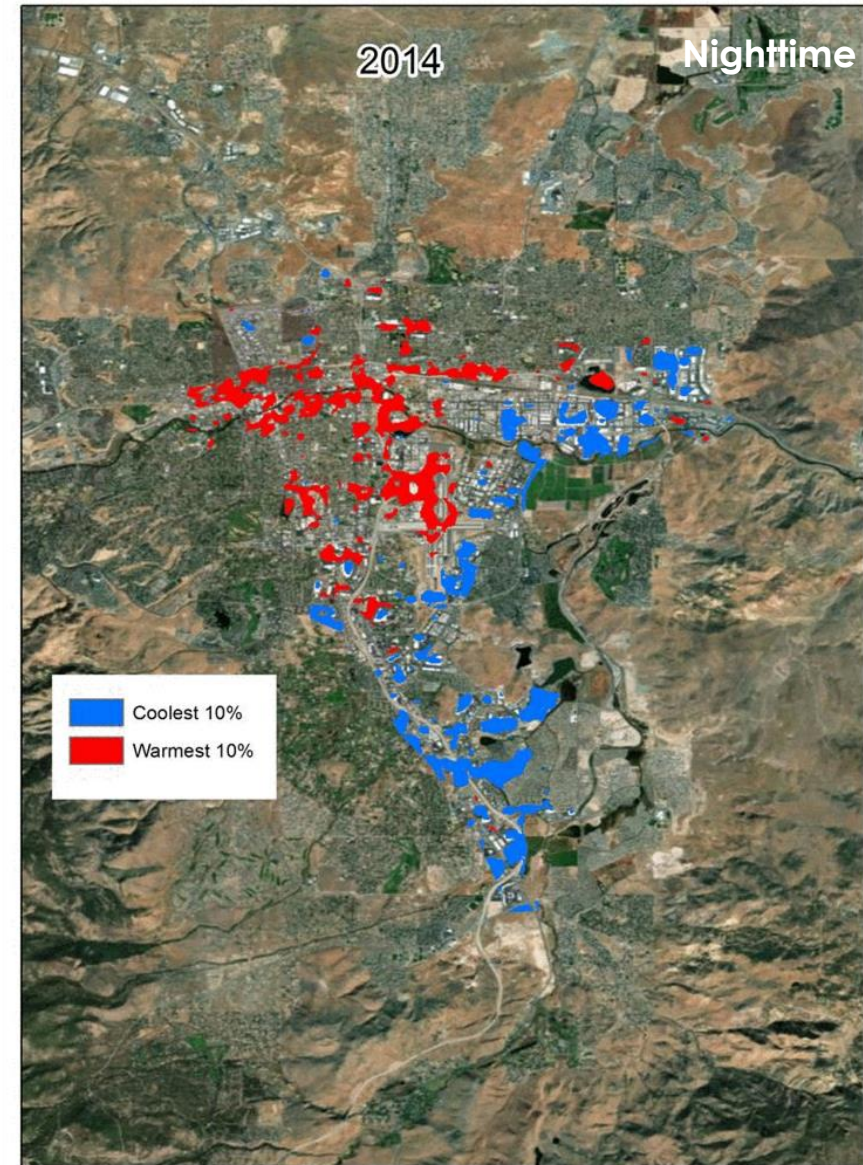
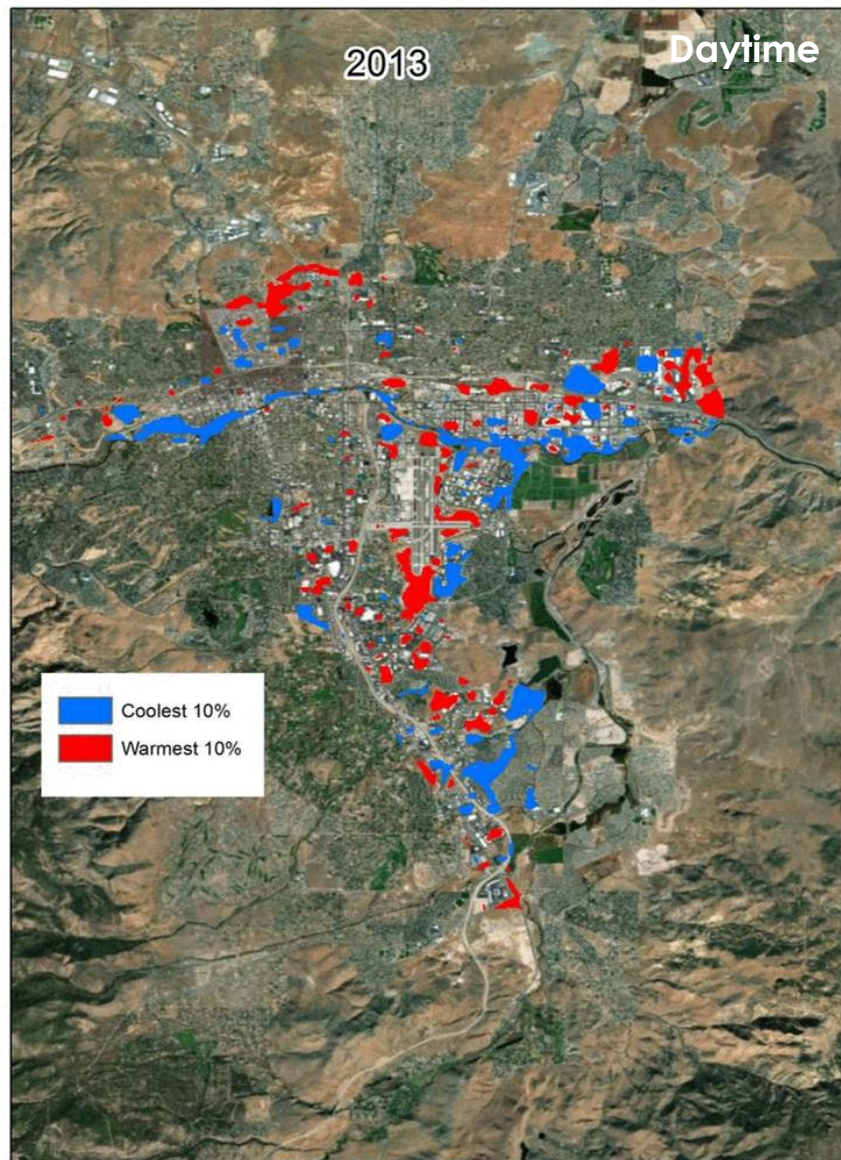


