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Title: Plant Communities and Elevation in the Diked Portion of Joe Ney Slough: A Baseline Assessment of a Marsh Restoration Project in Coos Bay, Oregon

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The need to preserve Oregon's estuaries has been expressed through the Land Conservation and Development Commission's Estuarine Resources Goal 16. The first use of the mitigation guideline set forth in this goal is in the Coos Bay estuary. The proposed North Bend Airport runway extension will fill 32 acres (13 ha) of tideland in Coos Bay. Mitigation of this fill is the breaching of the dikes in upper Joe Ney Slough near Charleston, Oregon, 6.5 miles (10.5 km) southeast of the airport site.

Vegetation and elevation data were gathered in the diked portion of Joe Ney Slough, a control site, and an area of marsh adjacent to the proposed runway extension. Through comparsion of vegetation and elevation at the Joe Ney Slough and control sites, the historic and future pattern of salt marsh vegetation is interpreted.

Thirteen plant communities are identified by cluster analysis of 682 vegetation samples from the Joe Ney Slough site: 1) Eleocharis-Agrostis alba, 2) Eleocharis-Juncus effusus var. pacificus-Jussiaea, 3) Juncus effusus var. gracilis-Lotus, 4) Oenanthe-Juncus effusus var. pacificus-Agrostis alba, 5) Carex lyngbyei, 6) Carex obnupta, 7) Agrostis alba-Potentilla, 8) Agrostis alba-Alopecurus-Potentilla,

9) Juncus balticus, 10) Holcus-Agrostis tenuis-Ranunculus, 11) Ranunculus, 12) Agrostis tenuis-Festuca arundinacea, 13) Festuca arundinacea-Agrostis tenuis. Total community biomass is mostly proportional to its areal extent. A vegetation and elevation map, both at a scale of 1 to 2,450, are presented.

Seven plant communities are identified by cluster analysis of 66 vegetation samples from the control site: 1) Salicornia, 2) Carex lyngbyei, 3) Deschampsia-Juncus balticus-Triglochin, 4) Agrostis alba-Triglochin-Plantago, 5) Agrostis alba-Potentilla, 6) Juncus balticus-Agrostis alba-Potentilla-Festuca rubra, 7) Potentilla-Festuca rubra. Biomass data indicate that standing crop is higher in this natural marsh than in the diked area. A vegetation map of this site at a scale of 1 to 1,420 is presented.

Analysis of 329 vegetation samples from the airport site identified a Salicornia community at elevations higher than 1.4 m above Mean Lower Low Water (MLLW). Upon dike breaching, 12.5 percent of the land area within the mitigation site can be expected to become mudflat. All but a few species present in this area today can be expected to disappear with reinstatement of estuarine waters. Salt marsh species associated with silty substrates are expected to become established between elevations of 1.4 and 2.4 m above MLLW.

Plant Communities and Elevation in the Diked Portion of Joe Ney Slough: A Baseline Assessment of a Marsh Restoration Project in Coos Bay, Oregon

by

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INTRODUCTION

Scope and Goals

Intertidal marshes have long been recognized as important ecological components of estuarine systems. However, two factors also make these lands important areas for industrial, commercial, and urban development: proximity to the estuarine waterway, and the ease with which they may be reclaimed. The need for preservation and restoration of intertidal marshes, as well as other important components of the estuarine system, has recently been recognized by the Oregon Land Conservation and Development Commission (LCDC). The goal of this research, which flows from this interest of the LCDC, is to establish a baseline vegetation and elevation study which can be used in assessing the use of diked estuarine lands for natural restoration of intertidal marsh.

LCDC Estuarine Resources Goal 16

The overall statement of this goal is: "to recognize and protect the unique environmental, economic, and social values of each estuary and associated wetland; and to protect, maintain, where appropriate develop, and where appropriate restore the long-term environmental, economic, and social values, diversity and benefits of Oregon's estuaries" (LCDC 1978). One of the guidelines for Estuarine Resources

Goal 16 introduced the concept of mitigation[1] of activities which would adversely effect the estuarine resources. The mitigation guideline is concerned with identifying and assessing sites to mitigate the effects of dredge and fill activities. The following factors are to be considered in mitigation site selection:

1. In selecting sites of similar biological potential, areas should preferably be chosen with similar ecological characteristics. The intention of the requirement is to provide an area that, with time, will develop a qualitatively and quantitatively similar fauna and flora. The emphasis is on similar potential, not substitute productivity. The area provided does not have to be fully developed biologically; the opportunity, at least, should exist for it to develop once the area is returned to the estuarine system. However, the surface area of the estuary should not be dismissed.

2. The most appropriate sites would be those in general proximity of the proposed dredge or fill action. These would probably contain the most similar ecological characteristics. If similar areas are not available nearby, then other areas in other parts of the estuary may be selected according to the similarity of the following characteristics (in order of importance, most important first);

    a. Salinity regime
    b. Tidal exposure and elevation
    c. Substrate type
    d. Current velocity patterns
    e. Orientation to solar radiation
    f. Slope

3. If similar areas, or those with a similar potential, cannot be found or provided, then mitigation efforts should seek to restore areas or resources which are in their greatest scarcity compared to their past abundance and distribution. That is, those resources which have been most severly impacted by man's activities, measured by a ratio of present to past abundance, should be restored through mitigation.

4. Appropriate locations for mitigation activities include:

    a. Dredged material islands, which can be lowered to the intertidal level, thus adding surface area back to the estuarine system.

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[1]Mitigation is defined in Webster's Third New International Dictionary as abatement or diminuition of something painful, harsh, severe, afflicting, or calamitous.

b. Diked marsh areas which have been abandoned or are in disrepair; and

c. Estuarine areas removed from effective circulation by causeways, or other fills, where circulation can be restored or improved through replacement of the causeway with piling or culverts.

5. The transfer of ownership of estuarine lands including wetlands and submersible lands, to public ownership; the dedication of estuarine lands for certain natural uses; and the provision of funds for research or land acquisition do not constitute mitigation as required by this goal (LCDC 1978).

Human Impact on Salt Marshes in Coos Bay, Oregon

Coos Bay, covering 5,012 ha is the largest estuary totally within Oregon (Akins and Jefferson 1973). The salt marshes within the Coos Bay Estuary have been heavily impacted by man's activities. Impacts associated with coal mining in the 1880's and 1890's led to the first large scale destruction by filling and construction (Hoffnagle and Olson 1974). Shortly thereafter, the rapidly developing logging industry, through construction of log storage facilities and mills adjacent to the sloughs, caused widespread damage and loss of marsh land. With the development of Coos Bay as a major port, sites for dredge spoil were needed and salt marshes were often chosen. Diking of tidelands for agricultural development has also contributed significantly to the loss of salt marsh acreage. Hoffnagle and Olson (1974) estimate that 90 percent of the Coos Bay salt marshes present 100 years ago have been reclaimed for various types of development. This is supported by Jefferson (1974) who states that "nine thousand eight hundred hectares in Coos Bay have been filled or diked."

Implementation of the LCDC mitigation guideline set forth in the Estuarine Resources Goal 16 was ordered by the Division of State Land to take place in the highly impacted Coos Bay estuary, in connection with the proposed extension of the North Bend Airport in the fall of 1978. This was the first use of the guideline. The proposed runway extension was projected to fill 13 ha of tideland (City - County Multi-Jurisdictional Airport Task Force 1978). Figure 1 shows the area of tideland to be filled by the proposed airport extension. The site chosen for mitigation was the diked portion of the Joe Ney Slough. Figure 2 shows the relative location of the Airport site and Joe Ney Slough site. In selecting this mitigation site, the Division of State Lands projected that the historic pattern of salt marsh and tideflat communities would become established with dike removal.

Research Objectives

The specific objectives of this study are:

1. To describe and map the plant communities in the diked portion of Joe Ney Slough, an adjacent undiked control site, and the airport site to be filled

2. To relate diked and undiked vegetation to measured tidal datums, and predict vegetational change at the mitigation site

3. To establish permanent plots in the diked portion of Joe Ney Slough in order to follow vegetation development after dike breaching for at least a ten year period

4. To compare vegetation in the mitigated area before breaching with vegetation in the long established control site

5. To estimate aerial standing crop biomass by community type in the diked marsh, control site, and airport site.

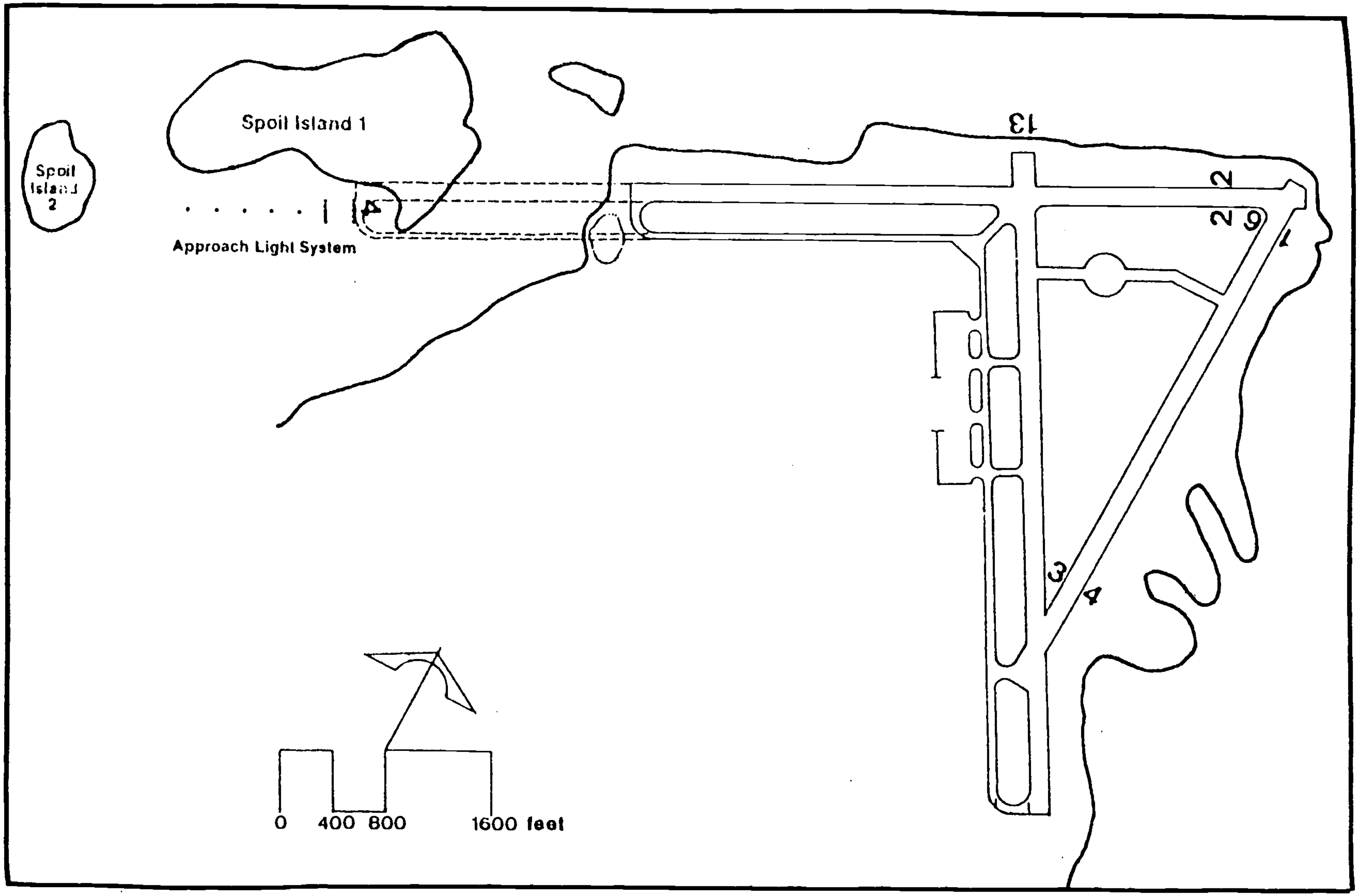

Figure 1 Area of fill for the proposed North Bend Airport runway extension. Source: City-County Multi-Jurisdictional Airport Task Force 1978.

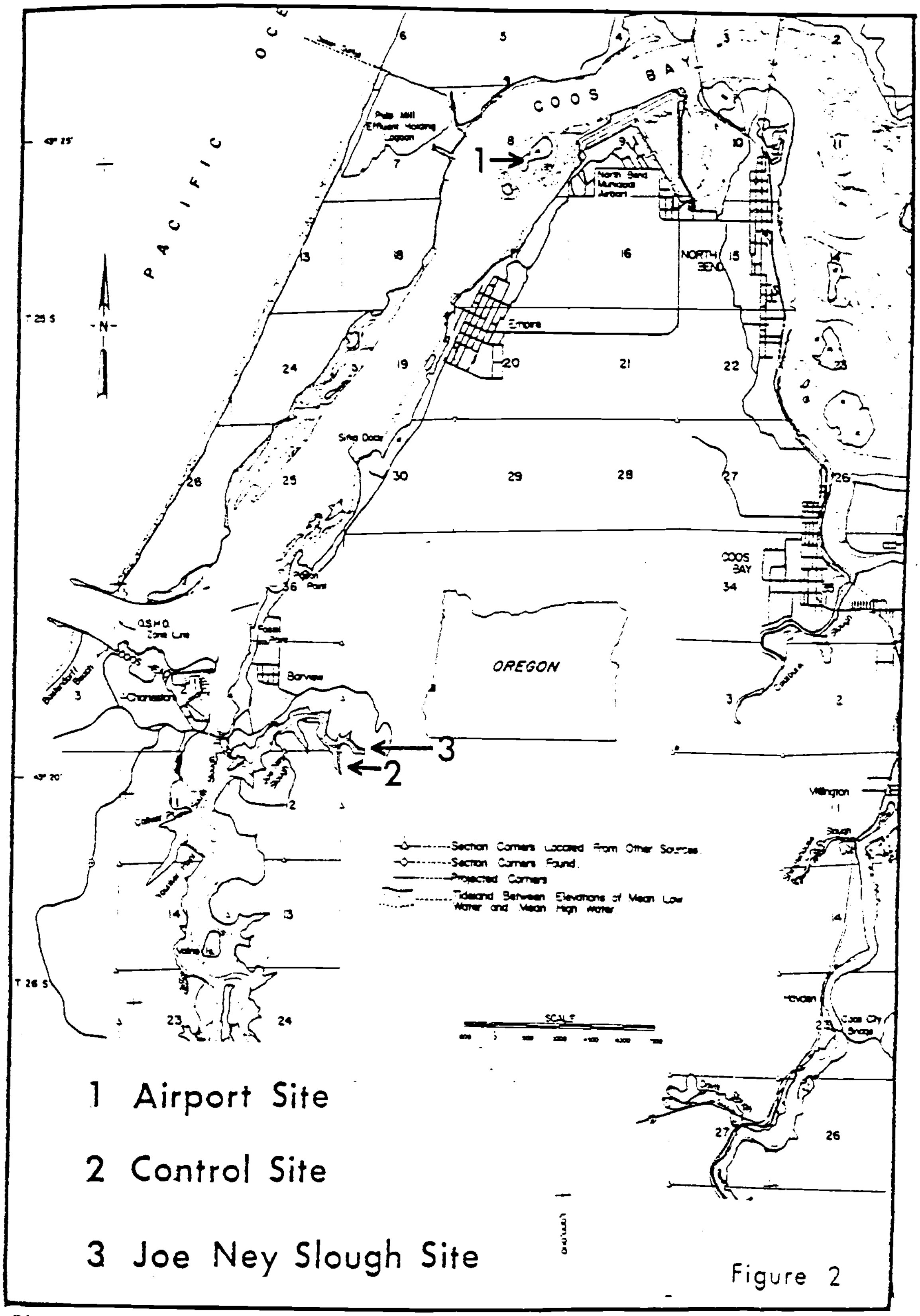

Figure 2. Location of the Joe Ney Slough, Control, and Airport sites within the Coos Bay estuary.

Site Descriptions

Joe Ney Slough Mitigation Site

Joe Ney Slough is located in the southern Coos Bay area (Figure 2). The mouth of the slough opens into South Slough, just south and east of Charleston, Coos County, Oregon. The diked portion proposed for mitigation, runs diagonally through Section 6 and 7, T26S, R13W. The majority of the area lies in the NW1/4 and NE1/4 of Section of 7. The area under study is approximately 26 ha.

The study site is predominantly level with numerous small depressions and ridges, which are remnants of the mudflat-salt marsh pattern prior to diking. Elevations within the study site range from 0.18 to 3.05 m above MLLW.[2]

Soils. The soils in the Coquille Series[3] dominate the mitigation site (U.S.D.A. 1969). These soils characteristically are very poorly drained, very strongly acid, and form from sediments deposited in water subject to tidal fluctuation. They occur on nearly level bottomland and stream deltas along coastal tideland between 0 and 3 m. Slopes are usually 0 to 1 percent. These soils are used for pasture and forage crops, wildlife habitat and recreation (U.S.D.A. 1969).

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[2] Unless stated otherwise, all elevations refer to height above Mean Lower Low Water (MLLW).

[3] The Coquille Series is now classified as a fine-silty, mixed, acid, mesic Typic Fluraquent.

Land use history. Only fragments of information were available on the settlement history of this tract of land. The following information was obtained through interviews with past and present land owners and from records kept by Coos County.

The dike in the upper portion of Joe Ney Slough was constructed by Mrs. Charlotte McMullin, "one of the grantor's predecessors in interest about year 1914" (Coos County). Aerial photographs flown in 1939 indicate that pasture improvement techniques such as ditching for drainage purposes began sometime prior to this date. The removal of *Juncus effusus* tussocks by tractor was also commonly practiced (J. Elmore Pederson personal communication, September 7, 1978).

Water rights to this land were sold by joint owners Edward Skog and Elmore Pederson on March 19, 1946 to Coos Head Timber Company, formerly Scott Paper Company (Phil Van Doren Menasha Corporation personal communication, September 7, 1978). The dike was in a state of disrepair at the time of purchase and was rebuilt with a new set of tide gates in 1947 (Wylie Smith,Coos Head Timber Company, personal communication, September 7, 1978). The precise period of time that the diked area was subject to inundation by saline waters between 1939 and 1947 is unknown. In 1963,two 36 inch tube tide gates were installed which remain to present day.

From 1947 to 1971 water was pumped during the dry season, May to October, to the Coos Head pulp mill located near Sitka Dock between Charleston and Empire. Pumping of water ceased when the Coos Head pulp mill had to shut down because of the prohibitive cost of pollution control measures. Pumping of water from Joe Ney Slough resumed again during the drought year of 1977, this time by the Coos Bay-North Bend Water Board. From March through November, 1977, 108.5 million gallons of water was pumped to supplement the supply in Tar Heel and Pony Creek reservoirs (Wylie Smith,Coos Head Timber Company personal communication, September 7, 1978). The Joe Ney Slough site has apparent potential for development as a municipal water storage facility, and is being considered as such by the Coos Bay-North Bend Water Board (City-County Multi-Jurisdictional Airport Task Force 1978).

The 1939 aerial photographs indicate that logging activities had been going on in the surrounding area for some time. Substantial areas adjacent to the mitigation site were logged in 1977, and again in September of 1978.

The land is presently owned by George Walker. No specific plans have been made for utilization of this land by the present day owners. The deed and check for purchase of this land by the City of North Bend is presently in escrow. (Al Roth, city manager of North Bend personal communication September 12, 1978).

Control Site

A relatively unmodified marsh was selected as a control in order to evaluate vegetation changes brought about by mitigation of the diked portion of Joe Ney Slough. The control, also within Joe Ney Slough, lies approximately 600 m west and 20 m south of the mitigation site (Figure 2). It is located in the NE1/4, NE1/4 of Section 12, T26S, R13W and covers 0.26 ha. Soils are in the Coquille Series. The surface of the marsh lies at least 60 cm above the tidal mudflat, and ranges in elevation from 1.46 m to 2.62 m. The development of tidal

[4]The control site will be, from here on, referred to as Beaver Marsh. This area is the home of a family of beaver *Castor canadensis*, who had built a large dam on the small creek adjacent to the marsh.

creeks in this small marsh is evident, but the creeks are generally very shallow.

This salt marsh, as far as could be ascertained, was undisturbed. It is presently owned by Robert Younker, who has no intention of altering its present state (Robert Younker personal communication September 10, 1978).

Airport Site

The airport site lies west of the present day North Bend Airport in the SE1/4 of Section 8, T25S, R13W (Figure 1). The majority of the area is intertidal mud/sandflat with a small subtidal channel running between the mainland and dredged-spoil island. Preliminary measurements taken from aerial photographs indicate that the tideland area between the mainland and islands has increased 100 percent over the period 1956 to 1977. This is attributed to sedimentation caused by funnelling of water on outgoing tides, in the narrow channel, between the northern spoil island and airport. As the sediment laden water loses velocity, when the channel widens, deposition occurs. The sediment source does not appear to be the spoil island which has lost only 10 percent of its area over the same 21-year period. (Jefferson Gonor, OSU School of Oceanography personal communication, May 7, 1979).

The sampling area at the airport site is located in a small portion of this large intertidal area, on the southeast side of the larger of the two dredged-spoil islands. Aerial photographs indicate that vascular plant colonization began sometime between 1964 and 1967. The sampling area is 8,444 m^2 and ranges in elevation between 1.4 m and 1.98 m

Salt Marsh Vegetation of the Oregon Coast

Salt Marshes are tracts of land covered with phanerogamic vegetation subject to periodic flooding by the sea (Chapman 1976). The combination of terrestrial and marine influences found in salt marshes produces a special habitat which supports a relatively small number of vascular plant species (Eilers 1974). Another striking aspect of salt marsh vegetation which has interested many investigators, is the series of belt-like plant communities which are easily recognized in the field. Numerous studies have attributed this zonation to such environmental factors as tidal inundation and exposure, tidal scour, turbidity, salinity, nutrient regime, drainage, succession, and biotic factors (Jefferson 1974). A more detailed discussion of selected factors influencing salt marsh establishment and development will be presented in a later section.

Early reports accompanying reconnaissance and hydrographic maps by the Coast and Geodetic Survey and the Army Corps of Engineers, report the presence of grassy vegetation and muddy substrates in Oregon estuaries (Jefferson 1974). Nesbit (1885) mentions areas of reclaimable tideland and describes the grassy meadow-like appearance of the vegetation. House (1914) notes the extensive marshes bordering Coos Bay and lists 13 species collected in and around the marshes in August, 1911.

More recently, Johannessen (1961) using old nautical charts and aerial photographs describes the shoreline and vegetation changes in the Coquille, Coos Bay, Umpqua, Alsea, Tillamook and Nehalem estuaries.

