**NASA DEVELOP National Program**

**2019 Spring Project Proposal**

**Maryland – Goddard**

**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*

**Project Overview**

***Project Synopsis*:** As members of the EPA’s Chesapeake Bay Program, the USGS, USDA Agricultural Research Service (USDA ARS), and Maryland Department of Agriculture (MDA) previously partnered with DEVELOP to establish methods that combine NASA Earth observation data with cover crop conservation data into a graphical user interface (GUI).This final third term project will employ the results of the preceding projects to generate a spring season time series analysis of vegetation abundance to establish the date of springtime termination of cover crops. This analysis will be used by the MDA to annually reduce management efforts for specific conservation districts. In particular, the MDA will utilize the GUI to verify spring cover crop loss as a means to increase overall conservation effectiveness. Additionally, the MDA can use these results to help identify the status of wintertime vegetation on cropland not enrolled in the Cover Crop Program. This additional analysis will allow managers to appropriately credit the environmental benefits of small grain crops and to target bare fallow cropland for conservation implementation.

***Community Concern:*** The use of winter cover crops on agricultural fields has been identified as a key conservation management practice for reducing the loss of nitrogen and sediment from farmland. Thus, cover crop implementation is a priority for the Chesapeake Bay Program Partnership. However, the management of the existing large cost-share program comes with several challenges that require the attention of the already overtaxed conservation district field staff, reducing their capacity for working with farmers to implement various important conservation practices. The remote verification of the farmer-induced spring kill date, as mandated by the Cover Crop Program for winter cover crops, would allow district staff to spend more time on effective activities than their current on-the-ground procedures allow.

***Source of Project Idea:*** The source of this project idea was originally from Dr. W. Dean Hively and Dr. Greg McCarty at the USGS and USDA, respectively. The USGS and USDA ARS previously collaborated with NASA DEVELOP to create tools that used Earth observations to analyze wintertime vegetative ground cover on agricultural fields. Dr. Hively contacted the former Maryland – Goddard Center Lead, Sean McCartney, about a follow-up project, and this project idea was proposed in the following communications.

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

***Study Location:*** MD

***Study Period:*** December 2006 – December 2018

***Advisors:*** Dr. W. Dean Hively (USGS Eastern Geographic Science Center), Dr. Greg McCarty (USDA ARS Hydrology and Remote Sensing Laboratory)

**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 | No |
| **USGS, Eastern Geographic Science Center** | Dr. W. Dean Hively, Research Physical Scientist | Collaborator | No |
| **USDA, Agriculture Research Service, Hydrology and 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 |

***End-User Overview***

***End User’s Current Decision-Making Process:***The MDA provides roughly $22M per year of cost-share funding to farmers for planting winter cover crops to reduce nutrient and sediment loss from farmland. For each enrolled field, the MDA records geospatial location and agronomic management details, and payments are provided for different management techniques. The MDA conducts winter cover crop compliance site visits for 10% of enrolled fields to ensure cover crops are not harvested by the farmers. Remote sensing is not currently involved; therefore, the compliance site visits are only able to cover a relatively small proportion of enrolled total fields.

***End User’s Capacity to Use NASA Earth Observations:***

*Maryland Department of Agriculture, Office of Resource Conservation* – Partners at the MDA are familiar with the results of USGS and USDA ARS research on remote sensing of winter cover crops, but they do not have experience in employing Earth observation data directly. MDA personnel routinely manage conservation data in a geospatial environment using SQL Server and ArcMap and have a partnership with Esri to support their work, but they do not currently utilize remote sensing. The MDA will enhance their organization’s capability to integrate remotely sensed data through the methodologies created by this project.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

*USGS, Eastern Geographic Science Center –* The USGS routinely utilizes NASA Earth observations and is an organization that has published a number of manuscripts that document successful methods for using Landsat and SPOT surface reflectance imagery to map wintertime vegetation on agricultural fields. However, the USGS has yet to scale their developed methodology to a statewide level or incorporate new geoprocessing platforms with multiple composite satellite scenes into their analysis of cover crop performance. The USGS will support the project through the conceptualization of goals and workflow and provision ofdata for calibration.

