

Vascular Vegetation of Buldir Island, Aleutian Islands, Alaska, Compared to Another Aleutian Island

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ABSTRACT. The vegetation of Buldir Island, Alaska, was studied from 1974 to 1976. On this treeless volcanic island, two distinct vegetation complexes were conspicuous, one with relatively tall dominant plants which generally occurred below 300 m elevation (called the Lowland Tall-plant complex), and the other composed of much shorter plants about 300 m elevation (called the Upland Short-plant complex). The lowland complex contained eight plant communities, but over 90% of the complex consisted of three; *Elymus*-umbel, *Elymus*-umbel-fern, and *Carex*-fescue meadow. The upland complex was less diverse, containing only four communities of which the moss-willow tundra was the most widespread. At Buldir 119 species of vascular plants were identified, considerably fewer than at a nearby larger island, Amchitka.

Key words: vascular plants, volcano, Aleutian Islands, plant ecology

RÉSUMÉ. La végétation de l'île Buldir, en Alaska, fut étudiée entre 1974 et 1976. Sur cette île volcanique dépourvue d'arbres, deux complexes distincts de végétation sont évidents, l'un formé de plantes dominantes relativement grandes, paraissant généralement à une altitude de moins de 300 m (nommé le complexe des plantes de grande taille des terres basses), et l'autre composé de plantes de taille beaucoup plus petite trouvées à une altitude de plus de 300 m (appelé le complexe des plantes de petite taille des terres élevées). Le complexe des terres basses comprenait huit communautés de plantes, mais trois de celles-ci comptaient pour 90% du complexe: *Elymus*-ombellifère, *Elymus*-ombellifère-fougère et *Carex*-fétuqué-pré. Le complexe des hautes terres ne présentait pas une telle diversité, ne contenant que quatre communautés, dont la toundra de mousse et de saule était la plus dispersée. A Buldir, 119 espèces de plantes vasculaires furent identifiées, un nombre considérablement inférieur à celui du compte sur Amchitka, une île voisine de taille supérieure.

Mots clés: plantes vasculaires, volcan, îles Aléoutiennes, écologie végétale

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INTRODUCTION

As part of an ecological evaluation of the endangered Aleutian Canada Goose, *Branta canadensis leucopareia*, and other species of birds at Buldir Island, Alaska, this vegetation study was conducted during the summers of 1974 through 1976. The objectives were to describe and delineate plant communities, to quantitatively assess community composition, and to identify all vascular plant species on the island.

The Aleutian Islands' flora is relatively well known. Hultén (1960, 1968) made extensive collections and summarized available information on plant distribution in the Aleutians, but he was never ashore at Buldir. Only two small plant collections have been made previously on the island (Coats, 1953). The only previous site-specific studies of plant communities in the Aleutians were conducted on Amchitka Island, 200 km east of Buldir (Shacklette *et al.*, 1969; Amundsen, 1977). This paper summarizes the study results at Buldir, and comparisons are made between the respective floras at Buldir and Amchitka. Nomenclature follows that of Hultén (1968).

STUDY AREA

Buldir is in the western Aleutian Islands (Fig. 1). It is the westernmost of the Aleutian volcanoes that were still active in the Quaternary period (Coats, 1953). Buldir's surface area is approximately 2000 ha and is composed of three volcanoes and an alluvial valley. The highest elevation is 655 m. A narrow, boulder-strewn beach is backed by nearly-vertical cliffs. Steep (20° to 40°+) vegetated slopes, rising from cliff tops toward the volcanic peaks, are frequently intersected by soil or rock slides. Plateaus occur on the flanks of volcanoes. The

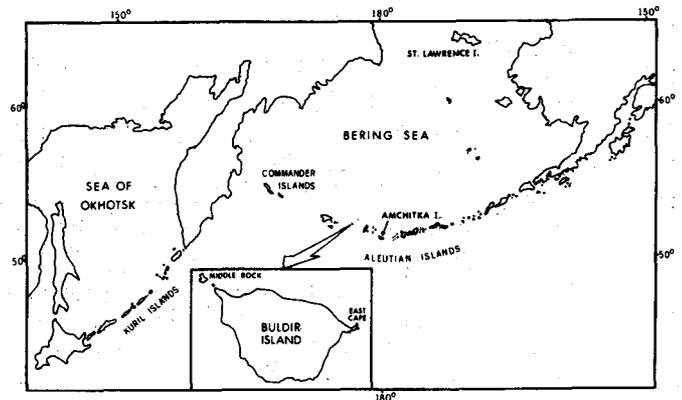


FIG. 1. Map of the Aleutian Islands, Alaska, with an enlargement of Buldir Island.

only permanent wetlands are Kittiwake Pond (1.2 ha), several small streams, and two small marshy areas less than 1 ha in extent in the alluvial valley.

U.S. Weather Service records for Shemya Island, 115 km west of Buldir, provide a useful indicator of conditions at Buldir. Average monthly temperatures range from 0° C in January and February to 9° C in August. At least partial overcast occurs on more than 90% of the days, and relative humidity near sea level averages over 90%. The region is famous for high wind velocity; the average at Shemya is over 30 km·h⁻¹, and velocities exceeding 150 km·h⁻¹ are recorded occasionally in winter.

