Modeling Native American Sacred Sites in Rocky Mountain National Park

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Abstract

Recent completion of System-wide Archeological Inventory Program (SAIP) investigations by the University of Northern Colorado (UNC) resulted in survey coverage of ~30,000 acres of Rocky Mountain National Park (RMNP), USA. Over 1,000 archeological sites were identified in SAIP. Among those sites were ones considered to represent past Native American religious activities. This project utilizes data from survey identified Native American sacred sites to develop a preliminary site location Geographic Information System (GIS) predictive model of sacred site landscapes within RMNP. ArcGIS/ArcView 3D Analyst, Spatial Analyst and Arc-SDM (for weights of evidence) extensions were used to develop a predictive model of sacred sites. A key factor in the model was line-of-sight to religiously significant peaks and mountains as determined by Native American consultations. Results, conclusions, and recommendations from this study may aid those wishing to attempt similar projects.

Introduction—Archaeology and Sacred Landscapes in Rocky Mountain National Park, Colorado

The University of Northern Colorado, under contract to the National Park Service, conducted a large-scale inventory of prehistoric and historic sites in Rocky Mountain National Park from 1998 through 2002, documenting 1000+ archeological sites within 29,000 survey acres (Figures 1 and 2). Mid-way in the survey program, it was realized some sites contained probable evidence of past Native American religious activities. 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.

Methodologies employed in the research program, to date, have included: 1) 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, 2) 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). Specific locations with archeological evidence of Native American religious practices are defined here as constituting *sacred sites*. As is common in most Native American religions, ritual-ceremonial practices and physical evidence of those practices may either be spatially unique, e.g., the only type of activity occurring at a particular location, or integrated secular *and* religious activities at the same location. For instance, in the latter case, religious rituals are known to have frequently accompanied economic activities such as hunting game or the gathering of certain wild plants for food or medicines. A second concept utilized in this study is that of the *sacred landscape*, the overall spatial patterning of human-constructed ceremonial sites and associated ritual features along with geographic landmarks, e.g., lakes, mountains, valleys, etc., believed to represent mythological events (e.g., creation) or locations of highly concentrated spiritual-power. Ultimately, it is the larger-scale sacred landscapes that are potentially most useful in reconstructing most Native American religious "world-views" in their physical (archeological) form. However, reconstruction of such landscapes is frequently problematic, given difficulties in identifying spatially patterned (and cognitive) religious phenomena in the archeological record. The key lies in careful spatial analysis of more easily recognizable landscape components, sites and ritual features, and testing their spatial-geographic relationships for patterning compatible with known or inferred Native American ethno-historic, religious belief and behavior.

The majority of suspected *sacred sites* documented in Rocky Mountain National Park contain several classes of rock constructed features thought to have been associated with a wide range of ritual practices, from individual and group spirit offerings on high and remote mountain tops to U-shaped walls, talus slope clearings, crescent-shaped walls, and circular or rectangular walled spaces believed associated with individualized spiritual (or vision) quests. Some rock alignments are suspected, based on location and orientation, as having been potentially associated with seasonal solar (solstice) ritual events while some high tundra concentrations of small to large rock cairns likely represent burials or ritual offering markers.

In the course of our research, suspected Native American features are separated from those believed to have been built with more modern Euro-Americans through careful documentation of their age-related physical condition, e.g., heavy uniform weathering of exposed rock surfaces versus the less severe weathering of recent, newly exposed (overturned) rocks and the degree of slumping of previously built-up features. A partial control for affirming variation in weathering and slumping conditions in older (pre-Euro-American) features and, a means of determining approximate age, is available in the use of lichenometry-measurement of a slow-growing, high altitude lichen, *Rhizocarpon rhizocarpon*, that colonizes freshly exposed rock surfaces and grows from a central point outward at a relatively constant rate over time. Size-frequency studies of rhizocarpon growth by James Benedict (1985: 43-47, 90-106; 1996) have led to the creation of master lichen growth curve that has been used for more than two decades in the southern Colorado Rockies. Recent studies of several suspected ritual features in Rocky Mountain National Park have established significantly ancient ages ranging from AD 900 to 1200 (Cassells 2002, 2005). In addition to rock features, ethnographic consultations with Ute Elders established the spiritual nature of certain trails as conduits of spirit power and their religious association with sacred sites and sacred natural features in the physical landscape (Brunswig and Lux 2004; Lux 2004, 2005).

