PRELIMINARY PREHISTORIC HEARTH MAPS FOR WHITE SANDS NATIONAL MONUMENT

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Preliminary Prehistoric Hearth Maps for White Sands National Monument[1]

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ABSTRACT

Natural Heritage New Mexico, in collaboration with White Sands National Monument, presents a draft map of hearths, which are remnants of prehistoric campfires and roasting pits dating from the Archaic period to the Jornada Mogollon. The use of these hearths from ~1760 B.C. to 1290 A.D. changed the gypsum sand ($CaSO_4 \bullet 2H_2O$) to plaster of Paris/anhydrite ($CaSO_4 \bullet H_2O$)(White 2003) within the monument. The hearths are under continuous threat due to wind erosion where flying sand wears away their surfaces, thereby necessitating a comprehensive survey for the hearths. Midway through the interpretation of the imagery, 41 sites were groundtruthed. Sixty-three percent were positive for containing hearth sites, 24% were possible sites, and 12% were negative. We found a total of 882 possible sites within the study area (40,387 ha; 99,796 ac) with a majority of the sites falling between elevations of 1,214 and 1,220 m (3,983 and 4003 ft) along the southern and eastern margins of the study area.

ACKNOWLEDGEMENTS

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ON THE COVER

Hearth site within White Sands National Monument, provided by David Bustos.

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INTRODUCTION

The remnants of prehistoric campfires and roasting pits dating from the Archaic period and continuing to the Jornada Mogollon have been found within the monument (White 2003). The use of these hearths, which occurred from ~1760 B.C. to 1290 A.D., changed the gypsum sand ($CaSO_4 \bullet 2H_2O$) to plaster of Paris/anhydrite ($CaSO_4 \bullet H_2O$)(White 2003) making relatively small, hardened pedestals. To date, only 32 hearth sites had been documented at the monument, but many more were thought to exist (White 2003). Based on pollen analysis, the hearths from both the Archaic and Jornada Mogollon periods were used in a climate with greater moisture and rainfall than today. This suggests that ponds and playas were possibly more numerous then and that they served as hunting areas and sites for wild plant gathering and ultimately supported a significant human population during those periods. Accordingly, understanding the full extent and distribution of prehistoric hearth sites may help shed additional light on use of the monument by these ancient peoples. As a first step, we used remotely sensed imagery to develop a preliminary map of potential hearth sites based on image interpretation and field reconnaissance that is to be used as a basis for initial analysis and the planning of subsequent archeological studies.

STUDY AREA

White Sands National Monument lies within the Tularosa Basin bounded on the west by the San Andres Mountains and the Sacramento Mountains on the east. The monument contains approximately half of the White Sands dune field with White Sands Missile Range and Holloman Air Force Base having stewardship of the remaining dune field. Within the monument is a portion of the ancestral, glacial Lake Otero referred to as Alkali Flat and North and South Lake Lucero that form the numerous playas and alkali flats at the western boundary of the dunes and are the source for the dune field. Lake Lucero is the topographically lowest area within the basin (1,185 m; 3,888 ft) and largest playa within the monument with water levels that fluctuate seasonally depending on inflow and evaporation (Bennett and Wilder 2009). We photo interpreted a portion of the monument circumscribed by NPS personnel containing 40,387 ha (99,796 ac)(Figure 1).

