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Modeling fine-scale forage species distributions to inform ungulate nutrition

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Predicting fine-scale forage distribution to inform ungulate nutrition

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ABSTRACT

The quantity and nutritional quality of forage are key drivers for ungulate populations, including mule deer (*Odocoileus hemionus*) and Rocky Mountain elk (*Cervus elaphus nelsoni*), in the western U.S., but current vegetation maps are too coarse spatially and temporally to effectively characterize fine-scale habitat. To address some of these gaps, we tested a novel approach using existing vegetation surveys, maps, and remotely sensed data to develop fine-scale forage species distribution models (SDMs) across Idaho, USA. We modelled 20 forage species that are suitable for mule deer and Rocky Mountain elk. Climatic, topographic, soil, vegetation, and disturbance variables were attributed to approximately 44.3 million habitat patches generated using multi-scale object-oriented image analysis. Lasso logistic regression was implemented to produce predictive SDMs. We evaluated if the

Background

- Decline in forage availability and nutritional quality → decline in ungulate populations (wild and domestic)
- Biotic and abiotic factors influence distribution and quality of forage
- Environmental factors used in SDMs to predict forage occurrence
- Few fine-scale vegetation assessments are applied across large extents

Research objectives

- Objectives
  1. Predict fine-scale forage species occurrence across Idaho
     - 20 species that are suitable forage for mule deer and Rocky Mountain elk
  2. Determine if indirect environmental variables improved model performance
     - Minimum precipitation, tree cover, fire frequency, etc. = direct influence
     - Elevation, aspect, etc. = indirect influence

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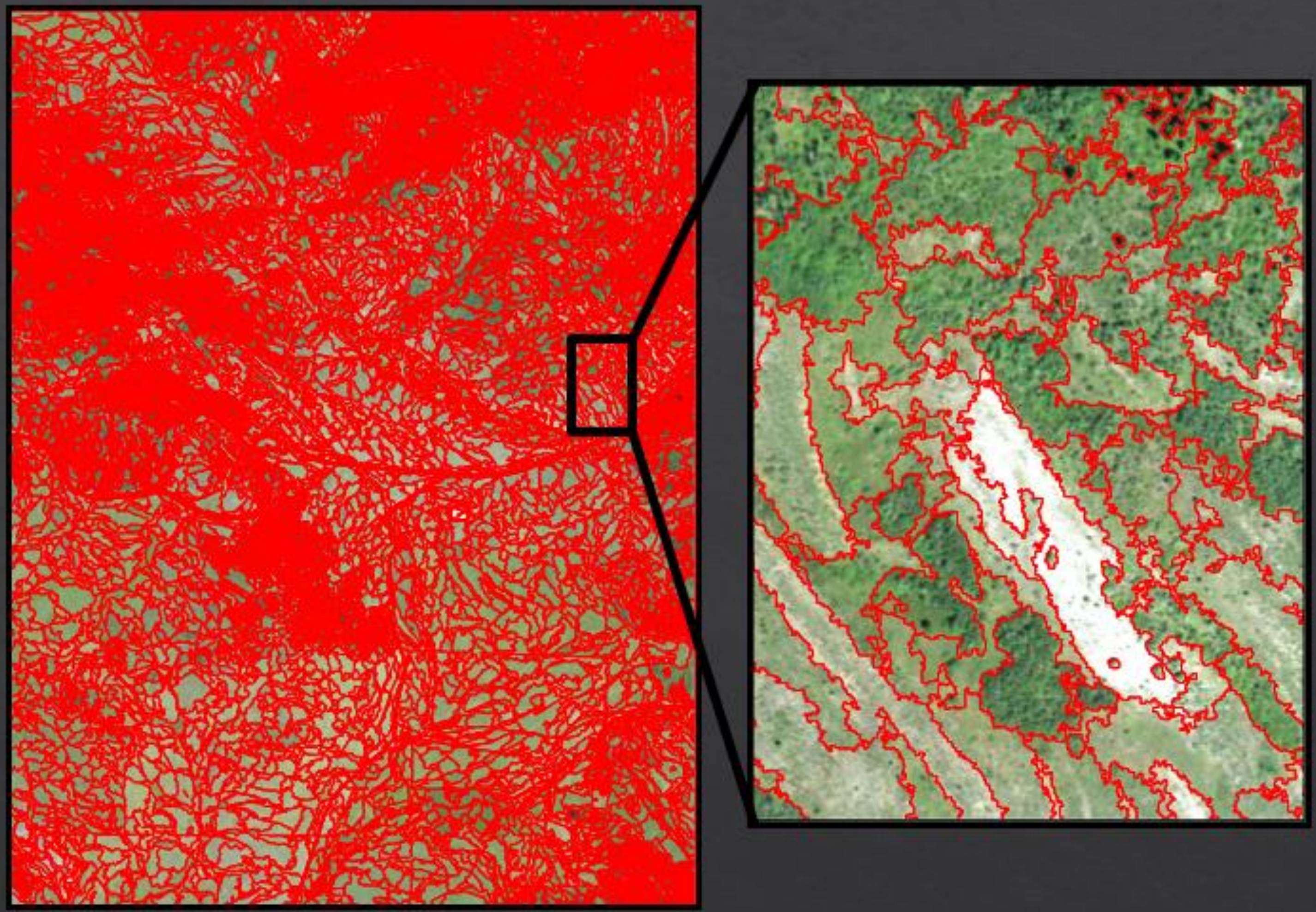
NAIP imagery

