NASA DEVELOP National Program
2024 Summer Project Work Plan

North Carolina – NCEI
Asheville Urban Development II

Mapping Urban Heat to Support Cooling Initiatives and Climate Resilience Planning in the Greater Asheville Area

Project Overview

Project Synopsis: Heat is the leading cause of weather-related mortality in the U.S., with extreme heat killing more people than all other weather-related disasters combined (NOAA). The burdens of extreme heat are experienced inequitably. Low-income neighborhoods in the U.S. are hotter on average, and past and ongoing exclusionary housing practices continue to deprive communities of equitable access to services that reduce exposure to climate impacts. To inform efforts designed to reduce urban heat island (UHI) impacts in the greater Asheville area, the City of Asheville (CoA) is creating an Urban Forest Master Plan that will guide green infrastructure development and support heat mitigation efforts. Alongside these efforts, Asheville GreenWorks led a community-wide, NOAA UHI mapping campaign that measured heat across Asheville neighborhoods on July 24, 2023. In partnership with Asheville GreenWorks and the CoA Sustainability Department, NASA DEVELOP will update the Asheville Urban Development I heat vulnerability analysis using land surface temperature (LST) data collected by Landsat missions 8 and 9 data, identify heat "hot spots" in Asheville neighborhoods based on LST and albedo, and model the temperature and economic impacts of heat mitigation strategies (tree planting, cool pavement, and white roofs).

Study Location: Asheville, NC
Study Period: 2019–2024

Advisors: Edward "Ed" Macie (Board of Directors, Asheville GreenWorks, CoA Urban Forestry Commission) ed.a.macie@gmail.com, Douglas Rao (NOAA National Centers for Environmental Information, North Carolina Institute for Climate Studies) douglas.rao@noaa.gov, Molly Woloszyn (NOAA National Integrated Drought Information System) molly.woloszyn@noaa.gov

Partner Overview

Partner Organizations:

Organization	Contact	Partner Type	Sector
Asheville GreenWorks	Eric Bradford, Interim Executive Director; **Chris Defiore**, Urban Forestry Consultant chris@ashevillegreenworks.org ; Sara Millar, Community Forestry Coordinator	End User	Non-Profit
Sustainability Department, The City of Asheville	Kiera Bulan, Sustainability Manager; **Chris Clarke**, Sustainability Coordinator cclarke@ashevillenc.gov; Bridget Herring, Sustainability Department Director	End User	Local Government

End User Overview

End User's Current Decision-Making Process & Capacity to Use Earth Observations: The CoA is developing an Urban Forest Master Plan that will mitigate the impacts of urban heat by identifying and prioritizing tree-planting locations in Asheville. Through their climate initiative, the CoA Sustainability Department declared a Climate Emergency through Resolution 20–25 and established a Climate Justice Initiative to collaborate with Black, Indigenous and People of Color (BIPOC) leaders and community members, one of the elements of which is a Climate Justice Index built in part using products created through the 2019 NASA DEVELOP Asheville Urban Development I project. The 2024 NASA DEVELOP Asheville Urban II project will update the 2019 heat vulnerability analysis conducted through the Asheville Urban Development I project to 2024 for integration in the to Asheville Climate Justice Data Map, utilize NASA Earth observations to map LST in Asheville between 2019–2024—augmenting *in situ* temperature data collected on July 24, 2023 through the NOAA Urban Heat Island mapping campaign—and inform heat mitigation efforts for the greater Asheville area.

Earth Observations Overview

Earth Observations:

Platform & Sensor	Parameter(s)	Use
ISS ECOSTRESS	Evapotranspiration	Calculate evapotranspiration over the study area as an input into the InVEST Urban Cooling Model.
Landsat 8 TIRS	Temperature	Landsat 8 OLI/TIRS data will be used to calculate and visualize land surface temperature (LST) over the study region from 2019–2024.
Landsat 9 TIRS-2		Landsat 9 OLI-2/TIRS-2 data will be used to calculate and visualize LST over the study region from 2019–2024.
MAXAR WorldView-2	Irradiance/Reflectance	Commercial satellite imagery will be used to calculate albedo for the hotspot analysis.
MAXAR WorldView-3	Irradiance/Reflectance	Commercial satellite imagery will be used to calculate albedo for the hotspot analysis.

