Untangling the Interactions Between Rural Outmigration, Grassland Degradation, and Sustainable Land Use in Mongolia

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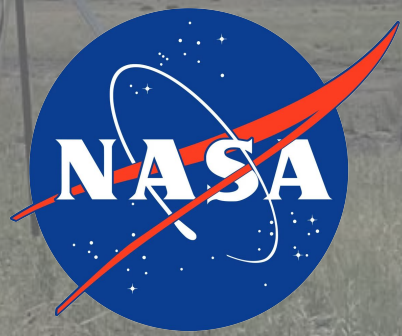

Team Members

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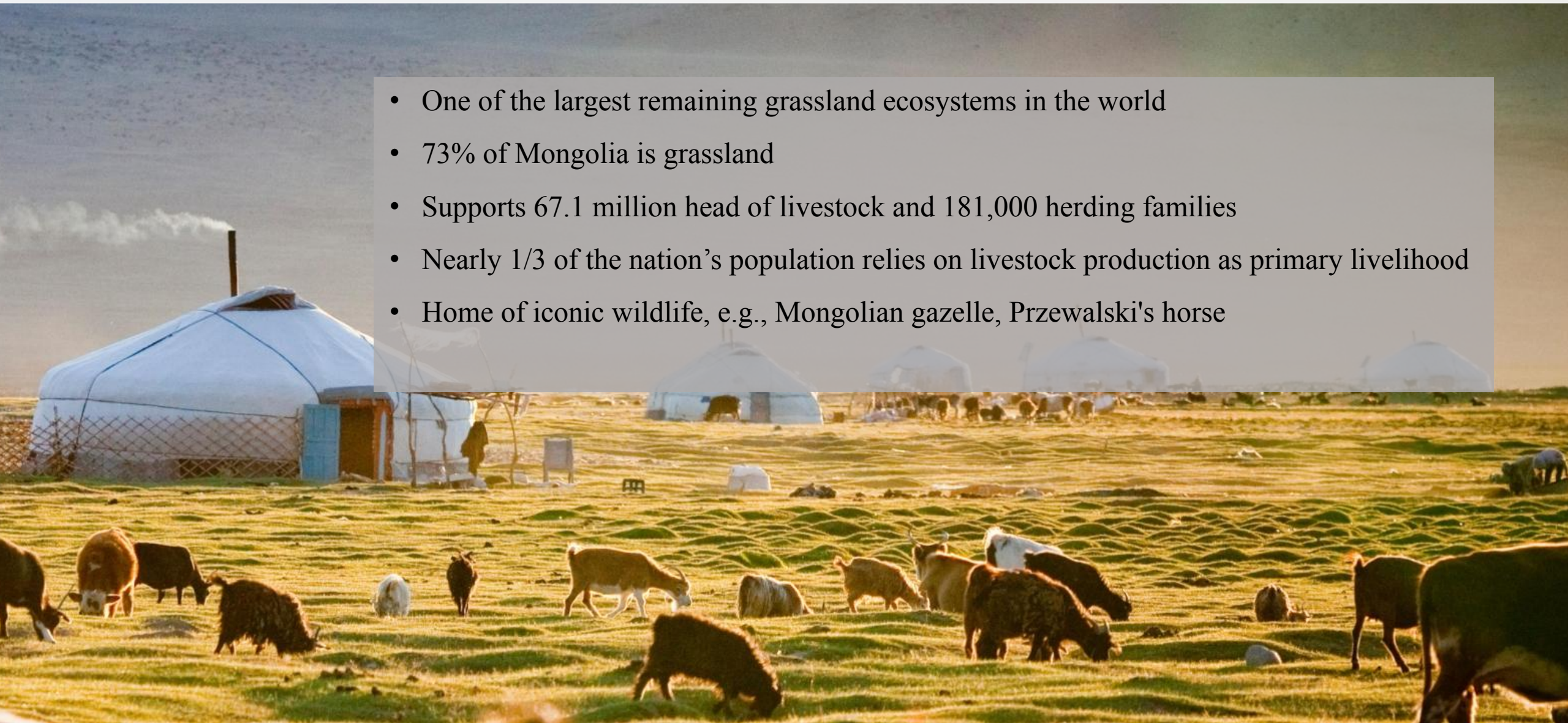
Ecosystem services of grassland system

- Covers expansive terrestrial land
- Performs many critical ecosystem services
- Supports high biodiversity and human livelihoods
- Plays a crucial role in climate feedback

