**NASA DEVELOP National Program**

**2018 Fall Project Proposal**

**Maryland – Goddard**

**Chesapeake Bay Agriculture & Food Security II**

*Operational Analysis of Winter Cover Crop Environmental Performance throughout the State of Maryland*

**Project Overview**

***Project Synopsis*:** 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 implementation data.This follow-on project will develop a user-friendly graphical user interface (GUI) in Google Earth Engine to streamline the analysis of wintertime ground cover and conservation benefits associated with the >26,000 annual agricultural fields enrolled in MDA’s winter cover crop cost share program. Data from Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI, and Sentinel-2 MSI will be combined with geospatial boundaries for enrolled fields to calculate performance (biomass, percent vegetative ground cover). County and watershed scale performance results will assist the MDA and other partners in managing the implementation of winter cover crops in order to maximize nutrient and sediment conservation by providing timely, well-calibrated, satellite analysis of wintertime vegetative ground cover on agricultural fields.

***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 effectiveness of winter cover crops varies widely depending on landscape, climate, and agronomic management.

***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. The MDA is interested in using the results of the previous DEVELOP project, but needs a user-friendly interface. Dr. Hively contacted former GSFC Center Lead Sean McCartney about a follow-up project.

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

***Study Location:*** MDer

***Study Period:*** December 2006 – April 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 spot checks 10% of fields to assess compliance with the winter cover crop conservation program guidelines. They estimate conservation performance only by using general CBP model coefficients, and they adjust payment rates based on best professional judgment of what techniques produce the most successful cover crops. However, they do not monitor actual environmental performance in the landscape. The results from the previous DEVELOP term contained scripts that are not user-friendly for the MDA staff, so the MDA has not yet implemented the remote sensing techniques.

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

*Maryland Department of Agriculture, Office of Resource Conservation –* Partners 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 handling Earth observation data directly. They routinely manage conservation data in a geospatial environment using SQL Server, and ArcMap, and have a partnership with Esri to support their work, but do not currently utilize remote sensing. They would have the capability to integrate remotely sensed data into their data handling through the methodologies created by this project.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

*USGS, Eastern Geographic Science Center –* The USGS works in partnership with the USDA, both of which are capable in using NASA Earth observations at the research scale. 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 methodology to a statewide level, or to incorporate new geoprocessing platforms or use of multiple composite satellite scenes into their analysis of cover crop performance (biomass and percent green ground cover). They support the project through conceptualization of goals and workflow, provision of in-field data for calibration, and design of tabular and graphical data analysis framework useful for depicting results of remote sensing output.

*USDA, Agriculture Research Service, Hydrology and Remote Sensing Laboratory –* The USDA works in partnership with USGS, both of which are capable in using NASA Earth observations at the research scale. 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 methodology to a statewide level, or to incorporate new geoprocessing platforms or use of multiple composite satellite scenes into their analysis of cover crop performance (biomass and percent green ground cover). They support the project through conceptualization of goals and work flow, provision of in-field data for calibration, and design of tabular and graphical data analysis framework useful for depicting results of remote sensing output.

***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 their role as boundary organization, they 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*:** Upon successful completion of the project, all deliverables will be handed off in person to project partners. The Google Earth Engine GUI will require software release and therefore continued interaction between the team POC and partners. The software release process will be initiated as soon as possible to support hand-off before or during the following term. Joint meetings will be held among USGS, USDA ARS, and MDA partners to discuss accomplishments and strategize for the transition to operational usage within the calendar year. The project team will communicate with the MDA so deliverables can be well-integrated with the MDA SQL Server database format. A geospatial analyst at MDA, working in collaboration with USGS and USDA ARS partners, plan to use the programmed system each year in the last weeks of April to provide timely reporting of winter cover crop performance. Additionally, the results will be used by the USGS and USDA ARS to support peer reviewed publications.

***Letters of Support*:**

* Dianna Hogan, Acting Center Director, USGS Eastern Geographic Science Center
* Glenn Moglen, Research leader, USDA-ARS Hydrology and Remote Sensing Laboratory.
* Jason Keppler, Program Manager, Maryland Department of Agriculture, Office of Resource Conservation
* Richard Batiuk, Associate Director of Science, Analysis, and Implementation, USEPA Chesapeake Bay Program