Ancillary Datasets:

Please note that additional datasets not listed here may be required for analysis.

- Buncombe County Open Data Explorer Building Footprints – Input into the InVEST Urban Cooling Model
- Centers for Disease Control and Prevention (CDC) Population Level Analysis and Community Estimates (PLACES) – Incorporate chronic disease prevalence data (e.g. asthma, COPD, heart disease, obesity) into the health vulnerability map at the census tract-level
- City of Asheville Climate Justice Index – Results from the 2024 NASA DEVELOP Asheville Urban Development II project will be used to update the CoA Climate Justice Index, which was prepared, in part, using the results of the 2019 NASA DEVELOP Asheville Urban Development I project
- City of Asheville Geographic Information Services Map Asheville – Map city parks; bike facilities; pedestrian network sidewalks and greenways; Asheville Regional Transit (ART) bus routes and bus stops for analyses of temperature and albedo hot spots
- City of Asheville Geographic Information Services Neighborhood Map (POC: Meredith Friedheim, Neighborhood Services Specialist: 828-712-3027 or neighborhoods@ashevillenc.gov) – Delineate Asheville neighborhoods for LST analysis
- City of Asheville Open Data Portal Asheville City Limits – Delineate the study area
- Multi-Resolution Land Characteristics Consortium (MRLC) National Land Cover Dataset (NLCD) – Map land cover type across the study area as an input into the InVEST Urban Cooling Model
- NOAA NCEP Global Forecast System (GFS) – Calculate humidity as an input into the InVEST Urban Cooling Model

- US Census Bureau American Community Survey (ACS) Data, 2020 5-Year Survey – Incorporate population data (e.g. population over 65) into the health vulnerability map at the census tract-level

Software & Scripting:

- Esri ArcGIS Pro 3.2.2 – Create static maps and map packages
- Google Earth Engine API – Acquire and process GFS humidity, Landsat LST, and NLCD land cover data
- Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) Urban Cooling Model (POC: kenton.w.ross@nasa.gov) – Calculate heat mitigation indices and estimate the temperature and economic impacts—based on energy savings from reduced A/C electricity consumption and gain in work productivity for outdoor workers—of tree planting, cool pavement, and white roof installations
- NASA DEVELOP UHEAT 2 (POC: Isabel Lubitz and kenton.w.ross@nasa.gov) – Google Earth Engine script created by Dr. Ross and past NASA DEVELOP teams for acquiring and processing Landsat land surface temperature data

Decision Support Tool & End Product Overview

End Products:

End Product	Partner Use	Datasets & Analyses
Updated Heat Vulnerability Maps (Static Maps and Map Layer Package)	The CoA Sustainability Department will incorporate heat vulnerability maps—a) heat exposure; b) social vulnerability—updated to 2024 from the 2019 Asheville Urban Development I project into the Asheville Climate Justice Index, which was created using the 2019 products.	Heat exposure maps at the census block level or Asheville neighborhood level will be updated to 2024 using LST data from Landsat 8 TIRS and Landsat 9 TIRS-2. NEMAC and UNCA have created a "heat-health vulnerability index for CoA and Buncombe County (based on satellite data)". If partners are interested in updating the social vulnerability map created through the 2019 Asheville Urban Development I project in addition to the NEMAC/UNCA product, this update can be completed utilizing census data.
Heat Hot Spot Analysis (Static Maps and Map Layer Package)	Land surface temperature and low-albedo surfaces—with the potential to incorporate evapotranspiration data—will be mapped to identify "hot spots" in locations where people live, work, and play outside (e.g. downtown, at bus stops, along bus routes, bike routes and other primary transportation corridors, parks, schools, etc.) throughout Asheville neighborhoods to assist partners in directing heat mitigation efforts. This map will differentiate between locations where tree planting is feasible and locations where alternative cooling methods and	Data collected by Landsat 8 TIRS and Landsat 9 TIRS-2 will be used to map LST hot spots using the NASA DEVELOP UHEAT 2 script. Areas of low albedo will be mapped using MAXAR WorldView-2 and -3 imagery to identify locations of high solar radiation absorption (e.g. dark asphalt and roofs) where heat mitigation efforts may be directed. Albedo data can be analyzed in conjunction with Buncombe Co. building footprints and Map Asheville street network data. Evapotranspiration data (if using) can

