

CROW CANYON ARCHAEOLOGICAL CENTER

Dedicated to Archaeological Research and Education

Dr. Linda Towle
Marilyn Colyer
Mesa Verde National Park
Mesa Verde, CO 81330

August 9, 2002

Dear Dr. Towle,

A final ecological and ethnobotanical report on the five-year Crow Canyon Archaeological Center study of Long Mesa following the July 1989 burn is inclosed. This covers the period July 1990-June 1994. I have recently analyzed the data from the last two years of our study (1993 and 1994), and integrated it with the results presented in two previous draft reports (dated April 1991 and May 1993). I apologize that this project has taken such a long time to come to this point. In recent years I have been mentoring interns at Crow Canyon in the analysis of plant remains from our many archaeological sites. However, the Long Mesa fire report is now complete. I have enclosed a paper copy of the complete report, and a disk with the following files:

MesaVerdeFireEffects.mdb = all raw data, in numerous files within an ACCESS database

MVACCESSFiles.mdb = detailed list of all ACCESS database files

MVAppendices1-2.wpd = Appendices 1 and 2, Word Perfect

MVFinalReport.wpd = Final report text and references cited, Word Perfect

MVFinalReport TableContents.wpd = Table of Contents, Word Perfect

MVFinalReportTable1.wpd = Table 1, Word Perfect

MVFinalReportTables2_5_6_7.xls, Tables 2, 5, 6, 7 in EXCEL

MVFinalReportTable3.wpd = Table 3, Word Perfect

MVFinalReportTable4.wpd = Table 4, Word Perfect

MVFinalReportTable8.wpd = Table 8, Word Perfect

If you have any questions or comments, please feel free to contact me at Crow Canyon.

Sincerely,

Karen R. Adams

Karen R. Adams, PhD

Director, Environmental Archaeology

kadams@crowcanyon.org

ALSO FIRE

ID	TableName	Contents	PreviousFile Name
	00PJBurnHerb	1990 Pinyon/Juniper Burned Plot, Herbaceous	UPJBURN.DBF
	00PJBurnTS	1990 Pinyon/Juniper Burned Plot, Trees and Shrubs	PJBURN.DBF
30	90PJUnBurnHerb	1990 Pinyon/Juniper Unburned Plot, Herbaceous	UPJBUBUR.DBF
10	90PJUnBurnTS	1990 Pinyon/Juniper Unburned Plot, Trees and Shrubs	PJUNBU.DBF
31	90SBBurnHerb	1990 Sagebrush/Bitterbrush Burned Plot, Herbaceous	USAGEBUR.DBF
11	90SBBurnTS	1990 Sagebrush/Bitterbrush Burned Plot, Trees and Shrubs	SAGE.DBF
32	90SBUnBurnHerb	1990 Sagebrush/Bitterbrush Unburned Plot, Herbaceous	USAGEUBU.DBF
12	90SBUnBurnTS	1990 Sagebrush/Bitterbrush Unburned Plot, Trees and Shrubs	SAGEUNBU.DBF
17	9192PJBurnHerb	1991 & 1992 Pinyon/Juniper Burned Plot, Herbaceous	U91PJBUR.DBF
13	9192PJBurnTS	1991 & 1992 Pinyon/Juniper Burned Plot, Trees and Shrubs	91PJBURN.DBF
18	9192PJUnBurnHerb	1991 & 1992 Pinyon/Juniper Unburned Plot, Herbaceous	U91PJUBU.DBF
14	9192PJUnBurnTS	1991 & 1992 Pinyon/Juniper Unburned Plot, Trees and Shrubs	91PJUNBU.DBF
19	9192SBBurnHerb	1991 & 1992 Sagebrush/Bitterbrush Burned Plot, Herbaceous	U91SBBUR.DBF
15	9192SBBurnTS	1991 & 1992 Sagebrush/Bitterbrush Burned Plot, Trees and Shrubs	91SBBURN.DBF
20	9192SBUnBurnHerb	1991 & 1992 Sagebrush/Bitterbrush Unburned Plot, Herbaceous	U91SBUBU.DBF
16	9192SBUnBurnTS	1991 & 1992 Sagebrush/Bitterbrush Unburned Plot, Trees and Shrub	91SBUNBU.DBF
21	93PJBurnHerb	1993 Pinyon/Juniper Burned Plot, Herbaceous	U93PJBUR.DBF
1	93PJBurnTS	1993 Pinyon/Juniper Burned Plot, Trees and Shrubs	93PJBURN.DBF
22	93PJUnBurnHerb	1993 Pinyon/Juniper Unburned Plot, Herbaceous	U93PJUBU.DBF
2	93PJUnBurnTS	1993 Pinyon/Juniper Unburned Plot, Trees and Shrubs	93PJUNBU.DBF
23	93SBBurnHerb	1993 Sagebrush/Bitterbrush Burned Plot, Herbaceous	U93SBBUR.DBF
3	93SBBurnTS	1993 Sagebrush/Bitterbrush Burned Plot, Trees and Shrubs	93SBBURN.DBF
24	93SBUnBurnHerb	1993 Sagebrush/Bitterbrush Unburned Plot, Herbaceous	U93SBUBU.DBF
	3SBUnBurnTS	1993 Sagebrush/Bitterbrush Unburned Plot, Trees and Shrubs	93SBUNBU.DBF
	4PJBurnHerb	1994 Pinyon/Juniper Burned Plot, Herbaceous	U94PJBUR.DBF
5	94PJBurnTS	1994 Pinyon/Juniper Burned Plot, Trees and Shrubs	94PJBURN.DBF
26	94PJUnBurnHerb	1994 Pinyon/Juniper Unburned Plot, Herbaceous	U94PJUBU.DBF
6	94PJUnBurnTS	1994 Pinyon/Juniper Unburned Plot, Trees and Shrubs	94PJUNBU.DBF
27	94SBBurnHerb	1994 Sagebrush/Bitterbrush Burned Plot, Herbaceous	U94SBBUR.DBF
7	94SBBurnTS	1994 Sagebrush/Bitterbrush Burned Plot, Trees and Shrubs	94SBBURN.DBF
28	94SBUnBurnHerb	1994 Sagebrush/Bitterbrush Unburned Plot, Herbaceous	U94SBUBU.DBF
8	94SBUnBurnTS	1994 Sagebrush/Bitterbrush Unburned Plot, Trees and Shrubs	94SBUNBU.DBF

MVFinalReport.wpd

A Five-Year Ecological and Ethnobotanical Study of Vegetation Recovery
After the Long Mesa Fire of July 1989
Mesa Verde National Park, Colorado

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Study period: July 1990 - June 1994
Final Report August 2002

ABSTRACT

Ecological and ethnobotanical data were gathered from July 1990 until June 1994 on Long Mesa, Mesa Verde National Park, following a July 1989 lightning-caused fire. Two burned plant communities included in this study were a *Pinus edulis*/*Juniperus osteosperma* (pinyon/juniper) woodland, and an *Artemisia tridentata*, *A. nova*/*Purshia tridentata* (sagebrush/bitterbrush) shrubland. At the same time, two corresponding unburned control communities were also examined. In the five years following the fire, vegetation in the burned pinyon/juniper woodland and sagebrush/bitterbrush shrubland has changed continuously, in contrast to nearby unburned control plots. In the burned pinyon/juniper plot, *Quercus* and other stump-sprouting shrubs dominate. *Chrysothamnus* became established there by seed. Herbaceous plant diversity doubled between 1990 and 1991, with some species (*Nicotiana attenuata*, *Chenopodium* spp., *Schoenocrambe linifolia*, and *Poa fendleriana*) displaying significant vigor and vitality early in recovery. This burned plot has a wider diversity of taxa than its counterpart unburned plot.

The recovery in the burned sagebrush/bitterbrush plot has been dominated by stump-sprouting *Amelanchier* and *Symphoricarpos*. Herbaceous plant diversity is high, with coverage and frequency of a number of plants differing notably from those in the unburned plot. Coverage and frequency of bare soil and litter varied between burned and unburned plots as well.

Comparisons of the burned pinyon/juniper plot to an earlier fire recovery study on Morfield Mesa revealed some differences in their recovery trajectories. Dominant herbaceous species in the first two years following each fire differed, likely in part due to purposeful seeding on Morfield to speed recovery. Shrubs shared in common between the two mesas also displayed higher coverages and frequencies on Long Mesa.

The present Long Mesa mosaic habitat provides humans a wide range of resources, simply because of the fire. The burned pinyon/juniper area has offered a changing array of edible and useful plants, starting first with a large amount of sound, usable firewood. The vigorous nature of some plants has diminished with time, revealing an important role for fire in their maintenance. Flexible stems for material culture needs have been promoted by vigorous stump-sprouting. For a wide variety of herbaceous plants, differences between burned and unburned plots extend to which taxa are present, and their frequencies and coverages.

INTRODUCTION

In 1990 Crow Canyon Archaeological Center, in cooperation with Mesa Verde National Park, initiated a five-year study of the effects of fire on vegetation following a July 1989 natural burn on Long Mesa. One objective of this research was to perform an ecological study of vegetation recovery of two mature plant communities following a fire, including comparison to two similar, unburned communities. The second objective was to evaluate the recovering vegetation in terms of its potential to satisfy food and material culture needs of humans, such as the Ancestral Puebloans who relied upon the region for their livelihood in the A.D. 600-1300 period. The research reported here conforms to an established study design (Adams 1990a, 1990b) and incorporates two previously published reports (Adams 1991, 1993a). Data and results represent the period July 1990 through June 1994. The Long Mesa study area, including the burned and unburned study plots, is depicted in Figure 1.