Mongolian grassland system



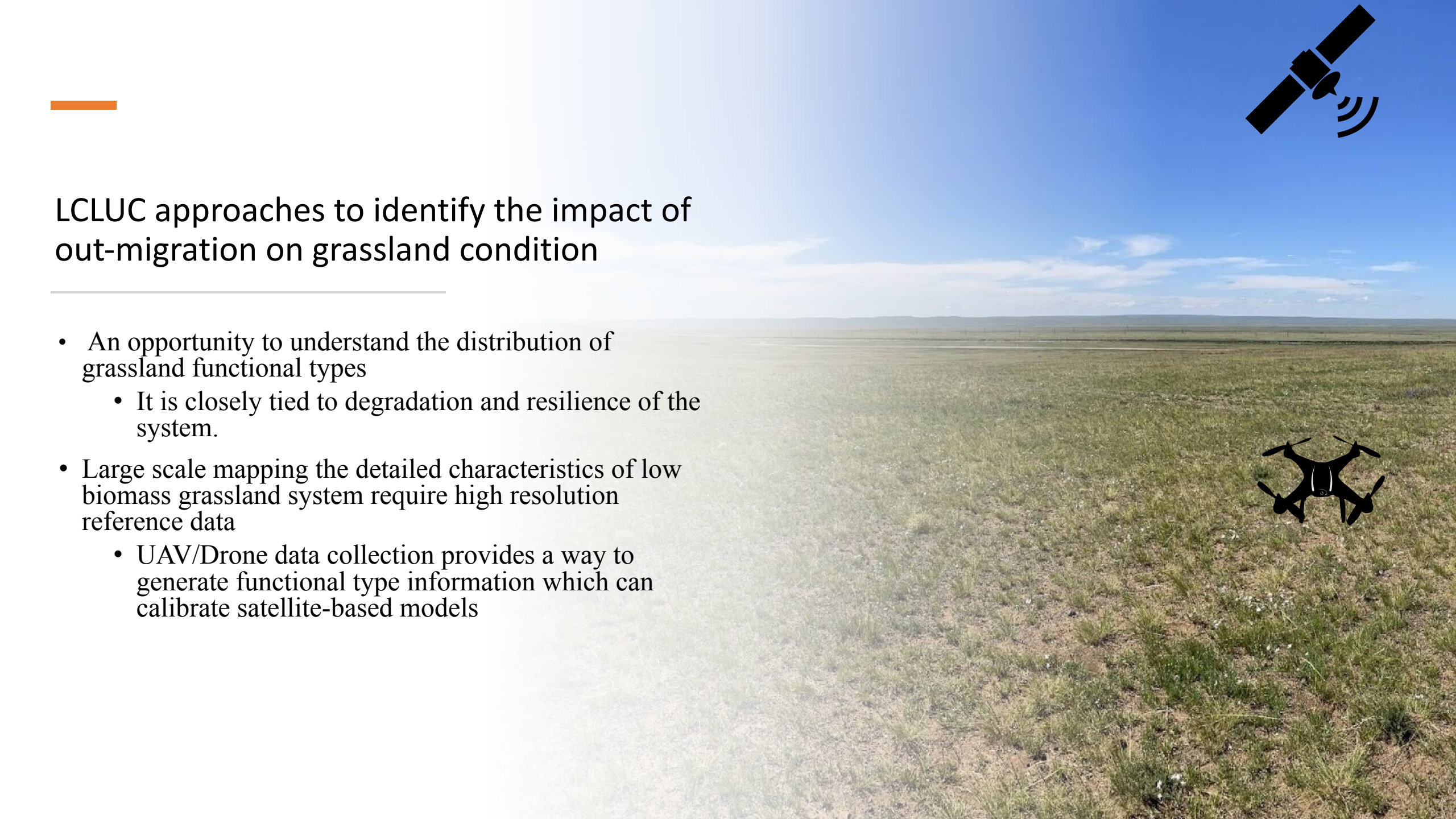
- One of the largest remaining grassland ecosystems in the world
- 73% of Mongolia is grassland
- Supports 67.1 million head of livestock and 181,000 herding families
- Nearly 1/3 of the nation’s population relies on livestock production as primary livelihood
- Home of iconic wildlife, e.g., Mongolian gazelle, Przewalski's horse

