Intersecting Paths: Comparative Modeling of Archaeology and Wildlife Migration in the Shoshone National Forest

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Introduction

The Absaroka Range forms the eastern edge of Yellowstone in northwestern Wyoming, with elevations from 1,800 to 3,600 m. The area includes river valleys, alpine basins, and steep, rugged volcanic plateaus.

Elk migrate through broad valleys and low passes. **Bighorn sheep** (BHS) stay in high, rugged terrain near cliffs and talus slopes.

Sheepeaters

Mountain Shoshone, referred to as Sheepeaters, were known for their pedestrian hunting with dogs (rather than horses). Shimkin (1947) reports that they would hunt BHS in the summer and winter, taking advantage of deep snow. He also reports that "*elk was exceeded only by bison and fish in its contribution to Shoshone life.*" and that they would be hunted by tracking and shooting by single men.

In contrast to this account, archaeological evidence points to BHS as being a vastly more important food source than elk, with elk remains being primarily decorative or used as flaking tools (e.g., Bugas-Holding and Mummy Cave).

Archaeological Modeling

We've modeled **archaeological site probability** in the Absarokas since 2009. In 2023, we built time-specific models to explore change over the Holocene.

In 2024, we used publicly available elk migration data to create an elk probability model, and found that **archaeology and elk probability are highly correlated.**

Data used here are from 2002-2022. Archaeology locales here are groupings of artifacts based on 15-m buffers. In this analysis, no minimum number of artifacts was necessary to be included.

This produced **1,218 locales** from over **230,000** individually mapped artifacts.

We separately modeled BHS traps using 5 locations, excluding Bull Elk Pass

Elk and Bighorn Sheep

Now, we apply the same method to elk and bighorn data to compare patterns, using data provided by the Beyond Yellowstone Program.

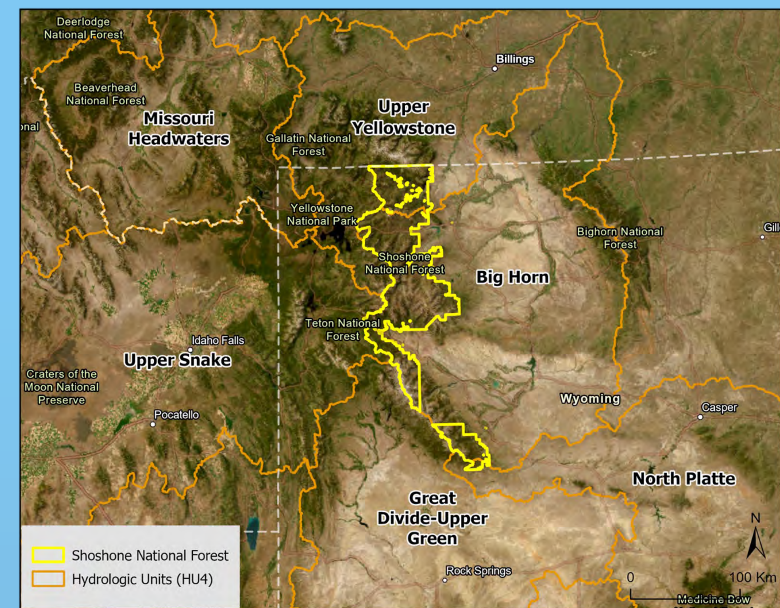
All models considered the same environmental inputs—elevation, slope, water, topography, and more.

This approach allows us to compare models of human occupation with elk and BHS.

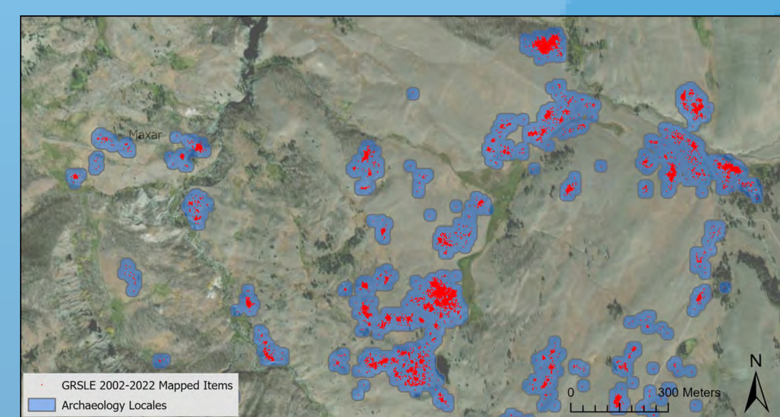
Wildlife clusters here are where a minimum of 5 10x10-m cells containing elk GPS coordinates are within 30 m of each other.

