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SECONDARY PLANT SUCCESSION AT CRATERS OF THE MOON NATIONAL MONUMENT,
IDAHO : THE FIRST TWO YEARS



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Introduction

Situated upon an active fault zone where the Snake River Plain of southeastern Idaho abuts on the Pioneer Mountain extension of the Challis volcanics (Murtaugh, 1961), Craters of the Moon National Monument is one of the most floristically diverse regions of the vast volcanic plain. In this area, montane species intermingle with cold desert species, but the transition zones between these representatives of the forest and desert provinces are not always clearly demarcated probably because of the relatively recent age of the basaltic substrate and the conspicuous absence of well-developed soils. Vegetatively the Monument consists of seral shrub and herb communities which are apparently integral stages of the overall successional scheme which culminates in the regional climax community of sagebrush and grass (Eggler, 1941). Almost to the extent of defying generalized descriptions, the composition of the plant communities of the Monument varies. This variation is apparently the result of extremely diverse topoeclaphic conditions in exposure, substrate age, texture, and depth. So diverse is the vegetation of the area that such mesic forms as the Douglas fir (Pseudotsuga menziesii Franco), Lewis' monkeyflower (Mimulus lewisii Pursh), and enchanter's nightshade (Circaea alpina L.) are found in its northern sectors while salt desert shrubs such as spiny hopsage (Grayia spinosa (Hook) Moq.) and shadscale (Atriplex confertifolia (Torr.) Wats.) occur in its southern extremities.

The political boundaries of Craters of the Moon National Monument encompass approximately 83 square miles of basaltic volcanic features produced during three (Stearns, 1963) or four (Murtaugh, 1961) major periods of volcanic eruptions that occurred in the last one million years along a recently-active volcanic rift known locally as the Great Rift Zone.

Excluding the summits of the Pioneer Mountains, the elevation of the lava plain exhibits a gradual slope from 5900 feet in the northwestern region to 5300 feet in the southeast. The relief is broken in at least fifty-five points by numerous cinder cones which are concentrated in a mile-wide strip running from northwest to southeast for 13 miles (Parsons, 1964), delimit the fissures of the Great Rift Zone, and rise as high as 800 feet above the adjacent plain which itself contributes to the unique irregularities of the lava landscape. Soils are generally poorly developed except in certain isolated relict areas, termed "kipukas," which were not inundated by the recent lava flows (Parsons, 1964). The thin layers of soil buried beneath thick layers of basaltic cinder are composed of Snake River loess (Passey, Hugie, and Williams, 1964) and the wind, which prevails from the southwest at velocities of 15 to 30 miles per hour at all seasons (Eggler, 1941), is apparently a major factor contributing to the development of soil. With the exceptions of several kipukas, unweathered basalt is universally present, indicating the geologically young age of the parent material, and soil profile horizons, for the most part, have not yet developed. Climatically, Craters of the Moon National Monument receives more annual precipitation than does the surrounding Snake River Plain, probably because of the higher elevation, the proximity of the area to the mountains, and the peculiar convection patterns created by the vast expanse of black surface (Lindsey, 1951).

Although the area was designated a national monument in 1924, it was not until 1938 that the first ecological studies were conducted. Since Eggler's descriptive study of primary succession in 1941, published accounts of vegetative studies within the Monument have been practically non-existent. Because certain facts concerning the patterns of secondary plant succession

were thought essential to the sound management policies on the part of the National Park Service administrators, because the effects of disturbance in this unusual area have never been assessed, and because of the author's special interest in the area, the following study was initiated in August of 1966.

The Martin Road area was selected for secondary plant succession studies because it is located within the protective boundaries of the Monument where grazing (except on the part of native mammals) and other types of man-caused disturbance are prohibited. The road site was closed to public access in late August of 1965 and was relocated approximately one mile north of the northwest Monument boundary, leaving a barren belt transect through a relatively stable climax community of sagebrush (Artemisia arbuscula) and rabbitbrush (Chrysothamnus nauseosus).

The study area is situated in the northwestern corner of the Monument (N. $\frac{1}{4}$, Sec. 25, T.2N., R.24E., Butte County, Idaho) (see Fig.1) on a relatively flat lava plain. With a gradual eastward slope from the base of the Pioneer Mountains and Sunset Cone, the northernmost cinder cone along the Great Rift, the general elevation of the area is approximately 5730 feet. The road closure area is approximately seven-tenths of one mile in length, varies in width from 19 to 23 feet, and is surrounded by vegetation typical of the older lava flows (see Fig. 2).

Soil appears to be very poorly developed in the study site and consists primarily of fine cinder that apparently covers an older pahoehoe lava flow extruded from nearby Sunset Cone (Murtaugh, 1961). The substrate consists of layers of unconsolidated parent material in the form of basaltic cinder alternating with layers of eolian deposits of Snake River loess. Although the terrain appears to be relatively flat, substrate depth is quite variable

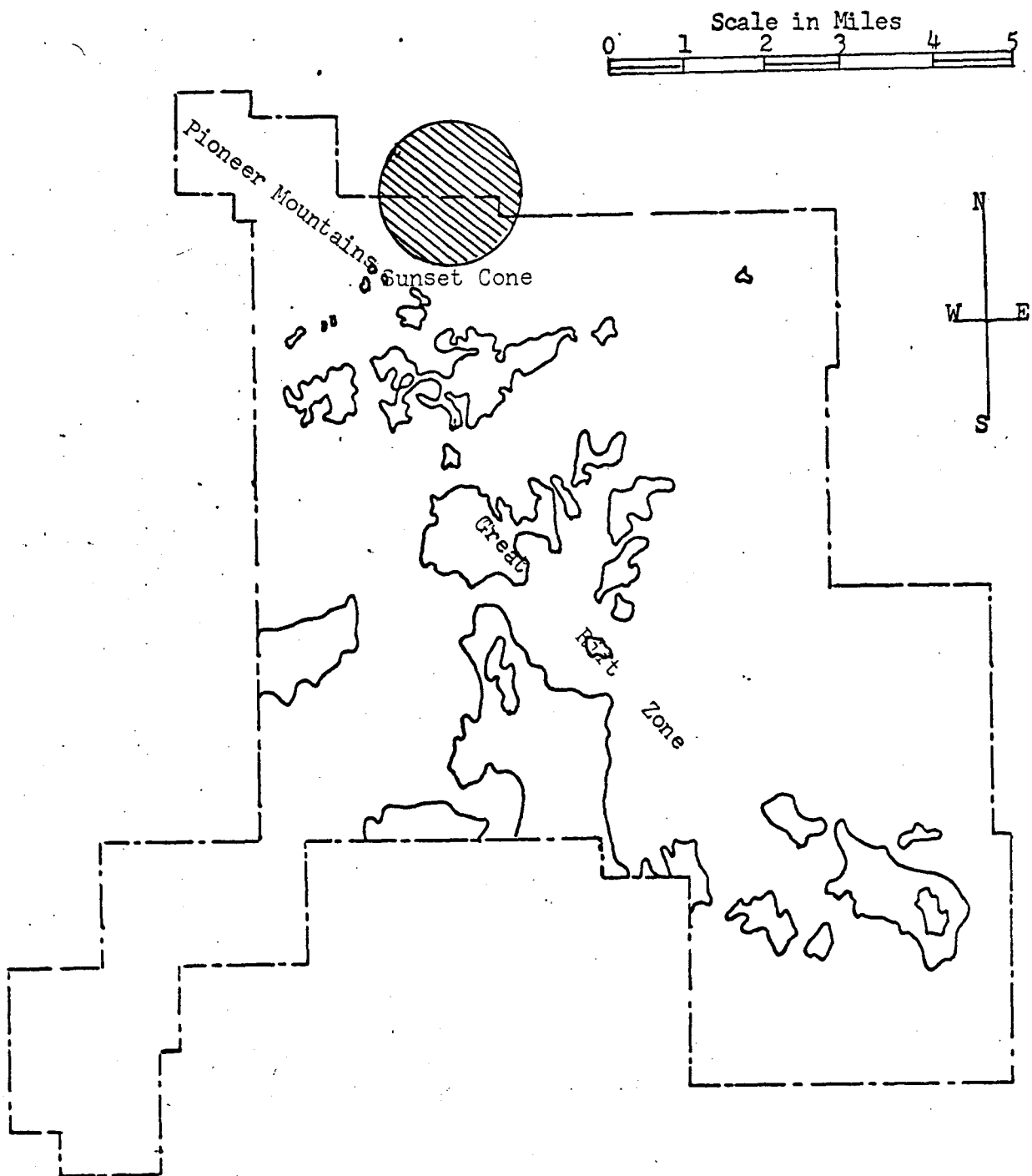


Figure 1. Map of Craters of the Moon National Monument showing political boundaries (broken lines), limber pine stands (irregular solid lines), and the Martin Road study site (shaded circle).

