**Fairfax County Urban Development**

*Identifying Urban Heat Mitigation Strategies for Climate Adaptation Planning in Fairfax County, Virginia*

**Project Team**

***Project Team:***

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***Advisors & Mentors:***

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**Project Overview**

***Project Synopsis:***

Fairfax County, VA is an urbanized county experiencing urban heat island effect in varying severities throughout the jurisdiction. This project utilized multiple NASA Earth observations coupled with local socioeconomic data to identify current urban heat island conditions and vulnerable populations as well as map heat mitigation capacity and project the effects of various cooling strategies. The Fairfax County Office of Environment and Energy Coordination (OEEC) aims to leverage the results in the development and implementation of Resilient Fairfax: Climate Adaptation and Resilience Plan, to be completed in June 2022.

***Abstract:***

Extreme high temperatures lead to increased instances of cardiovascular disease, pulmonary disease, and even death, as well as increased energy consumption and infrastructure costs. People in urbanized areas experience higher temperatures than rural areas due to diminished vegetation and increased impervious surfaces which absorb and radiate heat. Fairfax County, Virginia has embarked on Resilient Fairfax, a program aimed at addressing climate adaptation and resilience. The DEVELOP team partnered with the Fairfax County Office of Environmental and Energy Coordination (OEEC) to assess the extent of the urban heat island effect on the county and its most vulnerable populations. The team used data from Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS), as well as the ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) for the years 2013 to 2021 and found that the hottest spots were in densely urbanized areas, with temperatures as much as 47°F above that of undeveloped reference areas. The team used the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) urban cooling model and determined that areas with higher tree canopy cover had greater heat mitigation capacity. Estimates from the InVEST model showed that a 4.5% increase in canopy cover across the county could result in a temperature reduction of up to 2.4°F in some areas. The results will allow partners to assess heat distribution across Fairfax County and implement effective mitigation strategies, including locating prime locations for cooling centers and increasing canopy cover.

***Key Terms:***

urban heat island effect, land surface temperature, vulnerability, Landsat 8 TIRS, ECOSTRESS, InVEST, urban development, climate adaptation

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

***Study Location:*** Fairfax County, VA

***Study Period:*** 2013-2021 (June to August)

***Community Concerns:***

* Fairfax County residents are experiencing more extreme weather events such as heat waves, flooding, and storms. They are concerned about the predicted increase of such events and their consequences.
* Extreme heat exacerbates underlying health conditions (including cardiovascular and respiratory illnesses), causes heat-related illnesses such as heat stroke, and can even result in death.
* Heat waves increase energy consumption, resulting in high costs and risks to the existing power supply.
* Extreme high temperatures can degrade structural and functional materials, introducing the risk of failure or damage to infrastructure.
* Heat disproportionately affects those living in substandard housing with no air conditioning or those working outdoors, further exacerbating health risks to more vulnerable populations.

***Project Objectives:***

* Analyze mean land surface temperature from 2013 to 2021
* Visualize daytime hotspots and understand nighttime heat retention of hotspots
* Identify vulnerable populations impacted by the urban heat island effect
* Model heat mitigation capacity and compare the impacts of mitigation strategies

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Fairfax County, Office of Environmental and Energy Coordination** | Allison Homer, Senior Community Specialist & Planner;  Matthew Meyers, Division Manager | End User | No |

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

The Fairfax County Office of Environment and Energy Coordination (OEEC) is a relatively new organization, having officially launched July 1st, 2019. The office is responsible for advancing environmental policies across various Fairfax County organizations, and relies on engaging Fairfax County departments, authorities, residents, and businesses for input on priority and effectiveness of its programs. The OEEC is currently embarking on a formal effort aimed at promoting Fairfax County’s resilience to climate change by proactively identifying climate risks and potential mitigation strategies. The OEEC is familiar with remote sensing data and aims to increase its usage in policy and decision-making.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 8 OLI** | Surface Reflectance | Surface Reflectance data was used to calculate albedo, which provided input to the InVEST urban cooling model. |
| **Landsat 8 TIRS** | Provisional Surface Temperature Product | The Analysis-Ready Provisional Surface Temperature Product was used to determine daytime measurements of land surface temperature and hotspots within Fairfax County. |
| **ISS ECOSTRESS** | Land Surface Temperature, Evapotranspiration | Land Surface Temperature data was used to determine nighttime measurements of temperature to further the partners' understanding of the urban heat effect. Evapotranspiration data provided input to the InVEST urban cooling model. |

***Ancillary Datasets:***

* Fairfax County Existing Land Use Generalized - Land use raster provided input for the InVEST urban cooling model
* National Land Cover Database (NLCD) 2016 - Land cover raster provided input for the InVEST urban cooling model
* Fairfax County Tree Cover 2015 - Tree cover layer provided input for the InVEST urban cooling model
* Fairfax County Community Centers - Feature layer of community centers provided insight into location of cooling centers across the county
* Fairfax County Impervious Surfaces - Feature layer of impervious surfaces assisted in modeling of the urban heat island effect within the county
* Fairfax County Buildings - Feature layer of building footprints provided input for InVEST urban cooling model
* Fairfax County Water Polygons - Used to clip Potomac River out of county datasets
* US Census Bureau American Community Survey (ACS) - Socioeconomic data used to map distribution of heat vulnerable populations

***Modeling:***

* Natural Capital InVEST Urban Cooling Model (POC: Dr. Kenton Ross, NASA Langley Research Center) - Calculation of heat mitigation indices and assessment of potential mitigation scenarios

***Software & Scripting:***

* Esri ArcGIS Pro 2.8.0 – Raster and vector analysis, map production
* R 4.1.0 / RStudio 1.4.1717 – Raster file preparation and preliminary analysis
* Python 3 - Cloud masking, raster file preparation
* QGIS 3.16.9 - Raster and vector analysis, map production

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Urban Heat Anomaly Maps (empirical)** | Landsat 8 TIRS  ISS ECOSTRESS | The urban heat anomaly maps display the current heat hotspots in Fairfax County. This information will assist partners in making decisions about their heat mitigation strategy. | N/A |
| **Heat Mitigation Maps (modeled) -** | Landsat 8 OLI  ISS ECOSTRESS | These maps display the heat mitigation capacity of regions within Fairfax County and will assist the partners in understanding an area’s ability to counteract extreme heat. | N/A |
| **Heat Vulnerability Map** | Landsat 8 TIRS  ISS ECOSTRESS | The heat vulnerability map displays the distribution of heat vulnerable populations in Fairfax County in order to inform priority locations for mitigation plans. | N/A |
| **Urban Heat StoryMap** | N/A | The urban heat story map can be used by partners to educate the public on the urban heat island effect in Fairfax County as well as the importance of mitigation strategies such as tree canopy and cooling centers. | N/A |

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

The OEEC will be able to use the urban heat anomaly and urban heat mitigation maps to determine where extreme temperatures are most prevalent in Fairfax County, as well as an area’s effectiveness in counteracting extreme heat. The distribution of hotspots will be used to determine priority areas for mitigation initiatives, which may include increasing tree canopy cover or locating ideal locations for cooling centers. Additionally, the heat vulnerability map will allow end users to better understand the distribution of populations that are heat-sensitive and are located in areas that are exposed to higher temperatures. The results will assist the OEEC in assessing existing policies, as well as direct future planning to best mitigate extreme heat.

**References**

Office of Environmental and Energy Coordination. (n.d.). *Resilient Fairfax*. Fairfax County Virginia. <https://www.fairfaxcounty.gov/environment-energy-coordination/resilient-fairfax>

World Health Organization. (n.d.) *Climate Change and Health.* https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health