**Youngstown & Warren Disasters**

*Mapping Flood Susceptibility, Vulnerability, and Risk and Tree Canopy Coverage in Northern Ohio to Inform Stormwater Management and Flood Mitigation Efforts*

**Project Team**

***Project Team:***

Lauren Mahoney (Project Lead)

David Henriques

Thomas Ferrell

Nada Haddad

***Advisors & Mentors:***

Dr. Kenton Ross (NASA Langley Research Center)

Lauren Childs-Gleason (NASA Langley Research Center)

***Fellow:***

Olivia Landry

***Team Contact:*** Lauren Mahoney, mahoney.lauren@gmail.com

***Partner Contact:*** Jenna Johnston, jenna@weare.eco

**Project Overview**

***Project Synopsis:***

In collaboration with the cities of Youngstown and Warren, as well as the Environmental Collaborative of Ohio (ECO), this project developed an analysis of flood prone areas within the region of study to help inform decision making regarding proactive flood measures. The DEVELOP team examined historical flood trends as well as land and tree canopy cover to forecast potential future flooding events and to identify communities most vulnerable to flooding. The resulting analyses and products support end users’ implementation of proactive policies to help mitigate flood risk within the Youngstown and Warren areas.

***Abstract:***

Both pluvial and fluvial flooding events pose direct challenges on urban infrastructure and communities across the United States. Heavy rainfall events oversaturate the ground, overflow waterbodies, and overwhelm stormwater infrastructure. Vulnerable areas receive heavy damage from flooding events due to physical factors like increased impervious surfaces, poor stormwater systems, and limited greenspaces. These vulnerable neighborhoods are comprised of aging populations, minority communities, and lower income levels. Lack of data in these communities have made it difficult to implement policymaking and flood mitigation strategies. Using the Urban Flood Risk Mitigation model (InVEST) and the PlanetScope satellite constellation, the team visualized historical flooding and tree canopy coverage as a measure of flood susceptibility. The team also used the Arc-Malstrom model to provide further insight into where flooding accumulates via surface elevation depressions in the study area. To validate these models, the team explored the spatial variation of rainfall events using NASA’s Integrated Multi-satellite Retrievals for Global Precipitation Measurement (GPM IMERG). The resulting maps highlight areas surrounding the cities of Youngstown and Warren as being the most flood susceptible and socially vulnerable, while the city centers contain the lowest tree canopy coverage. The DEVELOP team collaborated with the Environmental Collaborative of Ohio (ECO) to create products for end users within the City of Warren’s Water Pollution Control Department, the Eastgate Regional Council of Governments and the Healthy Community Partnership of Mahoning Valley. These products help identify target areas for preventative flood mitigation measures as well as areas ideal for green infrastructure intervention.

***Key Terms:***

InVEST Urban Flood Risk Mitigation Model, Arc-Malstrom (Bluespot) Model, urban flooding, tree canopy cover, flood vulnerability

***National Application Areas Addressed:*** Disasters

***Study Location:*** Trumbull and Mahoning County, OH

***Study Period:*** January 2017 – December 2022

***Community Concerns:***

* Youngstown and Warren have experienced severe flooding in recent years caused by increased rainfall and exacerbated by aging stormwater infrastructure. This drives environmental and economic concerns within the community, such as pollution, property damage, and land use change.
* Trumbull and Mahoning Counties have an aging, declining population that is predominantly low income, and are lacking the resources to advance proactive flood measures. Many of the residents feeling the brunt of flood impacts are also low income and BIPOC and typically live in areas lacking tree coverage.
* Being in an urban environment with few pervious surfaces for rainfall to infiltrate, Youngstown and Warren are at an increased risk for flood events during severe rainfall. As storm events are projected to worsen in severity and duration due to climate change, these cities need to assess which areas are most susceptible to floods, and which populations are most socially vulnerable.

***Project Objectives:***

* Model runoff and runoff retention using the InVEST Urban Flood Mitigation Model using three flooding scenarios to produce interactive accessible maps that can be employed by community leaders to plan proactive flood mitigation measures.
* Produce a flood vulnerability map using the Social Vulnerability Index to account for the social determinants of high-risk communities during natural disasters.
* Model rainfall pooling from pluvial flooding using the Arc-Malstrom (Bluespot) model.
* Create maps of tree canopy cover and flood susceptibility that facilitate the identification of neighborhoods for targeted green infrastructure interventions.

**Partner Overview**

***Partner Organizations***

|  |  |  |
| --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** |
| **City of Warren, Water Pollution Control Department** | Ed Haller, Director | End User |
| **Eastgate Regional Council of Governments**  | Stephanie Dyer, Environmental Program Manager | End User |
| **Healthy Community Partnership Mahoning Valley** | Sarah Lowry, Director  | End User |
| **Environmental Collaborative of Ohio** | Courtney Boyle, Technical Services Lead; Jenna Johnston, Projects Coordinator; Katherine Zodrow, Stormwater Engineer | Collaborator |