End Product	Partner Use	Datasets & Analyses
	adaptation strategies—such as cool pavement, green and white roofs, and non-shade green infrastructure—are required (e.g. along main roads and utility corridors).	be acquired from the ISS ECOSTRESS program.
City-Wide Urban Cooling Model	Results of the InVEST Urban Cooling Model may be used by partners to assess the temperature and economic impacts of tree planting, cool pavements, and white roofs to guide heat mitigation efforts in areas where tree planting is feasible.	Data collected by Landsat missions 8 and 9, ISS ECOSTRESS, and MAXAR WorldView-2 and -3 along with ancillary datasets (humidity, building footprints, etc.) will be integrated into the InVEST Urban Cooling model based on program data requirements.
Communications Deliverable [optional]	This [communication deliverable] will compile data visualizations to communicate about urban heat and mitigation strategies in Asheville to support partners' community engagement efforts.	Options: ● Social media series ● 2-sided flier (either for printing or virtual use) ● Tri-fold brochure (typically for printing and in-person use) ● Video

Project Timeline & Previous Related Work

Project Timeline: Term II: 2024 Summer

Multi-Term Objectives:

- **Term 1:** 2019 Fall (NCEI) – Asheville Urban Development I
  - The Asheville Urban Development I project partnered with the CoA Urban Forestry Commission to map heat vulnerability—a combined measure of social vulnerability (based on data of residents aged 65 and older and percent of residents below the poverty line); heat exposure; and tree cover—and LST change from 1984–2018 in the greater Asheville area. The team also assessed the correlation between LST and tree cover at the census block group level in 2008, 2018, and the 10-year change between 2008 and 2018. The results of this project were used to successfully advocate for a Urban Forester for the CoA and the creation of the Urban Forest Master Plan (anticipated in 2025). This project set the stage to extend heat vulnerability analyses into 2024 and model cooling initiatives to direct heat mitigation efforts in Asheville.
- **Term 2:** 2024 Summer (NCEI) – Asheville Urban Development II
  - This project will partner with the City of Asheville Sustainability Department to update the heat vulnerability analysis conducted initially in 2019 to 2024 for inclusion in the Asheville Climate Justice Index produced by the City of Asheville; identify "hot spots" of high LST and low albedo/surface reflectance; and explore the heat mitigation impacts of cooling strategies. In addition to partnering with the Sustainability Department, NASA DEVELOP will also share the results of this project with Asheville GreenWorks to support urban forestry initiatives coordinated by GreenWorks. Building on the work of the first project term, which was utilized to advocate for urban forestry initiatives in Asheville, the results of this project will guide heat mitigation efforts in Asheville.

Similar Past DEVELOP Projects:

- 2019 Fall NC – Asheville Urban Development I (Internal DEVELOPedia link) Asheville Urban Development
- 2020 Summer MA – Cambridge Urban Development (Internal DEVELOPedia link) Cambridge Urban Development
- 2020 Summer & 2023 Summer MSFC – Huntsvaelopment I & II (Internal DEVELOPedia links Term I & Term II) Yonkers Urban Development I & II
- 2022 Summer AZ – Albuquerque Urban Development (Internal DEVELOPedia link) Albuquerque Urban Development
- 2022 Summer & Fall VEJ – Wichita Climate I & II (Internal DEVELOPedia link Term I & Term II) Wichita Climate I + II
- 2023 Spring VEJ – New York City Transportation & Infrastructure (Internal DEVELOPedia link) New York City Transportation and Infrastructure
- 2023 Summer VEJ – Portland Urban Development (Internal DEVELOPedia link) Portland Urban Development
- 2024 Spring MA – Bridgeport Urban Development (Internal DEVELOPedia link) Portland Urban Development

Notes & References:

Notes:

This project complements several ongoing initiatives supporting heat and tree canopy mapping in Asheville (see: "Related Projects" section). This project idea emerged as one of several potential projects discussed during preterm planning (see: "Other Project Ideas" section). Agendas and notes from preterm project discussions may be found in the NASADEVELOP_AVLHeat_AgendaNotes document.