Buldir is the most isolated of the Aleutians and has no protected beaches for boat landings. As a result, it is one of the few islands on which arctic foxes, *Alopex lagopus*, were never introduced (Jones, 1963). Unlike most of the islands with

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TABLE 1. Vascular plants found at Buldir Island 1974 to 1976

LYCOPODIACEAE <i>Lycopodium selago</i> L. <i>L. annotinum</i> L. <i>L. clavatum</i> L. <i>L. alpinum</i> L. <i>L. sabinaefolium</i> Willd.	PORTULACACEAE <i>Claytonia sibirica</i> L. <i>Montia fontana</i> L.	CORNACEAE <i>Cornus canadensis</i> L. × <i>suecica</i> L. <i>C. suecica</i> L.
SELAGINELLACEAE <i>Selaginella selaginoides</i> (L.) Link	CARYOPHYLLACEAE <i>Stellaria calycantra</i> (Ledeb.) Bong. <i>S. crispa</i> Cham. & Schlecht <i>S. humifusa</i> Rottb. <i>Cerastium aleuticum</i> Hult. <i>C. fischerianum</i> Ser. <i>Sagina crassicaulis</i> S. Wats. <i>S. intermedia</i> Fenzl. <i>Honckenya peploides</i> (L.) Ehrh.	PYROLACEAE <i>Pyrola minor</i> L.
EQUISETACEAE <i>Equisetum arvense</i> L.	RANUNCULACEAE <i>Anemone narcissiflora</i> L. <i>Coptis trifolia</i> (L.) Salisb. * <i>Ranunculus eschscheltzii</i> ² * <i>R. grandis</i> Honda ¹ <i>R. hyperboreus</i> Rottb. <i>R. occidentalis</i> Nutt.	EMPETRACEAE <i>Empetrum nigrum</i> L.
ATHYRIACEAE <i>Athyrium felix-femina</i> (L.) Roth	CRUCIFERAE <i>Cochlearia officinalis</i> L. <i>Cardamine umbellata</i> Greene * <i>Draba borealis</i> D.C. ³ <i>D. hyperborea</i> (L.) Desv.	ERICACEAE <i>Rhododendron camtschaticum</i> Pall. <i>Loiseleuria procumbens</i> (L.) Desv. * <i>Phyllodoce aleutica</i> (Spreng.) Heller ³ <i>Cassiope lycopodioides</i> (Pall.) D. Don <i>Vaccinium vitis-idaea</i> L.
ASPIDIACEAE <i>Dryopteris dilatata</i> (Hoffm.) Gray * <i>Polystichum braunii</i> (Spenn.) Fee ¹	SAXIFRAGACEAE * <i>Saxifraga aleutica</i> Hult. ¹ <i>S. bracteata</i> D. Don <i>S. punctata</i> L. * <i>Chrysosplenium wrightii</i> Fr. & Sav. ³	PRIMULACEAE <i>Primula cuneifolia</i> Ledeb. <i>Trientalis europaea</i> L.
GRAMINAE <i>Agrostis exarata</i> Trin. <i>Bromus sitchensis</i> Trin. <i>Calamagrostis nutkatensis</i> (Presl.) Steud. <i>Deschampsia beringensis</i> Hult. <i>Elymus arenarius</i> L. <i>Festuca rubra</i> L. <i>Phleum commutatum</i> Gandoger <i>Poa arctica</i> R. Br. <i>Puccinellia langeana</i> (Berl.) Sorens * <i>Arctophila fulva</i> (Trin.) Anderss. ²	ROSACEAE <i>Rubus arcticus</i> L. <i>R. chamaemorus</i> L. <i>Potentilla egedii</i> Wormsk. <i>P. hyparctica</i> Malte. <i>P. villosa</i> Pall. <i>Sibbaldia procumbens</i> L. <i>Geum cathifolium</i> Menzies <i>G. macrophyllum</i> Willd. * <i>G. rossii</i> (R. Br.) Ser ³	GENTIANACEAE <i>Gentiana aleutica</i> Cham. & Schlecht. <i>G. amarella</i> L.
CYPERACEAE <i>Carex anthoxantha</i> Presl. <i>C. circinnata</i> C. A. Mey. * <i>C. enanderi</i> Hult. ² * <i>C. glareosa</i> Wahlenb. ¹ <i>C. lyngbyaei</i> Hornem. <i>C. macrochaeta</i> C. A. Mey. <i>C. pluriflora</i> Hult.	GERANIACEAE <i>Geranium erianthum</i> D.C.	SCROPHULARIACEAE <i>Veronica americana</i> Schwein. <i>V. grandiflora</i> Gaertn. <i>V. serpyllifolia</i> L. <i>V. stelleri</i> Pall. <i>Mimulus guttatus</i> D.C. <i>Rhinanthus minor</i> Löve
JUNCACEAE <i>Juncus arcticus</i> Willd. <i>Luzula multiflora</i> (Retz.) Lej. <i>L. parviflora</i> (Ehrh.) Desv. <i>L. tundricola</i> Gorodk.	VIOLACEAE <i>Viola langsdorffi</i> Fisch.	LENTIBULARIACEAE <i>Pinguicula vulgaris</i> L.
LILIACEAE <i>Fritillaria camschatcensis</i> (L.) Ker-Gawl. <i>Streptopus amplexifolius</i> (L.) D.C.	ONAGRACEAE <i>Epilobium behringianum</i> Haussk <i>E. glandulosum</i> Lehm.	PLANTAGINACEAE <i>Plantago macrocarpa</i> Cham. & Schlecht.
ORCHIDACEAE <i>Platanthera convallariaefolia</i> (Fisch.) Lindl. <i>P. dilatata</i> (Pursh) Lindt. <i>Listera cordata</i> (L.) R. Br.	HALORAGACEAE <i>Hippuris montana</i> Ledeb.	RUBIACEAE <i>Galium trifidum</i> L.
SALICACEAE <i>Salix arctica</i> Pall. <i>Salix</i> sp. (either <i>S. rotundifolia</i> or <i>S. ovalifolia</i>)	UMBELLIFAEAE <i>Conioselinum chinense</i> (L.) BSP <i>Angelica lucida</i> L. <i>Heracleum lanatum</i> Michx. <i>Ligusticum scoticum</i> L.	CAPRIFOLIACEAE <i>Linnaea borealis</i> L.
POLYGONACEAE <i>Koenigia islandica</i> L. <i>Rumex fenestratus</i> Greene <i>Oxyria digyna</i> (L.) Hill <i>Polygonum viviparum</i> (L.) S. F. Gray		CAMPANULACEAE <i>Campanula lasiocarpa</i> Cham.
		COMPOSITAE <i>Erigeron peregrinus</i> (Pursh) Greene <i>Anaphalis margaritacea</i> (L.) Benth. & Hook. f. <i>Achillea borealis</i> Bong. * <i>Artemisia unalaskensis</i> Rydb. ¹ <i>Arnica unalaskensis</i> Less. <i>Chrysanthemum arcticum</i> L. * <i>Cacalia auriculata</i> D.C. ¹ <i>Senecio pseudo-arnica</i> Less. <i>Taraxacum trigonolobum</i> Dahlstedt. <i>Hieracium triste</i> Willd. <i>Petasites frigidus</i> L. (Franch.)

