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**VEGETATION RESOURCE MONITORING SYSTEM
CHIRICAHUA NATIONAL MONUMENT**

**By: W. H. Moir
1974**

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Resource Monitoring System, Chiricahua National Monument, Arizona

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FRONTISPIECE. Bullgrass along the Natural Bridge Trail exemplifies the scenic beauty and generally excellent condition of the natural resources at Chiricahua National Monument. Photo courtesy Mike Sipes, National Park Service, October 1974.

INTRODUCTION

To manage natural resources it is necessary to know what these resources are (vegetation, soil, water, scenery, etc.), how abundant or what condition they are in, and how they respond to a variety of natural or man-caused treatments. The Organic Act of the National Park Service specifies that the natural resources of parks and monuments shall be preserved for the benefit of present and future generations. Yet preservation is no simple task, for both natural succession and succession induced by the visitors themselves in the parks ~~will~~ act to alter the resource conditions from the time the parks were established (Stone 1966). To date Chiricahua National Monument has used rather subjective, visual means of assessing the condition and trends of its vegetation and soil resources. This method has been satisfactory because of the relatively low intensity of visitor use in the past, so that their accumulative effect upon vegetation, soil, scenic, geologic, and other resources has been relatively minor. Intensified or concentrated visitor use in small areas such as Massai Point or along nature trails requires more precise, quantitative methods of measuring resource conditions and trends. The former visual means cannot alert the land manager to deteriorating conditions with enough lead time to apply convenient restorative measures. Nor can the manager have quantitative information concerning the resource-bearing capacity, i.e., the maximum or sustained flow of monument visitors to any management area such that the natural resources there will not be irreparably damaged for future use (Alldredge 19)

In 1974 a resource monitoring system was installed at Chiricahua National Monument. This system consists of a variety of measurements from permanent field plots of existing vegetation and soil conditions in various management zones. The quantitative data and photographic records obtained from these plots over repeated periods will enable management to:

- o Objectively evaluate existing conditions of vegetation and soils and their trends in each management zone;
- o Identify areas of high visitor or maintenance impact, the nature of the impact, and decide whether deleterious or irreversible resource damage is resulting;
- o Determine when visitor or maintenance regulations or controls will be needed to restore deteriorated areas;
- o Procure baseline measurements from which succession and natural

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impacts (fire, insect outbreaks, flash floods, etc.) can be compared;

- o Help in appraising with increased precision the visitor carrying capacity in each management zone.

This paper describes the resource monitoring system initiated at Chiricahua National Monument in 1974. Since the monitoring systems is primarily involved with vegetation and certain soil characteristics, the vegetation types and landforms important in soil development and erodibility (uplands, canyon side-slopes, canyon bottoms) are reviewed, especially from the perspective of management zones and the comprehensiveness of the monitoring system. The following sections concern the theory and methods underlying the monitoring system, a review of the Monument's vegetation and landform-soil features, summaries and discussions of the 1974 data, and a resource evaluation in the management zones where data were procured.

THEORY AND METHODS

The first question when initiating a resource monitoring system concerns which resources are most likely to be affected by the existing and contemplated land use patterns. The geological resources of the Monument, while spectacular and impressive, have nonetheless a time scale of change that is little affected by present or future land uses. Hydrological resources are very important within the Monument's arid-type ecosystems, and certain aspects such as surface runoff can be measured as erosion or deposition of materials of the soil surface. Faunal resources, too, are likely to be critically affected by man's presence. Local, infrequent, or rare species are particularly noteworthy. Faunal populations, however, are most dependent upon vegetation and soil conditions for food, cover, and population maintenance. The vegetation and soil resources were assumed to have greatest sensitivity to the various effects of man in each management zone. Vegetation cover is a crucial, easily changed feature of the landscape. Second, perhaps, to the immutable rhyolite towers, the vegetative cover is the most visually apparent feature of the various ecosystems in the Monument. This cover, and the soils that sustain it, has central importance to wildlife populations and to hydrological parameters such as infiltration,

runoff, and sediment yields.

The resource monitoring system is concerned mainly, therefore, with the vegetation and soil resources. Since the system deals primarily with aspects of plant succession, the excellent treatise on this subject by Daubenmire (1968) is an important reference on theory and techniques. Techniques employed in the resource monitoring system have long been used by plant ecologists, soil scientists, or others concerned with field research. Procedures for collecting reliable and repeatable data on vegetation and soils have also been detailed by Moir and Franklin (1972), Ohmann (1973), Peterken (1967), and others. The sampling system used at Chiricahua National Monument was chosen after considering the particular vegetation, landform, soils, and likely land use and impact patterns. Another crucial sampling criterion for some locations within the Monument was that the data be geared more directly to management decisions than to descriptions of plant communities.

Both man-caused and natural factors affect vegetation and soil processes and conditions. Man-caused factors include both visitor and maintenance impacts. The former include flower picking (reducing plant diversity, threatening local extinction or rare or infrequent populations, eliminating seed production and dispersion), trampling (causing mechanical breakage of plant parts, impairing regeneration, accelerating soil erosion), wood gathering, and littering. Maintenance impacts are usually associated with such activities as trail repair (borrowing of fill materials), and have similar impacts as visitor use but can be more localized and restricted to areas of low visual sensitivity and high resource durability.

Natural impacts such as wildfire, grazing by wildlife, flash floods, or insect epidemics operate in diverse and often little understood ways upon the ecosystem. A fire, for example, may affect numerous populations in manners somewhat independent of the character of the vegetation (i.e. allogenic influences of Daubenmire 1968). In such an example as mistletoe buildup, on the other hand, a particular set of populations may be involved, and the environmental changes which drive plant succession are due to the activities of organisms within the ecosystem (autogenic influences). The effect of both natural and man-caused impacts (or new sustained rates of activity) is to initiate plant succession, which continues until a terminal, steady-state population dynamics (climax) is reached within the ecosystem. Since the time factor is important, the monitoring

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system is based upon repeated observations from permanent plots, and - increasingly important in the future - by comparing existing records with previous descriptions of vegetation or soil (see Daubenmire 1968, p 100 ff for discussion of ecological techniques for measuring succession).

Some Statistical Considerations

The basic unit of vegetation and soil observation is a 2 x 5 dm quadrat frame. Within this 0.1 m² area vegetation and soil surface features are visually estimated. Let us suppose that some management area contains N of these quadrats in some configuration. Some vegetation or soil property, X, from the i-th quadrat has the following components at times t₁ and t₂:

$$\begin{aligned} X_{i,t_1} &= \bar{X} + e_{i,t_1} \\ X_{i,t_2} &= \bar{X} + e_{i,t_2} + R \end{aligned} \quad (1)$$

Here $\bar{X}$ is the population mean value of the observed characteristic, e is an observational error which can be assumed to be normally distributed around some bias, and R is a real effect, or change-of-state of the observed characteristic during the time interval t₂ - t₁. R is, therefore, the measure of succession, the result of some man-caused or natural impact. The change that occurred in the i-th quadrat is expressed by the difference:

$$\begin{aligned} X_{i,t_2} - X_{i,t_1} &= R + (e_{i,t_2} - e_{i,t_1}) \\ &= R + e_i \end{aligned} \quad (2)$$

where e has the expected value E(e) = 0 and variance V(e) = σ_e^2 . The real effect has the expected value E(R) = 0 under the null hypothesis that there has been no real effect during the time interval. A variety of statistical tests can be used to test this null hypothesis depending upon the size of N (i = 1, 2, ..., N), assumptions concerning the homogeneity of the underlying population characteristics as reflected by the quadrat samples, the sampling design, and other considerations, none of which are within the scope of this

discussion but can readily be found in standard statistical books (i.e. Brunk 1960, Pearce 1965, Freund 1967). What is important here, however, is a brief examination of the components of the variance term, σ_e^2 , for if this term is too large as the result of sloppy field techniques, there is a high probability that a non-zero real effect will not be detected. This means that the land manager is likely to accept the null hypothesis when, in fact, a real change that he should know about has actually taken place (Type II error, see Brunk 1960, p 237).

The observational error, e , has three components: worker bias (B), location effect (L), and disturbance effect (D). Suppose a single worker, j , is observing the i -th of N quadrats located in an area. His bias, or tendency to consistently over- or underestimate, any resource condition can be expressed:

$$e_{ij} = B_j + \epsilon_{ij} \quad (3)$$

where ϵ_{ij} is the random error associated with worker j 's estimate of that resource condition. Since this bias is assumed to be consistent, successive measurements from the same quadrat by the same worker can eliminate it:

$$\begin{aligned} e_{ij,t_2} - e_{ij,t_1} &= B_j - B_j + (\epsilon_{ij,t_2} - \epsilon_{ij,t_1}) \\ &= \epsilon_{ij} \end{aligned}$$

where $V(\epsilon_{ij}) = \sigma_\epsilon^2$. (Here the variance associated with B has been incorporated into σ_ϵ^2 .) If different workers, j and k , are observing the resource condition of the i -th quadrat, the biases cannot be eliminated, and the variance associated with e has two components:

$$\sigma_e^2 = \sigma_{\Delta B}^2 + \sigma_\epsilon^2 \quad (4)$$

Equation 4 also assumes there is a certain homogeneity of variance between the two workers. This assumption can be warranted and the bias variance, $\sigma_{\Delta B}^2$, minimized by calibrating the two workers. If the new observer is given on-the-job quadrat training by the previous worker, he is likely to acquire the first worker's bias ($B_j \approx B_i$). When two workers have read sufficiently numerous

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quadrats together, in close agreement, they can be considered calibrated. The existence of worker bias at Chiricahua National Monument was tested after two workers (W. Moir and W. Murray) had read numerous quadrats together. The test consisted of reading 7 plot areas along Rhyolite Canyon Trail near the visitor center independently. The plots were BT type (discussed below) each consisting of 10 contiguous 2 x 5 dm quadrats. In each quadrat the amounts of natural forest floor litter, exposed soil, and vegetation basal area were each estimated to the nearest percent (see the following section). These characteristics had first been measured on 10 April by worker I (Moir) and again on 17 May by both workers independently. This interval was too short to assume that any real changes (R) had occurred in any of the plots, so that any differences between the workers on 17 May, measured as departures from the 10 April measurements, must be estimates of B. The null hypothesis is that $E(B) = 0$. Table 1 gives the results of this test. The t statistic used to test the null hypothesis is non-significant for each of the three soil surface characteristics, and one could conclude that the workers have been calibrated, that is, accept the null hypothesis that $B_I = B_{II}$. However, for soil, one notices that the t value of 2.17 is almost significant at the 5% probability level. Since the mean difference between worker II's soil estimate from worker I's is 1.1%, this can be taken as an approximate measure of how closely such a resource characteristic can be measured by different workers who have been calibrated, at least under conditions existing in Rhyolite Canyon. We note finally from Table 1 that there is no essential difference between worker I's April or May observations, giving credence to the assumption that there were no real changes in soil surface characteristics during the 5 week interval between observations.

TABLE 1. Repeatability of quadrat measurements of soil surface features from 7 plots in Rhyolite Canyon. The t statistic was calculated between workers I and II for May 17 as departures from the April 10 measurements.

SOIL SURFACE	WORKER AND DATE			t^a
	I 4/10	I 5/17	II 5/17	
	-----	%	-----	
SOIL & GRAVEL	2.6	2.8	1.6	2.17
LITTER	94.2	94.2	94.7	0.68
VEGETATION BASAL AREA	2.2	2.1	2.4	0.43

^a/ Student's t small sample test. P -- = 2.18 for 12 degrees freedom

Location effects are illustrated by the photograph pairs of Figure 1. On the left is a location in Picket Canyon originally photographed by Roseberry and Dole in 1937 and rephotographed from the same location in 1974. The 1974 photo shows grasses in the foreground and a small draw containing mountain mahogany shrubs in the right foreground. The second 1974 photograph was displaced only 10 m downslope and slightly closer to the draw. Here scouring runoff has exposed bedrock, and the paucity of grass cover in the foreground is not a vegetation change after 37 years but a camera location effect (see also Figure 16). Similarly, in successive observations from a quadrat there is a certain edge-effect, or discrepancy obtained from small differences in the exact placement of the quadrat frame. This can be written:

$$e_{ij} = L_j + \epsilon_{ij} \quad (5)$$

where L_j is the random error associated with the j -th placement in time of the quadrat frame. This error cannot be eliminated but can reasonably be assumed to be independent and additive to the error term, ϵ_{ij} , so that we get:

$$\sigma_e^2 = \sigma_L^2 + \sigma_\epsilon^2 \quad (6)$$

Although location effects cannot be eliminated they can be reduced by (a) precise location of the quadrat frame between fixed points, (b) reducing edge effects whenever possible by employing contiguous quadrats, and (c) systematically placing an adequate number of frames over a homogeneous vegetation type. These techniques will be discussed further in the section on methods.

Someone observing a natural variable such as litter in a quadrat frame may himself change the condition of that variable in the process of observing. Common examples of the disturbance effect are:

- o Crushing the vegetation or disturbing the litter in process of placing the quadrat frame;
- o Trampling over a site while looking for it;
- o Creating edge effects in the form of broken plantparts, disturbed

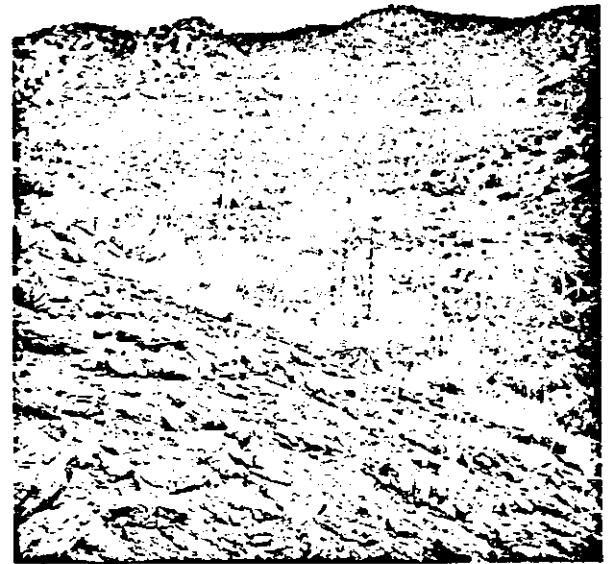
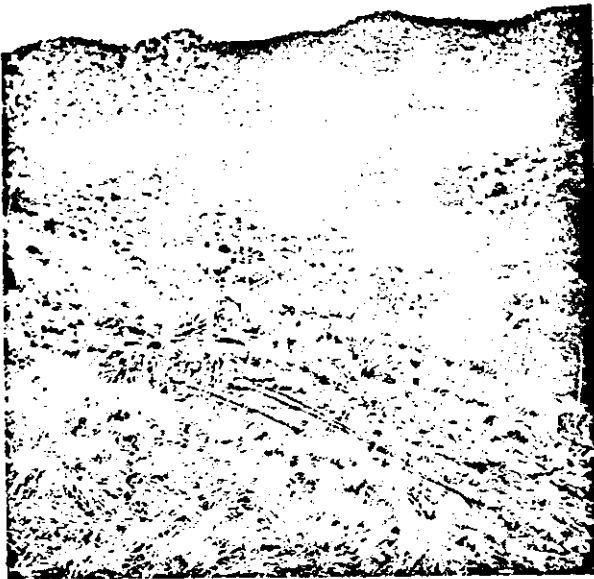


FIGURE 1. Grassy sideslope of Picket Canyon photographed March 1974. Left: lush cover of grasses at photopoint originally used in 1937 by Roseberry and Dole. Right: Photopoint displaced 10 m downslope and somewhat closer to the small draw containing mountain mahogany and other shrubs. Note the exposure of bedrock and cobbles in the foreground.

soil conditions, etc through trampling while examining a sequence of quadrats;

- o Altering the arrangement of natural objects within the quadrat frame in the process of scrutiny.

Such disturbance effects cannot be distinguished from the real effects of natural or man-caused impacts. One careless worker can create more damage than 100 visitors in a monitored location! As with location effects in the i -th quadrat by worker j we have:

$$e_{ij} = D_j + \epsilon_{ij} \quad (7)$$

$$\sigma_e^2 = \sigma_D^2 + \sigma_\epsilon^2 \quad (8)$$

where D_j has all the outward appearances of R , the real effect of equation 2. The variance, σ_D^2 , can be minimized by exercising all due care when visiting monitoring locations and quadrat sites. It is extremely important to approach these sites cautiously, for the stakes locating them are often difficult to find. One must not be hurried progressing from one site to the next, and physical motions around the carefully positioned quadrat frame should be deliberate and restrained. The worker must realize that disturbance effects immediately outside the quadrat areas can influence conditions within those areas on the following time. Thus disturbance effects, like location effects, cannot be distinguished from real effects.