Project suggestions from Dr. Ross:

- 1-term project focused on tree canopy but with land surface temperature as a supporting analysis.
- Canopy analysis based on CSDA-acquired Maxar data.
- Supporting medium-resolution analysis of canopy using Landsat 8 and 9 (perhaps with GEDI and object-based image analysis[1]).
- Supporting medium-resolution analysis of land surface temperature that can be used even in the tree canopy-focused project to support the effectiveness of canopy in mitigating heat. The urban heat analysis already has multiple code sets available to the team, so will not present a heavy burden.

References:

See Literature folder for further reading.

Davey Resource Group. (2019). Urban Tree Canopy Study: Asheville, NC. https://drive.google.com/file/d/0B5y5xB5sGeofNlIzQ1ZiT09PVGZnZWJLMFI5dUZwcTY5am1v/view?resourcekey=0-rpAjXutJC6Cd1Lbv_qMSWw

The City of Asheville. (2023). Municipal Climate Action Plan (MCAP). https://drive.google.com/file/d/1gMIA9K2L7Y1gcL5j61xike62vKaef6pq/view

[1]The GEDI and object-based image analysis could be a stretch goal for a high-performing team that was somewhat advanced in skill. Object-based image analysis is possible in ArcGIS Pro, but I believe is more frequently done with a dedicated software called eCognition. If this was desirable, we should work out an approach.

USGCRP. (2023). Fifth National Climate Assessment. Crimmins, A.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, B.C. Stewart, and T.K. Maycock, Eds. U.S. *Global Change Research Program, Washington, DC, USA*. https://doi.org/10.7930/NCA5.2023

2024 Summer Project Work Plan

Objectives and Priorities

1. **Update the heat vulnerability maps** (heat exposure, ~~tree canopy percent cover~~, social vulnerability) created through the 2019 Asheville Urban Development project to update the Asheville Climate Justice Map
    - *Note*: Some of the UNCA/NEMAC analyses (i.e. heat vulnerability index, temperature analyses) could potentially feed into the updatedar heat vulnerability maps. We can circle back to discuss this possibility further once the list of datasets is shared.

2. **Locate hotspots** (high land surface temperature + low albedo + potentially evapotranspiration) to inform cooling initiatives (e.g. tree planting, cooling pavement, etc.) conducted by the City of Asheville and Asheville GreenWorks
    - This analysis will differentiate between locations where tree planting is feasible and locations where alternative cooling methods and adaptation strategies are needed (e.g. along main roads and utility coordinators where tree planting is not feasible)

3. **Investigate the impact of heat mitigation strategies** (tree planting, white roofs, and cooling pavement) using the InVEST Urban Cooling Model to model the temperature impacts of planting trees and installing cool pavements and white roofs

Related Projects

1. **Urban Tree Canopy Analysis**: An updated tree canopy map will be created for Asheville (anticipated in 2025) through efforts supporting the Urban Forest Master Plan.

2. **UNCA Heat Analysis**: Ian Johnson at the National Environmental Modeling and Analysis Center (NEMAC) and Hope Donnellan, GreenWorks' UNC Asheville McCullough Fellow, have been working in the spring 2024 semester to complete analyses on the heat mapping data collected from GreenWorks' NOAA heat mapping data from summer 2023.

    Proposed assets include:

    - Searchable map so folks can look up their address
    - Heat-health vulnerability index for CoA and Buncombe County (based on satellite data)
    - Map of temps at different times of day for CoA
    - Heat & redlining map for CoA
    - Map highlighting neighborhoods that don't cool down overnight for CoA
    - Hot spots & cool spots - Map of highest and lowest 30% of temperatures
        - This map has the potential to highlight areas of impervious surface.
        - We also hope to tie this map to the CoA neighborhood map + canopy percentage (from the 2019 canopy study)
    - We also discussed creating a map layer that shows heat against the locations where there are community assets for cooling.

These assets (vector and raster files) will be made available to NASA DEVELOP to help them further the analyses.

3. **Priority Tree Planting Guide**: Samantha Trueman samantha.trueman@duke.edu (former GreenWorks employee) is working on a master's thesis that will create an interactive map with recommendations for tree planting based on species and location across Asheville.