https://insideidaho.org/

Image segmentation

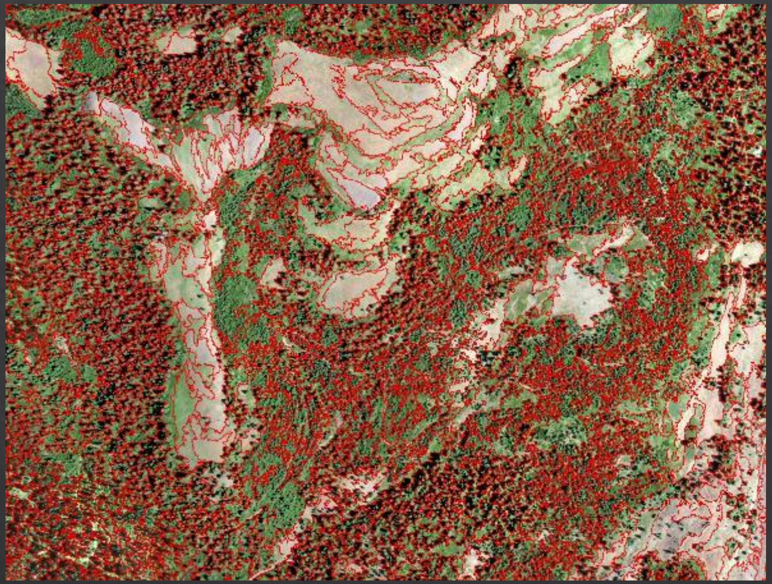
eCognition Developer 9.2



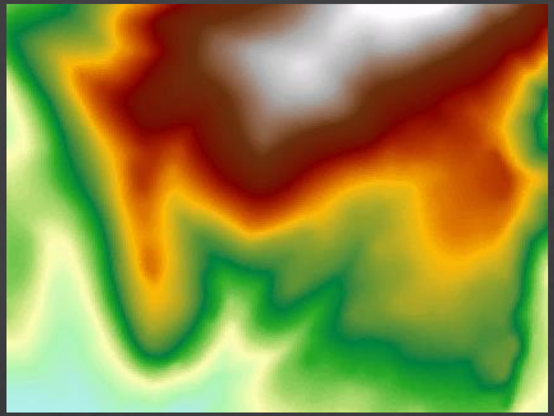
44.3 million polygons state-wide!