*Does not occur at Amchitka.

¹Nearest populations in western Aleutians or Asia.²Range discontinuous, occurring in eastern and western, but not central, Aleutians.³Occurs at elevations not found on Amchitka.

TABLE 2. Composition of Lowland Tall-plant communities at Buldir Island, Alaska

Species	<i>Elymus-umbel</i>	<i>Elymus-umbel-fern</i>	<i>Carex-fescue meadow</i>	<i>Carex lyngbyaei marsh</i>	<i>Artemisia-umbel-Elymus</i>	<i>Calamagrostis</i>	<i>Umbel-fern</i>
OVERSTORY							
<i>Elymus arenarius</i>	37.6 ¹ (3.4) ² 90.2 ³	16.6 (3.6) 71.6	4.0 (1.3) 35.0		8.0 (2.3) 53.3	1.7 (.8) 20.6	
<i>Heracleum lanatum</i>	20.9 (3.1) 69.9	20.6 (4.0) 73.7			29.3 (7.8) 93.3		29.5 (12.7) 80.0
<i>Angelica lucida</i>	16.5 (2.3) 67.1	12.9 (2.3) 61.1	7.7 (2.5) 38.3	1.5 (1.2) 16.7	2.3 (2.4) 20.0	5.0 (2.1) 44.1	27.0 (15.0) 40.0
<i>Athyrium felix-femina</i>		18.1 (4.6) 51.6					23.5 (16.1) 50.0
Fern spp. ⁴		16.3 (4.9) 31.6	2.7 (1.3) 15.0				
<i>Carex lyngbyaei</i>				72.3 (7.3) 87.5			
<i>Arctophila fulva</i>				5.6 (4.8) 8.3			
<i>Artemisia unalaskensis</i>					54.0 (9.5) 93.3		
<i>Calamagrostis nutkatensis</i>						52.4 (3.7) 97.1	
<i>Carex macrochaeta</i>			22.0 (5.6) 66.6			9.1 (4.1) 47.1	
<i>Luzula parviflora</i>				.8 (1.0) 20.8			
<i>Geum macrophyllum</i>							2.0 (1.6) 30.0
<i>Senecio pseudo-arnica</i>							1.1 (1.0) 30.0
MIDDLE STORY							
<i>Claytonia sibirica</i>	22.3 (3.8) 64.3	40.1 (4.8) 93.7			73.7 (4.7) 100.0		31.0 (7.4) 100.0
<i>Festuca rubra</i>	16.9 (3.3) 53.8	3.4 (1.5) 23.2	31.0 (5.3) 95.0	10.6 (4.4) 37.5	1.3 (1.0) 20.0	27.2 (4.2) 97.1	
<i>Cacalia auriculata</i>		5.0 (1.3) 27.4					
<i>Achillea borealis</i>	2.6 (.6) 23.1		7.4 (1.3) 78.3	1.7 (1.1) 29.2		2.2 (.6) 50.0	
<i>Angelica lucida</i>	3.7 (.8) 38.5	2.5 (.8) 30.5	8.3 (1.5) 70.0	3.8 (1.8) 37.5		7.8 (2.2) 52.9	5.0 (4.2) 40.0

TABLE 2. (Continued)

Species	<i>Elymus-umbel</i>	<i>Elymus-umbel-fern</i>	<i>Carex-fescue meadow</i>	<i>Carex lyngbyaei marsh</i>	<i>Artemisia-umbel-Elymus</i>	<i>Calamagrostis</i>	<i>Umbel-fern</i>
<i>Geranium erianthum</i>		1.4 (1.2) 16.8	5.7 (1.5) 48.3	3.0 (1.6) 29.2		3.1 (1.1) 38.2	
<i>Carex macrochaeta</i>			6.8 (2.8) 31.7			17.1 (4.1) 76.5	
<i>Epilobium behringianum</i>	3.8 (1.0) 37.1	2.3 (.8) 22.1		6.3 (2.4) 66.7	.5 (.5) 20.0		
<i>Deschampsia beringensis</i>				5.6 (3.8) 12.5			
<i>Ranunculus occidentalis</i>	2.4 (.6) 25.2	1.6 (.5) 25.3	1.2 (.5) 26.7	1.9 (1.0) 25.0	2.1 (1.4) 40.0		5.0 (1.5) 80.0
<i>Heracleum lanatum</i>					3.7 (1.5) 46.7		9.0 (8.5) 30.0
<i>Geum macrophyllum</i>	1.7 (.5) 23.1	1.2 (.5) 20.0			2.7 (.9) 53.3		3.5 (2.8) 30.0
<i>Epilobium spp.</i>	3.8 (1.0) 37.1	2.7 (1.0) 31.6	3.7 (1.0) 50.0			.4 (.1) 14.7	.6 (.7) 20.0
<i>Athyrium felix-femina</i>		2.8 (.8) 28.4	2.4 (1.3) 23.3			3.2 (1.3) 50.0	1.5 (1.5) 20.0
<i>Poa arctica</i>			.3 (.1) 25.0	3.2 (4.9) 33.0		3.6 (2.5) 52.9	
<i>Platanthera spp.</i>			1.3 (.5) 30.0				
<i>Ranunculus spp.</i>			2.1 (.8) 18.3				
<i>Fritillaria camschatcensis</i>			1.3 (.6) 18.3				
<i>Chrysanthemum arcticum</i>			3.1 (1.5) 21.7			1.3 (.7) 14.7	
<i>Luzula parviflora</i>			1.5 (.9) 21.7	1.3 (.8) 25.0			
<i>Saxifraga punctata</i>	2.1 (.5) 14.7						
<i>Erigeron peregrinus</i>			3.1 (2.5) 20.0				
<i>Anaphalis margaritacea</i>			1.2 (.7) 20.0				
<i>Trientalis europaea</i>						1.3 (1.2) 26.5	

