Sagebrush Ecosystem Council, June 17, 2020

Remote sensing approaches for detecting and mapping medusahead invasion in the Nevada Great Basin: development of regional mapping protocols using fine-scale phenological and spectral variation

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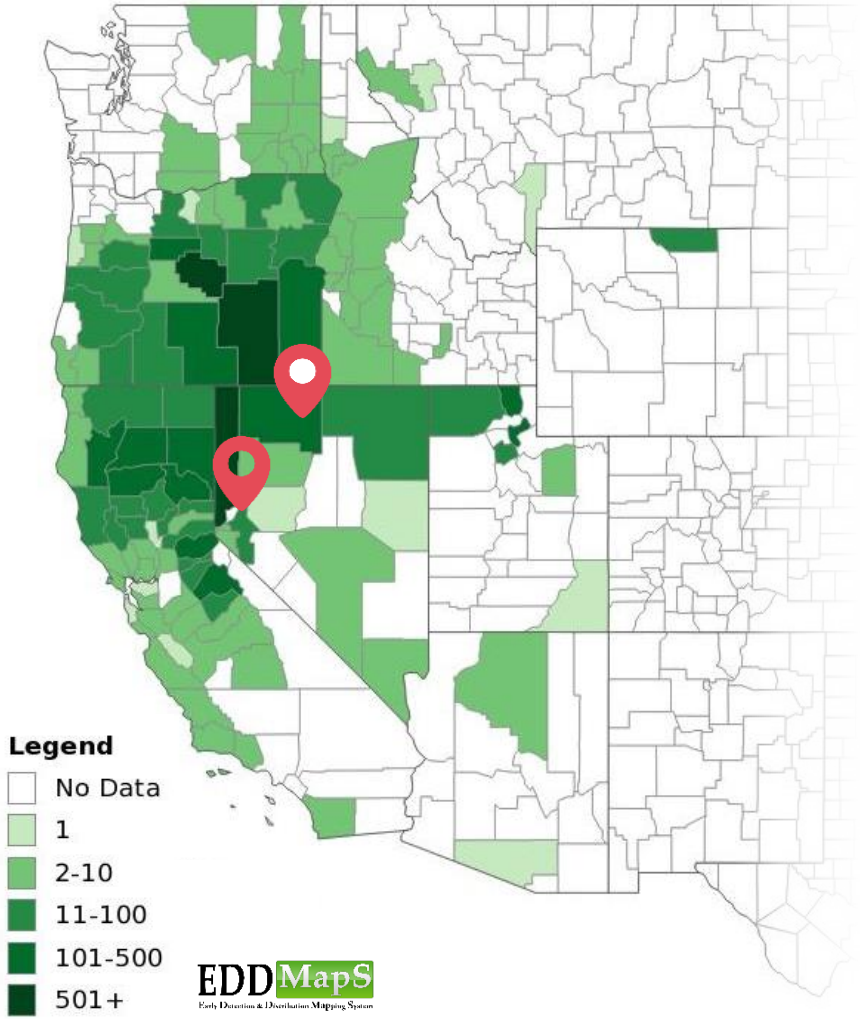
Medusahead: Existing Problem, Future Threat

- Alters fire regimes, reduces diversity, reduces forage, dense thatch resists decomposition
- Invasive in 17 western states
- Rapidly expanding range; outcompeting other invasive annuals such as cheatgrass
- Unlike cheatgrass, still an opportunity to contain its spread?

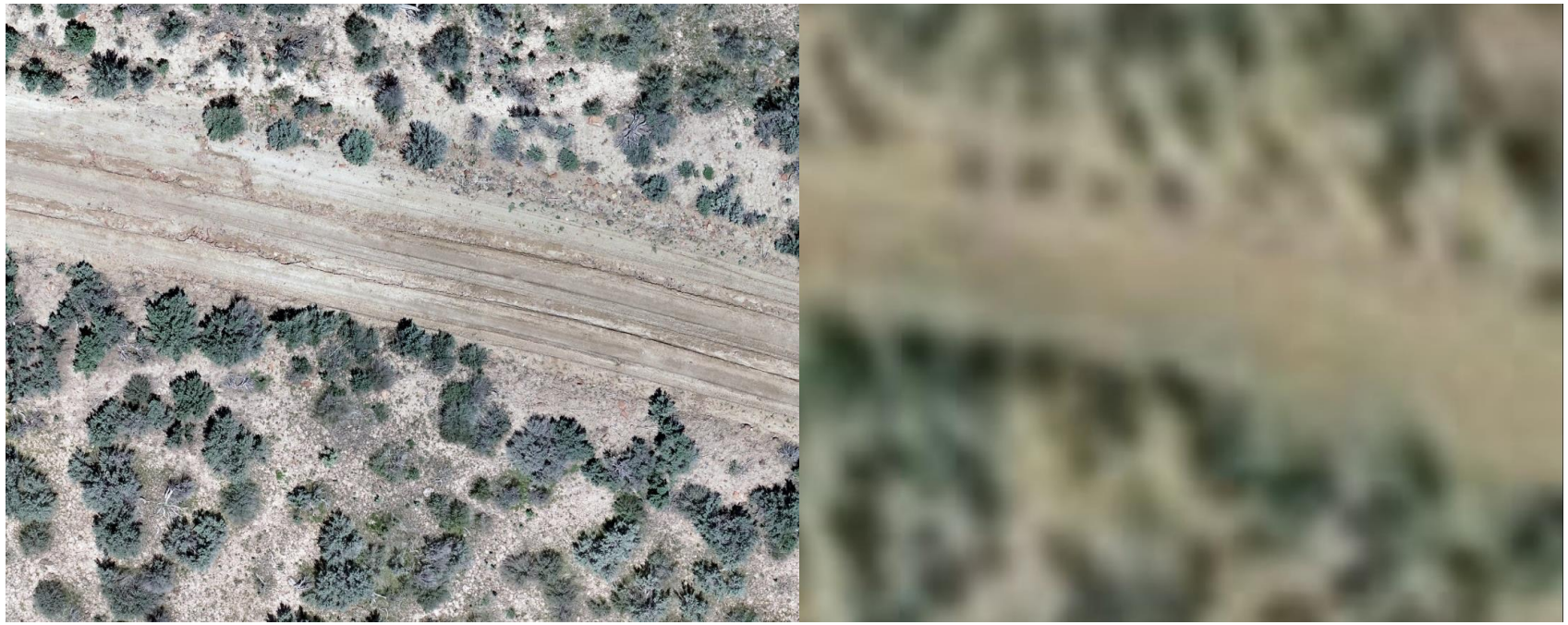


Challenges of Invasive Plants Mapping using Remote Sensing

- Getting to the species level
- High enough spatial resolution to detect new invasions (small patches)
- Improving our understanding of invasive plant spread dynamics requires long-term, high-resolution, species-specific datasets

Drone Orthomosaic **High-resolution Satellite Image**

08/12/2019
1-cm resolution



10/12/2018
0.5-m resolution

Existing Mapping Approaches

- Phenologically derived indices of “early-season annual grass” cover at 30-m Landsat resolution
  - Wet year vs Dry year phenology (e.g. Bradley & Mustard 2005)
  - Spring vs. Summer phenology (e.g. Boyte et al. 2015)
  - Medusahead is not mapped as a separate species
- Use classification of 1-m NIR NAIP to train a 30-m Landsat model of % medusahead cover, from a single late-season image (Bateman et al., in press)
- High-resolution (0.15-m) aerial NIR imagery, with object-oriented classification using textural analysis, from a single early-season image (Dronova et al. 2017)

Our General Approach

- UAV acquisition of very high resolution RGB imagery (1-cm) on multiple dates of maximum phenological differentiation (e.g. 3 flights)
- Field plots (“pure patches”) to train and validate image classification
- Classification uses machine learning (random forests) of each spectral band * date combination, plus textural indices

PHENOLOGY

Remote Sensing:

- Obtain aerial photographs at proper phenological stage
- Emphasize spectral differences

Medusahead:

- Yellow-green hue in late spring and early summer
- Stays green later in the season
- Golden cream color at the end of summer