Attribute variables

Python (Arcpy)

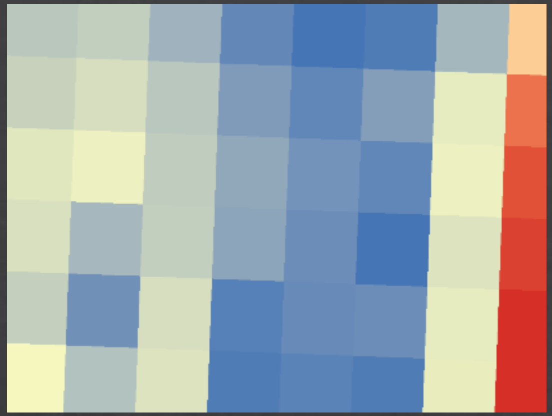


Elevation



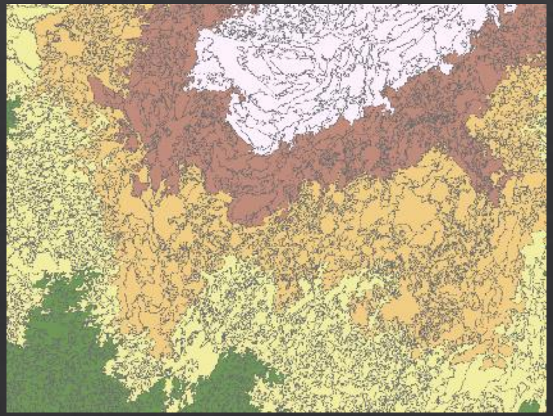
+

Minimum Temperature



+ ...

Attribute to polygons



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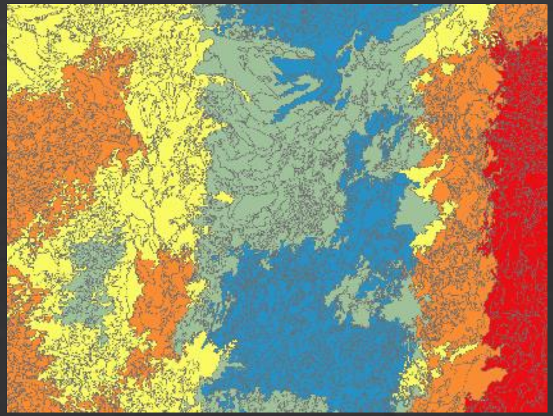
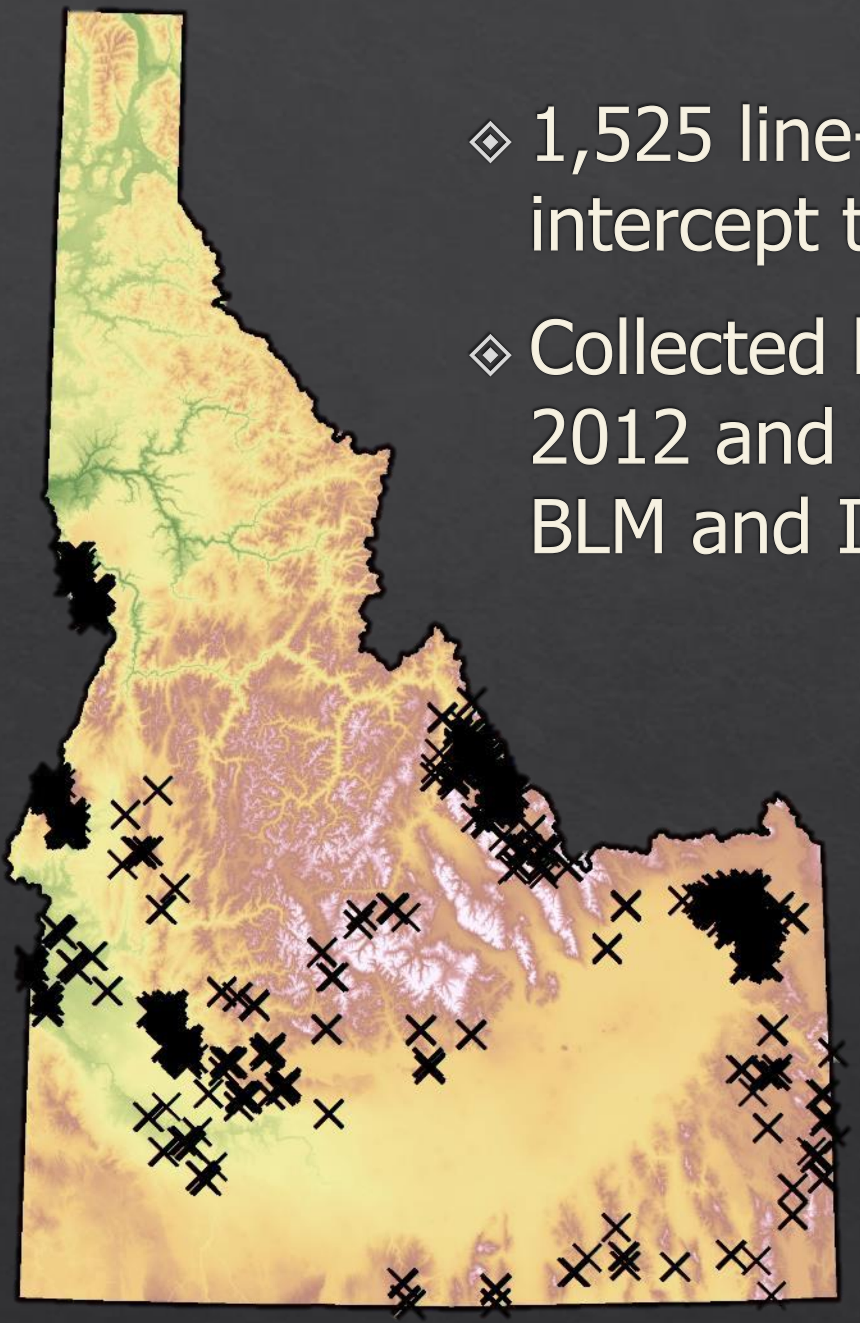