Biophysical Descriptives

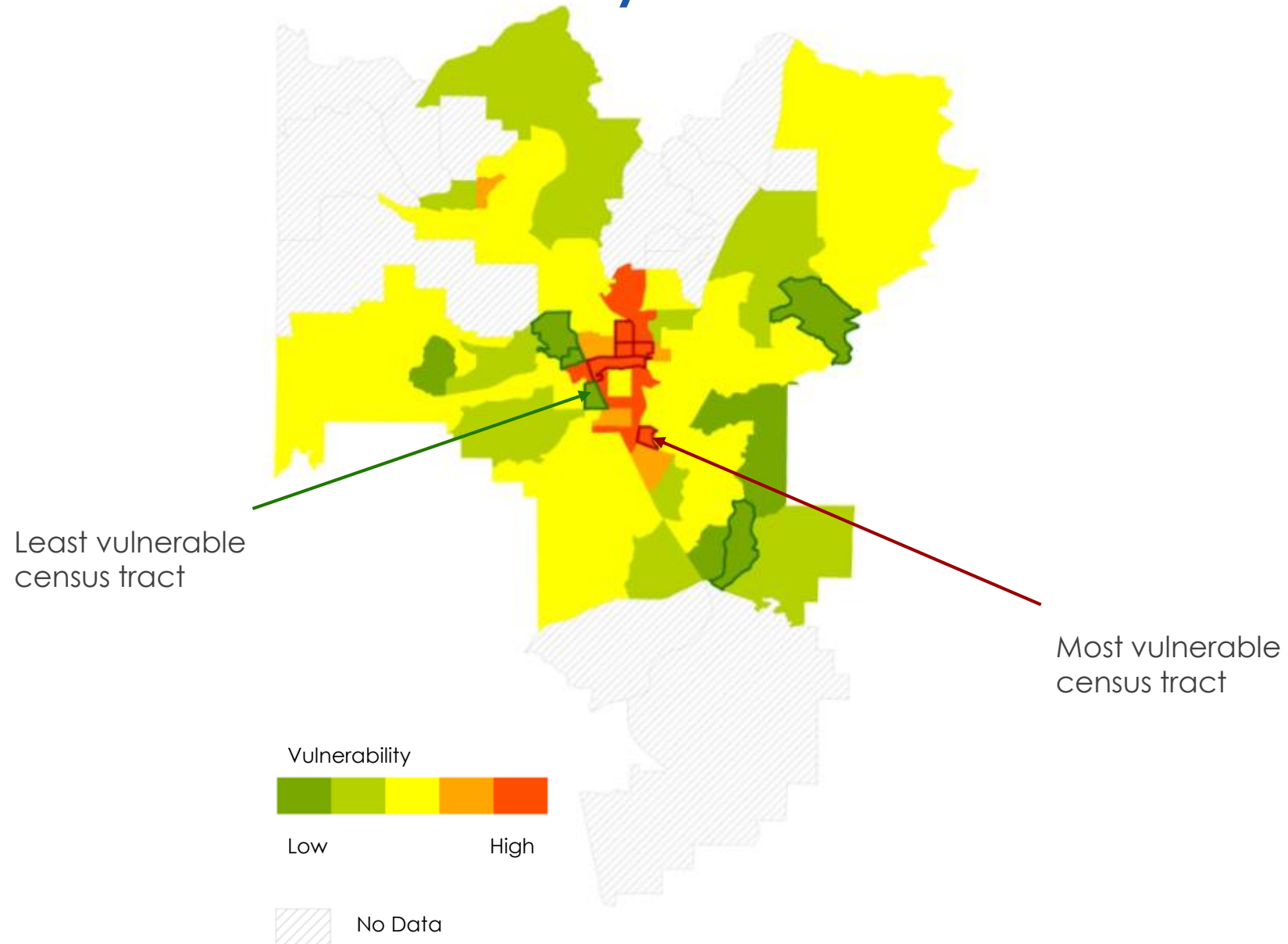
- ▶ Grass and trees have an inverse relationship with temperature
- ▶ Impervious surface had no significant relationship
- ▶ Soil (or barren land) has positive relationship with temperature

Biophysical variable	Daytime temperature lower 25th percentile	Daytime temperature upper 25th percentile
Grass	104.7	94.3
Tree Canopy	105.0	96.6
Impervious Surface	104.7	100.6
Soil (barren land)	101.3	106.6

