Evolution of the Shoshone National Forest Prehistoric Archaeological Site Probability Model

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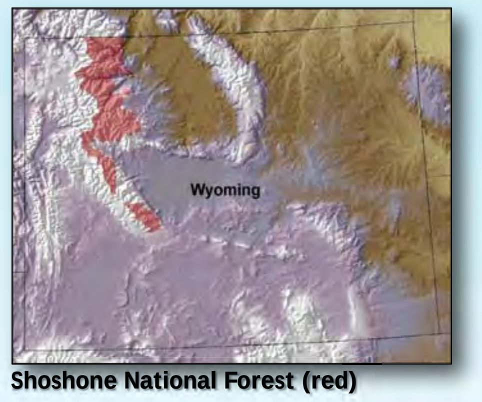
Introduction



Shoshone National Forest (red)

Inventory data collected from 2002 to 2008 were used to build an archaeological probability model in 2009 for the Greybull River drainage on the Shoshone National Forest (SNF) in northwestern Wyoming. We expanded the model in 2014 to cover the entire northern portion of the SNF, and building upon lessons learned from that model, in 2015 we reconstructed it for the entire SNF.

Using an iterative approach, we continuously evaluate the model results in different environmental settings to identify areas of potential model improvement. Here we outline this process and the most significant improvements.

Collect Data → Develop Model → Evaluate Results

Iterative approach to modeling

Stepwise Logistic Regression

Stepwise logistic regression is used to determine the contribution of environmental variables to site presence or absence. It produces an equation defining the probability curve between 0 (low site likelihood) and 1 (high site likelihood):

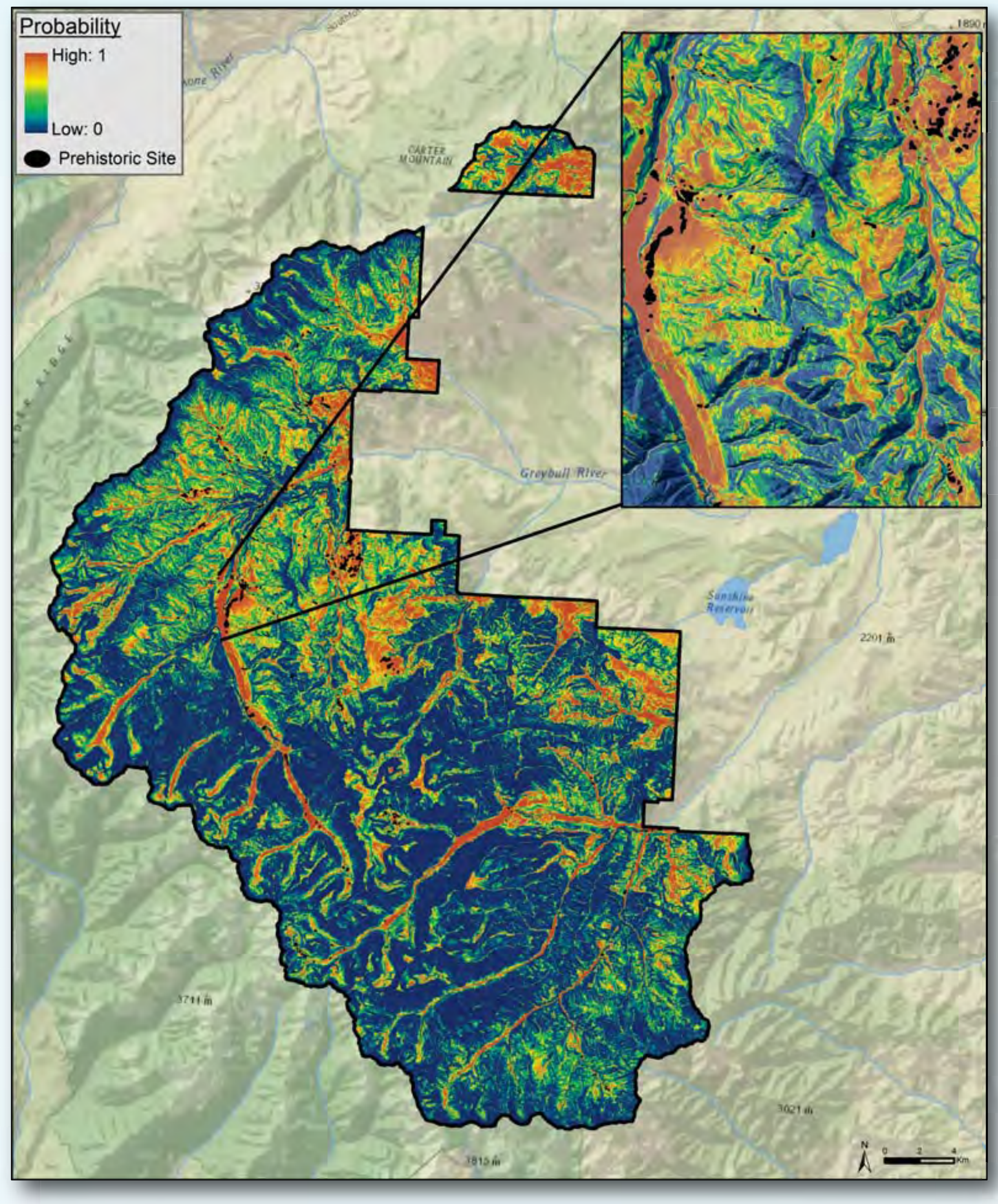
Probability(site) = 1/(1 + exp[linear combination])