Background Information

Background Reading:

- Climate Justice in Asheville
    - Asheville's Climate Justice Initiative.
    - CoA Climate Justice Index.
    - Office of Sustainability Climate Justice Screening Guide and Tool.
- CoA Sustainability, Climate, and Climate Justice.
- CoA Council Vision 2036.
- Living Asheville: A Comprehensive Plan for Our Future webpage and flipbook.
- Asheville Makes a Plan for Climate Resilience.

Asheville and Buncombe County GIS Resources:

- Buncombe County Geographical Information Systems
- City of Asheville Geographic Information Systems

Partner Info:

- Asheville GreenWorks: See PartnerInfo_Form_GreenWorks.docx.
- Sustainability Department, City of Asheville: See PartnerInfo_Form_SustainabilityDepartment.docx.

ARSET Trainings

Please note that trainings are optional, and project work should be prioritized before taking trainings.

1. Fundamentals of Remote Sensing link (on-demand training)

Data Acquisition

Data Resources:

- 2008–2018 Davey Resource Group (NASA DEVELOP Asheville Urban Development I project collaborator) Urban Tree Canopy Study and GIS files
- NEMAC Climate Risk and Resilience Data GIS files
- Neighborhood Organization Map - City of Asheville, NC GIS files
- Map Asheville
- Buncombe County Park Finder
- Asheville Greenways
- Buncombe County DEM
- Historic Aerial Map Viewer compares areas of Asheville from 1951, 1963, and 1975 to 2019 images
- Google Transit Feed Specification for Asheville Regional Transit (ART)

Data Processing & Analysis

InVEST

National Capital Project (Stanford University) Urban Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) – Data and modeling modeling platform for quantifying and mapping the impacts of alternative urban designs on multiple urban ecosystem services

- InVEST Urban Cooling (See the InVEST Urban Cooling User Guide and NASA DEVELOP StoryMap "Applying the InVEST Model")
    - Calculates an "Cooling Capacity Index" of heat mitigation based on shade, evapotranspiration, and albedo, as well as distance from cooling islands (e.g. parks).
    - The index is used to estimate a "Urban Heat Mitigation Index" calculating the cooling effect of large green spaces.
    - Finally, the model estimates the value of the heat mitigation service using two (optional) valuation methods:
        - Energy savings from reduced A/C electricity consumption (Fig. 1)
        - Gain in work productivity for outdoor workers

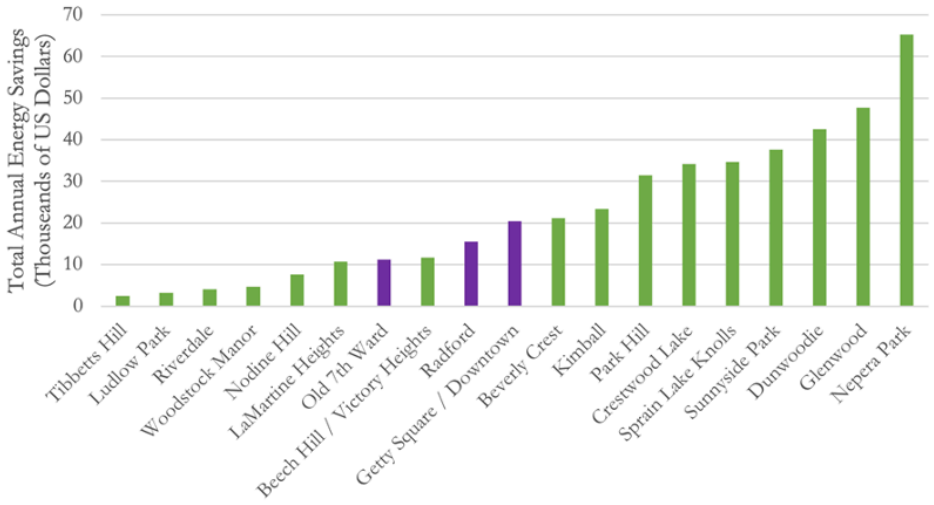

Figure 1. Change in total annual avoided energy spending from shading different neighborhoods. Source: NASA DEVELOP YonkersUrbanII_TechnicalReport.docx based on the InVEST Urban Cooling model.

NASA DEVELOP Project Examples

See NASADEVELOP_UrbanHeat_ProjectExamples for other examples.