1.Bare

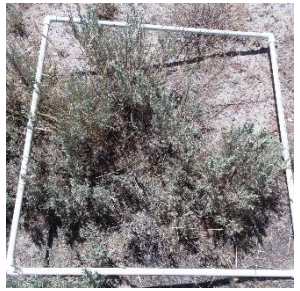
2. Bare

3. Medusahead Litter

4. Cheatgrass Litter

5. Cheatgrass Litter

6. Sagebrush



7. Mixed Litter

8. Medusahead Litter

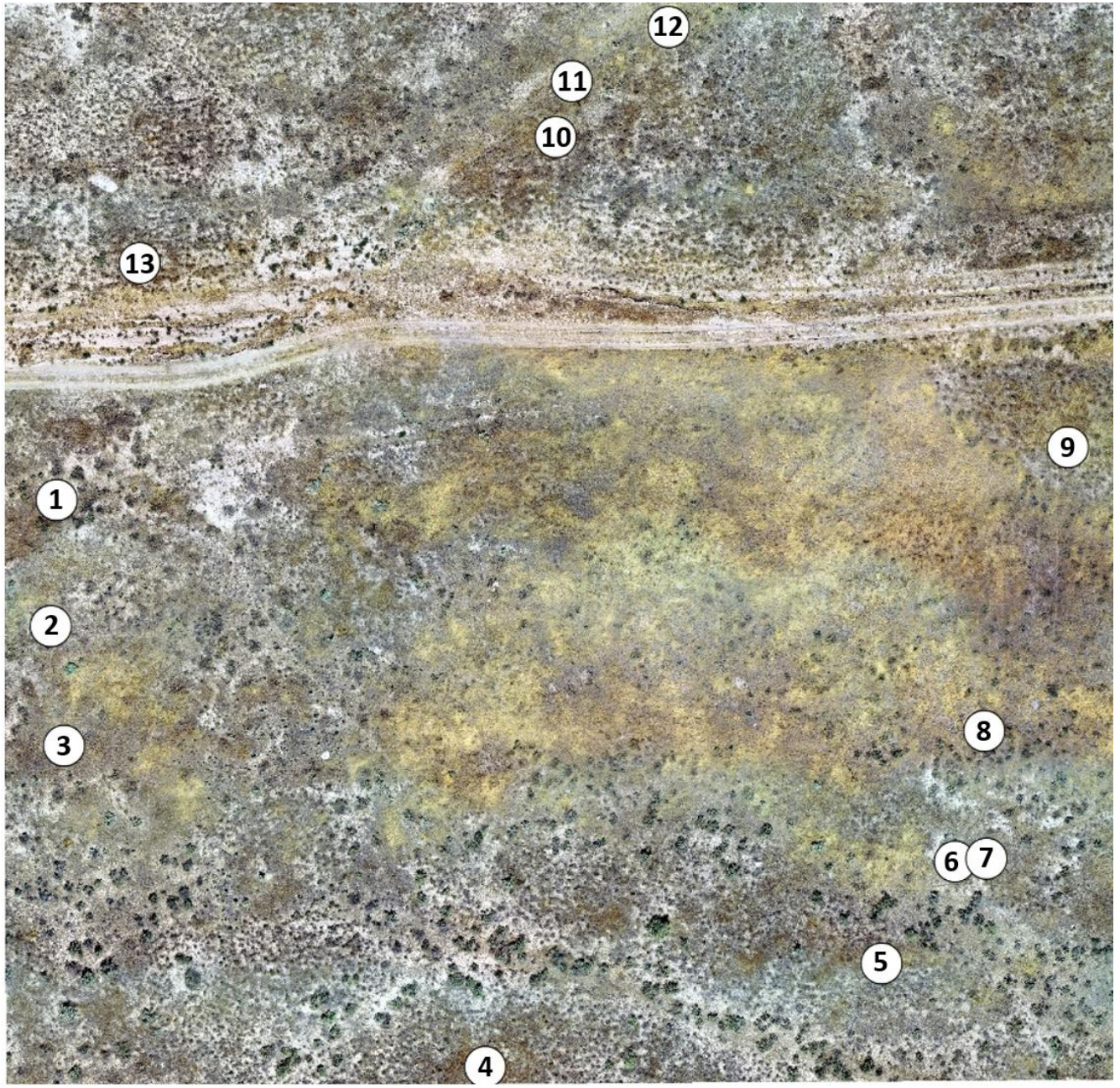
9. Medusahead Litter

10. Cheatgrass Litter

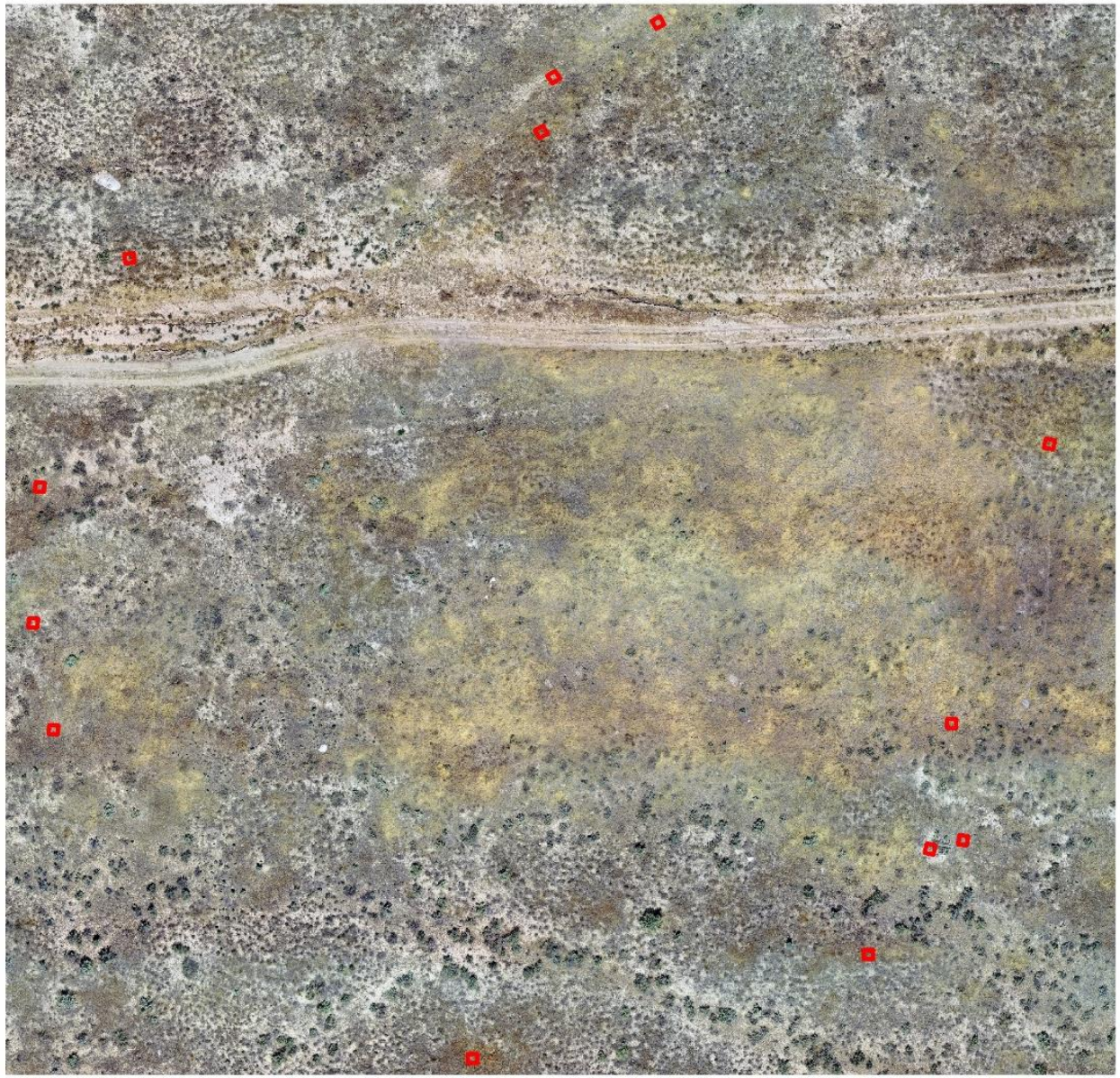
11. Bare

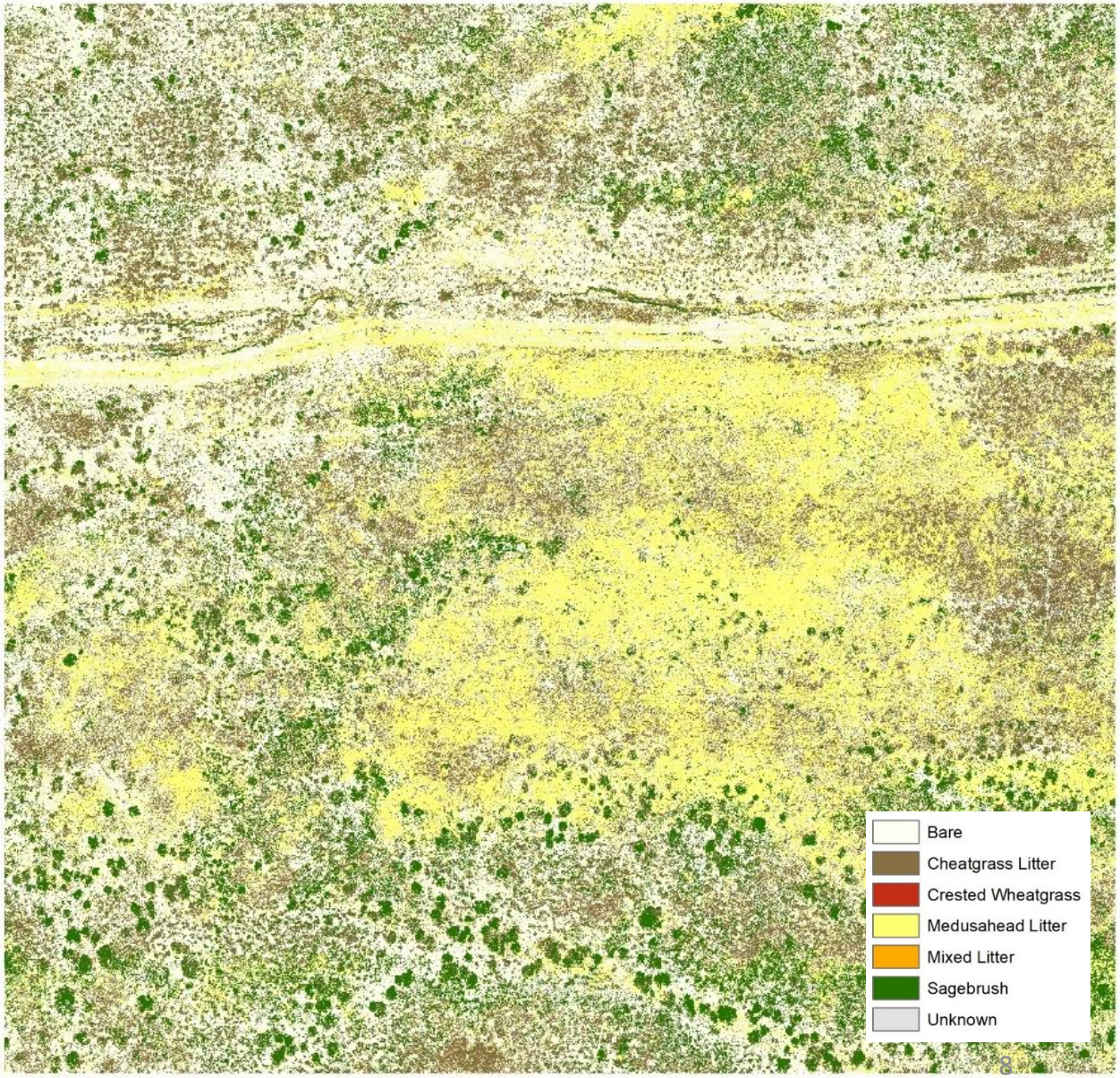
12. Medusahead Litter

13. Crested Wheatgrass



SINGLE-DATE CLASSIFICATION (AUGUST IMAGE)





Three Phases of our Project

- Peavine Mountain (n. Reno), 2017
  - Flew nine dates across the growing season
  - Compared RGB and near-IR cameras
  - Analysis completed, writing manuscript
- Paradise Valley, 2019
  - 5/1, 6/4, 8/13 flights over 5 distinct areas
  - RGB camera only
  - 1 late-season (August) flight in 2020
- Garson Road (w. Reno), 2020
  - Flew April, May in 2020
  - RGB camera only

Peavine Mt: Hoge Rd. (5-ha area)

- Can we distinguish invasive grasses to the species level using phenology?
- Do we need near-IR spectra, if we have enough dates of image collection?
- How many dates are needed? What is the optimal timing?

Peavine Mt: Hoge Rd. (5-ha area)

- Can we distinguish invasive grasses to the species level using phenology?

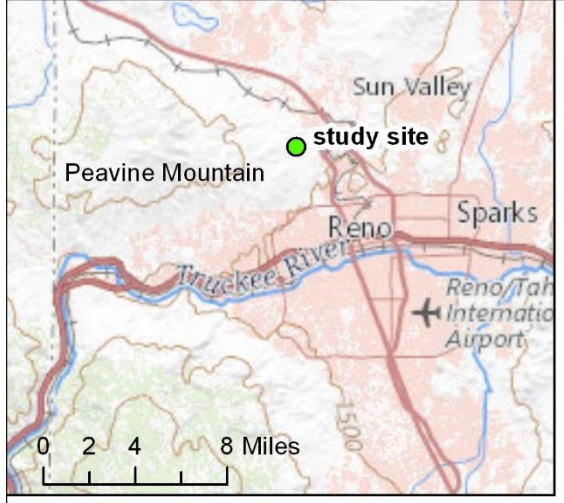
Yes, with ~ 90% accuracy

- Do we need near-IR spectra, if we have enough dates?

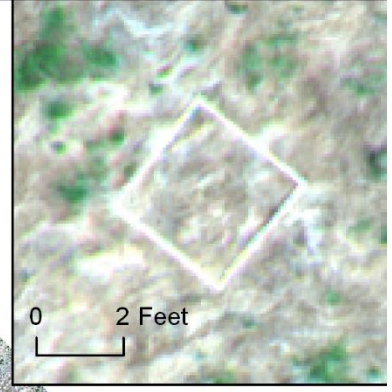
No, it doesn't add much to the accuracy

- How many dates are needed? What is the optimal timing?

CG green, MD white (prev. yr litter)
CG red, MD green
GC yellow/white, MD reddish

