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CHANGED SOUTHWEST FORESTS: RESOURCE EFFECTS AND MANAGEMENT REMEDIES[1]

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ABSTRACT: Over 150 years of occupancy by northern Europeans has markedly changed vegetative conditions in the Southwest. Less fire due to grazing and fire suppression triggered a shift to forests with very high tree densities, which in turn contributed to destructive forest fires. Options to deal with these changes include prescribed fire, thinning and timber harvest to mimic natural disturbances and conditions. However, there are barriers to implementing these activities on a scale large enough to have a significant benefit.

INTRODUCTION

In this paper, I discuss Southwest forests around the turn of the century, discuss how they looked before then, and then show changes in recent decades. I portray how these vegetative changes affect resource values and propose some actions to avoid future negative consequences.

THE PAST

Thousands of years of human occupation preceded the first accounts, paintings, and photographs of Southwest (SW) landscapes. We can only guess what the earliest occupants saw or thought of their landscape. We know that prehistoric people altered vegetative composition through farming and burning. The view through time's fuzzy lens clears as we near the present.

In the late 19th and early 20th century, visitors to Southwestern forests gave us our first indication of how these forests looked then, primarily from their written observations. Although there were exceptions, most descriptions portray, especially in ponderosa pine (Pinus ponderosa) forests, conditions that are much more open than what we see today (Whipple, 1856, U.S. Geological Survey, 1904, Cooper, 1960). A few pictures are available from this era, and they generally show the same thing. Groups of similarly sized trees with little understory but considerable grass beneath seem to have been the most common condition.

Fires burned frequently (2 to 10 years) at low intensity in lower elevations and less frequently but with moderate intensity at higher elevations (Swetnam and Baisan, 1996). Lightning is common in the Southwest, and Native Americans also contributed to fire frequency. Escaped domestic fires occurred as did intentional burning, although burning by Native Americans has not been documented in the SW to the degree it has further north (Swetnam and Baisan, 1996).

In 1910, Woolsey and also Lang and Stewart gave us the first quantified inventories. Neither inventory was Southwest-wide, and they do not give us a picture of conditions on a same-acreage, statistically sound basis. Nevertheless, they covered several areas and included a large number of plots, so they paint the best quantified picture available today of early 20th-century conditions. They agree with a) early photographs, b) early descriptions mentioned above, c) what a forester or ecologist would expect to find given knowledge of fire regimes, and d) what studies of stumps and other factors indicate was present (Covington, and Moore, 1994a).

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Table-1 shows trees per acre by diameter class from Woolsey's 1910 inventory. The table compares his figures with those from USDA - Forest Service inventories made in 1962 and again in 1985/87. Woolsey's inventory was from plots taken in typical stands on three National Forests in Arizona. The other two inventories were based on a plot-grid that covered all of Region-3: both Arizona and New Mexico. The information is grouped by 3-inch diameter classes.

Table-1, Trees per acre, by diameter class, from Southwest inventories.

3-INCH DBH CLASS	ACTUAL DBH-RANGE	TREES PER ACRE			TABLE NOTES
		1985/87 R3-INV	1962 R3-INV	1910 AVG 3-AZNF	
6	4.6 - 7.5	68.0	45.0	6.3	R3 inventory figures are for conifers only.
9	7.6 - 10.5	36.1	21.8	3.2	Specific numbers for diameter classes marked with an "*" are not available: the 1962 inventory grouped these into a single category.
12	10.6 - 13.5	18.1	11.1	2.5	
15	13.6 - 16.5	8.8	6.6	2.2	
18	16.6 - 19.5	4.5	4.0	2.0	
21	19.6 - 22.5	2.3	*	1.8	1910 data is from Woolsey, and was taken on the Coconino, Tusayan, and Prescott Forests
24	22.6 - 25.5	1.3	*	1.4	
27	25.6 - 28.5	0.6	*	0.7	
30	28.6+	0.4	0.6	0.8	
Total		140.0	93.6	20.8	

Woolsey's data were recently converted to basal area (BA) and show that average conditions in 1910 in ponderosa pine forests ranged from BA 22.9 square feet per acre (Tusayan Forest) to 25.4 (Prescott Forest) to 37.9 on the Coconino Forest. Other plots were taken in the best stands that could be found on several forests around Arizona and New Mexico and the average is a BA of 82.0 (Woolsey data converted to BA by the Forest Service). These are all well below today's densities, which are mostly above BA 100 per acre and often up to and even greater than 200 (Forest Service data).

POST-EUROPEAN SETTLEMENT CHANGES

A reduction in ecosystem fire occurred by the 1880's or before and about the same time that livestock grazing levels increased substantially. By 1890, cattle numbers were about 1.5 million head in Arizona and New Mexico (Baker et al, 1988). Grazing by domestic livestock removed grasses that had previously carried cool ground fires. This coincided with good moisture in the first few decades of the 20th century, which led to forests with far more trees than before. Without such moisture, grazing and other fire suppression would not have led to the overstocking. This is shown in the Chuska Mountains on the Navajo Reservation where extensive grazing by sheep and goats started in the 1820's, and fires declined. However, forest regeneration did not start until after 1900 as it did in the rest of the Region (Pyne, 1996).

Other factors contributed to reduced fine fuels and, therefore, reduction of fire frequency as the 19th century ended and the 20th began (Pyne, 1996). Loggers began removing mature trees. Bark beetles, fungi, and dwarf mistletoe infested the thickets that, in the absence of grass and fire, sprang up profusely. Severe droughts further reduced light fuels. Roads built by settlers, fixed landownership patterns, reservation of public lands, and ~~establishment of professional forestry also contributed. In combination, the result was suppression of~~

Coarse woody debris (CWD) is essential for ectomycorrhizal activity. While too little will reduce productivity, so will too much (Graham et al, in press). Optimum ranges presented by habitat type are most often exceeded in the Southwest in overly dense stands or following wildfires.

Fuller et al. (1955) report that high intensity fires consume much of the duff layer, exposing mineral soil to climatic elements that contribute to accelerated erosion. This makes difficult the reestablishment of many species of conifers. They also report that severe burning raises the pH level of the top two inches of soil by about one unit. Campbell et al, 1977) report that in the year following burning, runoff carried about 1.7 tons per acre of suspended and bedload sediment from severely burned watershed, as compared to a few pounds from the moderately and unburned watersheds. This affects both soil productivity and water quality. Growth on surviving trees will be lower due to crown scorch, and tree regeneration will often be reduced or absent. (Campbell et al, 1977). In some cases, the result of extremely hot fires is a change in the ecosystem from forest to brushfield (Covington et al, 1994).

Stream flow and water quality

The effects of more dense forests on stream flow is well documented. At Beaver Creek on the Coconino National Forest, researchers found that in ponderosa pine forests, on either Brolliar or Siesta-Sponseller soils, stream flow changed as follows with changing basal area (BA) (USDA Forest Service, 1974):

	Control	Changes			
Basal Area, (sqft/acre)	120	100	60	40	0
Streamflow, (percent change)	0	4	17	25	35

Other researchers have also found increases in water yield after harvest to reduce vegetative density. At Workman Creek in Central Arizona, water yields increased with harvest (Rich and Gottfried, 1976). Baker (1986) found that increases at Beaver Creek diminish and then end in about seven years, due to water use from increased forage plants and young trees. However, a long-term cycle of harvest and prescribed fire should maintain much of the increase.

As discussed above, today's forests are even above the baseline density used in the Beaver Creek study. This shows that they are providing less water for fish, riparian areas, groundwater recharge and downstream users than were the pre-settlement forests.

The results of this are evident in other ways too. Today, streams in the SW that were perennial a century ago do not flow year-round. Low flows in other streams are lower than they once were, with some intermittent streams drying up much earlier in the year. Low flows in turn affect water temperature and are a critical factor for fish and other aquatic life. However, where prescribed natural fire has occurred three or more times in the last two decades in the Gila Wilderness, streams are now flowing again that had not flowed for many years (personal communication, Steve Servis.)

Forest fires also affect many hydrologic processes. A 1978 (USDA Forest Service, 1979) study summarized the following: Water repellency increases with fire intensity, with more intense fires having the most effect. While removing vegetation normally increases soil moisture, Campbell et al. (1977) observed reduced soil moisture in the upper 30 cm. in an area severely burned, due to the repellency after fire. Debris flows increase following severe fires (Jensen and Cole, 1965; Klock and Healvey, 1976). During heavy rains, Campbell et al. (1977) observed an eightfold increase in runoff from a severely burned watershed compared to an unburned watershed during heavy autumn rains. They also report that runoff efficiency (ROE), the ratio of runoff to precipitation, increased from 0.8 percent on an unburned watershed to 3.6 percent on a severely burned watershed. Compared to a moderately burned watershed, ROE on a severely burned watershed was 375 percent greater during the rain season and 51 percent less during the snow season.

Archaeological Resources

Archaeological sites are also affected by hot forest fires. At the Henry Fire site in the Jemez Mountains, no effects were found on lithic artifacts, and ceramic artifacts were lightly sooted on lightly or moderately burned sites. However, in heavily burned sites, severe effects were present on artifacts, construction materials, and ground stone (Lentz et al, 1996). They concluded that where no heavy fuels burn in place, fire effects may be confined to the surface. However, where there is increased fire residence time because of a log or other heavy fuel loads, subsurface artifacts can be severely affected.

Studies after the La Mesa fire of 1977 note several types of damage to archeological resources (Traylor et al, 1990). First, they found damage from fire suppression and rehabilitation. They also found that on-site vegetation intensified the burn and did more damage. They noted some of the fire's greatest damage was to tuff, the major construction material of Pajarito Plateau masonry sites. They feel that the damage to tuff alone is a good indicator of the severity of La Mesa Fire compared to past fires. Especially where fire burned hottest, they found exterior surfaces flaking off and cracking. On one severely burned site, building stones had significantly deteriorated, losing much of their interior strength. Stones were so weak that they could not hold their own weight.

Wildlife

Because of the highly varied environmental gradients and disturbance regimes, wildlife communities were diverse before settlement (Covington et al, 1994). Since then, some species have been extirpated, others have declined, and yet others increased in abundance. For example, antelope are believed to have declined as ponderosa pine forests became denser (personal communication, Dave Patton). Other species that prefer open forests and may have declined include Grace's Warbler, Rock Wren, Western Woodpewee, and Chipping Sparrow (Finch et al, 1977). Today's dense forests should favor red squirrels and Mexican spotted owls. Some feel snag-dependent species may have declined; however, inventories today indicate that there may still be more snags than there were in 1910 when Woolsey found about 0.2 snags per acre greater than 18" in diameter.

The Southwestern Region of the Forest Service has a wildlife data base called RMWILD. This shows which species and groups of species use various habitats. It is notable that each canopy closure category and stand structure is used by large numbers of species. However, during this century, the amounts of grass/forb/shrub, seed/sap, and zero- to 40-percent canopy closure have drastically declined. It could be inferred from this that species that prefer vegetative stages and densities that have declined may also have declined. However, more work is needed to determine what specific changes have occurred.

Susceptibility to insect and disease

Trees that are close together, like other organisms, are more susceptible to disease and to attack by insects than are wider-spaced trees (Sartwell and Stevens, 1975). This spacing was one mechanism that kept presettlement forests from being more severely attacked. Researchers have found that bark beetles, mountain pine beetle, Douglas-fir beetle, spruce budworm, and dwarf mistletoe are among those pests that expand as forests become more dense (Johnson 1994). Mistletoes were always present but were kept in check by recurring fire (Alexander and Hawksworth, 1975).

MANAGEMENT NEEDS FOR SUSTAINABILITY

There is no one simple solution to returning Southwestern forests to healthy, sustainable conditions; many techniques must be used. And, these techniques must be applied in a patchwork of small and large blocks to create diversity, which has been largely lost over the past century (Pyne, 1996). Miller (1996) points out that a management philosophy is needed that incorporates a range of stand density and structure, and that activities must be carried out in a variety of block sizes. Following are some actions that can be used to treat these forests for sustainability:

Prescribed fire. Where prescribed fire can be properly controlled, it is a valuable tool in forest restoration. It is successfully used to reduce fuel loads and remove patches of trees.

Wildfire. Wildfires will occur. While some of the results will be negative, others will not and will help rectify the situation. For example, in many habitat types, they will help restore aspen to the ecosystem.

Thinning. Both pre-commercial and commercial thinning can reduce tree densities and, equally important, can remove or reduce lower canopy layers and thus reduce the likelihood of crown fire. Especially if done in a patchy pattern and in various size areas, it can greatly reduce homogeneity and enhance spatial and structural diversity (Edminister and Olsen, 1996). It proves useful in second-growth, even-aged stands, in overstocked, uneven-aged stands, and also in overstocked old-growth stands (Fiedler et al, 1996).

Harvests to mimic natural disturbances. Thinning and prescribed fire are most often mentioned when looking for ways to improve conditions in Southwestern forests. However, we have to consider how each habitat type functioned naturally to know if we can perpetuate a forest. Group selection may be most appropriate for ponderosa pine, but not mixed-conifer. Howe (1995) points out that single-tree or small-group selection can result in dysgenic effects to the long-term genetic makeup of forests that regenerated naturally as even-aged such as SW mixed-conifer forests. He also states that pioneer species can be maintained in an uneven-aged condition only with very low stocking. In the southwest, aspen and ponderosa pine on white and Douglas-fir habitat types could suffer in the long term with uneven-aged management unless stocking is maintained at low levels.

All of the above. In the end, we must give all of the above tools to the on-the-ground manager rather than establishing regional or national policies about using any one or a certain combination of them. Based on conditions on a landscape, and on individual sites within that landscape, decisions can be made to enhance that area's sustainability and productivity. I include productivity here because for eons, humans have counted on their forest lands to provide for their needs and most land owners continue to expect that. It can be done along with sustaining the long term health of the ecosystem (Johnson et al, in review).

Before many of these activities can be undertaken, socio-political change must occur. Prescriptive direction, such as the Mexican spotted owl (MSO) Recovery Plan and Northern Goshawk Guidelines, need to be adjusted or applied with flexibility considering pre-settlement condition and function of our forests. Where attitudes exist about meeting harvest targets in large trees, they must change. Current laws such as the

Endangered Species Act (ESA), National Environmental Policy Act (NEPA), and National Forest Management Act (NFMA) can be used successfully by a handful of people to delay and stop activities that must be carried out. These laws were all passed with good intentions to provide protection for the environment, but change is needed in interpretations that, to date, have taken them beyond their authors' original intentions.

CONCLUSION

Forests in the SW have lost much of their diversity; they have far more trees today than ever before, an unsustainable condition. This leads to severe, stand-replacing fires, followed by damage to resource values and decreased soil productivity. Water, sometimes considered the gold of the SW, is being used by the dense tree stands, reducing stream flows. Stand-replacing fires will increase flooding rather than restore normal flows. Wildlife populations change, favoring one suite of species over another. Cultural resource sites are damaged and sometimes destroyed by the hot fires.

We know what needs to be done to improve the situation-- thinning, prescribed burning, harvest to mimic natural disturbances, and a combination of these. Society has the resolve to suppress wildfires and provides hundreds of millions of dollars for this effort. This same resolve is needed to take the actions necessary to improve the health of our forests which in turn will reduce the need for firefighting. Power has been given to the few who want little to happen. This leads to future destruction of our forests if action is not taken soon.

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Dr. Reggie Fletcher
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June 30, 1995

Dear Reggie:

Enclosed is a brief report and plan for expanding the Monument Canyon Research Natural Area work that Esteban Muldavin and I started last year. We are excited about the results so far, and look forward to collecting more samples and further developing our understanding of this RNA.

I am also sending copies of this report/plan to Carl Edminster. I understand that you will transfer the dollars to the Rocky Mountain Station, and that Carl will add this as an amendment to our existing Cooperative Agreement "Regional Dendroecology Program." Also, I understand that RM will deduct an indirect cost of 17% (Is this the correct amount?). I have budgeted a $5,000 amount. Can you add the necessary amount to maintain this figure after deduction of the indirect? If not, I suggest reducing the "Other" expense category in my budget to reflect the reduced amount that will be added to our Coop Agreement.

Please call me if you need clarification on any aspects of the report/plan or budget.

Very sincerely,

Thomas W. Swetnam
Associate Professor

xc: Esteban Muldavin
Carl Edminster
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Age Structure and Demography of Ponderosa Pine in Monument Canyon Research Natural Area

Progress Report and Plan for Additional Research

June 28, 1995

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Introduction

In 1994 we initiated a research project aimed at evaluating the age structure of ponderosa pine old growth and "dog hair thickets" in the Monument Canyon Research Natural Area in the Jemez Mountains of Northern New Mexico. Our goal is to improve our knowledge and understanding of the demographics of pines in this area over the past three to five centuries. We are particularly interested in the temporal patterns of tree recruitment (i.e., successful germination and ingrowth of individuals into the population), and the relations of these patterns to climatic variation, fire history, and land-use history (i.e., fire suppression, and livestock grazing). Monument Canyon is one of the oldest RNAs in the Southwestern U.S. It was originally established to represent a particular manifestation of the ponderosa pine forest type. Today, the stand is a classic example of the results of fire exclusion in ponderosa pine. Most of the pure ponderosa pine type within the RNA is composed of an overstory of declining living trees, and standing snags that have accumulated from progressive mortality over the past half century. The understory is dominated by dense, stunted ponderosa pine thickets (dog hair). Vegetative ground cover is very sparse or totally absent under the ponderosa pine canopies.

In this brief report we describe the preliminary results of our work to date, and we also outline plans, budget, and schedule for additional work in Monument Canyon RNA.

Methods

The study area is approximately 360 acres in size and lies near the ridge line of a gently sloping (3-5%) mountain slope (tilted plateau). The slope is moderately dissected with wide-ridge platforms separated by three small drainages. A dirt road cuts across the top of the study area near the ridge line.

The ridge platforms support the typical forest stands of the RNA, dense doghair reproduction stands intermixed with a sparse overstory of mature trees. The habitat type on the platforms is ponderosa pine/Arizona fescue. The drainages tend to lack the reproduction stands and comprise a separate habitat type (ponderosa pine/Gambel oak). Because of limited resources, sampling was confined to the ponderosa pine/Arizona fescue habitat type on the ridge platforms, and the intervening drainages excluded.

Eleven, 400-square-meter plots were laid out on two perpendicular transect lines. Transect Line A traversed down a northwest to southeast tending ridgeline. The starting point of the line was determined systematic-randomly by locating the top of the ridge along the road and then orienting with a compass to traverse to the southeast along the ridge. The starting point of the transect was established 100 meters along the traverse from the road along a compass bearing of 230 degrees azimuth. The location along the road was marked with a wooden stake and flagged to the beginning of the transect. Six plots were established along the line at 100-meter intervals. A second Line B was established at right angles to the first at plot A1, and traversed the study area across the slope (rather than down the ridgeline). Four additional plots were established along this line at 100 meter intervals. An eleventh plot was opportunistically placed at a site containing a fire-scarred tree that had been previously sampled for the fire history of the stand.

Each plot is square and twenty meters on a side. The plots were marked with wooden stakes at each corner, at the midpoints of the sides, and in the center. For young age class trees (4 in. or less), 20 stems, distributed from one inch to four inches as available, were destructively sampled in each plot for later precise determination in the lab of the year of germination and establishment (root-crown/shoot node). For larger trees up to 20 inches, two transects were set up perpendicular to one another along the midlines of the plot. At two-meter intervals along the lines the closest tree to the point was chosen for sampling. Sampling entailed non-destructive boring of the trees as close to the root growth/shoot initiation point as possible (using 5mm increment corers). All trees larger than 20 inches were sampled on the plot (using a power 5mm borer). All trees on the plot were tally counted by 2 inch diameter rootcrown classes to give an estimate of stand density.

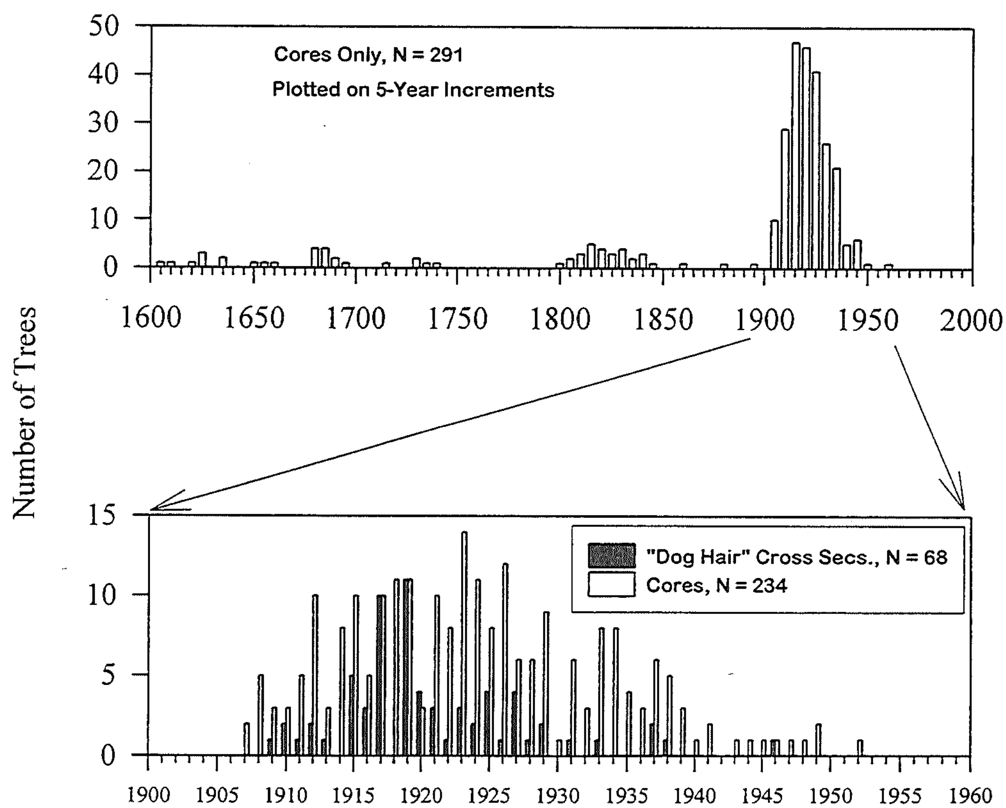
Additionally, four selected trees with fire scars (catfaces) were non-destructively sampled to augment the existing fire history collection from the stand.

Low altitude stereo aerial photography (70mm) and high resolution videography was flown over the study area. Natural color 8x8 inch prints were produced for mapping the stand structure at a scale of 1:6,000. The photos will also be used for estimating stand density (individual trees are visible).

Results to Date

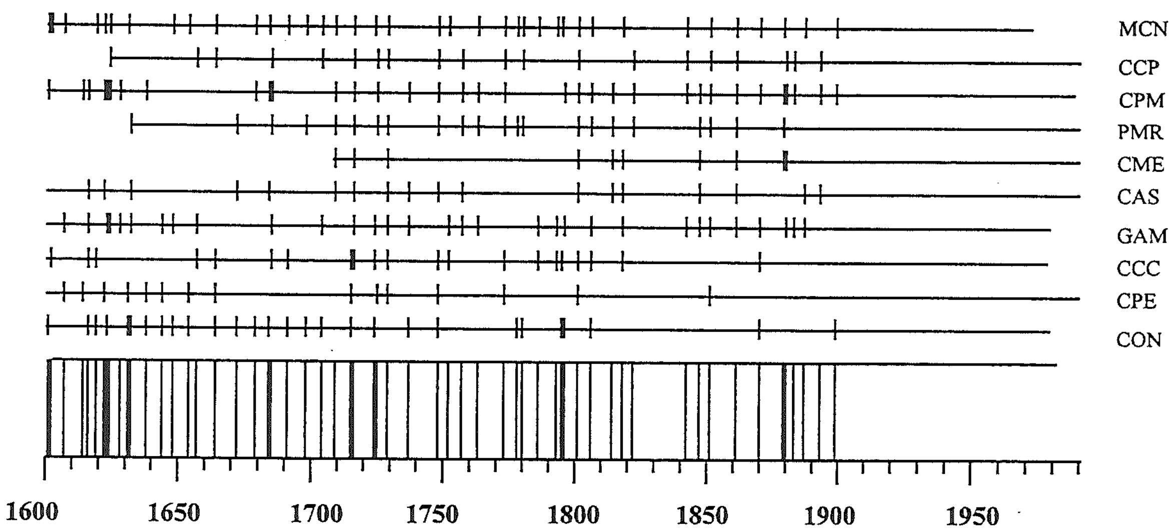
The temporal distribution of inner ring dates of pines in Monument Canyon strongly suggest that recruitment was highly episodic prior to ca. 1907 (Fig. 1). Although few trees over about 200 years in age were sampled there does appear to be several cohorts that established in the 1600s and 1700s AD. A more obvious cohort established in the early 1800s. This later cohort is very interesting because it generally corresponds with an unusually long interval between large fires in Monument Canyon RNA, the Jemez Mountains, and other locations in the Southwest where detailed fire histories have been reconstructed (Swetnam and Dieterich 1985; Touchan, Allen, and Swetnam 1995) (Fig. 2).

Figure 1. Ponderosa pine recruitment dates from Monument Canyon RNA. Dates are estimated from increment cores from living trees over 10 cm dbh, and from cross sections taken at root crown from poles in dog hair thickets. Since increment cores were taken near ground level, but often did not intersect the pith, these dates are considered less accurate than the dates from cross sections.



The recruitment dates also show the very obvious pulse of trees recruiting into the stand after the turn of the past century. This pulse seems to have lagged the end of the frequent, spreading surface fire regime by at least one decade. Hence, it appears that the timing of successful germination and establishment may also have depended on favorable climate and/or changing livestock impacts. These two possible explanations for the onset of widespread recruitment in the first decade of the twentieth century need further research.

Figure 2. Jemez Mountains master fire-scar chronologies from 10 ponderosa pine and mixed conifer stands (Touchan, Allen, and Swetnam 1995). Each horizontal line represents a fire-scar composite chronology from a stand, where at least ten fire-scarred trees were sampled. The fire chronology reconstructed from samples collected in Monument Canyon RNA is labeled MCN. The vertical tick marks on the lines are the fire dates recorded by at least 25 percent of the trees recording fires at that date. The overall composite of fire dates recorded by 25 percent or more of the trees in any site is shown by the vertical lines at the bottom. Note the long interval in the early 1800s, and elimination of large spreading fires around 1900 in all sites. The earlier elimination of spreading fires in three lowermost stands was probably due to early livestock grazing by Hispanic settlers in these stands located on Spanish land grants in the Chama River valley.



Additional Research Proposed

We propose to expand our collections of increment core and cross section samples in Monument Canyon. We also plan to undertake more detailed analysis of fire, climate, and land-use patterns in the area. We have several expanded and new objectives for this additional sampling and analysis:

1. We will collect additional increment cores from old growth trees, saplings, and poles (within and outside of doghair thickets) to improve the temporal resolution and sample size of our age distributions. We are particularly interested in determining if the observed early 1800s cohort is evident across a larger sampled area of the stand, and if earlier cohorts can be better distinguished (temporally) with additional samples. We are also interested in improving the sample size and temporal resolution of the post-1900 recruitment pulse, so that we might investigate possible interannual climatic associations with successful recruitment. The total number of additional trees to be sampled (increment cores and cross sections) will be at least 200, and up to 300. We will follow similar

methods as previously used in sampling along linear transects and within plots along the transects.

2. We will collect additional fire-scar samples within Monument Canyon, near to, and along the age structure transects to more closely interpret fire regime patterns in relation to the sampled trees.

3. We will sample snags and logs near to and along the transect where it is possible to obtain sapwood and bark dates. We will crossdate these specimens to identify dates of mortality. The purpose of this effort will be to identify (if possible) temporal patterns of mortality of overstory trees. For example, are the overstory trees dying in a more-or-less continuous manner, or are death dates clustered during certain years or periods (such as during droughts)? We will attempt to obtain samples from at least 30 trees for this preliminary investigation.

4. We will evaluate the relations between the resulting age structure patterns, fire history, and climatic variations over the past three centuries. We will use recent dendroclimatic reconstructions from the Jemez Mountains, and meteorological observations (such as from Jemez Springs and Los Alamos stations) to evaluation possible climate associations with the recruitment patterns.

5. We will explore possible new research topics and projects in Monument Canyon RNA with Carl Edminster of the Rocky Mountain Forest and Range Experiment Station, Reggie Fletcher of The Southwestern Region Office, and Craig Allen of the National Biological Service. Edminster has expressed an. interest in supporting some spatial analysis of the ponderosa pine age structure within Monument Canyon.

<u>Products</u>

We will prepare a final report for the project in the form of draft manuscript, that upon internal review and revision, will be submitted to a peer review journal for publication. We will also deliver as appendices all resulting data in hardcopy and magnetic form.

We also expect to develop ideas and plans for future research in Monument Canyon, in consultation and collaboration with individuals listed above (and possibly others).

<u>Schedule</u>

Collect specimens at Monument Canyon: Fall 1995 to Spring 1996, weather permitting, one trip by Swetnam and crew, two trips by Muldavin and crew

Process and analyze specimens:	Summer to Fall 1996
Write final report/manuscript:	Fall and Winter 1996
Deliver final report/manuscript to USFS:	December 31, 1996

References Cited

Swetnam, T. W. and J. H. Dieterich. 1985. Fire history of ponderosa pine forests in the Gila Wilderness, New Mexico. In: J. E. Lotan, B. M. Kilgore, W. C. Fischer, and R. W. Mutch, tech. coords., Proceedings-Symposium and Workshop on Wilderness Fire, November 15-18, 1983, Missoula, Montana. USDA Forest Service General Technical Report INT-182:390-397.

Touchan, R., C. D. Allen, and T. W. Swetnam. 1995b, In Press. Fire history an climatic patterns in ponderosa pine and mixed-conifer of the Jemez Mountains New Mexico. In: C. D. Allen, ed., Proceedings of the Second La Mesa Fir Symposium, 31 March to 2 April, 1994, Los Alamos, New Mexico, USDA Fores Service General Technical Report, RM-xxx.

Budget

Salaries/Wages:	
Swetnam's Assistants/Students for collection, processing, dating specimens	$3,000
Travel:	
Swetnam's crew from Tucson to Jemez	1,000
Other:	
misc field and lab supplies	500
page charges for publishing article	500
Total:	$5,000

Age Structure and Density of an Old Growth Ponderosa Pine Forest in Relation to Changes in Fire Regime and Climate Fluctuations.

MULDAVIN, ESTEBAN H., THOMAS W. SWETNAM and MARY STUEVER.

University of New Mexico, Albuquerque, NM University of Arizona, Tucson, AZ, and University of New Mexico, Albuquerque, NM, USA.

ABSTRACT

An old growth ponderosa pine forest in northern New Mexico was set aside at the turn of the century and protected from logging, fire and grazing as a Research Natural Area (RNA). As result, significant changes in age structure and density of the stand have occurred. We intensively sampled the trees from the smallest to the largest to determine their dates of establishment. The age (density) structure is distinctively bimodal with a sparse remnant overstory of older trees (>300 years) that, in many locations, is dead or dying. The understory ~~in these locations~~ is dominated by very dense pole stands in excess of 40,000 stems/ha, ranging in size from 2 cm to 50cm of varying size classes up to 50cm. Intermediate-aged trees are relatively rare. (density) Other locations have a healthy overstory and show a more even distribution across age size classes, but overall densities are low. A fire history chronology for the stand has been developed which stretches more than 300 years into the past. The changes in stand structure appear to be correlated with changes in fire regime with consequent impacts on recruitment of new individuals. Recruitment now reflects specific climatic pulses leading to high density, even aged cohorts that lack thinning or removal by fire. This high density of the understory ~~is suggested to~~ may have negative impacts on nutrient cycling that is increasing the rate of overstory mortality, leading to a very different kind of old growth forest than would have been expected under pre-settlement conditions.

DISCUSSION

* The lag after the cessation of fire in the successful recruitmen of the last significant cohort may indicate a dependence on favorable climate and/or changing impacts of herbivory (livestock). The previous fires may still have been needed to create the mineral seedbed needed for successful establishmen but the moisture may not have been available for germination until later in the century. The effects of herbivory need to be investigated further.

* Over time, the lack of fire has allowed a large build up of litte which now may be preventing further recruitment. The lack o saplings younger than 50 years suggest that seedlings are not able to become established through the deep litter layer.

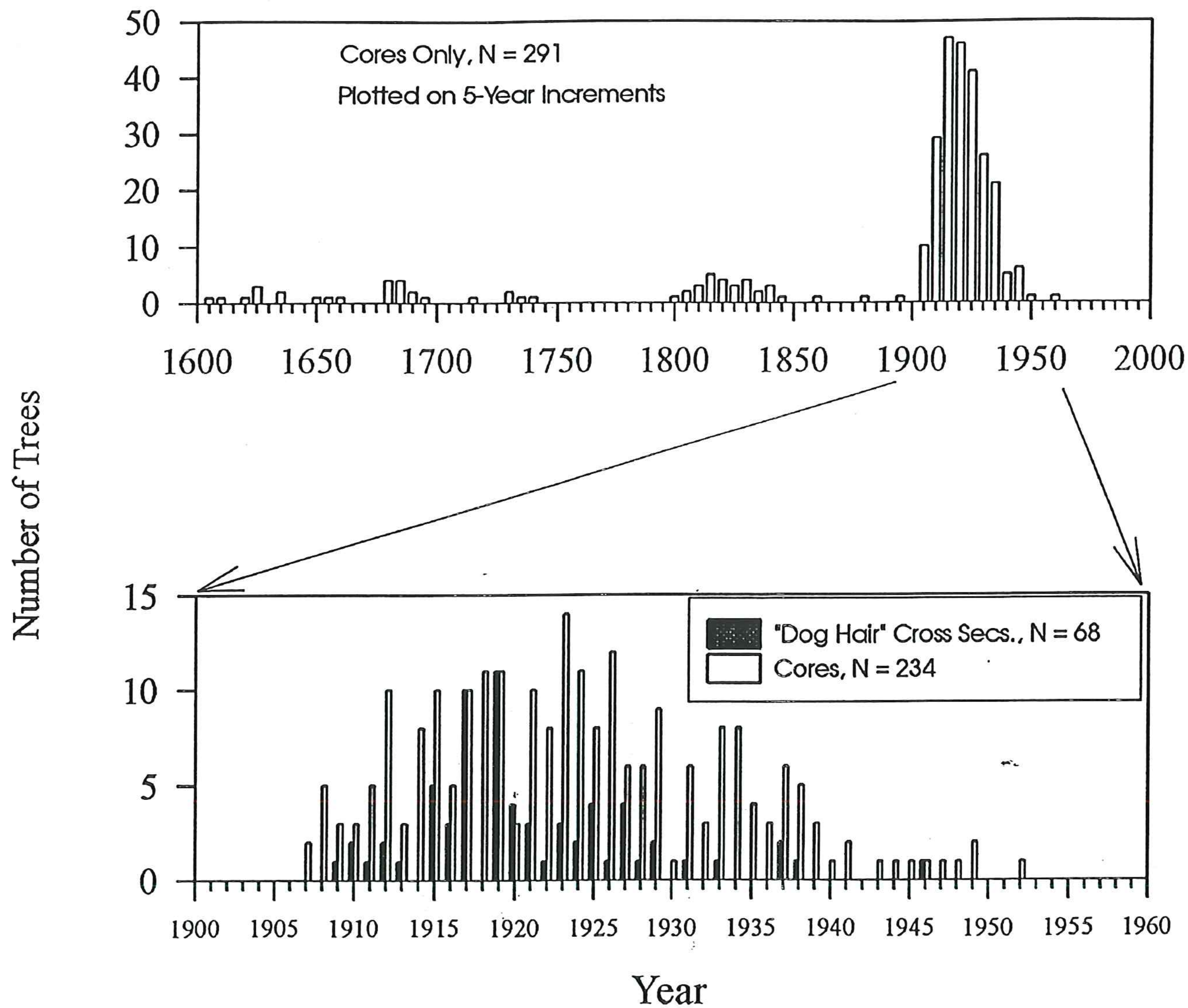
* Localized differences in stand density do occur which may be a function of fine scale environmental heterogeneity and an artifact of the behavior specific fires that have spread through this landscape.

* The dense dog-hair thickets are self-thinning over a long perio of time, rather than being thinned by surface fires. This has not only resulted in less vigorous trees, but the high densities of trees in the understory may be affecting overstory mortality through intense competition for water and nutrients. The lack of fire may also be slowing overall nutrient cycling, leading to ecosystem that is approaching a standstill, until the next fire.

Table 1. Stand Density. Number of stems per hectare and acre based on 11 random/systematic 20m X 20m square plots ($400m^2$).

Tree Diameter Class	Stems/Hectare	Stems/Acre
Seedlings/Saplings < 10 cm (4 in.)	3,534	1,657
Poles 10-25 cm (4-10 in.)	2,283	1,071
Small Saw Timber 25-50 cm (10-20 in.)	103	48
Large Saw Timber > 50 cm (20 in.)	34	16
TOTAL	5,954	2,792

Figure 3. Ponderosa pine recruitment dates from Monument Canyon RNA. Dates are estimated from increment cores from living trees over 10 cm dbh, and from cross sections taken at the root crown from poles in dog hair thickets. Since increment cores were taken near ground level, but often did not intercept the pith, these dates are considered less accurate than dates from cross sections.



Analysis

* Cross-sections of saplings and poles and the cores of larger trees were cross-dated where possible with the extensive chronology that has been developed for the area. On successfully cross-dated specimens, the year of establishment was determined within two years on the younger material and five years on the mature trees.

* Mean stand density by 5cm diameter root-crown size classes were computed, as well as overall stand density.

* The age of recruitment was then compared to the fire history record for the stand and the region (Touchan, Allen, and Swetnam 1995).

* The ratio of the number of living old trees to snags was also determined.

RESULTS

* Overall stand density is high (5,954 stems/ha) and concentrated in the smaller size classes (Table 1). Density also appears to vary spatially depending on localized site conditions. Open grassy sites tend to have lower densities as do cooler, more shaded sites (Fig. 1).

* The ratio of living overstory trees to snags is 19.4, or 1.75 snags/ha (Fig. 2). There are also numerous dead and down trees in the stand of similar size to the overstory that are only in the beginning stages of decomposition.

* Temporal distribution of inner ring dates suggests that recruitment was highly episodic prior to ca. 1907 (Fig. 3). A strong cohort was established in the early 1800's, with less conspicuous ones in the 1600 and 1700's.

* The 1800's cohort corresponds to an usually long interval between large fires in the early 1800's recorded both at Monument Canyon and other sites in the region (Fig.4)

* There is a very strong pulse of recruitment after the turn of the century that is associated with sapling and pole "dog-hair" thickets. This pulse seems to have lagged by a decade the end of a regime of frequent, spreading surface fires that occurred before 1900 (Fig. 4). There has been little or no recruitment of ponderosa since the 1940's.

METHODS

Sampling

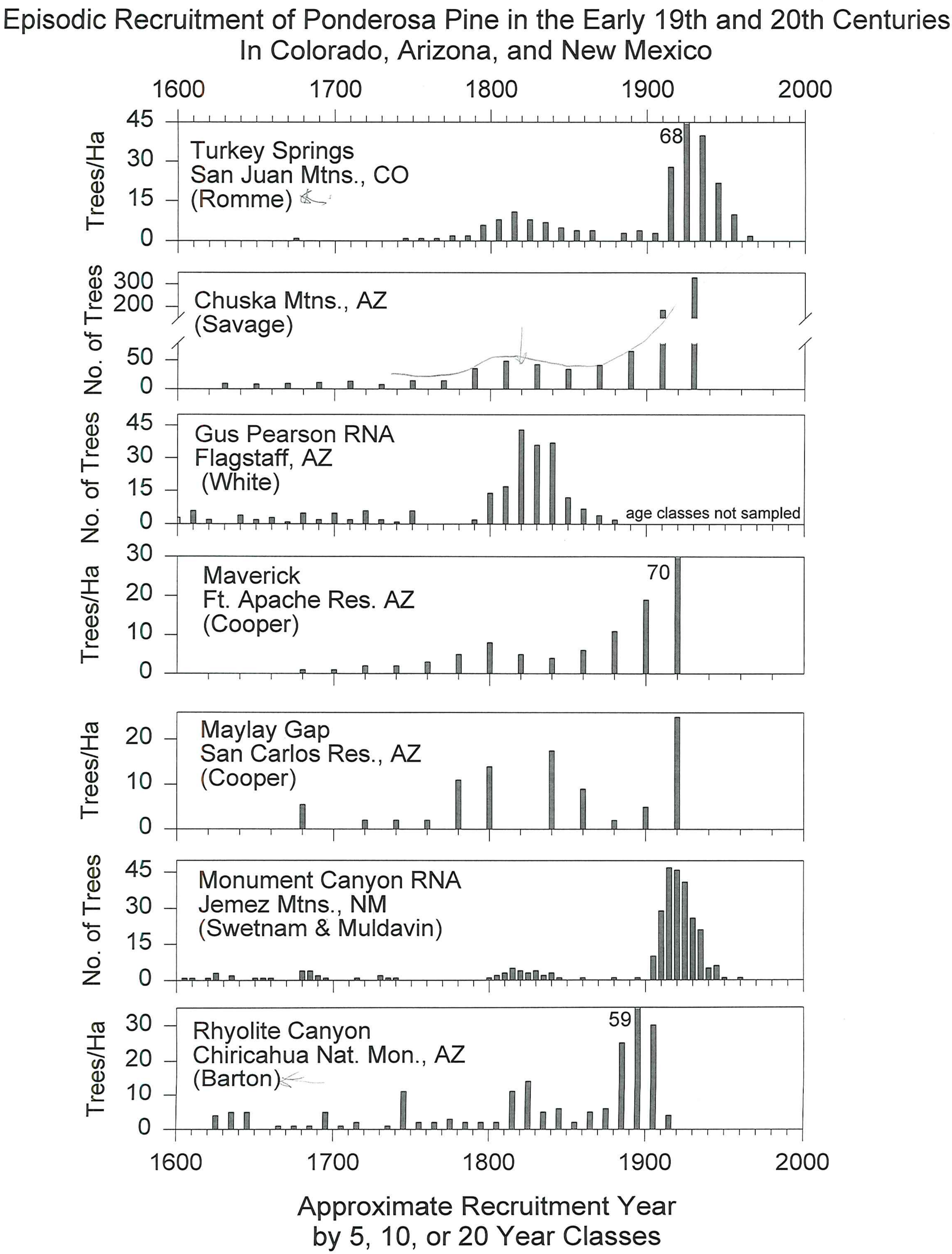
* Two transects at right angles, 500 meters long were established. One transect runs along the summit of a low-lying ridge. The other is at right angles to the first and traverses across three low-lying ridges and the intervening drainage-ways.

* Ten, 20m X 20m-square plots were established on the transects at 100 meter intervals starting from a random point.

* On each plot, 20 live trees under 10cm (4in) were randomly removed. The lower stems and associated root crowns were retained for cross-sectional analysis to determine the precise year of germination.

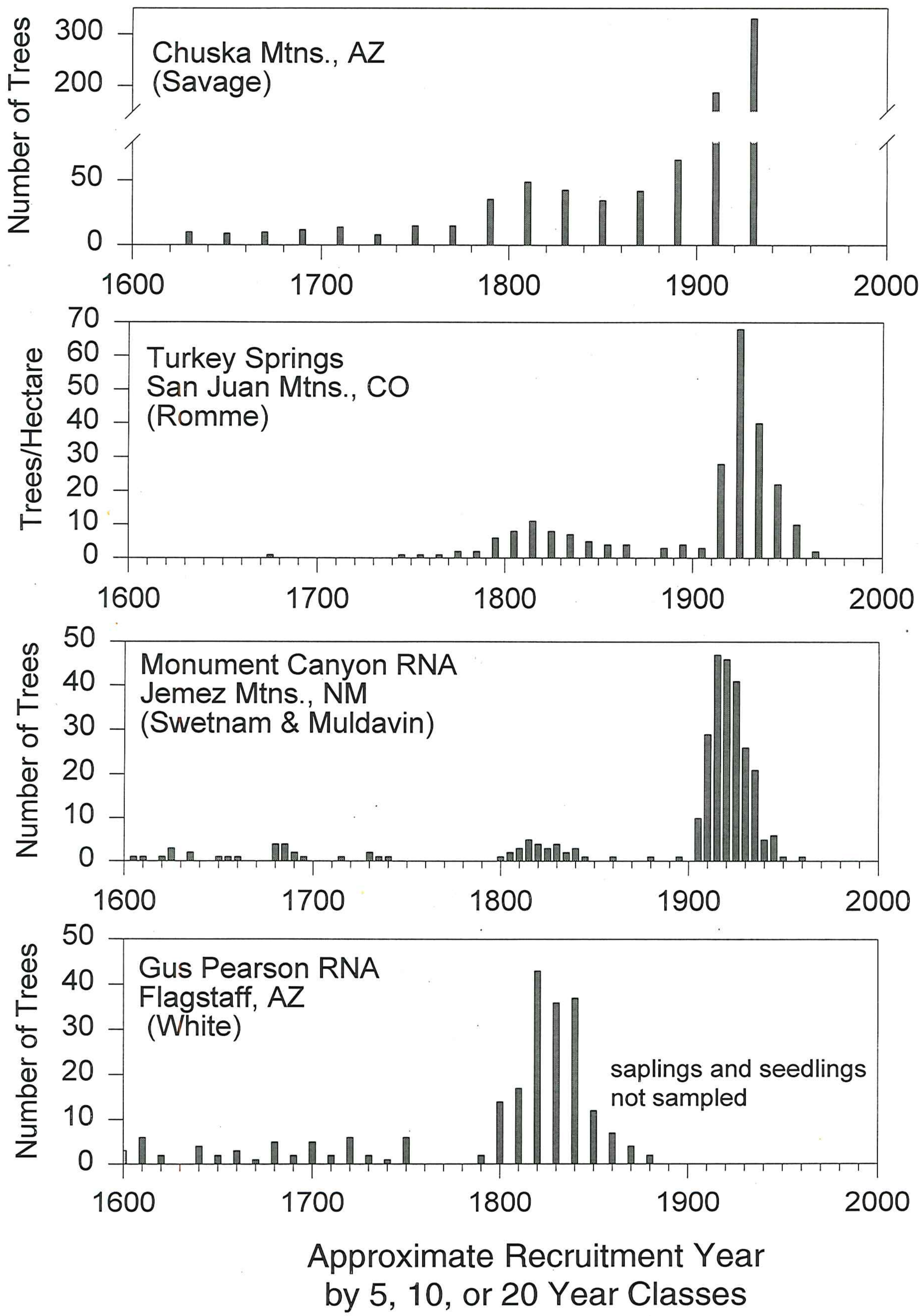
* All trees greater than 10cm (4 in) were cored with increment bores at, or as close as possible to the stem/root junction to also gain a precise germination date.

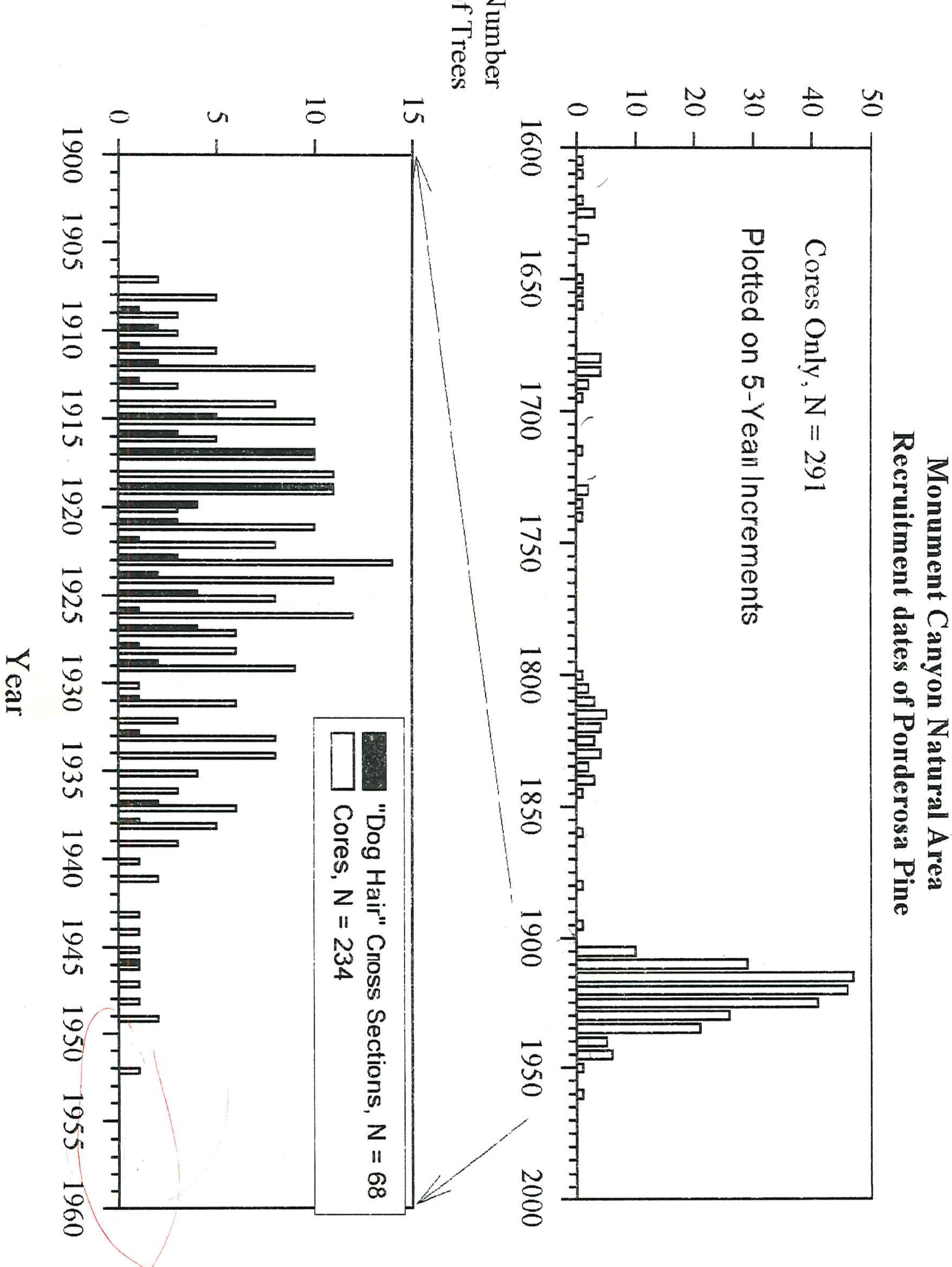
* Additional large trees greater than 50cm (20 in) within a radius of 22.5 meters (73 feet) of plot center were cored to increase the sampling depth for age of older trees.

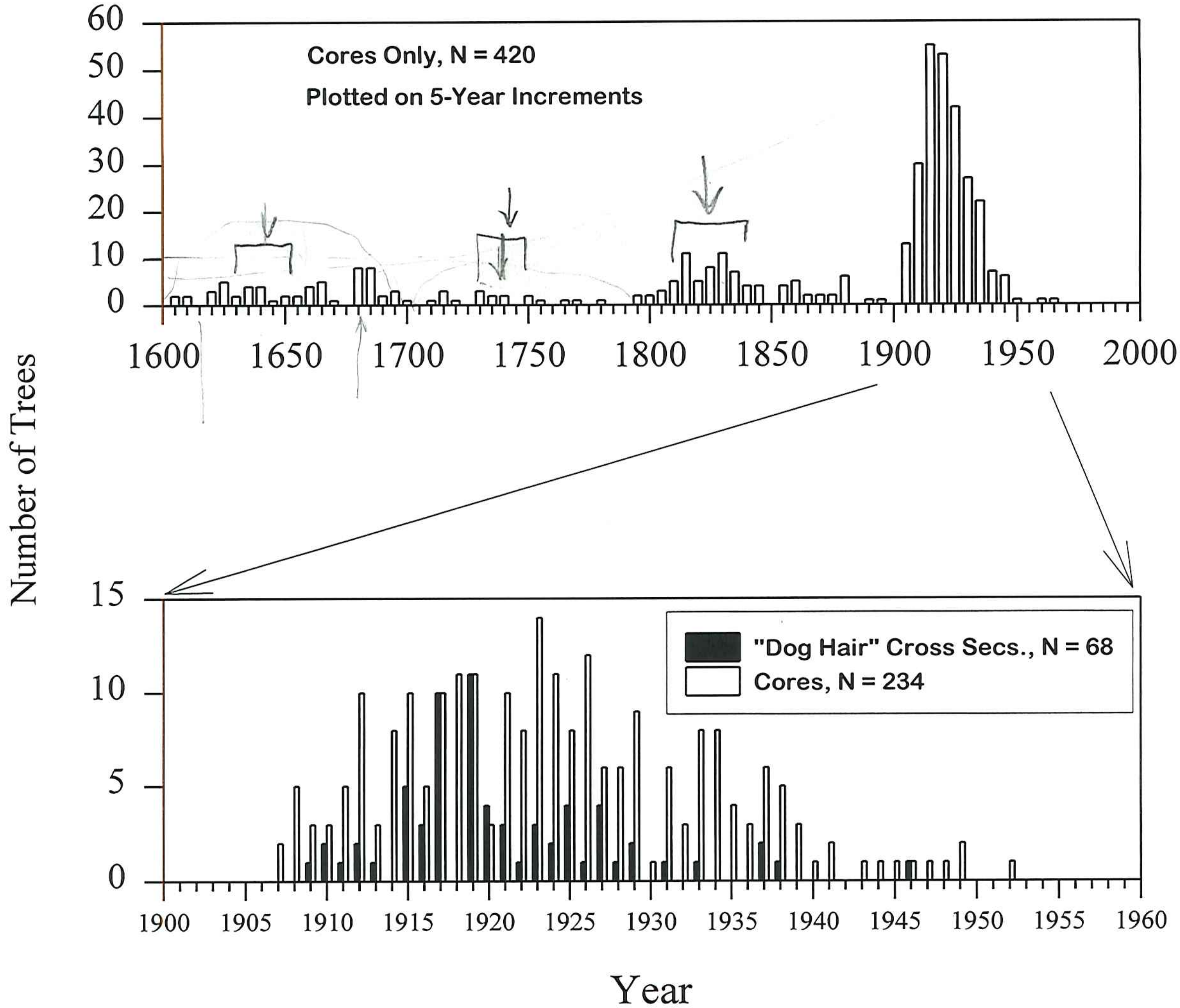


Episodic Recruitment of Ponderosa Pine in the Early 19th and 20th Centuries
In Colorado, Arizona, and New Mexico
1600
1700
1800
1900
2000
Trees/Ha
Turkey Springs
San Juan Mtns., CO
(Romme)
68
No. of Trees
Chuska Mtns., AZ
(Savage)
No. of Trees
Gus Pearson RNA
Flagstaff, AZ
(White)
age classes not sampled
Trees/Ha
Maverick
Ft. Apache Res. AZ
(Cooper)
70
Trees/Ha
Maylay Gap
San Carlos Res., AZ
(Cooper)
No. of Trees
Monument Canyon RNA
Jemez Mtns., NM
(Swetnam & Muldavin)
Trees/Ha
Rhyolite Canyon
Chiricahua Nat. Mon., AZ
(Barton)
59
Approximate Recruitment Year
by 5, 10, or 20 Year Classes

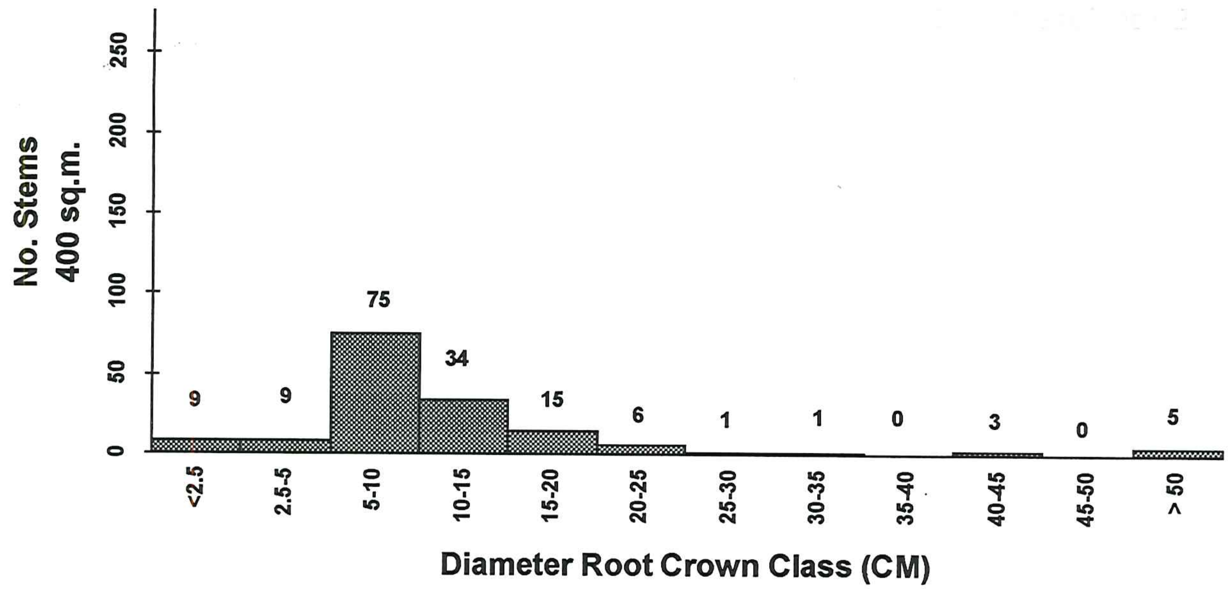
Episodic Recruitment of Ponderosa Pine in the Early 19th and 20th Centuries
In Colorado, Arizona, and New Mexico




Monument Canyon Natural Area
Recruitment dates of Ponderosa Pine
Cores Only, N = 291
Plotted on 5-Year Increments
Number of Trees
"Dog Hair" Cross Sections, N = 68
Cores, N = 234
Year


Cores Only, N = 420
Plotted on 5-Year Increments
"Dog Hair" Cross Secs., N = 68
Cores, N = 234
Number of Trees
Year
60
50
40
30
20
10
0
1600
1650
1700
1750
1800
1850
1900
1950
2000
15
10
5
0
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960

Plot A2 -- Grassy Understory



Plot A6 -- Cool Site

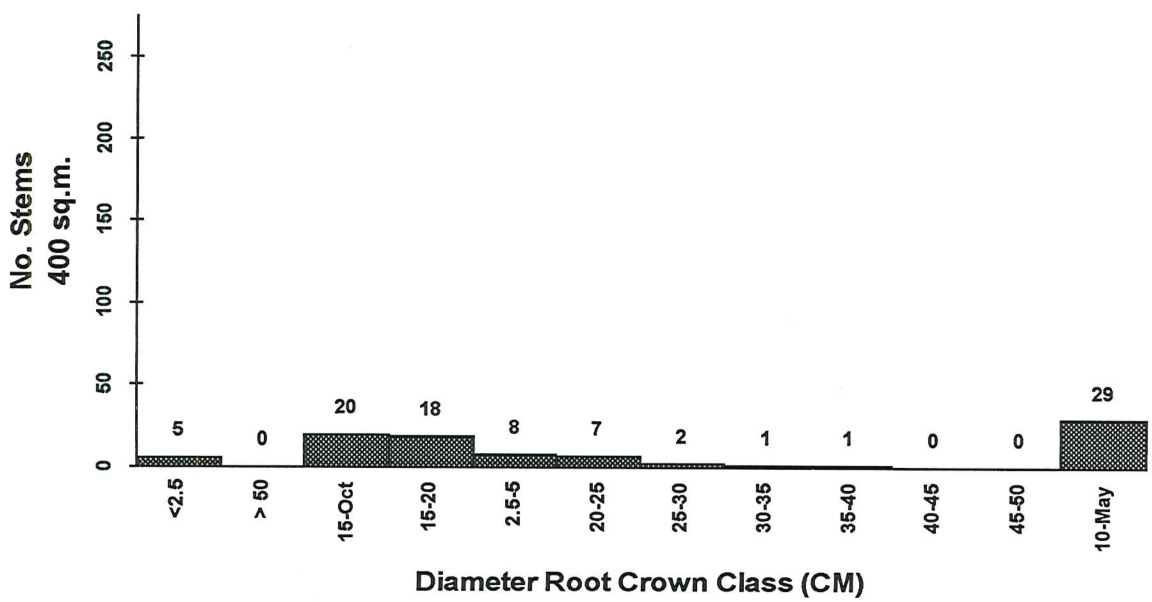
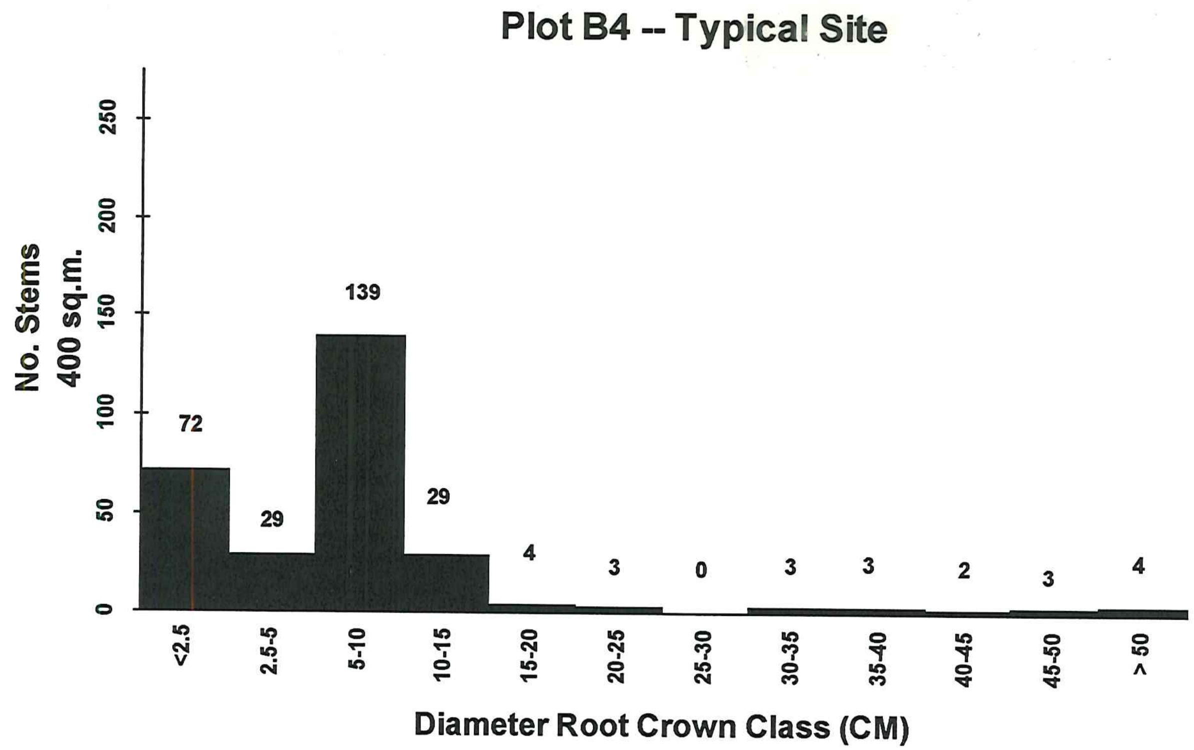
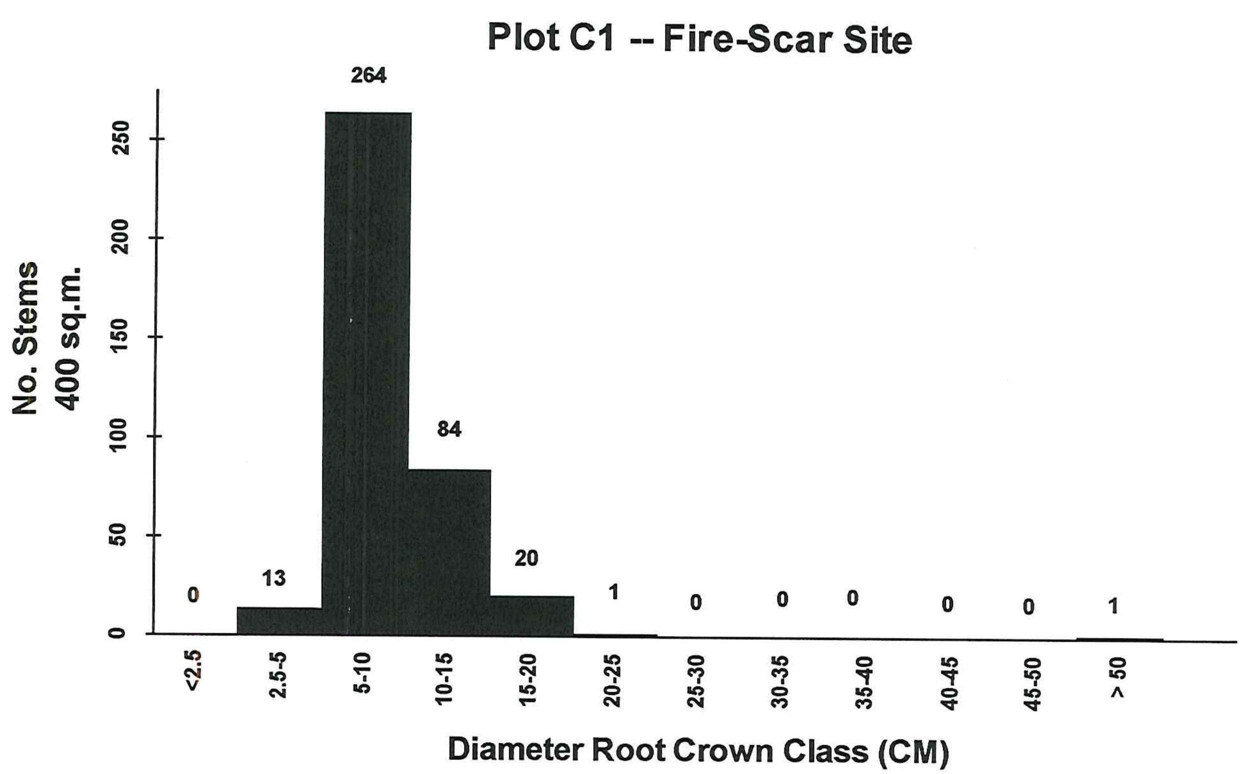


Figure 1. Histograms of stems by diameter classes per 400 sq. meter plot different types of sites within Moument Canyon RNA.





REFERENCES

Touchan, R.,C.D.Allen, and T.W.Swetnam. 1995. Fire history and climatic patterns in ponderosa and mixed-conifer forests of the Jemez Mountains, New Mexico. In Press. C.D. Allen, ed., Proceedings of the 2nd La Mesa Fire Symposium, March 29-31, 1994, Los Alamos, New Mexico. Gen. Tech. Report, RM-__. U.S.D.AForest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

lines bisecting xx, xx m2 plots evenly spaced along the transects. Additionally we sampled dog hair thickets by ......

[Este: can you fill in some details on the field methods]

Results to Date

The temporal distribution of inner ring dates of pines in Monument Canyon strongly suggest that recruitment was highly episodic prior to ca. 1907 (Fig. 1). Although few trees over about 200 years in age were samples there does appear to be one to a few cohorts that established in the 1600s and 1700s AD. A more obvious cohort established in the early 1800s. This later cohort is very interesting because it generally corresponds with an unusually long interval between large fires in Monument Canyon RNA, the Jemez Mountains, and other locations in the Southwest where detailed fire histories have been reconstructed (Swetnam and Dieterich 1985; Touchan, Allen, and Swetnam 1995) (Fig. 2).

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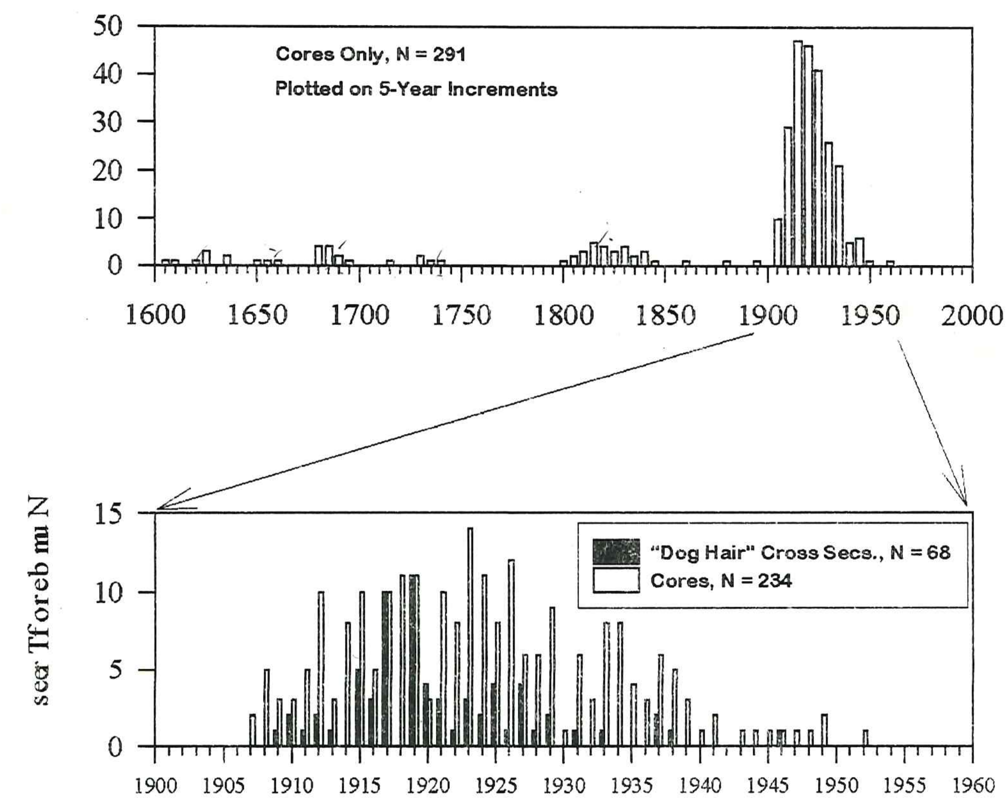


1994 Plot Data

Monument Canyon RNA - Section 9
Transect Line A   Plot 1

MARY STUEVER
SCOTT DAVIS
10-1-94

FORM 5b -- TREE INVENTORY

NUMBER BY DBH CLASS (Inches)

SPECIES CODE	0-2 <4.5'	0-2 >4.5'	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>20
		12	158	96	20	3						

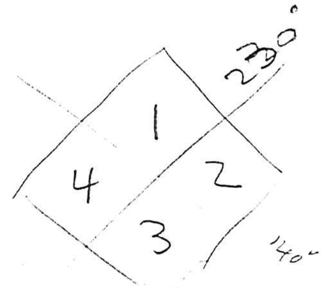
Cross section trees

SITE TREES SPP CODE	DRC ~~DBH~~	HT	CORE	COMMENT	SPP CODE	DRC ~~DBH~~	HT	CORE	COMMENT
94-MC A1-01	4.55				14	2.10			
02	2.55				15	3.20			
03	2.55				16	1.30			
04	4.32				17	1.95			
05	2.49				18	3.25			
06	4.05				19	1.15			
07	3.05				20	3.25			
08	3.30				21	2.19			
09	2.95				22	1.80			
10	1.90				23	2.1			
11	1.75								
12	1.95								
13	3.40								

0-1
1-2 ~~IIII~~ II
2-3 ~~IIII~~ II
3-4 ~~IIII~~ I
4+ III

Plot A-2 - Man Cayn.

Davis - Stuever 10/2/94



FORM 5b -- TREE INVENTORY

NUMBER BY DBH CLASS (Inches)

SPECIES CODE	0-2 <4.5'	0-2 >4.5'	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>20
Quad. 1.	6	1	15	1	X	1	1	1		1		4
Quad 2	2	X	4	5	2	X				2		1
Quad 3	X	3	33	17	7	5						
QUAD 4	1	5	23	11	6							
Total	9	9	75	34	15	6	1	1	–	3	–	5

SITE TREES SPP CODE	DRC" ~~DBH~~	QUAD ~~HT~~	CORE	COMMENT
A-2 01	1.95	3		
A-2 02	1.95	3		
A-2 03	3.05	4		
A-2 04	0.05	4 estimate		2" above grnd SEEDLING
05	2.32	4		
06	1.45	4		
07	0.75	1		SEEDLING 3.4' TALL.
08	1.50	1		SEEDLING 3.2' TALL
09	0.95	1		SEEDLING 2.6' Tall. Forks at 2" Above ground
10	1.60	2		4.5' TALL. 1 FT from large yellowbelly.

growing in clump - less than 1" diam.

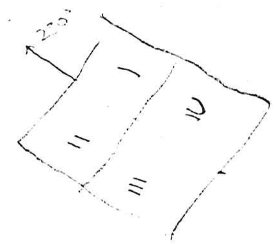
SPP CODE	DRC. ~~DBH~~	QVAD ~~HT~~	CORE	COMMENT
11	2.7	3		
12	3.85	3		
13	3.00	3		
14	2.45	4		
15	1.45	4		
16	3.55	1		
17	3.65	2		
18	1.50	2		4.45' tall.
19	3.95	2		
20	3.45	3		

0-1 III
1-2 ~~IIII~~ II
2-3 ~~IIII~~
3-4 ~~IIII~~

Oct 19, 1994

~~not~~ open undergrowth open stand — all alive 1 snag.
fragment

PLOT A-3
MONUMENT CANYON
10/4/94 DAVIS / STUEVER



FORM 5b -- TREE INVENTORY

NUMBER BY DBH CLASS (Inches)

SPECIES CODE	0-2 <4.5'	0-2 >4.5'	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>20
QUAD I		6	8	2	1							3
Q II	3	4	23	14	4	1	1					
Q III		2	20	13	5	3	1					
Q IV		3	22	9	8	2						1
PLOT TOTAL	3	15	73	38	18	6	2					4

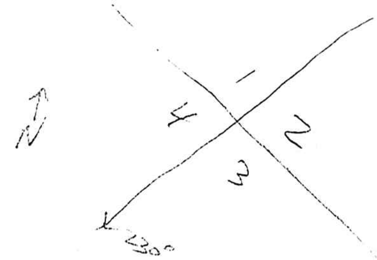
SITE TREES SPP CODE	DBH	HT	CORE	COMMENT	SPP CODE	DBH	HT	CORE	COMMENT
A3-01	1.4	1			A3-11	2.2	3		
A3-02	1.6	1			A3-12	3.3	3		
A3-03	1.4	1			A3-13	1.1	3		
A3-04	1.1	2			A3-14	3.2	4		
A3-05	2.45	2			A3-15	2.1	4		
A3-06	2.65	2			A3-16	3.1	4		
A3-07	.9	2			A3-17	3.4	4		
A3-08	.95	2			A3-18	3.35	2		
A3-09	2.3	2			A3-19	1.9	1		
A3-10	1.6	3			A3-20	2.05	1		

0-1	||
1-2	~~||||~~ ||
2-3	~~||||~~ |
3-4	~~||||~~

Oct 19, 1994 - Field house in #2? 4m by 2m.
open stas.

Monument Canyon 10/8/94
Transect A; Plot 6
STUEVER

FORM 5b -- TREE INVENTORY



NUMBER BY DBH CLASS (Inches)

SPECIES CODE	0-2 <4.5'	0-2 >4.5'	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>20
QUAD 1	1	4	2	4	5	5	1					
QUAD 2	1			1								
QUAD 3	3					PIFL in this QUAD		1	1			
QUAD 4		4	Abco in this Quad 27	PIFL in this Quad 15	13	2	1					add 10/19
PIPO Totals	5	8	29	20	18	7	2	1	1			
PIFL				1		1						
ABCO			2									

Ppo

SITE TREES SPP CODE	DBH	QUAD ~~HT~~	HT. ~~CORE~~	COMMENT	SPP CODE	DBH	QUAD ~~HT~~	CORE	COMMENT
A6 01	.3"	3	0.5'		A6 - 11	2.25	4		
A6 02	.5"	3	0.7'		A6 - 12	3.3	4		
A6 03	0.5"	2	1.2'		A6 - 13	3.5	4		
A6 -04	2.2	4			A6 14	1.65	1		
A6-05	3.3	4			A6 15	0.50	3		
A6-06	1.3	4			A6 - 16	0.30	3		
A6-07	1.90	1			A6-17	1.9	4		
A6-08	2.75	1			A6 - 18	2.80	4		
A6-09	1.50	1			A6 - 19	2.95	4		
A6-10	3.95	4			A6 - 20	3.35	4		

0-1
1-2
2-3
3-4

Plot A6 is right on transition to Abco/Fear h.t. It is on the SE facing slope near the ridgetop - (~10 m away) 5-20% slope.

