**NASA DEVELOP National Program**

**Spring 2017 Project Proposal**

**NASA Goddard Space Flight Center**

**Chesapeake Bay Agriculture**

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

**Project Overview**

***Project Synopsis*:** To assist the Maryland Department of Agriculture and other Chesapeake Bay Program 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, and 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. The US Geological Survey (USGS), the USDA-Agricultural Research Service (USDA-ARS), and the Maryland Department of Agriculture (MDA) have collaborated to develop remote sensing applications to evaluate winter cover crops at an experimental scale. Development of an operational system that combines timely, well-calibrated, Earth observation data with conservation implementation data, will enhance the ability of MDA and other Chesapeake Bay Program Partners to understand conservation performance and modify cost-share programs to improve environmental outcomes.

***Source of Project Idea:***

The source of the project idea was originally from Dr. W. Dean Hively and Dr. Greg McCarty at the USGS and USDA. The USGS and USDA-ARS project partners have worked with MDA to collect on-farm calibration data and develop methods for using satellite remote sensing to monitor winter cover crop performance. The MDA would now like to apply this methodology for cover crop remote sensing statewide, and move to an annual operational application of the techniques. The Center Lead at GSFC, Sean McCartney, and lead science advisor, Dr. John Bolten, traveled to the USDA-ARS Hydrology and Remote Sensing Laboratory in Beltsville, MD, to present on DEVELOP and inquire on potential collaborations. It was through this presentation the idea for the project came to DEVELOP.

***National Application Area Addressed:*** Agriculture

***Study Location:*** Chesapeake Bay watershed (MD, PA, VA, NY, DE, WV), with focus on the Eastern Shore of MD

***Study Period:*** December 2006to April 2016

***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 (MDA), Office of Resource Conservation | Jason Keppler, Program Manager for Watershed Implementation Programs | End-User | No |
| USGS Eastern Geographic Science Center | Dr. W. Dean Hively, Physical Scientist | Collaborator | No |
| USDA-ARS Hydrology and Remote Sensing Laboratory | Dr. Greg McCarty, Soil Scientist | Collaborator | No |
| EPA Chesapeake Bay Program | Rich Batuik, Associate Director of Science | Collaborator | Yes |

***End-User Overview***

***End-User’s Current Decision-Making Process:***

The MDA provides roughly $16M per year of cost share funding to farmers for winter cover crops. For each enrolled field they record geospatial location and agronomic management details, and different payments are provided for different management techniques. Currently, the MDA uses spot checks on 10% of fields to assess compliance with their winter cover crop conservation program and they estimate conservation performance only by using general Chesapeake Bay Program model coefficients. Thus, they adjust their payment rates based on best professional judgment of what techniques produce the most successful cover crops but do not measure actual cover crop conservation performance in the working farm landscape, and do not use remote sensing in the decision making process.

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

Maryland Department of Agriculture (MDA) – 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. 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 – They work in partnership with the USDA, and they are both 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 watershed or statewide level, and incorporate new platforms into their analysis of biomass and percent green ground cover.

USDA – They work in partnership with USGS, and they are both 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 watershed or statewide level, and incorporate new platforms into their analysis of biomass and percent green ground cover.

***Dissemination by Boundary Organizations*:**

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 progress to Chesapeake Bay Program (CBP) Partners including state agencies and CBP working groups. USGS has experienced a high level of interest in these methods in our interactions with state conservation agencies in NY, PA, DE, and MD.

***Project Communication & Transition Overview***

***In-Term Communication Plan:***

Dr. W. Dean Hively will be POC for communication with the DEVELOP team. 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. 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, will 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:**

USGS, Dave Kirtland, Director, Eastern Geographic Science Center

MDA, Jason Keppler, Program Manager, Department of Resource Conservation

EPA, Richard Batiuk, Associate Director, Science, Analysis, and Implementation

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **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:***

MDA – Annual shapefiles of cover crop enrollment and 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

USGS/USDA-ARS – Calibration dataset (>2000 measurements) of on-farm field sampling of winter cover crop performance (biomass) including photo archive, for determining percent groundcover classification

***Software & Scripting:***

ENVI, IDL - satellite image processing (NDVI, surface reflectance, calculated percent vegetative groundcover)

SQL Server – interface with MDA database to obtain field boundaries and agronomic management information

