Title: Detecting Early Season Invasive Plants in the Greater Yellowstone Ecosystem with UAS and Satellite Remote Sensing

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Background/Questions:
Cheatgrass (*Bromus tectorum*) and other early-season invasive (ESI) grasses are an emerging threat in the Greater Yellowstone Ecosystem (GYE), where climate trends of warmer spring temperatures and earlier snowmelt could increase ESI establishment and spread. Land managers need tools to identify localized ESI infestations quickly and inexpensively before they develop into uncontrolled invasions. Researchers have elsewhere exploited the distinctive phenology of cheatgrass to detect infestations from satellite imagery. The purpose of our project is to explore the use of various sources of remote sensing data for early detection and mapping of cheatgrass in the GYE, with a focus on evaluating sensor trade-offs related to ground sampling scale (pixel resolution), spatial extent, and temporal resolution.

Methods:
We developed cheatgrass mapping workflows using multitemporal Sentinel-2 imagery (10-m resolution), multitemporal PlanetScope imagery (3-m resolution), and single-date, 1-cm Uncrewed Aircraft Systems (UAS) imagery. We developed a field data collection protocol to map cheatgrass location and abundance, and using this approach, data collected from 2022-2024 by U.S. Geological Survey, National Park Service, and other GYE partners and shared/viewed in an online GIS interface. We are using this data to train and validate remote sensing indices and machine learning models of ESI detection in study areas in the GYE. Our image processing workflow uses open-source software and is documented in a Jupyter notebook that guides a user through the required analysis steps.

Results/Conclusions:
Our ESI mapping results showed that Sentinel-2 imagery worked well for distinguishing the timing of greenness and senescence in cheatgrass versus native grasses in our study region, except when excessive cloud cover precluded the observation of key phenological stages. PlanetScope satellite data provided cheatgrass maps at high spatial resolution, but the massive volume of imagery resulting from complete coverage of the GYE would pose a data management challenge. Our pilot study using UAS imagery suggest that such data can be highly effective for mapping smaller areas where ultra-high resolution and accurate cheatgrass maps could be used to target specific treatments. UAS flights and imagery collection can also occur when weather conditions prevent satellites from capturing clear views of the landscape. We expect the data and tools developed in this project will assist GYE land managers with early detection and rapid response to ESI infestations and facilitate eradication before widespread ESI colonization can occur.

Jason Kreitler is a research geographer for the U.S. Geological Survey working on natural resource management issues important to the Department of the Interior. His research investigates contemporary questions in remote sensing, landscape ecology, conservation planning, wildland fire, and land change science to understand the dynamics of western landscapes and the impacts of observed and projected changes on society.