Elk GPS dataset: 116,971 points from 70 collars, 2/11/2019-2/14/2022, **3,205 elk sites**.

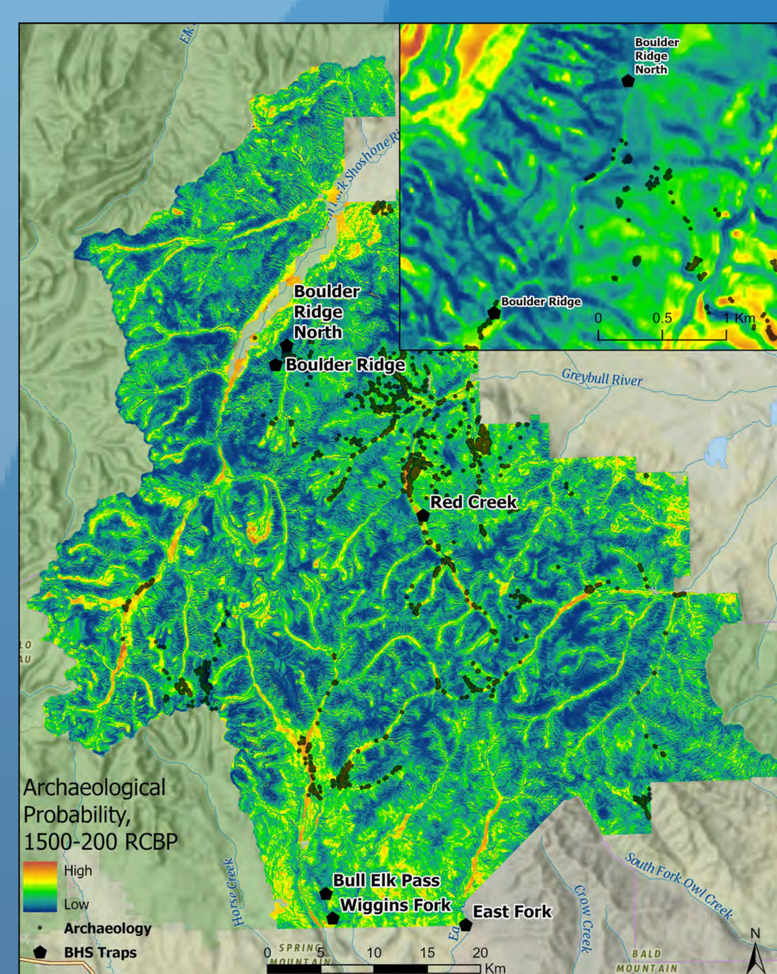
BHS GPS dataset: 73,118 points from 39 individuals, 2/2/2014-5/2/2017, **4,564 BHS sites**.