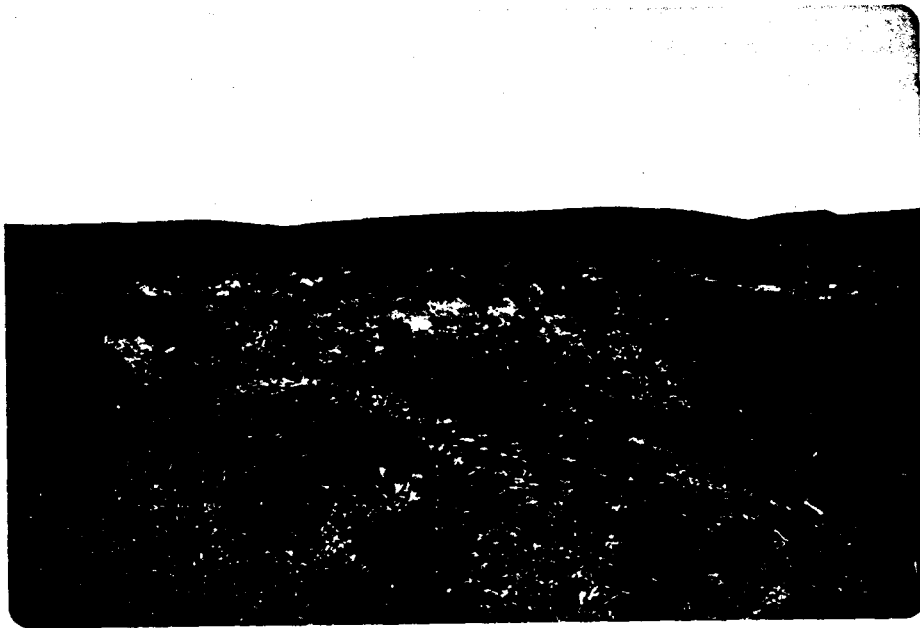


Figure 3. Martin Road Study site in late summer aspect showing regional climax vegetation of Artemisia and associated shrubs and herbs (Photo by Warren Van Camp).



Figure 4. Alternating layers of Snake River loess and basaltic cinders showing extension of loessial strata to depths of 24 feet (Photo by Warren Van Camp).

and appears to fluctuate with irregularities in the solid pahoehoe lava flow on which it is superimposed. Substrate depth is generally more than one foot but less than three feet and appears to be an important factor limiting the density of the vegetation in any given site. A 'wind pavement' of cinder is generally present on the surface of the roadbed while alternating layers of loess and cinder impart peculiar aspects to the subsurface characteristics. This peculiar stratification may be attributed to the deposition of cinder during periods of active volcanic activity followed by the deposition of loess during the periods of quiescence. Stratification of this type is readily evident elsewhere in the Monument where road cuts have exposed the profiles of cinder cones, some of which have loessial strata 24 feet beneath the cindered surface (see Fig. 3).

Colorimetric determination (Daubenmire, 1959) of the substrate pH indicates that variation from slightly acidic (pH 6.8) to neutral (pH 7.2) occurs with higher pH values prevalent in the strata less than 12 inches in depth and the lower values more common in the strata below 12 inches. The acidic nature of the substrate is not surprising since this characteristic of weathered basaltic lava has been studied extensively in other areas of the world (Doty and Mueller-Dombois, 1966). Unfortunately, most of the studies of young volcanic soils have been undertaken in areas where annual precipitation greatly exceeds that of Craters of the Moon National Monument. In such areas, the role of organic matter in soil-plant relationships would be expected to differ considerably from that existent in the Monument.

Considerable deviation from the normal climatic conditions of the Snake River Plain is indicated by United States Weather Bureau records maintained since December of 1958 at Monument headquarters located approximately one mile southwest of the study site. Although Blaisdell (1959) found the

average annual total precipitation on the surrounding Snake River Plain to be about ten inches, the same climatic index averages 15.8 inches for the Monument. This unusually high amount of precipitation may be attributed to the proximity of the area to the mountains, resulting in excessive orographic precipitation through the approach effect, and to the unusual convection patterns created by the blackened basaltic surface which were found to significantly increase the annual precipitation in a basaltic volcanic area in New Mexico (Lindsey, 1951). For the nine year period for which climatic data are available from the weather station at Monument headquarters, December and January appear to be the months of greatest total precipitation while July and October are the periods of least total precipitation (see Fig. 4).

Mean annual temperature in the area approaches 42° F., with August having the highest mean monthly temperature of 64.56° and January having the lowest mean monthly temperature of 20.03° (see Fig. 5). The frost-free period, and hence the growing season, averages 104 days in length although this figure is highly variable with extremes of 69 and 160 in the nine year period.

The climatic data collected at the weather station generally support Elaisdell's (1959) study. Distributional patterns of precipitation and temperature show that annual precipitation is the most variable climatic factor while mean temperature is the least variable. Superficially, the periodicity of precipitation, temperatures prevailing during the precipitation periods, and the influence of winds in determining the effectiveness of the precipitation appear to be the limiting climatic factors involved in the vegetative productivity and composition of the area. Unfortunately, very little factor analysis work has been undertaken in this unique area and

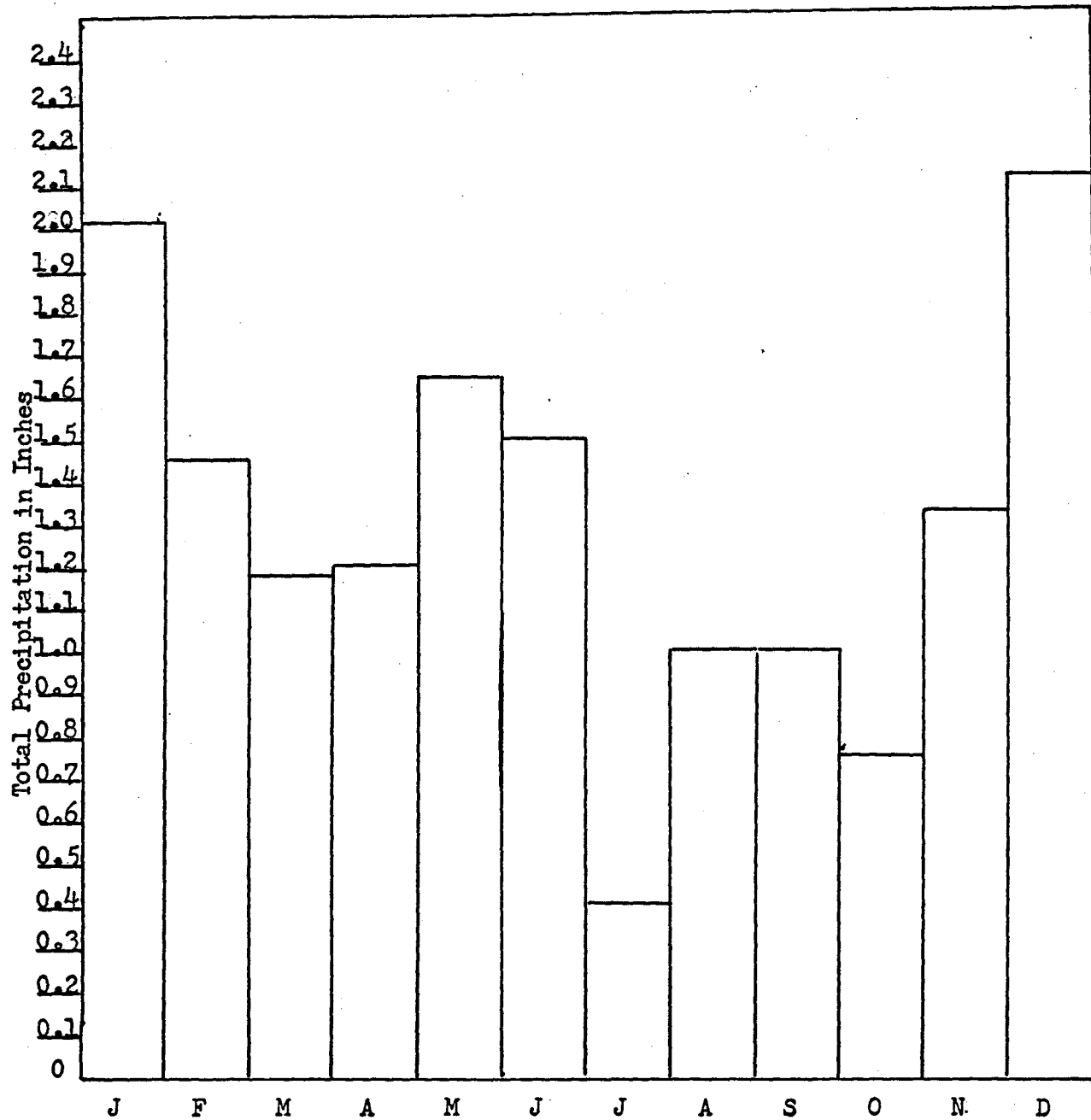


Figure 4. Mean monthly total precipitation and annual distribution of precipitation.

