**Asheville Urban Development**

*Using NASA Earth Observations to Quantify the Impact of Urban Tree Canopy Cover on Urban Heat and Identify Community Vulnerability in Asheville, North Carolina*

**Project Team**

***Project Team:***

Darcy Gray (Project Lead)

Amiya Kalra

Amy Kennedy

***Advisors & Mentors:***

Scott Stevens (North Carolina Institute for Climate Studies, NOAA National Centers for Environmental Information)

**Project Overview**

***Project Synopsis:*** The urban heat island effect is a phenomenon wherein a city has a higher temperature than the surrounding non-urban areas, due to several anthropogenic factors. With Asheville facing rapid population increase, the Asheville Urban Forestry Commission is concerned about the impacts of urban heat and interested in how trees may mitigate them. The Asheville Urban Development team examined urban heat in Asheville using NASA Earth observations in conjunction with tree cover and census data. The team evaluated relationships between these variables and investigated heat vulnerability throughout the city. These analyses quantified the impacts of urban tree canopy cover on urban heat islands.

***Abstract:***

Asheville, North Carolina has had a population growth of approximately 10 percent over the past decade, while the city’s tree canopy cover has simultaneously decreased by 6.4 percent. A well-known benefit of urban tree cover is the mitigation of the effects of urban heat islands through factors including shade and evapotranspiration. Thus, as Asheville’s population grows, the presence of trees and their cooling effects is crucial. The Asheville Urban Forestry Commission advises the City Council on issues pertaining to urban development with policies centered on tree cover preservation and growth. The Asheville Urban Development team partnered with the Urban Forestry Commission to complete a study using NASA Earth observations and ancillary datasets to explore relationships between changes in land surface temperature and tree cover over the last 10 years. The team used Landsat 5 Thematic Mapper (TM) and Landsat 8 Operational Land Imager (OLI) to calculate Land Surface Temperature (LST) changes from 1984 to 2018. The team also used socioeconomic data on the census block group level to create a heat vulnerability index in order to identify communities at risk. The team included tree cover and LST data in this index to represent exposure and adaptive capacity as factors in heat vulnerability. The end products illustrated a significant correlation between tree cover and LST in Asheville and identified vulnerable communities to support the Urban Forestry Commission’s decisions about tree planting and preservation.

***Keywords:***

heat vulnerability, land surface temperature, Landsat, urban forests, urban heat island effect

***National Application Areas Addressed:*** Urban Development

***Study Location:*** Asheville, NC

***Study Period:*** 1984 to 2019 (May to September)

***Community Concerns:***

* Over the last decade, the City of Asheville has experienced a growth of at least 10 percent population growth, while urban tree canopy cover has decreased by 6.4 percent.
* The urban heat island effect, caused by a lack of trees and an abundance of impermeable surfaces in cities, leads to urban areas having higher average temperatures than their surroundings.
* In many cities, urban heat islands exist in neighborhoods with large minority populations and low average income; there is evidence from recent on-the-ground heat mapping studies across the United States that such areas with higher average temperatures have higher rates of heat-related ambulance calls and emergency room visits.
* The Asheville Urban Forestry Commission acknowledges the existence of urban heat islands in Asheville and other problems associated with lack of tree cover, including stormwater runoff, excessive heat, air pollution, loss of aesthetic appeal, and loss of a sense of place.
* The Commission’s primary concern is how changes in temperature and tree cover in Asheville over the last few decades vary among different areas in the city and among different socioeconomic demographics.

***Project Objectives:***

* Analyze how land surface temperature and tree cover in Asheville have changed long-term by comparing data from the 1980s to present-day data to quantify changes and identify which areas have changed the most
* Explore the statistical relationship between changes in land surface temperature and changes in tree cover from 2008 to 2018
* Identify areas particularly vulnerable to heat in Asheville by generating a heat vulnerability index that incorporates temperature, tree cover, and socioeconomic data

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **City of Asheville, Urban Forestry Commission** | Ed Macie, Urban Forester | End User | No |

***Decision-Making Practices & Policies:***

In the past, the Urban Forestry Commission has worked with GIS specialists and urban planners to investigate urban heat vulnerability by integrating satellite-derived tree cover data with census data. During the summer of 2019, the Urban Forestry Commission conducted an in-depth analysis of urban tree canopy coverage using aerial imagery from the United States Department of Agriculture (USDA) Forest Service. The results were included in the Asheville Urban Development team’s analyses of urban heat vulnerability to show, at a finer scale, the communities that are most impacted by the canopy loss. This will enable the Urban Forestry Commission to prioritize canopy protection, inventory, and reestablishment efforts. The Commission will also use the results to highlight which neighborhoods in the city could benefit from expanded green infrastructure projects.