+ ...

26 total environmental variables



- 1,525 line-point intercept transects
- Collected between 2012 and 2016 by BLM and IDFG

Table 1
Forage species selected for distribution modelling and the number of times observed in the field data (out of 84,971 points). Scientific name, common name, and life form are included.

Scientific name	Common name	Life form	Number of points
Pseudoroegneria spicata	Bluebunch wheatgrass	Grass	11,481
Poa secunda	Sandberg bluegrass	Grass	7.067
Festuca idahoensis	Idaho fescue	Grass	5.818
Calamagrostis rubescens	Pinegrass	Grass	3.052
Carex spp.	Sedge spp.	Grass	2.134
Lupinus spp.	Lupine spp.	Forb	3.554
Balsamorhiza sagittata	Arrowleaf balsamroot	Forb	1.323
Achillea millefolium	Common yarrow	Forb	1.133
Geranium viscosissimum	Sticky purple geranium	Forb	373
Mahonia repens	Creeping Oregon grape	Shrub	1.103
Artemisia tridentata ssp. vaseyana	Mountain big sagebrush	Shrub	6.571
Purshia tridentata	Antelope bitterbrush	Shrub	3.317
Symphoricarpos albus	Common snowberry	Shrub	2.746
Amelanchier alnifolia	Saskatoon serviceberry	Shrub	721
Physocarpus malvaceus	Mallow ninebark	Shrub	386
Populus tremuloides	Quaking aspen	Tree	581
Prunus virginiana	Chokecherry	Tree	594
Pseudotsuga menziesii	Douglas-fir	Tree	413
Salix spp.	Willow spp.	Tree	699
Pinus contorta	Lodgepole pine	Tree	97

Statistical modelling

- Logistic regression
- Employed 'lasso' (least absolute shrinkage and selection operator) as a variable selector

