**Cincinnati & Covington Urban Development**

*Assessing Urban Heat in the Cincinnati and Covington Area using NASA Earth Observations*

**Project Team**

***Project Team:***

Paxton LaJoie (Project Lead)

Olivia Cronin-Golomb

Samuel Feibel

Katrina Rokosz

***Advisors & Mentors:***

Dr. Cedric Fichot (Boston University)

Dr. Kenton Ross (NASA Langley Research Center)

***Team POC:*** Paxton LaJoie, plajoie@wisc.edu

***Partner POC:*** Groundwork USA: Cate Mingoya, cate@groundworkusa.org

 Groundwork Ohio River Valley: Tanner Yess, tyess@groundworkorv.org

**Project Overview**

***Project Synopsis:***

This project utilized NASA Earth observations and ancillary datasets to monitor urban heat in the Cincinnati, Ohio and Covington, Kentucky area to support partners at Groundwork USA and Groundwork Ohio River Valley (ORV). The DEVELOP team used NASA Earth observations to calculate daytime and nighttime land surface temperature (LST) anomalies. Additionally, the Natural Capital Project’s Integrated Valuation of Ecosystem Service and Tradeoffs (InVEST) Urban Cooling Model was used to calculate a heat mitigation index for the area and to map the Urban Heat Island (UHI) magnitude. Partners can use this methodology to generate consistent vulnerability maps for Groundwork partner-cities nationwide.

***Abstract:***

The Urban Heat Island (UHI) effect is a phenomenon characterized by urban areas experiencing temperatures that are, on average, warmer than surrounding suburban and rural regions. UHIs are fueled by expansive impervious surfaces, vehicle emissions, and insufficient urban green space. They can have negative health impacts on densely populated urban centers like Cincinnati, Ohio and Covington, Kentucky. NASA DEVELOP partnered with Groundwork USA and Groundwork Ohio River Valley (ORV) to combine environmental education and outreach with analyses of NASA Earth observations for the summers of 2010 - 2020. The DEVELOP team used Landsat 5 Thematic Mapper (TM) and ISS ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) to calculate daytime and nighttime land surface temperature anomalies. The team found that the Cincinnati and Covington area is 8.32°F warmer during the day and 4.97°F warmer at night compared to non-urban areas. The team used the Natural Capital Project Integrated Valuation of Ecosystem Service and Tradeoffs (InVEST) Urban Cooling Model to map a heat mitigation index for the study area. The resulting maps show which communities are most vulnerable to impacts of increased urban heat. The team also assessed alternative tree canopy and albedo scenarios with the InVEST model to better understand the effectiveness of potential heat mitigation strategies. The team found that on a city scale, increasing tree cover was a more effective heat mitigation strategy than increasing albedo. This research provides partners at Groundwork USA and ORV with refined methodologies to support future education and outreach.

***Key Terms:***

heat mitigation, land surface temperature anomalies, climate preparedness, ECOSTRESS, InVEST Urban Cooling Model, environmental justice

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

***Study Location:*** Cincinnati, OH and Covington, KY

***Study Period:*** 2010 to 2020 (June through August)

***Community Concerns:***

* Densely populated urban environments, such as Cincinnati, Ohio and Covington, Kentucky, experience warmer temperatures compared to their rural counterparts. This phenomenon is known as the UHI effect.
* Potential health impacts of elevated urban heat include increases in heat-related morbidity and mortality, increased energy consumption from running air conditioners more frequently, and increased air pollution.
* The ability of the urban landscape to mitigate excess heat varies spatially, resulting in inequalities in the magnitude of heat impacts on vulnerable communities.

***Project Objectives:***

* Implement the National Capital Project InVEST Urban Cooling Model to calculate a heat mitigation index, the cooling capacity, and UHI extent for the study area
* Calculate daytime and nighttime LST anomalies using NASA Earth observation data
* Create an interactive StoryMap as an outreach material for Groundwork USA and Groundwork ORV to communicate and explore spatial patterns of urban heat in the Cincinnati and Covington area
* Update and refine urban heat monitoring methodologies to aid Groundwork USA and Groundwork ORV in producing consistent and reproducible vulnerability maps for any of their partner-cities nationwide

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Groundwork USA** | Steve Burrington, Executive Director; Lawrence Hoffman, Deputy Director of GIS; Cate Mingoya, Director of Capacity Building | End User | Yes |
| **Groundwork USA, Groundwork Ohio River Valley** | Sarah Morgan, GIS & Spatial Data Analyst; Tanner Yess, Co-Executive Director | End User | Yes |

