

SOIL SURVEY
AND
SURVEY OF RANGE AND ECOLOGICAL CONDITIONS
ON A SOUTHERN PART OF
BANDELIER NATIONAL MONUMENT

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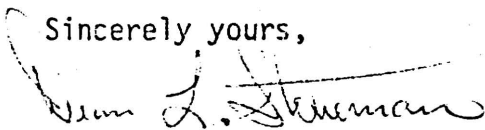
Mr. Roland Wauer, Regional Scientist
Southwest Regional Office
National Park Service
Box 728
Santa Fe, New Mexico 87501

Dear Mr. Wauer:

Studies of soils and vegetation on a southern part of Bandelier National Monument have been completed. These studies were conducted by Dr. Dean L. Stoneman, Soil Scientist, Mr. Roy S. Mann, Biologist, and Mr. Dellon N. Cox, Agronomist. These personnel have all had extensive experience in their respective fields.

As you will note from the contents of this report, we have concluded that the natural habitat at the Monument has been severely altered and degraded by the intrusion of non-native species, specifically burros and domestic cattle. It is apparent that this degradation will continue and restoration will be impossible unless the burros and cattle are excluded from Bandelier National Monument.

Sincerely yours,



Dean L. Stoneman
President

DLS:gs

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ABSTRACT

Soils, vegetation trends and conditions were assessed on a large part of Bandelier National Monument during the summer of 1974. In practically all parts of the study area a deteriorating situation was found. Because of vegetation deterioration, serious accelerated soil erosion has occurred and ecological changes are rapid. Results of this investigation indicate that burros and/or cattle graze on most of the Monument and are largely responsible for its rapidly deteriorating condition. In order to initiate restoration procedures for returning the Monument to a natural habitat, it will be necessary to eliminate the destructive activities of these grazing animals. The most effective method to achieve this end is the exclusion of cattle and burros on the Monument. Although serious damage has already occurred on the Monument, if the current rate of deterioration is allowed to continue, the value of the area as a natural habitat will be further degraded.

SOIL SURVEY
FOR
A SOUTHERN PART OF
BANDELIER NATIONAL MONUMENT

SOIL SURVEY FOR A SOUTHERN PART OF BANDELIER NATIONAL MONUMENT

INTRODUCTION

Approximately 25,000 acres of Bandelier National Monument were surveyed to determine soil characteristics and conditions. The area that was surveyed is shown on the Soil Map, but essentially is bounded by Forest Service land on the west, Cochiti Grant on the south, the Rio Grande on the southeast, Frijoles Canyon on the northeast and an arbitrary line on the northwest.

Soil names and classifications used in this report are tentative as correlation is not yet complete. This accounts for the term "unnamed" soils being used throughout the report. Wherever possible, soil mapping units were patterned after those used by the Forest Service in the adjacent areas. The soils are classified according to the "Soil Taxonomy of the National Cooperative Soil Survey" from the unedited text of selected chapters printed by Soil Survey, Soil Conservation Service, U. S. Department of Agriculture, Washington, D. C., December, 1970. This system does not classify "land types" such as rock land, consequently, map units consisting of land types are not classified in the descriptions of map units beyond the map unit names which indicate the land type.

It is not the intent of this report to replace on-site investigations and engineering tests for specific structures. In addition, this report is not designed to provide detailed data for

limited areas, but rather portrays general conditions on an overall basis. It should be kept in mind that some variation in soil characteristics may occur within individual delineations.

LOCATION AND TOPOGRAPHY

The 25,000 acres covered by this survey are in northcentral New Mexico approximately 50 miles north of Albuquerque and 22 miles west of Santa Fe. Within the area surveyed, elevations range from about 5300 feet along the Rio Grande to about 7100 feet along parts of the northwest boundary.

The topography of this area is variable and is composed primarily of narrow floodplains and terraces, steep rocky escarpments and gently to moderately sloping mesa tops. Some mountainous terrain occurs in the northwest part of the surveyed area. The most dominant aspect of the topography consists of the north-south and northwest-southeast trending mesas that are separated by very deep and steep-sided canyons. Many of these canyons are 700 to 800 feet deep.

CLIMATE

The climate at the survey area is arid to semiarid with an average precipitation around 15 to 17 inches. Most of the precipitation falls during the months of

July and August. The temperature regime is characterized by wide variations both seasonally and daily. The annual average temperature is near 50°F, whereas, December, the coldest month, averages about 26°F and the hottest month, July, averages near 72°F.

GEOLOGY

Bandelier National Monument is situated on the eastern flank of the Jemez Mountains. These mountains are essentially volcanic in origin and geology at the Monument is intimately associated with the volcanic nature of the region.

Briefly, rocks exposed in the survey area consist primarily of limited areas of Tertiary and perhaps Pleistocene sediments and extensive areas of rhyolite tuff with some basalt. Recent alluvium occurs along the Rio Grande and streams in the area.

The oldest rocks exposed in the survey area are red sandstones and shales of the Galisteo formation (probably Eocene and Oligocene) and sandstones and gravels of the Santa Fe formation (probably Miocene or later). These rocks are of limited extent and are exposed along the southeast flank of the San Miguel Mountains in the northwest part of the survey area.

Basalt flows underlie most of the area surveyed and are exposed primarily along deep arroyo cuts near the Rio Grande. Overlying the basalt in most places is the Bandelier rhyolite tuff. This tuff is generally thin near the Rio Grande, but thickens to 100 feet and more westward. Bandelier rhyolite tuff is the primary parent material for soils in the survey area and crops out in most canyons and ar-

royos as well as on the mesa tops in many places.

Unconsolidated deposits of pumice occur as patches covering the rhyolite tuff. However, these deposits are not of large extent and are usually only a few inches to several feet in thickness.

SOILS

The soils on the southern 2/3 of Bandelier National Monument were studied and mapped during the summer of 1974. The various kinds of soils were examined, described and notes were taken as to the soil characteristics. Soils having similar characteristics (consequently similar behavior) were grouped together into mapping units. Because of the soils occurrence (position and extent in the landscape) and the scale of maps used, it was impossible to separate each and every individual kind of soil and land type on the map. As the scale (detail) of mapping allowed, individual kinds of soil were separated into mapping units on the soil map. In some instances where it was necessary to combine different kinds of soil or rock land into a single unit, on the map, individual soils and their relationship, one to another, are described in the map unit descriptions.

Nine mapping units were delineated on the Soil Map. Of these nine map units, five are rock land types. Rock land is defined as land areas having enough rock outcrop and very shallow soil (less than 10 inches) to submerge other soil characteristics. Rock land is the dominant feature on the study area and occurs as rock outcrop on tops of mesas and canyon walls. The soils on the study area occur as thin mantles on mesa tops, shallow and moderately

deep soils on more stable topographically depressed areas, moderately deep and deep soils in pumice deposits and shallow to deep soils in the alluvial and colluvial canyon bottoms.

It is of interest to note that the rock land will support almost zero vegetative biomass on the steep canyon walls, and up to 350 pounds per acre per year where slopes are less than 15 percent. The shallow and moderately deep soils and the droughty pumice soils will support a vegetative biomass of 500 to 1800 pounds per acre per year. The deep alluvial soils will support a vegetative biomass of 4000 pounds or more per acre per year.

MAPPING UNIT DESCRIPTIONS

Map Unit 1 - Rhyolite Tuff Rock Land
Unnamed shallow soil complex,
3 to 15 percent slopes

Map Unit 1 is extensive and occurs on mesa tops. The parent material for this unit is primarily rhyolite tuff which crops out along tops and edges of the mesas and in eroded drainageways. These rock outcrops are a major feature in this map unit although shallow soils occur on the broader, flatter areas and in pockets, depressions, cracks and crevices in the rock. The unnamed shallow soil typically has a surface layer composed of about three inches of gravelly sandy loam that has weak, fine granular structure and a Unified Engineering Classification of SM. This layer is usually underlain by about six inches of clay loam with moderate, medium subangular blocky structure and a Unified Engineering Classification of CL. This layer is usually underlain by about three inches of gravelly sandy clay loam that

contain some visible calcium carbonate and has a weak, medium subangular blocky structure and a Unified Engineering Classification of SC or CL. This layer is usually underlain by rhyolite tuff.