Figure 1. Rocky Mountain National Park Location.

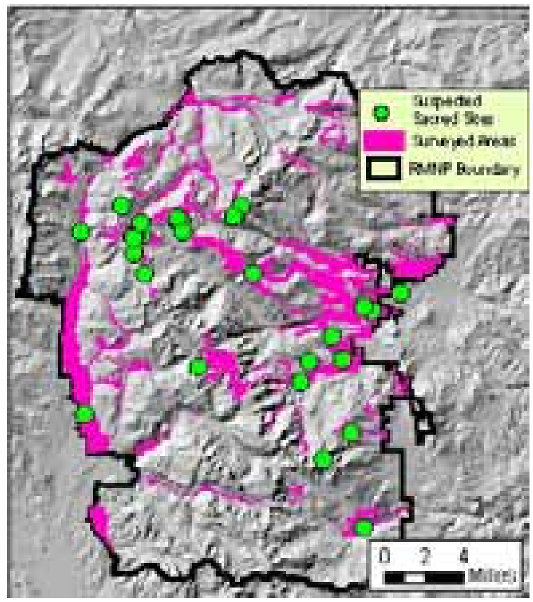


Figure 2. Suspected Sacred Sites.

In 2004, one of the two co-authors, Robert Brunswig, received a research contract to extend earlier archeological inventory based sacred landscapes research through high resolution analysis of earlier documented sites and conduct additional exploratory surveys for such sites within Rocky Mountain National Park. A previous inventory study of a large rock feature concentration in the tundra of the Park's Trail Ridge area had utilized sub-meter GPS technology to construct a site map accurate to within .5 m (Brunswig 2003). In 2005, a new, more accurate GPS unit (a Trimble Geo-XT™) was utilized to collect sub-meter spatial data on several previously documented but non-high resolution mapped sites and their associated features. The development of sub-meter resolution data sets for local site topography and precise feature locations has made possible GIS mapping and spatial modeling of suspected sacred sites at the "micro-level", an on-going project objective. A macro-scale project goal is GIS spatial-statistical correlation of topographic and environmental variables of suspected sacred sites and individual feature types throughout the Park in an attempt to derive patterns of distribution that, coupled with Native American ethnographic and ethno-historic evidence, may reveal elements of ancient cognitive landscapes created through a system (or multiple successive systems) of past native American beliefs and practices, cognitively imbedded in natural landscapes. A resulting GIS model, as accomplished in previous archeological GIS modeling studies in Rocky Mountain National Park (cf. Rohe 2003b, 2004), could be used to predict where such features and sites might be located and, subsequently, ground-truthed through surveys and, if identified, protected by park managers.

Conceptual Model for Sacred Features

During 2002-2003, a series of predictive models were developed by Christopher Rohe for Rocky Mountain National Park (Rohe 2003a). As part of the SAIP, Rohe created boolean, ordinal additive, and regression type predictive models for eleven categories of purely archeological sites, without reference to any possible ritual-ceremonial elements (see Table 1).

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	

Table 1. Predictive Models for Archeological Sites in Rocky Mountain National Park (Rohe 2003b)