Monument Canyon
Plot A-4
10/8 & 10/19, 94
STUEVER / DAVIS

1 2 4 3

transect 230°

FORM 5b -- TREE INVENTORY

NUMBER BY DBH CLASS (Inches)

SPECIES CODE	0-2 <4.5'	0-2 >4.5'	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>20
QUAD 1	1	–	9	7	7	3						Oct 19
QUAD 2	–	3	12	14	6	6	3					
QUAD 3	–	3	38	13	9	5	–	1				
QUAD 4	–	2	13	8	5	2	–					
Total	–	8	72	42	27	16	3	1				

SITE TREES SPP CODE	DBH	QUAD ~~PT~~	CORE	COMMENT	SPP CODE	DBH	QUAD ~~PT~~	CORE	COMMENT
A4 01	1.65	2			A4 11	1.2	2	6'	
A4 02	3.45	2			12	1.25	3	4.5'	
A4 03	2.30	1			13	2.65	3		
A4 04	3.70	1			14	3.35	3		
A4 05	1.65 ~~2.85~~	1	<4.5 high (4.3')		15	3.4 ~~2.5~~	4		
A4 06	2.10	2			16	2.3	4		
A4-07	3.70	2			17	1.9	4		
A4-08	2.05	2			18	3.5	4		
A4-09	2.75	2			19	1.95	3		
A4-10	1.50	2	5.5'		20	1.80	3		

0-1
1-2 ~~||||~~ |||
2-3 ~~||||~~ |
3-4 ~~||||~~ |

A5

to A-4

to A-6

FORM 5b -- TREE INVENTORY

NUMBER BY DBH CLASS (Inches)

SPECIES CODE	0-2 <4.5'	0-2 >4.5'	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>20
QUAD 1	—	2	55	28	16	3						
QUAD 2	—	3	55	27	9	3						
QUAD 3	—	4	53	26	7	6	1					
QUAD 4	—	1	64	41	10	—	2					
Total	—	10	227	122	42	12	3					

SITE TREES SPP CODE	DBH	QUAD ~~HT~~	CORE	COMMENT
A-5 01	2.30	3		
A-5 02	1.5	3		
A-5 03	2.4	3		
A-5 04	1.4	3		
A-5 05	3.0	3		
A6 06	3.3	2		
A-5 07	1.55	2		
A-5 08	2.90	2		
A-5 09	1.95	2		
A-5-10	2.00	2		
A-5 11	1.55	1	7' high	
12	3.40	1		
13	3.30	1		
14	2.10	1		
15	1.80	1		
16	2.05	4		
17	3.15	4		
18	1.95	4		
19	2.90	4		
20	2.75	4		

0-1
1-2
2-3
3-4

B-1 Monument Canyon RNA
10/2/94
Stuever / Davis

FORM 5b -- TREE INVENTORY

NUMBER BY DBH CLASS (Inches)

SPECIES CODE	0-2 <4.5'	0-2 >4.5'	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>20
QUAD 1	-	5	66	21	3							
QUAD 2	-	1	49	24	4	2	-	-	1	-	-	1
QUAD 3	-	1	34	11	9	5	2	-	-	-	-	-
QUAD 4		2	43	27	9	2	-	-	-	-	-	-
Plot Total		9	192	83	25	9	2	-	1	-	-	1

SITE TREES SPP CODE	DRC ~~DBH~~	QUAD ~~HT~~	CORE	COMMENT	SPP CODE	DRC ~~DBH~~	Quad ~~HT~~	CORE	COMMENT
B1 - 01	1.85	2			B1 - 11	3.05	4		
B1 - 02	2.2	1			B1 - 12	2.2	1		
B1 - 03	2.5	1			B1 - 13	1.9	1		
B1 - 04	2.05	1			B1 - 14	1.65	1		
B1 - 05	2.1	4			B1 - 15	2.4	3		
B1 - 06	1.3	2			B1 - 16	2.4	3		
B1 - 07	1.7	3			B1 - 17	3.5	3		
B1 - 08	1.6	1			B1 - 18	3.2	3		
B1 - 09	3.4	4			B1 - 19	1.65	4		
B1 - 10	3.25	4			B1 - 20	3.1	4		

0-1 |
1-2 ~~||||~~ ||
2-3 ~~||||~~ ||
3-4 ~~||||~~ |

B-2 Monument Canyon RNA
DAVIS STUEVER
10/2/94

FORM 5b -- TREE INVENTORY

NUMBER BY DBH CLASS (Inches)

SPECIES CODE	0-2 <4.5'	0-2 >4.5'	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>20
QUAD 1	–	1	9	15	5	6	4	1	–	–	–	–
QUAD 2	–	–	13	22	7	6	–	–	–	–	–	–
QUAD 3	–	–	4	11	11	3	4	1	–	–	–	–
QUAD 4	–	1	4	12	9	5	3	–	–	–	–	–
Plot Total	–	2	30	60	32	20	11					

SITE TREES SPP CODE	DRC	QUAD	CORE	COMMENT
B2-01	2.4	1		
B2-02	2.25	1		
B2-03	2.3	1		
B2-04	1.0	4		
B2-05	3.3	4		
B2-06	2.7	4		
B2-07	3.2	4		
B2-08	3.05	3		
B2-09	2.9	3		
B2-10	2.6	2		

SPP CODE	DBH	HT	CORE	COMMENT
B2-11	2.0	2		
B2-12	2.0	2		
B2-13	3.0	2		
B2-14	3.6	1		
B2-15	3.1	4		
B2-16	2.6	2		
B2-17	3.2	2		
B2-18	2.6	3		
B2-19	3.8	4		
B2-20	1.3	1		

0-1	
1-2	II
2-3	~~IIII~~ II
3-4	~~IIII~~ II

Monument Canyon RNA

Transect B
Plot 3

STUEVER / DAVIS 10/2/94

FORM 5b -- TREE INVENTORY

NUMBER BY DBH CLASS (Inches)

SPECIES CODE	0-2 <4.5'	0-2 >4.5'	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>20
QUAD 1	–	1	18	17	16	6	2					
QUAD 2	–	–	14	20	14	2						
QUAD 3	–	3	35	18	8	2						
QUAD 4	–	3	22	18	12	10						
Plot Total	–	7	89	63	50	20	2					

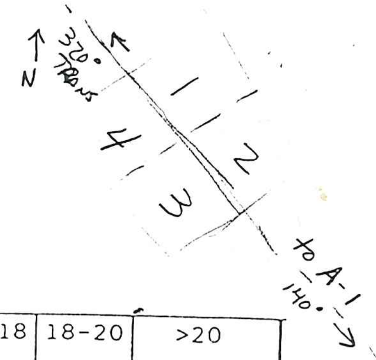
SITE TREES

SPP CODE	DBH	QUAD ~~HT~~	CORE	COMMENT
B3-01	2.7	2		
B3-02	2.6	3		
B3-03	2.8	3		
B3-04	3.35	3		
B3-05	2.6	3		
B3-06	1.6	4		
B3-07	1.3	4		
B3-08	1.5	4		
B3-09	1.1	3		
B3-10	2.0	1		
B3-11	1.9	1		

SPP CODE	DBH	HT	CORE	COMMENT
B3-12	3.4	2		
B3-13	2.5	2		
B3-14	2.8	1		
B3-15	2.3	2		
B3-16	3.5	3		
B-3-17	3.0	4		
B3-18	1.25	4		
B3-19	3.0	2		
B3-20	4.0	2		

0-1
1-2
2-3
3-4

Plot B-4
Monument Cnyn RNA
10/2/94 Stuever/Davis



FORM 5b -- TREE INVENTORY

NUMBER BY DBH CLASS (Inches)

SPECIES CODE	0-2 <4.5'	0-2 >4.5'	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>20
PIPO QUAD 1	31	8	38	10	1	–					1	1
PIPO QUAD 2	9	11	64	17	3	3						
PIPO QUAD 3	21	8	34	2				1	1		1	1
PIPO QUAD 4	11	2	3					2	2	2	1	2
Total	72	29	139	29	4	3	–	3	3	2	3	4
PIFL Pinus flexilis *	1	3										
Both species Plot Total	73	32	139	29	4	3		3	3	2	3	4

NO DESTRUCTIVE sampling of PIFL.

SITE TREES

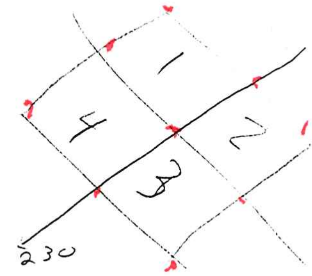
SPP CODE	DBH	HT	CORE	COMMENT	SPP CODE	DBH	HT	CORE	COMMENT
B4-01	0.6	1			B4-11	0.7	3		
B4-02	0.5	1			B4-12	0.6	4		
B4-03	1.2	1			B4-13	2.1	4		
B4-04	1.3	1			B4-14	2.0	3		
B4-05	1.8	1			B4-15	2.25	4		
B4-06	1.4	2			B4-16	3.05	4		
B4-07	0.9	2			B4-17	2.2	4		
B4-08	2.0	2			B4-18	3.5	2		
B4-09	3.1	3			B4-19	3.3	2		
B4-10	1.5	3			B4-20	3.6	1		

0-1
1-2
2-3
3-4

* all PIFL located in QUAD 4-

C-1 Subjective location
Plot Center is center of fir... tree.

10/9/94
Stucrer / Davis



FORM 5b -- TREE INVENTORY

NUMBER BY DBH CLASS (Inches)

SPECIES CODE	0-2 <4.5'	0-2 >4.5'	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>20
QUAD 1	—	3	96	23	1	—	—	—	—	—	—	—
QUAD 2	—	5	34	16	6	—	—	—	—	—	—	—
QUAD 3	—	3	65	34	11	—	—	—	—	—	—	—
QUAD 4	—	2	69	11	2	1	—	—	—	—	—	1
Total	—	13	264	84	20	1	—	—	—	—	—	1

SITE TREES SPP	CODE	DBH	QUAD	CORE	COMMENT
C-1	01	1.00	1		
C1	02	1.90	1		
C-1	03	2.80	1		
C-1	04	3.45	1		
C-1	05	0.95	1		
C-1	06	1.45	2		
C-1	07	3.25	2		
C-1	08	1.80	2		
C-1	09	2.80	2		
C-1	10	2.10	2		

SPP	CODE	DBH	QUAD	CORE	COMMENT
C1	11	0.75	3		
	12	1.30	3		
	13	3.95	3		
	14	1.80	3		
	15	2.60	3		
	16	2.15	4		
	17	1.80	4		
	18	3.55	4		
	19	3.80	4		
	20	1.55	4		

0-1
1-2
2-3
3-4

Tom:

This is the data I received in MCNCXS.DIF. Is it correct? If so, where are plots B1 to B4? Are missing tree numbers from specimens that were not readable? If the trees do not fit a chronology, is the sample still useable? What were the main reading problems, and can we solve some of them in our field sampling techniques this fall?

The other files look good in Lotus, Thanks.

Esteban

Sample #	inner rin	ring count
A1		
1	1918	
2	1926	54
3		52
4	1920	
5	1924	54
6	1922	
7	1920	72
8	1918	
9	1922	
10		56
11	1918	60
12	1918	59
13	1912	62
14		68
15	1913	73
16		48
17	1918	68
18	1910	66
19		40
21	1918	70
22	1989	66
22	1916	71
23	1918	62

Sample #	inner rin	ring cou
C1		
1		35
2		53
3	1917	77

4	1920	73
5		40
6		60
7	1920	73
8		59
9	1916	78
10	1917	66
11		30
12		43
13	1920	74
14		68
15	1916	67
16	1928	63
17	1928	63
18	1923	67
19	1914	80
20		50

Sample #	inner rin	ring count
A6		
4	1939	55
5		49
6		60
7	1926	53
8	1925	69
10	1920	74
11		62
12	1920	62
13	1918	76
14		63
17		53
18	1921	68
19		53

Sample #	inner rin	ring count
A5		
1		65
4		54
5	1911	82
6		50
8		80
9		59
11		52

12	1920	66
13	1920	74
14		45
15		50
16	1921	70
17	1922	59
19	1921	70

Sample #	inner rin	ring cou
A4		
1		50
2	1920	65
3	1938	52
4	1924	70
5		43
6	1911	63
7	1918	64
8		54
9	1926	69
10	1938	50
11		40
12	1947	45
13	1924	68
14	1920	72
15	1929	66
16	1916	61
17		53
18	1916	67
19		64
20	1934	65

Sample #	inner rin	ring cou
A3		
1		40
3		58
4		40
5		59
6		63
7		45
8		60
9	1928	62
10		40
11	1925	66

12	1918	69
14	1926	67
15	1930	55
16	1921	76
17	1913	
18	1928	72
19	1930	46
20	1927	68

Sample # A2	inner	rinring count
1		54
2		61
3		63
7		51
8		53
11		60
12		72
14		52
15		48
17	1932	60
18		50
20	1917	77

sample no.	inside date	add'l inside rings	pith estimate
133	1930	5	1925
134	1939	16	1923
135	1931	5	1926
137	1916	0	1916
138	1922	0	1922
139	1925	6	1919
140	1935	6	1929
141	1927	0	1927
142	1959	12	1947
143	1928	6	1922
144	1927	0	1927
145	1942	14	1928
146	1935	4	1931
147	1933	4	1929
148	1975	13	1962
149	1951	6	1945
150	1918	0	1918
151	1938	4	1934
152	1954	15	1939
153	1620	14	1606
154	1839	14	1825
155	1859	14	1845
156	1803	0	1803
158	1938	4	1934
159	1954	8	1946
160	1846	20	1826
161	1857	16	1841
162	1824	10	1814
163	1931	7	1924
164	1935	6	1929
165	1918	5	1913
166	1923	6	1917
167	1926	7	1919
168	1918	0	1918
169	1943	3	1940
170	1938	13	1925
172	1918	0	1918
173	1940	7	1933
174	1940	5	1935
175	1927	4	1923
176	1940	5	1935
177	1927	6	1921
178	1832	0	1832
179	1832	12	1820
180	1830	12	1818
181	1819	0	1819
182	1833	0	1833
183	1821	2	1819
185	1833	9	1824

TREE1.WK3
from
Swetnam MCNCORES.DIF

TREE1 133 — 325
inside Date.
inside Rings
pith estimate

EOD
1918 ✓ 0,62
Enclosure number 3 – 1, 0
MCNCXS.DIF

243	1931	16	1915
244	1926	11	1915
245	1926	13	1913
246	1915	5	1910
248	1925	6	1919
249	1838	11	1827
250	1752	17	1735
251	1852	20	1832
252	1833	8	1825
253	1846	15	1831
254	1937	10	1927
255	1950	12	1938
256	1916	4	1912
257	1924	0	1924
258	1940	20	1920
259	1940	18	1922
260	1915	0	1915
261	1914	0	1914
262	1919	7	1912
263	1914	5	1909
264	1917	0	1917
265	1924	8	1916
266	1924	6	1918
267	1918	4	1914
268	1925	5	1920
270	1930	8	1922
271	1921	8	1913
272	1913	4	1909
273	1913	0	1913
274	1926	7	1919
275	1911	3	1908
276	1921	8	1913
277	1934	15	1919
278	1925	15	1910
279	1914	5	1909
280	1918	7	1911
281	1936	6	1930
282	1662	6	1656
283	1914	3	1911
286	1649	20	1629
287	1942	12	1930
288	1912	0	1912
289	1950	11	1939
290	1922	6	1916
301	1930	4	1926
302	1922	0	1922
303	1925	0	1925
304	1930	0	1930
305	1921	5	1916
306	1954	17	1937
307	1919	0	1919

308	1925	0	1925
309	1926	8	1918
311	1939	14	1925
313	1959	9	1950
314	1951	12	1939
315	1950	8	1942
316	1930	0	1930
317	1949	10	1939
318	1938	6	1932
319	1913	0	1913
320	1931	6	1925
321	1670	8	1662
322	1693	7	1686
323	1695	9	1686
324	1739	8	1731
325	1701	16	1685

Date Cores	Count Cores
1600	0
1605	1
1610	1
1615	0
1620	1
1625	3
1630	0
1635	2
1640	0
1645	0
1650	1
1655	1
1660	1
1665	0
1670	0
1675	0
1680	4
1685	4
1690	2
1695	1
1700	0
1705	0
1710	0
1715	1
1720	0
1725	0
1730	2
1735	1
1740	1
1745	0
1750	0
1755	0
1760	0
1765	0
1770	0
1775	0
1780	0
1785	0
1790	0
1795	0
1800	1
1805	2
1810	3
1815	5
1820	4
1825	3
1830	4
1835	2
1840	3
1845	1

Date CXS/	Count CXS	Count Cores
1890	0	0
1891	0	0
1892	0	0
1893	0	0
1894	0	0
1895	0	0
1896	0	0
1897	0	0
1898	0	1
1899	0	0
1900	0	0
1901	0	0
1902	0	0
1903	0	0
1904	0	0
1905	0	0
1906	0	0
1907	0	2
1908	0	5
1909	1	3
1910	2	3
1911	1	5
1912	2	10
1913	1	3
1914	0	8
1915	5	10
1916	3	5
1917	10	10
1918	0	11
1919	11	11
1920	4	3
1921	3	10
1922	1	8
1923	3	14
1924	2	11
1925	4	8
1926	1	12
1927	4	6
1928	1	6
1929	2	9
1930	0	1
1931	1	6
1932	0	3
1933	1	8
1934	0	8
1935	0	4
1936	0	3
1937	2	6
1938	1	5
1939	0	3

@rgb(128,
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1850	0
1855	0
1860	1
1865	0
1870	0
1875	0
1880	1
1885	0
1890	0
1895	1
1900	0
1905	10
1910	29
1915	47
1920	46
1925	41
1930	26
1935	21
1940	5
1945	6
1950	1
1955	0
1960	1
1965	0
1970	0
1975	0
1980	0
1985	0
1990	0
1995	0
2000	

1940	0	1
1941	0	2
1942	0	0
1943	0	1
1944	0	1
1945	0	1
1946	1	1
1947	0	1
1948	0	1
1949	0	2
1950	0	0
1951	0	0
1952	0	1
1953	0	0
1954	0	0
1955	0	0
1956	0	0
1957	0	0
1958	0	0
1959	0	0
1960	0	0
1961	0	1
1962	0	0
1963	0	0
1964	0	0
1965	0	0
1966	0	0
1967	0	0
1968	0	0
1969	0	0
1970	0	0
1971	0	0
1972	0	0
1973	0	0
1974	0	0
1975	0	0
1976	0	0
1977	0	0
1978	0	0
1979	0	0
1980	0	0
1981	0	0
1982	0	0
1983	0	0
1984	0	0
1985	0	0
1986	0	0
1987	0	0
1988	1	0
1989	0	0
1990	0	0

1991	0	0
1992	0	0
1993	0	0
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	0	0
2000		

192 = Dead

All measurements in CM

all trees = PIPO unless otherwise noted

PHOTOS Shelley A5 - 13, A6 - 14, B4 - 16

near 10/19/94

(31 larger trees added) (3 PIST trees)

(216-253)

(missing bore #207 cut)

(254-290) (NO 257)

B4 #	DRC	CORE HT	B1 #	DRC	CORE HT	B2 #	DRC	CORE HT	B3 #	DRC	CORE HT	C1 #	DRC	CORE HT	C1 #	DRC	HT
158	11.5	10	188	11.8	9	216	17.5	9	288	20	4	[illegible]	19.5	11	320	15.7	4
159	11.5	7	189	21	8	217	25	13	289	11	3	301	14	8			
160	31	19	190	11	11	218	31	10	290	16.8	12	302	14.7	12			
161	36	8	191	14	9	219	25.8	18	254	12	9	303	16.5	7			
162	34.5	20	192	16	12	220	31	16	255	13.5	14	304	13	11			
163	13.2	6	193	14	7	221	13.5	15	256	18.5	8	305	13.5	[illegible]			
164	12.9	3	194	21.5	4	222	10	10	257	13	9	306	19.5	4			
165	12.3	5	195	16.8	2	223	16.3	11	258	13.8	9	307	10.5	10			
166	20	7	196	14.3	3	224	10	8	259	20.5	12	308	14	7			
167	14	4	197	15.5	12	225	19.2	6	260	18	11	309	14.5	10			
168	10.8	6	198	14	3	226	15.4	9	261	17.9	14	310	20.5	2			
169	8.5	12	199	16.7	10	227	16.5	3	262	17	10	311	22	20			
170	12	6	200	16.5	9	228	17.4	6	263	20.8	8	312	18	4			
171	9	10	201	16	9	[illegible]	14.9	7	264	19	12	313	17	16			
172	9	7	202	16	4	[illegible]	14.6	8	265	19	(14) 12	314	14.5	4			
173	9	3	203	16.4	8	[illegible]	15	2	266	21.5	12	315	10	8			
174	9.4	6	204	16	3	[illegible]	20.8	15	267	14.3	4	316	13	4			
175	12.2	3	205	23	14	[illegible]	20.8	5	268	19	8	317	11	4			
176	10.5	3	206	17.5	7	[illegible]	11.1	4	269	17	14	318	16.5	15			
177	15.4	5	207	12.5	4	[illegible]	21.7	7	270	13	9	319	14	5			
178	48.5	11	208	33	10	236	24	12	271	23.1	10	321	65	21			
179	35	9	209	33	11	237	23.7	9	272	25.5	12	322	64	15			
180	38.3	9	210	27.6	13	238	26.5	11	273	23.8	14	323	63	10			
181	36	12	211	36	16	239	31	10	274	26.2	18	324	52	10			
182	61	11	212	38	18	240	27	10	275	24	5	325	56	25			
183	42	8	213	51	25	241	31.5	10	276	25	10						
184	NONE		214	58	10	242	28.5	20	277	23.5	10						
185	47	10	215	67.5	15	243	[illegible]	15	278	23	5						
186	41	10	216			244	26.5	10	279	26	5						
187	41.5	9	251	62	22	245	44	7	280	26	7						
			252	45	15	246	25	5	281	23	5						
			253	61.5	10	247	25	5	282	66.5	11						
						248	27.5	5	283	25	7						
						249	80.4	19	284	66	20						
						250	59	16	285	65.5	9						
									[illegible]	68	35						

ALL PINES = PI[illegible]

all meas. in cm

A1 #	A1 dbh	A1 HT core	A2 #	A2 dbh	A2 HT core	A3 #	A3 drc	A3 core HT	A4 #	A4 drc	A4 HT core	A5 #	A5 drc	A5 HT	A6 #	A6 drc	A6 HT
1	16.	4	26	52	18	52	16	8	81	18	8	108	16.7	9	133	22	10
2	17	4	27	14	7	57	17	10	82	11.2	5	109	16.5	2	134	20	4
3	17.5	1	28	10	3	54	16.5	15	83	14.5	6	110	24.5	4	135	20.5	9
4	17.5	2	29	13	6	59	17	13	84	20.5	5	111	18	13	136	21	8
5	14	3	30	14	8	60	15.2	2	85	13	9	112	14.5	10	137	13.5	2
6	14.2	4	31	28	10	61	14.7	16	86	15.5	11.5	113	18	7	138	23	8
7	14.2	5	32	21	8	62	20.5	9	87	15.0	8	114	19.6	10	139	20	8
8	16.5	2	33	16	8	63	20	8	88	13	2	115	17.2	10	140	70	11
9	17.5	5	34	24	14	64	19.5	12	89	26	2	116	14	13	141	27	7
10	14	4	35	34	7	65	24	6	90	18.5	9	117	15.7	12	142	14.5	4
11	4.8	5	36	17	6	66	19	3	91	14	9	118	18	13	143	19	7
12	14	5	37	18.5	12	67	17.2	5	92	16	5	119	16	8	144	23	12
13	19	5	38	13	10	68	13.4	6	93	20	1	120	16	7	145	15	4
14	15.3	3	39	22	8	69	12.7	4	94	18	7	121	18	4	146	14.5	11
15	6.8	5	40	27.5	4	70	13.6	3	95	13.2	3	122	13	5	147	17	9
16	11	5	41	19	6	71	14	8	96	25	4	123	15	3	148	23.5	13
17	20.1	5	42	11.5	5	72	19.3	15	97	19	10	124	14	2	149	17	7
18	13.5	2	43	14	10	73	18	3	98	13	5	125	15	6	150	13.5	5
19	18.2	5	44	13	9	74	22.2	15	99	19	5	126	[illegible]	7	151	13.5	4
20	15.9	5	45	16	5	75	13.3	2	100	13	2	127	17	3	152	14	9
21	74.1	20	46	42	5	76	61.2	15	101	28.5	5	128	85	24	153	70.	15
22	85.2	10	47	52	20	77	71	28	102	80.	6	129	93	30	154	87.5	15
23	62.7	11	48	27.8	20	78	73	18	103	97	11	130	63	22	155	52	20
24	79.5	60	49	48	20	79	78	20	104	78	12	131	70	25	156	46	20
25	53	18	50	24.5	8	80	63	26	105	79	21	132	16.5	40	157	78	10
			51	33	20				106	32	11						
			52	60	12				107	30	15						
			53	55	13												
			54	71	11												
			55	44	10												

#129 = dead

1880?

[illegible] MEASUREMENTS IN CM

From tswetnam@selway.umt.eduTue Sep 19 10:27:36 1995
Date: Mon, 18 Sep 1995 11:20:52 +0000
From: Tom Swetnam <tswetnam@selway.umt.edu>
To: Esteban Muldavin <muldavin@sevilleta.unm.edu>
Subject: Re:

Hi Este,

I am attaching some lotus type files to this message. The MOCXSEC2.WK1 is the whole set of dated cross sections from the small trees, lines A through C

The MCNCORES.WK1 are dates from the increment cored trees. There are 169 trees listed in this file, so I am not sure if this is all of the trees we cored, but I think it is...

I suggest you call Shelly if you want to verify anything. She should know where the files are. She dated the specimens and entered the data in original spreadsheets, then I modified them (the ones I'm sending you). These are the most up to date ones I can find on my hard drive here in Missoula.

Let me know if I need to send these files in another format.

YES, I will be at Henri's and Kiyomi's defenses (major advisors are expected to be at these things!).

Tom
Dr. T. W. Swetnam
Laboratory of Tree-Ring Research
University of Arizona
Tucson, AZ 85721
tswetnam@ltrr.arizona.edu

From TSWETNAM@KATI.LTRR.Arizona.EDU Mon Jun 26 12:30:34 1995
Received: from KATI.LTRR.Arizona.EDU (KATI.LTRR.Arizona.EDU [128.196.218.133])by geo.ISPE.Arizona.EDU (8.6.10/8.6.10) with ESMTP id LAA01438 for <muldavin@sevilleta.unm.edu>; Mon, 26 Jun 1995 11:32:19 -0700
Received: from KATI/MAILQUEUE by KATI.LTRR.Arizona.EDU (Mercury 1.21); 26 Jun 95 11:29:29 MST7
Received: from MAILQUEUE by KATI (Mercury 1.21); 26 Jun 95 11:29:07 MST7
From: "Thomas Swetnam" <TSWETNAM@KATI.LTRR.Arizona.EDU>
Organization: Tree-ring Lab, Uni. of Arizona
To: muldavin
Date: Mon, 26 Jun 1995 11:28:46 -0700
X-Total-Enclosures: 3
X-Enclosure-Info: DOS,"mcncores.dif",,,,DIF
X-Enclosure-Info: DOS,"mcncsx.dif",,,,DIF
X-Enclosure-Info: DOS,"moncan1.dif",,,,DIF
Subject: Monument Canyon Data
Priority: normal
X-Mailer: Pegasus Mail/Windows (v1.22)
Message-Id: <4AA8ECB026F@KATI.LTRR.Arizona.EDU>
Status: R

Este:

I am appending the spreadsheet files. They were in a DIF format, but they should come through to you as ASCII. Let me know if you have problems reading them.

They are:

MCNCORES.DIF These are the dates for the trees we cored along the transects. Note that the innermost ring on the core from each tree is listed, and the number of rings added to estimate the pith date, if the pith was not present. We used the "Applequist" pith estimator method for this (ask me for more details if/when you need).

MCNCXS.DIF These are the dates from the cross sections you and Mary dug up. They are listed ny specimen number and plot ID (A1 to A6, and C1 ???). Note that not all cross sections were crossdateable, so ring counts are also listed.

MONCAN1.DIF This is the data extracted from my plotting program which produced the graphic I just sent to you. Numbers of individuals by 5-year increment (cores) and by year (cross sections) were computed in a spreadsheet, and are listed here.

```
↑DIR *.SSF

 Volume in drive C has no label
 Volume Serial Number is 1D28-5F45
 Directory of C:\GPS\PF23\DATA\LADRONES

L091101A SSF          2,034 09-14-94   11:20a
L091102A SSF          3,706 09-14-94   11:20a
L091103A SSF          3,536 09-14-94   11:20a
L091104B SSF          2,590 09-14-94   11:20a
L091105A SSF          2,254 09-14-94   11:20a
L091106D SSF          2,014 09-14-94   11:20a
L091107E SSF          2,576 09-14-94   11:20a
L091108F SSF          1,750 09-14-94   11:20a
L091109G SSF          1,774 09-14-94   11:20a
L091110H SSF          2,014 09-14-94   11:21a
L091111I SSF          1,606 09-14-94   11:21a
L091112J SSF          2,098 09-14-94   11:21a
L091112K SSF          2,034 09-14-94   11:21a
L091113A SSF          1,798 09-14-94   11:21a
L091113B SSF          2,034 09-14-94   11:21a
L091115E SSF          1,750 09-14-94   11:21a
L091116F SSF          2,230 09-14-94   11:21a
L091121G SSF          4,008 09-14-94   11:21a
L091122A SSF            554 09-14-94   11:21a
L091121B SSF          3,912 09-14-94   11:21a
L091123C SSF          2,034 09-14-94   11:21a
L091124A SSF          2,208 09-14-94   11:21a
L091125B SSF          2,428 09-14-94   11:21a
L091126C SSF          2,602 09-14-94   11:21a
L091127D SSF          2,666 09-14-94   11:21a
L091128E SSF          3,582 09-14-94   11:22a
L091129F SSF          2,492 09-14-94   11:22a
L091130G SSF          2,602 09-14-94   11:22a
L091131H SSF          2,690 09-14-94   11:22a
L091132I SSF          2,996 09-14-94   11:22a
L091133J SSF          2,602 09-14-94   11:22a
L091134K SSF          2,318 09-14-94   11:22a
L091135L SSF          2,666 09-14-94   11:22a
L091136M SSF          3,212 09-14-94   11:22a
       34 file(s)         83,370 bytes
                      71,225,344 bytes free

C:\GPS\PF23\DATA\LADRONES>
```

MON94 — others [illegible]

Apr 26 Q0426 17D
27
28

5A — 5/06/94 R050618A
5/19/94 0519 18A

09/14/93

Q94CH001. !

@ June 27. 1994

Oct 18 1993

Ladrone Sept 11

Mmmnel. Oct 19.

Swet SEV Aug 3 @

FRI 22:38:48 JUNE 24.

BASE. Ø5, 6, 16, 17, 20, 24

Q 5 6 16 24

Monument

04 05 07 24
AUGUST Ø2. 17:17:16
Tue 16.

17:17:32

6:30 22:38

RG4YCØ25

B → JUNE 30

Swet
AUG 03 22:23

SA
RØ5Ø618A MAY 06 1994 19:08
51918A 19 18:24
B 18:28
C
D
1919A 19 19:55

Regen
Q042617D April 26 17:31
17C 27
28

IDENTIFIERS / LOCATION

LEVEL I: SITE SURVEY SUMMARY - COMMUNITY ADDENDUM

Survey site name: Monument Cayon RNA	Source Code:
Site name: 〃	Directions to site: NM 4 to Vallecitos —
Surveyors: Muldavin	Survey date: 94-08-02 (YY MM DD)
Quad name/Scale: Jemez Springs / Redondo Peak	
Quadcode:	State/Prov:
County name:	
Localjuris/TRS:	Imagery/scale:

TOPOGRAPHY

Reconnaissance Diagram: Scale: See Attached Map →

Instructions for vegetation/habitat: This section is to be used to coarsely describe the communities and other special features on the site. For each observation point list the name of the community or special feature ie, "maple-basswood forest", "stone wall", "sinkhole", etc. in the Name field. Then provide a very general description of the community or feature. For communities include general impressions on the physiognomy, the strata present, dominant species, soil type, etc. If you wish to characterize the community at an observation point use the "Level II: Element Occurrence - Qualitative Community Characterization" form.

VEGETATION / HABITAT

#3 Bears Tree fire transect

Observation Point 1	Observation Point 2	Observation Point ~~3~~ 4
Name: West Side Boundary Rd. to #2 GPS MUL0194 GPS	Name: West Ridge Rd. up from junction with Boundary Rd. GPS MUL0159	Name: ~~MUL17094~~ MUL01794 GPS West Side Road - North end.
General description: PIPO/FEAR old growth patches on small slope; Dense stands of 4-6" PIPO dog hair with scattered yellows; PIPO/FEAR more open with only scattered repro.	General description: PIPO/QUUN – QUGA JUMO on steep slope Facing S.E >50% 128° ~~100%~~ RONE Steep boulder slope with Rhyolitic cliffs. POA CEMO Chrysothamnus. wpt 144 - dense 4-6" surrounded by yellows WPT136 - Lightning hit tree closed in stand - of 4-6" w/ dying yellow Surrounded by Adv Regen - PIPO three head left along ridge	General description: PIPO/FEAR Vector Walk. ~~##~~ WPT 10-11 4-8" NO 06 WPT 27 - Dead yellow at edge of valley. - Leading north. wpt 33-37 Old stand; open w/ scatter repro. >24" relatively good look some cutting wpt 62-63 canyon edge - Slope PSME/QUGA Succent PIPO mixed aged repro wpt 94 — Med age stand of 12-15" w/ few small scatter. PSME/ABCO, and PIPO Wpt 105 - Open PIPO/FEAR - >36"

Sample # A1	inner ring	ring count
1	1918	
2	1926	54
3		52
4	1920	
5	1924	54
6	1922	
7	1920	72
8	1918	
9	1922	
10		56
11	1918	60
12	1918	59
13	1912	62
14		68
15	1913	73
16		48
17	1918	68
18	1910	66
19		40
21	1918	70
22	1989	66
22	1916	71
23	1918	62

Sample # A2	inner ring	ring count
1		54
2		61
3		63
7		51
8		53
11		60
12		72
14		52
15		48
17	1932	60
18		50
20	1917	77

Sample # A3	inner ring	ring count
1		40
3		58
4		40
5		59
6		63
7		45
8		60
9	1928	62
10		40
11	1925	66
12	1918	69
14	1926	67
15	1930	55
16	1921	76
17	1913	
18	1928	72
19	1930	46
20	1927	68

Sample # A4	inner ring	ring count
1		50
2	1920	65
3	1938	52
4	1924	70
5		43
6	1911	63
7	1918	64
8		54
9	1926	69
10	1938	50
11		40
12	1947	45
13	1924	68
14	1920	72
15	1929	66
16	1916	61
17		53
18	1916	67
19		64
20	1934	65

Sample # A5	inner ring	ring count
1		65
4		54
5	1911	82
6		50
8		80
9		59
11		52
12	1920	66
13	1920	74
14		45
15		50
16	1921	70
17	1922	59
19	1921	70

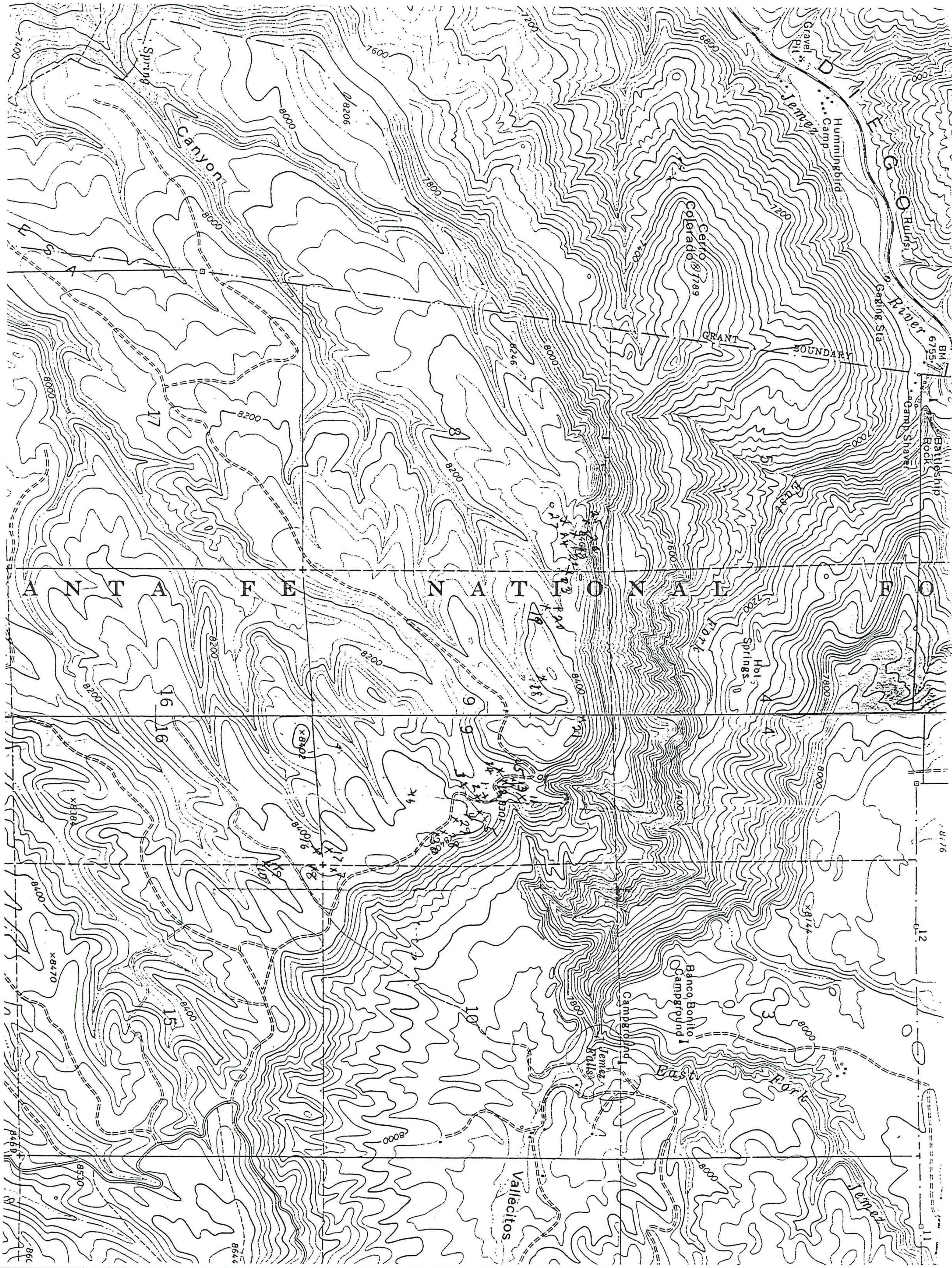
Sample # A6	inner ring	ring count
4	1939	55
5		49
6		60
7	1926	53
8	1925	69
10	1920	74
11		62
12	1920	62
13	1918	76
14		63
17		53
18	1921	68
19		53

Sample #	inner ring	ring count
C1		
1		35
2		53
3	1917	77
4	1920	73
5		40
6		60
7	1920	73
8		59
9	1916	78
10	1917	66
11		30
12		43
13	1920	74
14		68
15	1916	67
16	1928	63
17	1928	63
18	1923	67
19	1914	80
20		50

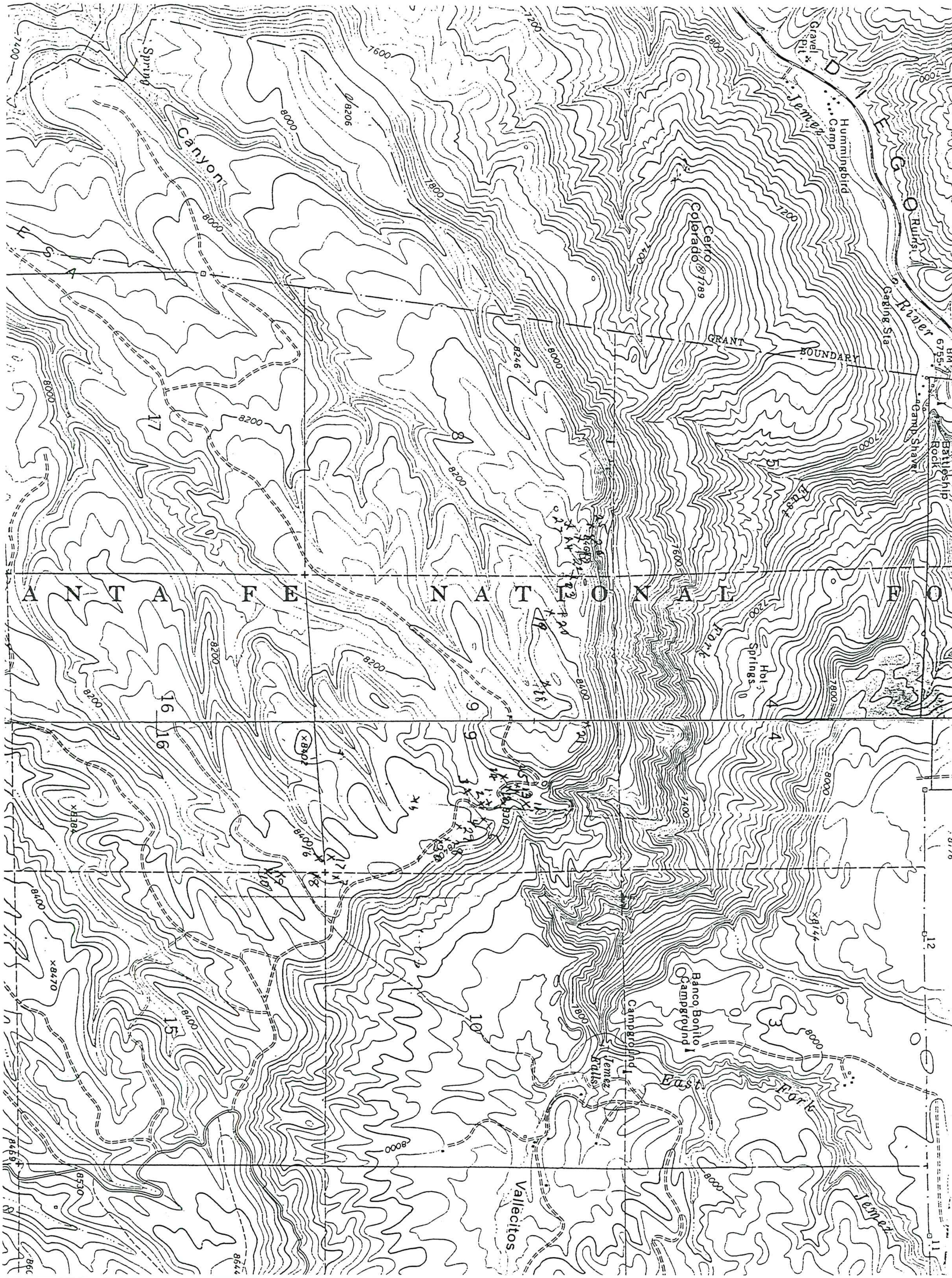
NMNHP -- GPS LOG

July 1993

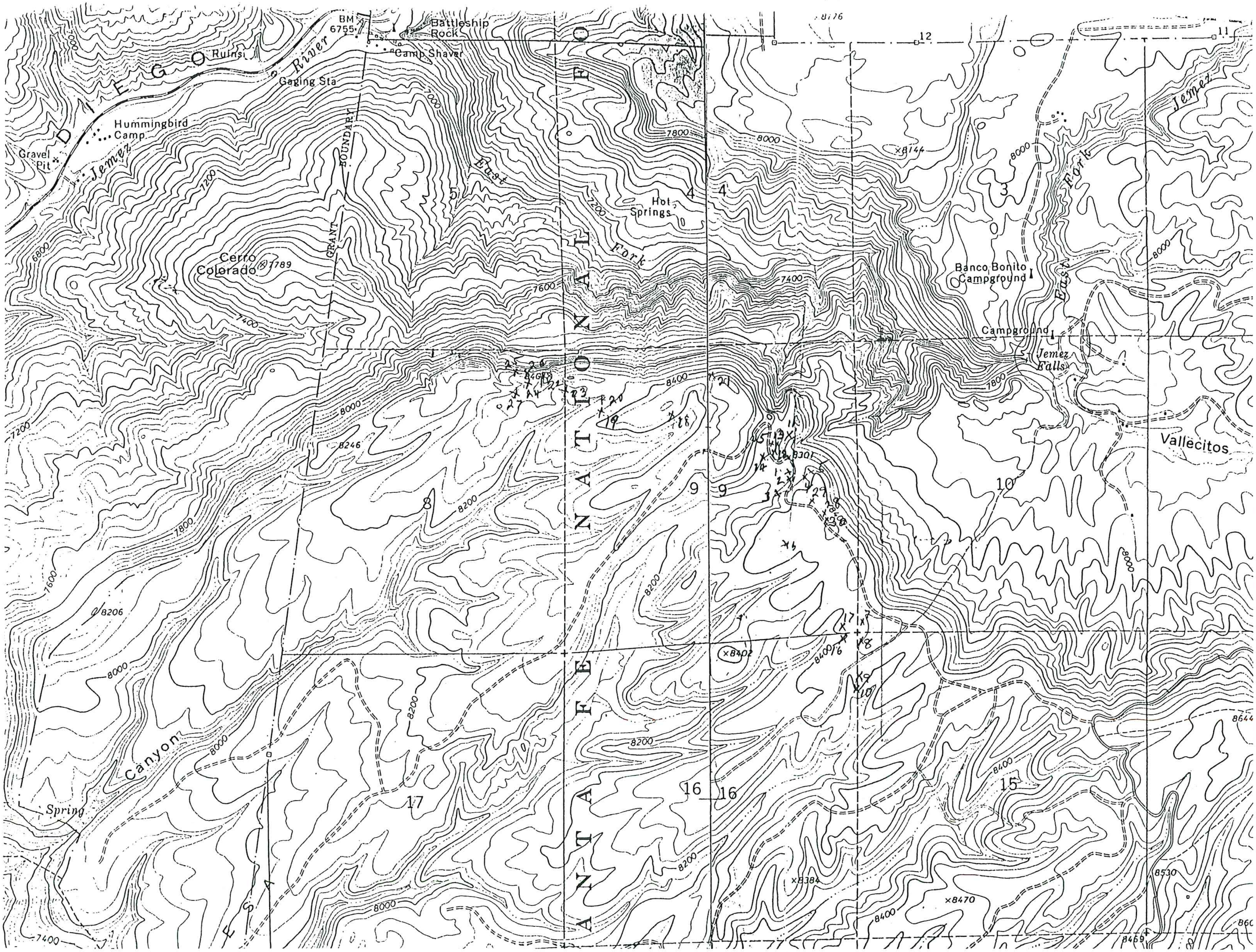
File No.	# Pts's or Range	Date	Time (24hr)	2D/3D ?	Raw Field Position Lat/Long or UTM	Elev. Field	Plot ID	Map	Class	Notes
MCA60000	25	10/19/94	11:32	2D	353332E 3963015N	—				N edge of Plt
MCA50000	25	11		mostly 2D						East edge of Plt
MCA4	43			2D						
MCA3	11			2D						
MCA2										
MCA1										
McB4	73			2D+3D						
MCC1	15			2D						
MCB1	15			2D						

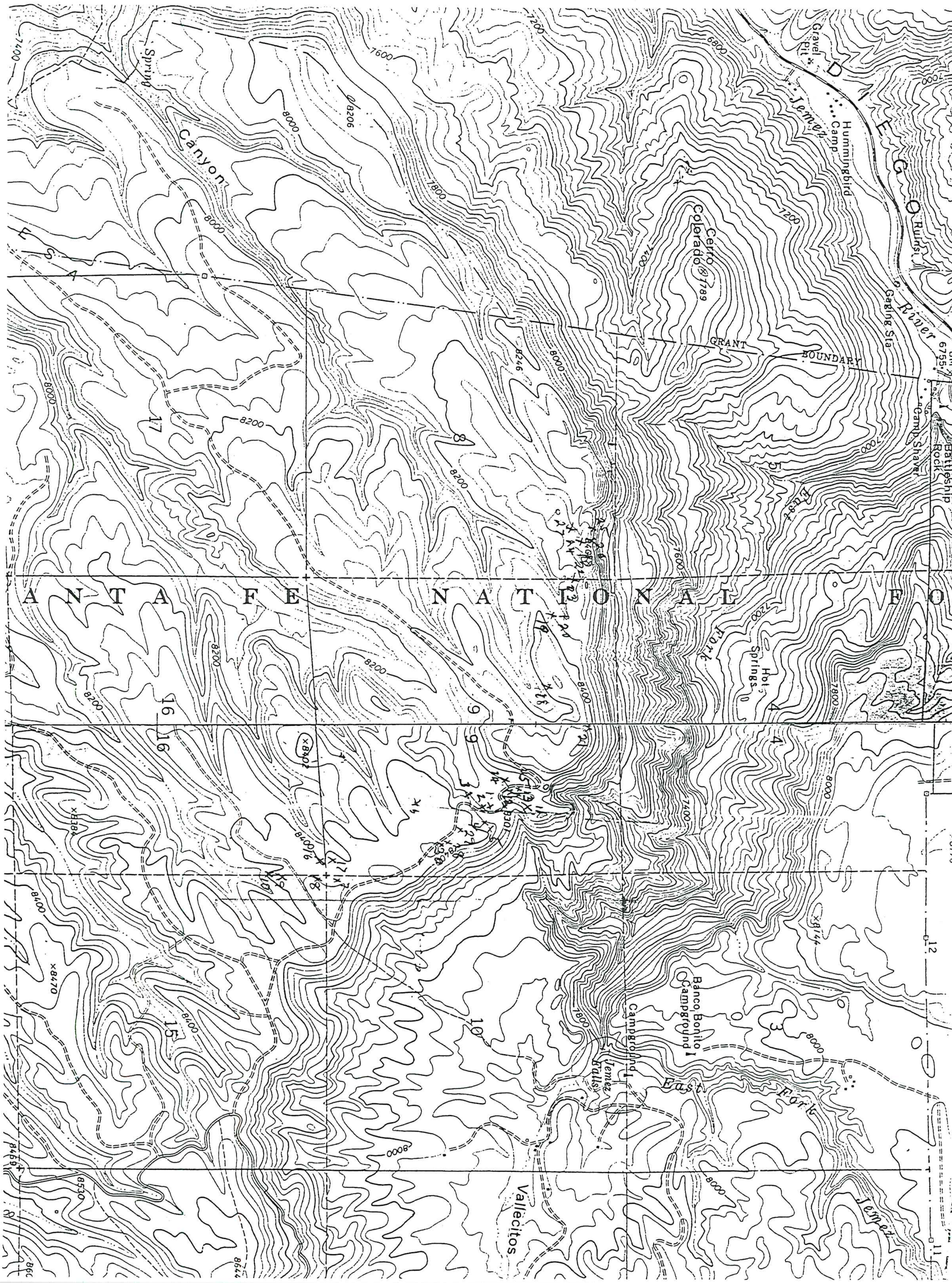


D I E G O
E S A
Spring
Canyon
Gravel pit
Hummingbird Camp
Jemez
River
Ruins
Gaging Sta
Cerro Colorado
7789
GRANT
BOUNDARY
BM 6755
Camp Shaver
Battleship Rock
East
Fork
Hot Springs
ANTA FE NATIONAL FO
Banco Bonito Campground
Campground
Jemez Falls
East Fork
Vallecitos
Jemez
8206
8246
8402
8384
8470
8530
8644

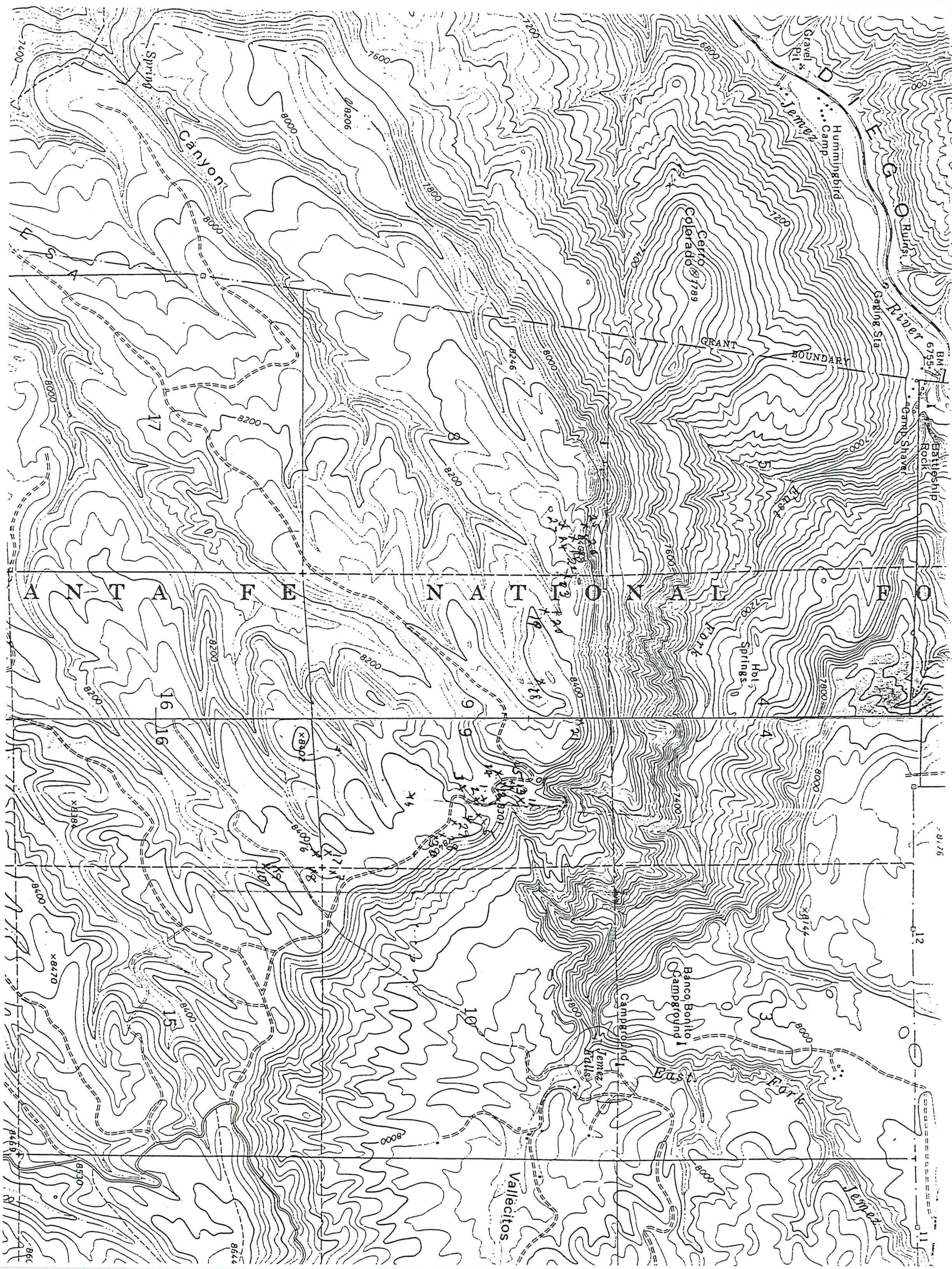


Spring
Canyon
Gravel Pit
Hummingbird Camp
Jemez
DIEGO
Ruins
River
Gaging Sta
Cerro Colorado
7789
GRANT
BOUNDARY
BM 6755
Camp Shaver
Battleship Rock
East
Fork
Hot Springs
ANTA FE NATIONAL FO
Banco Bonito Campground
Campground
Jemez Falls
East Fork
Vallecitos
Jemez

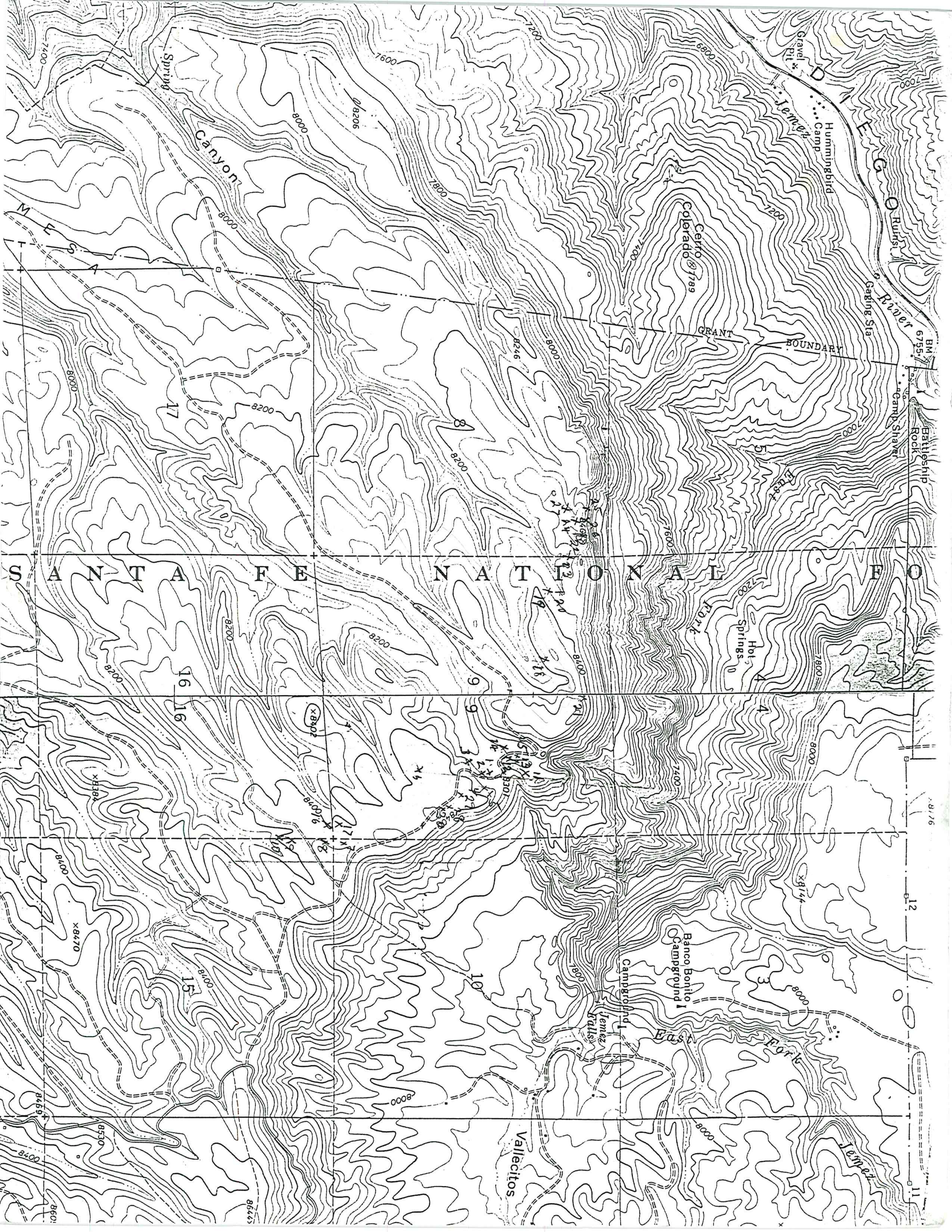

DIEGO
Jemez River
Ruins
Gaging Sta
Hummingbird Camp
Gravel Pit
BM 6755
Battleship Rock
Camp Shaver
GRANT BOUNDARY
Cerro Colorado
7789
East Fork
Hot Springs
Banco Bonito Campground
Campground
Jemez Falls
Vallecitos
SANTA FE NATIONAL FO
MESA
Spring Canyon
East Fork
Jemez
8206
8246
8402
8301
8384
8470
8144
8530
8644
8469
8176



Spring
Canyon
Gravel pit
Hummingbird Camp
Jemez
Ruins
River
Gaging Sta
BM 6755
Cerro Colorado 7789
GRANT
BOUNDARY
Camp Shaver
Battleship Rock
ANTA FE NATIONAL FO
Hot Springs
Fork
Banco Bonito Campground 1
Campground 1
Jemez Falls
East Fork
Vallecitos
Jemez



ANTA FE NATIONAL FO
Canyon
Spring
Cerro Colorado
7789
GRANT
BOUNDARY
Jemez River
Hummingbird Camp
Gravel Pit
Ruins
Gaging Sta
BM 6755
Camp Shaver
Battleship Rock
East Fork
Hot Springs
Banco Bonito Campground
Campground
Jemez Falls
East Fork
Vallecitos
Jemez



SANTA FE NATIONAL FO
MESA
Spring
Canyon
Gravel Pit
Hummingbird Camp
Jemez
DIEGO
Ruins
River
Gaging Sta
BM 6755
Cerro Colorado
7789
GRANT
BOUNDARY
Camp Shaver
Battleship Rock
East
Fork
Hot Springs
Banco Bonito Campground
Campground
Jemez Falls
East
Fork
Jemez
Vallecitos

R(L)
Natural ARcas
Santa Fe

MONUMENT CANYON NATURAL AREA

Purpose

To preserve in natural state a typical area of western yellow pine forest as found in northern New Mexico. The stands of western yellow pine in this region differ from those of the Colorado Plateau in being denser and more evenly spaced with trees of relatively small diameter.

Description

Location

Section 9, T. 18 N., R. 3 E., N.M.P.M. - Surveyed. All national forest land. The northern fringe and NE drop down over the rim of East Fork of the Jemez River, known here as Monument Canyon. The balance is plateau land at the head of a southwesterly drainage. Area 640 acres.

Acreage by Dominant Cover Type

All western yellow pine type.

Physiography and Climate

For the most part fairly level mesa, altitude 8100-8600 feet. The climate is characteristic of the western yellow pine zone, - short growing season, cool summers, precipitation about 20 inches.

Forest Value

3t10676

About 570 acres is commercial sawtimber; the remaining 70 acres is classed as inaccessible. The volume is estimated at 8500 board feet per acre. Pole growth and reproduction in seedling and sapling stages are excellent.

Agricultural Value

None

Grazing Value

Negligible. The carrying capacity of the entire section is estimated at 8 head of cattle yearlong.

Mineral Value

None in evidence.

Value for Other Public Use

None of specific importance.

Transportation

The area is on a trail from Jemez Springs to Upper Vallecitos. It is also within a mile of a programed Forest Service development road, and is crossed by a motorway cleared out for fire protection purposes, following the route of the above trail.

Public Sentiment

So far as known there would be little public interest in the area outside of scientific circles.

Plan of Management

The primary protective measure is to guard against cutting. Neither live nor dead timber should be cut unless in connection with fire or insect control. No roads or trails except those needed for protection of the area and adjacent Forest land, and no occupancy of any kind should be permitted. Conservative grazing may continue, but overgrazing must be avoided.

The area is part of a larger one designated in a cooperative agreement with the University of New Mexico providing for joint study of biological, archaeological, climatological, and related problems. This agreement under the title "Cooperative Agreement Between the Department of Agriculture and the University of New Mexico for the Purpose of Research and Observation in Certain Natural Sciences" is dated May 29, 1930, and is signed by the President of the University and the Secretary of Agriculture.

Approved:

/s/ F. E. Andrews
Forest Supervisor

G. A. Pearson /s/
Director, Southwestern Forest and Range Experiment Station

/s/ Frank O. W. Pooler
Regional Forester

Washington D.C.,

10/1/32

By virtue of the authority vested in me by Reg. 1-20 of the regulations of the Secretary of Agriculture relating to the occupancy, use, protection, and administration of the National Forests, I do hereby designate as the Monument Canyon Natural Area the lands described in a report dated ______, by ________________; said lands shall hereafter be administered as a Natural Area subject to the provisions of said regulation and the instructions thereunder.

R. M. Stewart /s/
Forester

DESIGNATION OF AREAS

§ 251.23 Experimental areas and research natural areas.

The Chief of the Forest Service shall establish and permanently record a series of areas on National Forest land to be known as experimental forests or experimental ranges, sufficient in number and size to provide adequately for the research necessary to serve as a basis for the management of forest and range land in each forest region. Also, when appropriate, the Chief shall establish a series of research natural areas, sufficient in number and size to illustrate adequately or typify for research or educational purposes, the important forest and range types in each forest region, as well as other plant communities that have special or unique characteristics of scientific interest and importance. Research Natural Areas will be retained in a virgin or unmodified condition except where measures are required to maintain a plant community which the area is intended to represent. Within areas designated by this regulation, occupancy under a special-use permit shall not be allowed, nor the construction of permanent improvements permitted except improvements required in connection with their experimental use, unless authorized by the Chief of the Forest Service.

(30 Stat. 35, amended, 16 U.S.C. 551)

[31 FR 5072, Mar. 29, 1966]

PETERSBURG WATERSHED

§ 251.35 Petersburg watershed.

All persons are hereby prohibited from entering upon the lands within the Tongass National Forest, described in the act of October 17, 1940 (54 Stat. 1197), except Federal and territorial officials, officials and employees of the town of Petersburg, Alaska, who may be required to enter thereon to operate, maintain, or improve the town's water system, and persons who have obtained permits from the proper town official, which are countersigned by a local forest officer. Timber may be removed from the area under the regulations relating to the disposal of national forest timber. However, the Forest Supervisor in charge of the Tongass National Forest shall permit such removal only under conditions which will adequately safeguard the water supply of the town of Petersburg.

[6 FR 46 Jan. 3, 1941]

SPECIAL USES

SOURCE: Sections 251.50—251.64 appear at 45 FR 38327, June 6, 1980, unless otherwise noted.

EDITORIAL NOTE: Sections 251.50—251.64 were approved by the Office of Management and Budget under control number 0596–0062.

§ 251.50 Special uses.

(a) All uses of National Forest System land, improvements, and resources, except those provided for in the regulations governing the disposal of timber (Part 223) and minerals (Part 228) and the grazing of livestock (Part 222), are designated "special uses" and must be approved by an authorized officer.

(b) Nothing in this section prohibits the temporary occupancy of National Forest System land for the protection of life or property in emergencies, if a special use authorization for such use is obtained at the earliest opportunity.

(c) With the exception of "recreation events" and "special events" as these terms are defined in § 251.51 of this part and unless otherwise provided by order issued under § 261.50 or by regulation issued under § 261.70 of this chapter, special-use authorization is not required for the noncommercial use or occupancy of National Forest System lands or facilities for camping, picknicking, hiking, fishing, hunting, horse riding, boating, or similar recreational activity.

(d) Unless otherwise required by order issued under § 261.50 or by regulation issued under § 261.70 of this chapter, the use of existing forest development roads and trails does not require a special-use authorization; however, any such use is subject to compliance with all Federal and State laws governing the roads or trails to be used.

[45 FR 38327, June 6, 1980, as amended at 49 FR 25449, June 21, 1984]

§ 251.51 Definit

(a) "Applic partnership, c or other busin eral, State or agency which authorization.

(b) "Author ployee of the has been dele perform the part.

(c) "Chief"— Service.

(d) "Easeme thorization fo conveys a con tional Forest S pensable accor

(e) "Holder" received a spec

(f) "Lease"— tion which cor cy and use of land or facilit and purpose, a compensable a

(g) "Nationa all lands, wat administered b

(h) "Permit zation which without conve to occupy ar System land purposes, and and terminabl

(i) "Recrea organized, or activity engag (10) or more tators, that i tertainment, not limited to or rallies, do rodeos, fairs,

(j) "Right-o to be used c struction, ope termination passing over, such land.

(k) "Secre Agriculture.

(l) "Specia sembly, den other activit or more pa

A1

possibly F1

D1 snag | G1 | F2 ← fire scarred tree ~12 scars #4 core >12" (30 cm)

	#	~~dbh~~ drc	~~core ht.~~	#	~~dbh~~ drc	core ht.	#	~~dbh~~ drc	core ht.	#	~~dbh~~ drc	core ht.
	1	40.6		8	95		1	41.5				
	2	73.7		9	16.2in		2	45.4				
inches	3	13.6		10	14.4in		3	80.4				
	4	85.8	snag	11	20.6in		4	82.0				
	5	37.0		12	23.3in		5	49.3				
in.	[illegible]	17.0		13	33.4		6	77.5				
	[illegible]	35.0		14	37.2		7	65.3				
	8	74.9	snag -rot	15	54.7		8	68.8				
in.	[illegible]	21.6	snag -rot	16	46.8		9	74.8				
	[illegible]	63.7		17	46.9		10	75.1				
		48.6		18	38.4		11	19.3in				
dbh	[illegible]	47.0 [illegible]	dead [illegible] 10 [illegible] ch 270	19	53.0		12	65.7				
		107.3		20	43.9		13	19in				
		73.5					14	48.9				
		42.0					15	64.8				
		[illegible]6.0					16	42.7				
		47.8					17	57.8				
		[illegible]					18	16.4in				
in		25.6	[illegible]				19	42.4				
A - C dbh		[illegible].6	snag -rot				20	86.3				
in	[illegible]	[illegible]3.4										
	[illegible]	1										
	1	[illegible]										
	2	58.5										
	3	16.8in										
	4	17.7in										
	5	50.3										
	6	31.9in	Snag									
	7	52.4										

- indicate [illegible]

x = [illegible] core

[illegible]

D2 - saplings from 10 - 200cm/ht

C2 - saplings

#	~~dbh~~ ht.	core ht.	#	~~dbh~~ ht.	core ht.	#	~~dbh~~ ht.	core ht.	#	dbh	core ht.
50	33cm		78	200cm		1-	85cm				
51	46cm		79	187cm		2	68 cm				
52	37cm		80	192cm		-3	50cm				
53	[illegible]					-4	50cm				
54	50cm					5	73cm				
55	71cm					6-	29cm				
56	56cm					7	40 cm				
57	39cm					8	60 cm				
58	73cm					9	—				
59	77cm					-10	86				
60	94cm					11	26cm				
61	100cm										
62	98cm										
63	[illegible]										
[illegible]	[illegible]										
65	[illegible]										
66	152cm										
67	167cm										
68	143cm										
69	24 cm										
70	28cm										
71	15cm										
72	[illegible]										
73	18cm										
74	123cm										
75	70cm										
76	13cm										
77	60cm										

in inches unless otherwise noted

D-2

2→4" DRC START @ #30

#	~~dbh~~ DRC	core ht.	#	dbh	core ht.	#	dbh	core ht.	#	dbh	core ht.
30	7.4										
31	7.3										
32	5.9										
33	5.7										
34	5.6										
35A	9.1										
35B	9.1										
36	6.3										
37	7.5										
38	9.0										
39	6.3										
40	3.1										
41	6.2										
42	8.7										
43	10.2										
44	11.0										
45	9.1cm										
46	3.6"										

D-2 D-3

#	~~dbh~~	~~core ht.~~	#	~~dbh~~ drc	core ht.	#	~~dbh~~ drc	core ht.	#	~~dbh~~ drc	core ht.
1	45cm		15	55	Snag [illegible]	[illegible]	[illegible]		[illegible]	[illegible]	
2	91cm		~~16~~	98		[illegible]	[illegible]		[illegible]	[illegible]	
[illegible]	[illegible]		~~17~~	81.5		3	[illegible]		[illegible]	55	
4	[illegible]		~~[illegible]~~	[illegible]		4	50 [illegible]	[illegible]	[illegible]	[illegible]	
5	77		~~[illegible]~~	52		[illegible]	36		[illegible]	66	[illegible]
6	74		~~[illegible]~~	51		[illegible]	[illegible]		[illegible]	[illegible]	
7	56.5		~~[illegible]~~			[illegible]	[illegible]		[illegible]	[illegible]	
8	66 dbh (base rotten)	Snag				[illegible]	47				
9	100.5					[illegible]	51				
10	61					[illegible]	[illegible]	[illegible]			
11	79					[illegible]	[illegible]	[illegible]			
12	[illegible]	[illegible]				[illegible]	[illegible]				
13	48					[illegible]	[illegible]				
~~14~~	[illegible]					[illegible]	[illegible]				
	D-4			[illegible]							
	[illegible]			44							
	[illegible]			73							
	[illegible]			17.5							
	[illegible]			92.5							
	DBH >core 23.8in			67.5							
	[illegible]			[illegible]							
	[illegible]										
	[illegible]										
	69.4										
	76										
	74.9cm										
	26in	32.2									

4062.62 - Cultural Practices. Research projects may use cash deposits that were made in conjunction with timber sales for such purposes as erosion control and slash disposal. Use K-V funds only in accordance with instructions in FSM 2477. Work that is strictly investigative in nature must not be charged to these deposit accounts, however.

4062.63 - Grazing. Charging a grazing fee for the use of forage on experimental ranges with National Forest status is optional. For research purposes, forage on National Forest System lands can be disposed of by a forage harvest permit. Issue written permits to provide for the temporary use of experimental ranges for grazing to avoid claims of dependency that may be construed eventually as a preference. Do not purchase animals for grazing experiments, except under unusual circumstances.

For grazing experiments that are conducted on other than National Forest Service lands, use cooperative agreements that specify provisions.

4063 - RESEARCH NATURAL AREAS. Research natural areas are part of a national network of ecological areas designated in perpetuity for research and education and/or to maintain biological diversity on National Forest System lands. Research natural areas are for nonmanipulative research, observation, and study. They also may assist in implementing provisions of special acts, such as the Endangered Species Act and the monitoring provisions of the National Forest Management Act.

4063.01 - Authority. The general provisions of the Organic Administration Act of 1897 (16 USC 551) authorize the Secretary of Agriculture to designate research natural areas. Under regulations at 7 CFR 2.42, the Secretary has delegated this authority to the Chief, who, pursuant to 36 CFR 251.23, selects and establishes research natural areas as part of the continuing land and resource management planning process for National Forest System lands (36 CFR 219.25 and FSM 1922).

4063.02 - Objectives. The objectives of establishing research natural areas are to:

1. Preserve a wide spectrum of pristine representative areas that typify important forest, shrubland, grassland, alpine, aquatic, geological, and similar natural situations that have special or unique characteristics of scientific interest and importance that, in combination, form a national network of ecological areas for research, education, and maintenance of biological diversity.

2. Preserve and maintain genetic diversity.

3. Protect against serious environmental disruptions.

4. Serve as reference areas for the study of succession.

5. Provide onsite and extension educational activities.

6. Serve as baseline areas for measuring long-term ecological changes.

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7. Serve as control areas for comparing results from manipulative research.

8. Monitor effects of resource management techniques and practices.

4063.03 - Policy. Research Natural Areas may be used only for research, study, observation, monitoring, and those educational activities that maintain unmodified conditions.

The selection and establishment of research natural areas within the National Forest System primarily emerges from continuing land and resource management planning and associated environmental analyses (FSM 1920 and FSM 1950). Forest plans shall include analysis of, and recommendations for, any proposed research natural areas establishment. Where proposals to establish research natural areas arise outside of the forest planning process, the affected Forest Supervisor shall prepare, as part of an establishment record, (see 4063) a forest plan amendment in accordance with land management planning regulations (36 CFR 219.10(f); FSM 1922.5, and environmental analysis policy and procedures (FSM 1950 and FSH 1909.15). Exhibit 1, section 4063.5, displays the relationship between planning for research natural areas and other planning activities.

Unless catastrophic circumstances significantly alter the conditions for which a research natural area was originally created such that it no longer may serve that function, the designation of a research natural area shall be in perpetuity.

The Forest Service shall cooperate with universities, private and professional organizations, and State and other public agencies to establish and maintain a national network of research natural areas primarily on federally administered lands, as well as on lands under other ownerships.

Funding of all on-the-ground resource protection and management activities on research natural areas within the National Forest System shall come from funds appropriated and allocated for the National Forest System. For obtaining appropriated Forest Pest Management Funds when necessary, see FSM 3400.

4063.04 - Responsibility. Research and National Forest System line officers are jointly responsible for selecting and establishing research natural areas.

4063.04a - Washington Office

1. The Chief. The Chief reserves the authority to approve all new research natural areas and to sign the implementing designation order. This authority may not be redelegated except as provided at FSM 1235.11 and FSM 1235.2.

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2. Deputy Chiefs for Research and for the National Forest System. Each Deputy Chief has the responsibility to review research natural area establishment records and the authority to recommend approval to the Chief with the concurrence of the other Deputy. As part of their review the Deputy Chiefs are responsible for evaluating how a proposed area fits into and benefits the national network of RNA's.

3. Staff Directors. The Washington Office Director of Timber Management Research (TMR) shall review establishment records for new research natural areas. When appropriate, the Director of TMR shall request review by, and recommendations from, the Directors of Lands, Land Management Planning, and Environmental Coordination and is responsible for presenting their recommendations to the respective Deputy Chiefs.

4063.04b - Regions and Stations

1. Regional Foresters and Station Directors. It is the responsibility of Regional Foresters and Station Directors to establish a Regional research natural area committee to determine needs for research natural areas within each Region and each National Forest and, with assistance from this committee, to prepare an establishment record for each recommended research natural area (FSM 4063.41). In consultation with Forest Supervisors and District Rangers, Station Directors have authority to approve all management plans and to oversee and coordinate approved research on all research natural areas, except for those research natural areas in congressionally designated areas (see 4063.05).

The authority to concur in issuance of mineral leases including access to research natural areas on National Forest System lands is reserved to the Regional Forester, in consultation with and concurrence of the Station Director.

The authority to approve management plans and to oversee and coordinate approved research on research natural areas in congressionally designated areas (4063.05) rests with Regional Foresters (FSM 2323.04c). In exercising this authority, they shall coordinate plans for research with Station Directors. The Regional Forester, with the concurrence of the appropriate Station Director, shall prepare recommendations to the Chief for any proposed Federal mineral, oil, and gas leases on research natural areas that are acquired land (FSM 2820) and on any oil and gas lease on National Forest System lands created from the public domain.

Only the Station Director, after consultation with the Forest Supervisor, can approve plans for temporary guaging stations and instrument shelters (4063.31).

2. Regional Research Natural Area Committee. The role of this committee is to identify the need for research natural areas on National Forest System lands and to ensure that prospective areas are identified in the forest planning process. Upon approval of a forest plan and obtaining results of subsequent surveys of the area, the committee recommends to the Regional Forester and Station Director establishment of research natural areas and assists in the preparation of establishment records.

4063.04c - Projects and Forests

1. Research Project Leaders. Research project leaders are responsible for coordinating with Forest Supervisors any planned research activities within, and adjacent to, research natural areas.

2. Forest Supervisors. Forest Supervisors have the responsibility to execute approved management plans for research natural areas and to administer, manage, and protect research natural areas. Forest supervisors must coordinate with the Station Director or Director's representative needed changes in management or protection.

The authority to approve mining plans of operations is reserved to the Forest Supervisor, in consultation with and concurrence of the Station Director.

3. District Rangers. District Rangers are responsible for direct administration, protection, and, in accordance with approved forest plans and/or project prescriptions, management of established research natural areas.

4063.05 - Definitions

1. Research Natural Area. "A physical or biological unit in which current natural conditions are maintained insofar as possible. These conditions are ordinarily achieved by allowing natural physical and biological processes to prevail without human intervention. However, under unusual circumstances, deliberate manipulation may be utilized to maintain the unique feature that the Research Natural Area was established to protect." (Federal Committee on Ecological Reserves 1977. See FSM 4063.43 Suggested References, item 1.)

2. Biological Diversity. The variety and variability among living organisms and the ecological complexes in which they occur. (Office of Technology Assessment report dated March 1987.)

3. Genetic Diversity. The various forms or qualities of those elements of germplasm that control transmission of hereditary characteristics.

4. Exotic Plants or Animals. Species not native to the place where found.

5. Special Management Areas. Certain lands within the National Forest System designated administratively or by Congress for special management consideration. Examples of administratively designated areas include Archeological Areas, Historical Areas, Geological Areas, Scenic Areas, National Recreation Trails, and Research Natural Areas. Examples of Congressional designations include Wilderness, National Primitive Areas, National Recreation Areas, National Scenic-Research Areas, National Scenic Trails, and National Historic Trails.

4063.1 - Size Standards. Research natural areas must be large enough to provide essentially unmodified conditions within their interiors. In the West, 300 acres (121.4 hectares) of land is generally considered the minimum size. In the East, where it may be impossible to find areas of 300 or more acres, consider establishing smaller areas, especially in grassland systems and in areas with special vegetative, aquatic, or geologic situations. Incorporate enough acres to ensure unmodified conditions within their interiors and to protect the features and/or qualities for which the research natural area is to be established.

4063.2 - Selection. Locate those research natural areas that best represent the ecological conditions needed to complete the natural area system in areas where conflicting uses are minimal. Whenever possible, select proposed areas that show no evidence of major disturbances by humans, such as livestock grazing or timber cutting, for the past 50 years. Where possible, select entire small drainages because they maintain interrelationships of terrestrial and aquatic systems, particularly valuable as baseline areas for research and monitoring, and because they are easier to delineate and protect on the ground.

In the selection of representative areas, a pristine condition is the goal. However, when candidate areas in a pristine condition are unavailable, then areas that reflect the pristine condition as closely as possible may be selected.

In certain geographic regions and in certain community types, it will be impossible to find candidate areas not containing exotic plant or animal life. Under these circumstances, the best available area that qualifies in all other respects should be chosen.

Do not regard failure to withdraw an area from mineral entry as a deterrent to selection and establishment of a desirable research natural area (4063.35).

4063.21 - Mapping and Recordation. Ensure that the boundaries of research natural areas are clearly identifiable in the field and in administrative records, (see 4063.5, the certification statement in exhibit 3). Accurately depict boundaries on maps that are used for Forest Service research and administrative purposes, but do not depict boundaries on maps that are for sale to the general public.

4063.3 - Protection and Management Standards. Standards for protection and management of a research natural area must support and promote the basic objectives and purposes of establishing the area. To ensure that the standards do not digress from original objectives over time, make sure that the establishment record clearly states the objectives for establishing the area and identifies the special values for which the area is being recognized (FSM 4063.41). In addition, comply with the following standards:

1. Protect research natural areas against activities that directly or indirectly modify ecological processes. The prime consideration in managing research natural areas is maintenance of unmodified conditions and natural processes.

2. Do not permit logging or wood gathering activities.

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3. In research natural areas where livestock grazing is not part of the management prescription, the Regional Forester and Station Director shall, as appropriate, establish a level of acceptable casual or incidental livestock use that can be tolerated and is consistent with the management prescription for the research natural area.

4. Where grazing is needed to establish or maintain vegetative communities, define objectives for grazing.

5. Prohibit any form of recreational use if such use threatens or interferes with the objectives or purposes for which the research natural area is established.

6. Where special orders are needed to limit, restrict, or control specific activities such as camping, seasons of use, or other uses, that are not compatible with the objectives of the research natural area, the Forest Supervisor shall issue orders pursuant to 36 CFR Part 261, Subpart B, to protect an area's features. Any such orders shall incorporate the special closure provisions of 36 CFR 261.53, (see FSM 5353 for penalties applicable to violations of orders).