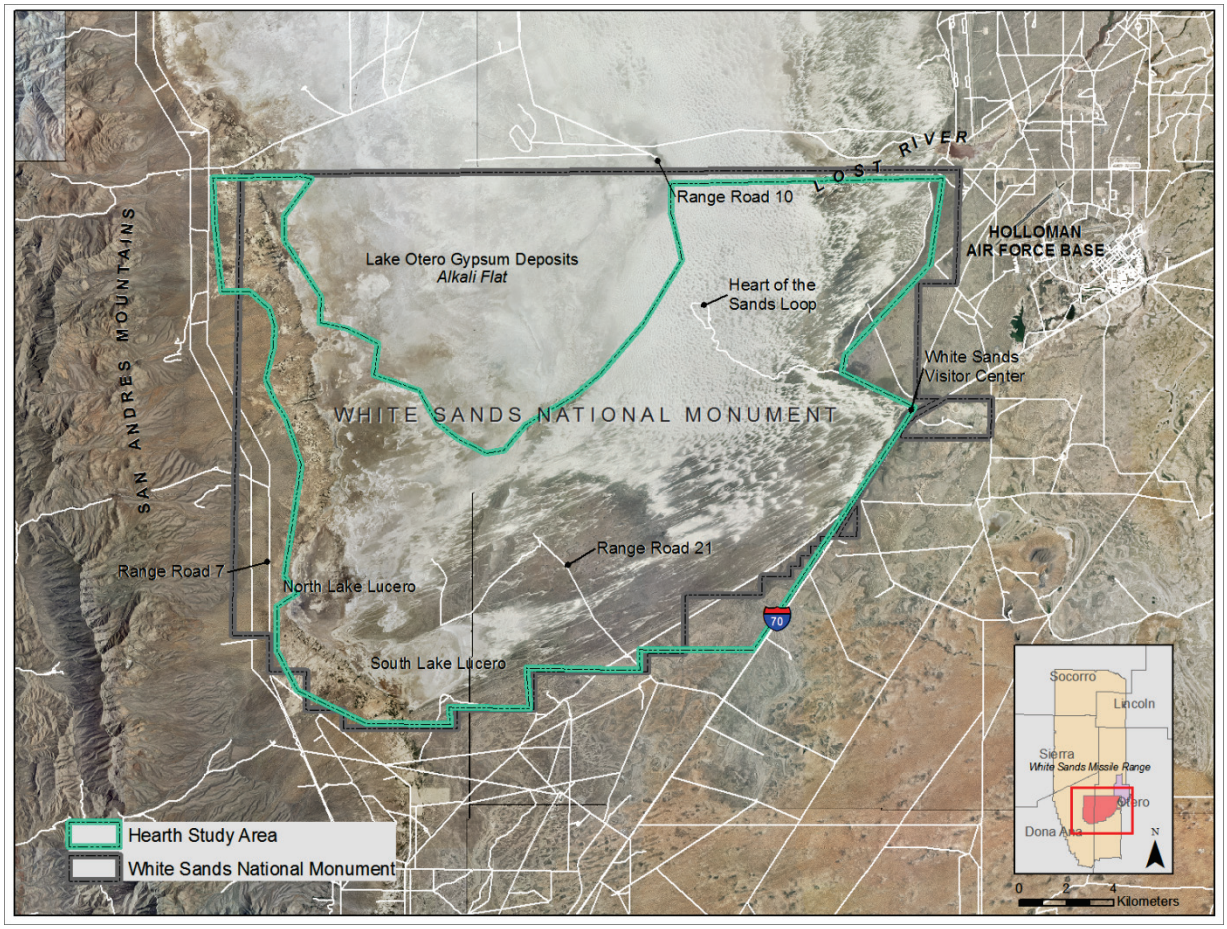

Figure 1. White Sands National Monument study area.

METHODS

Using recent (2003, 2005 and 2009) digital aerial orthophotography as the base, Natural Heritage New Mexico (NHNM) applied standard aerial photo interpretation techniques in a GIS to identify potential hearth sites. We were provided with a sample of 10 known hearth sites which we used to train the interpreters (Figure 2). The basic hearth image interpretation scenario was circular surface disturbance areas that were mostly within the interdune areas, but that could also occur on the gentle windward slopes of parabolic dunes and along the trailing arms.

The hearth map was based on available natural-color and color infra-red digital orthophotography acquired in June 2005 with a spatial resolution of one meter. Earth Data Analysis Center (EDAC) mosaicked the Digital Orthophoto Quarter Quadrangles (DOQQs) into a single file and added a Normalized Difference Vegetation Index (NDVI) as an additional band to emphasize areas of dense vegetative cover. The resulting image was a five-band file consisting of: visible blue, visible green, visible red, near infra-red, and the NDVI in bands one through five, respectively. We felt the NDVI and near infra-red band would be valuable in differentiating hearth sites from individual shrubs,

which tend to produce a similar visual expression with disturbance radiating out in a circle from the center of the shrub.