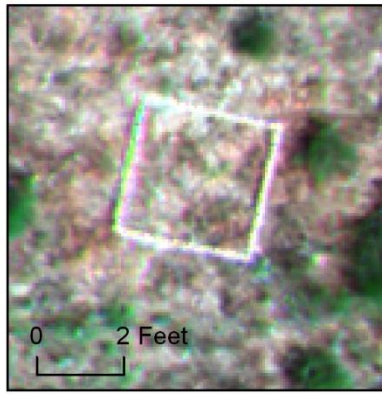


6/1/2017

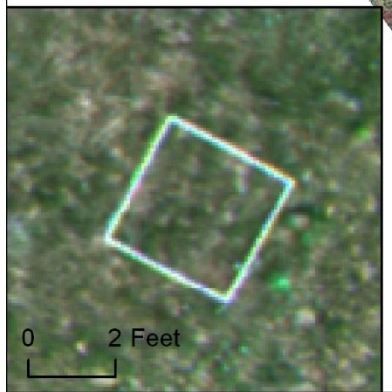


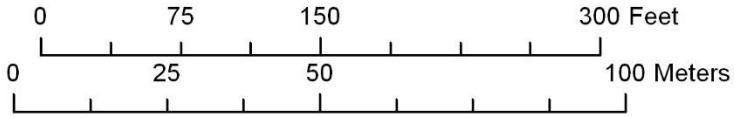
medusahead litter

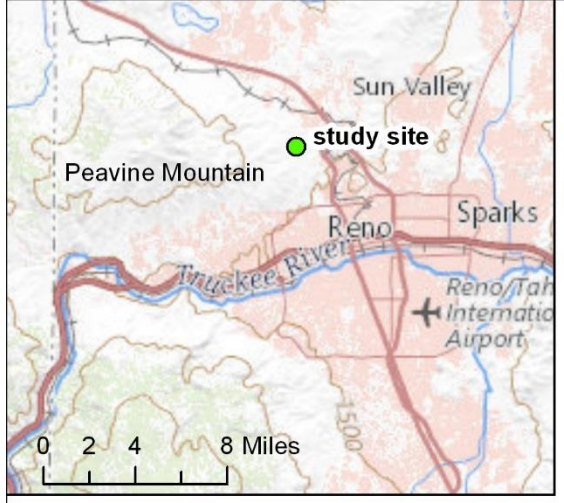
cheatgrass



medusahead







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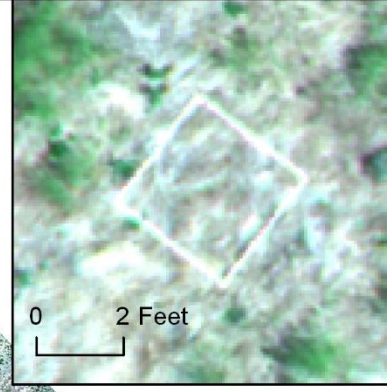
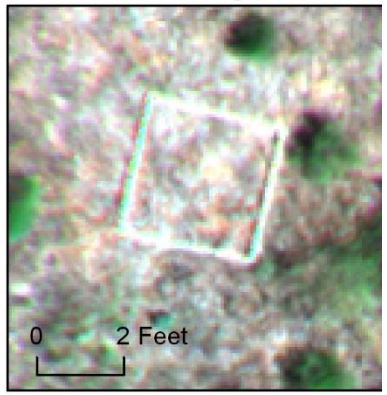
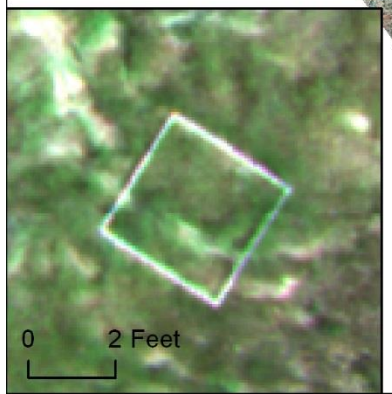


