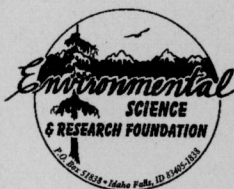


1998 LONG-TERM VEGETATION TREND MONITORING REPORT CRATERS OF THE MOON NATIONAL MONUMENT

Chad S. Horman and James Glennon



September 1998



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CRATERS OF THE MOON NATIONAL MONUMENT

TRANSECTS #1 (ASPEN, RESEARCH CAMP), #2 (SAGEBRUSH, NORTH END)
#5 (LIMBER PINE, INFERNO CONE) AND
#8 (THREE-TIP SAGEBRUSH/FESCUE, CAREY KIPUKA)

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Craters of the Moon National Monument

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1998 LONG-TERM VEGETATION TREND MONITORING REPORT

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SUMMARY

Four long-term vegetation trend monitoring transects were read in June of 1998. The transects read were: #1 (aspen, research camp), #2 (sagebrush, north end), #5 (limber pine, inferno cone) and #8 (three-tip sagebrush/fescue, Carey Kipuka). Significant changes in species composition occurred along each transect. Annual forb species were more numerous in this survey than in previous ones. Despite these changes, the dominant species along each transect remained unchanged. Aspen [*Populus tremuloides* (POTR)¹] and limber pine [*Pinus flexilis* (PIFL)] densities decreased from previous surveys, while trunk diameters increased slightly. However, additional surveys are needed before any strong conclusions can be made about trends in species composition or stand densities. Three non-native weeds, common dandelion [*Taraxacum officinale* (TAOF)], prickly lettuce [*Lactuca serriola* (LASU)] and goatsbeard [*Tragapogon dubius* (TRDU)], were found on transects 1, 5, and 8. This was the first time they had been recorded.

INTRODUCTION

The Long-term Vegetation Trend Monitoring Program was established in 1991 by Gerry Wright and Steve Bunting of the University of Idaho, Moscow. This was developed as the vegetative component of the Craters of the Moon National Monument's (CMNM) Inventory and Monitoring (I & M) program. The frequency data obtained in this program over the years should provide managers with information regarding species composition and density and indicate any changes/trends that may be occurring in the selected vegetation types. The history of previous vegetation studies completed at CMNM can be found in the report prepared by Sparhawk (1992).

METHODS

Eight permanent vegetation monitoring sites exist at CMNM. Each 100-meter transect is marked at each end by an orange and yellow metal fence post. Two of the eight sites are monitored each year on a rotating basis, resulting in each site being monitored every four years (Appendix 1). A complete description of the methods is reported by Sparhawk (1992).

In 1992, the Long-term Vegetation Trends Monitoring study began with the reading of the first two scheduled transects, #1 (aspen, research camp) and #5 (limber pine, inferno cone). The 1998 survey was the third reading for these two sites. Transects #1 and #5 were read prior to the scheduled rotation because funds were available and the additional data would be beneficial. This survey was the second rotation for transects #2 (sagebrush, north slope) and #8 (three-tip sagebrush/fescue, Carey Kipuka), four years after their initial reading. The location of the four transects are shown in Figure 1. Chad Horman, Restoration Ecologist from Environmental Science and Research Foundation Inc., James Glennon, Affiliate Herbarium Curator from Idaho State University and Associate Plant Scientist for Environmental Science and Research Foundation, Inc. and Michael Muntz, Resource Management Specialist from Craters of the Moon National Monument, performed the 1998 survey.

¹ Four letter codes follow standardized format of combining the first two letters of the genus and species as found in "Intermountain Range Plant Names and Symbols" USDA Forest Service General Technical Report IN-38.

GRASSES, FORBS and WOODY SPECIES:

A 100-m tape measure was stretched between the posts at each end of the transect line and a 50 cm X 50 cm (0.25 m²) nested frequency frame was placed to the right of each meter mark on the tape, resulting in 100 readings (Sparhawk 1992). The frequency frame consisted of four nested frames of varying sizes, 10 cm X 10 cm, 25 cm X 25 cm, 25 cm X 50 cm and 50 cm X 50 cm (Figure 2). Every plant species (grasses, forbs and woody species) rooted in the area enclosed by the frame was assigned a number 1-4, depending on which of the four nested frames the species first appeared. Meaning that if a species was first observed in the 25 cm X 25 cm area it would be given a two or if it first occurred in the 50 cm X 50 cm area it would score a four (Sparhawk 1992).

TREES:

When trees occurred in the transect, the trees were identified by species, counted and diameter at breast height (dbh) measurements were taken 1.4 meters from the base on the uphill side using a dbh tape for all live trees. In aspen and Douglas fir stands, data on every tree within 5 meters of either side of the transect line (resulting in a 10-meter wide transect) were collected. In limber pine stands, trees within 10 meters of the transect line (resulting in a 20-meter wide transect) were counted (Sparhawk 1992).

REFERENCE PHOTOGRAPHS:

A 1.5 meter pole marked in alternating black and white decimeter bands was placed one meter from the transect pole. A sign indicating the transect location, date and time was placed on the post and a photograph taken with a 50 mm lens on a 35 mm camera, using ASA 64 slide film (Sparhawk 1992).

DATA ANALYSIS:

Analysis consisted of calculating the sum frequency for each species or group of species. This was done by counting the number of times that a species occurred in one of the four nested frequency areas. Because there were 100 plots, this number represents a percentage of plots in which this species occurred (Sparhawk 1992).

Sum frequency values were used to compare similar readings from past surveys. These values followed a binomial distribution. Due to the binomial distribution, a confidence interval was calculated for each value. Significant differences were determined by comparing confidence intervals. If two values had confidence intervals that did not overlap, they were considered significantly different (Sparhawk 1992). A modified 95% confidence interval table for frequency values observed for 100 plots (Snedecor 1956) was used to determine significant differences. In addition chi-square analysis was used to determine if significant changes in overall species composition had occurred between surveys (Ludwig and Reynolds 1988).

RESULTS

TRANSECT #1 - ASPEN, RESEARCH CAMP

Transect #1 contained 37 species, including six grass species, 24 forb species and seven woody species (Table 1). Two grass and eight forb species were recorded that had not been found in previous surveys, while seven forb and one woody species recorded in other surveys were not found this one. Two non-native weeds, goatsbeard and common dandelion, were recorded for the first time.

Perennial grasses and perennial forbs had the highest sum frequency along the transect (Table 2). Pinegrass [*Calamagrostis rubescens* (CARU)] was the most abundant grass species. The dominant forbs were the perennials starry Solomon-seal [*Smilacina stellata* (SMST)] and heartleaf arnica [*Arnica cordifolia* (ARCO)]. Mountain snowberry [*Symphoricarpos oreophilus* (SYOR)] was the most frequently encountered woody species.

Chi-square analysis indicated significant ($P < 0.10$) changes in species composition had occurred since this transect was last read. Sum frequency values also indicated differences between years. Significant changes were observed in six species found in transect # 1 between the 1996 and 1998 surveys (Table 3). Slender wheatgrass [*Agropyron trachycaulum* (AGTR)], Nuttall aster [*Aster perelegans* (ASPE)], houndstongue hawkweed [*Hieracium cynoglossoides* (HICY)] and tuber starwort [*Stellaria jamesiana* (STJA)] all increased significantly in frequency. Tarragon [*Artemisia dracuncululus* (ARDR)] and Menzie's silene [*Silene menziesii* (SIME)] both significantly decreased in frequency from 1996 to 1998.

Aspen and chokecherry [*Prunus virginiana* (PRVI)] were the only two tree species found in the 10 m X 100 m transect, with aspen being the more numerous species (Table 4). No upland willow [*Salix scouleriana* (SASC)] was recorded within the transect. It is important to note that more dead aspen trees were recorded, 670/hectare, than were live, 590/hectare. The reason for the dead aspen was not known.

