Modeling Native American Sacred Sites in Rocky Mountain National Park

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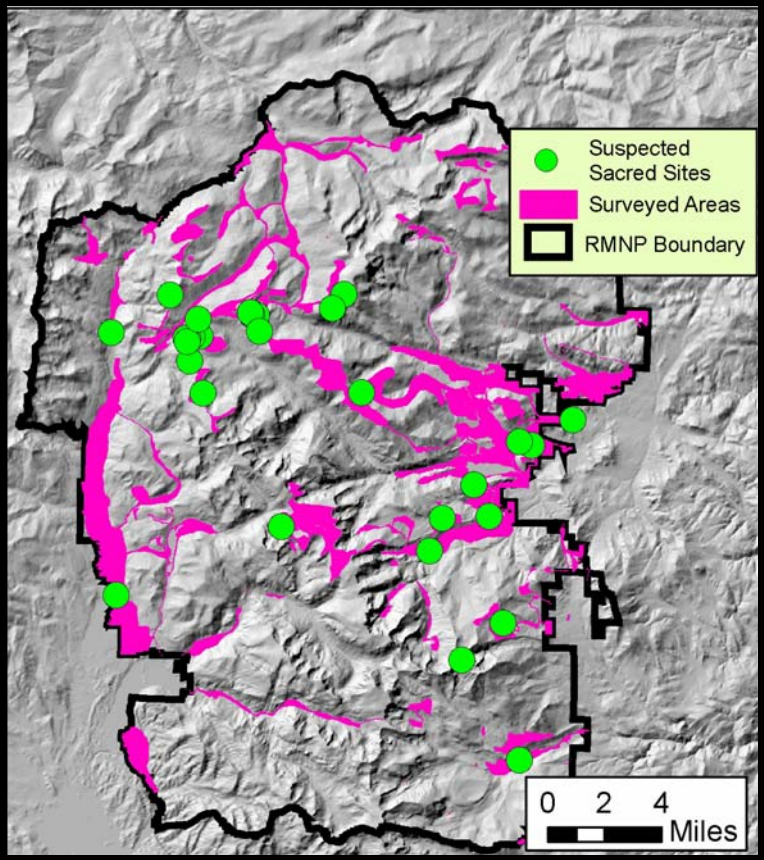
Rocky Mountain National Park (RMNP), Colorado

- 415 sq. miles
- Astride the Cont. Divide.
- Montane to Alpine.
- 60 peaks above 12,000ft.
- High Visitation.
- Near major urban areas.

Archeological Sites in RMNP



- Over 1,000 archeological sites in RMNP.
- Approx. 29% of RMNP has been surveyed.
- Many are prehistoric and early historic sites.
- 31 sites and feature cluster sites were identified as having well-established or highly probable Native American religious or ritual components.

System-wide Archeological Inventory Program (SAIP) 1998-2002

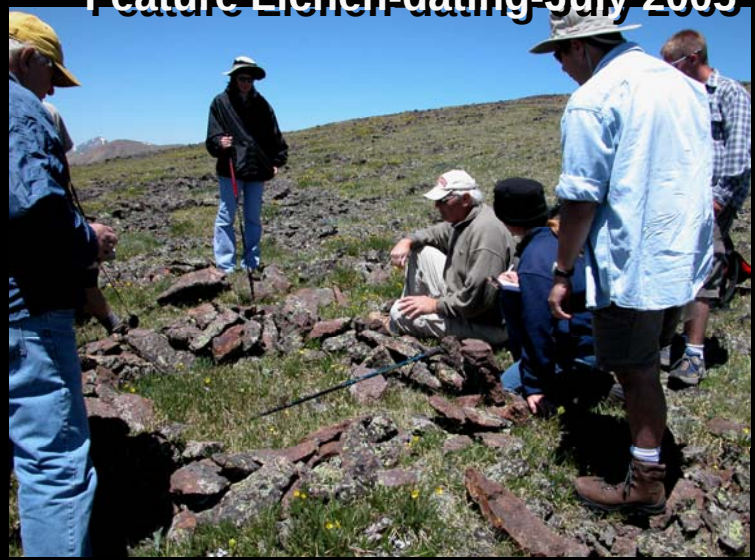
source: http://www.nps.gov/romo/resources/history/prehistoric.html

In 2000, a long-term research program was initiated in the Park and its surrounding mountain region to identify and study archeological features thought associated with **Native American ceremonial practices** and attempt to reconstruct models of their hypothesized relationships with their ancient cultural and environmental-topographic landscapes.

