**Cincinnati & Covington Urban Development II**

*Assessing Flooding and Landslide Susceptibility Along the Ohio-Kentucky Border*

**Project Team**

***Project Team:***

Paxton LaJoie (Project Lead)

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***Advisors & Mentors:***

Dr. Cedric Fichot (Boston University)

Dr. Kenton Ross (NASA Langley Research Center)

Dr. Matthew Crawford (Kentucky Geological Survey)

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**Project Overview**

***Project Synopsis:***

Neighboring cities Cincinnati, Ohio and Covington, Kentucky are densely populated urban environments that are vulnerable to potential flooding and landslides. The team utilized NASA Earth observations and ancillary data to create landslide susceptibility and exposure maps. Additionally, the team mapped rainfall runoff and runoff retention using the Natural Capital Project Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) Urban Flood Risk Mitigation Model. This project assisted partners at Groundwork USA and Groundwork Ohio River Valley (ORV) by creating reproducible maps through careful assessment of flooding and landslide related vulnerabilities.

***Abstract:***

Landslides and flooding are reoccurring environmental hazards that lead to health risks and economic burdens in the urban areas of Cincinnati, Ohio and Covington, Kentucky. These communities share underlying natural and artificial conditions that make them vulnerable to these hazards, including excessive precipitation, weak lithology, high impervious surface levels, and steep slopes. Despite the human and economic risks associated with these environmental hazards, the areas of highest vulnerability within the region remain unknown. NASA DEVELOP partnered with Groundwork USA and Groundwork Ohio River Valley (ORV) to assess the region’s susceptibility to landslides and flooding. The team utilized NASA Earth observations, including the Landsat 8 Operational Land Imager (OLI), Landsat 8 Thermal Infrared Sensor (TIRS), and Global Precipitation Measurement (GPM) Integrated Multi-satellitE Retrieval for GPM (IMERG), alongside ancillary datasets to map landslide susceptibility and exposure throughout the study area. The team also used ancillary data to map surface runoff and runoff retention using the Natural Capital Project’s Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) Urban Flood Risk Mitigation Model. The resulting landslide susceptibility and exposure maps highlight the neighborhoods around Avondale and Fairmount as areas of particularly high landslide exposure. Meanwhile, the InVEST outputs demonstrate that Downtown Cincinnati and the Queensgate neighborhood retain the least amount of rainfall. This research provides partners with a more complete hazard analysis of the greater Cincinnati area while also producing refined methodologies to enhance future flood and landslide vulnerability mapping throughout Groundwork USA’s nationwide network of communities.

***Key Terms:***

landslide exposure, InVEST Urban Flood Risk Mitigation Model, runoff retention, precipitation

***National Application Areas Addressed:*** Urban Development, Water Resources

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

***Study Period:*** July 2004 – June 2021

***Community Concerns:***

* Destructive flooding and landslide events pose significant safety risks to communities in Cincinnati, Ohio and Covington, Kentucky.
* Both flooding and landslide events can cause costly damage to urban infrastructure and repair costs can total millions of dollars.
* Socioeconomically vulnerable communities can disproportionately experience the effects of climate change and environmental hazards.

***Project Objectives:***

* Map regional landslide susceptibility and exposure using NASA Earth observations
* Implement the National Capital Project InVEST Urban Flood Risk Mitigation Model to identify areas of greatest stormwater flood risk and areas contributing to stormwater retention
* Develop a methodology for producing consistent flood and landslide vulnerability maps to aid Groundwork USA and Groundwork ORV in reproducing project analyses for partner cities nationwide
* Create an interactive StoryMap as an outreach product for Groundwork USA and Groundwork ORV to communicate flood and landslide risks to local communities

***Previous Term:***

2021 Spring (MA) – Cincinnati & Covington Urban Development

**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 | End User | Yes |
| **Groundwork Ohio River Valley** | Sarah Morgan, GIS & Spatial Data Analyst; Tanner Yess, Co-Executive Director | End User | Yes |

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

Groundwork USA is a network of nonprofit organizations focusing on the regeneration, improvement, and management of urban spaces to help mitigate environmental, economic, and social inequalities within marginalized communities. Groundwork ORV focuses on expanding environmental awareness and environmental justice in their local communities through means including the communication of spatial data. Groundwork USA and ORV personnel use NASA Earth observations and GIS mapping to educate the public about environmental issues and build local capacity for city-specific resilience planning. Currently, no standardized mapping procedure exists within the Groundwork network to assess flooding or landslide vulnerability in urban areas.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Landsat 8 OLI** | Surface Reflectance | Landsat 8 OLI surface reflectance data was used to calculate NDVI as a factor for assessing landslide susceptibility. |
| **Landsat 8 TIRS** | Surface Reflectance | Landsat 8 TIRS data was used to create a cloud mask for the surface reflectance data involved in the NDVI calculation. |
| **GPM IMERG** | Precipitation | GPM IMERG data rainfall data was used to determine the InVEST model’s depth in rainfall input. |