Linear combination includes a constant (y-intercept) and multipliers for the selected environmental variables that correlate with site locations.

Gain statistics (Kvamme 1988:329) approximate predictive efficiency:

Gain = 1 - (% of area predicted to contain sites / % sites within the predicted site area)

1st Iteration: GRSLE Model (Burnett and Todd 2009)



- 111,137 hectares, 310 known sites

Environmental Variables Considered
- Productivity
- Distance to streams
- Distance to water bodies
- Height above surroundings
- Aspect
- Slope
- Soil
- Surface Geology
- Land cover type (NLCD)

Probability Equation

1/(1 + exp[-5.566 + 0.004*stream distance + 0.249*slope])

Site Response
- Stream distance (-)
- Slope (-)

96% of known sites in 25% of model area, *Gain = 0.74*

Evaluation

Nonsites included inventoried areas and slopes over 30 degrees.

Large sites influenced the model output substantially more than small sites.

A relatively small portion of the SNF was modeled. Anticipating continued wildfires in the region, a more expansive model was needed.

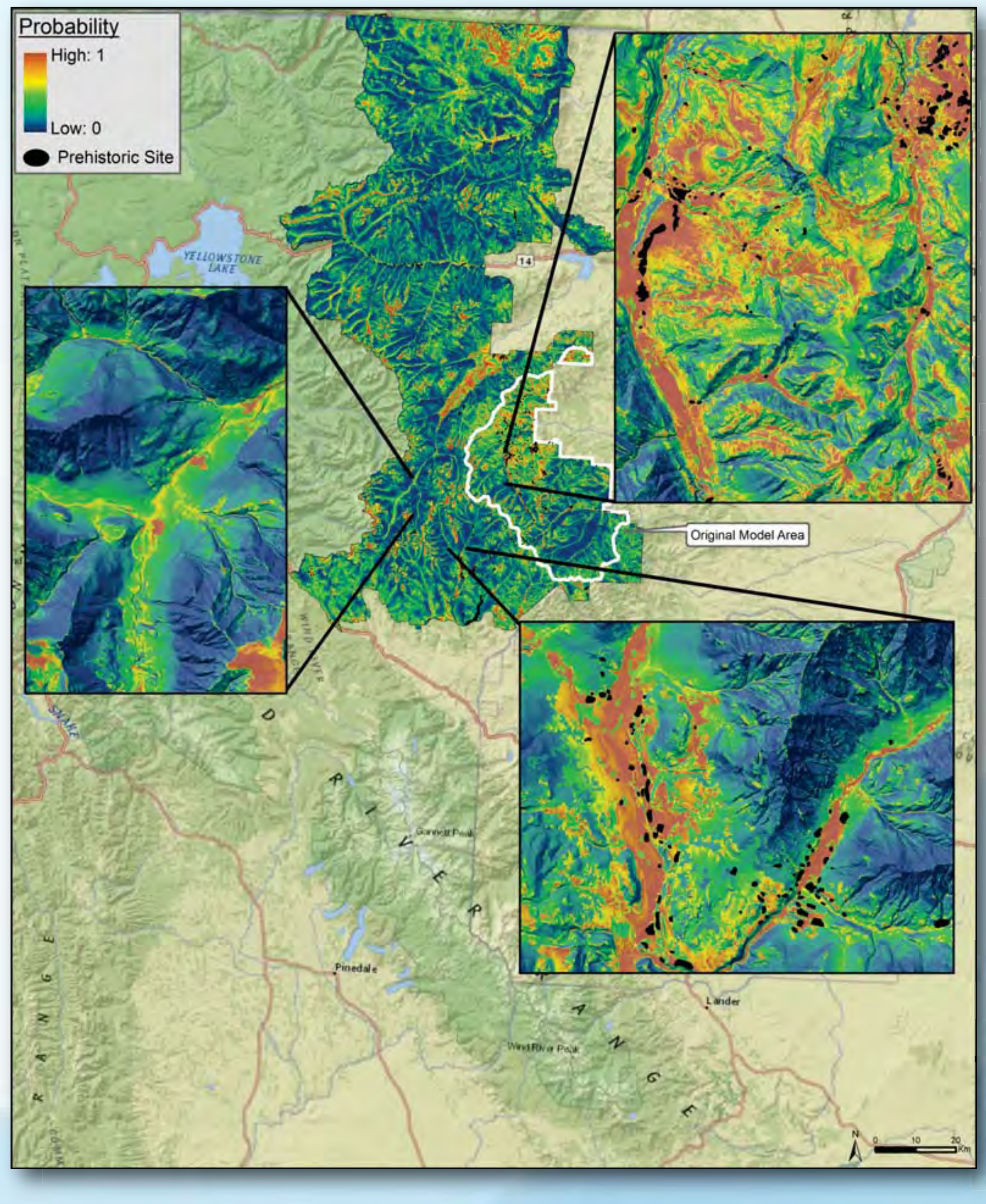
The updated model would need to incorporate not only data collected by GRSLE, but also data on file with the SNF and the state.