Where soils remain in this map unit, accelerated soil erosion is a common feature. Because of the abundance of rock outcrop and the thinness of soils, this map unit has rather severe limitations for most uses. The gentle to moderate slopes of this map unit make it amenable to foot traffic by people and animals. However, most animal trails are deeply worn.

The unnamed shallow soil in this map unit is tentatively classified by the "Soil Taxonomy of the National Cooperative Soil Survey" as a fine, loamy, mixed mesic family of Lithic Haplustalfs.

Where vegetation exists on this map unit, Blue Grama is the dominant grass with lesser amounts of Black Grama and Galleta. Juniper is the dominant woody species with lesser amounts of Pinon and occasional Ponderosa Pine in the drainageways.

Where this map unit joins the National Forest on the western boundary of the Monument, it is included in the Forest Service Mapping Unit 635 (uncorrelated map units from the field descriptive legend of Santa Fe National Forest Soil Survey as of July, 1974, Louis Young, Party Leader) Yelo-Comada complex, zero to 15 percent slopes.

Map Unit 2 - Unnamed shallow and moderately deep soil complex,
3 to 15 percent slopes

Map Unit 2 is of moderate extent and occurs on mesa tops, on sideslopes of

ridges, and in topographically depressed areas. The map unit occurs most frequently on east-and southeast-facing slopes. The unnamed shallow to moderately deep soil typically has a surface layer of about four inches of gravelly sandy loam that has weak fine granular structure and a Unified Engineering Classification of SM. This layer is usually underlain by about six inches of sandy clay loam that has moderate, medium subangular blocky structure and a Unified Engineering Classification of SC or SM. This layer is usually underlain by about six to 24 inches of gravelly sandy loam that is single-grained or has weak, medium subangular blocky structure and a Unified Engineering Classification of SM. This layer usually has some accumulation of lime in the upper part. Rhyolite tuff bedrock is usually encountered at depths of 12 to 36 inches. The small gravels throughout the soil profile consists mainly of rhyolite tuff and pumice.

The unnamed shallow and moderately deep soils in this map unit are tentatively classified by the "Soil Taxonomy of the National Cooperative Soil Survey" as fine loamy, mixed, mesic family of Lithic Haplustalfs.

Little Bluestem is the dominant grass on this map unit with lesser amounts of Blue Grama, Arizona Fescue and June Grass. Ponderosa Pine is the dominant woody species with lesser amounts of Pinon, Juniper and Apache Plume.

Soil erosion on this map unit is variable. Soil removal varies from slight sheet erosion to severe accelerated erosion where V-shaped gullies occur. Soils in this map unit have few limitations for most engineering uses except for those in which the shallow to moderate depth to bedrock is detri-

mental. The gentle to moderate slopes of this map unit make it amenable to foot traffic by people and animals.

On adjacent National Forest lands this map unit is included in Forest Service Mapping Unit 635 Yelo-Comada complex, zero to 15 percent slopes. Soils in this map unit are very similar to the Yelo soil series except they are shallower to bedrock.

Map Unit 3 - Unnamed pumice soil,
3 to 15 percent slopes

Map Unit 3 is of moderate extent and occurs primarily in pumice deposits on the mesas and in colluvial slopes in the canyons. The pumice deposits occur mainly on northeast-, east- and southeast-facing slopes. Typically, this soil contains a thin argillic horizon and some accumulation of lime below the argillic horizon. A typical profile would have about four inches of raw pumice gravel as a surface layer over a very gravelly sandy clay loam argillic horizon about six inches thick having weak, medium subangular blocky structure. The argillic horizon usually has a Unified Engineering Classification of SM or GM. Normally, below the argillic horizon is raw pumice with an accumulation of lime in the upper part. The pumice varies in depth from about 20 inches to greater than five feet. It is underlain by a variety of geological materials. In places the pumice was deposited on rhyolite tuff, whereas in other places it overlies shallow and moderately deep soils which, in turn, are underlain by rhyolite tuff. In the canyons the pumice overlies old cobbly, stony, colluvial soils.

Accelerated soil erosion is a common feature of this map unit as V-shaped

gullies frequently occur. The thin soils in these pumice deposits have few limitations for most engineering uses except those uses that require slow permeabilities.

The unnamed soil in this map unit is tentatively classified by the "Soil Taxonomy of the National Cooperative Soil Survey" as a cindery, mesic family of Typic Haplustalfs.

Grass is sparse on this map unit, but includes Blue Grama, Little Bluestem, Sideoats Grama and Arizona Fescue. Apache Plume is the dominant woody species with some Juniper and Pinon. In the higher elevations Ponderosa Pine is common.

On adjacent National Forest lands this map unit is included in the Forest Service Mapping Unit 635 Yelo-Comado complex, zero to 15 percent slopes and in Mapping Unit 638, pumice soil, tuff soil-rock outcrop complex, 41 to 120 percent slopes.

Map Unit 4 - Rhyolite Tuff Rock Land, 0 to 15 percent slopes

Map Unit 4 is extensive and represents large areas on mesa tops where soils have been eroded away leaving bare exposed rhyolite tuff bedrock. Shallow loamy soils material exists only in pockets, cracks and crevices in the bedrock.

Because of the exposed bedrock, this map unit has severe limitations for many engineering uses. Because of the gentle to moderate slopes, this map unit is amenable to foot traffic by people and animals.

Vegetation is sparse but with some Juniper and Pinon on the mesas and some Ponderosa Pine in drainageways. Blue Grama often occurs where patches of soil exist. This map unit is included in Forest Service Mapping Units 635, 638 and 117 on adjacent National Forest lands.

Map Unit 5 - Very Steep Rhyolite Tuff Rock Land, 45 to 120 percent slopes

Map Unit 5 is moderately extensive and occurs as very steep canyon walls and cliffs. It contains little or no vegetation and is generally inaccessible to humans and most animals. This unit has very severe restrictions for engineering uses and for most wildlife. This map unit is included in Forest Service Mapping Units 116 and 117 on adjacent National Forest lands.

Map Unit 6 - Unnamed stony, colluvial soil, 15 to 75 percent slopes

This map unit occurs as stony, cobbly colluvial soil materials at the foot of steep canyon walls. It occurs below the steep rock land on the canyon walls and above the gently sloping alluvial soils in the canyon bottoms. The colluvial soils vary greatly in depth. They are shallow on the upper slopes where they join the canyon walls and are several feet thick where they coalesce with the alluvial soils on the lower slopes. A typical profile consists of a deep, very stony cobbly sandy loam or loam. There is some accumulation of organic matter in the surface layer and organic matter decreases with depth. In a few localities, there is a weak

accumulation of lime in the lower part of the profile. The principal feature of a typical profile is the large amount of stone and cobble.

Steep slopes and stoniness make this map unit limiting for most engineering uses and make foot traffic difficult for people and many animals.

The typical soil in this map unit is tentatively classified by "Soil Taxonomy of the National Cooperative Soil Survey" as a loamy skeletal, calcareous, mesic family of Typic Ustorthents.

The vegetation on this unit consists mainly of Blue Grama, Sideoats Grama, Little Bluestem, Galleta Grasses and Pinon, Juniper, Mountain Mahogany, Curl Leaf Mahogany and occasional Ponderosa Pine.

This map unit is included in Forest Service Mapping Units 116 and 117 when it occurs on adjacent National Forest lands.

