AN ECOLOGICAL SURVEY OF THE MAMMALS OF THE CRATERS OF THE MOON NATIONAL MONUMENT

by
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INTRODUCTION

Purpose and Scope of Study

The many features of relatively recent volcanism, including cinder cones and slopes, kipukas, caverns, and extensive flows of several kinds of lava that characterize Craters of the Moon National Monument present a landscape that is diverse and therefore of special interest to the field biologist. The ecological distribution of small mammals is probably one of the more discernible biological responses to such an environmental complex. Furthermore, a portion of the Pioneer Mountains, composed of Tertiary volcanoes and intrusives (Anderson, 1929), is also within the Monument boundaries, thereby increasing the diversity of relatively undisturbed habitats available for study. Inasmuch as the area of later basaltic flows lies in contact with this older and sharply contrasting foothill terrain, a study of the ecological distribution of small mammals within the Monument is especially instructive.

Craters of the Moon National Monument is typified by a variety of habitats and plant communities. Mammals occurring in this area have different ecological requirements and limiting factors. Therefore, the uniqueness of the Monument makes possible a study of habitats and faunal relationships that can be found in few other places in the world.

Previous Work

The geologic features of the Craters of the Moon, the most outstanding characteristics of the Monument, have been studied extensively

by Stearns (1924, 1928, 1963) and later by Murtaugh (1961). The physical features of this area are typified by cinders, aa lava, and pahoehoe lava. The names of the lava are taken from Hawaiian words meaning "unfriendly" and "friendly," respectively. Aa lava is sharp and jagged, whereas pahoehoe lava is smooth and billowy.

The major botanical work was done by Eggler (1941), who described primary plant succession on pahoehoe lava flows and cinder cones, and made general observations on the vegetation of aa lava flows. Other contributions were made by Tisdale, et al. (1965) and by Urban (1968), who conducted an ecological appraisal of dwarf mistletoe (Arceuthobium camphlopodum Engelm.) infection on the Monument. Urban also wrote an unpublished, revised checklist of the plants of the Monument.

The fauna of the area has received little attention. The most extensive study was made by Horning (1966) on the insects and associated plant communities at various volcanic sites. Howell (1924) described a new race of pika (Ochotona princeps goldmani Howell) from Echo Crater, and Blossom (1937b) worked the areas surrounding the Monument and described a new race of chipmunk (Eutamias amoenus cratericus Blossom) from Grassy Cone. Larrison (1956) collected specimens and wrote an unpublished, preliminary list of mammals on the Monument. Ritchie (1968) determined the size of the present population of mule deer [Odocoileus hemionus hemionus (Rafinesque)] and assessed the condition of forage on the Monument in order to evaluate factors affecting survival of the deer, their behavior, and their pattern of range use. Additional information on the fauna of the Monument is contained in files and reports at Monument headquarters.

METHODS AND MATERIALS

Eighteen habitats were picked throughout the area which were representative of the variety on the Monument. They were chosen on the basis of accessibility and representative characteristics. Selection was restricted to apparently "typical" habitats or to those considered unusual. Study areas not frequented by tourists were chosen.

Several preliminary investigations were made during the fall of 1967 and spring of 1968 to acquaint myself with the Monument and to determine the representative habitats. The actual field work began on 5 June 1968 and ended on 6 September 1968. An average of three habitats were studied each week, with some of the more complex ones studied twice. Throughout this period of three months, work in the field involved 2,222 "trap nights," with an average of about 64 trap nights per habitat. Trapping success was approximately 26 per cent with the lowest success during July and the highest during August and the first week in September.

Four different types of traps were used: (1) Museum Special traps, (2) Victor rat traps, (3) California gopher traps, and (4) Havahart live animal traps. All of the traps except for the live traps were manufactured by the Animal Trap Company of Lititz, Pennsylvania. Museum Special traps were utilized in 92 per cent of the field work, rat traps in 7 per cent, and the gopher and live traps, 1 per cent. These percentages represent 2,035 trap nights, 160 trap nights, and 27 trap nights, respectively. The bait used was almost exclusively peanut butter

and oatmeal. Only one specimen, a red squirrel [Tamiasciurus hudsonicus (Erxleben)], was collected with a firearm.

A Bacharach hygro-thermograph was used to record temperature and relative humidity while trapping, except during rains. Relative humidity was additionally measured with a Taylor sling psychrometer. A Dwyer wind meter was used for wind speeds, but this instrument was employed only from the last part of July until the end of the study. Temperature, relative humidity, and wind speed were taken when the traps were set out and again when they were picked up. Continuous weather records were available at the Monument headquarters.

DESCRIPTION OF THE STUDY AREA

Physiography

Irving (1868) described this region as "an area of about 60 miles in diameter, where nothing meets the eye but a desolate and awful waste, where no grass grows nor water runs, and where nothing is to be seen but lava." This description epitomizes the visitor's first impression of the Monument (Figs. 1, 2, and 3). It is a tract which remained relatively unknown to white men until it was first described in detail by Limbert (1924), whose party made a two week excursion across the lava. It was this expedition that precipitated the formation of Craters of the Moon National Monument on 2 May 1924, by proclamation of President Coolidge.

The Monument is located at the base of the Pioneer Mountains 18 miles southwest of Arco, Idaho, on U. S. Highway 93-A. It encompasses about 53,545 acres or 83 square miles.

The Monument includes Quaternary volcanic features found parallel to a lengthy fissure known as the Great Rift. This rift zone extends southeast from the base of the Pioneer Mountains and forms the most elevated segment of the plain in the immediate area. The terrain slopes gently to the east, south, and west from the Rift Zone, with an elevation ranging from 5339 feet in the southeast corner of the Monument to 5960 feet at the base of the mountains. From here, it rises to 7688 feet, the highest point in the Monument (Ritchie, 1968).

Except for three square miles in the northwest corner, the Monument is located on the northern edge of the Snake River Plain,

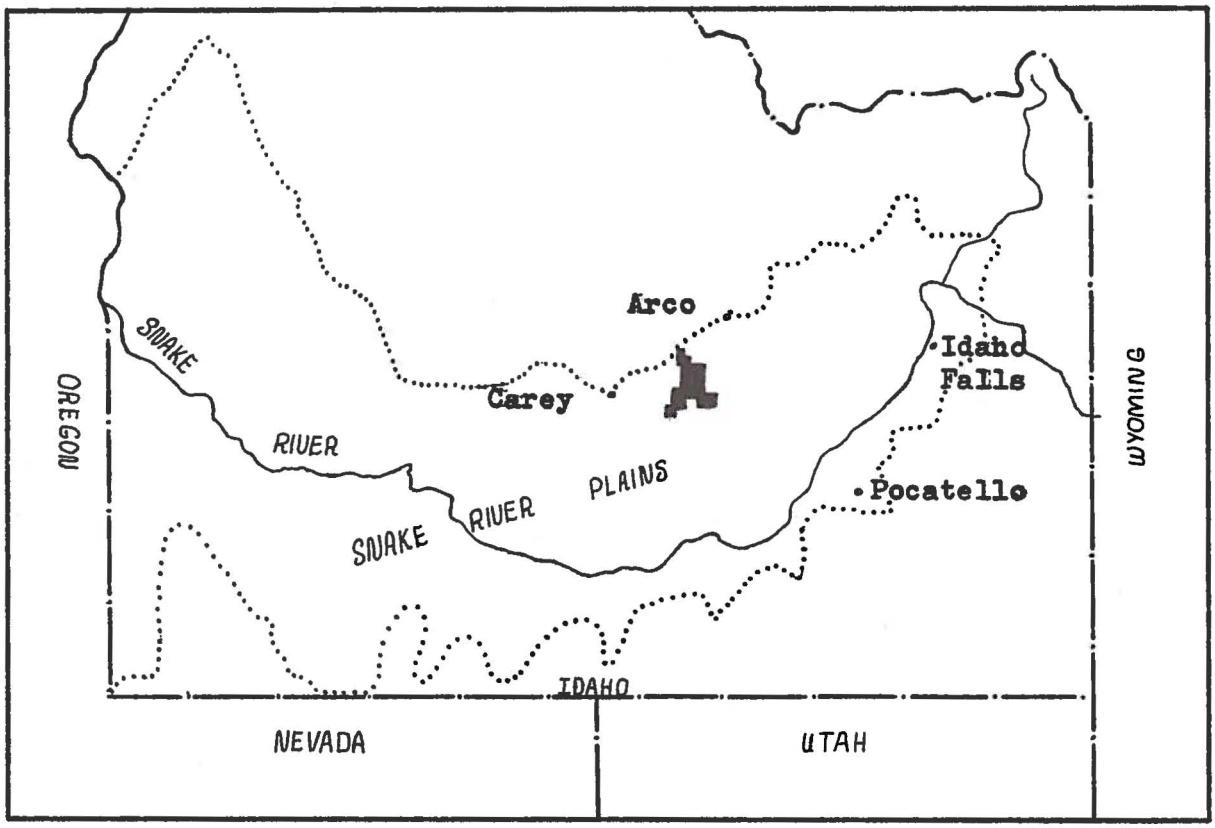


Fig. 1. Snake River Plains of southern Idaho, after Eggler (1941).

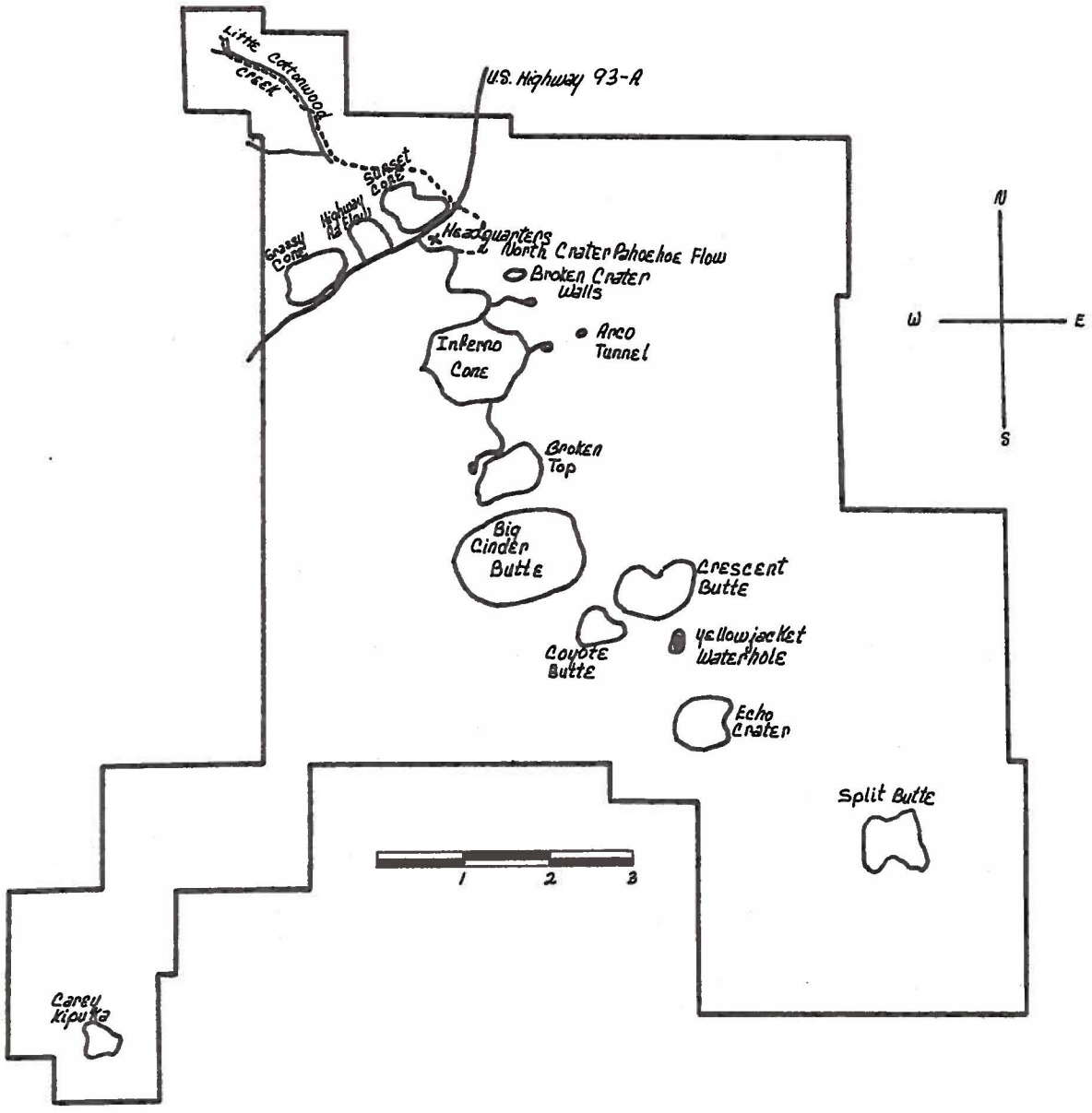


Fig. 2. Craters of the Moon National Monument. The landmarks are not drawn to scale.

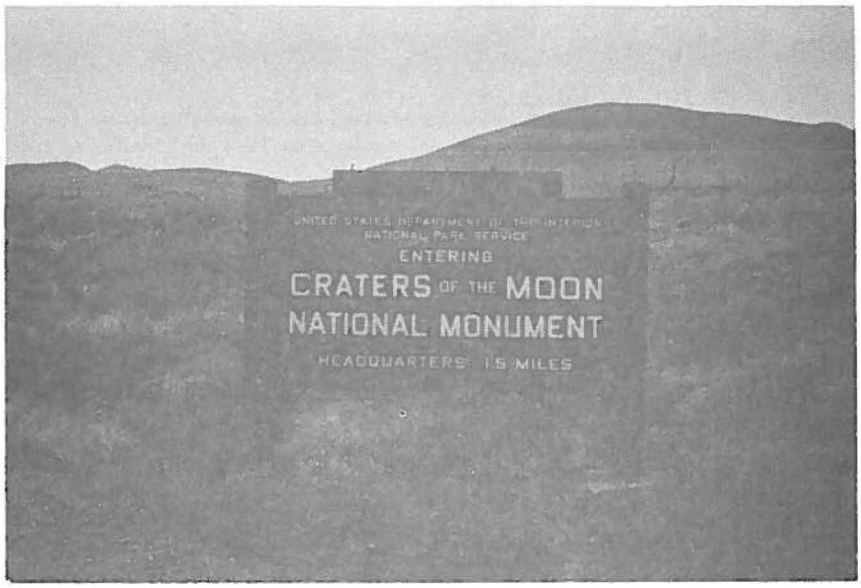


Fig. 3. The east entrance to the Monument.

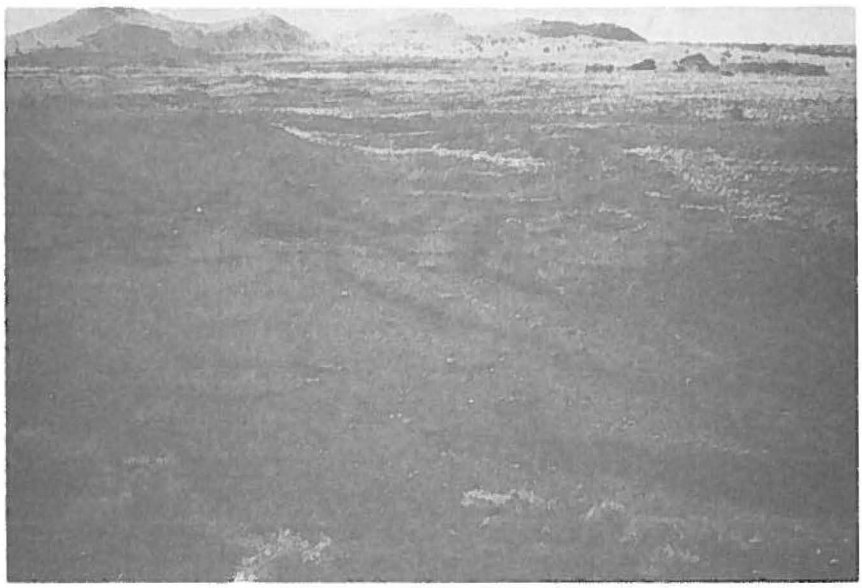


Fig. 4. The Great Rift, looking southeast toward the Watchman (left) and the Sentinel (right).

where it is the site of the most recent series of sporadic volcanic activity that has occurred throughout southern Idaho since Pliocene times (LaFehr, 1962). The activity along the Great Rift probably occurred during Pleistocene times (Murtaugh, 1961), and has produced several series of cinder cones, spatter cones, and lava cones during three (Stearns, 1963) or four (Murtaugh, 1961) periods of volcanic eruption. On either side of the chain of cones formed along the Rift Zone, lava flows extend for miles (Fig. 4). These flows are of two types: "aa" lava, and the more abundant "pahoehoe" lava. The latest flow has been determined to be at least 1650 years old, in spite of its fresh appearance (Stearns, 1963). A core was taken from the "Triple Twist Tree," a limber pine (Pinus flexilis James) growing in the North Crater Flow, by the Park Service in 1954. The count of 1350 rings was made by the Laboratory of Tree Ring Research at the University of Arizona, but the tree has an estimated age of 1500 years because of rotted heartwood. Therefore, some considerable period of time must be allowed for the lava to cool and soil to accumulate. The lava flow may be several times older than this (Stearns, 1963).

The soils are generally immature, with unweathered olivine basalt abnormally rich in magnetite (Parsons, 1965) universally present. The only exceptions are certain isolated relict areas called "kipukas," which are islands of old lands surrounded but not covered by later lava flows, and the geologically older Pioneer Mountains. For the most part, the soils are composed of loess, tiny cinders, and volcanic dust particles which have been blown into cracks and crevices in the flows and scattered on the cones, permitting the establishment of vascular plants. However, higher plants are found only in the crevices and cavities where

soil has accumulated on the flows. Only scattered lichens grow on the general flow surface (Eggler, 1941).

Vegetation on the Monument appears to be composed of a grass-sagebrush community, with sagebrush (Artemisia tridentata Nutt.) the apparently dominant species. The most important tree is limber pine, which is found in stands scattered throughout the Monument wherever soil and other conditions permit growth. In the northern part of the Monument, dense stands of Douglas fir [Pseudotsuga menziesii (Merle) Franco] are found on the north slopes of the older cones. In Cottonwood Canyon, quaking aspen (Populus tremuloides Michx.) and chokecherry (Prunus virginiana L.) are common.

Climate

Craters of the Moon National Monument is a semi-desert region with hot summers and cold winters typical of those found in southern Idaho along the Snake River Plain. Mean annual temperature is 5.5°C. with the lowest monthly mean of -7.8°C. occurring during January, and the highest monthly mean of 20.1°C. during July. The total annual precipitation averages 44.75 cm. July is the driest month with an average of 1.12 cm. Snowfall averages 232.71 cm. annually, with the most occurring in January.

Climatic data for the period of 1954 to 1968 (except for 1958) are summarized in Table 1. The data for the calendar year to 1968 are summarized in Table 2. All of the field work was conducted during the calendar year of 1968. During this time, the mean temperature was 5.4°C. The extreme low was -10.6°C. in December, and the extreme high was 35°C. in August. The total precipitation was 52.50 cm. The driest month was

Table 1. Climatological data for Craters of the Moon National Monument for the years 1954-1968 based on National Park Service files. No records are available for 1958. Temperatures are in degrees C., precipitation in cm.

