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The Effects of Water Level Fluctuations on Two Coastal Emergent Wetland Plant Communities of Saginaw Bay, Lake Huron

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Thomas M. Burton
Major professor

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THE EFFECTS OF WATER LEVEL FLUCTUATIONS ON TWO COASTAL EMERGENT WETLAND PLANT COMMUNITIES OF SAGINAW BAY, LAKE HURON

by

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ABSTRACT

THE EFFECTS OF WATER LEVEL FLUCTUATIONS ON TWO COASTAL EMERGENT WETLAND PLANT COMMUNITIES OF SAGINAW BAY, LAKE HURON

by Anne M. Vaara

Plant community composition was studied in two coastal wetland sites in Saginaw Bay, Michigan in 1994 and 1995. Plants were sampled along transects using circular plots with a 9.5 m radius from the shoreline to open water at two coastal sites, Cotter Road (T14N, R6E, section 14) and Vanderbilt Park (T14N, R7E) in July and early August during peak biomass. The Vanderbilt Park site was located along the windward side of a cove at Quanicassee, Michigan while the other was located in a more protected area along the leeward side of this cove. Mean annual lake levels decreased by 15 cm from 1994 to 1995. For both sites, species richness and stem density decreased with an increase in water depth and distance from shore with 80-85% of the plant species dropping out at depths greater than 55cm. Species richness increased two-fold for the strand and shallow areas (<25 cm deep) from 1994 to 1995 as water level dropped. Stem density also increased 2 to 5 fold for the strand communities. Few changes were evident at depths >25cm. Biomass weight differences were significant based on individual species type, however, biomass changed very little from year to year and from site to site, along the transects.

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INTRODUCTION

Wetland loss and degradation in Saginaw Bay has been estimated at over 50% or roughly 8,097 hectares since early settlement times (Jaworski and Raphael 1978). The Saginaw Bay coastal wetlands comprise 89% of Lake Huron coastal wetlands in Michigan and 33% of the total coastal wetlands for Michigan (Jaworski and Raphael 1978).

Coastal wetlands are changing environments because both long-term and short-term changes occur with water level fluctuations (Batterson et al., 1991, Burton 1985, Enslin and McIntosh, 1978). Enslin and McIntosh (1982) suggested that changes in the amount and composition of macrophytes occur frequently in response to water level changes, long term lake level and short term seiche and storm surge related changes, site moisture conditions, wave action, water chemistry, sedimentation and other processes.

Water depth is a major factor controlling the distribution of aquatic plants and is responsible for zonation in wetlands (Walker and Copeland, 1968; Stewart and Kantrud, 1972; Hroudova, 1980; Spence, 1982). Enslin and McIntosh (1978) mapped aquatic plant communities for several sites along the Saginaw Bay shoreline through interpretation of historical aerial photography for selected years from 1949 to 1978 and documented changes in plant zones in relation to lake level changes. The plant zones in their study were categorized into submergents, cattails, mixed emergents, sedges and grasses.

Keddy and Reznicek (1986) suggested that fluctuating water levels increase the area of shoreline vegetation, and the diversity of plant community types and species. Any stabilization of water levels would likely reduce marsh area, plant community zonation, and plant species diversity.

Keddy and Reznicek (1986) observed that plants that were intolerant of drying died during low water periods and were replaced by species emerging from reserves of buried seeds. This phenomenon was also documented by van der Valk (1981), Keddy and Reznicek (1982), Smith and Kadlec (1983).

The role of natural "disturbance" or stress in promoting species diversity has been discussed by Grubb (1977), Connell (1978), Huston (1979), White (1979), and Grime (1979). In Saginaw Bay, there is long term "disturbance" with year to year and seasonal water level fluctuations and short term "disturbance" in the form of seiche activity and storm surges. In 1994, Saginaw Bay experienced two large storm surges in May and June with water levels reaching approximately 90 cm above the monthly mean (Whitt 1996) which altered the plant and animal composition for that season. The storm surge destroyed vegetation zones along parts of the shore and the winds and waves ripped the tips of the flowers off many plant species (personal observation). Many plants grew vegetatively but never flowered. The effects of these storm surges included changes in wildlife distribution and the growth and structure of various plant species (personal observation). Long term effects from storm surges cannot be documented from this study.

