# Investigating Post Fire Archaeological Site Vulnerability:

## *A Multi-Component Approach*

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## *Introduction*

Geographic Information Systems or GIS are now an integral part of archaeological work both in terms of Cultural Resource Management (CRM) as well as academic and private archaeology (Dore & Wandsnider 2006). GIS are currently used to manage large databases of archaeological site location information, create models which predict site locations, as well as investigate patterns in human behavior (Alblas 2012). However, using GIS in archaeological work is not limited to these approaches (Lock & Harris 2006).

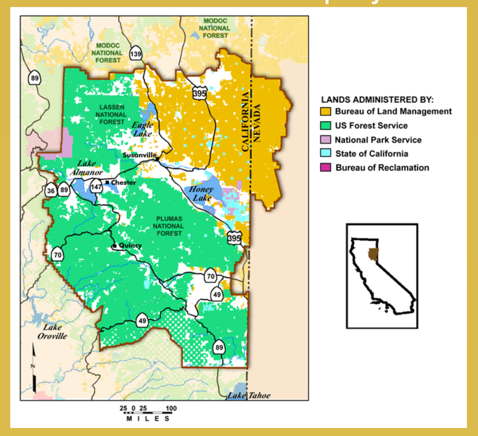
The impetus for this project is to assess the vulnerability of these sites in the Bureau of Land Management, Eagle Lake Field Office to looting after a devastating fire in August 2012. Goals for this project also include investigating potential site locations in order to monitor site condition.

*Photograph of damage to historic telephone line by Rush Fire.*

The 2012 Rush Fire ravaged over 315,000 acres in less than a month and was one of the largest fires in California to date. It left archaeological sites once covered in vegetation vulnerable to looting, erosion, and possibly caused the loss of vast amounts of archaeological data. Looting in particular is a major threat to cultural resources through out the world and is one of the most destructive forces facing archaeological sites in Northeastern California.

This project takes a multicomponent approach to investigating vulnerability. It asks the question of where are unrecorded sites likely to be located? By identifying these areas they may be monitored more carefully. A predictive model of unknown prehistoric archaeological site locations was created based on a variety of variables. It provides a range of probability for sites to be located within the area affected by fire. Viewshed was used to assess vulnerability of historic structures from roads within the project area.

Over 500 sites are known to exist within the fire perimeter. However, in terms of site record completion, not all of these archaeological sites were able to be assessed for the purpose of this project. In total, 211 sites within the burn area were identified for use in this project.



*Map indicating area of concern, courtesy of the Bureau of Land Management.*

This project is intended to serve as a pilot model for other similar predictive models. The model will be tested by archaeologist during the 2013 summer field season and the model may be expanded in the future to include the entire Eagle Lake Field Office area.

## *Methods*

<u>Archaeological Site Location Predictive Model:</u>

A predictive model indicating probability of finding prehistoric archaeological sites within the Rush Fire burn area was created in order to identify areas of concern for site monitoring and assessment. This model predicts the location of sites based on distance to streams, known archaeological site locations, elevation, slope, and aspect (or "northness"). Distance to riparian areas and hiking time needed to travel through the area were also considered but significance tests proved them to be not significant variables.

### Northness:

Northness, or the degree to which north or south slopes were favored for site location by prehistoric occupants of the area was calculated using the following equation:

Northness = cos ((aspect in degrees * PI)/180))

This produces a variable on a scale from 1 to -1, 1 being most North and -1 being most South. It also allows this variable to be used as part of a linear regression calculation.

### Hiking:

Hiking, or the time it would take prehistoric occupants to travel through the area on foot was also considered. Using Tobler's Hiking Function (Tobler 1993):

Walking time = 6 exp ( -3.5 * abs(slope + 0.05))

This equation estimates that walking time will be about 5km/hr though a given area.

### Statistics:

A set of points were created to represent random sites or in this case "non-sites" were selected. All variables (Elevation, Slope, Northness, Distance to Streams, Distance to Riparian Areas, and Hiking Time) were all tested to assess whether there was a significant difference for known sites versus random non-sites. All variables appeared significant to the 0.05 level except hiking time and distance to riparian areas, which were not statistically significant. Using a co-linear test all variables appear to be independent.

