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Title: PLANT COMMUNITIES AND HABITAT TYPES IN THE LAVA BEDS NATIONAL MONUMENT, CALIFORNIA

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A. H. Winward

This study was initiated July, 1977 with objectives to: 1) identify and map the Lava Beds National Monument by existing vegetation, 2) identify and map the Lava Beds National Monument by habitat types, and 3) identify and collect all vascular plant species encountered during the study. The habitat type classification scheme developed by Rexford Daubenmire was employed for this project.

Plant communities were quantified by measuring frequency of herbaceous vegetation, and by measuring line intercept cover and density for woody plant species. Plant community nomenclature was derived from dominants, as expressed by, 1) high canopy coverage and density for trees and shrubs and by 2) high frequency and constancy for herbaceous species. A visual prominence rating was used to evaluate plant communities encountered on extremely rocky sites or communities smaller than 1.2 hectares. The nomenclature for prominence-rated communities was based on prominence values. A total of 38 plant communities were identified of which 15 were

evaluated by visual prominence ratings. A map showing the location of each plant community was presented.

Habitat types were derived from data and notes taken at each sampling site, the plant community map, indicator species, and pertinent literature. A total of six forest and fourteen shrub habitat types were identified and a map was developed showing their location. Thirteen new habitat types were proposed, since they had not been previously described in the literature. The Cercocarpus ledifolius, Cercocarpus ledifolius-Holodiscus microphyllus var. glabrescens, Ribes cereum, Salvia dorrii ssp. carnosa-Chamaebatiaria millefolium, and Chamaebatiaria millefolium habitat types occurred on rocky basalt lava flows where alteration by man and grazing animals appeared extremely low. The Juniperus occidentalis/Cercocarpus ledifolius and Salvia dorrii ssp. carnosa/Eriogonum microthecum var. laxiflorum habitat types occurred on cinder cones and disturbance was not evident. The Juniperus occidentalis/Artemisia tridentata ssp. vaseyana/Stipa occidentalis habitat type was found on pumice-dominated soils and did not show evidence of alteration. The Symphoricarpos oreophilus/Festuca idahoensis habitat type occurred on rocky escarpments and it also lacked evidence of alteration by man and grazing animals. The Artemisia tridentata ssp. vaseyana-Purshia tridentata/Festuca idahoensis-Agropyron spicatum and Artemisia tridentata ssp. vaseyana/Stipa occidentalis

habitat types were proposed as equivalents to habitat types described by Volland (1976). In Volland's study subspecies of Artemisia tridentata were not differentiated. The Artemisia tridentata ssp. vaseyana/Agropyron spicatum (Stipa thurberiana phase) and Artemisia tridentata ssp. tridentata/Agropyron spicatum (Stipa thurberiana phase) were proposed as similar groupings to habitat types described by Eckert (1957) since he did not differentiate subspecies for Artemisia tridentata.

Eight plant communities were not classified to habitat types primarily due to insufficient information. A representative soil description was provided for each habitat type and for each unclassified community, except those types occurring on extremely rocky sites.

Plant Communities and Habitat Types in the Lava Beds National Monument, California

by

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Associate Professor, Rangeland Resources
in charge of major

Redacted for Privacy

Program Leader, Rangeland Resources

Redacted for Privacy

Head, Department of Animal Science

Redacted for Privacy

Dean of Graduate School

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Typed by Opal Grossnicklaus for Dean Hamilton Erhard

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PLANT COMMUNITIES AND HABITAT TYPES IN THE LAVA BEDS NATIONAL MONUMENT, CALIFORNIA

INTRODUCTION

As man puts more demands on his natural resources, better techniques for characterizing those resources must be developed. Classification of vegetation is vital with increasing intensities of land management. The problem lies in creating a classification system which accurately distinguishes between similar and dissimilar entities within a complex ecosystem. Classifications based on a single attribute of the ecosystem, such as tree height, are only useful in limited applications and may become worthless with changes in management policy. A classification based on several attributes of the ecosystem has a much broader appeal and practicality.

Natural resource managers have found that existing cover-type and site classifications have not always been satisfactory for implementing decisions. An era of environmental awareness requires public lands to be managed on ecologically sound principles.

Cover-type classifications are generally based on current vegetation which occupies a site at the time of sampling. Thus, these classifications often include extremely wide ranges of environmental conditions. Furthermore, the cover-type for a particular site is constantly changing due to advancing succession or sudden disturbances. For these reasons, an alternative is necessary for

meaningful classification of public resources.

A knowledge of the capabilities and limitations of all sites in a geographic location is imperative in order to prescribe ecologically sound management techniques. A classification system developed by Rexford Daubenmire in the western United States groups landscape units by similar biotic potentiality--the habitat type. The habitat type is the finest level in an ecosystem classification hierarchy which reflects potentiality. All land areas that potentially or currently support one plant association (a climax plant community) may be classified as the same habitat type (Daubenmire, 1968).

The mandate for the National Park Service is to preserve areas of exceptional value and produce a reasonable illusion of primitive America. With increasing visitor use and a more ecologically minded public, management of Park Service lands must conform to ecological potentials. Recognizing this, the National Park Service supported this study of the vegetation of the Lava Beds National Monument.

The objectives of this study were to:

1) Identify and map the Lava Beds National Monument by existing vegetation.

2) Identify and map the Lava Beds National Monument by habitat types.

3) Identify and collect all vascular plant species encountered during the study.

STUDY AREA

Location

The Lava Beds National Monument is located 77 kilometers southeast of Klamath Falls, Oregon in northeastern California (Figure 1). Most of the Monument lies within Siskiyou County with part of the eastern end extending into Modoc County.

The 18,713 hectare Monument is bordered by Tule Lake National Wildlife Refuge to the north and principally the Modoc National Forest to the east, south, and west. A relatively small area of private land and Klamath National Forest land meet the Monument on the northeast and southwest borders, respectively (Figure 2).

Two wilderness units were established in the Lava Beds National Monument by Congress on October 13, 1972. The Schonchin Lava Flow Unit in the north-central portion of the Monument consists of 7,471 hectares. The Black Lava Flow Unit in the southwest portion of the Monument consists of 4,047 hectares.

Climate

The elevation of the Lava Beds National Monument varies from 1,228 meters along the shore of Tule Lake in the northeast to 1,725 meters in the extreme southwest corner. Along this gentle gradient from the northern to the southern border, the microclimate becomes

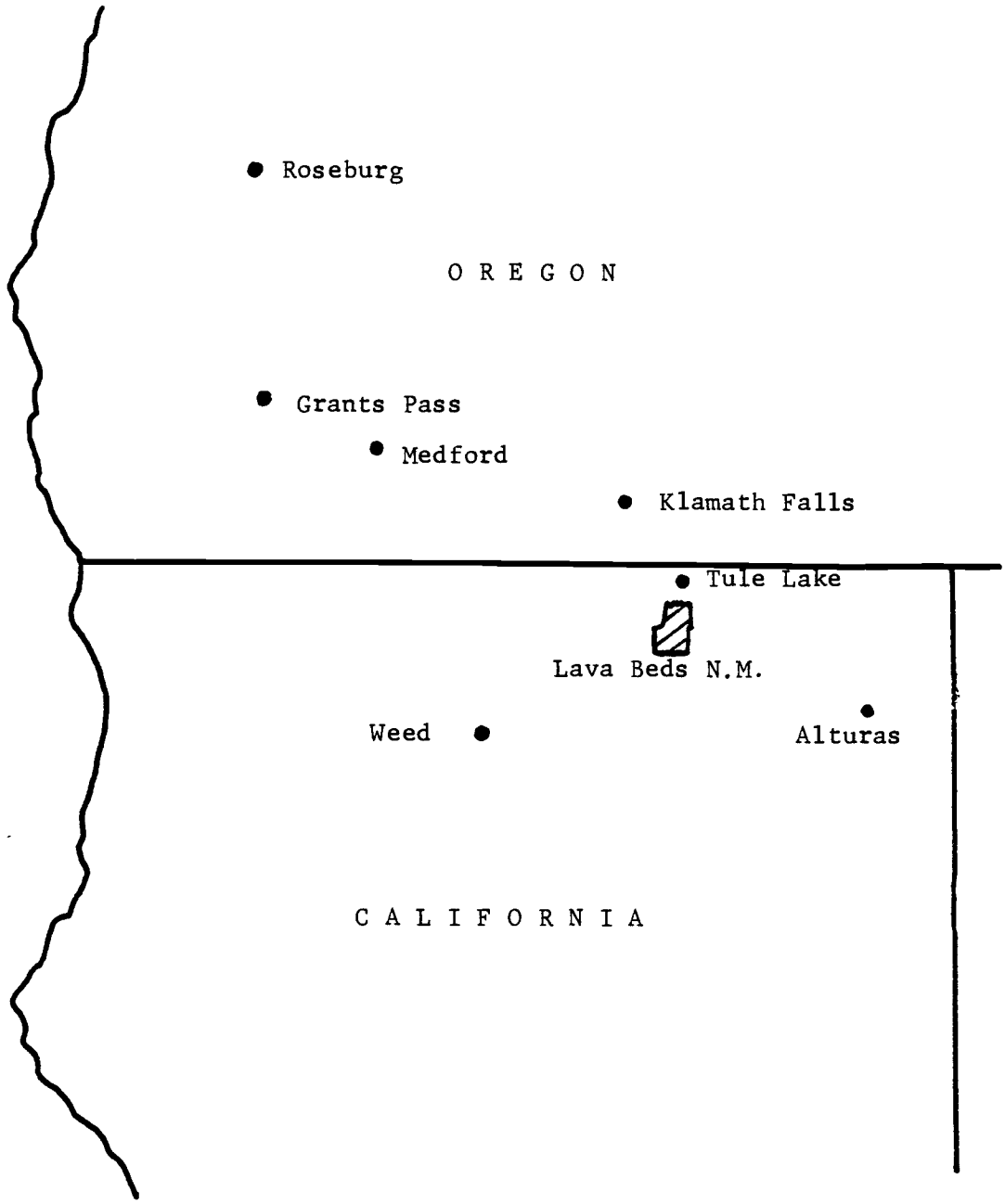

Figure 1. Location of the Lava Beds National Monument

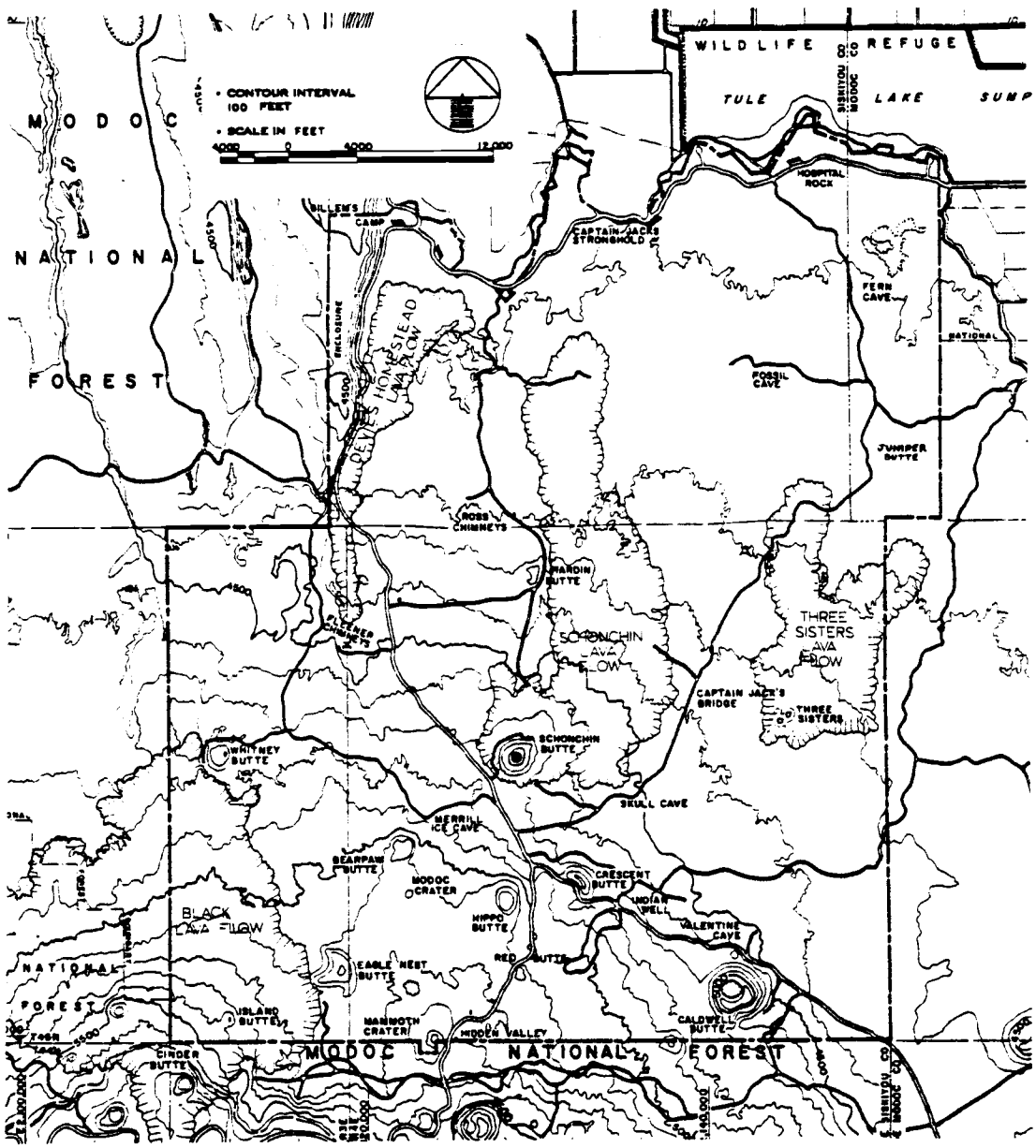

Figure 2. Lava Beds National Monument (revised from Olson, 1978)

increasingly moister and cooler. Weather records, on file at Monument headquarters, indicate that the 18 year average annual precipitation at Monument headquarters (elevation 1,454 meters) is 36.9 centimeters. Winters are relatively moist with most of the precipitation occurring as snow. Severe fire weather occurs normally during July, August, and September, the driest months due to low precipitation and high temperature. An increase in precipitation during the fall usually stimulates herbage regrowth (Figure 3). The summer growing season averages 89 days, but potential for frost exists every month. The mean temperature in January is -.9 C and in July 19.6 C.

Geology

The Lava Beds National Monument is principally known for its unique geology. A landscape dotted with cinder cones and basalt flows, the Monument also contains nearly 300 identified lava tubes. The following discussion is an overview of the general events and formations of the area.

Northeastern California was flooded by seawater during the Cretaceous Period (roughly 60 million years from present). For millions of years this sea slowly accumulated sediment, creating a level plain (Macdonald, 1966). Approximately 30 million years ago enormous basalt lava flows from long fissures poured across these level sediments, spreading hundreds of square kilometers. These

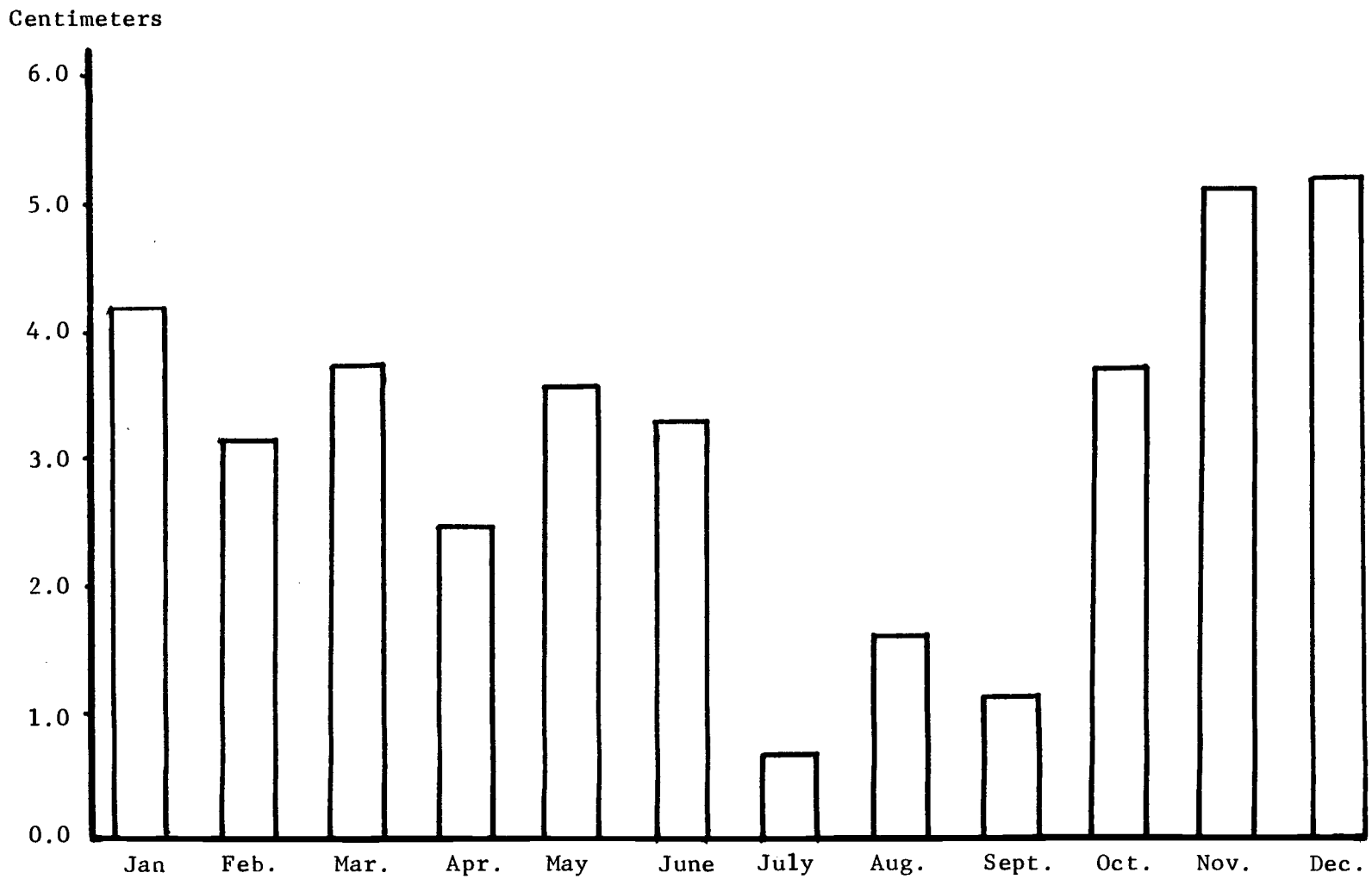

Figure 3. Average monthly precipitation at Lava Beds National Monument headquarters over an 18 year period.

eruptions were active for roughly 15 million years and gradually built up a high lava plateau. This area in northeastern California is called the Modoc Plateau (Alt and Hyndman, 1975).

Once these basalt eruptions had subsided, most of this area began to stretch and break vertically into large segments forming block fault mountains and basins. This stretching and cracking of the earth's crust relieved pressure allowing additional molten basalt to rise and mix with escaping steam. The heavier frothy shreds of basalt settled in a loose pile forming a cinder cone. The shape of the cinder cone was determined by the prevailing wind. Anytime from several days to years later, a basalt lava flow would issue forth from the base of the cinder cone. These young basalt flows were produced in small quantities unlike the earlier plateau basalts. The young basalts emerged from small cracks at the base of cinder cones instead of from fissures several kilometers long, and these young basalts covered areas less than 16 square kilometers (Alt and Hyndman, 1975). These younger basalts have been termed Modoc Basalt by Powers (1932).

As these Modoc Basalts flowed slowly over the landscape, the surface cooled and solidified while the interior remained fluid. Eventually the molten interior drained, leaving a hollow tube. The roof on many of these tubes later collapsed leaving sinkholes and natural bridges. Several lava tubes have ice and pools of water in

the lower portions. Warm air displaced by dense cold air in the winter, leaves many poorly ventilated lava tubes cold year round (Alt and Hyndman, 1975).

The Lava Beds National Monument actually lies on the north flank of a huge, gently sloping shield volcano (Anderson, 1941) that erupted approximately 100,000 years ago. This volcanic rose nearly 1,200 meters above the Modoc Plateau (Mertzman, 1977). Eventually its summit collapsed and later eruptions of eight smaller volcanoes around the rim practically obscured it (Anderson, 1941). A few of these later eruptions produced rhyolite, a volcanic rock which contains a much higher silica content than basalt. Rhyolite magmas have a pasty consistency and when they are associated with a lot of steam, yield violent explosions (Alt and Hyndman, 1975). Much of the ground surface in the Lava Beds National Monument was showered with frothy rhyolite pumice from Glass Mountain, 9.6 kilometers to the south. Radiocarbon tests of ponderosa pine (Pinus ponderosa)[1] wood samples taken from trees buried in the pumice at Glass Mountain showed that the eruption occurred 1,100 to 1,600 years ago (Chesterman, 1955).

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[1] All plant species in this paper will be referred to by their scientific name, except in parts of the history and when the work of others is referred to. Scientific names and common names are listed in Appendix A.

All of the cinder cones, except Juniper Butte, and most of the land surface in the Lava Beds National Monument are recent in age (California Division of Mines and Geology, 1958; Macdonald, 1966). Mammoth Crater is the source from which most of the basalt and lava tubes originated in the Monument today. It is estimated to be 30,000 years old. Since Mammoth Crater has ceased activity, more recent volcanic activities have occurred. These include Cinder, Schonchin, and Three Sisters Buttes, Fleener and Ross Chimneys, and Black Crater (Mertzman, 1977).

Juniper Butte and Gillem's Bluff are the oldest features within the Monument. They are Miocene in age, approximately 15 million years old. The next oldest rocks can be found above Gillem's Bluff inside the bighorn sheep enclosure. These volcanic rocks are known locally as Warner Basalt, and are Pleistocene in age (1.5 million years old) (California Division of Mines and Geology, 1958).

The area adjacent to and partly inside the northern portion of the Lava Beds National Monument includes sedimentary lake deposits found to be Pliocene, Pleistocene, and Holocene in age (13 million years ago to recent geologic time). These deposits are part of former Tule Lake and consist of sand, silt, clay, ash, and lenses of diatomaceous earth. The semiconsolidated shale and clay deposits contain fossil clams, snails, and tules (Scirpus spp.). The maximum

known thickness of the lake deposits is 721 meters (Hotchkiss, 1968).

Soils

There has been no detailed classification within the Lava Beds National Monument, but a general description of widespread great groups can be discussed.

The Lava Beds National Monument is part of the Basin and Range Physiographic Province as described by Franklin and Dyrness (1973). This Province is principally mantled with Haplargids, Durargids, and Vitrandepts. Haplargids are derived from basalt and typically have a stony loam surface horizon. The subsoil is generally either clay or stony loam. Durargids are similar to Haplargids except they have a silica-cemented hardpan at depths of 2 to 5 decimeters. Vitrandepts have formed in volcanic pumice or slightly weathered volcanic ash (Franklin and Dyrness, 1973). Vitrandepts tend to be gravelly and feel like sandy loams or loamy sands (U.S.D.A. Soil Conservation Service, 1975). Pumice soils have relatively high moisture-holding capacities and much of this moisture is readily available to plants (Youngberg and Dyrness, 1964).

History of Use

The Lava Beds National Monument is important historically because it was the site of the Modoc Indian War. A band of Modoc Indians took refuge in the rugged lava flows just south of Tule Lake within the Lava Beds National Monument. These Indians held out against volunteer and federal troops for nearly six months. Only 13 Indians were killed, but more than 200 soldiers died in the only Indian war fought in California.

After the Modoc Indians were removed in 1873, the economy grew steadily from livestock production and later farming. Beginning in 1907, most of Tule Lake was drained by diverting the Lost River into the nearby Klamath drainage. This same channel could then be used to bring Klamath River water into the Lost River Basin for irrigation purposes. Dikes and drainage canals in former Tule Lake leave little resemblance of the pristine lake. Tule Lake was reduced from roughly 40,470 hectares to its present 5,261 hectares. Cleghorn (1959) showed that the water level of Tule Lake fluctuated widely over the years before being drained. Apparently the northern end of the lake was shallow and small changes in the water level caused dramatic changes in the shoreline. This makes interpretation of the drainage more complex. Nevertheless, the reduction of Tule Lake undoubtedly had an influence on the surrounding animal

and plant communities.

Livestock grazing had a dramatic impact on the plant communities on the Lava Beds National Monument. Records on file at the Monument headquarters show that thousands of cattle grazed in this area with the arrival of white settlers after the Modoc War. Large numbers of wild horses were also reported to have grazed in this area after the Modoc Indians were removed. In 1900 sheep were introduced with a corresponding decrease in cattle numbers. By 1920 the only grazing in the area was by sheep. During this period sheep grazing was uncontrolled. As one band moved off an area, another band was moved on. Consequently, the Monument was overgrazed especially that portion lying adjacent to Tule Lake.

With the creation of the Modoc National Forest in 1908, which included the Lava Beds National Monument, grazing regulations were gradually imposed. On November 21, 1925, the Lava Beds National Monument was officially established by presidential proclamation. Under the administration of the Modoc National Forest, grazing units were set up within the Monument and adjacent areas. These grazing units were not handled normally since they had no definite boundaries. Snowfall varied each winter, so sheep were allowed to follow snow accumulations for their water source. Seven sheepmen were each grazing 1500 sheep on the Monument annually between December 15 and February 28.

On August 10, 1933, administration of the Lava Beds National Monument was transferred to the National Park Service and lifetime, nontransferable permits were granted to the seven individuals. During this time sheep grazing was restricted to the northern two-thirds of the Monument. The remaining portion of the Monument was held for mule deer winter range.

Eventually, as sheepmen died or sold their sheep, their grazing permits expired. By 1952, the number of sheep grazing permittees dwindled to one and this individual stopped using his allotment in 1974.

Uncontrolled grazing during the early 1900's reduced many native perennial plants allowing several exotic plants to invade. Presently, the exotic grass cheatgrass (Bromus tectorum), occurs in most plant communities on the Monument.

The impact of fire was not recognized when the Monument was established in 1925. Both the Forest Service and the National Park Service maintained a vigorous fire suppression policy. Fire records over the past 41 years have recorded 75 lightning-caused fires for an average of 1.8 fires per year (Johnson and Smathers, 1976). Obviously, fire is an important component of the Monument's ecosystem. Fire exclusion has led to an increase of many woody species and altered the structure of several plant communities. Early explorers

to southern Oregon and northern California noted the park-like appearance of the ponderosa pine forests. Today, these forests on the Monument contain a heavy understory of several different brush species. Previously, fire must have kept these brush species in check.

LITERATURE REVIEW

The habitat type system developed by Daubenmire (1952) was the classification scheme used for this project. Habitat types seem to work particularly well in the western United States and have gained broad acceptance. Pfister (1977) published a comprehensive list of past and current forest habitat type classification projects in the West. Although no listing is known for grassland and shrubland habitat types, many studies have been completed and published.

Ecological Concepts

A stand may be defined as a piece of vegetation which occupies a distinctive habitat. Each stand has its own parameters and has its own boundaries set by the observer (Daubenmire, 1953). A stand may be a portion of or the entire plant community. A plant community is an assemblage of living plants having mutual relationships among themselves and to their environment. It is never absolutely permanent, but remains dynamic through time and space. Succession constantly changes the composition of plant communities until a relative equilibrium can be reached with the existing environmental components (i.e. soil, climate, animals, and flora). A seral plant community has interrupted age-gradients in species populations showing that some of the species are temporary. A climax plant community

has self-regenerating species populations and no evidence exists to show that a different subsequent community follows (Daubenmire, 1952).

One habitat type is capable of supporting many plant communities which exist as disturbance-induced or seral plant communities. Succession can ultimately change these communities to the climax state. The climax plant community is the most meaningful expression of the environmental factors influencing a habitat type. Each habitat type, then, has a certain potential for vegetative development and represents a narrow range of environmental variation (Pfister et al., 1977). Vegetation patterns correlate with the changes in climate, soil, and fauna. It should be possible to use any of these components to classify the landscape into habitat types, but their practicality is questionable. Plant associations seem to be the best guide to habitat types (Daubenmire, 1968).