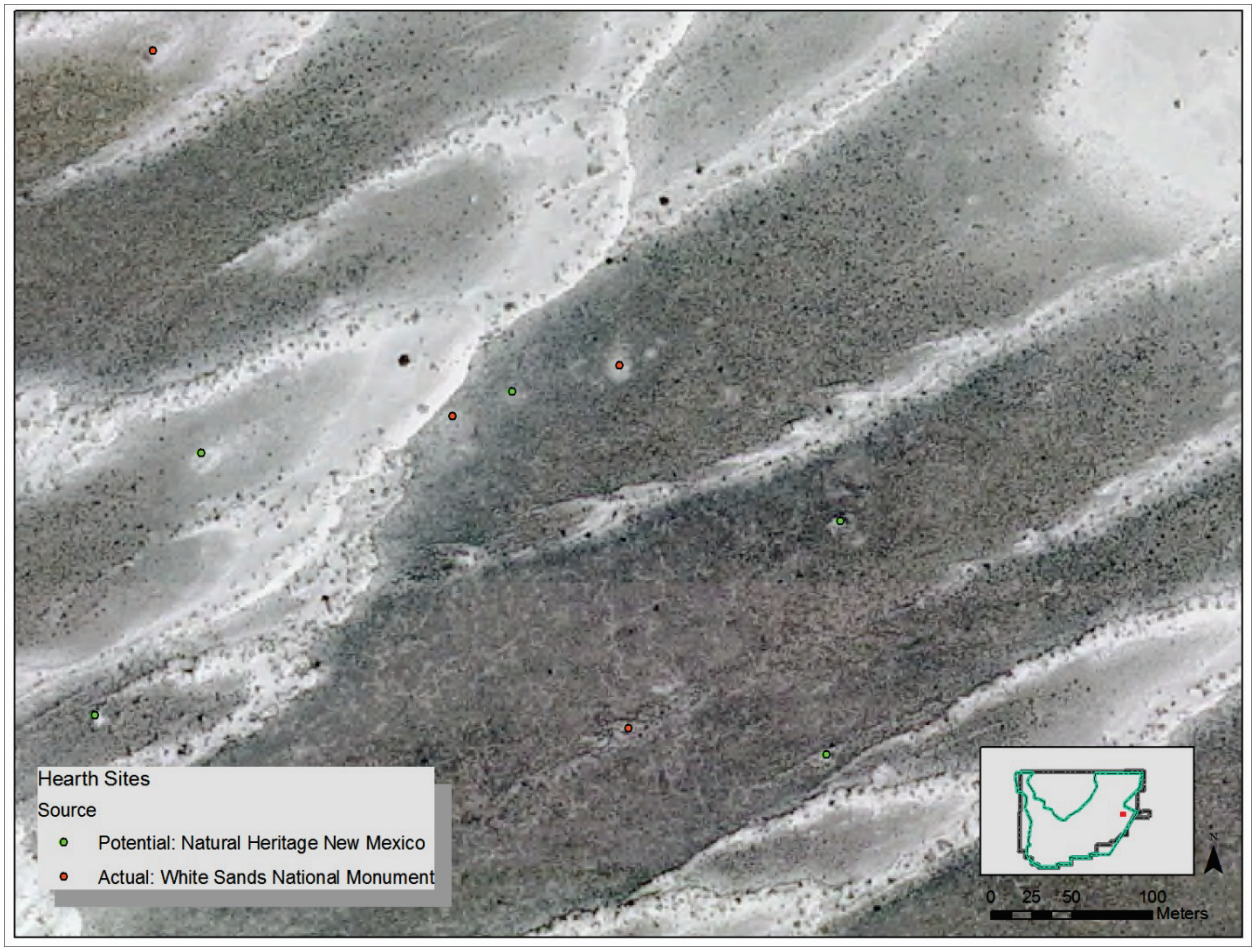

Figure 2. Hearth training sites and photo interpreted potential sites.