### Logistic Regression:

Logistic regression is an equation that can be used to predict the probability of site presence or absence in an un-sampled area. In this case, it is based on the sample area of site and non-sites as well as environmental variables (Hatzinikolaou 2006, Kvamme 2006). For this project known sites, non-sites, distance to streams, slope, elevation and northness were considered. The following equations were used in raster calculator:

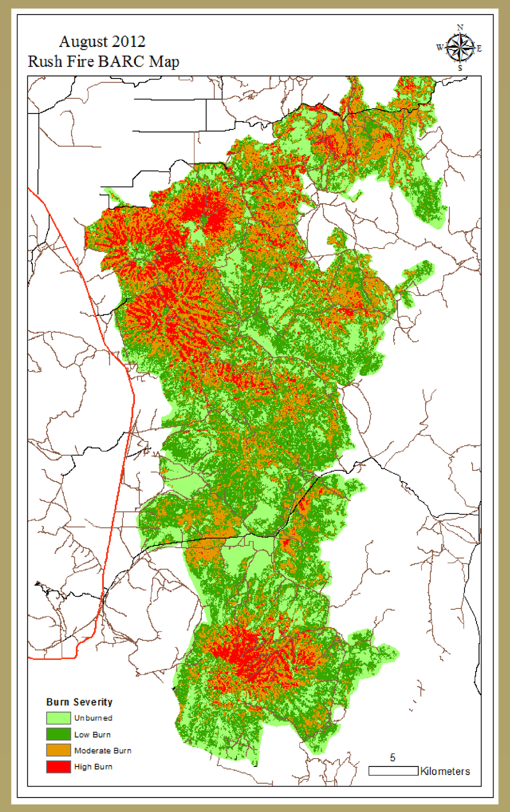
Sites = 13.841 – 0.0079(elevation) – 0.004826(streams) – 0.239856(slope) – 0.437441(northness)

Probability = 1/(1+ exp(-(constant + (x1 *map1) + (x2 * map2)))

<u>Burned Area Reflectance Classification (BARC) Map:</u>

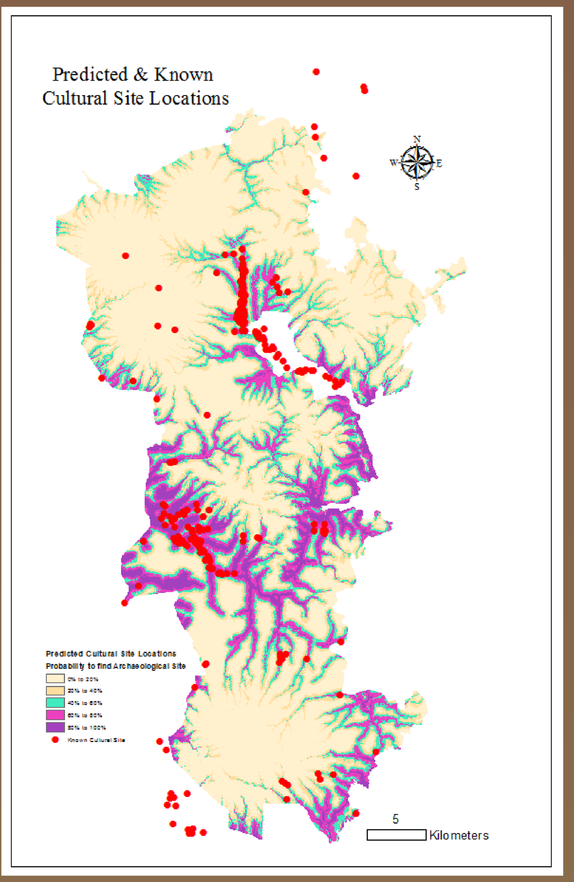
To understand which sites have been affected by the fire, a BARC map was acquired to assess burn severity at each of the archaeological sites. BARC maps are created through satellite near- and mid-infrared reflectance values which indicates what the severity of the damage to vegetation has been. The map returns a range of values which can be used to assess the burn severity (USDA Forest Service):

- Unburned / Very Low = < 75
- Low = 76 – 109
- Moderate = 110 – 187
- High = > 187




During the course of the past year, 55 sites were visited for inspection and only 17 of these were actually in areas which had been burned. This represents the intent of the BARC map to be a post-fire restoration planning tool and indicates that its reliability must be investigated through on the ground field research.

## *Data & Results*




The predictive model for archaeological sites within the Rush Fire burn area had interesting results (see map to left). In terms of northness, prehistoric archaeological sites seem to be located primarily on southern aspects, which was not expected. These tend to be hot in the summer and the area receives little cover. This may reinforce the theory that this area or parts of it is likely a winter habitation zone. Some parts of the area, particularly in the region around Deep Creek are known to have winter habitation sites in high densities. Prehistoric occupants in the area created winter dwellings using local brush and animal skins, warmth and sun exposure would likely be valued in these situations.

Lower slopes had a higher probability of archaeological sites as did lower elevations. These are not surprising results as most people would not want to live or camp on a steep slope or a mountain top with little cover. In general, areas that had high densities of known sites were fairly flat, near some kind of seasonal or permanent water source.

Less than 10 known sites fall within the lowest range of probability (0 to 20%) for predicted site locations. Further research indicates that these sites may not be accurately represented in terms of location. One site location was based on a description from a early 1900s manuscript while other site locations were recorded well after the fieldwork was completed. The rest of the sites in question were petroglyph site, the location of which is often unpredictable, generally only restricted by the location of suitable rock outcroppings and human ingenuity.

