FIRE EFFECTS AND FIRE HISTORY OF MESA VERDE NATIONAL PARK

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♦ INTRODUCTION

Mesa Verde consists of a series of mesas in a north to south trend. The mesa tops are narrow strips, cut by numerous canyons of varying depth. Mesa Verde sandstones, particularly the Cliff House Formation, form the canyon slopes. Long Mesa, an area of focus in this study, has an elevation 2180 m at the south to 2517 m at the north end. Long Canyon cuts down to an elevation of 2133 m. The vegetation on Long Mesa is a mosaic of mature pinon-juniper woodlands and mountain shrub associations. Shrub associations range from Gambels oak, (*Quercus gambelii*), and serviceberry, (*Amelancheir utahensis*), to Black Sagebrush, (*Artemesia nova*), and Bitterbrush, (*Purshia tridentata*).

Although there is a body of information concerned with the effect of fire on pinon-juniper woodlands, there are no adequate studies of the shrub-rich pinon-juniper ecosystem of Colorado. Succession following fire was documented by Erdman (1970) in Mesa Verde National Park. He reported that annuals dominate initially, then perennial grasses and forbs, followed by shrub invasion. The open shrub stage becomes a "thicket" approximately 100 years after the fire. The shrubs, he suggests, are outcompeted by pinon (*Pinus edulis*) and juniper trees (*Juniperus osteosperma*), which dominate by about 300 years.

Fire and its relationship to resource management in Mesa Verde National Park has been outlined by Omi and Emrick (1980). Focus was given to succession (cover and frequency of grass and shrub elements) following the 1873, 1934, and 1972 fires, and models predict the possibilities of control over moderate and severe fires in various vegetation classes within the Park. The study was concerned primarily with the nature of fire behavior and various fire-related management tools for use by resource management personnel.

Our observations suggest that there may be considerable heterogeneity in early post-fire successional patterns across a range of habitat types and fire severity within Mesa Verde National Park. Of particular interest is the distinct lack of pinon and juniper seedlings and saplings in all shrub associations on the northwest end of the Mesa. Thus, we cannot predict a successional pattern leading to a pinon-juniper woodland, such as found on the southern end of the Mesa, for other areas of the Park. We have developed two tentative working models which will provide the framework for the 1992 field season. The model of fire behavior and vegetation patterning of north-central Mesa Verde differs from that of south-central Mesa Verde in several critical respects. Differences in substrate, derived from Cliffhouse sandstones in the south and Menifee shales in the north, and geographic position relative to the wind patterns (upwind or downwind from potential ignitions), play critical roles in fire behavior and recovery. Our model also predicts a north-south variation in fire behavior that results from severity and frequency of previous fires, and the subsequent successional seres which result from the past fire experience. The effects of fire on small mammal and avian populations must also be considered, as pinon-juniper invasion is tied closely to desperser and predator activity (e.g. Ligon 1978). The masting reproductive cycle of pinon (Floyd and Richardson 1984) also affects potential regeneration within the fire cycle. Juniper reproduction also fluctuates from one year to the next. These and other factors are being considered by our research team as we search for predictions about fire responses in the Mesa Verde vegetation.

SPECIFIC OBJECTIVES AND METHODS OF 1991 FIELD SEASON

Objective 1. To measure parameters of fire severity along gradients of habitat and fire intensity within the 1989 Long Mesa Burn.

Objective 2. To document patterns of early post-fire succession in relation to gradients of habitat and fire intensity.

We use the term "intensity" to refer to the energy release of a fire, whereas "severity" refers to the ecological effects of the fire. The following parameters of fire severity were measured either a quantitative or semi-quantitative manner:

a. tree injury, i.e. % of trees killed, injured but not killed, and uninjured
b. ground cover, i.e. % cover of plants, unburned litter, burned litter, and bare mineral soil or rock
c. depth of soil char (an index to total heat release and of depth of which plant organs may have been injured and archeological materials damaged)
d. relative degree of rock spalling (another index of total energy release and potential damage to archeological materials)

Establishment of sampling grids: Three sampling grids were established to include the range of severity and affected vegetation on Long Mesa, within Long Canyon, and on the North Escarpment of Mesa Verde National Park. Grids were located by incorporating the extensive field expertise of NPS Resource Managers Steve Budd-Jack and Marilyn Colyer, and with the technical assistance of GIS specialist Allan Loy.

1. Long Mesa Southern Grid (Grid #1): This grid consists of a square kilometer, sampled every 100 meters, or a total of 121 sampling points. It was chosen to represent the heterogeneity of vegetation within the Pinon-juniper woodland region of the Park which has resulted from the 1934 fires (Wickiup Canyon and Wildhorse Fires), the 1972 Rock Springs fire, the 1989 Long Mesa Fire, and possibly an ill-documented fire in the region in 1873 (original maps by Erdman, no further documentation available). This sampling grid also spans Long Mesa and Long Mesa Canyon. "Control points" consist of vegetation missed by the 1989 fire.

Data were collected from May 15 through June 26, 1991. At each point we tallied all trees within a radius of 4 m and recorded the species, dbh, and condition of each (i.e. dead, injured, uninjured). The % cover of living plants, unburned litter, burned litter, bare mineral soil, and rock substrates were sampled within four 0.25 m^2 quadrats. Sampling within these plots was by means of a point-intercept (Mueller-Dombois and Ellenburg 1974). The sampling frame was placed 4 times (at 1 or 3 m either side of sampling point) and the vegetation or substrate intersected by junctions on the grid were recorded. Alternating with the placement of the sample quadrat, we excavated a shallow hole with a hatchet and measured the depth of soil char. The dominant grasses and forbs were recorded, and the number or burned and unburned stems of shrubs and trees were counted. Rock spalling was noted as an indicator of fire intensity.