Given the importance of water fluctuations in structuring macrophyte communities in the litoral zone of lakes (Keddy and Reznicek 1986, Enslin and McIntosh 1978), my hypothesis was that **water level fluctuations and exposure to wave energy at bayward edge of the wetland were important abiotic factors structuring plant community composition along the Saginaw Bay shoreline. My objective was to document changes in plant community composition for the emergent macrophytes of the**

littoral zone of Saginaw Bay in relation to water depth and distance from the shoreline over two annual cycles.

DESCRIPTION OF THE STUDY AREA

Two sites were selected in two coastal wetlands sites in Bay and Tuscola Counties in Saginaw Bay (Figure 1). The two study sites represented areas that had remained an emergent marsh since settlement by Europeans, although these sites are now partially or completely isolated from the wet meadow and lakeplain prairie because of agricultural drainage and/or levees. The two sites were:

1. **Cotter Road:** This site is located in Bay county (T14N, R6E, section 14), at the northern end of Cotter Road, approximately 7 miles east of Essexville (Figure 1) and 1.5 miles north of Highway 25. The area was classified in the 1978 National Wetlands Inventory Quanicassee, Michigan quadrangle as L2EM/ABH (lacustrine, littoral, emergent/aquatic bed, permanent water regime). This site was separated from adjacent uplands by a levee constructed in 1986 by the U.S. Army Corps of Engineers. There were agricultural fields located just south of the levee and a sandy ridge that separated the levee from the emergent zone. The emergent vegetation extended approximately 800 meters out from the strand (an area that is subject to routine flooding and drying) to open water (Figure 2). Dominant wetland plants included *Scirpus americanus* (three-square bulrush) and *S. acutus* (hardstem bulrush), *Typha angustifolia* (narrow-leaved cattail), *Calamagrostis canadensis* (blue-joint reed grass), *Lythrum salacaria* (purple loosestrife), *Eleocharis smallii* (Small's spikerush), *Eleocharis erythropoda* (bald spikerush) and *Carex* spp. (sedge).

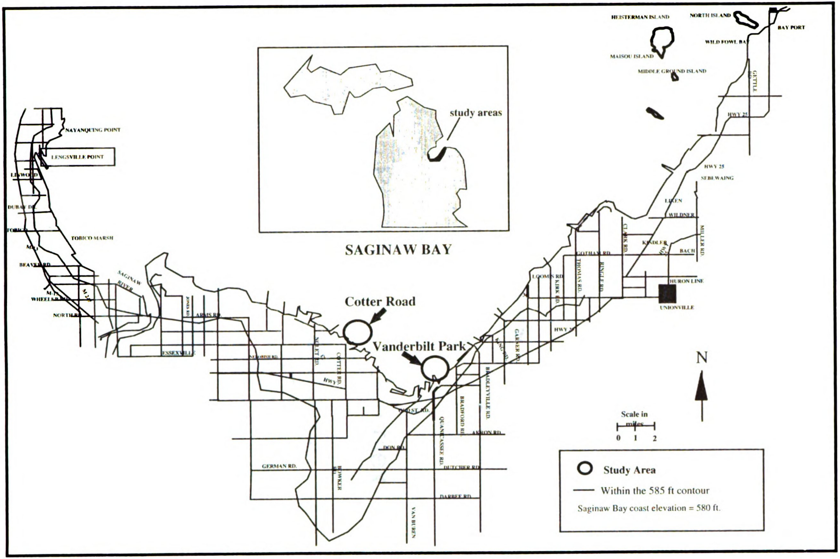
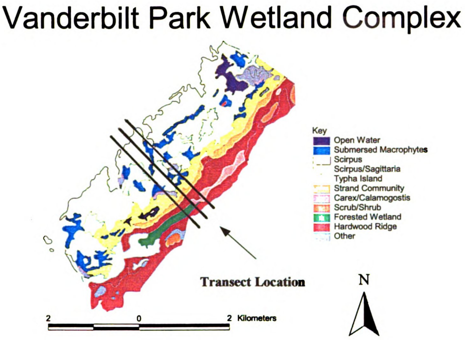


Figure 1. Saginaw Bay area map showing the study sites and the 585 ft. contour.