7. Do not permit roads, trails, fences, or signs on an established research natural area unless they contribute to the objectives or to the protection of the area. Boundary fencing is permitted for protection against livestock or excessive human use. Buildings are not permitted. In rare instances, temporary gauging stations and instrument shelters may be desirable. Follow procedures at FSM 4063.31 for authorizing temporary physical improvements.

8. Where pest management activities are prescribed, they shall be as specific as possible against target organisms and induce minimal impact to other components of the ecosystem.

9. If practicable, remove exotic plant or animal life.

4063.31 - Authorizing Temporary Physical Improvements. In approving plans for temporary gauging stations and instrument shelters the Station Director shall ensure that these plans specifically fix the tenure of the facility, list actions to be taken, assign time limits for completion of actions, and identify parties responsible for returning disturbed areas to a natural condition.

4063.32 - Resource Protection Guidelines. Specific management direction for research natural areas must consider measures to protect them from fire, insect, disease, and animal activity. As a general guide, extinguish as quickly as possible fires that endanger research natural areas using means that will cause minimal damage to the area (FSM 4063.5j). Allow natural fires to burn only within a prescription designed to accomplish objectives of the specific natural area. Take no actions against endemic insects, diseases, wild plants, or animals unless the Regional Forester and Station Director deem such action necessary to protect the features for which the research natural area was established or to protect adjacent resources. If exotic plants or animals have been introduced into an established research natural area, the Station Director and the Regional Forester shall exercise control measures that are in keeping with established management principles and standards to eradicate them, when practical.

In protecting research natural areas within congressionally designated areas (4063.5), the management direction for the research natural area must meet statuatory mandates (FSM 1920).

Follow provisions in FSM 2360 and FSH 1509.11, section 19, where the research natural area is likely to involve cultural resources listed in the National Register of Historic Places.

4063.33 - Scientific and Educational Use. Encourage the use of research natural areas by responsible scientists and educators. Generally, do not authorize educational use of a research natural area by anyone below the upper class college or graduate student level.

Direct scientists interested in using a research natural area to contact the appropriate Station Director to outline to the Station Director the activity planned. Station Directors approve study plans proposed by non-Forest Service scientists and execute cooperative agreements, where appropriate. As a condition of the cooperative agreement, the scientist shall be required to provide the Station Director, Regional Forester, and Forest Supervisor with copies of all data, reports, and publications resulting from the research including theses, dissertations, articles, monographs, etc. The final report on the results of the research project shall be submitted to the Forest Service no later than 1 year following completion of the research.

Access to a research natural area by parties external to the Forest Service is authorized and approved by the District Ranger and shall conform to conditions specified in approved study plans and/or cooperative agreements. For research in wilderness areas, see FSM 2323.

Forest Service scientists shall cooperate in research conducted by scientists from outside of the Forest Service, whenever possible, to keep informed as to the nature and progress of the work and to ensure that research natural area values are maintained. Ensure that scientists conducting research on a research natural area file copies of all research data, reports, and other pertinent documents with the Station, Region, and Forest.

All researchers conducting investigations which involve the collection of flora and/or fauna in a research natural area must, as a condition of approval by the Station Director (or Regional Forester in Congressionally designated areas (4063.5)) to use the area:

1. Obtain appropriate permits from State and Federal agencies.

2. Carefully control collection of endangered, threatened, or rare plants.

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3. Deposit a voucher sample of each plant collected in the herbarium of the State in which it is collected. The herbarium usually is located at a land-grant college or university.

4063.34 - Vegetation Management. Use only tried and reliable vegetation management techniques and then apply them only where the vegetative type would be lost without management. The criterion here is that management practices must provide a closer approximation of the naturally occurring vegetation and the natural processes governing the vegetation than would be possible without management. Unless the manager is certain that the management practice will meet this criterion, do nothing.

The Station Director, with the concurrence of the Forest Supervisor, may authorize management practices that are necessary for noxious weed control or to preserve the vegetation for which the research natural area was created. These practices may include grazing, control of excessive animal populations, or prescribed burning.

Take extra care to protect undisturbed ecological climax conditions, such as old-growth forests.

Use fire to preserve a vegetative type only when absolutely necessary and then only with extreme caution.

4063.35 - Withdrawal from Mineral Entry. The Regional Forester may ask the Bureau of Land Management to withdraw a research natural area from mineral entry after its establishment in conformance with section 204 of the Federal Land Policy and Management Act of 1976 (90 Stat. 2743, 43 U.S.C. 1701) (FSM 2761) (sec. 4063.2).

4063.36 - Mineral, Oil, and Gas Leases. Proposals to offer Federal mineral, oil, and gas leases on research natural areas are evaluated by the Regional Forester with concurrence of the Station Director using standards set forth in FSM 2820 and forwarded to the Chief for final decision.

4063.37 - Monumenting Boundaries. Upon establishment of a research natural area, clearly identify and monument corners and turning points of the boundary in the field.

4063.4 - Establishment. Document each recommended research natural area with an establishment record.

4063.41 - Establishment Record Content. Include all of the following information in the sequence listed in an establishment record for a recommended research natural area. Where a particular item does not pertain to the recommended research natural area, enter a brief statement explaining why it does not apply. Do not omit any item or leave the subject area blank. Use English units and then metric equivalents in parentheses throughout the record. Enclose the entire content in U.S. Government Printing Office cover 6200-M7.

1. Maps and Photographs. As a minimum, each record must contain (affixed to the inside of the front cover):

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a. A road map showing the location of the research natural area with respect to the nearest city and the recommended access routes to the area.

b. A map showing boundaries and ownership status of the proposed area with roads and trails at a scale approximating 2 inches per mile (32 mm/km).

c. A vegetational map using Society of American Foresters and/or Kuchler types with defined signs and symbols.

d. When available, a contour map.

Maps must indicate the direction "North". Include photographs where they add to the report. Copies of photographs should be submitted for entry in the Forest Service Permanent Image Collection housed at the National Agricultural Library through the WO Research Natural Area Coordinator. Submit a completed form FS 1600-1, Photographic Record, with photographs and slides. Refer to maps and photographs in the text of the establishment record.

2. Decision Notice/Designation Order. This is a separate written instrument by which the Chief officially designates a research natural area. See section 4063.42 for placement of the order and for assembling and transmitting the establishment record to the Chief.

Prepare a Decision Notice/Designation Order using the language and format shown in exhibit 2, section 4063.5, for research natural areas both within and outside of Congressionally designated areas (4063.05).

Decisions made by the Chief to establish a research natural area are subject to appeal under 36 CFR Part 217. Prepare a separate legal notice of the decision to be published in the Federal Register as required by 36 CFR 217.5. Refer to FSH 1509.12 for a sample format. Prepare an original and a yellow file copy and submit them along with the Decision Notice/Designation Order.

3. Signature Page. This becomes the second page of the record when the Decision Notice/Designation Order is added. Sign and date it in ink. Do not use "rubber stamp" or similar signature substitutes. Exhibit 3, section 4063.5 contains a suggested format for the signature page. However, the certification statement on meeting land management planning, environmental analysis, and boundary identification requirements is mandatory. This page and the remainder of the text that follows is affixed to the inside of the back cover.

4. Title. Exhibit 4, section 4063.5 displays the recommended format for a title page.

5. Text. Starting with "Introduction" and ending with "Appendix" use all of the following underlined titles in the establishment record.

a. Introduction. Include historical background, uses, and ownership. Identify if the proposed area is within designated wilderness, wild and scenic river, national recreation area, or other Congressionally designated areas (4063.05).

(1) Land Management Planning. Indicate whether or not the Research Natural Area was included in the analysis and recommendations in the Forest Plan. If not, reference the Forest Plan amendment making the recommendation.

b. Objectives. Clearly state the objective(s) of establishing the research natural area. They shall be based upon the elements and values the area contains and shall reflect how the research natural area can best serve the objectives listed under FSM 4063.02. These objectives form the basis for any subsequent protection and management standards (FSM 4063.3) devised for the area.

c. Justification Statement for Establishment of Area. Explain how the recommended research natural area fills a gap in the research natural area system and/or contains endangered, threatened, or unique species of plants or animals that merit habitat research.

d. Principal Distinguishing Features. Describe vegetation, aquatic or geologic types, unique floral assemblage, threatened or endangered biota, and so forth.

e. Location.

(1) State the Name of the National Forest. Indicate if other National Forest System lands are involved.

(2) Give the latitude and longitude in which the area occurs, in degrees and minutes.

(3) Use one of the following to describe the area:

(a) Government Land Office System. Provide the legal description in terms of township, range, section, part section, and so forth.

(b) Metes and Bounds. Use a clearly described, recognizable, permanent feature as a starting point.

(c) Where the topography is sharply defined, provide a narrative description of the boundary in conjunction with a topographic map. Record any monumentation and bearings and distances for portions not sharply defined by topography. As an example, ortho photography, County road survey markers, and monumented survey markers may be used as starting points to tie the research natural area to a known point.

(4) Give the total acreage (hectares) of the area.

(5) List elevations in feet (meters).

(6) Describe access to the area from nearby towns or cities. List recommended routes keyed to those shown on accompanying maps. Suggest mode(s) of travel. Identify existing obstructions and impediments to travel to and from the area and make recommendations for bypassing them.

f. Area by Cover Types. List in tabular form the Society of American Foresters (1980) and Kuchler types (post 1964) and acreages (hectares) involved for each type. Account for all areas (hectares) in the recommended area.

Where regional or local classifications of vegetation are well established, list them. In much of the West, where the Daubenmire system of classification has been established, list habitat types. Use regional, local, and habitat type classifications to supplement or refine the primary method of cover type classification.

Key these references to the cover type map.

g. Physical and Climatic Conditions. Describe physical and climatic conditions of the area. List the name of installation(s) that provided the climatological data, the length of the record, and the distance and direction of the installation from the recommended area.

h. Description of Values.

(1) Flora. List endangered, threatened, and unique species. List dominant species. A complete list is not needed for the establishment record, but record as much information as is available. Describe the habitat type of potential climax vegetation species, if possible, of the various vegetative canopy layers (such as trees, shrubs, and grasses). Use common and scientific names and list references to these names in footnotes. See section 4063.43, number 4, for the Forest Service authority on tree names.

(2) Fauna. List rare and endangered species. List common species if this information is available. A complete list is not needed for the establishment record, but record as much information as is available. Use common and scientific names and list references to these names in footnotes.

(3) Geology. Describe the geology of the area. Provide complete title citation of important geological reports that include the area. Include the date of the studies or surveys. Indicate the existence of any special interest areas related to geology.

(4) Soils. Describe and cite available soil maps and information.

(5) Lands. Address land status, whether acquired or reserved, any outstanding rights, and so forth (FSM 5491).

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(6) Cultural. Identify and describe known historical sites, Indian mounds, campsites, and so forth. Cite available cultural studies.

(7) Other. Use this category to address other features of local importance.

i. Impacts and Possible Conflicts. If establishment is not already covered by forest plans or unit guides, see FSM 1950 for environmental analysis requirements.

(1) Mineral Resources. Discuss the mineral resources thought to exist in or adjacent to the area. It may be necessary to have a qualified geologist or minerals specialist provide this information. If so, identify the professional by name, title, position, and address. Provide as much quantitative information as possible with discussion related to anticipated industry interest.

Note the intention to withdraw the area from mineral entry if the proposal is approved (FSM 4063.35).

(2) Grazing. List possible conflicts and changes that might result if the area is withdrawn from grazing use, or if there is a need for grazing in the area to achieve certain research natural area management objectives. Consider the condition of existing fences and the need and estimated cost for fencing to exclude livestock. Also consider what livestock or grazing allotment management might be necessary to achieve research natural area management objectives in lieu of fencing (FSM 4063.3).

(3) Timber. List values withdrawn from the timber producing base (FSM 4063.3). List total forested acres and acreage (hectares) of commercial forest.

(4) Watershed Values. Describe watershed values of the area.

(5) Recreation Values. Describe recreation values of the area. List possible conflicts with, or changes in, recreational use of the area (FSM 4063.3).

(6) Wildlife and Plant Values. (FSM 4063.33 and FSM 4063.34). Address the maintenance of suitable habitat for endangered and threatened species.

(7) Special Management Area Values. Identify whether establishment of a research natural area will impact the purposes or management for which a congressionally designated area (4063.05) was established.

(8) Transportation Plans. Identify transportation plans that will adversely impact the area. Also, indicate the research natural area's impacts on the forest transportation system (FSM 4063.32).

j. Management Prescription. Identify management prescriptions designed to ensure maintenance of the objectives for which the research natural area is recommended to be established. (Include prescription information from the land and resources management plan).

(1) Vegetation Management. If such practices as prescribed burning and livestock grazing are to be used to maintain ecologic conditions, describe those practices, explain their use, and list their proposed scheduling. This shall include the prescription for fire in and near the research natural area, including the use of prescribed fire and the control of natural fire. If parts of the research natural area are assigned for eventual prescribed burning, they shall be described as well as areas assigned for permanent protection from fire. Control of fire within research natural areas shall be by methods that cause the least disturbance. Normally, methods that employ machinery shall not be used.

In developing the prescription for fire, consider the role of natural fire in sustaining or managing the vegetation. If fire is prescribed, only part of the research natural area shall be allocated for prescribed burning and part shall be reserved for permanent protection.

k. Administration Records and Protection. List the title, position, and address of principal contacts responsible for administering and protecting the physical area, for approving and coordinating observational or nonmanipulative applied research, and for maintaining the area's research data file and list of herbarium and species samples collected. Highlight special protection needs. If increased law enforcement action is anticipated, identify provisions for adequately informing the public (FSM 5351).

l. Archiving. The Station Director shall establish and maintain a system for archiving data and reports from research natural areas in a manner that will facilitate the exchange and transfer of information among Stations and scientists.

m. References. List all supplementary information and cite published studies resulting from research conducted on the area.

6. Appendix. Document needed natural diversity elements; include appropriate pages from forest plans, regional guides, and environmental impact statements.

4063.42 - Assembly, Approval, and Filing. Assemble an original and two copies of the establishment record for a recommended research natural area in Forest Service manuscript covers (form FS-6200-M7). The original must contain all original materials and a signed signature page (exhibit 3, section 4063.5). Fasten maps and photographs to the left inside of

Name	Representing	Home Office Location
George Alter	Santa Fe N.F.	Santa Fe, NM
Carl White	U.N.M. [illegible]	[illegible] Alb. NM
Sam Loftin	Rocky Mnt. St.	Alb.
Deborah Finch	Rocky Mtn. Sta.	2205 Columbia SE Alb. 87106
Sandy Boyce	SFNF	[illegible] Springs, NM
Dale Brockway	Rocky Mtn Sta.	2205 Columbia SE, Alb
Mike Ryan	Rm	Ft Collins
Tom Swetnam	Univ. of Arizona	Tucson, AZ
Reggie Fletcher	Regional Office [illegible]	Alb.
Jerry W. Elson	Santa Fe NF	Santa Fe
Esteban Muldavin	Univ. of New Mexico (NMNHP)	Abq.
Doc Smith	School of Forestry Northern Ariz Univ	Flagstaff
Craig Allen	USGS - BRD	Bandelier Nat'l Mon.

Designation of Areas

§ 251.23 Experimental areas and research natural areas.

The Chief of the Forest Service shall establish and permanently record a series of areas on National Forest land to be known as experimental forests or experimental ranges, sufficient in number and size to provide adequately for the research necessary to serve as a basis for the management of forest and range land in each forest region. Also, when appropriate, the Chief shall establish a series of research natural areas, sufficient in number and size to illustrate adequately or typify for research or educational purposes, the important forest and range types in each forest region, as well as other plant communities that have special or unique characteristics of scientific interest and importance. Research Natural Areas will be retained in a virgin or unmodified condition except where measures are required to maintain a plant community which the area is intended to represent. Within areas designated by this regulation, occupancy under a special-use permit shall not be allowed, nor the construction of permanent improvements permitted except improvements required in connection with their experimental use, unless authorized by the Chief of the Forest Service.

(30 Stat. 35, amended, 16 U.S.C. 551)
[31 FR 5072, Mar. 29, 1966]

Petersburg Watershed

§ 251.35 Petersburg watershed.

All persons are hereby prohibited from entering upon the lands within the Tongass National Forest, described in the act of October 17, 1940 (54 Stat. 1197), except Federal and territorial officials, officials and employees of the town of Petersburg, Alaska, who may be required to enter thereon to operate, maintain, or improve the town's water system, and persons who have obtained permits from the proper town official, which are countersigned by a local forest officer. Timber may be removed from the area under the regulations relating to the disposal of national forest timber. However, the Forest Supervisor in charge of the Tongass National Forest shall permit such removal only under conditions which will adequately safeguard the water supply of the town of Petersburg.

[6 FR 46 Jan. 3, 1941]

Special Uses

Source: Sections 251.50—251.64 appear at 45 FR 38327, June 6, 1980, unless otherwise noted.

Editorial Note: Sections 251.50—251.64 were approved by the Office of Management and Budget under control number 0596-0062.

§ 251.50 Special uses.

(a) All uses of National Forest System land, improvements, and resources, except those provided for in the regulations governing the disposal of timber (Part 223) and minerals (Part 228) and the grazing of livestock (Part 222), are designated "special uses" and must be approved by an authorized officer.

(b) Nothing in this section prohibits the temporary occupancy of National Forest System land for the protection of life or property in emergencies, if a special use authorization for such use is obtained at the earliest opportunity.

(c) With the exception of "recreation events" and "special events" as these terms are defined in § 251.51 of this part and unless otherwise provided by order issued under § 261.50 or by regulation issued under § 261.70 of this chapter, special-use authorization is not required for the noncommercial use or occupancy of National Forest System lands or facilities for camping, picknicking, hiking, fishing, hunting, horse riding, boating, or similar recreational activity.

(d) Unless otherwise required by order issued under § 261.50 or by regulation issued under § 261.70 of this chapter, the use of existing forest development roads and trails does not require a special-use authorization; however, any such use is subject to compliance with all Federal and State laws governing the roads or trails to be used.

[45 FR 38327, June 6, 1980, as amended at 49 FR 25449, June 21, 1984]

§ 251.51 Definiti

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4. Disposal of Timber and Forage by Cooperative Agreement. For procedures to dispose of timber on National Forest System land by cooperative agreement, see FSH 1509.11.

4062.62 - Cultural Practices. Research projects may use cash deposits that were made in conjunction with timber sales for such purposes as erosion control and slash disposal. Use K-V funds only in accordance with instructions in FSM 2477. Work that is strictly investigative in nature must not be charged to these deposit accounts, however.

4062.63 - Grazing. Charging a grazing fee for the use of forage on experimental ranges with National Forest status is optional. For research purposes, forage on National Forest System lands can be disposed of by a forage harvest permit. Issue written permits to provide for the temporary use of experimental ranges for grazing to avoid claims of dependency that may be construed eventually as a preference. Do not purchase animals for grazing experiments, except under unusual circumstances.

For grazing experiments that are conducted on other than National Forest Service lands, use cooperative agreements that specify provisions.

4062.64 - Special Uses. On National Forest System lands, the Station Director has sole authority to authorize special uses on those experimental forests and ranges administered by the Director. The Director shall authorize only those special uses that contribute to a particular research program on the experimental forest and range in question. See FSM 2704.35 for authority to issue special use permits. See FSM 2715 for fee policy.

4063 - RESEARCH NATURAL AREAS. Research natural areas are part of a national network of ecological areas designated in perpetuity for research and education and/or to maintain biological diversity on National Forest System lands. Research natural areas are for nonmanipulative research, observation, and study. They also may assist in implementing provisions of special acts, such as the Endangered Species Act and the monitoring provisions of the National Forest Management Act.

4063.01 - Authority. The general provisions of the Organic Administration Act of 1897 (16 USC 551) authorize the Secretary of Agriculture to designate research natural areas. Under regulations at 7 CFR 2.42, the Secretary has delegated this authority to the Chief, who, pursuant to 36 CFR 251.23, selects and establishes research natural areas as part of the continuing land and resource management planning process for National Forest System lands (36 CFR 219.25 and FSM 1922).

4063.02 - Objectives. The objectives of establishing research natural areas are to:

1. Preserve a wide spectrum of pristine representative areas that typify important forest, shrubland, grassland, alpine, aquatic, geological, and similar natural situations that have special or unique characteristics of scientific interest and importance that, in combination, form a national network of ecological areas for research, education, and maintenance of biological diversity.

2. Preserve and maintain genetic diversity.

3. Protect against serious environmental disruptions.

4. Serve as reference areas for the study of succession.

5. Provide onsite and extension educational activities.

6. Serve as baseline areas for measuring long-term ecological changes.

7. Serve as control areas for comparing results from manipulative research.

8. Monitor effects of resource management techniques and practices.

4063.03 - Policy. Research Natural Areas may be used only for research, study, observation, monitoring, and those educational activities that maintain unmodified conditions.

The selection and establishment of research natural areas within the National Forest System primarily emerges from continuing land and resource management planning and associated environmental analyses (FSM 1920 and FSM 1950). Forest plans shall include analysis of, and recommendations for, any proposed research natural areas establishment. Where proposals to establish research natural areas arise outside of the forest planning process, the affected Forest Supervisor shall prepare, as part of an establishment record (FSM 4063), a forest plan amendment in accordance with land management planning regulations (36 CFR 219.10(f); FSM 1922.5) and environmental analysis policy and procedures (FSM 1950 and FSH 1909.15).

Unless catastrophic circumstances significantly alter the conditions for which a research natural area was originally created such that it no longer may serve that function, the designation of a research natural area shall be in perpetuity.

The Forest Service shall cooperate with universities, private and professional organizations, and State and other public agencies to establish and maintain a national network of research natural areas primarily on federally administered lands, as well as on lands under other ownerships.

Funding of all on-the-ground resource protection and management activities on research natural areas within the National Forest System shall come from funds appropriated and allocated for the National Forest System. For obtaining appropriated Forest Pest Management Funds when necessary, see FSM 3400.

4063.04 - Responsibility.

4063.04a - Washington Office.

1. Chief. The Chief reserves the authority to determine what important forest and range types are needed for a national network of research natural areas (36 CFR 251.23), and to maintain quality among Regions and Stations in the establishment and management of research natural areas through oversight and common standards.

2. Deputy Chiefs. The Deputy Chief for Research and the Deputy Chief for National Forest System have the responsibility to review the research natural area program. As part of their review the Deputy Chiefs are responsible for identifying important forest and range types needed for the national network of research natural areas and recommending approval of these types to the Chief with the concurrence of the other Deputy.

3. Staff Directors. The Washington Office Director of Forest Management Research shall maintain a national record of all research natural areas.

4063.04b - Regions and Stations.

1. Regional Foresters and Station Directors.

a. It is the responsibility of Regional Foresters, with concurrence of Station Directors, to approve all new research natural areas and to sign the implementing designation order. This authority may not be redelegated.

b. It is the responsibility of Regional Foresters and Station Directors to establish a Regional research natural area committee to determine needs for research natural areas within each Region and each National Forest and, with assistance from this committee, to prepare an establishment record for each recommended research natural area (FSM 4063.41). In consultation with Forest Supervisors and District Rangers, Station Directors have authority to approve all management plans and to oversee and coordinate approved research on all research natural areas, except for those research natural areas in congressionally designated areas (see FSM 4063.05).

c. The authority to concur in issuance of mineral leases including access to research natural areas on National Forest System lands is reserved to the Regional Forester, in consultation with and with the concurrence of the Station Director.

d. The authority to approve management plans and to oversee and coordinate approved research on research natural areas in congressionally designated areas (FSM 4063.05) rests with Regional Foresters (FSM 2323.04c). In exercising this authority, they shall coordinate plans for research with Station Directors. The Regional Forester, with the concurrence of the appropriate Station Director, shall prepare recommendations to the Chief for any proposed Federal mineral, oil, and gas leases on research natural areas that are acquired land (FSM 2820) and on any oil and gas lease on National Forest System lands created from the public domain.

e. Only the Station Director, after consultation with the Forest Supervisor, can approve plans for temporary gauging stations and instrument shelters (FSM 4063.31).

2. Regional Research Natural Area Committee. The role of this committee is to identify the need for research natural areas on National Forest System lands and to ensure that prospective areas are identified in the forest planning process. Upon approval of a forest plan and obtaining results of subsequent surveys of the area, the committee recommends to the Regional Forester and Station Director establishment of research natural areas and assists in the preparation of establishment records.

4063.04c - Projects and Forests.

1. Research Project Leaders. Research project leaders are responsible for coordinating with Forest Supervisors any planned research activities within, and adjacent to, research natural areas.

2. Forest Supervisors. Forest Supervisors have the responsibility to execute approved management plans for research natural areas and to administer, manage, and protect research natural areas. Forest supervisors must coordinate with the Station Director or Director's representative needed changes in management or protection.

The authority to approve mining plans of operations is reserved to the Forest Supervisor in consultation with, and concurrence of, the Station Director.

3. District Rangers. District Rangers are responsible for direct administration, protection, and, in accordance with approved forest plans and/or project prescriptions, management of established research natural areas.

4063.05 - Definitions.

1. Research Natural Area. "A physical or biological unit in which current natural conditions are maintained insofar as possible. These conditions are ordinarily achieved by allowing natural physical and biological processes to prevail without human intervention. However, under unusual circumstances, deliberate manipulation may be utilized to maintain the unique feature that the Research Natural Area was established to protect." (Federal Committee on Ecological Reserves 1977. See FSM 4063.43 Suggested References, item 1.)

2. Biological Diversity. The variety and variability among living organisms and the ecological complexes in which they occur. (Office of Technology Assessment report dated March 1987.)

3. Genetic Diversity. The various forms or qualities of those elements of germplasm that control transmission of hereditary characteristics.

4. Exotic Plants or Animals. Species not native to the place where found.

5. Special Management Areas. Certain lands within the National Forest System designated administratively or by Congress for special management consideration. Examples of administratively designated areas include Archeological Areas, Historical Areas, Geological Areas, Scenic Areas, National Recreation Trails, and Research Natural Areas. Examples of Congressional designations include Wilderness, National Primitive Areas, National Recreation Areas, National Scenic-Research Areas, National Scenic Trails, and National Historic Trails.

4063.1 - Size Standards. Research natural areas must be large enough to provide essentially unmodified conditions within their interiors. In the West, 300 acres (121.4 hectares) of land is generally considered the minimum size. In the East, where it may be impossible to find areas of 300 or more acres, consider establishing smaller areas, especially in grassland systems and in areas with special vegetative, aquatic, or geologic situations. Incorporate enough acres to ensure unmodified conditions within their interiors and to protect the features and/or qualities for which the research natural area is to be established.

4063.2 - Selection. Locate those research natural areas that best represent the ecological conditions needed to complete the natural area system in areas where conflicting uses are minimal. Whenever possible, select proposed areas that show no evidence of major disturbances by humans, such as livestock grazing or timber cutting, for the past 50 years. Where possible, select entire small drainages because they maintain interrelationships of terrestrial and aquatic systems, particularly valuable as baseline areas for research and monitoring, and because they are easier to delineate and protect on the ground.

In the selection of representative areas, a pristine condition is the goal. However, when candidate areas in a pristine condition are unavailable, then areas that reflect the pristine condition as closely as possible may be selected.

In certain geographic regions and in certain community types, it will be impossible to find candidate areas not containing exotic plant or animal life. Under these circumstances, the best available area that qualifies in all other respects should be chosen.

Do not regard failure to withdraw an area from mineral entry as a deterrent to selection and establishment of a desirable research natural area (FSM 4063.35).

4063.21 - Mapping and Recordation. Ensure that the boundaries of research natural areas are clearly identifiable in the field and in a certification page of the establishment record. Accurately depict boundaries on maps that are used for Forest Service research and administrative purposes, but do not depict boundaries on maps that are for sale to the general public.

4063.3 - Protection and Management Standards. Standards for protection and management of a research natural area must support and promote the basic objectives and purposes of establishing the area. To ensure that the standards do not digress from original objectives over time, make sure that the establishment record clearly states the objectives for establishing the area and identifies the special values for which the area is being recognized (FSM 4063.41). In addition, comply with the following standards:

1. Protect research natural areas against activities that directly or indirectly modify ecological processes. The prime consideration in managing research natural areas is maintenance of unmodified conditions and natural processes.

2. Do not permit logging or wood gathering activities.

3. In research natural areas where livestock grazing is not part of the management prescription, the Regional Forester and Station Director shall, as appropriate, establish a level of acceptable casual or incidental livestock use that can be tolerated and is consistent with the management prescription for the research natural area.

4. Where grazing is needed to establish or maintain vegetative communities, define objectives for grazing.

5. Prohibit any form of recreational use if such use threatens or interferes with the objectives or purposes for which the research natural area is established.

6. Where special orders are needed to limit, restrict, or control specific activities such as camping, seasons of use, or other uses, that are not compatible with the objectives of the research natural area, the Forest Supervisor shall issue orders pursuant to 36 CFR Part 261, Subpart B, to protect an area's features. Any such orders shall incorporate the special closure provisions of 36 CFR 261.53 (see FSM 5353 for penalties applicable to violations of orders).

7. Do not permit roads, trails, fences, or signs on an established research natural area unless they contribute to the objectives or to the protection of the area. Boundary fencing is permitted for protection against livestock or excessive human use. Buildings are not permitted. In rare instances, temporary gauging stations and instrument shelters may be desirable. Follow procedures at FSM 4063.31 for authorizing temporary physical improvements.

8. Where pest management activities are prescribed, they shall be as specific as possible against target organisms and induce minimal impact to other components of the ecosystem.

9. If practicable, remove exotic plant or animal life.

4063.31 - Authorizing Temporary Physical Improvements. In approving plans for temporary gauging stations and instrument shelters the Station Director shall ensure that these plans specifically fix the tenure of the facility, list actions to be taken, assign time limits for completion of actions, and identify parties responsible for returning disturbed areas to a natural condition.

4063.32 - Resource Protection Guidelines. Specific management direction for research natural areas must consider measures to protect them from fire, insect, disease, and animal activity. As a general guide, extinguish as quickly as possible fires that endanger research natural areas using means that will cause minimal damage to the area (FSM 4063.41). Allow natural fires to burn only within a prescription designed to accomplish objectives of the specific natural area. Take no actions against endemic insects, diseases, wild plants, or animals unless the Regional Forester and Station Director deem such action necessary to protect the features for which the research natural area was established or to protect adjacent resources. If exotic plants or animals have been introduced into an established research natural area, the Station Director and the Regional Forester shall exercise control measures that are in keeping with established management principles and standards to eradicate them, when practical.

In protecting research natural areas within congressionally designated areas (FSM 4063.05), the management direction for the research natural area must meet statuatory mandates (FSM 1920).

Follow provisions in FSM 2360 and FSH 1509.11, section 19, where the research natural area is likely to involve cultural resources listed in the National Register of Historic Places.

4063.33 - Scientific and Educational Use. Encourage the use of research natural areas by responsible scientists and educators. Generally, do not authorize educational use of a research natural area by anyone below the upper class college or graduate student level.

Direct scientists interested in using a research natural area to contact the appropriate Station Director to outline to the Station Director the activity planned. Station Directors approve study plans proposed by non-Forest Service scientists and execute cooperative agreements, where appropriate. As a condition of the cooperative agreement, the scientist shall be required to provide the Station Director, Regional Forester, and Forest Supervisor with copies of all data, reports, and publications resulting from the research including theses, dissertations, articles, monographs, etc. The final report on the results of the research project shall be submitted to the Forest Service no later than 1 year following completion of the research.

Access to a research natural area by parties external to the Forest Service is authorized and approved by the District Ranger and shall conform to conditions specified in approved study plans and/or cooperative agreements. For research in wilderness areas, see FSM 2323.

Forest Service scientists shall cooperate in research conducted by scientists from outside of the Forest Service, whenever possible, to keep informed as to the nature and progress of the work and to ensure that research natural area values are maintained. Ensure that scientists conducting research on a research natural area file copies of all research data, reports, and other pertinent documents with the Station, Region, and Forest.

All researchers conducting investigations which involve the collection of flora and/or fauna in a research natural area must, as a condition of approval by the Station Director (or Regional Forester in congressionally designated areas (FSM 4063.05)) to use the area:

1. Obtain appropriate permits from State and Federal agencies.

2. Carefully control collection of endangered, threatened, or rare plants.

3. Deposit a voucher sample of each plant collected in the herbarium of the State in which it is collected. The herbarium usually is located at a land-grant college or university.

<u>4063.34</u> - <u>Vegetation Management</u>. Use only tried and reliable vegetation management techniques and then apply them only where the vegetative type would be lost without management. The criterion here is that management practices must provide a closer approximation of the naturally occurring vegetation and the natural processes governing the vegetation than would be possible without management. Unless the manager is certain that the management practice will meet this criterion, do nothing.

The Station Director, with the concurrence of the Forest Supervisor, may authorize management practices that are necessary for noxious weed control or to preserve the vegetation for which the research natural area was created. These practices may include grazing, control of excessive animal populations, or prescribed burning.

Take extra care to protect undisturbed ecological climax conditions, such as old-growth forests.

Use fire to preserve a vegetative type only when absolutely necessary and then only with extreme caution.

<u>4063.35</u> - <u>Withdrawal From Mineral Entry</u>. The Regional Forester may ask the Bureau of Land Management to withdraw a research natural area from mineral entry after its establishment in conformance with section 204 of the Federal Land Policy and Management Act of 1976 (90 Stat. 2743, 43 U.S.C. 1701) (FSM 2761) (FSM 4063.2).

<u>4063.36</u> - <u>Mineral, Oil, and Gas Leases</u>. Proposals to offer Federal mineral, oil, and gas leases on research natural areas are evaluated by the Regional Forester with concurrence of the Station Director using standards set forth in FSM 2820 and forwarded to the Chief for final decision.

4063.37 - Monumenting Boundaries. Upon establishment of a research natural area, clearly identify and monument corners and turning points of the boundary in the field.

4063.4 - Establishment. Document each recommended research natural area with an establishment record.

4063.41 - Establishment Record Content. Include all of the following information in the sequence listed in an establishment record for a recommended research natural area. Where a particular item does not pertain to the recommended research natural area, enter a brief statement explaining why it does not apply. Do not omit any item or leave the subject area blank. Use English units and then metric equivalents in parentheses throughout the record. Enclose the entire content in the manuscript cover (Form FS-6200-7).

1. Maps and Photographs. As a minimum, each record must contain (affixed to the inside of the front cover):

a. A legible road map showing the location of the research natural area with respect to the nearest city and the recommended access routes to the area.

b. A map showing boundaries and ownership status of the proposed area with roads and trails at a scale approximating 2 inches per mile (32 mm/km).

c. A vegetational map using Society of American Foresters and/or Kuchler types with defined signs and symbols.

d. When available, a contour map.

Maps must indicate the direction "North". Include photographs where they add to the report. Copies of photographs should be submitted for entry in the Forest Service Permanent Image Collection housed at the National Agricultural Library through the WO Research Natural Area Coordinator. Refer to maps and photographs in the text of the establishment record.

2. Decision Notice/Designation Order. This is a separate written instrument by which the Regional Forester, with concurrence of the Station Director, officially designates a research natural area. See FSM 4063.42 for placement of the order and for assembling and transmitting the establishment record to the Regional Forester and Station Director.

Prepare a Decision Notice/Designation Order using language and format consistent with FSM 1950 and FSH 1909.15 for research natural areas both within and outside of congressionally designated areas (FSM 4063.05).

Decisions made to establish a research natural area are subject to appeal under 36 CFR Part 217. Publish notice of the decision as required by 36 CFR 217.5.

3. Signature Page. This becomes the second page of the record when the Decision Notice/Designation Order is added. Sign and date it in ink. Do not use "rubber stamp" or similar signature substitutes. Exhibit 01, FSM 4063.5 contains a suggested format for the signature page. However, the certification statement on meeting land management planning, environmental analysis, and boundary identification requirements is mandatory. This page and the remainder of the text that follows is affixed to the inside of the back cover.

4. Title. Exhibit 02, FSM 4063.5 displays the recommended format for a title page.

5. Text. Starting with "Introduction" and ending with "Appendix" use all of the following underlined titles in the establishment record.

a. Introduction. Include historical background, uses, and ownership. Identify if the proposed area is within designated wilderness, wild and scenic river, national recreation area, or other congressionally designated areas (FSM 4063.05).

(1) Land Management Planning. Indicate whether or not the Research Natural Area was included in the analysis and recommendations in the Forest Plan. If not, reference the Forest Plan amendment making the recommendation.

b. Objectives. Clearly state the objective(s) of establishing the research natural area. They shall be based upon the elements and values the area contains and shall reflect how the research natural area can best serve the objectives listed under FSM 4063.02. These objectives form the basis for any subsequent protection and management standards (FSM 4063.3) devised for the area.

c. Justification Statement for Establishment of Area. Explain how the recommended research natural area fills a gap in the research natural area system and/or contains endangered, threatened, or unique species of plants or animals that merit habitat research.

d. Principal Distinguishing Features. Describe vegetation, aquatic or geologic types, unique floral assemblage, threatened or endangered biota, and so forth.

e. Location.

(1) State the Name of the National Forest. Indicate if other National Forest System lands are involved.

(2) Give the latitude and longitude in which the area occurs, in degrees and minutes.

(3) Use one of the following to describe the area:

(a) Government Land Office System. Provide the legal description in terms of township, range, section, part section, and so forth.

(b) Metes and Bounds. Use a clearly described, recognizable, permanent feature as a starting point.

(c) Where the topography is sharply defined, provide a narrative description of the boundary in conjunction with a topographic map. Record any monumentation and bearings and distances for portions not sharply defined by topography. As an example, ortho photography, County road survey markers, and monumented survey markers may be used as starting points to tie the research natural area to a known point.

(4) Give the total acreage (hectares) of the area.

(5) List elevations in feet (meters).

(6) Describe access to the area from nearby towns or cities. List recommended routes keyed to those shown on accompanying maps. Suggest mode(s) of travel. Identify existing obstructions and impediments to travel to and from the area and make recommendations for bypassing them.

f. Area by Cover Types. List in tabular form the Society of American Foresters (1980) and Kuchler types (post 1964) and acreages (hectares) involved for each type. Account for all areas (hectares) in the recommended area.

Where regional or local classifications of vegetation are well established, list them. In much of the West, where the Daubenmire system of classification has been established, list habitat types. Use regional, local, and habitat type classifications to supplement or refine the primary method of cover type classification.

Key these references to the cover type map.

g. Physical and Climatic Conditions. Describe physical and climatic conditions of the area. List the name of installation(s) that provided the climatological data, the length of the record, and the distance and direction of the installation from the recommended area.

h. Description of Values.

(1) Flora. List endangered, threatened, and unique species. List dominant species. A complete list is not needed for the establishment record, but record as much information as is available. Describe the habitat type of potential climax vegetation species, if possible, of the various vegetative canopy layers (such as trees, shrubs, and grasses). Use common and scientific names and list references to these names in footnotes. See FSM 4063.43, paragraph 4, for the Forest Service authority on tree names.

(2) Fauna. List rare and endangered species. List common species if this information is available. A complete list is not needed for the establishment record, but record as much information as is available. Use common and scientific names and list references to these names in footnotes.

(3) Geology. Describe the geology of the area. Provide complete title citation of important geological reports that include the area. Include the date of the studies or surveys. Indicate the existence of any special interest areas related to geology.

(4) Soils. Describe and cite available soil maps and information.

(5) Lands. Address land status, whether acquired or reserved, any outstanding rights, and so forth (FSM 5491).

(6) Cultural. Identify and describe known historical sites, Indian mounds, campsites, and so forth. Cite available cultural studies.

(7) Other. Use this category to address other features of local importance.

i. Impacts and Possible Conflicts. If establishment is not already covered by forest plans or unit guides, see FSM 1950 for environmental analysis requirements.

(1) Mineral Resources. Discuss the mineral resources thought to exist in or adjacent to the area. It may be necessary to have a qualified geologist or minerals specialist provide this information. If so, identify the professional by name, title, position, and address. Provide as much quantitative information as possible with discussion related to anticipated industry interest.

Note the intention to withdraw the area from mineral entry if the proposal is approved (FSM 4063.35).

(2) Grazing. List possible conflicts and changes that might result if the area is withdrawn from grazing use, or if there is a need for grazing in the area to achieve certain research natural area management objectives. Consider the condition of existing fences and the need and estimated cost for fencing to exclude livestock. Also consider what livestock or grazing allotment management might be necessary to achieve research natural area management objectives in lieu of fencing (FSM 4063.3).

(3) Timber. List values withdrawn from the timber producing base (FSM 4063.3). List total forested acres and acreage (hectares) of commercial forest.

(4) Watershed Values. Describe watershed values of the area.

(5) Recreation Values. Describe recreation values of the area. List possible conflicts with, or changes in, recreational use of the area (FSM 4063.3).

(6) Wildlife and Plant Values. (FSM 4063.33 and FSM 4063.34). Address the maintenance of suitable habitat for endangered and threatened species.

(7) Special Management Area Values. Identify whether establishment of a research natural area will impact the purposes or management for which a congressionally designated area (FSM 4063.05) was established.

(8) Transportation Plans. Identify transportation plans that will adversely impact the area. Also, indicate the research natural area's impacts on the forest transportation system (FSM 4063.32).

j. Management Prescription. Identify management prescriptions designed to ensure maintenance of the objectives for which the research natural area is recommended to be established. (Include prescription information from the land and resources management plan).

(1) Vegetation Management. If such practices as prescribed burning and livestock grazing are to be used to maintain ecologic conditions, describe those practices, explain their use, and list their proposed scheduling. This shall include the prescription for fire in and near the research natural area, including the use of prescribed fire and the control of natural fire. If parts of the research natural area are assigned for eventual prescribed burning, they shall be described as well as areas assigned for permanent protection from fire. Control of fire within research natural areas shall be by methods that cause the least disturbance. Normally, methods that employ machinery shall not be used.

In developing the prescription for fire, consider the role of natural fire in sustaining or managing the vegetation. If fire is prescribed, only part of the research natural area shall be allocated for prescribed burning and part shall be reserved for permanent protection.

k. Administration Records and Protection. List the title, position, and address of principal contacts responsible for administering and protecting the physical area, for approving and coordinating observational or nonmanipulative applied research, and for maintaining the area's research data file and list of herbarium and species samples collected. Highlight special protection needs. If increased law enforcement action is anticipated, identify provisions for adequately informing the public (FSM 5351).

4063.5 - Exhibit 01

SIGNATURE PAGE

for

RESEARCH NATURAL AREA ESTABLISHMENT RECORD

(Name of the) Research Natural Area

(Name of the) National Forest

(Name of the County and State)

The undersigned certify that all applicable land management planning and environmental analysis requirements have been met and that boundaries are clearly identified in accordance with FSM 4063.21, Mapping and Recordation and FSM 4063.41 5.e(3) in arriving at this recommendation.

Prepared by ______________________________ Date ____________________
(Typed name, title, affiliation of person who prepared the report)

Recommended by ______________________________ Date ____________________
(Typed name), District Ranger, ____________ District

Recommended by ______________________________ Date ____________________
(Typed name), Forest Supervisor, ____________ National Forest

Concurrence of ______________________________ Date ____________________
(Typed name), Station Director, ________________ Station

4063.5 - Exhibit 02

TITLE PAGE

Establishment Record for ______________________________
(Name of Research Natural Area)

Research Natural Area within ___________________________
(Name)

National Forest, __________________, __________________.
(County) (State)

4064 - LONG-TERM WATERSHED INSTALLATIONS.

4064.02 - Objectives. Establish and maintain calibrated watershed installations on National Forest System and other lands to provide long-term data where and when appropriate.

4064.03 - Policy. Station Directors shall share long-term watershed data with appropriate cooperators.

4063.04 - Responsibility.

1. Designated research coordinators shall:

a. Maintain knowledge of the ecological conditions, past studies, current research, and logistical considerations for existing research natural areas (RNAs).

b. Encourage the research community to use facilities through internal and external contacts made at conferences and symposia.

c. Assure that Forest contact is aware of past and continuing research on the RNAs and coordinate with Forest contact and expedite processing of plans requiring Station Director's approval.

d. Encourage publication of results of scientific studies and obtain reprints of articles for the WESTFORNET library.

e. Encourage funding of studies to provide basic ecological inventory and characterization, and closely coordinate these efforts with the Forest contact. Consider outside funding sources such as Man and the Biosphere and National Science Foundation as well as in-house funding.

f. Maintain a continuing file of information and activities including records of how proposed.

g. Participate in periodic Forest activity reviews of RNAs to assure that they are being managed in accord with FSM 4063.

2. Regional Foresters and Station Directors. The Regional Forester and Station Director shall establish an RNA Committee composed of Research and Regional Office personnel. This committee and task group shall work with Forest Supervisors, members of Arizona and New Mexico State natural area committees, universities, and other regional and local groups to (1) study natural area needs on both public and private lands, (2) make initial selection of areas to be considered for RNA designation, (3) assure that existing and needed RNAs are addressed in Forest land management plans, and (4) develop solutions for administrative procedure and coordination problems. (Exhibit 1)

3. Research Project Leaders, Forest Supervisors, and District Rangers. Forest Supervisors shall:

a. Identify areas on the Forest which might represent forest and range land types that are not presently represented, request and schedule review of proposed areas by the RNA Committee, and participate as an ad hoc member of the task group reviewing potential areas on the National Forest.

b. Maintain the integrity of identified RNA candidate areas until Forest plans and establishment actions are completed. (Exhibit 2).

c. Assure that environmental analysis and operating plans for locatable and leasable minerals protect the integrity of established and candidate RNAs.

d. Assure that established and targeted RNA representations receive appropriate consideration in all alternative land management planning allocations. Document briefly in the planning record areas proposed but not meeting identified needs or standards for RNA establishment.

e. Prepare the required establishment reports for candidate areas identified in approved Forest plans in a timely manner.

f. Schedule and conduct reviews of RNAs periodically to assure that they are being managed in accord with FSM 4063 through FSM 4063.5 and recommend to the Committee actions necessary to effectively manage the program, resolve identified conflicts, and improve direction.

g. Designates Forest RNA contact to facilitate the RNA program by:

(1) Maintaining records of use and activity on established RNAs.

(2) Assuring the research coordinator (Exhibit 3) consults with the District Ranger during the review and approval of plans for use by the Station Director.

(3) Referring scientific inquiries to the appropriate research coordinator. (Exhibit 3)

(4) Assuring that establishment reports are prepared according to current direction in FSM 4063.41 and submitted in a timely manner.

(5) Developing a Forest program with consultation and assistance from Research to provide basic inventory, characterization, and RNA environment.

(6) Consulting with the research coordinator on any activities proposed which might have an influence on the ecological integrity of the RNA.

Exhibit 1

Research Natural Area Committee Charter

Objective

The Research Natural Area Committee is chartered to assist management in effective and efficient achievement of the research natural area objectives as outlined in FSM 4063. The committee, utilizing a task force approach, shall develop and recommend alternative courses of action to respond to needs identified by management in the annual plan of work.

Responsibilities

The committee shall:

1. Assure that proposed and recommended areas meet the criteria and qualify as research natural areas (RNAs).

2. Provide the necessary direction to assure that RNAs are adequately addressed by Forest land management plans.

3. Recommend appropriate standards and guidelines for establishment and maintenance of baseline data and for protection of resources to insure meeting RNA objectives.

4. Monitor progress in achieving objectives through review of Forest plans and conducting appropriate activity reviews.

5. Provide the necessary direction in the context of land management planning to establish and manage RNAs.

6. Examine selected areas with Forest Supervisors and District Rangers to assure the area qualifies and no unresolvable management conflicts exist.

7. Review establishment and land use reports prepared by the Forest Supervisor and make recommendations to the Regional Forester.

8. Commission a Research Natural Area Task Group to aid in Committee work. The task group shall include representatives from each of the following resource units; Range, Watershed and Air Management, and Wildlife, plus one Research scientist from Arizona and one from New Mexico. Ad hoc members shall be added as appropriate to complete specific parts of the work plan.

Membership

Chairperson - Director of Range Management
Member - Deputy for Resources
Member - Assistant Director, Rocky Mountain Station, Fort Collins
Member - RNA Task Group Leader

Meetings - Committee shall meet annually in September, or as scheduled, to establish an annual work plan and recommend appropriate courses of action to the Regional Forester. The task group shall meet as necessary to accomplish the annual work plan.

Reports

Committee shall:

1. Provide annual report to the Washington Office on status of designated RNAs in Region 3.

2. Document annual plan of work and provide annual report to Deputy Regional Forester, Resources, FSM 1350.

United States Department of Agriculture
Forest Service
Washington Office
14th & Independence SW
P.O. Box 96090
Washington, DC 20090-6090

Reply to: 4060-3 (LMP)

Date: July 19, 1993

Subject: Research Natural Areas Program Strategy

To: Regional Foresters, Station Directors, Area Director, and IITF Director

In 1991, National Forest System and Research made a financial commitment of $490,000 to the Forest Service Research Natural Area (RNA) Program. Designed as an annual commitment over a 5-year period, this fund has been crucial to the establishment of new RNA's and to commencement of new research and monitoring projects nationwide. The RNA Program has, partly due to that financial support, become a vigorous component of Forest Service activities in the areas of ecosystem management, biodiversity, research, and monitoring.

Just over a year ago, representatives of all Regions and Stations began working together to formulate a working plan or strategy to guide research and management activities on the 289 RNA's we have established throughout the National Forest System. The enclosed completed document will be used to advance Forest Service and natural resource management interests in the various ecosystems represented across the Nation by our RNA network.

We anticipate that actions taken to implement the strategy will aid the continued contribution of the RNA Program to the promotion of research, biodiversity, ecosystem management, and forest management, in general, over the coming years.

/s/ George M. Leonard
for

F. DALE ROBERTSON
Chief

Enclosure

1920 LRMP:!oc-1993:!!RNA StrategyForest Service:FMR:S.Krugman:pj:05-20-92:(202) 205-1555I CONCUR: J.WHITMORE:05/20/92I CONCUR: P.JOHNSON:05/20/92FS:LMP:P.Boland:1920 LRMP:!OC-1993:6/29/93:

D1

STRATEGY 3:

Streamline RNA establishment procedures.

RATIONALE. The current process for establishing RNA's is burdened with outdated procedures involving redundant efforts and expending unnecessary staff time and money. The role of RNA management in forest plan implementation is unclear.

Goal A: Review establishment requirements for RNA's and develop a revised, efficient process.

Goal B: Clarify the role of forest plans and National Environmental Protection Act (NEPA) procedures in RNA establishment and management.

Goal C: Standardize procedures for RNA evaluation, selection, and establishment once a revised process is approved.

OPPORTUNITIES TO CHANGE PROGRAM MANAGEMENT AND IMPLEMENTATION

STRATEGY 4:

Within management direction provided by forest plans, review RNA monitoring and management strategies and adjust as appropriate, to protect the areas and promote desired ecological conditions (composition, structure, function, and natural succession) for the sites.

RATIONALE. Past intervention in natural disturbance regimes (e.g., fire and pest suppression), intensive management on adjacent lands, and heavy research and recreational use in some sites have created situations in which review and adjustment of monitoring and management strategies are needed to ensure that the natural diversity and succession for which the areas are recognized are protected. Lack of monitoring and appropriate management adjustment can result in degradation of the sites, making them useless as reference areas for ecosystem management.

Goal A: Review monitoring requirements for RNA's in forest plans and recommend standardized but flexible baseline approaches to ecological monitoring for RNA's.

Goal B: Expedite effective, timely RNA management, linked to monitoring, with appropriate forest plan amendment if needed.

STRATEGY 5:

Expand research in RNA's without impacting the ecological values for which the areas are selected.

RATIONALE. Although RNA's are specified for nonmanipulative use, this has been difficult to define and enforce. As a result, some RNA's have received inappropriate use for research and administrative studies. On the other hand, many RNA's are not used at all for research and are greatly under-used by Forest Service Research and National Forest System managers.

D4

Goal A: Develop guidelines at regional and station levels for research and administrative studies on RNA's that ensure site protection, recognizing the need for flexibility due to the variable nature of different sites.

Goal B: Expand use of RNA's by Forest Service and external research communities in ways that contribute to forest plan goals and objectives.

Goal C: Establish flexible data management systems at regional and station levels that promote scientific study of RNA's and facilitate use of research and monitoring information in ecosystem management.

STRATEGY 6:

Improve support for the RNA Program through education, publicity, and communication.

RATIONALE. Lack of knowledge and support for the RNA Program within and outside the Forest Service currently limits the ability to establish new areas, manage established areas, use them within ecosystem management, and obtain scientific information from them.

Goal A: Develop a promotional program for National Forest System managers and researchers (Forest Service and external) that stresses the role of RNA's in ecological approaches to management.

Goal B: Develop promotional programs for the public emphasizing support and understanding of RNA's, not encouraging public use.

D5

MESSAGE SCAN FOR JERRY ELSON

To RNA

From: REGGIE A. FLETCHER:R03A
Postmark: Jun 14,93 1:47 PM Delivered: Jun 14,93 1:53 PM

Subject: Forwarded: RNA MANAGEMENT AREA PRESCRIPTION

Comments:
From: REGGIE A. FLETCHER:R03A
Date: Jun 14,93 1:47 PM
FYI, If you have any suggestions please pass to Tom.

Previous comments:
From: Tom Andrews:S28A
Date: Jun 14,93 1:27 PM
HI! Enclosed is the latest working of the RNA Management Area Prescription for the Plan Revision on one of Region 2's Forests. It will be a prototype for other Forests as they go into Plan Revision.
Any comments? Thanks, Tom

-----========X========-------

6.3 RESEARCH NATURAL AREA

Emphasis: Research Natural Areas (RNAs) form a network of ecological reserves designated for non-manipulative research, education, and the maintenance of biodiversity. This prescription is applicable to designated RNAs and areas which are proposed for RNA designation.

Desired Future Condition: RNAs are selected to preserve a spectrum of relatively pristine areas that represent a wide range of natural variability within important natural ecosystems and environments (e.g. forest, shrubland, grassland, alpine, aquatic, and geological environments) and areas that have special or unique characteristics of scientific importance. RNAs are also selected to: serve as reference areas for evaluating the range of natural variability and the impacts of management in similar environments; protect and maintain representative and key elements of biological diversity at the genetic, species, population, community, and/or ecosystem levels; serve as areas for the study of ecosystems and ecological processes including succession; provide onsite and extension educational activities; and serve as baseline areas for measuring ecological change.

RNAs are managed to maintain natural (relatively pristine/presettlement) conditions by allowing ecological processes to prevail with minimal human intervention. However, under some circumstances, deliberate manipulation may be utilized to maintain the ecosystem or unique features for which the RNA was established or to reestablish natural ecological processes. Vegetation, habitat, soil productivity, water quality, and ecological processes will be in natural condition (within the range of natural variability). Specific management direction (addressing fire, grazing, etc.) will be developed for each RNA as part of the Establishment Record or in separate Management Implementation Guidelines.

The setting is natural. The sights and sounds of people as well as other management activities within the area will be infrequent, but may be common in adjacent areas.

No new facilities will be provided. Motorized use is prohibited, except when necessary to provide research or educational access.

Recreational use is allowed, but not encouraged, except for interpretation and education. Publicity that would attract the general public to the area will be avoided.

No extractive uses are allowed, except those arising from existing mineral rights.

MANAGEMENT AREA STANDARDS AND GUIDELINES
(These apply in addition to Forestwide Standards and Guidelines.)

General

1 Protect the natural condition of the ecosystem and its processes and any species or values for which the RNA was proposed. **Standard**

Recreation Management

2 Allow nonvehicular recreation, except when it is a threat to the values for which the RNA was proposed. **Standard**

3 Allow trails which exist prior to RNA proposal for recreation and scientific or educational access, except when they are a threat to the values for which the RNA was proposed. **Guideline**

4 Utilize restrictions or closures under 36 CFR subpart B when necessary to protect the area from actual or potential damage due to public use. **Standard**

Travel Management

5 Prohibit the construction of new roads and trails, except when new trails are necessary to correct resource damage occurring from existing trails. **Standard**

6 Prohibit mountain bikes and all other vehicular use, except when they provide necessary access for scientific or educational purposes. **Standard**

7 Close or obliterate existing roads, except where they provide necessary access for scientific or educational purposes. **Guideline**

Vegetation Management

8 Prohibit logging and wood gathering activities. **Standard**

Range Management

9 Prohibit livestock grazing, except when it is used to approximate a natural grazing regime for maintaining the native vegetation. **Guideline**

Fish and Wildlife Management

10 Allow (but do not encourage) hunting and fishing, except when they are a threat to the values for the which the RNA was proposed. **Guideline**

11 Prohibit habitat manipulation for wildlife, unless it is part of Management Implementation Guidelines to provide for more natural conditions. **Guideline**

12 Allow habitat manipulation when it is necessary for the protection of Threatened, Endangered, and Sensitive Species. **Standard**

Fire and Fuels Management

13 Allow prescribed natural fires to burn. **Guideline**

14 Control human caused fires that are a substantial threat to human development outside RNA boundaries, and all fires where excessive fuel buildup from past fire suppression threatens the RNA. **Guideline**

15 Use fire suppression techniques which minimize disturbance. Use natural barriers to confine or contain fire where possible. **Standard**

16 Use management ignited prescribed fire when it is necessary to restore a natural fire regime or to reduce unnatural fuel loads. **Guideline**

Integrated Pest Management

17 Allow natural outbreaks of native insects and diseases to proceed without intervention, unless they are a substantial threat to important resources inside or outside of RNA boundaries. **Standard**

18 Use control methods which minimize disturbance. **Standard**

19 Control populations of exotic (non-native) plant and animal species, where feasible. Use control methods which minimize threats to native species. **Guideline**

Facilities Management

20 Prohibit buildings and developed recreation sites, unless there are exceptional circumstances (such as historic sites listed in the National Registry) which do not threaten the values for which the RNA was proposed. **Standard**

Minerals Management

21 Withdraw the area from mineral entry in conformance with Section 204 of Federal Land Policy and Management Act of 1976 (PL 94-576) when withdrawal is necessary to protect the values for which the RNA was proposed. **Standard**

Special Uses

22 Permit special uses only if they do not conflict with the values for which the RNA was proposed. **Standard**

23 Require approval of proposals for non-manipulative research by the RM Station Director (or representative) and the District Ranger. **Standard**

MANAGEMENT AREA M

MANAGEMENT AREA M

DESCRIPTION

This area consists of the one existing and two proposed Research Natural Areas (RNA). These areas offer ecosystem representation appropriate to meet needs identified by the Southwestern Region. The existing Monument Canyon RNA is a 640 acre section consisting primarily of Ponderosa Pine. The Canada Bonito RNA is 300 acres of Thurber Fescue, while the Ladrones Mesa RNA is 500 acres of Juniper savannah.

MANAGEMENT EMPHASIS

These areas will be managed to provide opportunities for non-disruptive research and education. This management includes allowing natural processes to occur and the protection of natural features. Use restrictions will be imposed as necessary to keep areas in their natural or unmodified condition. There will be no harvest of timber or firewood, nor will this area be assigned any grazing capacity.

The following areas will be proposed for designation to the Natural Research System:

Approximately 300 acres (Canada Bonito) for the protection and study of a high elevation Thurber fescue meadow.

Approximately 500 acres (Ladrones Mesa) for the protection and study of a juniper savannah.

Location and evaluation of other potential areas which lack Regional representation will continue throughout this planning period.

There are no vegetation modification practices proposed in this management area.

Land Suitability	Acres
Total suitable timber	0
Total Management Area	1,440

STANDARDS AND GUIDELINES

In addition to the forestwide standards and guidelines, the following specific standards and guidelines will apply to this management area:

PROGRAM ELEMENT	ACTIVITY MIH CODE	MANAGEMENT AREA M STANDARDS AND GUIDELINES
RECREATION	A08	**Allow nonmotorized dispersed recreation activites provided they do not modify the area or threaten or impair the research or educational value of the area.**

E1

MANAGEMENT AREA M

		Require recreation users to pack out all their trash.
		Cross-country vehicular travel is prohibited within study areas.
		No open campfires will be permitted within the study areas.
	A11	No new trail construction will occur.
	A13	Manage for a Visual Quality Objective of Preservation
WILDLIFE	C01	Evaluate these areas and determine their contribution to threatened and endangered species recovery objectives.
	C02	Prohibit introduction of non-native plant or animal species.
RANGE	D01 D02	Allotment plans utilize Level A to achieve management area objectives.
		Post boundaries, fence, or take other necessary action to prevent unauthorized livestock grazing.
TIMBER	E00	Prohibit all timber and firewood activities.
MINERALS	G04	Mineral leasing category: Limited surface use- No surface occupancy
LANDS	J01	Utility corridors are excluded
FACILITIES	L01 L04 L08 L12	Roads will not be constructed in this management area. Road management and closures will be implemented with the objective of closing roads where they currently exist, except as necessary to provide access for research, or adjacent management areas.
PROTECTION	P01-07	The fire suppression objective for Monument Canyon is to control 90% of the high intensity wildfires at 75 acres or less. Maximum loss from high intensity wildfires is 75 acres of the management area per decade.
		Low intensity wildfires will have no size limitations.
		Limit suppression action to the use of hand tools.
	P11 P12 P13	Fuel treatment will be commensurate with management objectives and direction for individual RNA's.
		Allow prescribed fire, using planned and unplanned ignitions in Ladrones Mesa and Canada Bonito RNA's to maintain these fire dependent ecosystems.

E2

FORM 6200-8 (1/64)
UNITED STATES GOVERNMENT

Memorandum

Department of Agriculture—Forest Service
Region 3, Santa Fe, New Mexico 87501

TO : Regional Forester

File No. 4060

FROM : R. E. Latimore, Forest Supervisor

Date: January 3, 1967

SUBJECT: Research Facilities - Natural Areas

Your reference: 9/26/66

Following is our report on the existing Monument Canyon Natural Area located on the Jemez Ranger District, Santa Fe National Forest.

This report format follows the five items listed in your memorandum.

1. Conformance with criteria as set forth in FSM 4063:

   a. 4063.3 - Size - Monument Canyon encompasses 640 acres. This size is sufficient to protect unmodified conditions in the interior areas.

   b. 4063.4 - Protection and Management - Monument Canyon has been protected against activities which directly or indirectly modify its research values with the following exceptions:

      1. The area is grazed by domestic livestock under National Forest Permit. There is very limited suitable grazing land within the area. Specific sites have occasionally been used as "salt grounds."

      2. A minor amount of dead wood has been removed from the area by wood haulers. There is no evidence of removal of living trees.

   c. 4063.41 - Identification - The Natural Area has been identified only on various maps and in plans. There is no on-the-ground identification at present.

   d. 4063-42 - Fences - There are no fences around or within the area.

   e. 4063-43 - Publicity - As far as we know, the area has been publicized only in very limited correspondence with professional groups such as the S.A.F., University of New Mexico, etc. We feel that the general public is completely unaware that the area exists.

F1

f. 4063.44 - Physical Improvements - There is an existing logging road through the area, constructed to harvest timber on the west side of the area (not within area). There is also a Forest Service telephone line across the area. There are no other improvements.

g. 4063.45 - Protection - There is no evidence of major fires in the past, nor known insect or disease control.

h. 4063.46 - Public Use - The area is subjected to very light use by the public - primarily for incidental picnicking and hunting use.

i. 4063.47 - Scientific and Educational Use - To the best of our knowledge, no specific research use has ever been made of the area.

j. 4063.48 - Vegetation Management - Nothing has been done.

k. 4063.49 - Mineral Entry - The area has not been withdrawn from mineral entry.

2. Present and past uses of Monument Canyon have been described under #1. Briefly, it is open to grazing, has had some dead wood removal, and is subject to some hunting and picnicking use.

3. We propose no new Research Natural Areas on the Santa Fe.

4. Should the existing Monument Canyon Natural Area remain in its present status, we anticipate only minor problems of continued administration and protection to present standards. To manage the area properly, it would be necessary to exclude grazing, discourage picnicking and wood hauling, and intensify our fire prevention efforts.

   The increase in management intensity necessary would depend on the amount of protection deemed necessary.

   Our most immediate management problem concerning Monument Canyon is one of fire control. The entire area is covered by an overmature, decadent stand of Ponderosa Pine and Mixed Conifer with a great number of snags. The understory is a very, very dense thicket of pine reproduction, much of which is snow damaged and lying on the ground. The area faces the prevailing southwest winds and lightning or man-caused fires could be disastrous. We have invested considerable from P&M and AFW funds in nearby TSI operations.

F2

5. Although you do not specifically ask for our recommendations, we would recommend that the Monument Canyon Natural Area be abolished unless the Research Station has some definite, immediate plans for use of the area.

   This recommendation is based upon:

   a. The fact that no research has yet been conducted on the area.

   b. The present and future fire threat, both to the area and adjoining Forest, because of conditions and types of fuels.

   c. Our desire to practice multiple-use management on all lands not specifically needed for single purposes.

   d. The increase in management necessary to meet the goals of a Natural Area. Increased expenditures do not seem to be justified under current use.

   e. Our feeling that areas within nearby wilderness areas satisfy the needs for natural areas.

We would further recommend that the area be scheduled for timber harvest in the near future, both to arrest timber mortality and decrease the fire hazard, subject to any harvesting restrictions deemed necessary by Timber Management, the Research Station, and the Forest.

DASchultz:amm

cc: R.O.
Jemez 1/4/67
RS amm

NGS
D.B.

G1

32

R(L)
Natural A^Reas
Santa Fe

MONUMENT CANYON NATURAL AREA

Purpose

To preserve in natural state a typical area of western yellow pine forest as found in northern New Mexico. The stands of western yellow pine in this region differ from those of the Colorado Plateau in being denser and more evenly spaced with trees of relatively small diameter.

Description

Location

Section 9, T. 18 N., R. 3 E., N.M.P.M. - Surveyed. All national forest land. The northern fringe and NE drop down over the rim of East Fork of the Jemez River, known here as Monument Canyon. The balance is plateau land at the head of a southwesterly drainage. Area 640 acres.

Acreage by Dominant Cover Type

All western yellow pine type.

Physiography and Climate

For the most part fairly level mesa, altitude 8100-8600 feet. The climate is characteristic of the western yellow pine zone, - short growing season, cool summers, precipitation about 20 inches.

Forest Value

About 570 acres is commercial sawtimber; the remaining 70 acres is classed as inaccessible. The volume is estimated at 8500 board feet per acre. Pole growth and reproduction in seedling and sapling stages are excellent.

Agricultural Value

None

Grazing Value

Negligible. The carrying capacity of the entire section is estimated at 8 head of cattle yearlong.

Mineral Value

None in evidence.

Value for Other Public Use

None of specific importance.

Transportation

The area is on a trail from Jemez Springs to Upper Vallecitos. It is also within a mile of a programed Forest Service development road, and is crossed by a motorway cleared out for fire protection purposes, following the route of the above trail.

Public Sentiment

So far as known there would be little public interest in the area outside of scientific circles.

Plan of Management

The primary protective measure is to guard against cutting. Neither live nor dead timber should be cut unless in connection with fire or insect control. No roads or trails except those needed for protection of the area and adjacent Forest land, and no occupancy of any kind should be permitted. Conservative grazing may continue, but overgrazing must be avoided.

The area is part of a larger one designated in a cooperative agreement with the University of New Mexico providing for joint study of biological, archaeological, climatological, and related problems. This agreement under the title "Cooperative Agreement Between the Department of Agriculture and the University of New Mexico for the Purpose of Research and Observation in Certain Natural Sciences" is dated May 29, 1930, and is signed by the President of the University and the Secretary of Agriculture.

Approved:

/s/ F. E. Andrews
Forest Supervisor

G. A. Pearson /s/
Director, Southwestern Forest and Range Experiment Station

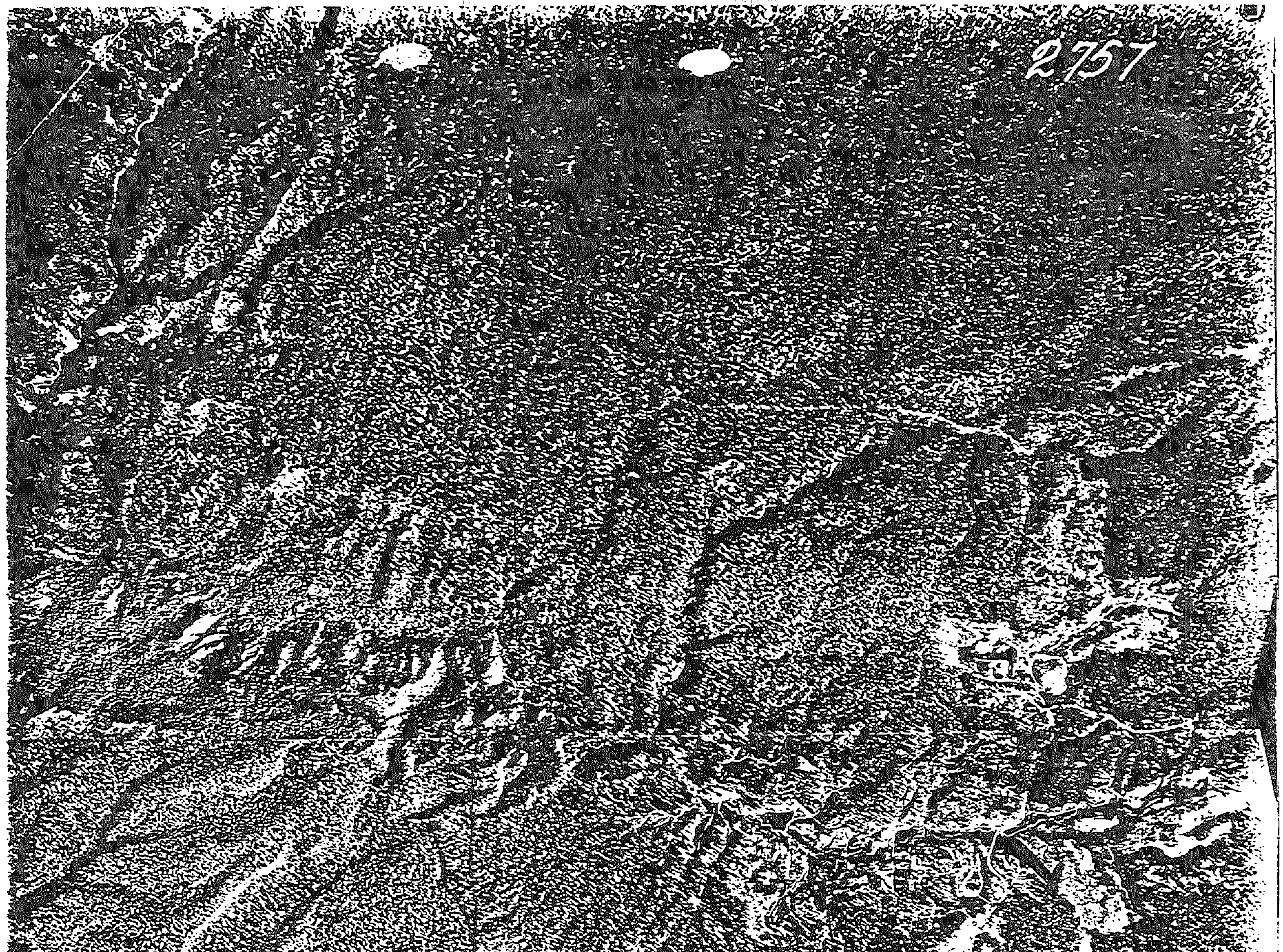
/s/ Frank O. W. Pooler
Regional Forester

Washington D.C.,

10/1/32

By virtue of the authority vested in me by Reg. 1-20 of the regulations of the Secretary of Agruculture relating to the occupancy, use, protection, and administration of the National Forests, I do hereby designate as the Monument Canyon Natural Area the lands described in a report dated ________, by ________________; said lands shall hereafter be administered as a Natural Area subject to the provisions of said regulation and the instructions thereunder.

R. M. Stewart /s/
Forester


2757

Monument Canyon Research Project
Summary of Field Sampling Protocols
Rev. 27-Jun-99

200 m centered grid and .5-ha fire record sampling area

A. Establishing a grid point marker.
1. Select pre-computed UTM coordinates.
2. Navigate by GPS to coordinate point in field.
3. Average GPS coordinate readings to maximize accuracy; record actual coordinates on data sheet, and correct waypoint in GPS unit.
4. Place and tag permanent plot stake.
5. Mark stake and two trees on either side of point with orange flagging, using enough flagging to allow good visibility and movement in wind. Write grid point number on tree flags.
6. Record slope and aspect.
7. Describe stand conditions briefly.

EQUIPMENT NEEDED:
- ☐ Data forms
- ☐ Rebar stakes, preferably ≥ 12 cm (30")
- ☐ Tags, wire, and nails
- ☐ Hand sledge
- ☐ Pliers with wire-cutters
- ☐ GPS
- ☐ Orange flagging
- ☐ Large Sharpie/marker
- ☐ Sighting compass
- ☐ Clinometer or laser rangefinder

B. Fire scar search.
1. Establish a search radius of 40 m from the grid point, using 2 100-m tapes, creating a circular plot of ≈ .5 ha, or by measuring distance to individual trees.
2. Search the sampling area for the best-recording fire-scar trees within the search radius. Apply a metal tag on the side of each tree facing the pin, flag each tree with yellow, and record:
   a. Tag number,
   b. Location (GPS waypoint, map location, or bearing (° M and distance from grid point),
   c. Species,
   d. Dbh, dsh, or drc (cm),
   e. Number and condition of visible fire scars,
   f. Tree condition code,
   g. Notes.

EQUIPMENT NEEDED:

- ☐ Data forms
- ☐ Yellow flagging
- ☐ Sighting compass
- ☐ GPS
- ☐ Laser range finder (optional)
- ☐ DBH tape
- ☐ Claw hammer
- ☐ 2-100 m tapes
- ☐ 50 m tape
- ☐ Tags and nails
- ☐ Tree condition code key

C. Fire scar collection.

1. Collect a section or other appropriate sample from the 2-3 best-recording trees, and complete LTRR Section Data Sheet.
2. Core trees (as close to the ground as possible) from which sections are collected if possible, recording coring height and side.

Note: The purpose of collecting scars from two trees is to increase sample depth for the time period they cover. Additional trees may be sampled if they will increase temporal coverage of the fire record (*e.g.* very old trees), even if there is no apparent replication at the location.

EQUIPMENT NEEDED:

- ☐ LTRR section forms
- ☐ MCN data forms
- ☐ Chainsaw and accessories
- ☐ Increment borers, accessories, straws, straw tubes
- ☐ Ultrafine Sharpies and heavy markers
- ☐ Packing tape

1-hectare intensive fire-sampling cells (10,000 m^2)

1. Locate pre-selected grid corner and cell orientation using map, compass, and GPS.
2. Tape or flag sides, using physiographic and land-use (roads, RNA boundary) features for convenience. Flag and GPS corners.
3. Systematically cruise cell, in strips of no more than 20 m (see *Group Search Procedures*).
4. For all fire-scarred objects, apply a metal tag and record:
    a. Unique identifying number,
    b. Location (GPS waypoint, map location),
    c. Species,
    d. Dbh, dsh, or drc (cm),
    e. Height (m),
    f. Scar location (if any), and approximate compass bearing (° M).
    g. Number and condition of visible lesions,
    h. Tree condition (code),
    i. Notes.
5. If a section or other appropriate sample is extracted, complete LTRR Section Data Sheet.
6. If a core is extracted, record coring side and height on data sheet.

If sampling area is defined by topographic or other features rather than pre-established grid points, area sampled will be computed during GIS analysis.

.25-hectare overstory size/density plots (50 m x 50 m = 2,500 m^2)

1. Locate a pre-selected grid point.
2. Record slope and aspect if not already on Grid Point Data Form.
3. Tape off 50 m x 50 m plot, centering the plot on the grid point, using 2 100-m tapes starting at lower-left corner. Align plot sides parallel and perpendicular to the slope contours. Flag and map or GPS corners
3. For *all*:
   - a. Standing trees, snags or fallen logs of any species ≥ 30 cm Dbh ,
   - b. Scarred trees, or
   - c. PIPO with old-growth morphology (see *Old-growth characters* decision rules),

   tag toward pin and record:
   - a. Tag number,
   - b. Species,
   - c. Number and condition of fire scars (if plot is in previously-surveyed 1-ha cell, these will have already been recorded),
   - e. Location (GPS waypoint or plot coordinates (m.m); the latter is easiest with two people),
   - f. Dbh, dsh, or drc (cm).
   - g. Condition (code).
   - h. Notes.
4. Take a photograph from pin facing 4 cardinal directions, using 50m (normal focal length) lens held at eye height. Record photo seuqnece on data sheet.

EQUIPMENT NEEDED:

- ☐ Data forms
- ☐ 3 100-m tapes
- ☐ 1 25-m or 50-m tape
- ☐ 6 corner pins
- ☐ Stake flags
- ☐ DBH tapes
- ☐ Claw hammer
- ☐ Tags, nails
- ☐ Camera
- ☐ (Right angle prism)
- ☐ (Sighting compass)

.1 hectare overstory age/spatial plots (20 m x 50 m = 1,000 m^2)

1. Orient a .1-ha (20 m x 50 m) plot end-to-end within the .25-ha plot, with the long axis parallel to contours (perpendicular to slope) using 2 50-m tapes.
2. For *all*:
   a. Standing trees, snags or fallen logs of any species with Dbh ≥ 25 cm,
   b. Scarred trees, or
   c. PIPO with old-growth morphology (see *Old-growth characters* rules),
   (all of which were tagged and recorded in .25-ha plot, Step 3), *and*
   d. Non-PIPO trees ≥ 20 cm Dbh,

collect at least 2 core(s) at right angles from as low on the tree stem as possible. If neither core hits the pith ring, collect additional cores until reaching pith. Record:
   a. Core letter and height (cm),
   b. Height (m) to dead crown/live crown/live crown top/leader,
   c. DBH (if not previously recorded),
   d. Mistletoe Rating (see card),
   e. Plot coordinates (m.m) from lower-left corner,
   f. Notes
4. For the overstory tree (DBH ≥ 25 cm) nearest each corner of the plot, record:
   a. Distance from corner (m.m),
   b. Number and mean Dbh of tree stems (any size and species) within root zone of each overstory tree, defined as a radius equal to 20 x Dbh of the overstory tree.[1]
   c. Distance to *n* nearest neighbors ≥ 25 cm Dbh outside the plot, including at least two trees beyond evident cluster. Neighbors do *not* have to be contained within sampling plot.[2]

EQUIPMENT NEEDED:

- ☐ Data forms
- ☐ 4 end pins
- ☐ 2 50-m tapes
- ☐ 2 20-m tapes
- ☐ 1-m tape
- ☐ Increment borers and accessories
- ☐ Straws and core tubes
- ☐ Binoculars
- ☐ Tags, claw hammer, nails
- ☐ Laser range finder
- ☐ (Clinometer)

[1] Need stem number and mean Dbh to calculate BA within competition radius. Use a BA prism?

[2] How many?

.01-ha contemporary size/age-structure/density subplots (10 m x 10 m = 100 m^2)

1. Select a corner of the .1-ha (20 m x 50 m) plot by random method (4 possibilities).
2. Tape off 10m x 10m plot, laying out tapes from lower-left corner. Flag and map corners.
3. Record mean slope (%) and aspect (° mag) for the subplot if not already recorded.
4. Core or collect stem from *all* live trees as follows:
   - ☐ Core if Dbh ≥ 5 cm
   - ☐ Collect stem if Dbh is 2.5-4.9 cm, severing at ground level and 1 m
   - ☐ Collect every fifth stem (randomly or systematically selected) if Dbh < 2.5 cm *or* height < 1.4 m

   For each cored or collected tree ≥ 2.5 cm, tag and record:

   a. Species,
   b. Tag number,
   c. Number and condition of fire scar (if plot is in previously-surveyed .1-ha cell, these will have already been recorded),
   c. Dbh, dsh, drc (cm),
   d. Height (m) to dead crown/live crown/live crown top/leader,
   e. Condition code.
   f. Subplot coordinates (m.m)

   For collected stems, tie flagging onto collected stems. Mark top and bottom of collected stems as well as remaining root in ground.
5. For all standing stems <2.5 cm Dbh *or* < 1.4 m height (including seedlings):

   a. Tally number living and dead by species,
   b. Estimate average height (m.m) by species,
   c. Flag and collect stem from every fifth plant, marking both ends of sample and top or root.
   d. Record number collected by species.