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

The City of Warren’s Water Pollution Control Department and the Environmental Collaborative of Ohio (ECO) are working to address water resource management and nonpoint source pollution. One of the ways they address this is by implementing preventative flood mitigation measures such as removing existing aging dams and adding green infrastructure solutions, including rain gardens, permeable pavement, and natural playspaces and gathering areas. Eastgate Regional Council of Governments is working on restoring the Mahoning River to its pre-industrial state through removing dams along the river, and is also interested in increasing green spaces and green infrastructure. Healthy Community Partnership Mahoning Valley works with community partners to improve the health and social determinants of health for its residents and a key tenet of this mission is through making sure residents have access to healthy greenspaces and safe transportation. Partners currently do not use remote sensing for their decision making and are unfamiliar with NASA EO.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **PlanetScope** | Surface reflectance  | PlanetScope data were used to create high resolution tree canopy coverage maps. |
| **GPM IMERG** | Precipitation | GPM IMERG data were used to display the spatial variation in precipitation in the study area, and to validate the results of the InVEST model.  |

***Ancillary Datasets:***

* U.S. Census Bureau, 2019, state, Ohio, Primary and Secondary Roads State-based Shapefile – Roads data was used for input into InVEST Urban Flood Mitigation Model
* U.S Census Bureau, Selected Demographic and Economic Data by Block Groups, Ohio, 2019 – Demographic data was used for flood vulnerability map
* Ohio Department of Administrative Services, Digital Elevation Model (DEM) – DEM was used to calculate elevation and slope within the flood susceptibility map
* USGS National Land Cover Database, 2010 – Land cover and land use data was used for input into the InVEST Urban Flood Mitigation Model
* USDA Gridded Soil Survey Geographic (gSSURGO) Database, 2020 – Soil type and drainage class was used as inputs into the InVEST Urban Flood Risk Mitigation Model
* USGS Watershed Boundary Dataset – Watershed and sewer shed data was used as inputs into the InVEST Urban Flood Risk Mitigation Model
* CDC Social Vulnerability Index – Used for flood vulnerability map along with U.S. Census Bureau data
* National Agriculture Imagery Project (NAIP) imagery – Used for the tree canopy cover accuracy assessment

***Modeling:***

* Natural Capital Project InVEST Urban Flood Risk Mitigation (POC: Dr. Kenton Ross, NASA Langley Research Center) – Calculate stormwater runoff as well as stormwater runoff retention for Trumbull and Mahoning Counties
* Arc-Malstrom Model – Calculating accumulation of pluvial flooding across surface landscape elevation depressions for Trumbull and Mahoning Counties

***Software & Scripting:***

* Google Earth Engine – Processing GPM IMERG precipitation data and creating area averaged chart of precipitation
* ArcGIS Pro 2.9.3 – Preprocessing data for the InVEST Urban Flood Risk Mitigation model, running the Arc-Malstrom model, and mapping social and flood vulnerability for Trumbull and Mahoning Counties
* InVEST Workbench 3.12.0 - Running the InVEST Urban Flood Risk Mitigation model.

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Tree Canopy Cover Map** | Map of tree canopy coverage to help identify neighborhoods for targeted green infrastructure interventions. | Employ image classification methods utilizing Planet data through NGA commercial data buy to produce high resolution land cover classification focused on tree canopy coverage. | N/A |
| **Runoff & Runoff Retention Maps** | These maps will allow partners to visualize areas that have high runoff and inversely, which areas retain runoff. This will allow them to identify areas prone to flooding from rainfall.  | This map will be an output of the InVEST model. This model will take inputs of rainfall depth, land use land cover (NLCD), soil hydrologic groups (gSSURGO), watershed boundaries (USGS WBD) and built infrastructure (OpenStreetMaps). | N/A |
| **Blue Spot Map** | This map will highlighting the surface elevations depressions where pluvial flooding accumulates and it will be paired with the Runoff/Runoff Retention map to aid partners in identifying areas that can be targeted for preventative flood mitigation measures. | Data from USGS for a Lidar DEM (3.4 m resolution) will be used to generate blue spot vectors that highlight local surface elevation depressions where water would accumulate.  | N/A |
| **Flood Vulnerability Map** | This map will aid partners in identifying areas with vulnerable sectors of the population that may be adversely affected by increased flooding.  | The vulnerability map will incorporate US census data and the Social Vulnerability Index from the CDC to identify demographic social determinants associated with vulnerable to flooding. | N/A |

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

The tree canopy cover and flood susceptibility end products will be used by the partners in the cities of Youngstown and Warren to identify specific locations for green infrastructure intervention, including but not limited to greenspaces, street trees, and pocket parks. This project will allow partners to understand how remote sensing imagery can be used to visualize areas with the highest flood risk and therefore inform where to focus preventative flood measures. The results of the flood susceptibility model will be used by the partners to plan and effectuate proactive and innovative changes for flood mitigation, rather than the status-quo reactive response to flood disasters.

**References**

LaJoie, P., Cronin, E., Perrotti, J., Shives, E., & Webster, S. (2021). Cincinnati and Covington Urban Development II: Assessing flooding and landslide susceptibility along the Ohio-Kentucky border. NASA DEVELOP National Program, Massachusetts – Boston. <https://ntrs.nasa.gov/citations/20210021222>

Stanford Natural Capital Project. (2022). *InVEST Documentation: Urban Flood Risk Mitigation model*. Natural Capital Project. <https://invest-userguide.readthedocs.io/en/latest/urban_flood_mitigation.html>

Zabret, K., & Šraj, M. (2015). Can Urban Trees Reduce the Impact of Climate Change on Storm Runoff? Urbani Izziv, 26, S165–S178. http://www.jstor.org/stable/24920954.