PLANT COMMUNITIES AND THEIR STANDING CROPS ON ESTUARIES OF THE EAST COAST OF VANCOUVER ISLAND

by

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Abstract

The emergent plant communities on eighteen estuaries on the east coast of Vancouver Island and one estuary on the mainland coast of British Columbia are described and their distribution mapped (scale 1 cm = 48 m, 1 cm = 158 m, 1 cm = 32 m). There are eleven types of estuaries. Monthly measurements of nitrogen (N) and standing crop by living, dead, senescent and duff portions were made on eleven communities in five estuaries; 1. Cowichan *Carex lyngbyei* and *Juncus balticus*; 2. Chemainus *Salicornia virginica* and *Distichlis spicata* - *Grindelia integrifolia*; 3. Little Qualicum *Carex lyngbyei* and *Potentilla pacifica* - *Carex lyngbyei*; 4. Campbell *Carex lyngbyei* and *Potentilla pacifica* - *Eleocharis palustris*; and; 5. Salmon *Carex lyngbyei*, *Deschampsia cespitosa* - *Carex lyngbyei* and *Poa pratensis* - *Agrostis alba* var. *stolonifera* - *Potentilla pacifica*. Root cores collected monthly from five plots in each community were grown in the dark at 20°C to measure root reserves. Kjeldahl nitrogen (N) was determined for representative samples as a rough measure of the quantity of protoplasmic constituents as opposed to structural components. The highest N values occurred in the living portions with the highest, 2.43%, occurring in April in the Cowichan *Carex lyngbyei* community. The standing crops (gm m^{-2}) are

Cowichan	*Carex lyngbyei*	588
Cowichan	*Juncus balticus*	754
Chemainus	*Salicornia virginica*	966

Chemainus	Distichlis spicata - Grindelia integrifolia	1437
Little Qualicum	Carex lyngbyei	1504
Little Qualicum	Potentilla pacifica - Carex lyngbyei	770
Campbell	Carex lyngbyei	487
Campbell	Potentilla pacifica - Eleocharis palustris	392
Salmon	Carex lyngbyei	773
Salmon	Deschampsia cespitosa - Carex lyngbyei	1092
Salmon	Poa pratensis - Agrostis alba var. stolonifera - Potentilla pacifica	772

The largest standing crops occur in the Carex lyngbyei, and Chemainus Salicornia virginica and Distichlis spicata - Grindelia integrifolia communities. While dry matter in the Carex lyngbyei communities disappeared between the growing seasons it accumulated in the Salicornia virginica and Distichlis spicata - Grindelia integrifolia communities. Dry matter accumulated to a lesser extent in the higher elevation communities. Etiolated shoots from root cores grew in the dark from 0 to a maximum of 573 days for the Little Qualicum Potentilla pacifica - Carex lyngbyei community. Root reserves are periodic with the decreasing trend in April and May coinciding with the initiation and rapid growth of the canopy. The peak in standing crop is followed by a peak in root reserves within one month. It is proposed that some carbohydrates and mineral elements are translocated, and reallocated between the below and above ground structures.

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1. INTRODUCTION

The impact of man's activities on estuarine ecosystems has become a major concern (Sorenson, 1973) in British Columbia.

The ecological values of the tidal marshes are widely recognized (Odum, 1961) and have long been noted as valuable habitat for shorebirds, ducks and geese (Burgess, 1970, Chattin, 1970, Burton, 1977). Recently it has become evident that juvenile salmon, notably chum and chinook, are feeding in sloughs and channels associated with tidal marshes (Dunford, 1975, Reimers 1973) (Fig. 1.) Fisheries biologists believe the use of estuarine marshes by juvenile salmon is an important aspect of their life history. The estuaries on the east coast of Vancouver Island are particularly noteworthy for they are part of a large coastal shelf extending south from Campbell River to Victoria. This shelf is rich in biota, eg. oysters, clams, crabs and algae as well as fish and birds. The abundance and diversity of flora and fauna is striking when compared to the lower diversity and productivity of British Columbia's numerous fiord systems (Ellis, pers. comm.). The coastal shelf and associated lowlands provide man with level building sites and it is here log storage and handling, coal mining, tourism, urban development, ports and transportation routes are concentrated. The impact of human activity on the natural systems is destructive and escalating. By the year 1996 the population of major urban centres, located on or adjacent to river deltas, is extrapolated to be double that given in the 1976 census (Table 1, Fig. 2). Associated development pressures

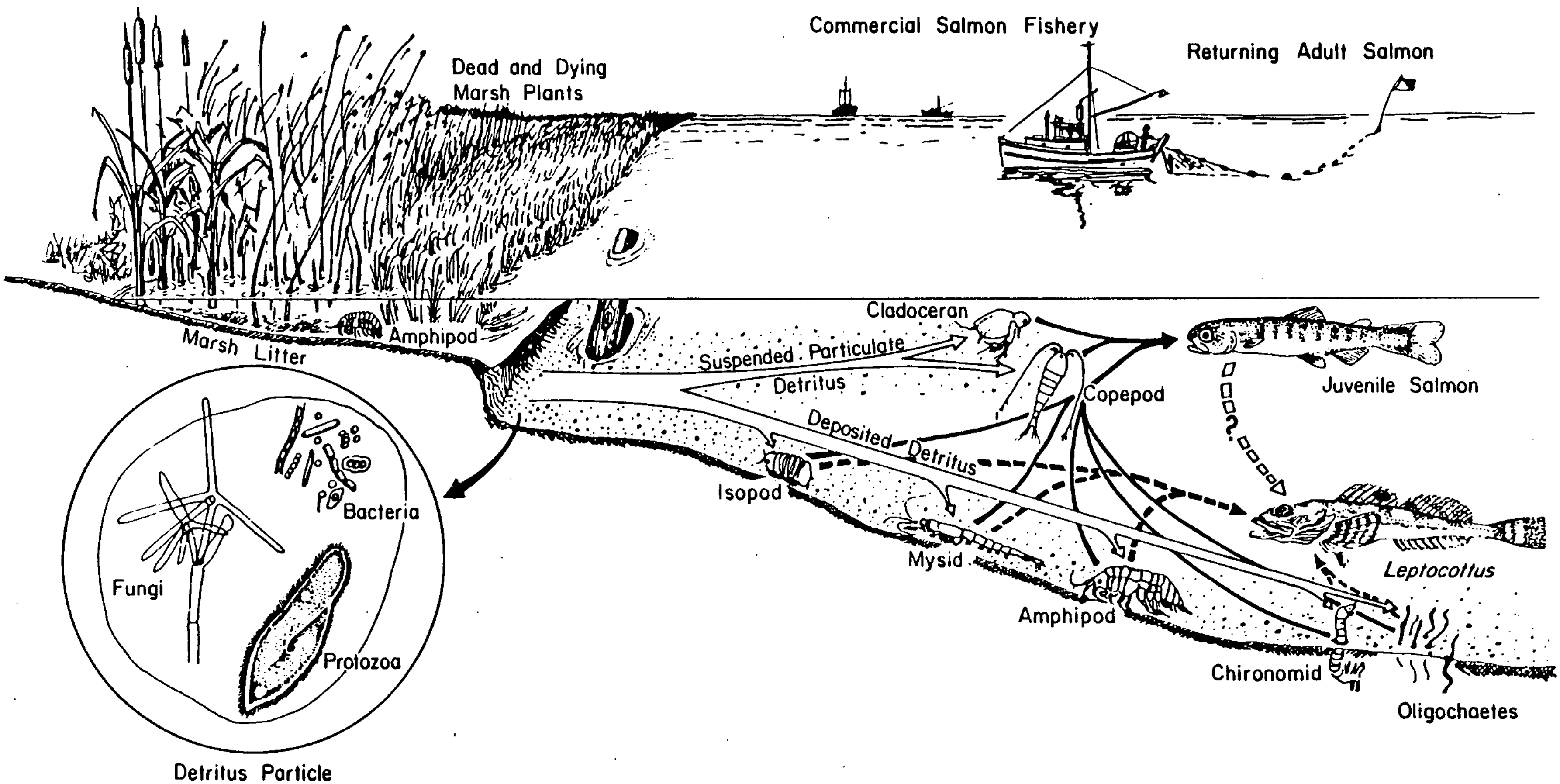

Figure 1. Diagram of the detritus food web typical of a slough/channel tidal marsh habitat in the Fraser River estuary (Kistritz, 1978).

Table 1. Populations and population projections for regional districts and their major urban centers, 1974 - 1996

Population centres by Regional District	Population [1] 1971	Population [1] 1976	Centre population [3] as a percent of regional district pop. 1971	Centre population [3] as a percent of regional district pop. 1976	Population [4] 1996
I Comox-Strathcona R.D.	47345	55761			99646
1. Campbell River, DM[2]	10000	11787	21	21	20926
2. Comox, T-V	4055	5226	9	9	8968
3. Courtenay, C	7187	7566	15	14	13950
4. Sayward, VL	465	380	1	.7	698
II Cowichan R.D.	38988	45138			67277
1. Duncan, C	4388	3960	11	9	6055
III Mount Waddington R.D.	10408	12306			18462
1. Port Hardy, DM	1777	3579	17	29	5354
IV Nanaimo R.D.	48006	60768			86426
1. Nanaimo, C	34029	39655	71	65	56177
2. Parksville, VL	2171	3158	5	5	4321
3. Qualicum Beach, VL	1245	1707	3	3	2593

1 British Columbia Research Management Services Division, 1974 and Census of Canada, 1976.

2 DM - district municipality
T-V - town
C - city
VL - village

3 Percentages calculated to nearest unit from population figures.

4 Population calculated using 1996 population projections and percentages.

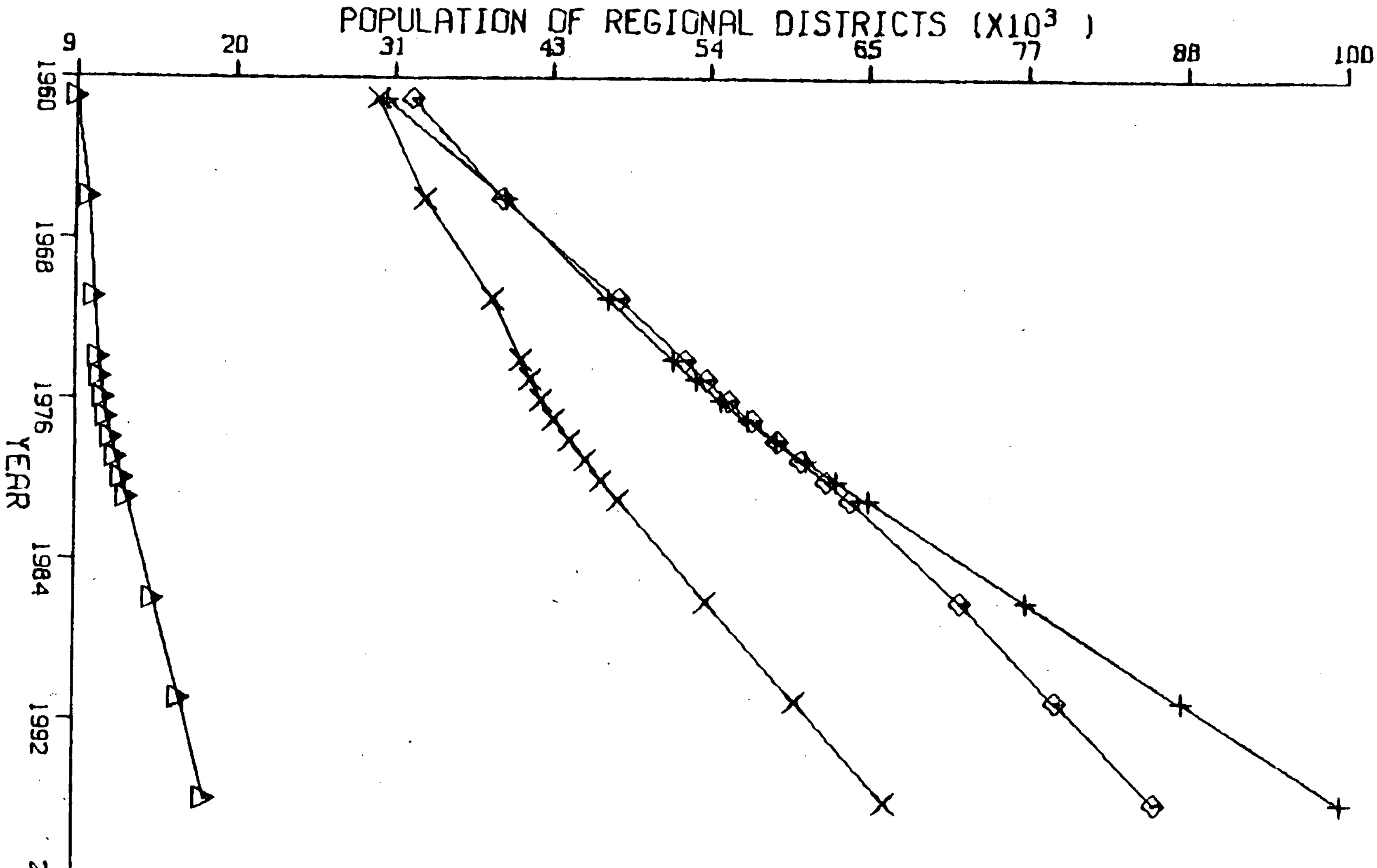

Figure 2: Populations and population projections for the Comox-Strathcona (+), Nanaimo (◇), Cowichan Valley (X) and Mount Waddington (△) Regional Districts, 1974-1996 (from B.C. Research Management Services Division, 1974).

on the estuarine systems will increase dramatically. The need for information to enable those responsible to better manage estuarine ecosystems is great now. The objectives of this study were set to provide an information base and identify areas requiring further study. More specifically they were to:

1. determine and describe the emergent plant communities in major estuaries on the east coast of Vancouver Island as they presently exist.
2. attempt to indicate the principal physical factors influencing plant species distribution.
3. estimate standing crop, determine its seasonal variations and quality.
4. delineate root reserve patterns in the estuarine communities.

1.1 Background

Eighteen estuaries in this study were selected from the east coast of Vancouver Island; a nineteenth estuary was selected from the mainland fiord system for comparative purposes. There were three criteria guiding the choice of estuaries. The first criterion was to obtain a representative group from the many estuaries, large and small, along the shelf; the second, to obtain a range of biophysical factors among the estuarine ecosystems; and third, to include estuaries under pressure for development. Appendix 1 and Figure 3 give the locations of the study areas. The nineteen estuaries, by name are the Goldstream, Cowichan, Chemainus, Nanaimo, Nonoose-

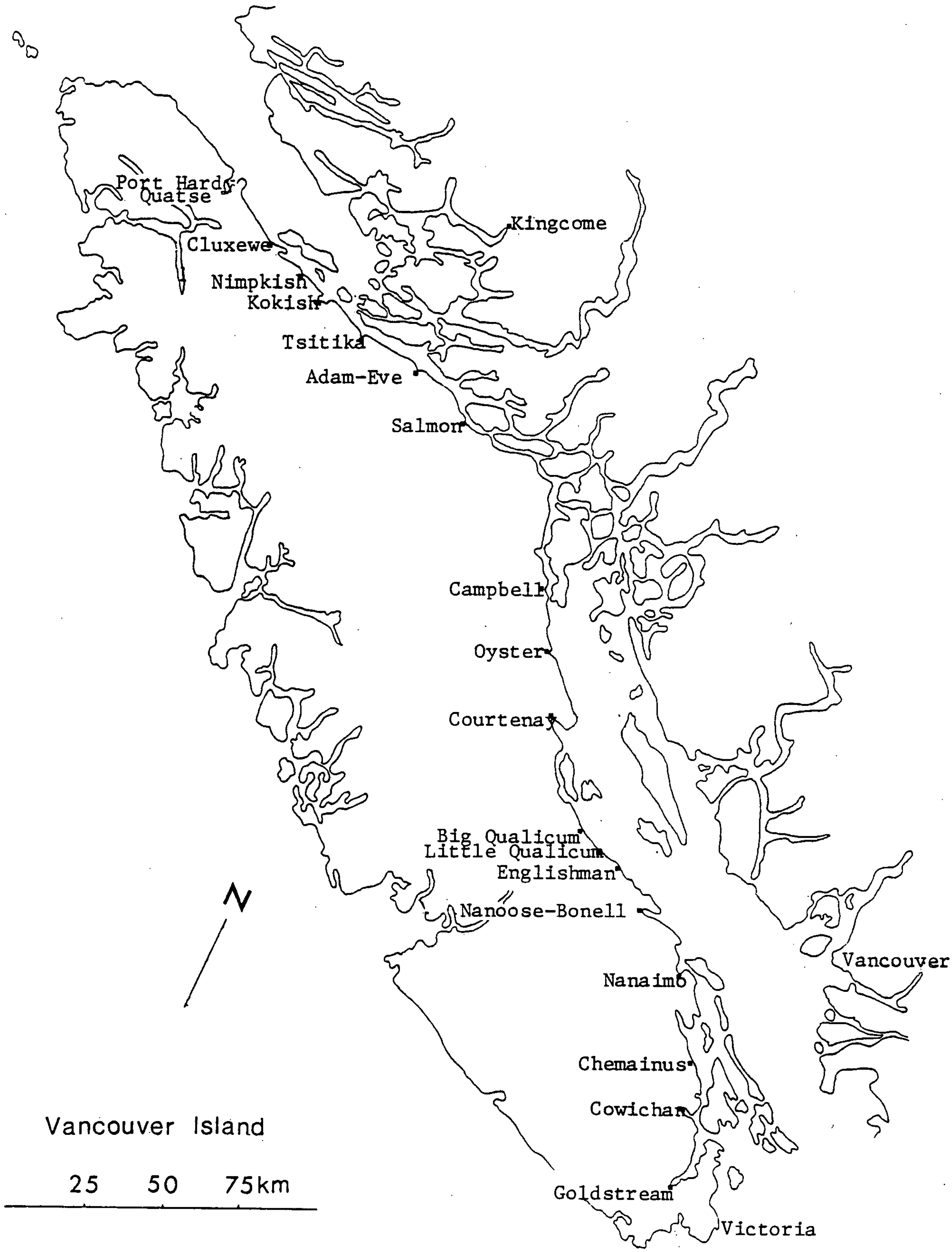

Figure 3. Map of Vancouver Island and adjacent mainland coast showing the general locations of the study areas.

Bonell, Englishman, Little Qualicum, Big Qualicum, Courtenay, Oyster, Campbell, Salmon, Adam-Eve, Tsitika, Kokish, Nimpkish, Cluxewe, Quatse and Kingcome River's estuaries. Each estuary is named after the principal river(s) in the delta. For the sake of brevity, estuaries are often referred to by the river's name only (i.e. Cowichan, instead of Cowichan River estuary), particularly when discussing plant communities. They are dealt with in the text in order from south to north. Terms are defined in the glossary in Appendix 2.

1.2 Physiography of the east coast of Vancouver Island

Estuaries on the east coast of Vancouver Island occur in either the Vancouver Island Ranges or the Nanaimo Lowlands. The Vancouver Island Ranges extend to the coast northwest of Kelsey Bay and there tidal marshes are limited to the sheltered mouths of glaciated and generally U-shaped valleys. The coastline rises abruptly from the sea to the mountains except in the Suquash Basin and Nahwitti Lowlands. These two physiographic units have a generally low relief with flats and rolling hills; the elevation in the Suquash Basin seldom exceeds 150 meters while the elevation in the Nahwitti Lowlands is generally below 610 meters. The Kokish, Nimpkish and Cluxewe Rivers' estuaries occur in the Suquash Basin and the Quatse occurs in the Nahwitti Lowlands. Estuaries south of Kelsey Bay lie within the Nanaimo Lowland described by Holland (1964) as "a strip of low lying country, below 2000 feet (610 meters) elevation, which extends southeastward for 175 miles (282 kilometers) along the east coast of Vancouver Island from Sayward on Johnstone Strait to Jordan River west of Victoria...largely underlain by sedimentary rocks of the Nanaimo Group of Upper Cretaceous age. It is flanked on its western side above the 2000 foot (610 meter) contour line by the Vancouver Island Ranges... The lowland consists of many low, wooded cuesta-like ridges separated by narrow valleys. The northwesterly elongation of the ridges of the Gulf Islands is the result of differential erosion of the Upper Cretaceous sedimentary rocks. The ridges are underlain by hard sandstone and conglomerate beds, and the valleys are eroded in shales and softer rocks or along fault zones." A more recent treatment of the geology of the area is that of Muller (1971). Table 2 summarizes geological descriptions for the estuaries studied. Major faults occur in the geological formations in some of the study areas (e.g., Kokish and Nimpkish) and more than one bedrock unit is present. The Kingcome is at the mouth of a glaciated river valley in the granitic Pacific Coastal Mountain Range.

1.3 Climate of the study areas on the east coast of Vancouver Island

There are few climatological stations located in the estuaries studied and the weather records in Tables 3 and 4 are from the nearest stations. In general, the climate of the east coast of Vancouver Island becomes cooler and wetter from south to north. South of Campbell River the estuaries are in the rain shadow of the mountains of the Vancouver Island Ranges. The

Table 2. Geologic formations in the study areas[1]

Estuary	Rock Unit	Age	Description
Goldstream Cowichan Nanoose-Bonell	Sicker Group	Late Paleozoic	Volcanic tuff and breccia of intermediate composition with argillite and chart overlain by Buttle Lake limestone. The Sicker Group are metamorphosed and intensely deformed in some areas
Cowichan Chemainus Nanaimo Nanoose-Bonell Englishman Little Qualicum Big Qualicum Courtenay Oyster Cluxewe	Late Mesozoic Sediments	Late Jurassic to Cretaceous	Greywacke, sandstone, conglomerate and shale, carbonaceous shale and coal
Campbell Salmon Adam-Eve Tsitika Kokish Quatse	Karmutsen Formation	Triassic and older (?)	Slightly metamorphosed basaltic lavas consisting of massive and amygdaloidal flows, pillow lavas and associated breccia. Thin limestone members may occur near the top of the formation
Adam-Eve	Island Intrusions	Middle to Late Jurassic	Large batholiths of granodiorite to quartz diorite composition with local stocks of quartz monzonite and granite differentiates

Table 2. (cont'd) Geologic formations in the study areas[1]

Estuary	Rock Unit	Age	Description
Kokish	Bonanza Subgroup	Late Triassic to Early Jurassic	Upper divisions of commonly red colored rhyodacite lavas, tuffs, breccias and ignimbrites interbedded with basaltic andesite lavas, tuffs and breccias. Lower division of basaltic to andesite tuff, breccia and lava flows interbedded with Lower Jurassic greywacke and argillite
Kokish Nimpkish	Quatse Formation	Late Triassic	Massive gray to thin bedded black limestone, in places with an upper part of calcareous greywacke and limestone breccia
Kokish Nimpkish	Parson Bay Formation	Late Triassic	Thin bedded carbonaceous limestone and interbedded tuffs

[1]From Muller (1971), and Keser and St. Pierre (1973)

Table 3. Mean temperature norms for stations nearest the study areas (Atmospheric Environment, 1973)

		Temperature (°C)						
Estuary	Station	max. mean daily temp	min. mean daily temp	mean annual daily temp	mean daily max.	mean annual daily max.	mean daily min.	mean annual daily min.
Goldstream	Victoria Int. Airport	Jul 16.4	Jan 2.9	9.6	Jul 21.9	13.9	Jan -0.1	5.3
Cowichan	Cowichan Bay	Jul 17.3	Jan 2.2	9.6	Jul 22.2	13.3	Jan -0.1	5.8
Chemainus	Crofton	-	-	-	-	-	-	-
Nanaimo	Departure Bay	Jul 18.3	Jan 3.5	10.6	Jul 23.2	14.5	Jan 0.8	6.6
Englishman	Parksville	-	-	-	-	-	-	-
Courtenay	Comox Airport	Jul 17.3	Jan 2.1	9.3	Jul 22.8	13.4	Jan -0.8	5.2
Campbell	Campbell	Jul 17.4	Jan 1.3	8.9	Jul 23.5	13.2	Jan -1.3	4.7
Quatse	Port Hardy Airport	Aug 13.8	Jan 2.4	7.9	Aug 17.3	11.2	Jan 0.0	4.7

Table 4 Mean precipitation norms for stations nearest the study areas (Atmospheric Environment, 1973)

		Precipitation (mm)					
		mean annual rainfall	number of days with measurable rain	mean annual total precipitation	max mean monthly precipitation	min. mean monthly precipitation	April to Sept. mean rainfall
Goldstream	Victoria Int. Airport	811.0	147	856.5	Jan 146.3	Jul 18.5	183.9
Cowichan	Cowichan Bay	905.5	150	961.4	Dec 163.6	Jul 21.6	209.3
Chemainus	Crofton	963.4	157	1029.0	Jan 175.8	Jul 20.6	221.2
Nanaimo	Departure Bay	886.5	138	929.6	Dec 157.0	Jul 26.2	239.3
Englishman	Parksville	875.0	162	952.2	Dec 159.8	Jul 28.2	248.9
Courtenay	Courtenay	1387.1	154	1506.5	Dec 261.4	Jul 33.8	320.0
Campbell	Campbell	1435.9	128	1538.5	Dec 270.3	Jul 39.1	334.8
Quatse	Beaver Harbour	1595.1	208	1637.2	Dec 230.4	Jul 51.6	481.8
Kingcome	Roy - nearest coastal mainland station is southeast of Kingcome	2112.8	159	2205.2	Dec 329.2	Jul 74.4	635.3

Goldstream, Cowichan and Chemainus, to some extent, are also in the rain shadow of the Olympic Peninsular Mountains and are correspondingly drier. Summers are long, cool and generally dry, and winters are short, mild and wet. It is often referred to as "a cool-summer Mediterranean climate", based on the Koppen classification system (Ackerman, 1941). North of Courtenay the summers are long, cool and relatively wet, and the winters are short, wet and mild. November, December and January are the wettest months. The Koppen classification system refers to it as "a marine west coast climate". The Kingcome estuary, where the oceanic clouds strike the mountains and undergo adiabatic cooling is notably wetter and probably cooler than Vancouver Island estuaries. The mean annual daily temperature ranges from a high of 10.6 °C at Departure Bay to 7.9°C at Port Hardy airport; the maximum mean daily temperatures range from 18.3°C at Departure Bay (Nanaimo) to 13.8°C at Port Hardy airport (Quatse). The mean annual rainfall increases from 811.0 mm at Victoria International Airport to 1595.1 mm at Port Hardy airport. At Roy, the nearest station to the Kingcome, the mean annual rainfall is 2112.8 mm, substantially greater than that for the aforementioned stations on Vancouver Island. For all study areas, the month of maximum mean precipitation is either December or January and the minimum is July. The April to September (i.e. growing season) mean rainfall increases from 183.9 mm at Victoria International Airport to 481.8 mm at Port Hardy airport and 635.3 mm at Roy. On Vancouver Island, the number of frost-free growing days ranges from 322 at Cowichan Bay to 280 at Campbell.

1.4 Hydrology of the river systems in the study areas

Hydrological data (Table 5) for rivers and their estuaries are limited and variable. Many river systems are not monitored and those that are seldom have gauging stations in their estuaries to record tidal influences. Most of the stations have not been recording for the same length of time and often the records are intermittent or discontinued. For example, only estimated July values were available for the Cluxewe and Quatse Rivers. Though records possess shortcomings they provide trends. On the basis of watershed size (Table 5) the five largest river systems are the Nimpkish with a watershed of 1989 square kilometers followd by the Kingcome at 1456 sq. km, Campbell at 1432 sq. km, Salmon at 1380 sq. km and Cowichan at 834 sq. km. The four smallest are the Goldstream at 70 sq. km, Quatse at 52 sq. km, Bonell at 47 sq. km, and Nanoose at 28 sq. km. The remainder range from 769 sq. km for the Puntledge and Tsolum, tributaries of the Courtenay River, to 52 sq. km for the Quatse. The mainstem length, number of tributaries and mean annual discharge are generally directly related to watershed size. The length of the Salmon River mainstem is 82.1 kilometers followed by the Nanaimo at 80.5 km, Kigcome at 74.4 km, Chemainus at 64.4 km, Nimpkish at 62.4 km, and Adam-Eve at 59.9 km. The six rivers with shortest mainstem lengths are the Goldstream at 11.1 km, Quatse at 12.1 km, Bonell at 12.6 km, Nanoose at 14.3 km, Campbell at 9.7 km, and Courtenay at 2.4 km. The Chemainus has 62 tributaries, the Adam-Eve and Salmon 55 each, the Tsitika 42, Cluxewe 36 and Englishman 27 down to 3 tributaries for the Nanoose, and 5 for the Little Qualicum. The six highest mean annual discharges are 129.13 cubic meters per second (cms) for the Nimpkish, 98.83 cms for the Campbell, 66.54 cms for the Salmon, 54.35 cms for the Courtenay (Puntledge and Tsolum), 53.24 cms for the Cowichan and 41.91 cms for the Nanaimo. The six lowest mean annual discharges are 7.39 cms for the Big Qualicum, 12.32 cms for the Little Qualicum, 13.14 cms for the Englishman, 14.39 cms for the Oyster, 17.98 cms for the Kokish and 18.75 cms for the Chemainus. The lowest flows occur in August and September at all but the Goldstream station where low flows occur in March. Maximum flows occur in December and January at all but the Oyster, Goldstream and Nanoose stations. June is the month of maximum discharge at the Oyster and Goldstream stations and April at Nanoose. During the growing season, April through September inclusive, the mean discharge varies from 87.4 cms at the Campbell to .1 cms at Nanoose. The discharge rates of the Goldstream, Cowichan, Nanaimo, Big Qualicum, Puntledge, Tsolum, Campbell and Salmon Rivers are regulated in many ways and by different agents; the rate of discharge varies depending on the agent. Details may be obtained from the Special Estuary Series reports, City of Victoria, Federal Department of Fisheries and Town of Sayward. The suspended sediment concentration of each river has been estimated though not measured. The rivers south of Courtenay flow over the Late Mesozoic Sediments, Sicker Group and glacial till, and have an estimated suspended sediment concentration of 0 - 50 milligrams per liter (mg/l). The rivers north of Courtenay mainly flow over basaltic lavas, granite differentiates and glacial till, and have an estimated

Table 5. Hydrological information pertaining to the study areas

Estuary	Watershed size[1] sq. km.	Mainstem length[1] km.	Tributaries[1]	Gauging[2] Station Number	Min. monthly[2] mean discharge cms	Max. monthly[2] mean discharge cms	Avg. April to Sept. mean discharge cms	Mean Annual Discharge cms	Water[1-2] Diversion	Suspended Sediment Concentration mg/l
Nimpkish	1989	62.4	24	08HF002	Aug 35.40	Jan 202.75	85.4	1926-1938 129.13	No	0-50
Kingcome	1456	74.4	24	-	-	-	-	-	No	201-400
Campbell	1432	9.7	8	08HD003	Sept 66.83	Dec 132.24	87.4	1949-1970 98.83	Regulated since 1947	0-50
Salmon	1380	82.1	55	08HD006	Aug 16.79	Dec 105.91	50.3	1956-1970 66.54	Regulated	0-50
Cowichan	834	45.5	23	08HA011	Aug 7.08	Dec 116.95	29.29	1960-1970 53.24	Regulated since 1965	51-200
Courtenay (see Puntledge and Tsolum below)	769	2.4	2	-	-	-	-	-	No	0-50
Nanaimo	725	80.5	14	08HB034	Aug 5.13	Dec 90.05	22.8	1965-1976 41.91	Regulated since 1963	51-200
Adam-Eve	622	59.9	55	-	-	-	-	-	No	0-50
Puntledge	518	18.1	1	08HB006	Aug 22.76	Dec 56.92	39.2	1914-1920, 1955-1957, 1964-1970,43.33	Regulated	0-50
Chemainus	378	64.4	62	08HA001	Aug 1.16	Dec 38.51	9.6	1914-1970, 18.75	No	51-200
Tsitika	376	38.6	42	08HF004	-	-	18.6	-	No	0-50
Kokish	357	20.9	15	08HF001	Aug 3.68	Dec 30.02	12.4	1927-1941 17.98	No	0-50
Englishman	287	35.4	27	08HB002	Sept 1.03	Dec 22.46	8.4	1913-1917, 1970 13.14	No	51-200
Tsolum	251	28.5	10	08HB011	Aug .84	Dec 24.27	5.0	1914-1917, 1955-1957, 1964-1970 11.02	Regulated since 1964	0-50
Little Qualicum	249	19.3	5	08HB029[3]	Aug 2.10[3]	Jan 24.66[3]	7.3	1960-1973 12.32[3]	No	51-200
Oyster	181	43.5	22	08HD002[3]	Sept 5.01[3]	June 24.72[3]	15.5	1914-1917 14.39[3]	No	0-50
Big Qualicum	145	25.1	23	08HB001	Aug 1.89	Jan 15.66	4.3	1913-1922, 1956-1970 7.39	Regulated	51-200
Cluxewe	117	32.2	36	-	-	-	-	estimated 4.25 July 8, 1974[1]	No	0-50
Goldstream	70	11.1	6	08ND012	Mar 6.23	June 140.45	-	1955-1970 39.07	Regulated	51-200
Quatse	52	12.1	11	-	-	-	-	estimated .42 July 5, 1974[1]	No	0-50
Bonell	47	12.6	-	-	-	-	-	-	No	51-200
Nanoose	28	14.3	3	08HB039[3]	Sept .02[3]	Apr .60[3]	.1	1970-1972 --[3]	No	51-200

[1] Ogmss, 1975
[2] Department of the Environment, 1971
[3] Department of the Environment, 1974
[4] Stichling, 1974

concentration of 51 -200 mg/l. The Kingcome River, flows over granodiorite and glacial till and is fed by large glaciers on the mainland coast. It is estimated to have a 201 - 400 mg/l suspended sediment concentration.

1.5 Fish

Lately, it has become evident that tidal marshes are utilized by juvenile salmon during, what may be, a critical aspect of their life history (Dorcey et al., 1978). The fish species found in the river systems flowing into the estuaries studied include coho, chum, chinook, pink and sockeye salmon, steelhead, and rainbow, cutthroat and Dolly Varden trout. Herring spawn in subtidal waters of the Goldstream, Cowichan, Nanaimo, Nanoose-Bonell, Courtenay, Nimpkish and Cluxewe Rivers' deltas (Table 6). Dolly Varden, rainbow and cutthroat trout are present in all the river systems and Dolly Varden and cutthroat may be found in the estuarine systems during their life histories. Coho occur in all estuaries but the Kingcome; chum are present in all but the Adam-Eve, Kokish, Nimpkish, Cluxewe and Kingcome; chinook are found in all but the Nanoose, Bonell, Oyster, Adam-Eve, Cluxewe and Quatse; pink occur only in the Courtenay, Salmon, Adam-Eve, Tsitika, Quatse and Kingcome; sockeye occur only in the Englishman, Little Qualicum, Campbell, Cluxewe and Quatse River systems. Steelhead may be found in all but the Bonell and Big Qualicum River systems. The size, year and trends of the salmon runs in each system may be obtained from Oguss et. al. (1975) and Environment Canada, Fisheries and Oceans salmon escapement records.

Table 6. Economic Fish Species in the River Systems[1]

Estuary	Mainstem Length km	Mainstem Length Accessible to Migrant Fish km	Coho	Chum	Chinook	Pink	Sockeye	Steelhead	Rainbow	Cutthroat	Dolly Varden	Herring
Goldstream	11.1	-	x	x	x			x	x	x	x	x
Cowichan River	45.5	45.5	x	x	x			x	x	x	x	x
Chemainus River	64.4	12.1	x	x	x				x	x	x	
		62.8						x				
Nanaimo River	80.5	64.4	x		x			x	x	x	x	x
Nanoose Creek	14.3	4.8	x	x				x	x	x	x	x
Bonell Creek	12.6	4.8	x	x					x	x	x	x
Englishman River	35.4	16.1	x	x	x		x	x	x	x	x	
Little Qualicum River	19.3	11.6	x	x	x		x	x	x	x	x	
Big Qualicum River	25.1	10.5	x	x	x				x	x	x	
Courtenay River	2.4	2.4	x	x	x	x		x	x	x	x	x
Puntledge River	18.1	-	x		x	x		x	x	x	x	
Tsolum River	28.5	22.5	x	x		x		x	x	x	x	
Oyster River	43.5	35.4	x	x		x		x	x	x	x	
Campbell River	9.7	5.6	x	x	x		x	x	x	x	x	
Salmon River	82.1	35.4	x	x	x	x		x	x	x	x	
Adam-Eve Rivers	59.9	8.9	x			x		x	x	x	x	
Tsitika River	38.6	33.8	x	x	x	x		x	x	x	x	
Kokish River	20.9	17.7	x		x			x	x	x	x	
Nimpkish River	62.4	-	x		x			x	x	x	x	x
Cluxewe River	32.2	20.9	x				x	x	x	x	x	x
Quatse River	12.1	12.1	x	x		x	x	x	x	x	x	
Kingcome River	74.4	-			x	x		x	x	x	x	

[1] Oguss 1975 and G. Reid Pers. Comm.

2. LITERATURE REVIEW

"Salt marshes of the North American Pacific Coast have been little studied and the relationships between species and their environment and among co-existing species are poorly understood (Zedler, 1977)." MacDonald and Barbour (1974) found this particularly so for British Columbia; Calder and Taylor's (1968) description of salt marsh communities in the Queen Charlotte Islands is their only literature source. Most of the data pertaining to British Columbia's coastal marshes are found in government reports and university theses; most focus on the Fraser and Squamish Rivers' estuaries. Burgess (1970) was the first to describe the composition of vegetation on Roberts and Sturgeon Banks of the Fraser River delta. He found that species distribution appeared to be determined by tidal flooding, local drainage and possibly by undemonstrated differences in soil and water salinity. Seed production was measured ; softstem bulrush and Lyngby's sedge produced the most seeds closely followed by three square bulrush. Forbes (1972) and McLaren (1972) mapped the distribution of the flora on the Fraser River delta foreshore, and islands in the south arm of the Fraser River, respectively. The foreshore vegetation of the Fraser River delta was described again by Yamanaka (1975). He collected plant and soil samples along fourteen transects running seaward from shore and determined an average dry matter yield of 4.9 tons per hectare over an estimated 1901 hectares. Ash, nitrogen and lignin were determined for plant samples, and pH, organic matter and electric conductivity were determined for soil samples. Plant species composition and average height of species were recorded. Later studies confined descriptions to specific areas on the Fraser River delta and used a larger scale for mapping. Hillaby and Barrett (1976) used systematic plots to describe the Roberts Bank salt marsh and indicate the 4.6 meter tidal contour was the line delineating the emergent (gumweed and saltbush) and submergent (saltgrass and saltwort) communities. The Musqueam Marsh, below Point Grey, was studied by Bell-Irving (1977). Plant species density and height, and benthos were randomly sampled along four transects. Heights of dominant species ranged for cat-tail 128 - 220 cm, Lyngby's sedge 111 - 180 cm, and softstem bulrush 102 - 234 cm. Moody (1978) related environmental factors and species distribution on the Brunswick Point Marsh. She found 2.82 meters (above chart datum) is the lower limit of emergent vegetation, salinity and temperature influence growth, and a peak aboveground phytomass of 909 gm m^{-2} for Lyngby's sedge, 397 gm m^{-2} for three square bulrush, and 565 gm m^{-2} for maritime bulrush. The Lyngby's sedge marsh on Woodward Island was studied by Kistritz and Yesaki (1979). They measured shoot growth, density, standing crop, root biomass, and carbon, nitrogen and phosphorus content of tissue over one year. Annual net primary production was estimated to be 634 grams ash-free dry weight per square meter (gm AFDW m^{-2}). Net annual detritus production was estimated to be 435 gm AFDW m^{-2} and 62% of this disappeared in dissolved and particulate organic matter between September and June; the balance was probably buried by alluvium. Belowground biomass was approximately four times larger than aboveground standing crop. The emergent plant communities of the Squamish River estuary are described by Lim and Levings (1973). The biomass of Lyngby's sedge communities ranged from 573-1657 gm dryweight (DW) m^{-2} (average 924 gm DW m^{-2}). Levings and Moody (1976) measured net primary production, over the period late March to mid-August, at 1322 gm DW m^{-2} on the central lobe of the Squamish River delta.

The emergent vegetation of other British Columbia estuaries is described in the Special Estuary Series, Task Force, and related environmental consultants reports. The Special Estuary Series lists the flora and maps the distribution of major species or plant communities for the Cowichan, Chemainus, Nanaimo, Kitimat, Campbell, Courtenay and Oyster Rivers' estuaries. Task force reports provide much the same data for the Cowichan, Nanaimo, and Squamish Rivers' estuaries. Most of the information in the Special Estuary Series and Task Force reports is from government files and unpublished data. The detail of the maps varies from delineation of vegetated areas through lumping vegetation types to plant community outlines.

Kistritz (1978) reviewed the literature on the role of detritus and the cycling of elements in tidal marsh ecosystems. Much of the literature is based on research carried out in salt marshes on the east coast of the United States and its applicability to British Columbia is limited. There is a large degree of variability both within and between marsh ecosystems as a result of variation in geological, hydrological and climatological factors. He concluded there is a need for data specific to west coast marshes.

3. THE PLANT COMMUNITIES OF THE ESTURARINE MARSHES ON THE EAST COAST OF VANCOUVER ISLAND

The plant communities in this study are composed of emergent plant species that live in brackish to saline water. The emergent plants, or vegetation, are vascular plants that occur in the intertidal zone, between the low and high high tide lines, on river deltas. There they are subject to the flood and ebb of the tide; often submerged on the flood tide, they "emerge" from the water on the ebb tide.

Emergent vegetation is a primary source of energy in the estuarine ecosystem and is utilized, either directly or indirectly, by many organisms and most visibly by birds, fish and wildlife. One of the initial steps in delimiting the energy pathways is determining the plant species and communities in the estuary. This section of the study describes and reports on the distribution of plant communities. It also attempts to identify some of the major factors influencing the plant species distribution.

3.1 Methods

The emergent plant communities are described after the aerial photograph technique in Mueller-Dombois (1974) and Daubenmire (1962). The technique was particularly suitable for this study as it is comparatively faster to do than other procedures which made it possible to describe the plant communities on the nineteen estuaries in two field seasons (May to September, 1975 and 1976). This would not have been

September, 1975 and 1976). This would not have been possible using another technique. Though the aerial photograph procedure does not produce quantitative data on plant species, it is a suitable technique for this study because the work is preliminary and the technique is reliable, as shown by Eilers (1975). Eilers studied Oregon's estuarine marshes and found plant communities identified using this technique were closely related to those identified with SIMORD (an ordination program based on the phytosociological reference stand ordination procedure of Whittaker (1967)). With substantiation of the technique for estuarine marshes it was possible to map the location and extent of the plant communities with confidence. The one disadvantage of the technique is that the transition zone between communities may vary in width; thus plant communities presented should be considered as graduating from central characteristics toward the margins.

The procedure involved determining tonal and textural variations associated with plant communities on aerial photographs (Appendix 3) and field checking, in the years 1975 and 1976. Plant species in each community were catalogued, including more terrestrial species just above the mean high water mark (Appendix 4). Species were identified according to Hitchcock et al. (1973). The dominant and subdominant plant species, those with the highest ocular estimation of percent coverage of a community, characterize the community. Field notes containing the percent coverage estimates are on file in the Special Collections Division at the University of British Columbia.

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Plant communities in each estuary were mapped from the aerial photographs so that map and photos may be coordinated. Correction for aberration was beyond the resources of this study so, where possible, only the centre of each aerial photograph was used to compose a map.

The area of each community was calculated and a simple linear correlation (Zar, 1974) was run between the total area of eleven dominant or subdominant species typing the communities and average April to September mean flows (Department of the Environment, 1974), and April to September mean rainfall (Atmospheric Environment, 1973).

3.2 Results and Discussion

The descriptions of the plant communities in nineteen estuaries on the east coast of Vancouver Island required the recording of a lot of detail and it is difficult to present the data here without a substantial loss of coherence in the text. Therefore, the data is presented in tables 7 to 45 and figures 4 to 22 in Appendix 5.

There is a great deal of variation in the description and distribution of the plant communities in the estuaries studied. The descriptive variability breaks the estuauries into four main groups. In the first group of estuaries vegetation indicative of brackish conditions occurs around the main river channels. Lyngby's sedge is found at the lowest elevations and with increasing elevation Baltic rush and cinquefoil. In areas distant from the influence of freshwater there is an increase in the occurence of plant species indicative of more saline conditions. Saltwort is found at the lowest elevations and with increasing elevation saltgrass, then saltbush, gumweed, meadow and mouse barley, and other grasses. In this group maritime bulrush rather than Lyngby's sedge is present when the substrate is water saturated, and jointed rush, rather than Baltic rush, is present when the substrate drainage is poor. Estuaries in this group are the Cowichan, Chemainus, Nanaimo, Englishman, Little Qualicaum and Big Qualicum.

In the second group of estuaries, species indicative of brackish conditions dominate the estuaries. Lyngby's sedge is dominant at the lowest elevations of the vegetated intertidal zone. As the elevation increases tufted hairgrass then cinquefoil and assorted species, mainly grasses, dominate. When the ecotone between marsh and forest is poorly drained bulrush and sweet gale are present, and when it is well drained, willow, twin-berry, Nootka rose and ninebark dominate. Estuaries in this group are the Courtenay, Oyster, Campbell, Salmon, Adam-Eve, Tsitika, Kokish, Nimpkish, Cluxewe, Quatse and Kingcome.

In the third group of estuaries, Lyngby's sedge occurs only in channels where freshwater flows constantly, and the marsh is dominated by saline indictor species. Saltwort is dominant at the lowest elevations in the vegetated intertidal zone and saltgrass then saltbush, maritime plantain and gumweed become dominant as the elevation increases. Salt marshes in this group are the Goldstream, Chemainus and Nanoose-Bonell.

In the fourth group of estuaries Lyngby's sedge or sedge species are limited to channels where freshwater flows constantly and saline indicators dominate. Saltwort dominates at the lowest elevations and, with increasing elevation, arrow-grass becomes dominant and may be associated with tufted hairgrass, Kentucky bluegrass, barley and other grasses at higher elevations. Salt marshes in this group are the Adam-Eve, Kokish and Cluxewe.

The four groups bring out two points. The first point is that brackish and salt marshes are described, the salt marshes being on the same deltas as the brackish marshes. The second point is that the dominant plant species at higher elevations in marshes north and south of Courtenay are different. In brackish marshes south of Courtenay rushes, cinquefoil and some saltgrass dominate while marshes from Courtenay north are dominated by tufted hairgrass and cinquefoil. And in salt marshes south of Courtenay saltgrass, saltbush and gumweed dominate while north of Courtenay arrow-grass and grasses dominate.

The two points may be explained by considering the dominant plant species. Plant species are known to indicate their growing conditions (Clements, 1939) and two indicator species are saltwort and Lyngby's sedge. The dominance of saltwort indicates saline conditions and Lyngby's sedge indicates brackish conditions. Saltwort and Lyngby's sedge separate salt marshes from brackish marshes and identify salinity as a major factor influencing species distribution. Salinity appears to be the factor splitting the island in half as brackish and salt marshes south of Courtenay have more saline indicator species dominant than do brackish and salt marshes north of Courtenay. Salinity is a well known factor influencing species distribution on brackish and salt marshes. But salinity itself is a function of many factors and it is those factors and their influence on salinity that are of interest. Consider the first point again; that is, there are brackish and salt marshes because of a difference in salinity. A hypothesis is that, on Vancouver Island, the difference in salinity is due to stream flow, the size of the delta and freshwater circulation. When flows are low and/or intermittent in the growing season, as they are on southeastern Vancouver Island, there is little freshwater to flush the vegetation and substrate of salts, and salinities are higher. The larger the delta the less effective the dilution affect of freshwater. Freshwater circulation may also be impeded by dykes, bermes or islands. South of Courtenay the distinction between salt and brackish marshes can be seen on the Chemainus River Estuary. The Chemainus has a large delta divided into salt and brackish marshes by the islands and dykes which impede freshwater circulation to the salt marsh on the southeastern lobe of the delta. Bonsall Creek is the only freshwater souce for the salt marsh. North of Courtenay the distinction is seen on the Adam-Eve Rivers' Estuary. Here the salt and brackish marshes are separated by a gravel berme and islands which restrict freshwater circulation to the salt marsh on the eastern lobe. The freshwater source for the salt marsh is an intermittent creek. (Salinities in soil cores collected in June 1976 from the marshes on the Chemainus, Cowichan, Little Qualicum and Campbell estuaries ranged from 26.0 to 37.5 milli micohms (MHO) for the salt marsh on the Chemainus and 1.79 to 15.4 milli MHO for the brackish marshes in the other estuaries. (A conductivity meter was used to measure the salinities of filtrates from soil pastes).

Reconsider the second point, that dominant plant species at higher elevations in salt and brackish marshes are indicative of more saline conditions south of Courtenay than they are north of Courtenay. Here the hypothesis is that, on Vancouver Island, the difference is due to precipitation ranges from 857 mm at the Victoria Island Airport to 1507 mm at Courtenay. North of Courtenay it increases to 1637 mm at Port Hardy Airport and it rains as Port Hardy 32% more of the year than it does at Victoria. I feel rainfall moderates salinity on brackish and salt marshes and found there is a significant positive correlation between precipitation and the area dominated by tufted hairgrass and cinquefoil (Appendix 5 Table 45). Tufted hairgrass and cinquefoil being more abundant in marshes north of Courtenay. South of Courtenay, where precipitation is lower, rushes, cinquefoil and saltgrass dominate at higher elevations.

The descriptive variability breaks the estuaries into the aforementioned four groups. However, when the principal physical factors influencing the distribution, as well as the descriptive variability, of the plant communities are considered there are eleven groups of estuaries. They are: 1. Kingcome, 2. Goldstream, Chemainus, Nanoose-Bonell, 3. Adam-Eve, Kokish, Cluxewe, 4. Cowichan, Chemainus, Nanaimo, 5. Englishman, Little Qualicam, 6. Big Qualicum, 7. Courtenay, Oyster, Campbell, 8. Salmon, Quatse, 9. Kokish, Nimpkish, 10. Quatse, Adam-Eve and 11. Tsitka.

The eleven groups are based on the interaction of six principal physical factors. The factors include: 1. time of maximum discharge, 2. the relationship between a river's average April to September mean discharge and the size of the river's delta, 3. mean annual total precipitation, 4. the relative protection of a river delta from wind and wave energy of the sea, 5. the particle size of the substrate, and 6. the duration and frequency of tidal inundation.

The first factor considered is time of maximum discharge. The time of maximum discharge for a river, spring or winter, influences the salinity during the growing season and the rate of accretion. During the spring freshet, the salinity is lowered by the large inflow of freshwater, and the rate of accretion is probably increased when sediments are trapped in the growing vegetation. River systems with a heavy spring freshet tend to originate from glaciers and snowfields and carry large suspended sediment loads commonly referred to as glacial flow. Glacial flow contributes to the rate of accretion on a delta and greatly alters the light regime for inundated vegetation. Rivers with a heavy spring freshet also have a lot of water energy that can scour away plants thereby decreasing species diversity on the deltas. In general, emergent vegetation on deltas subject to spring freshets is not diverse and is composed of brackish indicator species distributed in bands across the delta. In river systems subject to winter freshets, the lower flows in the growing season tend to result in higher salinites and lower rates of accretion on the deltas; during the winter, there is often little emergent vegetation to trap sediments and lower summer flows carry smaller suspended sediment loads. In general, emergent vegetation on deltas subject to winter freshets is composed of brackish indicator species around the freshwater channels and, with increasing distance from freshwater, an increasing abundance of saline indicator species.

The second factor concerns the relationship between a river's average April to September mean discharge and the size of the river's delta. It appears that some rivers continuously inundate all or a large portion of their deltas during the spring freshet. This long inundation period discourages the establishment of extensive stands of emergent vegetation which require daylight exposure time each day of the growing season. It is felt that where a delta is disproportionately small relative to the river's average April to September mean discharge the emergent vegetation will not be diverse or extensive, and will be restricted to the highest elevations in the intertidal zone.

The converse of this factor is also important. When a delta is disproportionately large relative to the river or creek's average April to September mean discharge the delta will be colonized by plant species considered indicative of saline conditions. Brackish indicator species will be restricted to freshwater channels.

The third factor considered is the mean annual precipitation. The role of precipitation appears to lie in its indirect effects. In estuarine marshes south of Courtenay, where the mean annual precipitation is low, less than 1030mm, it is not enough to dilute and wash away the salts brought to the soil surface by evapotranspiration. Marshes in this precipitation range will usually be dominated by plant species indicative of xeric and saline conditions. In marshes north of Courtenay, precipitation is greater than 1030mm, the rainfall appears to keep salinites relatively low and the marshes are dominated by species indicative of brackish conditions.

The fourth factor considered is protection of the river delta from the wind and wave energy of the sea. The substrate of relatively poorly protected deltas is subject to the erosional forces of the wind and waves. Hence, these deltas tend to have limited fine substrate and are mainly gravel. The wind and waves may also prevent species colonization, and damage and uproot established plants. The dominant plants of many exposed deltas are grasses. The deeper, fine substrate on relatively well protected deltas is established to a greater diversity of species and includes more forbs.

The fifth factor is the particle size of the substrate. Generally, it appears that the thicker the layer of fines the more diverse the plant species, and, conversely, the thinner the layer of fines the less abundant and diverse, and more fibrous rooting the plant species.

The sixth factor is the duration and frequency of tidal inundation. There are a few emergent plants that can survive long periods of inundation and a few terrestrial plants that can survive infrequent inundation. Lyngby's sedge and saltwort are the principal emergent species that are known to tolerate inundation from 38 to 62% of the daylight hours during the growing season and Sitka spruce is known to tolerate flooding for short periods of time four or five times each year. Plants occurring at elevations between the sedge and spruce are inundated for generally less than 30% of the daylight hours during the growing season and it is in this range that the greatest abundance of plant species occur (Kennedy, 1978). The more extensive the range, the more abundant and diverse are the plant species.

The inundation to emergence ratio also affects the timing of the initiation and cessation of growth, particularly at the lower elevations in the intertidal zone. Lyngby's sedge will initiate growth as soon as its daylight exposure time increases, in April, and will cease growth as daylight exposure declines from August on. At higher elevations, brackish indicator species may complete their life cycle very quickly, between April and June. Their initiation of growth co-occurring with favorable daylight exposure and cessation of growth occurring with increasing salinity or xerophytic conditions. It appears that no one factor controls the composition or distribution of a community. Rather it is a number of factors and their interaction.

These physical factors interact to varying degrees and in various ways to result in a multiplicity of distribution and compostion patterns in the plant communities on the estuaries. However, there are general patterns among the estuaries and these patterns lend themselves to a classification of estuaries. A binumerical key to the eleven groups of estuaries in this study follows.

A Binumerical Key to the Estuaries

1a.	River's maximum discharge occurs in the spring.	2
1b.	River's maximum discharge occurs in the winter.	7
2a.	River's average April to September mean discharge disproportionately large relative to the size of the delta.	3
2b.	River's average April to September mean discharge proportionate to the size of the delta.	4

3. Emergent vegetation is not extensive. The marsh is dominated by Carex lyngbyei communities which tend to occur as a fringe where there is shelter from fast moving water. On more elevated areas of the delta which are subject to periodic inundation, the vegetation is like that found on the river's islands. (eg. Skeena).

4a. Mean annual total precipitation > 1540 mm. 5

4b. Mean annual total precipitation < 1540 mm. 6

5. Emergent vegetation is extensive on the delta and is dominated by Carex lyngbyei communities at the lowest elevations in the vegetated intertidal zone. Eleocharis palustris is dominant in or adjacent to channels where freshwater flows and there is some substrate drainage at low tide. With increasing elevation, Deschampsia cespitosa dominates and may be found in association with, at the lower elevations of its range, Carex lyngbyei and then, with increasing elevation, assorted forbs and grasses (e.g. Potentilla pacifica, Trifolium wormskjoldii, Juncus balticus, Achillea millefolium, Lathyrus palustris, Poa pratensis, Ranunculus orthorhynchus, Agrostis tenuis, Elymus glaucus, Festuca subulata, Bromus pacificus). The number of associated species and plant communities in an estuary declines with increasing latitude. The extent of channelization of the backshore is dependent on the slope and size of delta; the gentler the slope and the larger the delta, the more channels. Dominant vegetation in backshore areas appears to be related to substrate drainage which is dependent on the extent of channelization (see Krajina

(1970) for a description of possible communities) (Kingcome).

6. Emergent vegetation is extensive on the delta with dominants on the foreshore including Scirpus americanus, Scirpus maritimus, Scirpus acutus, Carex lyngbyei and Typha latifolia. Towards the backshore, the vegetation is diverse and its distribution appears to be influenced by substrate drainage; bog, fen and swamp communities are common away from main channels, and brackish marshes of diverse species occur along channels (e.g. Scirpus acutus, Typha latifolia, Carex lyngbyei, Carex spp., Erigeron spp., Aster sp., Sidalcea hendersonii, Juncus spp., Sonchus arvense, Sagittaris latifolia, Alisma plantago-aquatica, and Agrostis spp.). Adjacent areas of ponded water are colonized by pondweeds (e.g. Potamogeton spp. Lemna minor, Lemna trisulca, Sparganium sp., Nuphar sp.) (eg. Fraser).

7a. River or creek's average April to September mean discharge is disproportionately small relative to the size of delta, and/or the freshwater circulation may be impeded to part of the delta by physical structures. 8

7b. River's average April to September mean discharge proportionate to the size of delta. 11

8a. Mean annual total precipitation in the region of the estuary is 660 -1540 mm. 9

8b. Mean annual total preci⁻itation in the region of the estuary is > 154 mm. 10

9. Carex lyngbyei is limited to channels where freshwater flows constantly. Salicornia virginica is dominant at the lowest elevations in the vegetated intertidal zone. With

increasing elevation _Distichlis spicata_ becomes dominant and species diversity increases (eg. _Atriplex patula_, _Plantago maritima_, _Hordeum brachyantherum_, _Hordeum murinum_, _Plantago lanceolata_, _Achillea millefolium_ and _Grindelia integrifolia_). Grasses and shrubs become dominant towards the backshore and species diversity is proportionate to the size of the delta. (Goldstream, Chemainus, Nanoose-Bonell).

10. Stands of _Carex lyngbyei_ or _Carex_ spp. are limited to channels where freshwater flows constantly. _Salicornia virginica_ is dominant at the lowest elevations in the vegetated intertidal zone. With increasing elevation, _Triglochin maritimum_ becomes dominant and may be associated with _Carex lyngbyei_ and/or _Deschampsia cespitosa_ at the higher elevations within its range.

    Grasses (_Deschampsia cespitosa_, _Agropyron repens_, _Poa pratensis_, _Hordeum brachyantherum_, _Agrostis tenuis_) tend to dominate at the highest elevations in the marsh (Adam-Eve, Kokish, Cluxewe).

11a. Mean annual total precipitation in the region of the estuary is 660 - 1540 mm. 12

11b. Mean annual total precipitation in the region of the estuary is > 1550 mm. 19

12a. Mean annual total precipitation in the region of the estuary is 660 - 1030 mm. 13

12b. Mean annual total precipitation in the region of the estuary is 1040 - 1540 mm. 18

13a. River delta is sheltered. 14

13b. River delta is exposed. 17

14a. River delta is embayed. 15

14b. River delta is mostly protected by a spit. 16

15. At low tide, the river's flow is mainly confined to one channel and vegetation indicative of brackish conditions occurs around it. In areas distant from the influence of freshwater during low tide there is an increase in the occurrence of plant species indicative of more saline conditions, particularly where freshwater circulation is impeded. In the vegetated intertidal zone, Carex lyngbyei is dominant at the lowest elevations where it is flushed by freshwater on the ebbing tide. Juncus balticus and Potentilla pacifica become dominant as the elevation increases. Juncus articulatus may occur at this elevation when the substrate is not well drained. Should drainage of part or all of the delta be impeded so that the soil is always water saturated Scirpus maritimus will be the dominant plant species (Cowichan, Chemainus, Nanaimo).

16. The plant communities are located landward of the spit which protects the vegetation from the worst wind and wave energy of the sea. Carex lyngbyei is dominant at the lowest elevation. As the elevation increases the sedge becomes codominant with grasses. Shrubs (e.g. Rosa nutkana, Rubus spectabilis, Rubus laciniatus, Cytisus scoparius) and grasses are dominant in the backshore. Vegetation landward of associated dunes or bermes is like that described under 9 (Englishman, Little Qualicum).

17. The emergent vegetation is usually confined to the streambed of the main channel and grows on sand and sandy gravels. Carex lyngbyei occurs at the lower elevations and

does not grow vigorously. The channel sides are sparsely covered by Potentilla pacifica, Plantago lanceolata, Trifolium pratense and Anthoxanthum odoratum. Alnus rubra occurs on the streambank. Emergent vegetation (e.g. Carex lyngbyei and Juncus balticus) will occur in deltaic channels landward of beach bermes. Grasses occur between a berme and channels, and grasses and shrubs occur between the channels and forest margin (Big Qualicum).

18. Carex lyngbyei is dominant at the lowest elevations of the vegetated intertidal zone. As the elevation increases, the sedge's vigor and abundance decrease and Deschampsia cespitosa becomes dominant. Scirpus americanus may occur in this elevation range when the substrate is well drained, sandy and saline. At higher elevations Potentilla pacifica becomes dominant and associated species may include, Trifolium wormskjoldii, Eleocharis palustris, Erigeron philadelphicus, Dodecatheon pulchellum, Sisyrinchium angustifolium, Castilleja levisecta, Sidalcea hendersonii, Mimulus guttatus, Vicia gigantea, Habenaria dilatata, Dactylis glomerata, Phleum pratense, Poa pratensis, Holcus lanatus, Agrostis tenuis, Agropyron repens and Festuca pratensis. When backshore areas adjacent to the treeline are not well drained Myrica gale and Scirpus acutus or Scirpus microcarpus and Carex lyngbyei dominate. When backshore areas adjacent to the treeline are well drained shrubs (e.g. Physocarpus capitatus, Salix spp., Lonicera involucrata and Rosa nutkana) dominate. Picea sitchensis is dominant in the forest. The extent and species diversity of each plant community in this type of estuary

is proportionate to the size of the protected area with good freshwater circulation, i.e., the smaller the protected area with good freshwater circulation the less extensive and diverse the plant communities (Courtenay, Oyster, Campbell).

19a. River delta is relatively well protected from wind and wave energy of the sea. 20

19b. River delta is relatively poorly protected from wind and wave energy of the sea. 27

20a. River delta is deeply embayed. 21

20b. River delta is shallowly embayed. 24

21a. A relatively thick layer of fine substrate overlies gravel. 22

21b. A relatively thin layer of fine substrate overlies gravel. 23

22. Carex lyngbyei is dominant at the lowest elevations of the vegetated intertidal zone. As the elevation increases the sedge's vigor and abundance decrease and Deschampsia cespitosa becomes dominant. At higher elevations Potentilla pacifica is a dominant species and may be associated with Poa pratensis, Agrostis alba var. stolonifera, Juncus balticus, Agropyron repens, Trifolium wormskjoldii, Achillea millefolium, Sidalcea hendersonii, Prunella vulgaris and Erigeron philadelphicus. In this type of estuary, t'e extent and species diversity of each plant community is proportionate to the area of delta with good freshwater circulation, i.e., the larger the area with good freshwater circulation the more extensive and diverse the plant communities (Salmon, Quatse).