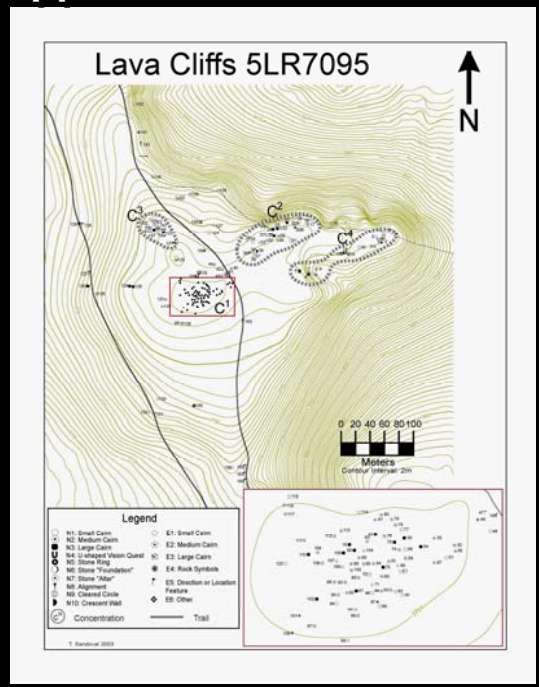
Feature Recording

Trimble GeoXT Used in Sacred Site Mapping

Feature Lichen-dating-July 2005



Large Rock Feature Site Mapped with Sub-Meter GPS



How can we identify archeological features thought associated with Native American ceremonial practices?

Methodologies employed in the research program, to date, have included:

- Extensive background studies of southern and central Rocky Mountain ethno-historic records for Native American religious practices, belief systems, and physical manifestations of those practices and beliefs.

- Consultation interviews and visits to the Park with Ute and Arapaho tribal elders (known to have historically lived in the area), and intensive archeological and spatial mapping of sites believed associated with prehistoric and early historic religious practices (cf. Brunswig 2003, 2005).

Sacred Sites

Specific locations with archeological evidence of Native American religious practices are defined here as constituting ***sacred sites.***

Prayer Circle on Glacial Erratic Boulder

Sacred circles for meditation, prayer, ritual, and spirit contact

Feature Lichen-Dated to AD 900

Vision quest features

Shrines/Altars: Offering places for local spirits

Can we model these *Sacred Sites* with GIS?

- Do existing GIS predicative models satisfy the RMNP needs for these sorts of sites?
- Is there an exploratory method that allows maximum flexibility for hypothesis testing and data manipulation?