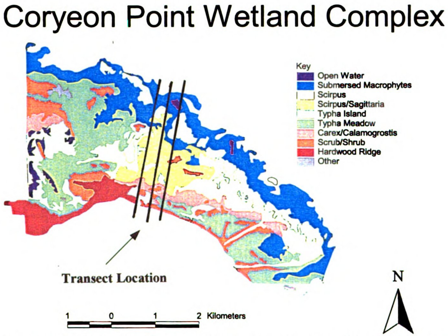


Figure 2. Area maps showing the vegetation types and zones and the wetland and upland systems for Cotter Road (Coryeon Point) and Vanderbilt Park. Maps were constructed using photo interpretation of 1993 aerial photographs by Lucinda Johnson (unpublished) and revised by Kurt Newman.

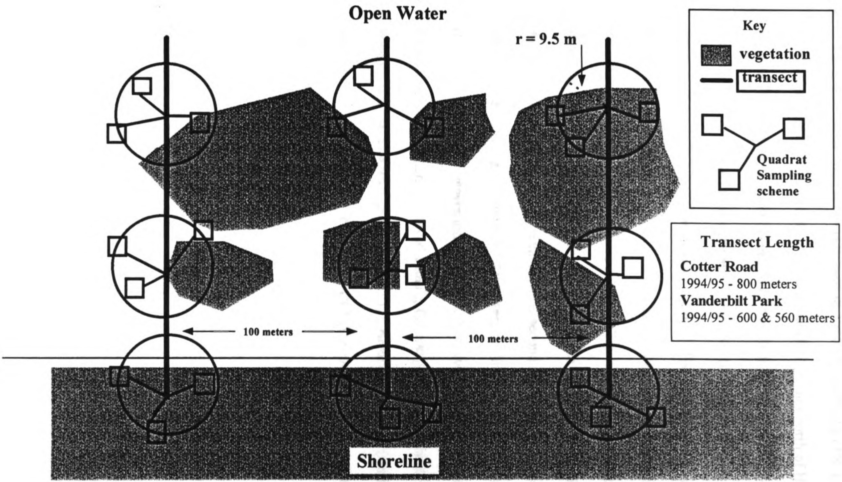


Figure 3. Coastal wetland vegetation sampling techniques for Cotter Road and Vanderbilt Park from the shoreline to open water. In 1994 and 1995, three quadrats were taken from a point-centered circular plot with a 9.5 m radius by randomly selecting a distance (1-9 m) and direction (0-360°) from the center point. The center points for these plots were located at 50 m intervals in 1994 and at 20 m intervals in 1995. Transects were established each year using a set azimuth from a stake installed on the shore in 1994 and extended from the strand to open water.

2. **Vanderbilt Park:** This site was located in Tuscola County, (T14N, R7E, section 21), on the north side of Gilmore Road, approximately 1.5 miles north of Highway 25 (Figure 1). The area had been identified by the 1978 National Wetlands Inventory Quanicassee, Michigan quadrangle as L2EM/ABH (lacustrine, littoral, emergent/aquatic bed, permanent water regime). The littoral wetland included in this study was bounded on the upland side by a sandy ridge that ran parallel to the shore. This sandy ridge was the first of two ridges in forested plant cover that paralleled the shore. A swale wetland between the two ridges was not included in this study. Agricultural fields were located inland of the second sandy ridge. The coastal marsh vegetation extended approximately 600 meters out from the shoreline to open water (Figure 2). Dominant vegetation included *Scirpus americanus* (three-square bulrush), *Typha angustifolia* (narrow-leaved cattail), *Calamagrostis canadensis* (blue-joint reed grass), *Lythrum salacaria* (purple loosestrife), *Eleocharis smallii* (small's spikerush) and *Eleocharis erythropoda* (bald spikerush), *Nymphaea odorata* (white water lily) and *Carex* spp. (sedge).