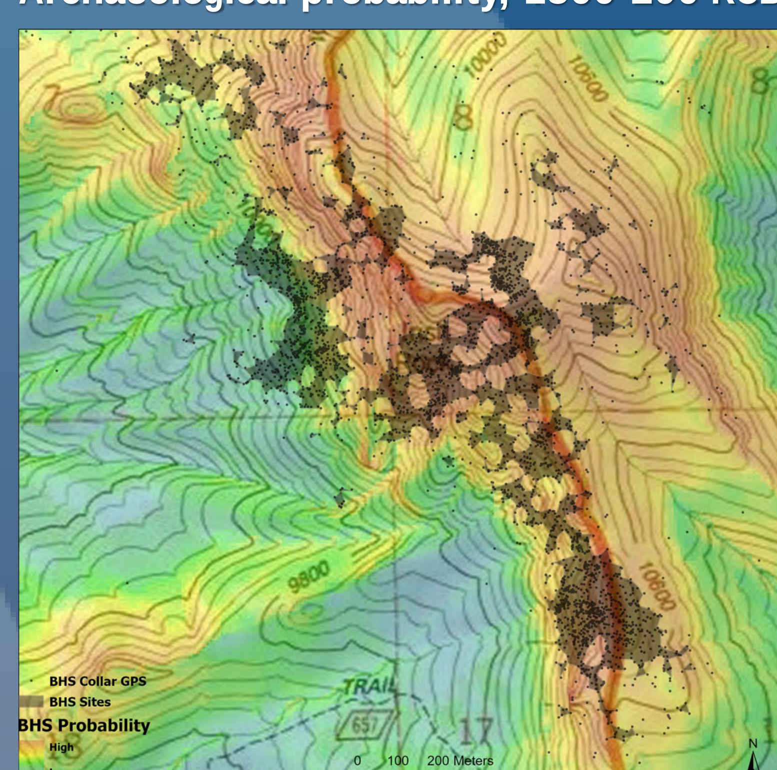
Shoshone National Forest



Archaeology locales



Archaeological probability, 1500-200 RCBP



BHS sites example

Probability Modeling

We used stepwise logistic regression in JMP 18 to model archaeology, elk, and bighorn sheep using the same environmental variables. Predictors elevation, relative elevation (500 m, 250 m, and 100 m), slope, cost surface, aspect, distances to streams and confluences (including and excluding ephemeral streams), and solar radiation (summer, winter, and equinox). The product is an equation defining a probability curve between 0 (low) and 1 (high):

Probability(locale) = 1/(1 + exp[-linear combination])

The *linear combination* includes a constant (or y-intercept) and the multipliers for the selected environmental variables that significantly discriminate true positive and true negative locations. Example linear combination (BHS model):

-0.722282 + (-0.00001922 × elevation) + (-0.00001091 × stream distance, no ephemerals) + (-0.00002098 × stream distance, with ephemerals) + (0.00006596 × solar radiation, winter) + (-0.00006287 × solar radiation, summer) + (-0.00003634 × solar radiation, equinox) + (0.00002992 × slope) + (0.00016491 × rel500) + (-0.00011051 × rel250) + (0.00001554 × rel100) + (0.00001566 × north) + (0.00001516 × east) + (0.00004009 × cost surface) + (0.00005699 × confluence distance, no ephemerals) + (-0.00006458 × confluence distance, with ephemerals)

The probability equation derived from statistical software is entered into GIS to produce the probability maps. High-probability areas (HPAs) have a probability ≥ 0.5.

Results

Elk: Moderate elevations, on broad terrain elevated at large scales but lower locally (e.g., high valleys), near confluences and perennial streams, with sunny winters and gentle slopes, favoring north- and east-facing slopes, and more accessible corridors. *See tables for additional results summaries.*

BHS: High, steep areas elevated above surroundings, near streams, with sunny winters and cooler summers, favoring southwest-facing slopes, with rugged, high-cost "escape" terrain.

Archaeology (1500-200 RCBP): Aligns strongly with elk, preference for gently sloping terrain, local high spots within broader valleys, near confluences, on northwest-facing slopes, with high summer solar exposure, and low travel cost.

- **66% of the archaeology HPAs are in Elk HPAs, in contrast to only 2% in BHS HPAs.**

BHS Traps: Favors moderately elevated ridges (high 500-m relative elevation, low 100-m relative elevation), gentle slopes, west-facing aspects, and mid-elevation zones. Trap placement on broad uplands or benches above drop-offs, not in deep valleys or surrounded steep terrain.

We intersected large, contiguous areas of very high BHS trap probability (p ≥ 0.95) with 500-m buffers of BHS collar GPS locations to identify the **top 10 probability areas** warranting further investigation (among 486 areas measuring at least ½-hectare). These may be helpful in identifying additional locales like the Boulder Ridge BHS trap.

Site Interpretation Example: The **Cow Creek trap** (far right) is an enigmatic wooden corral-type structure, not falling in what previously seemed like BHS habitat. Our modeling confirmed this, with BHS probability of only 0.03 (BHS trap probability = 0.00). In contrast, elk probability is 0.61 here. There is no evidence that elk were procured here, but the modeling lends credence to the suggestion that this is not a BHS trap.

Conclusions

Archaeological locales **strongly overlap** with elk habitat (see table), suggesting shared use of terrain but not necessarily direct hunting.