23. *Carex lyngbyei* is dominant on sand and *Deschampsia cespitosa* is dominant on gravel at the lowest elevations of the vegetated intertidal zone. With increasing elevation, *Deschampsia cespitosa* dominates and may be found in association with, at the lower elevations of its range, *Carex lyngbyei* and then, with increasing elevation, *Potentilla pacifica*, *Glaux maritima*, *Triglochin maritimum*, *Agropyron repens*, *Hordeum brachyantherum*, *Poa pratensis* and *Agrostis tenuis* (Kokish, Nimpkish).

24a. Spit and/or berme occurs on the delta. 25

24b. No spit and/or berme occurs on the delta. 26

25. *Deschampsia cespitosa* is dominant on gravel and *Carex lyngbyei* is dominant on sand at the lower elevations of the vegetated intertidal zone. *Deschampsia cespitosa* becomes dominant as the elevation increases. Near the treeline, *Deschampsia cespitosa* may be codominant with *Potentilla pacifica*, or *Hordeum brachyantherum*, *Trifolium wormskjoldii*, *Plantago lanceolata* and *Juncus effusus* may be dominant. On some estuaries, *Salicornia virginica*, *Plantago maritima* and *Triglochin maritimum*, species indicative of relatively saline conditions, may be found at the lower elevations of the vegetated intertidal zone. Vegetation landward of associated bermes is like that described under 10 (Quatse, Adam-Eve).

26. *Deschampsia cespitosa* is dominant on gravel and *Carex lyngbyei* is dominant on sand at the lower elevations of the vegetated intertidal zone. With increasing elevation, *Deschampsia cespitosa* dominates and may be found in association with *Carex lyngbyei* at the lower elevations of

its range and with _Trifolium wormskjoldii_, _Achillea millefolium_, _Triglochin maritimum_ and _Holcus lanatus_ adjacent to the forest. _Picea sitchensis_ is the dominant tree species on the delta (Tsitika).

27. _Deschampsia cespitosa_ is dominant on gravel and _Carex lyngbyei_ is dominant on sand at the lower elevations of the vegetated intertidal zone. On relatively large deltas, _Salicornia virginica_ may be dominant at the lower elevations. _Deschampsia cespitosa_, _Agropyron repens_, _Poa pratensis_, _Agrostis alba_ var. _stolonifera_, _Dactylis glomerata_ and _Bromus sitchensis_ are dominant at higher elevations. Where the delta is large and relatively gently sloping shrubs (e.g., _Rubus spectabilis_) will be dominant adjacent to the _Picea sitchensis_ forest (eg. west coast Vancouver Island).

3.2.1 Estuaries

In doing this study each estuary was surveyed in turn. During the course of the work it became evident that the role of physical factors in the composition and distribution of the plant communities in the estuaries was important. As a result, the physical factors have been discussed and the estuaries have been divided into eleven groups on the basis of the influence of the physical factors on the composition and distribution of the plant communities among estuaries. It is deemed useful to present a discussion of each estuary to give the nature of the plant communities and the physical factors influencing them on each estuary.

3.2.1.1 Goldstream Estuary

The plant communities of the Goldstream Estuary tend to be dominated by species indicative of saline conditions. These species include saltwort, saltgrass, Baltic rush and meadow barley. The abundance of the saline species increases with distance from the main streamflow. The brackish water species (e.g., Lyngby's sedge) are most abundant in the main channels of the stream. The vigor and abundance of Lyngby's sedge decreases with increasing distance from the main streamflow. The Cytisus scoparius - Rosa nutkana and Plantago lanceolata - Rumex salicifolius -Hordeum brachyantherum - Chenopodium album communities occur on landfill in the backshore. These two communities are almost never flooded.

The plant species distribution is related to the three principal physical factors, delta morphology, flow and precipitation. The Goldstream delta is large and generally elevated above the streamflow. Much of the delta appears not to be strongly influenced by freshwater, probably due to the reduced streamflow as much of it has been diverted for urban use. The dominance of species indicating physiologically dry conditions suggests that precipitation during the growing season is not great enough to reduce the predominantly saline conditions. As the glaciers receded, streamflow was probably much greater which would account for the extensive and elevated delta. Larger and more sediment laden flows formed the delta and many of the channels in it today. It is likely that the backshore floodplain, now isolated from the estuary by the landfill, was once a continuum of the wetland and was a possible source of freshwater distribution to the western half of the estuary.

3.2.1.2 Cowichan River Estuary

The emergent plant communities of the Cowichan River Estuary are dominated by species indicative of brackish and brackish saline conditions. The brackish water species (e.g., Lyngby's sedge, cinquefoil and Baltic rush) are most abundant north of the railroad while the brackish saline species (e.g., saltgrass, Baltic rush and saltwort) tend to be most abundant south of the railroad and within some dyked areas.

The plant species distribution is related not only to the principal physical factor streamflow but also to man's influences on it. The diffuse dispersal of an abundant streamflow in an estuary tends to maintain brackish water conditions which appear to be more productive than saline productive than saline water conditions. However, human activity (eg. roads, railways, landfills and dykes) has altered freshwater circulation in the Cowichan River Estuary. The road and railroad to the lumber storage area appear to have a major influence in obstructing freshwater circulation to the southern plant communities. As a result, communities are dominated by species indicative of brackish saline conditions. Dykes have also impeded freshwater circulation to emergent plant communities, fragmenting and salinizing emergent vegetation stands. It is probable that any further dredging, landfilling or dyking on the Cowichan River Estuary could decrease the abundance of brackish water species and the productivity of the estuary (Kennedy, 1978). As the glaciers receded, the streamflow of the Cowichan River was undoubtably greater and more broadly distributed to form a continuous wetland from the present estuary, inland. This wetland is also reduced, fragmented and alienated by roads, railway, landfill and dykes.

3.2.1.3 Chemainus River Estuary

The emergent plant communities on the Chemainus River delta form a brackish marsh to the northwest and a salt marsh to the southeast. The communities to the northwest, around the mouth of the Chemainus River, are dominated by species indicative of brackish (e.g., Lyngby's sedge) and physiologically dry (e g., Baltic rush and various grasses) conditions. Communities dominated by Baltic rush and various grasses tend to occur away from the main streamflow. The communities to the southeast, near the mouth of Bonsall Creek, are dominated by species indicative of saline conditions. These include saltwort, saltgrass and gumweed. Saltwort may be found at the lowest elevations of the vegetated intertidal zone and, as the elevation increases, saltgrass then gumweed may appear. Maritime bulrush, a saline water indicator, may be found in channels, within the dyked areas, where the substrate is saline and water saturated.

The plant species distribution is related to two principal factors, delta morphology and streamflow. The delta is very large, extending south to the Crofton pulp and paper mill, north to Chemainus Bay and east to the Shoal Islands. The islands have provided protection from the tidal currents of

Stuart Channel thus enabling the delta to build behind and around them. As the glaciers receded, the flow of the Chemainus River must have been greater than present in order to build the delta. Indeed, old channels in the agricultural areas, some supporting stunted Lyngby's sedge, suggest that the delta was once more extensively flooded. The lesser flow is now directed, by the landform, mainly to the northwest and north, over the brackish marsh and away from the saltmarsh to the southeast. Dykes and roads further inhibit freshwater circulation to the southeast where the dominant saline influence has resulted in a salt marsh.

Human activity has also had an influence on the distribution of estuarine flora on the Chemainus River delta. Two activities appear to have the most influence. The first is agriculture which has been actively pursued for at least 100 years (Bonsall, pers. comm.) on the delta. The dyking and draining of land for farming has eliminated most of the backshore channels and, with their loss, the continuum between estuarine wetland and forest has been broken. The second human activity is the water filtration station outfall at the southeastern end of the delta. Periodically, the station cleans its filters and flushes accumulated sediments through the outfall. It would appear that the sediments are accelerating accretion on the southeastern end of the delta. A resident adjacent to the outfall reports that he has had to dig out his boat channel since the outfall was established. Also, he indicates beds of eel-grass and algae used to occur between the inner and outer Shoal Islands (McDonald, pers. comm.). This area is now an intertidal mudflat suggesting sediment accumulation, probably from the filtration station, the most immediate source. Landfilling between the Crofton pulp and paper mill and outer Shoal Islands may further accentuate sedimentation and eliminate subtidal flora.

3.2.1.4 Nanaimo River Estuary

The emergent plant communities of the Nanaimo River Estuary tend to be dominated by species indicative of brackish, physiologically dry, and saline conditions. Initially, there may not appear to be a pattern to the species distribution though on closer examination of the data one is suggested. The brackish species (e.g. Lyngby's sedge and tufted hairgrass) appear to be more abundant and vigorous along main channels. The abundance and vigor of Lyngby's sedge is an example. In the western channel, through which most of the Nanaimo River flows, Lyngby's sedge is abundant and vigorous. In the main channels on the eastern half of the estuary, Lyngby's sedge is less abundant, lining only the immediate edges of the channels, and it is less vigorous being generally half as tall as the sedge in the main, western channel. The species indicative of physiologically dry conditions (e.g., Baltic rush, jointed rush and various grasses) most frequently occur away from the main streamflow, toward the backshore and within dyked areas. Jointed rush is the most abundant dominant or subdominant on the estuary, covering 16.4 hectares or 29 percent of the vegetated area studied. It is not known to occur as extensively or abundantly on any other estuary on Vancouver Island. It is possible that jointed rush may have a physiological advantage over, for example, Baltic rush, when the growing conditions include a water saturated substrate and a probably increasing soil salinity during the growing season. This might explain the unique distribution pattern of jointed rush on the Nanaimo River Estuary. The saline indicators (e.g., saltwort, saltgrass, saltbush and arrow-grass) tend to become more abundant away from the main streamflow and at the lower elevations of the vegetated area studied. Arrow-grass occurs most frequently along the seaward edge of the western island where it is not strongly influenced by freshwater. Saltwort becomes more abundant at the lower elevations on the eastern half of the delta where abundant saltwater negates freshwater influence.

The plant species distribution is again related to two principal physical factors, delta morphology and streamflow, and man's influence on them. The extensive delta is bounded to the south and east by rock formations of the Nanaimo Group (Muller, 1971) and to the west and southwest by elevated outwash deposits over bedrock. The size and elevation of the delta suggest that it was formed when the flow and sediment load of the Nanaimo River were greater, i.e., in proglacial times. Nowadays the flow into the estuary is regulated by upstream dams and its dispersal pattern across the estuary is influenced by human activity (i.e., dyking and dredging). The dyke, also serving as a road along the east bank of the Nanaimo River, inhibits freshwater flow, through channels visible over the agricultural land, to the eastern half of the delta. Other dykes, generally breached and oriented in various directions, would appear to impo¨nd water in areas. A number of these areas are dominated or subdominated by jointed rush. Possibly the abundance of jointed rush is related to dyking activity on the estuary. The dispersal of freshwater across the eastern half of the delta is further influenced by dredging of the western channel of the river. The main streamflow is drawn through the western channel where it creates brackish conditions suitable for the growth of Lyngby's sedge on the western portion of the delta. At the bifurcation of the Nanaimo River, an accreting gravel bar in the eastern channel assists, through deflection, the direction of flow to the western channel. This further reduces freshwater distribution to the eastern half of the estuary. The gravel bar has been known to repeatedly increase in size and then wash out (pers. comm. B. Smith). Three small channels occur on the island between the east and west channels. At one time the channels on the island may have distributed freshwater to the island's vegetation creating more brackish, rather than the existing saline conditions. Presently the channels are partially blocked at the freshwater source and thus have a limited influence, however they do provide a potential for studies on the influence of freshwater circulation on the distribution of emergent plant species.

The continuum from saline to freshwater wetlands was probably very evident before developments such as roads, dykes and landfill altered much of the backshore and floodplain. These developments appear to have broken the continuum and disrupted the wetland food webs. In the past, the Nanaimo and Cowichan River Valleys had the most extensive continuous wetland habitats on the east coast of Vancouver Island. The remaining, "disjointed" estuarine land, back channels, meandering creeks and ponds are both remnants and relics of that wetland habitat.

The loss of the continum is partially reflected in declining numbers of individuals (e.g., shellfish, salmon and waterfowl) at higher trophic levels of the food web.

3.2.1.5 Nanoose-Bonell Creeks' Estuary

The emergent plant communities of the Nanoose-Bonell Creeks' Estuary are dominated by species indicative of brackish saline and saline conditions. The species considered indicative of brackish saline conditions (e.g., Lyngby's sedge, saltwort, saltgrass and saltbush) occur in the main streamflow of Nanoose Creek. Lyngby's sedge, generally considered indicative of brackish conditions, has low vigor. This low vigor may be attributed to the higher salinities suggested by its associated species. The saline species (e.g., saltwort, saltgrass, saltbush, seaside plantain and seablite) occur throughout the lower elevations of the vegetated study area where they are mainly influenced by seawater. Toward the backshore, where inundation is less frequent and of short duration, the dominant species become more mesic. These species include Nootka rose, evergreen blackberry, thimbleberry, salmonberry, Canada thistle, velvet-grass, red alder, ninebark and reed canarygrass.

The plant species distribution is related to the principal physical factor, streamflow, and to human activity. The streamflows of Nanoose and Bonell Creeks are very small (Table 5) and Bonell Creek is known to dry up in the summer. This small combined streamflow appears to provide little freshwater influence in the estuary, resulting in the predominance of saline habitat as indicated by the dominance of saline indicator plants. Human activity (dyking and agriculture) appears to have altered drainage patterns and displaced natural backshore plant communities. Plant communities south of Bonell Creek drain very slowly at low tide. This drainage impediment appears to be a result of dyking and probably results in an increase in the relative salinity of the affected plant communities. The backshore is mainly used for hay crops and Phalaris arundinacea dominates one backshore field that has not been cultivated recently. Forage crops displace the more diverse, natural plant communities prominent along the streambanks of Nanoose and Bonell Creeks.

3.3.1.6 Englishman River Estuary

The emergent plant communities of the Englishman River Estuary are dominated by species indicative of brackish, saline and physiologically dry conditions. The brackish indicator species (e.g. Lyngby's sedge) occur at the lower elevations of the vegetated study areas, adjacent to freshwater. The saline indicator species (e.g., saltwort and saltgrass) also tend to occur at the lower elevations of the vegetated study area but away from the influence of freshwater. The brackish and saline growing conditions overlap where the Distichlis spicata - Carex lyngbyei Community occurs. In these areas the salinity probably increases through the growing season in relation to declining streamflow and precipitation, and increasing evapotranspiration. In this community, Lyngby's sedge is able to initiate growth and develop at the begining of the season when the salinities are lowest. Its reduced vigor suggests it is stressed by the increasing salinity. Saltgrass initiates growth after Lyngby's sedge and appears able to develop to average vigor as the salinities increase in the community. Species indicative of physiologically dry conditions (e.g., saltgrass, Baltic rush, gumweed and various grasses) occur toward the backshore where they are probably infrequent'~ and shallowly in ndated by brackish saline water.

The more mesic plant communitites in the study area occur along the main channel of the river, in the backshore and between the eastern dyke and residential area. The main channel communities are dominated by red alder, broom, evergreen blackberry and Nootka rose. The red alder community is only influenced by freshwater in the manner of most gravel bar communities. The broom, evergreen blackberry and Nootka rose community is growing on log debris which has probably elevated the substrate, resulting in improved drainage and reduced inundation. The Sonchus arvensis - Cirsium arvense and Holcus lanatus - Epilobium angustifolium communities in the backshore and within t'e dyked area are probably a result of a dyke and landfill. These appear to have eliminated tidal inundation of the areas and have facilitated their colonization by mesic species. The adjacent land, outside the dyke and unaffected by landfill, is colonized by emergent vegetation which suggests the dyked and landfilled areas might have supported emergent plant species before being altered.

The plant species distribution appears to be mainly influenced by two factors. The first is streamflow and the second is extensive human activity. The streamflow of the Englishman River today does not seem to be sufficient to maintain brackish conditions throughout the estuary. This is indicated by the prominence of saline species with increasing distance from the main flow. The distribution of the flow is influenced by the second factor, human activity. Human activity in the form of dykes, landfill, dredge spoil deposits, dredging, log handling and residential development have altered freshwater circulation in the estuary. Dykes, landfill and dredge spoil deposits tend to inhabit freshwater distribution and dredging channelizes flow. The activities have stopped with the end of log handling in the estuary and the protection of the residential development; however, their effects are still evident. Evidence for restricted freshwater circulation is found in the mesic plant communities in the dyked area and on the landfill, and in the increasing frequency of saline plants as distance from the main streamflow increases.

The Englishman River delta encompasses more area than was actually studied and was probably formed as the glaciers receded when the river's streamflow and sediment load were much greater. The study area is only a small portion of this delta; however, it appears that the marsh was larger when flows were proportionately greater. This is suggested by the presence of emergent plant species in some of the channels on the western delta. These channels may have constituted the continuum between estuarine and backshore wetlands before the western dyke was built. Now this continuum is disrupted by the dyke and the vegetation on the western delta appears to be entering mesic seral stages. The possible role of such backshore habitat within a spit and dune delta formation will be discussed under the Cluxewe River Esturary.

3.2.1.7 Little Qualicum River Estuary

The emergent plant communities of the Little Qualicum River Estuary are dominated by species indicative of brackish and saline brackish water conditions. The species indicating brackish conditions include Lyngby's sedge, cinquefoil and Baltic rush. Lyngby's sedge occurs at the lowest elevations of the vegetated study area where it is inundated on each flood tide. With increasing elevation and better substrate drainage the sedge is associated with cinquefoil. In these areas it is less vigorous than at lower elevations. With increasing elevation and relatively better substrate drainage, cinquefoil occurs with Baltic rush. At elevations where flooding is probably infrequent and of short duration, terrestrial species occur with increasing frequency. In these areas Nootka rose is the most abundant species. Nootka rose is also dominant on relatively more elevated land within the dyked areas. At lower elevations in the dyked areas grasses are abundant and reflect earlier agricultural activities. Saltgrass, the species indicating saline brackish conditions, tends to be most abundant on the left bank of the main channel.

The plant species distribution is related to the two physical factors, elevation and salinity. The first, elevation, influences the inundation: emergence ratio and substrate drainage. The inundation: emergence ratio is greater at lower elevations and lowest at higher elevations. Species viable after longer periods of submergence (e.g., Lyngby's sedge) occur at the lower elevations in the vegetated study area while species incapable of surviving long periods of inundation (e.g., Nootka rose) occur at the higher elevations. It appears that there are more species able to withstand shorter periods of submergence than there are species able to withstand longer periods of submergence. This is suggested by the increase in number of species with increasing elevation. The elevation also influences substrate drainage in that, with increasing elevation the substrate is relatively better drained at ebb tide. This allows oxygenation of the plant roots in the surface substrate. Few plant species are able to survive when their roots are in the anaerobic environment of a water saturated soil. Lyngby's sedge is one species that is apparently adapted and it is most abundant in the water saturated substrate at the lowest elevations in the vegetated study area.

The second physical factor affecting the plant species distribution, salinity, appears to be most influential on the left bank of the main channel. There the dyke inhibits flushing of the area by freshwater. Thus salts brought to the substrate surface by evaporation are concentrated in the soil; saline growing conditions result, and saltgrass is the dominant species. Through dyking, human activity has influenced the distribution of saltgrass. Other human activities have affected plant species distribution such as dredging, dredge spoil deposition, log handling and agriculture. Dredging the main river channel has probable resulted in some channelization and alteration in freshwater circulation. Dredge spoil placed on the dykes has accentuated this channelization. Also, dredge spoil deposition behind the right bank dyke has altered the inundation: emergence ratio of the plant communities by increasing the elevation. For example, the Potentilla pacifica

- Carex lyngbyei Community, between two more elevated areas colonized by the Potentilla pacifica - Juncus balticus Community and Nootka rose, dominates the southeast end of the dyke where relatively more spoil has been put. It is possible that the dredging and dredge spoil deposition activities may have been associated with main⁺a¹n¹ng ^ -'annel for log handling in the estuary. Log handling no longer occurs in the estuary. The estuary is no longer "sed for agriculture though the old farm fields, buildings and dykes are still evident. It is possible that the fields may have been freshwater wetland at one time and thus formed a continuum between estuarine wetland and upland vegetation. This is suggested by the channels in the fields and particularly the colonization of a channel by bulrush, a freshwater indicator species. This is also implied in descriptions of delta morⁿhology by Coates (1972).

The predominantly brackish water growing conditions on most of the estuary may seem incongrous with the preceding discussion of alterations in freshwater circulation due to dredging and dyking of the main channel. The maintenance of the brackish water growing conditions may be explained by the occurrence of upwelling ground water and localized water circulation patterns. The presence of water in the channels in the fields may support this view.

3.2.1.8 Big Qualicum River Estuary

The emergent plant communities of the Big Qualicum River Estuary tend to be dominated by species indicative of brackish water and brackish freshwater growing conditions. The brackish water indicator species, Lyngby's sedge, is found at the lower elevations, on finer substrates, where it is regularly inundated by tides. The two introduced species indicative of fair drainage and non-saline conditions, red clover and ribgrass, are found at relatively higher elevations on coarser substrates where they are infrequently inundated.

The plant species distribution in this estuary is closely related to two principal physical factors: elevation and soil particle size. The first physical factor, elevation, influences the inundation: emergence ratio of the species. The lower the elevation the higher the ratio and vice versa. Lyngby's sedge appears to have the highest inundation: emergence ratio as it occurs at the lowest elevations of the vegetated study area, and red clover and ribgrass appear to have the lowest inundation: emergence ratio as they occur at a relatively higher elevation in the vegetated study area. The second physical factor, soil particle size, may influence several things; the size of a species root system, fertility and the degree of substrate drainage. The root systems of the dominant plant species on the Big Qualicum River Estuary seem to be either relatively large or small. The larger rhizomatous root systems seem to exist in finer substrates but seem to have difficulty in gravels. This seems to limit distribution of Lyngby's sedge, a species normally with well developed rhizomes, on the widely distributed gravel substrates of the estuary. The dominant, short-lived species with determinant semi-tap roots (red clover (a nitrogen fixer) and ribgrass) may colonize gravel with little difficulty but are limited to relatively higher elevations by their inability to withstand inundation. The rapidity of drainage is also related to the particle size of the substrate. The larger the particle size, and the higher the elevation, the better the drainage and the drier the growing conditions. Thus more mesic plant species, such as sweet vernalgrass, tend to colonize the gravels at higher elevations of the study area.

Human activity has greatly influenced the plant species distribution on the estuary. In 1976, one year after the survey, a caterpillar tractor was used to scour the river bed downstream of the bridge and the vegetation on the river gravel bars was removed in the process (D. Morrison, pers. comm.). The establishment of the campgrounds on both river banks, or unspecified activity, required some landfull and/or substrate movement to fill old channels. No evidence of the old channels was observed. However, that channels existed in the past is implied in descriptions of delta morphology by Coates (1972), and by comparing the Big Qualicum River delta with similar deltas. These channels were vegetated with emergent plant species and represented the wetland habitat on the delta. See the discussion of the Oyster River Estuary for a comparable description of possible delta structure.

3.2.1.9 Courtenay River Estuary

The emergent plant communities of the Courtenay River Estuary are dominated by species indicative of brackish saline and brackish water conditions. The brackish saline indicator species (e.g., three-square bulrush) occurs on the southern side of Comox Harbour and the brackish indicator species (e.g., Lyngby's sedge, cinquefoil and tufted hairgrass) occur along the main channel of the Courtenay River.

This distribution of dominant plant species appears to be mainly related to the dispersal of the main streamflow in the study area. Three-square bulrush is abundant away from the main streamflow, and the influence of freshwater, while the brackish indicator species, particularly Lyngby's sedge, are most abundant adjacent to the main streamflow, where the influence of freshwater is greatest. The relatively restricted extent of three-square bulrush within a larger area of suitable salinity range is related to the elevation of the delta. The elevation influences substrate drainage which is generally insufficient for three-square bulrush over all but the most elevated areas within its salinity range.

The distribution of the dominant plant species has also been influenced by human activity involving dredging, dyking, marinas, dredge spoil deposition, landfilling, road construction, sewage treatment, an airstrip, a sawmill, agriculture and assorted urban developments. Dredging and dyking the main channel of the Courtenay River has accentuated channelization and impeded freshwater dispersal across the estuary. This is suggested by the abundance of brackish water indicator species around the main channel and their decreasing frequency of occurrence with distance from the channel. Dredging may also influence species distribution by destroying plants during marina construction. Dredge spoil deposition and landfilling may alter species distribution by increasing the elevation to a height where the affected areas may be colonized by more terrestrial plant species (e.g. milk-thistle, morning-glory, willow dock and reed canarygrass) which displace emergent plant species. Emergent plant species have also been displaced on the delta by the construction of roads, the sewage treatment plant, the airstrip, a sawmill, and assorted urban developments, and by agricultural crops. The displacement of emergent vegetation is suggested by the occurrence of emergent plants in adjacent, unaffected areas.

In the past, when the delta was not heavily developed, the emergent plant communities were probably very extensive. This is suggested by two things; first, emergent vegetation in the old channels in what is now agricultural land, and second, the large size and elevation of the delta.

3.2.1.10 Oyster River Estuary

The emergent plant communities of the Oyster River Estuary are dominated by species indicative of brackish water conditions. These species include Lyngby's sedge, Baltic rush and cinquefoil. Lyngby's sedge is generally found at the lowest elevations and Baltic rush at relatively higher elevations in the vegetated study area. Cinquefoil may be associated with either. Lyngby's sedge may also occur with wildrye, near the forest and road, and Baltic rush may also occur with saltgrass and bentgrass, near the road.

The distribution of the emergent plant species is principally related to two factors, delta morphology and human activity. The first, delta morphology or development, is related to the flow and sediment load of the Oyster River. The deltaic deposits extend from the University of British Columbia Research Farm in the northwest to the residential developments in the southwest which suggests the flow and ediment load of the Oyster River were greater as the glaciers receded. The river's present flow and sediment load seem to have a relatively limited influence on delta development. In addition, it appears that the vegetated study area is a channel that was formed when the river flow was greater. Similar channels occur in the research farm on the opposite bank of the river. It is proposed that these channels are remnants of a more extensive estuarine wetland. This estuarine wetland probably star+ed backshore of a beach berme or dune which protected it from the heavy wind and wave action it would otherwise be exposed to along the open coastline. The wetland appears to have run parallel with the shoreline and had convoluted channels. The convoluted channels wove emergent and terrestrial vegetation and forest stands into a network with two distinct results. First, more surface area was available for colonization by emergent plants. And second, the weaving of emergent vegetation stands between more terrestrial vegetation and forest stands terrestrial vegetation and forest stands provided habitat for all trophic levels. The network may also have facilitated a less perceptible influence on net primary productivity. The convoluted channels enhanced net primary productivity by making more energy sources and energy recycling opportunities available and by providing a large surface area for primary production. The second principal factor controlling the distribution of emergent plant species, human activity, also appears to be related to delta morphology in so much as the wetland backshore of a beach berme or dune is relatively easy to develop. On the south bank of the Oyster River, human activity has eliminated channels by landfilling and dredging to create a recreational resort (and possibly other unknown activities). The plant communities described occur in the remaining channel which drains into the marina through a culvert. The culvert and surrounding resort, residences and road restrict wetland use by higher trophic levels.

3.2.1.11 Campbell River Estuary

The emergent plant communities of the Campbell River Estuary are dominated by species indicative of brackish water conditions. These species include Lyngby's sedge, cinquefoil, common spike-rush and tufted hairgrass. The dominant species appear to be distributed relative to elevation; Lyngby's sedge tends to be dominant at the lower elevations, and with increasing elevations, cinquefoil and common spike-rush, and tufted hairgrass become dominant species. Sweet gale, hardstem bulrush, red alder, evergreen blackberry, broom, Nootka rose and salmonberry may be found adjacent to the forest. However, sweet gale and hardstem bulrush occur in freshwater areas where the soil is poorly drained and water saturated, possibly due to periodic flooding or the upwelling of ground water. The remaining species occur where the soil is better drained.

The plant species distribution is primarily related to two factors, elevation and human activity. Elevation influences the inundation: emergence ratio and substrate drainage. The inundation: emergence ratio is greatest at lower elevations and lowest at higher elevations. Species viable after long periods of submergence (e.g., Lyngby's sedge) occur at the lower elevations in the vegetated study area. Substrate drainage is also influenced by elevation in that, with increasing elevation the substrate is relatively better drained at ebb tide. Tufted hairgrass, cinquefoil and common spike-rush are most abundant on the better drained substrates at relatively higher elevations.

The limited distribution of the emergent plant species on the delta of the Campbell River is related to the second factor, human activity. Human activity tends to have displaced emergent plant species in almost all areas of the estuary, except on Indian Reserve No. 11. It appears that the emergent plant stands are more abundant on the Indian Reserve because the activities, dredging, landfilling, log handling, lumbering and roadways, are not as prevalent there. These activities have tended to eliminate or reduce the vigor of emergent plants in affected areas. In addition, Spit Road may be increasing the rate of succession in the plant stands south of the road as the road acts as a dyke, reducing the inundation: emergence ratio and improving the substrate drainage in the area.

3.2.1.12 Salmon River Estuary

The emergent plant communities of the Salmon River Estuary are dominated by species indicative of brackish water conditions. These species include Lyngby's sedge, tufted hairgrass, bentgrass, Kentucky bluegrass and cinquefoil. Lyngby's sedge occurs along the leading edge of the marsh and in channels. Tufted hairgrass if more frequent adjacent and backshore of the sedge stands. It is often associated with Lyngby's sedge and/or cinquefoil when it occurs near channels, and with Baltic rush and/or Kentucky bluegrass when it occurs away from channels. Bentgrass and Kentucky bluegrass are dominant towards the backshore and away from channels. The plant species associated with bentgrass and Kentucky bluegrass are more mesic with increasing distance from channels; adjacent to channels cinquefoil is the most abundant associated species. Cinquefoil generally occurs all over the marsh from approximately the midpoint in the distribution of Lyngby's sedge to the treeline. Hence, cinquefoil may be associated with many different plant species. Its vigor and abundance is greatest where the substrate is moist and the salinity is freshwater brackish.

The plant species distribution is related to two physical factors, elevation and water circulation. Elevation influences the inundation: emergence ratio and substrate drainage. On the Salmon River Estuary, Lyngby's sedge is dominant between .5 and 1.0 meter in elevation. In this elevation range it is exposed from 39 to 62 percent of the daylight hours during the growing season, and grows in water saturated soil. Basically, the sedge stands are in⁻ndated with brackish water on every flood tide.

Tufted hairgrass is dominant between 1.0 and 2.0 meters in elevation. In this elevation range it is expo⁻ed from 62 to 89 percent of the daylight hours during the growing season, and the soil is better drained than at lower elevations. The growth form of this grass facilitates its establishment. Firstly, the fibrous root system is able to anchor the tufts in the first few centimeters of relatively well drained soil. Secondly, the hummocks of grass surrounded by channels improve the rate and degree of drainage in the stand. And thirdly, the tufts direct rainfall to the roots where it decreases the soil salinity. The decline in the frequency of occurrence of tufted hairgrass with increasing elevation is possibly related to a number of factors including a smaller inundation: emergence ratio, competition from other plant species, and distance from freshwater flow.

Bentgrass and Kentucky bluegrass are dominant around 1.5 meters in elevation where they are exposed for at least 85 percent of the daylight hours during the growing season. The substrate is relatively very well drained. The grasses appear able to grow only where they are infrequently and inundated by brackish freshwater and have a very well drained soil. The infrequent inundation impedes competition from more terrestrial plant species found at higher elevations.

Cinquefoil occurs from around .8 to 2.0 meters in elevation where it is exposed from around 50 to 89 percent of the daylight hours during the growing season (Kennedy, 1978). The distribution of cinquefoil does not appear to be limited by the length of inundation as it is subdominant over a wide range of submergence times. However, it does appear to be influenced by substrate drainage and water circulation. At the lowest elevations in its distribution its stoloniforous root system allows it to become established in most shallowly drained soils. As the drainage improves with elevation its abundance and vigor increase. Away from channels and at the highest elevations within its distribution, where inundation becomes infrequent and short, and the soil is well drained, the abundance and vigor of cinquefoil declines. Cinquefoil, as earlier noted, is observed to be a species adapted to a range of growing conditions with its more vigorous growth occurring when the substrate is moist and the salinity is freshwater brackish.

The four dominant and/or subdominant plant species on the Salmon River Estuary, Lyngby's sedge, tufted hairgrass, Kentucky bluegrass and cinquefoil, also tend to be the predominant emergent plant species in brackish estuarine marshes north of Kelsey Bay. While tufted hairgrass, Kentucky bluegrass and cinquefoil can be found in brackish estuarine marshes to the south, they are more abundant and dominant in marshes north of Campbell River. This apparent increase in predominance is associated with physical factors including physiography and precipitation. The estuaries south of the Salmon River occur in the physiographic unit, the Nanaimo Lowlands, where deltaic deposits are more often sand than gravel (the gravels are usually small in size) and are extensive along sheltered coastline and in coves and bays. Estuaries north of Sayward to Kokish River occur in the Vancouver Island Ranges. Estuaries in this unit occur at the sheltered mouthes of valleys where deltaic deposits are more often gravel than sand, and the gravels are large in size. Thin layers of sand overlay the gravels toward the backshore. In general, the estuaries north of Sayward have more gravel in the substrate and are not as large as estuaries to the south. Also, in general, precipitation increases towards the north (see Table 4). The physiography and precipitation appear to influence the abundance and dominance of plant species in four ways. Firstly, the smaller the estuary the less diverse the habitat and the fewer associated plant species. Secondly, gravels may impede the growth of rhizomatous plants (e.g., Lyngby's sedge) while fibrous and/or shallow rooting species (e.g., tufted hairgrass, Kentucky bluegrass and cinquefoil) grow more easily between and around rocks. Thirdly, gravels are better drained soils resulting in more aerobic growing conditions for roots. Fourthly, the higher precipitation tends to wash salts out of the surface substrates and is assisted in this by the relatively good drainage in gravelly soils. Thus, soil salinities are generally lower in estuaries north of Sayward and more glycophytes occur, and are more extensive, in these northern estuaries.

3.2.1.13 Adam-Eve Rivers' Estuary

The plant communities of the Adam-Eve Rivers' Estuary are dominated by species indicative of brackish and saline conditions. The species indicating brackish conditions, Lyngby's sedge and tufted hairgrass, are dominant in areas adjacent to the river. Saltwort, seaside plaintain and arrow-grass, species indicative of saline conditions, are dominant at the lower elevations of the vegetated intertidal zone and on the eastern portion of the delta. The dominant species towards the backshore of the western portion of the delta are Kentucky bluegrass, cinquefoil, Sitka spruce and western hemlock, while towards the backshore of the eastern portion, the dominant species are tufted hairgrass, saltwort, wildrye and Sitka spruce.

The plant species distribution is related to the two principal physical factors, the rivers' discharge during the growing season and delta morphology. No dischare figures are available for the Adam or Eve Rivers, however, the dominance of saltwort along the leading edge of the marsh indicates salinities are relatively high in this area during the growing season. High salinities suggest the marine influence is greater than the freshwater influence. This is the small creek crossing the eastern portion of the delta appears to have an intermittent flow. In areas of low flow or limited freshwater influence, particularly at the lower elevations of the vegetated study area, the marine influence dominates, salinites are relatively higher, and species tolerant of higher salinities (e.g., saltwort, seaside plantain) occur. Delta morphology also appears to influence the tendency towards higher salinities. The right bank at the mouth of the river inhibits freshwater flow across the eastern portion of the delta. Reduced freshwater flow across this area heightens marine influence, and increases salinities. The extent of the marsh also appears to be a function of delta morphology. The marsh on the eastern portion of the delta probably exists due to protection afforded it by the right bank of the river, island and small spit of land along its foreshore. The marsh is extensive throughout the protected portion of the delta. The western portion may not be as extensively vegetated for two reasons. Firstly, exposure of the western delta to wind and water energy may inhibit accretion at the lower elevations which tends to result in low exposure: inundation ratios unsuitable for plant species establishment. Secondly, emergent plants tend to colonize gravels with difficulty and are probably dislodged by wind and waves at the lower elevations.

Human activity, in the form of log handling on the western portion of the delta, may emphasize some of the physical factors influencing plant species distribution. It is possible that the log handling site encourages the river to flow principally in the existing main channel instead of diffusing across the marsh. The river is situated so that it would appear to have run through the log sort area at one time. Old channels at the south end of the log sort further this suggestion. Restricted freshwater flow across the marsh increases the tendency towards higher salinities. Another result of log handling is the accumulation of beached logs on the backshore of the eastern portion of the delta. The logs have tended to increase the elevation which improved the substrate drainage and created conditions more suitable for the establishment of wildrye and Sitka spruce.

3.2.1.14 Tsitika River Estuary

The emergent plant communities of the Tsitika River Estuary are dominated by species indicative of brackish water conditions. These species include Lyngby's sedge and tufted hairgrass. Lyngby's sedge is found on sandy substrates at the lower elevations of the vegetated study area. Tufted hairgrass is found on gravel at lower elevations and on sandy substrate at higher elevations. At the treeline, plant communities are dominated by wildrye, cow-parsnip, giant vetch and Sitka spruce seedlings when log debris is present. When it is absent the dominant plants are springbank clover, yarrow, arrow-grass and velvet-grass.

The plant species distribution is related to two principal physical factors, elevation and substrate. At lower elevations Lyngby's sedge and tufted hairgrass dominate; Lyngby's segdge in sandy substrates and tufted hairgrass in gravel. These species are adapted to the higher inundation: emergence ratio at this elevation, however, the rhizome of Lyngby's sedge colonizes sand more readily than gravel substrates, and tolerates water saturated soils better than tufted hairgrass, which colonizes and grows fairly vigorously on the better drained gravels (details discussed previously). The wildrye, giant vetch, Sitka spruce and cow-parsnip in log debris along the treeline are at an elevation where the substrate is relatively well drained and otherwise suitable for colonization by trees. However, infrequent flood tide conditions can cause the log debris to move and dislodge seedlings. Wildrye is able to survive the infrequent flooding and log movement, and becomes established. Log debris has not accumulated on the delta's central lobe and there the forest is bordered by springbank clover, yarrow, arrow-grass and velvet-grass. Another physical factor that appears to be a parameter in the plant species distribution, particularly on the eastern lobe of the delta, is streamflow. As present, the main flow of the Tsitika River is in the eastern channel and during high water the river erodes the eastern lobe (pers. observation based on site inspections in 1974 and 1976). The dominant species on the eastern lobe is tufted hairgrass which grows in hummocks. The hummocky growth pattern is considered to give less resistance to running water and may result from it. In areas of high water energy on other estuaries tufted hairgrass has also been observed to grow in hummocks.

3.2.1.15 Kokish River Estuary

The emergent plant communities of the Kokish River Estuary are dominated by species indicative of brackish and saline conditions. The species indicative of brackish conditions, Lyngby's sedge, tufted hairgrass and cinquefoil, are located west of the railway, at the river mouth. Their distribution and the principal physical factors influencing their distribution are discussed in detail elsewhere (see discussion section for each species and Salmon River Estuary). The species indicative of saline conditions, saltwort, seaside plantain, saltgrass and saltbush, are dominant east of the railway. This eastern portion of the study area is bounded by a railway bed on the west and north, a landfill on the east, and the forest on the south. The area is encircled except for a seaward opening through which sea water circulates. The saline water condition, the principal physical factor governing the distribution of the species in the eastern portion of the estuary, appears to be influenced by human activity. This human activity is associated with the rail movement of logs to the log sorting area along the foreset beds of the delta. The railway bed inhibits freshwater flow to the east and therefore tends to promote the predominantly saline conditions there. However, brackish conditions may be found around two channels in this area. The dominance of Lyngby's sedge, a brackish water indicator species, along the channels suggests that the channels carry some freshwater. Since the estuary was surveyed in 1975 a dryland sort has replaced the water sort and outmoded the railway encircling the eastern half of the estuary. Freshwater flow to this half of the estuary could be improved by breaching the railway bed where the two channels used to flow from the river. It is expected that this would reduce the salinity and increase the vigor and abundance of the brackish water plant species. With modifications to the area's three openings, to control water quality and create an enclosure, the eastern half of the estuary might be used to rear salmonids (pers. comm. Dr. M. Brownlee).

3.2.1.16 Nimpkish River Estuary

The emergent plant communities of the Nimpkish River Estuary are dominated by species indicative of brackish water conditions. These species include tufted hairgrass, cinquefoil and Lyngby's sedge. Their distrib^ution and the principal physical factors influencing their distribution are discussed in detail elsewhere (see discussion section for each specie and Salmon River Estuary). At lower elevations, spike-rush is a dominant species and, at higher elevations on the two islands, Sitka spruce, Nootka rose, gooseberry and wildrye are dominant. On the south bank a freshwater marsh is dominated by sweet gale.

The principal physical factors influencing the distribution of these species are the inundation: emergence ratio and salinity. Favorable growing conditions for spike-rush are a relatively small inundation: emergence ratio and a brackish freshwater salinity range where the substrate is sandy. Sitka spruce, Nootka rose and gooseberry grow on well drained substrates where they are infrequently and then only shortly inundated and the salinity is brackish freshwater. On the downstream island the species are encircled by wildrye which probably provides some protection from salt spray. Wildrye is also dominant along the exposed south bank of the river. The grass seems to require growing conditions originating, on the Nimpkish River Estuary, from a combination of three factors, a very well drained gravel substrate, infrequent, short inundation, and salinity from salt spray. Behind the wildrye community, towards the backshore on the south bank, is a marsh where sweet gale grows in standing freshwater. Water collects in a depression which may be an old river channel or may be the result of earlier activity relating to logging. Human activity, particularly logging, has had other influences on the estuary. The abundance of alien species such as velvet-grass, orchard grass, timothy and crested dog's tail, suggest the area has been disturbed. Indeed, the streambed gravel distribution, and shape and size of the downstream island indicate past substrate alteration, possibly in conjunction with log movement. The presence of what appears to be an old log dump (see 0 on Figure 19) on the south bank lends some credence to this observation.

3.2.1.17 Cluxewe River Estuary

The emergent plant communities of the Cluxewe River delta are dominated by species indicative of brackish and saline conditions. Species indicative of brackish water conditions are most abundant on the eastern corner of the delta, at the river mouth, and include Lyngby's sedge, tufted hairgrass and cinquefoil. Their distribution and the principal physical factors influencing their distribution are discussed in detail elsewhere (see discussion section for each species and Salmon River Estuary). Species indicative of saline water conditions are most abundant west of the river mouth and include saltwort and arrow-grass. These species are mostly screened from the sea by a gravel berme which is colonized by Sitka spruce and wildrye. On a high tide, the saltwort and arrow-grass are covered with saltwater that enters the low land through a breach in the berme. The berme protects the western delta from the destructive wave and wind energy of the sea thus promoting the establishment of plants. However, it also impedes freshwater flow from the Cluxewe River which tends to increase the salinity range. The higher salinities are tolerated best by saltwort and arrow-grass. The east corner of the western delta is dominated by grasses rather than saltwort and arrow-grass. This is probably a natural situation which has been enhanced by previous attempts at draining the area. Old dykes and drainage ditches appear to have improved drainage and reduced the frequency and extent of inundation in the east corner and cinquefoil, tufted hairgrass, Kentucky bluegrass, meadow barley and wildrye are dominant there probably in response to the improved drainage and lower inundation: emergence ratio. The dominance of meadow barley and wildrye suggest the substrate salinity may be high, particularly in the latter half of the growing season, and may be considered indicative of physiologically dry growing conditions. Xerophytic growing conditions relating to good substrate drainage, saltspray and infrequent flooding influence the dominance of Sitka spruce and wildrye on the gravel berme.

It is proposed that the delta of the Cluxewe River reflects the kind of delta morphology that existed at the mouths of the Englishman, Little Qualicum, Oyster, and Campbell Rivers before human intervention. All the rivers appear, in an earlier time, to have flowed parallel to responses, both past and present, which characterize depositional areas of the east coast of Vancouver Island.

The physical similarities between the five aforementioned deltas may not be evident. The only apparent characteristic common to the Englishman, Little Qualicum, Campbell and Cluxewe deltas appears to be their spits. The Englishman and Cluxewe deltas have bermes as well as spits, and the Little Qualicum and Campbell deltas do not. The Oyster delta is not similar to the others in that it does not have either spits or bermes. However, it appears that the Oyster delta has had bermes. Convoluted channels on the Oyster River delta run parallel and backshore of a treed strip of land. This treed strip is considered to be an old berme. The basis for this conclusion is the similarities, in channelization pattern and location of channels, between the Cluxewe and Oyster Rivers' deltas. It is surmised that the morphology of the Big Qualicum River delta was once like that of the Oyster River delta. The reasons for this are its similar location on an open coastline and dark areas on air photographs. These dark areas are long and narrow and parallel with the shoreline which suggests old channels.

While the convoluted channelization patterns, river flow parallel to the shoreline, spits and bermes suggest low flows, the extensive deltaic deposits at each river mouth suggest large flows. This is not considered contradictory. Instead, it is considered indicative of a general trend toward smaller flows. It is thought that as the glaciers the shoreline before entering the sea, and the convoluted channels on the western delta of the Cluxewe River are thought to exemplify the channelization pattern associated with this parallel flow. It appears that the rivers flowed parallel to the shoreline because their energy was not great enough to overcome the opposing energy of the sea and flow into it. Instead, the sea forced the rivers to flow along the shoreline until they reached a breakout point. This might mean that a river flowed into the waves from behind a spit. A spit and/or berme are associated with each of the above rivers, and provide each river delta with some protection from the wind and wave energy of the sea. A berme is a nearly horizontal portion of the beach or backshore formed by the deposit of material by wave action. Suspended material in the river settles out upon contact with saltwater. Where the river's current is strong it carries suspended material into the sea forming a fan shaped delta, and where the current is not strong the material settles out of suspension along the shoreline at an elevation corresponding with the tide line. When the river breaks through the berme a spit and berme or pair of bermes result. The formation of spits and/or bermes at the mouths of the Englishman, Little Qualicum, Oyster and Campbell Rivers probably occurred at some time in the past, when the amount of suspended material in the rivers was higher, and their water energy was lower than the sea's. Presently, the spits and bermes appear to be maintained by longshore drift. Hale and McCann's ongoing work on the coastal geomorphology and dynamics of the Georgia Strait coastline is expected to detail the processes involved in the evolution of coastal units such as spits and bermes. It is anticipated that their work will clarify concepts of coastal processes and that as the glaciers receded the rivers' flow and suspended material were great enough to build the large deltas and then declined until the rivers' did not have the energy to flow into the sea. Hence, spits and bermes were formed. Large flows are considered to have preceded smaller flows. If it was the other way around, large flows would have eradicated the spits and bermes. Flows now are probably relatively slightly greater than when the spits and bermes were formed.

The morphology of the Englishman, Little Qualicum, Big Qualicum, Oyster, Campbell and Cluxewe Rivers' deltas encourages development for two reasons. Firstly the large, flat deltas offer ample space for human activity. The second is that it is relatively easy to dyke, drain and landfill channels surrounded by forest and protected from the elements by spits and bermes. The degree of development varies from delta to delta but in general those deltas with just bermes, (e.g., the Big Qualicum and Oyster Rivers' deltas), and the southern estuaries subject to the greatest population pressures exhibit the most extensive alterations. The concept of "extensive alterations" being relative to the total deltaic land area.

3.2.1.18 Quatse River Estuary

The emergent plant communities of the Quatse River Estuary are dominated by species indicative of brackish and saline conditions. These species include Lyngby's sedge, tufted hairgrass, colonial bentgrass, cinquefoil, saltwort and arrow-grass. The distribution of the specie indicating brackish conditions, and the principal physical factors influencing their distribution are discussed in detail elsewhere (see discussion sections for each species and Salmon River Estuary). The species indicating saline conditions occur at the lowest elevations in the vegetated study area and away from the influence of freshwater. Towards the backshore, grasses are dominant at lower elevations, and trees and shrubs are dominant at higher elevations, particularly on and adjacent to the roads and dykes.

Elevation appears to be the principal physical factor influencing the distribution of the emergent plant species on the Quatse River Estuary. With increasing elevation drainage improves and, in association, the plant species progress from saltwort to Lyngby's sedge; arrow-grass to Lyngby's sedge; tufted hairgrass to tufted hairgrass and colonial bentgrass; cinquefoil to grasses; to shrubs and forest. This natural progression has been interrupted by the road, dykes and industrial park construction. The road and dykes have improved drainage to their south encouraging the establishment of more terrestrial plant species (e.g., red alder, salmonberry and velvet-grass) which displace emergent species. The landfilling and earth moving for the Industrial Park have buried and removed other vegetation.

The soil salinity is a secondary physical factor warranting comment. On the Quatse River Estuary, the salinity appears to be related to elevation and precipitation. During the growing season the limited freshwater flow results in a predominantly marine influence, particularly at the lowest elevations where the soil is probably always saturated. There it is saline and saltwort dominates. As the elevation increases, the drainage improves and precipitation dilutes the salts, reducing the soil salinity. Lyngby's sedge, tufted hairgrass and other specie indicating brackish conditions occur in this area.

3.2.1.19 Kingcome River Estuary

The emergent plant communities of the Kingcome River Estuary are dominated by species indicative of brackish conditions. These species include Lyngby's sedge and tufted hairgrass. The distribution of the species and the principal physical factors influencing their distribution are discussed in detail elsewhere (see discussion sections for each species and Salmon River Estuary).

Unfortunately time and conditions precluded an exhaustive survey of the delta. Where possible, areas that were not examined in the field were typed from aerial photographs. These and areas that could not be typed are indicated by a question mark. All questionable areas are thought to be dominated by species from the Grass Family.

Two observations relative to the Kingcome River Estuary are worthy of comment. The first is the presence of freshwater indicator species, spike-rush and willow. Spike-rush stands are found along the leading edge of the vegetation and willow stands on midstream islands. The freshwater growing conditions required by spike-rush are probably prevalent during the growing season, when the river is in freshet. During the remainder of the year, the river flow is probably great enough to keep the salt wedge from penetrating to the willow stands on the midstream islands. The mean annual 2000 mm of precipitation in the region also help keep salinities low. The spring freshet and predominant freshwater conditions year-round on the Kingcome River Estuary are almost opposite to conditions in estuaries on the east coast of Vancouver Island. There the rivers are in freshet in the winter, usually December or January, and salinities are highest in the growing season when flows and precipitation are low.

The second observation is the relatively small number of species found on the estuary. On the Kingcome River Estuary, 42 plant species in six communities cover 145 hectares. The plant communities on the Salmon River Estuary cover a comparable area but have twice the number of plant species as those on the Kingcome River Estuary. On the Nanaimo River Estuary, the plant communities cover a little more than one-third of the area covered by communities on the Kingcome River Estuary yet have twice the number of plant species. The difference is considered to be related to two physical factors, sedimentation and water energy. The Kingcome River delta is accreting and estimated suspended sediment concentrations for the river are two, four and, in some instances, four hundred times greater than estimates for rivers on the east coast of Vancouver Island. This sediment covers plants, interfering with light absorption for photosynthesis, and may bury plants. Only the hardiest plants (e.g., Lyngby's sedge and tufted hairgrass) have a chance of growing under these conditions. Growing conditions are made more adverse by the river's energy. It is great enough at times to cut many, two meter deep channels through the southern, U-shaped island. These channels are so numerous that they may be encountered with every step in the tufted hairgrass community. Such water energy is capable of uprooting all but the most firmly rooted plants (e.g., Lyngby's sedge and tufted hairgrass) further limiting the number of plant species capable of becoming established on the delta.

3.3.2 Dominant Plant Species

The previous discussion is based on the dominant plant species of communities as indicators of their growing conditions (Clements, 1939). For example, on the basis of the dominance of saline indicator species on the Goldstream, the Goldstream is 1. a salt marsh, 2. grou~ed with the Chemainus and Nanoo e-Bonell salt marshes, and 3. has three principal physical factors (large size of delta, low streamflow and low precipitation) influencing the distribution of its plant communities. As so much of the discussion is based on the dominant plants as indicators of their growing conditions an explanation of the physical factors influencing the growth of the dominant plant species was useful.

Another reason for the discussion of the dominant species in the communities is man's lack of familiarity with estuarine plants. Estuarine vegetation in its natural form is not much used by mankind partly because the vegetation is in~ndated much of the time and human movements are very restricted. It therefore seemed useful to discuss the dominant species which characterize the estuaries and this discussion follows.

Acer macrophyllum Pursh, Fl. (broadleaf maple) Native tree

Broadleaf maple is a tree of lowlands, or bottomlands where permanent seepage has the soil wet for most of the vegetative season (Krajina, 1969/70). The presence of subsurface water flow indicates medium to very rich nutrient regimes due to the influx of nutrients in the seepage water (Klinka, 1977). Broadleaf maple is a subdominant in the Quercus garryana - Acer macrophyllum community on the Nanaimo River Estuary. Man's activities may have substantially reduced this maple on other estuaries for it is often associated with soils used for agricultural purposes.

Achillea millefolium L. (yarrow) native herb

Yarrow, as a compositous herb, has some salt tolerance. It usually occurs on well drained sites which are inundated for only short periods of time and may be found in association with grasses and cinquefoil. It is present on almost all estuaries and is a dominant or subdominant on the Cowichan, Nanoose-Bonell, Englishman, Salmon, Tsitika and Cluxewe Rivers' Estuaries. Yarrow might be dominant on more estuaries if more backshore areas remained.

Agropyron repens (L.) Beauv. (couch grass) introduced from Europe

Couch grass develops and reproduces in the latter half of July through September, on well-drained sites that tend to be inundated for relatively short periods of time. It seems to grow under physiologically dry conditions. The species life history, tendency towards well-drained sites, relatively short inundation period, and associated species suggest this. It is a dominant and/or subdominant on the Cowichan, Nanaimo, Englishman, Salmon and Adam-Eve Rivers' Estuaries. Some of the specimens collected appear to be a hybrid of Agropyron repens and Elymus glaucus.

Agrostis alba L. (bentgrass)	native and introduced, genotypes, temperate Eurasia and North America.
Agrostis alba var. stolonifera L. (bentgrass)	
Agrostis tenuis Sibth. (Colonial bentgrass)	

Bentgrasses tend to occur in the more elevated or backshore areas where the substrate is relatively well-drained and inundation, generally, is for only short periods of time. They are usually found in association with other grasses and forbs. Agrostis alba is a dominant and/or subdominant on the Goldstream, Nanoose-Bonell, Englishman and Oyster Rivers' Estuaries. Agrostis alba var. stolonifera is a dominant and subdominant on the Salmon River Estuary and Agrostis tenuis is a dominant and/or subdominant on the Nanaimo, Kokish, Cluxewe and Quatse Rivers' Estuaries.

Alnus rubra Bong. (red alder) native tree

Red alder, a pioneer species, is generally found in the lowlands to hills along the east coast of Vancouver Island. In the estuaries it may occur in the backshore where the soil nutrient regime is medium to very rich and there is permanent seepage or a very high water table. It is a dominant and/or subdominant on the Englishman, Campbell and Quatse Rivers' Estuaries.

<u>Anthoxanthum</u> <u>odoratum</u> L. (sweet vernalgrass) introduced

Sweet vernalgrass may be found on very well-drained sites such as shallow soil over gravel or over bedrock. It is almost never inundated but may be exposed to salt spray. It is a subdominant on the Little Qualicum, Big Qualicum and and Cluxewe Rivers' Estuaries.

<u>Arbutus</u> <u>menziesii</u> Pursh. (arbutus) native tree

Arbutus is a subdominant on the Shoal Islands in the Chemainus River Estuary. Here the forest is dry and the soil well drained, often shallow and nutrient poor with low supplies of calcium and magnesium. Arbutus is restricted to very well drained sites; never far from salt water, it is believed to be the most frost susceptible tree in Canada (Krajina 1969/70).

<u>Aster</u> <u>hesperius</u> Gray (marsh aster) native herb

Marsh aster occurs where conditions are physiologically dry. On the Goldstream Estuary, marsh aster grows in the relatively more elevated areas nearer the backshore. There the substrate is relatively well-drained, infrequently inundated, and possibly slightly saline.

Atriplex patula L. (saltbush) native herb

Saltbush is indicative of saline or brackish conditions. It is usually most frequently found in the lower vegetated intertidal zone where it is regularly inundated. Saltbush may range over silty sand to peaty soils. It is a subdominant on the Cowichan River Estuary, and a dominant on the Nanaimo and Kokish Rivers' Estuaries.

Barbarea orthoceras Ledeb. (wintercress) introduced herb

Wintercress is a dominant on the Cowichan River Estuary. Its presence suggests a disturbed site such as the substrate sloughed from a dyke on the estuary. It occurs on well-drained substrates which are not inundated. Other species, also indicative of dry, well-drained areas, which occur with wintercress include; Nootka rose, evergreen blackberry, white clover, Canada thistle and sour weed.

Bromus carinatus H. & A. (brome-grass) native

Brome generally occurs in the backshore, away from major channels. Here it is inundated for relatively short periods of time and then probably by only relatively slightly brackish freshwater. On the Salmon River Estuary, where it is a dominant, it may be exposed from 85 to 90 percent of the daylight hours during the growing season (Kennedy, 1978). It occurs on better drained substrates with Kentucky bluegrass, white clover, ribgrass and hairy cats-ear.

Bromus mollis L. (soft brome-grass) introduced

Soft brome is a subdominant on the Little Qualicum River Estuary. It may be found on well-drained fine gravel substrate behind dykes. It is not inundated but may be subject to salt spray. It is associated with other species commonly found on such dry sites, including; Nootka ro~e and sweet vernalgrass.

Carex lyngbyei Hornem. (Lyngby's sedge) native

Lyngby's sedge has a high frequency of occurrence on the nineteen estuaries studied being a dominant on all and a subdominant on eleven of the estuaries. It may also be present in other estuarine communities. It is generally found at the lower elevations of the vegetated intertidal zone where it has a low exposure, high inundation ratio. On the Salmon River Estuary, Lyngby's sedge occurs between .5 and 1.0 meter in elevation where it may be exposed from 39 to 62 percent of the daylight hours during the growing season (Kennedy, 1978). At the lower elevations of its distribution Lyngby's sedge grows in anaerobic, water saturated soil. This is possible due to the transport of air from above to below ground organs where it forms a layer around the roots and rhizomes reducing the anaerobic conditions at the organ's surface. As the relative elevation increases, moving towards the backshore, the substrate becomes better drained, at least the first few centimeters, and the number and frequency of plant species occuring with Lyngby's sedge increase. The species associated with it tend to be stoloniferous (eg. cinquefoil) or shallow, fibrous rooting species (eg. sea-milkwort) and use the upper few centimeters of relatively better drained substrate. As site conditions vary associated species vary. At sites tending towards higher salinites Lyngby's sedge may occur with saltgrass or saltwort and on sites with a relatively better drained substrate it may occur with tufted hairgrass. In general, Lyngby's sedge is indicative of brackish water conditions and it usually occurs at the lowest vegetated elevation and along major channels where it is flushed by brackish water. Further study is required to determine if Lyngby's sedge generally lines major channels because it requires flushing by brackish freshwater or because channel levees are of an optimal elevational range and close to the modifying influence of freshwater.

Carex obnupta Bailey (slough sedge) native

Slough sedge is a dominant on the Nimpkish River Estuary. It occurs in the more elevated areas of the estuary, usually in water saturated soils, where it is inundated for short periods of time by brackish water.

Carex rostrata Stokes (beaked sedge) native

Beaked sedge is a dominant on the Cluxewe River Estuary. It occurs with Lyngby's sedge in a pool of running water adjacent to the treeline. It is indicative of freshwater conditions but is tolerant of slightly brackish conditions.

Chenopodium album L. (pigweed) introduced herb from north temperate Eurasia

Pigweed is a subdominant on the gravel fill in front of the Nature House on the Goldstream Estuary. It is often found on dry, well-drained, disturbed sites such as around the Nature

House. Associated species are also those of disturbed sites, including: willow dock, ribgrass, broom, hairy cats-ear, common thistle and Canada thistle.

<u>Cirsium arvense</u> (L.) Scop. (Canada thistle) introduced herb from northern Eurasia

Canada thistle, a strongly rhizomatous species, is a species of disturbed sites. On the Englishman River Estuary, where it is a subdominant, it may be found in the backshore and within a dyked area. The backshore appears to have been altered by human activity, possibly dyking and/or log handling. It is extensively distributed in the dyked area because the area is relatively well drained and not tidally inundated. The presence of Nootka rose, elderberry, evergreen blackberry, broom, milk-thistle, groundsel, common thistle, velvet-grass and cheat with Canada thistle suggests the area is tending towards "old field" communities. It is likely that this area would have been flooded before the dyke was constructed, as indicated by the channels in the dyked area and the flooding of comparable, adjacent land outside the dyke. Without the dyke Canada thistle would not be a subdominant in this area.

<u>Cytisus scoparius</u> (L.) Link (broom) introduced shrub

Broom, an introduced species that displaces native species, is a subdominant and/or a dominant on the Goldstream, Chemainus, Nanaimo, Englishman and Campbell Rivers' Estuaries. It is often distributed through man's activities and may become established in disturbed areas, or along dykes, railways and roads, or around buildings on estuaries. Broom occurs on relatively well-drained substrate that is not inundated. It has some tolerance of salt spray.

Dactylis glomerata L. (orchard-grass) introduced from northern Europe cultivar

Orchard-grass is a dominant on the Salmon River Estuary and a subdominant on the Cluxewe River Estuary. It is most often found toward the backshore where the substrate is relatively well-drained and inundation is probably shallow, for a short period of time and of a more freshwater condition.

Deschampsia cespitosa (L.) Beauv. (tufted hairgrass) native

Tufted hairgrass , a circumboreal species, is a dominant and/or a subdominant on twelve of the estuaries studied, including; the Cowichan, Nanaimo, Courtenay, Campbell, Salmon, Adam-Eve, Tsitika, Kokish, Nimpkish, Cluxewe, Quatse and Kingcome Rivers' Estuaries. The frequency of occurrence of tufted hairgrass appears to be greater in estuaries north of Courtenay and on the Kingcome River Estuary. The fibrous rooted grass grows in dense, low tufts on relatively well-drained silted sands and gravels, and may be inundated on each tide by brackish water. The fibrous root system is better suited than a rhizomatous root system for growth in coarser substrates. On the Tsitika River Estuary, tufted hairgrass is the dominant species on two to four inch gravel while the rhizomatous Lyngby's sedge is the dominant species on an adjacent sand substrate. Another factor possibly influencing the distribution of tufted hairgrass is suggested by the simple linear correlation analysis. The correlation coefficient between the total area on which tufted hairgrass is either a dominant or a subdominant and the April to September mean rainfall for each estuary was significant; $r=.7606$ $r_{0.05(2),6} = 0.707$ ($n=8$) (Table 45). The interaction may be related to growth habit and precipitation. The caespitose nature of the plant directs rain to the root system where it may decrease the salinity around the roots and hence increase vigor. The interaction of anatomical features, substrate and precipitation and their influence on the distribution of tufted hairgrass requires further study.

Distichlis spicata (L.) Greene (saltgrass) native

Saltgrass is a subdominant and/or a dominant on the Goldstream, Cowichan, Chemainus, Nanaimo, Nanoose-Bonell, Englishman, Little Qualicum, Oyster, Salmon and Kokish Rivers' Estuaries. It has a higher frequency of occurrence on estuaries south of Courtenay where flows are low during the growing season (eg. Nanoose-Bonell) and in estuarine areas where freshwater flow is restricted, for example, by dykes (eg. Cowichan). It is usually inundated on each tide and is indicative of higher salinities though it may occur in brackish conditions. Associated species may reflect variations in site conditions. For example, on the Chemainus River Estuary, the Distichlis spicata - Salicornia virginica Community is found on a relatively wet, poorly drained, peaty soil and the Distichlis spicata -Grindelia integrifolia Community is found on a better drained soil.