Image interpretation varied across the monument because of differences in albedo intensities and vegetative cover. To adjust for this , we alternated between the different image years (2003, 2005, or 2009) and altered the image-viewing properties by switching image-band combinations, trying various histogram stretches, and adjusting the brightness. For example, the NDVI caused over-saturation within the inter-dune swales in the northeast of the monument where there was high contrast between the unstabilized dunes and the vegetated inter-dunes. Additionally, shadows caused by the dunes tend to have high NDVI values which would give the appearance of high vegetative cover. Altering the display of the imagery helped the visual interpretation so that texture and color variation were further enhanced.

We systematically scanned the imagery to cover the study area and placed a GIS-point feature on the center of the location we identified as a hearth. Typically, we mapped at 1:3,000 scale but also found 1:6,000 useful for context. We created a grid of 101 cells comprising approximately 500 ha

(1,235 ac) each to cover the study area (40,387 ha; 99,796 ac) within which we tracked our progress. Over the period of the contract, three separate interpreters were used.

Field Validation

In March 2009, NHNM delivered to WHSA a GIS containing 394 potential hearth sites along the eastern portion of the study area for a preliminary validation of our interpretive methods. WHSA determined which sites to visit and conducted a validation sampling to support the mapping process.

Results

Preliminary Field Validation

By April 2009, WHSA had completed groundtruthing of 41 sites and found that 26 were confirmed hearths (63%), 10 were possible (24%), and 5 were negative (12%)(Figure 3). With these field results, and a review in a GIS of these potential sites, WHSA requested that we adjust our methods slightly to include additional sites that we had originally rejected, particularly within the south-central portion of the study area.