METHODS

Plant Sampling

Emergent plants were sampled from two coastal marsh sites (Figure 1 and 2) along three line transects/site (Figure 3). A total of 738 quadrats were sampled within 246 sampling points along the line transects for a total of 7, 420 meters (3,320 m at Vanderbilt Park and 4,100 m at Cotter Road), (Figure 2). Site sampling was done in July and early August in 1994 and 1995 at or near peak biomass. Three transects/site were set 100 m apart, parallel to each other and perpendicular to the shore from the shoreline out to open water (Figure 2 and 3). The first point was set in the strand, a transition zone established using the change in vegetation from upland species along the ridge to wetland species along the shoreline. Plants were sampled from circular plots with a 9.5 m radius ($284m^2$) along transects at 50 m intervals in 1994 and at 20 m intervals in 1995. At each interval point, three 0.25 m^2 quadrats were sampled at randomly selected 1 to 9 m distances from the center point of the circular plot using a randomly selected azimuth (0-360°). The (0.25 m^{-2}) quadrat frame was constructed of PVC pipe 0.5m long on each side. The quadrat was placed over the sampled area so that the quadrat extended from the point selected to 0.5 m beyond the point. All stems were counted and identified to species. Any unknown species was collected and transported to the laboratory for identification using keys. Water depth was recorded for each sample point at the time of sampling.

Above ground biomass was determined by randomly selecting 30 stems for each common species and cutting them at the base of the plant. The stems were dried in bags

at 60° C to a constant weight. An average stem weight for each species was calculated as the mean of the 30 randomly collected stems. Average stem weight was multiplied by number of stems/quadrat to calculate biomass. Biomass was determined for rare species using weight classes of species with comparative phenology and biomass from other sites.

Data Analysis

Plant data were summarized for each circular plot using means of the three sampling quadrats. These data were summarized for the strand (shoreline) community and by depth from the strand to the outer edge (open water) of the emergent zone using 25cm water depth intervals in 1994 and 10cm water depth intervals in 1995. Relative density (RD), relative frequency (RF) and relative biomass (RB) were calculated for the strand and for each depth interval. RD + RF + RB were then added together to obtain an importance value ranking. Curtis (1947) used an importance value obtained by adding together relative frequency, relative density and relative dominance. For this study, we used relative biomass rather than relative dominance because dominance or importance of any species can be expressed as the percentage of total biomass (Barbour et. al.). The importance values were divided by 300 (the highest possible score), (Barbour et. al.), to obtain a percent of total community importance for a particular water level gradient range category.

Frequency = (number of quadrats in which a species occurred ÷ total number of plots sampled) * 100

Density = the mean number of individuals within each quadrat

Biomass = weight of vegetation per m^{-2} = number of stems of each species in a plot * mean weight per stem * 4

Importance Value (IV) = the relative contribution of a species to the entire community

IV = relative frequency + relative density + relative biomass

%IV = IV ÷ 300 * 100

RF = number of quadrats sampled that contained the species ÷ total number of quadrats sampled * 100

RD = number of stems per quadrat of each species ÷ total of the average stems per sample plot * 100

RB = average biomass/sample plot ÷ total biomass for all species in sample plots *100

Average Stems/Sample Plot = total number of stems in three quadrats ÷ 3

Importance values were used to describe both sites. By combining two or more measures in a site , a more comprehensive estimate of the importance of species in a stand can be obtained than is possible using any one measure of abundance (Greig-Smith, 1964). Species area curves were prepared for each plant community following procedures outlined in Barbour (1987).