Eleocharis palustris (L.) R. & S. (Spike-rush) native

Spike-rush is a subdominant and/or a dominant on the Little Qualicum, Courtenay, Campbell, Salmon and Nimpkish Rivers' Estuaries. It is generally found at relatively high elevations toward the backshore where it is shallowly inundated on each tide. It is a brackish freshwater species.

Elymus glaucus Buck. (blue wildr e) native

Blue wildrye is a dominant on the Salmon River Estuary. It is prominent in the latter half of the growing season relatively well-drained sites that are inundated for relatively short periods of time by brackish freshwater.

Elymus mollis Trin. (wildrye) native grass

Wildrye is a dominant on the Cowichan, Nanoose-Bonell, Englishman, Little Qualicum, Oyster, Salmon, Adam-Eve, Tsitika, Kokish, Nimpkish, Cluxewe and Kingcome Rivers' Estuaries. It is a subdominant on the Courtenay, Cluxe-e and Kingcome Rivers' Estuaries. Wildrye is generally found toward the backshore, adjacent to treelines, on beach bermes or elevated areas, such as wood debris piles. The substrate is usually well drained and very sandy. Wildrye is in-ndated infrequently and tolerant of salt spray. Associated species indicate a tendency toward more terrestrial habitat. These associated species include Sitka spruce, elderberry, salmonberry, willow dock and reed canarygrass.

Epilobium angustifolium L. (fireweed) native herb

Fireweed is a dominant in a dyked area of the Englishman River Estuary. The area is not inundated and is relatively well drained compared to adjacent, undyked land. The dominance of fireweed, a terrestrial, pioneer species, suggests the dyked area is becoming colonized by terrestrial plant species.

Fritillaria camschatcensis (L.) Ker.-Gawl. (chocolate lily) native

Chocolate lily may be found on a number of the estuaries studied but it is a subdominant on the Salmon River Estuary. It occurs on relatively elevated, well-drained substrates where it is emergent from 85 to 90 percent of the daylight hours during the growing season (Kennedy, 1978). Its higher frequency of occurrence on the Salmon River Estuary is probably due to the abundance of relatively elevated and well-drained areas.

Gaultheria shallon Pursh (salal) native shrub

Salal is dominant in the backshore area between a creek and slash burn on the Quatse River Estuary. Salal is an understory species of coastal forests and forest margins. Possibly the Gaultheria shallon community colonizes the area because it is relatively well drained and not inundated.

Glaux maritima L. (sea-milkwort) native herb

Sea-milkwort is a dominant on the Cowichan, Englishman and Salmon Rivers' Estuaries and a subdominant on the Cowichan, Nanaimo and Adam-Eve Rivers' Estuaries. It is generally found at the lower elevations of the vegetated intertidal zone where, on the Salmon River Estuary, it may be exposed for 39 percent of the daylight hours during the growing season (Kennedy, 1978). It is found in brackish to saline water conditions as suggested by associated species such as Lyngby's sedge, an indicator of brackish water conditions, and saltwort, an indicator of saline water conditions. It occurs on sandy and sandy gravel substrates.

Glyceria occidentalis (Piper) Nels. (western mannagrass) native grass

Western mannagrass is a dominant on the Courtenay River Estuary. It occurs towards the backshore where it is infrequently inundated by freshwater. The associated species are terrestrial plants and include hairy cats-ear, Canada thistle, miner's lettuce, common horsetail, field mint and meadow fescue.

Grindelia integrifolia DC. (gumweed) native herb

Gumweed is a dominant on the Chemainus, Nanoose-Bonell, Englishman and Salmon Rivers' Estuaries and a subdominant on the Nanaimo and Englishman Rivers' Estuaries. It may be inundated regularly by saline to brackish water. The substrate is relatively well drained and saline.

Heracleum lanatum Michx. (cow-parsnip) native herb

Cow-parsnip is a dominant on the Little Qualicum, Salmon, Tsitika and Kokish Rivers' Estuarie~ and a subdominant on the Cluxewe and Kingcome Rivers' Estuaries. It occurs in the ecotone between marsh and forest, or beach berme and forest, and is a species of a damp to wet substrate. It is infrequently inundated and then by freshwater.

<u>Holcus</u> <u>lanatus</u> L. (velvet-grass) introduced from northern Europe

Velvet-grass is a dominant on the Englishman and Quatse Rivers' estuaries and a subdominant on the Cowichan and Tsitika Rivers' Estuaries. It is a freshwater species that is infrequently inundated, and grows on relatively well drained substrates. On the Tsitika River Estuary it occurs in the backshore, adjacent to the forest. On the Cowichan, Englishman and Quatse Rivers' Estuaries it occurs within dyked areas and on landfill. Associated species include colonizers of disturbed sites.

<u>Hordeum</u> <u>brachyantherum</u> Nevski (meadow barley) native grass

Meadow barley is a dominant and a subdominant on the Goldstream and Kokish River Estuaries, and a dominant on the Salmon, Adam-Eve and Cluxewe Rivers' Estuaries. It may be shallowly inundated by brackish to saline water as indicated by associated species such as tufted hairgrass, an indicator of brackish conditions, and saltwort, an indicator of saline conditions.

<u>Hordeum</u> <u>murinum</u> L. (mouse barley) native grass

Mouse barley is a dominant on the Goldstream Estuary and a subdominant on the Englishman River Estuary. It is a brackish water species but appears to tolerate relatively high salinities as indicated by the associated species saltwort, saltbush and saltgrass. Mouse barley is usually found on a wet substrate and is inundated regularly by brackish to saline water.

Juncus articulatus L. (jointed rush) native

On the Nanaimo River Estuary, jointed rush is a dominant and a subdominant in 50.7 percent of the emergent vegetation. It rarely occurs on the other estuaries studied. Baltic rush, which may have a high frequency of occurrence on other estuaries, only covers 4.8 percent of the emergent vegetation on the Nanaimo River Estuary. The reasons for the dominance of jointed rush on this estuary are not clear though previous agricultural practises may have influenced its distribution. It occurs in dense stands and is extensive on the estuary. The substrate is wet. Possibly old dykes and very shallow depressions in the areas established to this species impede drainage. The associated species indicate jointed rush occurs in brackish to saline conditions. Associated species indicating brackish conditions are Lyngby's sedge, tufted hairgrass and cinquefoil. Associated species indicating saline conditions are saltwort, saltbush and saltgrass.

Juncus balticus Willd. (Baltic rush) native

Baltic rush is a subdominant on the Kingcome River Estuary, a dominant on the Goldstream, Chemainus, Nanoose-Bonell, Courtenay, Salmon and Quatse Rivers' Estuaries, and a subdominant and a dominant on the Cowichan, Nanaimo, Englishman, Little Qualicum, Oyster and Nimpkish Rivers' Estuaries. It has a high frequency of occurrence on estuaries south of Courtenay.

It is, generally, regularly and shallowly inundated by brackish water and the substrate is relatively well drained at low tide. The pithy shoots of Baltic rush suggest anatomical and physiological adaptation to a special environment.

Juncus effusus L. (common rush) native, circumboreal

Common rush is usually considered to be a freshwater marsh species or a species common to the transition zone between marsh and coastal forest. The substrate may appear well drained, though there is probably subsurface seepage, or the substrate may be wet to saturated. Common rush is seldom inundated. It is a dominant on the Cluxewe River Estuary but also occurs on other estuaries. There appear to be two possible reasons why common rush is not abundant. First, the limited area of the transition zone between a marsh and coastal forest on most of the estuaries studied, and second, the development of such zones.

Juncus ensifolius var. *ensifolius* Wikst. (dagger-leaf rush) native

Dagger-leaf rush is a subdominant on the Quatse River Estuary. Here it occurs with colonial bentgrass on a well-drained substrate behind a dyke. It is probably not inundated.

Juncus gerardi Loisel. (mud rush) native

Mud rush is subdominant on the Adam-Eve River Estuary. It occurs toward the backshore on a relatively well-drained substrate. It is shallowly and shortly inundated by saline to brackish water. Two associated species indicative of saline conditions are saltwort and saltbush.

Juniperus scopulorum Sarg. (juniper) native tree

Juniper is a dominant on the Chemainus River Estuary. It is not known to have a wide distribution on the east coast of Vancouver Island and grows widely dispersed. It prefers a drier climate, and well drained substrates, conditions which occur on the Shoal Islands and in the backshore of the Chemainus River Estuary.

Myrica gale L. (sweet gale) native shrub

Sweet gale, a species possessing nodules fixing atmospheric nitrogen symbiotically, is a dominant on the Campbell and Nimpkish Rivers' Estuaries where it occurs in freshwater marshes adjacent to the backshore forests. On the Campbell River Estuary the marsh has much standing water; associated oligotrophic species include hardstem bulrush and horsetail. On the Nimpkish River Estuary the marsh appears to be drier with less standing water and associated species, indicative of more mesic conditions, include salmonberry, self-heal, creeping buttercup, small bedstraw and water parsley.

Oenanthe sarmentosa Presl. (water-parsley) herb

Water-parsley is a subdominant on the Courtenay and Quatse Rivers' Estuaries. It occurs in the backshore where it may be infrequently inundated by brackish freshwater. It may also occur on other estuaries on relatively well drained substrates where it is regularly, shallowly and shortly inundated. Associated species include morning-glory, common horsetail, curly dock, yarrow, bedstraw, meadow fescue, Lyngby's sedge, black twin-berry and Pacific crabapple.

Pachistima myrsinites (Pursh) Raf. (false box) native shrub

Pachistima is a dominant on the Shoal Islands in the Chemainus River Estuary. It occurs in drier climates and on well drained substrates.

Phalaris arundinaceae L. (reed canarygrass) native and introduced

Reed canarygrass is a dominant on the Nanoose-Bonell Creeks' Estuar and a subdominant on the Courtenay River Estuary. It is used in agriculture as a hay crop and has probably escaped to the backshores of many of the estuaries. It is usually inundated by freshwater in winter but is not very salt tolerant. The associated species tend to be mesic and include alder, willow, Nootka rose, evergreen blackberry, Canada thistle, miner's lettuce, rough bedstraw, white sweet clover, pearly everlasting, water-hemlock, timothy and orchard-grass.

Picea sitchensis (Bong.) Carr. (Sitka spruce) native tree

Sitka spruce is a dominant on the Courtenay, Salmon, Adam-Eve, Tsitika, Nimpkish and Cluxewe Rivers' Estuaries where it occurs in the backshore. It forms a seral wet substrate stage in forest succession to the climax *Tsuga heterophylla* community for example, on the Salmon and Adam-Eve Rivers' Estuaries. Sitka spruce is often found on deltaic floodplains in the western hemlock biogeoclimatic zone where it may grow on nutrient rich, seepage substrates. It is the only conifer that tolerates slightly saline conditions and is thought to be able to use magnesium from the ocean spray and brackish tidal water (Krajina, 1969/1970).

Plantago lanceolata L. (ribgrass) introduced herb from northwest Europe

Plantago macrocarpa Cham. & Schlecht (plantain) native herb

Ribgrass, an alien species, has become a dominant and/or subdominant on the Goldstream, Big Qualicum, Salmon and Cluxewe Rivers' Estuaries and plantain, a native, is a dominant on the Kokish River Estuary. Ribgrass and plantain tend to occur more frequently toward the backshore, away from main channels, where they are shortly and shallowly inundated by brackish freshwater. The substrate is relatively porous and coarse.

Plantago maritima L. (seaside plantain) native herb

Seaside plantain is a dominant on the Nanoose-Bonell, Englishman and Quatse Rivers' Estuaries and a subdominant on the Adam-Eve and Kokish Rivers' Estuaries. It is found at the lower elevations of the vegetated intertidal zone where it is inundated during each flood tide. It is indicative of saline to brackish conditions; associated salt tolerant species are saltwort, saltbush, saltgrass, arrow-grass and gumweed. It may be found on sand to gravel substrates.

Poa compressa L. (Canada bluegrass) introduced

Canada bluegrass is a subdominant species on the Cowichan

River Estuary. It may be found where conditions are brackish and the substrate is relatively well drained. It is probably inundated by the higher tides.

<u>Poa pratensis</u> L. (Kentucky bluegrass) introduced

Kentucky bluegrass is a dominant and/or a subdominant on the Englishman, Salmon, Adam-Eve and Cluxewe Rivers' Estuaries. It tends to occur where the substrate is well drained, conditions are brackish, and inundation is short and shallow, conditions which appear to occur more frequently in northern estuaries. Mesic species such as black twin-berry, Pacific crabapple, salmonberry and Nootka rose are associated with Kentucky bluegrass towards the backshore, and forbs such as cinquefoil, springback clover, yarrow, tufted hairgrass and colonial bentgrass are associated with Kentucky bluegrass towards the foreshore.

<u>Potentilla pacifica</u> Howell (cinquefoil) native herb

Cinquefoil is present on all the estuaries studied and is a dominant and/or a subdominant on the Nanoo e-Bonell, Englishman, Little Qualicum, Big Qualicum, Courtenay, Oyster, Campbell, Salmon, Adam-Eve, Kokish, Nimpkish, Cluxewe, Quatse and Kingcome Rivers' Estuaries. It is a brackish freshwater specie- and may be found on silted sand to gravel from the lower elevations of the vegetated intertidal zone to the backshore. This broad distribution exposes it to a range of inundation, salinity, substrate and drainage regimes. At lower elevations it may be inundated on each tide, and subject to higher salinities and poor drainage. At higher elevations it may be inundated only shortly and shallowly, and subject to generally lower salinities and better drainage. Cinquefoil's broad distribution over a wide range of habitats may be related to its stoloniferous habit. The shallow rooting stolons root in the first few centimeters of almost water saturated soil in the lower elevations of the vegetated intertidal zone. They are also adapted to colonizing drier gravels where the roots can penetrate between rocks and stolons bridge rocks. A simple linear correlation between the total area on which cinquefoil is either a dominant or a subdominant and the April to September mean rainfall for each estuary suggests cinquefoil is more abundant where precipitation is greater ($r = .9217$ $r_{0.05(2),6} = 0.707$ ($n = 8$))(Table 45). This is probably related to precipitation reducing the salinity around the shallow rooting stolons. This effect is regarded as a factor in the distribution of cinquefoil, particularly towards the backshore, in estuaries north of Courtenay.

Pteridium aquilinum (L.) Kuhn (bracken) native fern

Bracken, a mesic species, is a dominant in the ecotone between marsh and forest on the Oyster River Estuary. It occurs on relatively well drained substrate and is not inundated. Associated species include false lily-of-the-valley, marsh pea, sword fern, foamflower and wall lettuce.

Pseudotsuga menziesii (Mirbel) France (Douglas fir) native tree

Douglas fir is a dominant on the Chemainus, Nanaimo and

Oyster Rivers' Estuaries. It is found in the backshore and on islands in the estuaries where it is probably never flooded. The best growth of Douglas fir occurs when the substrate is moderately well drained, and the soil nutrient regime is moderate but rich in bases such as calcium and magnesium (Krajina, 1969/1970). Associated species, particularly Garry oak, on the Chemainus and Nanaimo Rivers' Estuaries reflect drier growing conditions than on, for example, the Oyster River Estuary to the north.

Pyrus fusca Raf. (Pacific crabapple) native tree

Pacific crabapple, a small tree, is a dominant on the Little Qualicum and Kokish River's Estuarie- and a subdominant on the Chemainus and Little Qualicum Rivers' Estuaries. It occurs on dykes and in the backshore with more mesic species such as Garry oak, cascara, oregongrape, Douglas fir, broom, salal, thimbleberry and salmonberry. Infrequently, it may be shortly and shallowly inundated with brackish freshwater; in this case the substrate is relatively ell drained.

Quercus garryana Dougl. (Garry oak) native tree

Garry oak is a subdominant on the Chemainus River Estuary and a dominant on the Nanaimo River Estuary. It grows at the foot of mountains in areas of low annual total precipitation (660 - 1020 mm). Its frost resistance and shade tolerance are low, and its nutritional requirements are high, particularly with regard to bases such as calcium and magnesium (Krajina, 1969/1970).

Ribes sp. L. (gooseberry) native shrub

Gooseberry is a dominant on the Nimpkish River Estuary where it is associated with Sitka spruce, Nootka rose, red alder, salmonberry, slough sedge and skunk cabbage. It is infrequently flooded and then only shortly and shallowly by brackish freshwater, but soil moisture is usually maintained at high levels continuously from groundwater sources or heavy frequent precipitation.

Rosa nutkana Presl. (Nootka rose) native shrub

Nootka rose is a dominant and/or a subdominant on the Goldstream, Chemainus, Nanoose-Bonell, Englishman, Little Qualicum, Campbell, Salmon and Nimpkish Rivers' Estuaries. It has a high frequency of occurrence in estuaries south of Courtenay. This is related to the higher aridity index south of Courtenay. Nootka rose occurs in the backshore where the substrate is drier and may be silted sand to small gravel. It is infrequently or never inundated but appears to have some tolerance to salt spray.

Rubus spp. L. (blackberry, salmonberry) native shrub

Rubus spp. are dominants and/or subdominants on the Cowichan, Nanoose-Bonell, Englishman, Little Qualicum, Campbell, Nimpkish, Quatse and Kingcome Rivers' Estuaries. Blackberries tend to occur more frequently on dykes and in the backshore on the more southern estuaries studied and salmonberry tends to occur more frequently in the ecotone between marsh and forest on the more northern estuaries. They may be found on moister or seepage substrates and are never, or very infrequently, shortly and shallowly flooded. They appear to tolerate salt spray.

Rumex salicifolius Weinm. (willow dock) herb

Willow dock is a subdominant on the Goldstream and Courtenay Rivers' Estuaries where it is found on drier substrates. It is probably never or infrequently inundated by freshwater. It seems to tolerate salt spray.

Ruppia maritima L. (ditch-grass) native herb

Ditch-grass, a small herb, is a dominant on the Campbell River Estuary and is fo¨nd on some of the other estuaries studied. It tends to occur in shallow, standing or slow moving brackish water. Suitable areas for the growth of ditch-grass do not appear to be abundant or extensive on the estuaries studied.

Salicornia virginica L. (saltwort) native herb

Saltwort is a dominant and/or a subdominant on the Goldstream, Chemainus, Nanaimo, Nanoose-Bonell, Englishman, Adam-Eve, Kokish, Cluxewe, and Quatse Rivers' Estuaries. It may be found at the lower elevations of the vegetated intertidal zone, is indicative of saline conditions, and is probably inundated on each tide. Saltwort tends to occur on silted sand, sandy silt or, infrequently, peaty soils that are always moist or wet. The associated species include saltgrass, seaside plantain, saltbush, salt-marsh dodder, and gumweed which are also considered indicative of saline conditions.

<u>Salix</u> spp. L. (willow) native shrub

Willow are present on many of the estuaries studied and are dominant on the Kingcome River Estuary. They may be found in the backshore where it is infrequently flooded and then by freshwater. Their presence indicates mesic to hydric transition.

<u>Sambucus racemosa</u> L. (elderberry) native shrub

Elderberry is a subdominant on the Kingcome River Estuary and occurs on many of the estuaries studied. It is fo nd in the backshore, in the ecotone between marsh and forest, where it is never or infrequently, shortly and shallowly flooded by freshwater. The substrate is probably moderately drained. Associated species tend to be mesic and include orange honeysuckle, black twin-berry, salmonberry, field mint, cow-parsnip, wildrye, blue wildrye and orchard-grass.

<u>Scirpus acutus</u> Muhl. (hardstem bulrush) native

Hardstem bulrush is a dominant on the Cowichan and Little Qualicum Rivers' Estuaries and a subdominant on the Campbell River Estuary. It is a species of brackish freshwater condition- and occurs in water saturated, silted sand from which the water drains very slowly on the ebb tide. It may be shallowly inundated on each tide, though on the Campbell River Estuary, it is probably inundated by only the highest tides. The limited distribution of hardstem bulrush, on the east coast of Vancouver Island, is related to the deltas' relatively steeper slopes and better drainage as compared to, for example, certain areas of the Fraser River Delta.

Scirpus americanus Pers. (three-square bulrush) native

Three-square bulrush is a subdominant on the Cowichan River Estuary and a dominant on the Courtenay River Estuary. It occurs at the lower elevations of the vegetated intertidal zone where it is inundated on each flood tide. A species indicative of saline to brackish conditions, it occurs on relatively well-drained sandy substrates, generally out of the direct influence of the river or major channels. The limited distribution of three-square bulrush on the east coast of Vancouver Island is related to the limited area of relatively well-drained sandy substrate in the lower elevations of the vegetated intertidal zone. By contrast, it occupies large areas of the Fraser River delta foreshore.

Scirpus maritimus L. (seacoast bulrush) native

Seacoast bulrush is a dominant on the Chemainus, Nanaimo and Nanoose-Bonell Rivers' Estuaries. It occurs in standing water or water saturated soil that is generally very organic and anaerobic, smelling strongly of hydrogen sulphide. It is indicative of saline brackish conditions as suggested by the copresence of saltwort and Lyngby's sedge, species indicative of saline and brackish conditions. It may be inundated on each flood tide. The limited distribution of seacoast bulrush, on the east coast of Vancouver Island, is related to the deltas' relatively steeper slopes and better drainage as compared to, for example, areas of the Fraser River Delta where it is a common.

Scirpus microcarpus Presl. (small-fruit bulrush) native

Small-fruit bulrush is a dominant in the ecotone between marsh and forest on the Courtenay River Estuary. It is indicative of areas of freshwater seepage or shallow, standing water. Associated species include cinquefoil, milk-thistle, morning glory, common horsetail, curly dock, water-parsley, common forget-me-not and colonial bentgrass.

Sidalcea hendersonii Wats. (Henderson's checker-mallow) native herb

Henderson's checker-mallow is a subdominant on the Courtenay River Estuary and it is also present on other estuaries studied. It occurs on the relatively more elevated areas toward the backshore where it may be shortly and shallowly inundated by brackish freshwater on higher tides. The substrate is usually moist. The tendency to establish in more mesic habitats and the briefness of any inundation are indicated by the diversity of associated species which include arrow-grass, cinquefoil, springbank clover, curly dock, cat-tail, willow dock, St. John's-wort, camas, shooting star, bedstraw, Siberian miner's lettuce, blue-eyed grass, and golden Indian-paintbrush.

Sonchus arvensis L. (milk-thistle) introduced herb

Milk-thistle is a dominant and a subdominant on the Englishman River Estuary. The associated species indicative of brackish conditions are cinquefoil, ribgrass and couch grass, and associated specie indicative of saline conditions are saltwort, seaside plantain and saltgrass. It is probably infrequently, and then only shortly and shallowly, inundated by brackish or salt water. The substrate is relatively well-drained but continuously moist.

Spergularia canadensis (Pers.) G. Don (saltmarsh sandspurry) herb

Saltmarsh sandspurry is a dominant and a subdominant on the Nanaimo and Kokish Rivers' Estuaries. It may be found at the lower elevations of the vegetated intertidal zone where it is in-ndated by each tide. It is a species of brackish saline conditions and tends to occur on sandy, moist substrates.

Symphoricarpos albus (L.) Blake (snowberry) native shrub

Snowberry is a subdominant on the Campbell River Estuary where it is found in a logged clearing in the backshore. The area is probably never flooded and is colonized by mesic species, such as cascara, alder, Douglas-fir, Pacific crabapple, cedar, maple, Nootka rose, salmonberry, elderberry, gooseberry, hardhack, orange honeysuckle and oregongrape.

Thuja plicata Donn. (western red cedar) native tree

Western red cedar is a dominant in the backshore of the Quatse River Estuary. It is probably never flooded but, if so, then for only short periods by freshwater. It grows in nutrient rich, seepage soils. In the Coastal Western Hemlock Biogeoclimatic Zone the best growth of western red cedar occurs on soils rich in bases such as calcium and magnesium (Krajina 1969/1970).

Trifolium pratense L. (red clover) introduced herb

Red clover, a legume, is a subdominant on the Big Qualicum River Estuary. It tends to occur along the streambank at the ecotone between mars' and forest where it may be shortly and shallowly inundated by freshwater on the flood tide during the growing season. The substrate is gravel and well drained.

Trifolium wormskjoldii Lehm. (springbank clover) native herb

Springbank clover, a native legume, is a dominant and/or a subdominant on the Courtenay, Tsitika, Nimpkish, Cluxewe and Kingcome Rivers' Estuaries. It is indicative of freshwater to brackish freshwater conditions and may be inundated by each flood tide during the growing season. It invariably occurs on relatively well drained substrates. Being shallow rooting it may be dessicated in a well drained substrate if it is not rained on or inundated regularly. Springbank clover appears to have increased frequency of occurrence in the estuaries north of Courtenay where rainfall is greater during the growing season.

Triglochin maritimum L. (arrow-grass) native herb

Arrow-grass is a dominant and/or a subdominant on the Cowichan, Nanaimo, Englishman, Adam-Eve, Tsitika, Cluxewe and Quatse Rivers' Estuaries. It occurs on relatively well drained, sandy substrates where it is in"ndated on each flood tide. It is indicative of brackish to saline conditions as suggested by the associated species tufted hairgrass, Lyngby's sedge, and saltwort, species indicative of brackish and saline conditions respectively.

Tsuga heterophylla (Raf.) Sarg. (western hemlock) native tree

Western hemlock is a dominant on the Salmon, Adam-Eve and Quatse Rivers' Estuaries. It grow best in humid zones with long vegetative seasons and podzolized soils. Its nutritional requirements include a well balanced supply of nutrients in small quantities and a continuous uptake of water provided by rainfall (Krajina 1969/1970).

Typha latifolia L. (cat-tail) native herb

Cat-tail is a dominant on the Cowichan, Nanaimo, Little Qualicum, Courtenay, Salmon and Nimpkish Rivers' Estuaries. It is indicative of freshwater conditions though it is known to tolerate very low salinities. It tends to occur towards the backshore in water saturated soil or standing water. There it may be inundated on the higher flood tides during the growing season. Its growth is thought to be enhanced by changes in the water level.

Vicia gigantea Hook. (giant vetch) native herb

Giant vetch is a dominant on the Tsitika River Estuary and is present on some of the other estuaries studied. It trails over other species such as wildrye and young Sitka spruce in the ecotone between marsh and forest. It is probably never inundated during the growing season and tolerates salt spray. It occurs on well drained, sandy substrates.

Zostera marina L. (eel-grass) native herb

Eel-grass is a dominant and a subdominant on the

Chemainus River Estuary where it may be found at the lower elevations of the vegetated intertidal and subtidal zones. It is a subtidal species as it is subject to desiccation when exposed. On the Chemainus River Estuary it is exposed for short periods of time in tidal pools. Eel-grass occurs on sand or silted sand in saline conditions. It is an important forage for waterfowl and probably for many other animals.

4. ESTIMATING THE PRODUCTION OF DRY MATTER OF VANCOUVER ISLAND ESTUARIES

Annual production of dry matter by communities in estuaries can be, in terms of the world's vegetation systems, very high when elements of the estuarine environment are suitably combined. This is reflected in the heavy occupancy of the major estuarine systems of the world by man and other consumers in the biosphere. It is also true that production in some communities or parts of communities must be very low or nil when elements such as lack of light or water movement prevent or severely limit plant establishment and development. However, it is only in recent decades that attention has been directed by scientists and technologists to production in estuaries and the biophysical elements relating to it. Methods of estimating production are not yet well developed. In this study, so little was known about the North Pacific estuaries it was believed that crude estimates of the annual production of dry matter of major plant communities on estuaries would be informative and useful.

4.1 Standing Crop

Three methods of determining standing crop were used in this study. The three methods are peak standing crop (Yamanaka, 1975), periodic collections (Levings and Moody, 1976) and cleared plot (Kistritz and Yesaki, 1979). Each method involves collecting to ground level all the material from a plot of known area (eg. one square meter) then drying and weighing it to obtain the dry weight (DW) of the matter produced in the area.

In the peak standing crop method one collection is made at what is thought to be the time of maximum production in the sampled stand. The time of sampling is critical as early or late collections will not represent the peak. This method does not take into account the net changes in standing crop or the presence of material from previous growing seasons or other sources. In the periodic collections method, plots are periodically and systematically sampled. This method takes into account the net changes in the standing crop but does not eliminate the weight contributed by the presence of material from previous growing seasons or other sources. The cleared plot method removes the latter problem as the plots are cleared before the sampling program begins. In the cleared plot method periodic and systematic sampling of the plots allows the calculation of the net changes in the standing crop.

In this study eleven plant communities were sampled monthly from April to October inclusive. The plots clipped in April were treated as cleared plots and reclipped in October to measure the cleared plot standing crop for the period May to October. The largest monthly weights were designated peak standing crops. The standing crop by periodic collections was determined by summing monthly increment and was designated standing crop by summing increments.

4.1.1 Methods

Standing crop was obtained from eleven plant communities in five estuaries viz. Cowichan, Chemainus, Little Qualicum, Campbell and Salmon Rivers. The plant communities are typed by dominants; Lyngby's sedge, Baltic rush, saltwort, saltgrass-gumweed, cinquefoil-Lyngby's sedge, cinquefoil-spike rush, tufted hairgrass-Lyngby's sedge and Kentucky bluegrass-bentgrass-cinquefoil. Three transects were placed across the elevational gradient in each community and five, equidistantly spaced, .5 m^2 plots were placed one meter on each side of each transect. Five plots were sampled in each of the months April (4), May (5), June (6), July (7), August (8) and October (10). In October the plots clipped in April were sampled again. The plots were clipped to ground level with hand shears and the material was separated into living, dead, senescent and duff fractions. A senescent fraction was not collected for the salt marsh communities for two reasons: a) the difficulty of separating fractions of senescent material from a plant, and b) the late August and October development of senescent material. Living material consisted of material which grew in 1976 and was still green; dead material consisted of growth made before 1976 and was brown; senescent material was tissue which was produced in 1976 and was less than half green; and duff was small particles of amorphous material on the soil surface. Each portion was bagged, labelled and transported to the University of British Columbia where it was dried in a Pot Hole Drier at 54°C. Depending on the plant species this took from 48 hours to 1.5 weeks. Dried material was weighed, a standing crop calculated, and an analysis of variance for weight by month sampled, and community done.

Subsamples were ground in a Wiley Mill using a 2 mm mesh. To reduce the volume, the five replicates were combined by equal amounts. Percent ash and nitrogen were determined using methods in Black <u>et al.</u> (1965) and were used to caluclate ash free dry weight (AFDW) and weight of nitrogen in combined living and senescent, and dead and duff AFDW fractions.

4.1.2 Results

The three ways of calculating standing crop provide three sets of values (Table 46). Standing crop by summing increments ranges from 392 gm m^{-2} for the cinquefoil-spike rush community on the Campbell River Estuary to 1504 gm m^{-2} for the Lyngby's sedge community on the Little Qualicum River Estuary. Peak standing crop ranges from 613 gm m^{-2} in July for the cinquefoil-spike rush community on the Campbell River Estuary to 2082 gm m^{-2} in August for the saltwort community on the Chemainus River Estuary. Standing crop by cleared plot (May - October) ranges from 229 gm m^{-2} for the cinquefoil-spike rush community on the Campbell River Estuary to 726 gm m^{-2} for the saltwort community on the Chemainus River Estuary. The rank of each community varies by method.

The analysis for variance is significant ($p<.05$) for standing crop by summing increments and the living and senescent fractions by community and sampling date. The dead and duff fractions are not significant by sampling date. A multiple range test on standing crop yielded three subsets. The first subset consists of the communities not dominated by Lyngby's sedge; the second, the Lyngby's sedge communities on the

Table 46. Standing Crop

Estuary	Community	Standing Crop t $(B_t - B_{t-1})^a$ 1 gm m^{-2}	Peak Standing Crop month	Peak Standing Crop gm m^{-2}	Standing Crop Cleared Plot May – Oct. gm m^{-2}
Cowichan	*Carex lyngbyei*	588	July	1231	358
Cowichan	*Juncus balticus*	754	August	1155	364
Chemainus	*Salicornia virginica*	966	August	2082	726
Chemainus	*Distichlis spicata* – *Grindelia integrifolia*	1437	July	1420	519
Little Qualicum	*Carex lyngbyei*	1504	June	1746	443
Little Qualicum	*Potentilla pacifica* – *Carex lyngbyei*	770	June	868	413
Campbell	*Carex lyngbyei*	487	July	1223	527
Campbell	*Potentilla pacifica* – *Eleocharis palustris*	392	July	613	229
Salmon	*Carex lyngbyei*	773	July	1186	550
Salmon	*Deschampsia cespitosa* – *Carex lyngbyei*	1092	July	1210	408
Salmon	*Poa pratensis* – *Agrostis alba* var. *stolonifera* – *Potentilla pacifica*	772	May	1002	342

a. B_t standing crop at time t
B_{t-1} standing crop at the previous sample time

Cowichan, Campbell and Salmon; and the third, the Lyngby's sedge community on the Little Qualicum.

The living fraction of the standing crop in each community (Appendix 6. Figures 23 to 33) tends to rapidly increase to a peak then rapidly decrease, except for the Chemainus saltgrass-gumweed community which continued to slowly increase to October. Four communities reach their peak in June, six in July, one in July and August, and one in October. In general, brackish marsh communities peak in the first half of the growing season and salt marsh communities in the latter half. Brackish marshes south of Campbell River peak in June while those at Campbell River and north peak in July.

The dead fraction of the standing crop in each community tends to decrease from April to October at different rates for each community. The Lyngby's sedge communities appear to decrease quickly at the beginning of the growing season. The Cowichan and Campbell sedge communities did not have any dead to collect from May on, and the Little Qualicum and Salmon did not have dead fractions after June. The dead fraction for the Chemainus saltwort community is irregular with slight increases in June and August. A dead fraction was collected from the other communities each sampling time.

The senescent fraction of the standing crop in each community increases rapidly from April on in the four sedge communities and June on in the remaining communities.

The duff fraction of the standing crop in each community is irregular.

In general, as the living fraction of the standing crop is increasing to its peak, the dead fraction is declining, the senescent increasing and the duff fluctuating. After reaching its peak the living fraction declines and the senescent fraction increases rapidly. In the Cowichan, Little Qualicum and Salmon Lyngby's sedge communities (Figures 23, 24 and 25), the senescent fraction exceeds the living in August. In the Cowichan Baltic rush, Little Qualicum cinquefoil-Lyngby's sedge, and Campbell cinquefoil-spike-rush communities (Figures 26, 27 and 28), the living fraction peaks over three months (May, June and July) and the senescent fraction appears to increase as rapidly as the living declines, exceeding the living after August. The dead fraction exceeds the living in April only on the Cowichan and Campbell but exceeds the living for April and May on the Little Qualicum. In the Chemainus saltwort community (Figure 29) the dead fraction is greater than the living and both peak in August. In the Chemainus saltgrass-gumweed community (Figure 30) the decreasing dead fraction exceeds the increasing living until July. In the Campbell Lyngby's sedge community (Figure 31) the living peak spans May, June and July and the senescent increases though not as dramatically as in previous estuaries. In the Salmon tufted hairgrass-Lyngby's sedge community (Figure 32) the dead fraction exceeds the living fraction in April, May and June and the dead peak in April is greater than the living peak in July. In the Salmon Kentucky bluegrass-bentgrass-cinquefoil community (Figure 33) the dead fraction exceeds the living in April, May and June, and the dead peak in April is greater than the living peak in June.

In general, the dead fraction exceeds the living in communities at higher elevations and in salt marshes. In communities at higher elevations the dead fraction decreases to less than the living fraction over the growing season, while in salt marsh communities it does not.

The nitrogen analysis ranged from an April high of 2.43% in the Cowichan Lyngby's sedge community to an October low of .54% in the Campbell cinquefoil - spike rush community. Ranges for each fraction are, for the living fraction, the aforementioned overall high and October low of .64% in the Little Qualicum cinquefoil - Lyngby's sedge community; for the dead fraction, an October high of 1.61% in the Salmon tufted hairgrass - Lyngby's sedge community and an April low of .71% in the Little Qualicum cinquefoil -Lyngby's sedge community; for the senescent fraction, an April high of 1.26% in the Salmon Kentucky bluegrass - bentgrass - cinquefoil community and an October low of .54% in the Campbell cinquefoil - spike rush community; for the duff fraction, an October high of 1.84% in the Chemainus saltgrass - gumweed community and May low of .65% in the Cowichan Lyngby's sedge community.

In general, for all but the sedge communities, the nitrogen values of the living fractions in April are higher than the nitrogen values for the senescent dead and duff fractions. However, the nitrogen values for the living fractions decline to the lowest values by October. The percent nitrogen value of the senescent fraction tends to decrease over time and, while the percent nitrogen values of the dead and duff fractions also decrease in April and May, they increase from June (July) on and have the highest values, particularly the duff fraction (around 1%). The range of values for the duff fraction is the smallest of all the fractions.

The ash analysis ranged from a May low of .74% for the living fraction of the Little Qualicum Lyngby's sedge community to an August high of 75.12% for the duff fraction of the Cowichan Lyngby's sedge community. Ranges for each fraction are, for the living fracion, the aforementioned overall low and August high of 36.73% in the Chemainus saltwort community; for the dead fraction, a July low of 4.37% in the cinquefoil - Lyngby's sedge, and May high of 50.97% in the Lyngby's sedge communities on the Little Qualicum; for the senescent fraction, an October low of 4.11% in the Campbell cinquefoil - spike rush community and June high of 39.78% in the Little Qualicum Lyngby's sedge community; for the duff fraction, an August low of 14.55% and the aforementioned overall high. Though percent ash values fluctuate, in general, they decrease from April to October. The lowest percent ash values occur in the living fraction and increase through the senescent and dead fractions to the duff fraction.

The calculation of ash free dry weight (AFDW) and nitrogen values for the combination of living and senescent fractions for each community results in two types of graphs (Appendix 6, Figures 34 to 37). The first type, rapid rise to a peak, then rapid decline of AFDW, occurs for the Lyngby's sedge communities on the Cowichan, Little Qualicum, Campbell and Salmon, the Chemainus saltwort community and the Campbell cinquefoil - spike rush community. The second type, continuous increase of AFDW, occurs for the remaining communities. There is a decrease in August before the increase continues in the three communities, Cowichan Baltic rush (where decrease occurs in July also), Little Qualicum cinquefoil - Lyngby's sedge and

Salmon tufted hairgrass - Lyngby's sedge. Nitrogen values increase and decrease with AFDW in the Lyngby's sedge communities on the Little Qualicum, Campbell and Salmon, Chemainus saltwort communit and Campbell cinquefoil - spike rush community. In the Cowichan Lyngby's sedge community nitrogen values increase from August to October. In the remaining communities the nitrogen values increase from April to October.

The application of percent nitrogen and AFDW values to the combination of dead and duff weights for each community provides variable results though AFDW tends to decrease through the growing season (An~endix 6, Figures 38 to 41). Values for Lyngby's sedge communities decline rapidly, while values for the rest of the communities decline comparatively slowly. Weights are lowest, less than 50 gms, for the sedge communities. The salt marsh communities have the highest weights ranging between 230 and 120 gms. AFDW in the rest of the communities is between 130 and 20 gms. Nitrogen values fluctuate with AFDW and are less in October than in April.

4.1.3. Discussion

There is considerable variation in standing crop values by method and community. Of the three methods used, summing increments is considered to be most representative. Summing increments between sampling periods is more exacting than collecting the peak standing crop which overestimates the value as it does not account for the inclusion of previous years' growth. The cleared plot method does not account for reductions in standing crop at the end of the growing period but it eliminates the problem of previous years' growth and provides a definite time reference over which to measure the standing crop. However, in this study, the cleared plots were set up late, in May, and this limited the growth period and resulted in the standing crop values being underestimated. All three methods have the same problems with clipping to ground level, soil contamination (as indicated by the percent ash values), population density variability, sample size, and loss due to leaching, grazing and physical removal. None of the methods includes belowground organic matter.

The standing crop values obtained by summing increments (eg. Lyngby's sedge 487 to 1504 grams of dry weight per square meter (gm DW m^{-2})) compare to Levings and Moody's (1976) value of 1322 gm DW m^{-2} for Lyngby's sedge in the Squamish River estuary and Moody's (1978) value of 909 gm DW m^{-2} for Lyngby's sedge in the Brunswich Point Marsh on the Fraser River delta. Direct comparisons between standing crop values for emergent plant communities along the Pacific Northwest coast are difficult. Different communities are sampled (eg. maritime bulrush) and different methods (eg. peak standing crop) are used. Kistritz and Yesaki (1979) also found "large temporal and spatial variations associated with measurements of marsh plants" and that there is "a marked year to year variation in the timing and duration of growth..." In this study this is seen in the differences in the times of initiation and cessation of growth among the plant communites, for example, the brackish marsh communities initiated growth in late March and early April while the salt marsh communities initiated growth in late April. Kistritz (1978) also found this in his literature review.

The problems associated with the standing crop methodology and reproducability of the results lead to the conclusion that it is not a satisfactory approach to measuring the dry matter contributions of emergent vegetation to the detrital cycle in the estuarine food web. Also, the "quality" of the dry matter contributions to the detrital cycle, as indicated by the total nitrogen content of each community, is precluded by the problems with the standing crop technique and only one monthly measurement of nitrogen for each community.

While methodology and reproducability problems with standing crop limit the usefulness of the standing crop values, the fraction and ash free dry weight (AFDW) portion of the study indicate differences between the plant communities and their contributions to the detrital cycle. By summing increments the four largest standing crops occurred on the Little Qualicum Lyngby's sedge community at 1504 grams per square meter (gm m^{-2}) followed by the Chemainus saltgrass-gumweed community at 1437 gm m^{-2} then the Salmon tufted hairgrass-Lyngby's sedge at 1092 gm m^{-2} and finally the Chemainus saltwort community at 966 gm m^{-2}. The fraction and ash free dry weight data for each of these communities indicate the rates and timing of release of dry matter or particulate organic matter to the estuarine system. In the fraction data the living material increases from April to June or July then decreases to October. The dead decreases from April to October. The senescent increases from April to October and the duff is irregular and fluctuates around the same general values. In the sedge communities the dead portion never exceded the living and no dead was collected after June. Also, the living portion increased and decreased very sharply in both the portion and combined living and senescent AFDW data. This does not occur in the other communities and indicates that the sedge communities release matter to the detrital cycle throughout the year, not just in the growing season, and the release appears to be all or nearly all the matter from the community. In the other communities, the dead portion exceded the living until June and was present until October, and the combined living and senescent AFDW's increased to October. This indicates four things:

1. these communities release matter much more slowly than the sedge communities.
2. the matter released is principally from previous year's growth.
3. the release occurs mainly in the growing season.
4. there is a net accumulation of matter in the communities.

The accumulation of dead matter in the salt marsh communities is particularly pronounced with the dead fraction in the saltwort community always exceeding the living fraction and the combined dead and duff AFDW's decreasing only slightly. This indicates there is little matter released from the salt marsh communities to the estuarine system and matter accumulates in the community. In the higher elevation communities the accumulated matter appears to be incorporated into the substrate to such an extent that one may have to step up onto these communities from lower elevation communities. Alone, the standing crop values might suggest the sedge, higher elevation tufted hairgrass-sedge, and salt marsh saltwort and saltgrass-gumweed communities contribute the greatest amounts of matter to the detrital cycle in the estuarine food web. However, the portion and AFDW data point out that the rate and timing of release of matter to the estuarine system varies between sedge, higher elevation brackish marsh and salt marsh communities. The sedge communities have the highest rate of release and release all or almost all of the matter produced throughout the year. The higher elevation brackish marsh communities slowly release some of the matter produced in previous years during a growing season and accumulate matter through the remainder of the year. The salt marsh communities slowly release a little matter in the growing season and accumulate the rest. It appears that in a brackish marsh the emergent vegetation is a source of particulate organic matter for the detrital cycle in the food web with sedge releasing matter year ro¨nd and higher elevation communities releasing matter only during the growing season when energy demands are probably at their highest in the estuary. However, it appears that salt marshes contribute little particulate organic matter to the detrital cycle. Haines (1977) found this in cordgrass salt marshes at the University of Georgia Marine Institute on Sapelo Island and concluded that phytoplankton and terrestrial plant material were the probable major sources of particulate organic matter in salt marshes. Haines felt a major revision of ideas concerning the role of salt marshes in estuarine production might be required. This study suggests any revision take into account the differences between brackish and salt marshes. Brackish marshes release particulate organic matter to the detrital cycle in the estuarine food web while salt marshes release little. Terrestrial plant material contributes to the cycle in estuaries in either marsh, but phytoplankton are probably more abundant in salt marshes due to the higher salinities there. The side by side occurrence of many of Vancouver Island's east coast brackish and salt marshes suggests total productivity from all sources, emergent vegetation, terrestrial plant material and phytoplankton, within the estuarine ecosystem may be much higher than ever appreciated.

The differences in the rates and timing of release of the particulate organic matter to the detrital cycle of the estuarine food web separates sedge, salt and brackish marsh communities and raises the question, "Why are they different?" There appear to be two principal reasons. They are, one, mechanical damage and, two, plant species anatomy. The first reason, mechanical damage, is related to the distribution of the plant communities. Plant communities at lower elevations in the vegetated intertidal zone are subject to the action of waves twice daily on tidal in-ndation and this action breaks the plants down and carries them into the estuary over time. Plant communities at higher elevations are subject to only shallow inundation during much of the growing season. Wave energy diminishes with decreasing water depth so mechanical breakage from waves is less at higher elevations, and the ability of the waves to carry material into the estuary is reduced. The second reason, plant species anatomy, is related to the amount of structural material in the species. The amount of living, as versus structural material, in the plant communities studied is indicated by the nitrogen values. The highest amounts of living and lowest amounts of structural material are in the sedge communities, and the lowest living and highest structural amounts are in the salt and higher elevation brackish marsh communities. The higher structural component of the plant species of the salt and higher elevation brackish marsh communities makes them more difficult to break down than the sedge communities . Saltwort and saltgrass, in particular, have thick cell walls and the plants persist from growing season to growing season. The high salinities in salt marshes may also suppress microbial decomposers which were not inhibited in brackish marshes as indicated by the duff nitrogen values around one percent. In conclusion, the different rates and timing of release of the particulate organic matter in sedge, salt and higher elevation brackish marsh communities appears to be related to the amount of mechanical action the communities are subject to, and the plant species decomposition rates as influenced by their anatomy and salinity.

4.2 Root Reserves

Estimating the belowground dry matter production in estuarine marshes presents as many problems as estimating standing crop or aboveground dry matter production. The traditional method of measuring belowground dry matter involves collecting roots and separating live and dead material. This was impractical in this study as the communities involved formed root mats that made it difficult to remove samples from the ground let alone physically separate live and dead roots. Also, it is difficult to dist inguish between dead and living roots, and due to the density of the root mat, separation of the roots would result in a loss of material, in particular, the living rootlets and root hairs which are considered to represent a major portion of the live weight. An alternative, periodic collections of known volumes of roots was discarded due to the difficulty in washing soil out of some of the root mats. One could not be sure how much was root and how much was soil and if trends in the values were dependent on changes in the root reserves or soil content of the sample, particularly when different communities were being examined. A novel, indirect approach suggested by Burton and Jackson in 1962 was used. The length of time intact cores of root and soil grew in darkness was measured instead. The time the root cores grew in the dark and the air dried weight of etiolated clippings were used as a measure of the belowground energy reserves for the plant communities. The method allows for comparisons between estuaries and gives trends that are based on the plants and not on handling errors.

4.2.1 Methods

Root cores were collected from eleven plant communities in five estuaries viz. Cowichan, Chemainus, Little Qualicum, Campbell and Salmon Rivers. The plant communities are typed by dominants; Lyngby's sedge, Baltic rush, saltwort, saltgrass-gumweed, cinquefoil-Lyngby's sedge, cinquefoil-spike rush, tufted hairgrass-Lyngby's sedge, and Kentucky bluegrass-bentgrass-cinquefoil. One 9.9 cm in diameter by 11.9 cm deep core was taken from each of five .5 m^2 clipped plots in each community in each of the months April(4), May (5), June (6), July (7), August (8) and October (10). The cores were transported to the University of British Columbia where they were grown in a dark room at ca. 20°C, given tap water every 15 days and clipped every 30 days until growth ceased. Dates of setting out and termination of growth, and air dry weight of etiolated tissue were recorded. Analyses for variance (ANOV) in time and weight by communit and by month collected, and between community and month collected were done.

Each month the heights of two average shoots of Lyngby's sedge and/ or Baltic rush in each plot clipped the previous month were recorded.

In October, the number of shoots that regrew and the number of overwintering shoots (ca. 5 cm tall, blue-green, tapering to a point, thick cuticle) in each plot clipped in April through August inclusive were counted. The number of shoots and overwintering shoots in the plots clipped in October were also counted. Analysis for variance in the number of regrown shoots and overwintering shoots by time clipped was done.

4.2.2 Results

The ANOV is significant ($p < .05$) in all cases though barely so for weight. The same result is obtained when the sample population consists only of communities dominated by Lyngby's sedge.

A root core from the cinquefoil and Lyngby's sedge community on the Little Qualicum River Estuary grew for the

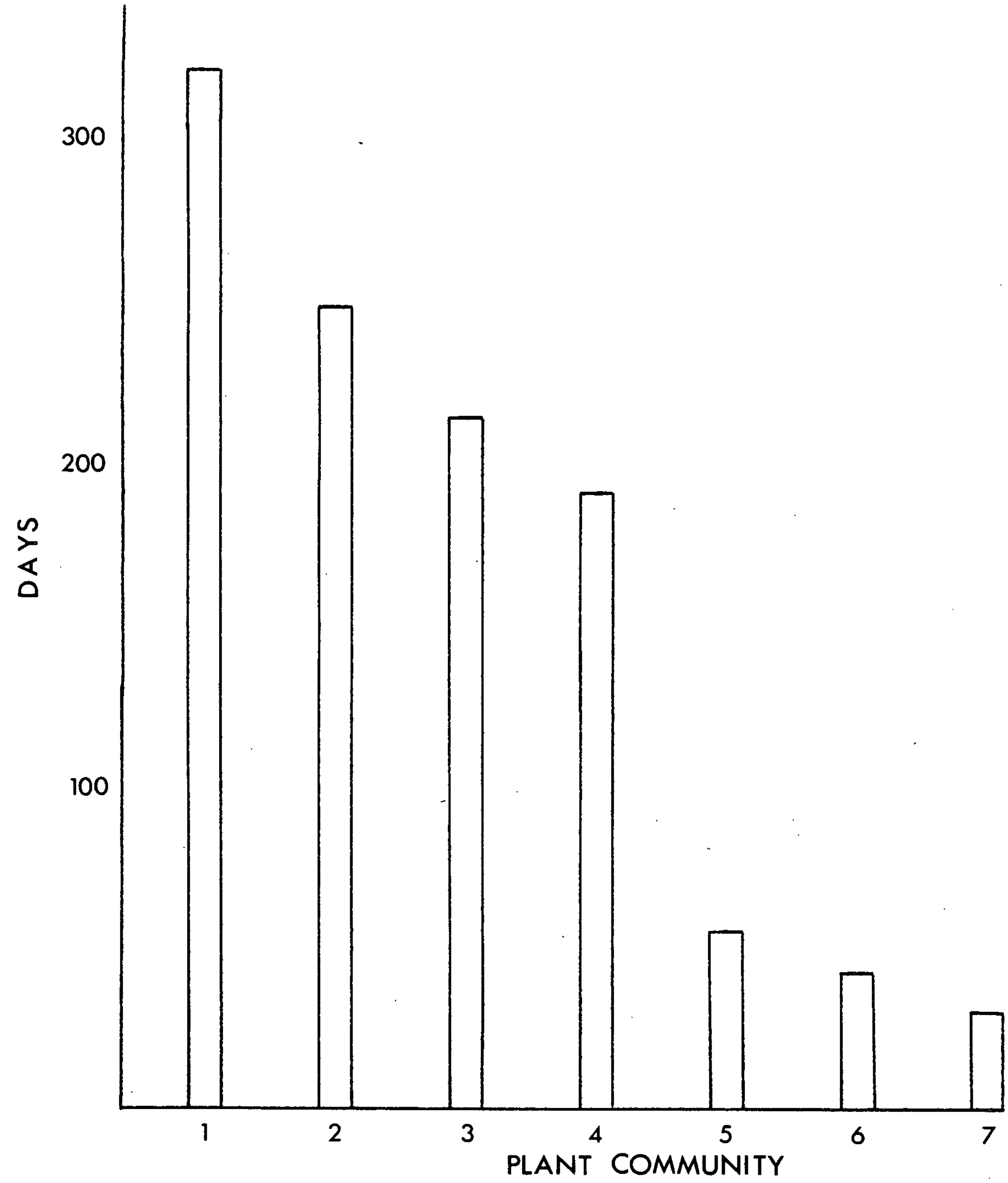

Figure 42. Exhaustion of root reserves in darkness: maximum time the (1) Carex lyngbyei, (2) Juncus balticus, (3) Deschampsia cespitosa and (4) Salicornia virginica plant communities, and the maximum time (5) Agropyron spicatum, Stipa comata and Festuca scabrella (Lobb, 1969), (6) Poa pratensis, and (7) Festuca rubra and Agrostis tenuis (Marx, 1961) grew in the dark.

longest time in the dark; 573 days. It was collected on October 13, 1976, set out in the dark room on October 21, 1976 and ceased growing on June 6, 1978. Figure 42 compares the maximum time root cores from four estuarine plant communities and three groups of grasses grew in the dark. The estuarine root cores grew 3.5 to 10 times longer than the grasses.

The average time the root cores from the eleven communities grew in the dark is graphed in Figure 43. The graph shows a drop in the number of days the root cores grew in the dark from April to May then an increase until August after which time it declines. The Cowichan Lyngby's sedge community (Figure 44) reaches maximum time in July then stays relatively stable between July and October. The Cowichan Baltic rush community is increases from April to August then stays relatively stable until October (Figure 45). The Chemainus saltwort community is irregular though it tends to decline from April to October (Figure 46). The Chemainus saltgrass- gumweed community declines from April to June then increases to October (Figure 46). The Little Qualicum Lyngby's sedge community increases from April to October (Figure 47). The cinquefoil-Lyngby's sedge community on the same estuary stays the same for April and May then increases to October (Figure 48). The Campbell River Lyngby's sedge community increases from April to August then declines slightly to October (Figure 49). The cinquefoil-spike rush community on the Campbell peaks in July and then stays relatively stable until October (Figure 50). The Lyngby's sedge community on the Salmon is like that on the Campbell while the tufted hairgrass-Lyngby's sedge and Kentucky bluegrass-bentgrass-cinquefoil communities on the Salmon increase (except

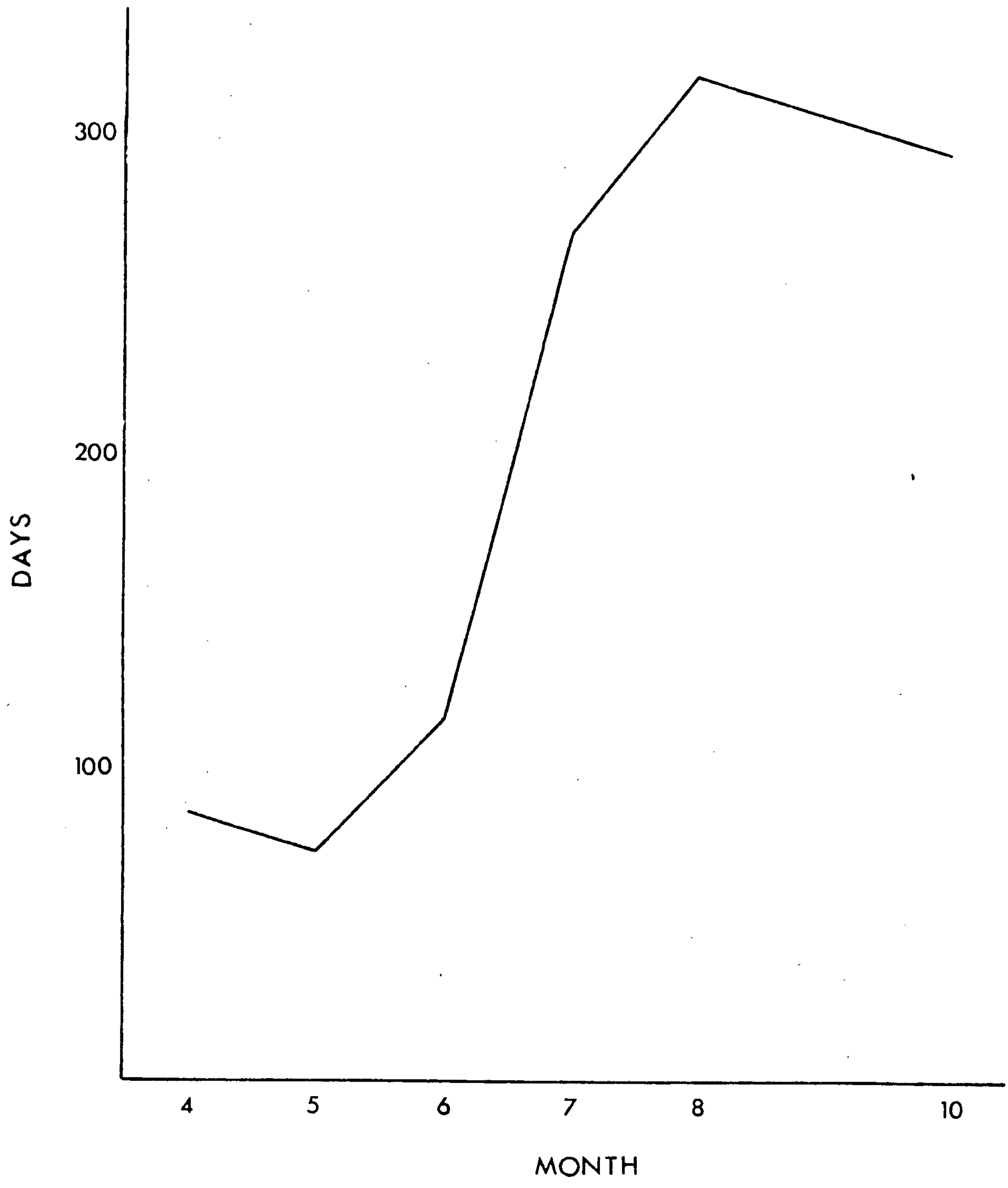

Figure 43. The average number of days root cores collected in April (4), May (5), June (6), July (7), August (8), and October (10) grew in the dark.

for a decrease from April to May for the tufted hairgrass-Lyngby's sedge community) to August then decline to October (Figures 51 and 52).

The height of Lyngby's sedge one month after clipping declines from April to August on the Cowichan; declines from June to August on the Little Qualicum Lyngby's sedge community, declines from April to July then increases to August on the Little Qualicum cinquefoil-Lyngby's sedge community declines April through July then remains relatively stable in August on the Campbell; and increases from April to May then decreases to August on the Salmon. The height of Baltic rush one month after clipping is the same in April and May, increases to June, decreases to July then remains relatively stable to August on the Cowichan; decreases from April to May, increases to June then decreases to August on the Little Qualicum; and decreases from April to May, remains relatively stable to June then decreases until August on the Campbell.

The number of Lyngby's sedge regrown shoots per month plots clipped decreases from April to July then increases to August on the Cowichan; decreases from April to May, increases to July then decreases to August on the Little Qualicum; decreases from April to June then increases to August on the Campbell; and decreases from April to June then remains relatively stable to August on the Salmon. On all estuaries, except for the Little Qualicum, the average number of shoots in the plots clipped in October is higher than the number of regrown shoots in the plots clipped previously.

The number of Lyngby's sedge overwintering shoots per month plots clipped decreases from April to May, increases to

July then decreases to August on the Cowichan; decreases from April to May then increases to August on the Little Qualicum; remains the same in April and May, decreases to June then increases to August on the Campbell; and decreases from April to June then increases to August on the Salmon. The average number of overwintering shoots in the plots clipped in October is higher or the same than for plots clipped previously.

4.2.3 Discussion

Burton and Jackson's method of estimating the belowground dry matter production does not obtain the weight of belowground dry matter produced, rather, it obtains two different measurements; 1. the number of days plants in a root core will grow in the dark, that is, until the energy reserves of the plants' roots are exhausted, and 2. the air dried weight of the etiolated shoots produced. The measurements obtained using this method are not comparable as the method has not been used on any other estuarine plant communities. However, the trends in the time the root cores grew in the dark are the same as Kistritz and Yesaki's (1979) results by the traditional method. The results of this experiment might be a comparable measure of the productivity of the root system if the gas exchange of the plants was monitored. Using gas exchange to measure respiration would allow the expression of the results in the traditional dry weight of matter produced. Also, the problems of distinguishing between living and dead root material, loss of material and soil contamination would be avoided.

The results of the root reserves portion of this study do not point out differences in belowground dry matter production between estuarine marshes but do point out relationships between the below and above ground structures of the emergent plant species when the living fraction of the standing crop section is considered. The changes in the root reserves coincide with canopy development. The decrease in the root reserves from April to May coincides with the initiation and rapid development of the canopy (living fraction in section 4.1 Standing crop), with the initiation and rapid development of the canopy. The increase from May to August coincides with the increase in standing crop, and the gradual decrease in root reserves after August occurs after the canopy dies back. What the root reserves consist of is unknown but they are probably a combination of some mineral elements and carbohydrates. Their storage location(s), and storage and translocation form(s) are unknown, as are the mechanism(s) and rate(s) of mobilization. However, it appears that the root reserves maintain the plant through unfavorable growing conditions, such as winter, and provide energy for the rapid initiation and development of the canopy as soon as the growing conditions are favorable in April. Diversion of the root reserves to the canopy results in the May depletion but enables the plant to make the most of the short daylight low tides in April and May. Once the canopy is established material is directed from the shoots to the roots and the reserves increase. The canopy dies back as the daylight low tides shorten and the plant is again maintained by the root reserves until the next favorable growing season. The number and height, one month after clipping, of the Lyngby's sedge stems that regrew on the plots after clipping help illustrate the root reserves discussion. The height decreases from April to August, however the plots clipped in April were no more than 10 cm shorter than the surrounding stands in October. Regrowth on the plots clipped in April was possible due to the existing flow of reserves from the roots to the canopy which the stems were able to take advantage of for their regrowth. After May the flow was from the shoots to the roots and it would appear there was little energy available to regrow stems. This is also the case for the number of stems that regrew, however, instead of decreasing to August they decrease to June or July then increase to August. This is parallel to the number of overwintering shoots which decreased from April to June then increased from June to August. The number of overwintering stems produced on the clipped plots appears to have been affected by the time the plots were clipped. The time the plots were clipped being synonymous with the state of the root reserves. Root reserves would not have been replenished for plots clipped in May and June and the plants in these plots did not have the root reserves to produce many overwintering shoots Plants clipped in July and August had replenished their root reserves and were able to produce overwintering shoots after being clipped. The number of stems that regrew after being clipped increased form June to August as a by-product of the formation of the overwintering shoots. Though this is not the traditional approach to quantifying belowground matter it obtained the same trends as Kistritz and Yesaki (1979) did for Lyngby's sedge on the Woodward Island marsh on the Fraser River delta, and it illustrates the interaction between the canopy and roots to quickly initiate and maximize growth and survive adverse conditions in the estuary.

5. CONCLUSIONS

The main conclusions of this study may be summarized as follows:

1. There is a great deal of variation in the species composition of plant communities both within and among estuaries.

2. There are salt and brackish marshes in estuaries on the east coast of Vancouver Island.

3. Different plant species dominate in estuarine marshes north and south of Courtenay. In brackish marshes south of Courtenay *Juncus* spp., *Potentilla pacifica* and *Distichlis spicata* dominate, while north of Courtenay *Deschampsia cespitosa* and *Potentilla pacifica* dominate. In salt marshes south of Courtenay *Distichlis spicata*, *Atriplex patula* and *Grindelia integrifolia* dominate, while north of Courtenay *Triglochin maritimum* and grasses dominate.