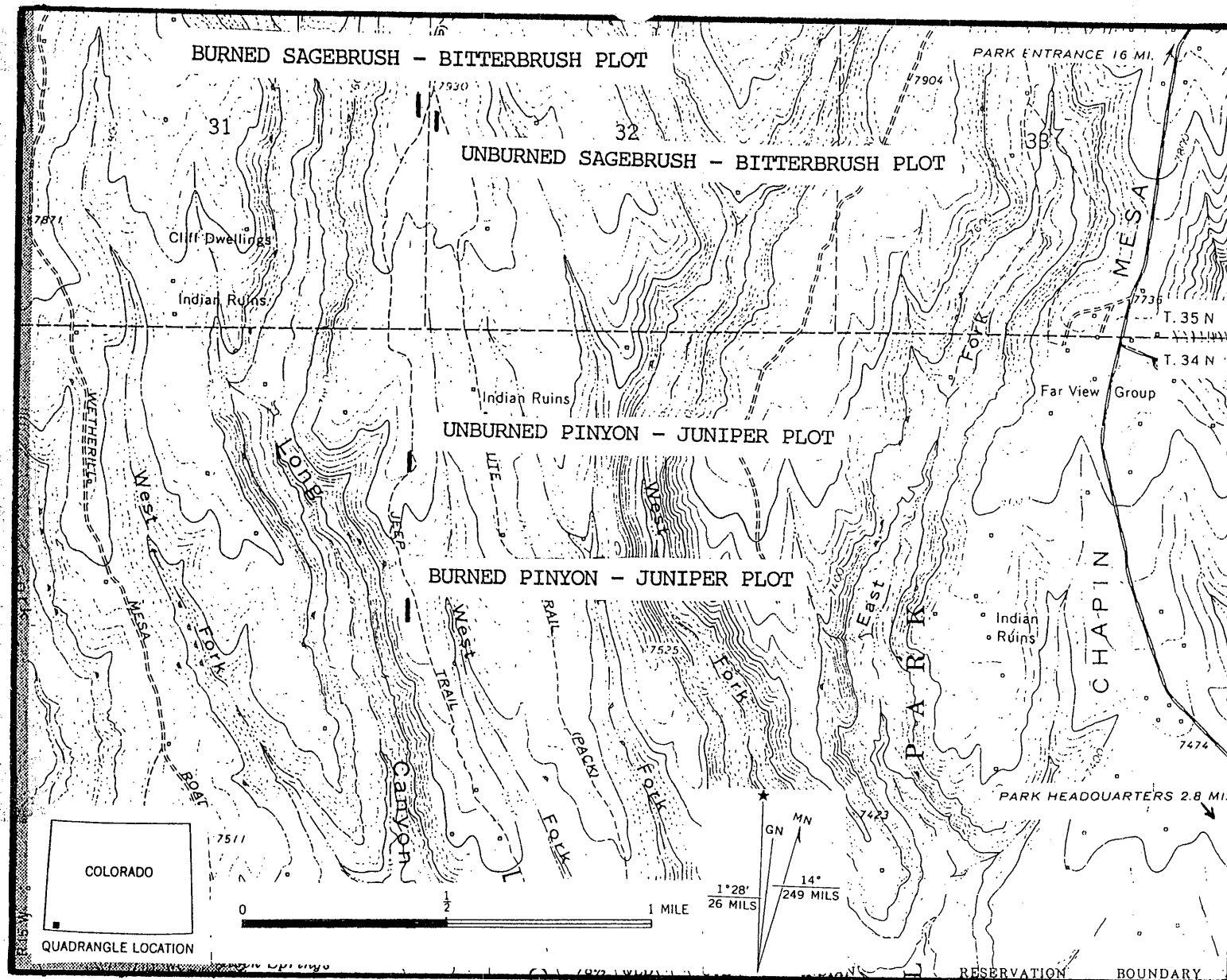


Figure 1. Plot locations in Long Mesa Study Area, T 34 and 35 N, R 15 W, Wetherill Mesa Quadrangle, Colorado - Montezuma County, 7.5 Minute Series.

METHODS

In order to enhance comparability with previous studies of Mesa Verde vegetation, the descriptive ecological methods and techniques of this research parallel those of earlier published analyses (Erdman et al. 1969; Erdman 1970). Basic plot size of 68.6 m x 15.2 m (225 x 50 feet) and sampling intervals of earlier research have been retained, but all measurements have been converted to the metric system. Definitions of terms and details of field methods are outlined in Appendix 1. Field data recording sheets comprise Appendix 2. Field observations of herbaceous vegetation are supported by a series of herbarium specimens identified via a regional flora (Welsh, et al. 1987), and verified against permanent collections curated in the University of Arizona Herbarium, Tucson. The plant collection has been given to Mesa Verde National Park.

The analytical concepts of "coverage" and "frequency" were employed to characterize vegetation in four vegetation plots. These are two burned study plots: (1) a pinyon/juniper (*Pinus edulis*/*Juniperus osteosperma*) community, and (2) a sagebrush/bitterbrush (*Artemisia tridentata*, *A. nova*/*Purshia tridentata*) community, and two closely matched nearby unburned control plots. Coverage, a type of analysis that takes plant dimensions into account, expresses the size or bulk of the shoots of each species in relation to space (Daubenmire 1968:41); it is sometimes referred to as "dominance". Frequency data expresses the number of times a species was encountered in 50 separate observations. "Density", or the number of individuals of a species per unit area (Daubenmire 1968:40), was calculated for a limited number of taxa in unburned plots. Common and scientific plant names referred to in this report are listed in Table 1. All field data has been entered into a series of ACCESS databases.

RESULTS

Ecological Insights.

The vegetation in the two burned plots contrasts with that of the unburned control plots, as do the two plant community types, pinyon/juniper vs. sagebrush/bitterbrush. Changes in vegetation from year to year were most dramatic in the burned plots. Trees, shrubs, herbaceous plants and abiotic components of each plot are discussed below.

Unburned Pinyon/Juniper Study Plot. Coverage and frequency data generally reveal that both pinyon (*Pinus edulis*) and juniper (*Juniperus osteosperma*) are dominant members of the unburned pinyon/juniper community on Long Mesa (Table 2). A look at these two taxa relative to each other is gained by additional analyses. Age-classes tallied in ten 1.2 m x 15.2 m belt transects suggests that juniper is a healthy species replacing itself (Table 3), and is well-represented by all size classes, including seedlings. Pinyon has nearly the same number of older trees as juniper, but fewer saplings and seedlings, suggesting that pinyon may be aging in this locality.

A Point Quarter Analysis in 1990 and 1994 provides another way to view these two predominant taxa, relative to one another (Table 4; Appendix 2). A calculation of Importance Value, essentially a sum of relative frequency, relative density and relative dominance for each taxon, reveals that juniper currently plays a dominating role in terms of size (coverage) and

distribution (frequency) on the landscape. Pinyon, by virtue of closer spacing, dominates in density. Thus, it appears that *Juniperus osteosperma* is the dominant conifer, and may remain so by virtue of continued seedling establishment. *Pinus edulis* plays an important, but less conspicuous role, having relatively older members and low seedling establishment.

Shrubs in this mature community reveal some variability over the five-year observation period (Table 2). Four of them, including *Cercocarpus montanus*, *Artemisia tridentata*/*A. nova*, *Purshia tridentata*, and *Amelanchier utahensis*, have moderate coverage, and frequencies ranging up to 32% (Table 2). Three additional shrubs (*Fendlera rupicola*, *Quercus gambelii*, and *Yucca baccata*) are present, but not prominent.

Herbaceous vegetation is well represented here. The total number of taxa identified increased from 8 in 1990 to 17 in 1994. Increasing coverage is apparent for a number of taxa over five years, for example *Comandra umbellata* and *Poa fendleriana*. Park Service efforts to reduce the number of wild horses that graze in the area may be partly responsible for these upward trends. In terms of frequency, the most consistently encountered herbaceous species are grasses (including *Elymus elymoides*, *Koeleria macrantha*, and *Poa fendleriana*), *Polygonum douglasii*, *Penstemon linarioides*, two species of *Lupinus*, and *Comandra umbellata*.

Abiotic plot components display limited variability over the five-year study. Bare soil ranges between 1-10% coverage. Litter, primarily in the form of decomposing foliage, has consistently been a predominant component of this mature community, averaging over 75% coverage, and present in nearly 100% of all plots examined. Rocks are present, but not a major community component.

Burned pinyon/juniper study plot. The burned pinyon/juniper study plot is noteworthy for its complete lack of living pinyon or juniper trees (Table 5). Only standing dead timber was observed, easily identified on the basis of bark and anatomical traits. Because dead specimens are not tallied in this research, and because no seedlings of either species were encountered, there are no records of either taxon for this plot over the five-year study period.

Five shrubs had regenerated via stump sprouting by the first year after the burn. The taxon first to be noticed was *Quercus gambelii*, responding to late summer and fall rains almost immediately following the 1989 fire. *Yucca baccata*, *Purshia tridentata*, *Cercocarpus montanus* and *Symphoricarpos* all began recovery from the base the following summer. Two additional shrubs, *Amelanchier utahensis* and *Fendlera rupicola*, joined the group by 1991. There was a trend to increasing coverage and frequency for most shrubs during the five-year study period, with *Quercus gambelii* and *Purshia tridentata* having the highest coverage and frequency.

Many herbaceous plants became established in the burned plot within the first two years following the 1989 fire (Table 5). The 11 taxa present in 1990 nearly doubled by 1991, and remained at this level. Non-native *Salsola iberica* and *Lactuca serriola* entered the plot in 1991. Native species that continued to increase in both coverage and frequency include *Comandra umbellata*, various grasses, *Machaeranthera canescens*, *Penstemon linarioides*, and *Viguiera*

multiflora. On the other hand, populations of *Chenopodium fremontii*, *Nicotiana attenuata*, and *Polygonum douglasii* peaked, then declined. By 1992, for example, no *Nicotiana attenuata* plants were observed within the burned plot. Additional herbaceous species, low in both coverage and frequency, were inconsistently encountered during the five-year study. The flowering and fruiting of herbaceous plants in 1991 included *Viguiera multiflora*, *Stipa hymenoides*, *Elymus elymoides*, *Penstemon linarioides*, *Eriogonum umbellatum*, *Nicotiana attenuata*, *Chenopodium fremontii* and *C. leptophyllum*, *Poa fendleriana*, *Heterotheca villosa*, *Polygonum douglasii*, *Schoenocrambe linifolia*, *Cordylanthus wrightii*, *Erigeron divergens*, and *Lappula redowskii*. By 1992, *Commandra umbellata* and *Petradoria pumila* had joined this list of actively reproductive plants.

Immediately following the fire, the burned plot had high coverage and frequency of bare soil, as one might expect. Over five years, there was a consistent increase in the amount of litter present, first composed of ash and charcoal from the fire, and later of decomposing vegetation from living plants. Rocks were consistently fairly low in coverage and frequency.

Comparison of the two pinyon/juniper study plots. There are sharp contrasts in vegetation between the unburned and burned pinyon/juniper plots. The recovering burned plot lacks any living pinyon or juniper trees. The shrubs shared in common between the two plots differ significantly in coverage and frequency. For example, *Amelanchier utahensis*, *Cercocarpus montanus*, *Fendlera rupicola*, and *Purshia tridentata*, are all well-represented in the unburned plot, compared to the burned plot. In contrast, *Quercus gambelii* displays a much higher coverage and frequency in the burned plot. *Yucca baccata* is the only species with similar representation in both locations. *Artemisia*, a predominant shrub component of the unburned plot, had not returned to the burned plot by 1994. *Symphoricarpos oreophilus* is a minor component in the burned plot only.

The herbaceous vegetation in the burned pinyon/juniper plot also contrasts sharply with that in the unburned control plot. When one compares the list of taxa in the two plots, the burned plot has 50% more taxa ($n=33$) than the unburned plot ($n=22$). Of fourteen species shared in common between the two plots, few display similar coverages and frequencies. Nineteen plants are unique to the burned plot, and eight to the unburned plot, increasing the general diversity of plant resources in the local area. Populations of *Chenopodium fremontii*, *Nicotiana attenuata*, and *Polygonum douglasii* peaked early in the burned plot, then rapidly declined. Herbaceous plants in the unburned plot were continuously reproductive, while many of these same plants in the burned plot became fully reproductive in the first and second years following the fire.