Johannessen discusses the vegetation found at low, intermediate, and high elevations in the marsh, but does not specifically relate this vegetation to tidal datums.

Colonization of the mudflat according to Johannessen (1961) is primarily by Triglochin maritimum but, Salicornia virginica, Carex lyngbyei, Scirpus americanus, and Scirpus maritimus may also perform a significant role.[5] Species abundant at intermediate heights are Distichlis spicata and Jaumea carnosa, which occur with several other species. Higher elevation marshes, which are more diverse, include Deschampsia cespitosa the most common, Potentilla pacifica, Agrostis alba, Hordeum brachyantherum, Juncus balticus, Juncus effusus, and many more (Johannessen 1961).

Johannessen (1961) also found, with the possible exception of Alsea Bay, that all the coastal marsh lands in Oregon were prograding at a rate from 2.8 to 8.2 m per year. Johannessen attributed this rapid increase to human activities, such as logging and cultivation, which have affected coastal watersheds. Jefferson (1974) also mentions that increased sedimentation could be the result of the extensive coastal fires which occurred in the 1800's. Eilers (1974) using aerial photographs from 1939 to 1972 found that certain sections of Dean's Marsh in Nehalem Bay were prograding at rates between 0.75 and 1.50 per year, much lower than that reported by Johannessen. Other sections of the Nehalem Marsh were regressing according to Eilers (1974). Jefferson (1974) and Eilers (1974) believe that Johannessen may have

[5]All nomenclature follows Hitchcock et al. 1955-1969. Species names have been changed wherever appropriate.

made a critical error in assuming that the mapped boundaries on old maps referred to the marsh edge when in fact the mapped boundaries may have referred to Mean High Water.

More contemporary studies by Eilers (1974), Jefferson (1974), Frenkel *et al*. 1978, and a review by Macdonald (1977a) have led to a much greater understanding of the salt marsh vegetation in Oregon. Jefferson (1974) in her survey of the marshes in virtually all Oregon estuaries identified six salt marsh vegetation types and 28 associations. Diagrams of species cover versus distance, aggregated ordinations, and examination of subsurface plant debris was used by Jefferson to determine succession. Comparisons with less detailed studies indicate that these vegetation types are characteristic of the Pacific Coast from 43°N to the Canadian border (Macdonald 1977a). Table 1 displays the vegetation types and plant associations found in Oregon salt marshes by Jefferson (1974).

Low sand marshes are found on sandy substrates on the inside of baymouth sand spits and at the sheltered edge of islands in sandy bays. The marsh surface is slightly elevated above the tideflats and experiences flooding at all high tides. Tidal drainage is diffuse. Dominant in the lower vegetation are *Salicornia virginica* or *Scirpus americanus*. The higher vegetation is composed mainly of *Distichlis spicata*, *Jaumea carnosa*, and *Plantago maritima*. There are frequent occurrences of *Spergularia canadensis*, *Spergularia macrotheca*, *Puccinellia pumila*, *Carex lyngbyei* and *Glaux maritima* (Jefferson 1974).

Table 1. Six vegetation types and 28 plant associations identified by Jefferson (1974) in Oregon coastal salt marshes.

Marsh Type and Plant Association
I Low Sand Marsh Type
1. Cyanophyta - Puccinellia - Spergularia macrotheca
2. Distichlis - Cladophora - Salicornia
3. Jaumea - Salicornia - Distichlis
4. Jaumea - Salicornia - Triglochin maritimum - Distichlis
5. Jaumea - Salicornia - Triglochin concinnum - Triglochin maritimum - Distichlis
6. Scirpus americanus
7. Ruppia
II Low Silt Marsh Type
1. Cladophora
2. Salicornia - Triglochin maritimum
3. Spergularia marina - Salicornia
4. Salicornia - Cotula
5. Eleocharis - Salicornia
6. Carex - Triglochin maritimum
7. Deschampsia - Carex - Triglochin maritimum
8. Salicornia - Cotula - Scirpus validus - Triglochin maritimum
9. Scirpus maritimus
III Sedge Marsh Type
1. Carex
IV Bulrush and Sedge Marsh Type
1. Scirpus validus
2. Scirpus validus - Carex
V Immature High Marsh Type
1. Salicornia - Distichlis - Plantago - Scirpus americanus - Glaux - Spergularia canadensis
2. Deschampsia - Potentilla - Trifolium - Juncus
3. Distichlis
4. Distichlis - Salicornia
5. Carex - Salicornia - Triglochin maritimum
6. Salicornia - Distichlis - Triglochin maritimum
7. Distichlis - Deschampsia - Carex
VI Mature High Marsh Type
1. Potentilla - Deschampsia
2. Salicornia - Distichlis - Juncus
3. Juncus gerardii - Deschampsia - Juncus lesueurii

Low silt marshes occur on silt or mud substrates where there are high rates of sedimentation. The surface is slightly sloping and is interrupted by colonies of Triglochin maritimum, and Salicornia virginica. Scattered between these colonies are plants of Eleocharis parvula and Spergularia marina (Jefferson 1974).

Sedge marshes occur most frequently on a silt substrate, between low silt marshes and more mature marshes, adjacent to islands, deltas, or dikes. This vegetation type is dominated by Carex lyngbyei. The marsh surface is nearly level and rises abruptly 30 cm or more above the surrounding mudflat. These marshes are flooded by most high tides (Jefferson 1974).

The bulrush and sedge vegetation type appears on substrates which are usually soft and saturated throughout the tidal cycle. The vegetation is dominated by Scirpus validus and Carex lyngbyei. This vegetation type occupies areas along dikes and tidal creeks where freshwater largely dilutes saltwater (Jefferson 1974).

Immature high marshes are situated landward of low sand marshes. The substrate is made up of large quantities or organic material and silt. The marsh surface is elevated 5-10 cm above surrounding low marshes, and 60 cm or more above adjacent tideflats. Deschampsia cespitosa is often mixed with Distichlis spicata as a co-dominant, on silty substrates. Other species occurring, but in lesser quantity, are Salicornia virginica, Juncus lesueurii[6] and Triglochin maritimum. On sandy substrates, Plantago maritima, Scirpus americanus, Glaux

[6]Jefferson apparently misidentified Juncus balticus callin this species J. lesueurii. J. lesueurii occurs on moist (freshwater) sandy substrates.

maritima, and Spergularia marina occur in this vegetation type.

Mature high marshes also develop on highly organic substrates, overlying clay sequences. They are typically elevated 90-100 cm above the adjacent tideflat and are only subject to innundation by the higher high tides. The dominant species are Deschampsia cespitosa, Juncus balticus and Agrostis alba. Forbs occurring at the highest elevations are Potentilla pacifica, Atriplex patula, and Grindelia integrifolia. Tidal runoff in these marshes follows well defined drainage creeks.

The most intensive study of salt marsh vegetation to date is Eilers (1974) study on West Island in Nehalem Bay. Using cover and species dry weight, Eilers identified ten plant communities. These are, from low to high elevations: 1) Scirpus maritimus, 2) Triglochin, 3) Carex-short and tall phase, 4) Carex-Deschampsia-Triglochin, 5) Triglochin-Deschampsia, 6) Carex-Deschampsia-Triglochin-Agrostis 7) Juncus-Agrostis, 8) Juncus-Agrostis-Festuca, 9) Aster-Potentilla-Oenanthe, 10) Carex-Aster-Oenanthe. Table 2 summarizes the plant communities and their elevation ranges on West Island, Nehalem Bay.

Eilers (1974) also thoroughly studied the elevation of these plant communities in relation to the tides. Such factors as tidal inundation and exposure period were identified as being the dominant influences determining the distribution of the community types.

Eilers (1974), also carried out a study of net aerial production of salt marsh vegetation on West Island. He found that net aerial production generally varied along an elevational gradient, with

Table 2. Plant communities, elevation range, and topographic units identified by Eilers (1974) on West Island Nehalem Bay.

West Island Plant Community		Elevation Range (m)	Topographic Unit
S	*Scirpus maritimus*	1.30-1.83	Edge
T	*Triglochin*	1.54-2.00	Edge
C	*Carex* (short)	0.77-2.06	Edge
	Carex (tall)	1.67-2.25	Low
CDT	*Carex* - *Deschampsia* - *Triglochin*	1.85-2.31	Edge-Low
TD	*Triglochin* - *Deschampsia*	1.68-2.34	Low
CDTAg	*Carex* - *Deschampsia* - *Triglochin* - *Agrostis*	2.15-2.49	Low-Transitional
JAg	*Juncus* - *Agrostis*	2.26-2.81	Transitional
JAgF	*Juncus* - *Agrostis* - *Festuca*	2.75-2.95	High
APD	*Aster* - *Potentilla* - *Oenanthe*	2.75-3.06	High
CAD	*Carex* - *Aster* - *Oenanthe*	2.89-2.95	High

increased production at higher elevation. Net aerial production rates varied from a mean minimum of 518 g/m^2/ yr for the Triglochin plant community, to a mean maximum of 1,936 g/m^2/yr for the Aster-Potentilla-Oenanthe plant community. Table 3 summarizes Eilers' finding on net aerial production for the different plant communities on West Island.

An estimate of the net aerial plant production exported to the estuary was also made by Eilers (1974). Approximately 47 percent of West Island lies below Mean Higher High Water, an area where the tides can remove plant material to the estuary. Removal of plant litter during, and between, growing seasons by tidal action contributed 511 mt/yr to the Nehalem Bay estuary (Eilers 1974). The net production values at West Island, though not as high as the maximum production values in the highly productive salt marshes of the southeastern United States, are comparable to marsh production rates of Atlantic coast salt marshes (Eilers 1974). Table 4 summarizes net aerial production for coastal salt marshes reported by various authors.

Salt marshes in Coos Bay have been studied by Macdonald (1969), Jefferson (1974), Hoffnagle and Olson (1974), Hoffnagle et al. (1976), and Frenkel et al. (1978). Part of Macdonald's study on the North American Pacific Coast salt marsh mollusc faunas was undertaken at Pony Slough in Coos Bay. He noted that the low marsh was dominated by Salicornia virginica and the high marsh by Deschampsia cespitosa. The lower limit of angiosperms was estimated to lie approximately at the Mean Lower High Water mark, which is exposed at least once every 24 hours (Macdonald 1969). Two marsh communities were identified

Table 3. Summary of net aerial production values for different plant communities on West Island Nehalem Bay. Source: Eilers 1974.

Community	Mean	Range	Community Total	Community (percent)	Marsh Area (percent)	Deviation (percent)
S	609[a]	347 - 1,164[a]	10,874,304[a]	1.0	2.3	- 1.3
T	518	227 - 857	26,136,726	2.4	6.5	- 4.1
C (Short)	875	533 - 1,051	69,148,625	6.4	10.1	- 3.7
(Tall)	1,746	1,276 - 2,629	131,746,176	12.2	9.6	+ 2.6
CDT	1,076	657 - 1,767	170,252,252	15.8	20.2	- 4.4
TD	1,468	947 - 2,204	31,877,620	3.0	2.8	+ 0.2
CDTAg	1,693	1,031 - 2,612	199,811,246	18.5	15.1	+ 3.4
JAg	1,479	746 - 2,180	178,985,622	16.6	15.4	+ 1.2
JAgF	1,574	943 - 2,709	27,471,022	2.6	2.3	+ 0.3
APO	1,936	839 - 2,820	222,390,256	20.7	14.7	+ 6.0
CAO	1,756	1,131 - 2,217	6,978,344	0.7	0.5	+ 0.2
MARSH	1,388	227 - 2,820	1,076,471,761	100.0	100.0	0.0

[a] g dry/m²/yr

Table 4. Summary of net aerial production values for coastal salt marshes reported by various authors.

Net Aerial Production (g/m^2/yr)	Locale	Dominant Species	Source
Intertidal Low Marsh			
445	Delaware	*Spartina alterniflora*	Morgan (1961)[a]
596	Rhode Island		Nixon & Oviatt (1972)
973	Georgia		Smalley (1959)
1,000	N. Carolina		Williams & Murdock (1966)[a]
1,714 - 1,410[b]	Oregon	*Carex lyngbyei*	Eilers (1974)
1,296	N. Carolina	*Spartina alterniflora*	Stroud & Cooper (1969)
1,675[c]	Georgia		Teal
1,700[d]	California	*Spartina foliosa*	Cameron (1972)
2,000	Georgia		Odum (1961)
Extratidal High Marsh			
230	Sweden	*Juncus gerardi*	Tyler (1971)
343	Sweden		Wallentinus (1970)[e]
560	N. Carolina	*Juncus roemerianus*	Foster (1968)[a]
796	N. Carolina		Stroud & Cooper (1969)
849	Florida		Heals (1969)[a]
850	N. Carolina		Williams & Murdock (1968)[a]
993	Long Island	*Spartina patens*	Harper (1918)
1,200[d]	California	*Salicornia subterminalis*	Cameron (1972)
1,296	N. Carolina	*Spartina patens*	Waits (1967)[a]
1,360	N. Carolina	*Juncus roemerianus*	Waits (1967)[a]
1,710	Oregon	*Juncus balticus*, *Aster subspicatus*	Eilers (1974)

[a]Cited in Keefe (1972)
[b]Intertidal and transitional
[c]kcal ÷ 4
[d]Maximum standing crop biomass
[e]Cited in Tyler (1971)

by Frenkel et al. (1978) in their study of Haynes inlet. The low marsh was a *Carex lyngbyei* community and the high marsh a *Deschampsia cespitosa*-*Atriplex patula* community. *Carex lyngbyei* and *Salicornia virginica* were noticed colonizing the silty substrate (Frenkel et al. 1978).

Part of Hoffnagle et al. (1976) study presents the net aerial productivity of six salt marshes in Coos Bay. Although general in nature and of very short duration (four months), this study provides the only production figures for salt marshes in this estuary. Table 5 summarizes the productivity values for the six different salt marshes studied by Hoffnagle et al. (1976).

Ecological Role of Tidal Marshes in the Estuarine Ecosystem

In order to appreciate and understand the importance of marsh restoration, a brief review of the role that the tidal marshes play in the estuarine ecosystem is included below.

An estuary can be defined as a "semi-enclosed coastal body of water which has free connection with the open sea and within which sea water is measurably diluted by fresh water from land drainage" (Pritchard 1967). Estuaries are generally believed to be very productive ecosystems with a mean primary productivity of 1,500 g/m^2/yr dry weight (Correll 1978). The particle consumers, or filter feeders, in estuaries depend on the primary production of emergent marsh plants, algae (including phytoplankton, benthic algal thalli, algal constituents of the periphyton), and upland plants (debris) on the drainage basin of the estuary (Correll 1978).

Table 5. Net aerial production of six salt marshes in Coos Bay. Source: Hoffnagle *et al*. 1976.

Marsh	Net Aerial Production ($g/m^2/yr$)	($g/m^2/4$ mos)
North Slough	1119	1119
Bull Island	1007	817
South Slough	764	664
Pony Slough	599	539
Salicornia Marsh	560	423
Coal Bank	378	263

The high productivity within estuaries compared to that of other ecosystems has been thought to be a function of high salt marsh productivity. Teal (1962) in studying a Georgia salt marsh, found that only five percent of the net primary productivity was consumed by grazers, leaving the majority, 95 percent, as the basis for the detrital food chain. Detritus which is exported from the salt marsh, acts as an organic substrate for bacteria and fungi, which are, inturn, a food source for a variety of detrital feeders such as, fiddler crabs, nematodes, snails, and mussels. The food value of detrital particles is actually increased through the decomposition process (Darnell 1967; Odum and De La Cruz 1967; Cooper 1974).

More recent research has questioned the relationship of high salt marsh productivity and concomitant estuarine production. Correll (1978), working with data on east coast estuaries found that phytoplankton were the most important primary producers in the estuary with submerged vascular plants playing a secondary but important role. This view is also supported by Haines' (1977) study in Georgia.

Salt marshes have also been identified as important nutrient sinks in the estuarine system. When nutrient-enriched waters enter a marsh, the nutrients are effectively trapped by the tidal circulation pattern, and assimilated in the productive biological system (Gosselink _et al_. 1974). Studies with phosphate-enriched waters show that salt marshes effectively buffer the effects of large additions of phosphate, creating homeostatic conditions in a system with variable inputs (Gosselink _et al_. 1974). Salt marsh plots fertilized with secondary treatment sewage sludge, removed roughly 558 kg of nitrogen and 444 kg of phosphorous per hectare from May through mid-November (Gosselink et al. 1974). These studies indicate that: 1) marshlands could be viewed as natural waste processing plants and, 2) that marsh lands may serve a valuable function for water pollution control in their natural state (Valiela et al. 1973). No comparable studies have been done in Oregon, but there is no reason to believe that these findings are not applicable to Oregon coastal salt marshes.

Geologically, tidal marshes play a significant role. They function as both sediment accretors, and as sediment depositories (Roman 1978). If not for the salt marshes, these sediments could accumulate in navigation channels promoting more frequent dredging (Roman 1978). Salt marshes also protect the estuarine margins from high energy wave forces (Frenkel et al. 1978; Niering and Warren 1974).

It is also well known that the tidal marsh/estuarine ecosystem serves as an important nursery ground for fish and shellfish (Gosselink et al. 1974). Tidal marshes also provide essential habitat and breeding sites for migrating birds and other forms of wildlife (Teal and Teal 1969). Oregon's coastal salt marshes situated on the Pacific flyway, are important resting grounds for ducks and geese (Akins and Jefferson 1973).

As discussed, tidal marshes play an important role in maintaining the integrity of many different estuarine system components. Ultimately, salt marshes have redeeming social and economic value, often unrecognized, in maintaining a health biological environment upon which man depends.

Diked Salt Marshes in Oregon

There is little literature on diked marsh lands along the Oregon coast. Jefferson (1974) mentions that diking has been the single most important agent in altering salt marsh landscapes. Few areas of old high marsh remain in Oregon because of diking (Jefferson 1974).

No inventory exists dealing specifically with the extent of diked tide lands in Oregon. The inventory of filled lands by the Division of State Lands in 1972 pertains only with fill on submerged or submersible lands. This excludes salt marsh areas above Mean High Water, and would not include tidal area lost to estuaries in the diking process. Furthermore, most of the diking of salt marshes has occurred prior to records kept by the Division of State Lands.

Effects of Diking on the Salt Marsh/Estuarine Ecosystem

The changes which accompany diking of salt marshes isolate the area from marine influence. Roman (1978) found that tidal restriction: 1) reduced soil water salinity, 2) lowered the water table level, and, 3) decreased tidal flushing. These changes favored establishment of different plant species characteristic of brackish, fresh water, and terrestrial systems. Roman (1978) also found that subsidence occurred in the soils of tidally restricted marshlands. This was noted by Jefferson (1974).

The raising of dikes also prevents the export of detrital material with the daily and seasonal cycle of the tides. Thus, the extensive diking along the Oregon coast has not just altered the marsh vegetation, its soils and topography, but the primary productivity available to detrital feeders in Oregon estuaries.

Factors Influencing Salt Marsh Establishment

In his studies in Norfolk, England salt marshes Chapman (1938) identified ten important environmental factors which affect salt marsh vegetation: 1) tides, 2) salinity, 3) drainage, 4) aeration, 5) water table, 6) rainfall, 7) soil, 8) evaporation, 9) temperature, 10) biota. It is the consensus among investigators, that the most important factor determining the distribution of plants and plant communities in salt marsh, is the elevation of the marsh surface in relation to the tides (Chapman,1938, Hinde, 1954, Adams, 1963, Ranwell, 1972, Eilers, 1974, Niering and Warren 1974, and others). A brief discussion on the tides of the Oregon coast would seem appropriate before considering the tidal factor in detail.

In Oregon a mixed tide occurs, with the heights of successive high and low water being different. Tidal heights vary at different locations along the coast, and within individual estuaries. The specific time of a high or low tide depends on the 19-year tidal cycle, season, configuration of the bay, and the distance upstream (Jefferson 1974).

The Charleston primary tide gauge (943-2780) shows that the maximum tidal range at Charleston is 4.4 m with the average range being 2.9 m. The maximum recorded high tide is 3.81 m and minimum recorded low tide is -0.6 m. The highest tides occur during the fall and winter months, and the lowest during the summer months (Mark Harbert, Division of State Lands, personal communication, March 3, 1979).

Closely associated with the tidal regime and marsh elevation, is the length of continuous submergence (or inundation period), and its complement the exposure period (Eilers 1974). These periods profoundly affect the salt marsh flora (Chapman 1964). When tides are flooding or receding, the marsh surface is exposed to the mechanical effects of the tide. This scour can wash away newly germinated seedlings, inhibiting the establishment of new plants. Chapman (1960) suggests that a specific period of emergence is necessary, during which an adequate root system may develop, for successful seedling establishment.

During the period of submergence, other factors associated with the tides affect salt marsh plants. Tidal submergence may rapidly alter ambient temperatures, reduce oxygen and carbon dioxide availability, and decrease incident light, thus reducing both the photosynthetic and respiration response of salt marsh plants (Macdonald 1977b). Experimental results by Mahall and Park (1976) show that inhibition of growth resulting from tidal immersion may be an important factor determining the seaward advance of *Salicornia virginica*.