4. There are eleven types of estuaries in the study based on the interrelationships of the six physical factors; 1. time of maximum discharge, 2. relationship between a river's average April to September mean discharge and the size of the river's delta, 3. mean annual total precipitation, 4. the relative protection from wind and wave energy of the sea, 5. the particle size of the substrate, and 6. the duration and frequency of tidal inundation.

5. The standing crop for each community is

		gm m-2
Cowichan	*Carex lyngbyei*	588
Cowichan	*Juncus balticus*	754
Chemainus	*Salicornia virginica*	966
Chemainus	*Distichlis spicata* - *Grindelia integrifolia*	1437
Little Qualicum	*Carex lyngbyei*	1504
Little Qualicum	*Potentilla pacifica* - *Carex lyngbyei*	770
Campbell	*Carex lyngbyei*	487
Campbell	*Potentilla pacifica* - *Eleocharis palustris*	392
Salmon	*Carex lyngbyei*	773
Salmon	*Deschampsia cespitosa* - *Carex lyngbyei*	1092
Salmon	*Poa pratensis* - *Agrostis alba* var. *stolonifera* - *Potentilla pacifica*	772

6. The *Carex lyngbyei* communities have the highest standing crops.

7. The living fraction of the standing crop is always larger than the senescent, dead or duff fractions in the *Carex lyngbyei* communities.

8. The living fraction is exceeded by the dead fraction for part of the growing season in the Cowichan *Juncus balticus*, Chemainus *Distichlis spicata* - *Grindelia integrifolia*,

Little Qualicum Potentialla pacifica - Carex lyngbyei, Campbell Potentilla pacifica - Eleocharis palustris, and Salmon Deschampsia cespitosa - Carex lyngbyei and Poa pratensis - Agrostis alba var. stonifera - Potentilla pacifica communities.

9. The living fraction is exceeded by the dead fraction for all of the growing season in the Chemainus Salicornia verginica community.

10. The ash free dry weight of combined living and senescent fractions in the Carex lyngbyei, Chemainus Salicornia virginica and Campbell Potentilla pacifica - Eleocharis palustris communities rises rapidly to a peak then declines.

11. The ash free dry weights of combined living and senescent fractions in the Cowichan Juncus balticus, Chemainus Distichlis spicata - Grindelia integrifolia, Little Qualicum Potentilla pacifica - Carex lyngbyei, Salmon Deschampsia cespitosa - Carex lyngbyei, and Poa pratensis - Agrostis alba var. stolonifera - Potentilla pacifica communities rise rapidly then level out.

12. The ash free dry weights of the combined dead and duff fractions decrease through the growing season for all the communities. The Carex lyngbyei communities decline most rapidly as there is no dead fraction after May or June.

13. The percent nitrogen content for all the communities was highest in April with the maximum being 2.43% for the living fraction of the Cowichan Carex lyngbyei community. The minimum was .54% for the senescent fraction of the Little Qualicum Potentilla pacifica - Carex lyngbyei community.

14. The highest nitrogen values occur in the living fractions of each plant community.

15. The root reserves vary through the growing season. They are low in April and May, rapidly increase to a peak in August, then slowly decline to October and through the winter months.

16. The spring decrease in root reserves coincides with the initiation of the aboveground growth.

17. The root reserves are greatest within one month of the peak standing crop.

18. The extent of the root reserves varies between plant communities.

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Appendix 1. Locations, in latitude and longitude, of the study areas

Estuary	Latitude	Longitude
Goldstream	48° 29'10"	123° 32'50"
Cowichan	48° 46'10"	125° 38'15"
Chemainus	48° 53'40"	123° 41' 5"
Nanaimo	49° 7'50"	123° 53'30"
Nanoose	49° 16'15"	124° 11'45"
Bonell	49° 15'50"	124° 11'40"
Englishman	49° 19'48"	124° 17'30"
Little Qualicum	49° 21'50"	124° 29'15"
Big Qualicum	49° 23'55"	124° 36'30"
Courtenay	49° 36'	125°
Oyster	49° 45'12"	125° 7' 0"
Campbell	49° 55'35"	125° 15'35"
Salmon	50° 15'35"	125° 55'30"
Adam-Eve	50° 27'45"	126° 16'50"
Tsitika	50° 29'40"	126° 34'50"
Kokish	50° 33'42"	126° 52'15"
Nimpkish	50° 35'	127°
Cluxewe	50° 40'50"	127° 10'30"
Quatse	50° 41'15"	127° 29'10"
Kingcome	50° 55'	126° 20'

Appendix 2 Glossary of terms

Emergent vegetation - phanerogamic vegetation subject to periodic flooding by the sea tide. In this study the presence of eelgrass, a subtidal plant species, and rockweed, an algae, are noted when they occur with emergent vegetation.

Estuary - semi-enclosed coastal bodies of water which have a free connection with the open sea and within which sea water is measurably diluted with freshwater from land drainage (Pritchard, 1967).

Estuarine marsh - lands covered by phanerogamic vegetation subject to periodic flooding by the sea tide.

Physiological drought - results from osmotic stress when the external water potential is lowered below that of the plant cells.

Standing crop - aboveground matter in a specific area, usually one square meter.

Salt marsh - lands covered by phanerogamic vegetation subject to periodic flooding by the sea tide (Chapman 1960, 1964). In this study it refers to marshes with high soil salinities (> 20 ppt.).

Tidal marsh - land covered by phanerogamic vegetation subject to periodic flooding by the sea tide.

Appendix 3. Aerial photographs used in the study

Estuary		Scale	Date	Source
Goldstream	B.C. 7401 No.166	1 cm = 634m		B.C. Government
Cowichan River	67068-67105	1 cm = 48 m	March 22/73	P.S.C.*
Chemainus River	67106-67139	1 cm = 48 m	March 22/73	P.S.C.
Nanaimo River	67159-67192	1 cm = 48 m	March 22/73	P.S.C.
Nanoose-Bonell Creeks	67193-67202	1 cm = 48 m	March 22/73	P.S.C.
Englishman River	67203-67210	1 cm = 48 m	March 22/73	P.S.C.
Little Qualicum River	67211-67219	1 cm = 48 m	March 22/73	P.S.C.
Big Qualicum River	67220-67227	1 cm = 48 m	March 22/73	P.S.C.
Courtenay River	67263-67295	1 cm = 48 m	March 22/73	P.S.C.
Oyster River	67296-67303	1 cm = 48 m	March 22/73	P.S.C.
Campbell River	67304-67320	1 cm = 48 m	March 22/73	P.S.C.
Salmon River	66881-66908	1 cm = 48 m	March 22/73	P.S.C.
Adam-Eve River	66909-66923	1 cm = 48 m	March 22/73	P.S.C.
Tsitika River	66924-66932	1 cm = 48 m	March 22/73	P.S.C.
Kokish River	66933-66937	1 cm = 48 m	March 22/73	P.S.C.
Nimpkish River	66938-66972	1 cm = 48 m	March 22/73	P.S.C.
Cluxewe River	66985-66993	1 cm = 48 m	March 22/73	P.S.C.
Quatse River	66994-67007	1 cm = 48 m	March 22/73	P.S.C.
Kingcome River	B.C. 7270 No.076	1 cm = 158m		B.C. Government

*Pacific Survey Corporation

Appendix 4. List of plant species

TREES

Alnus rubra Bong.	Red Alder
Pyrus fusca Raf.	Pacific Crabapple
Pseudotsuga menziesii (Mirbel) Franco	Douglas Fir
Picea sitchensis (Bong.) Carr.	Sitka Spruce
Tsuga heterophylla (Raf.) Sarg.	Western Hemlock
Populus trichocarpa T. & G.	Cottonwood
Sorbus scopulina Greene	Mountain-ash
Cornus stolonifera Michx.	Red-osier Dogwood
Acer macrophyllum Pursh	Common Maple
Thuja plicata Donn.	Western Red Cedar
Pinus contorta var. contorta Dougl.	Lodgepole Pine
Quercus quarryana Dougl.	Garry Oak
Abies grandis (Dougl.) Forbes	Grand Fir
Pyrus malus L.	Apple
Arbutus menziesii Pursh.	Arbutus
Rhamnus purshiana DC.	Cascara
Cornus nuttallii Aud.	Dogwood
Juniperus scopulorum Sarg.	Juniper
Prunus sp. L.	Cultivated Cherry
Prunus emarginata (Dougl.) Walp.	Chokecherry

SHRUBS

Salix sp. L.	Willow
Crataegus douglasii Lindl.	Black Hawthorn
Rosa nutkana Presl.	Nootka Rose
Rubus laciniatus Willd.	Evergreen Blackberry

Symphoricarpos albus (L.) Blake	Snowberry
Cytisus scoparius (L.) Link	Broom
Ribes sanguineum Pursh	Red Currant
Rubus parviflorus Nutt.	Thimbleberry
Rubus ursinus Cham. & Schlecht	Pacific Blackberry
Lonicera involucrata (Ric.) Banks	Black Twin-berry
Rubus spectabilis Pursh	Salmonberry
Osmaronia cerasiformis (T. & G.) Greene	Indian Plum
Gaultheria shallon Pursh	Salal
Vaccinium parvifolium Smith	Huckleberry
Vaccinium ovalifolium Smith	Blueberry
Ribes sp. L.	Gooseberry
Arctostaphylos nevadensis Gray	Kinnikinnick
Spiraea douglasii Hook	Hardhack
Rosa gymnocarpa Nutt.	Little Wild Rose
Physocarpus capitatus (Pursh) Kuntze	Ninebark
Myrica gale L.	Sweet Gale
Sambucus racemosa L.	Elderberry
Holodiscus discolor (Pursh) Maxim.	Ocean-spray
Salix hookeriana Barratt	Hooker Willow
Menziesia ferruginea Smith	Mock Azalea
Crataegus oxyacantha L.	Hawthorn
Berberis nervosa Pursh	Oregongrape
Lonicera ciliosa (Pursh) DC.	Orange Honeysuckle
Amelanchier alnifolia Nutt.	Serviceberry
Rubus pedatus J.E. Smith	Fiveleaved Bramble
Salix scouleriana Barratt	Scouler Willow

Berberis aquifolium Pursh	Oregongrape
Linnaea borealis L.	Twinflower
Lonicera hispidula (Lindl.) Dougl.	Hairy Honeysuckle
Pachistima myrsinites (Pursh) Raf.	Pachistima
Ribes sanguineum Pursh	Red Currant
Ulex europaeus L.	Gorse

FORBS

Myosotis laxa Lehm.	Forget-me-not
Ranunculus cymbalaria Pursh.	Seaside Buttercup
Epilobium watsonii Barbey	Watson's Willow-herb
Lactuca biennis (Moench) Fern.	Tall Blue Lettuce
Myosotis discolor Pers.	Yellow and Blue Forget-me-not
Viola sp. L.	Violet
Iris pseudacorus L.	Yellow Iris
Trientalis latifolia Hook	Starflower
Cerastium arvense L.	Mouse-ear Chickweed
Medicago sativa L.	Medic
Delphinium menziesii DC.	Menzies' Delphinium
Lomatium nudicaule (Pursh) Coult. & Rose	Desert-parsley
Silene noctiflora L.	Catchfly
Ranunculus acris L.	Meadow Buttercup
Tellima grandiflorum (Pursh) Dougl.	Fringecup
Montia perfoliata (Donn) Howell	Miner's Lettuce
Rumex maritimus L.	Seaside Dock

Bellis perennis L.	Daisy
Ranunculus orthorhynchus Hook	Buttercup
Trillium ovatum Pursh	Trillium
Trifolium tridentatum Lindl.	Sand Clover
Achlys triphylla (Smith) DC.	Vanillaleaf
Streptopus amplexifolius (L.) DC.	Twisted-stalk
Habenaria dilatata (Pursh) Hook	Bog-candle
Atriplex patula L.	Saltbush
Suaeda maritima (L.) Dumort.	Seablite
Stellaria humifusa Rottb.	Spreading Starwort
Angelica sp. L.	Angelica
Arenaria macrophylla Hook	Sandwort
Arenaria paludicola Robins	Sandwort
Arenaria stricta Michx.	Slender Sandwort
Barbarea vulgaris R. Br.	Wintercress
Cardamine integrifolia (Nutt.) Greene	Bittercress
Cerastium viscosum L.	Sticky Chickweed
Clintonia uniflora (Schult.) Kunth.	Clintonia
Collinsia parviflora Lindl.	Blue-eyed Mary
Dicentra formosa (Andr.) Walp.	Bleeding Heart
Draba sp. L.	Draba
Erythronium oregonum Applegate	Dogtooth-violet
Heliotropium curassavicum L.	Seaside Heliotrope
Lloydia serotina (L.) Sweet	Lloydia
Plectris congesta (Lindl.) DC.	Rosy Pink
Polypodium scouleri Hook. & Grev.	Polypody
Sanicula crassicaulis Poepp.	Sanicle

Sedum spathulifolium Hook.	Sedum
Stellaria crispa Cham. & Schlecht.	Crisped Sandwort
Apocynum androsaemifolium L.	Dogbane
Zostera marina L.	Eel-grass
Senecio sylvaticus L.	Groundsel
Cochlearia officinalis L.	Spoonwort
Montia sibirica (L.) Howell	Siberian Miner's Lettuce
Lilaeopsis occidentalis Coult. & Rose	Lilaeopsis
Polypodium glycyrrhiza D.C. Eat.	Licorice-fern
Corallorhiza mertensiana Bong.	Western Coral-root
Trifolium wormskjolkii Lehm.	Springbank Clover
Fragaria chiloensis (L.) Duchesne	Coastal Strawberry
Convolvulus sepium L.	Morning-glory
Mimulus guttatus DC.	Yellow Monkey-flower
Mentha spicata L.	Spearmint
Cicuta douglasii (DC.) Coult. & Rose	Water-hemlock
Lemna minor L.	Duckweed
Typha latifolia L.	Cat-tail
Montia parvifolia (Moc.) Greene	Miner's Lettuce
Sidalcea hendersonii Wats.	Henderson's Checker-mallow
Melilotus alba Desr.	White Sweet-clover
Prunella vulgaris L.	Self-heal
Ranunculus repens L.	Creeping Buttercup
Heliopsis helianthoides (L.) Sweet	Ox-eye Daisy

Camassia leichtlinii (Baker) Wats.	Camas
Dodecatheon pulchellum (Raf.) Merrill	Shooting-star
Lilium columbianum Hanson	Columbia Lily
Plantago major L.	Common Plantain
Plantago macrocarpa Cham. & Schlecht	Plantain
Lupinus sp. L.	Lupine
Sisyrinchium angustifolium Mill.	Blue-eyed Grass
Castilleja levisecta Greenm.	Golden Indian-paintbrush
Mentha arvensis L.	Field Mint
Urtica dioica L.	Stinging Nettle
Galium trifidum L.	Small Bedstraw
Adenocaulon bicolor Hook	Pathfinder
Oenanthe sarmentosa Presl.	Water-parsley
Tiarella trifoliata var. *trifoliata* L.	Foamflower
Taraxacum officinale Weber	Common Dandelion
Gymnocarpium dryopteris (L.) Newm.	Oak-fern
Athyrium filix-femina (L.) Roth.	Lady-fern
Blechnum spicant (L.) Roth	Deer-fern
Geum macrophyllum Willd.	Avens
Digitalis purpurea L.	Foxglove
Osmorhiza chilensis H. & A.	Sweet-root
Allium geyeri var. *tenerum* Jones	Geyer's Onion
Capsella bursa-pastoris (L.) Medic.	Shepherd's purse
Ranunculus uncinatus D. Don	Little Buttercup
Galium sp. L.	Bedstraw
Galium boreale L.	Northern Bedstraw
Cornus canadensis L.	Bunchberry

Lysichitum americanum Hulten & St.John	Skunk Cabbage
Stellaria media (L.) Cyrill.	Chickweed
Arabis glabra (L.) Bernh.	Towermustard
Armeria maritima (Mill.) Willd.	Sea-pink
Ruppia maritima L.	Ditch-grass
Asparagus officinalis L.	Asparagus
Potentilla pacifica Howell	Cinquefoil
Plantago lanceolata L.	Ribgrass
Triglochin maritimum L.	Arrow-grass
Plantago maritima L.	Seaside Plantain
Trifolium repens L.	White Clover
Cirsium arvense (L.) Scop.	Canada Thistle
Hypochaeris radicata L.	Hairy Cats-ear
Achillea millefolium L.	Yarrow
Cotula coronopifolia L.	Brass Buttons
Glaux maritima L.	Sea-milkwort
Salicornia virginica L.	Saltwort
Sonchus arvensis L.	Milk-thistle
Grindelia integrifolia DC.	Gumweed
Ambrosia chamissonia (Less.) Greene	Ragweed
Erigeron philadelphicus L.	Philadelphia Fleabane
Polygonum spergulariaeforme Meisn.	Spurry Knotweed
Lactuca muralis (L.) Fresen.	Wall Lettuce
Rumex crispus L.	Curly Dock
Ranunculus repens L. Buttercup	Creeping
Trifolium pratense L.	Red Clover
Equisetum arvense L.	Common Horsetail

Pteridium aquilinum (L.) Kuhn	Bracken
Lathyrus palustris L.	Marsh Pea
Epilobium angustifolium L.	Fireweed
Chenopodium album L.	Pigweed
Anaphalis margaritacea (L.) B. & H.	Pearly-everlasting
Cirsium vulgare (Savi) Tenore	Common Thistle
Rumex acetosella L.	Sour Weed
Geranium molle L.	Dovefoot Geranium
Hypericum formosum H.B.K.	St. John's-wort
Lotus corniculatus L.	Birdsfoot-trefoil
Arctium minus (Hill) Bernh.	Common Burdock
Barbarea orthoceras Ledeb.	Wintercress
Stachys cooleyae Heller	Colley's Hedge-nettle
Petasites frigidus (L.) Fries.	Coltsfoot
Trifolium dubium Sibth.	Least Hop Clover
Aster hesperius Gray	Marsh Aster
Rumex salicifolius Weinm.	Willow Dock
Cuscuta salina Engelm.	Salt-marsh Dodder
Spergularia canadensis (Pers.) G. Don	Canada Sandspurry
Heracleum lanatum Michx.	Cow-parsnip
Fritillaria camschatcensis (L.) Ker.-Gawl.	Chocolate Lily
Vicia gigantea Hook.	Giant Vetch
Maianthemum dilatatum (Wood) Nels. & Macbr.	False Lily-of-the-valley
Sium suave Walt.	Water-parsnip
Trientalis arctica Fisch.	Starflower
Polystichum munitum (Kaulf.) Presl.	Sword-fern

Aquilegia formosa Fisch.	Red Columbine
Galium asperrimum Gray	Rough Bedstraw
Galium aparine L.	Bedstraw
Hieracium albiflorum Hook.	White-flowered Hawkweed
Ranunculus sp. L.	Buttercup
Polygonum aviculare L.	Doorweed
Brassica campestris L.	Common Mustard
Symphytum asperum Lepech.	Rough Comfrey
Myosotis scorpioides L.	Common Forget-me-not

GRASSES

Holcus lanatus L.	Velvet-grass
Distichlis spicata (L.) Greene	Saltgrass
Elymus mollis Trin.	Wildrye
Phleum pratense L.	Timothy
Agrostis alba L.	Bentgrass
Phalaris arundinacea L.	Reed Canarygrass
Deschampsia cespitosa (L.) Beauv.	Tufted Hairgrass
Dactylis glomerata L.	Orchard-grass
Poa pratensis L.	Kentucky Bluegrass
Festuca occidentalis Hook	Western Fescue
Bromus secalinus L.	Cheat
Anthoxanthum odoratum L.	Sweet Vernalgrass
Melica subulata (Griseb.) Scribn.	Melic
Glyceria occidentalis (Piper) Nels.	Western Mannagrass
Agrostis alba var. stolonifera (L.) Smith	Bentgrass

Agropyron repens (L.) Beauv.	Couch Grass
Festuca rubra L.	Red Fescue
Elymus glaucus Buckl.	Blue Wildrye
Hordeum murinum L.	Mouse Barley
Hordeum brachyantherum Nevski.	Meadow Barley
Bromus sitchensis Trin.	Brome-grass
Glyceria borealis (Nash) Batch	Northern Mannagrass
Agrostis tenuis Sibth.	Colonial Bentgrass
Poa compressa L.	Canada Bluegrass
Poa sp. L.	Bluegrass
Calamagrostis canadensis (Michx.) Beauv.	Bluejoint Reedgrass
Bromus pacificus Shear	Pacific Brome
Bromus tectorum L.	Brome-grass
Aira sp. L.	Hairgrass
Bromus inermis Leys.	Smooth Brome
Lolium perenne L.	Ryegrass
Festuca bromoides L.	Fescue
Festuca subulata Trin.	Nodding Fescue
Festuca pratensis Huds.	Meadow Fescue
Hierochloe odorata (L.) Beauv.	Seneca Grass
Cynosurus cristatus L.	Crested Dog's-tail
Festuca sp. L.	Fescue
Bromus mollis L.	Soft Brome
Bromus carinatus H. &. A.	Brome

SEDGES

Carex lyngbyei Hornem.	Lyngby's Sedge
Scirpus microcarpus Presl.	Small-fruit Bulrush
Eleocharis palustris (L.) R. & S.	Spike-rush
Carex pansa Bailey	Sand-dune Sedge
Carex pluriflora Hulten	Sedge
Scirpus americanus Pers.	Three-square Bulrush
Carex lenticularis var. limnophila (Holm) Cronq.	Sedge
Scirpus acutus Muhl.	Hardstem Bulrush
Scirpus maritimus L.	Bulrush
Carex oederi Retz.	Green Sedge
Carex obnupta Bailey	Slough Sedge
Eleocharis pauciflora (Lightf.) Link	Few-flowered Spike-rush
Carex rostrata Stokes	Beaked Sedge

RUSHES

Juncus balticus Willd.	Baltic Rush
Juncus effusus L.	Common Rush
Juncus gerardii Loisel.	Mud Rush
Juncus acuminatus Michx.	Tapered Rush
Luzula divaricata Wats.	Woodrush
Juncus articulatus L.	Jointed Rush
Juncus ensifolius var. ensifolius Wikst.	Dagger-leaf Rush
Juncus falcatus E. Meyer	Sickle-leaved Rush
Luzula spicata (L.) DC.	Spiked Woodrush

Appendix 5. Descriptions , maps and area determinations of the plant communities on the estuaries studied.

Figure 4. Map showing the distribution of the plant communities on the Goldstream Estuary

Legend

Scale 1cm=32m

Plant Community

1 Plantago lanceolata-Rumex salicifolius-Hordeum brachyantherum- Chenopodium album
2 Cytisus scoparius - Rosa nutkana
3 Agrostis alba
4 Aster hesperius - Juncus balticus
5 Hordeum brachyantherum
6 Carex lyngbyei
7 Distichlis spicata - Salicornia virginica
8 Hordeum murinum - Carex lyngbyei
9 Salicornia virginica

L tidal

M marina
N nature house
SL subtidal

building

road

Table 7. Description of the plant communities on the Goldstream Estuary, September, 1976.

1	*Plantago lanceolata* - *Rumex salicifolius* - *Hordeum brachyantherum* - *Chenopodium album*
2	*Cytisus scoparius* - *Rosa nutkana*
3	*Agrostis alba*
4	*Aster hesperius* - *Juncus balticus*
5	*Hordeum brachyantherum*
6	*Carex lyngbyei*
7	*Distichlis spicata* - *Salicornia virginica*
8	*Hordeum murinum* - *Carex lyngbyei*
9	*Salicornia virginica*

Following is a list of the species in each plant community including dominant species indicated by a D and subdominant species indicated by an S.

	Community								
	1	2	3	4	5	6	7	8	9
TREES									
Alnus rubra Bong. (Red Alder)		x							
Pseudotsuga menziesii (Mirbel) Franco (Douglas Fir)		x							
SHRUBS									
Cytisus scoparius (L.) Link (Broom)	x	D							
Rosa nutkana Presl. (Nootka Rose)		D							
Rubus ursinus Cham. & Schlecht (Pacific Blackberry)		x							
Salix spp. L. (Willow)		x							
Lonicera involucrata (Rich.) Banks (Black Twin-berry)		x							
Rubus spectabilis Pursh (Salmonberry)		x							
Pyrus fusca Raf. (Pacific Crabapple)				x					
Crataegus douglasii Lindl. (Black Hawthorn)		x							

	Community								
	1	2	3	4	5	6	7	8	9
TREES (cont.)									
Osmaronia cerasiformis (T.&G.) Greene (Indian Plum)									
FORBS									
Plantago lanceolata L. (Ribgrass)	S	x		x					
Hypochaeris radicata L. (Hairy Cats-ear)	x								
Chenopodium album L. (Pigweed)	S								
Anaphalis margaritacea (L.) B. & H. (Pearly-everlasting)	x	x							
Achillea millefolium L. (Yarrow)	x	x	x	x					
Cirsium vulgare (Savi) Tenore (Common Thistle)	x	x		x					
Rumex acetosella L. (Sour weed)	x								
Geranium molle L. (Dovefoot Geranium)	x								
Rumex crispus L. (Curly Dock)	x								

	Community								
	1	2	3	4	5	6	7	8	9
<u>FORBS</u> (cont.)									
<u>Pteridium aquilinum</u> (L.) Kuhn (Bracken)		x							
<u>Trifolium pratense</u> L. (Red Clover)	x								
<u>Asparagus officinalis</u> L. (Asparagus)	x		x						
<u>Hypericum formosum</u> H.B.K. (St. John's-wort)	x	x							
<u>Arctium minus</u> (Hill) Bernh. (Burdock)	x								
<u>Cirsium arvense</u> (L.) Scop. (Canada Thistle)	x								
<u>Barbarea orthoceras</u> Ledeb. (Wintercress)	x								
<u>Stachys cooleyae</u> Heller (Stinging Nettle)		x							
<u>Petasites frigidus</u> (L.) Fries (Coltsfoot)		x							
<u>Potentilla pacifica</u> Howell (Cinquefoil)		x	x	x				x	
<u>Trifolium repens</u> L. (White Clover)	x								

	Community								
	1	2	3	4	5	6	7	8	9
<u>FORBS</u> (cont.)									
<u>Trifolium</u> <u>dubium</u> Sibth. (Least Hop Clover)	x								
<u>Grindelia</u> <u>integrifolia</u> DC. (Gumweed)			x	x		x		S	
<u>Erigeron</u> <u>philadelphicus</u> L. (Philadelphia Fleabane)		x	x	x		x			
<u>Aster</u> <u>hesperius</u> Grey (Marsh Aster)		x	x	D		x			
<u>Plantago</u> <u>maritima</u> L. (Seaside Plantain)			x						
<u>Salicornia</u> <u>virginica</u> L. (Saltwort)			x	x	x	x	D	x	D
<u>Rumex</u> <u>salicifolius</u> Weinm. (Willow Dock)	S								
<u>Triglochin</u> <u>maritimum</u> L. (Arrow-grass)					x	x	x	x	
<u>Glaux</u> <u>maritima</u> L. (Sea-milkwort)								x	
<u>Cuscuta</u> <u>salina</u> Engelm. (Salt-marsh Dodder)							x		
<u>Spergularia</u> <u>canadensis</u> (Pers.) G. Don (Canada Sandspurry)							x		

	Community								
	1	2	3	4	5	6	7	8	9
FORBS (cont.)									
Heracleum lanatum Michx. (Cow-parsnip)				x					
Epilobium watsonii Barbey (Watson's Willow-herb)		x							
Atriplex patula L. (Saltbush)				x	x		x	x	
GRASSES									
Dactylis glomerata L. (Orchard-grass)	x	x							
Poa pratensis L. (Kentucky Bluegrass)	x			x					
Festuca occidentalis Hook (Western Fescue)	x								
Bromus secalinus L (Cheat)	x								
Anthoxanthum odoratum L. (Sweet vernalgrass)	x								
Distichlis spicata (L.) Greene (Saltgrass)			S		x	S	D	S	S
Deschampsia cespitosa (L.) Beauv. (Tufted Hairgrass)			x		x	x	x	x	

	Community 1	2	3	4	5	6	7	8	9
<u>GRASSES</u> (cont.)									
<u>Melica</u> <u>subulata</u> (Griseb.) Scribn. (Melic)			x						
<u>Agrostis</u> <u>alba</u> L. (Bentgrass)			D	x	x			x	
<u>Hordeum</u> <u>brachyantherum</u> Nevski. (Meadow Barley)	S		x		D	x		x	
<u>Hordeum</u> <u>murinum</u> L. (Mouse Barley)					x		x	D	
<u>Agropyron</u> <u>repens</u> (L.) Beauv. (Couch Grass)					x				
<u>SEDGES</u>									
<u>Carex</u> <u>lyngbyei</u> Hornem					x	D	x	D	
<u>RUSHES</u>									
<u>Juncus</u> <u>balticus</u> Willd. (Baltic Rush)				D			x		

Table 8. Area of each plant community on the Goldstream Estuary

Plant Community	Area (hectares)	Percent (%)
Aster hesperius-Juncus balticus	1.4	23.3
Hordeum murinum-Carex lyngbyei	1.1	18.3
Cytisus scoparius-Rosa nutkana	.7	11.7
Hordeum brachyantherum	.6	10.0
Salicornia viriginica	.6	10.0
Agrostis alba	.6	10.0
Carex lyngbyei	.4	6.6
Subtotal	5.4	89.9
Plantago lanceolata-Rumex salicifolius-Hordeum brachyantherum-Chenopodium album	.3	5.0
Distichlis spicata-Salicornia virginica	.3	5.0
TOTAL	6.0	99.9

Figure 5. Map showing the distribution of the plant communities on the Cowichan River Estuary

Legend

Scale 1cm=48m

Plant Community

1 *Carex lyngbyei*

2 *Glaux maritima*

3 Dyke vegetation *Rubus laciniatus* - *Cytisus scoparius* - *Rubus ursinus*

4 *Distichlis spicata* - *Triglochin maritimum* - *Glaux maritima* - *Scirpus americanus*

5 *Carex lyngbyei* - *Agropyron repens*

6 *Juncus balticus*

7 *Typha latifolia*

8 *Distichlis spicata*

9 *Scirpus acutus*

10 *Distichlis spicata* - *Juncus balticus*

11 *Poa compressa* - *Achillea millefolium* - *Atriplex patula*

12 *Carex lyngbyei* - *Distichlis spicata*

13 *Barbarea orthoceras* - *Holcus lanatus*

14 *Agropyron repens* - *Cirsium arvense*

15 *Elymus mollis*

16 *Juncus balticus* - *Carex lyngbyei* - *Deschampsia cespitosa*

A agriculture

B log boom

D dredged

I industrial

L tidal

LBC lawn bowling club

dyke

railway

road

transect

Figure 5 (cont.)

LD log dump

SL tidal

buildings urban

Table 9. Description of the plant communities on the Cowichan River Estuary, May 1976

1	*Carex lyngbyei*
2	*Glaux maritima*
3	*Rubus laciniatus* - *Cytisus scoparius* - *Rubus ursinus* dyke vegetation
4	*Distichlis spicata* - *Triglochin maritimum* - *Glaux maritima* - *Scirpus americanus*
5	*Carex lyngbyei* - *Agropyron repens*
6	*Juncus balticus*
7	*Typha latifolia*
8	*Distichlis spicata*
9	*Scirpus acutus*
10	*Distichlis spicata* - *Juncus balticus*
11	*Poa compressa* - *Achillea millefolium* - *Atriplex patula*
12	*Carex lyngbyei* - *Distichlis spicata*
13	*Barbarea orthoceras* - *Holcus lanatus*
14	*Agropyron repens* - *Cirsium arvense*
15	*Elymus mollis*
16	*Juncus balticus* - *Carex lyngbyei* - *Deschampsia cespitosa*

Following is a list of the species in each plant community including dominant species indicated by a D and subdominant species indicated by an S.

	Community															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
TREES																
Pyrus fusca Raf. (Pacific Crabapple)			x										x			
Pseudotsuga menziesii (Mirbel) Franco (Douglas Fir)			x													
Populus trichocarpa T. & G. (Cottonwood)			x													
Alnus rubra Bong. (Red Alder)			x													
Acer macrophyllum Pursh. (Common Maple)			x													
Arbutus menziesii Pursh (Arbutus)			x													

	Community															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
SHRUBS																
Cytisus scoparius (L.) Link (Broom)			S													
Rubus ursinus Cham. & Schlecht (Pacific Blackberry)			S													
Rosa nutkana Presl. (Nootka Rose)			x										x		S	
Symphoricarpos albus (L.) Blake (Snowberry)			S													
Physocarpus capitatus (Pursh) Kuntze (Ninebark)			x													
Lonicera involucrata (Rich.) Banks (Black Twin-berry)			x													
Sambucus racemosa L. (Elderberry)			x													
Rubus laciniatus Willd. (Evergreen Blackberry)			S										x			

	Community															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<u>FORBS</u>																
<u>Potentilla</u> <u>pacifica</u> Howell (Cinquefoil)	x		x		x	S		x		x	x	x	x	x	x	x
<u>Lilaeopsis</u> <u>occidentalis</u> Coult. & Rose (Lilaeopsis)	x	x		x												
<u>Triglochin</u> <u>maritimum</u> L. (Arrow-grass)	x	x		S	x			x		x		x				
<u>Glaux</u> <u>maritima</u> L. (Sea-milkwort)	x	D		S		s				x				x		
<u>Plantago</u> <u>lanceolata</u> (Ribgrass)			x			x								x	x	x
<u>Epilobium</u> <u>angustifolium</u> L. (Fireweed)			x													
<u>Trientalis</u> <u>latifolia</u> Hook (Starflower)			x													
<u>Pteridium</u> <u>aquilinum</u> (L.) Kuhn. (Bracken)			x													
<u>Rumex</u> <u>crispus</u> L. (Curly Dock)			x			x					x		x	x		x
<u>Achillea</u> <u>millefolium</u> L. (Yarrow)			x			x				x	S		x	x		x
<u>Trifolium</u> <u>repens</u> L. (White Clover)			x										x			

	Community															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
FORBS (cont.)																
Trifolium pratense L. (Red Clover)			x													
Salicornia virginica L. (Saltwort)		x		x						x						
Erigeron philadelphicus L. (Philadelphia Fleabane)					x	x					x		x	x		x
Heracleum lanatum Michx. (Cow-parsnip)						x	x						x	x	x	x
Typha latifolia L. (Cat-tail)							D									x
Trifolium wormskjoldii Lehm. (Springbank Clover)					x	x		x				x				x
Equisetum arvense L. (Common Horsetail)			S													
Cirsium arvense (L.) Scop. (Canada Thistle)			x			x							x	D	x	
Plantago macrocarpa Cham. & Schlecht (Plantain)						x				x						x
Taraxacum officinale Weber (Common Dandelion)						x								x	x	
Fritillaria camschatcensis (L.) Kev.-Gawl. (Chocolate Lily)						x										

FORBS (cont.)	Community 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Rumex acetosella L. (Sour Weed)			x										x			
Plantago maritima L. (Seaside Plantain)								x								
Stellaria media (L.) Cyrill. (Chickweed)			x								x					
Cotula coronopifolia L. (Brass Buttons)												x				
Barbarea orthoceras Ledeb. (Wintercress)													D	x		
Mentha arvensis L. (Field Mint)													x			
Lathyrus palustris L. (Marsh Pea)													x		x	
Urtica dioica L. (Stinging Nettle)													x			
Myosotis discolor Pers. (Yellow and Blue Foreget-me-not)													x			
Viola sp. L. (Violet)													x			
Asparagus officinalis L. (Asparagus)													x	x		

	Community															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
FORBS (cont.)																
Hypericum formosum H.B.K. (St. John's-wort)													x			
Cerastium arvense L. (Mouse-ear Chickweed)													x			
Vicia gigantea Hook (Giant Vetch)													x			x
Lemna minor L. (Duckweed)												x				
Ranunculus sp. L. (Buttercup)													x			
Iris pseudacorus L. (Yellow Iris)																x
Ranunculus repens L. (Creeping Buttercup)			x													
Camassia leichtlinii (Baker) Wats. (Camas)						x										x
Myosotis laxa Lehm. (Forget-me-not)						x										
Brassica campestris L. (Common Mustard)			x													
Atriplex patula L (Saltbush)											S					

	Community															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
FORBS (cont.)																
Stellaria humifusa Rottb. (Spreading Starwort)	x															
GRASSES																
Distichlis spicata (L.) Greene (Saltgrass)	x	x	x	S		x		D		D	x	D	x			
Bromus tectorum L. (Brome-grass)			x													
Aira sp. (Hairgrass)			x													
Dactylis glomerata L. (Orchard-grass)			x													
Poa compressa L. (Canada Bluegrass)			x								S		x	x		
Agropyron repens (L.) Beauv. (Couch Grass)					S	x							x	D		
Deschampsia cespitosa (L.) Beauv. (Tufted Hairgrass)						x								x		S
Holcus lanatus L. (Velvet-grass)			x										S	x		
Elymus mollis Trin. (Wildrye)															D	

	Community															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<u>GRASSES</u> (cont.)																
Bromus inermis Leys. (Smooth Brome)			x													
<u>SEDGES</u>																
Carex lyngbyei Hornem. (Lyngby's Sedge)	D		x		D	x	x			x		D		x		S
Eleocharis palustris (L.) R. & S. (Spike-rush)	x									x		x				
Scirpus acutus Muhl. (Bulrush)									D			x				
Scirpus americanus Pers. (Three-square Bulrush)				S												
Scirpus maritimus L. (Bulrush)	x															
Carex obnupta Bailey (Slough Sedge)			x							x						
<u>RUSHES</u>																
Juncus balticus Willd. (Baltic Rush)			x			D	x	x		S	x		x	x	x	S
Juncus effusus L. (Common Rush)			x							x						

Table 10. Area of each plant community on the Cowichan River Estuary

Plant Community	Area (hectares)	Percent (%)
Carex lyngbyei	22.4	31.6
Juncus balticus	19.5	27.5
Distichlis spicata - *Juncus balticus*	9.9	14.0
Agropyron repens - *Cirsium arvense*	8.4	11.8
Carex lyngbyei - *Distichlis spicata*	4.2	5.9
Subtotal	64.4	90.8
Juncus balticus - *Carex lyngbyei* - *Deschampsia cespitosa*	2.4	3.4
Distichlis spicata	1.3	1.8
Carex lyngbyei - *Agropyron repens*	.9	1.3
Barbarea orthoceras - *Holcus lanatus*	.7	1.0
Glaux maritima	.5	.7
Distichlis spicata - *Triglochin maritimum* - *Glaux maritima* - *Scirpus americanus*	.3	.4
Poa compressa - *Achillea millefolium* - *Atriplex patula*	.2	.3
Typha latifolia	.1	.1
Elymus mollis	.1	.1
Scirpus acutus	.01	.01
TOTAL	70.9	99.9

Figure 6. Map showing the distribution of the plant communities on the Chemainus River Estuary

Legend

scale 1cm=48m

Plant Community

1 *Scirpus maritimus*

2 *Pyrus fusca* - *Rosa nutkana*

3 *Carex lyngbyei* - *Scirpus maritimus*

4 *Pyrus fusca* - *Rosa nutkana* - *Cytisus scoparius* - *Equisetum arvense*

5 *Arbutus menziesii* - *Quercus garryana* - *Anthoxanthum odoratum*

6 *Juniperus scopulorum* - GRAMINEAE

7 *Juncus balticus*

8 *Salicornia virginica* - *Distichlis spicata* - *Carex lyngbyei*

9 dyke vegetation *Cytisus scoparius* - *Rosa nutkana* - GRAMINEAE

10 *Pseudotsuga menziesii* - *Juniperus scopulorum* - *Pachistima myrsinites*

11 *Salicornia virginica* - *Distichlis spicata*

12 *Salicornia virginica*

13 *Distichlis spicata* - *Grindelia integrifolia*

14 *Carex lyngbyei*

15 *Salicornia virginica* - *Juncus balticus*

16 GRAMINEAE - *Juncus balticus*

17 GRAMINEAE

18 *Zostera marina*

19 *Salicornia virginica* - *Zostera marina*

A	agriculture		buildings, urban
B	log booms		dyke
F	forest		railway
I	industrial		road
			transect

Table 11. Description of the plant Communities on the Chemainus River Estuary, April 1975.

1	*Scirpus maritimus*
2	*Pyrus fusca* - *Rosa nutkana*
3	*Carex lyngbyei* - *Scirpus maritimus*
4	*Pyrus fusca* - *Rosa nutkana* - *Cytisus scoparius* - *Equisetum arvense*
5	*Arbutus menziesii* - *Quercus garryana* - *Anthoxanthum odoratum*
6	*Juniperus scopulorum* - GRAMINEAE
7	*Juncus balticus*
8	*Salicornia virginica* - *Distichlis spicata* - *Carex lyngbyei*
9	*Cytisus scoparius* - *Rosa nutkana* - GRAMINEAE
10	*Pseudotsuga menziesii* - *Juniperus scopulorum* - *Pachistima myrsinites*
11	*Salicornia virginica* - *Distichlis spicata*
12	*Salicornia virginica*
13	*Distichlis spicata* - *Grindelia integrifolia*
14	*Carex lyngbyei*
15	*Salicornia virginica* - *Juncus balticus*
16	GRAMINEAE - *Juncus balticus*
17	GRAMINEAE
18	*Zostera marina*

19 *Salicornia virginica* - *Zostera marina*

Following is a list of the plant species in each community including dominant species indicated by a D and subdominant species indicated by an S.

	Community																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
TREES																			
Abies grandis (Dougl.) Forbes (Grand Fir)					x					x									
Acer macrophyllum Pursh (Common Maple)					x					x									
Alnus rubra Bong. (Red Alder)					x				x										
Arbutus menziesii Pursh (Arbutus)					S					x									
Cornus nuttallii Aud. (Dogwood)				x															
Juniperus scopulorum Sarg. (Juniper)					x	D				D									
Prunus sp. L (Cultivated Cherry)				x	x	x													
Prunus emarginata (Dougl.) Walp. (Choke cherry)				x	x	x													
Pseudotsuga menziesii (Mirbel) Franco (Douglas Fir)				x	x				x	D									

	Community																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
<u>TREES</u> (cont.)																			
<u>Pyrus fusca</u> Raf. (Pacific Crabapple)		S		S						x									
<u>Quercus garryana</u> Dougl. (Garry Oak)		x			S	x				x									
<u>Rhamnus purshiana</u> DC. (Cascara)		x				x													
<u>Thuja plicata</u> Donn. (Western Red Cedar)					x	x			x										
<u>SHRUBS</u>																			
<u>Salix hookeriana</u> Barratt (Hooker Willow)				x					x										
<u>Salix scouleriana</u> Barratt (Scouler Willow)				x					x										
<u>Amelanchier alnifolia</u> Nutt. (Serviceberry)					x														
<u>Berberis aquifolium</u> Pursh (Oregongrape)		x		x	x	x													
<u>Berberis nervosa</u> Pursh (Oregongrape)										S									
<u>Cytisus scoparius</u> (L.) Link (Broom)				S		x			D										

	Community																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
SHRUBS (cont.)																			
Gaultheria shallon Pursh (Salal)				x					x										
Holodiscus discolor (Pursh) Maxim. (Ocean-spray)					x					x									
Linnaea borealis L. (Twinflower)										x									
Lonicera ciliosa (Pursh) DC. (Orange Honeysuckle)					x														
Lonicera hispudula (Lindl.) Dougl. (Hairy Honeysuckle)										x									
Lonicera involucrata (Rich.) Banks						x			x										
Osmaronia cerasiformis (T. & B.) Greene					x				x										
Pachistima myrsinites (Pursh) Raf. (Pachistima)									D										
Physocarpus capitatus (Pursh) Kuntze (Ninebark)									x										
Ribes sanguineum Pursh (Red Currant)									x										
Rubus laciniatus Willd. (Evergreen Blackberry)									x										

	Community																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
<u>SHRUBS</u> (cont.)																			
Rubus spectabilis Pursh (Salmonberry)						x				x									
Rubus ursinus Cham. & Schlecht (Pacific Blackberry)				x	x	x			x										
Rosa nutkana Presl. (Nootka Rose)		S		S	x	x			S	x									
Sambucus racemosa L. (Elderberry)					x	x			x										
Symphoricarpos albus (L.) Blake (Snowberry)		x		x	x	x			x	S									
Ulex europaeus L. (Gorse)					x														
<u>FORBS</u>																			
Achillea millefolium L. (Yarrow)				x		x				x						x	x		
Angelica sp. L. (Angelica)										x									
Apocynum androsaemifolium L. (Dogbane)										x									
Arctium minus (Hill) Bernh. (Common Burdock)					x														

	Community																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
<u>FORBS</u> (cont.)																			
<u>Arenaria</u> <u>macrophylla</u> Hook (Sandwort)							x												
<u>Arenaria</u> <u>paludicola</u> Robins. (Sandwort)							x												
<u>Arenaria</u> <u>stricta</u> Michx. (Slender Sandwort)							x												
<u>Asparagus</u> <u>officinalis</u> L. (Asparagus)						x										x	x		
<u>Atriplex</u> <u>patula</u> L. (Saltbush)				x			x				x		x			x			x
<u>Barbarea</u> <u>orthoceras</u> Ledeb. (Wintercress)																	x		
<u>Barbarea</u> <u>vulgaris</u> R. Br. (Wintercress)																	x		
<u>Bellis</u> <u>perennis</u> L. (Daisy)																	x		
<u>Camassia</u> <u>leichtlinii</u> (Baker) Wats. (Camas)										x									
<u>Cardamine</u> <u>integrifolia</u> (Nutt.) Green (Bittercress)																			
<u>Castilleja</u> <u>levisecta</u> Greenm. (Golden Indian-paintbrush)							x												

	Community																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
FORBS (cont.)																			
Cerastium arvense L. (Mouse-ear Chickweed)					x														
Cerastium viscosum L. (Sticky chickweed)					x														
Cirsium arvense (L.) Scop. (Canada Thistle)				x		x			x								x		
Cirsium vulgare (Savi.) Tenore (Common Thistle)				x		x			x								x		
Clintonia uniflora (Schult.) Kunth. (Clintonia)					x														
Collinsia parviflora Lindl. (Blue-eyed Mary)					x														
Cuscuta salina Engelm. (Salt-marsh Dodder)								x			x	x	x		x				
Dicentra formosa (Andr.) Walp. (Bleeding Heart)				x															
Draba sp. L. (Draba)									x										
Epilobium angustifolium L. (Fireweed)				x												x			
Equisetum arvense L. (Common Horsetail)				S					x										

	Community																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
FORBS (cont.)																			
Erigeron philadelphicus L. (Philadelphia Fleabane)							x				x		x			x			
Erythronium oregonum Applegate (Dogtooth-violet)										x									
Fragaria chiloensis (L.) Duchesne (Coastal Streawberry)					x														
Galium trifidum L. (Small Bedstraw)					x	x													
Geranium molle L. (Dovefoot Geranium)										x									
Glaux maritima L (Sea-milkwort)							x	x					x	x					
Grindelia integrifolia DC. (Gumweed)							x				x		D			x			
Heliotropium curassavicum L. (Seaside Heliotrope)										x									
Hypericum formosum H.B.K. (St. John's-wort)									x										
Hypochaeris radicata L. (Hairy Cats-ear)						x													
Lactuca muralis (L.) Fresen. (Wall Lettuce)										x									

	Community																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
FORBS (cont.)																			
Lathyrus palustris L. (Marsh Pea)					x														
Lilaeopsis occidentalis Coult. & Rose (Lilaeopsis)											x								
Lloydia serotina (L.) Sweet (Lloydia)										x									
Lomatium nudicaule (Pursh) Coult. & Rose (Desert-parsley)					x														
Maianthemum dilatatum (Wood) Nels. & Machr. (Flase Lily-of-the-valley)										x									
Oenanthe sarmentosa Presl. (Water-parsley)					x														
Montia parvifolia (Moc.) Greene (Miner's Lettuce)					x														
Petasites frigidus (L.) Fries. (Coltsfoot)					x														
Plantago lanceolata L. (Ribgrass)				x	x	x			x	x							x		
Plantago macrocarpa Cham. & Schlecht (Plantain)																	x		
Plectris congesta (Lindl.) DC. (Rosy Pink)					x														

	Community																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
FORBS (cont.)																			
Polypodium scouleri Hook & Grev. (Polypody)					x														
Polystichum munitum (Kaulf.) Presl. (Sword-fern)									x										
Potentilla pacifica Howell (Cinquefoil)							x	x			x			x		x			
Pteridium aquilinum (L.) Kuhn (Bracken)									x										
Rumex acetosella L. (Sour Weed)				x	x					x							x		
Rumex crispus L. (Curly Dock)				x												x			
Salicornia virginica L. (Saltwort)	x						x	S			D	D	x		D	x			D
Sedum spathulifolium Hook. (Sedum)					x					x									
Stellaria crispa Cham. & Schlecht. (Crisped Sandwort)				x															
Taraxacum officinale Weber (Common Dandelion)				x		x			x								x		
Tellima grandiflorum (Pursh) Dougl. (Fringecup)					x														

Community

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
FORBS (cont.)																			
Trientalis latifolia Hook (Starflower)					x														
Trifolium dubium Sibth. (Least Hop Clover)					x														
Trifolium pratense L. (Red Clover)				x	x				x								x		
Trifolium repens L. (White Clover)									x										
Trifolium wormskjoldii Lehm. (Springbank Clover)							x												
Triglochin maritimum L. (Arrow-grass)							x	x			x		x						
Typha latifolia L. (Cat-tail)	x																		
Urtica dioica L. (Stinging Nettle)									x										
Vicia gigantea Hook (Giant Vetch)				x					x	x						x			
Zostera marina L. (Eel-grass)																		D	S

	Community																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
GRASSES																			
Anthoxanthum odoratum L. (Sweet Vernalgrass)					x														
Dactylis glomerata L. (Orchard-grass)									x										
Distichlis spicata (L.) Greene (Saltgrass)							S	S			D		D		x	x			x
Elymus mollis Trin. (Wildrye)					x					x									
GRAMINEAE (Grasses)		x			x	x	S			S	x			x			D	D	
Hordeum brachyantherum Nevski. (Meadow Barley)													x			x			
SEDGES																			
Carex lyngbyei Hornem (Lyngby's Sedge)			D					S						D					
Scirpus maritimus L. (Bulrush)	D		x																

	Community																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
RUSHES																			
Juncus balticus Willd. (Baltic Rush)							D				x				D	D	x		
Juncus effusus L. (Common Rush)										x							x		

Table 12. Area of each plant community on the Chemainus River Estuary

Plant Community	Area (hectares)	Percent (%)
Salicornia virginica - Distichlis spicata	40.9	24.3
GRAMINEAE	27.7	16.4
Distichlis spicata - Grindelia integrifolia	25.0	14.8
Salicornia virginica	19.0	11.3
Arbutus menziesii - Quercus garryana - Anthoxanthum odoratum	16.5	9.8
Carex lyngbyei	14.7	8.7
GRAMINEAE - Juncus balticus	7.8	4.6
Salicornia virginica - Distichlis spicata - Carex lyngbyei	5.3	3.1
Subtotal	156.9	93.0
Juncus balticus	3.5	2.1
Scirpus maritimus	3.3	2.0
Pseudotsuga menziesii - Juniperus scopulorum - Pachistima myrsinites	1.8	1.1
Juniperus scopulorum - GRAMINEAE	.9	.5
Carex lyngbyei - Scirpus maritimus	.7	.4
Pyrus fusca - Rosa nutkana	.5	.3
Salicornia virginica - Zostera marina	.4	.2
Pyrus fusca - Rosa nutkana - Cytisus scoparius - Equisetum arvense	.1	.1
Salicornia virginica - Juncus balticus	.2	.1
Zostera marina	.1	.1
	168.4	99.9

Figure 7. Map showing the distribution of the plant communities on the Nanaimo River Estuary

Legend

Scale 1cm=48m

Plant Community

1 Carex lyngbyei

2 Scirpus maritimus

3 Triglochin maritimum

4 Spergularia canadensis

5 Triglochin maritimum - Spergularia canadensis - Salicornia virginica

6 Carex lyngbyei - Deschampsia cespitosa

7 Carex lyngbyei - Juncus balticus

8 Juncus balticus - Potentilla pacifica - Distichlis spicata

9 Agropyron repens - Distichlis spicata - Juncus balticus

10 Juncus articulatus

11 Atriplex patula - Grindelia integrifolia

12 Distichlis spicata

13 Salicornia virginica - Glaux maritima

14 Carex lyngbyei - Deschampsia cespitosa - Juncus articulatus

15 Distichlis spicata - Triglochin maritimum

16 Distichlis spicata - Juncus articulatus - Agrostis tenuis

17 Distichlis spicata - Juncus articulatus

18 Quercus garryana - Acer macrophyllum

19 Cytisus scoparius

20 *Potentilla pacifica*

21 *Pseudotsuga menziesii*

22 *Typha latifolia*

A agriculture

B log boom

CD car dump

D dredged

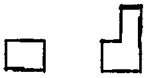
G gravel

GB gravel bar

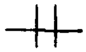
I industrial

L tidal

SL subtidal



U urban, buildings



dyke

Table 13. Description of the plant communities on the Nanaimo River Estuary, June 1976

1 *Carex lyngbyei*

2 *Scirpus maritimus*

3 *Triglochin maritimum*

4 *Spergularia canadensis*

5 *Triglochin maritimum* - *Spergularia canadensis* - *Salicornia virginica*

6 *Carex lyngbyei* - *Deschampsia cespitosa*

7 *Carex lyngbyei* - *Juncus balticus*

8 *Juncus balticus* - *Potentilla pacifica* - *Distichlis spicata*

9 *Agropyron repens* - *Distichlis spicata* - *Juncus balticus*

10 *Juncus articulatus*

11 *Atriplex patula* - *Grindelia integrifolia*

12 *Distichlis spicata*

13 *Salicornia virginica* - *Glaux maritima*

14 *Carex lyngbyei* - *Deschampsia cespitosa* - *Juncus articulatus*

15 *Distichlis spicata* - *Triglochin maritimum*

16 *Distichlis spicata* - *Juncus articulatus* - *Agrostis tenuis*

17 *Distichlis spicata* - *Juncus articulatus*

18 *Quercus garryana* - *Acer macrophyllum*

19 *Cytisus scoparius*

20 *Potentilla pacifica*

21 *Pseudotsuga menziesii*

22 *Typha latifolia*

Following is a list of the species in each plant community including dominant species indicated by a D and subdominant species indicated by an S.

	Community																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
<u>TREES</u>																						
<u>Quercus</u> <u>garryana</u> Dougl. (Garry Oak)																		D	x		x	
<u>Thuja</u> <u>plicata</u> Donn. (Western Red Cedar)																		x				
<u>Pyrus</u> <u>fusca</u> Raf. (Pacific Crabapple)																		x	x	x		
<u>Acer</u> <u>macrophyllum</u> Pursh. (Common Maple)																		S			x	
<u>Alnus</u> <u>rubra</u> Bong. (Red Alder)																		x				
<u>Abies</u> <u>grandis</u> (Dougl.) Forbes (Grand Fir)																		x			S	
<u>Pseudotsuga</u> <u>menziesii</u> (Mirbel) Franco (Douglas Fir)																		x			D	
<u>Pyrus</u> <u>malus</u> L. (Apple)																			x			
<u>SHRUBS</u>																						
<u>Cytisus</u> <u>scoparius</u> (L.) Link (Broom)																		x	D			
<u>Symphoricarpos</u> <u>albus</u> (L.) Blake (Snowberry)																		x			x	

	Community																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
<u>TREES</u> (cont.)																						
<u>Rubus</u> <u>laciniatus</u> Willd. (Evergreen Blackberry)																		x				
<u>Rubus</u> <u>spectabilis</u> Pursh (Salmonberry)																		x				
<u>Crataegus</u> <u>oxyacantha</u> L. (Hawthorn)																		x				
<u>Lonicera</u> <u>involucrata</u> (Rich.) Banks (Black Twin-berry)																		x			x	
<u>Rosa</u> <u>nutkana</u> Presl. (Nootka Rose)																		x	x	x		
<u>Vaccinium</u> <u>parvifolium</u> Smith (Huckleberry)																					x	
<u>FORBS</u>																						
<u>Potentilla</u> <u>pacifica</u> Howell (Cinquefoil)	x					x	x	S		x	x	x		x	x	x			x	D		x
<u>Erigeron</u> <u>philadelphicus</u> L. (Philadelphia Fleabane)						x	x	x	x							x		x	x	x		
<u>Triglochin</u> <u>maritimum</u> L. (Arrow-grass)	x	x	D	x	D	x						x	x	x	D		x					
<u>Glaux</u> <u>maritima</u> L. (Sea milkwort)	x							x	x	x	x	x	S	x	x		x					

Species	Community 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
FORBS (cont.)																						
Achillea millefolium L. (Yarrow)							x	x		x	x					x			x			
Salicornia virginica L. (Saltwort)	x				S			x		x	x		D	x	x	x	x	x				
Fritillaria camschatcensis (L.) Ker-Gawl (Chocolate Lily)								x														
Plantago lanceolata L. (Ribgrass)								x								x		x	x		x	
Plantago maritima L. (Seaside Plantain)	x			x						x				x	x	x	x					
Plantago macrocarpa Cham. & Schlecht (Plantain)								x								x						
Camassia leichtlinii (Baker) Wats. (Camas)								x														
Spergularia canadensis (Pers.) G. Don (Saltmarsh Sandspurry)	x	x	x	D	S								x		S							
Trifolium wormskjoldii Lehm. (Springbank Clover)						x								x								
Taraxacum officinale Weber (Common Dandelion)								x								x						
Grindelia integrifolia DC. (Gumweed)							x			x	S			x	x	x	x	x	x			

	Community																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
FORBS (cont.)																						
Pantago major L. (Common Plantain)											x					x						
Ruppia maritima L. (Ditch-grass)																						
Trifolium repens L. (White Clover)																x						
Trifolium pratense L. (Red Clover)																x		x			x	
Trifolium dubium Sibth. (Least Hop Clover)																x					x	
Lotus corniculatus L. (Birdsfoot-trefoil)																x						
Rumex crispus L. (Curly Dock)																x				x		
Oenanthe sarmentosa Presl. (Water-parsley)												x				x		x	x			
Cotula coronopifolia L. (Brass Buttons)										x							x					
Asparagus officinalis L. (Asparagus)								x														
Cirsium arvense (L.) Scop. (Canada Thistle)																		x	x			

Community

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
FORBS (cont.)																						
Maianthemum dilatatum (Wood) Nels. & Macbr. (False Lily-of-the-valley)																		x				
Ranunculus repens L. (Creeping Buttercup)																		x				
Lactuca muralis (L.) Fresen. (Wall Lettuce)																		x			x	
Lathyrus palustris L. (Marsh Pea)																		x				
Prunella vulgaris L.																		x				
(Self-heal)																		x	x		x	
Hypochaeris radicata L (Hairy Cats-ear)																		x	x		x	
Vicia gigantea Hook (Giant Vetch)																		x	x			
Tiarella trifoliata var. trifoliata L. (Foamflower)																					x	
Osmorhiza chilensis H. & A. (Sweet-root)																					x	
Rumex acetosella L. (Sour Weed)																					x	
Typha latifolia L. (Cat-tail)																						D

Community

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
FORBS (cont.)																						
Atriplex patula L. (Saltbush)	x			x				x	x	x	D			x		x	x	x	x	x		
Stellaria humifusa Rottb. (Spreading Starwort)														x								
Cirsium arvense (L.) Scop. (Canada Thistle)																		x	x	x		
Epilobium watsonii Barbey (Watson's Willow-herb)																				x		
Collinsia parviflora Lindl. (Blue-eyed Mary)																				x		
GRASSES																						
Poa pratensis L. (Kentucky Bluegrass)							x	x								x					x	
Dactylis glomerata L. (Orchard-grass)								x										x	x		x	
Distichlis spicata (L.) Greene (Saltgrass)					x	x		S	D	x	x	D		x	D	D	D	x	x			
Deschampsia cespitosa (L.) Beauv. (Tufted Hairgrass)	x					S		x			x	x		S		x	x					
Agropyron repens (L.) Beauv. (Couch grass)								x	D					x		x						

	Community																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
<u>GRASSES</u> (cont.)																						
Holcus lanatus L. (Velvet-grass)								x											x			
Hordeum brachyantherum Nevski. (Meadow Barley)						x		x		x									x			
Hordeum murinum L. (Mouse Barley)										x				x		x	x	x				
Phleum pratense L. (Timothy)																		x				
Agrostis alba L. (Bentgrass)														x				x	x			
Festuca rubra L. (Red Fescue)										x				x								
Agrostis tenuis Sibth. (Colonial Bentgrass)										x				x		S						
Elymus glaucus Buckl. (Blue Wildrye)																x						
Poa compressa L. (Canada Bluegrass)																		x	S			
Glyceria borealis (Nash) Batch (Northern Mannagrass)																x						

	Community																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
SEDGES																						
Carex lyngbyei Hornem. (Lyngby's Sedge)	D	x	x		x	D	D	x		x		x	x	D	S		x		x	x		
Scirpus acutus Muhl. (Bulrush)									x													
Scirpus maritimus L. (Bulrush)	x	D		x		x																
Scirpus americanus Pers. (Three-square Bulrush)			x																			
RUSHES																						
Juncus balticus Willd. (Baltic Rush)	x						D	D	S	x	x			x		x		x		x		x
Juncus articulatus L. (Jointed Rush)								x		D	x			S	x	S	D	x	x	x		

Table 14. Area of each plant community on the Nanaimo River Estuary

Plant Community	Area (hectares)	Percent (%)
Juncus articulatus	16.4	29.1
Carex lyngbyei	9.2	16.3
Distichlis spicata - Juncus articulatus - Agrostis tenuis	6.3	11.2
Carex lyngbyei - Deschampsia cespitosa - Juncus articulatus	4.2	7.4
Triglochin maritimum - Spergularia canadensis Salicornis virginica	4.1	7.3
Salicornia virginica - Glaux maritima	2.6	4.6
Cytisus scoparius	2.2	3.9
Juncus balticus - Potentilla pacifica - Distichlis spicata	2.1	3.7
Distichlis spicata - Juncus articulatus	1.7	3.0
Distichlis spicata - Triglochin maritimum	1.5	2.7
Spergularia canadensis	1.5	2.7
Subtotal	51.8	91.9
Quercus garryana - Acer macrophyllum	.9	1.6
Carex lyngbyei - Deschampsia cespitosa	.9	1.6
Pseudotsuga menziesii	.8	1.4
Carex lyngbyei - Juncus balticus	.5	.9
Atriplex patula - Grindelia integrifolia	.5	.9
Scirpus maritimus	.4	.7
Triglochin maritimum	.3	.5

Distichlis spicata	.2	.4
Agropyron repens - _Distichlis spicata_ - _Juncus balticus_	.1	.2
Potentilla pacifica	.02	.03
Typha latifolia	.02	.03
TOTAL	56.4	100.2

Figure 8. Map showing the distribution of the plant communities on the Nanoose-Bonell Creeks' Estuary

Legend

Scale 1cm=48

Plant Community

1 Rosa nutkana - Rubus laciniatus - Rubus parviflorus - Rubus spectabilis

2 Juncus balticus

3 Scirpus maritimus

4 Carex lyngbyei

5 Distichlis spicata - Salicornia virginica

6 Grindelia integrifolia - Elymus mollis

7 Salicornia virginica

8 Plantago maritima

9 Agrostis alba

10 Potentilla pacifica - Achillea millefolium - GRAMINEAE

11 Phalaris arundinacea

A agriculture

L tidal

S sunday school camp

SL subtidal

railway

road

buildings

Table 15. Description of the plant communities on the Nanoose-Bonell Creeks' Estuary, September 16, 1976

1 *Rosa nutkana* - *Rubus laciniatus* - *Rubus parviflorus* - *Rubus spectabilis*

2 *Juncus balticus*

3 *Scirpus maritimus*

4 *Carex lyngbyei*

5 *Distichlis spicata* - *Salicornia virginica*

6 *Grindelia integrifolia* - *Elymus mollis*

7 *Salicornia virginica*

8 *Plantago maritima*

9 *Agrostis alba*

10 *Potentilla pacifica* - *Achillea millefolium* - GRAMINEAE

11 *Phalaris arundinacea*

Following is a list of the plant species in each community including dominant species indicated by a D and subdominant species indicated by an S.