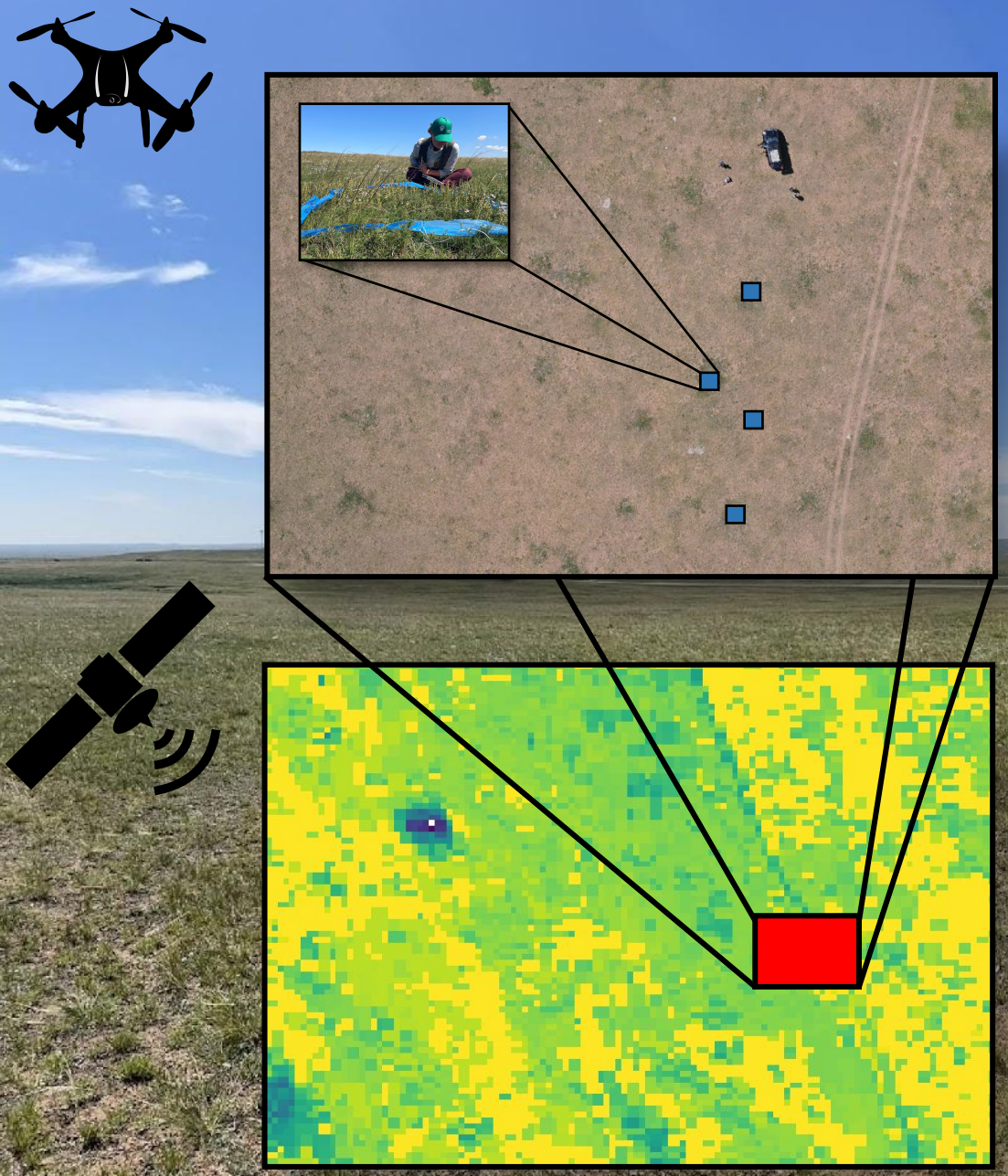
Changes in Herding and Family Structure in Mongolia

- The government-sponsored nomadic support system was abandoned
  - Decline in water wells
  - Less support in transportation, winter shelter, supplemental feed
- Extreme climate events threaten livestock husbandry
- Many herding families move to the capital Ulaanbaatar to seek non-herding jobs and to access better education and healthcare

LCLUC approaches to identify the impact of out-migration on grassland condition

- An opportunity to understand the distribution of grassland functional types
  - It is closely tied to degradation and resilience of the system.
- Large scale mapping the detailed characteristics of low biomass grassland system require high resolution reference data
  - UAV/Drone data collection provides a way to generate functional type information which can calibrate satellite-based models





Hypothesis:

- Declining rural population in Mongolia is

leading to changes in traditional livestock management practices, resulting in heterogeneous degradation in grassland cover and resilience and narrowing options for sustainable livelihood at the household level.