Tree densities and basal areas decreased over the past six years for all tree species (Table 5). Aspen density declined nearly 20% from 1992 to 1996 and even more sharply, 40%, from 1996 to 1998. This decrease has led to a smaller basal area, but not to a decrease in mean trunk diameter. Similar trends were observed with respect to chokecherry and upland willow densities. Mean tree diameters slightly increased from 1996 to 1998 for aspen and chokecherry (Table 5). Changes in upland willow diameter are not known because no trees were found in the transect.

TRANSECT # 2 - SAGEBRUSH, NORTH END

Thirty-two different species were recorded along transect #2, including five grass species, 21 forb species and six woody species (Table 1). This was an increase of one grass, 12 forb and one shrub species compared to what was recorded in 1994. However, four species found previously were not recorded in this survey.

Perennial grasses and perennial forbs had the highest sum frequencies along the transect (Table 6). Slender wheatgrass was the most frequent grass species. The perennial forb tapertip hawksbeard [*Crepis acuminata* (CRAC)] was found to be the most frequent forb species. The shrubs mountain snowberry, antelope bitterbrush [*Purshia tridentata* (PUTR)] and mountain big sagebrush [*Artemisia tridentata* ssp. *vaseyana* (ARTRV)] were similarly abundant, based on sum frequency values, along the transect.

Chi-square analysis indicated species composition differed significantly ($P < 0.01$) between the two surveys. Six species significantly increased in frequency between the 1994 and 1998 surveys (Table 7). Two were the perennial forbs tapertip hawksbeard and goosefoot violet [*Viola purpurea* (VIPU)]. The other four were the annual forbs: Blue-eyed Mary, [*Collinsia parviflora* (COPA2)], Watson cryptantha [*Cryptantha watsonii* (CRWA)], branchy groundsmoke [*Gayophytum racemosum* (GARA2)] and Douglas knotweed [*Polygonum douglasii* (PODOD)].

TRANSECT #5 - LIMBER PINE ON INFERNO CONE

Eight grass species, 21 forb species and six woody species, for a total of 35, were found in transect #5 (Table 1). In 1998, four grass species and six forb species were recorded that had not been previously, while three species recorded in 1996 were not found in this survey.

Perennial grasses, perennial forbs, annual forbs and shrubs were all relatively abundant along the transect (Table 8). The most frequently encountered grass was Kentucky bluegrass [*Poa pratensis* (POPR)]. The most abundant forb was the annual blue-eyed Mary. The shrub component of the understory was dominated by antelope bitterbrush, squaw current [*Ribes cereum* (RICE)] and rubber

rabbitbrush [*Chrysothamnus nauseosus* (CHNA)], all of which were equally abundant. Two non-native weeds, prickly lettuce and common dandelion, were recorded during the survey.

A significant ($P < 0.05$) change in species composition was found using chi-square analysis. Seven significant changes in species nested frequency values were found (Table 9). Two of the grass species changed significantly, with one increasing and the other decreasing. Sandberg bluegrass [*Poa secunda* (POSE)]/Kentucky bluegrass frequency increased by 19%, while Indian ricegrass [*Oryzopsis hymenoides* (ORHY)] became non-existent along the transect. All of the significant changes among the forbs were due to annual species. Blue-eyed Mary, dwarf monkeyflower [*Mimulus nanus* (MINA)] and monkeyflower [*Mimulus suksdorfii* (MISU)] all had significant increases in sum frequency, while branchy groundsmoke significantly decreased. The most curious change occurred in squaw currant frequency, which went from a sum frequency of 29% in 1992 to 0% in 1996 and back up to 28% in 1998.

The only tree species present in the transect was limber pine. Based on the 20 m X 100 m transect, tree density was estimated at 165 live trees/hectare and 10 dead trees/hectare. The mean $\pm$ SD trunk diameter was 19.5 cm $\pm$ 9.9 cm, resulting in a basal area of 4.9 m²/hectare.

There was approximately a 20% decrease in the number of limber pines/hectare between the 1996 and 1998 surveys (Table 10). The mean trunk diameter increased by one cm, but the basal area (m²/hectare) still decreased.

TRANSECT #8 - THREE-TIP SAGEBRUSH/FESCUE - CAREY KIPUKA

Eleven grass species, 29 forbs species and two shrub species were recorded along transect #8 (Table 1). Seventeen forb species were recorded in the 1998 survey that were not recorded in the 1994 survey. However, four species in the previous survey were not found in this one. The main difference between 1994 and 1998 was an increase in the number of annual species.

Perennial grasses, perennial forbs and annual forbs were all equally abundant along the transect (Table 11). Idaho fescue [*Festuca idahoensis* (FEID)] and prairie junegrass [*Koeleria cristata* (KOCR)] were the most common grasses along the transect. Two annual forbs, branchy groundsmoke and slenderleaf collomia [*Collomia linearis* (COLI)], and one perennial, pale agoseris [*Agoseris glauca* (AGGL)] had the highest sum frequencies of the forbs. Tall three-tip sagebrush [*Artemisia tripartita* (ARTR2)] was the most common shrub species. No tree species were found. Two non-native weeds, prickly lettuce and goatsbeard, were recorded along the transect.

Chi-square analysis indicated that a highly significant ($P < 0.001$) change in species composition had occurred. Significant increases were found for the grasses Idaho fescue and sandberg bluegrass (Table 12). Several annual forbs also increased in frequency. They were: blue-eyed Mary, slenderleaf collomia, branchy groundsmoke, prickly lettuce and Douglas knotweed. The perennial forbs that significantly increased were pale agoseris, timber milkvetch [*Astragalus convallarius* (ASCO)], silky lupine [*Lupinus sericeus* (LUSE)] and Hood's phlox [*Phlox hoodii* (PHLO)]. The only species decreasing significantly in sum frequency was tall three-tip sagebrush.

DISCUSSION

TRANSECT #1 - ASPEN, RESEARCH CAMP

The significant sum frequency changes observed did not represent a change in the dominant vegetation. Over the past six years, the dominant understory species have been pinegrass, starry Solomon-seal, heartleaf arnica and mountain snowberry. The abundant overstory species continues to be aspen. The presence of two non-native weed species, goatsbeard and common dandelion, could be

of concern. Since their frequency was extremely low, < 3%, they are not yet a large threat. They will need continued monitoring.

Regarding the results of the tree data, each of the tree species found in transect #1 showed a decrease in density while the mean dbh increased. Usually a decrease in the number of trees, coinciding with an increase in dbh, suggests the stand is in the natural process of self-thinning (Elzinga 1996). Elzinga (1996) suggested the decrease in the number of trees between the 1992 survey and the 1996 survey was not significant enough to suspect any other factors that could possibly attribute to the decrease. He did suggest in future surveys, the dead trees within the transect be tallied and the cause of death be identified if possible, to support the self-thinning theory.

Elzinga (1996) also suggested it may be possible that trees along the edge of the transect lines (border trees) counted in the first survey, may have been missed in subsequent surveys, resulting in a decrease in the number of trees. It was suggested that detailed instructions of exactly which border trees are to be included or excluded in the transect. Discussions determined all trees whose base is 1/2 or more inside the transect line would be included. All others would not. Another suggestion for future studies would be to mark the trees with aluminum tags so the same trees would be consistently counted year to year.

Based on this information, it would appear the stand is still self thinning since the dbh did slightly increase as the overall densities decreased. Dead trees were counted this year, but no previous survey results were reported. Another explanation for the change in numbers could be that some of the trees along the edge of the transect may have been missed. Finally, it could be the stand is declining. The results of the next few surveys will be important in determining which of the above explanations is the most likely. It would also be beneficial to count aspen suckers in order to know if the stand is regenerating or is becoming decadent.