Chris Rohe's GIS modeling

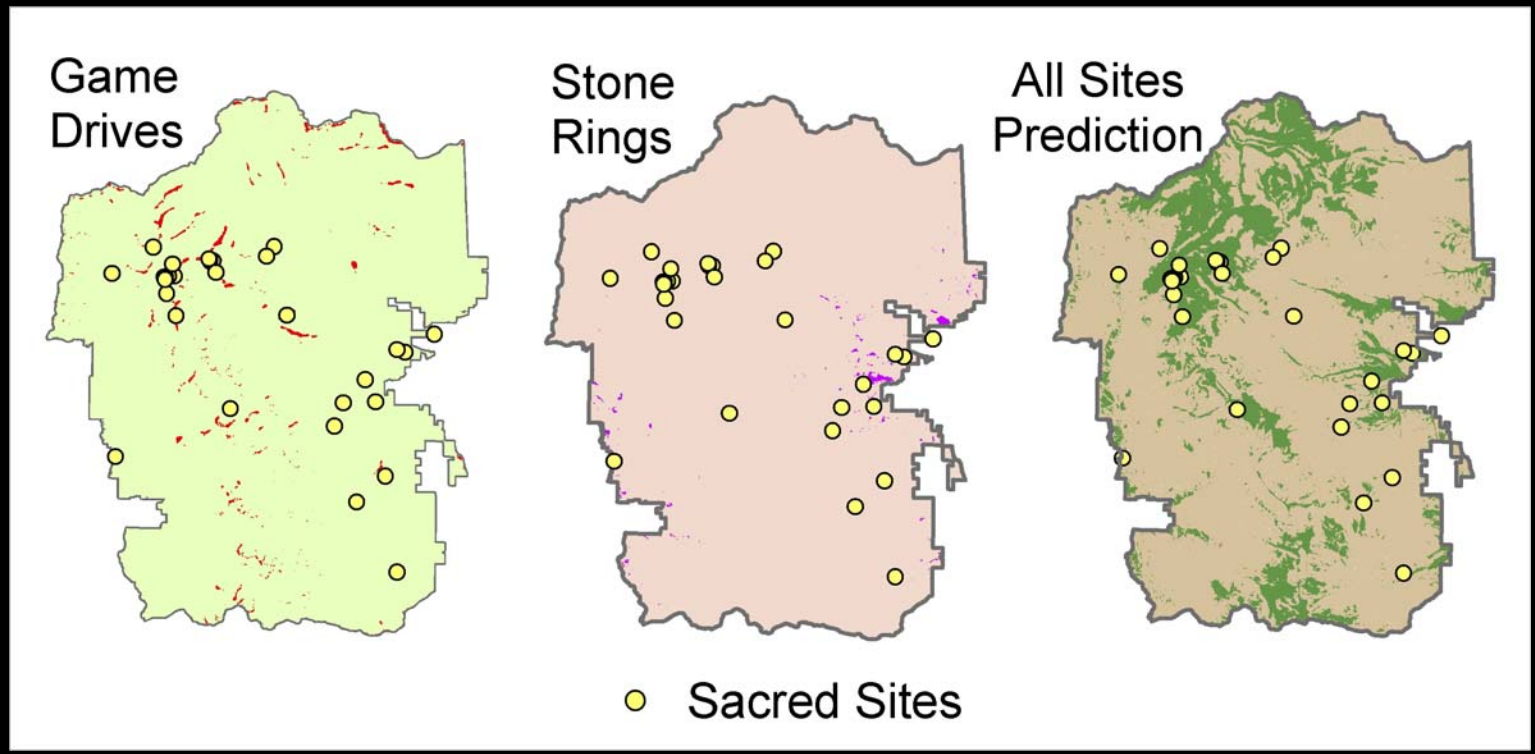
We first looked at existing modeling work.

Game Drives	Low Altitude Medium Lithic Scatters
High Altitude Isolated Finds	High Altitude Small Lithic Scatters
Low Altitude Isolated Finds	Low Altitude Small Lithic Scatters
High Altitude Large Lithic Scatters	Stone Rings
Low Altitude Large Lithic Scatters	Wickiups
High Altitude Medium Lithic Scatters	

Predictive Models for Archeological Sites in Rocky Mountain National Park, Colorado (Rohe 2003b)