In studying marsh elevation and inundation period in Nehalem Bay salt marshes, Eilers (1974) found two major discontinuities in the elevation gradient, one between 1.06 and 1.21 m, and the other between 2.59 and 2.74 m. Figure 3 shows annual maximum submergence period and diurnal periods exposed per year as related to elevation in Nehalem Bay, Oregon salt marshes. With the increase in elevation

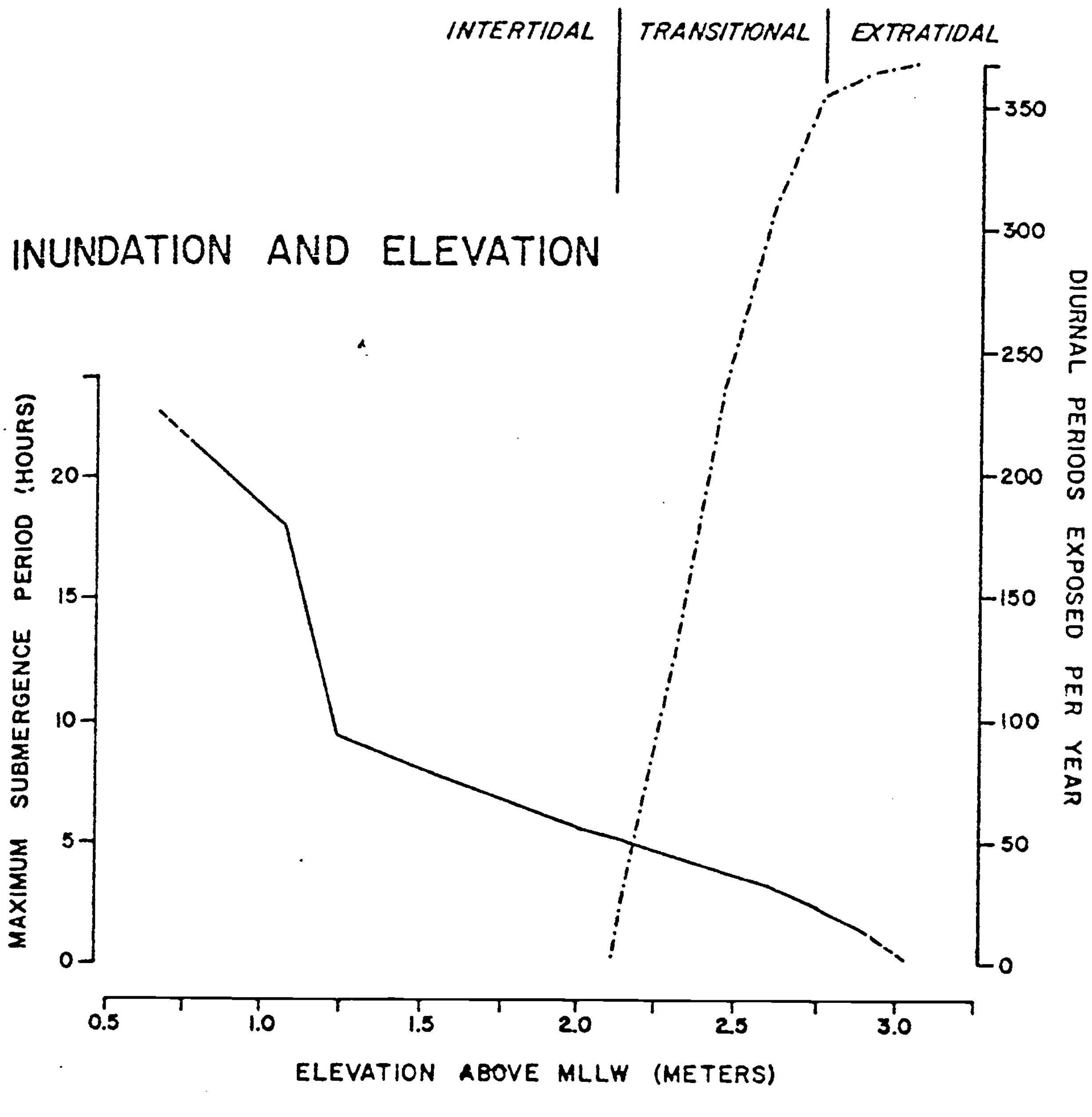


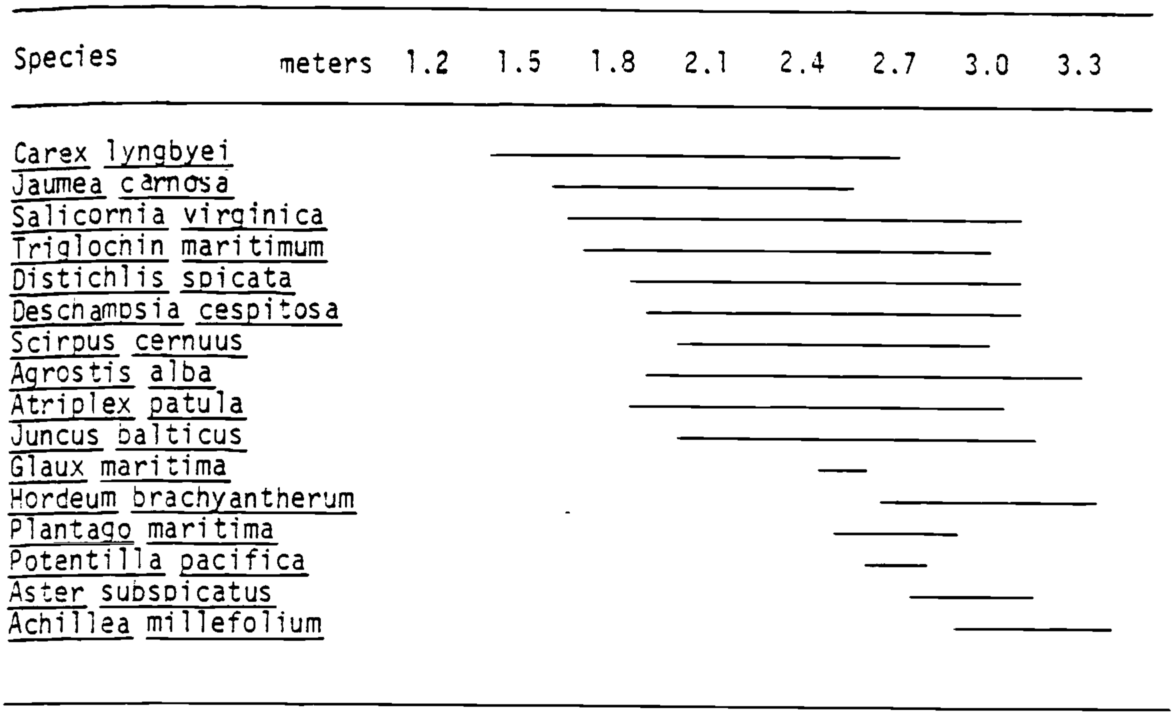
Figure 3. Annual maximum submergence and diurnal periods exposed per year as related to elevation in the salt marshes of Nehalem Bay, Oregon. Source: Eilers 1974.

from 1.06 to 1.21 m, inundation averaged for the total year, decreased from 17.83 to 9.44 hours per day. During the late growing season (September through October), the situation at this elevational discontinuity is similar, with a drop from 17.42 to 8.40 hours inundation per day. During the growing season (May through July) this break in elevation and associated inundation period occurs between 0.91 and 1.06 m. Thus, elevations between 0.91 and 1.06 m may be considered critical to the seaward development of salt marsh vegetation at Nehalem Bay.

The second and higher elevational discontinuity found by Eilers (1974) was between 2.59 and 2.74 m. This corresponds to Eilers' "upper transitional zone" on West Island. Above 2.74 m, the marsh surface is rarely subjected to tidal stress (Eilers 1974).

In her study of Oregon coastal salt marshes, Jefferson (1974) found that the growth of vascular salt marsh plants began just above mean tide level, and extends upward to a point between extreme high water and highest water during the growing season. Although Jefferson (1974) did not determine the specific elevations of her communities above MLLW, she found that low sand marshes extended to the lowest elevation in the intertidal of any marsh type followed by, low silt marshes, marshes with large amounts of freshwater drainage, bulrush marshes, sedge marshes, high sand marshes, and high silt marshes. Table 6 is an extrapolation of the elevational range of salt marsh plant species present in Joe Ney Slough from their known elevations in North Slough, Coos Bay based on Jefferson (1974).

Table 6. Elevation ranges of salt marsh plants found in Joe Ney Slough, relative to MLLW. (Adopted from Jefferson; 1974 ranges in North Slough, Coos Bay)



Researchers working on the establishment of salt marsh vegetation on dredge spoil sediments also realize the importance of elevation with respect to a tidal datum. A thorough review of marsh establishment work by Garbisch (1977) concludes that the two most important factors in preparing a site for establishment are surface slopes and surface elevations. Other related work by Woodhouse _et al_. (1972) and Barko _et al_. (1977) shows that revegetation of spoil banks is feasible, and discusses specific techniques and procedures which should be followed in marsh establishment.

The most valuable information then, when trying to predict vegetational changes after dike removal would be elevation with respect to a tidal datum. With this in mind, a detailed discussion of elevation and associated plant communities will be presented for the three study sites.

METHODS

Field Methods

Sampling

A systematic sampling scheme was chosen for the vegetation studies for three reasons: 1) it will allow future investigators to accurately reconstruct the sampling regime; 2) it enabled the largest possible area to be sampled in the shortest period of time; 3) the location of sample points was objective or unbiased by the investigator.

Joe Ney Slough Site

Thirty transects were established in the Joe Ney Slough mitigation site. Figure 4 locates and identifies all transects.[7] Transects were located perpendicular to the elevational gradient, with endpoints being established on opposite upland surfaces. The endpoints of each transect were permanently staked with 2 x 2 inch cedar posts. The western endstake of each transect, with the exception of transects 14, 15, and 16, for which the southern endstake was used, were tagged with numbered red and white nylon cattle tags. Tags were secured to the posts with stainless steel wire.

Sample points were located at 5 m intervals along each transect, originating from the labelled endstake. If a sample point corresponded to an obstacle, such as a log or creek channel, the point was moved to the nearest vegetated area.

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[7] Figure in pocket.

At each sample point, percent cover for each plant species was determined in a 20 x 50 cm plot frame. Cover is defined as the vertical projection of the crown or shoot area of a species to the ground surface, expressed as a fraction of percent of a reference area (Mueller-Dombois and Ellenberg 1974, and Daubenmire 1959). Cover gives a better and more convenient measure of biomass than does the number of individuals and therefore has greater ecological significance than density (Mueller-Dombois and Ellenberg 1974). Cover determinations were made in one of 12 cover classes. These are: 1) 0-1 percent; 2) 1-5 percent; 3) 5-10 percent; 4) 10-20 percent; 5) 20-30 percent; 6) 30-40 percent; 7) 40-50 percent; 8) 50-60 percent; 9) 60-70 percent; 10) 70-80 percent; 11) 80-90 percent; 12) 90-100 percent. The sample point corresponded to the lower left hand corner of the plot frame.

Permanent plots. Twenty permanent plots were established at this study site (Figure 4). These were established at different elevations throughout the study area to assess salt marsh development after dike breaching. Plant cover in a 100 x 100 cm sample frame was determined as above. The location of each permanent plot was staked and tagged in the same manner as transect endstakes.

Biomass. Only a gross estimate of aerial standing crop biomass was attempted in this study. A study of net primary productivity would be desirable for comparative purposes, but the time and manpower necessary were unavailable.

Twenty 20 x 50 cm samples were located within areas of homogenous plant cover in specific plant communities. The number of samples within a plant community was dependent on its areal extent within the study site. All rooted vegetation within the sample frame was clipped as close to the ground as possible, and the plant litter collected. Samples were collected during the period August 6-7, 1978. The samples were separated in the field into standing crop and litter and stored in sealed plastic bags in a refrigerator for three days. At this time samples were put in drying ovens at 80°C for 48 hours. Standing crop and litter samples were then weighed to the nearest 0.1 gm on a Mettler (P6) balance and weights recorded.

Soil. Although a study of soils was not one of the objectives of this research, six soil pits were excavated and their profiles described. Profile descriptions are presented in Appendix D.

Beaver Marsh

Ten transects were established systematically at 20 m intervals at this site for the vegetation study. Figure 5 locates and identifies transects on Beaver Marsh. These transects ran perpendicular to the elevation gradient from the upland to the edge of the tidal mudflat. Endstakes, serving as origin of the sampling scheme were established at the upland edge and three meters out from this point on the marsh surface. The upland stake was labelled as previously discussed.

Sample points were established every two meters along a transect. Cover determinations were made in a 20 x 50 cm sample frame as outlined above.

Permanent plots. Five permanent plots were established in this marsh so that salt marsh succession could be studied by later investigators.

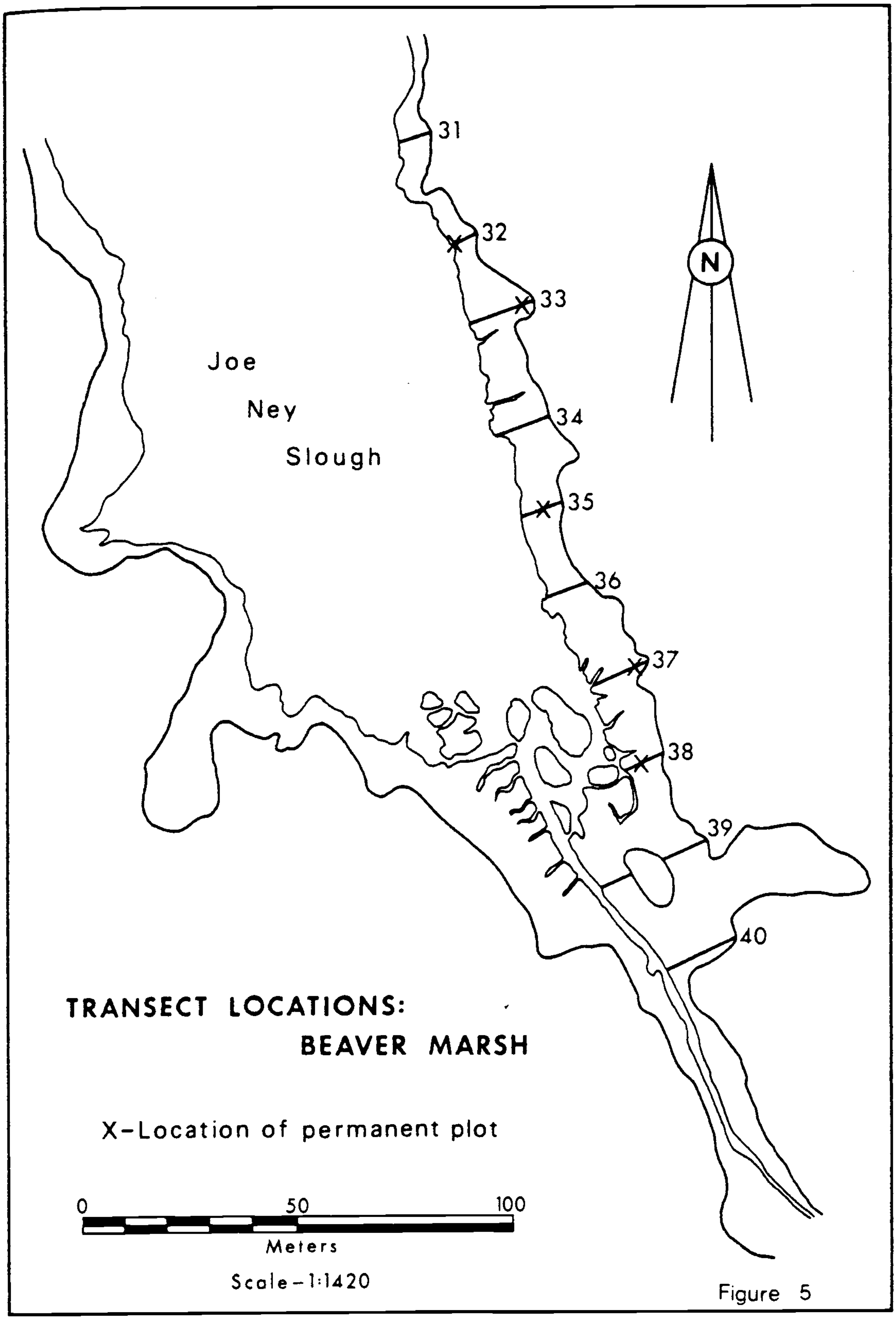

Figure 5. Transect and permanent plot locations in Beaver Marsh.

plots were subjectively placed at different elevations on the marsh surface. Cover determinations and tagging follow the procedure used at the Joe Ney Slough site.

Biomass. Ten 20 x 50 cm plots were clipped in the different plant communities at this study site. After clipping and collection of the litter on August 10, 1978, the samples were sorted by species. Samples were dried and weighed in the manner previously outlined. Species biomass per sample is presented in Appendix B.

Soils. One soil pit was excavated and the profile described. The profile description is presented in Appendix D.

Airport Site

Twenty six transects were sampled at this site (Figure 6). Transects ran from the beach debris line to points beyond the vegetated portion of the mudflat. Transect number one began at stake E1 along transect E established by J. Gonor and D. Hancock. Subsequent transects were established south of this at a 10 m interval. Cover for each species in a 20 x 50 cm sample frame was determined as previously outlined.

Biomass. Four 20 x 50 cm plots were clipped at this site on August 28, 1978. The nature of the vegetation required change in a clipping procedure slightly. All plant parts within the sample frame were clipped and collected, not just rooted plants as in all other biomass samples. All samples were then dried and weighed as outlined above.

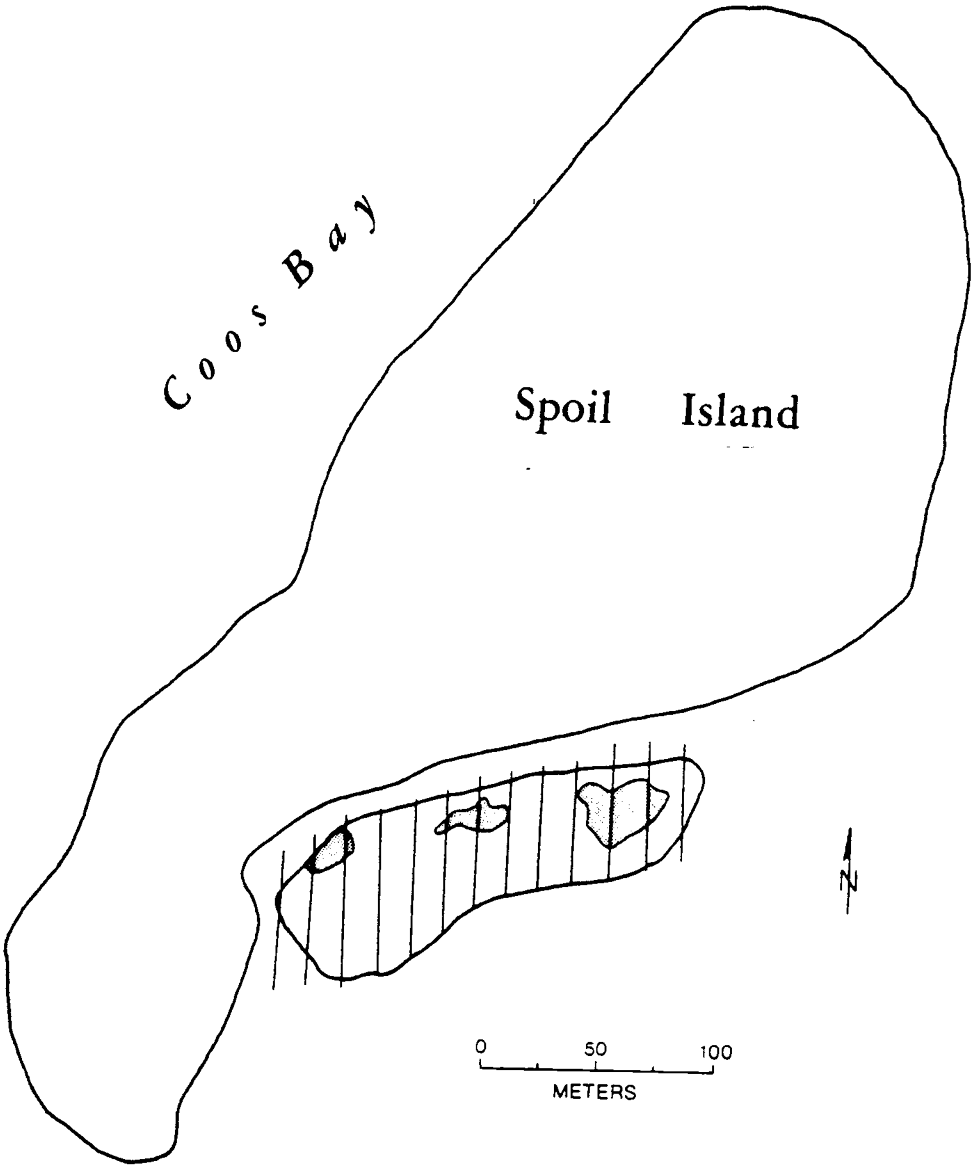

Figure 6. Transect locations at the airport sampling area. Only every other transect is shown for clarity.

Elevation

In order to establish the relationship of sample points to tidal datum, a program of levelling was initiated at each study site. Temporary tidal benchmarks were established at the head of Joe Ney Slough, by transferring the elevation of the tidal plane above MLLW from the Charleston tide gauge (943-2780). This method of tidal datum establishment is based on the assumptions that, the surface of the water is level, and the height of the tidal plane above MLLW is constant throughout the estuary. The accuracy of this method is dependent on the distance of the tidal plane transfer and wave action. The short distance (2.4 km) and ideal atmospheric conditions on the night of transfer, assured that the accurate establishment of tidal benchmarks (Mark Harbert, Division of State Lands personal communication, February 7, 1979).

Once temporary tidal benchmarks were established, the elevation above MLLW of virtually all sample points within the Joe Ney Slough and Beaver Marsh sites were determined. Only a rudimentary elevational network was established at the airport site. Elevations above MLLW were determined on four transects which ran from the beach debris line to a point just beyond the vegetated portion of the mudflat. Only four points along each transect were considered for elevation determinations. The landward edge of vegetation, a point in the center of the vegetated area, the seaward edge of vegetation, and the nick point, a geomorphic break on the tideflat beyond the vegetated area.

All sample points at Joe Ney Slough were then mapped on aerial photographs with a scale of 1 to 2,450. A 20 cm contour map was produced from this data base for the Joe Ney Slough site (Figure 7)[8]. No map was attempted for Beaver Marsh or the airport site because of too small an area and too few sample points respectively.

Analytic Methods

Vegetation data was processed by an agglomerative cluster program developed by Keniston (1978) for classification purposes. Only species with greater than 1 percent frequency were considered in the vegetation analysis in order to reduce the data input required by the program. Samples were grouped by this program according to the dissimilarity measure generated by the Bray-Curtis dissimilarity index. This is expressed as:

$$D_{jk} = \frac{\sum_{i=1}^{N} |X_{ij} - X_{ik}|}{\sum_{i=1}^{N} (X_{ij} + X_{ik})}$$

where; X_{ij} is the cover value of species i in the jth sample; x_{ik} is the cover value of species i in the kth sample; D_{jk} is the Bray-Curtis dissimilarity index; and N is the number of species.

This is an iterative process, whereby all samples are compared to one another and an index value determined. The strategy chosen for clustering was the group average solution. Inter-group resemblance in this strategy is defined as the mean of all resemblances between members of one group to members of another. This strategy introduces relatively little distortion to the relationships originally expressed in the inter-entity resemblance matrix (Boesch 1977). The end product of this cluster analysis is a dendrogram where the height of the arch

[8] Figure in pocket.

cross ties represents the dissimilarity between two clusters.

Due to its large size, the data set had to be broken into four groups and processed by the cluster program separately. The resulting dendrograms were then inspected, and distinct groups of samples identified for further cluster analysis.