RESULTS

Description of Plant Community Response to Water Level Changes

Plant community composition and stem density changed rapidly as water depth increased from the shoreline strand community to the outer edge of the emergent plant zone about 500 m from shore (Tables 1-4). The strand community (area subjected to alternating wet and dry conditions as lake level rises and falls due to seiche activity) was the zone of highest species richness (Tables 1-4) and stem density (Figure 4). Species richness and stem density decreased as depth increased so that the outer emergent plant zone was characterized by scattered stems of only 3-5 species (Tables 1-4). In fact, the deepest, most exposed outer fringe of scattered stems was often made up of only one species, *Scirpus americanus*, in most places along the coast.

The influence of water depth on plant community composition and stem density (Tables 1-4, Figure 4) was also illustrated by changes that occurred as mean lake levels dropped 15 cm from 1994 to 1995 (Table 5). Plants were sampled during July and August in 1994 and 1995. Mean lake levels during plant sampling in July and August, 1995, were 18.5 cm lower than they were during the same time period in 1994.

Decreased lake levels in 1995 resulted in substantial increases in species richness for the strand community from 13-14 species in 1994 to 25-26 species in 1995 (Tables 1-4, Figure 6) as new seedlings developed on the drying substrate. Stem density also reflected this change with stems increasing from 776 stems/m^{-2} in 1994 to 1779 stems/m^{-2}

Table 1. **Composition of the coastal plant community at Cotter Road in 1994.**

Water Level	Scientific Name	stems/m² Mean	± (S.E.)	Frequency %	Relative Density %	Relative Frequency %	Biomass grams dry wt/m⁻²	Importance Value (RD+RF+RB)	% of Total IV
Strand	*Lythrum salicaria*	52	13	100	36	18	427.4	64	21.6%
	Calamagrostis canadensis	190	129	44	17	8	179.1	49	16.5%
	Scirpus americanus	76	26	100	14	18	105.1	37	12.6%
	Carex spp.	128	77	78	10	14	53.2	35	11.9%
	Poaceae	36	27	33	5	6	222.9	31	10.5%
	Eleocharis spp.	127	127	22	5	4	21.2	22	7.5%
	Juncus spp.	38	18	56	4	10	6.4	15	5.2%
	Eleocharis calva	86	86	22	2	4	2.9	15	5.2%
	Potentilla anserina	25	15	33	2	6	2.5	9	3.2%
	Eupatorium spp.	4	2	44	1	8	0.9	8	2.9%
	Spartina pectinata	6	6	11	1	2	6.0	3	1.1%
	Aster spp.	4	4	11	1	2	2.8	3	0.9%
	Lysimachia quadriflora	3	3	11	1	2	2.1	3	0.9%
Totals		776.4					1032.5		
1-25cm	*Scirpus americanus*	110	39	57	22	19	143.6	65	21.7%
	Eleocharis smallii	163	92	29	32	10	81.5	55	18.5%
	Typha angustifolia	17	9	43	3	14	155.1	44	14.7%
	Lythrum salicaria	26	18	33	5	11	154.4	43	14.2%
	Eleocharis calva	120	120	10	24	3	3.9	27	9.1%
	Scirpus validus	9	5	43	2	14	12.9	18	6.1%
	Scirpus acutus	12	5	57	2	11	20.7	17	5.7%
	Calamagrostis canadensis	31	17	14	6	5	8.3	12	4.1%
	Sagittaria latifolia	6	4	14	1	5	3.4	7	2.2%
	Juncus spp.	9	9	10	2	3	1.6	5	1.8%
	Poaceae	1	1	10	0.2	3	0.7	4	1.2%
	Carex spp.	2	2	5	0.4	2	0.9	2	0.7%
Totals		508.6					587.0		

Table 1 con't. Composition of the coastal plant community at Cotter Road in 1994.