If we combine all of the above components of the observation error, e , and assume that these exert linear, additive, and independent effects, then we obtain from equations 3, 5, and 7:

$$e_{ij} = B_j + L_j + D_j + \epsilon_{ij} \quad (9)$$

and from equations 4, 6, and 8:

$$\sigma_e^2 = \sigma_{AB}^2 + \sigma_L^2 + \sigma_D^2 + \sigma_\epsilon^2 \quad (10)$$

for changes in successive measurements over the time period $t_2 - t_1$ for the i -th quadrat (out of N) by the j -th worker. If care is taken to keep as low as possible these apparent effects then the expected value of e_{ij} can be assumed to be zero. However, most statistical tests of the null hypothesis for equations 1 or 2 (that $E(R) = 0$) involve the variance term, σ_e^2 , in whatever test statistic is employed. For example, analysis of variance of an orthogonal two-factor experiment such as was used in the experiment on trampling of grasses (Table 9 below) computes the F statistic for effects of trampling:

$$F = \frac{\text{Mean Square Trampling}}{\text{Mean Square Error}}$$

and should any component of variance in equation 10 be large relative to the Mean Square Trampling (or Row Effect), then F will be small and possible real effects of trampling masked by sloppy observational procedures.

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We turn now briefly to the real effect R. Rejection of the null hypothesis is tantamount to acknowledging that some natural condition has, in all probability, changed in the time interval between successive measurements within the N quadrats at some management location. The question arises whether the changes are caused by man or by natural forces. One way to approach this question statistically is by comparing plots in visited versus non-visited areas. The latter, control areas can be wilderness or natural areas where visitor use can be assumed zero or at least minimal. Thus conditions in a set of plots at Massai Point (heavy visitor attendance) can be compared to similar conditions at Sugarloaf NNE where no visitors are likely and vegetation and landforms are very similar. One difficulty, however, is that natural forces (such as a cloudburst or trampling effect by deer) are apt to be local, so that the two areas are no longer homogeneous. Another difficulty is that only a single or few plots in any location might be affected by man or natural causes, in which case even small sample statistics are inadequate. In such cases judgement and intuition are more important in decision-making than statistical rigor. Collateral information can sometimes be gainfully used in these judgements. Broken manzanita branches near a parking lot and the tire imprints through the damaged area need no belabored statistics for interpretation. A fire through a woodland plot in a natural area is a highly probable explanation for vegetation differences before and after the event whether or not one is concerned with 1, 5, or 10% probability levels from a comparatively few plots. Knowledge that trail maintenance has occurred in a monitored location could explain the otherwise "chance" disappearance of cryptogams in a particular plot location there. Even if R can be detected with statistical significance, it cannot dispatch with the land-manager's judgement as to how seriously to regard it. The plots established in this resource monitoring system are designed to give natural resource information to the Superintendent. It may behoove him to be alerted to a possible change in some resource condition long before there is sufficiently overwhelming information to make that change statistically significant.

Field Techniques

The resource monitoring system at Chiricahua National Monument consists

of permanently established plots at locations in various management zones. There are also a number of permanently established photography sites (photo-points). Three types of plots will be described, each differing in the manner by which 2 x 5 dm quadrat frames are systematically deployed. Each plot technique is intended to satisfy criteria of reliability, sampling adequacy, and repeatability (Moir and Franklin 1972). In particular, for each monitoring site the system of plots:

- o Have permanently marked locations in order for different workers to find them;
- o Have systematic, relatively simple deployment of plots for others to repeat;
- o Are as objective as possible to minimize biases;
- o Should be measured by trained personnel to reduce the possibility of mistakes or inaccuracies entering the data;
- o Contemplates when possible the detection of significant differences within 10% of the mean at the 10% probability level;
- o Keep to the minimum the observation effects themselves upon the natural populations being measured.

Belt Transect (BT) Plots

A belt transect (BT) plot consists of 10 contiguous 2 x 5 dm quadrat frames arranged to form a rectangle 2.0 x 0.5 m (Figure 2). Vegetation in the BT plot is analysed by the canopy coverage method (Daubenmire 1959, excerpted in Appendix). The quadrat frame is painted in a manner that greatly facilitates visual estimation of vegetation into canopy coverage classes and soil surface features into percentiles. These soil surface features are as follows:

- o Soil and Gravel. Clastic mineral materials under 1 dm in maximum dimension. No effort is made to further separate these particles into finer sizes (sands, gravels, stones).
- o Loose Rocks. Clastic mineral particles over 1 dm in maximum dimension. The movability of large rocks was the field test for looseness. If rocks or boulders of whatever size over 1 dm could be moved without great exertion, they were classed as loose rocks even if the long dimension of the fragment was below the ground.
- o Bedrock. Consolidated or clastic rock fragments or boulders. Clastic rocks were regarded bedrock if apparently unmovable without great exertion.

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- o Litter. Nonliving organic debris on or, in the case of woody branches, near the ground surface.
 - o Vegetation Basal Area (BA). That portion of the ground surface from which living plant parts emerge. This includes grass culms, surface roots, layered branches, and woody stems.
 - o Soil lichens and mosses (soil cryptogams). A collective term for all cryptogams having mineral soil as their substrate. Saxicolous lichens and mosses (growing on gravels, rocks, boulders) are excluded.

In each 2 x 5 dm quadrat these soil surface features were estimated to the nearest percent using the painted sides of the frame as percentile guides. It is convenient to estimate percentages of the smaller quantities and find the largest percentage by subtraction from 100. Trace quantities are recorded as 0 percent, whereas surface properties not occurring within the quadrat area are left as blanks on the data form.

All living vegetation above the soil surface is estimated into one of six canopy coverage classes (Daubenmire 1959, 1968 p 43-44, and excerpted in Appendix of this paper). However, the canopy coverage method is not very precise for measuring canopies overhead, and can be restricted to measuring vegetation coverage between eye level and the ground surface. Such restrictions should be noted on the data form if consistent observations are to be made by different workers.

Location effects at each plot were minimized by permanently locating the corners of the long side of the 2.0 x 0.5 m rectangle with steel rods. A 2-meter stick banded into ten 2-decimeter sections can be used as a template between these rods to position exactly each of the 10 quadrats. The position of quadrats 1 through 10 is fixed by the geometry of these rods and the slope of the ground surface as indicated on the data sheets and Figure 2. A BT plot has 5 m of edge for the 10 quadrat frames, or 0.5 m/frame which as an index of location effect can be compared to T and F plot methods described below.

Selection of BT Plot Microsites

Plot locations were deliberately selected in microsites of high impact sensitivity. A sensitive area is where vegetation or soil succession is easily initiated by some kind of disturbance, and where such disturbance is also very probable in the interval between remeasurements. A trail switch-

back is sensitive because steep topography is involved (very little trampling is needed to trigger soil erosion) and because a certain fraction of hikers are inclined to shortcut the trail. Openings or inviting "pathways" between dense woody shrubs are sensitive microsites since people or large animals tend to funnel through these channels and because herbaceous vegetation here is easily damaged by crushing. Figure 3 illustrates several other examples of sensitive microsites at Chiricahua National Monument. When such a site is found, the long axis of the 2.0 x 0.5 m rectangle was oriented in a manner to reveal maximum potential impact. Commonly such impacts were judged to bring about:

- o Changing proportions of soil surface materials by trampling or erosion. This includes reduction of vegetation BA through plant death, increased exposure of loose rock or bedrock at the expense of removed litter, soil, and gravels (Figure 3), removal of saxicolous lichens by abrasion, loss of delicate soil cryptogams or annuals by crushing and soil disturbance.
- o Changing vegetation canopy coverage by actions of mechanical breakage, removal of plant parts (flower picking, grazing), or dieback from drought or fire.

At locations within the various management zones of the Monument BT plots were usually spaced at approximately uniform intervals and numbered sequentially. However exact intervals between plots were precluded by the deliberate selection of sensitive microsites.

25-Quadrat Transect (T) Plots

In this sampling procedure, permanent stakes are placed 25 meters apart within a plant community that is judged to be rather simple and homogeneous (Pielou 1969 especially p. 203). At a point 0.5 m from one stake and thereafter at 1 m intervals the 2 x 5 dm quadrat frame is placed for measurements of vegetation and soil properties as described above. The field configuration of a T plot is shown in Figure 4. Since the plant community being sampled is simple and homogeneous the 25 quadrats thus obtained are well above the minimal sample needed to reveal major dominance

Figure 2. Geometry of the belt transect method of vegetation and soil measurement, Chiricahua National Monument.

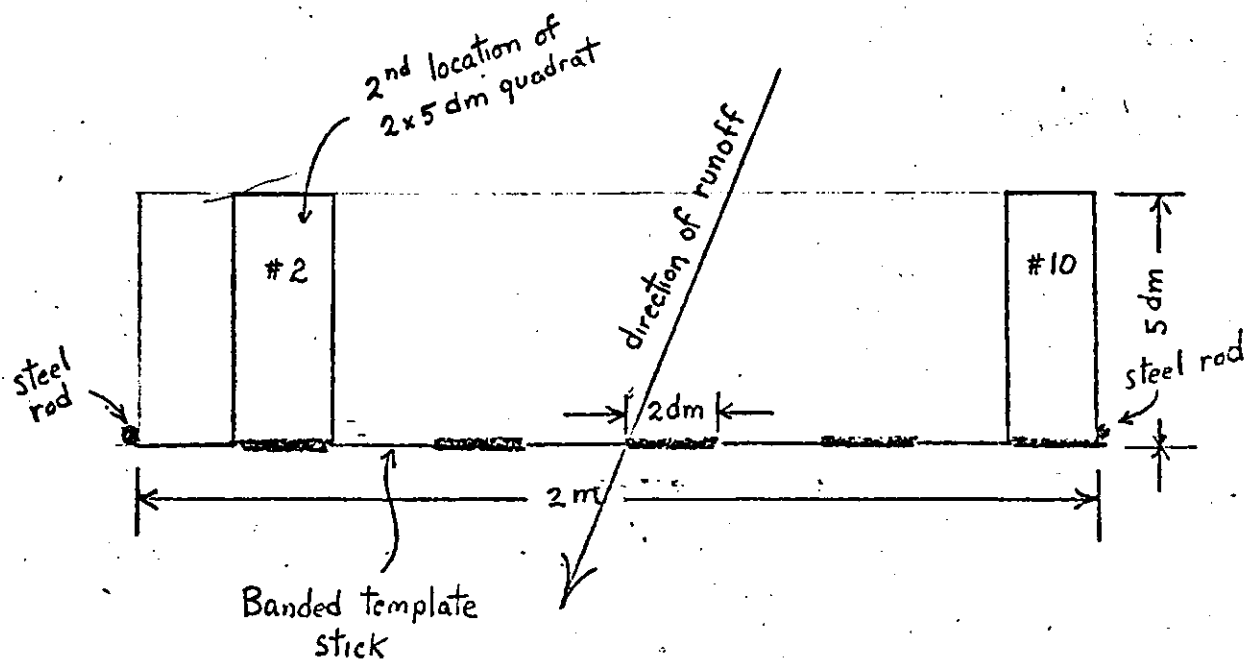




FIGURE 3. Sensitive microsites at Environmental study area (ESA, above) and Massai Point (right).

At the ESA microsite intense foot traffic near the spring easily causes bank erosion and threatens obscure mycotrophic plants in the oak litter near the meter stick.

At Massai Point off-trail visitor traffic among rhyolite towers can cause breakage of the small Toumey oak (upper center) or manzanita (both sides of meter stick). Note the abundance of gravels near the meter stick. As these are removed by erosive wear by water runoff or trampling, more of the underlying bedrock is exposed. In the 2 x 5 dm frame on the right are saxicolous lichens covering about 80% of the rock but subject to abrasion damage by foot traffic.



Will these microsites present the same configuration of natural objects when next photographed?

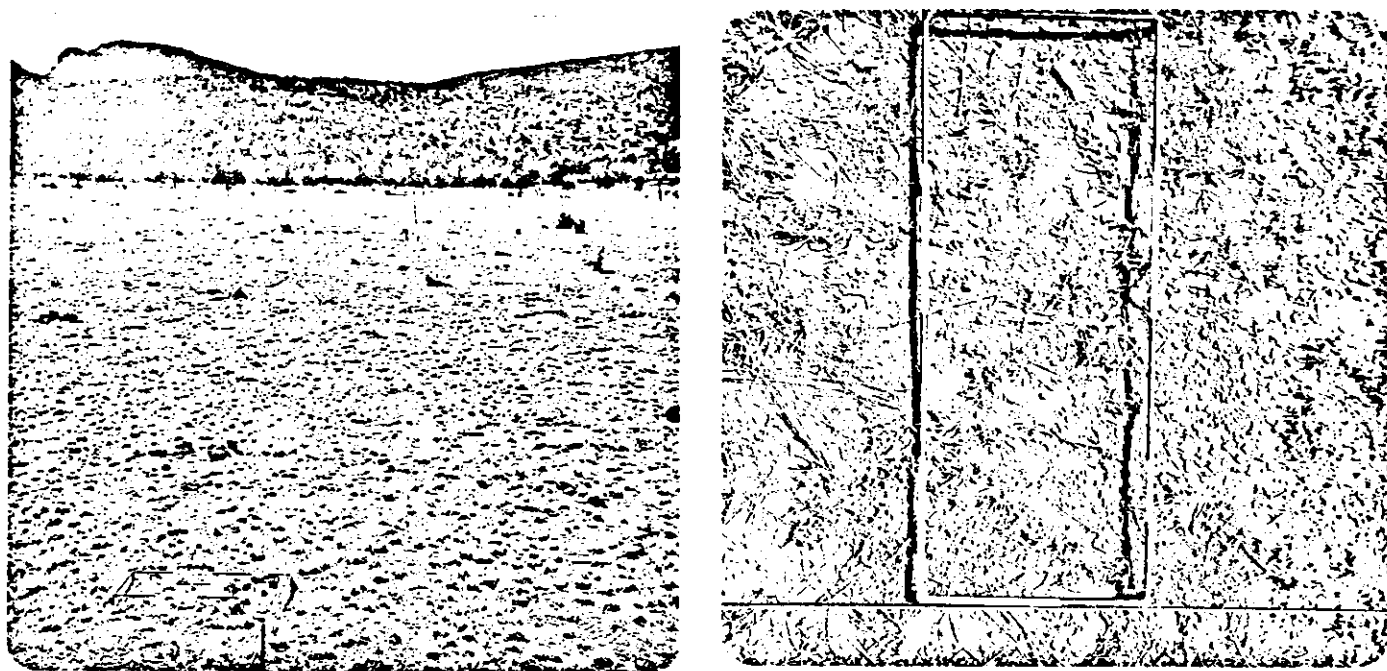


FIGURE 4. Plot T7 in steppe vegetation dominated by blue grama on an alluvial fan at SW Corner (Section 1), 12 April 1974. The T transect is 25 m long and staked at both ends. The 2 x 5 dm quadrat frame is used to measure vegetation and soil surface characteristics at 1 meter intervals along the line. Right: detail of the quadrat frame in position 24 along the transect line. Basal area of blue grama is 13%, litter 20%, soil and gravels 67%.

and soil surface relationships. Results should be closely reproducible despite a greater location effect than obtained from BT plots (edge of 1.4 m/frame in T plots). Should 25 quadrat measurements be judged insufficient for revealing major vegetation and soil relationships in more complex communities, then usually doubling this number using two parallel T plots in the same homogeneous plant community will suffice.

The T plot method also permits measurement of floristic diversity. A rectangle 25 x 6 m is defined by the two stakes each in the middle of the short sides. Within this rectangle all vascular plants not observed in the quadrats can nevertheless be recorded for constance; outside the rectangle but still within the immediate area of the same homogeneous plant community additional species can be recorded for presence. The plant list thus obtained can be used for computing measures of diversity in the sample area (Pielou 1966).

Forest (F) Plots

This technique has been described by Daubenmire (1968, especially his figure 26 on p 87) and works well for most temperate forest vegetation. In oak and pine-oak woodlands at Chiricahua National Monument a 25 x 5 m rectangle was permanently staked at each corner. Inside each 25-meter side 25 quadrats each 2 x 5 dm were observed as described for T plots. Two additional 25 x 5 m rectangles were added to each side of the original to give a 25 x 15 m macroplot divided into three equal 5 meter wide strips. All trees in each strip were tallied by Dbh (stem diameter at breast height, or 14 dm). All vascular plants not measured in the 50 quadrats were recorded for constance if occurring in the macroplot and for presence if just outside the plot. Whenever possible the 375 m² F plots were located within the center of the woodland or forest stand to minimize edge effects of adjacent plant community types.

Photographic Points

Succession can also be documented from permanently located camera locations (photopoints), and procedures for setting these up have been described by Mosby (1963) and Magell and Twiss (1965). Whenever possible to find the 1937 photopoints of Roseberry and Dole (1939), the vegetation types were rephotographed. Stakes, rock cairns, or painted rocks were used to precisely mark the camera tripod location to avoid location effects (Figure 1). Data recorded at each photopoint included a qualitative description of plant species within camera view, date and time of day, prominent soil or microsite features such as degree of erosion, lichen coverage of rocks (Figure 3), or mistletoe parasites. A scale was included in each photo view, usually a meter stick banded into 10 decimeter marks or 5 2-decimeter strips (Figure 3). This scale was placed next to some interesting feature such as a shrub invading an herbaceous meadow, staked end of a plot (Figure 4), fire scar on a tree trunk, or eroding soil bank. For clarity of interpretation the negative should be as large as possible. Black and white film of image size 56 x 56 mm (120 film) is minimum size. It is convenient to use film of ASA speed 400; for

slower film a tripod is absolutely essential. Of course a tripod is always preferred, since it allows the photographer to carefully adjust the camera view for obtaining the best visual information.

