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THE COMPLEXITY OF MULTIPLE GOAL RESOURCE MANAGEMENT AT U.S. NATIONAL PARKS:
CHARACTERIZATION OF FRAGILE PINYON-JUNIPER ECOSYSTEMS
AT
BANDELIER NATIONAL MONUMENT

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ABSTRACT

In the development of a comprehensive resource management scheme, National Parks may, by their purpose and varied ecosystems, require the holistic consideration of aquatic and terrestrial systems, habitats ranging from desert shrubland to northern conifer forest, cultural and natural resources, pristine maintenance, human recreation and the importance of all indigenous species to the proper functioning of the biological system. Yet, the lack of commercial value of Park resources has contributed to a lack of economic-based justification for the resources needed to adequately address the broad spectrum of biotic communities and goals often encountered within Park boundaries. Management can be further complicated by added resource utilization pressures from non-native animals, especially if the fragile and diverse pinyon-juniper ecosystems are present. Debates on ecological goals and inherentness of soil erosion in disturbed pinyon-juniper ecosystems have resulted in hesitation to implement presumed corrective actions. The argument that because soil erosion is quite common to pinyon-juniper ecosystems, it may be considered natural and therefore allowable, warrants no consideration.

Processes altering the quality of vegetation or causing reduced biological diversities are unallowable because ecological quality and diversity are the criteria which most distinguish Park wilderness from many other public lands. As such, these criteria should be prioritized as very important potential vegetation goals. The fragility of pinyon-juniper ecosystems is such that once disturbances exceed a threshold level, the ecosystem is subject to a retrogressive deteriocomplicating process, a series of ecosystem events adding to an ecological problem in a cumulative and unimpeded fashion, requiring successively more complex solutions.

Key Words: National Parks; resource management; pinyon-juniper; multiple-use.

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INTRODUCTION

Managers of National Parks have a unique set of resource management tasks in preserving historically valuable archaeological resources, managing humans in their pursuit of aesthetic enrichment, and maintaining a multitude of natural resources to reflect the European presettlement condition. Included in these tasks is viewing all indigenous species as significant to the proper functioning of biological systems, as opposed to concentrating on those of commercial value (Bennett 1983). The legislation primarily governing National Parks is the Wilderness Act of 1964, with the purpose of preserving the "primeval" natural conditions of areas designated as wilderness (Bennett 1983). However, difficulties exist in defining "natural" ecosystems for use in prescribing vegetation management goals for Park wilderness (Bonnicksen and Stone 1982, Barnes 1983). In cases where National Parks are also National Monuments, preservation of cultural resources is of prime importance in adhering with the Antiquities Act of 1906.

Expectations of large natural biological species diversities in National Parks have resulted in little or no allowance for disturbances that may have modified the ecological potential of Parks, thus burdening Park resource managers with unachievable goals (Schlatterer 1983). As a solution, some park managers have replaced traditional ecosystem succession goals, such as climax vegetation, with more achievable goals of potential vegetation. However, many Parks which have experienced disturbances do not advance beyond impact assessment. Even where impact assessments are the result of comprehensive scientific research, a lack of relict areas and debates on the criteria for determining ecological potentials has left Park managers with no clear concept of the ultimate goals. Avoiding unwanted or unknown long-term ecological consequences of resource manipulation, Park managers have hesitated to implement presumed corrective actions.

Pinyon-juniper ecosystems, because of their fragility and high variation in biotics, are especially difficult to maintain. The wide range of environmental conditions and numerous plant species of various life-forms within the pinyon-juniper zone precludes management generalizations which can be used throughout. For example, debates on rates

DRAFT

of soil erosion that should be considered normal for pinyon-juniper ecosystems has left Park managers uncertain about whether some ecosystem changes are allowable.³

Meshing these various natural and cultural resource goals into one effective multiple-goal management scheme is further complicated where there are additional resource utilization pressures from non-native animals, including the feral burro. Ecosystem disturbance by feral animals can complicate resource management by societal as well as ecological factors. Controversy has existed over the degree of competition between feral burros and wildlife, and the consequent reductions of large numbers of burros. Emotion on this issue sometimes interferes with management of cultural and natural resources. In addition, dealing with feral animals and the public's concern for them, can at times consume much of the resource managers effort, leaving too little for making decisions on other areas of resource management.