Urban albedo:

- See Cambridge Urban Development for an example of methods for mapping rooftop albedo (Fig. 2).

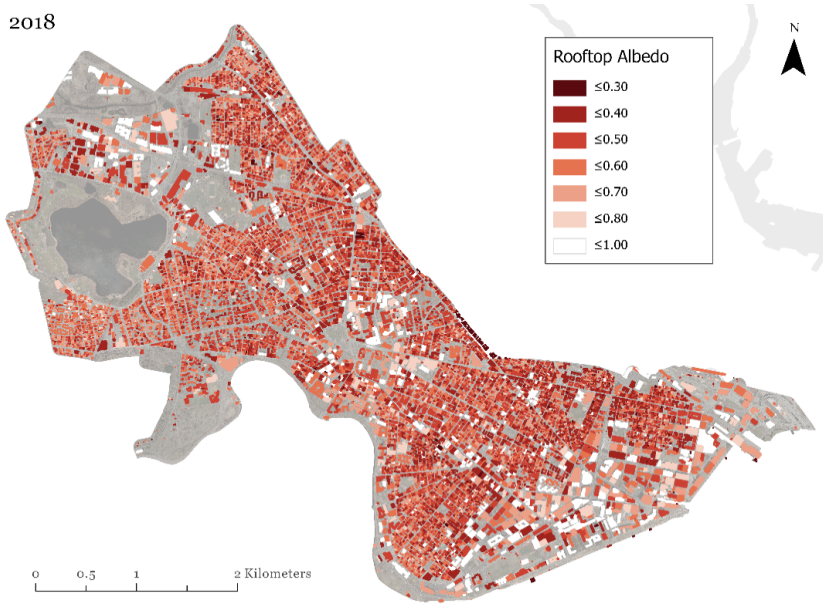

Figure 3. Map of Cambridge rooftop albedo using the 80th percentile HRO proxy results for 2018. High albedo values, symbolized by lighter-colored buildings, reflected more incoming solar radiation, which theoretically reduced the amount of heat trapped in the city. Building rooftops with low albedo values were represented by dark red and absorbed more of the incoming solar radiation, likely increasing urban heat.

Transportation analysis:

- See NYC Transportation and Infrastructure for an example of methods for calculating heat along transportation corridors (Figs. 3 & 4).

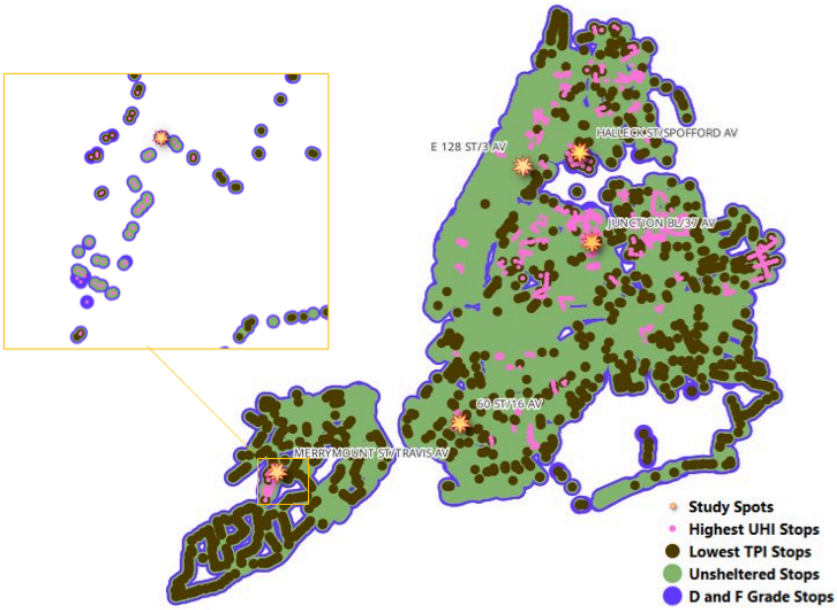

Figure 3. Bus stops mapped based on four vulnerability criteria: 1) the 90th percentile of urban heat island factor; 2) the 10th percentile of Transit Proximity Index (based on count of other transit stops within 0.25 miles of a stop); 3) unsheltered; and 4) with D or F report cards (assigned as a measure of speed, reliability,

bus bunching and wait time stops by Bus Turnaround Coalition's Bus Route). Source: NASA DEVELOP New York City Transportation and Infrastructure Technical Report.