Aspectation

Permanently established plots were visited both in spring (March-April) and late summer (September-October) of 1974 to obtain measurements of seasonal vegetation. Rarely can complete records of vegetation be obtained by a single visit to a site. Ideally the canopy coverage method of vegetational analysis is employed at the time each plant species achieves maximum foliar development. In practice this is usually impossible, so that particular concern focuses upon dominant species such as certain grasses, or periods when bursts of ephemeral plants (at Chiricahua mostly annual species) can be observed. Perhaps the two most important seasons at Chiricahua National Monument for recording vegetation features are late April (for sedges, spring annuals, and early wildflowers) and late August to mid September. The latter season is particularly important since summer rains produce the most intensive period of vegetative activity of the year. Of course, any time a change can be anticipated the permanent plots can be remeasured (discussed more fully later).

CLIMATE

General aspects of the climate at Chiricahua National Monument have been summarized from records during the inclusive period 1940-1973 from the weather station near the Visitor Center. The mean precipitation during this period was 17.9 inches (455 mm) with the wettest year (1972) at 25.5 inches (648 mm) and the driest (1970) at 9.82 inches (259 mm). The average seasonal distribution of precipitation is shown in Figure 5. Temperatures during the

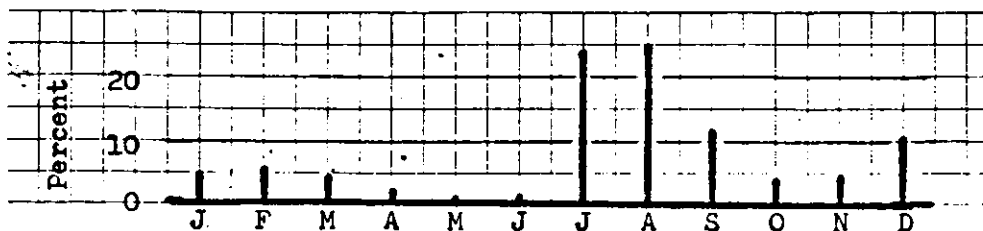


FIGURE 5. Monthly distribution of precipitation, CNM, for the period 1940-73

interval 1949-1973 inclusive were as follows:

Yearly mean maximum	72.8 °F (22.2 °C)
Yearly mean minimum	43.4 F (6.3 C)
Hottest month (June)	
mean maximum	89.5 F (31.9 C)
mean minimum	55.3 F (12.9 C)
Coldest month (Jan.)	
mean maximum	55.4 F (13.0 C)
mean minimum	29.4 F (-0.9 C)

Since May and June, the hottest months, average only about 2% of the year's precipitation, severe moisture stresses are in effect for much vegetation. About 50% of the year's precipitation occurs as convective showers in July and August when temperatures are also more moderate. This is the season when estivation or dormancy of many herbaceous species is broken and much of the year's herbage production takes place.

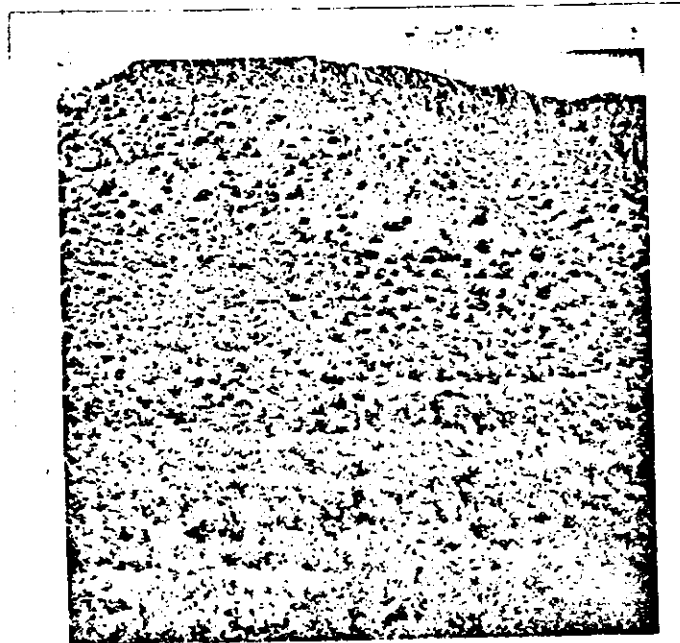


FIGURE 6. Jesse James Natural Area, 5 April 1974, showing vegetation in relation to landform. Alluvial soils of the canyon bottom support closed oak woodland. Lower colluvial canyon sideslopes have Emory oak savanna (right) or woodland chaparral (left); mid and upper slopes contain much mountain mahogany. Uplands and rock outcrop land have Toumey oak chaparral.

VEGETATION

No detailed plant synecological studies of the vegetation of Chiricahua National Monument have been made. Early work by Roseberry and Dole (1939) resulted in a vegetation type map which is remarkably accurate. They recognized four major types of vegetation primarily on the basis of structure and fire characteristics. These were timber types (Forests), woodlands, chaparral, and grasslands. In each of these types reconnaissance data was produced to illustrate major plant community types. In 1972 Moir performed reconnaissance in each of the five natural areas. Each natural area contained distinctive and rather typical vegetation types represented over much of the Monument. The major plant community types in each natural area are listed below (Arizona Academy of Science and Smith 1974):

NATURAL AREA	MAJOR PLANT COMMUNITY TYPES
West Picket Park	Canyon Cypress Forest; Cypress-Pinyon Woodland on north-facing slopes
Picket Park	Apache-Chihuahua Pine Forest
East Picket Park	Manzanita-Toumey Oak-Pinyon chaparral
South Shake Spring	Douglas fir-silverleaf oak among rhyolite columns; Cypress-Pinyon woodland on north-facing slopes
Jesse James	Arizona-silverleaf oak woodland on alluvium; Emory oak savanna on lower south-facing slopes; mountain mahogany rock outcrop land; Toumey oak savanna on upper south-facing slopes.

These natural areas do not embrace all the vegetation types of the Monument, however. A further complication involves the intergradation between vegetation types along environmental gradients or where strong microtopographical contrasts occur (such as among rhyolite columns or steep draws which accentuate contrasting slope effects). In the absence of detailed plant community data, I have chosen particular areas within Chiricahua National Monument as representing typical vegetation (Daubenmire 1966) and have generalized these types to other locales with the help of air photos (USGS 1973). Table 2 lists the major vegetation types.

Table 2 . Major vegetation types within Chiricahua National Monument

TYPE (Named after the dominant species)	CODOMINANTS	TYPICAL LANDFORM	TYPE LOCALITY	REFERENCES OR FIGURES
D-PP	CA,QR,QH,QP	North-facing canyons	Hunt Canyon	
D-QH	QR	Massive rhyolite columns	S. Shake Spr. NA	AAS & Smith p 13-18
CA	D,PE,QH,QR,AA	Intermittent streamsides	W. Picket Park NA	AAS & Smith p 33-35
QA-QH	PE,PL,JD,NM,ML	Cobbly alluvium	Rhyolite Canyon; Jesse James NA	Marshall 1957; Fig. 6
QA-QE	JD,Gr, PL	Cobbly alluvium	Campground	Fig. 22
PE-PL	JD,ML	Gravelly alluvium	Picket Park	Figs. 8,9,20,25
PP	QH,ML	Gentle upland slopes	upper Totem Can.	Roseberry & Dole 1939
PP-QH-AP	PC	Gentle upland slopes, ridges	Massai	
PL-CA-QH	PC,AP	Gentle upland slopes, ridges	Doughnut	Fig. 17
CA-QH	PC	steep north-facing colluvium	S. Shake Spr. NA; W. Picket Park NA	
PC	JD,CA,QH,QA	steep north-facing colluvium	N. Bonito Canyon	Fig. 16
QA-QE-Gr	JD,PL,AP	gentle south-facing lower slopes	Road Corridor near Monument entrance	Figs.10,12,13
QE-Gr	QA,AP	moderate and steep south-facing colluvial slopes	Jesse James NA	Figs 6,14
QT-Gr	CB	steep south-facing upper slopes		Roseberry & Dole 1939
AP-QT	PC,Gr	Upland rhyolite tablelands	E. Picket Park NA	Fig. 18
AP-QH	CA,PL,PC,QT	Upland rhyolite Tablelands	Massai, Sugarloaf NNE	
CB	PC	Ridges and rock outcrops		Fig. 24
AP	QT,QA,PC,JD	south-facing colluvial slopes and draws	Campground perimeter	Fig. 24
Gr-DW	MB,Ag,HL	south-facing colluvial slopes		Figs 1,15,16
Gr	PJ	alluvial fans	SW Corner	Fig. 4

I. Canyon Forests

Canyons with intermittent streamflow and deep north-facing ravines contain the most mesic vegetation of Chiricahua National Monument. Roseberry and Dole (1939) refer to these forests as "timber types"; Whittaker and Niering (1964, 1965) in the Santa Catalina Mountains, as "Canyon Woodland". Forest composition varies along the canyon gradient from mixtures of Douglas Fir and Ponderosa pine at highest, coolest elevations to mixtures of Arizona Cypress and sycamore at lowest elevation where Bonita Canyon leaves the Monument.

Hunt and Totem Canyons are type localities where the canyon forests occur in cool, north-facing drainages. Specimens of Douglas fir may attain heights exceeding 100 feet. Ponderosa pine is a tall and dominant tree also. This vegetation (designated D-PP in Table 2) features a stratum of understory evergreen oaks dominated by both netleaf (Quercus rugosa) and Palmer (Q. chrysolepis) oaks attaining heights around 30 feet. Silverleaf oak (Q. hypoleucoides) and madrone (Arbutus arizonica) are also found in this evergreen stratum. Ash (Fraxinus velutina) is an occasional understory tree. Shrubs include species of Rhamnus, Philadelphus microphylla, Rubus neomexicana, and the low box myrtle, Pachistima myrsinites. Common herbs are Galium triflorum, Aquilegia chrysantha, and Smilacina racemosa.

Descending Rhyolite Canyon, one finds Arizona cypress (Cupressus arizonica) to be the most consistent dominant species (vegetation type CA of Table 2). In upper Rhyolite canyon the cypress is codominant with Douglas fir, and netleaf, silverleaf, and Palmer oaks are abundant as understory. Just below the confluence with Sarah Deming Canyon the cypress adds Apache Pine (Pinus engelmannii) to the overstory, and Douglas fir becomes less important. Plots F3 and F4 in Rhyolite Canyon occur on cobbly, alluvial terraces. Here mixtures of silverleaf and Arizona white oak (Quercus arizonica) are the principal trees attaining heights of around 40 feet. Cypress is more or less restricted to the streambed itself, with Apache pine the dominant conifer of the terraces (type QA-QH). Understory is dominated by beargrass (Nolina microcarpa) and robust muhly grasses (Muhlenbergia longiligula and M. emersleyi). These are the pine-oak woodlands of various authors (Marshall 1957, Whittaker and Niering 1965). Another type of pine-oak woodland occurs near the drier end of the

canyon gradient. Just below the campground in Bonita Canyon occasional Chihuahuan pine (Pinus leiophylla) emerges above the oak layer of Arizona white and Emory oaks (Quercus arizonica, Q. emoryi) and alligator barked juniper (Juniperus deppeana). Understory plants here (plot F6) include manzanita (Arctostaphylos pungens), robust muhly grasses and pinyon ricegrass (Piptochaetium fimbriatum). The sycamore (Platanus wrightii) joins this assemblage along the streambed margins of Bonita Canyon from the campground to the Monument boundary. Woodlands of the Environmental Study Area (Figure 7) are of this vegetation type (QA-QE of Table 2).



FIGURE 7. Canyon Woodland of Arizona White and Emory oaks at Environmental Study Area. Vegetation of the forest floor has been severely depleted by man's activities prior to establishment of Chiricahua National Monument.

The soils of these canyon bottoms are probably the deepest and most stable to occur in the Monument. While the stream channels themselves are seasonally scoured by runoff, the adjoining cobbly terraces are usually litter covered with years of accumulation. The often gentle or near-level slopes also contribute to soil stability. There is seldom much evidence

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of recent gullying even in areas where litter or understory vegetation has been removed by man (Figure 7).

In Picket Park occurs basin fill of recent Quaternary gravelly alluvium. Gently sloping terrain along the washes contain mixtures of Apache and Chihuahua pine (type PE-PL), and the understory is conspicuously dominated by longtongue muhly (Muhlenbergia longiligula). Occasional alligator barked juniper, silverleaf and Emory oaks form an intermittent subdominant canopy stratum. Figures 8 and 9 show canopy structure and stand interior respectively of this mixed pine type where plot F1 is located. While the soils of these gravelly washes has been generally stabilized by litter and herbaceous cover, apparently some resorting or deposition of new alluvial materials does take place following intense runoff events (see discussion of plot F2 below).

FIGURE 8 (right). Mixtures of Apache and Chihuahua pines in Picket Park Natural Area, 22 March 1974. Many crowns of alligator barked juniper can also be seen.

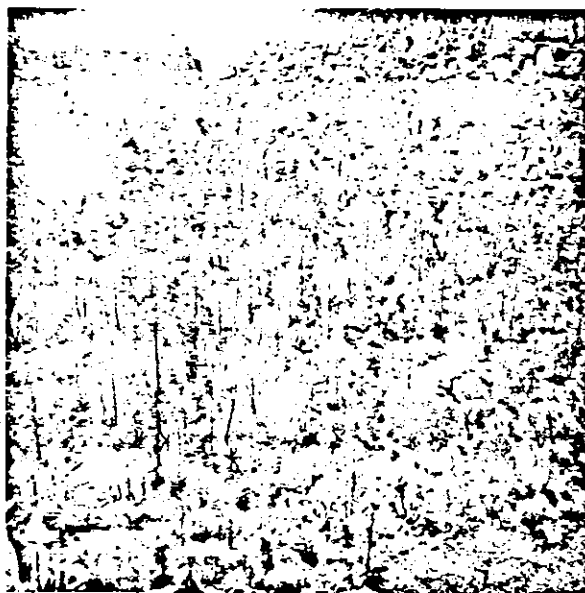


Figure 9 (left). Interior of plot F1 in Picket Park from NE stake as photo-point. Longtongue muhly dominates the understory flora. The meter stick is by Chihuahua pine. Manzanita branches in foreground. 22 March 1974.

II. Canyon Sideslopes

A variety of steppe, chaparral, woodland, or forest types are found on canyon sideslopes of Chiricahua National Monument. Particularly strong environmental gradients exist on these slopes (Whittaker and Niering 1964, 1968) which are often of impressive altitudinal range and dissected by draws or ravines. Upper slopes are usually very steep, rock outcrop terrain with excessive drainage; midslopes undulate from convex surfaces to shallow or steep drainages; and lower slopes may feature moderate drainage on deeper, colluvial soils of gentle or moderately steep slopes (Figure 6). In some places lower slopes contain sediments sorted and mixed by both stream and downslope movements (alluvial-colluvial mixtures); elsewhere localized basin-fill (Picket Park discussed above) or fans (SW Corner, Figure 4) are of Quaternary alluvium (Gile and Hawley 1966). Other localized parent materials of the canyon sideslopes include talus or rock land, the latter illustrated in Figure 2. Thus climatic gradients of the canyons of Chiricahua National Monument are also enhanced by complex drainage and soil patterns of the sideslopes to produce the variety of vegetation types (Figure 6).