Differences in abiotic components between the two plots are notable. In the unburned plot, litter is common and bare soil rare. Bare soil in the burned plot decreased in the years following the fire, accompanied by a corresponding increase in litter. Rocks in both locations are encountered on occasion, reflecting their presence in shallow soils overlying a sandstone mesa top.

Unburned Sagebrush/Bitterbrush Study Plot. The distribution of woody vegetation in the unburned *Artemisia tridentata*, *A. nova*/*Purshia tridentata* plot reveal relatively high coverage and frequency for these taxa (Table 6). Other shrubs, including *Amelanchier utahensis*,

Chrysothamnus depressus, *Symphoricarpos oreophilus* and *Tetradymia canescens*, all display low coverage and frequency. Most shrubs display minor variability in their representation through the five study years.

Herbaceous plants evidence some variability during the five years monitored. In general, many of the herbaceous species experienced little change in representation between the study years, however some were quite variable. The most predominant plants in terms of coverage and frequency in this plot include grasses (*Elymus elymoides*, *Koeleria macrantha*, *Poa fendleriana*, *Stipa comata*, and other Gramineae), *Petradoria pumila*, *Eriogonum* spp., *Lomatium triternatum*, and Compositae. The remainder are generally low in both coverage and frequency. The only non-native plant noted in this plot was *Lactuca serriola*.

Abiotic components display some variability in the five-year study. Bare soil occurs in nearly every plot examined. Litter is likewise ubiquitous, varying in coverage from year to year. Few rocks were encountered in this plot, which is located in deeper soils some distance from the mesa edge.

Burned Sagebrush/Bitterbrush Study Plot. Vegetation in the burned sagebrush/bitterbrush plot has undergone notable changes between 1990 and 1994 (Table 7). Only *Amelanchier utahensis* and *Symphoricarpos oreophilus* shrubs had stump sprouted in the first year following the fire. During 1991, *Purshia tridentata* stump-sprouted as well. By 1992, three additional stump-sprouting shrubs were noted, though *Amelanchier* and *Symphoricarpos* still predominated. *Artemisia* returned to the plot during the fifth year of observation. *Symphoricarpos oreophilus* was the first to flower and fruit, in 1991.

The nineteen herbaceous plants established in 1990 had nearly doubled by the following year, then the number stabilized at between 27-28 taxa. In the first year following the fire, coverage was consistently low and frequency of any given species was rarely above 20%. In the second and third years, a number of plants including *Chenopodium* spp., *Elymus elymoides*, *Koeleria macrantha*, *Poa fendleriana*, *Stipa comata*, *Eriogonum* spp., *Lupinus* spp., *Microsteris gracilis*, *Polygonum douglasii*, *Viguiera multiflora*, *Lomatium triternatum*, *Petradoria pumila*, and *Sphaeralcea coccinea*, generally increased in frequency, though coverage for most still remained fairly low. *Polygonum douglasii* and *Lupinus caudatus* displayed the highest coverage of the five-year study, each occurring at 4-10%, in different years. A much smaller number of species peaked and then declined, for example *Chenopodium leptophyllum*. Most of the herbaceous species occurred in very low coverage and/or frequency in any given year, and were not consistently encountered in the canopy coverage plots in every year of the study. By 1991, fully reproductive herbaceous plants included *Viguiera multiflora*, *Elymus elymoides*, *Stipa comata*, *Koeleria macrantha*, *Penstemon linarioides*, *Eriogonum* spp., *Chenopodium* spp., *Poa fendleriana*, *Heterotheca villosa*, *Cirsium undulatum*, *Polygonum douglasii*, *Schoenocrambe linifolia*, *Erigeron* spp., *Lithospermum ruderales*, *Achillea millefolium*, and *Lupinus* spp.

Bare soil distributed throughout the plot decreased in coverage from 34-50% (1990) to 11-25% (1994). This has been accompanied by a consistent increase in the amount of litter

present from 1-4% (1990) to 51-75% (1994). Rocks are present and frequently encountered.

Comparison of the two sagebrush/bitterbrush study plots. The dominant vegetation in the recovering burned sagebrush/bitterbrush plot is notably different from its unburned counterpart. The unburned plot is dominated by both *Artemisia* spp. and *Purshia tridentata*, which give the plot its name. In contrast, the burned plot is dominated by *Amelanchier utahensis* and *Symphoricarpus oreophilus*, has relatively little *Purshia tridentata*, and *Artemisia* spp. only as of 1994. Of the six shrubs shared in common between the two plots, coverage and frequency are generally different.

The herbaceous vegetation is also divergent. Thirty-six species are shared in common, and by 1992 researchers had recognized five taxa unique to the unburned plot, and eight taxa unique to the burned plot. *Chenopodium leptophyllum*, not present in the unburned plot, experienced a frequency peak in the burned plot in 1991. The major herbaceous cover differences in these two plots lies with coverage and frequency data for many species, while differences between the two plots for the remaining species seem negligible.

Differences exist in abiotic components in the two plots. In the unburned plot, litter is common and bare soil present in low amounts. Bare soil in the burned plot decreased in the years following the fire, accompanied by a corresponding increase in litter. Rocks occur in both plots.

Ethnobotanical Insights.

In the five years following the July 1989 fire on Long Mesa, vegetation recovery has been rapid, fostering a mosaic habitat with differential distribution of taxa between burned and unburned plots. Over the five-year study period, Long Mesa has been a continually changing mosaic habitat of great diversity. This section will discuss the vegetation changes in the burned plots as resources of potential interest to humans.

Burned Trees as Construction Timbers and Fuelwood. Over the long term, wood availability in a burned pinyon/ juniper woodland has been dramatically curtailed. However, in the first two decades following the fire, there may actually be easier access to resources such as construction timbers and fuelwood. Although every pinyon and juniper tree in the burned pinyon/juniper plot died as a result of the fire, many of the larger dead trees remained standing. These individuals, charred on the surface but essentially sound, would seem to represent usable construction timbers. Since most of the smaller side branches were consumed during the fire, and because the roots immediately began to loosen their hold in the shallow soil, acquisition of the timber might be relatively easy. Possibly trees could be pushed over a few years or so after burning. This stand of charred timber has been analyzed for availability of straight beams, greater than 4 cm diameter and 1 meter or longer in length; a report on this survey is forthcoming. It is reasonable to assume that the charred individuals might remain upright and be available for some period of time; a 1972 fire on nearby Moccasin Mesa produced another fairly large population of sound standing timber, many individuals still available in 1990. However, the common stone axe technology for working with green construction beams is ineffective in acquiring fire-dried beams. Also, one might expect occasional indications of surface charring on well-preserved beams, but

the Tree-Ring Lab has seen no evidence of this in unburned construction beams from a wide variety of prehistoric Southwestern sites (J. Dean, personal communication).

Another important use for the standing and down timber in the burned pinyon/juniper plot is fuelwood. The burn created a large volume of sound, dried wood, much of it in pieces easy to acquire and transport. Such a location might become preferred for gathering hearth fuel, at least for a while following a fire.

Shrubs as Tinder. Many of the shrubs in both burned plots died back to ground surface during the fire, leaving standing leafless branches that in some cases had not been charred completely through. These above ground parts, though limited in volume and weight, could still provide some easily acquired tinder to start a fire. The burned shrub material began rapidly breaking down, however, and offered small quantities of dead wood, relative to that available from dead trees. Archaeological sites in the region have revealed that the Ancestral Puebloans frequently burned *Artemisia*, *Cercocarpus*, *Purshia/Cowania*, *Amelanchier/Peraphyllum*, and on occasion utilized both *Fendlera* and *Quercus* in their hearths (Adams 1989a, 1989b, 1993b, 1999; Matthews 1985, 1986).

Shrubs offering flexible new branches. Immediately following the fire, root crown regeneration became vigorous in some shrubs. For *Quercus gambelii* and *Yucca baccata*, stump sprouting began soon after the ashes cooled in 1989. *Amelanchier utahensis*, *Cercocarpus montanus*, *Purshia tridentata* and *Symphoricarpos oreophilus* were producing long flexible shoots by the next summer. Burned *Purshia tridentata* and *Fendlera rupicola* stump sprouted some months later. *Artemisia* did not stump sprout in either burned plot, confirming observations by other researchers (Barney and Frischnecht 1974:93).

Young shoot growth is often flexible, even-diametered, straight and long. As such, some of these resources might offer useful materials for basketry or other artifact manufacture. Modern Native Americans, and the Ancestral Puebloans in the region, utilized such growth of both *Chrysothamnus* and *Rhus* for basketry manufacture and in other ways, and found reason to gather fibrous *Yucca* leaves (Blinman 1986; Adams 1993b; Palmer 1878). By 1992 in the burned sagebrush/bitterbrush plot, abundant straight supple shoots of *Amelanchier utahensis* and *Symphoricarpos oreophilus* ranged in length from 60-90 cm and in diameter from 3-9 mm. In the same year, *Fendlera rupicola* offered shoots 30-40 cm in length and from 2-4 mm in diameter. *Purshia tridentata* sprouts were between 10-35 cm long and 2-5 mm in diameter. *Chrysothamnus depressus* was recognized in the burned sagebrush/bitterbrush plot in 1992. At that time, a cluster of less than one dozen plants was observed, some of them reproductive. These plants also offered a number of long (up to 24"), flexible stems as potential basketry material. This species occurs elsewhere on Mesa Verde in disturbed areas including burns and road cuts (Welsh and Erdman 1964:14).

Herbaceous Taxa of Potential Interest to Humans. Certain characteristics of some of the non-woody plants in the burned plots may well have been of keen interest to humans whose subsistence and material culture needs depended upon knowledge of resource distribution within

the environment. Vigor (relative size and health of an individual), vitality (reproductive success of a plant) and density are qualities that the burn seems to have enhanced for a number of taxa. Some of the taxa encountered in this study are highlighted here.

Calochortus sp. Mariposa lily has been documented in both sagebrush/bitterbrush plots and in the burned pinyon/juniper plot, though in low amounts except for 1992. The nutritious bulbs of many species have been eaten by Native Americans, and grassland and savanna burning by the Chumash of California has been said to favor such bulb-forming plants (Ebeling 1986:204-205; 310).