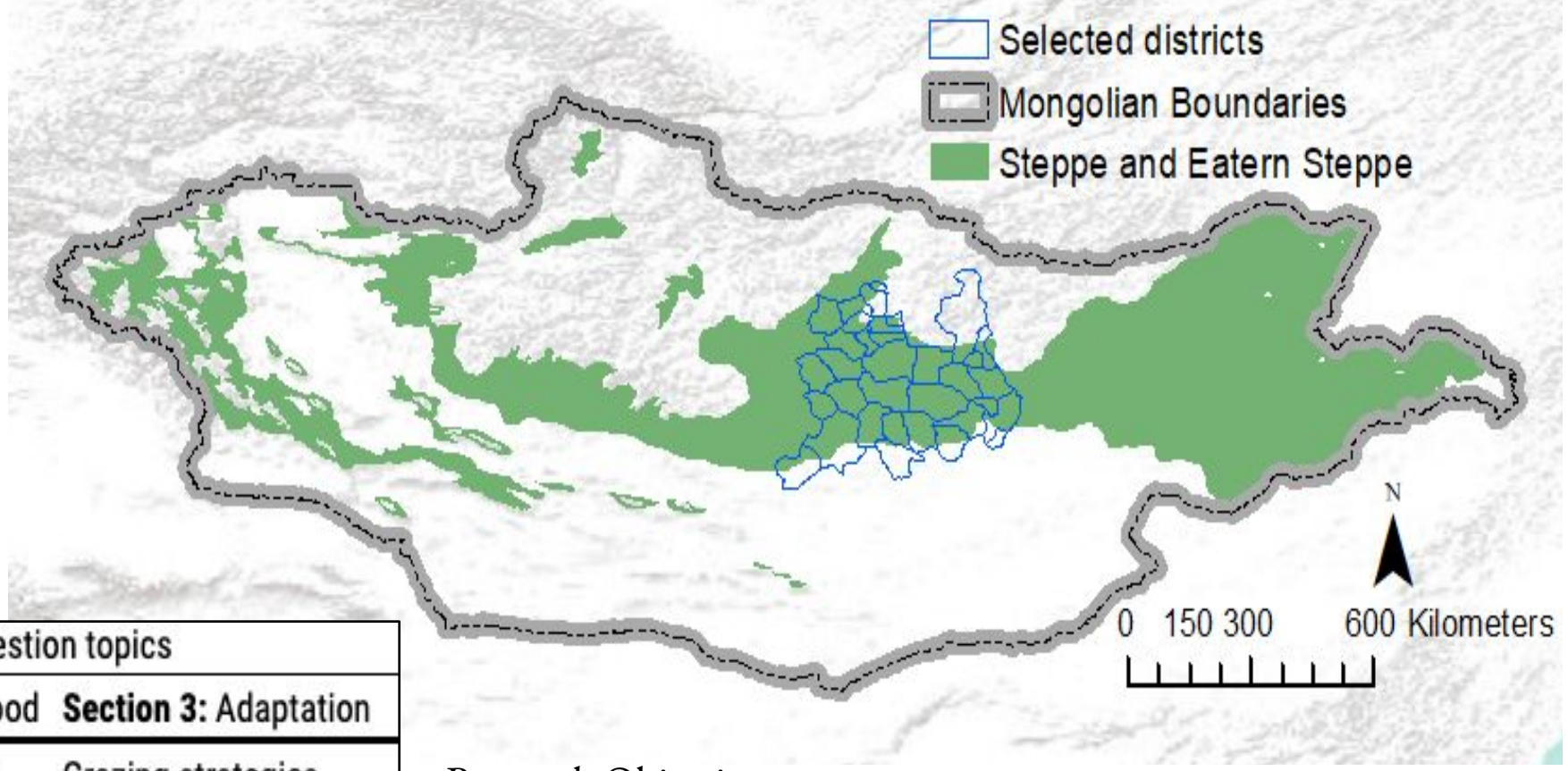


Table 1. Survey form themes and example question topics		
Section 1: Demographics	**Section 2:** Livelihood	**Section 3:** Adaptation
Household size	Herd composition	Grazing strategies
Ages	Herd management	Seasonal migration frq
Family members living elsewhere	Pasture tenure	Distances migrated/yr
	Alternative income	Fodder expenditures
	Remittances	Insurance expenditures
Section 4: Participatory Mapping		

Study area and general design of survey questions. The top figure shows the extent of Steppe and Eastern Steppe ecoregions and 32 focal districts in Tuv, Dundgovi, and Govisumber provinces.

Research Objectives

- Develop methods to leverage UAV data to calibrate Landsat- and Sentinel-based estimate of vegetation functional type, cover and resilience in Mongolian steppes?
- Understand the rural out-migration's impact on the spatial and temporal use of grasslands by livestock?

Project progress

Aug. 2022

Initial visit in Mongolia:

test drone data collection and meet with local partners

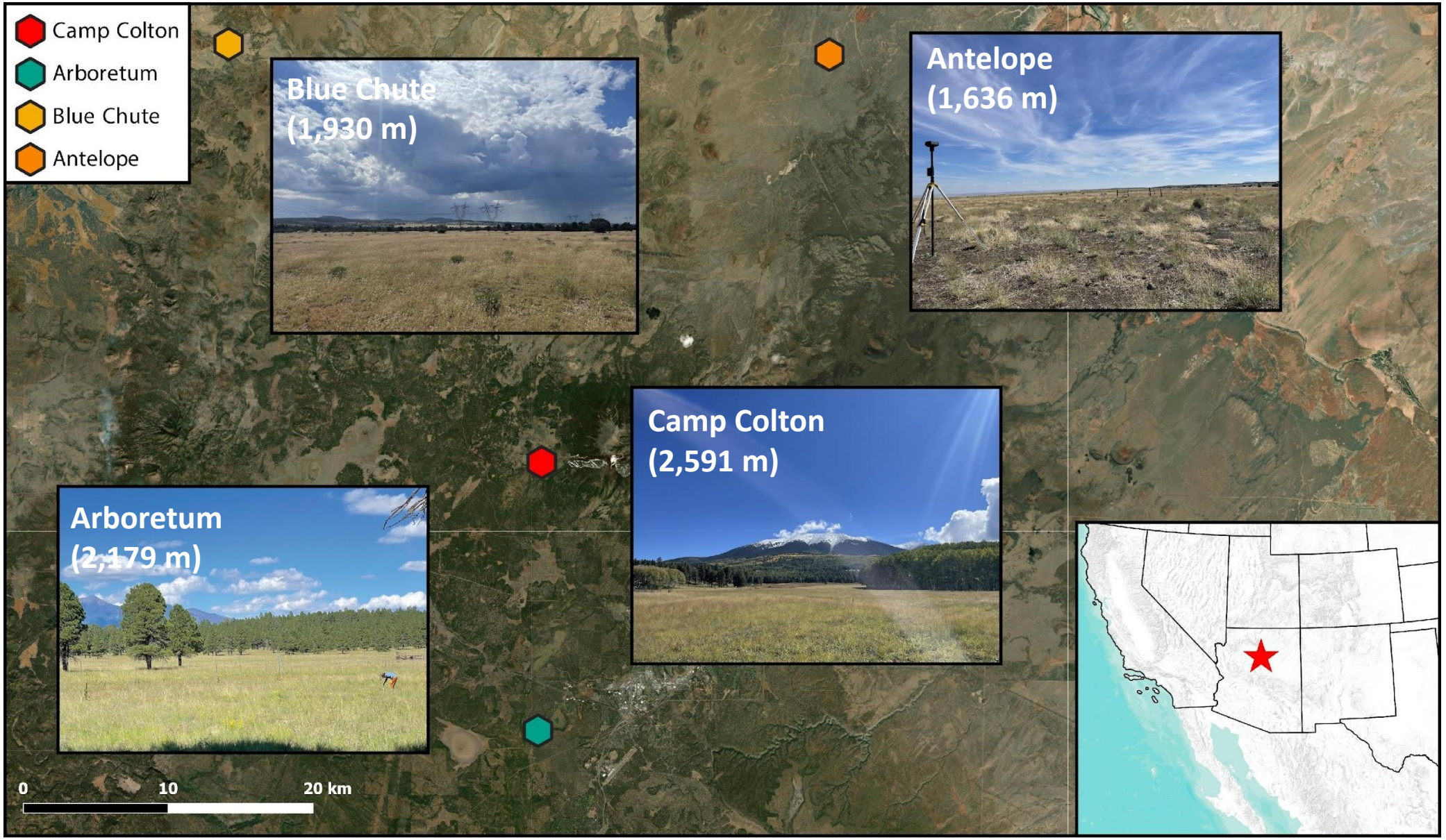
Currently

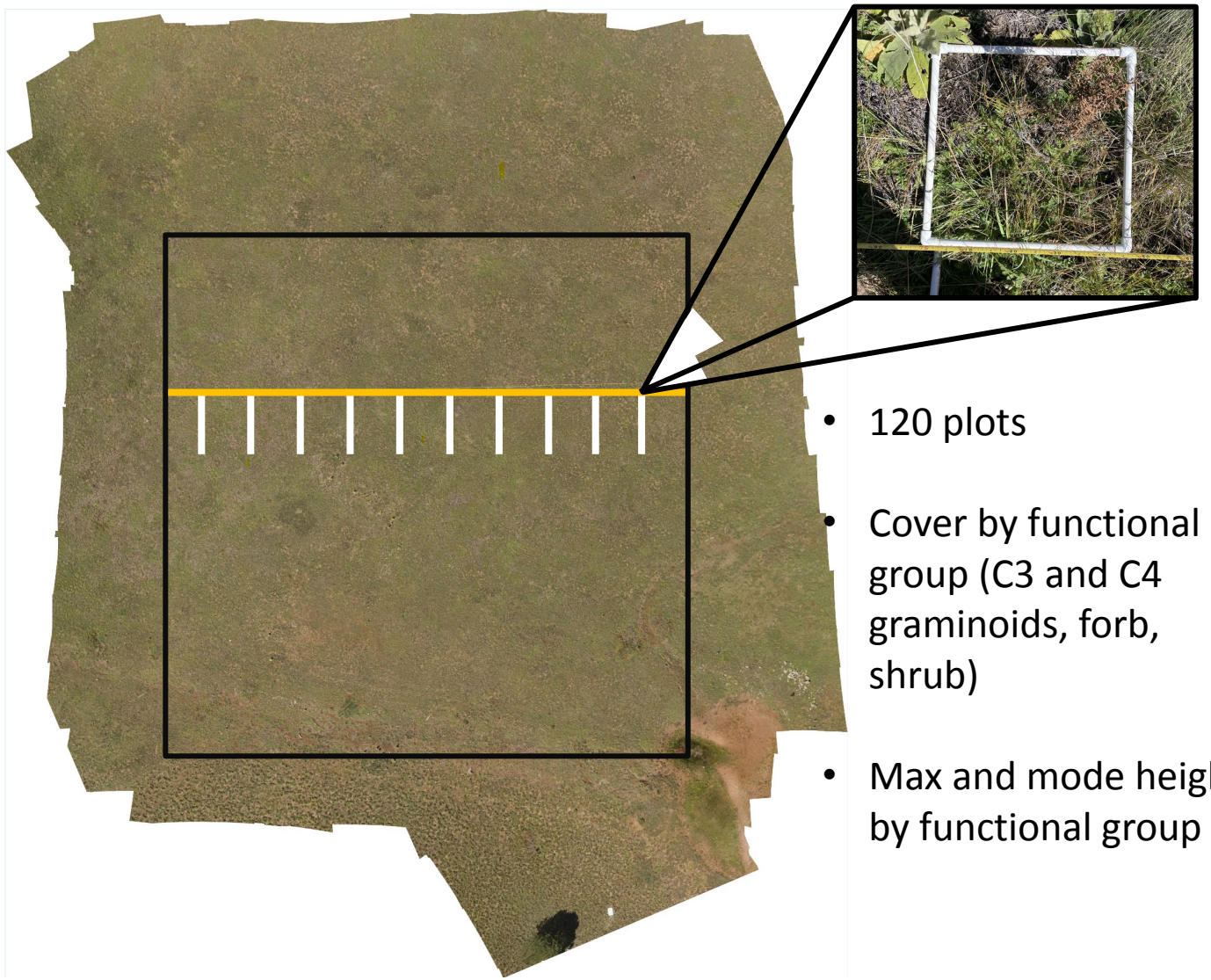
Processing drone data: determine the optimal flight and data processing protocol