Gently sloping lower slopes are often the most mesic of canyon sideslope environments. Where soils are relatively deep and receive runoff from above, pine-oak woodlands (QA-QH and QA-QE) similar to those of the cobbly alluvial terraces may be found, especially where exposures are northerly or easterly. Drainages of Whitetail Canyon along the Monument's east boundary and portions of lower slopes of Rhyolite Canyon exhibit these pine-oak woodlands. The most extensive woodland type of lower slopes, however, are the open oak woodlands (Whittaker and Niering 1965), or woodland savannas. The Monument visitor encounters oak savanna (QA-QE-Gr) immediately upon entering the Monument. The drive to the Visitor Center through gently dissected lower, north-facing slopes passes through low trees (15-20 feet, 5-7 m) of Arizona white and Emory oaks, alligator barked juniper, pinyon (Pinus cembroides), and occasional chihuahua pine. Grasses comprise a ubiquitous matrix of herbaceous vegetation among and between the trees. Plots T2, T3, and T4 (Figures 10,11,12 respectively) are located in these Arizona white oak and Emory oak savannas. Steep, lower, colluvial slopes of southerly exposures may contain Emory oak savannas (QE-Gr), as, for example, the mouth of Rhyolite Canyon or Jesse James Natural Area (Fig-

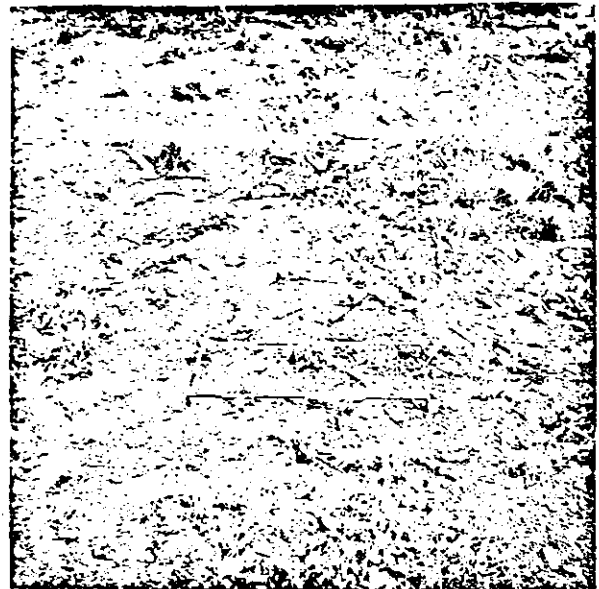
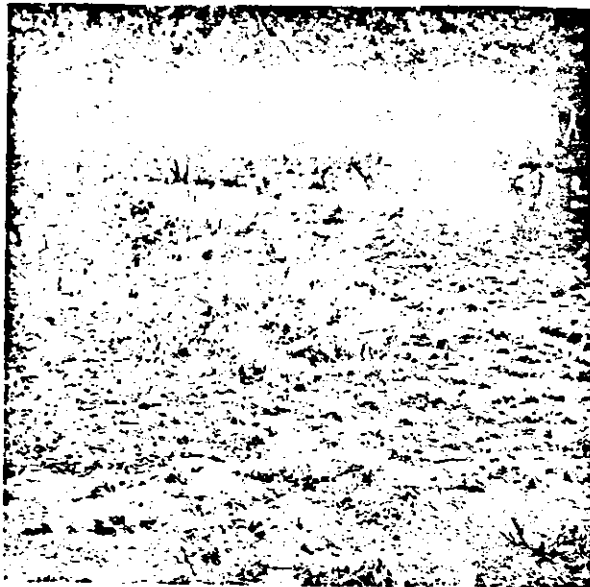
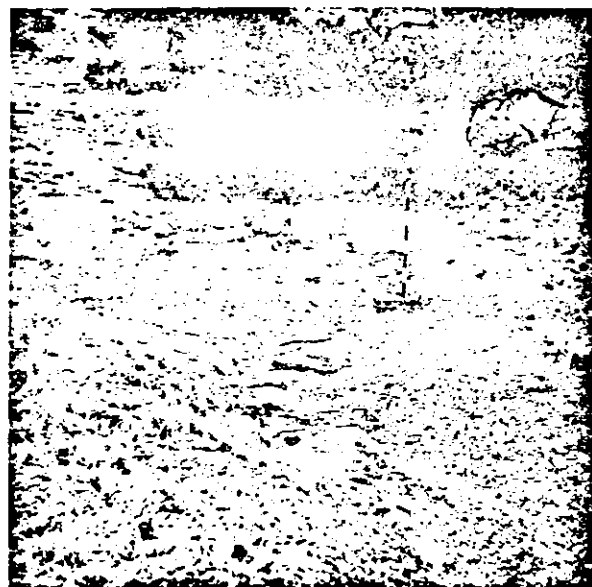


FIGURE 10. Plot T2 in Picket Canyon, 19 March 1974, where cattle grazing had recently occurred. The photopoint is the west stake of the 25 meter transect; the meter stick is at the east stake. The grass cover here is generally excellent. Right: microgully at quadrat #2 of plot T2. Within the 2 x 5 dm frame the soil surface features are: litter 15%, grass basal area 7%, soil and gravel 78%.

FIGURE 11. Small gully on alluvial lower slopes between plots T1 and T2 in Picket Canyon, 19 March 1974. As shown by the line and meter stick erosion here has cut about 3 dm. The 2 x 5 dm frame is in the gully bottom for scale. There is no evidence that this is accelerated erosion resulting from livestock grazing.



ures 6 and 14). Grasses again form the dominant herbaceous vegetation, but sotol (Dasyllirion wheeleri), century plant (Agave palmeri), manzanita, and false mesquite (Calliandra schottii) are also to be found. These open Emory oak savannas are a common feature of rocky lower slopes of the southern Arizona landscape (Darrow 1944, Lowe 1964). The Natural Bridge Trail coming out of North Bonita Canyon passes through woodland savanna (QA-QE-Gr) during its steep ascent on east-facing slopes to the tablelands of East Picket Park Natural Area. Upper south- or west-facing canyon sideslopes may contain Toumey oak savannas (QT-Gr), as mapped by Roseberry and Dole (1939) for upper slopes of Newton and Jesse James Canyons. Mountain mahogany (Cercocarpus breviflorus) is often a common species of the rough, broken land of these upper slopes.

Where grasses comprise the principal ground-layer vegetation of the open oak woodlands, we refer to woodland savanna. However, canyon sideslopes may also be dominated in the ground layer by such shrubby species as manzanita (Arctostaphylos pungens), mountain mahogany, Toumey oak, catclaw mimosa (Mimosa biuncifera), and others. Such are the woodland chaparral (type AP of Table 2) of the canyon slopes, as represented, for example, along the perimeter just west of the campground or in small draws such as shown in Figure 1. In the rough-broken land of upper sideslopes woodland chaparral is often of the type (AP-QT or AP-QH) discussed for the uplands in the following section. In some places only the shrubby life-form may occur, the trees being absent.

Piedmont grasslands, or shrubsteppe (Humphreys 1958, Lowe 1964; both these authors use the term, desert grassland), are the driest vegetation types found on south-facing slopes. In deep canyons the grassland may occupy a midslope position on convex ribs (Figure 6). Elsewhere grasslands may exist on very shallow soil over bedrock (Figure 1) or on alluvial fans. Common grasses on colluvial soils are sidecoats and hairy grammas (Bouteloua curtipendula and B. hirsuta), Texas bluestem (Andropogon cirratus), wolftail (Lycurus phleoides), and vine mesquite (Hilaria belangeri). Low shrubs are common and include sotol, turpentine bush (Haplopappus laricifolius), century plant, sacahuista, catclaw (Mimosa biuncifera), and ocotillo (Fouquieria splendens). Figure 15 in lower Picket Canyon is such a shrubsteppe (Gr-DW). The photographs show low grasses principally of hairy grama and vine mesquite and scattered low shrubs (Lycium pallidum, Xanthocephalum sarothrae, and Agave palmeri). The alluvial fan at SW Corner (Figure 4) exhibits



FIGURE 15. Shrubsteppe vegetation at plot T1 along lower slopes of Picket Canyon. Dominant grasses are vine mesquite and hairy grama. Low shrubs are wolfberry (Lycium pallidum), snakeweed (Xanthocephalum sarothrae), and century plant. Photographed 19 March 1974 from stake at the westpoint of the plot. Left: detail of soil surface conditions at the westpoint stake. There is no evidence of erosion here. Inside the 2 x 5 dm quadrat frame the soil surface exhibits 1% loose rock, 1% litter, 25% vegetation basal area, and 73% soil and gravel.

grassland almost exclusively dominated by blue grama (Bouteloua gracilis) and with very few shrubs (type Gr). After summer rains numerous annuals are very conspicuous. In the NW corner of the Monument (Section 22) alluvial soils of grassland piedmont feature considerable mesquite (Prosopis juliflora).

The north-facing slopes of canyons usually support closed or semi-closed canopies of woodland vegetation. Already mentioned were the pine-oak (QA-QH and QA-QE) woodlands. Cypress woodlands (CA-QH) are often conspicuous on lower slopes, draws, and small tributary canyons. Typical locations of these cypress woodlands are South Shake Spring and West Picket Park Natural Areas (Arizona Academy Science and Smith 1974). Common or codominant associated species are silverleaf oak, netleaf oak, mockorange (Philadelphus microphylla), and pinyon pine. Herbaceous vegetation is often considerably less conspicuous in these cypress woodlands than on opposite, south-facing slopes. Woodlands with pinyon

pine (type PC) can be found in areas of rough broken land (Figure 16). Associated trees include Arizona white and silverleaf oaks, alligator barked juniper, or occasional Arizona cypress. In some locales Chihuahua pine may be a minor tree of the pinyon woodland. Where soils permit grasses such as longtongue muhly, needle-and-thread (Stipa pringlei), or pinyon ricegrass may be found.

Among the large rhyolite columns of upper north-facing slopes is found the Douglas fir-silverleaf oak vegetation type (D-QH). South Shake Spring Natural Area is a typical location (see photos on pp 16-17 in Arizona Academy Sci. and Smith 1974) as are the massive columns along Rhyolite Canyon near its head. Silverleaf and netleaf oaks are common associated trees. Hoptree (Ptelea angustifolia) and mockorange may be occasional. The D-QH vegetation type can be regarded as gradational between the cypress canyon forests (CA) and upland pine-cypress (PL-CA-QH) or even silverleaf oak chaparral (AP-QH) types. Clearly, the large rhyolite columns create their own microclimatic and microdrainage patterns which permit Douglas fir and other mesic species to grow in cool and shaded couloirs.

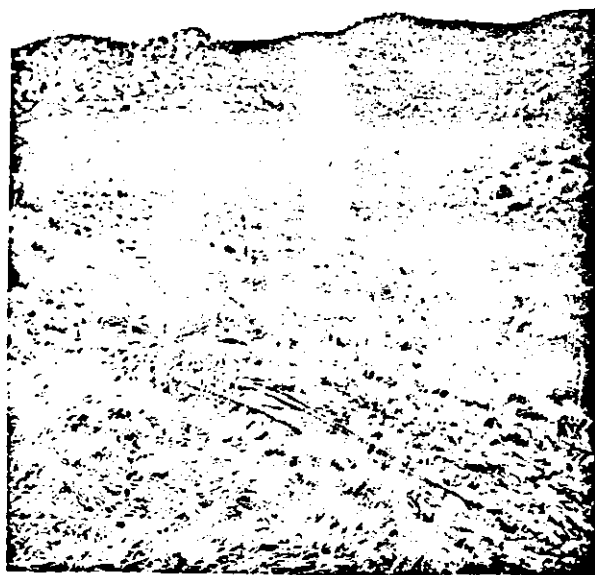
III. Uplands.

The plateaus or tablelands of rhyolite caprock are mostly of gentle to moderate, undulant slopes, gently dissected by canyon heads and rimmed by massive and spectacular rhyolite columns. Runoff is often excessive, and the exfoliating rhyolite tuff is scoured after heavy precipitation so that soil accumulates only in localized pockets. Elsewhere gravelly soil materials may be only a few centimeters over bedrock. The principal vegetation of these uplands is an open woodland chaparral (Roseberry and Dole 1939). Where shallow residual soils have persisted pine woodlands and pine forests can be found. Ponderosa pine (PP) forests occur along the gentle and moderately sloping draws near the heads of Totem, Sarah Deming, and Jesse James Canyons. The pines (Pinus ponderosa) appear self-sustaining insofar as both young and advanced regeneration can be found among mature trees (see Figure 10 Photo 14 in Roseberry and Dole 1939). Silverleaf oak and alligator barked juniper are common associated trees, and longtongue muhly (Muhlenbergia longiligula) dominates the herbaceous layer if soils are deep. Gentle upland slopes and ridges may also contain open woodland of Chihuahua pine

and Arizona cypress (PI-CA-QH). Roseberry and Dole's photopoint # 29 is of this upland type (Figure 17). Silverleaf oak, manzanita, and pinyon pine are dominant or co-dominant species. The taller pines and cypress, however, seldom exceed about 15 m (50 feet) in height.



FIGURE 16. Upper: Vegetation mosaic in Picket Canyon as photographed April 29, 1937 by R.D. Roseberry. Shrubsteppe vegetation in the foreground. The arrow shows a small ravine of brushy vegetation. The background shows a few tall Arizona Cypress along the streambed and on the upper slopes of rough, broken ground what Roseberry termed chaparral-pinyon-cypress vegetation type.



Below: Same view photographed March 19, 1974, an overcast afternoon. Very little vegetation change seems to have taken place in the ensuing 37 years. See also Figure 1.

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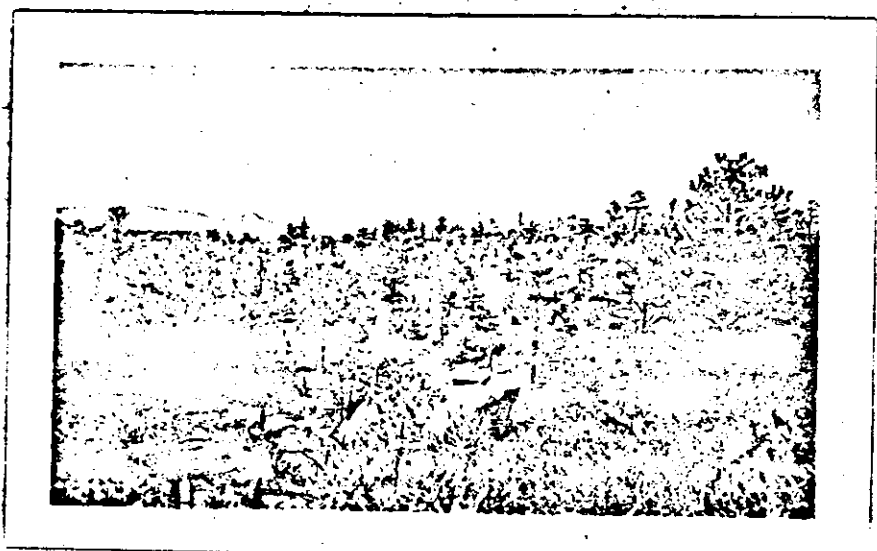


FIGURE 17. Gentle terrain is the feature of this upland landscape along the Heart of Rocks Trail. Chihuahuah pine and cypress woodland was photographed April 29, 1937 by N.E. Dole in the vicinity of Doughnut. He records the main species in this camera view as Chihuahuah pine, Arizona cypress, manzanita, silverleaf oak, and pinyon pine. Insert: The same landscape rephotographed March 25, 1974 by W.H. Moir and Mary Dodd. The branches in the extreme right foreground of the 1937 photo have now grown into the larger Chihuahuah pine. Pinyon and Chihuahuah pines, saplings in the 1937 photo, have grown to completely obscure the large boulder in the foreground of Dole's picture. Silverleaf oak and manzanita still dominate the understory vegetation.

Two major chaparral (woodland chaparral) vegetation types occur on uplands in the Monument. The Toumey oak chaparral (AP-QT) contains pinyon pine and occasional junipers (Juniperus deppeana and J. monosperma), all of low stature (mostly under 15 feet, or 5 m height), which punctuate a shrubby matrix consisting mostly of manzanita and Toumey oak. East Picket Park Natural Area (Figure 18) is a typical locality. Outcroppings of rhyolite caprock interrupt the shrubby vegetation. This bedrock and shallow gravelly areas may be lichen cov-

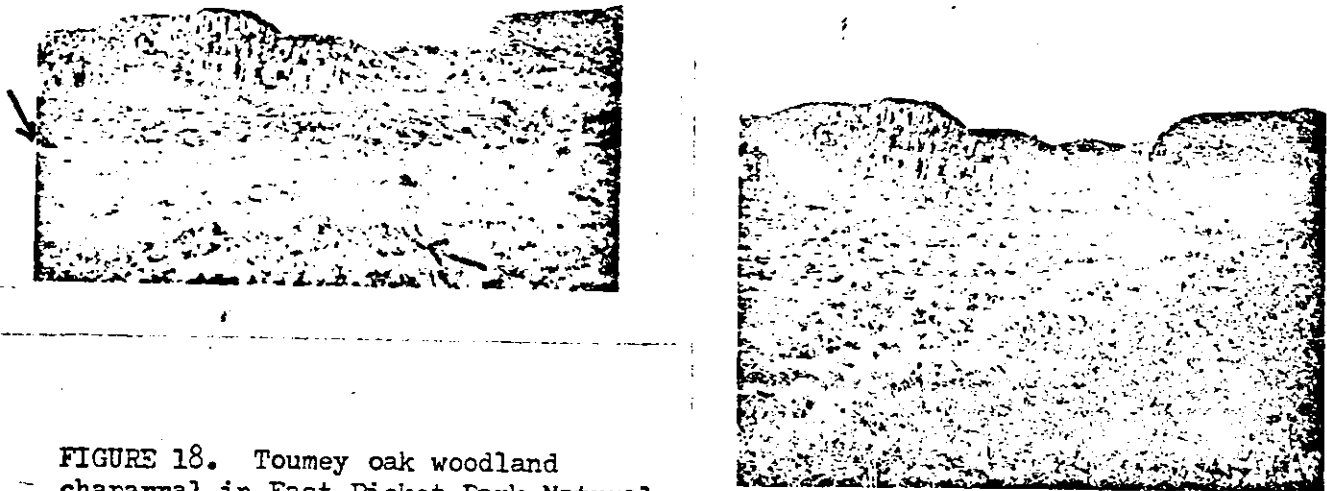


FIGURE 18. Toumey oak woodland chaparral in East Picket Park Natural Area, April 27, 1937. Arrows indicate a small opening and low pinyon pine which can also be seen in the photograph on the right 22 March 1974 by W.H. Moir and Dirk Lanning. Note meter stick against manzanita bush.

ered. Other species of the chaparral here include Wright's silktassel (Garrya wrightii), sacahuista (Molina microcarpa), century plants (Agave palmeri and A. parryi), and banana yucca (Yucca baccata). Here and there grasses are conspicuous, especially bullgrass (Muhlenbergia emersleyi), purpletop (Muhlenbergia rigida), Orcutt's three awn (Aristida orcuttiana), and Texas bluestem (Andropogon

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cirratus). Plots T10 and T11 are located within the Toumey oak chaparral in East Picket Park Natural Area (see also description in Arizona Academy of Science and Smith 1974).