Map Unit 7 - Unnamed sandy, gravelly alluvium, 1 to 3 percent slopes

Map Unit 7 is of moderate extent and occurs only in the bottoms of canyons along the major drainageways. The soils are mainly deep with varying amounts of sand, gravel, cobble and stones. Included in the map unit are areas of cobbly, stony stream wash and areas that are subject to seasonal flooding. The unnamed alluvium typically has a surface layer of about 12 inches of gravelly sandy loam containing some cobble and occasional stones. This layer is often high in organic matter and frequently has a layer of organic litter on the surface. This layer usually has strong fine

granular structure and a Unified Engineering Classification of SM. Underlying this layer is several feet of very gravelly cobbly sandy loam or loamy sand. This layer is usually stratified with stream washed cobble and stones.

Except near the streams or where flood hazards exist, this map unit has few use limitations. Deep soils, additional runoff water from surrounding areas and gentle slopes all combine to give this unit the largest biomass potential of any soil on the Monument.

The typical soil in this map unit is tentatively classified by the "Soil Taxonomy of the National Cooperative Soil Survey" as a coarse loamy, mixed, mesic family of Aquic Haplustolls.

Because of the additional moisture and shallow ground-water in some areas, this unit has the most diversified vegetation on the Monument. Some of the most frequent species of vegetation include Ponderosa Pine, Narrow Leaf Cottonwood, several species of Juniper, Pinon Pine, wild cherry, wild grape, wild rose, currants, wild strawberry, Virginia Creeper, Mountain Broome, Mountain Muhly, Sideoats Grama, Blue Grama, Little Bluestem and a variety of annual weeds and flowers.

Where these alluvial soils occur on adjacent National Forest lands, they are included in Forest Service Mapping Units 113, 116 and 117.

Map Unit 8 - Basalt Rock Land Complex, unnamed shallow soil, 3 to 15 percent slopes

Map Unit 8 is not extensive and occurs only in the southeastern part of the Monument near the Rio Grande. It occurs

as high basalt mesas above the river. This map unit is very similar to Map Unit 1, except the shallow soils are forming in basalt parent materials and basalt crops out rather than the rhyolite tuff as in Map Unit 1. Other characteristics of this map unit are the same as described in Map Unit 1. The user is referred to that description for further details of this unit.

This unit is included in the Forest Service Mapping Unit 113 where it occurs on adjacent National Forest lands.

Map Unit 9 - Sandstone Rock Land, 15 to 75 percent slopes

Map Unit 9 is not extensive and occurs in the southwestern part of the Monument near Red Rock Canyon. It occurs as steep hills of stratified sandstone and shale of the Galesteo geological formation. The beds of sandstone range in color from nearly white to buff to red with red being the dominant color. There are thin patches of rocky, stony shallow soils that occur in depressions, cracks and crevices in the bedrock. These shallow soils are cobbly sandy loam for the most part, but are deeper and clayey in areas where red shale crops out.

Erosion is severe and, because of the rock outcrops and steep slopes, this unit has severe limitations for most uses.

Blue Grama is the dominant grass on this map unit with lesser amounts of Little Bluestem, Sideoats Grama and Galleta. Juniper dominates the woody species with lesser amounts of Pinon, Mountain Mahogany, Oak Brush and occasional Ponderosa Pine between ridges

and in drainageways. This map unit is not known to occur on adjacent National Forest lands.

FORMATION OF THE SOILS

This section discusses the major factors of soil formation as they relate to the soils of Bandelier National Monument.

Factors of Soil Formation

Soil is formed in parent materials that have been deposited or accumulated by geologic agencies. It is produced by physical and chemical weathering and other soil-forming factors acting on the parent materials. The characteristics of a soil at any given point are determined by the kind of parent materials; the climate under which the soil materials accumulated and has existed since accumulation; the biological activity in and on the soil; the topography; and the length of time these soil-forming factors have acted on the soil materials.

Climate and biological activity are active factors in soil formation. They act on the parent material to slowly change it into a natural formation having genetically related horizons. The effects of climate and vegetation are conditioned by topography. The kind and nature of parent material effects the kind of profile that is formed. Finally, time is needed to change the parent material into a soil profile. The time needed to form horizons is variable, but generally long periods of time are needed for the formation of distinct horizons.

The interaction of all the soil-forming factors determines the characteristics of the soil profile. The interaction of the factors is complex, and it is difficult to isolate the effects of any one factor. In some areas the effects of four factors may be nearly constant so the effects of the fifth factor can be evaluated. Even in these areas, however, measurements of the effects cannot be exact.

Parent Material Factor

The soils in Bandelier formed primarily in four kinds of parent materials. These are acid igneous rocks, alluvial and colluvial sediments, basic igneous rock and sedimentary rocks.

The acid igneous parent materials include rhyolite, rhyolite tuff and pumice. The areas of Bandelier in which this type of parent material is dominant are in Map Units 1, 2, 3, 4, 5 and 6 as shown on the soil map at the back of this survey. This kind of parent material is the most common on the Monument and occurs as long broad mesas with steep canyon walls. The alluvial and colluvial sediments are materials that have been deposited in canyons between the mesas and along the Rio Grande. These materials, especially those directly adjacent to stream courses, have been transported mainly from hills and mountains upstream and vary in mineralogy as a reflection of the source area. The materials have been mixed and sorted in transport and have a wide range of minerals and particle sizes. The areas in Bandelier in which alluvial sediments are dominant are in Map Unit 7. Colluvial materials are usually located at the base of steep slopes and their character reflects the nature of upslope material.

Basic igneous parent materials make up a small percent of the Monument and occur along the Rio Grande. Basalt is the major kind of rock included in this type of parent material. Areas of soils formed in basic igneous parent materials are in Map Unit 8.

Sedimentary parent materials consist mainly of sandstone rocks. The major areas where these materials occur are in the area of Red Canyon in the southwestern part of the Monument. They are in Map Unit 9.

Climate Factor

The climate of Bandelier is continental. It is characterized by wide annual and daily temperature ranges and distinct seasons. Spring and fall are warm and dry. Summer is hot, and a moderate amount of rain falls as a result of thunderstorms. Winter is mild and precipitation falls as light showers and snow. Because of high temperature and low humidity, evaporation rates are high. The soils usually are not leached of the basic elements, because of the small to moderate amount of rainfall. As a result, most of the soils in Bandelier have a high base saturation. Even though the soils have not been leached of basic elements, some soils show evidence of calcium carbonate movement through the profile. Where this has occurred the soils are free of lime in their upper part, but have accumulations of lime in the lower part of the soil profile. These soils also show evidence of clay having been translocated from the A horizon to the B2t horizon in some cases.

Wetting and drying, freezing and thawing, and the depth to which the soils are wetted influence the formation of the soil horizons. The effects of these

actions are modified by other soil-forming factors. The presence and depth of lime accumulation in some of the soils indicate the average depth to which water moves. The finer-textured soils generally have a lime zone at shallower depths than the coarser-textured soils because the water does not penetrate so deeply. The coarse-textured soils and the alluvial soils, where they receive additional water because of runoff from surrounding areas, usually do not have a zone of lime accumulation.

Biological Activity Factor

Plant and animal life, both on and in the soil, is an active factor in soil formation. As plants die and decay, they add organic matter to the soil. This darkens the upper part of the soil profile. The soils at higher elevations have a darker surface layer than the soils at lower elevations in Bandelier because the soils at higher elevations receive more precipitation and support a larger biomass and organic materials decompose at a faster rate. The soils in swales and canyons, which receive runoff water from surrounding areas, are darkened to a greater depth than the surrounding soils. They support more plant life because they receive more moisture.

Many kinds of micro-organisms are needed to transform organic remains into humus from which plants can obtain nutrients. Earth worms and small burrowing animals such as badgers, gophers and ground squirrels, influence soil formation by mixing the organic and mineral parts of the soil. This action deepens the zone in which organic matter accumulates. Because

soil life thrives in a moist, warm environment, it is most active in Bandelier during the summer rainy season.

Topography Factor

The topography of Bandelier is characterized primarily by moderately to strongly sloping areas on the tops of large mesas and intervening very deep canyons with steep canyon walls.