Water Level	Scientific Name	stems/m^2 Mean	± (S.E.)	Frequency %	Relative Density %	Relative Frequency %	Biomass grams dry wt/m^{-2}	Importance Value (RD+RF+RB)	% of Total IV
26-50cm	*Scirpus americanus*	148	48	51	72	44	477.4	185	61.5%
	Typha angustifolia	8	3	24	4	21	152.5	48	16.1%
	Sagittaria latifolia	15	11	22	7	19	19.8	30	9.9%
	Eleocharis smallii	27	19	10	13	8	12.8	23	7.8%
	Scirpus acutus	6	4	5	3	4	8.2	8	2.7%
	Scirpus validus	2	2	5	1	4	3.4	6	1.9%
Totals		207.0					674.1		
51-75cm	*Scirpus acutus*	7	6	13	67	38	26.6	143	44.0%
	Typha angustifolia	3	2	13	24	53	36.7	135	41.5%
	Scirpus americanus	1	1	9	9	35	2.3	47	14.6%
Totals		10.9					65.6		

Table 2. Composition of the coastal plant community at Cotter Road in 1995.

Water Level	Scientific Name	stems/m^2 Mean	± (S.E.)	Frequency %	Relative Density %	Relative Frequency %	Biomass grams dry wt/m^{-2}	Importance Value (RD+RF+RB)	% of Total IV
strand	*Lythrum salicaria*	40	13	100	2	12	336.2	57	19.3%
	Eleocharis erythropoda	824	356	33	46	4	13.7	52	17.5%
	Calamagrostis canadensis	133	65	78	7	9	172.7	39	13.1%
	Carex lasiocarpa	126	70	56	7	7	120.7	29	9.8%
	Scirpus americanus	102	43	78	6	9	85.2	26	8.7%
	unknown seedlings	292	159	44	16	5	no sample	22	7.3%
	Juncus articulatus	125	101	56	7	7	27.2	17	5.8%
	Potentilla anserina	31	29	44	2	5	3.1	7	2.5%
	Solidago spp.	17	9	44	1	5	no sample	6	2.1%
	Stachys tennifolia	5	3	44	0.3	5	0.9	6	1.9%
	Panicum longifolium	27	27	33	2	4	no sample	6	1.9%
	Juncus effusus	16	16	33	1	4	2.7	5	1.8%
	Carex spp.	20	20	11	1	1	11.0	4	1.3%
	Lycopus americanus	5	3	22	0.3	3	0.6	3	1.0%
	Juncus balticus	1	1	22	0.05	3	0.3	3	0.9%
	Lysimachia quadriflora	4	4	11	0.2	1	2.3	2	0.6%
	Cirsium muticum	0.4	0.4	11	0.02	1	2.2	2	0.6%
	Aster spp.	2	2	11	0.1	1	1.4	2	0.5%
	Leersia oryzoides	3	3	11	0.1	1	0.5	2	0.5%
	Eleocharis obtusa	2	2	11	0.1	1	0.05	1	0.5%
	Poaceae	2	2	11	0.1	1	no sample	1	0.5%
	Impatiens capensis	0.4	0.4	11	0.02	1	0.5	1	0.5%
	Cornus stolonifera	1	1	11	0.1	1	no sample	1	0.5%
	Salix spp.	0.4	0.4	11	0.02	1	0.3	1	0.5%
	Carex viridula	0.4	0.4	11	0.02	1	0.05	1	0.5%
Totals		1779.1		808.0			781.6		

Table 2 con't. **Composition of the coastal plant community at Cotter Road in 1995.**