EQUIPMENT NEEDED:

- ☐ Data forms
- ☐ 4 end pins
- ☐ Hand pruners
- ☐ Small pruning saw
- ☐ 25-30 stake flags
- ☐ Large and Ultrafine markers
- ☐ DBH tape
- ☐ Clinometer or laser range finder
- ☐ Tags, nails
- ☐ Claw hammer
- ☐ Increment borers and accessories
- ☐ Straws and core tubes
- ☐ Laser range finder
- ☐ (Sighting compass)

2 m x 2 m ground layer and phenology microplots (4 m^2)

1. Locate the pre-selected anchor corner of a .01-ha (10m x 10m) subplot.
2. Use tape, frame, or flagging to create microplot. Stake (rebar or PVC) [3], flag, and map GPS corners (anchor corner will already be recorded for .01-ha subplot). Microplot will be read repeatedly over the course of the field season, so clear marking is important.
3. For each species in the shrub and herb layers (including all vascular and non-vascular herbaceous species, seedlings of woody species, and non-colonizable substrates such as bare rock), record:
   a. Percent cover,
   b. Number of stems,
   c. Growth and reproductive stage (vegetative, flowering, fruiting, seed set).
   d. Include the seedling stage in the collection. If species identity is uncertain, collect and field-press a voucher, preferably from outside the microplot.

[3] Q: Rebar or PVC preferred?

Pre-field sampling design.

Codes and protocols:

a. *Field methods.*
b. *Table of questions.*
c. *Tree condition codes.*
d. *Old-growth tree characteristics* table.
e. Field forms for grid point, 1-, .25-, .1-, and .01-ha, and 4m^2 sampling
f. Plot diagrams on graph paper for .25-, .1-, and .01--ha plots
g. Map of study area showing grid points.

Study area stratification:

a. Stratify study area into 4 physiographic zones:

N	WNE slopes: slope $\geq$ 15%, aspect 271-89° True (= 260-78° Mag)[4]
S	ESW slopes: slope $\geq$ 15%, aspect 91-269° True (= 80-258° Mag)
V	Valley bottom: slope $\leq$ 15%,
M	Mesa top: slope $\leq$ 15%,

1-ha intensive fire-sampling cells:

a. Randomly select *n* grid points (stratified by zone) for 1-ha intensive cells
b. Randomly select 1 of 4 possible orientations for each cell (NW, NE, SE, SW) from each grid point.

.25-ha overstory size/density plots:

a. Randomly select *n* grid points (stratified by zone) for plot locations.

2 m x 2 m ground layer and phenology microplots (4 m^2):

a. Randomly select *n* grid points (stratified by zone) for microplots.

[4] Magnetic North declination ≈ 11° east of True North; **TN = MN - D (°).**

Monument Canyon Research Project
Tree Condition Codes

1a. Live (L)? Go to 2.
1b. Dead (D)? Go to 3.

2. Rate condition based on crown health, growth form, apparent vigor:
   - Excellent (E)
   - Good (G)
   - Fair (F)
   - Poor (P) .

3. Rate macrocondition:
   - Standing/leaning snag (S)
   - Fallen (F)
   - Stump (P)

   Then go to 4.

4. Choose the first of:
   - Foliage/fine branches present (F)
   - Bark remaining (B)
   - Main limbs remaining (L)
   - Bole intact (I)
   - Role rotting (R)

Flagging conventions

Orange: Grid points
Yellow: Marked trees for fire-scar sampling

A Guide for Developing Natural Area Management and Monitoring Plans

(monitoring updated 2/91)

Pacific Northwest Interagency Natural Area Committee

February, 1990

Table of Contents

INTRODUCTION

These Natural Area management and monitoring plan guidelines were developed by the Pacific Northwest Interagency Natural Area Committee (hereafter, Committee). In writing these guidelines the Committee has attempted to keep in mind the different mandates, restraints, and laws pertaining to the participating agencies. These guidelines are not intended to usurp direction found in official land use planning documents but rather to provide additional guidance with regard to Natural Area management. The guidelines reflect the Committee's belief that effective Natural Area management will fall short unless guarded by a strong stewardship ethic.

The Committee supports an ecosystem-based approach to Natural Area management. Natural ecosystems interact physically and biologically with their surrounding environment; natural processes interact physically and biologically with each other. Ideal Natural Area stewardship would allow natural processes to proceed unencumbered. Most Natural Areas, however, have been modified to varying degrees by past and ongoing management. These modifications preclude a hands-off approach to stewardship. It is sometimes necessary today to intervene to restore ecological processes that have been altered by human activity.

This guide ~~is organized~~ describes in the format we recommend for Natural Area Management Plans. ~~By following the instructions from beginning to end you will be able to complete a management plan.~~ As outlined here management plans ~~will be~~ are divided into five sections (Figure 1). The first three outline the general framework for management and provide important background information on the Natural Area. The ~~last two~~ remaining sections identify specific management and monitoring needs. We have identified three levels or scales of focus that need to be considered ~~throughout the planning process~~: element, Natural Area and surrounding landscape. In each section, we list questions you should attempt to answer and information you should evaluate in developing management plans. The considerations we have outlined will not be appropriate in all cases, and there are undoubtedly others that we have neglected.

The Committee has a long history of cooperating on the identification and designation of Natural Areas. The management and monitoring plan guidelines represent the Committee's shared perspective on stewardship and a continued commitment to cooperation and communication. These guidelines represent a first working draft that we hope to improve upon with your input. We welcome your recommendations regarding the instructions and Natural Area management planning.

Figure 1. MANAGEMENT PLAN OUTLINE

(Name of Natural Area)
Management Plan

POLICY

The policy statement provides the reader background on the authorities, regulations, policies and philosophy of the establishment and management of Natural Areas.

BASIS FOR DEDICATION AND SETTING OBJECTIVES

The basis for establishment of the Natural Area describes why the Natural Area was established and identifies the primary objectives of management.

NATURAL AREA AND ELEMENT DESCRIPTION

NATURAL AREA: General information about the Natural Area is described, including physical features, location, elements, ecological requirements.

ELEMENTS: Lists elements and element occurrences, their location, current condition, ecological requirements and key threats.

SURROUNDING LAND USE: The surrounding land and land use is described, especially those characteristics that may influence the Natural Area and its management.

MANAGEMENT CONSIDERATIONS

This section is organized by topic area or consideration: logging; insects and disease; domestic grazing; fire management; public use; roads and utility rights-of-way; hunting, fishing, and trapping; archaeology; hydrology; and introduced species. For each consideration, a policy statement, current and needed information, and management actions are outlined.

MONITORING

This section outlines monitoring actions needed to track the condition of the element occurrences and Natural Area overall, and the effects of management actions.

SOURCES OF INFORMATION AND SOME TERMS

You can obtain information regarding Natural Areas in the Pacific Northwest from many places. These include the Pacific Northwest Interagency Natural Area Committee, The Nature Conservancy, Oregon and Washington State Heritage Programs, state Natural Area programs, agency specialists, university and college professors or scientists, and the many agency Natural Area coordinators in Oregon and Washington. You should develop a strong network with all of these people and groups.

Three references are invaluable for providing background on the Pacific Northwest Natural Area program and information on elements and on threatened and endangered species.

1. Natural Heritage Advisory Council to the State Land Board. 1988. Oregon Natural Heritage Plan. State Land Board, 1600 State St., Salem, OR 97310. 141 p.

2. Washington Natural Heritage Program. 1989. Washington Natural Heritage Plan. Department of Natural Resources, Olympia, WA 98504. 140 p.

3. Dyrness, C.T., et al. 1975. Research Natural Area Needs in the Pacific Northwest. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, GTR 38. 231 p.

Three terms will be used throughout this guide and merit definition.

1. Natural Area

Natural Area is the term we use to represent Research Natural Areas, Biological Study Areas, Natural Area Preserves, Preserves, and Natural Heritage Conservation Areas. All of these designations are based on three major objectives: 1) to preserve examples of all significant natural ecosystems for comparison with those areas influenced by humans; 2) to provide educational and research areas for ecological and environmental studies and monitoring; and 3) to preserve gene pools for typical and rare and endangered plants and animals.

2. Element

An element is the basic unit of the biologic and geologic environment identified as a needed component of a system of Natural Areas and defined in the Oregon and Washington Natural Heritage Plans. An element can be a native plant community, an aquatic ecosystem, a geologic feature, or endangered, threatened or sensitive plant or animal species. The term "cell" as used in Research Natural Area Needs in the Pacific Northwest is synonymous with the term element.

3. Element occurrence

This is the actual on-the-ground occurrence of the element. Examples include a particular forest stand that meets the definition of an element in the Heritage Plans, the nesting site for a particular bird that is included in the special species list, or a population of a rare plant species.

NATURAL AREA MANAGEMENT PLAN

I. POLICY

The policy statement should give the reader background on the overall context for establishment and management of Natural Areas. It should include references to the appropriate policies, regulations and authorities as well as a statement describing the philosophy of the establishment and management of the Natural Area.

The following is an example policy statement:

> Natural Areas are established for their significant biological and physical features. They are important in protecting typical and unique terrestrial and aquatic ecosystems for research and education. Natural Areas serve as outdoor laboratories and as a baseline to compare the effects of human manipulations in similar settings. They provide valuable gene pools for native organisms, including plant and animal species designated as endangered, threatened or sensitive. The (Agency) recognizes their role in sound land use management and has provided for their establishment and management in the following policies and regulations (state policy references).*
>
> The guiding principal of Natural Area management is to allow natural, ecological and physical processes to predominate, while preventing human-induced encroachments and activities which directly or indirectly modify ecological processes in the area. Active management should be undertaken where natural processes have been interrupted.

*Background information on federal agency policy and authority can be found in Appendix 1.

II. BASIS FOR DEDICATION AND SETTING OBJECTIVES

In this section you should describe why the Natural Area is being (was) established and set primary management objectives. The primary emphasis of management should be on the element occurrences. A list of elements is provided by the Oregon and Washington Natural Heritage Plans.

A. Basis for Dedication

The majority of Natural Areas are established to fill terrestrial and aquatic element needs as listed in the Oregon and Washington Natural Heritage Plans. In some cases, Natural Areas are established to protect endangered, threatened or sensitive plant or animal species. In this section, list the elements for which the Natural Area was dedicated to protect. Generally, the basis ~~primary objectives~~ for dedicating each Natural Area is ~~are~~ discussed in the most recent land management plan that addresses the geographical area in which the Natural Area resides.

Before a Natural Area appears in a general land use plan either a representative of the Interagency Natural Area Committee or a contractor has made one or more field visits and communicated with the local field office. Office and field visits are nearly always preceded and followed-up by correspondence. Additional information may have been documented as part of a dedication process. A file of this information should be assembled for each Natural Area. If unable to locate a file for an established or proposed Natural Area it is important to contact Sarah Greene or the contractor so files may be created or up-dated. Information on state or federally listed threatened or endangered species may be obtained from the Washington and Oregon Natural Heritage Programs and the U.S. Fish and Wildlife Service.

B. Setting Objectives

Setting objectives is the most important and difficult part of developing a Natural Area management plan. It involves making decisions about the relation between current and natural conditions using the most up-to-date information possible. Your objectives will fall into three categories: 1) primary objectives which focus on element occurrence management, 2) objectives associated with other values of the Natural Area, and 3) objectives related to research and educational use.

1. Elements and element occurrences

A Natural Area has been or is being established because it contains the best known and/or most representative example(s) of a particular element(s). Thus, based on the current state of understanding, your objective will often be <u>to maintain the natural condition of the element occurrence</u>. This does not necessarily imply that no management actions are needed, or that conditions should be held in a steady state.

If you know that an element occurrence is not in optimal condition, then your objective should be to improve it. The objective statement should specify the desired future conditions as specifically as possible. If you do not have adequate information to define the conditions, you should state what information you will need following the statement of objectives.

Each element occurrence should have its own statement of objectives. There may be occasions when the objective for one element conflicts with the objective for another element. In these cases priorities must be set. Some factors to consider when setting priorities are: ~~element rank~~, current threats, current condition, and manageability.

2. Other values

In a limited number of cases, other characteristics of the Natural Area merit special recognition in management. Other values might include migratory corridors or archeological sites. These values should be viewed as secondary to the primary values. Management to maintain or enhance them should occur only to the extent that primary values of the area are not jeopardized.

3. Research and education

Research and education compatible with element occurrence objectives are primary uses of Natural Areas. You may want to define specific objectives that encourage these uses. Research use should not degrade or jeopardize natural ecological conditions or processes.

III. NATURAL AREA AND ELEMENT DESCRIPTION

In this section you should provide information about the ecological requirements and threats associated with the Natural Area, element occurrences and surrounding landscape. Ecological requirements of threats need to be assessed at each of these levels. An element does not exist in a vacuum, rather it affects or is affected by the site in which it exists; in turn, the Natural Area is tied to the surrounding landscape in which it resides.

Ecological requirements are limiting factors or processes critical to perpetuation of the element/Natural Area, eg. fire, flooding, herbivory, light conditions. Threats include activities or processes that modify the perpetuation of the element/Natural Area, eg. fire suppression, domestic livestock grazing, introduced species. In some cases, information on ecological requirements and threats may be the same for the element, the Natural Area, and the surrounding landscape. It is not necessary to be repetitive as long as they are addressed in one of the 3 levels (element, Natural Area, landscape). Choose the most appropriate level and cross reference to other levels as necessary.

A. Natural Area description

The description of the Natural Area should provide general information about the Natural Area. In this section you should:

1. describe physical and abiotic features: size, aspects, elevational range, geology, soils, climatic conditions (rainfall, average temperatures, wind patterns, etc.), and hydrologic features;

2. outline site history;

3. describe terrestrial and aquatic communities (note: Those features that are element occurrences should be briefly identified here and described in more detail below); identify key species and include species inventories where available;

4. locate and describe human-made features (fences, structures), access points, and trails;

5. list and map elements on a topographic map;

6. describe ecological requirements that are common to all or most of the elements; and

7. describe and map threats, where possible, that are common to all or most of the elements.

C. Surrounding Land Use

Managing Natural Areas requires a thorough knowledge of surrounding land uses and their potential impacts on the Natural Area. Interaction between the Natural Area and its surroundings does not stop once boundaries are established around a Natural Area. Physical factors (such as wind, water movement and fire frequency) and biological factors (such as animal movement, insect outbreaks, disease transmission and plant population dynamics) on the Natural Area can be affected by surrounding land uses. Exposing a boundary to a clearcut can increase wind effects; building fences can inhibit wildlife movement; removing vegetation can increase water temperature.

Some potential or existing surrounding land uses to consider are:

1. timber sales sold or proposed (more than just a year or two in the future), and free-use programs like fire wood cutting;

2. recreation - proposed or existing trails, campgrounds, parking;

3. grazing - time and degree of use, class of livestock, water developments, salt block location;

4. water impoundments, pipes, troughs, proposed or existing hydro projects, including hydro electric, or irrigation storage or diversion;

5. roads - built or proposed, improvement and maintenance;

6. wildlife projects - guzzlers, introductions, trapping, habitat improvement;

7. vegetation management - any type of spraying (e.g. herbicides, fertilizers), and seeding or planting of non-native species;

8. mining - exploration, developments, claims, patents;

9. agricultural, residential or industrial development and associated pollution;

Describe physical features of the surrounding land (especially where different from Natural Area description). Identify political boundaries (other land ownership, administrative boundary). Identify land uses that are existing or potential in the surrounding landscape. Briefly discuss effects, benefits, or problems associated with these uses.

Completing this part of the management plan provides an excellent opportunity to involve others in Natural Area management. Keeping the lines of communication with other resource managers open is very important in helping to avoid potential conflicts and in integrating the Natural Area into your agencies overall land management. Make sure that all resource pecialists ~~managers~~ are aware of the existence of the Natural Area. When projects are being planned that may have an affect on the Natural Area identify your concerns as early in the process as possible.

IV. MANAGEMENT CONSIDERATIONS

A. Introduction

This section is divided into a number of topic areas or "Management Considerations". We have provided some philosophical direction, outlined information you should gather, and listed questions you should answer relating to each consideration. The Natural Area, elements, and surrounding landscape should be addressed in each management consideration. Management considerations can include, but are not necessarily limited to:

- Logging
- Domestic livestock grazing
- Fire
- Insects and ~~disease~~ pathogens
- Public uses
- Roads, utilities
- Hunting, fishing and trapping
- Archaeology
- Minerals
- Hydrology
- Introduced Species

You will need to determine which of these topics should be addressed in each Natural Area management plan.

For each consideration you should:

1. state the policy and its bearing on the management plan. If your agency doesn't have a specific policy statement, you will need to develop a policy statement. You might want to call another agency or local expert for help. Be aware of overriding legislation that may affect your management decisions, such as management direction in land-use planning documents and the Wilderness Act;

2. discuss existing and needed information regarding management consideration and its relation to the Natural Area and element occurrences; and

3. list management actions needed. You might want to order these actions in a priority sequence taking into account the relative importance of each element and the urgency of the action.

B. Logging

Almost all agencies have very specific restrictions on logging within Natural Areas. In general you should consider tree harvest of any kind -felling, firewood and salvage removal, fence posts, etc. - is not appropriate. Hazard trees might be an exception, but any felled trees should be left in place unless they are across a trail or in a road. Rarely is there an instance when salvage of windthrown or wildfire-killed trees is justifiable.

1. State the agency policy

2. Current and needed information

Some questions you should ask are: Has the area ever been logged? If so, when, in what manner, size, and position on the landscape? If logged, was area replanted, how much and with what? Are there hazard trees near the boundaries or near trails within the area?
Most importantly you should determine what, if any, logging is proposed outside the boundaries of the Natural Area. This should include information on planned sales as well as pending or sold sales. All kinds of timber harvest should be identified - salvage, firewood cutting, fence posts, shelterwood, and clear-cutting.

3. Management actions needed

Work with timber sale planners to tailor adjacent management to protect the integrity of the Natural Area. Modifications such as feathering edges of cuts to avoid straight boundaries, using seed source from the Natural Area, cautioning timber operators and timing cuts may help to reduce their effects.

C. Insects and ~~disease~~ pathogens

Every effort should be made to protect a Natural Area from an introduced insects and diseases. Generally, no management actions should be taken against endemic insects or pests. Sometimes their occurrence has been exacerbated by human activities, such as the proliferation of the mountain pine beetle in central Oregon resulting from fire suppression. These situations may require active management. Introduced insects or pests should be controlled if at all possible. Because of the small size of most Natural Areas, the surrounding landscape will play a dynamic role in whatever management actions are considered.

1. State the agency policy

2. Current and needed information

List all native and introduced insects and diseases known to occur in the area, or expected to become a problem in the future.

For each:

-define scope of the existing or potential infestation;
-determine what stage the infestation is in;
-determine what caused the outbreak (natural cycles versus surrounding land management practices);
-determine what direct and indirect effects the pest will have on the elements, Natural Area, and surrounding land; and
-identify control measures and discuss effectiveness, cost feasibility and secondary effects of each (what control measures are being used on adjacent lands?).

3. Management actions needed

-What restrictions should be placed on control methods used outside the Natural Area to protect native insects occurring in it?
-What management actions could be taken to reduce or mitigate the effects of introduced pests or unnatural native pest outbreaks?
-Should control actions be taken, if so how much, when and what kind?

D. Domestic grazing

In most cases within the Pacific Northwest, domestic livestock grazing does not mimic or simulate "natural" ecological processes or effects produced by native grazing animals (e.g. antelope, bison).

1. State the agency policy

2. Current and needed information

To determine what role, if any, should be played by domestic livestock in the maintenance or enhancement of element occurrences, you should try to reconstruct the role of large, hoofed grazing animals in the pre-settlement landscape, and compare that with the role of large, grazing animals of post-settlement (1820-present) times.

Participating agencies interpret the role of domestic livestock within Natural Areas in different ways. The following questions may prove useful in determining the future role and importance of domestic livestock grazing. List the animal species that grazed the element(s), past and present. Try to answer the following questions for each species in both pre-settlement and post-settlement times when applicable.

a. What is (was) the abundance and distribution of each grazing species?

b. When were the animals present in the landscape (within the "general vicinity" of the Natural Area)?

c. What is (was) the seasonal pattern of grazing in the general vicinity of the Natural Area?

d. What plant species are (were) most likely used for forage by each grazing species? What is known about the effect on each forage species?

e. What is known about the response of forage species to the timing, frequency, duration and intensity of each grazing species?

f. What effects did grazing have on non-forage species, including ground-dwelling lichens and mosses?

h. What are (were) the physical impacts of grazing on the Natural Area or the element occurrence (e.g., soil erosion patterns and rates, soil compaction, structural changes in the vegetation, nutrient inputs, streambank morphology, runoff, infiltration, erosion, and hydrologic regime)?

Significant differences within any paired response (pre and post settlement) warrants further consideration and should signal that a change in current grazing practices may be necessary.

3. Management actions needed

If you determine that grazing is an inappropriate or undesirable use, and that it should be eliminated or reduced, a number of on-the-ground management options are available, including:

- -permanent and drop fencing,
- -shifting season of grazing,
- -change in stocking level,
- -location of water and/or salt,
- -resting period,
- -vegetation or soil rehabilitation.

Consult your respective resource specialists (e.g., range conservationists, range biologists, plant ecologists, botanists) regarding site-specific tactics. If grazing is continued, detailed records should be kept on timing and duration of grazing. If possible, exclosures should be established to measure effects.

There also may be cases where management practices have increased native grazing populations, resulting in detrimental effects on the element occurrences. You may need to consider management actions to deal with this.

E. Fire management

Many parts of Oregon and Washington were historically and are currently affected by fire. In most cases allowing natural fires to burn will not be appropriate or possible. Your agency may have specific guidelines for developing fire management plans. Issues you need to consider include: 1) role of fire as a natural ecological process in maintenance of element occurrences; 2) fire protection needs and requirements affecting the Natural Area; and, 3) post-wildfire management.

1. State the agency policy

2. Current and needed information

To evaluate fire management issues and needs for your Natural Area, you need to:

a. describe the pre-settlement and current role of fire in the Natural Area. Include the season, ignition sources, frequency, and intensity of fires. Identify the reasons for any differences between the pre-settlement and current conditions;

b. describe how the pre-settlement and current fire regimes affect the elements on the Natural Area. Describe conditions of the elements that are a result of the differences between the current and historic regimes;

c. describe the condition of fuels at the site. Are the fuel loads today higher or lower? Describe how the fuels are distributed -- are there hotspots of fuel that should be reduced;

d. identify the agencies and people responsible for fire suppression and what fire suppression practices and equipment would most likely be used in the case of a wildfire;

e. determine the constraints to fire management in the area (i.e., smoke management, personnel, topography, access);

f. identify existing fire breaks and access that could be used for fire suppression; and

g. identify surrounding land uses that might increase chances of human induced fire (e.g. timber management, camping);

3. Management actions needed

a. <u>Fire Suppression and Post Fire Management</u>: The fire suppression plan should identify suppression techniques which minimize potential damage to the element occurrences within the Natural Area. Outline actions that could be taken to minimize the risks of catastrophic wildfires (ie. fuel reduction) and the need for intensive fire suppression activities (ie. developing fire breaks around the Natural Area).

The suppression plan should include information and be organized to be useful to suppression teams in the field. Good maps and/or air photos with visual as well as verbal descriptions of access points, fences, hazards, natural fire breaks, and fuels should be included along with a brief description of the preferred fire suppression actions. You should also include the names, addresses and phone numbers of important resource people (yourself, the fire specialist that has seen the site, neighbors, etc.).

b. Post-fire Management: Following wildfires or prescribed fires, the Natural Area should be allowed to regenerate without human intervention. All other forms of post-fire management should be undertaken only after consultation with the Natural Area coordinator or the Pacific Northwest Interagency Natural Area Committee.

c. Prescribing fire: Fire frequencies have been reduced in many areas due to suppression activities and/or the reduction of surrounding fuels. Use of let-burn policies will generally not be possible in the Natural Areas due to constraints of surrounding land uses. Even with a let-burn policy you may not be able to achieve a natural fire frequency. In most cases it will be necessary to conduct prescribed fires. You should include three levels of prescribed fire management planning: individual prescribed burn planning, site fire management planning and fire management program planning. The following information should be included in these planning documents.

1) The prescribed burn planning document should:

a) describe where the burn is to be conducted (site,unit name, maps, legal description, size, ownership);

b) describe what the unit looks like (topography, slope, aspect, soils, vegetation, fuels tonnage, duff and litter depths, fuel type);

c) state objectives for the element occurrence and how fire will help meet these objectives;

d) specify objectives of the planned burn;e) describe necessary fire conditions (flame length,height, fuel consumption);

f) prescribe the season, time of day, temperature, relative humidity, wind speed, and smoke management conditions;

g) describe fuel breaks, and ignition patterns;

h) list the crew;

i) list equipment;

j) describe site preparation;

k) plan for communications and public relations; and,

l) describe contingency plan (what are the likely escape scenarios and how would you respond).

2) The site fire management plan should:

a) identify the fire units;

b) establish a schedule of burn treatments;

c) provide the rationale for timing and frequency of burn treatments.

3) Fire management program planning should identify:

a) equipment needs;

b) staffing needs; and

c) training needs.

F. Public use

Public use is a broad topic and in this section includes such activities as hiking, camping, biking, stock-use, and research and education. Each agency will have guidelines for these uses. Public uses, excluding research and education, should be discouraged in Natural Areas. However, some agencies allow certain forms of public use as long as they do not degrade the element occurrences of the Natural Area. It is very difficult to determine when a use is compromising the overall objectives in time to do something about it. It is best to take a conservative approach to recreation use in natural areas. Some general comments on types of public uses follow:

<u>Hiking</u> should be restricted to already existing trails. Trails often exist prior to the establishment of Natural Areas. Maintenance of these trails should be kept to a minimum necessary for safety and protection of the Natural Area. Building new trails other than for research or education use should be prohibited.

<u>Camping</u> should be prohibited.

<u>Biking</u> with mountain bikes is a relatively new phenomenon. They are prohibited in Wilderness and also should be in Natural Areas.

<u>Stock-use</u> associated with recreational activities should be prohibited. If stock-use trails exist in a Natural Area and access cannot be denied, then stock should be prohibited from grazing or overnighting within Natural Area boundaries.

<u>Research and education</u> use should not be destructive to the Natural Area values. Though often difficult, it is very important to document what use is being made, when, by how many people, and where.

1. State the agency policies for all relevant public uses.

2. Current and needed information

<u>Hiking and Trails</u>. A map of all trails should be made. What type of trails are they, when were they built, how often are they checked? How many people use them? Is there erosion on them? Do people hike off the trails? Is any element occurrence or part of the Natural Area being degraded by they hiking trail? Are there trails outside the natural area that might encourage people to traverse into the area?

<u>Camping</u>. Have people camped in the Natural Area? Are signs posted to discourage camping? Do camping places exist. Are there campgrounds adjacent to the Natural Area. Do they appear to be encouraging recreational use within the Natural Area?

<u>Biking</u>. Is there ready access for mountain bikes? Are there signs of mountain bike use?

<u>ORV</u> use should be prohibited at all times. Commercial <u>activities</u> such as clamming, fern gathering, etc. should generally be discouraged.

Stock-use. What kinds of stock use the area, how much, and what time of year? Are stock grazing or overnighting in the Natural Area? Is there an alternate access route to the stock destination?

Education and Research. Who has or is using the area for research and education? How big are the groups, how often do they come, what level of education do they represent? Is there a research proposal? Do the users check in with the local field office? Is there a tracking system for following education and research use? What research needs and opportunities are there in the Natural Area? This section also provides an opportunity to discuss research needs.

3. Management actions needed

Hiking, trails, camping, biking. Adverse effects from these kinds of uses are often difficult to detect before damage has occurred, and very often once public use patterns are established they are very hard to change. Work with recreation planners. If public use is other than very incidental, at the very least monitoring at the element level should immediately begin. Signs explaining the purpose of the Natural Area and how it can help management are sometimes effective. You can reduce accessibility by blocking unneeded roads and trails.

Stock-use. If stock-use is a problem, users and managers need to work together to solve it. Alternate routes should be explored. If alternatives are not possible, stock should be prohibited from resting or grazing in the Natural Area. Signs or fences may be necessary.

Research and education. There are numerous possibilities for research on Natural Areas. Basic work should be encouraged - floral and faunal surveys, soils information, temperature/precipitation data, vegetation mapping. Managers may have resource questions that could be answered by research on the Natural Area. It is very useful to list these kinds of opportunities even if they appear "pie-in-the-sky". Research uses should be actively encouraged as long as they do not compromise the Natural Area values and objectives.

Research proposals should be reviewed on a case by case basis. Efforts should be made to minimize effects of the research on the Natural Area, eliminate conflicts between research projects and provide the best information about the Natural Area and the research question. Potentially impacting activities associated with research, such as clipping of vegetation, use of increment borers, temporary shelters for instrumentation, flagging, permanent markers to relocate long-term plots, and tagging trees are permissible but should be reviewed on a case by case basis.

In the past only college or graduate level educational use has been encouraged. Given the importance of Natural Areas and the importance of educating children to wise natural resource management, educational use below the college level could be encouraged only on a limited basis. This is especially true if a Natural Area is near a town or populated area. Such use should be carefully monitored. Because of the possibility of negative impacts, well-defined guidelines for use need to be considered. An agency field person should always participate in group field trips. Care must be taken not to disturb ongoing research and to instruct young people why a "gentle touch" is required in Natural Areas.

G. Roads and utility rights-of-way

Generally, roads should be prohibited in Natural Areas, though many Natural Areas have existing roads or unimproved tracks. Seldom is there a reason to build one after an area has been established. If roads exist, then maintenance is a management issue. Roads along the outside, especially along boundaries, can have adverse effects on the Natural Area. Utility corridors are not common but usually involve complicated agreements and easements particular to each situation. Establishment of new utility corridors should be prohibited.

1. State the agency policy

2. Current and needed information

You will need to determine what roads exist in the Natural Area. Where are they and who uses them? Is use seasonal? Are roads unimproved? Can they be made inaccessible? If there are roads outside the Natural Area are they up-slope or on a boundary? What kind of maintenance occurs? Does spraying or seeding take place? How heavily used are they? Do they pose a threat to the element(s) or the Natural Area?

If utility rights-of-way exist within a Natural Area or on adjacent lands, who is the agreement with? Do they know about the Natural Area and do they understand what its purpose is? How often and in what manner is the right-of-way maintained? Are there future plans for expanding or building new rights-of-way in the area?

3. Management actions needed

Consider closing roads. Consider altering road maintenance outside the Natural Area. Since utility-rights-of-way are rarely allowed on Natural Areas management actions will generally involve creating a network of people to keep you informed of possible adjacent developments or improvements.

H. Hunting, fishing, and trapping

The States of Oregon and Washington have jurisdiction over hunting, fishing, and trapping. Oregon Department of Fish and Wildlife (ODFW) and Washington Department of Wildlife (WDW) set seasons, fix bag limits, issue licenses, stock streams and lakes, and transplant game animals.

All of the above activities can have direct effects on Natural Areas. In general, introductions of non-native species to the Natural Area and/or fishing, hunting, and trapping of native species should be prohibited. Though federal agencies and natural area divisions of state agencies do not have much direct control over these activities, communicating your concern to ODFW or WDW may reduce potential conflict. In some cases you may be able to get introductions of non-native species, fishing, hunting, and trapping suspended or more tightly controlled.

There are biologists for each local district (ODFW) and region (WDW). Addresses for regional biologists and supervisors for both states are included in Appendix 2. State fish and wildlife biologists are good contacts for determining what native and non-native species may be hunted, fished or trapped in your area. These agencies publish hunting, trapping, and fishing regulations. In Oregon, the publication is titled Oregon Wildlife and Commercial Fishing Codes. In Washington, the publication is Game Code of Washington. These publications are available at any of the agencies' local offices or from their state offices (ODFW, P.O. Box 59, Portland, OR 97207; WDW, 600 Capitol Way, Olympia, WA 97297).

1. State the agency policies

2. Current and needed information

You will need to gather information for all hunting, fishing and trapping affecting the Natural Area. What game animals can be hunted in the Natural Area, what are the seasons and limits? Are there plans for introducing game animals or have they been introduced in the past? If so, when, sex ratios, where are they, what effect have they had on existing vegetation and riparian zones? What fur-bearing animals exist on the Natural Area? What are seasons and regulations (size, number, sex, type of traps) for trapping? What fish exist in the streams/lakes on the Natural Area, when is the fishing season, what is the limit, when and what does the department stock? Are any of these activities having a visible impact on the Natural Area? Are they affecting natural population levels or rates of reproduction?

3. Management actions needed

If, after careful consideration, you think some kinds of controls need to be set on these activities, you must communicate with the state departments.

I. Archaeology

The occurrence of archaeological values is ~~pervasive~~ extensive across public lands and is often the subject of research or management actions. Archaeological activities may vary from purely recordation surveys where no collection or excavation is performed, to intensive excavations usually focused in a confined area. Consequently, compatibility of archaeological research and management with Natural Area objectives will vary and each proposed action must be assessed by the agency. Archaeological resources are subject to vandalism and looting. Such unauthorized activities may impact Natural Area values as well as the archaeological resource. If archaeological resources occur on a Natural Area you may want to take extra measures to safeguard them.

1. State the agency policy

Archaeological research and salvage on federal lands that involves consumptive use of the resource is regulated by the Archaeological Resources Protection Act of 1979 and the National Historic Preservation Act of 1966. Through permit systems, both federal and state agencies have the authority to approve projects proposed by researchers outside the agency. As part of the permit application review process, the agencies may apply restrictive permit stipulations or exclude work from Natural Areas. If archaeological values are threatened, such as by natural erosion, then the relative merits of protecting/salvaging the archaeological values as opposed to impacts to Natural Area values must be weighed by the agency.

Threats from archaeological research and salvage are commonly limited in character, involving short-term human presence in the Natural Area and, if excavation is involved, relatively small areas of disturbance. Larger excavation projects, which rarely occur, would pose a more substantial threat and a more definite conflict.

2. Current and needed information

Are there known archaeological sites in or surrounding the Natural Area? Are there potential sites? If there are sites, what is their nature? What condition are they in? Is the archaeological resource or the Natural Area being damaged as a result of vandalism or looting?

3. Management actions needed

You will need to assess each proposal for archaeological work for its potential impact to the Natural Area values. It will then be allowed, modified, or disallowed as the situation warrants.

J. Mining

Some forms of mineral exploration and almost all mineral extraction are destructive to Natural Area values. Though rehabilitation measures are required following mining operations, no degree of restoration can recreate the natural conditions in the Natural Area. Natural Areas should be withdrawn from mineral exploration and entry, and implementation of this measure should always be explored. Practically speaking, it has been difficult to withdraw Natural Areas from mining on federal lands in the past. Short of withdrawal, you should evaluate the risks of potential conflicts with mining and define the kinds of measures that should be taken to avoid or reduce damage from mineral exploration and extraction. During the evaluation process you will likely need to contact knowledgeable sources of information, such as Mineral Leasing, Division of State Lands in Oregon (503 378-3805) and Lands and Minerals, Department of Natural Resources in Washington (206 753-5304).

1. State the agency policy

The Mining Law of 1872 provides the authority to usurp other federal land uses, including educational and research uses offered by Natural Areas. Unless specifically withdrawn from mineral entry, miners have the right to explore and exploit mineral resources on state and federal lands but not private lands. A mining plan of operation is required for any and all mining actions on Forest Service lands and for actions involving disturbance areas of more than 5 acres on BLM lands. The BLM's ACEC designation requires mining plans of operation to be submitted to the agency for approval prior to all proposed earth disturbing activities, not just for those activities disturbing more than 5 acres of surface. This designation increases the agency's discretionary authority to roughly an equivalent level as the Forest Service for resolving resource use conflicts. State agencies also have specific permit and leasing requirements.

2. Current and needed information

You should identify all potential as well as current mining activity on the Natural Area by answering the following questions:

-What, if any, minerals occur on or surrounding the Natural Area?
-Are there mining claims within the Natural Area, and if so where?
-What are the conditions of those claims?
-What kinds of assessment work have been done on the claims?
-What effects have they had on element occurrences and the Natural Area?
-What methods are used to extract those claimed minerals?
-What is the likelihood of exploration and eventual exploitation for the mineral resources present on the Natural Area (this depends on the concentration of the deposits, ease of extraction, and market conditions)?

L. Introduced species

Over the past 150 years, European settlement in the Pacific Northwest has led to the introduction and spread of many plant and animal species not previously known from Oregon and/or Washington. Some of these introduced non-native species rapidly invade both disturbed and natural habitats. You should aim to reduce or eliminate (where possible) introduced non-native populations that threaten element occurrences on the Natural Area. Considerations concerning introduced animals have also been addressed in other sections. This section focuses on introduced plant species.

1. State the agency policy, including relevant state noxious weed laws and county ordinances.

2. Current and needed information

   a. Using the comprehensive list or field survey of plant species present within the Natural Area, identify introduced species. You may want to consult published reports such as state or regional floras or weed manuals. Also, talk to university herbaria staff and county weed experts.

   b. Use the network and information sources listed above to determine which introduced species pose a serious ecological threat to the element occurrences within your Natural Area.

   c. For each introduced species that poses an existing or potential ecological threat:

      1) Obtain population counts (or estimates) and describe distributions.

      2) Map location of populations. If the species does not yet occur within the Natural Area, describe location, and distance from Natural Area.

      3) Describe the habitat characteristics. This could include: elevation, topography, aspect, slope steepness, slope position, soil type, other soil characteristics, vegetation type, successional stage, type of disturbance that creates or maintains habitat, and associated species.

      4) Determine what information and literature is available regarding the biology of the species? Consult your network.

      5) Determine what information and literature is available regarding control or management of the species? Consult your network. Focus on the techniques that have been employed, and their degree of success.

3. Management actions needed

If you determine an introduced species is threatening an element occurrence within the Natural Area, you should prepare a written control plan. This should include examining the effects of both the "no control" and control options, including short- and long-term impacts. Considerations for selecting one or more control methods should include: effectiveness, cost, secondary effects, and logistics.

NATURAL AREA MONITORING PLAN

A. Definition and Role of Monitoring

Monitoring is a procedure to gauge, check, track, or test for specified purposes. It provides information by which management actions may be evaluated and reported to others. Specifically, it addresses the question: are our management actions accomplishing element management objectives? Monitoring adds to the biological information about elements and element occurrences, enhances our knowledge about the interrelationships of various physical and biological variables, and thus increases our ability to manage Natural Areas.

Natural Area monitoring encompasses a variety of activities including making simple observations and taking notes; more intensive quantitative sampling; and review of administrative measures. All kinds of monitoring activities must include the following steps: 1) baseline information must be collected; 2) monitoring objectives must be established; 3) monitoring actions must be repeated over time using consistent standardized procedures; and 4) monitoring results must be interpreted relative to the vaseline information and the monitoring and management objectives. The success of your monitoring effort depends on the implementation of each of these steps.

B. Types of Monitoring

There are basically four types of monitoring: 1) ecological status monitoring, 2) management treatment monitoring, 3) defensibility monitoring, and 4) compliance monitoring. While distinctions between these types are not always clear, each needs to be addressed in a comprehensive monitoring plan.

1. Ecological status monitoring involves tracking species and communities relative to stated objectives. Ecological status monitoring should describe the element occurrence's status and its trend in status over time. Ecological status refers to such attributes as population size, community composition, community structure and area occupied.

2. Management treatment monitoring involves tracking the response of an element occurrence to on- and off-site management treatments. The purpose of management treatment monitoring is to assess the effectiveness of treatments. For example: management treatment monitoring would assess the ecological effects of a prescribed fire on selected species or plant community attributes. When possible, use a proper experimental design that includes untreated control areas. Whenever a management treatment is planned or anticipated it is important to establish and implement a monitoring strategy ahead of time. All on-site management treatments should be monitored. Monitoring effects of off-site management should be conducted whenever possible and prioritized by degree of potential impact.

V. MONITORING

A. Definition and Role of Monitoring

Monitoring is a procedure to gauge, check, track, or test for specified purposes. Natural Area monitoring encompasses a variety of activities including making simple observations and taking notes; more intensive quantitative sampling; and review of administrative measures.

Virtually all usages of the word "monitor" share two common traits. First, monitoring actions are repeated over time. Second, monitoring results are interpreted by comparison to a baseline. Of these two properties the most challenging and important is the establishment or record of an ecological baseline. Simply making observations or collecting data are of limited value unless they can be interpreted relative to a standard. The success of your monitoring effort is dependent upon the validity of a standard against which monitoring results can be compared.

In addition monitoring adds to the biological information about elements and element occurrences, enhances our knowledge about the interrelationships of various physical and biological variables, and thus increases our ability to manage Natural Areas. Monitoring also provides information by which management actions may be evaluated and reported to others.

In the broadest sense, monitoring compares current conditions to previous conditions as well as to stated management objectives. Specifically, it addresses the question: is our management plan accomplishing element management objectives? It will require making repeated visits or samples and keeping the data documented, consistent and easily retrievable. The longer monitoring is performed the more useful and accurate the information will be.

B. Types of Monitoring

There are basically four types of monitoring: 1) ecological status monitoring, 2) management treatment monitoring, 3) defensibility monitoring, and 4) compliance monitoring. While distinctions between these types are not hard and fast, each needs to be addressed in a comprehensive monitoring plan.

1. <u>Ecological status monitoring</u> involves tracking species and communities relative to stated objectives. Ecological status monitoring should describe the element occurrence's status and its trend in status over time. Ecological status refers to such attributes as population size, community composition, community structure and area occupied.

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3. Defensibility monitoring involves on the ground assessments of factors which affect your ability to protect the Natural Area and the element occurrences. It concerns the existing and anticipated land use within and around the Natural Area and its potential for degrading the element occurrences or their governing ecological processes. This could include inspection of fences, gates, barricades, and signs. It also involves looking for evidence of prohibited use, encroachment or degradation within the Natural Area, and changes or activities surrounding the Natural Area.

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4. Compliance monitoring requires you to inform and periodically re-contact a broad range of agencies and groups whose actions could effect your Natural Area. This involves informing all branches of your agency of the existence, location, management objectives and constraints pertaining to the Natural Area. It also involves informing other agencies that regulate actions which may affect conditions present within the Natural Area. Some actions of obvious concern include: land exchanges, road construction, right-of-way maintenance, bridge construction, right-of-way easements, noxious weed control projects, oil and gas exploration and drilling, grazing permits, actions affecting groundwater discharge or water quality, and introduction of game species. Compliance monitoring can be accomplished by:

-putting yourself on mailing lists for environmental reviews,
-networking with key individuals,
-making regular contacts with agencies,
-participating in the preparation of planning documents, and
-setting a schedule for continued contact.

C. Identifying Monitoring Needs

The following discussion outlines the chronology and relationship of activities in planning and implementing the Natural Area monitoring plan.

1. Begin by reviewing the management plan and prepare a list of monitoring needs by type of monitoring just described.

a. Review stated primary objectives for each element.

b. Review information about the element and the element occurrence. In particular, note its location, distribution, condition, and ecological requirements.

c. Review information on the element and element occurrence response to natural disturbance and management activities.

d. Review gaps or shortcomings of the information base.

e. Review available monitoring or research data, summaries and analyses.

f. Review threats to the element occurrence, Natural Area and surrounding landscape. Keep in mind that the threat assessment may provide a basis for determining monitoring needs and priorities.

2) Conduct a site inspection of the Natural Area to check and/or modify your list.

D. Writing the Monitoring Plan

You may find it convenient to summarize pertinent background information from the management plan. This could include a description of the element, distributional information, ecological information, and/or a description of threats.

1) Determine objectives. Each monitoring strategy should be organized around specific monitoring objectives. In some cases it may be necessary to develop separate strategies to address particular needs on the list. For example if: 1) check fences, 2) check signs and 3) monitor introduced species populations are all on your defensibility monitoring list, you will probably need to develop two strategies one for items 1) and 2) and one for item 3). The primary objectives identified for each element occurrence in your management plan (see section II Basis for Dedication and Setting Objectives) will serve as the basis for determining your ecological monitoring status objectives. You will have to develop additional objectives for the other monitoring needs you have identified.

2) Identify methodology. Once you have defined objectives you need to determine the appropriate methodology. The methods section should be specific enough to be easily repeated in the future. Address the following:

a) What kind(s) of observation(s) or data collection methods are required? Examples include:

* making observations/taking notes
* mapping
* photo-documentation
* measurements/sampling

b) How will data be collected? Identify if a certain expertise (botanist, hydrologist, recreation specialist, etc.) is required to collect the monitoring data.

* Will samples be taken?
* Will they be random or systematic?
* Will plots/transects be permanent?
* What standardized forms are necessary for collecting the data?

c) Location and intensity. Different portions of the Natural Area or element occurrence may require different levels of monitoring. For certain defensibility monitoring needs you may want to focus on the areas where the threats are greatest and the rates of change are expected to be highest. However, it is important to remember that if your sampling is placed subjectively it can't be used to characterize the status of the entire site. For most monitoring needs, especially ecological status monitoring it will be important to sample randomly throughout the natural area or specific strata.

d) Timing and Frequency. It is better to monitor element occurrences during certain time periods than others. Likewise some threats are more likely to occur during certain time periods than others. Focus monitoring efforts during these critical times.

Monitoring frequency should be determined by the biology of the element or nature of the threat and its potential to reduce the status of element occurrences. For example, the frequency of monitoring should be greater for an annual plant species than a forest community; for a highly invasive introduced plant species than one with slower growth and invasion rates; for an off-road vehicle problem, occurring year round than for one occurring only once a year.

e) How is the data to be documented and formatted, and where will it be stored?

f) How will the data be used or analyzed?

g) You may want to list equipment needs and outline time required and associated costs.

E. Documenting and Reporting Monitoring Results

A written report should be completed after the collection of monitoring data or a field inspection. This report can be brief but should include:

1. identification information such as the name of the surveyor, date of field work, date of report, and information on where the field data sheets and/or summarized data is stored;

2. description of changes in monitoring methodology, especially if methods modified from those described in the monitoring plan;

3. results section which summarizes the information or data;

4. discussion and interpretation of the monitoring data relative to previous or baseline data as well as to management objectives; identify current status (satisfactory, unsatisfactory or

unknown) and short- and long-term trends in status (improving, stable, declining, or unknown) and what factors appear to be influencing the observed trend;

5. suggestions regarding future management needs based on your interpretation of the short- and long-term trends; and,

6. recommendations on changes or additions to the monitoring plan based on your assessment of the adequacy of the monitoring methodology, situation (e.g., personnel, equipment, constraints, costs, options for implementation, anticipated environmental effects of action).

EXAMPLES OF ECOLOGICAL STATUS, DEFENSIBILITY AND COMPLIANCE MONITORING PLANS FOLLOW. EACH EXAMPLE VARIES SLIGHTLY IN FORMAT DEPENDING ON THE INFORMATION NEEDS FOR EACH TYPE OF MONITORING AND THE AUTHOR; THE INFORMATION IS IMPORTANT NOT THE SPECIFIC FORMAT.

ECOLOGIAL STATUS MONITORING - EXAMPLE

ELEMENT OCCURRENCE: *Limnanthes floccosa* ssp. *grandiflora*

PRESERVE: Agate Desert **SCHEDULE:** mid-late April

PREPARED: March 1990 **UPDATED:** December 1990

MONITORING HISTORY: 1990

DATA STORAGE: Data stored in C:\DATA\AGAT\DLIFL90.WK1

DESCRIPTION:

Limnanthes floccosa ssp. *grandiflora* is a low annual, 5-15 cm tall (Figure 1). It is usually branched near the base, and has relatively long, slender leaves which are completely divided into 5-9 segments; the lower segments themselves are often divided again into three segments. The entire leaf is usually under 3-4 cm long. The five yellowish to white petals are each about .5 to 1.5 cm long, as long as or slightly longer than the green sepals and have two rows of hairs near their bases. The stems and leaves have a sparse pubescence. (from Peck 1961)

Look-alikes: *Limnanthes floccosa* ssp. *grandiflora* Arroyo (LIFLGR), is distinctly less pubescent than the closely related *L. floccosa* ssp. *floccosa* which also occurs on the Agate Desert Preserve. Subspecies *floccosa* has smaller, generally more narrow and more densely clustered flowers than subspecies *grandiflora*.

Note: As of December 1986 the taxonomic status of LIFLGR was under revision. The taxon is expected to receive full species status.

ECOLOGY AND DISTRIBUTION:

Arroyo (1973) describes a complex of subspecies of *Limnanthes floccosa* from the Rogue Valley. LIFLGR occurs on an alluvial plain of the Rogue River in an area referred to as the Agate Desert, Jackson County, Oregon, where it is sympatric with the more widespread subspecies *floccosa*.

The Agate Desert lies at 1200 feet elevation and encompasses approximately 37 square miles. It is characterized by a mound and swale topography composed of shallow clayey-gravelly soils over an effectively impervious gravelly clay hardpan (Soil Conservation Service 1972). The mounds are up to a meter in height. The swales form vernal pools through winter and early spring. The two subspecies grow in concentric rings around vernal pools; subspecies *floccosa* is located on the drier, more elevated, outer ring and subspecies *grandiflora* grows in the lower, wetter, inner ring (Arroya 1973).

The mounded prairie vegetation can be broken into two distinct associations and a third ecotonal assemblage consisting of mounds, intermounds or pools, and mound-flanks, respectively. Grazing has eliminated native species from the mounds which are now dominated by introduced annual grasses including *Bromus* ssp., *Festuca* ssp., and *Taeniatherum caput-medusae*. The intermounds are dominated by *Deschampsia danthonioides, Hordeum geniculatum, Alopecuris saccatus, Lupinus micranthus,* and *Myosurus minimum*. The mound flanks are characterized by *Lasthenia californica, Trifolium depauperatum*, and *Plectritus congesta*.

LIFLGR germinates in February, begins flowering in late March to early April, and dries by late April. LIFLGR is partially autogamous while subspecies *floccosa* is highly autogamous, which combined with separate flowering time prevents significant intergradation between the subspecies (Arroyo 1973). The 3-5 nutlets produced dehisce with the calyx by late May. Jolliff (1981) found seed fill in *Limnanthes alba* to be extremely variable from year to year presumably in response to differences in precipitation. Seed fill in *Limnanthes floccosa* spp. *pumila* on Lower Table Rock is also quite variable. Observations suggest that LIFLGR is not as variable.

LIFLGR has been reported from seven sites, all within the Agate Desert region. Several sites occur within the Medford city limits and are zoned for commercial and industrial development. The Agate Desert Preserve hosts the only protected occurrence of the taxon.

CURRENT STATUS:

The Agate Desert occurrence of *Limnanthes floccosa* ssp. *grandiflora* is considered to be in fair to good condition. The population has increased over the past 5 years (Table 1). A dramatic increase in the population in 1988 followed the first year of exclusion from grazing. No population estimates were made in 1989; however the population appeared to be strong compared to the previous year and a total of 2089 plants were counted in a single 50 m^2 research plot.

The population area is probably smaller than its potential for the site due to several past impacts. The preserve was grazed prior to our acquisition in March 1987. Portions of the preserve were tracked by large, military vehicles in the 1940's. Small areas of the preserve (approximately 1000 m^2 in the northeast corner and on the west side) were scraped and flattened sometime in the past 10-30 years. A narrow shallow ditch winds through a series of pools from the center of the preserve toward the northwest. In the Spring of 1988, the City of Medford built an extension of Antelope Road at the south boundary of the preserve. The roadside ditch now intersects and partially drains a number of the pools on the preserve.

There were two wildfires on the preserve in late July and early August of 1989 that burned the east and northern portions of the preserve and approximately 75% of the LIFLGR habitat.

ELEMENT OCCURRENCE MANAGEMENT GOAL:

In order to set a management goal for the occurrence, we need a more detailed assessment of habitat suitability across the preserve as well as a better understanding of the relationship between population density and the following: (1) precipitation patterns, (2) compaction of soils, and (3) introduced species. In the interim, the following conditions will serve as "red-flags" for the population:

1) less than 1000 individuals;
2) distributed over less than 20% of the preserve;
3) average of less than 1.5 flowers/plant and/or less than 1 filled nutlets per flower; and/or
4) declining trend for more than three years.

If any combination of these conditions occur, additional management actions will be taken. These actions could include initiation of additional ecological and/or genetic research, habitat manipulation, and seed collection.

MONITORING OBJECTIVES:

1) Estimate population size (number of individuals), area, number of flowers/plant, and number of nutlets per flower.

MONITORING METHODS:

In 1990, a 30 X 30 meter grid system was set up to include the entire preserve (Figure 2). A true north compass line was established beginning 3 meters north of the surveyed southwest property corner (yellow capped rebar) on the edge of the right-of-way on Antelope road, located 0.25 miles from the intersection with Table Rock Road. A second parallel line was traversed 30 meters to the east. Two lines, 30 meters apart, were set perpendicular (true east/west) across the north/south axial cells, through the center of the preserve, 150 meters north of the initial boundary corner. At each thirty meter interval a steel spike was driven into the ground for future location and a 1.2 m long orange tipped lath stake was driven to use for sighting the location of points of the center cells that form the abscissa and ordinate of a coordinate system across the entire preserve. The grid system defines 230 cells across the preserve.

Each of the 230 cells should be surveyed for the presence of LIFLGR. Wire flags and binoculars assist in the location of cell corners. Fifteen percent of the cells where LIFLGR is present should be selected randomly and the total number of LIFLGR individuals within them counted and recorded. The number of flowers and nutlets per flower should be counted on plants in each of the sampled cells (Figure 3). For cells with more than 100 plants, 25% of plants should be randomly selected for counts of flowers and nutlets per flower. Once the plant count is completed, the subset of individual plants are selected randomly. To avoid bias in selecting plants, sample systematically across the cells in one meter swaths starting from the northwest then back and forth between the east and west side. Each individual within the swath is counted from north to south as encountered. Sampling was timed to precede curing to avoid damage to the plants.

Equipment: steel spikes (permanently installed, 80 four foot long lath stakes or PVC pipe replaced each year, sledge hammer, 50m tape, 1 roll film, Compass, data sheets, binoculars for sighting stakes, wire flags to mark macroplot corners.

LITERATURE CITED:

Arroyo, M.T.K. 1973. A taximetric study of intraspecific variation in the autogamous *Limnanthes floccosa* (Limnanthaceae). Brittonia 25:177-191,

Jolliff, G.D. 1981. Development and production of meadowfoam (*Limnanthes alba*). In: *New sources of fats and oils*, edited by E.H. Pryde, L.H. Princen, and K.D. Mukherjee, pp. 269-285.

Meinke, Robert. 1979. Threatened and endangered vascular plants of Oregon: an illustrated guide. US Fish and Wildlife Service, Portland, Oregon.

Peck, Morton E. 1961. A Manual of the Higher Plants of Oregon. Oregon State University Press. 916p.

Soil Conservation Service. 1972. Preliminary Soil Survey of Jackson County, Oregon. USDA Soil Conservation Service, Portland, Oregon.

TABLE 1. Population counts, estimates[1] and partial counts[2] for *Limnanthes floccosa* spp. *grandiflora* on the Agate Desert Preserve in Jackson County, Oregon.

	1984	1985	1986	1987	1988	1989
Number of individuals	400[1]	20	--	480	7664	2089[2]

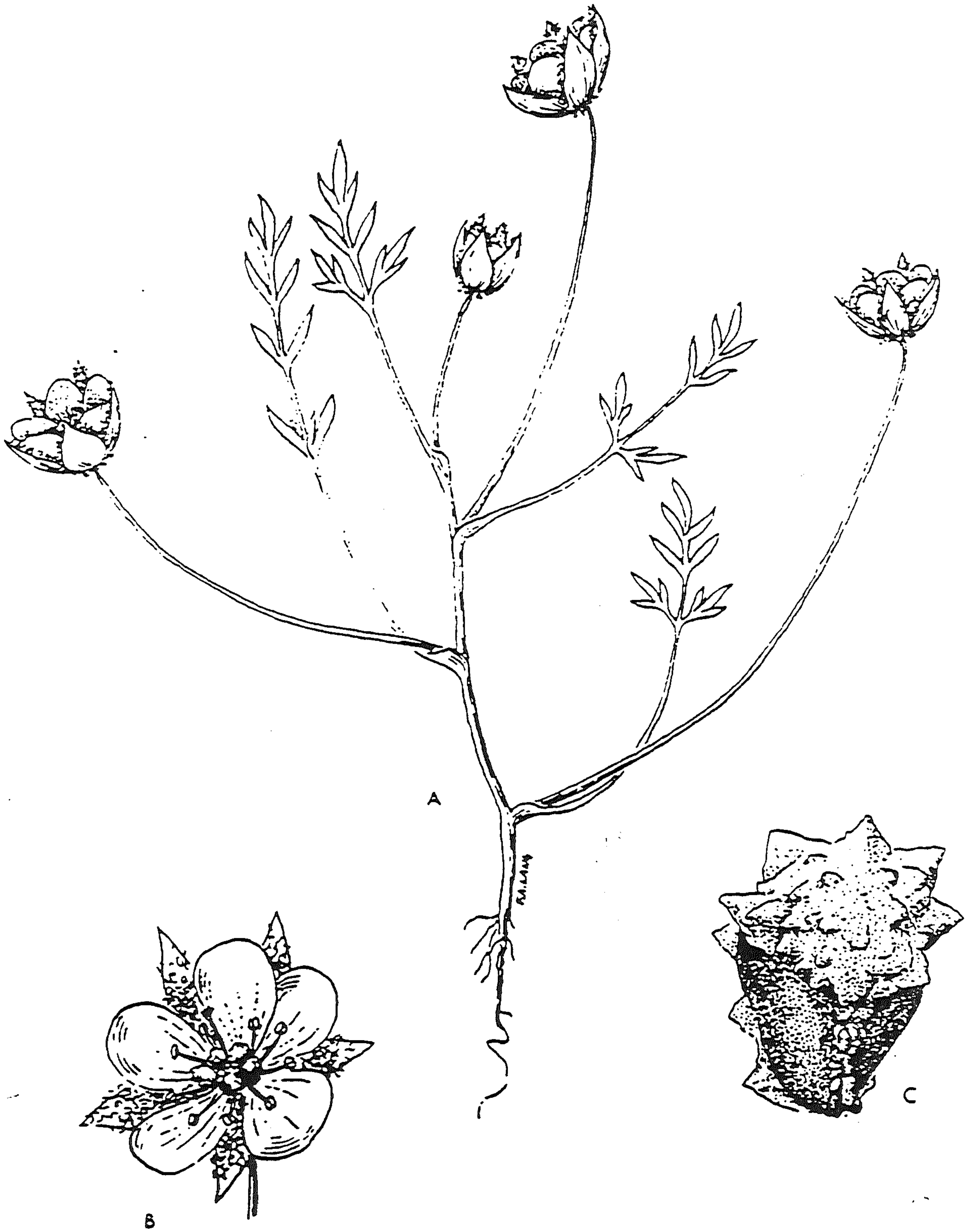

Figure 1. *Limnanthes floccosa* ssp. *grandiflora*. A: Habit, X 1.3; B: Flower, X 2.5; C: Fruit (Nutlet), X 10 (Drawn from Detling 3951, ORE). From Meinke 1979.

Agate Desert

Limnanthes floccosa ssp. *grandiflora*
Monitoring Grid

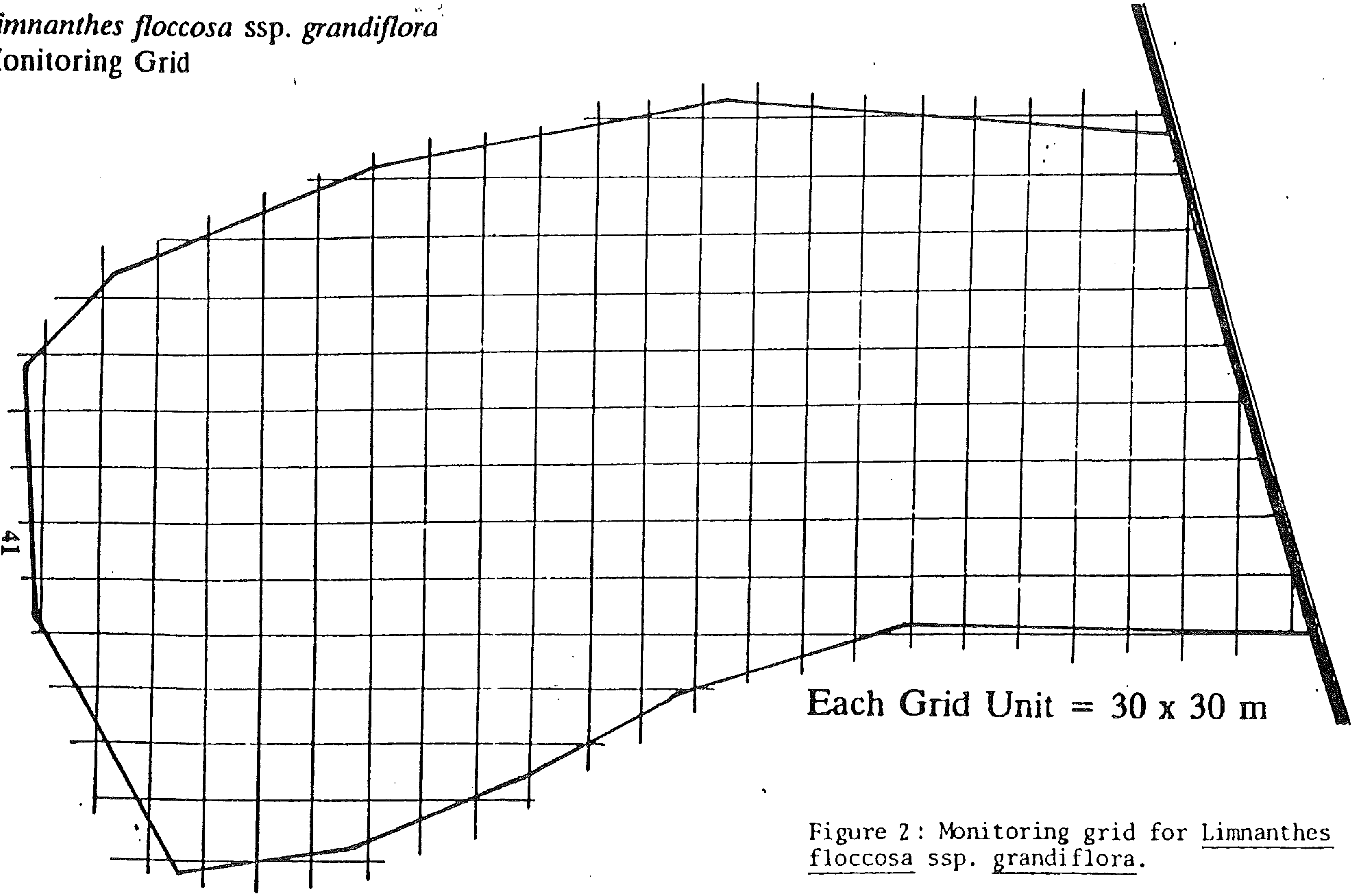

Figure 2: Monitoring grid for Limnanthes floccosa ssp. grandiflora.

Figure 3

Preserve:______________________________ Date:______________ Page ____ of ____

Element:__________________________ Macroplot:____ Observer:____________________

Notes: [1] Habitat - mound=1, flank=2, intermound=3, pool=4

Plot	Coord	Habitat[1]	Plant	#Flws	Nutlets/Flower									
					1	2	3	4	5	6	7	8	9	10

DEFENSIBILITY MONITORING - EXAMPLE

Natural Area Name: Rocky Prairie

Subjects or activities to be monitored:

1. condition of boundary fence, gates and signs
2. motorcycle or "three-wheel" ORV use
3. horse or cattle grazing
4. recreational use
5. litter or garbage dumping
6. invasion or spread of exotic plant species
7. land use activities on immediately north of and along eastern boundary

<u>1. Condition of boundary fence, gates and signs</u>

Objectives: Maintain 1 1/4 miles of perimeter fence, 6 gates and 4 signs.

Methodology:

Kind of observations or data collection methods: Visual inspection.

Type of expertise required: Knowledge of fence repair, ability to assess current land use

Location and intensity: Drive existing roads slowly to visually inspect east and west boundary fences. Walk and visually inspect north and south boundary fences.

Timing and frequency: Year around - once a month from April-September. Two times during the October-March period. Damage to fences, gates or signs could occur at any time during the year. However, human outdoor use increases as the weather improves during May, and extends (sometimes) into October. Exact scheduling to be determined by Region staff.

Data documentation, format and storage: Written descriptions of damage or theft, and needed repairs or replacement are recorded in the field on the "Site Inspection Form" ("Form").

Type of data analysis or type of use: Information reported on "Form" will describe work to be done. Natural Area Preserve Program (NAP Program) will be provided copies of all "Forms" and determine management action to be taken.

How data or information be collected: Recorded on "Form" in the field.

How data or information will be stored: "Forms" will be filed in Regional Office. Copies will be mailed to the NAP Program.

How data or information will be analyzed: Damage assessment will determine need for repair or reconstruction, staffing, materials and equipment costs. NAP Program will determine management actions to be taken.

2. Motorcycle or "three-wheel" ORV use

Objectives: Provide current, on-the-ground assessment of existing or potential damage associated with motorized vehicle use. Take management action to reduce risk to damage.

Methodology:

Kind of observations or data collection methods: Visual inspection.

Type of expertise required: Knowledge of ORV user behavior. Ability to interpret amount and type of use.

Location and intensity: This activity could occur anywhere within the Preserve. Signs of activity or damage will be most evident from one or two entry points (fence breaks or cuts). Identify precise location (for relocation by others) on aerial photograph or topographic map attached to "Form". Follow observed, recent tracks within the Preserve.

Timing and frequency: Damage could occur at any time during the year. However, human outdoor use increases as the weather improves during May, and extends (sometimes) into October. Once a month during the period April-September. At least two inspections during the period (October-March). Do not "bunch" site inspections closely together. Exact scheduling to be determined by Region staff.

Data documentation, format and storage: Written descriptions of damage and needed repairs or replacement are recorded in the field on the "Form". Forms will be stored in Regional Office. Copies will be mailed to the NAP Program.

Type of data analysis or type of use: Using "Forms" and consulting with Region field staff, damage assessment by the NAP Program will determine need for repair or reconstruction, staffing, materials and equipment costs.

3. Horse or cattle grazing

Objectives: Provide current, on-the-ground assessment of existing or potential damage associated with horse or cattle grazing or seasonal herding. Take management action to reduce risk to damage.

Methodology:

Kind of observations or data collection methods: Visual inspection.

Type of expertise required: Familiarity with cattle and horse utilization patterns. Ability to detect amount and type of use.

Location and intensity: This activity could occur anywhere in the Preserve, but would most likely be evident around gates or near fences. No open water exists in the Preserve. Identify precise location (for relocation by others) on aerial photograph or topographic map attached to Form.

Timing and frequency: Damage could occur at any time during the year. However, human outdoor use increases as the weather improves during May, and extends (sometimes) into October. Once a month during the period April-September. At least two inspections during the period (October-March). Do not "bunch" site inspections closely together. Exact scheduling to be determined by Region staff.

Data documentation, format and storage: Written descriptions of damage and needed repairs or replacement are recorded in the field on the "Form". Forms will be stored in Regional Office. Copies will be mailed to the NAP Program.

Type of data analysis or type of use: Using "Forms" and consulting with Region field staff, damage assessment by the NAP Program will determine need for repair or reconstruction, staffing, materials and equipment costs.

4. Recreational use

Objectives: Provide current, on-the-ground assessment of existing or potential damage associated with recreational use. Take management action to reduce risk to damage.

Methodology:

Kind of observations or data collection methods: Visual inspection.

Type of expertise required: Familiarity with recreational activities likely to be encountered. Ability to detect amount and type of use.

Location and intensity: This activity could occur anywhere within the Preserve, but most likely would occur in areas that are visually obstructed from the boundary roads. Identify precise location (for relocation by others) on aerial photograph or topographic map attached to Form.

Timing and frequency: Damage could occur at any time during the year. However, human outdoor use increases as the weather improves during May, and extends (sometimes) into October. Once a month during the period April-September. At least two inspections during the period (October-March). Do not "bunch" site inspections closely together. Exact scheduling to be determined by Region staff.

Data documentation, format and storage: Written descriptions of damage and needed repairs or replacement are recorded in the field on the "Form". Forms will be stored in Regional Office. Copies will be mailed to the NAP Program.

Type of data analysis or type of use: Using "Forms" and consulting with Region field staff, damage assessment by the NAP Program will determine need for repair or reconstruction, staffing, materials and equipment costs.

5. Litter or garbage dumping:

Objectives: Detect and remove garbage.

Methodology:

Kind of observations or data collection methods: Visual inspection.

Type of expertise required: Tenacity. Willingness to "do a good job", however menial.

Location and intensity: This activity could occur anywhere within the Preserve, but most likely would occur in easily accessable areas around fences and gates. Identify precise location (for relocation by others) on aerial photograph or topographic map attached to Form.

Timing and frequency: Damage could occur at any time during the year. However, human outdoor use increases as the weather improves during May, and extends (sometimes) into October. Once a month during the period April-September. At least two inspections during the period (October-March). Do not "bunch" site inspections closely together. Exact scheduling to be determined by Region staff.

Data documentation, format and storage: Written descriptions of amount and type of garbage, and recommended management remedy are recorded in the field on the "Form". Forms will be stored in Regional Office. Copies will be mailed to the NAP Program.

Type of data analysis or type of use: In normal situations, Region staff will determine how to remove garbage based on amount, type and location. The NAP Program will be consulted whenever a major project is anticipated.

Invasion or spread of exotic plant species:

Objectives: Locate and track changes in abundance and distribution of Scotch broom, gorse, mouse-ear hawkweed and spotted knapweed.

Methodology:

Kind of observations or data collection methods: Visual inspections. Map populations, measure area covered for each species, and provide estimate of population size or conduct a count of individual plants.

Type of expertise required: Be familiar with field identification of all four species. Have knowledge of mapping and sampling techniques.

Location and intensity: Inspect entire Preserve. Be extremely rigorous in and around known populations. Two highly invasive species occur within the Natural Area. Scotch broom (Cytisus scoparius) occurs in moderate abundance in the northern 10% and southern 5% of the site, and sporadically throughout the entire site. Mouse-ear hawkweed (Hieracium pilosella) occurs over 1/8 acre area in the "north swale". Immediately adjacent to the Preserve, two additional invasive species are known to occur within 50 yards of the Preserve boundary along the highway right of way and immediate environs: gorse (Ulex europeus), and spotted knapweed (Centaurea maculosa).

Timing and frequency: Each of the four species is most easily identified in June. However, earlier detection and mapping will increase the chance of effective control or containment within the same year. The NAP Program should do this work in May of each year. Late May or early June reconnaissance would probably be adequate during years with cool and/or overcast springs.

Data documentation, format and storage: Record population data on data sheets. Draw large-scale map of distribution on photomap attached to Form. Forms are stored in Regional Office. Copies are mailed to the NAP Program. The NAP Program will determine method of weed control and be responsible for on-the-ground implementation.

Type of data analysis or type of use: Pre- and post treatment population size and distribution data will be collected by the NAP Program. Treatment effectiveness will be assessed 1-4 weeks after the treatment (depending on method). The NAP Program will analyze changes in population abundance and effectiveness of management treatments (if any) and incorporate findings into Preserve management plan.

7. Adjacent land use:

Objectives: Be able to anticipate potentially damaging activities before they occur within the Preserve.

Methodology:

Kind of observations or data collection methods: Visual inspection

Type of expertise required: Familiarity with land use activities and patterns within the region.

Location and intensity: These activities are occuring outside of the Preserve, but could directly or indirectly have impacts on ecological processes or conditions within the Preserve.

Timing and frequency: Potential adverse activity could occur any time during the year. However, in the absence of known, specific threats, observations should be recorded at the same time that boundary conditions are monitored.

Data documentation, format and storage: Written descriptions of amount and type, location and pattern of use and suggested remedies to counter undesired use or trends is recorded in the field on the "Form". Forms will be stored in Regional Office. Copies will be mailed to the NAP Program.

Type of data analysis or type of use: The NAP Program will assess adjacent use and trends and consult with the Region to determine if management action is needed

COMPLIANCE MONITORING - EXAMPLE

Natural Area Name: Metolius RNA

The Metolius Research Natural Area (RNA) was established in 1931 to preserve an example of the interior ponderosa pine forest that covers(ed) much of central Oregon. Both ponderosa pine/bitterbrush and ponderosa pine-Douglas-fir/manzanita communities are typified in the RNA. The overriding management objective is to allow natural processes to take place without undue intervention by humans.

Subjects or activities to be monitored:

1. Within agency:
   a. engineering
   b. fire
   c. minerals
   d. insects/disease
   e. recreation
2. Utility company, power line maintenance
3. Deschutes County road maintenance
4. Oregon Department Fish and Wildlife
5. Public

[Any compliance monitoring activities, phone calls or personal contacts related to 1-5, need to be documented. Information on who was contacted, position, date, phone number, and pertinent information should be noted and kept in RNA file. Compliance monitoring should be summarized and evaluated on an annual basis.]

<u>1a. Engineering at district: FS road maintenance</u>

The objective is to make sure no projects are planned adjacent to the RNA without the Coordinator's knowledge and that planned projects do not effect the integrity of the RNA.

METHODS AND TIMING: RNA coordinator should make sure District engineering people know about and have a map of the three FS dirt roads that lie on the north, east and south boundaries of the RNA. Engineering shop should contact RNA coordinator (or responsible individual on district) whenever any road maintenance is to occur.

Regardless of any planned activity RNA coordinator should check with engineering every spring and fall. Pertinent information might include planned road maintenence, documentation of illegal road use, condition of road, etc.

1b. Fire

The objectives are to 1) comply with the fire suppression plan for using prescribed fire in the RNA and 2) comply with fire suppression plan for use of prescribed burning outside but adjacent to the RNA.

METHODS AND TIMING: There is a fire management plan for the Metolius RNA that seeks to reintroduce wildfire (via planned and unplanned ignitions) into the RNA. Compliance monitoring should be part of any fire suppression plan for the RNA and any fire suppresion plans for fires outside but adjacent to the RNA.

1c. Minerals, gas, geothermal

The objective is to protect the RNA from any mining activities outside the RNA that might compromise the management objectives for the RNA.

METHODS AND TIMING: RNA coordinator should make sure District and SO Minerals shops know about the existence of and have a map of the RNA. The RNA is withdrawn from mineral entry, nevertheless exploration outside the RNA could have possible adverse effects within the RNA. Regardless of any planned outside activity, RNA Coordinator should check with the minerals shop on a yearly basis. Pertinent information might include data on nearby active claims or potential for new claims nearby.

If activity is planned outside the RNA, then RNA Coordinator should contact company or individual involved. The company or person should be made aware of the RNA, its management objectives, and boundaries. Scientific input may be required at this point. The RNA Coorindator will need to make sure the activity planned by the company or individual and any mitigation measures required by the District comply with RNA objectives. This will involve clear documentation of contacts made, who, when, what was said and agreed upon.

1d. Insects/pathogens

The objectives are 1) to protect, in so far as possible, the RNA against the introduction of non-native insects or pathogens, and 2) to detect and document any natural insect or pathogen outbreak as early as possible.

METHODS AND TIMING: RNA coordinator should make sure relevant people on the district are aware of the existence of and have a map of the RNA. These people need to alert RNA Coorindator of any planned spraying activities or hand treatment of insects and/or pathogens outside the RNA. RNA Coordinator should check in yearly with this shop. Pertinent information might include location of nearest pest/disease outbreak, type, extent, proposed treatment, potential effects on RNA, etc.

1e. Recreation

The objective is to prevent recreation-use damage on the RNA.

METHODS AND TIMING: RNA Coordinator should make sure recreation people in the District know about the existence of and have a map of the RNA, and are aware of RNA management direction vis a vis recreation. Coordinator should check in annually, probably during the winter, with recreation staff to make sure no recreation activities are planned within the RNA or that any adjacent activities do not compromise the integrity of the RNA.

Compliance with the special order to close the entire RNA, all seasons, to all types of motorized vehicle use should be monitored at least twice a year. Snowmobile use will be the most likely infraction so recreation people should be reminded to check several times during this season.

2. Utility company, rights-of-way

The objective is to make sure all power companies are aware of the existence of the RNA.

METHODS AND TIMING: A powerline runs along the west side of County/FS road 14. Though this line is not within the RNA, the power company should be notified of the existence of the RNA and given a copy of the RNA's management plan. The RNA Coordinator should request the company get in touch if any relocation of the powerline is planned. Coodinator should check in with the power company annually. Pertinent information might include future maintenance, type, duration, timing, etc.

3. Deschutes County road department

The objective is to make sure the Deschutes County Road department knows about the existence of the RNA.

METHODS AND TIMING: The Deschutes County road department needs to be made aware of the existence of the RNA and should have a map of the RNA, especially in relation to County/FS road 14. Any plans for spraying, clearing, cutting, plowing, repaving, etc. could

Initial Assessment of Soils for a Forest Stand Structure Study, Monument Canyon Research Natural Area, Jemez Mountains, New Mexico

SUBTITLE:
A Forest ECOLOGIST
GOES UNDERGROUND...