TABLE 2. (Continued)

Species	<i>Elymus-umbel</i>	<i>Elymus-umbel-fern</i>	<i>Carex-fescue meadow</i>	<i>Carex lyngbyaei marsh</i>	<i>Artemisia-umbel-Elymus</i>	<i>Calamagrostis</i>	Umbel-fern
<i>Galium trifidum</i>				1.7 (1.0) 25.0			
<i>Conioselinum chinense</i>				.9 (1.0) 20.8			
Fern spp.			2.2 (1.6) 16.7				
<i>Veronica americana</i>				2.5 (1.3) 33.3			
GROUND STORY							
<i>Cardamine umbellata</i>	7.7 (1.0) 84.6	10.3 (2.0) 89.5	5.0 (1.8) 70.0	6.6 (1.6) 79.2	5.7 (1.8) 86.7	.7 (.1) 32.4	12.0 (2.0) 100.0
Moss	36.1 (3.6) 90.2	40.4 (5.6) 86.3	34.1 (6.0) 91.7	27.6 (7.8) 79.2	36.3 (2.9) 100.0	10.4 (2.1) 82.4	60.0 (10.1) 100.0
<i>Coptis trifolia</i>	3.3 (1.0) 76.2	3.6 (1.1) 71.6	3.6 (.8) 80.0	1.7 (.7) 58.3	.5 (.1) 46.7	2.0 (.8) 79.4	6.0 (1.4) 90.0
<i>Epilobium sp.</i>	.5 (.1) 20.3	1.2 (.4) 53.7		3.1 (1.1) 62.5			.6 (.7) 20.0
<i>Ranunculus spp.</i>	.2 (.1) 18.2	.3 (.1) 18.9	.6 (.1) 21.7				.9 (.7) 50.0
<i>Stellaria spp.</i>	.9 (.1) 24.5	1.0 (.3) 28.4	.3 (.1) 15.0				
Liverwort	1.9 (.3) 19.6	1.6 (.5) 22.1			3.7 (2.3) 26.7		
<i>Saxifraga bracteata</i>	2.6 (.6) 22.4						
<i>Achillea borealis</i>				.7 (.5) 20.8			
<i>Galium trifidum</i>				2.8 (1.1) 54.2			
<i>Ranunculus eschscheltzii</i>							.2 (.1) 20.0
Sample Size =	143	95	60	24	15	34	10

¹Mean percent cover value.

²Standard deviation in parentheses.

³Frequency of occurrence expressed in percent.

⁴Mostly *Athyrium*, but some *Dryopteris* and *Polystrichum*.

TABLE 3. Composition of Upland Short-plant communities at Buldir Island, Alaska

Species	Moss-willow	Fell-field	Moss-willow <i>Empetrum</i>	Talus
MIDDLE STORY¹				
<i>Salix</i> spp.	15.6 ² (2.2) ² 86.8 ⁴	6.2 (1.7) 76.5	8.1 (2.3) 72.2	
<i>Carex</i> spp.	4.4 (.7) 72.4	2.3 (.8) 64.7	2.8 (.6) 75.0	
<i>Polygonum viviparum</i>	3.4 (.4) 68.4	.9 (.1) 64.7	1.1 (.5) 55.6	
<i>Veronica</i> spp.	3.3 (.5) 61.8			
<i>Festuca rubra</i>	5.0 (1.0) 60.5		.6 (.4) 30.6	58.3 (9.1) 100.0
<i>Geum</i> spp.	5.0 (1.0) 56.6	2.1 (.9) 41.2		
<i>Arnica unalaskensis</i>	4.1 (1.0) 53.9	.2 (.1) 17.6	1.2 (.6) 58.3	
<i>Sibbaldia procumbens</i>	3.6 (.8) 50.0	.8 (.5) 35.3	1.0 (.4) 58.3	
<i>Viola langsdorffi</i>	2.4 (.5) 46.1		.7 (.4) 33.3	
<i>Achillea borealis</i>	3.8 (1.1) 46.1			2.5 (1.4) 27.8
<i>Primula cuneifolia</i>	3.0 (.9) 44.7	.8 (.3) 52.9	1.1 (.4) 75.0	
<i>Chrysanthemum arcticum</i>	1.7 (.5) 32.9			
<i>Trientalis europaea</i>	1.6 (.4) 31.6			
<i>Cornus suecica</i>	1.6 (.6) 18.4			
<i>Epilobium</i> spp.	1.3 (.5) 18.4			.2 (.1) 16.7
<i>Carex circinnata</i>	1.2 (.7) 15.8		5.3 (.7) 97.2	1.5 (1.0) 52.9
<i>Deschampsia beringensis</i>		.5 (.1) 47.1	.6 (.4) 22.2	
<i>Luzula tundricola</i>		.6 (.5) 35.3		
<i>Geum calthifolium</i>		.2 (.1) 23.5	7.4 (2.6) 83.3	

TABLE 3. (Continued)