Mean cover for each species was determined within each of these groups with the aid of the frequency program in the Statistical Package for the Social Sciences (SPSS). Only species with 5 percent or more mean cover were considered for community analysis. These new composite samples were then processed by the cluster program.

A similar procedure was followed for Beaver Marsh. Analysis of the Airport site data with only three species did not require computer analysis.

The areal extent of plant communities was measured from aerial photographs with the aid of an SAC GP-40 sonic digitizer/planimeter. The standing crop biomass values for different community types was calculated as the product of community area, and mean community biomass.

RESULTS

Joe Ney Slough Mitigation Site

Plant Communities

Sixty-five vascular plant species were identified in the Joe Ney Slough mitigation site during the course of this study (Table 7). Of these, 43 were used in classifying the plant communities. Voucher specimens are on file at the Oregon Institute of Marine Biology Charleston, Oregon.

Thirteen plant communities were identified by cluster analysis of 682, 0.1 m^2 vegetation samples. Figures 8-11 show dendrograms and groups determined for community analysis in the Joe Ney Slough mitigation site. Considerable variation in species dominance within plant communities exists. This variation stems from the response of individuals within the community to changing environmental gradients. Variation within communities is discussed here as it was identified in the field, and by the cluster analysis. Figure 12 is the dendrogram of composite samples, the basis for the plant community classification presented below.

Communities have been subdivided into two broad groups. The first group consists of hydric communities, where the water table is at or near the soil surface. The second group constitutes the grassland communities, characterized by better drainage and higher elevations. Table 8 presents community characteristics identified in the Joe Ney

Slough mitigation site. The distribution of plant communities is shown in Figure 13[9].

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[9]Figure in pocket.

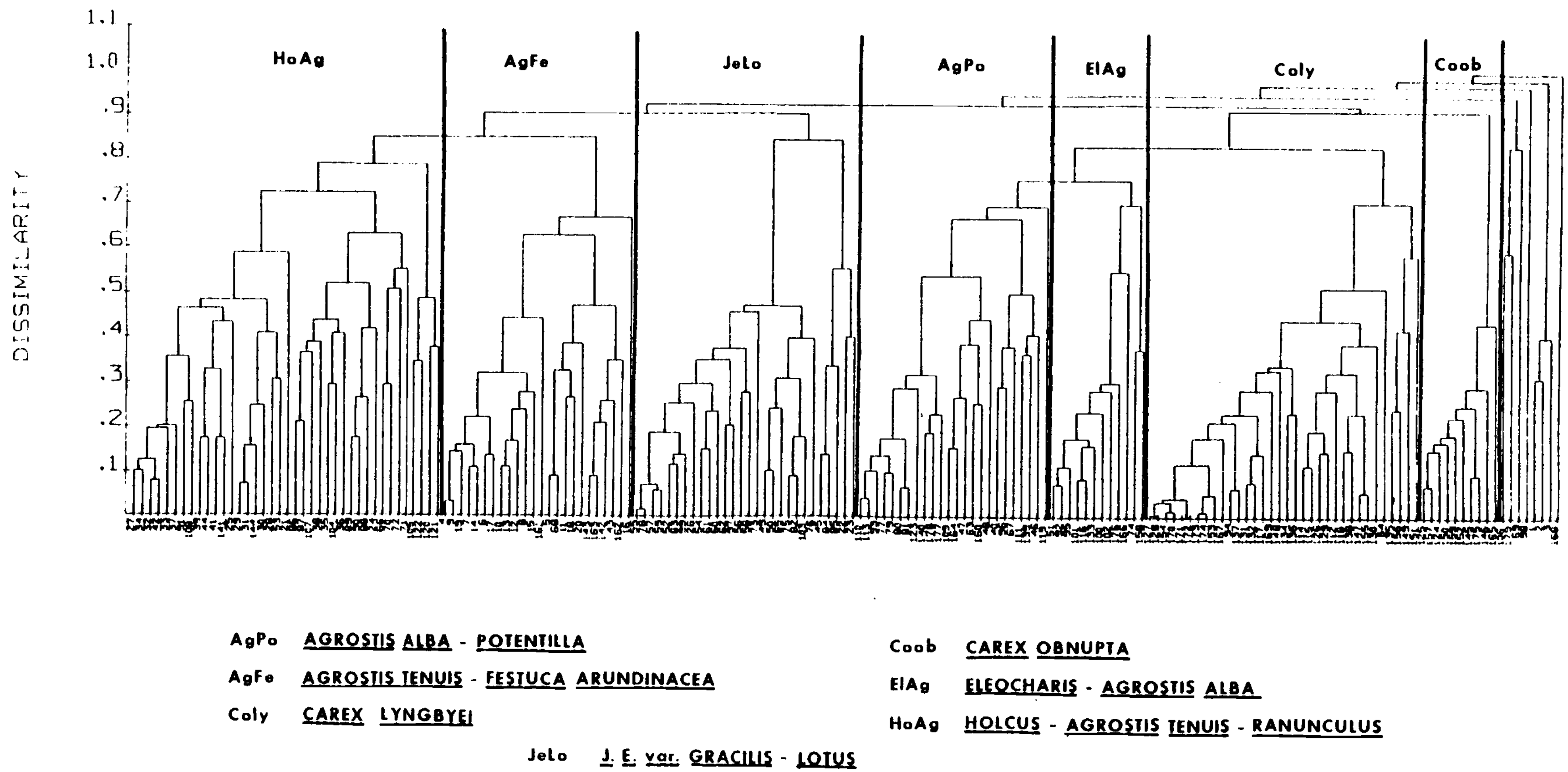
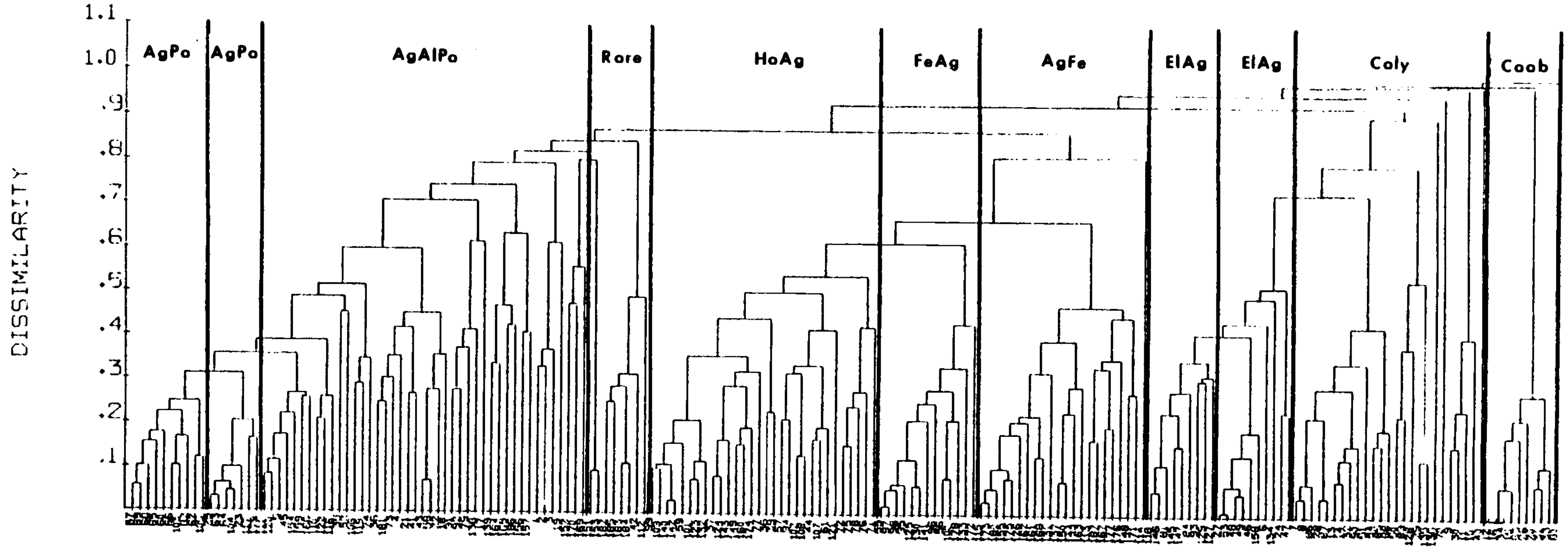
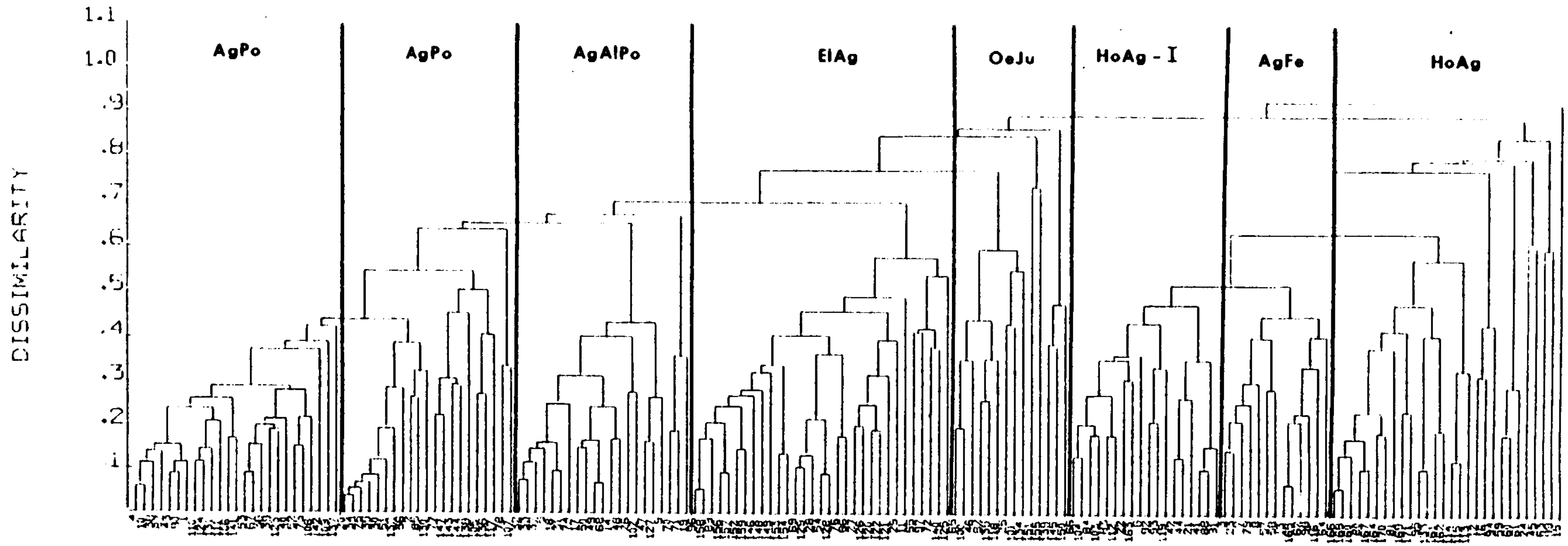


Figure 8. Dendrogram of samples 1-179 from the Joe Ney Slough mitigation site.



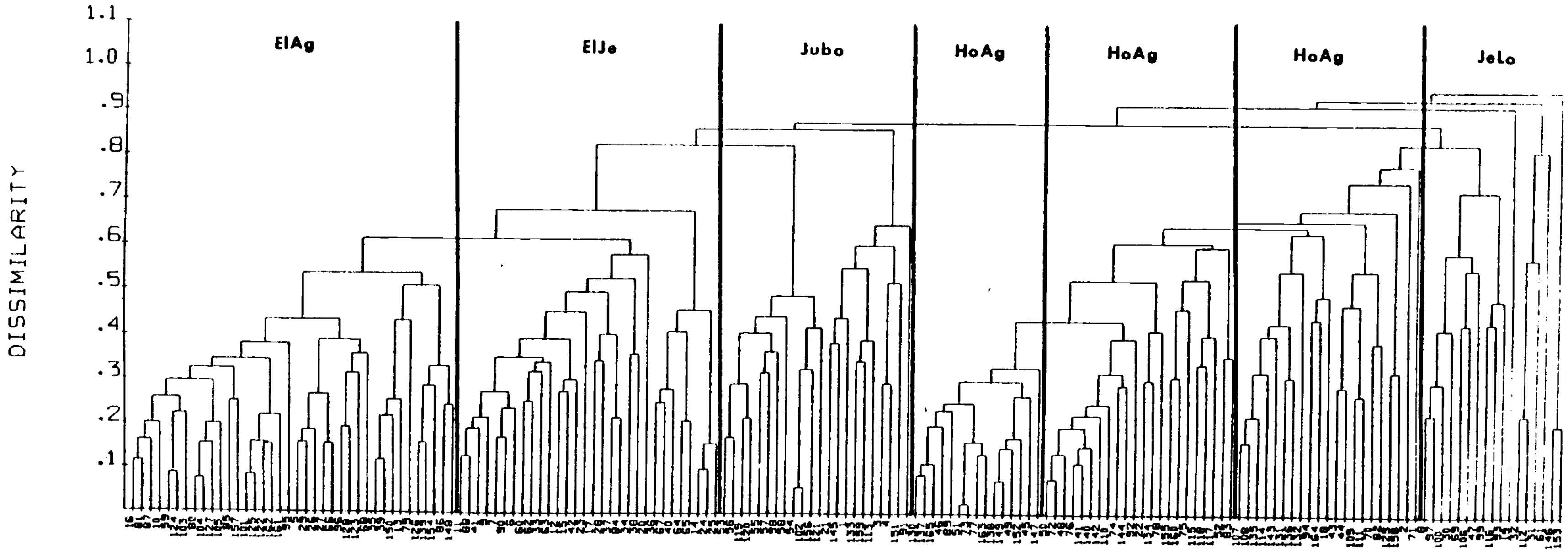
AgAlPo	AGROSTIS ALBA - ALOPECURUS - POTENTILLA
AgPo	AGROSTIS ALBA - POTENTILLA
AgFe	AGROSTIS TENUIS - FESTUCA ARUNDINACEA
Coly	CAREX LYNGBYEI
Coob	CAREX OBNUPTA
ElAg	ELEOCHARIS - AGROSTIS ALBA
FeAg	FESTUCA ARUNDINACEA - AGROSTIS TENUIS
HoAg	HOLCUS - AGROSTIS TENUIS - RANUNCULUS
Rore	RANUNCULUS

Figure 9. Dendrogram of samples 180-366 from the Joe Ney Slough mitigation site.



AgAlPo	AGROSTIS ALBA - ALOPECURUS - POTENTILLA
AgPo	AGROSTIS ALBA - POTENTILLA
AgFe	AGROSTIS TENUIS - FESTUCA ARUNDINACEA
ElAg	ELEOCHARIS - AGROSTIS ALBA
HoAg -I	HOLCUS - AGROSTIS TENUIS - RANUNCULUS
OeJu	OENANTHE - J. E. var. PACIFICUS - AGROSTIS ALBA

Figure 10. Dendrogram of samples 367-537 from the Joe Ney Slough mitigation site.



ElAg ELEOCHARIS - AGROSTIS ALBA

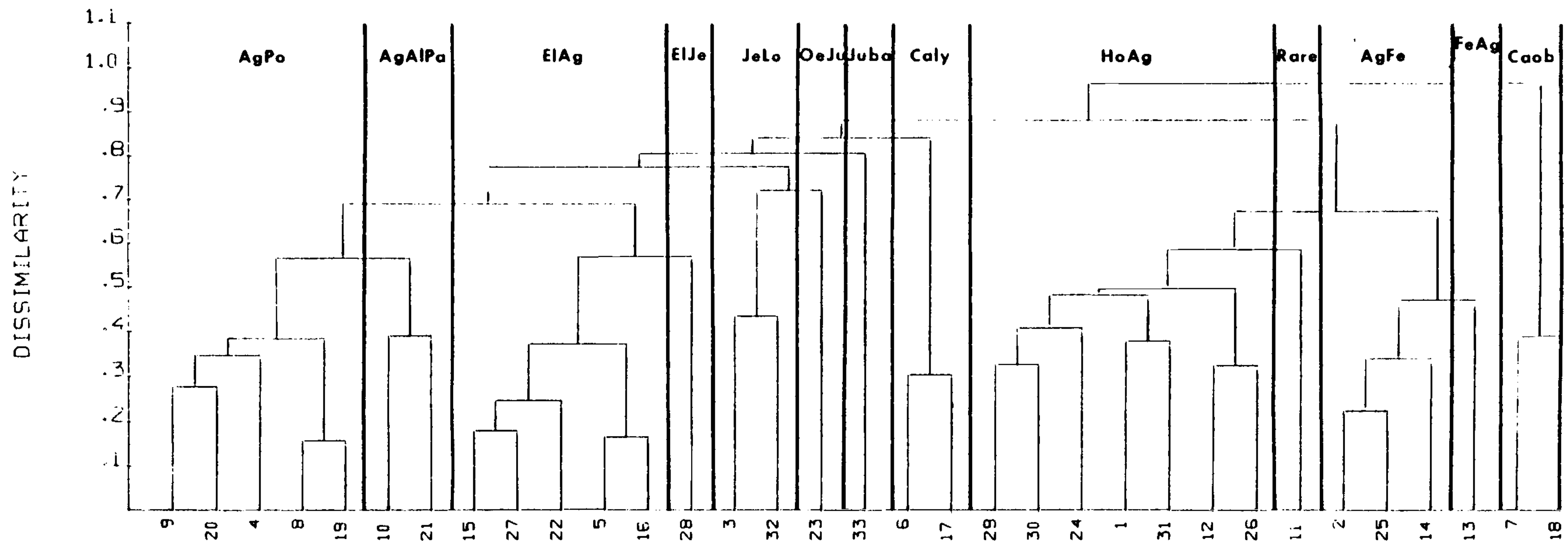
ElJe ELEOCHARIS - J. E. var. PACIFICUS - JUSSIAEA

Jubo JUNCUS BALTICUS

HoAg HOLCUS - AGROSTIS TENUIS - RANUNCULUS

JeLo J. E. var GRACILIS - LOTUS

Figure 11. Dendrogram of samples 538-682 from the Joe Ney Slough mitigation site.



AgAlPo AGROSTIS ALBA - ALOPECURUS - POTENTILLA
AgPa AGROSTIS ALBA - POTENTILLA
AgFe AGROSTIS TENUIS - FESTUCA ARUNDINACEA
Coly CAREX LYNGBYEI

ElAg ELEOCHARIS - AGROSTIS ALBA
ElJe ELEOCHARIS - J. E. var. PACIFICUS - JUSSIAEA
FeAg FESTUCA ARUNDINACEA - AGROSTIS TENUIS
HoAg HOLCUS - AGROSTIS TENUIS - RANUNCULUS
OeJu OENANTHE - J. E. var. PACIFICUS - AGROSTIS ALBA

JeLo J. E. var GRACILIS - LOTUS
Juba JUNCUS BALTICUS
Caob CAREX OBNUPTA
Rare RANUNICULUS

Figure 12. Dendrogram of composite samples showing plant communities in the Joe Ney Slough mitigation site.

Table 7. Plant species identified in the Joe Ney Slough mitigation site with indication of their frequency and mean cover in sampled quadrats.

Family and Species	Frequency (percent)	Mean Cover (percent)	Used in cluster analysis
ARACEAE			
Lysichitum americanum Hulten & St. J.	1.00	0.38	x
BETULACEAE			
Alnus rubra Bong.	1.60	0.58	x
CALLITRICHACEAE			
Callitriche stagnalis Scop.	1.00	0.12	x
CARYOPHYLLACEAE			
Cerastium viscosum L.	1.60	0.30	x
Stellaria calycantha (Ledeb.) Bong.	0.04	0.03	
COMPOSITAE			
Cirsium vulgare (Savi) Ten.	0.04	0.10	
Hypochaeris radicata L.	1.00	0.20	x
Madia sativa Mol.	0.03	0.02	
Senecio jacobaea L.	0.01	0.05	
CRUCIFERAE			
Cardamine occidentalis (Wats.) Howell	0.07	0.30	
CYPERACEAE			
Carex lyngbyei Hornem.	9.00	5.00	x
Carex obnupta Bailey	7.30	4.00	x
Eleocharis palustris (L.) R. & S.	33.00	17.80	x
Scirpus americanus Pers.	1.90	0.19	x
Scirpus microcarpus Presl.	2.40	1.60	x
EQUISETACEAE			
Equisetum	1.10	0.52	x
GERANIACEAE			
Geranium molle L.	0.01	0.06	
GRAMINEAE			
Agrostis alba L.	63.00	28.50	x
Agrostis tenuis Sibth.	38.00	17.60	x
Alopecurus geniculatus L.	24.90	7.80	x
Alopecurus pratensis L.	11.90	0.62	x
Anthoxanthum odoratum L.	0.01	0.09	
Bromus secalinus L.	2.00	0.30	x
Dactylis glomerata L.	0.03	0.04	

Table 7 (cont.)

Family and Species	Frequency (percent)	Mean Cover (percent)	Used in cluster analysis
Festuca arundinaceae Schreb.	9.70	5.30	x
Festuca bromoides L.	0.09	0.25	
Glyceria grandis Wats.	1.40	0.49	x
Glyceria occidentalis (Piper) Nels.	4.30	1.11	x
Holcus lanatus L.	38.20	16.60	x
Lolium multiflorum Lam.	0.04	0.18	
Lolium perenne L.	6.30	1.46	x
Poa palustris L.	13.20	2.09	
JUNCACEAE			
Juncus balticus Willd.	6.00	3.40	x
Juncus bolanderi Engelm.	0.06	0.12	
Juncus bufonius L.	0.07	0.04	
Juncus effusus L. var. *gracilis* Hook.	11.10	6.00	x
Juncus effusus L. var. *pacificus* Fern. & Wieg.	9.40	4.40	x
Juncus ensifolius Wikst. var. *ensifolius*	0.01	0.36	
LABIATAE			
Lycopus uniflorus Michx.	0.01	0.01	
Mentha arvensis L.	0.03	0.02	
Stachys mexicana Benth.	0.01	0.06	
LEGUMINOSAE			
Lotus corniculatus L.	17.40	6.70	x
Trifolium repens L.	0.01	0.01	
ONAGRACEAE			
Epilobium watsonii Barbey	5.00	0.99	x
Jussiaea uruguayensis Camb.	3.70	1.28	x
PLANTAGINACEAE			
Plantago hirtella H.B.K.	0.03	0.05	
Plantago lanceolata L.	1.70	0.39	x
POLYGONACEAE			
Polygonum persicaria L.	1.10	0.07	x
Polygonum spergulariaeforme Meisn.	0.01	0.01	
Rumex acetosella L.	0.04	0.01	
Rumex congolmeratus Murr.	0.01	0.01	
Rumex obtusifolius L.	6.10	1.13	x

Table 7 (cont.)