Layer Name	Description
Above Water	Elevation of each pixel above its nearest water source.
CosAspect	Aspect for north/south trending slopes. The result is a continuous scale from -1 to 1.
Cost Distance to Ridges	Provides a quantifiable value for the difficulty to traverse a specific slope. The further away from a ridge the higher the cost value, which is compounded by steeper slopes.
Cost Distance to Water	Provides a quantifiable value for the difficulty to traverse a specific slope. The further away from a WATER the higher the cost value, which is compounded by steeper slopes.
Elevation	Digital Elevation Model (DEM).
Linear Distance to Ridges	Euclidean distance to ridges generated from the DEM.
Linear Distance to Water	Euclidean distance to water sources generated from the DEM.
Relief	Elevation change with a 3 km. radius. This layer provides a measure of terrain roughness.
Relief Above	Amount of elevation change above a local area based on a 3 km. radius. This is a measure of terrain roughness above a regional area.
Relief Below	Amount of elevation change below a local area based on a 3 km. radius. This is a measure of terrain roughness above a regional area.
Shelter	A measure of how exposed a local area is in relation to surrounding terrain.
SinAspect	Aspect for east/west trending slopes. The result is a continuous scale from -1 to 1.
Slope (percent)	Determined from DEM—measures ground steepness.
Summer Light	This layer s computed by using the hillshading function in GIS. The shading is based on a sun azimuth of 177° and altitude 73.1° for summer solstice.
Vegetation	Vegetation areas in the park.
Vegetation Variety	Amount of vegetation variety in a 600m radius from each pixel.
Winter Light	This layers computed by using the hillshading function in GIS. The shading is based on a sun azimuth of 180° and altitude 26.2° for winter solstice

Examples of Archeological Site Predictions for RMNP



- Existing Models, while helpful did not fit the needs of exploring sacred site locations.
- Some models, at first glance, appeared useful (ex. game drives), others were too general (ex. all sites).

Weights-of-Evidence

- **ArcSDM 3.1 is a free ArcGIS/ArcView extension that provides techniques to combine two or more evidential themes for the generation of a response theme (Sawatzky etal. 2004).** http://ntserv.gis.nrcan.gc.ca/sdm/ARCSDM31/.

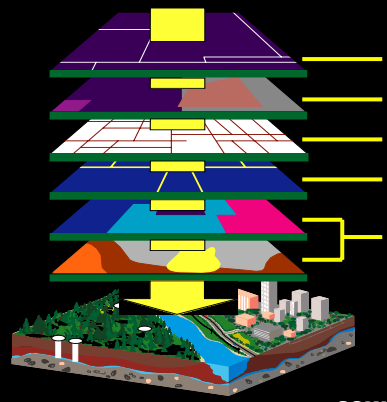
- **Includes the weights of evidence, logistic regression, fuzzy logic and neural network analysis capabilities.**

- **In GIS--Weights of evidence was initially developed for mapping mineral potential (Raines, Bonham-Carter, Kemp 2000).**

- **The approach has also been applied to archeological site prediction in California (see Hansen 2000 and Hansen et al. 2002).**

Why Weights-of-Evidence (WOE)?

- Map Inspection—commonsense method for a geographer!
- WOE evaluates the spatial distribution of known “events” relative to multi- and/or binary map patterns.



source: http://www.gisday.com

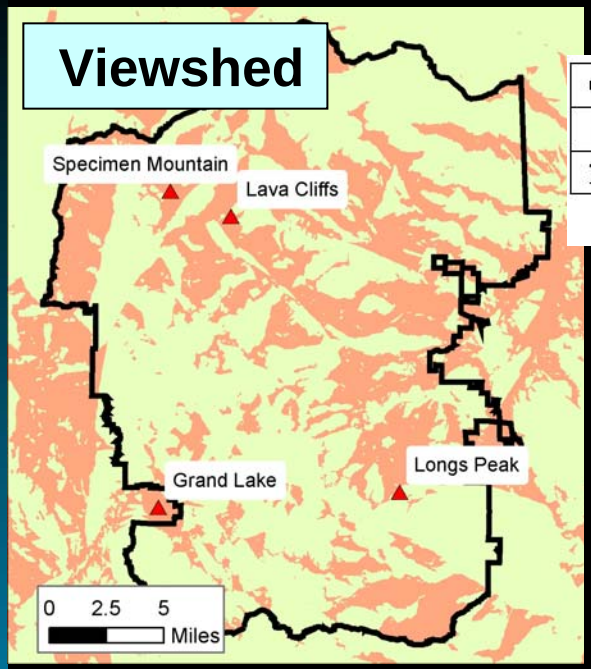
- Calculates weights of spatial association (W+ and W-) between an Evidence Layer and a Training Point Set.
- The weights (W+ and W-) can be used to reclassify and generalize an evidence layer.
- Evidential themes can then be combined to create a response theme. This includes a posterior probability—the chances that we will find similar features/sites in each cell of the grid theme (in our case the chances that we would find sacred sites).