Habitat typing is built around the concept of the plant association. It is the basic unit of vegetation classification and has the following characteristics: 1) definite composition, 2) uniform physiognomy, 3) uniform habitat conditions, and 4) climax condition. Plant associations have a certain degree of ecological amplitude. Thus, they are capable of experiencing a certain level of environmental variation without a corresponding change in their composition or structure. A pristine landscape consists of a mosaic of different,

well-defined climaxes. These climaxes contain stands which reappear wherever the habitats are similar (Daubenmire, 1968). Tansley (1935) classified these different types of climaxes into several categories. Collectively, the following are known as the "polyclimax theory." A climatic climax develops on gently, undulating relief with deep, loamy soils. An edaphic climax differs from the climatic climax by having extreme soil conditions such as rockiness or poor drainage. A topographic climax represents a deviation from the climatic climax due to the influence of relief, since north-facing slopes and south-facing slopes have strongly contrasting microclimates. These climaxes are considered primary and habitat types are usually best defined from them (Daubenmire, 1968). Secondary climaxes or disclimaxes are those climaxes maintained by some continuing disturbance. A fire climax is the result of recurrent burning which maintains fire-tolerant vegetation. A zootic climax occurs when an abundance of animals have sufficient impact on a site to change the vegetation away from the original climax. This change then stabilizes at a level corresponding to the animal pressure.

Continuum Versus Typal Community Approach

A great debate arises when dealing with the organization of plants in their communities. Two philosophies commonly heard are the continuum approach and the typal community approach. Gleason

(1939) avidly challenged the practice of describing "types" of vegetation. He contended that similarities between adjacent communities were caused by "nearly similar environmental selection, intensified by nearly similar environmental control, from a nearly similar population." He did not present any data in his paper. This idea was later supported by Curtis and McIntosh (1951) who utilized special plotless sampling and ordination techniques to analyze vegetation. The data from their continuum approach were interpreted as representing vegetation gradation from a wet to a dry environment. They graphed the abundance of each species along an environmental gradient and produced bell-shaped curves which never coincided. Thus, the continuum approach upheld Gleason's ideas that vegetation had no discrete boundaries, and plant communities could only be classified arbitrarily.

Daubenmire (1966) defended the typal community approach by distinguishing between flora and vegetation, and adding the component of competitive exclusion. He argued that the lowest level of flora is the species, and the lowest level of vegetation is the community. Each individual species is clearly a continuum because of its distinctive range, being the most abundant at the climatic optimum of its range. Sampling methods, which only measure species distribution and relative abundance over the landscape, undoubtedly yield data showing vegetation continua. In other words, sampling directed

towards flora shows that species are distributed independently.

Association tables published by many plant ecologists demonstrate that competition leads to similar community structure and composition. Mueller-Dombois and Ellenburg (1974) pointed out that a certain number of species in a community recur frequently in the same combinations, while other species do not. It is these frequently recurring plant combinations which form the basis for community distinction.

This debate probably will not be resolved within the near future but it should not prevent natural resource managers from using an ecologically-based classification. The primary objective of classification is to express the natural patterns of the landscape into something discrete. Land management based on discrete units is feasible, but land management based on a continuum is much more difficult.

Usefulness of Habitat Types

Recognizing habitat types can be of considerable value. Several management implications have been expressed by habitat types since Daubenmire's earlier publications. Perhaps the habitat type concept is one of the prime examples where the gap between the land manager and the researcher can be considerably reduced.

Habitat typing is not a panacea for all resource interpretations, but it tends to complement wildlife surveys, soil surveys, hydrologic surveys, and others. Some of the applications of habitat typing are as follows:

1) Habitat type mapping. Habitat type maps serve as the focal point in land-use planning.

2) Silvicultural implications. Habitat types can serve as guidelines for seed collecting, site selection for nursery stock, evaluation of cutting methods, and site preparation (Pfister, 1972). Productivity data and tree species distribution can be correlated with habitat types (Pfister, 1976).

3) Big game forage and cover. Different habitat types have unique biotic capabilities; thus, the resource manager can adjust game populations on a potential supply-current demand basis (Lyon, 1975).

4) Forage production for livestock. Same as the previous example.

5) Water production. Water yields are probably related to habitat types, so certain seepage areas might warrant special management (Pfister, 1976).

6) Recreation and aesthetics. Habitat types have been assigned suitability indexes to evaluate impacts of use on plant communities and predict recovery rates after disturbance (Helgath, 1975).

7) Resource protection. Habitat types can be used to assess fuel buildup and fire hazard. They can also be used to predict potential insect and disease problems (Pfister et al., 1971).

8) Ecotypic variation. Habitat types can be used to show racial variation in a species (Daubenmire, 1976; Winward, 1970).

9) Natural area preservation. Habitat types can be invaluable for recognizing and preserving representative associations of vegetation (Franklin et al., 1972).

Literature and Information Pertinent to the Study Area

Previous work on the flora of the Lava Beds National Monument has been infrequent. Applegate (1938) made the first comprehensive study and collection of the vascular plants occurring on the Monument. He found approximately 200 species during the seasons of 1935, 1936, and 1937, and listed them in his publication. From this list of 200 plants, many were found adjacent to the Monument and not inside the border. Wunner (1967) identified a few additional species occurring on the Monument, but basically provided little in addition to Applegate's earlier work.

Some plant community work has been done on the Lava Beds National Monument, but was general in its scope. Records on file at the Monument headquarters indicate that two men were employed in a survey which began May 7, 1936. The field work terminated on May 20, 1936, and the office work in connection with the survey was finished June, 1937. The final vegetation map was produced at a scale of 2 inches equal to 1 mile. Essentially no work has been done at the habitat type level on these lands.

Johnson and Smathers (1976) provided a brief review of the

Monument's past land use and some of the vegetational changes which they believe fire exclusion initiated. Their theoretical reconstruction of 1873 vegetation describes three major plant communities present. These were, 1) a grassland community dominated by bluebunch wheatgrass (Agropyron spicatum), 2) a woodland community co-dominated by ponderosa pine and western juniper (Juniperus occidentalis), and 3) a coniferous forest community dominated by ponderosa pine.

The grassland community currently supports many exotic plant species and there has been an increase in woody plants. The woodland community, through a combination of drought and attack by the western pine beetle (Dendroctonus brevicomis) in the 1920's, has lost most of the ponderosa pine trees. The coniferous forest community has experienced an increase of woody plants in the understory (Johnson and Smathers, 1976).

Using 41 years of fire history records kept by the Monument, Johnson and Smathers (1976) were able to breakdown the lightning-caused fire frequencies for the different plant communities. They found that the grassland community had one fire every .86 year; the woodland community had one fire every 2.1 years; and the coniferous forest community had one fire every 5.8 years.

Recently, the National Park Service has initiated a prescribed burning program in an attempt to restore the vegetation to its natural

condition. Fortunately photographs taken during the Modoc War provide an unusual insight to some of the primitive vegetation.

METHODS

This study began in July, 1977. Initial efforts were directed towards learning, 1) all plant species found on the Monument, 2) land features and landmarks within the Monument, and 3) the general plant communities representing homogeneous assemblages of vegetation. This was then followed by sampling representative stands of homogeneous units.

Plant Collection

Every attempt was made to collect, dry, and mount the vascular plant species encountered on the Monument. These plant species were identified using Munz (1959) A California Flora and Supplement. Updating species names, when possible, was accomplished using Hitchcock and Cronquist (1974) Flora of the Pacific Northwest. All plant specimens identified were checked for their rare status using the California Native Plant Society (1974) Inventory of Rare and Endangered Vascular Plants of California. Garrison et al. (1976) was used as the authority for common names.

Dried plants were mounted on herbarium sheets and covered with clear acetate. Each herbarium specimen contained the following: 1) date collected, 2) scientific name and common name, 3) collector, 4) locality and slope exposure, and 5) layer dominants in the

community. At the termination of the study, all specimens were given to the Lava Beds National Monument for incorporation into their herbarium.

Vegetation Sampling

Minimum size delineations for plant communities was roughly .4 hectare. Sites which were, 1) rocky with less than 20 percent vascular plant cover and more than 80 percent rock cover, or 2) smaller than 1.2 hectares were evaluated with a visual prominence rating. Prominence refers to species impact on a site (Winward and Youtie, 1976) and estimates ranged from 5 to 1 as follows:

5 = abundant--plants conspicuously scattered throughout and showing highest degree of influence on the site.

4 = moderately abundant but areas without individuals present.

3 = perennial species uniformly scattered throughout stand but in low abundance or most prominent annual species.

2 = perennial species encountered occasionally or in patches; if annuals, only moderately abundant.

1 = rare--found only through intensive search.

Vegetation sampling of plant communities neither too rocky or too small was similar to the method used by Poulton and Tisdale (1961) and Winward (1970). Stand selection for sampling was based on homogeneity of species composition, relative dominance, and

vigor. An attempt was made to sample at least five stands of each community type found as recommended by Poulton and Tisdale (1961).

A 30-meter base line was set-up running parallel with the contour within a stand. Plastic flagging was used to mark the approximate center of the base line. In addition, the position of the base line in relation to surrounding features was recorded on the transect forms and marked on the aerial photo overlay. Three 30-meter transect lines were established at right angles from the base line as shown in Figure 4.

Frequency for all vascular plant species, as defined by Pieper (1973), was measured using a 30 x 60 centimeter plot. The plot frame was placed parallel to the left side of each transect line and advanced in three-meter increments. Within each plot, a visual estimate of percent cover for total vegetation, litter, rock, and bare ground was made.

Density, as defined by Duvall and Blair (1963), was measured for shrubs using a 1 x 30 meter plot, also located parallel to the left side of each transect line. As each shrub was counted, it was recorded in general height classes as follows: (1) 0 to 15 centimeters; (2) 15 to 30 centimeters; (3) greater than 30 centimeters; and (4) dead. Trees were also recorded in general height classes as follows: (1) 0 to .3 meters; (2) .3 to 3 meters; (3) greater than 3 meters; and (4) dead. The basis for inclusion for both density and frequency was that

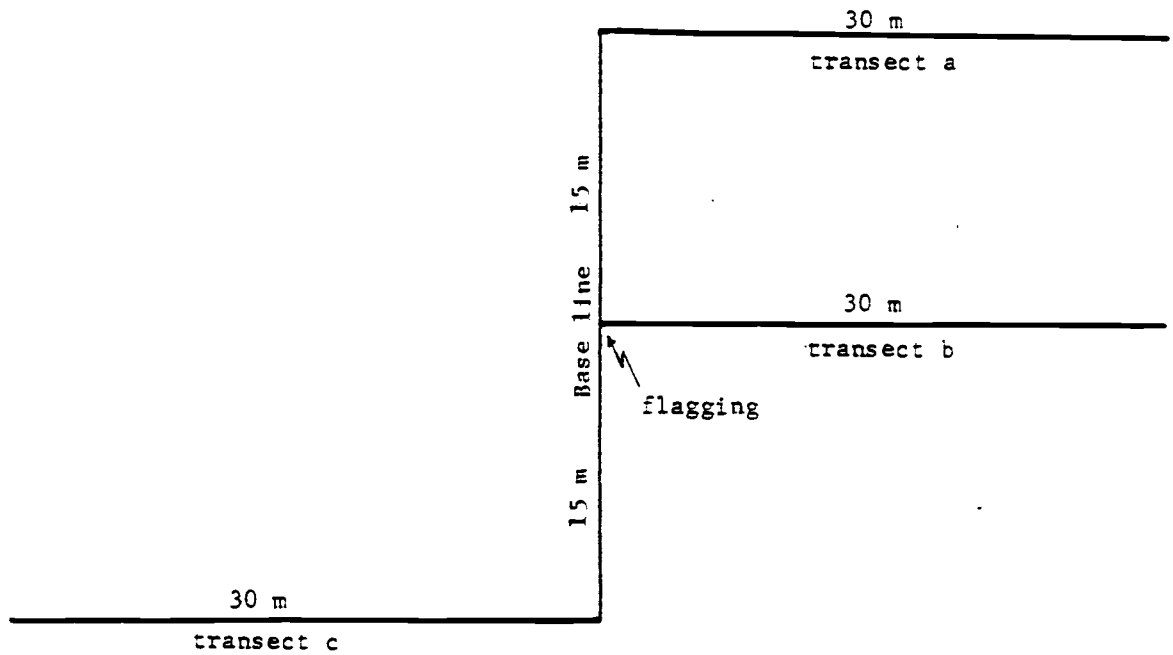

Figure 4. Location of transect lines in relation to the base line.

the plants be rooted within the plot.

The line intercept method, described by Canfield (1941), was used to measure shrub canopy cover. Large void spaces and dead portions (greater than 10 centimeters) within shrub canopies were not counted as cover. Line intercept was not used for Pinus ponderosa. Instead, canopy cover was measured with a type C forest densiometer at the time of sampling (Lemmon, 1956). Readings were taken every 100 paces for a total of four reading stations per community. The reading at each station included the mean of measurements taken facing each of the four cardinal directions. Five increment cores were taken at random in each Pinus ponderosa stand sampled to gain some insight to tree age.

All vascular plant species seen in a stand but not encountered in the frequency or density plots were recorded on the transect forms. Slope, aspect, elevation, date, and location of the base line were also recorded on the transect forms.

Soil Analysis

Soil descriptions for this project were accomplished during October, 1978. An attempt was made to describe at least one soil profile for each plant community. The rocky sites were not included for soil analysis. For each soil horizon the following were recorded: 1) horizon designation, 2) depth, 3) Munsel color notation, 4) boundary,

5) texture, 6) structure, 7) colorimetric pH, and 8) presence of carbonates. These attributes were determined by standard field methods defined by the U.S.D.A. Soil Conservation Service (1975). Horizon designations were later checked by Dr. G. H. Simonson, Oregon State University Soils Department. Soil profiles and rooting depth were described to a maximum depth of 102 centimeters.

Interpretation of Data

Frequency data from transect-sampled communities were arranged in a table by stands and plant species using the association table process described by Mueller-Dombois and Ellenburg (1974). A summary table was constructed from the association table presenting average frequency and constancy of each plant species by community. Since this table was very large and awkward, only plant species with at least two percent average frequency were listed in the final table. Cover and density data also were summarized and incorporated into respective tables. This was accomplished by first averaging by stand and then by community. Plant community nomenclature was derived from dominants, as expressed by, 1) high canopy coverage and density for trees and shrubs, and 2) high frequency and constancy for herbaceous species.

Prominence values were organized into a table by stands and plant species. This process was accomplished by cutting strips

vertically (stands) and then horizontally (plant species) to produce the best visual association. Similar dominant species, those plants with high prominence values, were used to group similar stands. These dominants formed the basis for community nomenclature. Prominence values for similar stands were then averaged to form a summary table.

Habitat type names were based on the climax or potential climax dominants on each site. For example, a Purshia tridentata/Agropyron spicatum habitat type is characterized by Purshia tridentata as the principal shrub, and Agropyron spicatum as the principal grass species. Other shrubs and grasses may be present but not as dominant as the two named (Daubenmire, 1970). Reaction categories (i.e., decreaser, increaser, or invader) were considered when establishing potential climax dominants on disturbed areas. A decreaser is a plant which is palatable and is the first to decrease under heavy grazing or site disturbance. An increaser is a plant low in palatability and tends to increase under heavy grazing or site disturbance. Both decreasers and increasers are present in the native vegetation. An invader is a plant which is not present in the native vegetation but establishes and increases under heavy grazing or site disturbance.

Mapping

Preliminary mapping of the plant communities was performed on color aerial photo overlays. The photographs were taken in 1974 and had an approximate scale of 1:17,125. A mirror stereoscope was used on the photographs to delineate major plant communities while in the lab. These boundaries were determined by differences in photographic tone, pattern, topographic location, and texture (Avery, 1977). Tentative delineations were then ground-truthed for accuracy, and lines adjusted where appropriate at the time of sampling. Final mapping of the plant communities was accomplished by using the aerial photo overlays and the mirror stereoscope, and was developed onto a photo mosaic of the Monument (scale approximately 1:16,023).

Habitat type mapping required the synthesis of data and notes taken at each sampling site, the plant community map, and pertinent literature. Habitat type determinations also involved recognizing indicator species of particular site potential. Final mapping was developed on a photo mosaic of the Monument (scale approximately 1:16,023).

RESULTS AND DISCUSSION

Transect-sampled Communities

Twenty-three plant communities were identified (Table 1) and mapped (Figure 5 in packet) on the study area. These included nine forest, nine shrub, and five grassland communities. These communities are grouped according to dominant tree, shrub, and grass species. Brief descriptions of all plant communities along with notes concerning character species are treated individually in the following sections.

Only communities represented by more than one stand were used to generate Tables 2, 3, 4, and 5. The mean frequency-constancy data (Table 2) and the mean woody plant foliage cover data (Table 3) were used to identify communities and their associated plant species. Generally, woody layer dominants were required to have a canopy cover exceeding one percent and four percent for tree and shrub species, respectively. Average visual cover estimates of vegetation, litter, rock, and bare ground are provided for each community in Table 4. Table 5 provides average shrub and tree density values by height class for each community. Greater emphasis was placed on foliage cover rather than plant density for describing the woody plant layers because of the higher variability in the density data.

Table 1. Transect-sampled communities, community codes, and index numbers.

Plant Community	community code	index no.
Pinus ponderosa/Purshia tridentata	Pipo /Putr	1
Juniperus occidentalis/Cercocarpus ledifolius/Festuca idahoensis	Juoc/Cele/Feid	2
Juniperus occidentalis/Agropyron spicatum	Juoc/Agsp	3
Juniperus occidentalis/Cercocarpus ledifolius	Juoc/Cele	4
Juniperus occidentalis/Artemisia tridentata ssp. vaseyana/Stipa occidentalis	Juoc/Artrv/Stoc	5
Cercocarpus ledifolius	Cele	6
Artemisia tridentata ssp. vaseyana/Festuca idahoensis-Agropyron spicatum	Artrv/Feid-Agsp	7
Artemisia tridentata ssp. vaseyana/Stipa thurberiana-Agropyron spicatum	Artrv/Stth-Agsp	8
Artemisia tridentata ssp. vaseyana/Stipa occidentalis	Artrv/Stoc	9
Artemisia tridentata ssp. vaseyana/Bromus tectorum	Artrv/Brte	10
Artemisia tridentata ssp. tridentata/Bromus tectorum	Artrt/Brte	11
Purshia tridentata/Bromus tectorum-Agropyron spicatum	Putr/Brte-Agsp	12
Purshia tridentata/Bromus tectorum-Stipa occidentalis	Putr/Brte-Stoc	13
Chrysothamnus nauseosus var. albicaulis/Bromus tectorum-Stipa thurberiana	Chnaa/Brte-Stth	14
Festuca idahoensis-Poa sandbergii	Feid-Posa 3	15
Elymus cinereus-Bromus tectorum	Elci-Brte	16
Stipa thurberiana-Agropyron spicatum	Stth-Agsp	17
Bromus tectorum-Stipa occidentalis	Brte-Stoc	18
Bromus tectorum	Brte	19
*Pinus ponderosa/Arctostaphylos patula	Pipo/Arpa	20
*Pinus ponderosa/Purshia tridentata-Arctostaphylos patula	Pipo/Putr-Arpa	21
*Pinus ponderosa/Haplopappus bloomeri	Pipo/Habl	22
*Juniperus occidentalis/Purshia tridentata	Juoc/Putr	23

*plant community fragments

Table 2. Mean frequency-constancy percentages for species with at least two percent mean frequency.

	Elci-Brte	Juoc/Cele	Cele	Artr/Brte	Brte	Juoc/Agsp	Putr/Brte-Agsp	Artr/Brte	Pipo/Putr	Artr/Stoc	Juoc/Artr/Stoc	Chnaa/Brte-Sath	Putr/Brte-Stoc	Juoc/Cele/Feid	Brte-Stoc	Feid-Posa 3	Artr/Feid-Agsp	Artr/Sath-Agsp	Sath-Agsp
No. of samples *	4	5	7	3	8	2	3	5	7	5	6	7	2	7	4	4	11	8	8
TREES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Juniperus occidentalis		*				*					*			*					
Pinus ponderosa									*										
SHRUBS	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Chrysothamnus viscidiflorus	3-25									2-40			5-100		4-25	3-50		2-38	3-13
Ribes velutinum		3-60				2-50	2-67												
Cercocarpus ledifolius		5-60	5-100											14-100			4-36		
Artemisia tridentata ssp. tridentata				6-100															
Chrysothamnus nauseosus var. albicaulis				4-33			7-100	2-40				5-71	2-50						
Artemisia tridentata ssp. vaseyana						8-100		9-100		23-100	8-83						18-100	19-100	4-25
Purshia tridentata							9-100		20-100	5-40	2-23		4-50	7-71			5-55		
Haplopappus bloomeri									5-43										
Leptodactylon pungens										4-20									
Tetradymia canescens												2-29	2-50			2-25			
Artemisia arbuscula																2-50			
GRASSES and GRASS-LIKES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Elymus cinereus	56-100																		
Sitanion hystrix	17-75	5-80	3-57	2-33	5-50			5-40	4-57	20-100	8-83	3-43	7-100	7-57	3-25	42-75	2-27	7-63	8-50
Bromus tectorum	98-100	16-60	22-100	99-100	94-100	12-100	95-100	100-100	16-29	14-80	36-100	96-100	100-100	8-29	100-100	34-75	13-64	46-88	86-100
Stipa occidentalis		5-20				4-50	10-67		7-86	24-100	15-100		24-100		20-100				
Poa sandbergii			13-86	2-67	15-50	2-50		15-80		3-20	9-67	75-100	3-100	31-71	4-50	99-100	52-100	64-100	45-100
Agropyron spicatum						50-100	38-100					21-100		27-100	9-75	5-25	50-100	34-100	22-100
Festuca idahoensis							7-33							78-100		87-100	64-100	9-63	2-25
Stipa thurberiana								2-40			2-33	51-100			4-25	2-25	29-100	50-100	48-100
Carex rossii									2-86	3-20			2-50						
Koeleria cristata														2-14			16-73	7-75	3-50
Bromus commutatus																4-25			
Festuca bromoides																		8-13	9-29
FORBS	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lepidium perfoliatum	31-75																		
Holosteum umbellatum	9-25				13-13														
Descurainia sofia	58-100				20-25													3-13	
Descurainia pinnata var. halictorum	4-25	5-40				4-50		4-60								3-25		2-13	3-38
Sisymbrium altissimum	31-100	5-20		12-100	35-88		2-33	2-40				4-29			32-100	3-50			12-75
Draba verna	5-50			66-67	50-50			96-100				82-86		13-14	3-25	94-100	23-45	25-25	63-75
Stephanomeria virgata		2-20					3-67												
Senecio canus		3-40								2-20									
Phacelia ramosissima		30-80				2-50	6-67												
Collomia tinctoria		24-80				13-100	2-67				11-67								
Epilobium paniculatum		2-20							3-43				2-50		10-50				
Clarkia rhomboidea		5-60				14-50	8-67		9-43										
Eriogonum nudum var. pubiflorum		9-60			2-13	39-100	18-100		6-43										
Penstemon cinereus		3-20							10-57					7-57			2-18	3-38	
Phacelia hastata		25-80				5-50	26-67		2-43		2-17		2-50		4-50				
Cryptantha ambigua		19-80	8-100			9-50				4-40	14-67			6-43	2-25		2-36	3-38	11-25
Gayophytum diffusum		3-60			2-13	15-50			20-86	15-100	9-83		45-50	15-71			21-55	8-13	6-25
Collinsia parviflora		15-60	4-43		6-13				57-100	66-100	81-100		44-50	55-100		19-75	31-55		9-25
Mentzelia albicaulis		31-100			12-13	27-100	40-100		22-86	13-60	40-100		45-100	8-43	12-100		4-36		2-13
Agastache parvifolia			2-43																
Eriogonum umbellatum ssp. polyanthum			4-43			2-50			2-14		4-50			9-86			3-45		
Plectritis macrocera				11-33															
Salsola kali				3-33															

Table 2. (Continued)

	Elci-Brte	Juns/Cala	Cala	Artr/Brte	Brte	Juns/Agpp	Potr/Brte-Agpp	Artr/Brte	Pipo/Pseu	Artr/Stoc	Juns/Artr/Stoc	Chrys/Brte-Stoh	Potr/Brte-Stoc	Juns/Cala/Feid	Brte-Stoc	Feid-Pseu 3	Artr/Feid-Agpp	Artr/Stoh-Agpp	Stoh-Agpp
No. of samples*	4	5	7	3	8	2	3	5	7	5	6	7	2	7	4	4	11	8	8
Erodium cicutarium				2-33	59-75			9-40				2-43							6-25
Mimulus rubellus				6-33						6-20	3-33				4-25			5-13	4-25
Lupinus subvexus var. transmontanus					13-38											21-50			
Cryptantha torreyana					10-13				24-57				9-50						
Penstemon lactus						3-100													
Mondardella odoratissima						10-50	17-67												
Stephanomeria tenuifolia						5-50	15-67												
Mimulus nanus						7-50					10-67								
Nama densum						7-50					2-17								
Clarkia lassenensis						2-50	8-33			3-40	4-67		2-50				4-27		5-13
Viola purpurea var. venosa							4-33												
Madia gracilis							2-33												
Galium aparine							7-67												
Collomia grandiflora							12-67						2-50	9-43			2-9		
Eriogonum vimineum									3-29	15-60	13-83		49-50		2-50				3-13
Eriogonum ovalifolium										6-20									
Microsteris gracilis										11-80	8-100			16-57		3-25	15-55		3-38
Phacelia lineris										27-60	23-83		2-50		9-50	4-25	21-55	10-25	5-50
Phlox caespitosa													2-50	32-86		15-25	5-73	6-75	
Arabis sparsiflora														3-29					
Silene douglasii														6-43					
Heuchera ovalifolia														2-29					
Microseris nutans														4-14					
Potentilla glandulosa														3-43					
Calochortus macrocarpus														2-29		10-25			
Achillea millefolium														9-57			2-45		
Linum micranthum														2-29			5-18		
Crepis acuminata														4-43		8-25		3-63	
Antennaria dimorpha														2-14		6-100	2-27	2-25	
Erigeron filifolius														2-14		5-25		3-50	2-13
Astragalus filipes															2-25		3-9		
Astragalus obscurus																2-50			
Eriophyllum lanatum var. lanatum																6-25			
Epilobium minutum																4-75			
Phlox hoodii																4-75			
Lomatium nevadense																9-50			
Gayophytum ramosissimum																	3-18		5-13
Astragalus purshii																		2-38	
Eriogonum strictum ssp. proliferum																		2-13	
Scutellaria nana																			3-13

*No frequency-constancy data--see cover data (Table 3).

Table 3. Mean foliage cover and standard deviation for woody species contributing at least one percent cover to each community.

SPECIES	Pipo/Purs	Juoc/Cela/Feid	Juoc/Agsp	Juoc/Cela	Juoc/Artr/Stoc	Cela	Artr/Feid-Agsp	Artr/Sith-Agsp	Artr/Stoc	Artr/Brte	Artr/Brte	Purs/Brte-Agsp	Purs/Brte-Stoc	Chna4/Brte-Sith	Brte-Stoc
Arctostaphylos patula		1.6 3.0													
Artemisia triklentata ssp. tridentata											18.4 4.7				
Artemisia tridentata ssp. vaseyana			3.4 3.2		4.3 4.8		10.6 5.8	11.9 2.6	15.5 3.9	7.7 1.9					
Cercocarpus ledifolius		17.0 7.7		19.4 11.9	3.1 3.1	28.1 10.3									
Chrysothamnus nauseosus var. albicaulis										1.1 1.4	3.6 6.2	4.1 3.2	1.0 .2	4.4 1.5	
Chrysothamnus viscidiflorus													3.7 .7		1.2 1.4
Juniperus occidentalis		5.2 6.8	13.6 17.5	20.2 12.5	9.3 6.6										
Pinus ponderosa	22.1 12.6														
Purshia tridentata	9.6 6.4	4.1 2.8		2.4 2.3			5.3 3.0	2.5 2.8	4.8 2.6		10.8 3.9	8.8 4.2			
Ribes cereum						1.3 1.7									
Ribes velutinum						1.8 1.2									

Table 4. Mean and standard deviation of vegetation, litter, rock, and bare ground cover by plant community.