Water Level	Scientific Name	stems/m^2 Mean	± (S.E.)	Frequency %	Relative Density %	Relative Frequency %	Biomass grams dry wt/m^{-2}	Importance Value (RD+RF+RB)	% of Total IV
1-10cm	*Scirpus americanus*	131	40	81	13	15	271.6	72.0	24.3%
	Eleocharis erythropoda	459	168	67	45	12	7.6	58.6	19.7%
	Calamagrostis canadensis	137	44	50	13	10	177.8	51.6	17.4%
	Lythrum salicaria	21	6	64	2	12	33.1	19.3	6.5%
	Scirpus acutus	30	14	38	3	7	36.1	15.9	5.3%
	Typha angustifolia	7	4	21	1	4	53.1	13.3	4.5%
	Unknown seedlings	88	47	24	9	4	no sample	13.0	4.4%
	Eleocharis obtusa	59	49	17	6	3	1.6	9.1	3.1%
	Juncus articulatus	33	28	29	3	5	2.1	8.9	3.0%
	Sagittaria latifolia	13	6	24	1	4	10.1	7.3	2.4%
	Juncus balticus	10	5	19	1	4	4.7	5.2	1.8%
	Leersia oryzoides	5	2	24	0.5	4	1.3	5.1	1.7%
	Potentilla anserina	6	6	12	1	2	1.3	3.0	1.0%
	Juncus effusus	1	0.4	14	0.3	3	0.1	2.9	1.0%
	Cirsium muticum	1	1	10	0.1	2	5.1	2.7	0.9%
	Juncus spp.	9	8	7	1	1	2.1	2.5	0.8%
	Convolulus arvense	2	2	7	0.2	1	4.4	2.2	0.8%
	Stachys tennifolia	6	4	7	1	1	1.2	2.1	0.7%
	Eupatorium perfoliatum	0.3	0.2	5	0.03	1	0.07	0.9	0.3%
	Scutellaria galericulata	0.2	0.1	5	0.02	1	0.03	0.9	0.3%
	Cladium mariscoides	0.5	0.5	2	0.05	0.4	0.4	0.6	0.2%
	Panicum longifolium	0.1	0.1	2	0.01	0.4	no sample	0.4	0.2%
Totals		1018.5					613.8		

Table 2 con't. **Composition of the coastal plant community at Cotter Road in 1995.**

Water Level	Scientific Name	stems/m² Mean	± (S.E.)	Frequency %	Relative Density %	Relative Frequency %	Biomass grams dry wt/m^{-2}	Importance Value (RD+RF+RB)	% of Total IV
11-25cm	*Scirpus americanus*	214	40	73	65	40	299.0	169	56.3%
	Sagittaria latifolia	56	12	60	17	33	50.8	61	20.4%
	Typha angustifolia	6	3	13	2	7	85.4	27	9.1%
	Eleocharis smallii	44	17	19	13	11	13.8	27	8.9%
	Scirpus acutus	10	6	10	3	5	18.0	12	4.0%
	Nymphaea odorata	1	0.4	5	0.2	3	1.2	3	1.0%
	Scirpus atrovirens	0.05	0.05	1	0.01	1	0.08	1	0.2%
Totals		**329.9**					**468.3**		
					58	41			
26-40cm	*Scirpus americanus*	50	18	39	11	24	85.7	132	44.0%
	Typha angustifolia	10	4	23	19	19	165.9	98	32.7%
	Sagittaria latifolia	17	10	17	7	6	5.0	40	13.2%
	Eleocharis smallii	6	6	5	1	6	1.9	13	4.4%
	Nymphaea odorata	0.5	0.3	5	2	3	0.9	7	2.2%
	Scirpus acutus	2	2	3	2	1	2.8	6	2.0%
	Scirpus validus	2	2	1			2.4	4	1.5%
Totals		**86.7**			20	22	**264.6**		
					32	20			
41-55cm	*Typha angustifolia*	5	3	12	22	38	61.3	102	33.9%
	Scirpus acutus	8	4	11	14	14	21.4	73	24.5%
	Scirpus americanus	6	3	21	12	6	10.1	70	23.4%
	Nymphaea odorata	4	2	8			7.8	36	11.9%
	Eleocharis smallii	3	3	3			1.3	19	6.3%
Totals		**25.1**					**101.9**		

Table 3. Composition of the coastal plant community at Vanderbilt Park in 1994.