Mary Stuever
Soils Project, University of New Mexico
Soil Morphology & Classification
Dr. Les McFadden, December 1995

LABORATORY OF TREE-RING RESEARCH

Date ______ Page ______ of ______

Species PIPO Collection date ______ Sample type: cores ___ Xsections ___ Other ___

Site ID, Location Monument Canyon RNA Collector(s) ______

X-sections taken for age structure Dating By ______

SPECIMEN ID Field	Lab.	~~Core~~ Pith ~~Lnth~~	# rings est. pith	T	Inner year	outer ~~Last~~ year	poss. death date ~~Ty-C~~	*MEASURING* Interval	by	Remarks, comments, observations micro rings, absent rings, etc.
D1-102B		1666				1753				much missing on outside – not death date
E1 200B		1637				1920	✓			fs ~ 1847; poss death date
A3-103B					1752	1957	✓			probably close to death date
E1-103B		1661				1953	✓			1950's death date
E1-102		1661				1769				
A6-102A		1647	12		1659	1773				
D1-100		1661				1711				>50 rings on this sample
A6-100		1573				1900	✓			death date ~1900
A2-103		1605				1793				not death date
A2-100		1667				1782	✓			poss death date
A3-101		1694				1943	✓			poss. death date
A5-100		1627				1771				really rotten around edge – prob. not death date
E1-100A		1650				1756				" " "
E1-101		1653				1761				" " "
D1-102A		1656				1729				Not death date
A6-101		1568				1703				
E1-100B		1731				1945	✓			
D1-101B					1650	1773				Not death date
A3-102		1668			1756					
E1-200		1621				1826				
D1-200		1673				1942	✓			poss. death date
A3-100		1695 ?				1753				not death date
A6-102B		1582				1700				not death date
A5101B		1619				1801	✓			probable death date

7-5-96

SITE Monument Canyon - saplings in D2
RNA

Sample number	inner ring	ring count	est # missing	date of injury	comments
D2-50		9			
51		7			
52		6			
53		14			
54		14			
55		13			
56		12			
57		17			
58		17			
59		15			
60		15			
61		22			
62		14			
63		16			
64		13			
65		18			
66		60			
67		57			
68		14			
69		10			
70		5			
71					
72		22			
73		6			
74		5			
75		13			
76		3			
77		75			
78		55			
79		46			
80		21			

7-5-96

SITE Monument Canyon - saplings in C2

RNA

Sample number	inner ring	ring count	est # missing	date of injury	comments
C2-1		20			
2		23			
3		15			
4		20			
5		25			
6		13			
7		13			
8		20			
9		10			
10		45			

X = not entered

LABORATORY OF TREE-RING RESEARCH

Date ______ Page ______ of ______

Species ______ Collection date ______ Sample type: cores X Xsections ___ Other ______

Site ID, Location Monument Canyon Natural Research Area (MCA) Collector(s) ______

Dating By Mariette Seklecki

SPECIMEN ID Field	Lab.	Core Lnth	est. pith	T	Inner year	Last year	Ty (not entered)	C	MEASURING Interval	by	Remarks, comments, observations micro rings, absent rings, etc.
G1 08	✓		1639		1649	1995					
09			1915		1916	1995					
03			1886		1891	1995					
07			1880		1888	1995					
10			—		1914 P	1995					
02			1737		1761	1995					missing 1880
01			1732		1746	1995					missing 10's rings from 1957 out - very suppressed
04			1778		1785	1995					
D1 06	✓		1710		1726	1995					
07	↓		1919		1935	1995					
08					Undateable		X				missing inner 11 cm
10			1748		1766	1995					
13			1826		1834	1995					
14			1824		1827	1995					
15			1920		1932	1995					
* 50			1695		1707	1995					
D2 09	✓		1636		1643	1995					
D1 12	✓		1833		1843	1995					
01			1826		1835	1995					
17			1902		1906	1995					
16			1712		1723	1995					
D2 01	✓		1878		1888	1995					
D1 21	✓		1904		1913	1995					
* 51			1920		1934	1995					
D2 03	✓		1868		1884	1995					
04			1633		1643	1995					
05			1663		1686	1995					
D1 20B	(20) ✓		—		1607 P	1995					
D2 06	✓		1670		1674	1995					
08			1630		1648	1995					

✓ MOC X = not entered

LABORATORY OF TREE-RING RESEARCH

(1)

Site Monument Canyon Research Natural Area   Collection date Fall 1995

Species PIPO   Collector

Specimen Number: Field	Lab.	Species	Core no.	Core length	Dating: Inner-most	Bark year	Dated by	Not entered Ctd. by	Estimated pith: number of rings	New inside date	Remarks
D2		PIPO	30		1930	1995	SD		~25		
			31		1927				10	1917	suppressed on inside
			32		1921				7		v small core (~2"); suppressed
			33		1945			X	not close to center	1945	v. bad core; injury, rxn wood, resin
			34		1909				—	1909	
			35A		1954			X	12		v. suppressed on inside
			35B		1953				16		" "
			36		1929				7		rxn wood
			37		1942				16		suppressed
			38		1930				13		suppressed
			39		1957				18		v. suppressed on inside
			40	No core							
			41		1917				5		" "
			42		1929				10		
			43		1919				8		
			44		1919				6		large rings on inside Then suppressed (early 20's)
			45		1974?				10		V. suppressed on outside ~1980's
			46		1939				6.		V. suppressed Throughout

LABORATORY OF TREE-RING RESEARCH

(2)

Site Monument Canyon MOC

Collection date Fall 1995

Species

Collector

Specimen Number: Field	Lab.	Species	Core no.	Core length	Dating: Inner-most	Dating: Bark year	Dated by	~~Cld.~~ not entered by	Estimated pith: number of rings	Estimated pith: New inside date	Remarks
D3		PIPO	01A		1857	1995	SD	X			Too far from center to determin
			01B		1842				14		V.suppressed 71970
			02		1863				9		
			03		1839				6		
			04		1807					1807	
			05		1838				8		V.suppressed 71950
			06		1878				12		
			07		1809				5		
			08		1881				6		
			09		1836					1836	
			10		1623	√1930		X			Dead ?
			11		1659			X	Too far from center	1659	V.suppressed 7 1950
			12		1831				10	1821	
			13		1832			X	Too far from center		
			14		1828				~10		
			15		1838				5	1833	
			16	2 pieces	1620				15		many missing rings 71950
			17		1885				8		
			18		1881				10		

LABORATORY OF TREE-RING RESEARCH

(3)

Site Monument Canyon MOC

Collection date Fall 1995

Species PIPO

Collector

Specimen Number: Field	Lab.	Species	Core no.	Core length	Dating: Inner-most	Bark year	Dated by	no entered Ctd. by	Estimated pith: number of rings	New inside date	Remarks
D3	continued	PIPO	19	no core		1995	SP	X			
			20		1658				10		v. suppressed >1950
			21		1855				14		
D4			01		1755				8		
			02		1903				~25		
			03		1834				2		
			04		1861				16		
There are 2 trees labeled 5A + 5B	(1)		05A		1821				—	1821	
	(2)		05B		1827			X	5	1822	
	(3)	relabeled	05A		1817				6		
	(4)		05B		1835			X	12		
			06A		1818				7		
			06B		1888			X	not near center	1888	
			07		1873				13		
*			08A		1690				10		only major dates put on this V. suppressed in several places
			08B	?	1843			X	No where near center		v. suppressed >1950
			09A		1664			X	Not near center		several breaks- piece(s) missing?
There are 2) 9B's	(1)		09B		1696			~	12		v. suppressed >1970
but they may not be the same tree	(2)		9B		1750			X	not near center		" "

Site Monument Canyon MOC Collection date Fall 1995

Species PIPO Collector

Specimen Number: Field	Lab.	Species	Core no.	Core length	Dating: Inner-most	Bark year	Dated by	~~Chd.~~ not entered by	Estimated pith: number of rings	New inside date	Remarks
D4		PIPO	10A		1673	1995	SD		10	1663	did not prick - difficult to date props up this
			11A		1048			X	Not real center		
			11B		<1680			X	BAD		BAD goes into late 1700's but there's a scar/or burned
			12A		1637			X	Not near center		v. suppressed throughout + burned
			12B		1638			X	"		v. suppressed "
			13		1683				7		
			14		1682				3		
			15A		~1860			X	–		several scars on inside - not going to get ~~too~~ close to pith date
			15B		1859				6		
			16A		1680			X	Not near center		
			16B		1651			X	Not near to center		
			17		1838				12		fire scar? in early 1870's
			18		1650				14		
			19A		1657			X	~20	1637	injury ~1662 (fs?)
			19B		1647				15	1632	v. suppressed >1880
			20		1631				15		v. suppressed throughout

SITE Monument Canyon RNA

X-sections

Sample number A1	inner ring	ring count	est # missing	date of injury	comments
8	1918				
6	1922				
1	1918				
4	1920				
9	1922				
23	1918	62			
22	< 1918?	66			
12	1918?	59			
14		68			
21	1918	70			
16		48			
19		40 ??			
11	1918	60			
17	1918?	68			
7	1920	72			
3		52			
5	1924	54			many missing on outside
2	1926	54			
10		56			
15	1913	73			
22	1916	71			
18	1910	66			injury 1959/1960 ?
13	1912	62			

SITE Monument Canyon RNA

X Sections

Sample number A2	inner ring	ring count	est # missing	date of injury	comments
20	1917	77			
3		63			
11		~60			injury on inside, suppression – looks dead
8		53		>2"	forget it
15		48		"	yuk
2		61			
14		52			
1		54			
12		72			
7		51		>2"	
18		>50		"	
17	1932	>60			
ADD 13	1924	63			
6		~45			
10		54			
9		40			
5		61			
19	1921	69			
16		72			

SITE Monument Canyon RNA

x-sections

Sample number A3	inner ring (iffy)	ring count	est # missing	date of injury	comments
12	1918?	67	2		
17	1913				injuries @ 1954, 1973 or 1974
18	1928	72			
14	1926	67			
16	1921	76			
15	1930	55			
19	1930	46			
20	1927	68			
5		59			
6		63			
9	1928	62			
11	1925	66			
7		>45?			These are all v. small
4		>40			in diameter
8		60?			(<2")
3		58			
10		40			
1		40			
ADD 13		43			

SITE Monument Canyon

x-sections

very "iffy"

Sample number A4	inner ring	ring count	est # missing	date of injury	comments
2	1920	65	~10 on outside		
17		53			
19		64			
9	1926	69			
12	1947	45			
5		43			lots of rxn wood
13	1924	68			
11		>40			rings v. suppressed
20	1934	65			
18	1916	67	20		
7	1918	64			
4	1924	70			
15	1929	66			
14	1920	72			
3	1938	52			
6	1911	63			
10	1938	50			
8		54			
1		~50			
16	1916	61	2-3 inside 25 outside		

SITE Monument Canyon RNA

X-sections

Sample number A5	inner ring	ring count	est # missing	date of injury	comments
13	1920	74			
6		50			
17	1922	59			
1		65			
11		52			
12	1920	66			
9		59			
14		45			
16	1921	~70			
19	1921	70			
4		54			
8		80			
15		50			
* a ~~second one~~	labelled as				
AS-06	1911	82			
but not	The same as above				
ADD 3		72			
5	1920	61			
10		65			
7		50			
20	1918	76			
18		48			

SITE Monument Canyon RNA

x-sections

Sample number A6	inner ring	ring count	est # missing	date of injury	comments
10	1920	74			
8	1925	69			
4	1939	55			
11		62			
14		63			
13	1918	76			injury ~1975
5 ?		49			also labelled as A6-08
7	1926	53			
18	1921	68			
17		53			
19		53			
6		60			
12	1920	62			
TDP 5	1924	70			
20	1932	62			

SITE Monument Canyon RNA

X-sections

Sample number C1	inner ring	ring count	est # missing	date of injury	comments
3	1917	77			
10	1917	66			~10 missing on out side
8		59			
17	1928	63			most missing on outside
9	1916	78			injury 1922?
6		60			
5		40			
1		35			v. small in diameter
11		30			(<2") + hard to
2		53			even count rings
12		43			
14		68			
20		50			
15	1916	67			
16	1928	63			
4	1920	73			
18	1923	67			
7	1920	73			
13	1920	74			
19	1914	80			

SITE Monument Canyon RNA

Sample number B1	inner ring	ring count	est # missing	date of injury	comments
16	1946	48			
15	1934	56			
17	1926	69			
9	1912	80			
3	1935	59			
19		48			~1" diameter
8		57			~1" diameter
4		69			
12		56			
2		~55			
10	1922	70			
1		47			
14		58			~1" diameter
6		~35			<1" diameter
20	1923	62			
5		62			
7		55			
18	1913	81			
11	1919	66			

SITE Monument Canyon RNA

X sections

Sample number B2	inner ring	ring count	est # missing	date of injury	comments
19	1910	81			
5	1921	72			
11		71			
16		60			
9		63			
14		73			
3	1934	59			
12		59			
7	1918	76			Fire Scar in 1922? 1989/90?
20		32			
8	1925	69			
15	1931	63			
1	1922	60			
17	1932	62			
2		55			
13	1938	54			
6	1933	61			
4		~45			1" diameter
10		61			
18	1917	71			

SITE Monument Canyon RNA X-sections

Sample number B3	inner ring	ring count	est # missing	date of injury	comments
17	1912	72			
13		65			
20		67			
16	1924	~70			
13	1934	56			
6		57			~1" diameter
4		61			
10		60			
19		62			
5		59			
15	1920?	71			
8		58			
3	1918	76			
2		~62			
9		54			~1" diameter
7		~52			" "
1		~68			
18		~50			~1" diameter
14		~70			

SITE Monument Canyon RNA

X-sections

Sample number BL	inner ring	ring count	est # missing	date of injury	comments
9	1915	79			
4		62			1" diameter only
13	1909	68			
7		~50			<1" diameter
15	1919	72			
17		50			
16	1916?	78			injury ~1934
5		77			~1 1/2" diameter
8	1929	65			
10		56			1" diameter
3		56?			" "
20	1915	79			
14		51			
19	1912	82			
6		54			
18	1920	74			

SITE Monument Canyon RNA

X-sections

misc

Sample number	inner ring	ring count	est # missing	date of injury	comments
523 (114)		64			
527		32			
52		31			
520 (92)		37			
526		60			
55		36			
533		25			
521 (97)		29			
502		30			
59		45			
528		38			

FIRE HISTORY DATA SHEET

date:

name: S. Danzer

project: Monument Canyon

site: Mon. Can. Nat'l Research Area

specimen ID#: MOC 4
species: PIPO
total # scars:
inner date: 1712 type: I
outer date: type:
b=bark s=scar r=ring p=pith

observations:

	year	scar	other	f-ring pos'n 1.	scar pos'n 2	clarity	comments
1	1743		✓				injury?
2	1745	✓			ME	ok	
3	1748		✓				injury?
4	1753		✓				injury
5	1763	✓			EE	good	
6	1773	✓			EE	good	
7	1786	✓			EE	good	
8	1795	✓			EE	ok	
9	1802	✓			EE	ok	
10	1806	✓			EE	ok	
11	1813	✓			ME	ok	
12	1818	✓			EE	good	
13	1842	✓			EE	good	
14	1851	✓			ME	good	small ring
15	1870	✓			EE	ok	" "
16	1880	✓			EE?	ok	v. small ring
17	1887	✓			EE	ok	
18							
19							
20							
21							
22							
23							
24							
25							

1. ax, where a = radial growth before false ring, x = width of a : total width of ring; r = release in late wood; d = resin ducts; l = light colored latewood.

2. no false ring: Do, EE, ME, LE, La, Un; false ring: bf = before false ring, fr = at or near false ring, af = after false ring and before latewood, lw = at latewood.

CORES

DENDROCHRONOLOGICAL SAMPLE - MEASUREMENT SHEET

Site	ID	Species	ID
Monument Canyon RNA			

DATA	Width ☐	Density ☐	Cell Size ☐	Chemical Elements ☐	Isotopes ☐	Other ☐

OPERATION	START - END	OPERATORS' FULL NAME
Collecting		
Preparing		
Dating		
Measuring		

ID A6 +	Dates First	Dates Last	Dates N	Dates Micro	Dates Absent	Dates Breaks	Dates By	Pith estimate Measures First	Measures ~~Last~~	Measures N	Measures By	Comments (suppression, release, scar, false ring, core length, ...)
miscellaneous cores												
A6-153	1790											duplicate # – not near center
A6-157	1652							1636		16		many missing on outside + within not center – break in wood
29-Jesse	1931							—		—		v. pronounced false rings!!
B2-21	1926							1916		8		
C4-219	1932							1928		4		
RHP42	1899	?						1893		6	?	
RHP45	1900	?						1894		6	?	
no ID	1843							1835		8	?	
RHP94	1733							1727		6		
133	1930							1925		5		
134	1939							1923		16		
135	1931							1926		5		
136	—							—		—		bad core – dead ~1940–1970

DENDROCHRONOLOGICAL SAMPLE - MEASUREMENT SHEET

Site	ID	Species	ID
Monument Canyon RNA			

DATA	Width ☐	Density ☐	Cell Size ☐	Chemical Elements ☐	Isotopes ☐	Other ☐

OPERATION	START - END	OPERATORS' FULL NAME
Collecting		
Preparing		
Dating		
Measuring		

ID	Dates							Pith est. ~~Measures~~				Comments (suppression, release, scar, false ring, core length, ...)
	First	Last	N	Micro	Absent	Breaks	By	First	~~Last~~	N	By	
137	1916							—		—		
138	1922							—		—		
139	1925							1919		6		
140	1935							1929		6		
141	1927							—		—		
142	1959							1947		12		
143	1928							1922		6		
144	1927							—		—		
145	1942							1928		14		
146	1935							1931		4		
147	1933			1951				1929		4		
148?	1975							1962		13		wound in 1980's (85 or 86)
149	1951							1945		6		
150	1918							—		—		
151	1938							1934		4		
152	1954							1939		15		
153	1620				1667 1873 1773 1951 [illegible] 1955			1606		14		
154	1839							1825		14		
155	1859							1845		14		
34 156	1803							—		—		
157												
158	1938							1934		4		
159	1954							1946		8		
160?	1846							1826		20		Not sure of This one
161	1857			1927	1902			1841		16		bad > 1970
162	1824							1814		10		

DENDROCHRONOLOGICAL SAMPLE - MEASUREMENT SHEET

Site	ID	Species	ID
Monument Canyon RNA			

DATA	Width ☐	Density ☐	Cell Size ☐	Chemical Elements ☐	Isotopes ☐	Other ☐

OPERATION	START - END	OPERATORS' FULL NAME
Collecting		
Preparing		
Dating		
Measuring		

ID	Dates First	Last	N	Micro	Absent	Breaks	By	Pith Est ~~Measures~~ First	~~Last~~	N	By	Comments (suppression, release, scar, false ring, core length, ...)
163	1931							1924		7		
164	1935							1929		6		
165	1918							1913		5		
166	1923							1917		6		
167	1926							1919		7		
168 ?	1918							—		—		
169 ?	1943							1940		3		v. suppressed + much rxn wood
170	1938							1925		13		prob in 1970's (injury)
171												
172	1918							—		—		
173	1940							1933		7		v suppressed rxn wood, injury ~1989
174 ?	1940							1935		5		v suppressed
175	1927							1923		4		injury ~1989/1990
176	1940							1935		5		several rings missing >1970
177	1927							1921		6		
178	1832			1873								Too far from center for pith est
179	1832			1971				1820		12		
180	1830							1818		12		
181 ?	1819											not close to center bad >1940? ~1856
182	1833							—		—		Not close to center
183	1821			1851 1902+04	1899 1971					2		
184												
185	1833							1824		9		
186												
187	1814							1808		6		
188	1924							—		—		

DENDROCHRONOLOGICAL SAMPLE - MEASUREMENT SHEET

Site		ID	Species		ID
Monument Canyon RNA			PIPO (mainly)		

DATA	Width ☐	Density ☐	Cell Size ☐	Chemical Elements ☐	Isotopes ☐	Other ☐

OPERATION	START - END	OPERATORS' FULL NAME
Collecting		
Preparing		
Dating		
Measuring		

ID B1	Dates First	Last	N	Micro	Absent	Breaks	By	Pith est ~~Measures~~ First	~~Last~~	N	By	Comments (suppression, release, scar, false ring, core length, ...)
189	1923	1994			1973	1973/4		1920		3		
190	—											BAD CORE - Rxn wood, suppress
191	1928							1924		4		
192	1933							1927		6		
193	1937							1923		14		
194	1922			1967				1916		6		
195	1948				1967			1940		8		
196	1916				1974			—		—		
197	1938							1936		2		
198	1935							1927		8		
199	1949			1967				1939		10		
200	1942			many	1967 1973			1935		7		
201	1929							1923		6		
202	1930				1967			1923		7		
203	1931				1967			1924		7		
204	1910				1971			—		-		
205	1930							1926		4		
206	1927							1922		5		
207	1949							1938		11		rxn wood - suppression
208	1934							1925		9		
209	1943							1936		7		
210	1918							1913		5		
211	1916							1911		5		
212	1900							1881		19		
213	1871							1865		6		
214	1706							1695		11		

DENDROCHRONOLOGICAL SAMPLE - MEASUREMENT SHEET

Site	ID	Species	ID
Monument Canyon RNA			

DATA	Width ☐	Density ☐	Cell Size ☐	Chemical Elements ☐	Isotopes ☐	Other ☐

OPERATION	START - END	OPERATORS' FULL NAME
Collecting		
Preparing		
Dating		
Measuring		

ID B1-B2	Dates First	Last	N	Micro	Absent	Breaks	By	Pith Est ~~Measures~~ First	~~Last~~	N	By	Comments (suppression, release, scar, false ring, core length, ...)
215	1673	1994						1655		18		
216	1915							—		—		lots of rxn wood - center is best guess!
B2 217	1924							1918		6		
218	1931							1918		13		
219												
220	1920							1913		7		
221	1922							—		—		
222	1934							—		—		
2 cores 223	1935							1926		9		2ND core 1923-pith date
224	1944?							1934		10		best guess - bad core
225	1930							1920		10		
226	1935							1932		3		
227	1933			1967				1924		9		
228												
229	1929							1924		5		
230	1920							—		—		
231	1940							1926		14		have 2 cores - 2ND has pith date of 1917
232	1911							1909		2		
233												
234												
235	1935							1923		12		
236	1933							1925		8		
237	1903	?						1899		4		badly mounted - inside not sure
238	1908							—		—		
239	1920							1912		8		
240	1927							1917		10		

DENDROCHRONOLOGICAL SAMPLE - MEASUREMENT SHEET

Site	ID	Species	ID
Monument Canyon RNA			

DATA	Width ☐	Density ☐	Cell Size ☐	Chemical Elements ☐	Isotopes ☐	Other ☐

OPERATION	START - END	OPERATORS' FULL NAME
Collecting		
Preparing		
Dating		
Measuring		

ID B2-B3	Dates First	Dates Last	Dates N	Dates Micro	Dates Absent	Dates Breaks	Dates By	Measures (pith est.) First	Measures ~~Last~~	Measures N	Measures By	Comments (suppression, release, scar, false ring, core length, ...)
241	1927							1917		10		
242	1918							1913		5		
243	1931							1915		16		
244	1926							1915		11		
245	1926							1913		13		
246	1915			1974				1910		5		
247												
248	1925							1919		6		
249	1838							1927		11		
250	1752							1735		17		
251	1852							1832		20		
252	1833							1825		8		
253	1846							1831		15		
B3-254	1937							1927		10		
255?	1950							1938		12		bad core - mostly rxn wood
256	1916							1912		4		
257	1924			1980				—		—		
258	1946							1920		20		
259	1940							1922		18		
260	1915				1955			—		—		
261	1914							—		—		
262	1919							1912		7		
263	1914							1909		5		
264	1917							—		—		
265	1924			1955				1916		8		
266	1924							1918		6		

DENDROCHRONOLOGICAL SAMPLE - MEASUREMENT SHEET

Site	ID	Species	ID
Monument Canyon RNA			

DATA	Width ☐	Density ☐	Cell Size ☐	Chemical Elements ☐	Isotopes ☐	Other ☐

OPERATION	START - END	OPERATORS' FULL NAME
Collecting		
Preparing		
Dating		
Measuring		

ID B3-C1	Dates First	Last	N	Micro	Absent	Breaks	By	Measures (Pith est.) First	~~Last~~	N	By	Comments (suppression, release, scar, false ring, core length, ...)
267	1918							1914		4		
268	1925							1920		5		
269	—							—		–		bad - not mounted right (young)
270	1930							1922		8		
271	1921							1913		8		
272	1913							1909		4		
273	1913							—		—		
274	1926							1919			7	
275	1911							1908		3		
276	1921			1976				1913		8		
277	1934							1919		15		
278	1925							1910		15		
279	1914							1909		5		
280	1918							1911		7		
281	1936							1930		6		
282	1662			1685 1739 [illegible]	1765 1955 1863 1956			1656		6		
283	1914							1911		3		
284												
285												
286?	1649							1629		20	?	Lots of probs - dating est
C1-287	1942							1930		12		
288	1912							—		—		
289	1950							1939		11		
290	1922							1916		6		
291												
292												

DENDROCHRONOLOGICAL SAMPLE - MEASUREMENT SHEET

Site	ID	Species	ID
Monument Canyon RNA			

DATA: Width ☐ Density ☐ Cell Size ☐ Chemical Elements ☐ Isotopes ☐ Other ☐

OPERATION	START - END	OPERATORS' FULL NAME
Collecting		
Preparing		
Dating		
Measuring		

ID C1	Dates First	Dates Last	Dates N	Dates Micro	Dates Absent	Dates Breaks	Dates By	Pith Est First	Pith Est ~~Last~~	Pith Est N	Pith Est By	Comments (suppression, release, scar, false ring, core length, ...)
293												
294												
295												
296												
297												
298												
299												
300												
301	1930							1926		4		
302	1922							—		—		
303	1925							—		—		
304	1930							—		—		
305	1921							1916		5		
306	1954							1937		17		
307	1919							—		—		
308	1925							—		—		
309	1926							1916		8		
310	—							—		—		bad core - rxn wood, injury, suppression
311	1939							1925		14		
312												
313	1959							1950		9		
314	1951							1939		12		
315	1950							1942		8		
316	1930							—		—		
317	1949							1939		10		
318	1938							1932		6		

DENDROCHRONOLOGICAL SAMPLE - MEASUREMENT SHEET

Site		ID	Species	ID
	Monument Canyon RNA			

DATA	Width ☐	Density ☐	Cell Size ☐	Chemical Elements ☐	Isotopes ☐	Other ☐

OPERATION	START - END	OPERATORS' FULL NAME
Collecting		
Preparing		
Dating		
Measuring		

ID	Dates							Pith Estimate Measures				Comments (suppression, release, scar, false ring, core length, ...)
	First	Last	N	Micro	Absent	Breaks	By	First	~~Last~~	N	By	
319	1913							—		—		
320	1931			1973				1925		6		
321	1670			1947	1773 1829			1662		8		bad > 1930
322	1693			1880 1900	1829			1686		7		core bad > 1950
323	1695							1686		9		
324	1739			1760	1873			1731		8		hit a branch? scar
325	1701				1739	1750 1850 1770 1847		1685		16		
326												
327												
328												
329												
330												
331												
332												
333												
334												
335												
336												
337												
338												
339												
340												
341												
342												
343												
344												

"ALL PINES = PI[illegible]"

all meas. in cm

A1			A2			A3			A4			A5			A6		
#	dbh	HT core	#	dbh	HT core	#	drc	core ht	#	drc	HT core	#	drc	HT	#	drc	HT
1	16.	4	26	52	18	52	16	8	81	18	8	108	16.7	9	133	22	10
2	17	4	27	14	7	57	17	10	82	11.2	5	109	16.5	2	134	20	4
3	17.5	1	28	10	3	54	16.5	15	83	14.5	6	110	24.5	4	135	20.5	9
4	17.5	2	29	13	6	59	17	13	84	20.5	5	111	18	13	136	21	8
5	14	3	30	14	8	60	15.2	2	85	13	9	112	14.2	10	137	13.5	2
6	14.2	4	31	28	10	61	14.7	16	86	14.5	1.5	113	18	7	138	23	8
7	14.2	5	32	21	8	62	20.5	9	87	15.0	8	114	19.6	10	139	20	8
8	16.5	2	33	16	8	63	20	8	88	13	2	115	17.2	10	140	70	11
9	17.5	5	34	24	14	64	19.5	12	89	26	2	116	14	13	141	27	7
10	14	4	35	34	7	65	24	6	90	18.5	9	117	15.7	12	142	14.5	4
11	4.8	5	36	17	6	66	19	3	91	14	9	118	18	13	143	19	7
12	14	5	37	18.5	12	67	17.2	5	92	16	5	119	16	8	144	23	12
13	19	5	38	13	10	68	13.4	6	93	20	1	120	16	7	145	15	4
14	15.3	3	39	22	8	69	12.7	4	94	18	7	121	18	4	146	14.5	11
15	6.8	5	40	27.5	4	70	13.6	3	95	13.2	3	122	13	5	147	17	9
16	11	5	41	19	6	71	14	8	96	25	4	123	15	3	148	23.5	13
17	20.1	5	42	11.5	5	72	19.3	10	97	19	10	124	12	2	149	17	7
18	13.8	2	43	14	10	73	18	3	98	13	5	125	15	6	150	13.5	5
19	18.2	5	44	13	9	74	22.2	15	99	19	5	126	[illegible]	7	151	13.5	4
20	15.9	5	45	16	5	75	13.3	2	100	13	2	127	17	3	152	14	9
21	74.1	20	46	42	5	76	61.2	15	101	28.5	5	128	85	24	153	70	15
22	85.2	10	47	52	20	77	71	28	102	80	6	129	93	30	154	87.5	15
23	62.7	11	48	27.8	20	78	73	18	103	97	11	130	63	22	155	52	20
24	79.5	60	49	48	20	79	78	20	104	78	12	131	70	25	156	46	20
25	53	18	50	24.5	8	80	63	26	105	79	20	132	16.5	40	157	78	10
			51	33	20				106	32	11						
			52	60	12				107	30	15						
			53	55	13												
			54	71	11												
			55	44	10												

#129 dead

1891

all measurements in cm

192 = Dead

All measurements in CM
all trees = PIPO unless otherwise noted

PHOTOS Shelley A5 - 15, A6 - 14, B4 - 16

near 10/19/94

(missing bore #207 out)

B4 (31 large not cored) (3 PIST trees 12 + saplings) | B1 | B2 (216-253) | B3 (254-290) (NO 257) | C1 | C1

#	DRC	CORE HT	#	DRC	CORE HT	#	DRC	CORE HT	#	DRC	CORE HT	#	DRC	CORE HT	#	DRC	HT
58	11.5	10	188	11.8	9	216	17.5	9	288	20	4	300	19.5	11	320	15.7	4
59	11.5	7	189	21	8	217	25	13	289	11	3	301	14	8			
60	31	19	190	11	11	218	31	10	290	16.8	12	302	14.7	12			
61	36	8	191	14	9	219	25.8	18	254	12	9	303	16.5	7			
62	34.5	20	192	16	12	220	31	16	255	13.5	14	304	13	11			
63	13.2	6	193	14	7	221	13.5	15	256	18.5	8	305	13.5	[illegible]			
64	12.9	3	194	21.5	4	222	10	10	257	13	9	306	19.5	4			
65	12.3	5	195	16.8	2	223	16.3	11	258	13.8	9	307	10.5	10			
66	20	7	196	14.3	3	224	10	8	259	20.5	12	308	14	7			
167	14	4	197	15.5	12	225	19.2	6	260	18	11	309	14.5	10			
168	10.8	6	198	14	3	226	10.4	9	261	17.9	14	310	20.5	2			
169	8.5	12	199	16.7	10	227	16.5	3	262	17	10	311	22	20			
170	12	6	200	16.5	9	228	13.9	6	263	20.8	8	312	18	4			
171	9	10	201	16	9	229	14.9	7	264	19	13	313	17	16			
172	9	7	202	16	4	[illegible]	14.6	8	265	19	~~(14)~~ 12	314	14.5	4			
173	9	3	203	16.4	8	[illegible]	15	2	266	21.5	12	315	10	8			
174	9.4	6	204	16	3	[illegible]	20.8	15	267	14.3	4	316	13	4			
175	12.2	3	205	23	14	[illegible]	20.8	5	268	19	8	317	11	4			
176	10.5	3	206	17.5	7	[illegible]	11.1	4	269	17	14	318	16.5	15			
177	15.4	5	207	12.5	4	235	21.7	7	270	13	9	319	14	5			
178	48.8	11	208	33	10	236	24	12	271	23.1	10	321	65	21			
179	35	9	209	33	11	237	23.7	9	272	15.5	12	322	64	15			
180	38.3	9	210	27.6	13	238	26.5	11	273	23.8	14	323	63	10			
181	36	12	211	36	16	239	31	10	274	26.2	18	324	52	10			
182	61	11	212	38	18	240	27	10	275	24	5	325	56	25			
183	42	8	213	51	25	241	31.5	10	276	25	10						
184	NONE		214	58	10	242	28.5	20	277	23.5	10						
185	47	10	215	67.5	15	243	34.5	15	278	23	5						
186	41	10	216			244	26.5	10	279	26	5						
187	41.5	9	251	62	22	245	44	7	280	26	7						
			252	45	15	246	25	5	281	23	5						
			253	61.5	10	247	25	5	282	66.5	11						
						248	22.5	5	283	25	7						
						249	80.4	19	284	66	20						
						250	59	16	285	65.5	9						
									286	68	35						

in inches unless otherwise noted

D-2

2→4" DRC START @ #30

#	~~dbh~~ DRC	core ht.	#	dbh	core ht.	#	dbh	core ht.	#	dbh	core ht.
30	7.4										
31	7.3										
32	5.9										
33	5.7										
34	5.6										
35A	9.1										
35B	9.1										
36	6.3										
37	7.5										
38	9.0										
39	6.3										
40	3.1										
41	6.2										
42	8.7										
43	10.2										
44	11.0										
45	9.1cm										
46	3.6"										

D2 - saplings from 10 - 200cm/ht

C2 - saplings

#	~~dbh~~ ht.	core ht.	#	~~dbh~~ ht.	core ht.	#	~~dbh~~ ht.	core ht.	#	dbh	core ht.
50	33cm		78	200cm		1-	85cm				
51	46cm		79	187cm		2	68cm				
52	37cm		80	192cm		-3	50cm				
53	45cm					-4	50cm				
54	50cm					5	73cm				
55	71cm					6-	29cm				
56	56cm					7	40cm				
57	79cm					8	60cm				
58	73cm					9	—				
59	77cm					-10	86				
60	94cm					11	26cm				
61	100cm										
62	98cm										
63	103cm										
64	94cm										
65	133cm										
66	152cm										
67	167cm										
68	143cm										
69	24cm										
70	28cm										
71	15cm										
72	120cm										
73	18cm										
74	123cm										
75	30cm										
76	13cm										
77	180cm										

D-2 D-3

#	~~dbh~~ drc	~~core~~ ~~ht~~. Snag	#	~~dbh~~ drc	core ht.	#	~~dbh~~ drc	core ht.	#	~~dbh~~ drc	core ht.
1	45 cm		15	55	Snag = [illegible]	1	63		15	62	
2	91 cm	Snag	~~16~~	98		2	50		16	104	
3	41 cm		~~17~~	81.5		3	51		17	55	
4	76.5		~~18~~	86		4	50 @ 0	5m [illegible]	18	52	
5	77		~~19~~	52		5	36		19	66	Snag - no sample
6	74		~~20~~	51		6	36		20	73.5	
7	56.5		~~21~~	47		7	41		21	35	
8	base rotten 66 dbh	Snag				8	47				
~~9~~	100.5					9	51				
10	61					10	87	Snag			
11	79					11	71	fire scar			
~~12~~	60 @ 0.75m - above ground surface					12	44.5				
13	58 "	" "				13	71				
~~14~~	66 drc					14	63				
	D-4		14	99							
1	78		15	44							
2	42		16	73							
3	30		17	17.5							
4	47		18	90.5							
5	DBH score 23.8 in		19	67.5							
6	47.5		20	62.9							
7	51										
8	48										
9	69.4										
10	76										
11	74.9 cm										
12	26	22.2									
13	62										

F1?

Fire scarred tree ~12 scars #4 core

D1 | snag | G1 | F2 | >12" (30 cm)

	#	drc	~~core ht.~~ snag	#	drc	core ht.	#	drc	core ht.	#	drc	core ht.
	1	40.6		8	95		1	41.5				
	2	72.7		9	16.2in		2	45.4				
inches	3	13.6		10	14.4in		3	80.4				
	4	85.8	snag	11	20.6in		4	82.0				
	5	37.0		12	23.3in		5	49.3				
in.	6	19.0		13	33.4		6	77.5				
	7	35.0		14	37.2		7	65.3				
	8	74.9	snag - rot	15	54.7		8	68.8				
in.	9	21.6	snag - rot	16	46.8		9	74.8				
	10	63.7		17	46.9		10	75.1				
	11	48.6		18	38.4		11	19.3in				
dbh	12	47.0 est.	dead log! ch 270	19	53.0		12	65.7				
	13	67.3		20	43.9		13	19in				
	14	73.5					14	48.9				
	15	48.0					15	64.8				
	16	66.0					16	42.7				
	17	47.8					17	57.8				
	18	60.0					18	16.4in				
in	19	25.6	snag				19	42.4				
(A+B) dbh	20	81.6	snag - rot				20	86.3				
in	21	23.4										
	G1											
	1	60.8										
	2	68.5										
	3	16.8in										
	4	17.7in										
	5	50.3										
	6	31.9in	Snag									
	7	62.4										

- indicate snags

x need core

ch core ht.

Date ________ X = not entered

LABORATORY OF TREE-RING RESEARCH

Page ____ of ____

Species ________ Collection date ________ Sample type: cores X Xsections ___ Other ____

Site ID, Location Man. Canyon Natural Research Area (MRA) Collector(s) ________

Dating By M. Sekleck

SPECIMEN ID Field	Lab.	Core Lnth	est. pith	T	Inner year	Last year	Ty (not entered)	C	MEASURING Interval	by	Remarks, comments, observations micro rings, absent rings, etc.
F1 17		✓	–		1798P	1995					
16			1629		1634	1995					
14A	14	--	1807		1844	1995					
10			1716		1726	1995					
D1 02		✓	1683		1713	1995					
E1 11		✓	1877		1897	1995					
08			1698		1716	1995					
unk (D1, E1, F1 ?)			—		1699 P	1995	X				No I.D #
F1 01		✓	1793		1802	1995					
11			1814		1817	1995					
08			1659		1661	1995					
04			1813		1815	1995					
14			1832		1834	1995					
D1 18		✓	1683		1685	1995					
D2 07		✓	1677		1679	1995					
G1 06		✓	1665		1672	1995					
E1 03		✓	1681		1692	1995					
E1 4A	(4)				Undateable		X				missing inner rings
D1 09					Undateable		X				
D1 19			–		1691		X		NOT NEAR CNTR		not close enough to center
D1 04		✓	11		1774 ?						
F1 12		✓	9		1837						fs ~ 1908
E1 06B		✓	12		1863						
D1 11		✓	14		1840						
F1 15		✓	8		1820 ?						bad core
E7 14		✓	8		1864						
F1 5A			6		1874 ?		X				scarred on inside rings
F1 5B			—		1785		X		NOT NEAR CE		NTER - Not sure A+B are same tree
E1 05		✓	16		1771 ?						
F1 5C		✓	18		1786						

LABORATORY OF TREE-RING RESEARCH

X = not entered

Date ______ Page ______ of ______

Species ______ Collection date ______ Sample type: cores X Xsections __ Other ______

Site ID, Location Mon. canyon Natural Research Area (MCA) Collector(s) ______

Dating By Mariette Seklecki

SPECIMEN ID Field	Lab.	Core Lnth	est. pith	T	Inner year	Last year	Not entered Ty	C	MEASURING Interval	by	Remarks, comments, observations micro rings, absent rings, etc.
02 02		✓									- missing inside 22cm
17			—		1851	1995	X		too twisted		- cor unable to untwisted earlier than 1851
? 02	Snag		1622		1628	1791	X				
10			1659		1682	1995					
11			1617		1627	1995					
21			1658		1664	1995					
18			1623		1627	1995					
19			1859		1862	1995					
14			1644		1668	1995					backwards btwn 1830-1694, core very messed up after 1676
12			1623		1627	1995					
16					1678		X				* core messed before 1678 - NOT TO center
E1 12		✓	1916		1923	1995					
20			1795		1817	1995					
16					1855 P	1995					
07			1726		1744	1995					
19			1691		1701	1995					
04			1665		1670	1995					
09			1842		1860	1995					
01			1715		1729	1995					
13					1862 P	1995					
17			1821		1831	1995					
02			1637		1640	1995					
15			1858		1865	1995					
F1 03		✓	1801		1810	1995					
02			1825		1831	1995					
07			1663		1681	1995					
09			1655		1658	1995					
20			1912		1918	1995					
19			1811		1823	1995					
18			1913		1924	1995					

Date______ **LABORATORY OF TREE-RING RESEARCH** Page 1 of 5

Species Research Collection date ______ Sample type: cores ✓ Xsections __ Other ______

Site ID, Location Monument Canyon Natural Area (MCA) Transect A1 + A2 Collector(s) ______

SPECIMEN ID Field	Lab.	est. pith	T	Inner year	Last year	Ty	Date by	Ckd. by	*MEASURING* Interval	by	Remarks, comments, observations micro rings, absent rings, etc.
1	1935	7		1942	1994						
2A / 2B	1924	13 / 9		1946 / 1933	1994						
3	1929	3		1932	1994						
4	1915	1		1916	1994						
5	1924	10		1934	1994						
6	1948	12		1960	1994						
7	1920	9		1929	1994						
8	??	—		—	—						No CORE
9	—	—		—	—						BAD CORE - don't have center
10	1933	6		1939	1994						
11	1930	8		1938	1994						
12	1937	5		1942	1994						
13	1930	12		1948	1994						
14	1953	10		1963	1994						
15	1940	9		1949	1994						
16	1915	9		1924	1994						
17	1934	11		1945	1994						
18	1925	9		1934	1994						
19	1936	5		1941	1994						
20	1919	9		1928	1994						
21	1611	8		1619	1994						
22	1717	7		1724	1994						~10 rings missing >1950
23	1840	18		1858	1994						4 rings missing >198
24	1681	+1		1682	1994						? rings missing in 1920's + 1950s (6 in all)
25	1692	15		1707	1994						fs in 1915? extremely suppressed after
26	A-2	10		1829	1994						
27	1938	4		1942	1994						
28	2cores	0		1928	1994						
29		0		1934	1994						
30	1927	<11		1938	1994						

Date____________ **LABORATORY OF TREE-RING RESEARCH** Page 2 of 5

Species ____________ Collection date ____________ Sample type: cores___ Xsections___ Other______

Site ID, Location Monument Canyon Nat'l Area Collector(s) ____________

MCA Transect A2 + A3

SPECIMEN ID Field	Lab.	est. pith	T	Inner year	Last year	Ty	Date by	Ckd. by	*MEASURING* Interval	by	Remarks, comments, observations micro rings, absent rings, etc.
31	1842	10		1852	1994						
32	2 cores	2		1924	1994					(6)	1939-1994
33		0		1928	1994						
34	1916	6		1922	1994						
35		0		1923	1994						
36	2 cores	7		1927	1994						2ND core bad core - worse surface
37		10		1945	1994						
38	1942	6		1948	1994						
39	1930	5		1935	1994						
40	1925	9		1934	1994						
41	1935	7		1942	1994						
42	1837	8		1845	1994						this was labelled 47 (there were 2 labeled #47)
43	1936	7		1943	1994						
44	?										No core
45	?										No core
46	1846	11		1857	1994						many rings missing on outside
47	1828	6		1834	1994						
48	1815	2		1817	1994						
49	?										No core
50				<1900							bad core - don't have center
51	1928	4		1932	1994						
52	1806	5		1811	1994						~10 rings missing after 1950
53	1822	15		1837	1994						
54	1916	18		1934	1994						injury in 1963-66
55	1814	9		1823	1994						~20 rings missing on outside
* 56	A3 1938	9		1947	1994						
57	1926	9		1935	1994						
58	1950	15		1965	1994						
59	1934	9		1943	1994						
60	1937	10		1947	1994						

LABORATORY OF TREE-RING RESEARCH

Date ____________
Species ____________ Collection date ____________ Sample type: cores ___ Xsections ___ Other ______
Site ID, Location Monument Canyon Nat'l Area Collector(s) ____________
MCA Transect A3 + A4

SPECIMEN ID Field	Lab.	est. pith	T	Inner year	Last year	Ty	Date by	Ckd. by	MEASURING Interval	by	Remarks, comments, observations micro rings, absent rings, etc.
61	1941	4		1945	1994						
62	1916	17		1933	1994						
63	1934	5		1939	1994						
64	1916	9		1925	1994						
65	1924	6		1930	1994						
66	1921	7		1928	1994						
67	1932	5		1937	1994						
68	1924	8		1932	1994						
69	1922	4		1926	1994						
70		0		1920	1994						
71	1938	16		1954	1994						
72	1933	3		1936	1994						
73	1926	7		1933	1994						
74		0		1918	1994						
75		0		1919	1994						
76	1736	3		1739	1994						scar in 1890 + 1892; 4-5 rings missing >1970
77	PROBLEM			<1700	1994						injured on inside - don't have center <1700
78	1687	5		1692	1994						~10 rings missing > 1950 - suppressed
79											
80	1682	10		1692	1994	(ha ha)					~25 rings missing @ end >1950
* 81	A4 1923	7		1930	1994						
82		0		1932	1994						
83	2 cores 1928	6		1934	1994						~8 rings missing >1970
84		0		1915	1994						
85	1949	10		1959	1994						
86		0		1918	1994						
87	1926	4		1930	1994						
88	1927	5		1932	1994						
89	1927	3		1930	1994						
90	1919	7		1926	1994						

Date ____________ **LABORATORY OF TREE-RING RESEARCH** Page 4 of 5

Species ____________ Collection date ____________ Sample type: cores __ Xsections __ Other ____

Site ID, Location Monument Canyon Nat'l Area Collector(s) ____________

MCA Transect A4 + A5

SPECIMEN ID Field	Lab.	est. pith	T	Inner year	Last year	Ty	Date by	Ckd. by	***MEASURING*** Interval	by	Remarks, comments, observations micro rings, absent rings, etc.
91	1944	11		1955	1994						
92	1924	10		1934	1994						
93	1932	7		1939	1994						
94	1927	3		1930	1994						
95	1938	5		1943	1994						
96	1932	10		1942	1994						
97	1930	11		1941	1994						
98		0		1919	1994						
99	1929	9		1938	1994						
100	1935	5		1940	1994						
101	1921	8		1929	1994						
102	Not near	center		1690	1994						no rings >1990; v. suppressed growth
103	1640	11		1651	1994						scars @ 1679, 1700
104		?		1639	1994						do not have center - center twisted
105	1625	11		1636	1994						v. suppressed >1980
106	1925	13		1938	1994						
107	1917	10		1927	1994						
108	1913	10		1913	1994						
109	1922	4		1926	1994						
110	A5	0		1920	1994						
111 ?	1924	7		1931	1994						not sure of inside - scar obsures some rings
112	1924	4		1928	1994						
113		0		1914	1994						
114	1927	12		1939	1994						
115	1929	13		1942	1994						injury ~1952
116	1935	5		1940	1994						had a tough life - several micro/missing
117	1928	5		1933	1994						messed up in the 50's
118	1912	10		1922	1994						
119	1920	7		1927	1994						
120		0		1915	1994						

LABORATORY OF TREE-RING RESEARCH

Date ____________

Species ____________ Collection date ____________ Sample type: cores ___ Xsections ___ Other ____

Site ID, Location monument canyon Nat'l Area Collector(s) ____________

MCA Transect A5

SPECIMEN ID Field	Lab.	est. pith	T	Inner year	Last year	Ty	Date by	Ckd. by	MEASURING Interval	by	Remarks, comments, observations micro rings, absent rings, etc.
121	2 cores	10.		1930	1994						
122	1927	6		1933	1994						
123	1918	8		1926	1994						
124	1927	9		1936	1994						
125		0		1919	1994						
126	1909	12		1921	1994						
127		0		1930	1994						
128	1684	17		1701	1994						
129											
130	1741	13		1754	1994						
131	1628	8		1636	1994						~15 rings missing >1950
132		0		1629	1994						

Initial Assessment of Soils for a Forest Stand Structure Study, Monument Canyon Research Natural Area, Jemez Mountains, New Mexico

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This study was completed as partial requirements for "Soil Morphology and Classification" course taught by Dr. Les McFadden, Earth & Planetary Sciences Department, University of New Mexico, Fall 1995.

Abstract

Ponderosa pine tree densities are generally high at the Monument Canyon Research Natural Area on the Santa Fe National Forest in New Mexico. Tree density varies locally, possibly due to fine scale environmental heterogeneity or perhaps influenced by previous fire effects. To determine if soil influences tree density, four soil pits were examined. Pits were placed on the ridgetop and midslope for both open and closed canopy sites. All pits were dug to bedrock, with pit depth varying from 57 cm to 165 cm. Results from this initial study indicate that soil characteristics do not appear to be an obvious influence in determining stand structure.

Introduction

The Monument Canyon Research Natural Area is located in Section 9, Township 18N, Range 3E, in the Jemez Mountains west of Santa Fe, New Mexico, on the Santa Fe National Forest (figure 1). The research natural area (RNA) was designated in 1932, but the area was selected then for the lack of any historical, extensive management activities (Peterson & Rasmussen 1986). The stand is an old growth ponderosa pine forest. The most significant management of the area has been the exclusion of forest fires. According to tree ring analysis studies (Touchan, et. al. 1995), the last major, large spreading fire in the area occurred around 1900.

Throughout western United States, fire exclusion has led to increased tree densities in the ponderosa pine forest (Mutch, 1994). Forests of the 19th century were described as open and park-like with scattered large trees and abundant forbs and grasses (Harrington and Sackett 1992). Researchers (Covington and Moore 1991) determined on one site in northern Arizona, that presettlement densities may have been around 23 trees per acre. The same site currently supports 851 trees per acre.

The conditions at Monument Canyon reflect these regional trends.

In the absence of fire, extensive recruitment of ponderosa pine regeneration has occurred, creating very dense pole stands often in excess of 5,000 stems/hectare. The old-growth overstory contains a significant portion of dead and dying trees, particularly where dense understory thickets of pine regeneration are established. Tree density varies spatially, and where lower densities occur, sites are open, grassy and the overstory appears healthy (Figure 3). These open stand conditions vary in size from approximately 200 square meters to about a hectare. Muldavin et. al. (1995) suggest that local differences in stand density may be an artifact of how previous fires spread through the landscape, or may be a function of fine scale environmental heterogeneity.

The purpose of this study is to compare soils in open and closed stands to initially assess if soil factors are important in determining stand density.

Materials and Methods

Soil pits were located adjacent to study plots from a forest stand structure study (Muldavin, et. al. 1995). Pit locations were subjectively selected to represent dense pole canopy conditions on ridgetop and mid-slope, and open canopy conditions on ridgetop and mid-slope. Pits were located between plots A3 and A4 (Figure 2). Pits were dug by hand to bedrock.

Pit 1 was located on the ridge in a dense canopy stand (Figure 4), northeast of the transect line between Plot A3 and A4 (Figure 2, inset). Pit 2 was located 50 meters southwest of Pit 1, on the ridge, in a small 1/20 hectare opening. Pit 3 was 41 meters east of Pit 2, mid-slope of a small drainage, and in a 1/2 hectare open stand (Figure 5). Pit 4 was 34 meters east of Pit 3, approximately on the same contour, but with a dense tree canopy (Figure 6).

Soil horizons for each pit were distinguished and described following guidelines suggested by Birkeland et. al. (1991) and Buol et. al. (1989). Field data was collected for each horizon for horizon boundaries and depths, color (wet and dry), ped structure, consistence (dry and wet), texture of non-gravel component, estimate of % gravel, observations on clay films, and reaction with hydrochloric acid. In addition, field observations included notes on roots and pores (size, location, quantity), and charcoal. PH was measured in the lab with a Hach pH meter using 1:1 soil:water solutions for each horizon.

Discussion

General Description of the Soils

The soils examined were not well-developed. The A and B horizons were sandy loam to loam with generally 50% or less gravel-size pumice. The C horizons were 80-99% pumice gravel, with a few cobble-size rocks. Bedrock was a solid, soft, light brown rock which resembled a pumice or other volcanic-ash derived rock. Roots were found in all horizons, and pumice gravels had reddish coatings.

The surface layer consisted of duff and pine needle litter. At three pits, a dark brown, narrow <1 cm layer of humus existed above the mineral layer. This layer was patchy at Pits 2 and 3 (both open canopy), and homogeneous in Pits 1 and 4 (dense canopy). The litter layer ranged from sparse at Pit 2 (0-3 cm deep and patchy) to moderately thick (7 cm deep) at Pit 3, which was adjacent to a few large, overstory pine trees. In the dense canopy sites, litter layers were 3-5 centimeters. Pine needles varied from light brown on the top to gray, closer to the O horizon.

The soils in all four pits had many similar characteristics. Each pit had an A horizon, which was generally brown to dark brown in color. The lighter B horizons were weakly developed with some clay content in all the pits. The C horizon consisted of red-stained pumice. The bottom of each pit was a soft, massive pumice bedrock.

The B horizons were generally weakly developed cambric horizons, and recognized weak development of structure, increased clay content, and colors lighter than the A horizons and darker than the C horizons.

The C horizons were dominated by pumice gravels. These cinders were a light yellow color, but mottled with a red stain. Gravel coatings decreased with depth. At lower depths, coatings were primarily on the underside of the gravel. Coatings were often striated or patchy. Roots varied from very fine to almost 3 cm in diameter.

Inclusions or horizons associated with fine roots were found in the C horizon for three of the pits. White mycellium was visible with these roots. These lighter color masses contained less gravel, and were effervescent with hydrochloric acid. This could indicates that calcium carbonate which is being exuded from the tree with other excess salts, or due to increased CO_2 exchange near the roots, the $CaCo_3$ is formed.

The bedrock is also pumice with a massive structure. The color varied in the pits from reddish brown to pink.

Detailed descriptions for each soil pit are attached.

Comparisons between Open and Closed Canopy sites

The depth to bedrock varied widely and did not appear to be correlated to stand density. Pit 1, on the ridgetop in a closed canopy stand was the deepest pit (165 cm). The open stand pit on the ridge was shallower (137 cm). At mid-slope the open stand pit was deeper (105 cm), and the closed canopy pit (Figure 7) was shallow (57 cm). Pit depth does correlate with slope position, with the almost level ridgetop pits being substantially deeper than the midslope pits.

There may possibly be a correlation between stand density and the depth of the A horizon. Pit 1 (closed canopy, ridgetop) had an A horizon 7 cm deep, and pit 2 (open canopy, ridgetop) had an A horizon 18 cm deep. A similar ratio occurred in the mid slope pits, with the closed canopy (pit 4) having an 8 cm A horizon, and the open canopy (pit 3) with a 20 cm A horizon. This one set of observations is not statistically valid, and further studies are necessary to determine if this relationship is consistent.

Soil texture, color, structure, consistence, roots, pores, and pH appear to be consistent among the pits when compared within each horizon. These characteristics not appear to be dependent on slope position or stand structure. There is a slight increase in clay films in the B horizon for the ridgetop pits compared to the midslope pits. More gravel

(% volume) occurs in the Open Canopy pit on the ridgetop, than the closed canopy pit. This observation does not repeat itself in the midslope pits where % gravel is similar.

If edaphic conditions were controlling stand density, I would expect to see soil characteristics that would enhance water holding capacity for the dense, closed canopy sites compared to the open sites. Water holding capacity in these sandy loam soils would be a function of depth, soil texture and rock fragment volume. The amount of clay in the soil would increase the water holding capacity and could be detected by observations of clay films, consistence, and structure. I did not observe any consistent differences between the open and closed canopy stands that would suggest edaphic control of the stand density. This initial conclusion is based on a small sample size, and further study should occur to verify these results.

Classification

I did not perform lab analysis to determine andic soil properties. With the volcanic origin of the parent material, it is possible these soils could key out to Andisols, if soil analysis determined andic soil properties in 60% or more of the solum as designated in the Keys to Soil Taxonomy, 6th Edition (1994).

Providing these are not Andisols, all the four pits were identified as Haploborolls. The depth of darker colors in Pit 1 (>40 cm) would qualify this soil as a Pachic Haploboroll. The other three pits were Typic Haploborolls.

Color requirements for the Mollisol order were marginal, and if interpreted more rigidly, would place these soils in the Inceptisol order. In this case, they would be Udic Ustochrepts.

Summary

Observations from these initial four soil pits do not support the theory that stand structure of ponderosa pine is dependent on edaphic conditions. Variations in stand structure may be influenced by non-edaphic factors such as previous fire (or other disturbance) history.

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Attachments

Figures

Figure 1. General location map for Monument Canyon Research Natural Area.

Figure 2. Map of the study area.

Figure 3. This photo, with the mid-slope, open canopy soil pit in the foreground, shows the variety of stand densities encountered on the study site.

Figure 4. Site of Pit 1, ridgetop, closed-canopy. Note the lack of understory vegetation, and the amount of shading in the stand.

Figure 5. Site of Pit 3, midslope, open canopy. Larger diameter, older trees dominate the open areas within the study site. Often thick mats of pine needles develop under these trees.

Figure 6. Site of Pit 4, midslope, closed canopy.

Figure 7. A close up view of soil pit #4, located on the midslope, closed canopy site. Depth is 57 cm to bedrock, although the soft rock was also dug through an additional 8 cm.

Soil Descriptions

Pit 1. Ridgetop, Closed Canopy

Pit 2. Ridgetop, Open Canopy

Pit 3. Midslope, Open Canopy

Pit 4. Midslope, Closed Canopy

Figure 1. General location map for Monument Canyon Research Natural Area.

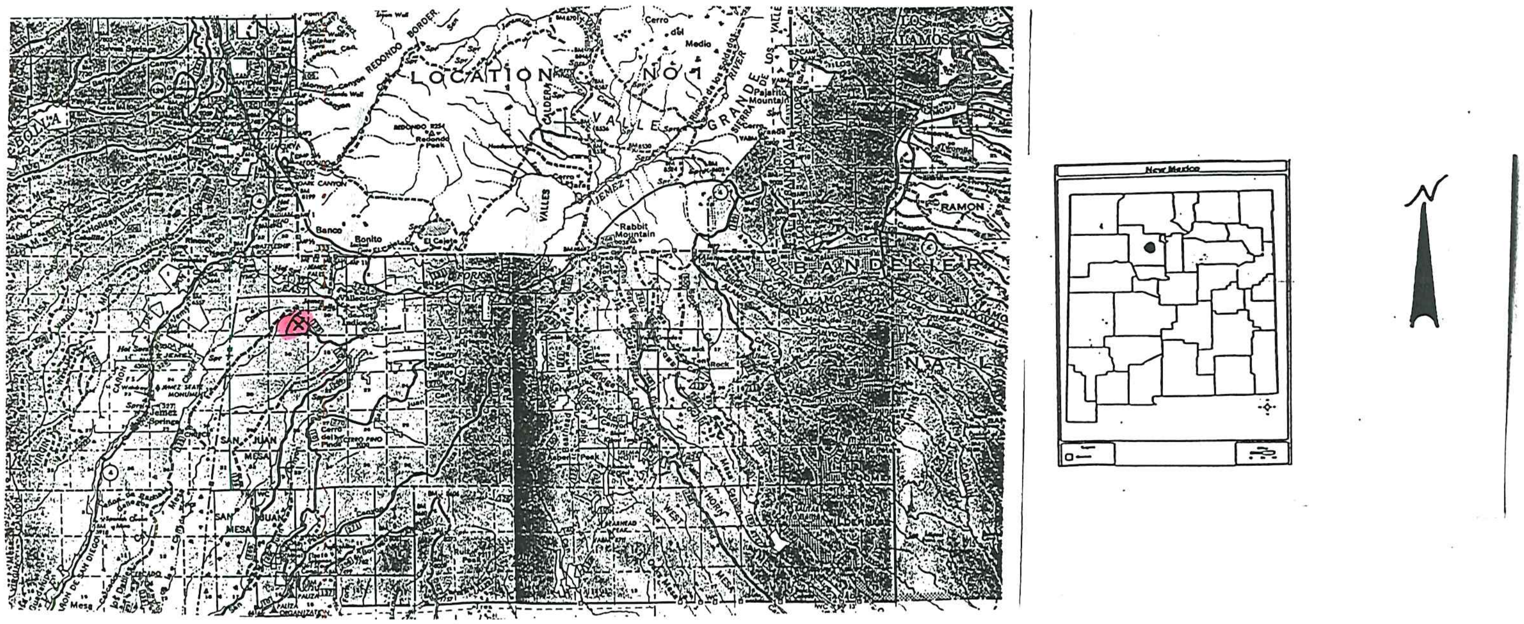


Figure 2. Map of the study area.

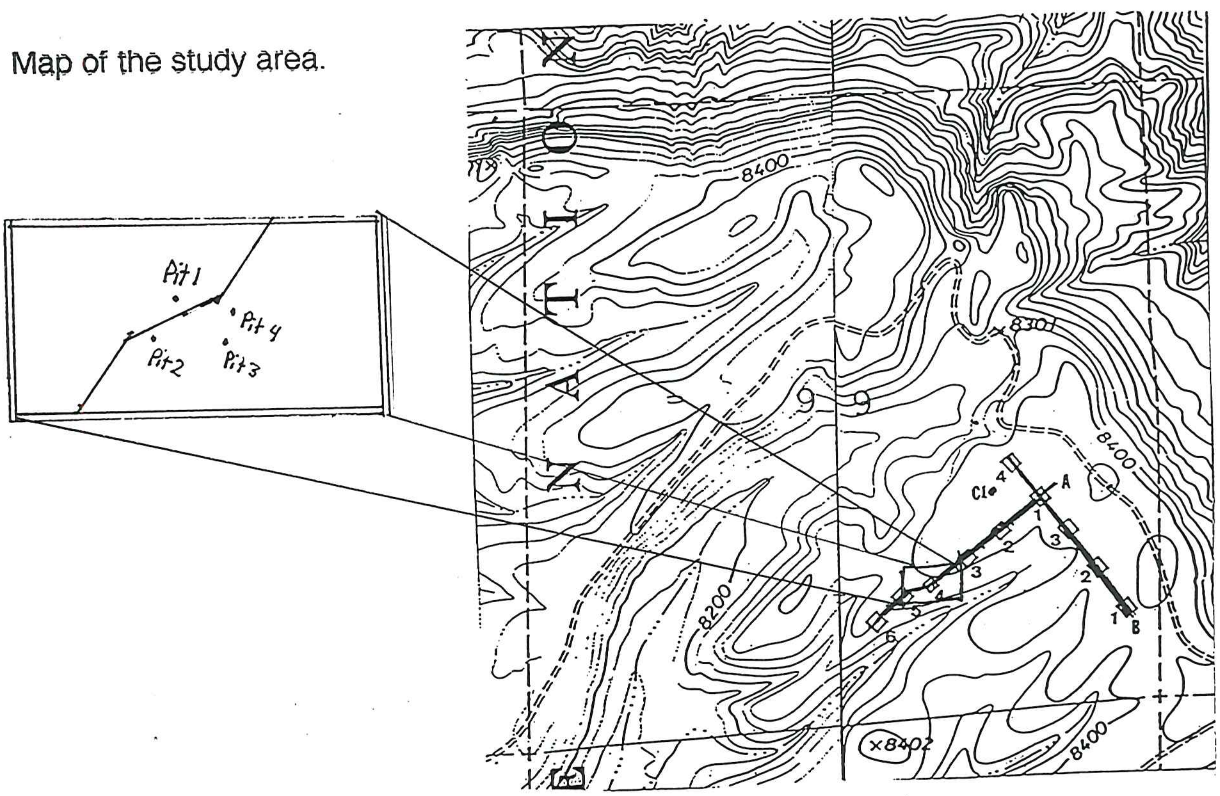


Figure 3. This photo, with the mid-slope, open canopy soil pit in the foreground, shows the variety of stand densities encountered on the study site.

Figure 4. Site of Pit 1, ridgetop, closed-canopy. Note the lack of understory vegetation, and the amount of shading in the stand.

Figure 5. Site of Pit 3, midslope, open canopy. Larger diameter, older trees dominate the open areas within the study site. Often thick mats of pine needles develop under these trees.

Figure 6. Site of Pit 4, midslope, closed canopy.

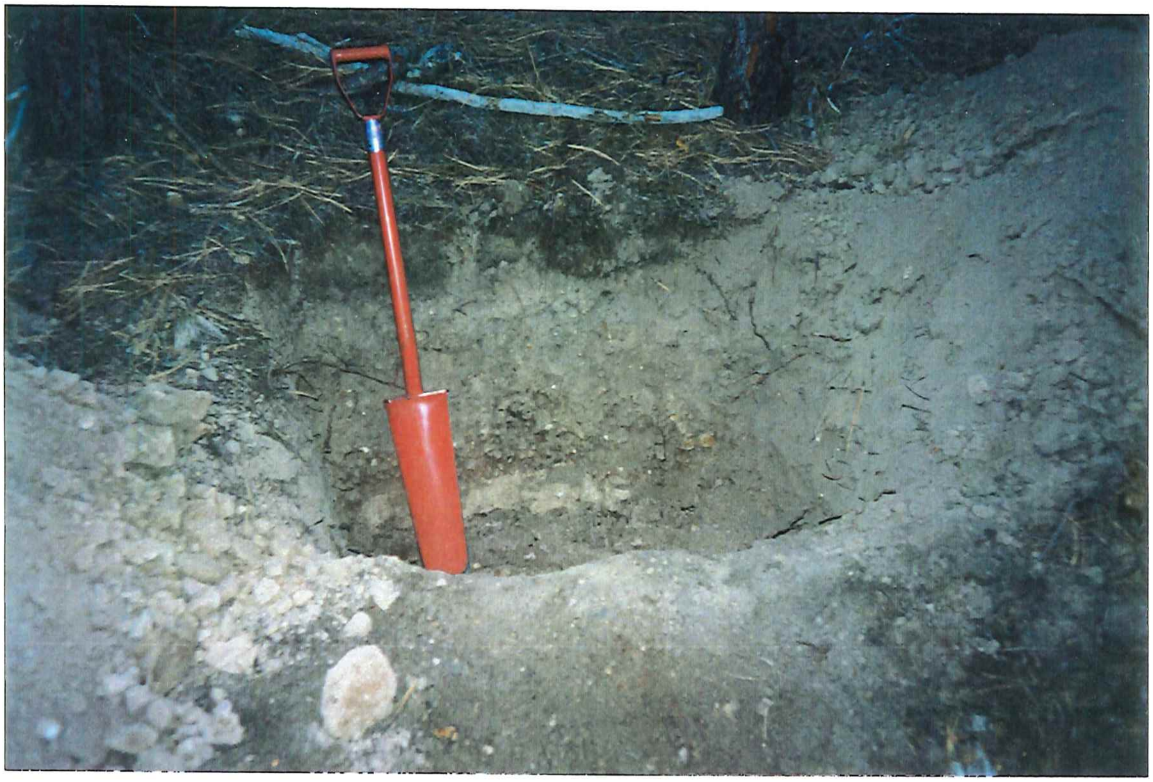


Figure 7. A close up view of soil pit #4, located on the midslope, closed canopy site. Depth is 57 cm to bedrock, although the soft rock was also dug through an additional 8 cm.

Pit #1 Ridgetop, Closed Canopy

Classification: Pachic Haploboroll (assuming lack of Andic soil properties)

Physiographic position: Located in a landscape of ridges and drainages running downslope from the northeast to the southwest, this pit was on a ridgetop approximately 1 kilometer from the rim where this landscape pattern originates. Slope was gentle (<5%), with a southwest aspect.

Vegetation: The pit was located in a dense thicket of pole-size ponderosa pine *(Pinus ponderosa* var. *scopulorum).* There were no understory species in the immediate vicinity of the pit, and very few herbaceous species observed in the stand.

Parent Material: Pumice

Sampled by: Mary Stuever

Remarks: Many pieces of charcoal <1mm and a few pieces up to 2mm wide were found throughout the A horizon.

Horizon Descriptions

O 4-0 cm. Consists mainly of pine needle litter. Needles nearer the top are brown; needles at the bottom of the litter layer are gray and partially decomposed. The first centimeter above mineral soil surface is sandy loam; brown (7.5YR 5/4) dry; dark brown (7.5YR 3/2) moist; weak, fine, subangular blocky structure; weakly coherent (dry), non-sticky and slightly plastic (wet); no visible roots; some very fine, round pores; no clay films observed; not effervescent; 10 percent gravel by volume; pH = 4.7; abrupt, smooth boundary.

A 0-7 cm. Sandy loam to loam; brown (7.5YR 5/3) dry; dark brown (7.5YR 3/2) moist; moderate, coarse, subangular blocky structure; weakly coherent (dry), non-sticky to slightly sticky and slightly plastic (wet); many very fine to fine roots; some very fine, round pores; very few, faint clay films on ped faces; not effervescent; 7 percent gravel by volume; pH = 5.8; clear, smooth boundary.

Bw1 7-39 cm. Sandy loam to loam; brown (7.5YR 6/4) dry; brown (7.5YR 4/3) moist; moderate, coarse, subangular blocky structure; weakly coherent (dry), non-sticky to slightly sticky and slightly plastic (wet); many very fine to fine roots, a few roots 0.5 cm diameter; several round pores <1 mm diameter; very few, faint clay films on ped faces; not effervescent; 15 percent gravel by volume; pH = 5.7; clear, wavy boundary.

Bw2 39-80 cm. Sand, very coarse to gravelly; gray (7.5YR 5/1) dry; very dark gray (7.5YR 3/1) moist; single grain structure; loose (dry), non-sticky and not plastic (wet); many very fine roots; no visible pores; many, faint clay films coating mineral grains (coating may be oxidation, rather than clay films); not effervescent; 85 percent gravel by volume; pH = 6.3; clear, wavy boundary.

C1 80-115 cm. Sand, very coarse to gravelly; coarse grains vary in color including reddish yellow (7.5YR 6/6), dark brown (7.5YR 3/2) and pinkish white (7.5YR 8/2) dry; moist colors are similar (7.5YR 7/6, 7.5YR 8/3, & 7.5YR 5/2); single grain structure; loose (dry), non-sticky and not plastic (wet); no visible roots except in inclusions described below; no visible pores; pumice gravels are mottled with red stain; not effervescent (except for inclusions); 95 percent gravel by volume; pH = 5.9; clear, wavy boundary.

incl. 82-90 cm. This is an inclusion in C1, primary surrounding root masses, approx. 4 cm x 8 cm; Sand, very coarse; pink (7.5YR 7/4) dry; light brown (7.5YR 6/4); single grain structure; loose (dry), non-sticky and not plastic (wet); many, very fine roots; several very fine round pores; white mycellium in association with roots, carbonate coatings on gravels; strongly effervescent; 70 percent gravel by volume; pH = 8.0; clear boundary.

C2 115-165 cm. Sand, gravelly; coarse grains vary in color including brown (7.5YR 5/2), reddish yellow (7.5YR 7/6) and pink (7.5YR 8/3) dry; moist colors include reddish yellow (7.5 YR 6/6), pinkish white (7.5YR 8/2), dark brown (7.5 YR 3/2), and brown (7.5 YR 4/3); single grain structure; loose (dry), non-sticky and not plastic (wet); no roots; no pores; pumice gravels are mottled with red stain, but stain is concentrated on the bottom sides; not effervescent; 99 percent gravel by volume; pH = 7.0; clear, smooth boundary.

Cr 165+ cm. Loam to silt loam; light brown (7.5YR 6/4) dry; strong brown (7.5YR 4/6) moist; soft volcanic bedrock; weak, medium, vertical platy structure; slightly hard (dry), slightly sticky and slightly plastic (wet); no roots; no pores; not effervescent; 5% gravel by volume; pH = 7.0.

Pit #2 Ridgetop, Open Canopy

Classification: Typic Haplobqroll (assuming lack of Andic soil properties)

Physiographic position: Located in a landscape of ridges and drainages running downslope from the northeast to the southwest, this pit was on a ridgetop approximately 1 kilometer from the rim where this landscape pattern originates. Slope was gentle (<5%), with a southrwest aspect.

Vegetation: The pit was located in an open stand of small sawtimber-size ponderosa pine *(Pinus ponderosa* var. *scopulorum).* Herbaceous species in the immediate vicinity of the pit included about a 5% canopy cover of grasses, including Arizona fescue *(Festuca arizonica),* mountain muhly *(Muhlenbergia montana),* and pine dropseed *(Blepharoneuron tricholepis),* and <1% of wild strawberry *(Fragaria* spp.) and groundsel *(Senecio* spp.).

Parent Material: Pumice

Sampled by: Mary Stuever

Horizon Descriptions

O 3-0 cm. The litter layer consisted many of pine needles, and was patchy, between 0 and 3 cm deep. There was not a duff layer, as at the other pits.

A1 0-9 cm. Sandy loam to loam; brown (7.5YR 5/3) dry; dark brown (7.5YR 3/2) moist; moderate, medium, subangular blocky structure; weakly coherent (dry), non-sticky to slightly sticky and slightly plastic (wet); many fine roots; many very fine, round pores; very few, faint clay films on ped faces; not effervescent; 25 percent gravel by volume; pH = 5.5; clear, wavy boundary.

A2 9-18 cm. Loam; brown (7.5YR 5/3) dry; dark brown (7.5YR 3/2) moist; moderate, medium, subangular blocky structure; weakly coherent (dry), slightly sticky and slightly plastic (wet); many very fine roots; many very fine to fine, round pores; common, faint clay films on ped faces; not effervescent; 50 percent gravel by volume; pH = 5.6; clear, smooth boundary.

Bw1 18-25 cm. Loam; reddish gray (5YR 5/2) dry; dark brown (7.5YR 3/2) moist; moderate, coarse, subangular blocky structure; slightly hard (dry), slightly sticky and slightly plastic (wet); many fine roots and a few roots to 1 cm diameter; many very fine to fine, round pores; common, faint clay films on ped faces; not effervescent; 40 percent gravel by volume; pH = 5.3; gradual, smooth boundary.

Bw2 25-37 cm. Sandy loam to loam; reddish brown (5YR 5/3) dry; dark reddish brown (5YR 3/3)) moist; single grain structure; loose (dry), slightly sticky and slightly plastic (wet); several fine roots and a few roots to 1.5 cm diameter; several fine, round pores; many, faint clay films coat mineral grains; not effervescent; 45 percent gravel by volume; pH = 5.9; clear, smooth boundary.

C1 37-47 cm. Loamy sand; reddish brown (5YR 5/3) dry; reddish brown (5YR 3/4) moist; single grain structure; loose (dry), non-sticky and not plastic (wet); many fine roots; no visible pores; pumice gravels are mottled with a reddish stain which may be caused oxidation; not effervescent; 90 percent gravel by volume; pH = 6.5; clear, smooth boundary.

C2 47-85 cm. Coarse sand, very coarse to gravelly; light reddish brown (5YR 6/3) dry, reddish brown (5YR 4/3) moist; single grain structure; loose (dry), non-sticky and not plastic (wet); few, fine roots in mass 10 cm wide by 5 cm tall (60-65 cm); no visible pores; pumice gravels are mottled with red stain; not effervescent except near roots where slightly effervescent; 98 percent gravel by volume; pH = 7.2; clear, smooth boundary.

C3 85-105 cm. Sand, coarse to very coarse; coarse grains vary in color including browns (7.5YR 4/2 & 7.5YR 5/3) and pinkish white (7.5YR 8/2) dry; for moist colors reddish yellow (5 YR 6/6), pinkish white (5YR 8/2), and dark reddish brown (5 YR 3/2); single grain structure; loose (dry), non-sticky and not plastic (wet); no roots; few pores to 0.5 cm diam; pumice gravels are mottled with red stains, concentrated on bottoms of gravels; not effervescent; 98 percent gravel by volume; pH = 7.5; gradual, smooth boundary.

C4 105-137 cm. Sand, very coarse to gravelly; coarse grains vary in color including dark brown (7.5YR 3/2), reddish yellow (7.5YR 6/6) and pinkish white (7.5YR 8/2) dry; moist colors include reddish yellow (7.5 YR 6/8), pinkish white (7.5YR 8/2), dark brown (7.5 YR 3/3), and brown (7.5 YR 4/3); single grain structure; loose (dry), non-sticky and not plastic (wet); few roots 2-3 cm diam; no visible pores; pumice gravels are mottled with red stain, but lighter than upper horizon; not effervescent; 99 percent gravel by volume; pH = 7.8; abrupt, smooth boundary.

Cr 137+ cm. Loam; pink (7.5YR 7/3) dry; reddish brown (7.5YR 5/4) moist; soft volcanic bedrock; weak, medium, subangular blocky structure; slightly hard (dry), slightly sticky and slightly plastic (wet); no roots; no pores; slightly effervescent in a few spots; 10% gravel by volume; pH = 8.4.

Pit #3 Midslope, Open Canopy

Classification: Typic Haploboroll (assuming lack of Andic soil properties)

Physiographic position: Located in a landscape of ridges and drainages running downslope from the northeast to the southwest, this pit was midslope about 20 m lower in elevation from the ridgetop and approximately 1 kilometer from the rim where this landscape pattern originates. Slope was moderate (15-25%), with a southeast aspect.

Vegetation: The pit was located in an open stand of mature ponderosa pine *(Pinus ponderosa* var. *scopulorum).* Understory species in the immediate area were limited by a thick layer of pine needles from a large pine tree near the pit. Understory species in the stand were dominated by grasses (>5% canopy cover) and included a few forbs (see Pit #2 for species list).

Parent Material: Pumice

Sampled by: Mary Stuever

Horizon Descriptions

O — 8-0 cm. Top layer consists of decomposed, partially decomposed, and fresh pine needles. The first centimeter above mineral soil level is sandy loam; brown (7.5YR 5/2) dry; dark brown (7.5YR 3/2) moist; moderate, medium, subangular blocky structure; slightly hard (dry), non-sticky and slightly plastic (wet); few fine roots; nonvisible pores; few, faint clay films on ped faces; not effervescent; 10 percent gravel by volume; pH = 5.1; abrupt, smooth boundary.

A1 — 0-9 cm. Loam; dark grayish brown (10YR 3/2) dry; very dark brown (10YR 2/2) moist; moderate, medium, subangular blocky structure; weakly coherent (dry), slightly sticky and slightly plastic (wet); many very fine to fine roots; many very fine, round pores; faint clay films on ped faces are common; not effervescent; 25 percent gravel by volume; pH = 5.3; clear, smooth boundary.

A2 — 9-20 cm. Loam; brown (7.5YR 5/2) dry; dark brown (7.5YR 3/2) moist; weak, coarse, subangular blocky structure; weakly coherent (dry), slightly sticky and slightly plastic (wet); many very fine to fine roots, several roots 0.5 cm diameter; many very fine round pores; faint clay films on ped faces are common; not effervescent; 20 percent gravel by volume; pH = 5.7; clear, smooth boundary.

Bw — 20-47 cm. Loam; reddish gray (5YR 5/2) dry; dark brown (5YR 3/2) moist; weak, medium subangular blocky structure; weakly coherent (dry), slightly sticky and slightly plastic (wet); many very fine roots, few roots up to 2 cm diameter; many fine round pores; no visible clay films; not effervescent; 50 percent gravel by volume; pH = 6.1; gradual, smooth boundary.

C1 — 47-60 cm. Sand; reddish brown (5YR 4/3) dry; dark reddish brown (5YR 3/3) moist; single grain structure; loose (dry), non-sticky and not plastic (wet); many very fine to fine roots; several fine to medium oval pores; pumice gravels are mottled with red stain; not effervescent (except for inclusions); 90 percent gravel by volume; pH = 6.1; clear, slightly wavy boundary.

C2 60-86 cm. Sand, coarse; reddish brown (5YR 4/4) dry; reddish brown (5YR 4/3) moist; single grain structure; loose (dry), non-sticky and not plastic (wet); many very fine to fine roots; no visible pores; pumice gravels are mottled with red stain; slightly effervescent; white mycellium present with roots throughout horizon; 98 percent gravel by volume; pH = 8.0; clear, smooth boundary.

C3 86-105 cm. Sand; coarse grains vary in color , but most are yellowish red (5YR 4/6) dry & moist; single grain structure; loose (dry), non-sticky and not plastic (wet); few roots > 1cm diam; no visible pores; pumice gravels are mottled with red stains, concentrated on bottoms of gravels; not effervescent; 99 percent gravel by volume; pH = 8.0; clear, smooth boundary.

Cr 105 + cm. Sandy loam; light brown (7.5YR 6/4) dry; reddish brown (5YR 4/4) moist; soft volcanic bedrock; weak, medium, subangular blocky structure; slightly hard (dry), slightly sticky and not plastic to slightly plastic (wet); no roots; no pores; not effervescent; 40% gravel by volume; pH = 7.4.

Pit #4 Midslope, Closed Canopy

Classification: Typic Haploboroll (assuming lack of Andic soil properties)

Physiographic position: Located in a landscape of ridges and drainages running downslope from the northeast to the southwest, this pit was midslope about 20 m lower in elevation from the ridgetop and approximately 1 kilometer from the rim where this landscape pattern originates. Slope was moderate (15-25%), with a southeast aspect.

Vegetation: The pit was located in an closed thicket of sapling and pole-size ponderosa pine *(Pinus ponderosa* var. *scopulorum).* There were no understory species in the immediate area.

