**NASA DEVELOP National Program**

****NASA Goddard Space Flight Center

*Spring 2017*

**Short Title: Chesapeake Bay Agriculture**

**Subtitle:** Using NASA Earth Observations to Map Winter Cover Crop Conservation Performance in the Chesapeake Bay Watershed

**VPS Title:** Catchment in the Rye: Conservation of the Chesapeake Bay

**Project Team & Partners**

**Project Team:**

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**Advisors & Mentors:**

Dr. W. Dean Hively (USGS Eastern Geographic Science Center)

Dr. Greg McCarty (USDA, Agricultural Research Service, Hydrology and Remote Sensing Laboratory)

**Partner Organizations:**

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| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| Maryland Department of Agriculture, Office of Resource Conservation | Jason Keppler, Program Manager for Watershed Implementation | End-User | No |
| USGS, Eastern Geographic Science Center | Dr. W. Dean Hively, Physical Scientist | Collaborator | No |
| USDA, Agricultural Research Service, Hydrology and Remote Sensing Laboratory | Dr. Greg McCarty, Soil Scientist | Collaborator | No |
| US Environmental Protection Agency, Chesapeake Bay Program | Rich Batiuk, Associate Director for Science, Analysis, and Implementation | Collaborator | Yes |

**Project Details**

**Applied Sciences National Application Addressed:** Agriculture

**Study Area:** Talbot, Somerset, Queen Anne’s, and Washington Counties, Maryland (MD)

**Study Period:** 2006 – 2016 (1 December – 15 January; 1 March – 15 April)

**Earth Observations & Parameters:**

Landsat 5, Thematic Mapper (TM) – spectral vegetation indices

Landsat 8, Operational Land Imager (OLI) – spectral vegetation indices

Sentinel-2, MultiSpectral Instrument (MSI) – spectral vegetation indices

**Ancillary Datasets Utilized:**

* MDA Enrollment Shapefiles – partner *in-situ* shapefile for cover crop enrollment in 2014, including agronomic management information on MD farms for monitoring progress in achieving conservation targets and for generating statistical outputs based on farms enrolled in the cover crop program. A second shapefile that includes all field boundaries on farms within the study area (partner *in-situ* data).
* USGS/USDA-ARS – calibration dataset (>2000 measurements) of on-farm field sampling of winter cover crop performance (biomass) and nitrogen content
* USGS National Land Cover Dataset (NLCD) – land cover
* USDA Cropland Data Layer – crop cover

**Software Utilized:**

* ESRI ArcGIS – vector and raster analysis and pre-processing of data
* Google Earth Engine API – data acquisition, atmospheric correction, data processing and output
* Python – statistical analysis
* R – statistical analysis

**Project Overview**

**80-100 Word Objectives Overview:**

The primary goals of this project were to automate key steps in acquiring yearly satellite imagery and compute vegetation metrics to assess winter cover crop performance in the Chesapeake Bay. As a test case, four Maryland counties were used to calculate NDVI derived biomass, nitrogen content, and percent nitrogen by field from 2006-2016. In addition, software was developed to calculate the same metrics in future years.

Monitoring cover crop performance in the Chesapeake Bay using Earth observations (EO) allows the MD Department of Agriculture (MDA) to confirm cover crop implementation and to inform adaptive management.

**Abstract:**

Winter cover crops are an essential component of adaptive management practices to reduce soil erosion, nutrient loss, and nutrient leaching leading to water quality degradation. The Maryland Department of Agriculture (MDA) and Chesapeake Bay partners (US Geological Survey and USDA Agricultural Research Service) oversee a cost-sharing program that offers subsidies to farmers enrolled in the winter cover crop program. The effectiveness of mitigating soil and nutrient loss varies by crop species, planting date, planting method, prior crop species, manure inputs, and growing degree days. In addition to field related factors, landscape factors may also influence winter crop performance. While methods to quantify crop performance are available, they are not automated for timely analysis. This study used Landsat 5 and 8 and Sentinel-2 imagery to quantify crop performance using vegetation indices to estimate biomass, and nitrogen uptake in three counties on the Eastern Shore of Maryland in the Chesapeake Bay, in addition to one western county, all located in Maryland. The methods developed in this project automate acquisition of annual satellite imagery and calculation of winter cover crop metrics. The crop performance data produced facilitates analysis for the MDA to monitor winter cover crop efficiencies at varying scales, for example by identifying underperforming versus satisfactory cover crop fields, as well as those with high biomass.

**Keywords:**

Winter cover crops, crop performance, biomass, vegetation indices, percent ground cover, nitrogen uptake, remote sensing

**Community Concerns:**

* Excess nitrogen can leach into groundwater and surface water, whereas winter cover crops utilize residual nitrogen that remains in the soil, preventing eutrophication and degradation.
* Winter cover crops help prevent sedimentation of surface water and bays by protecting from raindrop impact and decreasing erosion by wind and water.
* The MDA and Chesapeake Bay Program partners want to quantify the conservation performance of winter cover crops and automate this process to improve monitoring efforts.
* The MDA and Chesapeake Bay Program partners are interested to elucidate the factors affecting winter cover crop performance, such as crop species, crop rotation, planting date, and related landscape variables. We automated the process of acquiring Earth observation imagery to extract relevant field-level vegetation metrics, calibrated with long-term data.
* The software developed allows the MDA to calculate annual crop performance by field.

**Current Management Practices & Policies**:

The MDA currently manages a roughly $16 million per year winter cover crop program using largely analog methods. Farmer enrollments are recorded on paper forms and mailed to the MDA where they are then digitized and entered into an internal database. While this database contains agronomic metadata for each enrolled field, it is unable to capture crop performance metrics such as field biomass, percent ground cover, or nutrient uptake. NASA Earth observations will make it possible to determine crop performance, and can identify individual fields that are performing either better or worse than expected. In addition, the program validation process requires that MDA employees spend a great deal of time physically driving to individual fields to ensure that the crops were planted as intended.

**Decision Support Tools & Benefits:**

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| --- | --- | --- | --- |
| **End-Product** | **Earth Observations Used** | **Benefit & Impact** | **Software**  **Release** |
| Wintertime and Springtime Imagery Translated to NDVI and Fractional Vegetative Groundcover | Landsat 5 TM  Landsat 8 OLI  Sentinel-2 MSI | Support analysis of cover crop outcomes and monitor progress in achieving conservation targets | II |
| Performance Data Calculated for Cover Crop Fields | Landsat 5 TM  Landsat 8 OLI  Sentinel-2 MSI | Allow for improved tracking of conservation implementation, as well as support communication of conservation outcomes to farmers and soil conservation districts. | II |
| Tabular Reports at Watershed and Regional Scale | Landsat 5 TM  Landsat 8 OLI  Sentinel-2 MSI | Used to evaluate agronomics and temporal patterns of cover crop performance, and to support adaptive management of cover crop cost-share programs | I |