Archaeological and Ungulate Modeling in the Shoshone National Forest, Wyoming

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INTRODUCTION

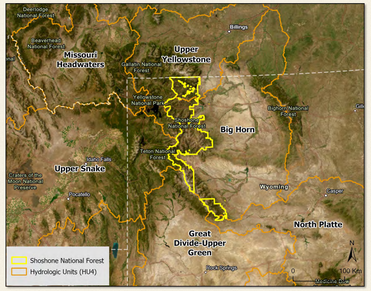
How do archaeological and ungulate patterns compare?

Shared mountain landscape

- Absaroka Range, northwest Wyoming wilderness area
- GRSLE artifact GPS data
- Elk, mule deer, and bighorn sheep collar GPS data
  - No bison or pronghorn in this dataset
- Same model area, raster grid, and predictors
- Compare archaeology, animal use, and procurement landscapes

Research questions

- How is archaeological material patterned?
- How is ungulate use patterned?
- Where do archaeology and ungulate use overlap, where do they diverge, and why?



Shoshone National Forest

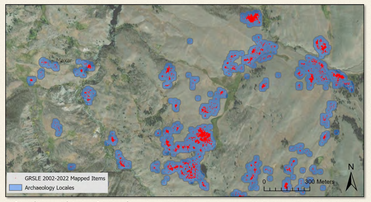
PROBABILITY MODELING METHODS

Artifact and collar GPS data were converted to comparable 10 x 10 m cell observations. Archaeology positives were capped at 2 ha per locale to limit very large artifact clusters. Ungulate positives were limited to locales with 5 or more occupied cells within 30 m and 2 or more collars. Nonsites were matched 1:1 to final positives. Random 70% of data to build the model, %30 to test.

Model Data Inputs

Model	Raw observations	Locales	Occupied cells	Final positives	Nonsites
Archaeology	270,315 GPS points	1,787	17,559	17,298	17,298
Elk	116,971 GPS fixes; 70 collars	6,900	101,232	101,232	101,232
Mule deer	40,107 GPS fixes; 38 collars	290	20,358	10,179	10,179
Bighorn sheep	73,118 GPS fixes; 39 collars	1,221	20,310	20,310	20,310

- Environmental predictors considered across models (z-score transformed):
  - Elevation
  - Slope
  - Surface roughness
  - Degrees from north, 0 to 180
  - Degrees from east, 0 to 180
  - Relative elevation: 100 m, 250 m, 500 m
  - Solar radiation: winter, summer, equinox
  - Stream distance, excluding ephemerals
  - Confluence distance, excluding ephemerals



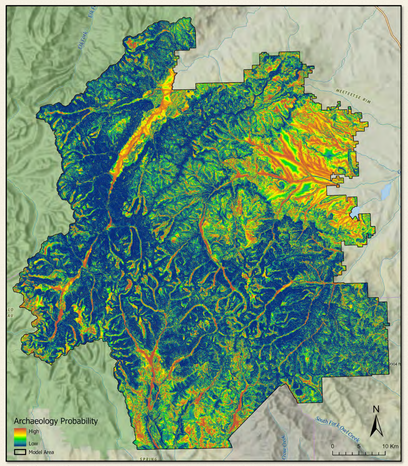
Archaeology Locales

Stepwise logistic regression

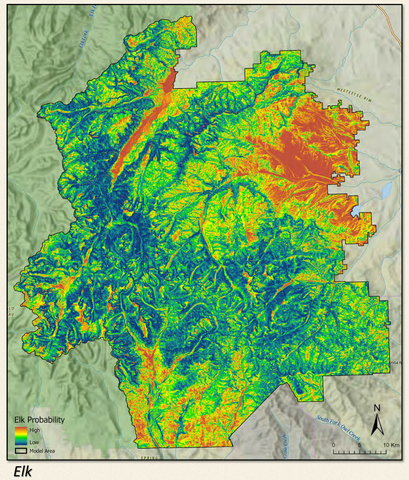
- "True positives" = known cell occurrences, "True negatives" = known cells lacking occurrences
- Stepwise selection identifies environmental predictors discriminating the true positives from the true negatives.
- Final equations applied to z-score raster predictors in GIS:
  - p = 1 / (1 + Exp[-linear predictor])
  - Bighorn sheep linear predictor: -0.432777 + (-0.324668 * DEM_z) + (0.320499 * confluence_distance_z) + (0.209459 * east_aspect_z) + (-0.901812 * rel250_z) + (1.750087 * rel500_z) + (0.308524 * roughness_z) + (0.370964 * slope_z) + (0.236767 * summer_solar_z) + (-0.276384 * winter_solar_z) + (-0.454011 * stream_distance_z)
- High probability: p >= 0.5
- Archaeology models ran 10 times, best was selected (model 7). Ungulate models ran once.

