BIOAg Project PROGRESS Report

Report Type: PROGRESS

Title: Direct observation of sediment and carbon connectivity: evaluating degradation pathways, conservation implementation and true cost accounting.

Principal Investigator(s) and Cooperator(s):

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Abstract: Soil erosion is the first order measure of agricultural soil sustainability. Clear economic incentives and accounting of public and private true cost are needed to identify pathways from conventional to transformational, biologically intensive management. Erosion occurs disproportionately from critical source areas, but the spatial distribution and temporal variability in erosion mechanisms are not well characterized. Conservation planning, agricultural management, and physical soil dynamics span scales from millimeters to kilometers. Our limited ability to observe diffuse erosion constrains the application of focused conservation implementation. We utilize an Unmanned Aerial Vehicle (UAV) imaging and photogrammetry to generate ultra-high resolution maps of diffuse erosion on the Palouse. Visible and near infrared sensors will measure soil organic carbon and erosion. We hypothesize that the colocation of spatial erosion patterns and on-farm yield and soil data allow processed explanations of spatially explicit true cost accounting.

Long-term objectives of the project as they relate to the BIOAg Program included:

1. To observe the erosion patterns and sediment cascade across landscape compartments throughout a fall-winter-spring season.
2. To determine the accuracy and precision of a photogrammetric measurement of the total sediment flux from a catchment.
3. To field test the use of multispectral imaging for measurement of surface soil carbon distribution.
4. To evaluate current conservation modeling of long-term erosion with observed erosion dynamics in coordination with the PCD and develop conservation management recommendations.
5. To evaluate true cost accounting spatially on the landscape based on sediment connectivity patterns and soil health and productivity metrics.

Project Description:

This project leverages UAV imagery taken across the winter period of water year 2021 to directly observe the location, severity, and evolution of soil erosion in the Palouse. Successive observations of four sites provides direct observation of erosion in space and time. Analysis of soil loss, soil carbon and yield patterns allow for a true cost accounting of long-term erosion and soil degradation. We build on past BioAG UAV and remote sensing grants, leverage Cook Agronomy Farm (CAF) Long Term Agronomic Research (LTAR) on soil metrics, yield, and econometrics, and collaborate with the Palouse Conservation District (PCD) to identify conservation projects based on critical source areas. Through the RCPP, we will achieve dissemination of this BioAG grant's results and adoption of this methodology to complement on farm experimentation with sustainable agricultural intensification.

Outputs

Overview of work in progress:

In 2020, we established one main study site and two cooperative sites working with a graduate student of Alex Fremier. Three missions were flown in November and December. Soil samples were taken at 0-5, 5-15, and 15-30 cm.

In 2021, missions will be flown approximately every two weeks. Multispectral images will be captured. Setup and flight of the CAF is ongoing, though limited due to residue management in the 2021 rotation as wheat stubble was not cultivated.

True cost accounting, critical source identification, documentation and dissemination is planned to follow the conclusion of the water Year 2021 winter season.

Methods:

In cooperation with the Palouse Conservation District and the CAF, one main site was selected north of Moscow, Idaho. Two sites east of Spangle WA with parallel methodologies were added in cooperation with Alex Fremier's student, a Spokane conservation district planner and WSU MS student. The main site has an average annual precipitation of approximately 600mm. The field is under mulch tillage, and the 2020 crop was garbanzos, planted into winter wheat for the 2021 season leaving low residue coverage. Historical imagery provided evidence of annual rill to gully formation. Missions will also be flown at CAF, but as noted above, heavy residue cover limit the utility photogrammetric methods of surface change.

Successive UAV missions capture the change over time across the 2021 water year. The Drone used is a Matrice 210 by DJI managed by Alex Fremier and Von Walden, equipped with a Zenmuse ™ 20 mega pixel camera. All missions were flown by Ames Fowler who is now a commercial remote pilot (#4371450), with help of an undergraduate assistant. Three flights were flown at elevations of approximately 65m 20m and 10m, with a double grid flown at 20m for effective three-dimensional reconstruction. A 3.5 ha portion of the field was selected to optimize UVA coverage at 20m flights on one set of batteries. A small catchment, with historic evidence of rill formation was flown at the 10m elevation. A total of 30 ground control points (GCP), made of 30cm steel squares mounted on metal post, were installed for the winter season and locations measured with a high accuracy differential global positioning system (d-gps). Flights occurred monthly with additional flights before and after precipitation events greater than 12mm, as possible. Dense point clouds were computed for each flight from the imagery and GCP locations using Agisoft Metashape PRO 1.6.

