Estimating vegetation structure and composition using UAV-based imagery

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Significance

- Grasslands vegetation structure and composition drive major ecosystem dynamics but are being altered by anthropogenic disturbances.[1]
- Measuring changes in vegetation allows land managers to understand consequences of change.[1]
- Unmanned Aerial vehicles (UAVs) may be able to help us scale up field-based measurements.[2]

Aims

- Test ability of UAV-based imagery to predict vegetation cover and height in low stature, low productivity grasslands.
- Determine important variables for predictions.
- Assess model performance across a range of grassland types.

Study site

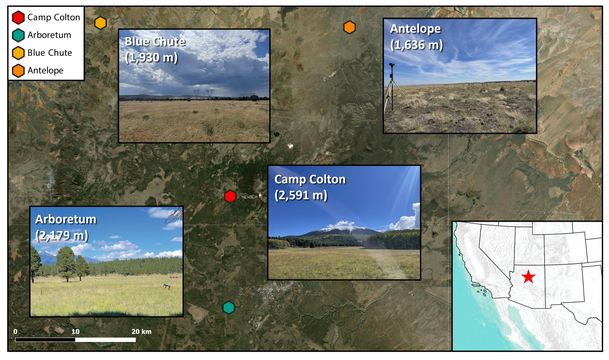

Figure 1. Study sites selected across an elevational gradient in Northern Arizona. Sites are a part of a larger USGS long term study.

References & Acknowledgments

[1]Bardgett, R. D., J. M. Bullock, S. Lavorel, P. Manning, U. Schaffner, N. Ostle, M. Chomel, G. Durigan, E. L. Fry, D. Johnson, J. M. Lavallee, G. Le Provost, S. Luo, K. Png, M. Sankaran, X. Hou, H. Zhou, L. Ma, W. Ren, X. Li, Y. Ding, Y. Li, and H. Shi. 2021. Combatting global grassland degradation. Nature Reviews Earth & Environment 2:720–735.
[2]Alvarez-Vanhard, E., T. Corpetti, and T. Houet. 2021. UAV & satellite synergies for optical remote sensing applications: A literature review. Science of Remote Sensing 3:100019.

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Results

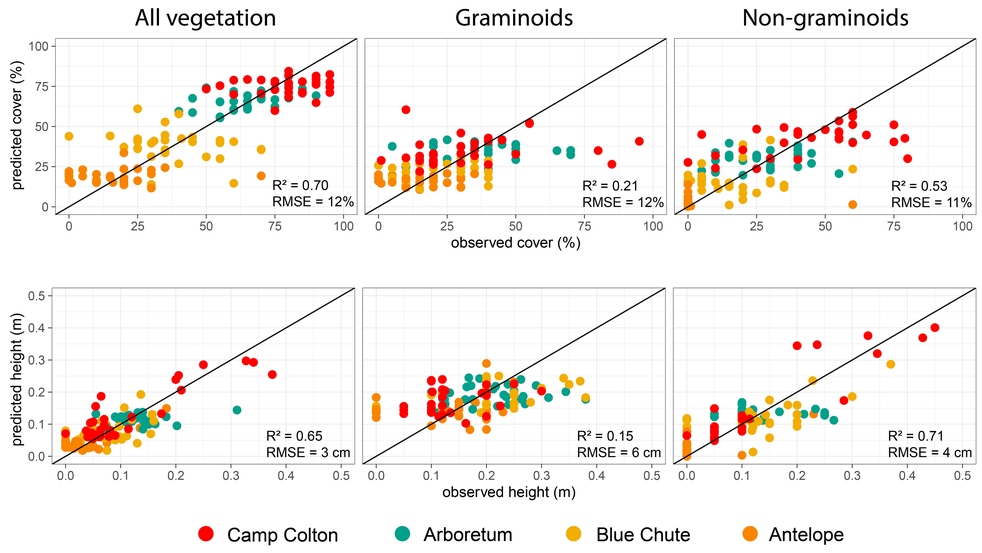

Figure 3. LOOCV predictions vs. observations for vegetation cover and height.