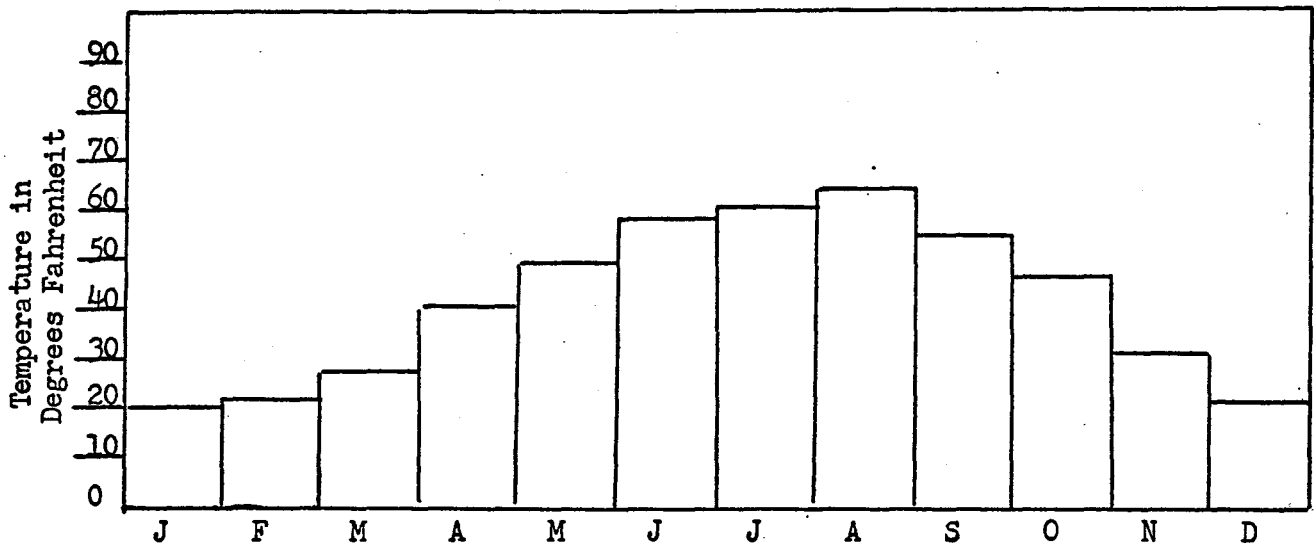


Figure 5. Average monthly temperatures and annual temperature distribution.

consequently little is known about the interaction of factors and the limiting roles each factor plays in the physiological requirements of the vegetative species of the lava fields.

Methods

The successional methods of Phillips (1959) for medium-sized vegetation were used. Sites for the meter-square quadrats were selected in a random manner by throwing metal quadrat stakes (3 feet in length) from various positions along the road. The point at which each stake landed was selected as the northeast corner of the given meter-square quadrat. Quadrat boundaries were delimited by positioning 3 red and white metal stakes (telephone pole cross-arm braces) at the corners of a meter-square rectangle about the stake marking the northeast corner of each quadrat. Ten such quadrats were erected along the .7 mile belt transect in August of 1966.

Since a pantograph was not available for basal area and cover determinations, direct metric measurements, facilitated by an improvised device consisting of two metric rulers mounted on a metal pin in such a manner that the lower scale was stationary while the upper was pivotable in horizontal position, were used. Using a scale of 1:25, the positions and total areas occupied by each plant were plotted on graph paper. Plastic overlay sheets superimposed on charts made during the first year of the study were used to show the changes that occurred in the vegetation of each quadrat during successive years. Photographic records of each quadrat were made during the second year of the study with the assistance of Warren Van Camp, a seasonal park naturalist on the Monument staff. Following termination of the investigator's research activities in the Monument, synthesis of the vegetative data was undertaken comparing the vegetative composition of the quadrats during the first and second years of secondary succession.

Results and Discussion

The results of the field work are presented in Appendix 3 in the form of vegetative quadrat maps and plastic overlay sheets. Quantitative data synthesized from the field data are presented in Table 1, and a comparison of importance value indexes of species for the two-year duration of the study is graphically presented in Figure 6.

The resultant quantitative data indicate several interesting trends in the revegetational dynamics of the study site. Introduced weedy species, for example Amaranthus graecizans and Salsola kali, are invading the area more rapidly than those species representative of the surrounding plain (except Eriogonum vimineum). This finding is not at all surprising if consideration is given to the disturbed nature of the denuded area on which secondary succession is occurring.

Generally, the ephemerals showed an increase in importance value during the second year. This increase may be attributed to the increased frequency of ephemeral representatives which was probably induced by the unusually heavy precipitation that occurred in the area during the early summer months of 1967. Perennial forms generally showed a decrease in importance value during the second year. This decline can be explained in terms of the slow increase in the cover, and, hence in the relative dominance, of these forms which was not sufficient to offset the effects of increased relative frequency and relative density of the ephemerals in calculating the importance value index.

With only two years of records available for what should be, perhaps, a twenty-year study, it is extremely difficult to assess the positions of the various species and the patterns and interactions involved in secondary plant succession at Craters of the Moon National Monument. Hopefully, if this study

is continued over a long enough period, the overall pattern of secondary succession can be accurately established from this meager starting point.

At the present, however, no further research at the Martin Road study site is planned.

Table 1
Quantitative Data

Species	Frequency (%)		Relative Frequency (%)		Density		Relative Density (%)		Relative Dominance (%)		Importance Value	
	1966	1967	1966	1967	1966	1967	1966	1967	1966	1967	1966	1967
<u>Forbs</u>												
Amaranthus graecizans	10	40	14	44	0.1	2.4	2.5	14.2	1.42	8.67	4.06	23.30
Chenopodium album	10	50	14	55	0.2	1.7	5.0	10.7	2.48	13.57	7.62	24.80
Cryptantha torreyana	20	--	28	--	0.2	--	5.0	--	2.48	--	7.76	--
Eriogonum vimineum	20	30	28	33	0.8	5.0	20.0	30.1	15.25	20.00	35.53	50.43
Gayophytum ramosissimum	30	40	42	44	0.6	1.2	15.0	9.1	15.60	11.19	31.02	20.73
Mentzelia albicaulis	--	10	--	11	--	0.1	--	0.0	--	0.28	--	0.40
Mentzelia dispersa	--	10	--	11	--	0.1	--	0.0	--	0.28	--	0.40
Mentzelia laevicaulis	10	--	14	--	0.1	--	0.0	--	4.96	--	5.13	--
Mimulus nanus	10	30	14	33	0.1	1.0	0.0	5.1	1.06	3.22	1.23	8.64
Nicotiana attenuata	20	70	28	77	0.3	1.9	7.5	12.5	8.86	6.43	19.70	19.70
Salsola kali	30	30	42	33	0.5	2.2	12.5	13.1	21.98	25.87	34.90	39.30
Sisymbrium altissimum	--	10	--	11	--	0.1	--	0.0	--	.42	--	0.50
Thlaspi arvense	10	--	14	--	0.1	--	0.0	--	4.96	--	5.13	--
<u>Grasses</u>												
Agropyron smithii	10	10	14	11	0.1	0.1	0.0	0.0	1.06	0.56	1.23	0.68
Bromus tectorum	20	--	28	--	0.2	--	5.0	--	4.96	--	10.24	--
Elymus cinereus	20	20	28	22	0.3	0.3	7.5	1.7	5.32	2.52	13.10	4.44
Sitanion hystrix	10	20	14	22	0.1	0.2	2.5	1.1	1.42	1.12	4.06	2.44
Stipa occidentalis	10	20	14	22	0.1	0.2	2.5	1.1	1.42	1.12	4.06	2.44
<u>Shrubs</u>												
Artemisia arbuscula	10	10	14	11	0.1	0.1	2.5	0.1	2.84	1.68	5.48	1.80
Purshia tridentata	10	10	14	11	0.1	0.1	2.5	0.1	3.55	3.08	6.19	3.20

