**Patuxent Water Resources**

*Assessing Land Cover and Land Use Change to Inform Watershed Resource Management*

**VPS Title:** Don’t Let Them Runoff: Culprits of the Upper Patuxent Watershed

**Project Team**

***Project Team*:**

Stephanie Rockwood (Project Lead)

Shaifali Prajapati

Connor Holzmann

Kyung “Robin” Kim

***Advisors & Mentors*:**

Dr. Kenton Ross (NASA Langley Research Center)

**Project Overview**

***Project Synopsis:*** The Patuxent Reservoirs Watershed Protection Group Technical Advisory Committee (PRWPG TAC) is a multi-jurisdictional government cooperative focused on improving water quality and wetland habitat within the 132 square mile Patuxent Reservoirs Watershed (PRW) in Maryland. The group collects and aggregates data related to watershed characteristics and recommends courses of action to government officials. To supplement *in situ* water quality metrics used by the PRWPG TAC, this project generated a consistent, reproducible set of land use and land cover (LULC) maps for the extent of the watershed. The team analyzed spatial and temporal trends in LULC to aid TAC officials in their management and preservation of the PRW.

***Abstract:***

The Patuxent Reservoirs Watershed, in Howard, Montgomery, and Prince George’s Counties in Maryland, is a significant source of water supply for the greater Washington, D.C., metropolitan area. The Patuxent Reservoirs Watershed Protection Group Technical Advisory Committee (PRWPG TAC) monitors water quality and releases annual reports in order to provide management recommendations to policymakers for reducing pollutant loads. However, more comprehensive data is needed to understand the relationship between water quality and land use change, as inconsistent data availability across the municipal boundaries of the watershed inhibits a holistic land use and land cover (LULC) assessment. To address this concern, the team created synthesized LULC raster datasets by aggregating data from the United States Geologic Survey (USGS) National Land Cover Database (NLCD), the National Oceanic and Atmospheric Administration (NOAA) Coastal Change Analysis Program (C-CAP), the United States Department of Agriculture (USDA) Cropland Data Layer (CDL), and NASA Earth observations. The team calculated annual LULC classification trends from 2008 to 2018 and mapped LULC change on five-year intervals from 1996 to 2016 to analyze overall spatiotemporal trends for the watershed. Team members also compared the synthetic LULC dataset to independently generated LULC maps provided by the PRWPG TAC for 2002 and 2010. The new synthetic raster provides greater specificity in terms of agricultural, wetland, and urban land cover classes. The maps allow the PRWPG TAC to assess the relationship between LULC changes and water quality. In addition, this method of map synthesis gives an easy and economical method for creating LULC datasets in the future.

**Keywords:**

water quality, watershed, land cover change, land use change, change analysis, agricultural runoff

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

***Study Location:*** Howard, Montgomery, and Prince George’s Counties, Maryland (MD)

***Study Period:*** January 1996 to December 2018

***Community Concern:***

* The PRWPG TAC is tasked with monitoring the Patuxent Reservoirs Watershed and relaying related metrics to government policymakers.
* The Triadelphia and Rocky Gorge reservoirs within the watershed supply drinking water to about 650,000 residents of the greater Washington, D.C., metropolitan area in Montgomery, Prince George’s, and Howard Counties in Maryland.
* Both agricultural and residential land use and eroding stream banks are significant nonpoint sources of pollution in the PRW.
* Both reservoirs require best management practices (BMPs) to maintain a level below their established total maximum daily load (TMDL) for phosphorus. The Triadelphia Reservoir requires BMPs for reducing sediment load.

***Project Objectives:***

* Incorporate NASA Earth observations into the established mapping procedures of the PRWPG TAC
* Draw on strengths of land cover data provided by National Oceanic and Atmospheric Administration (NOAA), the United States Department of Agriculture (USDA), and the United States Geologic Survey (USGS), augmented with team-produced land use classifications to supplement time gaps
* Produce a time series map of land use and land cover (LULC) maps using a combination of spectral & spatial classification
* Analyze land use change to provide inputs for hydrologic models
* Offer a reproducible methodology that can be easily utilized by the partner