Family and Species	Frequency (percent)	Mean Cover (percent)	Used in cluster analysis
PORTULACACEAE			
Montia fontana L. var. *tenerrima* (Gray) Fern. & Wieg.	0.01	0.01	
RANUNCULACEAE			
Ranunculus repens L.	29.30	11.20	x
ROSACEAE			
Potentilla pacifica Howell	43.90	15.70	x
Rubus discolor Weihe. & Nees.	0.09	0.28	
Rubus spectablis Pursh	1.90	0.64	x
RUBIACEAE			
Galium trifidum L.	9.10	0.85	x
SCROPHULARIACEAE			
Digitalis purpurea L.	0.01	0.01	
Mimulus guttatus DC.	1.10	0.09	x
Parenticula viscosa (L.) Car.	0.01	0.01	
Veronica americana Schwein.	3.60	0.53	x
SPARGANIACEAE			
Sparganium simplex var. *simplex* Huds.	5.60	1.70	
TYPHACEAE			
Typha latifolia L.	1.30	0.55	
UMBELLIFERAE			
Oenanthe sarmentosa Presl.	6.80	3.40	

Eleocharis-Agrostis alba-Community. Found in places where the soil is saturated, this community occurs in areas of low elevation, between 1.3 and 1.5 m adjacent to stream channels, and at elevations between 1.7 and 2.2 m, where standing water is present. The *Eleocharis-Agrostis alba* Community accounts for 16.2 percent (4.3 ha) of the study area and is best developed immediately north of the main dike, and in the mid-reaches of the southern arm. *Eleocharis palustris* is clearly the dominant species, with *Agrostis alba*, and *Potentilla pacifica* playing important but secondary roles. Other species found frequently in this community are *Alopecurus geniculatus*, *Carex obnupta*, *Juncus effusus* var. *pacificus*, *Sparganium simplex*, and *Carex lyngbyei*.

Average plant height in this community was 60 cm, but much variation existed. Drier sites exhibited more stunted growth of *Eleocharis palustris* and favored the development of *Agrostis alba* and *Potentilla pacifica*. The most mesic sites produced the most vigorous growth of *Eleocharis palustris*.

Eleocharis-Juncus effusus var. pacificus-Jussiaea Community. This community is interspersed within the *Eleocharis-Agrostis alba* Community and accounts for 1.7 percent (0.46 ha) of the study area. It is found in areas with standing water, between elevations of 2.0 and 2.2 m. A striking characteristic of this community is the gregarious growth of *J. e.* var. *pacificus*, individual clumps of which may exceed 1 m in diameter. The high frequency and high mean cover of Jussiae uruguayensis [5] and Sparganium simplex, both aquatic plants, reflect the hydric nature of this community. Other species occurring frequently but with low cover are Glyceria grandis, Galium trifidum, and Carex obnupta. Veronica americana and Mentha arvensis were also noted. Average plant height in this community was 80 cm.

Oenanthe-Juncus effusus var. pacificus-Agrostis alba Community. An assemblage of plants which tended to grow on saturated silty organic soils, this community is well developed at a few locations in the shade of the tree canopy along the margins of the study area. Oenanthe sarmentosa was dominant in shady areas, indicating that it may be more shade tolerant than other species in the study area, which thrive on saturated soils. Additional species noted in this community are Alopecurus geniculatus, Eleocharis palustris, Potentilla pacifica, and Epilobium watsonii. This community was found between elevations of 1.6 and 2.0 m and plants generally had an average height of 35 cm.

Juncus effusus var. gracilis-Lotus Community. Dominant in the north arm of the study area above the Eleocharis-Agrostis alba Community, this plant community accounts for 3.5 percent (0.94 ha) of the vegetated surface. The community was best developed between 1.7 and 2.2 m. Again, as with J. e. var. pacificus, the growth of J. e. var. gracilis is a striking feature noted in the field, with individual clumps reaching 70 cm in diameter. Stems of the subdominant,

[5] Jussiaea uruguayensis, introduced from South America, is not commonly found so close to the coast (La Rea Dennis Johnston Department of Botany Oregon State University personal communication, July 1, 1978).

Table 8. Community characteristics. Species indicated with at least ten percent mean cover, N = number of stands.

Species	Average Cover (percent)	Frequency (percent)
HYDRIC COMMUNITIES		
ELEOCHARIS - AGROSTIS ALBA N=89		
Eleocharis palustris	80	99
Agrostis alba	38	82
Potentilla pacifica	16	48
ELEOCHARIS - J.E. var. *PACIFICUS JUSSIAEA* N=30		
Eleocharis palustris	45	67
J. effusus var. *pacificus*	34	53
Jussiaea uruguayensis	34	53
Sparganium simplex	16	50
Lotus corniculatus	16	26
OENANTHE - J.E. var. *PACIFICUS AGROSTIS ALBA* N=14		
Oenanthe sarmentosa	40	64
J. effusus var. *pacificus*	20	21
Agrostis alba	20	79
J.E. var. *GRACILIS - LOTUS* N= 41		
J. effusus var. *gracilis*	58	81
Lotus corniculatus	23	63
Scirpus microcarpus	16	21
Potentilla pacifica	13	44
Agrostis alba	12	40
CAREX LYNGBYEI N=59		
Carex lyngbyei	60	83
Eleocharis palustris	21	69
Agrostis alba	12	46
bare ground	11	17
CAREX OBNUPTA N=20		
Carex obnupta	83	95

Table 8 (cont.)

Species	Average Cover (percent)	Frequency (percent)
GRASSLAND COMMUNITIES		
AGROSTIS ALBA - POTENTILLA		
N=87		
Agrostis alba	82	100
Potentilla pacifica	23	75
AGROSTIS ALBA - ALOPECURUS - POTENTILLA		
N=64		
Agrostis alba	41	89
Alopecurus geniculatus	41	59
Potentilla pacifica	23	61
J. effusus var. *gracilis*	11	16
JUNCUS BALTICUS		
N=17		
Juncus balticus	44	50
Agrostis alba	14	40
Potentilla pacifica	10	25
HOLCUS - AGROSTIS TENUIS - RANUNCULUS		
N=156		
Holcus lanatus	54	84
Agrostis tenuis	41	82
Ranunculus repens	38	64
Potentilla pacifica	15	46
RANUNCULUS		
N=8		
Ranunculus repens	67	75
Alopecurus geniculatus	20	25
Agrostis alba	15	62
Poa palustris	11	50
AGROSTIS TENUIS - FESTUCA ARUNDINACEA		
N=59		
Agrostis tenuis	77	98
Festuca arundinacea	25	51
Holcus lanatus	10	36

Table 8 (cont.)

Species	Average Cover (percent)	Frequency (percent)
FESTUCA ARUNDINACEA - AGROSTIS TENUIS		
N=13		
Festuca arundinacea	91	100
Agrostis tenuis	34	100
Holcus lanatus	22	100

Lotus corniculatus, grew within and on top of these clumps. Besides in the main area in the north arm, small patches of this community can be found in the upper portions of the southern arm of the study area between elevations of 2.1 and 2.5 m. Other species with high frequency are, Potentilla pacifica, Agrositis alba and Scirpus microcarpus. Average height of the vegetation in this community was 70 cm.

Carex lyngbyei Community. Most extensive along the main creek channel, east and south of the main dike, this community appears in the field to be monospecific. However, in some locales Eleocharis palustris and Agrostis alba occur in the understory. Dense stands of Typha latifolia, also considered a member of this community, occur in places along the margins of the main creek channel. This community accounts for 6.2 percent (1.7 ha) of the study area, and is best developed between elevations of 1.1 and 1.6 m. The average height of vegetation is 85 cm.

Carex obnupta Community. A gradual increase in elevation away from the creek channel gives rise to the Carex obnupta Community which accounts for 3.3 percent (0.9 ha) of the area. Plant cover is dominated by Carex obnupta with Eleocharis palustris and Agrostis alba making frequent occurrences. Maximum development of this community is between elevations of 1.2 and 1.6 m. The boundary between the Carex lyngbyei Community and Carex obnupta Community is very abrupt and could be attributed to freshwater seepage from the adjacent upland. The mildly to moderately alkaline condition of soil water found in the Carex lyngbyei Community (Appendix D) may be absent in the Carex obnupta Community because of the development of a freshwater lens, but, insufficient data was taken to demonstrate this relationship. The average height of the vegetation in this community is 165 cm.

Agrostis alba-Potentilla Community. Comprising 11.5 percent (3.0 ha) of the study area, this is the dominant grassland community between elevations of 1.5 and 2.0 m. The community is clearly dominated by Agrostis alba with Potentilla pacifica being an important, but secondary component. Other species occurring frequently within this community are Holcus lanatus, Alopecurus geniculatus, Eleocharis palustris, and Ranunculus repens. Extensive development of this community on poorly drained soils occurred above the southern dike and in transitional areas between hydric communities and higher elevation grassland communities. The average height of plants in this community was 40 cm primarily due to the decumbent growth of Agrostis alba.

Agrostis alba-Alopecurus-Potentilla Community. Also found within the same elevational belt as the above community, is the Agrostis alba-Alopecurus-Potentilla Community. The only distinguishable characteristic between this community and the Agrostis alba-Potentilla Community is the abundance of Alopecurus geniculatus. Other species occurring frequently are Ranunculus repens, Agrostis tenuis, Oenanthe sarmentosa, J. e. var. gracilis, and Poa palustris. The frequent occurrence of plant species characteristic of hydric communities implies that this community has developed on more poorly drained soils than those associated with Agrostis alba-Potentilla Community.

Juncus balticus Community. This assemblage can be found in a small area in the upper reaches of the southern arm of Joe Ney Slough, between elevations of 1.9 and 2.4 m. This community seemed to be transitional between the moister J. e. var gracilis-Lotus Community and the higher Holcus-Agrostis tenuis-Ranunculus Community. Other species noted in this association are Epilobium watsonii, Alopecurus geniculatus, Carex obnupta, and Eleocharis palustris. This community was not mapped because a distinct photographic signature could not be determined. Average height of vegetation was 40 cm.

Holcus-Agrostis tenuis-Ranunculus Community. An abrupt rise of 50 cm or more leads to this community, which has the most extensive distribution in the study area accounting for 44 percent (11.6 ha) of the vegetated surface. Maximum development of this community is between elevations of 1.9 and 2.6 m, but its total range is between 1.6 and 3.2 m. Two distinct phases within this widespread community were identified: The Agrostis tenuis Phase occurred at higher elevations and was dominated by Agrostis tenuis; and the Holcus lanatus Phase tended to dominate the mid and lower elevational areas.

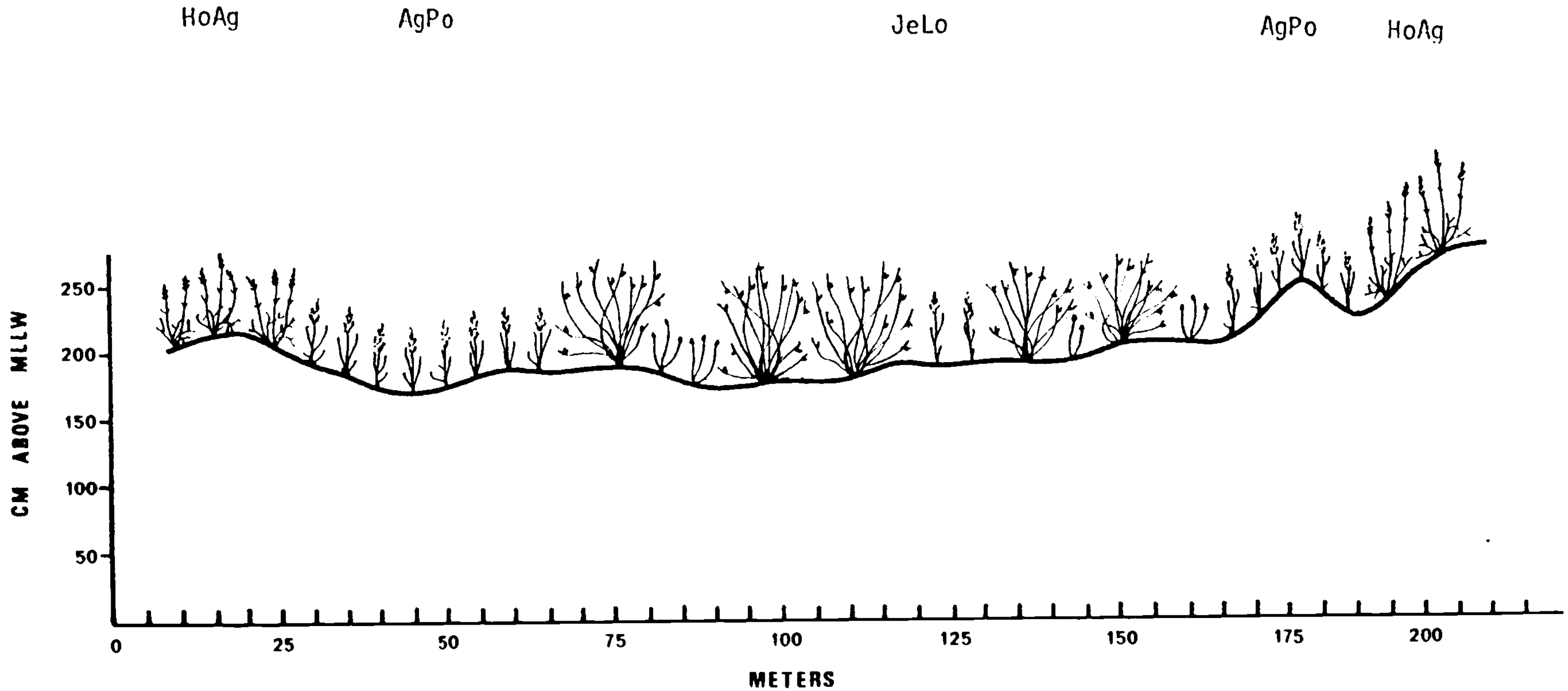
Both phases of this community were marked by a substantial cover of Ranunculus repens. Other species occurring frequently within this community type are Agrostis alba, Alopecurus geniculatus, Lotus corniculatus, and Poa palustris. Average height of plants was 70 cm.

Ranunculus Community. Interspersed within the Holcus-Agrostis tenuis-Ranunculus Community is the Ranunculus Community. In certain favorable localities rhizomatous Ranunculus repens dominated the plant cover. Other species noted in these dense patches were Alopecurus geniculatus, Agrostis alba, and Agrostis tenuis.

Agrostis tenuis-Festuca arundinacea Community. This association occupies 12.7 percent (3.4 ha) of the study area and is developed on the most well-drained soils. Other species occurring frequently are Holcus lanatus, Agrostis alba, Poa palustris, and Lolium perenne. Species occurring with low frequency and indicative of this relatively dry-site community are Festuca bromoides and Bromus secalinus. This more xeric assemblage occurs at elevations above 1.94 m and has an average height of 60 cm.

Festuca arundinacea-Agrostis tenuis Community. Dominant in 6 percent (0.17 ha) of the study area between elevations of 1.8 and 2.2 m, this community develops in areas dominated by the Holcus-Agrostis tenuis-Ranunculus Community where there is improved soil drainage. This association typically occurs on the edge of an abrupt elevational drop of 80 cm, a micro-topographic position which allows water to drain freely to the adjacent lowland area, creating a localized dry soil condition. This condition is further suggested by the occurrence of Bromus secalinus and Lolum perenne.

In order to illustrate the relationship of plant communities to elevation, profiles have been drawn along five transects in the Joe Ney Slough mitigation site. Figures 14-18 represent vegetation and elevation along transect 3, 7, 13, 16, and 28 respectively.

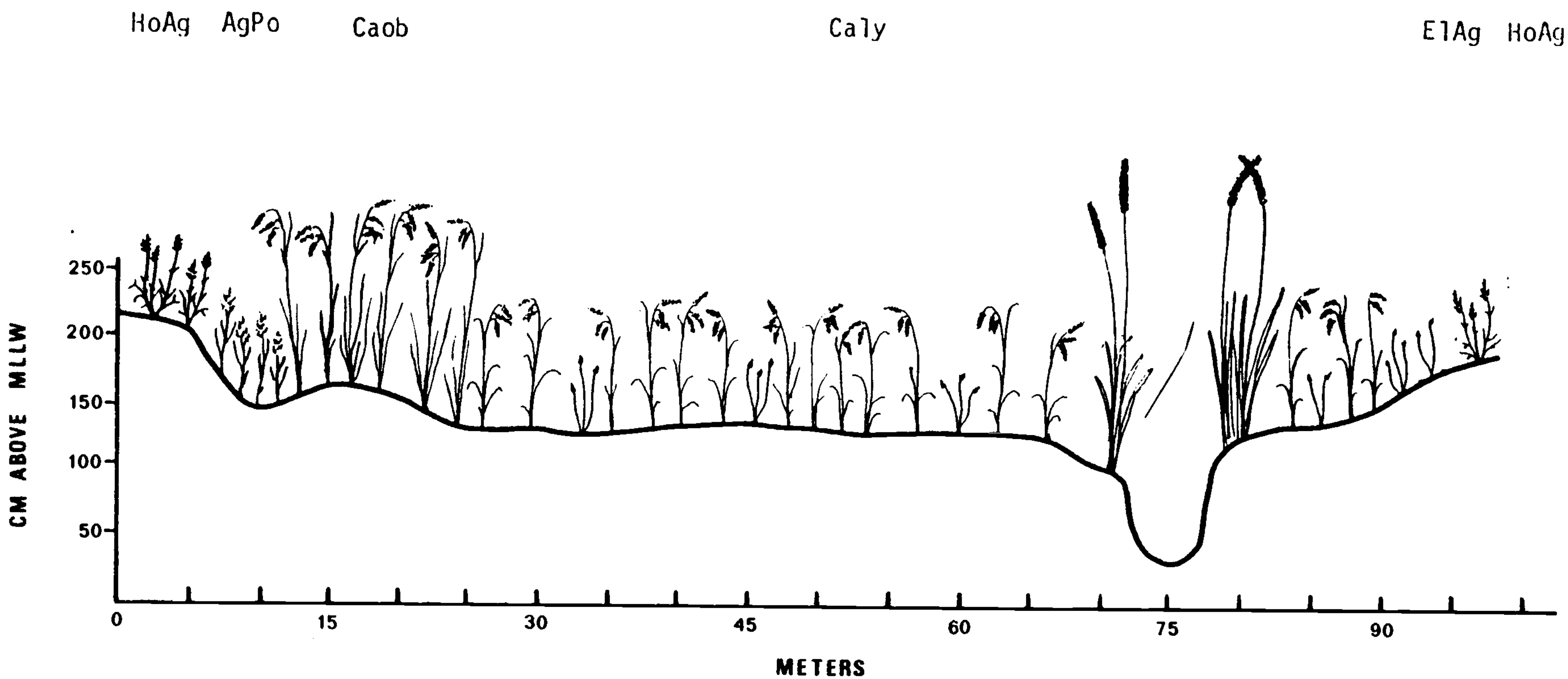


AgPo *Agrostis alba* - *Potentilla*

HoAg *Holcus* - *Agrostis tenuis* - *Ranunculus*

JeLo *Juncus effusus* var. *gracilis* - *Lotus*

Figure 14. Vegetation and elevation profile along transect 3 in the Joe Ney Slough mitigation site.



AgPo <u>Agrostis alba</u> - <u>Potentilla</u>

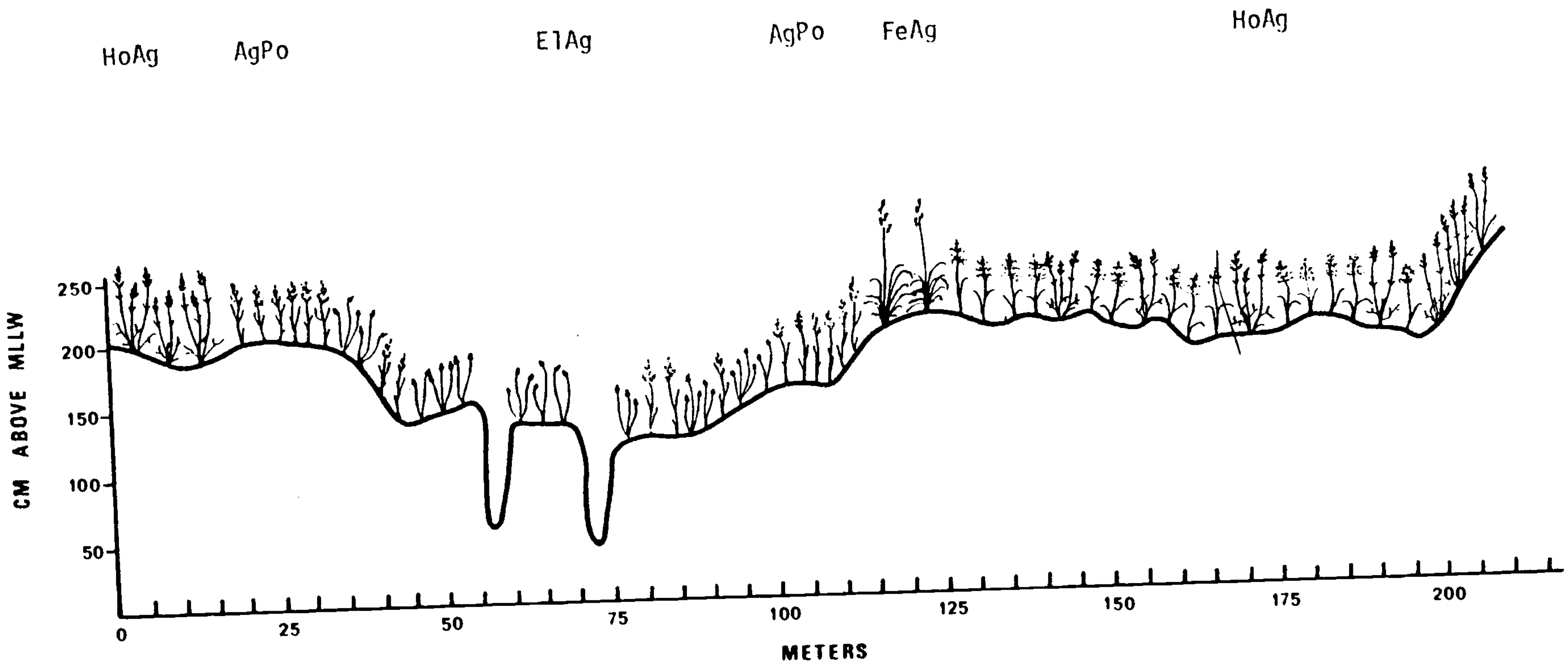
Caly <u>Carex lyngbyei</u>

HoAg <u>Holcus</u> - <u>Agrostis tenuis</u> - <u>Ranunculus</u>

ElAg <u>Eleocharis</u> - <u>Agrostis alba</u>

Caob <u>Carex obnupta</u>

Figure 15. Vegetation and elevation profile along transect 7 in the Joe Ney Slough mitigation site.



