**Potomac River Basin Water Resources**

*Assessing Water Quality and Quantity in the National Capital Region using NASA Earth Observations*

**Project Team**

***Project Team:***

Zach Kinloch

Divina Lade

Xavier García López

Haydee Portillo

***Advisors & Mentors:***

Sean McCartney (Science Systems and Applications, Inc., NASA Goddard Space Flight Center)

***Fellow:***

Carli Merrick (Maryland - Goddard)

***Team Contact:*** Divina Lade, divina.lade@gmail.com

***Partner Contact:*** Dan Myers, dmyers@stroudcenter.org

**Project Overview**

***Project Synopsis:***

This project aimed to help the National Park Service (NPS) better understand trends in water quality and supplement their ability to monitor changes in the National Capital Region Network. Land use/Land cover (LULC), Normalized Difference Vegetation Index (NDVI), Precipitation and Soil Moisture data were all analyzed against water quality data provided by NPS. The project found significant correlations between precipitation, soil moisture, NDVI, and water quality. Correlations were found between certain land use types and water quality metrics, but findings varied greatly between watersheds.

***Abstract:***

The Potomac River Basin (PRB) is responsible for providing drinking water to over 5 million residents and plays a significant role in the health of the Chesapeake Bay. Therefore, it is important to understand the relationship between water quality, landcover, and the hydrological cycle within the PRB. The National Park Service (NPS) has monitored 37 streams within the National Park Units in Maryland, Virginia, West Virginia and Washington, D.C. This project aimed to help the NPS better understand trends in water quality to supplement their ability to monitor changes in the National Capital Region Network (NCRN). Google Earth Engine, ArcGIS Pro, R, and Python were used for data retrieval, visualization, and analysis. Earth observations included Landsat 5 TM and Landsat 8 OLI/TIRS imagery. Ancillary data included the USDA Cropland Data Layer, Climate Hazards Group InfraRed Precipitation with Station Data (CHIRPS), and soil moisture data from the Famine Early Warning Systems Network (FEWS NET) Land Data Assimilation System (FLDAS). We compared Land use/land cover (LULC), Normalized Difference Vegetation Index (NDVI), precipitation and soil moisture data to water quality data provided by the NPS at a watershed level. LULC change maps were also generated for the PRB between 2008 and 2022. We found significant correlations between precipitation, soil moisture, NDVI, and water quality. Correlations were found between certain land use types and water quality metrics, but findings varied greatly between watersheds. These insights emphasize the imperative of strategic watershed management in preserving the integrity of key aquatic systems.

***Key Terms:***

Landsat, FLDAS, CHIRPS, GEE, Water Quality, Land Use Land Cover, NDVI, Hydrology

***National Application Area Addressed:*** Water Resources

***Study Location:*** Potomac River Basin watersheds (Young’s Branch, Blue Blazes Creek, North Fork Quantico Creek, Rock Creek, Oxon Run, Bush Creek); DC, MD, VA, WV

***Study Period:*** January 2007 – December 2022

***Community Concerns:***

* Climate change has altered precipitation patterns, impacting the water quantity and the local hydrological cycle, increasing the input of nutrients and changing the biochemical interactions between the aquatic and terrestrial ecosystems. The risk of waterborne diseases and exposure to harmful chemicals within the PRB threatens the quality of life for residents in the Washington metropolitan area, as the PRB is responsible for the drinking water for this area
* Land use developments have led to increased urbanization, flood vulnerability, and increased runoff of nutrients into streams, promoting eutrophication and making communities vulnerable to waterborne diseases.
* Currently, satellite data is not heavily utilized by NPS to observe water quality conditions and changes over time. The goal of this project was to use Earth observations to better enhance NPS’ ability to observe trends in water quality. This will allow them to understand where to better focus management actions.