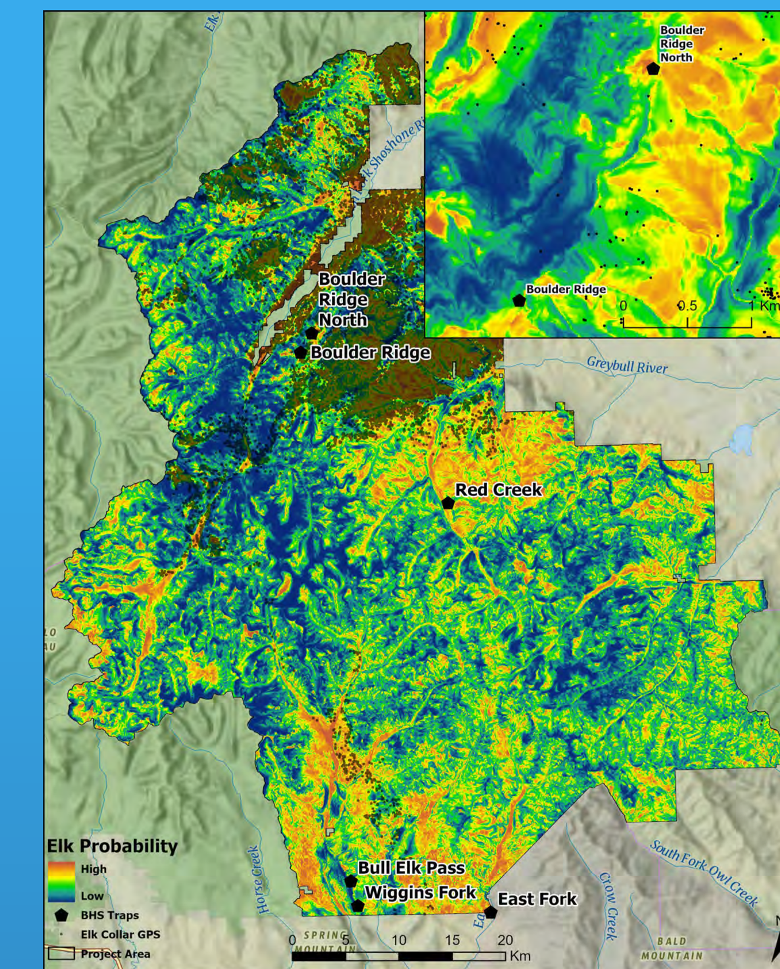
In contrast, bighorn sheep locales occupy rugged zones **rarely overlapping** with archaeological sites, indicating targeted forays for sheep rather than routine occupation of BHS habitat.

Ethnographic evidence confirms that bighorn were hunted **cooperatively** in challenging alpine terrain, whereas elk were likely taken **opportunistically** during broader foraging rounds.

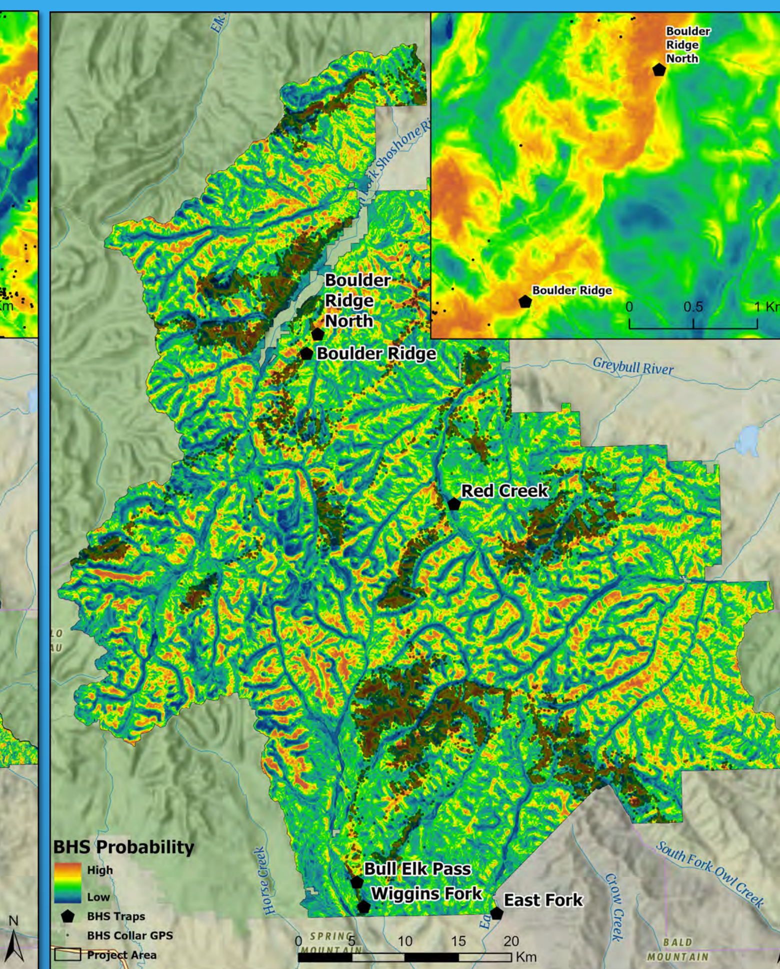
This work in developing a probability model for BHS trap locations represents a **novel contribution** to the field, bridging ecological modeling with archaeological probability.