Thus, the complexity of multiple-goal resource management at U. S. National Parks is such that it is becoming increasingly difficult to manage cultural and natural resources in accordance with the Federal Antiquities Act of 1906 and the Federal Wilderness Act of 1964. In short, the end result has been no action, which Niel West so aptly concluded, "is the worst choice for the land".

Bandelier National Monument is representative of the conditions addressed, and was selected as a case study to 1) discuss the complexity of managing the fragile semiarid pinyon-juniper ecosystems of National Parks, to attain multiple goals of historic scene [resource] preservation and preservation of archaeological artifacts and 2) explore management considerations where the already-complex management of cultural and natural resources has been confounded by the influence of feral animals (burros) on ecosystem components.

Bandelier National Monument consists of 13,257 hectares in the southern Rocky Mountains of northcentral New Mexico. It is situated in the southeast portion of the Jemez

³Symposium on pinyon-juniper ecosystems; April 26, 1988; Bandelier National Monument, Los Alamos, New Mexico 87544-9701.

Mountains; elevations range from 1,524 to 3,353 meters. Ecosystem variability is high, ranging from open shrublands of apache plume (Fallugia paradoxa), fourwing saltbush (Atriplex canescens), and big sagebrush (Artemisia tridentata) to spruce-fir (Picea engelmannii - Abies concolor) forests. Numerous north-south and northwest-southeast trending mesas are separated by very deep and steep-sided canyons often sporting vertical walls.

The habitats in the southern portion of the Monument have been highly disturbed by feral burros and trespass cattle (Earth Environmental Consultants, Inc. 1974, Koehler 1974, Potter and Berger 1977). Although the historic feral burro population has not been well documented, herd size reductions occurred intermittently between the years 1946 and 1983. The majority of reductions occurred between 1975 and 1983, lowering the herd size by 223 animals (Morgart and Ohmart 1976, Lissoway 1987). The degree of competition between burros and large herbivores remains a controversial subject (Zarn et al. 1977). In a study of the ecological impact of feral burros at Bandelier, Koehler (1974) and others (Morgart and Ohmart 1976, Potter and Berger 1977, Zarn et al. 1977, Howard and Marsh 1986) concluded that direct competition for forage between burros and mule deer can occur during the winter months.

In a soil survey of the southern two-thirds of Bandelier, Earth Environmental Consultants Inc. (1974) concluded that upland soils on the mesa tops were undergoing accelerated erosion (0.53 cm yr⁻¹) from climatic and biological activity. Ungulate grazing and hoof-action have exposed soil to wind and water erosion to the extent that natural movement of archaeological artifacts has begun.

Bandelier pinyon-juniper ecosystems are especially fragile because the soils are of shallow, highly erodible volcanic tuff origin (Morgart and Ohmart 1976). Thus, an increase in plant cover is of imminent importance to prevent the loss of historically valuable archaeological information and further site degradation. However, natural plant regeneration on southwestern semiarid rangeland is extremely slow following severe disturbance by ungulates (Piper 1968). Although, it has been recently concluded that with protection from

feral burros, a 120% to 160% increase in grass cover could be expected in one-seeded juniper (Juniperus monosperma)/sidecoats grama (Bouteloua curtipendula) habitats (Barnes 1983), the time necessary for such recovery is critical.

SITE CHARACTERIZATION METHODS

To facilitate discussion of the difficulties in managing pinyon-juniper ecosystems of National Parks, a characterization site was located on San Miguel Mesa at Bandelier National Monument. The mesa occupies approximately 2,633 hectares in the southern, more xeric portion of Bandelier and is predominantly a one-seed juniper - pinyon pine/blue grama (Bouteloua gracilis) "habitat type" (Barnes 1983). Soils were tentatively classified as a fine, loamy, mixed mesic family of Lithic Haplustalfs (EECI 1974). Undisturbed soils are shallow, typically consisting of eight cm of gravelly-sandy-loam underlain by 15 cm of clay loam and then eight cm of gravelly sandy clay loam, all containing calcium carbonate (EECI 1974). Rhyolite tuff bedrock is usually encountered at depths of 30 to 90 cm. The climate is semiarid with high diurnal temperatures and infrequent precipitation. The mean annual precipitation is 27.9 cm and the elevation is approximately 1944 m.