RESULTS: PROBABILITY SURFACES

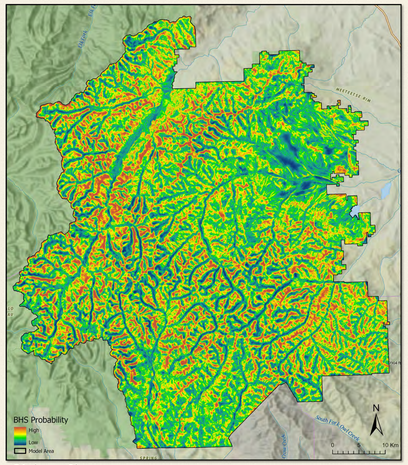
Each model identifies high-probability terrain from the same grid and predictor stack.



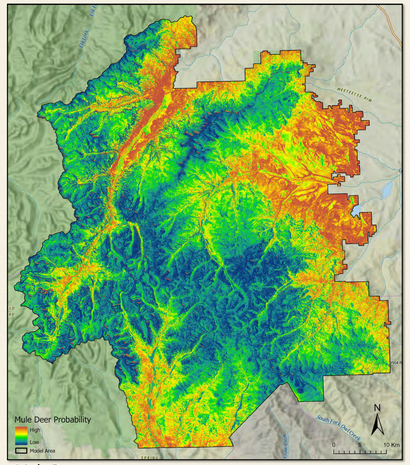
Archaeology



Elk



Bighorn Sheep



Mule Deer

RESULTS: MODEL EVALUATION

We present a few examples of several model performance evaluations:

- **Gain** = 1 - (high-probability area / test locales captured). Higher gain means more test locales captured with less mapped area.
- **Improvement over chance** = test locales captured minus high-probability area.
- **Cell accuracy** = percent of held-out test cells correctly classified as positive or negative.

Model Performance

Model	High-probability area	Test locales captured	Gain	Improvement over chance	Cell accuracy
Archaeology	13.1%	468 / 537 (87.2%)	0.85	74.1%	73.2%
Elk	30.6%	1,847 / 2,070 (89.2%)	0.66	58.7%	75.9%
Mule deer	27.4%	59 / 87 (67.8%)	0.60	40.4%	77.4%
Bighorn sheep	33.7%	307 / 366 (83.9%)	0.60	50.2%	69.0%

RESULTS: HIGH PROBABILITY AREA (HPA) OVERLAP

High probability areas from all four models are shown together.

Note overlaps of archaeology, elk, and deer in the major valleys and mountain margins.

Archaeology overlaps most with elk HPA, less with mule deer HPA, and minimally with bighorn sheep HPA.

Archaeology occupies a smaller subset of the broader elk-use landscape.

Mule deer shows moderate overlap with archaeology.

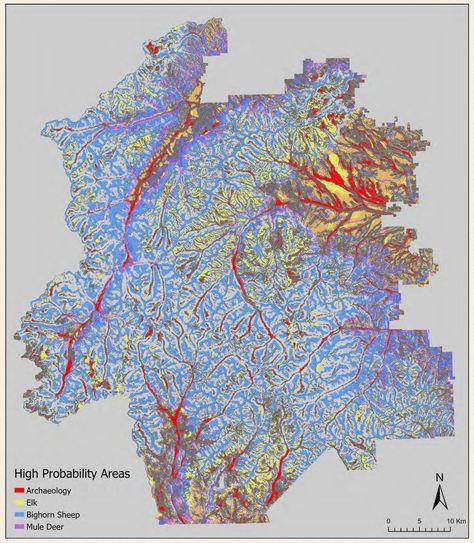
Elk and mule deer also overlap strongly with each other, suggesting broad shared-use terrain.

Bighorn sheep diverges sharply from archaeology. Only 7.5% of archaeology HPA overlaps bighorn sheep HPA, even though bighorn sheep has the largest HPA footprint at 33.7%.

Bighorn sheep use reflects a different, more specialized terrain pattern.

Overlap suggests shared environmental settings, not direct proof of hunting.

Divergence may help identify specialized procurement or task-specific activity areas.



Overlapping high probability areas, p >= 0.5.

Directional Overlap Matrix

Model	Total %	Archaeology	Elk	Mule Deer	Bighorn Sheep
Archaeology	13.1%	100.0%	73.2%	42.7%	7.5%
Elk	30.6%	31.3%	100.0%	53.7%	15.2%
Mule Deer	27.4%	20.3%	59.9%	100.0%	24.9%
Bighorn Sheep	33.7%	2.9%	13.8%	20.2%	100.0%

Example: 73.2% Archaeology in Archaeology × Elk cell = 73.2% of Archaeology HPA overlaps Elk HPA

CONCLUSIONS

Shared predictors facilitate this unique approach to model comparisons.

Archaeology has a comparatively small, selective HPA footprint: 13.1% of the model area, and this small area encapsulates 87.2% of the set-aside model test dataset. This represents a highly efficient model.

Archaeology overlaps most with elk HPA, moderately with mule deer HPA, and minimally with bighorn sheep HPA.

Elk and mule deer likely mark broad shared-use terrain: travel, occupation, and encounter potential.

Bighorn sheep marks a different landscape logic: rugged, specialized, and less tied to routine archaeological patterning.

Overlap is not direct evidence of hunting; it identifies shared terrain.

Divergence may be the key to finding specialized procurement or task-specific activity areas.

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