UAV-based products can accurately quantify overall vegetation cover and height.

Spectral data is most important for vegetation cover.

Structural data is most important for vegetation height.

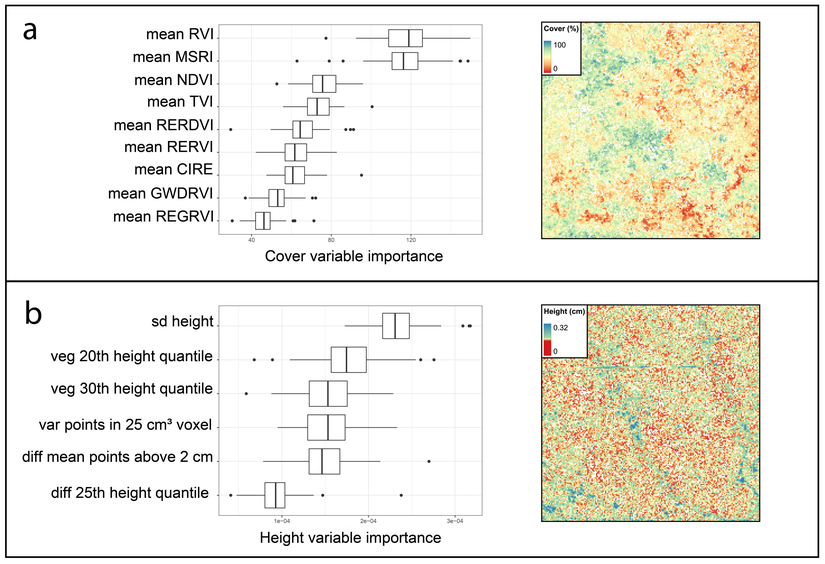

Figure 4. Top percentile of variable importance for (a) all vegetation cover (90th) and (b) all vegetation height (99th). Imagery show examples of predicted vegetation characteristics across a 1 ha UAV survey at the AR site.

Methods

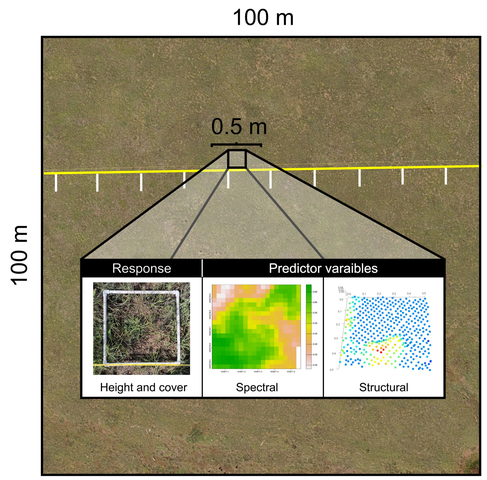

Figure 2. Sampling strategy for UAV survey areas (3/site).

Data collection

- Vegetation cover and height for all vegetation, graminoids, and non-graminoids were measured in ten 0.25 m^2 quadrats along a 100 m transect (n = 30 plots/site; Fig. 2).
- DJI Phantom 4 Multispectral UAV captured imagery at 60 m altitude over three 1 ha plots at each site.

Variable creation and modeling

- Orthomosaics and structure from motion point clouds were used to extract 105 spectral and 236 structural variables, respectively.
- Implemented Leave-One-Out Cross Validation (LOOCV) of random forest regression models to assess error rates and variable importance (Fig. 3 &4).

Next steps

- Apply alternative classification techniques (e.g., CNNs, random forests, KNNs) to improve classification of plant functional type composition.
- Different grassland types should be tested with similar methodologies.
- Drone-based imagery of vegetation characteristics and satellite imagery could be used to scale to the regional or national level.