Species	Moss-willow	Fell-field	Moss-willow <i>Empetrum</i>	Talus
<i>Veronica grandiflora</i>		.2 (.1) 17.6	1.3 (.5) 72.2	
<i>Salix arctica</i>			5.0 (2.6) 27.8	
<i>Dryopteris dilatata</i>				1.5 (.7) 61.1
<i>Angelica lucida</i>				6.2 (3.5) 44.4
<i>Epilobium behringianum</i>				.3 (.1) 27.8
GROUND STORY				
Moss	42.4 (4.6) 98.7	7.9 (2.0) 94.1	20.8 (3.7) 100.0	29.2 (7.0) 88.9
Lichen	9.8 (1.3) 80.3	4.4 (1.4) 100.0	5.0 (1.3) 80.6	3.3 (1.9) 27.8
<i>Cassiope lycopodioides</i>	5.2 (1.7) 55.3	2.8 (1.0) 64.7	11.2 (2.2) 77.9	
<i>Empetrum nigrum</i>	4.1 (1.4) 27.6		28.3 (4.0) 91.7	
<i>Hippuris montana</i>	4.4 (1.5) 25.0			
<i>Lycopodium clavatum</i>	1.6 (.9) 19.7			
<i>Selaginella selaginoides</i>	2.3 (.9) 18.4			
Fungi			1.8 (.5) 80.6	
<i>Cladonia</i> sp.			3.5 (1.3) 61.1	
<i>Achillea borealis</i>			.5 (.4) 19.4	
<i>Lycopodium alpinum</i>			1.4 (1.2) 16.7	
<i>Stellaria</i> spp.				6.6 (2.1) 88.9
<i>Cardamine umbellata</i>				9.7 (2.3) 83.3
Liverwort				6.7 (2.9) 55.6

TABLE 3. (Continued)

Species	Moss-willow	Fell-field	Moss-willow <i>Empetrum</i>	Talus
<i>Saxifraga bracteata</i>				8.7 (4.5) 50.0
<i>Coptis trifolium</i>				.2 (.1) 22.2
Sample Size =	76	17	36	18

¹No overstory in the Upland Short-plant community.

²Mean percent cover value.

³Standard deviation in parentheses.

⁴Frequency of occurrence expressed in percent.

foxes, Buldir has a diverse seabird population of over one million birds (G.V. Byrd, 1978, unpub. rep. in files of U.S. Fish and Wildlife Service, Adak, Alaska), which may have a fertilizing effect on the vegetation.

Human occupation of Buldir has been relatively sparse: one Aleut hunting camp (McCartney, 1977) and a small weather detachment of approximately 12 men during WWII (U.S. Department of Defense records, Washington, D.C.). As a result, Buldir has escaped the major disturbance seen on Amchitka and many other islands.

METHODS

Dominant plants below 300 m elevation were generally tall, whereas upland plants were short; therefore, two vegetation complexes were defined: the Lowland Tall-plant and the Upland Short-plant. Each complex was subjectively subdivided into communities recognizable by major differences in species composition. Community boundaries were located visually and drawn on 1:25 000-scale maps. The percent cover of each species in various communities was estimated by a two-stage, systematic sampling technique with replications. A random number table was used to select 1-m-wide strips in each delimited plant community, and the relative coverage of each species was visually estimated in five randomly-selected 1-m² plots in each 50-m length of transect. The random numbers selected were used for replication in every 50-m segment of a transect until a community boundary was reached. Within each plot the percent cover values of each species were recorded for each of three vertical height categories (i.e. stories): overstory, the tallest plant level; middle story, generally 10-25 cm tall; and ground story, plants < 10 cm tall. Cover values were arrived at by estimating percentages of a plot that were actually occupied by a plant species, and the combined values of a story seldom totalled 100% (e.g. a middle story was frequently composed of up to 20% stems of overstory plants or, in other cases, open space). Plots were sampled from mid-July to early September, during or just after the main flowering period. Every species of vascular plant found at Buldir was collected and determined, and voucher specimens were deposited in the herbarium at the University of Alaska (ALA).

RESULTS

Of the 119 species of vascular plants in 36 families identified at Buldir (Table 1), only about 30 are common enough to account for at least 5% of the cover in any of the plant communities (Tables 2 and 3). Approximately 55 taxa occur in at least 15% of the plots. The Lowland Tall-plant complex occurs generally below 300 m elevation and includes eight communities, seven of which are quantitatively described (Table 2). The Upland Short-plant complex occurs generally above 300 m elevation and includes four communities which are quantitatively described (Table 3). The distribution of communities is illustrated (Fig. 2).

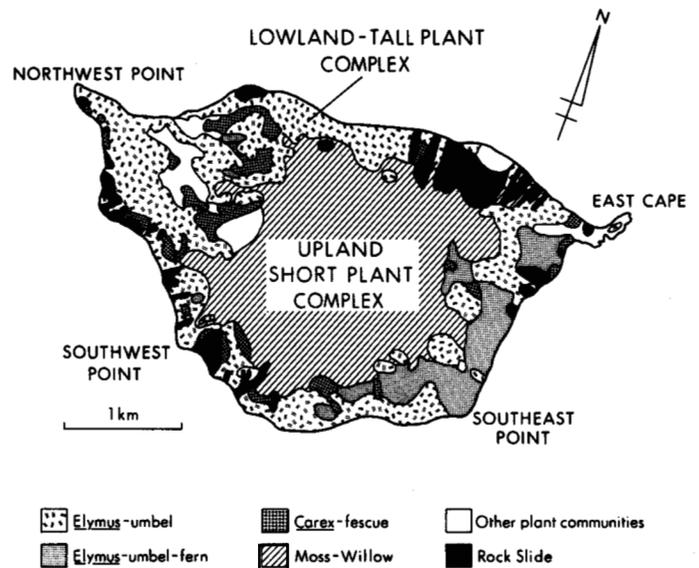


FIG. 2. Map showing the distribution of plant communities at Buldir Island, Alaska. As indicated, the white areas represent all the minor communities (e.g. mostly *Calamagrostis*, but also the *Carex lyngbyae* marshes and umbel-fern community at the base of Northwest Point, *Elymus-umbel-Artemisia* near East Cape, *Cochlearia-Achillea* near base of north arrow, and moss-willow-*Empetrum* at northwestern edge of the moss-willow-tundra community). The primary fell-field areas are under the words, "Upland Tall-plant Complex".