Chenopodium spp. Two species of goosefoot (*C. fremontii*; *C. leptophyllum*) seem enhanced by burning. Present in negligible amounts in unburned plots, each of these plants became visually dominant in a burned plot in the first year following the burn. One species, *Chenopodium fremontii*, not observed in the unburned pinyon/juniper plot, became a visually dominant member in the burned plot in the first year after the fire (Table 8). More important, perhaps, was the vigor and vitality evident in this population. Height and width of thirty plants selected along two straight line transects within the burned plot, revealed the plants averaged 1.17 meters in height and 0.60 meter in width. Some of the plants were as tall as the observers evaluating them. A total of 811 individual goosefoot plants were counted in the burned pinyon/juniper plot. The entire goosefoot population flowered in abundance for a number of weeks in the late summer and early fall, producing copious amounts of mature seeds. By 1991, although there were many more goosefoot plants estimated in this plot, the plants were much shorter and not nearly as wide. Another goosefoot, *Chenopodium leptophyllum*, became notable in the burned sagebrush/bitterbrush plot as well.

Extensive ethnographic records documenting goosefoot use by Native Americans in the Southwest have been summarized (Adams 1988:168-183). There are numerous references to leaves, plants, young shoots and stalks boiled as greens, sometimes eaten alone and other times mixed with meal, fat or meat. When abundant, the greens may be extensively and even exclusively relied upon. They can be eaten raw or boiled, and sometimes dried for winter use. Medicinally the greens have been applied to burns. Repeatedly the literature refers to the use of the seeds as food, which were gathered in quantity and sometimes stored. The value for humans of the large, healthy, and profusely reproductive goosefoot plants in the burned plots on Mesa Verde seems obvious. A constant supply of greens, and an abundant harvest of mature seeds, resulted in the first year following the burn. Astute observers would take full advantage of this circumstance.

The archaeological record is almost as extensive as that detailing historic uses. Most of the citations suggest a food use for the seeds, though a few records hint that seeds served as food offerings in burials (Adams 1988:177). The words "common", "widely distributed", "most widespread taxon" and "one of the most abundant plant foods" reveals an important role for these plants in prehistory.

Elymus elymoides. Squirreltail grass is most notable in the two sagebrush/bitterbrush plots, with high frequencies and coverages approaching 4%. The differences between burned and unburned plots seem negligible. The unburned pinyon/juniper plot also hosts a moderate amount

of *Elymus*.

Some *Elymus* species tolerate disturbance, a characteristic of human-dominated environments, and retain grains in their spikes long after the heads have ripened (Bohrer 1987:82). *Elymus* complex grains (including other genera such as *Bromus*, *Agropyron*, and *Sitanion*) have been recovered in southern Arizona archaeological sites, possibly as a food, material to generate steam in ovens, or as a roof thatching (Bohrer 1987:82-83). The Paiute have utilized squirreltail grains for food (Doebley 1984), and a number of Shoshone groups sowed wild seeds of some species of *Elymus* (Steward 1941).

Eriogonum spp. *Eriogonum racemosum* and *E. umbellatum* are notable only in the two sagebrush/bitterbrush plots. In both plots, their populations appear to have peaked in 1991. Kawaiisu groups in California reportedly ate the seeds of at least nine species of buckwheat, which they powdered to form a meal eaten in a number of ways (Zigmund 1981).

Koeleria micrantha. As a cool season grass, the relative presence of *Koeleria micrantha* in the sagebrush/bitterbrush plots seems significant. Cool season grasses utilize winter and spring moisture to promote their growth and maturity in early summer, a potentially critical time of year for gatherers and agriculturalists (Bohrer 1975:199). Although *Koeleria* has not been commonly recovered in Ancestral Puebloan sites, it did serve as an important food resource for modern Pueblos prior to the introduction of wheat (Jones 1931:33; Castetter 1935:22). High value may be attached to any cool season grass that produces some of the earliest mature caryopses (grains) of a growing season.

Lithospermum ruderae. A member of the borage family that produces a hard, white, and pearly-appearing "stoneseed", *Lithospermum ruderae* has been documented in both burned and unburned sagebrush/bitterbrush plots. This perennial species sprouted and became fully reproductive within the first season after the burn. Although no food use for this species is known, a prehistoric "necklace" on display in the Mesa Verde National Park Museum appears to have been made of the smooth and highly polished nutlets. The Pima are said to have eaten the fresh leaves of one species (Ebeling 1986:521). Thus, one concludes that the Ancestral Pueblos may have been interested in the plant for personal adornment purposes.

Lomatium triternatum. Biscuitroot is present only in the two sagebrush/bitterbrush plots. Differences in coverage and frequency between the two plots are not major. Many groups, especially in the northwestern states, have ground the roots into flour and made cakes from a variety of biscuitroot species (Yanovsky 1936:47-48).

Lupinus spp. *Lupinus caudatus* and *L. polyphyllus* have been documented in three of the four plots. *Lupinus caudatus* made a rapid and notable recovery in the burned sagebrush/bitterbrush plot. *Lupinus polyphyllus* did best in the unburned pinyon/juniper plot. Native Americans have used lupines as potherbs, preparing them in various ways (Ebeling 1986:237-239; Yanovsky 1936:37). The small seeds may also be edible.

Nicotiana attenuata. Another plant that appeared in full vigor and vitality in the burned

pinyon/juniper study plot during 1990 was *Nicotiana attenuata*. Like the *Chenopodium*, the *Nicotiana* plants were tall and broad (up to 1 meter in either dimension), and flowered and produced ripe fruit capsules following each rain until the first freeze in November of 1990. The size of individual leaves on lower stems was often larger than a human hand. On 10/19/90 a team of eight participants counted 86 healthy and robust tobacco plants, most of them fully reproductive. By 1991, the tobacco population had diminished noticeably in stature, with 30 measured plants averaging only 41 cm in height and 9 cm in width. A total of 174 plants were estimated in the plot in August of 1991, most of these less than 15 cm tall. The plot had no tobacco plants in 1992.

That this species was encountered in no other study plot seems significant. It has been noted as a member of the Mesa Verde vegetation (Welsh and Erdman 1964), but apparently is a diminutive member of the flora unless an area has burned (M. Colyer, personal communication) or is otherwise disturbed in some way. Obviously a viable seed source is available on Long Mesa, but the plant is not an obvious member of the modern unburned communities there.

The use of tobacco by modern Native American groups is well documented (Setchell 1921; Winter 2000). Flowering parts, leaves and even stems were desired, presumably in many cases for use in special ceremonies or rites (Adams 1990c). What is also well known is that many groups were aware that tobacco "grows rapidly and high wherever the ground has been newly burned over" (Setchell 1921:41). Native Americans in many regions of North America purposefully burned a plot of ground, cast tobacco seeds in the ashes, and then returned for harvest at a later time (Adams 1990c).

The archaeological record of tobacco use among the Ancestral Puebloans is accumulating (Adams and Toll 2000; Winter 2000). In the Mesa Verde region, tobacco has been documented in sites excavated as part of the Dolores Archaeological Project (Matthews 1986), and in sites in the Montezuma Valley (Brandt 1991). There is every reason to believe that burned pinyon/juniper woodland would provide the Ancestral Puebloans with abundant tobacco harvests in the first year following a burn.

Opuntia sp. (prickly pear). *Opuntia* sp. plants, low in frequency and coverage in the unburned pinyon/juniper plot, had returned in low representation to the burned pinyon/juniper plot by 1991. Both plots offer young tender pads in the early summer as a vegetative food product, but only the plants in the unburned plot became reproductive and capable of forming edible fruit. No prickly pear cacti were observed in either sagebrush/bitterbrush plot.

Poa fendleriana. *Poa fendleriana* was present in all four communities, though in the burned plots it was not observed during the first year after the fire. *Poa fendleriana* is another cool-season grass of value early in the growing season; its recovery in archaeological sites has been reported (Bohrer 1975:202).

Polygonum douglasii. *Polygonum douglasii* plants increased in coverage and frequency in both burned plots, starting the first year following the fire. They displayed the highest coverage values of any herbaceous taxon in 1992. A similar, but less-dramatic trend was also documented in both unburned plots. *Polygonum* spp. have both ethnographic (Ebeling 1986:37, 754) and archaeological records.

Schoenocrambe linifolia. In the five-year study, this perennial mustard has been documented only in the burned pinyon/juniper plot. It has been observed previously as a plant of open, disturbed areas on Mesa Verde (Welsh and Erdman 1964:18). In 1990, the plants displayed notable vigor and vitality from summer through late fall, providing a potential greens and seeds resource. For the following four years, they were also present in this burned plot. It offers an important greens and seed resource to humans, much as other members of the mustard family do (Ebeling 1986:371, 647; Adams 1988:205-211).

Sphaeralcea coccinea. Common globemallow plants have responded well to fire in the sagebrush/bitterbrush plot. Their presence in other plots is negligible. Elsewhere in the southwest, globemallow multiplies under various forms of disturbance, especially agriculture (Parker 1958). The pollen record of globemallow in southern Arizona Hohokam field contexts has helped explain various forms of ancient land manipulation by fire (Bohrer 1992). Although the ethnographic record is rather mute on globemallow use, stems of one species have been chewed for gum by the Hopis (Yanovsky 1936:43). The archaeological record at times records "Malvaceae" seeds from prehistoric deposits, which could include globemallow.

Stipa spp. A small amount of *Stipa hymenoides* grew in the burned pinyon/juniper plot in 1991. However, *Stipa comata* did well in both sagebrush/bitterbrush plots for most of this study. Ricegrass grains have been extensively utilized by historic groups, and are commonly encountered in archaeological sites (Bohrer 1975). One type of needlegrass (*Stipa speciosa*) was threshed by burning by the Kawaiisu, who then winnowed and boiled the loose grains (Zigmund 1981).

Viguiera multiflora. *Viguiera* plants are much more prominent in the two burned study plots. By the second and third years following the burn, both frequency and coverage had increased notably. Although *Viguiera* species elsewhere in the west have provided fish poisons (Ebeling 1986:759), the difficulty in telling charred achenes from those of *Helianthus* in archaeological contexts increases the possibility that *Viguiera* once offered a food resource as well.

DISCUSSION

Ecology.

It is clear that in both communities studied, there are notable differences between the burned study plot and its adjacent counterpart unburned control plot. The role of a herd of feral horses on Long Mesa in promoting vegetation differences is unknown. By the end of the five-year study, the burned pinyon/juniper woodland had no *Pinus edulis* or *Juniperus osteosperma*, for which the plot is named. Oak is clearly the dominant woody member here. Of the shrubs that have recovered via stump-sprouting, none had become reproductive by 1992. Only *Chrysothamnus nauseosus*, noted first in 1992 and the sole shrub suspected of having become established via seed, has flowered.

The recovery of the burned sagebrush/bitterbrush plot has been dominated by stump-sprouting *Amelanchier utahensis* and *Symphoricarpos oreophilus*. Of a number of shrubs that

returned to this plot, only *Symphoricarpos* has reproduced. Both *Artemisia tridentata/nova* and *Purshia tridentata* had become established in the burned sagebrush/ bitterbrush plot by the end of the five-year study.