	Community 1	2	3	4	5	6	7	8	9	10	11
TREES											
Alnus rubra Bong. (Red Alder)	x										x
Pyrus fusca Raf. (Pacific Crabapple)	x					x				x	
SHRUBS											
Salix. sp. L. (Willow)											x
Crataegus douglasii Lindl. (Black Hawthorn)						x					
Rosa nutkana Presl. (Nootka Rose)	D					x				D	S
Rubus laciniatus Willd. (Evergreen Blackberry)	D									x	x
Symphoricarpos albus (L.) Blake (Snowberry)						S					x
Cytisus scoparius (L.) Link (Broom)						x					
Ribes sanguineum Pursh. (Red Currant)						x					

	Community										
	1	2	3	4	5	6	7	8	9	10	11
<u>SHRUBS</u> (cont.)											
<u>Rubus parviflorus</u> Nutt. (Thimbleberry)	D										x
<u>Rubus spectabilis</u> Pursh. (Salmonberry)	D										
<u>Physocarpus capitatus</u> (Pursh) Kuntze (Ninebark)	x										
<u>FORBS</u>											
<u>Potentilla pacifica</u> Howell (Cinquefoil)		D		x	x			x	S	D	
<u>Plantago lanceolata</u> L. (Ribgrass)		x				x				S	x
<u>Triglochin maritimum</u> L. (Arrow-grass)				x	x				x		
<u>Plantago maritima</u> L. (Seaside plantain)					S			D	x		
<u>Trifolium repens</u> L. (White Clover)		x								x	x
<u>Cirsium arvense</u> (L.) Scop. (Canada Thistle)	x	x								x	

	Community										
	1	2	3	4	5	6	7	8	9	10	11
FORBS (cont.)											
Hypochaeris radicata L.		x								x	x
Trifolium pratense L. (Red Clover)											x
Equisetum arvense L. (Common Horsetail)											x
Pteridium aquilinum (L.) Kuhn. (Bracken)											x
Lathyrus palustris L. (Marsh Pea)											x
Epilobium angustifolium L. (Fireweed)											x
Atriplex patula L. (Saltbush)											S
Spergularia canadensis (Pers.) G. Don (Sandspurry)											x
Suaeda maritima (L.) Dumort. (Seablite)											x
Fragaria chiloensis (L.) Duchesne (Wild Strawberry)						x					

	Community										
	1	2	3	4	5	6	7	8	9	10	11
GRASSES											
Holcus lanatus L. (Velvet-grass)	x	x								x	
Distichlis spicata (L.) Greene (Saltgrass)			x	S	D		S	x	S	x	
Elymus mollis Trin. (Wildrye)						D					
Phleum pratense L. (Timothy)											x
Agrostis alba L. (Bentgrass)		x		x	x				D	S	x
Phalaris arundinacea L. (Reed Canarygrass)										x	D
Deschampsia cespitosa (L.) Beauv. (Tufted Hairgrass)				x	x				x		
Dactylis glomerata L. (Orchard-grass)										x	
Hordeum brachyantherum Nevski (Meadow Barley)		x		x					x	S	
Hordeum murinum L. (Mouse Barley)				x	x				x		
Poa compressa L. (Canada Bluegrass)						x				x	

	Community										
	1	2	3	4	5	6	7	8	9	10	11
GRASSES											
Holcus lanatus L. (Velvet-grass)	x	x								x	
Distichlis spicata (L.) Greene (Saltgrass)			x	S	D		S	x	S	x	
Elymus mollis Trin. (Wildrye)						D					
Phleum pratense L. (Timothy)											x
Agrostis alba L. (Bentgrass)		x		x	x				D	S	x
Phalaris arundinacea L. (Reed Canarygrass)										x	D
Deschampsia cespitosa (L.) Beauv. (Tufted Hairgrass)				x	x				x		
Dactylis glomerata L. (Orchard-grass)										x	
Hordeum brachyantherum Nevski (Meadow Barley)		x		x					x	S	
Hordeum murinum L. (Mouse Barley)				x	x				x		
Poa compressa L. (Canada Bluegrass)						x				x	

	Community										
	1	2	3	4	5	6	7	8	9	10	11
GRASSES											
Bromus tectorum L. (Brome-grass)						x					
Poa pratensis L. (Kentucky Bluegrass)										x	x
SEDGES											
Carex lyngbyei Hornem. (Lyngby's Sedge)			x	D	x				x	x	
Scirpus microcarpus Presl. (Small-fruit Bulrush)											x
Scirpus maritimus L. (Bulrush)			D	x							

	Community										
	1	2	3	4	5	6	7	8	9	10	11
RUSHES											
Juncus balticus Willd. (Baltic Rush)		D		x					S	x	
Juncus effusus L. (Common Rush)	x									x	S
Juncus articulatus L. (Jointed Rush)				x					x		x
Juncus ensifolius var. *ensifolius* Wikst. (Dagger-leaf Rush)											x
Juncus falcatus E. Meyer (Sickle-leaved Rush)											x

Table 16. Area of each plant community on the Nanoose-Bonell Creeks' Estuary

Plant Community	Area (hectares)	Percent (%)
Distichlis spicata - Salicornia virginica	4.5	19.9
Potentilla pacifica - Achilles millefolium - GRAMINEAE	3.6	15.9
Agrostis alba	3.1	13.7
Phalaris arundinacea	3.0	13.3
Rosa nutkana - Rubus laciniatus - Rubus parviflorus - Rubus spectabilis	2.2	9.7
Carex lyngbyei	2.1	9.3
Salicornia virginica	2.0	8.8
Subtotal	20.5	90.6
Juncus balticus	1.5	6.6
Grindelia integrifolia - Elymus mollis	.3	1.3
Plantago maritima	.2	.9
Scirpus maritimus	.1	.4
TOTAL	22.6	99.8

Figure 9. Map showing the distribution of the plant communities on the Englishman River Estuary

Legend

Scale 1cm=48m

Plant Community

1 Salicornia virginica - Triglochin maritimum

2 Distichlis spicata - Salicornia virginica

3 Distichlis spicata

4 Distichlis spicata - Carex lyngbyei

5 Grindelia integrifolia - Agrostis alba

6 Sonchus arvensis - Cirsium arvense

7 Holcus lanatus - Epilobium angustifolium

8 Carex lyngbyei

9 dyke vegetation Agrostis alba - Poa pratensis - Grindelia integrifolia

10 Carex lyngbyei - Juncus balticus

11 Elymus mollis

12 Glaux maritima - Plantago maritima - Distichlis spicata

13 Distichlis spicata - Hordeum murinum - Potentilla pacifica

14 Agrostis alba - Potentilla pacifica

15 Sonchus arvensis - Grindelia integrifolia - Agrostis alba

16 Agropyron repens - Achillea millefolium - Grindelia integrifolia - Cytisus scoparius

17 Cytisus scoparius - Rubus laciniatus - Rosa nutkana

18 Juncus balticus - Distichlis spicata

19 Alnus rubra

Figure 9 (cont.)

L tidal

SL subtidal

U urban

dyke

road

Table 17. Description of the plant communities on the Englishman River Estuary, August 1976.

1	*Salicornia virginica* - *Triglochin maritimum*
2	*Distichlis spicata* - *Salicornia virginica*
3	*Distichlis spicata*
4	*Distichlis spicata* - *Carex lyngbyei*
5	*Grindelia integrifolia* - *Agrostis alba*
6	*Sonchus arvensis* - *Cirsium arvense*
7	*Holcus lanatus* - *Epilobium angustifolium*
8	*Carex lyngbyei*
9	dyke vegetation *Agrostis alba* - *Poa pratensis* - *Grindelia integrifolia*
10	*Carex lyngbyei* - *Juncus balticus*
11	*Elymus mollis*
12	*Glaux maritima* - *Plantago maritima* - *Distichlis spicata*
13	*Distichlis spicata* - *Hordeum murinum* - *Potentilla pacifica*
14	*Agrostis alba* - *Potentilla pacifica*
15	*Sonchus arvensis* - *Grindelia integrifolia* - *Agrostis alba*
16	*Agropyron repens* - *Achillea millefolium* - *Grindelia integrifolia* - *Cytisus scoparius*
17	*Cytisus scoparius* - *Rubus laciniatus* - *Rosa nutkana*
18	*Juncus balticus* - *Distichlis spicata*

19 Alnus rubra

Following is a list of the species in each plant community including dominant species indicated by a D and subdominant species indicated by an S.

	Community																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
TREES																			
Pyrus fusca Raf. (Pacific Crabapple)						x			x							x	x		
Alnus rubra Bong. (Red Alder)																	S		D
Pseudotsuga menziesii (Mirbel) Franco (Douglas Fir)																	x		x
Thuja plicata Donn. (Red Cedar)																	x		
Abies grandis (Dougl.) Forbes (Balsam Fir)																			x
SHRUBS																			
Rosa nutkana Presl. (Nootka Rose)						x			x							x	D		x
Sambucus racemosa L. (Elderberry)						x										x			
Myrica gale L. (Sweet Gale)																			x

	Community																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
<u>SHRUBS</u> (cont.)																			
<u>Rubus laciniatus</u> Willd. (Evergreen Blackberry)						x											D		
<u>Cytisus scoparius</u> (L.) Link (Broom						x			x							S	D		x
<u>Holodiscus discolor</u> (Pursh) Maxim. (Ocean-spray)																	x		
<u>Rubus ursinus</u> Cham. & Schlecht (Pacific Blackberry)																			x
<u>Rubus spectabilis</u> Pursh (Salmonberry)																			x
<u>FORBS</u>																			
<u>Rumex acetosella</u> L. (Sour Dock)											x								
<u>Ambrosia chamissonis</u> (Less.) Greene (Ragweed)											x								x
<u>Trifolium wormskjoldii</u> Lehm. (Springbank Clover)								x											x
<u>Typha latifolia</u> L. (Common Cat-tail)								x											
<u>Ruppia maritima</u> L (Ditch-grass)	x																		

	Community																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
FORBS (cont.)																			
Asparagus officinalis L. (Asparagus)															x	x			
Sonchus arvensis L. (Milk-thistle)					x	S	x	x	x		x			x	x	x			x
Lathyrus palustris L. (Marsh Pea)																S	x		
Trifolium pratense L. (Red Clover)																x			x
Erigeron philadelphicus L. (Philadelphia Fleabane)																x		x	x
Fragaria chiloensis (L.) Duchesne (Coastal Strawberry)																	x		
Spergularia canadensis (Pers.) G. Don (Canada Sandspurry)	x	x	x					x		x		x							
Atriplex patula L. (Saltbush)		x	x		x			x						x				x	
Stellaria humifusa Rottb. (Spreading Startwort)		x	x										x						
Oenanthe sarmentosa Presl. (Water-parsley)			x		x									x				x	
Senecio sylvaticus L. (Groundsel)						x	x												

	Community 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
FORBS (cont.)																			
Polygonum spergulariaeforme Meisn. (Spurry knotweed)											x								
Rumex salicifolius Weinm. (Willow Dock)																		x	
Salicornia virginica L. (Pickleweed)	D	D	S	x	x				x			x	x	x	x			x	
Triglochin maritimum L. (Arrow-grass)	D	x	x	x	x			x	x	x	x		x	x					
Glaux maritima L. (Sea-milkwort)	x	x	x	x	x			x		x		D	x	x				x	x
Grindelia integrifolia DC. (Gumweed)		x	x		S	x			S		x			x	D	S	x	x	x
Epilobium angustifolium L. (Fireweed)							D												
Plantago maritima L. (Sea plantain)	x	x	x	x	x			x	x	x	x	D			x				x
Potentilla pacifica Howell (Cinquefoil)			x	x	x		x	x		x	x		S	D	x			x	x
Plantago lanceolata L. (Ribgrass)					x	x	x	x	x		x			x	x	S	x		x
Cirsium arvense (L.) Scop. (Canada Thistle)						S	x				x					x	S		

	Community																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
FORBS (cont.)																			
Cirsium vulgare (Savi) Tenore (Common Thistle)						x	x		x							x	x		
Rumex crispus L. (Curly Dock)						x	x		x								x		
Achillea millefolium L. (Yarrow)						x	x		x							S	x		x
Anaphalis margaritacea (L.) B. & H. (Pearly-everlasting)						x	x		x								x		x
GRASSES																			
Distichlis spicata (L.) Greene (Saltgrass)	x	D	D	D	x	x	x	x	x	x		D	D	x	x			D	
Holcus lanatus L. (Velvet-grass)						x	D	x											x
Dactylis glomerata L. (Orchard-grass)						x		x	x										
Elymus mollis Trin. (Dune wildrye)											D								
Deschampsia cespitosa (L.) Beauv. (Tufted Hairgrass)								x				x	x	x					
Phalarus arundinacea L. (Reed Canarygrass)																			x

	Community																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
GRASSES (cont.)																			
Hordeum murinum L. (Mouse Barley)		x	x	x	x			x		x			S	x					
Agrostis alba L. (Bentgrass)				x	S	x	x	x	S	x	x			D	S			x	x
Poa pratensis L. (Kentucky Bluegrass)						x	x		S							x	x		
Poa sp. L. (Bluegrass)						x	x		x										
Agropyron repens (L.) Beauv. (Couch Grass)						x									x	S			
Bromus secalinus L. (Cheat)						x	x												
Horeum brachyantherum Nevski. (Meadow Barley)						x	x	x						x					
SEDGES																			
Carex lyngbyei Hornem. (Lyngby's Sedge)	x	x	x	D				D		D		x	x	x					
RUSHES																			
Juncus balticus Willd. (Rush)				x	x	x	x	x	x	S	x			x	x	x	x	D	

Table 18. Area of each plant community on the Englishman River Estuary.

Plant Community	Area (Hectares)	Percent (%)
Holcus lanatus - *Epilobium angustifolium*	3.7	14.9
Sonchus arvensis - *Cirsium arvense*	3.5	14.1
Carex lyngbyei	2.4	9.6
Agrostis alba - *Potentilla pacifica*	2.3	9.2
Distichlis spicata - *Carex lyngbyei*	1.6	6.4
Carex lyngbyei - *Juncus balticus*	1.5	6.0
Glaux maritima - *Plantago maritima* - *Distichlis spicata*	1.5	6.0
Sonchus arvensis - *Grindelia integrifolia* - *Agrostis alba*	1.5	6.0
Salicornia virginica - *Triglochin maritimum*	1.3	5.2
Agropyron repens - *Achillea millefolium* - *Grindelia integrifolia* - *Cytisus scoparius*	1.3	5.2
Juncus balticus - *Distichlis spicata*	1.1	4.4
Distichlis spicata	.8	3.2
Subtotal	22.5	90.2
Alnus rubra	.7	2.8
Elymus mollis	.5	2.0
Cytisus scoparius - *Rubus laciniatus* - *Rosa nutkana*	.5	2.0
Grindelia integrifolia - *Agrostis alba*	.4	1.6
Distichlis spicata - *Hordeum murinum* - *Potentilla pacifica*	.2	.8
Distichlis spicata - *Salicornia virginica*	.1	.4
	24.9	99.8

Figure 10. Map showing the distribution of the plant communities on the Little Qualicum River Estuary.

Legend

Scale 1cm=48m

Plant Community

1 *Distichlis spicata*

2 *Pyrus fusca* - *Rosa nutkana*

3 *Elymus mollis*

4 *Potentilla pacifica* - *Carex lyngbyei* - *Eleocharis palustris* - *Juncus balticus*

5 *Typha latifolia*

6 *Carex lyngbyei*

7 *Potentilla pacifica* - *Carex lyngbyei*

8 *Potentilla pacifica* - *Juncus balticus*

9 *Rosa nutkana*

10 *Potentilla pacifica* - *Heracleum lanatum*

11 GRAMINEAE

12 *Rosa nutkana* - *Pyrus fusca* - *Rubus laciniatus* - *Rubus spectabilis* - *Rubus parviflorus*

13 *Scirpus acutus*

14 *Rosa nutkana* - *Anthoxanthum odoratum* - *Bromus mollis*

A agriculture

F forest

L tidal

R Canadian Wildife Service Reserve

SL subtidal

U urban buildings

dyke

road

transect

Table 19. Description of the plant communities on the Little Qualicum River Estuary, June 1975.

1 Distichlis spicata

2 Pyrus fusca - Rosa nutkana

3 Elymus mollis

4 Potentilla pacifica - Carex lyngbyei - Eleocharis palustris - Juncus balticus

5 Typha latifolia

6 Carex lyngbyei

7 Potentilla pacifica - Carex lyngbyei

8 Potentilla pacifica - Juncus balticus

9 Rosa nutkana

10 Potentilla pacifica - Heracleum lanatum

11 GRAMINEAE

12 Rosa nutkana - Pyrus fusca - Rubus laciniatus - Rubus spectabilis - Rubus parviflorus

13 Scirpus acutus

14 Rosa nutkana - Anthoxanthum odoratum - Bromus mollis

Following is a list of the plant species in each community including dominant species indicated by a D and subdominant species indicated by an S.

	Community													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
TREES														
Pyrus fusca Raf. (Pacific Crabapple)	x	D							x			S		
Acer macrophyllum Pursh (Common Maple)		x										x		
Thuja plicata Donn (Western Red Cedar)		x												
Pseudotsuga menziesii (Mirbel) Franco (Douglas Fir)		x												
Pyrus malus L. (Apple)		x												
Picea sitchensis (Borg.) Carr. (Sitka Spruce)									x					
SHRUBS														
Rosa nutkana Presl. (Nootka Rose)		D							D	x		S		D
Symphoricarpos albus (L.) Blake (Snowberry)			x						x					
Cytisus scoparius (L.) Link (Broom)									x					
Lonicera involucrata (Rich.) Banks (Black Twin-berry)									x					

	Community													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
<u>SHRUBS</u> (cont.)														
<u>Salix</u> sp. L. (Willow)									x					
<u>Rubus</u> <u>spectabilis</u> Pursh (Salmonberry)									x			S		
<u>Rubus</u> <u>laciniatus</u> Willd. (Evergreen Blackberry)												S		
<u>Rubus</u> <u>parviflorus</u> Nutt. (Thimbleberry)												S		
<u>FORBS</u>														
<u>Potentilla</u> <u>pacifica</u> Howell (Cinquifoil)	x			D		x	D	D		D	x			x
<u>Plantago</u> <u>lanceolata</u> L. (Ribgrass)	x			x					x		x			x
<u>Trifolium</u> <u>wormskjoldii</u> Lehm. (Springbank Clover)	x						x	x	x					
<u>Hypochaeris</u> <u>radicata</u> L. (Hairy Cats-ear)	x						x	x	x		x			x
<u>Triglochin</u> <u>maritimum</u> L. (Arrow-grass)	x			x			x	x						
<u>Trifolium</u> <u>dubium</u> Sibth. (Least Hop Clover)	x										x			

	Community													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
FORBS (cont.)														
Achillea millefolium L. (Yarrow)	x							x	x		x			
Rumex acetosella L. (Sour Weed)	x		x						x		x			x
Ambrosia chamissonis (Less.) Greene (Ragweed)			x											
Rumex crispus L. (Curly Dock)			x											
Montia perfoliata (Donn.) Howell (Miner's Lettuce)			x											
Barbarea orthoceras Ledeb. (Wintercress)			x	x						x	x			
Silene noctiflora L. (Catchfly)			x											
Ranunculus acris L. (Meadow Buttercup)				x										
Oenanthe sarmentosa Presl. (Water-parsley)				x										
Glaux maritima L. (Sea-milkwort)	x						x							
Ranunculus cymbalaria Lursh. (Seaside Buttercup)	x													

	Community													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
FORBS (cont.)														
Geranium molle L. (Dovefoot Geranium)	x										x			x
Typha latifolia L. (Cat-tail)					D	x							x	
Trifolium repens L. (White Clover)											x			
Grindelia integrifolia DC. (Gumweed)			x											x
Trifolium pratense L. (Red Clover)	x										x			
Tellima grandiflorum (Pursh) Dougl. (Fringecup)	x													
Taraxacum officinale Weber (Common Dandelion)							x	x		x	x			x
Fritillaria camschatcensis (L.) Ker.-Gawl. (Chocolate Lily)							x	x	x	x				
Erigeron philadelphicus L. (Philadelphia Fleabane)							x	x	x	x				
Epilobium angustifolium L. (Fireweed)							x	x	x	x				
Cirsium arvense (L.) (Canada Thistle)								x	x	x	x			

	Community													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
<u>FORBS</u> (cont.)														
<u>Vicia</u> <u>gigantea</u> Hook. (Giant Vetch)								x						
<u>Stellaria</u> <u>media</u> (L.) Cyrill. (Chickweed)								x			x			x
<u>Sisyrinchium</u> <u>angustifolium</u> Mill. (Blue-eyed Grass)									x					
<u>Maianthemum</u> <u>dilatatum</u> (Wood) Nels. & Macbr. (False Lily-of-the-valley)									x					
<u>Lathyrus</u> <u>palustris</u> L. (Marsh Pea)									x		x			
<u>Lilaeopsis</u> <u>occidentalis</u> Coult. & Rose (Lilaeopsis)							x							
<u>Heracleum</u> <u>lanatum</u> Michx. (Cow-parsnip)										D				
<u>Sidalcea</u> <u>hendersonii</u> Wats. (Henderson's Checker-mallow)								x						
<u>Medicago</u> <u>sativa</u> L. (Medic)											x			
<u>Heliopsis</u> <u>helianthoides</u> (L.) Sweet (Ox-eye Daisy)											x			
<u>Bellis</u> <u>perennis</u> L. (Daisy)											x			

	Community													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
<u>FORBS</u> (cont.)														
<u>Lomatium</u> <u>nudicaule</u> (Pursh) Coult. & Rose (Desert-parsley)											x		x	x
<u>Urtica</u> <u>dioica</u> L. (Stinging Nettle)												x		
<u>Delphinium</u> <u>menziesii</u> DC. (Menzies' Delphinium)														x
<u>Allium</u> <u>geyeri</u> var. <u>tenerum</u> Jones (Geyer's Onion)														x
<u>Cotula</u> <u>coronopifolia</u> L. (Brass Buttons)	x													
<u>Capsella</u> <u>bursa-pastoris</u> (L.) Medic. (Shepherd's-purse)		x												
<u>GRASSES</u>														
<u>Elymus</u> <u>mollis</u> Trin. (Wildrye)			D											
<u>Bromus</u> <u>tectorum</u> L. (Brome-grass)			x											x
<u>Holcus</u> <u>lanatus</u> L. (Velvet-grass)			x								x			
<u>Distichlis</u> <u>spicata</u> (L.) Greene (Saltgrass)	D			x										

	Community													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
GRASSES (cont.)														
Poa pratensis L. (Kentucky Bluegrass)							x	x		x	S			
Anthoxanthum odoratum L. (Sweet Vernalgrass)											S			S
Phalaris arundinacea L. (Reed Canarygrass)											S			
Lolium perenne L. (Ryegrass)											S			
Festuca bromoides L. (Fescue)														
Bromus mollis L. (Soft Brome)								x	x		x			S
SEDGES														
Carex lyngbyei Hornem. (Lyngby's Sedge)	x			S		D	D							
Eleocharis palustris (L.) R. & S. (Spike-rush)				S	x	x	x							
Scirpus microcarpus Presl. (Small-fruit Bulrush)									x					
Scirpus acutus Muhl. (Bulrush)													D	

	Community													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
<u>SEDGES</u> (cont.)														
<u>Carex pluriflora</u> Hulten (Sedge)							x							
<u>Carex pansa</u> Bailey (Sand-dune Sedge)							x							
<u>Scirpus maritimus</u> L. (Bulrush)					x									
<u>RUSHES</u>														
<u>Juncus balticus</u> Willd. (Baltic Rush)				S			x	D	S	x			x	
<u>Luzula spicata</u> (L.) DC. (Spiked Woodrush)									x					

Table 20. Area of each plant community on the Little Qualicum River Estuary

Plant Community	Area (hectares)	Percent (%)
Distichlis spicata	4.4	18.3
Potentilla pacifica - *Carex lyngbyei*	3.2	13.3
Potentilla pacifica - *Juncus balticus*	2.9	12.1
GRAMINEAE	2.9	12.1
Rosa nutkana - *Anthoxanthum odoratum* - *Bromus mollis*	2.9	12.1
Carex lyngbyei	2.5	10.4
Rosa nutkana - *Pyrus fusca* - *Rubus laciniatus* - *Rubus spectabilis* - *Rubus parviflorus*	2.1	8.8
Rosa nutkana	1.2	5.0
Subtotal	22.1	92.1
Typha latifolia	.6	2.5
Pyrus fusca - *Rosa nutkana*	.5	2.1
Scirpus acutus	.5	2.1
Elymus mollis	.1	.4
Potentilla pacifica - *Carex lyngbyei* - *Eleocharis palustris* - *Juncus balticus*	.1	.4
Potentilla pacifica - *Heracleum lanatum*	.1	.4
TOTAL	24.0	100.0

Figure 11. Map showing the distribution of the plant communities on the Big Qualicum River Estuary

Legend

Scale 1cm=48m

Plant Community

1 *Carex lyngbyei*

2 *Anthoxanthum odoratum* - *Potentilla pacifica* - *Plantago lanceolata* - *Trifolium pratense*

BL boat launch

C camping ground

D dredged

L tidal

SL subtidal

building

road

Table 21. Description of the plant communities on the Big Qualicum River Estuary. September, 1976.

1 Carex lyngbyei

2 Anthoxanthum odoratum - Potentilla pacifica - Plantago lanceolata - Trifolium pratense

	Community 1	Community 2
Trees		
Alnus rubra Bong. (Red Alder)		x
Acer macrophyllum Pursh (Common Maple)		x
Populus trichocarpa T. & G. (Cottonwood)		x
Pyrus fusca Raf. (Pacific Crabapple)		x
Shrubs		
Rubus spectabilis Pursh. (Salmonberry)		x
Salix sp. L. (Willow)		x
Rubus ursinus Cham. & Schlecht (Pacific Blackberry)		x
Rosa nutkana Presl. (Nootka Rose)		x

	Community 1	Community 2
Forbs		
Lathyrus palustris L. (Marsh Pea)		x
Potentilla pacifica Howell (Cinquefoil)	x	S
Plantago lanceolata L. (Ribgrass)		S
Trifolium pratense L. (Red Clover)		S
Vicia gigantea Hook (Giant Vetch)		x
Rumex crispus L. (Curly Dock)		x
Hypochaeris radicata L. (Hairy Cats-ear)		x
Cirsuim arvense (L.) Scop. (Canada Thistle)		x
Chenopodium album L. (Pigweed)		x
Erigeron philadelphicus L. (Philadelphia Fleabane)		x
Equisetum arvense L. (Common Horsetail)		x
Grindelia integrifolia DC. (Gumweed)		x
Anaphalis margaritacea (L.) B. & H. (Pearly-everlasting)		x
Plantago macrocarpa Chem. & Schlecht (Plantain)	x	
Ranunculus repens L. (Creeping Buttercup)		x
Glaux maritima L. (Sea-milkwort)	x	

	Community 1	Community 2
Grasses		
Deschampsia cespitosa (L.) Beauv. (Tufted Hairgrass)	x	x
Hordeum brachyantherum Nevski. (Meadow Barley)	x	x
Anthoxanthum odoratum L. (Sweet Vernalgrass)		S
Distichlis spicata (L.) Greene (Saltgrass)	x	
Hierochloe odorata (L.) Beauv. (Seneca Grass)		x
Dactylis glomerata L. (Orchard-grass)		x
Cynosurus cristatus L. (Crested Dog's-tail)		x
Holcus lanatus L. (Velvet-grass)		x
Festuca pratensis Huds. (Meadow Fescue)		x
Sedge		
Carex lyngbyei Hornen. (Lyngby's Sedge)	D	x
Scirpus microcarpus Presl. (Small-fruit Bulrush)		x
Eleocharis palustris (L.) R. & S. (Spike-rush)	x	

	Community 1	Community 2
Rush		
Juncus _balticus_ Willd. (Baltic Rush)	x	x
Juncus _effusus_ L. (Common Rush)		x

Table 22. Area of each plant community on the Big Qualicum River Estuary

Plant Community	Area (hectares)	Percent (%)
Carex lyngbyei	1.3	50.0
Anthoxanthum odoratum - *Potentilla pacifica* *Plantago lanceolata* - *Trifolium pratense*	1.3	50.0
TOTAL	2.6	100.0

Figure 12. Map showing the distribution of the plant communities on the Courtenay River Estuary

Legend

Scale 1cm=48m

Plant Community

1 Scirpus americanus

2 Deschampsia cespitosa - Potentilla pacifica - Carex lyngbyei

3 Scirpus microcarpus - Carex lyngbyei

4 Carex lyngbyei

5 Potentilla pacifica - Trifolium wormskjoldii

6 Phalaris arundinacea - Rumex salicifolium - Elymus mollis

7 Deschampsia cespitosa - Eleocharis palustris - Potentilla pacifica

8 Picea sitchensis

9 Juncus balticus - Potentilla pacifica - Carex lyngbyei

10 Deschampsia cespitosa - Potentilla pacifica - Carex lyngbyei -Sidalcea hendersonii

11 Typha latifolia

12 Oenanthe sarmentosa

13 Glyceria occidentalis

A agriculture

B log boom

D dredged

I industrial

L tidal

M marina

SL subtidal

U urban

═ road

□ building

Figure 12 (cont.)

P Municipality of Courtenay airstrip

S Municipality of Courtenay sewage treatment plant

Table 23. Description of the plant communities on the Courtenay River Estuary, July 1976.

1 *Scirpus americanus*

2 *Deschampsia cespitosa* - *Potentilla pacifica* - *Carex lyngbyei*

3 *Scirpus microcarpus* - *Carex lyngbyei*

4 *Carex lyngbyei*

5 *Potentilla pacifica* - *Trifolium wormskjoldii*

6 *Phalaris arundinacea* - *Rumex salicifolius* - *Elymus mollis*

7 *Deschampsia cespitosa* - *Eleocharis palustris* - *Potentilla pacifica*

8 *Picea sitchensis*

9 *Juncus balticus* - *Potentilla pacifica* - *Carex lyngbyei*

10 *Deschampsia cespitosa* - *Potentilla pacifica* - *Carex lyngbyei* - *Sidalcea hendersonii*

11 *Typha latifolia*

12 *Oenanthe sarmentosa*

13 *Glyceria occidentalis*

Following is a list of the species in each plant community including dominant species indicated by a D and subdominant species indicated by an S.

	Community												
	1	2	3	4	5	6	7	8	9	10	11	12	13
TREES													
Alnus rubra Bong. (Red Alder)								x					
Populus trichocarpa T. & G. (Cottonwood)								x					
Pyrus fusca Raf. (Pacific Crabapple)								x					
Picea sitchensis (Bong.) Carr. (Sitka Spruce)								D					
Sorbus scopulina Greene (Mountain-ash)								x					
Cornus stolonifera Michx. (Red-osier Dogwood)								x					
SHRUBS													
Physocarpus capitatus (Pursh) Kuntze (Ninebark)								x					
Salix sp. L. (Willow)								x					
Rubus ursinus Cham. & Schlecht (Pacific Blackberry)								x					
Rosa gymnocarpa Nutt. (Little Wild Rose)								x					

	Community												
	1	2	3	4	5	6	7	8	9	10	11	12	13
SHRUBS (cont.)													
Spiraea douglasii Hook (Hardhack)								x					
Rubus spectabilis Pursh (Salmonberry)								x					
Cytisus scoparius (L.) Link (Broom)								x					
Symphoricarpos albus (L.) Blake (Snowberry)								x					
Rosa nutkana Presl. (Nootka Rose)								x					
Lonicera involucrata (Rich.) Banks (Black Twin-berry)								x					
Myrica gale L. (Sweet Gale)								x					

	Community												
	1	2	3	4	5	6	7	8	9	10	11	12	13
<u>FORBS</u>													
<u>Triglochin</u> <u>maritimum</u> L. (Arrow-grass)	S	x					x		x	x			
<u>Spergularia</u> <u>canadensis</u> (Pers.) G. Don (Sandspurry)	x												
<u>Potentilla</u> <u>pacifica</u> Howell (Cinquefoil)	x	D	S	x	D	x	D		S	S	x		
<u>Glaux</u> <u>maritima</u> L. (Sea-milkwort)	x	x		x					x				
<u>Lemna</u> <u>minor</u> L. (Duckweed)	x												
<u>Plantago</u> <u>maritima</u> L. (Seaside Plantain)		x											
<u>Trifolium</u> <u>wormskjoldii</u> Lehm. (Springbank Clover)		x			D		x		x	x			
<u>Erigeron</u> <u>philadelphicus</u> L. (Philadelphia Fleabane)		x	x		x								
<u>Sonchus</u> <u>arvensis</u> L. (Milk-thistle)			x			x							
<u>Convolvulus</u> <u>sepium</u> L. (Morning-glory)			S			x						x	
<u>Equisetum</u> <u>arvense</u> L. (Common Horsetail)			x					x				x	x

	Community												
	1	2	3	4	5	6	7	8	9	10	11	12	13
FORBS (cont.)													
Rumex _crispus_ L. (Curly Dock)			x						x	x	x	x	
Galium _aparine_ L. (Bedstraw)								x		x		x	
Montia _sibirica_ (L.) Howell (Siberian Miner's Lettuce)								x		x			
Epilobium _angustifolium_ L. (Fireweed)								x					
Lupinus sp. L. (Lupine)								x					
Lilaeopsis _occidentalis_ Coult. & Rose (Lilaeopsis)				x					x				
Grindelia _integrifolia_ DC. (Gumweed)				x									
Plantago _macrocarpa_ Cham. & Schlecht (Plantain)									x				
Sisyrinchium _angustifolium_ Mill. (Blue-eyed Grass)										x			
Castilleja _levisecta_ Greenm. (Golden Indian-paint brush)										x			

	Community												
	1	2	3	4	5	6	7	8	9	10	11	12	13
FORBS (cont.)													
Plantago lanceolata L. (Ribgrass)						x		x					
Vicia gigantea Hook. (Giant Vetch)						x							
Cirsium arvense (L.) Scop. (Canada Thistle)						x		x				x	S
Typha latifolia L. (Cat-tail)			x							x	x		
Rumex salicifolius Wienm. (Willow Dock)			x		x	S	x	x	x	x			
Stachys cooleyae Heller (Cooley's Hedge-nettle)			x										
Trifolium dubium Sibth. (Least Hop Clover)						x		x					
Hypericum formosum H.B.K. (St. John's-wort)										x			
Hypochaeris radicata L. (Hairy Cats-ear)													
Pteridium aquilinum (L.) Kuhn (Bracken)								x					
Achillea millefolium L. (Yarrow)								x				x	

	Community												
	1	2	3	4	5	6	7	8	9	10	11	12	13
<u>FORBS</u> (cont.)													
<u>Camassia</u> <u>quamash</u> (Pursh) Greene (Camas)										x			
<u>Dodecatheon</u> <u>pulchellum</u> (Raf.) Merrill (Shooting-star)									x	x			
<u>Lilium</u> <u>columbianum</u> Hanson (Columbia Lily)								x					
<u>Plantago</u> <u>major</u> L. (Common Plantain)								x					
<u>Potentilla</u> <u>pacifica</u> Howell (Cinquefoil)							x		x	x	x	x	
<u>Mentha</u> <u>spicata</u> L. (Spearmint)									x	x			
<u>Aster</u> <u>hesperius</u> Gray (Marsh Aster)										x		x	
<u>Sium</u> <u>suave</u> Walt. (Water-parsnip)										x	x		
<u>Mentha</u> <u>arvensis</u> L. (Field Mint)												x	x
<u>Heracleum</u> <u>lanatum</u> Michx. (Cow-parsnip)													x
<u>Oenanthe</u> <u>sarmentosa</u> Presl. (Water-parsley)			x						x	x	x	S	x

	Community												
	1	2	3	4	5	6	7	8	9	10	11	12	13
FORBS (cont.)													
Atriplex patula L. (Saltbush)		x	S			x							
Symphytum asperum Lepech. (Rough Comfrey)			x										
Myosotis scorpioides L. (Common forget-me-not)			x										
Epilobium watsonii Barbey (Watson's Willow-herb)					x		x	x	x	x	x	x	
Cicuta douglasii (DC.) Coult. & Rose (Water-hemlock)						x							
Habenaria dilatata (Pursh) Hook (Bog-candle)										x	x		
Lactuca biennis (Moench) Fern. (Tall Blue Lettuce)								x					
GRASSES													
Deschampsia cespitosa (L.) Beauv. (Tufted Hairgrass)	x	D	x	x	x		D		x	S			
Distichlis spicata (L.) Greene (Saltgrass)		x											
Dactylis glomerata L. (Orchard-grass)			x			x		x					

	Community												
	1	2	3	4	5	6	7	8	9	10	11	12	13
<u>GRASSES</u> (cont.)													
<u>Elymus</u> <u>mollis</u> Trin. (Wildrye)						S							
<u>Phalaris</u> <u>arundinacea</u> L. (Reed Canarygrass)						S							
<u>Phleum</u> <u>pratense</u> L. (Timothy)					x			x					
<u>Glyceria</u> <u>occidentalis</u> (Piper) Nels. (Western Mannagrass)					x			x					D
<u>Holcus</u> <u>lanatus</u> L. (Velvet-grass)								x		x			
<u>Festuca</u> <u>pratensis</u> Huds. (Meadow Fescue)												x	x
<u>Agrostis</u> <u>tenuis</u> Sibth. (Colonial Bentgrass)		x	x					x			x	x	
<u>Agropyron</u> <u>repens</u> (L.) Beauv. (Couch Grass)			S							x			
<u>Hordeum</u> <u>brachyantherum</u> Nevski (Meadow Barley)								x	x				

	Community												
	1	2	3	4	5	6	7	8	9	10	11	12	13
<u>SEDGES</u>													
Carex lyngbyei Hornem. (Lyngby's Sedge)		D	S	D	x		x		S	S	x	x	
Scirpus microcarpus Presl. (Small-fruit Bulrush)			D					x					
Scirpus acutus Muhl. (Bulrush)				x	x								
Eleocharis palustris (L.) R. & S. (Spike-rush)				x			D		x				
Scirpus americanus Pers. (Three-square Bulrush)	D	x		x					x	x			
<u>RUSHES</u>													
Juncus balticus Willd. (Baltic Rush)		x		x	x		x		D	x			
Juncus effusus L. (Common Rush)					x					x			
Juncus acuminatus Michx. (Tapered Rush)					x								

Table 24. Area of each plant community on the Courtenay River Estuary

Plant Community	Area (hectares)	Percent (%)
Carex lyngbyei	10.7	48.6
Scirpus americanus	7.1	32.3
Deschampsia cespitosa - Potentilla pacifica - Carex lyngbyei	1.1	5.0
Oenanthe sarmentosa	.7	3.2
Juncus balticus - Potentilla pacifica - Carex lyngbyei	.5	2.3
Subtotal	20.1	91.4
Picea sitchensis	.5	2.3
Deschampsia cespitosa - Potentilla pacifica - Carex lyngbyei - Sidalcea hendersonii	.5	2.3
Phalaris arundinacea - Rumex salicifolius Elymus mollis	.3	1.4
Potentilla pacifica - Trifolium wormskjoldii	.2	.9
Typha latifolia	.2	.9
Scirpus microcarpus - Carex lyngbyei	.1	.5
Glyceria occidentalis	.1	.5
Deschampsia cespitosa - Eleocharis palustris -Potentilla pacifica	.01	.04
TOTAL	22.01	100.24

Figure 13. Map showing the distribution of the plant communities on the Oyster River Estuary

Legend

Scale 1cm=48m

Plant Community

1 *Carex lyngbyei*

2 *Elymus mollis* - *Carex lyngbyei*

3 *Juncus balticus* - *Distichlis spicata* - *Agrostis alba*

4 *Juncus balticus* - *Potentilla pacifica*

5 *Pseudotsuga menziesii* - *Pteridium aquilinum*

6 *Elymus mollis*

C campground

CU culvert

D dredged

L tidal

M marina

SL subtidal

building

road

Table 25. Description of the plant communities on the Oyster River Estuary, September 1976

1	Carex lyngbyei
2	Elymus mollis - Carex lyngbyei
3	Juncus balticus - Distichlis spicata - Agrostis alba
4	Juncus balticus - Potentilla pacifica
5	Pseudotsuga menziesii - Pteridium aquilinum
6	Elymus mollis

Following is list of the species in each plant community including dominant species indicated by a D and subdominant species indicated by an S.

	Community 1	2	3	4	5	6
Trees						
<u>Pseudotsuga</u> <u>menziesii</u> (Mirbel) Franco (Douglas Fir)					D	
<u>Picea</u> <u>sitchensis</u> (Bong.) Carr. (Sitka Spruce)					x	
<u>Pyrus</u> <u>fusca</u> Raf. (Pacific Crabapple)					x	
<u>Thuja</u> <u>plicata</u> Donn. (Western Red Cedar)					x	
<u>Tsuga</u> <u>heterophylla</u> (Raf.) Sarg. (Western Hemlock)					x	
<u>Acer</u> <u>macrophyllum</u> Pursh (Common Maple)					x	
Shrubs						
<u>Rosa</u> <u>nutkana</u> Presl. (Nootka Rose)					x	
<u>Physocarpus</u> <u>capitatus</u> (Pursh) Kuntze (Ninebark)				x	x	
<u>Lonicera</u> <u>involucrata</u> (Rich.) Banks (Black Twin-berry)				x	x	
<u>Symphoricarpos</u> <u>albus</u> (L.) Blake (Snowberry)					x	
<u>Berberis</u> <u>nervosa</u> Pursh (Oregon grape)					x	

	Community					
Forbs	1	2	3	4	5	6
Sonchus arvensis L. (Milk-thistle)	x	x		x		x
Achillea millefolium L. (Yarrow)			x			
Grindelia integrifolia DC. (Gumweed)	x		x			
Plantago lanceolata L. (Ribgrass)					x	
Maianthemum dilatatum (Wood) Nels. & Macbr. (False Lily-of-the-valley)					S	
Plantago maritima L. (Seaside Plantain)			x			
Potentilla pacifica Howell (Cinquefoil)	x	x	x	D		
Lilaeopsis occidentalis Coult. & Rose (Lilaeopsis)	x					
Pteridium aquilinum (L.) Kuhn. (Bracken)					D	
Lathyrus palustris L. (Marsh Pea)					x	
Polystichum munitum (Kaulf.) Presl. (Sword-fern)					x	
Tiarella trifoliata var. *trifoliata* L. (Foamflower)					x	
Lactuca muralis (L.) Fresr. (Wall Lettuce)					x	
Rumex crispus L. (Curly Dock)	x					
Vicia gigantea Hook (Giant Vetch)						x
Chenopodium album L. (Pigweed)						x
Atriplex patula L. (Saltbush)	x	x				

	Community					
	1	2	3	4	5	6
Grasses						
Elymus mollis Trin. (Wildrye)	x	D	x			D
Distichlis spicata (L.) Greene (Saltgrass)			S			
Poa pratensis L. (Kentucky Bluegrass)			x			
Agrostis alba L. (Bentgrass)	x		S			x
Hordeum brachyantherum Nevski. (Meadow Barley)		x				
Deschampsia cespitosa (L.) Beauv. (Tufted Hairgrass)	x					
Sedge						
Carex lyngbyei Hornem. (Lyngby's Sedge)	D	S		x		
Rush						
Juncus balticus Willd. (Baltic Rush)		x	S	D		

Table 26. Area of each plant community on the Oyster River Estuary

Plant Community	Area (hectares)	Percent (%)
Carex lyngbyei	.7	52.2
Juncus balticus - *Potentilla pacifica*	.2	14.9
Pseudotsuga menziesii - *Pteridium aquilinum*	.2	14.9
Elymus mollis - *Carex lyngbyei*	.1	7.5
Subtotal	1.2	89.5
Juncus balticus - *Distichlis spicata* - *Agrostis alba*	.1	7.5
Elymus mollis	.04	3.0
TOTAL	1.34	100.0

Figure 14. Map showing the distribution of the plant communities on the Campbell River Estuary

Legend
Scale 1 cm = 48 m

Plant Community

1	*Carex lyngbyei*
2	*Potentilla pacifica* - *Eleocharis palustris*
3	*Deschampsia cespitosa*
4	*Alnus rubra* - *Rubus laciniatus* - *Cytisus scoparius* - *Rosa nutkana* - *Rubus spectabilis*
5	*Deschampsia cespitosa* - *Potentilla pacifica*
6	*Myrica gale* - *Scirpus acutus*
7	*Ruppia maritima*
8	*Alnus rubra* - *Rosa nutkana* - *Symphoricarpos albus*

B	log boom	building
D	dredged	
I	industrial	road
L	landfill	
M	marina	
P	airstrip	transect
U	urban	

Table 27. Description of the plant communities on the Campbell River Estuary, July, 1976

1 *Carex lyngbyei*

2 *Potentilla pacifica* - *Eleocharis palustris*

3 *Deschampsia cespitosa*

4 *Alnus rubra* - *Rubus laciniatus* - *Cytisus scoparius* - *Rosa nutkana* - *Rubus spectabilis*

5 *Deschampsia cespitosa* - *Potentilla pacifica*

6 *Myrica gale* - *Scirpus acutus*

7 *Ruppia maritima*

8 *Alnus rubra* - *Rosa nutkana* - *Symphoricarpos albus*

Following is a list of the species in each plant community including dominant species indicated by a D and subdominant species indicated by an S.

	Community							
	1	2	3	4	5	6	7	8
Trees								
Rhamnus purshiana DC. (Cascara)								x
Alnus rubra Bong. (Red Alder)				S				S
Pseudotsuga menziesii (Mirbel) Franco (Douglas Fir)								S
Pyrus fusca Raf. (Pacific Crabapple)				x				S
Thuja plicata Donn. (Western Red Cedar)								x
Acer macrophyllum Pursh. (Common Maple)								x
Shrubs								
Holodiscus discolor (Pursh) Maxim. (Ocean-spray)				x				
Rubus laciniatus Willd. (Evergreen Blackberry)				S				
Cytisus scoparius (L.) Link (Broom)				S				
Myrica gale L. (Sweet gale)			x	x		D		
Rosa nutkana Presl. (Nootka Rose)				S				S
Lonicera involucrata (Rich.) Banks (Black Twin-berry)				x				
Rubus spectabilis Pursh. (Salmonberry)				S				S
Physocarpus capitatus (Pursh) Kuntze (Ninebark)				x				

	Community							
	1	2	3	4	5	6	7	8
Shrubs (cont.)								
Sambucus racemosa L. (Elderberry)				x				x
Rubus parviflorus Nutt. (Thimbleberry)								S
Rosa gymnocarpa Nutt. (Little Wild Rose)								x
Ribes sp. L. (Gooseberry)								x
Spiraea douglasii Hook (Hardhack)								x
Berberis nervosa Pursh (Oregongrape)								x
Vaccinium parvifolium Smith (Huckleberry)								x
Symphoricarpos albus (L.) Blake (Snowberry)								S
Amelanchier alnifolia Nutt. (Serviceberry)								x
Rubus pedatus J.E. Smith (Fiveleaved Bramble)								x
Rubus ursinus Cham. & Schlecht (Pacific Blackberry)								S
Lonicera ciliosa (Pursh) DC. (Orange Honeysuckle)								S
Salix sp. L. (Willow)								x

	Community							
	1	2	3	4	5	6	7	8
Forbs								
Potentilla pacifica Howell (Pacific Silverweed)	x	D	S	x	S	x		
Erigeron philadelphicus L. (Philadelphia Fleabane)			x	x	x			
Glaux maritima L. (Sea-milkwort)		x	x		x			
Sisyrinchium angustifolium Mill (Blue-eyed grass)			x					
Typha latifolia L. (Common Cat-tail)			x					
Prunella vulgaris L. (Self-heal)			x	x				
Cirsium arvense (L.) Scop. (Creeping Thistle)			x	x				S
Aquilegia formosa Fisch. (Red Columbine)				x				x
Vicia gigantea Hook. (Giant Vetch)				x				
Equisetum arvense L. (Common Horsetail)				x		x		
Epilobium angustifolium L. (Fireweed)				x				x
Fritillaria camschatcensis (L.) Ker-Gawl (Chocolate Lily)			x					
Maianthemum dilatatum (Wood) Nels. & Macbr. (False Lily-of-the-valley)								x
Triglochin maritimum L. (Arrow-grass)	x	x	x		x			
Lilaeopsis occidentalis Coult. & Rose (Lilaeopsis)	x	x						
Sidalcea hendersonii Wats. (Henderson's Checker-mallow)			x	x	x	x		

	Community							
	1	2	3	4	5	6	7	8
Forbs (cont.)								
Trifolium repens L. (White Clover)			x	x				x
Trifolium wormskjoldii Lehm. (Springbank Clover)		x	x	x				
Trifolium pratense L. (Red Clover)			x	x				
Castilleja levisecta Greenm. (Golden Indian-paintbrush)			x	x				
Achillea millefolium L. (Yarrow)			x	x				
Rumex crispus L. (Curly Dock)				x		x		x
Plantago lanceolata L. (Ribgrass)		x		x				x
Hypochaeris radicata L. (Hairy Cats-ear)				x				
Plantago maritima L. (Sea Plantain)		x			x			
Plantago macrocarpa Cham. & Schlecht (Alaska Plantain)			x		x			
Montia perfoliata (Donn) Howell (Miner's Lettuce)								x
Rumex acetosella L. (Sour Weed)								x
Lupinus sp. L. (Lupine)								x
Trifolium dubium Sibth. (Least Hop Clover)								x
Montia sibirica (L.) Howell (Siberian Miner's Lettuce)								x
Galium sp. L. (Bedstraw)								x

	Community							
	1	2	3	4	5	6	7	8
Forbs (cont.)								
Polystichum munitum (Kaulf.) Presl. (Sword Fern)								x
Trillium ovatum Pursh (Trillium)								x
Lilium columbianum Hanson (Columbia Lily)								x
Trifolium tridentatum Lindl. (Sand Clover)								x
Myosotis discolor Pers. (Yellow and Blue Forget-me-not)								x
Achlys triphylla (Smith) DC. (Vanillaleaf)								x
Pteridium aquilinum (L.) DC. (Bracken)								x
Streptopus amplexifolius (L.) DC. (Twisted-stalk)								x
Convolvulus sepium L. (Morning-glory)				x				x
Heracleum lanatum Michx. (Cow-parsnip)			x	x				
Habenaria dilatata (Pursh) Hook (Bog-candle)			x	x				
Oenanthe sarmentosa Presl.			x	x		x		
Hypericum formosum H.B.K. (St. John's-wort)			x	x		x		
Ranunculus orthorhynchus Hook (Buttercup)			x	x				
Lathyrus palustris L. (Marsh Pea)			x	x		x		
Dodecatheon pulchellum (Raf.) Merrill (Shooting-star)			x					

	Community							
	1	2	3	4	5	6	7	8
Forbs (cont.)								
Spergularia canadensis (Pers.) G. Don (Sandspurry)					x			
Ruppia maritima L. (Ditch-grass)							D	
Grasses								
Holcus lanatus L. (Velvet-grass)			x	x				x
Deschampsia cespitosa (L.) Beauv (Tufted Hairgrass)	x	x	D		D			
Hordeum brachyantherum Nevski (Meadow Barley)			x	x		x		
Hierochloe odorata (L.) Beauv. (Vanillagrass)			x					
Elymus mollis Trin. (Dune Wildrye)				x				
Aira sp. L. (Hairgrass)								x
Festuca sp. L. (Fescue)			x		x	x		
Agrostis tenuis Sibth. (Colonial Bentgrass)			x					

	Community							
	1	2	3	4	5	6	7	8
Sedges								
Carex lyngbyei Hornem. (Lyngby's Sedge)	D	x	x	x	S	x	x	
Eleocharis palustris (L.) R. & S. (Spike-rush)	x	D	x	x	x	x	x	
Scirpus microcarpus Presl. (Small-fruit Bulrush)								
Scirpus americanus Pers. (Three-square Bulrush)	x	S						
Scirpus acutus Muhl. (Hardstem Bulrush)						S		
Carex lenticularis var. *limnophila* (Holm) (Sedge) Cronq.			x					
Rushes								
Juncus articulatus L. (Jointed Rush)		x						
Juncus balticus Willd. (Baltic Rush)	x	S	x		x	x		
Juncus effusus L. (Common Rush)			x	x				

Table 28. Area of each plant community on the Campbell River Estuary

Plant Community	Area (hectares)	Percent (%)
Alnus rubra - Rubus laciniatus - Cytisus scoparius - Rosa nutkana - Rubus spectabilis	10.3	31.9
Deschampsia cespitosa	9.7	30.0
Carex lyngbyei	5.0	15.5
Alnus rubra - Rosa nutkana - Symphoricarpos albus	4.1	12.7
Subtotal	29.1	90.1
Potentilla pacifica - Eleocharis palustris	2.2	6.8
Deschampsia cespitosa - Potentilla pacifica	.9	2.8
Myrica gale - Scirpus acutus	.1	.3
Ruppia maritima	.04	.1
TOTAL	32.3	100.1

Figure 15. Map showing the distribution of the plant communities on the Salmon River Estuary

Legend

Scale 1 cm = 48 m

Plant Community

1 <u>Heracleum lanatum</u> - <u>Juncus balticus</u>

2 <u>Carex lyngbyei</u>

3 <u>Juncus balticus</u> - <u>Poa pratensis</u> - <u>Potentilla pacifica</u>

4 <u>Picea sitchensis</u> - <u>Tsuga heterophylla</u>

5 <u>Eleocharis palustris</u>

6 <u>Poa pratensis</u> - <u>Agrostis alba</u> var. <u>stolonifera</u> - <u>Potentilla pacifica</u>

7 <u>Heracleum lanatum</u> - <u>Potentilla pacifica</u>

8 <u>Elymus mollis</u>

9 <u>Deschampsiua cespitosa</u> - <u>Carex lyngbyei</u>

10 <u>Deschampsia cespitosa</u> - <u>Poa pratensis</u> - <u>Juncus balticus</u>

11 <u>Rosa nutkana</u> - <u>Potentilla pacifica</u> - <u>Agrostis alba</u> var. <u>stolonifera</u> - <u>Poa pratensis</u>

12 <u>Agropyron repens</u> - <u>Poa pratensis</u> - <u>Achillea millefolium</u>

13 <u>Potentilla pacifica</u> - <u>Achillea millefolium</u>

14 <u>Dactylis glomerata</u>

15 <u>Deschampsia cespitosa</u> - <u>Juncus balticus</u>

16 <u>Deschampsia cespitosa</u> - <u>Potentilla pacifica</u>

17 <u>Elymus glaucus</u> - <u>Juncus balticus</u> - <u>Potentilla pacifica</u>

18 <u>Dactylis glomerata</u> - <u>Deschampsia cespitosa</u>

19 <u>Plantago lanceolata</u> - <u>Fritillaria camschatcensis</u>

20 <u>Bromus carinatus</u> - <u>Poa pratensis</u> - <u>Potentilla pacifica</u>

21 <u>Glaux maritima</u> - <u>Distichlis spicata</u>

22	*Agrostis alba* var. *stolonifera* - *Plantago lanceolata*		
23	*Hordeum brachyantherum*		
24	*Grindelia integrifolia*		
25	*Typha latifolia*		
B	log boom	building	
D	dredged		
F	ferry terminal		
I	industrial	dyke	
L	tidal		
LD	log dump		
M	marina	road	
S	sewage treatment lagoon		
SL	subtidal		
U	urban	transect	

Table 29. Description of the plant communities on the Salmon River Estuary

1	Heracleum lanatum - Juncus balticus
2	Carex lyngbyei
3	Juncus balticus - Poa pratensis - Potentilla pacifica
4	Picea sitchensis - Tsuga heterophylla
5	Eleocharis palustris
6	Poa pratensis - Agrostis alba var. stolonifera - Potentilla pacifica
7	Heracleum lanatum - Potentilla pacifica
8	Elymus mollis
9	Deschampsia cespitosa - Carex lyngbyei
10	Deschampsia cespitosa - Poa pratensis - Juncus balticus
11	Rosa nutkana - Potentilla pacifica - Agrostis alba var. stolonifera - Poa pratensis
12	Agropyron repens - Poa pratensis - Achillea millefolium
13	Potentilla pacifica - Achillea millefolium
14	Dactylis glomerata
15	Deschampsia cespitosa - Juncus balticus
16	Deschampsia cespitosa - Potentilla pacifica
17	Elymus glaucus - Juncus balticus - Potentilla pacifica
18	Dactylis glomerata - Deschampsia cespitosa
19	Plantago lanceolata - Fritillaria camschatensis
20	Bromus carinatus - Poa pratensis - Potentilla pacifica
21	Glaux maritima - Distichlis spicata
22	Agrostis alba var. stolonifera - Plantago lanceolata
23	Hordeum brachyantherum

24 *Grindelia integrifolia*

25 *Typha latifolia*

Following is a list of the species in each plant community including dominant species indicated by a D and subdominant species indicated by an S.