The second major upland chaparral type is structurally similar to the Toumey oak chaparral but differs taxonomically. This has been designated a silverleaf oak chaparral (AP-QH type of Table 2). Low (about 10-15 feet, or 3-5 m), scattered Arizona cypress or Chihuahua pine comprise the very open tree layer. The shrubby matrix is dominated by manzanita and silverleaf oak. Toumey oak may be absent or occasional, as may netleaf oak. Pinyon pine may or may not be present, and grasses are often very minor. Open, gravelly areas may be devoid of vegetation except lichens or annuals. Often consolidated or fractured bedrock is to be found merely inches below the gravelled surface. Typical locations of silverleaf oak chaparral are Massai Point, Sugarloaf NNE (0.5 mi, 1 Km. NNE of Sugarloaf Lookout), and portions of the Heart of Rock Trail (BT plot 16, Murray's Nemesis). This chaparral type intergrades to the Chihuahua pine-Cypress woodland (PL-CA-QH) and to the Toumey oak chaparral (AP-QT).

A third chaparral type of sharp upland ridges and rock outcrop land can be designated a mountain mahogany (CB) chaparral. Associated shrubs may include deerbrush (Ceanothus greggii), manzanita, and dwarf silverleaf oak. Low trees such as pinyon pine may be severely wind trained. This chaparral type also intergrades to Toumey oak and silverleaf oak chaparrals, and perhaps is only a variation of these on particularly exposed topography.

DATA SUMMARIES

The overall dimensions of the resource monitoring system established in 1974 are given in Table 3. The number of plots given in the last column were those existing at the end of the late summer measurement period, not those lost or vandalized from the spring sample. Field data necessary for making future area-by-area or plot-by-plot comparisons are given in Part II (DATA) of this report, but are summarized in Tables 4-8. Because of deliberate location of BT plots in areas of high impact sensitivity, data derived from these plots cannot

Table 3. Resource Monitoring System, Chiricahua National Monument, 1974

MANAGEMENT ZONE	LOCATION	VEGETATION TYPE	PLOT TYPE	NUMBER OF PLOTS
Road Corridor	Massai	AP-QH	BT	7
	Bonita-Faraway	QA-QE-Gr	BT	12
Environmental Study Area		QA-QE	BT	8
Trail Corridor	Rhyolite Canyon	QA-QH	BT	8
		QA-QH	F	2
	Natural Bridge	CA	BT	8
	Heart of Rocks & Echo Canyon	AP-QH	BT	11
Natural Areas	Picket Park	PE-PL	F	2
	East Picket Park	AP-QT	T	2
	Jesse James	QA-QH	F	1
		QE-Gr	T	2
Wilderness	Sugarloaf NNE	AP-QH	BT	6
	Massai South	AP-QH	BT	10
	SW Corner	Gr	T	3
	Picket Canyon	QA-QE-Gr	T	1
		Gr	T	1
Campground	Whitetail Canyon	QA-QE-Gr	T	2
	Bonito Canyon	QA-QE	F	1
	Perimeter	AP	BT	13
	Perimeter	QT-Gr	BT	11

TABLE 4. Canopy coverage (C) in BT plots, Spring 1974, and number of plots where cover increased (+), remained constant (o), or decreased (-) between spring and summer. Coverage has been averaged to the nearest percent over the number of plots where the taxa occurred at each location. Canopy coverage for the annual species are summer observations only.

TAXA ^{a/}	MASSAI		MASSAI SOUTH		SUGARLOAF NNE		RHYOLITE CANYON		NATURAL BRIDGE		HEART OF ROCKS & ECHO CANY.		BONITA-FARAWAY		CAMPGROUND HI		CAMPGROUND LO	
	C	+ o -	C	+ o -	C	+ o -	C	+ o -	C	+ o -	C	+ o -	C	+ o -	C	+ o -	C	+ o -
ARPU	39	3 2	14	2 5 1	31	3	18	1 1	10	1 1	30	3 1	22	3 3	21	1 7 1	11	2 2
QUTO	12	1	22	2	24	1 2			19	4	17	1 4			16	1	22	1 4
QUHY	18	1 1	4	2	22	1 2	1	2	29	3 1	26	2 1						
QUEM													16	1	16	2		
QUAR							1	1 3	44	3			99	1	40	3		
QURE			17	1 1							40	1 1						
GAWR									22	2	4	1						
RHCO							8	1	0	1					0	1		
RHTR							9	2										
NOMI			0	1	15	1	9	3			20	1			11	3		
AGPA					1	1			0	1	0	1	0	1 1	0	1 1		
Catclaw ^{b/}							2	2 1 1					4	1	14	3 2	11	1 1
JUDE							2	1	99	1	23	1	30	1	12	2		
CUAR	55	2	20	1 1	28	1			39	1	99	1	99	1				
PICE	22	4	42	4					14	2 2 1	37	3						
PILE							2				29	1						
Other ^{c/}					0	2	2	4 1	0	3	0	4	0	6 1	11	5	1	5
Annuals	28	3	27	7	26	6	1	3	4	7	11	6	62	12	13	13	17	10
Graminoids	0	1	1	1 1	4	2 2	20	6 2	28	5	2	2	31	2 7 3	30	4 7 2	21	2 5 4
Parmelia	9	2 2 1	5	8 1	5	2 4	1	2	1	1 4	3	2 6 1	2	1 9 1	0	4	0	5
Lichens ^c	4		1	1 8 1	1	3 1	0	2	1	4 1	1	6 2	1		0	3 2	1	4 3 1
Soil Crypto- gams		3		1 6		3 1		2 1		2 2 1		5 1		4 3 3		4 1		1 1 2
No. Plots ^{d/}	7(7)		10(10)		5(6)		8(8)		9(8)		11(11)		12(12)		13(13)		11(11)	
Trash	1(1)		0(0)		0(0)		0(1)		0(0)		4(2)		0(0)		3(3)		0(0)	

^a See list of symbols. ^b Includes *Mimosa biuncifera* and species of *Acacia*. ^c Mostly summer perennial herbs.

^d In parentheses: data for new summer plots were entered in the constant (o) column.

TABLE 5. Soil surface characteristics at belt transect plots, Chiricahua National Monument, 1974

	LOCATION								
	MASSAI	MASSAI SOUTH	SUGARLOAF NNE	RHYOLITE CANYON	NATURAL BRIDGE	HEART OF ROCKS & ECHO CANY.	BONITA- FARAWAY	CAMPGROUND HI	CAMPGROUND LO
No. Plots ^{a/}	7	10	5-6	8	9-8	11	12	13	11
	----- % -----								
SOIL & GRAVEL ^{b/}									
Spring	45(13-86)	42(7-92)	58(33-90)	2(a-7)	9(2-31)	29(1-58)	52(5-78)	46(5-89)	61(29-94)
Summer	39(9-85)	43(4-87)	61(30-87)	2(a-6)	10(2-33)	32(1-54)	55(2-74)	48(2-82)	66(39-86)
LOOSE ROCK									
Spring	9(1-20)	2(a- 7)	6(1-18)	0(a-2)	3(a-19)	6(0-16)	7(1-12)	5(a-14)	11(1-18)
Summer	6(a-14)	1(a- 4)	4(0-15)	0(a-3)	4(a-17)	4(a-12)	7(2-11)	4(a-12)	8(a-19)
BEDROCK									
Spring	12(a-59)	3(a-15)	8(a-15)	0(a-3)	4(a- 9)	5(a-22)	4(a-22)	5(a-18)	4(a-17)
Summer	20(a-78)	4(a-15)	7(a-18)	0(a-2)	4(a-11)	8(a-34)	5(a-21)	7(a-22)	5(a-15)
LITTER									
Spring	34(3-66)	52(8-91)	27(0-64)	94(32-99)	83(60-95)	60(24-96)	28(4-87)	39(3-76)	20(3-52)
Summer	34(2-67)	51(13-91)	26(2-68)	96(94-99)	81(50-98)	55(25-77)	31(13-89)	38(6-81)	19(4-42)
VEG. BA									
Spring	a	0(a- 0)	0(a- 2)	2(0-5)	1(a- 5)	1(a- 1)	9(2-21)	5(0- 8)	4(1- 6)
Summer	0(a- 0)	0(a- 0)	1(a- 2)	2(a-4)	2(0- 6)	0(a- 4)	3(1- 6)	3(0- 7)	2(0- 5)
TOTAL ^{c/}									
Spring	100	99	99	98	100	101	100	100	100
Summer	99	99	99	99	99	99	101	100	100

^a Number of plots during both spring and summer measurements, if different.^b Numbers rounded to nearest percent, range of percentages in parentheses, a = absent; ^{c/} rounding errors may cause deviation from 100.

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be regarded as descriptions of plant or soil characteristics of the ecosystems where the samples were located. The system of such plots is, rather, a monitoring system, intended to reveal impacts at the earliest moment. The second point to be kept in mind examining the data of these tables is that they reflect existing vegetation and soil conditions, the $\bar{X}$ term of equation 1, and not the dynamic, or trend, term R. The short sampling interval between spring and summer measurements might suggest some revelation of R, but was primarily to determine aspectation, as discussed above, and not succession. Thus, the occurrence of annuals in the late summer plots is a seasonal feature, not necessarily a successional trend. Only year-to-year measurements in a given season might reveal the latter. The trend term, R, can, however, be reasonably deduced during field measurements from overall impressions of vegetation and soil patterns in each sample location and from collateral observations and comparing impacted from non-impacted microsites at each sample location.

Massai Point, Sugarloaf NNE, Massai South

These locations are all on upland topography. Rhyolite outcrops along upper slopes create a diversity of microenvironments, so that mesic tree species (Arizona cypress, silverleaf oak, netleaf oak) can be found along trailsides or gullies in areas that are otherwise primarily of the silverleaf oak chaparral (AP-QH) vegetation type (Table 2). Soils are shallow or skeletal throughout, often broken by bedrock cappings, outcrops, and ledges. Runoff is excessive. Where soil particles can accumulate, horizon sequences are usually gravelly AC/R (Soil Survey Manual Supplement 1962). Natural and visitor-intensified erosion on the gentle to moderately steep slopes or among the rhyolite columns can readily expose new bedrock (Figure 3). Massai Point is an area of heavy visitor usage at the terminus of the Road Corridor. Here exist a nature trail, exhibit center, parking lot and trailhead. Sugarloaf NNE and Massai South are backcountry areas of little, if any, visitor use. Access is difficult, for trails do not enter either location.

Massai Point apparently receives moderate off-trail visitor use. Old discontinued trails remain conspicuously footprinted. Corridors around rhyolite columns are moderately trafficked, and some trail shortcutting can be noticed by obvious pathways. Figure 19 is a trail cutoff area near the Parking Lot where

shortcutting is tempting to the visitor. The meter stick is at the right side of the plot near a small silverleaf oak; the 2 x 5 dm frame is in position 5 along the BT plot. Soil and gravels comprised around 85% of this plot in both spring and summer measurements, and litter was a mere 2%. Continued removal of soil surface materials along this old pathway in the future can be expected to cause channelization and further exposure of bedrock or angular rock fragments which at present comprise only about 12% of the plot. Revegetation using native plant species as barriers may be necessary to prevent further erosion and discourage off-trail use.

Data of Tables 4-5 suggest that soil and vegetation conditions at Massai Point are not very different, however, from control (no visitor use) locations at Sugarloaf NNE or Massai South. The soil surface features are of the same range of percentages at Massai Point as at the two control locations. Although

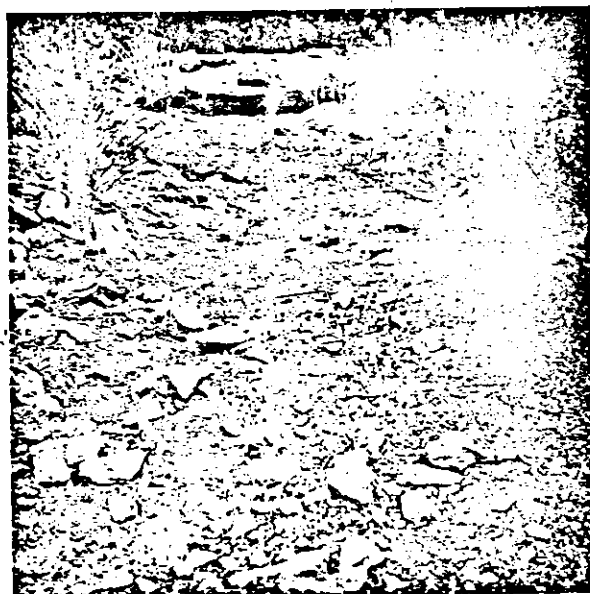


FIGURE 19. Belt Transect plot 5 at Massai Point, 20 March 1974. The meter stick near the silverleaf oak is on the right side of the plot and the 2 x 5 dm quadrat frame is near the center of a trail cutoff path near the Parking Lot.

Although exposed bedrock with means of 12-20% and maxima of 59-78% in spring and summer measurements at Massai Point appear to be somewhat higher than at either control location, such differences have no statistical meaning since the deliberate locations of BT plots at sensitive microsites precluded comparisons of overall environmental features of the different locations. Plots 2 and 3 at Massai Point both contributed in large measure to the increased exposure of bedrock between the spring and summer observations. Bedrock exposure at BT plot 2, located near the base of a rhyolite column, increased about 20% with a corresponding decrease in gravel and soil materials during that interval. At plot 3 a similar 20% increase of bedrock exposure could be accounted for by removal of litter from the plot. Whether such changes were visitor-induced or the normal result of seasonal runoff cannot be determined. However, any further increase of bedrock, or loose rock, exposure at Massai Point without similar increases at Massai South or Sugarloaf NNE can reasonably be attributed to visitor off-trail use.

Vegetation basal area is very minor at BT plot sites at Massai Point. We also observe that delicate soil cryptogams occurred in only 3 of the 7 plots (Table 4). These soil surface features are extremely susceptible of diminution by trampling and erosion. Nevertheless the lack of such critical features cannot necessarily be attributed to histories of visitor or maintenance uses, for we also note these soil and vegetation basal area features are rather low at the control locations. Apparently grasses (the principal contributor to vegetation BA at sensitive sites) are not a very important component of these upland silver-leaf oak chaparral habitats. Instead we find saxicolous lichens, particularly of the genus Parmelia, a major vegetation component (5-9% cover) of the rocky and gravelly pavements (see also Figure 3). If these lichens are susceptible to death by abrasion from trampling, then such losses are as yet undetectable at Massai, at least within the 7 BT plots there. Indeed, high ground percentages of these lichens suggest a considerable time interval of rock exposure (Webber and Andrews 1973) rather than accelerated emergence of lichen-free rocks through man's recent activities. Uses of lichenometric techniques to establish emergence rates of rhyolite, their colonization and growth rates by lichens needs considerable more study at Chiricahua National Monument. The apparent increased cover by Parmelia and other saxicolous lichens at Massai and other locations (Table 4) in

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certain of the BT plots has three plausible explanations: i) the increase is real as result of colonization or growth over new rock surfaces, ii) the increase is real from emergence of lichens under areas temporarily buried under litter (cf plot 3 at Massai), or iii) the increase is the result of oversight or inaccuracies from the previous spring measurements. Clearly, more attention to the lichen cover at monitored plots seems warranted.

The canopy coverage of vascular plants at Massai, Massai South, and Sugarloaf NNE has mostly remained about the same (within the limits of sampling precision) for most species during the interval between spring and summer. However, certain plots with manzanita, Toumey or silverleaf oaks revealed decreased or increased canopy coverage. In general, of the 43 BT plots where manzanita occurred at all locations in Table 4, the shrub increased canopy coverage in 7%, decreased in 26%, and remained about the same in 67% of them. In short, there appeared to be a minor dieback during early summer, and since this dieback occurred rather generally throughout the Monument, it cannot be attributed to visitor effects alone. The dieback also affected silverleaf oak (decreased cover in 33%, no change in 67% of the 15 plots where it occurred), but not, apparently, Toumey oak (10% decrease, 10% increase, 80% no change in 21 plots).

In summary, for Massai Point when contrasted to vegetation and soil surface conditions at Massai South and Sugarloaf NNE:

- o Off-trail use by visitors has resulted in apparent deterioration at localized sites, but except for plot 5 such past usage is not reflected in the data.
- o Future, or intensified, unrestricted visitor activities can be expected to product the following changes in the BT plots:
 1. Dieback through mechanical breakage of woody shrubs and thus reduction of canopy coverage values of Table 4;
 2. Removal of surface litter, soil, and gravel materials and resultant increases in the proportions of loose rock and bedrock in Table 5;
 3. Reduced cover of saxicolous Parmelia and other lichens as abrasion losses exceed colonization and growth rates.
- o Impact problems related to trail maintenance can be reduced by avoiding borrow areas and importing trail materials via the parking lot, and by judiciously closing off "inviting" entranceways to discontinued trails or shortcut areas through site management with native plant species .