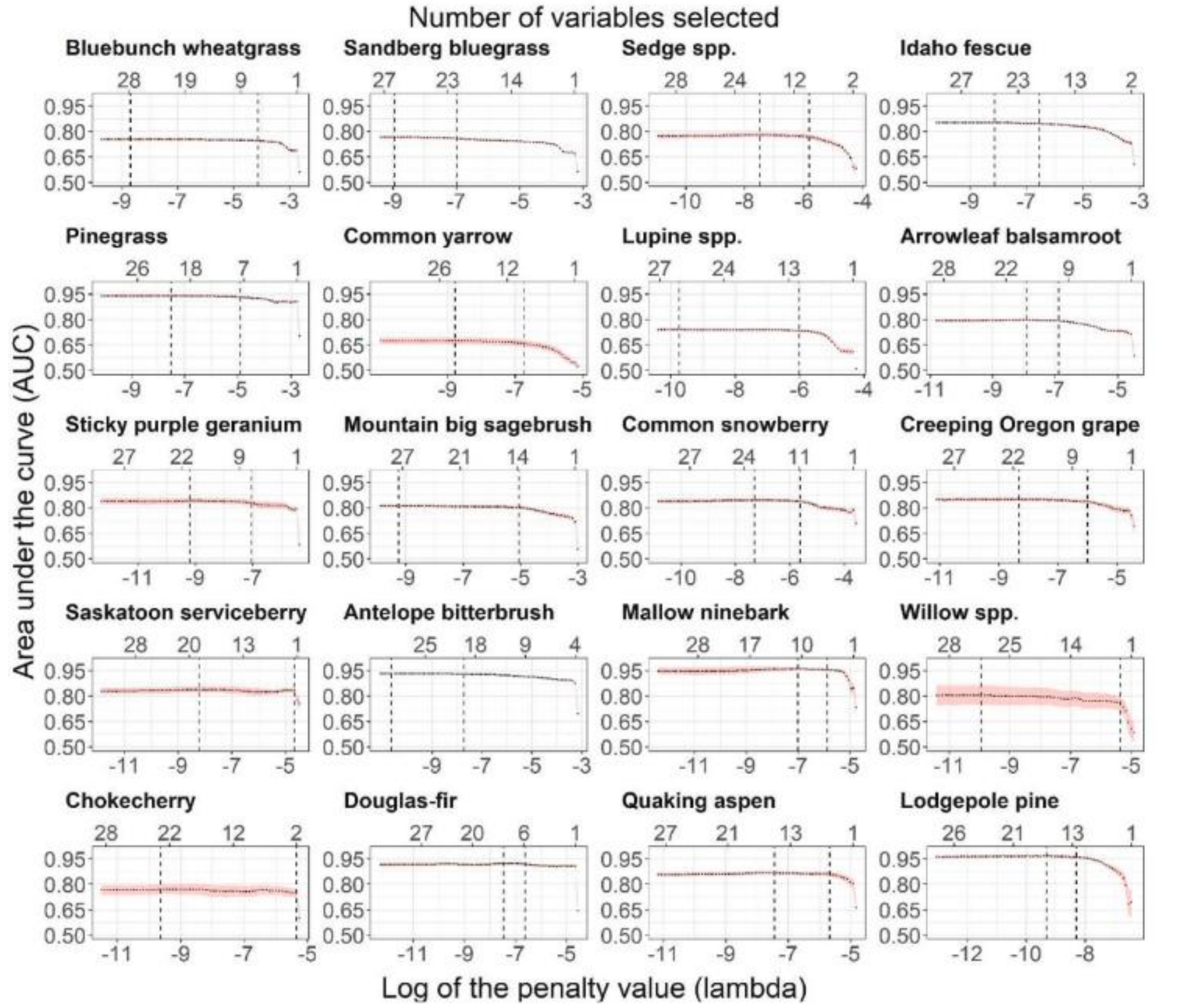


Fig. 4. Cross validation curves for all forage species distribution models containing both distal and proximal (distal-proximal) environmental variables with confidence interval ribbon shown in red. Vertical dashed lines indicate the penalty value (bottom x-axis) and number of environmental variables selected (top x-axis) for the highest predictive accuracy (left dashed line) and one standard error from the highest predictive accuracy (right dashed line). See Table 1 for forage species scientific names. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