Month	Aver. high	Aver. low	Mean temp.	Extreme high	Extreme low	Precip.	Amt. snow
Jan.	-2.2	-13.5	-7.8	7.2	-31.1	6.12	60.71
Feb.	0.9	-11.1	-5.2	11.8	-32.8	4.24	35.81
Mar.	4.6	-8.4	-1.7	16.7	-23.3	3.45	30.23
Apr.	11.6	-2.4	4.6	25.6	-12.2	3.30	20.32
May	17.7	2.3	9.8	33.3	-8.9	5.74	7.87
June	22.9	6.2	14.4	36.1	-6.1	3.68	0.0
July	29.6	10.7	20.1	40.0	-0.6	1.12	0.0
Aug.	27.5	8.9	18.3	36.1	-2.2	2.24	0.0
Sept.	21.8	4.4	13.1	36.1	-8.9	1.91	2.72
Oct.	15.0	-0.7	7.2	25.6	-12.2	2.24	5.05
Nov.	6.0	-5.9	-3.7	23.9	-20.6	3.18	19.05
Dec.	-0.7	11.6	-6.2	12.2	-25.0	7.54	50.95

Table 2. Climatological data for Craters of the Moon National Monument for 1968 based on National Park Service files. Temperatures are in degrees C., precipitation in cm.

Month	Aver. high	Aver. low	Mean temp.	Extreme high	Extreme low	Precip.	Amt. snow
Jan.	-2.4	-12.7	-7.6	5.6	-20.6	5.33	43.43
Feb.	2.4	-7.6	-2.3	9.4	-17.8	2.69	17.01
Mar.	7.9	-2.2	2.9	15.6	-9.4	1.17	0.0
Apr.	9.3	-4.4	2.4	17.2	-10.6	1.17	0.0
May	16.3	1.3	8.4	25.6	-9.4	5.66	Trace
June*	22.6	7.0	14.5	31.1	-1.1	7.54	0.0
July*	30.1	11.1	20.6	35.0	1.7	0.03	0.0
Aug.*	22.9	7.3	15.3	32.2	0.0	9.42	0.0
Sept.*	21.3	4.5	13.0	30.6	-3.9	2.36	0.0
Oct.	14.8	-0.7	7.1	20.6	-7.2	0.05	0.0
Nov.	3.2	6.6	-1.4	10.0	-12.2	4.19	7.62
Dec.	-2.8	12.3	-7.1	5.0	-25.0	12.88	99.06

* Most of the field work was performed during these months.

July with 0.03 cm. While I was in the field during the summer of 1968, I recorded the following extremes: for June the low was 0.6°C., the high was 32.2°C. For July the low was 7.8°C. and the high was 35°C., and for August the low was 2.8°C. and the high was 31.7°C. Although these readings differ from the Park Service records, they still illustrate the temperature extremes present on the Monument.

Precipitation and temperature records have been collected on the Monument since February 1954, except for 1958. There have been no significant measurements of wind speed. Winds are an almost daily occurrence. They usually blow from the southwest, beginning in the morning, reaching a maximum in the late afternoon, and diminishing by evening. Eggler (1941) estimated that normal wind speeds in open areas averaged about 15 to 20 miles per hour, with occasional stronger gusts up to 32 to 38 miles per hour. However, I found that wind speeds averaged approximately five miles per hour, with the strongest gust recorded at approximately 20 miles per hour. I also found that estimates of wind speed generally exceeded the actual speed by 10 miles per hour or more.

DESCRIPTION OF HABITATS

The place where an organism lives, including both its living and nonliving surroundings, is its habitat (Odum, 1959; Smith, 1966). Habitat may also refer to the place occupied by an entire community (Odum, 1959). Craters of the Moon National Monument is characterized by recent volcanic activity, but the composition of the different communities is noticeably diverse. All stages of succession are evident, with numerous and complicated interspersion of many of the microhabitats throughout the Monument.

Additional diversity occurs in the transition from the forested and riparian communities in Little Cottonwood Canyon to the barren lava in the southern portion of the Monument. The portion which stretches south from the base of the Pioneer Mountains is sagebrush-grass, a zone which is found throughout the Snake River Plain (Davis, 1952). The portion of the Monument enclosing Little Cottonwood Canyon contains a Douglas fir vegetation zone which is in contact with the sagebrush-grass zone of the lower region (Davis, 1952).

Reference to a given habitat is made according to the dominant species of life form or according to an outstanding geologic feature. They are grouped under two headings referred to as Cottonwood Canyon and (for the sake of convenience) the Monument proper. Common and scientific names of plants follow Davis (1952) and Urban (1968b).

Cottonwood Canyon

The habitats in this area are found along Little Cottonwood Creek from its origin to the point where it disappears into the ground.

Douglas fir station
Butte County, T. 2 N., R. 24 E., Sec. 21

There are four Douglas fir communities on the Monument, three of which are characterized by having a mixed shrub understory. No other coniferous stand on the Monument has an understory like this one. Possible explanations could be the higher elevation, the more mature soils, or the greater availability of water.

The Douglas fir station (Figs. 5 and 6) extends up a steep northeast-facing slope above Little Cottonwood Creek. It is bordered by the creek on the north and by sagebrush (Artemisia tridentata Nutt.) on the other sides. Well-used deer trails are interlaced throughout the stand. The climax community is composed of Douglas fir [Pseudotsuga menziesii (Merle) Franco] that range from sapling size to about three feet in diameter. The ground is covered with a thick layer of litter, and the understory is heavy where the trees are not too dense. The predominant understory plant is fire reedgrass (Calamagrostis koelerioides Vasey). Other grasses include Kentucky bluegrass (Poa pratensis L.), needlegrass (Stipa sp.), and bluebunch wheatgrass (Agropyron inerme Heller). The predominant forb is nettleleaf giant hyssop (Agastache urticifolia Kuntze), which grows in heavy stands in the more open areas. Indian paintbrush (Castilleja sp.), heartleaf arnica (Arnica cordifolia Hook.), sticky geranium (Geranium viscosissimum Fish. and Mey.), and asters (Aster spp.) are some of the less common forbs present. Shrubs

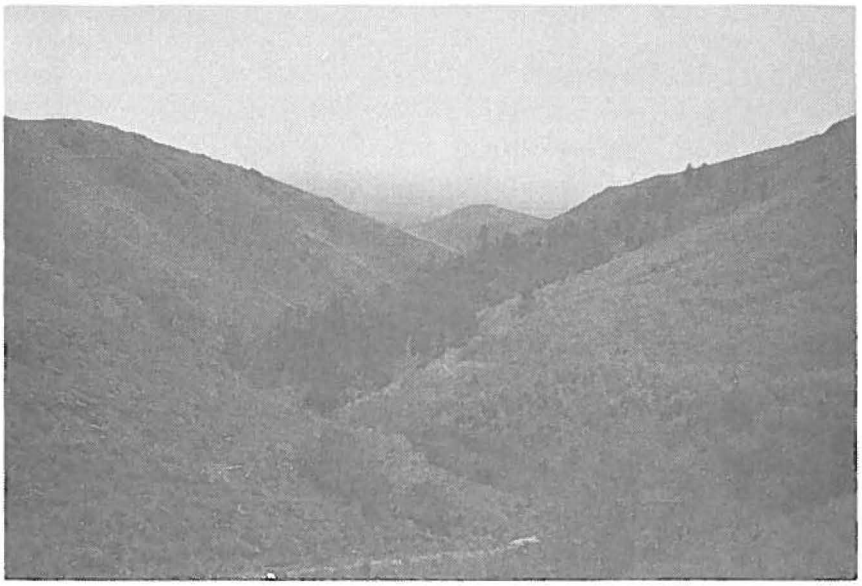


Fig. 5. The Douglas fir station, looking southeast down Little Cottonwood Canyon.



Fig. 6. The Douglas fir station, showing a deer trail.

include mountain snowberry (Symphoricarpos oreophilus Grey) and some serviceberry (Amelanchier alnifolia Nutt.).

Mature aspen station
Butte County, T. 2 N., R. 24 E., Sec. 22

Stands of quaking aspen (Populus tremuloides Michx.) extend up the canyon along each fork of Little Cotton Creek, which is generally composed of larger, older trees and a more diverse understory than the quaking aspen communities found on the drier slopes (Figs. 7 and 8). The quaking aspen in the stand above Martin Mine are about 25 to 30 feet in height, and have an approximate average age of 57 years. The age is based on increment borings I made on a number of trees in the stand.

The understory is heavy and varied. Fire reedgrass, Kentucky bluegrass, bluebunch wheatgrass [A. spicatum (Pursh) Scribn. and Smith], needlegrass, and giant wild rye (Elymus cinereus Scribn. and Merr.) are among the grasses. Forbs include nettleleaf giant hyssop, butterweed groundsel (Senecio serra Hook.), cinquefoil (Potentilla sp.), solomon plume (Smilacina sp.), aster, bedstraw (Galeum sp.), yarrow (Achillia millefolium L.), and common cowparsnip (Heracleum lanatum Michx.). Mountain snowberry is plentiful. However, the vegetation immediately adjacent to the creek is predominantly Hudson Bay currant (Ribes hudsonianum Richards.), with considerable amounts of bigsting nettle (Urtica dioica L.). Other plants along the creek include some mountain alder (Alnus sp.), and dogwood (Cornus stolonifera Michx.).

Stream and pond margin station
Butte County, T. 2 N., R. 24 E., Sec. 22

This is an extremely diverse riparian habitat that extends from a



Fig. 7. The mature aspen station in Little Cottonwood Canyon.

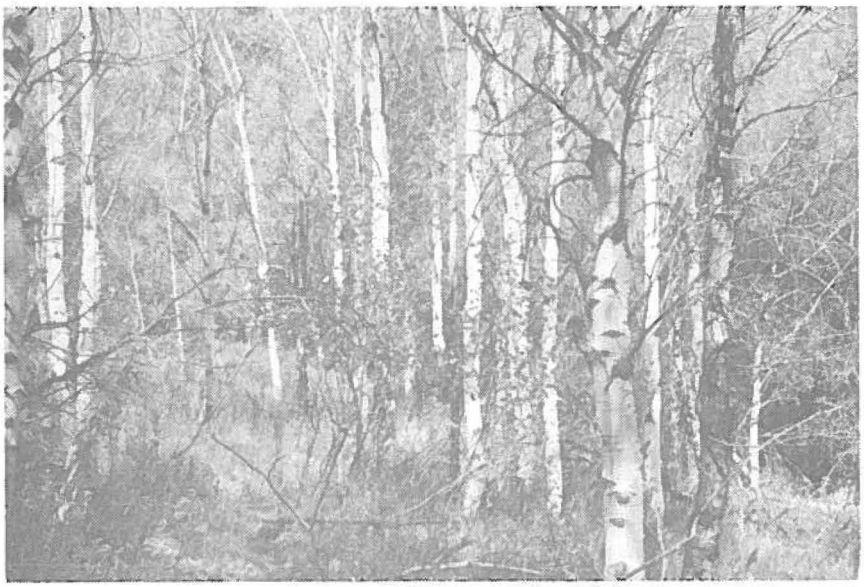


Fig. 8. The interior of the mature aspen station.

mature aspen stand through a beaver dam and meadow, beneath a shrub understory, and finally into a grassy flat (Fig. 9). The creek is small and shallow with a gravelly bottom and much litter. Grasses found along the creek include Kentucky bluegrass, giant wild rye, needlegrass, cheatgrass brome (Bromus tectorum L.), and bottlebrush squirreltail (Sitanion hystrix Nutt.). Sedges (Carex spp.) and rushes (Juncus spp.) are also present. Forbs, which are abundant and diverse, include lupine (Lupinus sp.), sharpleaf valerian (Valeriana acutiloba Rydb.), nettleleaf giant hyssop, thistle (Circium sp.), flannel mullein (Verbascum thapsus L.), niggerhead (Rudbeckia occidentalis Nutt.), bigsting nettle, monkey flower (Mimulus sp.), penstemon (Penstemon sp.), aster, and common cowparsnip. Quaking aspen, chokecherry [Prunus virginiana (Nutt.) Torr.], Hudson Bay currant, dogwood, woods rose (Rosa woodsii Lindl.), mountain alder, and willow (Salix sp.), are among the shrubs and trees.

Young aspen station
Butte County, T. 2 N., R. 24 E., Sec. 22

Although the quaking aspen in this stand are generally younger than the trees in the mature aspen stand, their smaller size may be the result of less moisture, because this is the most obvious difference between these habitats (Figs. 10, 11, and 12). The trees are about 10 to 15 feet high. This community differs from the aspen stands along the creek because of the availability of water. The average approximate age is 20 years, according to my increment boring samples. The habitat studied is confined to a draw extending down a north-facing slope, which evidently carries some water during the spring run-off. The understory includes Kentucky bluegrass, needlegrass, giant wild rye, bluebunch



Fig. 9. Little Cottonwood Creek.

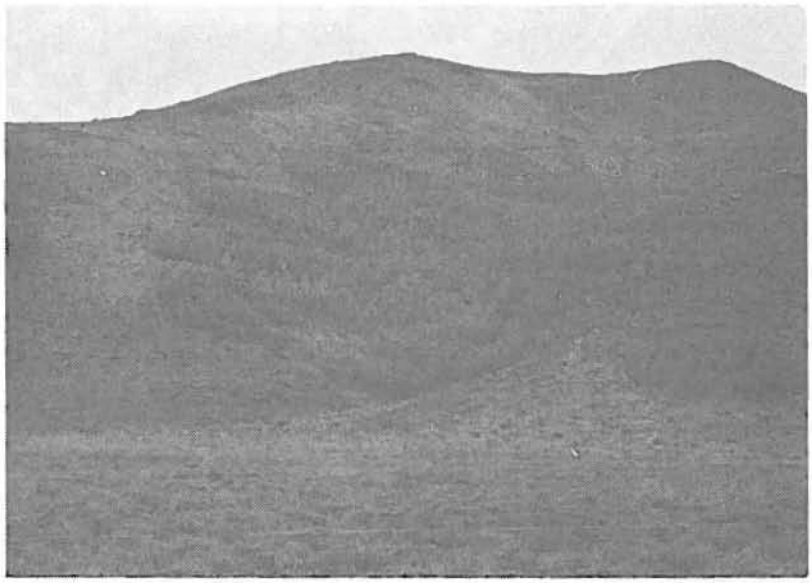


Fig. 10. The young aspen station.



Fig. 11. The lower end of the young aspen stand.



Fig. 12. The interior of the young aspen stand.

wheatgrass, fire reedgrass, and cheatgrass brome. The most abundant forbs are nettleleaf giant hyssop, and solomon-plume. Other forbs include sunflower (Helianthus annuus L.), yarrow, cinquefoil, dandelion (Taraxacum officinale Weber), Louisiana sagebrush (A. ludoviciana Nutt.), Indian paintbrush, aster, and sticky geranium. The common shrubs are mountain snowberry, serviceberry, big sagebrush, and rubber rabbitbrush [Chrysothamnus nauseosus (Pall.) Britt.].

Elymus station
Butte County, T. 2 N., R. 24 E., Sec. 27

This is an extensive meadow found in the drainage of Little Cottonwood Creek. All the water from the creek disappears into the ground in this area. This habitat, the most uniform plant community on the Monument, is covered almost exclusively by giant wild rye (Fig. 13). However, there are a few spots scattered throughout the area that contain field pennycress (Thlaspe arvense L.) and Richardson tanseymustard [Descurania richardsonii (Sweet) Schulz].

The Elymus station is bordered by portions of an old lava flow with shallow, rocky soil covered with xerophytes, such as big sagebrush, rubber rabbitbrush, penstemon, Sandberg bluegrass (P. secunda Presl.), and cheatgrass brome.

Within this flow, there are many sunken places that contain small meadows with such species as rushes (J. ensifolius Wikstr.), bluegrass, and needlegrass.

Mixed shrub stations
Butte County, T. 2 N., R. 24 E., Sec. 21 and 27

Located on the high south-facing slopes and ridges, this community



Fig. 13. The Elymus station.



Fig. 14. The mixed shrub station at the northwest end of the Little Cottonwood Canyon road.

occurs on the Tertiary andesites, latites, and rhyolites that come in contact with the Quaternary (Recent) basalt of the lower part of the Monument (Anderson, 1929a).

Two habitats were studied: one is located at the northwestern end of the Cottonwood Canyon road; the other is located immediately north of the road above the mouth of the canyon and just east of the Elymus station. Both are characterized by relatively xeric conditions (Figs. 14, 15, and 16). The former one is near the highest point in the Monument and is poorer in floral species than the other. Grasses include Sandberg bluegrass, cheatgrass brome, wheatgrass, giant wild rye, and bottlebrush squirreltail. Among the forbs are arrowleaf balsamroot [Balsamorhiza sagittata (Pursh) Nutt.], Hood's phlox (Phlox hoodii Richn.), and eriogonum (Eriogonum sp.). The most abundant shrubs are big sagebrush, and antelope bitterbrush Purshia tridentata (Pursh) D. C. . Other shrubs are rubber rabbitbrush, Douglas rabbitbrush [C. viscidiflorus (Hook.) Nutt.], mountain snowberry, and serviceberry.

The second habitat is more diverse in soil conditions, ranging from cinders and shallow, rocky soil to more stable, mature soils. The flora is essentially the same as that on the first shrub slope, with a more uniform mixture of shrubs. Additional species include Idaho fescue (Festuca idahoensis Elmer), Douglas chaenactis [Chaenactis douglasii (Hook.) H. and A.], plains prickly pear (Opuntia polyacantha Haw.), low sagebrush (A. arbuscula Nutt.), and gray horsebrush (Tetradymia canescens DC).



Fig. 15. This gully divides the mixed shrub slope at the northwest end of the Little Cottonwood Canyon road.



Fig. 16. Some of the plants found on the mixed shrub slope shown in Figs. 14 and 15.

Man-made structures
Butte County, T. 2 N., R. 24 E., Sec. 22

The Martin Mine is the site of old cabins and mine shafts which provide habitats for several small mammals, including the bushy-tailed wood rat [Neotoma cinerea (Ord)]. This animal would probably not occur at this particular spot if these structures were not present (Fig. 17). Strictly speaking, the roads and culvert pipes would also be considered under this category.

Monument Proper

Mature cinder cone station
Butte County, T. 2 N., R. 24 E., Sec. 34

Only vestiges of the oldest volcanic activity remain, with most of their flows being covered by later eruptions. These are ancient remnants of cinder cones probably formed sometime during the Pleistocene (Murtaugh, 1961).

These cones are considered "mature" because they support a heavy growth of plants typical of the old flows on the Snake River Plain. Grassy Cone, bordering the north side of U. S. Highway 93-A, was selected for study (Figs. 18 and 19). The cinder slopes of this cone support two major communities, mixed shrub and Douglas fir. The characteristic plants of the mixed shrub community include bluebunch wheatgrass, giant wild rye, cheatgrass brome, arrowleaf balsamroot, wayside gromwell (Lithospermum ruderale Lehm.), Cymopterus terebinthinus (Hook.) T. and G. (no common name), phacelia (Phacelia sp.), hawksbeard (Crepis sp.), eriogonum, rubber rabbitbrush, mountain snowberry, big sagebrush, and antelope bitterbrush.