Rhyolite Canyon and Natural Bridge Trails

These trails commence in cypress and pine-oak woodlands of the canyon floors. Most of the BT plots are concentrated at the start of the trails where visitor use is heaviest. Therefore the high proportion of woodland litter (81-96% in Table 5) is not unexpected. Since these trailside plots are mostly on gentle terrain and under heavy tree canopies, erosion of surface materials through rainfall impact and runoff is unlikely. Major changes anticipated from visitor activities include mechanical breakage of plant parts from off-trail passage, littering of trash, and flower picking. There is scarce evidence from Tables 4-5 that these activities have been very serious to date. The Natural Bridge Trail in particular appears in excellent trailside condition (Frontispiece Photo). We note the high proportion of trailside plots (5 of 8) with delicate soil cryptogams, and slightly lower occurrence in (3 of 8) plots along Rhyolite Canyon Trail. We also note the poor representation of summer annuals in these plots. The probability of both annuals and small cryptogams in the BT plots can be related to smothering effects of the litter mantle, effects of past trail maintenance work or visitor trampling, or to sampling probability. Several plots (numbers 7,8,11,12) along Rhyolite Canyon Trail contain goldenrods, gillias, comandras, and other wildflowers. The seriousness of flower picking in the past cannot be assessed, since monitoring plots cannot measure something not there. But these plots provide some guidelines concerning flower picking pressure, together with the vigor and persistence of wildflower species on the woodland floor.

In summary:

- o Gentle terrain and excellent cover of woodland litter along both trails suggest high resource durability and few visitor or maintenance impacts, at least along the initial kilometer of trail.
- o Trails can be maintained by borrowing or importing fill materials from trailheads to lessen any visual, botanical, or bank stability impacts.
- o Herbaceous and woody vegetation along immediate trail corridors appear generally in vigorous condition and lessen tendencies of hikers to leave the relatively wide trails.
- o Flower picking and trash removal problems may become more serious, especially on the nature trail segment of Rhyolite Canyon Trail.

Heart of Rocks and Echo Canyon Trails

Contrasting with the previous trails, both Heart of Rocks and Echo Canyon Trails at their commencement near parking lot trailheads show signs of wear. The initial kilometer of these trails occur mostly on upland habitats and topography similar to Massai Point and are subject to the same kind of adverse effects caused by trail cutting, exploring around rock columns, and so forth. Aesthetic deterioration is evidenced by frequent signs of trash within view of the BT plot microsites. Other signs of microsite disturbance, as itemized in the discussion of Massai, are locally evident along the start of both trails. Natural resource features of the BT plots include (Tables 4-5) low canopy coverage and basal area of grasses, rather heavy coverage of brushy oaks (Toumey, silverleaf, and netleaf) and manzanita, about 4% average cover of Parmelia and other lichens of rock and gravelly substrates, and soil cryptogams in 6 of the 11 plots. Surface organic litter averaging 55-60% over the 11 plots, reflects the more upland, less wooded aspect of these trail segments in contrast to the canyon trails discussed above (plots 6 and 7, however, are situated in the CA vegetation type).

Trail maintenance and visitor off-trail uses seem to present similar problems as at Massai Point. However, these problems are most serious only along the start of these trails. Where the trails intersect in upper Rhyolite Canyon and continue down the canyon, the plots revealed little or no signs of man-caused disturbance.

Bonita-Faraway Hills

Near the Monument entrance along the road corridor are two low, grassy hills inviting and accessible to the road traveller. Plots were established here for measuring the degree of use of such portions of the road corridor before the visitor reaches the Visitor Center. Slopes vary from gentle to moderate in the open woodland savanna (QA-QE-Gr) habitat. Soils are stable, and on gentle slopes consist of A1/AC/C horizon sequences (Soil Survey Manual Supp. 1962). The degree of rockiness increases as the hill summits are approached.

The plots showed no sign of visitor use (Tables 4-5). The location displays very high plant diversity. Numerous small, attractive cacti and colorful wildflowers of many kinds abound. Grasses averaged 31% canopy coverage, and vegetation basal area was the highest to be found of any sampling location. Summer annuals, too, were of remarkably high (62%) coverage, and were found in each of the 12 plots. Soil cryptogams were found in 10 of the plots. There appeared to be a real decline in grass basal area, probably as result of early summer drought. Basal area diminished from 9 to 3%, and in three plots a real decrease of graminoid cover was observed. Grasses, indeed, showed mixed responses during the interval between the spring and summer observations, as shown in Table 4 at Bonita-Faraway and other locations. Taken over the Monument as a whole, grasses and sedges occurred in 58 BT plots, declining in 17%, increasing in 28%, and remaining about the same in 55%. Natural causes appear to bring about these changes, but the explanations are probably not very simple. Certain grasses at Bonita-Faraway and other locations, such as hairy and slender grammas (Bouteloua hirsuta, B. filiformis) and other low, mat-forming species, may have been adversely affected by severe spring and early summer drought. Certainly many recently dead culms were noted in the quadrats. Other grasses, notably the robust or late-summer active "forest" grasses of more mesic woodland habitats (Frontispiece) showed increases in canopy coverage during the late summer observations and little, if any, death of basal culms. The degree of grass response to environmental conditions is also affected by microhabitat. At Bonita-Faraway declines in basal area were measured in 11 plots. The difference of about 6% appeared to be made up by small increases in percentages of litter (dead basal area culms become litter) or soil. These and similar changes should not be taken as measures of succession but as normal year-to-year, or seasonal variations in vegetative cover. Since similar seasonal changes were observed in the campground area (discussed next), in similar microhabitats, Bonita-Faraway is important, despite its location along the road corridor, as a non-used (by visitors) control area. While wildlife are abundant at this location, their grazing and trampling make little effect upon vegetation as measured in the BT plots. In summary:

- o There is little or no evidence of any deleterious wildlife or visitor impact in or near any of the 12 plots.

Campground

The campground area presents difficult and impressive resource maintenance problems. Reconnaissance in March 1974 indicated 3 zones of campground use impacts: the campground itself, the immediate campground perimeter extending perhaps 100 meters radially from the west edge of the camp and picnic sites, and the distant perimeter beyond this extending virtually to the base of the rhyolite cliffs. All zones have their special management problems, but this section will be confined to the immediate (high impact, or HI) and distal (low impact, LO) perimeter areas. Both areas contain primarily chaparral, or brush type shrub-woodland vegetation. The HI zone is more heavily canopied with shrubs (AP type and intergrade to QA-QE-Gr) and has gentle to moderate slopes with moderately shallow or shallow soils of colluvial origin. The LO zone has more open shrubby vegetation (QT-Gr) on moderate to steep slopes with mostly skeletal soils or bare rock land. A series of shallow, parallel drainages dissect both zones.

The reconnaissance suggested three main types of visitor impact in the perimeter area: trampling, wood gathering, and trash dispersion. Major findings are summarized:

- o A number of entry points into the campground perimeter from the main campground are obvious.
- o Once into the perimeter area, trails branch, network, and anastomose along numerous corridors.
- o People walk as much as possible through open grassy areas in marked preference to crashing through shrubby barriers.
- o The HI zone intergrades imperceptibly into the LO zone as terrain gets steeper, but there appears to be no non-use zone within 200 meters of the campground margin.

Thirteen BT plots in the HI zone were approximately equally spaced along the distance of the campground perimeter. Plots were selectively placed in the inviting, corridor-like openings for the most part. Soil surface features summarized for these plots in Table 5 by no means suggests a denuded, high-impact terrain. Rather, a respectable 5% of vegetation BA in spring compares well with the 9% at Bonita-Faraway Hills. In summer a decline in BA and mixed response of grass canopy coverage was observed similar to that at Bonita-Faraway Hills.

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Litter cover from 3-81 percent and the minor exposure of bedrock and loose rock fragments (about 5% each) suggest that erosion, vegetation destruction, and other unfavorable effects of the foot traveller are not as yet of severe magnitudes. However, continued and sustained traffic of campground wanderers into the perimeter could easily lead to accelerated deterioration of vegetation or soil properties. Table 4, for example, shows that delicate soil cryptogams, the first plants to disappear under trampling, occur in 38% of the plots in the HI zone (37% in the LO zone), but 83% of Bonita-Faraway plots. Fragile summer annuals, too, while occurring in all of the plots, averaged only 13% cover (62% at Bonita-Faraway). While such differences can have no statistical reliability, their suggestiveness of early site deterioration should be kept in mind. The status of Parmelia (in all of the plots) should be of considerable future interest too.

Eleven plots were established in the LO zone of the perimeter. Here the network of trails is reduced, and there are fewer campground wanderers. But slopes are steeper and soils more prone to erosion. Traffic along the fewer paths is potentially as serious as in the HI zone. Soil and loose gravels averaged 61-66% of surface features where the plots were located, and litter protection against erosion is only about half that of the HI zone. But grass basal area and canopy coverage are good (with some summer reduction as discussed for the Bonita-Faraway Hills location), and soil cryptogams and summer annuals at least moderately represented in the plot samples. Thus resource deterioration is not greatly evident at present, but cautionary measures against continued pressures from the campground seem warranted.

The management should be cognizant of possible synergistic interactions of visitor use and climatic events in the campground area. A summer cloudburst and intense runoff from slopes above the campground may result in greatly magnified damage if the vegetative cover is even moderately reduced because of campground traffic. Accelerated gully incisions are already of some concern and difficult to arrest just north of the amphitheater area. In summary:

- o The campground perimeter shows generalized rather than localized camper impacts as evinced by numerous meandering pathways, crushed vegetation, scattered trash, vandalized monitoring plots, and chopped woody branches and limbs.

- o Although resource deterioration has commenced, especially in the immediate campground perimeter, it has not progressed to alarm proportions.
- o Active management of camper activities to lessen their uncontrolled effects in the perimeter would appear to have restorative effects upon vegetation and soils at this stage.
- o Continued, sustained, and uncontrolled visitor use of the perimeter may "trigger" these slopes whereby precipitation runoff from an intense storm may produce great resource and campground damage.
- o An ounce of caution is worth a pound of cure.

Forest (F) Plots of Canyons

The F plots, unlike BT plots, are descriptive samples of plant and soil characteristics of the forest stands. Although the location of each macroplot is conditioned by somewhat subjective appraisal of vegetation homogeneity and buffering against edge effects, as discussed in Methods, there was no attempt to locate the 2 x 5 dm quadrat frames only in sensitive areas. The 50 quadrats reflect, therefore, vegetation and forest floor conditions within the 375 m² macroplot. Descriptions provided by these F plots are useful as baselines or benchmark measurements against which future changes can be compared (Moir 1973). For example, should a fire occur in one of the canyons where such a plot is located, the changes can be measured and compared with the pre-fire (baseline) forest condition.

Forest structure of the six plots is given in Table 6. The pine-oak woodlands (Marshall 1957) have two dominant canopy layers. Emergent pines (Pinus engelmanni, P. leiophylla) up to about 20 m form scattered cover while underneath is a semi-open (plots F1, F2) or continuous closed layer of mixed evergreen oaks and alligator barked juniper. Beside streambeds the Arizona cypress may also be important in the taller canopy stratum. Considerable variation in the tree structures of the six plots exists, and Table 6 suggests several distinct pine-oak woodland habitats. Open forests (stem densities around 500/ha) of pine and oak occur at Picket Park (vegetation type PE-PL). The ground flora (Table 7) of plots F1 and F2 is dominated by robust muhlys

TABLE 6. Forest size and taxonomic structure at F plots in canyons of Chiricahua National Monument, Spring 1974. Plots F1 and F2 occur in Picket Park, F3 and F4 Rhyolite Canyon, F5 Jesse James Canyon, and F6 Bonita Canyon. The five size classes are respectively 0-1, 1-2, 2-3, 3-4, and 4-5 dm Dbh (diameter at breast height). The + in the body of the table indicates presence outside the 25 x 15 m plot.

CANOPY LAYER and TAXA	PLOT AND SIZE CLASS																													
	F1					F2					F3					F4					F5					F6				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5					
Tall Conifers	-----stems/375 m ² -----																													
Cupressus arizonica											4	+			+									1						
Pinus leiophylla	1	3	1	2		3	2	3	1		3			1						+	+	1		3	+	+				
Pinus engelmanni						2			2	2	5	1								+	+	+								
Evergreen Oak Layer																														
Pinus cembroides	3					6					7					7						5			2					
Juniperus deppeana		6	1	2		15			1	2						1						4			62	8	1	1		
Quercus hypoleucoides		1									2	12	2	1		7	22					4	26	4						
Quercus arizonica											1	25	5	1		4	21	2	1			4	16	2	1	4				
Quercus emoryi	1	2					2	3	1		2								1				3		2	13	6	4		
Arbutus arizonica											1									+					+					
	-----stems/ ha-----																													
Total stem density ^{a/}	479					506					1360					1280					1360					980				
	(open)					(open)					(closed)															(closed)				

Table 7. Understory vegetation and soil surface characteristics in forest plots Chiricahua National Monument, 1974. The + indicates constance.

TAXA	COVER(%) / FREQUENCY(%) BY PLOT					
	F1	F2	F3	F4	F5	F6
SHRUBS	Arctostaphylos pungens	13/22	+			9/22
	Garrya wrightii	+	+	0/ 2	+	0/ 4
	Rhus coriophylla			+	2/ 2	
	Nolina microcarpa			2/14	1/ 4	
	Yucca schottii	0/ 2	1/ 4	0/ 4	+	
	Dasyllirion wheeleri		1/ 2			
	Agave palmeri					
	Quercus hypoleucoides		+	4/10	15/34	7/14
	Q. arizonica			2/ 4	2/ 6	3/ 8
	Q. emoryi	4/ 6				
	Rhamnus		3/ 4	1/ 2		2/ 6
	Rhus trilobata		1/ 4		+	2/10
	Bouvardia glaberrima			+		
	Toxicodendron radicans		0/ 4	+		
	Lonicera albiflora		+			
GRAMINOID PLANTS	Muhlenbergia sp.	9/38				
	M. longiligula	2/ 4	44/80	1/ 6	8/24	5/14
	M. emersleyi	0/ 2	+	11/14	2/ 8	6/22
	Andropogon cirratus	0/ 4		+		
	Aristida orcuttiana	14/68	0/ 2	1/14		1/ 2
	A. longiseta	1/ 2				
	Panicum bulbosum		0/ 2	+		
	Piptochaetium fimbriatum	+		+		8/24
	Carex sp.		1/ 8	0/ 2		0/ 2
FORBS	Clitoria mariana					12/74
	Oxybaphus	0/ 6	+			1/18
	Brickellia lemmonii		0/ 4			
	Brickellia	+				
	Polygala obscura	0/ 4		0/ 2		
	Phaseolus heterophyllus	1/10				
ANNUALS	Other perennial herbs		0/12	+		0/ 6
	Drymeria sperguloides	15/64	1/ 6			
	Muhlenbergia	6/20				
	Cyperus aristatus	3/52	0/ 4			
	Schistophragma intermedia	1/24	0/ 2			
	Bulbostylis funkii	11/62				
	Cyperus rusbyi	0/14	1/16			
	Acalypha neomexicana	0/ 6				0/ 6
	Other annuals	0/ 2				0/ 8
SOIL SURFACE						1/30
	Litter *	84(82)	95(95)	92(91)	89(89)	87
	Soil	12(15)	0 (1)	0 (0)	0	0
	Rocks			8 (8)	10(10)	12
	Vegetation Basal Area	5 (3)	5 (4)	1 (1)	1 (1)	0
	Soil cryptogams **	2 (8)	- (6)		- (4)	2
						4 (4)

* Average cover only: spring and summer (in parentheses) measurements

** Average frequency only.

(*Muhlenbergia longiligula*, *M. emersleyi*) and other perennial grasses (Figures 9 and 20). Annuals are conspicuous after summer rains on the gravelly wash sediments of plot F1. Scattered understory shrubs include manzanita, Schott's yucca, and squawbush (*Rhus trilobata*). Figure 20 shows plot F2 on gentle terrain of gravelly alluvium generally covered with a mantle of herbaceous cover and litter. The soil materials are relatively stable. However in summer a portion of vegetation and litter was buried by new alluvium washed from upslope areas (a portion of only 1 of the 50 quadrats was affected). The effect upon the overall plot was inconsequential, but serves to illustrate the dynamic nature of ecosystems and microsite changes within the ecosystem caused by natural outside (allogenic) forces.



FIGURE 20. Plot F2 in Picket Park Natural Area, 22 March 1974, from NW stake.

Plots F2, F3, and F4 are found on cobbly-bouldery streamside alluvium. The woodland canopy is closed (Figure 6) with stem densities around 1300/ha. Emergent pines are more scattered than at Picket Park (and absent in Jesse James Canyon), while dominants of the oak layer are mixtures of silverleaf and Arizona white oaks (type QA-QH). Alligator barked juniper is of rather minor occurrence, mostly in reproductive size class 1 (Table 6). Vegetation of the

understory is rather sparse with scattered shrubs (Nolina, Rhus trilobata, Arctostaphylos pungens, Yucca schottii), grasses, and shrubby, coppiced oak sprouts. Annuals are absent in the heavy woodland litter and alluvial cobbles of the forest floor.

