**Chesapeake Bay Agriculture & Food Security III**

*Quantifying Wintertime Agricultural Land Use and Springtime Management of Winter Cover Crops using Landsat and Sentinel to Support Environmental Conservation in Maryland*

**VPS Title:** Covering Our Bayses

**Project Team**

***Project Team:***

Benjamin Whong (Project Lead)

Bryan Eder

Julio Peredo

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***Advisors & Mentors:***

Jason Keppler (Maryland Department of Agriculture, Office of Resource Conservation)

Dr. W. Dean Hively (United States Geological Survey, Eastern Geographic Science Center)

Dr. Greg McCarty (United States Department of Agriculture, Agricultural Research Service, Hydrology and Remote Sensing Laboratory)

Dr. John Bolten (NASA Goddard Space Flight Center)

***Past or Other Contributors:***

Dr. Sunita Yadav

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**Project Overview**

***Project Synopsis:***

This project concluded a three-stage partnership with the Maryland Department of Agriculture (MDA) to assist in the analysis of their cover crop program. Building upon a graphical user interface (GUI) created in the fall of 2018, the current team utilized NASA Earth observations to remotely determine the termination date of winter cover crops and assess crop biomass threshold values during the spring season. Remotely monitoring cover crops eliminates the MDA’s need to manually verify adherence to cover crop and biomass protocols and saves valuable MDA resources.

***Abstract:***

Cover crops enrich soils, limit erosion, and reduce nutrient runoff from agricultural land. To promote their usage, the Maryland Department of Agriculture (MDA) subsidizes farmers who plant winter cover crops. In order to maximize environmental benefits, cover crops must be terminated in the spring, rather than harvested. Previous DEVELOP collaborations with the MDA used imagery from Landsat 5 Thematic Mapper (TM), Landsat 8 Operational Land Imager (OLI), and Sentinel-2 MultiSpectral Instrument (MSI) to analyze various agronomic parameters which affect cover crop effectiveness. The Spring 2019 DEVELOP team continued to work with this imagery through Google Earth Engine and created a new application to remotely sense the presence of cover crops during the spring season. This tool, Cover Crop Remotely Observed Performance (CCROP3), aims to confirm that cover crops have been planted and verify the dates on which they were terminated, thereby reducing the need for the MDA to manually spot-check fields. The resulting graphical user interface (GUI) will also be used by the MDA to analyze parameters that influence cover crop effectiveness, such as cover crop type, planting date, and fertilizer usage. This GUI has the potential to promote more informed decision making and more effective conservation efforts for the Chesapeake Bay.

**Keywords:**

remote sensing, graphical user interface, Google Earth Engine, Normalized Difference Vegetation Index, biomass, percent ground cover, time series

***National Application Area Addressed:*** Agriculture & Food Security

***Study Location:*** MD

***Study Period:*** December 2006 to March 2019

***Community Concerns:***

* Nitrogen, phosphorous, and other nutrients from Maryland farmlands can harm the Chesapeake Bay via eutrophication and hypoxia.
* Various recreational and commercial activities, including fishing and boating, suffer from low water quality in the Bay.
* Winter cover crops aid in Chesapeake Bay conservation efforts by preserving nutrients in the soil, thereby reducing harmful runoff into the Bay.
* Presence of crops during winter months mitigates soil erosion, thus promoting healthier soil.
* *In situ* spot checking of cover crops throughout Maryland is costly and labor intensive.
* The MDA and Chesapeake Bay Program partnership relies on the effective implementation of the cover crop program. Success in this regard requires a more efficient means of verifying farmers' adherence to program protocols.

