BIOAg Project Report

Report Type: Progress

Title: Technical transfer of cloud-based environmental monitoring (CBEM)

Principal Investigator(s) and Cooperator(s):
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Cooperators: Levi Keesecker (State Conservation Commission), Brad Johnson (Palouse and Garfield Conservation District), Renee Hadley (Walla Walla Conservation District)

Abstract: Sustainable agriculture in Washington State drives to be economically viable while being environmentally responsible through improvements made to both on- and off-farm practices. Effective and efficient monitoring programs are an essential piece of policy implementation and adaptive management for sustainability. In our previous BioAg research, we hypothesized that remotely sensed data are underutilized in these programs due to the lack of specific technical methods for monitoring riparian and natural vegetation in the agricultural setting and the need for a pipeline to integrate these methods into existing monitoring programs. We partnered with the Palouse Conservation District and Washington State Conservation Commission to develop robust methodologies for monitoring riparian structure as a proxy for ecosystem function that utilizes publicly available satellite imagery combined with the capabilities of cloud-based computing (Google Earth Engine) (Stahl, Fremier, Heinse, 2021. *BioScience*). We demonstrated the potential of cloud-based environmental monitoring (CBEM) techniques to improve feedback and evaluation of large-scale programs, such as VSP and CREP. Our next step is to complete the technical transfer of the new methodology to diverse Conservation Districts including Palouse, Walla Walla, and Pend Oreille for integration into monitoring programs (this extension proposal). We will meet iteratively with these groups to adapt workflows to their monitoring needs and to prepare online resources for practitioners across the state. Additionally, we will pilot a prototype GEE App to simplify the CBEM workflow for environmental monitoring in agricultural lands. Our goal is to make low-cost remote sensing technologies accessible and easily applicable to agricultural communities for more efficient and effective reporting of conservation practices.

Project Description: WSU will coordinate with each Conservation District point of contact to provide technical transfer of Cloud-Based Environmental Monitoring (CBEM). Each cooperator will help develop the policy/management question, review WSU analysis, and provide feedback on CBEM use and application in monitoring. WSU will coordinate with the SCC point of contact to inform coordinated implementation of CBEM across VSP counties.

Outputs:

- Overview of Work Completed and in Progress:
    - Peer-reviewed publication is now in the journal *BioScience*. https://doi.org/10.1093/biosci/biab100

- Delivered presentations both to the practitioner community and the broader research & development community to raise awareness of our efforts. The slides and/or video from each presentation are now publicly available online.
- Initial version of a publicly available User Library for cloud-based environmental monitoring is online. https://labs.wsu.edu/ecology/research-projects/cbem-user-library/
- Continuing to collaborate with Palouse and Walla Walla Conservation Districts to supporting monitoring needs. We are using these two districts as case studies to provide more general tools for all districts.
- Trained incoming GIS-capable staff at Walla Walla Conservation District on Earth Engine methods; collecting input to guide development of web-based products.
- Verbally agreed to present at upcoming session of a periodically occurring symposium on VSP monitoring, organized by the WA Conservation Commission.
- Have met with staff from multiple Conservation Districts across the state to discuss their current and future monitoring capabilities with UAV and Earth Engine image analysis.

- **Methods, Results, and Discussion (discussion for final reports only):**
- **Publications, Handouts, Other Text & Web Products:**
  - Stahl, A.T., Fremier, A.K., and Heinse, L. 2021. Cloud-based environmental monitoring to streamline remote sensing analysis for biologists. *BioScience* **71**:1249-1260. https://doi.org/10.1093/biosci/biab100.
  - Related article in review: Stahl, A.T., Fremier, A.K. (*in revision,* special issue of *Ecology and Society*). Translating adaptive riverine governance approaches across social-ecological boundaries.
  - User Library launched (and still under construction): provides options for those interested in learning about landscape change detection using Earth Engine: https://labs.wsu.edu/ecology/research-projects/cbem-user-library/
    - Apps Gallery: https://atstahl.users.earthengine.app/
    - Github repository: https://github.com/ATStahl/CBEM
- **Outreach & Education Activities:**
  - News/Blog coverage:
    - https://www.agclimate.net/2021/04/12/how-can-new-remote-sensing-technologies-help-evaluate-the-effectiveness-of-resource-conservation-measures/
    - https://dailyevergreen.com/101885/research-research-2/wsu-researchers-produce-technology-to-monitor-ecology/
    - https://news.wsu.edu/press-release/2021/02/15/eyes-sky-help-make-streamside-ecosystems-sustainable/
  - Presentations:
    - **Stahl, A.T. 2021.** Adding Earth Engine to the conservation toolbox. *Google's Geo for good Summit 2021*. (poster presentation) https://earthoutreachonair.withgoogle.com/events/geoforgood21