	Pipo/Purr	Juoc/Cele/Feid	Juoc/Agsp	Juoc/Cele	Juoc/ Arnv/ Stoc	Cele	Arnv/ Feid-Agsp	Arnv/ Sith-Agsp	Arnv/ Stoc	Arnv/ Brte	Arnv/ Brte	Purr/ Brte-Agsp	Purr/ Brte-Stoc	Chnau/ Brte-Sith	Feid-Poss 3	Elci-Brte	Sith-Agsp	Brte-Stoc	Brte
	n																		
	s																		
Vegetation	15	36	14	18	17	30	30	24	21	17	23	22	18	18	24	24	16	13	11
	6.1	11.3	7.8	6.9	3.9	12	1.9	5.5	2.9	5.8	3.1	4.6	1.4	6.4	6.9	6.4	4.3	2.4	3.2
Litter	60	37	16	36	21	21	23	19	24	33	42	20	20	33	20	32	28	13	49
	25.7	7.5	2.1	16.1	2.6	7.1	8.2	4.8	8.7	8.9	4.7	2.3	5.7	7.1	7.0	12.8	13.2	5.1	18.5
Rock	25	19	67	44	62	48	31	31	55	24	21	54	61	21	27	1	35	70	31
	25.9	10.6	7.1	23.8	5.4	17.3	10.5	11.8	11	11.8	15.4	3.2	.7	10.2	28.8	.5	18.5	9.0	25.9
Bare Ground	0	8	4	2	0	0	16	26	0	27	14	4	2	28	29	44	22	4	10
	0	6.5	2.1	1.8	.4	.4	10.1	8.9	0	5.2	17.6	5.9	2.8	12.0	21.1	11.4	11.7	3.6	7.7

Table 5. Mean and standard deviation of shrub and tree density/300 square meters by height class for each community.

	SHRUBS	Amelanchier alnifolia	Artemisia arbuscula	Artemisia cana	Artemisia tridentata ssp. tridentata	Artemisia tridentata ssp. vaseyana	Cercocarpus ledifolius	Ceanothus greggii	Chamaebatiaria millefolium	Chrysothamnus nauseosus var. graveolens	Chrysothamnus viscidiflorus	Haplopappus bloomeri	Leptodactylon pungens	Purshia tridentata	Ribes cereum	Ribes velutinum	Salvia dorrii ssp. carnosa	Tetradymia canescens	TREES	Juniperus occidentalis	Pinus ponderosa	Prunus emarginata	Prunus virginiana
	cm	x̄ s	x̄ s	x̄ s	x̄ s	x̄ s	x̄ s	x̄ s	x̄ s	x̄ s	x̄ s	x̄ s	x̄ s	x̄ s	x̄ s	x̄ s	x̄ s	x̄ s	m	x̄ s	x̄ s	x̄ s	x̄ s
Pipo/Putr	0-15						9 21					11 18		32 39					0-.3	1 2	1 2		1 3
	15-30					*	*			2 4		6 8		12 18					.3-3		2 4		2 6
	30+					2 5	2 4			2 4	*	30 42		182 90	4 7	*			3+		5 5		
	dead					1 4	*							84 85					dead		2 2		
Juoc/Cele/Feld	0-15					*	92 114	3 8		*				1 3					0-.3	3 3			1 4
	15-30					3 6	30 30							8 10		3 5			.3-3	5 5			
	30+	1 3		3 5		13 17	47 36			*	*			89 81	1 1	1 3			3+	4 7			
	dead					4 7	16 30							32 32					dead	*	*		
Juoc/Agsp	0-15					2 2								9 12					0-.3	2 2			
	15-30													2 2					.3-3				
	30+					39 54				9 12				20 18		2 2			3+	3 0			
	dead					20 28				2 2				2 2					dead				
Juoc/Cele	0-15						12 23												0-.3				11 22
	15-30						9 12												.3-3	1 1			5 7
	30+						36 33			4 5				3 4		11 11	1 1		3+	9 11			
	dead						21 12			1 1				1 1		1 1	1 3		dead	1 1			
Juoc/Artrv/Stoc	0-15					2 3	2 4			1 1		1 1		3 3					0-.3				1 3
	15-30					5 4					1 1	3 4		2 3					.3-3	2 2			1 1
	30+					71 51	4 5			1 3		2 4		21 23		1 2		1 3	3+	5 4			
	dead					40 25	5 9			1 1				3 4					dead	1 1			
Cele	0-15						2 2												0-.3				2 5
	15-30					*	1 3			*					*	1 3			.3-3				2 6
	30+					10 18	32 24		1 2	7 12		8 20		5 14	6 6	23 16			3+	*			
	dead					2 4	21 15			1 4				*		1 1			dead				*
Artrv/Feld-Agsp	0-15					7 21	8 16							1 4					0-.3	1 1			
	15-30					12 9	7 12				3 6	1 2		3 5				1 3	.3-3	1 2			
	30+					189 60	1 2			2 4	11 15	3 9		53 33	*	*		9 13	3+				
	dead					57 57	4 6			1 2	1 2			10 20					dead	*			
Artrv/Stth-Agsp	0-15					31 82					*								0-.3	*			
	15-30					22 23	*			*	3 5	3 7		1 2				3 7	.3-3				
	30+					183 64				4 12	5 8	9 21		13 14				12 19	3+				
	dead					29 18				2 4		1 4						1 2	dead				
Artrv/Stoc	0-15					13 11					1 1	5 10		2 4				1 1	0-.3				
	15-30					20 22					3 6	2 4		5 4					.3-3				
	30+					281 53				1 1	11 10	7 15	1 1	36 45				2 4	3+				
	dead					63 33				3 6				7 13					dead				
Artrv/Brte	0-15					12 15				8 18									0-.3				
	15-30					21 14				7 12								1 1	.3-3				
	30+					134 47				48 46		1 3							3+				
	dead					61 39				25 35									dead				

Table 5. (Continued)

	SHRUBS	Amelanchier pallida		Artemisia arbuscula		Arctostaphylos patula		Artemisia tridentata ssp. tridentata		Artemisia tridentata ssp. vaseyana		Cercocarpus ledifolius		Ceanothus prostratus		Chamaebatiaria millefolium		Chrysothamnus nauseosus var. artus		Chrysothamnus viscidiflorus		Haplopappus bloomeri		Leptodactylon pungens		Purshia tridentata		Ribes cereum		Ribes velutinum		Salvia dorrii ssp. carnosa		Tetradymia canescens		TREES	Juniperus occidentalis		Pinus ponderosa		Prunus emarginata		Prunus virginiana	
	cm	×	•	×	•	×	•	×	•	×	•	×	•	×	•	×	•	×	•	×	•	×	•	×	•	×	•	×	•	×	•	×	•	×	•	m	×	•	×	•	×	•	×	•
Artr/Brte	0-15							2	4																											0-.3								
	15-30							3	4																											.3-3								
	30+							122	55																											3+								
	dead							36	36																											dead								
Putr/Brte-Agsp	0-15									1	2																	1	2							0-.3							2	4
	15-30																																	1	2	.3-3								
	30+				•					3	4							42	13		2	4				40	29			11	17			4	8	3+								
	dead																	15	7							7	4									dead	1	2						
Putr/Brte-Stoc	0-15																																			0-.3								
	15-30																				2	2				3	0							7	9	.3-3								
	30+									2	2							12	7		73	28				22	21							20	28	3+								
	dead									4	5	2	2					25	3		92	73				19	26									dead								
Chnaa/Brte-Stth	0-15																																	*		0-.3								
	15-30																	9	14		1	4													*	.3-3								
	30+									5	14							103	55		19	50							•					8	18	3+								
	dead									11	11							50	68		1	3			•											dead								
Feid-Posa 3	0-15		2	4						1	2										4	5												1	2	0-.3								
	15-30																				13	19												1	2	.3-3								
	30+		18	19														3	3		21	25												6	12	3+								
	dead		5	6						8	15										3	5														dead								
Elci-Brte	0-15																	5	10		1	2														0-.3								
	15-30																	5	10		1	2														.3-3								
	30+																	12	24		19	14														3+								
	dead					9	16																													dead								
Stth-Agsp	0-15									16	41																							*		0-.3								
	15-30									3	5							*			3	10												2	5	.3-3								
	30+									9	23							2	5		27	75		1	4									7	14	3+								
	dead									38	42							2	3		10	19				8	14							1	2	dead	•							
Brte-Stoc	0-15																	1	2		80	160														0-.3					3	5		
	15-30																				16	24														.3-3					3	5		
	30+									1	2	2	4					11	15		23	32				1	2									3+								
	dead									8	6	9	11					3	3		8	17				8	6									dead					3	7		
Brte	0-15																																			0-.3								
	15-30									1	2															*										.3-3								
	30+																									*										3+								
	dead					2	4	7	16			1	4					4	12						•												dead	1	2	•					
								25	67																	18	52																

*Contributes less than one individual

Plant communities represented by only one stand are listed towards the end of Table 1 and are designated "plant community fragments." Data representing these communities are incorporated into tables following the description of each fragment.

1. Pinus ponderosa/Purshia tridentata (Pipo/Putr)

Seven stands of the Pipo/Putr community were sampled, and all were restricted to the southern portion of the Monument. It was the most common of the Pinus ponderosa dominated communities encountered, and was damaged most by the western pine beetle attack in the 1920's. Consequently, its range has receded and Juniperus occidentalis and Cercocarpus ledifolius have increased on these sites.

Elevation varied from 1,408 to 1,585 meters on undulating slopes of seven percent or less. Soils were 79 centimeters deep with sandy textured horizons throughout the profile. Pumice was the dominant feature in the profile and undoubtedly had a significant impact on the vascular flora. Litter cover averaged 60 percent in this type as a result of heavy pine needle accumulations. Rock cover was the next highest value at 25 percent, due primarily to exposed pumice on the ground surface. Vegetative cover, excluding Pinus ponderosa, made up the remaining 15 percent (Table 4).

Pinus ponderosa dominated the tree layer with an average canopy cover of 22.1 percent (Table 3). The average sampled tree

age was 116.5 years and ranged from a low of 52 years to a high of 225 years. At least one-fourth of the trees in each stand representing the Pipo/Putr community were too large to core. Other trees consistently present were Juniperus occidentalis and Prunus virginiana, but both were always in low amounts. Purshia tridentata dominated the shrub layer with an average canopy cover of 9.6 percent (Table 3) and was the most conspicuous shrub in all height classes (Table 5). Other shrubs generally present in this community were Cercocarpus ledifolius, Haplopappus bloomeri, and Ribes cereum. Stipa occidentalis was the most important perennial in the herbaceous layer with an average frequency of 7 percent and 86 percent constancy (Table 2). Perennial graminoids, Carex rossii and Sitanion hystrix, were generally present but with low frequency. Penstemon cinereus was the most frequent perennial forb with an average frequency of 10 percent and 57 percent constancy (Table 2). It is listed as rare by the California Native Plant Society (1974).

Pinus ponderosa is widely distributed in North America and grows on soils of igneous, metamorphic, and sedimentary origin (Fowells, 1965). It grows best on well-drained, deep sandy, gravel, and clay loams (Meyer, 1931). Pinus ponderosa is considered shade intolerant and may be replaced by Abies concolor, Libocedrus decurrens and others (Baker, 1949). Fire has played an important part in the shaping of Pinus ponderosa forests. Wright (1978)

documented several researchers' findings that fire kept these forests open and park-like with an understory of shrubs and herbs. Fire apparently thinned trees and allowed surviving trees to increase in diameter.

Purshia tridentata grows under a wide variety of climatic and soil conditions. It can generally be found on young, deep, coarse-textured, well-drained soils (Driscoll, 1964; Nord, 1965). It has been described as a pioneer species on volcanic deposits in California (Nord, 1965) and in Idaho (Eggler, 1941). It has the ability to sprout after mechanical damage or light burning on moist soils (Pechanec et al., 1965). This plant is probably best known for its browse value. In a digestibility study conducted on foods commonly eaten by deer in California, Purshia tridentata was the only browse tested which could sustain a deer as a single food supply for long periods (Bissell et al., 1955).

2. Juniperus occidentalis/Cercocarpus ledifolius/Festuca idahoensis (Juoc/Cele/Feid)

This community was common on several cinder cones in the southern half of the Monument. Seven stands were sampled and each occurred on north-facing aspects. Slopes ranged from 35 to 50 percent and elevation varied from a low of 1,439 meters to a high of 1,573 meters. Soils were 20 to 38 centimeters to the basalt cinder

parent material and tended to fluctuate with the pumice accumulations. The soil surface horizon was sandy textured with granular structure. Litter cover averaged 37 percent which was closely followed by vegetative cover with 36 percent. Rock cover and bare ground averaged 19 and 8 percent, respectively (Table 4).

The dominant tree in this type was Juniperus occidentalis with 5.2 percent average canopy cover (Table 3). It has become well established with individuals represented in each height class (Table 5). Dead Pinus ponderosa trees were commonly found scattered throughout most of these stands. Cercocarpus ledifolius dominated the shrub layer with 17 percent average canopy cover (Table 3). It also had numerous plants in each height class (Table 5). Purshia tridentata was an important member of this community but only had a canopy cover of 4.1 percent (Table 3). It appeared decadent in most stands and was producing relatively few seedlings (Table 5). The grass layer was clearly dominated by Festuca idahoensis with an average frequency of 78 percent and 100 percent constancy (Table 2). Agropyron spicatum was consistently present in this type but had a much lower average frequency (27 percent). The forb layer was rich with the most important perennials being Phlox caespitosa, Achillea millefolium, Eriogonum umbellatum ssp. polyanthum, and Silene douglasii (Table 2).

Juniperus occidentalis typically grows on shallow, rocky soils

overlying a basaltic substrate in northeastern California and central Oregon. It is a long-lived tree and may reach 1,000 years in age (Fowells, 1965). It will grow under a wide variety of soil and climatic conditions, but is largely limited by competing vegetation and fire. Reduction in wildfire frequency this past century has advanced Juniperus occidentalis invasion (Fowells, 1965; Burkhardt and Tisdale, 1976). Mule deer feed selectively on the foliage of certain trees while avoiding others. No explanation has been determined for this behavior (Fowells, 1965) but perhaps the deer are selecting certain ecotypes.

Cercocarpus ledifolius is generally found on warm, rocky and arid flats, slopes, and canyon walls in California (Sampson and Jespersen, 1963). Its leaves are well adapted to drought through their revolute blade margins and stomatal openings protected by pubescence (Daubenmire, 1974). Dealy (1975) found it susceptible to fire, and perpetuation of Cercocarpus ledifolius dominated communities was dependent on fire resistant rocky sites. These rocky sites were found to have older and larger trees which acted as a seed source for decimated adjacent stands (Dealy, 1975). Its browse value for deer is rated excellent in California by Sampson and Jespersen (1963). The Cercocarpus ledifolius plants in the Monument show obvious signs of heavy deer use expressed by high browse lines.

Festuca idahoensis is one of the most common and widely distributed grasses in the West. In semi-arid regions it is typically

found on north-facing, upland sites (Tisdale et al., 1965). This plant grows on a variety of soils but is generally found on well-drained, moderately deep, sandy or gravelly loams (U.S. Forest Service, 1937). Its palatability to grazing animals is high in the spring but decreases at maturity (McCall, 1940). It is susceptible to severe fire damage if burned in midsummer (Conrad and Poulton, 1966).

3. Juniperus occidentalis/Agropyron spicatum (Juoc/Agsp)

The Juoc/Agsp community was infrequently encountered on the slopes of cinder cones on the Monument. It ranged in elevation from 1,536 to 1,585 meters and was restricted to southern and southwestern slopes between 40 and 45 percent. Fire did not appear to have a strong influence on this type since Juniperus occidentalis had attained large sizes.

Soil depth was 23 centimeters to the basalt cinder parent material and the surface horizon was sandy textured with granular structure. The loose vesicular basalt cinders, combined with the exposure and steep slope, made this a harsh site for plant establishment and growth. Rock cover was the highest ground cover value (67 percent), which could be attributed to the cinders. Litter, vegetation, and bare ground cover averaged 16, 14, and 4 percent, respectively (Table 4).

Juniperus occidentalis dominated the tree layer with 13.6

percent average canopy cover (Table 3). Artemisia tridentata ssp. vaseyana dominated the shrub layer with an average 3.4 percent canopy cover (Table 3). It did not appear to be aggressively increasing in this type since the number of seedlings encountered was relatively low and the number of dead individuals relatively high (Table 5). Purshia tridentata was present but its average canopy cover was less than one percent. Other shrubs generally present were Cercocarpus ledifolius, Ribes velutinum, and Chrysothamnus nauseosus var. albicaulis. The grass layer was dominated by Agropyron spicatum with an average frequency of 50 percent and 100 percent constancy (Table 2). Eriogonum nudum var. pubiflorum was the most conspicuous perennial forb encountered (Table 2).

Agropyron spicatum is widely distributed and is found primarily on dry soils in the open or partial shade. It has been considered the most important indigenous grass in the Northwest (U.S. Forest Service, 1937). All classes of stock seem to relish this grass and it provides good forage in the spring, fall, and early winter. It has a relatively high nutrient content late in the season, and this probably explains its value as a winter feed (Sampson et al., 1951). Repeated close spring-long grazing has hastened its replacement by cheatgrass over a large part of its range (Stoddart, 1946). Valentine (1971) referenced that Agropyron spicatum is only slightly damaged by late summer burning.

4. Juniperus occidentalis/Cercocarpus ledifolius (Juoc/Cele)

This community occurred on western, eastern, and more commonly on southeastern slopes of cinder cones in the Monument. The trees in this type were extremely large and old. Stem diameters, 46 centimeters above the ground, exceeded 1.5 meters and 30 centimeters for a few individuals of Juniperus occidentalis and Cercocarpus ledifolius, respectively. Fire scars were present on the woody plants but major stand destruction had obviously been rare. Apparently the bare pumice and cinder soils restrict the movement of fire.

This type was encountered from 1,518 to 1,664 meters elevation on slopes ranging from 30 to 50 percent. Soil depth varied from 30 to 46 centimeters to the basalt cinder parent material and the soil profile remained sandy textured with granular structure throughout. Pumice was well incorporated in the profile. Rock cover averaged 44 percent while litter cover averaged 36 percent. Vegetation and bare ground averaged 18 and 2 percent cover, respectively (Table 4)

The dominant tree in this type was Juniperus occidentalis with 20.2 percent average canopy cover (Table 3). Prunus virginiana was generally encountered but was not numerous (Table 5). Cercocarpus ledifolius dominated the shrub layer with an average canopy cover of 19.4 percent (Table 3). It also was well represented in each of the different height classes (Table 5). Ribes velutinum was typically

found in this type and appeared to be associated with the slightly moister and cooler microenvironment beneath Juniperus occidentalis canopies. Dense mats of Tortula ruralis were also found beneath these trees. Other shrubs encountered of less importance to this community were Chrysothamnus nauseosus var. albicaulis and Purshia tridentata. The grass layer was extremely sparse with Stipa occidentalis, Sitanion hystrix, and Bromus tectorum poorly represented (Table 2). The forb layer was relatively rich and many species were associated with the microenvironment beneath Juniperus canopies. Phacelia ramosissima was exclusively tied to these sites and had an average frequency of 30 percent and 80 percent constancy (Table 2). Conversely, Phacelia hastata and Eriogonum nudum var. pubiflorum thrived in the open areas.

5. Juniperus occidentalis/Artemisia tridentata ssp. vaseyana/Stipa occidentalis (Juoc/Artrv/Stoc)

Six stands of the Juoc/Artrv/Stoc community were sampled in the southeastern portion of the Monument. This was also the area of the Monument which received a heavy mantle of pumice. Although fire scars were observed on individuals, catastrophic fires have apparently been relatively rare since Juniperus occidentalis trees had attained enormous size. The herbaceous layer was relatively sparse on these pumice soils which probably restricts fire movement.

Stipa occidentalis was consistently associated with these pumice-dominated sites.

This type ranged in elevation from 1,341 to 1,414 meters on gently undulating terrain (less than five percent slope). Soils were from 38 to 51 centimeters deep and the surface horizon was sandy textured with granular structure. Rock cover was relatively high, averaging 62 percent due to the pumice. Litter and vegetative cover averaged 21 and 17 percent, respectively (Table 4).

The dominant tree was Juniperus occidentalis with 9.3 percent average canopy cover (Table 3). Artemisia tridentata ssp. vaseyana dominated the shrub layer with an average 4.3 percent canopy cover (Table 3) and also dominated the greater-than-30-centimeter height class (Table 5). Other important shrubs present were Cercocarpus ledifolius and Purshia tridentata with average canopy covers of 3.1 and 2.4 percent, respectively (Table 3). Stipa occidentalis was the most important perennial grass with an average frequency of 15 percent and 100 percent constancy (Table 2).

Artemisia tridentata ssp. vaseyana is common in the western United States from foothills through coniferous forests. It tends to increase in density and foliage cover readily in the absence of periodic fire and after the herbaceous vegetation has been disturbed (Winward and Tisdale, 1977). Sheehy (1975) found the palatability of subspecies vaseyana to be relatively high to mule deer and sheep compared to the

other big sagebrush (Artemisia tridentata) subspecies.

Stipa occidentalis occurs on dry, well-drained soils of plains, ridges, and open forests (U.S. Forest Service, 1937). It has a deeply penetrating root system which makes it capable of enduring drought. Seedlings of this grass produce a deeper root than most grass species, thereby increasing its success on dry sites (Sampson, 1917). This probably explains its adaptability to pumice-dominated soils on the Monument. It is considered good forage for grazing animals, and since it matures late in the season, it produces green forage at a time when most grasses are dry (U.S. Forest Service, 1937).

6. Cercocarpus ledifolius (Cele)

Seven stands of the Cele community were sampled and all occurred in the southern one-third of the Monument. Elevation ranged from a low of 1,414 meters to a high of 1,637 meters on undulating basalt lava. This substrate was rough and angular with no discernible soil development. The Cercocarpus ledifolius plants were extremely large with thick canopies. One shrub, which had been cut for a fire break, was over 275 years old. Fire damage was observed on occasional individuals but never throughout a stand. Rock cover averaged 48 percent followed by vegetative cover with 30 percent. Litter cover made up the remaining percentage (Table 4).

Juniperus occidentalis and Prunus emarginata represented the

tree layer but contributed less than one percent canopy cover. Cercocarpus ledifolius dominated the shrub layer with an average 28.1 percent canopy cover (Table 3). Ribes velutinum and Ribes cereum were also present but only had average canopy covers of 1.8 and 1.3 percent, respectively. The herbaceous layer was depauperate and Poa sandbergii and Bromus tectorum comprised the bulk of it (Table 2).

7. Artemisia tridentata ssp. vaseyana/Festuca idahoensis-Agropyron spicatum (Artrv/Feid-Agsp)

The Artrv/Feid-Agsp community occurred in the southern portion of the Monument and ranged in elevation from 1,372 to 1,554 meters. In the central and southern portion of its range there was no differentiation by aspect, but in the more northern, lower portions of the Monument it was restricted to north-facing exposures. Overall, slopes ranged from 0 to 40 percent. Sites supporting Festuca idahoensis typically were the richest floristically in the Monument. Fire has probably been important in keeping Juniperus occidentalis from dominating these sites.

Soil depth ranged from 36 to 86 centimeters in a cobbly and stony profile. Surface horizon textures were generally sandy loam and subsurface horizon textures were sandy clay loam to clay loam. Rock cover averaged 31 percent and vegetative cover followed with

30 percent. Litter and bare ground averaged 23 and 16 percent, respectively (Table 4).

Juniperus occidentalis was consistently present in this type but always contributed less than one percent cover. Artemisia tridentata ssp. vaseyana dominated the shrub layer with an average 10.6 percent canopy cover (Table 3). Purshia tridentata also was important in this community and had an average canopy cover of 5.3 percent. Artemisia tridentata ssp. vaseyana was more numerous than Purshia tridentata in each height class (Table 5). Other shrubs encountered but low in number were Cercocarpus ledifolius, Tetradymia canescens, Leptodactylon pungens, and Chrysothamnus viscidiflorus. Festuca idahoensis and Agropyron spicatum consistently dominated the grass layer with average frequencies of 64 and 50 percent, respectively (Table 2). Poa sandbergii also was a consistent member of this layer and had an average frequency of 52 percent. It was omitted from the name because of its near ubiquitous occurrence on the Monument. In the forb layer the annuals, Collinsia parviflora and Draba verna, had the highest frequencies while Phlox caespitosa was the most frequent perennial (Table 2).

8. Artemisia tridentata ssp. vaseyana/Stipa thurberiana-Agropyron spicatum (Artrv/Stth-Agsp)

Eight stands were sampled in the Artrv/Stth-Agsp community which occurred in the middle one-third of the Monument. Elevation for this type ranged from a low of 1,262 meters to a high of 1,433 meters on gently undulating terrain. Fire has probably been

important in keeping Juniperus occidentalis from dominating these sites.

The soil surface and profile were extremely cobbly and stony throughout. Soils were 36 to 43 centimeters deep and surface horizons were sandy textured. Rock cover averaged 31 percent, due to basalt cobbles and stones exposed on the ground surface. Bare ground, vegetation, and litter cover averaged 26, 24, and 19 percent, respectively (Table 4).

Juniperus occidentalis was often present in these stands but contributed less than one percent cover. Artemisia tridentata ssp. vaseyana dominated the shrub layer with an average canopy cover of 11.9 percent (Table 3). Purshia tridentata also was an important component of this community but only had an average canopy cover of 2.5 percent. Artemisia tridentata ssp. vaseyana was much more numerous than Purshia tridentata in each of the height classes (Table 5). Chrysothamnus nauseosus var. albicaulis, Chrysothamnus viscidiflorus, Leptodactylon pungens, and Tetradymia canescens were additional shrubs encountered but were low in density. The grass layer was dominated by Stipa thurberiana and Agropyron spicatum with average frequencies of 50 and 34 percent, respectively (Table 2). Other important grasses in this type were Poa sandbergii and, to a lesser extent, Bromus tectorum. The forb layer was moderately rich, but both annuals and perennials had low frequencies. The most

conspicuous perennial was Phlox caespitosa with six percent average frequency and 75 percent constancy (Table 2).

Stipa thurberiana is common on the sagebrush desert and the ponderosa pine woodland (Hitchcock and Cronquist, 1974). Summer burning was reported to be slightly damaging to this species (Wright and Klemmedson, 1965). Uresk and Cline (1976) reported a nutrient content of Stipa thurberiana similar to Agropyron spicatum.

9. Artemisia tridentata ssp. vaseyana/
Stipa occidentalis (Artrv/Stoc)

This community occurred in the southeastern half of the Monument and varied in elevation from 1,256 to 1,554 meters. It was found on gently undulating terrain in pumice-dominated soils. Natural periodic burning has probably reduced the number of Juniperus occidentalis trees, since occasional dead individuals were encountered. The frequency of burning on these pumice-dominated soils however, has probably been much less than on stands found on non-pumice soils.

Soil surface horizons were sandy textured and subsurface horizons were clay loam textured. Soil depth ranged from 41 to 94 centimeters. Rock cover was relatively high (55 percent) and was attributed to the exposed pumice on the soil surface. Litter cover and vegetative cover averaged 24 and 21 percent, respectively

(Table 4).

Juniperus occidentalis was generally present in this type but was not numerous and always contributed less than one percent cover. Artemisia tridentata ssp. vaseyana dominated the shrub layer with an average canopy cover of 15.5 percent (Table 3) and 281 mature individuals per 300 square meters (Table 5). Purshia tridentata was subordinate to Artemisia tridentata ssp. vaseyana with an average canopy cover of 4.8 percent (Table 3). Other shrubs encountered but with low densities were Chrysothamnus viscidiflorus and Leptodactylon pungens (Table 5). Stipa occidentalis dominated the grass layer with 24 percent average frequency and 100 percent constancy (Table 2). Sitanion hystrix was the next important grass with 20 percent average frequency and 100 percent constancy. Annuals dominated the forb layer with Collinsia parviflora the most conspicuous (Table 2).

