Phenology-based UAV Remote Sensing for Classifying Invasive Annual Grasses to the Species Level

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INTRODUCTION

- Invasive plant species, such as cheatgrass and medusahead, alter wildfire regimes, degrade critical habitat for native species, and reduce rangeland productivity.
- Remote detection and monitoring of emerging weed invasions at the species level is a challenging endeavor with tremendous cost implications for land managers tasked with controlling weed invasions.
- Detailed Unmanned Aerial Vehicle (UAV) imagery facilitates potential to distinguish invasive plants at the individual species level, due to differences in plant phenology.

Fig 1.) Medusahead and cheatgrass are invasive annual grasses that outcompete native species, alter disturbance regimes, and can form extensive monocultures.

OBJECTIVES

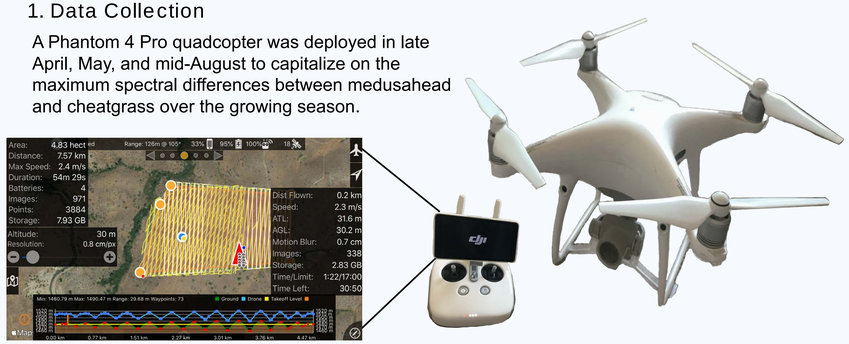
This study refines a novel methodology to separate invasive annual grasses based on plant phenology, increasing the utility of hyperspatial remote sensing data in invasive species management.

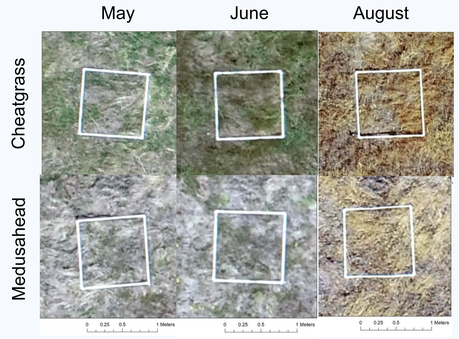
Fig 2.) The study system near Paradise Valley, Nevada features a high diversity of invasive and native plant species, representative of the Great Basin region.

METHODS

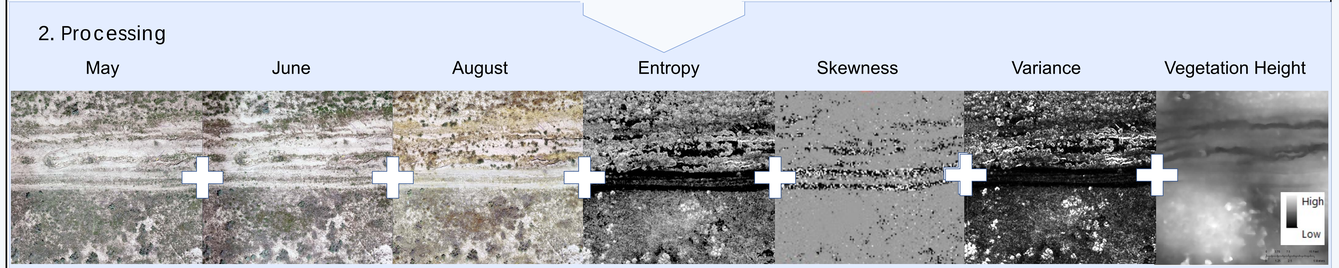
1. Data Collection

A Phantom 4 Pro quadcopter was deployed in late April, May, and mid-August to capitalize on the maximum spectral differences between medusahead and cheatgrass over the growing season.