Overall, the understory vegetation community appears stable. A species shift was observed among the less common species. The dominate species from previous years were still dominant. The aspen overstory may be in a downward trend. This decline may be due to natural self-thinning or due to sampling error of border trees.

TRANSECT #2 - SAGEBRUSH, NORTH END

The vegetation composition along transect #2 has changed since 1994. Most of the significant increases observed were due to annual forb species. The increase in annual species was likely due to the amount of winter and spring precipitation. The winter of 1993 and spring of 1994 were particularly dry with only 16.6 cm of precipitation falling between October 1993 and June 1994. This is about 60% less then the 42.3 cm which fell between October 1997 and June 1998.

Despite the increase in annual forbs and change in species composition, the dominant species remained relatively unchanged, except for the significant increase in the frequency of tapertip hawksbeard. Overall the vegetation trend appears stable.

TRANSECT #5 - LIMBER PINE ON INFERNO CONE

The fluctuations in species composition over the past three surveys makes it rather difficult to make conclusions as to the vegetation trend. This is especially true with respect to the grass species. More time and surveys will be required in order to better understand what is occurring.

One reason for the increase in species richness may have been due to available moisture. The annual forbs appeared to respond to the high amounts of precipitation which occurred during the winter and spring of 1997-98. A total of 42.3 cm of precipitation occurred during October 1997 through June 1998, 25% more than fell in the same period in 1995 and 1996. The extra moisture combined with the

cool temperatures during the spring apparently contributed to the abundance of annual forbs. A good example was the sudden increase in abundance of the two monkeyflower species which had not been recorded in previous surveys. It is not clear why branchy groundsmoke decreased in frequency when all of the other annual forbs maintained or increased in frequency. The perennial forbs appear to be maintaining a steady trend. The presence of the non-native prickly lettuce and common dandelion needs to be closely monitored in future surveys.

The shrub component remained relatively unchanged except for squaw currant. Since it is a perennial, it is very unlikely that it could suddenly disappear between 1992 and 1996 and then suddenly reappear at the same level two years after its disappearance. This anomaly was most likely due to sampling error. Sampling error could include such things as slight changes in quadrat placement, judgement calls concerning plants bordering the quadrat or misidentification by surveyors.

The decrease in limber pine numbers is probably not large enough to be of concern. The decrease was probably due to the exclusion of trees bordering the transect that may have been included in the previous surveys, but were not counted in this one. The counting of dead trees in future surveys will help in determining whether or not significant changes in stand density are occurring.

TRANSECT #8 - THREE-TIP SAGEBRUSH/FESCUE - CAREY KIPUKA

The results indicated the dominant grasses, Idaho fescue and prairie junegrass, are increasing, while the dominant shrub, tall three-tip sagebrush, decreased. It is not clear as to the reason for this change. It is possible the grasses are crowding out the shrubs or the shrubs are not replacing themselves as they mature and become decadent. It would be beneficial to do shrub density counts along the transect to determine the age structure of the stand to see if recruitment is occurring.

The biodiversity in the Carey Kipuka appears to be highly dependent on spring precipitation. The 1994 survey reported 12 forb species whereas 29 were recorded in 1998. This increase in species diversity is probably related to the increased amount of precipitation in 1998. The winter of 1993 and spring of 1994 were particularly dry with only 16.6 cm of precipitation falling between October 1993 and June 1994. This was about 60% less than the 42.3 cm which fell between October 1997 and June 1998.

No solid conclusions about trend can be made at this time. There are several reasons for this. First, the species composition was very different between the two years. The 1994 report indicated many of the plants, grasses and annual forbs in particular, had already set seed when the survey was conducted and identification was difficult causing the survey to be incomplete (Cummings 1994). Second, the effects of a dry versus a wet year created a situation of trying to compare two very different species compositions. The final reason is this was only the second time the transect was read. Even though some things changed, several more surveys are needed in order to begin to draw any strong conclusions.

RECOMMENDATIONS

Species compositions differed between surveys at a given site, making it difficult to determine trend changes. One possible way to monitor trend is to group the vegetation into five categories representing life form, i.e. perennial and annual grasses, perennial and annual forbs and shrubs. The sum frequency values from this grouping could be used to compare trend changes since it would not be as strongly influenced by changes in species composition within a given group. For example, if the frequency of perennial grasses significantly decreased over time and annual forbs increased, than an obvious change in trend is occurring. The combination of using both the life form grouping and the traditional species composition would allow more flexibility in observing vegetation changes over time.

A system needs to be devised which would make the collection of the tree density data more accurate. A possible solution to the problem, is to mark the trees with numbered aluminum tags. If they were marked, it would eliminate much of the error associated with counting trees along the transect border.

From a management standpoint, it would be useful to know if shrub and aspen stand age structure is changing over time. In order to determine if stand rejuvenation is occurring, the density of seedling, young, mature and decadent shrubs and aspens could be recorded and used to track changes in age structure. If seedlings or young shrubs and aspens were not being observed then steps could be taken to increase recruitment before the stand became too old and decadent.

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Table 1. 1998 Species List for Vegetation Trends Monitoring Transects # 1 (Aspen, Research Camp), #2 (Sagebrush, North End), #5 (Limber Pine, Inferno Cone) and #8 (Three-tip Sagebrush/fescue, Carey Kipuka) at Craters of the Moon National Monument, Arco, Idaho.

Species Code	Scientific name	Common Name	#1	#2	#5	#8
GRASSES						
AGSP	<i>Agropyron spicatum</i>	bluebunch wheatgrass		O*		X
AGTR	<i>Agropyron trachycaulum</i>	slender wheatgrass	X	X**	X**	
BRTE††	<i>Bromus tectorum</i>	cheatgrass				X
CAREX	<i>Carex</i> spp.	sedge spp.	X**			
CADO	<i>Carex douglasii</i>	Douglas sedge				X
CAFI	<i>Carex filifolia</i>	threadleaf sedge				X
CARU	<i>Calamagrostis rubescens</i>	pinegrass	X			
ELCI	<i>Elymus cinereus</i>	Great Basin wildrye		O		O
FEID	<i>Festuca idahoensis</i>	Idaho fescue	X**			X
KOCR	<i>Koeleria cristata</i>	prairie junegrass	X	X**		X
ORHY	<i>Oryzopsis hymenoides</i>	Indian ricegrass			O	
POA	<i>Poa</i> spp.	bluegrass species				
PONE	<i>Poa nevadensis</i>	Nevada bluegrass		X		
POPR†	<i>Poa pratensis</i>	Kentucky bluegrass		X	X**	
POSE	<i>Poa sandbergii</i>	Sandberg bluegrass			O	X
SIHY	<i>Sitanion hystrix</i>	bottlebrush squirreltail			X	X
STCO2	<i>Stipa columbiana</i>	subalpine needlegrass		X**	X**	
STCO3	<i>Stipa comata</i>	needle and thread grass		O		X**
STOC	<i>Stipa occidentalis</i>	western needlegrass			O	O
STTH	<i>Stipa thurberiana</i>	Thurber needlegrass			X**	
FORBS						
ACMI	<i>Achillea millefolium</i>	common yarrow	X			
AGGL	<i>Agoseris glauca</i>	pale agoseris	X	X**	X	X**
ALTE2	<i>Allium textile</i>	textile onion				X
ALTO	<i>Allium tolmiei</i>	Tolmie onion			X	
ARCO	<i>Arnica cordifolia</i>	heartleaf arnica	X			
ARDR	<i>Artemesia dracunculus</i>	Tarragon	O			
ARHO	<i>Arabis holboellii</i>	Holboell's rockcress	X**	X**	X	
ARLI	<i>Arabis lignifera</i>	woody rockcress				X
ASCO	<i>Astragalus convallarius</i>	timber milkvetch				X
ASFI	<i>Astragalus filipes</i>	Snake River Plains vetch				X
ASPE	<i>Aster perelegans</i>	Nuttall aster	X			
ASTER	<i>Aster</i> spp.	aster spp.			X	
BASA	<i>Balsamorhiza sagittata</i>	arrowleaf balsamroot	X	X		O
CANU	<i>Calochortus nuttallii</i>	sego lily	O			X**
CASTE	<i>Castilleja</i> spp.	Paintbrush species		O		

FORBS CONT.