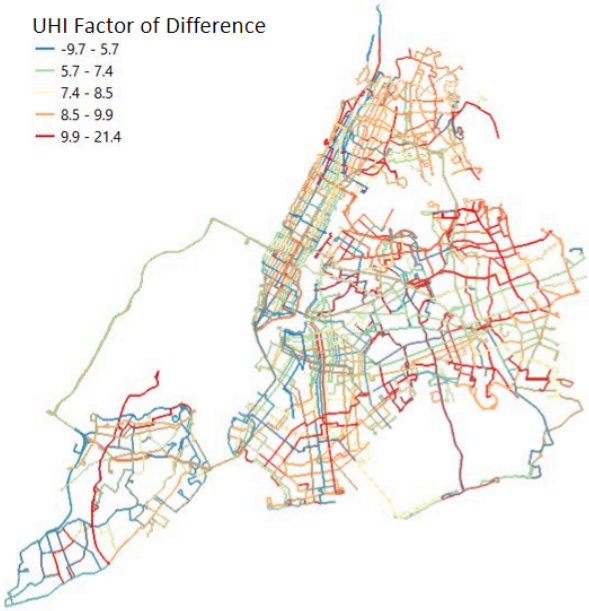

Figure 4. Bus routes with the highest urban heat island factor of difference (created in comparison with a corresponding rural area) averaged across their route. Source: NASA DEVELOP NYCTransportation_TechnicalReport.docx.

Greenspace proximity:

- See Yonkers Urban Development I for an example of methods for a proximity analysis assessing walkability to cooling centers (Fig. 5).

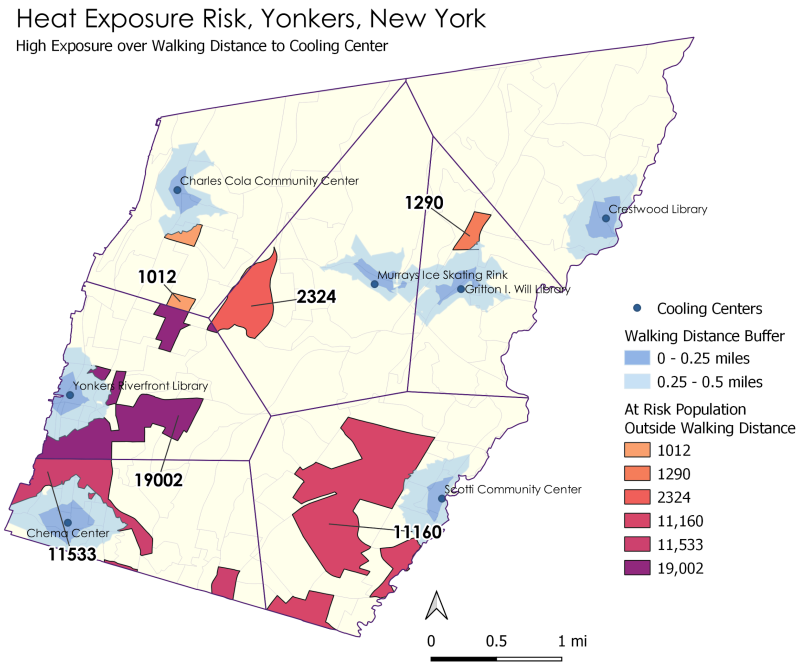

Figure 5. Areas within walking distance from existing cooling centers in Yonkers, NY. Source: NASA DEVELOP YonkersUrban_TechnicalReport.docx.

Other Project Ideas

(From preterm project discussions)

1. **Urban green space**
    - Nicole McNeill nicole@ashevillegreenworks.org : "A map that uses data and analysis to suggest where to create or preserve urban green space and where to build or rebuild natural systems as green infrastructure for climate resilience. See: https://e360.yale.edu/features/kate-orff-interview."