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Patuxent Reservoirs Watershed Protection Group, Technical Advisory Committee (PRWPG TAC)** | Susan Overstreet, Howard County;  Jean Kapusnick, Montgomery County;  Steven Nelson, Washington Suburban Sanitary Commission | End User | Yes |

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

The PRWPG TAC regularly conducts *in situ* water quality measurements, which serve as the primary data source to support recommendations for policymakers in regards to agricultural BMPs and improving water quality. These efforts support the implementation of TMDLs put into place for two of the reservoirs within the watershed, as well as the Patuxent Reservoirs Watershed Protection Agreement. Currently, the group is facing difficulties obtaining a comprehensive view of conditions from designated intervals within the Patuxent Watershed. Land cover mapping for the Patuxent Watershed is carried out at the county level, which has led to temporal gaps in state mapping data. Additionally, no procedure utilized thus far has been reliably consistent in mapping LULC across multiple counties, and no standardized mapping methodology exists for the entire watershed.

***Project Benefit to End User:***

The provision of a more holistic analysis will better equip the PRWPG TAC to preserve the Upper Patuxent watershed and prepare for future improvements to the watershed. Detailed analysis of LULC and change detection will enable the TAC to determine which areas of the watershed are at the greatest risk of contamination so the organization can work to maintain safe drinking water in at-risk areas. In addition, the reproducible nature of the project will facilitate further in-house research conducted by participating members of the PRWPG TAC for the future.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **Landsat 8 OLI** | Surface Reflectance | Landsat 8 OLI data served as inputs for modern classifications. |
| **Landsat 5 TM** | Surface Reflectance | Landsat 5 TM data served as inputs for historical classifications. |

***Ancillary Datasets:***

* USGS National Land Cover Database (NLCD) –National land cover and land use dataset (2001, 2006, and 2011) used to integrate into synthetic land cover land use classification
* NOAA Coastal Change Analysis Program (C-CAP) – Coastal land cover and land use dataset (1992, 1996, 2001, 2006, and 2010) used to integrate into synthetic land cover land use classification
* USDA Cropland Data Layer (CDL) – Land cover dataset tailored to agricultural regions (2002, 2008 through 2018) used to integrate into synthetic land cover land use classification
* PRWPG TAC Patuxent Reservoirs Geodatabase – *In situ* water quality measurements, disparate fine resolution commercial remote sensing data, and LULC maps for 2002 and 2010, used as a point of comparison and source of ground truth information

***Software & Scripting:***

* Esri ArcGIS Desktop 10.6.1 – Data analysis and map production
* Esri ArcGIS Pro 2.3 – Data analysis and map production

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Synthetic Land/Use Land Cover Time Series Maps (1996, 2001, 2006, 2011, 2016)** | Landsat 5 TM  Landsat 8 OLI | Unified land use and land cover map time series provided visual and spatial aid for change detection/analysis. | N/A |
| **Project Methodology Tutorial/Standard Operating Procedures (SOPs)** | Landsat 5 TM  Landsat 8 OLI | An SOP demonstrated to the partner how to replicate the process of creating Synthetic LULC maps in the future, as new data layers are released by the USGS, NOAA, and the USDA. | N/A |

**Project Handoff Package**

*Transition Plan:* The project handoff took place in the 10th week of the term through an in-person presentation at NASA Goddard Space Flight Center in Greenbelt, MD. All products in the handoff package were sent via email to the partner. A set of Synthetic LULC Time Series Maps were delivered in the form of GeoTiffs.

**Team POC:** Stephanie Rockwood, [steph.rockwood@gmail.com](mailto:steph.rockwood@gmail.com)

**Partner POC:** Susan Overstreet, [soverstreet@howardcountymd.gov](mailto:soverstreet@howardcountymd.gov)

            Jean Kapusnick, J[ean.Kapusnick@montgomerycountymd.gov](mailto:jean.kapusnick@montgomerycountymd.gov)

            Steven Nelson, [Steven.Nelson@wsscwater.com](mailto:Steven.Nelson@wsscwater.com)

**Handoff Package:**

* Synthetic Land Use/Land Cover Time Series Maps
* Project Methodology Tutorial/ Standard Operating Procedures (SOPs)
* Technical Paper
* PowerPoint Presentation

**References:**

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