Drone survey and ground truth in Arizona:

Test drive the drone sampling and image processing method

Sep. 2022


Camp Colton
Arboretum
Blue Chute
Antelope
Blue Chute
(1,930 m)
Antelope
(1,636 m)
Camp Colton
(2,591 m)
Arboretum
(2,179 m)
0
10
20 km



Field Data

- 120 plots
- Cover by functional group (C3 and C4 graminoids, forb, shrub)
- Max and mode height by functional group

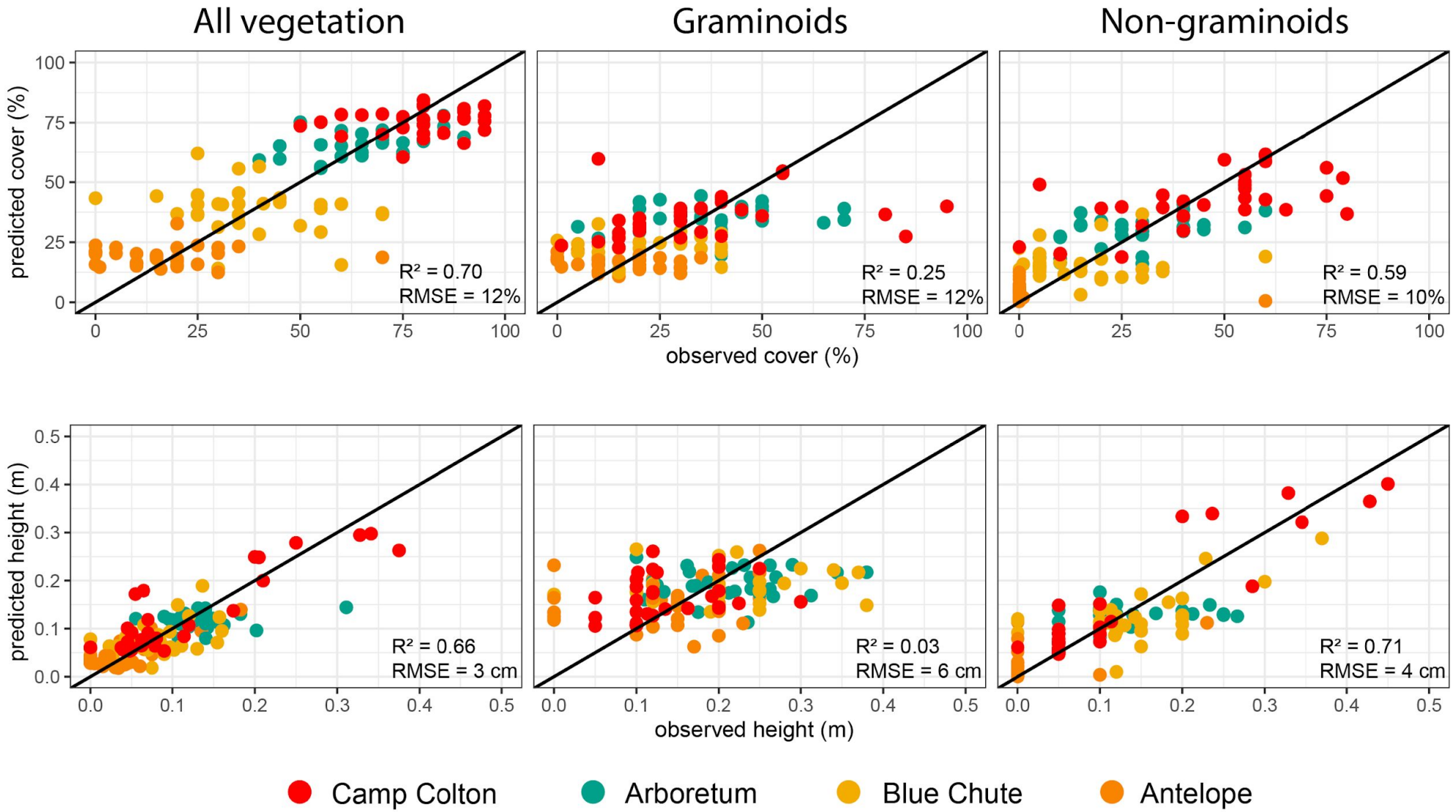
Height Data

- Percentile heights
- Height statistics (e.g., max, mean, sd)
- Voxel metrics
- 133 predictors

