**Huntsville Urban Development II**

*Utilizing NASA Earth Observations to Map the Urban Heat Island and Evaluate Heat Vulnerability in Huntsville, Alabama*

**Project Team**

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**Project Overview**

***Project Synopsis:***

This project mapped the changes in land surface temperature (LST), vegetation (NDVI), and impermeable structures (NDBI) in Huntsville, Alabama from 2019 to 2022. Combining these changes with heat vulnerability based on socioeconomic risk factors, the team assessed urban vulnerability and priority areas for urban tree planting within the city. Additionally, the team attempted to classify roof materials and their correlation with UHI based on land surface temperature.

***Abstract:***

Huntsville, Alabama has seen a boom in growth over recent years. One consequence of this urban expansion is the exacerbation of the Urban Heat Island (UHI) effect across the city. This project identified the areas within Huntsville the greatest potential for heat reduction and community health benefits from tree-planting efforts. The team created maps of land surface temperature (LST), the normalized difference vegetation index (NDVI), and the normalized difference built-up index (NDBI) over June through August from 2019 to 2022 using data from ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station, Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS), Landsat 9 OLI-2 and TIRS-2. The team identified areas with high LST, low NDVI, and high NDBI as areas with the greatest potential for heat reduction via tree-planting. Social factors relating to age, race, income, and self-reported health were adapted from Tree Equity Score to map community need for tree cover. When combining social with environmental factors, the team determined areas with the greatest potential for UHI mitigation: west-central and north downtown Huntsville. The team’s partner organization, the City of Huntsville, can use this priority map to guide their future tree-planting, and weigh the factors assessed according to their preference.

***Key Terms:***

Urban heat island, land surface temperature, NDVI, NDBI, NLCD, ECOSTRESS, Maxar

***National Application Area Addressed:*** Urban Development

***Study Location:*** Huntsville, AL

***Study Period:*** 2019 to 2022 (June to August)

***Community Concerns:***

* Asphalt and the lack of tree canopy allow for high surface temperatures and reduced evapotranspiration, creating warm and uncomfortable conditions in the Huntsville community.
* Additional heat can have negative health effects on the community, and certain groups in the population are more vulnerable than others.
* The partners were also concerned that the rapid urban expansion in Huntsville would cause the city to lose its natural beauty and “small town” feel. They hoped that identifying areas for more tree planting will help reduce high land surface temperatures and loss of beauty.

***Project Objectives:***

* **Map** changes in land surface temperature (LST) and vegetation/permeability over time.
* **Classify** roof materials’ impact on UHI.
* **Assess** priority areas for urban tree planting based on the UHI and heat vulnerability.

***Previous Term(s):***

2020 MSFC – Huntsville Urban Development

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** | **Sector** |
| **City of Huntsville** | Shane Davis, Director – Urban and Economic Development;Marc Byers, Arborist – Landscape Management;Amy Kenum, Manager – GIS Office | End User |  Local Government |

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

The current decision-making process for the city of Huntsville in their tree planting initiative is through donations. Plots of land owned by the city are selected and donors choose the plot of land they would like trees to be planted on. The plots are selected based on their lack of trees. This method does not take into consideration any environmental factors such as LST, NDVI, NDBI, or heat vulnerability. Annual tree planting events in the fall are planned by the city in partnership with the Land Trust of North Alabama. After adopting the Greenway Plan in 2006, the city is currently making efforts to have a greenway network consisting of 312 miles of interconnecting trails. Recently, the city has allocated funds to support the addition of 44 miles to the greenway system by 2023.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Landsat 8 OLI** | NDVI, NDBI | The team used near-infrared, shortwave-infrared, and red bands to calculate NDBI and NDVI at a 30-meter resolution for 2019 to 2022. |
| **Landsat 8 TIRS** | LST | The team used thermal bands to measure LST at a 30-meter resolution from 2019 to 2022 and validate ECOSTRESS data. |
| **Landsat 9 OLI-2** | NDVI, NDBI | The team used Near-infrared, shortwave-infrared, and red bands to calculate NDBI and NDVI at a 100-meter resolution for 2022. |
| **Landsat 9 TIRS-2** | LST | The team used thermal bands to measure LST at 100-meter resolution for 2022 and validate ECOSTRESS. |
| **ISS ECOSTRESS** | LST | This created accurate mapping of absolute and change in LST for the city of Huntsville. |
| **Terra MODIS**  | Nighttime LST | The team used the nighttime band to calculate the average nighttime LST at a 1000-m resolution for 2019 to 2022 and validate ECOSTRESS. |

***Ancillary Datasets:***

* American Forests Tree Equity Score — Public health data that inform heat vulnerability and potential for benefits from tree-planting.
* National Land Cover Database — Classify land cover to generate NDVI thresholds
* National Agriculture Imagery Program — Create confusion matrices to determine accuracy of NDVI threshold classifications

***Software & Scripting:***

* ECOSTRESS Swath to Grid Conversion Script – Swath data products to GeoTIFF conversion
* Google Earth Engine API – Extract land cover parameters (NDVI and NDBI) and LST values; develop training data for NDVI and NDBI
* ESRI ArcGIS Pro 2.4.0 – Raster manipulation and analysis, image classification, and generation of LST and land cover maps
* Python 2.7.15 – Convert ECOSTRESS swath data products into projected GeoTIFFS; extract LST and cloud mask data

***End Product(s):***

|  |  |  |
| --- | --- | --- |
| **End Product(s)** | **Earth Observations Used**  | **Partner Benefit & Use** |
| **Average LST Map** | ECOSTRESS | This map can help locate areas with the highest LST during the study period. This can allow for the partners to focus on these areas in their tree planting efforts. |
| **Change in LST Map** | ECOSTRESS | This map can help locate areas with increasing or decreasing LST during the study period. This can allow for the partners to predict where tree planting efforts will be needed.  |
| **Average NDVI Maps** | Landsat 8 OLI, Landsat 9 OLI-2 | These maps will allow our partners to visualize the impact urbanization has on vegetative surfaces. |
| **Average NDBI Maps** | Landsat 8 OLI, Landsat 9 OLI-2 | These maps will help our partners identify the extent of urban development within the city. This will allow our partners to identify areas that have experienced the greatest development during the study period |
| **Heat Vulnerability Map** | N/A | This map can identify the census blocks in Madison County that had the greatest heat vulnerability. This allows the partners to determine census blocks to prioritize for tree planting efforts. |

***Product Benefit to End User:***

The end products from this project will help the city determine specific areas for future tree plantings based on LST, land cover, and heat vulnerability maps provided by the team. The end results of this project will allow various departments within the city to develop long-range plans and ordinances to increase greenspaces and mitigate the UHI effect in Huntsville. The maps created by the team will function as a baseline for the city’s future efforts to create detailed maps showcasing areas highly vulnerable to the effects of UHIs. Since the city does not currently utilize remote sensing, this project will showcase to our partners the various ways Google Earth Engine and remote sensing tools can be utilized to analyze the impacts of urbanization.

**References**

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