Parent Material: Pumice

Sampled by: Mary Stuever

Remarks:

Horizon Descriptions

O 7-0 cm. Top layer consists of decomposed, partially decomposed, and fresh pine needles. The first centimeter above mineral soil level is a sandy loam; brown (7.5YR 4/2) dry; very dark brown (7.5YR 2.5/3) moist; weak, fine, subangular blocky structure; weakly coherent (dry), non-sticky and slightly plastic (wet); several fine roots; some, very fine, round pores; no visible clay films; not effervescent; 10 percent gravel by volume; pH = 5.1; abrupt, smooth boundary.

A 0-8 cm. Loam; dark brown (7.5YR 3/2) dry; black (5YR 2.5/1) moist; weak to moderate, medium, subangular blocky structure; weakly coherent (dry), slightly sticky and slightly plastic (wet); many very fine to fine roots, few roots up to 1 cm; several fine, round pores, few round pores 1 cm wide; few faint clay films on ped faces, and few distinct clay films lining pores; not effervescent; 25 percent gravel by volume; pH = 5.1; clear, wavy boundary.

Bw 8-36 cm. Loam; brown (7.5YR 5/3) dry; dark brown (7.5YR 3/3) moist; weak, fine, subangular blocky structure; weakly coherent (dry), slightly sticky and slightly plastic (wet); many very fine to fine roots, several roots 3-4 cm diameter; many fine round pores; faint clay films on ped faces are common; not effervescent; 40 percent gravel by volume; pH = 5.7; clear, irregular boundary.

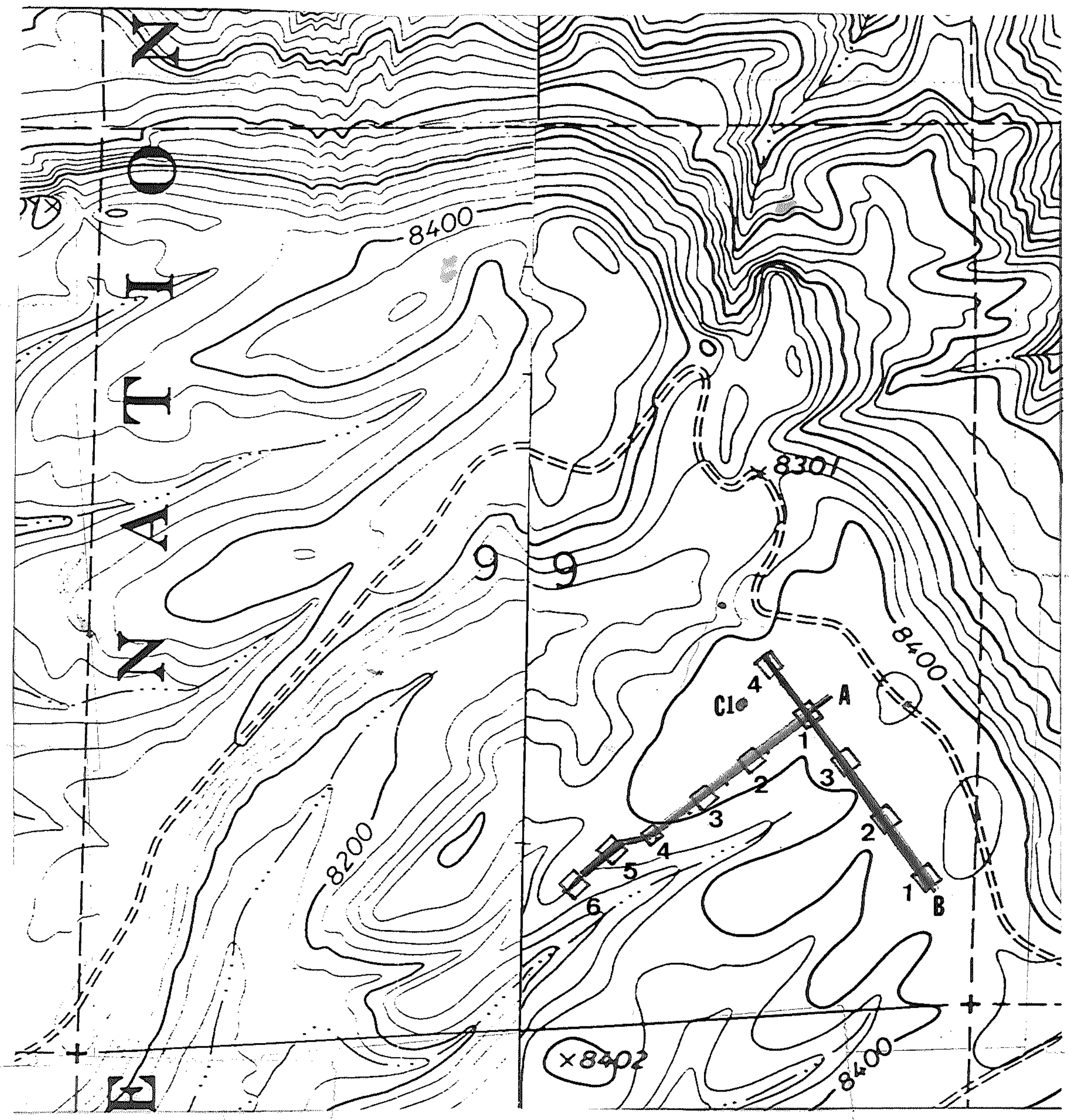
C 36-57 cm. Loamy sand; brown (7.5YR 5/4) dry; brown (7.5YR 5/2) moist; single grain structure; loose (dry), non-sticky and slightly plastic (wet); many very fine to fine roots, several roots up to 1 cm diameter; no visible pores; pumice gravels are mottled with red stain; not effervescent (except for inclusions); 85 percent gravel by volume; pH = 6.1; abrupt, smooth boundary.

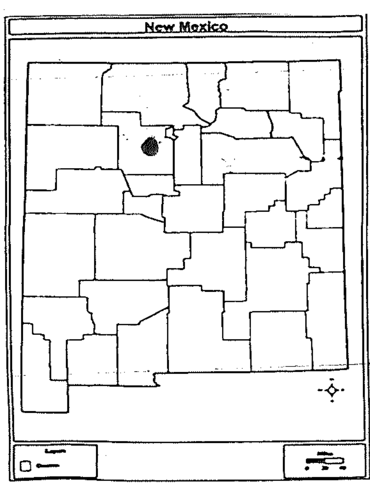
Cr 57 + cm. Loamy sand; light brown (7.5YR 6/4) dry; brown (7.5YR 5/4) moist; soft volcanic bedrock; massive structure; hard (dry), slightly sticky and slightly plastic (wet); not effervescent; 1 = 6.3.

Monument Canyon Research Natural Area

Santa Fe National Forest

Jemez Mountains, New Mexico





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Potential Nitrogen Contribution of Soil Cryptogams

to Post-Disturbance Forest Ecosystems

in Bandelier National Monument, NM.

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ABSTRACT

The nitrogen-fixation (N_2-fixation) potential and annual N contribution of soil cryptogamic crusts were estimated in three previously burned ponderosa pine (*Pinus ponderosa*) and one previously grazed pinyon/juniper (*Pinus edulis / Juniperus monosperma*) forest ecosystems in Bandelier National Monument, NM. The ponderosa pine forest sites were burned in the 1977 La Mesa Fire and burro grazing on the pinyon/juniper site ended in approximately (1983). The objective of this research was to determine whether estimated post-disturbance cryptogamic N inputs could offset N losses from the disturbance. Surface cover in each habitat was divided into litter cover, herbaceous cover, bare soil, and obvious cryptogams, in an attempt to quantify the spatial heterogeneity of soil properties. Line intercept transects were used to estimate percent surface cover of each cover type. Soil samples from each cover type were analyzed for total N, C, P, $\delta^{15}N$, and N_2-fixation potential. At this stage in the recovery process, the potential for cryptogamic N_2-fixation was determined to occur in all sampled habitats and cover types. Correlations between N_2-fixation potential and other soil variables indicated that none are suitable as indirect estimators of N_2-fixation potential. Estimates of ecosystem N input as a result of cryptogamic N_2-fixation range from 3.6 - 27.0 kg ha^{-1} yr^{-1}. Evidence from soil analyses indicate that soil loss was greatest at the pinyon/juniper site.

Keywords: acetylene reduction assay, microphytic crusts, nitrogen cycle, stable isotope analysis, $\delta^{15}N$.

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INTRODUCTION

In a stable forest ecosystem, inputs and losses of mass and energy are considered to be in equilibrium over broad spatial and temporal scales. Decomposition, the process by which nutrients stored in organic detritus are returned to their mineral forms, is slow in ponderosa pine (PP), which leads to an accumulation of organic matter in the absence of fire (C. White, chapter XX, this volume). Fire causes near immediate mineralization of nutrients. Carbon (C) is released as CO_2, nitrogen (N) as NH_4, and other mineral nutrients as their oxides in the ash. However, mineralization by fire is a radical process and results in a net loss of N by volatilization and loss of fine particulates in smoke and ash carried to the atmosphere (Vitousek and Howarth 1991).

The significance of this problem is better understood when viewed in a broad temporal context. Ponderosa pine forests, some pinyon/juniper (P/J) associations, chaparral, and some grasslands are dependent upon frequent fires to maintain a stable species composition (Figure 1). If fire-dependent ecosystems are stable, total ecosystem N will be relatively stable over long time periods. However, if the loss of N following fire is not returned through inputs, the plant community will # ultimately be unstable and unable to maintain itself.

Nitrogen losses from disturbed ecosystems can also occur as a result of soil erosion. The potential for soil erosion is influenced by the type and magnitude of the disturbance. Because grazing animals can disturb the structural integrity of surface soils, overgrazing can result in an increased susceptibility to soil erosion.

Cryptogamic crusts, also called microbiotic or microphytic crusts, can contain cyanobacteria, fungi, algae, lichens and mosses. Some species of cyanobacteria (free-living or as lichen symbionts) have the ability to "fix"or convert biologically unavailable atmospheric N_2 to biologically available forms. Observations of several post-disturbance habitats within Bandelier National Monument have indicated that colonization of bare mineral soils by cryptogamic crusts may be both rapid and extensive. The importance of soil lichens and cyanobacteria to the overall N budget is relatively unknown, but cryptogamic crusts may act to retain N by reducing erosion through soil stabilization (Eldridge 1993; W. White, chapter XX, this volume) and contribute N through atmospheric N_2-fixation (Rychert and Skujins 1974; Jeffries et al 1992). Harper and Marble (1988) and West (1990) are excellent reviews of the ecological role of soil cryptogamic crusts in arid and semiarid regions.

This research addresses the following questions related to the role of soil cryptogamic crusts in post-fire ponderosa pine forests, and previously grazed P/J woodlands.

1. Does the potential for cryptogamic N_2-fixation exist?
2. Can the spatial heterogeneity of potential N_2-fixation be assessed by field observation?
3. Do other soil properties correlate with N_2-fixation potential?
4. What is the potential N contribution of cryptogamic crusts to these ecosystems?

Question 1 is fundamental to this research, for if N_2-fixation does not occur the remaining questions are meaningless. Question 2 is based on *a priori* assumptions that were made in the field before any soil analyses were conducted. We assumed that the soil surface cover would affect N_2-fixation potentials and that soil covered by obvious cryptogams would have the highest potentials. Question 3 states an attempt to identify easily quantifiable soil properties that could be used to estimate N_2-fixation potential because the acetylene reduction method for estimation of N_2-fixation potential is labor-intensive. Question 4 addresses the overall importance of cryptogams to the N budget of these recovering ecosystems.

Research Approach

Because of the absence of pre-disturbance data, this research utilized several indirect approaches to address the questions listed above. Relative cryptogamic N_2-fixation potential was estimated by acetylene reduction assay. Biological N_2-fixation occurs when the enzyme nitrogenase breaks the N_2 triple bond and reduces atmospheric N to ammonium (NH_4^+). Nitrogenase also preferentially converts acetylene to ethylene in an atmosphere of approximately 10% acetylene. The acetylene reduction assay estimates nitrogenase activity by quantifying the amount of ethylene produced through time. Although the accuracy of potential N_2-fixation estimates by the acetylene reduction assay has been questioned (Weaver 1986), this analysis should be useful to compare the relative N_2-fixation potential between sites.

Cryptogamic N contribution can be estimated by means other than N_2-fixation potentials. Two separate and independent estimates of total cryptogamic N contribution (TCNC) were made based upon total soil N (TN) and stable nitrogen isotope ($\delta^{15}N$) values. The first estimate is based on differences in TN between soils of each of four surface cover types (litter, herbaceous, bare soil, and obvious cryptogams). We assumed that the nitrogen content of the bare soil represented the nitrogen content of the soil after fire and subsequent soil erosion. The bare soil is used as a standard for comparison because any subsequent inputs of N through wet and dry deposition is assumed to have occurred equally in all soil types. Thus the increase in N in the other soils should be a result of N_2-fixation by nodulated plants and cryptogams. This method yields a potentially conservative estimate of TCNC because any N contribution by non-crustal or free living N_2-fixing organisms occurring in the bare soil is not accounted for in the final estimate.

Stable isotope analysis of soil N can also be used to estimate N inputs. Nitrogen exists as two stable isotopes ^{15}N and ^{14}N. The relationship between the isotopes is expressed as a $\delta^{15}N$ value. The $\delta^{15}N$ value of a sample is calculated using the following equation (1):

$$\delta^{15}N = (R_{sample} / R_{standard} - 1) \times 1000$$

where R_{sample} is the ratio of ^{15}N:^{14}N in the sample, and $R_{standard}$ is the ratio of ^{15}N:^{14}N in an atmospheric N standard. Sources of N input tend to have a $\delta^{15}N$ near 0 because

N_2-fixation does not discriminate between isotopes (Figure 2). The $\delta^{15}N$ of soil N increases through time because biological processes such as N mineralization, nitrification, and denitrification discriminate against ^{15}N and selectively remove a greater proportion of ^{14}N (Evans and Ehleringer 1993). As the quantity of residual N decreases, its $\delta^{15}N$ increases. Stated differently, as N losses increase, soil $\delta^{15}N$ increases because processes that lead to N loss will discriminate against the heavier isotope. As N inputs increase, the soil $\delta^{15}N$ will decrease through time because N inputs do not discriminate against ^{15}N and "recent N" dominates the soil N pool.

A hypothetical soil profile distribution of $\delta^{15}N$ and TN (Figure 3) is based on profiles reported for a juniper/sagebrush ecosystem in southern Utah (Evans and Ehleringer 1993). This profile distribution is based on assumptions that surface N inputs have low $\delta^{15}N$ values, the $\delta^{15}N$ of soil N will increase the longer it remains in the soil, and the age of soil N generally increases with depth.

Surface soil TN and $\delta^{15}N$ values may indicate the recent occurrence of soil erosion (Figure 3). Erosion removes surface soil and its associated N resulting in altered profile N distributions. Eroded surface soils should have higher $\delta^{15}N$ and lower TN than undisturbed soils. Comparison of $\delta^{15}N$ of surface soils within or between sites may indicate relative degree of soil loss.

METHODS

Four previously disturbed forest sites in Bandelier National Monument (Figure 4) were chosen as study sites. Sites A, B, and C were located in ponderosa pine forests which burned in the 1977 La Mesa Fire and provide estimates of post-fire cryptogam establishment and potential N inputs. Site A (elev. 8230') was located on Apache Mesa, less than 1 km southwest of the Apache Springs Trailhead. Site B (elev. 7450') was located adjacent to one of Terry Foxx's permanent plots on Escobas Mesa. Sites A and B both have understory vegetation dominated by New Mexico locust (*Robinia neomexicana*), Gambel's oak (*Quercus gambelii*), and sheep fesque (*Festuca ovina*). Site C (elev. 6600') was within the P/J - ponderosa pine ecotone, south of Frijoles canyon and west of the trail that continues to Alamo Canyon. Site C has understory vegetation dominated by mountain muhly (*Muhlenbergia montana*), and junegrass (*Koeleria cristata*). Site D, a P/J woodland (elevation 6390') is east of the Burro trail in the southeastern portion of the Monument. Due to a past history of overgrazing and disturbance by livestock and feral burros (Koehler 1974; Allen 1989), this P/J woodland has very little interspace vegetation and most of the litter is under the canopy of the trees.

Line intercept transects were used to estimate the cover of four surface types: litter, characterized as having greater than 50% dead plant material on the surface, herbaceous vegetation, bare soil and cryptogamic crust, which was characterized as having greater than 50% recognizable lichen or algal surface crust. Transect data for sites A, B, and C are from previously burned areas only, whereas transect data for site

D includes mature pinyon and juniper trees and their associated litter mats. Three, 50 m transects were established within each of the four sites and cover was recorded by centimeter increments along the transects. Within each site, soil surface samples (approx. 3 cm dia. by 3 cm deep) were collected from within areas dominated by each of the four cover types. Soil samples (approximately seven/cover type/site) from all cover type/site combinations were analyzed for total soil N, C, P, and $\delta^{15}N$. Soil C was estimated by combustion and total P was estimated by **Kjeldahl digest** . Soil $\delta^{15}N$ and TN values were provided by Isotope Services, Inc., White Rock, NM. Ratios of elements (C:N, N:P) were calculated from respective analyses. Soils and vegetation transects for sites A, B, C, and D were sampled on 6/18/9~~4~~3, 5/27/9~~4~~3, 5/28/9~~4~~3, and 6/17/9~~4~~3, respectively.

Potential N_2-fixation in all soil samples was estimated using the acetylene reduction assay. Soil surface samples were incubated under optimal moisture conditions in closed chambers in an atmosphere of approximately 10% acetylene for 48 hrs in the Department of Biology greenhouse on the campus of the University of New Mexico. All soil samples from one habitat type were incubated simultaneously. However, it was not possible to standardize incubation conditions between sites because of the lack of environmental control in the greenhouse. Consequently, comparisons of N_2-fixation potential between sites are not valid.

The potential N contribution to these forest ecosystems was indirectly estimated using differences in soil TN and $\delta^{15}N$. These estimates of annual TCNC were calculated using the following equation (2):

$$(TCNC)/\text{cover type} = (TN_{sample} - TN_{bare}) * (BD) * (\%\ \text{cover}_{sample}) / 16\ \text{yr}$$

where TN_{sample} is the mean TN for the sample soil type (litter, herbaceous, or cryptogamic crust), TN_{bare} is the mean TN for the bare soil type, BD is a constant (3,000) that converts the value to kg ha^{-1} (assuming a bulk density of 1.0 g cm^{-3}), % cover$_{sample}$ is the % cover of that cover type, and 16 yr is the approximate amount of time since the La Mesa Fire. The sum of the TCNC for each cover type is an estimate of TCNC for a particular site.

The second estimate of cryptogamic crust N contribution is based on differences in $\delta^{15}N$ between soils of each cover type. The $\delta^{15}N$ value of a soil is a result of the effects of the fire and erosion, atmospheric and cryptogamic crust N inputs, and subsequent soil processing. Atmospheric inputs and soil processing are assumed to be equal in all soil types. The proportion of soil N (% contribution) for each cover type (X) is determined by the following equation (3):

$$[\delta^{15}N_{bare}(1\text{-}X)] + [\delta^{15}N_{cryp}(X)] = \delta^{15}N_{sample}$$

where $\delta^{15}N_{bare}$ is the $\delta^{15}N$ of the bare soil, $\delta^{15}N_{cryp}$ is the $\delta^{15}N$ of N derived from N2-fixation by cryptogamic crusts and $\delta^{15}N_{sample}$ is the $\delta^{15}N$ of the sample cover type soil. The TCNC for individual cover types is then determined by the following equation (4):

$$X * (TN_{sample}) * (BD) * (\%cover) \ / \ 15 \text{ yr}$$

where X is the % contribution of cryptogams to the $\delta^{15}N$ of the cover type soil and the other components are the same as in equation 2. The $\delta^{15}N$ values of the bare and sample soils are known and the N contributed by cryptogamic N_2-fixation is assumed to have a $\delta^{15}N$ of 0. Again, an estimate of site TCNC is generated by summing the TCNC for each cover type.

Within site correlations (Lotus 123 regression routine) were conducted between N_2-fixation potential and all other measured soil variables.

RESULTS

Above-ground cover estimates of cover categories in each site are shown in Figure 5. Herbaceous cover was greatest in sites A and B. The cover of bare soil and obvious cryptogams was greatest in sites C and D.

In general, soil N, C, P, and N:P (Figures 6, 7, 8, and 9 respectively) were highest in site A and lowest in site D. Soil $\delta^{15}N$ (Figure 10), and C:N ratios (Figure 11) were relatively constant in sites A, B, and C and higher and less uniform in site D.

Relative N_2-fixation potentials for all sites and cover types are shown in Figure 12. For most sites the obvious cryptogam cover had the highest potentials, while the bare soil had the lowest potentials.

Within site correlations between N_2-fixation potential and all other measured soil variables (Table 1) indicated that none of the variables were good indirect estimators of N_2-fixation potential.

Estimates of annual TCNC for method 1 (TN) and method 2 ($\delta^{15}N$) are shown in Table 2. Values of annual TCNC range from 3.4 - 25.4 kg ha^{-1} yr^{-1}.

DISCUSSION

Cryptogamic N Contribution

Two important findings were made with respect to potential N_2-fixation: 1) N_2-fixation potential exists in all cover types, and 2) total cryptogam cover may be a poor indicator of the overall importance of cryptogams at these sites. Current cover of cryptogamic crusts may be more sensitive to, or a function of, the amount of bare soil still available for cryptogam establishment following 16 years of ecosystem succession. For example, the relatively high cover of litter and herbaceous vegetation and low cover of cryptogams and bare soil in sites A and B (Figure 5) is probably a result of rapid post-fire recovery because of more mesic conditions at the upper elevations.

Although the estimated cover by cryptogams is now low at the upper elevation sites, little is known about cryptogam cover changes in these habitats following the La Mesa Fire (but see W. White, chapter 8 XX, this volume).

Although no between-site comparisons of N_2-fixation potential estimates were made, it is possible to compare the relative N_2-fixation potential of each cover type within the sites (Figure 12). At site A, soils covered by herbaceous vegetation and litter both had higher N_2-fixation potentials than obvious cryptogamic crusts, which is the cover type with the highest relative potential at all other sites. Bare soil had the lowest N_2-fixation potentials except for site B. At this point we do not understand the ecology of cryptogamic organisms well enough to offer an explanation for these results. Undoubtedly, our visual estimates of potential cryptogam activity do not correlate well with what is occurring in the real world. Although necessary information on cryptogam activity is lacking that would permit quantification of current cryptogamic N contributions under field conditions using N_2-fixation potentials, it is clear that N_2-fixation is occurring at all sites and in all cover types.

Estimates of total N contribution by soil cryptogamic crusts are remarkably similar between sites (Table 2). However, the total N contribution of cryptogams at the high elevation sites may be greater than at the low elevation sites, despite the discrepancy in cryptogam cover. Because of the more mesic environment, cryptogamic crusts of the upper elevation sites may have longer periods of active N_2-fixation, which could offset the differences in % cover. The litter and herbaceous cover types, which have highest. % cover in sites A & B, are more mesic than the bare soil or obvious cryptogam cover types and may promote even greater cryptogam activity. The total annual N input to comparable sites from wet and dry deposition is approximately 2 - 4 kg ha^{-1} yr^{-1} (Evans and Ehleringer 1993). Rychert and Skujins (1974) estimated cryptogamic N_2-fixation inputs to Great Basin Desert ecosystems to range from 10 - 100 kg N ha^{-1} yr^{-1}. The calculated estimates of annual cryptogamic N-contribution at these sites are within the range reported by other researchers and well above the estimates for atmospheric N input. Consequently, this is evidence that cryptogamic N_2-fixation is a very important source of N for these sites.

Interestingly, both the lowest and highest estimates of N contribution are from site B (Table 2). The relatively divergent and extreme estimates at this site may be the result of high N inputs from elk that use this area extensively (C. Allen, chapter XX). The resultant high TN inputs from elk would increase the estimated cryptogam N contribution from method 1, and the high $\delta^{15}N$ values of the elk-added N would lower the N contribution estimate from method 2, based on differences in $\delta^{15}N$ values.

Disturbance and Soil Erosion

Soil erosion is a process that removes soil and nutrients from ecosystems and leads to desertification. Lower elevation mesas at Bandelier National Monument were most susceptible to erosion following the La Mesa Fire, probably as a result of lower plant recovery rates (W. White 1981). Three lines of evidence from this study suggest that greater rates of soil erosion have occurred at the lower elevation P/J woodland site (D), probably because of its relative aridity and disturbance history. First, bare soil comprises 25 - 35% of the surface in sites C and D (Figure 5). Second, soil TN (Figure 6) and δ^{15}N (Figure ~~9~~ 10) are lowest and highest, respectively, in site D. This pattern is consistent with removal of N rich, low δ^{15}N surface soil and exposure of low N, high δ^{15}N subsurface soil (Figure 3). Third, the high surface soil C:N ratios (Figure ~~10~~ 11), characteristic of lower soil depths, recorded in the P/J site also suggest the removal of N rich surface soil. The interspace soils (herbaceous, bare soil and cryptogam cover types) are particularly susceptible because they are not protected by the tree canopies and their associated litter mats. Stabilization and recovery of these soils could take many years. Evidence from crust removal and reinoculation experiments in Utah suggest that it may take 40 - 85 years for full recovery of disturbed cryptogamic crusts (Belnap 1993).

CONCLUSIONS

Acetylene reduction assays of surface soils show that the potential for N_2-fixation occurs in all soils at all sites. The actual N contribution of cryptogamic crusts depends on the abundance and activity of the crust organisms. Actual contributions of N by crusts in the higher elevation sites may be greater than at lower elevations because of more favorable climatic conditions. Although soils with obvious cryptogam crusts generally had the highest N_2-fixation potential, this was not always the case. Visual observations of cryptogamic crusts are not reliable estimates of N_2-fixation potential. None of the soil analyses (TN, TC, C:N, TP, N:P, and δ^{15}N) were good estimators of N_2-fixation potential. Estimates of total N contribution by crusts show annual inputs ranging from 3.6 - 27 kg ha^{-1} yr^{-1}. These estimates indicate that cryptogamic N_2-fixation is an important source of N to these post-disturbance ecosystems. However, without broad-scale spatial estimates of all N inputs through time, as well as estimates of disturbance-induced N loss, it is impossible to determine whether or not these forested ecosystems maintain a stable N level. Undoubtedly, recovery from catastrophic disturbances such as the La Mesa Fire or severe overgrazing will require a much greater period of time than recovery from low intensity fires and grazing that were characteristic of ponderosa pine forests and P/J savanna before the arrival of Europeans. ~~man.~~

ACKNOWLEDGEMENTS

The authors would like to thank Craig Allen and the National Park Service for financial assistance. Partial support for C.S. White was provided by the Sevilleta Long-Term Ecological Research Project (Publication #57). Partial support for S.R. Loftin was provided by the Rocky Mountain Forest and Range Experiment Station in Albuquerque, NM.

Review comments by...

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TABLES

Table 1. Within site correlation coefficients (all cover types) of N_2-fixation potential against all other measured soil variables.

Variable	Site			
	A	B	C	D
N	0.37	<0.01	0.08	<0.01
C	0.38	0.04	0.08	<0.01
C:N	0.02	0.03	<0.01	0.03
P	0.38	<0.01	0.06	0.01
N:P	0.06	0.01	0.09	0.03
$\delta^{15}N$	0.02	<0.01	0.01	0.08

Table 2. Estimates of annual total cryptogam N contribution in kg ha^{-1} yr^{-1}. Calculations based on TN and $\delta^{15}N$ methods.

Site	Method 1 (TN)	Method 2 ($\delta^{15}N$)
A	24.6	20.2
B	25.4	3.4
C	8.3	11.4
D	14.3	12.6

FIGURES

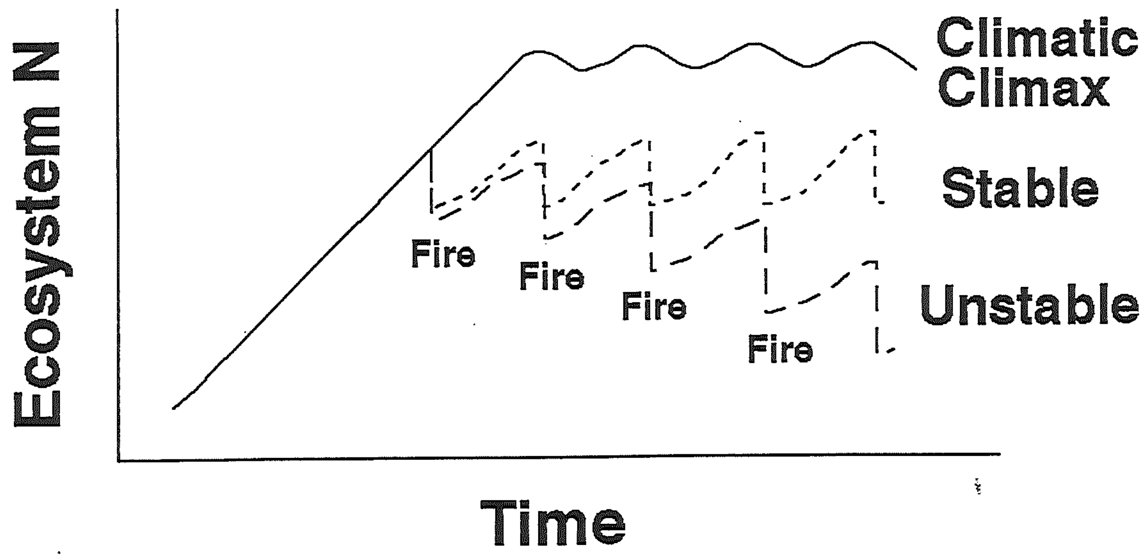

Figure 1. A conceptual outline of changes in ecosystem N as a function of time. The solid line represents succession to a climatic climax in the absence of any disturbances. The dotted and dashed lines represent the N dynamics of stable and unstable ecosystems, respectively, when subject to recurrent fire events.

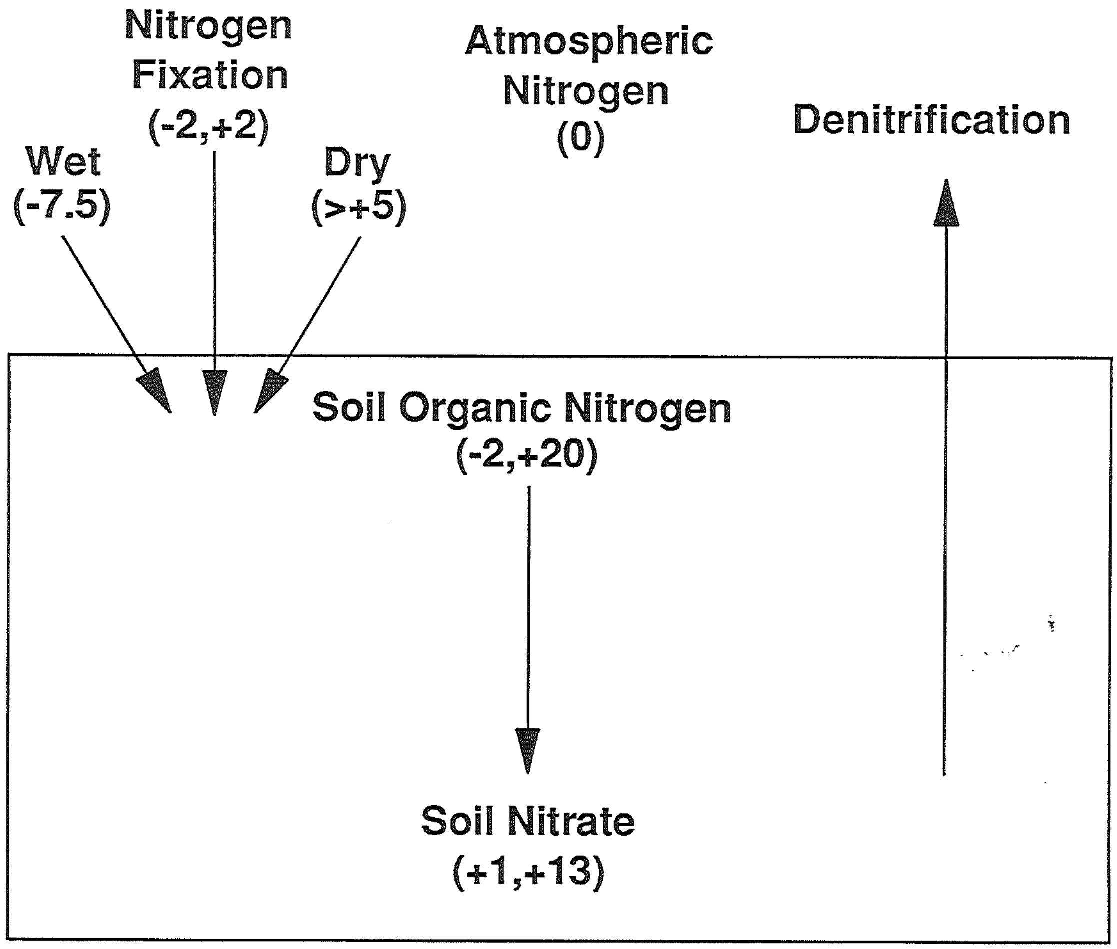

Figure 2. Conceptual model of ecosystem N and $\delta^{15}N$ dynamics. The values are means or ranges of $\delta^{15}N$. Nitrogen inputs from N_2-fixation and wet and dry precipitation have a mean $\delta^{15}N$ of zero. Through time the $\delta^{15}N$ of soil organic and inorganic N increases because of processes such as denitrification that descriminate against (leave behind) ^{15}N.

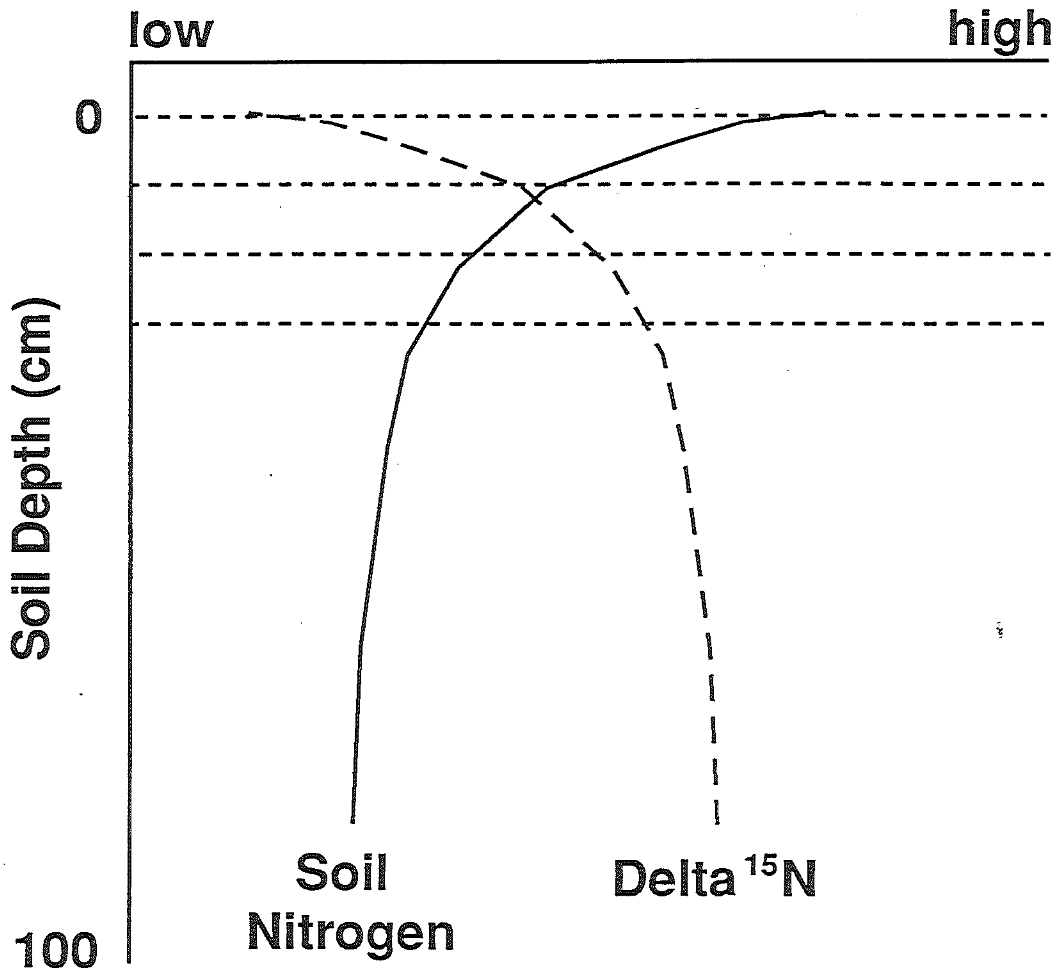

Figure 3. Hypothetical soil profile distribution of TN and $\delta^{15}N$ based on Evans and Ehleringer (1993). Dashed lines represent potential soil surfaces that would result from soil erosion.

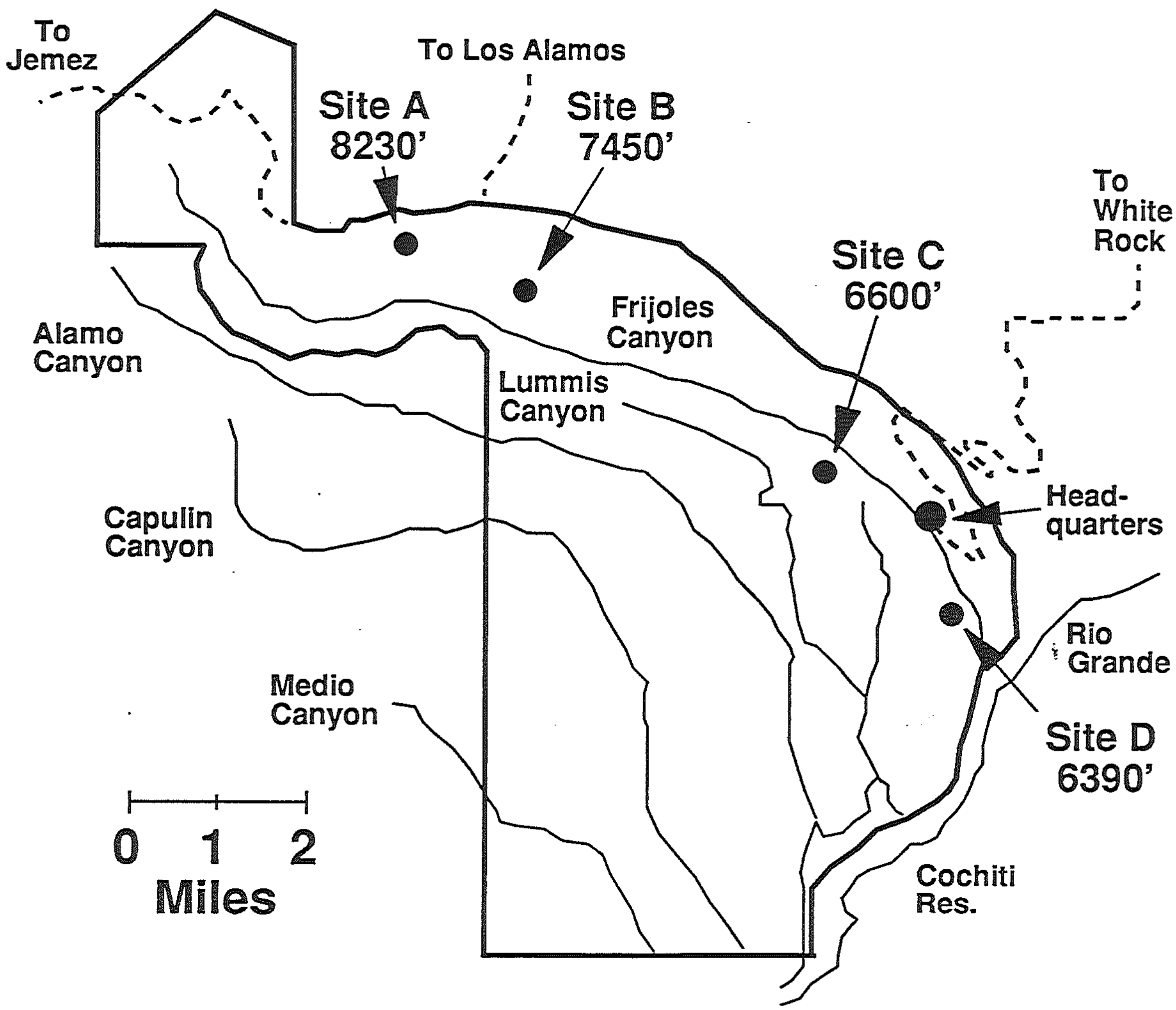

Figure 4. Location of study sites within Bandelier National Monument, NM.

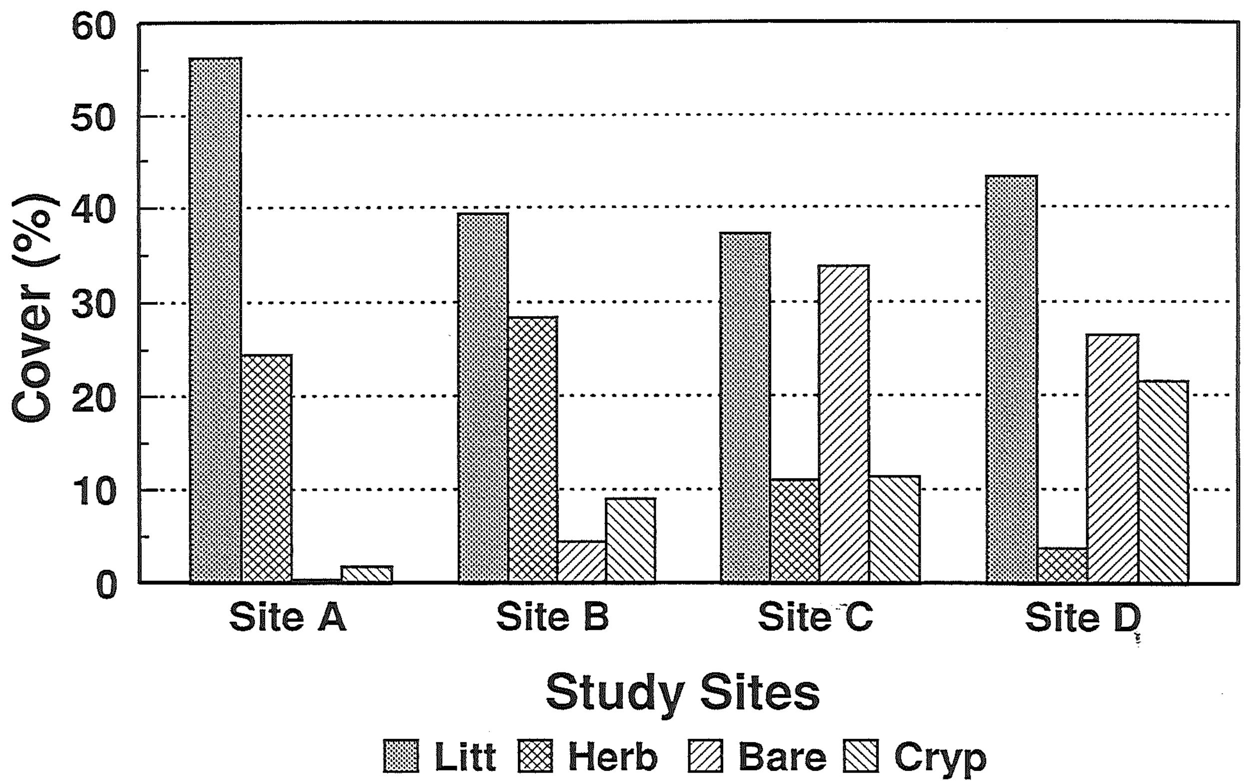

Figure 5. Mean surface cover of cover types (litter, herbaceous vegetation, bare soil and obvious cryptogams) within each study site.

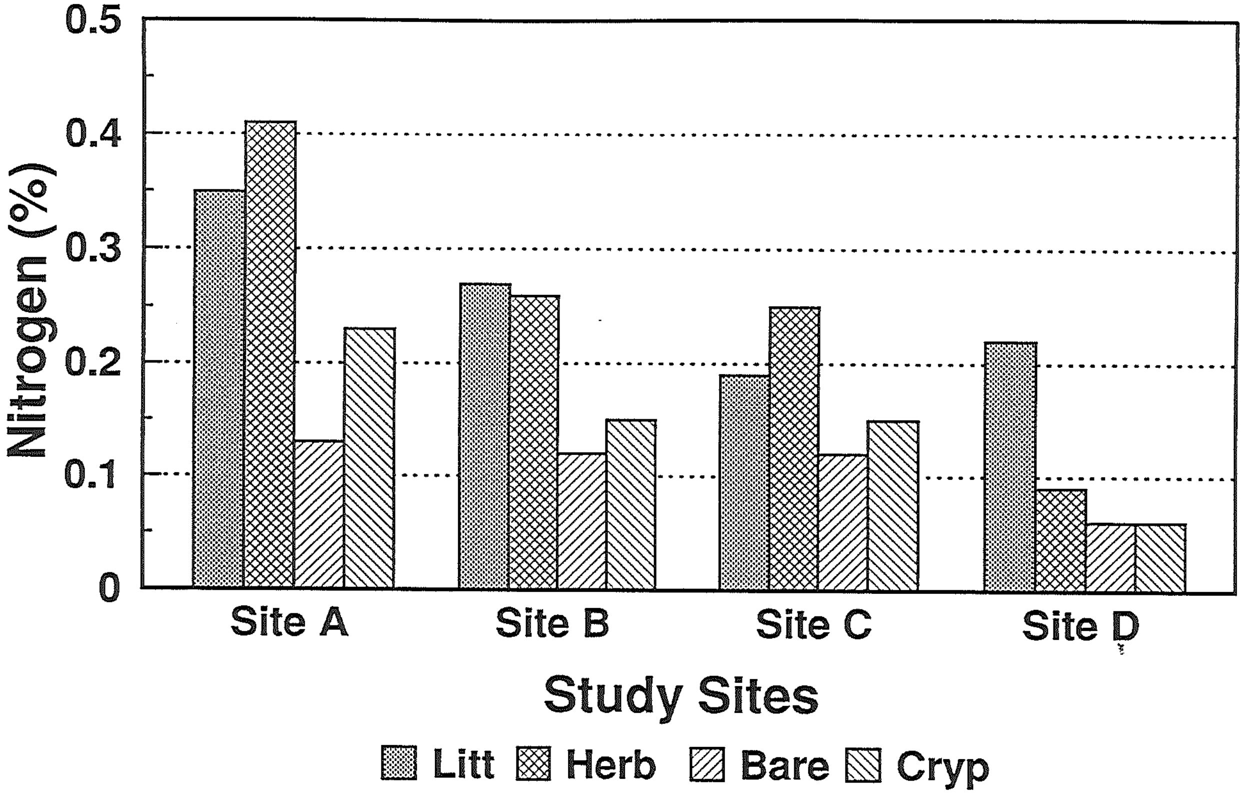

Figure 6. Mean soil N of cover types (litter, herbaceous vegetation, bare soil and obvious cryptogams) within each study site.

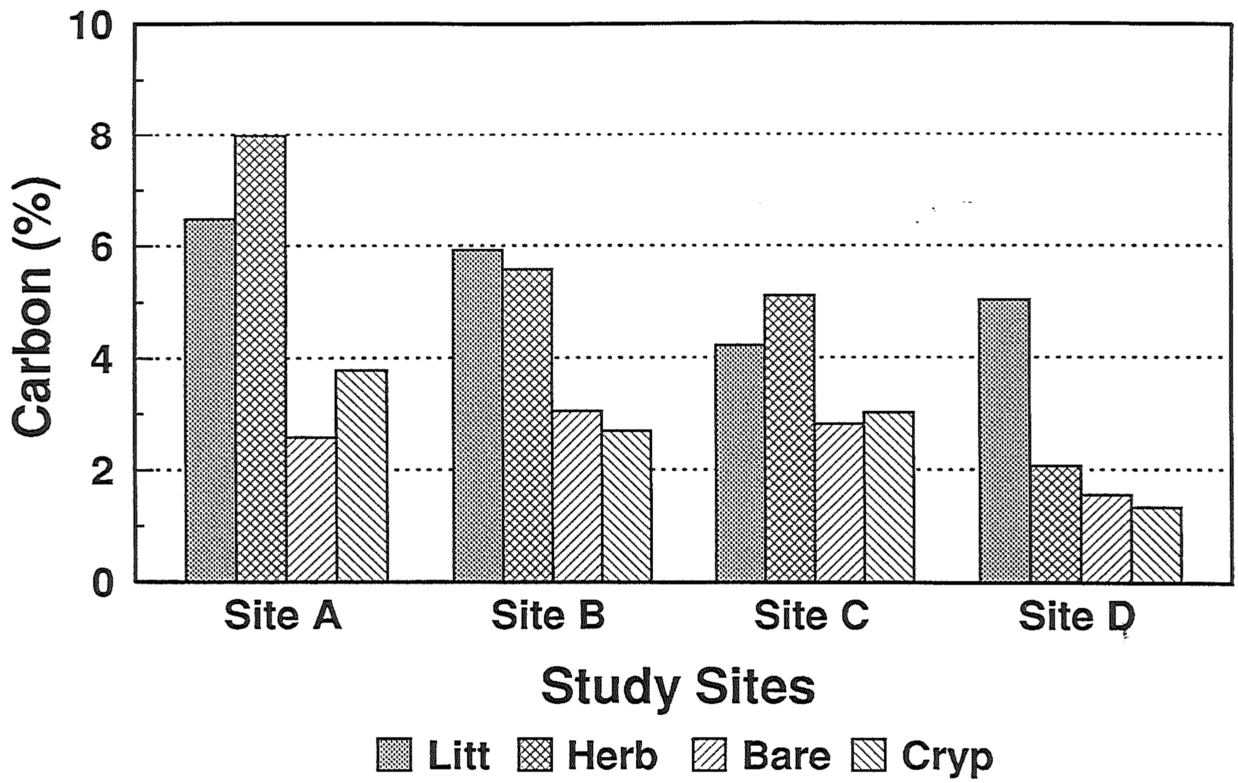

Figure 7. Mean soil C of cover types (litter, herbaceous vegetation, bare soil and obvious cryptogams) within each study site.

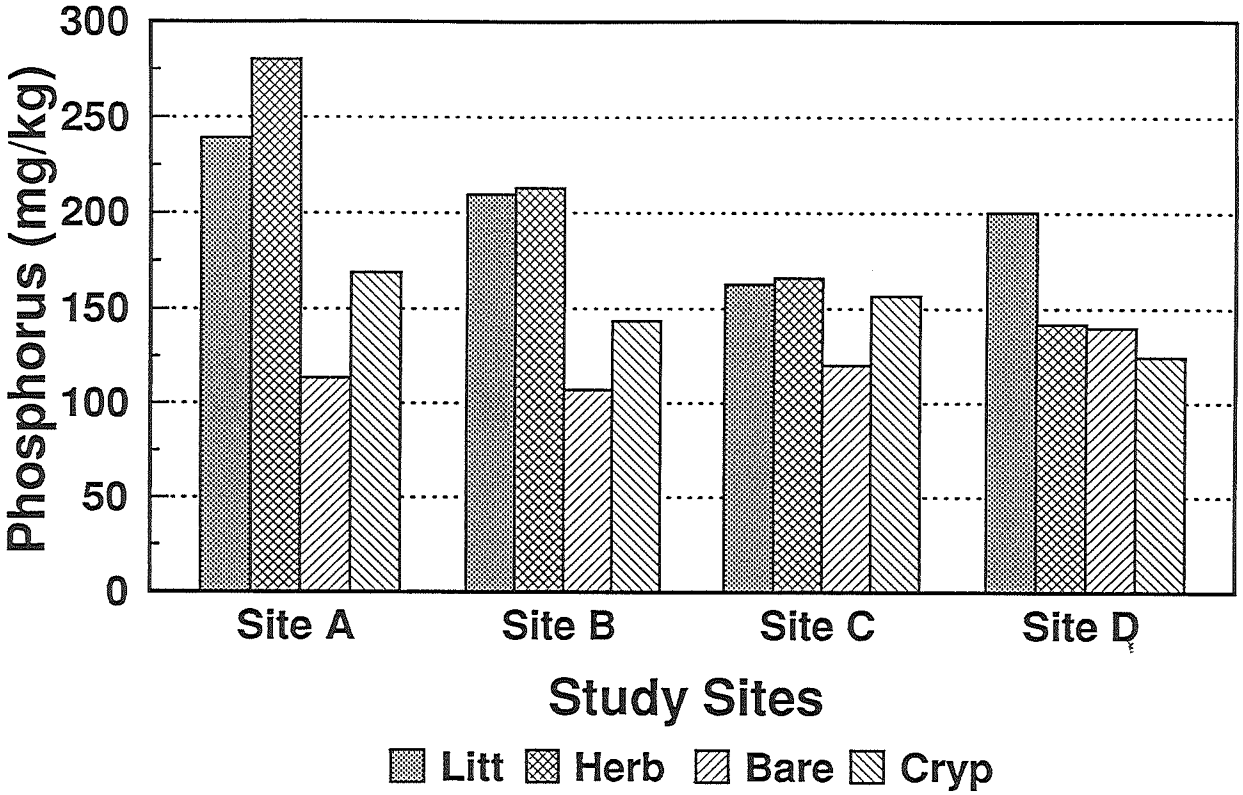

Figure 8. Mean soil P of cover types (litter, herbaceous vegetation, bare soil and obvious cryptogams) within each study site.

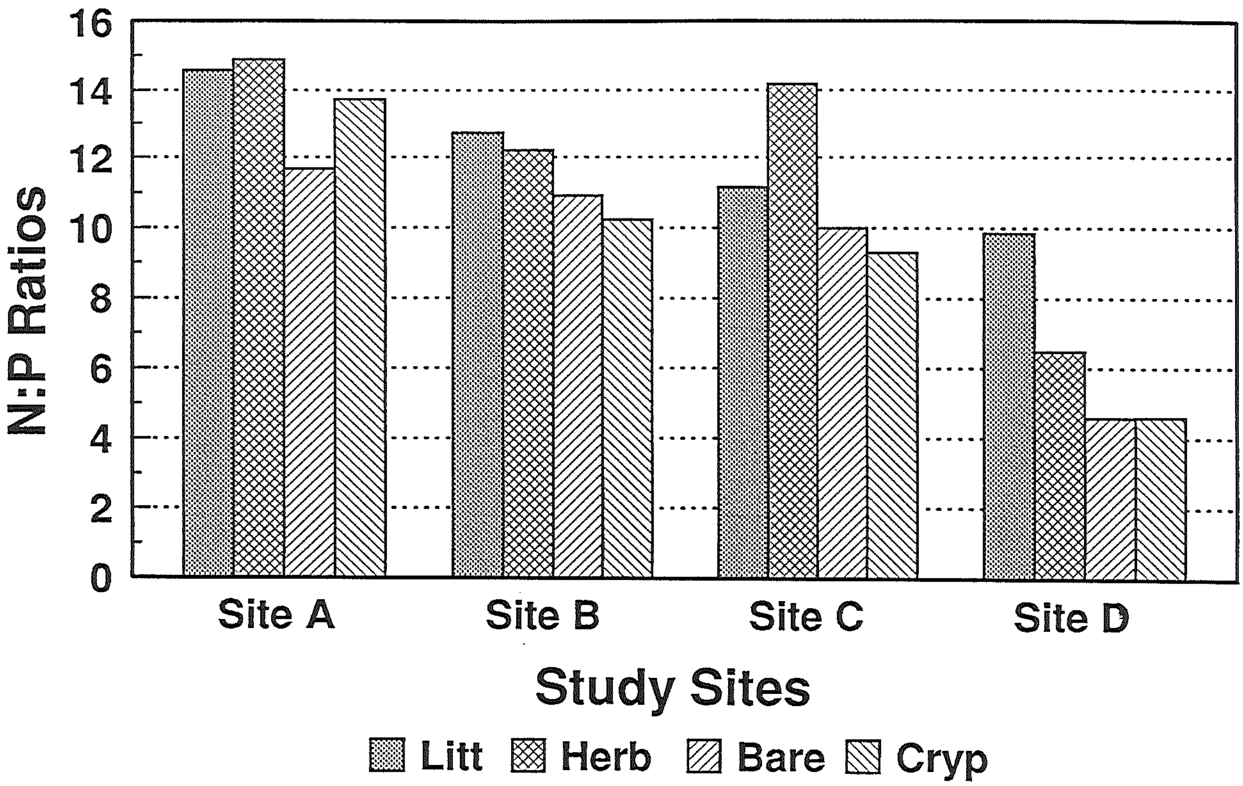

Figure 9. Mean soil N:P ratios of cover types (litter, herbaceous vegetation, bare soil and obvious cryptogams) within each study site.

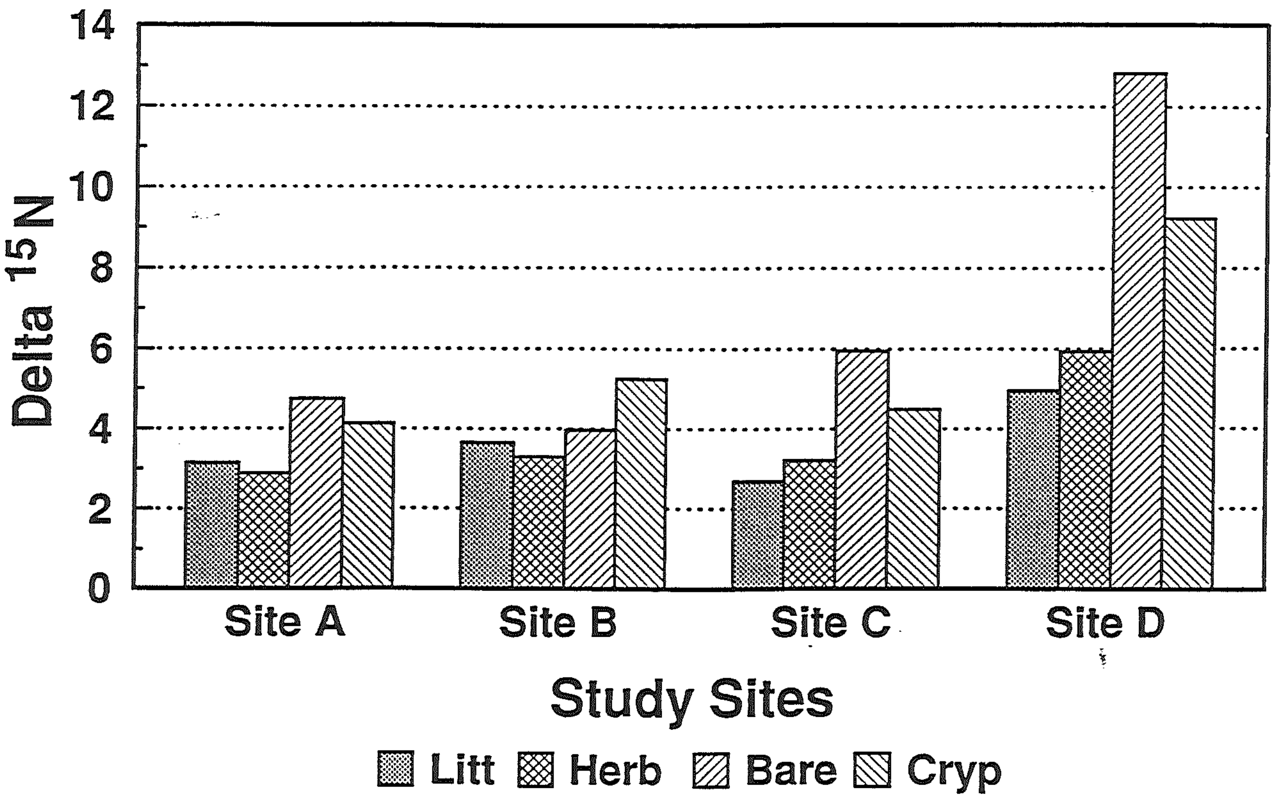

Figure 10. Mean soil $\delta^{15}N$ of cover types (litter, herbaceous vegetation, bare soil and obvious cryptogams) within each study site.

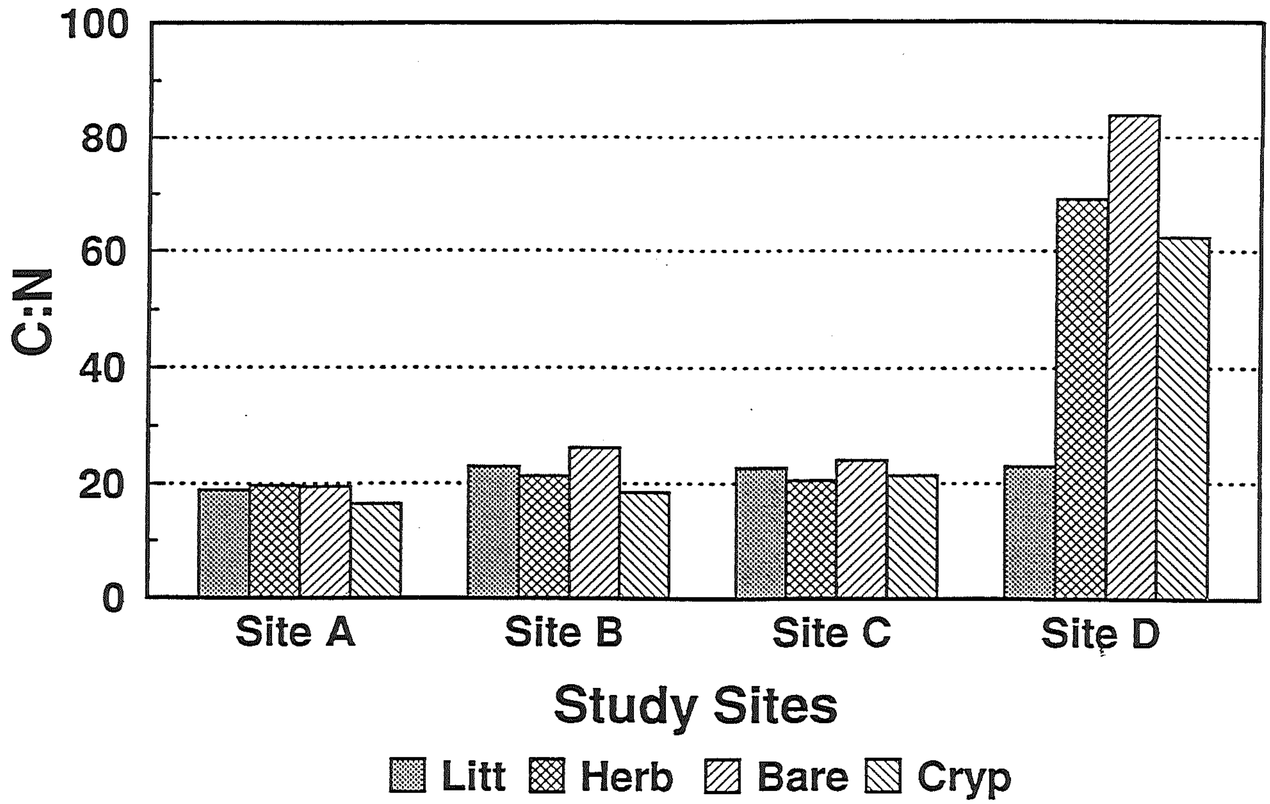

Figure 11. Mean soil C:N ratios of cover types (litter, herbaceous vegetation, bare soil and obvious cryptogams) within each study site.

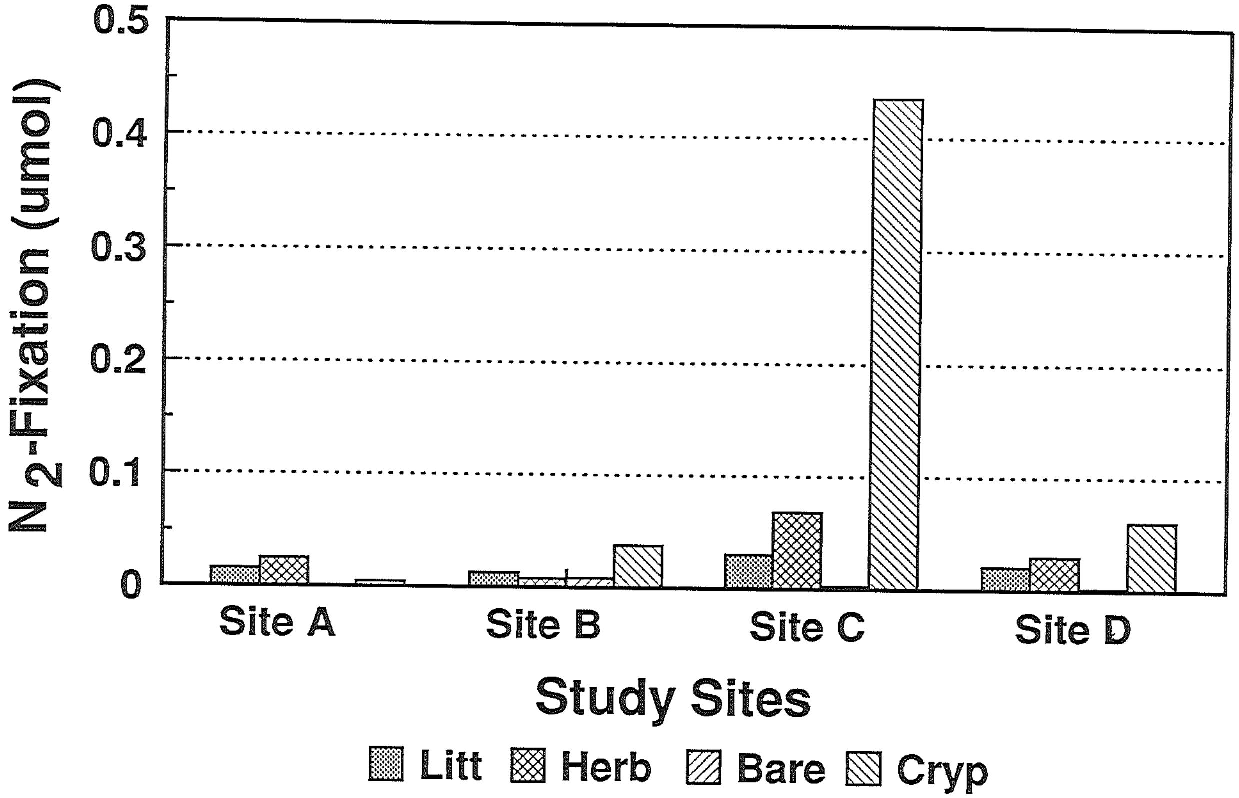

Figure 12. Total N_2-fixation (umol) for cover types witin sites. Due to uncontrollable environmental conditions during sample incubation, comparisons should not be made across sites.

<u>4063.04</u> - <u>Responsibility</u>.

1. Designated research coordinators shall:

a. Maintain knowledge of the ecological conditions, past studies, current research, and logistical considerations for existing research natural areas (RNAs).

b. Encourage the research community to use facilities through internal and external contacts made at conferences and symposia.

c. Assure that Forest contact is aware of past and continuing research on the RNAs and coordinate with Forest contact and expedite processing of plans requiring Station Director's approval.

d. Encourage publication of results of scientific studies and obtain reprints of articles for the WESTFORNET library.

e. Encourage funding of studies to provide basic ecological inventory and characterization, and closely coordinate these efforts with the Forest contact. Consider outside funding sources such as Man and the Biosphere and National Science Foundation as well as in-house funding.

f. Maintain a continuing file of information and activities including records of how proposed.

g. Participate in periodic Forest activity reviews of RNAs to assure that they are being managed in accord with FSM 4063.

2. <u>Regional Foresters and Station Directors</u>. The Regional Forester and Station Director shall establish an RNA Committee composed of Research and Regional Office personnel. This committee and task group shall work with Forest Supervisors, members of Arizona and New Mexico State natural area committees, universities, and other regional and local groups to (1) study natural area needs on both public and private lands, (2) make initial selection of areas to be considered for RNA designation, (3) assure that existing and needed RNAs are addressed in Forest land management plans, and (4) develop solutions for administrative procedure and coordination problems. (Exhibit 1)

3. <u>Research Project Leaders, Forest Supervisors, and District Rangers</u>. Forest Supervisors shall:

a. Identify areas on the Forest which might represent forest and range land types that are not presently represented, request and schedule review of proposed areas by the RNA Committee, and participate as an ad hoc member of the task group reviewing potential areas on the National Forest.

B/4

b. Maintain the integrity of identified RNA candidate areas until Forest plans and establishment actions are completed. (Exhibit 2).

c. Assure that environmental analysis and operating plans for locatable and leasable minerals protect the integrity of established and candidate RNAs.

d. Assure that established and targeted RNA representations receive appropriate consideration in all alternative land management planning allocations. Document briefly in the planning record areas proposed but not meeting identified needs or standards for RNA establishment.

e. Prepare the required establishment reports for candidate areas identified in approved Forest plans in a timely manner.

f. Schedule and conduct reviews of RNAs periodically to assure that they are being managed in accord with FSM 4063 through FSM 4063.5 and recommend to the Committee actions necessary to effectively manage the program, resolve identified conflicts, and improve direction.

g. Designates Forest RNA contact to facilitate the RNA program by:

(1) Maintaining records of use and activity on established RNAs.

(2) Assuring the research coordinator (Exhibit 3) consults with the District Ranger during the review and approval of plans for use by the Station Director.

(3) Referring scientific inquiries to the appropriate research coordinator. (Exhibit 3)

(4) Assuring that establishment reports are prepared according to current direction in FSM 4063.41 and submitted in a timely manner.

(5) Developing a Forest program with consultation and assistance from Research to provide basic inventory, characterization, and RNA environment.

(6) Consulting with the research coordinator on any activities proposed which might have an influence on the ecological integrity of the RNA.

C-1

Exhibit 1

Research Natural Area Committee Charter

Objective

The Research Natural Area Committee is chartered to assist management in effective and efficient achievement of the research natural area objectives as outlined in FSM 4063. The committee, utilizing a task force approach, shall develop and recommend alternative courses of action to respond to needs identified by management in the annual plan of work.

Responsibilities

The committee shall:

1. Assure that proposed and recommended areas meet the criteria and qualify as research natural areas (RNAs).

2. Provide the necessary direction to assure that RNAs are adequately addressed by Forest land management plans.

3. Recommend appropriate standards and guidelines for establishment and maintenance of baseline data and for protection of resources to insure meeting RNA objectives.

4. Monitor progress in achieving objectives through review of Forest plans and conducting appropriate activity reviews.

5. Provide the necessary direction in the context of land management planning to establish and manage RNAs.

6. Examine selected areas with Forest Supervisors and District Rangers to assure the area qualifies and no unresolvable management conflicts exist.

7. Review establishment and land use reports prepared by the Forest Supervisor and make recommendations to the Regional Forester.

8. Commission a Research Natural Area Task Group to aid in Committee work. The task group shall include representatives from each of the following resource units; Range, Watershed and Air Management, and Wildlife, plus one Research scientist from Arizona and one from New Mexico. Ad hoc members shall be added as appropriate to complete specific parts of the work plan.

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Membership

Chairperson	- Director of Range Management
Member	- Deputy for Resources
Member	- Assistant Director, Rocky Mountain Station, Fort Collins
Member	- RNA Task Group Leader

Meetings - Committee shall meet annually in September, or as scheduled, to establish an annual work plan and recommend appropriate courses of action to the Regional Forester. The task group shall meet as necessary to accomplish the annual work plan.

Reports

Committee shall:

1. Provide annual report to the Washington Office on status of designated RNAs in Region 3.

2. Document annual plan of work and provide annual report to Deputy Regional Forester, Resources, FSM 1350.

United States Department of Agriculture
Forest Service
Washington Office
14th & Independence SW
P.O. Box 96090
Washington, DC 20090-6090

Reply to: 4060-3 (LMP)

Date: July 19, 1993

Subject: Research Natural Areas Program Strategy

To: Regional Foresters, Station Directors, Area Director, and IITF Director

In 1991, National Forest System and Research made a financial commitment of $490,000 to the Forest Service Research Natural Area (RNA) Program. Designed as an annual commitment over a 5-year period, this fund has been crucial to the establishment of new RNA's and to commencement of new research and monitoring projects nationwide. The RNA Program has, partly due to that financial support, become a vigorous component of Forest Service activities in the areas of ecosystem management, biodiversity, research, and monitoring.

Just over a year ago, representatives of all Regions and Stations began working together to formulate a working plan or strategy to guide research and management activities on the 289 RNA's we have established throughout the National Forest System. The enclosed completed document will be used to advance Forest Service and natural resource management interests in the various ecosystems represented across the Nation by our RNA network.

We anticipate that actions taken to implement the strategy will aid the continued contribution of the RNA Program to the promotion of research, biodiversity, ecosystem management, and forest management, in general, over the coming years.

/s/ George M. Leonard
for

F. DALE ROBERTSON
Chief

Enclosure

1920 LRMP:!oc-1993:!!RNA StrategyForest
Service:FMR:S.Krugman:pj:05-20-92:(202) 205-1555I CONCUR:
J.WHITMORE:05/20/92I CONCUR: P.JOHNSON:05/20/92FS:LMP:P.Boland:1920
LRMP:!OC-1993:6/29/93:

BDDD

Research Natural Areas Program
USDA Forest Service

NATIONAL STRATEGY
-Opportunities for the Future-

BDDD

INTRODUCTION

The Forest Service Research Natural Areas (RNA's) Program maintains a network of 289 established areas and over 300 candidate areas representing common and unique natural ecosystems on National Forest System lands in the United States. These areas are managed in conditions minimally disturbed by human activities for nonmanipulative research, monitoring, education and to maintain natural diversity and ecological processes. Prompted by desires to improve the effectiveness of the current program and realizing that opportunities exist for an expanded role for RNA's in ecosystem management, RNA Coordinators agency-wide have been meeting over the last 2 years to evaluate new directions for the program.

The current document condenses these evaluations into a set of strategies aimed at defining opportunities for the next 5-10 years. The Strategy was developed by RNA Coordinators representing all Regions and Research Stations, with input from the national headquarters, and is intended for all managers and researchers who have a stake in the RNA Program.

This Strategy is an evolving document; it does not formulate direction or policy for the agency but is intended to motivate thinking and catalyze action as the ecosystem management approach is implemented. Specifically, it is hoped that ideas presented here will provide incentives and guides for integrating RNA's fully with new ecological approaches to management as forest land and resource management plans (forest plans) are implemented, amended, and revised.

The intent of the Strategy is to initiate immediate action toward some goals and to motivate planning toward others. Different priorities will guide implementation at national, regional, station, and forest levels.

For this report, **natural areas** are defined as areas managed for minimal human disturbance to perpetuate natural or near-natural ecological conditions (e.g., RNA's), and **reference areas** are defined as natural areas (designated or not) that serve as control sites (research or monitoring context) for comparison with treatments on lands where human disturbance occurs.

FUTURE ROLE OF RESEARCH NATURAL AREAS PROGRAM

In line with the Mission, Vision, and Guiding Principles for the Forest Service, the role of RNA's in the future will be characterized as follows:

The RNA's help ensure that we maintain representation of diverse natural ecosystems for future generations. The RNA Program finds, establishes, and maintains a network of sites that provides ecological reference areas of critical importance for research, monitoring, and education. The RNA Program works with other disciplines and staffs to coordinate the biodiversity and monitoring functions of many types of minimally disturbed areas (e.g., wilderness, special interest areas, wild and scenic rivers, etc.). Appropriate management of RNA's and integration of these areas with monitoring and management of other lands at many spatial and temporal scales enhance the ability of RNA's to provide for biological diversity and to support ecosystem processes. At the same time, expanded research on RNA's allows RNA's to contribute ecological knowledge that is essential for carrying out the Forest Service commitment to ecosystem management. The RNA Program is supported by all staff involved with ecological management, especially forest supervisors, district rangers, and their staffs, who support and utilize the essential contributions of RNA's.

OPPORTUNITIES FOR PROGRAM REORIENTATION

STRATEGY 1:

Promote linkages of the Research Natural Areas Program with efforts to implement ecosystem management.

RATIONALE. Successful development of ecosystem management depends on availability and use of ecological baseline information on natural composition, structure, and function and on effective monitoring. RNA's provide excellent reference areas for monitoring, yet this opportunity has been under-utilized. Further, opportunities exist to improve the biodiversity and monitoring functions on National Forest System lands by coordinating efforts of the RNA Program with other Forest Service programs that manage lands for minimal human disturbance.

Goal A: Work with ecosystem management programs within Forest Service at regional, station, and especially forest levels to integrate RNA's into ecological management strategies, emphasizing opportunities to coordinate biodiversity, and monitoring functions of many types of natural areas (RNA's, wilderness, special interest areas, etc.) and to use areas as baselines for monitoring.

Goal B: Develop national and regional priorities for RNA's that are responsive to goals of ecosystem management and to biodiversity needs at multiple spatial and temporal scales.

OPPORTUNITIES TO CHANGE ADMINISTRATIVE PROCEDURES

STRATEGY 2:

Provide means to adequately fund the RNA Program, specifically ensuring support to the national forests.

RATIONALE. The RNA program currently operates on an ad-hoc budget, derived from many staff areas. Lack of secure funds limits the ability of the RNA Program to carry out its functions or to be of significant use in ecosystem management.

Goal A: Secure Federal funding for the RNA program at all levels in National Forest System and Research budgets.

Goal B: Encourage creative funding for individual RNA activities through partnerships and cost sharing.

STRATEGY 3:

Streamline RNA establishment procedures.

RATIONALE. The current process for establishing RNA's is burdened with outdated procedures involving redundant efforts and expending unnecessary staff time and money. The role of RNA management in forest plan implementation is unclear.

Goal A: Review establishment requirements for RNA's and develop a revised, efficient process.

Goal B: Clarify the role of forest plans and National Environmental Protection Act (NEPA) procedures in RNA establishment and management.

Goal C: Standardize procedures for RNA evaluation, selection, and establishment once a revised process is approved.

OPPORTUNITIES TO CHANGE PROGRAM MANAGEMENT AND IMPLEMENTATION

STRATEGY 4:

Within management direction provided by forest plans, review RNA monitoring and management strategies and adjust as appropriate, to protect the areas and promote desired ecological conditions (composition, structure, function, and natural succession) for the sites.

RATIONALE. Past intervention in natural disturbance regimes (e.g., fire and pest suppression), intensive management on adjacent lands, and heavy research and recreational use in some sites have created situations in which review and adjustment of monitoring and management strategies are needed to ensure that the natural diversity and succession for which the areas are recognized are protected. Lack of monitoring and appropriate management adjustment can result in degradation of the sites, making them useless as reference areas for ecosystem management.

Goal A: Review monitoring requirements for RNA's in forest plans and recommend standardized but flexible baseline approaches to ecological monitoring for RNA's.

Goal B: Expedite effective, timely RNA management, linked to monitoring, with appropriate forest plan amendment if needed.

STRATEGY 5:

Expand research in RNA's without impacting the ecological values for which the areas are selected.

RATIONALE. Although RNA's are specified for nonmanipulative use, this has been difficult to define and enforce. As a result, some RNA's have received inappropriate use for research and administrative studies. On the other hand, many RNA's are not used at all for research and are greatly under-used by Forest Service Research and National Forest System managers.

Goal A: Develop guidelines at regional and station levels for research and administrative studies on RNA's that ensure site protection, recognizing the need for flexibility due to the variable nature of different sites.

Goal B: Expand use of RNA's by Forest Service and external research communities in ways that contribute to forest plan goals and objectives.

Goal C: Establish flexible data management systems at regional and station levels that promote scientific study of RNA's and facilitate use of research and monitoring information in ecosystem management.

STRATEGY 6:

Improve support for the RNA Program through education, publicity, and communication.