The sheltered, north-facing slope is the site of a Douglas fir

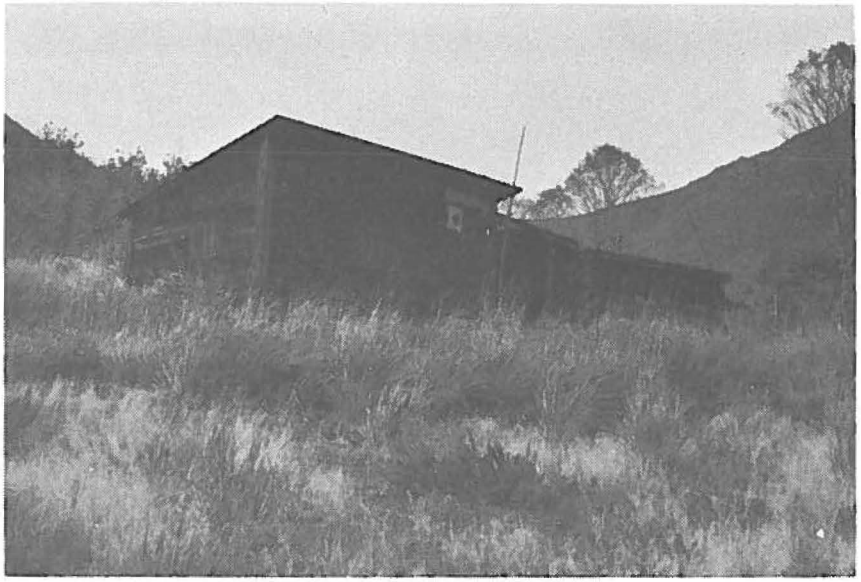


Fig. 17. The abandoned cabin at the old Martin Mine.



Fig. 18. Grassy Cone, a mature cinder cone, with North Crater Aa Flow in the foreground.

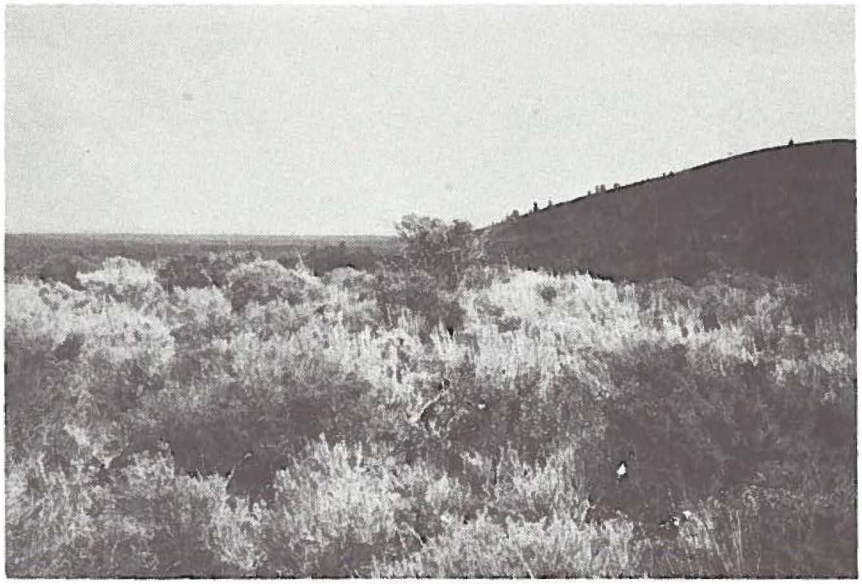


Fig. 19. The mixed shrub community on Grassy Cone.



Fig. 20. The Douglas fir community on Grassy Cone.

community (Fig. 20). This habitat features a climax of Douglas fir, with some limber pine (Pinus flexilis James), especially on the edge of the stand. The understory is represented by wheatgrass, arrowleaf balsamroot, hawksbeard, cinquefoil, chokecherry, antelope bitterbrush, big sagebrush, rubber rabbitbrush, mountain snowberry, and serviceberry. This combination of vegetation types is not restricted to Grassy Cone, but is found on the other ancient cones.

Aa lava stations
Butte County, T. 2 N., R. 24 E., Sec. 35;
T. 1 N., R. 25 E., Sec. 34.

The lava on the Monument can be divided into two distinct groups, aa and pahoehoe, according to physical appearance. The difference in physical features appears to be due to a different combination of gas and heat, according to Stearns (1963), who described aa lava as rough, jagged, and with a "spiny" surface. Vegetation is scarce, with little diversity, and is confined entirely to cracks, crevices, or pockets where sufficient soil has accumulated to support growth. Lichens are the only visible flora growing on the bare lava.

Two aa flows, although nearly the same age, show considerable variation in vegetative cover (Stearns, 1963). One is North Crater Aa Flow (Highway Flow), extending north from U. S. Highway 93-A (Figs. 17, 21, 22, and 23). It is a very rough, black, nearly barren flow with sparse vegetation. Typical plants include bottlebrush squirreltail, penstemon, cinquefoil, and tansybush [Chamaebatiaria millefolium (Torr.) Maxim.].

The other is Little Prairie Aa Flow, a portion of which lies immediately north of Split Butte (Figs. 24 and 25). Here the lava

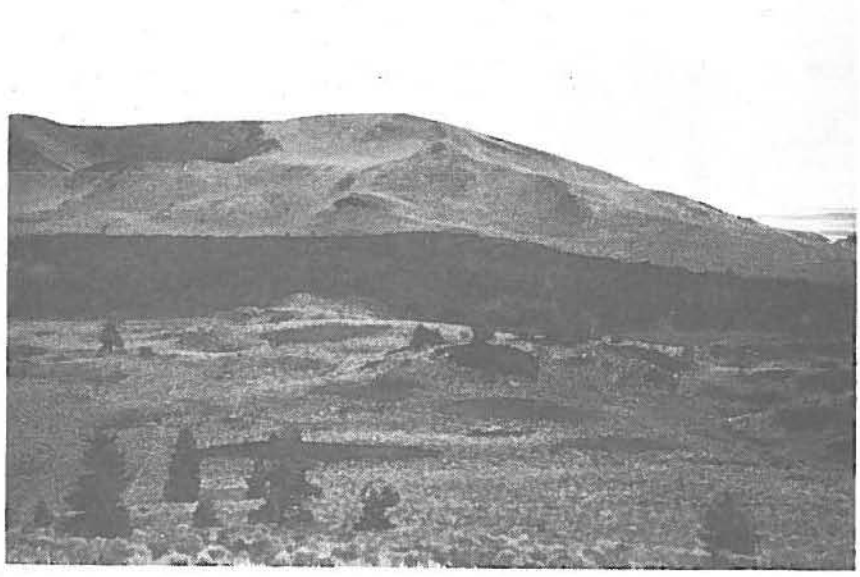


Fig. 21. North Crater Aa Flow.



Fig. 22. North Crater Aa Flow.

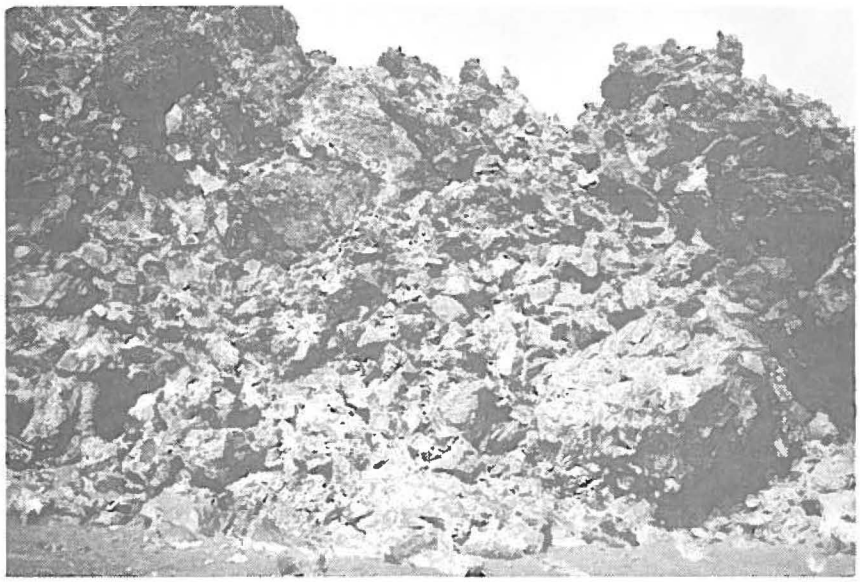


Fig. 23. North Crater Aa Flow.

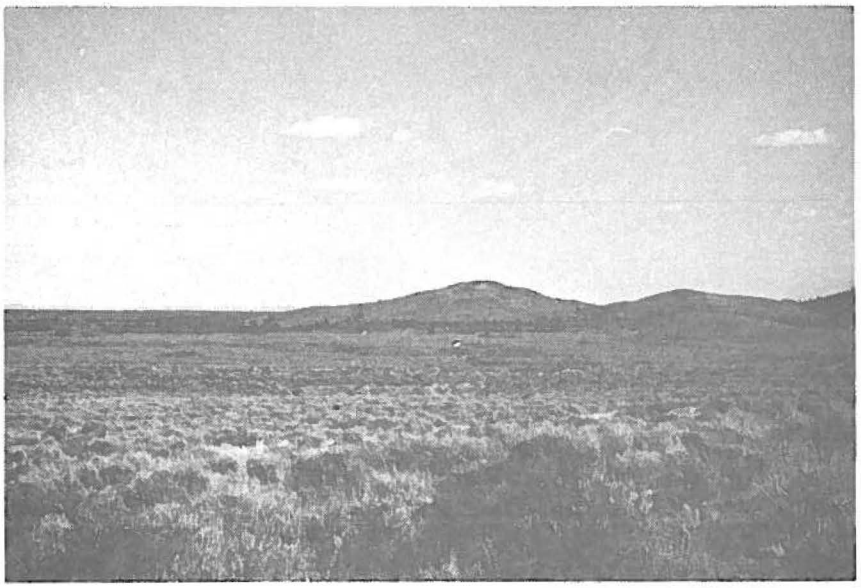


Fig. 24. The limber pine of Little Prairie Aa Flow, with Split Butte in the background.



Fig. 25. Little Prairie Aa Flow, showing the limber pine that appear at a distance in Fig. 24.

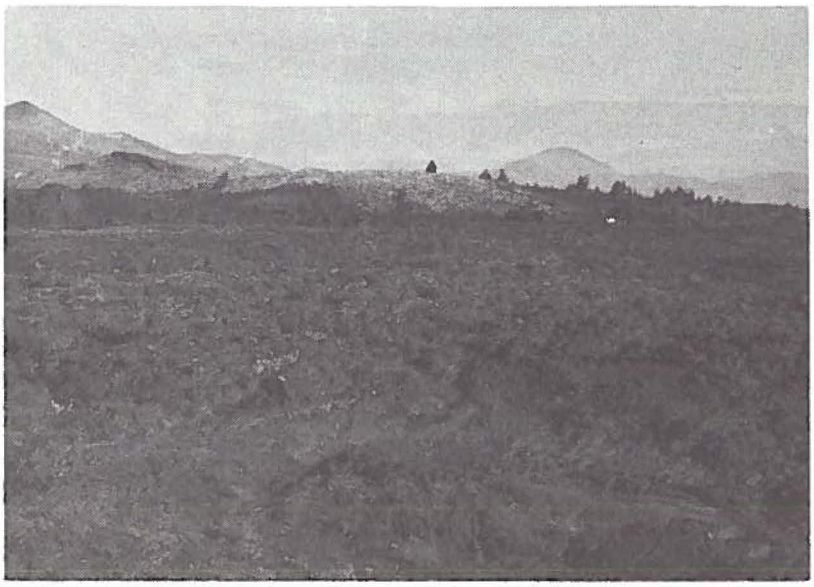


Fig. 26. North Crater Pahoehoe Flow.

appears to be much shallower and is not as rough as in the Highway Flow. The vegetation is much denser and more diverse. The apparently dominant species is big sagebrush, with limber pine scattered throughout the area. Other plants are Sandberg bluegrass, bluebunch wheatgrass, eriogonum, penstemon, antelope bitterbrush, and rubber rabbitbrush.

Pahoehoe lava station
Butte County, T. 2 N., R. 24 E., Sec. 36

Pahoehoe lava covers approximately half of the area of the Monument (Stearns, 1963). It has a smooth or ropy appearance characterized by rounded vesicles and hollow caverns and tubes (Figs. 26 and 27). It has a glassy surface that reflects blue in sunlight. Vegetation, as in aa lava, is confined to cracks, crevices, and holes where soil has been deposited.

North Crater Flow, found east of the campground, is the representative habitat. This flow is one of the more recent ones (Murtaugh, 1961; Stearns, 1963). Vegetation, though sparse, is more abundant than that occurring on some of the other flows. The most abundant species are cinquefoil, Lewis mockorange (Philadelphus lewisii Pursh), and tansybush. There are other species scattered throughout the area, including eriogonum, big sagebrush, rubber rabbitbrush, and wax currant (Ribes cereum Dougl.).

Broken crater wall station
Butte County, T. 2 N., R. 24 E., Sec. 36

As the name implies, these are crater wall fragments that have been carried from their original site by subsequent flows, usually settling wherever the flow stopped. These great blocks of lava form habitat "islands" throughout the area, providing shelter and observation



Fig. 27. Ropy pahoehoe lava in North Crater Pahoehoe Flow.

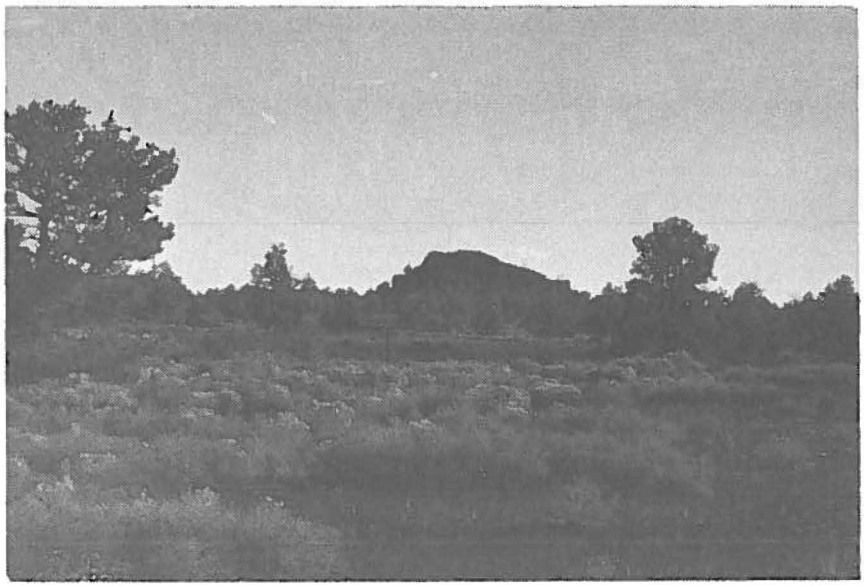


Fig. 28. Broken crater wall north of Devil's Orchard.

posts for many different animals.

Although scattered throughout the flows, there is a concentration of crater wall fragments in the area north of Devil's Orchard. One particularly large fragment was picked for study. It is about one-eighth mile north of the Devil's Orchard road and is bordered on its north side by the North Crater Flow, evidently having been carried to its present location by this flow (Figs. 28 and 29). The dimensions of this broken wall are approximately 200 feet long by 150 feet wide by 40 feet high. Vegetation is sparse and restricted to areas where soil has settled. Species represented are cinquefoil, eriogonum, penstemon, tansybush, rubber rabbitbrush, bush rockspirea [Holodiscus dumosus (Nutt.) Coult.], and limber pine.

Lava tube stations
Butte County, T. 1 N., R. 25 E., Sec. 6

The numerous caverns and tubes that are found on the Monument all occur in pahoehoe lava, according to Stearns (1963), who also states that they were formed within the flow by the hardening of the surface, and that as the flow continued underneath, the side walls also stiffened and a tube was formed.

Such tubes are abundant. There are probably many large ones and innumerable small ones that have never been discovered. Several very small tubes and pockets were studied, but the main representative was Arco Tunnel, a long, many branched tube less than 100 yards north of Beauty Cave (Fig. 30).

Mosses, found near the mouth of the tube, are the only obvious plants (Fig. 31).



Fig. 29. Broken crater wall north of Devil's Orchard.



Fig. 30. The entrance to Arco Tunnel.



Fig. 31. The entrance to Arco Tunnel.

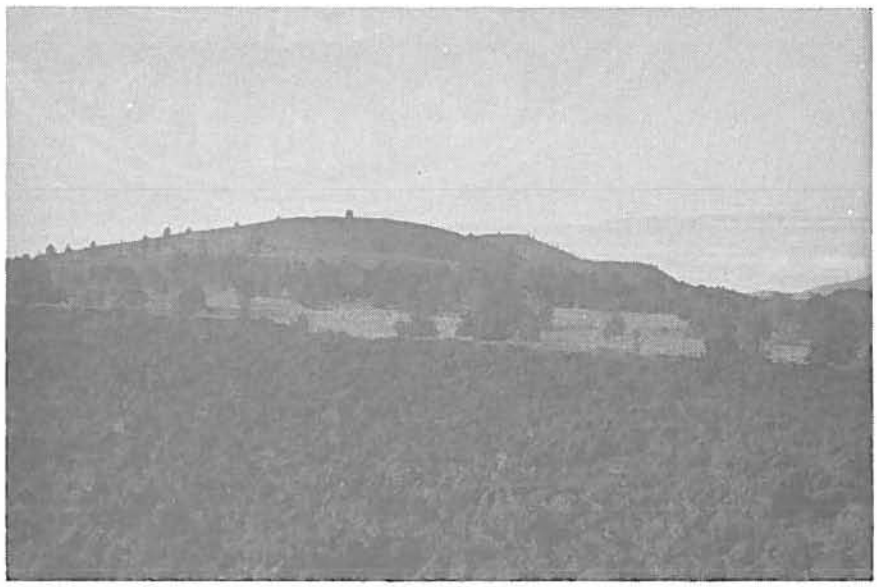


Fig. 32. The limber pine station on Inferno Cone.

The microclimate of the lava tubes changes very little winter or summer. During the summer of 1968, the temperature was about 10° C., and the relative humidity was 90 per cent. Variation in these factors was slight.

Limber pine station
Butte County, T. 1 N., R. 24 E., Sec. 1

Limber pine is present throughout the Monument, except on the younger flows. The distribution on the flows is erratic, and may be correlated with protection from the drying, prevalent winds by cinder cones and other windbreaks (Eggler, 1941). The best stands--those with the largest individuals and the greatest number of trees--occur in two locations. One is on the northeast side of Inferno and Paisley Cones extending into Devil's Orchard; the other is on the south end of Big Cinder Butte and stretches in a southeasterly direction to the end of the Monument (Eggler, 1941).