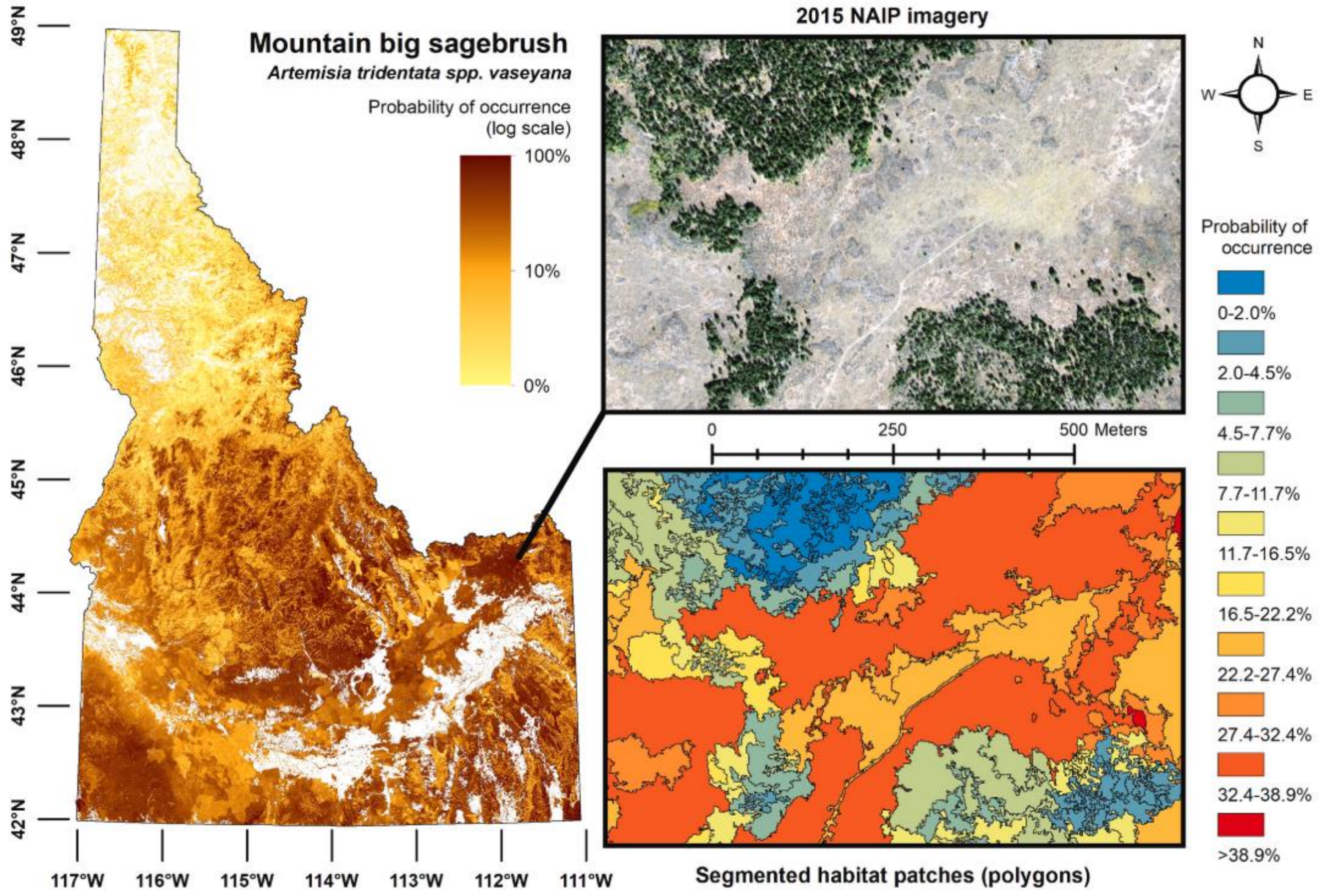
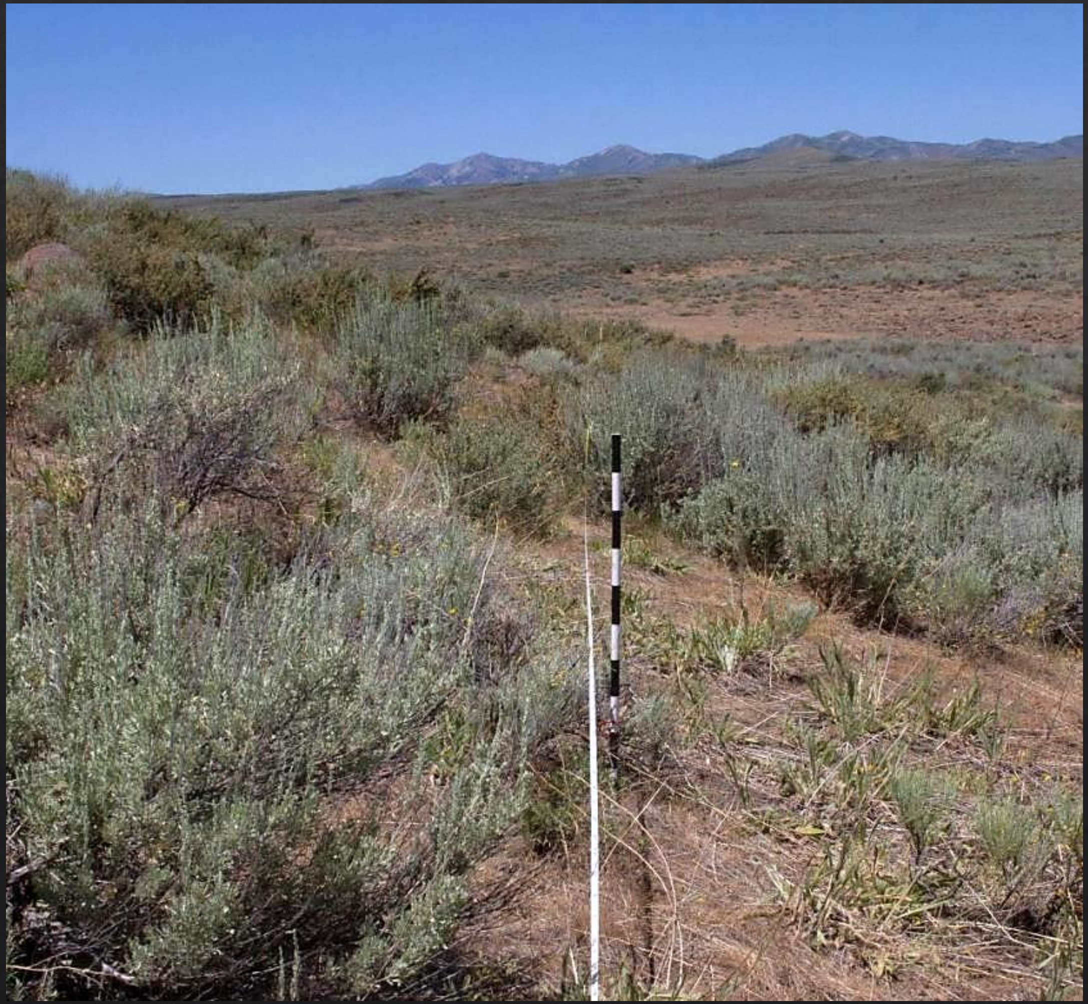