Rohe's predictive models made use of 17 GIS layers (2003b, 26) which included: 1) each pixel's elevation above the nearest water source; 2) north/south and east/west trending slopes; 3) cost-distance to ridges; 4) cost-distance to water; 5) elevation and slope; 6) the local relief of an area and the relief above and below that area; 7) linear distances to ridges and water; 8) vegetation and vegetation variety; and 9) winter light (see Rohe 2003b, 124-125). His models provided numerous inferential criteria for modeling archeological sites in RMNP. However, the authors believe that the location of archeological sites with a strong religious component will not necessarily be based on the same criteria of sites designed, for instance, for procuring economic resources or following some terrain access routes (trails and passes). For example, Rohe's study indicated strong relationships between sites and various GIS hydrological class layers (Above Water, Cost Distance to Water, and Linear Distance to Water). However, water is generally available in most areas of the park (especially in high elevation areas, where most sites appear to be located). Furthermore, one might argue that a greater distance from water would be desirable for some types of sacred features. According to Ute elders, many vision quest sites are situated in highly remote locations where lack of sustaining resources, e.g., food and water, is desirable given the goal is physical exposure and abstinence from food and water for protracted periods of time. In such cases, a relative distance from water might actually be a desirable trait. During preliminary modeling done for this study the authors decided not to include water related variables.

Of more than 400 prehistoric and early historic Native American archeological sites in RMNP, an initial number of 31 site or feature cluster areas were identified as having well-established or highly probable Native American religious or ritual components (see Figure 2). These sites might include possible vision quest features, older cairns suspected as possible offering sites or possibly burials, and stone rings. A discussion of the methodology used to assess the age and possible use of these sites can be found in a detailed discussion of site 5LR7095 (Trail Ridge) (see Brunswig 2003 and the brief earlier methods discussion). Table 2 shows the generalized variables examined in our initial attempt to model sacred sites and landscapes in RMNP.

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.

Table 2. Conceptual Model Variables for Sacred Site Location in RMNP.

GIS data layers created for sacred site model variables are listed in Table 2. An elevation based lifezone layer provided representation of montane, sub-alpine, and alpine areas within RMNP (30x30 meter cell resolution). Terrain roughness was examined using Rohe's methodology of local relief within a 3 km radius. A number of layers were used to examine aspect; including aspect itself, and Rohe's methodology for CosAspect (for N-S trending) and SinAspect (for E-W trending) layers. Rohe's shelter layer (see Table 2) was replicated in an attempt to examine the authors' belief that many sacred sites are actually in exposed areas, rather in more sheltered portions of the park. While aware of the changing nature of vegetation communities over time, the authors still thought it important to see if vegetation or vegetation variety could aid in the modeling of sacred sites. Lux (2005) provided an analysis of ancient trails in RMNP. Many of the sacred sites appear to be close to these trails and therefore a cost-distance from ancient trails variable was included in the model. Consultations with Ute elders suggested four sacred landmarks within the Park might be important for inclusion in our model: Longs Peak, Specimen Mountain, Grand Lake, and Lava Cliffs. Viewsheds from these locations were created and analyzed. Undoubtedly, other GIS data layers (including those in Rohe's work) will need to be examined (some of these are discussed in the summary section) in future work. However, the ones listed above provide a reasonable and time-efficient first look at modeling sacred site locations in RMNP.

Using Weights of Evidence to Model Sacred Site Distribution

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). ArcSDM 3.1 provides the weights of evidence, logistic regression, fuzzy logic and neural network analysis capabilities. The extension works best when a specific evidential theme is reduced to just two classes, although multi-class data can also be used (Raines, Bonham-Carter, and Kemp 2000, 46). Weights of evidence was initially developed for mapping mineral potential (Raines, Bonham-Carter, Kemp 2000; Bonham-Carter 1994). The approach has also been applied to archeological site prediction in California (see Hansen 2000 and Hansen et al. 2002). Weights of evidence was used as an exploratory technique in analyzing and predicting sacred sites in RMNP.

Weights of evidence is a Baysian statistical technique that can combine data from different evidential themes to predict the occurrence of events. Each evidential theme is analyzed and an output consists of the odds of occurrence or logits (Hansen 2000, 4). The logits are converted to natural logarithms and are used to calculate a positive and negative weight for each characteristic (Hansen 2000, 4). These individual theme/layer weights can be combined to produce an overall probability surface. In the weights of evidence technique, a training point set can be the actual known events, or one can even use imaginary points/events for exploratory purposes. The result—the weights can be governed by expert opinion (Raines, Bonham-Carter, and Kemp 2000, 46). Predictive modeling in archeology has been criticized, in part, because of an "environmental determinist" bias, which removes the deductive, explanatory modeling that can provide depth of understanding site location (see Wheatly and Gilings 2002, 178-181). Weights of evidence modeling is conducive to the inclusion and exploration of other sources of data that, while not completely eliminating the concerns of predictive modeling critics, can at least lessen these concerns by including model elements obtained through deduction, interviews, and attendent methodologies. For example, as noted earlier, the authors include insights from Ute elders on the role of varying landscape and religious and sacred ceremony. Thus, the weights of evidence technique was viewed has having significant data exploratory advantages.

