**Delaware Ecological Forecasting**

*Assessing Land Cover and Soil to Identify Suitable Sites for Tidal Marsh Migration in Delaware*

**Project Team**

***Project Team:***

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**Project Overview**

***Project Synopsis:***

Delaware’s tidal wetlands play a crucial role in the coastal ecosystem. The loss of these wetland areas puts the state at great economic risk and threatens the ecological stability of the Delaware coast. Partnering with the Delaware Department of Natural Resources and Environmental Control (DNREC), this project aims to identify changes in surrounding land use and suitable locations for tidal marsh. Maps were produced for both objectives that provide the partner with information to aid in future restoration and mitigation strategies.

***Abstract:***

Tidal wetlands provide vital resources for the state of Delaware, crucial not only for maintaining important ecosystem functions, but also for providing human populations with substantial services. Healthy wetland networks offer protection from severe weather, reduce flooding, improve water quality, and provide opportunities for education and recreation. However, human activities in combination with natural events, continue to cause substantial loss of wetland cover and damage wetland health. Over the last thirty years, the state of Delaware has experienced a net loss of roughly 5,000 acres of wetland. In collaboration with the Delaware Department of Natural Resources and Environmental Control (DNREC), the team used NASA Earth observations including Landsat 5 Thematic Mapper (TM), Landsat 8 Operational Land Imager (OLI), Terra Moderate Resolution Imaging Spectroradiometer (MODIS), and Global Precipitation Measurement Integrated Multi-Satellite Retrievals (GPM IMERG) to develop a methodology to monitor recent changes in wetland cover and forecast landward marsh migration due to sea-level rise, changes to climate, and human development. Trend analysis of current and past climate conditions in precipitation and temperature revealed an overall increase in both metrics. Using Land Change Modeler in TerrSet and Suitability Modeler in ArcGIS Pro, the team visualized landcover shifts over the last 20 years, indicating a general pattern of net wetland loss and identified locations where marsh migration could potentially occur in the future. These observations will enable better planning for restoration activities and inform decision-making to preserve wetland health and ecosystem functions.

***Key Terms:***

Delaware, coastal wetlands, remote sensing, Land Change Modeler, Landsat, sea-level rise

***National Application Areas Addressed:*** Ecological Forecasting, Water Resources

***Study Location:*** DE

***Study Period:*** January2000 – June 2021; Forecasting to 2050

***Community Concerns:***

* Twenty-five percent of Delaware’s land area is comprised of wetlands, which have great ecological significance in the region. They help to purify waters, store and sequester carbon, serve as a habitat for many native animal and plant species, and protect against flooding and storm events.
* Approximately 5,000 acres of Delaware’s wetlands have been lost over the last 30 years due to human activities, such as development and agriculture, and natural factors like severe weather events, sea-level rise, and erosion.
* Delaware has the lowest mean elevation in the US, making it particularly susceptible to sea-level rise and erosion during extreme weather events.

***Project Objectives:***

* Identifycurrent and future wetland habitats, marsh locations, and changing climate variables
* Analyze change inland use land cover (LULC), marsh migration, and climate variation over the study period
* Generatemaps of wetland habitat and marsh locations
* Predict areas of likely landward marsh migration in different land cover change scenarios

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Delaware Department of Natural Resources and Environmental Control; Division of Climate, Coastal, and Energy** | Dr. Kari St. Laurent, Research Coordinator/Environmental Scientist V | End User | Yes |

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

The DNREC Division of Climate, Coastal and Energy uses a combination of applied science, education, and policy to address climate, coastal, and energy issues in the state. The main goals of the division are to provide leadership towards sustainable communities and environments by ensuring healthy coastal ecosystems and a healthy economy for residents and future generations. This is accomplished through the Delaware Coastal Zone Act Program which regulates heavy industrial activities in the Delaware Coastal Zone and implementation of conservation practices or structures such as the Living Shoreline Project that aids in rebuilding natural habitats along the shoreline of Delaware.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Landsat 5 TM** | Normalized Difference Vegetation Index (NDVI), Surface Reflectance, Normalized Difference Built-Up Index (NDBI), Normalized Difference Water Index (NDWI),  Soil-Adjusted Vegetation Index (SAVI) | These datasets were used to investigate land use and land cover change in the study area. This data also provided information for forecasting. |
| **Landsat 8 OLI** | NDVI, NDBI, NDWI, SAVI | These datasets were used to investigate land use and land cover change in the study area. This data also provided information for forecasting. |
| **GPM IMERG** | Precipitation | This dataset was utilized in the climate analysis and also provided information for forecasting. |
| **Terra MODIS** | Land surface temperature | This dataset was utilized in the climate analysis and also provided information for forecasting. |

***Ancillary Datasets:***

* USDA National Agriculture Imagery Program (NAIP) (2018) - Aerial imagery used to create LULC change maps
* DNREC Delaware Wetlands Maps, 2007, 2017 – validate land-use change maps and habitat suitability
* State of Delaware Lidar DEM – elevation data for the entire state used to create tidal marsh suitability maps
* U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory Wetlands Mapper database – assess historical wetland cover types
* Delaware FirstMap – soil data, types, and characteristics used to create tidal marsh suitability maps
* United States Geological Survey (USGS) National Hydrology Dataset Flowlines – water flow in the state of Delaware used to create tidal marsh suitability maps
* USGS National Land Cover Database – indicate areas of impervious surfaces
* United States Department of Agriculture (USDA) National Agricultural Statistics Service Cropland Data Layer – indicate areas of cropland

***Modeling:***

* Land Change Modeler, Idrisi TerrSet (POC: Sean McCartney, sean.mccartney@nasa.gov) – Predict possible scenarios of land cover change for the forecasting study period

***Software & Scripting:***

* Google Earth Engine API – Data acquisition and manipulation, image processing, supervised classification
* Esri ArcGIS Pro 2.5 – Raster manipulation, map generation, image classification development
* QGIS 3.18 – Raster manipulation, map generation

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **LULC Change Maps** | Landsat 5 TM, Landsat 8 OLI, NAIP | These maps will provide the partner with an understanding of how tidal marsh areas have changed over the study period and how they potentially will change between 2020 and 2050. | N/A |
| **Tidal Marsh Maps** | Landsat 5 TM, Landsat 8 OLI | These maps identify areas where tidal marsh currently exists and areas best suited for tidal marsh habitat. The results will aid the partner in developing future restoration and mitigation strategies. | N/A |
| **Climate Analysis** | Precipitation from GPM IMERG, and surface temperature from Terra MODIS | This analysis will demonstrate how precipitation and temperature have changed between 2000 and 2021 through the use of maps and graphs and provides information about climate variability in Delaware. | N/A |
| **Delaware Ecological Forecasting StoryMap** | N/A | The StoryMap will provide the partner with an educational tool to inform the local population of land cover change, suitable sites for marshland, and climate variability in Delaware. | N/A |

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

Restoration and protection of tidal wetlands can help mitigate the continuous and documented environmental loss along the Delaware coast. Improved spatial understanding of inland marsh migration will assist the partner in making informed decisions about tidal marsh management and conservation practices. The products produced in this project focus on prospective land acquisition and marsh conservation and will aid the partner in the application of novel methods to support productive marsh migration. Furthermore, the methodologies developed by the team will enable the partner to use NASA Earth observations to monitor trends in tidal marsh areas for use in future projects. Map products may also be used by the partner to communicate the importance of tidal marsh restoration, as well as the value of land with suitable characteristics for transition into tidal marsh habitat, with public and private stakeholders.

**References**

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