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TRANSITION ZONE VEGETATION BETWEEN INTERTIDAL MARSH AND UPLAND IN OREGON AND WASHINGTON

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SUMMARY

This research describes the vegetation in the transition zone between intertidal coastal salt marsh and contiguous upland in the Pacific Northwest. A method of objectively delineating the transition zone and upper limit of marsh is developed.

Vegetation pattern is described in the intertidal marsh, ecotone (or transition zone) between intertidal marsh and contiguous upland, and upland in 20 marshes in Oregon and Washington including 8 Puget Sound marshes. The marshes were sampled along 190 transects parallel with the elevation gradient employing 2,583, 50 x 50 cm^2 microplots to assess intertidal marsh and transition zone vegetation and 1,709 one-meter line segments to assess upland understory shrub and herbaceous vegetation. Plant communities, identified by tabular analysis, are described individually by marsh. Distribution of species and species importance values are graphed for selected transects for each marsh and the position of the marsh transition zone as determined in the field is noted.

Intertidal marsh and transition zone samples are allocated into one of six zones based on plant community analysis and prior knowledge of plant species distribution: zone 1 = low marsh, zone 2 = high marsh, zone 3 = lower transition zone, zone 4 = transition zone, zone 5 = upper transition zone, and zone 6 = upland. Plant species frequency, percent cover, and importance value are determined in this report for each zone by aggregate, with the exception of zone 6, upland. Based on the relative <u>trends</u> in species importance values across the five zones, four lists of species are prepared: low marsh species, high marsh species, upland species, non-indicator species (Tables 16, 17, 18, and 19).

The accurracy of allocating 2,583 samples into one of five zones is tested by discriminant analysis which shows an average of 79 percent of microplot samples correctly classified. Zone 1, low marsh and zone 5, upper transition zone, are classified correctly more often than the other zones.

Upland vegetation, because it consisted mostly of forest with a dense shrub understory and sparse herbaceous cover, is assessed differently than was the dominantly herbaceous intertidal and transition zone vegetation. Upland tree frequency, cover, and basal area are calculated for each marsh. Shrub and herbaceous understory data are synthesized by average percent frequency and cover.

Selected salinity data were collected and demonstrate rapid decline in surface interstitial soil water salinity in the vicinity of the lower boundary of the transition zone, usually a decline from about 20 ppt to about 5 ppt. There is also a decline in salinity with soil depth giving evidence of a freshwater lens.

The lower and upper boundary of the transition zone and upper limit of marsh are objectively defined by the Multiple Occurrence Method (see pages 227-236) which could be applied to any microplot. A single score is derived for each microplot by summing the weighted cover values of each plant species encountered in the microplot sample. Low marsh species are weighted by multiplying cover values by +2, high marsh species by +1, upland species by -2, and non-indicator species by 0. The species are those that appear in species lists in Tables 16, 17, 18, and 19. A Multiple Occurrence Method score of >1 means that the microplot is in the marsh. A score <1 means that the microplot is in the upland. A sequence of microplot scores may be plotted with distance along a transect from low marsh to upland. The limit of marsh is defined by a score of 0. The region along a transect over which scores alternate positively and negatively is defined as the transition zone. A mean width of the transition zone for 129 marsh transects sampled is 6.52 m. Excluding three extremely complex marshes and using 102 transects, the mean width of the transition zone is 2.53 m.

INTRODUCTION

Research Objectives

The objective of this investigation is to first, describe the vegetation pattern in the ecotone between intertidal coastal marsh and contiguous upland in Oregon and Washington and second, propose a definition for the transition zone and the limit of the coastal intertidal wetland. The ultimate goal of this study is to aid in the development of guidelines for the specification of coastal wetlands so as to insure consistent wetlands protection with a minimum of judgmental decisions by the wetlands managing agency.

Background

Tidal Marshes and Productivity

Of critical concern to the people of the United States is the maintenance of productive ecosystems. Among the most productive natural ecosystems are intertidal marshes which range from 300 to 6,500 $g/m^2/yr$ net production (Odum, 1971; 1974; Cooper, 1974). It is widely recognized that primary and secondary productivity of estuaries is inextricably related to associated marsh systems (Smalley, 1960; Kuentzler, 1961; Teal, 1962; Reimold and Queen, 1974; Odum, *et al*., 1974). Indeed, Odum (1961:12) asserts that "the entire estuarine system, including marshes, flats, creeks, and bays, must be considered as *one* ecosystem or productive unit." The intertidal salt marsh functions as both an energy receptor and converter; its organic detritus, exported by tidal action to the bay, serves as an important energy and nutrient input into the estuarine system. While such a functional contribution of marsh productivity seems true for, and important to, east coast marshes and estuaries in the United States, adequate analysis of marsh function on the west coast has not yet been published.

Another value of coastal marshes is protection. Marshes, because of their naturally stressed condition, "may have more capacity to serve as self-purification than some other systems...not already adapted to some stress" (Odum and Copeland, 1974:72). Coastal marshes, being broad expanses of low slope angle serve as energy disipators, protecting estuarine margins from storm damage. Despite their acknowledged ecological and economic value (Gosselink et al., 1973), coastal salt marshes are heavily impacted by human activities (Darnell, 1976).

Legal and Institutional Background

Estuarine productivity, closely tied to the condition of surrounding tidal marsh, river, bay and ocean, has been diminished as these associated systems have been stressed by human impacts. Thermal, municipal and industrial pollution, diking, dredge and fill operations, channelization, reduced area of marsh, and altered run-off conditions have all placed estuarine systems in jeopardy. In recognition of the importance of estuaries as productive systems and of the stresses that these systems are placed under, a number of states have adopted legislation which helps protect sensitive ecological areas, such as intertidal marshes, in the coastal zone. Most of these laws prevent destruction of wetland values or provide for mitigation. Lagna (1975) has summarized Atlantic coastal states' wetlands legislation with respect to the extent of restriction on development, the review process, provision for compensation, and the definition of wetlands.

The Congress has also reacted to the need for protecting wetlands by enacting the Coastal Zone Management Act of 1972 (P.L. 92-583) establishing a national policy of protecting coastal wetlands and program for the management, beneficial use, protection and development of the resources of the coastal zone. This act encourages participation of states in planning and managing coastal zone resources by providing grants-in-aid. The courts have also responded to the need of protecting coastal wetlands, e.g., Candlestick Properties, Inc. vs. San Francisco Bay where the California Court of Appeals upheld the denial of a permit to fill bay lands (CEQ, 1973). Another instance of court action was in the Marco Island case where the Corps under Sec. 404, refused to permit the filling of a major acreage of mangrove wetland because of the significance of mangrove vegetation to the aquatic ecosystem. This case withstood challenge in court. Although the courts have frequently served favorable decisions in protecting wetlands, wetland litigation is fraught with legal and constitutional problems (Stever, 1977).

While coastal zone management legislation pertains, in part, to the protection of coastal wetlands, a broader concern for the integrity of wetlands is incorporated in Section 404 of the Federal Water Pollution Control Act Amendments of 1972 (Sec. 404, P.L. 92-500). Under this Section, the Army Corps of Engineers may issue permits for the discharge of dredged or fill material into navigable waters at specified disposal sites. Guidelines for the specification of disposal sites are to be developed by the Administrator of the Environmental Protection Agency in cooperation with the Army Corps of Engineers. Furthermore, the Administrator in cooperation with the Corps is authorized to prohibit the specification of any defined area as a disposal site and to deny or restrict use of any defined area for specification as a disposal site when he determines that material discharged will have an unacceptable adverse effect on municipal water supplies, shellfish beds, fishery areas, wildlife or recreational areas (Sec. 404, P.L. 92-500).

In order to implement its role in developing guidelines for the discharge of dredged and fill material and the specification of restricted disposal sites, the Environmental Protection Agency in cooperation with the Corps must be able to define areas considered as contiguous wetland to a navigable water and therefore an area contributary to the general productivity of the estuarine system. The research reported herein will aid the Environmental Protection Agency in carrying out this responsibility.

Intertidal Marsh Research

Coastal salt marshes have long been recognized as discrete ecosystems and have been studied as distinct vegetation units (Shaler, 1886; Ganong, 1903; Harshberger, 1909; Yapp, 1917; Morss, 1927; Wells, 1928; et al.). Intertidal marshes consist of low-growing, rooted vegetation in the intertidal zone developing on mud to sand substrate under the influence of tidal fluctuations, salinity gradients, and tide-transported material. Important reviews of salt marsh vegetation, its dynamics and ecosystem structure and function have appeared in recent years (Chapman, 1960; Ranwell, 1972; Reimold and Queen, 1974; Cooper, 1974; Odum et al., 1974; and, Chapman, 1977). The contribution of salt marsh production to estuarine systems and the interchanges between salt marsh and estuary are beginning to be better understood; and the pattern of salt marsh communities, zonation, and relation to tidal fluctuations have been explored in many regions of the temperate world.

Intertidal marshes are truly interfacial between marine and terrestrial ecosystems. They typically occupy areas in temperate to polar latitudes supplied with river or marine sediment and which are sheltered from high-energy wave attack (Odum and Copeland, 1974). Developing on sand or mud flats at near mean sea level, intertidal marshes exhibit autogenic succession where pioneer plants such as Salicornia spp., Triglochin maritimum, or Spartina spp. trap silts, clays and floating macrophytes, and, over a gentle gradient, form an elevated marsh surface above the surrounding flats. Thus, the developing intertidal marsh displays differences in tidal inundation, salinity, root zone aeration, and accretion of detritus. As the marsh surface elevates, it becomes dendritically laced with drainage channels which become a two-way distributary network supplying the marsh with nutrients and sediments and removing detrital material from the developing marsh. Natural levees, richly supplied with nutrients, line major drainage channels and are frequently characterized by single species plant communities. At times, fully developed marshes are subject to retrogradation, often due to lowered sea level or diminished sediment input. While the intertidal marsh develops under a complex environmental gradient, most marsh areas exhibit distinct zones which have been interpreted as plant communities (Chapman, 1960; Hinde, 1954; Eilers, 1975; Jefferson, 1975). While marsh pattern and floristics differ slightly from region to region, basically the dynamics remain the same the the general plant communities and flora show a striking physiognomic and floristic convergence (Chapman, 1960; Cooper, 1974; Reimold and Queen, 1974).

West Coast Research

Cooper (1974:59) recognizes "...two major groups of salt marshes in the United States--those characteristic of the East and Gulf Coasts on the one hand and those characteristic of the West Coast on the other." West Coast marshes, developing in sheltered estuarine systems, are of limited extent compared with East and Gulf Coast marshes which develop on a gently sloping coastal shelf, often behind a barrier beach. Excellent reviews of West Coast marsh vegetation studies appear in Macdonald (1977), Macdonald and Barbour (1975) and Eilers (1975).

While a number of marsh studies have been conducted in California, Oregon and Washington, salt marsh research has lagged appreciably. Johannessen (1961) provided a generalized survey of salt marshes in relation to a reconnaissance study of environmental changes along the Oregon coast. Jefferson (1975) and also Akins and Jefferson (1973) have reviewed coastal wetlands with particular reference to plant succession on salt marshes. Jefferson (1975) described and mapped salt marshes in 16 Oregon estuaries and identified six salt marsh types and 28 marsh communities. The types based on substrate, salinity and development included: Low Sand Marshes, Low Silt Marshes, Sedge Marshes, Bulrush and Sedge Marshes, Immature High Marshes and Mature High Marshes. Jefferson's study, however, was concerned principally with intertidal vegetation and lacked detail in describing the transition between intertidal marsh and upland vegetation.

Eilers (1975) conducted a detailed study of a marsh system in Nehalem Bay, Tillamook County, where he described 11 marsh communities and related these to tidal datums and determined the net, above ground production for each community (mean of 1388 $g/m^2/yr$). Eilers dealt, in part, with the broad transition zone between the intertidal zone and upland vegetation. Hoffnagle and Olson (1974) mapped and classified the Coos Bay marshes based on Jefferson's classification and superficially determined marsh productivity. Hoffnagle et al. (1976) conducted a more comprehensive study of Coos Bay marshes; but in neither Coos Bay study was much attention paid to the upper marsh vegetation.

In Washington, there has been research in four major salt marsh areas: Willapa Bay, Nisqually Delta (Puget Sound), Grays Harbor, and Nooksack Delta. The Willapa Bay marshes in south coastal Washington have been studied recently by Northwest Environmental Consultants (1975b) under contract with the Army Corps of Engineers. The largest Puget Sound salt marsh, in the Nisqually River Delta, has been investigated by Burg, et al. (1975). The latter study identified 12 plant associations and net production for 8 (mean 750 $g/m^2/yr$). An extensive study of the Grays Harbor estuarine system near Aberdeen, conducted jointly by Washington State Department of Ecology for the Army Corps of Engineers has mapped salt marsh vegetation using the system of Jefferson (1975). The National Ocean Survey (1975) studied the upper limit of salt marsh near Everett and the Northwest Environmental Consultants (1975a) have studied Jefferson Co. marshes. Disraeli (1977) has reported on six plant communities in a brackish marsh in the Nooksack Delta and has provided preliminary productivity data for each.

Intertidal Marsh Zonation

Under a strong gradient of inundation frequency and salinity, salt marshes exhibit a clear pattern of vegetation zonation. Three zones are generally recognized: (a) a subtidal zone below MLW consisting of tideflats often dominated by eel grass (Zostera marina) and species of algae, (b) an intertidal zone between MLW and MHW consisting of rooted vascular plants and laced by tidal channels, and (c) an extratidal zone above MHW characterized by the prevalence of non-marsh plants. Most salt marsh studies have analyzed the intertidal zone with special reference to marsh development, zonation pattern related tidal datums and other environmental measures, and the detrital transport relations to the subtidal and estuarine zone. Little attention has been paid to the nature of the transition between the intertidal zone and upland vegetation. It is within this zone that the upper limit of marsh will be found. This transition zone also may vary in width depending on the slope gradient.

At Nehalem Bay, Eilers (1975) recognized an intertidal marsh below MHW, a "transitional marsh" between MHW and 0.58 m above MHW and extr-tidal marsh 0.58 m above MHW. These vegetation patterns correlate with topographic units, creek density, and species diversity. Jefferson (1975), as did Eilers (1975), determined the distribution of salt marsh plants relative to MLLW, with special reference to the intertidal marsh. Likewise, Jefferson (1975) defined the elevation range of seven Oregon salt marsh types. In a preliminary study of the relation of upper limit of marshes to tidal datums (Frenkel et al., in press) reported a transition zone dominated by Potentilla pacifica with the presence of a number of species more commonly found in upland situations.

Definition of the Upper Limit of Intertidal Wetland

The Army Corps of Engineers (Federal Register, July 19, 1977, Part II, p. 37144) states:

> (t)he term "wetlands" means those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, the prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

Likewise, the U.S. Fish and Wildlife Service (Cowardin 1977:4-5) defines wetlands broadly and simply:

> as land where the water table is at, near or above the land surface long enough to promote the formation of hydric soils or to support the growth of hydrophytes. In certain types of wetlands, vegetation is lacking and soils are poorly developed or absent as a result of frequent and drastic fluctuations of surface-water levels, wave action, water flow, turbidity or high concentrations of salts or other substrate at some time during each year and their location within, or adjacent to, vegetated wetlands or deep-water habitats.

Both definitions refer wetlands with respect to saturated or inundated soils and to plant cover adapted to saturated conditions. The Corps stresses vegetation (total plant cover of an area), the Fish and Wildlife Service stresses flora (a list of species). It has been proposed that intertidal salt marshes be defined using any one, or combination of, criteria: species composition, vegetation (plant communities), soil moisture regime, tidal datums, salinity regime, nutrient status, productivity, substrate stratigraphy, and topography (Hawkes, 1966).

Tidal datum criteria. The National Ocean Survey (NOS) (1975) suggested, from an investigation of eight coastal study sites throughout the United States, that the upper limit of marsh (ULM) be defined at 0.76 m above MHW. The ecotone at this limit on the East and Gulf Coast was relatively narrow and occurred over 0.03 m elevation. In the West, the NOS found a broader ecotone extending over tens of meters and spanning elevations of up to a meter. The NOS therefore proposed the ULM in the West be defined as the <u>average</u> of the upper and lower ends of the transition zone, the latter being defined primarily by floristic composition. Based on this criteria, the ULM at Ebey Slough, Snohomish Estuary, Washington was 0.37 m above MHW (lower transition boundary 0.18 m and upper transition boundary 0.52 m above MHW). At Pinole, California the ULM was 0.85 m above MHW. Frenkel *et al*. (in press), based on preliminary work at three Oregon marshes, proposed a transition zone with a mean lower boundary of 0.36 m and upper boundary of 0.58 m above MHW, yielding an ULM at 0.47 m above MHW.

Boon *et al*. (1977), investigating the upper limit of marsh at 13 survey sites in the lower portion of the Chesapeake Bay, determined that the mean ULM at 7 saline intertidal sites was 0.29 m above MHW.

The basis of relating the ULM and transition zone boundaries to a tidal datum is that the vegetation pattern might be related to frequency of tidal inundation and both the NOS (1975) and Boon *et al*. (1977) provide tidal frequency immersion data related to tidal datums. However, Eilers (1975) suggests tidal inundation <u>period</u> rather than <u>frequency</u> is more significant to vegetation development. In all three of these studies, identification of the transition zone and the ULM was based on floristic criteria.

<u>Floristic and vegetation criteria</u>. The NOS (1975) identified the ULM based on different floristic criteria in each biogeographic region; e.g., in the Arcadian Region, ULM was defined by the presence of *Limonium*,

Carex paleacea, Rosa virginica and some Distichlis spicata while in the Virginian Region the ULM was identified by Suaeda, Distichlis spicata, Iva frutescens, Spartina patens, and Salicornia; Rhus radicans was the most common upland plant. Based on consultant analysis, the ULM in the Columbian Region was characterized by Carex lyngbyei, Typha latifolia with some Potentilla pacifica, Triglochin maritimum, Angelica lucida, Atriplex patula, Achillea millefolium and Solanum dulcamara. No quantitative nor consistent method of defining the flora and vegetation at the upper limit of marsh and transition zone was developed.

Frenkel et al. (in press) identified the transition zone in Oregon by strong dominance of Potentilla pacifica and the presence of Achillea millefolium, Angelica lucida, Aster subspicatus, Oenanthe sarmentosa, Trifolium wormskjoldii, and Vicia gigantea but did not provide a quantitative definition of vegetation in the transition zone.

Boone et al. (1977:44) defined the ULM "as the median point of the marsh-uplands vegetational transition zone, or the point in the transition sequence at which the coverage of true uplands plants is about equal to that of wetlands plants." These researchers divided tidal wetlands into saline and freshwater types. The saline transition zone was recognized by Iva frutescens at its lower side and by Baccharis halimifolia at its upper side. Abrupt appearance of uplands ground cover mixed with the upper marsh plants, Spartina patens and Distichlis spicata also enabled the researchers to identify the upper transition zone boundary. With considerable prior floristic work in the lower Chesapeake Bay, Boon et al. (1977) were able to compile lists of plants typically found in marsh, upland, and freshwater habitats. However, no quantitative use of vegetation data was made in defining the transition zone boundaries.

Boulé and Shea (1978) discussed the delineation of the upper limit of marsh within Snohomish Estuary, Washington. They used floristic criteria to identify the transition zone in Snohomish Estuary where they found a mixture of wetland (fresh and salt marsh) and upland species "which may or may not overlap with other community types (e.g., high marsh or swamp" (Boulé and Shea, 1978:39). As with the previous studies cited, these research workers also did not develop a quantitative method of defining the transition zone and upper limit of marsh.

Physical criteria. Since wetlands are defined, in part, by a condition of inundation and/or saturation by surface or ground water, measurement of water table and soil moisture saturation would appear to be an approach to delineating wetlands. One way of denoting wetlands in coastal areas is to use tidal inundation. This has been discussed.

Few studies have been made of ground water fluctuations. Among the problems that exist in using ground water fluctuations as a means of defining wetlands are: variations in substrate permeability, hydrostatic pressure in the ground water related to extrinsic factors, variations in infiltration due to surface vegetation, and complexity in measuring ground water levels and soil water saturation. For similar reasons Northwest Environmental Consultants (1977) dispensed with using ground water movement for defining aquatic lands.

Soil salinity in coastal intertidal marshes, like gound water, presents a number of problems as a means of delineating wetlands. Salinity varies diurnally, seasonally with depth in the soil profile, with distance from the marsh edge and with distance up river from the estuary mouth. These variations in salinity suggest the problems of employing soil salinity as a consistent means of recognizing intertidal coastal wetlands.

Approach. Based on our review of the literature and prior field experience, use of a combination of floristic and vegetation criteria appeared to be the most promising route toward delineating the limits of intertidal wetlands. Two problems, however, had to be addressed in following this route. First, objective lists of species considered to be wetland plants and upland plants respectively needed to be established. Second, a simple quantitative means of integrating floristic vegetation data in a single measure needed to be developed.

In analyzing the salt marsh communities on the Stikine Flats, southeast Alaska, del Moral and Watson (1978) present an objective means of identifying communities by classifying 120 microplots into 11 community types using the agglomerative clustering method, MDISP. This classification based on clustering was then tested by discriminant analysis. This approach could be used to provide objective lists of species and species importance in each plant community (Sparks et al., 1977).

Determination of a single measure of integrating floristic data exists in a number of coefficients of community (Mueller-Dombois and Ellenberg, 1974). For example, the Jaccard community index could be used to give a single measure. This index, ISj, is defined:

$$ISj = \frac{c}{a + b + c} \times 100$$

where, c is the number of common species, a is the number of species unique to one sample (community type) and b the number of species unique to a second sample (community type). Mueller-Dombois and Ellenberg (1974) present a number of such indexes, any of which could be used to provide single measures useful in determining whether or not a sample was upland or wetland, provided that an objective list of upland and wetland plant species was available.

METHODS

Selection of Study Sites

Introduction

In selecting intertidal marshes in Oregon and Washington for possible inclusion in a study concerning the transition of vegetation from marsh to upland, several criteria were used:

1. The marsh had to be effected by tidal fluctuations.
2. The marsh had to exhibit normal salinities in excess of about 10 ppt.
3. The marsh and upland had to be contiguous.
4. The marsh had to be essentially undiked in terms of its present functioning and relatively undisturbed.
5. The contiguous upland had to be free of recent or heavy human disturbance.
6. The marsh had to have relatively easy access.

The procedure followed in selection of potential study sites was four-fold: (1) literature search on previous intertidal marsh research and sites studied or recognized in the Pacific Northwest; (2) examination of aerial photographs to locate and screen-out potential marsh sites; (3) plot map locations of potential marsh sites; and (4) field check the most promising sites. To aid in marsh selection, a field screening form was prepared and is shown on Appendix A.

For both Oregon and Washington the same methods were used in field checking. Potential marshes were located and examined on site if possible. If not, the site was examined by binoculars, or comparatively with a nearby site. From the field check, seven marshes were selected in Oregon, five on the Washington Coast (Figure 1), and eight in Puget Sound and the San Juan Islands (Figure 2).

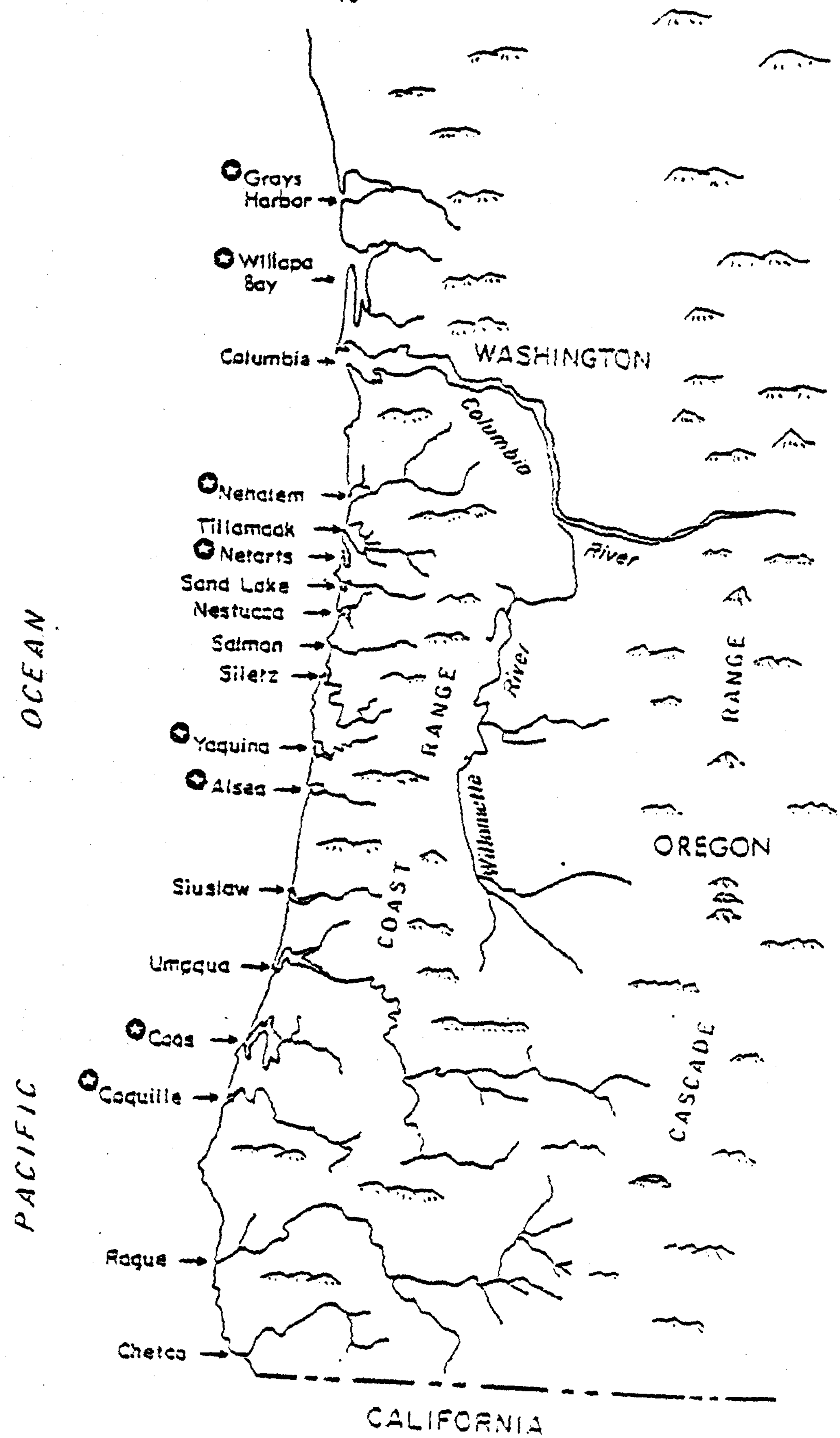

Figure 1. Location of study site esturaries along the Oregon and Washington coast.

Oregon

To obtain the needed information for Oregon, Jefferson's (1975) maps[1] on the location of intertidal saltmarshes were carefully studied. Marshes which appeared to meet the criteria above were marked and numbered. These marshes, and others not appearing on Jefferson's maps, were confirmed by examination of U-2 color infrared imagery (1:33,000) in the Environmental Remote Sensing Laboratory (ERSAL) at Oregon State University. With the aid of Jefferson's maps and imagery survey, 78 potential marsh sites were selected in 14 Oregon estuaries. The estuaries and a number of qualifying marsh sites per estuary are shown in Table 1.

Table 1. Preliminary distribution of marsh sites in Oregon estuaries.

Estuary	No. Sites Surveyed	No. Sites Selected	Estuary	No. Sites Surveyed	No. Sites Selected
Necanicum	8	0	Yaquina	9	1
Nehalem	7	2	Alsea	6	1
Tillamook	5	0	Siuslaw	8	0
Netarts	3	1	Umpqua	10	0
Sand Lake	5	0	Coos Bay	7	1
Nestucca	3	0	Coquille	2	1
Salmon River	1	0	Rogue	0	0
Siletz	4	0	Chetco	0	0

1 Jefferson's mapping was based on field reconnaissance, selected detail studies, and analysis of black and white aerial photographs of various scales. Marshes were identified by Jefferson on large-scale ozalid maps prepared by the Division of State Lands (c.f., State of Oregon Division of State Lands, 1973) and were reduced to 8½ x 11" format in Jefferson's (1975) thesis and in Akins and Jefferson (1973). Facimiles of Jefferson's original maps were prepared from colored photographs provided by Jefferson.

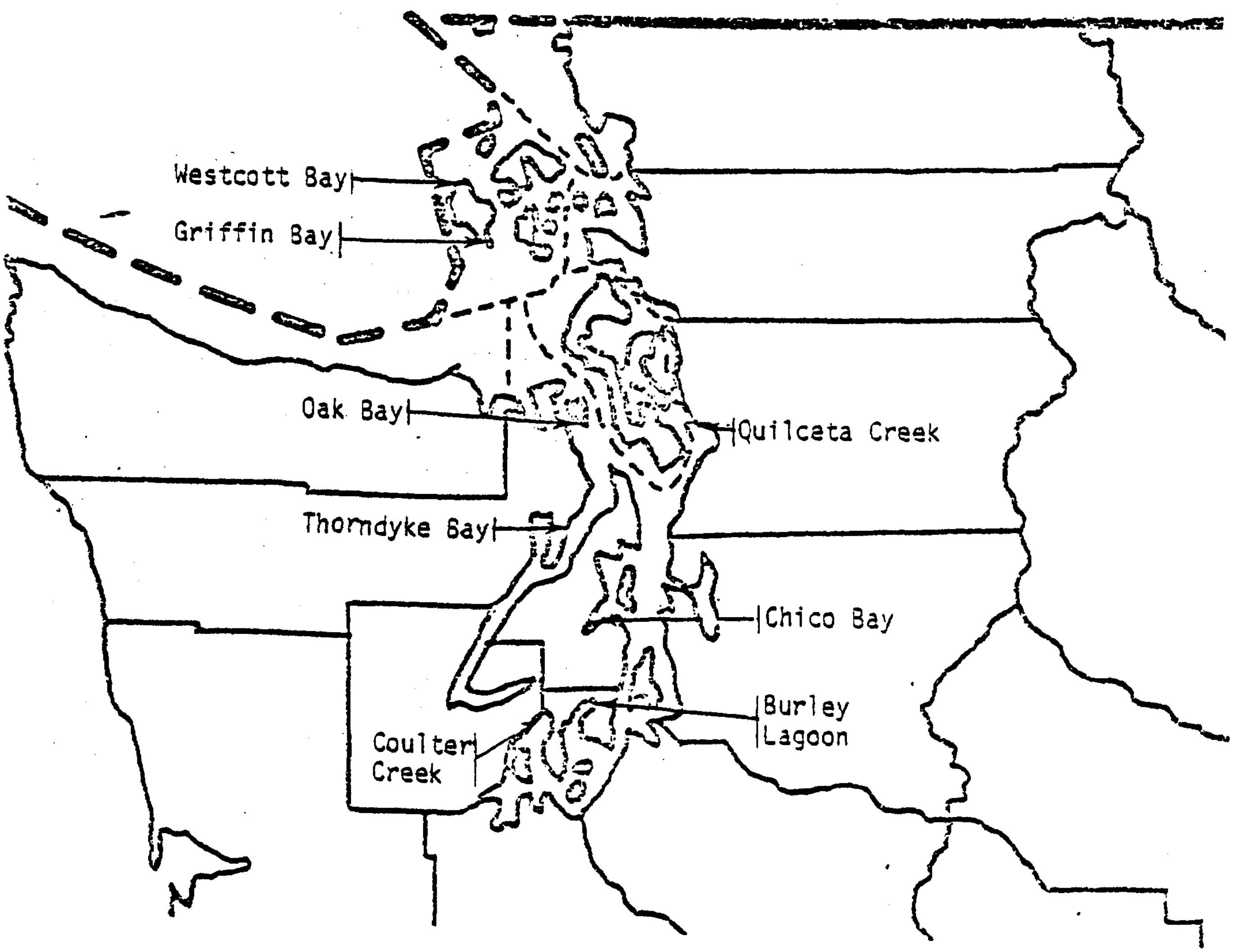

Figure 2. Location of study sites in the Puget Sound and vicinity.

Seven marshes were selected in Oregon (Table 2). More detailed descriptions of the individual marshes appears in Appendix E . The marshes span the coast from Coquille Estuary to Nehalem Bay and range from marshes on sandy substrate to fine silt substrate. Contiguous upland varies from coniferous forest to sand dune vegetation.

Table 2. Selected study marshes in Oregon.

Marsh	Designator Symbol	Designator No.	Estuary	Area (ha)	Marsh[1] Type	Upland Type
Bandon	CQ1	1	Coquille R.	150	Low-Sand to Immature High	Conifer. (wet)
Haynes Inlet	CB1	2	Coos Bay	11	Immature High	Conifer/ Ruderal
Waldport South	AB1	3	Alsea Bay	4	Mature High	Conifer.
Nute Slough	YB1	4	Yaquina Bay	2	Immature High	Conifer.
Netarts Sand Spit	NT1	5	Netarts Bay	10	Low-Sand to Mature High	Sand Dune, Shrub
West Island	NB2	6	Nehalem Bay	80	Low Silt, Sedge, Mature High	Conifer.
Sea Garden Road	NB3	7	Nehalem Bay	5	Low Silt	Conifer. (wet)

[1] Based on classification according to Jefferson (1975).

Washington

Previous studies concerning intertidal marshes in Washington were reviewed to gather information on site location (NOS, 1975; Northwest

Environmental Consultants, 1975; 1977; Hepp, 1973; Burg et al., 1975; Army Corps of Engineers, 1975; 1976). True color imagery (1:24,000) available at the Washington State Department of Natural Resources, Olympia (DNR) was examined for every coastal area in the Puget Sound, Willapa Bay, Grays Harbor, the open coast to Queets, and the Straits of Juan de Fuca. These photos were in the MLM-73 (1973) and MLM-74 (1974) Series taken for DNR by Carto-Photo of Eugene, Oregon.

Locations of marshes which appeared to meet the selection criteria, both from the literature and from aerial photograph inspection, were marked on 1:250,000 topographic maps and also on county highway maps (various scales). Altogether 132 possible sites were identified and distributed as shown in Table 3.

Table 3. Preliminary distribution of intertidal marsh sites in Washington.

Location	No. Sites Surveyed	No. Sites Selected	Location	No. Sites Surveyed	No. Sites Selected
Willapa Bay	14	3	East Puget Sound	11	1
Grays Harbor	17	2	West Puget Sound	51	5
San Juan Islands	12	2	Other	1	0

Subsequent to the literature and photo reconnaissance survey, many of the identified marshes were field surveyed in the same manner as those in Oregon. Thirteen marshes were selected in Washington (Table 4). More detailed descriptions of individual marshes appears in Appendix E. The marshes include representative types of coastal marshes and also of the Puget Sound and San Juan region.

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Table 4. Selected study marshes in Washington

Marsh	Designator Symbol	No.	Location (generalized)	Area (ha)	Marsh Type[1]	Upland Type
Niawiakum	WB1	8	Willapa Bay	18	Mature High	Conifer.
Cedar River	WB2	9	Willapa Bay	4	Immature High	Conifer.
Leadbetter Pt.	WB4	10	Willapa Bay	390	Low Sand	Sand Dune
The Sink	GH1	11	Grays Harbor	249	Low Sand	Sand Dune
Elk River	GH3	12	Grays Harbor	2	Immature High	Conifer.
Burley Lagoon	KS1	13	South Kitsap	4.8	High Mature	Conifer.
Coulter Creek	KS2	14	South Kitsap	1.4	Immature High	Conifer.
Chico Bay	KS3	15	South Kitsap	0.9	Low Sand	Rudeial
Thorndyke Bay	HC1	16	N. Hood Canal	13.2	High on Sand	Conifer.
Quilceda Creek	EP1	17	Snohomish Est.		Immature High	Conifer.
Oak Bay	NP1	18	North Puget	0.7	Low Sand	Conifer.
Westcott Bay	SJ1	19	San Juan Is.	0.8	Low Sand	Decid. For.
Griffin Bay	SJ2	20	San Juan Is.	0.5	Low Sand	Decid. For.

[1] Based on classification according to Jefferson, 1975.

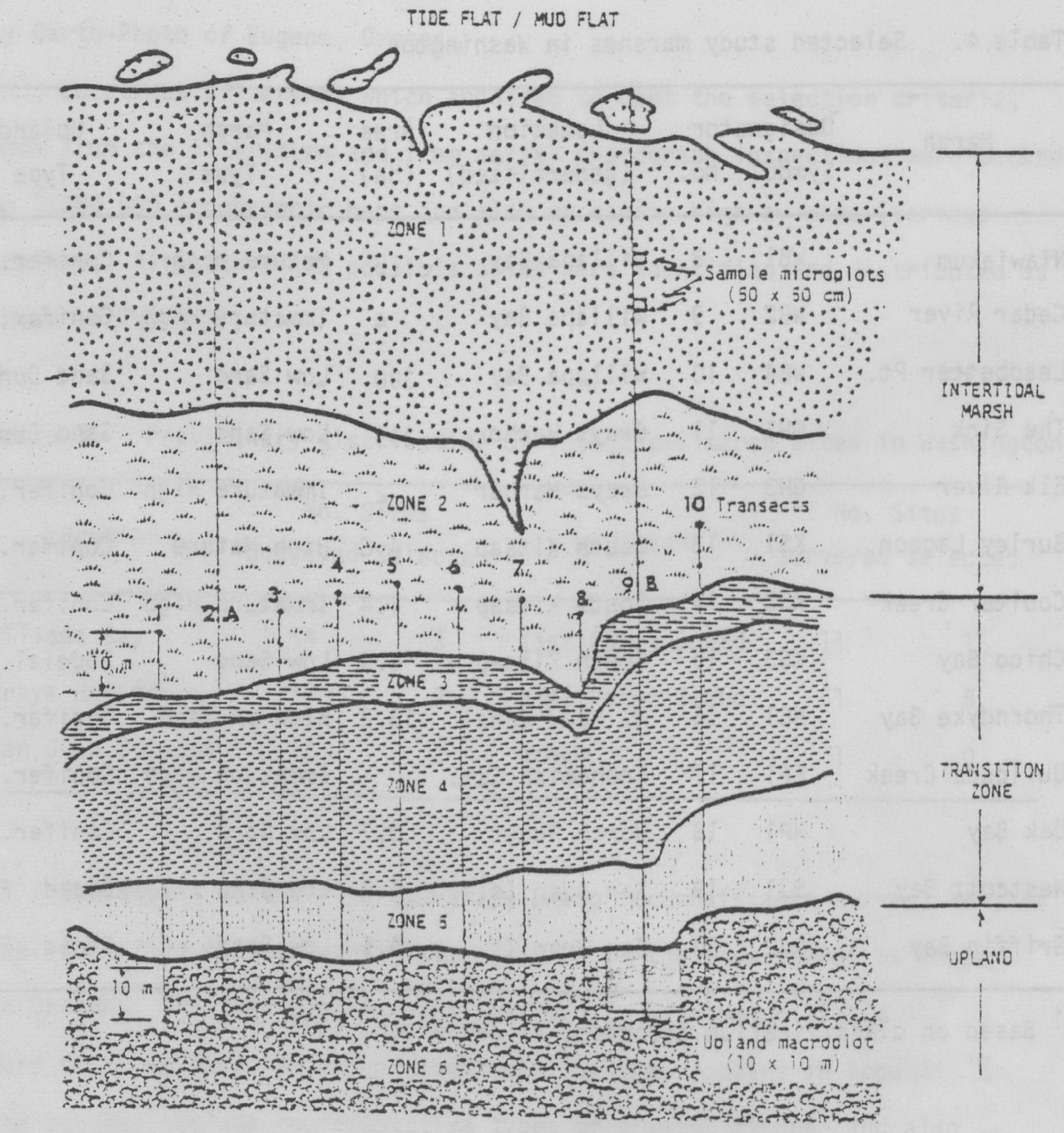

Figure 3. Arrangement of transects, microplots, and macroplots for an idealized marsh in which zones are depicted.

Field Methods

Marsh Vegetation Sampling

After preliminary reconnaissance of the selected marsh site, marsh vegetation was sampled along 10 to 15 systematically spaced transects. At least 2 transects extended from mudflat or primary tidal creek to a point 10 meters within the upland as judged in the field (Figure 3). Distance between transects varied from marsh to marsh, with spacing sufficient to adequately represent the marsh, transition zone, and upland vegetation. Transects were staked and labeled at their ends, at a point judged in the field based on biological evidence as the lower boundary of the transition zone, and at a point judged in the field as the upper boundary of transition zone. In most cases the lower end of each transect was extended at least 10 meters toward the mudflat or tidal creek from the lower boundary of the transition zone, ensuring sampling of intertidal, salt marsh vegetation. All transects were laid out with a 30 meter woven plastic tape.

Vegetation along the marsh and transition zone segment of each transect was sampled at systematic intervals with a 50 x 50 cm steel quadrat frame with a center cross brace which ensured an accurate estimate of percent species cover. Species cover, bare ground, litter, algae, and stranded material were recorded by Daubenmire cover class (Table 5) in each plot together with plot position along the transect.

Spacing between plots varied with the width of the vegetation zone being sampled. For the long transects, extending to mudflat or tidal creek within the intertidal segment of the marsh, plot spacing varied from 15 to 20 meters apart. For the segment 10 meters below the lower

Table 6. Summary of sampling information for 20 marsh sites in Oregon and Washington.

Marsh	CQ1	CB1	AB1	YB1	NT1	NB2	NB3	WB1	WB2	WB4	GH1	GH3	KS1	KS2	KS3	HC1	EP1	NP1	SJ1	SJ2	Total
No. Transects	12	10	10	9	10	9	13	10	10	10	11	10	10	10	5	12	9	10	5	5	190
long	3	3	2	3	10	1	3	2	2	3	3	10	3	3	2	5	3	10	5	5	81
short	9	7	8	6	0	8	10	8	8	7	8	0	7	7	3	7	6	0	0	0	109
Avg. Transect Length																					
long (m)	165	198	111	76	82	880	101	140	72	359	546	35	115	68	120	122	173	39	30	30	
short (m)	36	28	36	31	--	241	26	29	40	71	193	--	44	52	47	21	78	--	--	--	
No. Samples[1]																					
marsh	87	86	91	55	108	109	124	91	112	122	167	65	52	73	59	48	96	107	31	44	1712
transition	81	20	71	33	47	86	76	57	45	29	62	50	37	55	19	30	37	7	14	0	871
upland	120	69	100	90	102	90	130	100	122	47	51	100	85	100	50	120	56	82	45	50	1709

[1] Marsh samples in this table were, in most cases, defined in the field by placement of a stake at the lower boundary of the transition zone. Marsh samples being below this stake. In a few cases, it appeared difficult in the field to define a lower boundary of the transition zone and in those cases marsh samples were defined as those that were relegated to Zone 1 and 2 for analytical purposes.

Table 5. Species cover classes and percent mid-point values.

Cover Class[1]	Cover Range (%)	Midpoint Value (%)	Computer Code
+[2]	present neglig.	0.1	7
1	0 - 5	3.0	1
2	5 - 25	15.0	2
3	25 - 50	37.5	3
4	50 - 75	62.5	4
5	75 - 95	85.0	5
6	95 - 100	97.5	6

[1] Based on Daubenmire after Mueller-Dombois and Ellenberg (1974).

[2] Daubenmire did not use a + for species with negligible cover.

transition zone boundary, plot spacing was usually every 2 meters. Within the transition zone, plot spacing varied from 1 to 5 meters apart depending on the width of the transition zone (some transition zones were extremely wide). Table 6 summarizes the field data collection.

Choice of the 50 x 50 cm plot was based on species area data collected by Eilers (1975), Jefferson (1975), Frenkel and Eilers (1976) and experiments with the species area relation during the current research.

Subsequent to the vegetation sampling, elevation measurements were made by the National Ocean Survey field crew at selected marshes in Oregon and Washington. The staked transects provided precise orientation for elevation profiles. The marshes for which elevation and tidal data were taken were:

Bandon (Coquille Estuary)	CQ1	The Sink (Grays Harbor)	GH1
South Waldport (Alsea Bay)	AB1	Elk River (Grays Harbor)	GH3
Netarts Sand Spit (Netarts Bay)	NT1	Coulter Creek (South Kitsap)	KS2
West Island (Nehalem Bay)	NB2	Thorndyke Bay (Hood Canal)	HC1
Sea Garden Road (Nehalem Bay)	NB3	Quilceda Creek (East Puget Sound)	EP1
Cedar River (Willapa Bay)	WB2		

In the initial reconnaissance of each site, a thorough floristic survey was made with an attempt to collect species which were not immediately identifiable for later recognition. Hitchcock and Cronquist (1973) and Hitchcock et al. (1955-1969) were used as floras for the study.

Salinity

Interstitial soil water salinity was collected along several transects in a number of marshes. The consistent collection of salinity data at every sample plot proved too time consuming.

Soil cores for sediment description and salinity measurements were extracted to a depth of about 30 cm, generally below the "rooting zone", using a piston sampler made from the straight section of a "1½ inch diameter kitchen sink drain" and fitted with rubber stopper plunger. Interstitial salinities were taken from a few drops of solution extracted from about 1 to 2 cm^3 of sediment by compressing the sediment, which had been wrapped in No. 54 hardened filter paper, in a 25 cm^3 disposable plastic syringe. Salinities were measured to the nearest part per thousand with an A. O. Goldberg temperature compensated refractometer which had been calibrated with a standard sea water solution. Salinities were taken at the surface, 5 cm, 10 cm, 20 cm, and 30 cm. In this way, data were available to construct a soil salinity profile both vertically and horizontally.

Upland Vegetation Sampling

Because of the abrupt change in vegetation physiognomy at the upper edge of the marsh, the use of the same sampling system employed for sampling intertidal marsh and transition zone vegetation was impossible. While the marsh and transition zone vegetation were characterized by herbaceous growth, the upland was marked by a dense thicket of shrubs and a thick overstory of trees.

Most transects were extended 10 meters into the upland. In a few cases where the "upland" had a large component of freshwater wetland species, the upland segment of the transect was extended a greater distance to true terrestrial vegetation. In some upland situations the terrestrial upland shrub layer was so thick that upland transects were limited to 5 meters in length.

Along each upland segment of the transect, shrub and herb species occurrence was recorded at 1 meter intervals by estimating the number of centimeters of a species occurrence in each meter interval intercepted by the vertical projection of the line transect (Figure 4). This is a standard line transect technique (Mueller-Dombois and Ellenberg, 1974) and provides a data base for the calculation of herb and shrub species frequency and cover in the upland vegetation.

Tree species canopy cover was recorded to the nearest 5 percent in a 10 x 10 m upland macroplot centered 5 m toward the marsh from the terminal stake in the upland for each transect (Figure 4). Tree species basal area was recorded at the same point using a 10-factor cruising prism recording basal area in m^2/ha (Mueller-Dombois and Ellenberg, 1974).

The macroplot data taken from 10 macroplots per marsh was a useful assessment of the upland forest vegetation and could be analyzed in

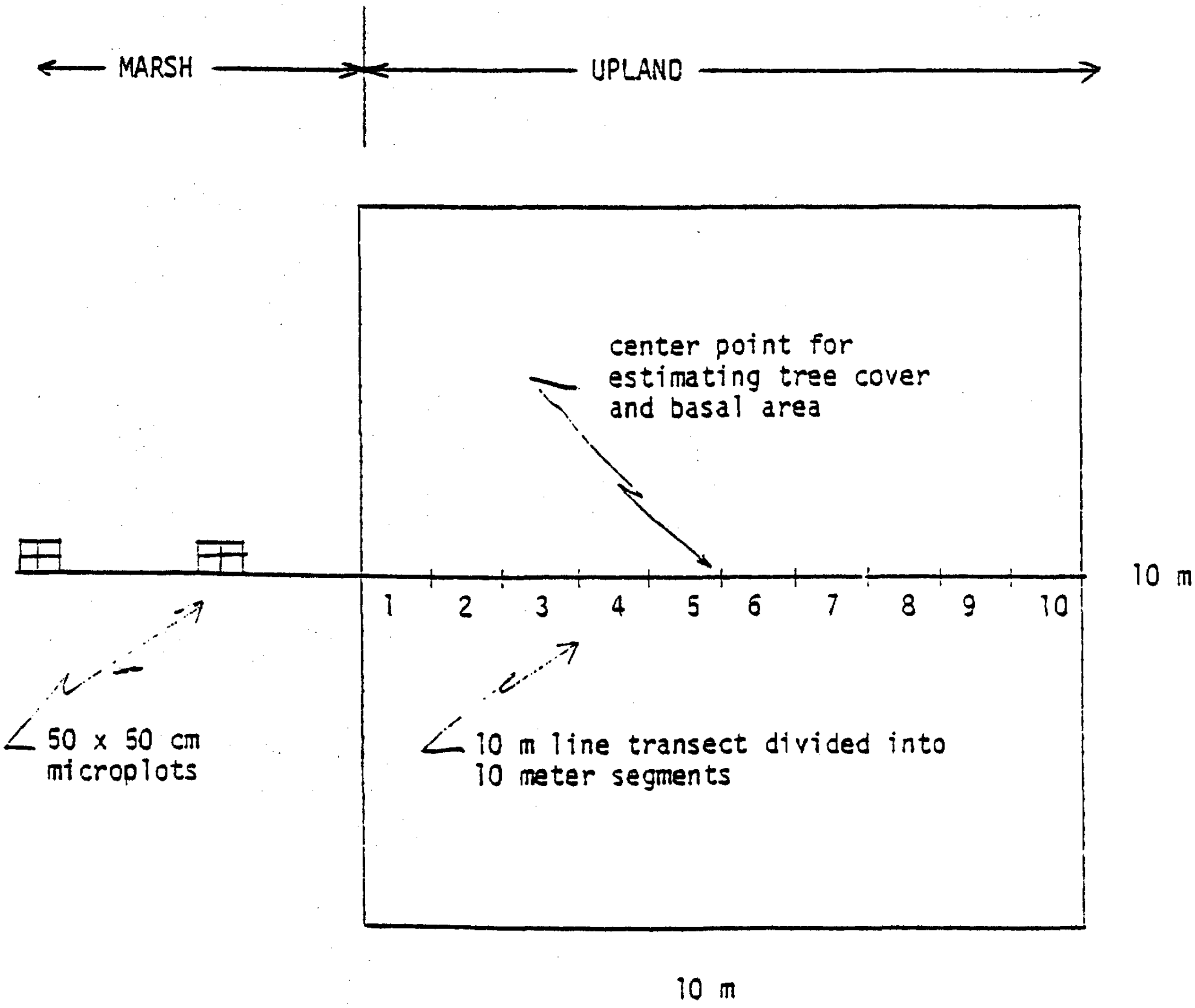

Figure 4. Upland sampling system used with each transect showing 10 x 10 m macroplot, 50 x 50 cm microplot used for sampling marsh and transition zone vegetation, and line transect for upland herbs and shrubs.

terms of tree species frequency, cover, and basal area. Together with 100, one meter segments (10 segments per transect for 10 transects), the line transect data was useful in characterizing the understory vegetation.

However, a methodological problem occurred in that the upland vegetation data,were incompatible with the marsh and transition zone vegetation because of the different sampling systems. To resolve this problem, the understory vegetation data for the first three-meter segments along each upland transect were treated as though they had been collected in three adjacent 50 x 50 cm square plots. This would be equivalent to a 25 x 100 cm rectangular plot centered and parallel with the line segment. Considering parallax problems in siting the vegetation cover intercepting a line transect segment, this distortion of the line transect data appeared acceptable for analytical purposes. This distortion was necessary in order to accomodate the data in the same computer program.

Marsh Zonation

In the field, after initial reconnaissance, a judgment was made as to the lower boundary of the transition zone between upland and marsh. Field determination of this ecotone boundary proved extremely difficult in many cases. In six marshes, field determination of the lower boundary of the transition zone was not made. The criteria used to help define this boundary are listed below. These criteria were considered as working hypotheses and were based on several years of field experience by the senior investigator. Not all of these criteria fit a particular marsh situation.

1. Sudden drop in dominance of *Deschampsia cespitosa*.
2. Sudden increase in dominance of *Potentilla pacifica*.

3. Appearance of individuals of *Aster subspicatus*, *Holcus lanatus*, *Trifolium wormskjoldii*, and *Vicia gigantea*.

4. Strong diminishing of low marsh species such as *Carex lyngbyei*, *Distichlis spicata*, *Glaux maritima*, *Jaumea carnosa*, *Orthocarpus castillejoides*, *Plantago maritima*, *Salicornia virginica*, *Triglochin maritimum* and others.

5. The build up of litter.

6. Beginning of strand material accumulation.

7. Sudden decrease in tidal creek density.

8. An occassional abrupt increase in slope perceived in the field.

The lower boundary tentatively recognized in the field was staked and referred to as MTZ.

A second judgment made in the field was the position of the upland-transition zone boundary; i.e., the beginning of the upland. Usually this decision was made rapidly and with little analysis. Primary criteria include:

1. Sudden appearance of numerous species known to be upland plants.

2. Change from herbaceous to forest and shrub physiognomy.

3. Abrupt change in slope.

Analytical Methods

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Basic Approach

Following a pilot study on Oregon coastal marshes in 1976 (Frenkel and Eilers, 1976) and the research of Macdonald (1977), Eilers (1975), Jefferson (1975), Macdonald and Barbour (1974) and Barbour (1970); it was assumed that no single plant species could adequately differentiate coastal intertidal wetland from upland. On the other hand, it was assumed that species groupings, or vegetation, might provide a possible means for distinguishing upland from wetland. Vegetation, which includes the relative abundance of a given species, appeared to be a more realistic measure of upland-wetland separation than either a single species or, for that matter, a small set of species.

The approach taken here may be likened to a series of successive approximations in defining the limits of a coastal intertidal wetland. The initial task of objectively determining lists of species which are intertidal and upland plants respectively involves six distinct phases. The second task of determining a single measure for defining whether a given micro-plot is intertidal marsh or upland is the final, seventh, phase. Phase I involved field sampling and the tentative identification of the lower and upper boundary of the transition zone in the field. Phase II involved the floristic classification of each marsh by a standard Braun-Blanquet technique showing, in tabular form, groups of samples with mutually present and absent species and the cover of those species. Phase III involved the classification of each sample into one of five zones based on a preliminary model of marsh zonation. A sixth zone was established for upland vegetation. Phase IV involved the determination, for each species, of its percent frequency, average percent cover, and marsh importance value in terms of its occurrence in one of the five zones. Phase V involved the classification of each species into one of four groups providing three lists of plant species identifying low marsh, high marsh, upland; and a fourth list of those species which poorly identified marsh zonation and upland situations. Phase VI involved the application of descriminant analysis as an objective test of the classification of samples into five zones as developed in Phase III. Phase VII uses the species lists developed in Phase V to produce a single measure for a microplot so as to classify it as either marsh or upland.

I. Field Identification

The perception of marsh zonation is well established in the ecological literature. Although actual distribution of species in a marsh and up into upland may be most realistically viewed as a flow of species across a complex gradient, it is convenient to view marsh vegetation in terms of clusters of species occuppying more or less distinct bands (Eilers, 1975). Thus, it was common for the field crew to view a given marsh type as a "low marsh", "high marsh", "transitional marsh" and upland. These terms were used frequently by the field crew and represented a tentative and intuitive model of the marsh-upland vegetation pattern. Furthermore, associated with each of these intuitive vegetation types was a typical assemblage of species (Appendix B and Tables 9, 10, 11, 12). Alternatively, when in the field, the occurrence of a number of species would be used by the field researchers in identifying a particular marsh type. Consideration would also be given to species presence, species dominance as indicated by cover, changes in cover, absence of certain species, position along a transect, microtopography, drifted or stranded material, etc. This intuitive field classification of vegetation has been called "entitation" (Mueller-Dombois and Ellenberg, 1974) and governed the specific decisions regarding the placement of stakes at the lower and upper boundary of the transition zone. This intuitive model of marsh-upland vegetation zonation perceived in the field then became further refined in the laboratory.

II. Floristic Classification

Field notebook data were entered into standard data forms, one form per transect, giving sample position along transects, stake positions, and percent bare ground, stranded material, litter and algae in terms of a Daubenmire cover class. Species occurrence and cover class were listed as was line transect data. Upland tree cover and cruising prism data were also filled-in. These standard data forms were used to complete computer coding forms where one coding form line or one IBM computer card represented a single sample. Later, it was necessary to use two cards per sample in order to accomodate additional species commonly found in the upland. Appendix C shows the data input arrangement on each computer card. This raw data was manipulated by a number of programs discussed subsequently.

Floristic data from individual marshes was processed by a computer program, PHYTO, developed by J. J. Moore (1970) and discussed by Frenkel and Harrison (1975). The program simulates the initial steps of the traditional Braun-Blanquet tabular analysis. The method is used most often for vegetation reconnaissance survey where vegetation units (plant communities) are identified on a local and regional scale. It proceeds from the field description of a number of homogeneous stands from which a number of samples are taken, to the subsequent arrangement in the laboratory of similar samples into groups, or associations, based on mutual presence and absence of species. Differential species, for which occurrence is restricted to certain groups of samples, are clearly depicted in tabular form. The program PHYTO rearranges both rows of species and columns of samples based on pairs of "division species" detected by program subroutine COR. Detected division species are moved to the left of the table, those without either or both "division species" remain on the right.

Data from each marsh were individually processed by the PHYTO program option autodivide, employing an objective algorithm to detect the two best pairs of opposing differential species. The data from marsh and transition zone samples only were used in this analysis. Upland transect data were not included. The output of this option was a partially structured table. This table was further altered by operator-given instructions to provide a "cleaner" tabular arrangement. Usually at least three groups, or associations, of species could be identified in each marsh. This floristic classification of the marsh vegetation represented an objective improvement over the intuitive field model of the marsh-upland ecotone and enabled a more objective classification of marsh vegetation into discrete zones.

III. Zonal Classification

Each sample was assigned to one of six marsh-upland zones based on floristic criteria. The criteria were developed from the association tables in which distinct groupings of species could be seen in relation to general positions in the marsh-upland continuum. Furthermore, a general list of species was prepared based on field research experience which showed the typical range of plant species in the marsh-upland continuum in Oregon and Washington (c.f., Appendix B). Descriptions of these zones is given in Table 7 together with brief criteria. While classification of samples into one of six zones might appear arbitrary,

Table 7. Marsh-upland zones used in analysis of Oregon and Washington coastal marsh vegetation.

Zone	Description	Criteria[1]
Zone 1	Low-Marsh	Occurrence of mudflat colonizers, association of low marsh species without any transition or upland species, dominance by one or more "marsh" species.
Zone 2	High Marsh	Replacement of mudflat colonizers by upper (high) marsh species with a few transition zone species, absence of upland species, dominance by upper (high) marsh species.
Zone 3	Lower Transition	First strong dominance by transition zone species, appearance occasionally of upland species, reduction in dominance of high marsh species.
Zone 4	Transition	Continued strong dominance by transition zone species but the entry of upland species and the loss of marsh species.
Zone 5	Upper Transition	Increased dominance of upland forbs and graminoids but not of woody plants, continued prominence of transition zone species.
Zone 6	Upland	Change from herbaceous to shrub or forest physiognomy, dominance by upland species and general loss of transition species.

[1] Criteria were relatively judgmental. Researchers evaluated individual species in a sample, dominance, and associations. Species list in Appendix B presents species distributions.

reproducible classification was achieved among the three researchers involved. The accuracy of this zonal classification was tested by discriminant analysis. The tentative allocation of samples to zones was necessary to process the data by discriminant analysis and was suggested by a statistical consultant. The zonal classification represented still a further refinement and simplification of the marsh-upland model over that developed by floristic classification and provided the analytical base for further treatment of species data.

IV. Analysis of Species Frequency, Cover and Importance

Of 154 vascular plant species encountered in this study in Oregon and Washington (Appendix B), 65 were selected for analysis of marsh and transition zone vegetation and 50 were selected for analysis of upland vegetation. Species were included for analysis if they occurred, regardless of cover, in two or more marshes or if they occurred in a single marsh in more than six microplots. All, except the very rare and ephemeral species met these criteria and were included in analysis. Species importance by marsh, by zone, and for all marshes was evaluated by calculating frequency, cover, and marsh importance values.

Frequency. Plant species frequency was calculated individually for each marsh, zone and in aggregate. Frequency (F) is the number of times a given plant species occurs (P) in a set of samples (N) and is expressed in percent:

$$F = \frac{P}{N} \times 100$$

Frequency provides for an objective assessment of species importance similar to cover and density. It is a non-absolute measure because it is a function of plot size and shape. Although plot size and shape were held constant in this study, species frequency still is considered a non-absolute measure of species importance. Frequency tends to give some indication of the uniformity of species distribution, but generally confounds the relation between density and dispersion (Grieg-Smith, 1964). The parameter is easily calculated but difficult to interpret in an objective way.

Frequency of upland shrub and herb species was determined by the number of occurrences in a set of one meter-long line transect segments (often 100 per marsh).

The SPSS (Statistical Package for the Social Sciences) Program, Version 6.5A calculated marsh by marsh frequencies with a separate cross-tabulation for each species by zone.

Cover. Plant species average percent cover was assessed individually by marsh, zone and in aggregate. Average percent cover (C) is the mean of all percent cover (c) measures for a given set of samples (N):

$$C = \frac{1}{N} \sum_{i=1}^{N} c_i$$

Species cover was estimated within microplots in the field as a cover class and converted to midpoint values (Table 5). Since cover (c) is the relative canopy coverage within a microplot and is expressed by percent, average cover is also expressed by percent. Cover is a surrogate for species dominance, the amount of control that a given species exerts locally. A species which exhibits high coverages, occupies most of the area under consideration and gives local character to the vegetation. It also, presumably has a competive advantage over a species with low cover.

While cover of the marsh and transition vegetation species was estimated in a microplot, species cover in the upland herb and shrub vegetation was estimated along one-meter segments of a line transect.

Species total percent cover and mean percent cover was calculated by the SPSS Version 6.5A Program with output by species, marsh, and marsh zone.

Marsh Importance Value. A single measure of species importance has often been the object of ecological research. Curtis and McIntosh (1951) have developed an objective measure combining three quantitative parameters--density, basal area, and frequency. While any one of these parameters may be regarded as an "importance value", together, they combine three somewhat different measures leading to a single value. We have modified the Curtis and McIntosh index to combine frequency and cover.

A species' marsh importance value (MIV) is the sum of the relative frequency (RF) and relative average percent cover (RC):

$$MIV = RF + RC$$

Relative frequency (RF) is the frequencies of a species (F) divided by the sum of all species frequencies and is expressed as a percent:

$$RF = \frac{F}{\sum_{i=1}^{s=65} f_i} \times 100$$

Likewise, Relative Cover (RC) is the average percent cover of a species (C) divided by the sum of all species' average percent cover and is also expressed as a percent:

$$RC = \frac{C}{\sum_{i=1}^{s=65} c_i} \times 100$$

Species marsh importance values have been computed by a specially written program which has the following outputs for each species by marsh and zone:

1. Zonal species frequency (frequency of each species in each zone for a given marsh)

2. Zonal total frequency (sum of all frequencies above regardless of species for each zone in a given marsh)

3. Zonal relative species frequency (relative frequency of each species for each zone with reference to the total frequency in each zone for a given marsh)

4. Zonal species dominance (average percent cover of each species in each zone for a given marsh)

5. Zonal total dominance (sum of all average percent cover values above regardless of species for each zone in a given marsh)

6. Zonal relative species dominance (relative percent cover of each species for each zone with reference to the total percent cover in each zone for a given marsh)

7. Zonal species importance value (sum of zonal relative frequency and zonal relative species dominance for each species in each zone for a given marsh)

These synthetic data have been analyzed in tabular form and have been presented for each marsh and selected transects in graphic form as well. These data form the basis for developing analytically supported species lists specific for the separating the marsh-upland continuum.

V. Marsh Group Species Classification

To develop lists of species which can enable the researcher and wetlands manager to better identify the separation of marsh from upland, critical inspection of the synthetic data developed in Phase IV (which shows species distribution in the marsh-upland vegetation complex) was undertaken. Three tables (frequency, average species cover and species marsh importance value by the five marsh zones for all marshes in aggregate) were inspected in terms of the trends the species exhibited in each zone. Four groups of species were recognized: low marsh, high marsh, upland-high transition zone, and a miscellaneous group of non-indicator species. For each group, a simple set of criteria was developed entering of the trends of each species across the five zones (Table 8). The degree to which a given species met the criteria was evaluated by assigning a point system: very good (vg) = 2, moderate (m) = 1, poor (p) = 1. A total of 4 points was possible for a given species.

VI. Discriminant Analysis

In order to objectively test the classification of samples into marsh zones which were based on marsh floristics, marsh samples were analyzed by stepwise discriminant analysis using the standard subprogram DISCRIMINANT in the Statistical Package for Social Sciences, Version 7.0. Marshes were independently analyzed with this program.

Discriminant analysis provides a means of statistically distinguishing two or more groups of cases, in this instance marsh zones.

> To distinguish between the groups the researcher selects a collection of discriminating variables that measure characteristics on which groups are expected to differ....The mathematical objective of discriminant analysis is to weight and linearly combine the discriminating variables in some fashion so that the groups are forced to be as statistically distinct as possible....Discriminant analysis attempts to do this by forming one or more linear combinations of discriminating variables. These discriminant functions are of the form
>
> $$D_i = d_{i1}Z_1 + d_{i2}Z_2 + \ldots + d_{ip}Z_p$$
>
> where D_i is the score on the discriminant function i, the d's are weighting coefficients, and the Z's are the standardized values of p discriminating variables used in the analysis. The maximum number of functions which can be derived is either one less than the number of groups or equal to the number of discriminating variables, if there are more groups than variables....Once the discriminant functions have been derived, we are able to pursue the two research objectives of this technique: analysis and classification.

Table 8. Criteria for classifying species into marsh groups and scoring system.[1]

Marsh Group	Criteria[2]
Low Marsh Species	(a) Decreasing frequency, cover and importance from marsh zone 1 to marsh zone 5 (b) High concentration of these three parameters in marsh zones 1 and 2, low in marsh zones 4 and 5
High Marsh Species	(a) Maximum concentration of frequency, cover, and importance in marsh zone 2, low concentration of these parameters in zones 1, 4 and 5 (b) Maximum concentration of these three parameters in marsh zone 2 and a steady decline from marsh zone 2 to 5
Upland Species	(a) Increasing frequency, cover and importance form marsh zone 1 to marsh zone 5 (b) High concentration of these three parameters in marsh zones 4 and 5 and low in marsh zones 1 and 2
Non-Indicator Species	Species for which frequency, cover, and importance showed no particular trends

[1] Criteria refers to the five marsh zones as developed in Phase III of the methodology

[2] Criteria were applied independently for frequency, dominance and importance

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> The analysis aspects of this technique provide several tools for the interpretation of data. Among these are statistical tests for measuring the success with which discriminating variables actually discriminate when combined into the discriminant functions....Since the discriminant functions can be thought of as the axes of a geometric space, they can be used to study the spatial relationships among groups....More importantly, the weighting coefficients can be interpreted much as in multiple regression or factor analysis. In this respect they serve to identify the variables which contribute most to differentiation along the respective dimension (function).
>
> The use of discriminant analysis as a classification technique comes after the initial computation. Once a set of variables is found which provides satisfactory discrimination for cases with known group memberships, a set of classification functions can be derived which will permit the classification of new cases with unknown memberships....
>
> As a check of the adequacy of our discriminant functions we can classify the original set of cases to see how many are correctly classified by the variables used. The procedure for classification involves the use of a separate linear combination of the discriminating variables for each group. These produce a probability of membership in the respective group, and the case is assigned to the group with the highest probability (Klecka, 1975: 435-436).

Variables are the 65 species used in analysis indicated by their cover values, cases as already mentioned are the five marsh zones which were initially classified by an intuitive marsh model. The selection of the best set of discriminating variables was controlled by a minimum Wilke's lambda. The analysis proceeds stepwise by choosing a variable (species) which best differentiates all groups (marsh zones), it registers the "effectiveness" of this species in classification and then moves on to the next most "effective" variable. Usually about 10 steps (species selected) were necessary to fully classify the marsh but often three or four species were most "effective". The discriminant functions, weighting factors, and standardized factors are all given in a summary printout. Included as a separate printout is a plot of the discriminant function 1 vs. discriminant function 2 showing a spatial separation of the five marsh zones. Finally, a matrix printout evaluates the predicted group membership versus the actual group.

While the discriminant analysis evaluates, marsh by marsh, the "accuracy" of our initial marsh zonation classification, it deals with the entire set of marsh zones. The technique could be used to evaluate the classification of just two zones or types, e.g., upland vs. marsh or marsh vs. transition zone, where variables remain species. This use of the technique to the problem at hand was not undertaken.

VII. Multiple Occurence Measure

The lists of species objectively defined in Phase III allocate plants into one of four categories (Table 8): low marsh species, high marsh species, upland species and species which are not indicators of upland or marsh. These four lists have been used in calculating a single measure for defining whether a sample is best classified as intertidal marsh or upland. This measure is computed simply by the Multiple Occurrence Method (see page 223) for any microplot and may be applied to a sequence of microplots along a transect from marsh to upland in order to define a transition zone and upper limit of marsh.

RESULTS AND DISCUSSION

General

Introduction

Description and analysis of results are divided into two major sections: field analysis which involves summary description, marsh by marsh, of field results with attention paid to floristic changes along transects, field identification of transition zone boundaries, description of upland; and synthetic analysis which involves treatment of species distribution across all marshes by zone, discriminant analysis upland vegetation synthesis and a definition of the transition zone. Additionally, salinities are treated in a brief section. In terms of the presentation of the methods, Phase I and II are dealt with in field analysis and Phase III - VII in synthetic analysis.

Intermarsh Floristic Variation

In any study spanning six degrees of latitude and investigating a diversity of coastal intertidal marsh habitats, some major floristic variations might be expected among the marshes studies. Appendix B shows all species encountered in the study with suggested distributional positions of species in the marsh-upland continuum based on field experience. Of 154 species encountered, 31 were judged "intertidal coastal salt marsh plants" (Table 9). These are plants which normally may be found in the intertidal marsh or at the upper levels of the marsh under the influence of periodic inundation by salt water. One may possibly separate these as "low marsh" species and "high marsh" species

Table 9. Intertidal coastal salt marsh vascular plant species in Oregon and Washington.[1]

Agrostis alba	MTUW	*Plantago maritima*	MTU
Atriplex patula	MT	*Potentilla pacifica*	MTUW
Carex lyngbyei	MTW	*Puccinelia pumila*	M
Cotula coronipifolia	MTW*	*Salicornia virginica*	MT
Cordylanthus maritimus	M	*Scirpus americanus*	MTW
Cuscuta salina	M	*Scirpus cernuus*	MTW
Deschampsia cespitosa	MTW	*Scirpus maritimus*	MT
Distichlis spicata	MT	*Scirpus validus*	MTW
Eleocharis palustris	MTW	*Spartina alterniflora*	M*
Festuca rubra	MTU	*Spergularia canadensis*	M
Glaux maritima	MT	*Spergularia macrotheca*	MT
Grindelia integrifolia	MT	*Stellaria humifusa*	MT
Hordeum brachyantherum	MTU	*Triglochin concinnum*	M
Jaumea carnosa	MT	*Triglochin maritimum*	MT
Juncus balticus	MT	*Zostera marina*	M
Lilaeopsis occidentalis	MTW	*Zostera nana*	M*
Orthocarpus castillejoides	M		

[1] Plants commonly found in the intertidal marsh (M) but also occasionally occurring in the transition zone (T) and in freshwater wetlands (W) and upland (U). Dominance in a particular position is shown by underlining. Asterisk refers to an introduced plant species.

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but this was not done in this tabulation [illegible] were notable for being *both* low marsh species *and* freshwater indicators. These are identified by "W" in Table 9. For example, *Scirpus americanus*, *S. cernuus*, *S. validus*, *Deschampsia cespitosa*, *Potentilla pacifica*, and *Eleocharis palustris* were observed not only within the lower marsh, often with much freshwater seepage, but occassionally in somewhat freshwater wetlands at the upper edge of the marsh.

A second group of plants were those that were found in more or less freshwater conditions (salinities less than 4 ppt). These include some of the low marsh species mentioned above and additional wetland plants which were never found in intertidal salt marsh positions such as *Lysichitum americanum*, *Typha latifolia*, *Carex obnupta*, and *Athyrium filix-femina* (Table 10). Many of these plants were encountered in the *upper* portion of marshes where the tight fabric of upper marsh substrate together with decomposing stranded material was interpreted as forming a dam which blocked the surface and upper subsurface freshwater drainage into the estuary. Such freshwater conditions were found in almost every marsh site and are frequently documented in the transect data.

The largest group of species encountered were upland vascular plants (Table 11). At least 122 plants were judged within this group. Many of these, widely established in upland situations, also grew in the upper portion of the intertidal marsh. These were regarded, provisionally as "transition zone" plants, e.g., *Aster subspicatus*, *Trifolium wormskjoldii*, and *Vicia gigantea* but a satisfactory list of these wide-ranging species was not made. It is noteworthy that few intertidal salt marsh species and freshwater wetland species are introduced but 30 percent of the upland flora are non-native plants, often weeds of pasture and ruderal situations.

Table 10. Freshwater wetland vascular plant species growing in and adjacent to intertidal coastal marshes in Oregon and Washington.[1]

Agrostis alba	MTUW	*Lysichitum americanum*	W
Alopecurus geniculatus	UW	*Mentha arvensis*	UW
Alnus rubra	TUW	*Myosotis laxa*	TUW
Athyrium filix-femina	TUW	*Oenanthe sarmentosa*	TUW
Bidens cernua	TUW	*Phalaris arundinacea*	TUW*
Carex lyngbyei	MTW	*Physocarpus capitatus*	UW
Carex obnupta	TW	*Potentilla pacifica*	MTUW
Cotula coronopifolia	MT*	*Polygonum persicaria*	TUW
Conioselinum pacificum	TUW	*Rhamnus purshiana*	UW
Deschampsia cespitosa	MTW	*Salix* spp.	UW
Eleocharis palustris	MTW	*Scirpus americanus*	MTW
Equisetum spp.	UW	*Scirpus cernuus*	MTW
Fraxinus latifolia	UW	*Scirpus microcarpus*	TW
Hordeum brachyantherum	MTUW	*Scirpus validus*	MTW
Juncus effusus	UW	*Typha latifolia*	W
Juncus gerardii	TUW	*Urtica dioica*	UW
Juncus lesueurii	TUW	*Veronica americana*	UW
Lilaeopsis occidentalis	MTW		

[1] Plants commonly found in freshwater wetlands (W) but also occurring in the marsh (M), transition zone (T) and upland (U). Dominance in a particular zone is shown by underlining. Asterisk refers to an introduced plant species.

Table 11. Upland vascular plant species commonly found adjacent to coastal salt marshes in Oregon and Washington.[1]

Abies grandis	U	*Elymus glaucus*	U
Achillea millefolium	TU	*Elymus mollis*	TU
Agropyron repens	U*	*Equisetum* spp.	UW
Agrostis alba	MTUW	*Epilobium watsonii*	TU
Aira caryophyllea	U*	*Erechtites arguta*	TU*
Aira praecox	U*	*Festuca megalura*	U*
Alopecurus geniculatus	UW*	*Festuca rubra*	MTU
Alnus rubra	TUW	*Fragaria chiloensis*	U
Ammophila arenaria	U*	*Fraxinus latifolia*	UW
Angelica lucida	TU	*Galium aparine*	TU*
Anthoxanthum odoratum	TU*	*Galium trifidum*	TU
Arbutus menziesii	U	*Galium triflorum*	TU
Arenaria macrophylla	U	*Gaultheria shallon*	U
Arctostaphylos ura-ursi	U	*Gnaphalium purpureum*	TU
Aster subspicatus	TU	*Goodyera oblongifolia*	U
Athyrium filix-femina	TUW	*Heracleum lanatum*	TU*
Artemisia suksdorfii	U	*Holcus lanatus*	TU*
Berberis aquifolium	U	*Holodiscus discolor*	U
Berberis nervosa	U	*Hordeum brachyantherum*	MTUW
Bidens cernua	TUW	*Hypochaeris radicata*	U*
Blechnum spicant	U	*Ilex aquifolium*	U*
Bromus pacificus	TU	*Juncus effusus*	TUW
Calamagrostis nutkaensis	TU	*Juncus gerardii*	TUW
Carex pansa	U	*Juncus lesueurii*	TUW
Cirsium arvense	U*	*Lathyrus japonicus*	U
Cornus canadensis	U	*Lathyrus palustris*	TU
Conioselinum pacificum	TUW	*Lonicera hispidula*	U
Cytisus scoparius	U*	*Lonicera involucrata*	U
Dactylis glomerata	U*	*Lotus uliginosus*	TU*
Dicentra formosa	U	*Lupinus littoralis*	TU

[1] Plants commonly found in upland habitats but also occasionally occurring in the marsh (M), transition (T), and freshwater wetlands (W). Dominance in a particular habitat is shown by underlining. Asterisk refers to an introduced plant species.

Maianthemum dilatatum	TU	*Rubus laciniatus*	U*
Melilotus alba	U*	*Rubus parviflorus*	U
Mentha arvensis	UW	*Rubus spectabilis*	U
Montia sibirica	U	*Rubus ursinus*	U
Myosotis laxa	TUW	*Rumex acetosella*	U*
Myrica californica	U	*Rumex crispus*	U*
Oenanthe sarmentosa	TUW	*Rumex obtusifolius*	TU*
Osmaronia cerasiformis	U	*Rumex occidentalis*	TU
Phalaris arundinaceae	TUW*	*Sagina crassicaulis*	TU
Physocarpus capitatus	UW	*Salix hookeriana*	TU
Picea sitchensis	TU	*Salix* spp.	UW
Plantago coronopus	U*	*Sambucus racemosa*	U
Plantago lanceolata	TU*	*Senecio jacobaea*	U*
Plantago major	TU*	*Senecio vulgaris*	U*
Plantago maritima	MTU	*Sidalcea hendersonii*	TU
Polypodium glycyrrhiza	U	*Solanum nigrum*	TU*
Poa macrantha	U	*Sonchus oleraceus*	TU*
Potentilla pacifica	MTUW	*Stellaria calycantha*	TU
Polygonum paronychia	U	*Symphoricarpus albus*	U
Polygonum persicaria	TUW	*Thuja plicata*	U
Poa pratensis	U*	*Tiarella trifoliata*	U
Prunus spp.	U	*Trifolium pratense*	U*
Prunella vulgaris	TU*	*Trifolium repens*	U*
Pseudotsuga menziesii	U	*Trifolium wormskjoldii*	TU
Pteridium aquilinum	U	*Tsuga heterophylla*	U
Pyrus fusca	U	*Urtia dioca*	UW
Rhamnus purshiana	UW	*Vaccinium ovatum*	U
Ribes divaricatum	U	*Vaccinium parvifolium*	U
Ribes sanguineum	U	*Veronica americana*	UW
Rosa gymnocarpa	U	*Vicia gigantea*	TU
Rosa nutkana	U	*Vicia sativa*	U*
Rubus discolor	U*		

A few species were initially judged as having very broad habitat requirements and these species defied classification into the salt marsh, freshwater, and upland lists (Table 12).

Table 12. Vascular plant species with broad habitat associations and considered "non-indicator" species for wetland-upland differentiation of coastal Oregon and Washington salt marshes.[1]

Agrostis alba	MTUW	Juncus balticus	MTUW
Festuca rubra	MTU	Plantago maritima	MTU
Hordeum brachantherum	MTUW	Potentilla pacifica	MTUW

1 Plants commonly found in coastal intertidal salt marshes (M) but also occurring in the transition zone (T), upland (U), and freshwater wetlands (W). Dominance in a particular position is shown by underlining.

Many of these species were extremely widespread in all habitats. This was particularly true of Agrostis alba. However, it is possible that various ecological races have developed for this and other species which were not recognized based on reconnaissance taxonomy.

Appendix D shows the distribution of 65 vascular plant species commonly found in intertidal marsh and marsh-upland transition zone, regardless of abundance. While differences in abundance of various species were observed latitudinally, along the coast vs. in the Puget Sound, and among various substrates (coarse sand, sand, and silt); the actual ranges of plant species were continuous through the two-state study area. Some species showed greater expression in marshes to the north; e.g., Stellaria humifusa and Puccinellia pumila. No distinctly southern group of species occurred. Puget Sound marshes showed less strong zonation and more complex species distributions but no latitudinal variations were discerned. All together the intertidal marsh flora was strongly repetitive.

Field Analysis

In this section each study site is assessed in the same general manner. The format includes: a brief description of the study site including a locational map and in most cases a site map; mention of significant prior studies, if any; marsh type after Jefferson's (1975) classification; special characteristics of the marsh and upland; plant community pattern based on PHYTO; location of transition zone boundaries based on field assessment; discussion of typical transects with selected figures of species distribution along transects; summary of upland tree data; and, summary of upland shrub and understory herb data. Detailed locational information is given for each site in Appendix E.

Accompanying each study site discussion are typical samples of plant species cover profiles along transects, e.g., Figure 8. The standardized format for these profiles was to: (a) plot species percent cover by solid line figures where contiguous microplot samples along a given transect included the species in question; (b) plot species cover with a dashed line where the species in question was absent but was expected because of its presence elsewhere along the transect; (c) shade the area along the transect where tree cover prevailed and where sampling used line segments rather than microplots; (d) plot tree cover by solid black rectangle scaled to percent canopy cover; (e) plot profile elevation in meters above National Geodetic Vertical Datum of 1929 (NGVD) or an arbitrary datum provided by the NOS (1978) where available; (f) plot distance along profile with zero set at the "end-upland" stake (usually 10 m from the open marsh); and, (g) plot the position of the lower boundary of the transition zone stake (MTZ) and upper boundary of the transition zone stake (UP) as determined in the field.

After the site-by-site descriptions which follow, site-specific data has been aggregated and is discussed in the section entitled "Synthetic Analysis".

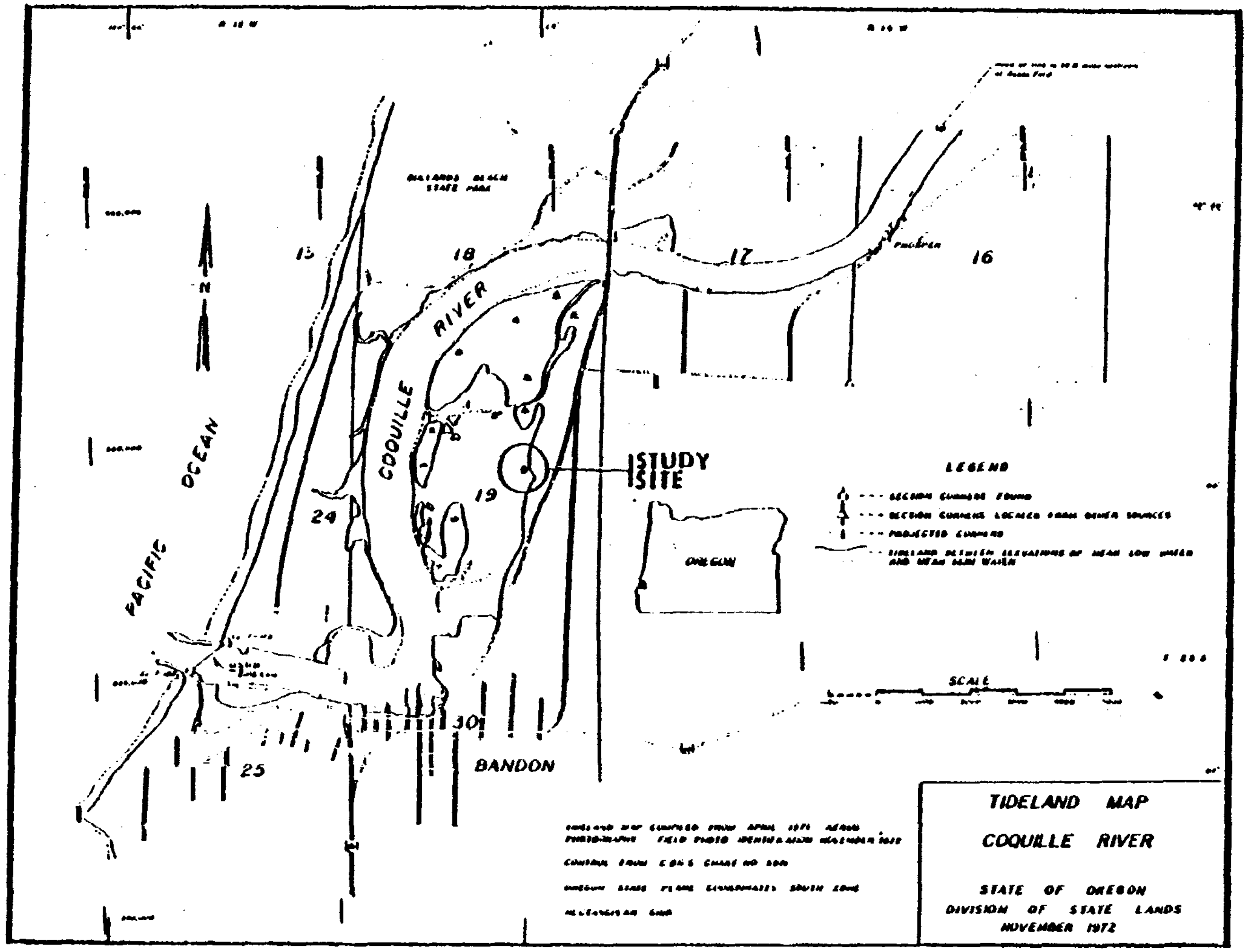

Figure 5. Location of Bandon study site, CQ1.

Bandon CQ1

Site Description. Situated in the Coquille River estuary, the most southerly Oregon estuary supporting extensive salt marsh vegetation (Figure 5), the Bandon marsh occupies about 150 ha on the east side of the river about 1 km north of Bandon. The marsh was classified by Jefferson (1975) as predominantly a low sand marsh with an extensive area of immature high marsh to the north and a fringe of mature high marsh adjacent to the upland. We concur with this classification. The marsh exhibits much freshwater seepage as indicated by extensive flats with Scirpus americanus, Lilaeopsis occidentalis and Scirpus cernuus. Johannessen (1961) suggested that the marsh is prograding rapidly and he interpreted the marsh creek system based on this assumption. However, exposed rooted Picea sitchensis stumps within the intertidal zone in the southern portion of the marsh suggests historic retrogradation or isostatic depression. Regardless, a developmental history of the marsh would be a worthwhile academic study. More recently, the marsh has been grazed by cattle and is fenced within the forest. No evidence of recent grazing damage was observed.

Generally devoid of extensive creek development, the marsh has one major creek which extends northward parallel to the upland. A broad expanse of sandy substrate marks the marsh center and is covered by dense mats of Ruppia maritima. The upper section of the marsh is heavily clogged with drift logs, many of which are piled-up against the fringing forest. Upland is characterized by a wet Picea sitchensis forest. A striking freshwater wetland with Lysichitum americanum which receives ground water seepage from "fossilized" sand dunes, was found along almost all transects. The marsh gradient was low with a sudden "step" usually between 5 and 20 m distant from the forested fringe.