RATIONALE. Lack of knowledge and support for the RNA Program within and outside the Forest Service currently limits the ability to establish new areas, manage established areas, use them within ecosystem management, and obtain scientific information from them.

Goal A: Develop a promotional program for National Forest System managers and researchers (Forest Service and external) that stresses the role of RNA's in ecological approaches to management.

Goal B: Develop promotional programs for the public emphasizing support and understanding of RNA's, not encouraging public use.

MANAGEMENT AREA M

MANAGEMENT AREA M

DESCRIPTION

This area consists of the one existing and two proposed Research Natural Areas (RNA). These areas offer ecosystem representation appropriate to meet needs identified by the Southwestern Region. The existing Monument Canyon RNA is a 640 acre section consisting primarily of Ponderosa Pine. The Canada Bonito RNA is 300 acres of Thurber Fescue, while the Ladrones Mesa RNA is 500 acres of Juniper savannah.

MANAGEMENT EMPHASIS

These areas will be managed to provide opportunities for non-disruptive research and education. This management includes allowing natural processes to occur and the protection of natural features. Use restrictions will be imposed as necessary to keep areas in their natural or unmodified condition. There will be no harvest of timber or firewood, nor will this area be assigned any grazing capacity.

The following areas will be proposed for designation to the Natural Research System:

Approximately 300 acres (Canada Bonito) for the protection and study of a high elevation Thurber fescue meadow.

Approximately 500 acres (Ladrones Mesa) for the protection and study of a juniper savannah.

Location and evaluation of other potential areas which lack Regional representation will continue throughout this planning period

There are no vegetation modification practices proposed in this management area.

Land Suitability	Acres
Total suitable timber	0
Total Management Area	1,440

STANDARDS AND GUIDELINES

In addition to the forestwide standards and guidelines, the following specific standards and guidelines will apply to this management area:

PROGRAM ELEMENT	ACTIVITY MIH CODE	MANAGEMENT AREA M STANDARDS AND GUIDELINES
RECREATION	A08	Allow nonmotorized dispersed recreation activites provided they do not modify the area or threaten or impair the research or educational value of the area.

E 1

MANAGEMENT AREA M

		Require recreation users to pack out all their trash.
		Cross-country vehicular travel is prohibited within study areas.
		No open campfires will be permitted within the study areas.
	A11	No new trail construction will occur.
	A13	Manage for a Visual Quality Objective of Preservation
WILDLIFE	C01	Evaluate these areas and determine their contribution to threatened and endangered species recovery objectives.
	C02	Prohibit introduction of non-native plant or animal species.
RANGE	D01 D02	Allotment plans utilize Level A to achieve management area objectives.
		Post boundaries, fence, or take other necessary action to prevent unauthorized livestock grazing.
TIMBER	E00	Prohibit all timber and firewood activities.
MINERALS	G04	Mineral leasing category: Limited surface use- No surface occupancy
LANDS	J01	Utility corridors are excluded
FACILITIES	L01 L04 L08 L12	Roads will not be constructed in this management area. Road management and closures will be implemented with the objective of closing roads where they currently exist, except as necessary to provide access for research, or adjacent management areas.
PROTECTION	P01-07	The fire suppression objective for Monument Canyon is to control 90% of the high intensity wildfires at 75 acres or less. Maximum loss from high intensity wildfires is 75 acres of the management area per decade.
		Low intensity wildfires will have no size limitations.
		Limit suppression action to the use of hand tools.
	P11 P12 P13	Fuel treatment will be commensurate with management objectives and direction for individual RNA's.
		Allow prescribed fire, using planned and unplanned ignitions in Ladrones Mesa and Canada Bonito RNA's to maintain these fire dependent ecosystems.

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FORM 6200-8 (1/64)
UNITED STATES GOVERNMENT
Memorandum

Department of Agriculture—Forest Service
Region 3, Santa Fe, New Mexico 87501

TO : Regional Forester

File No. 4060

FROM : R. E. Latimore, Forest Supervisor

Date: January 3, 1967

SUBJECT: Research Facilities - Natural Areas

Your reference: 9/26/66

Following is our report on the existing Monument Canyon Natural Area located on the Jemez Ranger District, Santa Fe National Forest.

This report format follows the five items listed in your memorandum.

1. Conformance with criteria as set forth in FSM 4063:

   a. 4063.3 - Size - Monument Canyon encompasses 640 acres. This size is sufficient to protect unmodified conditions in the interior areas.

   b. 4063.4 - Protection and Management - Monument Canyon has been protected against activities which directly or indirectly modify its research values with the following exceptions:

      1. The area is grazed by domestic livestock under National Forest Permit. There is very limited suitable grazing land within the area. Specific sites have occasionally been used as "salt grounds."

      2. A minor amount of dead wood has been removed from the area by wood haulers. There is no evidence of removal of living trees.

   c. 4063.41 - Identification - The Natural Area has been identified only on various maps and in plans. There is no on-the-ground identification at present.

   d. 4063-42 - Fences - There are no fences around or within the area.

   e. 4063-43 - Publicity - As far as we know, the area has been publicized only in very limited correspondence with professional groups such as the S.A.F., University of New Mexico, etc. We feel that the general public is completely unaware that the area exists.

f. 4063.44 - Physical Improvements - There is an existing logging road through the area, constructed to harvest timber on the west side of the area (north within area). There is also a Forest Service telephone line across the area. There are no other improvements.

g. 4063.45 - Protection - There is no evidence of major fires in the past, nor known insect or disease control.

h. 4063.46 - Public Use - The area is subjected to very light use by the public - primarily for incidental picnicking and hunting use.

i. 4063.47 - Scientific and Educational Use - To the best of our knowledge, no specific research use has ever been made of the area.

j. 4063.48 - Vegetation Management - Nothing has been done.

k. 4063.49 - Mineral Entry - The area has not been withdrawn from mineral entry.

2. Present and past uses of Monument Canyon have been described under #1. Briefly, it is open to grazing, has had some dead wood removal, and is subject to some hunting and picnicking use.

3. We propose no new Research Natural Areas on the Santa Fe.

4. Should the existing Monument Canyon Natural Area remain in its present status, we anticipate only minor problems of continued administration and protection to present standards. To manage the area properly, it would be necessary to exclude grazing, discourage picnicking and wood hauling, and intensify our fire prevention efforts.

   The increase in management intensity necessary would depend on the amount of protection deemed necessary.

   Our most immediate management problem concerning Monument Canyon is one of fire control. The entire area is covered by an overmature, decadent stand of Ponderosa Pine and Mixed Conifer with a great number of snags. The understory is a very, very dense thicket of pine reproduction, much of which is snow damaged and lying on the ground. The area faces the prevailing southwest winds and lightning or man-caused fires could be disastrous. We have invested considerable from PSM and APW funds in nearby TSI operations.

F2

5. Although you do not specifically ask for our recommendations, we would recommend that the Monument Canyon Natural Area be abolished unless the Research Station has some definite, immediate plans for use of the area.

   This recommendation is based upon:

   a. The fact that no research has yet been conducted on the area.

   b. The present and future fire threat, both to the area and adjoining Forest, because of conditions and types of fuels.

   c. Our desire to practice multiple-use management on all lands not specifically needed for single purposes.

   d. The increase in management necessary to meet the goals of a Natural Area. Increased expenditures do not seem to be justified under current use.

   e. Our feeling that areas within nearby wilderness areas satisfy the needs for natural areas.

We would further recommend that the area be scheduled for timber harvest in the near future, both to arrest timber mortality and decrease the fire hazard, subject to any harvesting restrictions deemed necessary by Timber Management, the Research Station, and the Forest.

DASchultz:amm

cc: R.J.
[illegible]

[illegible]
Natural Areas
Santa Fe

MONUMENT CANYON NATURAL AREA

Purpose

To preserve in natural state a typical area of western yellow pine forest as found in northern New Mexico. The stands of western yellow pine in this region differ from those of the Colorado Plateau in being denser and more evenly spaced with trees of relatively small diameter.

Description

Location

Section 9, T. 18 N., R. 3 E., N.M.P.M. - Surveyed. All national forest land. The northern fringe and NE drop down over the rim of East Fork of the Jemez River, known here as Monument Canyon. The balance is plateau [illegible]

[illegible]

All western yellow pine type.

Physiography and Climate

For the most part fairly level mesa, altitude [illegible] feet. The climate is characteristic of the western yellow pine zone, - short growing season, cool summers, precipitation about 20 inches.

Forest Value

About 570 acres is commercial [illegible]; the remaining 70 acres is classed as inaccessible. The volume is estimated at [illegible] board feet per acre. Pole growth and reproduction in seedling and sapling stages are excellent.

Agricultural Value

None

Grazing Value

Negligible. The carrying [illegible] estimated at [illegible] head of cattle yearlong.

[illegible]

[illegible]

[illegible]

None of specific importance.

G L

Transportation

The area is on a trail from Jemez Springs to Upper Vallecitos. It is also within a mile of a programed Forest Service development road, and is crossed by a motorway cleared out for fire protection purposes, following the route of the above trail.

Public Sentiment

So far as known there would be little public interest in the area outside of scientific circles.

Plan of Management

The primary protective measure is to guard against cutting. Neither live nor dead timber should be cut unless in connection with fire or insect control. No roads or trails except those needed for protection of the area and adjacent Forest land, and no occupancy of any kind should be permitted. Conservative grazing may continue, but overgrazing must [illegible]

[illegible] designated in cooperative agreement with the University of New Mexico providing for joint study of biological, archaeological, climatological, and related problems. This agreement under the title "Cooperative Agreement Between the Department of Agriculture and the University of New Mexico for the Purpose of Research and Observation in Certain Natural Sciences" is dated May 29, 1930, and is signed by the President of the University and the Secretary of Agriculture.

Approved:

/s/ F. E. Andrews
Forest Supervisor

G. A. Pearson /s/
Director, Southwestern Forest and Range Experiment Station

/s/ Frank C. W. Pooler
Regional Forester

Washington D.C.,

11 1/32

[illegible] authority vested in me by Reg. L-20 of the regulations [illegible] relating to the [illegible], protection, [illegible] hereby designate [illegible] the [illegible] report [illegible] and the instruc- [illegible].

R. Y. Stuart /s/
Forester


2757

Collect specimens at Monument Canyon: Fall 1995 to Spring 1996, weather permitting, one trip by Swetnam and crew, two trips by Muldavin and crew

Process and analyze specimens: Summer to Fall 1996

Write final report/manuscript: Fall and Winter 1996

Deliver final report/manuscript to USFS: December 31, 1996

Budget

Salaries/Wages:	
Swetnam's Assistants/Students for collection, processing, dating specimens	$2,000
Muldavin's Assistants for field collections	500
Travel:	
Swetnam's crew from Tucson to Jemez	1,000
Muldavin's crew Albuquerque to Jemez	500
Other:	
misc field and lab supplies	500
page charges for publishing article	500
Total:	$5,000

Monument Canyon Research Project
Questions and methods
12 July, 1998

Question	Data required to address	Field sampling scale	Method of analysis
STRUCTURE			
What was the pre-settlement density and spatial distribution of overstory trees?	Number of pre-settlement trees in known area. Distance between closest 3 overstory trees.	.1- to .5-ha plots or aerial photographs.	Extrapolate stem number per ha from plot samples. Compute indices of spatial distribution (e.g., aggregation, nearest-neighbors distance). Visual (GIS) display of overstory stem spatial distribution.
What is the present spatial structure of the forest?	Number of all trees in known area. Distance between closest # overstory trees.	.01-ha subplots or aerial photographs.	
What was the size structure of the pre-settlement forest?	Size (dbh, height) of all pre-settlement trees, interpolated to [date?]	.1- to .5-ha plots	Histogram and distribution analysis of overstory trees by dbh or dbh class using diameter at pre-settlement date.
What is the present forest size structure?	Size (dbh, height?) of all current trees.	.01-ha subplots, or 4-6 corner-side trees from .1-ha plots	Histogram and distribution analysis of all trees on subplot, by dbh or dbh class.
COMPOSITION			
What was the pre-settlement overstory composition ?	Species identity of all pre-settlement trees.	.1- to .5-ha plots.	Percentages of overstory trees by species.
What is the present overstory and understory composition?	Species identify of all trees currently in stand.	.01-ha plots.	

DYNAMICS			
What was the age structure of the pre-settlement forest?	Year of origin of all pre-settlement trees.	.1- to .5-ha plots.	Histogram and distribution analysis of pre-settlement trees by age or age class.
What is the present age structure of the forest?	Year of origin of all present trees on stand.	.01 ha plots.	
In what years did individuals of fire-sensitive species establish?	Year of origin of all fire-sensitive species.	.1- to .5-ha plots.	Histogram and distribution analysis of non-PIPO trees by age or age class.
Was establishment of fire-sensitive species associated with long fire intervals?	Age of all non-PIPO species. Years of fire events at that location.	.1- to .5-ha plots. 1-ha cell or cruising.	Analyze correlation of year-of-origin with fire intervals.
FIRE			
In what years and locations did fires occur?	Analysis of sections from complete inventory of fire-scarred trees. GPS/GIS location of fire-scarred trees.	1-ha cell or cruising.	
What percentage of overstory trees were scarred by each fire event?	Comparison of number of fire-scarred trees with total stand density.		
Is the distribution of fire-scarred trees associated with other attributes (stand density, topography)?	Comparison of location of fire-scarred trees with other site and stand attributes.	Site attributes at .01 ha.	
FOREST HEALTH			
What is the condition and	Measures of condition for	.1- to .5-ha plot.	Descriptive statistics for condition

health of the present overstory trees?	pre-settlement trees. Radial growth increment pre- and post-1999 fire.		classes.
Is competition with undergrowth affecting overstory tree health?	Number and basal area of understory trees within canopy of overstory trees, and/or nearest-neighbor distances for overstory trees.	.1- or .01-ha plot.	Competition indices; nearest-neighbor distances with condition classes; correlation of these with tree health and vigor.

Monument Canyon Research Project
Summary of Field Sampling Protocols
8 July, 1998

1-hectare cells (100m x 100m = 10,000m^2)

1. Locate desired grid corner using map or GPS.
2. Tape off 100 m sides. Flag and GPS corners.
3. Systematically cruise cell, in strips of no more than 20 m.
4. For *all*:
    a. Fire-scarred trees,

    record:
    a. Unique identifying number,
    b. Location (GPS, map, tag, flag),
    c. Species,
    d. DBH,
    e. Height,
    f. Scar location (if any),
    g. Number of visible lesions,
    h. Condition of lesion (intact, hollow, rotten)
    I. Condition code,
    j. Notes.
5. Extract a section or other appropriate sample.
6. Collect cores from other trees (*e.g.* very large trees) of interest, and record data a-j.

Alternative 1: Cruise sampling areas defined by topographic or other features; compute densities during analysis.
Alternative 2: Divide 1-ha cell into four .25-ha (each 50m x 50m) or two 50m x 100m sections (.5-ha) and make complete inventory of overstory trees.

.1 hectare plots (20m x 50m = 1,000 m^2)

1. Select a starting grid point by random method.
2. Tape off 20m x 50m plot; flag, map, and GPS corners (one corner will already be recorded for 1-ha cell).
3. For *all*:

   a. Trees with DBH $\geq$ 30 cm,
   b. Scarred trees,
   c. Non-PIPO trees of any size,
   d. Standing snags or fallen logs,

extract a core or collect entire stem (except non-PIPO seedlings, which can be tallied by species), and record:

   a. Unique identifying number,
   b. Species,
   c. Presence, location, and condition of fire scar (if plot is in previously-surveyed 1-ha cell, these should have already been recorded),
   d. Location (GPS, map, tag, flag),
   e. DBH,
   f. Height,
   g. Condition code,
   h. Distance to 3 nearest neighbors of any size,
   i. Number of stems, and/or basal area, underneath the canopy (overstory),
   j. Notes.

In addition, for the live tree nearest each corner of the plot, regardless of size or species, collect a core or entire stem, and record:

   a. All of a-h above,
   a. Distance from corner.

.01-ha subplot (10m x 10m = 100m^2)

1. Select a starting corner of the .1-ha (20m x 50m) plot by random method.
2. Tape off 10m x 10m plot; flag, map, and GPS corners (one corner will already be recorded for .1-ha subplot).
3. Record mean percent slope and aspect for the subplot.
4. Core or collect stem from *all* live trees with dbh $\geq$ 5 cm, and record:
   a. Species,
   b. Presence, location, and condition of fire scar (if plot is in previously-surveyed 1-ha cell, these should have already been recorded),
   c. DBH,
   d. Height,
   e. Condition code.

5. Tally the number of standing stems <5 cm dbh by species, collect stem from every tenth tree, and:
   a. Tally number living and dead,
   b. Estimate average height.

1m x 1m microplot (1m^2)

1. Select a starting corner of the .01-ha (10m x 10m) subplot by random method.
2. Use tape or frame to create microplot; map and GPS corners (one corner will already be recorded for .01-ha subplot).
3. For each species in the herb layer (including all vascular and non-vascular herbaceous species, seedlings of woody species, and non-colonizable substrates such as bare rock), record total:
   a. Percent cover,
   b. Number of stems.
4. Take a canopy photograph.

United States
Department of
Agriculture

Forest Service

Rocky Mountain
Forest and Range
Experiment Station

Fort Collins,
Colorado 80526

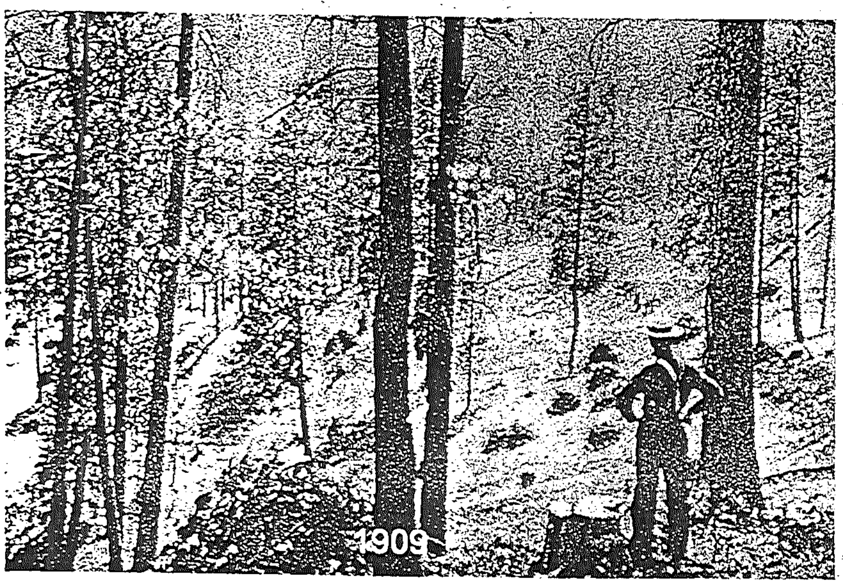
General Technical
Report RM-GTR-278

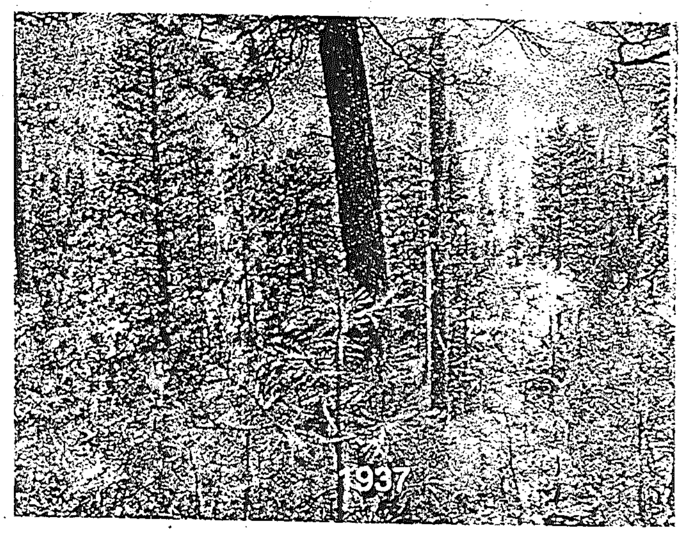
Conference on Adaptive Ecosystem Restoration and Management:

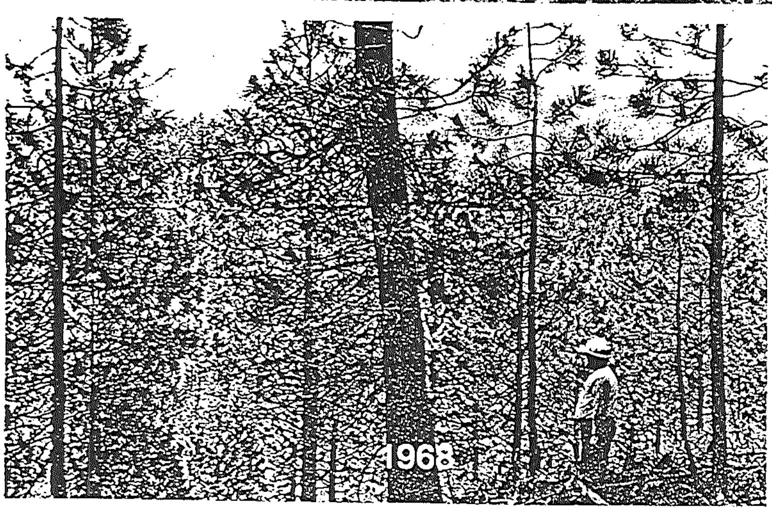
Restoration of Cordilleran Conifer Landscapes of North America

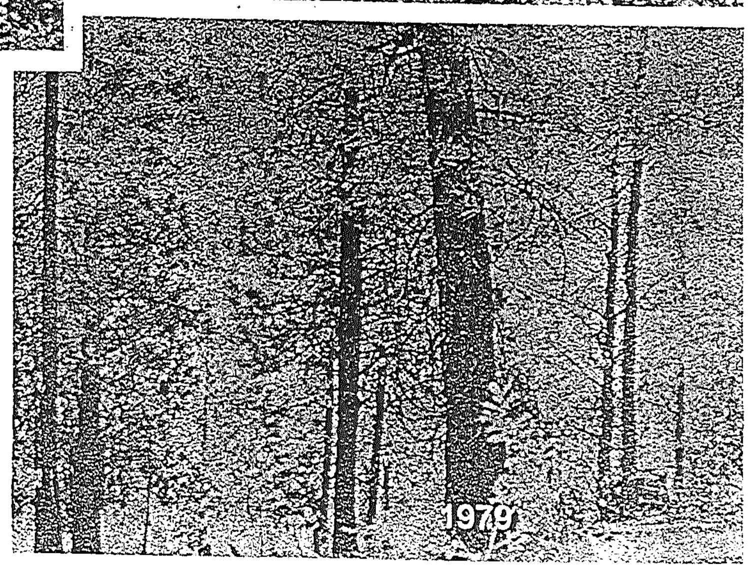
June 6-8, 1995

Flagstaff, Arizona









NOUVELLE SOUTHWEST

Stephen J. Pyne[1]

ABSTRACT. The new Southwest is a product of the old. The region boasts an ideal formula for natural fires. Its dramatic terrain and well-defined wet-dry cycles, both annual and secular, have long established it as an epicenter for lightning fires. But the real narrative of Southwest fire history belongs to its human firebrands, who have co-existed, if not co-evolved, with the regional biota throughout the Holocene. Different waves of human colonization have shaped distinctive fire regimes.

The Old Southwest simmered over chronic fires like a cauldron. That pattern changed abruptly with European-derived settlement. Grazing provided the primary shock wave; but high-grade logging, fixed land ownership, connections to national markets, the reservation of lands for parks, forests, and native tribes, the introduction of exotic flora, and urbanization, all redefined the relationship of humans to the lands around them and in so doing have altered, by means both direct and indirect, the regional fire regimes. Increasingly the landscape has assumed forms that humans find unattractive, even threatening. Increasingly the region's fires appear more unmanageable. Overall, burning has decreased, and where it survives it displays a severity not previously experienced and an ecological synergy very different from prehistoric conditions.

But however significant fire was to the Old Southwest, its removal was only one part of fashioning the New Southwest, and reinstating fire will not by itself restore that old landscape. It is not obvious by what means fire should be reinstated, nor to what ends it should be applied. For better or worse the standards for fire regimes reside in contemporary humans, not in nature and not in history.[2]

The fire bust of June 1990 followed a classic formula but one intensified in puzzling ways.

In the Southwest fire seasons follow a natural rhythm of wet and dry, a two-cycle engine for which lightning typically provides the spark. This interplay of wet and dry takes several forms. Part is topographic, in which the Southwest's fabulous terrain creates differentials between moisture and aridity. Slopes that face south or north betray different levels of moisture. So do plateaus that range from high to low. So does the contrast between peak and ravine. Someplace is nearly always dry and nearly always wet. The greater cause, however, is climatic, the summer monsoon. Surges of moisture from the south strike mesa and mountain, and thunderstorms tower up like spumes of surf on a reef. Rain descends in drying veils. Lightning kindles fires that flash from the peaks like beacons.

The process is spotty, like a handful of popcorn scattered on a skillet. One moment there is a deluge, the next a flood of desert sun. Ideally, there is enough storm to hurl lightning and wind, not enough to quench burning snags. Add to this winds that splash out from thunderheads like water from an overturned bucket, spillage that makes for dust storms in the desert, fire storms in the mountains. Altogether it is one of the great ecological rituals of the region, and it accounts for the fact that the Southwest has the highest concentration of lightning fires in the United States.

The figures are astonishing. Between 1960 and 1974 there were 12 days in Arizona and New Mexico when more than 100 lightning fires started; on June 28, 1960 lightning kindled 143 fires. In 1970 lightning ignited 100 fires on July 18, and the next day brought 100 more. On June 24, 1971 103 lightning fires burned 75,713 acres. The Southwest's national forests average more fires per year than any other region; they have the second highest rate of burned acreage, from both wild and controlled

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[2] *"Nouvelle Southwest" is adapted from WORLD FIRE by Stephen Pyne. Copyright © 1995 by Stephen J. Pyne. Reprinted by arrangement with the author and Henry Holt and Co.*

fires; and critical fire weather occurs here with greater frequency and persistence than anywhere else in the nation. Yet despite prodigious numbers of fires, there are few truly devastating burns. The sheer number of ignitions, plus the exquisite minuet between rain and fire, assures a certain equilibrium that balances large numbers of fires with smaller sizes of individual fires. As the monsoon persists, the wet triumphs over the dry. The number of fires rises steadily from May to August while the average size of those fires diminishes.

But while fire busts are frequent, they are rarely immense and even more rarely fatal. The Dude Creek fire outside Payson, Arizona in late June 1990 shocks because it was both. It took familiar elements—some ancient, some modern—and compounded them into an event that looked grotesque, alien, out of character. Perhaps it was. The conflagration savaged forests, houses, and a fire suppression organization.

The fire blew up on the hottest day ever recorded in Phoenix (122.5°), which argued that it was an old story intensified. But it burned through a forest vastly different than in presettlement times, through summer homes and trailer parks that had little historic precedent, through a society that had sought to eliminate fire of all kinds. Old and new had come together with as much force and fury as wet and dry. When a microburst of wind drove the fire through a squad of firefighter inmates, killing six and hospitalizing four others, it prodded debate about how fire and American society could coexist here, which is to say, about what the character of each had become.

That extraordinary fire load is not simply a product of natural processes. For millennia humans have busily restructured the geography and seasonality of Southwestern fire—sometimes complementing and sometimes countering the natural order. Lightning had to compete not only with rain but with aboriginal firesticks. Human inhabitants added other sources of ignition in the service of hunting, raiding, foraging, and horticulture, and as an inadvertent by-product of a seasonal nomadism whose routes became trails of smoke from camp fires, signal fires, and escaped fires of diverse origins.

"The most potent and powerful weapon in the hands of these aborigines," concluded S.J. Holsinger, of the General Land Office, at the turn of the century, "was the firebrand. It was used alike to capture the deer, the elk, and the antelope, and to vanquish the enemy. It cleared the mountain trail and destroyed the cover in which their quarry took refuge." Obviously burning on this scale "must have exerted a marked influence upon the vegetation of the country. Their fires, and those of the historic races, unquestionably account for the open condition of the forest... The high pine forests were their hunting grounds, and the vast areas of foothills and plateau, covered with nut-bearing pines, their harvest fields..." It is important to note that the aboriginal fire regimes were themselves in transition as peoples migrated into or departed out of the region.

There is an old adage in firefighting which says that the fine fuels drive the fire. Fine fuels include grasses, conifer needles, low shrubs, the portion of the fuelbed that reacts most quickly to changes in moisture and heat, that most readily combusts. It determines the ease of ignition and the rapidity of fire spread. Under aboriginal rule, fine fuels blossomed, and the Southwest burned easily and often. Lightning and firestick competed to see which would burn a particular site or in what season. The density of that competition fashioned, like bees in a hive, an intricate honeycomb of burned and unburned sites. In dry years fires simmered for weeks, smoldering and flaring as the opportunity permitted. The principle check against conflagrations was simply the magnitude of low-intensity burning on all sides.

There are eyewitness accounts to the burning, but the most compelling evidence was recorded in the land itself, the golden grasslands, hillside montages of brush and grass, and most spectacularly oak and pine savannas. Early explorers spoke enthusiastically about the great natural parklands of the region in which mature ponderosa pines marched in majestic columns. In 1882 Capt. Clarence Dutton, exploring the Kaibab Plateau for the U.S. Geological Survey, exulted that:

> "The trees are large and noble in aspect and stand widely apart... Instead of dense thickets where we are shut in by impenetrable foliage, we can look far beyond and see the tree trunks vanishing away like an infinite colonnade. The ground is unobstructed and inviting. There is a constant succession of parks and glades ... the pines standing at intervals varying from 50 to 100 feet, and upon a soil that is smooth, firm, and free from undergrowth. All is open, and we may look far into the depths of the forest on either hand."

For his report on a prospective wagon road through northern Arizona, Army surveyor Lt. E.F. Beale wrote in 1858 that:

> We came to a glorious forest of lofty pines, through which we have traveled ten miles. The country was beautifully undulating, and although we usually associate the idea of barrenness with the pine regions, it was not so in this instance; every foot being covered with the finest grass, and beautiful broad grassy vales extending in every direction. The forest was perfectly open and unencumbered with brush wood, so that the traveling was excellent.

The apparent explanation for the character of these semi-tended fields is that only a fraction of ponderosa pine seedlings survived the regular onslaught of fire through bunch grass. Great trees that toppled over ripped up the ground at their roots, creating pockets of grass-free soil for a few years; so did the fallen trunks when, after a period of decomposition, they burned to white ash. In the critical years that followed, seedlings thrived, and reached a state in which they could survive routine fires. Around Flagstaff, for example, fire-scarred pine testify to fires that burned an average of every 1.5 years. Mature trees grouped oddly, clustered in ways that betrayed their origin in the churned-up soil of old root-holes, or aligned along the trend of fallen boles. The macro-geography of such forests depended on the micro-geography of fire refugia.

The paradox that the land was both burned and forested baffled some observers, like the Norwegian naturalist and explorer Carl Lumholtz who witnessed an astonishing profligacy of aboriginal burning across the border with Mexico. "These Indians, the pagans as well as the Christians, keep up the custom of burning off the grass all over the sierras during the driest season of the year... [so that] fires are seen continually burning day and night all over the mountains up to the highest crests, leaving the stony ground, blackened and barren, but the forests stand green." That was the rub. Despite this fantastic amount of firing, Lumholtz became convinced that "the continuous, immense forests here could never be destroyed by the Indians" because, paradoxically, all this chronic burning inoculated the forests against wildfires. They ensured the forests' "indestructibility."

All this changed with the advent of European colonization. Settlers introduced some new ignitions and removed several old ones, but it was by utterly restructuring the regional fuel complex that they remade the fire regimes of the Southwest. Generally colonization made itself felt in the New World primarily through agriculture. This impact was muted in the Southwest, however. Regional aridity, hostile tribes, distance from major markets, the slow movement of westering Americans, the retarded admission of Arizona and New Mexico into statehood—which meant that the vast majority of lands remained public—all militated in the Southwest against the kind of pervasive agricultural settlement that typified most of the American frontier. Logging and landclearing remained relatively local; farming concentrated on irrigation rather than lands fire-flushed for nutrients. Indians, sequestered onto special reservations, became inconsequential as a source of fire. When Gifford Pinchot visited Arizona in 1900, he watched a distant Apache setting "the woods on fire" to improve his hunting, trailing fire like a broken lance in the dirt. Instead, settlement followed hoof, not axe. Pastoralism prevailed—first through Hispanics, then through partial adoption by select tribes of indigenes (like the Navajo), and then, with mounting force, through Americans. Livestock came to the Southwest in immense numbers. Cattle and sheep—the sheep were "ten times worse," Pinchot insisted—hit the region like a shock wave, dissembling fire regime after fire regime in ways that may prove irreversible. Flocks roamed in the hundreds of thousands, pounding forests and prairies, leaving clouds of biotic dust to blow in their wake. (Pinchot was wrong: the cattle were worse because sheep often browsed on tree seedlings and cattle did not, allowing that arboreal reproduction to blossom unchecked.) When the big ranches collapsed, hundreds of smaller homestead ranches took up the slack. The epidemic of herds continued.

In the old Southwest grass had infiltrated every landscape, and some it dominated. Now exotic herbivores seized every blade and pursued the succulent grass into every niche. No place was spared. Rolling hills of oak, high desert grasslands, mountain meadows, slopes dappled with chaparral, open pine forests like the columns of the great cathedral of Seville—the relentless hoofs and hungry teeth found them all. Thanks to his herds the reach of the rancher far exceeded his own numbers. He became the biotic conquistador of the Southwest. There was no sanctuary, no refugia from the conquest. The indigenous fires went the way of the grizzly bear and the mountain lion. Only on Indian reservations could it survive in anything like its former state and then only if tribes did not take up herding with the same ruthlessness evident elsewhere in the region. What had fed the flames of fast combustion now stoked the slow combustion of metabolizing livestock. Well before systematic fire control cattle and sheep cropped fire from the land, and they did so with a thoroughness that later engine companies, smokejumpers, and helitack crews could never equal.

The evidence is written widely if complexly in the land. The finely bounded mosaic that had constituted the Southwest scene smeared; desert succulents, mesquite, juniper, and chaparral replaced grasses in desert basins and across high plateaus; brush congealed into jungles; open forests, once dappled with glades of sun and shadow, snarled with downed logs, dense tangles of understory, and young groves of pine and fir reproduction "thick as the hair on a dog's back." In 1902 S.J. Holsinger observed that "in Arizona you will find no young forests of any considerable extent antedating a period of forty years, and almost all of the regrowth has sprung up within the last quarter of a century." Surveying southern Arizona in the early 1920s, Aldo Leopold reasoned that "one is forced to the conclusion that there have been no widespread fires during the past 40 years." Forty years later Charles Cooper mapped the peculiar age structure of Arizona pine and determined that the forest derived from a small number of cohorts, all of which became established during the favorable climatic periods of the early 20th century but which survived because they were spared fires. Others have disputed the climatic argument for broadcast regeneration—1919 as an *annus mirabilis*, for example—but agreed with the outcome. What had been restricted to microsites and select times now thrived everywhere, year after year. Trees and brush multiplied like fruit flies in a jar of bananas. They spread, a scabby reaction to a vast ecological infection.

If it is not everything, timing accounts for much of this condition. An interesting study has compared the forest structure on the Chuska Mountains in the Navajo Reservation to that elsewhere in northern Arizona. The Navajos acquired livestock from the Spaniards, and their herds soon swelled. Huge numbers of sheep and goats came to the Chuskas by the 1820s. As the flocks advanced, fires receded. But the rapid reforestation that followed American grazing later in the century did not immediately occur here. Regeneration apparently had to wait for a favorable climate, which occurred throughout the region in the early decades of the 20th century. The congestion of the Chuska forests thus came synchronously with that elsewhere in the Southwest, the product of a beneficent climate that promoted regeneration and the absence of fire thinning made possible by intensive grazing.

Grazing had plenty of accessories. Loggers aggravated the scene by culling whatever mature or old growth timber they could reach. Bark beetles, fungi, and dwarf mistletoe infested the thickets that, in the absence of grass and fire, sprang up in unnatural profusion. Droughts like that which gripped the region at the turn of the century magnified grazing's shock wave, further reducing the light fuels needed to carry fire. So did the other instruments of settlement, the fire-breaked roads, the patterns of fixed land ownership that prevented the seasonal cycling of peoples and fires, the introduction of exotic flora, the mining and urbanization that created local markets for livestock and the railroads that bound herds to national ones, the reservation of public lands and the establishment of professional forestry. For all their different means, however, they tended to lead to the same end, the suppression of light fire and the encouragement of fuel arrays that promoted intense fires.

The fine fuels—the grasses and forbs—that had carpeted aboriginal Arizona now massed into three-dimensional jungles that readily transformed surface fires into crown fires. In places young growth—two meters high and 70 years old—existed in a comatose state, unable to grow and unwilling to die, waiting until fire could shock them back to life. A century after Beale rejoiced in the open pinelands of the region, Wallace Covington and Margaret Moore estimated that tree density had exploded from 23 per acre to 851, tree basal area from 23 to 315 ft^2 per acre, and crown closure from 8% to 93%. Where Dutton had praised the wooden colonnades of the Kaibab, tree densities had ratcheted upward from 55.9 to 276.3 per acre, tree basal area from 44 to 245 ft^2 per acre, and crown closure from 16% to over 70%. Herbage had correspondingly plummeted, from 1000 to 112 tons/acre in northern Arizona, and from 589 to 117 on the Kaibab. Near Flagstaff a site that herbaceous plants had once covered 83% in 1876 covered only 4% in 1990. More ominously fuel loads rocketed from 2 and 0.2 tons/acre, respectively, to 44 and 28 tons/acre. The land metamorphosed from a pine savanna to a forest tangled in dog-hair thickets. In recent years the woody invasion has also included houses. While the ultimate reasons for this biotic drama reside in the character of settlement, the immediate cause has been the elimination of fire.

The march of woody weeds was only a beginning. Biodiversity declined, and those creatures inimical to ranching or dependent on the old fire regime melted away like Arawaks before smallpox. Worse, the land started to erode. In southern Arizona a spectacular cycle of arroyo-cutting began in eerie lock-step to the cattle invasion. Elsewhere there were slides, debris flows, and garden-variety siltation on a bigger scale than ever known before. Alarmed, irrigation association campaigned for forest reserves and grazing control. (To oppose overgrazing was not to promote burning, however. Humus remained the guarantor of water.) The cumulative outcome was a colossal degradation of the landscape for which the tree, elsewhere a talisman of land health, was ironically an emblem of decay. By the early 1920s the declination had reached its nadir. Even cattle and sheep could no longer thrive on the land and had to be shipped to feed pens for fattening. Economically ranching depended for the most part on public subsidies, even as it remained a political power, that relationship not being entirely coincidental. The debate over the relative contributions of climate and anthropogenic activities continues but clear-eyed observers of the day had no doubt about the chain of causality. In 1933 Aldo Leopold wrote epigrammatically that "when the cattle came the grass went, the fires diminished, and erosion began."

By the time organized fire protection arrived it had only to confirm the fire ban announced by overgrazing. Fire suppression was, at first, an exercise in regional mopup. Aboriginal fires were sequestered onto reservations. Livestock had perverted fuels and quelled the impact of lightning fires; fires had little to burn, or they burned amid open forests, easily extinguished by pine boughs and blankets. Even ranchers that sought to "green up" spring pasture by burning found it difficult to do so. Arguments for "light burning" as the "Indian way" were dismissed by professional foresters as "Paiute forestry," and advocates were treated with the condescension normally reserved for perpetual-motion mechanics and circle-squarers.

But of course fire could never be abolished. Tremendous extents of the Southwest were committed to public reservations for Indians, forests, parks, the military, wildlife refuges, and other purposes. These lands remained quasi-natural, persisting in forms that would not yield to farm or city. Something like the native fuels endured, though often leavened with pyrophytic weeds. Lightning too continued its restless foraging, eager to seize whatever fuels came within its strike. Fire endured.

As decades rolled by, however, the fires that escaped now burned with unprecedented intensity and magnitude. Increasingly the saga of settlement moved from irony to tragedy. Fire had enhanced biodiversity; fire exclusion, through hoof and later shovel, destroyed it. Anthropogenic burning had improved fire control; fire suppression worsened it. Ranchers had sought to replace the wild with the domestic, and so they had done with grizzlies and cattle; but in the process they had also replaced the domesticated fire with the feral fire. If the land became less suitable for wild fauna, it became progressively more prone to wild fire.

That trend continued despite the New Deal's investment in conservation measures, including the Civilian Conservation Corps. Crown fires—large by virtue of their intensity as well as their size—increased from 10,127 acres per year in the 1940s to 15,117 acres per year in the 1980s, despite a massive commitment to high-tech firefighting. Fires that had rarely exceeded 3,000 acres in presettlement times now routinely reached 10,000 to 20,000 acres. It became apparent that to remove fire was as powerful an ecological act as to introduce it. In 1972 the Tall Timbers Research Station mustered a task force that singled out the pine forests of the Southwest as a case study in the consequences of fire exclusion. Slowly, grudgingly, the fire establishment admitted that its successes, ever more costly, were self-defeating. The tragedy of American fire history was not that wildfires were suppressed but that controlled fires were no longer set.

These concerns were not restricted to the Southwest, but when, some 25 years ago, the clamor for reform shook the national fire establishment, the Southwest quickly responded. For the new era this meant that somehow, in some form, preferably benign, fire had to be retained in the landscape. Where it had disappeared, it had to be restored. Prescribed fire for fuel reduction, for conversion of woodlands to pasture, for wilderness ecology, and for improved wildlife habitat became acceptable, if not commonplace. Excepting the South, the Southwest practiced more broadcast burning than any other region. But it was not enough.

Nowhere has anyone reintroduced fire as fully as it has been removed. Restoration failed to keep pace with even annual requirements, much less to make inroads in reducing a century's backlog of burning; those fires did little more than make the minimum payment on a credit card charged to its maximum limits. Often the fuel situation has worsened, particularly as logging exploded on the region's national forests in the 1980s and slash proliferated. It is easy to fund a dramatic fire fight; tough to justify the quiet burning which, if it is done properly, does not become a public spectacle. It was difficult to restore fire without restoring the other conditions that had helped sustain it. The end could only follow from the means. Somehow those accumulated fuels had to be disposed of.

The new Southwest is a product of the old Southwest. Those fuel loads on public lands are a kind of environmental debt, like toxic dumps, that will take decades of determined action to clean up; it is not clear that either the resolve or the money is there to do it; the backlog is too great, and the requisite social consensus too elusive. The logging of large trees inflames environmentalists. The removal of small trees does not suit the economics of sawmill logging. Above all, air quality considerations increasingly regulate the pattern of open burning. Woodsmoke must compete with industrial sources—smelters, coal-fired power plants, automobiles—for its share of the regional airshed. In 1975 and 1979 air pollution alerts in Phoenix resulted, in part, from an overload of broadcast burning on the Mogollon Rim. It is hard to explain to residents of the seventh largest metropolitan area that they can no longer burn fireplaces at will, but tens of thousands of acres need to be broadcast burned. The cultural distinctions make no difference to regional airsheds or to lungs degenerate with emphysema.

And now ex-urban sprawl plasters the private lands within and around the public domain with houses—another woody weed—adding all the problems of a suburban environment but with few of its correctives. Exurbanites are reclaiming a rural landscape but without a rural economy, and so increase the complexity (and expense) of fire protection without improving the prospects for fuel treatment, broadcast burning, or fire services. The developer is replacing the rancher, and summer homes and trailer parks and tourists, the throngs of sheep and cattle that once penetrated every meadow and forest paddock. A four-wheeled seasonal transhumance has replaced its four-hoofed predecessor. But the outcome for fire regimes remains unchanged. The fuel situation worsens, without a corresponding improvement in ignition.

Like shots fired in the dark, sooner or later lightning will hit the right combination of fuel, wind, and terrain with perhaps fatal effects, particularly when lightning discharges, as it does here, with the scatter of a shotgun blast. Increasingly it appears that wildfire is the only legally and politically acceptable form of burning, as though drive-by shootings were the only sanctioned form of target practice. As drought seized the region in the late 1980s, wildfires increased. The Dude Creek fire was its climax, and its prophecy.

The character of Southwestern fire reflects the changing character of its human occupation. The classic Southwest blaze is a trying fire that exposes and assays, sometimes in dramatic fashion, the relationship between the natural landscape and the humans who live on it. It is difficult to reconstruct the impact of early humans, whose firesticks coincided with the colossal climatic fluctuations that ended the last ice age. Probably the Southwest featured a diffuse geography of burning in which firestick and grass created a regime that always simmered but rarely boiled, the intensity of fires following the tidal surges of rain and drought, the human firebrands smoothing out the jerky rhythms of lightning and wind, the very ubiquity of the burning helping to dampen catastrophic eruptions.

It is easier to document the dramatic alterations that have accompanied European settlement. The landscape mosaic became coarser, less able to absorb chronic disturbances. From some sites fire vanished—flooded into irrigable fields, paved into cityscapes, eaten away by livestock, or swatted out by determined fire crews. From others, fire receded temporarily, only to return in altered but reinvigorated form. Elsewhere it was kept in check only through ever-increasing investments in fire suppression. The slow growth rates in the semi-arid Southwest bought time; decades might pass before the consequences of fire exclusion became apparent or irreversible.

Now that interdependence is again shifting. Whatever climatic changes may occur, human-inspired change is outstripping it. Overall, human activity is increasing the total number of fires even as it shrinks to a razor's edge the border between a controlled fire and a wild fire. Smaller numbers of fires break free, but these rage over larger areas and with greater ferocity. Like the interest on a compounding debt, wildfire threatens to claim an ever larger proportion of the region's fire economy. The rural landscape that had once helped buffer between the urban and the wild continues to shrivel; in its place, houses insinuate into every nook and cranny of private land. There is little slack, small margin for error. The gradient between the wild and the urban steepens, building like an electrical charge. Eventually it will arc.

In Southern California, the intermix fire is a familiar morality play, almost a distinctive art form. Certainly the environment is built to burn. Clearly, the construction of expensive wood-shingled houses in mountains bristling with decadent chaparral and exposed to Santa Ana winds is an act of hubris. But the worst fires typically begin with arson. This transforms an environmental dilemma into a simple parable of human madness or malice.

It is more difficult to interpret fire in the Southwest, where lightning, not humans, normally supplies ignition. The relationships are more complex and balanced, the ironies more subtle. The tensions between nature and humans are multiple, not readily decoded into simple dialectics. The region remains a fire-baked mosaic of history and geography. It is not clear, for example, whether the Dude Creek fire was a freak event, the fiery manifestation of a record-shattering heat wave, or the calling card for a new era in which, regardless of technological investments, the pressure of human population and the legacy of suppressed fires will combine to make a truly ungovernable fire regime. Was it the old amalgam, merely intensified? Or is it a new compound, volatile as nitroglycerin, ready to explode at the first stumble? It seems to be both.

But neither is it obvious how to restore fire. However significant fire was to the Old Southwest, its removal was only one part of fashioning the New Southwest, and its reinstatement will not by itself restore that old landscape. It is not apparent by what means fire should be reinstated, nor to what ends it should be applied. Hardest of all is the determination of an environmental standard. The existential Earth offers no absolutes, only the record of many pasts and the prospects of many futures. The privileging of past peoples and landscapes speaks with no more authority. That anthropogenic fire has been an inextricable part of Southwest history does not declare how it might become a part of the Southwest's future. The one hard fact is that the existing scene had, for various reasons to various groups, become unattractive, unacceptable, and in the broadest sense increasingly uninhabitable. But however conceived, fire would remain, an inevitable end, an unavoidable means.

Fire belongs in the mountain Southwest, and unless the peaks flatten, the monsoon evaporates, the seasons homogenize, or the biota vanishes, those fires will continue. They ought to continue. The issue is how to relate to fire—how to keep it from destroying people and to how to keep people from transforming flame into a destroyer. Otherwise the border between the human and the natural will grind with greater and greater force, and out of that friction will come fire that no one wants and no one can control. The summer beacon will become a pyre on the mountain.

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18 December, 1997

To: potential Monument Canyon RNA investigators

From: Tom Swetnam

Re: draft of science and restoration plan

After a long delay and many months past the date when I said I would send you a draft of a plan for the Monument Canyon RNA research and restoration effort – here it is.

This is only part of it. We still need to write 1) short descriptions of the different science and monitoring project components, 2) identify budgets for those projects, and 3) write the detailed restoration plan. I am asking you now to help with 1) and 2). Please summarize the project that you would do in concert with the overall plan in a maximum of 2 pages single space,11 pt font. Identify the objectives, and very brief outline of the procedures/methods, and expected products. For a start, plan on a 2 or 3 year project. Also, provide an estimated budget with the usual categories of salaries, equipment/supplies, travel, other. <u>Please keep these costs to a minimum</u>. At this point, I do not have a good idea of what kind of funding level we might obtain, but there are a couple of new funding initiatives and opportunities that we might tap into. At this point, my wild guess is we should be aiming for under $300K for all projects for 3 years. The restoration costs will probably come from other sources.

Please send me your project summary and budget by January 30, 1998. The best way would be by e-mail as an attachment (either MS Word or WordPerfect documents, or text) or as text in the message. My email address is: tswetnam@ltrr.arizona.edu. Floppy disks by snail mail would also work

You will note that the draft, at this point, is almost entirely the Introduction and Justifications sections. These sections are fairly lengthy and detailed (maybe too much so), but the intention here was to lay out the logical case for the restoration and science projects. I wanted to cover as many of the bases as possible in the justifications, especially adhering to current Forest Service policy. Given that this is a somewhat unprecedented project we need to make this case very carefully. I would be very grateful for any comments and suggestions on this draft.

2200

MONUMENT CANYON RESEARCH NATURAL AREA

A SCIENCE AND RESTORATION PLAN

Executive Summary

[to be written - 1 to 2 pages]

Introduction

The Monument Canyon Research Natural Area was established by order of R.M. Stewart, Southwestern Regional Forester in 1932 (Appendix A). This is the oldest RNA in the Southwestern Region, and one of the oldest in the country. The purpose of this 640 acre RNA, located on the Santa Fe National Forest in the heart of the Jemez Mountains (Fig. 1), was stated succinctly in this opening sentence of the original establishment document:

"To preserve in natural state a typical area of western yellow pine forest as found in northern New Mexico."

Despite the best intentions of several generations of Forest Service managers to protect this RNA, it currently exists as a highly unnatural ponderosa pine stand. The RNA is now covered with extensive "dog-hair" thickets of ponderosa pine (Fig. 2, Table 1) that are an artifact of 20th century land-use history. Intensive livestock grazing followed by active fire suppression efforts eliminated frequent and extensive surface fires in Monument Canyon after 1890. Prior to this time, surface fires burned at frequencies of about once or twice per decade for at least four centuries, and probably for thousands of years (Fig. 3). These frequent surface fires maintained the open stand characteristics of the old-growth ponderosa pine forest that still existed at the time of the RNA establishment in 1932. The lack of extensive fires after 1890, coupled with exceptional seed crop years in the 1910s and 20s and excellent seed beds following reduced grazing in the 1920s, led to establishment of a very large cohort of tree seedlings (Fig. 2, 4). Under natural conditions these tree seedlings would have been thinned by frequent, lightning-ignited surface fires. These young trees were evident at the RNA establishment date, as indicated by this statement in the original document: *"Pole growth and reproduction in seedling and sapling stages are excellent."*

Over the following 60 years this pine reproduction developed into the nearly impenetrable stands of dog-hair thickets which now occupy a large proportion of the RNA (Deickman 1980, Moir and Fletcher n.d.). These small diameter trees have virtually ceased growing, and in many places they are bent over by snow into a tangle of stems. Most of the original overstory old-growth trees are surrounded by the thickets, and as a result, they are in a state of extreme competitive stress and physiological decline. A consequence of this weakened condition is that many of these old trees have succumbed in recent years during moderate droughts. These conditions certainly do not reflect the typical "*natural state*" of ponderosa pine forest in northern New Mexico or the Southwest. Region-wide, and particularly in the Jemez Mountains, these unnatural conditions are leading to increasingly large, severe, and destructive crown fires. These patterns of change in ponderosa pine forests have been well documented throughout the western United States (Cooper 1961, Agee 1993, Swetnam and Baisan 1996, Covington and Moore 1996), and are the basis for regional and national forest restoration initiatives (Arno and Brown 1981, Mutch et al. 1993, Covington et al. 1997).

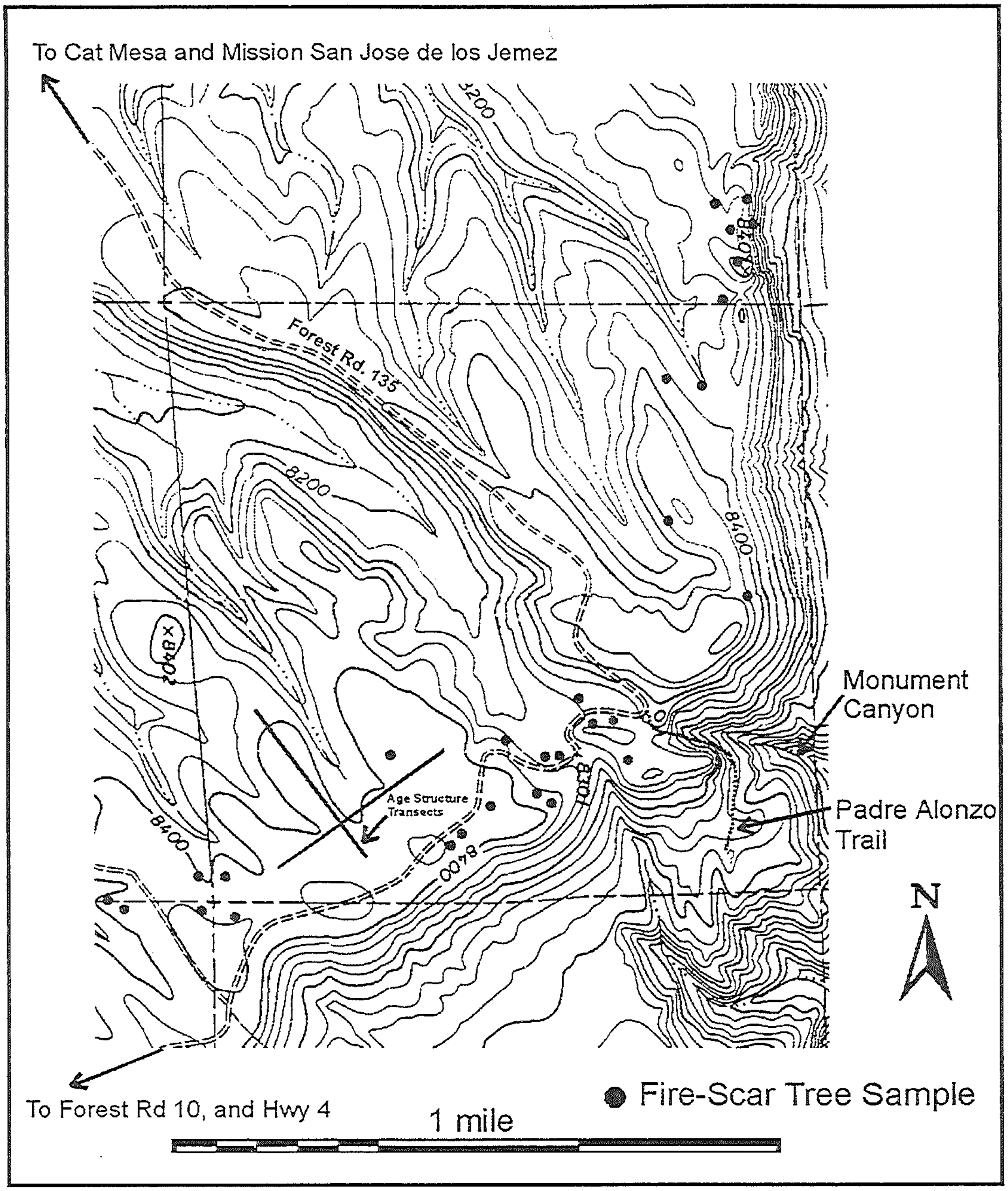

Figure 1. Map of Monument Canyon RNA in Jemez Mountains, New Mexico. The approximately square 640 acre section is about one mile southwest of Vallecitos de los Indios.

Monument Canyon RNA has a number of attributes which justify new management actions aimed towards the goal of restoring the original conditions for which it was established as an RNA. These initiatives represent a profound opportunity to restore an old-growth ponderosa pine stand and to "make good" on the original promise of this RNA. The purpose of this document is to (1) describe the justifications for a restoration and scientific program in Monument Canyon RNA, (2) to briefly outline the elements of the scientific initiatives, and (3) to outline proposed restoration procedures. This proposed restoration and science program will assure that the 65 years of protection investment in this area will not have been in vain, and that the scientific and educational values of Monument Canyon RNA are promoted.

The restoration procedures we propose involve mechanical thinning of post-fire suppression dog-hair thickets, various treatments of the thinned biomass, including chipping and burning, followed by maintenance prescribed burns at intervals approximating the natural range of fire intervals this forest sustained in the previous four centuries. We propose to restore approximately one-half of the RNA and to leave the other half in its current condition.

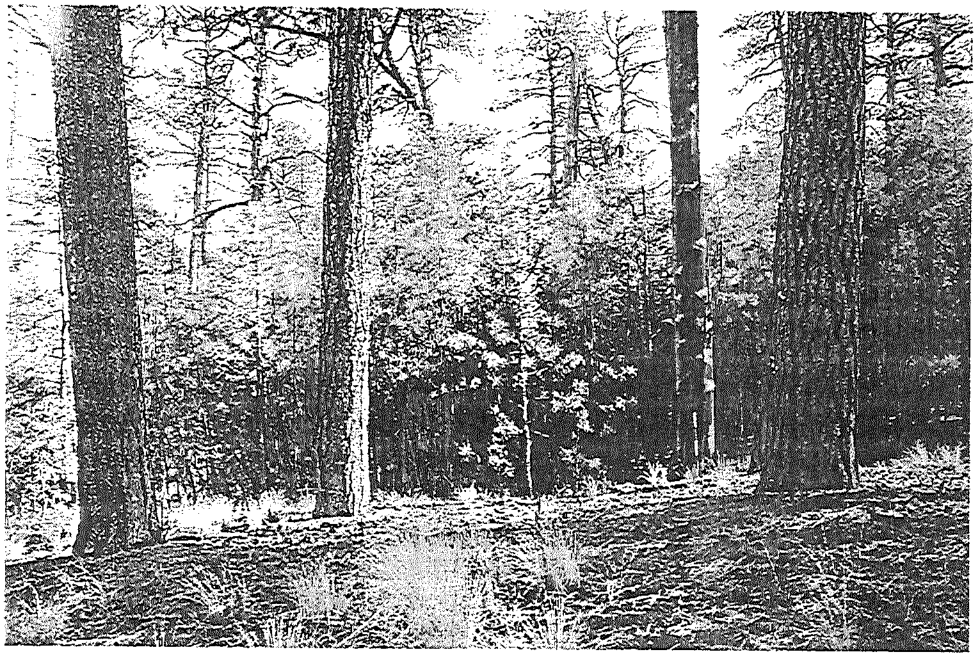

Figure 2. Typical view of dense, "dog-hair thicket" of ponderosa pine trees in Monument Canyon RNA growing under a canopy of widely-spaced old-growth trees.

Table 1. Stand density in Monument Canyon RNA measured in eleven 20m X 20m square plots ($400m^2$) (Muldavin et al. 1995).

Tree Diameter Class	Stems/Hectare	Stems/Acre
Seedlings/Saplings < 10 cm (4 in.)	3,534	1, 657
Poles 10-25 cm (4-10 in.)	2,283	1,071
Small Mature Trees 25-50 cm (10-20 in.)	103	48
Large mature Trees > 50 cm (20 in.)	34	16
Total	5,954	2,792

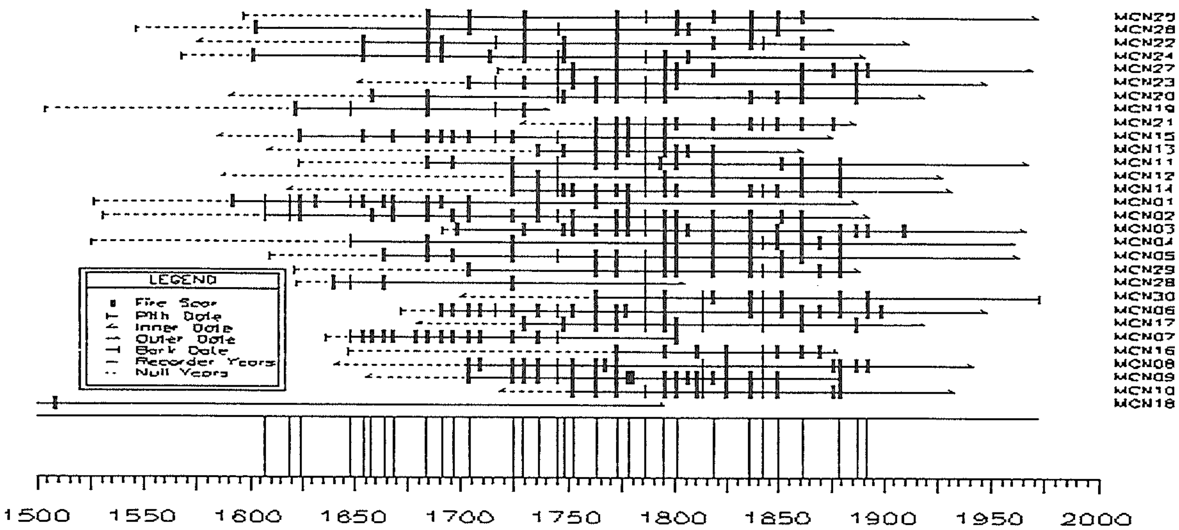

Figure 3. Master fire chronology from existing collection of fire-scarred samples from Monument Canyon RNA. The horizontal lines are tree records and the vertical tick marks are individual fire dates. The vertical lines at the bottom show fire dates recorded by at least 25% of the trees. Note especially the high fire frequency before circa 1890 and striking lack of fire after this time.

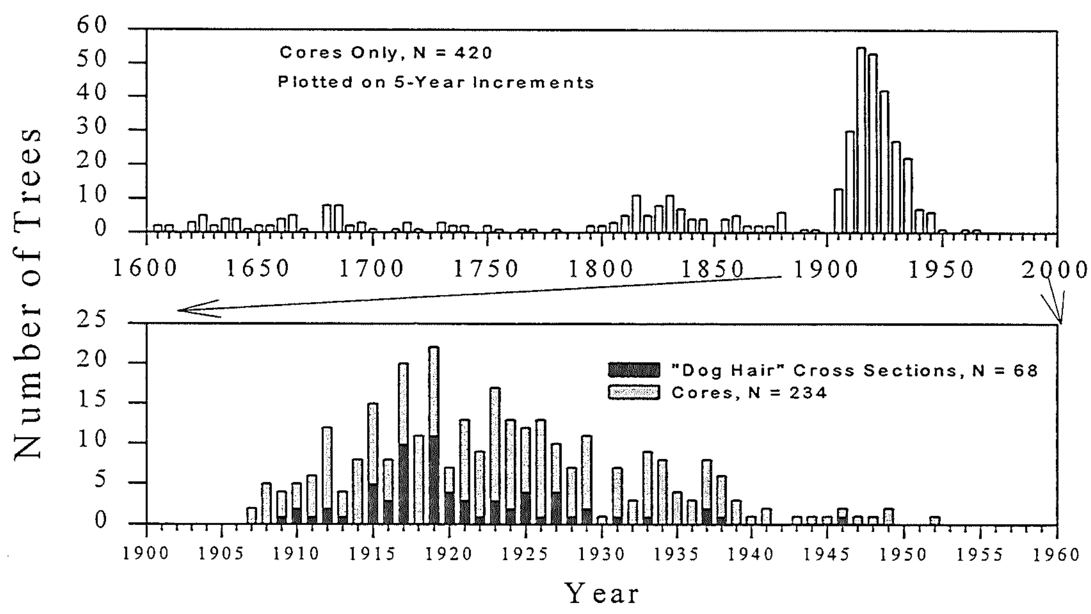

Figure 4. Ponderosa pine recruitment patterns over the past four centuries in Monument Canyon RNA. The upper graph shows the long-term patterns. Note especially the pulses of tree recruitment in the early 1800s corresponding with a reduction in fire frequency, and the pulse after 1900 following the end of widespread fires. The lower graph shows a higher resolution time series of recruitment dates in the 20th century. Cross sections were taken from 68 suppressed poles at ground level to determine more accurate germination dates. The 20th century data indicate that pines were recruiting into the stand over a several decade period.

1950, Cooper 1961, Pollock and Suckling 1996, Covington and Moore 1994, Fulé et al. 1997). These conditions were generally characterized as open, park-like ponderosa pine forests, with grass understories and large-tree densities of about 15 to 25 trees per acre. Frequent surface fires were the primary natural process creating and sustaining these stand structures. With the high pre-settlement fire frequencies evident in Monument Canyon RNA (Fig. 3), it is highly unlikely that dog-hair thickets existed anywhere in this area before the 1930s.

The large cohort of seedlings destined to be dog-hair thickets were already mostly present in the area at the time of the RNA establishment in 1932 (Fig. 4). Managers did not recognize at that time, however, that without surface fires or mechanical thinning these trees would become tangled thickets causing extreme fire hazards and a long-term decline in the vigor and drought resistance in the old-growth overstory trees. Essentially, they did not know that the dense carpet of young seedlings and saplings present at the establishment date would ultimately defeat their purpose of preserving this ponderosa pine stand in a natural state.

The bottom line is that these extensive dog-hair thickets are highly unusual and unnatural, in both an ecological and historical sense. The RNA management guidelines make specific allowance, *"under unusual circumstances"*, to directly manipulate RNAs in order to *"maintain the unique feature that the RNA was established to protect."* If we are to follow the requirements of the RNA policies set forth in the Forest Service Manual to maintain unmodified, natural conditions, these dog-hair thickets must be thinned, and the original conditions for which the RNA was established – i.e., "natural state" northern New Mexico ponderosa pine -- must be restored.

A later section on the proposed restoration methods will describe further the reasoning and justification for specific restoration procedures, and the goal of restoring forest structures as they would probably have existed today if fires had been allowed to prevail through the 20th century. For now, there are two other issues that bear discussion -- prescribed burning and mechanical thinning of trees within the RNA -- and the relevant policy/directive statements from the Forest Service Manual.

Prescribed Burning and Mechanical Thinning in RNAs

The use of prescribed fires in RNAs is specifically allowed in section 4063.32:

Allow natural fires to burn only within a prescription designed to accomplish objectives of the specific natural area.

And in section 4063.41 pertaining to the planning that is required for new RNAs, the following directive for prescribed burning is given under Establishment Record Content:

(1) Vegetation management. If such practices as prescribed burning and livestock grazing are to be used to maintain ecological conditions, describe those practices, explain their use, and list their proposed scheduling. This shall include the prescription for fire in and near the research natural area, including the use of prescribed fire and control of natural fire. If parts of the research natural area are assigned for eventual prescribed burning, they shall be described as well as areas assigned for permanent protection from fire. Control of fire within research natural areas shall be by methods that cause least disturbance. Normally methods that employ machinery shall not be used.

In developing the prescription for fire, consider the role of natural fire in sustaining or managing the vegetation. If fire is prescribed, only part of the research natural area shall be allocated for prescribed burning and part shall be reserved for permanent protection.

Thus, although the original establishment document for Monument Canyon RNA did not include a plan for prescribed burning (obviously, since this would have been heresy in 1932!) there are no policy roadblocks to instituting a such today. What is required is a plan that meets the criteria outlined above.

Regarding mechanical thinning, we conclude, as Covington et al (1992) and others have elsewhere in western pine forests (Arno and Ottmar 1991), that prescribed burning alone is insufficient to safely restore Monument Canyon RNA forests (We will take up this argument again in the restoration methods section). Therefore, we propose to conduct a mechanical thinning program in advance of a prescribed burning program. The Forest Service Manual is not specific about allowing the cutting trees of trees in RNAs for restoration, nor does it specifically forbid such treatments. However, in our opinion, several directives provide allowance for this type of vegetation management in certain circumstances. For example, as previously quoted under 4063.3:

"*...under unusual circumstances, deliberate manipulation may be utilized to maintain the unique feature that the research natural Area was established to protect.*"

And under 4063.34, Vegetation Management, we have:

Use only tried and reliable vegetation management techniques and <u>then apply them only where the vegetation type would be lost without management</u>. <u>The criterion here is that management practices must provide a closer approximation of the naturally occurring vegetation and the natural processes governing the vegetation than would be possible without management</u>. Unless the manager is certain that the management practice will meet this criterion, do nothing

The Station Director, with the concurrence of the Forest Supervisor, may authorize management practices that are necessary for noxious weed control <u>or to preserve the vegetation for which the research natural area was created</u>. These practices may include grazing, control of excessive animal populations, or prescribed burning. [emphasis added]

Several points are notable here. "Vegetation management", which by any practical definition includes tree thinning, may be allowed where the vegetation type would be lost without it, and it should follow naturally occurring patterns and processes in this type. These points are, respectively, one of our justifications (see section below on loss of the RNA resources), and a guiding principle of our proposed restoration. Although *certainty* is a tough criterion for any management action involving the natural world, we can be reasonably and confidently certain that the proposed restoration will result in vegetation more closely approximating natural processes and conditions, and that continued lack of management of this vegetation will not. Although the second paragraph does not specifically mention tree thinning, it does indicate that similar actions may be approved, particularly to preserve original vegetation conditions for which the RNA was created. Also the last sentence specifies examples of allowable practices - notably prescribed burning, and control of excessive animal populations - but it does not specifically exclude tree thinning. Moreover, it can be reasonably argued that *excessive animal populations* are not necessarily more of a threat to natural or original conditions and ecosystems, then excessive plant populations. Indeed, some scientists have referred to unnaturally dense ponderosa pine thickets in terms usually applied to animal populations - i.e, "tree outbreaks" or "tree irruptions" (Covington and Moore 1994).

Scientific Justifications for Restoration and Science Program.

Under Forest Service Manual section 4063 we have the following description:

Research natural areas are part of a national network of ecological areas designated in perpetuity for research and education and/or to maintain biological diversity on National Forest System lands. Research natural areas are for non-manipulative research, observation, and study.

And under section 4063.33, Scientific and Educational Use, we have:

Encourage the use of research natural areas by responsible scientists and educators.

Despite this clear research mandate, there appears to have been very little research conducted in Monument Canyon RNA over the past 60 years. Other than our own fire history and stand age structure studies (Muldavin et al.1995, Touchan et al. 1995) and a soil study (White 1997) we are aware of only the botanical survey conducted by Deickman (1980), and the stand assessment by Moir and Fletcher (n.d). Thus, new scientific initiatives within the RNA would begin to make broad and systematic scientific use of the unique features of this area for which it was ostensibly set aside and protected for more than 65 years.

We believe that there are many unique features of Monument Canyon RNA that establish it as a potentially important location for scientific research. These features and possible research topics are briefly itemized below. The specific scientific initiatives we are proposing are described in more detail in a later section.

Note that a number of these potential scientific initiatives are linked to the proposed restoration effort, which offers opportunities to conduct needed scientific research and to educate. The restoration program we propose is manipulative in the initial phases (and is justified by the unusual circumstances of the changed condition of this RNA), but this manipulation would not be carried out for the sake of the proposed science. Rather, it would be done to restore original conditions for which the RNA was established, which is a specifically allowed criterion by the Forest Service Manual for vegetation manipulation in RNAs. The science would then be capitalizing on the opportunity to study the ecosystem components before, during, and after the restoration program.

This research will be extremely valuable for improving our knowledge and experience in restoring Southwestern ponderosa pine forests to conditions (i.e., structures and processes) more similar to those which prevailed in the pre-settlement era. Other, larger scale forest restoration and science initiatives with similar objectives are currently underway in Arizona (Covington et al. 1996). Hence, these initiatives in Monument Canyon RNA represent another set of case studies that, with the Covington et al. studies, will enable us to evaluate and compare a broad range of Southwest ponderosa pine forest conditions, to test alternative restoration treatments, and to conduct new scientific studies on multiple components of these ecosystems.

1. Ancient Trees and Tree-Ring Material.

Monument Canyon RNA has never been timber harvested. The area has not sustained significant human impacts in the past 65 years, except for the effects of fire suppression (described above), the construction of a road, incidental snag felling, and occasional grazing by stray livestock. Such a circumstance on relatively level, accessible mesa tops is quite rare both in the Jemez Mountains and northern New Mexico.

The uniqueness of this area in terms of old-growth ponderosa pine is attested by the tree-ring data we have collected. The oldest living trees sampled in Monument Canyon germinated in the late 1500s. In a collection of 20 trees specifically targeted for maximum age we found 4 trees with inner ring dates before 1590 (the oldest was 1570), and 5 trees with inner ring dates between 1603 and 1630. These 370 to 420+ year old trees are among the oldest ponderosa pines in the Southwest, and this stand would easily classify as one of the oldest extant ponderosa pine stands of this size in the Southwest (Swetnam and Brown 1992).

Additionally, Monument Canyon RNA contains very old remnant logs, stumps, and snags that contain valuable tree-ring resources. For example, the oldest dated tree ring in a fire-scar sample from the RNA was 1408 (Fig. 3). Of 30 fire-scar specimens from dead trees, 5 had tree rings dating back into the early 1500s. These remnant tree-ring materials can be readily sampled and they contain extremely interesting and valuable histories of fire, climate, and other environmental changes. Detailed, extensive reconstructions of fire history and age structure patterns in Monument Canyon would provide the longest temporal perspective available anywhere in North America on fire, climate, tree demography, and people in ponderosa pine forests (see below).

2. Significant Cultural History.

There is a unique and exciting potential at Monument Canyon RNA for conducting inter-disciplinary, ecological and archaeological research. Some historical background on this area is needed to introduce this topic:

Monument Canyon RNA is located in an area that, prior to the mid-1600s, was one of the most densely human populated and utilized ponderosa pine landscapes in North America. The RNA is located on the northernmost extensions of San Juan and Cat Mesas. These mesas contain several very large, historic period (post-1600) puebloan townhouse ruins (Elliott 1993, 1997). Some of these townhouses had hundreds of rooms and were several stories tall. There are also hundreds of one or two room Jemez "field house" ruins scattered throughout the area. A recent archaeological survey located 5 field houses within Monument Canyon RNA, and dozens of others in the vicinity. The field houses and other evidence indicates that the mesa tops were being cultivated (Elliott 1997), probably within the open ponderosa pine forests and savannas. Tree-ring dates from several archaeological sites indicate that at least some of these large pueblos were occupied by the Jemez people in the early 1600s, and probably as late as the 1690s following the Pueblo Revolt.

The Spanish Mission of San Jose de los Jemez was located approximately 3 1/2 miles southwest of Monument Canyon RNA at the mouth of Church Canyon where it joins San Diego Canyon. The Mission ruins are located at the upper end of the modern-day village of Jemez

Springs. The uppermost head of Church Canyon is located within Monument Canyon RNA (Fig. 1). The Mission was constructed between about 1609 and 1621, and it was burned and abandoned in the Pueblo Revolt of 1680 (Elliott 1993). The historical records suggest that at least some of the pubelos on San Juan and Cat Mesa were occupied by the Jemez people prior to construction of the Mission. In the early 1600s these people were forced by the Spanish missionaries and soldiers to move down into San Diego Canyon to live and to build the Mission. There was also a fairly large pueblo, called Giusewa, already existing and probably occupied on the site of the Mission. It is unclear if some of the San Juan or Cat Mesa pueblos were still partly occupied during the Mission era.

A historic trail, known as the Padre Alonzo Trail, travels from the Mission up Church Canyon to the rim of Cat Mesa above Jemez Springs. This trail was apparently a travel route for the missionaries to and from the Rio Grande pueblos, missions, and the colonial capitals at San Juan, and later, Santa Fe. A 1779 Spanish map including the Jemez Mountains shows a house or structure of some type located in "El Vallecillo", that was probably near or along the trail. It is also likely that the trail predates the Spanish era and connected the pueblo of Giusewa with the San Juan and Cat Mesa pueblos. A 1915 Forest Service map shows the trail proceeding from the rim of Cat Mesa north and through the western half of section 9, which later became Monument Canyon RNA. A Forest Service road follows the line of this trail to the sharp curve at the north end of the RNA, where the original trail can still be followed down the escarpment to the north toward the East Fork of the Jemez River and into the far western end of Vallecitos de los Indios. At the base of the escarpment the Padre Alonzo trail passes by a picturesque view of balancing rocks and pillars in a small side canyon, whose head is also within the RNA (Fig. 1). This was probably a resting point for many weary travelers before ascending the escarpment up to the mesa on the way to the Mission. An 1890 photograph obtained from the Museum of New Mexico labels this view "In the Monumental Canyon near Jemez Hot Springs, New Mexico". As noted on the 1932 establishment document, this small side canyon to the East Fork was called "Monument Canyon", and was undoubtedly the origin of the RNA's name.

The implications of this history are several. First, Monument Canyon RNA is located in the heart of one of the richest historical-cultural landscapes in northern New Mexico. Many cultural changes involving Puebloans and Spaniards occurred in this area during the historic period (post-1600), and many ancient trees and tree-ring specimens are present on the RNA containing environmental histories extending well before the 1600s. Therefore, we have an unparalleled opportunity to combine archival, archaeological, and tree-ring evidence in assessments of ecological change across this landscape. In sum, Monument Canyon RNA has historical significance far beyond what was recognized in its original establishment because of (1) its location within a major population center of the ancestral Jemez people, (2) its close proximity to the historic 17th century Spanish Mission, (3) the presence on site of the historic Padre Alonzo Trail linking the Mission, the mesa pueblos, and the colonial capitals, (4) it is the oldest RNA established in the Southwest, and (5) the RNA contains one the largest and oldest stands of unharvested, old-growth ponderosa pine remaining in the Southwest.

3. Other Scientific and Educational Justifications

In addition to the exciting potential for using Monument Canton RNA and its restoration program as an opportunity to conduct fire history, climate, tree demography, and cultural historical investigations, there are a number of other scientific studies that we propose (see later section) that would be in keeping with the scientific mandate of this RNA. These studies also promise to greatly improve our knowledge of the natural variability of ponderosa forest ecosystems and the effects of restoration treatments. These include:

- studies of forest structural changes using repeat aerial photography (photos are available for 1935, 1954, 1963, 1975, 1981, and 1992)
- studies of pre versus post-restoration forest tree recruitment and growth, changes in herbaceous understory grasses and other plants, nutrients, tree roots and myocrrhizae, birds, elk, deer, rodents, and insects

The opportunity to carry out these studies in concert with the restoration program in such a unique and interesting area has attracted considerable scientific expertise and talent to this effort (see description of scientific program below). Again, this represents an important chance to do management-relevant science in an area that was preserved and protected for that purpose for more than 60 years.

The educational opportunities resulting from the restoration and science are numerous. The restoration itself would be a valuable learning experience and demonstration for managers, scientists and the public on the potentials and problems related to restoration of ponderosa pine forests. As will be discussed in the restoration procedures in a later section, we propose to treat/restore only part of the RNA. This will provide opportunities to directly compare and contrast conditions of restored and un-restored forest. This is likely to be a very striking demonstration of aesthetic differences, as well as improvement in some ecological conditions in the restored area (e.g., growth and vigor of ancient overstory trees, drought-caused mortality rates, etc.).