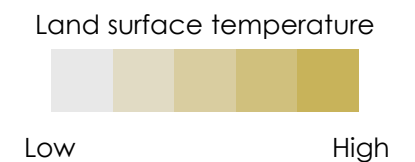
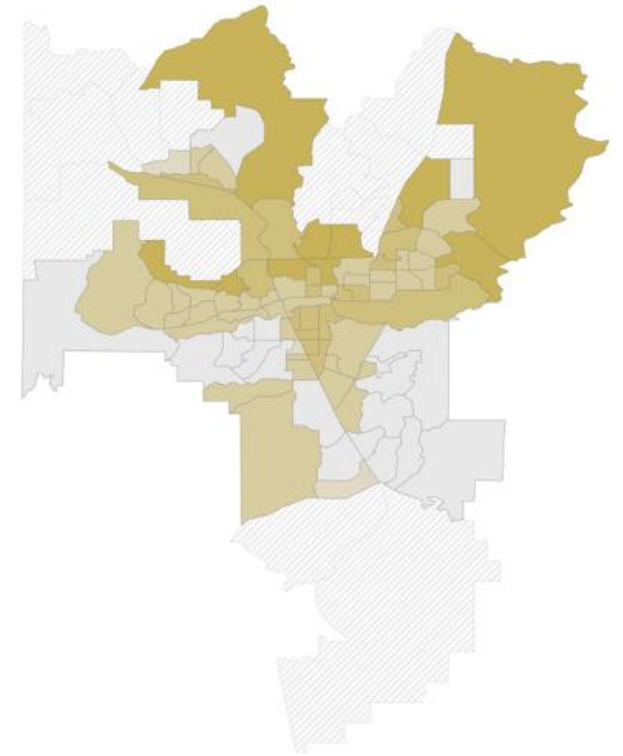
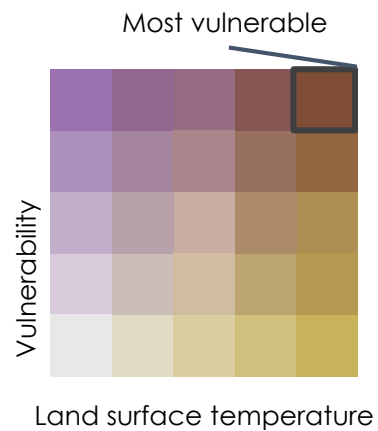
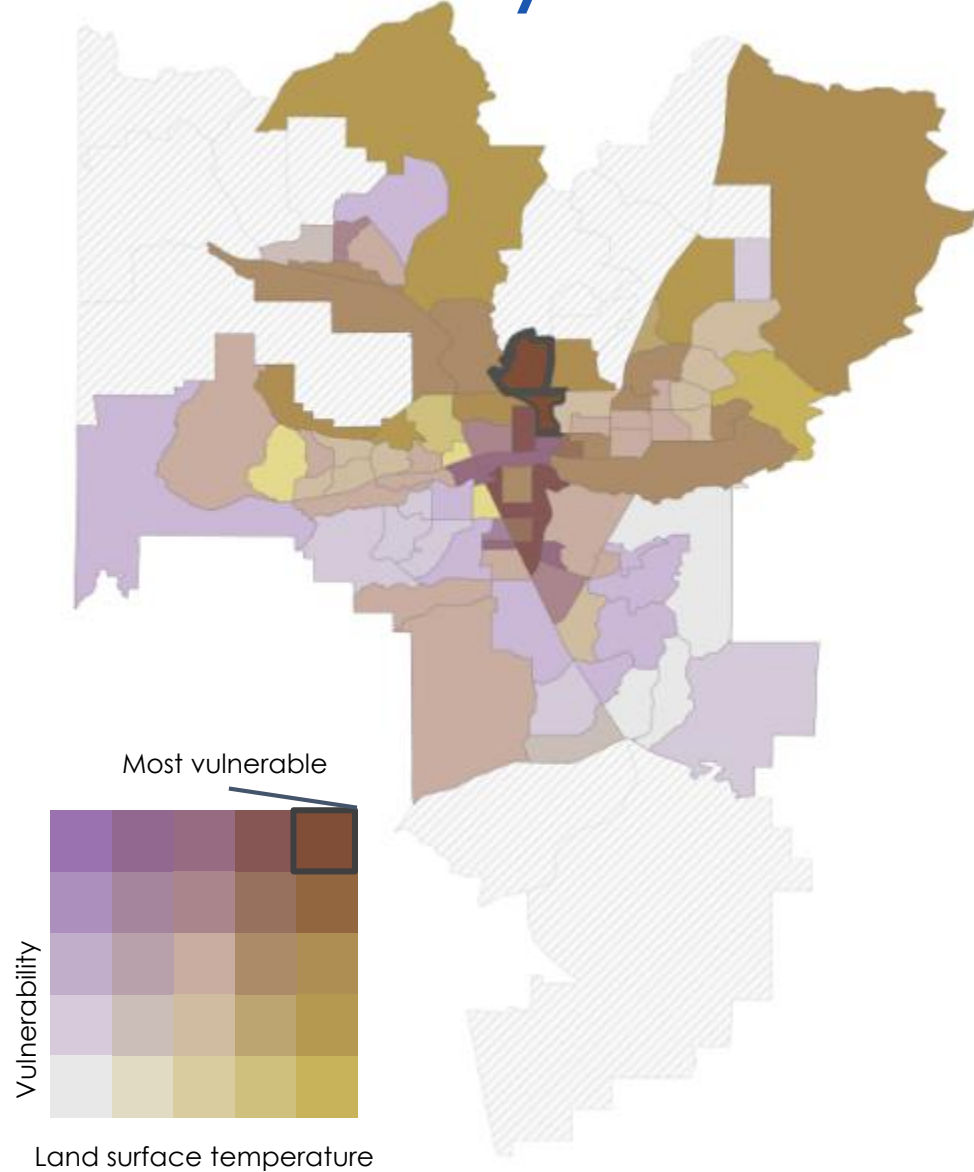
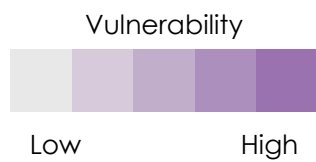
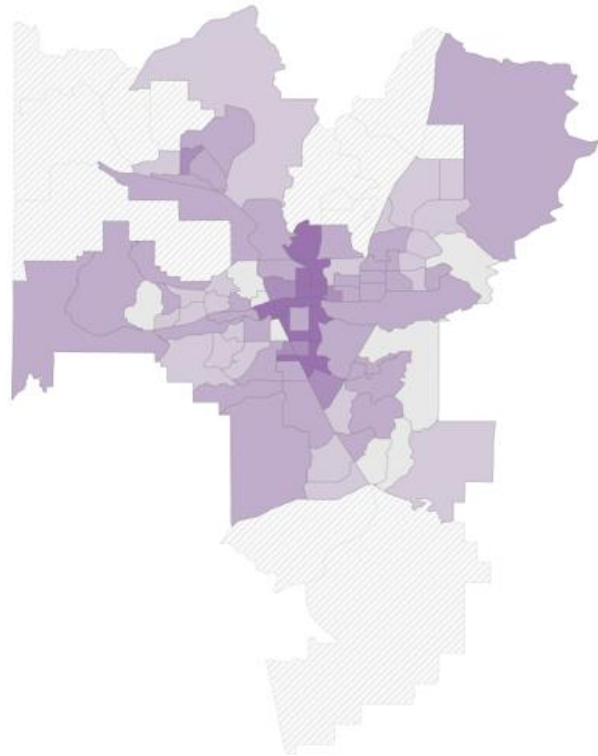
Time Series of LST



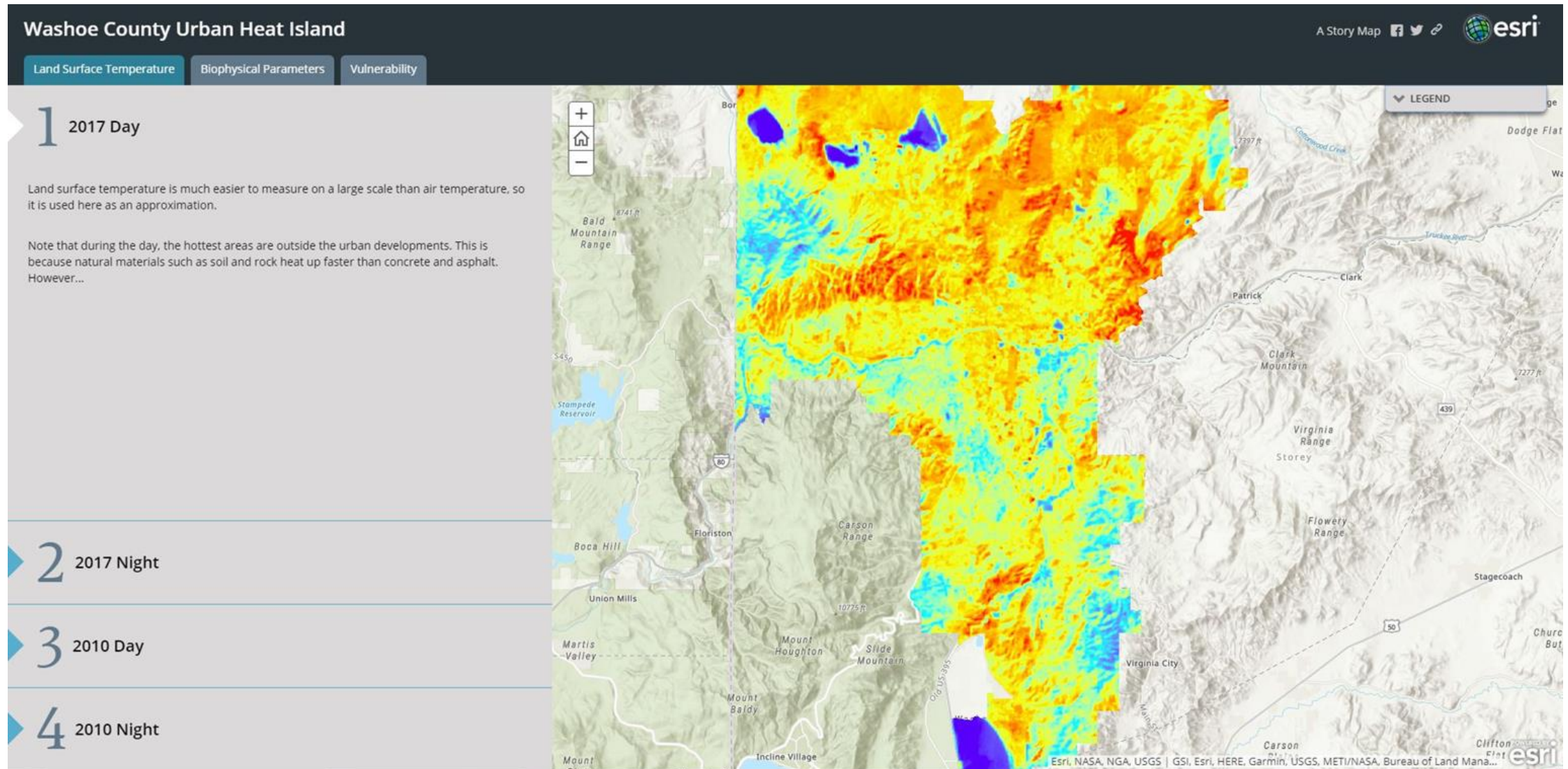
Heat Vulnerability



Heat Vulnerability



Web Mapping Application





Conclusions





Errors and Uncertainties

- ▶ Coarse resolution of Landsat imagery
- ▶ Other biophysical variables
- ▶ Air temperature \neq land surface temperature



