A Model to Study Fire Effects on Cultural Resource Studies of Mesa Verde

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Abstract. On 8 July 1989, lightning struck the dry terrain of Long Mesa in Mesa Verde National Park and ignited a 2-week burn that scorched 1,200 ha. As a result, park management initiated studies of the effects of high-intensity fire on cultural resources. Mesa Verde National Park was established to protect works of prehistoric humans including pit-houses and cliff dwellings of the Anasazi. Later, park management was charged with the preservation of historic buildings and wood structures of 20th-century Americans. Our research will provide the necessary background information to predict specific fire effects on cultural sites. We mapped the vegetation communities, reconstructed the prehistoric fire history of half of Mesa Verde, and will document postfire succession. These data sets, incorporated into spatially explicit layers in the park's Geographic Information System, will be used to model the risk and specific effects of fire as related to particular classes of cultural resources.

Key words: Anasazi, postfire succession, vegetation mapping.

Mesa Verde is a series of north–south mesas in sandstone and shale substrates. Mancos Shale of marine origin is topped by Point Lookout Sandstone, then covered in parts of Mesa Verde National Park by the diverse Menifee Shale. The Cliffhouse Sandstone is exposed above these formations, and it is in this final layer that the most impressive cliff dwellings were built (Griffiths 1990). Water is ephemeral throughout the Mesa system—seeps and springs are infrequently encountered. The Mancos River forms the eastern boundary of the park and provides the only perennial water source.

We focused our postfire succession study on Long Mesa, the site of the 1989 fire that burned 1,200 ha. Long Mesa, one of the western mesas, ranges in elevation from 2,180 m in the south to 2,517 m at the north end. Long Canyon floor is 2,133 m. The vegetation on Long Mesa is a mosaic of mature piñon–juniper woodlands and mountain shrub associations. Shrub associations range from oak (*Quercus gambelii*) and serviceberry (*Amelanchier utahensis*) to sagebrush (*Artemisia nova*) and bitterbrush (*Purshia tridentata*).

Piñon (*Pinus edulis*) and juniper (*Juniperus osteosperma*) woodlands dominate the lower, southern ends of the mesas, whereas mountain shrub communities dominate on the northern ends. Differential fire frequency is hypothesized to be the major factor controlling this pattern (e.g., Erdman 1970). Douglas-fir (*Pseudotsuga menziesii*) forms dense stands on the north escarpment or on steep north-facing slopes. Ponderosa pine (*Pinus ponderosa*) is found in a few limited stands in Morefield and Prater canyons and in isolated pockets elsewhere. Scattered, small deciduous forest communities include aspen (*Populus tremuloides*) and maple (*Acer* sp.).

Methods and Preliminary Results

Mapping of Vegetation and Woody Fuels

The first step in modeling the effects of fire on cultural resources was to compile a digital map to define the vegetation of Mesa Verde to accurately predict the fire potential of each plant community. Landsat TM and SPOT panchromatic scenes from May and June 1990 were used as a spatial and spectral base. An unsupervised classification of the image and initial field surveys showed that 17% of the image was in shadow and that important vegetation characteristics were obscured. To mitigate the topographic effects in the image data, a transformation was used to separate the spectral and illumination information (Pouch and Campagna 1990). The transformed image was then reclassified. Ground-truth efforts guided by this reclassification were made with relevé stand analyses (Mueller-Dombois and Ellenburg 1974) of more than 300 sites, each located with a Trible Basic Pathfinder Global Positioning System (GPS). Species cover and abundance ratings were clustered with TWINSPAN, a multivariate clustering program (Gauch 1982). This ordination was used to guide the final supervised classification of the image data with training signatures from the mean spectral signatures of the clustered sample points. In this way, the spectral and field information were related to one another.