Shrub taxa vary in distribution. Shrubs are initially more diverse in unburned plots than in recently burned ones, but by the end of five years the balance is nearly equal. While generally the coverage and frequency of individual shrub taxa are also greater in the unburned plots, burning seems to have greatly enhanced both the coverage and frequency of Gambel's oak in the burned pinyon/ juniper plot during the first year of recovery.

Shrub taxa also vary in other basic characteristics. The growth mode noted first for all the shrubs in the burned plots was root crown or stump-sprouting, the production of long, flexible and leafy stems from the underground portion of the plant. None of these individuals had matured enough to become reproductive in the first summer following the burn. On the other hand, the shrubs in the unburned control plots varied in age class, with many of the larger ones flowering and fruiting.

The herbaceous vegetation has been greatly affected by burning in both communities studied, especially in the first year after the fire. For example, herbaceous plant diversity doubled in the burned pinyon/juniper plot between 1990 and 1991, with some species (*Nicotiana*, *Chenopodium*, *Schoenocrambe*, *Poa*) expressing significant vigor and vitality in 1990. Herbaceous plant diversity in the burned sagebrush/bitterbrush plot is high, and although many plants are shared in common with its unburned counterplot, coverage and frequency can be quite different. It is obvious that the diversity in herbaceous vegetation fostered by burning has helped to create a mosaic of habitats on Long Mesa.

The amount of litter and bare ground also differs between unburned and burned plots. Unburned plots have relatively high coverage and frequency of litter, compared to the burned plots. Unburned plots also have low amounts of bare ground, relative to burned plots.

Ethnobotany.

A mosaic habitat with four separate vegetation types, two of them fostered by fire, offers humans a much wider range of choices than two unburned vegetation types alone. Blackened plots have undergone constant vegetation development. Such a situation provides an increased array of resources for both fauna and humans. In the burned pinyon/juniper plot humans could harvest wild tobacco, goosefoot, muttongrass and mustard greens/seeds in the first year following the fire. Sound, fire-blackened firewood could be gathered along with construction beams, depending on technology available to work with dead wood. Flexible rabbitbrush stems are first available three years after a fire. The unburned pinyon/juniper plot offers various grasses, prickly pear cacti, and lupines, along with living trees for fuelwood and construction timber harvest, and pinyon nut and juniper berry crops.

The burned sagebrush/bitterbrush plot offers a variety of resources as well. Flexible sucker shoots developed from all shrubs except for sagebrush. Potential foods in this plot include

mariposa lily bulbs, goosefoot greens/seeds, squirreltail grass grains, buckwheat seeds, junegrass grains, biscuitroot roots, lupines, muttongrass, knotweed, common globemallow, and needlegrass. The unburned sagebrush/bitterbrush plot has many of the same resources, plus stoneseeds for adornment.

Previous research.

Previous research has focused on the role of fire and the major successional stages that lead to climax pinyon/juniper communities on the Mesa Verde. A natural lightning-caused fire in July of 1959 (Morfield Burn) provided the opportunity for Erdman (1970) to evaluate the earliest stages of succession for a minimum of four years following the burn. These data can be compared to information from the present study. Erdman also documented a stand of mature pinyon/juniper woodland on Long Mesa to serve as a control.

Since the locations of the newly burned pinyon/juniper plots in the two studies differed (Long Mesa, this study; Morfield Burn, previous study), one might not expect the vegetation recovery trajectories to be identical. Another potentially confusing aspect is that a mixture of commercial seed was air-dropped over the Morfield Burn in October of 1959 (Erdman 1970:5), presumably influencing the sequence of natural succession. During the first two years, the pioneer vegetation of the Morfield Burn was dominated by a sunflower (*Helianthus annuus*) and a goosefoot (*Chenopodium praetericola*), with domestic wheat (*Triticum aestivum*), an introduced brome grass (*Bromus japonicus*), and a native brome grass (*B. carinatus*) present at the site (Erdman 1970:5). In contrast, the Long Mesa burn was dominated by a different species of goosefoot (*Chenopodium fremontii*), and totally lacked evidence of sunflower. If *Chenopodium/Helianthus* constitutes an early seral stage throughout the Mesa Verde, as suggested by Erdman (1970:5), for some reason that stage was not repeated in the first year following the 1989 Long Mesa burn. The ability of feral horses to keep a wild sunflower population completely in check should be considered.

On Long Mesa, the early trajectory of vegetation recovery also included vigorous populations of *Nicotiana attenuata*, *Schoenocrambe linifolia*, and *Poa fendleriana*. Without considering the effects of the introduced commercial seed, a number of herbaceous plants shared in common displayed similar representation between the five year old Long Mesa (this study) and four year old Morfield burned pinyon/juniper plots (Erdman 1970:5). These taxa included *Machaeranthera canescens*, *Viguiera multiflora*, *Stipa hymenoides*, *Lappula redowskii*, *Lupinus* spp., *Chenopodium* spp., and *Penstemon linarioides*. Bare soil, litter and rock were quite similar in coverage and frequency as well.

The two locations are similar in respect to recovery of woody vegetation. In the Morfield Burn, many of the fire-adapted shrubs sprouted following the burn, and developed vigorously within the first year. This also happened in the Long Mesa plot. In both locations, Gambel's oak sprouted and was in leaf within weeks of the burn, revealing an impressive adaptability to fire. The same was true for *Yucca baccata* on Long Mesa. By the third year on Long Mesa, six shrubs and yucca were all present as stump-sprouters, basically the same ones noted in the Morfield burn area (Erdman 1970:19) four years after the fire. Notably, the coverages and

frequencies of the shrubs monitored in the Long Mesa burn plot were consistently higher, and in some cases much higher than those in the Morfield plot.

By co-incidence, both unburned control plots representing mature pinyon/juniper woodland were located on Long Mesa. Erdman (1970:13) described pinyon and juniper as co-dominants, with juniper displaying a higher "Importance Value" (which takes into account density, frequency and dominance of taxa). The current study essentially reached the same conclusions. The relative dominance and relative frequency of these two taxa in 1990 appear to be the same as they were in 1963. Juniper trees still have larger (and often multiple) trunks. Relative density of pinyon is higher in the current study, influenced by a smaller mean distance to the trees encountered. Although both pinyon and juniper were well-represented by seedlings in 1963, by 1990 only juniper displayed a balance of age classes suggestive of a healthy taxon replacing itself.

Acknowledgments

We are grateful for the cooperation and support of Mesa Verde National Park personnel in developing and initiating this research. Marilyn Colyer assisted in choosing the study plots, and has provided us with a large dose of encouragement from our earliest visits to Long Mesa. Dr. Jack Smith and Superintendent Robert Heyder supported and smoothed the way for research to begin in a timely manner. Crow Canyon participants and research staff joined us throughout the project. Rebecca VanDevender keyed out the entire herbarium collection. Wendy Youmans and Nancy Shulman helped develop raw data into the data tables of this report. Crow Canyon Archaeological Center fully supported this research.

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Table 1. Scientific names with common equivalents. Names correspond to *A Utah Flora* (Welsh et al. 1987).

Scientific Name	Common Name
<i>Achillea millefolium</i>	Yarrow
<i>Amelanchier utahensis</i>	Serviceberry
<i>Arabis holboellii</i>	Rockcress
<i>Artemisia ludoviciana</i> , <i>A. nova</i> , <i>A. tridentata</i>	Sagebrush
<i>Astragalus scopulorum</i>	Gravel milkvetch
<i>Balsamorhiza sagittata</i>	Balsamroot
<i>Bromus</i> spp.	Brome grass
<i>Bromus tectorum</i>	Cheatgrass
<i>Calochortus nuttallii</i>	Mariposa lily
<i>Cercocarpus montanus</i>	Mountain mahogany
<i>Chenopodium fremontii</i> , <i>Chenopodium leptophyllum</i>	Goosefoot
<i>Chrysothamnus depressus</i>	Rabbitbrush
<i>Cirsium undulatum</i> , <i>Cirsium</i> sp.	Thistle
<i>Comandra umbellata</i>	Toadflax
<i>Cordylanthus wrightii</i>	Wright's birdbeak
<i>Crepis acuminata</i>	Mountain hawksbeard
<i>Cymopterus purpureus</i>	Spring parsley
<i>Delphinium nuttallianum</i>	Delphinium
<i>Dracocephalum parviflorum</i>	Obedient plant
<i>Elymus elymoides</i>	Squirreltail
<i>Elymus smithii</i>	Western wheatgrass
<i>Erigeron divergens</i> , <i>E. engelmannii</i> , <i>E. pumilus</i> , <i>E. speciosus</i>	Daisy
<i>Eriogonum racemosum</i>	Redroot buckwheat
<i>Eriogonum umbellatum</i>	Buckwheat
<i>Fendlera rupicola</i>	Fendlerbush
<i>Gayophytum ramosissimum</i>	Gayophytum
Gramineae	Grass
<i>Grindelia arizonica</i>	Gumweed
<i>Helianthus annuus</i> , Compositae	Sunflower
<i>Heterotheca villosa</i>	Hairy goldenaster
<i>Juniperus osteosperma</i>	Juniper
<i>Koeleria macrantha</i>	Junegrass
<i>Lactuca serriola</i>	Prickly lettuce
<i>Lappula redowskii</i>	Stickseed
<i>Lithospermum ruderae</i>	Stoneseed
<i>Lomatium triternatum</i>	Biscuitroot
<i>Lupinus caudatus</i> , <i>L. polyphyllus</i>	Lupine
<i>Machaeranthera canescens</i>	Hoary aster
<i>Microsteris gracilis</i>	Phlox
Monocotyledon	Monocotyledon
<i>Nicotiana attenuata</i>	Tobacco
<i>Opuntia</i> (prickly pear)	Prickly pear cactus
<i>Orthocarpus purpurea-albus</i>	Owlclover

<i>Pedicularis centranthera</i>	Pinyon/juniper lousewort
<i>Penstemon linarioides</i>	Penstemon
<i>Penstemon strictus</i>	Rocky Mountain
<i>Petradoria pumila</i>	Rock goldenrod
<i>Phacelia heterophylla</i>	Phacelia
<i>Pinus edulis</i>	Pinyon
<i>Poa fendleriana</i>	Muttongrass
<i>Poa pretensis</i>	Kentucky bluegrass
<i>Polygonum douglasii</i>	Knotweed
<i>Purshia tridentata</i>	Bitterbrush
<i>Quercus gambelii</i>	Gambel's oak
<i>Salsola iberica</i>	Tumbleweed
<i>Schoenocrambe linifolia</i> , <i>Cruciferae</i>	Mustard
<i>Sphaeralcea coccinea</i>	Common globemallow
<i>Stipa comata</i>	Needlegrass
<i>Stipa hymenoides</i>	Ricegrass
<i>Symphoricarpos oreophilus</i>	Snowberry
<i>Tetradymia canescens</i>	Gray horsebrush
<i>Tragopogon</i> sp.	Goat's beard
<i>Viguiera multiflora</i>	Goldeneye
<i>Wyethia arizonica</i>	Mulesears
<i>Yucca baccata</i>	Yucca

Cover and frequency of vegetation in the unburned pinyon/juniper plot.