10. Artemisia tridentata ssp. vaseyana/
Bromus tectorum (Artrv/Brte)

Five stands were sampled in the Artrv/Brte community which was encountered in the northern one-third of the Monument. Elevation varied from 1,219 to 1,256 meters on gently undulating terrain. Vegetation on this type was the result of heavy grazing by sheep in the early 1900's because of its close proximity to Tule Lake.

Consequently the presumed original grass dominants, Stipa thurberiana and Agropyron spicatum, were reduced tremendously and Bromus tectorum increased. Burned Artemisia tridentata ssp. vaseyana shrubs were occasionally found indicating the occurrence of natural fire previously.

Soils were 33 to 41 centimeters deep in an extremely cobbly and stony profile. The surface horizon was sandy loam textured and subsurface horizon was clay loam textured. Litter cover averaged 33 percent followed by bare ground with 27 percent. Rock cover and vegetative cover were 24 and 17 percent, respectively (Table 4).

Artemisia tridentata ssp. vaseyana dominated the shrub layer with 7.7 percent average canopy cover (Table 3) and 134 mature individuals per 300 square meters (Table 5). Chrysothamnus nauseosus var. albicaulis had an average 1.1 percent canopy cover (Table 3) and 48 mature individuals per 300 square meters (Table 5). Bromus tectorum heavily dominated the grass layer with an average frequency of 100 percent and 100 percent constancy (Table 2). Poa sandbergii and Sitanion hystrix had much lower average frequencies with 15 and 5 percent, respectively. Stipa thurberiana and Agropyron spicatum were seldom encountered in the frequency plots, but were present in each stand. Draba verna, an annual, was the most common forb with an average frequency of 96 percent and 100 percent constancy. Perennial forbs were poorly represented in this type.

Bromus tectorum, an introduced winter annual (Young et al., 1969), germinates in the fall or winter and produces mature seed in the spring or early summer (Klingman and Ashton, 1975). It may act as a summer annual and germinate in the spring if there is not sufficient fall moisture (Stewart and Hull, 1949). Year-to-year climatic variations seem to have a significant influence on annual plants such as Bromus tectorum. Hull (1949) reported yields of Bromus tectorum varying more than nine and one-half times in Idaho. The density of Bromus tectorum in this community could probably be expected to fluctuate greatly depending on the precipitation. Extensive sagebrush (Artemisia spp.) areas have been invaded by Bromus tectorum as a result of fire and/or overgrazing (Tisdale et al., 1969). Bromus tectorum persists in communities even though an occasional poor growth year may reduce yields. Caryopses have been shown to remain viable more than one year (Hull and Hansen, 1974), thus guaranteeing its existence through poor growth years. The grazing value of this plant is good only during a few weeks in the spring when it is green and lush (Sampson et al., 1951).

11. Artemisia tridentata ssp. tridentata/ Bromus tectorum (Artrt/Brte)

This community was restricted to the extreme northern portion of the Monument from 1,219 to 1,280 meters elevation on gently

undulating terrain. The understory was dominated almost entirely by annuals indicating severe past disturbance. This community also was close to former Tule Lake and undoubtedly received heavy grazing pressure in the past. Fire has been a part of this type as evidenced by the burned shrubs present. Fire records on file at Monument headquarters indicated that these stands may have last burned in the 1940's.

The soil profile was extremely cobbly and stony. Soils were 30 to 38 centimeters deep with a sandy loam textured surface horizon. Litter cover averaged 42 percent, the highest value; vegetative, rock, and bare ground cover averaged 23, 21, and 14 percent, respectively (Table 4).

The shrub layer was dominated by Artermisia tridentata ssp. tridentata with an average canopy cover of 18.4 percent (Table 3) and 122 mature individuals per 300 square meters (Table 5). Chrysothamnus nauseosus var. albicaulis was commonly found in this type with an average canopy cover of 3.6 percent (Table 3). Bromus tectorum dominated the herbaceous layer with an average frequency of 99 percent and 100 percent constancy (Table 2). Stipa thurberiana and Agropyron spicatum were rare and the most frequent forb was the exotic annual, Draba verna.

Artemisia tridentata ssp. tridentata grows in deep, well drained soils of lower foothill and valley bottoms. This

particular subspecies of Artemisia tridentata is the tallest form and mature plants are commonly 120 to 180 centimeters in height. Sites supporting Artemisia tridentata ssp. tridentata are usually productive (Winward and Tisdale, 1977). This plant does not sprout after fire or other disturbances but is a prolific seeder (Harniss and McDonough, 1976). Sheehy (1975) reported its palatability to mule deer and sheep as low.

12. Purshia tridentata/Bromus tectorum-Agropyron spicatum (Putr/Brte-Agsp)

The Putr/Brte-Agsp community occurred on southeastern to southwestern exposures of cinder cones in the southern quarter of the Monument. Elevation ranged from 1,451 to 1,615 meters on 38 to 50 percent slopes. Periodic burning appeared to be a natural component of this type because burned Purshia tridentata shrubs and burned Juniperus occidentalis trees were present. Fire records showed that one stand of this community on the southern slopes of Caldwell Butte burned August, 1950; July, 1956; and May, 1965. It is not clear when the other two stands last burned. Bromus tectorum has probably increased due to the influence of recent fire.

Soil depth was 20 centimeters to the basalt cinder parent material. The surface horizon was dominated by cinder and pumice and was sandy textured. Rock cover averaged 54 percent; vegetative, litter,

and bare ground cover were much lower averaging 22, 20, and 4 percent, respectively (Table 4).

Purshia tridentata dominated the shrub layer averaging 10.8 percent canopy cover (Table 3). Chrysothamnus nauseosus var. albicaulis was conspicuous with an average 4.1 percent canopy cover. Other less abundant shrubs encountered were Artemisia tridentata ssp. vaseyana, Chrysothamnus viscidiflorus, Ribes velutinum, and Tetradymia canescens (Table 5). The grass layer was dominated by Bromus tectorum and Agropyron spicatum with average frequencies of 95 and 38 percent, respectively (Table 2). In the forb layer Eriogonum nudum var. pubiflorum was the most common with an average frequency of 18 percent and 100 percent constancy.

13. Purshia tridentata/Bromus tectorum-Stipa occidentalis (Putr/Brte-Stoc)

Two stands of the Putr/Brte-Stoc community were sampled; one occurred east of Red Butte at 1,542 meters elevation and the other occurred east of Caldwell Butte at 1,353 meters elevation. Both stands were found on gently undulating terrain and evidence of fire was obvious because charred woody debris was common. Remains of Artemisia tridentata ssp. vaseyana were found in the stand east of Red Butte and remains of Pinus ponderosa were found in the stand east of Caldwell Butte. Fire records on file at Monument

headquarters indicate that both stands burned in the early 1940's and the stand east of Caldwell Butte burned again in 1955.

Pumice dominated the soils of both stands. Soil depth for the stand east of Red Butte was 41 centimeters and the surface horizon was sandy loam textured. Soil depth for the stand east of Caldwell Butte was greater than 102 centimeters and the surface horizon was sandy textured. Rock cover averaged 61 percent, due to the pumice on the ground surface. Litter, vegetation, and bare ground cover averaged 20, 18, and 2 percent, respectively (Table 4).

The shrub layer was dominated by Purshia tridentata with an average 8.8 percent canopy cover (Table 3). Chrysothamnus viscidiflorus was well represented on these coarse soils with an average canopy cover of 3.7 percent (Table 3) and 73 mature individuals per 300 square meters (Table 5). It also showed a high degree of decadence with an average of 92 dead individuals per 300 square meters. Other shrubs present in low densities were Artemisia tridentata ssp. vaseyana, Chrysothamnus nauseosus var. albicaulis, and Tetradymia canescens. Artemisia tridentata ssp. vaseyana was associated with the stand east of Red Butte. The grass layer was dominated by Bromus tectorum and Stipa occidentalis with average frequencies of 100 and 24 percent, respectively (Table 2). Annuals primarily dominated the forb layer and Mentzelia albicaulis was the most frequent.

14. Chrysothamnus nauseosus var. albicaulis/Bromus tectorum-Stipa thurberiana (Chnaa/Brte-Stth)

This community was widely distributed over the northern two-thirds of the Monument. It occurred between 1,244 and 1,390 meters elevation on gently undulating terrain. Fire records on file at Monument headquarters indicate that the large fires of 1941 and 1949 burned sites now supporting this community. Remnants of burned Artemisia tridentata ssp. vaseyana shrubs were frequently found and living plants were generally observed near rocky microsites within this type. Heavy grazing likely played an important role in reducing Stipa thurberiana and Agropyron spicatum throughout this community, particularly in the northern stands near former Tule Lake.

Soils were 30 to 66 centimeters deep with sandy loam textured surface horizons. The soil surface and profile were extremely cobbly and stony, making digging difficult. Litter cover averaged 33 percent followed by bare ground with 28 percent. Rock cover and vegetative cover were 21 and 18 percent, respectively (Table 4).

Juniperus occidentalis was often present in these stands but contributed less than one percent cover. Chrysothamnus nauseosus var. albicaulis dominated the shrub layer with 4.4 percent average canopy cover (Table 3) and 103 mature individuals per 300 square meters (Table 5). Other important shrubs present were Artemisia tridentata ssp. vaseyana, Chrysothamnus viscidiflorus, and Tetradymia

canescens. The grass layer was dominated by Bromus tectorum and Stipa thurberiana with average frequencies of 96 and 51 percent, respectively (Table 2). Poa sandbergii and Agropyron spicatum also were important and consistent components of this layer, but did not appear to share the same dominance as the previous two grasses. Annuals primarily dominated the forb layer and Draba verna was the most frequent.

Chrysothamnus nauseosus var. albicaulis is common on open slopes and flats from 914 to 2,438 meters elevation in California (Munz, 1959). It is often associated with sagebrush and increases after site disturbances such as heavy grazing, fire, or cultivation (McKell and Chilcote, 1957). It has the capability to resprout after top removal, but root plowing effectively destroys it (Robertson and Cords, 1957). The herbage of Chrysothamnus nauseosus var. albicaulis is rated fair to poor for sheep, goats, and deer but in late fall and winter these animals plus antelope feed closely on the flower tops and current leafage (Sampson and Jespersen, 1963).

15. Festuca idahoensis-Poa sandbergii (Feid-Posa 3)

The Feid-Posa 3 community occurred on two contrasting sites; one on the 33 percent northern slope of Hardin Butte, and the other on level ground inside the bighorn sheep enclosure (northwest corner). Elevation ranged from 1,341 to 1,372 meters. Evidence of fire was found on both sites since burned brush debris was common. Fire

records on file at Monument headquarters showed that the enclosure burned recently from a wildfire on July 11, 1973. Records also showed that Hardin Butte burned completely from a large wildfire in 1949 and partially in 1972. Burning has apparently removed the woody overstory from both of these sites and left Festuca idahoensis and Poa sandbergii as the dominant plants.

Soils of the Hardin Butte site and the enclosure site were 28 and 61 centimeters to parent material, respectively. The surface and subsurface horizons of the former were sandy textured while the surface and subsurface horizons of the latter were sandy clay loam textured and clay textured, respectively. Bare ground averaged 29 percent followed closely by rock cover with 27 percent. Vegetation and litter cover averaged 24 and 20 percent, respectively (Table 4).

Festuca idahoensis and Poa sandbergii were the dominant plants in this community with average frequencies of 87 and 99 percent, respectively (Table 2). Table 5 shows the shrubs encountered in this type. Artemisia arbuscula was associated with the enclosure site and Artemisia tridentata ssp. vaseyana and Tetradymia canescens were associated with the Hardin Butte site. Chrysothamnus viscidiflorus was common to both sites.

Poa sandbergii occurs from 914 to 2,438 meters elevation in California on hillsides and open plains (Munz, 1959). It is one of the most drought resistant bluegrasses (Poa spp.) and withstands

trampling well. It begins growth, flowers, and produces mature seed early in the spring while moisture is still available (U.S. Forest Service, 1937). Because of its early growth, late summer burning is not damaging (Valentine, 1971). This plant is readily grazed by all classes of livestock in the spring, in the early summer, and in the fall after the leaves have air-cured (U.S. Forest Service, 1937).

16. Elymus cinereus-Bromus tectorum (Elci-Brte)

The Elci-Brte community occurred as small isolated patches in the northern portion of the Monument. This type was consistently found on alluvial bottomland varying in elevation from 1,250 to 1,262 meters. Undoubtedly, fire has been common in this community. Burned Artemisia tridentata stumps were occasionally found in these stands and were suspected to be a subspecies tridentata since it was the predominant subspecies surrounding these areas. Fire records on file at Monument headquarters show that these stands burned several times in the 1940's. Grazing pressure also was probably heavy in these stands since they were close to former Tule Lake.

Soils of the Elci-Brte community were greater than 102 centimeters deep and carbonates were generally found in one of the subsurface horizons. The surface horizon varied in texture from loam to sandy clay loam and the subsurface horizon was generally clay loam textured. Bare ground averaged 44 percent and litter, vegetation,

and rock cover averaged 32, 24, and 1 percent, respectively (Table 4).

Only dead individuals of Artemisia tridentata ssp. tridentata were observed in this type. Chrysothamnus nauseosus var. albicaulis and Chrysothamnus viscidiflorus occurred only in low numbers (Table 5). Elymus cinereus and Bromus tectorum were the dominant plants with average frequencies of 56 and 98 percent, respectively (Table 2). The most abundant forbs were Descurainia sofia and Sisymbrium altissimum, both typically found on disturbed sites on the Monument.

Elymus cinereus is a coarse and robust perennial bunchgrass (Hitchcock, 1951). It is common on fine-textured soils of flood plains or basin bottoms which are usually saline and/or alkaline. Elymus cinereus is a variable species since it is reported with salt rabbitbrush (Chrysothamnus nauseosus var. artus) and on better drained sites with big sagebrush (Lesperance et al., 1978). It is desirable forage in the winter when moisture has softened the leaves and in the spring when tender new growth appears. As the plant matures the leaves become tough and rank, thus decreasing its forage value (Sampson et al., 1951).

17. Stipa thurberiana-Agropyron spicatum (Stth-Agsp)

This community occurred in the western half of the Monument

from 1,262 to 1,530 meters elevation. There was no differentiation by aspect on slopes between 0 and 10 percent. From 10 to 50 percent slope, this type generally occurred on east-facing exposures. Fire influence was always noted in this type because burned Artemisia tridentata ssp. vaseyana remains were common. Several stands representing this type were prescribed burned within the last few years.

Soils ranged from 41 to greater than 102 centimeters deep, and were generally very cobbly and stony. Surface horizons were typically sandy to sandy loam textured. Rock cover and litter cover averaged 35 and 28 percent, respectively. Bare ground averaged 22 percent and vegetative cover averaged 16 percent (Table 4).

Stipa thurberiana and Agropyron spicatum dominated this community with average frequencies of 48 and 22 percent, respectively (Table 2). Although Agropyron spicatum had a lower average frequency, it was always associated with Stipa thurberiana. Table 5 demonstrates shrub mortality encountered in this type due primarily to fire. Tetradymia canescens was always observed as a resprout from a burned base.

18. Bromus tectorum-Stipa occidentalis (Brte-Stoc)

This community occurred in the southeastern half of the

Monument from 1,256 to 1,475 meters elevation. Slope varied from 0 to 12 percent and exposure was generally northeast. Wildfires were primarily responsible for shaping the structure of this community. Juniperus occidentalis and Artemisia tridentata ssp. vaseyana were probably significantly reduced in these stands since their burned debris could be found. Chrysothamnus viscidiflorus appeared to have increased on these disturbed pumice soils.

Soil depth was 51 centimeters with a mantle of pumice dominating the sandy textured surface horizon. Rock cover was extremely high, averaging 70 percent. Vegetation and litter cover both averaged 13 percent and bare ground averaged 4 percent (Table 4).

Tree and shrub cover were very low and only Chrysothamnus viscidiflorus contributed more than one percent canopy cover (Table 3). An average of 48 woody stumps per 300 square meters in each stand could not be identified because they were burned too close to the ground surface. Woody stumps, where identifiable, and plants commonly encountered in plots were Artemisia tridentata ssp. vaseyana, Cercocarpus ledifolius, Chrysothamnus nauseosus var. albicaulis, Purshia tridentata, and Prunus emarginata (Table 5). Prunus emarginata appeared to have invaded from surrounding basalt outcrops. Bromus tectorum and Stipa occidentalis dominated the grass layer with average frequencies of 100 and 20 percent, respectively

(Table 2). The forb layer was dominated by annuals with Sisymbrium altissimum and Mentzelia albicaulis the most conspicuous.

19. Bromus tectorum (Brte)

The Bromus tectorum community was generally encountered in the extreme northern portion of the Monument from 1,225 to 1,280 meters elevation on gently undulating terrain. One exception was a stand near Caldwell Butte at 1,384 meters which was prescribed burned May 19 and 20, 1977. Almost every plant community identified on the Monument had Bromus tectorum present. It probably has the potential to dominate most of these communities if they are disturbed sufficiently by fire or grazing. The stands near former Tule Lake were grazed heavily in the past and all stands showed evidence of past fire disturbance. The few shrub bases encountered while sampling were barely exposed at the ground surface making identification difficult. Artemisia tridentata stumps were occasionally found in these stands and subspecies tridentata was presumed to be associated with the sites closest to former Tule Lake (Table 5).

Soil depth ranged from 20 to 91 centimeters and surface horizons were generally sandy loam textured. Profile composition ranged from extreme stoniness to gravelly particle sizes. Litter cover averaged 49 percent followed by rock cover with 31 percent. Vegetation and bare ground cover averaged 11 and 10 percent, respectively (Table 4).

Bromus tectorum was the dominant plant in this type averaging 94 percent frequency (Table 2). Perennial grasses were not common and only Sitanion hystrix and Poa sandbergii were conspicuous. Bromus tectorum density appeared to be reduced around small colonies of Sitanion hystrix, thus demonstrating the strong competitiveness of the latter. A smut (Ustilago bromiuara) (Young et al., 1969) also was attacking Bromus tectorus and was responsible for reducing the annual seed crop tremendously. Annuals dominated the forb layer with Sisymbrium altissimum the most common (Table 2).

Because of the importance of Sitanion hystrix in this community, some specific characteristics concerning this plant are provided below. It is a perennial bunchgrass occurring on dry, gravelly soils, or on saline sites (U.S. Forest Service, 1937). Palatability generally ranks fair for grazing animals (Sampson et al., 1951). Franklin and Dyrness (1973) reported Sitanion hystrix occurring in at least 25 plant communities but dominating only two. Thus, it is typically considered a seral species and may increase after site disturbance (Schlatterer and Hironaka, 1972). It is a competitive species because it is able to establish naturally into exotic annual grass complexes in the Intermountain Region (Hironaka and Tisdale, 1963; Tisdale et al., 1969). Sitanion hystrix also has been found to be moderately resistant to burning, with resistance lower during late spring and early summer burns (Wright, 1971).

Plant Community Fragments

20. Pinus ponderosa/Arctostaphylos patula (Pipo/Arpa)

Only one stand of the Pipo/Arpa community was encountered and sampled on the Monument. It was found on the northern face of Island Butte. This butte is a cinder cone surrounded by younger basalt lava forming a kipuka or island. The nearest road is roughly two air-kilometers away from the butte. There was no evidence of grazing disturbance on the butte and natural fires have not been suppressed.

This community occurred at 1,646 meters elevation on a 40 percent, north-facing slope. Soils were approximately 30 centimeters to the basalt cinder parent material and the surface and subsurface horizons were both sandy textured. Litter cover in this community was extremely high (91 percent) due to the abundance of pine needles on the ground surface. Vegetative cover, excluding Pinus ponderosa, averaged eight percent followed by bare ground with only one percent.

Pinus ponderosa was the dominant tree and forest densiometer readings showed it had an average canopy cover of 39.3 percent (Table 6). A 35 centimeter increment core was too small to sample the Pinus ponderosa trees in this type. Based on other cores taken in the Monument, these trees were greater than 250 years old. Seedlings and pole size trees of Abies concolor occurred in this type and

appeared to be increasing. Abies concolor is a shade tolerant tree but less drought resistant and much more susceptible to fire than Pinus ponderosa (Fowells, 1965). The shrub layer was dominated by Arctostaphylos patula with 16.6 percent canopy cover and 60 mature individuals per 300 square meters (Table 6). Other shrubs encountered in plots but low in number were Cercocarpus ledifolius, Ceanothus velutinus, Purshia tridentata, and Ribes cereum. Salix scouleriana and Ribes roezlii var. cruentum did not occur in plots but appeared to be associated with Abies concolor in this stand. The herbaceous layer was extremely sparse and no species were encountered in the frequency plots. Graminoids present in the stand, although not in the sample plots, were Stipa occidentalis and Carex rossii; forbs present were Pyrola picta and Penstemon duestus.

Arctostaphylos patula is common in open forests from 610 to 2,743 meters elevation in California (Munz, 1959). It frequently forms dense stands on old burns in pure ponderosa pine and mixed conifer types in Oregon and California (U.S. Forest Service, 1937). This species can withstand repeated burning by resprouting and making rapid growth. Abies concolor is especially noted for invading and shading out this plant. Browse rating is poor to fair for mule deer in California and is probably most utilized during winters with light snowfall. Chemical analysis shows that crude protein content remains relatively low during the year (Sampson and Jespersen, 1963).

Table 6. Frequency, percent cover, and density/300 square meters by height classes of species for the Pinus ponderosa/Arctostaphylos patula community.

Species	Frequency	% Cover	Density			
TREES			0-.3 m	.3-3 m	3+ m	dead
Pinus ponderosa	-	39.3	-	7	3	-
SHRUBS			0-15 cm	15-30 cm	30+ cm	dead
Arctostaphylos patula	7	16.6	-	-	60	7
Cercocarpus ledifolius	-	1.1	-	-	-	-
Ceanothus velutinus	-	1.3	-	-	3	-
Purshia tridentata	3	.4	-	-	3	-
Ribes cereum	-	.1	-	-	10	-

21. Pinus ponderosa/Purshia tridentata-Arctostaphylos patula (Pipo/Putr-Arpa)

This community was found on the slopes of two cinder cones near the extreme southern border of the Monument. It varied in elevation from 1,554 to 1,597 meters and was found on 50 percent, north-facing slopes. One sample was taken from a stand on Eaglenest Butte. Evidence of natural fire was observed as fire scars on Pinus ponderosa.

Soils were 25 centimeters to the basalt cinder parent material. The A horizon had an abundance of pumice and cinder incorporated into it and was sandy textured. Litter cover averaged 66 percent due primarily to the pine needle accumulation. Pumice exposed through the pine needle mat produced an average rock cover of 11 percent. Vegetative cover and bare ground averaged 17 and 7 percent, respectively.

Pinus ponderosa dominated the tree layer with 14.9 percent canopy cover (Table 7). No increment cores were taken from this stand but Pinus ponderosa had several individuals in both young and mature age classes. Abies concolor did not occur in the plots but was represented by several young trees. Pinus lambertiana and Libocedrus decurrens also occurred in the tree layer but were not common. The shrub layer was principally dominated by Purshia tridentata. It had an average canopy cover of 14.1 percent and 107 mature individuals per 300 square meters (Table 7). Arctostaphylos patula, although

Table 7. Frequency, percent cover, and density/300 square meters by height classes of species for the Pinus ponderosa/Purshia tridentata-Arctostaphylos patula community. (Cover and density only for woody species).

Species	Frequency		% Cover	Density		
TREES			0-.3 m	.3-3 m	3+ m	dead
Pinus ponderosa	3	14.9	-	17	27	-
Prunus virginiana	-	.2	3	17	-	3
SHRUBS			0-15 cm	15-30 cm	30+ cm	dead
Arctostaphylos patula	7	3.4	-	-	13	-
Cercocarpus ledifolius	-	3.3	-	-	7	-
Ceanothus velutinus	13	2.4	-	-	23	-
Haplopappus bloomeri	-	-	-	-	3	-
Purshia tridentata	7	14.1	3	13	107	17
Symphoricarpos oreophilus	3	.7	-	3	17	-
GRASSES AND GRASS-LIKES						
Bromus tectorum	7					
Carex rossii	3					
Sitanion hystrix	7					
FORBS						
Clarkia rhomboidea	10					
Collinsia parviflora	20					
Cryptantha torreyana	10					
Eriogonum nudum var. pubiflorum	3					
Gayophytum diffusum	3					
Monardella odoratissima	17					
Montia perfoliata	3					
Potentilla glandulosa	3					
Silene douglasii	10					

not as conspicuous as Purshia tridentata, was important for distinguishing between this community and the Pipo/Putr community. Thus, with its 3.4 percent canopy cover, it was used in this community's nomenclature. Ceanothus velutinus was an important shrub in this type but had a lower canopy cover than Arctostaphylos patula. Bromus tectorum, Carex rossii, and Sitanion hystrix represented the graminoid layer, but had low frequencies (Table 7). Stipa occidentalis did not occur in the frequency plots but was present in the stand. The most conspicuous perennial forbs were Monardella odoratissima and Silene douglasii with 17 and 10 percent average frequencies, respectively.

22. Pinus ponderosa/Haplopappus bloomeri (Pipo/Habl)

This community occurred as one stand representing two small adjacent sites located on each side of a fire break south of Eaglenest Butte. Both sites were prescribed burned in 1975; one on June 27, and the other on August 22. Based on surrounding stands, both sites probably supported a Pipo/Putr community before burning. Most of the Purshia tridentata plants were killed and had not resprouted (Table 5).

The Pipo/Habl community occurred at 1,554 meters elevation on level ground. Soils were 76 centimeters deep to a layer of basalt cobbles and stones. The surface horizon was sandy textured due to the high pumice content. The subsurface horizon was sandy loam textured. The average litter cover was 61 percent consisting of pine needle

accumulations and burned plant debris. Average rock cover was 29 percent due to the exposed pumice gravel. Average vegetative cover and bare ground were eight and two percent, respectively.

The dominant tree in this community was Pinus ponderosa with an average canopy cover of 30.4 percent (Table 8). The average sampled tree age was 225 years, but up to half of the trees on these sites were too large to core. Several seedlings of Pinus ponderosa were present in this community, probably due to the reduced understory. Dominating the shrub layer was Haplopappus bloomeri. It was the only shrub encountered contributing to foliage cover (Table 8). Density values show that there were an enormous number of Haplopappus bloomeri seedlings present on these burned sites. Purshia tridentata and Ribes cereum had a relatively moderate number of seedlings present. The Purshia tridentata seedlings generally occurred in clusters, thus demonstrating the importance of rodent caches for the perpetuation of this species. The grass and grass-like layer was dominated by Stipa occidentalis and Carex rossii with average frequencies of 20 and 17 percent, respectively (Table 8). Both of these plants appeared to have increased slightly after burning compared to adjacent unburned Pipo/Putr communities. Several perennials and annuals comprised the forb layer. Penstemon cinereus was the most important perennial with an average frequency of 17 percent (Table 8). Burning did not appear to reduce this plant significantly.

Table 8. Frequency, percent cover, and density/300 square meters by height classes of species for the Pinus ponderosa/Haplopappus bloomeri community. (Cover and density only for woody species)

Species	Frequency	% Cover	Density			
TREES			0-.3 m	.3-3 m	3+ m	dead
Pinus ponderosa	3	30.4	17	-	3	-
SHRUBS			0-15 cm	15-30 cm	30+ cm	dead
Artemisia tridentata ssp. vaseyana	-	-	-	-	-	4
Haplopappus bloomeri	49	1.6	660	27	64	-
Purshia tridentata	3	-	55	-	4	173
Ribes cereum	5	-	42	4	5	-
GRASSES AND GRASS-LIKES						
Carex rossii	17					
Sitanion hystrix	12					
Stipa occidentalis	20					
FORBS						
Arabis holboellii	3					
Collinsia parviflora	27					
Cryptantha ambigua	4					
Gayophytum diffusum	67					
Mentzelia albicaulis	39					
Mimulus nanus	17					
Nama densum	7					
Penstemon cinereus	17					
Phacelia hastata	4					
Silene douglasii	2					

Haplopappus bloomeri is found on sandy or rocky soils near coniferous woods (Munz, 1959). Dayton (1931) reports that it is often found in forest openings created by burns or other disturbances. Its forage value is extremely low.

