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AMCHITKA BIOENVIRONMENTAL PROGRAM

PLANT ECOLOGY OF AMCHITKA ISLAND

FINAL REPORT

by

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C. C. Amundsen

The University of Tennessee
Department of Botany

January, 1972

Prepared for Battelle, Columbus Laboratories,
under Atomic Energy Commission Prime
Contract No. AT(26-1)-171

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505 King Avenue
Columbus, Ohio 43201

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5

6

TABLE OF CONTENTS

	<u>Page</u>
INTRODUCTION	1
PROCEDURES AND METHODS	3
Reconnaissance	3
Sampling	3
Factor Analysis	4
Temperature.	4
Drainage Patterns	4
Transects.	4
Soil Samples	4
Plant Collections.	4
Mapping	5
RESULTS	5
Topoenvironment.	5
Vegetation Sampling.	5
Productivity Sampling	6
Climate	10
Peat Depth and Movement, and Soil Drainage	12
Depth	12
Movement	12
Soil Drainage	12
Decomposer Organisms	14
Plant Collections.	14
Mapping.	15
DISCUSSION AND CONCLUSIONS	15
The Lowland Tundra.	17
The Upland Tundra	18
The Beach	19
Community Comparisons and Dynamics	19
Succession	23
THE EFFECTS OF MAN'S PAST AND PRESENT ACTIVITIES ON AMCHITKA	23
PROBABLE EFFECTS OF NUCLEAR TEST SHOCK ON THE AMCHITKA TERRESTRIAL ECOSYSTEM	24
REFERENCES	25

TABLE OF CONTENTS
(Continued)

Page

APPENDIX I

HIGHER PLANTS OF AMCHITKA COLLECTED 1967-1969	I-1
---	-----

APPENDIX II

CHARACTER AND PRODUCTIVITY OF FOURTEEN CLIP PLOTS	II-1
---	------

APPENDIX III

MAPS OF PLANT COMMUNITY TYPES ON AMCHITKA	III-1
---	-------

LIST OF TABLES

Table 1. Indexes of Species for Four Major Plant Community Types on Amchitka	8
Table 2. Significant Temperature Observations at the Three Plant Ecology Study Temperature Stations on Amchitka Island	11
Table 3. Approximate Areas of Community Types	16

LIST OF FIGURES

Figure 1. Community-Type Distribution Along the Moisture Gradient on the Maritime Tundra Landscape of Amchitka	7
Figure 2. A Modal Soil-Depth Profile Through an Upland Tundra-Lowland Tundra Transitional Basin	13
Figure 3. A Model of the Terrestrial Ecosystem of Amchitka	20

PLANT ECOLOGY OF AMCHITKA ISLAND

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ABSTRACT

Amchitka Island, in the western end of the Aleutian chain, has a maritime tundra regime that is reflected in a rather uniform meadow-like vegetation of relatively few plant taxa. The tundra vegetation exists as a continuum of types that fall into definable topoenviromental units along a moisture gradient from fen to bog, and a wind blowout-solifluction zone at higher, exposed sites.

The terrestrial vegetation of the Island is the primary basic energy source for all the other organisms which depend on the existence of the Island ecosystem. The effects of ground shock on tundra vegetation are little known. Construction activities have damaged and destroyed vegetation on the Island.

The nature and the dynamics of the terrestrial vegetation are discussed, along with observations on the effects and consequences of current and planned activities on Amchitka.

INTRODUCTION

Since the fall of 1967, Battelle's Columbus Laboratories and its subcontractors have studied the marine, freshwater, and terrestrial ecosystems at Amchitka Island, Alaska. These studies are designed to predict, evaluate, and document the effects on the biota and environment from underground nuclear tests, to recommend measures for minimizing the effects, and to predict and evaluate the potential hazards to man that might result from the accidental release of radionuclides to the environment and their subsequent transport to humans via food chains. These studies are sponsored by the U.S. Atomic Energy Commission's Nevada Operations Office as a part of its supplemental nuclear test-site activities.

The Department of Botany of the University of Tennessee, Knoxville, under sub-contract to Battelle Memorial Institute, Columbus, Ohio, has studied the terrestrial plant ecology of Amchitka Island. This study was undertaken to provide base-level information on terrestrial ecosystem factors and processes in keeping with the objectives of a U.S. Atomic Energy Commission Bioenvironmental Safety Program.

The specific objectives of the plant ecology study included: (1) inventory and collection of vascular and cryptogamic flora, (2) definition and mapping of consequential landscape units, (3) investigation of the status and dynamics of the terrestrial ecosystem, (4) investigations of the effects of man's past and projected activities on the terrestrial

ecosystem, and (5) prediction of the probable consequences of underground nuclear testing plant ecology including any changes in the rates of processes leading to plant community shifts.

Amchitka, one of the most southerly of the Aleutians, supports a terrestrial maritime tundra ecosystem which is not widely represented geographically (Shear, 1964). The isolation of the Island, the maritime conditions, and the low-energy climate have predominated in the development of a rather uniform vegetation of relatively few important species. A list of species collected (using the nomenclature of Hultén, 1968) appears in Appendix I. The terrestrial vegetation of Amchitka provides food and shelter for many of the resident and migrant avian populations, serves as a habitat for the terrestrial invertebrates, exchanges nutrients with aquatic and marine habitats, and has a direct relationship with the organic soils which mantle much of the Island. There are no indigenous terrestrial mammals, but the rat has become well established and does serve as an unimportant primary consumer. The marine mammals, pelagic birds, and the nonanadromous marine fish may benefit indirectly from nutrients supplied in some estuarine situations.

Few comprehensive studies on terrestrial plant ecology have been conducted in areas with the geoclimatic conditions found in the western Aleutians. Hultén (1960, 1968) summarized qualitative observations on the plant communities of the Aleutians (including the work of Tatewaki, 1930-1931). Shacklette et al. (1969) have published a vegetation analysis; their study includes ecological observations. Although the flora of the Aleutians is relatively well known, this study includes additional records. Most of the many detailed ecological studies on the vegetation of continental Arctic and sub-Arctic tundra landscapes have dealt with vegetation over permafrost (e.g., Johnson et al., 1966); there is no permafrost on Amchitka.

The final report on the bioenvironmental program conducted for Long Shot underground nuclear test (October, 1965) did not include any mention of terrestrial vegetation studies (Seymour and Nakatani, 1967). A mimeographed memorandum lists species present along four vegetation transects taken near Long Shot, but no discussion is included (Jones, 1967). A general vegetation map was previously prepared for the eastern one-half of the Island, but although the author of this report has had access to copies of the map, I have not seen any accompanying text (Conti and Spetzmann, 1965).

The geological stratigraphy and structure of Amchitka are fairly well known (Powers et al., 1960; Carr et al., 1966).

Climatic records are incomplete, but a 5-year record (February 1943 to January 1948) indicates the cool, cloudy, windy regime of the Island (U.S. Army Corps of Engineers, 1968). There was no adequate climatological station in operation on the Island during the period of the present study, and our ecology study included temperature stations only.

This report covers field work and laboratory analysis of collections and data from September, 1967, through October, 1969. Reconnaissance and appropriate sampling were carried on during all seasons.

The terrestrial plant ecology studies were conducted along traditional lines of reconnaissance, vegetation sampling, plant collection, ecosystem factor analysis, and interpretation. The terrestrial landscape was divided into three topoenvironments; beach, lowland tundra, and upland tundra. Communities were delineated within these

topoenvironments on the basis of floristics, drainage, microtopography, and exposures. By using available aerial photographs followed by ground checks, more-or-less discrete plant community boundaries were mapped on 1:25,000 maps (U.S. Army Map Service, 1959) of the Island at a scale compatible with the maps and photographs available. These maps are included in Appendix III.

PROCEDURES AND METHODS

Reconnaissance

Reconnaissance began in September 1967. Observations led to the distinction of three topoenvironmental units: beach, lowland tundra, and upland tundra.

Qualitative observations were made on undisturbed soils as well as areas disturbed by World War II military occupation and around the Long Shot site. Some inferences on secondary succession could be drawn from these examinations since approximate dates of disturbance were known.

Every major drainage on the Island was visited during the reconnaissance survey. Observations revealed upland areas where active frost heave and fall, resulting in soil mixing and movement, was a factor in successional processes. Salt spray was observed to blow over the highest ridges (about 365 meters)

Sampling

Eighty-six 1-m² quadrats were studied during the summer of 1968 to objectively sample empirically distinct major communities. The abundance-vigor-coverage scale of Domin as modified by Dahl (Evans and Dahl, 1955) was used.

No quantitative plots were taken in the beach topoenvironment where qualitative examination revealed only two synusial communities. At the highest elevations on the Island, large areas of substrate are discontinuously vegetated with low vigor "stripe" stands of subshrub-grass and objective selection of plots would have been difficult. A floristic survey revealed no consequential compositional differences between the discontinuous strip communities and continuous communities at lower elevations. Quantitative analyses were made in major undisturbed communities of the upland tundra and lowland tundra topoenvironmental units.

Before the beginning of the 1968 growing season, 14 1-m² quadrats were located and all standing dead graminoid, herbaceous, and fern biomass above the level of fresh litter was clipped and removed. These plots were clipped to the same level to remove the summer production of nonwoody plant material during the first week of October, 1968. Air temperatures had dropped to a low of 34 F at the 47-meter elevation at the Old Camp and to 31 F at the 198 meter elevation near mid-Island before the harvest clipping, and seasonal growth was assumed to have ceased. The samples were air-dried and weighed to arrive at comparative estimates of annual production in several community types.

Factor Analysis

Temperature

To provide some estimations of varying microclimatic conditions on Amchitka, Taylor Six's maximum-minimum thermometers were placed at three stations on the Island. Stations B and C were in the areas of the production plots discussed above and Station A was near the Old Camp. Regular readings were made at the Old Camp and the field thermometers were read and reset at irregular intervals. One thermometer near mid-Island was broken by rock fall from gravel pit construction in April, 1968. All three stations had thermometers 1 meter above ground surface; Station B also had a thermometer at 0.3 meter. Thermometers were sheltered in Gamma (Γ)-shaped boxes, open to the east, north, west, and below.

Drainage Patterns

To aid in interpreting internal soil-drainage patterns that were apparently reflected in the vegetation, six organic-soil-depth grids were taken across transitional topo-environmental areas. Depth probes were made every 5 meters across six "basin" areas. Vegetation was classified into recognized types at the probe transects. Interpretations by Everett (1968) were added to the minimal soil studies accomplished for our plant ecology study.