Lowland Tall-plant Complex

Elymus-umbel community

This is the most extensive lowland community (Table 4, Fig. 3), occurring on all aspects and reaching from just above



FIG. 3. *Elymus-umbel* plant community at Buldir Island.

sea level to the upper reaches of the lowland complex. The overstory averages nearly 60 cm tall, but it frequently exceeds 1 m. *Elymus arenarius*, *Heracleum lanatum*, and *Angelica lucida* are the most important overstory species. In the middle story *Claytonia sibirica* and *Festuca rubra* are dominant. No other species has high cover values, but this diverse story contains 45 species. Unidentified mosses cover over 35% of the ground story (Table 2) where *Cardamine umbellata* and *Coptis trifolia* are ubiquitous but have low cover values. Seventeen other species occur in the ground story.

Elymus-umbel-fern community

This community is situated mostly on southern, southeastern, and eastern sea-facing slopes (Fig. 4). It has one of the tallest overstories (Table 4), and it was subjectively determined to have a relatively high stem density. The overstory includes the three dominant species in the *Elymus-umbel* community. Nevertheless, *Elymus arenarius* is less important, although it is found in over 70% of the plots. Instead, *Athyrium felix-femina* is much more important. *Heracleum lanatum* and *Angelica lucida* have similar cover values and frequencies of occurrence in the two communities. The cover value estimated for *Athyrium* (Table 2) is probably too low since a significant portion of the value for unidentified fern could probably be referred to *Athyrium felix-femina*.

The *Elymus-umbel-fern* community has an overstory diversity similar to the *Elymus-umbel* community, approximately 21 species. *Claytonia sibirica* is the most common plant in the middle story, but 34 other species are found. Mosses cover about 40% of the ground, and 17 other species occur.

Carex-fescue meadow community

This community is most frequently found at the upper edge of the lowland complex. The key overstory species are *Carex macrochaeta* and *Angelica lucida*. The middle story is one of the most diverse, containing 51 species. *Festuca rubra* is the primary species; but *Angelica lucida*, *Achilla borealis*, *Carex*

TABLE 4. Surface areas and average overstory height of plant communities at Buldir Island, Alaska

Community	Area covered		Canopy Height (cm)		Sample size
	Ha	(%)	Mean	S.D.	
Lowland Tall-plant					
<i>Elymus-umbel</i>	287.9	(14.3)	58.9	3.8	75
<i>Elymus-umbel-fern</i>	203.3	(10.1)	72.1	2.8	70
<i>Carex-fescue</i> meadow	175.3	(8.7)	37.6	4.1	60
<i>Cochlearia-Achillea</i>	14.6	(0.7)	—	—	—
<i>Carex lyngbyaei</i> marsh	14.1	(0.7)	52.6	3.9	24
<i>Artemisia-umbel-Elymus</i>	11.2	(0.6)	41.5	1.8	15
<i>Calamagrostis</i>	7.4	(0.4)	52.2	2.0	36
Umbel-fern	7.3	(0.4)	79.4	4.9	10
Upland Short-plant					
Moss-willow tundra	869.9	(43.4)	22.4 ¹	—	—
Fell-field	130.7	(6.5)	5.0 ²	—	—
Moss-willow- <i>Empetrum</i>	49.2	(2.5)	—	—	—
Talus	8.5	(0.4)	16.7 ³	2.2	18
Other					
Recent slides	212.6	(10.5)	—	—	—
Lakes and ponds	13.2	(0.7)	—	—	—
TOTAL	2005.2				

¹Maximum height of scattered tall plants; usually no overstory.

²Tallest plant recorded; most were shorter.

³Refers to middle story; no overstory.

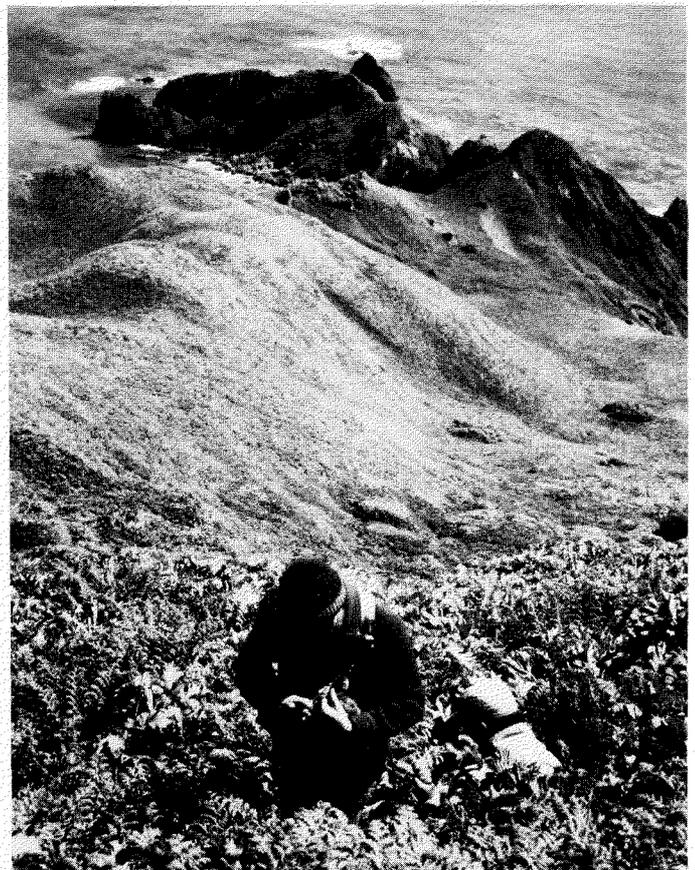


FIG. 4. *Elymus-umbel-fern* community at Buldir Island. Note height of overstory.

macrochaeta, and *Geranium erianthum* are also common. The ground story is diverse, containing 19 species. Mosses are most common, and *Coptis trifolia* and *Cardamine umbellata* are frequently found.