23. Juniperus occidentalis/Purshia tridentata (Juoc/Putr)

This community was represented by one stand encountered in the southeastern portion of the Monument. It occurred at 1,341 meters elevation on level terrain. It appears to have replaced a Pipo/Putr community based on adjacent stands and the numerous dead Pinus ponderosa trees present. The Pinus trees probably succumbed to drought and western pine beetle attacks in the 1920's. Many young Juniperus occidentalis individuals were increasing and Purshia tridentata appeared over-mature and decadent.

Soils were 48 centimeters deep, which was mostly pumice. The soil surface horizon was sandy textured with granular structure. Litter cover averaged 40 percent due partially to dead Pinus ponderosa stems and branches. Rock cover averaged 33 percent and vegetation made up the remaining cover with 27 percent.

Dominating the tree layer was Juniperus occidentalis with 3.3 percent average canopy cover (Table 9). Pinus ponderosa was not re-establishing in this stand and was only represented by an occasional individual. Based on several cross-sectioned trees, many of the

Table 9. Frequency, percent cover, and density/300 square meters by height classes of species for the Juniperus occidentalis/Purshia tridentata community. (Cover and density only for woody species)

Species	Frequency	% Cover	Density			
TREES			0-.3 m	.3-3 m	3+ m	dead
Juniperus occidentalis	-	3.3	-	-	-	-
SHRUBS			0-15 cm	15-30 cm	30+ cm	dead
Chrysothamnus nauseosus var. albicaulis	-	-	-	-	-	3
Chrysothamnus viscidiflorus	-	.9	-	-	27	-
Purshia tridentata	3	14.3	-	3	97	13
Ribes velutinum	7	2.4	-	-	7	-
Tetradymia canescens	-	.6	-	-	7	-
GRASSES						
Bromus tectorum	83					
Stipa occidentalis	3					
FORBS						
Collinsia parviflora	60					
Collomia grandiflora	7					
Collomia tinctoria	10					
Cryptantha torreyana	60					
Gayophytum diffusum	17					
Mentzelia albicaulis	57					
Phacelia hastata	53					
Phacelia linearis	13					

dead trees were over 200 years old when they died. The shrub layer was dominated by Purshia tridentata with an average canopy cover of 14.3 percent (Table 9). It had a relatively high number of individuals in the greater-than-30-centimeters height class, but few young individuals were encountered. Subordinate shrubs present were Ribes velutinum, Chrysothamnus viscidiflorus, and Tetradymia canescens. The grass layer was extremely sparse with only two species encountered. Bromus tectorum had the highest average frequency with 83 percent while Stipa occidentalis was a distant second with only three percent frequency (Table 9). The forb layer was composed primarily of annuals but one perennial, Phacelia hastata, was conspicuous with 53 percent average frequency.

Prominence-rated Communities

Analysis of prominence values produced 15 distinct plant communities (Table 10). These included two forest, ten shrub, one grassland, and two forb communities. These communities are grouped according to dominant tree, shrub, and grass species. Many of these communities were represented by one stand, thus they are relatively uncommon within the Monument. A map was constructed which includes these communities (Figure 5 in packet). Complete data summarization for each species encountered in each plant community is presented in Table 11. Brief descriptions of these plant communities along with

Table 10. Prominence-rated communities, community codes, and index numbers.

Plant Community	community code	index no.
Pinus ponderosa/Purshia tridentata/Festuca idahoensis	Pipo/Putr/Feid	24
Juniperus occidentalis/Artemisia tridentata ssp. vaseyana/Stipa thurberiana	Juoc/Artrv/Stth	25
Symphoricarpos oreophilus/Festuca idahoensis	Syor/Feid	26
Chrysothamnus nauseosus var. artus/Elymus cinereus	Chnaa 2/Elci	27
Chrysothamnus viscidiflorus/Stipa comata	Chvi/Stco 2	28
Chrysothamnus viscidiflorus/Bromus tectorum	Chvi/Brte	29
Ribes velutinum/Elymus cinereus	Rive/Elci	30
Cercocarpus ledifolius-Holodiscus microphyllus var. glabrescens	Cele-Homig	31
Chamaebatiaria millefolium	Chmi	32
Salvia dorrii ssp. carnosa/Eriogonum microthecum var. laxiflorum	Sadoc-Ermil	33
Salvia dorrii ssp. carnosa-Chamaebatiaria millefolium	Sadoc-Chmi	34
Ribes cereum	Rice	35
Bromus tectorum-Secale cereale	Brte-Sece	36
Monardella odoratissima-Cycladenia humilis	Mood-Cyhu	37
Descurainia sofia	Deso	38

Table 11. Species prominence values for each plant community.

	Brte-Seca	Deso	Chna2/Elci	Chvi/Sico2	Chvi/Brte	Juoc/Arrv/Sith	Pipo/Purs/Feid	Moco-Cyhy	Cele-Hosm2	Chmi	Sadoc/Ermil	Syvu/Feid	Rive/Elci	Sadoc-Chmi	Rice
No. of samples*	1	1	1	1	1	1	1	2	1	2	8	1	4	12	9
TREES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Juniperus occidentalis						5	3	1			1	1	1	1	1
Pinus ponderosa							5		2						
Prunus emarginata								1							1
Prunus virginiana								1					2		1
SHRUBS	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Chrysothamnus nauseosus var. artus			5												
Artemisia tridentata ssp. tridentata			2										2		
Chrysothamnus viscidiflorus			3	5	5							4	1		1
Tetradymia canescens				3									1		
Artemisia tridentata ssp. vaseyana				1	1	5		1			1	3		3	3
Chrysothamnus nauseosus var. albicaulis					2	3			3	1	2	2	3	4	4
Leptodactylon pungens						2			1	1				1	1
Purshia tridentata						3	5	2			2	1		1	1
Arctostaphylos patula							2								
Ceanothus prostratus							2								
Cercocarpus ledifolius							3	1	5					1	2
Ribes velutinum								1			1	4	5	2	2
Holodiscus microphyllus var. glabrescens									4	1				2	
Chamaebatiaria millefolium									3	5				4	3
Ribes cereum										2		2	1	2	5
Salvia dorrii ssp. carnosa											5			5	2
Symphoricarpos oreophilus												5	1		
Amelanchier pallida												2	1		
Salix lasiandra													1		
Rosa woodsii var. ultramontana													1		
Sambucus cerulea													2		1
GRASSES and GRASS-LIKES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Secale cereale	2														
Bromus tectorum	3	1	2	3	3	2		1			2		2	1	2
Elymus cinereus			3		2								4		
Sitanion hystrix			1	3	2	2	1	1		1	1	3		1	1
Stipa comata				5											
Stipa thurberiana				3		5					1			1	1
Agropyron spicatum				3		3	3				1			1	1
Poa sandbergii				2	2	3	3			1	1			1	1
Festuca bromoides						1								1	
Festuca idahoensis							5					5			
Stipa occidentalis								1	1						
Carex rossii										1					
Poa ampla												3			
FORBS	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tragopogon dubius	1				1										
Erodium cicutarium	1				3										
Descurainia sofia	2	3	3		2	2							1		
Sisymbrium altissimum	1		3	2	2			2			1		2		
Salsola kali		3													
Lactuca serriola		1													
Atriplex rosea		2													
Amaranthus graecizans		1													
Kochia scoparia		1													
Lepidium perfoliatum			1												

Table 11. (Continued)

	Brte-Sece	Desc	Chaa2/Elci	Chvi/Sco2	Chvi/Brte	Juoc/Arrv/Stth	Pipo/Putr/Feid	Mood-Cyhu	Cele-Homig	Chmi	Sadoc/Ermil	Syor-Feid	Rive/Elci	Sadoc-Chmi	Rice
No. of samples*	1	1	1	1	1	1	1	2	1	2	8	1	4	12	9
Phacelia linearis			1	3	1	3									
Machaeranthera canescens				1											
Penstemon cinereus				2			3								
Astragalus curvicarpus				1	1										
Descurainia pinnata var. halictorum				2							2				
Draba verna				3		3						3			
Gayophytum diffusum				2				1			1				
Mentzelia albicaulis				2				2			2				
Crepis acuminata				2			3					2			
Phlox caespitosa				2		2	4					3			
Vicia americana					1										
Amsinkia tessellata					1								1		
Eriogonum umbellatum ssp. polyanthum						1									
Calochortus macrocarpus						2	3								
Cryptantha ambigua						2		2		1	1			2	1
Antennaria geyeri							2								
Microsteris gracilis							3								
Achillea millefolium							2					4			
Collinsia parviflora							3	2							
Potentilla glandulosa							4			1				1	
Dimeresia howellii								3							
Clarkia lassenensis								1							
Cycladenia humilis								4							
Stephanomeria tenuifolia								3			2				
Monardella odoratissima								4			1				
Gilia congesta ssp. palmifrons								1			1				
Mentzelia laevicaulis								1			1				
Delphinium nudicaule								1			1				
Eriogonum nudum var. pubiflorum								2			2				
Collomia tinctoria								1			1				
Clarkia rhomboidea								2			1				
Phacelia hastata								2			1				
Phacelia ramosissima								1			1		1		
Chaenactis douglasii									1						
Penstemon duestus									3					2	2
Arabis sparsiflora									1	1		1	1	1	1
Cirsium vulgare										1					
Woodsia scopulina										1					
Eupatorium occidentale										2				1	
Scrophularia lanceolata										3			1	3	2
Mimulus rubellus											1				
Eriogonum microthecum var. laxiflorum											4				
Gallum aparine											1		1		
Balsamorhiza sagittata												1			
Silene douglasii												3			
Erigeron filifolius												3			
Castilleja linariaefolia												1			
Urtica dioica var. holosericea													3		
Polygonum coccineum													1		
Agastache parvifolia													1	1	3

*Mean prominence values are given for communities with two or more samples

notes concerning character species are treated individually in the following sections.

24. Pinus ponderosa/Purshia tridentata/Festuca idahoensis (Pipo/Putr/Feid)

This community occurred as two small stands; one on the north face of Caldwell Butte, and the other on the north face of Hippo Butte. Elevation varied from 1,463 to 1,548 meters and slope ranged from 35 to 45 percent. Previously this community probably covered the northern slopes of many cinder cones in the southern one-third of the Monument. Each of these cones had a large number of dead Pinus ponderosa, which probably succumbed to massive western pine beetle attack and drought in the 1920's. The Pipo/Putr/Feid community on Hippo Butte was experiencing another attack by unidentified beetles and about ten trees were already dead with others dying. The surrounding Juoc/Cele/Feid community was slowly encroaching upon this community.

Soils found in the Pipo/Putr/Feid community were approximately 38 centimeters to the basalt cinder parent material. The surface horizon was sandy textured which graded into a sandy loam texture in the C horizon.

Pinus ponderosa was the dominant tree over Juniperus occidentalis in this community (Table 11). Purshia tridentata dominated

the shrub layer over three other shrubs encountered. The grass layer was dominated by Festuca idahoensis over Agropyron spicatum, Poa sandbergii, and Sitanion hystrix. Phlox caespitosa and Potentilla glandulosa were the most prominent forbs (Table 11).

25. Juniperus occidentalis/Artemisia tridentata ssp. vaseyana/Stipa thurberiana (Juoc/Artrv/Stth)

This community was encountered in the northwestern corner of the Monument (near Gillem's Camp) and as scattered patches in the Artrv/Stth-Agsp community. The Juoc/Artrv/Stth community appeared to be on sites which had not burned as regularly and intensively as the Artrv/Stth-Agsp community. Comparing photographs taken of Gillem's Camp in 1873 and at present shows a dramatic increase of Juniperus occidentalis as a result of fire exclusion. For many decades Gillem's Camp was the Monument's headquarters.

The Juoc/Artrv/Stth community occurred from 1,250 to 1,402 meters elevation on west, east, and south-facing aspects. Slope varied from 0 to 40 percent. Soils were only 33 centimeters deep and the surface horizon was sandy loam textured. The profile was extremely cobbly and stony throughout.

Juniperus occidentalis was the only tree present in this community and was well distributed (Table 11). Artemisia tridentata ssp. vaseyana was the most prominent shrub while Purshia tridentata,

Chrysothamnus nauseosus var. albicaulis, and Leptodactylon pungens were uniformly scattered throughout but low in number. Stipa thurberiana dominated the herbaceous layer among four other grasses and seven forbs.

26. Symphoricarpos oreophilus/Festuca idahoensis (Syor/Feid)

This community occurred on three east-west rocky escarpments in the northwestern portion of the Monument. The Syor/Feid community was found at 1,341 meters elevation and was restricted to north-facing exposures. Grazing was probably minor in this type because of its remoteness from the main Monument floor. Evidence of fire was present which has kept Juniperus occidentalis numbers low. The rockiness of this type made soil analysis difficult and several attempts were made to find a suitable digging spot. Soils were found to be 56 centimeters deep with a loamy textured surface horizon grading into a silty clay textured subsurface horizon. Small pieces of siltstone, roughly one millimeter in diameter, were found incorporated in the B horizon.

Symphoricarpos oreophilus was the dominant shrub in this community with Chrysothamnus viscidiflorus and Ribes velutinum subordinate members (Table 11). Festuca idahoensis was the clear dominant in the grass layer with Poa ampla and Sitanion hystrix less conspicuous members. A rich variety of several perennial and

one annual species made up the forb layer. Poa ampla and a rich complement of perennial forbs were typically associated with Festuca idahoensis on north-facing exposures on the Monument.

Symphoricarpos oreophilus generally can be found on relatively dry, stony sites in California (Munz, 1959). The browse value of this plant is considered good for deer but not as high as mountain-mahogany (Cercocarpus spp.) and serviceberry (Amelanchier spp.) (Dayton, 1931).

27. Chrysothamnus nauseosus var. artus/Elymus cinereus (Chnaa2/Elci)

This community was represented by one small stand in the northeastern corner of the Monument where it occurred on alluvial bottomland at 1,250 meters elevation. At one time this area was probably seasonally under water, depending on the level of Tule Lake. A topographic map surveyed in 1884 on file at the Lava Beds National Monument headquarters shows that water from Tule Lake came at least one-half mile south into the Monument at the northeast corner. This was confirmed by the presence of fresh water clam shells. Another interesting relict of former Tule Lake was the presence of Juncus balticus and Carex praegracilis stands. These plants formed dense mats but were never found to be more than several square meters in area.

Soils of the Chnaa2/Elci community were 81 centimeters deep. The surface horizon was sandy loam textured and the subsurface horizon varied from silty loam to silty clay texture. The pH changed from 8.4 in the A horizon to 9.2 in the lower B horizon.

Chrysothamnus nauseosus var. artus was the dominant shrub in this community and thereby received the highest prominence rating (Table 11). Chrysothamnus viscidiflorus was low in abundance but uniformly distributed. Artemisia tridentata ssp. tridentata only occurred on the periphery of this type with a few stringers reaching in. Elymus cinereus was the dominant grass and occurred uniformly throughout the community.

Chrysothamnus nauseosus var. artus generally grows on alkaline sites (Hitchcock and Cronquist, 1974), and is not abundant in California (Munz, 1959).

28. Chrysothamnus viscidiflorus/Stipa comata (Chvi/Stco 2)

The Chvi/Stco 2 community was represented as a small stand near the northern base of Hardin Butte and as scattered pockets in the western portion of the Monument. This community was always encountered in depressions where coarse alluvium had accumulated and varied in elevation from 1,317 to 1,372 meters. The soil profile was greater than 102 centimeters deep and the texture remained sandy throughout. Soil structure remained granular throughout the

profile and no basalt cobbles were encountered while digging. Burned shrub remains of Artemisia tridentata ssp. vaseyana were generally encountered in this community. Fire records on file at Monument headquarters indicate that the Hardin Butte stand burned in 1972 and all stands burned several times in the 1940's.

The dominant shrub in this community was Chrysothamnus viscidiflorus with Tetradymia canescens in low abundance (Table 11). Stipa comata was clearly the dominant grass out of five others encountered. Several perennial and annual forbs made up the remainder of the vegetative composition.

Chrysothamnus viscidiflorus is a common, generally subdominant shrub in many sagebrush communities and is not highly desirable to browsing animals (Young and Evans, 1974). Chrysothamnus viscidiflorus has been shown to be highly competitive with other associated plants and sprouts profusely after fire destroys the top (McKell and Chilcote, 1957). The ability of this plant to quickly establish after the soil has been disturbed makes it valuable for soil protection (Plummer, 1977).

Stipa comata is a perennial bunchgrass common on dry, sandy or gravelly plains and foothills. This plant is valuable as forage because it begins growth early in the spring and, with sufficient precipitation, also produces new growth in the summer and fall. The mature caryopsis has a sharp, bearded callus which may be

mechanically harmful to grazing animals in its later growth stages (U.S. Forest Service, 1937). Wright (1971) reported Stipa comata as only moderately resistant to burning due to the fine leaves and litter accumulation at the base.

29. Chrysothamnus viscidiflorus/Bromus tectorum (Chvi/Brte)

This community occurred as one small stand near Hospital Rock at 1,235 meters elevation. Soil depth was 53 centimeters and the gravelly profile had a sandy loam texture throughout. This type appeared to be highly disturbed from past burning and grazing. There were burned Artemisia tridentata shrubs evident, and small mounds supporting Sisymbrium altissimum indicated rodent activity. Grazing by domestic sheep during the early 1900's was probably heavy in this stand because of its close proximity to former Tule Lake.

Chrysothamnus viscidiflorus dominated the shrub layer and received the highest prominence rating (Table 11). The majority of these shrubs were decadent. Young Artemisia tridentata ssp. vaseyana plants were encountered and appeared to be increasing in this stand. Subspecies determination was extremely difficult on this site because it was near the transition between subspecies vaseyana and tridentata. Bromus tectorum dominated the grass layer and Elymus cinereus was encountered only in small clusters, perhaps on deeper and finer soils. Erodium circutarium was the

most conspicuous forb.

30. Ribes velutinum/Elymus cinereus (Rive/Elci)

This community occurred on basalt outcrops along the northern periphery of the Monument and on basalt outcrops along a ridge face above Gillem's Camp. Elevation varied from a low of 1,228 meters to a high of 1,298 meters. Stands adjacent to former Tule Lake were apparently used by Indians to grind seeds since mortars bored in the basalt were common.

Ribes velutinum dominated the shrub layer and received an average prominence rating of five (Table 11). Other important shrubs encountered with lower prominence ratings were Chrysothamnus nauseosus var. albicaulis and Artemisia tridentata ssp. tridentata. One individual of the latter was nearly two meters tall with a 31 centimeter stem diameter, 46 centimeters above the ground. Salix lasiandra and Polygonum coccineum were rare in the stands near former Tule Lake but may have been more prominent before the lake was drained. They were more numerous outside the Monument in areas where lake water still exists. Elymus cinereus dominated the grass layer and also received an average prominence rating of five. Bromus tectorum was the only other grass encountered, receiving an average prominence rating of two. The most important forb out of ten encountered was Urtica dioica var. holosericea, an introduced plant from Eurasia (Hitchcock and Cronquist, 1974). It received an average prominence value of three.

The prickly shrub, Ribes velutinum, grows on dry sites from desert hillsides to ponderosa pine forests (Hitchcock and Cronquist, 1974). It is considered marginally valuable as browse for mule deer (Van Dersal, 1939). Observations of burned Ribes velutinum individuals on the Monument have shown that it is capable of resprouting after top disturbance.

31. Cercocarpus ledifolius-Holodiscus microphyllus var. glabrescens (Cele-Homig)

This community occurred on the southern half of a lava flow (Black Lava Flow) in the southwestern corner of the Monument. It was found from roughly 1,524 to 1,707 meters elevation and no differentiation by aspect was observed. This lava flow was the youngest feature on the Monument and was believed to have originated within the last 300 to 500 years (Mertzman, 1977). The barren substrate was a severe type for plant establishment. Crustose lichens were common and were probably the first pioneers. The vascular plants required a crack or crevice in the basalt lava to establish.

Cercocarpus ledifolius and Holodiscus microphyllus var. glabrescens were the most prominent plants in this community (Table 11). Eggler (1941), working in Craters of the Moon National Monument, Idaho, found Sericotheca glabrescens [Holodiscus microphyllus var. glabrescens] a pioneer on young lavas. Pinus ponderosa was

occasionally encountered but was probably limited by the lack of soil development. The herbaceous layer was generally sparse except for the occurrence of Penstemon duestus, a plant typically found in relatively dry, rocky habitats (Munz, 1959).

Holodiscus microphyllus var. glabrescens is common to warm, rocky sites and its browse value is considered low (Dayton, 1931).

32. Chamaebatiaria millefolium (Chmi)

The Chamaebatiaria millefolium community was the most sparsely covered type encountered on the Monument. It occurred on the northern half of a lava flow (Black Lava Flow) in the southwestern corner of the Monument. This type also was found on a lava tube collapse system near Eaglenest Butte. Elevation varied from 1,463 to 1,524 meters and aspect did not influence community structure significantly. At 1,524 meters elevation Cercocarpus ledifolius and Holodiscus microphyllus var. glabrescens dominated the rough basalt areas.

Chamaebatiaria millefolium was the dominant plant in this community and received the highest prominence rating (Table 11). Ribes cereum was present but was only seen occasionally. Two forbs, Scrophularia lanceolata and Eupatorium occidentale, were always associated with extremely rocky sites on the Monument and

were the most important here. No trees were found in this community and the grass layer was poorly developed.

The aromatic shrub, Chamaebatiaria millefolium, is adapted to arid, sunny, and well-drained sites (Van Dersal, 1939). It was never found outside of the extremely rocky lava flows and lava tube collapses on the Monument. It did not appear to be competitive or aggressive with other vascular plant species. Van Dersal (1939) reported Chamaebatiaria millefolium as slightly valuable mule deer browse.

33. Salvia dorrii ssp. carnosa/Eriogonum microthecum var. laxiflorum (Sadoc/Ermil)

This community was typically found on the south-face of cinder cones on the Monument. Elevation varied from a low of 1,298 meters on Juniper Butte to 1,646 meters on Hippo Butte. It could be found near cinder cone rims on solid basalt outcrops or on basalt cinders below the rim. Evidence of fire influence was not observed in this type and probably was not a strong factor on these rocky soils.

Juniperus occidentalis was the only tree encountered in this type and was not common (Table 11). Salvia dorrii ssp. carnosa dominated the shrub layer receiving the highest prominence rating. The most conspicuous grass, Bromus tectorum, was only moderately abundant. The half-shrub, Eriogonum microthecum var. laxiflorum (classified

as a forb by Garrison et al., 1976), dominated the forb layer and was incorporated into the community name. It often approached Salvia dorrii ssp. carnosa in prominence.

Salvia dorrii ssp. carnosa grows on dry, rocky sites in California. It is not a high quality browse plant, ranking poor to fair for deer. It does not sprout after complete top removal, thus fire would be expected to kill it (Sampson and Jespersen, 1963). It is known for its colorful flowers and aromatic odor.

Eriogonum microthecum var. laxiflorum is common on dry, rocky sites in California (Munz, 1959). Its forage value varies with the associated plants but is generally rated fair for grazing animals (U. S. Forest Service, 1937).

34. Salvia dorrii ssp. carnosa-Chamaebatiaria millefolium (Sadoc-Chmi)

This community occurred on basalt lava flows from roughly 1,250 to 1,356 meters elevation and on lava tube collapses up to 1,597 meters elevation on the Monument. The lava tube collapses appeared to be drier sites with less soil development than the lava flows. A compensating environment may explain this community's restriction to collapses at the higher elevations. This type was similar to the Chamaebatiaria millefolium community and overlapped into its elevational range. The Sadoc-Chmi community

occurred on basalt which was at least twice as old as the basalt substrate supporting the Chmi community (approximate ages of lava flows have been determined by Mertzman (1977)). With the passage of more time a greater diversity of vascular plants have gradually colonized these rocky sites. The Sadoc-Chmi community displayed twice as many shrub species as the Chmi community (Table 11).

Juniperus occidentalis was generally present in these stands but was not numerous (Table 11). The shrub layer was dominated by Salvia dorrii ssp. carnosa with Chamaebatiaria millefolium nearly as conspicuous. Both plants were considered highly important on the site and were therefore included in the community name. Chrysothamnus nauseosus var. albicaulis received the same average prominence rating as Chamaebatiaria millefolium but the former was not considered as good an indicator of the site. Dominating the forb layer was Scrophularia lanceolata, a reliable indicator of extremely rocky sites on the Monument. The grass layer was generally patchy and inconsistently present.

35. Ribes cereum (Rice)

The Ribes cereum community occurred on basalt lava flows similar to the Cele, Cele-Homig, Chmi, and Sadoc-Chmi communities. Elevation varied from roughly 1,356 to 1,414 meters for this type. The Rice, Cele, and Sadoc-Chmi communities were found on

basalt much older than basalt substrate expressing Chmi and Cele-Homig communities (Mertzman, 1977). The Rice community occurred in an elevational belt between the Sadoc-Chmi community and the Cele community. The Sadoc-Chmi community had the widest elevational range but was restricted to basalt lava tube collapses above 1,356 meters. The Cele and Rice communities were not encountered in these collapses.

Observations showed that Artemisia tridentata ssp. vaseyana and Chrysothamnus nauseosus var. albicaulis had a tendency to increase on these rocky sites given additional time and soil development. Conversely, Chamaebatiaria millefolium showed a tendency to decrease under these conditions. Eggler (1941) found this same relationship on lava flows in Craters of the Moon National Monument, Idaho.

Ribes cereum dominated the shrub layer and Chrysothamnus nauseosus var. albicaulis was slightly less prominent (Table 11). Prunus emarginata was occasionally found in small patches (less than .4 hectare) in this community, but were not large enough to evaluate separately. On the periphery of the Rice community where it was more susceptible to burning, Prunus emarginata readily sprouted and increased after burning. The most prominent grass among four others encountered was Bromus tectorum. The most conspicuous forbs were Agastache parvifolia, Scrophularia lanceolata,

and Penstemon duestus. Agastache parvifolia was a good indicator of extremely rocky sites and is listed as very rare and endangered in California (California Native Plant Society, 1974).

In California, Munz (1959) reported Ribes cereum common on dry, rocky sites. Sampson and Jespersen (1963) ranked it as poor to fair forage for deer in California and reported its capability to resprout vigorously after top removal.

36. Bromus tectorum-Secale cereale (Brte-Sece)

The Brte-Sece community was found in scattered patches along the northern border of the Monument adjacent to former Tule Lake. Apparently much of the area supporting this community was periodically under water before Tule Lake was drained. Fresh water clam shells were commonly found throughout. The Brte-Sece community occurred at 1,231 meters elevation and showed no differentiation by aspect. Soils were 33 centimeters to parent material with loamy textured surface horizons. Small pieces of siltstone were found incorporated in the lower horizons.

Bromus tectorum was extremely dense and was given a prominence rating of three (Table 11) which is the highest value an annual can receive (Winward and Youtie, 1976). Secale cereale apparently had invaded from nearby grain fields. Descurainia sofia, the dominant forb, was well dispersed throughout this community.

Secale cereale is an introduced annual grass, resembling wheat in habit. It is commonly cultivated and easily escapes into nearby fields and disturbed sites (Hitchcock, 1951).

37. Monardella odoratissima-Cycladenia humilis (Mood-Cyhu)

The Mood-Cyhu community was represented by two small stands, each on the southeastern exposure of cinder cones. One was found on Bearpaw Butte at 1,609 meters elevation and the other on Caldwell Butte at 1,481 meters elevation. These sites were extremely arid and harsh. The substrate consisted of loose vesicular basalt cinders on 40 percent slopes. It was common to see small plants buried in the unstable cinders. Water penetration was so rapid in these cinders that seedling establishment must be extremely difficult.

The Mood-Cyhu community was the only type encountered on the Monument that was dominated by perennial forbs. Monardella odoratissima and Cycladenia humilis were both moderately abundant (Table 11). The tree, shrub, and grass layers were represented by individuals in very low numbers and inconsistent distribution. One significant plant which was commonly found in this community was Dimeresia howellii. This annual forb is listed as rare in California (California Native Plant Society, 1974).