Transects

With the cooperation of the surveying office of Holmes and Narver, Inc., two semi-permanent transects were established along a major tundra meadow expression in an area transitional between lowland and upland tundra topoenvironmental units. Stakes were set to mark the lines and to evaluate any peat movement. Vegetational surveys were taken along these transect lines for use should there be a subsequent chance to check community shifts.

Soil Samples

To attempt an approximation of other important compartments in the ecosystem of the Island, soil samples were collected in the 01-02 horizons and placed in Berlese funnels for invertebrate collections. The intent was to characterize the decomposer fauna at different seasons. Samples from fall, winter, spring, and summer yielded low numbers of invertebrate soil fauna. The dearth of information on decomposer organisms is a problem in most tundra studies (Pitelka, 1969).

Plant Collections

Collections, chiefly of vascular plants, continued through July, 1969. Specimens are now on deposit in the Tennessee State Herbarium, The University of Tennessee, Knoxville, for final verification and mounting. Duplicates will be appropriately distributed.

Mapping

Vertical aerial photographs (U.S. Coast and Geodetic Survey, 1948) were available for the entire Island (scale 1:23,000). Color aerial infrared positives taken for the U.S. Geological Survey in 1968 which covered about 40 percent of the Island were also available. The infrared and black and white aerial photographs, with ground checks and vegetation sampling establishing control for the mapping, were used to outline six community types on 1:25,000 topographic maps. Areas of community types mapped were approximated by dot-grid counts.

RESULTS

Topoenvironment

The reconnaissance revealed that the vegetation of the Island, disregarding the beach communities, exists as a structural and compositional continuum along a moisture gradient from sedentary fen* to wind desiccated subshrub-grass stripe communities at the drier and generally higher end of the gradient. For convenience, this maritime tundra ecosystem can be divided into two topoenvironmental categories or units--poorly drained lowland and relatively well-drained upland. The beach communities represent a third separate and distinct topoenvironmental entity, although the dominants of the beach grass community (Elymus arenarius, Calamagrostis nutkaensis, Festuca spp., see Appendix I) are important in, and in fact dominate, certain communities of the tundra vegetation.

Although there is some floristic evidence of a change in community composition and environmental dynamics at approximately 75 to 90-meter elevation, the separation of upland and lowland topoenvironments is a division based on topography and the restriction of drainage rather than on altitude.

Within the three topoenvironmental units, 10 plant-community types were recognized. (See Figure 1.) In the upland tundra unit the types were: crowberry-grass-dominated stripes interspersed with bare areas, secondary succession vegetation, upland graminoid stands, and crowberry-grass-sedge meadow. In the lowland tundra unit the types were: crowberry-sedge-grass meadow, sedge-lichen meadow, "breakaway" tundra (tundra vegetation not firmly rooted), and ephemeral pools. Community types of significant distribution in the beach unit were: beach grass and a diffuse succulent plant community.

Vegetation Sampling

Quantitative sampling was done in four community types, and qualitative observations were made in the others. Eighty-six 1-m² quadrats were taken: 8 in the

*Fen: A treeless, wet, meadow-like peat flat (Ahti and Hepburn, 1967).

upland graminoid type and 37 in crowberry-grass-sedge meadow of the upland tundra topoenvironment, 35 in crowberry-sedge-grass meadow, and 6 in sedge-lichen meadow of the lowland tundra.

The four community types sampled systematically account for about 67 percent of the terrestrial vegetation of Amchitka. The only other significantly large undisturbed-community type is the crowberry-grass stripe type at higher elevations which is a topographic expression of the crowberry-grass-sedge meadow. The disturbance-created secondary succession community type contains typical upland unit species.

The vegetation was subjectively divided into three strata for sampling: Strata A-grasses, sedges, herbs and ferns; Strata B-subshrubs; and Strata C-mosses, lichens, and liverworts. Eighty-two species were sampled in the plots, 53 in Strata A, 9 in Strata B, and 20 in Strata C. The Domin-Dahl scale (tabulated below) was employed to evaluate the abundance-coverage of all species. As Class "+" is too subjective for a one-growing-season sampling effort, it was not used. The remaining 10 classes of the scale were recorded (as well as no occurrence). The Domin-Dahl values were converted to a weighted index value by multiplying the average Domin-Dahl value times percent frequency. The maximum possible index value would be 1000 (Domin-Dahl average of 10 x 100 percent frequency) but the highest calculated was 750 (*Empetrum nigrum*, crowberry, in the crowberry-grass-sedge community of the upland tundra). Table 1 indicates the index values for all species sampled in the four community types. The distinctions separating these community types as well as the continuous relationships between them can be derived from the table.

Domin-Dahl Values

+	Occurring as a single individual with reduced vigor; no measurable cover
1	Occurring as one or two individuals with normal vigor; no measurable cover
2	Occurring as several individuals, no measurable cover
3	Occurring as numerous individuals but with cover less than 4 percent of total area
4	Cover up to 1/10 (4 to 10 percent) of total area
5	Cover about 1/5 (11 to 25 percent) of total area
6	Cover 1/4 to 1/3 (26 to 33 percent) of total area
7	Cover 1/3 to 1/2 (34 to 50 percent) of total area
8	Cover 1/2 to 3/4 (51 to 75 percent) of total area
9	Cover 3/4 to 9/10 (76 to 90 percent) of total area
10	Cover 9/10 to complete (91 to 100 percent)

Productivity Sampling

The fourteen 1-m² quadrats selected for productivity sampling included 3 in the upland graminoid type (S21, S22, S29), 2 in the secondary succession type (S23, S26), 3

FIGURE 1. COMMUNITY-TYPE DISTRIBUTION ALONG THE MOISTURE GRADIENT ON THE MARITIME TUNDRA LANDSCAPE OF AMCHITKA

Numerals indicate separately mapped vegetation units.

TABLE 1 INDEXES OF SPECIES FOR FOUR MAJOR PLANT COMMUNITY TYPES ON AMCHITKA^(a)

Species	Strata	Community Type											
		Upland Grass			Crowberry-Grass-Sedge			Crowberry-Sedge-Grass			Sedge Lichen		
		D-D	F	Index	D-D	F	Index	D-D	F	Index	D-D	F	Index
<i>Calamagrostis nutkanaensis</i>	A	0.9	100	(190)	5.4	100	540	3.4	81	275	2	17	34
<i>Carex macrochaeta</i>	A	0.0	88	(528)	3.7	63	233	5.0	70	350	3.5	33	116
<i>Carex lyngbyaei</i>	A	4.9	88	(431)	4.2	14	59	4.4	46	202	5.0	33	165
<i>Equisetum arvense</i>	A	2.6	88	(279)	2.5	49	123	2.3	69	159	2.0	67	134
<i>Empetrum chinense</i>	A	4.4	63	(277)	4	3	12	N			N		
<i>Cladonia sibirica</i>	A	3.8	50	(190)	2.0	6	12	2.0	5	10	N		
<i>Polygum viviparum</i>	A	2.8	63	(176)	2.9	23	67	4	3	12	N		
<i>Viola lanceolata</i>	A	3.6	50	(175)	2.3	23	53	2.8	11	31	1	17	17
<i>Athyrium</i> sp.	A	5.3	38	(201)	8	3	24	5.5	5	28	N		
<i>Festuca rubra</i>	A	3.5	50	(175)	2.9	26	75	3.0	11	33	2.5	50	115
<i>Angelica lucida</i>	A	3.7	38	(141)	3.4	23	78	2.8	32	90	2.7	50	135
<i>Lymus arenarius</i>	A	7	12	(84)	N			N			N		
<i>Phleum alpinum</i>	A	2	12	(24)	3	3	9	N			N		
<i>Carex filiformis</i>	A	4	12	(48)	2	3	6	N			N		
<i>Luzula</i> sp.	A	2.0	38	(76)	3	3	9	2	5	10	3	17	51
<i>Plantago macrocarpa</i>	A	4.0	25	(100)	2.5	11	28	2.0	5	10	4	17	68
<i>Senecio pseudo-arnica</i>	A	3	12	(36)	N			N			N		
<i>Gadium trifidum</i>	A	2.7	38	(103)	2	3	6	N			N		
<i>Fritillaria camtschatcensis</i>	A	4	12	(48)	N			N			N		
<i>Mnium</i> sp.	C	3.5	25	(88)	N			N			N		
Unknown mosses	C	2.0	38	(76)	2.0	6	12	1.5	27	41	N		
<i>Carex circinnata</i>	A	3	12	36	3.2	63	(202)	3.4	57	194	3.0	50	150
<i>Agrostis</i> sp.	A	N			3.5	23	(81)	1.8	16	29	N		
<i>Platanthera dilatata</i>	A	4.0	25	100	2.3	46	(106)	3.1	19	60	2	17	34
<i>Coptis trifolia</i>	A	3	12	36	2.4	63	(151)	2.5	59	148	2.3	50	115
<i>Lycopodium</i> sp.	A	N			2.5	66	(165)	2.0	49	98	2.0	33	66
<i>Geum calthifolium</i>	A	N			3.8	26	(99)	4.7	8	38	N		
<i>Erigeron peregrinus</i>	A	3.7	38	141	3.9	43	(168)	3.8	35	133	5.0	33	165
<i>Arnica unalaschensis</i>	A	N			4.6	29	(133)	5	3	15	N		
<i>Anemone narcissiflora</i>	A	3	12	36	3.8	11	(42)	4	3	12	N		
<i>Campanula lasiocarpa</i>	A	N			2.4	20	(48)	3	3	9	N		
<i>Tofieldia coccinea</i>	A	N			2	3	(6)	N			N		
<i>Antennaria dioica</i>	A	N			2	3	(6)	N			N		
<i>Sibbaldia procumbens</i>	A	N			2.0	6	(12)	2	3	6	N		
<i>Veronica</i> sp.	A	N			2.3	9	(21)	3	3	9	N		
<i>Lupinus nootkatensis</i>	A	N			2	3	(6)	N			N		
<i>Empetrum nigrum</i>	B	N			7.5	100	(750)	7.0	100	700	4.2	83	349
<i>Cornus suecica</i>	B	N			3.1	43	(133)	3.2	27	86	3.0	33	99
<i>Linnæa borealis</i>	B	N			3.2	57	(182)	2.7	35	95	3	17	51

TABLE 1. (Continued)