Woody fuels were assessed in a subsample of the sampling points ($n = 26$). Canopy fuels—dead snags and woody fuels in live trees and shrubs—were measured (Meeuwig and Budy 1981). Downed fuels were sampled on transects with the plane–intercept method (Brown 1974). These data will be used in the fire behavior model BEHAVE (Burgan and Rothermel 1984) to predict the fire potential within the major vegetation communities in Mesa Verde National Park.

Fire History and Fire Effects

Our study of fire history and fire effects at Mesa Verde Park had two objectives (Floyd-Hanna and Romme 1993*[1]). First was to document the postfire succession patterns following the 1989 fire on Long Mesa. This large fire affected at least three different vegetation types—piñon–juniper, mountain shrub, and Douglas-fir. Three permanent sampling grids containing 291 sampling points were established to document postfire patterns. Percent cover of plants, litter, or bare substrates was recorded in 1991, 1992, and 1994.

The second objective was to develop and apply a method of dating past fires in Mesa Verde (for background see Arno and Sneck 1977; Romme 1982). Because few fire-scarred trees are in Mesa Verde National Park and no unequivocal fire scars were located, we developed a method to age shrubs, which resprout vigorously after fires, using annual ring counts to determine their time of origin. All dominant shrub species were sampled and aged in the historically documented 1934, 1959, 1972, and 1989 burns. Although there is some variability within an individual plant as to the date of shoot emergence, we determined that by selecting the centermost shoot and restricting ourselves to the species *Quercus gambelii* we could determine reliably the known fire date. In

[1]Asterisk indicates unpublished material.

1992 and 1994, we applied this method to sample areas of unknown fire history in the northern portion of Mesa Verde National Park.

Results of the postfire succession sampling indicate that perennial resprouting has returned the cover of the northern sector of the burn to a shrub-dominated community much like the prefire community, whereas the southern burned areas (formerly piñon–juniper) are proceeding through a herbaceous phase of succession. The effects of prefire vegetation have been significant, and previous fire history has also affected the postfire successional patterns since the 1989 fire. Noxious weed invasion of the southern end of the fire is becoming an increasing problem.

Using the technique to age shrubs, we successfully identified and mapped prehistoric fires that occurred between 1850 and the 1920's. The median fire return interval varied from 55 years in the west to greater than 130 years in the eastern portion of the sampling area.

Discussion

Effects of Fire on Cultural Resources

These data will allow us to predict the probability of occurrence and the effect that a fire might have on a given type of archaeological site, depending on its location in the landscape. Data layers, each spatially defined for points or extrapolated to areas, will be as follows (Figure):

1. Median fire interval—expressed as a probability of occurrence: high = 0.02 (from a 50-year fire return interval), medium = 0.01 (from a 100-year fire return interval), and low < 0.01 (for fire return intervals greater than 100 years).
2. Vegetation—fuels and fire intensity potential—expressed as high, medium, or low intensity. High potential occurs in Douglas-fir forests or piñon–juniper woodlands, medium potential occurs in sparse piñon–juniper woodlands, and low potential occurs in mountain shrublands and meadows.
3. Significant and vulnerable cultural resources—Although all cultural resources at Mesa Verde have intrinsic value, some are more vulnerable to fires than other. The following classification was