Moreover, the benefits of open ponderosa pine forests and prescribed burning at approximately natural fire frequencies will be demonstrable to urban-wildland interface homeowners. On this point it is notable that there are more than 100 homes within the nearby Vallecitos de los Indios area. Most of these homes are nestled within dense ponderosa pine thickets and pole stands that are not too dissimilar from Monument Canyon RNA. These homes are greatly threatened by future wildfires, and this threat would be substantially reduced by judicious thinning of the dense thickets and some of the poles around these houses. Yet, there is often a reluctance to undertake this effort for various reasons (e.g., costs, privacy, uncertainty about the appearance of thinned stands, etc.). The restoration project at Monument Canyon would be a very conveniently located demonstration area for educating and convincing these home owners about the role of natural fire, the threats of catastrophic wildfire, and the improved aesthetic values and reduced wildfire threat of more open stands.

Justification Based on Probable Loss of Monument Canyon RNA Resources

An additional justification for a restoration program in Monument Canyon is the high probability that this stand will cease to exist as an old-growth ponderosa pine forest sometime early in the next century. Without a restoration effort the overstory will continue to decline, with individuals and groups of trees succumbing at an increasing rate to episodic droughts, beetle attacks, and other pathogens. There are already signs, for example, that the overstory is losing vigor and the old-growth structure is beginning to unravel. These signs include the extremely slow ring-growth in the past 30 to 50 years in many trees, very thin crowns in the old trees surrounded by thickets, and the apparent increasing amount of mortality in the overstory. There are currently about 2 to 4 snags per acre in the RNA. Many of these snags, perhaps a majority, died during the past 5 to 10 years.

So, one might ask: Is it too late to save the old-growth in Monument Canyon? Aren't all of these old trees destined to die sooner or later anyway? Although the answer to the later question is undoubtedly true, the answer to the former is "probably not". Many very old trees are present in the RNA, but the majority of the overstory trees are in the age range of about 150 to 250 years old (see Fig 4). There is no particular reason why these trees would die in large numbers if they were in a normal state of growth and vigor. Second, although many recently dead overstory trees are present in some areas on the RNA, there are some areas where the overstory seems to have suffered little mortality, so far. With the highly dense understory conditions, however, it is probably just a matter of time before these stressed trees are also overcome *prematurely* by drought or pathogens. Under a carefully planned and executed restoration effort there is a high probability of successfully preventing this from happening, and for preserving and sustaining the original old growth structure in this stand.

Another likely destiny of an un-restored Monument Canyon RNA is total destruction of the stand in a catastrophic crown fire. As in all Southwestern ponderosa pine ecosystems we are aware of, this result would be highly anomalous, both historically and ecologically. To the best of our knowledge, such high intensity fires over large areas evidently did not occur in the pre-settlement ponderosa forests of the Southwest (Cooper 1961, Covington and Moore 1994, Swetnam and Baisan 1996). Unfortunately, a number of these anomalous catastrophic fires have occurred in the Jemez Mountains since the early 1970s. In fact, the Jemez may have the highest incidence of such fires of any mountain range in the Southwest. The most recent destructive crown fire was the 1995 xx,xxx acre Dome Fire on Bandelier National Monument and the Santa Fe National Forest just 15 miles to the east.

The urban-wildland interface area of the Vallecitos, and surrounding ponderosa pine stands, including Monument Canyon RNA, are among the most threatened areas in the Jemez by future conflagrations. The potential for loss of private property and human lives in this area is great, not to mention the high costs of fighting such fires and losses in forest and watershed resources. In this context, it makes eminent sense to remove from the RNA the greatest contributing factor to these high intensity fires – the accumulated dog-hair thickets and ladder fuels. Wisely, the Jemez Ranger District is currently conducting thinning and prescribed burning in the areas around the RNA (particularly on San Juan Mesa). This will lessen the chances of catastrophic fires sweeping through the area. However, leaving Monument Canyon RNA as an island of anomalous, dense, dog-hair thickets would continue to invite disaster in the Vallecitos area, with the RNA as the possible starting point for the next blow-up fire!

While a restoration program in the RNA would not guarantee that a future crown fire will not destroy the stand, it will greatly decrease the probability of this outcome. And as previously pointed out, the restoration effort itself can be used to learn and to educate, thereby contributing to the larger regional and national effort to reduce the hazards and costs of devastating, catastrophic fires in pine forests.

Summary Justification Statement

Given that...

1. The natural conditions for which the Monument Canyon RNA was established to protect were modified by human intervention in contradiction to the prime consideration in management of RNAs.
2. Unusual and unnatural circumstances now exist in the RNA (i.e., dog-hair thickets).
3. The RNA has considerable ecological and historical values, some of which will be lost without a restoration program, but will be enhanced or sustained with a restoration program.
4. There are considerable scientific and educational values that will be obtained from restoration and scientific initiatives in the RNA.
5. Deliberate manipulations will be required to safely restore and then maintain the original, natural conditions for which the RNA was established.
6. The above considerations meet necessary criteria and justifications set forth or called for in the Forest Service Manual for manipulative, vegetation management within RNAs.

It is therefore reasonable and justified by Forest Service policy to undertake a restoration program in Monument Canyon RNA.

To achieve these conditions we propose to (1) restore as closely as possible the forest structures that would exist today in Monument Canyon RNA had frequent, extensive surface fires been allowed to continue to prevail without human intervention, and (2) to sustain frequent, extensive surface fires in Monument Canyon RNA in the future management of this area.

Science/Monitoring Study Design

Research will be an integral part of the pre-restoration, restoration, and maintenance phases of the proposed management plan for Monument Canyon. In this section we describe a plot based study design that will be implemented to serve as a sampling framework for stand age structure, fire history, and for monitoring of soils and animal populations. Following the plot design description are brief summaries of each of the proposed research activities.

Establishment of a Core Array of Permanent Plots

A core component of the research design is the establishment of 25 permanently-marked plots on a 300 X 300 m grid across the entire RNA (costs described in Appendix 1). Vegetation composition, structure, fuel loadings, and fire effects will be measured at these 20 X 50 m plots using the detailed NPS fire monitoring protocols (USDI National Park Service 1992; Table 2, Fig. 5) that include: measuring and tagging all overstory trees; sampling pole-sized trees and seedlings, brush, and herbaceous layers; running 4 dead-and-downed fuel line-transects/plot; and measurement of a variety of fire behavior and fire effects variables (e.g., rate of spread, flame length, flame zone depth, scorch and char heights, % crown scorched, and burn severity) Use of these established NPS protocols will facilitate comparisons with: a) the large fire-monitoring datasets being developed by the NPS (~1282 plots established since 1985 in the western US alone); and b) the similar forest restoration research being conducted by Covington et al. (1997) in Grand Canyon National Park. Additional data on herbaceous species diversity and cover will be collected at these core plots using a modified-Whittaker plot design (Stohlgren et al. 1995), allowing more accurate assessments of these vegetation parameters. This gridded core array of vegetation plots will serve as framework for establishing the locations of other research activities in the RNA. By focussing a variety of research activities on this gridded array of plots we will facilitate: a) comprehensive, consistent coverage of the whole RNA; and b)

Outline of Research and Monitoring Activities

[each proposed research project to be briefly described in 1 to 3 pages]

-baseline structure plots (a 2-person crew, direction by CDA, Tom, Este); would include herbaceous data collection using modified Whitaker...
-historical forest structure (Tom, Este, CDA, Carl Edminister)
-fire history (Tom, CDA), 150 m grid (50 pts.), take 2 best samples in cell around each point
-Forest (tree) growth response (Tom)
-archeological survey (Mike Elliott, Rita Moots, Mike Bremmer, CDA) finish RNA survey (~350 acres @$12/acre = $4200, plus 500 acre buffer þcontextþ zone = $7000)
-pellet transects (1m wide strip along each 50 m leg of plot) will also be established to determine relative use through time by ungulates (note that a large elk population exists locally that could affect ecosystem responses to restoration treatments).
-Nutrients (Carl White), check resin capsules -Mycorrhizal fungi (?)
-Birds (Terry Johnson)
-Rodents (Mike Bogan)
-Aerial photo interp of forest changes (e.g., effects of 1950þs drought): 1935, 195? (USGS), 1954, 1963, 1975, 1981, 1992+) (CDA, Este?)

Forest Structure and Fire Restoration Plan

{to be written]

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Monument Canyon RNA...

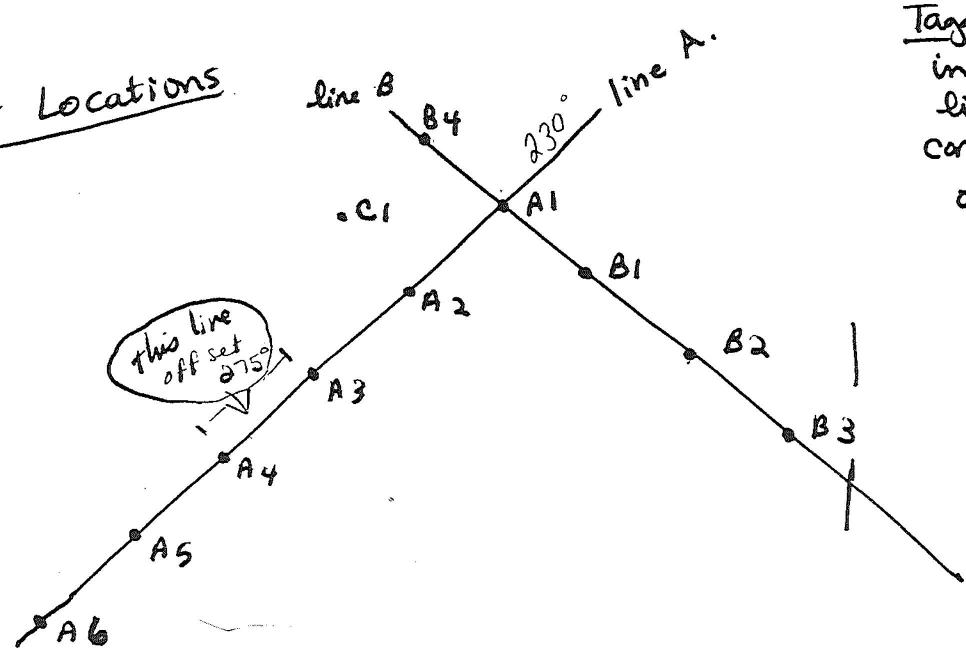
Stand Characteristics

- Following information is from study in progress (includes Rocky MtN Station, USFS, NM Natural Heritage Program & U of A Lab of Tree Ring Research.)

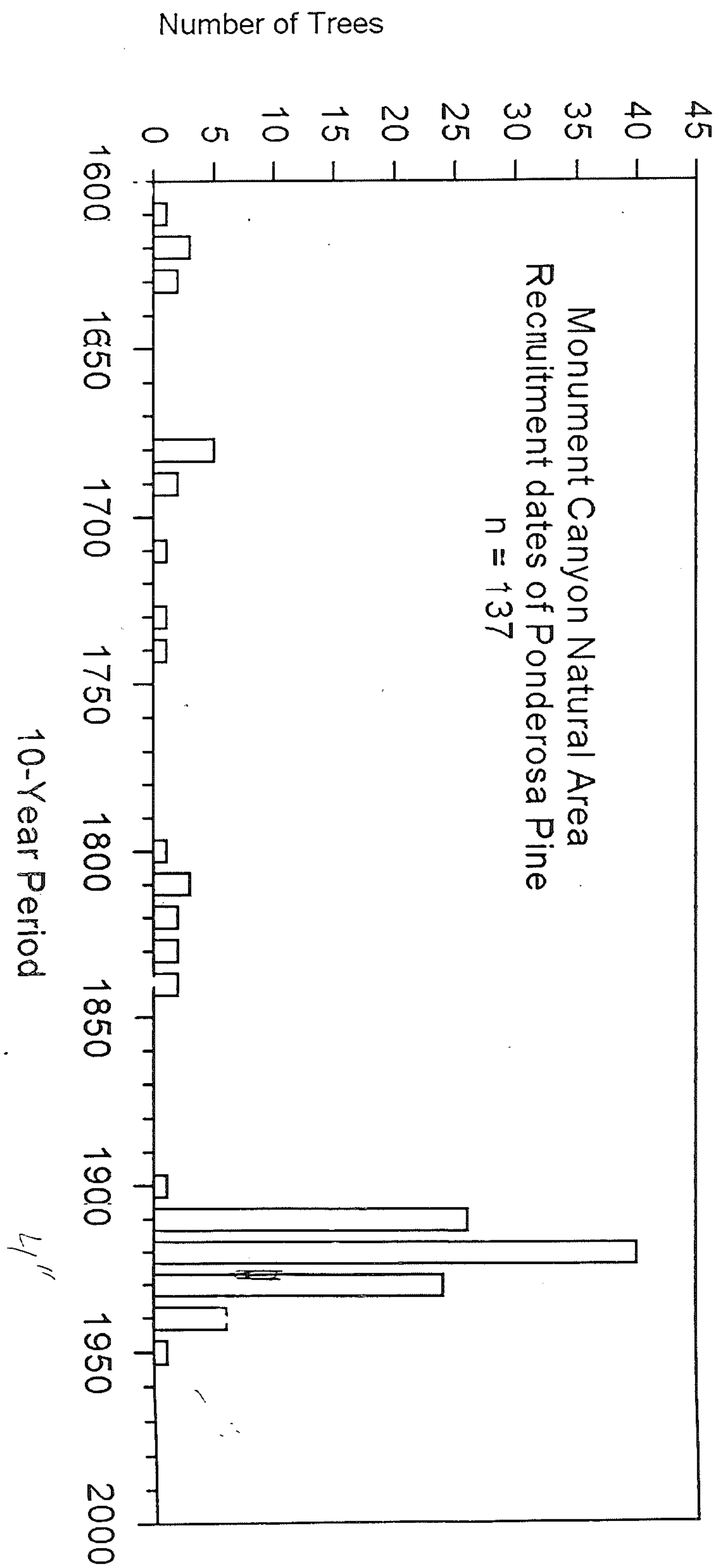
SOME of STUDY OBJECTIVES
- establish stand establishment dates/patterns
- determine current stand dynamics.

Inventory based on 11 plots 400 sq.m.	stems/Hectare	stems/acre
seedlings/saplings to 4" DBH	3535	~1658
poles 4" to 10" DBH	2283	~1071
small sawtimber 10" to 20" DBH	102	~ 48
large sawtimber	34	~ 16
Total	5954	2792

Plot Locations



Tagged Trees are located in each plot or along line - # on tag corresponds to sample no. on forms.
- Find a tagged tree.
- Guess age.
- Look up actual age on forms attached.



Monument Canyon Natural Area
Recruitment dates of Ponderosa Pine
n = 137
Number of Trees
0
5
10
15
20
25
30
35
40
45
1600
1650
1700
1750
1800
1850
1900
1950
2000
10-Year Period

(A-DAS

Monument Canyon RNA · Section 9 · trees tagged/sampled 10/19/94

sample	pith	inside	outside	age in	
no.	estimate	date	date	years	
1	1935	1942	1994	60	
2	1924	1933	1994	71	
3	1929	1932	1994	66	
4	1915	1916	1994	80	
5	1924	1934	1994	71	
6	1948	1960	1994	47	
7	1920	1929	1994	75	
10	1933	1939	1994	62	
11	1930	1938	1994	65	
12	1937	1942	1994	58	
13	1930	1948	1994	65	
14	1953	1963	1994	42	
15	1940	1949	1994	55	
16	1915	1924	1994	80	
17	1934	1945	1994	61	
18	1925	1934	1994	70	
19	1936	1941	1994	59	
20	1919	1928	1994	76	
21	1611	1619	1994	384	
22	1717	1724	1994	278	
23	1840	1858	1994	155	
24	1681	1682	1994	314	
25	1692	1707	1994	303	
26	1819	1829	1994	176	
27	1938	1942	1994	57	
28	1928	1928	1994	67	
29	1934	1934	1994	61	

Monument Canyon RNA · Section 9 · trees tagged/sampled 10/19/94

sample no.	pith estimate	inside date	outside date	age in years	
30	1927	1938	1994	68	
31	1842	1852	1994	153	
32	1922	1924	1994	73	
33	1928	1928	1994	67	
34	1916	1922	1994	79	
35	1923	1923	1994	72	
36	1920	1927	1994	75	
37	1935	1945	1994	60	
38	1942	1948	1994	53	
39	1930	1935	1994	65	
40	1925	1934	1994	70	
41	1935	1942	1994	60	
42	1837	1845	1994	158	
43	1936	1943	1994	59	
46	1846	1857	1994	149	
47	1828	1834	1994	167	
48	1815	1817	1994	180	
51	1928	1932	1994	67	
52	1806	1811	1994	189	
53	1822	1837	1994	173	
54	1916	1934	1994	79	
55	1814	1823	1994	181	
56	1938	1947	1994	57	
57	1926	1935	1994	69	
58	1950	1965	1994	45	
59	1934	1943	1994	61	
60	1937	1947	1994	58	
61	1941	1945	1994	54	
62	1916	1933	1994	79	

Monument Canyon RNA · Section 9 · trees tagged/sampled 10/19/94

sample	pith	inside	outside	age in	
no.	estimate	date	date	years	
63	1934	1939	1994	61	
64	1916	1925	1994	79	
65	1924	1930	1994	71	
66	1921	1928	1994	74	
67	1932	1937	1994	63	
68	1924	1932	1994	71	
69	1922	1926	1994	73	
70	1920	1920	1994	75	
71	1938	1954	1994	57	
72	1933	1936	1994	62	
73	1926	1933	1994	69	
74	1918	1918	1994	77	
75	1919	1919	1994	76	
76	1736	1739	1994	259	
77	1700	1770	1994	295	
78	1687	1692	1994	308	
80	1682	1692	1994	313	
81	1923	1930	1994	72	
82	1932	1932	1994	63	
83	1928	1934	1994	67	
84	1915	1915	1994	80	
85	1949	1959	1994	46	
86	1918	1918	1994	77	
87	1926	1930	1994	69	
88	1927	1932	1994	68	
89	1927	1930	1994	68	
90	1919	1926	1994	76	
91	1944	1955	1994	51	
92	1924	1934	1994	71	

Monument Canyon RNA · Section 9 · trees tagged/sampled 10/19/94

sample	pith	inside	outside	age in	
no.	estimate	date	date	years	
93	1932	1939	1994	63	
94	1927	1930	1994	68	
95	1938	1943	1994	57	
96	1932	1942	1994	63	
97	1930	1941	1994	65	
98	1919	1919	1994	76	
99	1929	1938	1994	66	
100	1935	1940	1994	60	
101	1921	1929	1994	74	
102	1690	1690	1994	305	
103	1640	1651	1994	355	
104	1639	1639	1994	356	
105	1625	1636	1994	370	
106	1925	1938	1994	70	
107	1917	1927	1994	78	
108	1913	1913	1994	82	
109	1922	1926	1994	73	
110	1920	1920	1994	75	
111	1924	1931	1994	71	
112	1924	1928	1994	71	
113	1914	1914	1994	81	
114	1927	1939	1994	68	
115	1929	1942	1994	66	
116	1935	1940	1994	60	
117	1928	1933	1994	67	
118	1912	1922	1994	83	
119	1920	1927	1994	75	
120	1915	1915	1994	80	
121	1920	1930	1994	75	

Monument Canyon RNA · Section 9 · trees tagged/sampled 10/19/94

sample	pith	inside	outside	age in	
no.	estimate	date	date	years	
122	1927	1933	1994	68	
123	1918	1926	1994	77	
124	1927	1936	1994	68	
125	1919	1919	1994	76	
126	1909	1921	1994	86	
127	1930	1930	1994	65	
128	1684	1701	1994	311	
130	1741	1754	1994	254	
131	1628	1636	1994	367	
132	1629	1629	1994	366	

Monument Canyon RNA - Section 9
Transect Line A Plot 1

MARY STUEVER
SCOTT DAVIS
10-1-94

FORM 5b -- TREE INVENTORY

NUMBER BY DBH CLASS (Inches)

SPECIES CODE	0-2 <4.5'	0-2 >4.5'	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>20
		12	158	96	20	3						

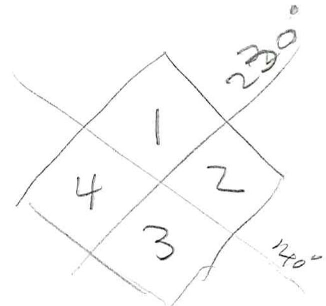
SITE TREES SPP CODE	DRC ~~DBH~~	HT	CORE	COMMENT
94-MCA1 01	4.55			
02	2.55			
03	2.55			
04	4.32			
05	2.49			
06	4.05			
07	3.05			
08	3.30			
09	2.95			
10	1.90			
11	1.95			
12	1.95			
13	3.40			

SPP CODE	DRC ~~DBH~~	HT	CORE	COMMENT
14	2.10			
15	3.20			
16	1.30			
17	1.95			
18	3.25			
19	1.15			
20	3.25			
21	2.19			
22	1.80			
23	2.1			

0-1
1-2 ~~IIII~~ II
2-3 ~~IIII~~ II
3-4 ~~IIII~~ I
4+ III

Plot A-2 - Mon. Cayn.

Davis - Stuever 10/2/94



FORM 5b -- TREE INVENTORY

NUMBER BY DBH CLASS (Inches)

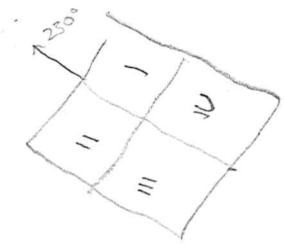
SPECIES CODE	0-2 <4.5'	0-2 >4.5'	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>20
Quad. 1.	6	1	15	1	X	1	1	1		1		4
Quad 2	2	X	4	5	2	X				2		1
Quad 3	X	3	33	17	7	5						
QUAD 4	1	5	23	11	6							
Total	9	9	75	34	15	6	1	1	–	3	–	5

SITE TREES SPP CODE	DRC" ~~DBH~~	QUAD ~~HT~~	CORE	COMMENT	SPP CODE	DRC. ~~DBH~~	QUAD ~~HT~~	CORE	COMMENT
A-2 01	1.95	3			11	2.7	3		
A-2 02	1.95	3			12	3.85	3		
A-2 03	3.05	4			13	3.00	3		
A-2 04	0.05	4 estimate		2" ABOVE grnd SEEDLING	14	2.45	4		
05	2.32	4			15	1.45	4		
06	1.45	4			16	3.55	1		
07	0.75	1		SEEDLING 3.4' TALL.	17	3.65	2		
08	1.50	1		SEEDLING 3.2' TALL	18	1.50	2		4.45' tall.
09	0.95	1		SEEDLING 2.6' Tall. Forks at 2" above grnd	19	3.95	2		
10	1.60	2		4.45' TALL. 1 FT from large yellowbelly.	20	3.45	3		

growing in clump - less than 1" diam.

0-1 |||
1-2 ||||| ||
2-3 |||||
3-4 ||||

PLOT A-3
MONUMENT CANYON
10/4/94 DAVIS / STUEVER



FORM 5b -- TREE INVENTORY

NUMBER BY DBH CLASS (Inches)

SPECIES CODE	0-2 <4.5'	0-2 >4.5'	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>20
QUAD I		6	8	2	1							3
Q II	3	4	23	19	4	1	1					
Q III		2	20	13	5	3	1					
Q IV		3	22	9	8	2						1
PLOT TOTAL	3	15	73	38	18	6	2					4

SITE TREES

SPP CODE	DBH	HT	CORE	COMMENT
A3-01	1.4	1		
A3-02	1.6	1		
A3-03	1.4	1		
A3-04	1.1	2		
A3-05	2.45	2		
A3-06	2.65	2		
A3-07	.9	2		
A3-08	.95	2		
A3-09	2.3	2		
A3-10	1.6	3		

SPP CODE	DBH	HT	CORE	COMMENT
A3-11	2.2	3		
A3-12	3.3	3		
A3-13	1.1	3		
A3-14	3.2	4		
A3-15	2.1	4		
A3-16	3.1	4		
A3-17	3.4	4		
A3-18	3.35	2		
A3-19	1.9	1		
A3-20	2.05	1		

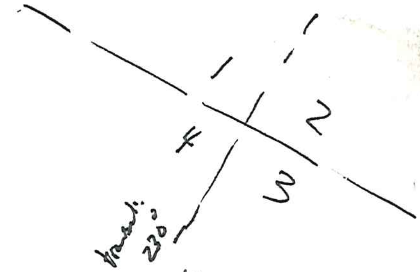
0-1 ||
1-2 |||| ||
2-3 |||| |
3-4 ||||

Monument Canyon

Plot A-4

10/8 & 10/9, 94

STUEVER / DAVIS



FORM 5b -- TREE INVENTORY

NUMBER BY DBH CLASS (Inches)

SPECIES CODE	0-2 <4.5'	0-2 >4.5'	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>20
QUAD 1	1	–	9	7	7	3						
QUAD 2	–	3	12	14	6	6	3					
QUAD 3	–	3	38	13	9	5	–	1				
QUAD 4	–	2	13	8	5	2						
Total	–	8	72	42	27	16	3	1				

SITE TREES SPP CODE	DBH	QUAD	CORE	COMMENT	SPP CODE	DBH	QUAD	CORE	COMMENT
A4 01	1.65	2			A4 11	1.2	2	6'	
A4 02	3.45	2			12	1.25	3	4.5'	
A4 03	2.30	1			13	2.65	3		
A4 04	3.70	1			14	3.35	3		
A4 05	1.65 ~~2.05~~	1	<4.5 high (4.3')		15	3.4 ~~2.3~~	4		
A4 06	2.10	2			16	2.3	4		
A4-07	3.70	2			17	1.9	4		
A4-08	2.05	2			18	3.5	4		
A4-09	2.75	2			19	1.95	3		
A4-10	1.50	2	5.5'		20	1.80	3		

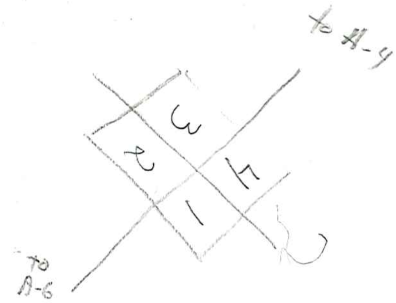
0-1

1-2 ||||| ||||

2-3 ||||| |

3-4 ||||| |

[A5]



FORM 5b -- TREE INVENTORY

NUMBER BY DBH CLASS (Inches)

SPECIES CODE	0-2 <4.5'	0-2 >4.5'	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>20
QUAD 1		2	55	28	16	3						
QUAD 2		3	55	27	9	3						
QUAD 3		4	53	26	7	6	1					
QUAD 4		1	64	41	10	–	2					
Total		10	227	122	42	12	3					

SITE TREES SPP CODE	DBH	QUAD ~~HT~~	CORE	COMMENT
A-5 01	2.30	3		
A-5 02	1.5	3		
A-5 03	2.4	3		
A-5 04	1.4	3		
A-5 05	3.0	3		
A6 06	3.3	2		
A-5 07	1.55	2		
A-5 08	2.90	2		
A-5 09	1.95	2		
A-5-10	2.00	2		

SPP CODE	DBH	QUAD ~~HT~~	CORE	COMMENT
A-5 11	1.55	1	7' high	
12	3.40	1		
13	3.30	1		
14	2.10	1		
15	1.80	1		
16	2.05	4		
17	3.15	4		
18	1.95	4		
19	2.90	4		
20	2.75	4		

0-1
1-2
2-3
3-4

Monument Canyon 10/8/94
Transect A; Plot 6
STUEVER

N

FORM 5b -- TREE INVENTORY

NUMBER BY DBH CLASS (Inches)

SPECIES CODE	0-2 <4.5'	0-2 >4.5'	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>20
PIPO QUAD 1	1	4	2	4	5	5	1					
PIPO QUAD 2	1			1								
PIPO QUAD 3	3					PIFL in this QUAD		1	1			
PIPO QUAD 4		4	Abco in this Quad 27	PIFL in this Quad 15	13	2	1					
PIPO Totals	5	8	29	20	18	7	2	1	1			
PIFL				1		1						
ABCO			2									

SITE TREES SPP CODE	DBH	QUAD ~~HT~~	HT. ~~CORE~~	COMMENT
A6 01	.3"	3	0.5'	
A6 02	.5"	3	0.7'	
A6 03	0.5"	2	1.2'	
A6-04	2.2	4		
A6-05	3.3	4		
A6-06	1.3	4		
A6-07	1.90	1		
A6-08	2.75	1		
A6-09	1.50	1		
A6-10	3.95	4		

SPP CODE	DBH	QUAD ~~HT~~	CORE	COMMENT
A6-11	2.25	4		
A6-12	3.3	4		
A6-13	3.5	4		
A6 14	1.65	1		
A6 15	0.50	3		
A6-16	0.30	3		
A6-17	1.9	4		
A6-18	2.80	4		
A6-19	2.95	4		
A6-20	3.35	4		

0-1	卌
1-2	卌
2-3	卌
3-4	卌

Plot A6 is right on transition to Abco/Fear h.t. It is on the SE facing slope near the ridgetop - (~10 m away) SE - 20% slope.

B-1 Monument Canyon RNA
10/2/94
Stuever / Davis

FORM 5b -- TREE INVENTORY

NUMBER BY DBH CLASS (Inches)

SPECIES CODE	0-2 <4.5'	0-2 >4.5'	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>20
QUAD 1	–	5	66	21	3							
QUAD 2	–	1	49	24	4	2	–	–	1	–	–	1
QUAD 3	–	1	34	11	9	5	2	–	–	–	–	–
QUAD 4		2	43	27	9	2	–	–	–	–	–	–
Plot Total		9	192	83	25	9	2	–	1	–	–	1

SITE TREES

SPP CODE	DRC ~~DBH~~	QUAD ~~HT~~	CORE	COMMENT
B1-01	1.85	2		
B1-02	2.2	1		
B1-03	2.5	1		
B1-04	2.05	1		
B1-05	2.1	4		
B1-06	1.3	2		
B1-07	1.7	3		
B1-08	1.6	1		
B1-09	3.4	4		
B1-10	3.25	4		

SPP CODE	DRC ~~DBH~~	Quad ~~HT~~	CORE	COMMENT
B1-11	3.05	4		
B1-12	2.2	1		
B1-13	1.9	1		
B1-14	1.65	1		
B1-15	2.4	3		
B1-16	2.4	3		
B1-17	3.5	3		
B1-18	3.2	3		
B1-19	1.65	4		
B1-20	3.1	4		

0-1	I
1-2	~~IIII~~ II
2-3	~~IIII~~ II
3-4	~~IIII~~ I

B-2 Monument Canyon RNA
DAVIS - STUEVER
10/2/94

FORM 5b -- TREE INVENTORY

NUMBER BY DBH CLASS (Inches)

SPECIES CODE	0-2 <4.5'	0-2 >4.5'	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>20
QUAD 1	–	1	9	15	5	6	4	1	–	–	–	–
QUAD 2	–	–	13	22	7	6	–	–	–	–	–	–
QUAD 3	–	–	4	11	11	3	4	1	–	–	–	–
QUAD 4	–	1	4	12	9	5	3	–	–	–	–	–
Plot Total	–	2	30	60	32	20	11	–				

SITE TREES SPP CODE	DRC ~~DBH~~	QUAD HT	CORE	COMMENT
B2-01	2.4	1		
B2-02	2.25	1		
B2-03	2.3	1		
B2-04	1.0	4		
B2-05	3.3	4		
B2-06	2.7	4		
B2-07	3.2	4		
B2-08	3.05	3		
B2-09	2.9	3		
B2-10	2.6	2		

SPP CODE	DBH	HT	CORE	COMMENT
B2-11	2.0	2		
B2-12	2.0	2		
B2-13	3.0	2		
B2-14	3.6	1		
B2-15	3.1	4		
B2-16	2.6	2		
B2-17	3.2	2		
B2-18	2.6	3		
B2-19	3.8	4		
B2-20	1.3	1		

0-1	
1-2	||
2-3	|||| ||||
3-4	|||| |||

Monument Canyon RNA

Transect B
Plot 3

STUEVER / DAVIS 10/2/94

FORM 5b -- TREE INVENTORY

NUMBER BY DBH CLASS (Inches)

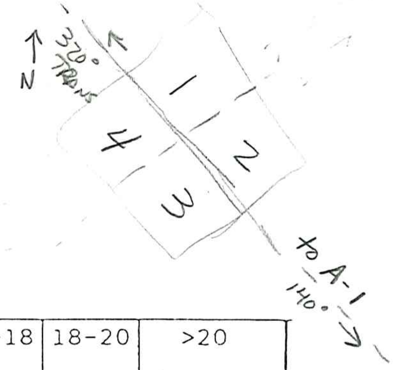
SPECIES CODE	0-2 <4.5'	0-2 >4.5'	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>20
QUAD 1	–	1	18	17	16	6	2					
QUAD 2	–	–	14	20	14	2						
QUAD 3	–	3	35	18	8	2						
QUAD 4	–	3	22	18	12	10						
Plot Total	–	7	89	63	50	20	2					

SITE TREES SPP CODE	DBH	QUAD ~~HT~~	CORE	COMMENT
B3-01	2.7	2		
B3-02	2.6	3		
B3-03	2.8	3		
B3-04	3.35	3		
B3-05	2.6	3		
B3-06	1.6	4		
B3-07	1.3	4		
B3-08	1.5	4		
B3-09	1.1	3		
B3-10	2.0	1		
B3-11	1.9	1		

SPP CODE	DBH	HT	CORE	COMMENT
B3-12	3.4	2		
B3-13	2.5	2		
B3-14	2.8	1		
B3-15	2.3	2		
B3-16	3.5	3		
B-3-17	3.0	4		
B3-18	1.25	4		
B3-19	3.0	2		
B3-20	4.0	2		

0-1
1-2
2-3
3-4

Plot B-4
Monument Cnyn RNA
10/2/94 Stuever/Davis



FORM 5b -- TREE INVENTORY

NUMBER BY DBH CLASS (Inches)

SPECIES CODE	0-2 <4.5'	0-2 >4.5'	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>20
PIPO QUAD 1	31	8	38	10	1	–					1	1
PIPO QUAD 2	9	11	64	17	3	3						
PIPO QUAD 3	21	8	34	2				1	1		1	1
PIPO QUAD 4	11	2	3					2	2	2	1	2
Total	72	29	139	29	4	3	–	3	3	2	3	4
PIFL Pinus flexilis *	1	3										
Both Species Plot Total	73	32	139	29	4	3		3	3	2	3	4

SITE TREES

SPP CODE	DBH	HT	CORE	COMMENT
B4-01	0.6	1		
B4-02	0.5	1		
B4-03	1.2	1		
B4-04	1.3	1		
B4-05	1.8	1		
B4-06	1.4	2		
B4-07	0.9	2		
B4-08	2.0	2		
B4-09	3.1	3		
B4-10	1.5	3		

SPP CODE	DBH	HT	CORE	COMMENT
B4-11	0.7	3		
B4-12	0.6	4		
B4-13	2.1	4		
B4-14	2.0	3		
B4-15	2.25	4		
B4-16	3.05	4		
B4-17	2.2	4		
B4-18	3.5	2		
B4-19	3.3	2		
B4-20	3.6	1		

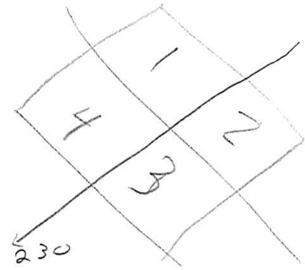
0-1 ||||
1-2 ~~||||~~
2-3 ~~||||~~
3-4 ~~||||~~

* add PIFL located in QUAD 4 - NO DESTRUCTIVE sampling of PIFL.

C-1 Subjective location
Plot Center is center of fire scar tree.

10/9/94
Stuever / Davis

↑N



FORM 5b -- TREE INVENTORY

NUMBER BY DBH CLASS (Inches)

SPECIES CODE	0-2 <4.5'	0-2 >4.5'	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>20
QUAD 1	—	3	96	23	1	—	—	—	—	—	—	—
QUAD 2	—	5	34	16	6	—	—	—	—	—	—	—
QUAD 3	—	3	65	34	11	—	—	—	—	—	—	—
QUAD 4	—	2	69	11	2	1	—	—	—	—	—	1
Total	—	13	264	94	20	1	—	—	—	—	—	1

SITE TREES

SPP	CODE	DBH	QUAD ~~HT~~	CORE	COMMENT
C-1	01	1.00	1		
C1	02	1.90	1		
C-1	03	2.80	1		
C-1	04	3.45	1		
C-1	05	0.95	1		
C-1	06	1.45	2		
C-1	07	3.25	2		
C-1	08	1.80	2		
C-1	09	2.80	2		
C-1	10	2.10	2		

SPP	CODE	DBH	QUAD ~~HT~~	CORE	COMMENT
C1	11	0.75	3		
	12	1.30	3		
	13	3.95	3		
	14	1.80	3		
	15	2.60	3		
	16	2.15	4		
	17	1.80	4		
	18	3.55	4		
	19	3.80	4		
	20	1.55	4		

0-1	|||
1-2	~~||||~~ |
2-3	~~||||~~
3-4	~~||||~~

Monument Canyon Research Natural Area Notes--John Hayden

10/24/95

10:45 am+: Met with Estban Muldavin, NM Heritage Project. Agreed to contract w/NMHP for assistance on Monument Canyon project.

Proceeded to Monument Canyon RNA w/Mary Stuever, arriving mid pm.

At MC RNA, reviewed Plots A-1 and B-1 through B-5 on the ground and began establishing line 230 degrees from Plot B-1.

Left MC RNA about 5:00 pm, returning about 7:15 pm.

10/26/95

Leave residence and travel in personal vehicle (Izusu Trooper) to Monument Canyon RNA. Established "D" line and plots. Returned to residence. Travel 4 hrs., work 7 hrs. Trip odometer= 102 miles in plus 102 miles return for a total of 204 miles.

10/28/95

Leave residence and travel in personal vehicle (Trooper) to MC RNA. Using 10 baf prism, located and flagged "count trees" for D-series plots. Also established another four plots and flagged count trees thereon. Returned to residence same day. Travel 4 hrs., work 8 hrs. Trip odometer = 85 miles in and 102 out for a total of 187 miles.

"D" Series Plots:

Ran transect bearing 230 degrees (from true north) *from south edge* of Plot B-1 and established plot numbers D-1 through D-5 at 100 meter intervals. Following are observations and notations on each plot:

Plot No.: D-1
Position on Slope: Near drainage head
Aspect: south **% slope: 5-10**
Overstory: scattered mature/overmature Pipo; 6 living, 3 snags

Understory: scattered poles 4 ea.,

Regeneration: scattered saplings 4 ea.

Comments: TREES MARKED WITH **WHITE** FLAGGING

Plot No.: D-2
Position on Slope: slope above drainage bottom
Aspect: NNE **% slope: 10**
Overstory: mature-overmature and snags mod. density; Pipo; 6 ea living; 2 ea snags
Understory: Poles 7 ea and saplings 3 ea;varying ages; mod. dense; Abco and Psme present.
Regeneration: 95% Pipo, remainder Abco and Psme; very young and dense in places.
Comments: Probably ecotone with Abco/Fear(?). **May be candidate for "C" type plot** due to presence of young REGEN. TREES MARKED WITH **WHITE** FLAGGING.

Plot No.: D-3
Position on Slope: slope on shoulder of ridge
Aspect: NW % slope: 10-20
Overstory: scattered mature/ overmature Pipo; 8 ea living, 2ea snags.

Understory: few poles, 7 ea; Pipo

Regeneration: mod. dense, 3ea saplings Pipo 95%, Abco <5%
Comments: Some Abco REGEN. TREES MARKED WITH WHITE FLAGGING.

Plot No.: D-4
Position on Slope: Top of ridge
Aspect: W **% slope: 5**
Overstory: scattered Pipo mature/overmature, 3 ea

Understory: mod. dense poles, 12 ea

Regeneration: mod. dense Pipo; saplings 5 ea

Comments: Abco REGEN <1% TREES MARKED WITH WHITE FLAGGING.

Plot No.: D-5
Position on Slope: top of ridge
Aspect: S **% slope: 0-5**
Overstory: very scattered overmature, 1 ea living, 3 ea snags
Understory: mod dense Poles, 8 ea and Saplings, 7ea; Pipo
Regeneration:

Comments: Plot center within 2 meters of edge of old over-grown roadway. TREES MARKED WITH WHITE FLAGGING.

Details of remaining plots established and set up on 10/28/95:

Plot No.: E-1 (100m 230 degrees from B-2 and 100m 140 degrees from D-1)
Position on Slope: top of ridge
Aspect: SW **% slope: 0-5**
Overstory: mod. dense overmature, 7 ea living
Understory: mod. dense Poles, 7 ea; and Saplings, 11 ea
Regeneration:
Comments: Poles are doms and codom, saplings apprear to be suppressed, with no "new" REGEN. TREES MARKED WITH WHITE, WHITE/YELLOW STRIPE, AND CHARTRUSE.

Plot No.: F-1 (100 m, 230 degrees from B-3)
Position on Slope: top of ridge
Aspect: SW **% slope: 5**
Overstory: mod. dense overmature, 8 ea
Understory: mod dense poles, 12 ea; fewer saplings, 3 ea.
Regeneration:
Comments: TREES MARKED WITH CHARTRUSE, YELLOW, AND YELLOW/WHITE STRIPE FLAGGING.

Plot No.: F-2 (100M, 230 degrees from F-1)
Position on Slope: hill slope
Aspect: W **% slope: 10-20**
Overstory: mod. dense overmature, 11 ea living, 1 ea standing snag.
Understory: mod dense saplings, 11 ea of varying ages; no Poles
Comments: Probably represents ecotone with Abco/Fear HT as evidenced by Abco and Psme REGEN est.<5%.
TREES MARKED WITH **YELLOW** FLAGGING.
THIS MOD. DENSE DOGHAIR THICKET MAY BE CANDIDATE FOR "C" TYPE PLOT.

Plot No.: G-1 (100m, 140 degrees from F-1)
Position on Slope: slope near top of main ridge
Aspect: SSE **% slope: 5-10**
Overstory: scattered overmature, 4 ea living and 2 ea standing snags.
Understory: dense Poles, 14 ea and saplings, 11 ea
Regeneration:
Comments: TREES MARKED WITH RED/WHITE STRIPE, ORANGE, AND YELLOW FLAGGING

TABLE 1: Number of trees by rough size class per plot:

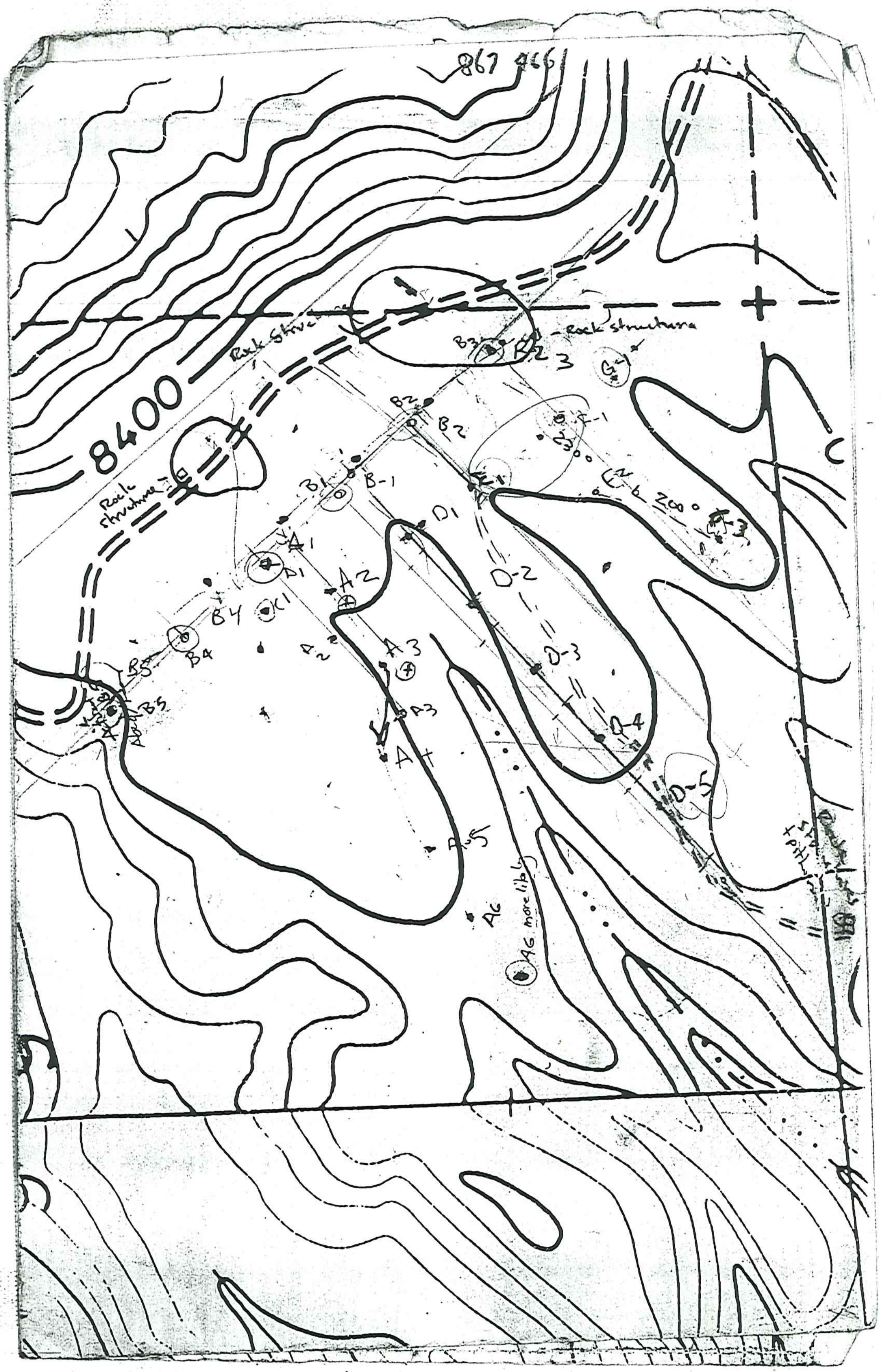
MONUMENT CANYON PLOTS: D1-D-5; E-1; F-1-F-2; AND G-1

Location					Totals	
(PLOT NO)	OVER-STORY	POLES	SAPLING	SEEDLIN		SNAGS
D-1	6	3	4		13	3
D-2	6	7	3		16	2
D-3	8	3	10		21	2
D-4	3	5	12		20	0
D-5	1	8	7		16	3
E-1	7	11	7		25	0
F-1	8	12	3		23	0
F-2	11	0	11		22	1
G-1	4	14	11		29	2
					0	
	54	63	68	0	185	13

PLOTS LAID OUT FROM BASELINE "B". TREES SELECTED USING 10BAF PRISM AIMED BREAST HT [4 1/2' ABOVE GRND] ON SUBJECT TREES.

OVERSTORY=12"DBH AND ABOVE; POLES=4-11.9"DBH; SAPLINGS=>4.0"DBH

JS HAYDEN 10/29/95



8400
Rock structure
Rock Struc
B2
B-1
B1
A1
A2
A3
A5
A6
B4
B5
C1
D1
D-2
D-3
D-4
D-5

11.2 m Radius

JOHN HAYDON
11/2/95

	D-1	D-2 ($\frac{200}{4\ DF}$ $2\ WF$)	
<1	(15)		200 Pipo 4 Psme 2 Abco
<2" < 4.5' ht		(63)	63 Pipo 3 Psme 2 Abco
<2 > 4.5 ht	(22)	(48)	Pipo -48 Pifl -1
2-4	smalls (47)		9 Pipo - 52 Psme - 0 Abco - 1 Pifl - 1 9 dead
4-6	(11)	3 small (20)	Pipo - 20 -3 - dead
6-8	(8)	(7)	Pipo - 7
8-10		(2)	Pipo - 2
10-12			
12-14	(1)		
14-16		(1)	Pipo - 1
16-18	(1)	(1)	Pipo - 1
18-20		s (1)	Pipo Snag - 1
20-22			
22-24	(1)		
24-26	(1)		
26-28			
28-30			
30-32		(S) (1)	Pipo Snag - 1
34-36		(1)	Pipo
dead	T = 8 mort	14	
live	T = 92 live	202	
Seedlings	15 Se	206	
	115	422	

Note
Psme
Abco
Pifl

PLOT NO. → D-1 | D-2
SPECIES → Pipo

	D-1 Pipo live	D-1 Pipo dead	Totals	D-2 Pipo live	D-2 Pipo dead	Abco WF	Psme DF	Pifl	Totals
Seedlings <1' ht	15	0	15	200		2	4		206
<2"ϕ <4.5' ht	~~0~~	0	0	63		2	3		68
<2"ϕ >4.5' ht	22 ~~[illegible]~~	0 ~~5~~	22	48				1	49
2-4"ϕ	47	5	52	52	9	1	0	1	63
4-6	11 ~~8~~	3	14	20	3				23
6-8	8	0	8	7					7
8-10	—		—	2					2
10-12	—		—						
12-14	1	0	1						
14-16	—			1					1
16-18	1	0	1	1					1
18-20	—		—	—	1(s)				1
20-22	—		—						
22-24	1	0	1						
24-26	1	0	1						
26-28	—		—						
28-30	—		—						
30-32	—		—		1(s)				1
32-34	—		—						
34-36	—		—	1 Pipo					1
Seedlings	15			200		2	4	2	206
live	92			195		3	3	2	205
dead	8			~~#~~	14				14
	115		115	409 +		5 +	7 +	2 =	423
				395	14				

SWETNAM 95 data

Monument Canyon Research Natural Area - 1995, Fall trip
Age structure data

Transect	ID No.	Inner year	pith estimate	new inner year	Outer year	Transect
D1	1	1835	9	1826	1995	D2
	2	1713	30	1683	1995	
	4	1774	11	1763	1995	
	6	1726	16	1710	1995	
	7	1935	16	1919	1995	
	10	1766	18	1748	1995	
	11	1840	14	1826	1995	
	12	1843	10	1833	1995	
	13	1834	8	1826	1995	
	14	1827	3	1824	1995	
	15	1932	12	1920	1995	
	16	1723	11	1712	1995	
	17	1906	4	1902	1995	
	18	1685	2	1683	1995	
	20	1607	0	1607	1995	
	21	1913	9	1904	1995	
	50	1707	12	1695	1995	
	51	1934	14	1920	1995	

ID No.	Inner year	pith estimate	new inner year	Outer year
1	1888	10	1878	1995
3	1884	16	1868	1995
4	1643	10	1633	1995
5	1686	23	1663	1995
6	1674	4	1670	1995
7	1679	2	1677	1995
8	1648	18	1630	1995
9	1643	7	1636	1995
10	1682	23	1659	1995
11	1627	10	1617	1995
12	1627	4	1623	1995
14	1668	24	1644	1995
18	1627	4	1623	1995
19	1862	3	1859	1995
21	1664	6	1658	1995
30	1930	25	1905	1995
31	1927	10	1917	1995
32	1921	7	1914	1995
34	1909	0	1909	1995
35	1953	16	1937	1995
36	1929	7	1922	1995
37	1942	16	1926	1995
38	1930	13	1917	1995
39	1957	18	1939	1995
41	1917	5	1912	1995
42	1929	10	1919	1995
43	1919	8	1911	1995
44	1919	6	1913	1995
45	1974	10	1964	1995
46	1939	6	1933	1995

Transect	ID No.
D3	1
	2
	3
	4
	5
	6
	7
	8
	9
	12
	14
	15
	16
	17
	18
	20
	21

Inner year	pith estimate	new inner year	Outer year
1842	14	1828	1995
1863	9	1854	1995
1839	6	1833	1995
1807	0	1807	1995
1838	8	1830	1995
1878	12	1866	1995
1869	5	1864	1995
1881	6	1875	1995
1836	0	1836	1995
1831	10	1821	1995
1828	10	1818	1995
1838	5	1833	1995
1620	15	1605	1995
1885	8	1877	1995
1881	10	1871	1995
1658	10	1648	1995
1855	14	1841	1995

Transect	ID No.	Inner year
D4	1	1755
	2	1903
	3	1834
	4	1861
	5	1821
	0	1817
	6	1818
	7	1873
	8	1690
	9	1696
	10	1673
	13	1683
	14	1682
	15	1859
	17	1838
	18	1650
	19	1647
	20	1631

pith estimate	new inner year	Outer year
8	1747	1995
25	1878	1995
2	1832	1995
16	1845	1995
0	1821	1995
6	1811	1995
7	1811	1995
13	1860	1995
10	1680	1995
12	1684	1995
10	1663	1995
7	1676	1995
3	1679	1995
6	1853	1995
12	1826	1995
14	1636	1995
15	1632	1995
15	1616	1995

Transect	ID No.	Inner year	pith estimate
E1	1	1729	14
	2	1640	3
	3	1692	11
	4	1670	5
	5	1771	16
	6	1863	12
	7	1744	18
	8	1716	18
	9	1860	18
	11	1897	20
	12	1923	7
	13	1862	0
	14	1864	8
	0	1865	7
	15	1820	8
	16	1855	0
	17	1831	10
	19	1701	10
	20	1817	22

new inner year	Outer year
1715	1995
1637	1995
1681	1995
1665	1995
1755	1995
1851	1995
1726	1995
1698	1995
1842	1995
1877	1995
1916	1995
1862	1995
1856	1995
1858	1995
1812	1995
1855	1995
1821	1995
1691	1995
1795	1995

Transect	ID No.	Inner year	pith estimate	new inner year
F1	1	1802	9	1793
	2	1831	6	1825
	3	1810	9	1801
	4	1815	2	1813
	5	1786	18	1768
	7	1681	18	1663
	8	1661	2	1659
	9	1658	3	1655
	10	1726	10	1716
	11	1817	3	1814
	12	1837	9	1828
	14	1834	2	1832
	15	1844	37	1807
	16	1634	5	1629
	17	1798	0	1798
	18	1924	11	1913
	19	1823	12	1811
	20	1918	6	1912

Outer year
1995
1995
1995
1995
1995
1995
1995
1995
1995
1995
1995
1995
1995
1995
1995
1995
1995
1995

Transect	ID No.	Inner year	pith estimate	new inner year	Outer year
G1	1	1746	14	1732	1995
	2	1761	24	1737	1995
	3	1891	5	1886	1995
	4	1785	7	1778	1995
	6	1672	7	1665	1995
	7	1888	8	1880	1995
	8	1649	10	1639	1995
	9	1916	1	1915	1995
	10	1914	0	1914	1995

Vegetation Studies in Research Natural Areas of the Rio Grande Basin, New Mexico

Work Plan: Investigation 3

Stand Structure of an Old Growth Ponderosa Pine Forest

and the Implications for Management

Cooperative Agreement No. 28-C4-807

Prepared by: Dr. Esteban Muldavin

New Mexico Natural Heritage Program
Department of Biology
University of New Mexico
Albuquerque, NM

12/8 pm
Keyboard not
functioning normally -

for the

ain Forest and Range Experiment Station
Albuquerque NM

12/8 pm
Keyboard not
functioning properly,
running a macro program,
Have Este, Marilyn or
Keith repair before using!

Steven

December 1994

Monument Canyon Research Natural Area
Jemez Ranger District, Santa Fe National Forest

Data Collection for future study of tree establishment patterns and fire ecology.

Methods.

The area for this study is in the south east quarter of section 9, T 21? R 4E. The study area is south of the road, and has three prominent ridge tops sloping to the south. The terrain is gentle, but stand structure in the drainages was observed to be more open and less doghair. The purpose of this data collection is to charaterize the dogha[illegible] component of the stand, and so the decision was made to generally keep the plots near the ridge tops.

Ten 400 square meter plots were laid out on two perpendicular transect lines, 100 meters apart. Transect A runs at 230 degrees along the third ridge from the east section line. The transect can be located from the "Cat Mesa" forest service road, by going west from the RNA sign at the east section line approx. .2? miles to a set of trees marked with white paint on the north side of the road. From the tree marked '164-3' (which has a yellow survey stake at DBH) go 77 meters at 318 degrees. At this point the beginning of the transect line is 15 meters at 257 degrees.

The plot center for A-1 is located, 100M at 230 degrees from the beginning of the transect. Plot centers for A-2 and A-3, are each 100 M along this 230 degree transect line [illegible] the transect line was heading off toward the drainage, the transect line was [illegible] 275 degrees and the plot center for A-4 is 100M along that adjusted line. A-5 and A-6 are located 100 M and 200 M from A-4 on the original transect of 230 degrees. All plots are square and oriented at 230 and 140 degrees. Transect line B runs perpendicular to Transect A, and comes off of the plot center for A-1. Plots B-1, B-2, B-3 are 140 degrees and 100 M apart. Plot B-4 is 100 M from A-1 at 320 degrees.

An eleventh, subjective plot, was located with the plot center being a fire history stump that was previously sampled. This plot is located approximately 340 degrees from the plot center of A-2.

At each plot, stumps of twenty live trees under 4" diameter root collar were removed to send to Laboratory of Tree Ring Research at the University of Arizona. Trees were selected throughout each plot to represent a distribution of sizes under 4" available at that plot. [illegible] tree was felled with a hand saw leaving a stump 3 to 6" high. The stump wa[illegible] up using pulaskis, shovels, and axes. Each stump is labeled with 94-MC-plot number-tree number.

All trees on each plot were tallied in 2" diameter root collar classes. Tallies were made by quarter for [illegible] plots except A-1.

FAX TRANSMITTAL

Seldom Seen Expeditions, Inc.
Natural Resources and Environmental Education Consulting
P. O. Box 474
Placitas, New Mexico 87043
(505) 867-4661, FAX (505) 867-5844

TO: Esteban Muldavin, New Mexico Natural Heritage Program

FROM: Mary Stuever

DATE: October 17, 1994

No. of PAGES: 2

SUBJECT: Monument Canyon

This is a draft version of methods notes that I wrote up the first week we were on the project, and hastily edited this morning. Hopefully, it will be helpful to you all this week. When and where do you want to meet on Wednesday? Dave's and Lisa's cafe in La Cueva opens at 7:30 a.m.

Inventory & Monitoring Program Manager
South Florida Natural Resources Center
Everglades National Park
40001 S.R. 9336
Homestead, FL 33034

David E. Busch, Ph.D.

(305) 242-7843 **FAX (305) 242-7836**

MEMORANDUM

DAVID_BUSCH @ NPS.GOV

DATE: 6/16/95

TO: 1995 ESA Annual Meeting Speakers Esteban Muldavin

FROM: Dave Busch

SUBJECT: Contributed Poster Session

As you may already know, the abstract you submitted for inclusion in the program of the 1994 ESA Annual Meeting has been accepted.

Your poster is scheduled for the following session, date and time:

59, Tues afternoon, Aug. 1

I will be serving as the chair for this session. Please note the following important points concerning your presentation:

1. Poster boards will be 8 feet wide by 4 feet tall (244 x 120 cm). Given that the boards are so wide, you should have sufficient room for a headline strip at the top. Make this header at least 6 inches (~16 cm) high and include on it title, authors, and affiliations in letters not less than 1 inch (2.5 cm) high. Push pins will be provided. Put a large copy of your abstract in the upper left corner of the poster.
2. Posters will be up all day on the day of your session. Mount your poster on the assigned board between 8:00 and 8:30 of the day when your poster will be displayed. Leave the poster in place all day. I recommend you visit the poster several times during the day to see if there is anyone there who would like to discuss your poster.
3. We ask that you spend at least two hours with your poster, from 8:30-10:30 AM for morning sessions, or from 1:00 to 3:00 PM for afternoon sessions. The Poster session Tour will come through during this time.
4. New this year are Poster Session Tours, in which you will be invited to give a brief (5 minutes!) overview of the highlights of your poster. This is to minimize the number of times you have to give the same introductory speech to interested people, to give a group an overview of a particular session, and to foster discussion among all participants of your poster session. Poster Session Tours will be led by myself, and will begin at 9:00 AM for morning sessions and 2:00 PM for afternoon sessions. I will introduce you and keep you on time. Please help me by keeping your overview short and to the point. If you are engaged in a discussion when I come through with the tour, please suspend your discussion for the short time it takes to present your overview.
5. Participation in the poster tour is voluntary. If you would prefer I not bring the tour by your poster, you must let me know in advance.
4. **If you have to cancel your presentation, please notify me and the ESA Program Chair as soon as possible.** Any individual who fails to provide timely notification of cancellation is prohibited from presenting a paper the following year.

Please contact me if you have any questions or concerns. I look forward to seeing you at the meeting and hearing your talk. Your contribution will help make the 1995 meeting a success.

Date: Tue, 29 Oct 1996 09:29:51 -0500
From: FIRESCAR@aol.com
To: muldavin@sevilleta.unm.edu
Subject: Re: Mon Canyon,

Hi Este,
Glad to hear you are proposing some work in Monument. Sign me on. You might add that we would try to salvage fire-scarred speciemens (logs, etc.) and date snags before burning treatments, and sample some of the cut trees for ages if thinning is to be done. I'm at a meeting here in Montana and tied up today and tomarrrow, then off to UC Davis for a couple of seminars. WIll be back in my office next week.
Tom

The University of New Mexico

New Mexico Natural Heritage Program
Department of Biology
2500 Yale Blvd. SE, Suite 100
Albuquerque, NM 87131-1091
Telephone (505) 277-1991

28 October 1996

Debbie Finch
Project Leader
Rocky Mountain Range Experiment Station
2205 Columbia SE
Albuquerque, NM 87106

Dear Debbie

I would like to provide a clarification on the costs the costs associated with for our RNA proposal "Cryptogamic Crust Community Structure and Dynamics in Pinyon Juniper Woodlands of the Southwest: a comparison between Research Natural Areas and adjacent managed areas." We submitted the amount of $25,000 based on our past experience of what it would takes to set up long-term experimental and monitoring plots and transects for cryptogams and vegetation. We expect to put in place 20 intensive plots, split between treatment and controls, on at least two RNA sites. On each plot we will measuring composition, abundance and structure of cryptogams at a sub-centimeter scale along with soil surface characteristics and vascular plant components. The details of the proposed sampling design will provided in a Study Plan as part of the project deliverables. For our part, we would be willing to cost-share upwards of 20% for in-kind services and direct costs. The project can also be scaled back if necessary to a single initial site for approximately 60% of the costs. If you have any questions let me know.

Sincerely,

Esteban Muld

Dr. Esteban Muldavin

Vegetation Studies in Research Natural Areas of the Rio Grande Basin, New Mexico

Work Plan: Investigation 3

Stand Structure of an Old Growth Ponderosa Pine Forest

and the Implications for Management

Cooperative Agreement No. 28-C4-807

Prepared by: Dr. Esteban Muldavin

New Mexico Natural Heritage Program
Department of Biology
University of New Mexico
Albuquerque, NM

for the

Rocky Mountain Forest and Range Experiment Station
Albuquerque NM

October 1995

Investigation 3, "Stand Structure of an Old Growth Ponderosa Pine Forest and the Implications for Management," concentrates on describing the forest structure at the Monument Canyon Research Natural Area in the Jemez Mountains of Northern New Mexico. This is one of the oldest RNA's in the Southwest and supports a old growth ponderosa pine forest that has had fire, grazing and logging excluded for almost a century. The effects of these exclusions on stand structure and ultimately the forest health were the primary focus of the research.

1. Sampling Design and Implementation. The study area is approximately 360 acres in size and lies near the ridge line of a gently sloping (3-5%) mountain slope (tilted plateau). The slope is moderately dissected with wide-ridge platforms separated by three small drainages (see attached map). A dirt road cuts across the top of the study area near the ridge line. The ridge platforms support the typical forest stands of the RNA, dense "doghair" reproduction stands intermixed with a sparse overstory of mature trees (yellowbarks). The habitat type on the platforms is ponderosa pine/Arizona fescue. The drainages tend to lack the reproduction stands and comprise a separate habitat type (ponderosa pine/Gambel oak). Because of limited resources, sampling was confined to the ponderosa pine/Arizona fescue habitat type on the ridge platforms, and the intervening drainages excluded.

Ten, 400-square-meter plots will be laid out on two perpendicular transect lines adjacent to the 1994 transect lines. Transect Line D will traversed down a northwest to southeast trending ridgeline. The starting point of the transect was established 100 meters southwest of 1994 sample points A2 and B3. Five plots were established along the line at 100-meter intervals. Line E was established at right angles to the first at plot D1, and traversed the study area across the slope (rather than down the ridgeline). Four additional plots will be established along this line at 100 meter intervals. An additional two plots will be opportunistically placed at low density sites.

Each plot is square and twenty meters on a side. The plots will be marked with wooden stakes at each corner, at the midpoints of the sides, and in the center. For trees up to 20 inches, two transects will be set up perpendicular to one another along the midlines of the plot. At two-meter intervals along the lines the closest tree to the point will be chosen for sampling. Sampling will entail non-destructive boring of the trees as close to the root growth/shoot initiation point as possible (using 5mm increment corers). All trees larger than 20 inches will be sampled on the plot (using a power 5mm borer). All trees on the plot will be tally counted by 2 inch diameter rootcrown classes to give an estimate of stand density. Also, selected trees with fire scars (catfaces) will be non-destructively sampled to bolster the fire history record of the stand. **And finally, on three of the low density plots, 20 young age class trees (4 in. or less) will be destructively sampled for later precise determination in the lab of the year of germination and establishment (a total of 60 seedlings and saplings).**

Low altitude stereo aerial photography (70mm) and high resolution videography will be flown over the study area. Natural color 8x8 inch prints will be produced for mapping the stand structure at a scale of 1:6,000. The photos will also be used for estimating stand density (individual trees are visible).

resolution of the post-1900 recruitment pulse, so that we might investigate possible interannual climatic associations with successful recruitment. The total number of additional trees to be sampled (increment cores and cross sections) be at least 200, and up to 300. We will follow similar methods as previously used in sampling along linear transects and within plots along the transects.

2. We will collect additional fire-scar samples within Monument Canyon, near to, and along the age structure transects to more closely interpret fire regime patterns in relation to the sampled trees.

3. We will sample snags and logs near to and along the transect where it is possible to obtain sapwood and bark dates. We will crossdate these specimens to identify dates of mortality. The purpose of this effort will be to identify (if possible) temporal patterns of mortality of overstory trees. For example, are the overstory trees dying in a more-or-less continuous manner, or are death dates clustered during certain years or periods (such as during droughts)? We will attempt to obtain samples from at least 30 trees for this preliminary investigation.

4. We will evaluate the relations between the resulting age structure patterns, fire history and climatic variations over the past three centuries. We will use recent dendroclimatic reconstructions from the Jemez Mountains, and meteorological observations (such as from Jemez Springs and Los Alamos stations) to evaluation possible climate associations with the recruitment patterns.

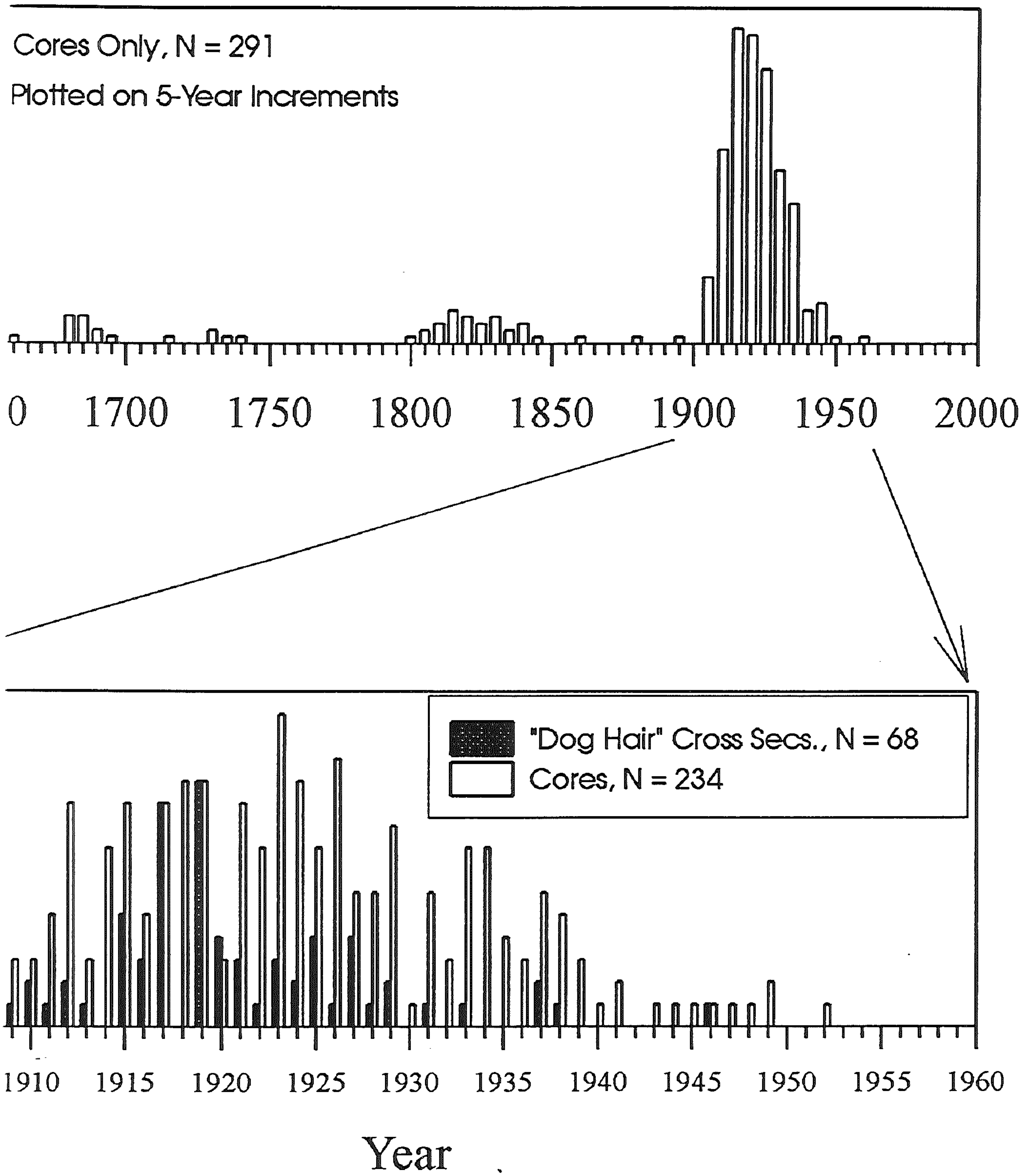
5. We will explore possible new research topics and projects in Monument Canyon RNA with Carl Edminster of the Rocky Mountain Forest and Range Experiment Station, Reggie Fletcher of The Southwestern Region Office, and Craig Allen of the National Biological Service. Edminster has expressed an. interest in supporting some spatial analysis of the ponderosa pine age structure within Monument Canyon.

Products

We will prepare a final report for the project in the form of draft manuscript, that upon internal review and revision, will be submitted to a peer review journal for publication. We will also deliver as appendices all resulting data in hardcopy and magnetic form.

We also expect to develop ideas and plans for future research in Monument Canyon, in consultation and collaboration with individual listed above (and possibly others).

Schedule


Cores Only, N = 291
Plotted on 5-Year Increments
0
1700
1750
1800
1850
1900
1950
2000
"Dog Hair" Cross Secs., N = 68
Cores, N = 234
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
Year

ABSTRACT FORM
1995 ANNUAL MEETING, ECOLOGICAL SOCIETY OF AMERICA

DEADLINE FOR RECEIPT OF SUBMITTED ABSTRACTS IS 30 JANUARY 1995. Mail the original plus 4 copies to Jill Baron, ESA Program Chair, Natural Resource Ecology Laboratory, Colorado State Uni... Fort Collins, CO 80523 USA. Please read all instructions in the *Bulletin of the Ecological Society of America* ("Call for Posters and Papers," September 1994, 75(3):132–134) before typing on this special for...

Preference

Oral contributed paper ☐
Poster session ☒
Invited symposium paper ☐
ESA member yes ☒ no ☐

Author to contact: Esteban H. Muldavin
Institution: New Mexico Natural Heritage Program,
Address: University of New Mexico, 2500 Yale Blvd. SE
Albuquerque NM 87131 E-mail address Muldavin@Sevilleta.UNM.EDU
Phone number: 505 - ~~255~~ 277-1991 Who will present the paper? Muldavin

Session topic code (see *Bulletin* 75(3):132–134):
First choice 2 9 ; Second choice 1 1 ; Session topic if choice is "Other" (07 or 48): ______

Audiovisual equipment required: 35-mm slide projector ☐; Overhead projector ☐; Other (specify) ☐ ______

MULDAVIN, ESTEBAN H., THOMAS W. SWETNAM and MARY STUEVER. University of New Mexico, Albuquerque, NM 87131 USA, University of Arizona, Tucson AZ USA and University of New Mexico, Albuquerque, NM 87131 USA. Age structure and density of an old growth ponderosa pine forest in relation to changes in fire regime and climate fluctuations.

Beginning at the turn of the century, an old growth ponderosa pine forest in northern New Mexico was protected from logging, fire and grazing as a Research Natural Area. As result, significant changes in age structure and density of the stand have occurred. We intensively sampled the trees to determine their dates of establishment. The age structure is distinctively multi-modal with a remnant overstory of older trees (>300 years) that, in many locations, is dead or dying. The understory in these locations is dominated by very dense pole stands in excess of 5,954 stems/ha. that are less than 50cm DRC. Intermediate aged trees are relatively rare. Other locations have a healthy overstory, show a more even age distribution, and densities are low. A 300+ yr. fire history chronology for the stand has been developed. Changes in stand structure appear to be correlated with changes in fire regime with consequent impacts on recruitment. Recruitment may reflect specific climatic pulses leading to high density, even aged cohorts that lack thinning or removal by fire. High density in the understory is suggested to have negative impacts on nutrient cycling and moisture competition which are increasing the rate of overstory mortality, leading to very different kind of old growth forest than would have been expected under pre-settlement conditions.

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PLEASE NOTE: Submitting this abstract is a guarantee from you that the research reported has been completed and will not have been published before the time of the meeting.

INSTRUCTIONS:

1. Your entire abstract—including AUTHOR(S), Institution, City, STATE, Zip code, COUNTRY, and Title—must be typed within the blue rectangle. Leave no margins at the top or on the side within the rectangle and continue lines as near the right margin as possible. Do not touch the blue line. Practice typing the abstract before using the form.
2. Capitalize the AUTHOR(S) NAME(S), and place the senior author's last name first. Indent 4 spaces after the first line of the citation. Leave a blank line between the title and abstract text.
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MURPHY, PETER G. and REBECCA R. SHARITZ. Michigan State University, East Lansing, MI 48824 USA and Savannah River Ecology Laboratory, Aiken, SC 29801 USA. Long-term recovery of northern hardwood forest following gamma irradiation.

A northern Wisconsin hardwood forest was exposed to 3300 hours of pointsource gamma irradiation from 3 May to 16 October 1972. Cumulative . . .

Age Structure and Demography of Ponderosa Pine in Monument Canyon Research Natural Area

Progress Report and Plan for Additional Research

June 28, 1995

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Introduction

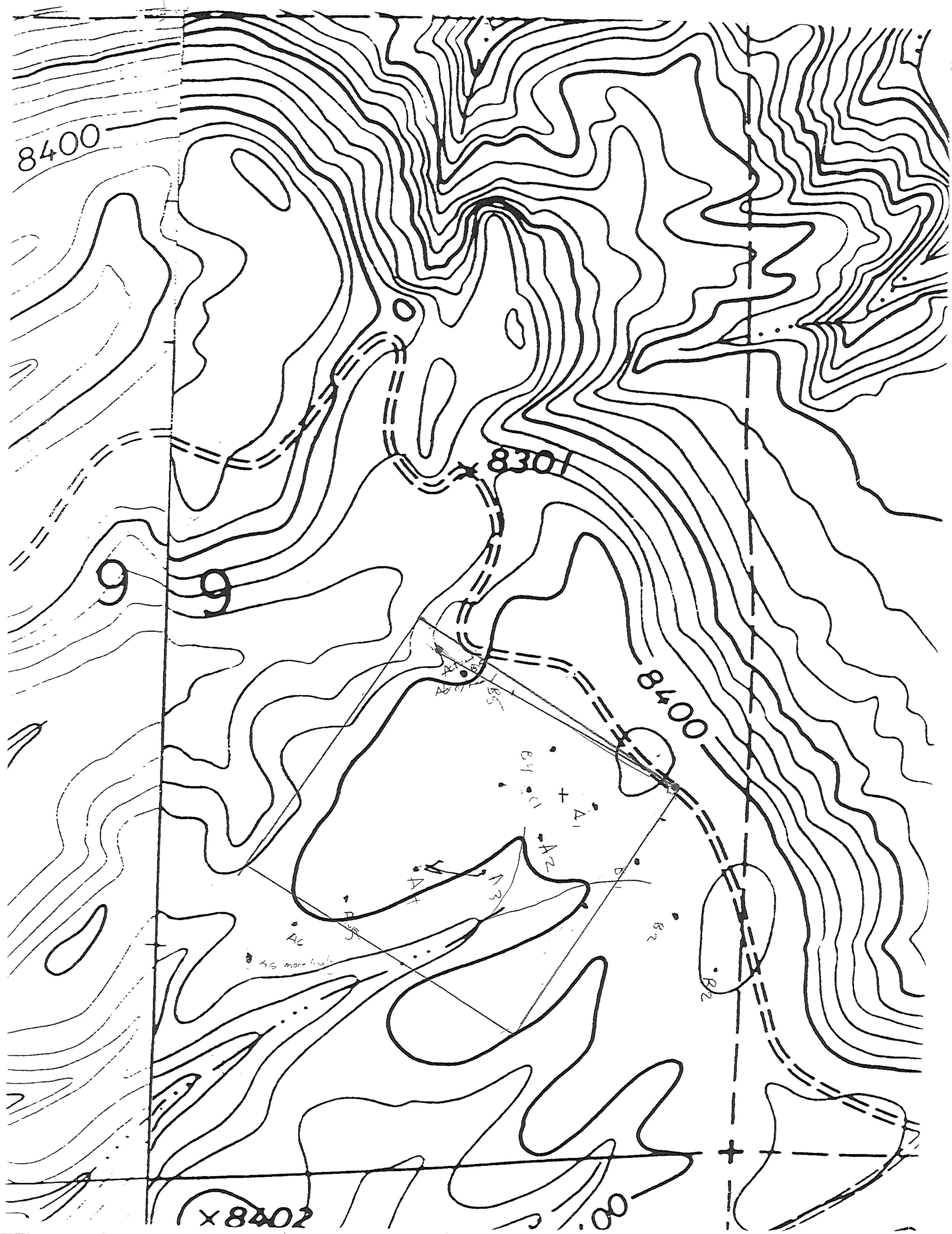
In 1994 we initiated a research project aimed at evaluating the age structure of ponderosa pine old growth and "dog hair thickets" in the Monument Canyon Research Natural Area in the Jemez Mountains of Northern New Mexico. Our goal is to improve our knowledge and understanding of the demographics of pines in this area over the past three to five centuries. We are particularly interested in the temporal patterns of tree recruitment (i.e., successful germination and ingrowth of individuals into the population), and the relations of these patterns to climatic variation, fire history, and land-use history (i.e., fire suppression, and livestock grazing). Monument Canyon is one of the oldest RNAs in the Southwestern U.S. It was originally established in 19xx to represent a particular manifestation of the ponderosa pine forest type. Today, the stand is a classic example of the results of fire exclusion in ponderosa pine. Most of the pure ponderosa pine type within the RNA is composed of an overstory of declining living trees, and standing snags that have accumulated from progressive mortality over the past half century. The understory is dominated by dense, stunted ponderosa pine thickets ("dog hair"). Vegetative ground cover is very sparse or totally absent under the ponderosa pine canopies.

In this brief report we describe the preliminary results of our work to date, and we also outline plans, budget and schedule for addition work in Monument Canyon

Methods

11 / 400 500 at 100 m intervals.

We established two linear transects of xxx m length on the eastern side of the RNA. We established xx, xx m2 plots ~~evenly~~ spaced along the transects and then sampled with increment borers all living pines within x meters of perpendicular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