Species	Strata	Community Type								
		Upland Grass			Crowberry-Grass-Sedge			Crowberry-Sedge-Grass		
		D-D	F	Index	D-D	F	Index	D-D	F	Index
<i>Loiselcuria procumbens</i>	B	N			4.6	76	(120)	2.4	32	77
<i>Cassiope lycopodioides</i>	B	N			2.8	14	(39)	3	3	9
<i>Salix arctica</i>	B	N			4	3	(12)	N		N
<i>Salix ovalifolia</i>	B	N			4	3	(12)	N		N
<i>Thamnochloa verticillaris</i>	C	N			2.0	69	(138)	1.6	57	91
<i>Dicranum</i> sp.	C	N			2.2	46	101	2.2	32	70
<i>Mycoblastus</i> sp.	C	N			3.5	17	(60)	4.5	5	23
<i>Alectoria</i> sp.	C	N			3.0	14	(42)	N		N
<i>Climacium dendroides</i>	C	N			3	3	(9)	N		N
<i>Bryum</i> sp.	C	N			3.3	9	(30)	N		N
Unknown liverworts	C	N			1.3	20	(26)	1.0	14	14
<i>Salix rotundifolia</i>	B	N			4	3	(12)	4	3	(12)
<i>Saxifraga</i> sp.	A	N			2	3	(6)	2	3	(6)
<i>Ranunculus occidentalis</i>	A	N			4	3	(12)	4	3	(12)
<i>Illicium triste</i>	A	N			3	3	(9)	3	3	(9)
<i>Carex</i> sp.	A	N			N			5	3	(15)
<i>Achillea borealis</i>	A	2.7	38	103	2.4	46	110	2.1	62	(130)
<i>Vaccinium vitis-idaea</i>	B	N			2.1	77	162	2.7	98	(265)
<i>Cladonia pacifica</i>	C	N			5.9	94	555	7.4	97	(718)
<i>Rhacomitrium lanuginosum</i>	C	N			3.6	51	184	3.6	78	(281)
<i>Antitrichia curtipendula</i>	C	N			3.5	6	21	2.8	16	(45)
<i>Ptilium crista-castrensis</i>	C	N			2.8	14	39	4.0	11	(44)
<i>Hypnum</i> sp.	C	N			2	3	6	2.0	8	(16)
<i>Peltigera</i> sp.	C	N			4.0	6	24	2.5	16	(40)
Unknown lichens	C	N			N			2.0	5	(10)
<i>Trisetum spicatum</i>	A	N			N			N		2
<i>Carex pluriflora</i>	A	4.8	50	240	2.9	23	67	3.9	46	179
<i>Carex anthoxantha</i>	A	4.3	38	163	1	3	3	2.7	16	43
<i>Eriophorum</i> sp.	A	N			N			1.5	5	8
<i>Juncus</i> sp.	A	4.0	25	100	3	3	9	2.8	11	31
<i>Rubus</i> sp.	A	2.0	38	76	3.2	49	157	3.9	59	230
<i>Trisetum europaea</i>	A	N			2.1	60	126	2.5	78	195
<i>Epilobium</i> sp.	A	2	12	24	N			2.7	8	22
<i>Cerastium</i> sp.	A	1.0	25	25	N			1	3	3
<i>Listera cordata</i>	A	N			1.8	17	31	1.0	5	5
<i>Chrysanthemum arcticum</i>	A	N			4.0	6	24	4	3	12
<i>Caltha palustris</i>	A	N			N			N		3.0
<i>Cystopteris</i> sp.	A	N			N			N		2
<i>Polytrichum</i> sp.	C	N			2.3	40	92	2.3	27	62
<i>Sphagnum</i> sp.	C	N			5	3	15	3.3	8	26
<i>Hylocomium splendens</i>	C	N			2.7	40	108	2.5	27	68
<i>Rytidiadelphus loreus</i>	C	3.0	50	150	2.8	51	143	2.4	27	65
<i>Plagiothecium undulatum</i>	C	N			2	3	6	N		2

(a) Indexes were calculated by multiplying the average Domin-Dahl (D-D) abundance-coverage values for each species by the percent frequency of occurrence (F) in the community type. Eighty-six 1-m² quadrats were taken, 8 in upland grass, 37 in crowberry-grass-sedge, 35 in crowberry-sedge-grass, and six in sedge-lichen communities. The calculation of indexes allows the samples to be compared regardless of the number of plots. Strata (synonym) used for convenience denote: A - grasses, herbs, and ferns; B - shrubs; and C - mosses, lichens, and liverworts. Complete species nomenclature appears in Appendix I except for species listed as unknown.

Note: Highest index for each species is in parentheses. N means no occurrence.

in crowberry-grass-sedge (S24, S27, S30), 2 in sedge-lichen (S25, S31), 1 in crowberry-sedge-grass (S28), and 3 in crowberry-grass stripe (S32, S33, S34). The mineral content of these samples will be included in a separate report.

All quadrats were subjectively located to be characteristic of the community types they represented except S22 which was a 100 percent stand of sedge (Carex lyngbyaei) in an upland graminoid-type area where a pond frequently overflowed and produced an apparent nutrient flush.

The upland graminoid type clip plots had the highest average annual production, the three plots producing 69.0, 111.0, and 507.0 grams of air-dry harvested material. The 507.0-gram production was harvested from the sedge plot (S22). The 86.0 and 90.0 grams of dry material produced by secondary succession plots indicate a similarity between successional and upland graminoid stands. The four plots in crowberry meadow produced between 19.0 and 40.0 grams, while two plots in sedge-lichen meadow (characterized by the lack of crowberry which was not harvested from either) produced 21.0 and 29.0 grams of material. The higher-elevation crowberry-stripe plots produced from 0.0 grams to 11.0 grams of harvested material. Appendix II gives a summary of the character and productivity of the 14 clip plots.

Climate

A climatic summary prepared for prospective construction on Amchitka (U.S. Army Corps of Engineers, 1968) reads:

"Amchitka Island lies along the North Pacific belt of storms and therefore its maritime climate is characterized by abundant wind, rain and fog. Mean annual temperature between 1943 and 1948 at the airbase (225 feet alt.) was +40 F., with both daily and seasonal variations small. Extremes recorded were +15 F and +65 F. The mean July temperature fell in the 44 to 49 F range for the recorded years. The annual precipitation ranged from 30 to 35 inches including a mean annual snowfall of about 70 inches. Cloud ceilings averaged less than 1,000 feet and visibility was less than 3 miles during 60 percent of the year and during 83 percent of the summer. Winds averaged 20 to 25 miles per hour during the summer and seldom exceeded 70 miles per hour. Winds during the winter averaged 25 miles per hour and frequently exceeded 100 miles per hour."

Significant temperatures and elevations for the three temperature stations established for the plant ecology study are listed in Table 2.

Even these incomplete temperature records point out the lack of ecologically oriented meteorological records. The 5-year (1943-1948) maximum (65 F) was equaled and the 5-year minimum was lowered (15 to 11 F) in only 6 months of operation of a thermometer station at 0.3 meter height.

TABLE 2. SIGNIFICANT TEMPERATURE OBSERVATIONS AT THE THREE PLANT ECOLOGY STUDY TEMPERATURE STATIONS ON AMCHITKA ISLAND

Station A: Old Camp, map coordinates 573947, gentle N. slope, 47-meter elevation, upland successional community type. One " μ " tube thermometer at 1 meter.

Station B: Ultra Basin, map coordinates 476015, very gentle S. slope, 38-meter elevation, crowberry-grass-sedge community type. One " μ " tube thermometer at 1 meter, one at 0.3 meter.

Station C: Chitka Point Ridge, map coordinates 367145. Moderate N. slope, elevation 198 meters, crowberry-grass-stripe community type. One " μ " tube thermometer at 1 meter.

Station	Record Period	Max, F (Date or Period)	Min, F (Date or Period)	"Summer Mean" (Of Frost-Free Days), F	Frost-Free Days
A 40	9 Feb 68-7 Oct 68	60 (19 Jul)	19 (per. 9 Feb-12 Mar)	46.5	138+
B 40	20 Mar 68-5 Oct 68	60 (per. 9-24 Aug)	17 (per. 20 Mar-22 Mar)	46.5	85+
12	20 Mar 68-5 Oct 68	65 (per. 9-24 Aug)	11 (per. 20 Mar-22 Mar)	51.0	43+(a)
C 40	2 Jun 68-3 Oct 68	60 (per. 13 Jul-3 Aug)	31 (per. 2 Jun-13 Jul and 11 Aug-3 Oct)	Insufficient readings(b)	Insufficient readings(b)

(a) Frost (32 F or below) occurred during the period 24 Aug-5 Oct at the low station but not at the high station. The frost-free days are probably closer to 80 than 40.

(b) Readings were too irregular for calculation. The frost as late as June indicates the lesser number of frost-free days, as no other stations showed spring frost after 22 May.

Peat Depth and Movement, and Soil Drainage

Depth

Six soil-depth grids were taken (probes 5 m apart on lines 10 m apart) with steel probes to determine the depth of the lithified breccias and lavas. The grids represented a systematic probing of six drainage basins on the eastern one-half of the island [over Banjo Point and Amchitka formations (Powers et al., 1960)] at elevations of approximately 70 meters. The grids indicated the deepest soil was not always in the lowland valley or stream bottoms but was more often at the lower slope transitions. Figure 2 is a graphic representation of the soil depths on a modal profile. The depth profiles are complicated by a slow slippage or slump of wet peat toward stream bottoms and sea cliffs where the topography of the bedrock contact promotes downslope movement. The lesser depths in valleys and stream bottoms suggest that besides compaction and subsidence, a hydric dissolution of the organic material occurs, and the brownish coloration of many streams indicates that a considerable amount of organic material may be carried in solution and suspension even in streams with low gradients.

Movement

In March and April, 1968, surveys by Holmes and Narver, Inc., assisted in establishing two semipermanent, staked transect lines in Ultra Basin. Control points established by the present author in March, 1968, were used. Laths were set at 3-meter intervals along lines 228.6 and 176.7 meters long. The peat depths in the transect area varied from 0.3 to 0.6 meters. The control points at each end were tied to the Island base control net by triangulation. The upper line crosses a terrace-like area with a slight slope to the northwest while the longer, lower line, nearly parallel but approximately 38 meters downslope, crosses a steep northwest slope (25 degrees), 61 meters across, at about midline. The lower line was located to cross this steeper slope where apparent past movement of the peat has produced peat pressure ridges at a right angle to the fall line. All the laths were checked and tapped in vertically (in relation to the horizon) to bedrock in September, 1968.