Soils on gentle slopes commonly have a more distinct profile than the soils on steeper slopes. This is because the steeper areas generally erode before distinct horizons can form. Also, the amount of moisture that enters the soil decreases as the slope increases. Where slopes are greater than three percent, generally more than half the rainfall runs off. Several factors other than slope influence the amount of runoff. Some of these are amount of bedrock exposure, soil texture, intensity of rainfall and vegetative cover.

In Bandelier there is an exception to these general rules in that the gently sloping soils on flood plains do not have distinct horizons because they formed in recently deposited alluvial sediments and have not had time to develop.

Time Factor

A considerable length of time is required for the formation of soils. After the parent materials have been deposited or have accumulated in place through weathering, the surface soil is darkened by the accumulation of organic matter. Calcium carbonate (lime) and soluble salts are leached downward from the surface

soil. The movement of clay downward proceeds more slowly. When clay is leached from the A horizon, it accumulates and develops a B horizon. The rate of this process depends on several factors, including how rapidly the parent materials are weathered, the soil temperature, the amount of moisture moving through the profile and percentage of clay.

The nature of the parent material greatly influences the rate of soil formation. Quartz, for example, weathers so slowly that soils high in quartz may not have distinct horizons, regardless of time. Soils in Bandelier that formed in igneous materials, mostly rhyolite and basalt, form at moderate rates. In Bandelier, under present conditions, rainfall is low to moderate and long periods of time are required to leach lime from the upper horizons. Some of the alluvial soils in the canyons have faint horizons because the materials in which they are forming have been deposited so recently that the horizon-forming processes have had little time to work.

The age of the soil is not the same as the geological age of the parent material. The soils are always younger than the geological parent materials. Long periods of time are required before the geological material is stable with respect to slope and erosion. It must be relatively stable before the soils can form. In Bandelier, the oldest soils are on the mesas. These soils generally have the most distinct horizons.

TRENDS IN SOIL FORMATION ON BANDELIER NATIONAL MONUMENT

It was noted that most of the mapping

units on Bandelier National Monument were actively eroding. This is especially true with respect to the upland soils on the mesa tops. The rather strong profile development in these upland soils indicates that they were formed under more stable conditions than presently exist. Consequently, it is evident that the soils are in a process of degradation. Since the soil-forming factors of parent material and topography are essentially the same today as they were when the strong profiles were developed and since adequate time was available for the profile development, then the reasons for the degradation process must lie in the factors of climate and/or biological activity.

A gradual decrease in effective precipitation could account for a decrease in vegetation biomass, which would allow for less vegetative soil protection and, consequently, erosion would increase. However, this process would be gradual and erosion would occur over a long period of time. There is evidence that indicates relatively recent active erosion. For example, fairly extensive areas, where Blue Grama is the dominant grass, were noted where the clumps of grass were on erosional pedestals approximately two inches higher than the unvegetated soil. This would indicate that about two inches of soil had eroded in the life time of the grass plants. If the grass covered approximately 25 percent of the ground surface and the average age of the grass plants is seven years, then the rate of erosion is approximately 1.5 inches of soil erosion in seven years or about .21 inches per year on these sites. This is equivalent to about 35.7 tons of soil removal per acre per year, a rate far too high to be accounted for by a gradual decrease in precipitation alone.

The vegetative study done in conjunction

with this soil survey indicates that historical use of the Monument for livestock grazing and the present grazing by trespass livestock and feral burros has had and is having an effect on the kinds and amounts of vegetation. Obvious erosion is caused by foot traffic of animals where trails are deeply worn (even into the bedrock). Runoff water collects from surrounding areas and erodes the trails into gullies. Besides this more obvious erosion, the use of grass by burros or livestock upsets the delicate balance among a drying climate, soil and plants, resulting in accelerated sheet erosion, which is difficult or impossible to reverse in several life times of man.

Map Unit 4 illustrates severe erosion. It is a rock land that probably had at least a shallow soil which has been removed by erosion. Areas in this map unit will not recover to form soil for at least several hundred years, even under ideal conditions. Consequently, this area will not presently support the biomass that once existed.

It is concluded that the present process of soil degradation is caused partly by a drying climate and that the degradation of soils is being greatly accelerated by past and present livestock and burro use.

PHYSICAL AND CHEMICAL PROPERTIES OF SOILS FOR TYPICAL PROFILES*

Map Symbol	Depth From Surface (inches)	Textural Classification			Range in Permeability (in/hr)	Available Water Holding Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential	Hydrologic Group ¹	Erodeability of Exposed Soil	
		U.S.D.A.	Unified	AASHTO						By Water	By Wind
1 (Rock Land Part) (Shallow Soil)	-	Rock	-	-	-	-	-	-	D	-	-
	0-3	Gravelly, sandy loam	SM	A-2	1-2.5	.07-.10	7.0-7.8	Low		Severe	Slight
	3-9	Clay	CL	A-6	.20-.63	.17	7.5-8.0	Moderate	C		
	9-12	Gravelly, sandy clay loam	SC or CL	A-4 or A-6	1-2.5	.10	8.0-8.6	Low			
	12+	Rock	-	-	-	-	-	-			
2	0-4	Gravelly, sandy loam	SM	A-2	1.0-2.5	.07-.10	6.8-7.5	Low			
	4-10	Sandy clay loam	SC or SM	A-2 or A-4	1.0-2.5	.15	7.0-8.0	Low	C	Severe	Slight
	Variable, but usually 10-20	Gravelly, sandy loam	SM	A-2	2.0-3.5	.07-.10	8.0-8.6	Low			
	Variable, but usually rock within 12-36	Tuff rock	-	-	-	-	-	-			
3	0-4	Gravel	GP	A-1	>10	.05	6.8-7.5	Very low			
	4-10	Very gravelly, sandy clay loam	GM	A-1	2.0-5.0	.05-.10	7.0-8.2	Low	B	Moderate	Slight
	10-60	Gravel	GP	A-1	>10	.05	8.2-8.6	Very Low			
4	-	Rock	-	-	-	-	-	-	D	-	-
5	-	Rock	-	-	-	-	-	-	D	-	-
6	0-60	Very stony cobbly sandy loam	GM	A-1	2-10	.05-.10	6.8-8.2	Low	C	Moderate	Slight
7	0-12	Gravelly, sandy loam	SM	A-2	2-3	.05-.07	6.8-7.8	Low	B	Slight	Slight
	12-60	Very gravelly sandy loam	GP	A-1	2-10	.05-.07		Low			
8		Same as Map Symbol 1									
9	0-6	Very gravelly loam	GM	A-1		.05-.10	6.8-8.2	Low			
	6+	Rock	-	-	-	-	-	-	D	Severe	Slight

*Data shown are extrapolated from actual tests performed on representative samples of soil horizons or are estimated. Because of slight horizontal and vertical soil variations within soil mapping units, these data should be considered as general. For specific structures, on-site tests should be performed.

¹Hydrologic Group: A high intake rate, low runoff
 B moderately high intake rate, moderately low runoff
 C moderately low intake rate, moderately high runoff
 D low intake rate, high runoff

SURVEY OF RANGE AND ECOLOGICAL CONDITIONS
FOR A SOUTHERN PART OF
BANDELIER NATIONAL MONUMENT

SURVEY OF RANGE AND ECOLOGICAL CONDITIONS FOR A SOUTHERN PART OF BANDELIER NATIONAL MONUMENT

INTRODUCTION

This report is the result of a field study conducted during the months of July and August, 1974, on a portion of Bandelier National Monument.

It is not the intent of this report to provide a complete biological inventory, but rather to provide practical resource information regarding the overall ecological status of the vegetation types and an impression of the primary forces contributing to that status.

Emphasis is placed on particular plant species that are considered as climax dominants, or indicators of range conditions and successional trends. Observations are made on the degree of use of important forage species and their relative positions in the plant community.

Plant communities and soils data are used to classify the area surveyed into range sites. Range site names and classification follow the criteria of Range Sites as developed by U.S.D.A, Soil Conservation Service, for New Mexico.

The vegetation map illustrates the extent and relationship of each site. Range sites are determined basically on soil characteristics and botanical composition. Therefore, a close correlation and similarity will be found between soil map and vegetation map.