Preliminary Findings

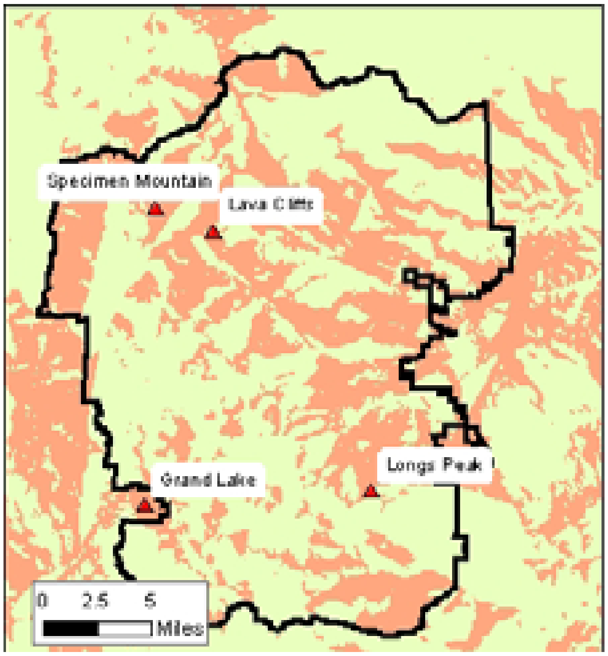
The weights of evidence method was used to explore all variables noted in Table 2. A series of "weights tables" were created for each layer and analyzed. A simple example can be represented by the viewshed layer. Table 3 shows a simplified weights table for that theme. The Class field represents non-visible (1) and visible (2 areas). The Unit Areas represents the .5

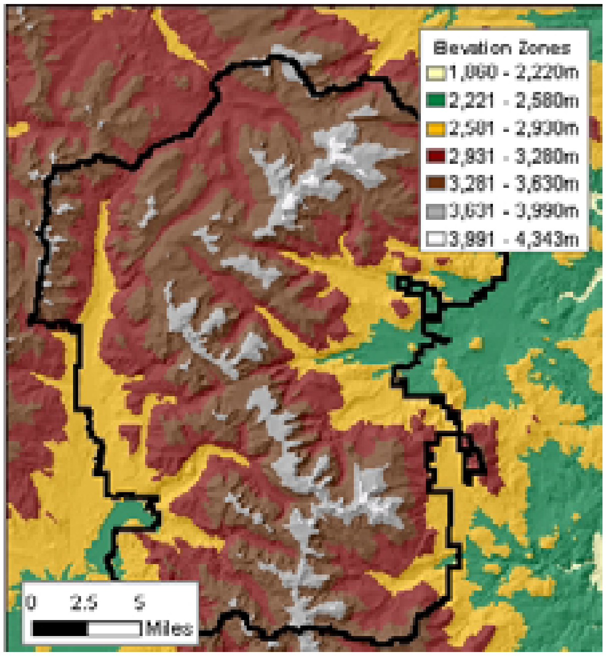
square kilometer unit area that was used to calculate the weights. The unit area for this preliminary study is likely too large and should be reduced. Large unit areas will inflate the final probabilities. The #Points field identified the number of sites that lie in each Class area. Documentation for the extension suggests that weights (W+) of .1 to .5 are mildly predictive, .5 to 1 moderately predictive, and 1 to 2 strongly predictive. The contrast (C) of the class can also provide a similar method of analyzing association. Most layers used in the weights of evidence modeling were in the end mild to moderately predictive. In addition, the weights of evidence method requires layers be conditionally independent from one another.