Carex lyngbyaei marsh community

The only two *Carex* marshes at Buldir occur along the westernmost stream in the alluvial valley. *Carex lyngbyaei* forms dense stands averaging over 50 cm tall in standing or slowly moving water. *Luzula parviflora* and *Arctophila fulva* are the only other common overstory plants, although 15 other species are recorded. Common middle story plants are *Festuca rubra* and *Epilobium behringianum*, and 28 other species occur in this layer. Mosses are the most common ground story plants.

Artemisia-umbel-Elymus community

This restricted community occurs in isolated patches on northeast and southeast slopes in draws or creek drainages. *Artemisia unalaskensis* and *Heraclium lanatum* are the major overstory species. *Elymus arenarius* occurs in over 50% of the plots, but it has a low cover value. Only four other overstory species are found. *Claytonia sibirica* is even more common in this community than in the *Elymus-umbel* and *Elymus-umbel-fern* communities. It nearly excludes other plants, covering nearly 75% of the story. Mosses dominate the understory. *Cardamine umbellata* and *Coptis trifolia* are frequently recorded, but they have low cover values.

Calamagrostis community

Most of the relatively flat alluvial valley is covered by this community, and patches are also found on the lower adjacent slopes. This community has a very high stem density. *Calamagrostis nutkatensis* dominates the overstory, but *Carex macrochaeta* and *Angelica lucida* are also important. The middle story has *Festuca rubra*, *Carex macrochaeta*, and 18 other species. Dead plants, representing undecayed production from previous years, cover over 80% of the ground story.

Umbel-fern community

This tall community is found primarily near the base of Northwest Point in relatively deep soil, riddled with nesting burrows of Storm Petrels, *Oceanodroma* spp. *Elymus arenarius* is practically absent whereas *Heraclium lanatum*, *Athyrium felix-femina*, and *Angelica lucida* dominate the overstory. *Claytonia sibirica* is the most common species in the middle story. *Ranunculus occidentalis* is also frequently found, and eight other species are present. Mosses blanket approximately 60% of the ground story, where *Cardamine umbellata* and *Coptis trifolia* are also important.

Cochlearia-Achillea community

No quantitative description was made for this community which occurs in scattered locations along the few sandy shorelines just above high-tide line. The most common species are *Cochlearia officinalis*, *Achillea borealis*, *Draba hyperborea*, *Senecio pseudo-arnica*, and *Honckenya peploides*.

Upland Short-plant Complex

Moss-willow tundra community

This community is the most extensive on Buldir (Table 4, Fig. 5) covering over 80% of the upland complex. The community has scattered tall plants, but only the middle and ground stories are well developed. Areas of solifluction give parts of this community a stair-step appearance, caused by alternating strips of vegetation and bare soil, .3 to 1 m wide. Several species of willow (including *S. arctica*) are dominant. *Carex* spp., *Polygonum viviparum*, *Veronica* spp., and *Festuca rubra* are also found frequently, but all have cover values of less than 5%. The middle story has at least 38 different species.

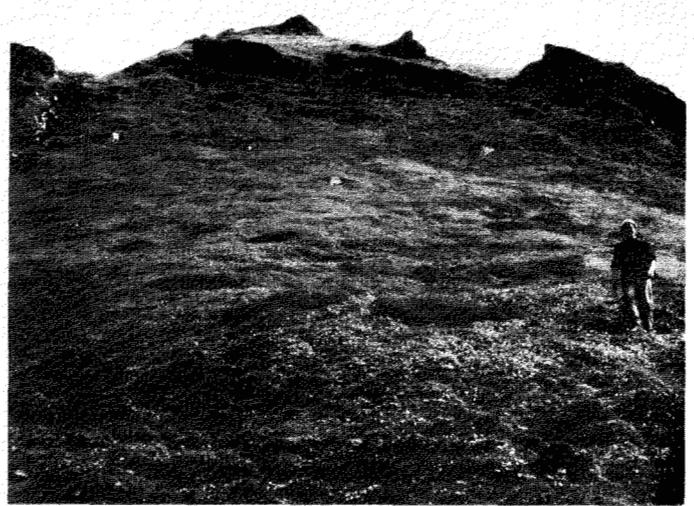


FIG. 5. The moss-willow tundra community at Buldir Island.

Mosses cover over 40% of the ground in this community. Various unidentified lichens, *Cassiope lycopodioides*, and *Empetrum nigrum* are also frequently found. The moss-willow tundra has one of the most diverse ground stories, 30 species.

Fell-field community

This community occurs on windswept ridges and plateaus at high elevations (Fig. 6). To be classified as fell-field an area must have less than 20% plant cover. The tallest plant found in this community is 5 cm tall, so no overstory is identified. *Salix* spp. is the only taxon in the middle story with a cover value greater than 5%, though 14 other species are recorded. Like the middle story, the ground story is mostly bare or covered by gravel. Mosses are the dominant species, and lichens occur in every plot.

Moss-willow-*Empetrum* community

Scattered patches occur at lower edges of the upland overlooking the alluvial valley. There is no overstory. A thinly vegetated middle story contains *Salix* spp., *Geum calthifolium*, and *Carex circinnata*. A thick mat of *Empetrum nigrum*, mosses, *Cassiope lycopodioides*, and 10 other species of dwarf plants, interspersed with bare areas, form the ground story.