*USDA, Agriculture Research Service, Hydrology and Remote Sensing Laboratory –* USDA personnel frequently use NASA Earth observations. They have published a number of manuscripts that document successful methods for using Landsat and SPOT surface reflectance imagery to map wintertime vegetation on agricultural fields. However, they have yet to scale their developed methodology to a statewide level or incorporate new geoprocessing platforms with multiple composite satellite scenes into their analysis of cover crop performance. They will support the project by providing expertise regarding methodologies and analysis.

*US Environmental Protection Agency, Chesapeake Bay Program* – The EPA Chesapeake Bay Program provides coordination, oversight, and regulation for conservation practices designed to meet water quality objectives in a six-state region comprising the Chesapeake Bay watershed. Partners will provide guidance and support to the project team.

***Dissemination by Boundary Organizations*:**

*US Environmental Protection Agency, Chesapeake Bay Program* – The EPA Chesapeake Bay Program provides

coordination, oversight, and regulation for conservation practices designed to meet water quality objectives in a six-state region comprising the Chesapeake Bay watershed. In its role as a boundary organization, it will communicate project results to Chesapeake Bay Program partners, including the CBP Agricultural Working Group and state agencies involved with conservation management in NY, PA, DE, VA, WV, and MD.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** Dr. W. Dean Hively will be the primary POC for communication with the DEVELOP Project Lead. In-person meetings, as well as weekly and biweekly teleconference calls and email exchanges, will be maintained throughout the course of the term.

***Transition Plan*:** Prior to the completion of the project, all deliverables will be handed off to partners during a detailed project review seminar. The updated Google Earth Engine script will require software release and therefore continued interaction between the team POC and partners following the term. Joint meetings will be held among partners to discuss accomplishments and strategize for the transition to operational usage following the software release process. The project team will communicate with the MDA throughout the term so that deliverables can be well-integrated with the MDA SQL Server database format. Additionally, the results will be used by the USGS and USDA ARS to support peer-reviewed publications.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 5 TM** | Normalized Difference Vegetation Index | Vegetation indices will be used to identify the spring kill date of winter cover crops and measure biomass and percent green ground cover provided by wintertime vegetation. |
| **Landsat 8 OLI** | Normalized Difference Vegetation Index | Vegetation indices will be used to identify the spring kill date of winter cover crops and measure biomass and percent green ground cover provided by wintertime vegetation. |
| **Sentinel-2 MSI** | Normalized Difference Vegetation Index | Additional multi-spectral satellite data is desired, as available, to increase temporal frequency. |

***Ancillary Datasets:***

Maryland Department of Agriculture 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) that includes a photo archive for determining percent ground cover classification

***Software & Scripting:***

Google Earth Engine API – Satellite image processing (surface reflectance band extraction, Normalized Difference Vegetation Index, Enhanced Vegetation Index, calculated percent vegetative ground cover, and calculated biomass), data extraction, statistical analysis, and production of tables and graphs summarizing satellite-derived measures. The previously created GUI will be expanded to include functionality to verify spring kill of winter cover crops.

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Vegetation Analysis Tool** | This product will enhance the GUI created in the previous term to include functionality to verify spring kill of winter cover crops and identify the status of wintertime vegetation on cropland not enrolled in the Cover Crop Program. | Landsat 5 TM, Landsat 8 OLI, and Sentinel-2 MSI will be used to calculate spectral vegetation indices to determine vegetation presence, biomass, and percent vegetative ground cover. | IV |
| **Vegetation Analysis Tool Tutorial** | Partners will be able to follow this step-by-step guide to navigating the Vegetation Analysis Tool. | N/A | N/A |

***End-User Benefit*:** This project will save the MDA resources in the form of both time and money by providing them with a tool to remotely verify that winter cover crops are being managed according to the guidelines set by the department. The results will streamline the verification process for the MDA, providing more flexibility for resources to be allocated elsewhere. Additionally, the results will help the MDA to appropriately credit the environmental benefits of small grain crops and to target bare fallow cropland for conservation implementation, further expanding the Cover Crop Program.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 3 Terms: 2017 Spring, 2018 Fall, and 2019 Spring