Plot F6 in Bonita Canyon differs in several features from the above pine-oak woodlands. Here Emory oak replaces the silverleaf and Arizona white oaks as major evergreen species (type QA-QE). Alligator barked juniper has very impressive regeneration and is a major tree of the oak stratum. The lower stem density (about 1000/ha) can be attributed to partial cutting, a factor which may also influence the juniper regeneration. Notice from Table 6 that pinyon pine is invariably present (in all the F plots) as young regeneration (size class 1), but appears unable to survive in the shaded understory of the canyons. The ground vegetation (Table 7) of plot F6 differs appreciably from plots F3-F5 only by the dominance of butterfly-pea (Clitoria mariana), a plant of restricted distribution in Arizona but locally abundant at several canyon locations at Chiricahua National Monument. Proximity of plot F6 to the group site of the campground may have resulted in some vegetational changes in the past. Perhaps the soil exposure of 11-14% is reflection of camper activities here. But the mantle of woodland litter is good, the cover of grasses respectable, and there is rather high wildflower species diversity in the area. The flora has certainly not been impoverished to the extent pictured in Figure 7 at the not too distant Environmental Study Area.

T Plot Locations

At selected locations where description of the herbaceous ground flora was of special interest, the monitoring system consisted of T plots. Table 8 summarized the data. In this table the first group of taxa are perennial grasses from the late summer observations (at this season identification is most certain, and foliar measurements are often at the year's maximum after summer rains). The second group of taxa (starting with Acalypha neomexicana) include some of the summer annuals, an important lifeform in these savanna or grassy habitats. Woody species at the various T plots have not been included in Table 8, but will be summarized in text below. Soil surface features, the final group in Table 8, are spring measurements for plots T10 and T11 and summer measurements for the remaining plots.

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Plots T1 and T2 in lower Picket Canyon (Figures 10 and 15) were located where trespass grazing had occurred. At T1 mat-forming grasses were dominant (Hilaria belangeri and Bouteloua spp.) on the gentle lower slope of mixed alluvium-colluvium. The coverage and basal area of these palatable grasses, collectively 45 and 9% respectively, suggest that cattle grazing has been of slight, if any, consequence. The basal area of late summer had declined about 18% from the spring observations, but there was no cattle grazing during that interval. More likely the decline resulted from the very dry winter and spring, and possibly from hot, droughthy summer intervals. Gully erosion had taken place on the slope (Figure 11), but older gullies exhibit revegetation and stabilization. T2 is just below T1 on alluvium with open Arizona white-Emory oak savanna. Grazing and cattle bedding may have reduced canopy coverage during the spring measurement period (30% total canopy coverage), but basal area was very high (17%) and no instance of overgrazing could be concluded. By late summer canopy coverage had reached about 50% (all perennial grasses totaled from Table 8); basal area of the grasses at 7% was very high. Numerous annuals were also present along with various perennial forbs (broad leafed herbs), all contributing the rich ground flora diversity at this oak savanna location. Any depauperization of palatable herbaceous species by past cattle grazing in this area was undetectable. This conclusion is reinforced by comparing the vegetation of plots T1 and T2 with that of ungrazed plots T5 and T6 (Table 8).

Portions of Whitetail Canyon received greater grazing impacts than Picket Canyon. T3 and T4, both in oak savanna as was T2, have considerably lower grass canopy coverages than the Picket Canyon sites. Summer basal area was only 1-2%, markedly lower than at plots T1 and T2. Recent, unhealed gullying was conspicuous on red lakebed soils of plot T3. Poor vegetation cover is apparent in Figures 12 and 13. We note, however, that the lakebed soils are very erodible even in absence of livestock. The recent grazing influence in Whitetail Canyon is only of sporadic, local severity, as the general canyon area within the Monument usually showed minor, if any, ground vegetation deterioration. Steeper hillsides appeared to have no cattle influence whatever at areas examined. Hence the plots T3 and T4 are not typical measures of recent grazing impact, but function primarily to indicate degree of recovery from the

Photo 22

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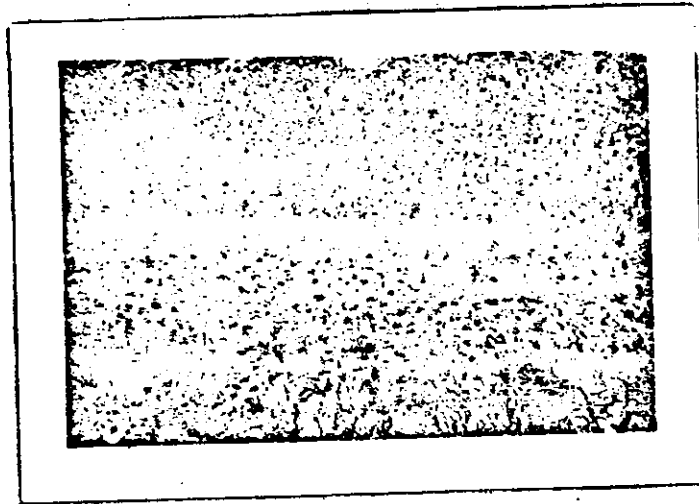


FIGURE 21. Pine woodland of Apache and Chihuahua pines and understory of Arizona white and silverleaf oaks, alligatorbarked juniper, and pinyon pine along washes of upper Bonita Canyon, photographed April 23, 1937 by R.D. Roseberry. Rises contain open woodland savanna. Insert: same view on March 20, 1974. Shrub cover has increased somewhat on the rises.

more severely affected areas.

Man's more distantly past activities in the Monument portions of Whitetail Canyon cannot be discounted as having influence on present day vegetation. Mining and grazing activities in upper Whitetail Canyon were certainly well established in early days. Feral cattle often sought refuge in wild, inaccessible canyons of the area (Ralph Morrow, pers. communication to W.H. Moir, 11 January 1975). Upper Bonita Canyon (near the divide of Bonita and Whitetail drainages) was photographed in 1937 by R.D. Roseberry (Figure 21). The photograph shows mixtures of Apache and Chihuahua pines along drainages and oak savanna (QA-QE-Gr) on rises. Shrubs appear more or less restricted to one small draw. The same view photographed in 1974 (Figure 21 insert) suggests shrub invasion into former grass-dominated hillsides. Causes for such change cannot be proven, but man's activities (including grazing) and fire suppression have both been suggested (Hastings and Turner 1965, Humphrey 1958).

Plots T5 and T6 in Jesse James Natural Area were located on steep, south-facing, cobbly colluvial slopes of low Emory oak savanna (Figures 6 and 14). Grasses are the dominant lifeform of the herbaceous vegetation (Table 8) with principal species including Texas bluestem, sideoats grama, hairy grama, and bullgrass. Shrubs observed for constance within 3 meters of the transect line included manzanita, sotol, century plant (Agave palmeri), Selloa (Selloa glutinosa), and Yucca (Yucca schottii). Numerous perennial forbs, including false mesquite (Calliandra schottii), blue curls (Trichostema arizonicum), Brachystigma wrightii, and cud-weed (Gnaphalium wrightii), contributed to the extremely high plant species diversity of this location. These plots in a remote section of the Monument can serve as ungrazed (by domestic livestock) controls and baseline measurements of future change.

Plots T7-T9 are located on a gently sloping alluvial fan in section 1 of the Monument SW Corner (Figure 4). Livestock grazing continues to be a factor of vegetation expression. Blue grama is the dominant grass, but annuals are also a very prominent feature of vegetation after summer rains. Six-weeks three awn (Aristida adscensionis), summer poppy (Kallstroemia parviflora), and Portulaca are more abundant of the many annuals in these pastures. Basal area of the perennial grasses (4-10% in Table 8) is good, suggesting that livestock

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management here has not reduced the capacity of the graze-tolerant blue grama for forage production. There are no signs of soil erosion. Plot T9 in the adjoining pasture, being grazed in 1974 by horses, had similar vegetation composition, although certain annual species seemed of greater dominance than in plots T7 and T8 across the fence. Activities of burrowing rodents produced a weedy patchiness, but this was not reflected in the immediate location of the transect where blue grama was continuously (100 % frequency) present.

The plots in East Picket Park Natural Area (T10, T11) are in somewhat similar microhabitats as many of the BT plots of the campground perimeter. An open chaparral woodland vegetation (type AP-QT) is interrupted by exposures of rhyolite bedrock to produce a patchy mosaic of brush (mostly manzanita and Toumey oak), scattered low pinyons and junipers, and lichen or grass-dominated gravelly or rocky openings. Vegetation basal area was only 1-2% (compare with campground H1 and L0 perimeter areas in Table 5 where plots were selectively placed mostly in herb dominated openings), and bedrock exposures averaged 8 and 20 % in the two plots. Local patches of green Parmelia species often reached in excess of 80% cover over rocks and gravels (suggesting absence of heavy trampling), but in plots T10-T11 the average Parmelia cover over 25 quadrats was only 1-2%. Grasses of mixed composition totaled about 13% canopy coverage by late summer, and annuals were a very conspicuous cover over gravel and soil surfaces. Along plot T10 woody cover by manzanita was 29% and 8% in respective spring and summer measurements, a significant dieback during the summer interval; along plot T11 manzanita cover was 25 and 22% in spring and summer respectively, a nonsignificant difference. Since both plots are proximate to each other within the same plant community, their differences indicate considerable variation in response of manzanita to apparently natural microenvironmental factors. Toumey oak at 10-12% cover in plot T11 remained unchanged in the spring and late summer measurement. The location of these plots is well off and beyond sight of the Natural Bridge Trail and little, if at all, frequented by visitors or staff. Therefore the data and plant responses between measurement intervals can be useful as baseline measurements or controls for similar habitat (which is widespread in the Monument) in which visitor impacts might initiate succession.

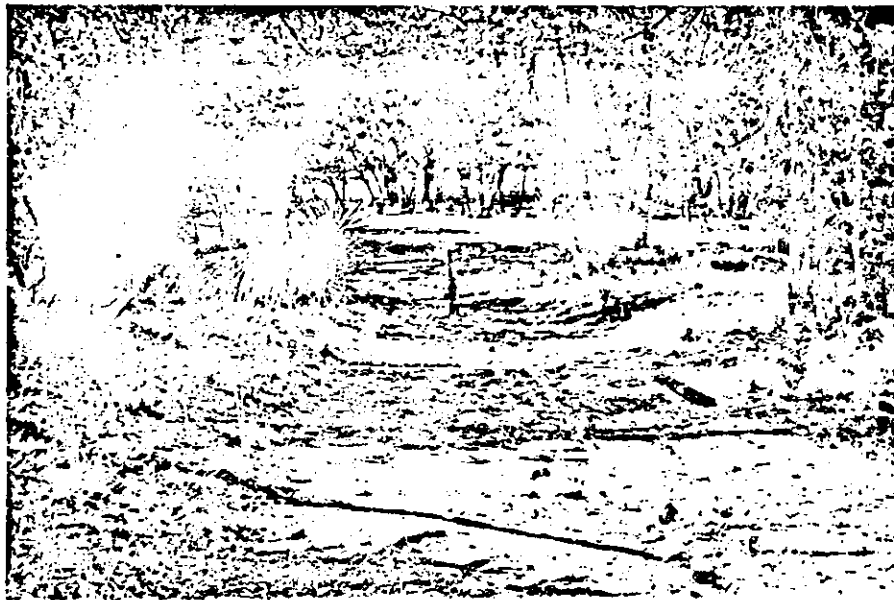
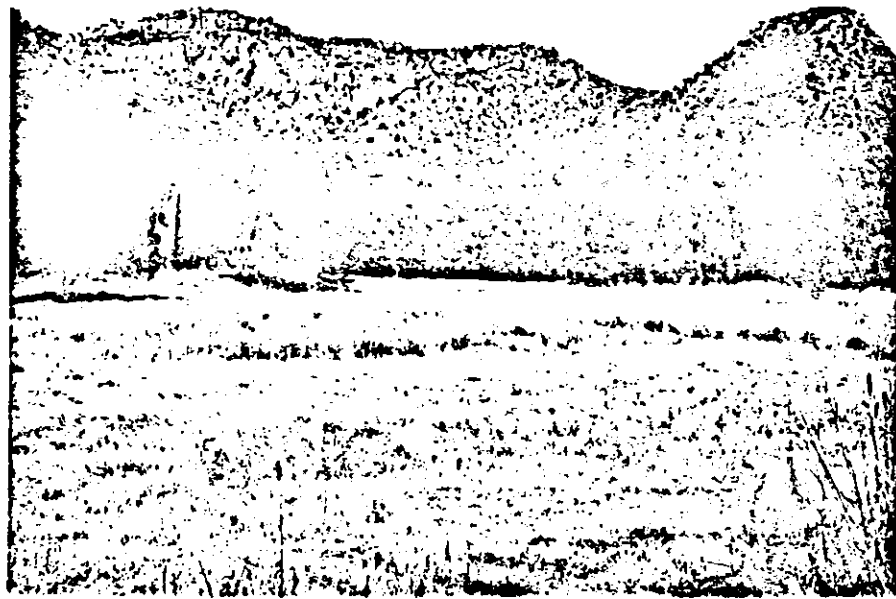


FIGURE 22. Environmental Study Area, 1974. Upper: grassy meadow consisting of a mosaic of mesic grass and grass-sedge associations. Lower: Oak woodland along discontinued old road. In the immediate left foreground are grass clumps of Orcutt's three awn and side oats grama in oak litter; the sunny patch and elsewhere in this vicinity (and especially under alligator barked juniper) exhibit dense and nearly pure swards of pinyon ricegrass.

Environmental Study Area (ESA)

Several contrasting habitats are found at ESA. Much of the area is oak woodland (QA-QE) of rather general distribution along lower canyon floors and canyon sideslopes. But unique areas of mesic or wet meadows and springs and seepages are also found (Figures 3, 22, 23). Much of the existing vegetation reflects heavy use by man within recent decades, but prior to the establishment of the Monument (Figure 3). Elsewhere within the oak woodland are patchy mosaics of grasses and occasional shrubs that escaped the more severe effects of grazing, vehicular damage, fuel removal, garbage disposal, and other pre-Monument activities. The area is presently managed to accomodate group education and interpretation. Study groups often from local schools may be brought here for guided interpretative talks or exercises on ecological themes. The size of the group,



FIGURE 23. Spring and seepage area at the Environmental Study Area, 1974. Here occur a number of aquatic and emergent plants of very restricted distribution in Chiricahua National Monument. A steep path across the stream and high intensity of visitor use in this immediate area can easily alter the otherwise pristine appearance of this fragile resource.

and their age and behavior are extremely critical considerations governing which habitats at ESA will be visited and the duration of their stay. Certain areas such as the spring and seepage site or portions of the wet meadow (Figure 23) can be easily damaged or vandalized. Here perhaps is the most sensitive microsite in the entire Monument! On the other hand much of the grassy meadow appears to be of high resistance to heavy trampling and of high durability. Unfortunately the meadow area is also very close to the spring, and the proximity of both fragile and durable natural resource areas must be kept in mind when deciding whether or not to bring certain groups into the area.

An experiment was set up at ESA to test the resiliency of several woodland grass species to trampling. BT plots were established in replicate areas of i) pinyon ricegrass patches (Piptochaetium fimbriatum), and ii) three-awn and sideoats grama patches (Aristida orcuttiana and Bouteloua curtipendula). The general setting for this experiment is shown in Figure 22. The trampling treatment consisted of walking visitor groups over the treatment plots and recording the number of passages. Whenever possible the visitors were not aware that they were subjects of this experiment and the exact location of the plots was not made known to them until after the trial. In this manner scuffling or exaggerated trampling was avoided or kept to a minimum. Variations due to microsites were reduced by selecting plots in small, relatively homogeneous areas at ESA where habitat features reflected little disturbance, at least in recent years. The experimental design can be assumed orthogonal. However, possible grass x trampling interaction effects were precluded because of difficulties in managing visitor groups when large numbers of replications are necessary.

The analysis of variance and results of the trampling experiment are given in Table 9. Between the dates of April 24 and October 2, 1974 some people had walked over the treatment plots. Trampling during this interval had no effect upon the basal area cover of either grass type. However the canopy coverage of pinyon ricegrass in the control plots increased 20% but only 4% on the average in the trampling plots. Three awn and side oats grama plots increased 10% on the control but only 4% on the trampled plots. The differences caused by trampling upon canopy coverage were significant at the 5% probability level. In view of the large number of people who had walked across these plots, however, we can conclude that grasses of the oak woodland forest floor have a remarkable durability and

resilience to man's off-trail trampling. But it must also be remembered that these canyon floor sites are well-mantled with woodland litter, and are level or gently sloping so that erosion disturbances accompanying foot traffic are minimal. This experiment by no means implies that microsites other than the woodland floors of the canyons are as resistant to the possible effects of off trail hiking.

VEGETATION & DATE	TRAMPLING		CONTROL	
	BA	COVER	BA	COVER
	----- % -----			
Pinyon Ricegrass				
April 24	3.5 2.4	62 46	3.6 4.8	60 59
October 2	3.8 2.5	62 54	4.3 4.7	80 79
Three Awn - Sideoats				
Grama April 24	1.7 2.2	23 16	2.6 0.7	43 10
October 2	1.6 1.9	26 20	2.7 1.1	52 20

Table 9. Grass trampling experiment, Environmental Study Area, 1974.

