# Simultaneous prediction and mapping of 30m grass species abundance over Western U.S. rangelands

Devendra Dahal[1], Neal Pastick[1], Sujan Parajuli[1], Stephen Boyte[2], Logan Megard[1], Bruce Wylie[2]

[1]KBR, contractor to the U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center, Sioux Falls, SD 57198, USA. Work performed under USGS contract 140G0121D0001.
[2]USGS EROS Center, Sioux Falls, SD 57198, USA.

## Introduction

- Exotic species can have long-term effects in any ecosystem. However, invasion of exotic grass species in arid/semi-arid western U.S rangelands not only impacts conservation and weed control but persists because of altered wildfire regimes.
- Key exotic annual grass species like cheatgrass (*Bromus tectorum*) and medusahead (*Taeniatherum caput-medusae*) can be highly problematic for land managers. However, beneficial perennial species like Sandberg's bluegrass (*poa secunda*), which is native to the region, share similar characteristics with cheatgrass and medusahead. Sharing characteristics can complicate distinguishing the exotic from the native in remote sensing studies, leading to difficulty in interpreting results for land managers. Availability of these species maps can provide valuable information to land managers, policy makers, and other scientists.
- We are testing a method to concurrently develop several exotic annual grass species percent cover maps (30m spatial resolution), along with a Sandberg's bluegrass map, for the sagebrush biome of the western U.S. (Figure 1).
- Development of cloud-free, 30m weekly near infrared (NIR), shortwave infrared (SWIR), and normalized difference vegetation index (NDVI) data based on Harmonized Landsat and Sentinel 2 (HLS) datasets can help us achieve the goal of generating early estimates of exotic grass species abundance.

## Methods

- We automated procedures to acquire 30m HLS data and develop cloud-free weekly spectral data and vegetation indices (e.g., NDVI, and NDWI) using machine learning techniques.
- Field observations, weekly spectral composites and other environmental datasets are integrated with machine learning models for the simultaneous prediction of the abundance of exotic annual grasses and Sandberg's bluegrass.
- We use an ensemble of models to improve predictions and develop spatially explicit estimates of model uncertainties for three cover types (i.e. exotic annual grasses, cheatgrass, Sandberg's bluegrass across four HLS tiles as pilot study.

## Results and Discussions

- Despite a limited amount of training data, we achieve satisfactory accuracies for multiple species percent cover mapping within the 4-tile area. Accuracy results are reported as mean absolute error (MAE), and median absolute error (MeAE) of percent cover and Pearson's correlation coefficient ($r$) (Table 1).
- We developed percent cover 2020 maps for exotic annual grasses, cheatgrass, and Sandberg's bluegrass. We also generated uncertainty maps for each percent cover map, which provides a level of confidence for each mapped pixel (Figure 2).
- Comparing the annual herbaceous maps from this study with previously published 2020 annual herbaceous maps for larger area shows similar spatial distribution of the annual herbaceous cover (Figure 3).
- We anticipate publishing four early estimate 2021 maps for 1) exotic annual grasses 2) cheatgrass, 3) medusahead, and 4) Sandberg's bluegrass for much of the western U.S. (defined by red polygon in Figure 1) no later than May 31, 2021.

## Reference

Pastick, N.J., et al., Characterizing Land Surface Phenology and Exotic Annual Grasses in Dryland Ecosystems Using Landsat and Sentinel-2 Data in Harmony. *Remote Sensing*, 2020. 12(4): p. 725.

Boyte, S.P., et al., Estimating carbon and showing impacts of drought using satellite data in regression-tree models. *International Journal of Remote Sensing*, 2017. 39(2): p. 374-398.

Clements, C.D., et al., Improving Seeding Success on Cheatgrass-Infested Rangelands in Northern Nevada. *Rangelands*, 2017. 39(6): p. 174-181.