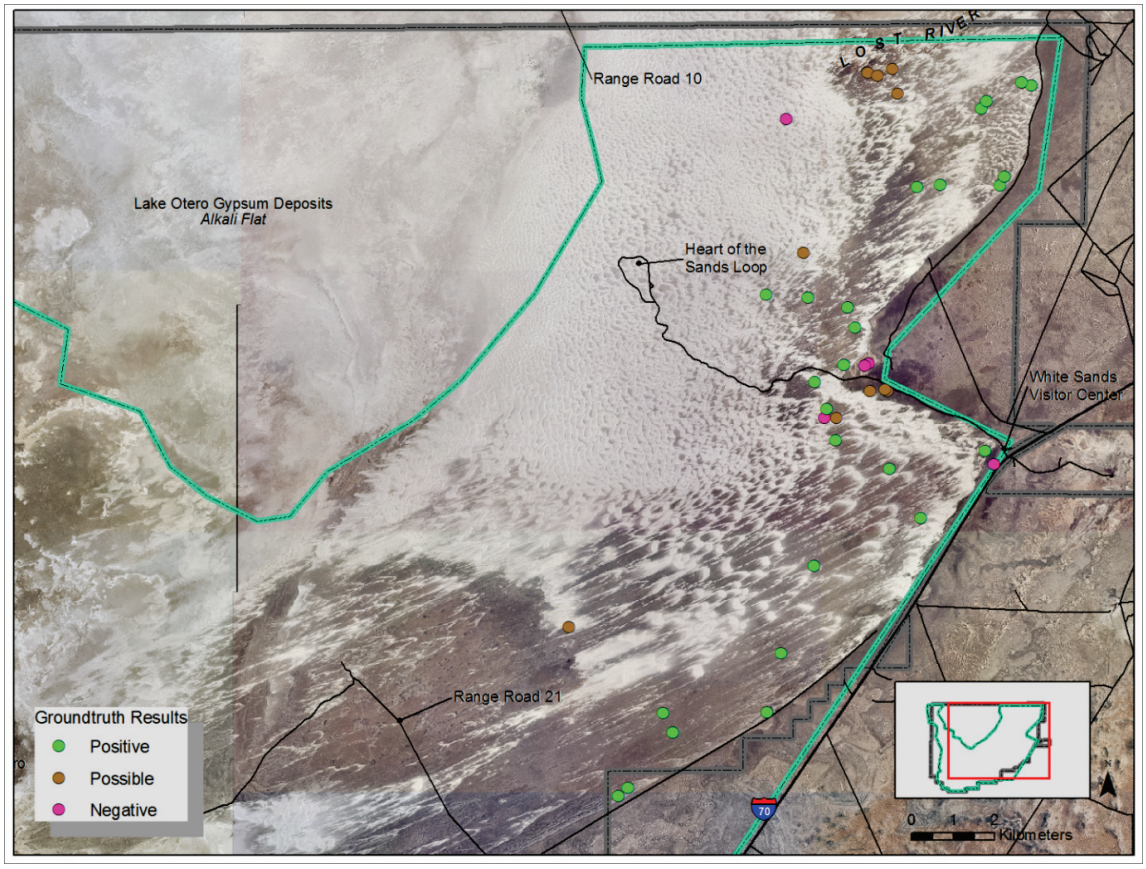

Figure 3. Preliminary field validation results.

HEARTH MAP OF WHITE SANDS NATIONAL MONUMENT

The photo interpretive survey of the study area yielded a total of 882 potential hearth sites (Figure 4). Potential hearths ranged in elevation from 1,186 to 1,245 m (3,891 to 4,085 ft) with the majority falling between 1,214 and 1,220 m (3,983 and 4,003 ft)(Figure 5). The hearth sites are significantly clustered (P-value =0.0, σ=26.48) and appear to have the most relictual remnants along the southern and eastern margins of the study area. After Seager et al. (1987), the eastern sites fall within the older gypsiferous lake floor and distal piedmont deposits while the southern sites fall primarily within inactive dunes and eolian sand. Field validation will determine whether the less numerous interdune sites within the active dunes, older lake deposits, young alluvial fans along the western margin, and Lake Otero gypsum deposits hold any evidence of hearth remnants.

The products developed under this project were placed onto a CD and delivered to the park and included: a digital copy of the report and GIS layers in ArcGIS 9.3 file geodatabase format. GIS layers include the point locations of potential hearths and the study-area boundary. The point-location layer includes the results of the field surveys as well as the coordinate information.