Future Work

- ▶ Continue UHI analysis using future datasets
- ▶ Consider other biophysical variables
- ▶ Implementing mitigation techniques based on results



Acknowledgements

Dr. David Hondula, Arizona State University, DEVELOP Arizona Science Advisor

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Daniel Inouye, Branch Chief | Washoe County Health District's Air Quality Management Division

Cynthia Albright, AICP – CUD, GISP | Principal, Urban Planning and Design | Stantec Consulting Services, Inc.





Thank you!

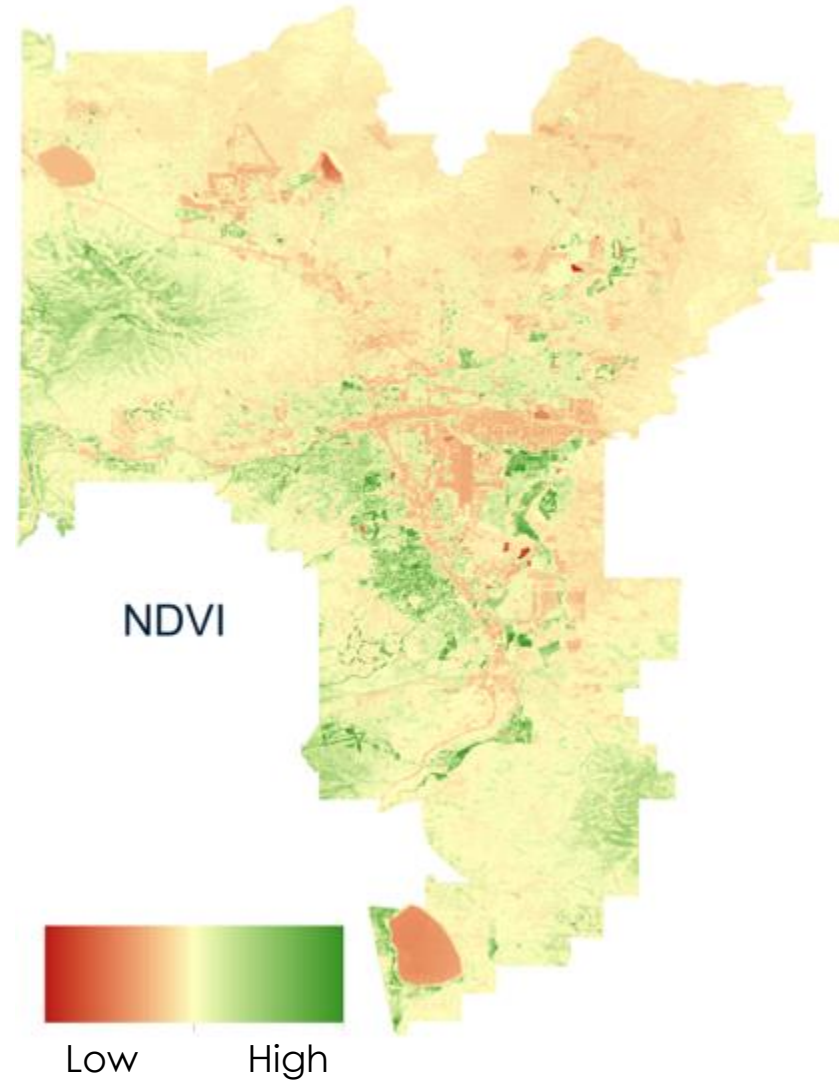




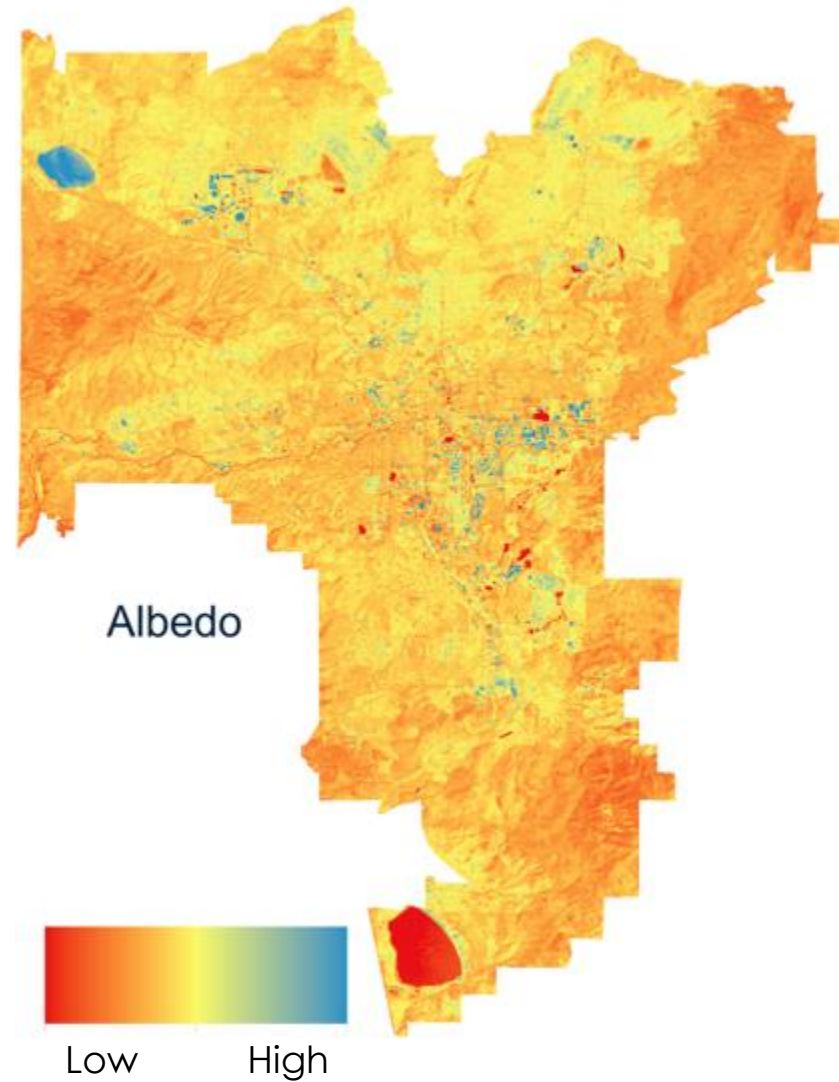
Backup Slides



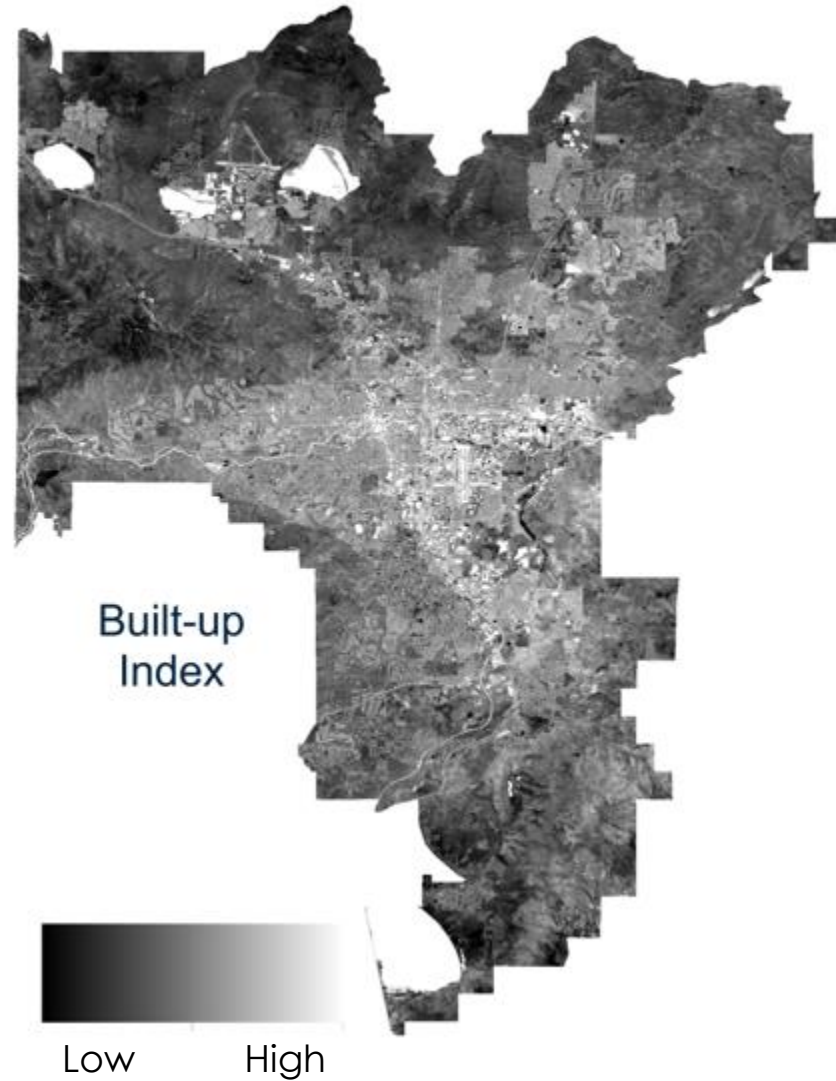
Assessing Biophysical Parameters



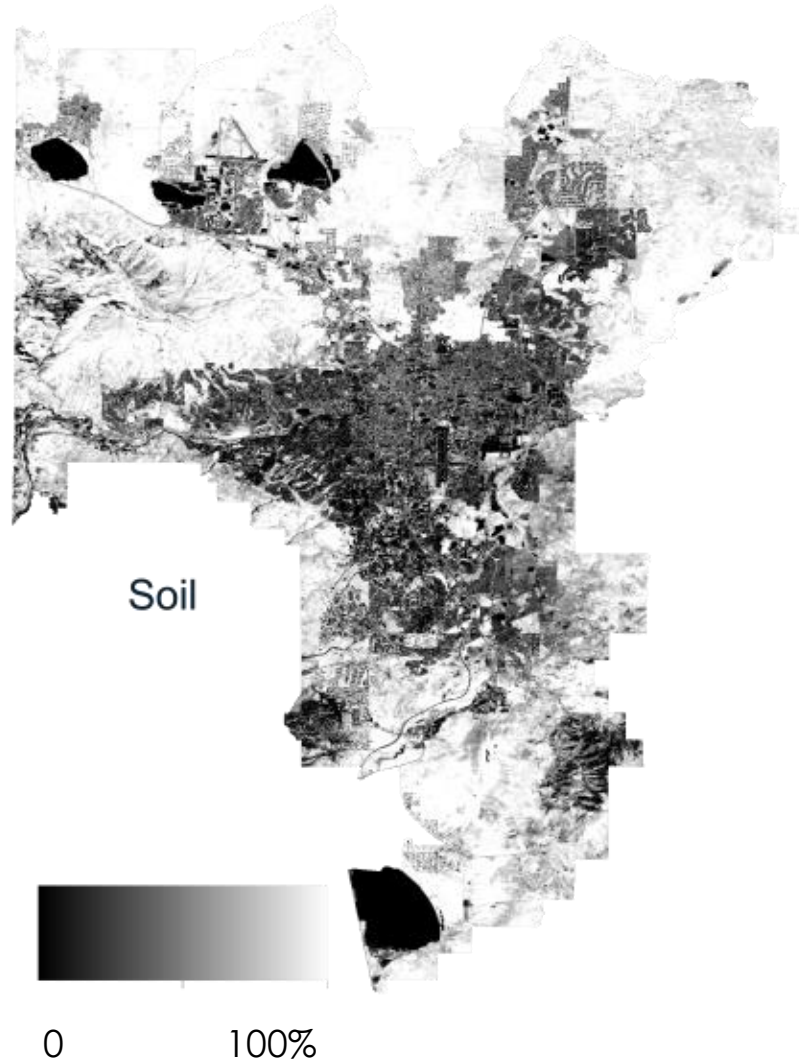