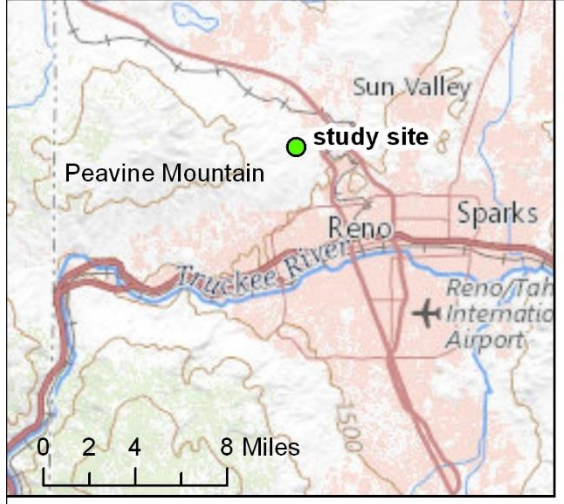
medusahead litter

cheatgrass

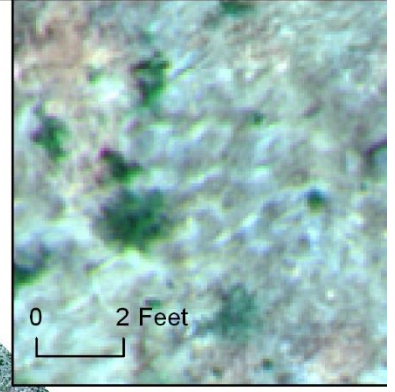


medusahead



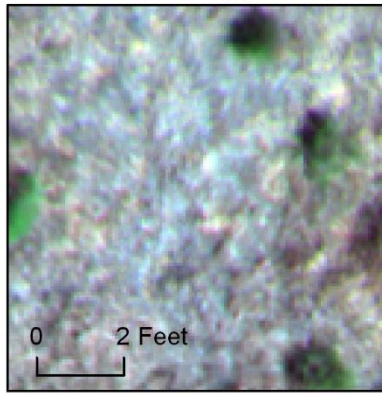


7/20/2017

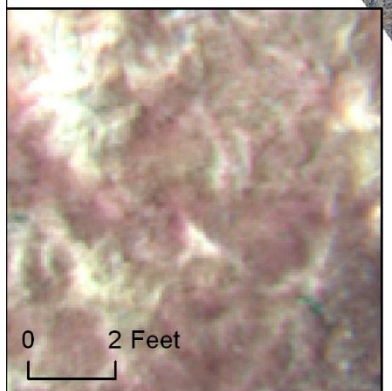


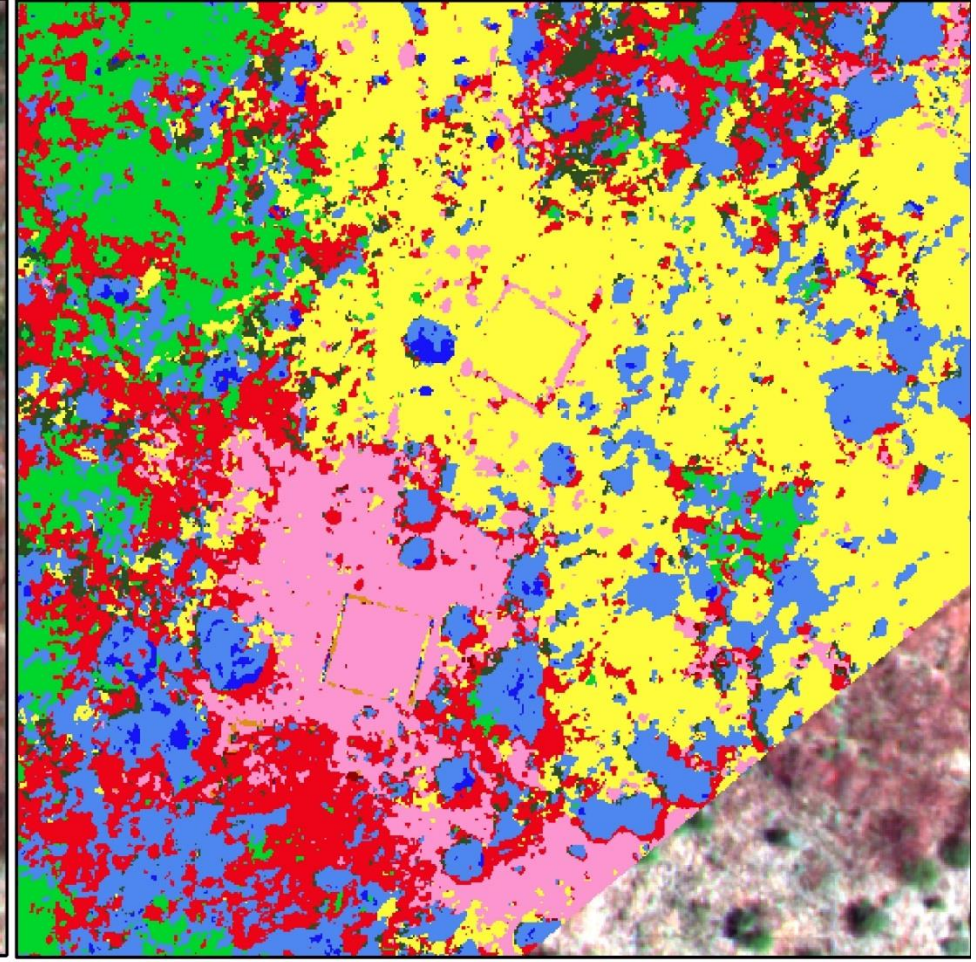
medusahead litter

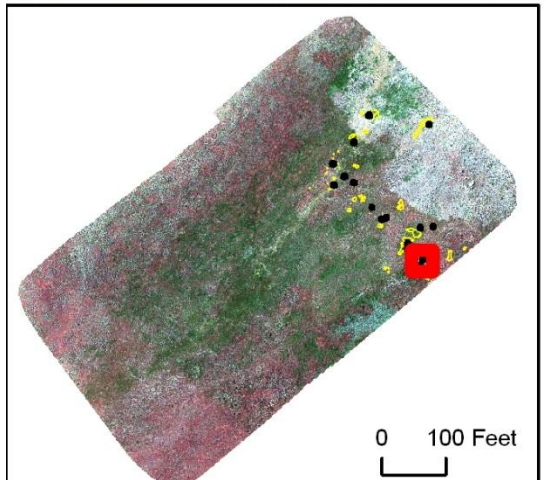
cheatgrass



medusahead







0 10 Feet

Cheatgrass

Medusahead

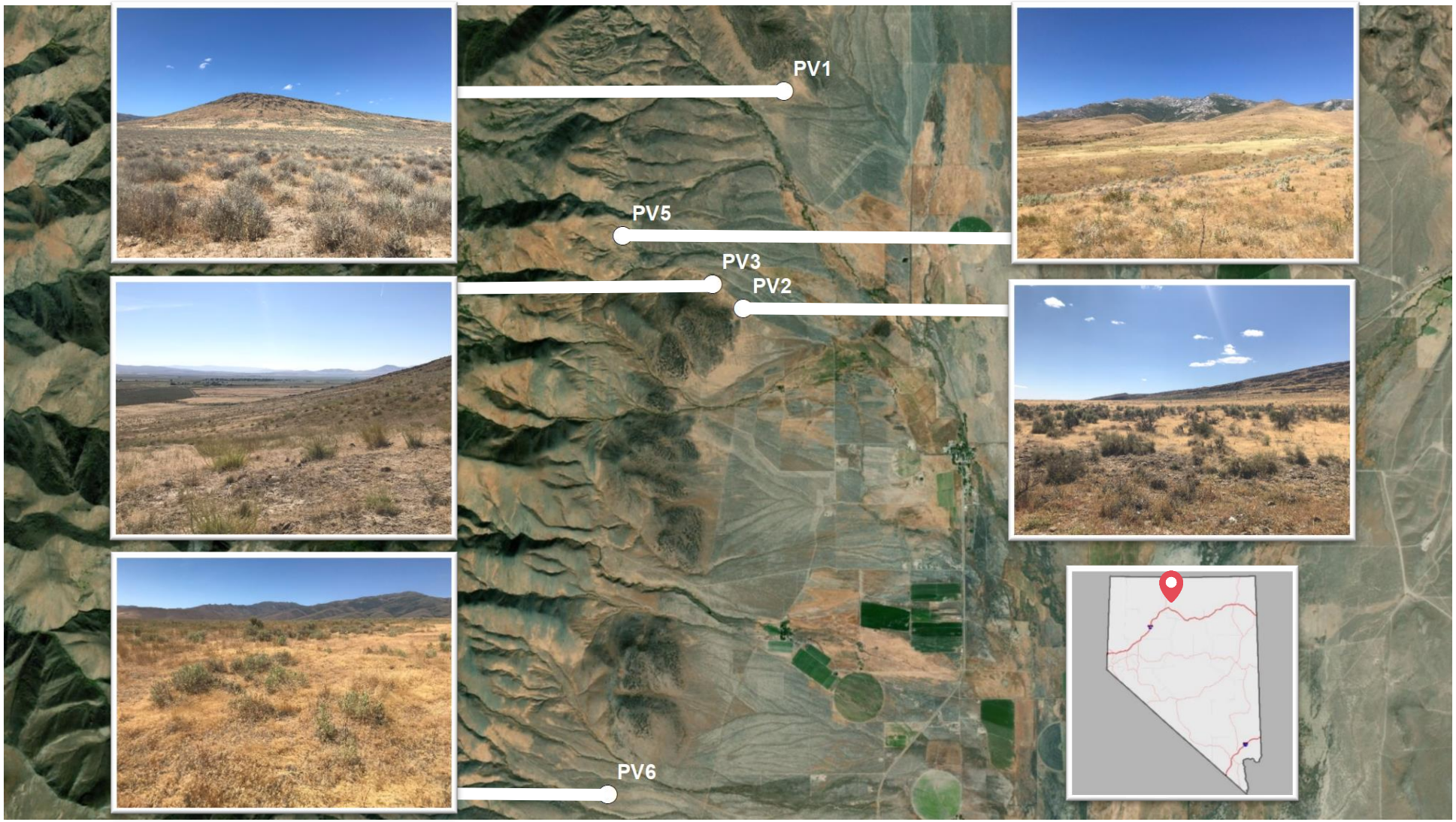
Perennial Forb

Shrub