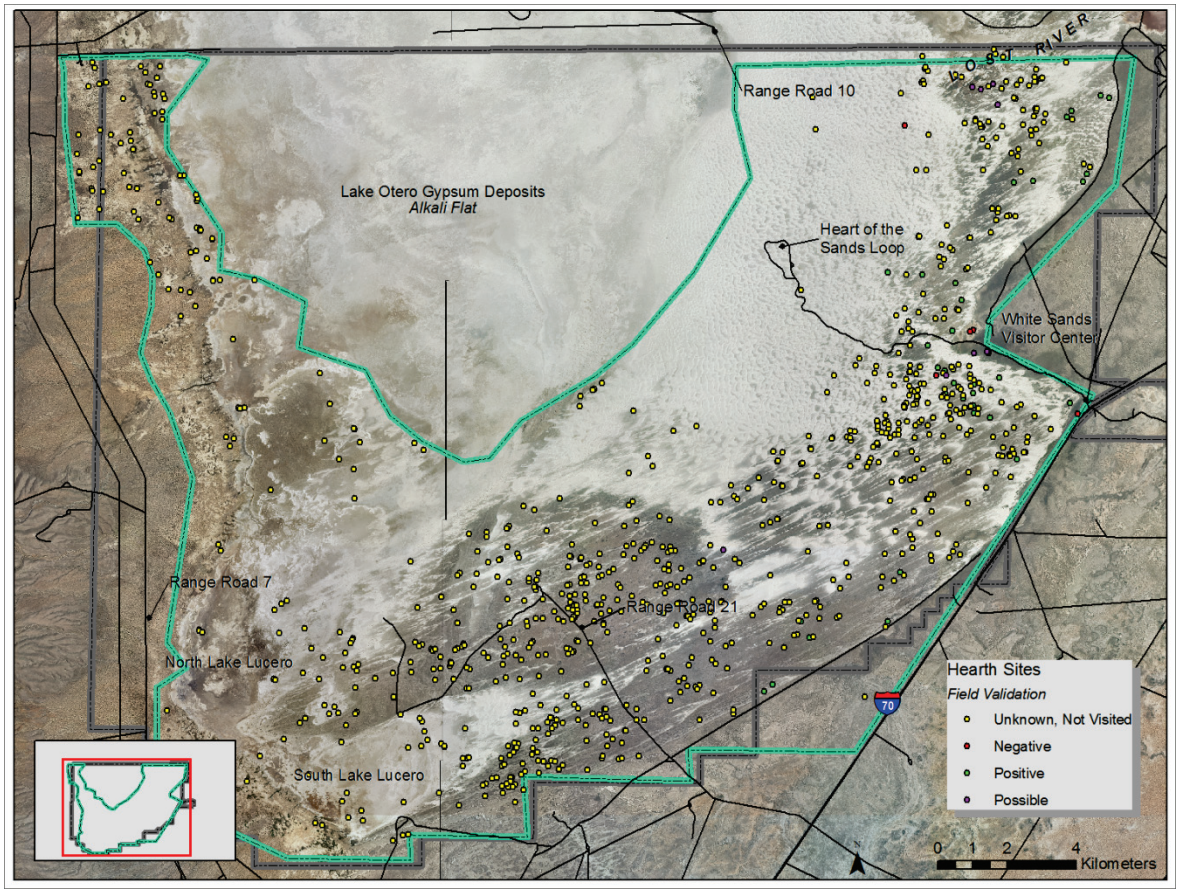

Figure 4. Potential and known hearth sites.

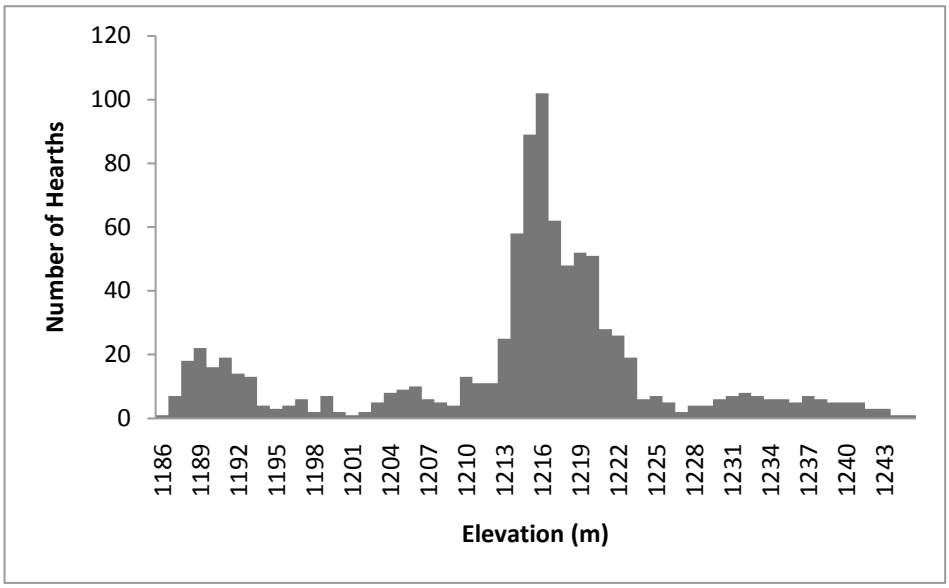

Figure 5. Number of potential hearths by elevation within the study area.

DISCUSSION

With this limited study, it appears elevation and surface geology are reasonable predictors for identifying potential hearth sites. Targeting field surveys to some of the outliers, such as those within the Lake Otero deposits and young alluvial fans, may help to narrow this model distribution of hearth sites within the monument and to be used as a predictor for other sites within the Tularosa basin. That is, using these predictors, a probabilistic surface model could be developed for the Tularosa basin as an aid to the aerial photo interpretation, thereby saving time on desktop surveys.

While there was informal testing at mid-project by park personnel that served as proof-of-concept on the photo interpretation rule base and line work for the map, no final accuracy assessment was conducted for the map. Regardless, the GIS can be updated after additional field surveys and augmented with additional information such as surveyor and date.

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