In August of 1984, 1985, and 1986 understory cover, density, and frequency of plant species was estimated from four permanent line transects using rated microplots in the Community Structure Analysis (CSA) method (Morris 1973). An importance value (IV) index was computed from relative cover, density, and frequency to assess the structural importance of each plant species in the community. The total IV for all species and maximum possible IV for any species was 3.0. Foliar cover was estimated from 100, 5 x 10 cm rated microplots per transect; density was based on the number of individuals per 10-0.5 m² circular plots; frequency was calculated as the proportion of 0.5 m² circular plots in which a species was present.

The four permanent transects were sampled for soils in September 1987. At every 23 m along each of the transects, three nonrhizosphere soil subsamples were collected to a depth of 15.25 cm with a 5-cm-dia bucket auger. The subsamples were composited by transect,

mixed in a sterile plastic bag, and analyzed for chemical and physical properties.⁴

DISCUSSION

The three year mean for total plant cover was 16.4 and the lowest cover value in 1984 for any sample transect was seven percent (Figure 1). Mean cover, density, and frequency (Table 1) for all species increased in 1985 by 16, 11, and 29 percent, respectively. The majority of this increase was accounted for by tailcup lupine which increased from a mean of 0 to 4.5% cover for the four transects (Figure 2).

Blue grama, an "increaser", was the dominant understory plant as based on the mean importance value (IV) of 1.7 (Table 1). The decrease in mean blue grama cover from 10.25% in 1984 to 8.73% in 1985 represents a 15% decrease. There was no change in blue grama cover from 1985 (10.25%) to 1986 (10.21%). Broom snakeweed (*Xanthocephalum* ~~*Gutierrezia*~~ *sprothrae*), an "invader", had the second highest mean IV, 0.29, and increased in cover 47% from 1984 to 1985. Although the short-term changes measured here are insignificant time-wise, long-term changes such as that, a decrease in a decreaser, blue grama, coupled with an increase in an invader, snakeweed, would indicate a trend of deterioration.

This compared to the results of a study by Potter (1985), who established six-year old exclosures on San Miguel Mesa in an attempt to separate the vegetation changes caused by non-native herbivore grazers (burros and trespass cattle) from those caused by major native grazers (elk, deer, and large rodents). In plots excluding all grazers, Potter found a highly significant decrease in blue grama cover and a highly significant increase in snakeweed. The changes in blue grama and snakeweed cover were similar to those in this characterization, where no grazers were excluded. This suggests that the measured changes were caused by factors other than grazing and supports the concept proposed by Arnold et al. (1964), that control of grazing animals alone in low productivity pinyon-juniper ecosystems will not change the successional trajectory. Furthermore, the measured changes

⁴Samples were analyzed by the New Mexico State University Soil and Water Testing Laboratory.

Table 1. Mean understory plant community data for San Miguel Mesa, Bandelier National Monument, New Mexico. Each value represents the mean of four sampling transects.