CHDO	<i>Chaenactis douglasii</i>	Douglas chaenactis	X**	X**	O	X**
CHFR2†	<i>Chenopodium fremontii</i>	Fremont goosefoot	X**			
CIRSI	<i>Cirsium</i> spp.	thistle spp.				X**
COPA2†	<i>Collinsia parviflora</i>	blue-eyed Mary	O	X**	X	
COLI†	<i>Collomia linearis</i>	slenderleaf collomia				X**
CORA†	<i>Cordylanthus ramosus</i>	bush birdbeak				X**
CRAC	<i>Crepis acuminata</i>	tapertip hawksbeard	X	X		X
CRT0†	<i>Cryptantha torreyana</i>	Torrey's cryptantha	O		O	
CRWA†	<i>Cryptantha watsoni</i>	Watson cryptantha	X**	X**	X**	
CRYPT	<i>Cryptantha</i> spp.	cryptantha spp.				X
CYTE	<i>Cymopterus terebinthinus</i>	desert parsley			X	
DEAN	<i>Delphinium andersonii</i>	Anderson's larkspur			X	
ERPU2	<i>Erigeron pumilus</i>	low fleabane				X**
ERHE2	<i>Eriogonum heracleoides</i>	whorled buckwheat		O		X**
EROV	<i>Eriogonum ovalifolium</i>	dwarf buckwheat			O	
ERUM	<i>Eriogonum umbellatum</i>	sulfur buckwheat		X**	X	X**
FRAT	<i>Fritillaria atropurpurea</i>	leopard-lily	X			
GABI	<i>Galium bifolium</i>	twinleaf bedstraw	X**	X**		
GANU†	<i>Gayophytum nuttallii</i>	big flower groundsmoke			X	
GARA2†	<i>Gayophytum racemosum</i>	branchy groundsmoke		X**	X	X
GEVI	<i>Geranium viscosissimum</i>	sticky geranium	O			
GILIA	<i>Gilia</i> spp.	gilia spp.				X**
GYMN3†	<i>Gymnosteris</i> spp.	gymnosteris spp.				X**
HEUN	<i>Helianthella uniflora</i>	oneflower helianthella	X**	X		
HICY	<i>Hieracium cynoglossoides</i>	houndstongue hawkweed	X	O		
IMAG	<i>Ipomopsis aggregata</i>	skyrocket gilia	X			
LASE††	<i>Lactuca serriola</i>	prickly lettuce			X**	X**
LIRU	<i>Lithospermum ruderales</i>	wayside gromwell	X	X		O
LOTR	<i>Lomatium triternatum</i>	narrow leaf lomatium		X**		X
LUSE	<i>Lupinus sericeus</i>	silky lupine	X	X		X
MEAL2†	<i>Mentzelia albicaulis</i>	whitestem mentzelia		X**	X	X**
MINA†	<i>Mimulus nanus</i>	dwarf monkeyflower		X**	X**	
MISU	<i>Mimulus suksdorfii</i>	monkeyflower			X**	
OSOC	<i>Osmorhiza occidentalis</i>	Sweet-anise	X			
PENST	<i>Penstemon</i> spp.	penstemon species		O		
PHHA	<i>Phacelia hastata</i>	scorpion weed		X	X	
PHLO	<i>Phlox longifolia</i>	longleaf phlox		X**		X**

FORBS CONT.

PODOD†	<i>Polygonum douglasii</i>	Douglas knotweed	X**	X**	X**	X**
POAR	<i>Potentilla arguta</i>	acute cinquefoil	X			
POGL	<i>Potentilla glandulosa</i>	gland cinquefoil	X	X**		
SEIN	<i>Senecio integerrimus</i>	lambstongue groundsel				X**
SESE	<i>Senecio serra</i>	butterweed groundsel	X			
SIME	<i>Silene menziesii</i>	Menzie's silene	O			
SMST	<i>Smilacina stellata</i>	starry Solomon-seal	X			
SOLID	<i>Solidago</i> spp.	goldenrod species	O			
STJA	<i>Stellaria jamesiana</i>	tuber starwort	X**			
STEPH	<i>Stephanomeria</i> spp.	wire lettuce species				O
TAOF‡	<i>Taraxacum officinale</i>	common dandelion	X**		X**	
TRDU‡	<i>Tragopogon dubius</i>	yellow goatsbeard	X**			X**
VIPU	<i>Viola purpurea</i>	goosefoot violet		X**		

WOODY SPECIES

ALIN	<i>Alnus incana</i>	mountain alder	O			
AMAL	<i>Amelanchier alnifolia</i>	serviceberry	X	X**		
ARTRV	<i>Artemisia tridentata</i> ssp. <i>vaseyana</i>	mountain big sagebrush	X	X	X	
ARTR2	<i>Artemisia tripartita</i>	three-tip sagebrush				X
CHNA	<i>Chrysothamnus nauseous</i>	rubber rabbitbrush	X	X	X	
CHVI	<i>Chrysothamnus viscidiflorus</i>	green rabbitbrush		X		X
LEPU	<i>Leptodactylon pungens</i>	prickly phlox			X	
PIFL	<i>Pinus flexilis</i>	limber pine			X	
POTR	<i>Populus tremuloides</i>	quaking aspen	X			
PUTR	<i>Purshia tridentata</i>	antelope bitterbrush		X	X	
PRVI	<i>Prunus virginiana</i>	chokecherry	X			
RICE	<i>Ribes cereum</i>	squaw currant			X	
ROWO	<i>Rosa woodsii</i>	Wood's rose	X			
SASC	<i>Salix scouleriana</i>	upland willow	O			
SYOR	<i>Symphoricarpos oreophilus</i>	mountain snowberry	X	X		

* Indicates species found in a previous survey but were not found in this survey

** Indicates first time species has been recorded in survey.

† Indicates an annual species.

‡ Indicates a non-native species.

Table 2. Plant Species Frequency Data for 100 Plots in the Vegetation Trends Monitoring Transect # 1 - Aspen, Research Camp - at Craters of the Moon National Monument, Arco, Idaho.

Species	10X10	25X25	25X50	50X50	SUM
GRASSES					
CARU	85	6	4	0	95*
AGTR	5	6	6	9	26
KOCR	1	1	2	3	7
POA	0	1	0	3	4
CAREX	1	2	0	0	3
FEID	0	0	1	0	1
PERENNIAL GRASS	86	8	3	0	97
ANNUAL GRASS	0	0	0	0	0
FORBS					
SMST	14	19	13	11	57*
ARCO	36	14	1	3	54*
ASTER	10	6	7	12	35
STJA	4	13	4	6	27
LUSE	0	4	3	8	15
FRAT	1	2	2	6	11
HICY	2	2	2	4	10
ACMI	2	0	2	2	6
CRAC	0	0	5	1	6
POGL	2	0	1	3	6
LIRU	1	0	2	2	5
GABO	2	1	0	0	3
IPAG	2	0	1	0	3
SESE	0	0	2	1	3
TRDU	0	2	1	0	3
ARHO	0	1	1	0	2
ARLO	0	1	0	1	2
CHFR2	1	0	1	0	2
CRWA	2	0	0	0	2
TAOF	0	2	0	0	2
AGGL	0	1	0	0	1
BASA	0	0	0	1	1
OSOC	1	0	0	0	1
PODOD	1	0	0	0	1
PERENNIAL FORB	58	28	6	8	100
ANNUAL FORB	2	0	0	0	2
WOODY SPECIES					
SYOR	8	14	13	9	44*
PRVI	0	0	3	3	6
POTR	1	1	0	3	5
AMAL	0	1	0	1	2
ARTRT	1	0	0	0	1
CHNA	0	0	1	0	1
ROWO	0	0	0	1	1
WOODY SPECIES	10	15	14	14	53

* Highest sum frequency values ($P < 0.05$) for each life form.