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

Table 3. Weights Table for Viewshed Layer.

The viewshed layer shows areas where at least one of four sacred landmarks was visible (see Figure 3). Viewshed was associated with the sacred sites layer, with 23 of 30 sites falling within the viewshed and found to be mildly to moderately predictive. Elevation was analyzed through creation of a elevation zone map which showed moderately predictive weights for higher elevation zones (see Figure 4).





Three additional variables, used in the model, were: 1) northerly facing slopes, 2) local relief, and 3) cost-distance to known prehistoric and early historic trails (see Figure 5). Measures of aspect, north-to-south facing slopes, and east-to-west facing slopes were examined. Slopes that trended toward north showed the strongest weights and this layer was the only aspect related theme used in the final analysis (see Figure 5a). Similar to Rohe's analysis (Rohe 2003b), local relief, local relief above an area, and local relief below an area were examined (all with a 3 km. radius) (Figure 5b). Overall local relief showed the strongest weights. However, both the above

and below relief layers also had strong weights. Above and below relief layers were not used because of the strong association between these layers and the elevation zones layer, thus breaking the rule of conditional independence. Visual inspection of maps suggested that many of the sites were fairly close to known prehistoric and historic trails. A cost-distance (using slope) from trails layer was used in the final analysis (see Figure 5c)
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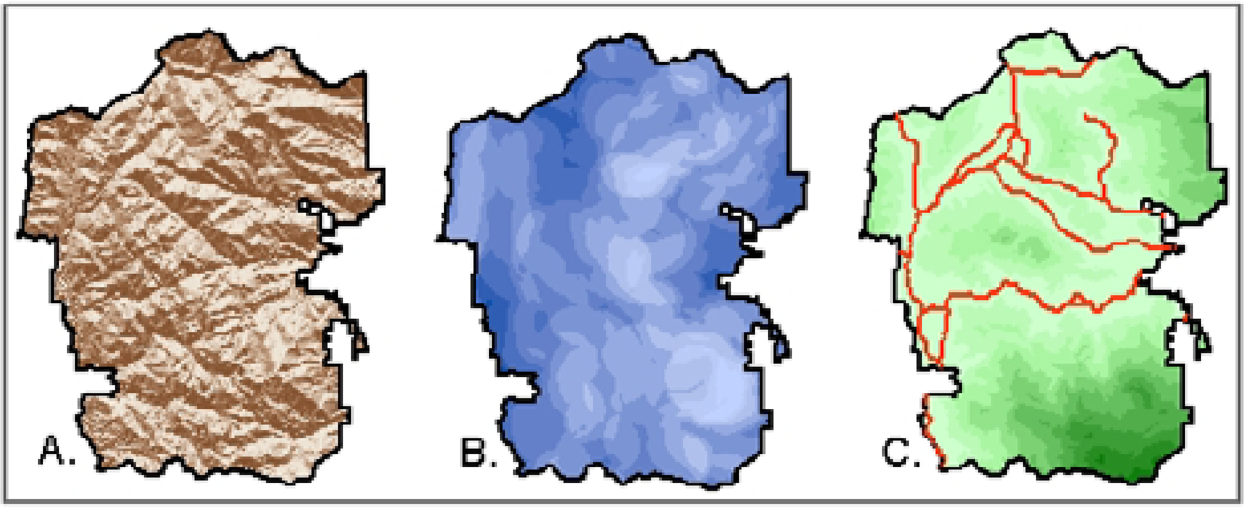

Figure 5. "A": Light colors represent more northerly facing slopes. "B": Light colors represents areas with great local relief. "C": Known and suspected prehistoric and historic trails (red). Cost-Distance surface from the trails (light green=less cost).

Two other variables were not used in the final analysis. Both vegetation and vegetation variety layers were created and examined using the weights of evidence method. Initial analysis of these layers did not show any strong weights. The vegetation layer also is partially dependent on the elevation zone layer; using vegetation could have broken the weights of evidence assumption of conditional independence. A shelter layer of exposure was also generated (see Rohe 2003b). This layer had calculated weights similar to the local relief variable. An attempt was made to use both of these layers in the final model. This resulted in decreased conditional independence—suggesting that these two layers were somewhat dependent on each other. Use of the local relief layer provided slightly higher conditional independence and probability measures.