	Community																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TREES																									
Alnus rubra Bong. (Red Alder)				x																					
Pyrus fusca Raf. (Pacific Crabapple)	x			x			x				x			x											
Picea sitchensis (Bong.) Carr. (Sitka Spruce)				D													x								
Tsuga heterophylla (Raf.) Sarg. (Western Hemlock)				D																					
Acer macrophyllum Pursh. (Common Maple)				x																					

	Community																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
SHRUBS																									
Lonicera involucrata (Rich.) Banks (Black Twin-berry)				x		x	x				x						x								
Rubus spectabilis Pursh. (Salmonberry)				S			x				x											x			
Rosa nutkana Presl. (Nootka Rose)				x							D								x						
Salix hookeriana Barratt (Hooker Willow)				x													x								
Salix sp. (Willow)																						x			
Cytisus scoparius (L.) Link (Broom)																						x			
Sambucus racemosa L. (Elderberry)				S																					
Vaccinium parvifolium Smith (Huckleberry)				x										x											
Holodiscus discolor (Pursh) Maxim. (Ocean-spray)				x										x											
Rubus ursinus Cham. & Schlecht (Pacific Blackberry)				x										x								x			
Osmaronia cerasiformis (T. & G.) Greene (Indian Plum)				x																					

	Community																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
SHRUBS (cont.)																									
Rubus parviflorus Nutt. (Thimbleberry)				x																		x			
FORBS																									
Fritillaria camschatcensis (L.) Ker.-Gawl. (Chocolate Lily)	x		x	x		x	x	x		x	x	x	x			x	x	x	S	S					
Trifolium pratense L. (Red Clover)	x																					x			
Plantago lanceolata L. (Ribgrass)	x					x		x			x			x				x	S	x		D			
Heracleum lanatum Michx. (Cow-parsnip)	D		x	x		x	D	x		x	x					x	x	x							x
Potentilla pacifica Howell (Cinquefoil)	S	x	S		x	D	D	x	x	x	D	x	S		x	D	S	x	S	D			x	x	S
Triglochin maritimum L. (Arrow-grass)	x	x	x		x				x	x					S	x								x	
Sisyrinchium angustifolium Mill. (Blue-eyed Grass)	x		x										x				x								
Trifolium wormskjoldii Lehm. (Springbank Clover)	x					x			x	x		x	x			x	x			x					
Plantago macrocarpa Cham. & Schlecht (Plantain)	S		x		x	x	x	x	x	x	x					x	x							x	

	Community																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
FORBS (cont.)																									
Achillea millefolium L. (Yarrow)	x		x			x	x	x		x	x	S	S	x		x	x	x	x	x				S	
Lilaeopsis occidentalis Coult. & Rose (Lilaeopsis)	x	x																							
Montia sibirica (L.) Howell (Siberian Miner's Lettuce)	x			x			x	x																	
Vicia gigantea Hook. (Giant Vetch)	x			x			x							x											
Lathyrus palustris L. (Marsh Pea)	x		x					x																	
Ranunculus uncinatus D. Don (Little Buttercup)	x			x							x														
Epilobium angustifolium L. (Fireweed)	x																					x			
Dodecatheon pulchellum (Raf.) Merrill (Shooting-star)	S		x			x																			
Sium suave Walt. (Water-parsnip)	x		x			x				x		x				x	x								
Castilleja levisecta Greenm. (Golden Indian-paintbrush)	x					x																			
Pteridium aquilinum (L.) Kuhn (Bracken)				x														x							

	Community																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
<u>FORBS</u> (cont.)																									
<u>Ranunculus</u> <u>repens</u> L. (Creeping Buttercup)				x		x																x			
<u>Geum</u> <u>macrophyllum</u> Willd. (Avens)				x																x					
<u>Plantago</u> <u>maritima</u> L. (Seaside Plantain)						x						x			x	x					x		x	x	
<u>Grindelia</u> <u>integrifolia</u> DC. (Gumweed)	x							x				x												D	
<u>Trifolium</u> <u>repens</u> L. (White Clover)													x							x		x			
<u>Digitalis</u> <u>purpurea</u> L. (Foxglove)														x								x			
<u>Hypochaeris</u> <u>radicata</u> L. (Hairy Cats-ear)														x						x		x			
<u>Sidalcea</u> <u>hendersonii</u> Wats. (Henderson's Checker-mallow)	x																x								
<u>Prunella</u> <u>vulgaris</u> L. (Self-heal)				x													x	x							
<u>Petasites</u> <u>frigidus</u> (L.) Fries (Coltsfoot)				x																					
<u>Arctium</u> <u>minus</u> (Hill) Bernh. (Common Burdock)				x																		x			

	Community																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
FORBS (cont.)																									
Stachys cooleyae Heller (Cooley's Hedge-nettle)				x																					
Osmorhiza chilensis H. & A. (Sweet-root)				x																					
Adenocaulon bicolor Hook (Pathfinder)				x																					
Galium sp. L. (Bedstraw)																				x					
Allium geyeri var. *tenerum* Jones (Geyer's Onion)						x																			
Plantago major L. (Common Plantain)																		x						x	
Barbarea orthoceras Ledeb. (Wintercress)	x																								
Glaux maritima L. (Sea-milkwort)	x	x			x	x			x	x						x					D		x		
Taraxacum officinale Weber (Common Dandelion)	x					x					x		x					S							
Rumex crispus L. (Curly Dock)	x																								
Erigeron philadelphicus L. (Philadelphia Fleabane)	x		x			x				x	x					x	x	x							

	Community																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
FORBS (cont.)																									
Maianthemum dilatatum (Wood) Nels. & Macbr. (False Lily-of-the-valley)				x																					
Cirsium arvense (L.) Scop. (Canada Thistle)	x			x		x		x					x						x			x			
Cirsium vulgare (Savi) Tenore (Common Thistle)																						x			
Galium trifidum L. (Small Bedstraw)				x																					
Corallorhiza mertensiana Bong. (Western Coral-root)				x																					
Polystichum munitum (Kaulf.) Presl. (Sword-fern)				x										x											
Gymnocarpium dryopteris (L.) Newm. (Oak-fern)				x																					
Tiarella trifoliata var. *trifoliata* L. (Foamflower)				x																					
Athyrium filix-femina (L.) Roth. (Lady-fern)				x																					
Lactuca muralis (L.) Fresen. (Wall Lettuce)				x																					
Rumex acetosella L. (Sour Weed)				x									x	x											

	Community																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
<u>FORBS</u> (cont.)																									
Blechnum spicant (L.) Roth (Deer-fern)				x																					
Spergularia canadensis (Pers.) G. Don (Canada Sandspurry)		x																			x				
Salicornia virginica L. (Saltwort)																					x		S		
Equisetum arvense L. (Common Horsetail)																						S			
Mentha arvensis L. (Field Mint)																						x			
Capsella bursa-pastoris (L.) Medic. (Shepherd's-purse)																								x	
Typha latifolia L. (Cat-tail)																									
Atriplex patula L. (Saltbush)													x								x		S	x	

	Community																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
GRASSES																									
Phleum pratense L. (Timothy)								x						x				x		x		x			
Holcus lanatus L. (Velvet-grass)						x		x					x	x								x			
Deschampsia cespitosa (L.) Beauv. (Tufted Hairgrass)		x			x	x			D	D			x		D	D	x	D					x	x	
Distichlis spicata (L.) Greene (Saltgrass)																					S				
Elymus mollis Trin. (Wildrye)	x							D				x	x	x			x								
Hierochloe odorata (L.) Beauv. (Seneca Grass)	x					S						x					x	x	x					x	
Poa pratensis L. (Kentucky Bluegrass)	x		S			D		S	x	D	S	S		x		x	x	x	x	D					
Agrostis alba var. *stolonifera* L. (Bentgrass)	x					D					S		x	x			x					D			
Hordeum brachyantherum Nevski. (Meadow Barley)									x	x		x				x	x			x			D		
Bromus carinatus H. & A. (Brome-grass)	x							x								x		x		D		x			
Elymus glaucus Buckl. (Blue Wildrye)	x							x		x						x	D	x	x						

	Community																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
GRASSES (cont.)																									
Agropyron repens (L.) Beauv. (Couch Grass)						x						D													
Agrostis tenuis Sibth. (Colonial Bentgrass)													x						x					x	
Festuca rubra L. (Red Fescue)						x							x												
Dactylis glomerata L. (Orchard-grass)	x					x								D			x	D							
SEDGES																									
Eleocharis palustris (L.) R. & S. (Spike-rush)	x	x	x		D				x						S										x
Carex lyngbyei Hornem. (Lyngby's Sedge)	x	D	x		x				S	x					x	x									
Eleocharis pauciflora (Lightf.) Link (Few-flowered Spike-rush)		x																							
RUSHES																									
Juncus balticus Willd. (Blatic Rush)	D		D		x	x	S	x	x	D	x		x		D		D		S				x	x	
Luzula divaricata Wats. (Woodrush)				x																					

Table 30. Area of each plant community on the Salmon River Estuary

Plant Community	Area (hectares)	Percent (%)
Picea sitchensis - Tsuga heterophylla	46.9	29.5
Poa pratensis - Agrostis alba var. stolonifera - Potentilla pacifica	23.6	14.9
Carex lyngbyei	22.1	13.9
Deschampsia cespitosa - Carex lyngbyei	18.9	11.9
Deschampsia cespitosa - Potentilla pacifica	14.7	9.3
Elymus glaucus - Juncus balticus - Potentilla pacifica	14.4	9.1
Heracleum lanatum - Juncus balticus	6.1	3.8
Subtotal	146.7	92.4
Elymus mollis	2.5	1.6
Juncus balticus - Poa pratensis - Potentilla pacifica	2.2	1.4
Dactylis glomerata	1.5	.9
Rosa nutkana - Potentilla pacifica - Agrostis alba var. stolonifera - Poa pratensis	1.4	.9
Heracleum lanatum - Potentilla pacifica	1.2	.8
Agropyron repens - Poa pratensis - Achillea millefolium	.8	.5
Plantago lanceolata - Fritillaria camschatcensis	.4	.3
Bromus carinatus - Poa pratensis - Potentilla pacifica	.4	.3
Deschampsia cespitosa - Poa pratensis - Juncus balticus	.3	.2
Glaux maritima - Distichlis spicata	.3	.2
Agrostis alba var. stolonifera - Plantago lanceolata	.3	.2
Dactylis glomerata - Deschampsia cespitosa	.2	.1
Hordeum brachyantherum	.2	.1
Grindelia integrifolia	.2	.1
Eleocharis palustris	.1	.06

Plant Community	Area (hectares)	Percent (%)
Deschampsia cespitosa - Juncus balticus	.1	.06
Potentilla pacifica - Achillea millefolium	.03	.02
Typha latifolia	.03	.02
TOTAL	158.9	100.2

Figure 16. Map showing the distribution of the plant communities on the Adam-Eve Rivers' Estuary

Legend
Scale 1 cm = 48 m

Plant Community

1 *Salicornia virginica* - *Triglochin maritimum* - *Plantago maritima* - *Glaux maritima*

2 *Carex lyngbyei*

3 *Deschampsia cespitosa* - *Carex lyngbyei* - *Glaux maritima* - *Potentilla pacifica*

4 *Poa pratensis* - *Potentilla pacifica*

5 *Picea sitchensis* - *Tsuga heterophylla*

6 *Picea sitchensis* - *Elymus mollis*

7 *Hordeum brachyantherum* - *Salicornia virginica*

8 *Deschampsia cespitosa*

9 *Deschampsia cespitosa* - *Juncus gerardii*

10 *Deschampsia cespitosa* - *Salicornia virginica*

11 *Deschampsia cespitosa* - *Agropyron repens*

12 *Picea sitchensis*

B log boom

D dredged

I industrial

L tidal zone

SL subtidal

building

road

Table 31. Description of the plant communities on the Adam-Eve Rivers' Estuary, June 1975.

1 Salicornia virginica - Triglochin maritimum - Plantago maritima - Glaux maritima

2 Carex lyngbyei

3 Deschampsia cespitosa - Carex lyngbyei - Glaux maritima - Potentilla pacifica

4 Poa pratensis - Potentilla pacifica

5 Picea sitchensis - Tsuga heterophylla

6 Picea sitchensis - Elymus mollis

7 Hordeum brachyantherum - Salicornia virginica

8 Deschampsia cespitosa

9 Deschampsia cespitosa - Juncus gerardii

10 Deschampsia cespitosa - Salicornia virginica

11 Deschampsia cespitosa - Agropyron repens

12 Picea sitchensis

Following is a list of the species in each plant community including dominant species indicated by a D and subdominant species indicated by an S.

	Community											
	1	2	3	4	5	6	7	8	9	10	11	12
Trees												
Picea sitchensis (Bong.) Carr. (Sitka Spruce)					D	D						D
Alnus rubra Bong. (Red Alder)					x							
Pyrus fusca Raf. (Pacific Crabapple)					x	x						
Tsuga heterophylla (Raf.) Sarg. (Western Hemlock)					D							x
Pseudotsuga menziesii (Mirbel) Franco (Douglas Fir)												x
Shrubs												
Rosa nutkana Presl. (Nootka Rose)					x	x						
Rubus spectabilis Pursh. (Salmonberry)					x	x						
Gaultheria shallon Pursh. (Salal)					x							x
Vaccinium ovalifolium Smith (Blueberry)					x							
Lonicera involucrata (Rich.) Banks (Black Twin-berry)					x							
Vaccinium parvifolium Smith (Huckleberry)						x						S
Ribes sp. L. (Gooseberry)						x						
Arctostaphylos nevadensis Gray (Kinnikinnick)												x
Rubus ursinus Cham. & Schlecht (Pacific Blackberry)						x						x

	Community											
	1	2	3	4	5	6	7	8	9	10	11	12
Forbs												
Salicornia virginica L. (Saltwort)	S					x	D	x	x	D		
Triglochin maritimum L. (Arrow-grass)	S	x	x	x				x	x	x	x	
Plantago maritima L. (Seaside Plantain)	S		x			x	x	x		x	x	
Glaux maritima L. (Sea-milkwort)	S	S	S			x	x	x		x	x	
Potentilla pacifica Howell (Cinquefoil)		S	S	D	x	x		x				
Trifolium wormskjoldii Lehm. (Springbank Clover)			x	S	x	x					x	
Epilobium angustifolium L. (Fireweed)			x	x								
Achillea millefolium L. (Yarrow)				x	x	x	x	x			x	
Fritillaria camschatcensis (L.) (Chocolate Lily) Ger-Gawl.				x	x							
Erigeron philadelphicus L. (Philadelphia Fleabane)				x								
Vicia gigantea Hook (Giant Vetch)				x	x							
Heracleum lanatum Michx. (Cow-parsnip)				x	x	x						
Arctium minus (Hill) Bernh. (Common Burdock)				x								
Maianthemum dilatatum (Wood) Nels. & Macbr. (False Lily-of-the-valley)					x							x
Ranunculus sp. L. (Buttercup)	x											
Sium suave Walt. (Water-parsnip)					x							

	Community											
	1	2	3	4	5	6	7	8	9	10	11	12
Forbs (continued)												
Cirsium arvense (Canada Thistle)					x							
Trientalis arctica Fisch (Starflower)					x							
Polystichum munitum (Kaulf.) Presl. (Sword-fern)					x							x
Aquilegia formosa Fisch. (Red Columbine)					x							
Hypochaeris radicata L. (Hairy Cats-ear)					x							
Anaphilis margaritacea (L.) B. & H. (Pearly-everlasting)					x							
Vicia gigantea Hook (Giant Vetch)						x						
Galium asperrimum Gray (Rough Bedstraw)						x						
Galium aparine L. (Bedstraw)												x
Lathyrus palustris L. (Marsh Pea)						x						
Grindelia integrifolia DC. (Gumweed)	x						x	x		x		
Spergularia canadensis (Pers.) (Sandspurry) G. Don	x		x				x					
Cochlearia officinalis L. (Spoonwort)	x											
Cuscuta salina Engelm. (Salt-marsh Dodder)							x			x		
Montia sibirica (L.) Howell (Siberian Miner's Lettuce)											x	
Lilaeopsis occidentalis Coult. & Rose (Lilaeopsis)			x									

	Community											
	1	2	3	4	5	6	7	8	9	10	11	12
Forbs (continued)												
Hieracium albiflorum Hook (White-flowered Hawkweed)												x
Lactuca muralis (L.) Fresen. (Wall Lettuce)												x
Polypodium glycyrrhiza D.C. Eat. (Licorice-fern)												x
Corallorhiza mertensiana Bong. (Western Coral-root)												x
Fragaria chiloensis (L.) Duchesne (Coastal Strawberry)												x
Rumex acetosella L. (Sour Weed)						x						x
Atriplex patula L. (Saltbush)	x	x	x					x	x	x	x	
Zostera marina L. (Eel-grass)	x											
Stellaria humfusa Rottb. (Spreading Starwort)			x	x				x		x		
Ranunculus orthorhynchus Hook (Buttercup)					x							

	Community											
	1	2	3	4	5	6	7	8	9	10	11	12
Grasses												
Deschampsia cespitosa (L.) (Tufted Hairgrass) Beauv.	x		D	x			x	D	D	D	D	
Distichlis spicata (L.) Greene (Saltgrass)			x									
Poa pratensis L. (Kentucky Bluegrass)				D		x		x				
Elymus mollis Trin. (Wildrye)				x	x	D		x	x			
Holcus lanatus L. (Velvet-grass)				x	x	x						
Hordeum brachyantherum Nevski. (Meadow Barley)				x		x	D	x	S	x	x	
Festuca rubra L. (Red Fescue)						x		x				
Agropyron repens (L.) Beauv. (Couch Grass)						x					D	
Festuca subulata Trin. (Nodding Fescue)												S

	Community											
	1	2	3	4	5	6	7	8	9	10	11	12
Sedges												
Carex lyngbyei Hornem. (Lyngby's Sedge)	x	D	S	x								
Rushes												
Juncus gerardii Loisel. (Mud Rush)									S			

Table 32. Area of each plant community on the Adam-Eve Rivers' Estuary

Plant Community	Area (hectares)	Percent (%)
Salicornia virginica - Triglochin maritimum - Plantago maritima - Glaux maritima	7.3	24.7
Picea sitchensis - Elymus mollis	4.6	15.6
Deschampsia cespitosa - Salicornia virginica	4.4	14.9
Carex lyngbyei	3.1	10.5
Deschampsia cespitosa - Carex lyngbyei - Glaux maritima - Potentilla pacifica	2.8	9.5
Poa pratensis - Potentilla pacifica	1.8	6.1
Picea sitchensis - Tsuga heterophylla	1.3	4.4
Hordeum brachyantherum - Salicornia virginica	1.3	4.4
Subtotal	26.6	90.1
Deschampsia cespitosa	1.0	3.4
Deschampsia cespitosa - Juncus gerardii	.8	2.7
Picea sitchensis	.6	2.0
Deschampsia cespitosa - Agropyron repens	.5	1.7
TOTAL	29.5	99.9

Figure 17. Map showing the distribution of the plant communities on the Tsitika River Estuary

Legend

Scale 1 cm = 48 m

Plant Community

1 *Carex lyngbyei*

2 *Carex lyngbyei* - *Deschampsia cespitosa*

3 *Elymus mollis* - *Vicia gigantea*

4 *Picea sitchensis* - *Heracleum lanatum* - *Vicia gigantea*

5 *Picea sitchensis*

6 *Deschampsia cespitosa*

7 *Trifolium wormskjoldii* - *Achillea millefolium* - *Triglochin maritimum* - *Holcus lanatus*

L tidal

SL subtidal

Table 33. Description of the plant communities on the Tsitika River Estuary, July, 1976.

1 *Carex lyngbyei*

2 *Carex lyngbyei* - *Deschampsia cespitosa*

3 *Elymus mollis* - *Vicia gigantea*

4 *Picea sitchensis* - *Heracleum lanatum* - *Vicia gigantea*

5 *Picea sitchensis*

6 *Deschampsia cespitosa*

7 *Trifolium wormskjoldii* - *Achillea millefolium* - *Triglochin martimum* - *Holcus lanatus*

Following is a list of the species in each plant community including dominant species indicated by a D and subdominant species indicated by an S.

	Community 1	2	3	4	5	6	7
Trees							
Picea sitchensis (Bong.) Carr. (Sitka Spruce)				D	D		
Shrubs							
Lonicera involucrata (Rich.) Banks (Black Twin-berry)					x		
Forbs							
Glaux maritima L. (Sea-milkwort)	x	x				x	
Potentilla pacifica Howell (Cinquefoil)	x	x	x			x	
Plantago maritima L. (Seaside Plantain)	x	x				x	
Spergularia canadensis (Pers.) G. Don (Sandspurry)	x						
Vicia gigantea Hook. (Giant Vetch)			D	D	S		
Galium asperrimum Gray (Rough Bedstraw)			x	x	x	x	
Heracleum lanatum Michx. (Cow-parsnip)			x	D	S		
Montia parvifolia (Moc.) Greene (Miner's Lettuce)				x	x		
Montia sibirica (L.) Howell (Siberian Miner's Lettuce)							
Triglochin maritimum L. (Arrow-grass)		x					S
Adenocaulon bicolor Hook. (Pathfinder)					x		
Oenanthe sarmentosa Presl. (Water-parsley)		x			x		

	Community						
	1	2	3	4	5	6	7
Forbs (continued)							
Tiarella trifoliata var. unifoliata (Hook) (Foamflower)					x		
Trifolium wormskjoldii Lehm. (Springbank Clover)		x	x			S	D
Achillea millefolium L. (Yarrow)		x	x			x	S
Plantago lanceolata L. (Ribgrass)		x				x	
Rumex crispus L. (Curly Dock)						x	
Galium trifidum L. (Small Bedstraw)							x
Atriplex patula L. (Saltbush)			x				
Stellaria humifusa Rottb. (Spreading Starwort)						x	
Grasses							
Deschampsia cespitosa (L.) Beauv. (Tufted Hairgrass)	x	D	x		x	D	x
Elymus mollis Trin. (Wildrye)			D	x		x	x
Holcus lanatus L. (Velvet-grass)			x	x	x		S
Hordeum brachyantherum Nevski. (Meadow Barley)	x	x	x	x	x	S	x

	Community						
	1	2	3	4	5	6	7
Grasses (continued)							
Festuca subulata Trin. (Nodding Fescue)		x	x	x	x	x	
Bromus pacificus Shear (Pacific Brome)				x	S		
Agrostis tenuis Sibth. (Colonial Bentgrass)							x
Sedges							
Carex lyngbyei Hornem. (Lyngby's Sedge)	D	D				x	x
Rushes							
Juncus balticus Willd. (Baltic Rush)		x				x	

Table 34. Area of each plant community on the Tsitika River Estuary

Plant Community	Area (hectares)	Percent (%)
Carex lyngbyei - Deschampsia cespitosa	1.2	31.1
Deschampsia cespitosa	1.2	31.1
Carex lyngbyei	.9	23.3
Elymus mollis - Vicia gigantea	.4	10.4
Subtotal	3.7	95.9
Picea sitchensis	.1	2.6
Trifolium wormskjoldii - Achillea millefolium - Triglochin maritimum - Holcus lanatus	.04	1.0
Picea sitchensis - Heracleum lanatum - Vicia gigantea	.02	.5
TOTAL	3.9	100.0

Figure 18. Map showing the distribution of the plant communities on the Kokish River Estuary

Legend

Scale 1 cm = 48 m

Plant Community

1 *Deschampsia cespitosa* - *Potentilla pacifica*

2 *Carex lyngbyei*

3 *Deschampsia cespitosa* - *Potentilla pacifica* - *Plantago macrocarpa*

4 *Heracleum lanatum* - *Pyrus fusca*

5 *Elymus mollis*

6 *Atriplex patula* - *Spergularia canadensis*

7 *Salicornia virginica* - *Spergularia canadensis* - *Distichlis spicata*

8 *Salicornia virginica* - *Potentilla pacifica* - *Plantago maritima*

9 *Hordeum brachyantherum*

10 *Deschampsia cespitosa* - *Potentilla pacifica* - *Hordeum brachyantherum* - *Agrostis tenuis*

B log boom

F ferry terminal

I industrial

L tidal

O oil storage tank

SL subtidal

railway

road

Table 35. Description of the plant communities on the Kokish River Estuary, August 1975.

1 Deschampsia cespitosa - Potentilla pacifica

2 Carex lyngbyei

3 Deschampsia cespitosa - Potentilla pacifica - Plantago macrocarpa

4 Heracleum lanatum - Pyrus fusca

5 Elymus mollis

6 Atriplex patula - Spergularia canadensis

7 Salicornia virginica - Spergularia canadensis - Distichlis spicata

8 Salicornia virginica - Potentilla pacifica - Plantago maritima

9 Hordeum brachyantherum

10 Deschampsia cespitosa - Potentilla pacifica - Hordeum brachyantherum - Agrostis tenuis

Following is a list of the species in each plant community including dominant species indicated by a D and subdominant species indicated by an S.

	Community 1	2	3	4	5	6	7	8	9	10
Trees										
Alnus rubra Bong. (Red Alder)			x							
Picea sitchensis (Bong.) Carr. (Sitka Spruce)				S						
Pyrus fusca Raf. (Pacific Crabapple)				D						
Shrubs										
Myrica gale L. (Sweet Gale)										
Gaultheria shallon Pursh. (Salal)				x						
Rubus spectabilis Pursh. (Salmonberry)				x						
Lonicera involucrata (Rich.) Banks (Black Twin-berry)				x						
Forbs										
Potentilla pacifica Howell (Cinquefoil)	D	x	D		x			S	x	S
Glaux maritima L. (Sea-milkwort)	x	x	x				x	x	x	x
Trifolium wormskjoldii Lehm. (Springbank Clover)			x							
Achillea millefolium L. (Yarrow)			x							x
Heracleum lanatum Michx. (Cow-parnsip)			x	D						

	Community									
	1	2	3	4	5	6	7	8	9	10
Forbs (continued)										
Triglochin maritimum L. (Arrow-grass)	x	x					x	x	x	x
Vicia gigantea Hook. (Giant Vetch)										
Plantago maritima L. (Seaside Plantain)	x		x				x	S	x	
Sisyrinchium angustifolium Mill. (Blue-eyed Grass)			x	x						
Plantago macrocarpa Cham. & Schlecht (Plantain)			D							
Oenanthe sarmentosa Presl. (Water-parsley)			x							
Fritillaria camschatcensis (L.) Ker.-Gawl (Chocolate Lily)			x							
Maianthemum dilatatum (Wood) Nels. & Macbr. (False Lily-of-the-valley)				x						
Hypochaeris radicata L. (Hairy Cats-ear)				x						
Salicornia virginica L. (Saltwort)							D	S	x	
Cochlearia officinalis L. (Spoonwort)								x		
Spergularia canadensis (Pers.) G. Don (Canada Sandspurry)	x					D	S		x	
Stellaria humifusa Rottb. (Spreading Starwort)			x					x		
Atriplex patula L. (Saltbush)	x				x	D			x	

	Community									
	1	2	3	4	5	6	7	8	9	10
Grasses										
Deschampsia cespitosa (L.) Beauv. (Tufted Hairgrass)	D	x	D					x	x	S
Hordeum brachyantherum Nevski (Meadow Barley)			x		x			x	D	S
Poa pratensis L. (Kentucky Bluegrass)			x	x						x
Agropyron repens (L.) Beauv. (Couch Grass)			x	x						
Hierochloe odorata (L.) Beauv. (Seneca Grass)			x							
Bromus sitchensis Trin. (Brome-grass)				x						
Holcus lanatus L. (Velvet-grass)				x						
Elymus mollis Trin. (Wildrye)					D					
Distichlis spicata (L.) Greene (Saltgrass)						x	S	x		
Agrostis tenuis Sibth. (Colonial Bentgrass)			x							S
Sedge										
Carex lyngbyei Hornem. (Lyngby's Sedge)	x	D					x	x	x	x

Table 36. Area of each plant community on the Kokish River Estuary

Plant Community	Area (hectares)	Percent (%)
Carex lyngbyei	2.0	26.2
Salicornia virginica - Potentilla pacifica - Plantago maritima	1.5	19.7
Hordeum brachyantherum	1.1	14.4
Deschampsia cespitosa - Potentilla pacifica	1.0	13.1
Deschampsia cespitosa - Potentilla pacifica - Plantago macrocarpa	.7	9.2
Deschampsia cespitosa - Potentilla pacifica - Hordeum brachyantherum - Agrostis tenuis	.7	9.2
Subtotal	7.0	91.8
Salicornia virginica - Spergularia canadensis - Distichlis spicata	.3	3.9
Elymus mollis	.2	2.6
Heracleum lanatum - Pyrus fusca	.1	1.3
Atriplex patula - Spergularia canadensis	.03	.4
TOTAL	7.6	100.0

Figure 19. Map showing the distribution of the plant communities on the Nimpkish River Estuary

Legend

Scale 1 cm = 48 m

Plant Community

1 Deschampsia cespitosa - Potentilla pacifica

2 Juncus balticus - Trifolium wormskjoldii - Potentilla pacifica

3 GRAMINEAE - Juncus balticus - Rubus spectabilis

4 Eleocharis palustris

5 Deschampsia cespitosa - Trifolium wormskjoldii - Potentilla pacifica

6 Carex lyngbyei

7 Picea sitchensis - Rosa nutkana - Ribes sp.

8 Carex obnupta

9 Myrica gale

10 Deschampsia cespitosa - Potentilla pacifica - Juncus balticus

11 Typha latifolia

12 Elymus mollis

B barge

L tidal

O old log dump

SL subtidal

Table 37. Description of the plant communities on the Nimpkish River Estuary, August 1975.

1 Deschampsia cespitosa - Potentilla pacifica

2 Juncus balticus - Trifolium wormskjoldii - Potentilla pacifica

3 GRAMINEAE - Juncus balticus - Rubus spectabilis

4 Eleocharis palustris

5 Deschampsia cespitosa - Trifolium wormskjoldii - Potentilla pacifica

6 Carex lyngbyei

7 Picea sitchensis - Rosa nutkana - Ribes sp.

8 Carex obnupta

9 Myrica gale

10 Deschampsia cespitosa - Potentilla pacifica - Juncus balticus

11 Typha latifolia

12 Elymus mollis

Following is a list of the species in each plant community including dominant species indicated by a D and subdominant species indicated by an S.

	Community											
	1	2	3	4	5	6	7	8	9	10	11	12
Trees												
Alnus rubra Bong. (Red Alder)			x				x					
Picea sitchensis (Bong.) Carr. (Sitka Spruce)							D		x			x
Pyrus fusca Raf. (Pacific Crabapple)							x		x			
Shrubs												
Rubus spectabilis (Salmonberry)							x		x			x
Myrica gale L. (Sweet Gale)							x		D			
Rosa nutkana Presl. (Nootka Rose)							D		x			
Ribes sp. L. (Gooseberry)							D					
Forbs												
Trifolium wormskjoldii Lehm. (Springbank Clover)		S	x	x	D			S		S		
Plantago maritima L. (Seaside Plantain)	x	x										

	Community											
	1	2	3	4	5	6	7	8	9	10	11	12
Forbs (continued)												
<u>Montia</u> <u>sibirica</u> (L.) Howell (Siberian Miner's Lettuce)	x											
<u>Potentilla</u> <u>pacifica</u> Howell (Cinquefoil)	S	S	x	x	D	x		S	x	D		x
<u>Plantago macrocarpa</u> Chem. & Schlecht (Plantain)		x			x					S		
<u>Plantago</u> <u>lanceolata</u> L. (Ribgrass)		x			x			x	x			
<u>Triglochin</u> <u>maritimum</u> L. (Arrow-grass)		x							x	S		
<u>Spergularia</u> <u>canadensis</u> (Pers.) G. Don. (Canada Sandspurry)		x										
<u>Dodecatheon</u> <u>pulchellum</u> (Raf.) Merrill (Shooting-star)		x								x		
<u>Sisyrinchium</u> <u>angustifolium</u> Mill. (Blue-eyed Grass)		x								x		
<u>Glaux</u> <u>maritima</u> L. (Sea-milkwort)	x	x								S		
<u>Prunella</u> <u>vulgaris</u> L. (Self-heal)		x	x		x				x	x		
<u>Heliopsis</u> <u>helianthoides</u> (L.) Sweet (Ox-eye Daisy)			x		x							

	Community											
	1	2	3	4	5	6	7	8	9	10	11	12
Forbs (continued)												
Plantago lanceolata L. (Ribgrass)			x		x		x					
Hypochaeris radicata L. (Hairy Cats-ear)			x		x				x	x		
Ranunculus repens L. (Creeping Buttercup)			x		S		x	x	x	x		
Erigeron philadelphicus L. (Philadelphia Fleabane)			x									
Equisetum arvense L. (Common Horsetail)			x					x				
Achillea millefolium L. (Yarrow)		x			x		x		x	x		
Lilaeopsis occidentalis Coult. & Rose (Lilaeopsis)				x		x						
Galium trifidum L. (Small Bedstraw)					x			x	x	x		
Oenanthe sarmentosa Presl. (Water-parsley)							x	x	x			
Rumex crispus L. (Curly Dock)							x					
Athyrium filix-femina (L.) Roth. (Lady-fern)							x					

	Community											
	1	2	3	4	5	6	7	8	9	10	11	12
Forbs (continued)												
Lysichitum americanum Hulten & St. John (Skunk Cabbage)							x					
Urtica dioica L. (Stinging Nettle)							x					
Trifolium repens L. (White Clover)							x					
Stachys cooleyae Heller (Cooley's Hedge-nettle)							x					
Mentha arvensis L. (Field Mint)					x				x			
Cochlearia officinalis L. (Spoonwort)	x									x		
Typha latifolia L. (Cat-tail)											D	
Galium boreale L. (Northern Bedstraw)												x
Atriplex patula L. (Saltbush)	x											

	Community											
	1	2	3	4	5	6	7	8	9	10	11	12
Grasses												
Deschampsia cespitosa (L.) Beauv. (Tufted Hairgrass)	D	x	S		D			x	x	D		
Holcus lanatus L. (Velvet-grass)			S		x			S	x			x
Poa pratensis L. (Kentucky Bluegrass)			S		x		x	x		x		x
Calamagrostis canadensis (Michx.) Beauv. (Bluejoint Reedgrass)			S		x				x			
Bromus sitchensis Trin. (Brome-grass)							x					
Dactylis glomerata L. (Orchard-grass)							x					
Phleum pratense L. (Timothy)							x					
Hordeum brachyantherum Nevski (Meadow Barley)					x					x		x
Distichlis spicata (L.) Greene (Saltgrass)										x		
Elymus mollis Trin. (Wildrye)												D

	Community											
	1	2	3	4	5	6	7	8	9	10	11	12
Cynosurus cristatus L. (Crested Dog's-tail)			S		S		x					
Agrostis tenuis Sibth. (Colonial bentgrass)							x		x			
Sedge												
Carex lyngbyei Hornem. (Lyngby's Sedge)	x	x	x			D			x	S		
Eleocharis palustris (L.) R. & S. (Spike-rush)		x		D	x	x				x		
Scirpus microcarpus Presl. (Small-fruit Bulrush)					x							
Carex oederi Retz. (Green Sedge)		x	x						x	S		
Carex obnupta Bailey (Slough Sedge)							x	D				
Rushes												
Juncus balticus Willd. (Baltic Rush)		S	S		x			x		D		
Juncus effusus L. (Common Rush)								x				
Juncus falcatus E. Meyer (Sickle-leaved Rush)					x							

Table 38. Area of each plant community on the Nimpkish River Estuary

Plant Community	Area (hectares)	Percent (%)
Juncus balticus - Trifolium wormskjoldii - Potentilla pacifica	2.3	28.6
Deschampsia cespitosa - Potentilla pacifica	1.2	14.9
Carex lyngbyei	.9	11.2
Carex obnupta	.8	10.0
Eleocharis palustris	.6	7.5
Deschampsia cespitosa - Potentilla pacifica - Juncus balticus	.6	7.5
Picea sitchensis - Rosa nutkana - Ribes sp.	.6	7.5
Deschampsia cespitosa - Trifolium wormskjoldii - Potentilla pacifica	.5	6.2
Subtotal	7.5	93.4
Myrica gale	.3	3.7
GRAMINEAE - Juncus balticus - Rubus spectabilis	.1	1.2
Elymus mollis	.1	1.2
Typha latifolia	.03	.4
TOTAL	8.0	99.9

Figure 20. Map showing the distribution of the plant communities on the Cluxewe River Estuary

Legend

Scale 1 cm = 48 m

Plant Community

1 Carex lyngbyei

2 Carex lyngbyei - Deschampsia cespitosa

3 Potentilla pacifica - Trifolium wormskjoldii - Agrostis tenuis

4 Trifolium wormskjoldii - Deschampsia cespitosa - Poa pratensis - Potentilla pacifica

5 Deschampsia cespitosa - Potentilla pacifica

6 Hordeum brachyantherum - Trifolium wormskjoldii - Potentilla pacifica

7 Plantago lanceolata - Juncus effusus - Hordeum brachyantherum

8 Elymus mollis

9 Picea sitchensis

10 GRAMINEAE

11 Potentilla pacifica - Agrostis tenuis

12 Heracleum lanatum - Anthoxanthum odoratum - Dactylis glomerata

13 Poa pratensis - Salicornia virginica

14 Deschampsia cespitosa - Triglochin maritimum

15 Carex lyngbyei - Triglochin maritimum

16 Carex rostrata

17 Deschampsia cespitosa - Elymus mollis

18 Achillea millefolium - Poa pratensis - Elymus mollis

C	campground	+++	dyke
L	tidal	=	road
SL	subtidal		

Table 39. Description of the plant communities on the Cluxewe River Estuary, July 1975.

1 Carex lyngbyei

2 Carex lyngbyei - Deschampsia cespitosa

3 Potentilla pacifica - Trifolium wormskjoldii - Agrostis tenuis

4 Trifolium wormskjoldii - Deschampsia cespitosa - Poa pratensis - Potentilla pacifica

5 Deschampsia cespitosa - Potentilla pacifica

6 Hordeum brachyantherum - Trifolium wormskjoldii - Potentilla pacifica

7 Plantago lanceolata - Juncus effusus - Hordeum brachyantherum

8 Elymus mollis

9 Picea sitchensis

10 GRAMINEAE

11 Potentilla pacifica - Agrostis tenuis

12 Heracleum lanatum - Anthoxanthum odoratum - Dactylis glomerata

13 Poa pratensis - Salicornia virginica

14 Deschampsia cespitosa - Triglochin maritimum

15 Carex lyngbyei - Triglochin maritimum

16 Carex rostrata

17 Deschampsia cespitosa - Elymus mollis

18 Achillea millefolium - Poa pratensis - Elymus mollis

Following is a list of species in each plant community including dominant species indicated by a D and subdominant species indicated by an S.

	Community																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Trees																		
Alnus rubra Bong. (Red Alder)						x	x		x									
Pyrus fusca Raf. (Pacific Crabapple)						x	x											
Picea sitchensis (Bong.) Carr. (Sitka Spruce)								x	D	x								
Tsuga heterophylla (Raf.) Sarg. (Western Hemlock)									S									
Shrubs																		
Rubus spectabilis Pursh. (Salmonberry)						x			x									
Lonicera involucrata (Rich.) Banks (Black Twin-berry)							x	x	x									
Rosa nutkana Presl. (Nootka Rose)							x	x	x									
Ribes sanguineum Pursh. (Red Currant)								x										
Vaccinium parvifolium Smith (Huckleberry)								x	S									
Gaultheria shallon Pursh. (Salal)								x	D									
Rubus parviflorus Nutt. (Thimbleberry)									x									

	Community																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Forbs																		
<u>Potentilla</u> <u>pacifica</u> Howell (Cinquefoil)	x	x	D	S	D	S	x			x	D	x						
<u>Trifolium</u> <u>wormskjoldii</u> Lehm. (Springbank Clover)			S	D	x	D	x			x								
<u>Achillea</u> <u>millefolium</u> L. (Yarrow)			x	x	x	x	x	x	x	S	S	x						S
<u>Plantago</u> <u>maritima</u> L. (Seaside Plantain)			x		x								x		x			
<u>Plantago</u> <u>lanceolata</u> L. (Ribgrass)			x			x	D											
<u>Salicornia</u> <u>virginica</u> L. (Saltwort)	x												D					
<u>Triglochin</u> <u>maritimum</u> L. (Arrow-grass)	x	x			x								x	D	S		x	
<u>Heracleum</u> <u>lanatum</u> Michx. (Cow-parsnip)		x	x			x	x	x		S		S						
<u>Equisetum</u> <u>arvense</u> L. (Common Horesetail)						x												

	Community 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Forbs (continued)																		
Ranunculus sp. L. (Buttercup)						x												
Stachys cooleyae Heller (Cooley's Hedge-nettle)						x												
Oenanthe sarmentosa Presl. (Water-parsley)							x											
Maianthemum dilatatum (Wood) Nels. & Macbr. (Fase Lily-of-the-valley)							x		x									
Fritillaria camschatcensis (L.) Ker. - Gawl. (Chocolate Lily)							x											
Glaux maritima L. (Sea-milkwort)		x				x		x										
Lathyrus palustris L. (Marsh Pea)								S	x									
Vicia gigantea Hook (Giant Vetch)								x										
Trifolium repens L. (White Clover)								x	x									

	Community																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Forbs (continued)																		
Plantago lanceolata L. (Ribgrass)								x	x			x						
Fragaria chiloensis (L.) Duchesne (Coastal Strawberry)								x	x									
Castilleja levisecta Greenm. (Golden Indian-paintbrush)								x	x									
Lilaeopsis occidentalis Coult. & Rose (Lilaeopsis)		x																
Trientalis arctica Fisch. (Starflower)									x									
Galium aparine L. (Bedstraw)									x									
Atriplex patula L. (Saltbrush)								x		x			x	x				
Stellaria humifusa Rottb. (Spreading Starwort)		x				x								x				

	Community																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Grasses																		
Deschampsia cespitosa (L.) Beauv. (Tufted Hairgrass)		D	x	S	D	x	x			S	x		x	D	x		D	S
Poa pratensis L. (Kentucky Bluegrass)			x	S	x	x	x	x		S	x	x	D				x	S
Hordeum brachyantherum Nevski. (Meadow Barley)		x		x	x	D	D			S	S	x						
Distichlis spicata (L.) Greene (Saltgrass)	x												x					
Holcus lanatus L. (Velvet-grass)						x	x											
Elymus mollis Trin. (Wildrye)								D	x	x			x	x	x		D	S
Aira sp. (Hairgrass)								x										
Dactylis glomerata L. (Orhard-grass)								x			x	S						
Hierochloe odorata (L.) Beauv. (Seneca Grass)								x				x						

	Community																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Grasses (continued)																		
Anthoxan odoratum L. (Sweet Vernalgrass)												S						
Agrostis tenuis Sibth. (Colonial Bentgrass)			S	x	x	x				x	D		x	x	x			
Sedges																		
Carex lyngbyei Hornem. (Lyngby's Sedge)	D	D	x		x									x	D	D		
Scirpus microcarpus Presl. (Small-fruit Bulrush)							x											
Carex rostrata Stokes (Beaked Sedge)																D		
Rushes																		
Juncus balticus Willd. (Baltic Rush)								x										
Juncus effusus L. (Common Rush)							x											

Table 40. Area of each plant community on the Cluxewe River Estuary

Plant Community	Area (hectares)	Percent (%)
Poa pratensis - Salicornia virginica	16.2	31.3
Picea sitchensis	14.6	28.2
Elymus mollis	7.6	14.7
Carex lyngbyei	4.0	7.7
Carex lyngbyei - Deschampsia cespitosa	2.5	4.8
Deschampsia cespitosa - Triglochin maritimum	2.1	4.1
Subtotal	47.0	90.8
Potentilla pacifica - Agrostis tenuis	1.2	2.3
GRAMINEAE	.9	1.7
Plantago lanceolata - Juncus effusus - Hordeum brachyantherum	.5	1.0
Heracleum lanatum - Anthoxanthum odoratum - Dactylis glomerata	.5	1.0
Deschampsia cespitosa - Potentilla pacifica	.4	.8
Hordeum brachyantherum - Trifolium wormskjoldii - Potentilla pacifica	.3	.6
Deschampsia cespitosa - Elymus mollis	.3	.6
Potentilla pacifica - Trifolium wormskjoldii - Agrostis tenuis	.2	.4
Achillea millefolium - Poa pratensis - Elymus mollis	.2	.4
Carex lyngbyei - Triglochin maritimum	.1	.2
Carex rostrata	.1	.2
Trifolium wormskjoldii - Deschampsia cespitosa - Poa pratensis - Potentilla pacifica	.01	.02
Total	51.7	100.0

Figure 21. Map showing the distribution of the plant communities on the Quatse River Estuary

Legend

Scale 1 cm = 48 m

Plant Community

1 *Carex lyngbyei* - *Potentilla pacifica*

2 *Carex lyngbyei*

3 *Deschampsia cespitosa* - *Carex lyngbyei* - *Potentilla pacifica*

4 *Carex lyngbyei* - *Agrostis tenuis* - *Oenanthe sarmentosa*

5 *Gaultheria shallon*

6 *Juncus balticus* - *Potentilla pacifica*

7 *Deschampsia cespitosa* - *Triglochin maritimum* - *Plantago maritima*

8 *Carex lyngbyei* - *Deschampsia cespitosa*

9 *Rubus spectabilis* - *Agrostis tenuis*

10 *Holcus lanatus* - *Agrostis tenuis*

11 *Agrostis tenuis* - *Juncus ensifolius var. ensifolius*

12 *Alnus rubra* - *Rubus spectabilis*

13 *Thuja plicata* - *Tsuga heterophylla*

14 *Deschampsia cespitosa* - *Agrostis tenuis* - *Potentilla pacifica*

15 *Carex lyngbyei* - *Triglochin maritimum*

16 *Salicornia virginica*

17 *Triglochin maritimum*

B log boom

H houseboat

I industrial

L tidal

LD log dump

SL subtidal

building

dyke

road

Table 41. Description of the plant communities on the Quatse River Estuary, July 1975.

1	Carex lyngbyei - Potentilla pacifica
2	Carex lyngbyei
3	Deschampsia cespitosa - Carex lyngbyei - Potentilla pacifica
4	Carex lyngbyei - Agrostis tenuis - Oenanthe sarmentosa
5	Gaultheria shallon
6	Juncus balticus - Potentilla pacifica
7	Deschampsia cespitosa - Triglochin maritimum - Plantago maritima
8	Carex lyngbyei - Deschampsia cespitosa
9	Rubus spectabilis - Agrostis tenuis
10	Holcus lanatus - Agrostis tenuis
11	Agrostis tenuis - Juncus ensifolius var. ensifolius
12	Alnus rubra - Rubus spectabilis
13	Thuja plicata - Tsuga heterophylla
14	Deschampsia cespitosa - Agrostis tenuis - Potentilla pacifica
15	Carex lyngbyei - Triglochin maritimum
16	Salicornia virginica
17	Triglochin maritimum

Following is a list of species in each plant community including dominant species indicated by a D and subdominant species indicated by an S.

	Community																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Trees																	
Thuja _plicata_ Donn. (Western Red Cedar)					S							x	D				
Picea _sitchensis_ (Bong.) Carr. (Sitka Spruce)					S				x	x		S					
Tsuga _heterophylla_ (Raf.) Sarg. (Western Hemlock)					S							x	D				
Alnus _rubra_ Bong. (Red Alder)					x					x		D					
Pinus _contorta_ var. _contorta_ Dougl. (Lodgepole Pine)					x												
Pyrus _fusca_ Raf. (Pacific Crabapple)				x								x	x				
Shrubs																	
Rubus _spectabilis_ Pursh. (Salmonberry)				x	S				S			D	S				
Lonicera _involucrata_ (Rich.) Banks (Black Twin-berry)				x	x							x	x				

	Community																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Shrubs (continued)																	
Gaultheria shallon Pursh. (Salal)					D					x		x					
Menziesia ferruginea Smith (Mock Azalea)					S												
Vaccinium parvifolium Smith (Huckleberry)					S							x	x				
Rosa nutkana Presl. (Nootka Rose)					x							x	x				
Sambucus racemosa L. (Elderberry)									x			x					
Salix sp. L. (Willow)									x	x		x					
Spiraea douglasii Hook (Hardhack)									x			x					
Physocarpus capitatus (Purch) Kuntze (Ninebark)									x								
Rubus parviflorus Nutt. (Thimbleberry)									x								

	Community																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Forbs																		
Hypochaeris radicata L. (Hairy Cats-ear)	x								x	x		x	x					
Glaux maritima L. (Sea-milkwort)			x				x	S	x					x	x	x		
Plantago maritima L. (Seaside Plantain)	x						D	S		x					x	x		
Salicornia virginica L. (Saltwort)															x	D	x	
Rumex acetosella L. (Sour Weed)									x									
Cirsium arvense (L.) Scop. (Canada Thistle)									x	x								
Rumex crispus L. (Curly Dock)									x									
Lactuca muralis (L.) Fresen. (Wall Lettuce)									x									
Stellaria media (L.) Cyrill. (Chickweed)									x	x								

Forbs (continued)	Community 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Epilobium angustifolium L. (Fireweed)									x	x		x					
Arabis glabra (L.) Bernh. (Towermustard)									x	x		x					
Armeria maritima (Mill.) Willd. (Sea-pink)									x								
Cochlearia officinalis L. (Spoonwort)															x		
Mentha arvensis L. (Field Mint)										x							
Blechnum spicant (L.) Roth (Deer-fern)										x							
Geum macrophyllum Willd. (Avens)										x		x					
Ranunculus repens L. (Creeping Buttercup)										x							
Ranunculus sp. L. (Buttercup)										x			x				

	Community																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Forbs (continued)																	
<u>Potentilla</u> <u>pacifica</u> Howell (Cinquefoil)	D		S	x		D	x	x	x	x				D			
<u>Plantago</u> <u>macrocarpa</u> Cham. & Schlecht (Plantain)	x		x			x								x			
<u>Trifolium</u> <u>wormskjoldii</u> Lehm. (Springbank Clover)	x		x	x		x			S	x			x	x			
<u>Triglochin</u> <u>maritimum</u> L. (Arrow-grass)	x		x			x	D	x	x	x				x	S	x	D
<u>Achillea</u> <u>millefolium</u> L. (Yarrow)			x	x		x			x	x				x			
<u>Heracleum</u> <u>lanatum</u> Michx. (Cow-parsnip)			x	x					x								
<u>Fritillaria</u> <u>camschatcensis</u> (L.) Ker.-Gawl. (Chocolate Lily)			x	x		x											
<u>Oenanthe</u> <u>sarmentosa</u> Presl. (Water-parsley)			x	S	x	x				x			x				
<u>Maianthemum</u> <u>dilatatum</u> (Wood) Nels. & Macbr. (False Lily-of-the-valley)				x	x							x	x				

	Community																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Forbs (continued)																		
Erigeron philadelphicus L. (Philadelphia Fleabane)				x		x												
Montia sibirica (L.) Howell (Siberian Miner's Lettuce)				x									x					
Vicia gigantea Hook (Giant Vetch)				S					x									
Galium boreale L. (Northern Bedstraw)				x					x				x					
Trientalis arctica Fisch. (Starflower)				x	x													
Cornus canadensis L. (Bunchberry)					x													
Tiarella trifoliata var. *trifoliata* L. (Foamflower)					x													
Lysichitum americanum Hulten & St. John (Skunk Cabbage)					x													
Pteridium aquilinum (L.) Kuhn (Bracken)					x													

	Community																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Forbs (continued)																	
<u>Trifolium</u> <u>pratense</u> L. (Red Clover)										x			x				
<u>Trifolium</u> <u>repens</u> L. (White Clover)										x			x				
<u>Spergularia</u> <u>canadensis</u> (Pers.) G. Don (Sandspurry)										x						x	x
<u>Digitalis</u> <u>purpurea</u> L. (Foxglove)									x	x							
<u>Prunella</u> <u>vulgaris</u> L. (Self-heal)										x							
<u>Trifolium</u> <u>dubium</u> Sibth. (Least Hop Clover)										x							
<u>Anaphalis</u> <u>margaritacea</u> (L.) B. & H. (Pearly-everlasting)										x							
<u>Polystichum</u> <u>munitum</u> (Kaulf.) Presl. (Sword-fern)													x				
<u>Pteridium</u> <u>aquilinum</u> (L.) Kuhn. (Bracken)					x												

	Community																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Forbs (continued)																	
<u>Stellaria</u> <u>humifusa</u> Rottb. (Spreading Starwort)	x						x	x		x				x			
<u>Atriplex</u> <u>patula</u> L. (Saltbush)			x							x							
Grasses																	
<u>Deschampsia</u> <u>cespitosa</u> (L.) Beauv. (Tufted Hairgrass)	x		S	x		x	D	D	x			x	S	D	x		
<u>Holcus</u> <u>lanatus</u> L. (Velvet-grass)	x								x	D		x	x				
<u>Distichlis</u> <u>spicata</u> (L.) Greene (Saltgrass)															x		x
<u>Poa</u> <u>pratensis</u> L. (Kentucky Bluegrass)			x	x		x			x	x			x	x			
<u>Hordeum</u> <u>brachyantherum</u> Nevski. (Meadow Barley)			x			x			x	x				x			
<u>Agrostis</u> <u>tenuis</u> Sibth. (Colonial Bentgrass)			x	S		x			S	D	D		x	D			

	Community																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Grasses (continued)																	
Hierochloe odorata (L.) Beauv. (Seneca Grass)				x													
Agropyron repens (L.) Beauv. (Couch Grass)	x												x				
Sedges																	
Carex lyngbyei Hornem. (Lyngby's Sedge)	D	D	S	D			x	D	x	x				x	D		
Scirpus microcarpus Presl. (Small-fruit Bulrush)	x											x					
Carex rostrata Stokes (Beaked Sedge)												x					
Rushes																	
Juncus balticus Willd. (Baltic Rush)	x		x			D											
Juncus effusus L. (Common Rush)					x												

	Community																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Rushes (continued)																		
Juncus ensifolius var. ensifolius Wikst. (Dagger-leaf Rush)	x								x	x	S	x						
Juncus falcatus E. Meyer (Sickle-leaved Rush)	x																	

Table 42. Area of each plant community on the Quatse River Estuary

Plant Community	Area (hectares)	Percent (%)
Carex lyngbyei - Triglochin maritimum	6.6	28.7
Carex lyngbyei - Deschampsia cespitosa	2.8	12.2
Holcus lanatus - Agrostis tenuis	2.5	10.9
Alnus rubra - Rubus spectabilis	2.3	10.0
Deschampsia cespitosa - Agrostis tenuis - Potentilla pacifica	1.9	8.3
Salicornia virginica	1.9	8.3
Carex lyngbyei - Potentilla pacifica	1.1	4.8
Juncus balticus - Potentilla pacifica	1.0	4.3
Agrostis tenuis - Juncus ensifolius var. ensifolius	.8	3.5
Subtotal	20.9	91.0
Thuja plicata - Tsuga heterophylla	.6	2.6
Deschampsia cespitosa - Carex lyngbyei - Potentilla pacifica	.5	2.2
Deschampsia cespitosa - Triglochin maritimum - Plantago maritima	.4	1.7
Rubus spectabilis - Agrostis tenuis	.3	1.3
Carex lyngbyei	.1	.4
Gaultheria shallon	.1	.4
Triglochin maritimum	.1	.4
Carex lyngbyei - Agrostis tenuis - Oenanthe sarmentosa	.01	.04
TOTAL	23.0	100.0

Figure 22. Map showing the distribution of the plant communities on the Kingcome River Estuary

Legend

Scale 1 cm = 158.4 m

Plant Community

1 Carex lyngbyei

2 Deschampsia cespitosa

3 Elymus mollis

4 Potentilla pacifica - Trifolium wormskjoldii - Juncus balticus

5 Salix sp.

6 Sambucus racemosa - Rubus spectabilis - Heracleum lanatum - Elymus mollis

A agriculture

B boat dock

H Halliday's

L logging company

LD log dump

+++ dyke

Table 43. Description of the plant communities on the Kingcome River Estuary, July 1976.

1 Carex lyngbyei

2 Deschampsia cespitosa

3 Elymus mollis

4 Potentilla pacifica - Trifolium wormskjoldii - Juncus balticus

5 Salix sp.

6 Sambucus racemosa - Rubus spectabilis - Heracleum lanatum - Elymus mollis

Following is a list of species in each plant community including dominant species indicated by a D and subdominant species indicated by an S.

	Community 1	2	3	4	5	6
Trees						
<u>Picea</u> <u>sitchensis</u> (Bong.) Carr. (Sitka Spruce)						x
<u>Pyrus</u> <u>fusca</u> Raf. (Pacific Crabapple)						x
Shrubs						
<u>Salix</u> sp. L. (Willow)					D	x
<u>Lonicera</u> <u>ciliosa</u> (Parsh) DC. (Orange Honeysuckle)						x
<u>Lonicera</u> <u>involucrata</u> (Rich.) Banks (Black Twin-berry)						x
<u>Sambucus</u> <u>racemosa</u> L. (Elderberry)						S
<u>Rubus</u> <u>spectabilis</u> Pursh. (Salmonberry)						S

	Community					
	1	2	3	4	5	6
Forbs (continued)						
<u>Potentilla</u> <u>pacifica</u> Howell (Cinquefoil)		S	x	S	x	
<u>Sium</u> <u>suave</u> Walt. (Water-parsnip)	x	x			x	
<u>Triglochin</u> <u>maritimum</u> L. (Arrow-grass)	x	x				
<u>Plantago</u> <u>macrocarpa</u> Cham. & Schlecht (Plantain)		x		x		
<u>Glaux</u> <u>maritima</u> L. (Sea-milkwort)		x				
<u>Arctium</u> <u>minus</u> (Hill) Bernh. (Common Burdock)		x	x	x	x	
<u>Trifolium</u> <u>wormskjoldii</u> Lehm. (Springbank Clover)		x		S		x
<u>Erigeron</u> <u>philadelphicus</u> L. (Philadelphia Fleabane)		x		x		
<u>Fritillaria</u> <u>camschatcensis</u> (L.) Ker. - Gawl. (Chocolate Lily)		x	x	x		

Forbes (continued)

	Community 1	2	3	4	5	6
Mentha arvensis L. (Field Mint)		x	x	x		x
Galium sp. L. (Bedstraw)			x			x
Maianthemum dilatatum (Wood) Nels. & Macbr. (False Lily-of-the-valley)		x	x	x		
Sonchus arvensis L. (Milk-thistle)		x	x	x		
Achillea millefolium L. (Yarrow)		x	x	x		
Heracleum lanatum Michx. (Cow-parsnip)		x	x	x		x
Plantago major L. (Common Plantain)		x				
Oenanthe sarmentosa Presl. (Water-parsley)		x	x	x		
Montia sibirica (L.) Howell (Siberian Miner's Lettuce)				x		

	Community					
	1	2	3	4	5	6
Forbes (continued)						
Lupinus sp. L. (Lupine)			x	x		
Ranunculus orthorhynchus Hook (Buttercup)		x				
Lathyrus palustris L. (Marsh Pea)		x	x	x		
Grasses						
Festuca subulata Trin. (Nodding Fescue)		x	x	x		
Hordeum brachyantherum Nevski (Meadow Barley)		x		x		
Elymus mollis Trin. (Wildrye)			D	x		S
Deschampsia cespitosa (L.) Beauv. (Tufted Hairgrass)	x	D		x	x	
Elymus glaucus Buckl. (Blue Wildrye)				x	x	x
Hierochloe odorata (L.) Beauv. (Seneca Grass)				x		

	Community					
	1	2	3	4	5	6
Grasses(continued)						
Festuca pratensis Huds. (Meadow Fescue)			x	x		
Agrostis tenuis Sibth. (Colonial Bentgrass)		x		x		
Dactylis glomerata L. (Orchard-grass)						x
Bromus pacificus Shear (Pacific Brome)				x		
Poa pratensis L. (Kentucky Bluegrass)				x		
Sedge						
Carex lyngbyei Hornem. (Lyngby's Sedge)	D	D		x	x	
Eleocharis palustris (L.) R. & R. (Spike-rush)	x	x			x	
Rush						
Juncus balticus Willd. (Baltic Rush)		x		S		

Table 44. Area of each plant community on the Kingcome River Estuary

Plant Community	Area (hectares)	Percent (%)
Deschampsia cespitosa	74.2	51.2
Carex lyngbyei	41.6	28.7
Potentilla pacifica - Trifolium wormskjoldii - Juncus balticus	17.8	12.3
Subtotal	133.6	92.2
Salix sp.	8.5	5.9
Elymus mollis	2.2	1.5
Sambucus racemosa - Rubus spectabilis - Heracleum lanatum - Elymus mollis	.5	.3
TOTAL	144.8	99.9

Table 45. Simple linear correlation between species, and flow and precipitation

Species	Flow r	Flow r^2	Precipitation r	Precipitation r^2
Agrostis spp.	.2684	.0721	.4531	.2053
Carex lyngbyei	.2026	.0411	.4528	.2050
Deschampsia cespitosa	.4365	.1906	.7606* $.05>P>.02$	.5758
Distichlis spicata	.4944	.2444	.5624	.3163
Hordeum brachyantherum	.1591	.0253	.4088	.1671
Hordeum murinum	.2004	.0402	.4180	.1747
Juncus articulatus	.0546	.00298	.1584	.0251
Juncus balticus	.3682	.1356	.5192	.2696
Potentilla pacifica	.1847	.0341	.9217** $.001<P<.002$	.8496
Salicornia virginica	.4311	.1858	.2670	.0713
Scirpus spp.	.1366	.0187	.1377	.0190
	$n = 14$, $r_{0.05(2),12}=0.532$		$n = 8$, $r_{0.05(2),6}=0.707$	

Appendix 6. Living, dead, senescent and duff fractions.
Figures 23-41.
The months in the figures are April (4), May (5), June (6), July (7), August (8) and October (10).

Figure 23. Mean monthly dry weights (gm $.5m^2$) living (.), dead (O), senescent (△) and duff (+) plant fractions from the Cowichan *Carex lyngbyei* community.

Statistics for graph

Portion	Month	Range	Observations	Minimum	Maximum	Std. Dev.
	4	13.1	5	34.9	48.0	5.4
	5	140.7	5	80.3	221.0	63.2
Living	6	45.5	5	213.5	259.0	18.2
	7	168.5	5	116.4	284.9	64.5
	8	78.5	5	0.0	78.5	30.3
	10	8.5	5	4.4	12.9	3.3
	5	90.8	5	0.0	90.8	40.6
	6	0.0	5	0.0	0.0	0.0
Dead	7	0.0	5	0.0	0.0	0.0
	8	0.0	5	0.0	0.0	0.0
	10	0.0	5	0.0	0.0	0.0
	4	0.0	5	0.0	0.0	0.0
	5	20.8	5	4.7	25.5	8.7
Senescent	6	26.2	5	38.1	64.3	11.0
	7	34.0	5	90.8	124.8	12.7
	8	65.5	5	107.4	172.9	26.4
	10	133.5	5	99.2	232.7	53.0
	5	105.5	5	0.0	105.5	46.0
	6	28.2	5	0.0	28.2	14.8
Duff	7	17.4	5	0.0	17.4	7.9
	8	21.1	5	0.0	21.1	10.2
	10	0.0	5	0.0	0.0	0.0

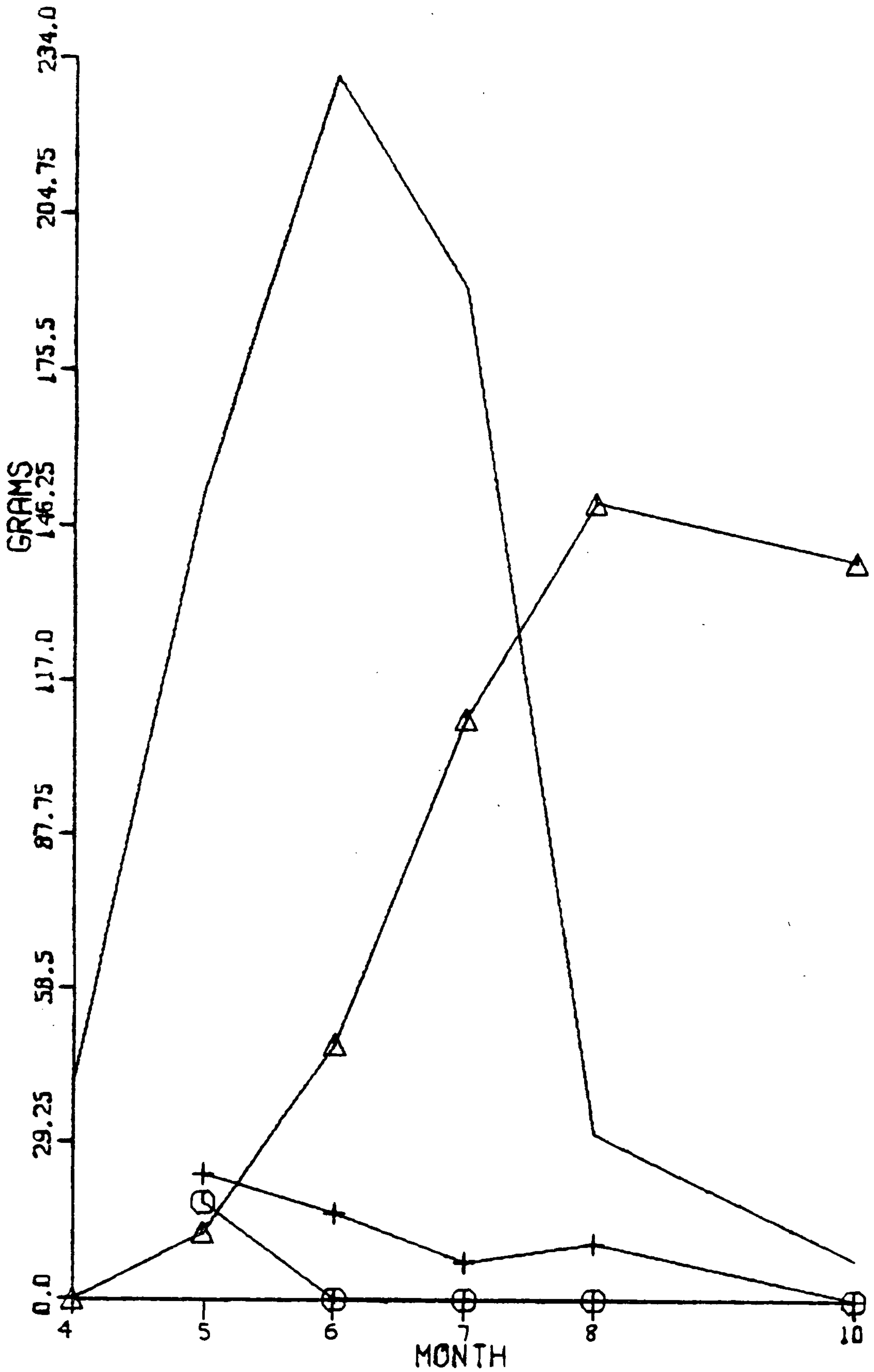

GRAMS
0.0
29.25
58.5
87.75
117.0
146.25
175.5
204.75
234.0
4
5
6
7
8
10
MONTH

Figure 24. Mean monthly dry weights (gm .5m^2) of living (.), dead (O), senescent (△) and duff (+) plant fractions from the Little Qualicum *Carex lyngbyei* community.