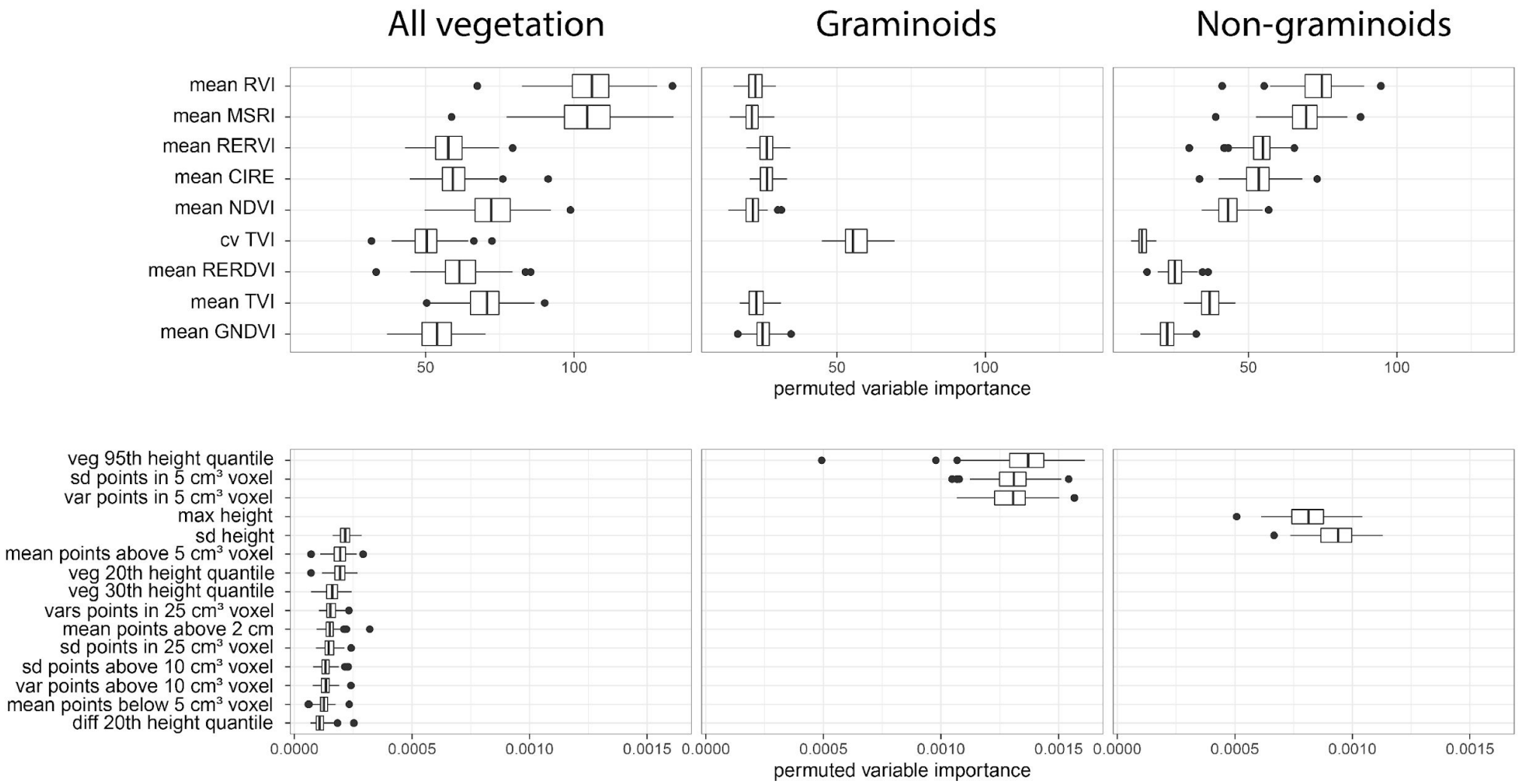
Spectral Data

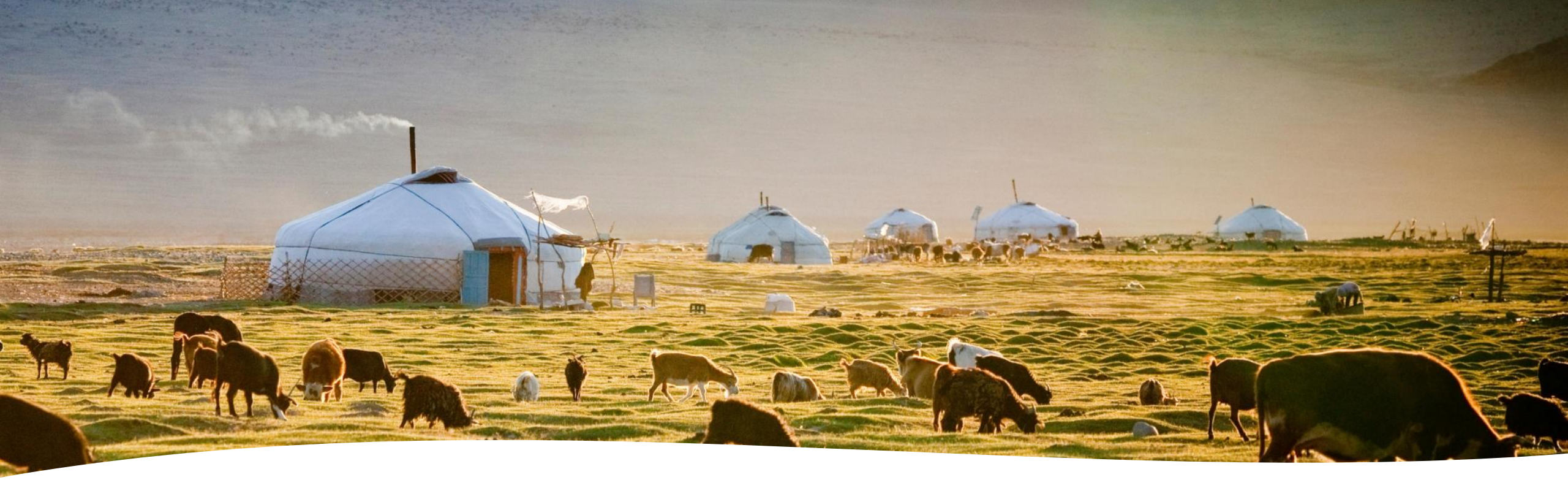
- RGB bands
- Mean and standard deviation of 6 vegetation indices
- 12 predictors