Variable	Cover (%)			Density (# 0.5 m ⁻²)			Frequency (%)			Importance		
	1984	1985	1986	1984	1985	1986	1984	1985	1986	1984	1985	1986
Litter	8.77	3.32	5.25									
Rock	4.30	6.07	5.73									
Bare Soil	73.60	72.05	72.58									
Subtotal	86.67	81.44	83.56									
Species ⁵												
blue grama	10.25	8.73	10.18	16.30	12.03	12.08	95	95	92	1.95	1.34	1.76
lupine	0.00	4.53	0.00	0.00	4.40	0.03	0	28	2	0.00	0.54	0.02
annuals	0.38	0.48	0.70	1.73	3.18	2.28	43	55	49	0.32	0.36	0.41
snakeweed	1.30	2.78	3.75	0.40	0.63	0.55	23	30	27	0.21	0.28	0.38
prickly pear	0.47	0.58	0.50	0.38	0.00	0.10	18	0	10	0.14	0.03	0.08
gold flower	0.00	0.18	0.18	0.30	0.90	0.90	8	20	0	0.05	0.12	0.08
globe mallow	0.10	0.10	0.18	0.00	0.20	0.13	0	18	7	0.01	0.08	0.05
red threeawn	0.12	0.40	0.45	0.05	0.15	0.28	5	13	15	0.04	0.07	0.11
cholla	0.07	0.00	0.00	0.00	0.25	0.00	0	15	0	0.01	0.06	0.00
mullein	0.00	0.23	0.30	0.00	0.10	0.15	0	5	7	0.00	0.03	0.06
wolly Indianwheat	0.00	0.00	0.00	0.00	0.08	0.00	0	5	0	0.00	0.02	0.00
apache plume	0.00	0.10	0.00	0.00	0.13	0.00	0	3	0	0.00	0.02	0.00
false terragon	0.45	0.15	0.00	0.45	0.05	0.00	5	3	0	0.08	0.02	0.00
galleta	0.05	0.13	0.13	0.05	0.00	0.00	3	0	2	0.02	0.01	0.01
rabbitbrush	0.00	0.03	0.00	0.00	0.00	0.00	0	0	0	0.00	0.00	0.00
fringed sage	0.42	0.00	0.40	0.16	0.00	0.13	8	0	5	0.07	0.00	0.05
pincushion cactus	0.02	0.00	0.18	0.00	0.00	0.00	0	0	0	0.00	0.00	0.01
mtn. mahogany	0.02	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00	0.00	0.00
pinon(seedling)	0.00	0.18	0.00	0.00	0.08	0.00	0	3	0	0.00	0.02	0.00
Subtotal	13.65	18.60	16.95	19.82	22.38	16.63				2.93	3.00	3.02

⁵Plant species names follow Nickerson et al. (1976).

may indicate that the area continued to deteriorate through the 1970's and early 1980's.

The three year mean cover for litter, rock, and bare soil was 5.8, 5.4, and 72 percent, respectively (Table 1). A 62 percent decrease in litter from 1984 to 1985 was most likely caused by the physical action of the torrential spring rains, which may have also exposed more rock, explaining the 29 percent increase in rock.

Soil chemical and physical properties of transects 1-3 were similar and had a relatively uniform range in values (Table 2). Properties of transect four were substantially higher than transects 1-3 (Table 2). The most notable soil properties in sample four were the high P, Ca, Mg, total N and organic matter (Table 2). These values were most likely the result of large amounts of decomposing burro fecal deposits on San Miguel Ruin, which was closely upslope of the transect.

In 1985 lupine flourished on transect 4, and had an IV of 0.6 (Figure 2). Significant contributions by annual plants to importance values and to the vegetative composition must be evaluated in relation to precipitation patterns (Reppert and Francis, 1973) and in relation to the natural vegetation change following disturbance. Annual plants in semi-arid areas fluctuate significantly from year to year in both cover and density as a result of variation in precipitation (Daubenmire 1968). The study area received approximately 21 cm of precipitation from March through May 1985, which was almost quadruple the mean for that period. The combined effect of the high precipitation levels and the atypical soil properties resulted in the abundance of lupine. Tailcup lupine concentrates alkaloids in its seeds and young plants (Stubbendieck et al. 1981) as an adaptation to alkaline soils such as that of transect 4 (Table 2). Lupine and other annuals are beneficial in that they protect a site from erosion, however their forage value is poor and they may be poisonous (Stubbendieck et al. 1981).

Ruins at Bandelier are perched atop rivulet-born hills where desert pavement and caliche impedes water infiltration and percolation to depths where roots can utilize it. Without adequate soil-root binding, the potential for movement of artifacts becomes greater as rivulets "grow" into erosion streams and then gullies, which then widen and lengthen;

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Table 2. Mean soil chemical and physical properties at San Miguel Mesa, Bandelier National Monument, New Mexico.