- **Stahl, A.T. 2021.** Adding satellite data to the toolbox of conservation professionals with Earth Engine. *Geo for Good Lightning Talks Series #5: Nature Conservation*. https://earthoutreachonair.withgoogle.com/events/lightningtalk5
- **Stahl, A.T.** 2021. Developing practical remote sensing workflows for ecosystem monitoring. Invited presentation at the *Washington Association of District Employees Annual Meeting.* https://sites.google.com/site/wadistrictemployees/wade-conference/presentations (https://www.youtube.com/watch?v=dCJT-4gyqWg)
- **Stahl, A.T.** 2021. Potential options for effective and efficient riparian monitoring with drone and satellite data. Invited presentation at the *Eastern Washington Riparian Planting Symposium.* https://ybfwrb.org/outreach/annual-symposium/

Impacts

- **Short-Term:** Knowledge gained from this research will be shared through reports and technical documentation. The prototype App will create a tool for agriculture-related agencies across Washington State to directly and effectively access remotely sensed data.
- **Intermediate-Term:** This project will continue to develop a hub for remote sensing at WSU. The outputs of this study will provide an improved methodology for aerial and satellite data for monitoring of riparian vegetation or other areas with natural vegetation structure in agricultural areas. With subsequent work to address variability among counties, this methodology can be applied to enhance existing monitoring approaches for the VSP and CREP, evaluating the effectiveness of conservation actions over time at multiple scales with minimal cost. Additionally, this set of current and future projects will make these technical capabilities accessible to practitioners worldwide, particularly those in economically disadvantaged areas. The ability to demonstrate the effectiveness of voluntary stewardship will likely assist counties in meeting VSP requirements and thus avoiding direct regulatory oversight.
- **Long-Term:** This and subsequent projects will establish a program at WSU that effectively integrates these technologies, serving as a resource for state and federal agencies as well as farming communities and producer-oriented groups to track technical advances and seek assistance in remote sensing applications. Information gathered from effectiveness monitoring over broader spatial extents and through time may inform CREP buffer requirements and identify reliable indicators that can serve as measurable benchmarks for VSP reporting and evaluation of VSP and other conservation programs. Demonstrating the effectiveness of actions to conserve natural vegetation structure in agricultural areas may help to refine practices or validate incentive programs that make conservation economically feasible for the agricultural community.

Additional funding applied for/secured:

- Smith Conservation Fellowship application submitted in Fall 2021 (in review)

- BioAg grant awarded: Rajagopalan et al., Deploying satellite-imagery based machine-learning models for large-scale mapping of tillage practices.
- USDA-ARFI DSFAS-CIN grant proposal submitted (declined, but plan to resubmit in next cycle): Rajagopalan et al., Robust soil organic carbon estimation and pathways for successful carbon incentivizing program participation
- CAHNRS ERI grant proposal submitted (declined): Water for agriculture: satellite imagery applications to enhance knowledge gaps and decision support.
- NSF-Macrosystems Program: Low-cost sensors to quantify the hydrological impact of river restoration across expansive climate and geologic gradients. (Submission date: November 2022)

Graduate students funded:

Recommendations for future research:
Next steps include

- continuing collaboration with practitioners and state officials to identify monitoring gaps that remote sensing technologies may be able to fill
- seeking additional funding sources to provide ongoing guidance and technical support
- seeking extramural research funding to advance conservation science with a focus on agricultural areas, including foundations such as the Cedar Tree Foundation (Smith Fellows – application attached)