Monardella odoratissima is common to open, rocky sites up to mid-elevations in the mountains (Hitchcock and Cronquist, 1974).

Cycladenia humilis also is reported to be common to open, rocky sites (Munz, 1959), and is not palatable to grazing animals (Hermann, 1966).

38. Descurainia sofia (Deso)

The Deso community occurred as a single small fragment of Monument land in the northern portion. This site was once cultivated and the tillage lines could still be seen on the aerial photographs. The site supporting the Deso community was found on level ground at 1,237 meters elevation and also was under water in the past before Tule Lake was drained. The soil surface was a maze of cracks which were more than 30 centimeters deep. The surface horizon was silty clay textured with strong subangular blocky structure. The subsurface horizon also was silty clay textured but in addition had a mottling of white diatomaceous earth.

Descurainia sofia was the dominant plant in this community with Salsola kali slightly less abundant but given the same prominence rating (Table 11). Several other less abundant annual plants made up the remainder of the floristic list.

Descurainia sofia is an annual forb which has become naturalized from Europe. It is a common weedy species of dry localities and is capable of invading many different sites (Munz, 1959).

Salsola kali also is an annual forb which has become

naturalized from Europe. It probably entered this country as an impurity in flax (Linum spp.) seed and quickly spread throughout the drier areas of the United States and Canada (Dayton, 1960). Salsola kali seems to flourish on arid land which has been disturbed by cultivation, overgrazing, rodents, or other activities. Plant communities dominated by annual forbs like Descurainia sofia and Salsola kali are characteristic of early seral stages of plant succession in sagebrush regions (Tisdale et al., 1969). Salsola kali may serve as nutritious forage when other plants are not suitable. Chemical analysis shows that it contains more protein and carbohydrates than clover (Trifolium spp.) but is less palatable and less digestible (Dayton, 1960).

Habitat Types

The habitat types described in this section have been defined on the basis of natural vegetation present prior to the entrance of European man in the Monument's ecosystem. Natural fire was an important feature previously; consequently, much of the area supported pyric climax vegetation. During this century, and especially the past 30 years, fire suppression efforts have reduced the incidence of burns allowing several tree and shrub species an opportunity to dominate areas where they once served a minor role. Although some of the habitat types described in this section are presently becoming dominated by these

species, the habitat types have been named after the vegetation which dominated these areas when fire was a natural part of the local environment. This is in accordance with the National Park Service's mandate to preserve areas of exceptional value and produce a reasonable illusion of primitive America.

Because of previous disturbances by grazing or because of an altered burning pattern, many of the communities encountered on these habitat types were in a seral condition when sampled. Therefore, placing some communities into habitat types required a projection based on remnant plants considered indicators of the climax association. Also, literature from studies on the same or similar sites as well as past records and photographs were used to make these projections.

Twenty habitat types were identified (Table 12) and mapped (Figure 6 in packet) on the study area. These have been broken into six forest and fourteen shrub habitat types, and are grouped according to dominant tree and shrub species. A brief discussion is included for each type including its indicator species and, in many cases, the authority who has described it or a similar type previously. Soil descriptions of these habitat types are presented in Appendix B. Data previously presented for plant communities which express the approximate species composition at climax for each habitat type may be used to reference the following information on habitat types.

Table 12. Habitat types, community codes, and index numbers.

Habitat type	community code	index no.
Pinus ponderosa/Purshia tridentata-Arctostaphylos patula/Stipa occidentalis	Pipo/Putr-Arpa/Stoc	1
Pinus ponderosa/Purshia tridentata/Festuca idahoensis	Pipo/Putr/Feid	2
Pinus ponderosa/Purshia tridentata/Stipa occidentalis	Pipo/Putr/Stoc	3
Juniperus occidentalis/Cercocarpus ledifolius	Juoc/Cele	4
Juniperus occidentalis/Agropyron spicatum	Juoc/Agsp	5
Juniperus occidentalis/Artemisia tridentata ssp. vaseyana/Stipa occidentalis	Juoc/Artrv/Stoc	6
Symphoricarpos oreophilus/Festuca idahoensis	Syor/Feid	7
Artemisia arbuscula/Festuca idahoensis	Arar/Feid	8
Artemisia tridentata ssp. vaseyana-Purshia tridentata/Festuca idahoensis-Agropyron spicatum	Artrv-Putr/Feid-Agsp	9
Artemisia tridentata ssp. vaseyana/Agropyron spicatum (Stipa thurberiana phase)	Artrv/Agsp (Stth phase)	10
Artemisia tridentata ssp. vaseyana/Stipa comata	Artrv/Stco 2	11
Artemisia tridentata ssp. vaseyana/Stipa occidentalis	Artrv/Stoc	12
Artemisia tridentata ssp. tridentata/Agropyron spicatum (Stipa thurberiana phase)	Artrt/Agsp (Stth phase)	13
Purshia tridentata/Agropyron spicatum	Putr/Agsp	14
Cercocarpus ledifolius	Cele	15
Cercocarpus ledifolius-Holodiscus microphyllus var. glabrescens	Cele-Homig	16
Ribes cereum	Rice	17
Salvia dorrii ssp. carnosa/Eriogonum microthecum var. laxiflorum	Sadoc/Ermil	18
Salvia dorrii ssp. carnosa-Chamaebatiaria millefolium	Sadoc-Chmi	19
Chamaebatiaria millefolium	Chmi	20

Data presented in Tables 2 and 3 for transect-sampled communities provide mean frequency-constancy values for the herbaceous layer and mean woody foliage cover for the woody layer, respectively. Tables 6-9 provide data for the "plant community fragments" and Table 11 provides values for prominence-rated communities.

1. Pinus ponderosa/Purshia tridentata-Arctostaphylos patula/Stipa occidentalis (Pipo/Putr-Arpa/Stoc)

The Pipo/Putr-Arpa/Stoc habitat type was encountered at the highest elevations on the Monument. It was restricted to north-facing, 40 to 50 percent slopes on cinder cones near the Monument's southern boundary. Young individuals of Abies concolor, with an understory of Ceanothus velutinus, were consistently encountered in patches in this type. Pinus ponderosa appeared to make its best growth in this type, but was probably dependent on periodic burning to prevent Abies concolor from shading it out. This habitat type presently supports the Pipo/Putr-Arpa and the Pipo/Arpa communities.

The Pipo/Putr-Arpa community was believed to most closely approximate the climax for this habitat type. Man-induced disturbances appeared low and fire scars on the Pinus ponderosa trees indicated the presence of natural fire maintaining this community's structure.

The Pipo/Arpa community also contained fire scarred Pinus ponderosa and occurred on similar slopes, exposures, and soils as the Pipo/Putr-Arpa community. Only one stand of the Pipo/Arpa community was encountered and it was found on a kipuka which showed no evidence of alteration by man. It occurred at approximately 49 meters higher elevation than the Pipo/Putr-Arpa community. The former differed from the latter in having higher Arctostaphylos patula cover and lower Purshia tridentata cover. Greater tree canopy coverage in the Pipo/Arpa community (39.3 percent) compared to the Pipo/Putr-Arpa community (14.9 percent) may have been partly responsible for the lower Purshia tridentata cover. Volland (1976) reported Purshia tridentata decreasing with tree canopy closure in the Pipo/Putr-Arpa/Stoc habitat type. Since no description of the Pipo/Arpa community was found in the literature and since only one stand was encountered on the Monument, it was deemed best to place it within the Pipo/Putr-Arpa/Stoc habitat type.

Indicators for this type were Pinus ponderosa, Purshia tridentata, Arctostaphylos patula, and Stipa occidentalis. The presence of Abies concolor, Libocedrus decurrens, Ceanothus velutinus, and Ribes roezlii var. cruentum was unique to this habitat type on the Monument. Volland (1976) has described this habitat type and he also mentioned the presence of Abies concolor, Libocedrus decurrens, and Ceanothus velutinus which could increase with fire protection. This type is

reported to be mule deer summer range (Volland, 1976).

2. Pinus ponderosa/Purshia tridentata/Festuca idahoensis (Pipo/Putr/Feid)

The Pipo/Putr/Feid habitat type occurred on the northern exposures of cinder cones in the southern half of the Monument, except near the extreme southern border. This habitat type comprised areas by the same community designation as well as the Juoc/Cele/Feid community.

The Pipo/Putr/Feid community was only encountered as small remnants since Pinus ponderosa has been replaced on most of this habitat type by Juniperus occidentalis and Cercocarpus ledifolius. The destruction of Pinus ponderosa has been associated with western pine beetle attacks and drought in the 1920's. The Pinus trees on these buttes were on the edge of their ecological range and were probably most susceptible to damage. Photographs taken of Bearpaw Butte in May, 1936 on file at Monument headquarters show beetle-damaged Pinus ponderosa dominating the tree layer with an open understory of Purshia tridentata and Festuca idahoensis. Natural, periodic fires probably maintained low Purshia tridentata densities and high grass cover.

Presently, Juniperus occidentalis and Cercocarpus ledifolius dominate the woody layers and Purshia tridentata appears decadent

from the closing canopy. Fire suppression has undoubtedly allowed fire-susceptible species to increase.

Indicators for this type were Pinus ponderosa, Purshia tridentata, and Festuca idahoensis. Often the Pinus component was replaced by Juniperus occidentalis and Cercocarpus ledifolius. Phlox caespitosa was more frequent on this habitat type than on any other.

This habitat type has been described by Dyrness and Youngberg (1966), Dealy (1971), Volland (1976), and Pfister et al. (1977). Descriptions by the first three authorities were completed in adjacent Oregon and floristics closely match conditions in the Monument. Dyrness and Youngberg (1966) found the quality of Pinus ponderosa trees low--short, stubby boles and light-colored, scanty foliage. They correlated low vigor to high susceptibility to western pine beetle and their stands contained beetle-killed trees. Dealy (1971) and Volland (1976) mentioned the importance of this habitat type for spring, summer, and fall deer habitat.

Restoring this habitat type by prescribed burning to remove Juniperus occidentalis and Cercocarpus ledifolius is a possibility, but re-establishment of Pinus ponderosa may be difficult. Mortality of planted seedlings could be high, since this tree species is on the edge of its ecological range.

3. Pinus ponderosa/Purshia tridentata/Stipa occidentalis (Pipo/Putr/Stoc)

The Pipo/Putr/Stoc habitat type supported the majority of the current Pinus ponderosa dominated stands on the Monument. This type encompassed areas supporting the Pipo/Putr and Pipo/Habl communities and additionally included stands of the Juoc/Putr, Putr/Brte-Stoc and Brte communities east of Caldwell Butte.

The Pipo/Putr community appeared to approximate the climax for this habitat type. Fire scars on Pinus ponderosa left evidence of periodic fires burning this type. Fire suppression probably allowed Purshia tridentata densities to increase and perhaps lowered Stipa occidentalis' cover. Scattered individuals of Juniperus occidentalis and Cercocarpus ledifolius have invaded due to fire suppression.

The site supporting the Pipo/Habl community was prescribed burned in 1975, and based on adjacent unburned stands, Haplopappus bloomeri appeared to increase while Purshia tridentata was killed. Numerous Purshia tridentata seedlings have since established which should eventually restore this layer.

The Juoc/Putr and Putr/Brte-Stoc communities occurred on the periphery of Pinus ponderosa's range, and were separated from each other by the primary Monument highway. Both communities contained dead Pinus ponderosa trees which probably succumbed to

drought and western pine beetle attacks during the 1920's. Fire records, on file at Monument headquarters, indicated that during the period between 1934 and 1972 the Juoc/Putr community only experienced spot burns. This probably allowed Juniperus occidentalis to increase and Purshia tridentata to become over-mature, dense, and eventually decadent. According to the Monument's fire records, the Putr/Brte-Stoc community on the north side of the road has burned completely--the last time being in 1955. This appeared to slow Juniperus occidentalis invasion and Purshia tridentata seemed less decadent. Fires have consumed most of the Pinus ponderosa logs in the Putr/Brte-Stoc community but occasional snags were still evident.

The site supporting the Brte community just east of Caldwell Butte also was on the northern range of Pinus ponderosa since snags and logs of it were common. This site was prescribed burned May 19 and 20, 1977 and was sampled in July, 1978. Purshia tridentata was represented in the shrub layer mostly as dead individuals although occasional resprouts were encountered. Stipa occidentalis was present in the stand but was not encountered in the frequency plots. Bromus tectorum and several annual forbs dominated the herbaceous layer.

Indicators for this type were Pinus ponderosa, Purshia tridentata, and Stipa occidentalis. Altered stands of this habitat type encountered had at least one climax layer dominant present with the others evident.

Penstemon cinereus was more frequent on this habitat type than on any other. Volland (1976) has described this habitat type and Dyrness and Youngberg (1966) have reported a similar type; the former authority included Stipa occidentalis in the nomenclature whereas the latter authorities did not. Both descriptions reported Stipa occidentalis' low coverage and this may explain why Dyrness and Youngberg (1966) left it out of their nomenclature. Volland (1976) was used as the authority since Stipa occidentalis appears to have high diagnostic value in distinguishing this habitat type from other Pipo/Putr habitat types described in the Northwest. Volland (1976) mentioned that this type is summer range for mule deer.

Restoration of this habitat type for the Juoc/Putr, Putr/Brte-Stoc, and Brte communities east of Caldwell Butte may be possible through prescribed burning followed by planting Pinus ponderosa seedlings. Mortality of planted seedlings in the Monument could be high since these communities are on Pinus ponderosa's northern ecological range.

4. Juniperus occidentalis/Cercocarpus ledifolius (Juoc/Cele)

The Juoc/Cele habitat type (proposed) occurred on eastern, southeastern, and western aspects of cinder cones in the southern half of the Monument. It only occupied areas by the same community

designation. Juniperus occidentalis and Cercocarpus ledifolius were successfully reproducing and individuals in all height classes were seen. There was no indication of another community attempting to establish on these sites. Natural fire did not appear to have a strong influence on this type, which probably allowed woody plants to become extremely large. The herbaceous layer was sparse on these pumice and cinder dominated soils and was primarily dominated by native forbs. No herb appeared to consistently dominate this layer.

This type has not been described previously in the literature, but since stands encountered on the Monument appeared to be in an undisturbed condition, it is proposed as a new habitat type.

5. Juniperus occidentalis/Agropyron spicatum (Juoc/Agsp)

The Juoc/Agsp habitat type occurred on southern and southwestern slopes of cinder cones in the southern one-third of the Monument. It only supported the community by the same designation. Fire did not seem to have a strong influence on this type since Juniperus occidentalis typically had attained large sizes. The herbaceous layer was sparse and patchy on these cinder and pumice dominated soils which also probably restricted fire movement.

Indicators for this type were Juniperus occidentalis and Agropyron spicatum. Climax stands of the Juoc/Agsp habitat type have been described by Driscoll (1964).

6. Juniperus occidentalis/Artemisia tridentata ssp. vaseyana/ Stipa occidentalis (Juoc/Artrv/Stoc)

The Juoc/Artrv/Stoc habitat type (proposed) occurred in the southeastern corner of the Monument correlating with areas which contained a mantle of rhyolite pumice. This type only included the community by the same designation. Juniperus occidentalis trees associated with this type were extremely large and had obviously escaped fire for a long period of time. Evidence of fire was encountered on woody plants as occasional burned individuals or fire scars, but total stand destruction did not appear to have occurred. The pumice soils and frequent basalt outcrops appeared to be responsible for reducing the movement of fire. Fire records on file at Monument headquarters indicated only spot fires within this type during the period between 1934 and 1972.

Indicators for this type were Juniperus occidentalis, Artemisia tridentata ssp. vaseyana, and Stipa occidentalis. No descriptions of this type were found in the literature, but since no evidence of disturbance was apparent, it is proposed as a new habitat type.

7. Symphoricarpos oreophilus/Festuca idahoensis (Syor/Feid)

The Syor/Feid habitat type (proposed) occurred on escarpments inside the bighorn sheep enclosure in the northwestern portion of the Monument. It only supported the community by the same designation.

There was no evidence of past heavy grazing, probably due to the remoteness of this type from a watering source. Periodic fires probably burned this type because burned woody debris was encountered and Juniperus occidentalis numbers were very low. Symphoricarpos oreophilus appeared to be reproducing and maintaining its dominance. Festuca idahoensis was relatively dense and seemed to be vigorous.

Indicators for this type were Symphoricarpos oreophilus and Festuca idahoensis. Poa ampla was conspicuous and appeared to be associated with Festuca idahoensis. This type has not been described previously in the literature but Dealy (1975) described a Cele/Syor/Feid habitat type (Dealy treated Cercocarpus ledifolius as a tree) which was floristically similar. The Cele/Syor/Feid habitat type occurred at a higher elevation (1800 meters) and in a greater precipitation zone (45 centimeters) than the Syor/Feid habitat type. The latter occurred at 1,341 meters elevation and precipitation at the Monument headquarters (1,454 meters) was only 36.9 centimeters. Dealy (1975) reported Cercocarpus ledifolius occurring in a narrow belt between the lower Pinus ponderosa tree line and the Juniperus occidentalis zone. The distribution of Cercocarpus ledifolius in the Monument was restricted to the southern one-third where conditions were effectively moister and cooler. Since the Syor/Feid community appeared to be unaltered, it is proposed as

a new habitat type.

8. Artemisia arbuscula/Festuca idahoensis (Arar/Feid)

The Arar/Feid habitat type occurred inside the bighorn sheep enclosure in the northwestern portion of the Monument. It only supported the Feid-Posa 3 community on soils with a heavy restrictive clay layer. Fire records on file at Monument headquarters showed that the area inside the enclosure burned July 11, 1973. Only scattered patches of the Arar/Feid type remained but these were not large enough to sample. Festuca idahoensis and Poa sandbergii currently dominate the majority of this habitat type. Young individuals of Artemisia arbuscula were observed in the burned area.

Indicators for this habitat type were Festuca idahoensis and the scattered presence of Artemisia arbuscula. Astragalus obscurus and Phlox hoodii were unique to this type in the forb layer. Climax stands of this habitat type have been described by Eckert (1957), Culver (1964), Dealy (1971), Hall (1973), and Volland (1976) in adjacent Oregon. This habitat type is a valuable source of forage for mule deer during the winter, spring, and early summer because of the relatively high palatability of Artemisia arbuscula and a good selection of grasses and forbs (Dealy, 1971). Total forage production potential is relatively low because of rockiness and shallow soil which reduce the soil moisture holding capacity.

9. Artemisia tridentata ssp. vaseyana-Purshia tridentata/ Festuca idahoensis-Agropyron spicatum (Artrv-Putr/Feid-Agsp)

The Artrv-Putr/Feid-Agsp habitat type (proposed) was typically found in the southern one-third of the Monument on soils lacking pumice. This type supported the Artrv/Feid-Agsp community and one stand of the Stth-Agsp community east of Hippo Butte.

The Artrv/Feid-Agsp community appeared to approximate the climax for this habitat type. Natural periodic fire probably kept Juniperus occidentalis from invading and reduced the density of Artemisia tridentata ssp. vaseyana. Purshia tridentata may have been favored by light burns. Evidence of fire was found as burned debris of these woody plants mentioned. Fire suppression is probably allowing these woody plants to increase which may be decreasing grass cover.

The site supporting the Stth-Agsp community east of Hippo Butte was prescribed burned July 7, 1977 and was sampled July, 1978. An Artrv/Feid-Agsp community was found on the other side of a road which formed a fire break between these two communities. Artemisia tridentata ssp. vaseyana and Purshia tridentata were mostly encountered as dead individuals in this type. Annual forbs had the highest average frequencies and grass species had low average frequencies. Out of five grasses, Bromus tectorum had the highest average frequency with 53 percent. Stipa thurberiana, Poa sandbergii, Agropyron

spicatum, and Festuca idahoensis followed with 20, 20, 10, and 3 percent average frequencies, respectively. All of the perennial grasses had much lower average frequencies on the burned site compared to the unburned adjacent site across the road. Many of the bunchgrasses present on the burned site had not produced new growth and were treated as dead individuals which did not contribute to frequency tabulations.

Indicators for this habitat type were Artemisia tridentata ssp. vaseyana, Purshia tridentata, Festuca idahoensis, and Agropyron spicatum. A rich complement of forbs was typically associated with this type on the Monument. An altered stand encountered had the woody layer removed by fire leaving Stipa thurberiana and Agropyron spicatum with slightly higher frequencies than Festuca idahoensis. Volland (1976) has described a similar habitat type but he did not define subspecies for Artemisia tridentata. He reported Purshia tridentata with approximately half the mean foliage cover as Artemisia tridentata and this same relationship occurred in the Artrv/Feid-Agsp community on the Monument. Purshia tridentata cover decreased at lower elevations on the Monument where effective moisture was probably less. Dealy (1971) reported this same relationship near Silver Lake, Oregon going from an Artr-Putr/Feid habitat type to lower and drier sites. Volland (1976) mentioned fire protection promoting Juniperus occidentalis invasion and soil disturbances causing increases of Bromus

tectorum and Chrysothamnus ssp. within the Artr-Putr/Feid-Agsp habitat type. Herbage was reported to double after burning this type (Volland, 1976). The Artrv-Putr/Feid-Agsp habitat type is proposed as an equivalent of Volland's (1976) type.

10. Artemisia tridentata ssp. vaseyana/Agropyron spicatum (Stipa thurberiana phase) (Artrv/Agsp (Stth phase))

The Stth phase of the Artrv/Agsp habitat type (proposed) occurred in the northern two-thirds of the Monument except on sites with pumice-dominated soils. It was an assimilation of areas occupied by the Juoc/Artrv/Stth, Artrv/Stth-Agsp, and Artrv/Brte communities plus portions of the Chnaa/Brte-Stth, Stth-Agsp, and Brte communities.

The Artrv/Stth-Agsp community was the most common on this phase and appeared to approximate the climax. Man-induced disturbances appeared low and burned debris of Juniperus occidentalis and Artemisia tridentata ssp. vaseyana was generally found indicating the presence of past natural fire. Fire suppression is probably allowing Juniperus occidentalis to invade and Artemisia tridentata ssp. vaseyana to increase in density.

The Juoc/Artrv/Stth community was relatively uncommon and soils were similar to the Artrv/Stth-Agsp community. The Juoc/Artrv/Stth community appeared to represent small islands which had escaped natural fire during this century. The Juniperus occidentalis

trees were not extremely large, thus they probably invaded during this century. Evidence of this invasion is available by comparing photographs taken of Gillem's Camp in 1873 and in 1978. The Stth phase of the Artrv/Agsp habitat type above Gillem's Camp shows a tremendous increase of Juniperus occidentalis over this time period.

The Artrv/Brte community occurred in the northern portion of the Monument where grazing had been severe during the early part of this century. Burned Artemisia tridentata ssp. vaseyana debris indicated the occurrence of natural periodic fire and occasional Stipa thurberiana and Agropyron spicatum individuals indicated the former grass dominants.

The portion of the Chnaa/Brte-Stth community included in this phase was the area where evidences of Artemisia tridentata ssp. vaseyana were observed. Artemisia tridentata ssp. vaseyana was generally represented as burned debris but occasional live individuals were encountered. The understory of this community showed signs of grazing disturbance with closer proximity to former Tule Lake. Disturbance was indicated by high Bromus tectorum frequency and low Stipa thurberiana and Agropyron spicatum frequencies.

All but one stand of the Stth-Agsp community located east of Hippo Butte (discussed previously) occurred on this phase. Grazing disturbance was not apparent but recent fire alteration was observed. Burned Artemisia tridentata ssp. vaseyana debris and stumps which indicated

its former presence were common. Several stands of this community were prescribed burned in the last few years and the remaining stands burned recently according to fire records on file at Monument headquarters.

The Brte community occurred in the northern portion of the Monument near former Tule Lake where past grazing pressure was severe. The portion of this community included in this phase was the area where evidences of Artemisia tridentata ssp. vaseyana were observed. Artemisia tridentata ssp. vaseyana was generally represented as a rare individual or as burned debris. Bromus tectorum frequency was high and perennial plants were few. Stipa thurberiana and Agropyron spicatum were uncommon but present.

Indicators for this type were Artemisia tridentata ssp. vaseyana, Stipa thurberiana, and Agropyron spicatum. Altered stands varied tremendously from the climax association but they always had climax layer dominants present or evident. Eckert (1957) described a similar phase of this habitat type but he did not define subspecies for Artemisia tridentata. He reported Stipa thurberiana on a slightly less fertile and slightly coarser soils than the typical Artr/Agsp association. He pointed out that Stipa thurberiana did not replace Agropyron spicatum in this phase but had a slightly higher basal cover and frequency. The Stth phase of the Artrv/Agsp habitat type is proposed as a similar grouping to Eckert's (1957) type.

Restoration of the Artrv/Brte and Brte communities plus northern stands of the Chnaa/Brte-Stth community in this type should be possible. Photographs taken of the northern end of the Monument in 1873 show low Artemisia tridentata cover with a conspicuous understory of perennial bunchgrasses. These grasses are presumed to be Stipa thurberiana and Agropyron spicatum and their re-establishment would be the primary goal. Prescribed burning in the spring followed by seeding Stipa thurberiana and Agropyron spicatum in the fall would probably be a rapid method toward restoring the dominant native grasses. Spring burning would destroy the current seed production of Bromus tectorum and prepare a seedbed. Fall seeding would allow any dormancy requirements of the perennial grasses to be met over the winter period. Native seed could be collected from the Fleener's Chimney area and broadcast seeded manually. After seeding a pipe harrow dragged by horses could be used to bury the seeds and also turn over some of the germinating Bromus tectorum plants.

11. Artemisia tridentata ssp. vaseyana/Stipa comata (Artrv/Stco 2)

The Artrv/Stco 2 habitat type was represented as a small stand near the northern base of Hardin Butte and as scattered pockets in the western portion of the Monument. It only supported the Chvi/Stco 2 community. This habitat type was found in depressions where coarse alluvium had accumulated; soils were deep and sandy textured. Fire

records on file at Monument headquarters showed that the Hardin Butte stand burned in 1972 and the stands in the western portion of the Monument burned several times in the 1940's. Only the Hardin Butte stand was sampled and it showed Chrysothamnus viscidiflorus dominating the shrub layer. Artemisia tridentata ssp. vaseyana was rare and was typically represented as occasional burned remains. Reconnaissance of this type in the western portion of the Monument revealed Chrysothamnus viscidiflorus dominant with Artemisia tridentata ssp. vaseyana subordinate in the shrub layer. This evidence strongly suggests Artemisia tridentata ssp. vaseyana and Stipa comata as the climax layer dominants. A good condition Artrv/Stco 2 community was not encountered.

Indicators for this type were Artemisia tridentata ssp. vaseyana and Stipa comata. Winward (1970) identified an Artrv/Stco 2 habitat type showing similar species composition in seral stages and a similar soil profile.

12. Artemisia tridentata ssp. vaseyana/Stipa occidentalis (Artrv/Stoc)

The Artrv/Stoc habitat type (proposed) occurred in the southeastern half of the Monument on areas which contained a mantle of rhyolite pumice. This type supported the community by the same designation, one stand of the Putr/Brte-Stoc community found east of Red Butte, and the Brte-Stoc community. The latter two

communities were much less common on the Monument and appeared to have burned more recently than the Artrv/Stoc community.

Several important differences were found between the Artrv/Stoc habitat type and the Juoc/Artrv/Stoc habitat type discussed previously. The former had higher visual estimates of vegetation and litter cover and lower rock cover than the latter (refer to Table 4 under Artrv/Stoc and Juoc/Artrv/Stoc communities, respectively). The Artrv/Stoc habitat type had a textural B horizon and had an average pumice depth of 23 centimeters (Appendix B). The Juoc/Artrv/Stoc habitat type lacked a B horizon and had an average pumice depth of 44 centimeters. Basalt outcrops did not appear to be as frequent in the Artrv/Stoc habitat type as in the Juoc/Artrv/Stoc habitat type. Through a combination of less pumice, lower rock cover, and higher vegetative and litter cover, the former has probably been more susceptible to burning than the latter. Juniperus occidentalis appeared to be increasing in the Artrv/Stoc habitat type due to fire suppression, since only trees in the smaller height classes were present.