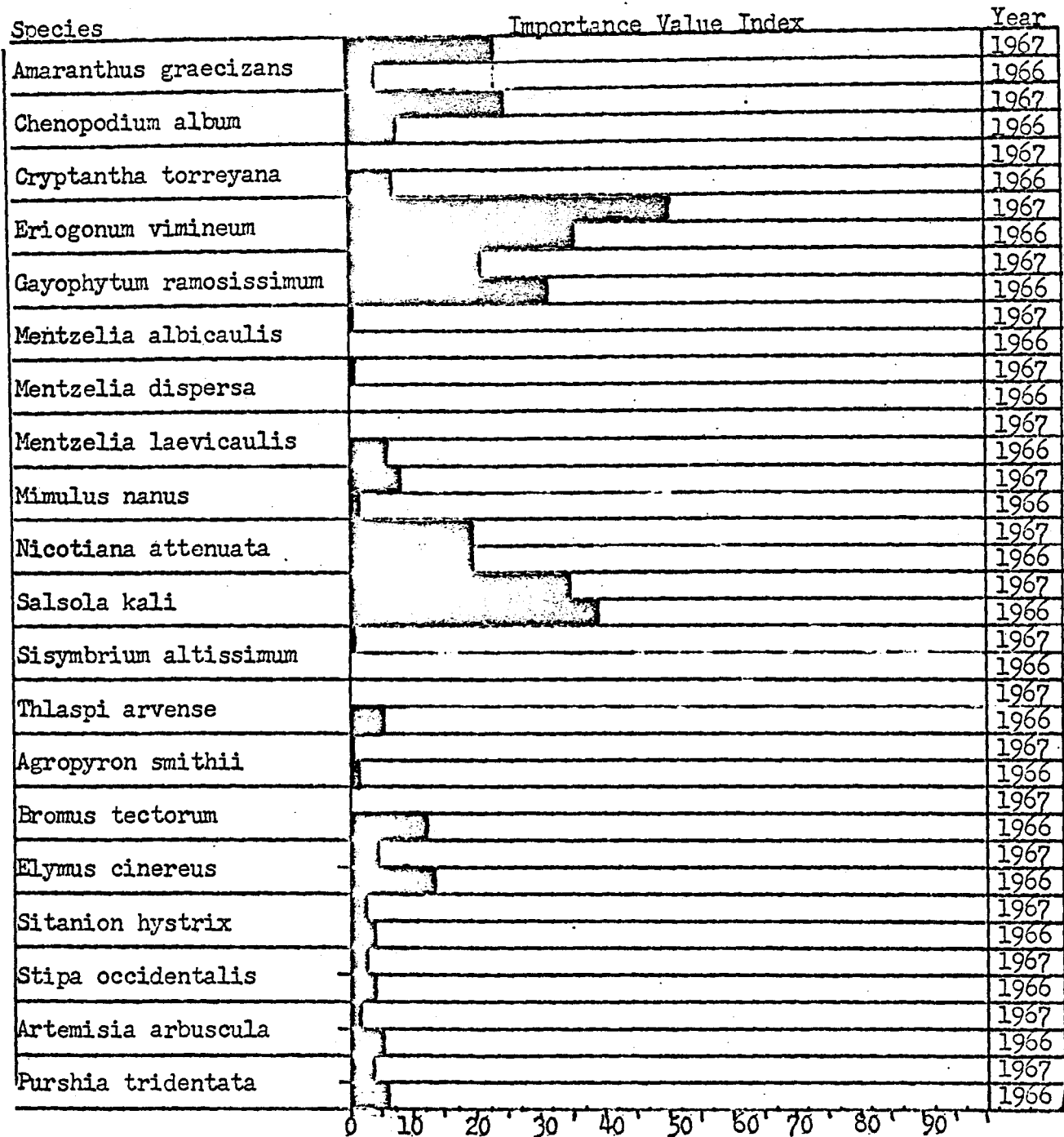


Figure 6. Comparison of importance value indexes by species for the two years during which analyses were conducted.

APPENDIX

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APPENDIX I. A CHECKLIST OF PLANTS OF THE
STUDY SITE

Roadbed

Polygonaceae	<u>Eriogonum vimineum</u> , <u>Polygonum aviculare</u> , <u>Rumex crispus</u>
Chenopodiaceae	<u>Chenopodium album</u> , <u>C. murale</u> , <u>Salsola kali</u> var. <u>tenuifolia</u>
Amaranthaceae	<u>Amaranthus graecizans</u>
Cruciferae	<u>Sisymbrium altissimum</u> , <u>Thlaspi arvense</u>
Rosaceae	<u>Purshia tridentata</u>
Leguminosae	<u>Melilotus officinalis</u>
Loasaceae	<u>Mentzelia albicaulis</u> , <u>M. dispersa</u> , <u>M. laevicaulis</u>
Onagraceae	<u>Gayophytum ramosissimum</u>
Polemoniaceae	<u>Collomia linearis</u>
Hydrophyllaceae	<u>Phacelia hastata</u>
Boraginaceae	<u>Cryptantha nana</u> , <u>C. torreyana</u>
Solanaceae	<u>Nicotiana attenuata</u>
Scrophulariaceae	<u>Mimulus nanus</u> , <u>Verbascum thapsus</u>
Compositae	<u>Artemisia arbuscula</u> , <u>Chaenactis douglasii</u> , <u>Chrysothamnus</u> <u>nauseosus</u> , <u>C. viscidiflorus</u> , <u>Grindelia squarrosa</u> , <u>Helianthus annuus</u> , <u>Lactuca serriola</u> , <u>Matricaria</u> <u>inodora</u>
Gramineae	<u>Agropyron cristatum</u> , <u>A. smithii</u> , <u>Bromus tectorum</u> , <u>Elymus cinereus</u> , <u>Stipa occidentalis</u> , <u>Sitanion hystrix</u>