Annual Forb

Crested Wheatgrass

Second Pilot Study: Paradise Valley study area



DATA COLLECTION

- Flight Dates
  - May 1st
  - June 4th
  - August 13th
- 1 cm Resolution
- 30 m Relative Altitude
- Overlap
  - 80% forward overlap and 60% side overlap
- 6 Ground Control Points

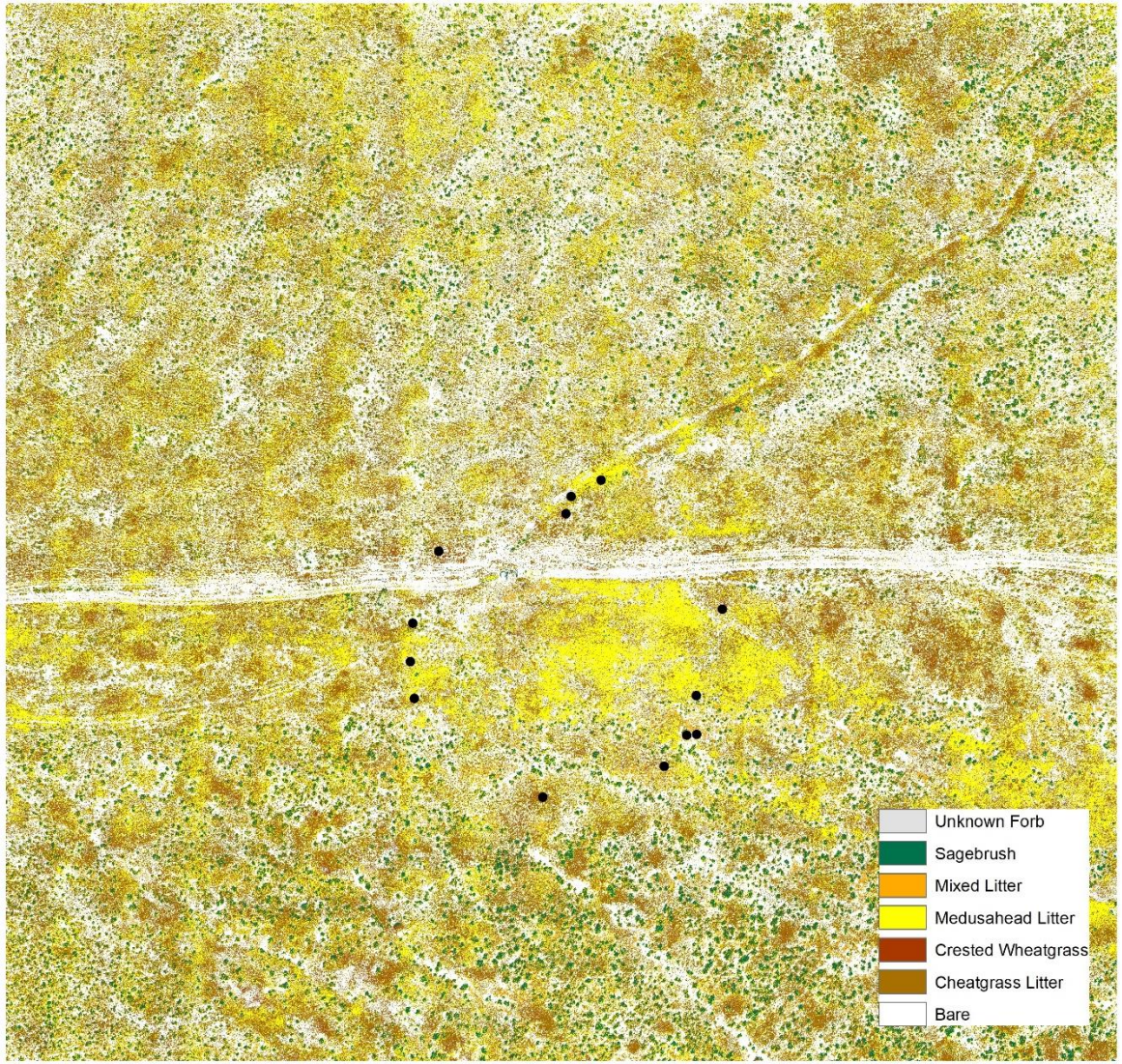
PV6 CLASSIFICATION

- Overall Accuracy: 0.72, Kappa = 0.63
- MD correctly predicted 79% of the time
- 82% of MD predictions are correct