Table 3. Comparative Sum Frequencies for All Species Found in All Surveys Conducted on the Vegetation Trends Monitoring Program's Transect # 1 - Aspen, Research Camp - Site at Craters of the Moon National Monument, Arco, Idaho.

GRASSES	1992	1996	1998
AGROP/AGSP/AGTR†	3	6	26*
CAREX	0	0	3
CARU	98	86*	95
KOCR	3	2	7
POA	0	8	4
PERENNIAL GRASS	NA	NA	97
ANNUAL GRASS	NA	NA	0
FORBS			
ACMI	2	6	6
AGOSE/AGGL†	0	1	1
ARCO	48	49	54
ARDR	0	34*	0*
ARHO	0	0	2
ASPE	34	0*	35*
BASA	2	1	1
CANU	2	1	0
CHFR2	0	0	1
COPA2	0	1	0
CREPI/CRAC†	12	5	6
CRTO/CRWA†	0	1	2
FRAT	1	1	11
GABO	0	0	3
GEVI	0	2	0
HEUN	0	0	2
HICY	0	0	10*
IPAG	3	2	3
LIRU	4	0	5
LUSE	10	16	15

FORBS CONT.	1992	1996	1998
OSOC	0	3	1
PODOD	0	0	1
POAR/POGL†	3	9	6
SENEC/SESE†	7	0	0
SIME	3	14	0*
SMST	63	68	57
SOLID	0	2	0
STJA	0	0	27*
TAOF	0	0	2
TRDU	0	0	3
PERENNIAL FORB	NA	NA	100
ANNUAL FORB	NA	NA	2
WOODY SPECIES			
AMAL	2	0	2
ALIN	0	2	0
ARTRV	0	1	1
CHNA	0	2	1
CHRY3	3	0	0
POTR	1	2	5
PRVI	4	2	6
ROWO	1	4	1
SASC	0	1	0
SYOR	33	60*	44
WOODY SPECIES	NA	NA	53

† Indicates two species that may have been confused for one another during different surveys.

* Indicates significant change from the previous monitoring period using the 95% confidence intervals for frequency observed for 100 plots.

Table 4. Tree Density, Mean Diameter and Basal Area for Tree Species Found in the 10 m x 100 m Transect for Transect #1 - Aspen, Research Camp - in the Long-term Vegetation Trends Monitoring Project at Craters of the Moon National Monument, Arco, Idaho, 1998.

Species	#trees/hectare	Mean $\pm$ SD dia.	Basal area
Aspen	590	14.4 $\pm$ 5.9 cm	9.6 m ² /hectare
Chokecherry	40	8.9 $\pm$ 2.1 cm	0.2 m ² /hectare

Table 5. Comparative Results of Tree Density, Mean Diameter at Breast Height (dbh) and Basal Area Trees Found in the Transect #1 - Aspen, Research Camp - in 1992, 1996 and 1998 at Craters of the Moon National Monument, Arco, Idaho.

Aspen	1992	1996	1998
# trees/hectare	1,140	940	590
mean dbh (cm)	12.0	13.6	14.4
basal area (m ² /hectare)	12.8	13.6	9.6
Chokecherry			
# trees/hectare	200	80	40
mean dbh (cm)	4.1	8.5	8.9
basal area (m ² /hectare)	0.3	0.4	0.5
Upland willow			
# trees/hectare	80	1	0
mean dbh (cm)	6.3	14.2	0
basal area (m ² /hectare)	0.2	0	0

Table 6. 1998 Plant Species Frequency Data for 100 Plots in the Vegetation Trends Monitoring Transect # 2 - Sagebrush, North End, Craters of the Moon National Monument, Arco, Idaho.

Species	10X10	25X25	25X50	50X50	SUM
GRASSES					
AGTR	16	27	22	17	82*
STCO2	7	11	9	10	37
POPR	3	3	2	3	11
PONE	0	1	1	1	3
KOCR	0	1	0	0	1
PERENNIAL GRASS	27	36	19	13	95
ANNUAL GRASS	0	0	0	0	0
FORBS					
CRAC	10	25	17	10	62*
ERUM	2	12	14	10	38
BASA	1	7	7	9	24
PHHA	6	5	8	4	23
CRWA	4	9	4	5	22
GARA2	4	6	3	5	18
LUSE	1	4	8	5	18
COPA2	5	1	4	4	14
VIPU	4	4	1	4	13
LIRU	1	2	4	5	12
PODOD	2	1	5	3	11
HEUN	2	2	1	3	8
AGGL	0	1	3	1	5
MEAL2	0	3	1	1	5
MINA	0	1	2	2	5
ARHO	0	0	1	3	4
GABO	2	2	0	0	4
POGL	1	0	2	1	4
CHDO	0	1	0	1	2
LOTR	0	1	0	0	1
PHLO	0	0	0	1	1
PERENNIAL FORB	27	41	22	6	96
ANNUAL FORB	12	14	5	9	40
SHRUBS					
SYOR	11	15	7	10	43*
PUTR	6	10	9	10	35*
ARTRV	1	12	4	11	28*
CHNA	2	2	2	0	6
CHVI	0	1	2	2	5
AMAL	0	0	1	0	1
SHRUB	20	28	14	14	76

* Highest sum frequency values ($P < 0.05$) for each life form.

Table 7. Comparative Sum Frequencies for All Species Found in All Surveys Conducted on the Vegetation Trends Monitoring Program's Transect # 2 - Sagebrush, North End - Craters of the Moon National Monument, Arco, Idaho.

GRASSES	1994	1998
AGSP/AGTR†	74	82
ELCI	3	0
KOCR	0	1
PONE	0	3
POPR	3	11
STCO2/STCO3†	20	37
PERENNIAL GRASS	NA	95
ANNUAL GRASS	NA	0
FORBS		
AGGL	0	5
ARHO	0	4
BASA	26	24
CASTI	1	0
CHDO	0	2
COPA2	0	14*
CRAC	41	62*
CRWA	0	22*
ERHE/ERUM†	41	38
GABI	0	4
GARA2	0	18*
HEUN	0	8
HICY	9	0
LIRU	9	12
LOTR	0	1
LUSE	5	18
MEAL2	0	5
MINA	0	5
PENST	3	0
PHHA	14	23

FORBS CONT	1994	1998
PHLO	0	1
PODOD	0	11*
POGL	0	4
VIPU	0	13*
PERENNIAL FORB	NA	96
ANNUAL FORB	NA	40
SHRUBS		
AMAL	0	1
ARTRV	40	28
CHNA	3	6
CHVI	7	5
PUTR	47	35
SYOR	41	43
SHRUB	NA	76

† Indicates two species that may have been confused for one another during different surveys.

* Indicates significant change from the previous monitoring period using the 95% Confidence Intervals for frequency observed for 100 plots.

Table 8. 1998 Plant Species Frequency Data for 100 Plots in the Vegetation Trends Monitoring Transect # 5 - Limber Pine, Inferno Cone - at Craters of the Moon National Monument, Arco, Idaho.