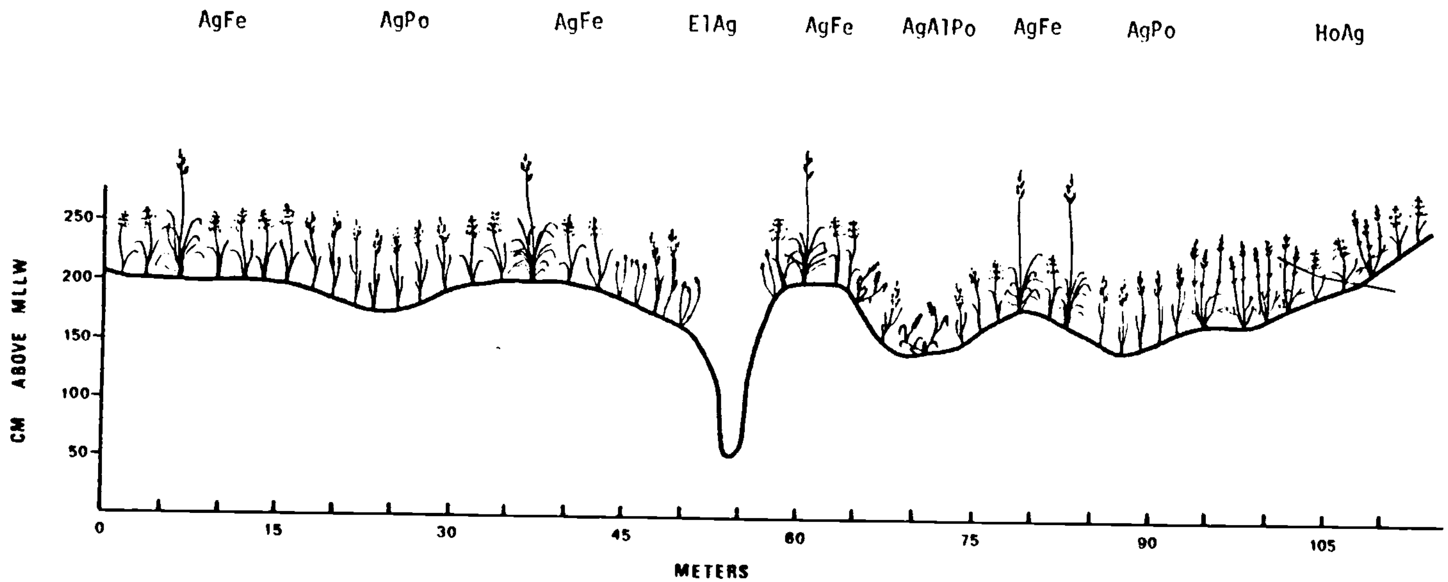
AgPo *Agrostis alba-Potentilla*

FeAg *Festuca arundinacea - Agrostis tenuis*

ElAg *Eleocharis - Agrostis alba*

HoAg *Holcus - Agrostis tenuis - Ranunculus*

Figure 16. Vegetation and elevation profile along transect 13 in the Joe Ney Slough mitigation site.



AgAlPo Agrostis alba - Alopecurus - Potentilla

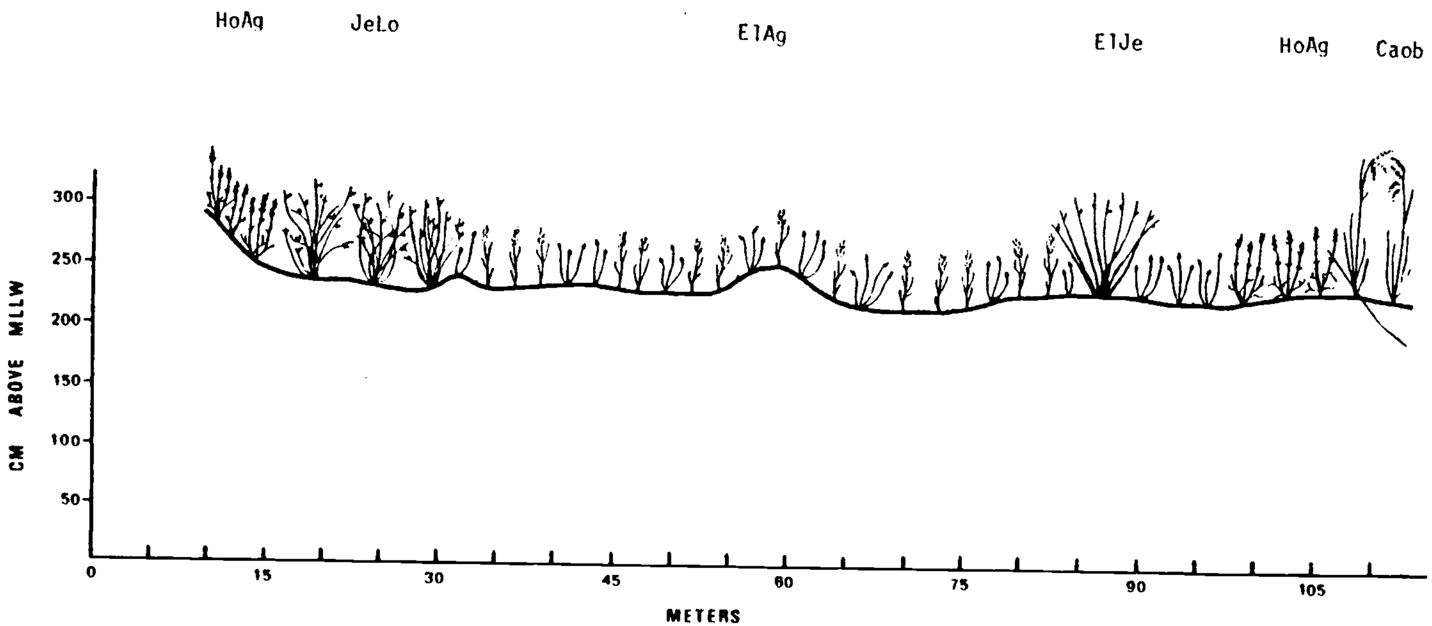
HoAg Holcus - Agrostis tenuis - Ranunculus

AgFe Agrostis tenuis - Festuca arundinacea

ElAg Eleocharis - Agrostis alba

AgPo Agrostis alba - Potentilla

Figure 17. Vegetation and elevation profile along transect 16 in the Joe Ney Slough mitigation site.



HoAg Holcus - Agrostis tenuis - Ranunculus

ElJe Eleocharis - J. e. var. pacificus - Jussiaea

ElAg Eleocharis - Agrostis alba

JeLo Juncus effusus var. gracilis - Lotus

Caob Carex obnupta

Figure 18. Vegetation and elevation profile along transect 2B in the Joe Ney Slough mitigation site.

Plant Communities Summary

Hydric plant communities dominated by *Eleocharis palustris*, *Carex lyngbyei*, *Carex obnupta*, *J. e.* var. *gracilis*, and *J. e.* var. *pacificus* occur in areas below 1.7 m and at higher elevations where water-logged soil conditions exist. As one moves towards higher elevations and drier soil conditions, *Agrostis alba*, *Holcus lanatus*, *Agrostis tenuis*, *Ranunculus repens*, and *Potentilla pacifica* become the most dominant and frequently occurring species. The driest sites are characterized by the occurrences of *Bromus secalinus* and *Festuca bromoides*. Differences in soil moisture lead to a complex mosaic of plant communities in the Joe Ney Slough study site.

Biomass

Results of the biomass sampling (Table 9) indicate that total standing crop per community is proportional to the area covered by that community (Table 10). The notable exceptions to this generalization are the *Carex obnupta*, *J. e.* var *gracilis*-*Lotus*, *Festuca arundinacea*, *agrostis tenuis* and *Eleocharis*-*J. e.* var. *pacificus* Communities. The reason for this is the large stature and persistent perennial nature of the dominant and subdominant species, *Carex obnupta*, *J. e.* var. *gracilis*, *J. e.* var. *pacificus* and *Festuca arundinacea* in these communities. A significant amount of the biomass measured August 10, 1978, in these plant communities can be attributed to the previous years' growth. This is not the case with the other species in the study area.

Table 9. Summary of twenty biomass samples in the Joe Ney Slough mitigation site. Values are the mean weight of samples taken within a community. N - number of samples.

Community	Standing Crop (g/m^2)	Litter (g/m^2)	Total (g/m^2)
Eleocharis - *Agrostis alba* N=3	195	9	204
Eleocharis - *J. e.* var. *pacificus* - *Jussiaea* N=2	170	142	312
J.e. var. *gracilis* - *Lotus* N=3	130	469	699
Carex lyngbyei N=2	61	62	123
Carex obnupta N=2	780	722	1502
Agrostis alba - *Potentilla* N=1	188	48	236
Agrostis alba - *Alopecurus* N=1	100	50	150
Holcus - *Agrostis tenuis* - *Ranunculus* N=3	125	90	215
Agrostis tenuis - *Festuca arundinacea* N=1	193	72	265
Festuca arundinacea - *Agrostis tenuis* N=1	263	397	660

Table 10. Estimate of total areal biomass per community in the Joe Ney Slough mitigation site on August 7, 1979.

Community	Area (ha)	Biomass (g/m^2)	Total (mt)
Eleocharis - *Agrostis alba*	4.20	204	8.7
Eleocharis - *J. effusus* var. *pacificus* - *Jussiaea*	0.46	312	1.3
J. effusus var. *gracilis* - *Lotus*	0.96	699	6.7
Carex lyngbyei	1.70	123	2.1
Carex obnupta	0.90	1502	13.5
Agrostis alba - *Potentilla*	3.04[b]	236[a]	7.2
Holcus - *Agrostis tenuis* - *Ranunculus*	11.60	215	24.9
Agrostis tenuis - *Festuca arundinacea*	3.38	265	8.9
Festuca arundinacea - *Agrostis tenuis*	0.17	660	0.1
		Total	41.9

[a]This figure incorporates the biomass value for the *Agrostis alba* - *Alopecurus* Community type.

[b]This figure incorporates the area of the *Agrostis alba* - *Alopecurus* Community type, and the *Juncus balticus* Community type, because they were not differentiable on aerial photographs.

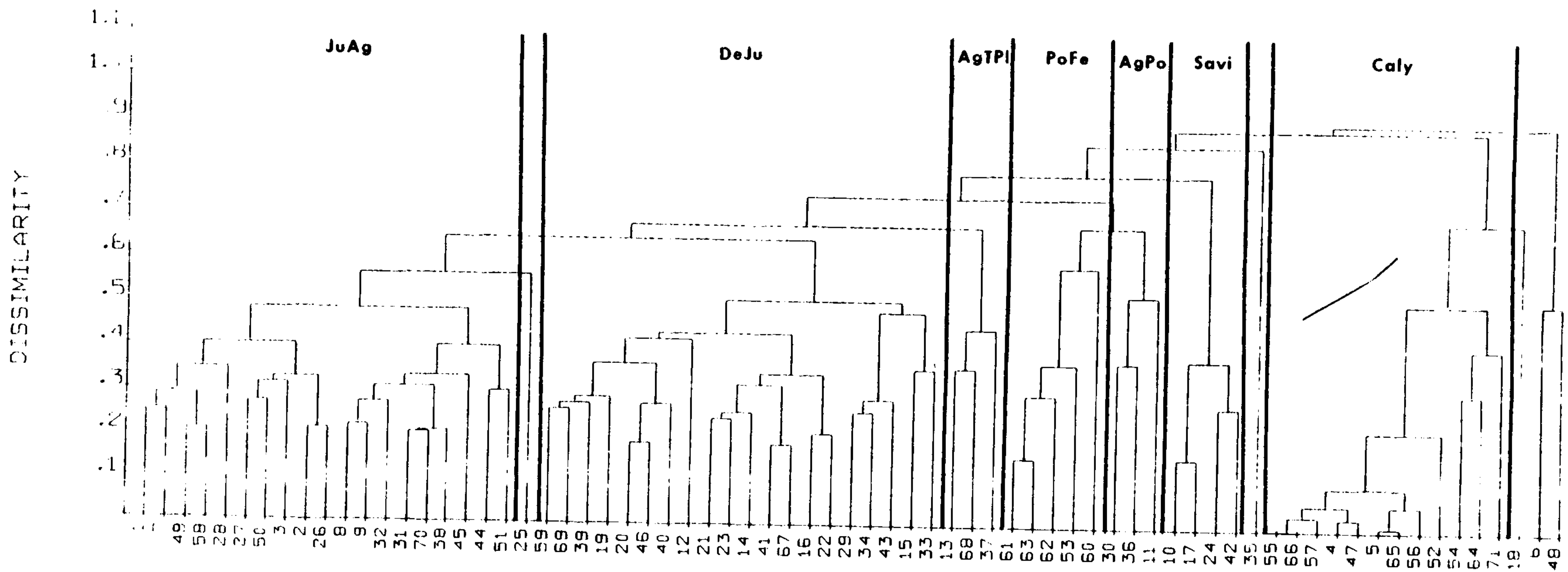
BEAVER MARSH

Plant Communities

A total of twenty eight vascular plant species were identified in 66, 0.1 m^2 and 5, 1.0 m^2 vegetation samples. Table 11 summarizes cover data for this immature high marsh.

Seven plant communities were identified by cluster analysis of 66 stand samples from this marsh. Figure 19 is the dendrogram depicting plant communities identified by cluster analysis. Community characteristics are summarized in Table 12. Different plant communities have developed in distinct elevational belts in response to the varying influence of the tide as one moves from low to high elevation. The distribution of plant communities is shown in Figure 20.

Salicornia Community. The plant community found lowest in the marsh, at elevations between 1.5 and 1.74 m is dominated by *Salicornia virginica* and is developed on the seaward fringe of the marsh surface 60 cm or more above the adjacent mudflat. This community occupies 3.3 percent (87m^2) of the marsh surface. Other species occurring with high frequency are *Deschampsia cespitosa*, *Juncus balticus*, *Triglochin maritimum*, and *Carex lyngbyei*. *Carex lyngbyei* was noted to be colonizing the landward edge of the mudflat at approximately 1.2 m in elevation. This corresponds well to the finding by Eilers (1974) and Frenkel *et al*. (1978) who noted the seaward limit of this species to be approximately 1.0 m above MLLW in other Oregon salt marshes.



AgPo	AGROSTIS ALBA - POTENTILLA	DeJu	DESCHAMPSIA - JUNCUS BALTICUS - TRIGLOCHIN
AgTPl	AGROSTIS ALBA - TRIGLOCHIN - PLANTAGO	JuAg	JUNCUS BALTICUS - AGROSTIS ALBA - POTENTILLA - FESTUCA RUBRA
Caly	CAREX LYNGBYEI	PoFe	POTENTILLA - FESTUCA RUBRA
Savi	SALICORNIA		

Figure 19. Dendrogram of samples from the Beaver Marsh site showing plant communities.

Table 11. Plant species identified in Beaver Marsh with indication of their frequency and mean cover in sampled quadrats.

Family and Species	Frequency (percent)	Mean cover (percent)	Used in Cluster Analysis
CAPRIFOLIACEAE			
Lonicera involucrata (Rich) Banks	1.4	0.21	
CHENOPODIACEAE			
Atriplex patula L. var. hastata (L.) Gray	11.1	2.30	x
Salicornia virginica (L.)	22.5	8.60	
COMPOSITAE			
Achillea millefolium L.	1.4	0.35	
Aster subspicatus Nees	4.2	0.53	x
Grindelia integrifolia DC.	2.8	0.08	
Jaumea carnosa (Less.) Gray	2.8	0.25	x
CUSCUTACEAE			
Cuscata salina Engelm.	1.4	0.04	
CYPERACEAE			
Carex lyngbyei Hornem.	42.3	18.60	x
Carex obnupta Bailey	1.4	0.49	
Scirpus cernuus Vahl.	1.4	0.04	
Scirpus microcarpus Presl.	1.4	0.21	
EQUISETACEAE			
Equisetum spp.	8.5	2.30	x
ERICACEAE			
Gaultheria shallon Pursh	1.4	0.35	
Rhododendron macrophyllum G. Don	1.4	0.49	
GRAMINEAE			
Agrostis alba L.	43.7	13.00	x
Calamagrostis nutkaensis (Presl.)	5.6	1.80	x
Deschampsia cespitosa (L.) Beauv.	57.7	24.20	x
Distichlis spicata (L.) Greene	16.9	2.90	x
Festuca rubra L.	42.3	15.00	x
Hordeum brachyantherum Nevski	18.3	1.60	x
JUNCACEAE			
Juncus balticus Willd.	76.1	37.40	x

Table 11 (cont.)

Family and Species	Frequency (percent)	Mean Cover (percent)	Used in Cluster Analysis
JUNCAGINACEAE			
Triglochin maritimum L.	50.7	15.10	x
PLANTAGINACEAE			
Plantago maritima L.	5.6	1.70	x
PRIMULACEAE			
Glaux maritima L.	29.6	1.80	x
ROSACEAE			
Potentilla pacifica Howell	59.2	14.80	x
RUBIACEAE			
Galium trifidum L.	2.8	0.12	x
UMBELLIFERAE			
Oenanthe sarmentosa Presl.	1.4	0.21	x

Carex lyngbyei Community. This association is well developed between elevations of 1.7 and 2.0 m and accounts for 16.8 percent (442 m^2) of the marsh surface. It is characterized by monospecific stands of Carex lyngbyei, with an average height of 90 cm. This community has also developed at elevations between 2.3 and 2.6 m, where freshwater seepage from the upland and the adjacent creek, have created a saturated soil condition, a situation also observed elsewhere in Oregon by Frenkel et al. (1978).

Deschampsia-Juncus balticus-Triglochin Community. This assemblage typifies the immature high marsh vegetation type identified by Jefferson (1974) and was observed between elevations of 2.0 and 2.45 m accounting for 3.7 percent (988 m^2) of the marsh surface. Although the vegetative cover is dominated by Deschampsia cespitosa, Juncus balticus, and Triglochin maritimum, many other species characteristic of lower and higher marsh plant communities were found scattered in this association. Species occurring with high frequency but low cover include: Potentilla pacifica, Festuca rubra, Glaux martima, Hordeum brachyanterum, Salicornia virginica, Distichlis spicata, and Atriplex patula. Average height of the vegetation was 60 cm.

Agrostis alba-Triglochin-Plantago Community. Poorly developed on Beaver Marsh this mid-marsh community occurs along tidal creeks where disturbance drainage and flooding are important factors in community development. Plantago maritima was only found growing along tidal

Table 12. Characteristics of plant communities found in Beaver Marsh. Species indicated with at least 10 percent mean cover. N = Number of stands.

Species	Average Cover (percent)	Frequency (percent)
SALICORNIA		
N=4		
Salicornia virginica	65	100
Deschampsia cespitosa	15	75
Juncus balticus	10	100
Triglochin maritimum	10	75
CAREX LYNGBYEI		
N=11		
Carex lyngbyei	87	100
bare ground	40	72
DESCHAMPSIA - JUNCUS BALTICUS - TRIGLOCHIN		
N=18		
Deschampsia cespitosa	55	100
Juncus balticus	30	80
Triglochin maritimum	25	90
Festuca rubra	15	60
Potentilla pacifica	10	70
Distichlis spicata	10	40
AGROSTIS ALBA - TRIGLOCHIN - PLANTAGO		
N=2		
Agrostis alba	60	66
Triglochin maritimum	45	100
Plantago maritimum	36	66
Festuca rubra	30	100
Deschampsia cespitosa	17	66
Juncus balticus	14	100
AGROSTIS ALBA - POTENTILLA		
N=3		
Agrostis alba	40	100
Potentilla pacifica	40	100
JUNCUS BALTICUS - AGROSTIS ALBA - POTENTILLA - FESTUCA RUBRA		
N=18		
Juncus balticus	75	95
Agrostis alba	27	63
Potentilla pacifica	20	73

Table 12 (cont.)

Species	Average Cover (percent)	Frequency (percent)
Festuca rubra	20	63
Deschampsia cespitosa	15	58
Triglochin maritimum	10	53
POTENTILLA - FESTUCA RUBRA N=5		
Potentilla pacifica	46	100
Festuca rubra	40	80
Carex lyngbyei	27	100
Equisetum spp.	20	40
Agrostis alba	12	80
Deschampsia cespitosa	10	40

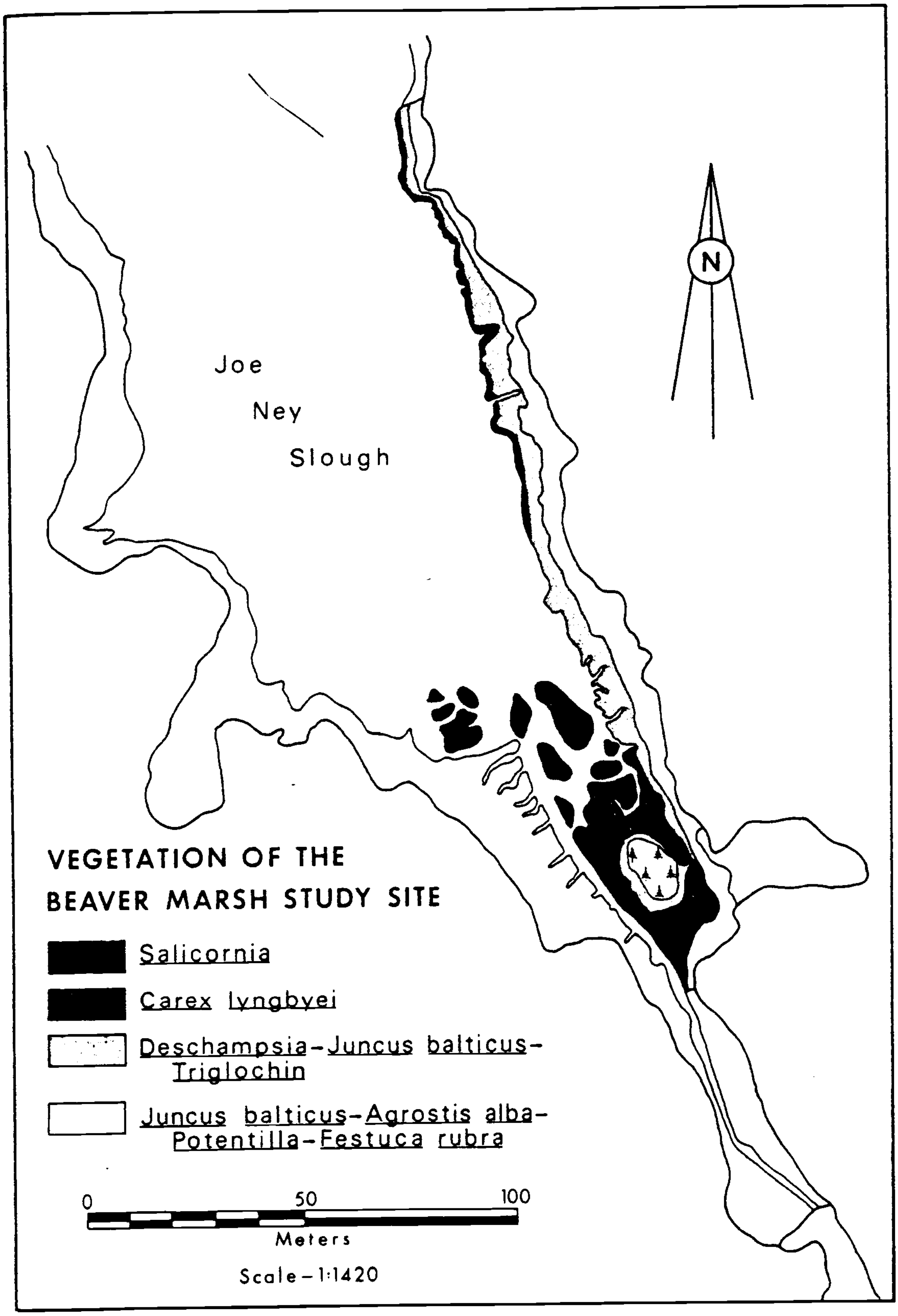


Figure 20. Vegetation of Beaver Marsh.

creeks and in areas where wood debris had accumulated on the marsh surface. Frequent clumps of Triglochin maritimum were also found growing in these tidal creek edge habitats. Other species occurring with high frequency, reflecting non-creek channel vegetation, are Festuca rubra, Agrostis alba, Juncus balticus, and Deschampsia cespitosa.