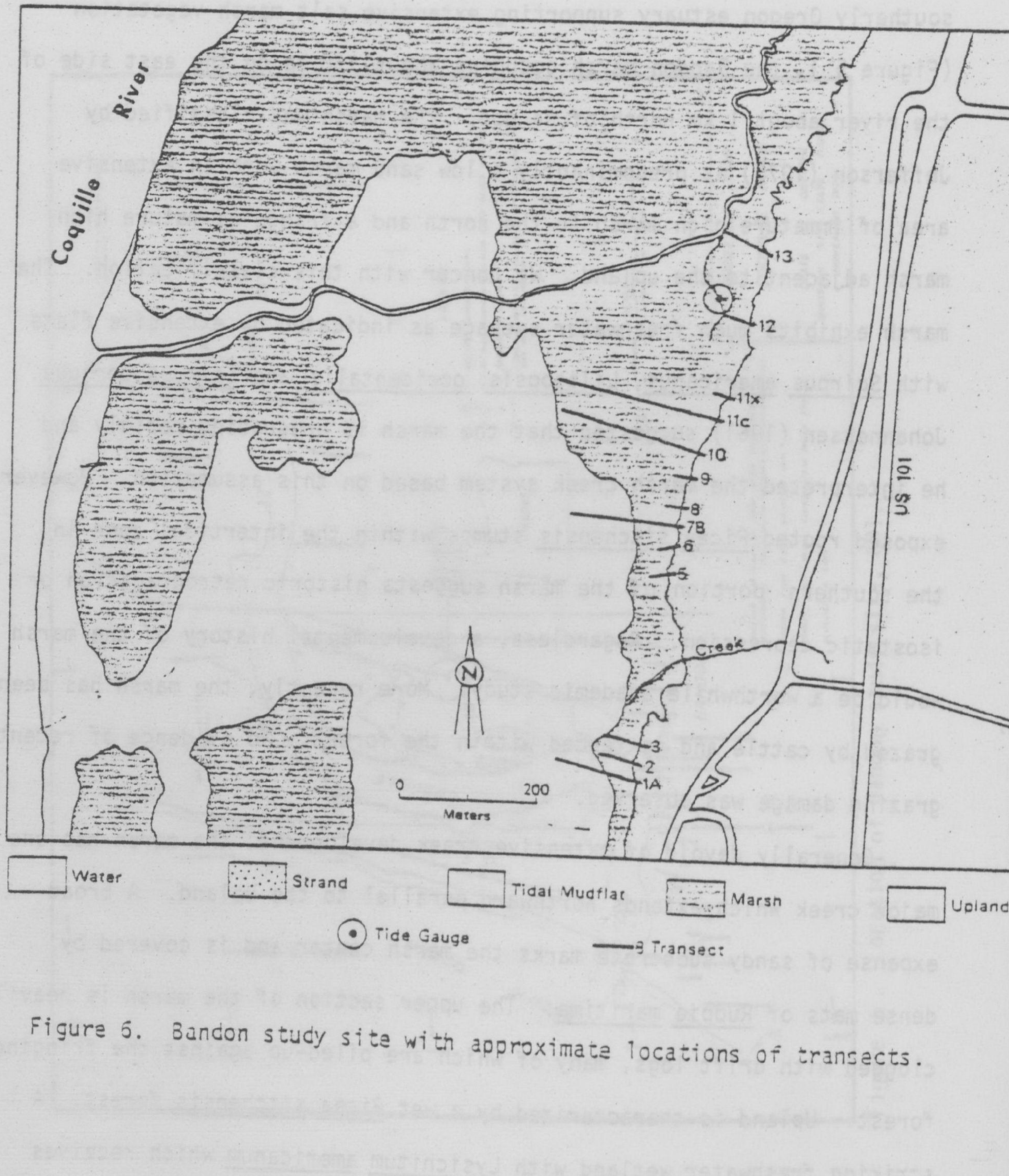

Figure 6. Bandon study site with approximate locations of transects.

Plant communities. Sampling along 12 transects with 168 microplots and 120 meter segments in the upland, permitted adequate characterization of the marsh vegetation. Figure 6 shows transect locations. Three marsh zones (low marsh, upper marsh, and upper transition) containing four major plant communities were identified (Figure 7). The four marsh communities were: (1) Scirpus americanus community dominated by this species but with thick mats of Ruppia maritima; (2) Scirpus americanus - Scirpus cernuus community also a low marsh assemblage but slightly higher in the marsh; (3) Juncus balticus - Potentilla pacifica community, a complex middle to high marsh assemblage usually found above the gradient nickpoint referred to above; and, (4) Vicia gigantea - Holcus lanatus community marking the upper drier fringes of the marsh often above heavy drift log accumulation.

The Scirpus americanus community, a low diversity low marsh community, colonizes the sand-flat and is flooded twice daily by every tide. With low tide, there is much evidence of freshwater seepage. Ruppia mats are a marked feature of this low marsh community.

The Scirpus americanus - Scirpus cernuus community, the principal low marsh assemblage, includes the following characteristic species:

Scirpus americanus
Scirpus cernuus
Liliaeopsis occidentalis
Jaumea carnosa
Orthocarpus castillejoides
Salicornia virginica
Plantago maritima

Other widespread low marsh plants, Carex lyngbyei, Distichlis spicata, Triglochin maritimum and Glaux maritima are also present. Slightly higher than the pure Scirpus americanus community, this low marsh group also is effected by freshwater seepage.

Representing the upper marsh zone was the heterogeneous Juncus balticus - Potentilla community. Included in this poorly defined

Presence	Code	Species	Serial number
		Low marsh zone	
[illegible]	[illegible]	Scirpus americanus	[illegible]
[illegible]	[illegible]	Scirpus cernuus	[illegible]
[illegible]	[illegible]	Lilaeopsis occidentalis	[illegible]
[illegible]	[illegible]	Jaumea carnosa	[illegible]
[illegible]	[illegible]	Orthocarpus castillejoides	[illegible]
[illegible]	[illegible]	Salicornia virginica	[illegible]
[illegible]	[illegible]	Plantago maritima	[illegible]
		Upper transition zone	
[illegible]	[illegible]	Vicia gigantea	[illegible]
[illegible]	[illegible]	Holcus lanatus	[illegible]
[illegible]	[illegible]	Achillea millefolium	[illegible]
[illegible]	[illegible]	Oenanthe sarmentosa	[illegible]
[illegible]	[illegible]	Galium triflorum (trifidum)	[illegible]
[illegible]	[illegible]	Rumex occidentalis	[illegible]
[illegible]	[illegible]	Stellaria calycantha (crassifolia)	[illegible]
[illegible]	[illegible]	[illegible] arguta	[illegible]
[illegible]	[illegible]	Picea sitchensis	[illegible]
		Upper marsh zone	
[illegible]	[illegible]	Carex lyngbyei	[illegible]
[illegible]	[illegible]	Distichlis spicata	[illegible]
[illegible]	[illegible]	Triglochin maritimum	[illegible]
[illegible]	[illegible]	Glaux maritima	[illegible]
		Other species	
[illegible]	[illegible]	Juncus balticus	[illegible]
[illegible]	[illegible]	Agrostis alba	[illegible]
[illegible]	[illegible]	Potentilla pacifica	[illegible]
[illegible]	[illegible]	Aster subspicatus	[illegible]
[illegible]	[illegible]	Deschampsia cespitosa	[illegible]
[illegible]	[illegible]	Trifolium wormskjoldii	[illegible]
[illegible]	[illegible]	Hordeum brachyantherum	[illegible]
[illegible]	[illegible]	Carex obnupta	[illegible]
[illegible]	[illegible]	Eleocharis palustris	[illegible]
[illegible]	[illegible]	Galium aparine	[illegible]
[illegible]	[illegible]	Cuscuta salina	[illegible]
[illegible]	[illegible]	Festuca rubra	[illegible]
[illegible]	[illegible]	Atriplex patula	[illegible]
[illegible]	[illegible]	Lathyrus palustris	[illegible]

Figure 7. Plant community table, Bandon study site.

community were a number of low marsh species such as *Carex lyngbyei* and *Distichlis spicata* but also typical high marsh species such as *Deschampsia cespitosa*, *Potentilla pacifica*, *Agrostis alba*, *Aster subspicatus*, and *Trifolium wormskjoldii*. Because of the inclusion of these plants with upland affinities, the community is regarded as marking either the uppermost marsh zone or the lower transition zone.

A distinctive upper transition zone assemblage, the *Vicia gigantea - Holcus lanatus* community typically included a number of upland plants suggesting its strong upland affinity. Yet, *Juncus balticus*, *Potentilla pacifica*, *Agrostis alba*, and *Aster subspicatus* were often locally dominant in this assemblage. This community was found among and often above the major accumulation of drifted logs.

Transects and transition zone. Twelve transects, three of which extended to the mudflat, were established over 1 km of the marsh. Figure 8 to 10 show three typical transects. The lower boundary of the transition zone was defined by the simultaneous appearance of such upland species as *Trifolium wormskjoldii* and *Aster subspicatus* and the disappearance of the typical low marsh species discussed above.

Upland vegetation was a dense *Picea sitchensis* forest with a moist understory often marked by *Lysichitum americanum* and *Oenanthe sarmentosa*. Three trees dominated as seen from the frequency and basal area data:

	Freq. (%)	Avg. Cover (%)	B.A. (m^2/ha)
Picea sitchensis	100	41	11.3
Alnus rubra	100	29	4.0
Myrica californica	58	5	0.4

Upland understory species with greater than 10 percent frequency in 120 samples included:

	Freq. (%)	Avg. Cover (%)
Alnus rubra	13.3	1.5
Gaultheria shallon	13.3	2.1
Lysichitum americanum	10.0	2.9
Maianthemum dilitatum	17.5	2.5
Oenanthe sarmentosa	32.5	6.3
Picea sitchensis	30.8	12.6

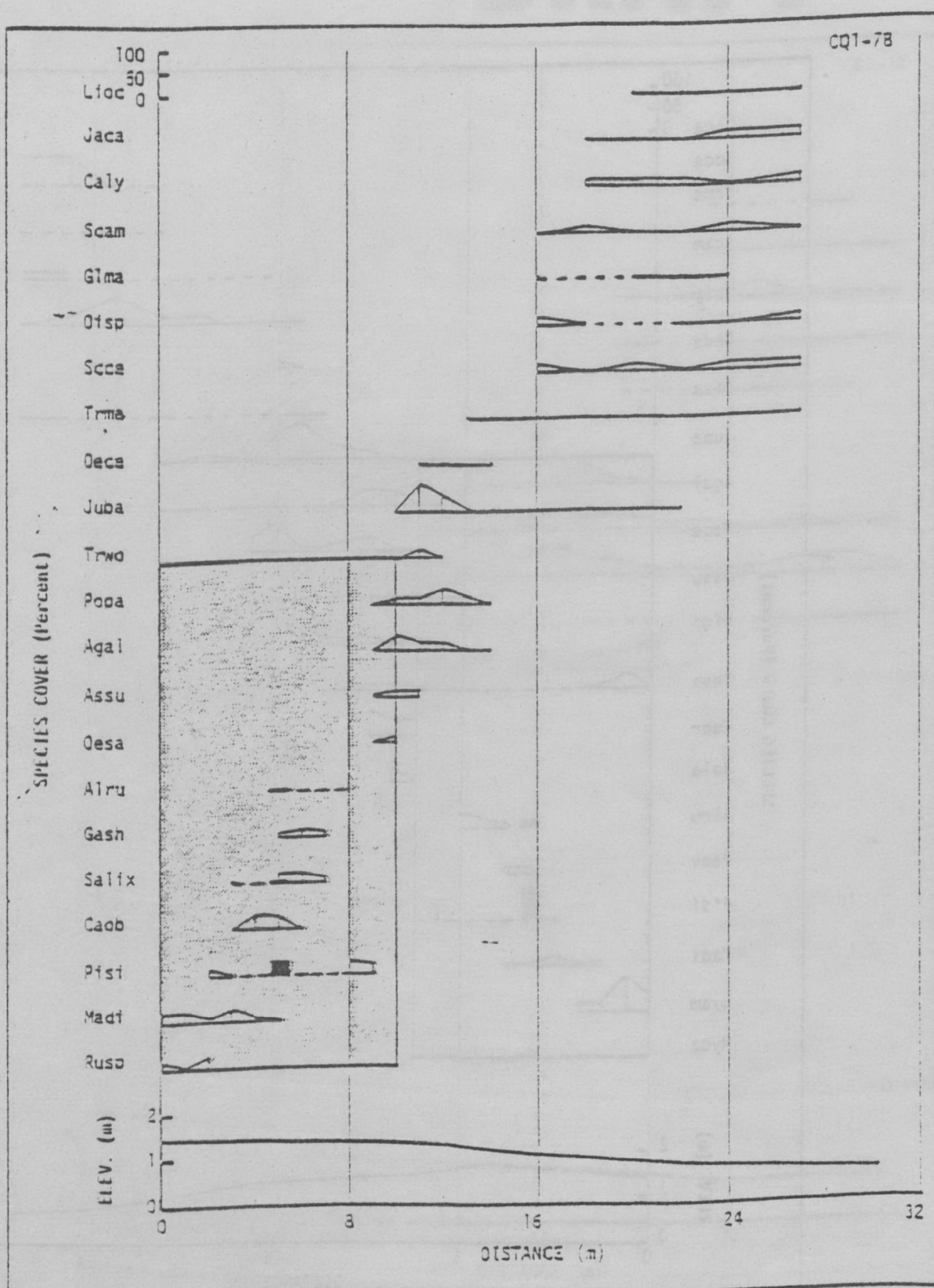

Figure 8. Plant species cover along transect CQ1-7B at Bandon study site.

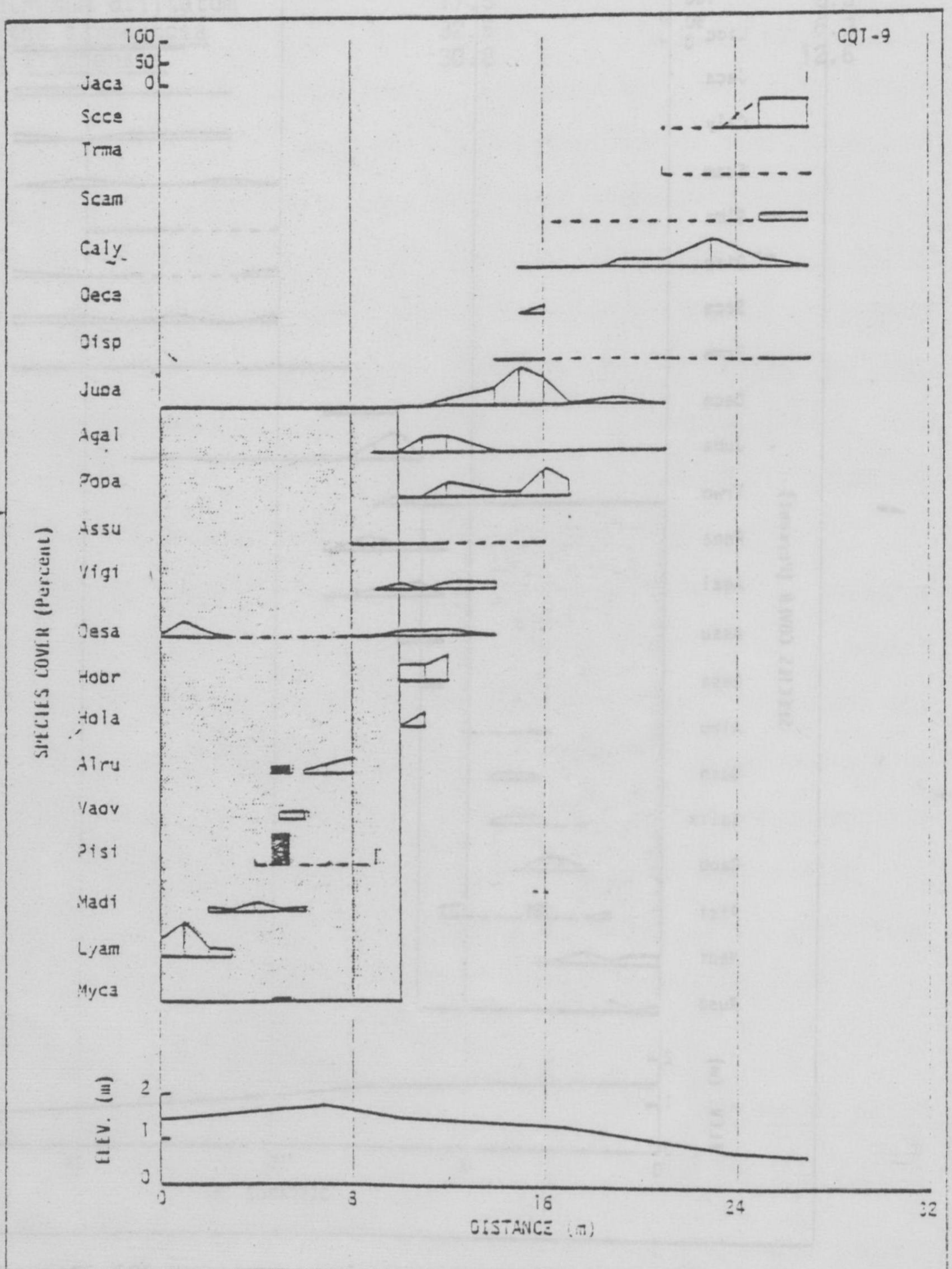

Figure 9. Plant species cover along transect CQI-9 at Bandon study site.

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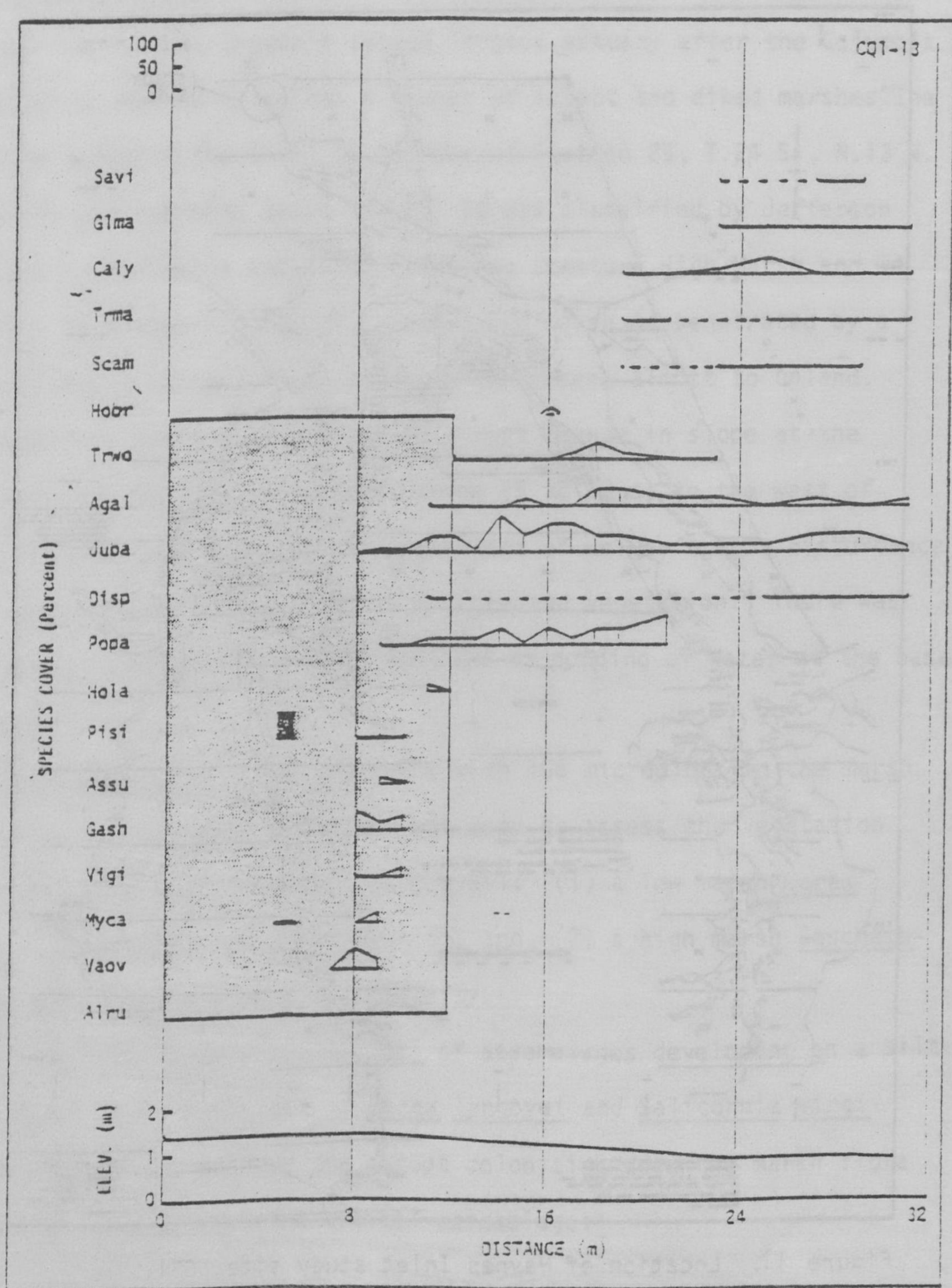

Figure 10. Plant species cover along transect CQ1-13 at Bandon Study site.

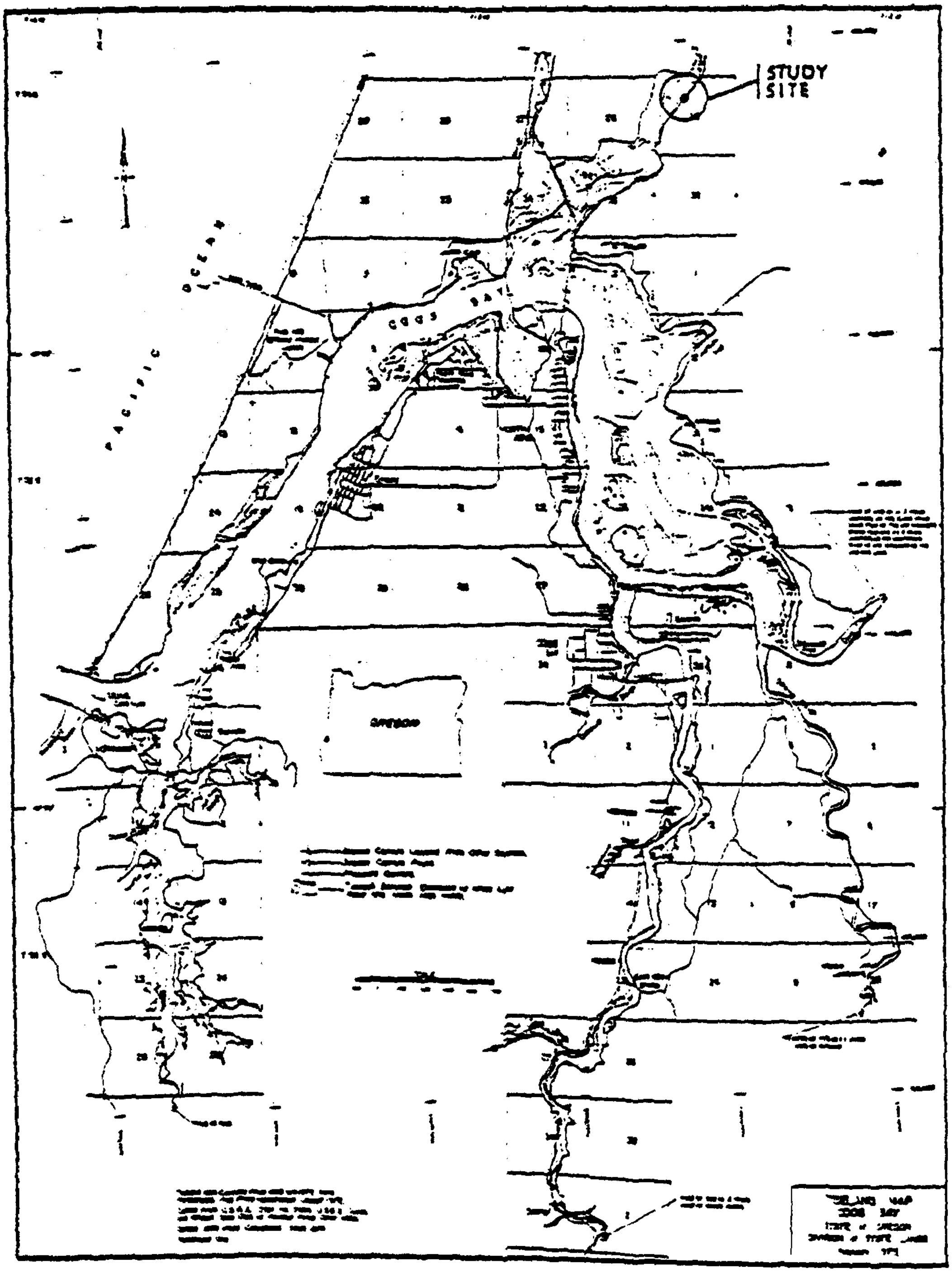

Figure 11. Location of Haynes Inlet study site, CB1.

Haynes Inlet CB1

Site description. In the northeasternmost extension of the Coos Bay estuarine system, Oregon's second largest estuary after the Columbia River Estuary, Haynes Inlet has a number of intact and diked marshes. The study site occupies the SW¼, of the NW¼ of Section 25, T.24 S., R.13 W. (Figure 11) and embraces about 11 ha. It was classified by Jefferson (1975) and by Hoffnagle and Olson (1974) as Immature High Marsh and we agree with this general classification. The marsh is penetrated by a number of deeply incised tidal creeks which extend almost to upland. The gradient is extremely low with an abrupt change in slope at the upland margin. The upland is very narrow (5 to 10 m) to the west of the old Oregon Coast Highway, the embankment of which forms a disturbance in the otherwise shrubby and partially forested vegetation. There was no freshwater seepage, few drift logs, and no ponding of water at the base of the upland.

Plant communities. Ten transects with 106 microplots in the marsh and 67 upland line segment samples were used to assess the vegetation (Figure 12). Two marsh communities prevail: (1) a low marsh Carex lyngbyei - Distichlis spicata community, and, (2) a high marsh Deschampsia cespitosa - Atriplex patula community.

The low marsh community, typical of assemblages developing on a silt substrate, was being colonized by Carex lyngbyei and Salicornia virginica. A short distance from the abrupt colonizing edge, the marsh flora increased to include the more typical assemblage:

Carex lyngbyei	(2)	Salicornia virginica	(2)
Distichlis spicata	(3)	Triglochin maritimum	(3)

The numbers, above, refer to typical cover classes.

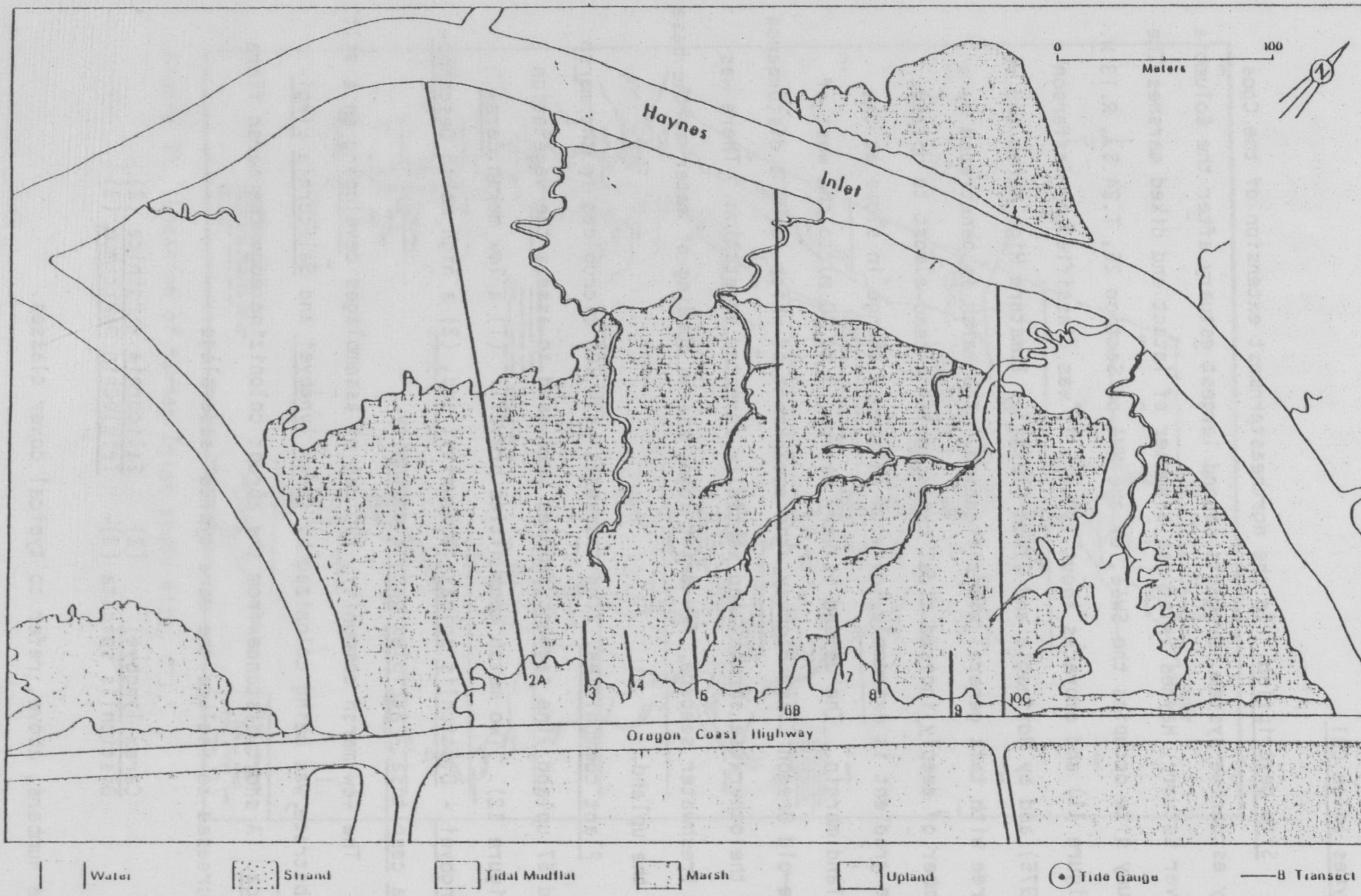

Figure 12. Haynes Inlet study site with approximate locations of transects.

Typical of an immature high marsh, the high marsh community was characterized by Deschampsia cespitosa but included all of the low marsh species but usually with diminished cover. Common species marking the high marsh were:

Deschampsia cespitosa	(3)	Agrostis alba	(2)
Atriplex patula	(1)	Carex lyngbyei	(2)
Distichlis spicata	(3)	Triglochin maritimum	(2)

Transects and Transition Zone. Three long transects permitted description of lower marsh structure. Two short transects CB and CB illustrate the structure of the upper marsh (Figure 13 to 15). No transition zone existed in this marsh; few upland species extended into the high marsh. Therefore the lower and upper boundary of the transition zone were coincident and occurred where there was an abrupt change in slope.

Upland vegetation was affected by disturbance, in fact, only two upland transects extended a full ten meters from the marsh. Six trees were present as shown by frequency data in 10 macroplots:

	Freq. (%)	Avg. Cover (%)
Alnus rubra	30	10
Myrica californica	10	2
Picea sitchensis	50	12
Pseudotsuga menziesii	30	7
Salix hookeriana	100	59
Tsuga heterophylla	10	--

Because of the disturbance and proximity to the road, no basal area data were possible.

Upland shrub and herb understory data from 67 upland line segments, reflected two kinds of upland habitats: an open shrubby habitat with plants early in successional stage, and a more closed coniferous forest habitat as seen from the following roster of species with greater

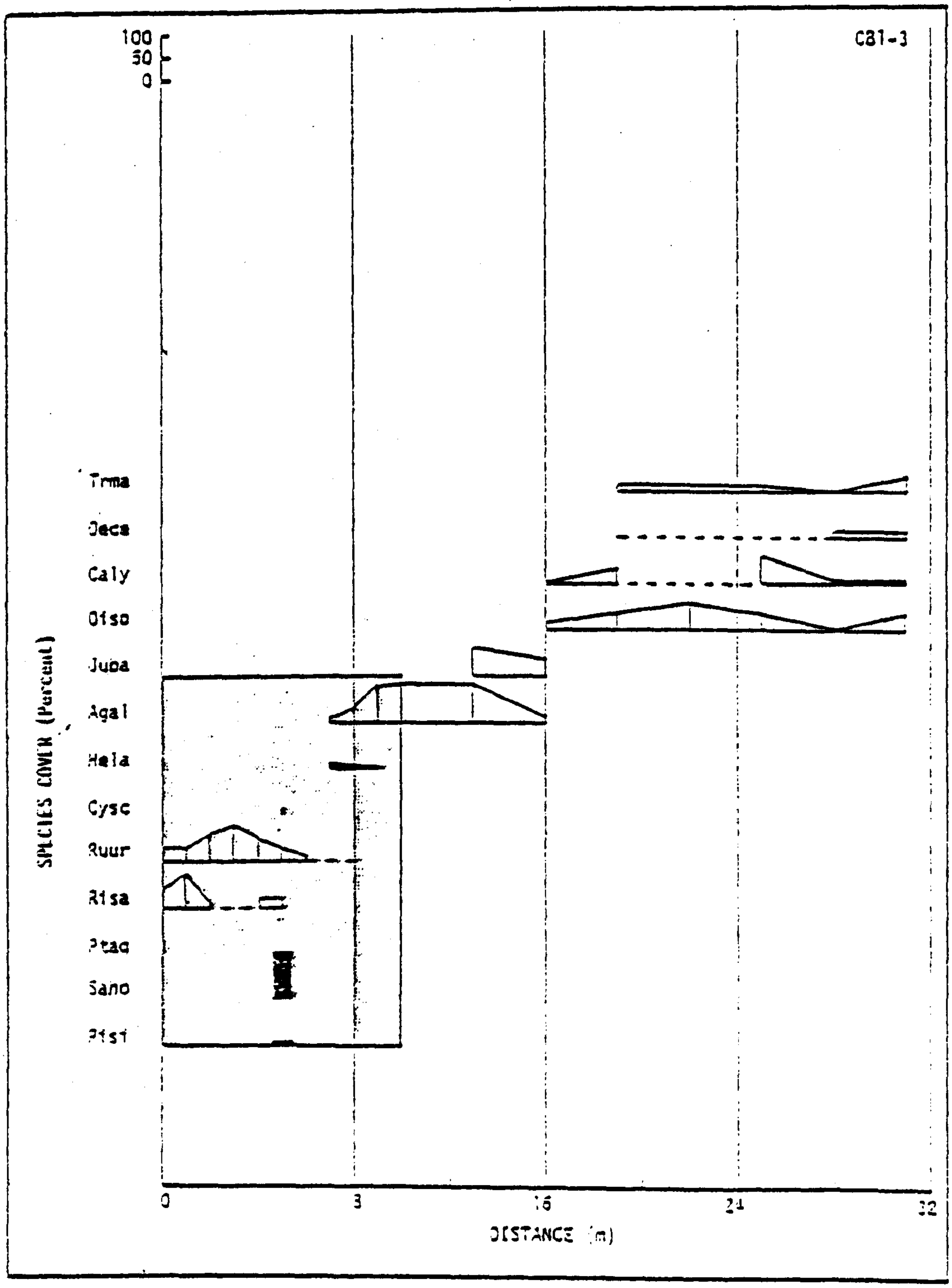

Figure 13. Plant species cover along transect C31-3 at Haynes Inlet study site.

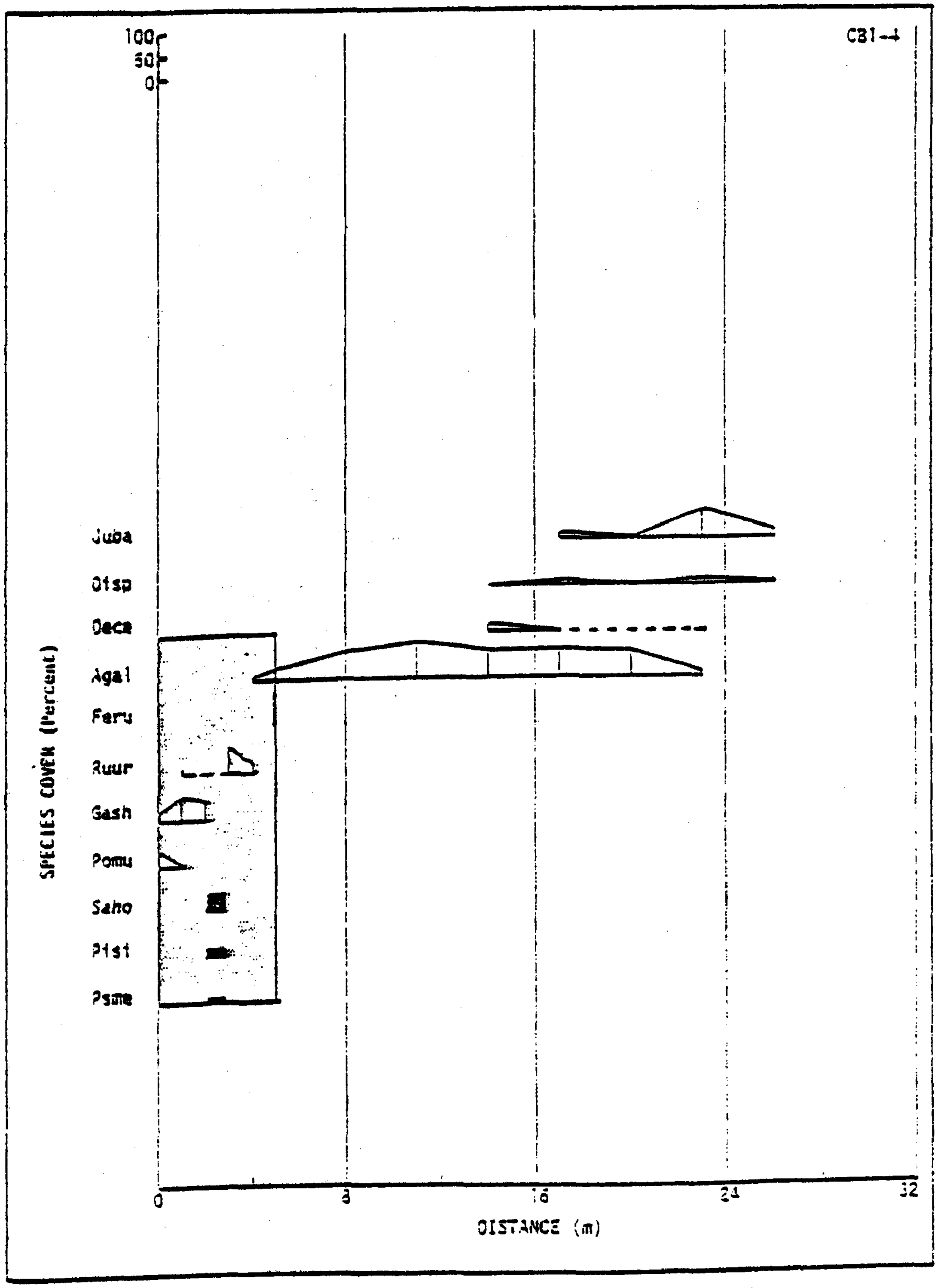

Figure 14. Plant species cover along transect CB1-4 at Haynes Inlet study site.

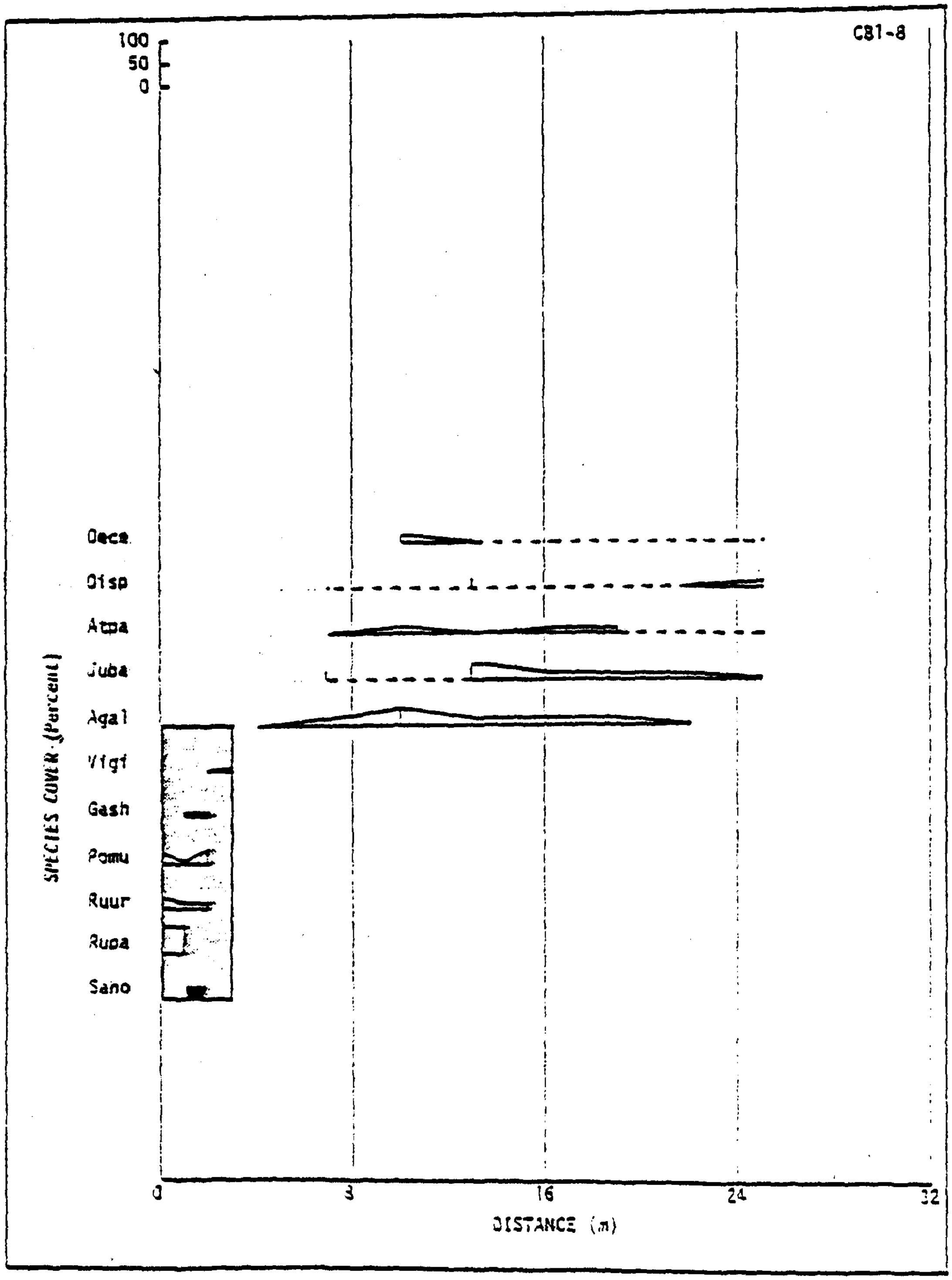

Figure 15. Plant species cover along transect CB1-8 at Haynes Inlet study site.

than 10 percent frequency:

	Freq. (%)	Avg. Cover (%)
Achillea millefolium	14.9	2.7
Agrostis alba (?)	22.4	6.3
Gaultheria shallon	20.9	5.7
Holcus lanatus	11.9	2.5
Polystichum munitum	25.4	7.3
Rubus discolor	16.4	7.5
Rubus parviflorus	13.4	4.0
Rubus ursinus	62.7	16.8

Waldport South AB1

Site description. Situated about 1.5 km east of Eckman Lake on the south shore of Alsea Bay about 8 km from the mouth of the estuary, Waldport South marsh occupies about 3.5 ha (Figure 16). Although the proximate upland was formed by artificial landfill at least 40 years ago as evidenced in 1939 airphotos, the marsh and adjacent upland show relatively little recent disturbance. The marsh was classified by Jefferson (1975) as Sedge Marsh (in the western embayment) and Mature High Marsh. While much Mature High Marsh exists we would estimate that about half the aerial extent of the marsh would be better classified as Immature High Marsh. This marsh was one of the sites of the Frenkel and Eilers (1976) pilot study for the delineation of marsh-upland boundaries and Transect 2 and 5 of the current research were close to the transects WS1 and WS2 described in this pilot study (Figure 17). The marsh exhibits deeply incised tidal creeks, strong marsh zonation, few drift log accumulations and is generally developed on fine silt substrate as evidenced by a number of sediment cores. There is no indication of freshwater seepage and ponding of freshwater at the upper edge of the marsh.

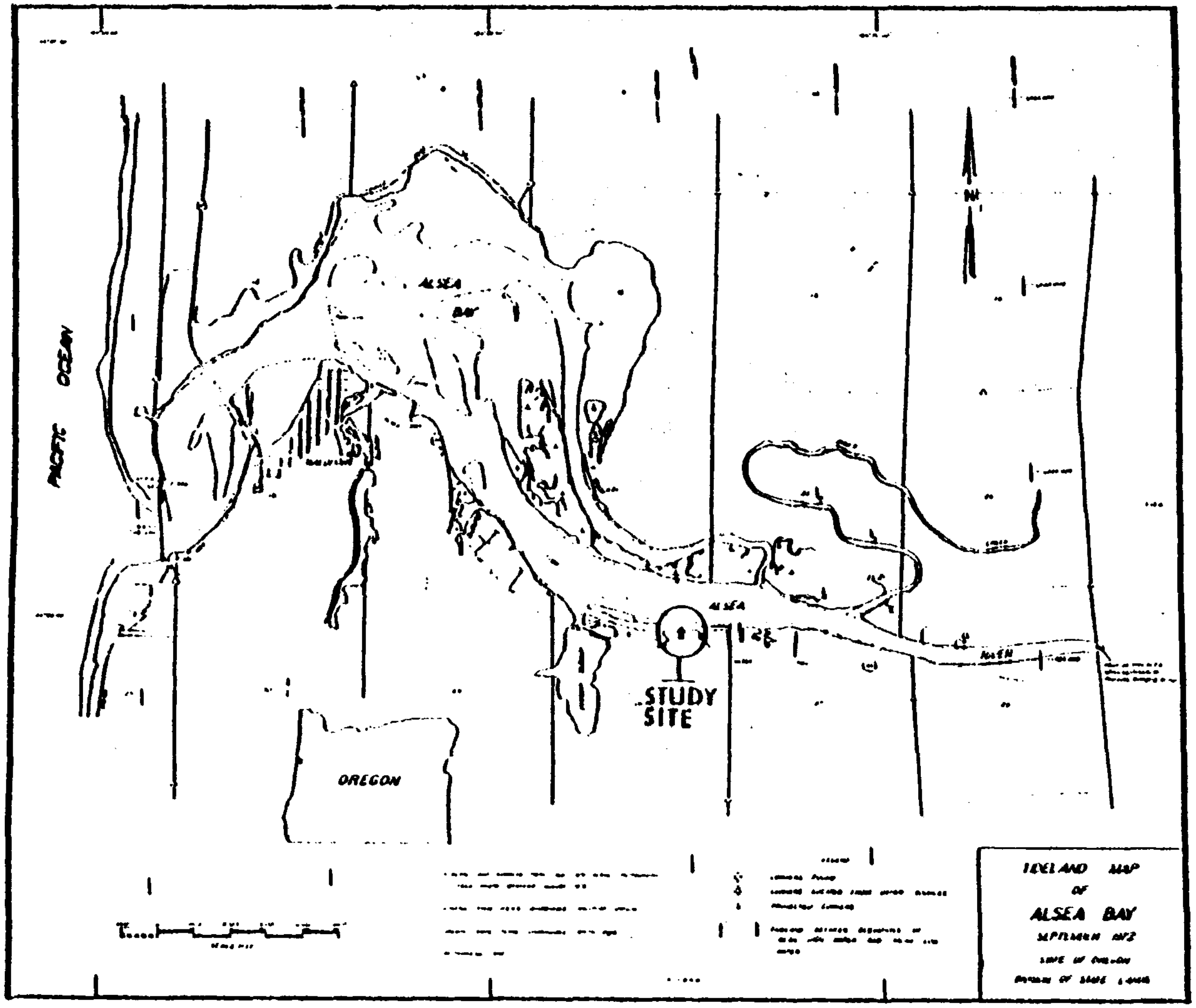

Figure 16. Location of Waldport South study site, AB1.

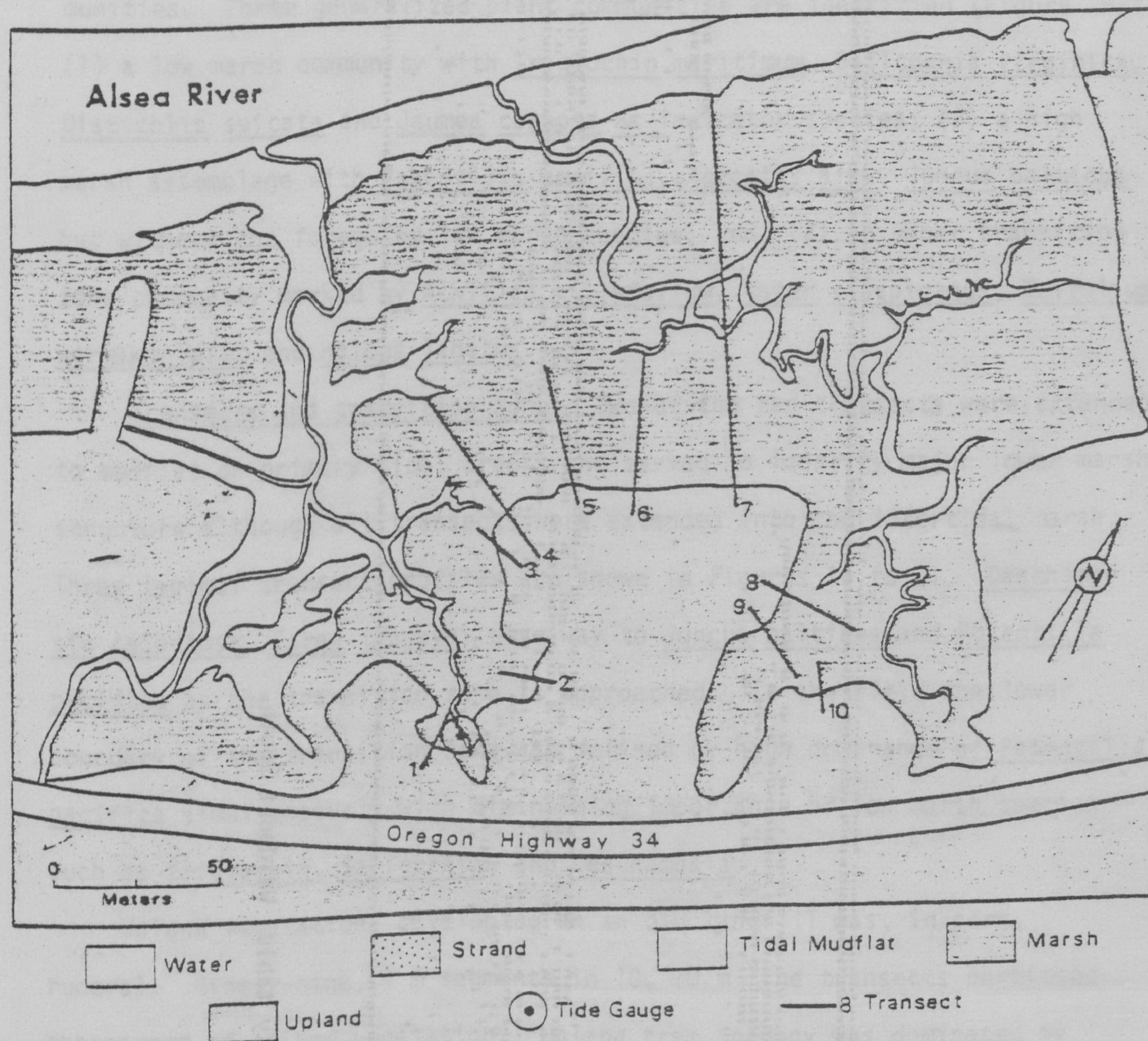

Figure 17. Waldport South study site with approximate locations of transects.

[illegible]	CODE	SERIAL NUMBER	
		LOW MARSH ZONE	
59	33	TRIGLOCHIN MARITIMUM	[illegible]
42	28	SALICORNIA VIRGINICA	[illegible]
18	9	DISTICHLIS SPICATA	[illegible]
11	10	JAUMEA CARNOSA	[illegible]
8	32	STELLARIA HUMIFUSA	[illegible]
6	30	SCIRPUS CERNUUS	[illegible]
		UPPER TRANSITION ZONE	
20	1	ACHILLEA MILLEFOLIUM	[illegible]
16	3	ASTER SUBSPICATUS	[illegible]
11	23	TRIFOLIUM WORMSKJOLDII	[illegible]
12	16	HOLCUS LANATUS	[illegible]
2	43	POA PRATENSIS	[illegible]
8	64	RUBUS URSINUS	[illegible]
5	42	PLANTAGO LANCEOLATA	[illegible]
4	50	HYPOCHAERIS RADICATA	[illegible]
6	41	PICEA SITCHENSIS	[illegible]
		OTHER SPECIES	
111	19	JUNCUS BALTICUS	[illegible]
94	2	AGROSTIS ALBA	[illegible]
66	4	ATRIPLEX PATULA	[illegible]
94	45	POTENTILLA PACIFICA	[illegible]
56	14	GLAUX MARITIMA	[illegible]
53	9	DESCHAMPSIA CESPITOSA	[illegible]
34	8	CAREX LYNGBYEI	[illegible]
23	18	GRINDELIA INTEGRIFOLIA	[illegible]
21	17	HORDEUM BRACHYANTHERUM	[illegible]
7	11	FESTUCA RUBRA	[illegible]
9	13	GALIUM [illegible]	[illegible]
3	20	LILAEOPSIS OCCIDENTALIS	[illegible]
3	12	GALIUM APARINE	[illegible]
1	7	CUSCUTA SALINA	[illegible]
1	53	ANGELICA LUCIDA	[illegible]
1	[illegible]	[illegible]	[illegible]

Figure 18. Plant community table, Waldport South.

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Plant communities. Ten transects with 162 microplots situated in the marsh and marsh-upland transition can be used to define plant communities. Three generalized plant communities are identified (Figure 18): (1) a low marsh community with Triglochin maritimum, Salicornia virginica, Distichlis spicata and Jaumea carnosa as indicator species; (2) a high marsh assemblage with Potentilla pacifica, Agrostis alba, Juncus balticus but without the foregoing low marsh species; and, (3) an upper transition zone community marked by Achillea millefolium, Aster subspicatus, Trifolium wormskjoldii, and Holcus lanatus.

Transects and transition zone. Two of the ten transects were extended to mudflat or primary tidal creeks and served to identify major lower marsh structure although all transects were extended into the intertidal marsh. Three typical transect profiles are shown in Figures 19 to 21. Deschampsia cespitosa, Carex lyngbyei give way to Juncus balticus and Potentilla pacifica as the transition zone is approached. In the field the lower boundary of the transition zone was defined by high dominance of Potentilla pacifica simultaneously with diminishing importance of low marsh species such as Triglochin, Salicornia, and Deschampsia.

Upland vegetation, developing on an old landfill was, in part, ruderal. Ninety-nine, 1 m segments in 10, 10 m line transects permitted assessment of upland vegetation. Upland tree canopy was dominated by conifers and consisted of:

	Freq. (%)	Avg. Cover (%)	B.A. (m^2/ha)
Alnus rubra	80	17	3.5
Picea sitchensis	100	46	5.3
Pseudotsuga menziesii	20	3	0.2
Pyrus fusca	10	1	0.2
Rhamnus purshiana	50	4	0.3
Tsuga heterophylla	20	1	0.2

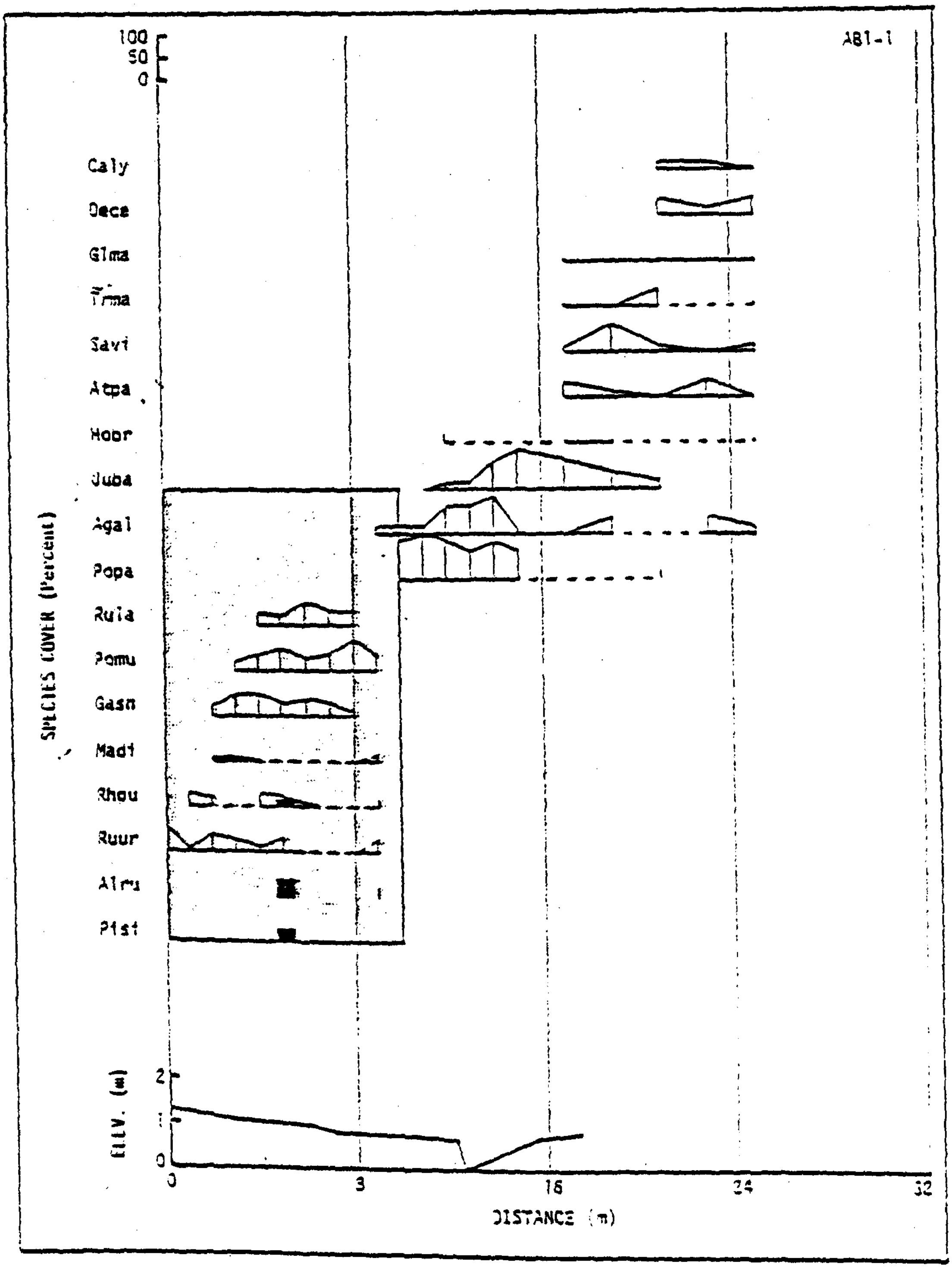

Figure 19. Plant species cover along transect AB1-1 at Waldport South study site.

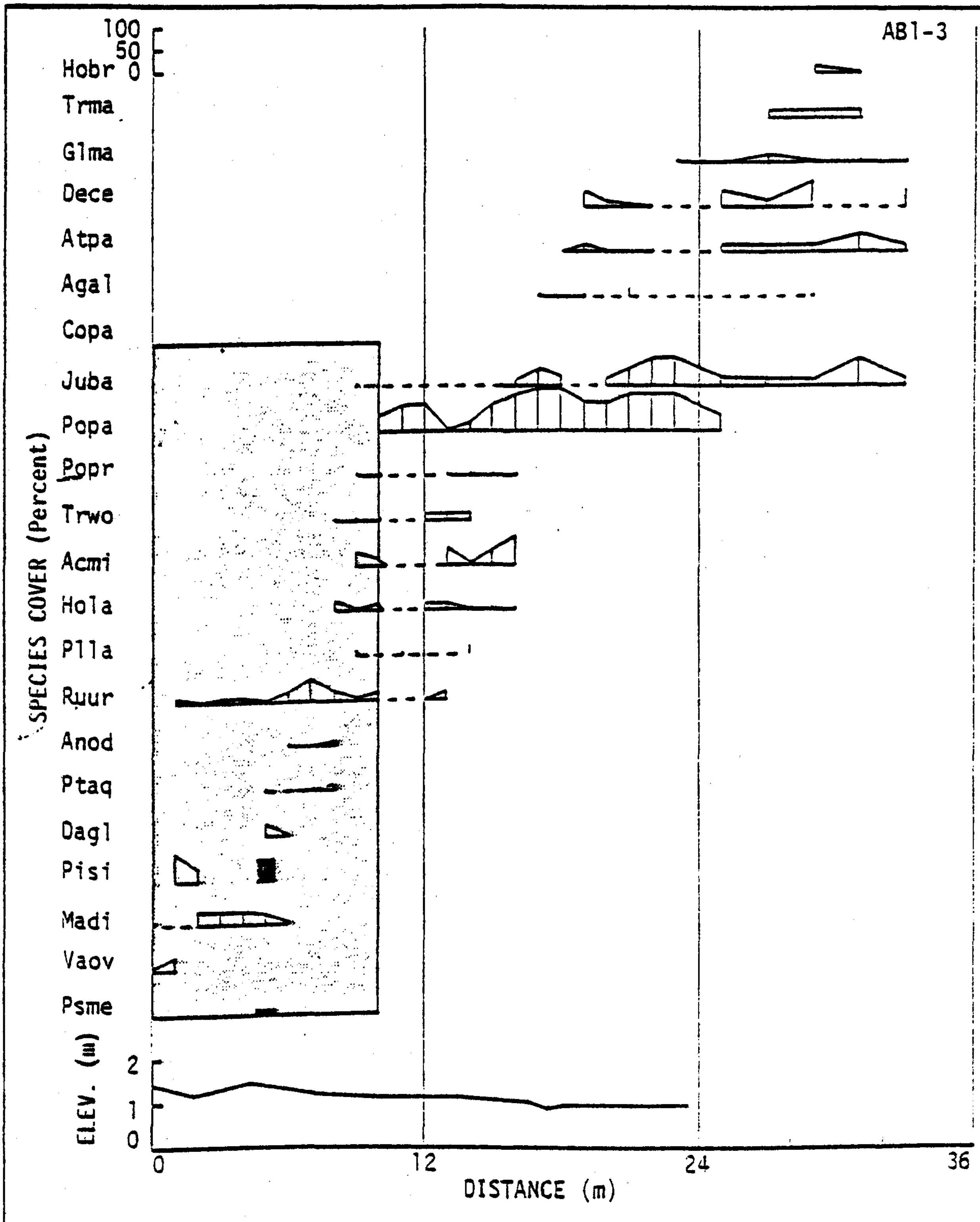

Figure 20. Plant spcies cover along transect AB1-3 at Waldport South study site.

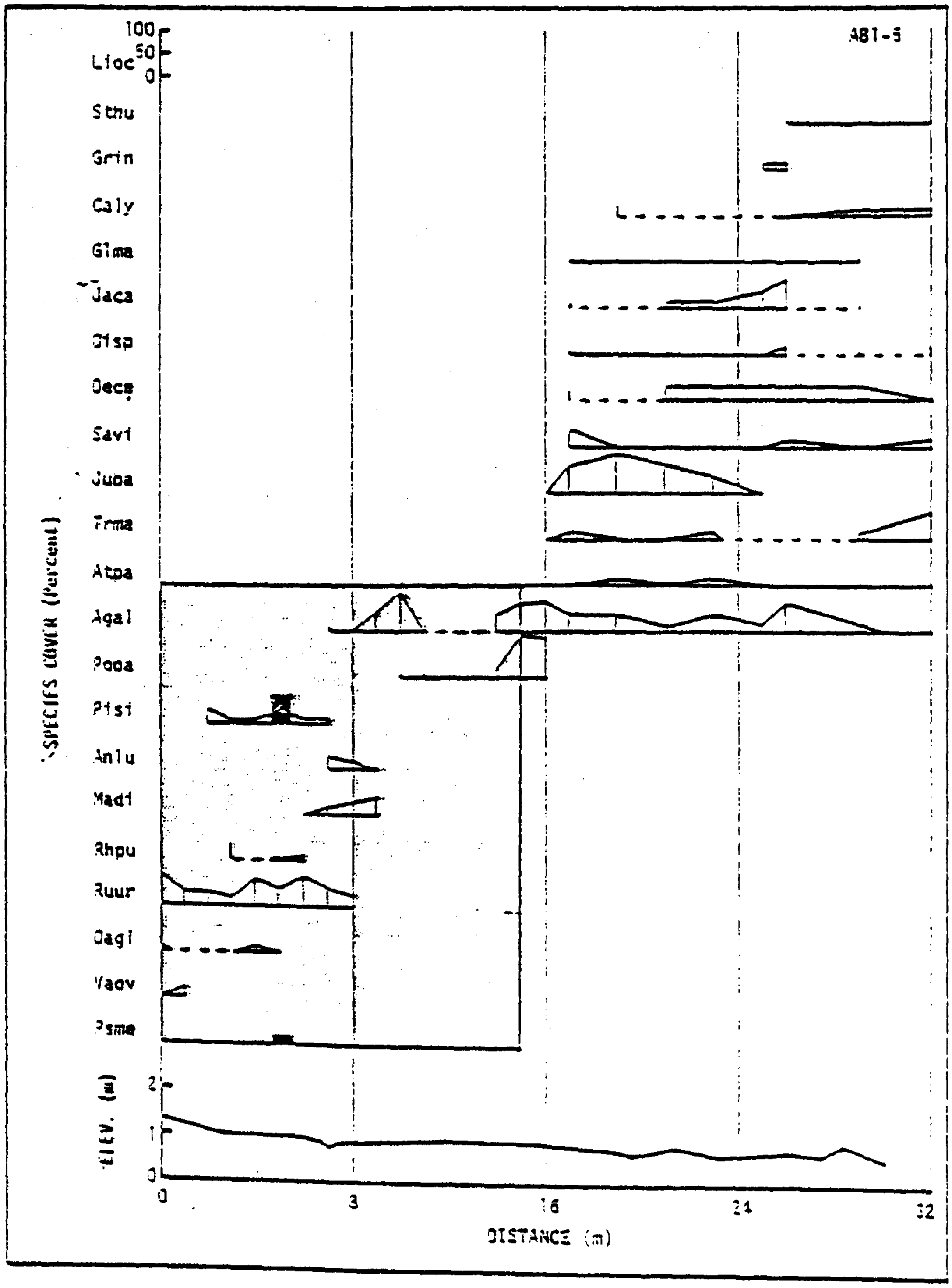

Figure 21. Plant species cover along transect AB1-5 at Waldport South study site.

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Upland understory shrub and herb layer as analyz[illegible] transect segments consisted of the following species with frequencies greater than 10 percent:

		Freq. (%)	Avg. Cover (%)
o	Achillea millefolium	13.1	1.4
o	Agrostis alba (?)	10.1	1.5
o	Dactylis glomerata	20.2	1.6
o	Galium aparine	11.1	0.2
o	Holcus lanatus	11.1	1.5
f	Maianthemum dilatatum	21.2	3.6
f	Picea sitchensis	42.4	14.1
f	Polystichum munitum	12.1	3.8
o	Pteridium aquilinum	30.0	9.7
f	Rhamnus purshiana	12.1	2.0
o	Rubus laciniatus	26.3	6.1
f/o	Rubus ursinus	75.8	20.0

Plant species commonly found in forest are indicated by (f) and those of open areas by (o). From this list, one can see the presence of plants of both kinds of vegetation cover found on this old landfill.

Nute Slough YB1

Site description. Located on the north shore of Yaquina River about 16 km from the estuary mouth but 22 km downstream of head of tide, Nute Slough marsh is about 0.5 km east of Nute Slough proper (Figure 22). The marsh was mapped by Jefferson (1975) as a Mature High Marsh and this appears to be the most appropriate classification for the more extensive eastern segment. The narrower western portion where most of the sampling in this research occurred is best described as an Immature High Marsh. The marsh is cut by a few creeks and has moderate accumulations of stranded logs in its upper portion. The appearance of dense stands of Scirpus microcarpus and Carex obnupta at the interface between marsh and coniferous forest, suggests freshwater seepage collecting at

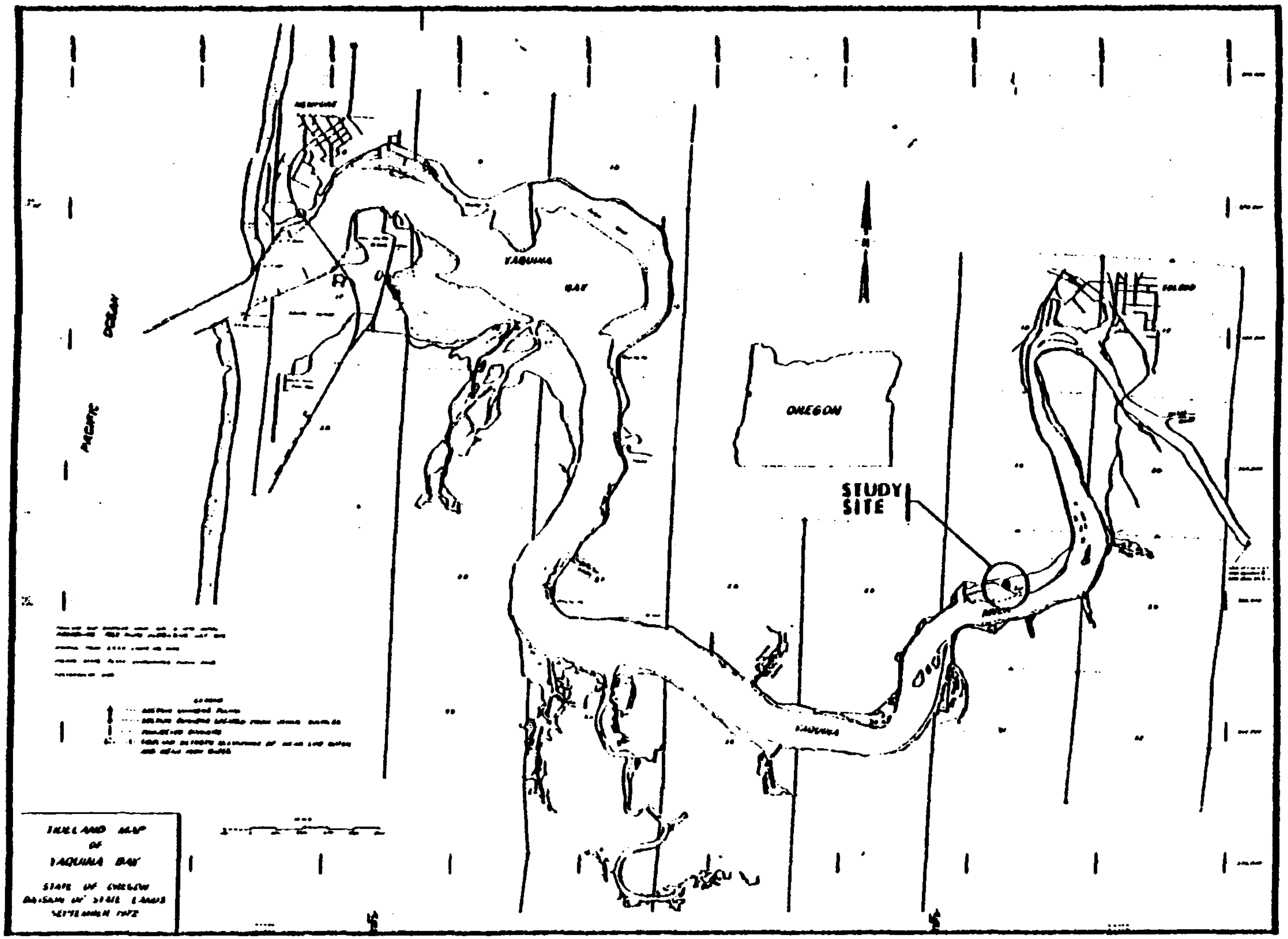

Figure 22. Location of Nute Slough study site, YB1.

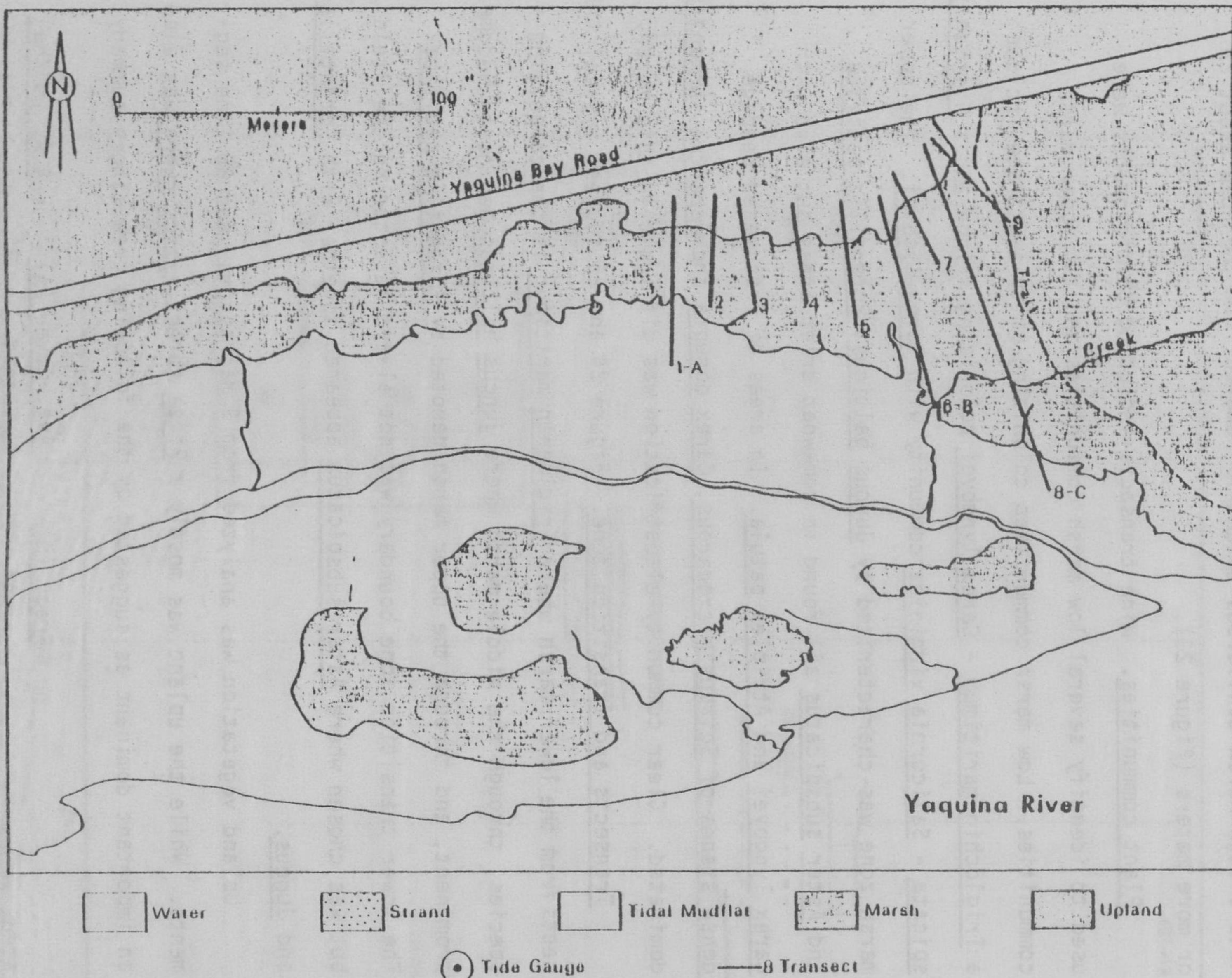

Figure 23. Nute Slough study site with approximate locations of transects.

at the base of the upland. While the Newport Road embankment normally forms an artificial upland to contiguous salt marshes in this area, the Nute Slough Marsh coniferous upland is removed from the road about 20 or more meters (Figure 23).

Plant communities. Nine transects including 88 microplots were used to identify several low marsh communities and two upper marsh communities. Low marsh communities colonizing silty substrate include: a *Triglochin maritimum* - *Carex lyngbyei* colonizing fringe and a *Distichlis spicata* - *Salicornia virginica* community with *Carex lygbyei*. The upper marsh zone was characterized by *Juncus balticus*, *Potentilla pacifica* and *Aster subspicatus* all found in somewhat drier areas but also with *Carex lyngbyei* and *Atriplex patula*. In areas of freshwater seepage dense stands of *Scirpus microcarpus*, *Carex obnupta* and *Oenanthe sarmentosa* dominated. Clear community classification was difficult in this marsh.

Transects and transition zone. Figure 24 and 25 suggest typical transects from the lower marsh where *Triglochin maritimum* is the colonizing species, through the middle marsh where *Juncus balticus* begins to become prominent, and through the upper marsh denoted by *Potentilla pacifica*. The lower transition zone boundary was not always selected in the field but was chosen where *Aster subspicatus* appeared together with *Potentilla* and *Juncus*.

Upland vegetation was analyzed from 9 macroplots, and 85 line segments. While the upland was mostly a *Picea* forest, *Alnus rubra* was also an important dominant as suggested by the following tree canopy summary:

	Freq. (%)	Avg. Cover (%)	B.A. (m^2/ha)
Alnus rubra	89	23.0	2.4
Picea sitchensis	100	51.0	4.4
Pyrus fusca	44	2.3	0.4
Salix hookeriana	11	1.0	--

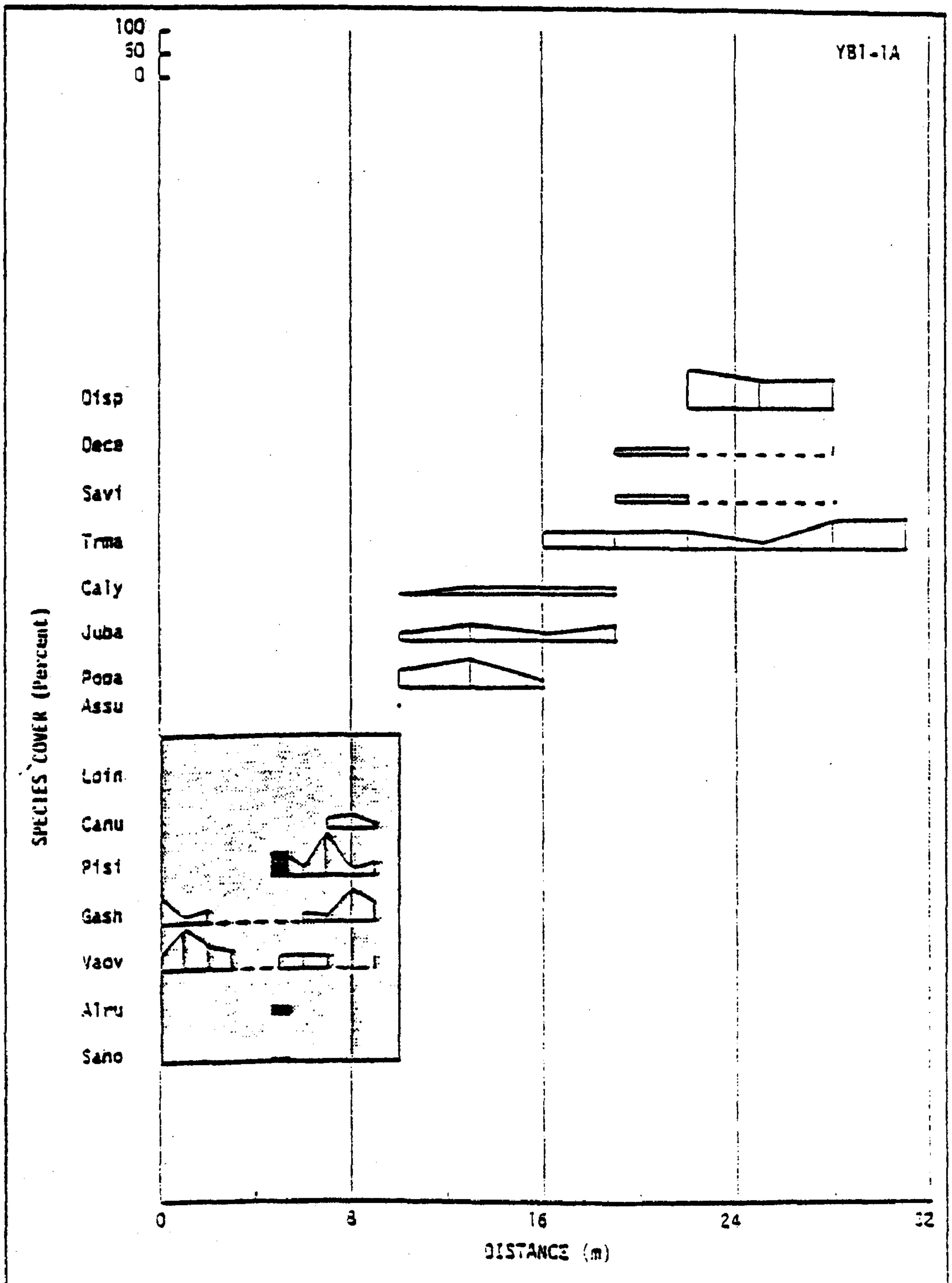

Figure 24. Plant species cover along transect YB1-1A at Nute Slough study site.

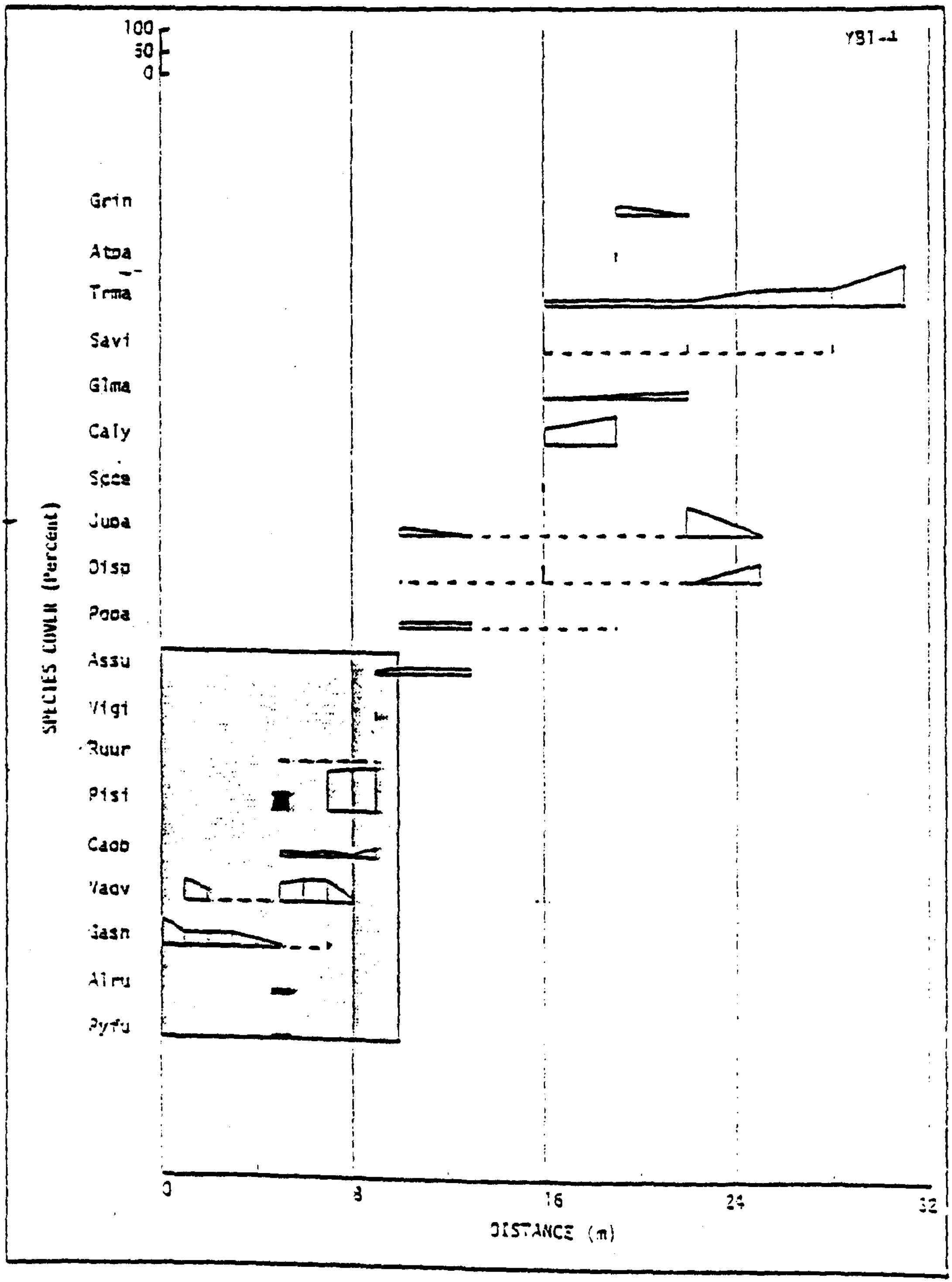

Figure 25. Plant species cover along transect YB1-4 at Nute Slough study site.

Upland shrub and herb understory, assessed by line intercept, suggested the occurrence of freshwater wetland conditions as seen by the following list of species with frequency greater than 10 percent and wetland plants denoted by (w):

		Freq. (%)	Avg. Cover (%)
(w)	Carex obnupta	23.5	8.3
	Gaultheria shallon	50.6	19.5
	Lonicera involucrata	21.2	5.3
(w)	Lysichitum americanum	10.6	3.7
	Picea sitchensis	20.0	11.5
	Rubus ursinus	14.1	2.5
	Vaccinium ovatum	49.4	21.0

While wet condition prevailed in 5 transects, the other 4 transects were dominated by typical coastal coniferous forest understory species.