Inferno Cone is a cinder cone with very little vegetation, except for the limber pine community extending about half way up the northeast side (Fig. 32). Although limber pine is the prominent species, antelope bitterbrush appears to be the most abundant woody species (Fig. 33). Other plants are cheatgrass brome, bottlebrush squirreltail, Sandberg bluegrass, Douglas chaenactis, phacelia, eriogonum, big sagebrush, rubber rabbitbrush, and wax currant.

Young cinder cone stations
Butte County, T. 2 N., R. 24 E., Sec. 25;
T. 1 N., R. 24 E., Sec. 12

Three community types include essentially all vegetation found on the cinder cones (Eggler, 1941). A pioneer community of herbs occupies



Fig. 33. The limber pine community on Inferno Cone.



Fig. 34. The south-facing slope of Broken Top.

a major part of the young cones (Figs. 34, 35, and 36). Trees dominate the second type, being restricted to protected sites, chiefly on the north-facing slopes. The dominant vegetation on the old cones is shrubs, which occupy the south slopes.

The young cinder cones, characterized by pioneer communities, form a contrast with the tree and shrub communities of the mature cones. The soil consists of unweathered cinders, and Eggler (1941) found that even the youngest cinder cones will support vascular plants, which is a major difference between lava flow and cinder cone vegetation.

Two representative habitats were studied. One occupies an exposed slope which faces the southwest on a small, unnamed cone just northeast of the junction of U. S. Highway 93-A and the Cottonwood Canyon road. The other is on the south-facing slope of Broken Top. The plant species on the unnamed cone consist of bitterroot lewisia (Lewisia rediviva Pursh), Douglas chaenactis, and varileaf phacelia (P. heterophylla Pursh). Plants bordering the open cinders include thorn skeletonplant (Lygodesmia spinosa Nutt.), Cymopteris terebinthinus (Hook.) T. and G., and antelope bitterbrush. Plants on Broken Top are eriogonum (E. ovalifolium Nutt.), varileaf phacelia, and Douglas chaenactis, while plants bordering the cinders are fleabane (Erigeron sp.), lupine, and antelope bitterbrush.

Coyote Butte
Butte County, T. 1 N., R. 25 E., Sec. 19

The plant community on this old cinder cone differs from those on other cones (Figs. 37, 38, and 39). The most abundant plants are grasses, with a heavy mixture of forbs. Shrubs are sparse. This

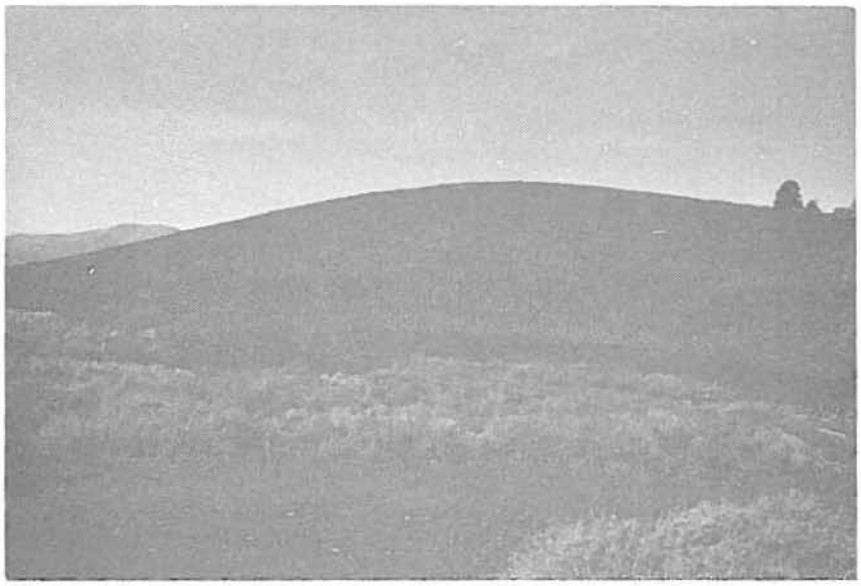


Fig. 35. The south-facing slope of Broken Top.



Fig. 36. Primary plant succession on Broken Top.



Fig. 37. Coyote Butte, with a cloud cover over Big Cinder Butte in the background.



Fig. 38. Coyote Butte, looking south from Big Cinder Butte.

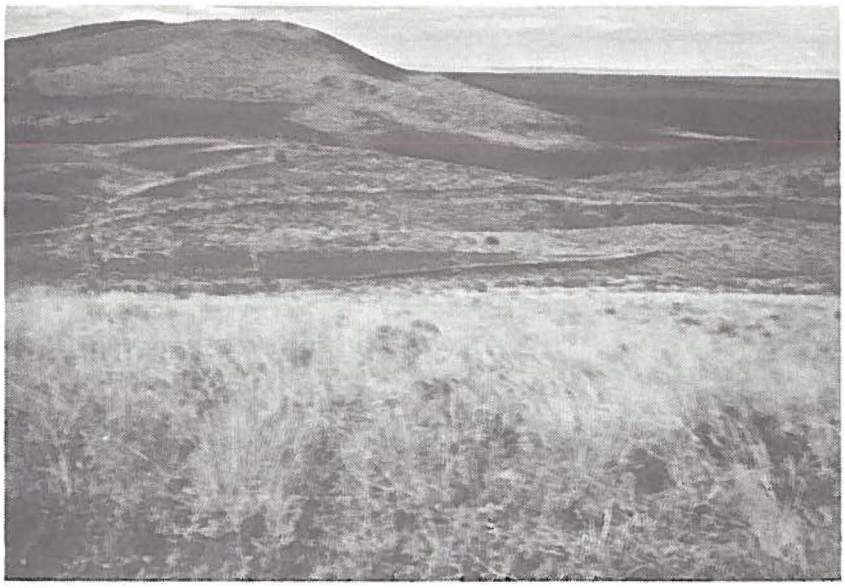


Fig. 39. Some of the vegetation on Coyote Butte.

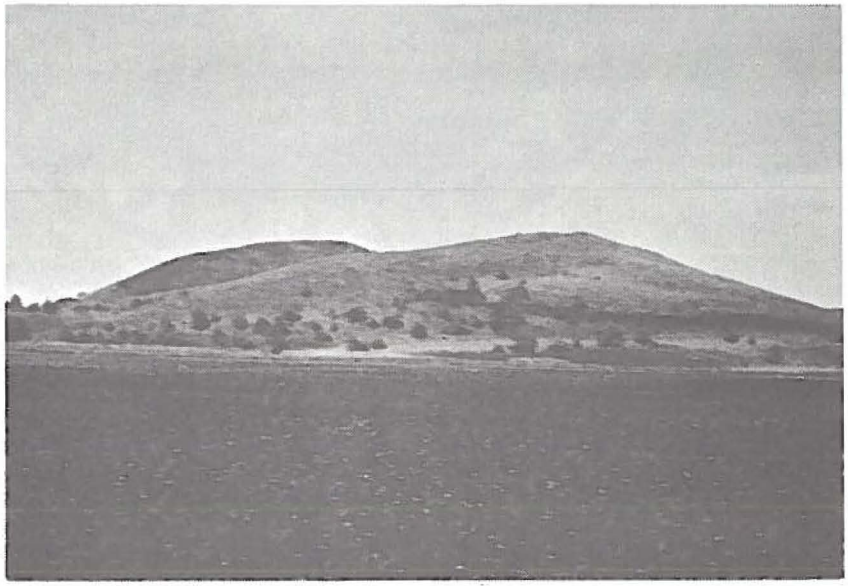


Fig. 40. Crescent Butte.

community is apparently the result of a fire that burned off the area approximately 10 years ago (Urban, personal communication). There are still several dead limber pines on the cone.

The most abundant grass is Sandberg bluegrass; other species include western needlegrass (S. occidentalis Thurb. ex S. Wats.), Idaho fescue, and cheatgrass brome. Giant wild rye is abundant on the north-facing slope, and a hybrid of Indian ricegrass [Oryzopsis hymenoides (R. and S.) Ricker] and western needlegrass is plentiful on the east-facing slope. Forbs consist of eriogonum, sulfur eriogonum (E. umbellatum Torr.), tailcup lupine (L. caudatus Kell.), varileaf phacelia, Douglas chaenactis, arrowleaf balsamroot, Lomatium dissectum (Nutt.) M. and C. (no common name), Cymopteris terebinthinus (Hook.) T. and G., and penstemon. Most of the shrubs are found near the bottom of the butte and consist mainly of antelope bitterbrush, rubber rabbitbrush, and some big sagebrush.

Craters stations
Butte County, T. 1 N., R. 25 E.,
Sec. 17, 20, and 29

A crater is a depression in a volcanic vent (Stearns, 1963). The plant communities in craters and on cinder cones are similar. There are exposed crater walls with pioneer species and craters with three-shrub communities. These habitats were represented by Crescent Butte and Echo Crater.

As the name implies, the crater in Crescent Butte is in the shape of a crescent. The northern wall has been breached, thus providing an entrance into an otherwise bowl-shaped depression (Figs. 40 and 41). It is a crater composed almost entirely of cinders, and contains a well-

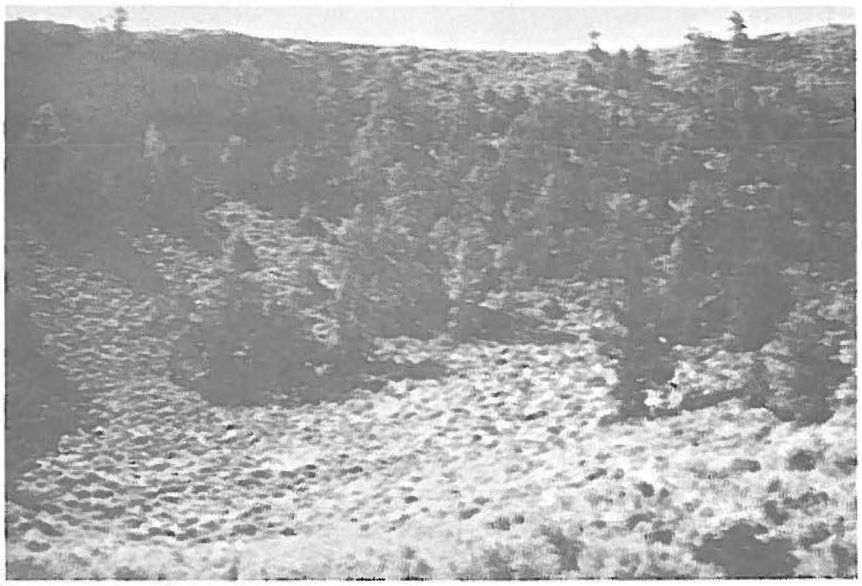


Fig. 41. Crescent Butte.

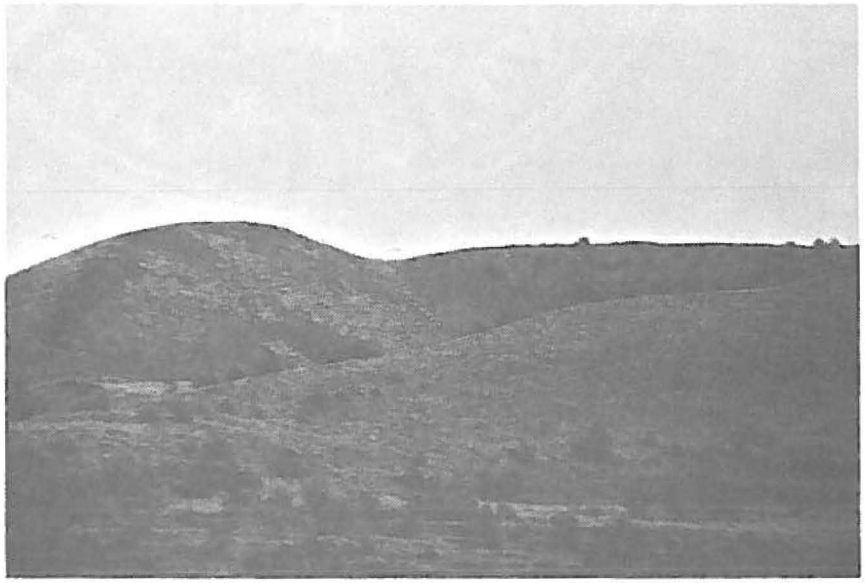


Fig. 42. The crater of Crescent Butte.

developed tree-shrub community. The shrub community extends from the depression in the northern rim around either side to the north-facing slope, which is occupied by a stand of trees (Fig. 42).

The west-facing slope is steep, with coarse cinders and sparse vegetation including scattered individuals of big sagebrush, antelope bitterbrush, and a couple of limber pines.

The east-facing slope is covered with heavy vegetation represented by giant wild rye, eriogonum, phacelia, big sagebrush, antelope bitterbrush, Douglas rabbitbrush, and Cymopteris terebinthinus (Hook.) T. and G.

The north-facing slope cover consists of giant wild rye, bluebunch wheatgrass, sulfur eriogonum, Hood's phlox, penstemon, hawksbeard, big sagebrush, mountain snowberry, wax currant, Douglas rabbitbrush, and limber pine.

The most abundant plants on the floor of the crater are giant wild rye and Douglas rabbitbrush.

Echo Crater is a very old formation, nearly as old as the ancient cinder cones at the base of the Pioneer Mountains (Stearns, 1963). From a distance, this crater is shaped like a huge easy chair with the back toward the west (Fig. 43). The back culminates at a point 100 feet or more above the crater floor, and the east-facing side is a sheer cliff (Fig. 44). Piles of cinders and black lava lie against the cliff (Fig. 45). From the highest point on the west side, the crater rim gradually drops on either side, reaching a low point on the east side. The rim is irregular, especially on the east side. The slope gradually levels out as the elevation of the rim decreases.

The vegetation on the outer slope is a mixed shrub community

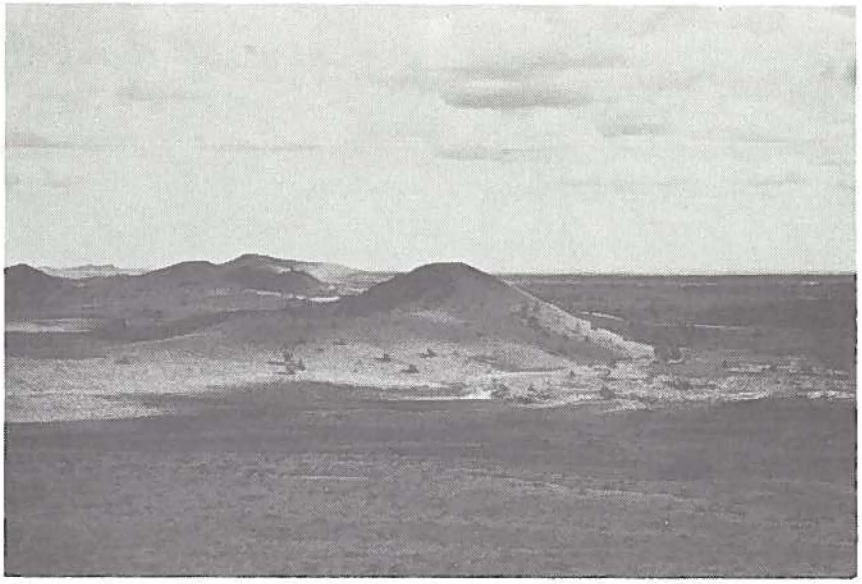


Fig. 43. Echo Crater, looking south.

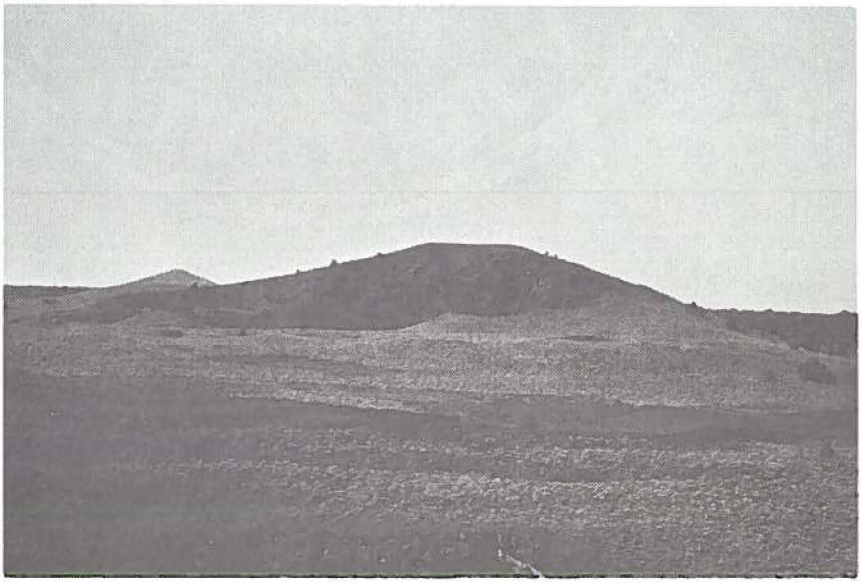


Fig. 44. Echo Crater, looking southwest.



Fig. 45. Inside of Echo Crater, looking north.

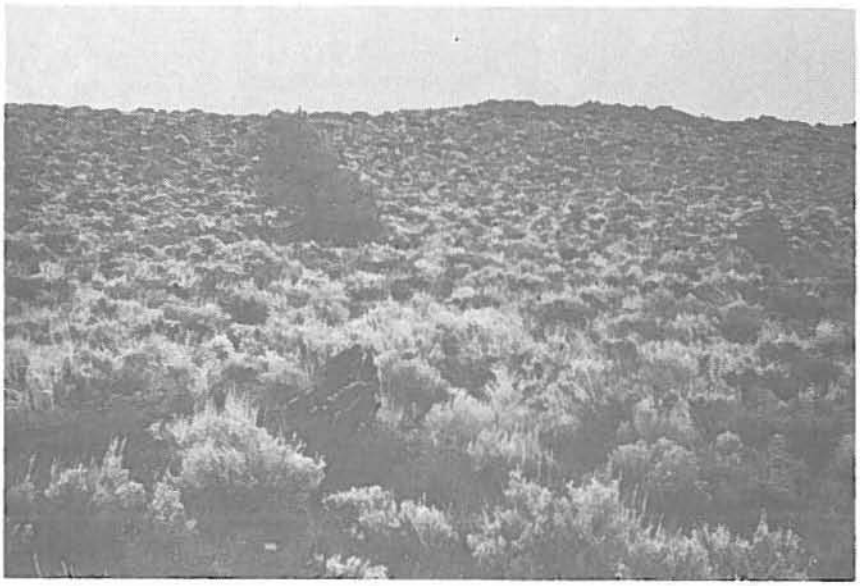


Fig. 46. The outside of Echo Crater.

like those found on the ancient cinder cones to the north (Fig. 46). The rim of the crater is characterized by patches of vegetation scattered among exposed cinders and blocks of lava. These plants include Sandberg bluegrass, giant wild rye, Hood's phlox, sulfur eriogonum, blazingstar mentzelia [Mentzelia laevicaulis (Dougl.) T. and G.], thistle, antelope bitterbrush, and big sagebrush.

The sporadic plant cover on the rock and cinder slopes against the east-facing crater wall includes cheatgrass brome, bottlebrush squirreltail, eriogonum, big sagebrush, rubber rabbitbrush, antelope bitterbrush, and tansybush.