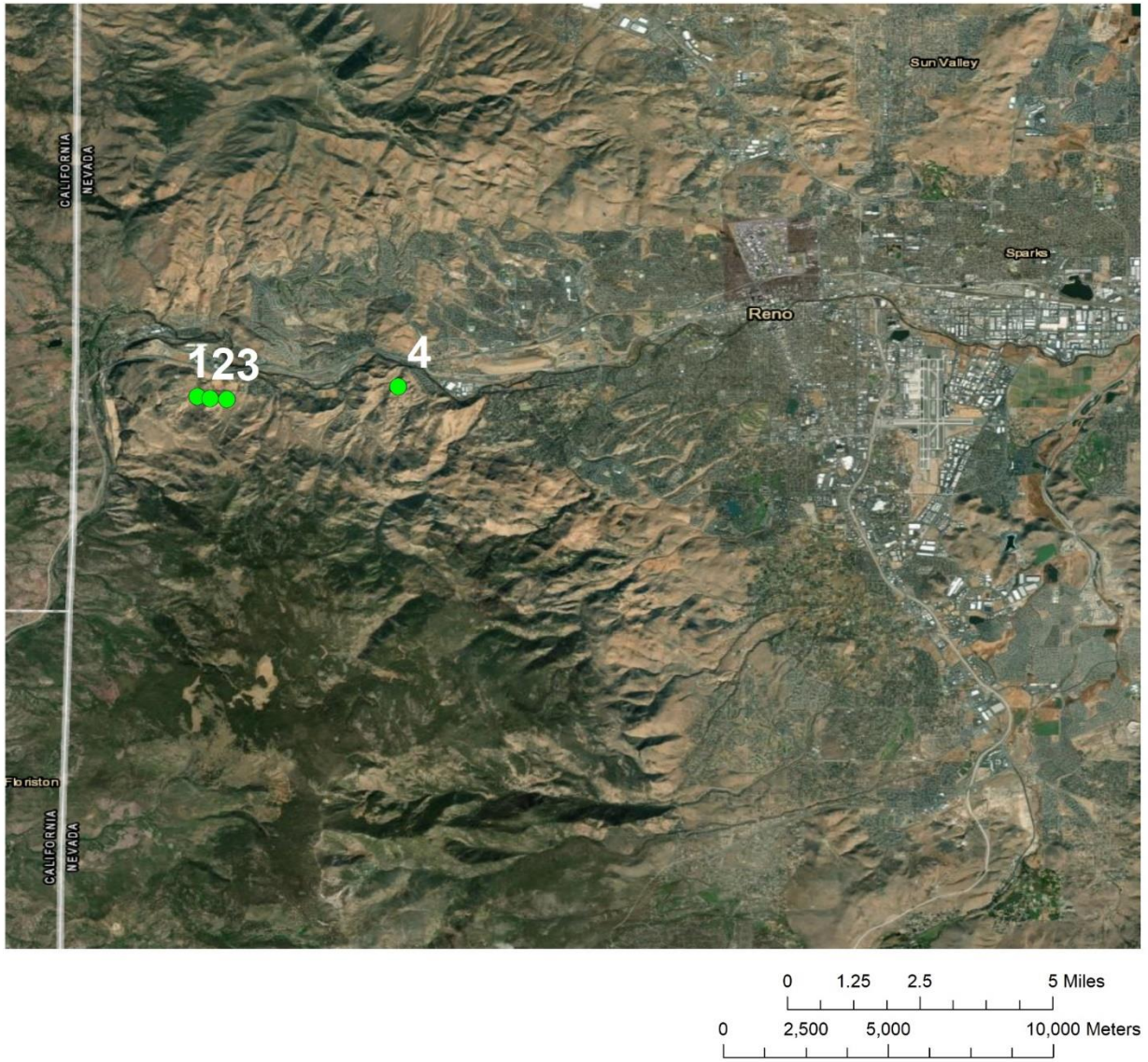
Actual Values

Predicted Values

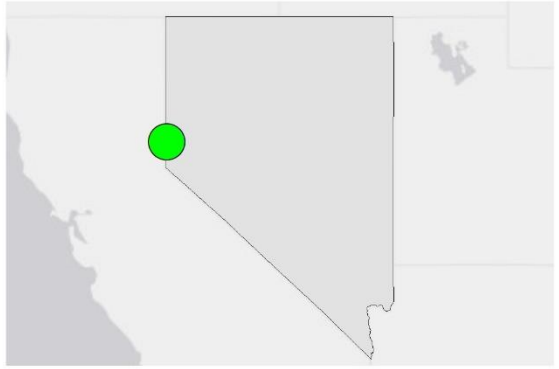
	Bare	Cheatgrass Litter	Crested Wheatgrass	Medusahead Litter	Mixed litter	Sagebrush	Unknown Forb
Bare	**2149**	255	25	133	30	105	31
Cheatgrass Litter	305	**1907**	51	230	9	13	113
Crested Wheatgrass	20	102	**147**	13	0	1	35
Medusahead Litter	124	279	0	**1981**	8	18	10
Mixed litter	102	50	0	65	**495**	4	4
Sagebrush	35	25	4	95	105	**218**	0
Unknown Forb	135	259	31	14	1	1	**263**



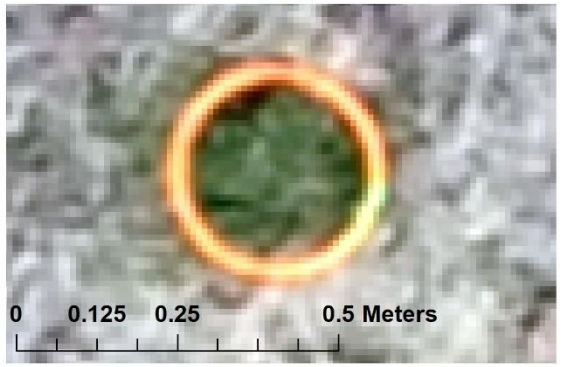
Third Pilot Study: Garson Road, west Reno