Trans No.	<u>Percent</u>				<u>General Chemistry</u>				<u>Nutrient Concentration (ug.g-1)</u>							
	<u>Tex.</u>	<u>Sand</u>	<u>Silt</u>	<u>Clay</u>	<u>%OM</u>	<u>pH</u>	<u>EC</u>	<u>SAR</u>	<u>NO₃</u>	<u>NH₄</u>	<u>TKN</u>	<u>P</u>	<u>Na</u>	<u>K</u>	<u>Ca</u>	<u>Mg</u>
1	Loam	47	31	22	1.1	6.1	0.17	0.44	2.7	1.75	835	3.1	8.3	8.6	21	3.5
2	Loam	52	30	18	0.8	6.4	0.30	0.47	2.3	1.63	616	1.4	11.3	14.5	34	6.2
3	S.Lm	59	27	14	0.8	6.4	0.32	1.83	2.3	1.60	616	1.6	27.8	11.3	13	2.8
4	S.Lm	64	21	15	2.2	7.2	0.77	0.97	2.4	1.93	960	37.6	41.9	23.9	97	15.0

eventually gully erosion will cut into ruins rendering them unstable. An obvious sign of soil erosion was pedestalled plants with exposed roots, a condition which was common in the San Miguel Ruin area (Figure 3). The microphytic crust of intermingled mosses, lichens, algae, and fungi that is common to pinyon-juniper communities where disturbances have been minor (West 1984) was absent. Desert pavement was present in the study area (Figure 4) and mesa tops showed some evidence of caliche. These soil conditions will hinder seed germination and seedling reestablishment success, therefore some soil preparation is necessary. However, rough terrain and Park Service wilderness management policy prevent the use of machinery for soil preparation.

Natural plant regeneration on southwestern semiarid rangeland is extremely slow following severe disturbance by ungulates (Piper 1968). Therefore, reliance on natural revegetation to stabilize disturbed soils may be too slow to prevent further development of water rivulets and their conversion into small streams and then gullies. A 120 to 160 percent increase in grass cover following protection from feral burros was predicted for juniper/sideoats grama habitat types (Barnes 1983). However, while post-disturbance recoveries of this magnitude might be expected to occur in post-disturbance sites, the time required for such recovery is critical to minimize soil loss and artifact displacement. If initial grass cover in these areas is low, the resultant grass community following a natural increase of that magnitude may still fall short of that necessary to achieve adequate site protection and artifact stabilization. Lastly, pinyon-juniper ecosystems usually have an insufficient supply of seed reserves of desirable forage plants for their reestablishment in low productivity areas (Koniak and Everett 1982, West 1984).

Revegetation can also present special problems to National Parks because of uncertainty about the desired ultimate vegetation composition. The policy of managing vegetation composition to reflect "primeval" natural conditions is problematic. Schlatterer (1983) discussed problems in setting climax vegetation as a goal. An assumption that the present climate is the same as that of the pre-European period cannot be made. It is also difficult to define pristine vegetation composition because records are sometimes too general

or incomplete. While relict sites may exist, there is no assurance that similar site conditions could be achieved because of historic changes in biotics that may have modified the potential of the area. In pinyon-juniper ecosystems, these modifications often result in reduced site vegetation potentials that are permanent (West 1984). The permanency is especially true of wooded sites where allelopathy by pinyon and juniper trees, in addition to harsh soil and other environmental conditions, prevent soils from being covered by plants or litter for any effective period of time (West 1984).

As opposed to using relict sites, Barnes (1983) explored the use of habitat type analyses in classifying habitat types of a relatively non-impacted pinyon-juniper ecosystem in the Pajarito Plateau and estimating site quality and recovery potential of that which was moderately to heavily impacted. Extensive data were collected on plant species cover, density and frequency to establish "baseline" data of pinyon-juniper woodland for current and future comparison to impacted sites. The baseline data was established by classifying habitat types of pinon-juniper woodland that had experienced minimal impact from logging, grazing or recreational use 40 years prior. This data represents the area, number and distribution components of the potential vegetation for the type and should be used as such established goals. Because plant species diversity is important in distinguishing Park wilderness from that of other public lands, it should serve as a primary component of vegetation potential goals.