Netarts Sand Spit NT1

Site description. The only Low Sand Marsh studied in Oregon (two Washington marshes were Low Sand), Netarts Sand Spit marsh is located in Cape Lookout State Park on the bay-side (east) of the 10 km-long sand spit which forms the western side of one of Oregon's most intact estuaries. The study site extends over about 1 km, and is centered about 3 km north of the campground (Figure 26). Two broad types of marsh are evident along the bay-side of the spit: a Low Sand Marsh type which colonizes the low gradient sand flat and presents a gradual gradient to upland and a Mature High Marsh type which is elevated abruptly 40 to 120 cm above the sand flat. The latter type shows signs of retrogradation, while the former appears to be prograding. The two types correlate with upland characteristics. Where the sand spit dune system is low and weakly stabilized, the Low Sand Marsh prevails. Where the upland is marked by stabilizing Picea and Pinus forest the Mature High

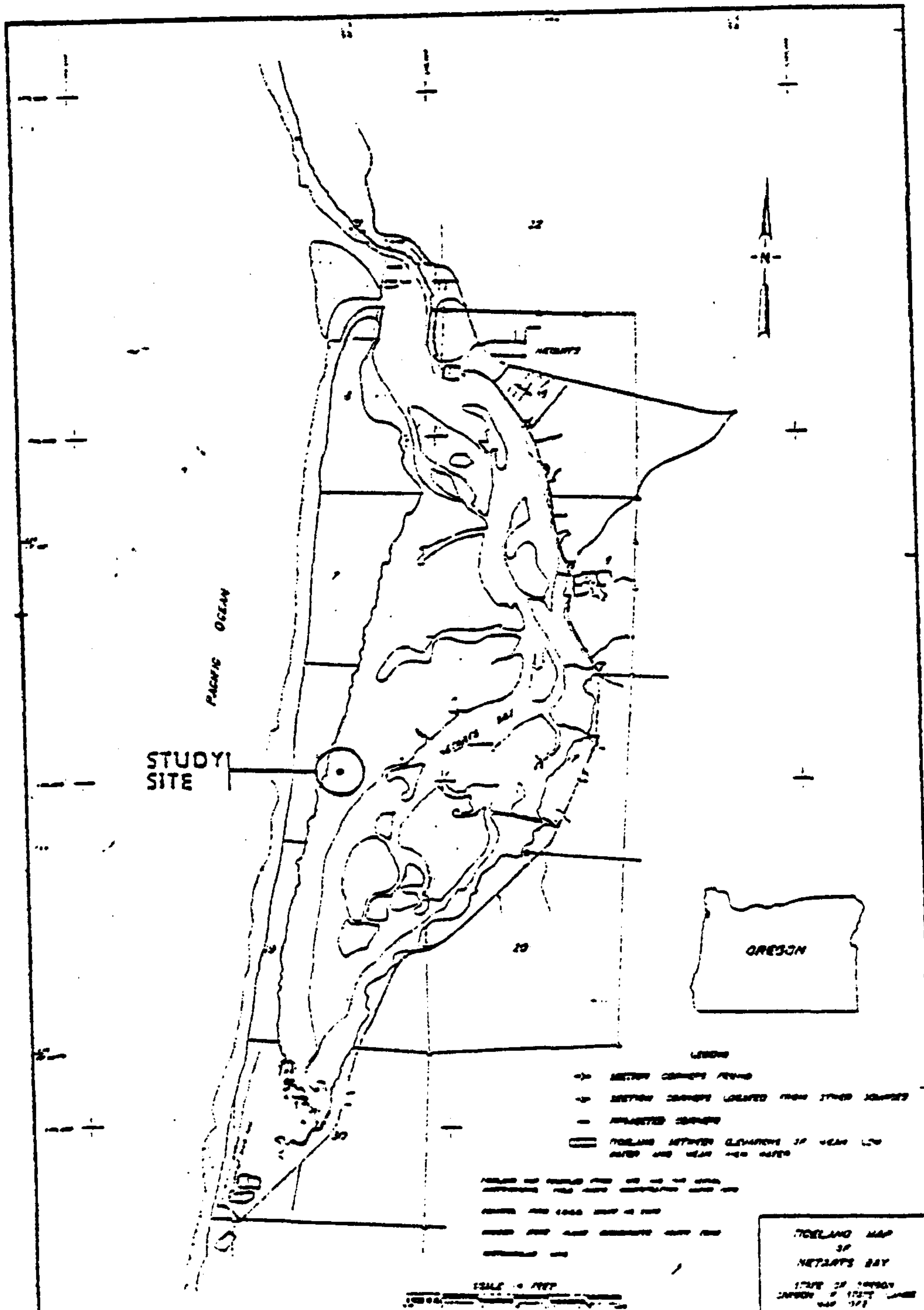

Figure 26. Location of Netarts Bay study site, NT1.

Marsh type is common. This dual type is hypothesized as being caused by historical breaching of the sand spit causing scouring of the marsh vegetation by ocean waves and the occurrence of the Low Marsh Type. Commonly colonizing the sand flat at the outer edge of the low sand marsh is Scirpus americanus, suggesting freshwater seepage. For the high marsh, freshwater seepage is suggested, in places, at the upper portion of the marsh by the presence of Carex obnupta. Jefferson (1975) recognized the two types of marsh but judged the high marsh as Immature High Marsh. From the species composition we suggest it is better classified as Mature High Marsh. Presently, intensive studies of marsh function (pers. comm. J. Gallagher), salinity variation (pers. comm. M. Liverman) and marsh plant anatomy (pers. comm. D. Seliskar) are taking place.

Both the marsh and estuary have been little disturbed. Historically homesteading has occurred on the spit and there was cattle grazing but this must have occurred at least 50 years ago. Creek development is very sparse. Drift log accumulation is slight. A very important influence on the marsh vegetation are rafts of Zostera marina which become stranded and decompose, often killing marsh vegetation. It appears that "pans" and other depressions in the lower marsh may have their origin from this phenomena.

Upland vegetation can be classed in two types: stabilized sand dunes dominated by Ammophila arenaria and stabilized sand dunes dominated by Picea sitchensis and Pinus contorta.

Plant communities. Ten transects including 155 microplots were distributed so as to fully describe the variation of marsh and marsh-upland ecotone vegetation (Figure 27). Plant community structure was relatively simple (Figure 28). Two types of low marsh communities

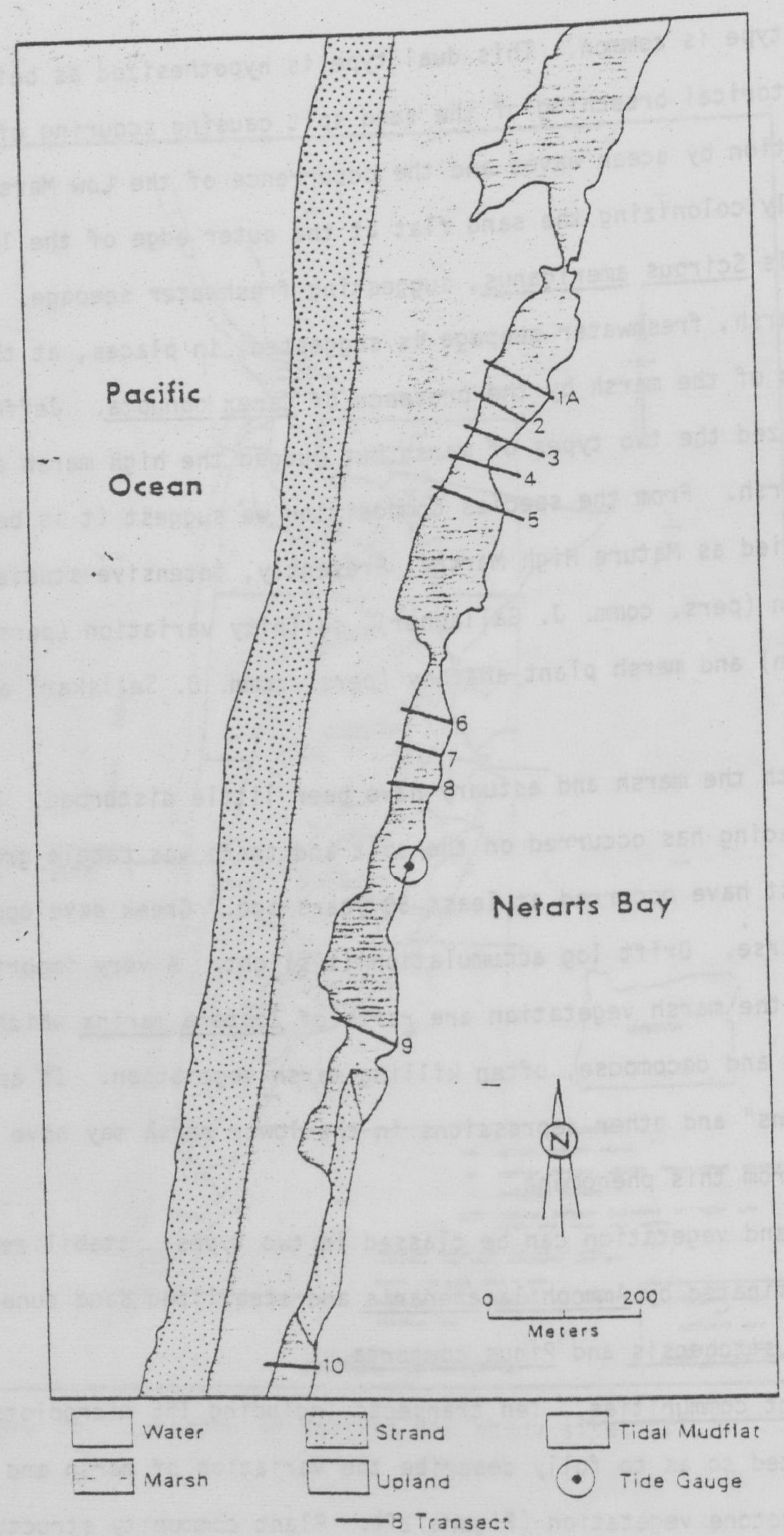

Figure 27. Netarts Sand Spit study site with approximate locations of transects.

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were common: a single species community with *Scirpus americanus* and a more diverse community characterized by *Salicornia virginica*, *Jaumea carnosa*, and *Plantago maritima*. *Distichlis spicata* was also dominant in this community but ranged well into the upper marsh. A single type of upper marsh prevailed dominated by *Deschampsia cespitosa*, *Potentilla pacifica*, *Juncus balticus* and *Agrostis alba*. All of these upper marsh species ranged into the transition between marsh and upland. The transition zone community was marked by the entry of *Juncus lesueurii*, *Aster subspicatus*, *Trifolium wormskjoldii*, and *Achillea millefolium*. *Elymus mollis* was often important in identifying the transition zone, as well.

Transects and transition zone. Figures 29 to 32 illustrate typical transects with profiles across Netarts Sand Spit marsh. Transect NT1-1A typifies the transects across a high marsh as can be seen by the 1.2 m nickpoint at the outer edge where *Salicornia virginica* is dominant. A slight "levee" forms corresponding with dominance by *Deschampsia* and *Atriplex*. The transition zone was defined in the field by the sudden appearance of *Potentilla* and *Elymus mollis*. Upland was defined by forest and shrub species which enter at an abrupt change in slope. One transect, NT1-4, illustrates the pattern for the low sand marsh where *Scirpus americanus* forms a colonizing fringe followed by a low marsh community marked by *Distichlis*, *Salicornia* and *Jaumea*. A high marsh assemblage follows with *Potentilla* dominant, and a transition zone identified by the entry of *Elymus mollis*.

Upland vegetation was assessed along the 10 transects with 6 macroplots and 102 line segments. The tree canopy reflected the typical species found on stabilized dunes:

PRESENCE	CODE	SERIAL NUMBER	Relevés
		LOW MARSH ZONE	
58	20	SALICORNIA VIRGINICA	[illegible]
36	14	JAUMEA CARNOSA	[illegible]
12	24	PLANTAGO MARITIMA	[illegible]
28	21	SCIRPUS AMERICANUS	[illegible]
13	31	SPERGULARIA CANADENSIS	[illegible]
9	35	TRIGLOCHIN MARITIMUM	[illegible]
6	7	CUSCUTA SALINA	[illegible]
5	24	PUCCINELLIA PUMILA	[illegible]
4	14	GLAUX MARITIMA	[illegible]
3	34	TRIGLOCHIN CONCINNUM	[illegible]
		UPPER TRANSITION ZONE	
22	43	JUNCUS EFFUSUS	[illegible]
19	3	ASTER SUBSPICATUS	[illegible]
14	48	EPILOBIUM WATSONII	[illegible]
11	1	ACHILLEA MILLEFOLIUM	[illegible]
9	46	JUNCUS LESUEURII	[illegible]
9	37	ANGELICA LUCIDA	[illegible]
6	54	CALAMAGROSTIS NUTKAENSIS	[illegible]
5	42	GALIUM APARINE	[illegible]
4	43	GAULTHERIA SHALLON	[illegible]
4	30	STELLARIA CALYCANTHA BONGARDIANA	[illegible]
		OTHER SPECIES	
44	9	DESCHAMPSIA CESPITOSA	[illegible]
35	4	DISTICHLIS SPICATA	[illegible]
43	19	JUNCUS BALTICUS	[illegible]
56	23	POTENTILLA PACIFICA	[illegible]
54	6	ATRIPLEX PATULA	[illegible]
40	2	AGROSTIS ALBA	[illegible]
31	17	HORDEUM BRACHYANTHERUM	[illegible]
14	39	ELYMUS MOLLIS	[illegible]
6	15	[illegible]	[illegible]
5	61	SPERGULARIA MACROTHECA	[illegible]
4	33	FESTUCA RUBRA	[illegible]
3	37	STELLARIA HUMIFUSA	[illegible]
2	36	SCIRPUS CERNUUS	[illegible]
2	42	PLANTAGO LANCEOLATA	[illegible]
1	11	GALIUM TRIFIDUM	[illegible]
1	29	ORTHOCARPUS CASTILLEJOIDES	[illegible]

Figure 28. Plant community table, Netart Sand Spit study site.

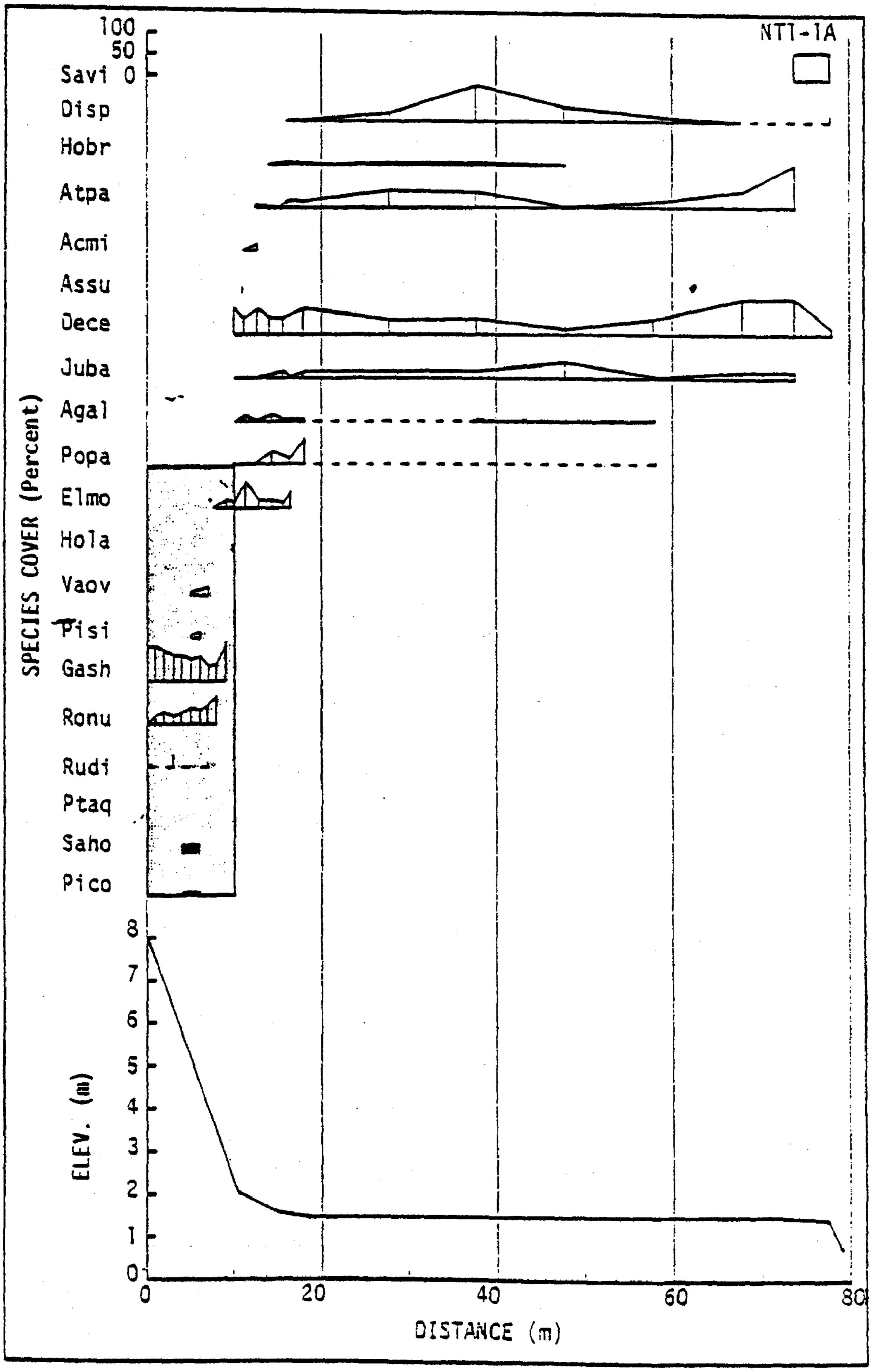

Figure 29. Plant species cover along transect NT1-1A at Netarts Sand Spit study site.

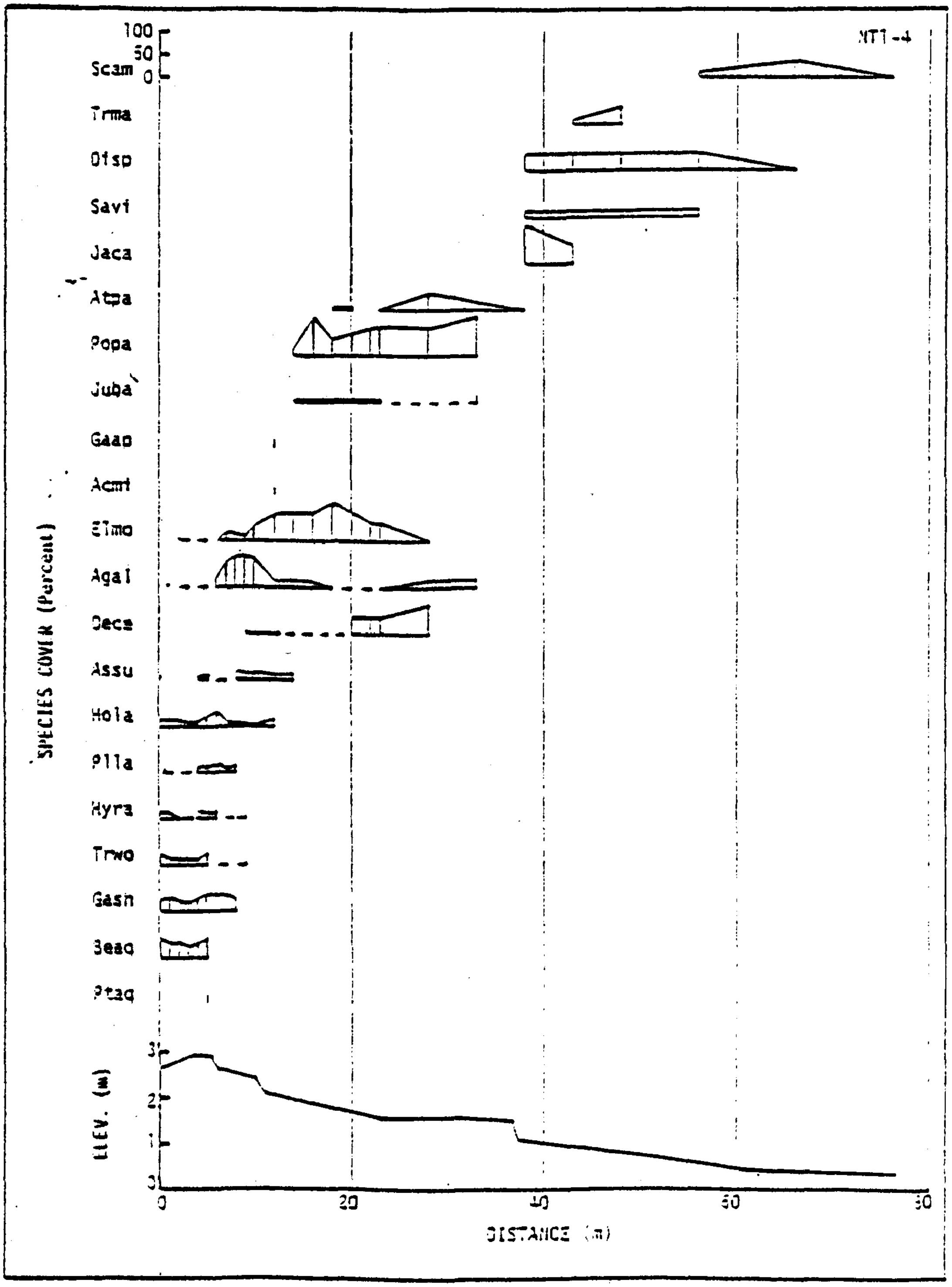

Figure 30. Plant species cover along transect NT1-4 at Netarts Sand Spit study site.

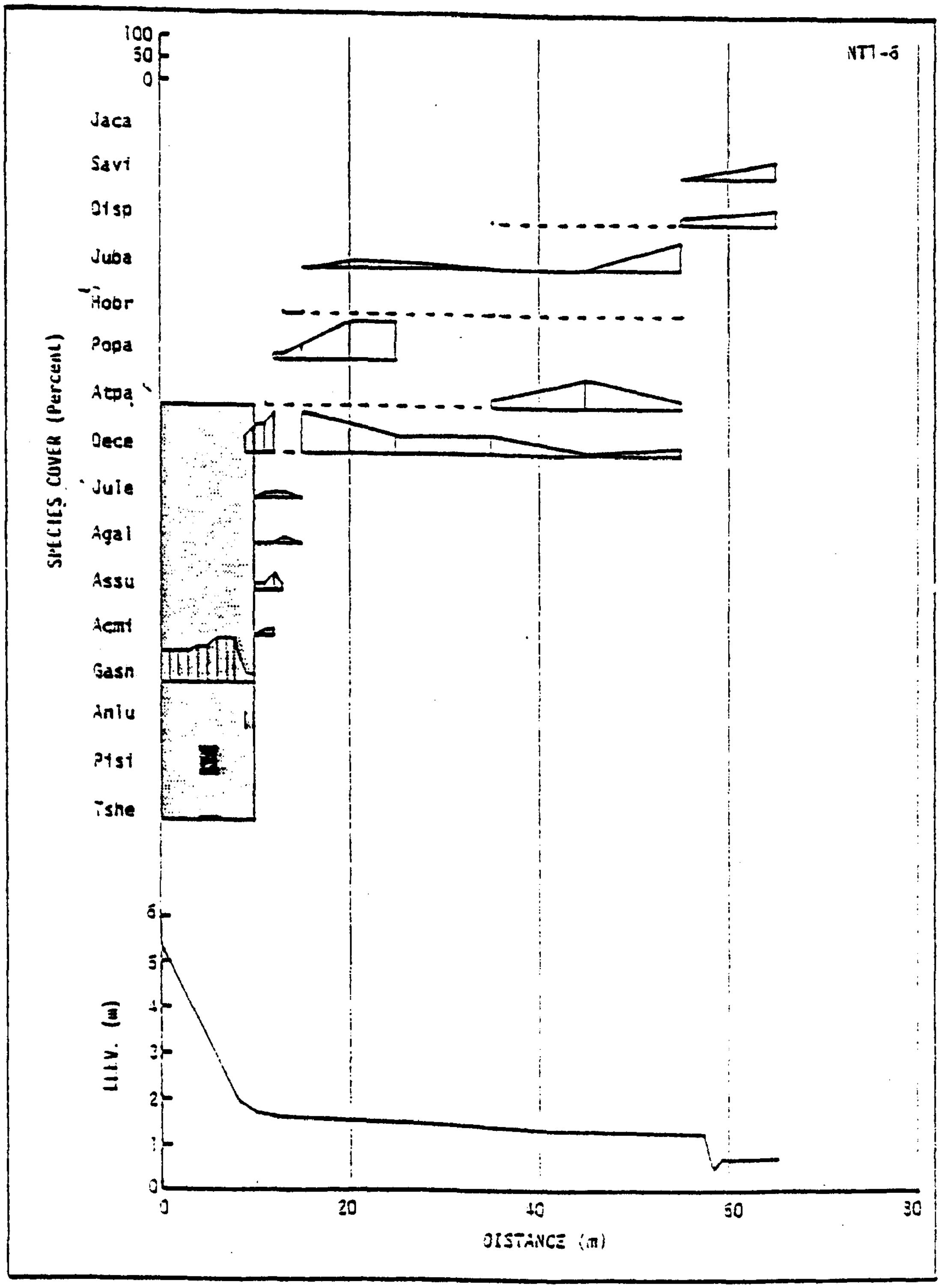

Figure 31. Plant species cover along transect NT1-6 at Netarts Sand Spit study site.

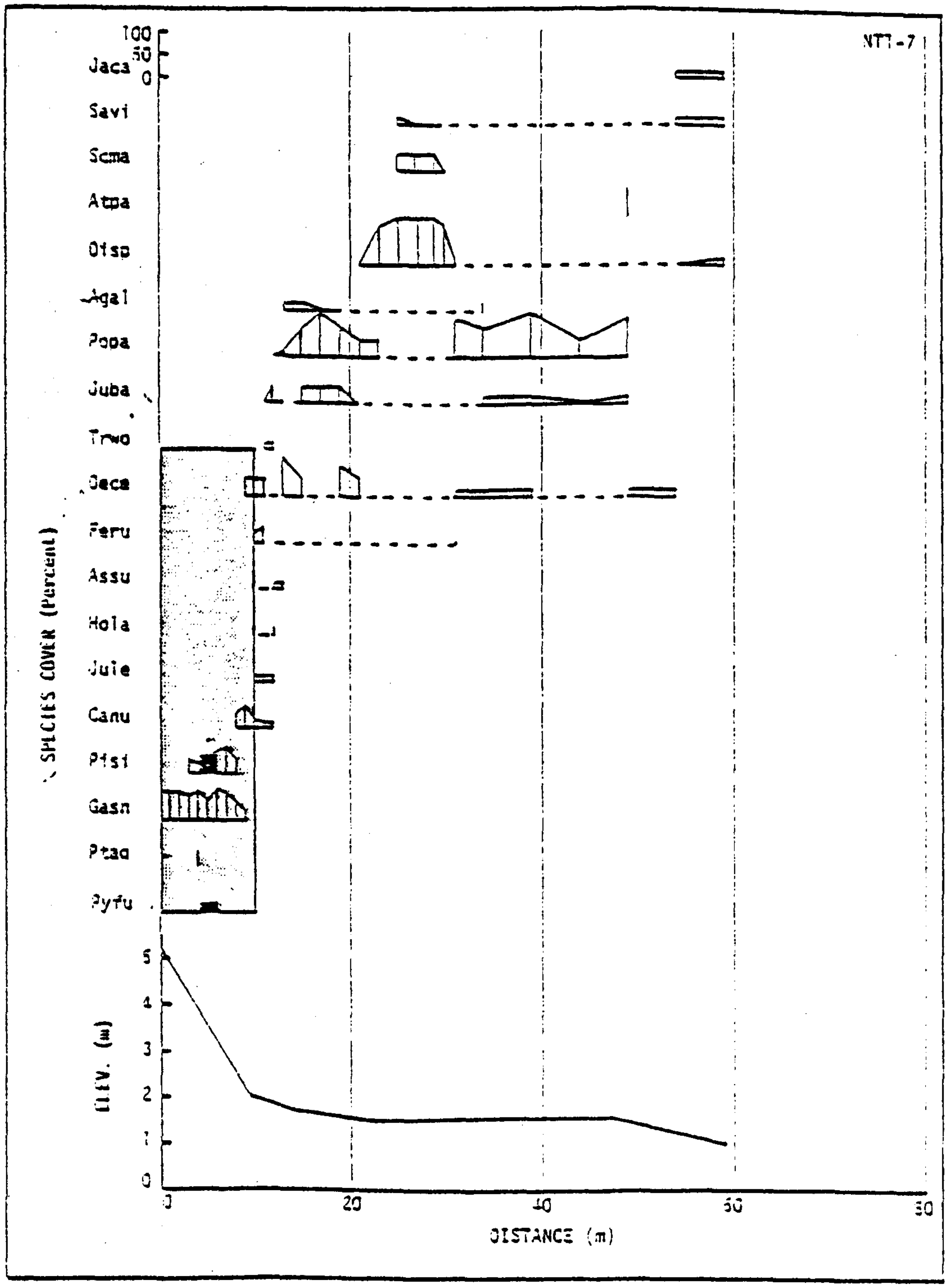

Figure 32. Plant species cover along transect NT1-7 at Netarts Sand Spit study site.

	Freq. (%)	Avg. Cover (%)	B.A. (m^2/ha)
Myrica californica	10	2	0.1
Picea sitchensis	60	19	2.8
Pinus contorta	40	5	0.5
Pyrus fusca	10	2	0.2
Salix hookeriana	20	2	0.3
Tsuga heterophylla	20	1	0.2

Understory shrub and herb vegetation reflects the two upland vegetation types mentioned earlier: open stabilized sand dune (o) and forested dunes (f) as is shown in the following roster of species with frequencies in excess of 10 percent:

	Freq. (%)	Avg. Cover (%)
(o) Agrostis alba (?)	20.6	4.0
(o) Ammophila arenaria	17.6	11.6
(o) Angelica lucida	11.8	1.9
(o) Aster subspicatus	30.4	2.3
(o) Calamagrostis nutkaensis	10.8	3.3
(o) Deschampsia cespitosa	12.7	2.6
(o) Elymus mollis	34.3	7.9
(o) Festuca rubra	16.7	2.4
(f) Gaultheria shallon	68.6	35.2
(o) Holcus lanatus	32.3	2.8
(o) Juncus lesueurii	36.3	3.0
(f) Picea sitchensis	27.4	6.3
(o/f) Pteridium aquilinum	14.7	4.1
(f) Rosa nutkana	18.6	4.8
(o) Trifolium wormskjoldii	22.5	2.3

Six transects were in forest or partially forested upland, and four were in open stabilized dunes.

West Island NB2

Centered in Nehalem Bay, West Island marsh is one of the most thoroughly studied marshes in Oregon (Eilers, 1975) and was included in the present research because of the background research compiled for this marsh (Figure 33). Comprising about 80 ha, the marsh has been little disturbed but supports about 0.4 ha of incipient upland

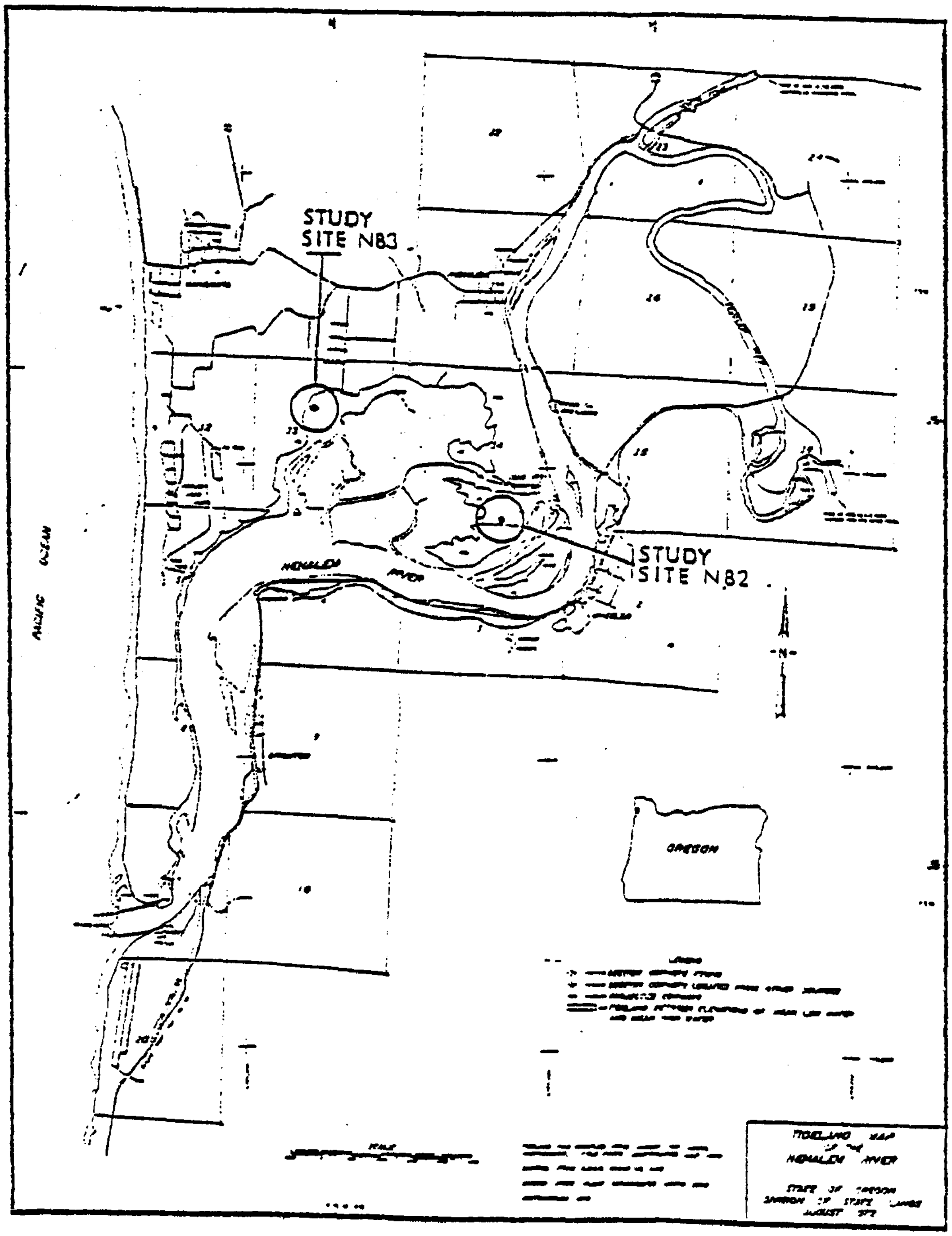

Figure 33. Location of West Island and Sea Garden Road study sites, NB2 and NB3.

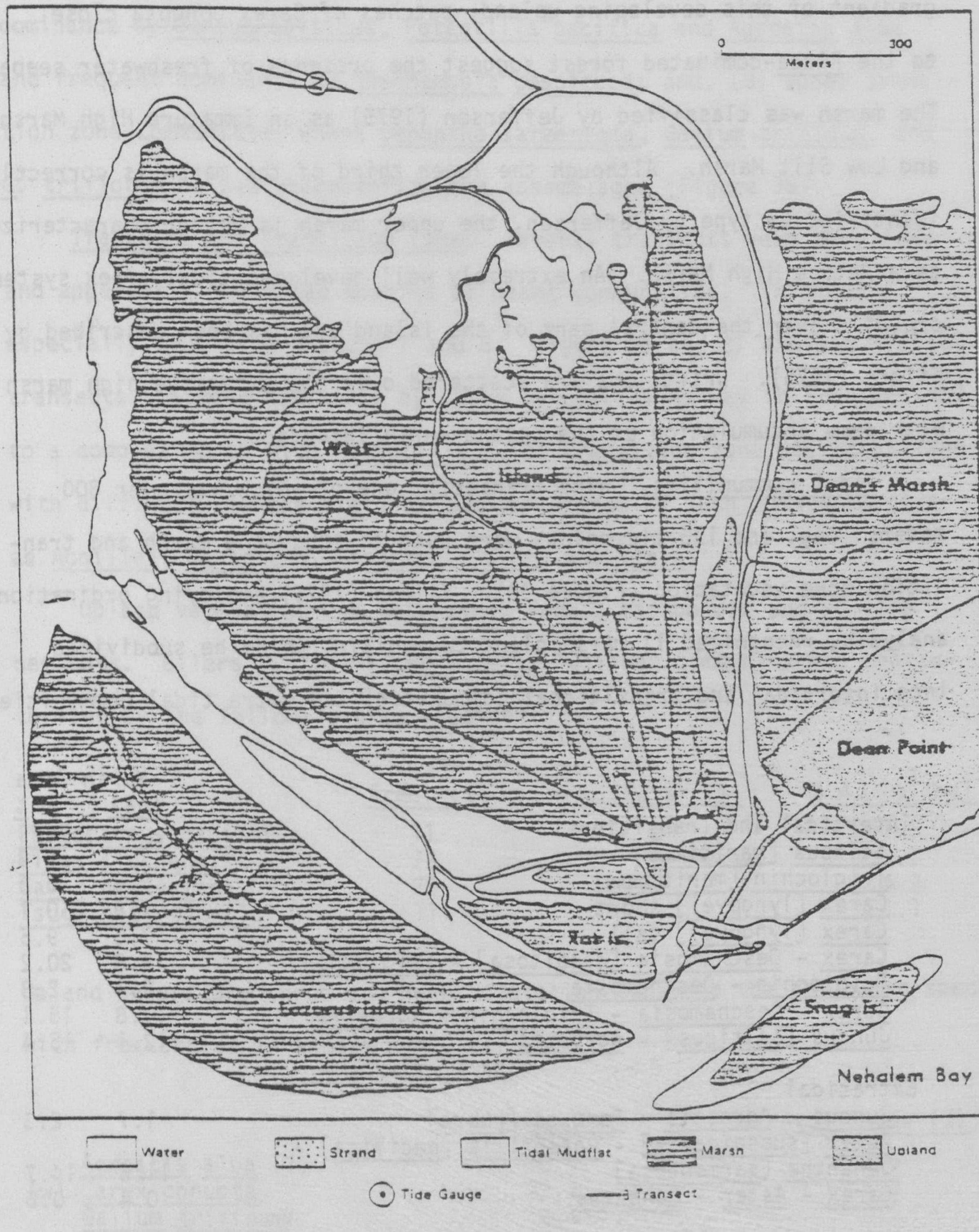

Figure 34. West Island study site with approximate locations of transects.

coniferous vegetation developed on old drift logs. Despite the low gradient of this developing upland, patches of *Carex obnupta* close to the *Picea*-dominated forest suggest the presence of freshwater seepage. The marsh was classified by Jefferson (1975) as an Immature High Marsh and Low Silt Marsh. Although the lower third of the marsh is correctly identified by type by Jefferson, the upper marsh is better characterized as a Mature High Marsh. An extremely well developed tidal creek system prevails over the central part of the island and has been described by Eilers (1975). Drift logs are scattered over the extensive high marsh with some accumulation at the upland-marsh interface.

Plant communities. Nine transects, one of which was over 800 meters long, and 195 microplots were used to study the marsh and transition zone vegetation (Figure 34). Eilers (1975) employing ordination analysis, recognized 11 marsh plant communities which he subdivided into intertidal and transitional communities and extra tidal communities:

	Marsh (ha)	Area %
Intertidal and Transitional		
Scirpus [*maritimus*]	1.7	2.3
Triglochin [*maritimum*]	5.0	6.5
Carex [*lyngbyei*] short	7.9	10.1
Carex [*lyngbyei*] tall	7.5	9.6
Carex - *Deschampsia* [*cespitosa*] - *Triglochin*	15.8	20.2
Triglochin - *Deschampsia*	2.1	2.8
Carex - *Deschampsia* - *Triglochin* - *Agrostis*	11.8	15.1
Juncus [*balticus*] - *Agrostis*	12.1	15.4
Extratidal		
Juncus - *Agrostis* - *Festuca* [*rubra*]	1.7	2.3
Aster [*subspicatus*] - *Potentilla* [*pacifica*] - *Oenanthe* [*sarmentosa*]	11.5	14.7
Carex - *Aster* - *Oenanthe*	0.4	0.5

While most of these communities were encountered in the present sampling, because the analysis was different, communities were classed as: (1) low and upper marsh communities where *Carex lyngbyei*, *Triglochin maritimum* were identifying species; (2) middle marsh communities with strong dominance by *Juncus balticus*, *Potentilla pacifica* and *Agrostis alba* and frequent dominance by *Deschampsia cespitosa*; and, (3) upper transition zone communities where *Oenanthe sarmentosa*, *Galium trifidum*, and *G. triflorum* helped characterize the assemblages (Figure 35).

Transects and Transition Zone. Several transects were very long and apparently traversed mosaics of plant communities. This was especially true of transects 7 and 8. Figure 36 and 37 exhibit typical transects. Strong dominance by *Carex lynbyei* gives way in Transect NB2-1 to a complex marsh with *Potentilla*. The transition zone was identified with difficulty in the field by the appearance of such upland species as *Achillea*, *Heracleum*, *Oenanthe*, *Aster*, and *Vicia*.

Upland vegetation was determined from 8 macroplots and 90 line segments. Eilers' (1975) *Picea* - *Salix* "upland" community was characterized by the following tree species:

	Freq. (%)	Avg. Cover (%)	B.A. (m^2/ha)
Physocarpus capitatus	11	2	1.1
Picea sitchensis	78	16	2.1
Salix hookeriana	78	42	4.2
Tsuga heterophylla	11	--	1.1

Upland understory shrub and herb vegetation included the following species with frequencies in excess of 10 percent:

		Freq. (%)	Avg. Cover (%)
	Agrostis alba (?)	10.0	0.6
(w)	*Carex obnupta*	22.2	5.3
	Galium trifidum/	14.4	0.1
	Lonicera involucrata	27.8	5.8
(w)	*Oenanthe sarmentosa*	61.1	24.6
	Salix hookeriana	20.0	6.4

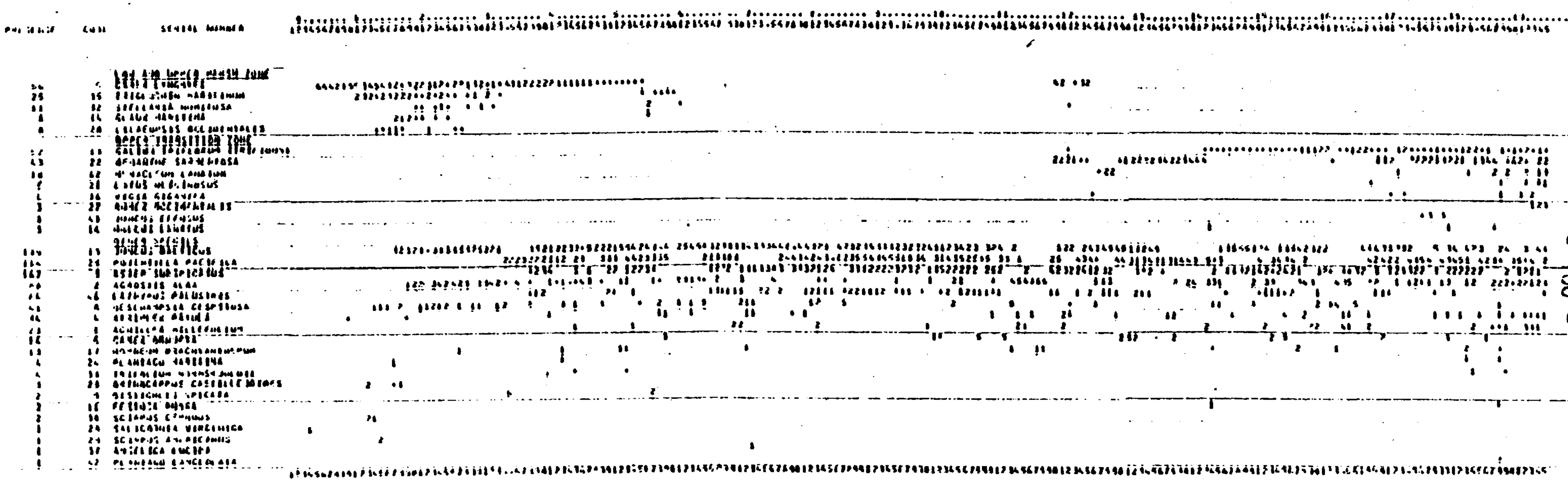

Figure 35. Plant community table, West Island study site.

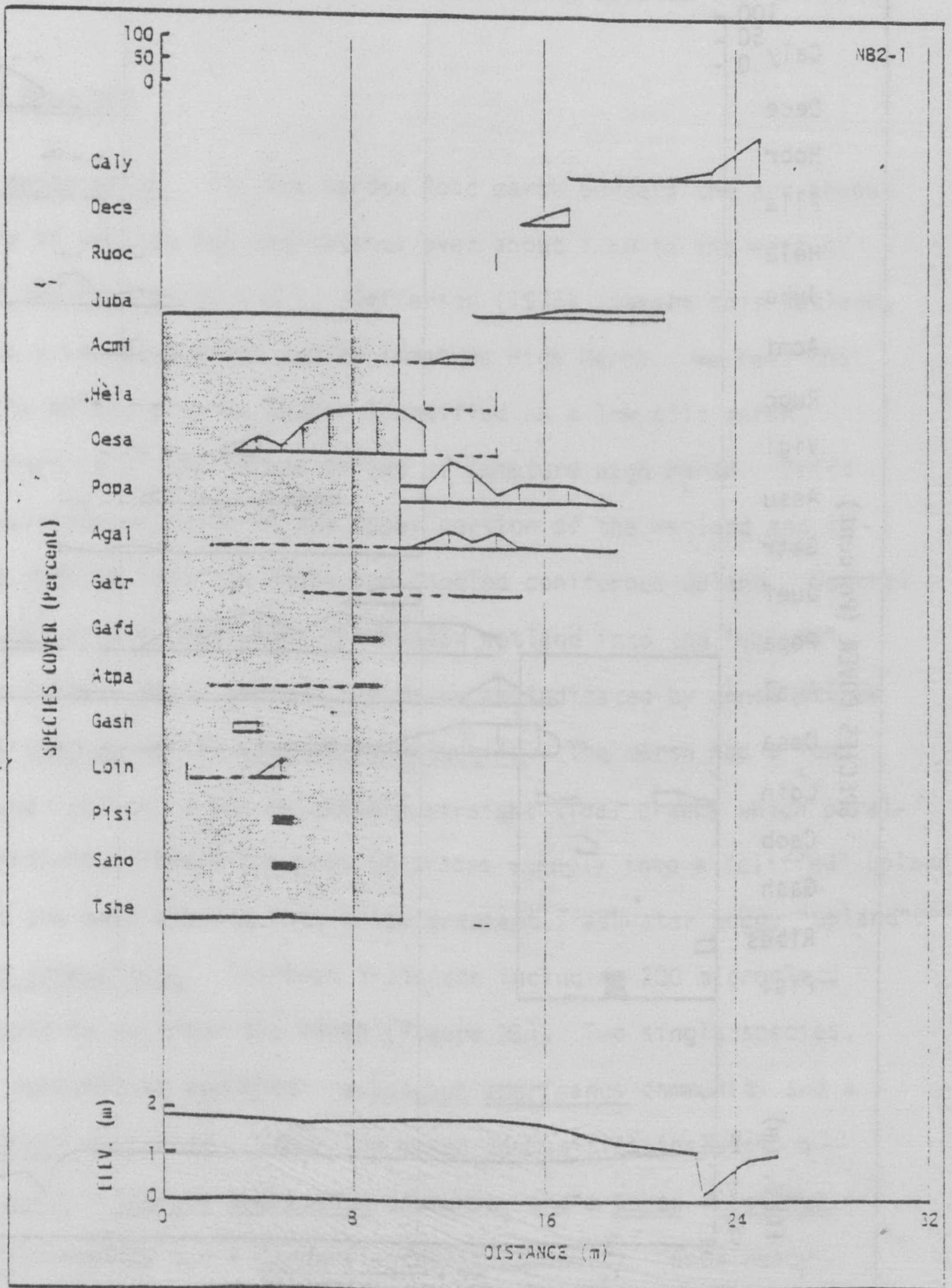

Figure 36. Plant species cover along transect NB2-1 at West Island study site.

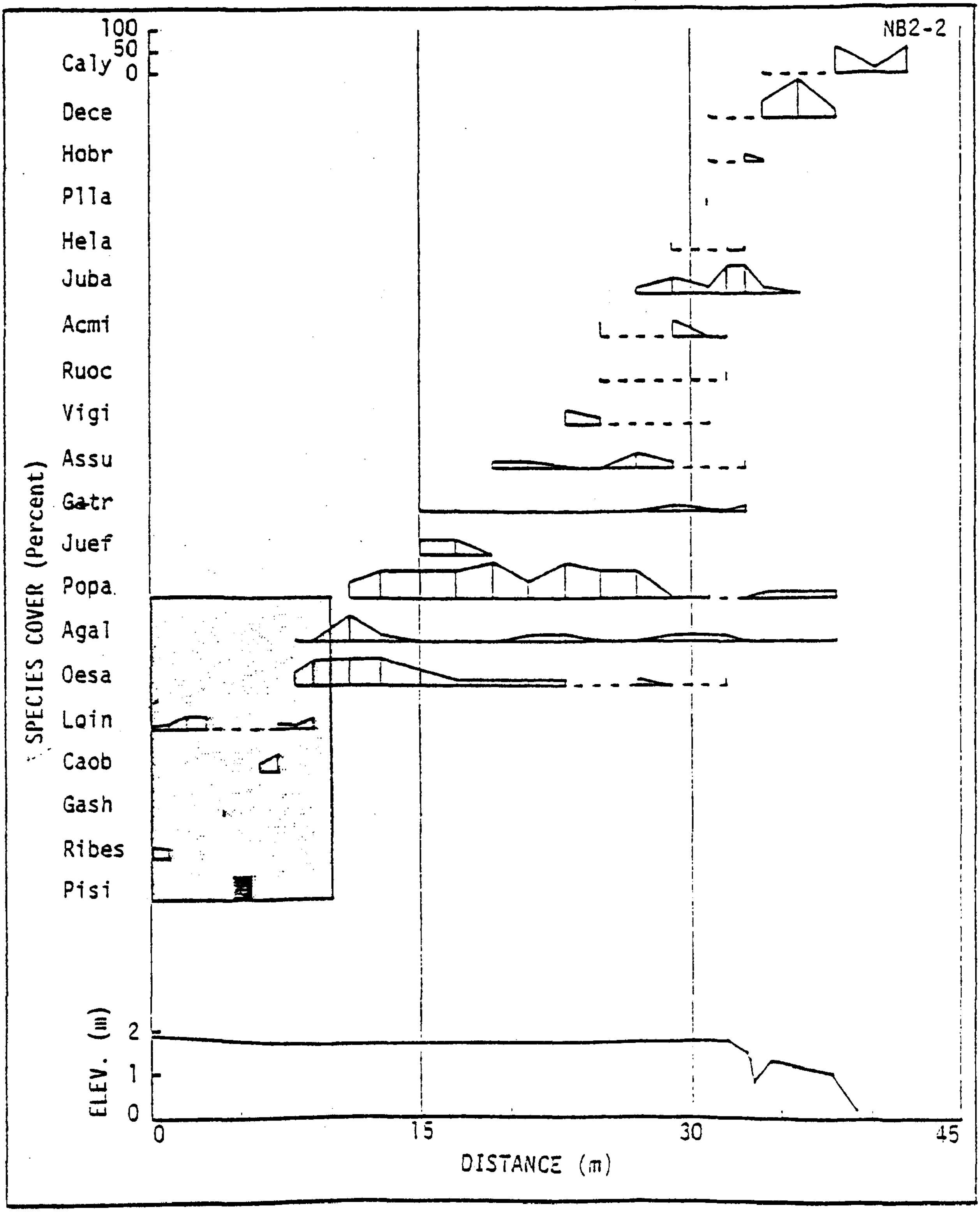

Figure 37. Plant species cover along transect NB2-2 at West Island study site.

Species with a (w) in the preceding list are plants commonly found in wet situations in uplands and together with some Lysichitum americanum suggest freshwater accumulation in this developing upland.

Sea Garden Road NB3

Site description. The Sea Garden Road marsh borders the arc-shaped north shore of Nehalem Bay and extends over about 1 km to the west of the end of the road (Figure 33). Jefferson (1975) classed this wetland, in part, as a Low Sand Marsh and an Immature High Marsh. We feel that the majority of the area is better identified as a low silt marsh, although there is a very narrow fringe of Immature High Marsh. Drift wood accumulation is thick in the upper portion of the wetland and in many cases extends into the dense and tangled coniferous upland. Several transects traverse a contiguous freshwater wetland into the "upland". Freshwater seepage marks most of the marsh as indicated by dense stands of Scirpus americanus and Eleocharis palustris. The marsh has a low gradient and includes a few relatively straight tidal creeks which parallel the gradient. Toward the west it grades steeply into a "cliffed" upland and toward the east extends into a low gradient freshwater boggy "upland".

Plant communities. Thirteen transects including 200 microplots were imployed to describe the marsh (Figure 38). Two single species, low marsh communities occurred: a Scirpus americanus community and a Carex lyngbyei community. Other low marsh communities included: a Carex lyngbyei - Scirpus americanus community and a Carex - Scirpus - Triglochin community and a Carex-Eleocharis community. As already mentioned all these assemblages are effected by freshwater seepage. Another complex assemblage found higher in the marsh was identified

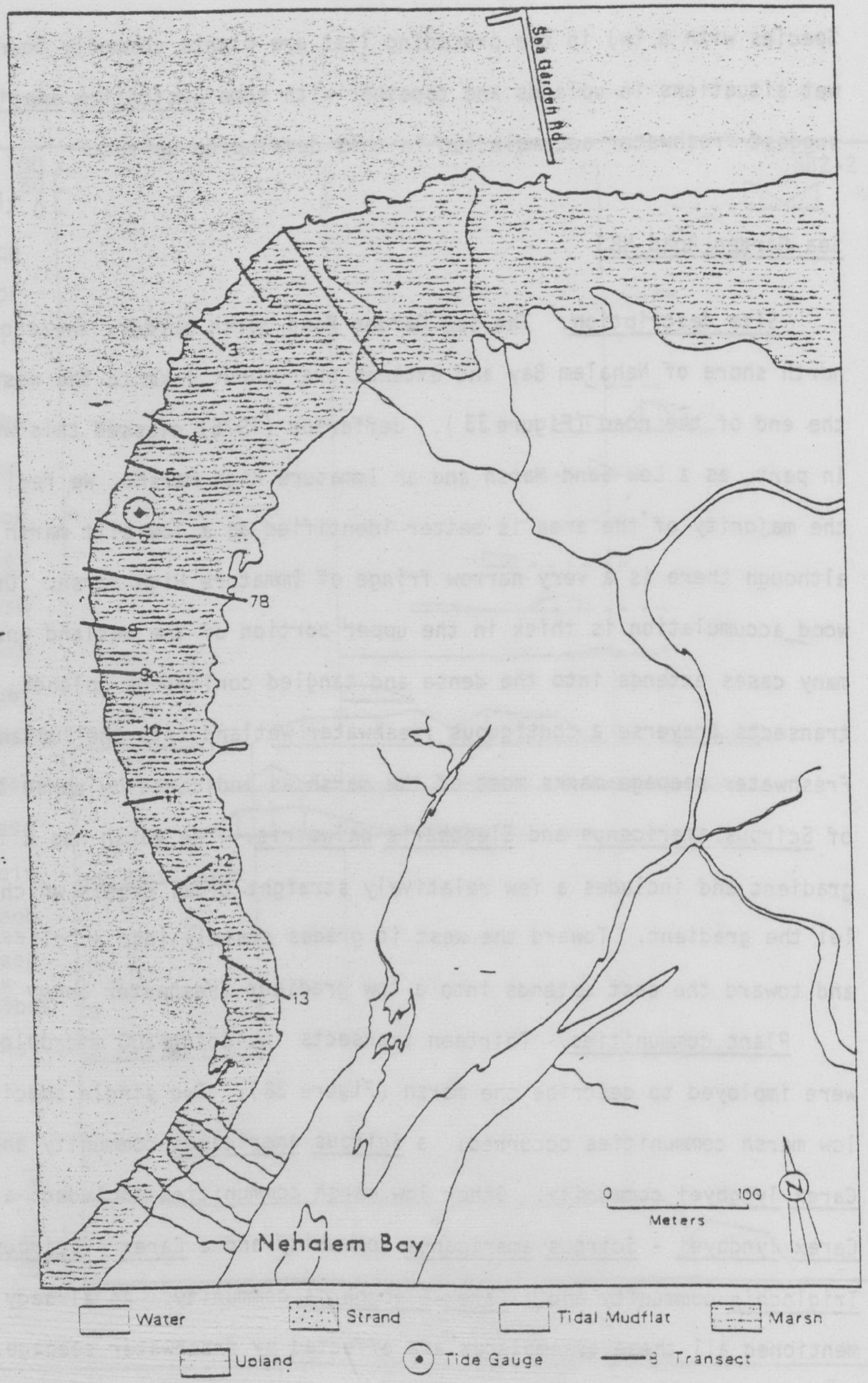

Figure 38. Sea Garden Road study site with approximate locations of transects.

by *Lilaeopsis occidentalis*, *Juncus balticus* and *Trifolium wormskjoldii*. Toward the upland, a freshwater marsh marked by *Scirpus microcarpus* or *Oenanthe sarmentosa* was present. Clear community separation was not possible.

Transects and transition zone. Illustrative of the transects are Figure 39. The repeated pattern along transects was for the colonizing edge to be dominated by *Carex lyngbyei* with a little *Triglochin maritimum* appearing at the western section of the study marsh. *Scirpus americanus* and/or *Eleocharis palustris* became codominant with the *Carex* as one moved toward upland, and suggested freshwater seepage. The marsh often had a slightly more dry upper middle section where *Deschampsia cespitosa*, *Potentilla pacifica*, *Agrostis alba*, *Juncus balticus* and *Trifolium wormskjoldii* occurred along a number of transects. The upper section of most transects exhibited ponding of freshwater, much drift log accumulation, and dense stands of freshwater indicators such as: *Scirpus microcarpus*, *Equisetum* spp., *Oenanthe sarmentosa*, *Carex obnupta* and *Athyrium filix-femina*. The lower boundary of the transition zone was difficult to place in the field and was not always chosen because of this difficulty. This was largely due to the fact that a saline wetland was being replaced by a freshwater wetland. In most cases the decision for identifying the lower transition zone boundary was based on the appearance of the above freshwater indicators and the reduced dominance or disappearance of the marsh and brackish water indicators such as *Eleocharis palustris* and *Scirpus americanus*.

Upland vegetation was assessed by 13 macroplots, and 130, 1 m line segments. Tree canopy reflected the gradient of a moist, almost swampy forest on the east, to a drier forest on the west. The following tabulation of overstory trees aggregates this habitat gradient.

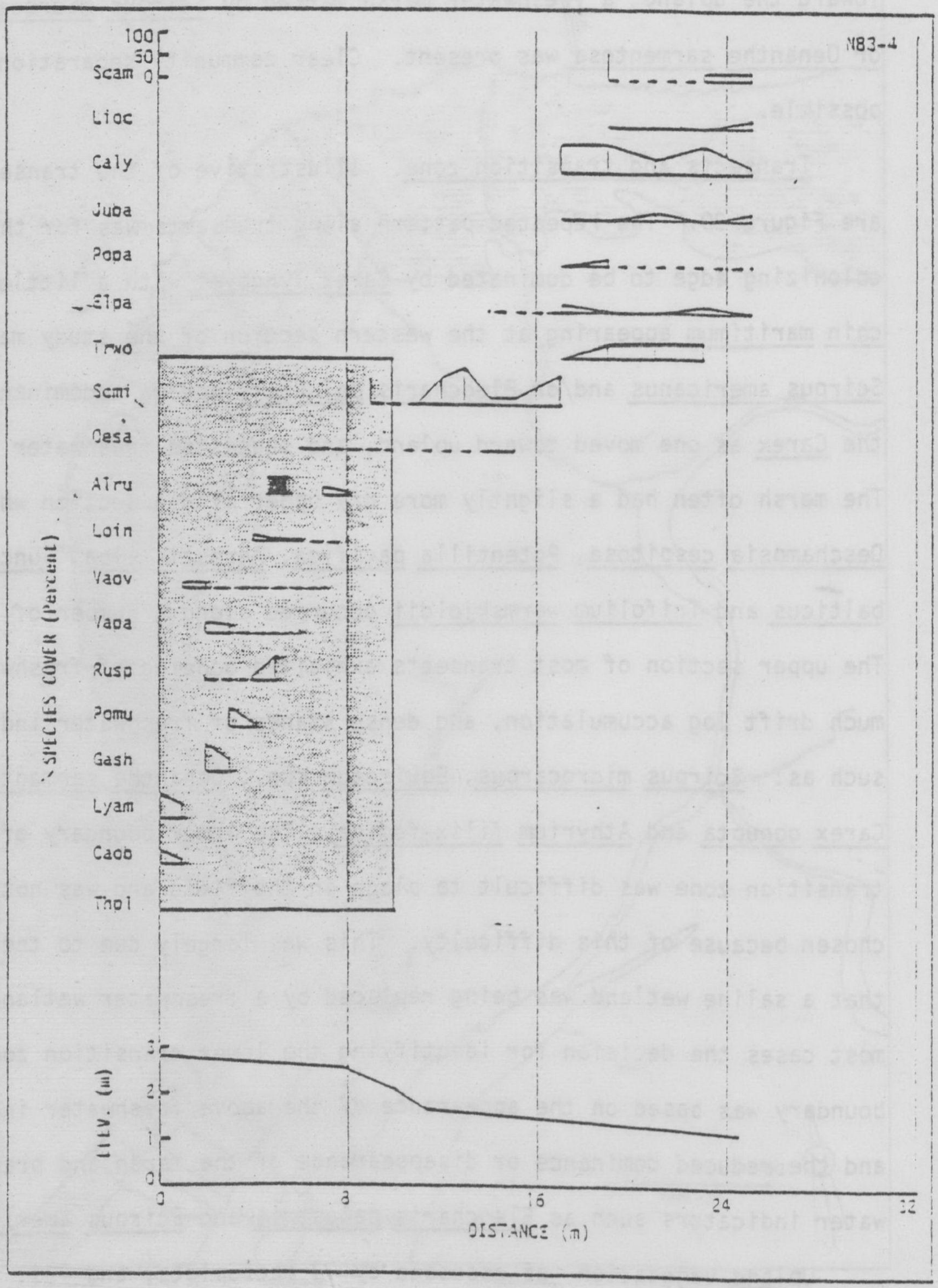

Figure 39. Plant species cover along transect N83-4 at Sea Garden Road study site.

	Freq. (%)	Avg. Cover (%)	B.A. (m^2/ha)
Alnus rubra	77	29	2.9
Physocarpus capitatus	38	11	0.7
Picea sitchensis	77	20	3.4
Pseudotsuga menziesii	1.5	2	0.2
Salix hookeriana	31	10	2.2
Thuga plicata	15	--	0.2
Tsuga heterophylla	38	6	1.2

Upland understory shrubs and herbs with frequencies of 10 percent or more are listed below and exhibit the same wet-dry habitat dichotomy as indicated by (w) for wet, and (d) for dry habitat species:

		Freq. (%)	Avg. Cover (%)
(w)	*Carex obnupta*	10.8	1.6
(w)	*Equisetum* spp.	12.3	2.0
(d)	*Gaultheria shallon*	50.8	18.8
(w)	*Lysichitum americanum*	17.7	5.1
(w)	*Oenanthe sarmentosa*	14.6	0.9
(w/d)	*Rubus spectablis*	30.0	6.3
(d)	*Vaccinium ovatum*	15.4	4.7
(d)	*Vaccinium parvifolium*	10.8	1.5

Niawiakum WB1

Site description. Situated on the east side of Willapa Bay, the marsh covers 18 ha on the south shore of the Niawiakum River mouth (Figure 40). This site is approximately 1.5 km east of Bay Center. Because the Niawiakum flows into the Palix River and not the Bay proper, the marsh has developed in partial protection from the main thrust of winter storms on the Bay. Although the marsh itself does not appear to have been directly disturbed, much of the surrounding upland has been logged. The marsh was classified as an Immature High Marsh and Mature High Marsh (after Jefferson, 1975). Creek development was quite extensive throughout the marsh. In the upper marsh both drift logs and freshwater seepage were found. The marsh gradient was slight with an

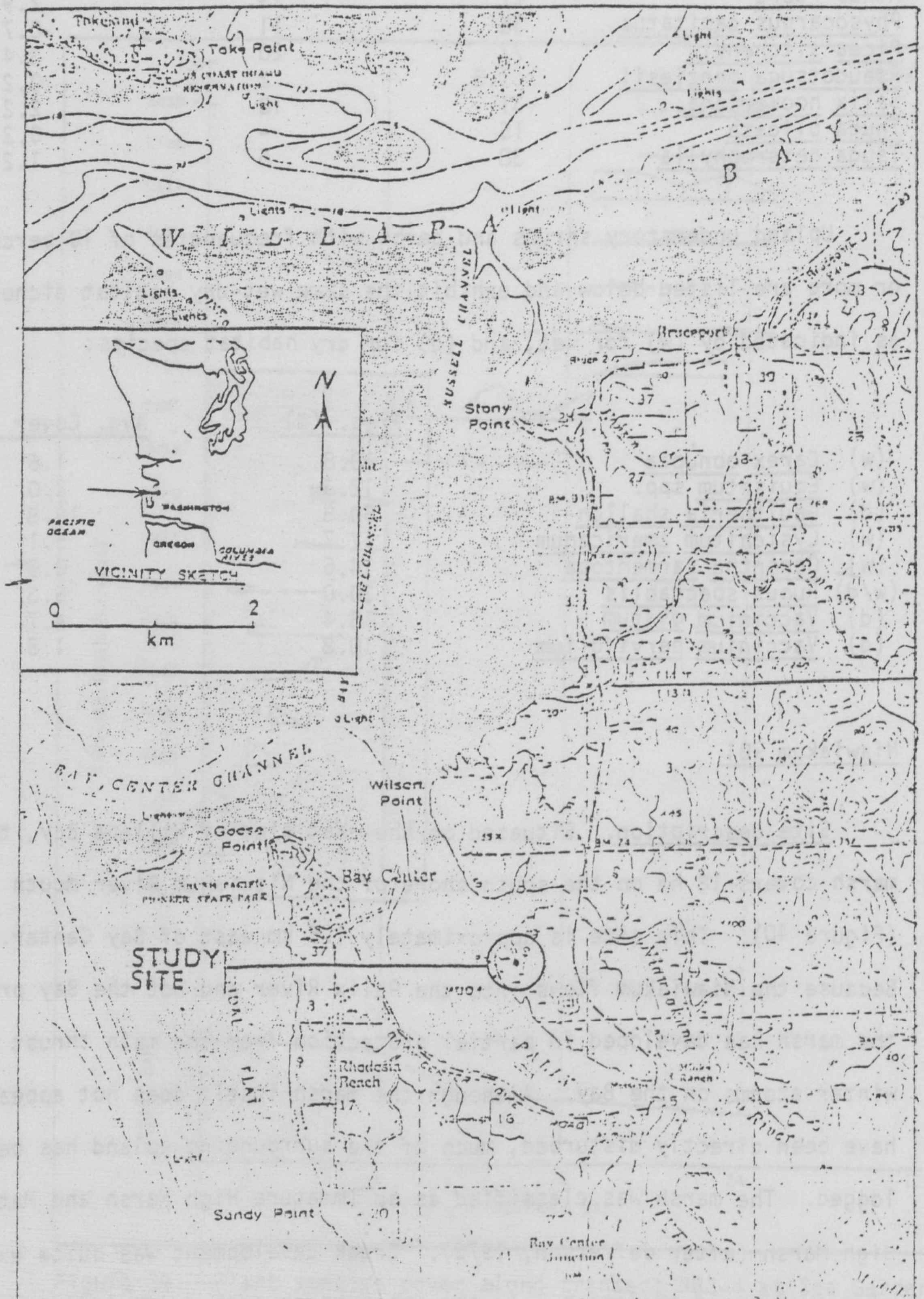

Figure 40. Location of Niawiakum study site, WB1.

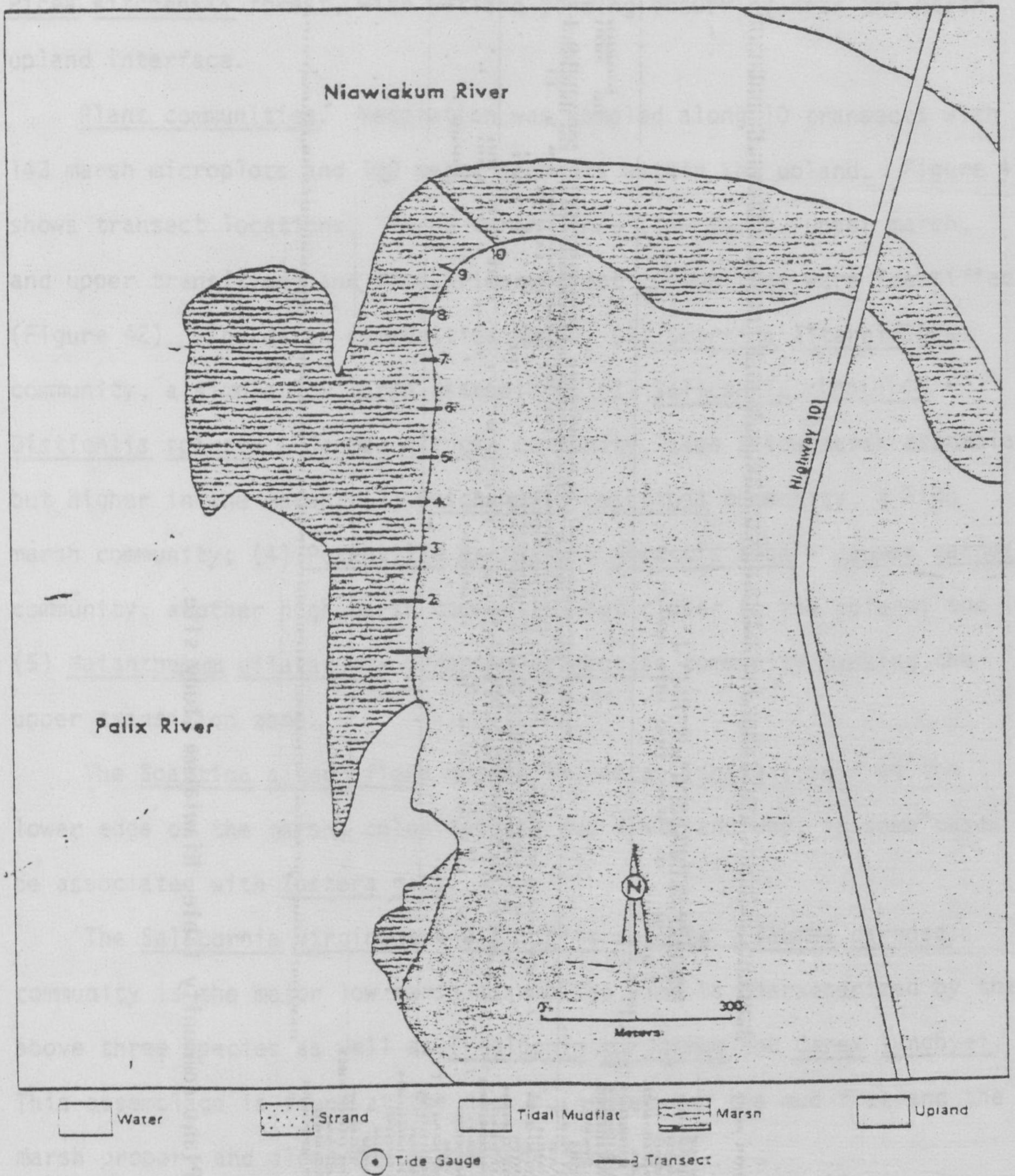

Figure 41. Niawiakum study site with approximate locations of transects.

PRESENCE	CODE	SERIAL NUMBER
		LOW MARSH ZONE
47	29	SALICORNIA VIRGINICA
18	16	JAUMEA CARNOSA
13	5	CAREX LYNGBYEI
6	31	SPERGULARIA CANADENSIS
6	44	[illegible] NANA
5	55	SPARTINA ALTERNIFLORA
		MIDDLE TRANSITION ZONE
11	40	[illegible]
10	22	OENANTHE SARMENTOSA
		[illegible]
47	28	POTENTILLA PACIFICA
63	2	AGROSTIS ALBA
42	19	JUNCUS BALTICUS
44	35	TRIGLOCHIN MARITIMUM
41	15	GLAUX MARITIMA
55	8	DESCHAMPSIA CESPITOSA
58	9	DISTICHLIS SPICATA
65	17	HORDEUM BRACHYANTHERUM
16	4	ATRIPLEX PATULA
30	32	STELLARIA HUMIFUSA
11	11	FESTUCA RUBRA
7	3	ASTER SUBSPICATUS
4	33	STELLARIA CALYCANTHA
3	34	SCIRPUS CERNUUS
2	15	GRINDELIA INTEGRIFOLIA
2	26	PLANTAGO MARITIMA
2	37	ANGELICA LUCIDA
2	12	GALIUM APARINE
2	1	ACHILLEA MILLEFOLIUM
1	21	ORTHOCARPUS CASTILLEJOIDES
1	25	PUCCINELLIA PUMILA
1	27	RUMEX OCCIDENTALIS
1	[illegible]	TRIFOLIUM WORMSKJOLDII

Figure 42. Plant community table, Niawiakum study site.

abrupt drop to the mudflat at the lower marsh edge. The upland was a Picea sitchensis forest, with wetland ponding occurring near the marsh-upland interface.

Plant communities. Vegetation was sampled along 10 transects with 143 marsh microplots and 100 meter segments within the upland. Figure 41 shows transect locations. Three marsh zones (low marsh, upper marsh, and upper transition) and five primary plant communities were identified (Figure 42). The marsh communities were: (1) Spartina alterniflora community, a simple low marsh assemblage; (2) Salicornia virginica - Distichlis spicata - Jaumea carnosa community, also a low marsh assemblage, but higher in the marsh; (3) Deschampsia cespitosa community, a high marsh community; (4) Potentilla pacifica - Agrostis alba - Jaumea carnosa community, another high marsh community, but closer to the upland; and (5) Maianthemum dilatatum - Oenanthe sarmentosa community marking the upper transition zone.

The Spartina alterniflora community, establishing itself at the lower edge of the marsh, colonizes the mud flat, and may, in some cases, be associated with Zostera nana.

The Salicornia virginica - Distichlis spicata - Jaumea carnosa community is the major low marsh assemblage, and is characterized by the above three species as well as Triglochin maritimum and Carex lyngbyei. This assemblage is found at the nick point between the mud flat and the marsh proper, and along the major tidal creeks.

The Deschampsia cespitosa community is a complex assemblage where there is some intermixing of low marsh and high marsh species; however, the low marsh species are dominant only at the edges of tidal creeks within the assemblage.

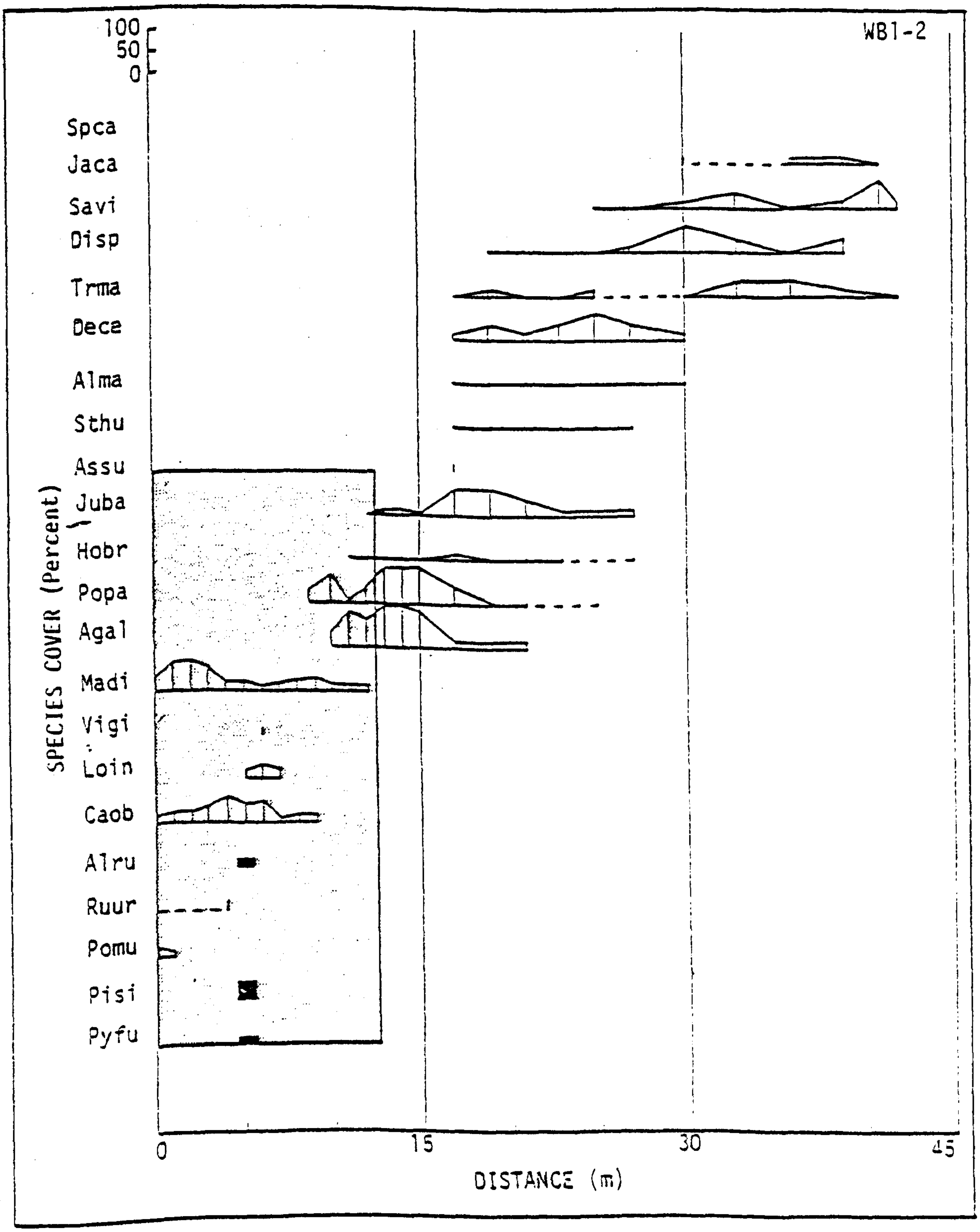

Figure 43. Plant species cover along transect WB1-2 at Niawiakum study site.

The *Potentilla pacifica* - *Agrostis alba* - *Juncus balticus* community, also a high marsh assemblage, was found at a higher position in the marsh than the *Deschampsia cespitosa* community. Low marsh species were infrequent, and tended to drop out in the upper portions of the assemblage, where they were replaced locally by *Festuca rubra*, and upland species.

The *Maianthemum dilatatum* - *Oenanthe sarmentosa* community formed a distinctive upper transition zone assemblage; however, *Potentilla pacifica* and *Agrostis alba* were locally dominant in this assemblage. Drift logs tended to accumulate in this community.

Transects and transition zone. Ten transects, two of which extended into the mud flat, were established at regular intervals in the marsh. Figure 43 and 44 show typical transects. The lower marsh transition zone boundary was marked by the appearance of upland species, most notably *Festuca rubra*.

Upland vegetation was a *Picea sitchensis* forest characterized in places by a moist understory. Frequency, cover, and basal area data for tree species are:

	Freq. (%)	Avg. Cover (%)	B.A. (m^2/ha)
Alnus rubra	100.0	24.0	4.3
Osmaronia cerasiformis	10.0	4.0	0.2
Picea sitchensis	100.0	33.0	7.6
Pyrus fusca	40.0	12.0	1.1
Rhamnus purshiana	10.0	2.0	--
Salix hookeriana	20.0	0.8	--
Tsuga heterophylla	40.0	5.0	0.6

Upland understory species with greater than 10 percent frequency in 100 samples included:

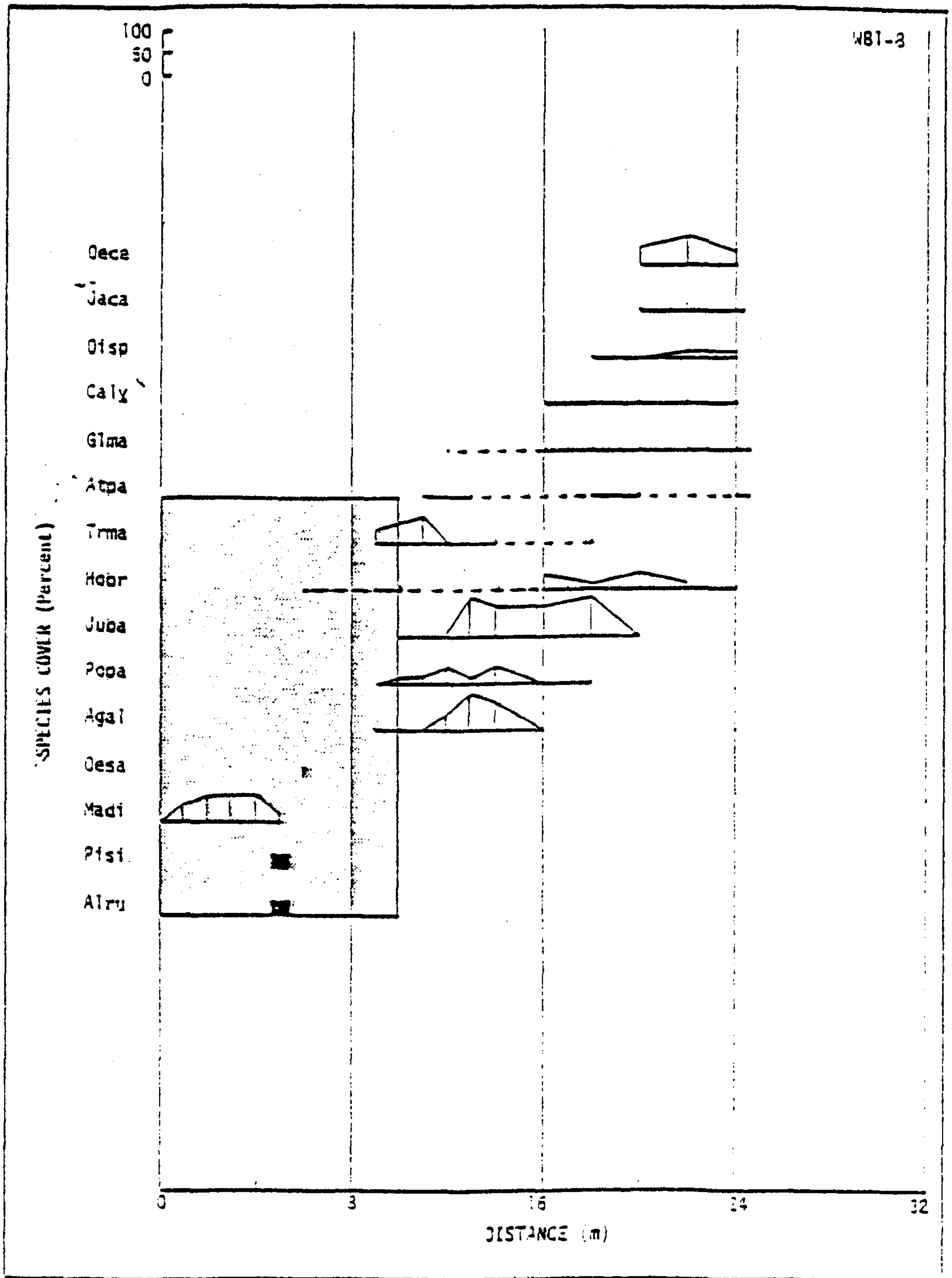

Figure 44. Plant species cover along transect WB1-3 at Niawiakum study site.

		Freq. (%)	Avg. Cover (%)
	Agrostis alba	15.0	1.8
w	Carex obnupta	17.0	7.5
	Gaultheria shallon	21.0	7.3
	Maianthemum dilatatum	68.0	19.0
	Montia siberica	10.0	0.4
w	Oenanthe sarmentosa	17.0	2.3
	Polystichum munitum	21.0	10.2
	Rubus ursinus	15.0	2.3

Cedar River WB2

Site description. On the north shore of Willapa Bay, the marsh occupies 3.5 ha on the west bank of Cedar River, near the river's mouth 4 km north of Tokeland (Figure 45). The marsh did not appear to be disturbed, although parts of it were said, by the owner, to have been grazed in the past. The marsh system may be divided into two areas. We classified a large area in the northern portion of the marsh as a High Mature Marsh. This marsh supported an extensive tidal creek system, and contained virtually no drift logs. The marsh gradient was low with an abrupt drop of 1.5 m to Cedar River. The smaller southern area of the marsh was classified as a Immature High Marsh in which there was no tidal creek development, and few drift logs. The marsh gradient was steeper than in the High Mature Marsh. Freshwater seepage was more evident in the southern area of the marsh, as indicated by Lileaopsis occidentalis. Upland vegetation above the entire marsh was a Tsuga heterophylla - Picea sitchensis forest. Areas of wetland ponding were found within the upland, near the marsh margin.