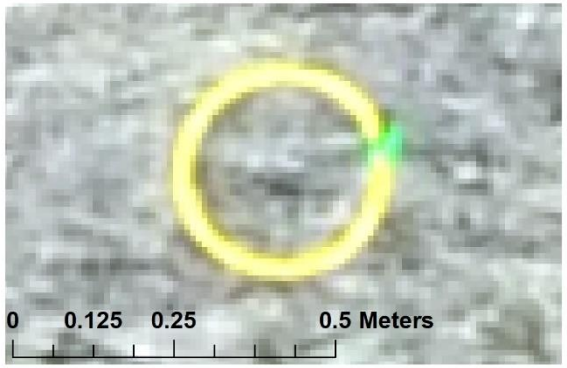
Study Site



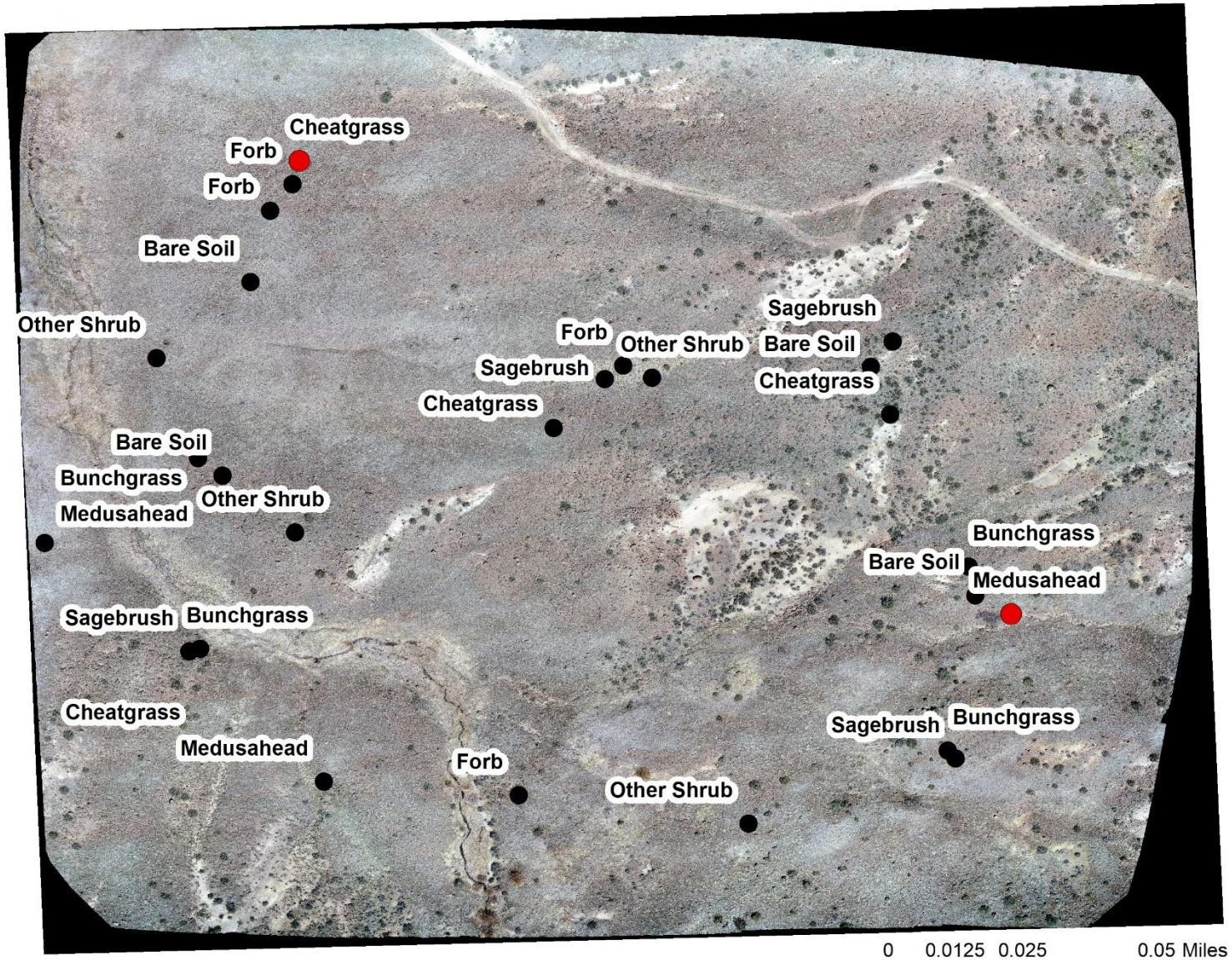
Cheatgrass



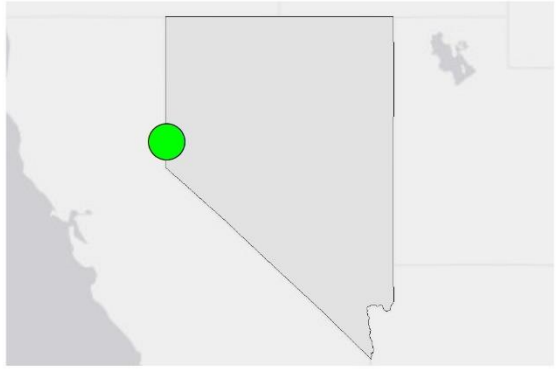
Medusahead



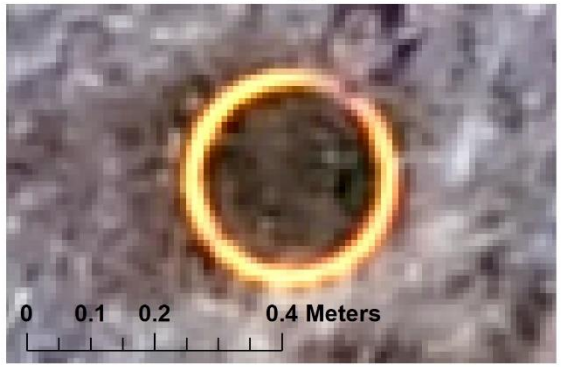
APRIL 2020



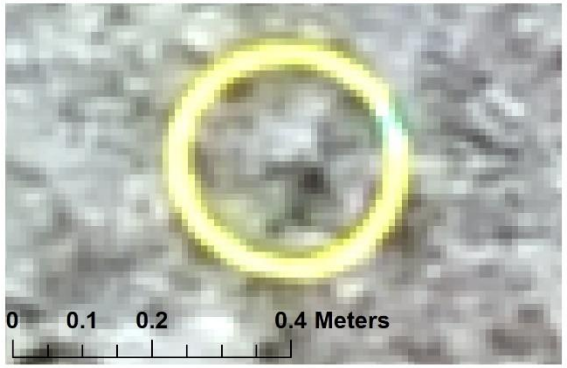
Study Site



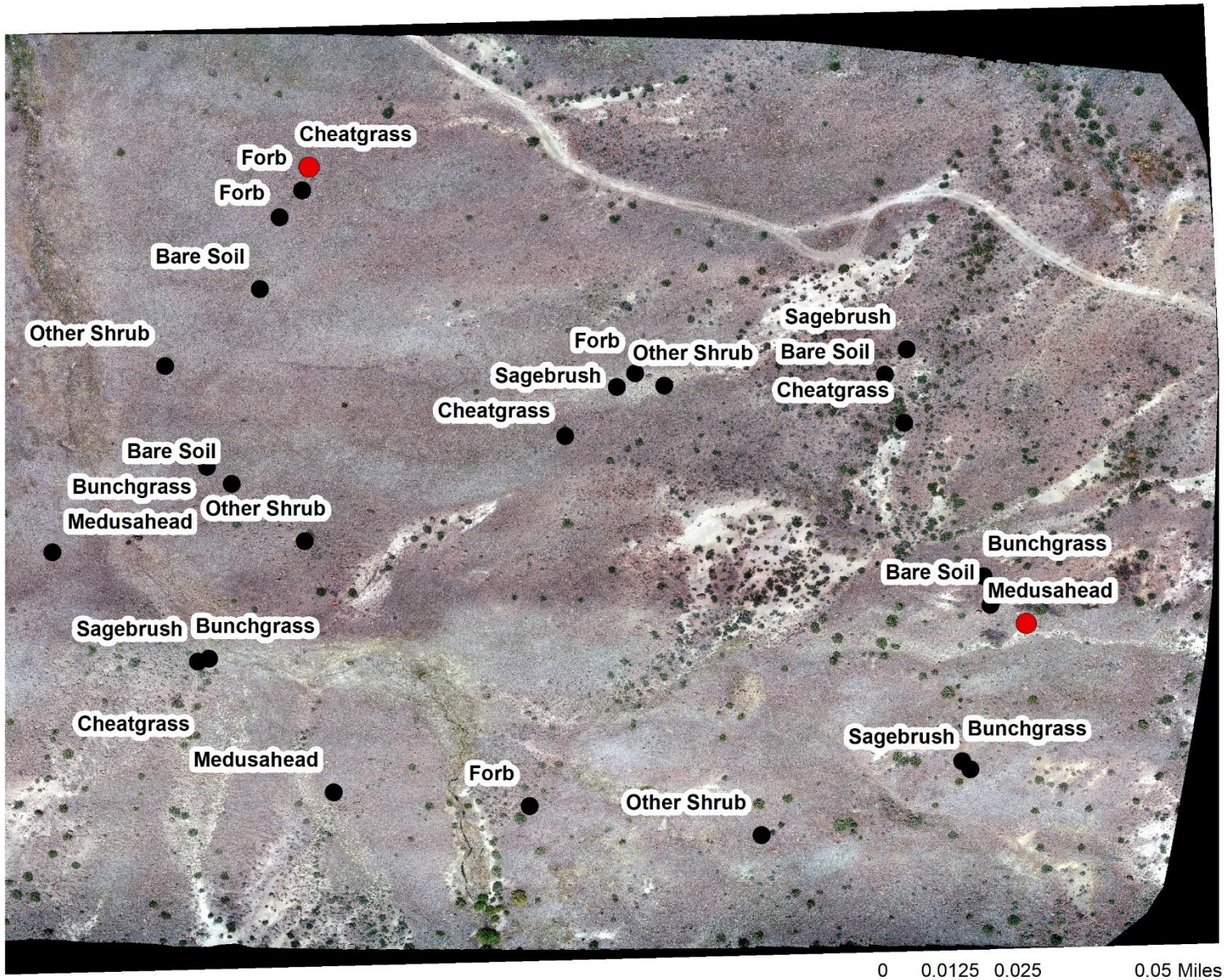
Cheatgrass



Medusahead

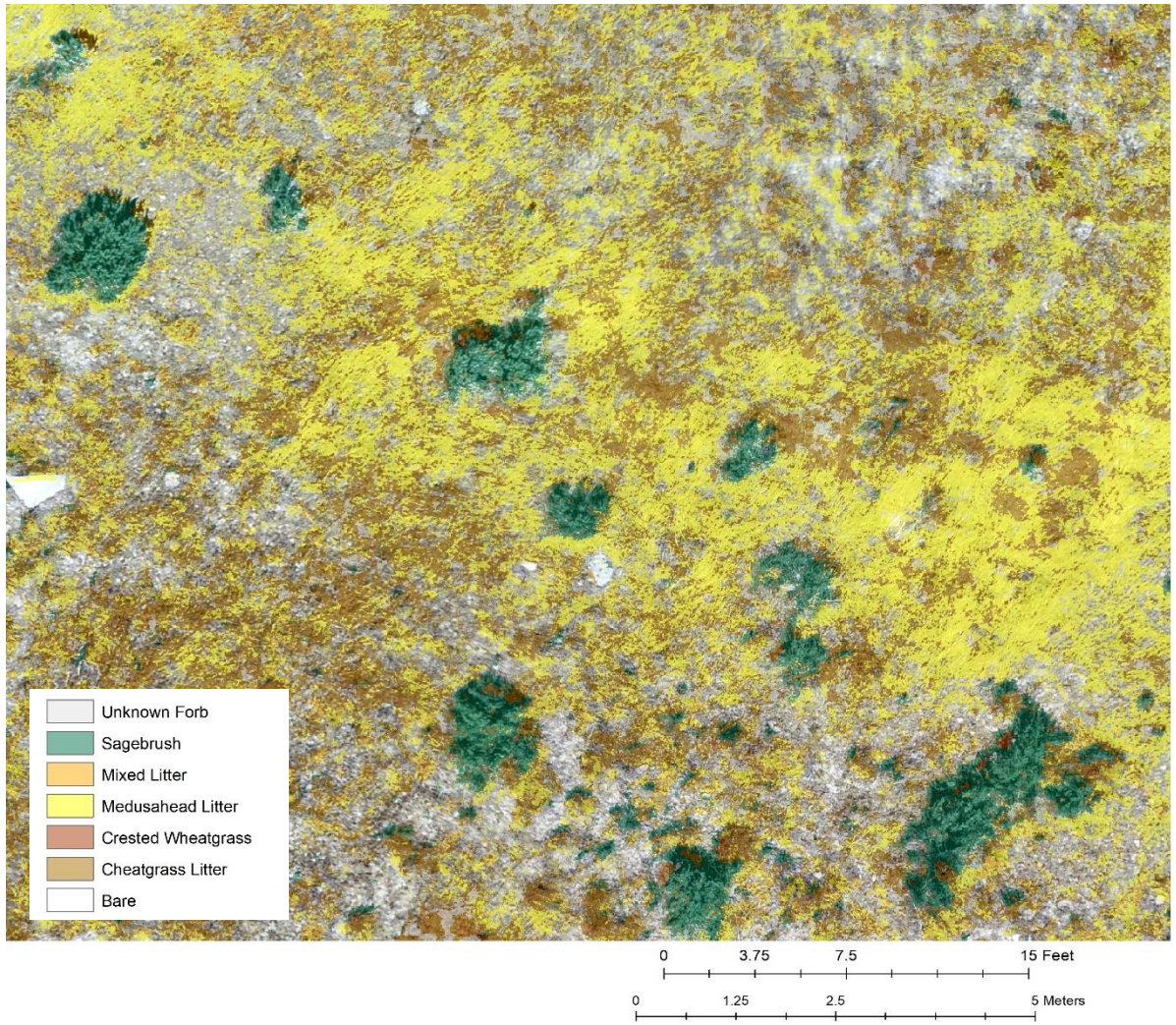


MAY 2020



APPLICATIONS: *Site-specific Classifications*

- Early detection of new invasions
- Monitoring of invasive spread and rate of change
- Target control efforts according to weed abundance, patch size, etc.
- Multi-species mapping and monitoring: can add classification of other plant species or vegetation types of special interest