2. **Mapping heat and air quality along transportation corridors in Asheville**
    - Kiera Bulan kbulan@ashevillenc.gov : "...we also considered the possibility of expanding the scope a bit to evaluate trash routes in addition to bus routes and considered bus lines vs bus stops (or both) and a prioritization or inclusion of data that considers where people live/work/play outdoors (i.e. schools, bus stops, recreation centers, etc)."
    - Nicole McNeill nicole@ashevillegreenworks.org : "A targeted analysis of heat & air quality along transportation lines, plus our schools and public parks so that we can better understand where to add shade trees and structures." We could incorporate targeted health vulnerability analysis at these "hot spot" locations to help the public understand the complexity of their heat risk, especially since we have the incredible talent of Jen Runkle to assist us in making this analysis as valuable and impactful as possible
    - Karen MacNeil/Urban Forestry Commission urbanforestalliance@gmail.com : "Perhaps in addition to transportation corridors there could be some data collected on larger developments such as malls, airports, schools, hospitals, large housing developments etc. Schools would be of highest interest to me as an upstream determinant of public health."

3. **Flood risk in the Asheville area**
    - Nicole McNeill nicole@ashevillegreenworks.org "Ian from NEMAC mentioned that flood risk had been studied as part of the recent resilience planning, so if flooding is a priority for the city, we can think about how to update or build on the existing data."
    - Kiera Bulan kbulan@ashevillenc.gov – Information about past projects – "2018 Climate Resilience Assessment and the tools available to us through Land of Sky's AccelAdapt software (which maps risk and vulnerability). I think a more in depth conversation with NEMAC, Land of Sky, and the City for future scoping of what could be updated or enhanced would be interesting."

Wishlist Items

With 10 weeks to conduct this project, it is important to prioritize tasks and objectives. First, focus on the objectives outlined in this proposal and if there is additional time, the following additional analyses can be pursued. Additionally, any wishlist items that are not completed can be listed as "future work" ideas in your presentation and technical report at the end of the term!

Wishlist Item #1:

NEMAC/UNCA analyses – Asheville GreenWorks has expressed interest in having the NASA DEVELOP team produce finalized maps based on datasets compiled by a team from UNCA/NEMAC. GreenWorks plans to share a list of these datasets with tallis.l.monteiro@ama-inc.com and the NASA DEVELOP team.

Wishlist Item #2:

Health outcomes – Asheville GreenWorks has expressed interest in evaluating trends in the between urban heat and health outcomes in Asheville to support work that GreenWorks is conducting in collaboration with a nurse scientist.

End Product	Partner Use	Datasets & Analyses
Health Outcomes Correlation Analysis	The results of statistical analyses will be used to explore relationships between greenspace access, land surface temperature, and health outcomes. These analyses can inform partners' efforts to support community resilience.	Correlations between the urban heat island effect (land surface temperature) and health outcomes (e.g. EMS calls, cardiovascular health) will be assessed using statistical analyses (e.g. linear regression).

Wishlist Item #3:

Green space coverage overtime – This product *will not be necessary* given the urban tree canopy study that will be conducted through the Urban Forest Master Plan in 2025.

End Product	Partner Use	Datasets & Analyses
Urban Green Space Static Maps and Map Layer Package	Partners wish to examine trends in green space coverage across Asheville along with proximity (walking and biking) to green spaces within Asheville neighborhoods due to	Trends in green space coverage in Asheville between 1984–2024 will be approximated by calculating NDVI across the study period using data collected by Landsat missions 5, 7, 8, and 9. Walkability and bikeability to

	community interest in promoting green space access.	green space in 2024 will be calculated around current green space locations (determined using NDVI data along with park and greenway boundaries) using CoA data on pedestrian network sidewalks and greenways and bike facilities.

Platform & Sensor	Parameter(s)	Use
Landsat 5 TM	Vegetation	Landsat 5 TM data will be used to calculate and visualize Normalized Difference Vegetation Index (NDVI) over the study region from 1984–1999.
Landsat 7 ETM+		Landsat 7 ETM+ data will be used to calculate and visualize NDVI over the study region from 1999–2013.
Landsat 8 OLI/TIRS		Landsat 8 OLI data will be used to calculate and visualize NDVI over the study region from 2013–2021.
Landsat 9 OLI-2/TIRS-2		Landsat 9 OLI-2 data will be used to calculate and visualize NDVI over the study region from 2021–2024.