FIG. 6. The fell-field community at Buldir Island. Note the lush lowland association far below.

Talus community

Vegetated boulder slides occur locally from sea level to over 500 m elevation. Although the community spans both the lowland and upland complexes, it is placed in the upland because it most resembles communities in that complex. As in other upland communities, no overstory occurs. *Festuca rubra* covers over 50% of the middle story. *Dryopteris dilatata*, *Angelica lucida*, *Achillea borealis*, and *Epilobium behringianum* are found frequently, but only *Angelica* has a cover value of over 5%. The ground story includes 14 taxa. Mosses, *Stellaria* spp., *Cardamine umbellata*, liverworts, and *Saxifraga bracteata* are all important.

DISCUSSION

Buldir's vascular flora is less diverse than that of Amchitka: 119 species in 36 families compared to 206 species in 46 families (Amchitka totals from Amundsen, 1977). A comparison of the vegetation on the two islands is interesting because they approximate the extremes of the range of habitat diversities found in the Aleutians. Many of the larger islands (e.g. Amlia, Atka, Adak, Kanaga, Tanaga) are similar floristically to Amchitka, whereas some of the smaller volcanic islands (e.g. Chagulak, Kasatochi, Gareloi, Segula) may be similar to Buldir.

It is not surprising that four of the eleven plant families and numerous species found on Amchitka but not on Buldir were associated with freshwater ponds. Amchitka has over 2000 ponds (J.A. McCann, 1963, unpub. rep. in files of U.S. Fish and Wildlife Service, Anchorage, Alaska) compared to only two small potholes and Kittiwake Pond on Buldir. Three additional families and several species unique to Amchitka have disjunct distributions and probably were introduced by humans. These introductions are understandable since thousands of military personnel and tons of equipment were moved to the island during WWII. More recent activities associated with nuclear testing also provided opportunities for

introductions. In contrast, Buldir has had very little human activity.

Two families found on Amchitka but not on Buldir include species that grow on sandy beaches, which are fairly widespread at Amchitka but very restricted at Buldir. The other two families found on Amchitka but not on Buldir, Iridaceae and Papaveraceae, include a single species each.

The most striking difference between the floras of Amchitka and Buldir is the relative extent of *Empetrum*-dominated communities on Amchitka and *Elymus*-dominated communities on Buldir. *Empetrum nigrum* is the most important plant in two communities that together cover approximately 55% of Amchitka (Amundsen, 1977). Mixed with *Empetrum* in these communities are numerous species of the grass, sedge, and rush families. These families include 55 species at Amchitka but only 21 at Buldir, where the only community dominated by *Empetrum* covers less than 3% of the island. The genera *Poa* and *Carex* and the species *Calamagrostis nutkatensis* are better represented and more widespread at Amchitka. The *Empetrum*-grass-sedge communities occur at Amchitka from a few feet above sea level to above 250 m elevation, on nearly flat to moderate slopes (Amundsen, 1977). These rolling plateaus at low elevations are widespread on Amchitka but nearly absent on Buldir, where steep slopes rise quickly to high windswept plateaus and peaks. The steep slopes below approximately 300 m on Buldir are primarily covered by two communities dominated by *Elymus arenarius*. The community dominated by this species on Amchitka, and on many other Aleutian Islands (V. Byrd, pers. obs.), is restricted to a narrow fringe along the coastline and covers only 2% of Amchitka.

Amundsen (1977) is one of several authors who have noticed the particularly lush vegetation, frequently *Elymus*, and several umbellifers, associated with remains of old native villages. The lushness is attributed to fertilization from decayed faunal remains. The feces from over one million seabirds on Buldir must provide fertilization and may at least partially account for the extent of this normally restricted community. Another factor probably involved is drainage. *Elymus* communities elsewhere are normally found on fairly sandy, well-drained sites. The steep hillsides on Buldir have loamy soils, and drainage is good.

Buldir has 13 species of plants not found at Amchitka. Six of these are primarily Asiatic or western Aleutian in origin, and apparently Buldir is at, or near, the eastern edge of their ranges. Four of the remaining species are found at elevations on Buldir which exceed the highest occurring at Amchitka.

Coats (1953) pointed out that the relatively restricted flora of Buldir might be attributed to its isolation and small land area, which reduce the chances of dispersing seeds landing on suitable sites for establishment. He also suggested that restricted flora might indicate that Buldir is geologically younger than islands to the east and west.

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REFERENCES

- AMUNDSEN, C.C. 1977. Terrestrial plant ecology. In: Merritt, M.L. and Fuller, R.G. (eds.). The Environment of Amchitka Island, Alaska. Technical Information Center, Energy Research and Development Administration, Springfield, VA.
- COATS, R.R. 1953. Geology of Buldir Island, Aleutian Islands, Alaska. U.S. Geological Survey Bulletin 989A. 26 p.
- HULTÉN, E. 1960. Flora of the Aleutian Islands. 2nd edition. Weinheim: J. Cramer; Hertfordshire, England: Wheldon and Wesley Ltd. 376 p.
- _____. 1968. Flora of Alaska and Neighboring Territories. Stanford: Stanford University Press. 1008 p.
- JONES, R.D. 1963. Buldir Island, site of a remnant breeding population of Aleutian Canada Geese. Annual Report of the Wildfowl Trust 14:80-84.
- MCCARTNEY, A.P. 1977. Prehistoric human occupation of the Rat Islands. In: Merritt, M.L. and Fuller, R.G. (eds.). The Environment of Amchitka Island, Alaska. Technical Information Center, Energy Research and Development Administration, Springfield, VA. 59-113.
- SHACKLETTE, H.T. *et al.* [8 additional authors]. 1969. Vegetation of Amchitka Island, Alaska. U.S. Geological Survey Professional Paper 648. 66 p.