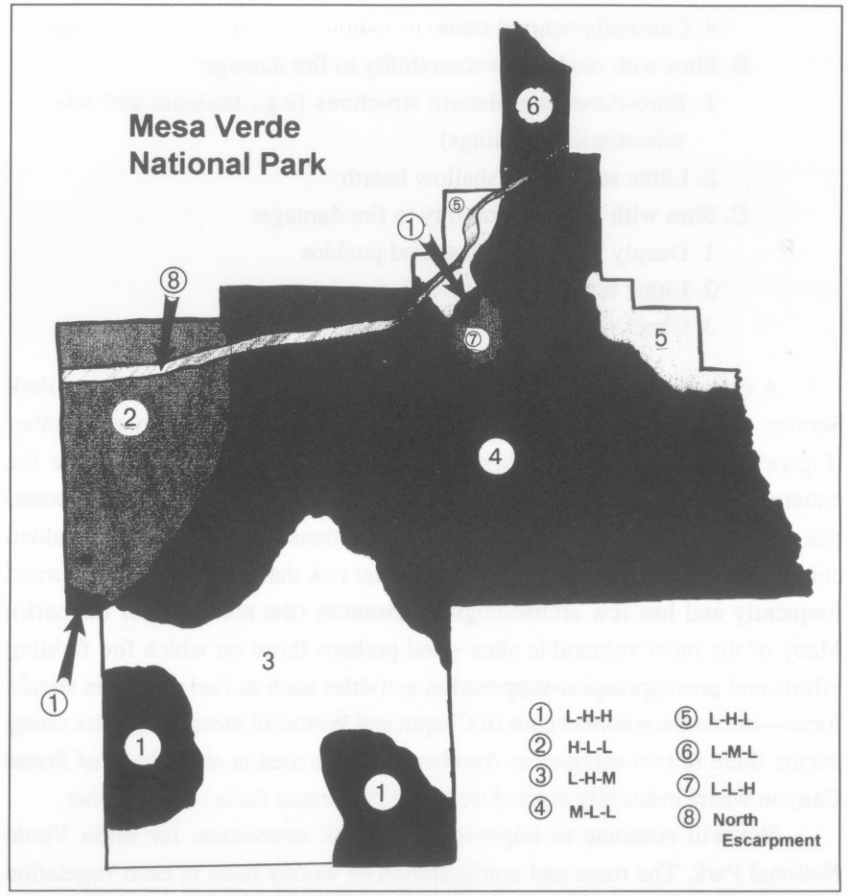

Figure. A fire-risk summary of Mesa Verde National Park showing fire probability–fire intensity–vulnerability of cultural resources; L = low; M = medium; H = high. This is a simplified example of three layers for illustrative purposes.

developed by a group of archaeologists, ecologists, and fire behavior specialists (Romme et al. 1993):

A. Sites with high vulnerability to fire damage:
   1. Native American historic structure (e.g., sweat lodges and corrals)
   2. Alcoves and cliff dwellings containing organic materials (e.g., packet rat middens, wooden beams, corn cobs)
   3. Rock-art panels

4. Culturally-scarred trees

B. Sites with moderate vulnerability to fire damage:

1. Euro-American historic structures (e.g., museum and administration buildings)
2. Lithic scatter and shallow hearth

C. Sites with low vulnerability to fire damage:

1. Deeply buried, unexcavated pueblos
2. Lithic scatter
3. Check dams

A risk model is being developed by the authors and other National Park Service personnel where these three categories of risk overlap each other (Figure). Although each data layer is not yet complete, we begin to see the pattern of fire risk at Mesa Verde National Park as a mosaic of superimposed risk probabilities. For example, an area with dense fuels and highly valued cultural sites such as Chapin Mesa is at higher risk than an area that has burned frequently and has few archaeological resources (the north end of the park). Many of the most vulnerable sites—and perhaps those on which fire fighting efforts and presuppression-suppression activities such as fuel reduction should focus—are on the southern ends of Chapin and Wetherill mesas. High risk rating occurs there in two categories. Another high risk area is at the head of Prater Canyon where culturally scarred trees and dangerous fuels exist together.

We will continue to improve on the risk assessment for Mesa Verde National Park. The mass and configuration of woody fuels in each vegetation type will be used to predict actual fire behavior under particular sets of weather conditions (e.g., using BEHAVE, a fire behavior model), and this information will add significantly to our modeling potential. Fire history will be determined for the northeastern and southern portions of the park in 1994. Completion of the inventory and mapping of cultural sites in 1994 and combining of these data with the risk model will allow accurate assessment of the vulnerability of archaeological sites to fire.

Acknowledgments

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