In July, 1969, the upper line, located on a very gentle slope, showed no signs of movement. All stakes were checked for stability. On the lower line, 21 stakes were displaced angularly, 6 indicating movement at the peat surface, and 15 indicating movement at or near the peat-bedrock interface. Displacement from the vertical had a mode of 15 to 20 centimeters. This displacement indicates a fairly substantial movement of peat during the period.

The observations taken in July 1969 when compared with those of the summer of 1968 indicate that no plant-community shifts have yet occurred as a result of this movement. The authors have retained the survey data supplied by Holmes and Narver, Inc., for further observations and the lines are being maintained.

Soil Drainage

The depth of peat and the degree of drainage reflected by the stage of decomposition of the organic material correlate with the distribution of plant communities in the lowland tundra-upland tundra topoenvironmental units. Cooperative field work with Everett

FIGURE 2. A MODAL SOIL-DEPTH PROFILE THROUGH AN UPLAND TUNDRA-LOWLAND TUNDRA TRANSITIONAL BASIN

The vertical exaggeration is about 10 to 1. The maximum depth represented is 3 meters; the width of the area about 365 meters. Soil group designations (lower-case letters) are from Everett (1968).

on Amchitka in the summer of 1968 indicated a good correlation between the distribution of certain soil groups and specific tundra community types. Figure 2 shows the distribution of plant communities along the peat depth-drainage gradient and the soil groups defined by Everett in 1968.

Distinctive conical "moss mounds" up to 2 meters high occur in the lowland tundra topoenvironmental unit. Growth of these mounds (increase in height and breadth) occurs when plants, that grow faster with improved aeration and solar exposure promoted by the mounds, contribute greater amounts of litter. The complex origin of these mounds is indicated by the fact that the substrate for the current vegetation varies from grass to sedge to moss peat. The higher plants found on these mounds are characteristic of the upland tundra communities.

Decomposer Organisms

Since a contemporary study was underway on the geomorphology and pedology of the Island, the plant ecology study considered only empirical descriptions of soils for correlation with the results of the pedology investigations (Everett, 1968). As the lack of information on decomposer organisms in Amchitka soil was recognized, samples from the litter horizon were taken in all seasons. Invertebrates were collected using Berlese funnels. Springtails (Collembola) and mites (Acari) as well as nematodes were found in all the samples, even that taken when the litter contained visible ice. Slugs (Plumonata) and earthworms (Oligochaeta) were collected in various communities during the summer. These organisms are known to be important decomposers in humus and probably have a comparable function in the organic horizon on Amchitka. No specific identifications of these organisms have been made.

In addition to the invertebrates, fungal hyphae are often numerous in the organic horizon. One fruiting fungus (Hygrophorus sp., Basidiomycetes) has been identified from undisturbed vegetation. Fungi found growing in old military structures were not investigated because both the wood substrate and the fungi were introduced to the Island. Many fungi are also known to be important decomposers in humus, and the parallel with the invertebrates is obvious. Lupinus nootkatensis, an important pioneer species on Amchitka, exhibits the bacterial nodules characteristic of the legumes, but, in general, bacterial populations are found to be relatively low in substrates of high acidity, such as those common on Amchitka. A lichen [Mycoblastus sanguinaris (L.) Norm.], commonly found growing on Empetrum at moderate to high elevations on the Island, appears to act as a mechanical or parasitic pathogen.

Plant Collections

Phanerogamic and important cryptogamic flora were collected for herbarium deposit and for identification purposes.

Mapping

The 10 community types defined and listed for the three topoenvironmental units (Figure 1) were grouped into 6 types for mapping:

- (1) Beach vegetation, including beach grass and diffuse succulent types
- (2) Wet tundra, including the ephemeral pools, "breakaway" tundra, and sedge-lichen meadow types of the lowland tundra
- (3) Crowberry meadow, including the crowberry-sedge-grass type and the crowberry-grass-sedge type (These types are floristically delineated in Figure 1 but could not be separated by tone on the photographs available.)
- (4) Upland graminoid, including floristically and edaphically similar riparian stands
- (5) Secondary succession, in large areas extensively distributed by military occupation
- (6) Crowberry-grass stripe, the solifluction-deflation zone of the the exposed uplands.

Type representations of mappable size were traced on U.S. Army Map Service 1:25,000 maps. (See Appendix III.) Table 3 lists approximate areas, by map sheet, of community types and groups mapped, as well as the areal relation of the mapped units to the total Island area.

DISCUSSION AND CONCLUSIONS

The climate of Amchitka is cool, with only slight diurnal-nocturnal temperature fluctuation and fairly evenly distributed precipitation (U.S. Army Corps of Engineers, 1968).

Most of the landscape expresses a maritime tundra continuum, that, although there is no permafrost, in aspect and plant genera resembles better known arctic and sub-arctic tundra. The tundra vegetation can be divided into two topoenvironmental units, lowland and upland, based on floristics, autecological and synecological responses, exposure, and soil moisture drainage. A distinct topoenvironmental unit is expressed on the sandy beaches which are discontinuous, often as the result of rather impressive sea cliffs. The community types and the types and type groups mapped in the topoenvironmental units are shown in Figure 1, and the approximate total areas of the mapped types and groups appear as Table 3.

TABLE 3. APPROXIMATE AREAS OF COMMUNITY TYPES

U.S. Army Map Number and Approximate Land Area, (mi ²)(a)	Community Type and Numbers, mi ² (b)					
	1 Beach	2 Wet	3 Meadow	4 Graminoid	5 Succession	6 Stripe
(1) 2123 IV NW (3.5)	.11	.88	2.34	.18	0	0
(2) 2023 I NE (12.2)	.36	2.04	6.62	.12	3.01	0
(3) 2023 I NW (24.3)	.50	5.01	16.55	.50	1.76	<.1
(4) 2024 II SW (8.2)	<.1	.38	6.08	.15	.76	.81
(5) 2024 III SE (10.8)	.11	.43	5.85	.11	<.1	4.26
(6) 2024 III NE (15.5)	.16	.79	6.40	.96	<.1	7.20
(7) 2024 III NW (22.8)	.23	.23	13.70	.68	<.1	7.98
(8) 1924 II NE (11.5)	.12	.24	2.12	.48	.12	8.40
Approx. Totals (109 miles ²)	1.59 miles ²	10.00	59.66	3.18	5.65	28.65
Approx. Percent of Total	1.5	9.2	54.7	2.9	5.2	26.3

(a) Mapped on eight U. S. Army Map Service 1:25,000 scale maps covering Amchitka Island. Designations such as "2123 IV NW" refer to the specific maps used. Maps (1) to (8) run generally from east to west, from low to high elevations.

(b) Community types follow Figure 1 and text discussion.

The Lowland Tundra

The lowland tundra terrestrial communities vary in composition and structure from the wettest expression – ephemeral pools usually dominated by Juncus balticus, Alopecurus aequalis or Sparganium hyperboreum – to the driest of the lowland communities – meadows of Empetrum nigrum (crowberry) – Carex spp. (sedge) – Calamagrostis nutkaensis (reedgrass). The tundra continuum changes from lowland to upland units with a distinct shift in annual productivity dominance from sedge to grass, and a more obvious presence of crowberry. The crowberry-sedge and crowberry-grass meadows together cover approximately 54.7 percent of the Island.

Between the ephemeral pools and the crowberry meadow are two intermediate communities which together cover approximately 9.2 percent of the Island. The first is a "breakaway" tundra, dominated by sedges and lichens (particularly conspicuous is the lichen Cladonia pacifica). The "breakaway" community type, characterized by the lack of abundant well-rooted plants, is reflected by the ease with which the living vegetation is disturbed or literally "broken away" even by foot traffic. The second intermediate community is a sedge-lichen meadow that, while containing in general the same species as the breakaway tundra, also contains enough occasional grass, sedge, and crowberry to stand up under light foot traffic but not vehicular traffic. Quantitative vegetational samples taken in the sedge-lichen meadow indicate that Carex pluriflora and Carex anthoxantha are characteristic of the type (see Table 1).

The semiaquatic grasses Alopecurus aequalis and Sparganium hyperboreum are found only in the ephemeral-pool habitats, but all the other plants of the lowland tundra communities grow in varying densities throughout the lowland unit.

The primary factor controlling the cover and abundance of the various species of lichens, sedges, grasses, subshrubs and herbs is the drainage of the substrate. As the moisture gradient changes from an area of waterlogged fen to an area of less-wet bog* that has some drainage (even though it may be severely retarded), the trend toward more mesomorphic plants follows. Extremely hydromorphic plants, such as Juncus balticus and Caltha palustris are found in abundance in the often extensive areas of nearly closed drainage, and occasionally in slowly circulating shallow water. At the drier end of the lowland tundra gradient, these plants usually are found in areas that have been disturbed and hold standing water as a result of subsidence or compaction (such as old vehicle tracks). The more mesomorphic plants, such as crowberry and reedgrass, while more abundant at the dry end of the lowland moisture gradient, can be found in portions of generally very wet areas with slightly improved drainage. Low hummocks of peat (again often caused by past disturbances) support those species less tolerant of excess moisture.

Conspicuous moss mounds in lowland tundra support vascular plants common to the upland tundra unit. Crowberry, Loiseleuria procumbens, Vaccinium vitis-idaea, and Calamagrostis nutkaensis are most often encountered on the moss mounds that provide the better drainage conditions preferred by the upland plants.

The substrate for the lowland tundra topoenvironmental vegetation is mostly a sedge-lichen peat, generally varying from a depth of 0.3 to 0.6 meter on moderate slopes to depths in excess of 4.25 meters on lower slope transitions. The lowland tundra is

*Bog: An acid treeless peatland...relatively dry (Ahti and Hepburn, 1967).

dotted with ponds and shallow lakes which are often supported by peat. Small streams are common. The terrain varies from flats to moderate slopes, and the absorbent peat over an impervious bedrock retains enough water to limit the dominant plant species to those that are relatively hydromorphic.

The Upland Tundra

On better drained tundra surfaces on Amchitka, the vegetation is generally dominated by grass or crowberry or a mixture of the two. The prominent grasses are Calamagrostis nutkaensis (reedgrass), Elymus arenarius (seagrass), and Festuca rubra (fescue)*. The three grasses are important members of the beach-grass community. The upland tundra also includes several important sedge species (Carex circinnata, C. lyngbyaei, C. macrochaeta), and certain Juncus and Luzula species are conspicuous in some situations. Salix spp. and Vaccinium spp. are found on well-drained sites, and Loiseleuria procumbens (alpine azalea) is also an important member of some of the subshrub communities.