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 5 TM** | Spectral vegetation indices | Vegetation indices will be used to measure biomass and percent green ground cover provided by winter cover crops. |
| **Landsat 7 ETM+** | Spectral vegetation indices | Vegetation indices will be used to measure biomass and percent green ground cover provided by winter cover crops. |
| **Landsat 8 OLI** | Spectral vegetation indices | Vegetation indices will be used to measure biomass and percent green ground cover provided by winter cover crops. |
| **Sentinel-2 MSI** | Spectral vegetation indices | 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 MD 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

NASA DEVELOP Wintertime and Springtime Imagery Translated to NDVI and Fractional Vegetative Ground cover – GUI input

NASA DEVELOP Performance Data Calculated for Cover Crop Fields – GUI input

NASA DEVELOP Tabular Reports at Watershed and Regional Scale – GUI input

NASA DEVELOP Large-scale NDVI extraction automation scripts – GUI input

NASA DEVELOP Statistical analysis automation scripts – GUI input

***Software & Scripting:***

Google Earth Engine API – Satellite image processing (surface reflectance band extraction, NDVI and EVI, calculated percent vegetative ground cover, calculated biomass), data extraction and statistical analysis, and production of tables and graphs summarizing satellite-derived measures. A GUI will be created to routinely produce these calculations and output in a fashion that communicates information clearly to support adaptive management decision making by the end user.

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Cover Crop Performance Google Earth Engine GUI** | This product will enable MDA users to easily accomplish the data processing steps required to 1) search, acquire, and composite Landsat and Sentinel wintertime imagery, 2) overlay field boundaries for MDA cover crop enrollment, 3) create the calibration, calculate performance outcomes, and 4) create tables, graphs, and maps depicting the environmental outcomes associated with various agronomic management strategies for winter cover crops. | Steps 1-3 have already been prototyped by the previous DEVELOP team and will now be streamlined with the GUI format. Input data requires field boundary shapefiles, satellite imagery (Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI, Sentinel-2 MSI), and calibration datasets. Step 4 will result from tabular and graphical summarization of performance calculations from step 3. | IV |
| **Cover Crop Performance Google Earth Engine GUI Tutorial** | Partners will be able to follow a step-by-step guide to navigate the Google Earth Engine GUI. | N/A | N/A |

***End-User Benefit*:** This project will focus on the re-integration of remote sensing analysis with the MDA cover crop implementation dataset, and automate the production of cover crop environmental performance reports at county and watershed scale. The user-friendly GUI interface will allow MDA to operationally use remote sensing analysis of cover crop performance, providing information to support adaptive management of cover crop cost-share programs to promote the most effective environmental outcomes. Producing tables and figures summarizing the results of the remote sensing analysis will allow conservation districts to better understand cover crop performance in their counties, and will enable a more accurate understanding of the links between cover crops and water quality outcomes in the Chesapeake Bay region.

Jason Keppler from the MDA reports: “The proposed project builds upon the previous work to better quantify the benefits of cover crop implementation that lead to a restored Chesapeake Bay. With statewide implementation of the new cover crop database system, this project will assist the Department to more effectively manage and monitor this critical program that reduces residual nutrients on agricultural land.”

**Project Timeline & Previous Related Work**

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

***Multi-Term Objectives:***

* **Term 1:** 2017 Spring (GSFC) – 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 mix of code and platforms for different stages of the processing, and results were produced in four counties, with calculated performance measures joined to each shape file record of cover crop field enrollment. Methods were described to the end user, and codes were transferred but were a bit complicated to use. Analytical results are currently being written into a journal article for publication.
* **Term 2 (Proposed Term):** 2018 Fall (GSFC) – Chesapeake Bay Agriculture II
  + This term will begin with the mix of coding produced by Term 1 and construct a Google Earth Engine GUI to streamline the analysis and make it user-friendly, to support operational use by the end user. After calculated performance measures are joined to shapefile enrollment records, the project will work with the end user to design tabular and graphical output summarizing results at the county and watershed scale, and will develop a GUI system for the routine output of clear and useful performance reports.
* **Term 3:** 2019 Spring (GSFC) – Chesapeake Bay Agriculture III
  + A third and final term would mark the culmination of this DEVELOP partnership, 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 verification of cover crop spring kill, and increase overall conservation effectiveness in support of cover crop management. The partners’ support would continue following an in-person hand-off of results and deliverables, since the software release process will delay final dissemination of results.

***Previous Terms:***

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

2015 Spring (VA) – Virginia Agriculture: Providing a Quantitative Tool based on NASA Earth Observations for Assessing Virginia's Growing Agriculture Economy

2014 Fall (VA) – Virginia Agriculture: Utilizing NASA Earth Observations to Monitor Vineyards in Virginia

**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.

***References:***

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>

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

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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. and 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