U.S. Department of the Interior
U.S. Geological Survey

# We can develop **early-season maps** of multiple **grass species** concurrently with **machine learning** and **remote sensing**

This research is funded by:
- National Land Imaging program
- US Fish & Wildlife
- BLM
- Land Change Science program

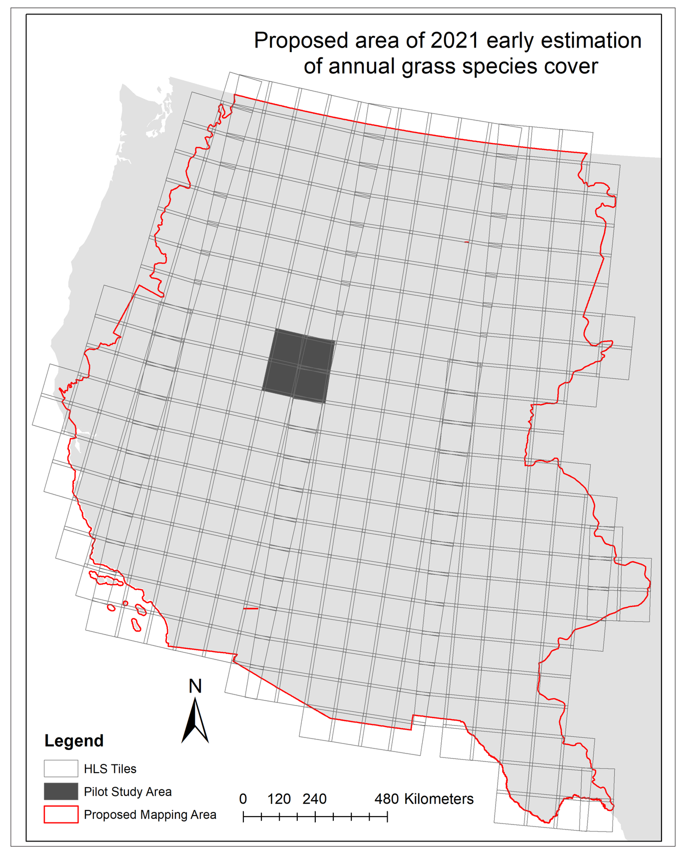
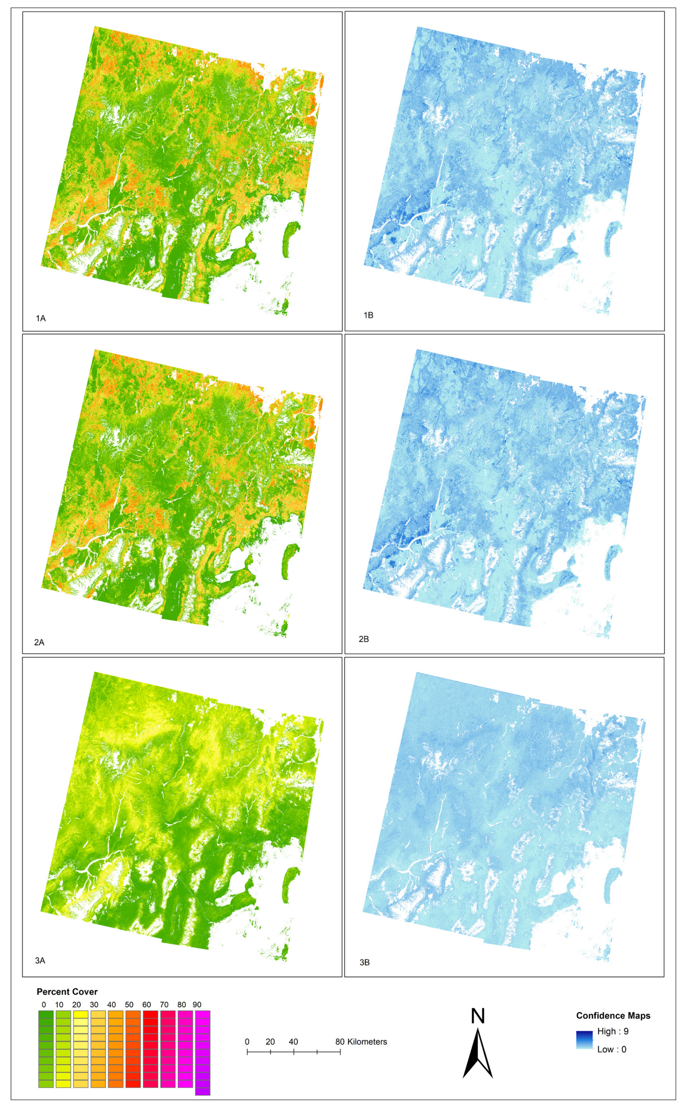



**Figure 1.** Proposed study area for early estimation of herbaceous cover maps (red polygon), HLS tiles as input processing units (gray grids), pilot study area (black shaded area) for which results are reported in this study, and the western half of the conterminous United States as gray background.