The upland tundra grades from the crowberry-grass-sedge meadow to the wind-desiccated crowberry-grass-stripe zone which is broken by solifluction-deflation zones at higher elevations on the island. The stripe zone covers about 26.3 percent of the Island. The crowberry-grass-sedge meadow type is the most stable vegetation on the Island on moderate, relatively well-drained topography.

Certain sites on the Island (approximately 2.9 percent of the area) support almost purely graminoid communities. These better-drained sites are located at the edges of permanent lakes, along well-established streams, just above steep sea cliffs, and on steep slopes with a relatively well-developed soil. Many of these stands (reedgrass, seagrass, various sedges, fescue) cover considerable acreage and grow to a meter or more.

This secondary succession type vegetation covers about 5.2 percent of the Island, most of it near the eastern end. Exposed soil on berms as well as other areas that were disturbed by road and building construction during the 1940's, often well drained because they are artificially elevated, supports the graminoid species mentioned above as well as crowberry. The secondary succession toward an expression of the upland tundra supports the "most stable" ranking of the crowberry-grass-sedge meadow community.

Succession to upland tundra vegetation is also occurring on mixed gravel-soil surfaces of the Island. Such surfaces are generally either abandoned military roads and building sites or lag-gravel surfaces ("desert pavements") in the crowberry-grass-stripe deflation solifluction zones on exposed hills and ridges. Lupinus nootkatensis is often the pioneer in both cases. This robust perennial herb with its perennating bud close to the ground surface provides both shelter and nitrogen-enriched soil for the establishment of crowberry, grasses, and herbs. Many small islets of vegetation have developed on the gravel surfaces.

Subsequent secondary succession on gravel roads presents few problems of interpretation. Desert pavement or lag-gravel surfaces at higher elevations (generally above 75 meters) have complex origins and processes of maintenance. A possible contributing

*Festuca altaica (identified by chromosome analysis by Dr. Wm. Mitchell of the Alaska Agricultural Experiment Station) intermingles with F. rubra in many situations. The two grasses are very similar in habit and in site preference.

factor is the apparent pathogenicity of a lichen of the genus Mycoblastus on the crowberry. Once the upland vegetation has been destroyed, whether by physical or organic agents, an uninsulated bare gravel-soil surface subject to wind erosion and frost action results. The processes that control the establishment or reestablishment of vegetation on the exposed sites are not completely clear. Many of these surfaces have likely existed since vegetation developed on the Island under the present climatic regime. The pattern of the vegetated crowberry-grass stripes and intervening gravel surfaces is continually changing over the years. Even with the migration of the vegetation and the downslope and vertical frost heaving movement of the gravel, the overall aspect of the undisturbed portions of this landscape type is unlikely to change much with the present floral composition of the Island.

In summary, the upland tundra topoenvironmental unit vegetation grades from meadow to subshrub stands, reflected by the lesser accumulations of peat as drainage improves and mineral-soil-forming processes are less inhibited. The lag gravel-soil surfaces are the "driest" well-represented substrates on the Island except for the beaches, but, when rainfall is copious, even these soils remain at field capacity.

The Beach

The dominant beach community above high-tide on beaches wide and high enough to prevent frequent storm flooding is a grass stand. The same sort of community appears on the small islets off the coast and on some of the larger sea stacks. The aspect dominant is seagrass, but reedgrass, fescues, and Poa eminens are also common. Early in the growing season, geophytic herbs (especially Ranunculus spp. Geum macrophyllum, certain Umbelliferae) provide a conspicuous touch of green, but as the grasses develop fully, and the "canopy" closes, the vernal plants are less noticeable. The conspicuous but small Potentilla villosa is common in niches in rocks on the sea cliffs and stacks, often with Mimulus guttatus.

A rather diffuse community composed of decumbent succulent herbs is generally found between the grass community and the mean-high-tide mark. These often storm-washed halophytes nowhere provide a very dense cover. The principal species are Senecio pseudo-arnica, Mertensia maritima, Honkenya peploides, and Lathyrus maritimus.

The soil of the beach communities, which comprise about 1.5 percent of the terrestrial landscape, is almost wholly mineral substrate. Very lush but localized expressions of the beach community vegetation occur on the seashell-bone-calcium rich middens at the sites formerly occupied by Aleuts on or near many beaches on the island. Urtica lyallii is also found on many of the middens.

Community Comparisons and Dynamics

That many species are well represented in more than one plant community type complicates the convenient delineation of type boundaries. Prominent among these widely distributed species are the grasses Calamagrostis nutkaensis, Elymus arenarius, and Festuca spp., the sedges Carex circinnata, C. pluriflora and C. macrochaeta, the

COMPARTMENT DISCUSSION FOR FIGURE 3 (See preceding page)

1. INPUT: No long-term solar energy input record is available for Amchitka. An Eppley pyranometer was installed in the spring of 1969, but has produced only partial records due to recorder failure. The work of Budyko (1958) indicates the expected annual net radiation for the central Aleutians to be between 40 and 60 kg-cal/cm²/year. This is probably high; 20 to 40 should be more realistic.
 Subaerial nutrients include salt spray, animal feces, dissolved nutrients in rain and snow, etc. Atmospheric contributions include nitrogen fixed by soil microflora.
2. PRIMARY PRODUCERS: Includes cryptogams and phanerogams. Basic annual productivity study results for the "A" stratum are listed in Table 3.
3. STANDING UNALTERED DEAD PLANT MATERIAL: Includes the previous year's crop as well as fresh litter.
4. SOIL AND/OR PEAT: Represents mineral soil as well as altered dead organic material. Soil and peat analyses have been made in a separate study (Everett, 1968). The peat component of this compartment is a very large part of this ecosystem.
5. PARASITIC FUNGI, PATHOGENS: Smuts and rusts have been seen on grasses. A lichen of the genus Mycoblastus appears pathogenic to the crowberry.
6. PRIMARY CONSUMERS: The authors' analyses of the contents of bird crops and stomachs indicate the consumption of fruits and leaves of many species. Rats are known to eat the underground parts of some plants. Invertebrates eat living as well as dead plant material. Samples indicate that springtails and other insects, mites, spiders, and nematodes are present in the vegetation and in the litter at all times of the year.
7. SECONDARY CONSUMERS: The predation of falcons and rats is probably of only slight importance. Eagles have been attempting to take rats. Fish take a good number of invertebrates. Certain invertebrates, such as spiders, prey heavily on other invertebrates.
8. SOIL MICROFLORA: Although bacteria do not normally flourish in acid peat, nitrogen-fixing bacteria are associated with the native lupine, and visual evidence indicates the presence of both sulfur and iron-reducing bacteria. Fungal hyphae are present in the 02 horizon, and basidiocarps are found infrequently.
9. SOIL FAUNA: Soil invertebrates are present at all seasons of the year, even in frozen litter.
10. RESPIRATION: Compartment is included to indicate that gross as well as net productivity should be considered.
11. OUTPUT: Included are hydric solution of peat, run-off which carries suspended organic and mineral matter, mineral weathering, blowout, and the "calving" of peat. Radiation and evapotranspiration energy losses are also included.

subshrub *Empetrum nigrum*, mosses of the genus *Racomitrium* and several lichens of the genus *Cladonia*. Although many species are prominent in terms of aspect dominance, their annual productivity and gross biomass vary greatly.

The crowberry, the lichen, and the ubiquitous mosses are perhaps the most widely distributed elements of several communities. The gross biomass of the crowberry is probably the greatest of any of the Island species; annual increments are difficult to measure. The annual productivity of lichens is negligible by comparison with that of other species (Ahti and Hepburn, 1967). The highest annual productivity by species on the Island is contributed by the major grasses, *Calamagrostis nutkaensis* (reedgrass), and *Elymus arenarius* (seagrass). The individually productive sedges seldom form large, dense stands as do the grasses, except in special circumstances (see Appendix II, Sample S22). The greatest annual productivity on a unit area basis is in the graminoid communities of the upland tundra unit and in the beach topoenvironmental unit.

The greatest gross biomass is found in the combined meadow types totaling over 50 percent of the Island's area. The annual productivity per unit area is not the greatest in the meadows because neither the grass nor the sedge form extensive closed stands in the rather thick crowberry mat (see Table 3).

As is common in bog and fen communities, even the relatively low unit area biomass production of these communities greatly exceeds annual decay and decomposition rates, and the system is far out of balance. One principal reason is the dearth of consumers and reducing organisms. Primary consumers of viable plant material are limited to certain species of birds, the rats, and certain invertebrates (nematodes, mites, slugs, insects, etc.). These invertebrates also play a part in the decomposition of standing dead plant material and raw litter and humus. Detailed investigation of bacterial decomposers was not undertaken; such organisms are seldom abundant under the acid conditions existing in peat substrates. Many fungi are known to be important in the decomposition of organic material under acid conditions. Visual examination of the decomposing layers of the substrate reveals conspicuous hyphae, but mushrooms or other fungal fruiting bodies are infrequent on the peat.

A tentative schematic model of the terrestrial ecosystem of Amchitka is presented in Figure 3. Although this model indicates a balance, the inabundant decomposing bacteria and fungi reduce the chances for any sort of sustaining balance.

A minimal subaerial supply of certain necessary nutrients (from bird droppings, rat scat, insect casts, sea spray, and other phenomena) is available, but the system is heavily weighted toward nutrients storage. This imbalance has resulted in a continuing slow accumulation of plant residues and altered organic matter which has produced a rather thick layer of peat on flat to moderately sloping topography (Shacklette and Rubin, 1969).

The system is complicated by the slow slipping of the peat toward stream bottoms and sea cliffs. This flow is apparent in flow lines, crevasses, and "peat falls" or "calving" over abrupt subsurface topography.

The movement of the peat occasions slowly but nearly continually changing drainage patterns. Many streams flowing over peat not derived from aquatic plants indicates stream migration. The peat movement has pushed the streams over and new channels have been cut into the peat. Lobes and large blocks of peat observed in the streams also indicate the peat override of existing channels.

Earthquake shocks are known to have greatly accelerated the peat movement on steeper topography, particularly at the higher elevations, and at the top of the sea cliffs where large slide and slump scars are conspicuous.