Plant communities. To identify the vegetation, 159 marsh microplots and 133 upland meter segments were sampled along 10 transects (Fig. 46). Five marsh communities were identified, occurring over three marsh zones: lower marsh, upper marsh, and upper transition. The five communities

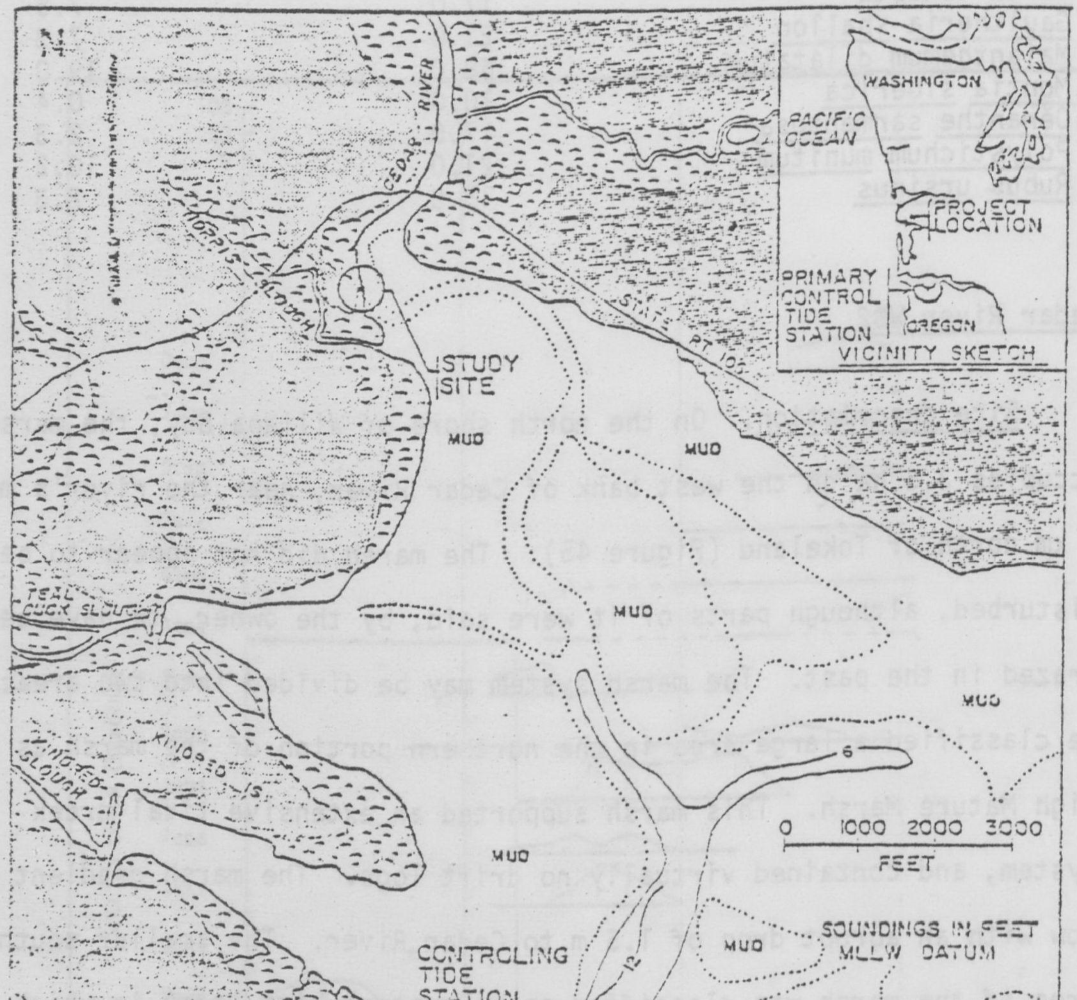

Figure 45. Location of Cedar River study site, WB2.

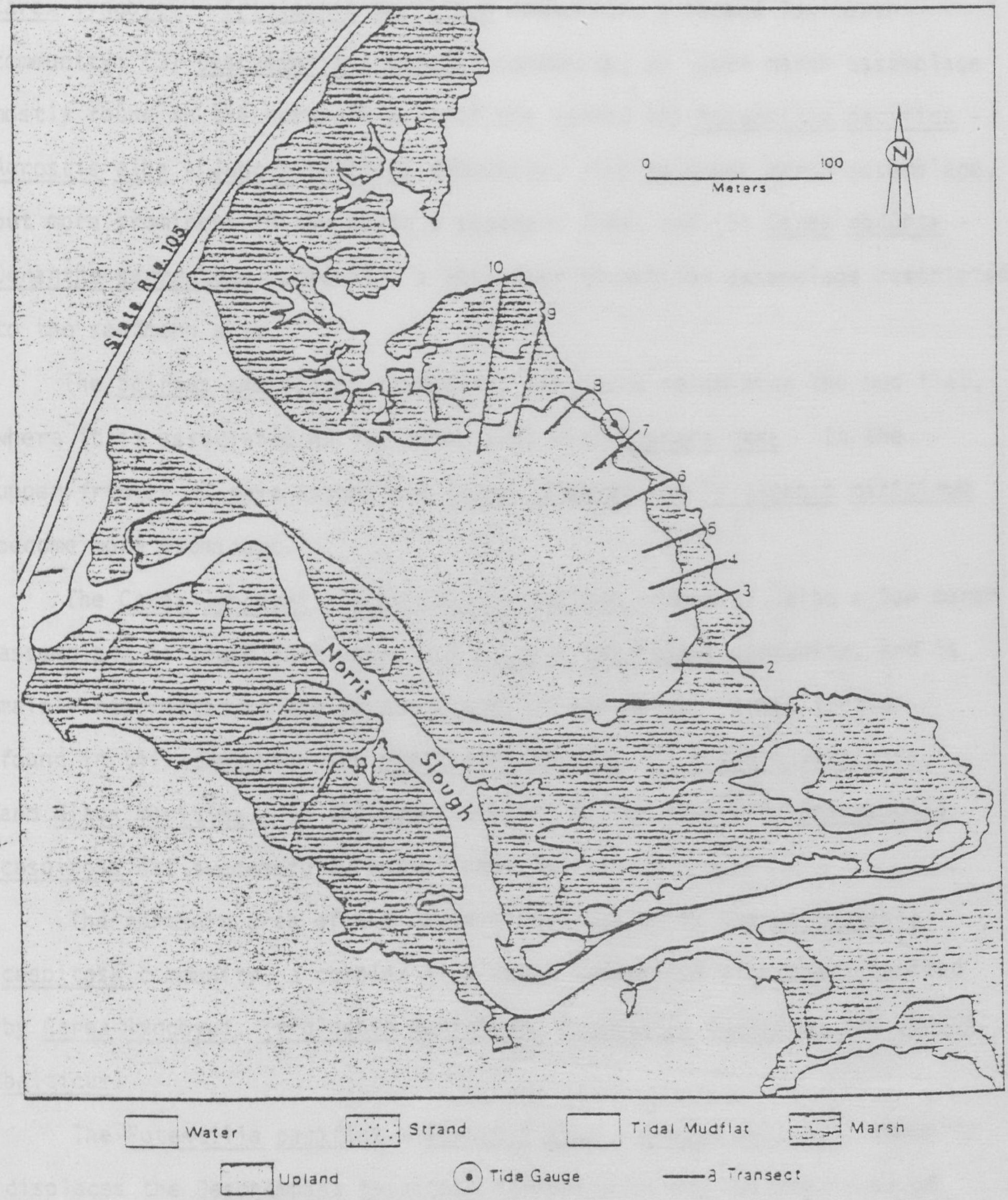

Figure 46. Cedar River study site with approximate locations of transects.

were: (1) Scirpus americanus community, a low marsh assemblage; (2) Carex lyngbyei - Triglochin maritimum community, a second low marsh community; (3) Deschampsia cespitosa community, an upper marsh assemblage mostly found in the northern area of the marsh; (4) Potentilla pacifica - Agrostis alba - Juncus balticus community, also an upper marsh assemblage, but more prominent in the marsh's southern area; and (5) Carex obnupta - Oenanthe sarmentosa community, a wet, upper transition assemblage restricted to the southern area.

The Scirpus americanus community, was found colonizing the mud flat, where it is associated at its outer edge with Zostera nana. In the upper fringes of this assemblage Carex lyngbyei and Triglochin maritimum become more prominent.

The Carex lyngbyei - Triglochin maritimum community, also a low marsh assemblage is found just above the Scirpus americanus community, and is mainly restricted to the southern area of the marsh. Other species found in this community are Distichlis spicata, Salicornia virginica, and Glaux maritima. In the upper portion of the community Deschampsia cespitosa has successfully established itself.

The northern area of the marsh is delineated by the Deschampsia cespitosa community, a complex high marsh assemblage also characterized by Carex lyngbyei, Triglochin maritimum, Potentilla pacifica, and Juncus balticus.

The Potentilla pacifica - Agrostis alba - Juncus balticus community displaces the Deschampsia cespitosa community in the southern area of the marsh, although, Deschampsia cespitosa, with Carex lyngbyei, is a characteristic species of this assemblage. In the upper portions of this assemblage upland species are found.

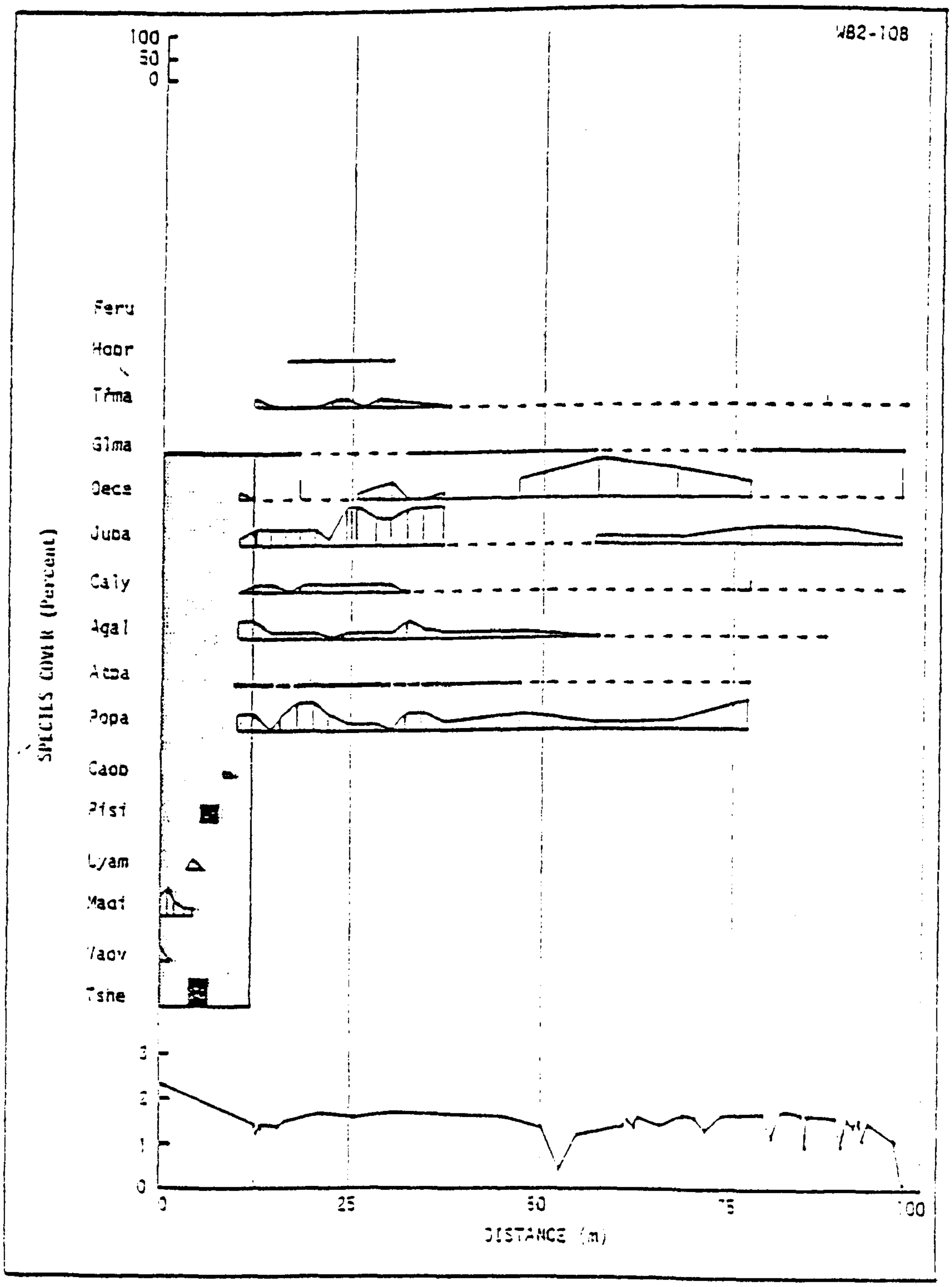

Figure 47. Plant species cover along transect W82-108 at Cedar River study site.

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The upper transition zone is marked by the Carex obnupta - Oenanthe sarmentosa community, a wet assemblage, in which such species as Potentilla pacifica and Triglochin maritimum may be found, but never dominate.

Transects and transition zone. Ten transects were established in the marsh, seven in the southern area and three in the northern area. One transect from the northern area and all transects in the southern area were mud flat. Figure 47 shows a typical transect. The transition zone lower boundary was defined as the lower extent of such upland species as Aster subspicatus and Calamagrostis nutkaensis.

The upland vegetation was a Tsuga heterophylla - Picea sitchensis forest, where, in places, there was a moist understory marked by Carex obnupta. Frequency, cover, and basal area data for tree species were:

	Freq. (%)	Avg. Cover (%)	B.A. (m^2/ha)
Alnus rubra	70.0	16.0	2.4
Picea sitchensis	80.0	19.0	2.4
Pyrus fusca	30.0	2.0	--
Rhamnus purshiana	20.0	2.0	--
Tsuga heterophylla	90.0	38.0	7.9

Upland understory species with greater or equal to 10 percent in 133 samples were:

	Freq. (%)	Avg. Cover (%)
Agrostis alba	12.0	1.1
Calamagrostis nutkaensis	27.1	7.3
Maianthemum dilatatum	46.6	14.1
Oenanthe sarmentosa	19.5	4.4
Rubus ursinus	15.3	2.9
Vaccinium ovatum	11.3	4.8

Leadbetter Point WB4

Site description. Located on the west shore of Willapa Bay, at the north tip of the North Beach Peninsula (Figure 48), the marsh covers an

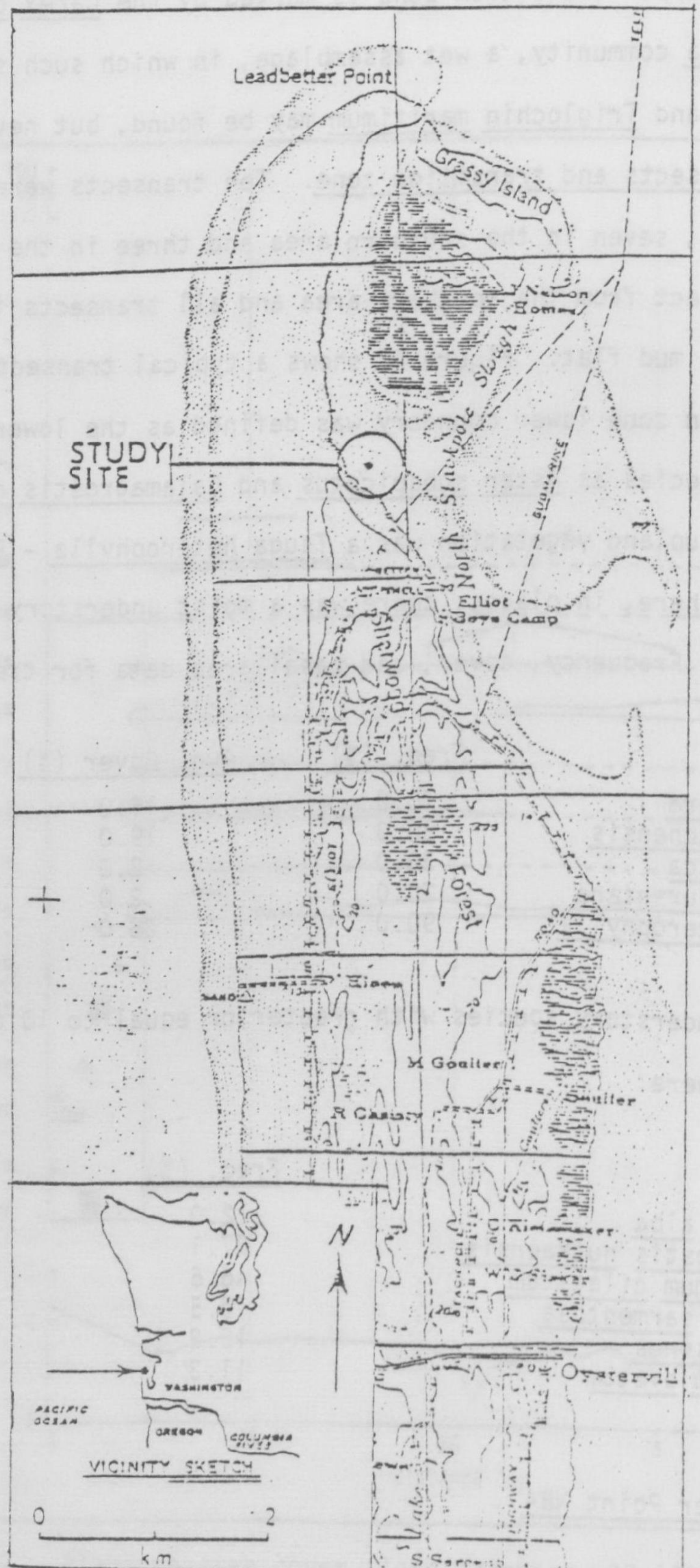

Figure 48. Location of Leadbetter Point study site WB4.

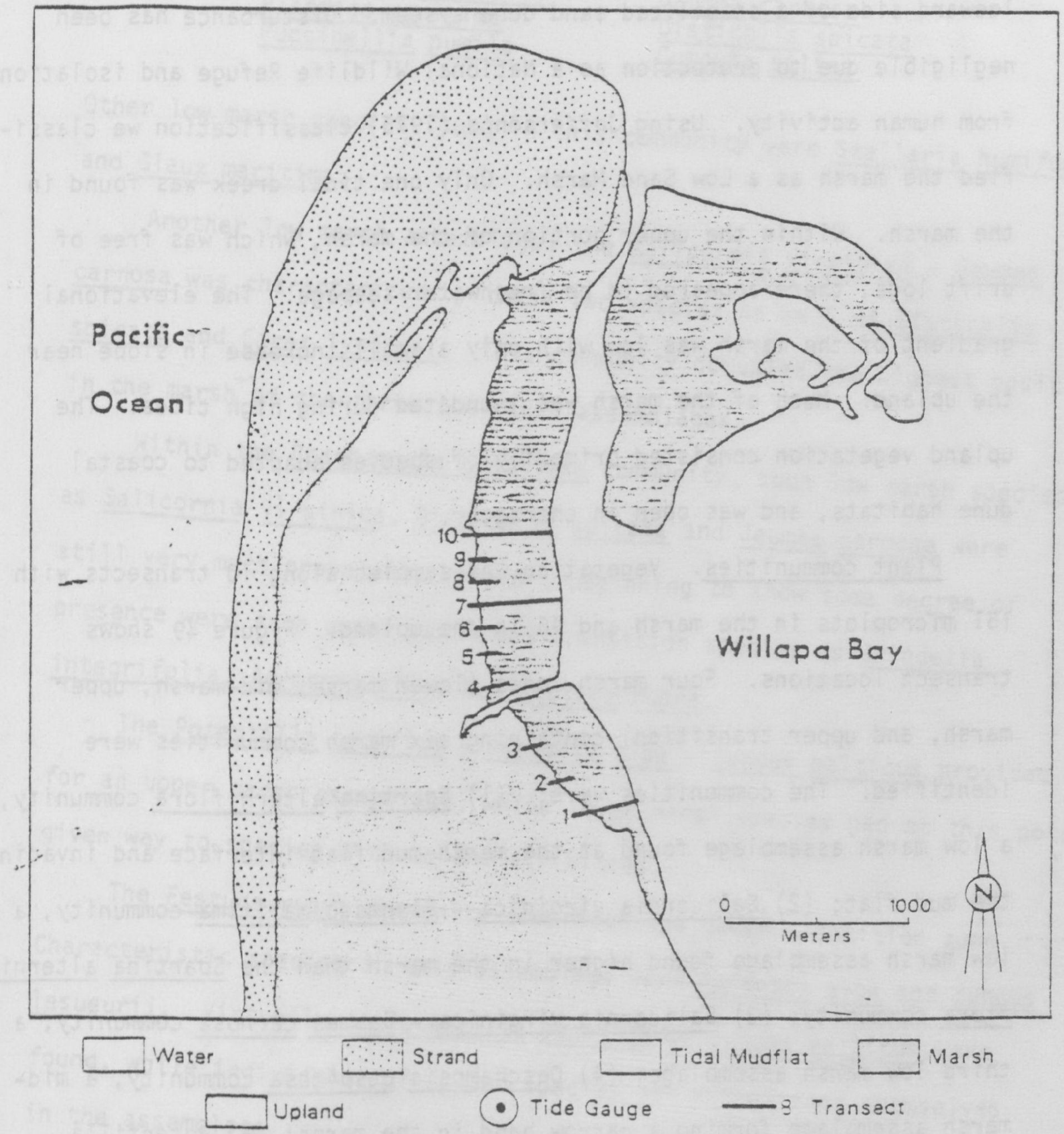

Figure 49. Leadbetter Point study site with approximate locations of transects.

area of 390 ha. The marsh is of recent origin, having developed on the leeward side of a stabilized sand dune system. Disturbance has been negligible due to protection as a National Wildlife Refuge and isolation from human activity. Using Jefferson's (1975) classification we classified the marsh as a Low Sand Marsh. Only one tidal creek was found in the marsh. Within the upper portion of the marsh, which was free of drift logs, there appeared to be freshwater seepage. The elevational gradient of the marsh was low with only a small increase in slope near the upland. Much of the marsh was inundated during high tides. The upland vegetation consisted primarily of species adapted to coastal dune habitats, and was open in character.

Plant communities. Vegetation was sampled along 10 transects with 151 microplots in the marsh and 46 in the upland. Figure 49 shows transect locations. Four marsh zones (lower marsh, mid-marsh, upper marsh, and upper transition) containing six marsh communities were identified. The communities were: (1) *Spartina alterniflora* community, a low marsh assemblage found at the marsh-mud flat interface and invading the mud flat; (2) *Salicornia virginica* - *Plantago maritima* community, a low marsh assemblage found higher in the marsh than the *Spartina alterniflora* community; (3) *Salicornia virginica* - *Jaumea carnosa* community; a third low marsh assemblage; (4) *Deschampsia caespitosa* community, a mid-marsh assemblage forming a narrow band in the marsh; (5) *Potentilla Pacifica* - *Agrostis alba* - *Juncus balticus* community found in the higher marsh; and, (6) *Festuca rubra* community, forming the upper transition.

The *Spartina alterniflora* community, a single species community, was found only at one location in the southern portion of the marsh.

The *Salicornia virginica* - *Plantago maritima* community was a fairly widespread low marsh assemblage with the characteristic species:

Salicornia virginica	_Jaumea carnosa_
Plantago maritima	_Distichlis spicata_
Puccinellia pumila	_Cuscuta salina_

Other low marsh species found in this community were _Stellaria humifusa_ and _Glaux maritima_.

Another low marsh assemblage, the _Salicornia virginica_ - _Jaumea carnosa_ was characterized by these two species as well as _Distichlis spicata_ and _Carex lyngbyei_. This community occupied the highest position in the marsh of the three low marsh assemblages.

Within the _Deschampsia cespitosa_ community, such low marsh species as _Salicornia virginica_, _Distichlis spicata_ and _Jaumea carnosa_ were still very much prevalent; however, beginning to show some degree of presence were such upper marsh and transition species as _Grindelia integrifolia_, _Agrostis alba_, and _Festuca rubra_.

The _Potentilla pacifica_ - _Agrostis alba_ - _Juncus balticus_ provided for an upper marsh assemblage, while lower marsh species had at this point given way to species with upland affinities.

The _Festuca rubra_ community comprised the upper transition zone. Characteristic species in this assemblage were _Agrostis alba_ and _Juncus lesueurii_. Virtually no _Potentilla pacifica_ or _Juncus balticus_ were found, while individuals of upland species had established themselves in the assemblage.

Transects and transition zone. Ten transects, three of which extended to the mud flat, were established over 2 km of the marsh. Figure 50 and 51 show two typical transects. The lower limit of the transition zone was marked where two or more species with upland affinities appeared together in abundance, and in the absence of low marsh species.

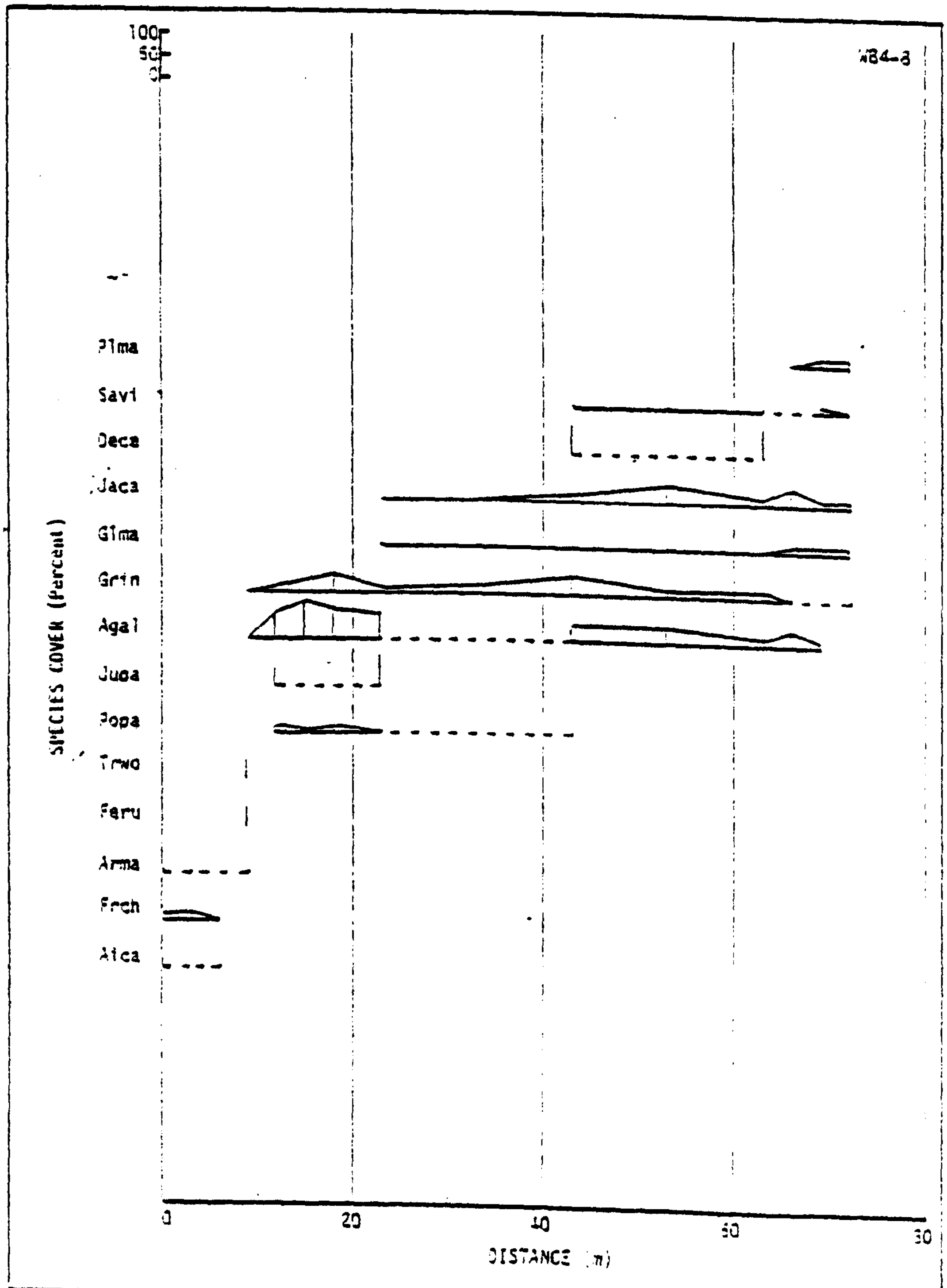

Figure 50. Plant species cover along transect WB4-8 at Leadbetter Point study site.

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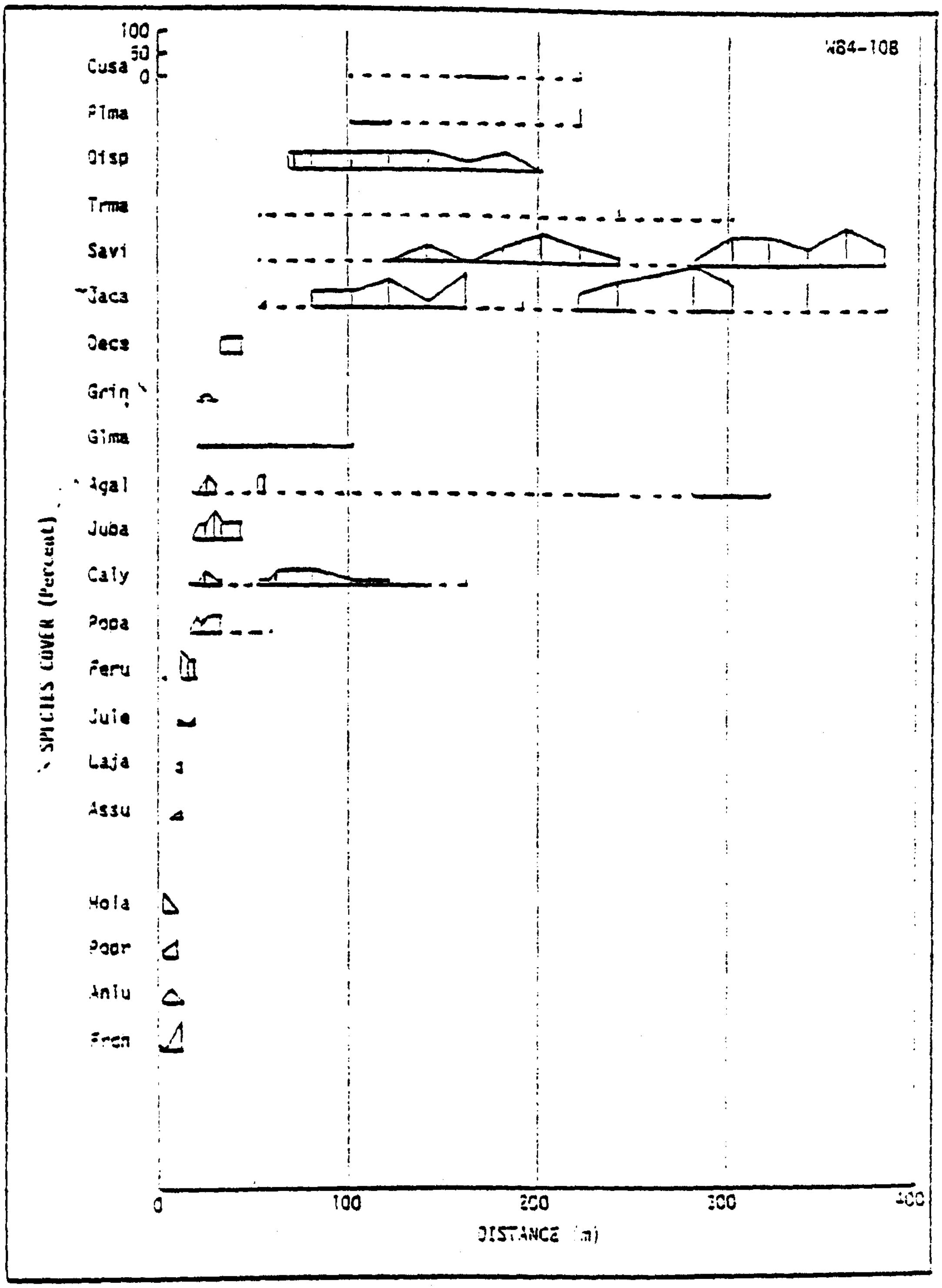

Figure 51. Plant species cover along transect W84-10B at Leadbetter Point study site.

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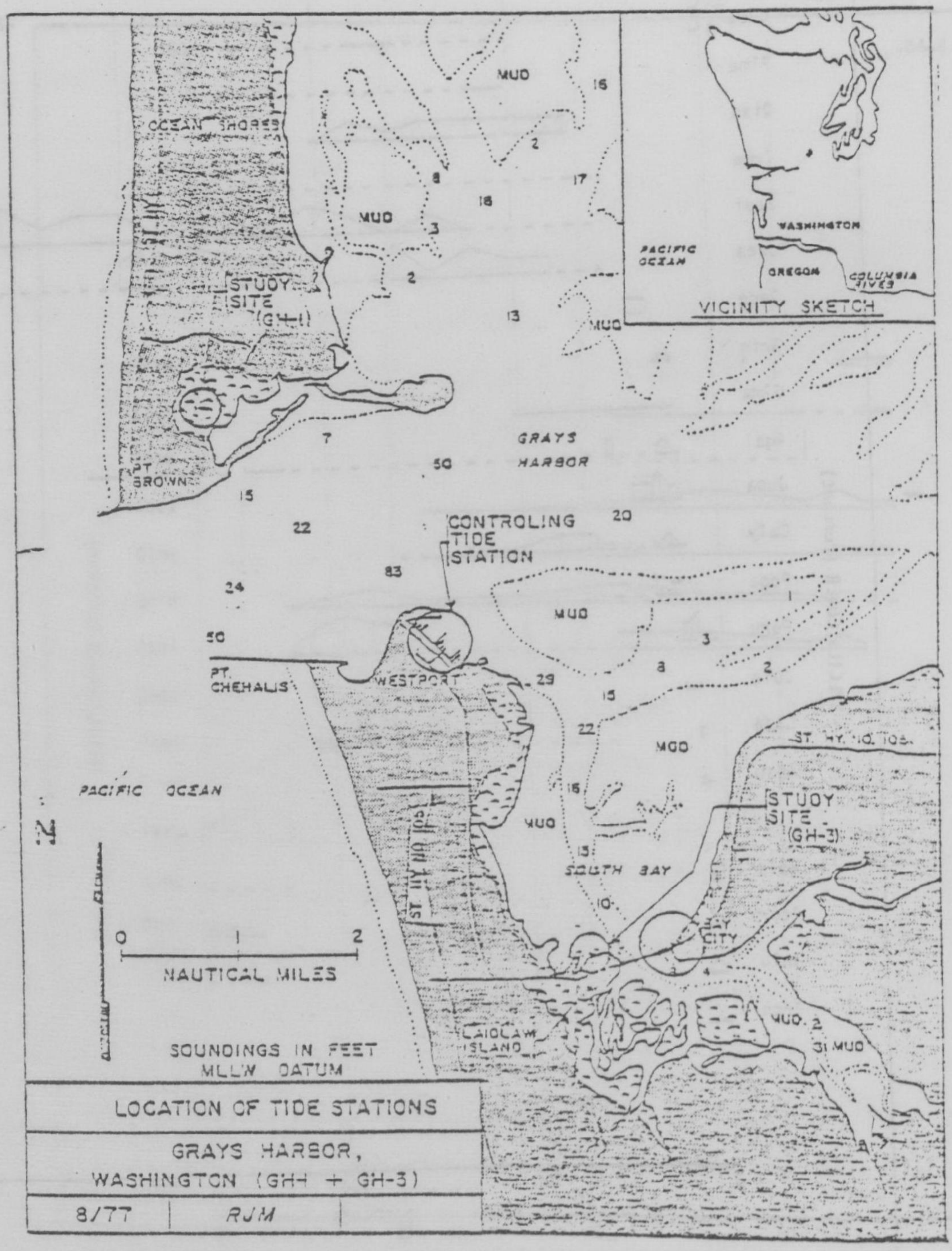

Figure 52. Location of The Sink and Elk River study sites, GH1 and GH3.

The upland vegetation was composed of species adapted to maritime sand dune habitats. Upland species with 10 percent frequency or greater in 46 microplots included:

	Freq. (%)	Avg. Cover (%)
Achillea millefolium	26.1	1.7
Aira praecox	10.9	0.4
Ammophila arenaria	23.9	4.8
Angelica lucida	10.9	2.3
Elymus mollis	47.8	5.8
Festuca rubra	52.2	6.3
Fragaria chiloensis	39.1	5.5
Holcus lanatus	17.4	2.0
Hypochaeris radicata	32.6	2.1
Juncus lesueurii	19.6	2.8
Lathyrus japonicus	15.2	2.0
Plantago lanceolata	19.6	1.2
Potentilla pacifica	25.5	6.7
Poa pratensis	11.8	1.4
Rumex acetosella	15.7	0.5
Stellaria calycantha	19.6	2.6
Vicia gigantea	11.8	5.4

The Sink GH1

Site description. Situated three km northeast of Point Brown on the Grays Harbor side of the Oyhut Peniinsula (Figure 52), this 249 ha marsh is approximately 5 km south of Ocean Shores. The marsh is used for waterfowl hunting during the fall of each year; however, there does not appear to be any excessive disturbance of the marsh. Although Rowntree (1977) had conducted biomass studies within the marsh, he did not classify it. We classified the marsh as a Low Sand Marsh. Long, wide tidal creeks were found in the marsh; there was no extensive network of small tidal creeks. Drift logs were found, but they did not clog the upper portion of the marsh as seen in other marshes. Freshwater seepage as indicated by Carex obnupta and Lilaeopsis occidentalis. occurred in places along the marsh's upper limit. The upland was

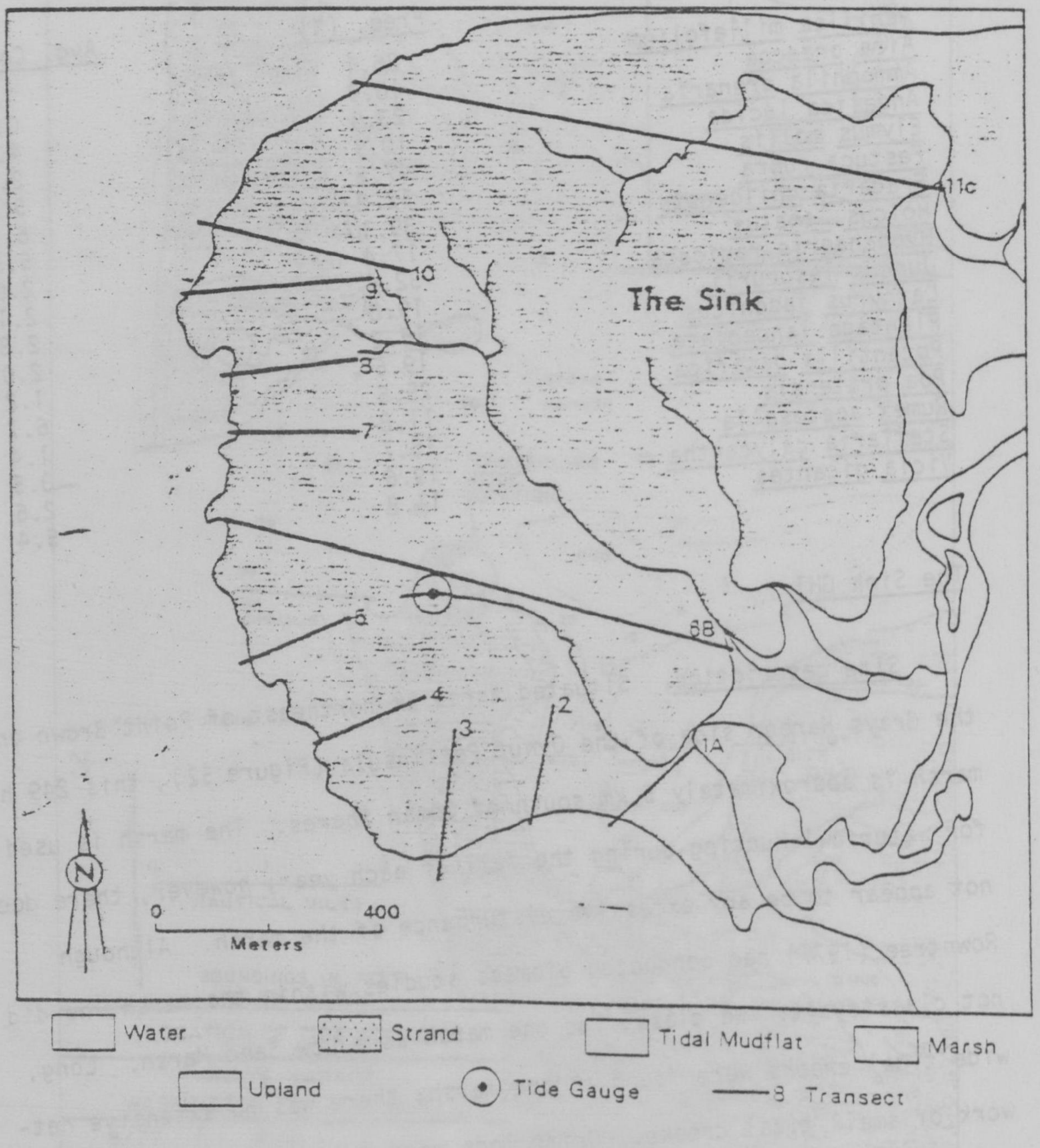

Figure 53. The Sink study site with approximate locations of transects.

non-forested, characterized by sand dune species with pockets of Salix scrub. Figure 53 shows the study site.

Plant communities. Sampling along 11 transects with 230 microplots in the marsh and 51 meter segments in the upland permitted characterization of the vegetation. Lower and upper marsh zones containing four communities were identified. The four marsh communities were: (1) Salicornia virginica - Jaumea carnosa - Distichlis spicata community, an extensive low marsh community; (2) Potentilla pacifica - Agrostis alba - Juncus lesueurii community, a high marsh assemblage; (3) Potentilla pacifica - Agrostis alba - Juncus balticus community, also a high marsh community; and, (4) Holcus lanatus community, forming the upper transition assemblage.

The Salicornia virginica - Jaumea carnosa - Distichlis spicata community is by far the largest, in areal extent, of any community in the marsh. Characteristic species are:

Salicornia virginica
Jaumea carnosa
Distichlis spicata
Puccinellia pumila

Stellaria humifusa
Plantago maritima
Triglochin concinnum

This assemblage gives way to two similar plant plant communities in the upper marsh. Both the Potentilla pacifica - Agrostis alba - Juncus lesueurii community and the Potentilla pacifica - Agrostis alba - Juncus balticus community may both occupy the same elevational position in the marsh.

The upper transition zone is marked by the Holcus lanatus community. Potentilla pacifica may dominate in this assemblage, however, a number of species with upland affinities are also found. This assemblage does not characterize the transition zone for the entire marsh.

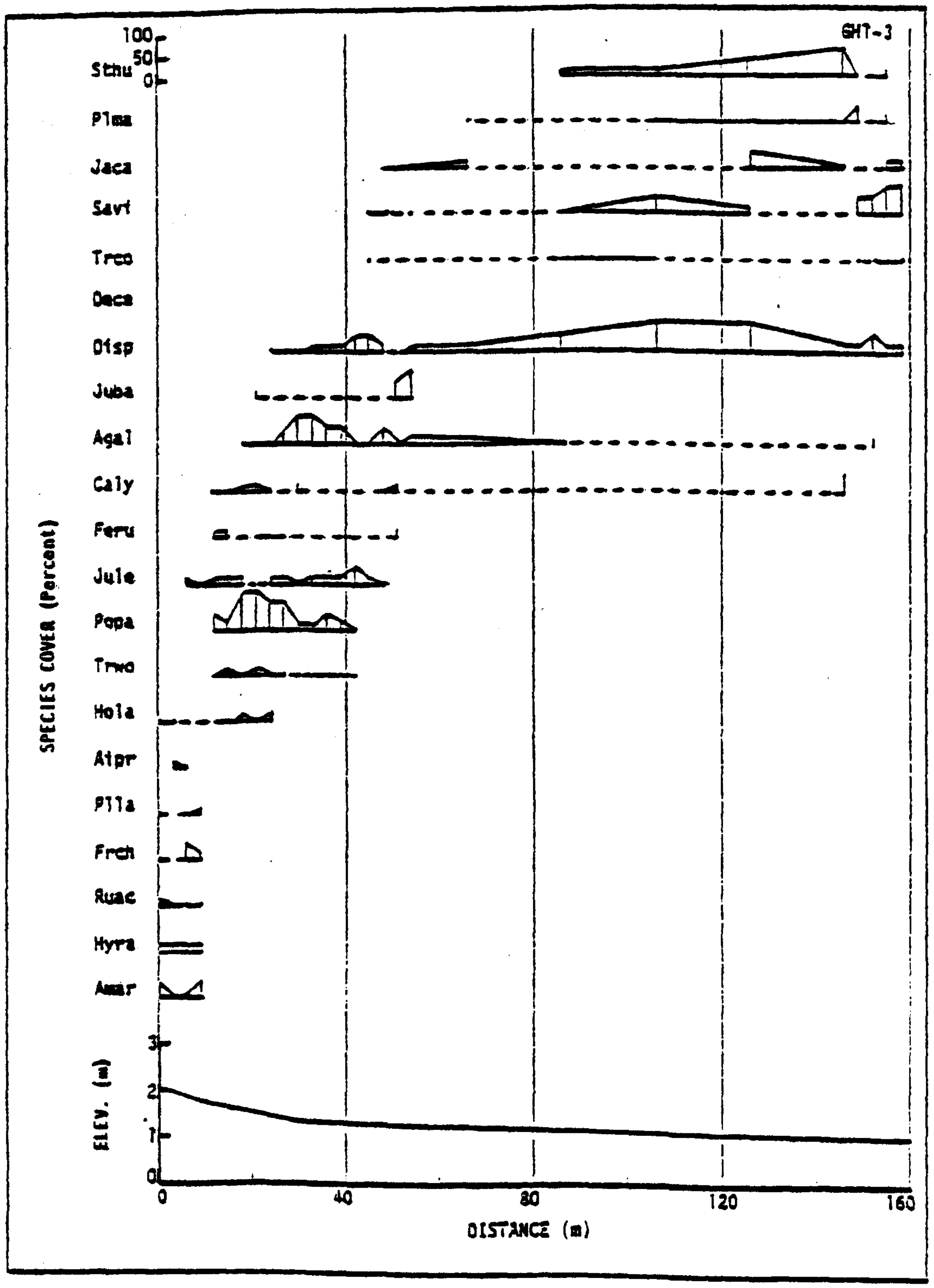

Figure 54. Plant species cover along transect GH1-3 at The Sink study site.

Transect and transition zone. Eleven transects, of which three extended to the mud flat, were placed at regular intervals over the entire marsh area. Figure 54 and 55 show typical transects. The lower boundary of the transition zone was defined by the simultaneous appearance of several upland species such as *Holcus lanatus* and *Lotus uliginosus* in the upper marsh.

The upland vegetation was comprised of plants adapted to sand dune habitats and species adapted to wet areas. Only one tree species, *Alnus rubra*, was encountered in the upland. The frequency and cover data for *Alnus* was:

	Freq. (%)	Avg. Cover (%)
Alnus rubra	9.0	7.0

Upland species with greater than 10 percent frequency in 51 samples were:

	Freq. (%)	Avg. Cover (%)
Agrostis alba	27.4	2.7
Aira praecox	13.7	1.3
Alnus rubra	11.8	8.7
Ammophila arenaria	23.5	4.5
Angelica lucida	11.8	2.4
Carex obnupta	27.4	7.9
Festuca rubra	11.8	2.6
Fragaria chiloensis	31.4	5.2
Galium triflorum	17.6	0.2
Holcus lanatus	60.8	8.7
Hypochaeris radicata	33.3	4.7
Juncus balticus	13.7	3.5
Juncus lesueurii	21.6	1.4
Lotus uliginosus	39.2	14.8
Plantago lanceolata	19.6	1.2
Potentilla pacifica	25.5	6.7
Poa pratensis	11.8	1.4
Rumex acetosella	15.7	0.5
Stellaria calycantha	19.6	2.6
Vicia gigantea	11.8	5.4

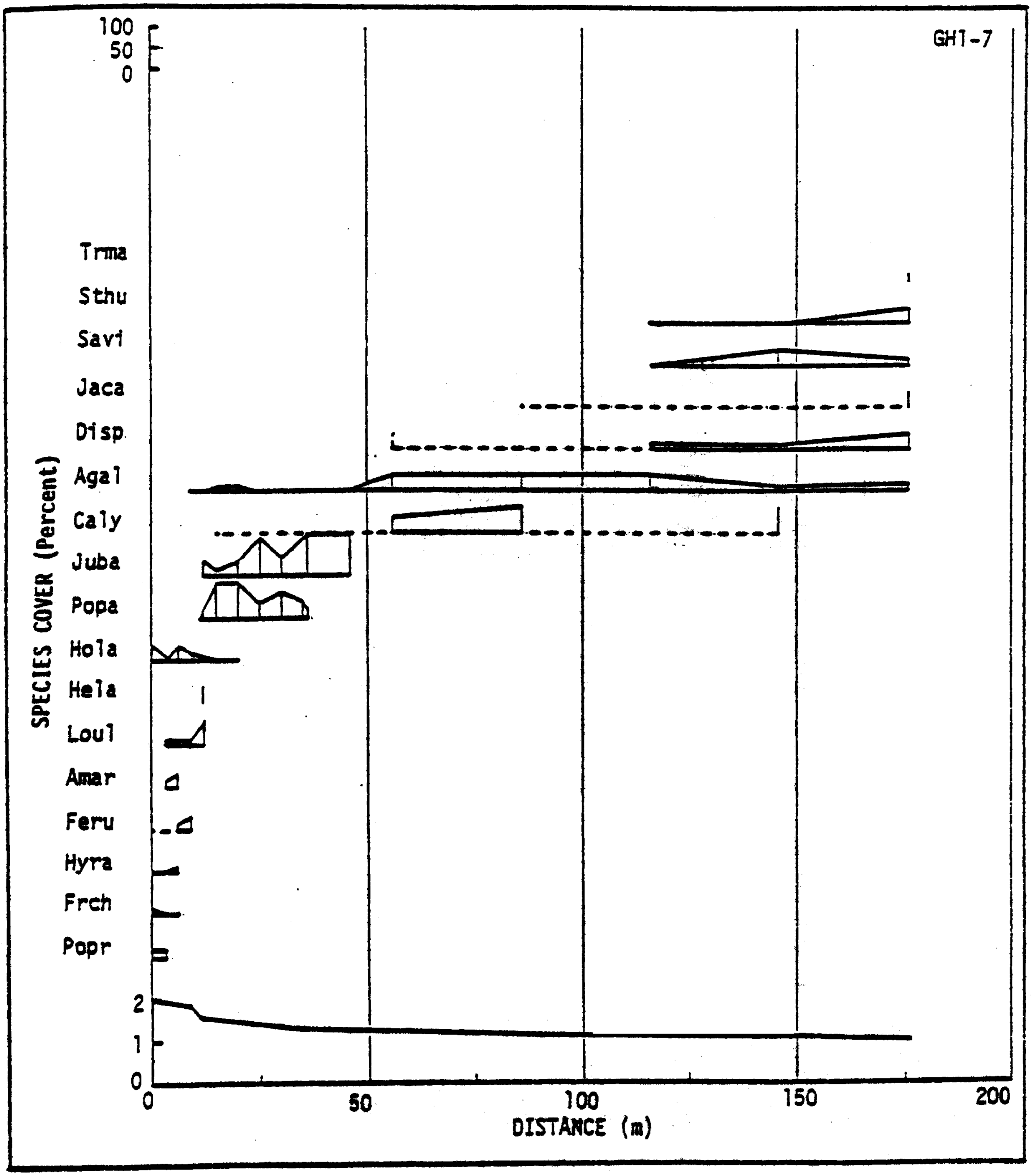

Figure 55. Plant species cover along transect GH1-7 at The Sink study site.

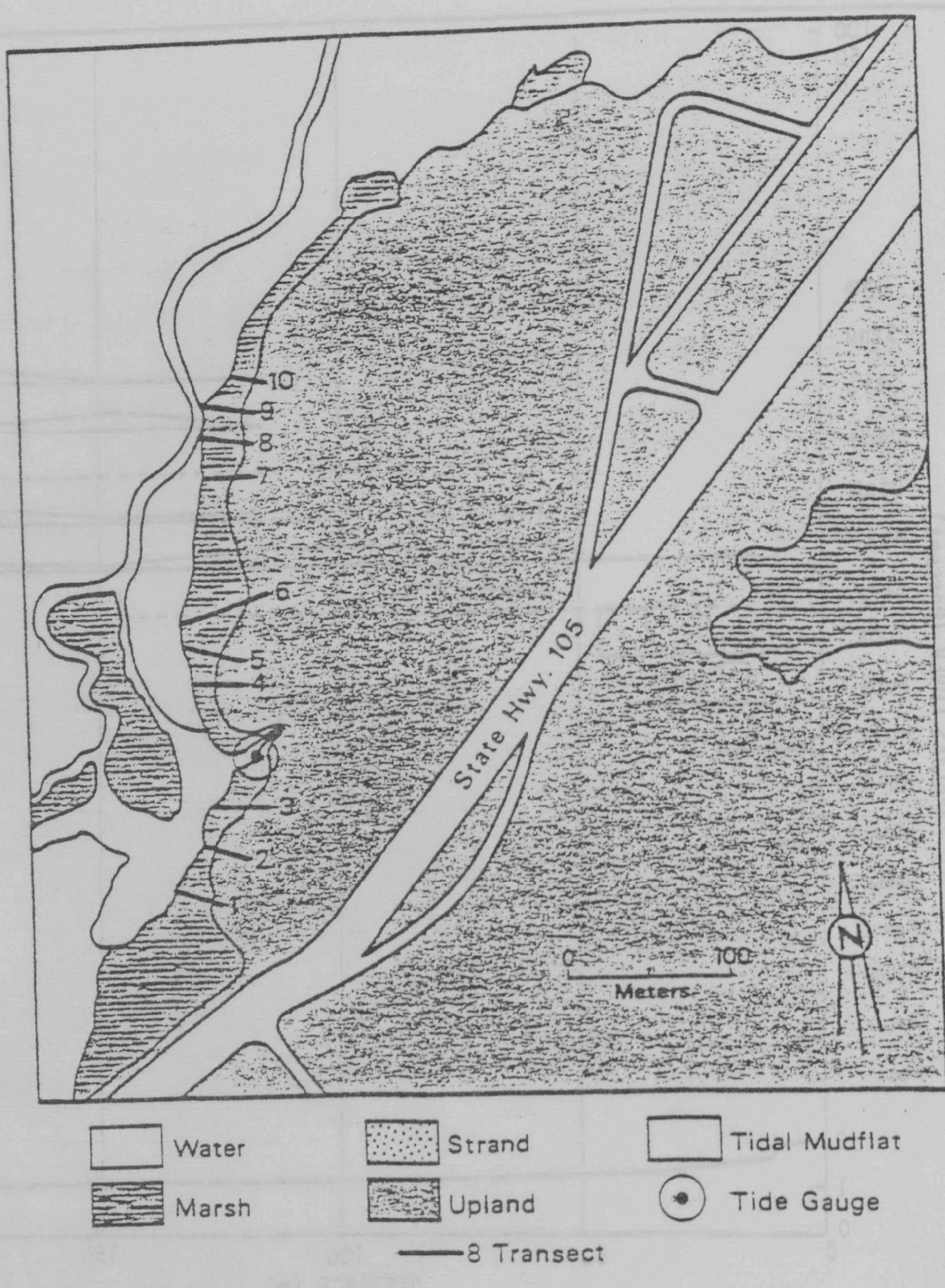

Figure 56. Elk River study site with approximate locations of transects.

Elk River GH3

Site description. The marsh occupies 2 ha of land on the South Shore of Grays Harbor, west of the mouth of Elk River (Figure 52) about 2 km west of Bay City. We classified the marsh as an Immature High Marsh. Creek development was minimal, as was the number of drift logs. Freshwater seepage was not noticeable. There was a steep drop from the lower portion of the marsh to the mud flat, where Zostera nana was found. From the lower portion of the marsh through the upper portion of the marsh, a slight gradient occurred. The upland was a Picea sitchensis forest.

Plant communities. Sampling took place along 10 transects with 116 marsh microplots and 100 meter segments in the upland. Figure 56 shows transect locations. Two marsh zones (lower marsh and upper marsh) with three plant communities were identified (Figure 57). The three communities were: (1) Salicornia virginica - Triglochin maritimum - Distichlis spicata community, forming the lower marsh assemblage; (2) Deschampsia cespitosa community, an upper marsh community, but found in the lower portion of this zone; and, (3) Agrostis alba - Potentilla pacifica community, also an upper marsh community, found above the Deschampsia cespitosa community.

Within the Salicornia virginica - Triglochin maritimum - Distichlis spicata community, such low marsh species as Jaumea carnosa, Spergularia canadensis, and Puccinellia pumila were found.

The Deschampsia cespitosa community is a poorly defined community in this marsh where there is a mixing of both lower and upper marsh species. Also entering into this community was Festuca rubra, a species with upland affinities.

PRESENCE	CODE	SERIAL NUMBER	0........1.........2.........3.........4.........5.........6.........7.........8.........9.........10.........11........ 123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345
		LOW MARSH ZONE	
42	29	SALICORNIA VIRGINICA	4111 4231 342 4632741 51132 2 2 1 31 2 2 1 31 1121121 2
48	35	TRIGLOCHIN MARITIMUM	3 3299423225 421122 24 1212 121 2 2 2 1 1141 23222 1
27	9	DISTICHLIS SPICATA	1222 1 1 3122131122111111 2222 1 2
24	14	GLAUX MARITIMA	1211 11111 111111 1111 11 211
12	19	JAUMEA CARNOSA	2 237 1 1 1 2 221 1
11	31	SPERGULARIA CANADENSIS	1 2 12 2 112 2 2 1
8	26	PUCCINELLIA PUMILA	2 112121 1
6	24	PLANTAGO MARITIMA	4 2 1 1 22
5	44	ZOSTERA NANA	31111
		UPPER TRANSITION ZONE	
58	2	AGROSTIS ALBA	11 11 1122311 22333345 11 12112223334233114443544454512
31	33	ELYMUS MOLLIS	1 111221722222221122222223233122
		OTHER SPECIES	
44	4	ATRIPLEX PATULA	1 2 1 2 1 1212 2 11 1 111 22 32112121211111232343 12 22 1 42211214 241231421 37322
62	17	HORDEUM BRACHYANTHERUM	1 1 2111112134 11111 2 3223 1 1 2212221331 3323 3 2 1223141 2 2 3121111222222112
51	25	POTENTILLA PACIFICA	1 22 2 3 1 2 132 32 232 141222334342212232 2 3 4 2 31 3121 3 123231 1
50	8	DESCHAMPSIA CESPITOSA	1 1 12 3 4235342544234 1331459559451 1234 23314222 223514 4
38	19	JUNCUS BALTICUS	1 32 2 2 1 11 322333 1 1 1 1 4 31 2 31 2 1 2221
9	32	STELLARIA HUMIFUSA	1 11111 1 1 1
6	11	FESTUCA RUBRA	111 11 2
5	37	STELLARIA CALYCANTHA	1 1 1 1 1
2	41	PICEA SITCHENSIS	13
1	34	TRIGLOCHIN CONCINNUM	1
1	40	MAIANTHEMUM DILATATUM	1
1	50	HYPOCHAERIS RADICATA	1
1	1	ACHILLEA MILLEFOLIUM	2
			123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345

Figure 57. Plant community table, Elk River study site.

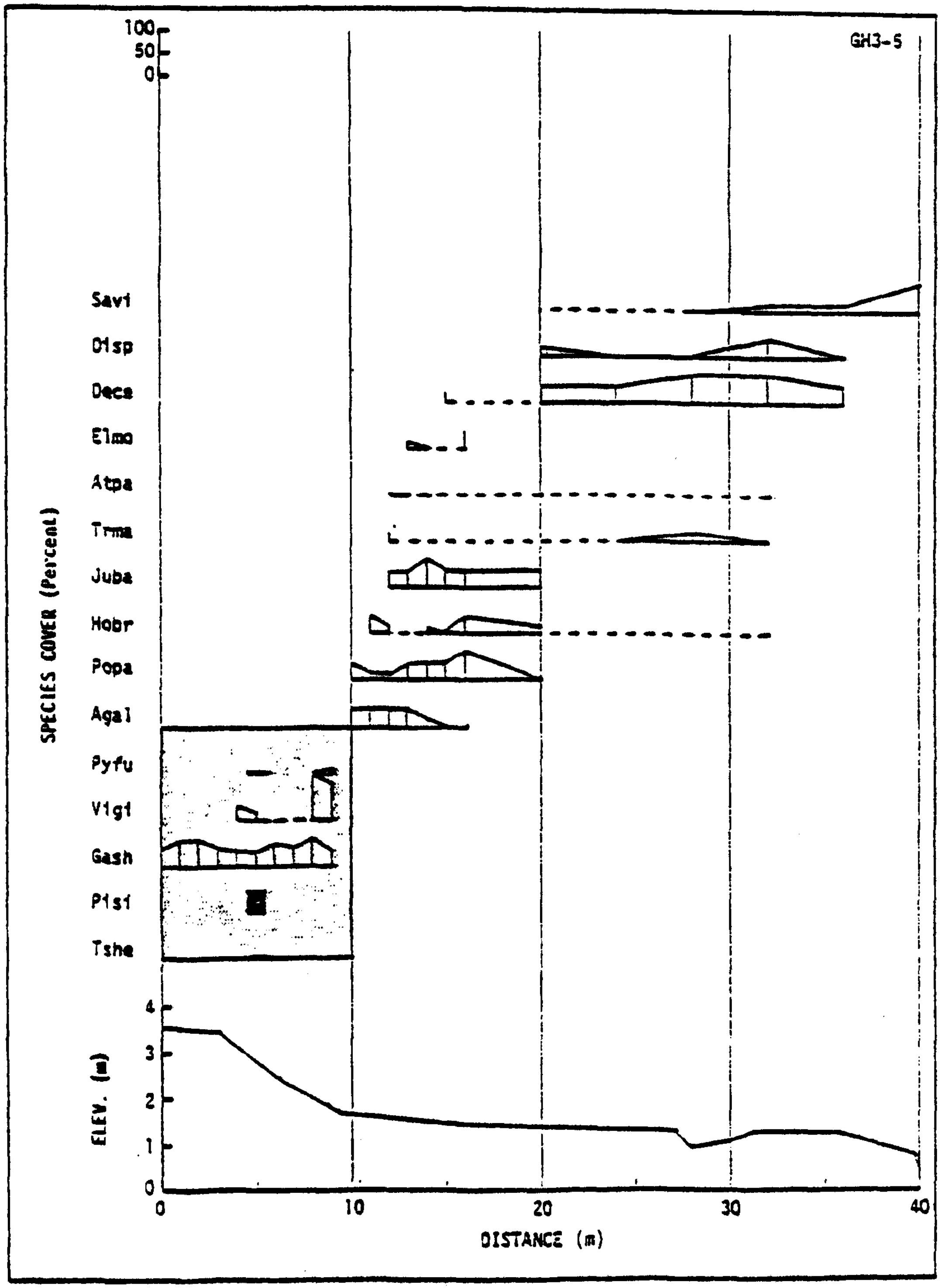

Figure 58. Plant species cover along transect GH3-5 at Elk River study site.

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In the *Agrostis alba* - *Potentilla pacifica* community all marsh plants had dropped out. In this assemblage such plants as *Atriplex patula*, *Hordeum brachyantherum*, and *Juncus balticus* were abundant, as was *Elymus mollis*, another species with upland affinities.

Transects and transition zone. Ten transects were spaced at regular intervals for the entire length of the marsh. Because of the short width of the marsh all transects extended to the mud flat. Figure 58 shows a typical transect. The lower position of the transition zone was marked where *Elymus mollis* first appeared in the upper marsh zone.

The upland vegetation was characterized by a *Picea sitchensis* forest. Frequency, cover, and basal area data for tree species found in the upland are as follows:

	Freq. (%)	Avg. Cover (%)	B.A. (m^2/ha)
Alnus rubra	60.0	13.0	1.4
Myrica californica	10.0	—	—
Picea sitchensis	100.0	41.0	7.0
Pyrus fusca	100.0	14.0	1.2
Rhamnus purshiana	50.0	8.0	0.2
Tsuga heterophylla	80.0	16.0	1.7

Understory vegetation with frequency greater or equal to 10 percent included:

	Freq. (%)	Avg. Cover (%)
Gaultheria shallon	81.0	33.0
Maianthemum dilatatum	34.0	9.2
Polystichum munitum	15.0	3.8
Rubus ursinus	11.0	1.5
Vaccinium ovatum	26.0	8.5
Vicia gigantea	19.0	5.2

Burley Lagoon KS1

Site description. At the head of Burley Lagoon, Henderson Bay on Puget Sound the marsh comprises an area of approximately 5 ha just south

Figure 59. Location of Burley Lagoon study site, KS1.

of the town of Burley (Figure 59). No evidence of marsh disturbance was found, although within the mud flat old pilings were noticed. The marsh was classified as an Immature High Marsh. Numerous small and several large tidal creeks were found throughout the marsh. The presence of such species as _Scirpus validus_, _Juncus effusus_, and _Carex lyngbyei_ gave an indication that freshwater seepage was occurring within the marsh. Although drift material was found in the upper portion of the marsh, it never was a major presence. The marsh gradient was low with an abrupt drop of about a meter to the mud flat. The upland was a _Thuja plicata_ forest. _Oenanthe sarmentosa_, _Carex obnupta_, and _Equisetum_ spp. gave indication that ponding was occurring in the upland.

Plant communities. Sampling along 10 transects with 89 marsh microplots and 95 upland meter segments provided the data for identifying two marsh zones: a low marsh and a high marsh. The low marsh zone was represented by a series of small communities characterized by such species as _Distichlis spicata_, _Salicornia virginica_, _Carex lyngbyei_, and _Glaux maritima_. Other species found within these communities were _Potentilla pacifica_, _Deschampsia cespitosa_, and _Juncus effuses_.

The upper marsh zone was a complex assemblage in which the lower marsh species tended to drop out. Characteristic species of this zone were _Deschampsia cespitosa_, _Potentilla pacifica_, _Aster subspicatus_, and _Juncus effusus_. Also _Carex lyngbyei_ and _Triglochin maritimum_ co-dominated within certain portions of this assemblage. The occurrence of such species as _Scirpus validus_ and _Juncus gerardii_ suggested that there was freshwater seepage within the upper marsh.

Transects and transition zone. Ten transects were placed parallel to the marsh gradient, with three extending to the mud flat. Figure 60 shows a typical transect. No transition zone was identified.

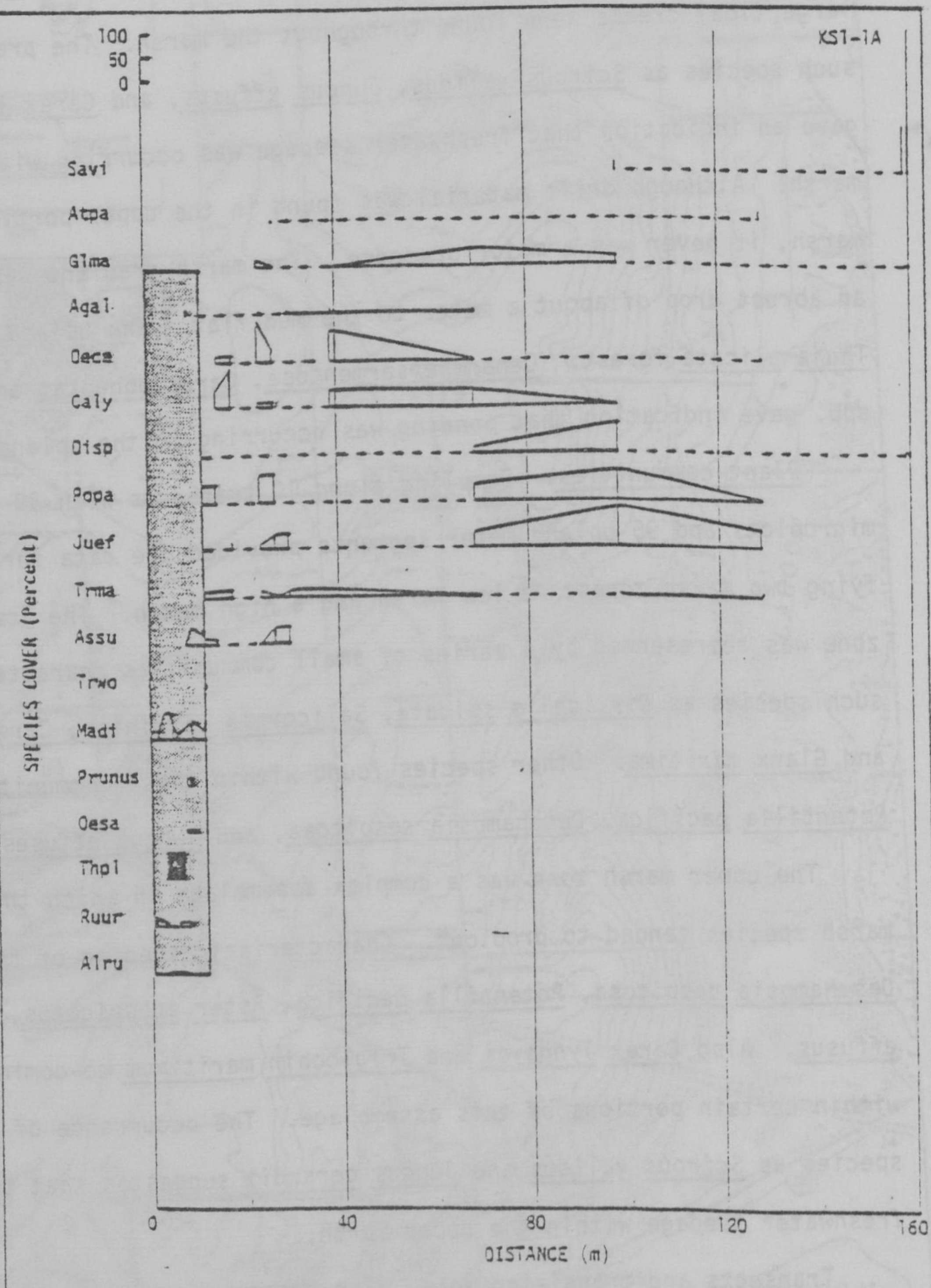

Figure 60. Plant species cover along transect KS1-1A at Burley Lagoon study site.

Upland vegetation was a Thuja plicata forest with scattered wet areas marked by Oenanthe sarmentosa and Equisetum spp. Frequency, cover, and basal area of tree species are as follows:

	Freq. (%)	Avg. Cover (%)	B.A. (m^2/ha)
Acer macrophyllum	10.0	0.0	0.2
Alnus rubra	70.0	9.0	1.4
Picea sitchensis	--	--	0.1
Prunus spp.	10.0	--	--
Pyrus fusca	20.0	1.0	0.1
Thuja plicata	80.0	35.0	6.7

Understory species with 10 percent frequency or greater in 95 samples included:

	Freq. (%)	Avg. Cover (%)
Aster subspicatus	17.9	4.4
Carex obnupta	10.5	1.0
Equisetum spp.	49.5	16.5
Gaultheria shallon	17.9	10.1
Lonicera involucrata	18.9	5.5
Maianthemum dilatatum	38.9	11.6
Oenanthe sarmentosa	27.4	6.0
Pteridium aquilinum	18.9	8.8
Rubus ursinus	35.8	6.7
Thuja plicata seedlings	32.6	10.5
Vicia gigantea	10.5	3.1

Coulter Creek KS2

Site description. Situated at the head of North Bay of Case Inlet, Puget Sound, the marsh occupies less than a hectare on the north side of the mouth of Coulter Creek (Figure 61). This location is approximately 2.5 km northwest of the town of Allyn. The marsh has been divided into two portions by a land fill which is being used as a junk yard. The eastern portion dissected by Coulter Creek, was classified as a Low Sand Marsh with a narrow band of Mature High Marsh. This portion rises steeply from the creek to the upland. There was no evidence of freshwater

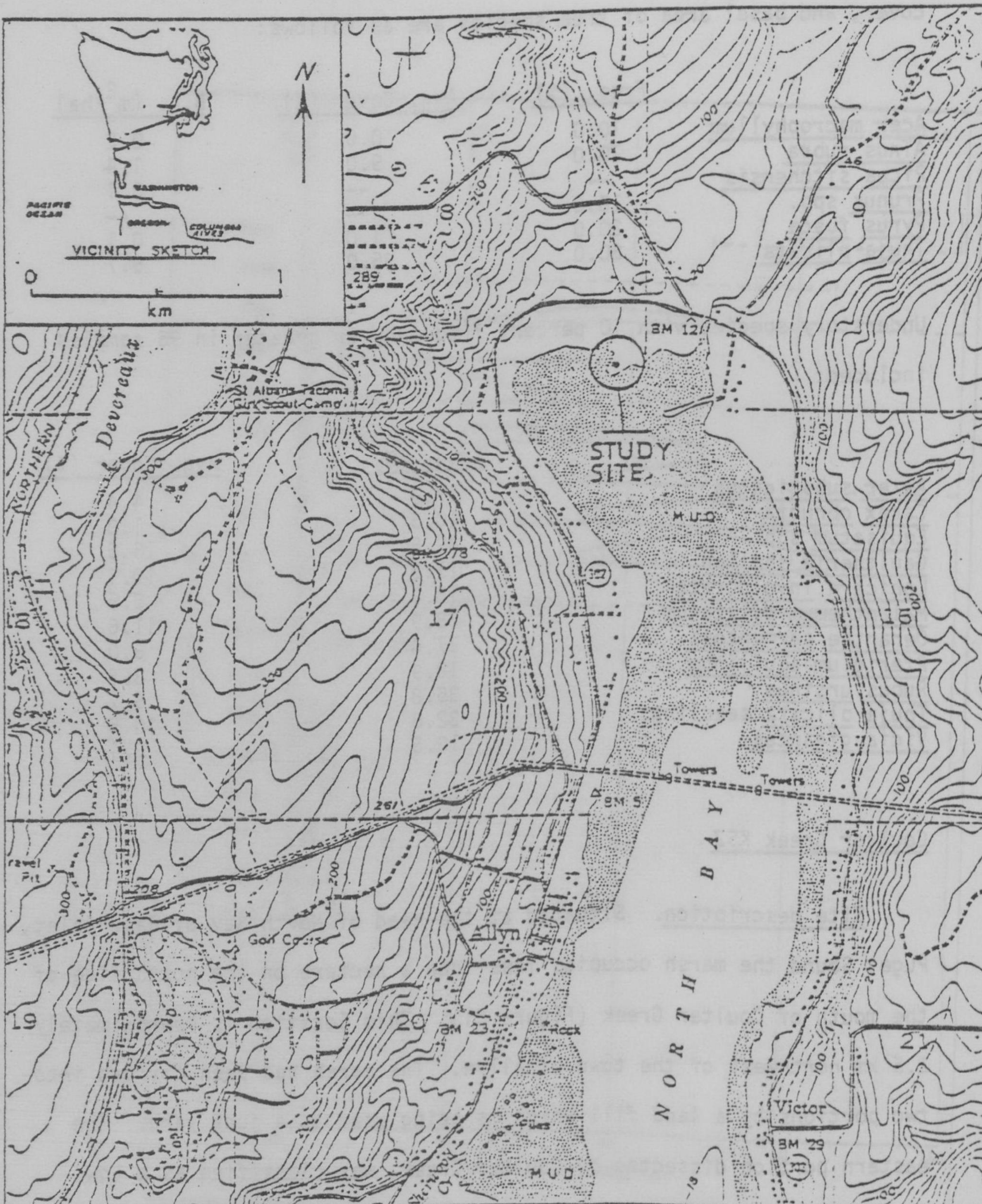

Figure 61. Location of Coulter Creek study site, KS2.

seepage or drift material. The upland had been disturbed, in that trees had been removed from the marsh edge to about 5-10 m inland. Rosa nutkana was the prominent species on this cleared land.

The western portion of the marsh was classified as an Immature High Marsh. Several small and large tidal creeks were evident. Upland vegetation such as Picea sitchensis and Gautheria shallon had become established on drift logs in the upper marsh. Although no freshwater indicator species were found in the marsh, ponding in the upland was evident by the presence of Carex obnupta, Oenanthe sarmentosa and Equisetum spp. These wetland species grew beneath a canopy of Picea sitchensis, Thuja plicata and Fraxinus latifolia. The marsh gradient was low, with an abrupt drop to mud flat.

Plant communities. Ten transects, along which 128 microplots were placed in the marsh and 100 meter segments in the upland, were used to sample the vegetation. Within the lower zone, two marsh communities were identified: a Distichlis spicata - Salicornia virginica - Jaumea carnosa community; and a Carex lyngbyei community. A Potentilla pacifica - Aster subspicatus community composed the higher marsh zone.

The Distichlis spicata - Salicornia virginica - Jaumea carnosa community, a low marsh assemblage, was found only in the western portion of the Coulter Creek marsh. Characteristic species in this assemblage include Carex lyngbyei, Plantago maritima, Triglochin maritima. Other species found in the low marsh were Glaux maritima, Atriplex patula, Hordeum brachyantherum, and Juncus effusus.

The Carex lyngbyei community, also a low marsh assemblage, was restricted to the eastern portion of the marsh, where it was influenced greatly by the flow of Coulter Creek. Characteristic species included Triglochin maritimum and Spergularia canadensis.

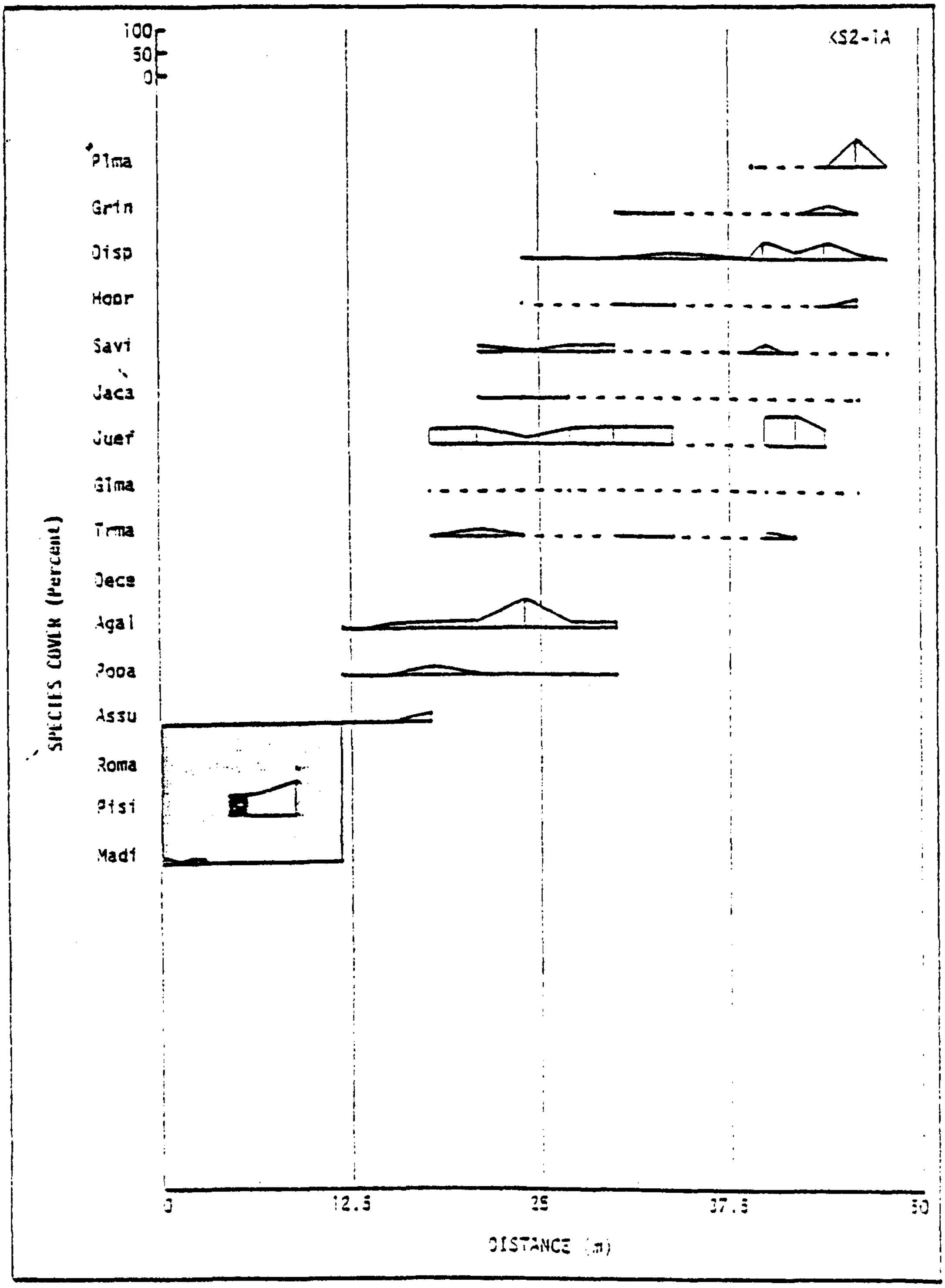

Figure 62. Plant species cover along transect KS2-1A at Coulter Creek study site.

The Potentilla pacifica - Aster subspicatus community was the upper marsh assemblage found in both portions of the marsh. Characteristic species were Agrostis alba and Juncus balticus. To some degree, lower marsh zone species were found in this assemblage. In the western portion of the marsh, upland species had established themselves on old drift logs. Although drift logs did not clog the upper marsh zone in the western portion of the marsh, this was not the case in the eastern portion.

Transects and transition zone. Ten transects were placed in the marsh with seven located in the western portion and three in the eastern section. Two transects in the western portion and one in the eastern portion extended to the mud flat. Figure 62 shows a typical transect. No well defined transition zone was identified in any portion of the marsh, although at the extreme upper edge of the marsh several individuals of upland species were found.

The upland vegetation, like the marsh, was divided into two portions. Although tree species were found in both the western and eastern portions, only the western portion was forested. The understory of this forest was a mosaic of wet and dry conditions. The eastern portion was dominated by Rosa nutkana. Frequency, cover, and basal area of the tree species for both uplands combined are:

	Freq. (%)	Avg. Cover (%)	B.A. (m^2/ha)
Acer macrophyllum	10.0	3.0	0.3
Alnus rubra	20.0	1.0	0.2
Fraxinus latifolia	70.0	13.0	1.7
Picea sitchensis	60.0	16.0	2.1
Pyrus fusca	10.0	1.0	0.2
Rhamnus purshiana	10.0	--	--
Thuja plicata	70.0	7.0	1.4

Shrub and herb vegetation with 10 percent or greater frequency for 100 line segment samples included:

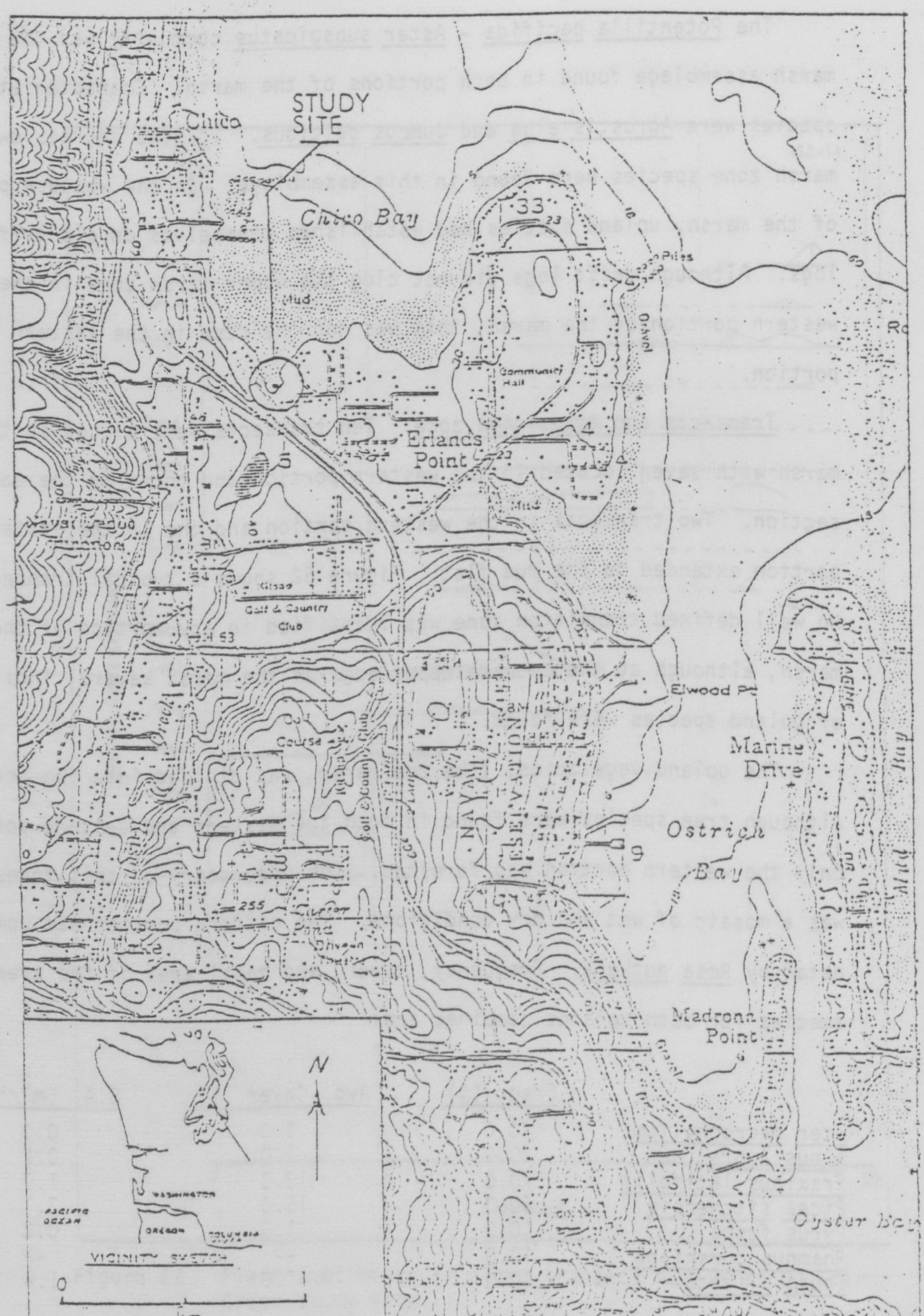

Figure 63. Location of Chico Bay study site, KS3.

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	Freq. (%)	Avg. Cover (%)
Agrostis alba	21.0	5.6
w Carex obnupta	18.0	4.7
w Conioselinum pacificum	11.0	1.1
Elymus mollis	10.0	3.0
w Equisetum spp.	15.0	3.3
Gaultheria shallon	14.0	6.0
Maianthemum dilatatum	47.0	8.9
w Oenanthe sarmentosa	10.0	2.5
Rosa nutkana	52.0	14.3
Rubus ursinus	13.0	2.9

The letter (w) refers to a freshwater indicator.

Chico Bay KS3

Site description. Several kilometers north of Bremerton a marsh, one ha in size, has formed at the head of Chico Bay, a small embayment of Dyes Inlet (Figure 63). We classified the marsh as a low Sand Marsh. Two creek channels, created by Chico Creek, dissect the marsh into three lobes which finger into the bay. Freshwater seepage was not apparent in the marsh. The marsh was devoid of drift material. The upland surrounding the marsh has been heavily disturbed with a resultant ruderal flora. Also part of the upland was comprised of stream bank species found along Chico Creek.

Plant communities. Five transects with 79 marsh microplots and 50 meter samples in the upland provided the data to characterize the vegetation at this study site. Two marsh zones (lower marsh and upper marsh), including two plant communities, were identified. The two communities were: (1) Salicornia virginica - Distichlis spicata community, accomodating the lower marsh zone; and (2) the Aster subspicatus Potentilla pacifica - Agrostis alba community, marking the upper marsh zone.