	1990		1991		1992		1993		1994	
	Cover	Freq.	Cover	Freq.	Cover	Freq.	Cover	Freq.	Cover	Freq.
	%	%	%	%	%	%	%	%	%	%
TREES										
<i>Juniperus osteosperma</i>	20.14	32.00	32.60	58.00	27.99	52.00	27.30	46.00	28.30	50.00
<i>Pinus edulis</i>	26.36	52.00	37.60	68.00	32.70	56.00	29.90	52.00	30.70	52.00
SHRUBS										
<i>Amelanchier utahensis</i>	5.09	18.00	9.18	30.00	6.53	24.00	6.40	16.00	4.60	12.00
<i>Artemisia tridentata/nova</i>	6.58	26.00	3.67	24.00	5.91	26.00	4.80	20.00	4.50	18.00
<i>Cercocarpus montanus</i>	8.06	18.00	9.83	30.00			7.80	18.00	10.00	22.00
<i>Chrysothamnus depressus</i>					0.28	4.00				
<i>Fendlera rupicola</i>	2.07	8.00	2.12	10.00	5.18	12.00	3.80	10.00	3.20	10.00
<i>Purshia tridentata</i>	6.21	20.00	10.90	34.00	5.53	28.00	7.10	32.00	7.40	32.00
<i>Quercus gambelii</i>	1.44	2.00	1.46	4.00	2.67	4.00	1.60	2.00	1.60	2.00
<i>Yucca baccata</i>	1.03	4.00	1.48	6.00	0.55	2.00	0.50	4.00	0.50	4.00
HERBS										
<i>Balsamorhiza sagittata</i>			+	8.00	+	8.00	@	4.00	#	8.00
<i>Chenopodium sp.</i>									+	2.00
<i>Comandra umbellata</i>	+	18.00	@	26.00	@	26.00	#	22.00	1-4	28.00
<i>Cordylanthus wrightii</i>			+	4.00	@	18.00	#	14.00	#	6.00
<i>Crepis acuminata</i>									+	2.00
<i>Delphinium nuttallianum</i>							+	2.00		
<i>Elymus elymoides</i>	@	28.00	+	10.00	@	12.00	#	10.00	#	8.00
<i>Eriogonum speciosus</i>	+	2.00	+	2.00			@	4.00	@	4.00
<i>Eriogonum umbellatum</i>	+	2.00								
Gramineae			+	12.00	1-4	70.00				
<i>Koeleria macrantha</i>			+	2.00	+	12.00	#	18.00	#	8.00
<i>Lupinus caudatus</i>			@	20.00	@	16.00			@	4.00
<i>Lupinus polyphyllus</i>			@	24.00	#	34.00	1-4	40.00	1-4	50.00
<i>Machaeranthera canescens</i>									@	4.00
<i>Opuntia (p. pear)</i>	+	4.00	+	6.00	+	4.00	@	4.00	@	4.00
<i>Penstemon linarioides</i>	+	22.00	@	44.00	@	38.00	#	28.00	#	34.00
<i>Petradora pumila</i>	+	8.00	@	30.00	@	20.00	#	20.00	#	22.00
<i>Poa fendleriana</i>	#	66.00	1-4	82.00	1-4	58.00	1-4	74.00	4-10	84.00
<i>Polygonum douglasii</i>			+	4.00	@	42.00	#	10.00	#	18.00
<i>Stipa comata</i>									+	2.00
<i>Viguiera multiflora</i>							+	2.00		
<i>Wyethia arizonica</i>					+	2.00				
GROUND										
Bare soil	1-4	46.00	4-10	68.00	1-4	58.00	1-4	52.00	1-4	42.00
Litter	51-75	92.00	76-90	100.00	76-90	100.00	76-90	100.00	76-90	100.00
Rock	+	10.00	+	14.00	+	18.00	@	6.00	@	6.00

+ Occurring as a single individual with reduced vigor; no measureable cover

@ Occurring as 1-2 individuals with normal vigor; no measureable cover

Occurring as several individuals; measureable cover less than 1%.

Table 3. Age class analysis of the unburned pinyon/juniper study plot in 1990* and 1994. Seedlings are less than 30.4 cm in height; saplings are greater than 30.4 cm, but less than 5 cm in diameter; trees are greater than 5 cm in diameter.

Species	Seedlings	Saplings	Trees	Total
<i>Juniperus osteosperma</i>				
1990	7	16	14	37
1994	5	22	4	31
<i>Pinus edulis</i>				
1990	1	9	16	26
1994	1	3	3	7

* Based on 9 of 10 data points.

Table 4. Point quarter analysis of pinyon and juniper in the unburned pinyon/juniper study plot in 1990 and 1994. See Appendix 2 for explanation of calculations.

Species	Number of Trees	Mean distance (meters)	Basal* area (sq. cm)	Density No/.4047 hectare.	-----Relative-----			Importance Value (Dens+Freq+Dom)
					Dens. %	Freq. %	Dom. %	
<i>Juniperus osteosperma</i>								
1990	26	6.71	22,332	90	29	56	87	172
1994	25	7.24	73,094	77	39	60	96	195
<i>Pinus edulis</i>								
1990	14	4.33	3262	216	71	44	13	128
1994	15	5.96	3022	114	59	39	4	101
All Trees								
1990	40	11.04	25,594	306	100	100	100	300
1994	40	13.2	76,116	191	100	100	100	300

* Basal areas for all trunks of multiple-trunked individuals have been summed to find the total basal area for the specimen.

Table 5. Cover and frequency of vegetation in the burned pinyon/juniper plot.

	1990		1991		1992		1993		1994	
	Cover	Freq.	Cover	Freq.	Cover	Freq.	Cover	Freq.	Cover	Freq.
	%	%	%	%	%	%	%	%	%	%
SHRUBS										
<i>Amelanchier utahensis</i>			0.79	8.00	1.02	4.00	1.83	4.00	2.00	4.00
<i>Cercocarpus montanus</i>	0.22	2.50			0.31	4.00	1.10	6.00	1.50	8.00
<i>Fendlera rupicola</i>			0.54	2.00	0.37	2.00	0.80	4.00	0.50	2.00
<i>Purshia tridentata</i>	1.09	7.50	1.98	10.00	2.73	16.00	2.70	18.00	0.30	16.00
<i>Quercus gambelii</i>	8.31	25.00	11.92	28.00	12.92	26.00	14.40	80.00	13.00	26.00
<i>Symphoricarpos oreophilus</i>	0.08	4.00	0.41	2.00	0.07	2.00	0.20	2.00	0.20	2.00
<i>Yucca baccata</i>	1.21	5.00	1.77	6.00	2.54	6.00	3.30	8.00	2.70	8.00
HERBS										
<i>Bromus tectorum</i>							+	2.00	+	2.00
<i>Calochortus nuttallii</i>							+	2.00		
<i>Chenopodium fremontii</i>	#	34.00	#	56.00	@	36.00	+	2.00	#	8.00
<i>Cirsium sp.</i>					+	2.00			+	2.00
<i>Cirsium undulatum</i>							+	2.00	#	8.00
<i>Comandra umbellata</i>	+	10.00	+	22.00	@	22.00	#	26.00	1-4	30.00
<i>Cordylanthus wrightii</i>	+	2.00			+	2.00				
<i>Cymopterus purpureus</i>							#	10.00		
<i>Elymus elymoides</i>			+	4.00	+	8.00	#	6.00	#	14.00
<i>Erigeron divergens</i>	+	2.00	+	4.00	+	2.00				
<i>Erigeron engelmannii</i>									+	2.00
<i>Eriogonum umbellatum</i>			+	4.00					+	2.00
Gramineae	+	6.00			+	12.00	@	4.00		
<i>Helianthus villosa</i>					+	6.00	@	4.00	@	4.00
<i>Helianthus macrantha</i>					+	10.00				
<i>Lactuca serriola</i>			@	36.00	#	56.00	#	12.00		
<i>Lappula redowskii</i>	+	2.00	+	14.00	+	12.00	#	6.00		
<i>Lupinus caudatus</i>			+	2.00	+	2.00			#	4.00
<i>Lupinus polyphyllus</i>			+	8.00	+	2.00	#	12.00	#	12.00
<i>Machaeranthera canescens</i>			+	2.00	#	38.00	1-4	38.00	1-4	56.00
<i>Microsteris gracilis</i>					+	4.00				
<i>Nicotiana attenuata</i>	+	4.00	+	4.00						
<i>Opuntia (p. pear)</i>			+	4.00	+	2.00				
<i>Pedicularis centranthera</i>							@	4.00		
<i>Penstemon linarioides</i>	@	20.00	@	30.00	#	26.00	1-4	22.00	1-4	34.00
<i>Phacelia heterophylla</i>									+	2.00
<i>Poa fendleriana</i>			@	22.00	+	8.00	#	22.00	#	14.00
<i>Polygonum douglasii</i>	@	26.00	#	84.00	1-4	96.00	1-4	76.00	#	44.00
<i>Salsola iberica</i>			+	6.00						
<i>Schoenocrambe linifolia</i>	+	2.00	@	20.00	@	24.00	#	34.00	#	24.00
<i>Stipa hymenoides</i>			+	2.00					+	2.00
<i>Tragopogon sp.</i>			+	4.00			@	4.00		
<i>Viguiera multiflora</i>	+	4.00	@	38.00	#	52.00	1-4	60.00	1-4	64.00
GROUND										
Bare soil	51-75	94.00	34-50	100.00	11-25	92.00	11-25	90.00	26-33	88.00
Litter	4-10	84.00	26-33	100.00	34-50	100.00	34-50	100.00	34-50	92.00
Rock	+	10.00	+	40.00	+	26.00	#	10.00	#	8.00

Occurring as a single individual with reduced vigor; no measureable cover

Occurring as 1-2 individuals with normal vigor; no measureable cover

Occurring as several individuals; measureable cover less than 1%.

Table 6. Cover and frequency of vegetation in the unburned sagebrush/bitterbrush plot.