***Project Objectives:***

* Analyze cover crop vegetation density in enrolled fields across the state of Maryland
* Finalize a graphical user interface (GUI) by adding NDVI time series functionality to help the MDA confirm planting and termination dates of cover crops
* Provide an interactive tool, Cover Crop Remotely Observed Performance (CCROP3), which allows the MDA to analyze cover crop performance through a set of filtering parameters, ultimately bolstering conservation efforts for the Chesapeake Bay via remote sensing technology

***Previous Terms:*** 2017 Spring (GSFC) – Chesapeake Bay Agriculture

 2018 Fall (GSFC) – Chesapeake Bay Agriculture & Food Security II

**Partner Overview**

***Partner Organizations:***

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

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

As members of the Environmental Protection Agency’s (EPA) Chesapeake Bay Program, the MDA, United States Geological Survey (USGS), and United States Department of Agriculture Agricultural Research Service (USDA ARS) have committed to restoring the Chesapeake Bay, its tributaries, and surrounding land. To this end, the MDA oversees the Maryland Agricultural Water Quality Cost-Share (MACS) Program. This program awards $22M per year to farmers who plant winter cover crops, which support nutrient uptake and mitigate soil erosion. The MDA is currently testing a further initiative, known as the Healthy Soil Biomass (HSB) pilot program, which will reward farmers who maintain their cover crops later in the spring. As part of these programs, the MDA makes seasonal visits to 10% of enrolled fields to monitor the termination dates of winter cover crops. This process is time intensive and creates stress on the labor capabilities of MDA field teams.

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

This project will provide the MDA with a Google Earth Engine GUI to remotely sense the presence of cover crops throughout winter and spring months. The MDA will be able to use this tool to verify that fields are being managed in the spring in accordance with the guidelines laid out by their cost-sharing program. The GUI will eliminate the need for the MDA to manually spot-check a subset of fields, conserving time and resources. The MDA will also be able to apply this tool for their HSB program. The results of this project will provide the MDA with more detailed data on variables influencing cover crop efficiency, enabling them to potentially adjust their guidelines to better reward fields that practice effective conservation strategies.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 5 TM** | Normalized Difference Vegetation Index (NDVI), surface reflectance  | Identified the spring kill date of winter cover crops and measured biomass and percent green ground cover provided by wintertime vegetation. |
| **Landsat 8 OLI** |  NDVI, surface reflectance | Identified the spring kill date of winter cover crops and measured biomass and percent green ground cover provided by wintertime vegetation. |
| **Sentinel-2 MSI** | NDVI, surface reflectance  | Identified the spring kill date of winter cover crops and measured biomass and percent green ground cover provided by wintertime vegetation. |

***Ancillary Datasets:***

* MDA Field Boundary Shapefiles – Annual field boundary shapefiles of statewide cover crop enrollment and agronomic management information on Maryland farms; used for monitoring progress in achieving conservation targets and for generating remote sensing statistical outputs based on farms enrolled in the Cover Crop Program
* USGS/USDA-ARS Calibration Dataset – Calibration dataset (>2000 measurements) of on-farm field sampling of winter cover crop performance (biomass) including photo archive for determining percent ground cover classification

***Software & Scripting:***

* Google Earth Engine API – Satellite image processing, data acquisition, processing, analysis, and output generation.
* R 3.4.3 – Process data and apply statistical analysis.
* ESRI ArcGIS Pro 2.2.2 – Reproject shapefiles into WGS 1984 (WKID 4326) and elimination of empty field data for compatibility with Google Earth Engine.

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **CCROP3 Vegetation Analysis Tool** | Landsat 5 TMLandsat 8 OLISentinel-2 MSI | This product enhanced the GUI created in the previous term by including functionality to verify the planting and termination of cover crops, supporting both MACS and HSB. | IV |
| **CCROP3 Vegetation Analysis Tool Tutorial** | N/A | Partners will be able to follow a step-by-step guide to navigating the Vegetation Analysis Tool. | N/A |

**Project Handoff Package**

*Transition Plan:* All deliverables were handed off to partners during a detailed project review seminar. Joint in-person meetings were held among the partners and the team to discuss accomplishments and strategize for the transition to operational usage following the project handoff. The project team communicated with the MDA throughout the term to ensure the integration of deliverables with the MDA SQL Server database format.

*Software Release Plan*: The updated Google Earth Engine script will undergo a software release process that extends past the end of the term. Both the team POC and software release POC will communicate with the partners throughout this process, ensuring that their questions and needs are addressed.

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**Software Release POC:** Julio Peredo, juliop1@umbc.edu

**Partner POC:** Jason Keppler, jason.keppler@maryland.gov

**Handoff Package:**

* CCROP3 Vegetation Analysis Tool Tutorial
* Technical Paper
* Poster
* Presentation
* Project Video

**References:**

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