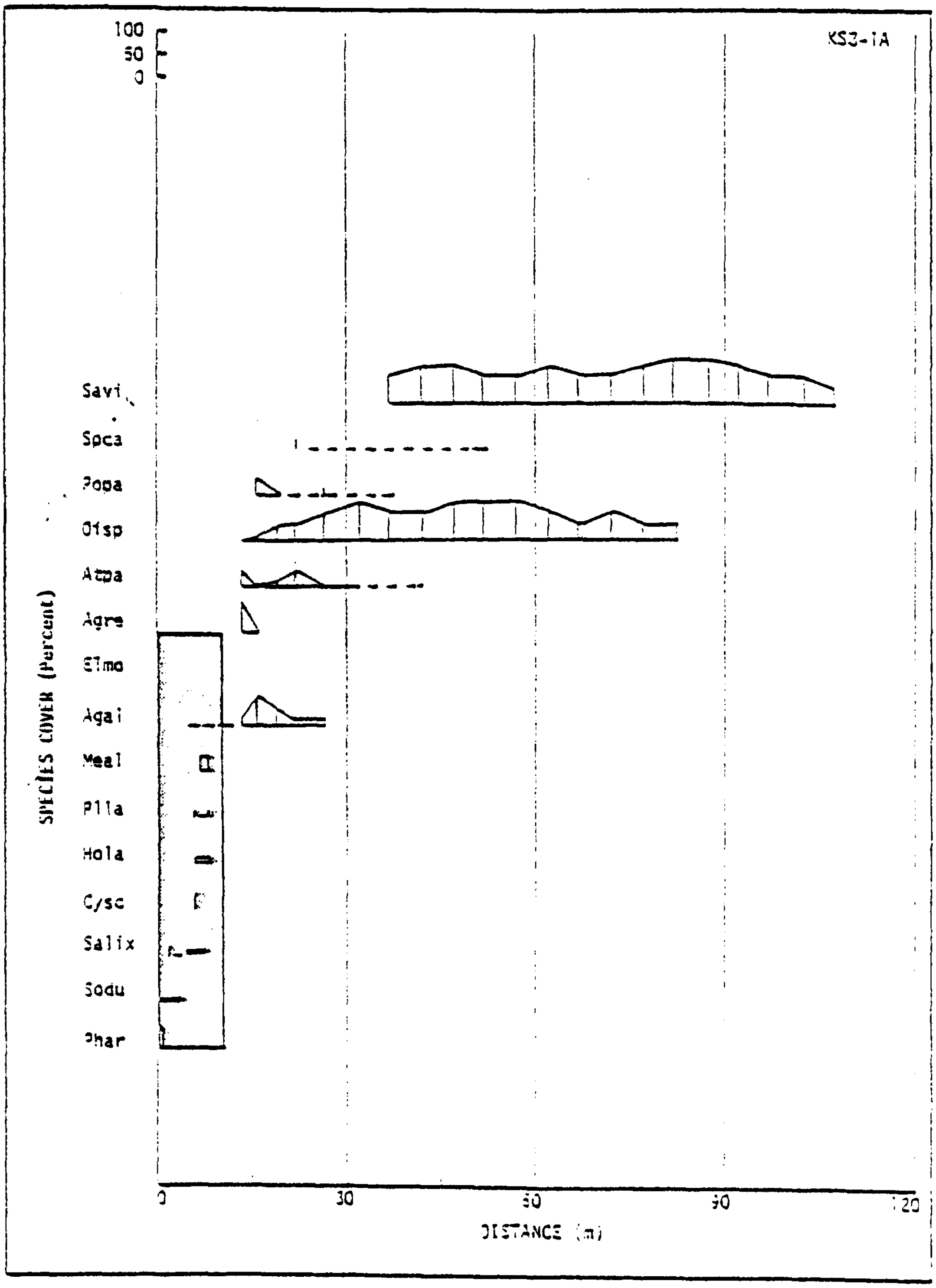

Figure 64. Plant species cover along transect KS3-1A at Chico Bay study site.

The Salicornia virginica - Distichlis spicata community comprised the greater percentage of the areal extent of the Chico Bay marsh. Other species found within this assemblage were Spergularia canadensis and Carex lyngbyei.

The Aster subspicatus - Potentilla pacifica - Agrostis alba community, the upper marsh assemblage, formed a relatively narrow band between the lower marsh and the upland. Within this assemblage both low marsh species and species with upland affinities, such as Holcus lanatus and Agropyron repens were present. These latter two species suggest that there may have been some recent disturbance in the upper marsh zone.

Transects and transition zone. Five transects, two of which extended into the mud flat, were distributed at even intervals across the entire width of the marsh. Figures 64 and 65 show typical transects. No definite transition zone was identified, although upland species were found in the upper marsh zone. A very narrow transition zone, perhaps, could be delimited within the upper marsh where Distichlis spicata finally dropped out, while the upland species continued to be present.

The upland vegetation consisted of two different habitats: a ruderal habitat; and a stream bank habitat. No tree species were found in the ruderal habitat, and within the stream bank habitat the only tree species encountered was a Salix spp. The frequency and cover of this species was:

	Freq. (%)	Avg. Cover (%)
Salix spp.	30.0	3.0

Understory vegetation within this stream bank "forest" and those species in the ruderal habitat with a 10 percent frequency in 50 samples included:

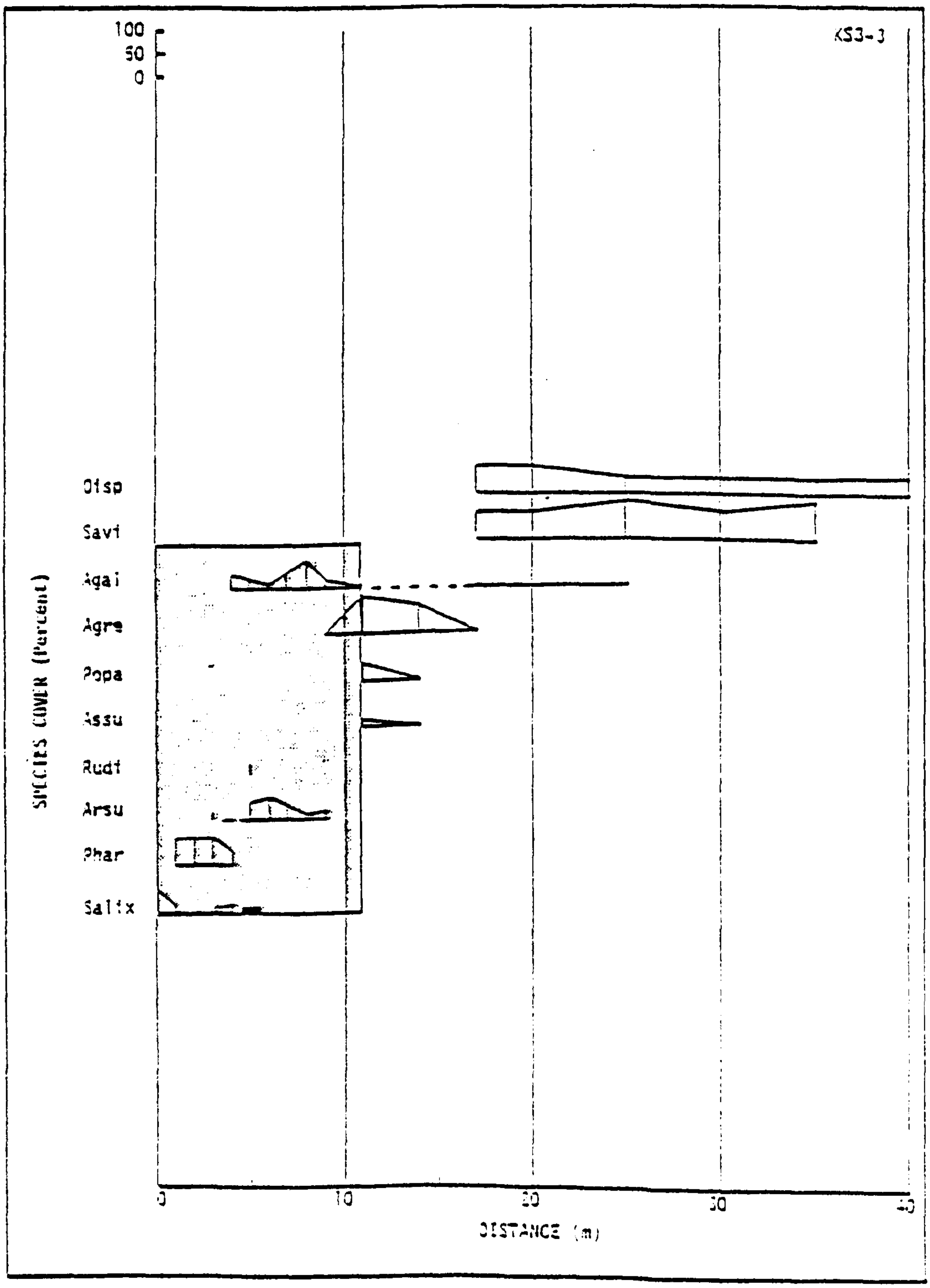

Figure 65. Plant species cover along transect KS3-3 at Chico Bay study site.

	Freq. (%)	Avg. Cover (%)
Agrostis alba	24.0	6.5
w *Phalaris arundinacea*	50.0	22.5
Solanum nigrum	14.0	1.2

Thorndyke Bay HC1

Site description. Located on the northeast coast of the Toanados Peninsula, the marsh occupies an area of approximately 13 ha within Thorndyke Bay (Figure 66). The marsh has developed behind a barrier beach which is breached at its southern end by Thorndyke Creek. This breach provides the only means by which the marsh is influenced by tidal action. Northwest Environmental Consultants has conducted vegetation studies within the marsh on two different occasions (1975, 1976). Using Jefferson's (1975) classification they classified the marsh as being almost equally divided between an Immature High Marsh and a Mature High Marsh, with small areas of Low Sand or Silt Marsh occurring throughout the bay. We feel that Silt Marsh is an inappropriate classification. Toward the head of the Bay, a large influx of freshwater has resulted in stands of *Typha latifolia* and *Scirpus validus*. *Alnus rubra* was found growing on old logs scattered within the freshwater-brackish marsh. Along Thorndyke Creek there was a heavy accumulation of drift logs, the result of probably both tidal action and logging of the upland surrounding the Bay. The upland is a second growth forest with such species as *Picea sitchensis*, *Tsuga heterophylla*, *Thuja plicata*, and *Alnus rubra*. In several places within the upland, freshwater wetland occurred with *Carex obnupta*, *Oenanthe sarmentosa*, and *Lysichitum americanum*. Although the Bay and the surrounding upland are owned by the Pope and Talbot Timber Company, the Bay is used as a waterfowl hunting area. The marsh gradient was low, with sudden abruptness at the Creek's edge.

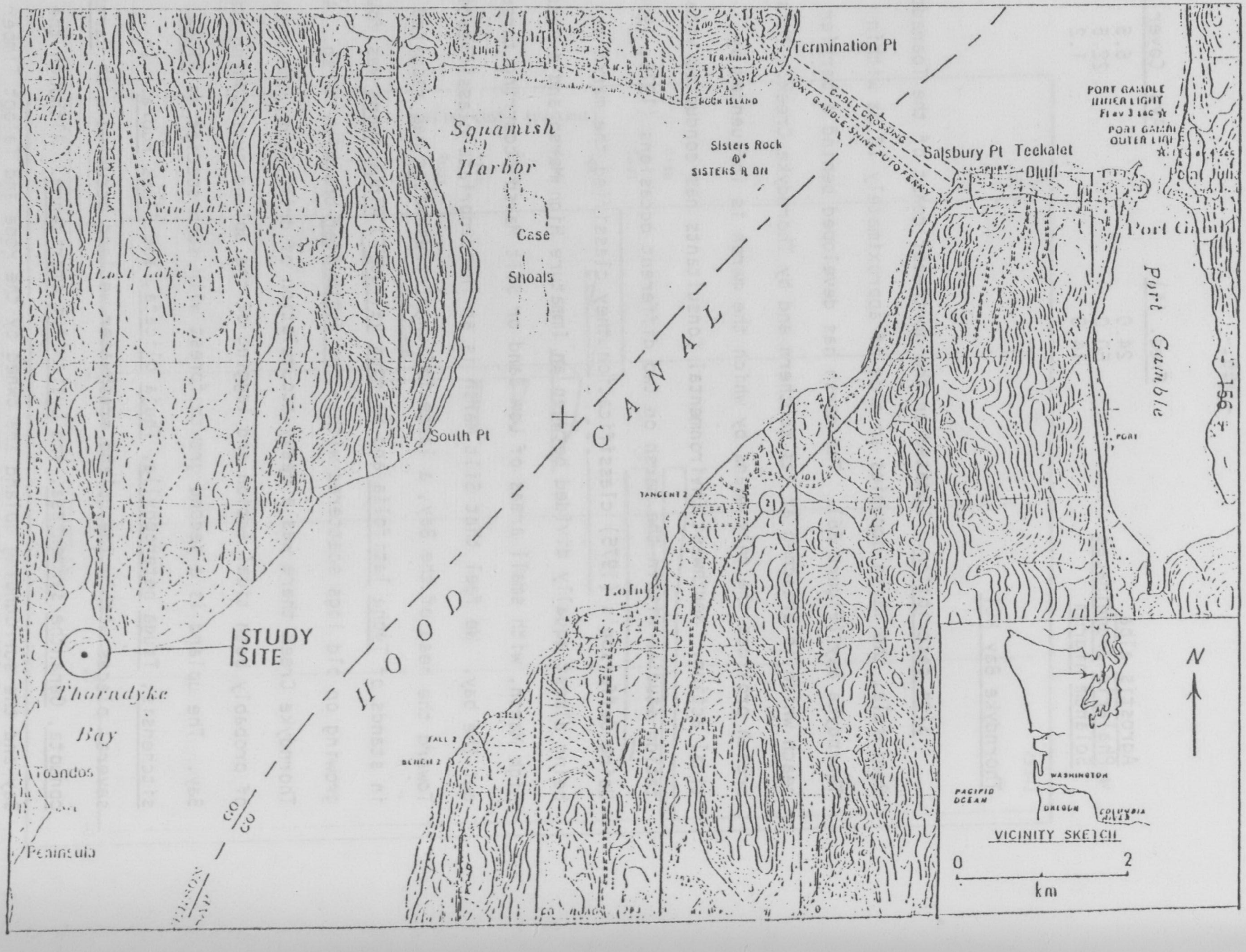

Figure 66. Location of Thorndyke Bay study site, WA.

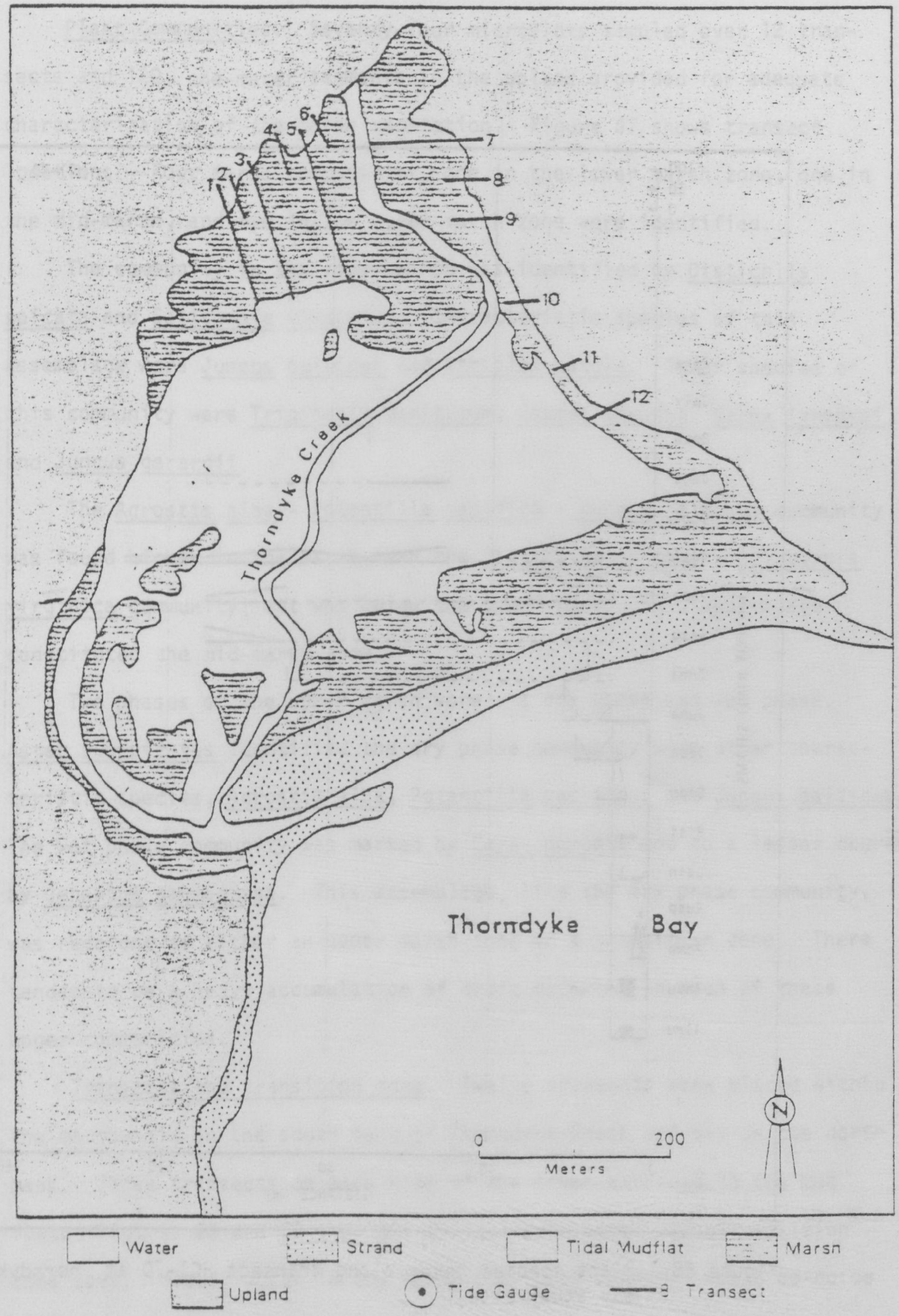

Figure 67. Thorndyke Bay study site with approximate locations of transects.

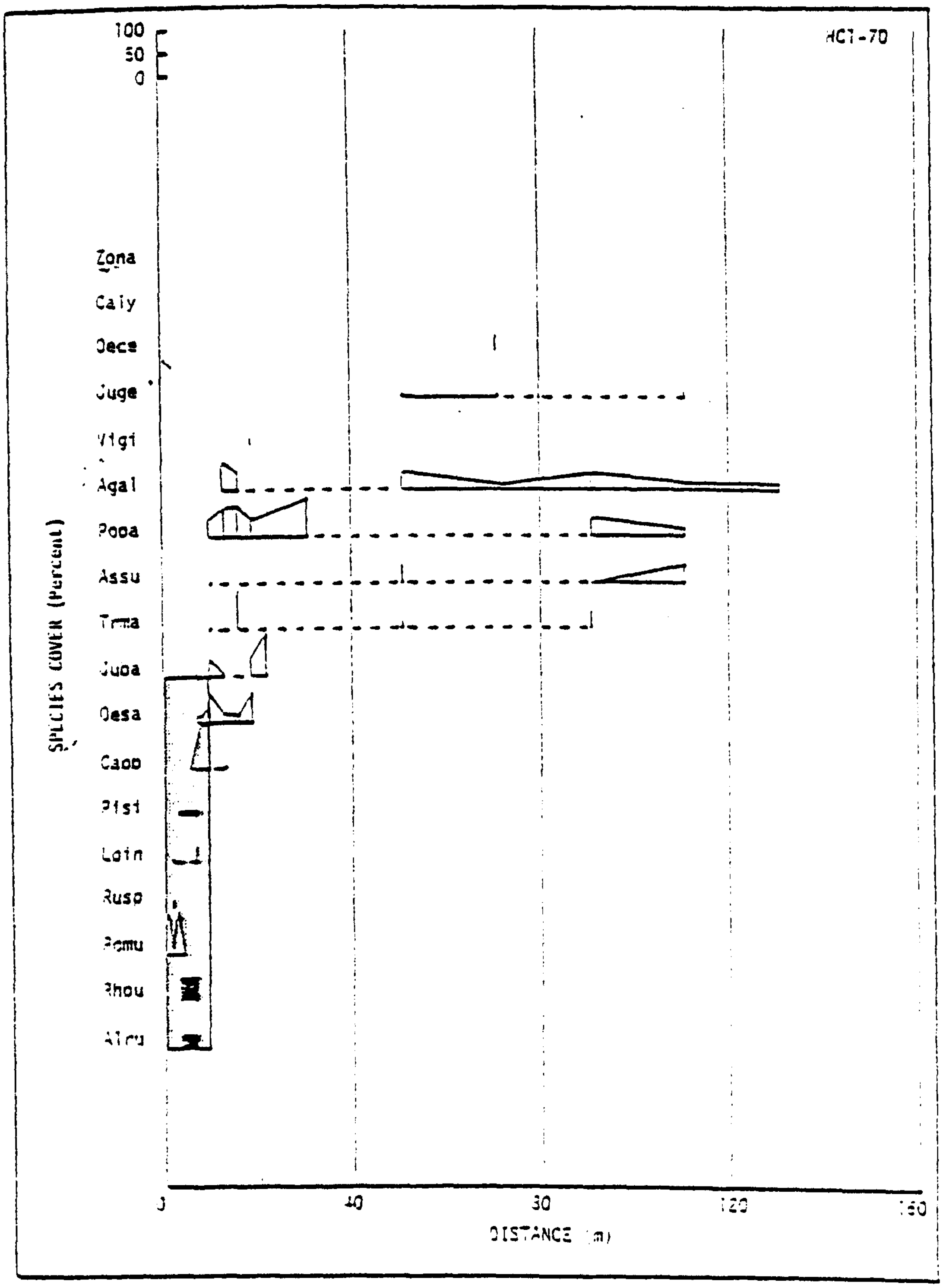

Figure 68. Plant species cover along transect HC1-7D at Thorndyke Bay study site.

Plant Communities. Seventy-four microplots sampled over 12 transects and 120, one-meter segments in the upland provided for adequate characterization of the marsh vegetation. Figure 67 shows transect locations. Four marsh communities, one in the lower marsh zone, one in the mid-marsh, and two in the upper marsh zone were identified.

The community in the lower marsh was identified by Distichlis spicata and Salicornia virginica. Characteristic species of this assemblage were Juncus balticus and Atriplex patula. Other species of this community were Triglochin maritimum, Jaumea carnosa, Carex lyngbyei, and Juncus gerardii.

The Agrostis alba - Potentilla pacifica - Juncus balticus community was found higher in the marsh than the Distichlis spicata - Salicornia virginica community, but was below the upper zone. This assemblage constituted the mid-marsh zone.

Two phases of the upper marsh were: a dry phase and wet phase. Aster subspicatus identified the dry phase community with other characteristic species, Agrostis alba, Potentilla pacifica, and Juncus balticus. The wet phase community was marked by Carex obnupta and to a lesser degree by Oenanthe sarmentosa. This assemblage, like the dry phase community, was regarded as either an upper marsh zone or a transition zone. There tended to be a heavy accumulation of drift material in both of these upper communities.

Transects and transition zone. Twelve transects were placed within the marsh, six on the south bank of Thorndyke Creek and six on the north bank. Three transects on each side of the creek extended to the mud flat. Figures 68 and 69 show two typical transects. If a transition zone does, indeed, occur in the marsh its lower boundary would coincide

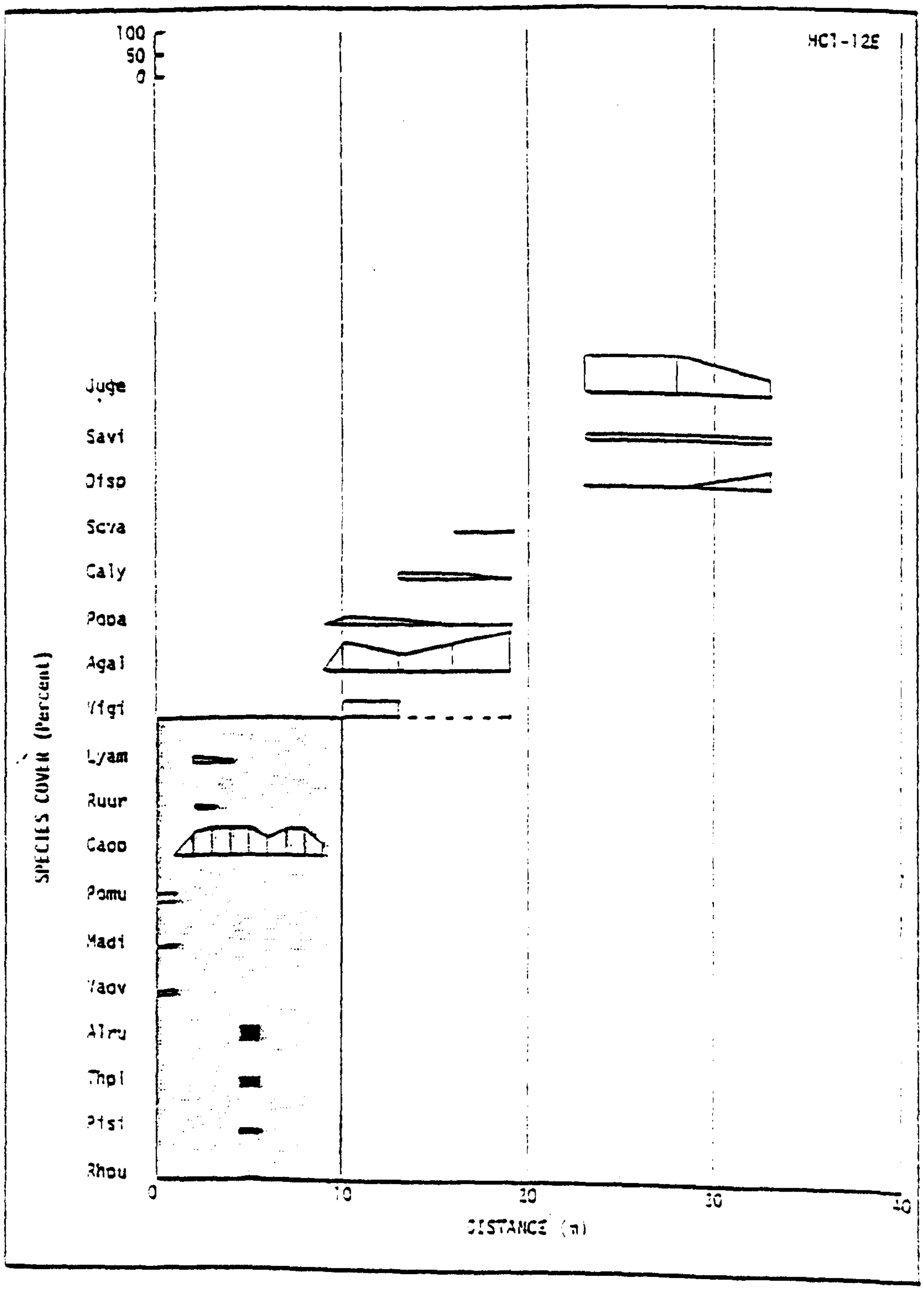

Figure 69. Plant species cover along transect HC1-12E at Thorndyke Bay study site.

with the appearance of upland species such as Vicia gigantea and Aster subspicatus and the exclusion of low marsh species.

Upland vegetation had two distinct habitats: on the south side of Thorndyke Creek a Typha latifolia wetland, on the north side of the creek the upland was a Picea sitchensis - Alnus rubra forest, with localized wetland situations. Frequency, cover, and basal area of tree species with this forest community were:

	Freq. (%)	Avg. Cover (%)	B.A. (m^2/ha)
Acer macrophyllum	17.0	3.0	0.2
Alnus rubra	50.0	14.0	1.0
Prunus virginiana	17.0	8.0	--
Rhamnus purshiana	17.0	5.0	0.5
Thuja plicata	25.0	5.0	0.7
Tsuga heterophylla	25.0	1.0	0.3

Several understory species were found in both of the upland communities. The data for these species were combined to provide frequency and cover values. Those understory species with greater than 10 percent frequency for all 120 segments included:

		Freq. (%)	Avg. Cover (%)
(w)	Carex obnupta	15.8	7.2
(w)	Epilobium watsonii	15.0	1.5
(f/w)	Galium aparine	15.8	1.5
(f)	Gaultheria shallon	12.5	8.4
(w)	Juncus balticus	10.8	1.4
(f)	Polystichum munitum	10.0	4.4
(f/w)	Potentilla pacifica	16.7	1.9
(f)	Rubus ursinus	10.0	1.6
(f/w)	Triglochin maritimum	13.3	2.8

In the above list those species found in wet situations, principally in the Typha latifolia community, are denoted by (w) and those found in forest situations by (f).

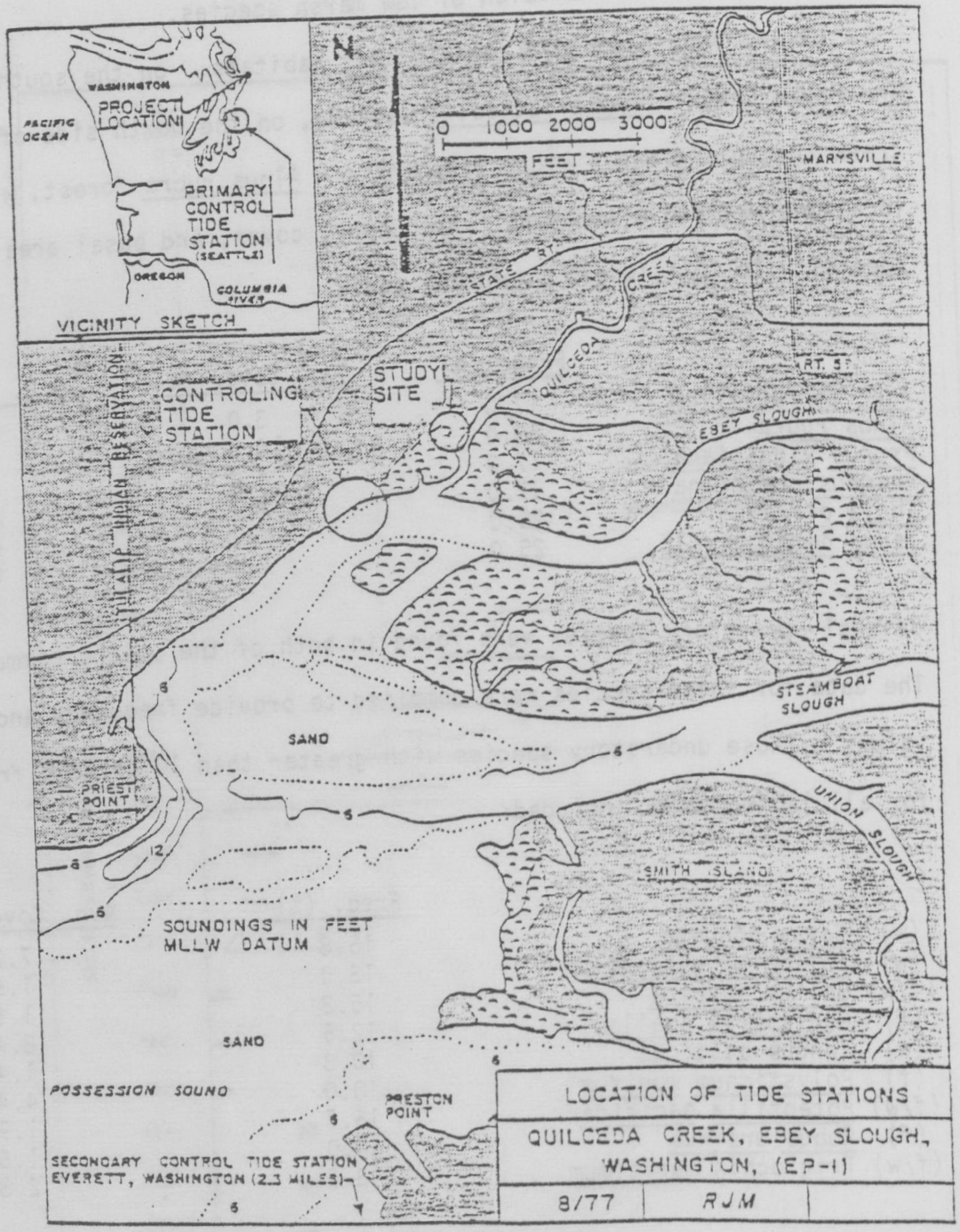

Figure 70. Location of Quilceda Creek study site, EP1.

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Quilceda Creek EP1

Site description. The marsh occupies 22 ha of land on the west bank of Quilceda Creek, where the Creek flows into Ebey Slough of the Snohomish Estuary (Figure 70). This location is approximately 7 km west of the town of Marysville. The marsh in the Quilceda Creek arm of the Snohomish Estuary, along with the marsh on the western side of Steamboat Island, may be the only marsh lands in the Snohomish Estuary not modified by man. The Quilceda Creek marsh has been the site of two other wetland delineation studies by the NOS (1975) and by Northwest Environmental Consultants (1978). Although Hepp (1973) provided an environmental analysis of the Quilceda Creek Estuary, she did not classify the marsh. Following Jefferson (1975), we classified the marsh as an Immature High Marsh. Numerous small tidal creeks and several large ones were found throughout the marsh. Drift logs were located in the upper portion of the marsh and, in some cases, provided a substrate for the establishment of *Picea sitchensis* and *Juniperus scopulorum* seedlings. Freshwater seepage was also noted in the upper marsh, as indicated by the presence of *Scirpus validus* and *Lilaeopsis occidentalis*.

The upland was unique in that it appeared to have been, at one time, part of the Quilceda Creek marsh system. Now it is about 0.5 m above the present marsh. Old tidal channels with marsh species were found in the upland. The upland was primarily a herb community, with heavy influx of freshwater, and with tree species growing on old drift logs.

Plant communities. Ten transects, with a total of 133 marsh microplots and 60 upland meter segments were employed to sample the vegetation. Figure 71 shows transect locations. Four marsh zones (low marsh, mid

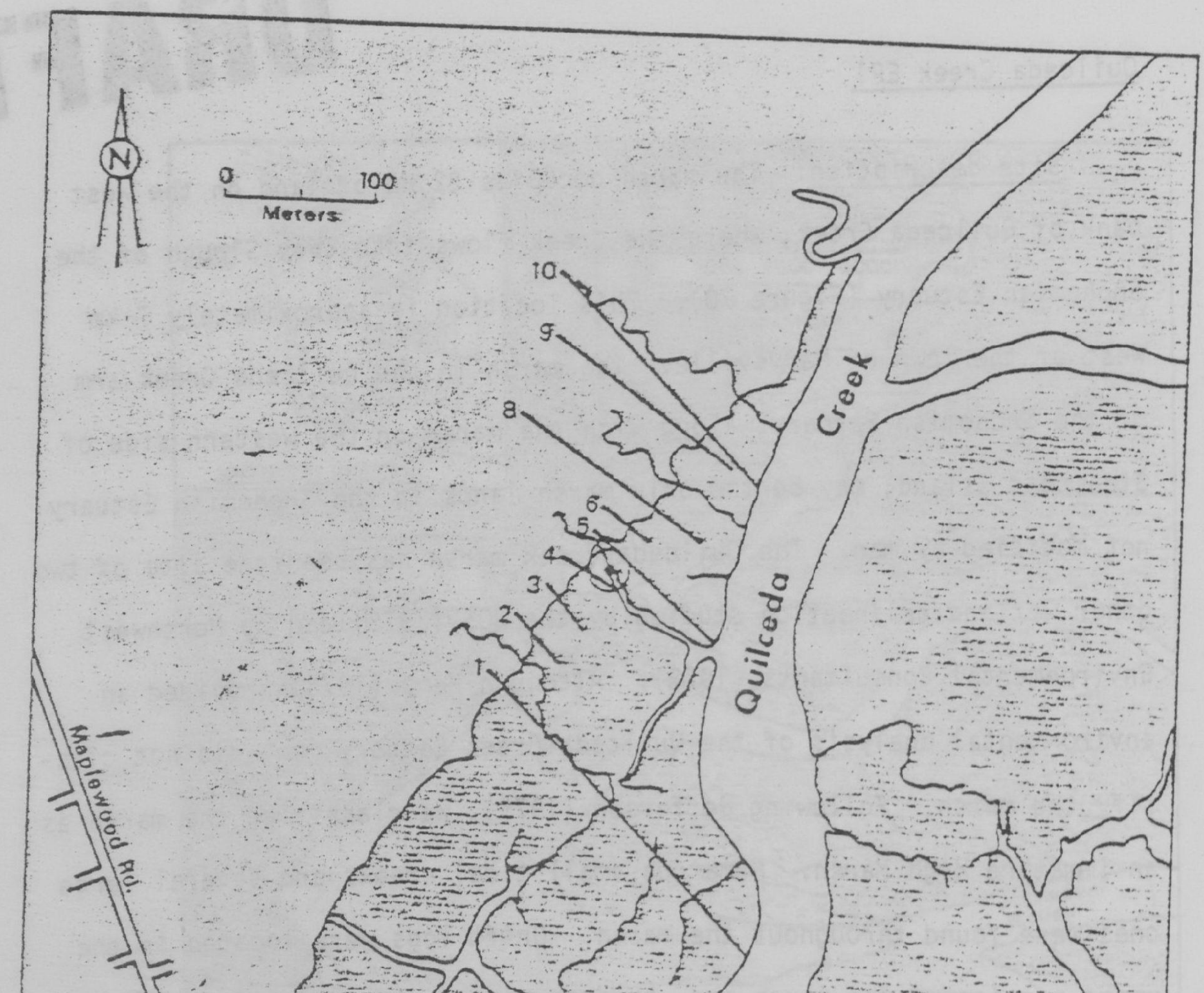

Figure 71. Quilceda Creek study site with approximate locations of transects.

marsh, upper marsh, and upper transition) accomodating five major communities were: (1) Carex lyngbyei - Triglochin maritimum community, forming the low marsh assemblage; (2) Potentilla pacifica - Agrostis alba - Deschampsia cespitosa community, the mid-marsh assemblage; (3) Aster subspicatus - Potentilla pacifica - Agrostis alba - Juncus balticus community, a complex high marsh assemblage; (4) Aster subspicatus - Lonicera involucrata community, distinguishing the upper dry transition; and, (5) Scirpus validus community, marking the upper wet transition.

The Carex lyngbyei - Triglochin maritimum community, is found from the edge of Quilceda Creek to about 100 m upwards into the marsh. It is also found along the major tidal creeks in the other marsh zones. Species found in this community, other than Carex lyngbyei and Triglochin maritimum, are Lilaeopsis occidentalis, Scirpus cernuus, Potentilla pacifica, and Deschampsia cespitosa. Most of these latter species suggest that there is freshwater seepage in the lower marsh.

The Potentilla pacifica - Agrostis alba - Deschampsia cespitosa community reflects a marsh position between the upper and lower marsh zones. Within this assemblage the low marsh species Carex lyngbyei and Triglochin maritimum begin to be replaced with the higher marsh species Aster subspicatus. The presence of Lilaeopsis occidentalis indicates freshwater seepage in this zone.

The Aster subspicatus - Potentilla pacifica - Agrostis alba - Juncus balticus constitutes either a high marsh zone or a lower transition zone. The lower marsh zone species have been completely replaced, while species with upland affinities such as Sidalcea hendersonii and Trifolium wormskjoldii are found scattered throughout the community.

The Aster subspicatus - Lonicera involucrata community forms a very distinctive dry phase upper transition zone assemblage. Although

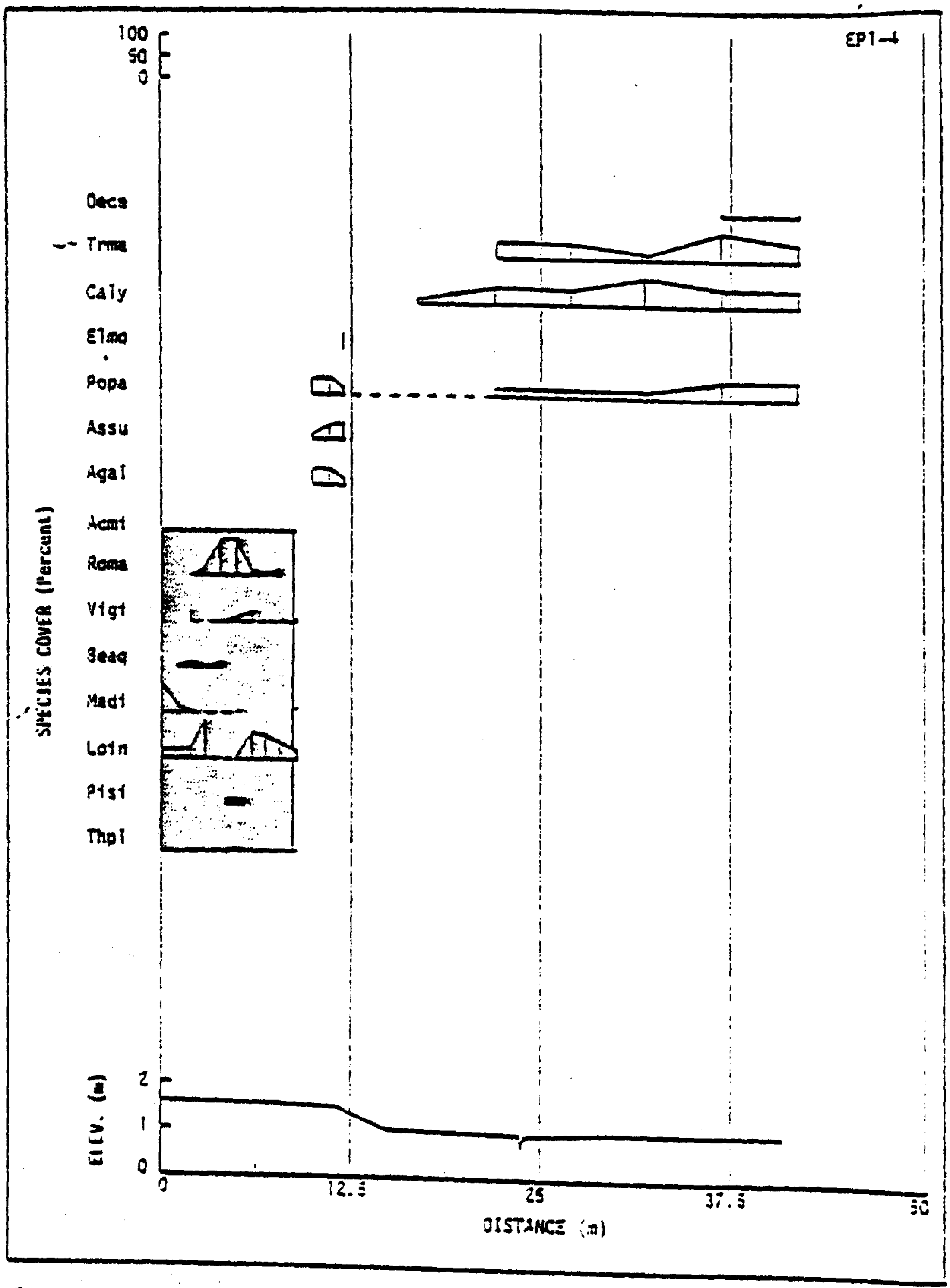

Figure 73. Plant species cover along transect EP1-4 at Quilceda Creek study site.

Juncus balticus, *Agrostis alba*, and *Potentilla pacifica* were locally dominant within this community, the assemblage included many upland species.

The *Scirpus validus* community forms a wet phase upper transition zone. Almost pure stands of *Scirpus validus* could be found among the drift logs which tended to accumulate through the entire upper transition zone.

Transects and transition zone. Ten transects were placed within the marsh. Three of these transects extended to the creek bank. Figure 73 and 74 show two typical transects. The lower boundary of the transition zone was determined by the disappearance of the low marsh species in conjunction with the appearance of upland species.

Upland vegetation consisted of an open habitat with tree species growing on old drift logs scattered throughout. Ponding was also found to occur throughout the upland. Frequency, cover, and basal area of the tree species are:

	Freq. (%)	Avg. Cover (%)	B.A. (m^2/ha)
Alnus rubra	11.0	9.0	--
Picea sitchensis	67.0	15.0	1.1
Thuja plicata	67.0	3.0	0.6

Shrub and herb species with greater than 10 percent frequency in 60 samples included.

	Freq. (%)	Avg. Cover (%)
Agrostis alba	33.3	5.2
Angelica lucida	15.0	3.7
Aster subspicatus	30.0	4.1
Berberis aquifolium	11.7	0.9
Gaultheria shallon	15.0	7.5
Lonicera involucrata	46.7	13.0
Maianthemum dilatatum	46.7	9.8
w *Oenanthe sarmentosa*	15.0	1.7
Rosa gymnocarpa	26.7	7.3
Vicia gigantea	23.3	2.6

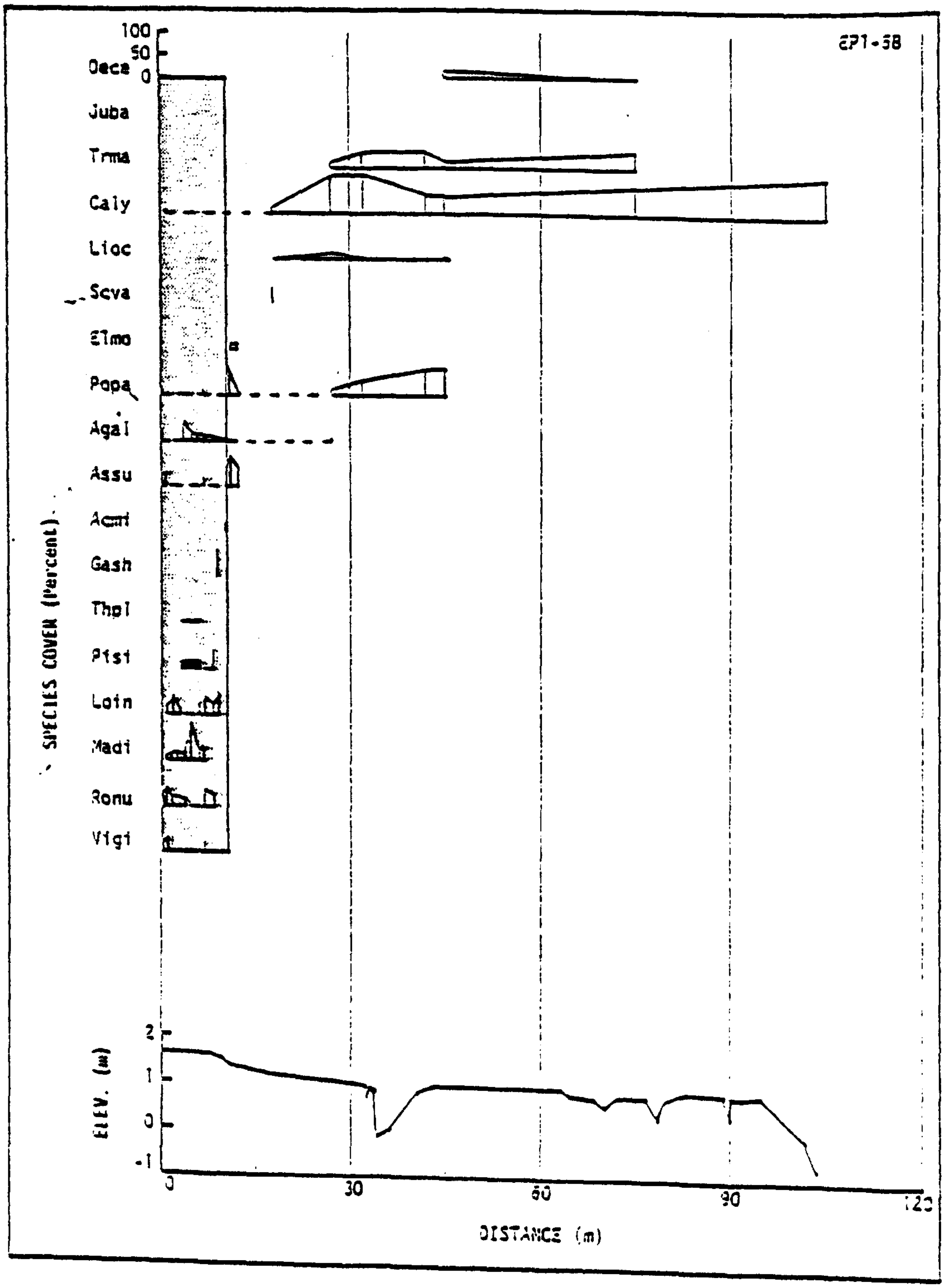

Figure 74. Plant species cover along transect EP1-5B at Quilceda Creek study site.

Oak Bay NP1

Site description. Located on the southwest coast of Indian Island, Jefferson County (Figure 75), the marsh occupies an area of 0.7 ha, and is protected from Oak Bay by a gravel-to-sand textured berm. Without this protection, the marsh might possibly be severely damaged by wave action from the heavy boat and barge traffic on Oak Bay. The one tidal channel within the marsh is fairly deep, and enters Oak Bay at the northern end of the marsh. Northwest Environmental Consultants (1975) divided the marsh into two main sections: a western section and an eastern section. The marsh was classified as having some Low Sand Marsh and an extensive High Immature Marsh. We could not classify the western section of the marsh by Jefferson's system but the eastern section was classified as almost wholly Low Sand Marsh, with very little High Immature Marsh.

The marsh ends abruptly at the upland which is a steep slope. Due, in part, to this phenomena, as well as the heavy accumulation of drift material at the marsh-upland interface, the marsh transition zone is virtually non-existent. The abruptness between marsh and upland may also account for the lack of freshwater seepage and wetland ponding in the interface. The upland is an open woodland characterized by *Pseudotsuga menziesii* and *Arbutus menziesii*. The marsh gradient is low with a slight abruptness at the Creek edge.

Plant communities. Vegetation was characterized by means of 10 transects along which a total of 114 microplots were placed in the marsh and 83 meter segments in the upland. Figure 76 shows transect locations. Two marsh zones (low marsh and upper marsh) containing four communities were identified (Figure 77). The four communities were: (1) *Salicornia*

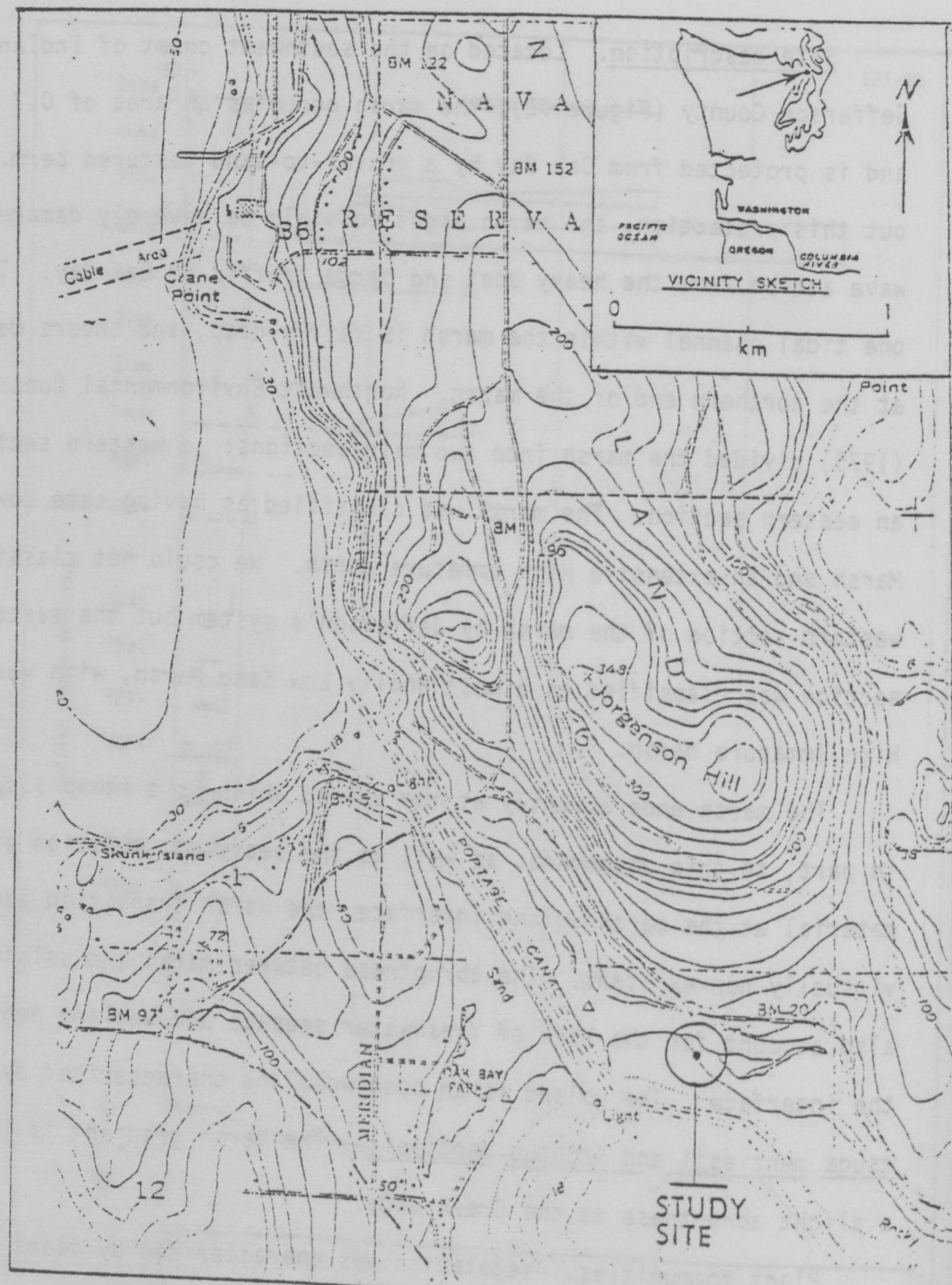

Figure 75. Location of Oak Bay study site, MP1.

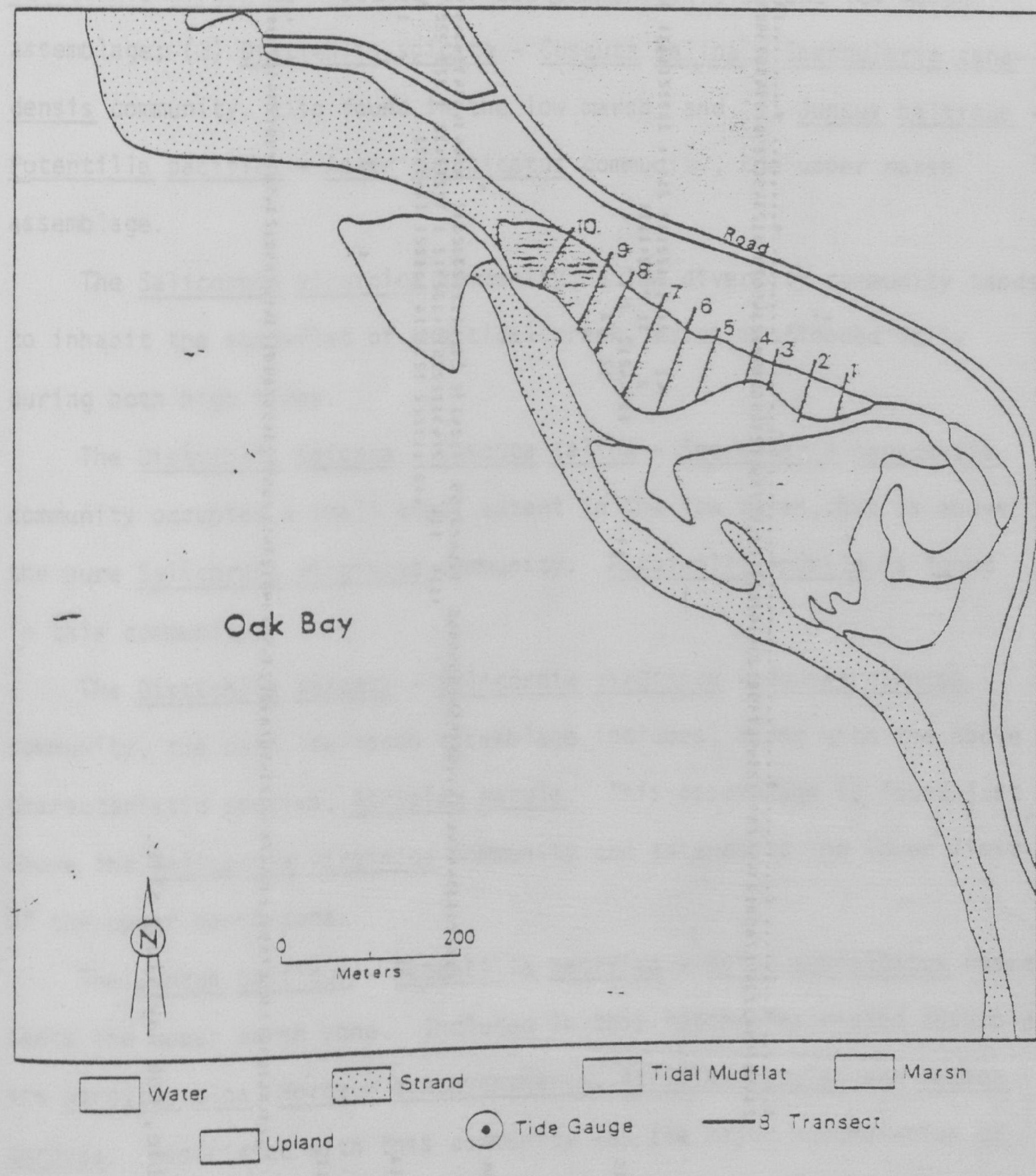

Figure 76. Oak Bay study site with approximate locations of transects.

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                                        0.........1.........2.........3.........4.........5.........6.........7.........8.........9.........10........11......
PRESENCE    CODE          SERIAL NUMBER 1234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345

             LOW MARSH ZONE
  31     9   DISTICHLIS SPICATA                                                                           42  12+ 1+122112 2111++ 3222211111 1  11
  11     7   CUSCUTA SALINA                                                                               2    31 2 12+1111
  13    31   SPERGULARIA CANADENSIS                                                        ++          13344212  2 1     +
   4    26   PUCCINELLIA PUMILA                                                                            12    3        1
             TRANSITION ZONE
   9    19   JUNCUS BALTICUS                                                                                                                  +32312 514
   6    25   POTENTILLA PACIFICA                                                                                                           312 +4 33  1
   7     3   ASTER SUBSPICATUS                                                                                                                 1  +23++2
   4     2   AGROSTIS ALBA                                                                                                                   1      2 11
   3    17   HORDEUM BRACHYANTHERUM                                                                                                            1     11
             OTHER SPECIES
  79    28   SALICORNIA VIRGINICA                    +1122333344444+444455555555555556666  115423455  1524112 2324112123323 12  4344 14334134345
  48    10   JAUMEA CARNOSA                                                                      +114  111   12143312235 12+132312 1 32212+32 3 323 222+   2  4 1  1
  40     4   ATRIPLEX PATULA                                                                              ++22111212 1233214 131221 1343422          223 14 1 3221
   2    15   GRINDELIA INTEGRIFOLIA                                                                                                         1   3
   2    34   TRIGLOCHIN CONCINNUM                                                                                                   1   1
   2    35   TRIGLOCHIN MARITIMUM                                                                                       1       2
   2    49   GAULTHERIA SHALLON                                                                                                                  1  1
   2    54   CALAMAGROSTIS NUTKAENSIS                                                                                                          1         1
   1    24   PLANTAGO MARITIMA                                                                                                                  1
   1    12   GALIUM APARINE                                                                                                                 +
                                        1234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345
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Figure 77. Plant community table, Oak Bay study site.

virginica community, a low marsh assemblage; (2) Distichlis spicata Salicornia virginica - Jaumea carnosa community, a second low marsh assemblage; (3) Distichlis spicata - Cuscuta salina - Spergularia canadensis community, also found in the low marsh; and (4) Juncus balticus - Potentilla pacifica - Aster subspicatus community, the upper marsh assemblage.

The Salicornia virginica community, a low diversity community tends to inhabit the sand-flat of the tidal creek, which is flooded daily during both high tides.

The Distichlis spicata - Cuscuta salina - Spergularia canadensis community occupies a small areal extent in the low marsh, but is above the pure Salicornia virginica community. Puccinellia pumila is found in this community.

The Distichlis spicata - Salicornia virginica - Jaumea carnosa community, the main low marsh assemblage includes, along with the above characteristic species, Atriplex patula. This assemblage is found just above the Salicornia virginica community and extends to the lower limit of the upper marsh zone.

The Juncus balticus - Potentilla pacifica - Aster subspicatus represents the upper marsh zone. Included in this rather restricted assemblage are Agrostis alba, Hordeum brachyantherum, Atriplex patula, and Jaumea carnosa. Associated with this community was the major accumulation of drift logs. Because the upland slopes down to the upper edge of this community, it may be regarded as a poorly defined transition zone.

Transects and transition zone. Ten transects, five of which extended across the creek-sand-flat, were established across the entire length of the marsh. Figure 78 and 79 show two typical transects. The upper marsh may be regarded possibly as a transition zone due to the

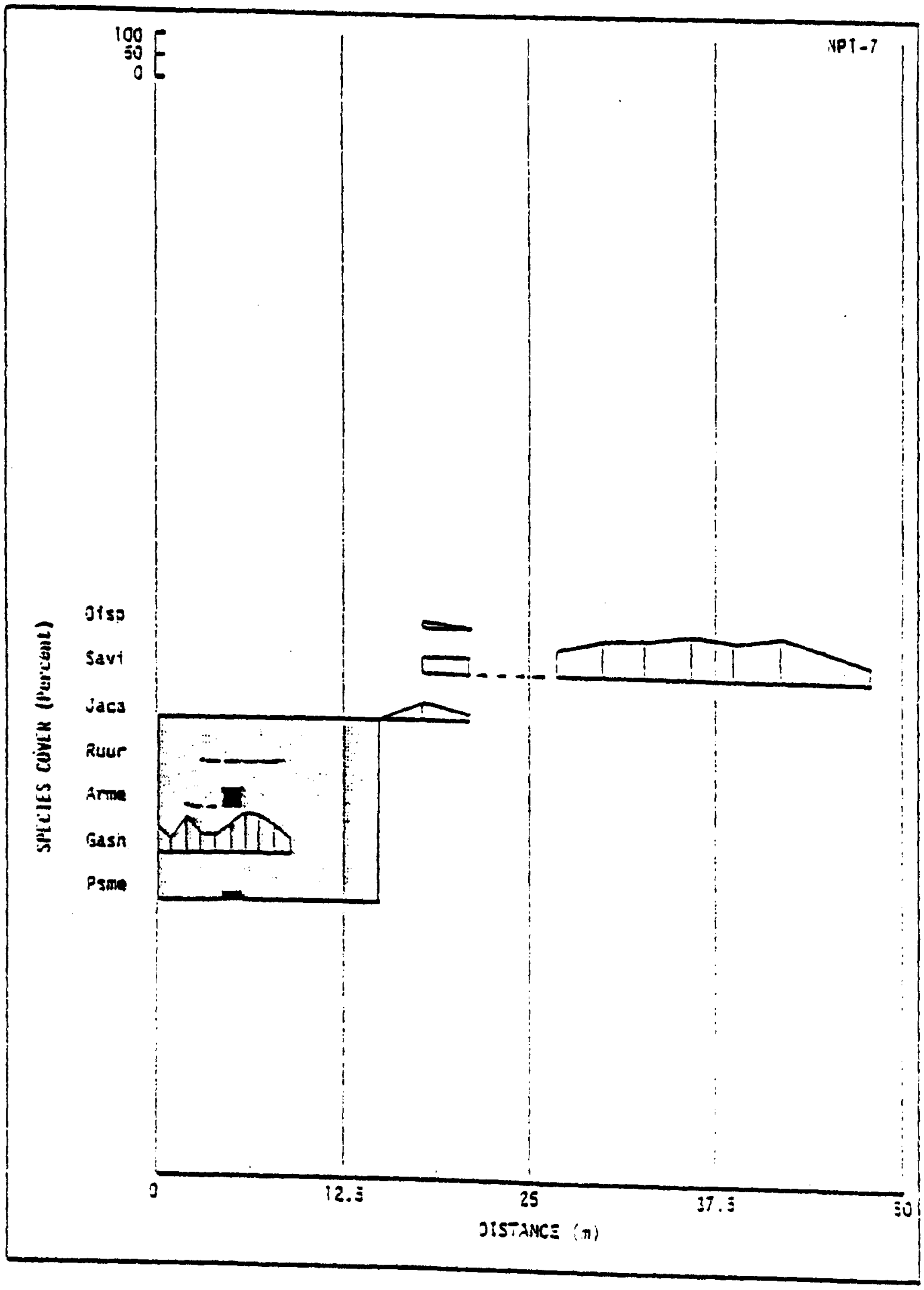


Figure 78. Plant species cover along transect NPI-7 at Oak Bay study site.

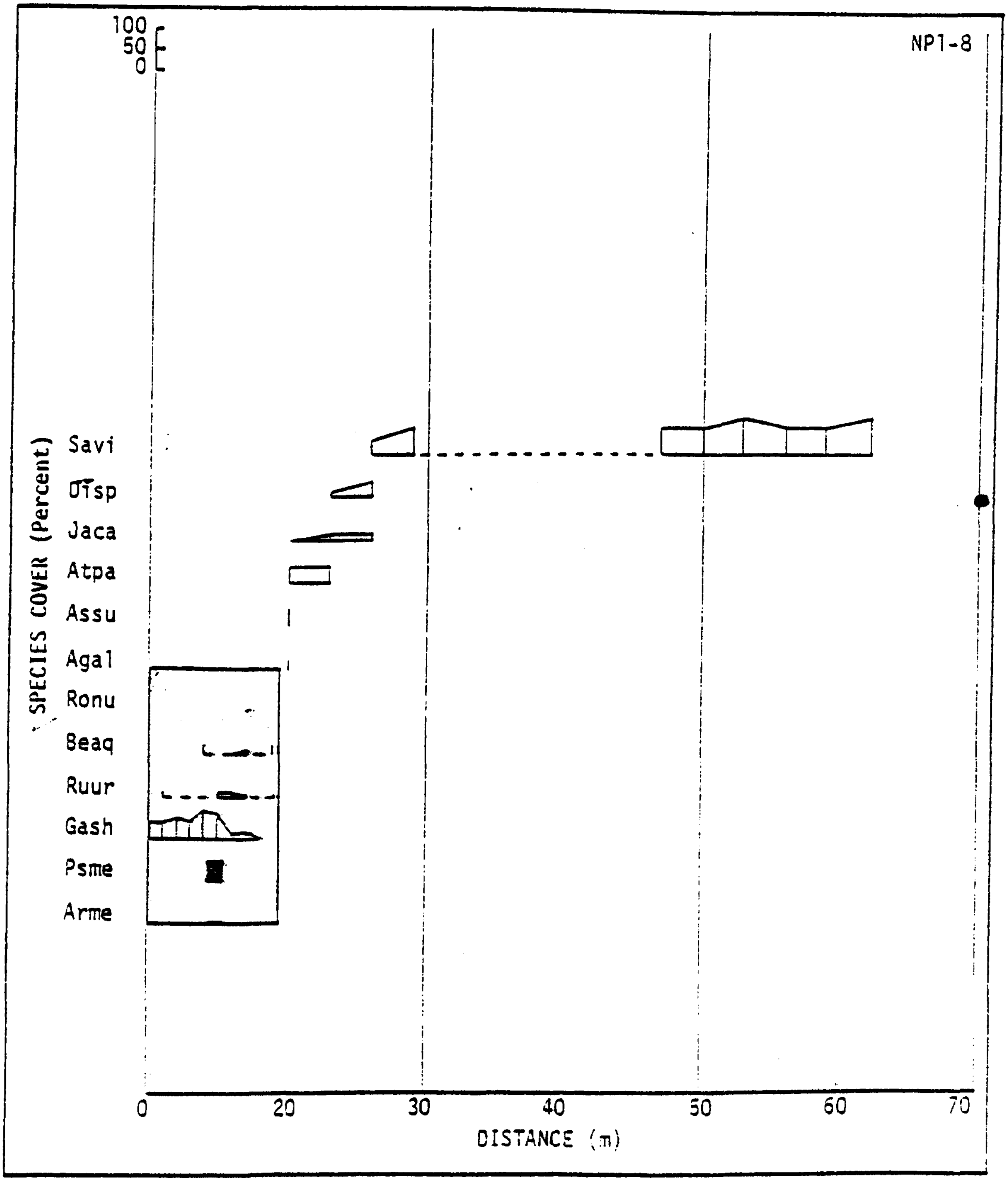


Figure 79. Plant species cover along transect NP1-8 at Oak Bay study site.

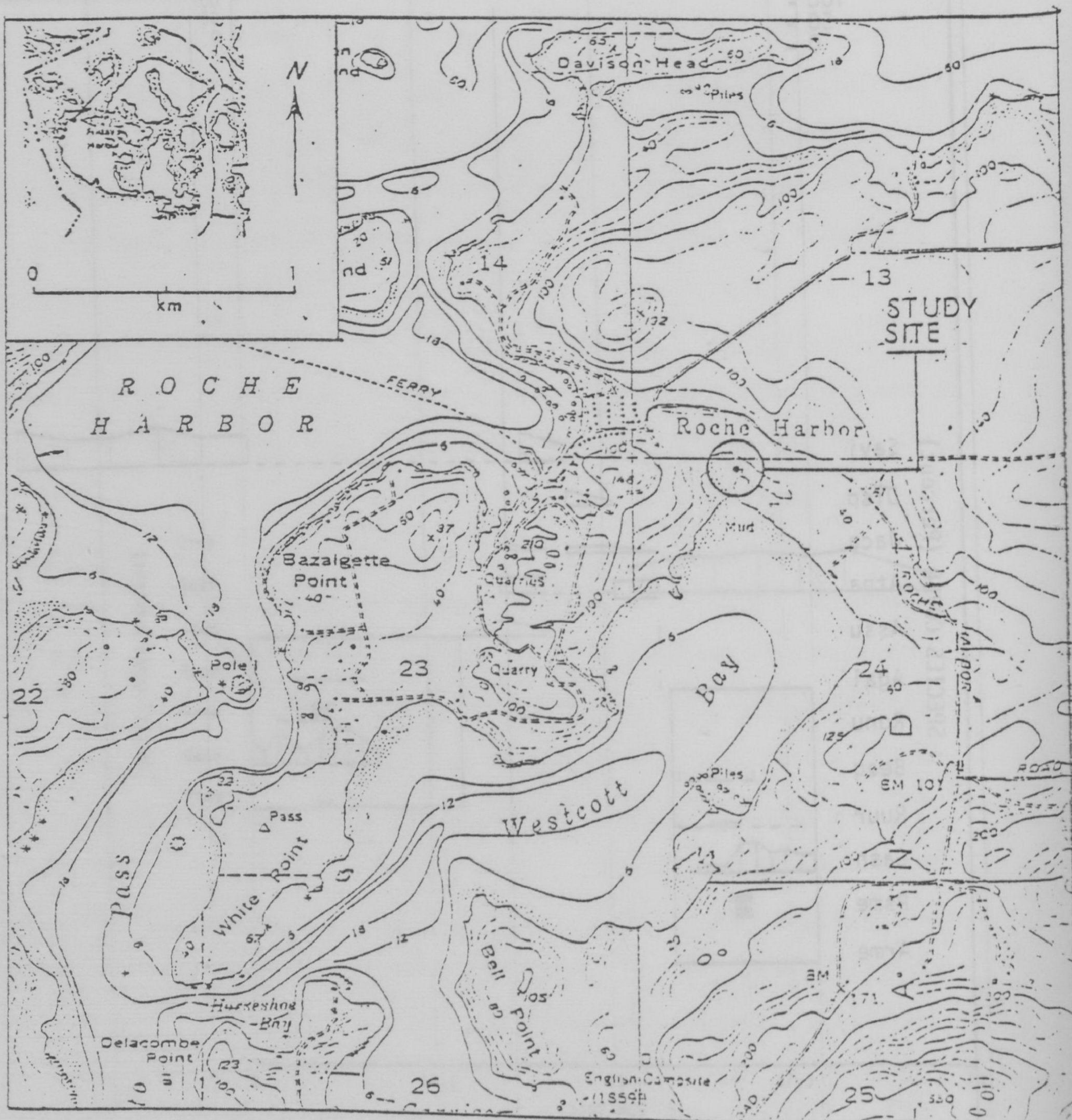


Figure 80. Location of Westcott Bay study site, SJ1.

appearance within the assemblage of the upland species Calamagrostis nutkaensis and Gaultheria shallon, and the disappearance of the low marsh species.

Upland vegetation was an open Pseudotsuga menziesii - Arbutus menziesii forest. These tree species, together with the open nature of the forest suggest, a dry site condition. The understory with Gaultheria shallon and Rubus ursinus support this assumption. Four trees dominated as seen from the frequency, average cover, and basal area data:

	Freq. (%)	Avg. Cover (%)	B.A. (m^2/ha)
Arbutus menziesii	80.0	19.0	3.6
Prunus emarginata	10.0	10.0	--
Pseudotsuga menziesii	90.0	22.0	3.4
Thuja plicata	10.0	--	--

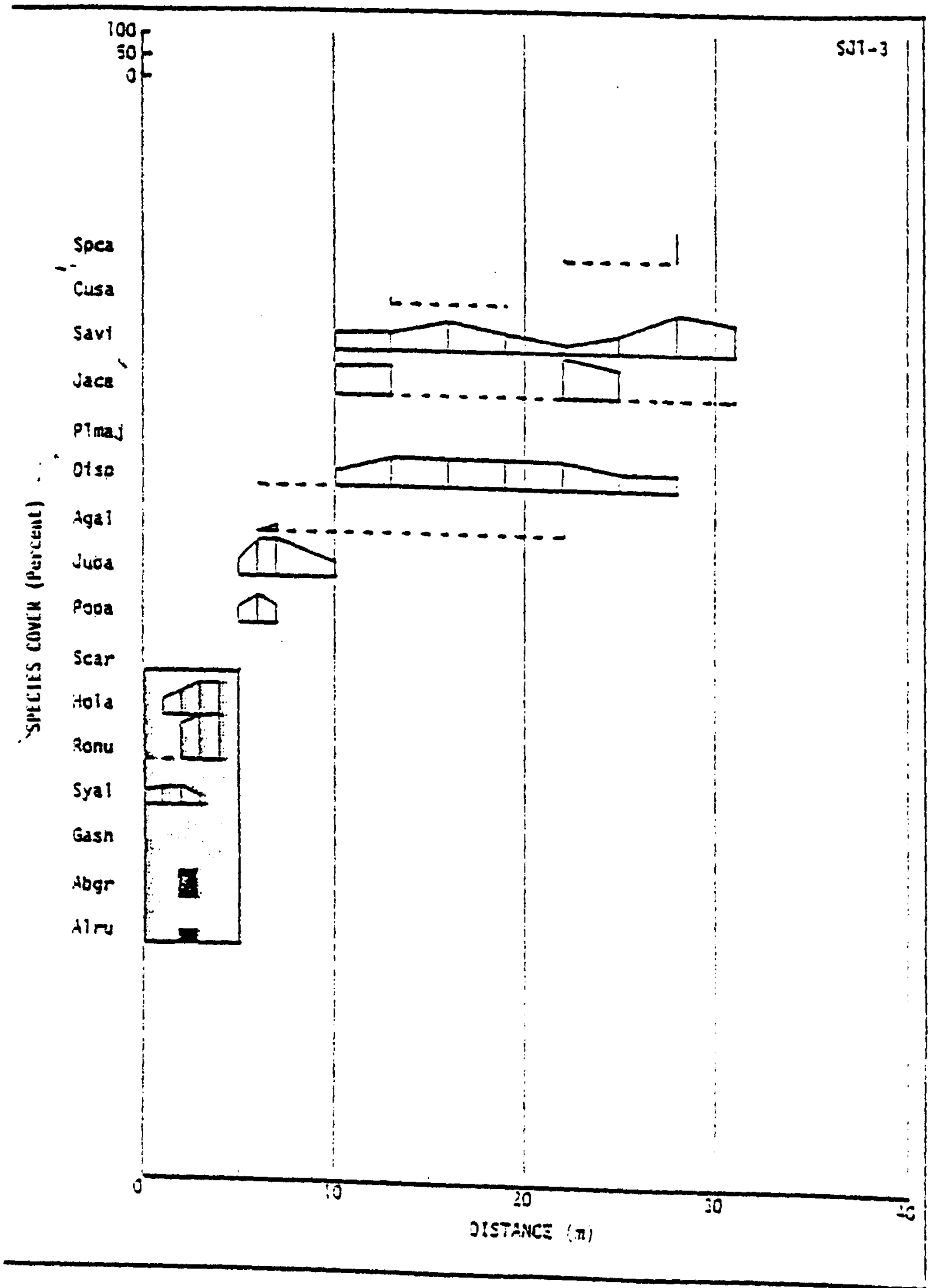
The understory species with greater than 10 percent frequency in the 83 samples were:

	Freq. (%)	Avg. Cover (%)
Berberis aquifolium	16.9	2.5
Gaultheria shallon	85.5	41.3
Pteridium aquilinum	14.5	3.0
Rosa nutkana	27.7	4.1
Rubus ursinus	21.7	1.3

All species are common dry-site species.

Westcott Bay SJ1

Site description. Situated on the northwest side of San Juan Island, the marsh has formed at the head of Westcott Bay, just southeast of Roche Harbor (Figure 80). The marsh, 0.8 ha in size, was classified as a Low Sand Marsh. Tidal creeks, freshwater seepage, and drift logs



'igure 81. Plant species cover along transect SJ1-3 at Westcott Bay study site.

were virtually non-existent. A fence had been built between the marsh and the upland. The upland, for the most part, is used for pasture. Along the fence line Arbutus menziesii, Juniperus scopulorum and Rosa gymnocarpa were found. The gradient of the marsh did not rise very far above the mud flat, resulting in the marsh being inundated completely twice daily.

Plant communities. Along five transects placed from the mud flat to within the upland, 45 microplots were used to characterize the marsh vegetation and 45 line segments were employed to describe the upland. Within the marsh, a lower zone community identified by Distichlis spicata - Salicornia virginica - Jaumea carnosa; an upper marsh community identified by Agrostis alba - Potentilla pacifica; and, a wet-phase of the upper marsh community marked by Carex obnupta - Juncus gerardii were recognized.

The Distichlis spicata - Salicornia virginica - Jaumea carnosa community, the only low marsh assemblage in Westcott Bay, includes such additional characteristic species as:

Cuscuta salina	Plantago maritimum
Spergularia canadensis	Puccinellia pumila
Triglochin maritimum	

The Agrostis alba - Potentilla pacifica community, was the principal upper marsh community. Juncus balticus was an important species within the community, while Hordeum brachyantherum and Achillea millefolium only had minor occurrence.

The Carex obnupta - Juncus gerardii community provided a wet-phase upper marsh assemblage indicating that there is some freshwater seepage in portions of the upper marsh.

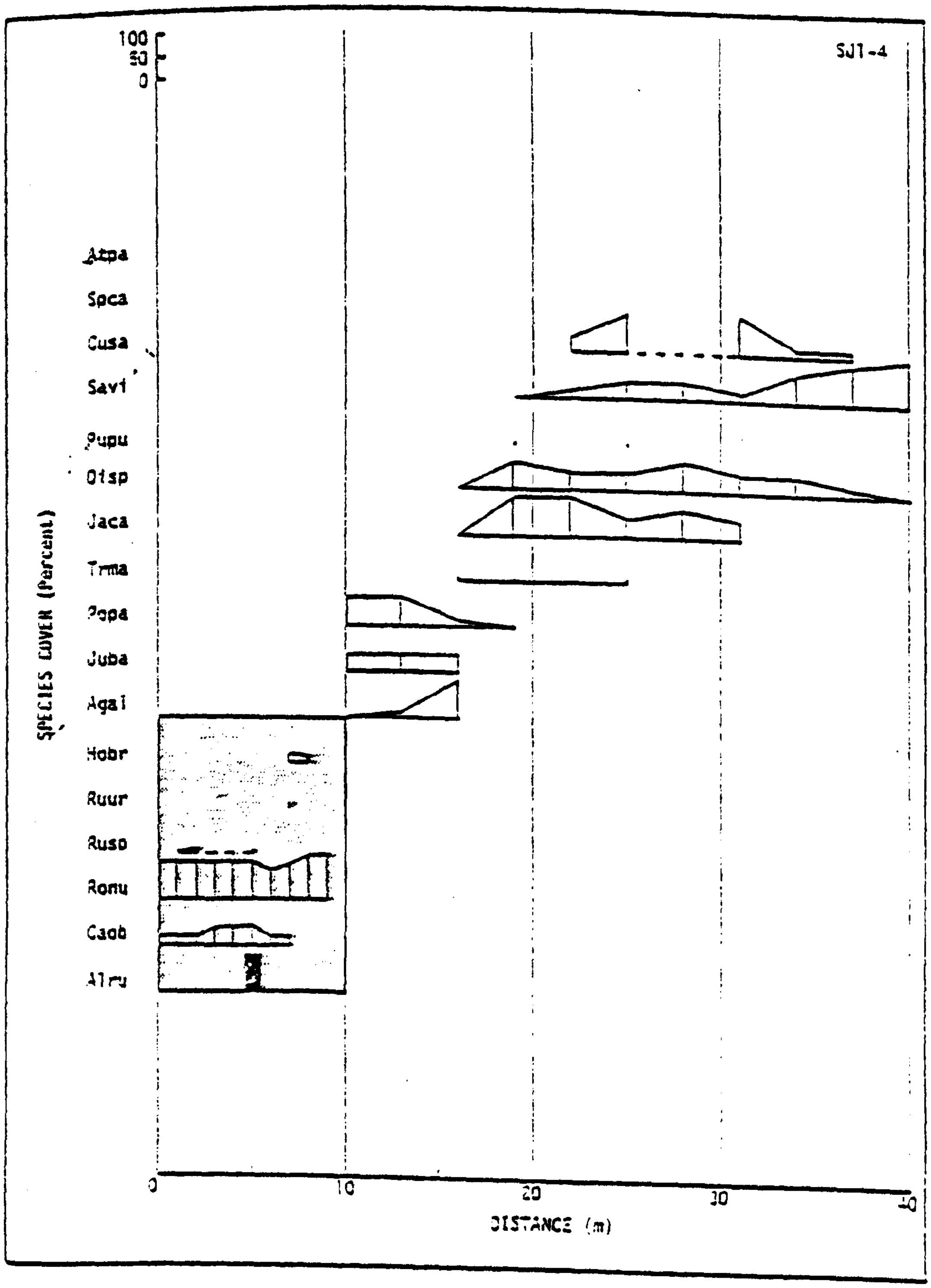


Figure 82. Plant species cover along transect SJ1-4 at Westcott Bay study site.

Transects and transition zone. Due to the smallness of the marsh, only five transects were established. Figures 81 and 82 show typical transects. No transition zone, per se, was found between the upper marsh and the upland. Only a few upland species such as *Achillea millefolium* and *Galium aparine* were found to a limited degree, in the higher portions of the upper marsh.

Upland vegetation was characterized either by grazing activity or wetland conditions. Where grazing was active at the present time, the vegetation appeared clipped; where grazing had taken place in the near past, *Rosa nutkana* was present; and, where grazing had either occurred in the distant past or had never occurred, a *Salix* thicket was found. The understory in this thicket reflected both dry upland conditions and localized wet upland environments. The frequency and average cover of tree species in the upland area as follows:

	Freq. (%)	Avg. Cover (%)
Abies grandis	40.0	14.0
Alnus rubra	80.0	28.0
Arbutus menziesii	20.0	1.0
Juniperus scopulorum	20.0	1.0
Salix spp.	60.0	15.0

Understory species with greater than 10 percent frequency in the upland were:

	Freq. (%)	Avg. Cover (%)
Carex obnupta	17.8	4.9
Rosa nutkana	97.8	91.3

Griffin Bay SJ2

Site description. Located at the southeastern tip of San Juan Island (Figure 33) this Low Sand Marsh, occupying an area less than 1 ha,

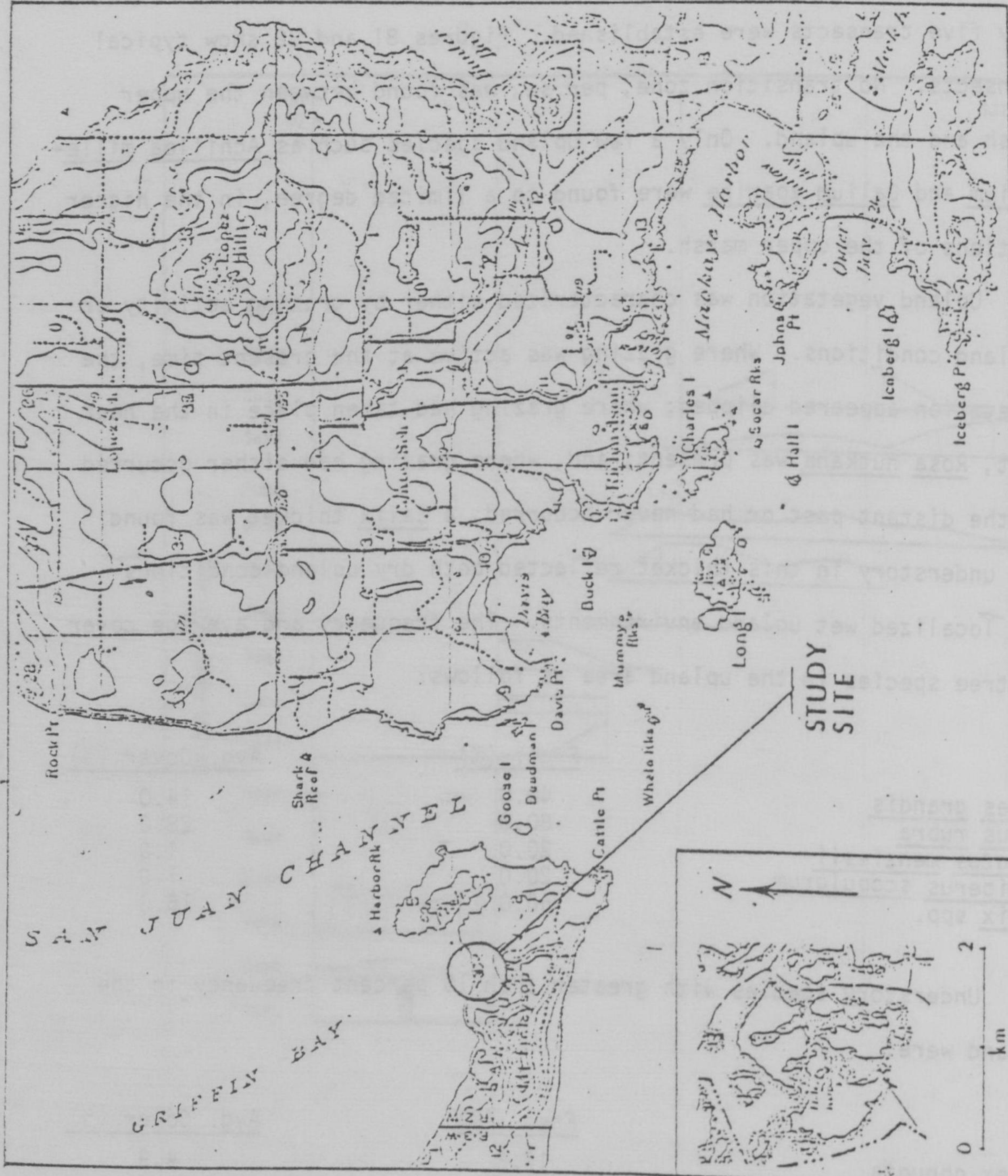


Figure 83. Location of Griffin Bay study site, SJ2.

was clogged with drift logs. There was no evidence of freshwater seepage or creek development in the marsh. The upland was a coniferous forest. The gradient of the marsh was low.