The vegetation on the floor of the crater consists of bluebunch wheatgrass, Idaho fescue, giant wild rye, sulfur eriogonum, penstemon, cinquefoil, big sagebrush, antelope bitterbrush, rubber rabbitbrush, wax currant, tansybush, and some limber pine (Fig. 47).

Trench Mortar Flat
Butte County, T. 1 N., R. 25 E., Sec. 18

This habitat is characterized by cinders which cover the lava of previous volcanic activity (Fig. 48). There are numerous small piles of aa lava scattered throughout the area, with some lava tubes and vesicles present. One of the outstanding features is the tree molds (Fig. 49). These are casts formed by molten lava that has solidified around a tree in the path of a flow (Stearns, 1963).

This large, flat area is typified by primary succession, with sparse plant distribution. There are some areas of more advanced succession, but these are restricted to small patches within the flat and along the edge. The plants on the flat itself are eriogonum,

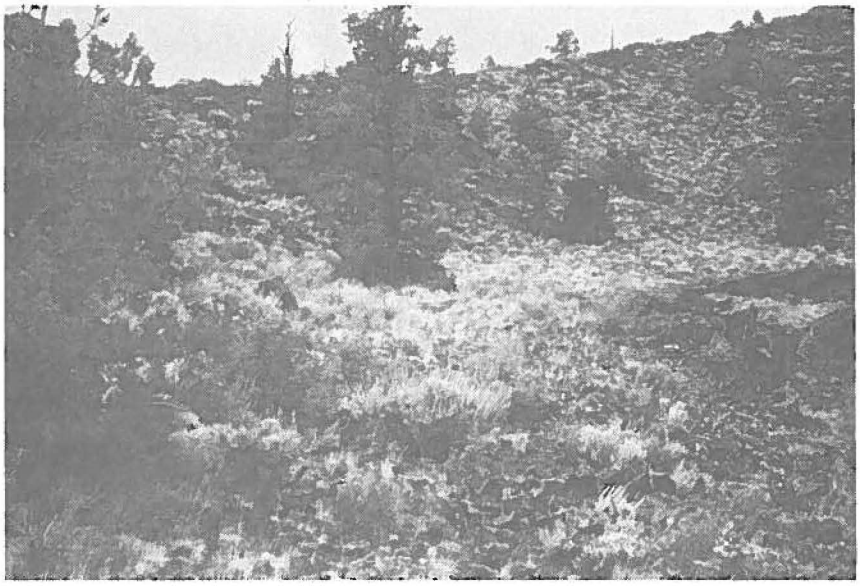


Fig. 47. The floor of Echo Crater.

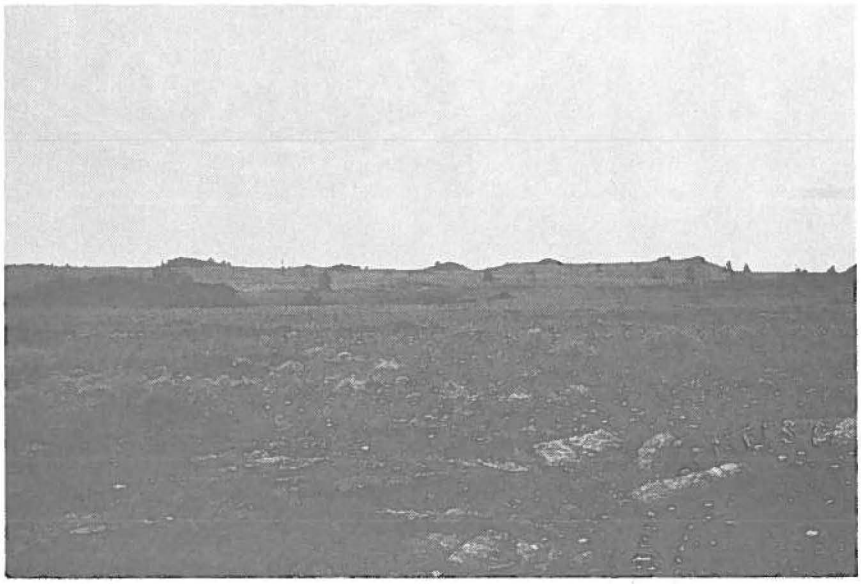


Fig. 48. Trench Mortar Flat.

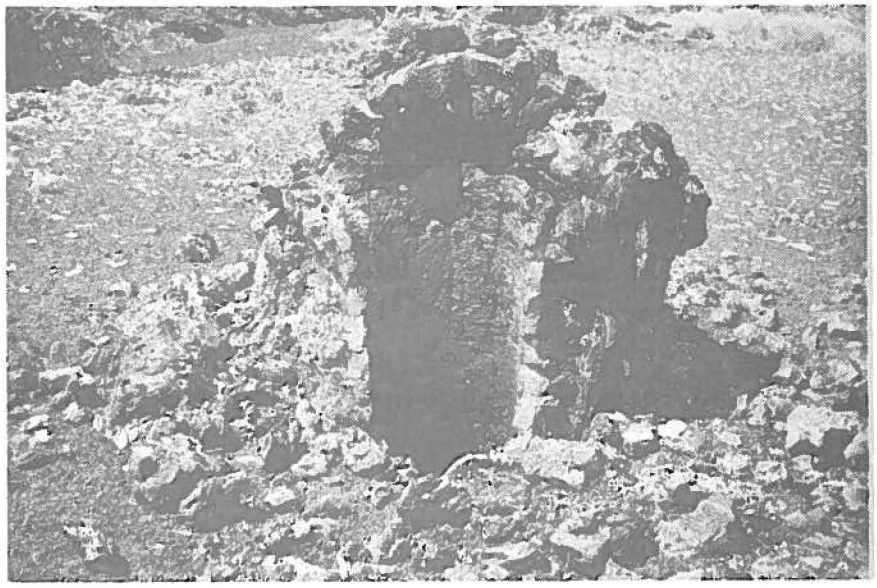


Fig. 49. A tree mold in Trench Mortar Flat.

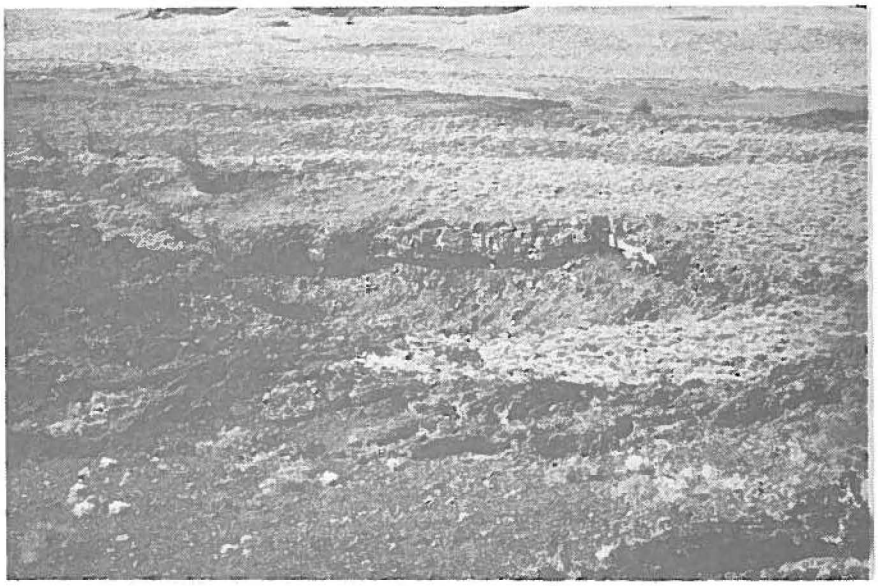


Fig. 50. The depression in the Great Rift containing Yellowjacket Waterhole.

Douglas chaenactis, aster (A. canescens Pursh), and phacelia. The plants found around the edge and in the more sheltered areas include sulfur eriogonum, Hood's phlox, lupine, rubber rabbitbrush, antelope bitterbrush, and some big sagebrush. Grasses are scarce. Those that are present are cheatgrass brome and bottlebrush squirreltail. An occasional limber pine also occurs in the area.

Water hole station
Butte County, T. 1 N., R. 25 E., Sec. 20

Most of the water holes occur in depressions of rough, broken lava (Stearns, 1963). A considerable amount of snow will fill these depressions during the winter. When the snow melts, it will drip down into crevices, where it is frozen by cold air. Because lava is a poor conductor of heat, a small amount of this ice will melt during the summer and form a pool of water, but the ice below will remain unmelted, so the water temperature seldom rises above 1.1° C. The lava on the Monument is so extensively fissured that no water is found except where it rests upon an impermeable body of ice and lava (Stearns, 1963).

Nearly all of the water holes are scattered along the Great Rift because of the depressions formed in the rift itself. Yellowjacket Waterhole was selected for study. There is no available water for some distance in the surrounding area, so this site is a gathering place for thirsty animals. Yellowjacket Waterhole is at the bottom of a deep depression consisting of rough block lava (Figs. 50 and 51). It is situated on the west side of a rough aa flow about one-half mile directly south of Crescent Butte.

The water hole itself is about three feet in diameter, and



Fig. 51. Yellowjacket Waterhole is located at the bottom of this depression.

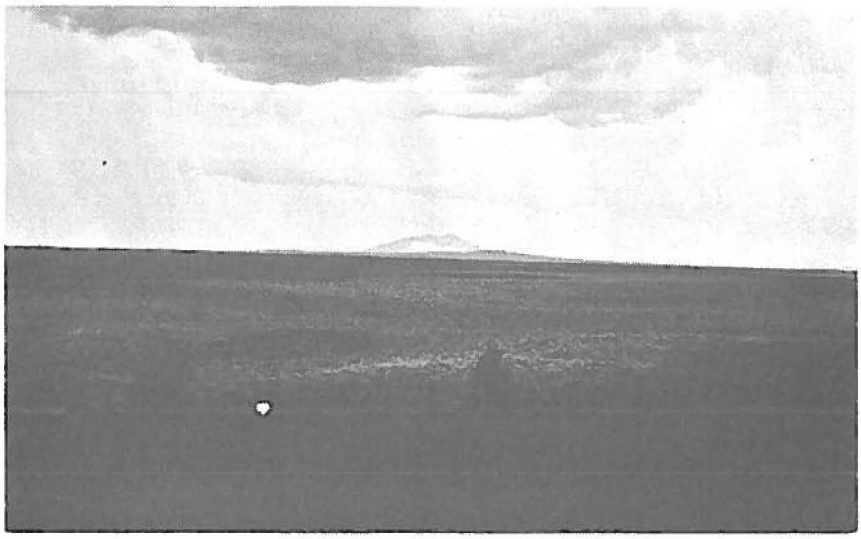


Fig. 52. Little Prairie, with Big Southern Butte in the background.

during the period of study had many feathers and dead insects floating on the surface. Vegetation around the water hole is sparse and consists of a few plants growing out of cracks in the depression. These plants include prairie junegrass [Koeleria cristata (L.) Pers.], cinquefoil, tansybush, and big sagebrush.

Little Prairie
Butte County, T. 1 N., R. 25 E.,
Sec. 20 and 21

Little Prairie, a mixed shrub community in the southeastern portion of the Monument, spreads a considerable distance over lava flows and cinders (Fig. 52). It is composed of a dense covering of shrubs with little understory (Fig. 53).

The study area is located at the western edge of the community approximately one-half mile east of Yellowjacket Waterhole. The dominant community is represented by a fairly even mixture of big sagebrush, antelope bitterbrush, and rubber rabbitbrush. Other shrubs include wax currant, and golden currant (R. aureum Pursh). The most abundant plant cover, other than shrubs, is giant wild rye. Mostly bare cinders are evident between shrubs. The few understory plants that are present include Indian ricegrass, Hood's phlox, Douglas chaenactis, sulfur eriogonum, and phacelia.

Kipuka station
Blaine County, T. 1 S., R. 24 E.,
Sec. 19 and 20

A kipuka is "an island of old land surrounded but not covered by a lava flow" (Stearns, 1963). There are several such kipukas on the Monument, but the largest undisturbed one is Carey Kipuka, located



Fig. 53. The plant cover of Little Prairie.

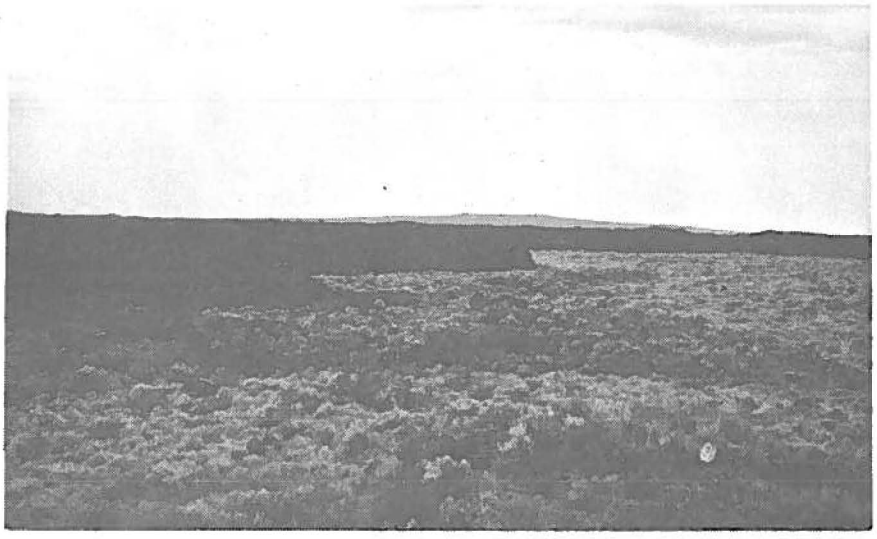


Fig. 54. The aa lava flow bordering Carey Kipuka.

approximately 11 miles southwest of headquarters and 14 miles east of Carey, Idaho. It is isolated in a very rough aa flow, with the narrowest portion of the lava about three-fourths of a mile wide (Tisdale, et al., 1965). Added to the Monument in 1962, this site is relatively untouched by fires and grazing (Figs. 54, 55, and 56).

An extensive study was made of Carey Kipuka by Tisdale, et al., in 1965. They described it as a sagebrush-grass habitat with local variations forming three recognizable plant communities, two of which occupy most of the area. The following description of the habitats is based on their work.

A threetip sagebrush (A. tripartita Rydb.)/Idaho fescue community occurs over a large part of the area, particularly on the north and east slopes and in depressions where it is cooler and moister and the soils are deep. Other plants in this community include Sandberg bluegrass, bluebunch wheatgrass, prairie junegrass, longleaf phlox (Phlox longifolia Nutt.), nodding microseris [Microseris nutans (Geyer) Schultz-Bip.], tapertip hawksbeard (Crepis acuminata Nutt.), onion (Allium acuminatum Hook.), nineleaf lomatium [Lomatium triternatum (Pursh) T. and G.], vetch (Astragalus stenophyllus T. and G.), big sagebrush, rubber rabbitbrush, Douglas rabbitbrush, and antelope bitterbrush.

The big sagebrush/Idaho fescue/bluebunch wheatgrass community is largely confined to the drier south and west slopes. Other principle plants found in this community are Sandberg bluegrass, onion, longleaf phlox, nodding microseris, and nineleaf lomatium. Plants that are present, but poorly represented, include prairie junegrass, tapertip hawksbeard, and vetch.

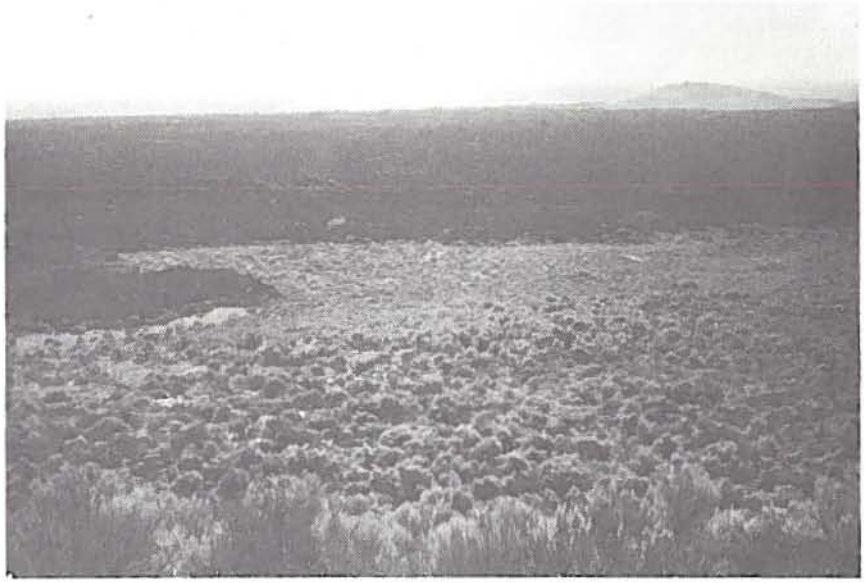


Fig. 55. The aa lava flow bordering Carey Kipuka.

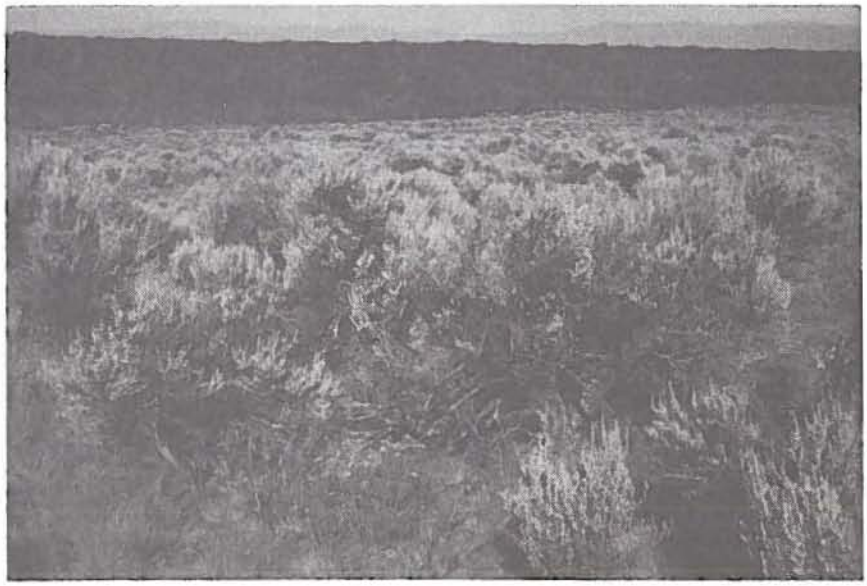


Fig. 56. Some of the plant cover on Carey Kipuka.

The sagebrush [A. longiloba (Osterhout) Beetle]/Idaho fescue/ Thurber needlegrass (S. thurberiana Piper) community is small, but it is sharply defined and edaphically determined. The vegetation is thin, the result of poor, shallow soil. The other plants are Sandberg bluegrass, bottlebrush squirreltail, pussytoes (Antennaria stenophyllus Gray), mat eriogonum (E. caespitosum Nutt.), Hood's phlox, and Beckwith violet (Viola beckwithii T. and G.).

Cheatgrass brome has invaded the kipuka in recent years, though its presence is restricted to a few small, rocky spots on top and to a couple of disturbed areas where soil test holes were dug.