UAV-based products can provide overall vegetation height and cover



Spectral variables most important for cover estimate while structural variable are most important for height estimate





Next step

- Functional type mapping using drone image
- Planed drone survey this summer in Mongolia
- Household survey later this year in Mongolia
- Utilize drone derived products to calibrate mid-resolution satellite-based models

Estimating vegetation structure and composition using UAV-based imagery

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Montana State University, Office of Research and Economic Development[3]
Proposal: Untangling the Interactions Between Rural Outmigration, Grassland Degradation, and Sustainable Land Use in Mongolia (Grant #:80NSSC22K0468)

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 these measurements[2]

Aims

- Use UAV-based imagery to predict vegetation cover and height
- Determine important variables for predictions
- Assess model performance across a range of grassland types

Study site

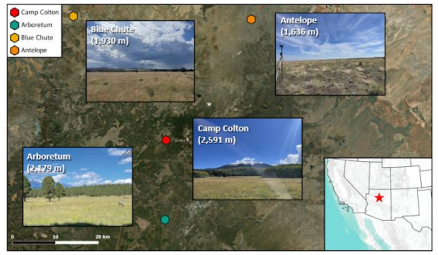

Figure 1. Study sites selected across an elevational gradient in Northern Arizona. Sites are a part of a larger USGS long term study.

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

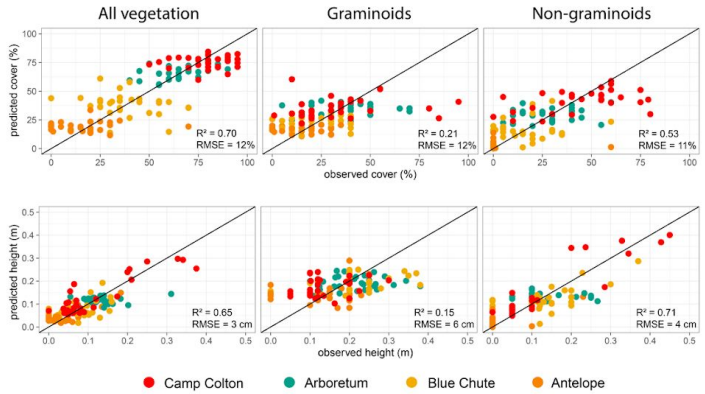

Figure 3. LOOCV predictions vs. observations for vegetation cover and height.

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

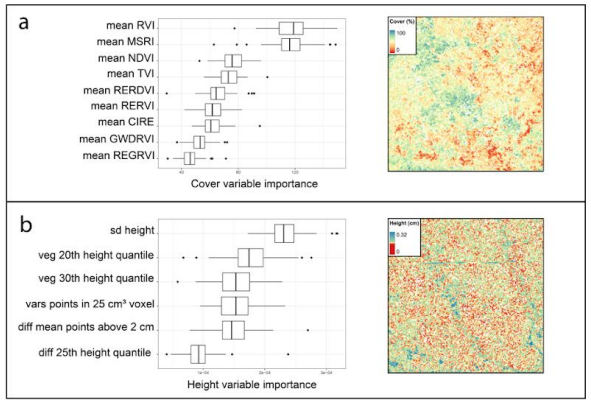

Figure 4. Top percentile of variable importance for (a) all vegetation cover (90th) and (b) all vegetation height (99th). **Most important predictors for cover only included spectral variables while the most important height predictors only included structural variables**. Examples of predicted vegetation characteristics also shown.

Methods

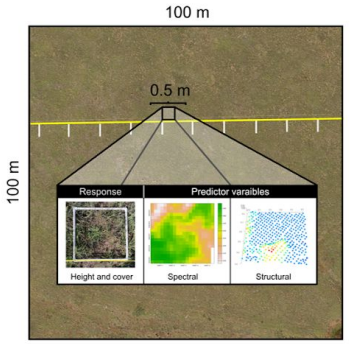

Figure 2. Three 1 ha areas were surveyed at each site. Ten plots (0.25 m^2) were surveyed across a transect (N=120).

Data collection

- Vegetation cover and height were measured for all vegetation, graminoids, and non-graminoids (Fig. 2)
- DJI Phantom 4 Multispectral UAV captured imagery at 60 m altitude

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

- Classification techniques (e.g., CNNs, random forests, KNNs) may provide a more accurate representation 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

Poster 1-11
Tuesday
5:00-7:00 pm

Ryan Blackburn,
Smithsonian National Zoo & Conservation Biology Institute

Thank you

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