Plant communities. A total of 44 microplots along 5 transects were used to sample the marsh vegetation. An additional 50 line segments were used to characterize the upland vegetation. Three communities were determined in the two zones (lower and upper) that were identified. These communities were: (1) *Salicornia virginica* community, a low marsh assemblage dominated by *Salicornia*; (2) *Salicornia virginica - Distichlis spicata* community, also a low marsh assemblage, but found higher in the marsh than the pure *Salicornia virginica* community; and (3) *Juncus balticus* community, forming the upper marsh assemblage.

The *Salicornia virginica* community was found in pure stands bordering the mud flat of Griffith Bay, and upward into the marsh for several meters. Drift material is found throughout the community.

The *Salicornia virginica - Distichlis spicata* community, occurred in the low marsh just above the *Salicornia virginica* community. These two species tended to dominate throughout.

The *Juncus balticus* community formed the upper marsh assemblage with minor occurrence of such species as *Agrostis alba*, *Hordeum brachyantherum*, and *Potentilla pacifica*. There also tended to be a large accumulation of drift material in this community.

Transects and transition zone. Five transects were placed parallel to the marsh gradient. All ran from the mudflat to within the upland vegetation. Figures 84 and 85 illustrate profiles along these transects. As in the Westcott Bay marsh, no well-defined transition zone was identified. The only upland species found in the higher portion of the upper marsh was *Festuca rubra*, which occurred in one microplot at the marsh-upland interface.

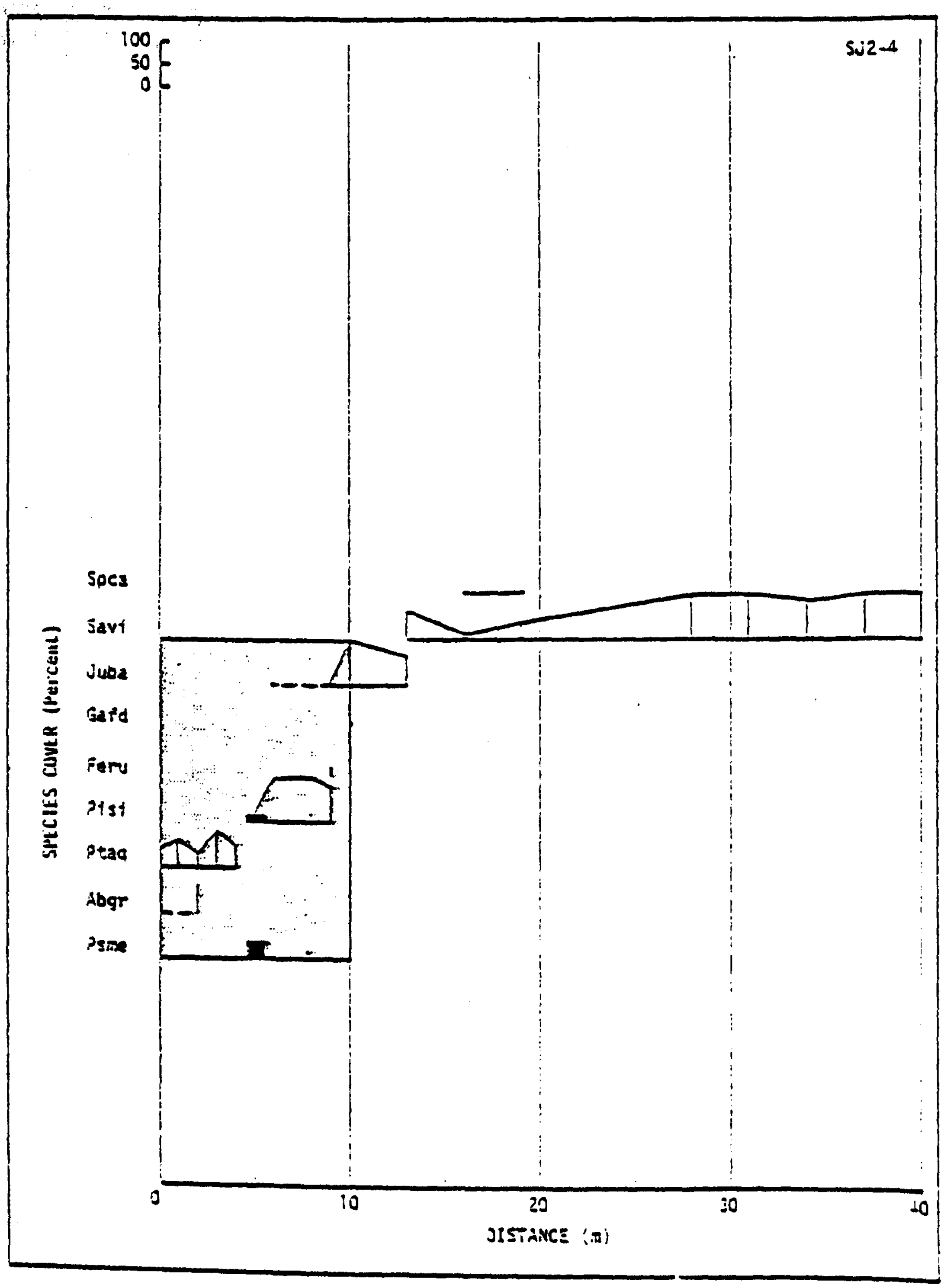


Figure 84. Plant species cover along transect SJ2-4 at Griffin Bay study site.

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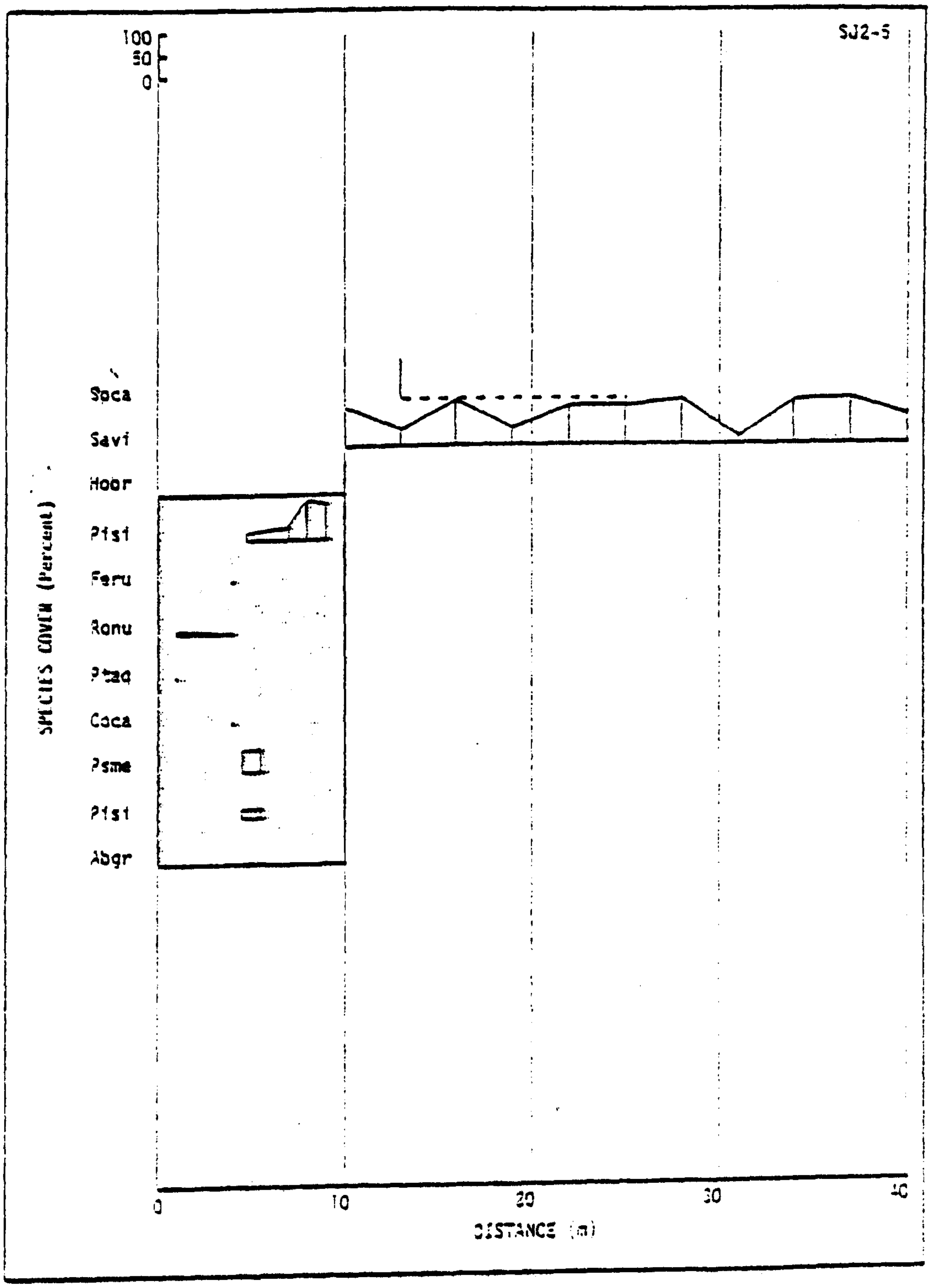

Figure 85. Plant species cover along transect SJ2-5 at Griffin Bay study site.

The upland was a *Pseudotsuga menziesii* - *Picea sitchensis* forest with numerous *P. sitchensis* seedlings in the understory. At the edge of the forest, *Juncus balticus* and *Festuca rubra* were found. Following are the frequency, average cover, and basal area data of the tree species found in the upland:

	Freq. (%)	Avg. Cover (%)	B.A. (m^2/ha)
Abies grandis	60.0	2.0	1.2
Picea sitchensis	100.0	26.0	3.4
Pseudotsuga menziesii	80.0	27.0	3.8
Rhamnus purshiana	20.0	0.4	--
Tsuga heterophylla	40.0	18.0	2.2

Understory species with a 10 percent frequency or greater for the 50 meter segments included:

	Freq. (%)	Avg. Cover (%)
Festuca rubra	18.0	6.2
Gaulthera shallon	18.0	9.4
Juncus balticus	18.0	6.2
Picea sitchensis	16.0	11.7
Pteridium aquilinum	26.0	9.5

Synthetic Analysis

Introduction

To objectively define the limits of coastal intertidal wetlands, data collected along 190 individual transects and among 20 marsh study sites were aggregated. The first step in aggregation was to assign a given microplot sample to one of five marsh zones based on the investigator's knowledge of plant species distribution and intuitive knowledge of marsh structure. Discriminant analysis tested the validity of this assignment. The second step, was to calculate plant species percent frequency, average percent cover, and importance value in each of these five zones. In step three, progressive trends among the species synthetic data calculated in step two were used to compile three lists of species which were, in turn, used to identify marsh-upland vegetation groups: Low Marsh, High Marsh, and Upland. Species were evaluated as to how well they conformed to a given vegetation group. A fourth species list was prepared which included plants with broad habitat associations and, therefore, plants which are poor predictors of these vegetation groups.

While five marsh zones were used in this synthetic analysis, upland vegetation could be treated as a sixth zone. Because field data collection for the upland was based on a different sampling system than for the marsh data, synthesis of upland tree, shrub, and understory herb vegetation data is dealt with separately.

The synthetic analysis provided the basis for an objective definition of the upper limit of wetland which is presented in the next major section.

Zonal Analysis

Frequency. Table 13 shows average species frequency for 65 plant species in each marsh zone, where zone 1 is the lowest zone and zone 5 the highest zone adjacent to upland. While all data were aggregated in this table, frequency trends varied from marsh to marsh. For example, *Deschampsia cespitosa* in the sand-based Bandon marsh had higher relative frequencies in zone 3 to 5 than it did in many of the silt-based marshes where it had its highest relative frequencies in zone 2, as was the case also of Nute Slough in Yaquina estuary. Print-out data is available of zone frequencies on a marsh-by-marsh basis.

The frequency distribution suggests the spatial "homogeneity" of a given species and quantifies the degree of "repetitiveness" of a plant in a set of samples. The analysis of this table is discussed below in the "Species Classification" section (page 201).

Cover. Table 14 presents average species percent cover in each of the five marsh zones where zone 1 is the lowest and zone 5 the highest marsh zone. The table aggregates the data for 2,583 microplots distributed over 190 transects and 20 marshes. Species with greater than one percent cover in all marshes and all zones in order of decreasing cover are:

Potentilla pacifica	12.6	*Triglochin maritimum*	4.4
Juncus balticus	11.6	*Aster subspicatus*	3.9
Agrostis alba	9.2	*Jaumea carnosa*	3.9
Salicornia virginica	8.6	*Atriplex patula*	1.9
Carex lyngbyei	7.8	*Juncus effusus*	1.7
Distichlis spicata	6.9	*Scirpus americanus*	1.2
Deschampsia cespitosa	6.0		

This list of dominant marsh species in all Pacific Northwest coast marshes, is biased by over representation of sampling in the upper

Table 13. Average species frequency by marsh zone.

Species	Marsh Zone and Number of Samples				
	1 724	2 771	3 402	4 430	5 255
Achillea millefolium	0.1	0.1	2.1	8.5	14.0
Agrostis alba	4.3	38.3	56.1	66.8	46.3
Aster subspicatus	0	4.4	25.5	39.5	37.7
Atriplex patula	5.9	30.4	23.3	17.0	16.0
Carex lyngbyei	33.9	37.8	24.7	11.6	4.0
Carex obnupta	0	0	0.8	2.1	16.2
Cuscuta salina	3.6	4.0	0.2	0.3	0
Deschampsia cespitosa	2.5	37.8	26.5	11.6	6.5
Distichlis spicata	43.4	53.2	21.1	11.7	3.3
Eleocharis palustris	0.8	2.8	2.9	1.6	1.4
Festuca rubra	0	2.1	4.4	9.7	7.5
Galium aparine	0	0.2	0.2	0.3	4.5
Galium triflorum	0	0.8	6.2	5.3	7.3
Glaux maritima	10.3	30.6	17.0	4.4	0.4
Grindelia integrifolia	0	8.2	3.2	3.4	0
Holcus lanatus	0	0	0	2.5	17.1
Hordeum brachyantherum	0.5	17.1	14.9	12.1	4.4
Jaumea carnosa	20.6	26.0	7.3	2.6	0
Juncus balticus	1.3	41.4	54.2	57.0	31.2
Lilaeopsis occidentalis	5.1	9.8	3.2	1.5	1.3
Lotus uliginosus	0	0	0.4	0.8	3.3
Oenanthe sarmentosa	0	0	1.4	8.2	22.4
Orthocarpus castillejoides	1.6	3.6	0	0.3	0
Plantago maritima	8.8	7.0	2.1	0.9	0.1
Potentilla pacifica	0.1	27.6	65.6	69.2	46.5
Puccinellia pumila	5.7	2.8	0	0	0
Rumex occidentalis	0	0.1	0.5	0.3	2.2
Salicornia virginica	54.2	40.6	8.4	0.3	0
Scirpus americanus	8.8	7.7	2.2	0.9	0.2
Scirpus cernuus	6.8	6.8	0	0.4	0
Spergularia canadensis	9.9	5.5	1.4	0.1	0
Stellaria humifusa	4.2	9.3	2.2	0.9	0
Trifolium wormskjoldii	0	1.8	9.2	14.0	17.5
Triglochin concinnum	2.2	1.4	0.2	0	0
Triglochin maritimum	33.5	38.2	23.0	7.7	3.2
Vicia gigantea	0	0	0.2	1.8	9.6
Angelica lucida	0	0	0.7	2.8	3.0
Elymus mollis	0	0	1.5	9.1	11.1
Stellaria calycantha	0.2	1.0	0.9	0.2	1.6
Maianthemum dilatatum	0	0	0	1.1	12.3
Picea sitchensis	0	0	0	1.3	3.0
Plantago lanceolata	0	0	0	1.1	3.8
Juncus effusus	0	5.5	6.6	4.7	5.4
Zostera nana	6.3	0.1	0	0	0

Average Species Frequency by Marsh Zone (Cont.)

Species	Marsh Zone and Number of Samples				
	1 724	2 771	3 402	4 430	5 255
Juncus lesueurii	0	1.2	3.9	6.1	7.8
Lathyrus palustris	0	0.3	0.3	3.4	2.8
Scirpus validus	0	0.2	2.2	1.1	2.7
Poa pratensis	0	0	0.3	0.5	2.8
Gautheria shallon	0	0	0	0	4.7
Hypochaeris radicata	0	0.1	0.4	0	0.8
Spergularia macrotheca	0.2	0.1	0.9	0.5	1.3
Scirpus microcarpus	0	0	1.5	2.8	4.0
Carex pansa	0	0	0.3	1.3	[illegible].9
Calamagrostis nutkaensis	0	0	0.2	2.7	4.5
Epilobium watsonii	0	0.1	0.8	0.9	0.3
Agropyron repens	0	0.4	1.7	5.0	1.3
Lonicera involucrata	0	0	0	0.8	3.0
Spartina alterniflora	1.6	0	0	0	0
Equisetum sp.	0	0	0.5	0.3	3.1
Juncus gerardii	0	0.7	0.2	1.2	4.3
Erechtites arguta	0	0	0	0.4	2.3
Heracleum lanatum	0	0.1	0	0.1	1.4
Physocarpus capitatus	0	0	0.2	0.6	1.9
Rubus ursinus	0	0	0	0.8	4.0
Sidalcea hendersonii	0	0	0.3	0.2	0.4

Table 14. Average percent cover by marsh zone.[1]

Zone	1	2	3	4	5	Avg. Tot.
No. Samples	724	771	402	430	255	2583
Species						
Achillea millefolium	0.021	.020	0.192	0.765	4.758	0.639
Agrostis alba	0.151	9.011	12.972	19.518	12.240	9.214
Aster subspicatus	0	0.910	6.970	10.291	8.386	3.898
Atriplex patula	0.127	3.754	2.150	2.212	0.647	1.929
Carex lyngbyei	12.404	9.931	6.329	1.767	0.642	7.785
Carex obnupta	0	0	0.082	0.192	5.295	0.568
Cuscuta salina	0.612	0.246	0.037	0.087	0	0.265
Deschampsia cespitosa	0.208	13.986	6.618	3.056	2.663	6.034
Distichlis spicata	11.524	10.466	2.450	0.629	0.142	6.854
Eleocharis palustris	0.428	0.398	0.476	0.210	0.405	0.388
Festuca rubra	0	0.255	0.537	1.220	1.298	0.491
Galium aparine	0	0	0	0.007	0.238	0.025
Galium triflorum	0	0.013	0.305	0.290	0.272	0.126
Glaux maritima	0.280	1.273	0.612	0.051	0.012	0.564
Grindelia integrifolia	0	1.625	0.474	0.244	0	0.600
Holcus lanatus	0	0	0	0.120	3.315	0.347
Hordeum brachyantherum	0.004	1.516	1.367	1.507	0.694	0.986
Jaumea carnosa	7.838	5.190	0.734	0.007	0	3.862
Juncus balticus	0.257	12.643	17.005	23.436	13.648	11.756
Lilaeopsis occidentalis	0.298	0.767	0.262	0.077	0.154	0.381
Lotus uliginosus	0	0	0.008	0.007	1.968	0.197
Oenanthe sarmentosa	0	0	0.216	0.757	7.484	0.899
Orthocarpus castillejoides	0.035	0.105	0	0.035	0	0.047
Plantago maritima	1.914	0.889	0.075	0.007	0	0.815
Potentilla pacifica	0	4.968	20.540	33.138	23.880	12.554
Puccinellia pumila	0.336	0.294	0	0	0	0.182
Rumex occidentallis	0	0.004	0.022	0	0.549	0.059
Salicornia virginica	22.572	7.024	0.972	0.035	0	8.582
Scirpus americanus	3.596	0.620	0.261	0.022	0	1.237
Scirpus cernuus	1.055	0.504	0	0.007	0	0.447
Spergularia canadensis	1.164	0.313	0.008	0.087	0	0.436
Stellaria humifusa	1.142	0.879	0.017	0.158	0	0.612
Trifolium wormskjoldii	0	0.048	0.697	1.132	2.196	0.528
Triglochin concinnum	0.142	0.048	0	0	0	0.054
Triglochin maritimum	6.339	6.393	3.684	0.708	0.394	4.421
Vicia gigantea	0	0	0	0.165	3.695	0.392
Angelica lucida	0	0	0.200	0.158	0.607	0.117
Elymus glaucus	0	0	0.198	2.662	1.839	0.656
Stellaria calycantha	0	0.013	0.023	0	0.037	0.011
Maianthemum dilatatum	0	0	0	0.007	0.395	0.090
Picea sitchensis	0	0	0	1.126	1.161	0.302
Plantago lanceolata	0	0	0	0.014	0.512	0.053
Juncus effusus	0	2.803	3.910	0.647	1.079	1.659
Zostera nana	0.728	0.004	0	0	0	0.205
Juncus lesueurii	0	0.228	0.689	1.702	1.231	0.580
Lathyrus palustris	0	0.004	0.008	0.752	0.313	0.159
Scirpus validus	0	0.130	0.362	0.021	0.394	0.138

Poa pratensis	0	0	0.038	0.101	0.095	0.032
Gaultheria shallon	0	0	0	0	0.212	0.021
Hypochaeris radicata	0	0.004	0.001	0	0.024	0.004
Spergularia macrotheca	0.004	0	0.053	0.042	0.024	0.019
Scirpus microcarpus	0	0	0.886	0.577	0.726	0.306
Carex pansa	0	0	0.253	0.171	0.347	0.102
Calamagrostis nutkaensis	0	0	0.037	0.014	1.394	0.146
Epilobium watsonii	0	0	0.023	0.008	0.024	0.007
Agropyron repens	0	0.004	0.461	0.364	0.245	0.158
Lonicera involucrata	0	0	0	0.035	1.338	0.138
Spartina alterniflora	0.539	0	0	0	0	0.151
Equisetum spp.	0	0	0.082	0.145	0.784	0.114
Juncus gerardii	0	0.273	0.008	0.122	0.826	0.185
Erechtites arguta	0	0	0	0.014	0.596	0.061
Heracleum lanatum	0	0	0	0.007	0.671	0.067
Physocarpus capitatus	0	0	0.075	0.070	0.177	0.041
Rubus ursinus	0	0	0	0.007	0.236	0.024
Sidalcea hendersonii	0	0	0.015	0.087	0.071	0.024

[1] Average species percent cover is calculated by summing the species percent cover and dividing by the number of samples in a given zone.

marsh because of the concern in this research in defining the marsh-upland ecotone. Only one species in the list is regarded as a general upland-adapted plant and that is Aster subspicatus.

Importance value. Combining species frequency and average percent cover in each of the five marsh zones and normalizing cover and frequency in terms of relative frequency and relative cover, one obtains an importance value for each species (see p. 39). Table 15 presents average importance values for each of 65 common marsh and transition zone species in each of 5 marsh zones.

Species in zone 1 with average importance values greater than 3.0 in order of declining frequency are:

Salicornia virginica	51.1	Spergularia canadensis	5.3
Carex lyngbyei	34.7	Plantago maritima	3.9
Distichlis spicata	29.9	Scirpus cernuus	3.7
Triglochin maritimum	28.3	Zostera nana	3.7
Jaumea carnosa	12.7	Glaux maritima	3.5
Scirpus americanus	6.4		

While this is a list of species "importance" in zone 1 and does not directly concern importance in the other zones, only one species, Glaux maritima is regarded as more typical of high marsh than low marsh. Glaux is a small, widely distributed species in the upper part of low marsh and lower parts of high marsh.

In zone 2, species with average importance values in excess to 3.0 include:

(5)	Juncus balticus	24.9	(5)	Atriplex patula	10.0
(1)	Distichlis spicata	22.8	(5)	Potentilla pacifica	9.3
(1)	Salicornia virginica	18.8	(1)	Glaux maritima	6.1
	Deschampsia cespitosa	18.8		Hordeum brachyantherum	4.8
(1)	Carex lyngbyei	16.9		Juncus effusus	3.0
(5)	Agrostis alba	16.3		Lileaopsis occidentalis	3.0
(1)	Triglochin maritimum	13.0			

Table 15. Average species marsh importance value by zone.[1]

Species	Zone / No. Samples: 1 / 724	2 / 771	3 / 402	4 / 430	5 / 255
Achillea millefolium	0.04	0.05	0.79	3.06	4.87
Agrostis alba	1.92	16.30	30.34	34.88	27.46
Aster subspicatus	0.00	1.69	12.20	18.27	16.58
Atriplex patula	2.27	9.97	8.26	5.21	6.44
Carex lyngbyei	34.68	16.89	11.30	4.55	1.14
Carex obnupta	0.00	0.00	0.32	0.74	9.44
Cuscuta salina	1.61	1.23	0.06	0.19	0.00
Deschampsia cespitosa	1.12	18.81	10.50	4.21	2.38
Distichlis spicata	29.93	22.76	7.34	3.25	0.98
Eleocharis palustris	0.79	1.59	1.40	0.89	0.55
Festuca rubra	0.00	0.55	2.29	8.68	2.91
Galium aparine	0.00	0.06	0.06	0.08	1.01
Galium triflorum	0.00	0.16	2.24	1.23	1.38
Glaux maritima	3.53	6.11	3.89	1.03	0.09
Grindelia integrifolia	0.00	2.62	1.41	2.22	0.00
Holcus lanatus	0.00	0.00	0.00	0.57	4.78
Hordeum brachyantherum	0.14	4.82	5.57	3.64	1.29
Jaumea carnosa	12.65	10.60	2.73	0.65	0.00
Juncus balticus	0.64	24.93	34.43	32.56	14.57
Lileaopsis occidentalis	1.89	2.95	1.09	0.42	0.30
Lotus uliginosus	0.00	0.00	0.23	0.37	1.47
Oenanthe sarmentosa	0.00	0.00	0.87	4.11	10.67
Orthocarpus castillejoides	0.57	0.67	0.00	0.09	0.00
Plantago maritima	3.89	1.90	0.55	0.24	0.02
Potentilla pacifica	0.02	9.34	33.36	39.44	25.55
Puccinellia pumila	1.87	0.75	0.00	0.00	0.00
Rumex occidentallis	0.00	0.03	0.15	0.09	0.72
Salicornia virginica	51.12	18.80	4.03	0.14	0.00
Scirpus americanus	6.37	2.45	0.85	0.19	0.04
Scirpus cernuus	3.74	1.91	0.00	0.07	0.00
Spergularia canadensis	5.31	1.71	0.52	0.06	0.00
Stellaria humifusa	1.65	2.08	0.41	0.26	0.04
Trifolium wormskjoldii	0.00	0.44	2.70	4.74	5.83
Triglochin concinnum	0.69	0.47	0.28	0.03	0.00
Triglochin maritimum	28.26	13.01	7.75	2.78	1.04
Vicia gigantea	0.00	0.00	0.06	0.58	3.68
Angelica lucida	0.00	0.00	0.30	0.71	0.92
Elymus mollis	0.00	0.00	0.49	3.64	8.46
Stellaria calycantha	0.09	0.18	0.15	0.04	0.25
Maianthemum dilatatum	0.00	0.00	0.00	0.26	3.44
Picea sitchensis	0.00	0.00	0.00	0.76	2.47
Plantago lanceolata	0.00	0.00	0.00	0.43	0.95
Juncus effusus	0.00	2.97	3.35	2.27	2.62
Zostera nana	3.67	0.03	0.00	0.00	0.00
Juncus lesueurii	0.00	0.35	1.17	2.16	1.85
Lathyrus palustris	0.00	0.07	1.48	1.12	1.25
Scirpus validus	0.00	0.12	0.13	0.10	0.58

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Average Species Marsh Importance Value by Zone[1] (Cont.)

Species	Zone / No. Samples	1 / 724	2 / 771	3 / 402	4 / 430	5 / 255
Poa pratensis		0.00	0.00	0.09	0.15	0.57
Gaultheria shallon		0.00	0.00	0.00	0.00	1.54
Hypochaeris radicata		0.00	0.03	0.07	0.00	0.15
Spergularia macrotheca		0.06	0.03	0.22	0.13	0.27
Scirpus microcarpus		0.00	0.00	1.97	2.76	3.18
Carex pansa		0.00	0.00	0.38	0.36	0.73
Calamagrostis nutkaensis		0.00	0.00	0.06	0.65	1.74
Epilobium watsonii		0.00	0.02	0.24	0.24	0.07
Agropyron repens		0.00	0.12	1.43	2.44	1.37
Lonicera involucrata		0.00	0.00	0.00	0.26	2.00
Spartina alterniflora		1.54	0.00	0.00	0.00	0.00
Equisetum spp.		0.00	0.00	0.37	0.59	2.88
Juncus gerardii		0.00	0.68	0.06	0.54	2.76
Erechtites arguta		0.00	0.00	0.00	0.10	1.23
Heracleum lanatum		0.00	0.03	0.00	0.02	0.47
Physocarpus capitatus		0.00	0.00	0.23	0.49	1.14
Rubus ursinus		0.00	0.00	0.00	0.37	2.03
Sidalcea hendersonii		0.00	0.00	0.17	0.16	0.18

[1] Average species marsh importance value by zone is calculated by summing the species importance values in a given zone and dividing by the number of marshes.

Again, this list refers only to dominance in zone 2 and does not refer to other zones. One can see the persistence of a number of zone 1 species into zone 2 by the indication of (1) for zone 1. Zone 5 species dominants are denoted by (5).

Plant species with importance values greater than 3.0 in zone 3 include:

(5)	*Juncus balticus*	34.4	(1)	*Triglochin maritimum*	7.8
(5)	*Potentilla pacifica*	33.4	(1)	*Distichlis spicata*	7.3
(5)	*Agrostis alba*	30.3		*Hordeum brachyantherum*	5.6
(5)	*Aster subspicatus*	12.2	(1)	*Salicornia virginica*	4.0
(1)	*Carex lyngbyei*	11.3	(1)	*Glaux maritima*	3.9
	Deschampsia cespitosa	10.5		*Juncus effusus*	3.4
(5)	*Atriplex patula*	8.3			

One can see the disappearance in this zone 3-dominance list, of several zone 1 dominants and the first entry of a number of species with dominance in zone 5. Of particular significance is *Aster subspicatus* which has no presence in zone 1 and diminished importance in zone 2. This list of species represents a typical roster of plants, which was regarded in the field as the lower boundary of the transition zone. It suggests an equal mixture of zone 1 dominants with zone 5 dominants.

Zone 4 was considered the "modal" transition zone with a mixture of upland plant species and marsh species. The following is a list of species with importance values greater than 3.0:

(5)	*Potentilla pacifica*	39.4	(1)	*Carex lyngbyei*	4.6
(5)	*Agrostis alba*	34.9		*Deschampsia cespitosa*	4.2
(5)	*Juncus balticus*	32.6	(5)	*Oenanthe sarmentosa*	4.1
(5)	*Aster subspicatus*	18.3		*Hordeum brachyantherum*	3.6
	Festuca rubra	8.7	(5)	*Elymus mollis*	3.6
(5)	*Atriplex patula*	5.2	(1)	*Distichlis spicata*	3.3
(5)	*Trifolium wormskjoldii*	4.7	(5)	*Achillea millefolium*	3.1

This list shows further elimination of zone 1 dominants and the prevalence of zone 5 dominants, many of which are regarded as upland species

Zone 5, adjacent to the upland, contained many upland plants and was also marked by drift log accumulation denoting occassional tidal influence. The species with importance values greater than 3.0 in zone 5 were:

	Agrostis alba	27.5		Atriplex patula	6.4
	Potentilla pacifica	25.6		Trifolium wormskjoldii	5.8
	Aster subspicatus	16.6		Achillea millefolium	4.9
	Juncus balticus	14.6		Holcus lanatus	4.8
(w)	Oenanthe sarmentosa	10.7		Vicia gigantea	3.7
(w)	Carex obnupta	9.4		Maianthemum dilatatum	3.4
	Elymus mollis	8.5	(w)	Scirpus microcarpus	3.2

None of these was among the dominants listed for zone 1. Most are regarded either as upland species or as freshwater indicators as denoted by (w) suggesting the occurrence of freshwater conditions at the upland-marsh interface.

To gain an overall impression of the distribution of species across the marsh to upland gradient, importance values have been plotted individually for the 20 marshes as shown in Appendix F for selected plant species. In these plots one can see marsh by marsh differences in species importance; for example, the importance of Salicornia virginica in the low sand marshes; the broad distribution of Potentilla pacifica in high marshes. These plots may be looked upon as idealized transects across the 20 marshes as they have "average-out" the variations along 10 or more transects in many study sites.

The above zonal analysis shows clearly that species are distributed across a gradient from mud flat to upland and that a distinct and unique assemblage of plants can not be assigned to a given zone. The analysis suggests dominant groups of species *within* a given zone but has not attempted to evaluate the trends *between* zones.

Species Classification

To assess the distributional pattern of species across all five zones and between zones, trends in species frequency, average percent cover, and average importance value in each of the 5 zones were examined Species were assigned to one of three vegetation groups: Low Marsh, High Marsh and Upland in terms of meeting criteria set forth in Table 8. The output of this analysis is three sets of species characteristic of each of these groups. Additionally, a judgment was made as to how well a given species met the stated criteria.

Table 16 lists 16 species considered in the Low Marsh group of these 13 regarded as very good indicators of low marsh. The meaning of this list is that dominance by any one of these species suggests a low marsh situation. Dominance by more than one of these species strengthens the suggestion. Use of this list is explained in the section dealing with the delineation of the upland-marsh boundary.

Table 17 shows those species regarded as High Marsh plants. Only six species were allocated to this group, four of which were judged to fit the importance value criteria as "very good". Of this group, four species tended to have closer relations to saline conditions and were seldom observed in freshwater wetland situations. These were *Atriplex patula*, *Glaux maritima*, *Grindelia integrifolia* and *Lilaeopsis occidentallis*. Of these, *Grindelia* had preference for drier situations and frequently grew on decaying drift logs, and natural levees. *Lilaeopsis* was found in wet areas especially with brackish conditions. *Lilaeopsis*, *Glaux* and *Atriplex* were all low-growing plants found in more or less open mud-silt situations in the high marsh.

Two species in the High Marsh list, *Deschampsia cespitosa* and *Eleocharis palustris*, had strong positions in the High Marsh group but

Table 16. Low marsh species defined by frequency, cover and importance value in five marsh zones.[1]

Species	Evaluation[2] Frequency	Cover	Points[3] (Freq. + Cover)	Importance Value[4]
Carex lyngbyei	m	m	2	vg
Cuscuta salina	vg	vg	4	vg
Distichlis spicata	vg	vg	4	vg
Jaumea carnosa	vg	vg	4	vg
Orthocarpus castillejoides	m	p	1	m
Plantago maritima	vg	vg	4	vg
Puccinellia pumila	vg	vg	4	vg
Salicornia virginica	m	vg	3	vg
Scirpus americanus	m	m	2	vg
Scirpus cernuus	vg	vg	4	vg
Spartina alterniflora	vg	vg	4	vg
Stellaria humifusa	p	m	1	m
Spergularia canadensis	vg	m	3	m
Triglochin concinnum	vg	vg	4	vg
Triglochin maritimum	m	m	2	vg
Zostera nana	vg	vg	4	vg

[1] Criteria for low marsh species were: (a) decreasing frequency and cover from marsh zone 1 to marsh zone 5; and, (b) high concentration in zones 1 and 2, low concentration in zones 4 and 5.

[2] Evaluation of each species in meeting these two criteria were: very good (vg), moderate (m), and poor (p).

[3] Points were independently assigned for both frequency pattern and cover pattern: 0=p, 1=m, and 2=vg. A total of 4 points was possible.

[4] Average species importance value was calculated by summing the percent relative frequency and percent relative cover.

Table 17. High marsh species defined by frequency, cover, and importance value in five marsh zones.[1]

Species	Evaluation[2] Frequency	Cover	Points[3] (Freq. + Cover)	Importance Value[4]
Atriplex patula	m	vg	3	m
Deschampsia cespitosa	vg	vg	4	vg
Eleocharis palustris	p	m	1	m
Glaux maritima	vg	vg	4	vg
Grindelia integrifolia	m	vg	3	vg
Lilaeopsis occidentalis	m	vg	3	vg

[1] Criteria for high marsh species were: (a) maximum concentration in marsh zone 2, low concentration in marsh zones 1, 4 and 5; and, (b) maximum concentration in marsh zone 2 with a steady decline in marsh zones 3, 4, and 5.

[2] Evaluation of each species in meeting these two criteria were: very good (vg), moderate (m), and poor (p).

[3] Points were independently assigned for both frequency pattern and cover pattern: 0=p, 1=m, and 2=vg. A total of 4 points was possible.

[4] Average species importance value was calculated by summing the percent relative frequency and percent relative cover.

Table 18. Upland species defined by frequency, cover, and importance value in five marsh zones.[1]

Species	Evaluation[2] Frequency	Cover	Points[3] (Freq. + Cover)	Importance Value[4]
Achillea millefolium	vg	vg	4	vg
Agropyron repens	m	m	2	m
Angelica lucida	vg	m	3	vg
Aster subspicatus	vg	m	3	vg
Calamagrostis nutkaensis	vg	m	3	vg
Carex obnupta[5]	vg	vg	4	vg
Carex pansa	vg	m	3	m
Elymus mollis	vg	m	3	vg
Epilobium watsonii	m	m	2	m
Equisetum spp.[5]	m	vg	3	vg
Erechtites arguta	vg	vg	4	vg
Festuca rubra	m	vg	3	m
Galium aparine	vg	vg	4	vg
Galium triflorum/	vg	m	3	m
Gaultheria shallon	vg	vg	4	vg
Heracleum lanatum	m	vg	3	vg
Holcus lanatus	vg	vg	4	vg
Hypochaeris radicata	m	m	2	m
Juncus gerardii	m	m	2	m
Juncus lesueurii	vg	m	3	m
Lathyrus japonicus/	m	m	2	m
Lonicera involucrata	vg	vg	4	vg
Lotus uliginosus	vg	vg	4	vg
Maianthemum dilatatum	vg	vg	4	vg
Oenanthe sarmentosa[5]	vg	vg	4	vg
Physocarpus capitatus	vg	m	3	vg
Picea sitchensis	vg	vg	4	vg
Plantago lanceolata	vg	vg	4	vg
Poa pratensis	vg	m	3	vg
Rubus ursinus	vg	vg	4	vg
Rumex occidentalis	m	m	2	m
Scirpus microcarpus[5]	vg	m	3	vg
Scirpus validus[5]	m	p	1	p
Sidalcea hendersonii	m	m	2	m
Spergularia macrotheca	m	p	1	m
Trifolium wormskjoldii	vg	vg	4	vg
Vicia gigantea	vg	vg	4	vg

[1] Criteria for upland species were: (a) increasing frequency and cover from marsh zone 1 to marsh zone 5; and, (b) high concentration in zones 4 and 5, low concentration in zones 1 and 2.

[2] Evaluation of each species in meeting these two criteria were: very good (vg), moderate (m), and poor (p).

[3] Points were independently assigned for both frequency pattern and cover pattern: 0=p, 1=m, and 2=vg. A total of 4 points was possible.

[4] Average species importance value was calculated by summing the percent relative frequency and percent relative cover.

[5] Freshwater wetland plant.

were also found in freshwater wetlands. Indeed, both are widely distributed in the interior Pacific Northwest in these wetland habitats.

Table 18 depicts 37 species considered as indicators of "upland" conditions of which 25 were regarded as "very good" indicators. "Upland", in this case is used in a qualified manner because 5 of the species were considered freshwater indicators:

Carex obnupta	*Scirpus microcarpus*
Equisetum spp.	*Scirpus validus*
Oenanthe sarmentosa	

Dominance by any one of the "dry" upland species in Table 18 would suggest an area as upland. Codominance would help confirm the suggestion.

Six species could not easily be classified into one of the above three groups. Each presents a different situation requiring discussion. Three of these (*Agrostis alba*, *Juncus balticus* and *Potentilla pacifica*) are very strong dominants in the upper portion of the marsh. Table 19 shows these "non-indicator" species.

Table 19. Species with poor zonal segregation as defined by frequency and cover and importance value in five marsh zones.[1]

Species	Species
Agrostis alba	*Juncus effusus*
Hordeum brachyantherum	*Potentilla pacifica*
Juncus balticus	*Stellaria calycantha*

Agrostis alba. Considered among the top dominants in zone 2 through 5, *A. alba* showed a tendency to occur lower in the marsh than *Potentilla pacifica* but often higher than *Deschampsia cespitosa*. A very serious

[1] Species did not meet any of the criteria set for defining low marsh species, high marsh species, and upland species. These species are discussed in the text.

problem relates to plant identification. Agrostis alba var. palustris is the commonly found Agrostis in the marsh proper. Also very common is the less strict A. alba var. alba. A. alba var. stolonifera is closely related and may occur higher in the marsh, it is less rhizomatous. Agrostis tenuis, similar in vegetative characteristics, but with a more open inflorescence, may also occur in the upper marsh as it is a very common pasture grass throughout the Pacific Northwest. In the field we did not attempt to distinguish between these four taxa and therefore the distribution of Agrostis alba in our analysis is not ecologically meaningful.

Hordeum brachyantherum. Seldom dominant over much area but frequently present in the upper marsh and through the transition zone, H. brachyantherum is a widespread grass in sunny freshwater moist habitats. The plant apparently can tolerate a certain amount of salinity. Closely allied to Deschampsia cespitosa in its occurrence in the marsh and in meadowed wetlands in inland situations, H. brachyantherum did not show strong relationship between the "upland" and upper marsh groups. It probably should be regarded as a "wetland" indicator.

Juncus balticus. A member of a large and complex group of rushes, J. balticus frequently was the dominant in the broad area from high marsh to upland. Confined to open (non-shaded) habitats, J. balticus was strongly rhizomatous and tended not to form distinct clumps or bunches as did the freshwater indicator, J. effusus.

Juncus effusus. Even more complex taxonomically than J. balticus, J. effusus was distinguishable by its distinct clumped form. It grew not only in many of the Puget Sound marshes but also in freshwater meadows throughout coastal Oregon and Washington. It was regarded more as a freshwater wetland indicator than a salt marsh plant.

Potentilla pacifica. Considered initially as a good indicator of the transition zone, P. pacifica together with Juncus balticus and Agrostis alba frequently dominated the upper portion of the marsh. In places, as at Netarts Sand Spit marsh P. pacifica formed the vegetation matrix among clumps of Deshampsia cespitosa, in other areas, as at Waldport South marsh, Potentilla formed mats in the transition zone. Like so many upper marsh plants, P. pacifica grows under freshwater wetland conditions at the edges of open (non-shaded) ponds. And in some occasions P. pacifica was seen isolated at creek edges lower in the marsh, possibly reflecting freshwater seepage at this special topographic position.

Stellaria calycantha. This species should be listed as a upland species. It appears in the list of non-indicator plants because of an early taxonomic confusion with S. humifusa. The latter Stellaria is commonly found in the upper portions of the low marsh and is a good indicator of upper low marsh conditions. It has dark red stems and somewhat obtuse leaves about a centimeter or less long. S. calycantha grows typically in zone 5 and in fairly shady situations as an element of tall grassland. Its leaves are longer, more lanceolate, and its stems are green. It is also a taller growing plant.

Discriminant Analysis

To evaluate the classification of samples into one of five marsh and marsh-upland transition zones, marsh data were processed by discriminant analysis on a marsh-by-marsh basis. Plant species with their percent cover values were variables and the discriminant analysis provided two kinds of output. First, it provided an objective evaluation

Table 20. Percent of microplot samples correctly classified into marsh zones based on intuitive marsh model as evaluated by discriminant analysis.

	Marsh Zone and Number of Samples					
Study Marsh Zone No.	1 724	2 771	3 402	4 430	5 255	Total 2583
Bandon	96.7	40.7	40.0	75.8	81.8	75.6
Haynes Inlet	76.7	94.6	23.1	83.3	100.0	80.2
Waldport South	0.0	93.8	41.7	97.3	84.6	85.7
Nute Slough	100.0	67.7	53.3	66.7	100.0	75.0
Netarts Sand Spit	100.0	69.2	80.8	68.0	80.0	81.9
Sea Garden Road	100.0	82.2	20.0	75.0	72.5	73.8
West Island	82.9	44.4	75.0	43.8	62.5	72.0
Niawiakum	65.0	90.4	28.0	86.5	71.4	73.6
Cedar Creek	100.0	72.3	75.0	50.0	91.3	82.2
Leadbetter Point	94.1	71.4	50.0	40.0	87.5	73.5
The Sink	92.8	77.0	34.5	85.0	66.7	76.4
Elk River	90.5	86.8	80.7	84.8	33.3	84.3
Burley Lagoon	100.0	80.0	60.7	66.7	100.0	74.2
Coulter Creek	100.0	76.7	83.8	62.5	50.0	82.0
Chico Bay	100.0	50.0	77.8	83.3	75.0	85.9
Thorndyke Bay	66.7	59.3	84.0	0.0	75.0	57.7
Quilceda Creek	50.0	86.7	73.5	66.7	48.0	70.7
Oak Bay	97.2	40.0	88.9	100.0	100.0	84.2
Westcott Bay	100.0	40.0	50.0	100.0	100.0	91.1
Griffith Bay[1]	100.0	100.0	100.0	100.0	--	100.0
TOTAL	85.6	71.2	59.5	71.8	77.9	79.0

[1] No zone 5 classified or predicted

of the sample classification which was provisionally based on an intuitive model of marsh zonation. Second, it provided a set of discriminant functions for classifying the marsh and transition data. These functions give weighting to those plant species which were the best discriminators among all five zones.

Evaluation of zonal classification. Table 20 shows the percent samples correctly classified in one of five marsh zones. Thus, for the Bandon marsh 60 microplot samples of 168 samples were originally assigned to zone 1 based on our intuitive marsh model. The discriminant analysis, with 65 available variables (species with cover values), developed 4 functions using 12 variables which classified 58 of the samples in zone 1. Therefore, we could regard our classification of samples into zone 1 as 96. percent correct (58/60 x 100). Appendix G gives details of the discriminant analysis predictions by marsh.

Certain regularities appear in Table 20. The classification of samples into zone 1, the low marsh, averaged 85.6 percent correctly classified, therefore, the low marsh was the zone most easily classified correctly. The range varied from 0 percent in a number of marshes. In the case of Waldport South marsh, 6 samples should have been classified into zone 2. If we were to eliminate the Waldport South marsh performance, correct classification of zone 1 increases to 90.1 percent. The reason for excellent classification of the low marsh is that the low marsh tends to be reasonably uniform in composition and has a distinctive flora.

Zones 4 and 5 have the next best classification. With zone 5, an average of 77.9 percent of the samples were correctly classified into

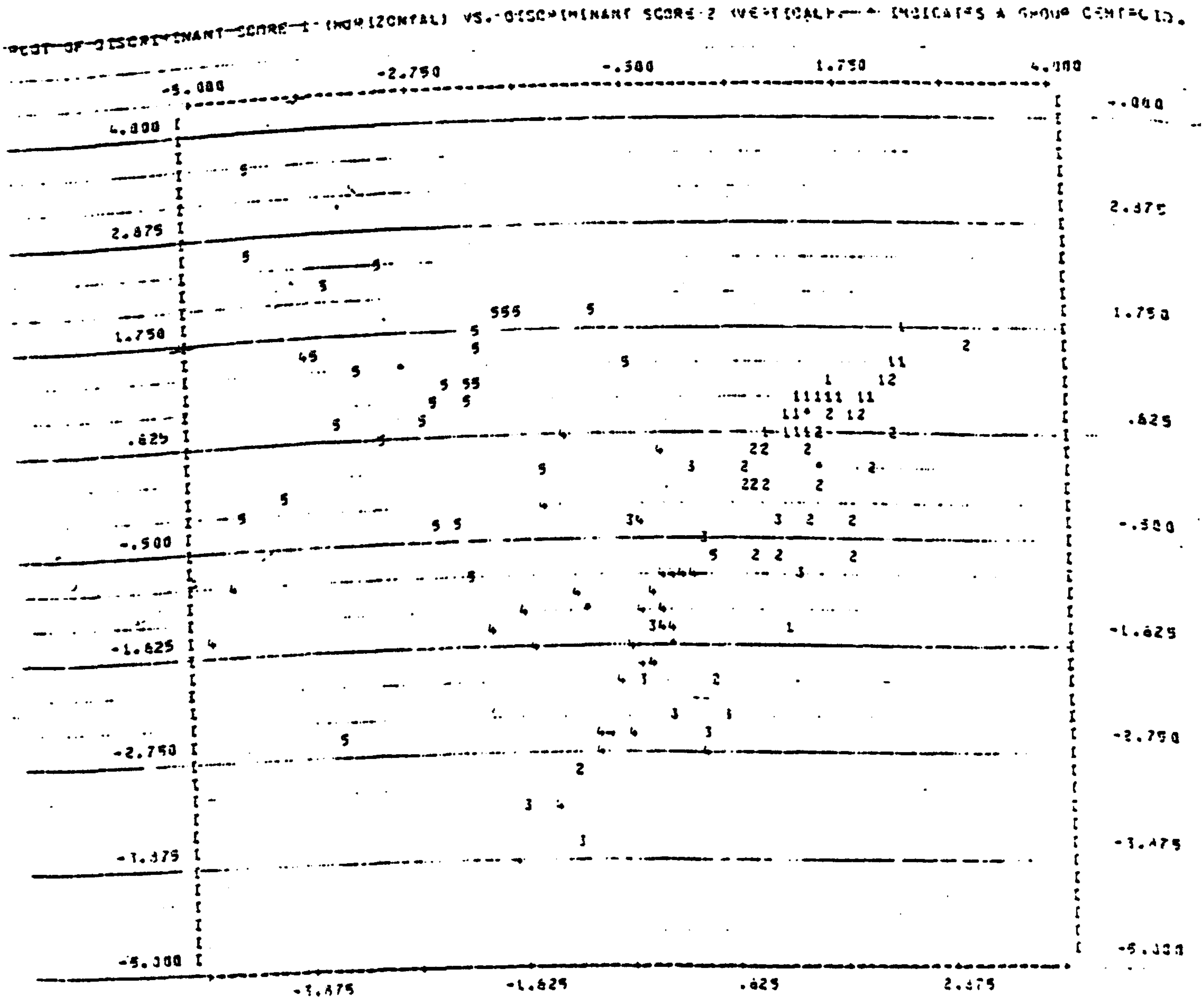

Figure 36. Spatial distribution of discriminant score 1 vs. discriminant score 2 for Bandon study site.

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this high marsh zone with prediction ranges varying from 33 percent correct in the Elk River marsh to 100 percent correct in a number of marshes. Likewise, zone 4 was correctly classified at 71.8 percent. The relatively good prediction for both zones 4 and 5 was attributed to clear classification criteria based on the presence of many upland species in those zones.

Zone 2, regarded as a high marsh intertidal zone, was correctly classed 71.2 percent of the times. Like Zone 1, this zone had a fairly clear floristic definition.

Zone 3, regarded in the field as the lower edge of the transition zone, was the most difficult zone to classify correctly. Only 59.5 percent of the samples originally assigned to this zone were correctly classified. Since this zone occurs precisely at that point where the marsh species composition is most variable, it is understandable that the classification is most imperfect.

Considering all zones and all marshes, 79.0 percent of the 2,583 microplots were correctly classified based on the intuitive marsh model.

One of the outputs of discriminant analysis is a spatial plot of the discriminant score of the "most powerful" function vs. the discriminant score of the next "most powerful" function of the four functions used in analysis. The degree of "discriminating power" of a discriminant function is given in the summary table of the computer print-out and usually represents about 90 percent for the first two functions. The computer program was instructed to solve the discriminant functions using the selected 12 best variables (species) and calculates the respective species weightings. Figure 86 shows a typical spatial plot in which the zone numbers are the original classifications. Thus, in the Bandon marsh zone 5 is most clearly separated from the other four zones by the

Table 21. Species selected by discriminant analysis for zonal classification with number of times selected.

Potentilla pacifica	17	Galium trifidum	2
Juncus balticus	12	Zostera nana	2
Aster subspicatus	11	Eleocharis palustris	2
Agrostis alba	11	Grindelia integrifolia	2
Deschampsia cespitosa	10	Lonicera involucrata	2
Carex obnupta	8	Distichlis spicata	2
Oenanthe sarmentosa	7	Spergularia macrotheca	2
Salicornia virginica	7	Rubus ursinus	1
Achillea millefolium	6	Physocarpus capitatus	1
Picea sitchensis	4	Spartina alternifolia	1
Triglochin maritimum	4	Spergularia canadensis	1
Elymus mollis	4	Galium aparine	1
Atriplex patula	4	Heracleum lanatum	1
Trifolium wormskjoldii	4	Carex pansa	1
Hordeum brachyantherum	4	Lathyrus palustris	1
Vicia gigantea	3	Jaumea carnosa	1
Glaux maritima	3	Lotus uliginosus	1
Carex lyngbyei	3	Stellaria humifusa	1
Maianthemum dilatatum	3	Juncus lesueurii	1
Calamagrostis nutkaensis	3	Erechtites arguta	1
Angelica lucida	3	Equisetum spp.	1
Holcus lanatus	3	Juncus effusus	1
Scirpus americanus	2	Agropyron repens	1
Festuca rubra	2	Scirpus cernuus	1
Plantago lanceolata	2	Gaultheria shallon	1
Scirpus microcarpus	2	Plantago maritima	1
		Juncus gerardii	1

first two discriminant functions. Zone 2 and 3 appear somewhat confounded. Furthermore, in this plot we can identify a single sample originally classified as zone 4 in the spatial field of zone 5 samples, an obvious misclassification.

Discriminant functions and species weightings. The degree to which a given species aides in discriminating between all zones in a given marsh may be measured by the weighting given to that species in the four selected discriminant functions. Species weightings are given as "standardized discriminant function coefficients". Furthermore as the program progresses step-wise, variables (species) are entered and removed so as to provide the best classification. Thirteen or fewer species were identified for each marsh. The species that were entered into discriminant functions are shown in Table 21 with the number of times a species was used. The importance (weighting) of any given species in classifying a given marsh is not shown. The number of species used to classify a given marsh varied from 5 to 13.

It should be recognized that other plant species which correlate with selected species and therefore are also good discriminators between zones are not identified by the program. For example, *Potentilla pacifica* was chosen in classifying 17 marshes, yet *Vicia gigantea* was not used by the discriminant analysis program. The distribution of these two species among the five zones correlated fairly closely. The discriminant program determined that Potentilla was, in almost all cases, a better discriminator among all five zones than was Vicia. This does not mean that Vicia is also a good discriminator. In fact, Vicia is an excellent discriminator between zone 3 and zone 4.

Table 21 shows species selected by discriminant analysis. Certain species which were very dominant but appeared in several zones such as Potentilla, Juncus, and Agrostis were used repeatedly by the discriminant analysis as variables. Other species, which are also good variables for classification, were not used in analyis very often, e. g., Carex lyngbyei, Jaumea carnosa, Distichlis spicata, Plantago maritima, Eleocharis palustris, Glaux maritima, Grindelia integrifolia, Orthocarpus castillejoides, and Vicia gigantea. However, it most be remebered that only those species giving the best discrimination were chosen. Other species, which have similar distributions among the zones to the selected species and which might have been almost as good discriminators were not chosen. Furthermore, this analysis was aimed at classifying the entire marsh (all five zones) and associated transition zone, not just the upper section of the marsh. Therefore, not too much significance should be given to the species-list in Table 21.

Discriminant analysis could be applied to differentiating upland from upper marsh and a different set of species might be anticipated.

To assess the species weightings, one must inspect the standardized discriminant function coefficients in the summary printout. There appeared to be no simple way to summarize this data so that an example will be used with Waldport South study site where nine species were selected and entered into four discriminant functions. The first two functions account for 97.6 percent of the "variation". The weightings are evaluated by disregarding the signs in Table 22 where just the coefficients are displayed for the first two functions. Achillea millefolium, Potentilla pacifica and Plantago lanceolata received the highest weightings. These were all upper marsh species. Glaux and Salicornia were the two low marsh species. Several upland species were identified by this analysis such as Maianthemum, Picea and Plantago lanceolata.

Table 22. Standardized discriminant function coefficients for the first two discriminant functions for Waldport South study site.

Species	Functions 1	2
Achillea millefolium	-1.52899	-1.13105
Aster subspicatus	- .35290	.22273
Glaux maritima	.30059	- .28424
Juncus balticus	- .25366	.36787
Potentilla pacifica	-1.01605	.98698
Salicornia virginica	.25136	- .24822
Maianthemum dilatatum	- .31389	- .38600
Picea sitchensis	- .17218	.36711
Plantago lanceolata	- .69921	- .31996

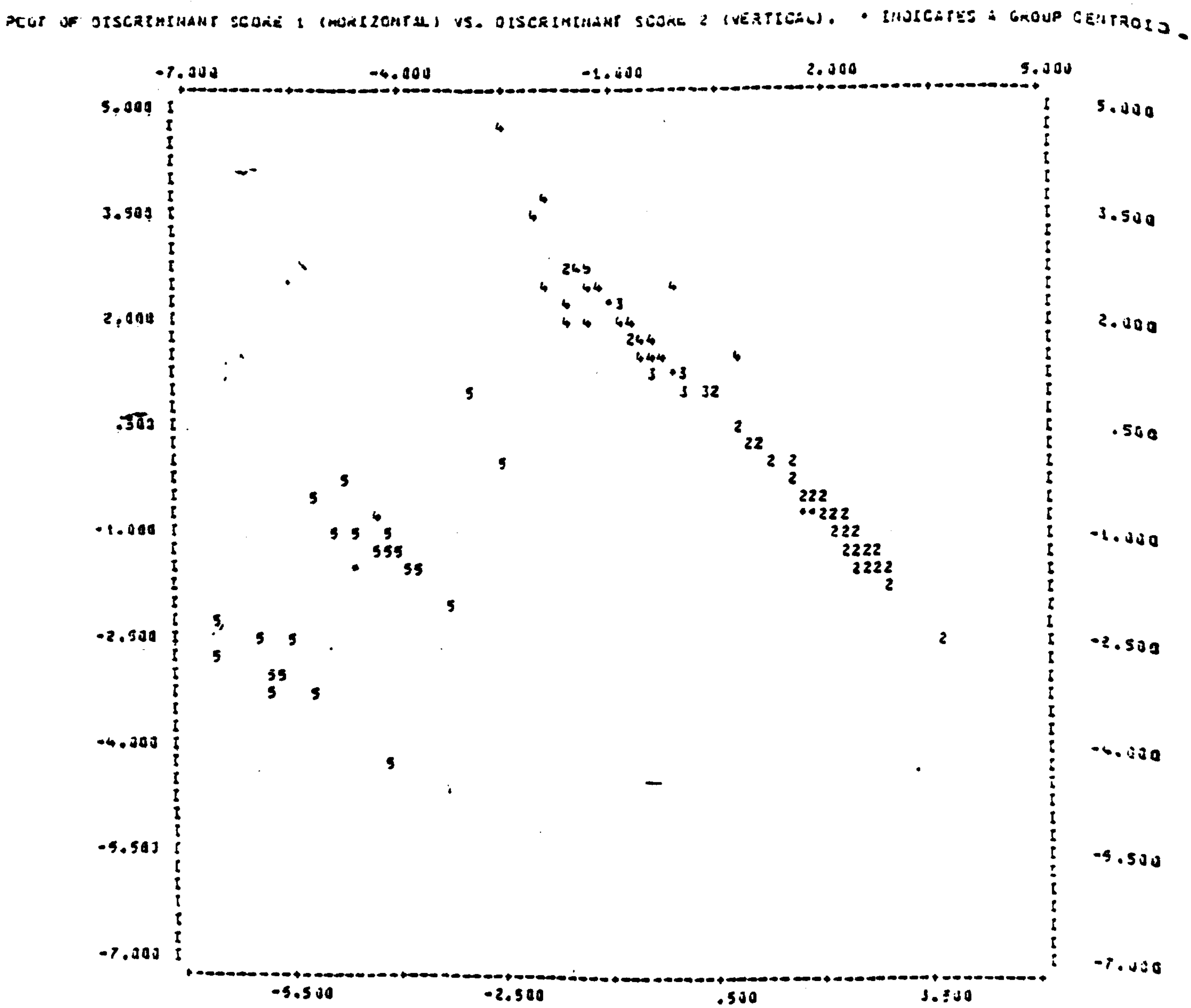


Figure 87. Spatial distribution of dominant score 1 vs. discriminant score 2 for Waldport South study site.

Figure 87 shows the clear separation of zone 5 from the other zones, a separation that agrees with the prevalence of upland species in the discriminant functions. No true low marsh zone 1 was identified in this data set.

Upland Vegetation Synthesis

Introduction. As already noted, because upland vegetation had different physiognomy than marsh, it was sampled differently. Where tree cover existed at a study site, total percent cover and basal area data were collected at each transect section in the upland. This data could be used to evaluate tree species importance with respect to frequency, percent cover, and dominance as measured by basal area.

Upland shrub and understory herb data were collected along a line transect, often with about 100, meter-long transect segments per marsh and provided both frequency data and average percent cover using a total of 1,709 line segment samples.

Trees. Table 23 summarizes the tree data for all 20 sites. Individual study site tree data appear in Appendix H. The first field of columns reports tree data with respect to the sites at which the species were recorded and therefore better reflects local vegetation characteristics. Thus, a marsh site such as Leadbetter Point where there was no coniferous forest in the upland would not be used in the computation of the importance of *Picea sitchensis*. The second field of columns summarizes tree data for all marshes. Absolute constancy merely is the number of marshes in which a given tree occurred.

Clearly the forested upland was dominated by *Picea sitchensis* which not only had the greatest local frequency (80%) but also the greatest

Table 23. Upland tree frequency, mean percent cover, and basal area for 20 study sites.

Species	Marshes of Occurrence[1]				All Marshes 20		
	Absol. Const. (n)	Freq. (%)	Mean Cover (%)	B.A. (m^2/ha)	Freq. (%)	Mean Cover (%)	B.A. (m^2/ha)
Abies grandis	2	50	8	1.2	5	0.8	0.1
Acer macrophyllum	3	12	2	0.2	2	0.3	+
Alnus rubra	14	60	16	2.1	42	11.2	1.5
Arbutus menziesii	2	50	10	3.6	5	1.0	0.4
Fraxinus latifolia	1	70	13	1.7	4	0.7	0.1
Juniperus scopulorum	1	20	1	--	1	0.1	-
Myrica californica	4	22	2	0.2	4	0.4	+[2]
Osmaronia cerasiformis	1	10	4	0.2	1	0.2	+
Physocarpus capitatus	2	25	7	0.9	3	0.7	0.1
Picea sitchensis	14	80	26	4.1	56	18.2	2.9
Pinus contorta	1	40	5	0.5	2	0.3	+
Prunus spp.	1	10	++[3]	0.1	1	++	+
Prunus emarginata	1	10	10	+	1	0.5	+
Prunus virginiana	1	17	8	+	1	0.4	+
Pseudotsuga menziesii	5	61	12	1.9	15	3.0	0.5
Pyrus fusca	8	33	4	0.4	13	1.6	0.2
Rhamnus purshiana	7	25	3	0.2	9	1.1	0.1
Salix spp.	3	55	8	0.7	8	1.2	0.1
Salix hookeriana	6	43	19	1.4	13	5.7	0.4
Sambucus racemosa	1	10	++	+	1	++	+
Thuja plicata	7	40	7	1.4	14	2.5	0.7
Tsuga heterophylla	10	37	9	1.7	19	4.5	0.9

[1] Values are calculated on basis of sites at which species occur.

[2] + basal area < 0.05 m^2/ha

[3] ++ mean cover < 0.5%

total frequency (56%), mean percent cover, and mean basal area. The next most important species was Alnus rubra; followed respectively by Tsuga heterophylla, Pseudotsuga menziesii, Thuja plicata, Salix hookeriana, and Pyrus fusca. This total list obscures regional and site specific patterns which are seen in the tree summary in Appendix H. Thus, the rain shadow situation in the San Juans and northern Puget Sound is reflected by drier forest conditions with local importance of Arbutus menziesii, Abies grandis, Pseudotsuga menziesii and Juniperus scopulorum. On the extreme coast Picea sitchensis, Alnus rubra, Myrica californica and Salix hookeriana prevail. The understory vegetation further emphasizes these localized differences.

Shrub and herb understory. Upland understory vegetation assessed by line transect accounted for 90 species several of which ranged into the upper portion of the marsh. Appendix I gives the average percent frequency and average percent cover of all understory species based on 1,709 samples. Those species with greater than 5 percent frequency are listed here in order of declining frequency:

	Avg. %			Avg. %	
	Freq.	Cover		Freq.	Cover
Gaultheria shallon	24.9	10.7	Lonicera involucrata	8.0	2.0
Maianthemum dilatatum	16.9	4.1	Picea sitchensis	7.4	3.8
Rubus ursinus	14.5	3.0	Vaccinium ovatum	6.6	2.3
Agrostis alba	11.2	2.3	Aster subspicatus	6.1	0.8
Oenanthe sarmentosa	10.9	2.6	Polystichum munitum	6.0	1.7
Rosa nutkana	10.9	1.0	Pteridium aquilinum	6.0	2.1
Carex obnupta	8.7	2.5	Vicia gigantea	5.8	1.1
Holcus lanatus	8.1	1.9	Potentilla pacifica	5.4	0.6
			Elymus mollis	5.1	0.9

Several types of upland vegetation were present; the different types are obscured by the aggregated data in the above list and appendix. These types might be grouped as follows:

Picea sitchensis forest--dry	Pisi dry
Picea sitchensis forest--wet	Pisi wet
Pinus contorta - *Picea sitchensis* forest	Pico-Pisi
Ammophila arenaria - *Elymus mollis* stabilized dune	Amar dune
Pseudotsuga menziesii successional forest	Psme succ
Ruderal	Ruderal

Table 24 shows the distribution of these six generalized upland vegetation types among the twenty study sites. Several sites had more than one type of upland vegetation. There was no overall correlation between marsh vegetation and upland, except for the presence of *Salicornia*, *Jaumea*, *Distichlis* and *Plantago* dominated marshes near sand dunes.

Data are available to analyze and classify in greater detail upland vegetation, but such an analysis was not attempted.

Table 24. Distribution of upland vegetation types among study sites.

	Upland Vegetation Type[1]					
Study Site	Pisi dry	Pisi wet	Pico-Pisi	Amar Dune	Psme Succ	Ruderal
Bandon		x				
Haynes Inlet	x					
Waldport South	x					
Nute Slough	x					
Netarts Sand Spit			x	x		
West Island	x	x				
Sea Garden Road	x	x				
Niawiakum River	x					
Cedar River	x	x				
Leadbetter Point				x		
The Sink				x		
Elk River	x					
Burley Lagoon		x				
Coulter Creek		x				
Chico Bay						x
Thorndyke Bay	x	x				
Quilceda Creek		x				x
Oak Bay					x	
Westcott Bay					x	
Griffin Bay	x				x	

1 Upland vegetation types are listed in text

Salinity

Interstitial water salinity data were collected from seven sites. The procedures of data collection are given on page 26. Except for the Bandon marsh where salinity profiles were collected at two different dates along the same transects (6-15-77 and 7-13-77 along transect 7B), salinity profiles were taken at only one time. Figure 88 a-g shows typical salinity profiles at three depths (surface, 10 cm, 20 cm). Field judgments of transition zone position are indicated in these figures by MTZ.

Salinity in the lower marsh either decreases slightly with distance from mudflat or commonly increases to about the high marsh. At this point, salinities diminish rapidly as the transition zone is approached. Often within the transition zone there is a slight increase in salinity. Salinities vary with depth. Surface salinities at all positions in the marsh tend to be higher than salinities at 10 cm, than are salinities at 20 cm depth. The gradient in salinities with depth tends to greatest in the first 10 cm and diminishes over the second 10 cm depth. Greatest differences between surface salinities and those at 10 and 20 cm depth occur in the upper portion of low marsh and in the high marsh below the transition zone. This pattern suggests the presence of a fresh-to-brackish water lens in the middle marsh.

Salinities vary with season, localized climatic regime, estuary conditions, tidal regime, and marsh type; consequently, each profile must be discussed with respect to these specific considerations. Highest salinities in the Pacific Northwest occur in late August and September (Jefferson 1975, Barbour 1973). No attempt was made to assess this seasonal pattern; however, the two profiles for Bandon marsh (CQ1-7B) in Figure 88 a and b support this statement. The 15-6-77 observation

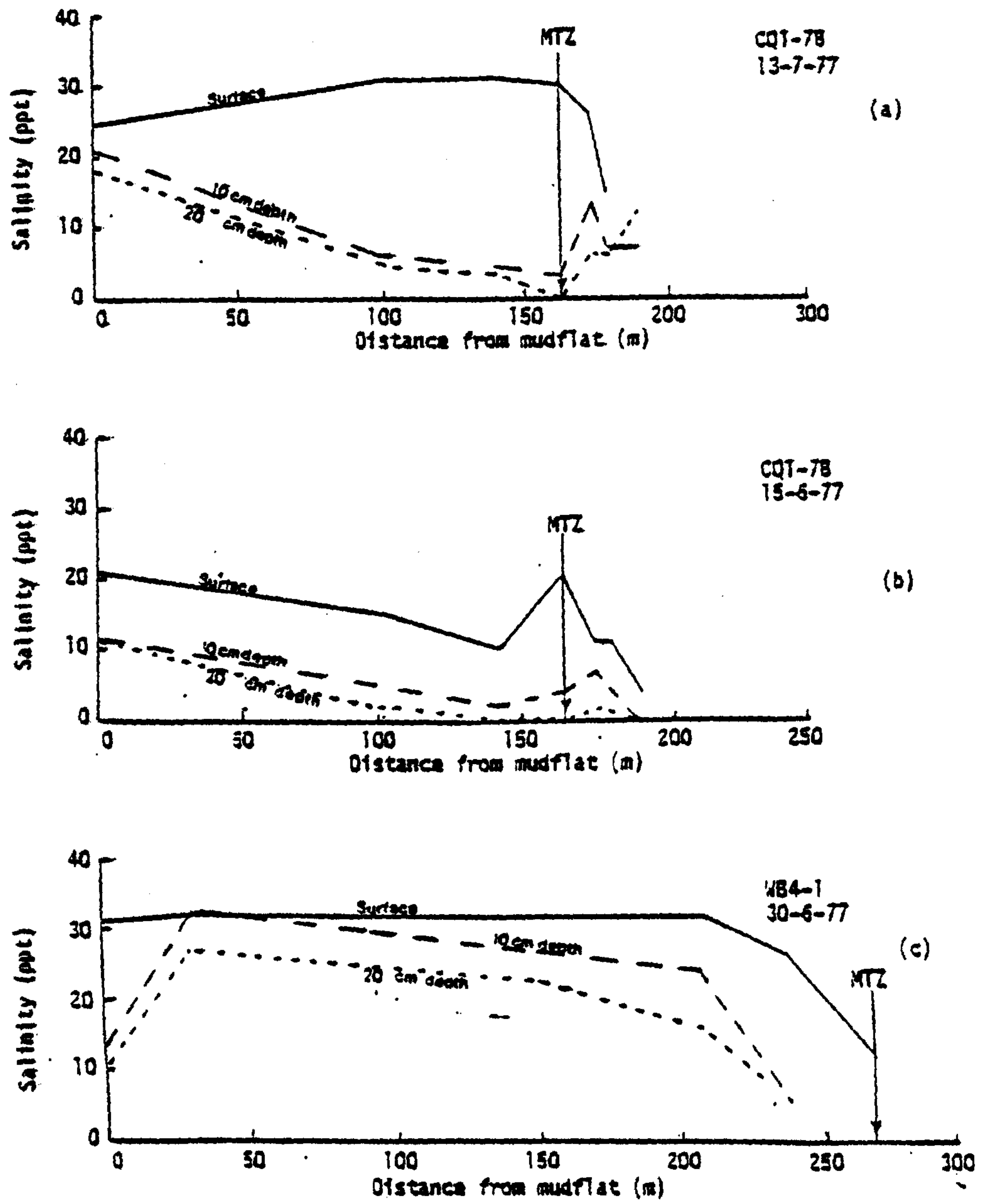
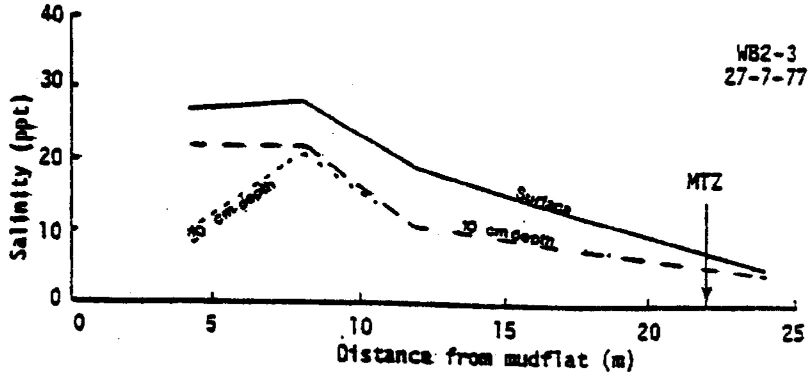
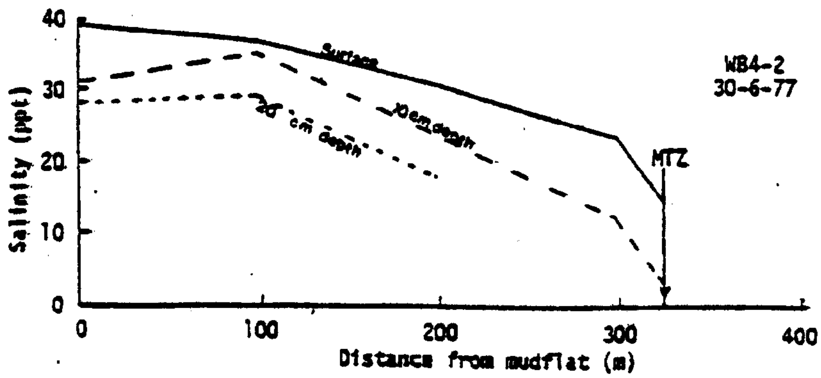


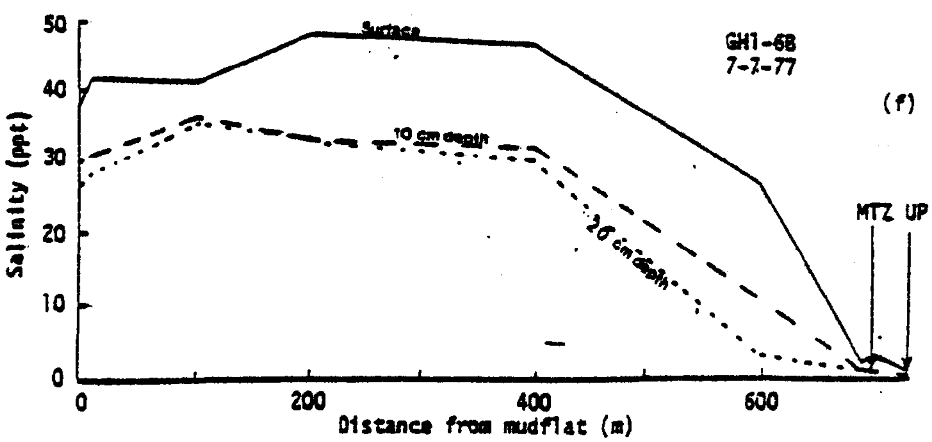
Figure 88. Salinity profiles along selected transects at (a) Bandon CQ1-7B 13-7-77, (b) CQ1-7B 15-6-77, (c) Leadbetter Point WB4-1, (d) Cedar River WB2-3, (e) Leadbetter Point WB4-2, (f) The Sink GH1-6B, and (g) West Island NB2-2.


WB2-3
27-7-77
Salinity (ppt)
Distance from mudflat (m)
Surface
10 cm depth
30 cm depth
MTZ

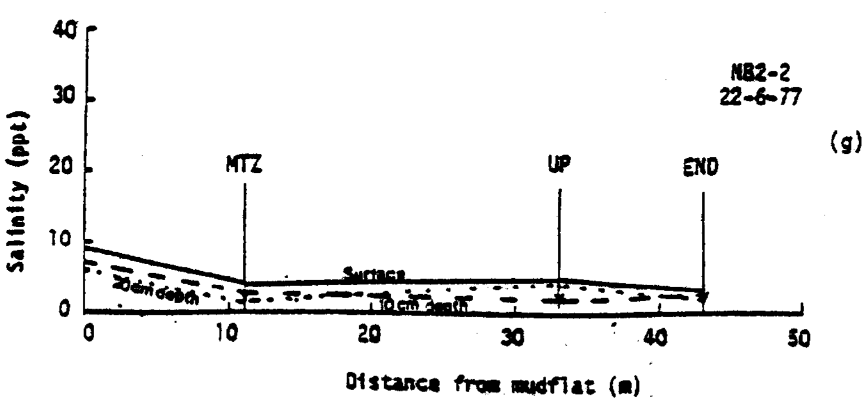
(d)


WB4-2
30-6-77
Salinity (ppt)
Distance from mudflat (m)
Surface
10cm depth
20 cm depth
MTZ

(e)


GH1-6B
7-7-77
Salinity (ppt)
Distance from mudflat (m)
Surface
10 cm depth
20 cm depth
MTZ
UP

(f)


NB2-2
22-6-77
Salinity (ppt)
Distance from mudflat (m)
MTZ
UP
END
Surface
20cm depth
10 cm depth

(g)

occurred after an early June rain. Estuary salinities were lower (21 ppt compared with 25 ppt) in June than in July. Similarly, the middle marsh salinities were low at all depths. The slight rise in salinity in the transition zone could be accounted for by the presence of high tides in late May and early June contributing saline water to this arêa and local surface evaporation leading to high concentrations (∿20 ppt). By 13-7-77, surface salinities throughout the low and middle marsh had increased, largely due to repeated inundation of saline water and local surface evaporation. The subsurface salinities were kept low by fresh-water percolation mentioned in the discussion of the Bandon marsh.

Two long transects were studied for salinity in a Low Sand Marsh at Willapa Bay (WB4-1 and WB4-2) at Leadbetter Point (Figure 88 c and e). A pattern similar to that of the Bandon marsh can be seen. Salinities were high at the surface and through the low marsh related to tidal inundation followed by evaporation. Only where Deschampsia cespitosa appeared in the high marsh, did salinities begin to diminish. Salinities at the surface in the field-judged lower boundary of the transition zone were 10 to 15 ppt with salinities at 10 or more cm deep at about 5 ppt.

A very long transect at Grays Harbor (GH1-6B) was surveyed and showed a similar pattern to that described for Willapa Bay (Figure 88 f) except salinities in the transition zone were judged to be less than 5 ppt. The Grays Harbor transect was also in a Low Sand Marsh. In another transect at Grays Harbor surface salinities ranging from 95 to 105 ppt (10 measurements) were recorded in the mud flat at the edge of colonizing Salicornia and Spergularia canadensis. These exceptionally high salinities occurred in what appeared to be an algal mat (like roofing felt) and were attributed to rapid evaporation of surface tidal water.

In a silt-based Immature High Marsh at Cedar River, Willapa Bay (Figure 88 d) a steady decline in salinities occur from the low marsh to the transition zone where salinities through the profile range about 5 ppt. Salinities recorded at another silt-based marsh, a Mature High Marsh at West Island in Nehalem Bay after a three day intense rain storm were understandably low (Figure 88 g).

The study of salinity as a control for vegetation characterizing the transition zone was not made but these very preliminary observations suggest that salinities throughout the soil profile in the transition zone range about 6 ppt or less except where local surface evaporation has caused locally high surface salinities.

Definition of the Transition Zone and the Upper Limit of Wetland

The concept of a transition zone was assumed at the initiation of this project. It was supposed that between the upland and marsh there was a zone within which plant species of both upland and marsh cooccur. This ecotone, or transition zone, was tentatively observed in the field and its lower and upper boundary staked. Since the identification of the ecotone was based on the intermixture of upland plants and marsh plants, there was implied a further judgment as to what species should be classed as upland plants and what species should be classed as marsh plants. It was, moreover, assumed that the limit of a wetland (coastal intertidal marsh) would be somewhere in , or at the boundaries of, this ecotone.

Delineation of the zone and limit between two vegetation types will necessarily be arbitary. The basis of this research is to propose a logical and objective means of defining this zone and limit. The starting point for this definition is the four lists of species which were arrived at by analysis of zonal trends within 190 marsh transects. These species lists are given in Tables 16, 17, 18, and 19 in which low marsh, high marsh, upland, and non-indicator species are identified.

Since the zone and limit of wetland is between two vegetation types, marsh and upland, a definition of that zone and limit must consider vegetation characteristics not just presence and absence of species. One of the most easily measured and significant vegetation characterstics is cover, and, in this research cover was recorded by cover class. Use of cover class is a rapid, repeatable, and recognized means of judging species importance in a sample.

Following is proposed a method which will minimize arbitrary decisions and objectify the definition of the transition zone and upper limit of coastal intertidal marsh.

Multiple Occurrence Method. A single score is derived for each microplot sample along a transect by what is called a Multiple Occurrence Method (MOM) based on species composition, percent cover (cover class), and species weighting depending on whether a species is a low marsh species, high marsh species, upland species, or non-indicator species. Weightings are assigned arbitrarily. Since we are dealing with the separation of true marsh from true upland, low marsh and upland species are given equal weightings but of opposite sign. High marsh species were judged less indicative and therefore given less weighting but of the same sign as low marsh species. Non-indicator species, because they do not differentiate marsh from upland, are given weighting of zero which removes that species from computation. Weightings, of course, can be varied in this method and species membership in any weighting group can also be varied if there is reason to do so. Weighting categories are:

Species Type[1]	Weighting Coefficient
Low Marsh	2
High Marsh	1
Upland	-2
Non-Indicator	0

The procedure is to simply sum the species cover value (c_i) multiplied by the appropriate weighting coefficient (w_i) to get a single Multiple Occurrence Method score (M), where (i) refers to any species:

$$M = \sum_{i=1}^{n} w_i c_i$$

[1] See Tables 16, 17, 18, and 19

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Thus, for the microplot sample at 48 m from the [illegible] 0 along transect CQ1-13 (Bandon Marsh), the following species and their cover were observed:

Species	Weighting Coefficient	Cover Class
Agrostis alba	0	2
Carex lyngbyei	2	2
Deschampsia cespitosa	1	1
Glaux maritima	1	1
Juncus balticus	0	2
Salicornia virginica	2	+ (disregard)
Scirpus americanus	2	+ (disregard)
Trifolium wormskjoldi	−2	+ (disregard)

Species in this analysis with negligible cover (+ = less than 1%) are disregarded on the assumption that many extraneous factors could account for a few single occurrences and that a species' lack of performance is indicated by negligible cover. In the above example, the MOM score (M) will be:

$$M = \underset{\text{Agal}}{0(2)} + \underset{\text{Caly}}{2(2)} + \underset{\text{Dece}}{1(1)} + \underset{\text{Glma}}{1(1)} + \underset{\text{Juba}}{0(2)} = 6$$

Since the low marsh and high marsh coefficients are positive, where there is dominant marsh vegetation, as in this case, M will be positive. Where upland species are dominant, M will be negative. The limit of marsh is defined by M = 0. Thus, in a sequence of microplot samples along a transect, scores will be highly positive indicating a marsh situation; as the transition zone is approached, with more high marsh species, scores will dimish crossing 0 at the point where the vegetation shifts from marsh to upland. This pattern is shown in Figure 89

for three transects in the Bandon Marsh. The position of the field-observed lower boundary of the transition zone is shown by "MTZ Obs". in each of these plots and occurs within 1 to 2 meters of the computed

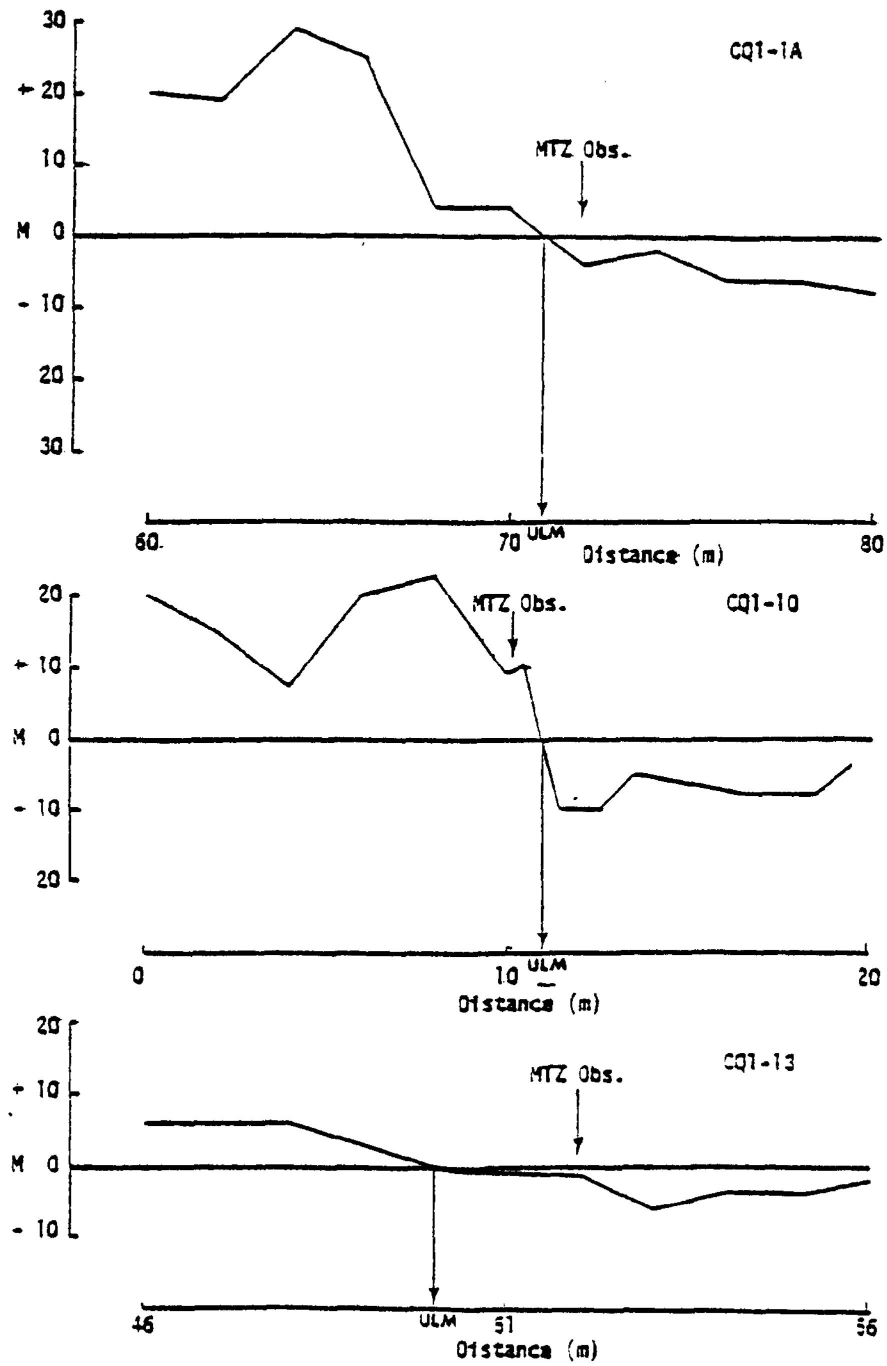

Figure 89. Multiple Occurrence Method score (M) along three selected transects at Bandon study site showing Case I situations.

value. The limit of marsh derived by MOM is shown by an arrow perpendicular to the distance scale. In this case (Case I), the limit of marsh is coincident with the transition zone. In otherwords, the transition zone has shrunk to a line. This is noted by "ULM".