Man-made structures
Butte County, T. 2 N., R. 24 E., Sec. 35

This habitat consists of the headquarters, residential area, and campgrounds. It involves such items as buildings and landscaped areas that have been directly influenced or created by man. There are several differences between this habitat and the man-made structures in Cottonwood Canyon. The location and surrounding plant communities are distinct. The headquarters area is in the midst of an ancient, disrupted cone dating from the Pleistocene (Murtaugh, 1961). The plant community is the sagebrush community typical of the cold desert region. The Martin Mine area in Little Cottonwood Canyon rests along the creek and lies in the midst of a mature aspen stand. However, the presence of man is the greatest influential factor. He is an inhabitant of the headquarters area, but only a casual visitor to Martin Mine.

CHECKLIST OF THE MAMMALS OF THE CRATERS OF THE MOON NATIONAL MONUMENT

Probably the first white men to explore the area were J. W. Powell and Arthur Ferris, both of Arco, Idaho. They were in this area in the late 1880's, looking for a source of water for cattle (Stearns, 1963). Shortly after the turn of the century, several different explorers penetrated this region, including such men as I. C. Russell (1902), H. T. Stearns (1924), and R. W. Limbert (1924). With the discoveries and observations that resulted from their work, the first records of mammals on what is now the Monument came into being. The following list is a summary of all the mammals, other than domesticated species, ever recorded in this area. Some of these mammals no longer occur on the Monument, and some observations are based solely on sight records, but these points will be discussed in the Annotated List of Species. Classification is based mainly on Miller and Kellogg (1955); the common names have been taken from Hall and Kelson (1959).

Class Mammalia

Order Insectivora

Family Soricidae

Sorex vagrans Baird — Vagrant shrew

Order Chiroptera

Family Vespertilionidae

Myotis evotis (Allen)	Long-eared myotis
Plecotus townsendii Cooper	Western big-eared bat

Order Lagomorpha

Family Ochotonidae

Ochotona princeps (Richardson)	Pika

Family Leporidae

Sylvilagus idahoensis (Merriam)	Pygmy rabbit
S. nuttallii (Bachman)	Nuttall's cottontail
Lepus americanus Erxleben	Snowshoe rabbit
L. townsendii Bachman	White-tailed jack rabbit
L. californicus Gray	Black-tailed jack rabbit

Order Rodentia
Suborder Sciuromorpha

Family Sciuridae

Marmota flaviventris (Audubon and Bachman)	Yellow-bellied marmot
Citellus columbianus (Ord)	Columbian ground squirrel
C. lateralis (Say)	Golden-mantled ground squirrel
Eutamias minimus (Bachman)	Least chipmunk
E. amoenus (Allen)	Yellow pine chipmunk
Tamiasciurus hudsonicus (Erxleben)	Red squirrel

Family Geomyidae

Thomomys talpoides (Richardson)	Northern pocket gopher

Family Heteromyidae

Perognathus parvus (Peale)	Great Basin pocket mouse
Dipodomys ordii Woodhouse	Ord's kangaroo rat

Family Castoridae

Castor canadensis Kuhl	Beaver

Suborder Myomorpha

Family Cricetidae
Subfamily Cricetinae

Reithrodontomys megalotis (Baird)	Western harvest mouse
Peromyscus maniculatus (Wagner)	Deer mouse
Neotoma cinerea (Ord)	Bushy-tailed wood rat

Subfamily Microtinae

Microtus montanus (Peale)	Montane vole
M. longicaudus (Merriam)	Long-tailed vole
Ondatra zibethicus (Linnaeus)	Muskrat

Family Zapodidae

Zapus princeps Allen	Western jumping mouse

Suborder Hystricomorpha

Family Erethizontidae

Erethizon dorsatum (Linnaeus)	Porcupine

Order Carnivora

Family Canidae

Canis latrans Say	Coyote
Vulpes vulpes Linnaeus	Red fox

Family Ursidae

Euarctos americanus Pocock	Black bear
Ursus horribilis Ord	Grizzly bear

Family Procyonidae

Procyon lotor (Linnaeus)	Raccoon

Family Mustelidae

Mustela erminea Linnaeus	Ermine
M. frenata Lichtenstein	Long-tailed weasel
Taxidea taxus (Schreber)	Badger
Spilogale gracilis Merriam	Western spotted skunk
Mephitis mephitis (Schreber)	Striped skunk

Family Felidae

Felis concolor Linnaeus	Mountain lion
Lynx rufus (Schreber)	Bobcat

Order Artiodactyla

Family Cervidae

Cervus canadensis Erxleben	Wapiti
Odocoileus hemionus (Rafinesque)	Mule deer

Family Antilocapridae

Antilocapra americana (Ord)	Pronghorn

Family Bovidae

Bison bison (Linnaeus)	Bison
Ovis canadensis Shaw	Mountain sheep

ANNOTATED LIST OF SPECIES

Included under each species is a discussion of its occurrence on the Monument, its ecological distribution, and its relative abundance as determined by this study. Probable mammalian sign is noted wherever it is significant.

Sorex vagrans Baird.--Vagrant shrew. Previously unknown on the Monument, the presence of shrews was hypothetical. On 13 June 1968, a female was collected in a small lava tube about six inches in diameter in North Crater Flow. The only vegetation present was some small penstemons. Although more common in areas with available water (Larrison, 1967), this shrew was also found in drier localities (Davis, 1939). This specimen, the only one collected to date, was found at least one-half mile from the nearest water supply.

Myotis evotis (Allen).--Long-eared myotis. On 9 and 10 July 1939, Davis (1939) collected this species of bat in Great Owl Cavern, which is a lava tube about 400 feet long, 40 feet high, and 50 feet wide, with water dripping from the walls and ceiling.

M. evotis is a species that is not gregarious and is commonly found singly or in small groups (Davis, 1939; Larrison, 1967). As a result, few records are available of its roosting and hibernation habits. Those bats in Great Owl Cavern were evidently attracted to that locality because it was the only water available for miles, according to Davis

(1939), who also stated that this was his first experience of this species roosting in a cave.

During the summer, bats are common during dusk near the headquarters area and in Little Cottonwood Canyon. The water of the lava tubes, campgrounds, and Little Cottonwood Creek, as well as an abundance of flying insects, would probably draw them to the area. There were no specimens collected.

Plecotus townsendii Cooper.--Western big-eared bat. More nocturnal than other bats, this species does not become active until late dusk (Larrison, 1967). These bats will roost in clusters in caves, mine shafts, buildings, and hollow trees. Habitat preferences away from roosts are unknown (Palmer, 1954).

The earliest record of a specimen taken on the Monument was one collected in Needles Cave and identified by G. S. Miller, Jr., of the Smithsonian Institute as Corynorhynus rafinesquii Thomas. Plecotus, according to Handley (1959), has priority over Corynorhynus, now regarded as a subgenus. Also, I believe that P. townsendii is the species on the Monument, because the distribution of P. rafinesquii is in the southeastern United States. A big-eared bat was found clinging to a limber pine growing on the west side of Echo Crater, as reported by Newman (1958), and Handley (1959) examined one specimen of P. townsendii from the Monument.

I observed bats that were active after dark until nearly midnight on warm summer nights. If the literature previously mentioned is correct, then this species was probably the one seen. At any rate, bats are common on the Monument, although little is known about them.

Ochotona princeps (Richardson).--Pika. This species is usually found in subalpine areas on rock slides and talus slopes high in the mountains near timber line (Burt and Grossenheider, 1964; Larrison, 1967). However, the pika occurring on the Monument is a desert-dwelling race described as the subspecies O. p. goldmani by A. H. Howell (1924). The type specimen was taken from Echo Crater on 21 August 1924, and other specimens were examined by Davis (1939) from Grassy Cone, Great Owl Cavern, and Fissure Butte.

The pika occurs in old lava flows throughout the area, and has been observed at least three times since 1966 on North Crater Flow. Larrison (1956) believes that another race, O. p. lemhi, may occur in the rock outcroppings above Little Cottonwood Creek, but this is still hypothetical.

Although they have been reported from several different sites in the Monument, they were not abundant during 1968. I found some old piles of vegetation in North Crater Flow and on Echo Crater, the type locality, but no fresh sign or animals were seen, and no specimens were taken.

Sylvilagus idahoensis (Merriam).--Pygmy rabbit. The sagebrush-grass zone of the Great Basin, including southern Idaho and the Monument, comprises the habitat of this animal. It prefers areas where "tall sagebrush grows densely" (Hall and Kelson, 1959).

On the Monument, this species occurs where the flows are the oldest, or at least where the shrubs are plentiful and well developed. Also, ecotones formed by the meeting of shrub communities and lava flows are favorable locations. Davis (1939) examined one specimen from the south base of Grassy Cone. A pygmy rabbit was observed on 17 July 1963

behind the residential area and another was found dead on Highway 93-A next to the northeast entrance sign on 15 March 1966 (Superintendent's Monthly Narrative Reports, 1966).

These are the only three validated records of occurrence, so the pygmy rabbit does not appear to be common in the area. No specimens were collected.

Sylvilagus nuttallii (Bachman).--Nuttall's cottontail. A resident of sagebrush and timbered areas, the cottontail normally seeks refuge in thickets and rock piles (Davis, 1939).

Sight records of this species are sporadic, beginning with Stearns (1928) who did not differentiate between S. nuttallii and S. idahoensis. Blossom (1937a) also listed its occurrence. The next record was made in 1960 by F. O. Henderson (Superintendent's Monthly Narrative Reports), who mentions the identification of five specimens.

Burt and Grossenheider (1964) state that this is the only cottontail over most of its range. Although this species shares part of its habitat with the pygmy rabbit, I recorded more sightings of S. nuttallii than any other rabbit or hare. Four individuals were observed on 11 July 1968 on Carey Kipuka; two were seen on 17 July 1968 in a limber pine/sagebrush community along the Great Owl Cavern road; one was found in a limber pine/bitterbrush community north of Devil's Orchard on 21 July 1968; another was seen on the Loop Drive on 23 July 1968 on the east side of Inferno Cone; and one animal was collected along the fire access road on 31 July 1968 in a pahoehoe flow one-half mile south of Broken Top. There were no specimens taken.

Lepus americanus Erxleben.--Snowshoe rabbit. Secretive in nature, these rabbits are normally found in meadows, thickets, and forests of the mountainous parts of the state (Davis, 1939).

Records of occurrence on the Monument are few. Stearns (1928) lists them as one of the common mammals of the area. A. T. Bicknell reports seeing them in 1935 (Superintendent's Monthly Narrative Reports). Larrison (1956) mentions sight records as well as scats found in the aspen groves near Little Cottonwood Creek.

The occurrence of this animal is probably restricted to the Cottonwood Canyon area, except in winter. They are probably more plentiful than the records indicate, but it is doubtful that they are abundant. There were no specimens collected.

Lepus townsendii Bachman.--White-tailed jack rabbit. Largest of the hares in Idaho, this species has a fairly uniform distribution throughout its range (Davis, 1939). Generally its range extends to higher altitudes than that of the black-tailed jack rabbit. It is most common in areas of grass and scattered shrubs between the sagebrush communities of the Snake River Plain and the mountain forests (Larrison, 1967). It will range to the higher elevations during the summer and descend to the lower valleys and foothills during the winter, where it may be found with the black-tailed jack rabbit.

This animal does not seem to be plentiful anywhere in its range. Records of occurrence on the Monument are few. Larrison (1956) reports scats collected in rock outcroppings on the high ridges in the Cottonwood Canyon area, and a possibility of their presence in the high grassy areas. Another was observed on 14 January 1960 in Little Cottonwood

Canyon (Field Observations, 1960). One specimen was found dead on U. S. Highway 93-A at the base of Grassy Cone on 1 August 1968. No specimens were taken.

Lepus californicus Gray.--Black-tailed jack rabbit. A species of sagebrush areas and foothills, it is found at lower elevations than L. townsendii (Whitlow and Hall, 1933; Davis, 1939).

This species is uncommon on the Monument. Larrison (1956) states that it occurs mainly in sagebrush areas around the edges of the Monument where there is little lava. The only published record on the Monument is Stearns (1928). I saw one specimen on 11 August 1968 along the road to Carey Kipuka in a sagebrush area just south of the Monument boundary.

Marmota flaviventris Audubon and Bachman.--Yellow-bellied marmot. These animals occur in rocky outcroppings, lava fields, and alpine talus slopes (Larrison, 1967). They are abundant in lava fields of the Snake River Plain, as one can see along U. S. Highway 93-A from the Monument to Arco.

Scattered throughout the Monument, marmots are abundant in the lava flows where the vegetation is growing. Limbert (1924), Stearns (1928), and Blossom (1937a) report seeing rockchucks or woodchucks. Davis (1939) collected a skull and a specimen from the mouth of Little Cottonwood Canyon. Observation records of marmots have been made almost annually in the Park Service files from the time of their inception.

I observed several marmots living on a rock outcropping just above headquarters most of the summer. One specimen was collected as a road kill just outside the east boundary on 9 June 1968.

Citellus columbianus (Ord).--Columbian ground squirrel. The largest member of this genus in Idaho, C. columbianus occupies a wide range of habitats, including prairies and mountainous areas. Apparently they prefer rough, rocky, partially forested hillsides, and favor living in colonies (Howell, 1938).

The greatest number of C. columbianus was observed near the creek. A large colony was found at the edge of the quaking aspen stand on the south fork of Little Cottonwood Creek, and another was above the beaver dam on the north of main fork of the creek. Both colonies had burrows in banks that were covered with sagebrush. Two specimens were collected. One was taken at its burrow in the old road above Martin Mine on 5 June 1968, and the other was collected in the sagebrush area bordering the eastern edge of the grassy flat on 26 June 1968.

Citellus lateralis (Say).--Golden-mantled ground squirrel. This mammal is often mistakenly called a chipmunk. It occupies mountain slopes and foothills, living in rocky, sparcely timbered areas (Howell, 1938; Larrison, 1967).

Distributed over much of the state, C. lateralis is a frequent visitor to forest camps and parks. In Craters of the Moon National Monument, they are abundant in the campground, and have come to be somewhat of a nuisance in the residential area by burrowing in the lawns and eating cultivated plants. Records are available in the Superintendent's Monthly Narrative Reports for 1934, 1935, 1936, 1950, 1951, 1952, and 1953. Field Observations list 1962, 1963, and 1964, and the Temporary Observation files contain records for 1965 and 1967. Davis collected four animals in 1939, and Blossom (1937a) also reported their presence.

I collected three specimens, all from the residential area.

When Larrison (1956) made his observations of C. lateralis, he noted that they were scarce outside of the visitors' area. During 1968, I observed a golden-mantled ground squirrel at the mouth of Cottonwood Canyon on 14 June, one on 14 August on the north slope of Broken Top, on 15 August on Trench Mortar Flat, and another at Yellowjacket Waterhole on 27 August. Also, there are areas in Trench Mortar Flat and on Echo Crater with signs that are possibly those of C. lateralis.

Eutamias minimus (Bachman).--Least chipmunk. This mammal predominantly inhabits the sagebrush plains, but commonly ascends into adjacent foothills (Howell, 1929). In addition, Davis (1939) believes that their presence may be correlated with the presence of basaltic outcroppings, which is certainly the case on the Monument.

Although the National Park Service files at the Monument are full of sight records, none of them give any confirmation of identification other than the genus. The only record of E. minimus collected in the area was reported by Davis (1939) who examined two specimens, one from the southern portion of the Monument in Blaine County, the other from the north base of Sunset Cone. The Field Observations for 1962, 1963, and 1964 assert that E. minimus was observed, but I feel that this is doubtful. None of the total number of specimens collected during the summer of 1968 was E. minimus. Larrison (1956) states that this animal occurs in the sagebrush areas around the edges of the Monument. Probably E. minimus is the less common chipmunk on the Monument.

Eutamias amoenus (Allen).--Yellow pine chipmunk. Chipmunks are

second in abundance only to deer mice. According to the experience of Hall and Kelson (1959), the habitat of E. amoenus always includes conifers. However, many of the sight records made during the summer of 1968 were secured in areas some distance from coniferous stands. I observed chipmunks in every habitat studied, except the Elymus station, Carey Kipuka, and Arco Tunnel. E. amoenus has been collected on several occasions.

Two subspecies have been determined for the Monument, E. a. amoenus and E. a. cratericus. The latter is believed to be endemic to the area. The type locality for E. a. cratericus is Grassy Cone. This subspecies, a resident of the lava beds, was described by Blossom (1937b), who examined specimens from Grassy Cone, Sunset Cone, Broken Top, and the public campgrounds. Davis (1939) examined specimens from Grassy Cone and Sunset Cone.

E. a. amoenus was described by Howell (1929), who examined a specimen from Echo Crater. Davis (1939) also examined a specimen from the same locality. Thirty of the specimens collected by me were determined to be E. a. amoenus (J. A. White, personal communication).

Tamiasciurus hudsonicus (Erxleben).--Red squirrel. The distribution of this typically arboreal mammal coincides closely with the distribution of coniferous forests in Idaho (Davis, 1939).

Stearns (1928) mentions the pine squirrel in his list of the "common varieties" of mammals on the Monument, and Blossom (1937a) states that red squirrels of the genus Tamiasciurus are "few." Records for 1935, 1950, 1951, and 1957 all mention pine squirrels or tree squirrels (Superintendent's Monthly Narrative Reports). Evidently

T. hudsonicus is the animal referred to in these reports. Field Observations lists additional reports. A specimen was seen above Martin Mine in 1959, and several were observed in Devil's Orchard during 1963 and 1964.

I observed two red squirrels on 9 July 1968 in the Douglas fir stand above Martin Mine and another was seen on 10 July 1968 in the conifers on Grassy Cone. One individual was seen in the Douglas fir stand on 1 August 1968 and a specimen was collected in the same locality on 27 September 1968.

These animals are common in the Douglas fir stands in the Monument. No T. hudsonicus was found outside of these areas. However, reports in other years record observations in other parts of the Monument (Superintendent's Monthly Narrative Reports, 1951 and 1957; Field Observations, 1963 and 1964).

Thomomys talpoides (Richardson).--Northern pocket gopher. Gophers are likely to occur in deserts, prairies, open forests, grasslands and meadows (Palmer, 1954). Widely distributed throughout Idaho, these animals may be found in soils suitable for burrowing (Larrison, 1967).

Records of occurrence on the Monument are few, probably because gophers usually go unnoticed by many people. Stearns (1928) mentions them, and Blossom (1937a) says that they are common on the margin of the lava. Larrison (1956) took specimens from along Little Cottonwood Creek, and found a population of gophers in the cinders area of the central and southern parts of the Monument. I found numerous diggings along the creek, on the ridge just west of the young aspen stand, in the

mixed shrub community above Little Cottonwood Canyon, and in the mature aspen stand. Three specimens were collected just below the mine along the Martin Mine road near Little Cottonwood Creek on 14 June 1968, and one was taken in one of the sunken grassy spots in the ancient lava flow extending south of the Elymus station. No evidence of pocket gophers was seen south of U. S. Highway 93-A.

Little is known about the gophers on the Monument, except that they are scattered throughout the area and are fairly common. Studies on the Monument are needed on these animals, especially in view of the fact that so many subspecies occur throughout their entire geographical range.