The Artrv/Stoc community appeared to approximate the climax for this habitat type. Natural periodic fire probably kept Juniperus occidentalis from invading and reduced the density of Artemisia tridentata ssp. vaseyana. Burned debris of both of these plants were often observed in this community.

The stand of the Putr/Brte-Stoc community located

east of Red Butte appeared to have burned recently but it was not clear when this occurred. Fire records on file at Monument headquarters indicated several small fires near this community between 1934 and 1972. Burned Artemisia tridentata ssp. vaseyana plants were encountered and Bromus tectorum and Chrysothamnus viscidiflorus were conspicuous indicating disturbance. The dominance of Purshia tridentata (5.8 percent foliage cover) may have resulted from a relatively mild burn allowing high survival. The mean foliage cover for Purshia tridentata in the Artrv/Stoc community was 4.8 percent (Table 3), thus this was only one percent less than Purshia tridentata's foliage cover in this particular stand of the Putr/Brte-Stoc community. Perhaps the present dominance of Purshia tridentata reflects its ability to recover rapidly on pumice soils. Nord (1965) reported that Purshia tridentata seedling establishment after fire was faster on pumice soils than on basaltic soils in Modoc County, California. The stand of the Putr/Brte-Stoc community east of Red Butte occurred on pumice-dominated soils similar to the Artrv/Stoc community.

The Brte-Stoc community appeared to represent a highly altered Artrv/Stoc habitat type since Chrysothamnus viscidiflorus and Bromus tectorum were conspicuous and dead Artemisia tridentata ssp. vaseyana individuals were common. Nord (1965) reported rabbitbrush (Chrysothamnus spp.) occupying pumice soils for three to five years after fire disturbance. Three of four sites supporting the Brte-Stoc community

burned in July, 1973. The fourth site showed similar evidence of recent burning, but it could not be determined when it last burned (fire records after 1972 were not found). Many of the burned shrubs in the Brte-Stoc community were only present as short stumps making identification impossible. Most of these individuals were probably Artemisia tridentata ssp. vaseyana which was found on surrounding sites. This community occurred on pumice-dominated soils similar to the Artrv/Stoc community.

Indicators for this type were Artemisia tridentata ssp. vaseyana and Stipa occidentalis. Recently altered stands within this habitat type showed low Artemisia tridentata ssp. vaseyana cover with a conspicuous dominance of Chrysothamnus viscidiflorus, Bromus tectorum, and less commonly Purshia tridentata. A similar habitat type has been described by Volland (1976) on rhyolite pumice in adjacent Oregon, but he did not define subspecies for Artemisia tridentata. He mentioned disturbed stands with Chrysothamnus viscidiflorus common. The Artrv/Stoc habitat type is proposed as an equivalent of Volland's (1976) type.

13. Artemisia tridentata ssp. tridentata/Agropyron spicatum (Stipa thurberiana phase) (Artrt/Agsp (Stth phase))

The Stth phase of the Artrt/Agsp habitat type (proposed) occurred in the extreme northern portion of the Monument adjacent to

former Tule Lake. It supported the Artrt/Brte community plus portions of the Chnaa/Brte-Stth and Brte communities. This phase has been altered significantly from the climax association primarily through altered burning patterns and past severe grazing.

The Artrt/Brte community appeared to be highly disturbed from past grazing since the understory was dominated almost entirely by annuals. Stipa thurberiana and Agropyron spicatum were uncommon; only rare individuals were encountered. Burned woody plant debris left evidence of past fire influence and fire suppression probably promoted Juniperus occidentalis invasion and greater densities of Artemisia tridentata ssp. tridentata.

The portion of the Chnaa/Brte-Stth community included in this phase was the area where remnant debris of Artemisia tridentata ssp. tridentata was found. Small, occasional patches of Artemisia tridentata ssp. tridentata were encountered in this community but its burned debris was generally scattered throughout. The understory was highly disturbed by past grazing since Bromus tectorum frequency was high and Stipa thurberiana and Agropyron spicatum frequencies were low. Stipa thurberiana and Agropyron spicatum became increasingly infrequent with closer proximity to former Tule Lake.

The portion of the Brte community included in this phase also was the area where evidences of Artemisia tridentata ssp. tridentata

were observed. Occasional live individuals were found but often only their burned debris was encountered. This community was highly altered since annuals dominated and Stipa thurberiana and Agropyron spicatum were rare.

Indicators for this phase were Artemisia tridentata ssp. tridentata, Agropyron spicatum, and Stipa thurberiana. Because of the highly altered condition of this type, often only remnants of the former climax layer dominants were found. Eckert (1957) described a similar phase of this habitat type but he did not define subspecies for Artemisia tridentata. The transition zone between Artemisia tridentata ssp. vaseyana and Artemisia tridentata ssp. tridentata on the Monument was gradual and soils of the Artrv/Agsp (Stth phase) and Artrt/Agsp (Stth phase) were very similar (Appendix B). Thus, there did not appear to be an abrupt environmental break between these two types. Artemisia tridentata ssp. tridentata appeared to indicate a slightly warmer and drier environment than subspecies vaseyana. Agoseris grandiflora and Lupinus subvexus var. transmontanus were found with subspecies tridentata and they appeared to be adapted to a relatively drier and warmer environment since they were not found at higher elevations with subspecies vaseyana. Conversely, Crepis acuminata, Frasera albicaulis, and Geum triflorum var. ciliatum were found with subspecies vaseyana and they became increasingly uncommon at lower elevations. Through the transition between subspecies vaseyana and subspecies

tridentata there was no apparent evidence to suggest a change in the former grass dominants, Stipa thurberiana and Agropyron spicatum. The Stth phase of the Artrt/Agsp habitat type is proposed as a similar grouping to Eckert's (1957) type.

Restoration of the altered communities which form this phase should be possible by using a similar approach discussed under the Stth phase of the Artrv/Agsp habitat type.

14. Purshia tridentata/Agropyron spicatum (Putr/Agsp)

The Putr/Agsp habitat type occurred on southeastern to southwestern exposures of cinder cones in the southern quarter of the Monument. It only supported the Putr/Brte-Agsp community. Evidence of past burning was generally seen as burned Purshia tridentata shrubs and an occasional burned Juniperus occidentalis tree. The conspicuous presence of Chrysothamnus nauseosus var. albicaulis and Bromus tectorum indicated past periodic burning. This was especially true on the Caldwell Butte stand which last burned May, 1965 according to fire records on file at Monument headquarters. The other stands may have burned in the 1930's but the fire records were not clear enough to verify this. The stand on Crescent Butte had the lowest cover of Chrysothamnus nauseosus var. albicaulis and the lowest frequency of Bromus tectorum compared to the other stands representing this type. This may suggest it has experienced

a longer interval since it last burned than the other stands. Artemisia tridentata ssp. vaseyana was a small component of this community (contributing less than one percent mean foliage cover) and only an occasional dead individual was encountered. Thus, it did not appear to have been an important part of this community historically.

Indicators for this type were Purshia tridentata and Agropyron spicatum. Daubenmire (1970) has described climax stands of this habitat type in southeastern Washington. He also mentioned that Artemisia tridentata was poorly represented in this type and that the soils were typically stony loam to sandy textured. The Putr/Agsp habitat type on the Monument had sandy textured soils (Appendix B). In Oregon, Hall (1973) described a more general Putr/bunchgrass habitat type on coarse textured soils. He reported that the grass layer was dominated by Agropyron spicatum on southerly slopes and by Festuca idahoensis on northerly slopes.

15. Cercocarpus ledifolius (Cele)

The Cele habitat type (proposed) occurred roughly above 1,414 meters elevation in the southern one-third of the Monument. It only supported the community by the same designation. This habitat type was found on basalt lava flows greater than 1,000 years old (Mertzman, 1977). Man-induced disturbances and alteration by fire and grazing

were not found.

Cercocarpus ledifolius was the indicator for this type. This habitat type has not been described previously in the literature and the only comprehensive synecological work reported on Cercocarpus ledifolius has been by Dealy (1975), but he did not mention this habitat type. His samples were taken in the 45 to 65 centimeter precipitation zone which is much higher than the precipitation received at the Monument headquarters (36.9 centimeters at 1,454 meters elevation). The Cele habitat type on the Monument had nearly 50 percent rock cover and appeared to represent the xeric end of Cercocarpus ledifolius' ecological range in this area. Since no evidence of disturbance was found, it is proposed as a new habitat type. No characteristic understory species were found to be useful in describing or naming this type.

16. Cercocarpus ledifolius-Holodiscus microphyllus var. glabrescens (Cele-Homig)

The Cele-Homig habitat type (proposed) occurred on the southern half of the Black Lava Flow in the southwestern corner of the Monument. This lava flow has been estimated to have originated within the last 1,000 years because it lacked pumice from the Glass Mountain eruption (Mertzman, 1977). He estimated its age between 300 to 500 years old. Disturbance by man and alteration by fire and grazing appeared very low. This type only supported the community by the same

designation.

Indicators for this habitat type were Cercocarpus ledifolius and Holodiscus microphyllus var. glabrescens. The forb, Penstemon duestus, was more common on this type than on any other and appeared to be associated with extremely rocky sites. This type has not been previously described, but since no evidence of disturbance was encountered, it is proposed as a new habitat type.

17. Ribes cereum (Rice)

The Rice habitat type (proposed) occurred on basalt lava flows between roughly 1,356 and 1,414 meters elevation on the Monument. According to Mertzman (1977), these basalt lava flows were greater than 1,000 years old. This type only supported the community by the same designation. Man-induced disturbances and alteration by fire and grazing were not evident.

The indicator for this type was Ribes cereum. Agastache parvifolia was generally the most common forb and it appeared to be associated with extremely rocky sites. This type has not been described previously in the literature, but since no evidence of disturbance was found, it is proposed as a new habitat type.

18. Salvia dorrii ssp. carnosa/Eriogonum microthecum var. laxiflorum (Sadoc/Ermil)

The Sadoc/Ermil habitat type (proposed) occurred on the southern exposure of cinder cones. It was found on either solid basalt outcrops or on basalt cinders below the rim. This type only supported the community by the same designation. Disturbances by man and alteration by fire and grazing were not found.

Indicators for this type were Salvia dorrii ssp. carnosa and the suffrutescent plant, Eriogonum microthecum var. laxiflorum. No previous descriptions of this type were found in the literature, but since no evidence of disturbance could be found, it is proposed as a new habitat type.

19. Salvia dorrii ssp. carnosa-Chamaebatiaria millefolium (Sadoc/Chmi)

The Sadoc-Chmi habitat type (proposed) occurred on basalt lava flows from roughly 1,250 to 1,356 meters elevation and on lava tube collapses up to 1,597 meters elevation. The basalt substrate supporting this type has been estimated to be greater than 1,000 years old (Mertzman, 1977). Disturbances by man and alteration by fire and grazing were not found. This type only supported the community by the same designation.

Indicators for this type were Salvia dorrii ssp. carnosa and

Chamaebatiaria millefolium. Scrophularia lanceolata and Penstemon duestus were the most common forbs; both appeared to be associated with these extremely rocky sites. This type has not been described previously in the literature, but since no evidence of disturbance was detected, it is proposed as a new habitat type.

20. Chamaebatiaria millefolium (Chmi)

The Chmi habitat type (proposed) occurred on the northern end of the Black Lava Flow and on a lava tube collapse system near Eaglenest Butte. The Black Lava Flow has been estimated to have originated within the past 300 to 500 years (Mertzman, 1977). The lava tube collapse system near Eaglenest Butte has not been dated but it appeared to be relatively young since there was no discernible soil development and it lacked pumice from the Glass Mountain eruption. This type only supported the community by the same designation. Man-induced disturbances and alteration by fire and grazing were not observed.

Chamaebatiaria millefolium was the indicator for this type. Scrophularia lanceolata and Eupatorium occidentale were the most common forbs and appeared to be associated with these extremely rocky sites. This type has not been described previously but Eggler's (1941) work in Craters of the Moon National Monument, Idaho mentioned Chamaebatiaria millefolium and its reduced density response to

greater lava flow age. He reported that this plant increased for a time on younger flows but then decreased on older flows. The age span between the younger and older flows was several thousand years (Eggler, 1941). Since no indication of disturbance was observed, this type is proposed as a new habitat type.

Unclassified Communities

Eight plant communities were not classified to habitat types because of one or more of the following features: 1) severe alteration of community structure, 2) insufficient time for climax expression, or 3) insufficient data. These communities were mapped simply as unclassified sites on the habitat type map (Figure 6 in packet). A brief description explaining why each community was not classified and its possible climax layer dominants follows. Soil descriptions for each of these communities are presented in Appendix B.

The Festuca idahoensis-Poa sandbergii community, on the north-face of Hardin Butte, burned in 1972 according to fire records on file at Monument headquarters. This fire appeared to remove the woody layer since dead individuals and debris of Artemisia tridentata ssp. vaseyana and Purshia tridentata were encountered. No evidence of Pinus ponderosa was found on this site as was the case on the other buttes farther south in the Monument. Hardin Butte occurred at a lower elevation and was much farther north in the Monument than the

other buttes with Pinus ponderosa evidence. Thus it appears that Artemisia tridentata ssp. vaseyana, with Purshia tridentata subordinate, are the climax dominants in the shrub layer. Festuca idahoensis is expected to maintain its dominance in the herbaceous layer. It appears to be similar to the Artrv/Feid habitat type described by Winward (1970).

The Elymus cinereus-Bromus tectorum community occurred in the northern portion of the Monument. Grazing was probably heavy in this type previously because of its proximity to former Tule Lake. Burned Artemisia tridentata stumps were occasionally encountered and were suspected to be subspecies tridentata since it was the predominant subspecies surrounding these areas. The projected climax layer dominants are Artemisia tridentata ssp. tridentata in the shrub layer and Elymus cinereus in the herbaceous layer. Culver (1964) described a similar type in adjacent Oregon, but did not define subspecies for Artemisia tridentata.

The Chrysothamnus nauseosus var. artus/Elymus cinereus community was represented by one small stand on an alkaline basin in the northeastern corner of the Monument. Since this site may have been periodically under water before Tule Lake was drained, the present community may be a relatively new expression of this site. Chrysothamnus nauseosus var. artus and Elymus cinereus will probably remain as important components of this type due to their adaptability to

alkaline soils. Artemisia tridentata ssp. tridentata occurred on the periphery of this basin with small stringers reaching into the type. It presumably will not become dominant in this type due to the alkaline soils.

One stand of the Chrysothamnus viscidiflorus/Bromus tectorum community was encountered and sampled near Hospital Rock. This stand was located close to former Tule Lake where it was probably heavily grazed. The understory beneath Chrysothamnus viscidiflorus was dominated by annuals, and perennial species were uncommon. Stipa thurberiana and Agropyron spicatum were not observed in this stand but were found in nearby adjacent stands. Elymus cinereus occurred in scattered clusters which may indicate pockets of deep, fine-textured soil. Burned Artemisia tridentata plants were encountered and young plants were established. Subspecies determination for Artemisia tridentata was extremely difficult on this site because, based on surrounding stands, it appeared to be in the transition between subspecies vaseyana and tridentata. The projected climax layer dominants are probably a mosaic of Artemisia tridentata ssp. tridentata and Artemisia tridentata ssp. vaseyana in the shrub layer with Stipa thurberiana and Agropyron spicatum in the herbaceous layer. Small patches of Artemisia tridentata ssp. tridentata may have been associated with the Elymus cinereus clusters.

The majority of the Ribes velutinum/Elymus cinereus community

occurred in narrow belts on basalt outcrops in the extreme northern portion of the Monument. One additional stand was sampled on basalt outcrops above Gillem's Camp in the northwestern corner. Rare individuals of Salix lasiandra and Polygonum coccineum were observed in the extreme northern stands and were presumed to have been more prominent before Tule Lake was drained. They were more numerous outside the Monument in areas where lake water still exists. Urtica dioica var. holosericea was a common and conspicuous forb in these stands near former Tule Lake, but it was not present prior to settlement since it is native to Eurasia. Thus, stands near former Tule Lake have probably experienced significant changes in community structure since settlement. The Rive/Elci community above Gillem's Camp was farther removed from Tule Lake and showed less of these influences. This stand did not contain Salix lasiandra, Polygonum coccineum, or Urtica dioica var. holosericea, and contained slightly higher amounts of Artemisia tridentata ssp. tridentata and slightly lower amounts of Elymus cinereus than the stands near former Tule Lake. These latter stands may be developing a community structure more similar to the former above Gillem's Camp. The projected climax layer dominants appear to be Ribes velutinum, with Artemisia tridentata ssp. tridentata subordinate in the shrub layer, and Elymus cinereus in the grass layer. More information is needed to reliably determine the habitat type since this type has not been described previously in the literature.

The Bromus tectorum-Secale cereale community occurred within and on the fringe of former Tule Lake. Much of the area supporting this community was probably periodically under water before Tule Lake was drained. This community was dominated by annuals and no perennial species were observed. It may eventually be dominated by Artemisia tridentata ssp. tridentata in the shrub layer and Stipa thurberiana and Agropyron spicatum in the herbaceous layer based on the projected climax for surrounding stands.

The Descurainia sofia community occurred on the lake bed of former Tule Lake, therefore this site was previously under water most of the time. Evidence of farming activities was seen as remnant tillage lines on the aerial photograph of this area. As a result, a low seral community presently dominates this site. Without the influence of water and agricultural activities, this site will slowly proceed toward a new equilibrium. It is almost impossible at this point to predict what the eventual climax layer dominants will be.

The Monardella odoratissima-Cycladenia humilis community occurred on bare cinders on the southeastern exposure of Bearpaw Butte and Caldwell Butte. Literature concerning these species is brief and no descriptions of this community are known. There was no evidence of disturbance and both plants appeared to be maintaining their populations. Interestingly, the proportion of these two plants relative to each other was distinctly different on the two buttes.

There was more Cycladenia humilis relative to Monardella odoratissima on the Bearpaw Butte site, while the reverse occurred on the Caldwell Butte site. Whether this difference was within the natural variability of the type or whether there was a distinct site difference was not known. More investigation is needed to analyze these sites. Since these plants are reported to occupy open, rocky habitats (Munz, 1959) and there was no evidence of disturbance, this community may represent the climax for this site.

Distribution of Rare Plants

A total of 233 vascular plants were collected, identified, and pressed for incorporation into the Monument's herbarium (Appendix A). One "Very Rare and Endangered" plant and four "Rare" plants were identified as listed by the California Native Plant Society (1974).

Agastache parvifolia

This was the "Very Rare and Endangered" plant and was typically associated with the extremely rocky sites. It was rarely found in the Rive/Elci and Sadoc-Chmi communities, but was fairly common and evenly distributed in the Rice and Cele communities.

Castilleja psittacina

This "Rare" plant occurred on the basalt lava tube collapse

system which forms Skull Cave. Only a few individuals were seen during this study, but other pockets of plants may exist on similar habitats. Further work is needed for this plant in the Monument.

Dimeresia howellii

This "Rare," small annual occurred on loose basalt cinders of cinder cones in the southern half of the Monument. It was generally found in the Mood-Cyhu community where it was numerous.

Erigeron elegantulus

This "Rare" plant was only found on the fire road into Eaglenest Butte and in the adjacent Artrv/Stoc community. It appeared to be restricted to the loose pumice soils near the Pinus ponderosa forest.

Penstemon cinereus

This species was the most common of the "Rare" plants found. It was occasionally encountered in the Artrv/Stth-Agsp, Artrv/Feid-Agsp, Chvi/Stco 2, Juoc/Cele, and Juoc/Cele/Feid communities, but was more common in the Pinus ponderosa communities. The Pipo/Habl community was the result of prescribed burning and had the highest frequency of this plant. Prescribed burning in the Pinus ponderosa forests is probably not damaging Penstemon cinereus.

Interpretation of Vegetation Maps

The plant community map (Figure 5 in packet) and the habitat type map (Figure 6 in packet) document a resource base which will complement wildlife surveys, geological surveys, soil surveys, and others. A few precautions for the interpretation of the vegetation maps are noted below to avoid possible confusion.

Both maps contain areas where a mosaic of two or more types occur. These complexes could not be separated at the scale of mapping for this project. Commonly hummocky topography supported a mosaic of distinct types in the swales and on the microridges. Additionally, rocky basalt outcrops superimposed on this added a third complexity to mapping. To fully interpret these complexes all types forming the mapping delineation should be read before implementing a management strategy.

A superficial comparison of the community map with the habitat type map often appears to express a concurrence in their delineations. Frequently community boundaries are synonymous with habitat type lines, but it must be emphasized that this is not always true.

CONCLUSION

Several environmental gradients which had an influence on the vegetation occurred within the Lava Beds National Monument. A precipitation gradient extended from the lower northeastern corner of the Monument to the higher southwestern corner. This produced a slow but continuous change in the flora over the landscape. The woody layer in the northeastern portion of the Monument was dominated by Artemisia tridentata ssp. tridentata which graded into Artemisia tridentata ssp. vaseyana and eventually Pinus ponderosa with increasing elevation. The herbaceous layer also showed a similar trend. The dominant perennial grasses on the lower end of the Monument, Stipa thurberiana and Agropyron spicatum, eventually yielded to Festuca idahoensis and Agropyron spicatum at higher elevations.

Microclimatic gradients also occurred with local changes in exposure. This phenomenon was particularly noticeable on the numerous cinder cones which dot the Monument's landscape. At a constant elevation on a cinder cone, dramatic changes in community structure and vegetative cover occurred on north-facing exposures compared to south-facing exposures. Specific vegetation changes were dependent on the elevation of the cinder cone. Undulating topography also induced microclimatic changes due to the development of small

north-facing and south-facing exposures and changes in soil depth.

An edaphic gradient occurred in the Glass Mountain rhyolite pumice deposits on the Monument. The southeastern portion of the Monument was dominated by pumice but increasingly less pumice was encountered toward the northwestern portion. Pumice-dominated soils characteristically supported Stipa occidentalis in the herbaceous layer. Soils lacking pumice supported a variety of grasses depending on elevation, soil texture, and soil depth. Elymus cinereus and Stipa comata were found in fine- and coarse-textured alluvial basins, respectively.

Different aged basalt lava flows superimposed over the entire area created additional diversity in the Monument's vegetation. Basalt lava flows younger than 1,000 years old supported the Chamaebatiaria millefolium habitat type at lower elevations and the Cercocarpus ledifolius-Holodiscus microphyllus var. glabrescens habitat type at higher elevations. The Salvia dorrii ssp. carnosa-Chamaebatiaria millefolium, Ribes cereum, and Cercocarpus ledifolius habitat types, in order of increasing elevation, occurred on basalt lava flows greater than 1,000 years old.

Uncontrolled livestock grazing after the Modoc Indians were removed in 1873 had a significant impact on the Monument's vegetation. Plant communities in the extreme northern end of the Monument were severely altered by heavy livestock use since they were close to a

water source, Tule Lake. The presumed original grass dominants, Stipa thurberiana and Agropyron spicatum, are presently uncommon near former Tule Lake and were probably reduced as a result of heavy grazing. Bromus tectorum, an exotic annual, currently dominates the herbaceous layer on these sites. Other conspicuous exotic annuals present are Sisymbrium altissimum, Erodium cicutarium, and Descurainia sofia. With increasing distance from former Tule Lake, less evidence of past grazing disturbance was apparent.

One of the major goals of the National Park Service is to re-establish vegetation similar to presettlement conditions. Although livestock grazing no longer occurs on the Monument, it could be carefully used to improve the northern end. Since Bromus tectorum begins growth before most perennial species early in the spring, grazing during this period could potentially harvest most of Bromus tectorum's production. Livestock would be removed from the area before soil moisture was depleted thereby allowing regrowth of perennial grasses. This practice would favor perennial species by reducing Bromus tectorum's competition for moisture and nutrients and by removing much of its seed. In addition, early grazing of Bromus tectorum may reduce the potential fire hazard created by dense, dry stands of this grass later in the season.

Few areas, excluding the basalt lava flows and lava tube collapeses, lacked evidence of past fire influence. Burned tree and

shrub remains, fire-scarred trees, and charcoal in soil profiles indicated that fire has been an important component of many stands. A prescribed burning program is currently attempting to reduce the density of Bromus tectorum and fire-susceptible woody plants which have increased from years of fire suppression. The Bromus tectorum community in the Gillem's Camp area was prescribed burned June 6, 1975, July 6, 1977, and July 5, 1978. The density of Bromus tectorum may have been reduced by these burns, but to date the long-run population stability has probably not been threatened. Bromus tectorum density fluctuations are probably influenced more by precipitation than by prescribed burning. In addition, burning this grass in the summer after its seeds have shattered will not destroy the current seed production, thus a large supply of viable seeds will be available to re-establish the stand.

Perennial herbs are relatively uncommon in stands near former Tule Lake. Consequently, the primary seed source after site disturbance is Bromus tectorum, Descurainia sofia, Sisymbrium altissimum, and Erodium cicutarium. Photographs taken of the extreme northern end of the Monument in 1873 showed a low Artemisia tridentata cover with a conspicuous understory of perennial bunchgrasses. Hand planting or harrowing native seed into these areas would probably be a rapid method toward restoring the native species. Further research into the possibility of seeding native species on the

extreme northern end of the Monument is recommended.

Finally, areas which have remained relatively undisturbed by man and livestock grazing should be allowed to burn with a natural fire frequency. For example, Island Butte, a cinder cone island (kipuka) surrounded by younger lava located in the Black Lava Flow Wilderness Unit, should be left to burn by natural fire. Natural fires have burned this butte historically since burned logs and lightning-scarred trees were observed. Fire suppression has never been necessary because of its isolation in the lava flow. Prescribed burning this butte would unnecessarily alter its natural burning cycle. Potentially, Island Butte could yield a large amount of information about natural fire frequencies and plant succession in this area. Conversely, other areas in the Monument where natural fire has been suppressed this century require further prescribed burning research to recreate the pristine vegetation.

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APPENDICES

APPENDIX A

Species code, scientific name, and common name of plants collected and cited in text and tables.