Statistics for graph

Portion	Month	Range	Observations	Minimum	Maximum	Std. Dev.
	4	213.3	5	40.6	253.9	93.8
	5	19.5	5	229.7	249.2	8.3
Living	6	125.4	5	188.0	313.4	50.5
	7	172.8	5	83.1	255.9	70.5
	8	45.8	5	101.5	147.3	22.0
	10	20.6	5	6.3	26.9	8.1
	5	149.2	5	0.0	149.2	69.2
Dead	6	0.0	5	0.0	0.0	0.0
	7	0.0	5	0.0	0.0	0.0
	8	0.0	5	0.0	0.0	0.0
	10	0.0	5	0.0	0.0	0.0
	4	0.0	5	0.0	0.0	0.0
	5	16.7	5	22.5	39.2	7.6
Senescent	6	106.4	5	43.7	150.1	44.1
	7	160.3	5	31.8	192.1	75.6
	8	102.0	5	75.2	177.2	45.6
	10	151.4	5	171.7	323.1	58.5
	5	110.2	5	0.0	110.2	55.1
	6	83.6	5	42.4	126.0	37.6
Duff	7	248.2	5	4.3	252.5	104.5
	8	105.8	5	10.9	116.7	42.6
	10	57.2	5	26.1	83.3	26.0

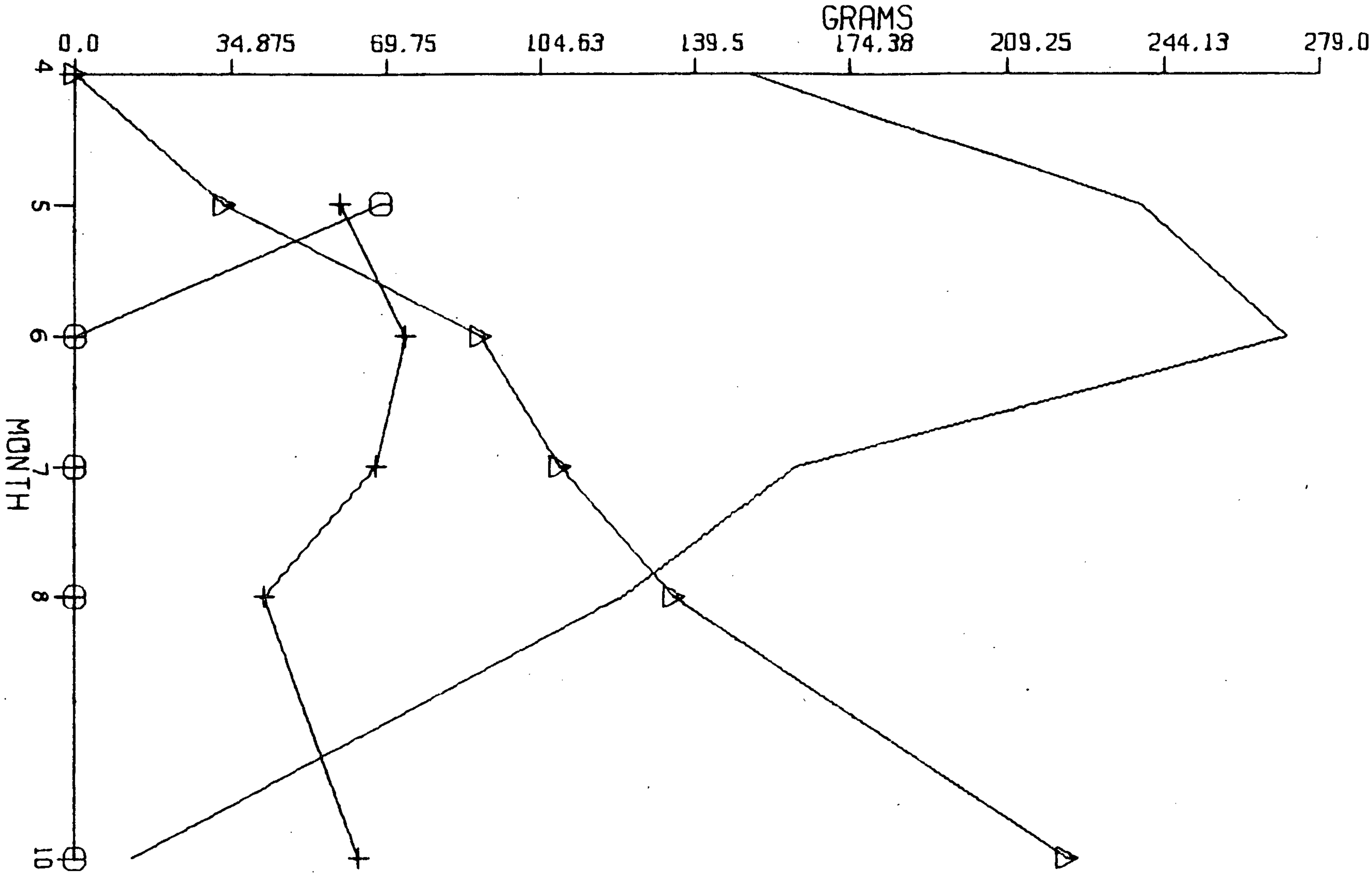

GRAMS
0.0
34.875
69.75
104.63
139.5
174.38
209.25
244.13
279.0
MONTH
4
5
6
7
8
10

Figure 25. Mean monthly dry weights (gm $.5m^2$) of living (.), dead (O), senescent (△) and duff (+) plant fractions from the Salmon *Carex lyngbyei* community.

Statistics for graph

Portion	Month	Range	Observations	Minimum	Maximum	Std. Dev.
	4	57.2	5	46.1	103.3	21.5
	5	42.9	5	111.4	154.3	17.6
Living	6	77.4	5	169.1	246.5	31.5
	7	36.5	5	187.8	224.3	16.2
	8	46.8	5	127.4	174.2	18.4
	10	52.6	5	2.4	55.0	22.9
	5	36.4	5	0.0	36.4	16.6
Dead	6	0.0	5	0.0	0.0	0.0
	7	0.0	5	0.0	0.0	0.0
	8	0.0	5	0.0	0.0	0.0
	10	0.0	5	0.0	0.0	0.0
	4	0.0	5	0.0	0.0	0.0
	5	14.3	5	2.7	17.0	5.9
Senescent	6	13.6	5	15.7	29.3	5.6
	7	38.6	5	41.4	80.0	16.9
	8	56.9	5	53.8	110.7	22.8
	10	63.1	5	124.9	188.0	23.0
	5	61.2	5	20.4	81.6	26.5
	6	27.6	5	15.3	42.9	11.9
Duff	7	27.4	5	19.6	47.0	11.1
	8	33.7	5	19.2	52.9	13.6
	10	35.0	5	2.2	37.2	15.8

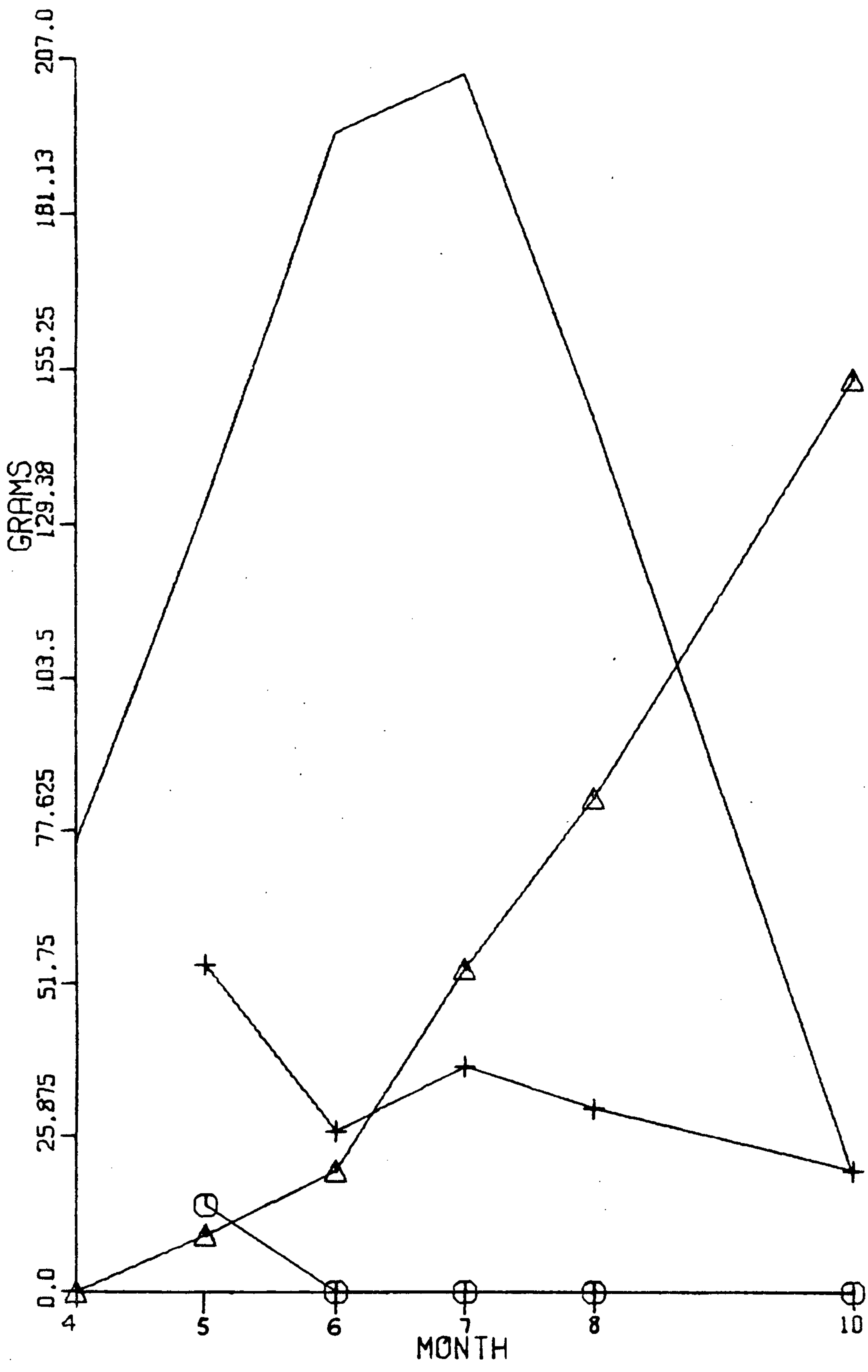

GRAMS
207.0
181.13
155.25
129.38
103.5
77.625
51.75
25.875
0.0
4
5
6
7
8
10
MONTH

Figure 26. Mean monthly dry weights (gm $.5m^2$) living (.), dead (O), senescent (Δ) and duff (+) plant fractions from the Cowichan *Juncus balticus* community.

Statistics for graph

Portion	Month	Range	Observations	Minimum	Maximum	Std. Dev.
	4	16.1	5	17.0	33.1	6.6
	5	51.7	5	64.7	116.4	20.2
Living	6	46.5	5	92.9	139.4	16.8
	7	37.5	5	84.6	122.1	16.6
	8	45.9	5	47.7	93.6	18.8
	10	29.8	5	3.7	33.5	12.1
	4	57.4	5	88.6	146.0	21.6
	5	73.8	5	28.4	102.2	30.6
Dead	6	24.2	5	37.5	61.7	9.2
	7	79.0	5	43.7	122.7	33.8
	8	64.3	5	26.0	90.3	27.5
	10	0.0	5	0.0	0.0	0.0
	4	0.0	5	0.0	0.0	0.0
	5	0.0	5	0.0	0.0	0.0
Senescent	6	0.0	5	0.0	0.0	0.0
	7	1.3	5	1.5	2.8	0.5
	8	46.5	5	11.3	57.8	18.9
	10	90.1	5	132.0	222.1	36.8
	5	73.6	5	22.3	95.9	35.1
	6	27.2	5	26.0	53.2	12.9
Duff	7	13.9	5	9.8	23.7	5.5
	8	348.1	5	9.5	357.6	151.7
	10	7.8	5	14.0	21.8	2.9

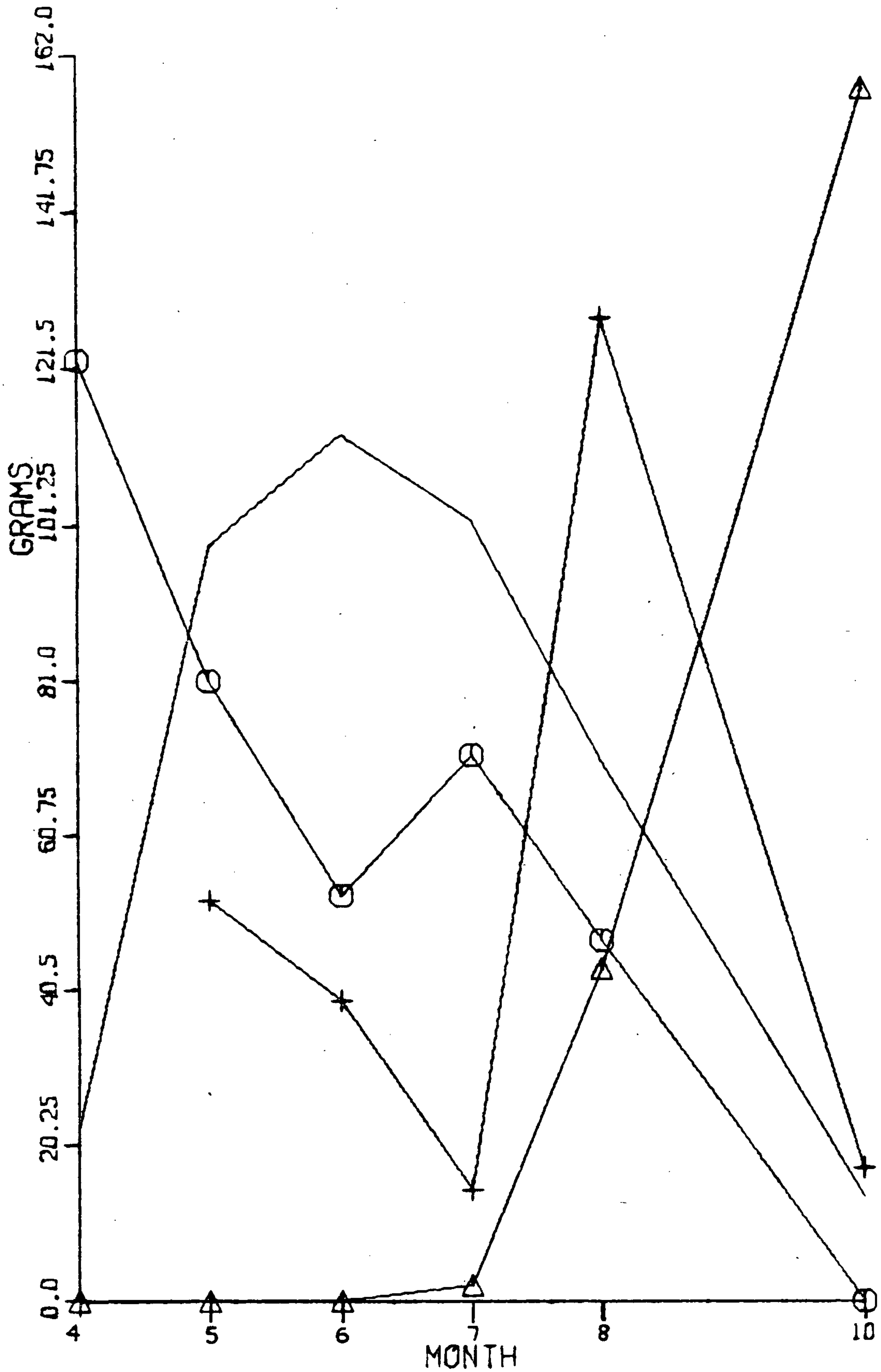

GRAMS
0.0
20.25
40.5
60.75
81.0
101.25
121.5
141.75
162.0
MONTH
4
5
6
7
8
10

Figure 27. Mean monthly dry weights (gm .5m^2) of living (.), dead (O), senescent (△) and duff (+) plant fractions from the Little Qualicum Potentilla pacifica - Carex lyngbyei community.

Statistics for graph

Portion	Month	Range	Observations	Minimum	Maximum	Std. Dev.
	4	16.3	5	11.0	27.3	5.9
	5	63.9	5	44.7	108.6	24.4
Living	6	49.6	5	104.4	154.0	20.0
	7	75.4	5	70.2	145.6	30.2
	8	39.7	5	73.9	113.6	15.0
	10	15.8	5	20.2	36.0	6.1
	4	163.7	5	70.8	234.5	78.8
	5	108.5	5	45.9	154.4	43.9
Dead	6	157.9	5	5.6	163.5	66.7
	7	129.4	5	0.0	129.4	60.3
	8	56.5	5	5.4	61.9	20.3
	10	0.0	5	0.0	0.0	0.0
	4	0.0	5	0.0	0.0	0.0
	5	0.0	5	0.0	0.0	0.0
Senescent	6	0.0	5	0.0	0.0	0.0
	7	27.4	5	15.5	42.9	10.8
	8	42.9	5	20.1	63.0	15.6
	10	125.7	5	98.1	223.8	49.9
	5	24.4	5	16.3	40.7	11.1
	6	37.6	5	5.2	42.8	14.0
Duff	7	59.2	5	0.0	59.2	25.1
	8	114.7	5	14.2	128.9	47.8
	10	18.1	5	9.9	28.0	8.2

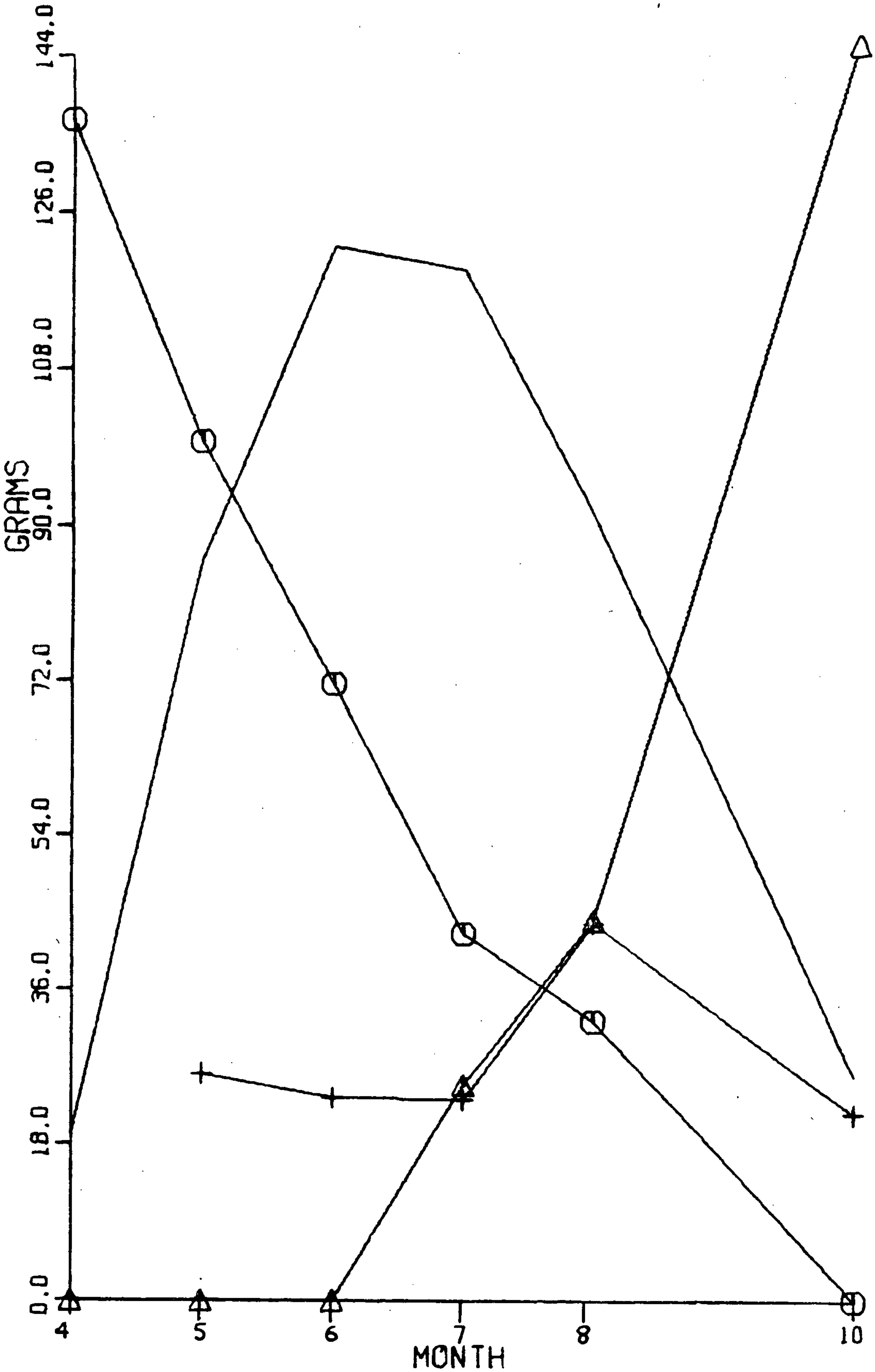

GRAMS
0.0
18.0
36.0
54.0
72.0
90.0
108.0
126.0
144.0
MONTH
4
5
6
7
8
10

Figure 28. Mean monthly dry weights (gm $.5m^2$) of living (.), dead (O), senescent (△) and duff (+) plant fractions from the Campbell <u>Potentilla pacifica</u> - <u>Eleocharis palustris</u> community.

Statistics for graph

Portion	Month	Range	Observations	Minimum	Maximum	Std. Dev.
	4	5.9	5	13.6	19.5	2.2
	5	46.1	5	59.3	105.4	18.1
Living	6	48.4	5	82.8	131.2	21.2
	7	77.5	5	84.5	162.0	29.8
	8	63.5	5	53.7	117.2	24.6
	10	28.5	5	22.8	51.3	10.9
	4	19.6	5	29.6	49.2	8.8
	5	9.9	5	11.0	20.9	3.8
Dead	6	38.7	5	3.6	42.3	16.3
	7	22.8	5	3.1	25.9	9.7
	8	0.0	5	0.0	0.0	0.0
	10	0.0	5	0.0	0.0	0.0
	4	0.0	5	0.0	0.0	0.0
	5	0.0	5	0.0	0.0	0.0
Senescent	6	0.0	5	0.0	0.0	0.0
	7	11.2	5	10.5	21.7	4.8
	8	8.1	5	29.3	37.4	3.2
	10	26.0	5	49.5	75.5	11.0
	5	13.6	5	0.0	13.6	6.1
	6	0.0	5	0.0	0.0	0.0
Duff	7	33.9	5	3.5	37.4	14.5
	8	0.0	5	0.0	0.0	0.0
	10	6.2	5	0.0	6.2	2.8

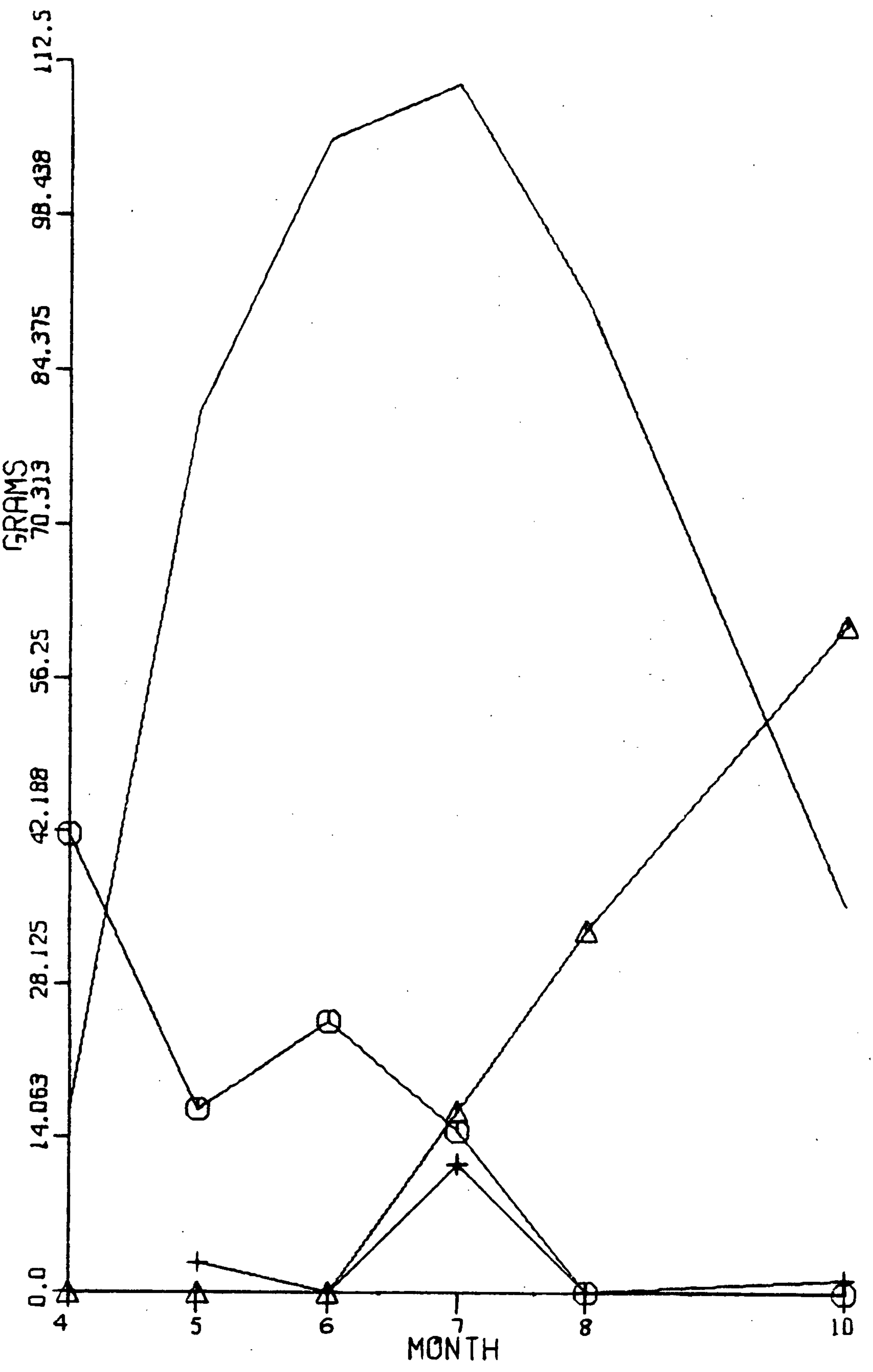

GRAMS
0.0
14.063
28.125
42.188
56.25
70.313
84.375
98.438
112.5
MONTH
4
5
6
7
8
10

Figure 29. Mean monthly dry weights (gm $.5m^{-2}$) of living (.), dead (O), and duff (+) plant fractions from the Chemainus *Salicornia virginica* community.

Statistics for graph

Portion	Month	Range	Observations	Minimum	Maximum	Std. Dev.
	4	6.4	5	3.5	9.9	2.6
	5	32.5	5	54.4	86.9	12.8
Living	6	68.3	5	49.6	117.9	25.1
	7	45.0	5	136.3	181.3	17.9
	8	216.7	5	72.1	288.8	82.0
	10	84.1	5	39.8	123.9	33.2
	4	97.9	5	227.1	325.0	41.2
	5	164.8	5	169.1	333.9	64.3
Dead	6	133.1	5	223.0	356.1	53.0
	7	133.7	5	221.3	355.0	49.9
	8	180.8	5	284.4	465.2	86.1
	10	132.9	5	106.3	239.2	56.9
	5	63.1	5	3.4	66.5	24.8
	6	39.9	5	17.3	57.2	15.3
Duff	7	0.0	5	0.0	0.0	0.0
	8	0.0	5	0.0	0.0	0.0
	10	0.0	5	0.0	0.0	0.0

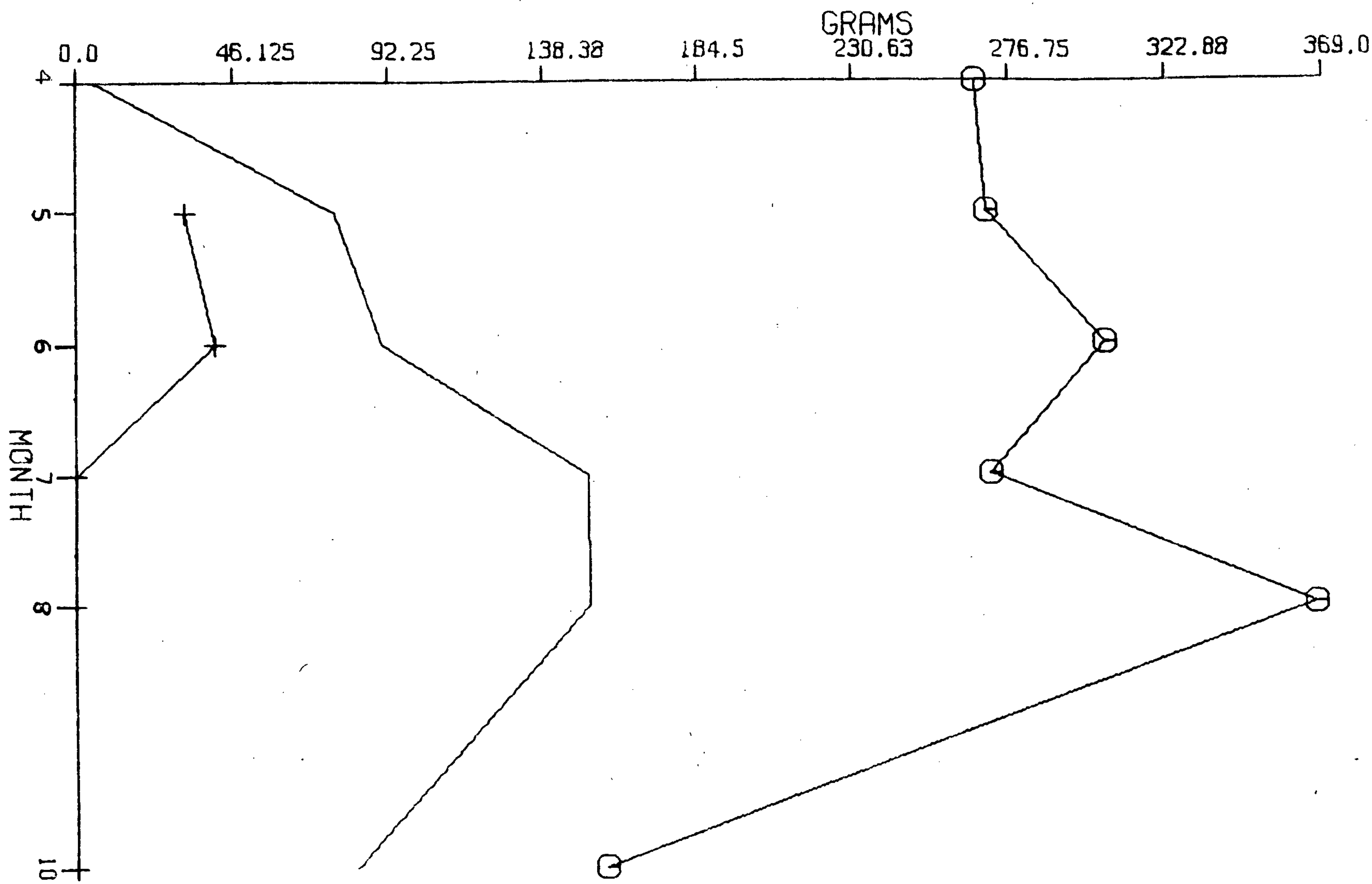

GRAMS
0.0
46.125
92.25
138.38
184.5
230.63
276.75
322.88
369.0
MONTH
4
5
6
7
8
10

Figure 30. Mean monthly dry weights (gm $.5m^2$) living (.), dead (O), and duff (+) plant fractions from the Chemainus <u>Distichlis spicata</u> - <u>Grindelia integrifolia</u> community.

Statistics for graph

Portion	Month	Range	Observations	Minimum	Maximum	Std. Dev.
	4	35.8	5	1.0	36.8	13.9
	5	56.8	5	22.1	78.9	24.3
Living	6	72.1	5	59.0	131.1	29.6
	7	39.3	5	135.6	174.9	16.7
	8	138.8	5	93.3	232.1	50.5
	10	47.7	5	151.4	199.1	18.2
	4	120.1	5	168.3	288.4	52.7
	5	89.4	5	138.4	227.8	39.1
Dead	6	94.9	5	102.7	197.6	38.6
	7	52.4	5	141.7	194.1	23.1
	8	68.0	5	98.7	166.7	26.4
	10	65.7	5	90.7	156.4	28.0
	4	0.0	5	0.0	0.0	0.0
	5	31.8	5	35.8	67.6	13.1
	6	32.4	5	50.2	82.6	12.2
Duff	7	18.1	5	24.2	42.3	6.6
	8	32.6	5	16.9	49.5	12.3
	10	97.8	5	22.1	119.9	37.4

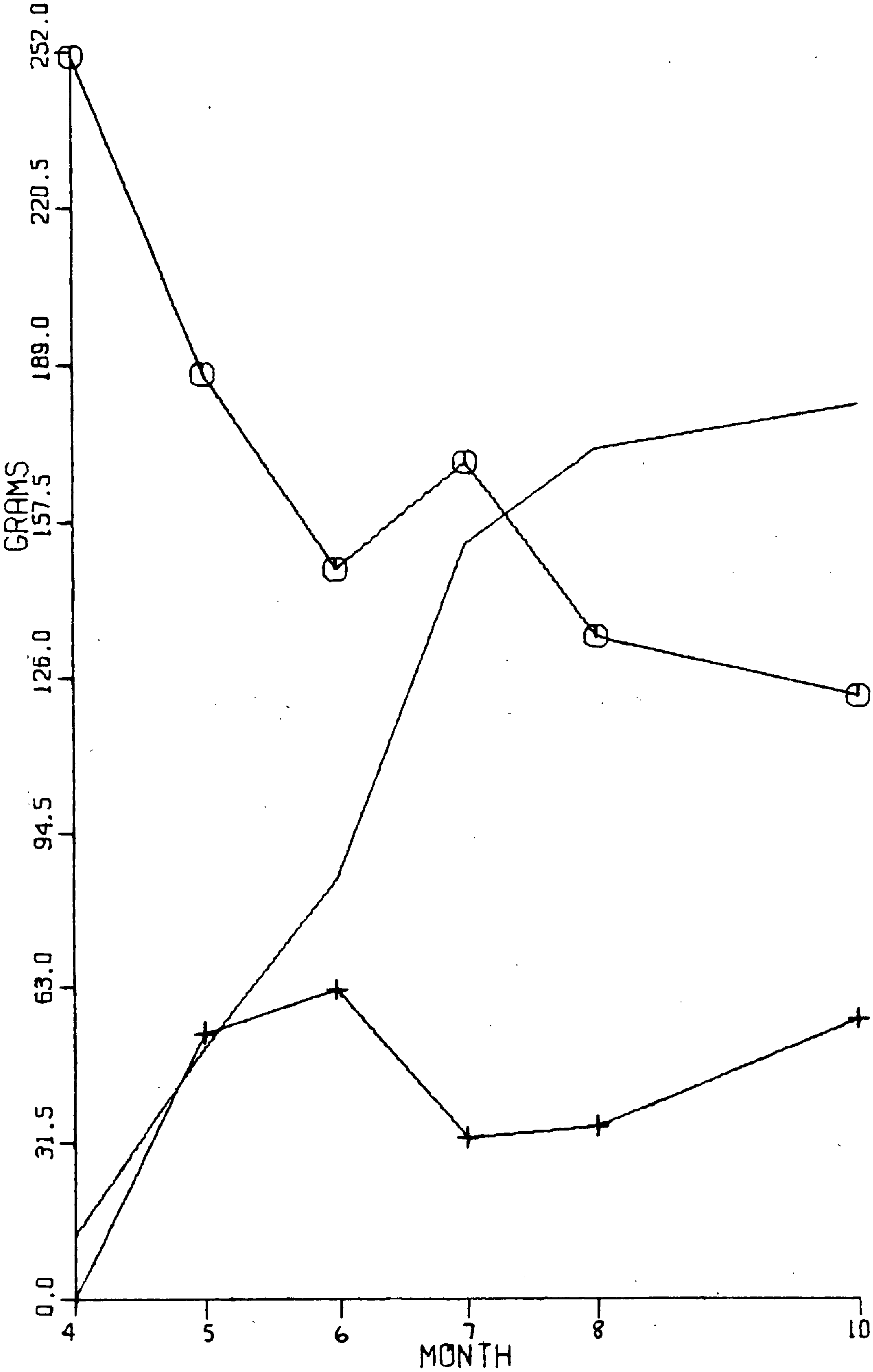

GRAMS
252.0
220.5
189.0
157.5
126.0
94.5
63.0
31.5
0.0
4
5
6
7
8
10
MONTH

Figure 31. Mean monthly dry weights (gm .5m^2) of living (.), dead (O), senescent (△) and duff (+) plant fractions from the Campbell *Carex lyngbyei* community.

Statistics for graph

Portion	Month	Range	Observations	Minimum	Maximum	Std. Dev.
	4	115.7	5	18.8	134.5	43.3
	5	122.2	5	123.3	245.5	50.2
Living	6	131.5	5	115.2	246.7	64.5
	7	61.8	5	184.3	246.1	25.7
	8	79.2	5	125.0	204.2	31.8
	10	13.5	5	2.1	15.6	6.5
	5	0.0	5	0.0	0.0	0.0
Dead	6	0.0	5	0.0	0.0	0.0
	7	0.0	5	0.0	0.0	0.0
	8	0.0	5	0.0	0.0	0.0
	10	0.0	5	0.0	0.0	0.0
	4	0.0	5	0.0	0.0	0.0
	5	14.1	5	8.6	22.7	5.7
Senescent	6	33.8	5	10.0	43.8	14.8
	7	23.4	5	40.3	63.7	9.2
	8	19.5	5	47.5	67.0	7.1
	10	72.1	5	64.5	136.6	28.1
	5	20.8	5	4.9	25.7	7.5
	6	5.0	5	12.2	17.2	2.1
Duff	7	42.7	5	10.0	52.7	21.5
	8	37.0	5	13.0	50.0	14.8
	10	11.9	5	7.8	19.7	4.8

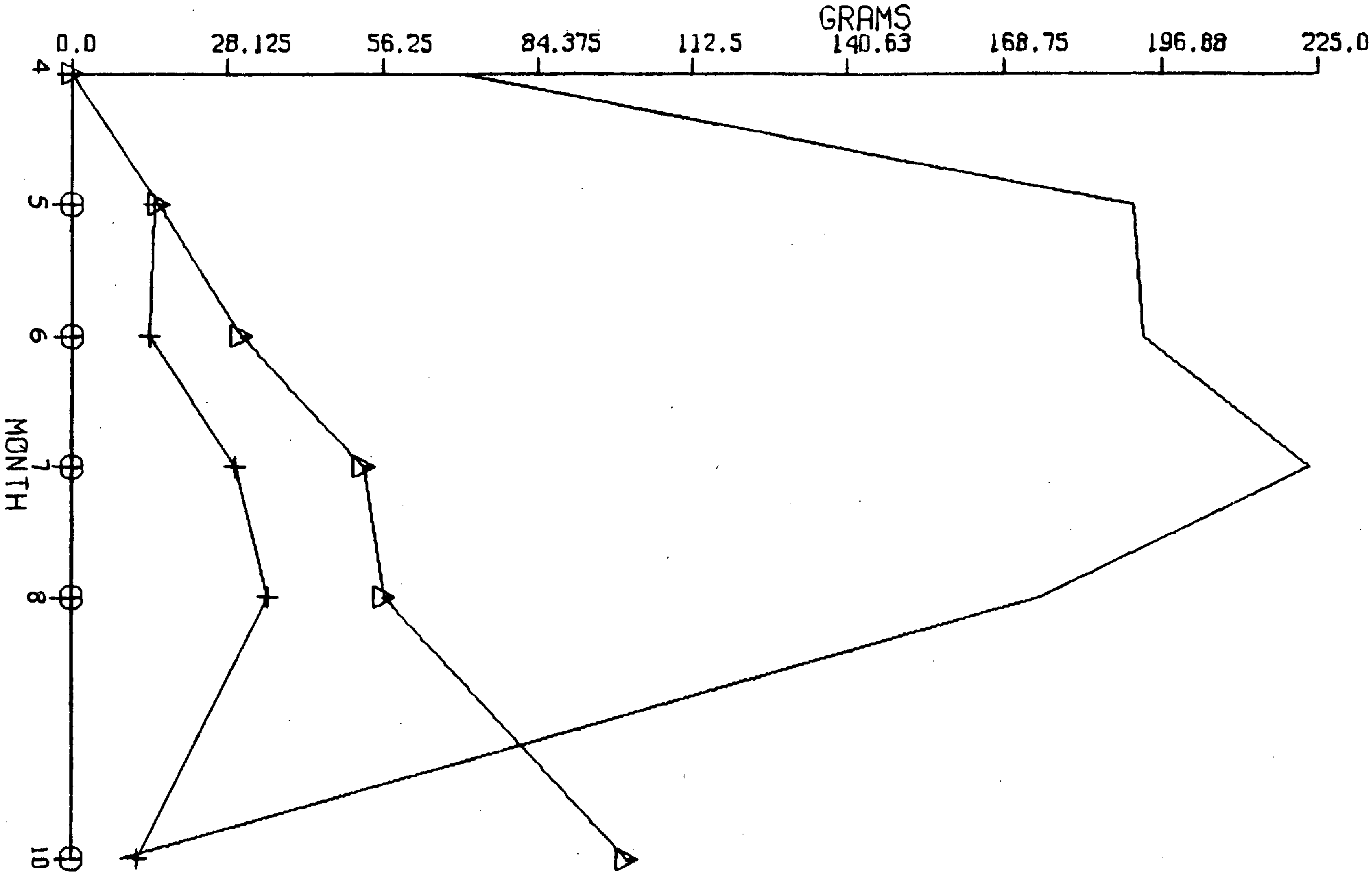

GRAMS
0.0
28.125
56.25
84.375
112.5
140.63
168.75
196.88
225.0
MONTH
4
5
6
7
8
10

Figure 32. Mean monthly dry weights (gm .5m^2) of living (.), dead (O), senescent (△) and duff (+) plant fractions from the Salmon _Deschampsia cespitosa_ - _Carex lyngbyei_ community.

Statistics for graph

Portion	Month	Range	Observations	Minimum	Maximum	Std. Dev.
	4	6.9	5	16.4	23.3	2.9
	5	36.1	5	29.5	65.6	14.0
Living	6	24.9	5	87.1	112.0	10.2
	7	131.1	5	85.4	216.5	50.7
	8	70.7	5	80.1	150.8	28.8
	10	14.1	5	60.6	74.7	5.5
	4	148.8	5	115.9	264.7	59.2
	5	70.6	5	86.0	156.6	28.9
Dead	6	49.6	5	86.8	136.4	20.9
	7	99.8	5	63.3	163.1	43.8
	8	88.5	5	36.8	125.3	37.3
	10	45.5	5	18.3	63.8	16.8
	4	0.0	5	0.0	0.0	0.0
	5	0.0	5	0.0	0.0	0.0
Senescent	6	0.0	5	0.0	0.0	0.0
	7	36.7	5	17.1	53.8	13.4
	8	54.7	5	42.3	97.0	23.8
	10	54.1	5	124.1	178.2	24.5
	5	17.5	5	4.3	21.8	7.9
	6	41.6	5	19.7	61.3	15.8
Duff	7	11.0	5	13.5	24.5	4.8
	8	45.8	5	20.1	65.9	18.4
	10	36.6	5	6.6	43.2	13.0

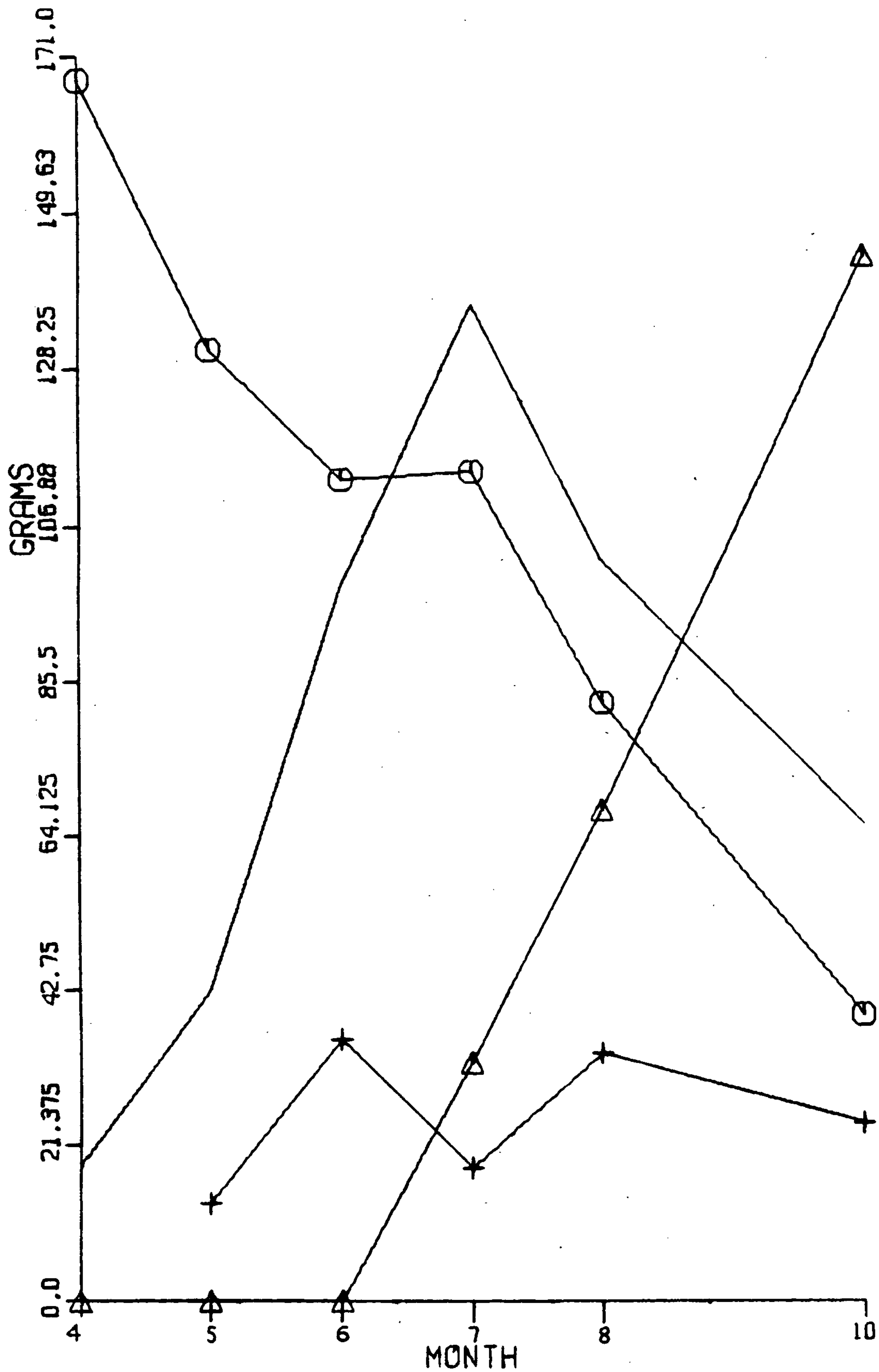

GRAMS
171.0
149.63
128.25
106.88
85.5
64.125
42.75
21.375
0.0
4
5
6
7
8
10
MONTH

Figure 33. Mean monthly dry weights (gm .5m^2) of living (.), dead (O), senescent (△) and duff (+) plant fractions from the Salmon <u>Poa</u> <u>pratensis</u> - <u>Agrostis</u> <u>alba</u> var. <u>stolonifera</u> - <u>Potentilla</u> <u>pacifica</u> community.

Statistics for graph

Portion	Month	Range	Observations	Minimum	Maximum	Std. Dev.
	4	10.7	5	12.9	23.6	4.5
	5	45.6	5	47.9	93.5	17.6
Living	6	44.1	5	63.7	107.8	17.4
	7	23.6	5	63.2	86.8	9.6
	8	18.1	5	51.2	69.3	7.4
	10	20.0	5	11.1	31.1	7.2
	4	129.9	5	66.9	196.8	49.5
	5	74.5	5	104.2	178.7	29.5
Dead	6	83.9	5	62.3	146.2	33.2
	7	58.2	5	41.0	99.2	22.1
	8	23.8	5	1.0	24.8	10.1
	10	4.3	5	0.0	4.3	1.9
	4	0.0	5	0.0	0.0	0.0
	5	0.0	5	0.0	0.0	0.0
Senescent	6	0.0	5	0.0	0.0	0.0
	7	16.0	5	13.2	29.2	6.3
	8	20.0	5	44.1	64.1	8.8
	10	44.2	5	81.3	125.5	17.7
	5	30.4	5	32.2	62.8	11.9
	6	35.1	5	42.7	77.8	16.8
Duff	7	18.6	5	32.4	51.0	8.1
	8	100.2	5	26.6	126.8	37.6
	10	53.5	5	42.2	95.7	22.3

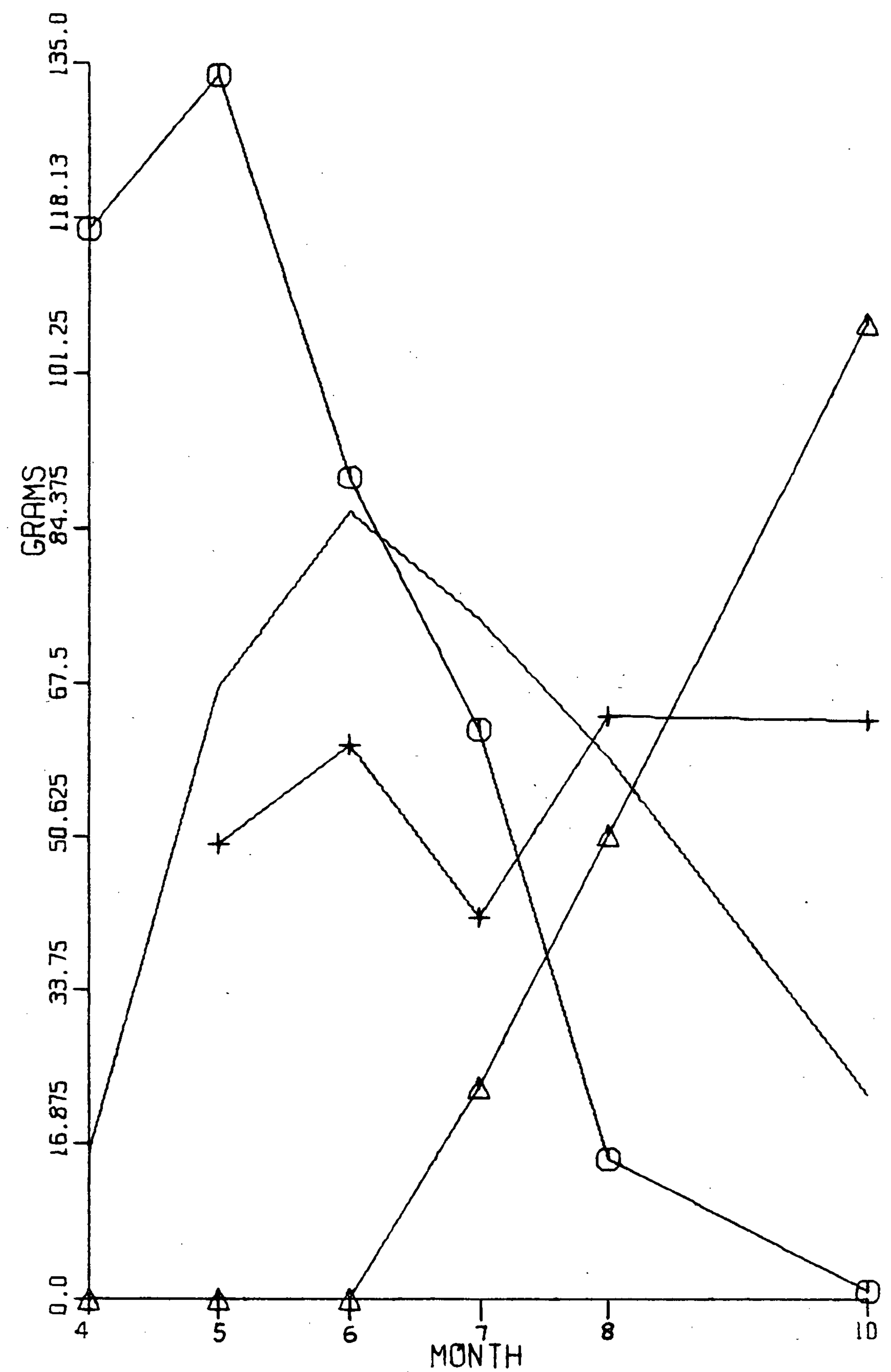

GRAMS
135.0
118.13
101.25
84.375
67.5
50.625
33.75
16.875
0.0
4
5
6
7
8
10
MONTH

Figure 34. Mean monthly nitrogen (B) and ash free dry (8) weights ($gm\ .5m^{-2}$) of combined living and senescent fractions in the Cowichan Carex lyngbyei community.

Statistics for the graph

	Month	Range	Observations	Minimum	Maximum	Std. Dev.
	4	0.6	5	1.7	2.3	0.3
	5	4.3	5	2.4	6.7	1.9
Nitrogen	6	1.2	5	5.0	6.2	0.5
	7	2.7	5	3.7	6.4	1.1
	8	0.6	5	2.2	2.8	0.2
	10	3.1	5	2.4	5.5	1.2
	4	11.1	5	29.7	40.8	4.6
	5	144.6	5	77.8	222.4	64.0
AFDW	6	57.2	5	229.8	287.0	24.6
	7	140.5	5	189.9	330.4	55.3
	8	31.7	5	117.0	148.7	12.6
	10	100.0	5	76.0	175.9	39.1

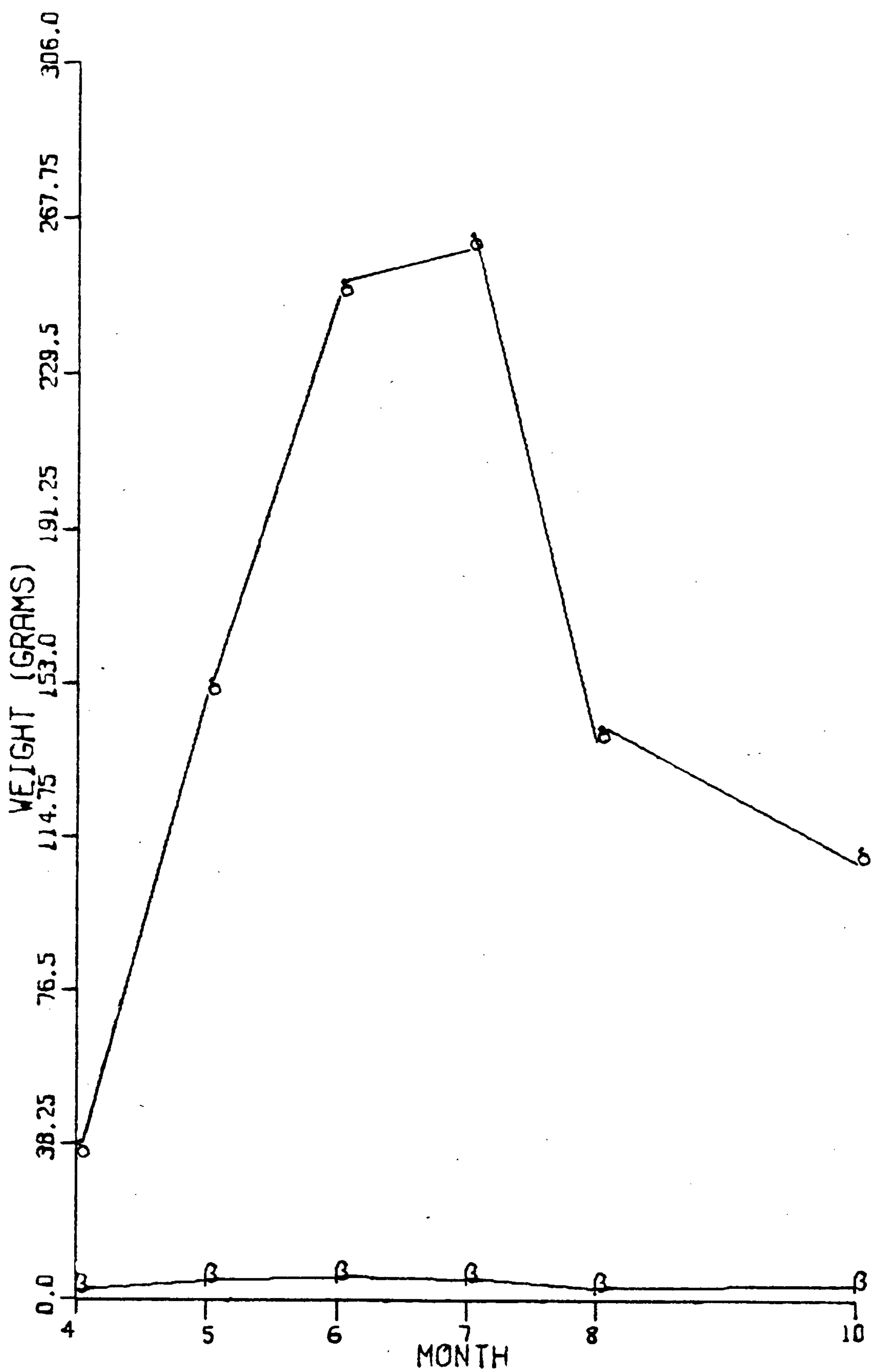

WEIGHT (GRAMS)
306.0
267.75
229.5
191.25
153.0
114.75
76.5
38.25
0.0
MONTH
4
5
6
7
8
10

Figure 35. Mean monthly nitrogen (B) and ash free dry (8) weights (gm .5m^{-2}) of the living fraction in the Chemainus <u>Salicornia virginica</u> community.

Statistics for the graph

	Month	Range	Observations	Minimum	Maximum	Std. Dev.
	4	0.3	5	0.2	0.5	0.1
	5	1.1	5	1.8	2.8	0.4
Nitrogen	6	2.3	5	1.7	4.0	0.9
	7	1.3	5	3.8	5.1	0.5
	8	5.9	5	2.0	7.9	2.2
	10	2.5	5	1.2	3.6	1.0
	4	4.7	5	2.6	7.2	1.9
	5	23.0	5	38.6	61.6	9.1
AFDW	6	47.2	5	34.3	81.5	17.3
	7	32.5	5	98.5	131.0	13.0
	8	137.1	5	45.6	182.7	51.9
	10	61.8	5	29.3	91.1	24.4

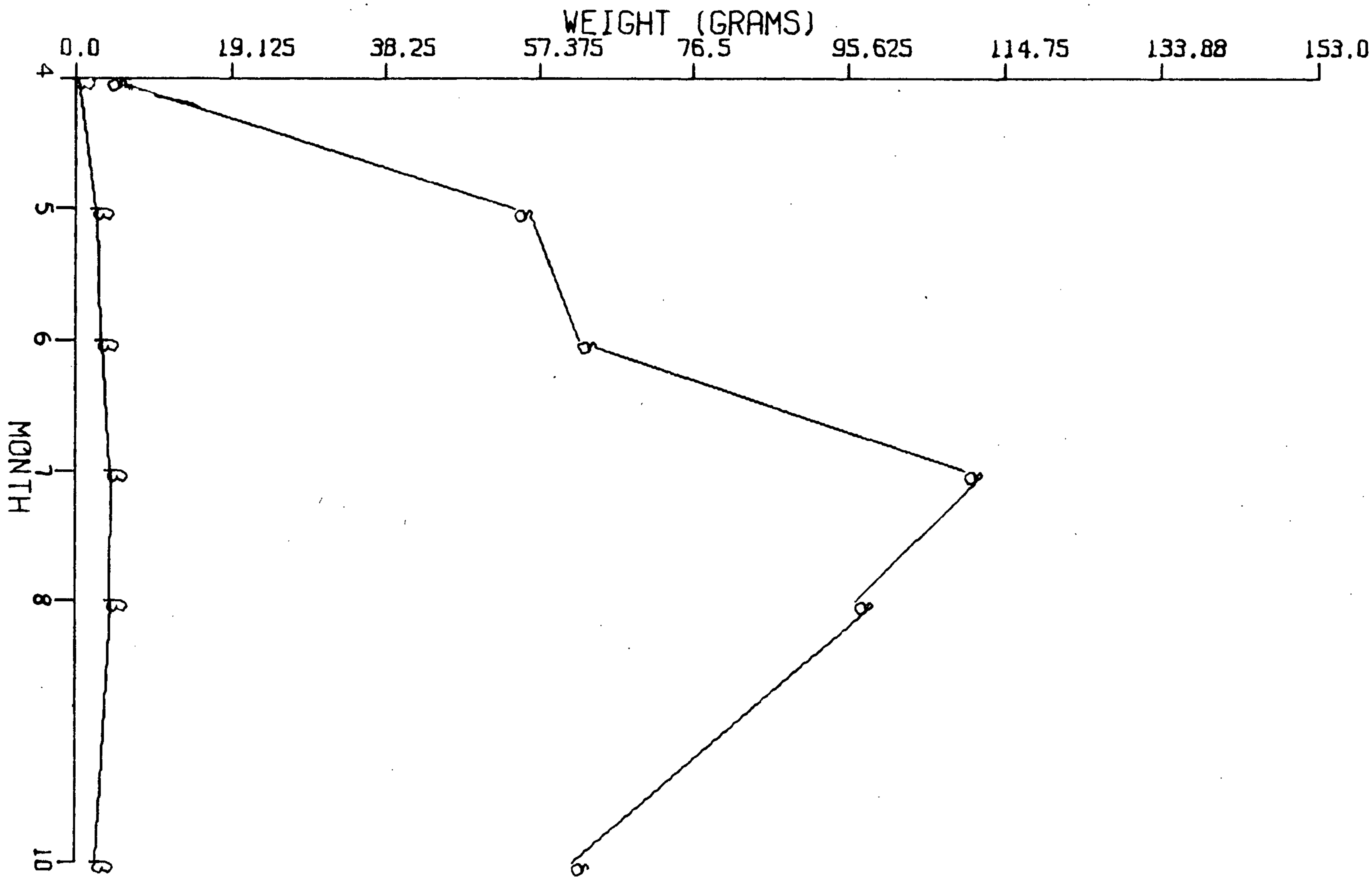

WEIGHT (GRAMS)
0.0
19.125
38.25
57.375
76.5
95.625
114.75
133.88
153.0
MONTH
4
5
6
7
8
10

Figure 36. Mean monthly nitrogen (B) and ash free dry (8) weights ($gm\ .5m^{-2}$) of the living fraction in the Chemainus <u>Distichlis spicata</u> - <u>Grindelia integrifolia</u> community.

Statistics for the graph

	Month	Range	Observations	Minimum	Maximum	Std. Dev.
	4	1.6	5	0.0	1.6	0.6
	5	1.8	5	0.7	2.5	0.8
Nitrogen	6	2.4	5	1.9	4.3	1.0
	7	0.9	5	3.0	3.9	0.4
	8	2.9	5	1.9	4.8	1.0
	10	1.0	5	3.2	4.2	0.4
	4	30.8	5	0.9	31.7	11.9
	5	49.6	5	19.3	68.9	21.2
AFDW	6	60.8	5	49.8	110.6	25.0
	7	30.9	5	106.6	137.5	13.2
	8	119.6	5	80.4	199.9	43.5
	10	42.4	5	134.5	176.9	16.2

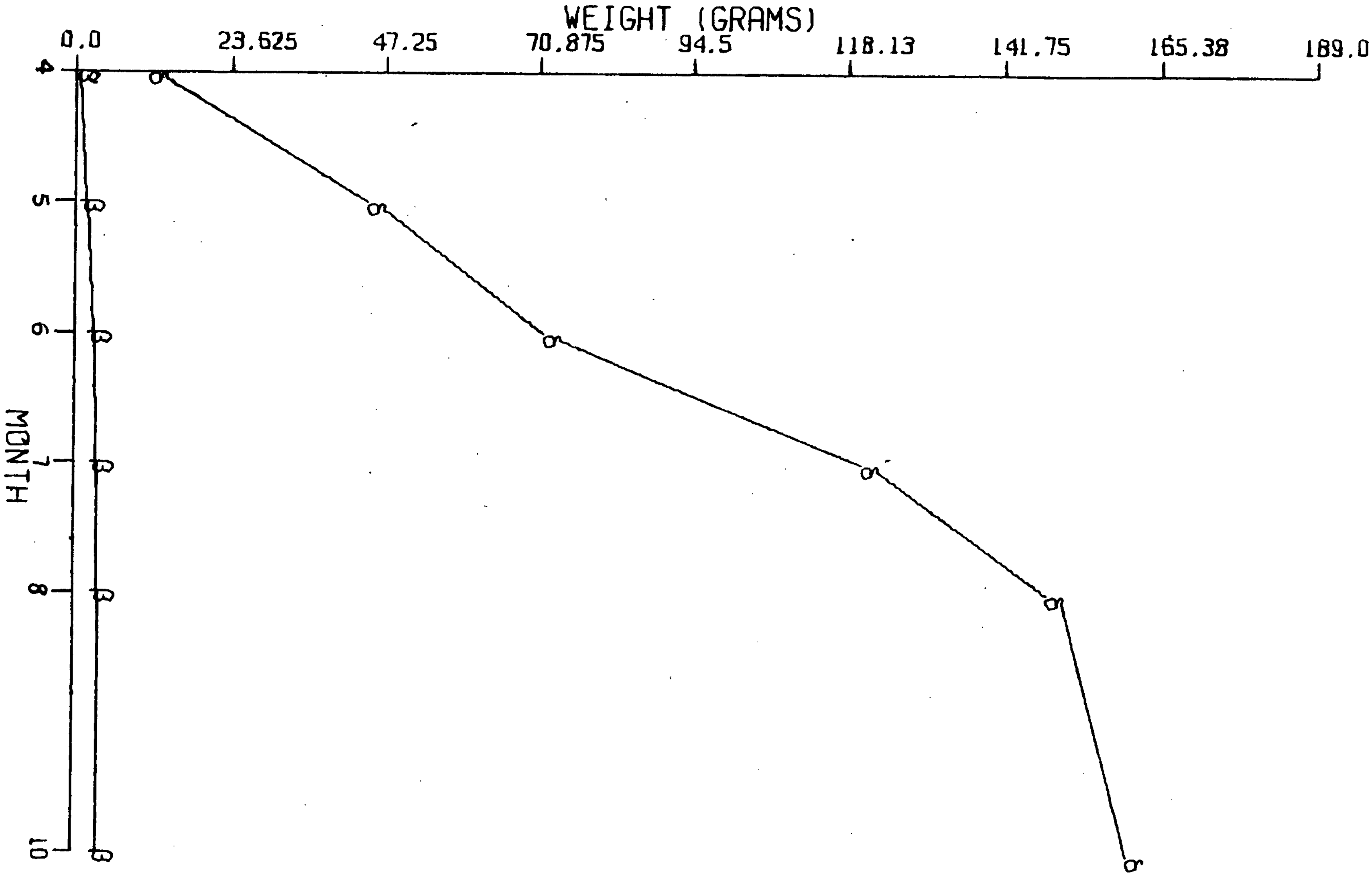

WEIGHT (GRAMS)
0.0
23.625
47.25
70.875
94.5
118.13
141.75
165.38
189.0
MONTH
4
5
6
7
8
10

Figure 37. Mean monthly nitrogen (B) and ash free dry (8) weights (gm $.5m^{-2}$) of combined living and senescent fractions in the Little Qualicum Potentilla pacifica - Carex lyngbyei community.