Each site is described with pertinent information and observations in the appropriate section of this report.

GENERAL CONDITIONS

Bandelier National Monument is extremely variable in its vegetation patterns because of its rough terrain. A finely detailed vegetation map would be virtually impossible to develop using normal map scales. The factors contributing to the complexity that are directly related to topography include:

Exposure: Many plant community differences may be readily distinguished because of exposure. These differences may be detected on the tops of the larger north-south trending mesas that have gentle slopes along the steep sides of these mesas. The exposure effect as seen on the mesas is sometimes subtle as soil-moisture relationships are changed due to varying degrees of solanation on a particular site. Increased solanation will tend to produce a site exhibiting more xeric characteristics than one receiving less light and heat. Similarly, the effects of the deep canyons are striking in this regard.

Drainage: The effects of drainage

patterns within Bandelier are pronounced due to the extremes in topography. Some areas are excessively drained, while others are receiving additional moisture from the runoff. This set of circumstances occurs universally, but in Bandelier it appears to be a predominant characteristic which contributes to major differences in plant communities with close proximity to each other. Animal trails are providing drainageways that significantly affect soil-moisture conditions.

Erosion: Soil erosion has a very marked influence on the present biota and the likelihood that secondary succession can proceed at a normal rate consistent with climactic conditions. The recent and present erosion is partially a result of topography plus other disturbances. Erosion status of different sites throughout the Monument range from slight to severe. Sheet, rill and gully erosion is occurring at accelerated rates throughout the area. Such erosion invariably results in more xeric sites at the higher elevations and excessive deposition and disturbances at the lower elevations. Microclimates are being drastically altered and vegetation is reacting to these differences by reduced production of vegetative materials, loss of vigor, replacement of more mesic species by those better adapted to drier conditions, and reduced rates of succession. Many sites are now in a condition that makes average annual precipitation data virtually meaningless when viewed from an effective moisture standpoint. Rainfall becomes much less effective when infiltration and water holding capacity are reduced. An average annual rainfall of 16 inches may have an effectiveness of only eight inches or less under degraded soil and vegetative conditions. Increased evaporation

rates further decrease the meaning of total annual averages and finally plant vigor may be such that the plants are unable to effectively use that water normally available for plant use. These factors contribute to the wide variability of vegetation within areas that could normally be incorporated into common sites. Therefore, the vegetation map has range sites identified which consist of inclusions of areas not typical of the site.

Edaphic: The soils portion of this report clearly identifies the relationship of topography and soils. Both the minor and major differences that occur within the soils are reflected by minor and major differences in the vegetation.

Grazing Use: The degree of use or grazing pressure on a particular site often is directly related to topography. Bandelier National Monument provides clear examples of this effect. Although evidence of use by deer and feral burros may be found throughout the survey areas, grazing is restricted in some areas and promoted in others due to topographic features. Accessibility is a principal factor related to degree of use. Evidence of cattle use is found in the lower ends of principal canyons and mesas and along the Rio Grande.

ECOLOGICAL CONSIDERATIONS

Range Sites: Range site names, or range site complexes, have been assigned to each major vegetation type surveyed. However, some areas do not conform to typical site concepts because of several factors. Perhaps the more common problem encountered concerns that of degraded or deteriorating sites. Oftentimes range technicians will fail to recognize the relationship between the deteriorating

site and its capability to express vegetationally the normal climax type of plants. Many areas within the Monument should be viewed as deteriorated sites and the quality and quantity of their vegetation should not be rated in the standard sense of "range condition" without qualifying the standard by which the rating is assigned. This report attempts to qualify such range condition ratings within the respective site descriptions as necessary.

Two other considerations regarding the use of range sites and their delineations deal with two aspects of conditions found in the survey area. One of these concerns the atypic characteristics of some sites and the other concerns the wide range of variability within very small areas. Rather than mapping "micro-sites", several sites are identified as complexes or groups. The intent of such grouping is to incorporate those significant types and their variations into workable vegetation descriptions.

Range Condition: The designation of condition classes to range sites is for the express purpose of assigning an ecological status rating for that site. The most common designations use the terms excellent, good, fair or poor. These terms denote in a general way the degree of deviation that has occurred from a climax state. The condition class is based on numerical ratings as follows.

Excellent - Those plants which normally constitute a climax condition (both quantitatively and qualitatively) still comprise 76 to 100 percent of the existing vegetation.

Good - The climax community has been degraded to the extent that

only 51 to 75 percent of the original species composition remains.

Fair - More than half of the original plant constituents have been replaced, but those remaining still comprise 26 percent or more.

Poor - No more than 25 percent of the original plant community remains.

For the purpose of this report, condition is expressed as a percentage figure only. For those who wish to interpret these figures into a named condition class, they may do so by using the above information. It is felt, however, that a term alone does not provide precise enough information to those concerned with the management of natural ecosystems. For instance, a designation of "poor" would indicate a condition ranging from totally bare ground to a vegetational cover that provides important protection to soil, suitable wildlife habitat, or significant forage for grazing animals, and could be approaching another condition class very rapidly. Designations such as five percent or 25 percent convey a clearer concept of the ecological status of a particular site.

It might be assumed that due to the nature of Bandelier National Monument's status as a protected wilderness area that range conditions or ecological status would be high. This is not necessarily the case.

Trend: Trend is the term used to denote the direction a site is taking from a secondary successional standpoint. At any given time a site is either in a state of successional progress (developing toward a climax condition) which is commonly considered as an upward trend, or in a state of regression (continuing a decline in condition away from a climax state) usually termed a downward

trend. In addition, the site may be relatively stable, not exhibiting evidence of either succession or regression.

Factors which are used in this report to determine trends include:

- . stability of the soil surface;
- . reproduction occurring with climax dominant species, increaser and invader species, and reproduction of those species currently being grazed or browsed;
- . degree of use of forage species and the reaction of the plant to that use;
- . plant vigor;
- . amount of vegetative litter carried over from one growing season to another;
- . average age of indicator species;
- . growth forms of indicator species.

Within Bandelier National Monument there are trend differences, but on the average trends are downward and will probably continue so for a considerable period of time.

SITE DESCRIPTIONS

Eight vegetation mapping units are identified and delineated on the vegetation map. Although most areas delineated follow closely those of the soils map, several differences occur. This is due largely to different groupings within a unit and soils differences that do not reflect vegetation differences. Site numbers correspond to numbers on the vegetation map. Vegetation units mapped are as follows.

. Site 1, Shallow Pumice Complex

This extensive site is found on the mesa tops. Frequent outcrops of rhyolite tuff reduce the depth of this site's soil virtually to zero in small areas throughout the Monument. The site has characteristics of typical shallow sites, but the interspersed pumice found in conjunction with sandy loam soils provides characteristics found on cinder sites. The complex association of the two conditions prevents the separation into two distinct sites.

Pinon Pine (*Pinus edulis*) and One-Seed Juniper (*Juniperus monosperma*) exert a dominating influence on this site. Production of these two species is estimated at 352 pounds per acre per year on the more southern ends of the mesas, and 620 pounds per acre on the northern portions of the site. Pinon occurs throughout the site, but diminishes in incidence of occurrence on the areas nearest the Rio Grande. In these areas Juniper constitutes virtually 100 percent of the association.

In addition to the Juniper and Pinon occurring on this site, four other species are of particular importance, either as indicators or influencing the capability of the site to express inherent productivity. These are True Mountain Mahogany (*Cercocarpus montanus*), Little Bluestem (*Andropogon scoparius*), Sideoats Grama (*Bouteloua curtipendula*) and Blue Grama (*Bouteloua gracilis*). When future evaluations are conducted, these species should be given special attention.