Fig. 1. Habitat patches (i.e., polygons) developed from NAIP imagery and attributed with percent probability occurrence of mountain big sagebrush using a model containing distal and proximal (distal-proximal) environmental variables. Statewide values are mapped using a natural log scale and aggregated to 30 m resolution. The inset example is from the Caribou-Targhee National Forest in eastern Idaho.

Model validation

Rinker Rock Creek Ranch, near Hailey ID
183 polygons validated (2018, 2019, 2020)



Taylor Ranch Wilderness Research Station, Frank Church Wilderness
9 polygons validated (2019)

Validation results

Forage species	Number of observations	Observed occurrence (%)	Predicted occurrence (%)
Idaho fescue	877	2.7 ± 6.6	2.2 ± 2.2
Arrowleaf balsamroot	478	1.4 ± 2.5	0.6 ± 0.3
Sticky purple geranium	30	0.1 ± 0.4	0.1 ± 0.03
Mountain big sagebrush	4614	13.7 ± 13.9	11.3 ± 4.3

Discussion

- For the validation, models had good average accuracy
- But, the models didn't capture heterogeneity of between adjacent polygons
  - The resolution of the environmental variables were coarser than the polygons

Discussion

- Generated a novel dataset
- Forage occurrence data can be used to manage habitat, which influences nutritional quantity and quality

Thank you!