Assessing Biophysical Parameters



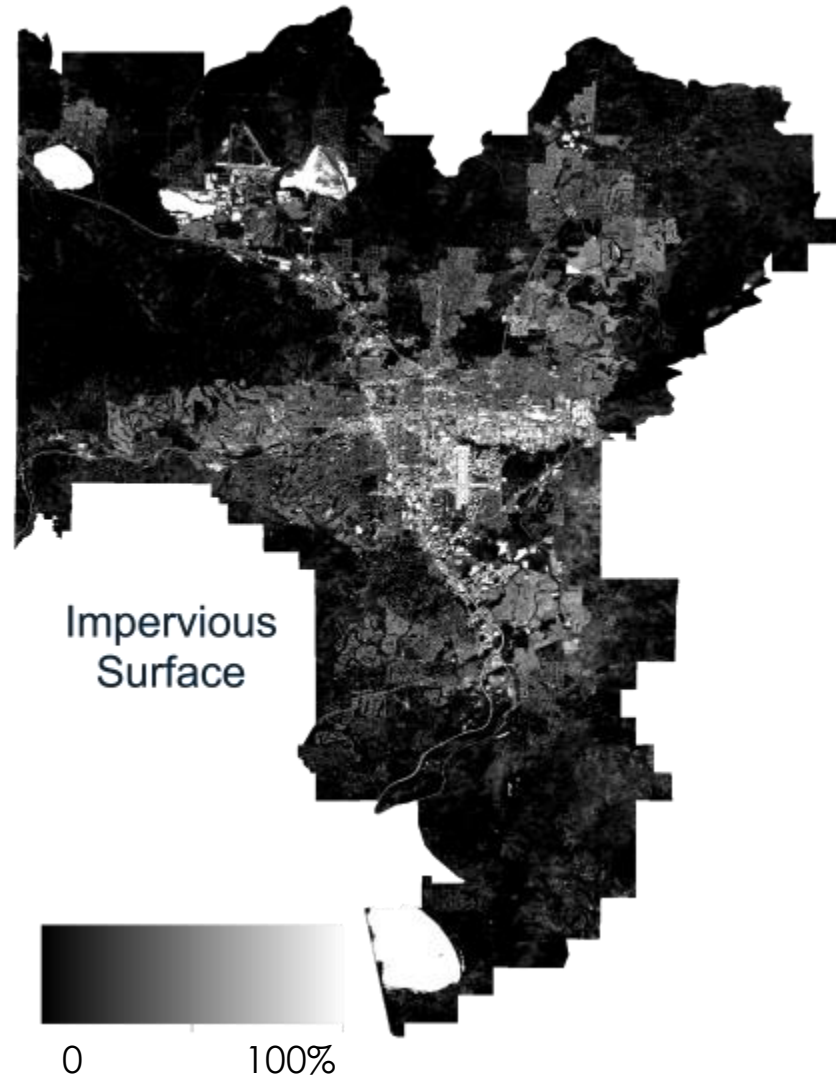
Assessing Biophysical Parameters



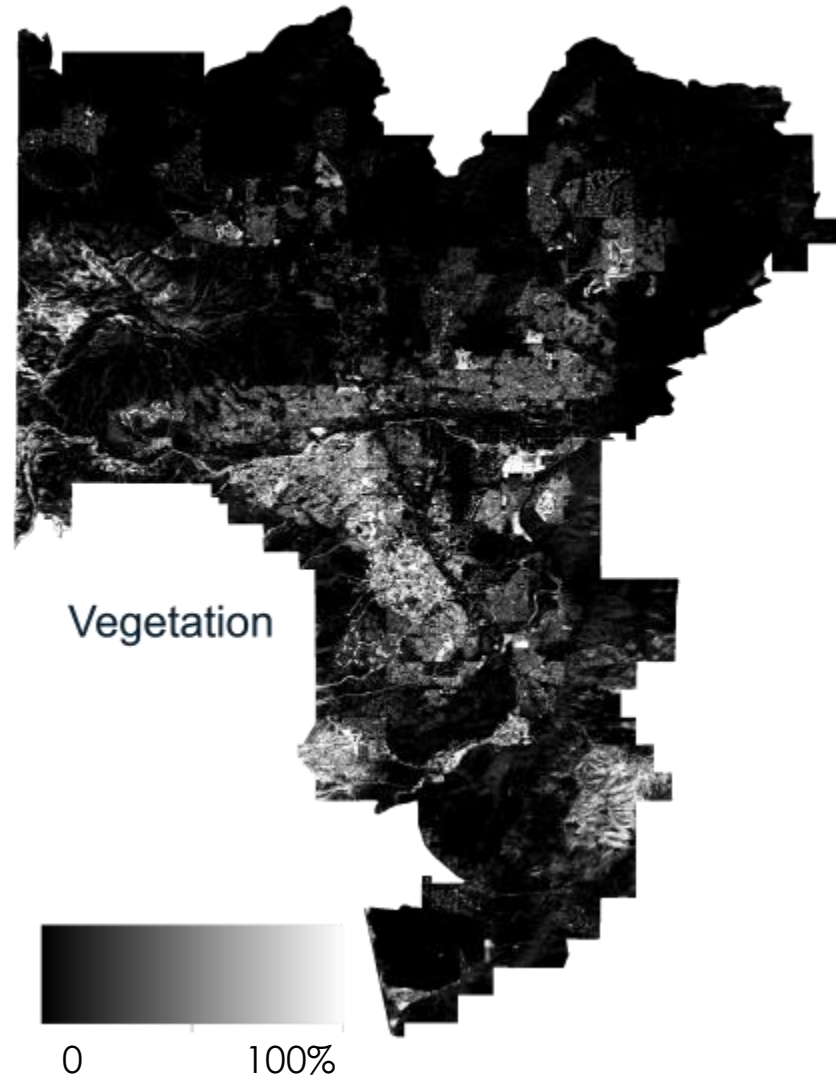
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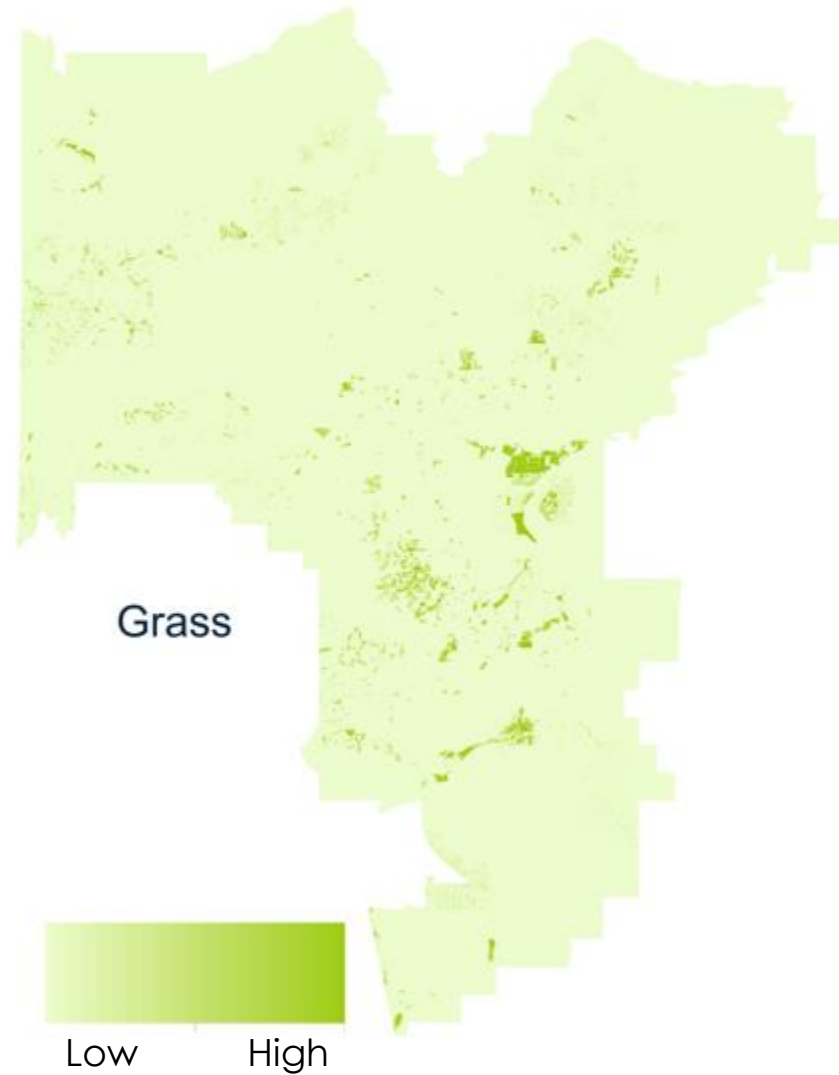
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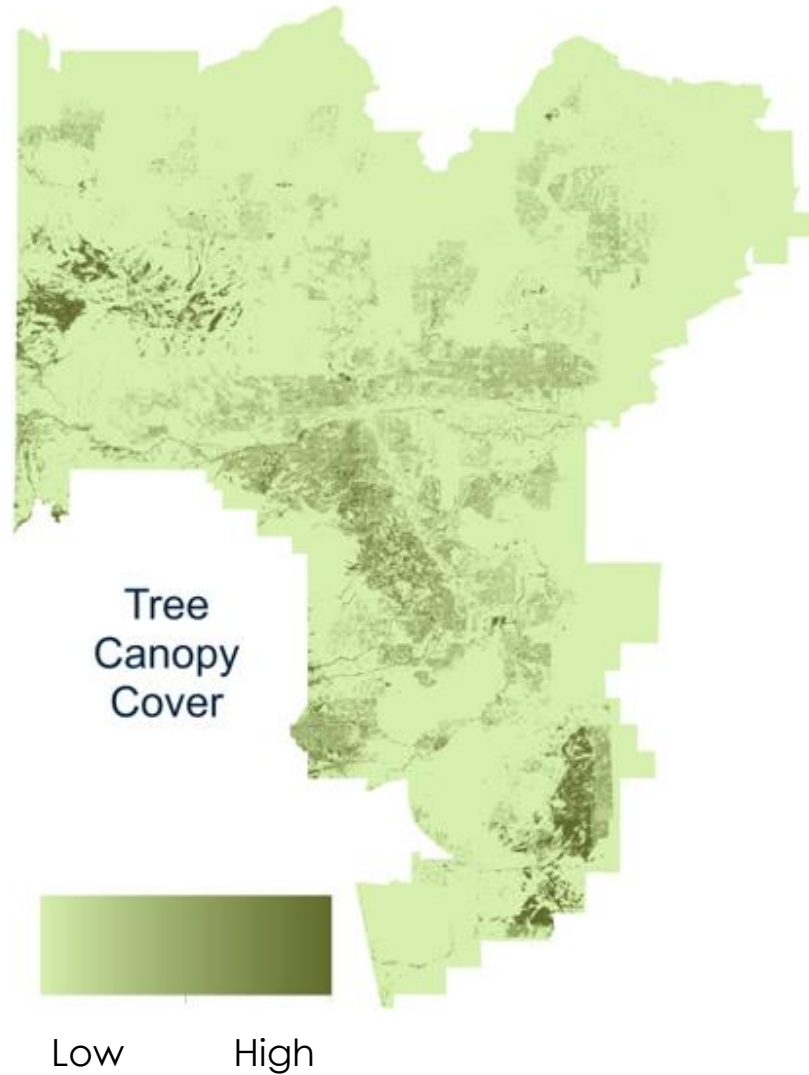
Assessing Biophysical Parameters