It is recognized that along some transects there will be a series of contiguous samples which have MOM scores of 0 (Figure 90 a-b). In this case (Case II), it is proposed that the limit of marsh be defined by the midpoint between the sequence of M values of 0. For AB1-5 this would be at 43.7 m and for WB1-2 it would be at 27.0 m. The transition zone is given by the belt in which the MOM score is 0, with a respective lower and upper limit for AB1-5 of 41.2 m and 46.2 m and for WB1-2 a lower and upper limit of 25 m and 29 m respectively.

A third situation is where a series of microplot samples along a transect have MOM scores that alternate above and below the zero line (Figure 91 a-c). In this case (Case III), it is proposed that the same procedure be followed as in Case II; namely, the limit of marsh is given by the midpoint between the first and last MOM scores that reach 0. The transition zone is defined as that belt between those two "end" 0 values. To illustrate, for WB1-8 (Figure 91 a), the transition zone extends from 8 m to 17.5 m and the limit of marsh is defined at 12.75 m. For NB2-8 (Figure 91 b), the transition zone exists between 5 m and 10 m and the limit of marsh is at 7.5 m. For NB3-6 (Figure 91 c), the transition zone extends from 11 m to 13.3 m and the upper limit of marsh is defined at 12.15 m.

Assuming that there are only these three possible cases for the pattern of transition zone occurrence along a transect as discussed above, how frequent are those cases? We have computed MOM scores for 129 marsh transects. These transects were all of those which were

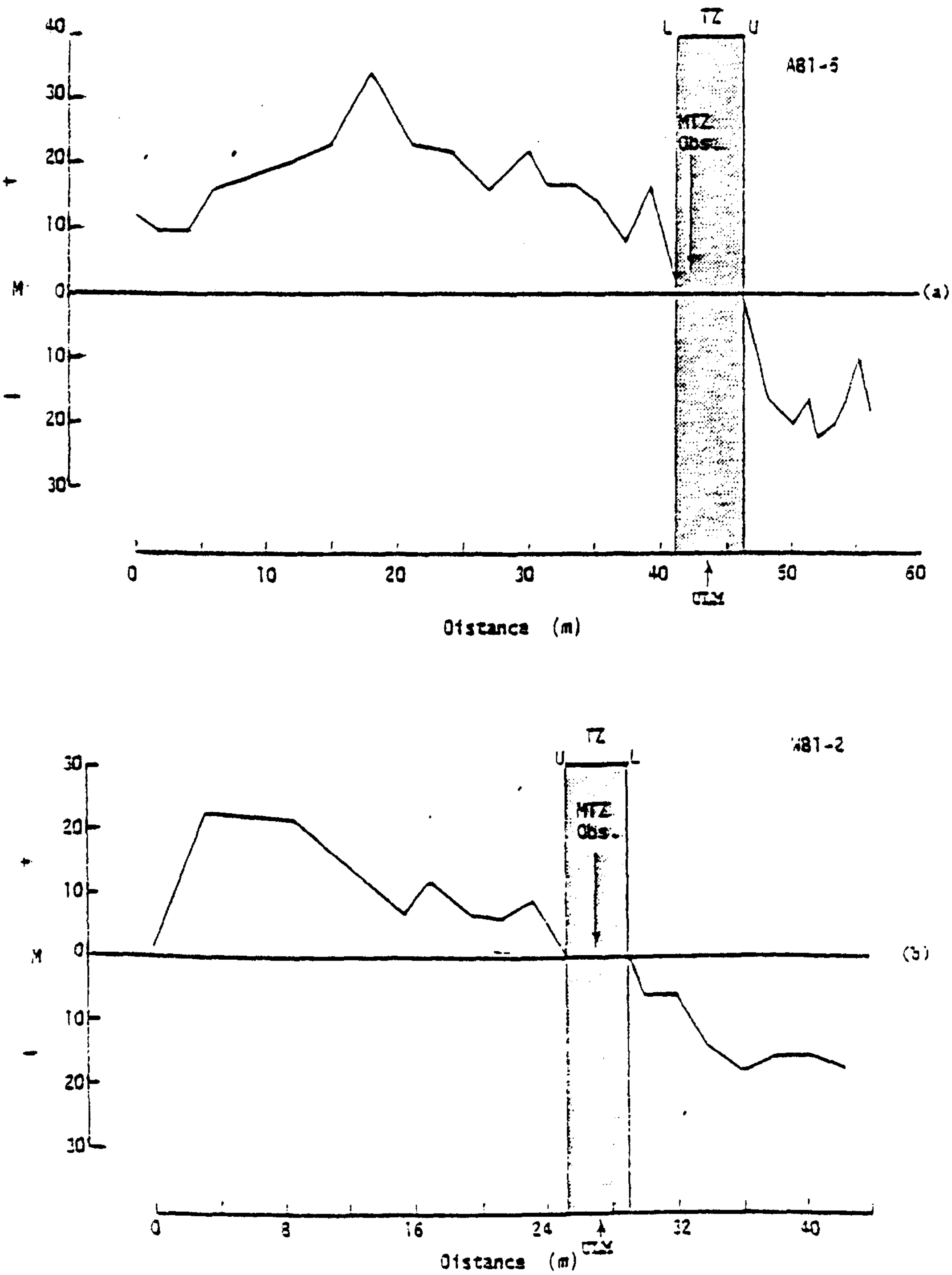

Figure 90. Multiple Occurrence Method score (M) along two transects at (a) Waldport South and (b) Niawiakum study sites showing Case II situations.

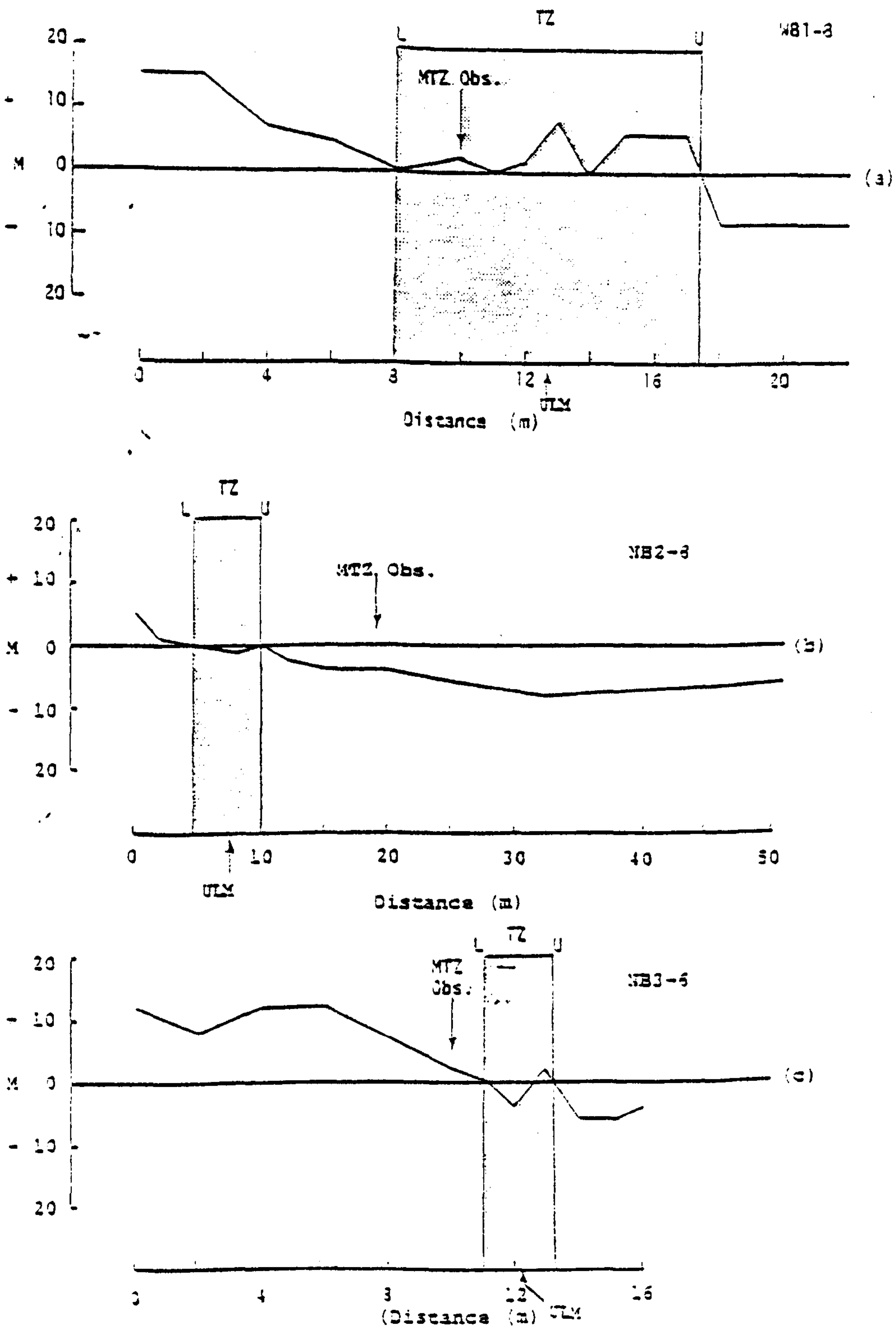

Figure 91. Multiple Occurrence Method score (M) along three transects at (a) Niawiakum, (b) West Island, and (c) Sea Garden Road study sites showing Case III situations.

Table 25. Distribution of transition zone occurrence of selected marsh transects showing mean transition zone width.

Study Site	No. Sampled Transects	Number Case I	Number Case II	Number Case III	Mean Width of Transition Zone (m)
Bandon	12	8	0	4	0.76
Haynes Inlet	3	2	1	0	2.67
Waldport South	10	4	2	4	3.13
Nute Slough	2	2	0	0	0.00
Netarts Sand Spit	10	7	0	3	1.04
West Island	8[1]	4	0	4	12.76
Sea Garden Road	13	9	0	4	0.84
Niawiakum	2	0	1	1	6.70
Cedar River	10	6	1	3	3.49
Leadbetter Point	2	0	1	1	5.50
The Sink	11	2	1	8	31.45
Elk River	10	6	0	4	2.67
Burley Lagoon	2	1	0	1	0.00
Coulter Creek	10	3	0	7	9.52
Chico Bay	2	2	0	0	0.00
Thorndyke Bay	12[2]	1	3	8	13.55
Quilceda Creek	8[3]	7	0	1	0.65
Oak Bay	2	2	0	0	0.00
Westcott Bay	2	1	0	1	1.10
Griffin Bay	2	2	0	0	0.00

[1] Several West Island transects crossed a number of sloughs and pans in their upper ends and appearance of marsh MOM scores caused by these situations were disregarded.

[2] Four Thorndyke Bay transects exhibited MOM scores of 0 or less at the lower starting point, caused by a berm and transition zone width could not be determined.

[3] Quilcada Creek transect 9 was not included as the transition zone was unclear because of log accumulation and land buildup.

hysometrically levelled by the NOS, together with selected transects from other marshes which were not levelled. The upper and lower boundary of the transition zone coincided for 69 transects or 53.4 percent of the sampled transects and represent Case I. Ten out of 129 marsh transects exhibited "sequential" transition zones (Case II). The third pattern of alternate values of MOM score about the zero line (Case III), was observed in 50 marsh transects.

A mean width of transition zone for all 129 marsh transects sampled was 6.32 m. This figure takes into account certain marshes which had exceptionally long and complex transition zones as determined by the Multiple Occurrence Method. These were: West Island (NB2), The Sink (GH1), and Thorndyke Bay (HC1). Table 25 summarizes the occurrence of Cases I, II, III and shows the mean width of the transition zone for sampled marshes. If one were to exclude the data from these three complex marshes, the mean transition zone based on 102 transects is 2.53 m.

The narrowness and relative precision in defining the transition zone surprised us. Initially, we were of the opinion that a very broad, and often ill-defined, transition zone was present in the Pacific Northwest and that it would not be possible to delineate a narrow zone, and certainly not an upper limit of marsh. This initial perception has been tempered by the application of the Multiple Occurrence Method; however, it must be realized that the application of this method merely provides a logical frame work for defining the upper limit of a coastal wetland within a broad ecotone. Application of this method with other species lists and weightings would lead to other locations of the transition zone and upper limit of marsh.

The Multiple Occurrence Method could easily be programmed for computer calculation and plotting. Sets of four species groups would be set-up in the computer together with assigned weightings. Data sets representing perhaps 10 transects, and microplot samples taken at regular intervals from what is judged low marsh through upland, could then be input to the program. A series of 10 MOM score profiles, upper limit of marsh distances, transition zone boundary distances could be the output.

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REFERENCES

Akins, G. J. and C. A. Jefferson. 1973. Coastal wetlands of Oregon. Oregon. (Oregon Coastal Conservation and Development Commission. Natural Resource Inventory Report). Florence, Oregon Coastal Conservation and Development Commission.

Barbour, M. G. 1970. The flora and plant communities of Bodega Head, California. Madrono, v. 20, p. 289-336.

Barbour, M. G. et al. 1973. Coastal ecology Bodega Head. Berkeley, Univ. California Press.

Boon, J. D. III et al. 1977. Delineation of tidal wetlands boundaries in lower Chesapeake Bay and its tributaries. Gloucester Point, Virginia Institute of Marine Sciences.

Boulé, M. E. and G. B. Shea. 1978. Delineation of jurisdictional boundaries within the Snohomish Estuary. (Draft study under Army Corps of Engineers Seattle District contract DACW67-77-C-0082 by Northwest Environmental Consultants).

Burg, M. E. et al. 1975. Vegetation associations and primary productivity of the Nisqually salt marsh on southern Puget Sound, Washington, p. 109-144 in: Herman, S. G. and A. M. Wiedemann (eds.), Contribution to the Natural History of the Southern Puget Sound Region, Washington. Olympia, The Evergreen State College.

Chapman, V. J. 1960. Salt marshes and salt deserts of the world. New York, Interscience Publishers, Inc.

Chapman, V. J. 1977. Wet coastal ecosystems (Ecosystems of the World I). Amsterdam, Elsevier Scientific Publ. Co.

Cooper A. W. 1974. Salt marshes, p. 55-98 in: H. T. Odum et al. (eds.), Coastal Ecological Systems of the United States, II. Washington, D.C., The Conservation Foundation.

Council on Environmental Quality. 1973. Environmental Quality (Fourth Annual Report). Washington, D.C., Council on Environmental Quality.

Cowardin, L. M. et al. 1977. Classification of wetlands and deep water habitats of the United States (an operational draft). Washington, D.C., U.S. Fish and Wildlife Service.

Curtis, J. T. and R. P. McIntosh. 1951. An upland forest continuum in the prairies-forest border region of Wisconsin. Ecology, v. 32, p. 476-496.

Darnell, R. M. 1976. Impacts of construction activities in wetlands of the United States. (Ecological Research Series EPA-600/3-76-045). Corvallis, Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency.

del Moral, R. and A. F. Watson. 1978. Vegetation on the Stikine Flats, southeast Alaska. Northwest Science, v. 52, p. 137-150.

Disraeli, D. 1977. Gradient Analyses of the vegetation in a brackish marsh, Bellingham Bay, Washington. M.S. Thesis, Western Washington State Univ., Bellingham, Wash.

Eilers, H. P. III. 1975. Plants, plant communities, net production and tide levels: the ecological biogeography of the Nehalem salt marshes, Tillamook County, Oregon. Ph.D. dissertation. Corvallis, Oregon State Univ.

Frenkel, R. E. and H. P. Eilers. 1976. Tidal datums and characteristics of coastal marshes in selected Oregon estuaries. (Final report on a pilot study conducted for the Environmental Protection Agency). Corvallis, Department of Geography, Oregon State Univ.

Frenkel, R. E. and C. M. Harrison. 1974. An assessment of the usefulness of phytosociological and numerical classificatory methods for the community biogeographer. Journal of Biogeography, v. 1, p. 27-56.

Frenkel, et al. (in press). Pacific Northwest coastal marshes: vegetation zones and tidal datums. International Geographical Union, Commission on the Coastal Environment Coastal Symposium, New Orleans, April 12-13, 1978.

Ganong, W. F. 1903. The vegetation of the Bay of Fundy salt and diked marshes. Botanical Gazette, v. 36, pp. 161-186, 280-302, 349-367.

Grieg-Smith, P. 1964. Quantitative plant ecology, 2nd Ed. London, Butterworths.

Gosselink et al. 1973. The value of the tidal marsh. (Work paper No. 3, Urban and Regional Development Center, Univ. Florida). Gainsville, Urban and Regional Development Center, Univ. Florida.

Harshberger, J. W. 1909. The vegetation of the salt marshes of northern coastal New Jersey. Philadelphia Academy of Natural Science Bulletin, v. 61, p. 372-400.

Hawkes, A. L. 1966. Coastal wetlands--problems and opportunities: North Amer. Wildlife Conf., Trans., v. 31, p. 59-77.

Hepp, D. L. 1973. The Quilceda Creek estuary, a preliminary environmental analysis. 5th Year Senior Project, Landscape Architecture Dept., Univ. Washington.

Hinde, H. P. 1954. The vertical distribution of salt marsh phanerogams in relation to tide levels. Ecological Monographs, v. 24, p. 209-225.

Hitchcock, C. L. and A. Cronquist. 1973. Flora of the Pacific Northwest. Seattle, Univ. of Washington Press.

Hitchock, C. L. et al. 1955-1969. Vascular plants of the Pacific Northwest, Parts I-V. Seattle, Univ. of Washington Press.

Hoffnagle, J. et al. 1976. A comparative study of salt marshes in the Coos Bay Estuary: A National Science Foundation Student Originated Study, 334 pp. (unpublished).

Hoffnagle, J. and R. Olson. 1974. The salt marshes of the Coos Bay Estuary, 87 pp. (unpublished report prepared for the Port of Coos Bay).

Jefferson, C. A. 1975. Plant communities and succession in Oregon coastal salt marshes. Ph.D. dissertation. Corvallis, Oregon State Univ.

Johannessen, C. L. 1961. Shoreline and vegetation changes of the estuaries, p. 100-138, in: S. N. Dicken (ed.), Some recent physical changes of the Oregon Coast. (Final Report on Office of Naval Research Contract Nonr 277164 Project NR 388-062). Eugene, Univ. of Oregon, Department of Geography.

Klecka, W. P. 1975. Discriminant analysis, p. 434-467 in: Nie, N. H. et al. Statistical package for the social sciences, 2nd Edition. New York, McGraw-Hill.

Kuenzler, E. J. 1961. Structure and energy flow of a mussel population in a Georgia salt marsh. Limnology and Oceanography, v. 6, p. 400-415.

Lagna, L. 1975. The relationship of Spartina alterniflora to Mean High Water: Marine Sciences Research Center, State Univ. New York at Stony Brook New York Sea Grant Institute, NYSSGP-RS-75-002.

Macdonald, K. B. 1977. Plant and animal communities of Pacific North American salt marshes, p. 167-191, in: V. J. Chapman (Ed.) Wet coastal ecosystems (Ecosystems of the World I). Amsterdam, Elsevier Scientific Publ. Co.

Macdonald, K. B. and M. G. Barbour. 1974. Beach and salt marsh vegetation of the North American Pacific Coast, p. 175-233, in: Reimold, R. J. and W. H. Queen (eds.), Ecology of halophytes. New York, Academic Press.

Moore, J. J. 1970. Phyto: a suite of programs in Fortran IV for manipulation of phytosociological tables according to the principles of Braun-Blanquet. Dublin, University College, Dept. Botany.

Morss, W. L. 1927. The plant colonization of marshlands in the estuary of the River Nith. Journal of Ecology, v. 15, p. 310-343.

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and methods of vegetation ecology. New York, John Wiley.

National Ocean Survey (NOAA). 1978. Preliminary report on the relationship between the upper limit of coastal wetlands and tidal datum along the Pacific Coast. (A study conducted for the Environmental Protection Agency). Rockville, National Ocean Survey, NOAA.

National Ocean Survey (NOAA). 1975. The relationship between the upper limit of coastal marshes and tidal datums. Rockville, National Ocean Survey (a pilot study conducted for the EPA).

Northwest Environmental Consultants. 1975a. The tidal marshes of Jefferson County, Washington. Bainbridge Island, Northwest Environmental Consultants (report for Jefferson Co. Planning Dept.).

_________. 1975b. [Willapa Bay Project] Bainbridge Island, Northwest Environmental Consultants.

Odum, E. P. 1961. The role of tidal marshes in estuarine production. The Conservationist, v. 15, p. 12-13.

Odum, H. T., et al. (eds). 1974. Coastal ecological systems of the United States, I-IV. Washington, D.C. The Conservation Foundation.

Odum, H. T. and B. J. Copeland. 1974. A functional classification of the coastal systems of the United States, p. 5-84, in: H. T. Odum et al. (eds.), Coastal ecological systems of the United States, I. Washington, D.C., The Conservation Foundation.

Ranwell, D. S. 1972. Ecology of salt marshes and sand dunes. London, Chapman and Hall.

Reimold, R. J. and W. H. Queen (eds.). 1974. Ecology of halophytes. New York. Academic Press.

Rowntree, R. 1978. Biomass values for dominant salt marsh angiosperms in five Pacific Coast estuaries, 1976-77. (A report under contract with Army Corps of Engineers Waterways Exp. Stn. DACW07-77-C-0003). Vicksburg, Army Corps of Engineers, Waterways Exp. Stn.

Shaler, N. S. 1886. Beaches and tidal marshes of the Atlantic Coast. National Geographic Monograph 1, 97 p.

Smalley, A. E. 1960. Energy flow of salt marsh grasshopper population. Ecology, v. 94, p. 672-677.

Sparks, L. H. et al. 1977. The distribution of vascular plant species on Sergief Island, southeast Alaska. Syesis, v. 10, p. 1-9.

State of Oregon, Division of State Lands. 1973. Oregon estuaries. Salem, Division of State Lands, 25 p.

State of Washington, Department of Ecology. 1977. Aquatic lands definition study (report prepared by Northwest Environmental Consultants under contract 77-054 030-3-012NG). Olympia, State of Washington, Dept. Ecology.

Stever, D. W. Jr. 1977. Trends in wetlands litigation. Environmental Comment (The Courts and Land Use II), Urban Land Institute, August.

Teal, J. M. 1962. Energy flow in the salt marsh ecosystem of Georgia. Ecology, v. 43, p. 614-624.

U.S. Army Corps of Engineers (DOD). 1976. Maintenance dredging and the environment of Greys Harbor, Washington. Summary Report. Seattle, Army Corps of Engineers, Seattle District.

Wass, M. L. and Wright, T. D. 1959. Coastal wetlands of Virginia (Special report in applied Marine science and ocean engineering no. 10). Glouster Point, Virginia Institute of Marine Science.

Wells, B. W. 1928. Plant communities of the coastal plain of North Carolina and their successional relations. Ecology, v. 9, p. 230-242.

Yapp, R. H., D. Johns, and O. T. Jones. 1917. The salt marshes of the Dovey Estuary II: The salt marshes. Journal of Ecology, v. 5, p. 65-103.

APPENDIX-A

MARSH RECONNAISSANCE FORM

Estuary: ____________________ Date: ____________________

Location: ____________________ Surveyor: ____________________

____________________ Photo-identified: ____________________

____________________ Marsh designator: ____________________

Marsh type: ____

Marsh size: Large________ Medium________ Small________

Marsh vegetation zonation: Strong________ Moderate________ Weak________

Marsh creek development: Strong________ Moderate________ Weak________

Stranded material: Abundant________ Moderate________ Little________

Fresh water seepage: Strong________ Moderate________ Little________

Marsh disturbance: Heavy________ Moderate________ Little________

Type____

Upland disturbance: Heavy________ Moderate________ Little________

Type____

Upland vegetation: ____

Transition zone depression: Clear________ None________

Ease of access: Easy________ Moderate________ Difficult________

Type of access: Car________ Walk________ Boat________

Access description: ____

____

Tidal Bench Mark: Yes________ No________ No.________

Remarks:

Overall recommendation: Excellent________ Good________ Poor________

APPENDIX 3

Species Encountered In and Adjacent to Pacific Northwest Intertidal Salt Marshes, Summer Field Season, 1977

Code	Species and Author	Common Name	Occurrence[1]
Abgr	Abies grandis (Dougl.) Forbes	grand fir	U
Acma	Acer macrophyllum Pursh	bigleaf maple	U
Acmi	Achillea millefolium L.	western yarrow	TU
Agre	Agropyron repens (L.) Beauv	quackgrass	U*
Agal	Agrostis alba L.	redtop	MTU ♦
Aica	Aira caryophyllea L.	silver hairgrass	U*
Aipr	Aira praecox L.	early hairgrass	U*
Alca	Alopecurus geniculatus L.	Carolina foxtail	U ♦*
Alru	Alnus rubra Bong.	red alder	TU ♦
Amar	Ammophila arenaria (L.) Link	European beachgrass	U*
Anlu	Angelica lucida L.	sea-watch	TU
Anod	Anthoxanthum odoratum L.	sweet vernalgrass	TU*
Arme	Arbutus menziesii Pursh	Pacific madrona	U
Arma	Arenaria macrophylla Hook.	bigleaf sandwort	U
Aruv	Arctostaphylos uva-ursi (L.) Spreng.	kinnikinnick	U
Assu	Aster subspicatus Nees	Douglas' aster	TU
Atfi	Athyrium filix-femina (L.) Roth.	lady-fern	TU ♦
Atpa	Atriplex patula L. var. hastata (L.) Gray	common orache	MT
Arsu	Artemisia suksdorfii Piper	Suksdorff's sagebrush	U
Beaq	Berberis aquifolium Pursh	tall Oregon grape	U
Bene	Berberis nervosa Pursh	shining Oregon grape	U
Bice	Bidens cernua L.	nodding beggar-tick	TU ♦
Blsp	Blechnum spicant (L.) Roth.	deer fern	U
Brpa	Bromus pacificus Shear	Pacific brome-grass	TU
Canu	Calamagrostis nutkaensis (Presl)	Pacific reedgrass	TU
Caly	Carex lyngbyei Hornem.	Lyngby's sedge	MT ♦
Caob	Carex obnupta Bailey	slough sedge	TU ♦
Capa	Carex pansa Bailey	sand-dune sedge	U
Ciar	Cirsium arvense (L.) Scop.	Canadian thistle	U*
Coca	Cornus canadensis L.	bunchberry	U
Coco	Cotula coronopifolia L.	brassbuttons	MT ♦*
Coma	Cordylanthus maritimus Nutt. ex. Benth.	salt-marsh bird's-beak	M
Copa	Conioselinum pacificum (Wats.) Coult. & Rose	Pacific hemlock	TU ♦
Cusa	Cuscuta salina Engelm.	Salt-marsh dodder	M +
Cysc	Cytisus scoparius (L.) Link	Scotch broom	U*

1
- * - Introduced plant
- MT - Marsh and Transition Zone
- T - Transition Zone exclusively
- TU - Transition and Upland
- U - Upland exclusively
- ♦ - Freshwater indicator

Note: Tendency for occurrence shown by underlining, e.g., MT - occurs more in marsh than transition zone.

Code	Species and Author	Common Name	Occurrence[1]
Dagl	Dactylis glomerata L.	orchard grass	U*
Deca	Deschampsia cespitosa (L.) Beauv.	tufted hairgrass	MT W
Difo	Dicentra formosa (Andr.) Walp.	Pacific bleedingheart	U
Disp	Distichlis spicata (L.) Greene		MT
Elgl	Elymus glaucus Buckl.	western rye grass	U
Elpa	Eleocharis palustris (L.) R. & S.	common spike-rush	MT W
Elmo	Elymus mollis Trin.	dune wildrye	TU
Equis	Equisetum species L.	horsetail	U W
Epwa	Epilobium watsonii Barbey	Watson's willow-herb	TU
Erar	Erechtites arguta DC.	cut-leaved coast burnweed	TU*
Feme	Festuca megalura Nutt.	foxtail fescue	U*
Faru	Festuca rubra L.	red fescue	MTU
Frch	Fragaria chiloensis (L.) Duchesne	coastal strawberry	U
Frla	Fraxinus latifolia Benth.	Oregon ash	U W
Gaap	Galium aparine L.	cleavers	TU*
Gafd	Galium trifidum L.	small bedstraw	TU
Gatr	Galium triflorum Michx.	sweetscented bedstraw	TU
Gash	Gaultheria shallon Pursh	salal	U
Glma	Glaux maritima L.	saltwort	MT
Gnpu	Gnaphalium purpureum L.	purple cudweed	TU
Goob	Goodyera oblongifolia Raf.	western rattlesnake-plantain	U
Grin	Grindelia integrifolia DC.	Willamette valley gumweed	MT
Hela	Heracleum lanatum Michx.	cow-parsnip	TU*
Hola	Holcus lanatus L.	common velvetgrass	TU*
Hodi	Holodiscus discolor (Pursh) Maxim.	creambush oceanspray	U
Hobr	Hordeum brachyantherum Nevski	meadow barley	MTU W
Hyra	Hypochaeris radicata L.	spotted cats-ear	U*
Ilaq	Ilex aquifolium L.	English holly	U*
Jaca	Jaumea carnosa (Less.) Gray	jaumea	MT
Juba	Juncus balticus Willd.	Baltic rush	MT
Juef	Juncus effusus L. var	soft rush	TU W
Juge	Juncus gerardii Loisel.	mud rush	TU W
Jule	Juncus lesueurii Boland.	salt rush	TU W
Jusc	Juniperus scopulorum Sarg.	Rocky Mountain juniper	U
Laja	Lathyrus japonicus Willd.	maritime peavine	U
Lapa	Lathyrus palustris L.	marsh peavine	TU
Lioc	Lilaeopsis occidentalis Coult. & Rosa	lilaeopsis	MT W
Lohi	Lonicera hispidula (Lindl.) Dougl.	hairy honeysuckle	U
Loin	Lonicera involucrata (Rich.) Banks	bearberry honeysuckle	U
Locu	Lotus uliginosus Schk.	bird's-foot trefoil	TU*
Luli	Lupinus littoralis Dougl.	seashore lupine	TU
Lyam	Lysichitum americanum Hulten & St. John	skunk cabbage	W

Code	Species and Author	Common Name	Occurrence[1]
Madi	*Maianthemum dilatatum* (Wood) Nels. & Macbr.	false lily of the valley	TU
Meal	*Melilotus alba* Desr.	white sweetclover	U*
Mear	*Mentha arvensis* L.	field mint	U W
Mosi	*Montia sibirica* (L.) Howell	western spring beauty	U
Myla	*Myosotis laxa* Lehm.	small flowered forget-me-not	TU W
Myca	*Myrica californica* Cham.	Pacific wax-myrtle	U
Oesa	*Oenanthe sarmentosa* Presl.	Pacific water-parsley	TU W
Orca	*Orthocarpus castilleioides* Benth.	paintbrush owl-clover	M
Osce	*Osmaronia cerasiformis* (T. & G.) Greene	Indian plum	U
Phar	*Phalaris arundinaceae* L.	reed canary grass	TU W
Phca	*Physocarpus capitatus* (Pursh) Kuntze	Pacific ninebark	UW
Pisi	*Picea sitchensis* (Bong.) Carr.	Sitka spruce	TU
Plco	*Plantago coronopus* L.	cut-leaved plantain	U*
Plla	*Plantago lanceolata* L.	English plantain	TU*
Plmaj	*Plantago major* L.	common plantain	TU*
Plma	*Plantago maritima* L.	seaside plantain	MTU
Pogl	*Polypodium glycyrrhiza* D.C. Eat.	licorice-fern	U
Poma	*Poa macrantha* Vasey	seashore bluegrass	U
Popa	*Potentilla pacifica* Howell	Pacific silverweed	MTU W
Popar	*Polygonum paronychia* Cham. & Schlecht.	black knotweed	U
Pope	*Polygonum persicaria* L.	heart weed	TU W
Popr	*Poa pratensis*	Kentucky bluegrass	U*
Prem	*Prunus emarginata* Dougl.	bittercherry	U
Prvi	*Prunus virginiana* L.	common chokecherry	U
Prunus	*Prunus* spp.	cherry	U
Pruv	*Prunella vulgaris* L.	self-heal	TU*
Psme	*Pseudotsuga menziesii* (Mirb.) Franco	Douglas-fir	U
Ptaq	*Pteridium aquilinum* (L.) Kuhn	bracken fern	U
Pupu	*Puccinellia pumila* (Vasey) Hitchc.	dwarf alkaligrass	M
Pyfu	*Pyrus fusca* Raf.	western crabapple	U
Rhpu	*Rhamnus purshiana* DC.	cascara	U W
Ridi	*Ribes divaricatum* Dougl.	straggly gooseberry	U
Risa	*Ribes sanguineum* Pursh	redflowering currant	U
Rogy	*Rosa gymnocarpa* Nutt.	little wild rose	U
Ronu	*Rosa nutkana* Presl	Nootka rose	U
Rudi	*Rubus discolor* Weihe & Nees	Himalayan blackberry	U*
Rula	*Rubus laciniatus* Willd.	evergreen blackberry	U*
Rupa	*Rubus parviflorus* Nutt.	thimbleberry	U
Rusp	*Rubus spectabilis* Pursh	Salmonberry	U
Ruur	*Rubus ursinus* Cham. & Schlecht.	Pacific blackberry	U
Ruac	*Rumex acetosella* L.	sheep sorrel	U*
Rucr	*Rumex crispus* L.	curly dock	U*
Ruob	*Rumex obtusifolius* L.	bitterdock	TU*
Ruoc	*Rumex occidentalis* Wats.	western dock	TU
Sacr	*Sagina crassicaulis* Wats.	stick-stemmed pearlwort	TU
Savi	*Salicornia virginica* L.	pickleweed	MT

Code	Species and Author	Common Name	Occurrence
Sano	*Salix hookeriana* Barratt	Hooker's willow	TU
Salix	*Salix* spp.	willow	U W
Sara	*Sambucus racemosa* L.	red elderberry	U
Scam	*Scirpus americanus* Pers.	American bullrush	MT W
Scce	*Scirpus cernuus* Vahl.	low clubrush	MT W
Scma	*Scirpus maritimus* L.	seacoast bullrush	MT
Scmi	*Scirpus microcarpus* Presl	small-fruited bullrush	T W
Scva	*Scirpus validus* Vahl.	softstem bullrush	MT W
Seja	*Senecio jacobaea* L.	tansy ragwort	U*
Sevu	*Senecio vulgaris* L.	common groundsel	U*
Sihe	*Sidalcea hendersonii* Wats.	Henderson's checker-mallow	TU
Sudu	*Solanum dulcamara* L.	black nightshade	TU*
Sool	*Sonchus oleraceus* L.	common sow-thistle	TU*
Spal	*Spartina alterniflora* Loisel.	smooth cordgrass	M*
Spca	*Spergularia canadensis* (Pers.) G. Don	Canadian Sandspurry	M
Spma	*Spergularia macrotheca* (Hornem.) Heynh.	beach sandspurry	MT
Stca	*Stellaria calycantha* (Ledeb.) Bong.	northern starwort	TU
Sthu	*Stellaria humifusa* Rottb.	low starwort	MT
Syal	*Symphoricarpus albus* (L.) Blake	common snowberry	U
Thpl	*Thuja plicata* D. Don	western red cedar	U
Titr	*Tiarella trifoliata* L.	foam flower	U
Trpr	*Trifolium pratense* L.	red clover	U*
Trre	*Trifolium repens* L.	white clover	U*
Trwo	*Trifolium wormskjoldii* Lehm.	springbank clover	TU
Trco	*Triglochin concinnum* Davy	graceful arrow-grass	M
Trma	*Triglochin maritimum* L.	seaside arrow-grass	MT
Tshe	*Tsuga heterophylla* (Raf.) Sarg.	western hemlock	U
Tyla	*Typha latifolia* L.	common cat-tail	W
Urdi	*Urtica dioica* L.	stinging nettle	U W
Vaov	*Vaccinium ovatum* Pursh	evergreen blueberry	U
Vapa	*Vaccinium parvifolium* Smith	red huckleberry	U
Veam	*Veronica americana* Schwein.	American brooklime	U W
Vigi	*Vicia gigantea* Hook.	giant vetch	TU
Visa	*Vicia sativa* L.	common vetch	U*
Zoma	*Zostera marina* L.	eelgrass	M
Zona	*Zostera nana* Roth	dwarf eelgrass	M*

APPENDIX C

Arrangement of Raw Data on Computer Cards

Computer Card Column	Coded Item		Computer Card Column	Coded Item	
1-2	Marsh Number		36	*Lotus uliginosus*	C.C.
3-4	Transect Number		37	*Oenanthe sarmentosa*	C.C.
5-7	Transect Position (0 = bottom)		38	*Orthocarpus castillejoides*	C.C.
8-10	Transect Position (0 = top)		39	*Plantago maritima*	C.C.
11	Marsh Zone		40	*Potentilla pacifica*	C.C.
12	Bare Ground Cover Class	(C.C.)	41	*Puccinellia pumila*	C.C.
13	Stranded Material	C.C.	42	*Rumex occidentalis*	C.C.
14	Litter	C.C.	43	*Salicornia virginica*	C.C.
15	Algae/*Ruppia*	C.C.	44	*Scirpus americanus*	C.C.
16	*Achillea millefolium*	C.C.	45	*Scirpus cernuus*	C.C.
17	*Agrostis alba*	C.C.	46	*Spergularia canadensis*	C.C.
18	*Aster subspicatus*	C.C.	47	*Stellaria humifusa*	C.C.
19	*Atriplex patula*	C.C.	48	*Trifolium wormskjoldii*	C.C.
20	*Carex lyngbyei*	C.C.	49	*Triglochin concinnum*	C.C.
21	*Carex obnupta*	C.C.	50	*Triglochin maritimum*	C.C.
22	*Cuscuta salina*	C.C.	51	*Vicia gigantea*	C.C.
23	*Deschampsia cespitosa*	C.C.	52	*Angelica lucida*	C.C.
24	*Distichlis spicata*	C.C.	53	*Elymus mollis*	C.C.
25	*Eleocharis palustris*	C.C.	54	*Stellaria calycantha/*	C.C.
26	*Festuca rubra*	C.C.	55	*Maianthemum dilatatum*	C.C.
27	*Galium aparine*	C.C.	56	*Picea sitchensis*	C.C.
28	*Galium trifidum/*	C.C.	57	*Plantago lanceolata*	C.C.
29	*Glaux maritimum*	C.C.	58	*Juncus effusus*	C.C.
30	*Grindelia integrifolia*	C.C.	59	*Zostera nana*	C.C.
31	*Holcus lantatus*	C.C.	60	*Juncus lesueurii*	C.C.
32	*Hordeum brachyantherum*	C.C.	61	*Lathyrus palustris*	C.C.
33	*Jaumea carnosa*	C.C.	62	*Scirpus validus*	C.C.
34	*Juncus balticus*	C.C.	63	*Poa pratensis*	C.C.
35	*Lilaeopsis occidentalis*	C.C.	64	*Gaultheria shallon*	C.C.

Arrangement of Raw Data on Computer Cards (Continued)

Computer Card Column	Coded Item		Computer Card Column	Coded Item	
65	Hypochaeris radicata	C.C.	23	Athyrium filix-femina	C.C.
66	Spergularia macrotheca	C.C.	24	Berberis aquifolium	C.C.
67	Scirpus microcarpus	C.C.	25	Cirsium arvensis	C.C.
68	Carex pansa	C.C.	26	Cirsium canadensis	C.C.
69	Calamagrostis nutkaensis	C.C.	27	Conioselinum pacificum	C.C.
70	Epilobium watsonii	C.C.	28	Cystisus scoparius	C.C.
71	Agropyron repens	C.C.	29	Dactylis glomerata	C.C.
72	Lonicera involucrata	C.C.	30	Fragaria chiloensis	C.C.
73	Spartina alternifolia	C.C.	31	Gnaphalium purpureum	C.C.
74	Equisetum spp.	C.C.	32	Ilex aquifolia	C.C.
75	Juncus gerardii	C.C.	33	Lathyrus japonicus	C.C.
76	Erechitites arguta	C.C.	34	Lonicera hispidula	C.C.
77	Heracleum lanatum	C.C.	35	Lupinus littoralis	C.C.
78	Physocarpus capitatus	C.C.	36	Lysichitum americanum	C.C.
79	Rubus ursinus	C.C.	37	Montia sibirica	C.C.
80	Card No. 1	1	38	Myrica californica	C.C.
1-2	Marsh No.		39	Myosotis laxa	C.C.
3-4	Transect No.		40	Phalaris arundinacea	C.C.
5-7	Sample Position (0 = bottom)		41	Polystichum munitum	C.C.
8-10	Sample Position (0 = top)		42	Pseudotsuga menziesii	C.C.
11	Marsh Zone		43	Pteridium aquilinum	C.C.
12-15	Blank		44	Pyrus fusca	C.C.
16	Abies grandis	C.C.	45	Rhamnus purshianus	C.C.
17	Aira caryophyllea	C.C.	46	Ribes sanguineum	C.C.
18	Aira praecox	C.C.	47	Rhododendron macrophyllum	C.C.
19	Alnus rubra	C.C.	48	Rosa nutkana	C.C.
20	Ammophila arenaria	C.C.	49	Rumex acetosella	C.C.
21	Anthoxanthum odoratum	C.C.	50	Rubus discolor	C.C.
22	Arenaria macrophylla	C.C.	51	Rubus laciniatus	C.C.

Arrangement of Raw Data on Computer Cards (Continued)

Computer Card Column	Coded Item		Computer Card Column	Coded Item	
52	Rubus parviflorus	C.C.	60	Thuja plicata	C.C.
53	Rubus spectabilis	C.C.	61	Tsuga heterophylla	C.C.
54	Salix hookeriana	C.C.	62	Typha latifolia	C.C.
55	Salix spp.	C.C.	63	Vaccinium ovatum	C.C.
56	Sambucus racemosa	C.C.	64	Vaccinium parvifolium	C.C.
57	Senecio jacobea	C.C.	65	Veronica americana	C.C.
58	Sidalcea hendersonii	C.C.	↓		
59	Solanum nigrum	C.C.	80	Card No. 2	2

Arrangement of Raw Data in Computer Cards (Continued)

Computer Cards Raw Data Input Explanation

I.

Marsh No.	Designator	Name	No. Transects	No. Samples[1]
01	CQ1	Bandon	12	168
02	CB1	Haynes Inlet	10	106
03	AB1	Waldport South	10	162
04	YB2	Nute Slough	9	88
05	NT1	Netarts Sand Spit	10	155
06	NB2	West Island	9	195
07	NB3	Sea Garden Rd.	13	200
08	WB1	Niawiakum	10	148
09	WB2	Cedar River	10	157
10	WB4	Leadbetter Pt.	10	151
11	GH1	The Sink	11	229
12	GH3	Elk River	10	115
13	KS1	Burley Lagoon	10	89
14	KS2	Coulter Cr.	10	128
15	KS3	Chico Bay	5	78
16	HC1	Thorndyke Bay	12	78
17	EP1	Quilceda Cr.	9	133
18	NP1	Oak Bay	10	114
19	SJ1	Wescott Bay	5	45
20	SJ2	Griffin Bay	5	44
TOTAL			190	2583

II. Sample positions are numbered in meters in Cols. 5-7 starting at mudflat extending to field-judged boundary between the transition zone and upland along a given transect.

III. Sample positions are numbered in meters in Cols. 8-10 starting at the uppermost stake in upland and extending to the mudflat. This numbering should agree with that by the NOS.

IV. Marsh zone in Col. 11 refers to investigator's best judgment, based on species composition, of the position of a given sample into one of 6 classes.

Zone	Position
1	lower marsh
2	middle marsh
3	lower transition zone
4	transition zone
5	upper transition zone
6	upland

---

[1] Samples refer to marsh and transition zone samples based on 50 x 50 cm plots. Additionally 570 upland "line transect samples" were punched onto computer cards, 3 upland samples per transect.

DRAFT

Arrangement of Raw Data in Computer Cards (Continued)

Computer Card Raw Data Input Explanation (Continued)

V. Cols. 12-15 are used to judge a variety of sample characteristics: bare ground, drifted or stranded material, litter, and algae. Data were recorded by cover class (see VI).

VI. Species cover is recorded by cover class in Cols. 16-79 on card 1 and Cols. 16-65 on card 2.

Cover Class	% Cover	% Midpoint Cover
7 (+)	<1	0.1
1	1-5	3.0
2	5-25	15.0
3	25-50	37.5
4	50-75	62.5
5	75-95	85.0
6	95-100	97.5

VII. Col. 80 is used for indicating the card number in a multicard data set for a given sample. Card No. 1 generally included marsh species, card No. 2 upland species.

APPENDIX D

Selected Species Distribution Among Sampled Marshes in Oregon and Washington

Species	Marsh and Marsh No.																			
	CQ1 1	CB1 2	AB1 3	YB1 4	NT1 5	NB2 6	NB3 7	WB1 8	WB2 9	WB4 10	GH1 11	GH3 12	KS1 13	KS2 14	KS3 15	HC1 16	EP1 17	NP1 18	SJ1 19	SJ2 20
Achillea millefolium	X	X	X		X	X	X	X	X	X		X	X				X		X	
Agrostis alba	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Agropyron repens															X					
Angelica lucida			X	X	X	X		X	X		X		X	X			X			
Aster subspicatus	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X		
Atriplex patula	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Calamagrostis nutkaensis					X				X									X		
Carex lyngbyei	X	X	X	X		X	X	X	X	X	X		X	X	X	X	X			
Carex obnupta	X			X		X	X		X		X		X			X	X		X	
Carex pansa				X						X	X									
Cuscuta salina	X		X	X	X					X	X							X	X	
Deschampsia cespitosa	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X			
Distichlis spicata	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Eleocharis palustris	X			X			X		X		X									
Elymus mollis					X					X	X	X		X	X		X			
Epilobium watsonii											X					X				
Equisetum sp.							X						X							
Erechtites arguta	X												X				X			
Festuca rubra	X	X	X		X	X		X	X	X	X	X								X
Galium aparine	X		X		X			X	X		X					X		X	X	
Galium trifidum/ G. triflorum	X		X		X	X			X		X		X			X	X			X
Gaultheria shallon					X													X		

Selected Species Distribution Among Sampled Marshes in Oregon and Washington (Cont.)

Species	Marsh and Marsh No. CQ1 1	CB1 2	AB1 3	YB1 4	NT1 5	NB2 6	NB3 7	WB1 8	WB2 9	WB4 10	GH1 11	GH3 12	KS1 13	KS2 14	KS3 15	HC1 16	EP1 17	NP1 18	SJ1 19	SJ2 20
Glaux maritima	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x			x
Grindelia integrifolia		x	x	x	x			x		x	x		x	x		x		x		
Heracleum lanatum						x			x											
Holcus lanatus	x		x		x	x				x	x		x		x		x			
Hordeum brachyantherum	x	x	x		x	x		x	x	x	x	x	x	x	x	x	x	x	x	x
Hypochaeris radicata			x						x			x								
Jaumea carnosa	x	x	x	x	x			x	x	x	x	x	x	x	x	x		x	x	
Juncus balticus	x	x	x	x	x	x	x	x	x	x	x	x		x		x	x	x	x	x
Juncus effusus						x							x	x		x				
Juncus gerardii													x			x			x	
Juncus lesueurii					x					x	x									
Lathyrus palustris	x									x	x									
Lilaeopsis occidentalis	x	x	x	x		x	x		x		x						x			
Lonicera involucrata							x						x				x			
Lotus uliginosus		x				x	x				x									
Maianthemum dilatatum		x	x					x	x			x	x				x			
Oenanthe sarmentosa	x	x		x		x	x	x	x	x			x			x	x			
Orthocarpus castillejoides	x				x	x		x	x	x	x						x			
Physocarpus capitatus							x													

Selected Species Distribution Among Sampled Marshes in Oregon and Washington (Cont.)

Species	Marsh and Marsh No.																			
	CQ1	CB1	AB1	YB1	NT1	NB2	NB3	WB1	WB2	WB4	GH1	GH3	KS1	KS2	KS3	HC1	EP1	NP1	SJ1	SJ2
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Picea sitchensis	x		x						x			x					x			
Plantago lanceolata		x	x		x	x				x	x									
Plantago maritima	x			x	x	x		x	x	x	x	x	x	x			x	x	x	
Poa pratensis			x							x	x									
Potentilla pacifica	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Puccinellia pumila					x			x		x	x	x						x	x	
Rubus ursinus		x	x											x						
Rumex occidentalis	x	x				x		x	x				x			x	x			
Salicornia virginica	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
Scirpus americanus	x				x	x	x		x	x	x									
Scirpus cernuus	x	x	x	x	x	x	x	x	x											
Scirpus microcarpus				x			x							x						
Scirpus validus													x			x	x			
Sidalcea hendersonii																	x			
Spartina alterniflora								x		x										
Spergularia canadensis		x		x	x			x	x	x	x	x		x	x	x		x		
Spergularia macrotheca					x					x									x	

Selected Species Distribution Among Sampled Marshes in Oregon and Washington (Cont.)

Species	Marshland Marsh No. CQ1 1	CB1 2	AB1 3	YB1 4	NT1 5	NB2 6	NB3 7	WB1 8	WB2 9	WB4 10	GH1 11	GH3 12	KS1 13	KS2 14	KS3 15	HC1 16	EP1 17	NP1 18	SJ1 19	SJ2 20
Stellaria calycantha/ S. crassifolia	x				x			x		x	x	x		x						
Stellaria humifusa			x		x	x		x	x	x	x	x		x						
Trifolium wormskjoldii	x	x	x	x	x	x	x	x	x	x	x	x	x	x			x			
Triglochin concinnum					x					x	x	x						x		
Triglochin maritimum	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	
Vicea gigantea	x					x	x		x		x		x			x				
Zostera nana		x						x	x			x				x				

APPENDIX E

Study Site Locational Information

Bandon Marsh - Coquille Estuary

#1 CQ1

Location:

State: Oregon

County: Coos

NW¼ of the SE¼ and the SW¼ of the NE¼ of Sec. 19, T25S, R14W
Latitude: 43° 08' N
Longitude: 124° 24' W

Approximate Size: 150 ha

Access: South of the Highway 101 bridge crossing of the Coquille River (Approx. 1 km), turn west onto "old" Highway 101. Continue south on this road for 0.7 km. Park car near small creek. Take a trail 0.5 km west along the north side of the creek which ends at the marsh. The northern end of the marsh may also be approached from the south end of the Highway 101 bridge.

General Description: The upper portion of the marsh is covered by strand material; the lower marsh exhibits weak zonation. *Scirpus americanus* and *Carex lyngbyei* are found in the lower marsh; with these species, *Salicornia virginica*, *Distichlis spicata*, and *Triglochin maritimum* characterize the central marsh. *Deschampsia cespitosa* is found in a narrow strip just bayward of the transition zone. Freshwater seepage has altered the species composition of both the lower and higher marsh. *Scirpus americanuus* and *S. cernuus* give evidence of this condition. The upland is a *Picea sitchensis* forest with freshwater wetland species such as *Lysichitum americanum* forming the understory.

Ownership: Port of Bandon and
Franz Shindler, Bandon, Oregon

Haynes Inlet - Coos Bay

#2 CB1

Location:

State: Oregon

County: Coos

NE¼ of the NW¼ of Sec. 25, T24S, R13W
Latitude: 43° 25' 50" N
Longitude: 124° 10' 20" W

Approximate Size: 11 ha

Access: A few hundred meters north of the Coos Bay Bridge (Highway 101), turn east on North Bay Drive (Oregon Coast Highway). Drive for approximately 3.5 km. Park car just on the north side of Larson Slough. The marsh borders the highway at this point, and is a few meters walk down a small embankment to the marsh.

General Description: This Immature High Marsh occupies a position between Haynes Inlet and North Bay Drive. Within the lower marsh *Carex lyngbyei*, *Triglochin maritimum*, and *Salicornia virginica* dominate; while *Deschampsia cespitosa* predominates in the higher marsh. The upland is a narrow strip along an embankment between North Bay Road and the marsh. The primary upland species are *Picea sitchensis*, *Salix hookeriana*, and *Rubus ursinus*.

Ownership: Private
Contact George Rice, Coos Bay, Oregon

Waldport South - Alsea Bay

#3 AB1

Location:

State: Oregon

County: Lincoln

NW¼ of the NE¼ of Sec. 28, T13S, R11W
Latitude: 44° 25' N
Longitude: 124° 01' W

Approximate Size: 3.5 ha

Access: The marsh borders Highway 34 (Alsea Highway). Approximately 3 km east of Waldport, or 1.6 km east of Eckman Lake. The marsh is easily accessible along a short path from the highway.

General Description: The low marsh along tidal creeks is occupied by the tall form of *Carex lyngbyei*. With increasing elevation *C. lyngbyei* is followed by *Triglochin maritimum*, *Agrostis alba*, *Distichlis spicata*, *Salicornia virginica*, and *Deschampsia cespitosa*. The transition zone is strongly dominated by *Potentilla pacifica*. The upland, created by a land fill at least 40 years old, supports a dense growth of *Picea sitchensis* and *Alnus rubra*.

Ownership: Ronald G. Paulson, Waldport, Oregon

Nute Slough - Yaquina Bay

#4 YB2

Location:

State: Oregon

County: Lincoln

SE¼ of the NW¼ of Sec. 30, T11S, R10W
Latitude: 44° 35' 00" N
Longitude: 123° 57' 29" W

Approximate Size: 1.5 ha

Access: Take Toledo exit off of Highway 20. In Toledo take West Yaquina Bay Road to Newport. Continue on road until 1 km west of Moody (or just east of Nute Slough). The marsh is a short walk south of the road.

General Description: In the lower portion of the marsh *Triglochin maritimum* dominates, with associated species *Carex lyngbyei* and *Distichlis spicata*. Nearer the upland these species give way to *Potentilla pacifica*, *Juncus balticus*, and to a degree, *Aster subspicatus*. The upland is a *Picea sitchensis* forest with *Gaultheria shallon* and *Vaccinium ovatum* being the main understory shrubs.

Ownership: Private

Netarts Sand Spit - Netarts Bay

#5 NT1

Location:

State:	Oregon
County:	Tillamook
	SW¼ of Sec. 7 and NE¼ of Sec. 18, T2S, R10W Latitude: 45° 25' 00" N Longitude: 123° 57' 30" W
Approximate Size:	9.6 ha
Access:	Go 19.2 km southwest from Highway 101 in Tillamook to Cape Lookout State Park. Proceed to north end of camping area. There is a gate blocking vehicle passage, although the road continues for another 2.5 km. The marsh study site is 3.0 km from the gate on the bay side of the sand spit.
General Description:	The marsh has formed along a small narrow strip on the leeward side of the Netarts Bay Spit. Within this narrow, but elongated marsh, two vegetation types can be found: Low Sand and Immature High. Freshwater seepage is apparent in the marsh. The upland vegetation consists of both *Picea sitchensis* - *Pinus contorta* forest and *Ammophila arenaria* dune vegetation.
Ownership:	Oregon State Parks and Recreation Branch

West Island - Nehalem Bay

#6 NB2

Location:

State: Oregon

County: Tillamook

NW¼ and NE¼ of the NW¼ of Sec. 3, T3N, R10W; and NE¼ and SE¼ of the SW¼, and SW¼ of the SE¼ of Sec. 34, T2N, R10W
Latitude: 45° 42' 25" N
Longitude: 123° 53' 00" W

Approximate Size: 80 ha

Access: From the cities of Nehalem or Wheeler take a shallow draft boat to the NE part of the Island. This is accessible by a channel just north of Rat Island. West Island is inaccessible by boat during low tide.

General Description: Creek density is low in the lower and higher portions of the Island, and high between these two areas. The lower marsh is dominated by *Triglochin maritimum*, *Scirpus maritimus*, and *Carex lyngbyei*. In the central portion of the Island are found *C. lyngbyei*, *Deschampsia cespitosa*, and *Agrostis alba*. At higher elevations *Aster subspicatus*, *Potentilla pacifica*, and *Oenanthe sarmentosa* may be found. A small upland built upon drift wood is located at the extreme NE corner and other scattered areas. *Picea sitchensis* and *Salix hookeriana* are dominant in the upland.

Ownership: Tillamook County and E. Kahrs

Sea Garden Road - Nehalem Bay

#7 NB3

Location:

State: Oregon

County: Tillamook

NE¼ and SE¼ of the NW¼ of Sec. 33, T3N, R10W
Latitude: 45° 42' 30" N
Longitude: 123° 55' 00" W

Approximate Size: 5 ha

Access: Approximately 2 km west of the Central Business District of Nehalem, on Highway 101, turn south on Sea Garden Road. Follow road to end. The marsh is just a few meters west of the roads end.

General Description: Within this marsh *Carex lyngbyei* and *Scirpus americanus* are dominant throughout. These species, along with the appearance of *Eleocharis palustris* and *Lilaeopsis occidentalis* suggest freshwater seepage in the marsh. The upland is a *Picea sitchensis* - *Alnus rubra* forest. In many places freshwater wetland species such as *Typha latifolia* and *Oenanthe sarmentosa* form the understory.

Ownership: Investments Syndicates, Inc., Seattle, Washington

Niawiakum - Willapa Bay

#8 W81

Location:

State: Washington

County: Pacific

SW¼ of the NE¼ of Sec. 9, T13N, R10W
Latitude: 46° 39' N
Longitude: 123° 55' W

Approximate Size: 18 ha

Access: Just south of Highway 101 Bridge crossing the Niawiakum River, turn off Highway (west) onto logged-over property owned by the Weyerhaeuser Company. From parked car, walk westward through logged area, continue through forest 1 km. Forest ends abruptly at base of steep slope at marsh.

General Description: An extensive creek system along with the dominance of such species as *Deschampsia cespitosa*, *Potentilla pacifica*, and *Juncus balticus* suggest that the marsh is a Mature High Marsh. On the banks of the major tidal creeks, and at the marsh-mud flat interface are found *Carex lyngbyei* and *Triglochin maritimum*. Introduced *Spartina alterniflora* occurs in single species patches as a colonizing plant. The upland is forested (*Picea sitchensis* and *Alnus rubra*) with understory species indicative of moist conditions.

Ownership: Weyerhaeuser Company

Cedar River - Willapa Bay

#9 WB2

Location:

State: Washington

County: Pacific

SW¼ of the SW¼ of Sec. 31, T15N, R10W
Latitude: 46° 45' N
Longitude: 124° 00' W

Approximate Size: 3.5 ha

Access: Take Highway 105 west from Raymond for approximately 24 km. Just after crossing Cedar River, park car. The marsh is 0.5 km south of highway, on west side of river and east side of Norris Slough.

General Description: This marsh system may be subdivided into two main areas. One area to the north is an extensive Mature High *Deschampsia cespitosa* marsh. The second area is a narrow fringing marsh between Willapa Bay and a forested upland. Predominant species in the lower part of this fringing marsh are *Carex lyngbyei* and *Triglochin maritimum*. *Deschampsia cespitosa*, *Potentilla pacifica* and *Juncus balticus* dominant in the upper portions of the marsh. The forested *Tsuga heterophylla* - *Picea sitchensis* upland, slopes down to the marsh.

Ownership: Ray Nelson, Tokeland, Washington

Leadbetter Point - Willapa Bay

#10 WB4

Location:

State: Washington

County: Pacific

NE¼ of Sec. 9, T13N, R11W
Latitude: 46° 38' N
Longitude: 124° 10' W

Approximate Size: 390 ha

Access: Drive north on North Beach Peninsula through Oysterville. From Oysterville continue east 1/2 km on Pacific Avenue. Then turn north on Stackpole Road (road will become graveled). Continue north on road through undeveloped State Park until road ends in a small parking area. The marsh is approximately 1 km north of parking area on the east shore of the peninsula.

General Description: Leadbetter marsh is a recently developed Low Sand Marsh dominated by *Salicornia virginica*. This species is found in pure stands as well as being associated with *Jaumea carnosa*. At the upper edge of the marsh *Deschampsia cespitosa*, *Potentilla pacifica*, and *Carex lyngbyei* are found. The upland is composed of stabilized sand dunes.

Ownership: United States Fish and Wildlife Service

The Sink - Grays Harbor

#11 GH1

Location:

State: Washington

County: Grays Harbor

SE¼ of Sec. 22, SW¼ of Sec. 23, and NE¼ of Sec. 27 of T17N, R12W
Latitude: 46° 57' N
Longitude: 124° 09' W

Approximate Size: 249 ha

Access: Take Highway 109 west from Hoquiam to Ocean Shores exit - Highway 115. Drive south past Ocean Shores, the highway will turn into a complex of small residential roads. Proceed in a SW direction. Eventually the marsh will come into view. Park as close as possible (about 1/2 km) and walk to marsh. U.S. Coast Guard Station light house is to north of marsh; sewage disposal plant to south of marsh. Point Brown is about 3 km to the southwest.

General Description: This is an extensive Low Sand Marsh interlaced with tidal drainage channels. *Distichlis spicata* and *Salicornia virginica* dominate. Associated with these dominant species are *Spergularia canadensis*, *Jaumea carnosa*, *Triglochin concinnum* and *Plantago maritima*. The upland is characterized by a sandy substrate, with pockets of *Salix* scrub and extensive stabilized dunes.

Ownership: Washington State Department of Game

Elk River - Grays Harbor

#12 GH3

Location:

State: Washington

County: Grays Harbor

NW¼ of Sec. 20, T16N, R11W
Latitude: 46° 48' N
Longitude: 124° 05' W

Approximate Size: 2 ha

Access: Take Highway 105 southwest from Aberdeen for about 30 km. Two km west of Bay City, park car on the west side of Elk River after crossing the bridge. The marsh is just a few meters walk north from the highway and west of a small forested uplant.

General Description: This marsh has formed on a narrow strip of land on the south shore of Grays Harbor west of the mouth of Elk River within the upper portion of the marsh, *Deschampsia cespitosa* dominates. At the marsh-mud flat interface *Distichlis spicata* and *Salicornia virginica* are found; while near the upland, *Potentilla pacifica* has established itself. *Hordeum brachyantherum* and *Juncus balticus* are scattered throughout the marsh. The upland is forested with *Picea sitchensis* dominant.

Ownership: ABH Corporation, Aberdeen, Washington

Burley Lagoon - Kitsap Peninsula

#13 KS1

Location:

State: Washington

County: Kitsap

SE¼ of NE¼ of the SW¼ of Sec. 12, and NW¼ of the SE¼ of Sec. 11, T22N, R1E
Latitude: 47° 35' N
Longitude: 122° 38' W

Approximate Size: 5.0 ha

Access: Follow State Highway 16 south from Bremerton for about 26 km. Take the Burley Exit, going west into Burley. The marsh is across the lagoon from the town.

General Description: A high marsh dominated at the outer margins by *Triglochin maritimum* and *Carex lyngbyei*. *Deschampsia cespitosa*, *Glaux maritima*, and *Potentilla pacifica* dominate the greatest extent of the marsh. *Carex lyngbyei* dominates along the many tidal creeks in the marsh. The upland forest is a mixture of *Alnus rubra*, *Thuja plicata*, *Picea sitchensis*, and *Pyrus fusca*.

Ownership: Investment Syndicates, Inc., Seattle, Washington

Coulter Creek - North Bay

#14 KS2

Location:

State: Washington

County: Mason

SE¼ of the SE¼ of Sec. 8, T22N, R1W
Latitude: 47° 24' N
Longitude: 122° 51' W

Approximate Size: 0.6 ha

Access: Follow State Highway 302 northward from Allyn, Washington. Just north of Allyn, turn onto State Highway 3 and travel approximately 2.4 km northwestward to the bridge crossing Coulter Creek. The marsh is 200 m downstream from the bridge on the north bank.

General Description: This marsh is dissected by numerous tidal creeks. Outliers of upland vegetation have invaded the upper portions of the marsh by developing on stranded material. The western segment of the marsh is an Immature High Marsh dominated by *Deschampsia cespitosa*; while a smaller eastern segment, which is dissected by Coulter Creek, is dominated by *Carex lyngbyei*, *Salicornia virginica*, and *Distichlis spicata*. The forest upland is dominated by *Picea sitchensis* and *Thuja plicata*.

Ownership: Robert Overtone, Olympia, Washington

Chico Bay - Dyes Inlet

#15 KS3

Location:

State: Washington

County: Kitsap

SE¼ of the NW¼ of Sec. 5, T24N, R1E
Latitude: 47° 31' N
Longitude: 122° 38' W

Approximate Size: 1 ha

Access: Follow State Highway 3 north out of Bremerton approximately 11 km. Take Chico Exit, loop back towards Bremerton for about 0.5 km, turn east and cross under Highway 3. Turn left on first paved road after passing under highway. Follow road to end, about 1 km. The marsh will be on the right side of the road, approximately 50 m to the east.

General Description: This marsh developing on coarse substrate, has several large creek channels dissecting it. The lower marsh is predominately *Salicornia virginica* and *Distichlis spicata*; and in the upper marsh is found *Agrostis alba*. The upland supports either a ruderal flora or stream bank vegetation.

Ownership: Private
Anne Irving, Bremerton, Washington

Thorndyke Bay - Hood Canal

#16 HC1

Location:

State: Washington

County: Jefferson

SE¼ of the SW¼ and the SE¼ of Sec. 24, T27N, R1W
Latitude: 47° 48' 45" N
Longitude: 122° 44' 30" W

Approximate Size: 13.3 ha

Access: Take South Point Exit from State Highway 104 (approximately 4 km west of Hood Canal Bridge). Proceed southward to within 1.6 km of South Point. Take right on Thorndyke Road and continue for another 7-8 km. There will be a gated-road on the east side of the road and a sign "Thorndyke Gun Club". The marsh is 1.5 km northeast down the road from the gate.

General Description: This marsh has developed behind a barrier beach that is opened at one end by the flow of Thorndyke Creek. Sand- and silt-sized grains predominate throughout the High Marsh. Very little Low Marsh occurs except for a few colonizing mats on the mud flat, and or material that has sluffed-off the margins of the high marsh. A large fresh-water influx is evident across the northwest portion of the marsh, where dense thickets of *Scirpus validus* dominate. Forest forms the eastern margin of the marsh.

Ownership: Pope and Talbot, Inc.
Contact: Milton Philbrook
Port Gamble, Washington 98364
(206) 297-3341

Quilceda Creek - Snohomish Estuary

#17 EP1

Location:

State: Washington

County: Snohomish

NE¼ of Sec. 31 and NW¼ of Sec. 32, T30N, R5W
Latitude: 48° 02' N
Longitude: 122° 12' W

Approximate Size: 22 ha

Access: Take Marysville Exit off of I-5. Proceed westward toward Tualip Indian Reservation. About 1 km west of Indian Creek Bridge, make a left turn on Maplewood Road. Continue southward to end of road. The marsh is several meters east from end of road.

General Description: This marsh has formed on the northwest side of Quilceda Creek and Ebey Slough of the Snohomish River. It is a highly dissected marsh. It is located on a terrace which rises abruptly above the mud flat of the creek. *Carex lyngbei* and *Triglochin maritimum* predominate throughout the marsh, as well as does *Potentilla pacifica*, *Agrostis alba*, and *Juncus balticus*. The upland is composed of native vegetation growing on old drift material, or ruderal in nature.

Ownership: Tualip Tribal Council

Oak Bay - Admiralty Inlet

#18 NP1

Location:

State: Washington

County: Jefferson

NE¼ of the NE¼ of Sec. 7, T29N, R1E
Latitude: 48° 1' 25" N
Longitude: 122° 42' 30" W

Approximate Size: 0.7 ha

Access: Take the Hadlock-Fort Flagler Exit from State Highway 113 a few kilometers south of Port Townsend. Proceed through Hadlock towards Fort Flagler and cross Portage Canal Bridge. Once across the bridge continue southward for approximately 1 km. Take the second road to the right into Jefferson County Park. The marsh is just to the south of a parking lot and picnic area.

General Description: This marsh is protected from Oak Bay by a berm. The lagoon and tidal channels are fairly deep, and open to Oak Bay. The vegetation is dominated by *Salicornia virginica*. The upland vegetation occupies a steep slope which ends abruptly at the marsh. Therefore the transition zone is quite narrow. Prominant species in the upland are *Pseudotsuga menziesii*, *Arbutus menziesii*, and *Rosa nutkana*.

Ownership: Jefferson County Parks Department

Westcott Bay - San Juan Is.

#19 SJ1

Location:

State: Washington

County: San Juan

NE¼ of the NW¼ of Sec. 24, T36N, R4W
Latitude: 38° 37' N
Longitude: 123° 08' W

Approximate Size: 0.8 ha

Access: Follow Roche Harbor Road from Friday Harbor. 1 km east of Roche Harbor a lone, abandoned, white farm house fronts the marsh. The marsh is visible from this point, approximately 180 m down a southwest-facing hill. Fences border the upland.

General Description: This marsh is discontinuous, having outliers of *Salicornia virginica* - *Distichlis spicata* mats separated from the upland by mud flat and drainage channels. The vegetation is characterized by high dominance of a few species. The upland is separated from the marsh by a fence that protects the marsh from extensive sheep grazing. *Alnus rubra* dominates the overstory, while *Arbutus menziesii*, *Juniperus scopulorum*, *Abies grandis*, and *Salix* spp. occur sporadically.

Ownership: Private

Griffin Bay - San Juan Island

#20 SJ2

Location:

State: Washington

County: San Juan

NE¼ of Sec. 7, T38N, R2W
Latitude: 38° 28' N
Longitude: 122° 59' W

Approximate Size: 0.5 ha

Access: Follow road south out of Friday Harbor toward American Camp on the southeast part of the Island. Continue through American Camp to end of the road at Fish Creek. The marsh is 270 meters east of Fish Creek Bay over a small, forested hill.

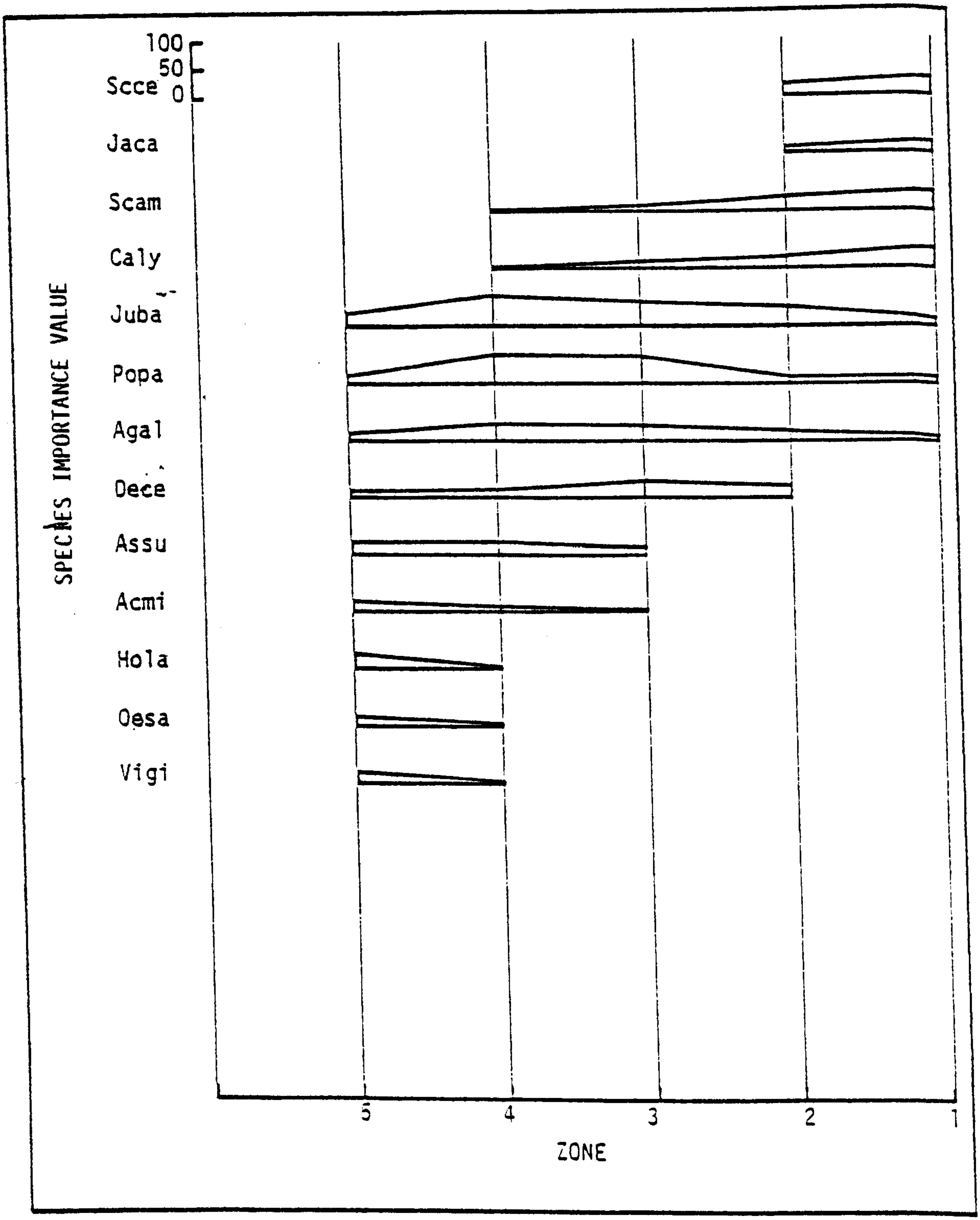
General Description: This marsh is fronted by a barrier beach that is open on the west end. Large areas of mud flat, and broad, shallowly dissected drainage channels predominate. Marsh vegetation is dominated by Salicornia virginica and Distichlis spicata. The upland is a mixed stand of Tsuga heterophylla, Pseudotsuga menziesii, Picea sitchensis, and Abies grandis.