Statistics for the graph

	Month	Range	Observations	Minimum	Maximum	Std. Dev.
	4	0.5	5	0.4	0.9	0.2
	5	1.7	5	1.2	2.9	0.7
Nitrogen	6	1.1	5	2.2	3.3	0.4
	7	1.5	5	1.5	2.9	0.6
	8	1.2	5	1.4	2.7	0.5
	10	2.6	5	2.3	4.9	1.0
	4	14.8	5	10.0	24.7	5.4
	5	56.7	5	39.7	96.4	21.6
AFDW	6	44.8	5	94.3	139.1	18.0
	7	78.6	5	77.7	156.3	32.6
	8	75.5	5	86.6	162.1	27.6
	10	117.2	5	105.6	222.8	46.5

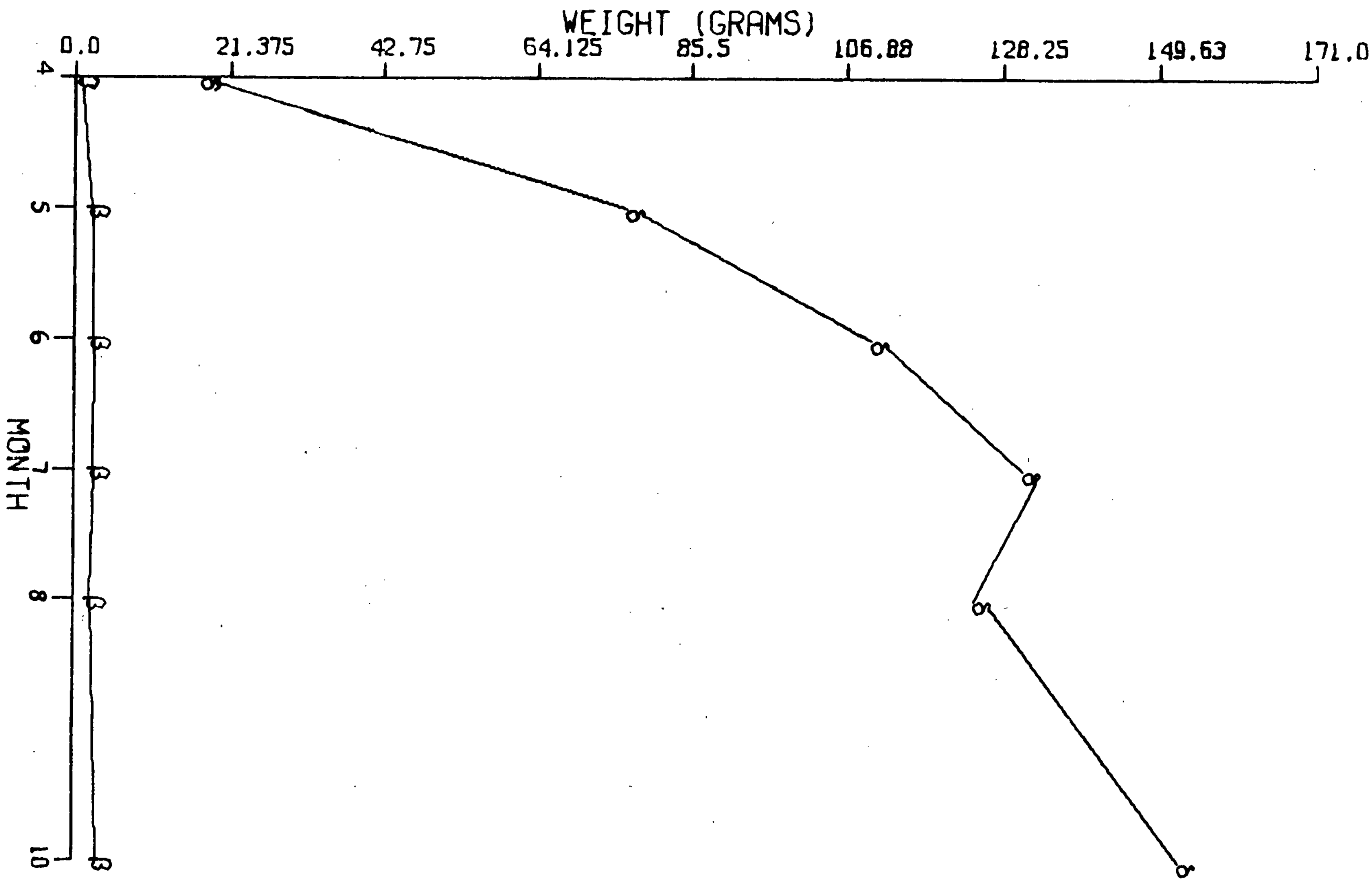

WEIGHT (GRAMS)
0.0
21.375
42.75
64.125
85.5
106.88
128.25
149.63
171.0
MONTH
4
5
6
7
8
10

Figure 38. Mean monthly nitrogen (O) and ash free dry (Ø) weights (gm .5m^{-2}) of combined dead and duff fractions in the Cowichan *Carex lyngbyei* community.

Statistics for the graph

	Month	Range	Observations	Minimum	Maximum	Std. Dev.
	5	2.1	5	0.0	2.1	1.1
	6	0.4	5	0.0	0.4	0.2
Nitrogen	7	0.2	5	0.0	0.2	0.1
	8	0.3	5	0.0	0.3	0.1
	5	66.5	5	0.0	66.5	30.9
AFDW	6	7.2	5	0.0	7.2	3.8
	7	4.9	5	0.0	4.9	2.3
	8	5.3	5	0.0	5.3	2.5

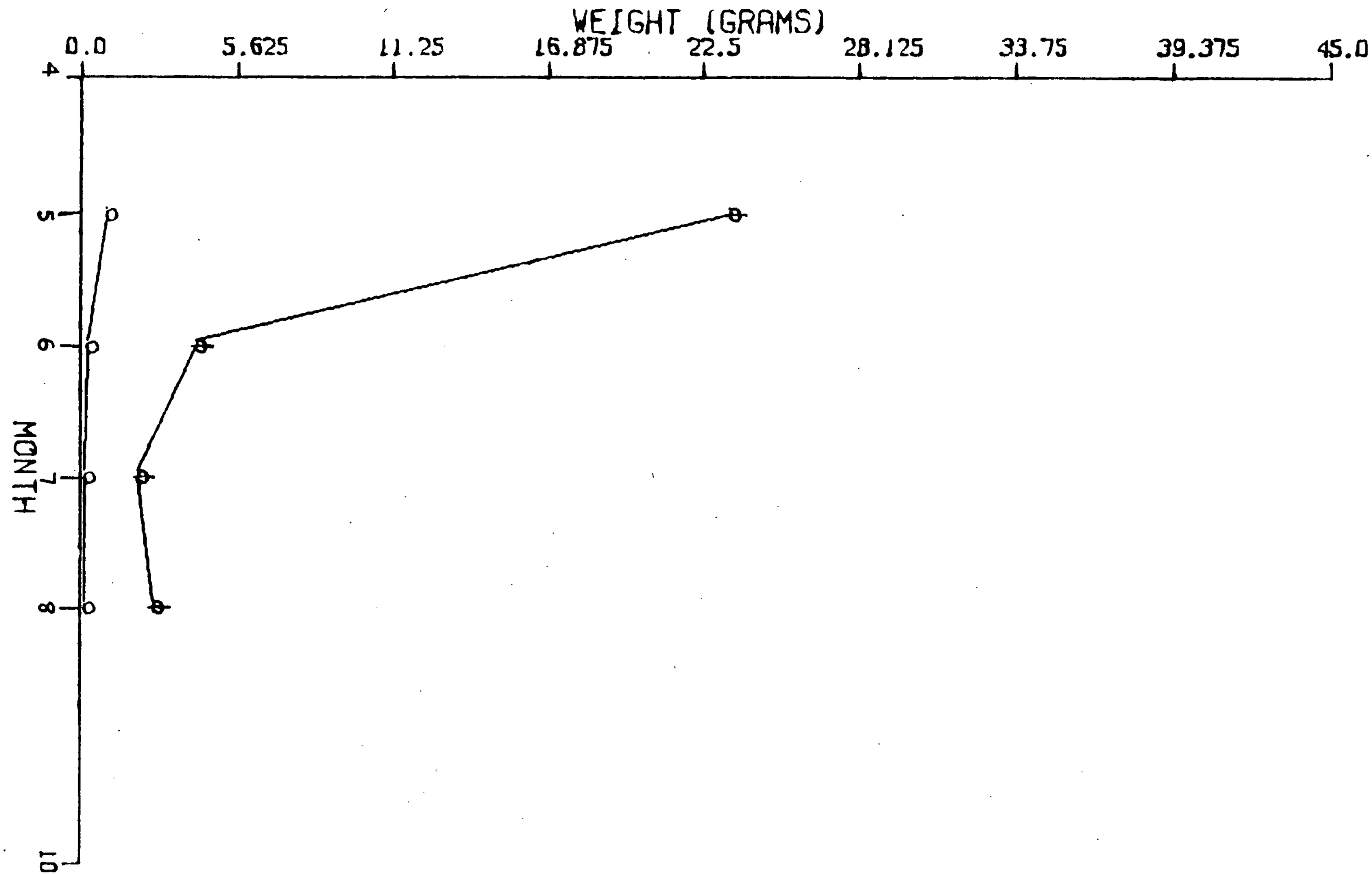

WEIGHT (GRAMS)
0.0
5.625
11.25
16.875
22.5
28.125
33.75
39.375
45.0
MONTH
4
5
6
7
8
10

Figure 39. Mean monthly nitrogen (O) and ash free dry (Ø) weights (gm $.5m^{-2}$) of combined dead and duff fractions in the Chemainus <u>Salicornia virginica</u> community.

Statistics for the graph

	Month	Range	Observations	Minimum	Maximum	Std. Dev.
	4	2.7	5	6.2	8.8	1.1
	5	4.1	5	5.4	9.5	1.7
Nitrogen	6	3.6	5	7.5	11.1	1.5
	7	3.5	5	5.8	9.3	1.3
	8	4.3	5	6.7	11.0	2.0
	10	4.2	5	3.4	7.6	1.8
	4	69.8	5	162.0	231.9	29.4
	5	102.3	5	127.9	230.2	41.5
AFDW	6	73.3	5	150.9	224.3	31.4
	7	81.8	5	135.4	217.2	30.5
	8	109.8	5	172.7	282.5	52.3
	10	98.1	5	78.4	176.5	42.0

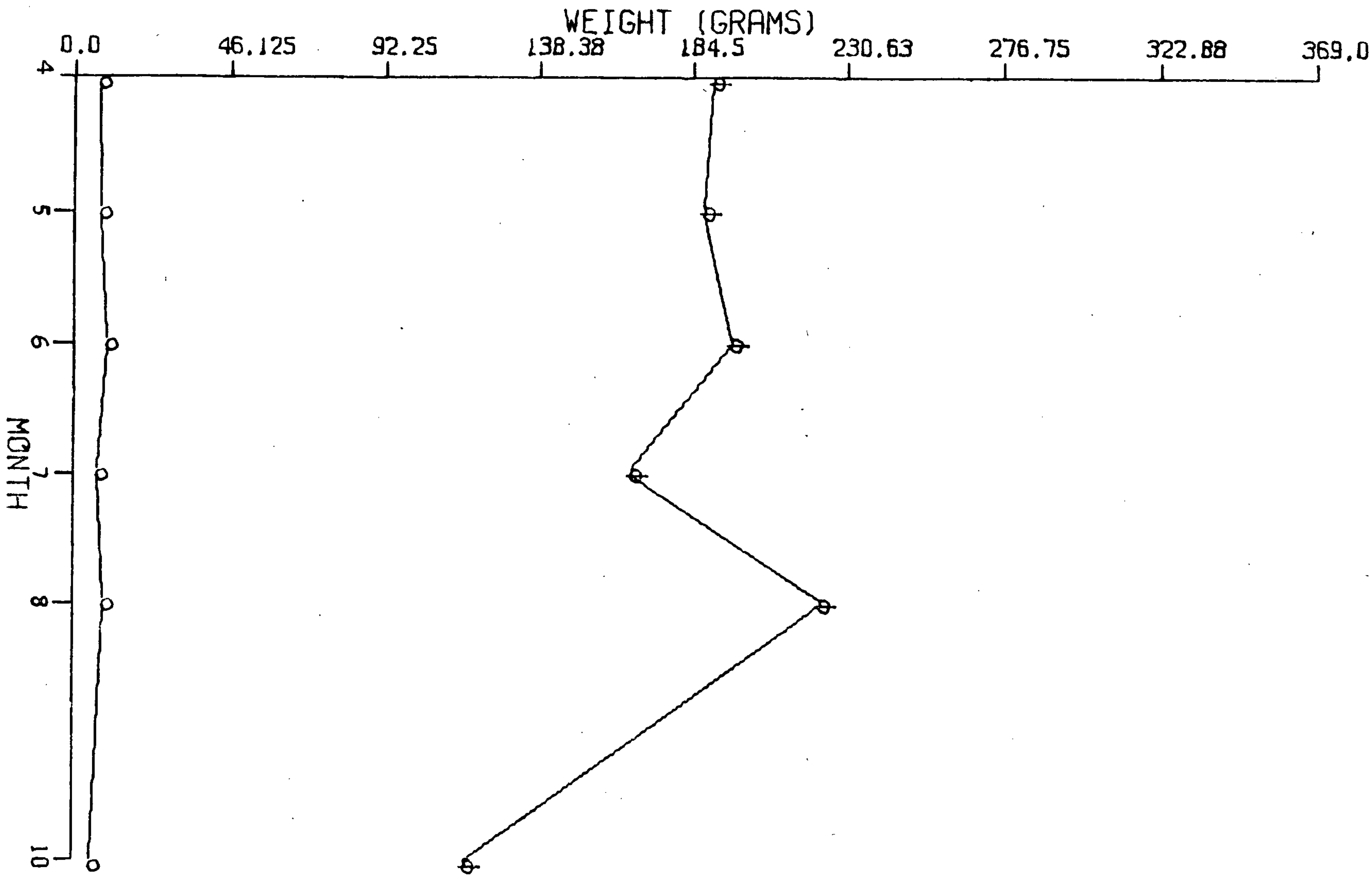

WEIGHT (GRAMS)
0.0
46.125
92.25
138.38
184.5
230.63
276.75
322.88
369.0
MONTH
4
5
6
7
8
10

Figure 40. Mean monthly nitrogen (0) and ash free dry (Ø) weights (gm $.5m^{-2}$) of combined dead and duff fractions in the Chemainus *Distichlis spicata* - *Grindelia integrifolia* community.

Statistics for the graph

	Month	Range	Observations	Minimum	Maximum	Std. Dev.
	4	3.5	5	4.9	8.4	1.5
	5	3.3	5	5.6	9.0	1.2
Nitrogen	6	1.7	5	4.8	6.4	0.7
	7	1.5	5	4.3	5.8	0.7
	8	2.7	5	3.8	6.5	1.0
	10	3.3	5	4.5	7.7	1.3
	4	107.2	5	150.2	257.4	47.0
	5	93.4	5	154.1	247.5	35.3
AFDW	6	60.4	5	147.3	207.6	25.2
	7	52.6	5	147.0	199.5	22.9
	8	73.9	5	106.6	180.5	26.8
	10	78.8	5	122.9	201.7	31.9

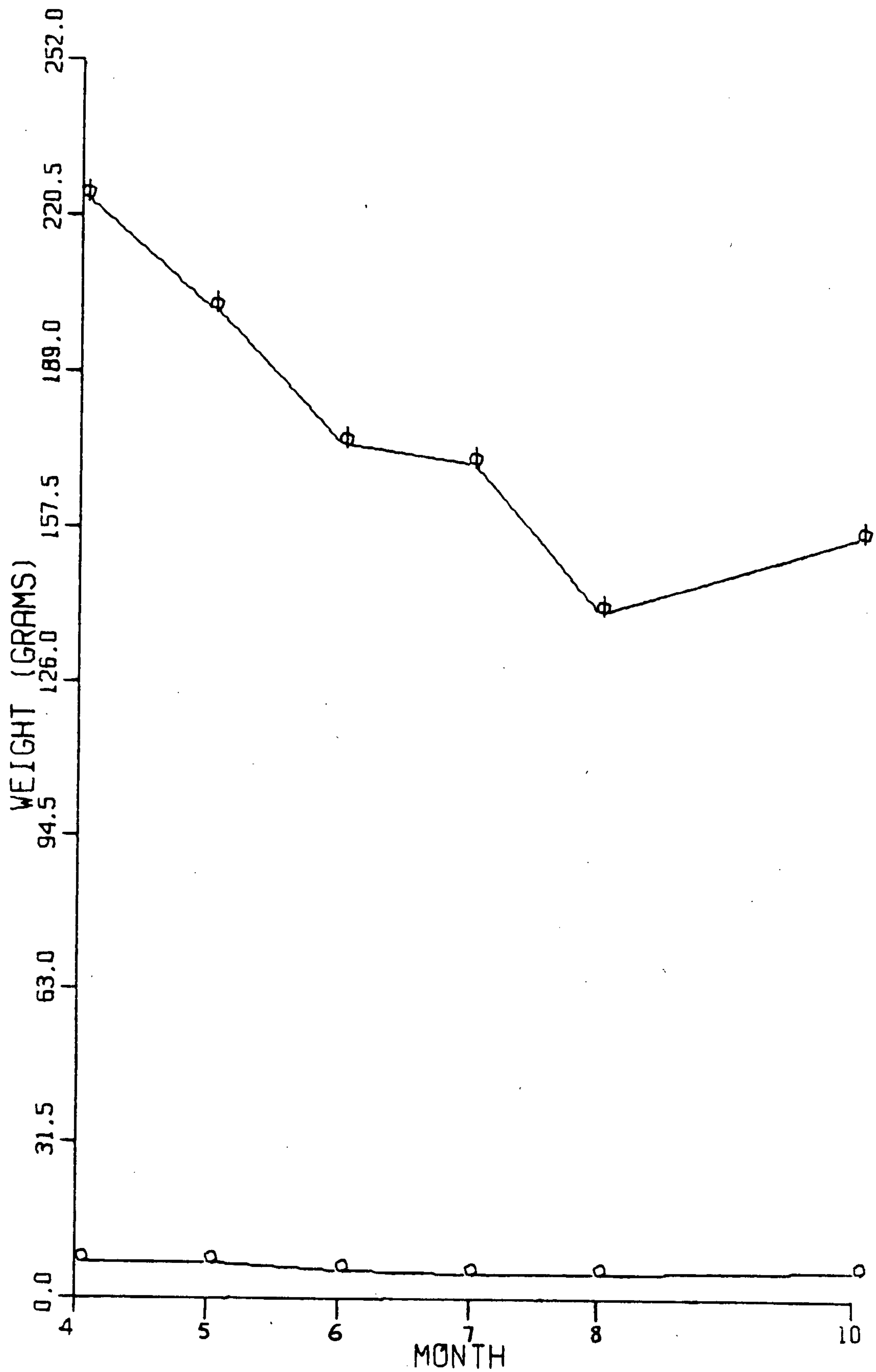
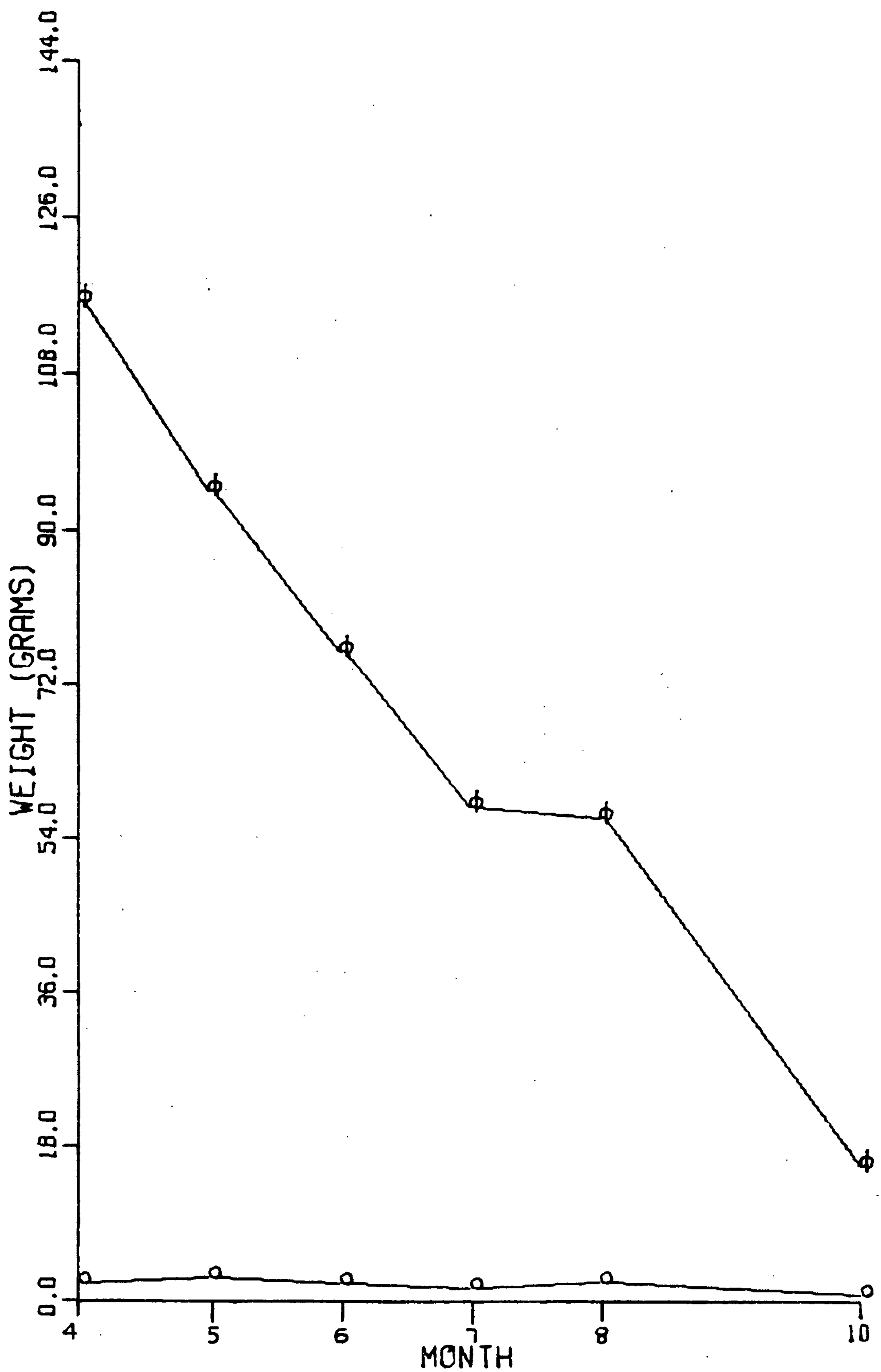

WEIGHT (GRAMS)
0.0
31.5
63.0
94.5
126.0
157.5
189.0
220.5
252.0
4
5
6
7
8
10
MONTH

Figure 41. Mean monthly nitrogen (O) and ash free dry (Ø) weights (gm .5m^{-2}) of combined dead and duff fractions in the Little Qualicum <u>Potentilla pacifica</u> - <u>Carex lyngbyei</u> community.

<u>Statistics for the graph</u>

	Month	Range	Observations	Minimum	Maximum	Std. Dev.
	4	2.3	5	1.0	3.3	1.1
	5	2.8	5	1.4	4.2	1.2
Nitrogen	6	3.4	5	0.7	4.2	1.5
	7	3.9	5	0.0	3.9	1.8
	8	4.6	5	0.9	5.5	1.9
	10	0.6	5	0.3	0.9	0.3
	4	139.2	5	60.2	199.4	67.0
	5	96.5	5	46.2	142.7	40.8
AFDW	6	146.0	5	19.7	165.7	62.6
	7	166.3	5	0.5	166.7	75.7
	8	116.8	5	23.1	139.9	47.6
	10	13.2	5	7.2	20.4	6.0


WEIGHT (GRAMS)
0.0
18.0
36.0
54.0
72.0
90.0
108.0
126.0
144.0
MONTH
4
5
6
7
8
10

Appendix 7. Graphs of the number of days root cores from the plant communities studied grew in darkness. Figures 44-52, the months in the figures are April (4), May (5), June (6), July (7), August (8) and October (10).

Figure 44. Exhaustion of root reserves in darkness for the Cowichan _Carex lyngbyei_ community: average time (.), height (x) of regrown shoots and number of overwintering (▭) and regrown (o) shoots. Note, for overwintering and regrown shoots, plots sampled in October had not been clipped before. Regrown shoots for October are the number of shoots in a previously unclipped .5m^2 plot in the sedge stand.

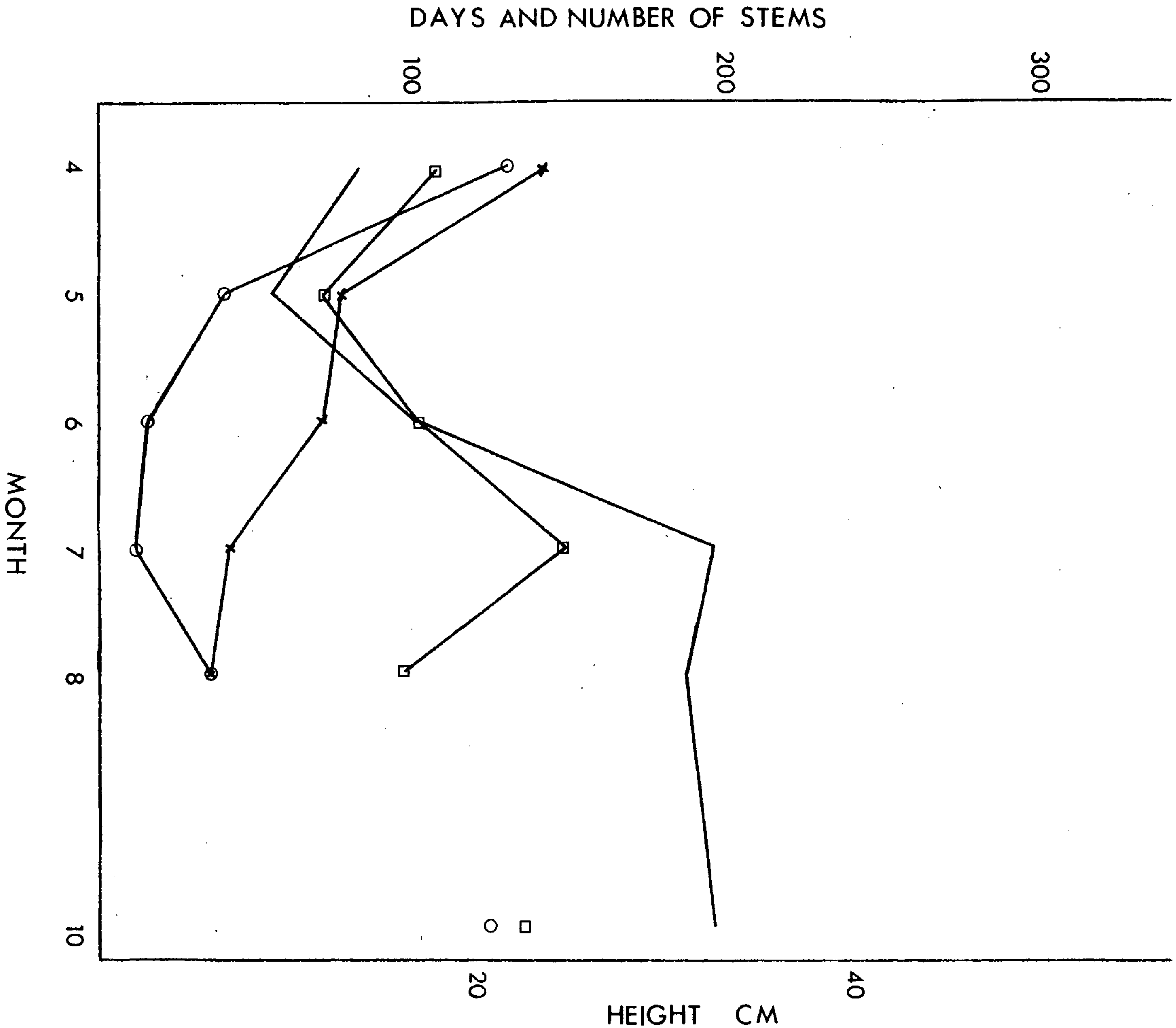

DAYS AND NUMBER OF STEMS
100
200
300
MONTH
4
5
6
7
8
10
20
40
HEIGHT CM

Figure 45. Exhaustion of root reserves in darkness for the Cowichan _Juncus balticus_ community: average time (.) and height (x) of regrown stems.

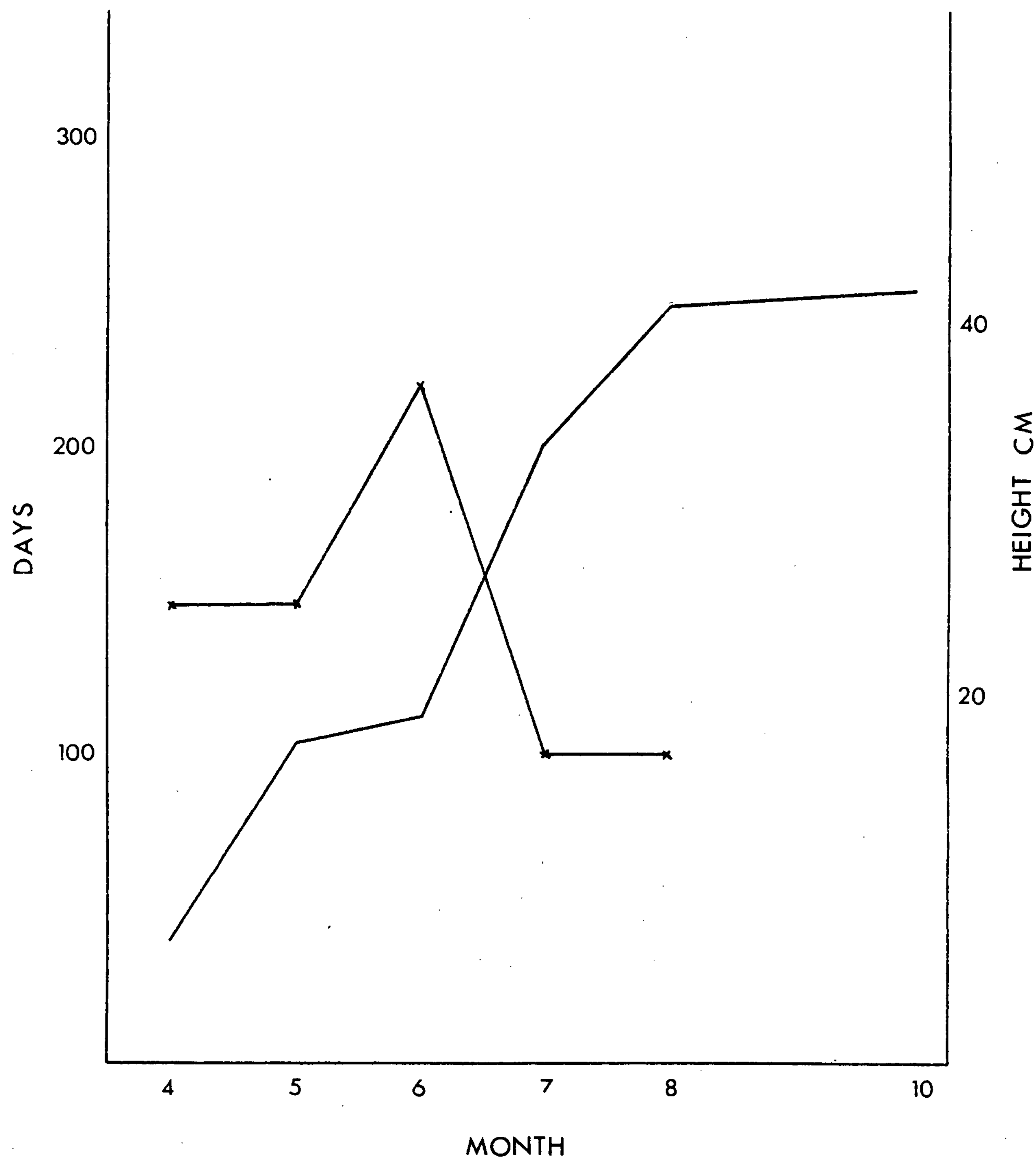
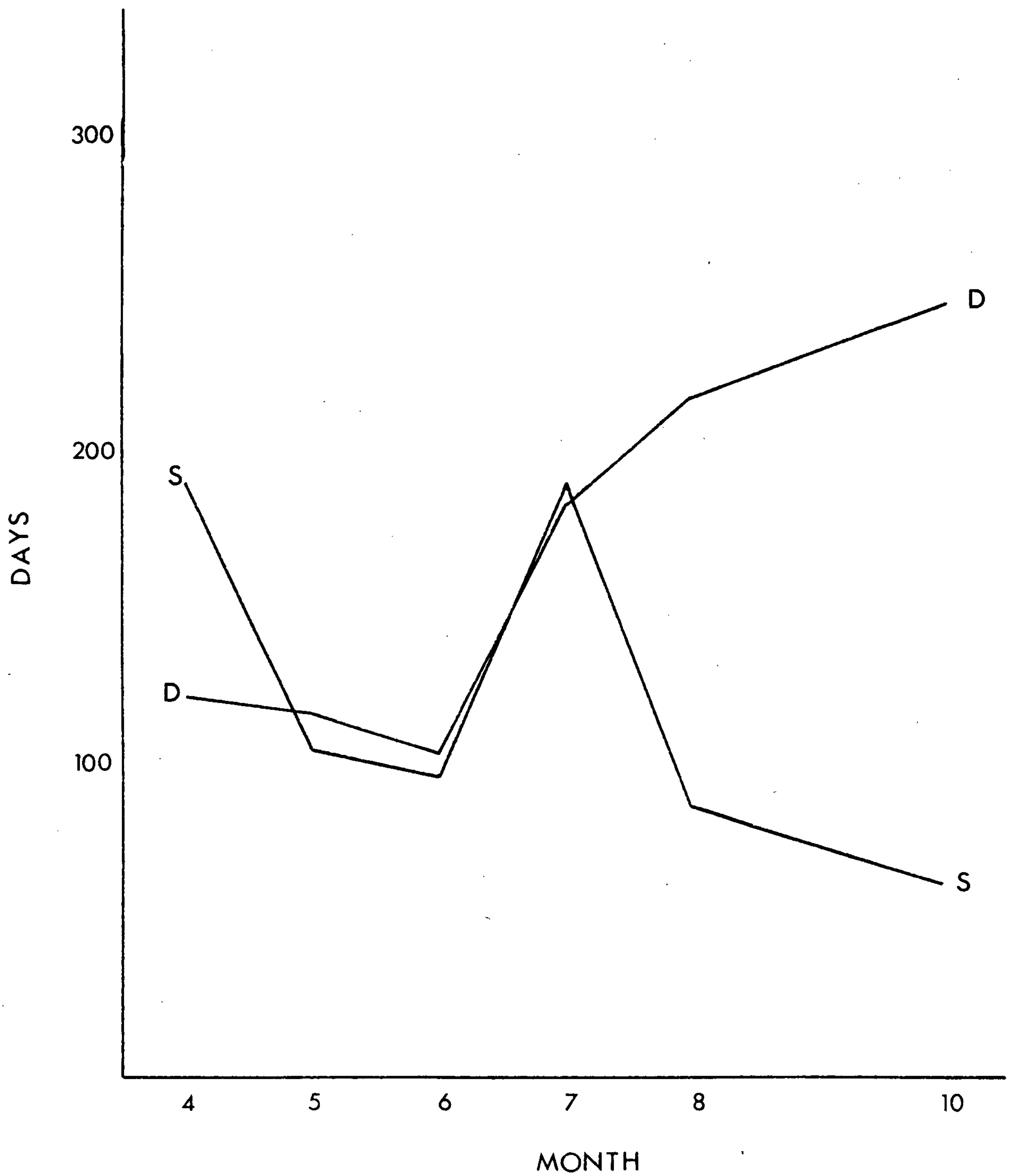

300
200
100
DAYS
40
20
HEIGHT CM
4
5
6
7
8
10
MONTH

Figure 46. Exhaustion of root reserves in darkness for the Chemainus *Salicornia virginica* (S) and *Distichlis spicata* - *Grindelia integrifolia* (D) communities: average time (days).



300
200
100
DAYS
S
D
D
S
4
5
6
7
8
10
MONTH

Figure 47. Exhaustion of root reserves in darkness for the Little Qualicum *Carex lyngbyei* community: average time (.), height of regrown shoots (x), and number of overwintering (□) and regrown (o) shoots. Note, for overwintering and regrown shoots, plots sampled in October had not been clipped before. Regrown shoots for October are the number of shoots in a previously unclipped .5m^2 plot in the sedge stand.

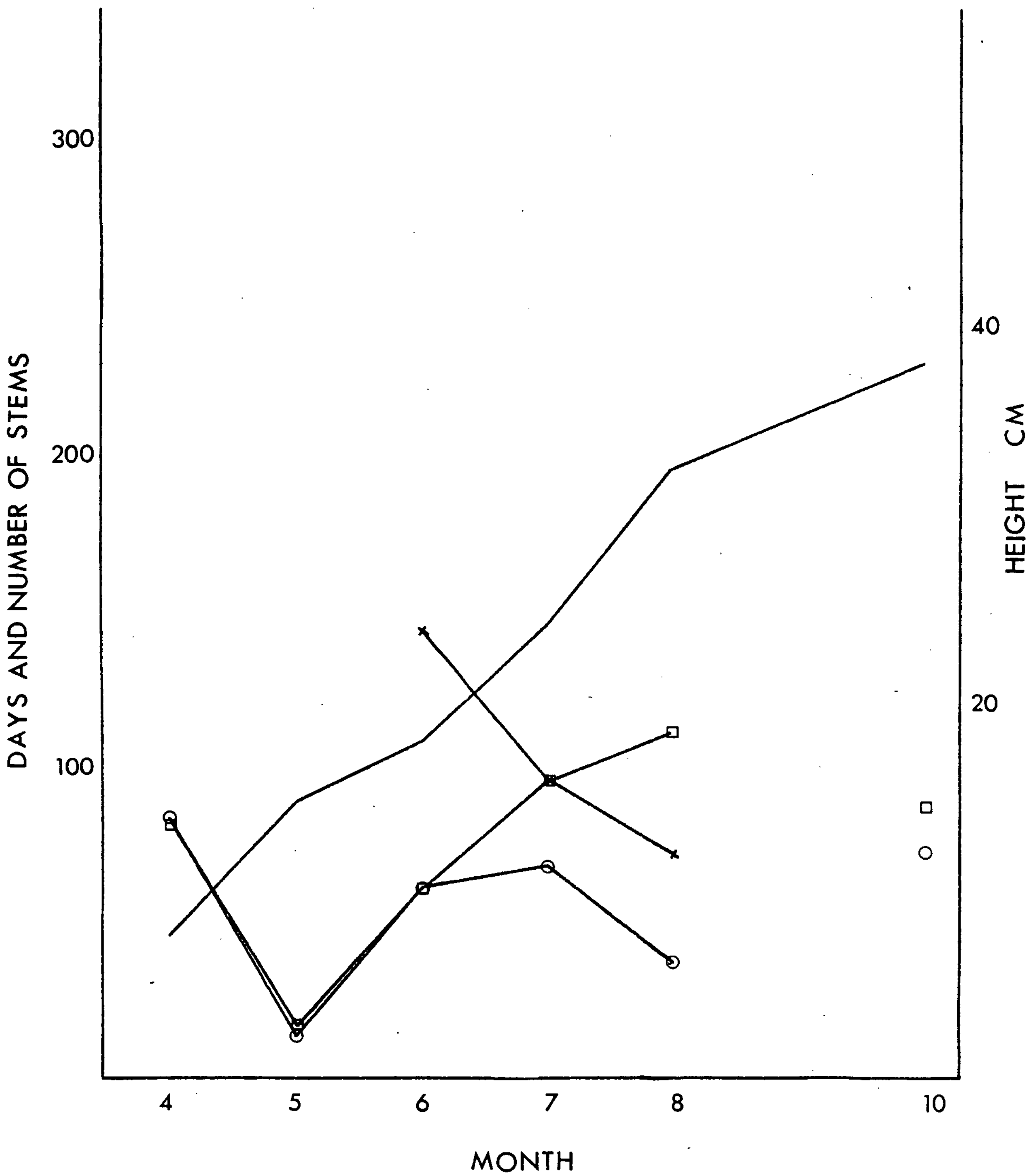

DAYS AND NUMBER OF STEMS
300
200
100
HEIGHT CM
40
20
4
5
6
7
8
10
MONTH

Figure 48. Exhaustion of root reserves in darkness for the Little Qualicum *Potentilla pacifica* - *Carex lyngbyei* community: average time (.), and average height (x) of regrown shoots of Lyngby's sedge (C) and Baltic rush (J).

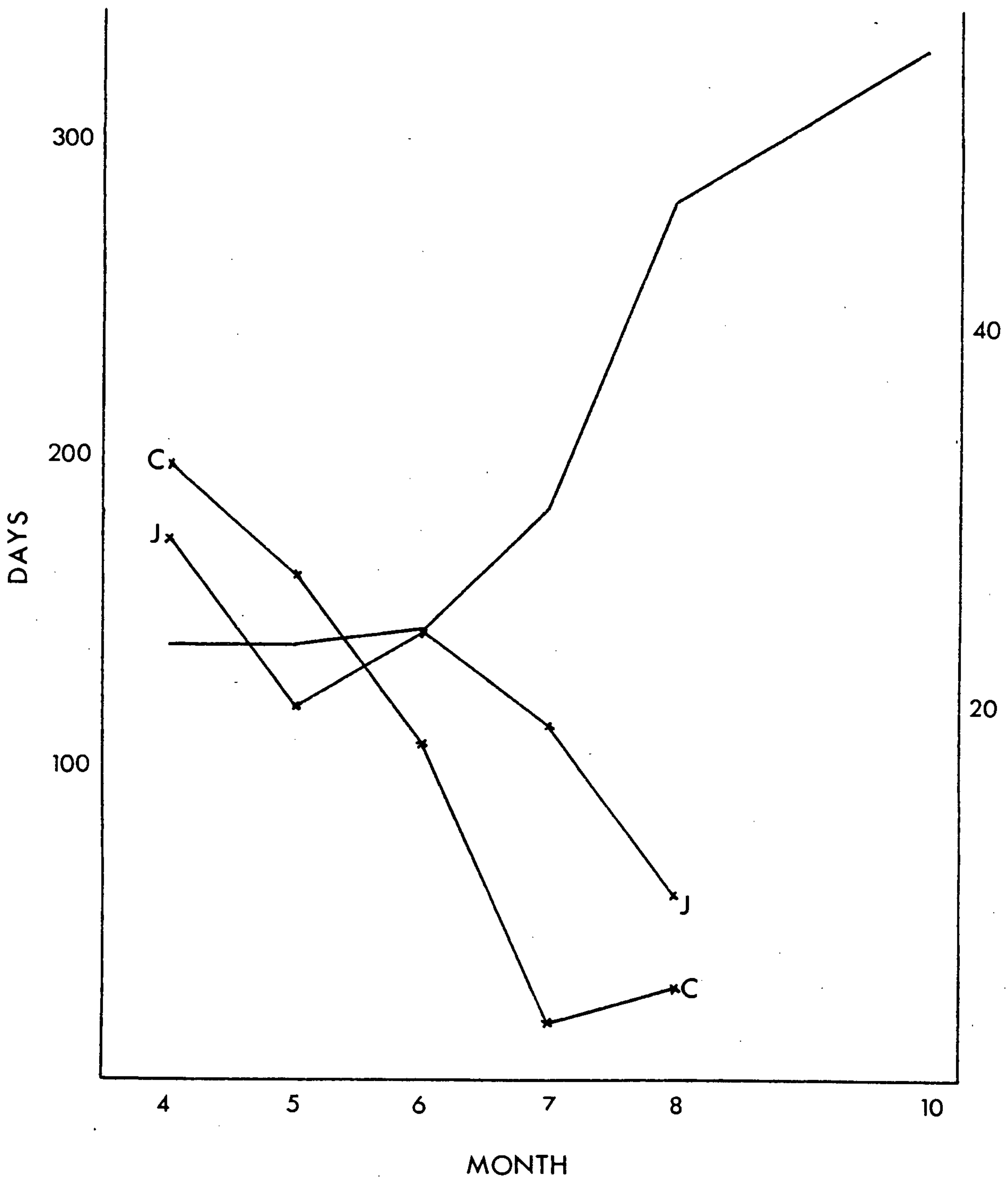

300
200
100
DAYS
40
20
HEIGHT CM
C
J
J
C
4
5
6
7
8
10
MONTH

Figure 49. Exhaustion of root reserves in darkness for the Campbell Carex lyngbyei community: average time (x), height of regrown shoots (x), and number of overwintering (□) and regrown (o) shoots. Note, for overwintering and regrown shoots, plots sampled in October had not been clipped before. Regrown shoots for October are the number of shoots in a previously unclipped .5m^2 plot in the sedge stand.

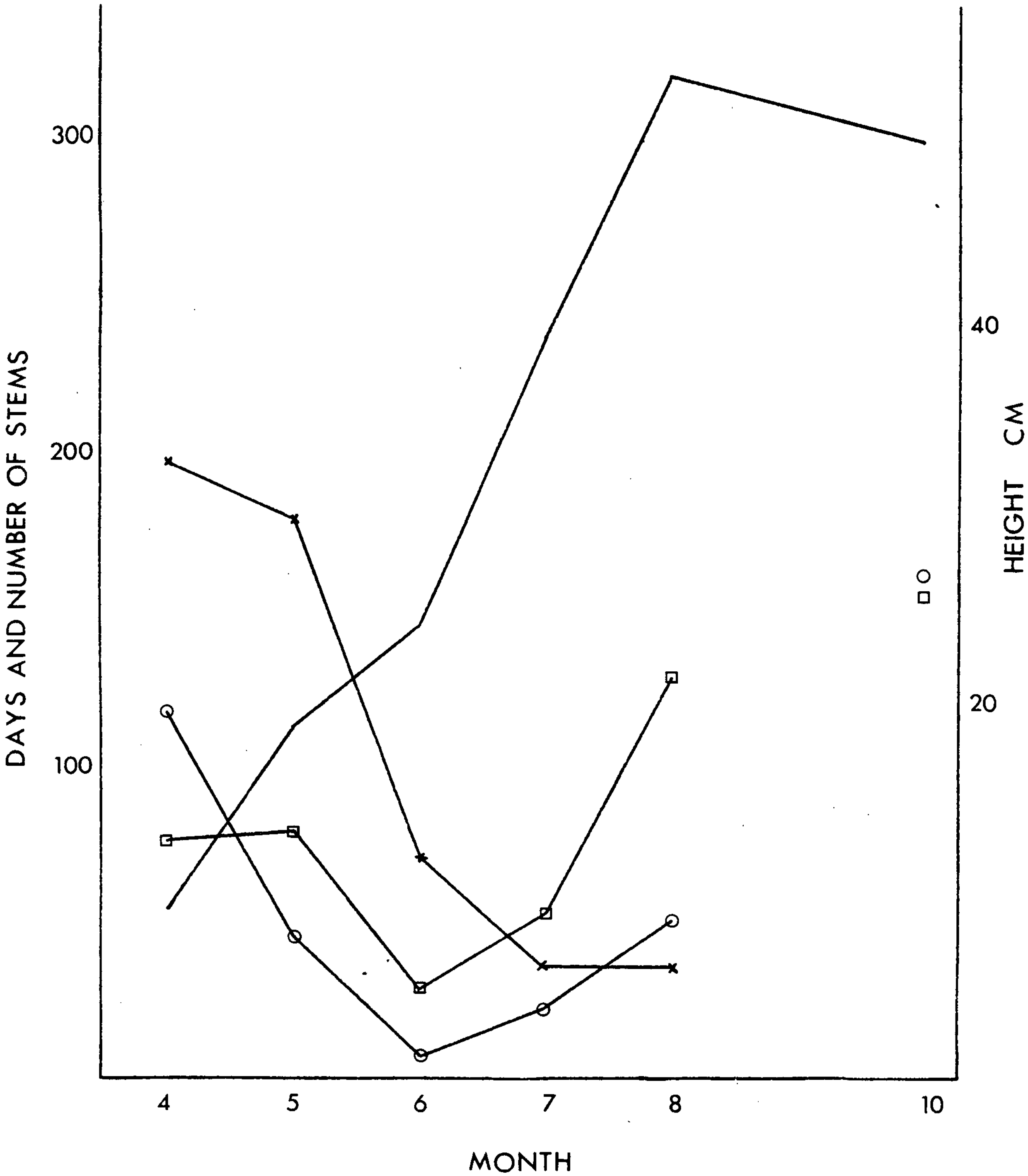

DAYS AND NUMBER OF STEMS
100
200
300
HEIGHT CM
20
40
4
5
6
7
8
10
MONTH

Figure 50. Exhaustion of root reserves in darkness for the Campbell Potentilla pacifica - Eleocharis palustris community: average time (.) and height (x) of regrown stems.

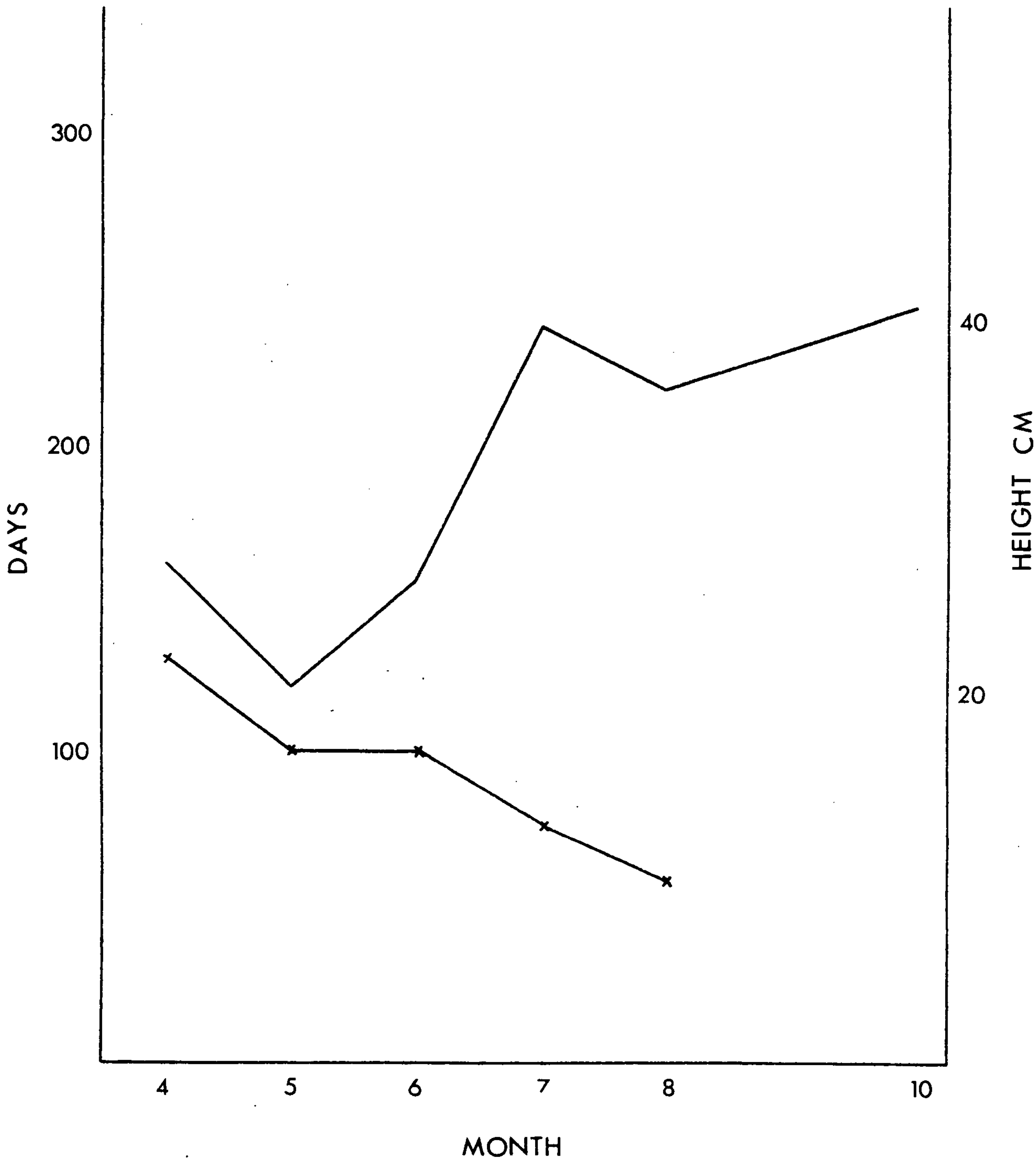

300
200
100
DAYS
40
20
HEIGHT CM
4
5
6
7
8
10
MONTH

Figure 51. Exhaustion of root reserves in darkness for the Salmon *Carex lyngbyei* community: average time (.), height of regrown shoots (x), and number of overwintering (□) and regrown (o) shoots. Note, for overwintering and regrown stems, plots sampled in October had not been clipped before. Regrown stems for October are the number of stems in a previously unclipped .5m^2 plot in the sedge stand.

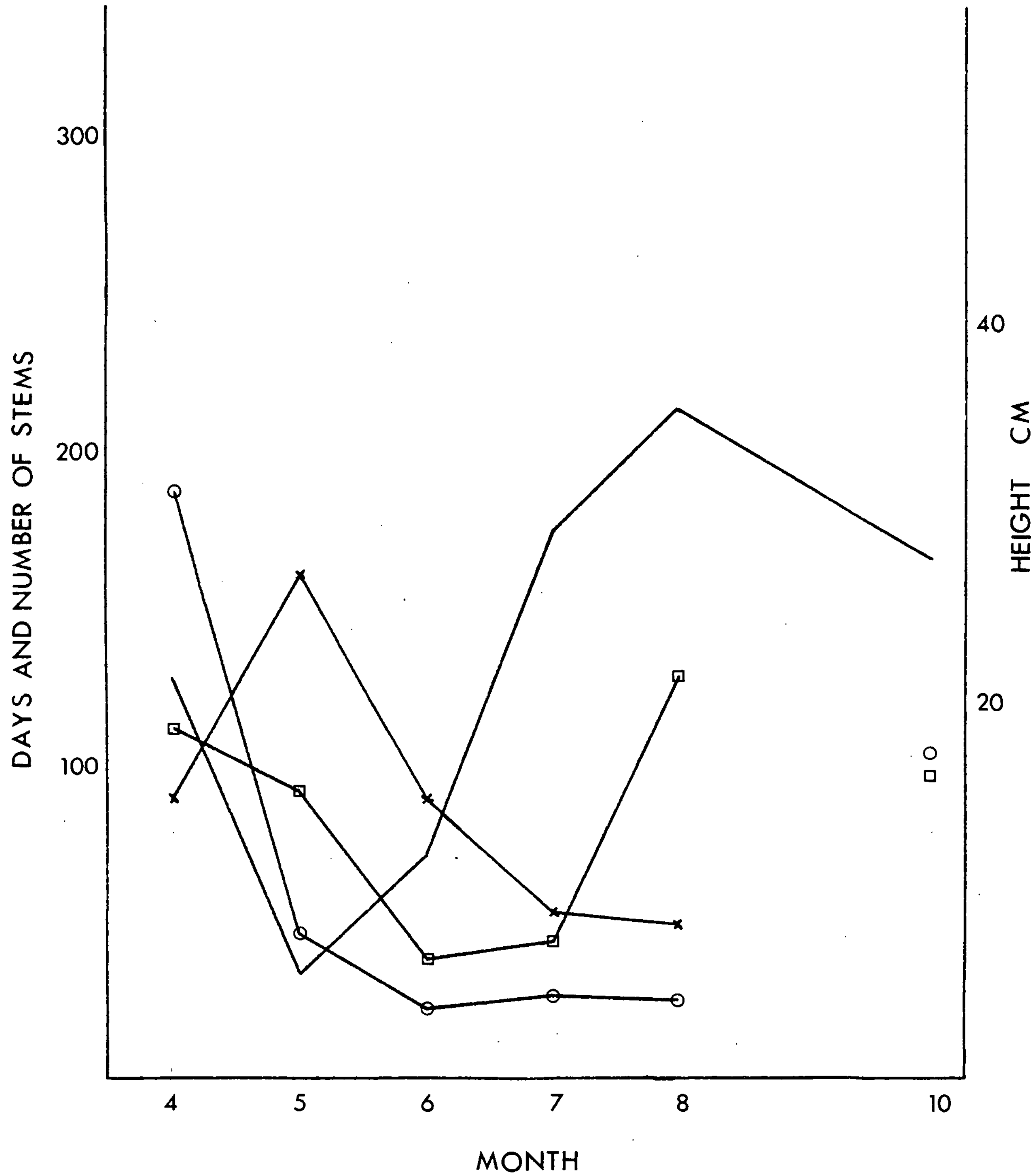
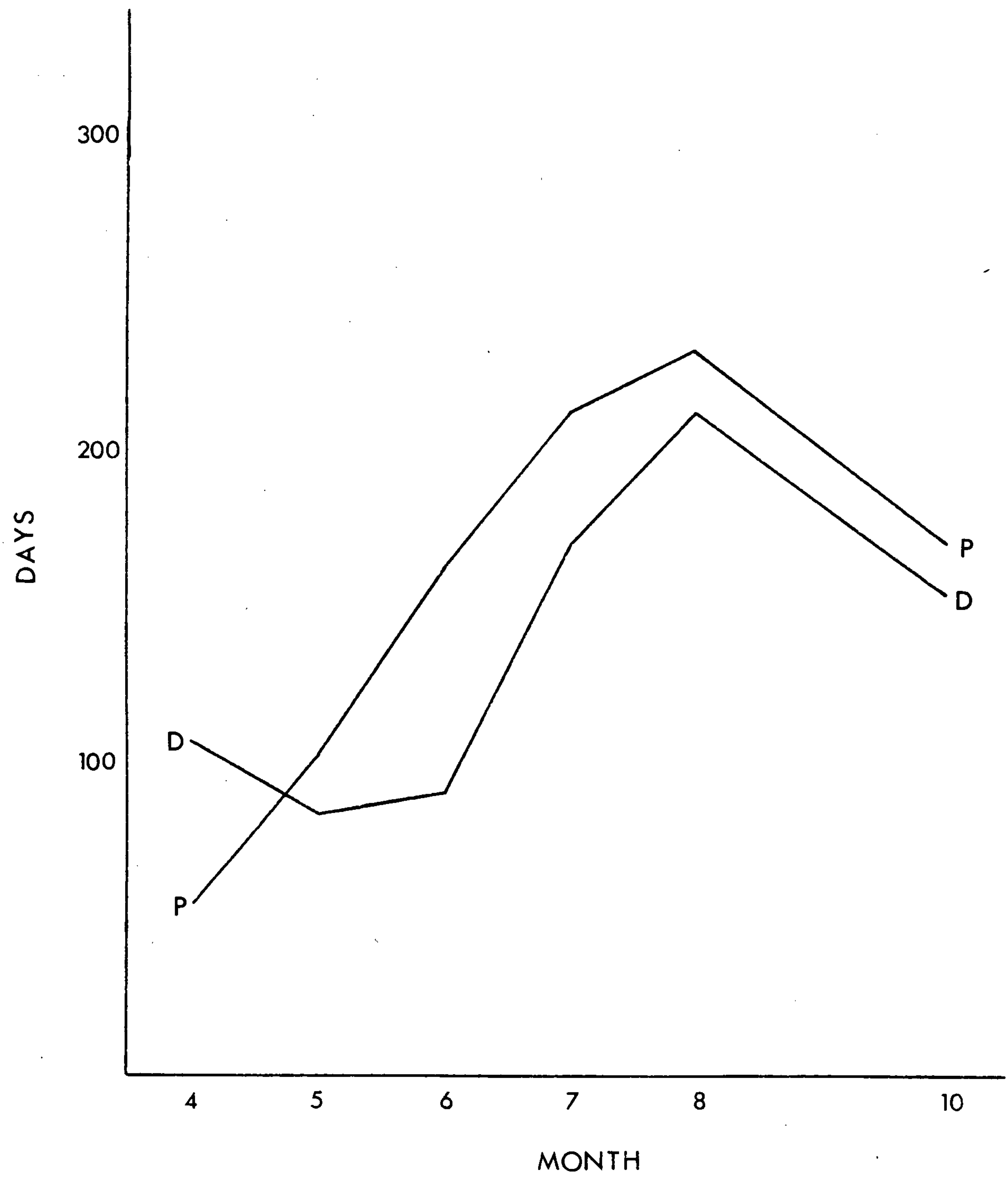

DAYS AND NUMBER OF STEMS
300
200
100
HEIGHT CM
40
20
4
5
6
7
8
10
MONTH

Figure 52. Exhaustion of root reserves in darkness for the Salmon *Deschampsia cespitosa* - *Carex lyngbyei* (D) and *Poa pratensis* - *Agrostis alba* var. *stolonifera* - *Potentilla pacifica* (P) communities: average time (.).


300
200
100
DAYS
D
P
P
D
4
5
6
7
8
10
MONTH