Model results show that these traps occur in a **distinct subset** of bighorn habitat, favoring topographic conditions ideal for communal hunting. Now that we have begun to model these resources, we can use them to guide further targeted research.

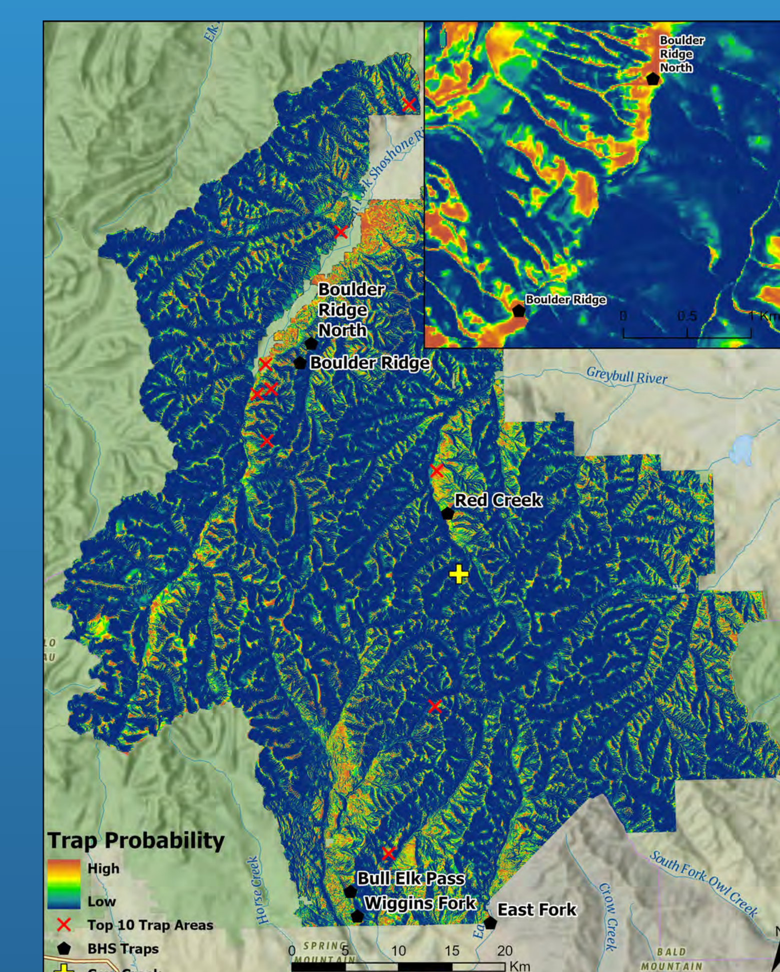
Similar unique **task-specific locales** occur in the region that are worth considering for this type of modeling approach, e.g., white bark pine nut processing locale that are also known to occur in unique, distinct settings away from typical modeled archaeological HPAs.