We plan to characterize the soil organic carbon of the main site utilizing near infrared (NIR) imagery. The MICA Sense NIR sensor will be used to gather multispectral images. For image calibrations, we gathered soil samples from 0-5, 5-15, and 15-30cm at each of the GCPs at the CAF site for bulk density and SOC content. SOC will be measured by loss-on-ignition. The relationship between the spectral bands of the Mica-sense and the SOC content will be evaluated following Aldana-Jague et al. (2016) in the application of ordination and a support vector machine (SVM) algorithm. Surface filtering may be applied following (Anders et al. 2019). We will fly the CAF following spring tillage with the mica sense and replicate the SOC analysis then. We will compare the distribution of SOC to the measured distribution of erosion and transport from the photogrammetry workflow to evaluate erosion redistribution of surface SOC.

Ongoing collaboration with the PCD to identify critical source areas (CSAs) follows a land type approach – modeling soil erosion as a function of slope, climate, soil, crop rotation, and residue management at a 30m resolution. The spatial distribution of observed erosion at the sites flown will be compared to the model outputs. Additionally, we will relate the high-resolution surface morphology to the 30m modeled grid cell to categorize the dominant physical processes and most applicable BMPs following the framework of Rittenburg et al. (2015). In particular, the isolation of infiltration excess and saturation excess runoff patterns by land type will allow physically based recommendations of conservation implementation where the BPM selection is directly matched to the landform processes.

We will develop a spatially explicit method of true cost accounting of soil erosion by addressing the nutrient and yield loss to the producer and the sediment and nutrient pollutant load to society in addition to the commonly calculated enterprise budgets (Duffy 2012). We will pair the observed sediment cascade, change in surface roughness, and SOC patterns with CAF yield and production cost data to expand the accounting approach of Taylor and Young (1985). This approach is expected to show the CSA pattern reflected in high cost to both the producer and society. If these high cost features are observed, they will provide strong evidence for identifying and treating CSAs. This treatment may provide opportunities for introducing transformational agricultural management (e.g., working buffers, grazed perennials, etc.).

Publications, Handouts, Other Text & Web Products:

- In progress: Incorporation of improved CSA identification in space and time for ranking of projects in the RCPP.
- Anticipated for summer 2021: Peer-reviewed manuscript evaluating the spatial and temporal sediment connectivity across a hydrologic season (2021-2022) and the implications of the observed patterns on true cost accounting of soil loss and conservation planning.

Outreach & Education Activities:

- One undergraduate student has been trained in the basics of drone technology, image data collection, operation of the d-gps, and soil sampling.
- Anticipated for spring 2021: True cost accounting methodology and spatial soil loss results will be presented to the PCD and L TAR partners. Recommendations on future application in on farm assessment of spatial true cost accounting.
- Anticipated for summer 2021: A written report to BioAG on completed work, future collaboration with the LTAR network and the PCD, and future funding opportunities.

Impacts (Anticipated)

Short-term: Knowledge gained and shared: Ames Fowler will be trained in remote sensing and field data collection methodologies as well as communication to collaborators. The physical and economic understanding gained in this project will directly inform his ongoing collaboration with the PCD to identify and prioritize CSAs. The results and developed methodologies will be shared through reports and a manuscript described in expected outputs. This project also furthers the development of the UAV program at WSU.

Intermediate-term: The growing development of the WSU UAV program will promote regional use of high-resolution UAV monitoring by the CAF and PCD in ongoing collaborations enhancing the in-field application of precision conservation and promoting on farm research of erosion, soil health, and true cost accounting. The results of this work will be incorporated into the project ranking process in the new PCD RCPP project, which will be in its first year at the start of this project.

Long-term: This project builds on the land grant mission of Washington State University, combining leading scientific theory, cutting edge technology, and long-term place-based research to translate academic advancement to in-field applications. The WSU UAV program, with interdisciplinary collaborators, will connect producer management and conservation adoption to the physical practices controlling yield, profitability, soil health, and water quality. Increasing the resolution of our physical understanding will improve conservation fund use efficiency, enable conservation planning from sub-field to watershed scale and illuminate transformative management pathways.

Additional funding applied for/secured: none to date.

Graduate students funded: Ames Fowler PhD candidate.

Recommendations for future research: Awaiting results.

Work Cited:

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