Perognathus parvus (Peale).--Great Basin pocket mouse. Occurring throughout the arid parts of southern Idaho, this small mouse favors open, desert flats (Larrison, 1967).

The Monument is the type locality for the subspecies P. p. idahoensis, which was described by Goldman (1922). Davis (1939) examined specimens from both the type locality of Echo Crater and the mouth of Little Cottonwood Canyon, and feels that this subspecies is apparently restricted to the lava flows north of the Snake River.

Blossom (1937a) reported pocket mice of the genus Perognathus as "common." Larrison (1956) stated that P. parvus is common throughout the Monument, and are especially abundant in the brushy pahoehoe lava. However, I collected only one specimen; it was taken on 29 August 1968 on Little Prairie. The population density of this species may have been low during 1968.

Dipodomys ordii Woodhouse.--Ord's kangaroo rat. This mammal is restricted to the southern part of the state in arid or semi-arid regions, and prefers sandy soils (Larrison, 1967).

Blossom (1937a) mentions the presence of Dipodomys in Laidlow Park a few miles southwest of the Monument, the closest record of incidence to this area.

One specimen was found dead in the Spatter Cones parking lot by Park Naturalist D. L. Carter on 7 April 1968. However, because of the circumstances under which this specimen was found, the surrounding environment, and the lack of any other record, I do not consider that it provides a valid record of occurrence.

Castor canadensis Kuhl.--Beaver. Beavers, our largest rodents, inhabit streams and waterways throughout the state. This animal is a newcomer to the area since it became a national park. The first specimen was found as a road kill by Superintendent A. F. Houston on U. S. Highway 93-A near the eastern boundary in May, 1950 (Superintendent's Monthly Narrative Reports).

It was a few years before the next record appeared. Newman (1958) says: "Surprising as it may seem, fresh beaver cuttings on aspen and willows were found in June, 1956, on Little Cottonwood Creek above the water supply source. Whether the beavers have established themselves permanently in the stream is not known. Over a point of the Pioneer Mountains to the west is Big Cottonwood Creek, and beavers are found there in rather large numbers and the cuttings may have been made by a straggler from this group."

Subsequent records were made in 1963, 1964, and 1966 (Superintendent's Monthly Narrative Reports). On 10 September 1964, beaver moved downstream and dammed the entrance to a mineshaft and flooded it with water. The beaver still live in this mineshaft, although they have built two or three secondary dams below the main one. There is only one colony on the Monument.

Reithrodontomys megalotis (Baird).--Western harvest mouse. This small mouse occurs in grassy areas in the dry lowlands and desert plateaus throughout southern Idaho (Larrison, 1967). Larrison (1956) listed it as a hypothetical species on the Monument. The first specimen known in the area was collected by Wayne B. Whitlow on 22 August 1968 on Crescent Butte. This animal was taken on the cinder slopes inside the crater bowl, a site characterized by dense vegetation. Insufficient study may account for the lack of any previous record of this species in the area. However, R. megalotis is probably not common on the Monument.

Peromyscus maniculatus (Wagner).--Deer mouse. Osgood (1909) said of the genus Peromyscus that "one or more of its numerous species inhabit almost every part of North America; moreover, these mice, wherever found, are among the most abundant of small mammals." The most common mammal in Idaho, P. maniculatus is said by Larrison (1967) to be most numerous in the sagebrush-grass habitat and less common in grassy areas.

Although practically ubiquitous on the Monument, there are surprisingly few records of occurrence. The early records were secured by Blossom (1937a) and Davis (1939). Larrison (1956) stated that they are common, except in grassy areas. Superintendent's Monthly Narrative

Reports (1964) records deer mice as nuisances, and Field Observations (1962, 1963, and 1964) reports them as "common throughout the year."

Their abundance can hardly be exaggerated: 548 deer mice were trapped (approximately six times more than all other species combined), and I could collect them almost at will any evening after dusk in any habitat. The fewest specimens for any habitat studied were taken in the Elymus station, which yielded only seven deer mice. A total of 97 specimens were retained. Table 3 gives an index for the deer mice captured in each habitat/100 trap nights.

Neotoma cinerea (Ord).--Bushy-tailed wood rat (Fig. 57). The presence of these animals can be detected by the presence of copious urine deposits, abundant droppings, and a distinctive, musky odor (Larrison, 1967). Wood rats in Idaho commonly occur in rocky situations. Basaltic cliffs, natural caves, old mine tunnels, and deserted buildings are favorite haunts (Davis, 1939).

Plentiful on the Monument, wood rats occur in craters and caves on the flows, andthe Superintendent's Monthly Narrative Reports for 1935 mention their presence. Observation Records from 1961, 1963, and 1964 state that "evidence is widespread throughout the Monument." I observed many individuals in the broken crater walls and in the abandoned buildings in Little Cottonwood Canyon. Nine specimens were collected.

Microtus montanus (Peale).--Montane vole. Most voles occurring on the plains of the Snake River are this species, according to Larrison (1967), who also says that voles are subject to cyclic variations in abundance, a phenomenon which can be seen on the Monument. The

Table 3. The number of Peromyscus maniculatus per 100 trap nights in each habitat studied, except for man-made structures.

Habitat	Trap Nights	No. of specimens	Per cent success
Aa lava			
Split Butte	27	17	63
North Crater Aa Flow	375	36	10
Carey Kipuka	75	42	56
Craters			
Crescent Butte	84	41	49
Echo Crater	88	28	32
Trench Mortar Flat	50	24	48
Coyotte Butte	50	22	44
Limber pine community	150	64	43
Little Prairie	50	21	42
Pahoehoe lava flow	161	62	39
Douglas fir community	135	34	25
Broken crater walls	100	20	20
Mature cinder cone	252	43	17
Young cinder cone			
Unnamed young cinder slope	56	9	16
Broken Top	100	10	10
Mixed shrub slope			
Slope No. 1	75	12	16
Slope No. 2	100	12	12
Yellowjacket waterhole	50	7	14
Lava tubes	58	7	12
Mature aspen community	150	14	9
Stream and pond margin	110	9	8
Young aspen community	100	8	8
Elymus community	151	7	5

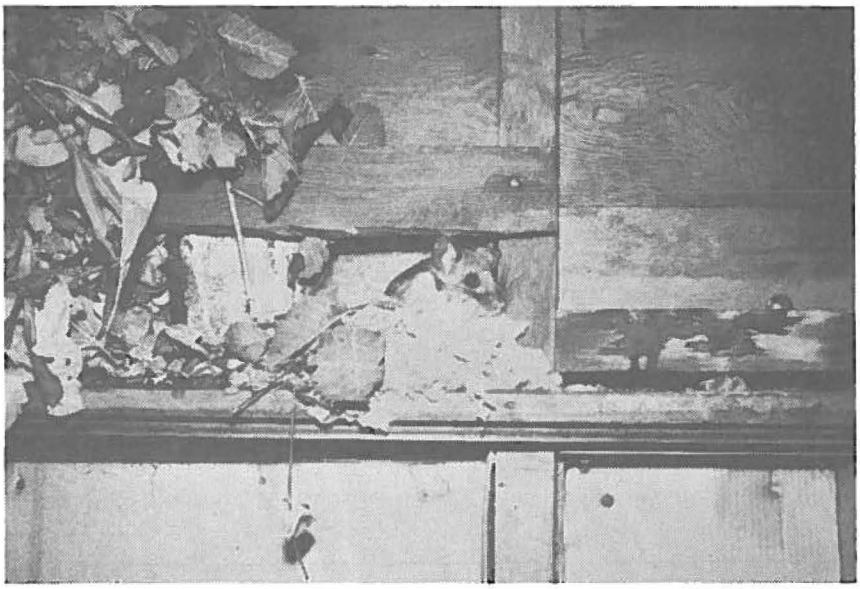


Fig. 57. A bushy-tailed wood rat in the abandoned cabin at Martin Mine.



Fig. 58. A deer trail on Inferno Cone.

The Superintendent's Monthly Narrative Reports for 1964 states that Microtus were abundant during that year and may have been responsible for the damage to shrubs and lawns around the Visitor's Center. In contrast, only 16 Microtus were collected during the summer of 1968.

Blossom (1937a) first reported Microtus in the area and stated that they were "common." Larrison (1956) mentions that M. montanus occurs in the volcanic areas. In 1968, I collected one specimen of M. montanus on 9 June in North Crater Aa Flow, one on 14 June along Little Cottonwood Creek, two on 26 June on the Elymus station, one on 3 July in the residential area, and one on 23 August on Crescent Butte. These six animals were the only specimens of M. montanus taken. The range of these voles extends throughout the Monument.

Microtus longicaudus (Merriam).--Long-tailed vole. Occurring in a variety of habitats, this vole is essentially a boreal species, generally occurring at higher elevations than M. montanus. The range of distribution on the Monument is essentially the same as M. montanus, including cinder areas overgrown with grass (Larrison, 1956).

Davis (1939) examined one specimen from Grassy Cone. This is the only record of the species prior to Larrison's (1956 report. Other records include those given for M. montanus, which mention only the genus Microtus. I collected 10 specimens, five from Grassy Cone, two from the mature aspen stand, and one each from Little Cottonwood Creek, the young aspen stand, and Echo Crater. Davis (1939) postulates that M. longicaudus may crowd out M. montanus at higher elevations because it is better adapted to these conditions. It is questionable whether or not differences in altitude of the Monument are sufficient to allow such a spatial

relation, but most of the records are for M. longicaudus. At any rate, the genus Microtus on the Monument presents an interesting problem for further study.

Ondatra zibethicus (Linnaeus).--Muskrat. Large, aquatic microtines, these rodents occur throughout Idaho and, indeed, all of North America in ponds, lakes, marshes, and streams (Booth, 1950; Larrison, 1967).

There is only one record of occurrence for this species on the Monument. Superintendent F. A. Henderson reported the incident as follows: "A muskrat was seen several times during the week of October 23 on the lawn of residence 22B where it was eating grass and using the area underthe fire hose house as a shelter. It is not known why the animal selected this area for a visit" (Superintendent's Monthly Narrative Reports, 1961). The presence of this individual was apparently fortuitous; however, a muskrat might establish itself in Cottonwood Creek.

Zapus princeps Allen.--Western jumping mouse. This is the only species of jumping mice known to occur in Idaho. They are usually found in the vicinity of water and are unable to live in true desert conditions (Davis, 1939).

Larrison (1956) observed a specimen on 25 June 1956 in the lush vegetation along Little Cottonwood Creek. Two specimens were collected by Wayne B. Whitlow on 14 June 1968 in the grass along Little Cottonwood Creek a short distance below Martin Mine. These are the only records of this species on the Monument. This species is probably restricted to the Cottonwood Canyon area where water is readily available.

Erethizon dorsatum (Linnaeus).--Porcupine. Found throughout Idaho, the porcupine's range coincides closely with the distribution of coniferous forests, although it often occurs in non-timbered areas if sufficient food is available.

Porcupines have evidently been more plentiful on the Monument than they are now because the early records describe considerable damage done to trees and a number of animals killed as nuisances (Superintendent's Monthly Narrative Reports, 1927, 1928, 1930, 1932, 1933, and 1935). Additional records include Stearns (1928), Blossom (1937a), Larrison (1956), and Field Observations (1959, 1961, and 1962). I found quills and droppings in Little Cottonwood Canyon during 1968. Eddie O. Huckins sighted two animals; one was seen on 24 August 1968 at the mouth of the canyon, the other on Little Cottonwood Creek just below Martin Mine on 28 August 1968.

According to the reports, porcupines are found in wooded areas scattered throughout the Monument.

Canis latrans Say.--Coyote. Found throughout the state in a variety of habitats, coyotes are most common on the sagebrush plains of southern Idaho (Davis, 1939; Larrison, 1967).

Records of occurrence on Craters of the Moon National Monument are plentiful, with the earliest ones reported by Limbert (1924) and Stearns (1924 and 1928). Other records include those of Blossom (1937a) and Larrison (1956). The park service files contain records from Superintendent's Monthly Narrative Reports (1935, 1936, 1937, 1946, 1947, 1960, 1966, and 1967), Field Observations (1962 and 1964), Monthly Interpretive Report (1962), and Temporary Observation files (1966). I

found tracks and droppings on Carey Kipuka on 11 July 1968.

Throughout the years there have been extensive control campaigns against the coyote (Larrison, 1967). In the winter of 1937 and 1938 the State of Idaho trapped and poisoned heavily around the boundaries of the Monument, killing many coyotes (Superintendent's Monthly Narrative Reports, 1938). This greatly reduced the number of animals in the area, but in spite of such measures, C. latrans is a common mammal in the Monument.

Vulpes vulpes Linnaeus.--Red fox. Since the work of Miller and Kellogg (1955), the species V. fulva of North America has been determined to be conspecific with V. vulpes of Asia and Europe (Churcher, 1959).

Found in the mountainous part of the state, red foxes usually occur in or near moist coniferous forests (Davis, 1939; Larrison, 1967). Previously unknown from the Snake River Plains, these animals have increased in density in some plains areas beginning about 1960, according to Fichter and Williams (1967), who also state that several accounts offer evidence of the "movement by foxes away from the coniferous forests of the mountains and even into the cool desert of the foothills and the Snake River Plain."

To date, there is no positive record of V. vulpes occurring on the Monument. Russell (1902) states that foxes visit the plains of this area, and Blossom (1937a) reports that they are "not common on lava." Larrison (1956) mentions that foxes are "reported from the Monument," but there is no sight record or specimen reported anywhere in the literature. However, with the recent increase in numbers and the extension of its range, a valid record of V. vulpes on the Monument may become a reality

in the future.

Euarctos americanus Pocock.--Black bear. Although not often seen, these bears are common in forested and mountainous areas, and some have been seen and captured on the lava beds in the Snake River Plains (Davis, 1939; Larrison, 1967).

In spite of the fact that E. americanus may have once been a resident on or a regular visitor to the area, invasion by man has made their appearance uncommon on the Monument. Stearns (1924, 1928) states that the caves and caverns were once favorite places in which bears would "hole up." Limbert (1924) also mentions black bears, but the best records are in the Superintendent's Monthly Narrative Reports. A black bear was seen in June 1929 just outside the east entrance of the Monument. Two signs of bear were seen about eight miles south of headquarters in April, 1934, and a bear, judged to be two years old, was seen in Little Cottonwood Canyon on 3 May 1934; the June 1934 report states that this same bear had been seen several times in the same area. No other observation was made until September 1964, when a two-year-old was killed within a quarter mile of the Monument boundary.

Because of the increasing number of visitors each year, bears will be less likely to occur on the Monument. However, Larrison (1956) suggests that E. americanus is somewhat more common in the adjacent lava areas.

Ursus horribilis Ord.--Grizzly bear. Formerly widespread throughout Idaho, the grizzly bear is now confined to the wilder regions of the mountains of the state (Davis, 1939; Larrison, 1967).

Several old records exist of its occurrence in the lava beds of the Snake River Plain. Before the Monument was created, Era Martin reported that he had killed several black and grizzly bears in the vicinity of the Monument (Stearns, 1928). Limbert (1924) states that grizzly bears were inhabitants of the Monument and that he had found fresh signs of grizzlies. Whether he actually saw an animal is not known. Blossom (1937a) reports that the grizzly bear was last seen on the lava in 1915.

Although grizzly bears were once present, they are now extinct on the Monument. None are known to persist in the Snake River Plains (Larrison, 1956), and the occurrence of U. horribilis in the Monument at any time in the future is doubtful.

Procyon lotor (Linnaeus).--Raccoon. Usually found near water-courses throughout forested areas, raccoons favor deciduous stands, although specimens have been reported in basaltic outcroppings and sagebrush areas in southern Idaho (Larrison, 1967).

The only record of raccoons on the Monument is a mature individual seen crossing U. S. Highway 93-A, 500 yards inside the east boundary in August 1961 (Field Observations). Raccoons are not common in the area and may be only casual visitors.

Mustela erminea Linnaeus.--Ermine. This mammal is a fairly common carnivore at lower elevations, and may be found in rock piles and slides, according to Larrison (1967), who also states that it is usually replaced by M. frenata at higher altitudes in the more rugged mountains.

Weasels are said to be common animals on the Monument. Blossom (1937a) collected a weasel; the Superintendent's Monthly Narrative

Reports (1934, 1935, 1936, 1960, and 1966) mention weasels; additional records may be found in the Temporary Observation files (1968). However, none of these reports offer further identification. Sightings of M. erminea are mentioned in the Superintendent's Monthly Narrative Reports for 1959 and 1961, and there is one sight record for this species in the Temporary Observation file 1968.

The accuracy of these observations may be questionable, since they were all sight records. On 2 August 1968, I found a weasel dead on the road in Little Cottonwood Canyon within the Douglas fir stand and identified it as M. erminea.

Mustela frenata Lichtenstein.--Long-tailed weasel. Sub-alpine rock slides in partially open or forested areas will harbor these animals which occur throughout the state (Larrison, 1967).

Records include those mentioned for the genus Mustela discussed in the account of M. erminea. Observations of M. frenata include Field Observations (1964), Superintendent's Monthly Narrative Reports (1964), and the Temporary Observation files (1965 and 1967). All of these sightings were made near the residential area. Whether or not the weasels seen were M. frenata is not known. There is no positive record of this animal on the Monument. Larrison (1956) lists it as a hypothetical species. However, it is likely that M. frenata is present, possibly fairly common, when one considers that weasels are seen. There is a need for a study of the status of weasels in this area.

Taxidea taxus (Schreber).--Badger. This mammal is widely distributed in the southern half of the state (Davis, 1939). Badgers occur from timberline to the most arid plains, but they are usually most

abundant in open sagebrush plains (Larrison, 1967).

Although not abundant the badger is fairly common on the Monument. Records include the Superintendent's Monthly Narrative Reports (1937, 1946, 1954, and 1966), Field Observations (1961, 1962, and 1963), and Temporary Observation files (1966). Blossom (1937a) mentions Taxidea, and Larrison (1956) found sign and one specimen. Three animals were seen crossing U. S. Highway 93-A at the east boundary by the maintenance crew on 9 July 1968.

Because nearly every report mentions a different site, including the residential areas and Little Cottonwood Canyon, badgers are likely to occur anywhere on the Monument. However, Davis (1937) felt that the number of badgers was declining, due to poison campaigns against the coyote. The population in this area may have stabilized now, since this practice has been discontinued around the Monument, at least for awhile.

Spilogale gracilis Merriam.--Western spotted skunk. Occurring throughout Idaho, except in the northern panhandle, spotted skunks are found most commonly along streams, especially in the vicinity of basaltic outcroppings and rock piles (Davis, 1939; Larrison, 1967).

S. gracilis is reported by a number of workers, but only one actual sight record is available on the Monument. Russell (1902), and Stearns (1928) both mention the presence of skunks in the area, but it is not known whether they are referring to S. gracilis or Mephitis mephitis. Blossom (1937a) states that Spilogale has been "reported," and Larrison (1956) says that it has been "reported by several persons as occurring in the lava beds areas." The only observation was by Superintendent A. F. Houston, who told about a spotted skunk living

under one of the cabins (Superintendent's Monthly Narrative Reports, 1951).