	1990		1991		1992		1993		1994	
	Cover %	Freq. %	Cover %	Freq. %	Cover %	Freq. %	Cover %	Freq. %	Cover %	Freq. %
SHRUBS										
<i>Amelanchier utahensis</i>	6.28	16.00	6.82	26.00	6.57	20.00	8.00	20.00	7.60	20.00
<i>Artemisia tridentata/nova</i>	17.30	84.00	11.48	92.00	12.41	74.00	11.10	76.00	10.60	72.00
<i>Chrysothamnus depressus</i>	1.91	10.00	2.06	20.00	0.90	8.00	0.70	16.00	0.50	12.00
<i>Purshia tridentata</i>	24.10	76.00	15.63	92.00	14.67	72.00	18.60	78.00	18.10	74.00
<i>Symphoricarpos oreophilus</i>	2.33	6.00	3.26	8.00	4.21	14.00	5.10	14.00	3.50	8.00
<i>Tetradymia canescens</i>							0.40	10.00	0.50	6.00
HERBS										
<i>Achillea millefolium</i>	+	2.00	+	2.00	+	2.00	+	2.00	#	6.00
<i>Artemisia ludoviciana</i>	+	4.00								
<i>Astragalus scopulorum</i>	+	2.00	+	6.00	+	4.00	@	4.00	@	4.00
<i>Calochortus nuttallii</i>					+	34.00	+	2.00	#	10.00
<i>Chenopodium fremontii</i>	+	2.00			+	2.00	+	2.00		
<i>Cirsium undulatum</i>					+	2.00			+	2.00
<i>Compositae</i>			@	40.00	@	42.00			#	8.00
<i>Cordylanthus wrightii</i>					+	26.00				
<i>Crepis acuminata</i>			+	2.00			+	4.00	#	28.00
<i>Cruciferae</i>					+	2.00				
<i>Delphinium nuttallianum</i>			+	2.00						
<i>Elymus elymoides</i>	@	28.00	#	68.00	1-4	74.00	1-4	62.00	1-4	62.00
<i>Elymus smithii</i>			+	14.00			#	8.00	#	12.00
<i>Erigeron divergens</i>							+	2.00		
<i>Erigeron engelmannii</i>	+	6.00	+	8.00	+	8.00	+	4.00	+	2.00
<i>Erigeron pumilus</i>			+	8.00					+	2.00
<i>Eriogonum speciosus</i>	+	2.00	+	4.00						
<i>Eriogonum racemosum</i>			#	82.00	#	70.00	1-4	66.00	1-4	62.00
<i>Eriogonum umbellatum</i>	@	60.00	#	64.00	@	34.00				
<i>Gayophytum ramosissimum</i>					+	10.00				
<i>Gramineae</i>			#	60.00	@	22.00	+	2.00		
<i>Koeleria macrantha</i>			1-4	84.00	#	44.00	1-4	54.00	1-4	68.00
<i>Lactuca serriola</i>					+	10.00				
<i>Lithospermum ruderae</i>	+	2.00	@	22.00	+	8.00	#	6.00	#	18.00
<i>Lomatium triternatum</i>			+	22.00	@	34.00				
<i>Lupinus caudatus</i>			+	16.00	@	16.00	#	30.00	1-4	52.00
<i>Machaeranthera canescens</i>									@	4.00
<i>Microsteris gracilis</i>			+	8.00	@	38.00				
<i>Monocotyledon</i>			+	18.00						
<i>Orthocarpus purpurea-albus</i>			+	2.00			#	8.00		
<i>Penstemon linarioides</i>	+	6.00	@	24.00	@	28.00	#	8.00	#	12.00
<i>Penstemon strictus</i>			+	4.00	+	2.00				
<i>Petrorhiza pumila</i>	1-4	62.00	4-10	90.00	4-10	72.00	4-10	72.00	1-4	76.00
<i>Phacelia heterophylla</i>							+	2.00	+	2.00
<i>Poa fendleriana</i>	1-4	80.00	4-10	90.00	4-10	86.00	1-4	66.00	4-10	82.00
<i>Polygonum douglasii</i>	+	2.00	+	10.00	@	56.00	1-4	64.00	#	26.00
<i>Sphaeralcea coccinea</i>	+	2.00	+	2.00						
<i>Stipa comata</i>	+	2.00	#	54.00	#	50.00	1-4	32.00	+	2.00
<i>Viguiera multiflora</i>					+	2.00	+	2.00		
GROUND										
Bare soil	4-10	90.00	11-25	100.00	11-25	100.00	4-10	92.00	4-10	88.00
L ¹	26-33	88.00	34-50	100.00	34-50	100.00	76-90	100.00	51-75	100.00
R			+	10.00			+	2.00		

+ Occurring as a single individual with reduced vigor; no measureable cover

@ Occurring as 1-2 individuals with normal vigor; no measureable cover

Occurring as several individuals; measureable cover less than 1%.

Table 8. Characteristics of *Chenopodium fremontii* in the burned pinyon/juniper plot, following the fire.

	Height (m)*		Width (m)		Number Estimated**
	AVG.	RANGE	AVG.	RANGE	
10/19/90	1.17	0.57-1.60	0.60	0.05-1.65	811
08/08/91	0.12	0.05-0.38	0.03	0.01-0.11	6820
09/24/92	0.26	0.06-0.46	0.01	0.003-0.02	2227

* Height and width of 30 plants encountered and measured along a straight-line transect.

** A crew of eight people, equally-spaced across the width of the plot, walked a straight line and called out estimates of the number of plants in their direct paths.

Appendix 1. Definitions of terms, methods, and techniques employed in this study. Plot sizes or sampling intervals parallel those of earlier studies, but may seem unusual since they have been converted to the metric system.

Age class: used to view the overall health of a taxon, by evaluating the number of individuals of various age classes present in a study plot. Age class data was gathered only for pinyon (*Pinus edulis*) and juniper (*Juniperus osteosperma*) in the unburned pinyon/juniper community. Total numbers of seedlings (< 30.4 cm in height), saplings (> 30.4 cm in height, but less than 5 cm (2 inches) diameter breast height) and trees (> 5 cm diameter breast height) were tallied within the study plot in a series of 10 belt transects of 1.2 x 15.2 meters (4 x 50 feet).

Coverage: a type of analysis that takes plant dimensions into account, expressing the size or bulk of the shoots of each species in relation to space (Daubenmire 1968:41).

Trees and Shrubs: For this project, coverage for trees and shrubs was gathered via a **line intercept** method. This consists of mentally imagining a polygon around the periphery of any trees or shrubs whose individual canopies overlap permanently established lines approximately 25 cm above ground surface. An observer can then follow the established line and record the lengths of segments along it that cross the polygons of individual plants. The sums of the measurements for each taxon, in relation to the total length of the line studied (15240 cm/6000 inches), is used to compute a coverage percentage. Each taxon is evaluated independently, thus if two separate shrubs overlap the same area along a line, each is considered to do so.

Herbaceous Vegetation: Coverage for non-woody taxa was determined via movable metal frames known as **canopy coverage plots** (or "understory windows"), in this case of 30.5 x 61 cm size (12 x 24 inches). Here coverage is measured as an expression of the percentage of ground included in a vertical mental projection of polygons drawn about the total natural spread of foliage of each taxon included within a plot. The values for coverage class are actually estimations (available in Appendix 2). The values for each taxon, plus for rock, litter and bare soil, are computed separately, regardless of superimposed canopies of different species, but ignoring intraspecific overlap. Thus, the sums of coverages for a particular plot might easily exceed 100 % (Daubenmire 1968:44).

Density: is usually understood as the number of individuals of a species per unit area (Daubenmire 1968:40). For the fire effects study, density of pinyon and juniper per 0.4047 hectare (1 acre) have been determined only for the unburned pinyon/juniper community. Only individuals greater than 10 cm (4 inches) basal diameter (by convention measured at ~1 meter above ground for trees) are included. Density data was accumulated using the Point Quarter Method (Cottam and Curtis 1956), which focuses on 10 individual data points spaced at 15.2 meter (50 feet) intervals, and accumulates data on the basal diameter of the nearest tree in each of four quadrants around each data point. The calculations for density are available in Appendix 2.

Frequency: is defined as the percentage of occurrence of a taxon in a series of samples of uniform size (Daubenmire 1968:53). Frequency provides information on the uniformity of distribution, complimenting data on how many (density) and how much (coverage). Trees

and Shrubs: frequencies for woody taxa were calculated by dividing the number of sublines along which each taxon was recognized by the total number of sublines (50), and converting to percentage.

Herbaceous Vegetation: frequencies for herbaceous vegetation were calculated by dividing the total number of canopy coverage plots in which each taxon occurred by the total number of canopy coverage plots (50), and converting to percentage.

Importance Value: Using information gathered for the Point Quarter Method (Cottam and Curtis 1956; Erdman 1970), relative density, relative dominance (essentially coverage), and relative frequency calculations for pinyon and juniper are possible. The sum of these three relative values are assumed to express the relative importance of each taxon in a given study plot by simultaneously considering numbers (density), size (coverage), and repeated occurrence (frequency).

Rules: Some field rules adopted in this research include the following.

1. In both burned and unburned plots, dead specimens are not tallied or included in vegetation monitoring.
2. For canopy coverage plots, if a tree or shrub impedes placement of the coverage frame along a line, the frame is placed as near to the desired location as possible.
3. For coverage estimates, when there is overlap among individuals of the same taxon (species), the overlapping area is not counted twice. When there is overlap among two or more separate taxa or categories, the coverage of each is added independently of the rest.

Study Plot: each study plot is consistently the same size, and marked at the same intervals (see attached drawing). The basic plot size is 15.2 x 68.6 meters (50 x 225 feet). Frequency and coverage data for trees and shrubs is gathered along a total of 10 lines spaced at 7.6 meter (25 feet) intervals, with each line divided into 5 sublines of 3.04 meters (10 feet) length, for a total of 50 sublines for data gathering. Frequency and coverage data for herbaceous vegetation is gathered in 50 total 30.5 x 61 cm (12 x 24 inch) canopy coverage plots, again evenly spaced as in the attached drawing. Point Quarter Data is accumulated along a long axis of the plot at 15.2 meter (50') intervals; since a total of 136.8 meters is necessary to accommodate a total of 10 data points, the long axis of the study plot must be extended an extra 68.6 meters. The age class data for pinyon and juniper trees is monitored in a total of 10 belt transects, each 1.2 x 15.2 meters (4 x 50 feet) in size and located adjacent to the lines where line-intercept and canopy coverage plots are evaluated.

Appendix 2. Field Forms utilized in study of Long Mesa. Order of forms which follow:

Diagram of plot layout.

Cumulative Plant Species List.

Trees and Shrubs, Dominance and Frequency Data (2 pages)

Trees and Shrubs, Summarized Line Data.

Pinyon and Juniper, Age Classes.

Understory Data (2 pages)

Understory Data, Summarized.