Using Barnes' plant density and frequency data, plant species richness for relatively nonimpacted pinyon-juniper/blue grama habitat sites was estimated, as shown in Table 3, and compared to that of analagous but impacted sites having experienced heavy grazing. Table 3 also lists the per hectare plant species richness averaged from 20 Utah and 10 New Mexico pinyon-juniper sites (Harner and Harper 1976). Although the impacted Bandelier site had 67% (30 species less) of the species richness in the non-impacted site, it averaged approximately 120% (10 species more) of the species richness for the Utah-New Mexico habitat type representative.

The first comparison supports the concept that ecosystem disturbance generally

Table 3. Plant species richness of three pinyon-juniper ecosystems; 1) baseline and 2) impacted at Bandelier National Monument and 3) a representative of the type.

<u>No. Species in Bandelier PJ/Blue Grama Type</u>			
<u>Life-form</u>	<u>Baseline (0.64 ha)</u>	<u>Impacted (0.38 ha)</u>	<u>Average (1.0 ha)⁶</u>
Trees	2	2	2
Shrubs	19	9	10
Perennial grasses	24	16	8
Perennial forbs	33	26	17
Annuals & biennials	13	8	14
Total Vascular	91	61	51
Microphytes	-	-	6

⁶Harner and Harper (1976) decreases species diversity (Odum 1988).

The second comparison might be explained by the concept that site heterogeneity and favorability accounts for most (84% in New Mexico) of the observed variation in species diversity (Harner and Harper 1976). If left unmanaged, disturbed pinyon-juniper ecosystems are likely to incur encroachments of pinyon and juniper trees into most areas that have lost their understory cover. Eventually, as foliar cover by these trees increases, plant species diversity will be lowered further by competition factors such as allelopathy. Lack of seed sources and wind may also contribute to interspace soil surfaces being void of plants or litter for any effective period of time.

Plant species richness and most other plant parameters quantify vegetation. However, the quality of vegetation is a most important distinguishing criteria of Park wilderness, therefore plant parameters for determining such must be incorporated into assessments of site quality and potential vegetation. Monitoring the proportion of C3 grasses to C4 grasses is one method used to monitor quality of vegetation since C3 grasses generally constitute a high percentage of total grass cover on relict pinyon-juniper sites compared to that of grazed sites (Jameson et al. 1962, Mason et al. 1967, Thatcher and Hart 1974).

While, the habitat type systems use of one to a few dominant plant species yields quick information on quality of seral plant communities, all plant species including microphytes must become increasingly important in monitoring quality of mature communities or as mature communities are approached. This may be accomplished by determining importance value indices for all plant species. Although a painstaking process, these indices should be determined for all existing vegetation units in a Parks wilderness. Then only by their comparison to the respective potential vegetation for a community, could adequate assessments of plant community quality be made and vegetation management goals clarified.

CONCLUSION

Debates on inherentness of soil erosion and ecosystem goals of pinyon-juniper ecosystems have retarded progress toward post-impact rehabilitation at National Parks. The question

DRAFT

of acceptable erosion rates in pinyon-juniper ecosystems is only somewhat controversial, but, in the mind of the management generalist, may be additional cause to hesitate in acting toward stabilization of ruins and deteriorating natural resources. At Bandelier, for example, few argue that because soil erosion is quite common to pinyon-juniper ecosystems, it is a natural process and therefore, should be justified by interpreting the causes. This seems to promote acceptance of reduced biological diversity, which is not in accordance with the Federal Wilderness Act, nor is it appropriate for the purpose and aesthetics of many parks such as Bandelier.

The fragility of pinyon-juniper ecosystems is such that once disturbances initiate retrogression, a series of ecosystem processes each having their individual events and stages add to the total problem in a cumulative fashion, requiring successively more complex solutions. This phenomenon I describe as deteriocomplication.