Agrostis alba-Potentilla Community. This assemblage has developed in a few areas on Beaver Marsh between elevations of 2.35 and 2.5 m. This community is comparable to the Agrostis alba-Potentilla Community found in the diked portion of Joe Ney Slough, where moist fresh water soil conditions exist.

Juncus balticus-Agrostis alba-Potentilla-Festuca rubra Community. Occurring on high elevations in Beaver Marsh between 2.35 and 2.6 m, this association accounts for 42 percent (1,103 m^2) of the total marsh surface. The difference between this community and the Deschampsia-Juncus balticus-Triglochin Community is the increased importance of Juncus balticus and Agrostis alba, and the marked reduction of Deschampsia cespitosa. This community corresponds well with Eilers' (1974) Juncus-Agrostis community on West Island, Nehalem Bay, where it occupied a transitional position between high and low marsh. The average height of this plant community was 40 cm.

Potentilla-Festuca rubra Community. Developed highest on the marsh surface between elevations of 2.5 and 2.6 m this community occurs where there is significant amount of freshwater seepage. Presence of

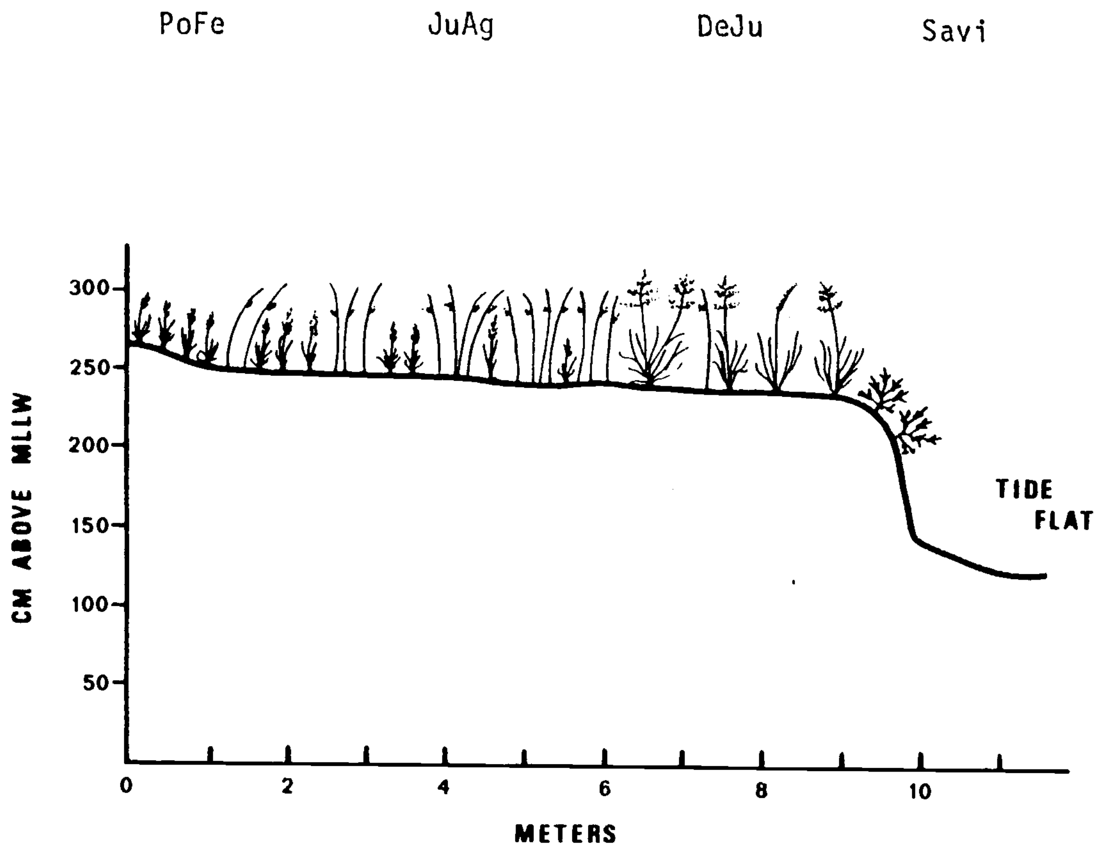
Carex obnupta and *Calamagrostis nutkaensis* also indicates the relation of this community to localized freshwater seepage. The aerial extent of this community was not determined because the community was not identifiable on the available aerial photographs. Average height of the vegetation was 30 cm where *Festuca* and *Potentilla* prevailed. Figure 21 and 22 are elevation and vegetation profiles along selected transects in Beaver Marsh.

Summary

A stepwise elevational series of plant communities is developed on Beaver Marsh. Species such as *Salicornia virginica* and *Carex lyngbyei*, which are tolerant of substantial periods of inundation, dominate the lower elevation communities. As one moves landward and higher in elevation, species characteristic of immature high marshes such as *Deschampsia cespitosa*, become dominant. The highest elevational areas are dominated by *Juncus balticus* with fresh water wetland graminoid species such as *Agrostis alba* contributing significantly to plant cover.

Biomass

Mean biomass for ten clippings in Beaver Marsh are presented in Table 13. Biomass values in the Beaver Marsh communities are substantially higher than biomass figures in the diked portion of Joe Ney Slough. This can be attributed to the persistent perennial nature of such species as *Deschampsia cespitosa*, and *Salicornia virginica*, and high cellulose content as in *Juncus balticus*. This

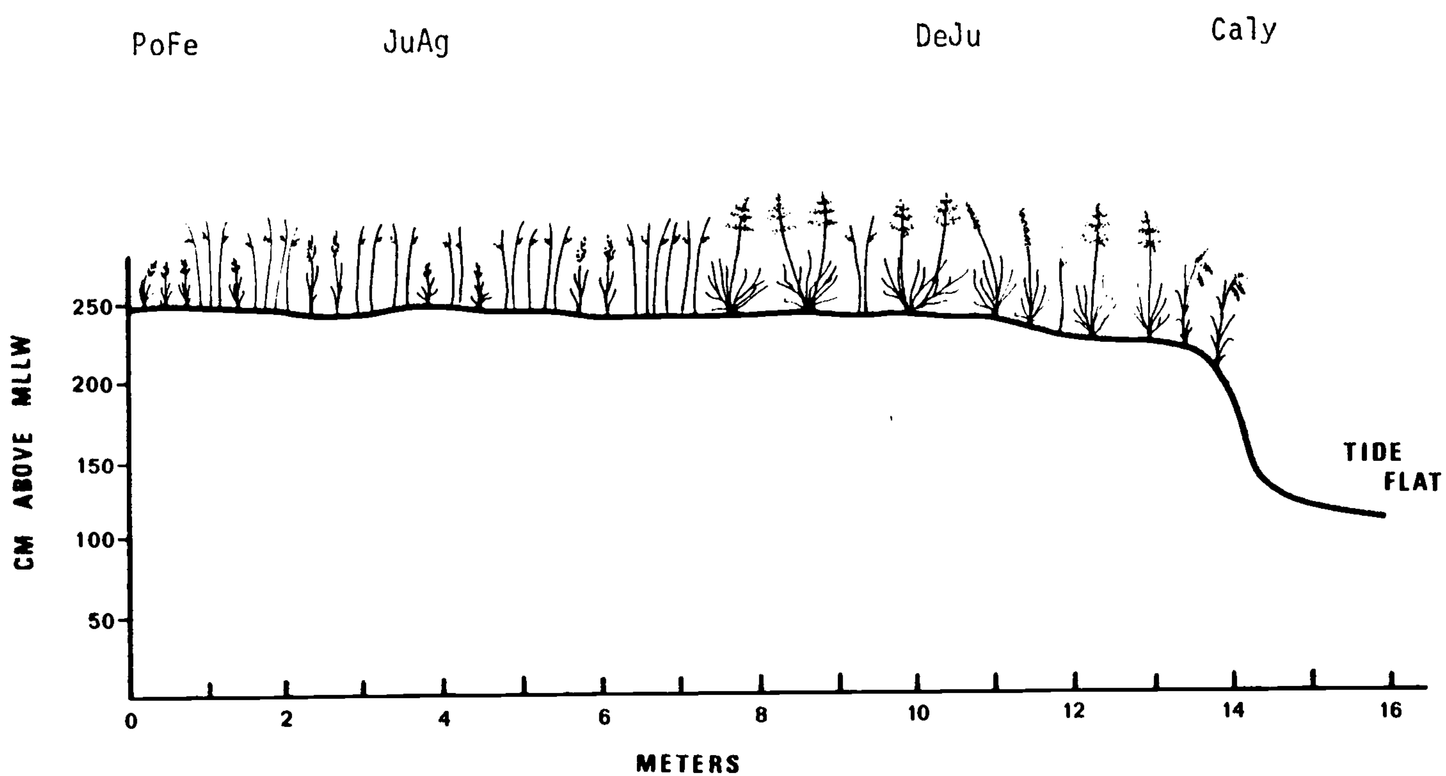


JuAg Juncus balticus - Agrostis alba - Potentilla - Festuca rubra

PoFe Potentilla - Festuca rubra Savi Salicornia

DeJu Deschampsia - Juncus balticus - Triglochin

Figure 21. Vegetation and elevation profile along transect 33 in Beaver Marsh.



DeJu Deschampsia - Juncus balticus - Triglochin   PoFe Potentilla - Festuca rubra

JuAg Juncus balticus - Agrostis alba - Potentilla - Festuca rubra   Caly Carex lyngbyei

Figure 22. Vegetation and elevation profile along transect 38 in Beaver Marsh.

Table 13. Summary of ten biomass samples in Beaver Marsh. Values are the mean weight of samples taken within a community. N = number of samples.

Community	Standing crop (g/m^2)	Litter (g/m^2)	Total (g/m^2)
Salicornia N=1	704		704
Carex lyngbyei N=1	308	158	466
Deschampsia - *Juncus balticus* *Triglochin* N=3	882	684	1566
Juncus balticus - *Agrostis alba* - *Potentilla* - *Festuca rubra* N=5	546	716	1262

Table 14. Estimate of total aerial biomass per community in Beaver Marsh on August 10, 1978.

Community	Area (m^2)	Biomass (g/m^2)	Total (kg)
Salicornia	87	704	61
Carex lyngbyei	442	466	206
Deschampsia - *Juncus balticus* - *Triglochin*	988	1566	1547
Juncus balticus - *Agrostis alba* - *Potentilla* - *Festuca rubra*	1103	1265	1395
		Total	3209

same situation was noted for a few of the communities in the diked portion of Joe Ney Slough. Total aerial standing crop biomass in Beaver Marsh is presented in Table 14.

AIRPORT STUDY SITE

A small salt marsh began to form on the southeast side of the larger of the two dredged-spoil islands sometime between 1964 and 1967 (Figure 6). The marsh is comprised of three vascular plant species: *Salicornia virginica*, *Spergularia canadensis*, and *Ruppia maritima*. Salicornia growing in small isolated clumps, dominates the newly formed marsh. A total of 329, 0.1 m^2 samples were taken in the 8,444 m^2 sampling areas along 26 transects. Table 15 summarizes cover data for this colonizing marsh. *Salicornia virginica* grew in a very sparse stand, occupying approximately 4.7 percent of the sample area. The other species had negligible cover.

Biomass

Biomass was harvested on August 28, 1978, from four selected plots each with 100 percent cover. Only *Salicornia virginica* was present in the biomass samples. Table 16 summarizes the biomass data and shows a mean biomass of 151 g/m^2 for a plot with 100 percent *Salicornia virginica*. Assuming that biomass is proportional to canopy cover, the mean biomass per square meter would be 0.047(151)= 7.1 g/m^2 and the toal biomass for the 8,444 m^2 sampling area would be about 60 kg. Thus, the biomass presently produced by vascular plants at this small, incipient marsh is negligible. It was observed

Table 15. Plant species frequency and cover at the dredged - spoil island sampling area, North Bend Airport study site.

Species	Occurence[a] No.	Occurence[a] Frequency (percent)	Cover[b] Total (percent)	Cover[b] Mean (percent)
Salicornia virginica	39	11.9	1,536	4.7
Spergularia canadensis	6	1.8	40	0.1
Ruppia maritima	5	1.5	37	0.1

[a]Occurence with respect to 329 sample plots.

[b]Cover with respect to a 32.9 m^2 area sampled by 329, 0.1 m^2 plots.

Table 16. Summary of four selected biomass samples taken on August 28, 1978 in the sampling area, North Bend Airport study site[a].

Sample No.	Total Biomass (g/m^2)
I	147
II	127
III	154
IV	174
Mean	150.5

[a]Samples were deliberately selected so as to represent 100 percent canopy cover. Sampling area was 0.1 m^2 per plot.

that biomass increased with elevation which is consistent with the way in which marsh plants colonize fresh mud/sand flats.

Almost all colonization by Salicornia virginica was above elevations of 1.4 m, which is consistent with the finding by Frenkel et al. (1978), on the seaward extent of Salicornia virginica at Netarts Sand pit, Tillamook County, and at Bandon salt marsh Coos County. All these marshes have a sandy substrate in common.

DISCUSSION

Airport Study Site

The proposed North Bend Airport runway extension will affect the *Salicornia* marsh identified in the Airport sampling area (Figures 1 and 6). The easternmost portion of the sampling area would probably be buried by the associated fill activities. Indirect effects of the fill and pilot channel construction will far exceed those of the fill itself. Erosion adjacent to the pilot channel can be expected to undermine areas in the eastern portion of the study area. If sedimentation rates continue at the same level as they have for 21 years, or increase, an expansion of intertidal area can be expected. As elevation of the tide flats increases, salt marsh colonization and expansion would be expected.

Comparison of the Joe Ney Slough and Beaver Marsh Sites

In order to interpret restored marsh development upon removal of the Joe Ney Slough dike, an assessment of the pre-dike marsh vegetation is helpful. This historic interpretation of salt marsh vegetation is based on the assumptions that the plant communities and elevations identified in Beaver Marsh (the control) are characteristic of the expanse of marsh which existed before diking.

Prior to diking, the area below 1.4 m was probably tidal mudflat. Vascular plant growth on this surface would have been limited to species such as the rooted aquatic plant, *Zostera marina*. A thin band of

Salicornia virginica would have characterized the seaward edge of the salt marsh, 60 cm or more above the tide flat, between elevations of 1.5 and 1.7 m. Landward of this community, between 1.7 and 2.0 m in elevation, a Carex lyngbyei Community would have prevailed. This species would have also colonized the mudflat in favorable sites immediately seaward of the Salicornia Community. Above this community, between elevations of 2.0 and 2.45 m, a Deschampsia-Juncus balticus-Triglochin Community would have been dominant, an assemblage which probably accounted for a large percentage of the pre-diking vegetation. Historically however, the dominant plant community on a total areal basis was probably the Juncus balticus-Agrostis alba-Potentilla-Festuca rubra Community, lying between elevations of 2.35 and 2.6 m. Remnant populations of Juncus balticus can still be found at a few locations in the diked Joe Ney Slough mitigation site. Landward, and still higher in elevation, the Potentilla-Festuca rubra Community would have prevailed. Above this community, which lies between 2.5 and 2.6 m, a floristic change would be expected. Plants associated with freshwater seepage and upland plant communities would appear.

With diking, the historic pattern of salt marsh vegetation, as presented above, changed significantly. The former tidal mudflat, below 1.4 m, was colonized by plants tolerant of brackish conditions and is now dominated by Carex lyngbyei, J. effusus var. gracilis, Carex obnupta, and Eleocharis palustris. Elevations between 1.5 and 2.0 m, once occupied by the Salicornia and Carex lyngbyei Communities respectively, became locales for the Agrostis alba-Potentilla Community. Above 2.0 m, both the Deschampsia-Juncus balticus-Triglochin and Juncus balticus-Agrostis alba-Potentilla-Festuca rubra Communities, present before diking, have been replaced by the Holcus-Agrostis tenuis-Ranunculus Community. The high elevation, Potentilla-Festuca rubra Community, reflective of moist freshwater habitats, has been replaced by the dry Agrostis tenuis-Festuca arundinacea grassland community.

Associated with this change, from salt marsh plants, to introduced non-halophytic European plant species, was a change in community peak standing crop biomass. A comparison of the Holcus-Agrostis tenuis-Ranunculus and Deschampsia-Juncus balticus Communities within the same elevational belts in the diked and undiked marsh respectively, illustrates this well. The salt marsh community on the average has eight times more biomass.

A number of physical changes have come about in the Joe Ney Slough site as a result of diking. The tidally-restricting dikes prevent the area from being inundated by saline estuarine waters. This allowed a freshwater habitat to become established within the diked area. An elevational change also appears to have taken place. Comparison of elevation data from both study sites indicate that the land surface behind the dike has subsided between 30 and 50 cm. This observation is based on the assumptions that: 1) the elevations present in Beaver Marsh today are similar to those which existed in the Joe Ney Slough site before diking, 2) the micro-topography in Beaver Marsh reflects the pre-diking micro-topography in the Joe Ney Slough site, and 3) the present day micro-topography in the Joe Ney Slough site reflects the pre-diking micro-topography. The subsidence within the diked area can be attributed to the compaction of sediments, and the decomposition of soil organic material. The restriction of tidal action prevents the export of detrital material from the former salt marsh to the estuary.

Activity associated with the man's occupancy of the diked lands has also modified the land surface. The moderate-to-intensive grazing which took place between 1914 and 1977 tended to compact the soil surface. Compaction has also occurred where vehicular traffic, associated with logging activities, has run over the former marsh surface. Grading for the purpose of tussock removal has also occurred, destroying the geomorphic signs of the former salt marsh.

The many changes in habitat which have taken place in the diked portion of Joe Ney Slough make predictions of vegetation change after dike removal difficult. It is unlikely that the pristine vegetation pattern, as interpreted through Beaver Marsh, will become re-established following dike removal.

A projection of the vegetation which may become established, based on field reconnaissance of breached diked lands in South Slough, Coos Bay and in the Salmon River estuary, immediately after dike removal is presented below.

Upon dike removal the area below 1.4 m (3.3 ha) would be expected to become tidal mudflat. The *Carex lyngbyei*, the only salt-tolerant species presently growing below this elevation, may be able to maintain some of its present day distribution. This will depend on the inundation period of the lands below 1.4 m. Between the elevations of 1.4 and 2.4 m, early successional species associated with silty substrates would be expected to begin colonization. No present-day plants within this elevation belt would be expected to survive. Species noted colonizing silty substrates in other breached dike lands are *Carex lyngbyei*, *Triglochin maritimum*, *Distichlis spicata*, *Salicornia virginica*, and

Cotula coronopifolia. Above 2.4 m, a complete vegetation die-off would not be expected. _Potentilla pacifica_ and _Agrostis alba_, both slightly tolerant of saline conditions, would be expected to maintain their populations. This is based on 1 year's observation in the breached dike lands in the Salmon River estuary.

Summary

The diking of intertidal salt marshes have substantially altered the landscape of Oregon's estuaries. Upon diking, subsidence occurs altering the relationship of the land surface to tidal datums. The associated exclusion of saline waters, allows plants not adapted to the saline habitat to become established. These non-halophytic species dominate plant community composition as seen today. A change in community biomass is associated with this floristic change. The restriction of the daily ebb and flow of the tide also prevents the important exchange of inorganic nutrients and organic material produced by the vascular plant communities. With less nutrients, the marsh becomes less productive and with restricted return of organics to the estuary there is a diminished food base for detrital feeders and other important members of the estuarine intertidal and subtidal system.

Recommendations

The information obtained on vegetation and elevation prior to dike breaching provides a unique opportunity to observe secondary salt marsh succession, and to critically assess the use of diked intertidal lands for marsh restoration. It must be emphasized that no complete studies to date have been undertaken to aid coastal planners in chosing and realizing the potential of an individual mitigation site. Only through prior study, dike breaching, and subsequent follow-up research, will the ultimate goal of this research be achieved.

It is recommended that the western and southern dikes in Joe Ney Slough be completely removed in the next implementation of the mitigation guideline in Coos Bay. If at all possible, this should be carried out in the fall, when the most abundant seed source and highest tides occur along the Oregon coast. This would provide the most favorable conditions for initial colonization by salt marsh plants. It is also recommended that dikes which are in a poor state. of repair be opened to allow the process of salt marsh establishment to begin. Restoration of salt marshes should not have to await the filling of some other portion of the estuary. Saving only 10 percent of the Coos Bay salt marshes through the concept of in-kind mitigation will not help restore the integrity of the Bay's estuarine system. Wherever possible, through dike breaching and planting of dredged spoils with salt marsh plants, the area of intertidal marsh should be increased.