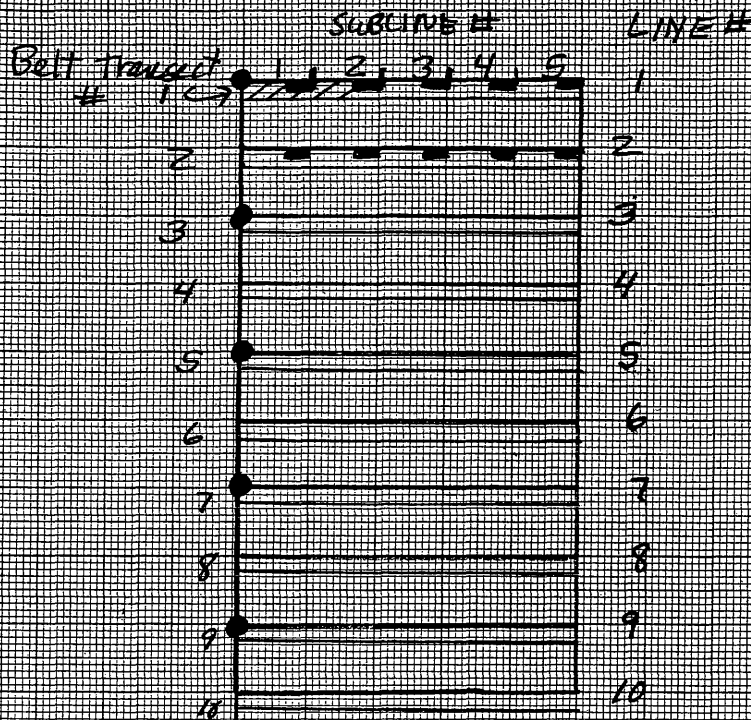
Point-Quarter Method, Raw Data.

Point-Quarter Method, Summarized Data.

Notes.

46 1510

K&E 10. X 10. TO THE CENTIMETER 18 X 25 CM.
KEUFFEL & ESSER CO. MADE IN U.S.A.



● = point quarter method points
— Herbaceous understory plot locations

6/21/90

PLANT SPECIES LIST

PAGE # _____

BURNED PLOT # ___ or UNBURNED PLOT # ___ Date ___

Names of observers _____

List of species observed:

-Date first documented

Species

Crow Canyon
Collecting No.

This image shows a full page of primary-ruled paper. It features three vertical columns of horizontal dashed lines, designed for handwriting practice. The first column on the left contains 10 rows of lines. The middle column also contains 10 rows of lines. The third column on the right contains 10 rows of lines. There are no margins or other markings on the page.

6/22/94

TREES AND SHRUBS, LINES 1-5

BURNED PLOT # or UNBURNED PLOT # Date

Names of observers _____

Trees and Shrubs: Dominance and Frequency

For each species, record the total number of cm of canopies that project over each subline.

Each line = 15.2 meters (50 feet). Each subline = 3.04 meters (10 feet).

-- Please put a large "X" through any line that your group did not do on this day.

[illegible][illegible]

6/22/90

TREES AND SHRUBS, LINES 6-10.

BURNED PLOT # _____ of UNBURNED PLOT # _____ Date _____

Names of observers _____

Trees and Shrubs: Dominance and Frequency.

For each species, record the total number of cm of canopies that project over each subline.

Each line = 15.2 meters (50 feet). Each subline = 3.04 meters (10 feet).

Please put a large "X" through any line that your group did not do on this day.

[illegible]

6/22/90

4 TREES AND SHRUBS, SUMMARIZED LINE DATA.

BURNED PLOT # ___ or UNBURNED PLOT # ____

Date _____

Names of observers

SUMMARIZED LINE DATA

Trees and Shrubs: Dominance and Frequency

To calculate % Cover for each tree and shrub species:

Total # of cm of projected canopy X 100

Total # of cm along all lines (15240 cm or 6000")

To calculate % Frequency for each tree and shrub species:

Total # of sublines along which species observed X 100

Total # of all sublines (50)

[illegible]

6/22/90

PINYON AND JUNIPER, AGE CLASSES.

BURNED PLOT # ___ or UNBURNED PLOT # _____ Date _____

Names of observers _____

Pinon (*Pinus edulis*) and juniper (*Juniperus osteosperma*) Abundance and Reproduction.
Use metric calipers for measuring small diameters; diameter tapes work best on larger trees.

of trees of each class in each 1.2 m (4') x 15.25 m (50') Belt Transect

	Transect #									
	1	2	3	4	5	6	7	8	9	10
<u>Pinus edulis</u>										
seedlings, < 30.4 cm high	---	---	---	---	---	---	---	---	---	---
saplings, stems < 5 cm diam.	---	---	---	---	---	---	---	---	---	---
trees, stems > 5 cm diam.	---	---	---	---	---	---	---	---	---	---
<u>Juniperus osteosperma</u>										
seedlings, < 30.4 cm high	---	---	---	---	---	---	---	---	---	---
saplings, stems < 5 cm diam.	---	---	---	---	---	---	---	---	---	---
trees, stems > 5 cm diam.	---	---	---	---	---	---	---	---	---	---

SUMMARY of DATA:

Species	Total Seedlings	Total Saplings	Total Trees	Grand Total
<u>Pinus edulis</u>	-----	-----	-----	-----
<u>Juniperus osteo</u>	-----	-----	-----	-----

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UNDERSTORY, LINES 1-5.

BURNED PLOT # ___ or UNBURNED PLOT # ____

Date _____

Names of observers

UNDERSTORY OBSERVATIONS-- done in 30.5 cm (1') x 61 cm (2') plots.

[illegible]

Species:

ROCK

LITTER

BARE SOIL

- + = occurring as a single individual with reduced vigor; no measurable cover
 1 = occurring as 1-2 individuals with normal vigor; no measurable cover
 2 = occurring as several individuals; no measurable cover
 3 = occurring as numerous individuals, but with cover less than 4 % of area
 4 = cover up to 1/10 (4-10%) of total area
 5 = cover about 1/5 (11-25%) of total area
 6 = cover 1/4 to 1-3 (26 - 33%) of total area
 7 = cover 1/3 - 1/2 (34 - 50%) of total area
 8 = cover 1/2 - 3/4 (51-75%) of total area
 9 = cover 3/4 - 9/10 (76 - 90%) of total area
 10 = cover 9/10 to complete (91 - 100%) of total area

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UNDERSTORY, LINES 6-10.

BURNED PLOT # ___ or UNBURNED PLOT # ____ Date _____

Names of observers _____

UNDERSTORY OBSERVATIONS-- done in 30.5 cm (1') x 61 cm (2') plots.

	Line 6					Line 7					Line 8					Line 9					Line 10				
plot #	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Coverage class (+, 1-10)																									

Species:

ROCK

LITTER -----

BARE SOIL

[illegible]

000	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017	018	019	020	021	022	023	024	025	026	027	028	029	030	031	032	033	034	035	036	037	038	039	040	041	042	043	044	045	046	047	048	049	050	051	052	053	054	055	056	057	058	059	060	061	062	063	064	065	066	067	068	069	070	071	072	073	074	075	076	077	078	079	080	081	082	083	084	085	086	087	088	089	090	091	092	093	094	095	096	097	098	099
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9 = cover 3/4 - 9/10 (76 - 90%) of total area

10 = cover 9/10 to complete (91 - 100%) of total area

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UNDERSTORY DATA, SUMMARIZED.

BURNED PLOT # ___ or UNBURNED PLOT # ____

Date _____

Names of observers

SUMMARIZED PLOT DATA

UNDERSTORY DATA:

Species

Total of all Coverage Classes
50 Total Observations

Average Coverage Class
(Round up or down)

ROCK

LITTER.

BARE SOIL

6/22/90

POINT QUARTER METHOD-RAW DATA

UNBURNED PLOT # _____

Date _____

Names of observers _____

Done For Pinus edulis and Juniperus osteosperma ONLY, that are > 10 cm (4") basal diameter. *basal*

Point Quarter Method. Do 10 total points, at 15.2 meter (50') intervals. By convention, diameter of trees is measured at Breast Height (~ 1 meter above ground).

Point Quadrant 1 = NE Quadrant 2 = SE Quadrant 3 = SW Quadrant 4 = NW

1. Species

Distance to tree (meters) _____

Diameter (cm), B.H. _____

Basal area (sq cm)* _____

2. Species

Distance to tree (meters) _____

Diameter (cm), B.H. _____

Basal area (sq cm)* _____

3. Species

Distance to tree (meters) _____

Diameter (cm), B.H. _____

Basal area (sq cm)* _____

4. Species

Distance to tree (meters) _____

Diameter (cm), B.H. _____

Basal area (sq cm)* _____

5. Species

Distance to tree (meters) _____

Diameter (cm), B.H. _____

Basal area (sq cm)* _____

6. Species

Distance to tree (meters) _____

Diameter (cm), B.H. _____

Basal area (sq cm)* _____

7. Species

Distance to tree (meters) _____

Diameter (cm), B.H. _____

Basal area (sq cm)* _____

8. Species

Distance to tree (meters) _____

Diameter (cm), B.H. _____

Basal area (sq cm)* _____

9. Species

Distance to tree (meters) _____

Diameter (cm), B.H. _____

Basal area (sq cm)* _____

10. Species

Distance to tree (meters) _____

Diameter (cm), B.H. _____

Basal area (sq cm)* _____

* Calculate Basal Area (sq cm) via the formula: Basal Area = 3.1416 x radius squared

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POINT QUARTER METHOD, SUMMARIZED DATA

UNBURNED PLOT # _____ Date _____
 Names of observers _____

Done For Pinus edulis and Juniperus osteosperma ONLY, that are > 10 cm basal diameter.
 SUMMARIZED DATA from Point Quarter Method. See explanations below.

Species	# of Trees	Mean distance (meters)	Total Basal Area (square cm)	Density (No./4047) hectares	Relative Density-%	Relative Frequency-%	Relative Dominance-%	Importance Value (D+F+D)
<u>Pinus</u> <u>edulis</u>	_____	_____	_____	_____	_____	_____	_____	_____
<u>Juniperus</u> <u>osteosperma</u>	_____	_____	_____	_____	_____	_____	_____	_____

Mean distance = add all distances of all pinyon trees, and divide by the total # of pinyon trees. Repeat for juniper.

* Basal diameter of trees is taken at "breast height", ~ 1 meter above ground. Sum all basal areas from field worksheets.

Density (No./4047 square meters) = $\frac{\text{total basal area}}{\text{mean distance to pinyons, squared}}$

This will give us the absolute density per .4047 hectares (= 1 acre of previous studies). Repeat for juniper.

Relative Density % = $\frac{\text{absolute density of pinyon}}{\text{sum of absolute densities, pinyon + juniper}} \times 100$.

Relative Frequency % = $\frac{\text{Total \# of the 10 points that had pinyon}}{\text{Total \# of points with pinyon + total \# of points with juniper}} \times 100$

Relative Dominance % = $\frac{\text{total basal area of pinyon}}{\text{total basal area of pinyon + juniper}} \times 100$; same for juniper

Importance Value = sum the Relative values for Density + Frequency + Dominance.

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NOTES.

BURNED PLOT # ____ or UNBURNED PLOT # ____ Date ____

Names of observers _____

NOTES:

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