Ownership: Private

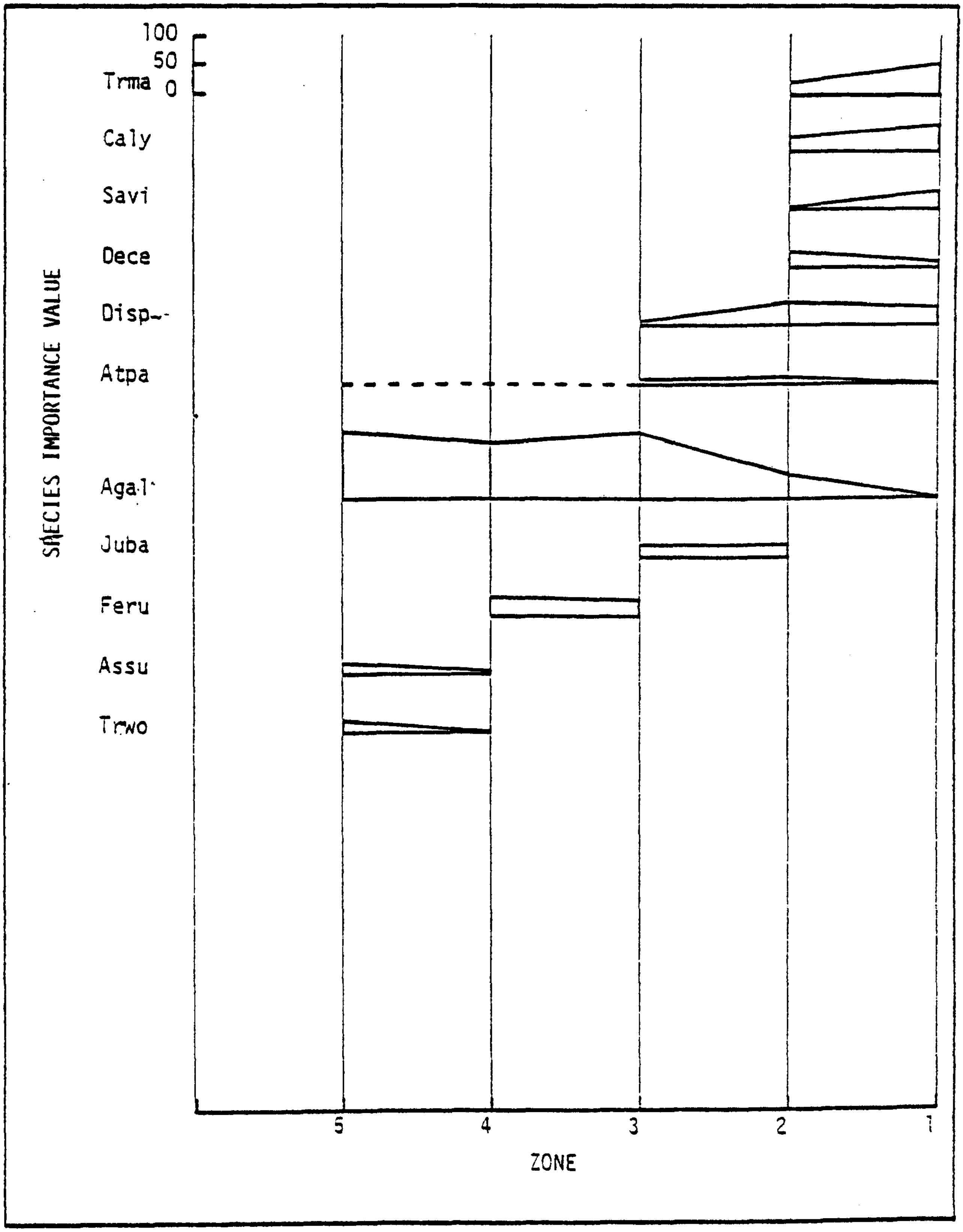
APPENDIX F

Selected Species Importance Values by Zone for 20 Study Sites

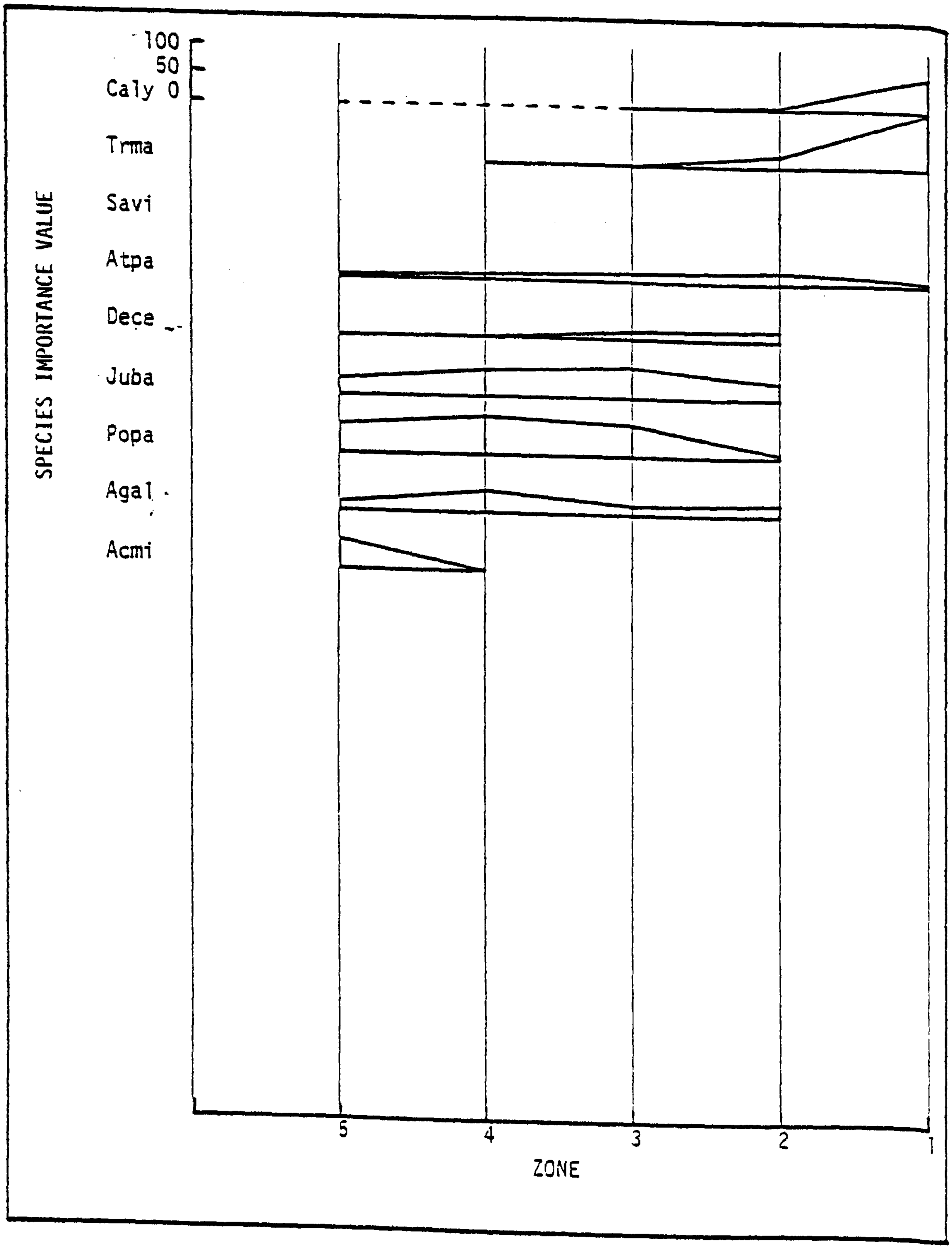
Selected Species Importance Values by Zone at Bandon Study Site, CQ1



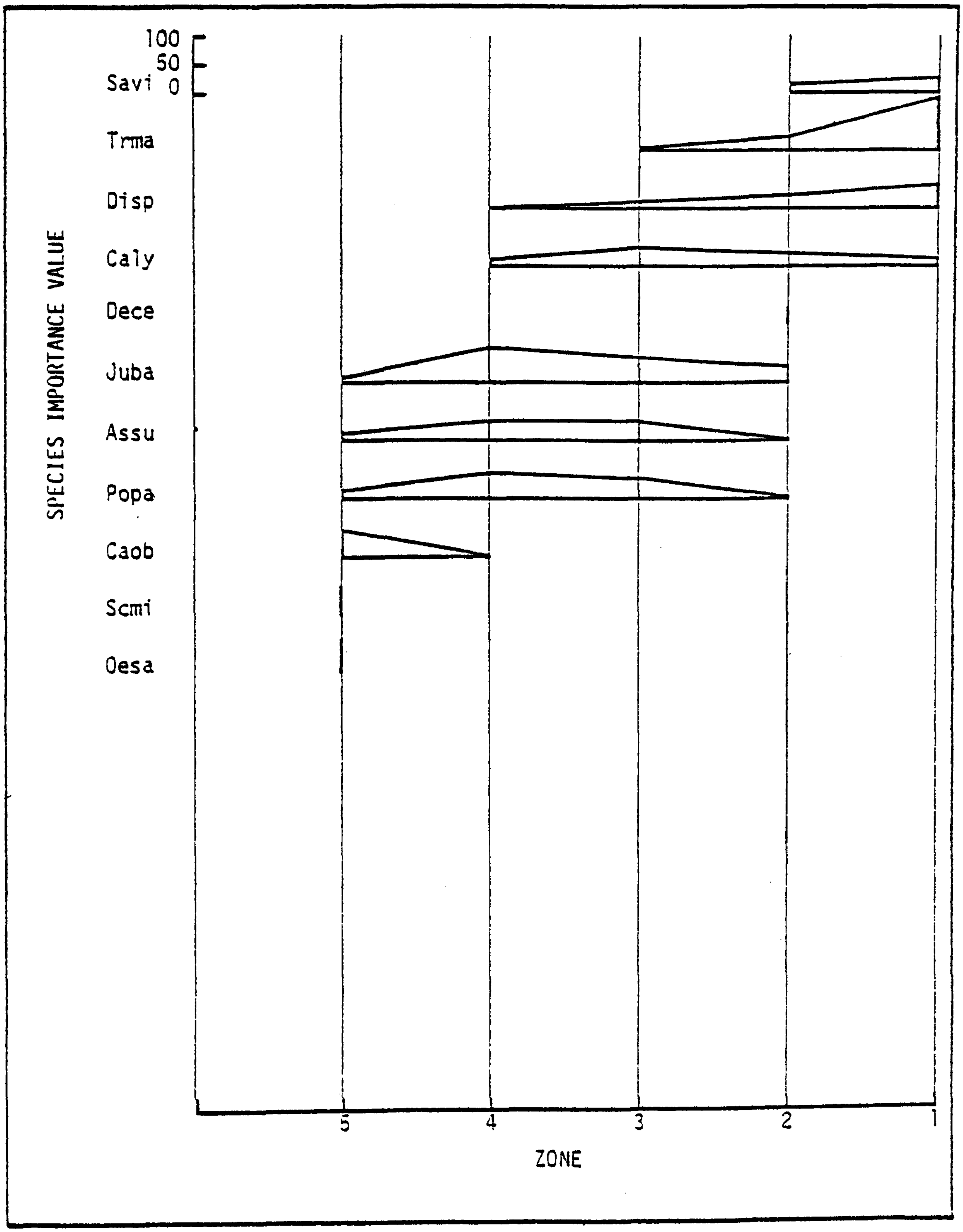
Selected Species Importance Values by Zone at Haynes Inlet Study Site, CB1



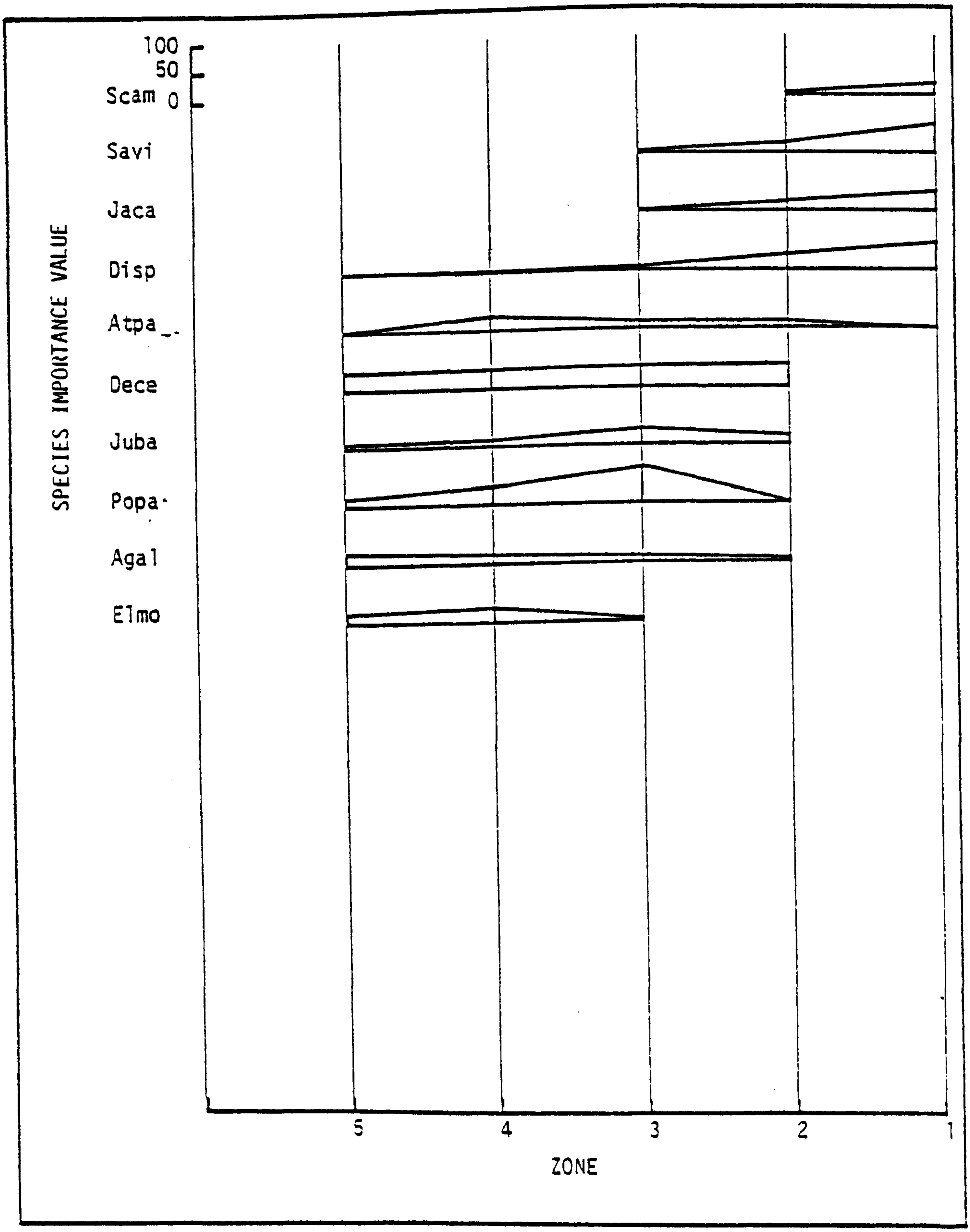
Selected Species Importance Values by Zone at Waldport South Study Site, AB1



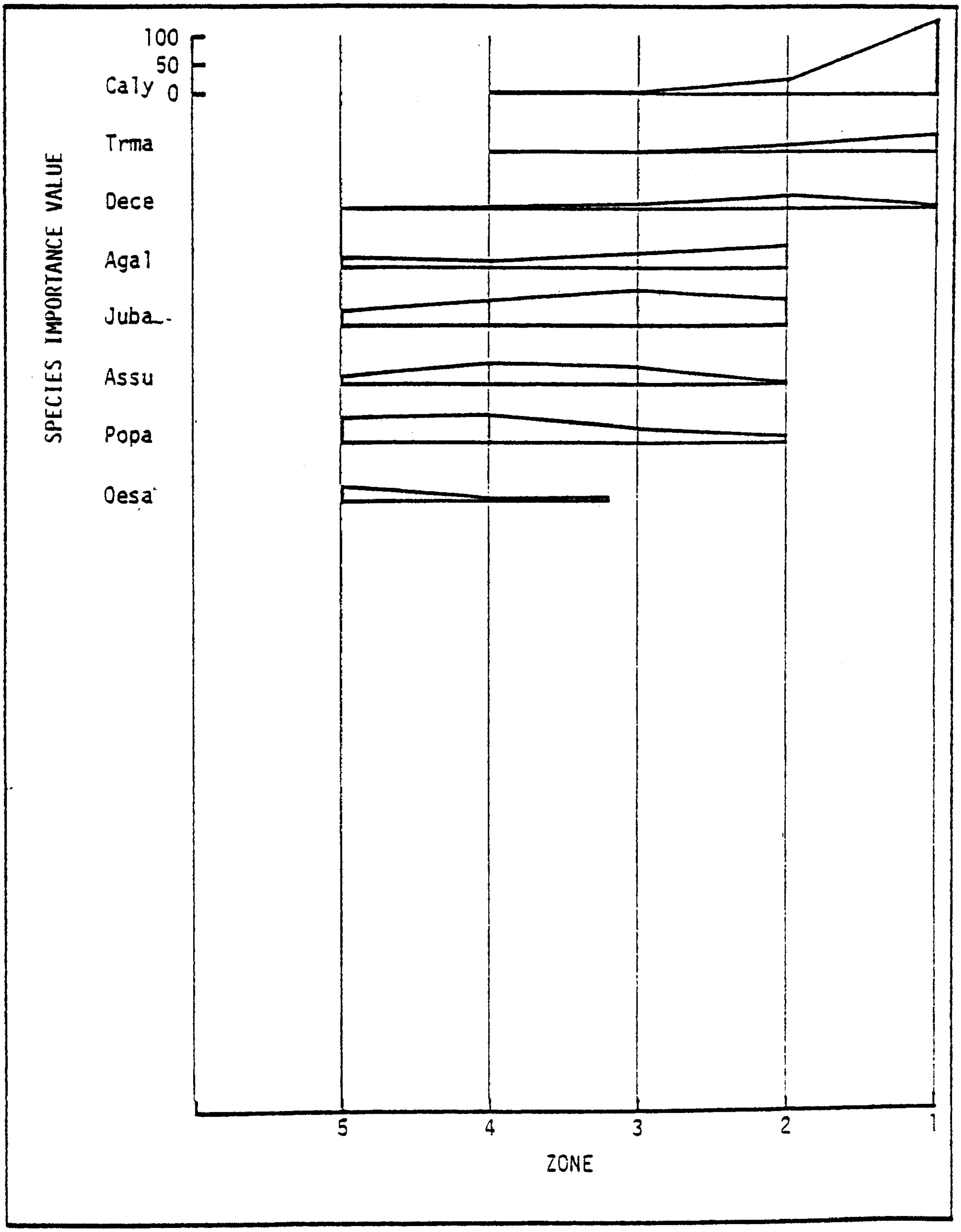
Selected Species Importance Values by Zone at Nute Slough Study Site, YB1



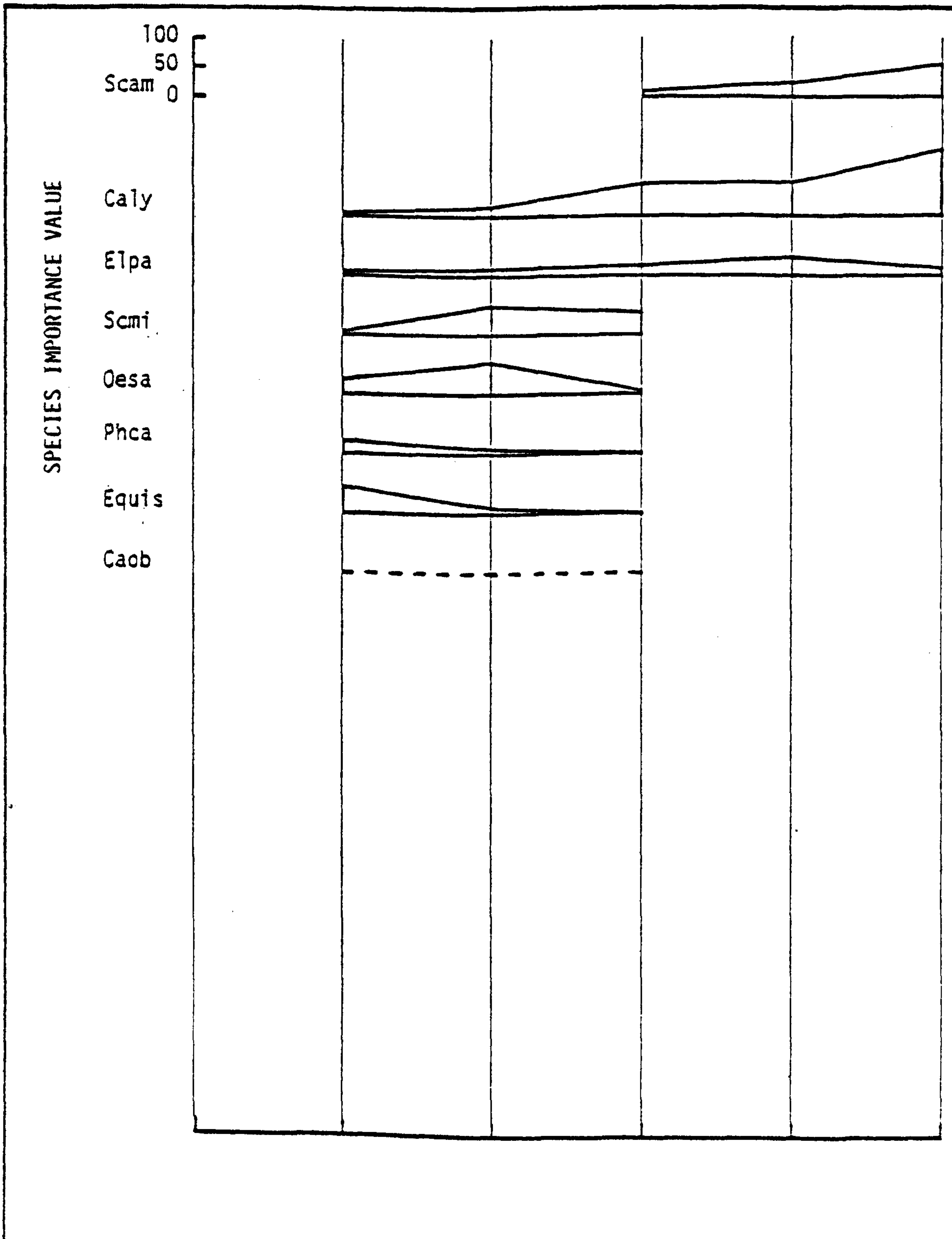
Selected Species Importance Values by Zone at Netarts Sand Spit Study Site, NT1



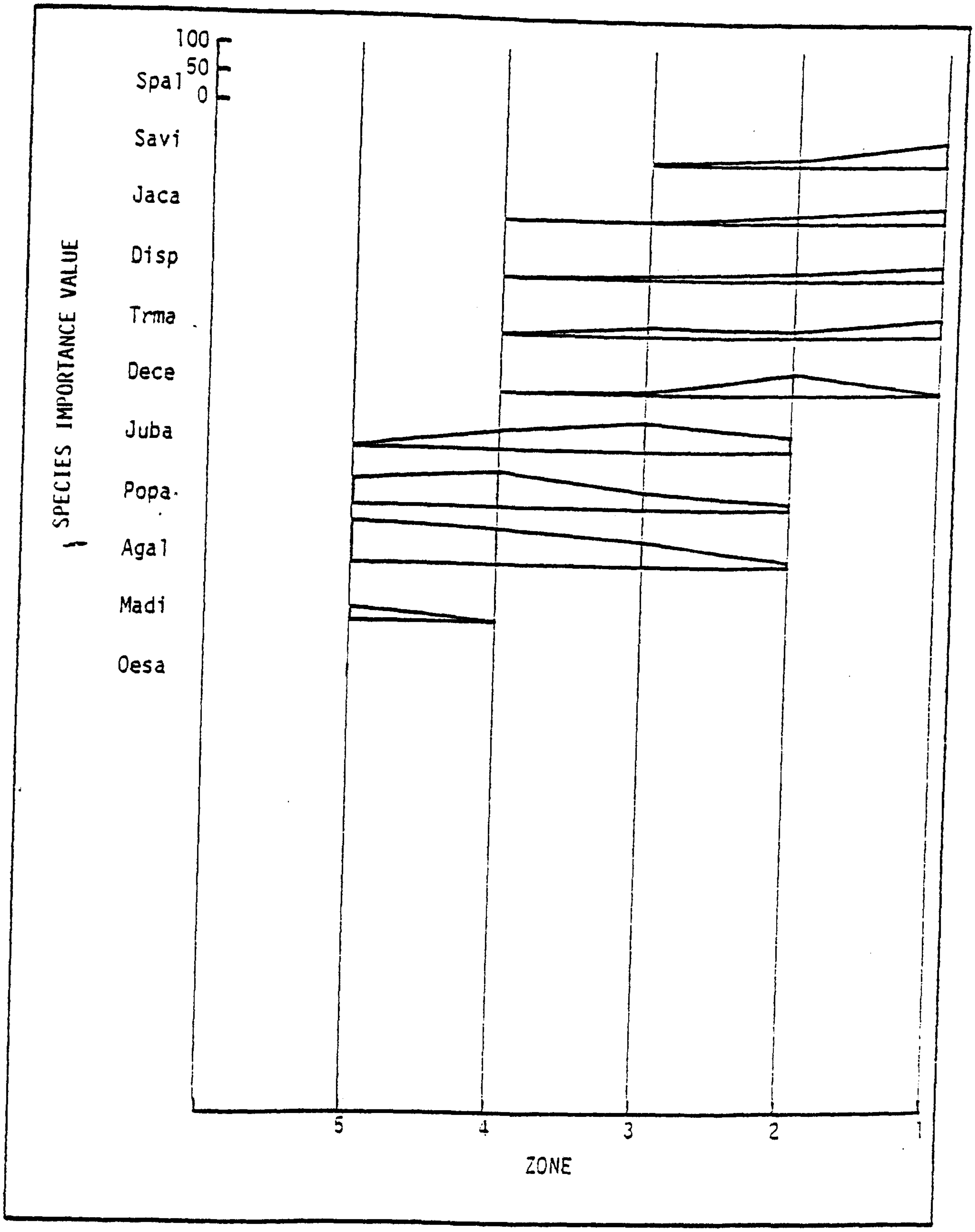
Selected Species Importance Values by Zone at West Island Study Site, NB2



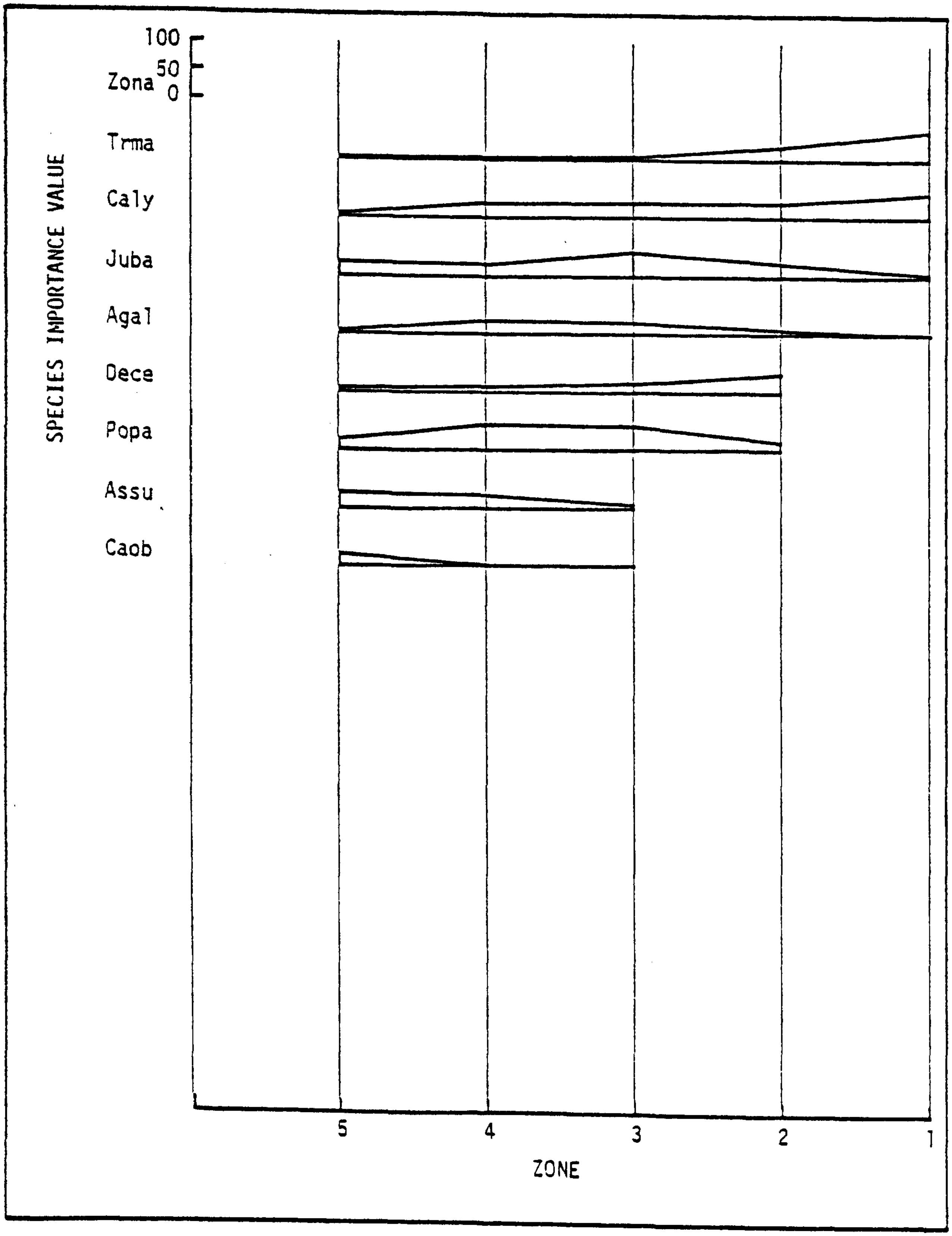
Selected Species Importance Values by Zone at Sea Garden Road Study Site, NB3



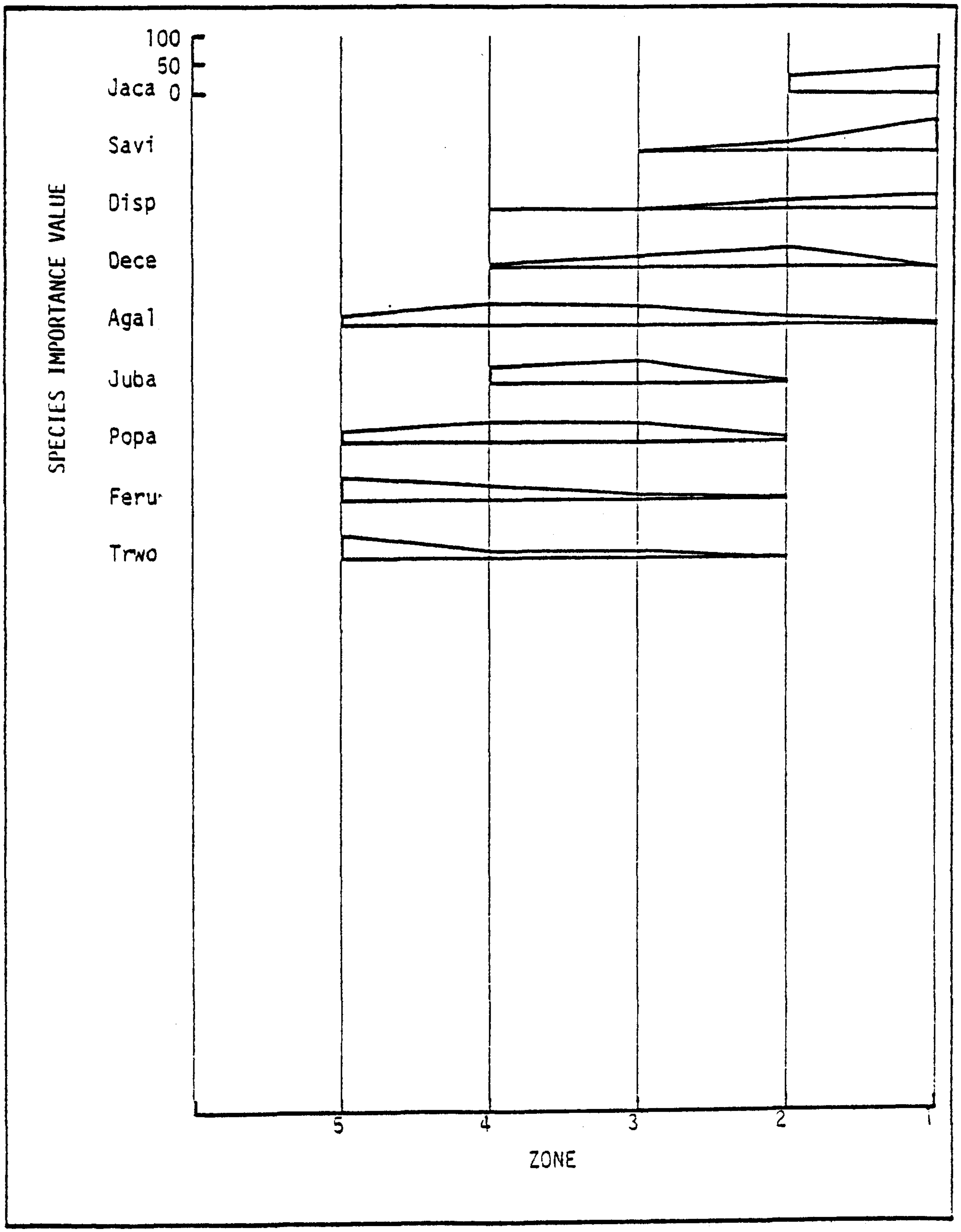
Selected Species Importance Values by Zone at Niawiakum Study Site, WB1



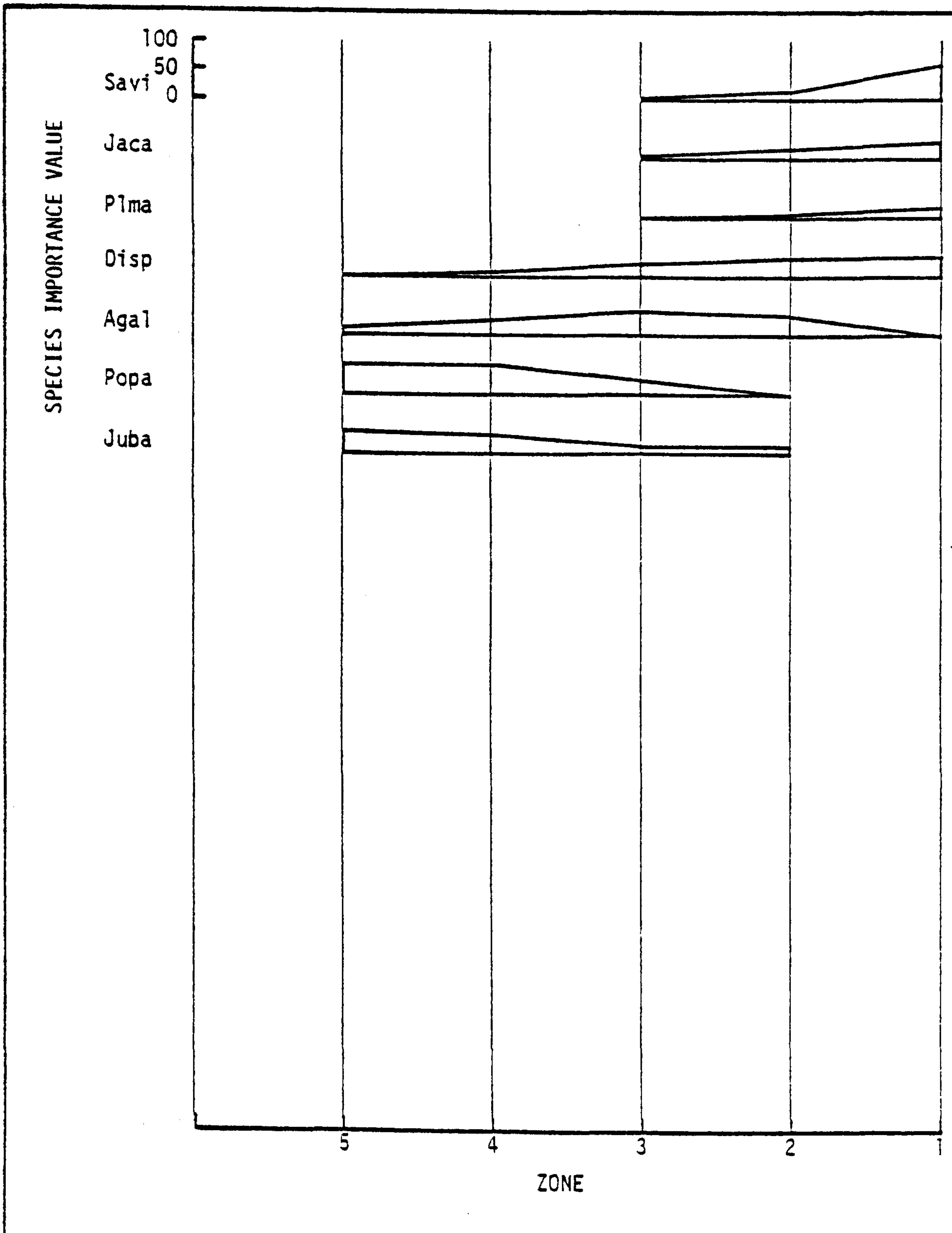
Selected Species Importance Values by Zone at Cedar River Study Site, WB2



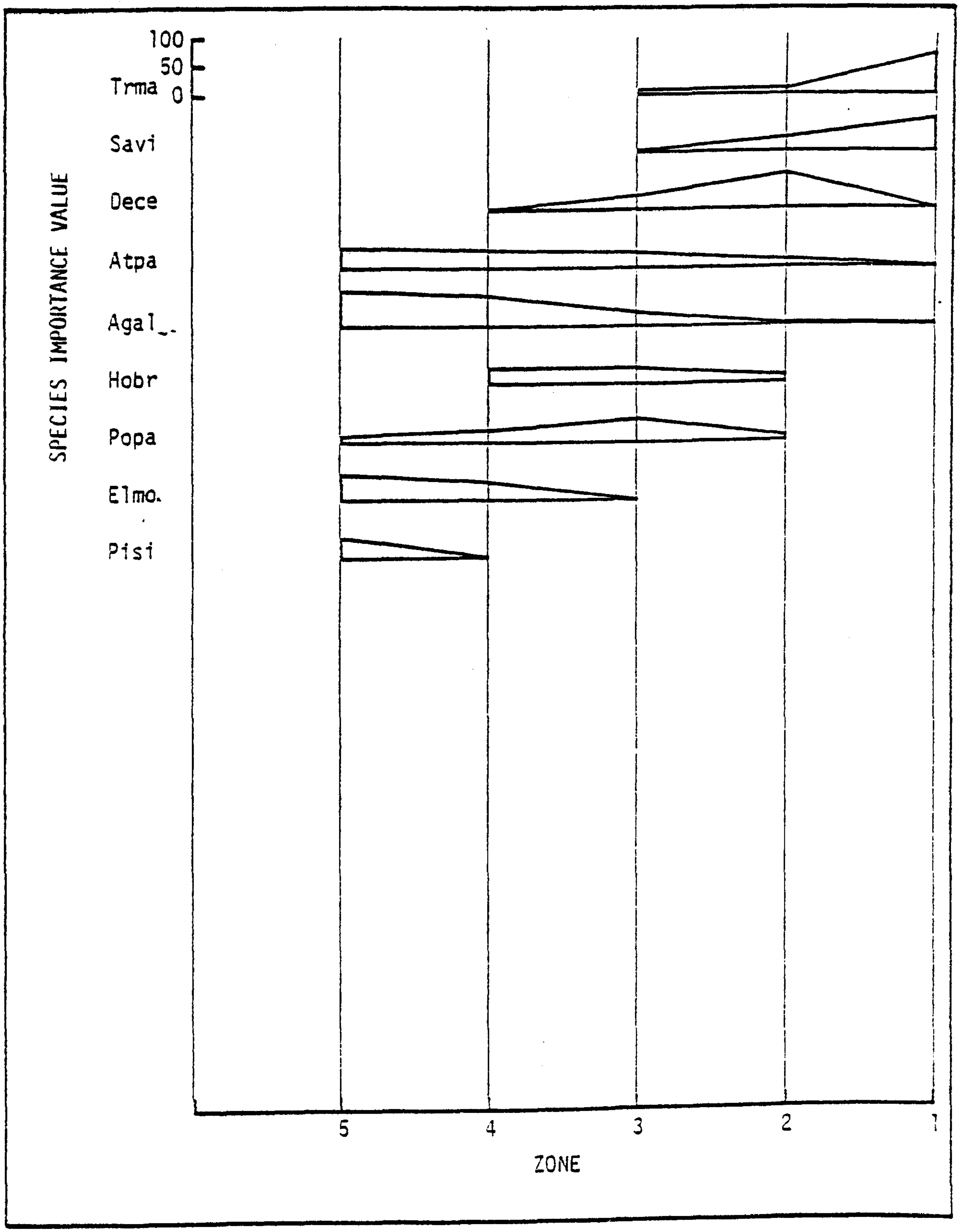
Selected Species Importance Values by Zone at Leadbetter Point Study Site, WB4



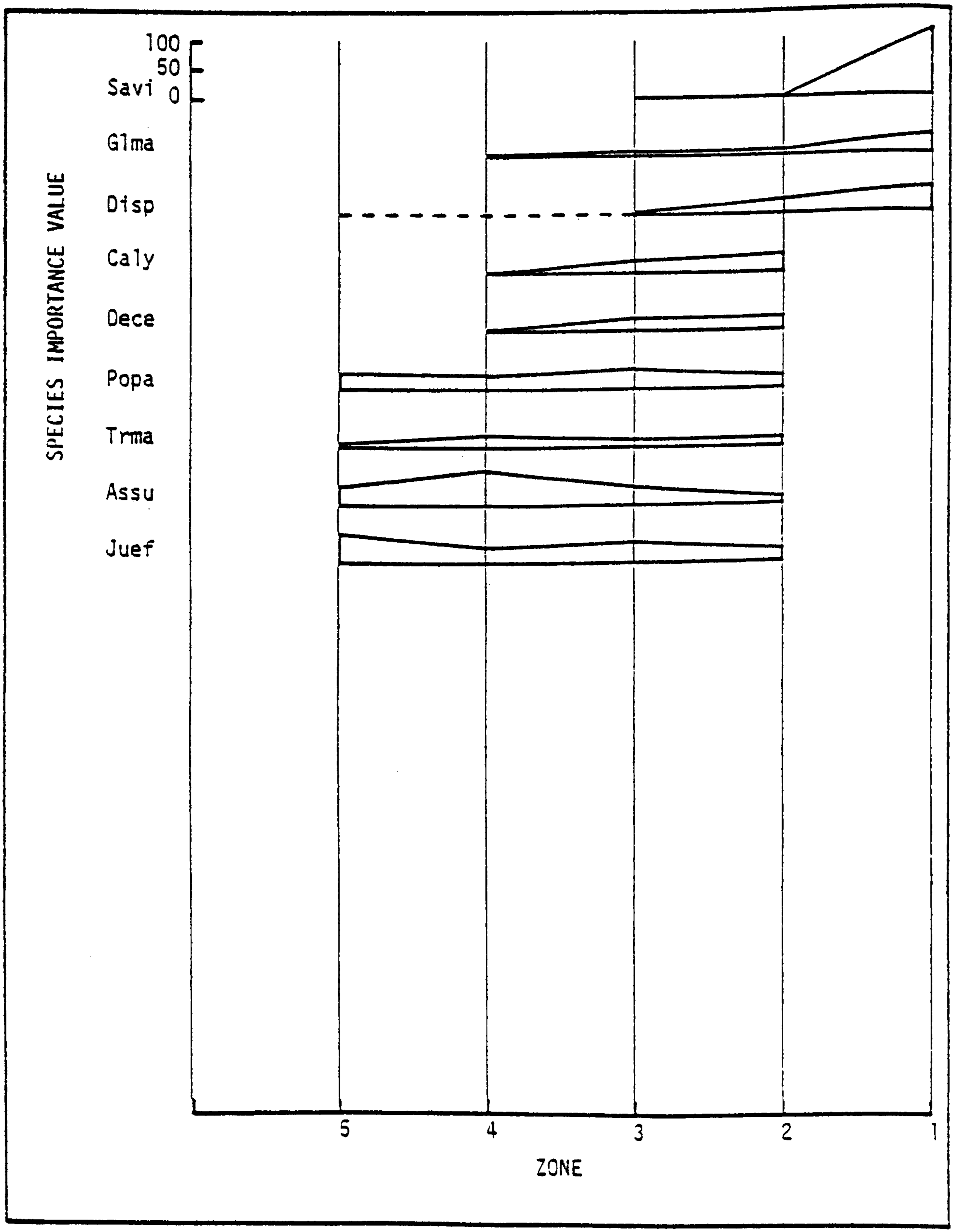
Selected Species Importance Values by Zone at The Sink Study Site, GH1



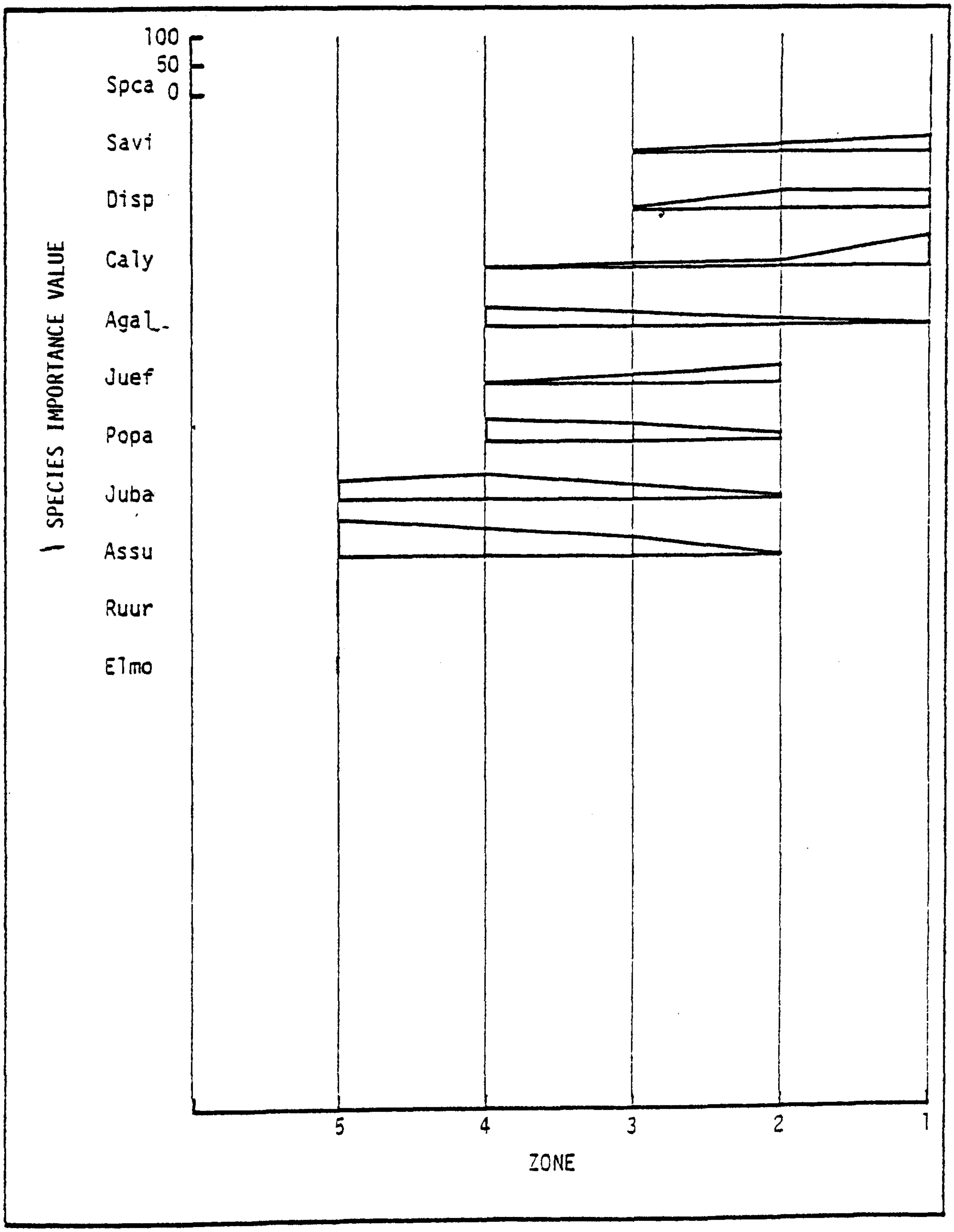
Selected Species Importance Values by Zone at Elk River Study Site, GH3



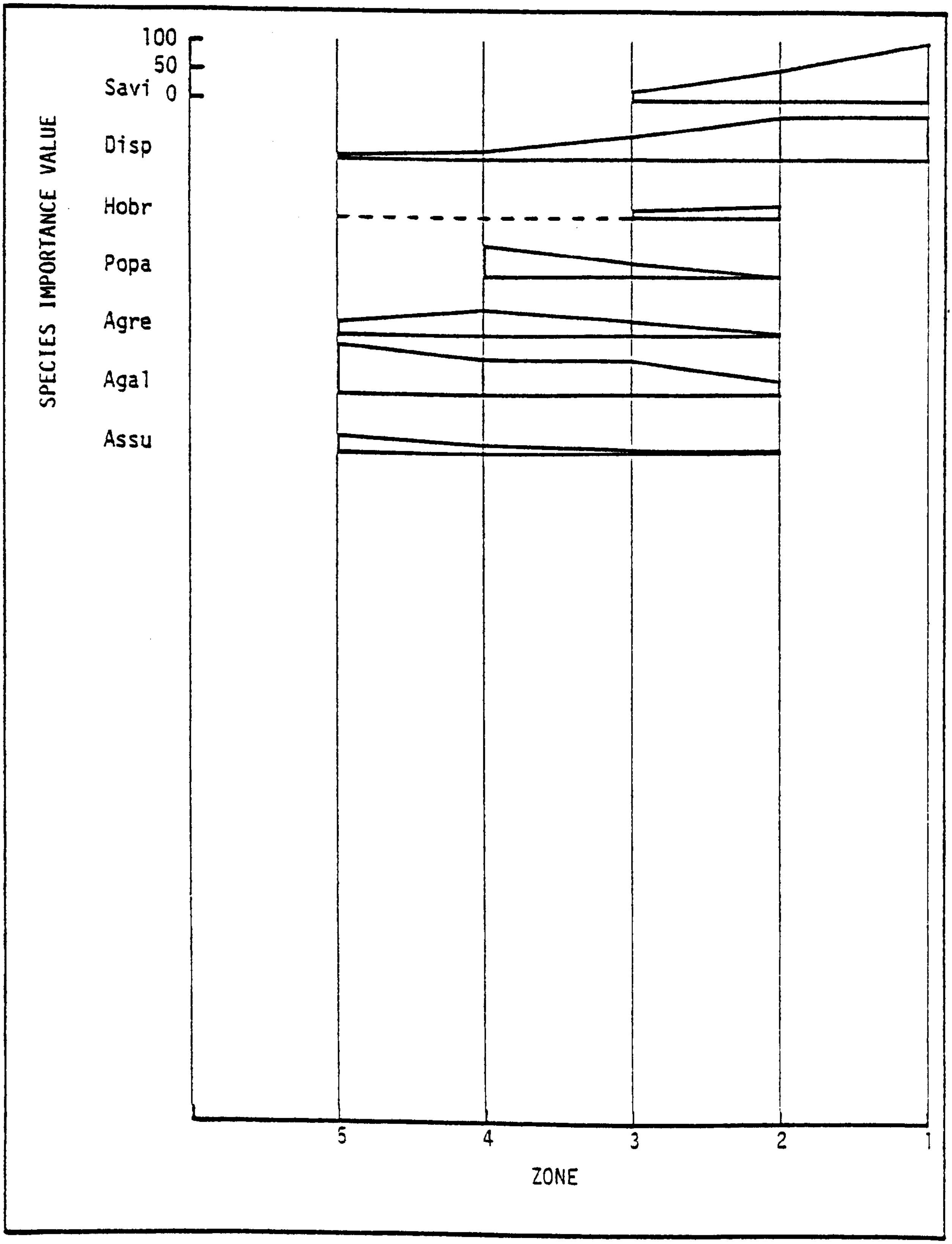
Selected Species Importance Values by Zone at Burley Lagoon Study Site, KS1



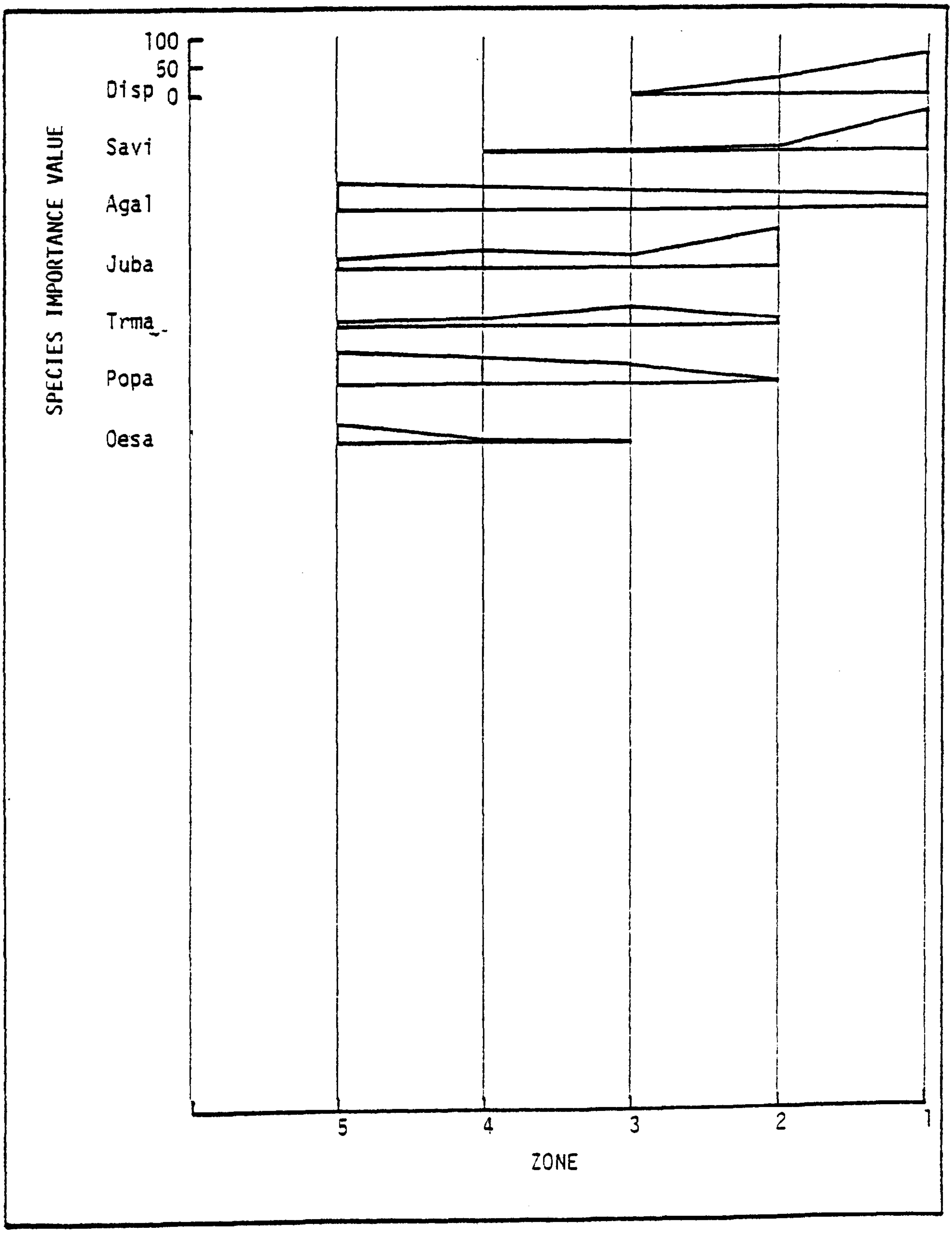
Selected Species Importance Values by Zone at Coulter Creek Study Site, KS2



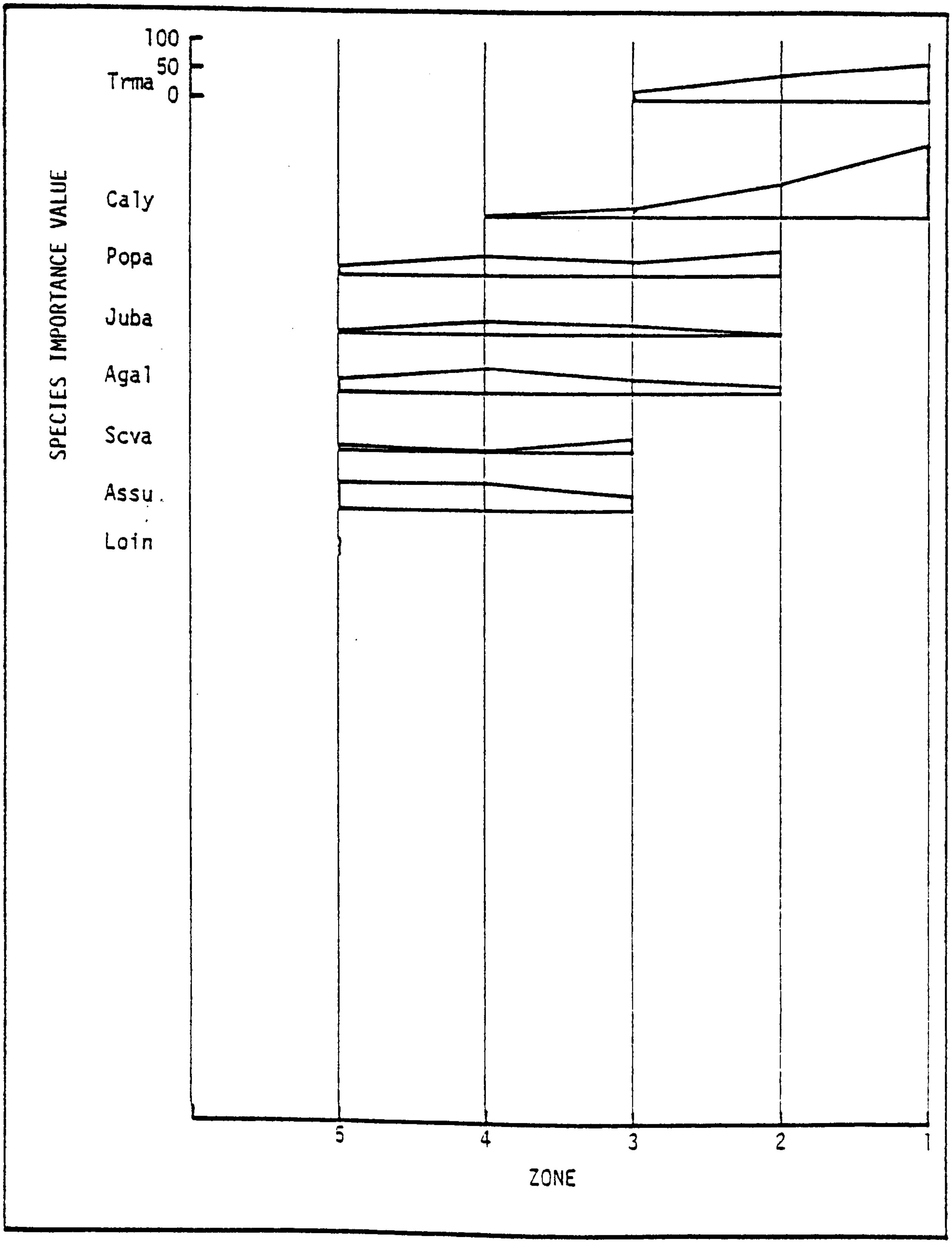
Selected Species Importance Values by Zone at Chico Bay Study Site, KS3



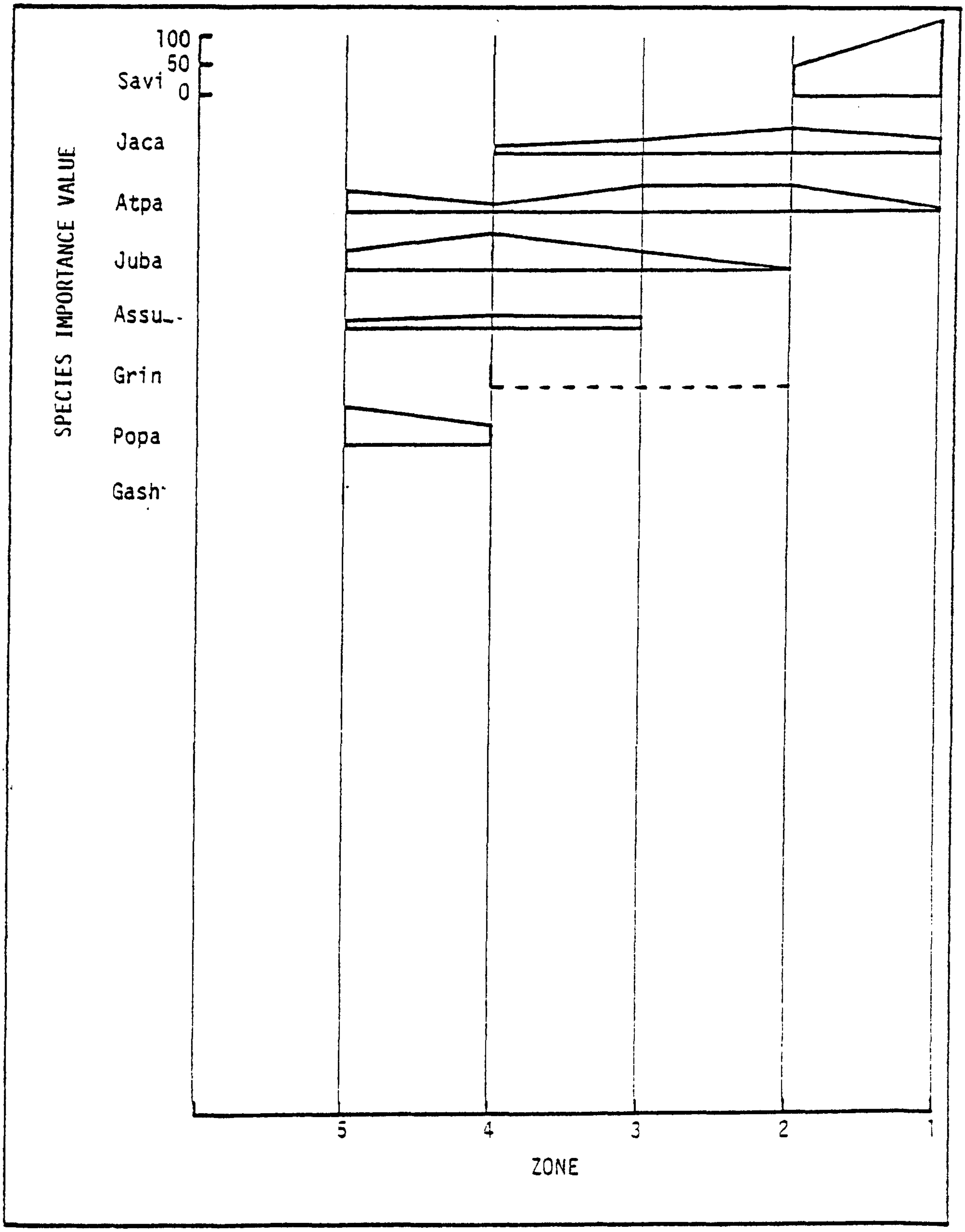
Selected Species Importance Values by Zone at Thorndyke Bay Study Site, HC1



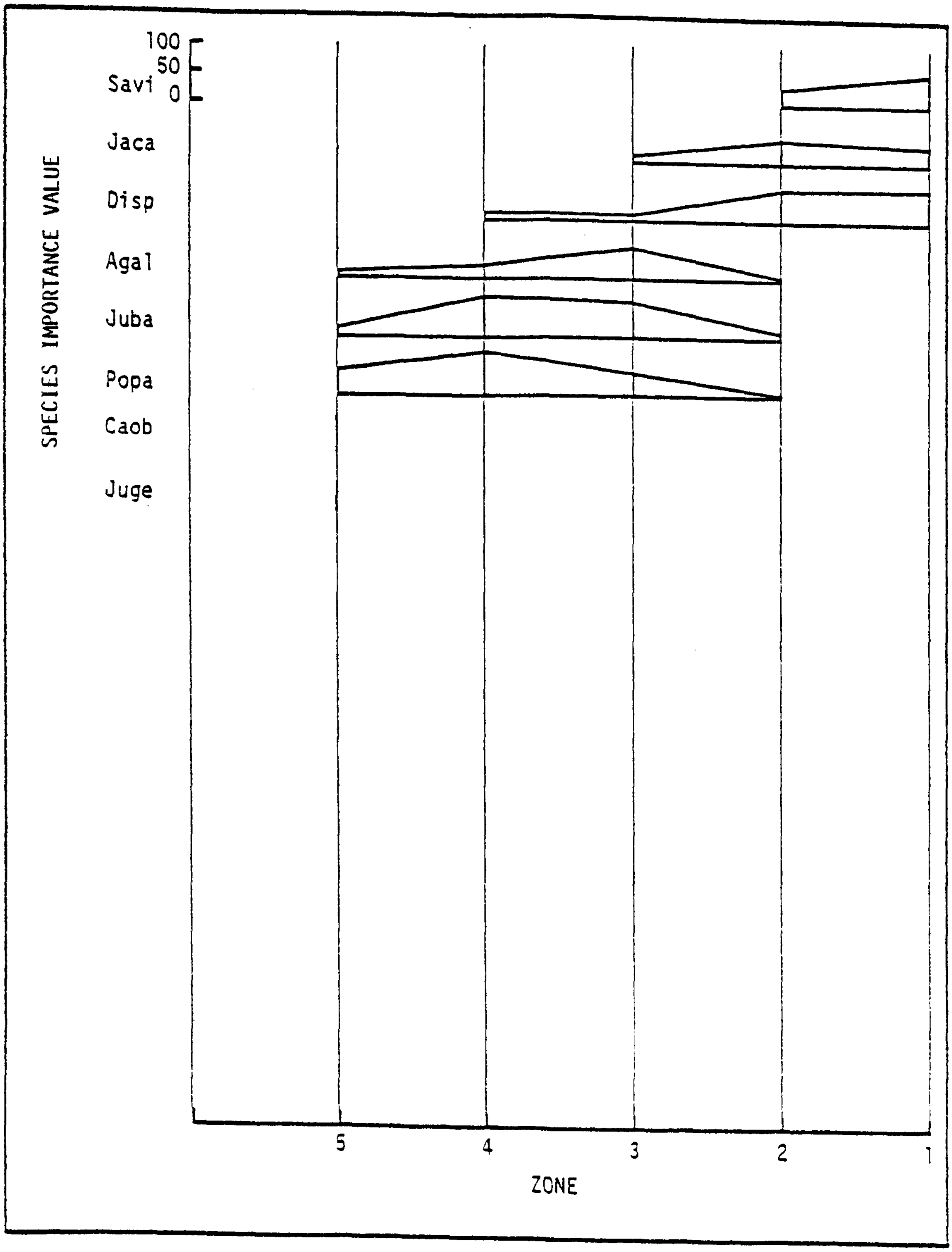
Selected Species Importance Values by Zone at Quilceda Creek Study Site, EP1



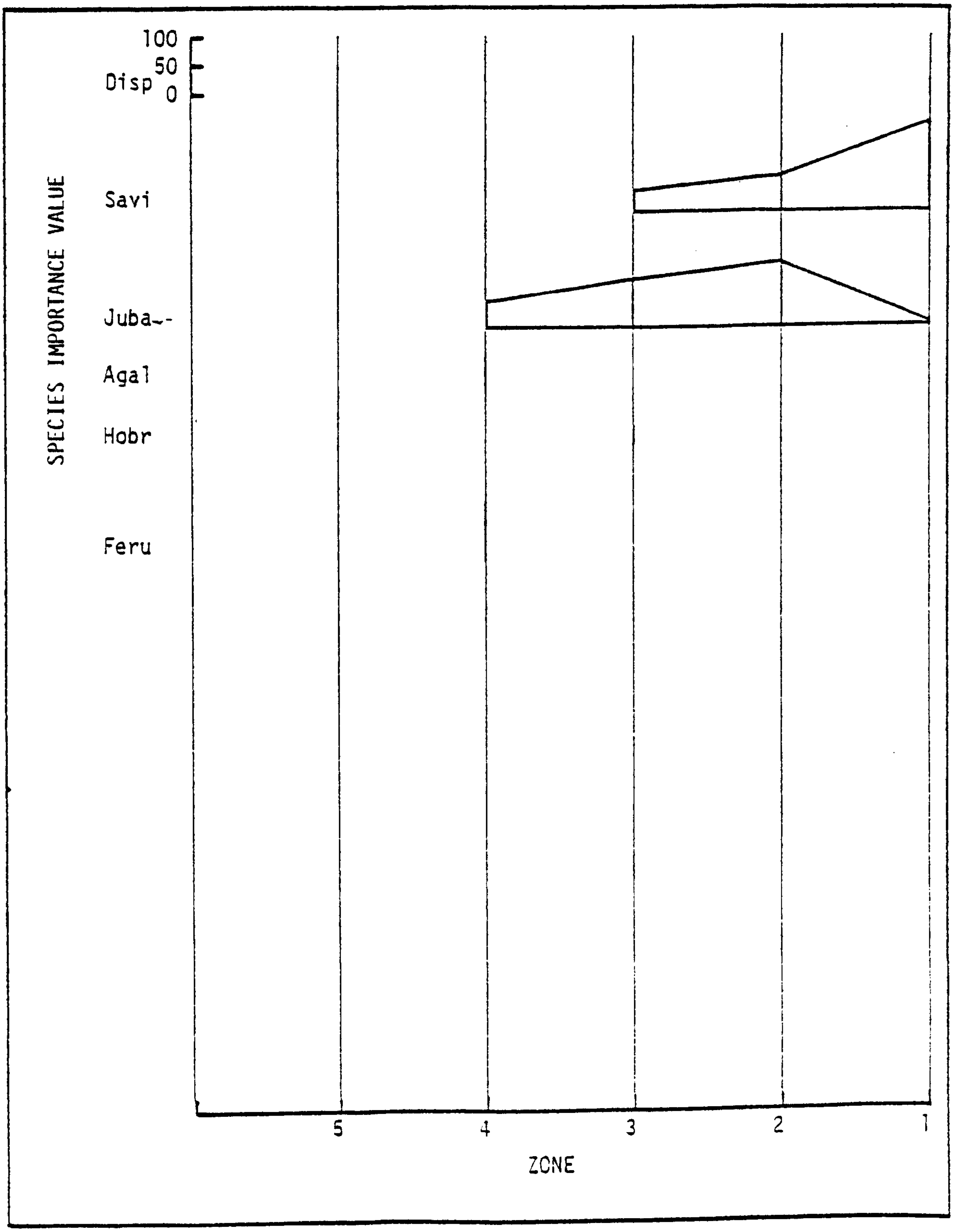
Selected Species Importance Values by Zone at Oak Bay Study Site, NP1



Selected Species Importance Values by Zone at Westcott Bay Study Site, SJ1



Selected Species Importance Values by Zone at Griffin Bay Study Site, SJ2



APPENDIX G

Discriminant Analysis Prediction Results

PREDICTION RESULTS - Bandon Marsh

ACTUAL GROUP NAME	CODE	N OF CASES	PREDICTED GROUP MEMBERSHIP GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5
GROUP 1	1	60	58. 96.7 PCT	2. 3.3 PCT	0 0 PCT	0 0 PCT	0 0 PCT
GROUP 2	2	27	14. 51.9 PCT	11. 40.7 PCT	1. 3.7 PCT	1. 3.7 PCT	0 0 PCT
GROUP 3	3	15	2. 13.3 PCT	2. 13.3 PCT	6. 40.0 PCT	5. 33.3 PCT	0 0 PCT
GROUP 4	4	33	2. 6.1 PCT	0 0 PCT	3. 9.1 PCT	25. 75.8 PCT	3. 9.1 PCT
GROUP 5	5	33	2. 6.1 PCT	0 0 PCT	1. 3.0 PCT	3. 9.1 PCT	27. 81.8 PCT

75.6 PERCENT OF KNOWN CASES CORRECTLY CLASSIFIED

CHI-SQUARE = 324.537 SIGNIFICANCE =

PREDICTION RESULTS - Haynes Inlet

ACTUAL GROUP NAME	CODE	N OF CASES	PREDICTED GROUP MEMBERSHIP GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5
GROUP 1	1	30	24. 80.0 PCT	6. 20.0 PCT	0 0 PCT	0 0 PCT	0 0 PCT
GROUP 2	2	56	2. 3.6 PCT	54. 96.4 PCT	0 0 PCT	0 0 PCT	0 0 PCT
GROUP 3	3	13	0 0 PCT	9. 69.2 PCT	3. 23.1 PCT	1. 7.7 PCT	0 0 PCT
GROUP 4	4	6	0 0 PCT	1. 16.7 PCT	1. 16.7 PCT	4. 66.7 PCT	0 0 PCT

81.0 PERCENT OF KNOWN CASES CORRECTLY CLASSIFIED

CHI-SQUARE = 175.317 SIGNIFICANCE = 0

PREDICTION RESULTS - Waldport South

ACTUAL GROUP NAME	CODE	N OF CASES	PREDICTED GROUP MEMBERSHIP GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5
GROUP 1	1	6	0 0 PCT	6. 100.0 PCT	0 0 PCT	0 0 PCT	0 0 PCT
GROUP 2	2	80	0 0 PCT	75. 93.8 PCT	2. 2.5 PCT	3. 3.7 PCT	0 0 PCT
GROUP 3	3	12	0 0 PCT	1. 8.3 PCT	5. 41.7 PCT	6. 50.0 PCT	0 0 PCT
GROUP 4	4	37	0 0 PCT	0 0 PCT	0 0 PCT	36. 97.3 PCT	1. 2.7 PCT
GROUP 5	5	26	0 0 PCT	0 0 PCT	0 0 PCT	4. 15.4 PCT	22. 84.6 PCT
UNGROUPED	6	1	0 0 PCT	0 0 PCT	0 0 PCT	1. 100.0 PCT	0 0 PCT

85.7 PERCENT OF KNOWN CASES CORRECTLY CLASSIFIED

CHI-SQUARE = 434.536 SIGNIFICANCE = 0

PREDICTION RESULTS - Nute Slough

ACTUAL GROUP NAME	CODE	N OF CASES	PREDICTED GROUP MEMBERSHIP GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5
GROUP 1	1	24	24. 100.0 PCT	0 0 PCT	0 0 PCT	0 0 PCT	0 0 PCT
GROUP 2	2	31	6. 19.4 PCT	21. 67.7 PCT	1. 3.2 PCT	3. 9.7 PCT	0 0 PCT
GROUP 3	3	15	1. 6.7 PCT	2. 13.3 PCT	8. 53.3 PCT	4. 26.7 PCT	0 0 PCT
GROUP 4	4	15	0 0 PCT	2. 13.3 PCT	3. 20.0 PCT	10. 66.7 PCT	0 0 PCT
GROUP 5	5	3	0 0 PCT	0 0 PCT	0 0 PCT	0 0 PCT	3. 100.0 PCT

75.0 PERCENT OF KNOWN CASES CORRECTLY CLASSIFIED

CHI-SQUARE = 164.375 SIGNIFICANCE = 0

PREDICTION RESULTS - Netarts Sand Spit

ACTUAL GROUP NAME	CODE	N OF CASES	PREDICTED GROUP MEMBERSHIP GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5
GROUP 1	1	50	50. 100.0 PCT	0 0 PCT	0 0 PCT	0 0 PCT	0 0 PCT
GROUP 2	2	39	9. 23.1 PCT	27. 69.2 PCT	3. 7.7 PCT	0 0 PCT	0 0 PCT
GROUP 3	3	26	1. 3.8 PCT	2. 7.7 PCT	21. 80.8 PCT	2. 7.7 PCT	0 0 PCT
GROUP 4	4	25	0 0 PCT	1. 4.0 PCT	4. 16.0 PCT	17. 68.0 PCT	3. 12.0 PCT
GROUP 5	5	15	0 0 PCT	0 0 PCT	0 0 PCT	3. 20.0 PCT	12. 80.0 PCT

81.9 PERCENT OF KNOWN CASES CORRECTLY CLASSIFIED

CHI-SQUARE = 371.613 SIGNIFICANCE = 0

PREDICTION RESULTS - West Island

ACTUAL GROUP NAME	CODE	N OF CASES	PREDICTED GROUP MEMBERSHIP GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5
GROUP 1	1	15	15. 100.0 PCT	0 0 PCT	0 0 PCT	0 0 PCT	0 0 PCT
GROUP 2	2	45	4. 8.9 PCT	37. 82.2 PCT	0 0 PCT	4. 8.9 PCT	0 0 PCT
GROUP 3	3	15	0 0 PCT	5. 33.3 PCT	3. 20.0 PCT	6. 40.0 PCT	1. 6.7 PCT
GROUP 4	4	80	0 0 PCT	11. 13.7 PCT	1. 1.2 PCT	60. 75.0 PCT	8. 10.0 PCT
GROUP 5	5	40	0 0 PCT	1. 2.5 PCT	0 0 PCT	10. 25.0 PCT	29. 72.5 PCT

73.8 PERCENT OF KNOWN CASES CORRECTLY CLASSIFIED

CHI-SQUARE = 353.365 SIGNIFICANCE = 0

PREDICTION RESULTS - Sea Garden Road

ACTUAL GROUP NAME	CODE	N OF CASES	PREDICTED GROUP MEMBERSHIP GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5
GROUP 1	1	105	45. 42.9 PCT	0 0 PCT	18. 17.1 PCT	0 0 PCT	0 0 PCT
GROUP 2	2	27	15. 55.6 PCT	12. 44.4 PCT	0 0 PCT	0 0 PCT	0 0 PCT
GROUP 3	3	44	6. 13.6 PCT	1. 2.3 PCT	33. 75.0 PCT	3. 6.8 PCT	1. 2.3 PCT
GROUP 4	4	16	1. 6.3 PCT	1. 6.3 PCT	7. 43.8 PCT	7. 43.8 PCT	0 0 PCT
GROUP 5	5	8	0 0 PCT	1. 12.5 PCT	1. 12.5 PCT	1. 12.5 PCT	5. 62.5 PCT

72.0 PERCENT OF KNOWN CASES CORRECTLY CLASSIFIED

CHI-SQUARE = 338.000 SIGNIFICANCE = 0

PREDICTION RESULTS - Ntawtakum

ACTUAL GROUP NAME	CODE	N OF CASES	PREDICTED GROUP MEMBERSHIP GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5
GROUP 1	1	20	13. 65.0 PCT	3. 15.0 PCT	4. 20.0 PCT	0 0 PCT	0 0 PCT
GROUP 2	2	52	1. 1.9 PCT	47. 90.4 PCT	2. 3.8 PCT	2. 3.8 PCT	0 0 PCT
GROUP 3	3	25	0 0 PCT	7. 28.0 PCT	7. 28.0 PCT	11. 44.0 PCT	0 0 PCT
GROUP 4	4	37	0 0 PCT	1. 2.7 PCT	3. 8.1 PCT	32. 86.5 PCT	1. 2.7 PCT
GROUP 5	5	14	0 0 PCT	0 0 PCT	3. 21.4 PCT	1. 7.1 PCT	10. 71.4 PCT

73.6 PERCENT OF KNOWN CASES CORRECTLY CLASSIFIED

CHI-SQUARE = 256.231 SIGNIFICANCE = 0

PREDICTION RESULTS - Cedar River

ACTUAL GROUP NAME	CODE	N OF CASES	PREDICTED GROUP MEMBERSHIP GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5
GROUP 1	1	49	49. 100.0 PCT	0 0 PCT	0 0 PCT	0 0 PCT	0 0 PCT
GROUP 2	2	47	9. 19.1 PCT	34. 72.3 PCT	4. 8.5 PCT	0 0 PCT	0 0 PCT
GROUP 3	3	24	2. 8.3 PCT	2. 8.3 PCT	18. 75.0 PCT	2. 8.3 PCT	0 0 PCT
GROUP 4	4	14	1. 7.1 PCT	1. 7.1 PCT	5. 35.7 PCT	7. 50.0 PCT	0 0 PCT
GROUP 5	5	23	1. 4.3 PCT	0 0 PCT	1. 4.3 PCT	0 0 PCT	21. 91.3 PCT

82.2 PERCENT OF KNOWN CASES CORRECTLY CLASSIFIED

CHI-SQUARE = 379.210 SIGNIFICANCE = 0

PREDICTION RESULTS - Leadbetter Point

ACTUAL GROUP NAME	CODE	N OF CASES	PREDICTED GROUP MEMBERSHIP GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5
GROUP 1	1	51	48. 94.1 PCT	3. 5.9 PCT	0 0 PCT	0 0 PCT	0 0 PCT
GROUP 2	2	56	12. 21.4 PCT	40. 71.4 PCT	4. 7.1 PCT	0 0 PCT	0 0 PCT
GROUP 3	3	16	0 0 PCT	6. 37.5 PCT	8. 50.0 PCT	2. 12.5 PCT	0 0 PCT
GROUP 4	4	20	0 0 PCT	3. 15.0 PCT	9. 45.0 PCT	8. 40.0 PCT	0 0 PCT
GROUP 5	5	8	0 0 PCT	0 0 PCT	0 0 PCT	1. 12.5 PCT	7. 87.5 PCT

73.5 PERCENT OF KNOWN CASES CORRECTLY CLASSIFIED

CHI-SQUARE = 270.225 SIGNIFICANCE = 0

PREDICTION RESULTS - The Sink

ACTUAL GROUP NAME	CODE	N. OF CASES	PREDICTED GROUP MEMBERSHIP GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5
GROUP 1	1	69	64. 92.8 PCT	5. 7.2 PCT	0 0 PCT	0 0 PCT	0 0 PCT
GROUP 2	2	61	7. 11.5 PCT	47. 77.0 PCT	3. 4.9 PCT	4. 6.6 PCT	0 0 PCT
GROUP 3	3	29	1. 3.4 PCT	9. 31.0 PCT	10. 34.5 PCT	9. 31.0 PCT	0 0 PCT
GROUP 4	4	40	0 0 PCT	2. 5.0 PCT	3. 7.5 PCT	34. 85.0 PCT	1. 2.5 PCT
GROUP 5	5	30	0 0 PCT	0 0 PCT	0 0 PCT	10. 33.3 PCT	20. 66.7 PCT

78.4 PERCENT OF KNOWN CASES CORRECTLY CLASSIFIED

CHI-SQUARE = 455.325 SIGNIFICANCE = 0

PREDICTION RESULTS - Elk River

ACTUAL GROUP NAME	CODE	N. OF CASES	PREDICTED GROUP MEMBERSHIP GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5
GROUP 1	1	21	19. 90.5 PCT	1. 4.8 PCT	1. 4.8 PCT	0 0 PCT	0 0 PCT
GROUP 2	2	38	1. 2.6 PCT	33. 86.8 PCT	4. 10.5 PCT	0 0 PCT	0 0 PCT
GROUP 3	3	20	1. 5.0 PCT	3. 15.0 PCT	16. 80.0 PCT	0 0 PCT	0 0 PCT
GROUP 4	4	33	0 0 PCT	0 0 PCT	4. 12.1 PCT	28. 84.8 PCT	1. 3.0 PCT
GROUP 5	5	3	0 0 PCT	0 0 PCT	0 0 PCT	2. 66.7 PCT	1. 33.3 PCT

84.3 PERCENT OF KNOWN CASES CORRECTLY CLASSIFIED

CHI-SQUARE = 237.309 SIGNIFICANCE = 0

PREDICTION RESULTS - Burley Lagoon

ACTUAL GROUP NAME	CODE	N OF CASES	PREDICTED GROUP MEMBERSHIP GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5
GROUP 1	1	1	1.	0	0	0	0
			100.0 PCT	0 PCT	0 PCT	0 PCT	0 PCT
GROUP 2	2	50	1.	40.	9.	0	0
			2.0 PCT	[illegible]	[illegible]	0 PCT	0 PCT
GROUP 3	3	28	1.	10.	17.	0	0
			3.6 PCT	35.7 PCT	60.7 PCT	0 PCT	0 PCT
GROUP 4	4	6	0	0	2.	4.	0
			0 PCT	0 PCT	33.3 PCT	66.7 PCT	0 PCT
GROUP 5	5	4	0	0	0	0	4.
			0 PCT	0 PCT	0 PCT	0 PCT	100.0 PCT

74.2 PERCENT OF KNOWN CASES CORRECTLY CLASSIFIED

CHI-SQUARE = 153.149 SIGNIFICANCE = 0

PREDICTION RESULTS - Coulter Creek

ACTUAL GROUP NAME	CODE	N OF CASES	PREDICTED GROUP MEMBERSHIP GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5
GROUP 1	1	30	30.	0	0	0	0
			100.0 PCT	0 PCT	0 PCT	0 PCT	0 PCT
GROUP 2	2	43	5.	33.	4.	0	0
			14.3 PCT	76.7 PCT	9.3 PCT	0 PCT	0 PCT
GROUP 3	3	37	1.	2.	31.	3.	0
			2.7 PCT	5.4 PCT	[illegible]	[illegible]	0 PCT
GROUP 4	4	16	0	0	6.	10.	0
			0 PCT	0 PCT	37.5 PCT	62.5 PCT	0 PCT
GROUP 5	5	2	1.	0	0	0	1.
			50.0 PCT	0 PCT	0 PCT	0 PCT	50.0 PCT

[illegible] PERCENT OF KNOWN CASES CORRECTLY CLASSIFIED

CHI-SQUARE = 307.370 SIGNIFICANCE = 0

PREDICTION RESULTS - Chico Bay

ACTUAL GROUP NAME	CODE	N OF CASES	PREDICTED GROUP MEMBERSHIP GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5
GROUP 1	1	45	45. 100.0 PCT	0 0 PCT	0 0 PCT	0 0 PCT	0 0 PCT
GROUP 2	2	14	6. 42.9 PCT	7. 50.0 PCT	1. 7.1 PCT	0 0 PCT	0 0 PCT
GROUP 3	3	9	1. 11.1 PCT	0 0 PCT	7. 77.8 PCT	1. 11.1 PCT	0 0 PCT
GROUP 4	4	6	0 0 PCT	0 0 PCT	1. 16.7 PCT	5. 83.3 PCT	0 0 PCT
GROUP 5	5	4	0 0 PCT	0 0 PCT	1. 25.0 PCT	0 0 PCT	3. 75.0 PCT

85.9 PERCENT OF KNOWN CASES CORRECTLY CLASSIFIED

CHI-SQUARE = 211.458 SIGNIFICANCE = 0

PREDICTION RESULTS - Thorndyke Bay

ACTUAL GROUP NAME	CODE	N OF CASES	PREDICTED GROUP MEMBERSHIP GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5
GROUP 1	1	3	2. 66.7 PCT	1. 33.3 PCT	0 0 PCT	0 0 PCT	0 0 PCT
GROUP 2	2	27	0 0 PCT	16. 59.3 PCT	11. 40.7 PCT	0 0 PCT	0 0 PCT
GROUP 3	3	25	0 0 PCT	3. 12.0 PCT	21. 84.0 PCT	0 0 PCT	1. 4.0 PCT
GROUP 4	4	15	0 0 PCT	1. 6.7 PCT	14. 93.3 PCT	0 0 PCT	0 0 PCT
GROUP 5	5	8	0 0 PCT	0 0 PCT	2. 25.0 PCT	0 0 PCT	6. 75.0 PCT

57.7 PERCENT OF KNOWN CASES CORRECTLY CLASSIFIED

CHI-SQUARE = 89.260 SIGNIFICANCE = .000

PREDICTION RESULTS - Quilceda Creek

ACTUAL GROUP NAME	CODE	N OF CASES	PREDICTED GROUP MEMBERSHIP GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5
GROUP 1	1	8	4. 50.0 PCT	3. 37.5 PCT	1. 12.5 PCT	0 0 PCT	0 0 PCT
GROUP 2	2	45	1. 2.2 PCT	39. 86.7 PCT	5. 11.1 PCT	0 0 PCT	0. 0 PCT
GROUP 3	3	34	0 0 PCT	3. 8.8 PCT	25. 73.5 PCT	6. 17.6 PCT	0 0 PCT
GROUP 4	4	21	0 0 PCT	0 0 PCT	7. 33.3 PCT	14. 66.7 PCT	0 0 PCT
GROUP 5	5	25	0 0 PCT	0 0 PCT	7. 28.0 PCT	6. 24.0 PCT	12. 48.0 PCT

70.7 PERCENT OF KNOWN CASES CORRECTLY CLASSIFIED

CHI-SQUARE = 213.476 SIGNIFICANCE = 0

PREDICTION RESULTS - Oak Bay

ACTUAL GROUP NAME	CODE	N OF CASES	PREDICTED GROUP MEMBERSHIP GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5
GROUP 1	1	75	73. 97.3 PCT	2. 2.7 PCT	0 0 PCT	0 0 PCT	0 0 PCT
GROUP 2	2	25	15. 60.0 PCT	10. 40.0 PCT	0 0 PCT	0 0 PCT	0 0 PCT
GROUP 3	3	9	1. 11.1 PCT	0 0 PCT	8. 88.9 PCT	0 0 PCT	0 0 PCT
GROUP 4	4	2	0 0 PCT	0 0 PCT	0 0 PCT	2. 100.0 PCT	0 0 PCT
GROUP 5	5	3	0 0 PCT	0 0 PCT	0 0 PCT	0 0 PCT	3. 100.0 PCT

84.2 PERCENT OF KNOWN CASES CORRECTLY CLASSIFIED

CHI-SQUARE = 293.763 SIGNIFICANCE = 0

PREDICTION RESULTS - Westcott Bay

ACTUAL GROUP NAME	CODE	N OF CASES	PREDICTED GROUP MEMBERSHIP GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5
GROUP 1	1	26	26. 100.0 PCT	0 0 PCT	0 0 PCT	0 0 PCT	0 0 PCT
GROUP 2	2	5	2. 40.0 PCT	2. 40.0 PCT	0 0 PCT	1. 20.0 PCT	0 0 PCT
GROUP 3	3	2	0 0 PCT	0 0 PCT	1. 50.0 PCT	1. 50.0 PCT	0 0 PCT
GROUP 4	4	7	0 0 PCT	0 0 PCT	0 0 PCT	7. 100.0 PCT	0 0 PCT
GROUP 5	5	5	0 0 PCT	0 0 PCT	0 0 PCT	0 0 PCT	5. 100.0 PCT

91.1 PERCENT OF KNOWN CASES CORRECTLY CLASSIFIED

CHI-SQUARE = 142.222 SIGNIFICANCE = 0

PREDICTION RESULTS - Griffin Bay

ACTUAL GROUP NAME	CODE	N OF CASES	PREDICTED GROUP MEMBERSHIP GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5
GROUP 1	1	36	36. 100.0 PCT	0 0 PCT	0 0 PCT	0 0 PCT	0 0 PCT
GROUP 2	2	3	0 0 PCT	3. 100.0 PCT	0 0 PCT	0 0 PCT	0 0 PCT
GROUP 3	3	4	0 0 PCT	0 0 PCT	4. 100.0 PCT	0 0 PCT	0 0 PCT
GROUP 4	4	1	0 0 PCT	0 0 PCT	0 0 PCT	1. 100.0 PCT	0 0 PCT

100.0 PERCENT OF KNOWN CASES CORRECTLY CLASSIFIED

CHI-SQUARE = 132.460 SIGNIFICANCE = 0

APPENDIX H

Upland Tree Frequency, Average Cover, and
Basal Area for 20 Study Sites

Marsh	CQ1			CB1			AB1			YB1			NT1		
Number of Samples	12			10			10			9			10		
Vegetation Attribute	Freq. (%)	Mean Cover (%)	B.A. (m²/ha)	Freq. (%)	Mean Cover (%)	B.A. (m²/ha)	Freq. (%)	Mean Cover (%)	B.A. (m²/ha)	Freq. (%)	Mean Cover (%)	B.A. (m²/ha)	Freq. (%)	Mean Cover (%)	B.A. (m²/ha)
Species															
Abies grandis															
Acer macrophyllum										89	23	2.4			
Alnus rubra	100	29	4.0	30	10	*	80	17	3.5						
Arbutus menziesii															
Fraxinus latifolia															
Juniperus scopulorum													10	2	0.1
Myrica californica	58	5	0.4	10	2	*									
Osmaronia cerasiformis															
Physocarpus capitatus										100	51	4.4	60	19	2.8
Picea sitchensis	100	41	11.3	50	12	*	100	46	5.3				40	5	0.5
Prunus spp.															
Prunus emarginata															
Prunus virginiana															
Pseudotsuga menziesii				30	7	*	20	3	0.2	44	2	0.4	10	2	0.2
Pyrus fusca							10	1	0.2						
Rhamnus purshiana							50	4	0.3						
Salix spp.	25	2	0.7							11	1	+	20	2	0.3
Salix hookeriana				100	59	*									
Sambucus racemosa															
Thuja plicata													20	1	0.2
Tsuga heterophylla				10	++	*	20	1	0.2						

[1] Frequency (%) = $\frac{\text{no. plots of species occurrence}}{\text{total no. of plots taken}} \times 100$

Mean cover (%) = $\frac{\text{total cover for a given species in all plots}}{\text{total no. of plots}} \times 100$

"++" = mean cover < 0.5%

Basal area is calculated using a 10-factor prism
"+" = basal area < 0.05 m²/ha

[2] The asterisk (*) indicates no basal area calculation made at site.

Marsh	NB2			NB3			WB1			WB2			WB4[3]		
Number of Samples	9			13			10			10			10		
Vegetation Attribute		Mean			Mean			Mean			Mean			Mean	
Species	Freq. (%)	Cover (%)	B.A. (m^2/ha)	Freq. (%)	Cover (%)	B.A. (m^2/ha)	Freq. (%)	Cover (%)	B.A. (m^2/ha)	Freq. (%)	Cover (%)	B.A. (m^2/ha)	Freq. (%)	Cover (%)	B.A. (m^2/ha)
Abies grandis															
Acer macrophyllum				77	29	2.9	100	24	4.3	70	16	2.4			
Alnus rubra															
Arbutus menziesii															
Fraxinus latifolia															
Juniperus scopulorum															
Myrica californica							10	4	0.2						
Osmaronia cerasiformis	11	2	1.1	38	11	0.7									
Physocarpus capitatus	78	16	2.1	77	20	3.4	100	33	7.6	80	19	2.4			
Picea sitchensis															
Prunus spp.															
Prunus emarginata															
Prunus virginiana				85	2	0.2									
Pseudotsuga menziesii							40	12	1.1	30	2	+			
Pyrus fusca							10	2	+	20	2	+			
Rhamnus purshiana															
Salix spp.	78	42	4.2	31	10	2.2	20	1	+						
Salix hookeriana															
Sambucus racemosa				15	++	0.2	10	++	0.1						
Thuja plicata	11	++	1.1	38	6	1.2	40	5	0.6	90	38	7.9			
Tsuga heterophylla															

[3] No trees present in upland.

Marsh	GH1			GH3			KS1			KS2			KS3		
Number of Samples	11			10			10			10			5		
Vegetation Attributes		Mean			Mean			Mean			Mean			Mean	
Species	Freq. (%)	Cover (%)	B.A. (m^2/ha)	Freq. (%)	Cover (%)	B.A. (m^2/ha)	Freq. (%)	Cover (%)	B.A. (m^2/ha)	Freq. (%)	Cover (%)	B.A. (m^2/ha)	Freq. (%)	Cover (%)	B.A. (m^2/ha)
Abies grandis															
Acer macrophyllum							10	++	0.2	10	3	0.3			
Alnus rubra	9	7	+	60	13	1.4	70	9	1.4	20	1	0.2			
Arbutus menziesii															
Fraxinus latifolia										70	13	1.7			
Juniperus scopulorum															
Myrica californica				10	++	+									
Osmaronia cerasiformis															
Physocarpus capitatus															
Picea sitchensis				100	41	0.7				60	16	2.1			
Prunus spp.							10	++	0.1						
Prunus emarginata															
Prunus virginiana															
Pseudotsuga menziesii															
Pyrus fusca				100	14	1.2	20	1	0.1	10	1	0.2			
Rhamnus purshiana				50	8	0.2				10	++	+			
Salix spp.													80	8	*
Salix hookeriana															
Sambucus racemosa							10	++	+						
Thuja plicata							80	35	6.7	70	7	1.4			
Tsuga heterophylla				80	16	1.7									

Marsh	HC1			EP1			NP1			SJ1			SJ2		
Number of Samples	12			9			9			5			5		
Vegetation Attribute / Species	Freq. (%)	Mean Cover (%)	B.A. (m^2/ha)	Freq. (%)	Mean Cover (%)	B.A.[2] (m^2/ha)	Freq. (%)	Mean Cover (%)	B.A. (m^2/ha)	Freq. (%)	Mean Cover (%)	B.A.[2] (m^2/ha)	Freq. (%)	Mean Cover (%)	B.A. (m^2/ha)
Abies grandis										40	14	*	60	2	1.2
Acer macrophyllum	17	3	0.2												
Alnus rubra	50	14	1.0	11	9	*				80	28	*			
Arbutus menziesii							80	19	3.6	20	1	*			
Fraxinus latifolia															
Juniperus scopulorum										20	1	*			
Myrica californica															
Osmaronia cerasiformis															
Physocarpus capitatus															
Picea sitchensis	50	14	1	67	15	1.1							100	26	3.4
Prunus spp.															
Prunus emarginata							10	10	+						
Prunus virginiana	17	8	+												
Pseudotsuga menziesii							90	22	3.4				80	27	3.8
Pyrus fusca															
Rhamnus purshiana	17	5	0.5										20	++	+
Salix spp.										60	15	*			
Salix Hookeriana															
Sambucus racemosa															
Thuja plicata	25	5	0.7	67	3	0.6	10	++	+						
Tsuga heterophylla	25	1	0.3										40	18	2.2