Noting the abundance of toolstone in Paleozoic outcrops, distance to these outcrops should be considered for the updated model.

Improved methods for calculating aspect should be employed (degrees from north, degrees form east).

Cost surface should be incorporated, which combines trends in slope and surface roughness to describe the difficulty of moving across terrain.

2nd Iteration: North Shoshone Model (Burnett and Todd 2015a)



- 775,888 hectares, 592 known sites

Environmental Variables Considered
- Distance to Paleozoic bedrock
- Degrees from north
- Degrees from east
- Distance to water
- Elevation
- Height above surroundings
- Slope
- Cost surface
- Land cover type (NLCD)

Probability Equation

1/(1 + exp[-3.805 + -0.00002*distance to Paleozoic + -0.003*east + 0.002*distance to water + -0.0007*elevation + 0.130*slope + -0.003*cost surface + -0.642* not NLCD42 + 0.642 NLCD42 + -0.757* not NLCD90 + 0.757*NLCD90 + -0.699* not NLCD95 + 0.699*NLCD95])

Site Response
- Distance to Paleozoic bedrock (+)
- Degrees from east (+)
- Distance to water (-)
- Elevation (+)
- Slope (-)
- Cost surface (+)
- Evergreen Forest (-)
- Woody wetlands (-)
- Emergent herbaceous wetlands (-)

85% of known sites in 7.3% of model area, *Gain = 0.91*

Evaluation

Steep slopes (>30 deg.) were included as nonsites in proportion to their abundance in the model area.

The influence of large sites was reduced by maximizing site contribution to 2 hectares.