Conceptual Model

Variable(s)	Potential Importance
Elevation	High elevation areas have spiritual significance for many Native American cultures.
Local Relief	Relief in the local area provides an understanding of terrain roughness. These could include an understanding of whether certain sites are in “dramatic” settings, with significant down-valley or up-slope views.
Aspect and related measures.	Sites and individual features may have an orientation to view summer sunrise/sunset; or an orientation to north/south. In some cases, e.g., rock wall alignments, aspect and directional orientation may point to landmarks of great spiritual power or landmarks in line with the rising of sun or moon during times of seasonal change such as solstices and equinoxes, phases of the moon, constellation movements, etc.
Shelter	Exposed areas may or may not be desirable in predicting sacred feature/site locations. Sheltered circumstances might not be desirable for ceremonial or ritual activities, but may be locations where native or transplanted ritually significant plants could flourish and be obtained.
Vegetation and vegetation variety	Native American and prehistoric groups are known to have used certain plants for ritual purposes, many of which could be found or transplanted to, or near, ceremonial locations.
Historic Native American trails	Access to known prehistoric and early historic trails in the park may be a predictor of the location of sacred features. For instance, the Ute often located ritual/ceremonial sites on or near trails due to the belief they (the trails) were conduits of spirit power, but situated their camps well away from those same trails.
Visibility of known sacred landmarks from sacred sites and features in the park	Ute elders have identified certain sacred landmarks in RMNP. Visibility of these features from various sacred sites and individual features may be an important predictor variable for sacred landscape patterning.

Ultimately used 5 out of 7 Conceptual Model Elements, Viewshed, Elevation, Coaspect, Local Relief, and Ancient trails

- Nearly all variables showed some association with **Sacred Sites**.
- Use of some variables together broke assumption of *Conditional Independence* assumed for WOE.
- Example *Local Relief* and *Shelter*.
- No association with Vegetation Variety and Vegetation types also broke assumption of *Conditional Independence* of variables (elevation).

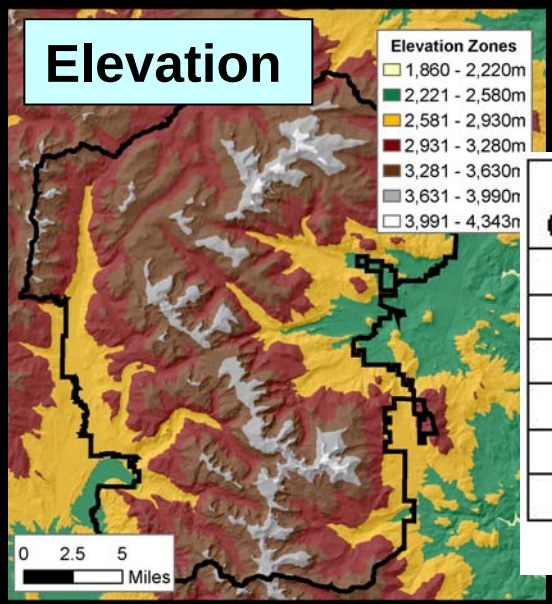


Class	Area Sq km	Area Units	#Points	W+	W-	C
1	671.2930	1343	7	-1.0221	0.7317	-1.7538
2	408.6700	817	23	0.6878	-0.8878	1.5757

Weights Table for Viewshed Layer.

W+ (positive weight) and C's (Contrast):