Elk model



BHS model



BHS trap probability

Model efficiencies

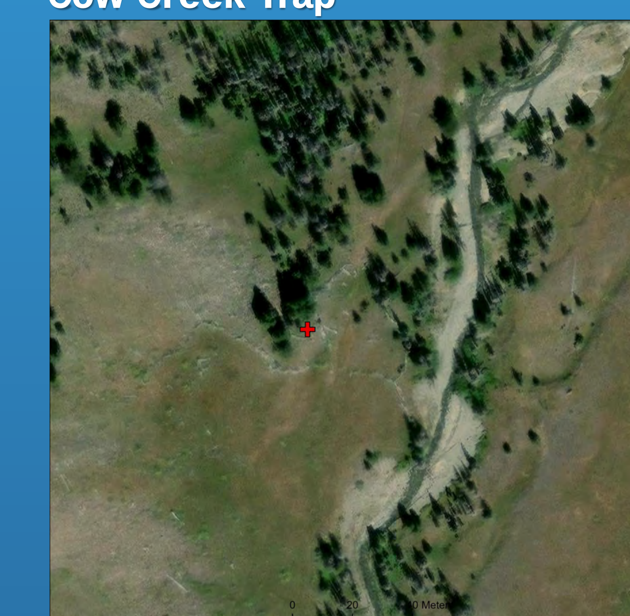
Model	% Predicted Hectares	% Sites Predicted	Gain*
Elk	34	84	0.59
BHS	*31*	*79*	*0.61*
BHS Trap	11	100	*0.89*
Archaeology	12	69	*0.83*

*Gain = % Predicted Hectares / % Sites Predicted

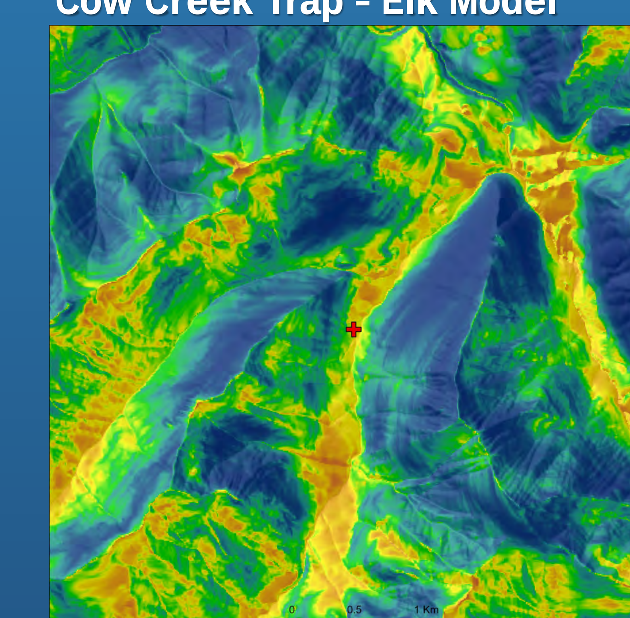
Comparative archaeological data

Resource	Total	# in Elk HPA	% in Elk HPA	# in BHS HPA	% in BHS HPA
Hectares surveyed	3645	3008	83%	285	8%
All artifacts	235138	213955	91%	1605	1%
RCBP Diagnostics					
8000+	47	42	89%	3	6%
8000-5000	59	53	90%	2	3%
5000-3000	71	65	92%	6	9%
3000-1500	355	322	91%	2	1%
1500-200	604	561	93%	5	1%

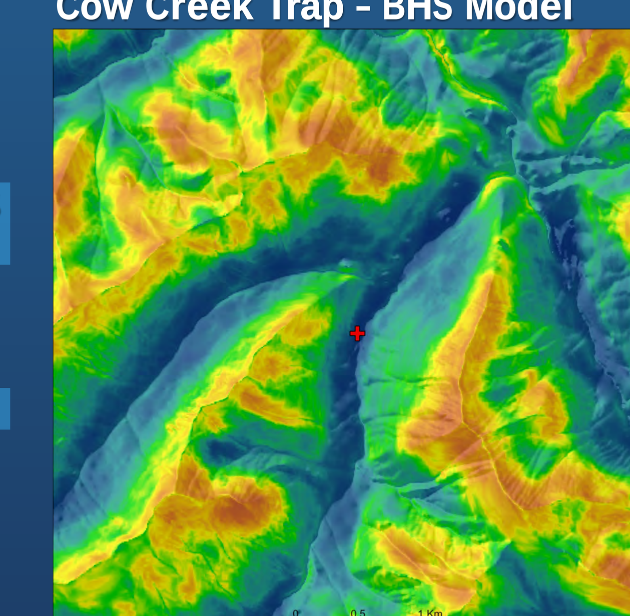
Cow Creek Trap



Cow Creek Trap - Elk Model



Cow Creek Trap - BHS Model



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