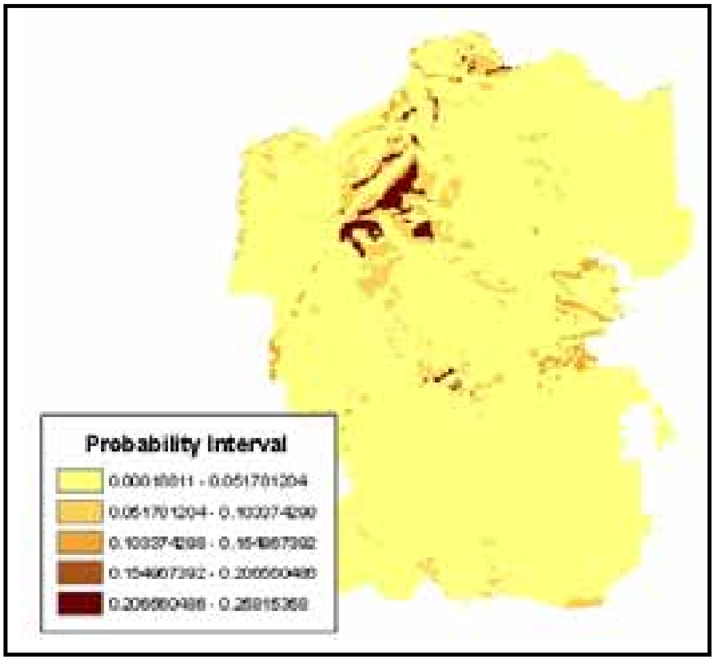

Figure 6. Preliminary Model Prediction Probabilities.

Figure 6 (above) shows the final model used in this preliminary exploration of sacred site prediction in RMNP. Because of the large unit area (.5 sq. km.) used in the analysis, probability numbers are likely significantly inflated. It is probably best for the reader to look at the probability numbers as a poorer-to-better scale. A few runs of the data were accomplished with a much smaller unit area (.01 sq. km.). The overall patterns were nearly identical—although the probability numbers were much lower. A smaller unit area also significantly increased computer processing time.

Summary and Future Work Needed

This study describes a first attempt to apply the weights of evidence method to the modeling of sacred sites in Rocky Mountain National Park. It was provisionally determined that representations of elevation, viewsheds of known sacred landmarks, local relief, north facing slopes, and nearness to known prehistoric and early historic trails were important variables for modeling sacred site locations with the current site data set. The study also indicates that the weights of evidence method is a valuable heuristic device for exploring data associations and testing hypotheses.

Assessing the significance of this model (or future ones) still needs to be done via further statistical testing and/or additional ground survey. Testing the statistical significance of the model will, in part, be accomplished by splitting the database into two randomly selected groups and using one group to test the other as the site data base grows (cf. Kvamme 1988). Unfortunately, the small sample size of this study did not allow for this approach. A more intense evaluation of earlier archeological work may turn up more sites that are suspected to have had significant ritual purposes, thus increasingly our sample size to a more acceptable level.

Our preliminary GIS analysis leads the authors to believe that a micro-level study of individual multi-feature sites or smaller multi-site concentration areas, could provide valuable insights to the overall modeling approach. One such site, 5LR7095, in the Park's Trail Ridge area, with its more than 180 rock features will provide an ideal case study for such an undertaking. Highly precision GPS data and environmental studies of this specific area are available (Brunswig 2003).

Other factors not tested in this preliminary study, which the authors intend to examine, include:

- Individual feature alignments to solar, astronomical, and other features.
- Role of geology—building materials for features, and whether rock/geology types help either individual archeological features our landmarks (like a specific mountain) "stand out".
- Viewsheds of individual sacred landmarks and there linkages to other sacred sites and landmarks outside of the Park boundaries.

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