Assessing Biophysical Parameters



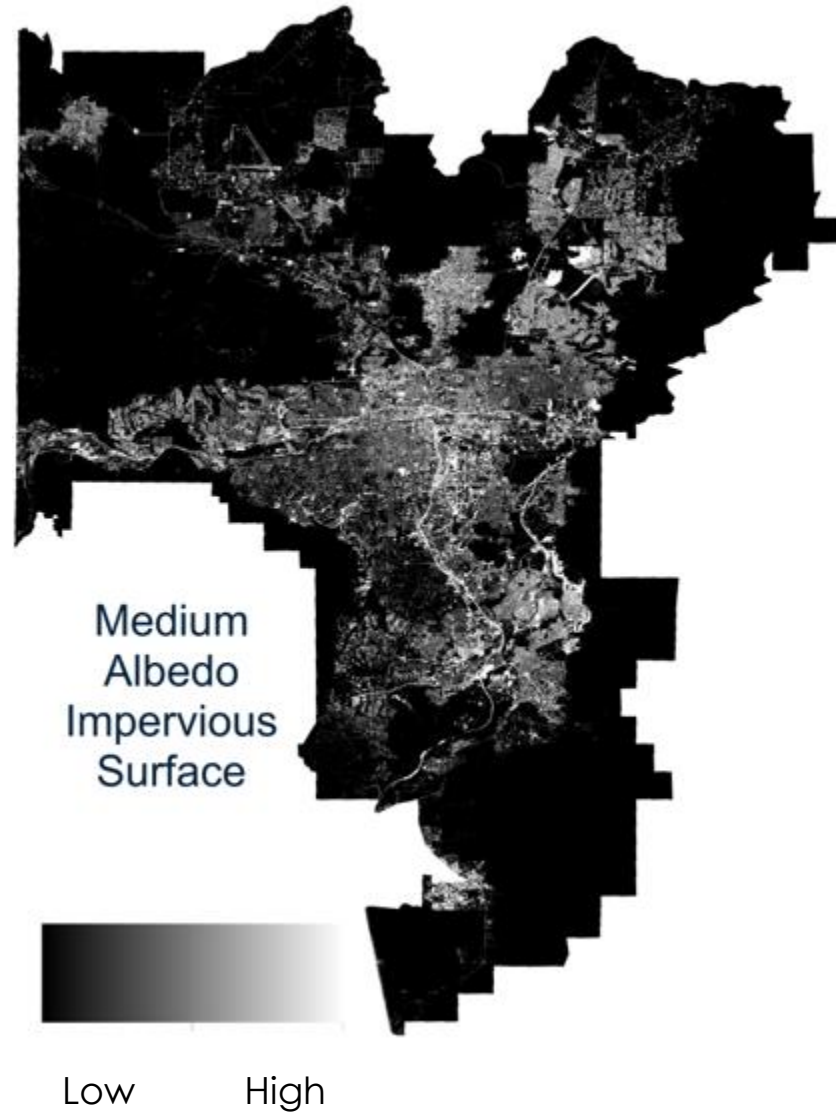
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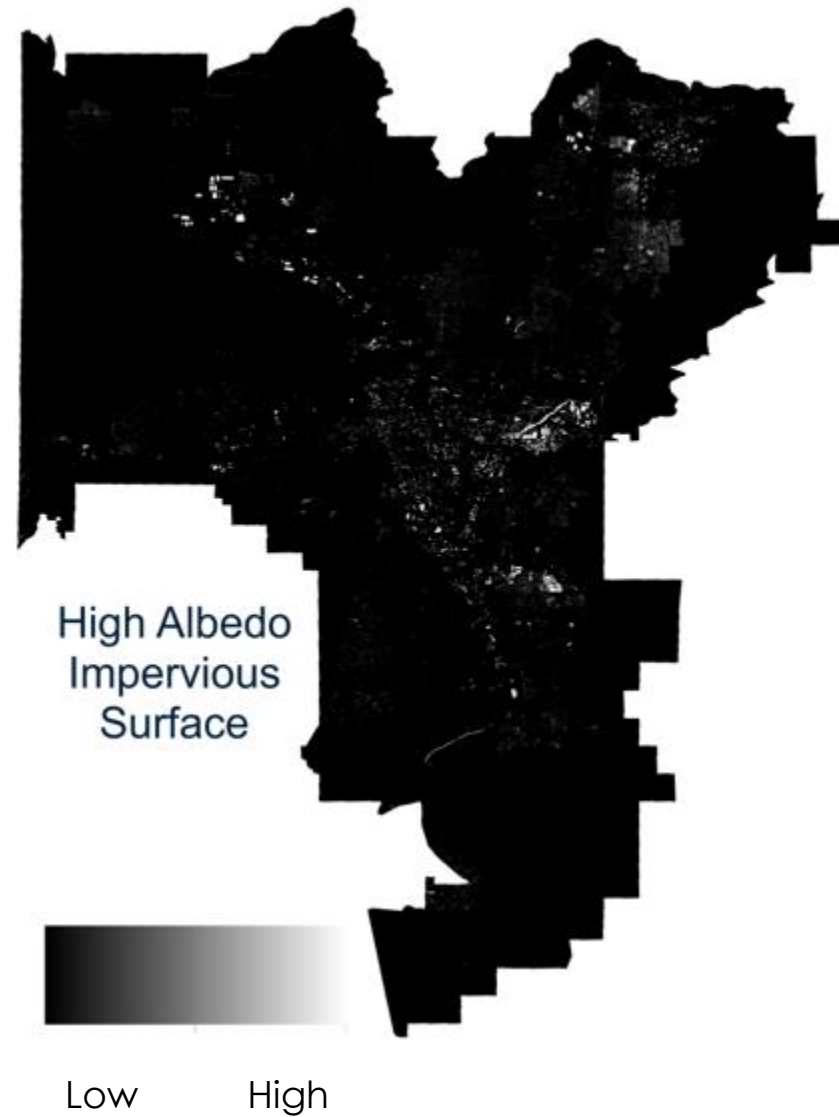
Assessing Biophysical Parameters