Succession

The concept of succession toward a mesophytic "climax" does not apply on Amchitka. Although there are seral expressions, such as the examples of secondary succession on gravel surfaces and road berms, long-term successional processes are not unidirectional. The constantly changing drainage, resulting from peat accumulation and movement, causes long-term alternate drying and swamping over local areas and precludes local stability. The succession is multidirectional, progressive towards a mesophytic climax in some areas, and regressive towards a hydrophytic climax in others. If these dynamic processes remain undisturbed, the overall vegetation of the Island will change little in time but may change considerably in space.

A relative dearth of species, coupled with the existing soil and climatic factors, precludes direct comparisons of the Amchitka ecosystems with other better known ecosystems. In the poor and relatively isolated Amchitka flora, plant populations display more or less conspicuously different phenotypes that have developed and adapted to a wide range of habitats.

Given the dynamic ecosystem and the poor flora, only a major impact will create significant changes with time.

THE EFFECTS OF MAN'S PAST AND PRESENT ACTIVITIES ON AMCHITKA

The landscape of Amchitka has been affected to varying degrees by military and subsequent civilian activities on the Island. The more obvious causes of change have been military construction of roads and buildings, current construction of roads and drill sites, disturbance-induced mud flows, waste disposal, and traffic over fragile tundra. Denudation by fire has been inconsequential as the peat never appears to dry out enough to burn, even though the standing dead material has carried fire during the period of this study.

Succession toward indigenous climax vegetation has progressed relatively well, although slowly, on the berms around old roads and buildings, and is occurring very slowly on abandoned gravel roads. These types of construction disturbances have generally improved drainage, and the succession reflects the drainage changes. If the Island installations were to be abandoned at this point, similar succession would occur. Embanking Infantry Road from the harbor-camp area to Aleut Point has caused a more-complex reaction, e.g., wind baffling and creation of lees in association with cuts and fills, blockage of drainage, increased exposure of previously less exposed areas, addition of silt to produce local mucks. The resulting succession at abandoned nuclear test sites will be similar to the succession experienced since World War II. Some protected areas will recover slowly and other areas, exposed to wind or flooded, will remain relatively barren. Some damaged areas may even increase in size.

The consequences of the disposal of liquid organic and inorganic materials and solid waste are not so easily predicted. The leakage of the highly basic, oil-containing drill

mud from sumps at the drill sites has killed some vegetation, but not a significant amount on an areal basis.

Observations over 14 months indicate a differential sensitivity to drill-mud leakage among the major life forms of terrestrial plants on Amchitka. The Cladonia lichens appear to be the most sensitive, the deeply rooted sedges the least. Grasses and subshrubs exhibit intermediate sensitivity. The submerged leaves of emergent aquatic plants were necrotically discolored in streams that were apparently only slightly polluted. The drill-mud polluted streams appear to have more iron bacteria than unpolluted streams nearby.

The "mud sump" and the drainage ditch from it at the Long Shot site did not support any higher vegetation even after nearly 4 years. Abrasive materials leaked into the streams may increase the rate of downcutting of their peat floors. Some improvement in drainage in certain areas may cause community shifts.

Organic pollution in a stream flowing into Clevenger Lake has no doubt changed nutrient levels which will affect plant development along the stream. Oil in the stream has complicated analysis of the effects of organic pollution.

Gouges left by heavy tracked vehicles as much as 25 years ago are striking evidence of the fragility of most of the tundra, and the very low rate of recovery of certain community types. Many of the old tracks are water filled during the rainy seasons and support little higher vegetation at any season. The natural eradication of these tracks, and some heavily used footpaths as well, will take many years. Although heavy equipment now in use causes severe damage, the smaller "Sno Tracs" cause relatively little damage except on the extremely fragile "breakaway" and sedge-lichen tundra.

PROBABLE EFFECTS OF NUCLEAR TEST SHOCK ON THE AMCHITKA TERRESTRIAL ECOSYSTEM

The changes in the terrestrial ecosystem that will result from further underground shocks from nuclear testing will depend on (1) the intensity of the shock, (2) the amount of excess water in the peat and soil substrates at the time of the test, and (3) the particular topoenvironmental unit affected. There is no way to deduce how wet the substrate was at the time of previous shocks, and no way to guess the local intensity necessary to cause the disturbances that did occur. The expression of future nuclear shock effects could be similar.

Barring a shock of such great intensity that catastrophic land movement occurs, the chief effect will be the acceleration of substrate movement rates and a resulting more rapid shift in drainage patterns. The communities that are most sensitive to the degree of drainage restriction are those whose structure and composition are related to a fairly narrow range of moisture conditions. The upland graminoid type exists on relatively well-drained soils on steep slopes and along stream and lake banks. A severe shock may cause mass movement on the slopes and fracture of the stream banks. Both phenomena can lead to drainage restrictions and fairly rapid shifts to a more hydric vegetation type. The breakaway tundra and sedge-lichen meadow types are in general restricted to areas of nearly closed drainage. Any substrate fracturing that allows improved drainage will

allow the establishment of more-mesic vegetation in these areas. None of the types discussed above occurs in large expressions near proposed test sites, but the sensitivity of the steep graminoid communities at other locations on the Island should be considered if future underground nuclear testing makes it necessary to select additional testing sites.

In addition to the acceleration of peat movement rates, and the resulting drainage changes as the surface topography is altered, a severe shock might fracture the lithified layer that prevents the deep percolation of the surface water. This type of drainage would drive the plant communities toward the drier expressions of the continuum now extant, and could result in local flushes of nutrient-rich geogenous water that would accelerate plant growth and development for a time. The effects of such fracturing on the vegetation are not likely to be permanent, however. In view of the tundra ecosystem and the amount of clay in the deep, gleyed soil, the fractures will seal up (the time necessary depending on just how wide they are) and the present ecosystem will most likely recover.

The testing would have the least effect on the vegetation of the Island if it were conducted at a time when the tundra were dry or very well frozen.

Should any leakage of radioactivity occur, it would have the greatest chance of uptake in the terrestrial vegetation during the late spring flush of growth and during the summer period when the perennial plants are producing photosynthate for current growth and carbohydrate storage. There apparently is no season on the Island when all growth ceases, at least in the common grasses. Seagrass, reedgrass, fescue, and Bromus sitchensis (as well as certain ferns) were all observed to be actively "tillering" throughout the fall, winter, and early-spring seasons. The large plant biomass below the ground surface as well as the insulating effect of dead leaves and other slowly decomposing litter probably promotes this "off-season" growth. The data collected are insufficient to completely define the all-season status of the terrestrial vegetation.

The shock from Milrow in October, 1969, caused some fracturing of peat and moss mounds in the area of ground zero and within a limited radius of the test site. In addition, some flooding of lowland tundra occurred. There was accelerated calving of peat over sea cliffs and some sea cliff and sea stack fall. There was no immediate measurable movement of the staked lines at Ultra Creek, some 4.5 kilometers from ground zero.

REFERENCES

- Ahti, T. and R. L. Hepburn. 1967. Preliminary studies in woodland caribou range, especially on lichen stands, in Ontario. Ontario Dept. Lands Forest., Div. Res., Res. Rept. (Wildlife) No. 74. 134 pp.
- Budyko, M. I. 1958. The heat balance of the earth's surface. U.S. Dept. of Commerce, Office of Technical Services, Washington, D.C. (PB-131 692). 259 pp.
- Carr, W. J., L. M. Gard, Jr., and W. D. Quinlivan. 1966. Geologic reconnaissance of Amchitka Island, December 1966. Denver, U.S. Geological Survey, USGS-474-42. 14 pp.

- Conti, M. A. and L. A. Spetzmann. 1965. Terrain atlas, potential for nuclear testing. Amchitka Test Area, Western Aleutian Islands, Alaska. U.S. Geological Survey, Military Geology Branch. (Maps only).
- Evans, F. C. and E. Dahl. 1955. The vegetational structure of an abandoned field in southeastern Michigan and its relation to environmental factors. *Ecology* 36: 685-705.
- Everett, K. R. 1968. Amchitka Bioenvironmental Program. Geomorphology and pedology of Amchitka Island. Annual progress report. Battelle Memorial Institute, Columbus Laboratories, U.S. AEC report BMI-171-106. 80 pp.
- Hultén, E. 1960. Flora of the Aleutian Islands. 2d ed. Weinheim, J. Kramer. 418 pp.
- Hultén, E. 1968. Flora of Alaska and Neighboring Territories. Stanford, California, Stanford Univ. Press. 1,008 pp.
- Johnson, A. W., L. A. Viereck, R. E. Johnson, and H. Melchior. 1966. Vegetation and flora. In: *Environment of the Cape Thompson Region, Alaska*, ed. by N. J. Wilimovsky and J. N. Wolfe. U.S. AEC report PNE-481. Pp. 277-354.
- Jones, R. D., Jr. 1967. Location of Amchitka transects. U.S. Fish and Wildlife Service Memorandum (dated 12 April 1967, copied 7 June 1967) D. L. Spencer, Kenai, Alaska.
- Pitelka, F. A. 1969. Ecological studies on the Alaskan arctic slope. *Arctic* 22: 333-340.
- Powers, H. A., R. R. Coats, and W. H. Nelson. 1960. Geology and submarine physiography of Amchitka Island, Alaska. U.S. Geol. Surv. Bull. 1028: 521-554.
- Seymour, A. H. and R. E. Nakatani. 1967. Long Shot Bioenvironmental Safety Program. Final report. Seattle, Univ. of Washington, College of Fisheries, U.S. AEC report TID-24291. 49 pp.
- Shacklette, H. T. 1966. Unattached moss polsters on Amchitka Island, Alaska. *Bryologist* 69: 346-352.
- Shacklette, H. T. and others. 1969. Vegetation of Amchitka Island, Aleutian Islands, Alaska. U.S. Geol. Surv. Prof. Pap. 648. 66 pp.
- Shacklette, H. T. and M. Rubin. 1969. Radiocarbon dating of ash deposits on Amchitka Island, Alaska. U.S. Geol. Surv. Prof. Pap. 650-B: 81-83.
- Shear, J. A. 1964. The polar marine climate. *Ann. Assoc. Amer. Geogr.* 54: 310-317.
- Tamm, C. O. 1953. Growth, yield and nutrition in carpets of a forest moss (*Hylocomium splendens*). *Meddeland. Statens Skogsforskninginst.* 43(1): 1-140.
- Tatewaki, M. 1930-31. Notes on the plants of the western Aleutian Islands collected in 1926. *Trans. Sapporo Natur. Hist. Soc.* 11: 152-156; 12: 200-209.