At Bandelier for example, deteriocomplication of pinyon-juniper ecosystems may include several processes: 1) the gradual reduction in understory plant cover leading to water and wind sheet erosion of soil, plant pedestalling, exposure of caliche and desert pavement formation; 2) the conversion of water rivulets into streams, then gullies; 3) the gradual increase in pinyon and juniper tree dominance and their exclusion of understory, culminating in reduced biological diversity. The complexity of the problem increases at each event in the deteriocomplicating process and each respective management solution demands more time, labor, and financial resources. At Bandelier, ~~for example,~~ whereas only regulation of grazing in the early 1960's might have eliminated a decline in plant cover, the successive corrective actions required after that may have included a large-scale reduction of feral burros, indiscriminate seeding without soil preparation, rock and stick rubbing of erosion streams, litter enhancement, and ~~finally,~~ soil preparation with discriminate seeding. Further lack of action within the next ten years, may result in the need to implement a more-comprehensive reclamation effort including ~~revegetation~~ and topsoiling. Eventually, control of gully erosion using check dams and then selective cutting of pinyon and juniper trees may be deemed necessary in more of a rehabilitation effort.

The concept that more than grazing regulation is needed to change successional trajectories of disturbed low productivity pinyon-juniper ecosystems has been supported by studies at Bandelier. The lack of natural seed sources and poor soil conditions are likely to preclude any appreciable plant regeneration, ruling out reliance on natural recovery as a management option. Soil stabilization through artificial seeding of native plant seed is warranted.

Restoration, where the exact predisturbance conditions are replicated, was intended for areas of archaeological value and is realistic only in those areas considered to be minimally disturbed (Box 1978). Reclamation, where the sites are made habitable to organisms originally present in approximately the same composition and density, may be the goal at most disturbed pinyon-juniper ecosystems. Reclamation is important to shorten the time period of plant succession to a stable community (Ogle and Redente 1988).

Reclamation in severely disturbed pinyon-juniper ecosystems of National Parks presents technical and political problems which preclude the use of effective machine-intensive surface reclamation methodologies. While harsh soil conditions, the lack of topsoil and lack of litter largely prevent establishment of seeded plants, there are simple solutions. Logs, brush, and twigs should be used as soil drifts to rebuild the topsoil, improve the seedbed for seedling establishment, moderate soil surface temperatures and serve as moisture retainers (West 1984). This practice is economically feasible, produces no undersirable effects, and can be implemented immediately. In remote and designated wilderness areas where vehicles are forbidden, the deadwood can be gathered from the area. Ample time should be allowed for soil accumulation prior to seeding.

Broadcast aerial seeding, although labor extensive, is expensive. Manual seeding of small scattered patches using hand rakes will be more effective, make the reclamation less obvious and increase the forage value to wildlife (West 1984). The expense would be minimal, especially if volunteer groups such as scouts and youth conservation corps are involved.

Although soil stability can be provided by annuals such as lupine, care should be

taken to avoid species which create "closed community situations", where species that are aggressive retard succession by slowing invasion of other species (Ogle and Redente 1988). Pinyon and juniper tree invasion can also present such a closed community, after which the reclamation effort will require drastic measures including selective cutting. The plant species diversity that is inherent to each of a Parks habitat types should be known and should be prioritized as a potential vegetation goal, especially in designated wilderness areas.

Although total plant cover is important to soil stabilization, environmental resistance factors will regulate the ultimate cover (Ogle and Redente 1988).

Park resource management, perhaps more than that of any other public land, requires flexibility. High site heterogeneity of Parks requires that impacted areas be addressed by management efforts of general ecologists who are able to apply their knowledge and skills to different ecosystem types within the Park such that prescribed corrective actions in resource management plans be tailored specifically to each ecological unit. Because there is less commercial value attached to the resources of Parks there has been little economic-based demand for this type of professional and, therefore, a lack of them. In other than pristine situations, there may be no alternative but to manage ecosystems for ecological potentials, which allows for climate change, the effects of disturbances, and other biotic and abiotic changes.

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DRAFT

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