***Ancillary Datasets:***

* Kentucky Geological Survey Landslide Inventory, 2021 – Landslide inventory used in conjunction with national database for susceptibility map validation
* Kentucky Transportation Cabinet Roads, 2020 – Road data incorporated as built infrastructure for input into the InVEST Urban Flood Risk Mitigation Model
* Ohio Department of Transportation Roads, 2020 – Road data incorporated as built infrastructure for input into the InVEST Urban Flood Risk Mitigation Model
* Ohio-Kentucky-Indiana (OKI) Regional Council of Governments Regional Building Footprints, 2010 – Building footprint data for input into the InVEST Urban Flood Risk Mitigation Model
* 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 Rivers and Lakes, 2010 – River vector used to mask the Ohio River from flooding and landslide analyses
* U.S. Census Bureau, 2015, state, Kentucky, Primary and Secondary Roads State-based Shapefile –Roads data used for landslide susceptibility mapping
* U.S. Census Bureau, 2015, state, Ohio, Primary and Secondary Roads State-based Shapefile – Roads data used for landslide susceptibility mapping
* U.S. Census Bureau, Selected Demographic and Economic Data by Block Groups, Kentucky, 2019 - Census data used for landslide exposure maps
* U.S Census Bureau, Selected Demographic and Economic Data by Block Groups, Ohio, 2019 - Census data used for landslide exposure maps
* University of California, Santa Barbara Climate Hazards Group Infrared Precipitation with Station data – Gridded rainfall estimates from rain gauge and satellite observations used to assess rainfall variability across the study period from 2004 to 2021
* USDA Gridded Soil Survey Geographic (gSSURGO) Database, 2020– Soil type and drainage class for calculating curve numbers for the InVEST Urban Flood Risk Mitigation Model
* USDA Soil Survey Geographic (SSURGO) Database, Tabular and Spatial data, 2020 – Percent of clay in soils data used for landslide susceptibility mapping
* USGS National Elevation Dataset 1/9 Arc-Second Digital Elevation Model (DEM) – Regional DEM used in landslide susceptibility mapping
* USGS National Land Cover Database, 2010 – Land cover and land use data for input into the InVEST Urban Flood Risk Mitigation Model
* USGS State Geologic Compilation Map, 2017 – Geologic makeup of the study area used to assess rock formations relative to landslide susceptibility
* USGS U.S. Landslide Inventory, 2019 – Nationwide landslide inventory used to validate the study area’s landslide susceptibility map

***Modeling:***

* Natural Capital Project InVEST Urban Flood Risk Mitigation (Dr. Kenton Ross, NASA Langley Research Center) – Calculated stormwater runoff reduction

***Software & Scripting:***

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

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Flood Risk Mitigation Map Package** | GPM IMERG | Partners at Groundwork will use the spatially explicit outputs from the InVEST Urban Flood Risk Mitigation Model to better identify high stormwater flood risk areas in both cities. These products will include Runoff Retention Maps and Runoff Value Maps. | N/A |
| **Static Landslide Susceptibility and Exposure Maps** | Landsat 8 OLI  Landsat 8 TIRS | Gridded landslide susceptibility maps will allow partners to identify landslide potential at a finer spatial resolution than current local alerts. Landslide exposure maps will allow partners to assess landslide vulnerability relative to key populations and infrastructure locations. | N/A |
| **Project Methodology Standard Operating Procedure** | N/A | A detailed walkthrough of both the InVEST and landslide mapping project methodologies will allow partners to replicate these analyses in other Groundwork trust cities. | N/A |

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

The results of this work will be scalable to local and national levels. At the local level, the results of this project will assist Groundwork USA and Groundwork ORV in understanding local landslide and flooding vulnerabilities faced by communities in the Cincinnati and Covington area. Long term, the provided Standard Operating Procedure will be implemented by Groundwork USA to generate maps and GIS products for any of its trusts nationwide. Additionally, Groundwork ORV will incorporate these data and findings into their Climate Safe Neighborhoods initiative to better identify opportunities for targeted intervention.

**References**

Baum, R.L. and Johnson, A.M. (1996). Overview of landslide problems, research, and mitigation, Cincinnati, Ohio, area, U.S. Geological Survey.

City of Cincinnati Department of Transportation and Engineering. (2019). 2019 Columbia Parkway Landslide Report. 1–33.

First Street Foundation. (2020). The First National Flood Risk Assessment: Defining America’s Growing Risk. 1–116.