Data are now being stored on a MacIntosh LC computer on JMP Version 2 Statistical Package. This program allows data to be directly transferred to SAS format. SAS is available at San Juan College if further analysis is required. This particular statistical package was chosen to allow data comparability and ease of comparison of Mesa Verde fire recovery data with that being collected in a similar methodology at Yellowstone National Park (Turner et al. submitted manuscript). Data analysis will be carried out during the winter, 1991.

2. Long Mesa Northern Grid (Grid #2): The second grid was placed within the treeless, shrub-dominated community which extends over much of the northern sector of Mesa Verde Park. As the vegetation was fairly homogenous and the known fire history less complex than that of the Southern Grid, the size was reduced to 1 km by 0.6 km, and the number of sampling points to 66. Data were collected as outlined above. Data collection was completed October 13, 1991.

3. North Escarpment Grid (Grid #3): The Long Mesa fire jumped over the North Escarpment and ran in strips down toward the base of this steep slope. The terrain was very difficult to sample, so the grid placement and sampling structure was modified for safety of the personnel. Grid #3 covers the Douglas-Fir (*Pseudotsuga menzesii*) shrub association which is found infrequently and typically on north-facing slopes, in the Park. The grid ran 0.5 km in length and 0.4 km in width, and samples points were placed every 50 m. Data collection was identical to that described above.

Objective 3. To test a new method of dating prehistoric fires based on ages and growth patterns in the stems of perennial shrubs that resprout virorously following fire.

We located healthy stands of Gambels Oak, Fendlerbush (*Fendlera rubicola*), Mountain Mahogany (*Cercocarpus montanus*), Serviceberry and Bitterbrush in areas of known fire history. Locations were made with experitse of Allan Loy, who outlined on a GIS layer the known fires, and assisted our pin-pointing smaller fires with the Global Positioning System (GPS) unit owned by Mesa Verde. Shrubs were cut with a bow-saw as low to the ground as possible. Cross sections were taken back to the lab, sanded, and annual ring counts were made with a dissecting microscope. Each sample was aged by at least 2 investigators to check the accuracy of the method. In addition, several samples were taken from the same individual of a given species to determine how shoot production varies over time as the shrub resprouts after a fire. The preliminary data reported here are intended only as a test of the shrub-dating method to determine stand origin date, and are based on a small sample size ($n=48$ cores). Additional shrubs samples will be made before the sampling method for the 1992 field season if finalized.

Samples were collected from the 1934 Wickuop and Wildhorse Mesa Fires, the 1959 Morfield Canyon fire, and the 1972 Moccasin Mesa and Rock Springs Canyon fires. These fires were selected because they are the most extensive fires in recorded history in Mesa Verde National Park. The shrub annual ring counts (pooled for all species) were compared across known fire dates. There is a significant ($p<0.05$) added variance component among fires for shrub annual ring numbers. Thus, we conclude that shrubs are more closely related in their dates of origin within each known fire than between fires, and that the proposed method for determining stand origin dates from shrub annual ring counts is valid. Further sampling is needed to expand the reliability of this conclusion.

We test the null hypothesis that the true age of shrubs from the 1934 fire is 56 years. The sample size is very low, so that although the Shapiro-Wilk W test indicates a normal distribution, we will focus on the non-parametric Signed-Rank test. This test shows that the sample mean does not approximate the hypothesized age of 56 years. Further sampling will be done in the 1934 fires to increase sample size. However, shrubs sampled in the 1959 Morfield burn averaged 30.8 years, allowing us to accept the null hypothesis that they are truly 31 years of age (distribution not normal, therefore Signed-Rank test $p>0.5$). Also, shrubs sampled from the two 1972 fires have an average age of 17.6, and we accept the null hypothesis that they are sampled from a shrub population of age 18 years ($T=-0.5$, $p>0.05$). Thus, we feel confident that, with perfection of the shrub-dating method, we will be able to age stands by shrub-dating and prepare a stand origin map in 1992.

Gambels oak shows the greatest promise as a species of focus for the stand origin map (Table 1). It is the most abundant shrub species in the Park, and the variation in ages from one population is small relative tot he other shrub species. False rings are less common than in other species.

Table 1. Determination of shrub stand origin from Gambels Oak annual ring counts.

Fire date	N	Mean & SE	Test null hyp. that sample X= predicted stand age
1934	2	38.5 + 3.3	----
1959	17	33.3 + 1.1	t=3.35, p<.05 reject null hypothesis
1972	7	18.5 + 1.8	t=0.86P>.05 accept null hypothesis

Thus, our estimates of age in oak stands do not consistently support the predicted age, as in the 1959 burn. Overestimates as seen in the 1959 fire samples may be caused by false rings. Further analysis will be made to determine if more accurate ring counts can be made. Thus, we must be tentative in concluding the the proposed method will accurately age shrub stands in Mesa Verde.

♦ SUMMARY

During the 1991 field season at Mesa Verde National Park, the fire research team accomplished two goals. First, grid systems were established across the diversity of vegetation types burned in 1989 on Long Mesa. These grids will be used to follow the effects of fire on early successional patterns. We will assist in establishing a long-term monitoring of these grids by NPS resource management staff. Our second objective was to test a method for dating past fires using the annual rings of shrubs which resprout after fires. This method is needed because fire scarring tree species are not available in the Mesa Verde National Park system. Preliminary sampling of shrubs indicate that, if perfected and restricted to certain species, a shrub-daing method will adequately predict stand origin dates. A stand origin map will be created in 1992 which will be used to date past fires in the Mesa Verde region.

♦ LITERATURE CITED

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