Mountain Mahogany varies considerably throughout the site in regard to its relative productivity. It is estimated that in some small areas of the northeast portion of the study area, Mountain Mahogany contributes up to 40 percent of the total annual production of the site. An average relative production is estimated at less than five percent for the entire site. Many areas have only rarely

occurring isolated individual plants. Two significant features of the Mountain Mahogany found are that reproduction of this species is virtually absent and heavy use of it is universal throughout the study area. There is significant difference noted on the degree of use between True Mountain Mahogany and Hairy Mountain Mahogany (*C. breviflorus*). Hairy Mountain Mahogany is not abundant in the study area and use by deer or burros is none to slight. True Mountain Mahogany is used intensively with use being as high as 90 percent in some areas and as little as 50 percent in others. Average use throughout the study area is estimated at 65 percent. It may be assumed that seedlings are destroyed at a rate that prevents normal replacement of the older plants. Total production of this species can be expected to decline with time if present conditions continue.

Mountain Mahogany is apparently a very important browse species in the Monument. There is considerable evidence that the plant is utilized by both deer and burros and that direct competition for forage results. It appears as though the plant is providing key winter browse for deer particularly in the area west of Frijoles Canyon and north of Frijolito Ruin. This area is also used by burros as several were observed there during the survey.

Little Bluestem is of considerable importance on much of this site due to its absence on most of the site and as an indicator on other portions of the site. On all the area comprising Site 1 Mapping Unit, condition trends are down with the exception of that mesa area east of the lower end of Alamo Canyon. In that area Little Bluestem is the principal plant

contributing to the upward trend. The plant is reproducing and establishing in small gullies initiating healing of these areas. Again, this species is one that would be important in evaluating progress if a measurement of vegetational changes is desired in subsequent studies. It appears also that Little Bluestem would establish rather quickly in those pumice areas of this site, which are often bare, if grazing pressures were reduced.

Estimates on degree and season of use are made with regard to Little Bluestem. Apparently the older well established plants are used principally in the winter when snow is on the ground. Average use is about 50 percent on these coarser plants. In most areas surveyed, it was found that younger plants of this species were used to the extent that they could be reached by grazing animals. Where plants were partially protected, such as in a narrow crack, it is common to find that all the plant that would have protruded has been removed.

Sideoats Grama is another key species on this site. It would normally be found in considerable abundance on the shallow site complex. However, it is found to be only rarely occurring and generally found in well protected areas. This species has a very high relative palatability. The average degree of use on this plant is estimated to be in excess of 75 percent. It would not be expected to increase on Site 1 under present conditions, but would be an important indicator of range improvement if grazing pressures were reduced. Reproduction of this species is occurring only rarely over most of the site.

Several of the points made regarding Little Bluestem apply to Sideoats, with the exception that primary season of use is probably different. It is assumed that this plant is being heavily used

TABLE I
Botanical Composition and Productivity
Range Site 1

<u>SPECIES</u>	<u>% COMPOSITION</u>		<u>PRODUCTION LB/AC</u>
	<u>RANGE</u>	<u>AVE.</u>	<u>AVERAGE</u>
Decreasers:			
Fourwind Saltbush (<i>Atriplex canescens</i>)	T(trace)	T	I(insignificant)
Little Bluestem	0-5	1	6
Sideoats Gram	0-2	T	I
Black Grama (<i>Bouteloua eriopoda</i>)	0-2	T	I
True Mountain Mahogany	2-18	3	19
Increases:			
Blue Grama	5-35	12	74
Oakbrush (<i>Quercus turbinella</i>)	0-7	T	I
One-Seed Juniper	30-85	55	341
Pinon Pine	15-45	18	112
Cholla (<i>Opuntia imbricata</i>)	2-3	T	I
Threeawn (<i>Aristida divaricata</i>)	1-5	2	12
Yucca sepcies	T	-	-
*Apache Plume (<i>Fallugia paradoxa</i>)	2-15	3	19
Galleta (<i>Hilaria jumesii</i>)	3-10	2	12
Gambel Oak	0-5	T	I
Invaders:			
Wooly Groundsel (<i>Senecio Longilobus</i>)	T	-	I
Snakeweed (<i>Gutierrezia sarothrae</i>)	2-15	4	25
Prickly Pear (<i>Opuntia sp.</i>)	T	T	I

Average Condition Rating 26%, see condition map for condition ratings by area.
*Characteristic of pumice portions only.

in spring and late summer and to a lesser degree in winter. This, of course, is much more detrimental to the plant than if the opposite were true. Just as Little Bluestem should be regarded as an indicator for the pumice portions of Site 1 complex, Sideoats could be viewed as the counterpart for the shallow and rocky portions of this complex in future studies.

Blue Grama is the predominant herbaceous plant of this site and is found in pure stands throughout the mesas. It should be viewed as an indicator plant from the following standpoint.

Because of the relatively high rate of occurrence of Blue Grama in the study area, the site rarely exhibits its productivity potential. Blue Grama will tend to increase under grazing pressures to the extent that other more productive species are excluded. It appears as though this is the general condition at Bandelier on this site. The low growth form exhibited by Blue Grama on most of the area provides built in protection from much overgrazing. Black Grama has been displaced by Blue Grama over much of the area.

Production of Blue Grama is estimated to range from 40 pounds per acre per year to 250 pounds per acre per year. Average production for the site is estimated at 100 pounds per acre per year. Table 1 summarizes vegetation relationships on Vegetation Map Unit 1 and reflects general conditions of the site. A range is listed under the percent composition column to indicate the variability to expect from each species.

Site 2, Cinder-Sandy Complex

This site is characterized by the presence of Ponderosa Pine occurring in

moderately open to open stands. Soils in this complex range from shallow to moderately deep, are usually sandy loams with varying amounts of pumice gravel. The site is found primarily on the mesas particularly toward the northern end of the study area.

A much more favorable soil-moisture relationship occurs on this site than on Site 1 and the vegetation reflects those differences. The heaviest use is being made of the browse species on this site, with less use on the grasses. Utilization estimates on several important forage species provides some interesting indicators regarding probable season of use and relationships to other sites.

Several very palatable grass species, normally considered as "key" plants, are apparently being utilized only slightly. In one area where browse and grasses occur together, it is noted that Little Bluestem, June Grass and Mountain Muhly are used very lightly and probably primarily in the winter. Reproduction appears good and vigor is noted as being good. It appears as though these grasses are increasing and contributing to an upward trend. Conversely, in the same area the following estimates were made: Mountain Mahogany utilization is estimated at 80 percent and no new plants are establishing. *Rhus trilobata* is being browsed to an estimated 40 percent level and Apache Plume is being used at a 50 percent level. Gambel Oak is browsed to approximately 15 percent, while an unidentified species (similar to *Q. turbinella*) is about 40 percent utilized. Considerable evidence of burros is found in the area and deer to a lesser degree.

Regarding Site 2, in general, Little Bluestem contributes the greatest amount of herbaceous vegetation. It is estimated to be 1750 pounds per acre in an area of open Ponderosa occurring on

TABLE II
Botanical Composition and Productivity
Range Site 2

SPECIES*	% COMPOSITION		PRODUCTION LB/AC AVERAGE
	RANGE	AVE.	
Decreasers:			
Little Bluestem	2-65	15	360
June Grass	0-10	7	192
Arizona Fescue	T-5	3	66
Mountain Muhly	0-10	5	110
Mountain Mahogany	5-25	10	240
Skunkbush Sumac	T	I	-
Increasers:			
Pinon Pine	-	10	240
One-Seed Juniper	-	15	360
Rocky Mountain Juniper	2-15	2	48
Bottlebrush Squirreltail	0-3	2	48
Mullein (<i>Verbascum thapsus</i>)	0-2	I	-
Blue Grama	1-10	7	168
Oak spp.	3-10	3	66
Lycium spp.	T	I	-
Pingue	0-25	5	110
Apache Plume	0-15	5	110
Invaders:			
Croton sp.	0-5	T	-
Broom Snakeweed	0-2	2	48

Average Condition Rating 72%, see condition map for specific ratings by area.
*Ponderosa Pine Omitted.

pumice over sandy loam. This same area has small isolated patches of Little Bluestem producing at considerably higher rates. It is concluded that many portions of the site are capable of higher production than they now express.