SOURCE OF VARIATION	DF	SUMS OF SQUARES		MEAN SQUARE		F	
		BA	COV.	BA	COV.	BA	COV.
Between Vegetation	1	.101	56	.101	56	1.10	3.4
Trampling	1	.151	232	.151	232	1.64	14.5*
Error	5	.467	78	.092	16		
Total	7	.719	366				

* Significant at the 5% probability level.

For the ESA area in summary:

- o A variety of habitats exist ranging from highly fragile (the spring-seepage area) to relatively durable and resilient (oak woodlands) to visitor use.
- o Man's activities here prior to the establishment of the Monument have severely impacted much of the area, but much of the area also exhibits at least some degree of natural vegetation composition.
- o Utilization of the area for visitor group activities must be determined on bases of the size of the group, their planned activities, the duration of their visit, their behavior, which habitats are to be visited, and the proximity of fragile and durable habitats.
- o If deleterious effects upon the habitats within ESA by visiting groups are noted, these habitats should be allowed a "rest and recovery" period by redirecting group activities to alternative areas such as the Stafford Cabin.
- o Plant collecting activities around the spring-seepage area should be prohibited.
- o Vegetative restoration efforts along old roadways and other denuded sites should be attempted.
- o Interpretative displays in degraded areas can emphasize to the visiting public some of the more heavy-handed and permanent consequences of man's dominance within some of the Monument's typical ecosystems. Displays involving the ecological costs and environmental consequences of accomodating the visitor in the Monument can also be made. Should these costs be hidden? Or should the interpretative program of the Monument be extended to include man in the ecosystem? The opportunity is there.

RESOURCE EVALUATION - - 1974

Data from monitored locations and photographic sites permits assessment of vegetative and soil conditions at Chiricahua National Monument as stated by the objectives in the Introduction. A tabularized summary of this evaluation is given in Table 10.

Generally the resources examined at Chiricahua National Monument in 1974 appeared in excellent condition even at locations that maintained heavy visitor traffic in past years. Such generalization is supported by photography of Roseberry and Dole in 1937, and other earlier Monument photographs. These

TABLE 10. Summary of natural resource conditions (vegetation and soils) and estimates of visitor carrying capacities at locations within Chiricahua National Monument, 1974.

LOCATION	CONDITION	CAUSES OF IMPACT	EXTENT	RESTORATIVE MEASURES	CARRYING CAPACITY (x present visitor use intensities)
Massai Point	Good	Off-trail use	Local	Site Management ^{a/}	x 1.5
Bonita-Faraway Hills	Excellent				x 3
Environmental Study Area	Poor	Pre-Monument Activities	General		x 1 (Spring Area) x 2 (Woodlands)
Rhyolite Canyon Trail	Exc.	Off-trail use; Flower picking	Local	Site Management	x 2
Natural Bridge Trail	Exc.	Off-trail use.	v. local		x 3
Heart of Rocks & Echo Canyon Trails	Fair	Off-trail use, Trash	Local	Site mangt; policing; guided groups.	x 1
Natural Areas (Picket Park, E. Picket Park, Jesse James)	Exc.				x 3 ^{b/}
Sugarloaf NNE	Exc.				x 1
Massai South	Exc.				x 0.8
SW Corner, Picket, Whitetail Canyons	Exc	Livestock grazing	Local	Fencing	x 3
Campground	Fair	Trampling, trash, wood-gathering	General	Build trail; site management; poli- cing.	x 1 (near perimeter) x 0.8 (distal peri- meter)
Wilderness ^{c/}	Exc.				x 3

^{a/} Site management refers to Action Plans Chir-N-5 and Chir-N-6 of the Natural Resources Management Plan, Chiricahua Natuonal Monument 1974. See also USDA Forest Service 1974.

^{b/} This factor assumes present levels and minimal impact in natural areas from scientific research.

^{c/} Other general backcountry locations. Additional monitoring sites are desirable. Estimates of carrying capacity are based upon Roseberry and Dole's 1937 photography and general reconnaissance of backcountry areas in 1974.

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photos generally revealed a vegetation little different from that of today, many thousands of visitors later (Figures 16,17,21,24, and 25). With certain exceptions at local areas such as the spring at ESA the vegetation of the Monument appears hardy and durable, or slow rates of change in the absence of fire, and probably in climax or near-climax condition over many areas. So long as vegetative cover remains high, soil stability is also good in the canyon bottoms and lower canyon slopes. Upper canyon slopes and upland rhyolite plateau surfaces generally have rough, broken lands, rock outcrop and bare rock lands, and shallow or skeletal lithosols or excessive runoff. But even here vegetative cover is often very good, as evidenced by the monitoring system, recent aerial photography (USGS 1973), and ground photography of past workers (Roseberry and Dole 1939). In general these upland expressions of vegetation, soils, and geology appear the natural, normal consequences of erosion-sedimentation processes little affected by man's presence in the Monument.

Floristic diversity within the Monument continues to be high. Plant specimens collected in 1939 and 1940 by Ora M. Clark are still well represented by populations apparently maintaining themselves within the various ecosystems. Maintenance of interesting local populations such as Berberis wilcoxii and Pachistima myrsinites (possibly relicts of postglacial pluvial climates) under present management prescriptions seems assured. In particular, the identification of five natural area locations within the monument (Arizona Academy Science and Smith 1974) serves, in part, an important genetic pool purpose (Moir 1972, Franklin et al 1972). In addition perceptual diversity appears quite high in most areas used by the Monument visitor (Frontispiece). Although flower picking along certain heavily used trail segments may have produced certain floristic impoverishment, evidence for this cannot be produced. Certain cactaceae may have been removed from certain locales, but backcountry locations and even the Road Corridor (at Bonita-Faraway Hills) seem to be supporting good populations. The abundance of other attractive wildflower species at many locations of this resource monitoring system, guarantees at the very least seed sources for possible reintroductions at locally impoverished sites.

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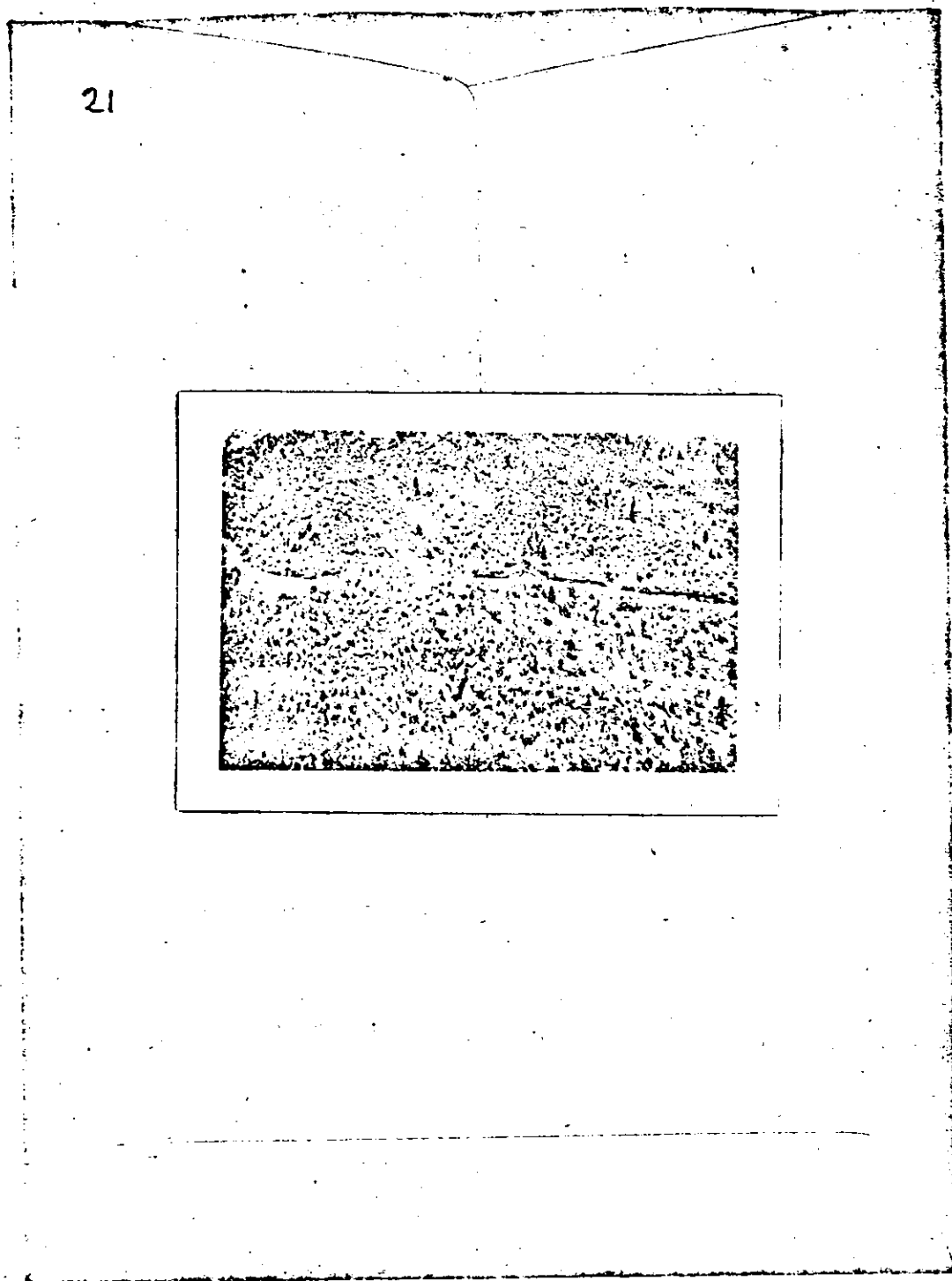


FIGURE 24. Chaparral and woodland chaparral photographed in April 1937 by R.D. Roseberry. Insert: identical area photographed March 1974. Almost identical vegetation mosaics are seen. The roadbank to the left has been colonized by shrubs on the lower part, but otherwise little change has taken place. The same trees, mostly Arizona cypress, form scattered individuals and copses in some of the draws.

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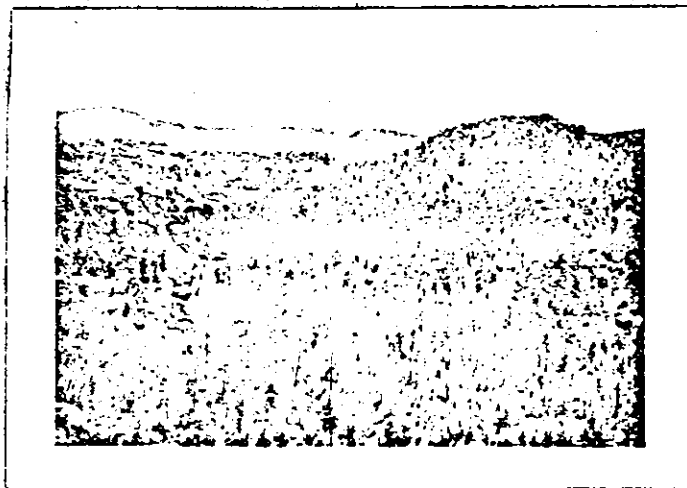


FIGURE 25. Pine Woodland at Picket Park photographed April 1937 by R.D. Roseberry. Insert: same view in March 1974 of nearly identical vegetation expression.

Resource deterioration, where occurring under visitor use, is usually confined to local sites as summarized in Table 10. Locations given other than excellent rating revealed localized sites of vegetation or soil wear. For example most of Heart of Rocks or Echo Canyon Trails mostly exhibit stable, diverse, undisturbed vegetation along most of the trail corridor, but have sufficient signs of off-trail use and trash along the initial kilometers to give only fair rating. Only the campground perimeter shows a more generalized visitor use, but even this is not so severe as of 1974 to warrant a poor resource rating. Portions of the ESA location along lower Bonita Canyon also have generalized deterioration, but the poor rating is reflection of slow successional rates of recovery since the resource damage was done in pre-Monument years.

The last column of Table 10 is a second approximation to visitor carrying capacity. Here the objective is to increase levels of visitor use in the management zones without reduction of the resource condition. Certain assumptions governed the carrying capacity estimates of the last column (Wagar 1974, Alldredge 19 , Lime and Stankey 1971, USDA Forest Service 1974). These are:

- o Future management prescriptions do not markedly differ from existing ones. New policies of visitor regulation or control, intensified site management, or other changes could mostly increase use intensities in most management zones.
- o Only the consequences upon natural resources were considered. People-to-people interactions might serve to reduce the estimated carrying capacities, especially in backcountry areas.
- o Maintenance of the resource status quo was the key determinant. Should undesirable succession trends be observed, then the carrying capacity estimates must be lowered. Similar reductions must be contemplated if restorative or resource improvement efforts are desired management objectives.
- o Visitor attitudes toward the natural resources remain much as they are now. As attitudes, behaviors, and perceptions change then the estimates of the last column must be revised. These changes may result from new directions in environmental education or emergence of new social norms.

Under these assumptions, inferences based upon resource condition existing at the monitored sites suggest that most of the Monument is operating at or below the visitor carrying capacity. Only the campground, Heart of Rocks and

Echo Canyon trails, Environmental Study Area, and Sugarloaf NNE seem to be operating at or near the visitor limits. Most other locations could doubtless sustain greater visitor numbers. Only Massai South, a sensitive and critical control location, might be treated more circumspectly with less visitor or maintenance travel. Here steep slopes and concealed locations of BT plots just off the ridge make them susceptible to unintentioned disturbance, thus losing their validity as controls. Similarly the spring area at ESA might benefit from some visitor reduction, but monitoring at this location is presently inadequate to sufficiently document this quantitatively.

MAINTAINING, REVIEWING AND UPDATING THE MONITORING SYSTEM

No system is perfect, especially prototypes. To be of continuing value to management the resource monitoring system at Chiricahua National Monument must be reviewed, revised, and maintained. Some locations are not being monitored at present and should be (e.g. the Spring at ESA); other areas need further sampling. Management needs and use patterns of the resources may change. New programs, such as intensified scientific research, may be undertaken in future years. Some monitoring sites become vandalized or lost, while others are perhaps better relocated. During the 4 month interval between revisiting the monitoring plots in spring and late summer, the attrition rate of monitoring plots (mainly lost or vandalized) could be estimated. At heavy visitor use areas 10 out of a total of 67 BT plots were lost or vandalized in that interval. At that rate the annual attrition is a whopping 45%! Of course many of these plots can be repaired (this usually involves reinstallation of one of the corner stakes), without loss of information. But this high rate (attrition in backcountry locations was 0%) emphasizes the need for maintenance. All plots will require future reobservations of their vegetation and soil conditions. Better sampling techniques may become available. Fortunately the dimensions of the resource monitoring system are flexible. The system can be continually adjusted and

tailored to changing needs and conditions at Chiricahua National Monument.

The immediate concern is to continue monitoring the natural resources as part of the Monument's in-house operations. New staff must be trained in the location of field microsites, photographic locations, and the necessary field procedures. A continuous chain of qualified personnel must be assured for future measurements that have high reliability, as discussed under statistical considerations. Cognizance and familiarity with vegetation and soil resources to be measured is an absolute must. Voucher specimens must be examined and reviewed from time to time for familiarity with flora within the numerous plots. If omissions, inaccuracies, and mistakes enter into the data, then the objectives of the resource monitoring system can hardly be met, and more damage than benefit will result. The old computer maxim is also true here: "Garbage in, Garbage out"!

Observations from the monitoring can be more directly geared to measurements of visitor numbers and activities in different management zones, for correlations and more precise estimates of carrying capacities and successional causes. The problem of determining trends will arise as plots are revisited and remeasured. Data analyses follow data collection. Whether comparisons are based upon statistical or non-statistical procedures, there must nevertheless be data summaries that form the bases for decision-making. Statistical work can be farmed out, if necessary. But the system of data collection and summarizing must not be so complicated that valid judgements cannot be made by simple and straightforward examinations of plot data, if need be. Data obtained from control locations are especially useful for these judgements, as are collateral observations at monitoring sites. A system of storing and retrieving field data sheets, assuring against loss, and providing records of continuity for each plot must also be established as the in-house operation. Data that is inaccessible or cumbersome to get to is not likely to be used, but data at one's fingertips may be heavily relied on. The resource monitoring system can readily form the data basis for evaluating natural resource condition and evaluation during important changes of staff, as for example the periodic turnover of the Monument's Superintendant. Indeed, resource evaluations, in view of the National Park Service's resource preservation mandate, ought

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to be at least as important as inventories of facilities and equipment! The monitoring system, then, provides an objective, continuing basis of resource measurement and evaluation from one administration to the next.

Plot locations should be revisited and remeasured as often as management deems warranted for issuing regulations, controls, or restorative measures. The natural resources at some locations will change very slowly and at other locations quite rapidly as visitor use intensifies or natural events take place. However, no location should be frequented too often, because accumulated observational disturbances may then exceed or mask possible real effects. Just how often any location should be remeasured is a matter of management's needs and good judgement, as well as available staff time and funding.

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