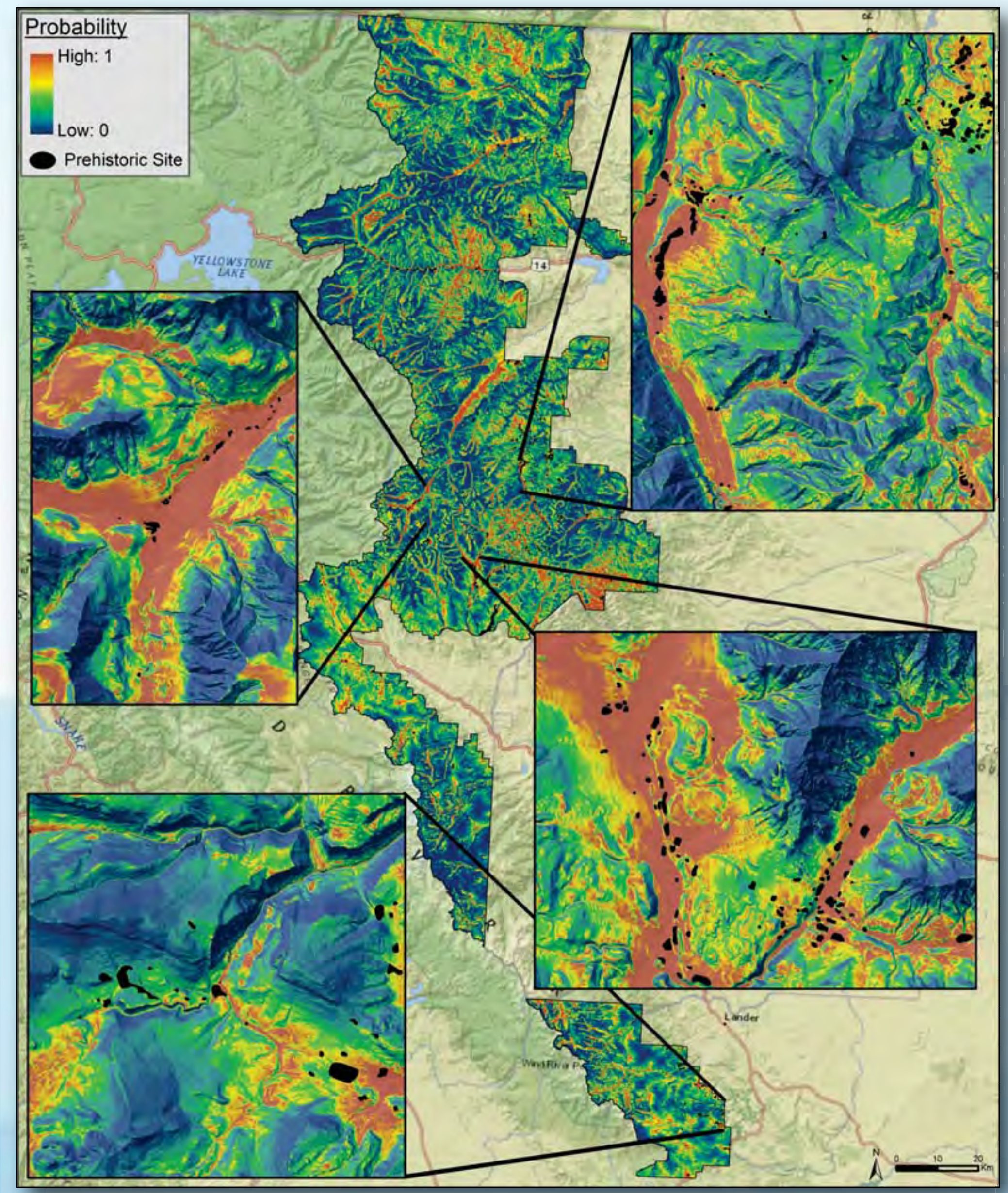
Distance to Paleozoic bedrock returned the opposite site response as anticipated.

Distance to all water sources (streams, water bodies, and springs) were condensed into a single environmental variable, but each source type may affect site location differently.

The model interpreted forested areas as having low site probability, but sites exposed in burned areas after this model was produced suggested this was misrepresenting actual site patterning.

Solar radiation and distance to confluences should be considered in the next iteration.

3rd Iteration: Complete Shoshone Model (Burnett and Todd 2015b)



- 996,654 hectares, 785 known sites

Environmental Variables Considered
- Degrees from north
- Degrees from east
- Distance to streams
- Distance to water bodies
- Distance to springs
- Distance to confluences
- Elevation
- Height above surroundings
- Slope
- Cost surface
- Solar radiation

Probability Equation

1/(1 + exp(4.210 + 0.00009*north + -0.0006*east + 0.001*distance to streams + -0.0002*distance to water bodies + -0.00004*distance to springs + 0.0004*distance to confluences + 0.0003*elevation + 0.006*height above surroundings + 0.001*slope + -0.0003*cost surface + -0.0004*solar])

Site Response
- Degrees from north (-)
- Degrees from east (+)
- Distance to streams (-)
- Distance to water bodies (+)
- Distance to springs (+)
- Distance to confluences (-)
- Elevation (-)
- Height above surroundings (-)
- Slope (-)
- Cost surface (+)
- Solar radiation (+)

74.8% of known sites in 9.6% of model area, *Gain = 0.87*

Evaluation

Reduced model efficiency may be a factor of spanning across too broad an area.

Removing land cover reduced the effect that forested areas had on the previous model.

Newly employed variables were found to significantly contribute to the model.

Estimates of model parameters can still be heavily biased due to sample area coverage and resulting spatial autocorrelation. New statistical techniques should be tested to better account for autocorrelation.

Alternate modeling approaches (e.g., generalized least squares) should be explored and compared against the stepwise logistic regression model.

Conclusions

Rather than building bigger models, more precise models may be produced by focusing on smaller areas. Model boundaries heavily influence results, and these should be explicitly defined based upon contiguous ecoregions rather than somewhat arbitrary management boundaries.

Models change with scale, the addition of new information, site types considered, and statistical techniques employed. Individual models offer a snapshot, but when viewed as a dynamic, iterative process, modeling should change with time and continue to inform inventory and management strategies in new and interesting ways.

Acknowledgements

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