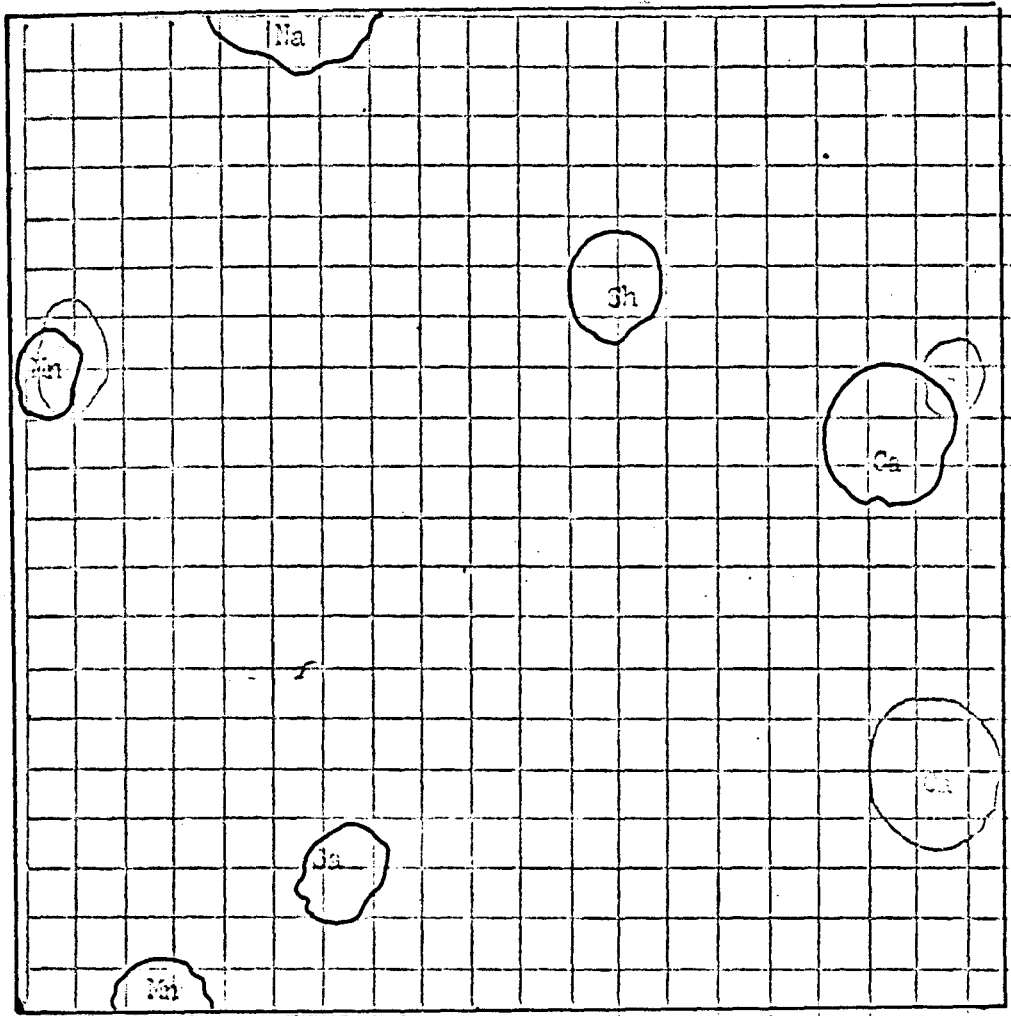
APPENDIX II. ABBREVIATIONS USED IN QUADRAT ANALYSIS

<u>Species</u>	<u>Abbreviation</u>
<u>Amaranthus graecizans</u>	Ag
<u>Chenopodium album</u>	Ca
<u>Cryptantha torreyana</u>	Ct
<u>Eriogonum vimineum</u>	Ev
<u>Gayophytum ramosissimum</u>	Gr
<u>Mentzelia albicaulis</u>	Ma
<u>Mentzelia dispersa</u>	Md
<u>Mentzelia laevicaulis</u>	MI
<u>Mimulus nanus</u>	Mn
<u>Nicotiana attenuata</u>	Na
<u>Salsola kali</u>	Sk
<u>Sisymbrium altissimum</u>	Sa
<u>Thlaspi arvense</u>	Ta
<u>Agropyron smithii</u>	As
<u>Bromus tectorum</u>	Bt
<u>Elymus cinereus</u>	Ec
<u>Sitanion hystrix</u>	Sh
<u>Stipa occidentalis</u>	So
<u>Artemisia arbuscula</u>	Aa
<u>Purshia tridentata</u>	Pt

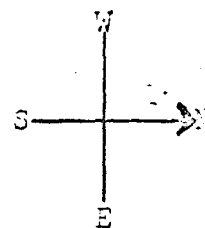
APPENDIX 3. QUADRAT MAPS AND OVERLAY SHEETS

i.....	Quadrat 1
ii.....	Quadrat 2
iii.....	Quadrat 3
iv.....	Quadrat 4
v.....	Quadrat 5
vi.....	Quadrat 6
vii.....	Quadrat 7
viii.....	Quadrat 8
ix.....	Quadrat 9
x.....	Quadrat 10

Note: Appendix 3 in the original paper consists of 10 quadrat analysis sheets from the 1966 season accompanied by 10 acetate overlay sheets showing the 1967 analyses of the same quadrats. Xerographic reproduction of the paper produced the 10 quadrat analysis sheets with the 1967 data SUPERIMPOSED UPON the 1966 analysis. The outlines of the vegetation analyzed in 1967 in all cases appear in bolder lines while the 1966 outlines are less prominent. All photographs were taken in 1967.



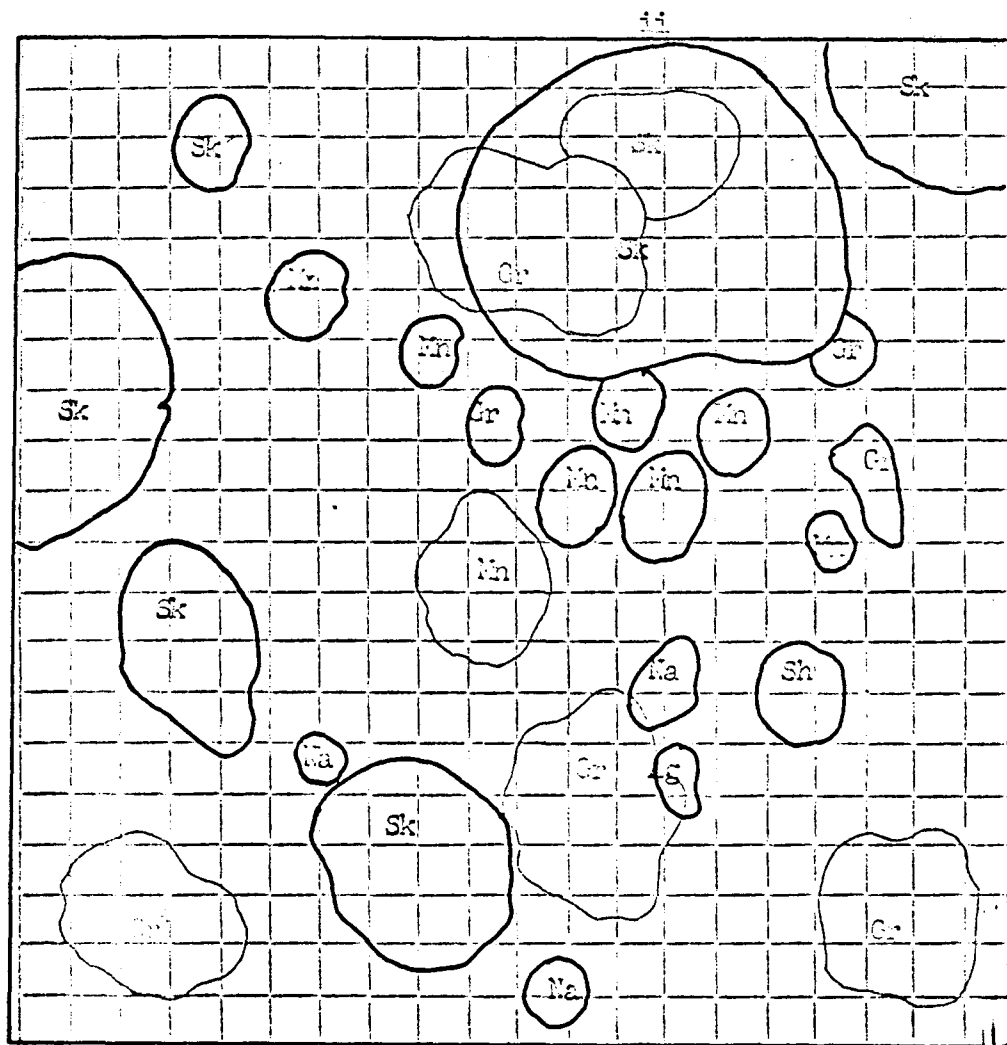
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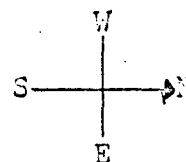
Quadrat #1 1967



OCT 1967



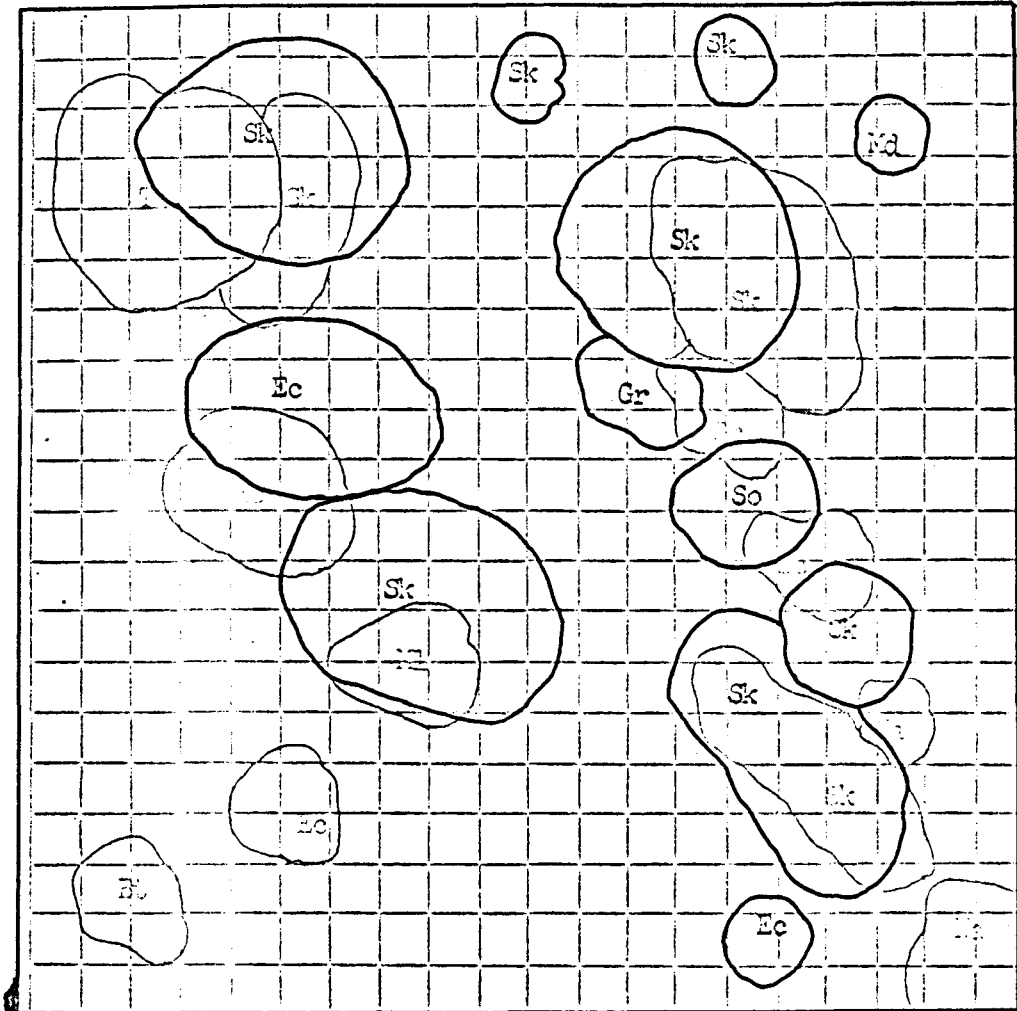
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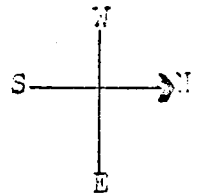
Quadrat #2 1967