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

The network of nonprofit organizations that composes Groundwork USA primarily focuses on the regeneration, improvement, and management of urban spaces to help mitigate environmental, economic, and social inequalities within marginalized communities. Groundwork ORV is focused on expanding environmental awareness and environmental justice through means including the communication of spatial data. Groundwork USA and ORV personnel acquire data and prioritize projects through several means. When possible, they use NASA Earth observations and GIS mapping to educate the public about environmental issues within their communities and build local capacity for city-specific resilience planning.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 5 TM** | LST | Landsat 5 TM was used to calculate albedo values used as an input for the InVEST Urban Cooling Model. It was also used to visualize and quantify UHI extent through the calculation of daytime LST anomalies.  |
| **ISS ECOSTRESS** | LST, Evapotranspiration | ISS ECOSTRESS data was used to calculate nighttime LST to monitor UHI extent, as well as calculate evapotranspiration as an input for the InVEST Urban Cooling Model. |

***Ancillary Datasets:***

* USGS National Land Cover Database – land cover and land use data for input into the InVEST Urban Cooling Model
* Kenton County Planning and Development Services (PDS) Kenton County Forested Areas, 2012 – tree canopy data used to determine shade values for the InVEST Urban Cooling Model Biophysical table
* Kenton County PDS Lidar Building Heights, 2012 – building heights and locations derived from Lidar data within Kenton County
* Ohio-Kentucky-Indiana (OKI) Regional Council of Governments Regional Building Footprints, 2010 – building footprint data used to calculate building intensity, a Biophysical table input
* OKI Regional Council of Governments Counties, 2010 – county data used as reference to create the study area shapefile
* OKI Regional Council of Governments Jurisdictions, 2010 – jurisdiction data used as reference to create the study area shapefile
* OKI Regional Council of Governments Hamilton County Tree Canopy (2 files), 2010 – tree canopy data used to determine shade values for the InVEST Urban Cooling Model Biophysical table
* OKI Regional Council of Governments DEM, 2010 – a regional DEM used to determine building heights for calculation of building intensity, a Biophysical table input

***Modeling:***

* Natural Capital Project InVEST Urban Cooling Model (Dr. Kenton Ross, NASA Langley Research Center) – Calculate a heat mitigation index, as well as map the UHI and cooling capacity for the study area

***Software & Scripting:***

* Esri ArcGIS Pro 2.7.26828 – Data visualization, spatial analysis
* Google Earth Engine (GEE) – Image processing for temperature data
* RStudio 4.0.0 – Data processing for non-GEE datasets

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Heat Vulnerability Map Package** | Landsat 5 TM, ISS ECOSTRESS  | Partners will use the heat vulnerability package outputs from the InVEST model to better understand heat mitigation ability and possible intervention methods in both cities. | N/A |
| **Land Surface Temperature Anomaly Maps** | ISS ECOSTRESS | Partners will use daytime and nighttime LST data and visualizations to help inform decision-makers of where to prioritize for future urban cooling practices. | N/A |
| **Project Methodology Standard Operating Procedure** | N/A | A detailed tutorial for illustrating the project methodology, so that partners can replicate these analyses in other Groundwork trust cities. | N/A |

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

The results of this work will be of both short-term and long-term value to Groundwork USA and Groundwork ORV. At the local scale, analysis of remote sensing data via the InVEST Urban Cooling Model will provide Groundwork ORV with previously unavailable insight into the heat mitigation ability and future heat mitigation strategies of urban spaces in the Cincinnati, Ohio and Covington, Kentucky area. Groundwork ORV will incorporate these data and findings into their Climate Safe Neighborhoods initiative to better identify opportunities for targeted intervention. This project will also provide a Standard Operating Procedure that will allow Groundwork USA to generate reproducible heat vulnerability maps for any of its partner-cities across the United States, building the capacity of local partners to work with NASA Earth observation data in communities nationwide.

***Project Continuation Plan:***

The spring 2021 term of the project handed off mapped daytime and nighttime LST anomalies for both cities, a heat vulnerability map package, and step-by-step instructions for adapting the InVEST methodology to other areas. The second term of the project will finalize any results not completed in the first term and will focus on creating an urban flood risk map package and static landslide vulnerability maps for the Groundwork USA and Groundwork ORV partners.

**References**

Muche, M. E., Hutchinson, S. L., Hutchinson, J. S., & Johnston, J. M. (2019). Phenology-adjusted dynamic

curve number for improved hydrologic modeling. *Journal of Environmental Management*, *235*, 403-413. doi:10.1016/j.jenvman.2018.12.115

Ronchi, S, Salata, S., and Arcidiacono, A. (2020) “Which Urban Design Parameters Provide Climate-Proof Cities? An Application of the Urban Cooling InVEST Model in the City of Milan Comparing Historical Planning Morphologies.” *Sustainable Cities and Society,* *63,* 102459.

<https://doi.org/10.1016/j.scs.2020.102459>.