Considerable variation exists within the site with several species occurring in patches, strips and isolated pockets. Some characteristics of the various species that were noted are as follows: June Grass rarely produces more than 10 percent of the herbaceous cover and Mountain Muhly is found in similar proportions. Little Bluestem will be the plant to increase at the greatest rate as conditions improve. Excluding the Ponderosa, Little Bluestem is estimated to be producing 25 percent or more of the total vegetation materials on the site in some areas. Arizona Fescue occurs as a widely distributed plant through the site, but does not comprise more than five percent of the herbaceous vegetation.

Blue Grama reacts as an increaser species on this site and exhibits a much more upright and productive growth form than on the shallow soils of the mesas, although it generally lacks normal vigor. Its production generally ranges from 90 to 170 pounds per acre on this site and may comprise up to 10 percent of the vegetation (excluding Ponderosa Pine) in some areas. If grazing pressures are increased, Blue Grama would be expected to increase on this site. It appears, at this time, that it is not significantly increasing and probably is not competing well with the climax dominant plants on the site.

Apache Plume is the dominant shrub on the pumice soils. This plant is

probably an increaser species on this site and it is reproducing fairly well with an estimated use rate of 50 percent. It appears as though Mountain Mahogany is being replaced by this plant, as the vigor and ability of Mountain Mahogany to establish seedlings is reduced.

Pingue (*Actinea richardsoni*, also commonly known as *Hymenoxys richardsonii*) occurs in some portions of the site in significant stands. In isolated areas it may comprise up to 25 percent of the herbaceous material, but such stands are not extensive.

Erosion is generally slight with most of the site in a stable condition. Exceptions occur in the drainageways where gully erosion is active.

Site 3, Rhyolite Rock Land

This site consists primarily of virtually bare rhyolite on the mesas. Soils have been eroded to the extent that only trapped or displaced soils material remains over much of the area. A shallow sandy loam is associated with this site and produces meaningful vegetation.

It is important to recognize that this site does not fall within the concept of a true range site. Since range site conditions are based upon the premise that soil and vegetation evolved simultaneously and that any stage of that development represents a climax state, it becomes impractical to assign condition values for a site which no longer exists. It is possible, however, to analyze the vegetation now occupying the site and predict what it will do under varying conditions. Following are some findings and observations regarding this fairly extensive land type.

Four plant species are characteristic of the site. They are One-Seed Juniper, Pinon, Blue Grama and Broom Snakeweed. All of these plants may be found throughout the site.

On the upper portions of the mesas Juniper and Pinon are found in about equal quantities and together constitute approximately 80 percent of the total production. On the lower ends of the mesas nearest the Rio Grande, Juniper alone comprises approximately 30 percent of the vegetative production and Pinon occurs only rarely. Ponderosa Pine is found on the upper portions of these sites.

There are other differences that occur between the upper and lower portions of this site. They are primarily differences related to production rather than in species occurrence.

The exception to the above concerns Blue Grama. Blue Grama is estimated to produce 40 to 45 pounds per acre where a thin mantle of soil remains. In this situation it produces a very dense ground cover, but obviously is inhibited by intraspecific competition and adverse site conditions. Use of Blue Grama by grazing animals is found to be negligible.

Broom Snakeweed produces approximately 60 pounds per acre in the upper sections of the site and an estimated five pounds per acre in the lower mesa portion. Although the four above listed plants occur on a most consistent basis, none of them are being measurably utilized by grazing animals.

On this site also, it is found that Mountain Mahogany is being severely browsed and no measurable reproduction is occurring. The use on those plants in the upper part of the site and west

of Frijole Canyon is estimated to be in excess of 80 percent. No young Mountain Mahogany plants are found in the area. Browsing is generally less severe in the other parts of this site, but young plants, if any, are being destroyed at the same rate establishment is attempted. It appears that use of this plant is primarily by deer in the upper portions and by burros in the lower portions. It is not clearly apparent why this might be, as burros are using the same areas as the deer.

Oak Brush utilization follows a similar pattern. Approximately 50 percent of the current year's growth was taken in the same area as the heavily used Mountain Mahogany, but only about 25 percent was utilized further down on the mesas. Apache Plume does not demonstrate as clear a difference in use as discussed above, but heaviest utilization does occur in the same area as did the heaviest use of Mountain Mahogany and Oak.

From a trend aspect, Black Grama is probably the best indicator grass species on this site. It can be considered as a decreaser species and will indicate whether the site is stabilizing by its increase. It is now probably being utilized primarily in the winter months and to a lesser degree in the late summer. In isolated areas of the site it is contributing up to 20 percent of the total vegetation production. Use is estimated at 15 percent in some areas and 60 percent in others.

Little Bluestem may be found throughout the site, but not in significant quantities. This plant also has a potential for occupying portions of the site and could be used in trend studies. Presently it is being severely overused in most places where it occurs. Where protected, it demonstrates good vigor.

Other less important species found on this site include Galleta, Hairy Grama, Poverty Threawn, Cholla, Yucca, Metcalfe Muhly and Prickly Pear. The trend is considered to be downward on this site. An ecological status determination can not be made using standard concepts, but if viewed from a probable ability of other plants higher on the successional scale of occupying the site in its present edaphic state, one should consider a rating of 40 percent or less.

Site 4, Meadow-Bottomland Woodland Complex

This site corresponds partially with Soil Mapping Unit 7. It is found only in the bottoms of the principal canyons or drainageways and can be divided into three types. Much of the site is a woodland type and would not be considered as suitable for grazing. Other less extensive portions are similar to a meadow site and are very productive from a forage standpoint. The smallest portion of this complex would be considered bottomland, receiving beneficial surface water periodically. Such areas are very small and are of little consequence from a vegetational standpoint.

The dominant feature of the complex is the woodland aspect or predominance of trees. Herbaceous plant growth and production is limited in many parts of this site complex due to the canopy cover. Principal woody species occurring throughout the site include Cottonwood, Box Elder, Rocky Mountain Juniper, One-Seed Juniper, Ponderosa Pine, Pinon, Aligator Juniper, Alder, Water Birch, Douglas Fir, Willows and others.

Although much of this site can not be considered well suited to grazing, considerable evidence of cattle use is found in the lower portions of the area. Burro use is found to be very intensified in the canyon bottoms.

Important herbaceous plants occurring in this complex are:

Western Wheatgrass (*Agropyron smithii*): This is the most common grass species found in the canyon bottom complex. It occurs on each of the site types included in the complex and is probably the most important forage plant on the sites from a quantity standpoint. Production of Western Wheatgrass is estimated to range from 150 pounds per acre per year in some of the woodland portions of this site to as high as 4000 pounds on some of the small bottomland types. Those areas considered as meadow produce an estimated 700 pounds per acre of this species. Use rates are inconsistent. Some areas show use of 50 to 70 percent, while others, in close proximity and no barriers between them, appear to be unused.

June Grass: June Grass is most important on those sites similar to meadows. Like Western Wheatgrass it is reduced in productivity in the woodland types, but occurs throughout the complex. Use of this plant is found to be fairly heavy with some areas estimated to be used in excess of 80 percent. This plant is probably used heaviest in the spring and early summer. Several isolated areas in this site complex appear to be bedding grounds for burros. In these areas, use is particularly heavy on June Grass as well as other species. Hoof damage to plants should not be overlooked in evaluating the heavily used areas. Damage to vegetation due to trampling is found to be more detrimental than grazing in some areas.

Nodding Brome: Nodding Brome is found throughout the complex, but does not, in most cases, constitute a significant portion of the vegetation. Mountain Brome occurs rarely. Both of these plants are decreasers on the site types and will serve as trend indicators.

Kentucky Bluegrass and Red Top: Kentucky Bluegrass and Red Top are invaders on this site. Bluegrass now exerts considerable influence on several of the meadow types. These plants will probably continue to increase as niches are available due to decreasing native species.