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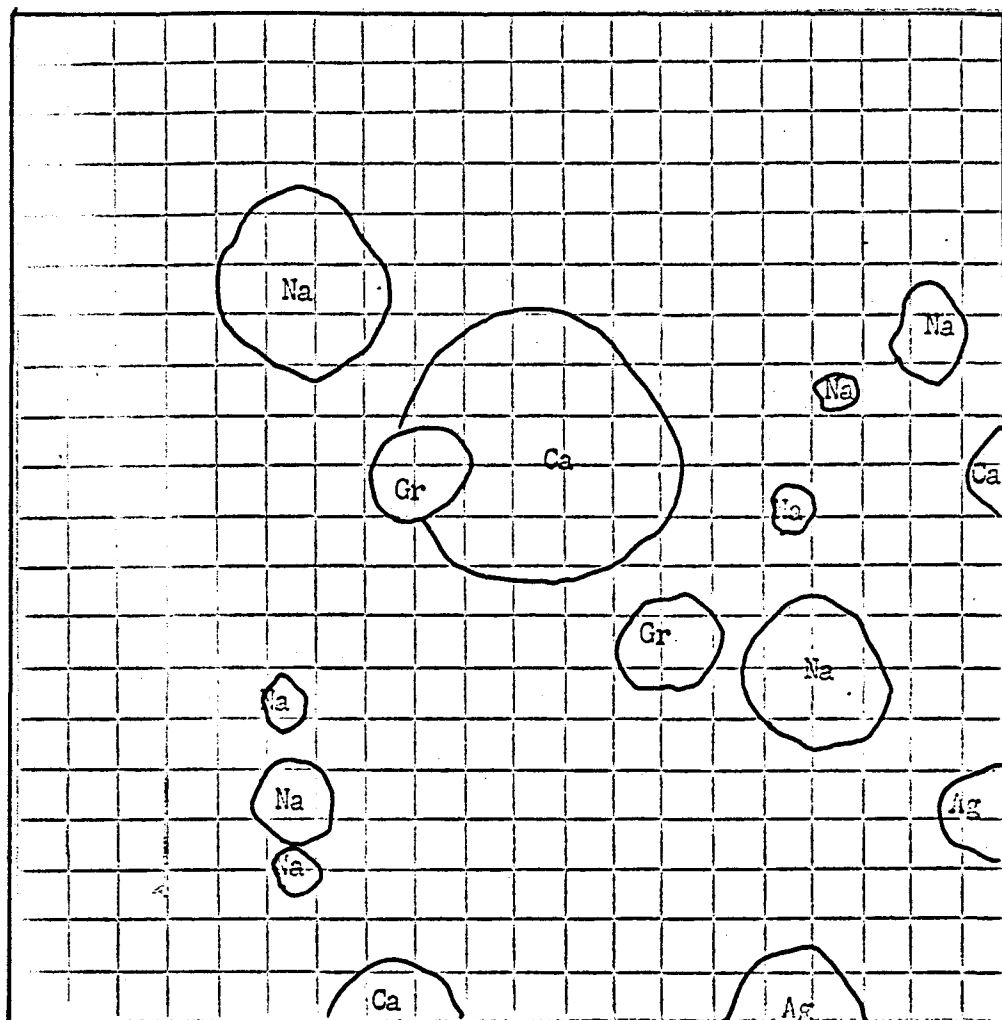


Quadrant B 1967

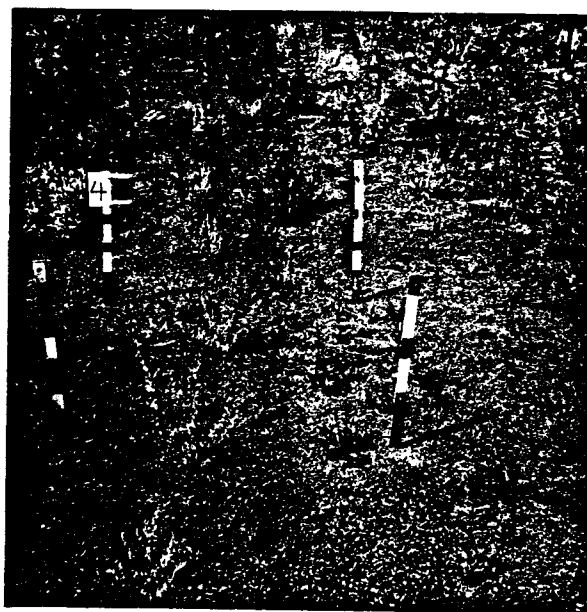


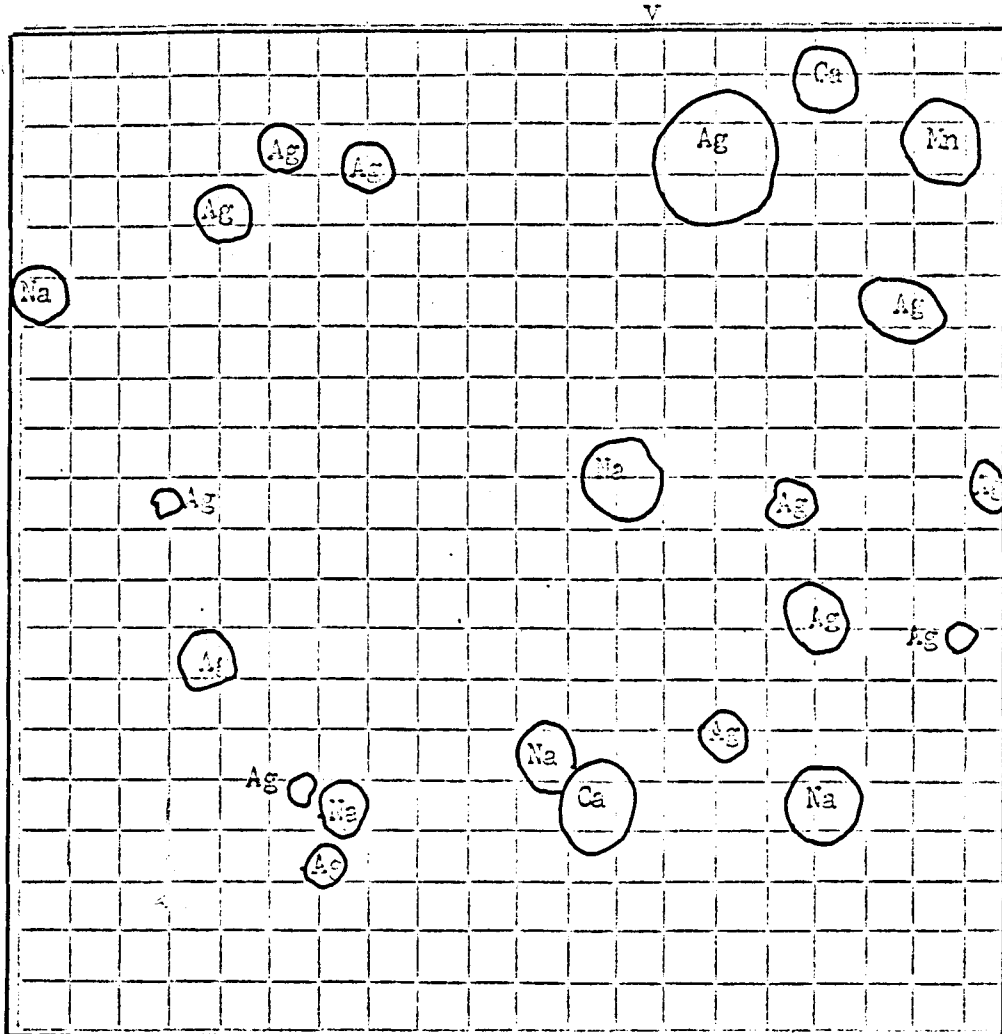
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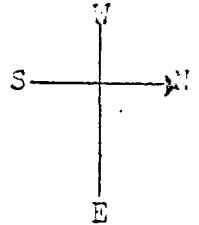


Quadrat #4 1967.