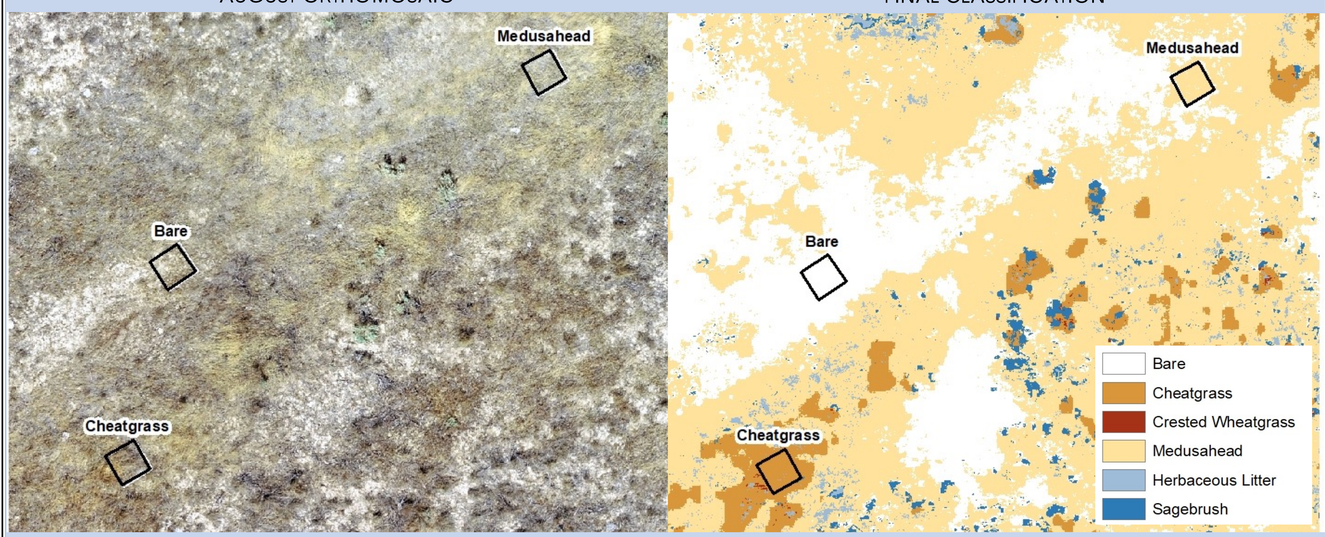


2. Processing



Using imagery collected from the field, a final orthomosaic image, Digital Terrain Model (DTM), and Digital Surface Model (DSM) of the site were processed in Pix4Dmapper Pro software (Pix4D, Switzerland). Spectral attributes (red, green, and blue bands) used for classification are derived from the processed orthomosaic image. First-order occurrence measures were used to apply texture filters over the green band from the orthomosaic image (entropy, skewness, and variance). Vegetation height was generated by subtracting the DTM from the DSM.

3. Random Forest Classification



RandomForestSRC classifier was applied to the response variable (vegetation class type) and explanatory variables (spectral, textural, height, and phenological characteristics) in R statistical package (Version 3.6.2, CRAN) to create a classified vegetation map.

RESULTS

Overall accuracy for the classification using:

3-dates	**82%** Kappa Coefficient: 0.77
3-dates + Texture	**90%** Kappa Coefficient:0.87
3-dates + Texture + Height	**96%** Kappa Coefficient:0.95

Actual Values

Predicted Values	Bare	Cheatgrass	Crested Wheatgrass	Medusahead	Herbaceous Litter	Sagebrush	Row Total
Bare	8037	20	27	156	3	0	8243
Cheatgrass	0	7957	7	0	42	123	8129
Crested Wheatgrass	0	114	787	0	3	0	904
Medusahead	66	79	0	7305	115	1	7566
Herbaceous Litter	0	105	0	50	4185	0	4340
Sagebrush	0	32	0	2	117	1379	1530
Column Total	8103	8307	821	7513	4465	1503	**96%**

Table 1.) Confusion matrix illustrating the performance of the classification which uses all variables.

CONCLUSIONS & APPLICATIONS

The study demonstrates a multitemporal classification that exploits differences in growing-season phenology to classify invasive plants to the species level. Use of UAVs allowed for collection of imagery at optimal times for distinguishing key species of interest and provided valuable information on vegetation textural and height attributes. This classification will serve as the base for subsequent investigations:

- Modeling areas at high risk for future invasion, prioritizing management efforts
- Scaling from UAV to satellite-scale classifications allowing for large-scale monitoring
- Using archival data to reconstruct past patterns of invasion

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