Species code	Scientific name	Common name
Trees		
Abco	Abies concolor (Gord. & Glend.) Lindl. ex Hildebr.	white fir
Juoc	Juniperus occidentalis Hook.	western juniper
Lide 2	Libocedrus decurrens Torr.	incense-cedar
Piat	Pinus attenuata Lemm.	knobcone pine
Pico	Pinus contorta Dougl. ex Loud.	lodgepole pine
Pije	Pinus jefferyi Grev. & Balf.	Jeffery pine
Pila	Pinus lambertiana Dougl.	sugar pine
Pimo	Pinus monticola Dougl. ex D. Don	western white pine
Pipo	Pinus ponderosa Dougl. ex Loud.	ponderosa pine
Potr	Populus tremuloides Michx.	quaking aspen
Prem	Prunus emarginata (Dougl.) Walpers	bitter cherry
Prvi	Prunus virginiana L.	common chokecherry
Shrubs		
Ampa	Amelanchier pallida Greene	pale serviceberry
Arpa	Arctostaphylos patula Greene	greenleaf manzanita
Arar	Artemisia arbuscula Nutt.	low sagebrush
Artrt	Artemisia tridentata ssp. tridentata Nutt.	basin big sagebrush
Artrv	Artemisia tridentata ssp. vaseyana (Rydb.) Beetle	mountain big sagebrush
Case	Castanopsis sempervirens (Kell.) Dudl.	sierra chinkapin
Cepr	Ceanothus prostratus Benth.	squawcarpet ceanothus
Ceve	Ceanothus velutinus Dougl. ex Hook.	snowbrush ceanothus
Cele	Cercocarpus ledifolius Nutt.	curlleaf mountain-mahogany
Cemo	Cercocarpus montanus Raf.	true mountain-mahogany
Chmi	Chamaebatiaria millefolium (Torr.) Maxim.	desert sweet
Chnaa	Chrysothamnus nauseosus var. albicaulis (Nutt.) Rydb.	rubber rabbitbrush
Chnaa 2	Chrysothamnus nauseosus var. artus (A. Nels.) Cronq.	rubber rabbitbrush

Species code	Scientific name	Common name
Chvi	Chrysothamnus viscidiflorus (Hook.) Nutt.	green rabbitbrush
Grsp	Grayia spinosa (Hook.) Moq.	spiny hopsage
Habl	Haplopappus bloomeri Gray	rabbitbrush goldenweed
Homig	Holodiscus microphyllus var. glabrescens (Greenm.) Ley.	littleleaf holodiscus
Lepu 2	Leptodactylon pungens (Torr.) Nutt.	granite gilia
Putr	Purshia tridentata (Pursh) Dc.	antelope bitterbrush
Rice	Ribes cereum Dougl.	wax currant
Riroc	Ribes roezlii var. cruentum Rehd.	blood sierra gooseberry
Rive	Ribes velutinum Greene	desert gooseberry
Rowou	Rosa woodsii var. ultramontana (Watts.) Jeps.	woods rose
Rugl	Rubus glaucifolius Kell.	silverleaf raspberry
Sala 2	Salix lasiandra Benth.	Pacific willow
Sasc	Salix scouleriana Barratt	scouler willow
Sadoc	Salvia dorrii ssp. carnosa (Dougl.) Cronq.	desert sage
Sace	Sambucus cerulea Raf.	blue elderberry
Syor	Symphoricarpos oreophilus Gray	mountain snowberry
Teca	Tetradymia canescens Dc.	gray horsebrush
Grasses		
Agcr	Agropyron cristatum (L.) Gaertn.	fairway crested wheatgrass
Agda	Agropyron dasystachyum (Hook.) Scribn.	thickspike wheatgrass
Agre	Agropyron repens (L.) Beauv.	quackgrass
Agsp	Agropyron spicatum (Pursh) Scribn. & Smith	**bearded bluebunch wheatgrass**
Brca	Bromus carinatus H. & A.	California brome
Brco	Bromus commutatus Schrad.	hairy brome
Brte	Bromus tectorum L.	cheatgrass brome
Elci	Elymus cinereus Scribn. & Merrill	giant wildrye
Febr	Festuca bromoides L.	fescue
Feid	Festuca idahoensis Elmer	Idaho fescue
Kocr	Koeleria cristata Pers.	prairie junegrass
Orhy	Oryzopsis hymenoides (R. & S.) Ricker	Indian ricegrass
Poam	Poa ampla Merrill	big bluegrass
Poca	Poa canbyi Scribn.	Canby bluegrass
Popr	Poa pratensis L.	Kentucky bluegrass

Species Code	Scientific name	Common name
Posa 3	Poa sandbergii Vasey	Sandberg bluegrass
Sece	Secale cereale L.	winter rye
Sihy	Sitanion hystrix (Nutt.) J. G. Sm.	bottlebrush squirreltail
Stco 2	Stipa comata Trin. & Rupr	needleandthread
Stoc	Stipa occidentalis Thurb. ex Wats.	western needlegrass
Stth	Stipa thurberiana Piper	thurber needlegrass
Taas	Taeniatherum asperum (Simonkai) Nevski	medusahead
Vuoc	Vulpia octoflora	sixweeks fescue
Grasslike		
Capr 5	Carex praegracilis Boott	clustered field sedge
Caro	Carex rossii Boott	Ross sedge
Juba	Juncus balticus Willd.	baltic rush
Forbs and Allies		
Acmi	Achillea millefolium L.	western yarrow
Agpa	Agastache parvifolia Eastw.	small-leaved agastache
Agg11	Agoseris glauca var. laciniata (D. C. Eat.) Smiley	pale agoseris
Aggr	Agoseris grandiflora (Nutt.) Greene	agoseris
Amgr	Amaranthus graecizans L.	amaranth
Ampo	Amaranthus powellii Wats.	Powell amaranth
Amte	Amsinkia tessellata Gray	tessellate fiddleneck
Andi	Antennaria dimorpha (Nutt.) T. & G.	low pussytoes
Ange 2	Antennaria geyeri Gray	pussytoes
Anmi	Antennaria microphylla Rydb.	pussytoes
Apsis	Apocynum sibiricum var. salignum (Greene) Fern.	dogbane
Arho	Arabis holboellii Horrem.	Holboell rockcress
Arsp 2	Arabis sparsiflora Nutt.	sickle-pod rockcress
Aram 2	Arceuthobium americanum Nutt. ex Engelm.	dwarf mistletoe
Arca 6	Arceuthobium campylopodum Engelm.	yellow leafless mistletoe
Arnu	Arenaria nuttallii Pax	Nuttall sandwort
Asfa 2	Asclepias fascicularis Dcne.	Mexican milkweed

Species code	Scientific name	Common name
Ascu 2	Astragalus curvicarpus (Sheld.) Macbr.	curvepod loco
Asfi	Astragalus filipes Torr. ex Gray	milkvetch
Asle	Astragalus lentiginosus Dougl. ex Hook.	specklpod loco
Asob	Astragalus obscurus Wats.	milkvetch
Aspu	Astragalus purshii Dougl. ex Hook.	Pursh loco
Atro	Atriplex rosea L.	tumbling orach
Basa	Balsamorhiza sagittata (Pursh) Nutt.	arrowleaf balsamroot
Blsc	Blepharipappus scaber Hook.	blepharipappus
Cama	Calochortus macrocarpus Dougl.	sagebrush mariposa
Caap 2	Castilleja applegatei Fern.	paintbrush
Cali 2	Castilleja linariaefolia Benth.	Wyoming paintbrush
Caps	Castilleja psittacina (Eastw.) Penn.	paintbrush
Ceso	Centaurea solstitiales L.	yellow centaurea
Chdo	Chaenactis douglasii (Hook.) H. & A.	Douglas chaenactis
Chal	Chenopodium album L.	lambsquarters goosefoot
Chle	Chenopodium leptophyllum (Moq.) Wats.	slimleaf goosefoot
Civu	Cirsium vulgare (Savi) Airy-shaw	bull thistle
Clla	Clarkia lassenensis (Eastw.) Lewis & Lewis	clarkia
Clrh	Clarkia rhomboidea Dougl. ex Hook.	clarkia
Copa	Collinsia parviflora Lindl.	littleflower collinsia
Cogr 2	Collomia grandiflora Dougl. ex Lindl.	collomia
Coti	Collomia tinctoria Kell.	collomia
Coar 2	Convolvulus arvensis L.	field bindweed
Coca 2	Conyza canadensis (L.) Cronq.	horseweed
Crac	Crepis acuminata Nutt.	tapertip hawksbeard
Croc	Crepis occidentalis Nutt.	western hawksbeard
Cram	Cryptantha ambigua (Gray) Greene	cryptantha
Crce	Cryptantha celosiodes (Eastw.) Pays.	cryptantha
Crci	Cryptantha circumscissa (H. & A.) Johnst.	cryptantha
Crin 2	Cryptantha intermedia (Gray) Greene	cryptantha
Crto	Cryptantha torreyana (Gray) Greene	Torrey cryptantha
Cyhu	Cycladenia humilis Benth.	small cycladenia
Cyfr	Cystopteris fragilis (L.) Bernh.	brittle bladderfern
Dean	Delphinium andersonii Gray	Anderson larkspur
Denu	Delphinium nudicaule T. & G.	orange larkspur

Species code	Scientific name	Common name
Depih	Descurainia pinnata var. halictorum (Ckll.) Detl.	pinnate tansymustard
Deso	Descurainia sophia (L.) Webb.	flixweed tansymustard
Diho 2	Dimeresia howellii Gray	dimeresia
Drve 2	Draba verna L.	spring draba
Drau 2	Dryopteris austriaca (Jacq.) Woynar ex Schinz & Thell.	woodfern
Epmi	Epilobium minutum Lindl. ex Hook.	willowweed
Eppa	Epilobium paniculatum Nutt. ex T. & G.	autumn willowweed
Ersp 4	Eriastrum sparsiflorum (Eastw.) Mason	eriastrum
Ercha	Erigeron chrysopsidis ssp. austinae (Greene) Cronq.	yellow fleabane
Erel 5	Erigeron elegantulus Greene	fleabane
Erfi	Erigeron filifolius Nutt.	threadleaf fleabane
Erli	Erigeron linearis (Hook.) Piper	lineleaf fleabane
Ermil	Eriogonum microthecum var. laxiflorum Hook.	slenderbush eriogonum
Ernup	Eriogonum nudum var. pubiflorum Benth.	barestem eriogonum
Erov	Eriogonum ovalifolium Nutt.	cushion eriogonum
Erstp	Eriogonum strictum ssp. proliferum (T. & G.) S. Stokes	eriogonum
Erump	Eriogonum umbellatum ssp. polyanthum (Benth.) Jones	sulphur eriogonum
Ervi	Eriogonum vimineum Dougl.	broom eriogonum
Erlaa	Eriophyllum lanatum var. achillaeoides (Dc.) Jeps.	woolly eriophyllum
Erlai	Eriophyllum lanatum var. integrifolium (Hook.) Smiley	small woolly eriophyllum
Erlal	Eriophyllum lanatum var. lanatum (Pursh) Forbes	woolly eriophyllum
Erci	Erodium cicutarium (L.) L' Her.	alfilaria
Erpe	Erysimum perenne (Wats. ex Cov.) Abrams	erysimum
Esca	Eschscholzia californica Cham.	California poppy
Euoc	Eupatorium occidentale Hook.	westerm eupatorium
Euse	Euphorbia serpyllifolia Pers.	thymeleaf euphorbia
Fral 2	Frasera albicaulis Dougl.	frasera
Gaap	Galium aparine L.	catchweed bedstraw
Gadi	Gayophytum diffusum T. & G.	groundsmoke
Gara	Gayophytum ramosissimum Nutt. ex T. & G.	hairstem groundsmoke
Getrc 2	Geum triflorum var. ciliatum (Pursh) Fassett	prairiesmoke avens
Gicop	Gilia congesta var. palmifrons (Brand) Cronq.	ballhead gilia
Hean	Helianthus annuus L.	common sunflower
Heov	Heuchera ovalifolia Nutt.	ovalleaf alumroot

Species code	Scientific name	Common name
Hicy	Hieracium cynoglossoides Arv.-Touv.	houndstongue hawkweed
Houm	Holosteum umbellatum L.	jagged chickweed
Huna	Hulsea nana Gray	dwarf hulsea
Isti	Isatis tinctoria L.	isatis
Ivax	Iva axillaris Pursh	poverty sumpweed
Kosc	Kochia scoparia (L.) Schrad.	burning-bush
Lase	Lactuca serriola L.	prickly lettuce
Lara	Lagophylla ramosissima Nutt.	slender rabbitleaf
Lare	Lapulla redowskii (Hornem.) Greene	western stickseed
Lagl	Layia glandulosa (Hook.) H. & A.	whitedaisey tidytips
Lepe	Lepidium perfoliatum L.	clasping pepperweed
Lemo	Leucocrinum montanum Nutt.	common starlily
Liha	Linanthus harknessii (Curran) Greene	linanthus
Limi	Linum micranthum Gray	flax
Lipel	Linum perenne ssp. lewisii (Pursh) Eat. & Wright	Lewis flax
Liru	Lithophragma rupicola Greene	woodlandstar
Lone	Lomatium nevadense (Wats.) Coult. & Rose	bisquitroot
Lotr	Lomatium triternatum (Pursh) Coult. & Rose	nineleaf lomatium
Lusut	Lupinus subvexus var. transmontanus C. P. Sm.	lupine
Maca 2	Machaeranthera canescens (Pursh) Gray	tansy aster
Magr	Madia gracilis (Smith) Keck	tarweed
Mami	Madia minima (Gray) Keck	tarweed
Mavu	Marrubium vulgare L.	common hoarhound
Meof	Melilotus officinalis (L.) Lam.	yellow sweetclover
Meal 2	Mentzelia albicaulis Dougl. ex Hook.	whitestem mentzelia
Mela 2	Mentzelia laevicaulis (Dougl.) T. & G.	blazingstar mentzelia
Minu	Microseris nutans (Geyer) Schultz-Bip.	nodding microseris
Migr	Microsteris gracilis (Hook.) Greene	microsteris
Mina	Mimulus nanus H. & A.	dwarf monkeyflower
Miru	Mimulus rubellus Gray in Torr.	monkeyflower
Mood	Monardella odoratissima Benth.	Pacific monardella
Mope	Montia perfoliata (Donn) How.	minerslettuce
Nade	Nama densum Lemmon	nama
Niat	Nicotiana attenuata (Grah.) Hook.	coyote tobacco

Species code	Scientific name	Common name
Orco	Orobanche corymbosa (Rydb.) Ferris	broomrape
Orfa 2	Orobanche fasciculata Nutt.	broomrape
Peci	Penstemon cinereus Piper	penstemon
Pedu	Penstemon duestus Dougl. ex Lindl.	scabland penstemon
Pela	Penstemon laetus Gray	gay penstemon
Pesp	Penstemon speciosus Dougl. ex. Lindl.	royal penstemon
Phha	Phacelia hastata Dougl. ex Lehm.	phacelia
Phhe	Phacelia heterophylla Pursh	varileaf phacelia
Phli	Phacelia linearis (Pursh) Holz.	threadleaf phacelia
Phra	Phacelia ramosissima Dougl. ex Lehm.	branching phacelia
Phca 2	Phlox caespitosa Nutt.	tufted phlox
Phho	Phlox hoodii Rich.	Hood's phlox
Phch	Phoenicaulis cheiranthoides Nutt.	wallflower phoenicaulis
Phbod	Phoradendron bolleanum var. densum (Torr.) Fosb.	mistletoe
Phjul	Phoradendron juniperinum var. ligatum (Trel.) Fosb.	juniper mistletoe
Pitr	Pityrogramma triangularis (Kauf.) Maxon	California goldfern
Plte	Plagiobothrys tenellus (Nutt.) Gray	popcornflower
Plma 3	Plectritis macrocera T. & G.	longhorn plectritis
Pomi	Polemonium micranthum Benth.	littlebells polemonium
Poco 4	Polygonum coccineum Muhl.	knotweed
Pomu	Polystichum munitum (Kaulf.) Presl.	western swordfern
Pobi 2	Potentilla biennis Green	cinquefoil
Pogl	Potentilla glandulosa Lindl.	gland cinquefoil
Ptan	Pterospora andromedea Nutt.	woodland pinedrops
Pypi	Pyrola picta Smith	whitevein pyrola
Rusat	Rumex salicifolius ssp. triangulivalis Danser	willow dock
Saka	Salsola kali L.	Russianthistle
Scla	Scrophularia lanceolata Pursh	lanceleaf figwort
Scna	Scutellaria nana Gray	dwarf skullcap
Seca	Senecio canus Hook.	woolly groundsel
Sido 2	Silene douglasii Hook.	Douglas silene
Sial	Sisymbrium altissimum L.	tumblemustard
Soas	Sonchus asper (L.) Hill	prickly sowthistle
Stlo	Stellaria longipes Goldie	longstalk starwort
Stte	Stephanomeria tenuifolia (Torr.) Hall	wirelettuce

Species code	Scientific name	Common name
Stvi	Stephanomeria virgata Benth.	wirelettuce
Trdu	Tragopogon dubius Scop.	goatsbeard
Urdih	Urtica dioica var. holosericea (Nutt.) C. L. Hitchc.	nettle
Urur	Urtica urens L.	nettle
Veth	Verbascum thapsus L.	flannel mullein
Viam	Vicia americana Muhl. ex Willd.	American vetch
Vipuv	Viola purpurea var. venosa Kell.	goosefoot violet
Wosc	Woodsia scopulina D. C. Eat.	woodsia
Wymo	Wyethia mollis Gray	woolly wyethia
Zipa	Zigadenus paniculatus (Nutt.) Wats.	foothill death camas

APPENDIX B

Representative soil descriptions for each habitat type and for each unclassified plant community.

Habitat types

Pinus ponderosa/Purshia tridentata-Arctostaphylos patula/ Stipa occidentalis

The ground surface was well covered with pine needles. The A1 horizon had a large amount of cinder and pumice incorporated into it. The C horizon was composed of gravelly basalt cinders and several basalt cobbles. Solum depth was greater than 102 centimeters. Two soil pits represent the following description:

01 0-1 cm. Pinus ponderosa litter; abrupt smooth boundary.

A1 1-28 cm. Dark gray (10YR 4/1) dry; sand, granular; pH 6.8; gradual irregular boundary.

C 28-102+ cm. Dark yellowish brown (10YR 4/4) dry; sand; granular; pH 7.0.

Pinus ponderosa/Purshia tridentata/Festuca idahoensis

The A1 horizon had cinder and pumice incorporated into it. Burned and decaying Pinus ponderosa debris was occasionally found in the A1 horizon. The C horizon was composed of gravelly basalt cinders. Solum depth was greater than 102 centimeters. Three soil pits represent the following description:

pumice + cinder: 0-1 cm. White (10YR 8/1) dry and strong brown (7.5YR 5/6) dry; abrupt smooth boundary.

A1 1-30 cm. Very dark gray (10YR 3/1) dry; sand; granular; pH 6.8; clear smooth boundary.

C 30-102+ cm. Strong brown (7.5YR 5/6) dry; sand; granular; pH 6.6.

Pinus ponderosa/Purshia tridentata/Stipa occidentalis

The A1 and AC horizons had a large amount of pumice incorporated into them. Solum depth averaged 74 centimeters. Four soil pits represent the following description:

pumice 0-3 cm. White (10YR 8/1) dry; abrupt smooth boundary.

A1 3-15 cm. Very dark gray (10YR 3/1) dry; sand; granular; pH 5.8; clear wavy boundary.

C 15-71 cm. Very pale brown (10YR 8/3) dry; pumice; clear wavy boundary.

IIAC 71-79 cm. Dark gray (10YR 4/1) dry; fine sand; granular; pH 6.8; clear wavy boundary.

IIR 79 cm. Basalt.

Juniperus occidentalis/Cercocarpus ledifolius

The A1 horizon had cinder and pumice incorporated into it. The C horizon was composed of gravelly basalt cinders. Solum depth was greater than 102 centimeters. Two soil pits represent the following description:

pumice + cinder 0-1 cm. White (10YR 8/1) dry and dark reddish brown (5YR 3/4) dry; abrupt smooth boundary.

A1 1-38 cm. Dark grayish brown (10YR 4/2) dry; sand; granular; pH 6.6; clear wavy boundary.

C 38-102+ cm. Dark reddish brown (5YR 3/4) dry; sand; granular; pH 6.6.

Juniperus occidentalis/Agropyron spicatum

The A1 horizon had cinder and pumice incorporated into it. The C horizon was composed of gravelly basalt cinders. Solum depth was

greater than 102 centimeters. One soil pit represents the following description:

pumice + cinder — 0-1 cm. White (10YR 8/1) dry and yellowish brown to black (10YR 5/4-2/1) dry ; abrupt smooth boundary.

A1 — 0-23 cm. Dark brown (10YR 4/3) dry; sand; granular; pH 7.0; clear wavy boundary.

C — 23-102+ cm. Yellowish brown (10YR 5/4) dry; sandy loam; granular; pH 6.8.

Juniperus occidentalis/Artemisia tridentata ssp. vaseyana/Stipa occidentalis

The A1 and AC horizons had a large amount of pumice incorporated into them. Solum depth averaged 44 centimeters. Two soil pits represent the following description:

pumice — 0-3 cm. White (10YR 8/1) dry; abrupt smooth boundary.

A1 — 3-14 cm. Dark gray (10YR 4/1) dry; sand; granular; pH 6.4; clear wavy boundary.

C — 14-32 cm. White (10YR 8/1) dry; pumice; clear wavy boundary.

IIAC — 32-44 cm. Dark brown (10YR 4/3) dry; sandy loam; granular; pH 6.8; clear wavy boundary.

IIR — 44 cm. Basalt.

Symphoricarpos oreophilus/Festuca idahoensis

The soil profile contained a large amount of basalt cobbles and stones. Solum depth was 56 centimeters. One soil pit represents the following description:

A1 — 0-10 cm. Very dark grayish brown (10YR 3/2) dry; loam; granular; pH 6.8; clear wavy boundary.

B2t 10-56 cm. Very dark brown (10YR 2/2) dry; silty clay; subangular blocky; pH 6.8; siltstone particles (1 mm diameter) common; clear wavy boundary.

R 56 cm. Basalt.

Artemisia arbuscula/Festuca idahoensis

Basalt cobbles were occasionally encountered in the soil profile. Solum depth was 61 centimeters. One soil pit represents the following description:

A1 0-13 cm. Grayish brown (10YR 5/2) dry; sandy clay loam; granular; pH 7.0; abrupt smooth boundary.

B21t 13-46 cm. Dark brown (7.5YR 3/2) dry; clay; blocky to prismatic; pH 7.2; clay skins common on ped surfaces; clear wavy boundary.

B22ca 46-61 cm. Dark brown (7.5YR 4/4) dry; clay; subangular blocky; pH 8.4; carbonates strongly effervescent; clear wavy boundary.

R 61 cm. Basalt.

Artemisia tridentata ssp. vaseyana-Purshia tridentata/ Festuca idahoensis-Agropyron spicatum

The soil profile contained a large amount of basalt cobbles and stones. Solum depth averaged 61 centimeters. Two soil pits represent the following description:

A1 0-25 cm. Dark brown (10YR 4/3) dry; sandy loam; granular; pH 6.8; clear wavy boundary.

B2t 25-61 cm. Dark brown (7.5YR 4/4) dry; clay loam; subangular blocky; pH 7.0; clear wavy boundary.

R 61 cm. Basalt.

Artemisia tridentata ssp. vaseyana/Agropyron spicatum (Stipa thurberiana phase)

The soil profile contained a large amount of basalt cobbles and stones. Solum depth averaged 43 centimeters. Ten soil pits represent the following description:

A1 0-23 cm. Dark brown (10YR 4/3) dry; sandy loam; granular; pH 7.0; abrupt smooth boundary.

B2t 23-43 cm. Yellowish brown (10YR 5/4) dry; clay loam; subangular blocky; pH 7.2; clear wavy boundary.

R 43 cm. Basalt.

Artemisia tridentata ssp. vaseyana/Stipa comata

This soil was very deep and relatively free of basalt cobbles and stones. Solum depth was greater than 102 centimeters. One soil pit represents the following description:

A1 0-30 cm. Dark grayish brown (10YR 4/2) dry; sand; granular; pH 7.0; clear wavy boundary.

AC 30-102+ cm. Dark brown (10YR 4/3) dry; sand; granular; pH 7.2.

Artemisia tridentata ssp. vaseyana/Stipa occidentalis

The A1 horizon had a large amount of pumice incorporated into it. Basalt cobbles were occasionally encountered in the soil profile. Solum depth averaged 61 centimeters. Four soil pits represent the following description:

pumice 0-3 cm. White (10YR 8/1) dry; abrupt smooth boundary.

A1 3-23 cm. Grayish brown (10YR 5/2) dry; sand; granular; pH 6.7; clear wavy boundary.

B2t 23-61 cm. Brown (7.5YR 5/4) dry; clay loam; granular; pH 6.8; clear wavy boundary.

R 61 cm. Basalt.

Artemisia tridentata ssp. tridentata/Agropyron spicatum (Stipa thurberiana phase)

The soil profile contained a large amount of basalt cobbles and stones. Solum depth averaged 30 centimeters. Six soil pits represent the following description:

A1 0-20 cm. Very dark grayish brown (10YR 3/2) dry; sandy loam; granular; pH 7.0; clear wavy boundary.

B2t 20-30 cm. Very dark gray (10YR 3/1) dry; clay loam; blocky; pH 7.0; clay skins common on ped surfaces; clear wavy boundary.

R 30 cm. Basalt.

Purshia tridentata/Agropyron spicatum

The A1 horizon had cinder and pumice incorporated into it. The C horizon was composed of gravelly basalt cinders. Solum depth was greater than 102 centimeters. One soil pit represents the following description:

pumice + cinder 0-1 cm. White (10YR 8/1) dry and yellowish brown to black (10YR 5/4-2/1) dry; abrupt smooth boundary.

A1 1-20 cm. Dark grayish brown (10YR 4/2) dry; sand; granular; pH 6.8; clear wavy boundary.

C 20-102+ cm. Dark yellowish brown (10YR 4/4) dry; sand; granular; pH 7.0.

Unclassified Communities

Festuca idahoensis-Poa sandbergii (northern face of Hardin Butte)

The A1 horizon had cinder incorporated into it. The C horizon was composed of gravelly basalt cinders. Solum depth was greater than 102 centimeters. One soil pit represents the following description:

A1 0-28 cm. Dark grayish brown (10YR 4/2) dry; sand; granular; pH 6.8; clear wavy boundary.

C 28-102+ cm. Dark yellowish brown (10YR 4/4) dry; sand; granular; pH 7.2.

Elymus cinereus-Bromus tectorum

These soils were very deep and relatively free of basalt cobbles and stones. Solum depth was greater than 102 centimeters. Two soil pits represent the following description:

A1 0-18 cm. Gray (10YR 6/1) dry; sandy clay loam; granular; pH 6.8; abrupt wavy boundary.

B21t 18-33 cm. Grayish brown (10YR 5/2) dry; clay loam; subangular blocky; pH 8.0; diffuse wavy boundary.

IIB22ca 33-89 cm. Light brownish gray (2.5Y 6/2) dry; sandy clay loam; subangular blocky; pH 8.2; carbonates strongly effervescent; clear wavy boundary.

IIIB23t 89-102+ cm. Light brownish gray (2.5Y 6/2) dry; clay loam; subangular blocky; pH 8.2; clay skins present on ped surfaces.

Chrysothamnus nauseosus var. artus/Elymus cinereus

The soil profile was relatively free of basalt cobbles and stones. Solum depth was 74 centimeters. One soil pit represents the following description:

A1 0-20 cm. Grayish brown (10YR 5/2) dry; sandy loam; granular; pH 8.4; carbonates strongly effervescent; abrupt wavy boundary.

IIB21t 20-38 cm. Grayish brown (10YR 5/2) dry; silty loam; subangular blocky; pH 8.8; carbonates strongly effervescent; clear wavy boundary.

IIB22t 38-81 cm. Light brownish gray (2.5Y 6/2) dry; silty clay; subangular blocky; pH 9.2; carbonates strongly effervescent; clear wavy boundary.

IIIR 81 cm. Basalt.

Chrysothamnus viscidiflorus/Bromus tectorum

The soil profile contained basalt gravel and cobbles. Solum depth was 53 centimeters. One soil pit represents the following description:

A11 0-4 cm. Very dark grayish brown (10YR 3/2) dry; sandy loam; granular; pH 6.6; abrupt smooth boundary.

A12 4-30 cm. Dark grayish brown (10YR 4/2) dry; sandy loam; granular; pH 7.2; clear wavy boundary.

AC 30-53 cm. Dark brown (10YR 4/3) dry; sandy loam; granular; pH 7.4; clear wavy boundary.

R 53 cm. Basalt.

Bromus tectorum-Secale cereale

The soil profile contained a few basalt cobbles. The C horizon contained weathered basalt gravels and cobbles. Solum depth was greater than 64 centimeters. One soil pit represents the following description:

A1 0-10 cm. Very dark gray (10YR 3/1) dry; loam; granular; pH 7.0; clear wavy boundary.

B2t 10-33 cm. Dark gray (10YR 4/1) dry; clay loam; subangular blocky; pH 8.4; clay skins present of ped surfaces; siltstone particles (2 mm diameter) common; clear wavy boundary.

C 33-64+ cm. Grayish brown (2.5Y 5/2) dry; sandy clay; subangular blocky; pH 8.2; siltstone particles (2 mm diameter) common.

Descurainia sofia

This soil was deep and relatively free of basalt cobbles and stones. Cracks, 30 centimeters deep, were common in the Ap horizon. Solum depth was 89 centimeters. One soil pit represents the following description:

Ap 0-38 cm. Dark gray (10YR 4/1) dry; silty clay; subangular blocky; pH 6.4; clay skins present on ped surfaces; diffuse irregular boundary.

B2 38-102+ cm. Light brownish gray (10YR 6/2) dry; silty clay; subangular blocky; pH 6.2; clay skins present on ped surfaces; pockets of white (7.5YR 8/1) dry diatomaceous earth common; silty clay; platy structure.