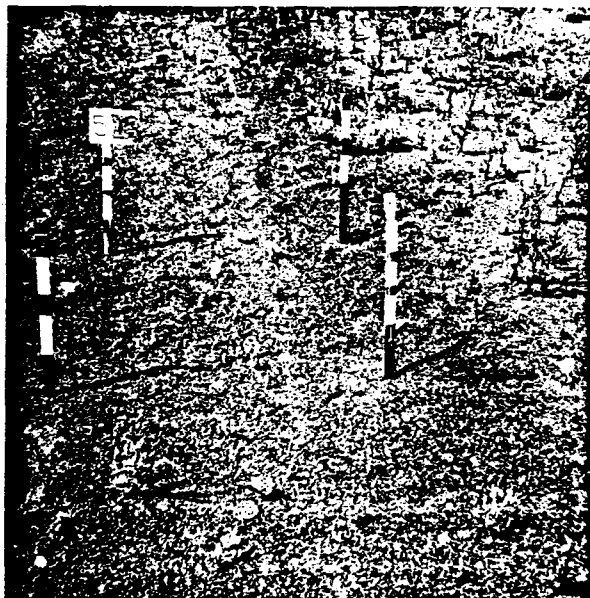




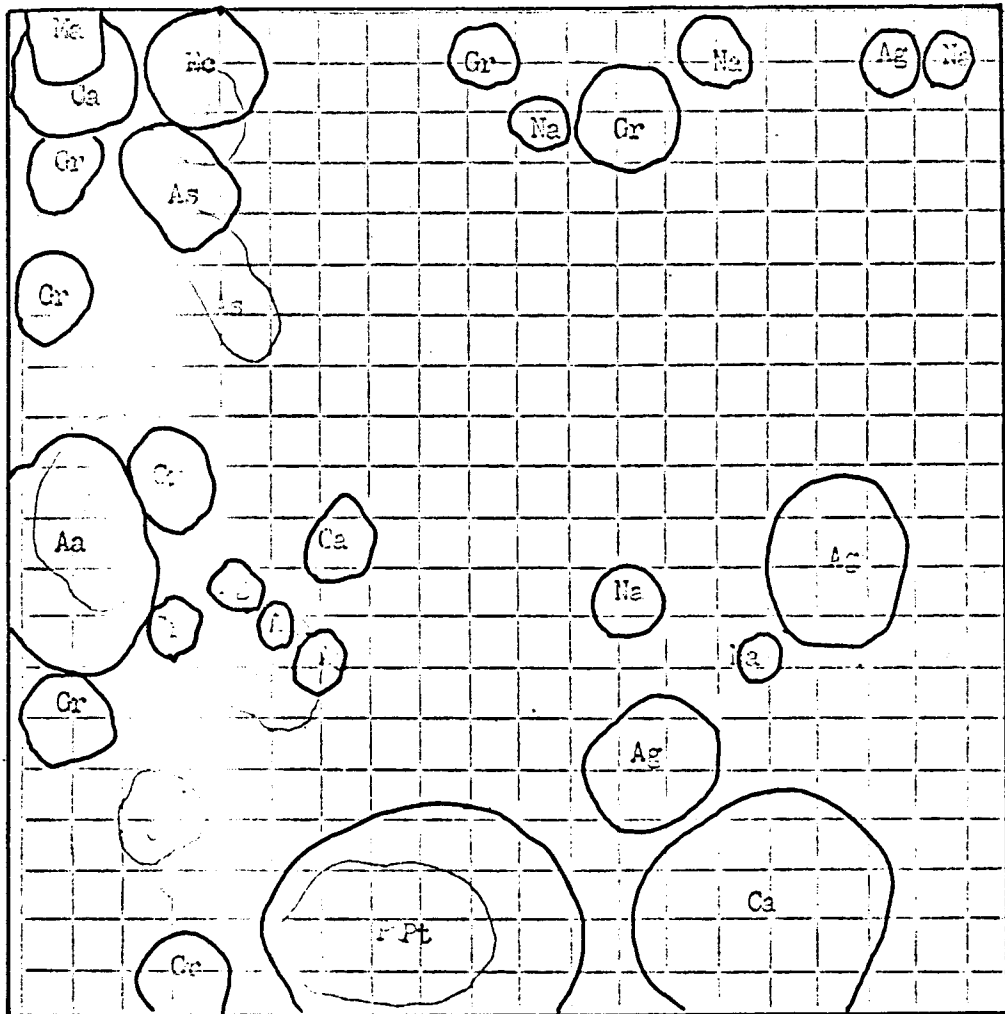
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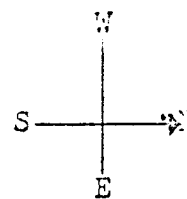
Quadrat #5 1967



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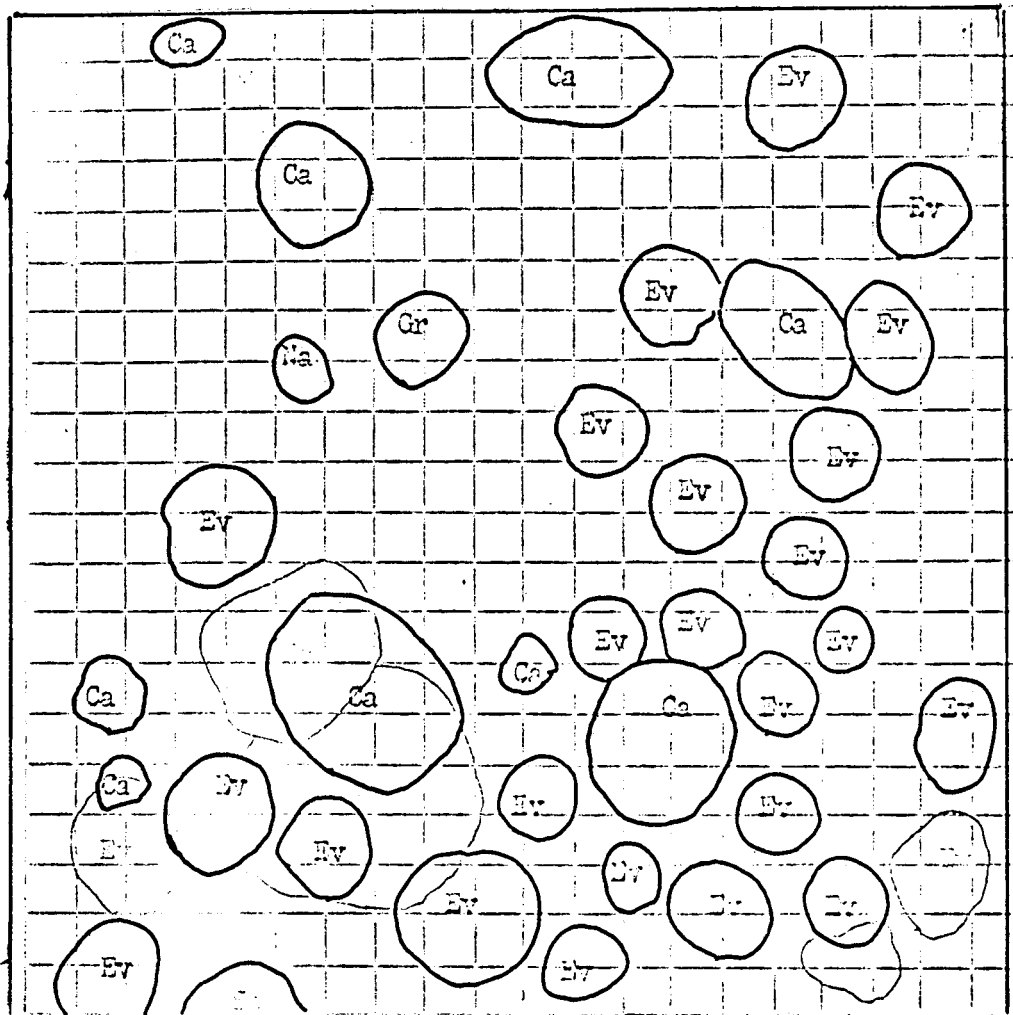
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Quadrat #6 1967