U.S. Army Corps of Engineers. 1968. Bidding document for road construction on Amchitka Island, DACA 85-68-B-0027. (Climatic summary, pp. SP-12-SP14).

U.S. Army Corps of Engineers, Map Service. 1957. Aleutian Islands; Rat Islands. 1:25,000. 8 sheets.

U.S. Coast and Geodetic Survey. 1948. (Black and white vertical aerial photographs of Amchitka Island.) Scale approx. 1:23,000.

APPENDIX I

HIGHER PLANTS OF AMCHITKA COLLECTED 1967-1969

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HIGHER PLANTS OF AMCHITKA COLLECTED 1967-1969

LYCOPODIACEAE

- Lycopodium alpinum* L *
L. annotinum L *
L. clavatum L *
L. sabinaefolium L var *sitchensis* (Rupr.) Fern
L. selago L * ssp *selago*

SELAGINELLACEAE

- Selaginella selaginoides* (L.) Link *

ISOETACEAE

- Isoetes muricata* Dur ssp *maritima* (Underw.) Hult *

EQUISETACEAE

- Equisetum arvense* L *

OPHIOGLOSSACEAE

- Botrychium lunaria* (L.) Sw *

THELYPTERIDACEAE

- Thelypteris phegopteris* (L.) Slosson *

ATHYRIACEAE

- Athyrium filix femina* (L.) Roth ssp *cyclosorum* (Rupr.) Christens *
A. distentifolium Tausch ssp *americanum* (Maxon) Hult *
Cystopteris fragilis (L.) Bernh. ssp *fragilis* *
Woodsia scopulina (D.C.) Eat *

ASPIDIACEAE

- Dryopteris dilatata* (Hoffm.) Gray ssp *americana* (Fisch.) Hult *
Gymnocarpium dryopteris (L.) Newn *

POLYPODIACEAE

- Polypodium vulgare* L. ssp *occidentale* (Hook.) Hult *

PINACEAE

- Picea sitchensis* (Bong.) Carr * (introduced, not reproducing)

SPARGANIACEAE

- Sparganium hyperboreum* Laest *

POTAMOGETONACEAE

- Potamogeton vaginatus* Turcz *

GRAMINEAE

- Agrostis alaskana* Hult *
A. borealis Hartm *
A. exarata Trin
Alopecurus aequalis Sobol *
A. alpinus Sm ssp *Stejnegeri* (Vasey) Hult
Bromus sitchensis Trin var *aleutensis* (Trin.) Hult *
Calamagrostis canadensis (Michx.) Beauv ssp *langsдорffii* (Link) Hult *
C. nutkaensis (Presl.) Steud *
Deschampsia beringensis Hult
D. caespitosa (L.) Beauv ssp *orientalis* Hult *
Elymus arenarius L ssp *mollis* (Trin.) Hult *
Festuca altaica Trin *
F. brachyphylla Schult *
F. rubra L ssp *aucta* (Krecz. and Bohr.) Hult *
Hierochloa odorata (L.) Wahlenb
Hordeum brachyantherum Nevski *

- Phleum commutatum* Gandoger var *americanum* (Fourn.) Hult *
Poa alpina L *
P. arctica R. Br ssp *Williamsii* (Nash) Hult
P. eminens Presl *
P. hispidula Vasey
P. lanata Scribn. & Merr. var *vivipara* Hult *
P. malacantha Kom
P. turneri Scribn
Puccinellia Langeana (Berl.) Sorens *
Trisetum spicatum (L.) Richter ssp *Alaskanum* (Nash) Hult *
Vahlodea atropurpurea (Wahlenb.) E. Fries ssp *paramushirensis* (Kudo) Hult *

CYPERACEAE

- Carex anthoxantha* Presl *
C. bigelowii Torr *
C. circinnata C. A. Mey *
C. kelloggii W. Boott *
C. lyngbyae Hornem *
C. macrochaeta C. A. Mey *
C. pluriflora Hult *
C. saxatilis L ssp *laxa* (Trautv.) Kalela
C. stylosa C. A. Mey
Eriophorum russeolum E. Fries var *majus* Sommer *
E. russeolum E. Fries ssp *rufescens* (Anders.) Hyl *
E. angustifolium Honck *

JUNCACEAE (Specimens not yet keyed)

- Juncus arcticus* Willd ssp *sitchensis* Engelm
J. biglumis L
J. drummondii E. Mey
J. ensifolius Wikstr
J. triglumis L ssp *albescens* (Lange) Hult
Luzula multiflora (Retz.) Lej ssp *jultiflora* var *frigida* (Buchenau) Sam
L. multiflora (Retz.) Lej ssp *Kobayashi* (Satake) Hult
L. parviflora (Ehrh.) Desv ssp *parviflora*
L. tundricola Gorodk
L. wahlenbergii Rupr ssp *piperi* (Cov.) Hult
L. arcuata (Wahlenb.) Sw ssp *unalaschensis* (Buchenan) Hult

LILIACEAE

- Fritillaria camschatcensis* (L.) Ker-Gawl *
Maianthemum dilatatum (How.) Nesl. & Macbr *
Streptopus amplexifolius (L.) DC *
Tofieldia coccinea Richards *

IRIDACEAE

- Iris setosa* Pall ssp *setosa* *

ORCHIDACEAE

- Dactylorhiza aristata* (Fisch.) Soo *
Listera cordata (L.) R. Br *
Platanthera convallariaefolia (Fisch.) Lindl *
P. dilatata (Pursh) Lindl *
P. chorisiana (Cham.) Rehb *
P. tipuloides (L.f.) Lindl var *behringiana* (Rydb.) Hult *

SALICACEAE

- Salix arctica* Pall ssp *crassijulis* (Trautv.) Skvortz *
S. cyclophylla Rydb *
S. polaris Wahlenb
S. rotundifolia Trautv *

*Voucher specimens in collection at University of Tennessee

URTICACEAE

Urtica Lyallii Wats.*

POLYGONACEAE

Koenigia islandica L.*
Cochlearia officinalis L. ssp. *oblongifolia* (DC.) Hult.*
Draba borealis D.C.
D. aleutica Ekman
D. hyperborea (L.) Desv.
Subularia aquatica L.

SAXIFRAGACEAE

Leptarrhena pyrolifolia (D. Don) Ser.*
Parnassia kotzebuei Cham & Schlecht.*
Saxifraga aleutica Hult.
S. bracteata D. Don*
S. bronchialis L. ssp. *cherlerioides* (D. Don) Hult.
S. foliolosa R. Br. var. *foliolosa*
S. punctata L. ssp. *Nelsoniana* (D. Don) Hult.*
S. punctata L. ssp. *insularis* Hult.*

ROSACEAE

Geum calthifolium Menzies*
G. macrophyllum Willd. ssp. *macrophyllum**
G. pentapetalum (L.) Makino*
Potentilla egedii Wormsk. ssp. *grandis* (Torr. & Gray) Hult.
P. hyperborea Malte*
P. pulchella R. Br.*
P. villosa Pall.*
Rubus arcticus L. ssp. *stellatus* (Sm.) Boiv. emend. Hult.*
R. chamaemorus L.*
Sibbaldia procumbens L.*

LEGUMINOSAE

Lathyrus palustris L. ssp. *pilosus* (Cham.) Hult.
L. maritimus L. ssp. *pubescens* (Hartm.) C. Regel*
Lupinus nootkatensis Donn*
Trifolium repens L.*

GERANIACEAE

Geranium erianthum D.C.*

CALLITRICHACEAE

Callitriche anceps Fern.*
C. hermaphroditica L.*

VIOLACEAE

Viola langsdorffii Fisch.*

ONAGRACEAE (Specimens not yet keyed)

Epilobium anagallidifolium Lam.
E. behringianum Haussk.
E. glandulosum Lehm.
E. sertulatum Haussk.

HALORAGACEAE

Hippuris montana Ledeb.
H. vulgaris L.*
Myriophyllum spicatum L.*

UMBELLIFERAE

Conioselinum chinense (L.) BSP.*
Ligusticum scoticum L. ssp. *Hultenii* (Fern) Calder & Taylor*
Angelica lucida L.*
Heracleum lanatum Michx.*

CORNACEAE

Cornus canadensis L. x *suecica* L.
C. suecica L.*

PYROLACEAE

Pyrola asarifolia Michx. var. *purpurea* (Bunge) Fern.*
P. minor L.*

EMPETRACEAE

Empetrum nigrum L. ssp. *nigrum**

ERICACEAE

Cassiope lycopodioides (Pall.) D. Don*
Loiseleuria procumbens (L.) Desv.*
Rhododendron camtschaticum Pall. ssp. *camtschaticum**
Vaccinium uliginosum L. ssp. *microphyllum* Lange.*
V. vitis-idaea L. ssp. *minus* (Lodd.) Hult.*

DIAPENSIACEAE

Diapensia lapponica L.

PRIMULACEAE

Primula cuneifolia Ledeb. ssp. *saxifragifolia* (Lehm.) Sm & Forrest*
Trientalis europaea L. ssp. *arctica* (Fisch.) Hult.*

GENTIANACEAE

Gentiana aleutica Cham & Schlecht.*
G. amarella L. ssp. *acuta* (Michx.) Hult. var. *plebeja* (Cham & Schlecht) Hult.*

BORAGINACEAE

Mertensia maritima (L.) S. F. Gray ssp. *maritima**
M. maritima (L.) S. F. Gray ssp. *asiatica* Takeda*

SCROPHULARIACEAE

Castilleja unalaschcensis (Cham & Schlecht.) Malte.*
Limosella aquatica L.*
Mimulus guttatus DC.*
Pedicularis chamissonis Stev.*
Rhinanthus minor L. ssp. *borealis* (Sterneck) Love*
Veronica americana Schwein*
V. grandiflora Gaertn.
V. serpyllifolia L. ssp. *humifusa* (Dickson) Syme.
V. stelleri Pall.
Euphrasia mollis (Ledeb.) Weltst.*

LENTIBULARIACEAE

Pinguicula vulgaris L. ssp. *vulgaris**

PLANTAGINACEAE

Plantago macrocarpa Gham. & Schlecht.*

RUBIACEAE

Galium aparine L.*
G. trifidum L. ssp. *columbianum* (Rydb.) Hult.*

CAPRIFOLIACEAE

Linnaea borealis L. ssp. *borealis**

CAMPANULACEAE

Campanula chamissonis Fedorov*
C. lasiocarpa Cham. ssp. *lasiocarpa**

COMPOSITAE

Achillea borealis Rong.*
Anaphalis margaritacea (L.) Benth & Hook f.*
Antennaria dioica (L.) Gaertn.*
Arnica unalaschcensis Less.*
Chrysanthemum arcticum L. ssp. *arcticum**
Erigeron peregrinus (Pursh) Greene ssp. *peregrinus**
Hieracium gracile Hook. var. *alaskanum* Zahn.
H. triste Willd.*
Petasites frigidus (L.) Franch.
Senecio pseudo-arnica Less.*
Taraxacum trigonolobum Dablistedt*

APPENDIX II

CHARACTER AND PRODUCTIVITY OF
FOURTEEN CLIP PLOTS

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CHARACTER AND PRODUCTIVITY OF
FOURTEEN CLIP PLOTS

Comparative 1968 growing season herb-grass production of fourteen 1-m² plots in six community-types on Amchitka Island. Plots were clipped to remove all standing dead Stratum A biomass (ferns, sedges, grasses, herbs) above the level of dead litter during the early winter of 1968; and herbs, sedges, grasses, and ferns of Stratum A were harvested in October, 1968, after the frequent occurrence of freezing and near-freezing air temperatures, as well as phenological observations, indicated the aestival growing season had ended. Brief annotations indicate characteristic plants of the type sampled as well as the appearance of the plots in July, 1969, nine months after harvest. Samples were air dried to a constant weight.