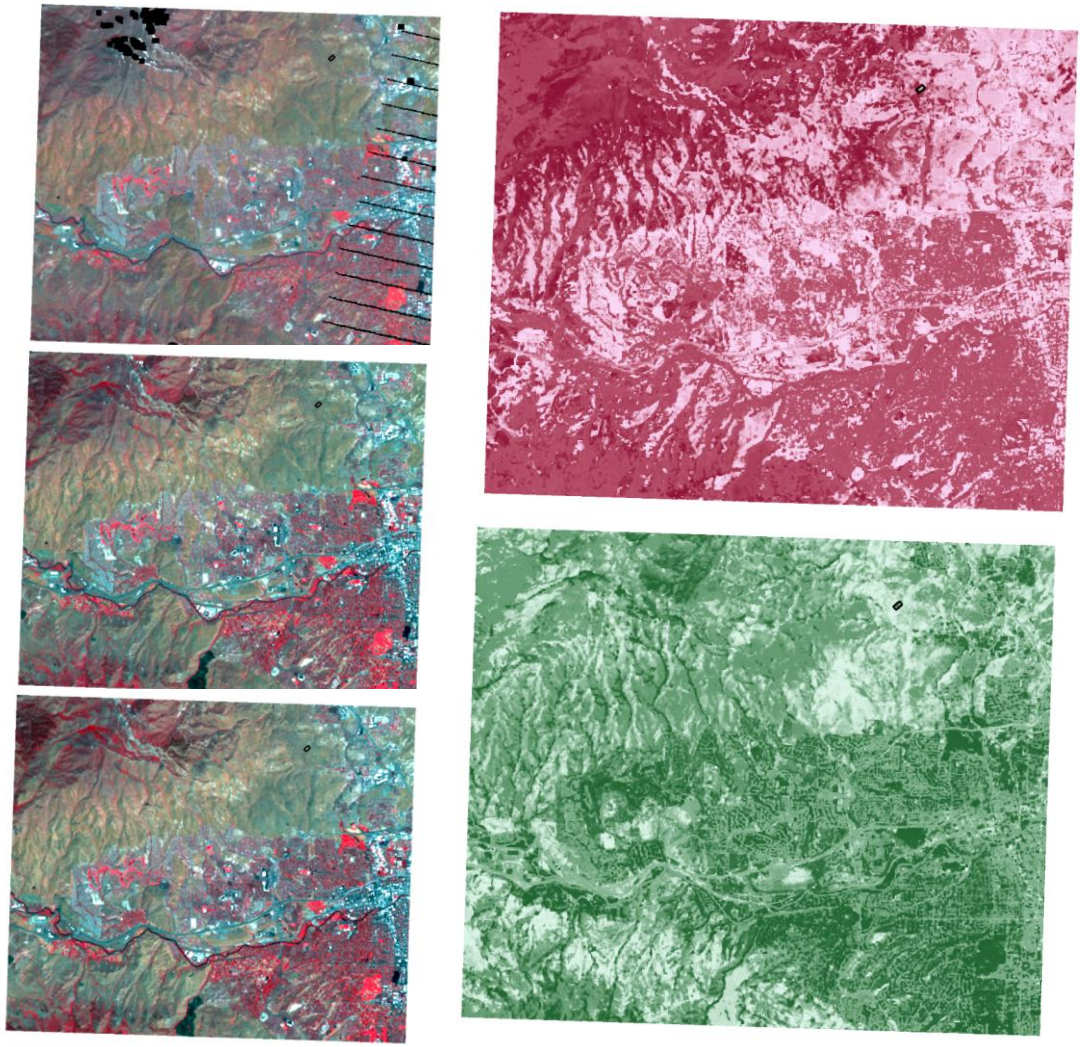
APPLICATIONS: *Effectiveness Monitoring*

- Consistent weed mapping over subsequent years provides a measure of management effectiveness

- Weed records provide a tool for prioritizing control efforts and resources

FUTURE DIRECTIONS

- Spatial modeling of areas at high risk for future invasion (species distribution models)
  - Target on-the-ground efforts to detect unknown invasion clusters
  - Prioritize areas for restoration following disturbance
- Scale from UAV to Moderate-Resolution satellite platform (e.g. Landsat, Sentinel).
  - Regional scale monitoring
  - Archival data to reconstruct past patterns of invasion



Questions? Discussion?

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