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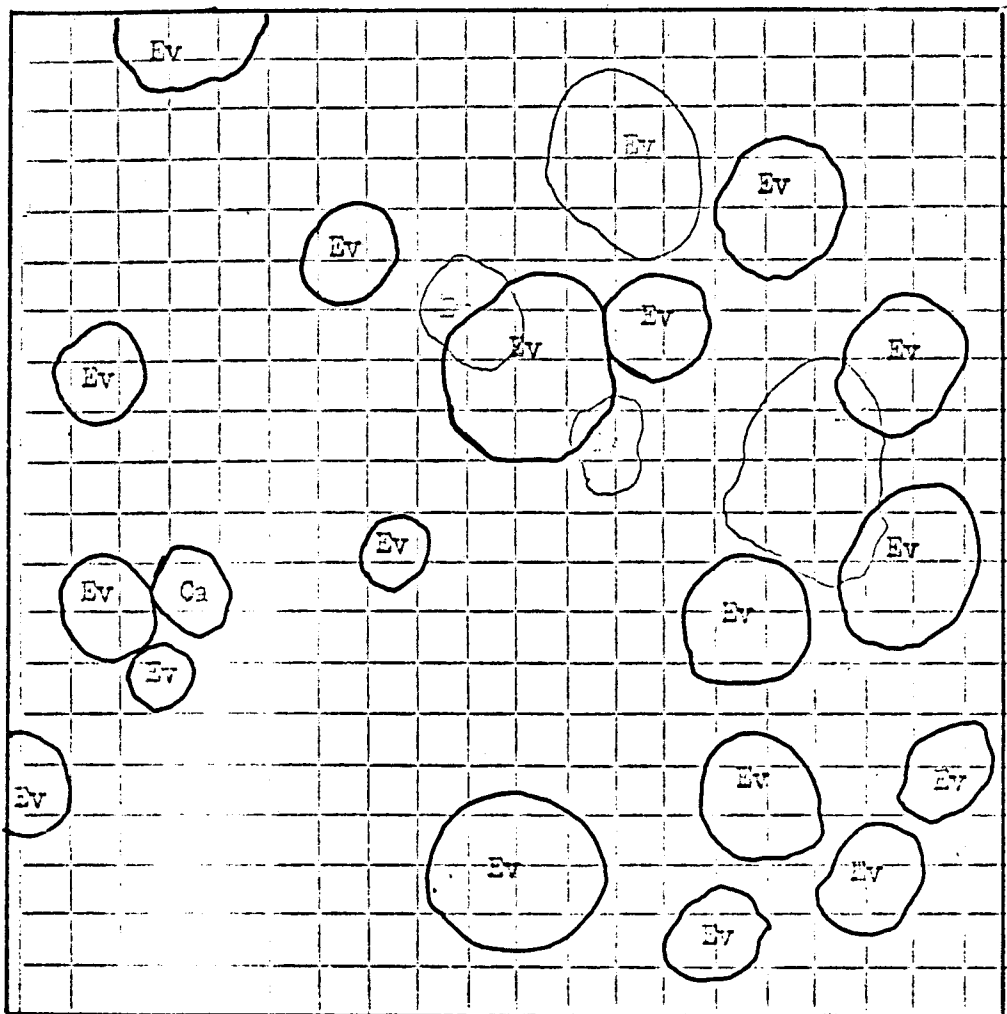


Quadrat 27 1967

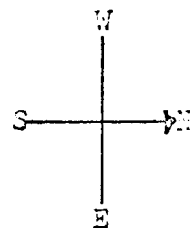


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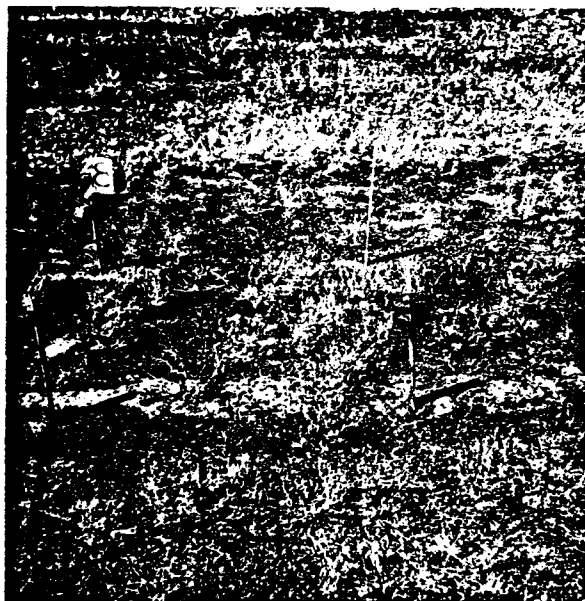
viii



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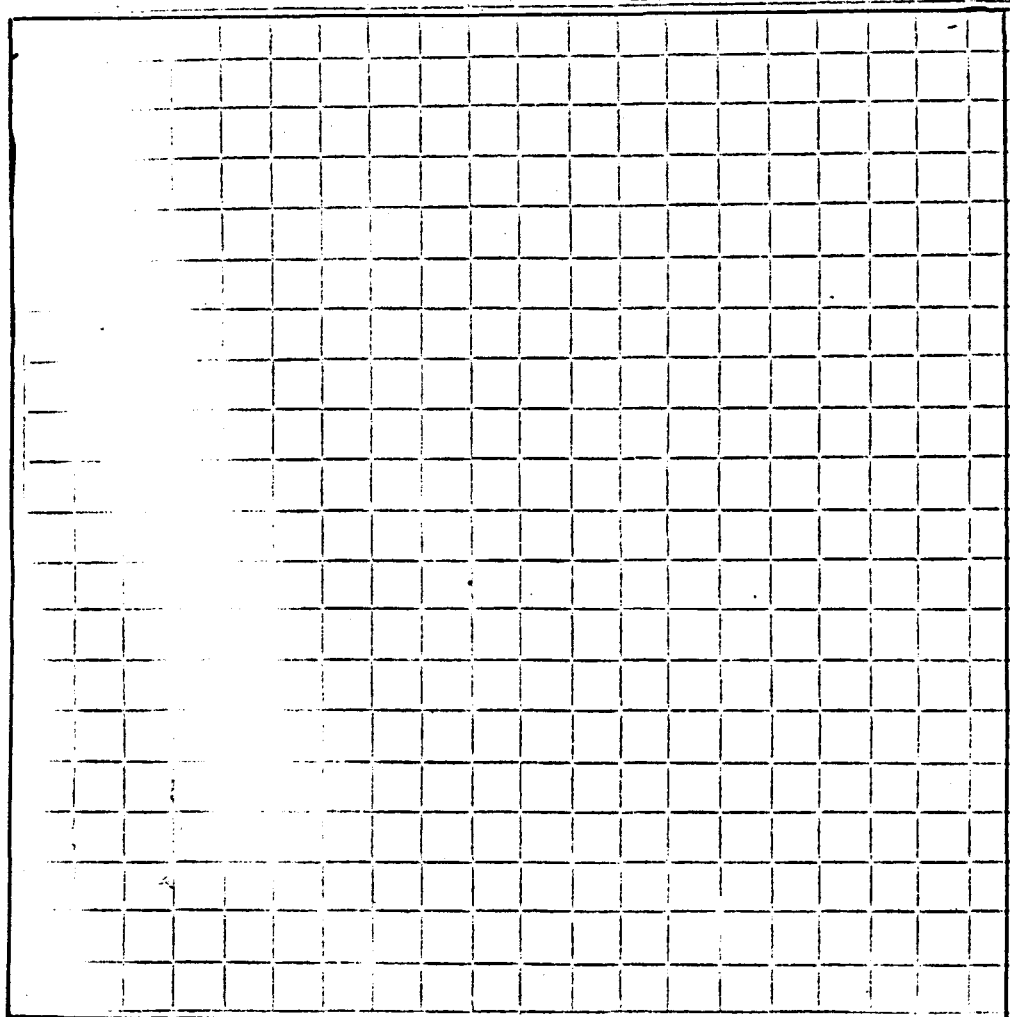


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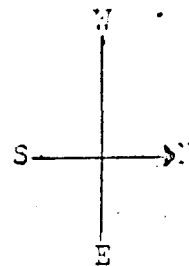


OCT 1967

ix



Scale: 1 cm = 25 cm



Quadrat #9 1967



OCT 1967

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