***Multi-Term Objectives:***

* **Term 1:** 2017 Spring (Maryland – Goddard) – Chesapeake Bay Agriculture
  + This term focused on integrating Earth observation data with cover crop enrollment field boundaries to provide large-scale analysis of cover crop performance in MD. The goal was achieved using a mixture of code platforms. Results were produced in four counties, with calculated performance measures joined to each shapefile record of cover crop field enrollment. Methods were described and codes were transferred to the end user. Analytical results are currently being written into a journal article for publication.
* **Term 2:** 2018 Fall (Maryland – Goddard) – Chesapeake Bay Agriculture & Food Security II
  + This term began with the mixture of coding produced by Term 1 and constructing a Google Earth Engine GUI to streamline the analysis, making it user-friendly. After calculated performance measures were joined to shapefile enrollment records, the project worked with the end user to design tabular and graphical outputs summarizing results at the county and watershed scale. The team developed a GUI system for the routine output of clear and useful performance reports.
* **Term 3 (Proposed Term):** 2019 Spring (Maryland – Goddard) – Chesapeake Bay Agriculture & Food Security III
  + A third and final term would mark the culmination of this DEVELOP multi-term project, tying in the results of the preceding projects with spring season time series analysis of vegetation abundance to establish the date of springtime termination of cover crops on Maryland enrolled fields. The additional tools created in this term would be used annually to assist the MDA to reduce conservation district workload associated with the verification of cover crop spring kill and increasing overall conservation effectiveness in support of cover crop management. The partners’ support would continue following an in-person handoff of results and deliverables since the software release process will delay the final dissemination of results.

***Previous Terms:***

2018 Fall (GSFC) – Chesapeake Bay Agriculture & Food Security II: Operational Analysis of Winter Cover Crop Environmental Performance throughout the State of Maryland

2017 Spring (GSFC) – Chesapeake Bay Agriculture: Using NASA Earth Observations to Map Winter Cover Crop Conservation Performance in the Chesapeake Bay Watershed

***Related DEVELOP Work:***

2018 Spring (CO) – Minnesota & Texas Agriculture & Food Security: Employing NASA Earth Observations to Model Current and Historic Distribution of Crop Wild Relatives, in Support of USDA ARS Genetic Resource Conservation Efforts

2018 Spring (LaRC & JPL) – North Dakota & Georgia Agriculture & Food Security: Using NASA Earth

Observations and SAR to Enhance Crop Classification Accuracy from Ground Surveys to Larger Scales in the Long Term Agroecosystem Research (LTAR) Network

**Notes & References:**

***Notes*:** This project was proposed by the USGS Eastern Geographic Science Center (Dean Hively co-PI, USGS Professional Page:<https://profile.usgs.gov/whively>), in partnership with the USDA-ARS Hydrology and Remote Sensing Laboratory (Greg McCarty, co-PI), and is supported by the USGS Land Change Science mission area. They are based at the USDA-ARS Beltsville Agricultural Research Center, in Beltsville, Maryland, nearby to Goddard Space Flight Center. Information about the Maryland Department of Agriculture winter cover crop cost-share program can be found here:<http://mda.maryland.gov/resource_conservation/Pages/cover_crop.aspx>

***References:***

Hively, W.D., Duiker, S.W., McCarty, G.W., & Prabhakara, K. (2015). Remote sensing to monitor cover

crop adoption in southeastern Pennsylvania. *Journal of Soil and Water Conservation, 70*(6), 340-352. doi:10.2489/jswc70.6.340.

Hively, W.D., Lang, M., McCarty, G.W., Keppler, J., Sadeghi, A., & McConnell, L. (2009). Using satellite

remote sensing to estimate winter cover crop nutrient uptake efficiency. *Journal of Soil and Water Conservation, 64*(5), 303-313. doi:10.2489/jswc64.5.303

Hively, W.D., McCarty, G.W., & Keppler J. (2009). Federal-state partnership yields success in remote

sensing analysis of conservation practice effectiveness: Results from the Choptank River Conservation Effects Assessment Project. *Journal of Soil and Water Conservation, 64*(5), 154A. doi:10.2489/jwsc64.5.154A

Prabhakara, K., Hively, W.D. & McCarty, G.W. (2015). Evaluating the relationship between biomass,

percent groundcover and remote sensing indices across six winter cover crop fields in Maryland, United States. *International Journal of Applied Earth Observation and Geoinformation, 39*, 88-102. https://doi.org/10.1016/j.jag.2015.03.002