**Table 1.** Summary of training and testing accuracies from regression tree models showing mean absolute error (MAE), and median absolute error (MeAE) of percent cover and Pearson's correlation coefficient ($r$). AnnHerb is exotic annual grasses, BRTE is cheatgrass, and POSE is Sandberg's bluegrass.

| | Training accuracies | | | Test accuracies | | |
|---|---|---|---|---|---|---|
| **Species** | **MAE** | **MeAE** | ***r*** | **MAE** | **MeAE** | ***r*** |
| **AnnHerb** | 8.56 ±1.5 | 5.10 ±0.9 | 0.92 ±0.08 | 10.51 ±1.5 | 6.08 ±1.2 | 0.87 ±0.03 |
| **BRTE** | 8.56 ±1.5 | 5.15 +1.0 | 0.92 ±0.08 | 10.51 ±1.5 | 6.18 ±1.1 | 0.87 ±0.03 |
| **POSE** | 7.56 ±1.4 | 5.52 ±1.5 | 0.85 ±0.15 | 9.23 ±1.2 | 6.59 ±1.4 | 0.74 ±0.07 |

**Figure 2.** Percent cover maps (Panel A) and confidence level maps (Panel B) 2020 for pilot area (small black box in Figure 1). All exotic annual herbaceous: panel 1; Cheatgrass (Bromus tectorum): panel 2; and Sandberg's bluegrass (poa secunda): panel 3. Smaller confidence values denote higher confidence in the mapped pixel.



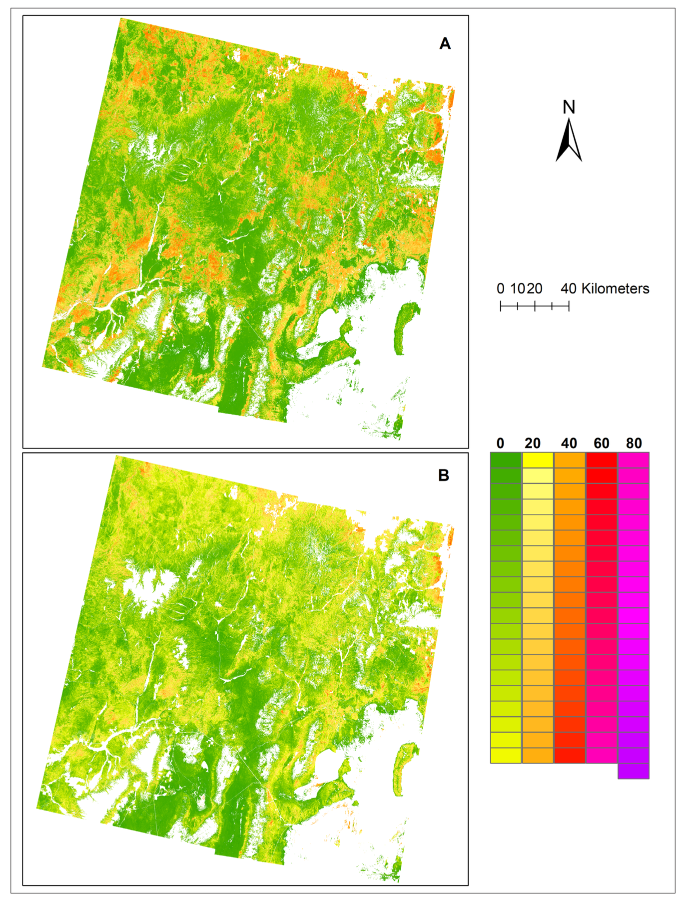




**Figure 3.** Comparison of annual herbaceous 2020 maps generated from two different models. A) this study where models were developed just for the pilot area (4 HLS tiles) with ~600 training points. B) Previously published data where models were developed for a larger area (132 HLS tiles) with ~11,000 training points.

February 2021