The LCDC should aslo locate, assess and protect potential mitigation sites in each of Oregon's estuaries. Furthermore, a site specific marsh restoration plan should be prepared for each mitigation site. This will help assure that industrial, commercial, and urban development does not occur on sites which have a high potential for mitigation use.

Suggested Additional Research

Many pertinent research topics could be developed to gain information on the effects of dike removal on tidally restricted intertidal lands.

A few of these are:

1) Prior to dike breaching, soil analysis (including profile description, bulk density, and nutrient status) should be conducted and a water table monitoring system implemented. This would allow a comparison of present day diked soil-water patterns with those patterns after breaching. Plots should also be established to estimate accretion rates.

2) After dike breaching, intense vegetation and elevation studies should be conducted at: 1, 2, 5, and 10 years. This would give valuable information on the rates of colonization by salt marsh plants, and subsequent community development. Field reconnaissance is recommended during interim periods.

3) Establishment of sedimentation plots and re-surveying of the permanent plots, at five year intervals, should be carried out at Beaver Marsh. This would provide some of the first information on succession and accretion in an immature high marsh.

4) Sampling of the newly formed mudflat after dike breaching would provide important information on estuarine invertebrate colonization and community change through time.

5) Re-surveying of the vegetation and elevation in the Airport sampling area, at 1, 2, 5, and 10 years would provide valuable information on sedimentation rates and salt marsh expansion at this site.

Of these, the highest priority should be given to a continuation study of vegetation and elevation in the Joe Ney Slough study site, after dike breaching.

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APPENDIX A

Location of permanent plots and percent species cover in the Joe Ney Slough and Beaver Marsh study sites. Sampled August 1-3, 1978. See Figures 4-5.

Joe Ney Slough

Transect # 1
Location: 46 m from labelled endstake
Label # 41 Av. ht. 75 cm Elevation 3.0 m

Species	Cover	Community
Agrostis tenuis	55	Agrostis tenuis-Festuca arundinacea
Dactylis glomerata	8	
Festuca arundinacea	95	
Holcus lanatus	8	

Transect # 4
Location: 10 m from labelled endstake
Label # 42 Av. ht. 65 cm Elevation 2.1 m

Species	Cover	Community
Agrostis tenuis	75	Holcus-Agrostis tenuis-Ranunculus
Carex obnupta	15	
Festuca arundinacea	3	
Holcus lanatus	75	
Lotus corniculatus	75	
Plantago lanceolata	3	
Potentilla pacifica	8	
Ranunculus repens	85	
Rubus spectablis	1	
Rumex obtusifolius	3	

Appendix A - Con't.

Transect # 8
Location: 16 m from labelled endstake
Label # 43 Av. ht. 80 cm Elevation 1.8 m

Species	Cover	Community
Agrostis alba	95	Agrostis alba-Potentilla
Agrostis tenuis	3	
Carex obnupta	35	
Galium trifidum	1	
Holcus lanatus	25	
Lotus corniculatus	8	
Potentilla pacifica	65	

Transect # 9
Location: 5 m from labelled endstake
Label # 44 Av. ht. 65 cm Elevation 2.1 m

Species	Cover	Community
Agrostis tenuis	95	Holcus-Agrostis tenuis-Ranunculus
Holcus lanatus	65	
Ranunculus repens	35	
Rumex acetosella	1	

Transect # 11
Location: 10 m from labelled endstake
Label # 45 Av. ht. 55 Elevation 1.6 m

Species	Cover	Community
Agrostis alba	95	Agrostis alba-Alopecurus-Potentilla
Alopecurus geniculatus	35	
Carex obnupta	1	
Eleocharis palustris	25	
Lotus corniculatus	1	
Potentilla pacifica	3	

Appendix A - Con't.

Transect # 10
Location: 81 m from labelled endstake
Label # 46   Av. ht. 45 cm   Elevation 1.6 m

Species	Cover	Community
Agrostis alba	15	*Oenanthe-J. e.* var *pacificus-Agrostis alba*
Eleocharis palustris	25	
J. e. var *gracilis*	35	
Oenanthe sarmentosa	85	
Potentilla pacifica	8	
Veronica americana	35	

Transect # 13
Location: 32 m from labelled endstake
Label # 47   Av. ht. 65 cm   Elevation 1.8 m

Species	Cover	Community
Agrostis tenuis	85	*Holcus-Agrostis tenuis-Ranunculus*
Galium trifidum	1	
Holcus lanatus	75	
Lotus corniculatus	35	
Ranunculus repens	25	
Rumex obtusifolius	1	

Transect # 12
Location: 66 m from labelled endstake
Label # 48   Av. ht. 70 cm   Elevation 1.9 m

Species	Cover	Community
Agrostis tenuis	8	*Festuca arundinacea*
Festuca arundinacea	95	*Agrostis tenuis*
Holcus lanatus	3	

Appendix A - Con't.

Transect # 13
Location: 165 m from labelled endstake
Label # 49 Av. ht. 35 cm Elevation 1.7 m

Species	Cover	Community
Agrostis alba	75	Agrostis alba-Potentilla
Alopecurus geniculatus	35	
Holcus lanatus	55	
Potentilla pacifica	55	

Transect # 14
Location: 35 m from labelled endstake
Label # 50 Av. ht. 65 cm Elevation 1.6 m

Species	Cover	Community
Agrostis alba	25	Agrostis tenuis-Festuca arundinacea
Agrostis tenuis	95	
Alopecurus geniculatus	15	
Holcus lanatus	25	
Lolium perenne	3	

Transect # 15
Location: 45 m from labelled endstake
Label # 51 Av. ht. 40 cm Elevation 2.0 m

Species	Cover	Community
Agrostis alba	1	Juncus balticus
Agrostis tenuis	65	
Juncus balticus	95	
J. b. var. gracilis	1	
Lolium perenne	3	
Potentilla pacifica	55	
Rumex obtusifolius	8	

Appendix A - Con't.

Transect # 16
Location: 52 m from labelled endstake
Label # 52 Av. ht. 55 cm Elevation 1.4 m

Species	Cover	Community
Agrostis alba	45	Eleocharis-Agrostis-alba
Alopecurus geniculatus	1	
Callitriche stagnalis		
Eleocharis palustris	55	
Galium trifidum	1	
Glyceria occidentalis	8	
Lotus corniculatus	8	
Polygonum persicaria	8	
Polygonum spergulariaeforme	3	
Potentilla pacifica	55	
Prunella vulgaris	1	
Ranunculus repens	3	
Sparganium simplex	1	

Transect # 17
Location: 37 m from labelled endstake
Label # 53 Av. ht. 30 cm Elevation 1.6 m

Species	Cover	Community
Agrostis alba	8	Agrostis alba-
Agrostis tenuis	25	Alopecurus-Potentilla
Alopecurus geniculatus	85	
Potentilla pacifica	3	

Transect # 19
Location: Adjacent to drainage ditch nearest labelled endstake
Label # 54 Av. ht. 40 cm Elevation 1.5 m

Species	Cover	Community
Agrostis alba	45	Agrostis alba-
Agrostis tenuis	15	Alopecurus-Potentilla
Alopecurus geniculatus	55	
Oenanthe sarmentosa	75	
Ranunculus repens	15	

Appendix A - Con't.

Transect # 21
Location: 36 m from labelled endstake
Label # 55   Av. ht. 65 cm   Elevation 1.9 m

Species	Cover	Community
Agrostis alba	35	Holcus-Agrostis tenuis-Ranunculus
Agrostis tenuis	65	
Alopecurus geniculatus	25	
Holcus lanatus	65	
Lotus corniculatus	8	
Potentilla pacifica	75	
Ranunculus repens	65	

Transect # 22
Location: 21 m from labelled endstake
Label # 56   Av. ht. 55 cm   Elevation 1.9 m

Species	Cover	Community
Agrostis alba	25	Eleocharis-Agrostis alba
Alopecurus geniculatus	55	
Carex obnupta	1	
Eleocharis palustris	95	
Potentilla pacifica	85	
Ranunculus repens	15	

Transect # 24
Location: 32 m from labelled endstake
Label # 57   Av. ht. 65 cm   Elevation 2.1 m

Species	Cover	Community
Agrostis alba	8	Eleocharis-Agrostis alba
Alopecurus geniculatus	1	
Eleocharis palustris	95	
Galium trifidum	3	
J. e. var. pacificus	3	
Potentilla pacifica	65	
Rumex conglomeratus	1	
Sparganium simplex	1	

Appendix A - Con't.

Transect # 26
Location: 26 m from labelled endstake
Label # 58 Av. ht. 70 cm Elevation 2.5 m

Species	Cover	Community
Agrostis tenuis	85	Holcus-Agrostis tenuis
Holcus lanatus	65	Ranunculus
Juncus balticus	55	
Ranunculus repens	95	

Transect # 28
Location: 26 m from labelled endstake
Label # 59 Av. ht. 70 cm Elevation 2.3 m

Species	Cover	Community
Agrostis alba	8	Holcus-Agrostis tenuis
Agrostis tenuis	55	Ranunculus
Alopecurus geniculatus	3	
Eleocharis palustris	45	
Epilobium watsonii	25	
Galium trifidum	3	
Glyceria occidentalis	1	
Holcus lanatus	15	
Juncus bolanderi	1	
J. e. var. gracilis	3	
J. e. var. pacificus	3	
Mimulus guttatus	3	
Potentilla pacifica	3	
Ranunculus repens	95	
Veronica americana	8	

Appendix A - Con't.

Transect # 30
Location: 29 m from labelled endstake
Label # 60 Av. ht. 70 cm Elevation 2.5 m

Species	Cover	Community
Agrostis tenuis	75	Holcus-Agrostis tenuis-Ranunculus
Epilobium watsonii	1	
Holcus lanatus	85	
Ranunculus repens	65	

BEAVER MARSH

Transect # 32
Location: 6.4 m from labelled endstake
Label # 61 Av. ht. 75 cm Elevation 2.1 m

Species	Cover	Community
Agrostis alba	3	Deschampsia-Juncus balticus-Triglochin
Atriplex patula	1	
Deschampsia cespitosa	55	
Glaux maritima	1	
Hordeum brachyantherum	8	
Juncus balticus	35	
Salicornia virginica	35	
Triglochin maritumum	25	

Transect # 33
Location: 3 m from labelled endstake
Label # 62 Av. ht. 50 cm Elevation 2.4 m

Species	Cover	Community
Agrostis alba	55	Agrostis alba-Triglochin-Plantago
Atriplex patula	3	
Deschampsia cespitosa	8	
Festuca rubra	45	

Appendix A - Con't.

Species	Cover
Glaux maritima	1
Juncus balticus	3
Plantago maritima	35
Potentilla pacifica	8
Triglochim maritimum	25

Transect # 35
Location: 5 m from labelled endstake
Label # 63 Av. ht. 65 cm Elevation 2.4 m

Species	Cover	Community
Atriplex patula	25	Deschampsia-Juncus balticus-Triglochin
Deschampsia cespitosa	55	
Distichlis spicata	15	
Festuca rubra	45	
Glaux maritima	3	
Hordeum brachyantherum	8	
Juncus balticus	45	
Potentilla pacifica	25	
Salicornia virginica	3	
Triglochin maritimum	8	

Transect # 37
Location: 3 m from labelled endstake
Label # 64 Av. ht. 45 cm Elevation 2.3 m

Species	Cover	Community
Agrostis alba	35	Juncus balticus-Agrostis alba-Potentilla-Festuca rubra
Atriplex patula	1	
Deschampsia cespitosa	15	
Festuca rubra	55	
Glaux maritima	3	
Juncus balticus	65	
Potentilla pacifica	8	
Triglochin maritimum	25	

Appendix A - Con't.

Transect # 38
Location: 4.5 m from labelled endstake
Label # 65   Av. ht. 60 cm   Elevation 2.0 m

Species	Cover	Community
Carex lyngbyei	75	Carex lyngbyei
Deschampsia cespitosa	35	
Juncus balticus	15	
Triglochin maritimum	8	

APPENDIX B

Species and community biomass in the ten biomass samples taken in Beaver Marsh, August 10, 1978.

Community	Species	Species Biomass (g/m^2)	Community Biomass (g/m^2)
Salicornia	*Agrostis alba*	6.8	705
	Salicornia virginica	660	
	Triglochin maritimum	38.1	
Carex lyngbyei	*Carex lyngbyei*	147	466
	Juncus balticus	2.8	
	Triglochin maritimum	158	
	Litter	158	
Deschampsia-Juncus balticus-Triglochin	*Atriplex patula*	17.2	2224
	Deschampsia cespitosa	126.3	
	Juncus balticus	75.9	
	Potentilla pacifica	9.7	
	Salicornia virginica	13.6	
	Triglochin maritimum	2.1	
	Litter	1296.6	
	Atriplex patula	12.4	1258
	Deschampsia cespitosa	181	
	Juncus balticus	102.3	
	Potentilla pacifica	3.6	
	Salicornia virginica	201.2	
	Triglochin maritimum	51	
	Litter	707	
	Agrostis alba	117	1218.4
	Carex lyngbyei	50.2	
	Deschampsia cespitosa	689.5	
	Juncus balticus	236.4	
	Potentilla pacifica	76.3	
	Litter	49.2	

Appendix B - Con't.

Community		Species Biomass (g/m²)	Community Biomass (g/m²)
Juncus balticus-Agrostis alba-Potentilla-Festuca rubra	Atriplex patula	5	1219.5
	Distichlis spicata	7.4	
	Festuca rubra	200.4	
	Juncus balticus	280	
	Potentilla pacifica	64.8	
	Litter	661.9	
	Agrostis alba	6	1147
	Deschampsia cespitosa	107.6	
	Distichlis spicata	73.4	
	Festuca rubra	7.7	
	Glaux maritima	4.7	
	Jaumea carnosa	60.4	
	Juncus balticus	200.3	
	Potentilla pacifica	25.8	
	Salicornia virginica	15.1	
	Triglochin maritimum	59.8	
	Litter	586.2	
	Agrostis alba	96.6	1213.2
	Deschampsia cespitosa	29.1	
	Distichlis spicata	8.1	
	Festuca rubra	14.6	
	Glaux maritima	1.5	
	Juncus balticus	222.2	
	Agrostis alba	76.4	1643.4
	Distichlis spicata	1.9	
	Festuca rubra	347.2	
	Juncus balticus	398.4	
	Potentilla pacifica	1.9	
	Triglochin maritimum	13.5	
	Litter	804.1	

Appendix B - Con't.

Community		(g/m²)	Total (g/m²)
Juncus balticus-Agrostis alba-Potentilla-Festuca rubra	Agrostis alba	10	1100
	Carex lyngbyei	15.1	
	Equisetum sop.	2.8	
	Festuca rubra	27.7	
	Juncus balticus	327.8	
	Potentilla pacifica	26.6	
	Litter	690	

APPENDIX C

Length and bearing of transects in the Joe Ney Slough and Beaver Marsh study sites. For position see Figures 4 and 5.

Transect Number	Transect Length (m)	Sample Numbers	Bearing (True)
		JOE NEY SLOUGH	
1	113	1- 24	104°
2	107	25- 46	105°
3	103	47- 68	103°
4	98	69- 89	105°
5	74	90-105	106°
6	72	106-121	104°
7	95	122-140	61°
8	95	141-160	65°
9	89	161-179	56°
10	96	180-199	51°
11	104	200-220	49°
12	145	221-249	22°
13	215	250-293	350°
14	175	294-328	285°
15	195	329-366	288°
16	120	367-390	286°
17	105	391-411	351°
18	95	412-430	353°

Appendix C - Con't.

Transect Number	Transect Length (m)	Sample Numbers	Bearing (True)
19	85	431-447	353°
20	90	448-467	351°
21	80	468-483	375°
22	85	484-500	358°
23	185	501-537	16°
24	100	538-557	38°
25	120	558-581	48°
26	122	582-607	51°
27	100	608-627	53°
28	115	628-649	43°
29	98	650-669	51°
30	65	670-682	38°

Appendix C - Con't.

Transect Number	Transect Length (m)	Sample Numbers	Bearing (True)
		BEAVER MARSH	
31	7.0	1 - 5	241°
32	7.3	6 -10	241°
33	10.8	11-17	245°
34	11.5	18-24	243°
35	8.0	25-29	240°
36	8.8	30-35	242°
37	14.0	36-43	243°
38	7.0	44-47	241°
39	23.3	48-57	241°
40	15.0	58-66	241°

APPENDIX D

Description of seven soil profiles within the Joe Ney Slough and Beaver Marsh study sites; November, 1979, (Measurement in centimeters; munsell color notation is for moist soil condition).

Community	Depth (cm)	Description
Carex lyngbyei	0-5 cm	Many very fine roots; few fine roots.
	5-16 cm	Dark brown (10 YR 3/3); silt loam; weak, fine granular structure; very friable; slightly sticky, slightly plastic; many very fine roots; common fine roots; common medium roots; medium acid; clear, wavy boundary.
	16-47 cm	Dark gray (5 YR 4/1); silty clay with fine reddish brown mottles (5 YR 4/4); strong, medium, angular, blocky structure; firm, sticky, and very plastic; common very fine roots; neutral.
	47-below	Dark gray (10 YR 4/10); loamy sand; with black mottles (7.5 YR 2.5/0); moderate, medium, angular, blocky structure, very friable; very sticky, non-plastic, few very fine roots; mildly to moderately alkaline, water present below 50 cm.

Appendix D - Con't.

Community	Depth (cm)	Description
Holcus-Agrostis tenuis-Ranunculus	0-3 cm	Grass remains decomposing litter
	3-8 cm	Dark grayish brown (10 YR 4/2); silty clay with yellowish red (10 YR 4/6) mottles localized around roots; moderate, very fine subangular blocky structure; slightly sticky and plastic; many very fine roots; medium acid.
	26-44 cm	Grayish brown (10 YR 5/2); sandy loam with yellowish red (5 YR. 4/8) mottles; moderate, medium, subangular blocky structure; friable, slightly sticky, plastic; common very fine roots; medium acid.
	46-60 cm	Brown dark brown (10 YR 4/3); silty clay seems very organic; with black (24 YR 2.5/0) and dusky red (2.5 YR 3/2 mottles; strong, medium, subangular blocky structure; firm, sticky; very plastic; many fine roots; medium acid.
	60-below	Grayish brown, (10 YR 5/2) silty clay; with strong brown mottles (7.5 YR 5/6); strong, medium, subangular blocky structure; very friable; very sticky, very plastic, few very fine roots; medium acid.

Appendix D - Con't.

Community	Depth (cm)	Description
Deschampsia-Juncus balticus-Triglochin	0-10 cm	Dark reddish brown (5 YR 3/2); organic silty clay; weak, very fine, granular structure; sticky, non plastic; many very fine roots, few fine roots, common medium roots and rhizomes; mildly to moderate alkaline; salinity 13 ppt.
	10-16	Very dark graybrown (10 YR 3/2); organic silty clay; no structure; sticky, non-plastic; many very fine roots, common fine roots and rhizomes neutral; salinity 13 ppt.
	16-22	Brown-dark brown (10 YR 4/3); dense fibrous peat with silty clay; no structure; common fine roots; common medium roots; slightly acid-neutral; gradual boundary; salinity 5 ppt.
	22-57 cm	Gray (5 YR 5/1); clay; massive structure; very sticky, very plastic; common very fine roots, commong fine roots; neutral; salinity 5 ppt.
	57-below	Dark gray (2.5 YR 4/0) loamy sand; no structure; slightly sticky, non-plastic; common very fine roots, common fine roots and rhizomes; neutral; salinity 3 ppt.

Appendix D - Con't.

Community	Depth (cm)	Description
Festuca arundinacea-Agrostis tenuis	0-3 cm	Many very fine roots; organic
	3-7 cm	Very dark grayish brown (10 YR 3/2); silt; moderate, fine granular structure; hard, slightly sticky, plastic; common very fine roots; medium acid.
	7-20 cm	Black (2.5 YR 2.5/0); silt loam, with many medium yellowish red (5 YR 4/6) and red (2.5 YR 4/8) mottles; moderate subangular blocky structure; firm, slightly sticky, slightly plastic; many very fine roots; charcoal present; medium acid.
	20-23 cm	Reddish gray (5 YR 5/2); silt loam; with strong brown (7.5 YR 5/8) mottles; moderate fine angular blocky structure; friable; nonsticky, nonplastic; common very fine roots; medium acid.
	23-34 cm	Very dark grayish brown (10 YR 5/2); silt loam; with common to medium, yellowish brown (10 YR 5/4), strong brown (7.5 YR 5/6) mottles; strong, fine angular blocky structure; firm, nonsticky, plastic; common very fine roots; medium acid.
	34-55 cm	Dark Brown (10 YR 4/3); silty clay; strong, medium angular blocky structure; firm; slightly sticky, slightly plastic; common very fine roots; strongly acid.
	55-60 cm	Dark band; log decomposing.

Appendix D - Con't.

Community	Depth (cm)	Description
Holcus-Agrostis tenuis-Ranunculus	0-3 cm	Organic, roots and rhizomes.
	3-19 cm	Brown dark brown (10 YR 4/3); silt, moderate very fine granular structure; friable, nonsticky, non-plastic; many very fine roots; strongly acid.
	19-46 cm	Brown dark brown (10 YR 4/3) silt loam; with red (2.5 YR 5/6) mottles; medium subangular blocky structure; friable, slightly sticky; slightly plastic; many very fine roots; slightly acid.
	46-below	Dark gray brown (10 YR 4/2); clay; massive structure with yellowish-red (5 YR 5/8) mottles; sticky; plastic, medium acid; saturated.

Appendix D - Con't.

Community	Depth (cm)	Description
Eleocharis - *J. e.* var. *pacificus* - *Jussiaea*	0-10 cm	Root zone water saturated; many medium roots and rhizomes.
	10-100 cm	Gray (5 YR 5/1); clay; very sticky; very plastic; slightly acid; soil saturated, standing water.

Appendix D - Con't.

Community	Depth (cm)	Description
Agrostis alba-Alopecurus-Potentilla	0-1 cm	Organic; many very fine roots; common fine roots and rhizomes.
	1-27 cm	Gray brown (10 YR 5/2); silt loam, with reddish-yellow (7.5 YR 6/8) and reddish brown (5 YR 4/4) mottles; strong, medium, subangular blocky structure; firm, slightly sticky, non-plastic; many very fine roots; medium acid.
	27-below	Dark gray brown (10 YR 4/2); silt loam; with yellow (10 YR 8/6) and dark reddish brown (5 YR 3/3) mottles; strong, medium angular blocky; very firm, non-sticky, very plastic, common very fine roots; strongly acid; soil saturated.