Condition ratings for Site 4 range from 40 percent to 75 percent. The lower ratings apply best to the meadow types and the higher ratings apply to the woodland aspect of the complex.

Site 5, Canyon Walls-Breaks Complex

This site includes colluvium associated with the steep canyons. Some portions of the canyon walls are typical of breaks sites forming benches occasionally. The benches tend to have grasses as a principal vegetation type, but are either inaccessible to most wildlife or livestock or are of such rarity that they may be insignificant.

On an average, this site complex is far less susceptible to influence by grazing than any of the other areas in the Monument. Most portions are steep and have bare rock at the surface which can not be considered as fragile or responsive to any management or treatment.

There are sections and slopes that provide forage for deer and burros. Most of the use made on these slopes is on browse species. Observations made

during this survey indicate that the only damage occurring on this site complex was from burros. Burro trails are having an effect on erosion rates on isolated portions of this land type. Taking the entire site into consideration, such damage is negligible.

In formulating management plans for the Monument, it would be most realistic to deduct the acreage falling into the Site 5 category before arriving at conclusions involving carrying capacities or population relationships of grazing animals.

The site does have other very important values that are magnified by the fact that it lies within a wilderness area. Other than esthetic values, it provides a virtually undisturbed environment that houses native plants which may not be found in other parts of the Monument. It will also become increasingly important as a seed source to permit the natural restoration of other areas should conditions permit. This site represents the best "true wilderness" environment to be found within Bandelier National Monument.

Site 6, Breaks-Sandstone Hills Complex

This site is dominated by Pinon and Juniper. These two species represent approximately 90 percent of the total vegetational production on the site. Both species are considered increasers on the site. A total productive capacity for the site is estimated to be 900 pounds per acre per year. Blue Grama, producing an estimated 36 pounds per acre, accounts for approximately four percent of the total. It is rated as having very poor vigor.

Sideoats Grama and Little Bluestem are found in trace amounts throughout the

TABLE III
Botanical Composition and Productivity
Range Site 6

<u>SPECIES</u>	<u>% COMPOSITION</u>		<u>PRODUCTION LB/AC</u>
	<u>RANGE</u>	<u>AVE.</u>	<u>AVERAGE</u>
Decreasers:			
Sideoats Grama	T-1	T(trace)	I(insignificant)
Little Bluestem	T-2	T	10 or less
Mountain Mahogany	0-4	2	18
Increasers:			
Blue Grama	2-5	4	36
Galleta	T-1	.5	5
Cholla	0-3	1	9
Apache Plume	0-3	1	10
Gambel Oak	1-4	2	18
One-Seed Juniper	60-70	60	540
Pinon	25-40	30	270
Invaders:			
Broom Snakeweed	0-2	.5	5
Annual weeds	1-2	1	10

Average Condition Rating 35%, see condition map for specific ratings by area.

TABLE IV
Botanical Composition and Productivity
Range Site 8

<u>SPECIES</u>	<u>% COMPOSITION</u>		<u>PRODUCTION LB/AC</u>
	<u>RANGE</u>	<u>AVE.</u>	<u>AVERAGE</u>
Decreasers:			
Wolftail (<i>Lycurus phleoides</i>)	0-3	2	8
Sideoats Grama	10-20	15	60
Black Grama	0-15	10	40
Increasers:			
Hairy Grama (<i>Bouteloua hirsuta</i>)	0-7	5	20
Cane Bluestem (<i>Andropogon barbinodus</i>)	0-2	2	8
Blue Grama	1-10	5	20
Pinon	rare	-	I
Rabbit Brush	0-4	2	8
One-Seed Juniper	5-65	45	180
Threeawn species	T	T	I
Shrub Live Oak	0-15	10	40
Apache Plume	0-3	2	8
Borbs	1-5	2	8

Average Condition Rating 60%, see condition map for specific ratings by area.

site. They are decreaser species on this site and provide a suitable index for trend. The trend is considered to be slightly downward. Table III lists a summary for this site.

Site 7, Pumice Slopes

This site comprises a relatively small portion of the survey area and is characterized by virtually pure stands of Apache Plume in some areas. Herbaceous cover is generally very limited and large areas of bare surface pumice is common.

Little Bluestem appears to be the most stabilizing plant occurring on the site, but it is generally not found in sufficient quantities to be effective. Sideoats Grama and Little Bluestem are principal decreaser plants to be found on the site. Both have apparently been diminished due to grazing.

Estimated use on these species is 85 percent on Sideoats Grama and 60 to 70 percent on Little Bluestem. Some reproduction is occurring with Little Bluestem, but virtually none with Sideoats. Apache Plume is being utilized, by burros primarily, at an estimated 20 to 25 percent level over most of the site.

Where the site occurs on slopes not in drainageways, erosion is slight. In areas where runoff water is transported through the site, gully erosion occurs.

Site 8, River Breaks-Terraces Complex

This site is similar in many respects

to Site 5, but differs in that it is more open, has broader and more productive benches occurring in greater numbers. The site borders the Rio Grande and is heavily used by cattle and burros.

The site is protected to a large degree by large rhyolite blocks which provide protection to plants from grazing and to soil from erosion. This characteristic accounts for the site being in better condition than would otherwise be expected.

The slopes portion of the site appears to have an improving trend, at least it is stable. The lower terraces portion is being heavily grazed by cattle and is suffering a deteriorating condition.

Principal species relationships are shown in Table IV for the slopes and benches portion of the site. The lower terraces next to the river should be considered disturbed sites and not typical of naturally developed sites. Invader species, including Salt Cedar (*Tamarix* spp.), Russian Thistle and Russian Olive, are contributing to the continued decline of these areas from a natural environment aspect, as their numbers increase and native plant species are displaced. The present grazing is accelerating the decline.

SUMMARY AND CONCLUSIONS

A field survey of vegetation and site characteristics was conducted on a portion of Bandelier National Monument during the summer of 1974. Vegetation and soil patterns were found to be complex and variable, but several characteristics were found to be common to most of the area surveyed. Range condition trends were deteriorating over most of the area

and ecological changes were rapid due to these soil losses. Burros and/or cattle were found to graze nearly all of the study area and were causing profound deterioration of the natural environment. Range condition or ecological status of sites was found to be extremely low and deteriorating on most areas.

Because of the fact that Bandelier is a National Monument and wilderness area, one would expect it to represent a reasonably undisturbed and unique natural setting. Bandelier National Monument is not unique in this respect. Most of the study area is a mirror image of the overgrazed, unproductive ranches found throughout the Southwest.

Sites exhibit the same symptoms of mismanagement and misunderstanding that plague arid grazing lands wherever carrying capacities are exceeded by any class of livestock. Most damage is being done directly by wild burros. It appears as though competition is also direct between burros and mule deer. When such demands exceed supplies, then both competing species contribute to the deterioration of the natural ecosystem.

It is the conclusion of this investigation that the wild burros of Bandelier can not be managed as a compatible constituent of the natural ecosystem. Such a statement is based on several conditions peculiar to the Monument.

Terrain and, consequently, inaccessibility, prevents an accurate count of the number of animals utilizing the area at any given time or from year to year. The same factors preclude a reasonable understanding of the population dynamics of the burros, other than by in-

tensive measurement of ecological deterioration of their habitat.

The status of the Monument prevents, and should prevent, the construction of essential management facilities necessary to bring this class of livestock under a sound management program. Such facilities would consist of complete boundary fences, cross-fencing or areas within the Monument to establish management pastures, corrals, access roads for transportation of animals, as necessary, access trails for the livestock to insure proper distribution, and related watering facilities. A supplemental feed program might be necessary some years.

From the foregoing it may be apparent that the concepts on which a wilderness area are based are not consistent with present conditions. If the current rate of deterioration continues and controls are not initiated on livestock within the Monument, one of the most rare and outstanding values of the region will be lost: an area in which one may go to study or just appreciate its natural state.

The findings of this survey regarding the vegetational trends and conditions, indicate that Bandelier National Monument is not the place for an unmanaged population of livestock. Its resources are far too limited to afford it.