Finally, a viewshed analysis was conducted on all historic sites within the burn area. These sites are all European contact period to 50 years old in age. They are all visible from fairly well traveled roads and likely already heavily looted.

## *Conclusions*

GIS is an immensely important and useful tool for archaeologists. Those archaeologists monitoring thousands and sometimes as is the case at BLM ELFO, over a million acres of land find this tool to be a fundamental part of their work. GIS has a huge range of applications for archaeology. From simply recording an individual archaeological site, managing thousands of sites, creating predictive models, identifying trade routes and territories, etc., GIS is widely applicable.

In this project the breadth of work was focused on creating a predictive model for currently unknown archaeological site locations within the 2012 Rush Fire burn area. Using logistical regression, this created a map indicating the probability of finding sites within the burn area. This predictive model appears fairly accurate with only a few known sites falling within the predicted 0 to 20% predicted site probability area. Upon further investigation, these the integrity of the location of many of these archaeological sites tended to be suspect.

Within the what appears to be the moderate to high burn areas there were 55 sites have been identified as significant by the Eagle Lake Field Office Archaeologist. Fieldwork in the past year has indicated that only 17 of these were burned severely so further fieldwork must be done in order to understand how many sites were truly affected by the fire.

Viewshed analysis showed that all historic sites (archaeological sites aged 50 years old to European contact) recorded within the burn area were visible from a road and therefore had a high likelihood for looting.

## *Discussion:*

As with any study, this project faced a number of limitations. These included varying quality of data available. While it is known that there are some 500 sites or more just within the burn area, only 211 of these sites could be used for the purpose of this project. This had to do with incomplete data for the known archaeological sites as well as poor site recording techniques. Other issues have to do with the way in which archaeological work is conducted in a management situation (Dore & Wandsnider 2006). Little information was available about each of the sites in the project area. While this project only created a predictive model for prehistoric sites, it did not take into account the type of site or interpretation of site use. This makes the model very broad. In the future creating predictive models based on habitation sites, hunting sites and other site types may prove more useful and accurate. Finally, it is important to note that humans do not always act rationally and in a way that may be predicted, this will inevitably lead to site location which may never be modeled.

## *References*

Alblas, Linda
2012 Archaeological Visibility Analysis with GIS. The Council of European Geodetic. Surveyors. Department of Archaeology, University of Glasgow.

Dore, Christopher D. and LuAnne Wandsnider
2006 Modeling in a Compliance World. *In* GIS and archaeological site location modeling. Mark W. Mehrer and Konnie L. Wescott, eds. Taylor & Francis Group: Baton Rouge, FL.

Hatzinikolaou, Eugenia G.
2006 Quantitative Methods in Archaeological Predixction: From Binary to Fuzzy Logic. *In* GIS and archaeological site location modeling. Mark W. Mehrer and Konnie L. Wescott, eds. Taylor & Francis Group: Baton Rouge, FL.

Kvamme, Kenneth L.
2006 There and Back Again: Revisiting Archaeological Location Modeling. *In* GIS and archaeological site location modeling. Mark W. Mehrer and Konnie L. Wescott, eds. Taylor & Francis Group: Baton Rouge, FL.

Lock, Gary and Trevor Harris
2006 Enhancing Predictive Archaeological Modeling: Integrating Location, Landscape, and CUlture.. *In* GIS and archaeological site location modeling. Mark W. Mehrer and Konnie L. Wescott, eds. Taylor & Francis Group: Baton Rouge, FL.

Tobler, Waldo
1993 NON-ISOTROPIC MODELING. In THREE PRESENTATIONS ON GEOGRAPHICAL ANALYSIS AND MODELING. NATIONAL CENTER FOR GEOGRAPHIC INFORMATION AND ANALYSIS. TECHNICAL REPORT 93-1.

USDA Forest Service
Remote Sensing Application Center. http://www.fs.fed.us/eng/rsac/baer/barc.html. Accessed: April 9, 2013.

Wescott, Konnie L. and James A. Kuiper
2000 Using a GIS to Model Prehistoric Site Distribution in the Upper Chesapeake Bay. In Practical Applications of GIS for Archaeologists: A Predictive Modeling Kit. Konnie L .Wescott. and R. Joe Brandon, eds. Taylor & Francis Group: USA.

Wheatley, David
1995 Cumulative Viewshed Analysis: a GIS-based method for investigating intervisibility, and its archaeological application. http://www.southampton.ac.uk/~dww/Cumulative/. Department of Archaeology, University of Southampton.

Wheatley, David and Mark Gillings
2002 Spatial Technology and Archaeology: the Archaeological Applications of GIS. Taylor and Francis Group: London