ArcGIS – Vector and raster analysis and pre-processing of data

Python – Data extraction and statistical analysis

R, crystal reports – produce summary tables and graphs summarizing satellite-derived measures

* Calibration of Landsat imagery to measure vegetative groundcover
* Augment Landsat imagery with other sensors (Sentinel, Worldview) to increase temporal resolution
* Link Earth observation measurements with geospatial field boundaries in SQL Server (cover crop farmer enrollment database)
* Produce reports to understand winter cover crop conservation effectiveness and support adaptive management

**Decision Support Tool & End-Product Overview**

***End Products***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| Wintertime Imagery Translated to NDVI and Fractional Vegetative Groundcover | Support analysis of cover crop outcomes and monitor progress in achieving conservation targets. | Compilation of Landsat and Sentinel calibration to surface reflectance and possible normalization, application of calibration fit to derive fractional vegetation | I |
| Performance Data Calculated for Cover Crop Fields | Knowledge of cover crop performance would allow improved tracking of conservation implementation, as well as support communication of conservation outcomes to farmers and soil conservation districts | Integration of processed imagery with field boundaries and agronomic data obtained from MDA SQL Server database, extracting reflectance information associated with each field | I |
| Tabular Reports at Watershed and Regional Scale | Used to evaluate agronomics and temporal patterns of cover crop performance, and to support adaptive management of cover crop cost-share programs | Satellite mapping and farm implementation data | I |

***End-User Benefit:***

Implementation of a well-calibrated, Landsat-based remote sensing technology at the state and watershed scale will greatly enhance the ability of MDA and Chesapeake Bay Program Partners to assess winter cover crop performance. The End-User will have an improved ability to assess the effectiveness of winter cover crop conservation programs, and will be empowered to use adaptive management approaches to improve conservation program performance. Within MDA, information will be used to identify and promote the most successful cover cropping strategies. Within other state jurisdictions, tools for using Earth observation data to monitor the conservation benefits of wintertime vegetation will become available.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 2 terms: 2017 Spring (Start) to 2017 Summer (Completion)

***Multi-Term Objectives:***

* **Term 1:** 2017 Spring (GSFC) – Chesapeake Bay Agriculture
  + This term will focus on integrating Earth observation data with field boundaries to provide large-scale analysis of cover crop performance in MD, and explore implementation in other states within the Chesapeake Bay watershed.
* **Term 2:** 2017 Summer (GSFC) – Chesapeake Bay Agriculture II
  + This term will focus on upscaling the methodologies created in the first term to the greater Chesapeake Bay watershed

***Related DEVELOP Work:***

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

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

Summer 2014 (Wise County) – Rwanda Agriculture II: Utilizing NASA’s Earth Observations to Estimate Rice Yield and Study Soil Erosion in Rwanda

Spring 2014 (Wise County) – Rwanda Agriculture: Utilizing NASA’s Earth Observations to Estimate Rice Yield and Study Soil Erosion in Rwanda

Summer 2011 (LaRC) – Virginia Agriculture: Monitoring Crop Tillage Practices and Carbon Sequestration with NASA EOS for Enhanced Agricultural Management Decision Support

**Notes & References:**

***Notes:***

This project is led 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>

Manuscripts related to our use of remote sensing to map wintertime vegetative groundcover include:

Hively, W.D., Duiker, S.W., McCarty, G.W., and Prabhakara, K., 2015, Remote sensing to monitor cover crop adoption in southeastern Pennsylvania: Journal of Soil and Water Conservation, v. 70, no. 6, p. 340-352, DOI:10.2489/jswc70.6.340.

Prabhakara, K., W.D. Hively, and G.W. McCarty. 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. DOI: 10.1016/j.jag.2015.03.002

Hively, W.D., G.W. McCarty, and J. Keppler. 2009. Federal-state partnership yields success in remote sensing analysis of conservation practice effectiveness: Results from the Choptank River Conservation Effects Assessment Project. (Technology Transfer Feature) Journal of Soil and Water Conservation 64(5):154A. http://www.jswconline.org/content/64/5/154A.full.pdf

Hively, W.D., M.Lang, G.W. McCarty, J. Keppler, A. Sadeghi, and L. McConnell. 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 <http://www.jswconline.org/content/64/5/303.full.pdf>