These animals may be more common than we realize, although they are seldom seen because of their nocturnal habits.

Mephitis mephitis (Schreber).--Striped skunk. Widely distributed throughout Idaho, striped skunks prefer forested areas near water (Larrison, 1967).

Other than the references listed in the previous account, only one record is known for the striped skunk on the Monument. Blossom (1937a) states that they have been reported from the area. I briefly observed a skunk on 1 August 1968 along Little Cottonwood Creek just below Martin Mine. Although it appeared to be a striped skunk, this is not a positive record.

M. mephitis is not as common in southern Idaho as S. gracilis (Larrison, 1967). It is likely that they do occur on the Monument, but they are probably not abundant.

Felis concolor Linnaeus.--Mountain lion. Rarely found in the vicinity of the habitations of man, this species has a scattered distribution throughout the mountainous areas of the state (Davis, 1939; Larrison, 1967).

The first record of mountain lions on the Monument was secured by A. T. Bicknell in 1935 (Field Observations). On 9 July 1962, another one was seen at the mouth of Little Cottonwood Canyon pursuing a deer; three more observations were made during September of that year. A mountain lion was seen on 30 June 1964 stalking a deer on Inferno Cone, and

Superintendent Paul Fritz found mountain lion tracks in the snow in Little Cottonwood Creek drainage on 30 November 1966 (Superintendent's Monthly Narrative Reports). During the winter of 1967-1968, Floyd Standlee saw an individual while plowing snow on the Monument.

Mountain lions may be considered as casual on the Monument. Since they feed primarily on deer, which are abundant in the area, two animals could possibly live on the Monument, unless man or some other factor would keep them away.

Lynx rufus (Schreber).--Bobcat. Common in southern Idaho, bobcats occur locally in mixed timber, partially open forests, and in broken terrain of the desert regions (Davis, 1939; Larrison, 1967).

Reported abundant in the lava fields north of the Snake River (Davis, 1939), bobcats are fairly commonly seen on the Monument. Early records of occurrence of this species include those of Stearns (1928) and Blossom (1937a). Larrison (1956) saw three individuals near the northwest edge of Sunset Cone, and found scats in the central part of the Monument. Superintendent's Monthly Narrative Reports include observations on the roads and trails (1946, 1947, and 1951), in Little Cottonwood Canyon (1960 and 1966), in the pahoehoe lava approximately halfway between Great Owl Cavern and the tree molds (1964), and additional records for 1935, 1936, and 1960. A bobcat was seen by a visitor, David DuVal, near the Great Owl Cavern parking lot on 6 June 1968.

Cervus canadensis Erxleben.--Wapiti. Found in the mountainous regions of the state, this species usually inhabits forested areas where the timber is not heavy (Larrison, 1967).

The presence of wapiti on the Monument is uncommon. Blossom (1937a) reports that a few have occurred in the mountains near the margin of the lava. Some droppings of wapiti were found along the northern boundary by men from the Idaho Fish and Game Department on 29 September 1959 (Superintendent's Monthly Narrative Reports), and on 3 August 1963 five head were seen by miners on the ridges above Little Cottonwood Canyon (Field Observations; Superintendent's Monthly Narrative Reports).

Odocoileus hemionus (Rafinesque).--Mule deer. Found in a variety of habitats throughout Idaho, mule deer are common in partially open, forested areas and may move into desert regions during the winter (Larrison, 1967).

The only ungulate species regularly found on the Monument (Ritchie, 1968), the population of mule deer may now consist of several hundred animals. Many observation records of these animals are available in the Park Service files at the Monument. For a much more comprehensive investigation on the status of the mule deer in Craters of the Moon National Monument, the reader is referred to Ritchie (1968).

Antilocapra americana (Ord).--Pronghorn. Occurring in scattered herds throughout the arid portions of southern Idaho, the greatest concentration of this species is in the Lost River, Lemhi, and Pahsimeroi areas, with considerable numbers also in the region of Owyhee County (Larrison, 1967). Pronghorns may be found in the open plains or sage-brush flats, generally avoiding timber and broken country (Davis, 1939).

Records of occurrence on the Monument are plentiful. Stearns (1928) says that pronghorn skulls were found on the lava flows. Blossom (1937a) reports that they occurred near the margin of the lava. Larrison (1956) observed pronghorns in Little Prairie and in the flat along the lower part of Little Cottonwood Creek. Also, there are numerous sight records in the Park Service files at the Monument (Superintendent's Monthly Narrative Reports, 1932, 1946, 1947, 1951, 1963, 1964, 1965, 1966, and 1967; Field Observations, 1962, 1963, and 1964; Monthly Interpretive Reports, 1962; and Temporary Observation files, 1965 and 1966). In addition to these records, I saw pronghorns in the sagebrush area just outside the park boundary south of Carey Kipuka on 11 July and 11 August 1968.

Pronghorns have no permanent population on the Monument, but they are common visitors, moving freely through the area. These animals are found often in the sagebrush communities on the Monument outside of the flows. Most of the sightings have been made on the ancient flows around Sunset Cone and Grassy Cone, although a few individuals have been seen in the more southerly regions of the Monument.

Bison bison (Linnaeus).--Bison. About 100 years ago, there were places in southern Idaho that were "absolutely swarming with buffalo" (Irving, 1868). At the present time, bison in the wild state are extinct (Davis, 1939), and herds are now restricted to relatively small areas established by man.

Records of occurrence of bison on the area now occupied by the Monument are few and very old. Russell (1902) states that horns and bones found on the Snake River Plain show that it was part of their

former range. The Idaho State University Museum has in its possession the skeletal remains from the Snake River Plains of 60 or more bison. Stearns (1928) says that a bison horn was found in Buffalo Caves. Larrison (1956) says that bison were formerly reported by Indians and that some bones were found on the Monument.

Ovis canadensis Shaw.--Mountain sheep. Formerly occurring throughout much of the mountainous portions of the state, native sheep are now restricted in the summer to the higher mountains of central Idaho, and winter in the higher valleys (Davis, 1939; Smith, 1954). The habitats of mountain sheep are confined almost entirely to granitic regions extending from the open grassland parks of the winter range to the subalpine summer range found between timberline and alpine tundra (Smith, 1954).

In 1914, the vicinity of the Monument was part of the natural range of mountain sheep, according to Era Martin, who also said that, at the time, there were many animals in the area (Bottolfsen, 1949). Since then, pressure from man and grazing animals has driven them back into the Salmon River country north of the Monument (Bottolfsen, 1949; Superintendent's Monthly Narrative Reports, 1949; and Smith, 1954).

Russell (1902) states that mountain sheep were present on the Snake River Plain during the winter months, and that their horn cores could be found among clumps of sagebrush. Limbert (1924) tells of finding a complete skeleton inside a cavity in a lava flow in the vicinity of Echo Crater. Stearns (1928) says that skulls of mountain sheep were occasionally found on the lava. The Superintendent's Monthly Narrative Reports mention four different observation records: In 1924, three head wintered on a dry fork of Antelope Creek about three miles northwest of

Little Cottonwood Creek. On 8 July 1949, a young ram was seen one-half mile north of the Martin Ranch and was working its way toward the Monument. On 12 July 1949, the same animal was observed about one-half mile from the Monument boundary. During February, 1966, a band of mountain sheep was reported in Antelope Creek about 20 miles northwest of the Monument; this was the first record of occurrence in this locality since 1949.

Local people have hoped that the mountain sheep population will gradually be restored, inasmuch as the area covered by the Monument has been excluded from grazing since 1924 (Bottolfsen, 1949). However, because the land around the Monument is still heavily utilized by livestock, I believe that these animals will continue uncommon in the Monument for some time.

Species Possibly Occurring on Craters of the Moon National Monument

There are other species that may occur on the Monument, but have not yet been found. Larrison (1956) listed hypothetical occurrences; I have updated and modified his list in view of more recent discoveries (Table 4).

The bases for these assumptions are records of distribution and habitat preferences according to Davis (1939), Hall and Kelson (1959), and Larrison (1967). Probably the most questionable supposition is the presence of Merriam's shrew, which is a hypothetical species for Idaho, and one which is rarely collected (Hall and Kelson, 1959).

Table 4. Species possibly occurring on Craters of the Moon National Monument.

Sorex merriami Dobson	Merriam's shrew
S. palustris Richardson	Water shrew
Citellus townsendii (Bachman)	Townsend's ground squirrel
Glaucomys sabrinus (Shaw)	Northern flying squirrel
Onychomys leucogaster (Maximilian)	Northern grasshopper mouse
Lagurus curtatus (Cope)	Sagebrush vole
Microtus richardsoni (DeKay)	Water vole

DISCUSSION

As has been pointed out in the Introduction, Craters of the Moon National Monument is characterized by diverse plant communities and a landscape featuring recent volcanism. Included within the Monument, then, is fauna with different ecological requirements and limiting factors.

Saunders (1921) considers habitats the most fundamental distributional units. Certain kinds of mammals, according to Davis (1939), are not restricted to a certain habitat, but are able to succeed in more than one. Although there is a transition from the forested and riparian communities in Little Cottonwood Canyon to the "barren" lava in the southern part of the Monument, there seems to be few species of mammals restricted to any one area.

Deer mice were found in every habitat I trapped, including my apartment. My lowest trapping success for these mammals was in the Elymus stand in Little Cottonwood Canyon (Table 3). I collected only seven specimens from that habitat. Marmots are likely to be found in nearly any rocky place; the absence of suitable rock refuges is a greater limiting factor than a given set of climatic conditions or particular food plants (Davis, 1939). Generally speaking, the limiting factor for most of the other mammals on the Monument seems to be primarily food and/or shelter.

The mammals that are restricted to any given habitat or community include beavers, snowshoe rabbits, and jumping mice. Available free water is probably the limiting factor, either directly or indirectly, because the water supply influences the type of food and shelter available.

Most of the mammals may occur in more than one habitat because (1) adjacent habitats are not well defined and (2) because of population pressure (Davis, 1939). Limber pine is distributed throughout the Monument. Sometimes it is widely scattered over an area, and sometimes it occurs in fairly dense stands. Yellow pine chipmunks are common inhabitants of these areas. However, their distribution at Craters of the Moon National Monument includes the flows, cinder cones, and other habitats with no limber pine, which may be explained by poorly defined habitats.

The known ranges of the golden-mantled ground squirrel and the Columbian ground squirrel were extended by this study. Davis (1939) states that he never found Columbian ground squirrels far from water, but I observed them in the older lava flows two or three miles from the nearest known available water. There are no previous records on the Monument of golden-mantled ground squirrels occurring far from areas frequented by man. However, I found signs of these mammals on Echo Crater. Population pressure may provide an explanation for these extensions of ranges. It is especially notable in the golden-mantled ground squirrel population because man has furnished them with more sources of food and shelter during the summer. Some of these individuals are probably pushed into the surrounding vicinity by the large population

of squirrels occurring in the tourist areas.

The Monument has been formed by several series of volcanic eruptions of different ages which form a mosaic of lava flows, cones of various types, and craters. This fact, in conjunction with the rather harsh climate, has resulted in several different stages of succession throughout the area. The niches provided have contributed to the diversity of the fauna of Craters of the Moon National Monument. Few species of mammals are found on the younger cinder cones with a less well-developed plant community, and on the younger, seemingly barren lava flows. The most common mammal in these areas is the deer mouse. Usually the older flows have more vegetation and, consequently, more species of mammals. Common inhabitants of these flows include deer mice, marmots, pikas, chipmunks, bushy-tailed wood rats, and bobcats. The mature cinder cones support a mixed shrub community typical of the Snake River Plain. Grassy Cone and Sunset Cone are remnants of the earliest volcanic activity on the Monument. Mammals found on these mature cones include deer mice, chipmunks, and rabbits. These ancient cones also have stands of Douglas fir growing on the north-facing slopes. Common mammals of these areas are deer mice, red squirrels, voles, chipmunks, and mule deer. Little Prairie, which is quite old, is a large, mixed shrub community in the southern portion of the Monument. It provides a suitable habitat for the Great Basin pocket mouse. Carey Kipuka, which is an old and relatively undisturbed island of land within a lava flow, has deer mice, voles, bushy-tailed wood rats, rabbits, and coyotes as common inhabitants. Ecotones, which are transition zones between two communities (Oosting, 1956), provide additional habitats.

An example is the edge of the flows. This is one of the habitats of pygmy rabbits.

There also appeared to be evidence that cyclic fluctuations in the population density of a number of small mammals, such as voles, have occurred in this area. Voles have been abundant in previous years (Superintendent's Monthly Narrative Reports, 1964) on the Monument. I collected only 16 specimens of voles in 1968. During the same year, the population was known to be high in other parts of southeastern Idaho (E. Fichter, personal communication). If the total number of voles taken, including sight observations, was any criterion of abundance, then it is possible that the population density was at an ebb.

In the last 100 years, 44 different species of mammals have been known to occur in this area, although some of these are no longer found on the Monument, such as grizzly bears and bison. Other observations include casual or accidental records of occurrence, such as the presence of kangaroo rats, muskrats, raccoons, red foxes, and elk. About 41 per cent or 18 of the 44 species that have been found on the Monument are rodents.

I collected a total of 630 specimens from the Monument and kept 165 specimens as skulls and study skins. In 1968 I recorded 26 different species on Craters of the Moon National Monument.

Two new records of occurrence were verified for the Monument during 1968. I collected one specimen of vagrant shrew in a lava tube in North Crater Flow, which is pahoehoe lava. These occur in a wide range of habitats, and are more common near water (Larrison, 1967). Davis (1939) says that all of the species of shrews in Idaho are aquatic

or semi-aquatic in habit. The known water supply nearest to the location where I found this shrew is about half a mile away. The presence of this shrew may indicate hidden pockets of water in the lava, providing a micro-habitat favorable for this species. A western harvest mouse was collected on Crescent Butte by Wayne B. Whitlow. This location is in a desert area, which is one of the habitats of this species (Davis, 1939). Insufficient study may account for the lack of any previous records of these species on the Monument.

In the Annotated List of Species, I have mentioned seven species which could possibly occur on the Monument. The occurrence of Merriam's shrew is hypothetical for Idaho, but the distribution, according to Hall and Kelson (1959) includes southern Idaho. They also say that "most specimens of this rare shrew have come from open arid places." The Monument certainly meets this requirement. The water shrew occurs along the borders of ponds and streams in meadows, marshes, or woods (Hall and Kelson, 1959). Its range extends over the state (Larrison, 1967). Little Cottonwood Canyon appears to be a suitable habitat for this species. Townsend's ground squirrel may be found in sagebrush areas throughout southern Idaho (Larrison, 1967). Some specimens have been taken near Arco (Hall and Kelson, 1959), so their range may include the Monument. Northern flying squirrels, found in mountain forests throughout most of the state (Larrison, 1967), may be found in the Douglas fir stand in Little Cottonwood Canyon. Northern grasshopper mice inhabit the semi-arid part of the state (Davis, 1939), so the Monument may be included in part of their range. Sagebrush voles may be found in sagebrush areas of the Snake River Plain (Davis, 1939). However, according to

Larrison (1967), they are not common, which may explain the lack of any record of their occurrence on the Monument. Water voles are semi-aquatic in habit and strictly boreal in occurrence (Davis, 1939). Little Cottonwood Creek may provide a favorable habitat on the Monument for this species.

During the course of this study, there were many problems that occurred to me that I think deserve attention. Almost nothing is known about the bats on the Monument. A complete study of the taxonomy and natural history of these animals should be undertaken. A taxonomic study of the chipmunks in the area is needed, with emphasis on subspecific distribution. The subspecies Eutamias amoenus cratericus, described by Blossom (1939b), may not be valid (J. A. White, personal communication). The chipmunks on the Monument do not lose their winter pelage until late summer. When specimens of E. a. amoenus collected at different seasons of the year are compared, they are different in appearance. Although Blossom collected his specimens in October, this subspecies should be verified. The natural history of the deer mice on the Monument is probably one of the more obvious problems, and one that demands a great deal of attention. Little is known about the weasels on the Monument, so a study is needed on these mammals.

In addition to natural history and taxonomic problems, studies are needed in predator-prey relationships. This is a problem with special interest because of the abundance of deer mice. There is little known about the cyclic fluctuations of the population densities of small mammals on the Monument. Finally, a study of the mammalian parasites would be fruitful. There is a heavy infestation of bot flies on deer mice and chipmunks during the summer months.

SUMMARY

Characterized by features of relatively recent volcanism, the diverse landscape of the Craters of the Moon National Monument is of special interest to the field biologist, and the ecological distribution of small mammals is probably one of the more discernible biological responses to such an environmental complex.

In spite of the unusual features of the Monument, little research has been done in the area. The more intensive studies have been concerned with the geology on the area, primary plant succession, appraisal of the dwarf mistletoe, ecology of the insects, and the status of the mule deer.

Little-known to white men prior to 1924, the area was declared a national monument by proclamation of President Coolidge on 2 May of that year. Located on the northern edge of the Snake River Plain, the Monument is the site of the most recent series of sporadic volcanic activity that has occurred throughout southern Idaho since Pleiocene times. The flows, composed of aa and pahoehoe lava, are believed to be at least 1650 years old, in spite of their fresh appearance. Vegetation, which is restricted to cracks and crevices on the flows, is predominantly a grass-sagebrush community, with limber pine scattered throughout the Monument. Douglas fir and quaking aspen are plentiful in Little Cottonwood Canyon.

Craters of the Moon National Monument is situated in a semi-desert

region typified by hot summers and cold winters. The highest monthly mean is 20.1° C. during July, and the lowest monthly mean is -7.8° C. during January. The total annual precipitation averages 44.75 cm., with an average high of 7.42 cm. in December, and an average low of 1.12 cm. during July. Prevailing winds from the southwest are an almost daily occurrence.

Work in the field amassed 2,222 trap nights over a period of three months. Museum Special traps, Victor rat traps, California gopher traps, and Havahart live animal traps were used in collecting, with Museum Special traps accounting for 92 per cent of the trap nights. Temperature and relative humidity were measured with a Taylor sling psychrometer and a Bacharach hygro-thermograph.

The plant communities are diverse: the transition from the forested and riparian communities in Little Cottonwood Canyon to the "barren" lava in the southern portion of the Monument is especially notable.

All stages of succession are evident, with numerous and complicated interspersion of many of the microhabitats throughout the Monument.

Eighteen different habitats were selected as study areas. They were chosen on the basis of accessibility and representative characteristics.

In the last 100 years, 44 different species of mammals have been known to occur in this region, although many of these are no longer found on the Monument. During 1968, two new records of occurrence were verified for the Monument. One specimen of a vagrant shrew (Sorex vagrans

Baird) and one specimen of a western harvest mouse [Reithrodontomys megalotis (Baird)] were collected.

Furthermore, an indication of the abundance of deer mice [Peromyscus maniculatus (Wagner)] was established. The known ranges of the golden-mantled ground squirrel [Citellus lateralis (Say)] and the Columbian ground squirrel [C. columbianus (Ord)] were extended. There also appeared to be evidence that cyclic fluctuations in the population density of a number of small mammals, such as voles (Microtus sp.), have occurred in this area. Generally speaking, all the mammals known to occur on the Monument in recent years have been discussed, although there are other species that may be present, but have not yet been found.

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