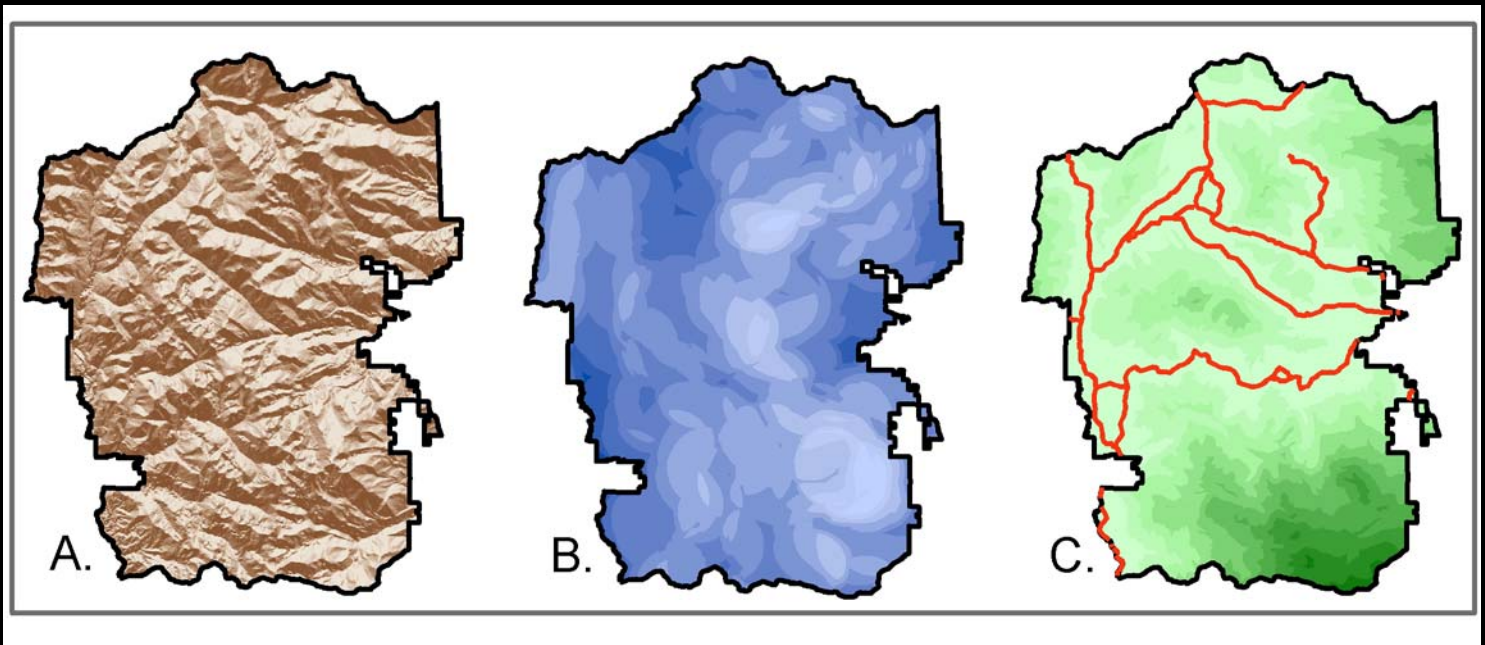
0 to .5	Mildly Predictive
.5 to 1.0	Moderately Predictive
1.0 to 2.0	Strongly Predictive
> 2.0	Extremely Predictive



Class	Area Sq km	Area Units	#Points	W+	W-	C
3	36.2012	72	2	0.6741	-0.0333	0.7073
4	222.1618	444	7	0.0954	-0.0262	0.1216
5	345.0526	690	0	0.0000	0.0000	0.0000
6	363.5822	727	9	-0.1498	0.0684	-0.2182
7	106.9334	214	11	1.3141	-0.3380	1.6522
8	6.0318	12	1	1.8315	-0.0276	1.8591

Weights Table for Elevation Zones Layer.

Other Variables Used in Model:



CoAspect

- Light areas represent more north facing slopes.