Species	10X10	25X25	25X50	50X50	SUM
GRASSES					
POPR	12	16	12	12	52*
SIHY	6	3	1	5	15
AGTR	0	1	0	3	4
STCO2	0	0	0	2	2
STTH	0	1	0	0	1
PERENNIAL GRASS	18	22	7	16	63
ANNUAL GRASS	0	0	0	0	0
FORBS					
COPA2	30	25	6	5	66*
PHHA	8	6	5	6	25
DEAN	4	4	7	7	22
MINA	7	7	2	4	20
CRWA	10	4	2	3	19
MISU	3	6	3	2	14
ALTO	3	2	3	3	11
GARA2	5	3	2	0	10
ARHO	2	1	0	6	9
GANU	0	2	3	3	8
CYTE	0	3	3	1	7
ERUM	0	2	1	4	7
MEAL2	0	2	0	2	4
PODOD	0	0	2	1	3
LASE	0	1	1	0	2
TAOF	0	0	1	1	2
AGGL	1	0	0	0	1
ASTER	0	0	1	0	1
PERENNIAL FORB	16	15	13	12	56
ANNUAL FORB	40	21	6	7	74
WOODY SPECIES					
PUTR	2	7	10	9	28*
RICE	7	11	3	7	28*
CHNA	1	5	8	6	20*
PIFL	1	3	1	5	10
ARTRV	0	1	0	1	2
LEPU	0	1	0	0	1
SHRUB/TREE	10	26	16	15	67

* Highest sum frequency values ($P < 0.05$) for each life form.

Table 9. Comparative Sum Frequencies for All Species Found in Surveys Conducted on the Vegetation Trends Monitoring Program's Transect # 5 - Limber Pine, Inferno Cone - in 1992, 1996 and 1998, Craters of the Moon National Monument, Arco, Idaho.

GRASS	1992	1996	1998
AGTR	0	0	4
POSE/POPR†	35	31	52
ORHY	0	31*	0*
SIHY	3	9	15
STCO2/STOC/STTH†	24	4*	3
PERENNIAL GRASS	NA	NA	63
ANNUAL GRASS	NA	NA	0
FORB			
AGGL	0	1	1
ALTO	0	2	11
ARHÖ	3	1	9
ASTER	3	1	1
CHDO	0	1	0
COPA2	0	15*	66*
CRT0/CRWA†	0	27*	19
CYTE	3	6	7
DEAN	0	8*	22
EROV	0	1	0
ERUM	10	9	7
GANU	0	0	8
GARA2	4	43*	10*
LASE	0	0	2
MEAL2	2	8*	4
MINA	0	0	20*
MISU	0	0	14
PHHA	7	36*	25
PODOD	0	0	3
TAOF	0	0	2
PERENNIAL FORB	NA	NA	56

Woody species	1992	1996	1998
ANNUAL FORB	NA	NA	74
ARTRV	2	0	2
CHNA	25	25	20
LEPU	1	2	1
PIFL	3	4	10
PUTR	34	33	28
RICE	29	0*	28*
SHRUB/TREE	NA	NA	67

† Indicates two species that may have been confused for one another during different surveys.

* indicates significant change using the 95% confidence intervals for frequency observed for 100 plots.

Table 10. Comparative Results of the Tree Density, Mean Diameter at Breast Height (dbh) and the Basal Area of Trees Found in the 20m X 100m Transect (10m out on Each Side of the Transect Line) for Transect # 5 - Limber Pine, Inferno Cone - of the Vegetation Trends Monitoring Program for 1992, 1996 and 1998 at Craters of the Moon National Monument, Arco, Idaho.

PIFL	1992	1996	1998
# trees/hectare	200	200	165
avg. dbh (cm)	19.1	18.2	19.56
basal area (m ² /hectare)	5.7	5.2	4.9

Table 11. 1998 Plant Species Frequency Data for 100 Plots in the Vegetation Trends Monitoring Transect # 8 - Three-tip Sagebrush/fescue, Carey Kipuka - Craters of the Moon National Monument, Arco, Idaho.

Species	10X10	25X25	25X50	50X50	SUM
GRASSES					
FEID	28	23	16	12	79*
KOCR	23	21	15	9	68*
POSE	11	9	6	9	35
CAFI	5	4	1	2	12
AGSP	1	4	2	3	10
BRTE	2	4	1	0	7
CADO	2	1	0	3	6
STCO3	0	1	0	1	2
SIHY	0	1	0	0	1
PERENNIAL GRASS	55	24	10	4	93
ANNUAL GRASS	2	4	1	0	7
FORBS					
GARA2	27	16	11	12	66*
AGGL	10	20	15	20	65*
COLI	13	24	15	13	65*
PODOD	9	11	9	4	33
LUSE	6	7	9	8	30
PHLO	9	9	5	3	26
LASE	2	8	2	5	17
ASCO	4	3	4	4	15
ARLI	1	6	4	3	14
COPA2	2	1	6	5	14
CRAC	0	1	4	4	9
LOTR	0	2	1	4	7
MEAL2	1	1	3	1	6
SEIN	1	2	1	2	6
ALTE2	0	2	1	2	5
ASFI	2	1	1	1	5
GILIA	1	3	0	1	5
CRYPT	1	2	0	1	4
CORA	0	1	1	1	3
ERPU2	0	2	1	0	3
ERUM	1	0	1	1	3
CALOC	0	0	2	0	2
CIRSI	0	0	1	0	1
ERHE2	0	0	1	0	1
GYMN3	0	0	0	1	1
TRDU	0	0	0	1	1
PERENNIAL FORB	32	35	17	7	91
ANNUAL FORB	39	33	14	7	93
SHRUBS					
ARTR2	4	9	8	14	35*
CHVI	1	0	1	2	4
SHRUB	5	10	9	14	38

* Highest sum frequency values ($P < 0.05$) for each life form.

Table 12. Comparative Sum Frequencies for All Species Found in All Surveys Conducted on the Vegetation Trends Monitoring Program's Transect # 8 - Three-tip Sagebrush/fescue, Carey Kipuka - Craters of the Moon National Monument, Arco, Idaho.

GRASSES	1994	1998
AGSP	2	10
BRTE	4	7
CADO/CAREX†	3	5
CAFI/CAREX†	3	12
ELCI	3	0
FEID	53	79*
KOCR	53	68
POSE	11	35*
SIHY	1	1
STOC/STCO3†	4	2
PERENNIAL GRASS	NA	93
ANNUAL GRASS	NA	7
FORBS		
AGGL	0	65*
ALTE2	11	5
ARLI	3	14
ASCO/ASTRA†	2	15*
ASFI/ASTRA†	2	5
BASA	2	0
CALCO	0	2
CIRSI	0	1
COLI	0	65*
COPA2	0	14*
CORA	0	3
CRAC	3	9
CRYPT	2	4
ERHE2	0	1