Upland Graminoid Type

Sample S21. Riparian situation in Ultra Basin (elevation 38 meters, map coordinates 476015). Dominated by Calamagrostis, Festuca, and Angelica. The Empetrum-Rhacomitrium strata just above the 01 horizon was not clipped. In July, 1969, Calamagrostis, nutkaensis, Festuca rubra, Angelica, and Carex lyngbyaei were conspicuous on the plot. The fescue appeared to have been somewhat aided by the clipping.

1968 production: 111.0 grams.

Sample S22. Sedge meadow expression of upland graminoid type on a slight slope in Ultra Basin (elevation 38 meters, map coordinates 473017). A pure stand of Carex lyngbyaei. 01 horizon absent, 02 horizon not disturbed. The area was subject to nutrient flushes from a nearby, overflowing pond. In July, 1969, the Carex lyngbyaei in the clip plot was indistinguishable in density and vigor from undisturbed vegetation of the same species nearby.

Production: 507.0 grams.

Sample S29. Hillside expression of upland graminoid type on Chitka Point Ridge (elevation 198 meters, map coordinates 365147). Conspicuous dominants were Calamagrostis, Festuca, and Polygonum. The Salix arctica-Sphagnum species stratum at 01 horizon was not clipped. In July, 1969, Calamagrostis and the other dominants were recovering with no apparent ill effects from the clipping.

Production: 69.0 grams.

Secondary Succession Type

Sample S23. On WWII road berm east of Charlie runway (elevation 53 meters, map coordinates 621944) Calamagrostis, Deschampsia, Festuca, and Poa spp. predominate. No distinct O (organic) horizon; mineral soil was left undisturbed. In July, 1969, Deschampsia could not be identified, but the other original dominants appeared to be unaffected by the clipping.

Production: 86.0 grams.

Sample S26. On the road berm near the location of the S23 plot (elevation 53 meters, map coordinates 622944). Dominants were Deschampsia, Calamagrostis, Carex machrochaeta, and Agrostis. No distinct O horizon. The mineral soil was left undisturbed. In July, 1969, Calamagrostis, Carex macrochaeta, and Angelica dominated the plot. The other originally conspicuous grasses were less in evidence, but productivity did not appear affected.

Production: 90.0 grams.

Crowberry-Grass-Sedge Type

Sample S24. In Ultra Basin on a slight slope near the thermometer station (elevation 46 meters, map coordinates 475017). Stratum A was mostly Calamagrostis and Carex macrochaeta. Empetrum mat and lichens and mosses were not disturbed. In July, 1969, both the sedge and the grass species were recovering without any noticeable change.

Production: 33.0 grams.

Sample S27. Near the location of the secondary succession plots (S23, S26) but on an undisturbed slight slope (elevation 46 meters, map coordinates 622943). Calamagrostis, Festuca, and Carex circinnata dominated. The Empetrum layer and Sphagnum above the O1 horizon were not disturbed. In July, 1969, Calamagrostis and Carex circinnata dominated, and no effects of the clipping were apparent.

Production: 40.0 grams.

Sample S30. In Ultra Basin on gentle slope (elevation 38 meters, map coordinates 476013). Calamagrostis, Agrostis, and Carex anthoxantha were the species prominent in the Stratum A. The Empetrum in Stratum B was not disturbed. In July, 1969, the plot appeared no different from adjoining undisturbed vegetation.

Production: 19.0 grams.

Sedge-Lichen Type

Sample S25. East of Charlie runway on a flat, poorly drained "terrace" (elevation 38 meters, map coordinates 622942). Characterized by Carex

pluriflora, Rubus spp. Some scattered Empetrum (and the Cladonia pacifica-Sphagnum spp. layer just above the 01 horizon) was not disturbed. In July, 1969, Carex sp. and several herbs appeared to be producing normally in this plot.

Production: 29.0 grams.

Sample S31. In Ultra Basin on a poorly drained flat very near Sample S30 (a distinct community boundary between the two plots) (elevation 38 meters, map coordinates 476013). Scattered Carex pluriflora and Carex anthoxanthea. The Cladonia pacifica and mixed moss layer was not disturbed. In July, 1969, the vascular plants appeared little affected, but the undisturbed Cladonia lichen appeared to be blowing out or otherwise declining, perhaps as a result of the removal of the higher vegetation.

Production: 21 grams.

Crowberry-Sedge-Grass Type

Sample S28. In Ultra Basin in a small hollow near the thermometer station and plot S24 (elevation 46 meters, map coordinates 475017). Dominated by Carex pluriflora with other scattered Carex spp., as well as a little Calamagrostis. The lichen-moss layer and Empetrum stratum were not disturbed. In July, 1969, the sedges and grasses growing in the clip plot had about the same density and vigor as observed nearby.

Production: 25.0 grams.

Crowberry-Grass-Stripe Type

Sample S32. In "striped" vegetation on a steep north exposure of Chitka Point Ridge (elevation 190 meters, map coordinates 362145). Plot not completely vegetated, about 1/2 bare mineral soil, 1/2 Empetrum, some Festuca (probably F. brachyphylla) and one small Lupinus. The Empetrum and Rhacomitrium were not clipped. In July, 1969, the Festuca and the Lupinus were recovering, and Polygonum was noted in the crowberry mat. No change in productivity was evident.

Production: 11.0 grams.

Sample S33. In striped vegetation on a terrace with a northeast exposure on Chitka Point Ridge and near S32 (elevation 183 meters, map coordinates 361147). Plot sparsely vegetated, with one Sibbaldia cushion, one clump Trisetum, and one Loiseleuria plant. Only the Trisetum was clipped. In July, 1969, one small stool of Trisetum was growing, as well as two Potentilla pulchella plants and one small Coptis trifolia. Although there appeared to be no effect from the clipping, the Loiseleuria was gone.

Production: 1.0 gram.

Sample S34. In a bare step between vegetated risers on Chitka Point Ridge, just above S33 on a flat surface (elevation 183 meters, map coordinates 361147). Potentilla pulchella was the only plant present, and was clipped to ground level, but did not survive. No other plants came in during the 1968 summer. In July, 1969, two Potentilla pulchella seedlings and one Salix rotundifolia seedling were growing. In this active solifluction zone, permanent establishment does not necessarily follow initial germination and seedling success.

Production: 0. gram.

APPENDIX III

MAPS OF PLANT COMMUNITY TYPES ON AMCHITKA

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MAPS OF PLANT COMMUNITY TYPES ON AMCHITKA

The maps following are keyed to Amchitka Plant Types as follows:

- (1) Beach vegetation, including beach grass and diffuse succulent types
- (2) Wet tundra, including the ephemeral pools, "breakaway" tundra, and sedge-lichen meadow types of the lowland tundra
- (3) Crowberry meadow, including the crowberry-sedge-grass type and the crowberry-gas-sedge type. These types are floristically delineated in Figure 1 but could not be separated by tone on the photographs available.
- (4) Upland graminoid, including floristically and edaphically similar riparian stands
- (5) Secondary succession (in large areas extensively disturbed by military occupation)
- (6) Crowberry-grass stripe, the solifluction-deflation zone of the exposed uplands.

Figure 1 in the text indicates relative elevation and moisture conditions for the six types and Table 3 lists approximate areas of community types.

B E R I N G
S E A

AMCHITKA VEGETATION LEGEND

The 10 community types defined and listed for the three topoenvironmental units were grouped into 6 types for mapping:

- (1) Beach vegetation, including beach grass and diffuse succulent types
- (2) Wet tundra, including the ephemeral pools, "breakaway" tundra, and sedge-lichen meadow types of the lowland tundra
- (3) Crowberry meadow, including the crowberry-sedge-grass type and the crowberry-grass-sedge type (These types can be floristically delineated but could not be separated by tone on the photographs available.)
- (4) Upland graminoid, including floristically and edaphically similar riparian stands
- (5) Secondary succession, in large areas extensively disturbed by military occupation
- (6) Crowberry-grass stripe, the solifluction-deflation zone of the exposed uplands.

Type representations of mappable size were traced on U.S. Army Service Maps. Scale 1:25,000.

P A C I F I C
O C E A N

AMCHITKA VEGETATION LEGEND

The 10 community types defined and listed for the three topoenvironmental units were grouped into 6 types for mapping:

- (1) Beach vegetation, including beach grass and diffuse succulent types
- (2) Wet tundra, including the ephemeral pools, "breakaway" tundra, and sedge-lichen meadow types of the lowland tundra
- (3) Crowberry meadow, including the crowberry-sedge-grass type and the crowberry-grass-sedge type (These types can be floristically delineated but could not be separated by tone on the photographs available.)
- (4) Upland graminoid, including floristically and edaphically similar riparian stands
- (5) Secondary succession, in large areas extensively disturbed by military occupation
- (6) Crowberry-grass stripe, the solifluction-deflation zone of the exposed uplands.

Type representations of mappable size were traced on U.S. Army Service Maps. Scale 1:25,000.

AMCHITKA VEGETATION LEGEND

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