Local Relief

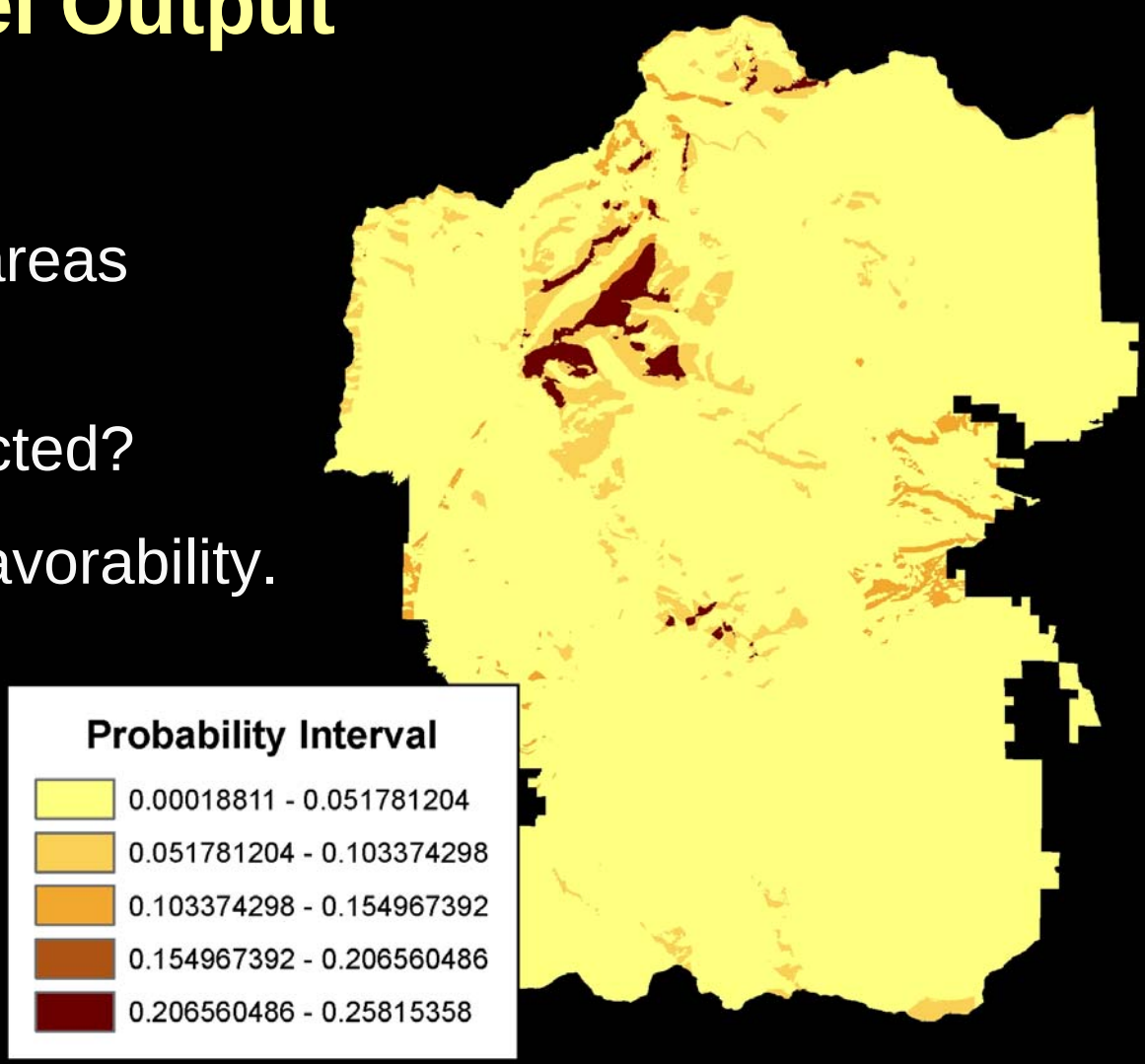
- Light areas represent greater change in local relief.
- Elevation change within a 3 km. Radius.

Ancient Trails

- Cost distance from trails (slope).
- Light colored areas lower cost to trails.