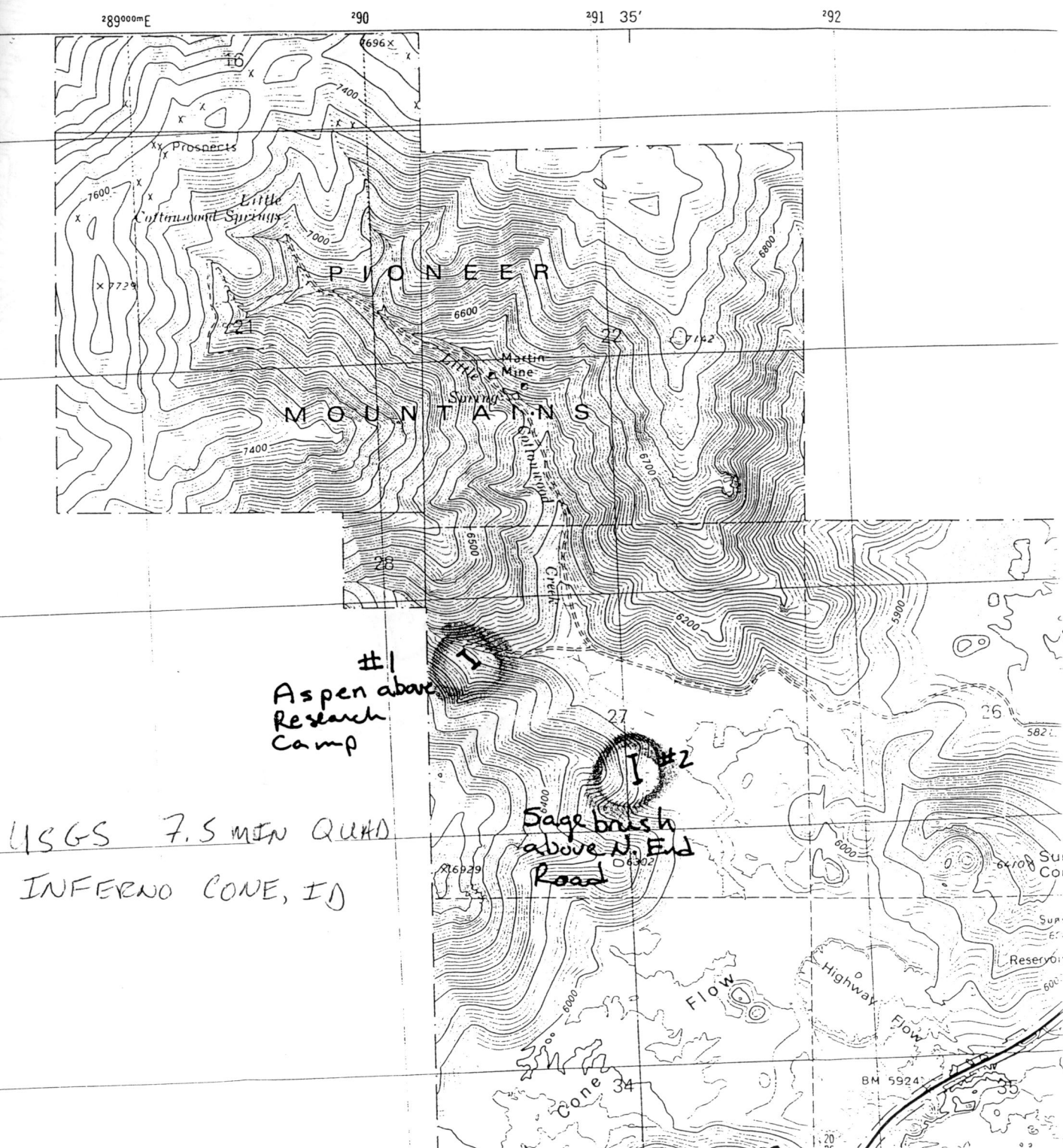
FORB CONT.	1994	1998
ERPU2	0	3
ERUM	0	3
GARA2	25	66*
GILIA	0	5
GYMN3	0	1
LASE	0	17*
LIRU	1	0
LOTR	1	7
LUSE	11	30*
MEAL2	0	6
PHLO	0	26*
PODOD	0	33*
SEIN	0	6
STEPH	4	0
TRDU	0	1
PERENNIAL FORB	NA	91
ANNUAL FORB	NA	93
SHRUB		
ARTR2	57	35*
CHVI	3	4
SHRUB	NA	38

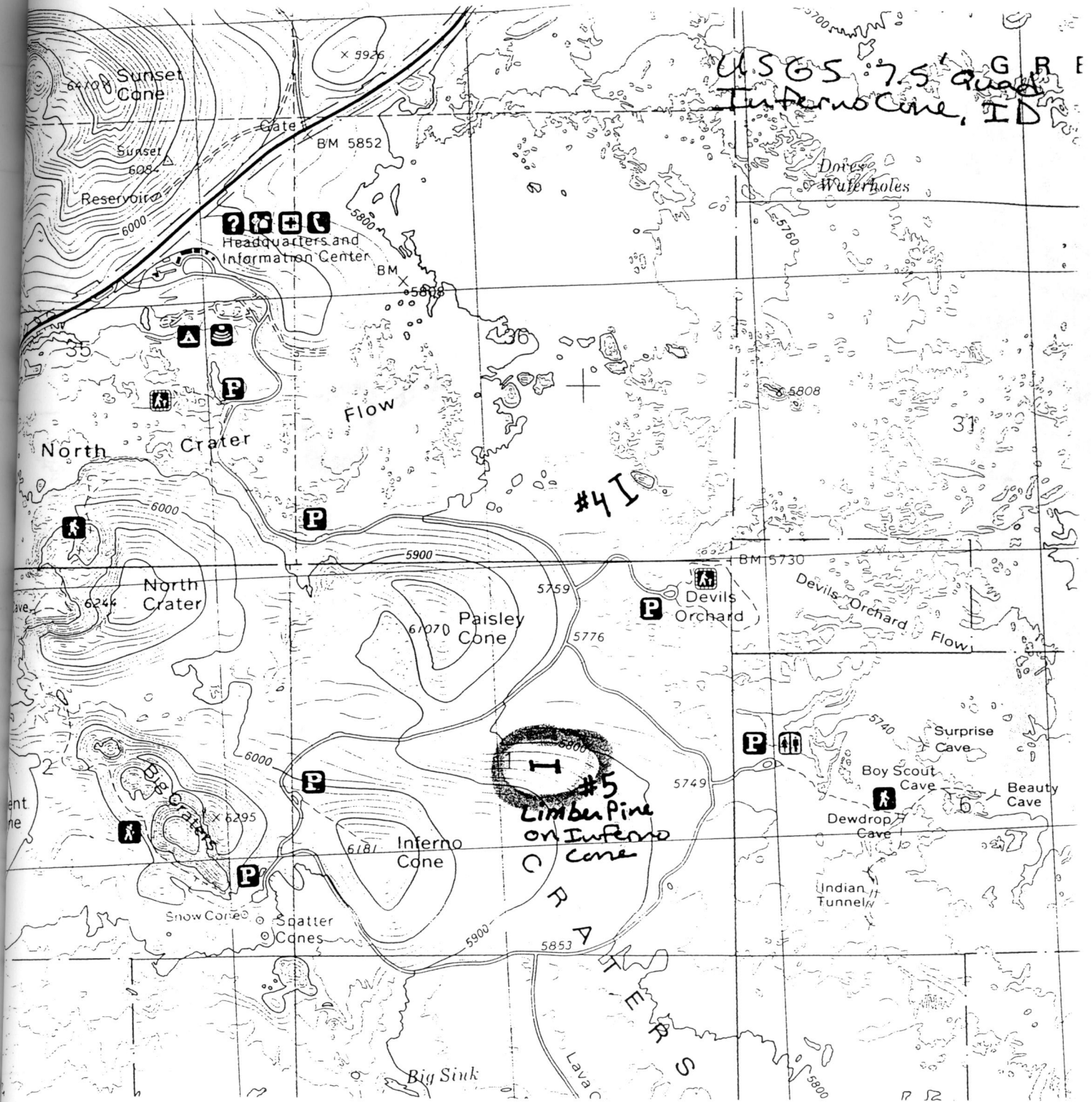
† indicates two species that may have been confused for one another during different surveys.