Assessing Biophysical Parameters



Assessing Biophysical Parameters



Assessing Biophysical Parameters



Class Name



High Resolution Object-based Classification

Dataset: NAIP Imagery

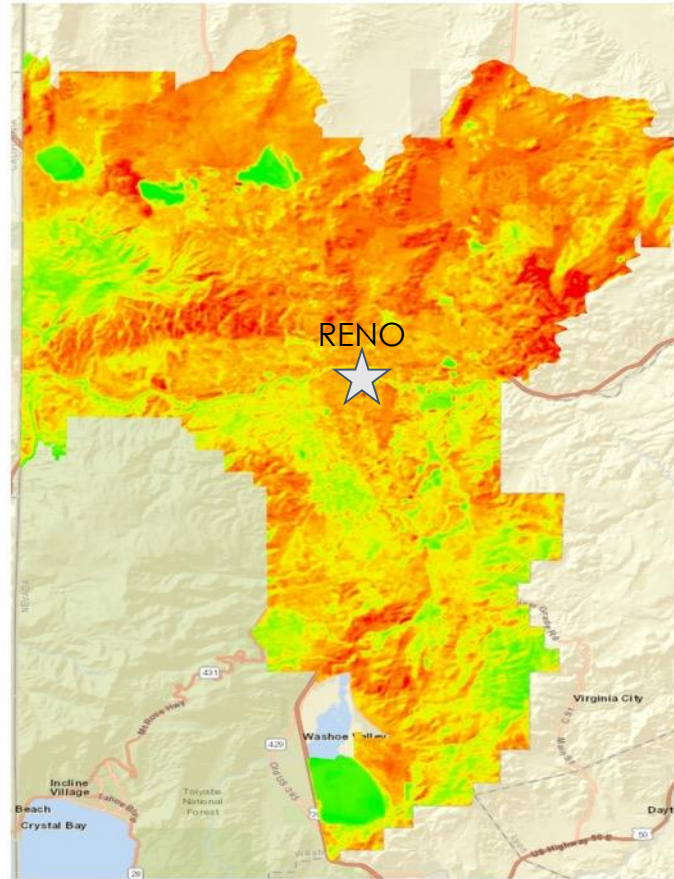
Time: 2017

Biophysical Parameters:
Grass, Tree, High-, Medium- and
Low-albedo Imperviousness,
Soil, Shade, Water

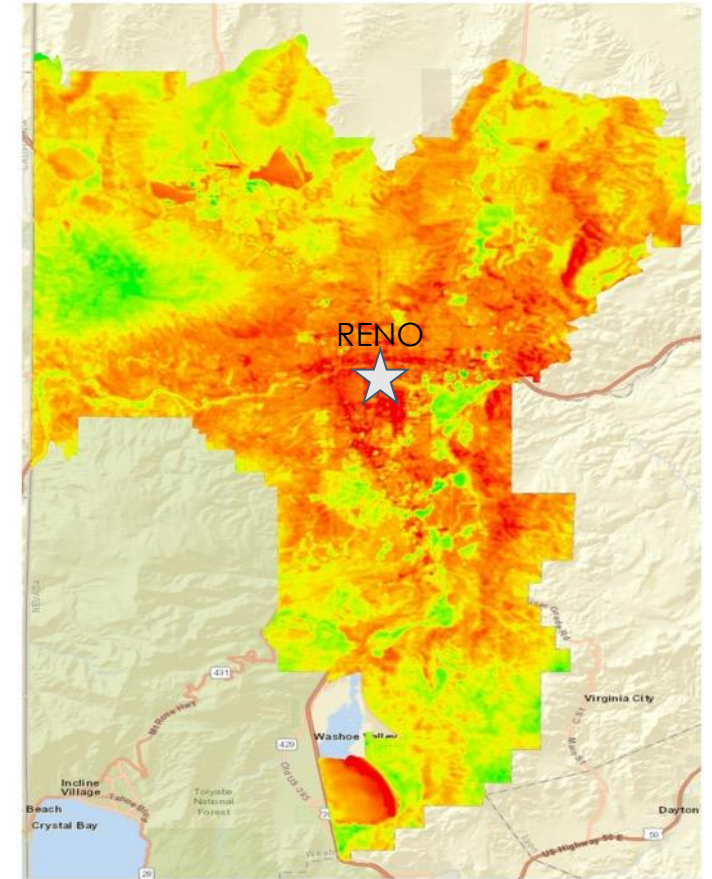


Measuring the UHI

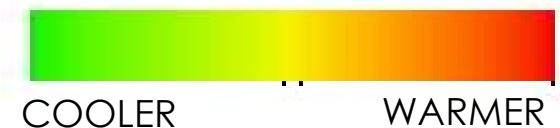
- ▶ ASTER nighttime temperature image
- ▶ Landsat daytime and nighttime temperature image
- ▶ UHI intensity



Day 2017



Night 2017





UHI Assessment

Ward	Quadrant	Daytime°C	Nighttime°C	Delta°C	NDVI	NDBI	Albedo
1	SW	101.1	66.7	34.4	0.2	-0.077	0.171
2	SW	101.2	66	35.2	0.17	-0.073	0.183
3	SE	103.6	67.9	35.7	0.13	-0.057	0.182
4	NW	103.6	64.1	39.5	0.13	-0.008	0.184
5	SW	103.3	66.3	37	0.18	-0.042	0.173
6	SE	105.4	69.3	36.1	0.11	-0.051	0.189
7	NE	105.8	67.5	38.3	0.18	-0.056	0.177
8	NE	105.9	68.2	37.7	0.12	-0.025	0.183
9	NE	105.4	65.8	39.6	0.17	-0.043	0.175
10	NE	106.7	65.4	41.3	0.15	0.002	0.18

Descriptives of diurnal and nocturnal UHI (average urban vs. suburban vs. rural temperatures)

Statistics by wards within sparks and Reno