***Project Objectives:***

* Create land use change maps (2008–2022)
* Compare land cover changes with water quality
* Analyze the relationship between hydrological conditions and water quality
* Generate engaging social media posts about the project

**Partner Overview**

***Partner Organization(s):***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organizations** | **Contact (Name, Position/Title)** | **Partner Type** | **Sector** |
| **National Park Service, Inventory & Monitoring Program, National Capital Region Network (NCRN)** | Dr. Liz Matthews, Program Manager/Ecologist | End User | Federal Government |
| **Stroud Water Research Center** | Dr. Dan Myers, Postdoctoral Associate | Collaborator |  Non-profit |

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

Inventory & Monitoring Program NCRN currently monitors 37 streams using gauges and field instruments. The NCRN is part of the Chesapeake Bay watershed, the largest estuary in the Washington D.C. area. Due to a long-term decline in water quality, the NPS is interested in analyzing relationships between water quality and landcover in an effort to focus management actions on streams that are most likely to improve. Management practices include streambank erosion control, riparian vegetation recovery, stormwater management, etc. Currently, satellite data are not being heavily utilized in this process.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Landsat 8 OLI**  | Normalized Difference Vegetation Index (NDVI)  | Average seasonal NDVI data was used to analyze the relationship between land cover change and water quality |
| **Landsat 8 TIRS** | Normalized Difference Vegetation Index (NDVI)  | Average seasonal NDVI data was used to analyze the relationship between land cover change and water quality |
| **Landsat 5 TM** | Normalized Difference Vegetation Index (NDVI)  | Average seasonal NDVI data was used to analyze the relationship between land cover change and water quality |

***Ancillary Datasets:***

* National Park Service NCRN water quality data (2005-present) - Current water quality data collected by NPS from streams in the NCRN
* USDA Cropland Data Layer - Average seasonal NDVI data was used to analyze the relationship between land cover change and water quality
* Famine Early Warning Systems Network (FEWS NET) Land Data Assimilation System (FLDAS) - Average seasonal soil moisture data was used to analyze the relationship between hydrological conditions and water quality
* Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) - Average seasonal precipitation data was used to analyze the relationship between hydrological conditions and water quality

***Software & Scripting:***

* ArcGIS Pro 2.9.6 - Shapefile buffering and data visualization
* Google Earth Engine (GEE) API - Extract remote sensing data in CSV format, as well as extract Land Use/Land Cover and NDVI imagery
* Python 3.10.6 (via Google Collab and Jupyer Lab) - Conduct correlation tests
* R 4.3.1 (via RStudio) - Conduct correlation tests

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

|  |  |  |
| --- | --- | --- |
| **End Product(s)** | **Earth Observations Used**  | **Partner Benefit & Use** |
| **Land Use Change Maps**  | N/A | These maps will provide a deeper understanding of how land use/land cover has changed over the study period throughout the locations that NPS manages within the Potomac River Basin as well as apply the project’s methodology to other areas of interest |
| **Remotely Sensed Data** | Landsat 5 TM, Landsat 8 OLI, Landsat 8 TIRS | These raster and CSV files will allow NPS the ability to apply the project’s methodology to other areas of interest within the Potomac River Basin. |
| **Statistical Correlations between Remotely Sensed Data and Water Quality Data** | Landsat 5 TM, Landsat 8 OLI, Landsat 8 TIRS | These graphs and CSV files will provide NPS the results of the project. This will allow them to understand some of the current water quality trends within the Potomac River Basin. This will also give them the ability to observe the difference in water quality between high-managed areas vs low-managed areas. |

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

Building on the project's advancements, the integration of satellite and earth observation data offers the National Park Service (NPS) an unprecedented vantage point in monitoring the water quality within the National Capital Region Network. Previously limited in scope, NPS will soon have the capability to zoom in on specific sub-basins, gaining finer insights and tracking even subtle changes in water quality and land use. The satellite-derived information, combined with the project's methodologies, will guide NPS in the future, facilitating more granular, real-time decisions. Harnessing this technology, NPS is poised to optimize watershed management strategies, ensuring sustainable water quality for the expansive communities dependent on the Potomac River Basin. This leap forward, powered by satellite data, augments NPS's potential to set a new standard in environmental stewardship not only within the Potomac area but also potentially inspiring similar advancements across other national parks.

**References**

Bricker SB, Clement CG, Pirhalla DE, Orlando SP, Farrow, DRG (1999) National estuarine eutrophication assessment. Effects of nutrient enrichment in the Nation’s Estuaries. NOAA, National Ocean Service, Special Projects Office and National Centers for Coastal Ocean Science, Silver Spring. <http://spo.nos.noaa.gov/projects/cads/nees/Eutro_Report.pdf>

Chesapeake Bay Foundation (2012) State of the Bay report. <http://www.cbf.org/about-the-bay/state-of-thebay/2012-report>

University of Maryland, Center for Environmental Science (UMCES), Integration & Application Network, EcoCheck (2011) Chesapeake Bay report card <http://ian.umces.edu/ecocheck/reportcards/chesapeakebay/2011/>