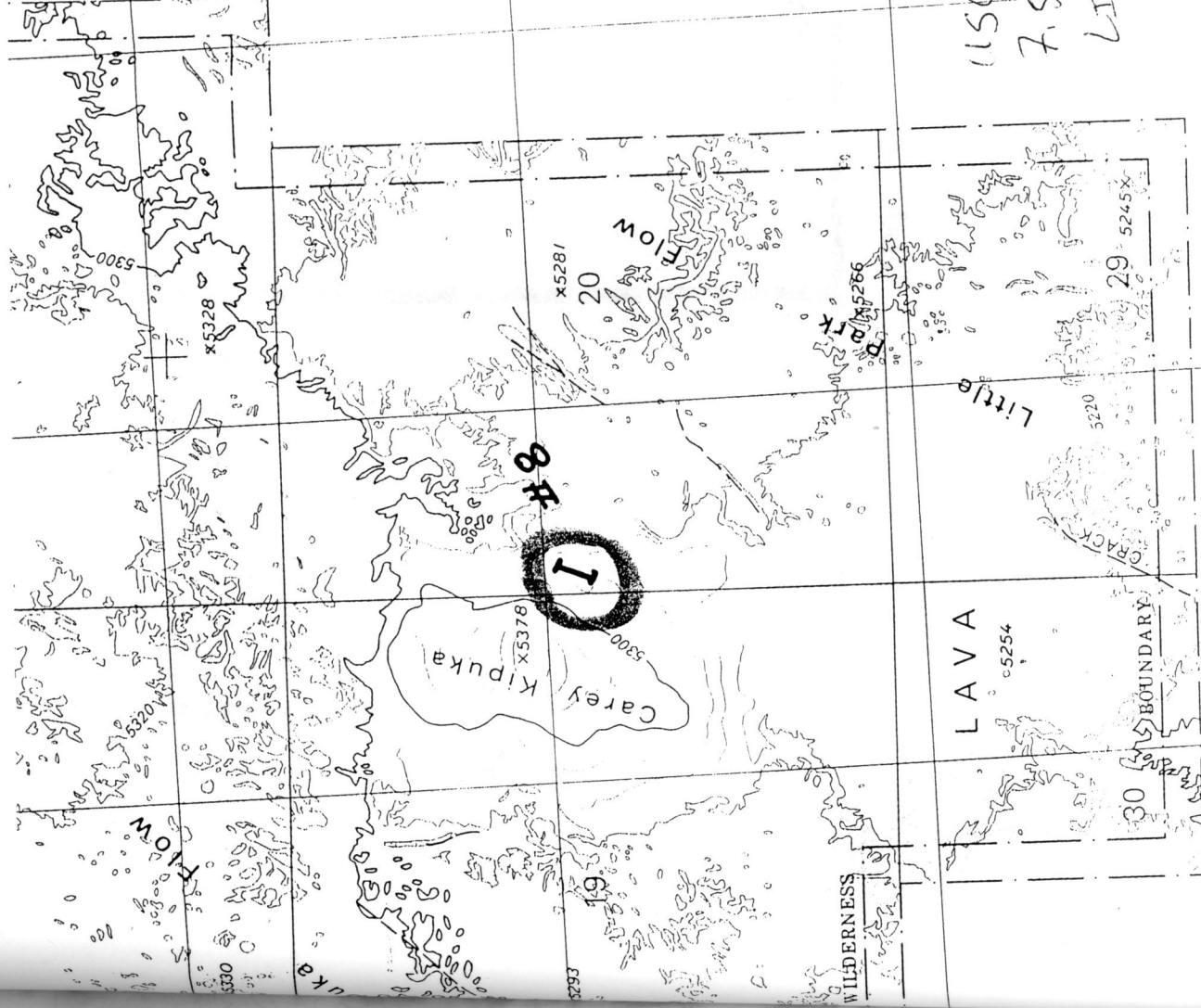
* indicates significant change from the previous monitoring period using the 95% confidence intervals for frequency observed for 100 plots.

Figure 1.

Map Locations of The Craters of The Moon National Monument's 1992 Long-term Vegetation Trends Monitoring Transects 1, 2, 5 And 8.







LAVA

05254

7/11/80

30 BOUNDARY

29.

5245X

11565

7.5 min QUAD

LITTLE PARK, ID

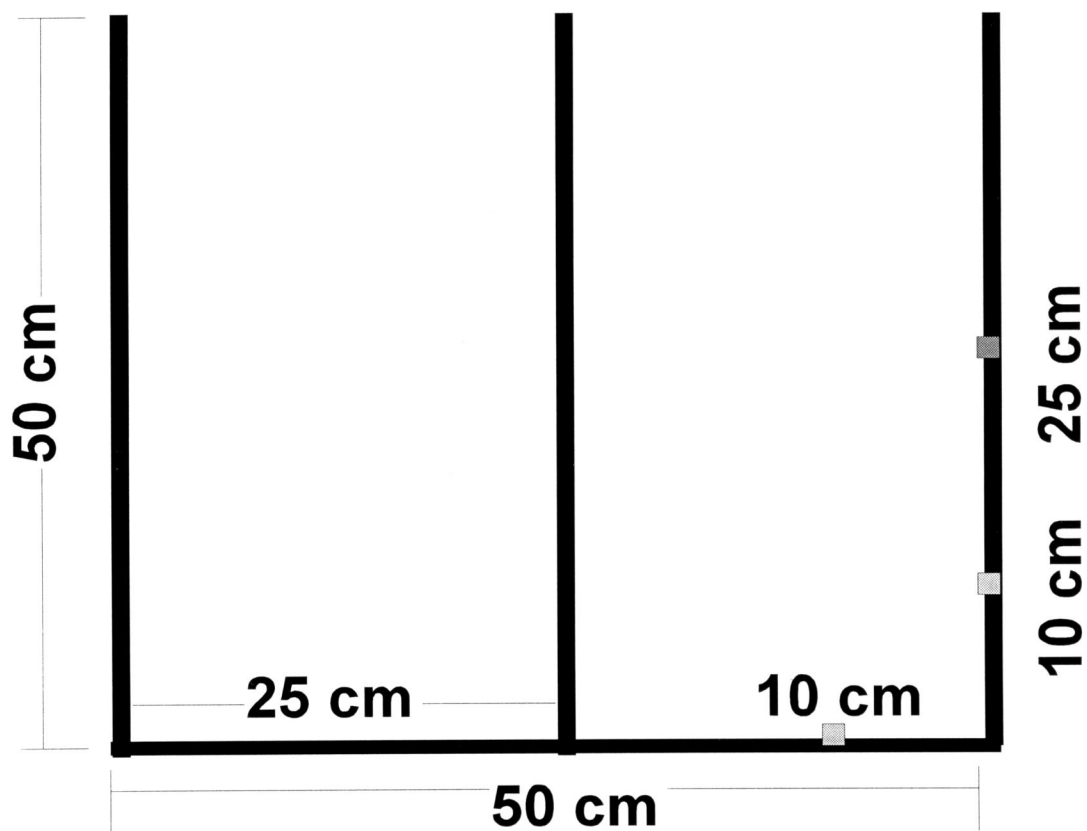
286

37'30"

288

Figure 2.

Illustration of Frequency Frame Used in The Craters of The Moon National Monument's Long-term Vegetation Trends Monitoring Program



Appendix 1.

Rotation Schedule and UTM Coordinates for the Craters of the Moon National Monument's Long-term Vegetation Trend Monitoring Transects

<u>Year</u>	<u>Transect #/Location</u>	<u>UTM Coordinates</u>
92, 96, 2000...	1. Aspen above research camp	290.28 E, 4816.73 N
	5. Limber pine on Inferno Cone	239.97 E, 4813.15 N
93, 97, 2001...	6. East BLM transect	293.53 E, 4818.63 N
	3. Douglas Fir on Grassy Cone	291.54 E, 4814.30 N
94, 98, 2002...	8. 3-tip sage on Carey Kipuka	286.60 E, 4799.85 N
	2. Sagebrush slope, north end	291.01 E, 4816.30 N
95, 99, 2003...	4. Cinder gardens, devil's orch.	294.53 E, 4814.22 N
	7. West BLM transect	293.47 E, 4818.50 N