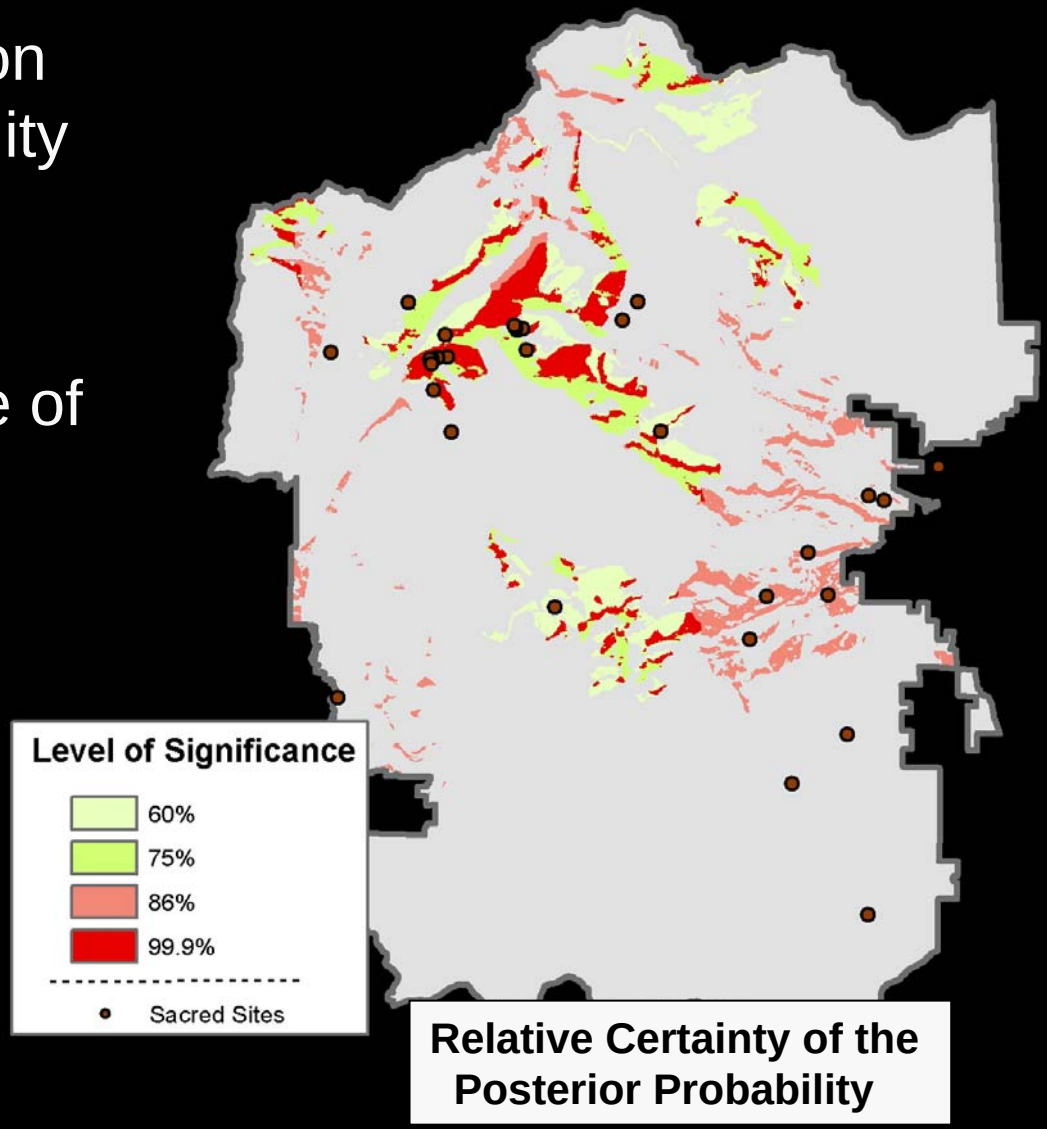
Initial Model Output

- High-elevation areas highlighted.
- What was expected?
- Probability vs. favorability.



How meaningful are the results?

- Approximate *t-test* on the Posterior Probability map.
- Clearly raises questions of the value of this model for large areas of RMNP.



Conclusions:

- WOE may overestimate probability of an event.
- Think in terms of relative favorability, not exact probabilistic maps.
- Weights of evidence method is a valuable heuristic device for exploring data associations and testing hypotheses. *Weights can be governed by expert opinion.*
- Sample size issues; sites vs. individual features.
- More in-depth look at other variables, such as soils, geology, feature alignment (with features outside RMNP) is needed.

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