***Project Benefit to End User:***

The Urban Forestry Commission received maps of the city that show how urban tree cover has changed over time in relation to land surface temperatures. In order to demonstrate which communities have been most impacted by these changes, the team provided maps that display census block groups by their level of vulnerability. These maps will enable the Urban Forestry Commission to continue to advise the city on future development plans and tree plantings. The end user can also use this information to advocate for their work and increase visibility and public awareness of the issue of urban heat islands in Asheville.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 5 TM** | surface reflectance radiance | This imagery was used to derive measurements of Land Surface Temperature (LST) from 1984 to 2011. |
| **Landsat 8 OLI** | surface reflectance radiance | This imagery was used to derive measurements of LST from 2013 to 2019. |

***Ancillary Datasets:***

* USDA, National Agriculture Imagery Program (NAIP) - Imagery to identify urban tree canopy cover and detect cover change over time, processed and made available by the Davey Resource Group as part of an Urban Tree Canopy Study
* 2010 United States Census – 2019 census block group shapefile
* 2015 American Community Survey – Socioeconomic data to indicate heat-vulnerable communities

***Software & Scripting:***

* Esri ArcMap 10.6.1 – Map generation, raster analysis, land cover classification
* Google Earth Engine – Data acquisition, raster processing
* Microsoft Excel – Data analysis, data preparation

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Analysis of Spatial Correlation between Tree Cover and Land Surface Temperature** | Landsat 5 TMLandsat 8 OLI | The product helped the end users quantify how areas with healthy and productive urban tree canopy impact land surface temperature compared to uncovered areas in the city. | N/A |
| **Spatial Analysis and Map of Temperature Change over Time in Asheville** | Landsat 5 TMLandsat 8 OLI  | The product helped the end users quantify temperature change in the city over the past 35 years, and demonstrated which areas are experiencing the most change in heat. | N/A |
| **Heat Vulnerability Map** | Landsat 8 OLI | The product shows the end users what areas of the city are most vulnerable to heat using tree cover, LST, and socioeconomic factors that contribute to heat vulnerability. This will help the partners identify areas to focus their work to improve environmental equity in the city. | N/A |
| **DEVELOP Project Brochure** | N/A | The brochure provided the partners with something they can easily hand out to participants attending tree-related events in Asheville. It will also provide them with the most salient points from the research, which will help them identify action items for their future work. | N/A |
| **Interactive Web Mapper** | Landsat 5 TMLandsat 8 TM  | This mapper provided the partners with a public-facing product that can be used to engage with residents about issues surrounding urban heat in Asheville.  | N/A |

**Project Handoff Package**

***Transition Plan:*** The team presented their results to the wider Asheville community at the Climate Change and Asheville’s Urban Forest Symposium on November 14, 2019. The team also gave data and accompanying tutorial materials to the Urban Forestry Commission and other stakeholders during an Urban Forestry Commission meeting on November 18, 2019.

***Team POC:*** Darcy Gray, dgray4@tulane.edu

***Partner POC:*** Ed Macie, ed@edmacie.com

***Handoff Package:***

* Analysis of Spatial Correlation between Tree Cover and Land Surface Temperature
* Spatial Analysis and Map of Temperature Change over Time in Asheville
* Heat Vulnerability Map
* Technical Paper
* DEVELOP Project Brochure
* Interactive Web Mapper

**References**

City of Asheville. (2019). *Code of ordinances*. Asheville, NC. Retrieved on September 26, 2019, from

https://library.municode.com/nc/asheville/codes/code\_of\_ordinances?nodeId=PTIICOOR\_CH20TR

City of Asheville Tree Commission. (2019). *Asheville Tree Commission annual report* [PDF file]. Asheville, NC. Retrieved on September 26, 2019, from https://drive.google.com/file/d/1A9v72lCHXgKbzzlm27gIeFC1BvWYP4W1/view

Davey Resource Group. (2019, Oct 23). Urban tree canopy study, Asheville, North Carolina [PDF file]. Retrieved on October 28, 2019, from https://drive.google.com/drive/folders/183EXsfkstrpvvgmW9L3xbIPzjPLQunzH

Popovich, N. & Flavelle, C. (2019, Aug 9). Summer in the city is hot, but some neighborhoods suffer

more. *The New York Times*. Retrieved on October 28, 2019, from https://www.nytimes.com/

Walton, D. (2019, March 9). Urban forestry proposals aim to save Asheville’s trees. *Mountain XPress*.

Retrieved on October 28, 2019, from https://mountainx.com/