Water Level	Scientific Name	stems/m^2 Mean	± (S.E.)	Frequency %	Relative Density %	Relative Frequency %	Biomass grams dry wt/m^{-2}	Importance Value (RD+RF+RB)	% of Total IV
strand	*Scirpus americanus*	264	28	100	49	21	299.2	125	41.6%
	Juncus spp.	154	50	89	29	19	48.8	56	18.8%
	Lythrum salicaria	15	13	56	3	12	118.5	36	12.0%
	Typha angustifolia	4	2	44	1	9	50.0	19	6.4%
	Poaceae	52	30	44	10	9	no sample	19	6.3%
	Cornus stolonifera	9	9	22	2	5	17.6	10	3.2%
	Eleocharis calva	10	7	22	2	5	1.3	7	2.2%
	Equisetum spp.	8	8	22	2	5	2.0	7	2.2%
	Salix spp.	3	2	22	1	5	2.1	6	1.9%
	Mentha arvensis	8	8	11	2	2	1.7	4	1.4%
	Scirpus acutus	2	2	11.0	0.4	2	6.4	4	1.3%
	Impatiens capensis	1	1	11.0	0.2	2	1.4	3	0.9%
	Potentilla anserina	1	1	11.0	0.2	2	0.1	3	0.9%
	Rumex spp.	1	1	11.0	0.2	2	no sample	3	0.9%
Totals		534.2					549.1		
26-50cm	*Scirpus americanus*	61	34	33	39	26	75.4	101	33.8%
	Sagittaria latifolia	40	26	29	25	23	56.8	75	25.1%
	Eleocharis smalli	50	41	25	32	19	18.3	60	20.0%
	Typha angustifolia	5	2	29	3	23	52.0	51	17.0%
	Nymphaea odorata	1	1	8	1	6	1.4	8	2.6%
	Scirpus acutus	1	1	4	1	3	1.5	5	1.5%
Totals		157.7					205.4		
51-75cm	*Scirpus americanus*	41	15	38	70	38	170.8	125	54.9%
	Typha angustifolia	4	2	17	7	17	91.0	33	14.5%
	Nymphaea odorata	3	1	17	5	17	8.4	23	10.1%
	Sagittaria latifolia	5	4	10	9	11	6.3	21	9.0%
	Scirpus acutus	2	2	8	4	9	8.4	13	5.7%
	Eleocharis smalli	2	2	8	4	9	2.0	13	5.6%
Totals		58.3					286.9		

Table 3 con't. Composition of the coastal plant community at Vanderbilt Park in 1994.

Water Level	Scientific Name	stems/m^2 Mean	± (S.E.)	Frequency %	Relative Density %	Relative Frequency %	Biomass grams dry wt/m^{-2}	Importance Value (RD+RF+RB)	% of Total IV
71-100cm	*Scirpus americanus*	39	20	59	87	73	129.4	177	79.6%
	Typha angustifolia	2	2	7	4	9	29.4	17	7.7%
	Eleocharis smalli	1	1	7	2	9	0.9	12	5.2%
	Scirpus acutus	2	2	4	4	5	5.7	9	4.0%
	Nymphaea odorata	1	1	4	3	5	3.3	8	3.4%
Totals		44.9					168.7		

Table 4. **Composition of the coastal plant community at Vanderbilt Park in 1995.**

Water Level	Scientific Name	stems/m^2 Mean	± (S.E.)	Frequency %	Relative Density %	Relative Frequency %	Biomass grams dry wt/m^{-2}	Importance Value (RD+RF+RB)	% of Total IV
strand	*Eleocharis pauciflora*	1620	936	33	63	4	5.4	67	22.4%
	Scirpus americanus	253	146	100	10	11	329.3	66	21.9%
	Lythrum salicaria	48	28	56	2	6	209.7	36	12.2%
	Typha angustifolia	11	6	22.0	0.4	3	110.9	18	6.0%
	Eleocharis erythropoda	224	129	44	9	5	1.5	14	4.6%
	Carex viridula	118	68	56	5	6	12.9	12	4.2%
	Juncus effusus	33	19	78	1	9	6.0	11	3.6%
	Calamagrostis canadensis	33	19	44	1	5	23.4	9	3.1%
	Juncus balticus	11	6	44.0	0.4	5	5.3	6	2.0%
	Lycopus americanus	2	1	44.0	0.1	5	0.2	5	1.7%
	unknown seedlings	63	36	22	2	3	no sample	5	1.6%
	Lobelia nuttallii	18	10	33	1	4	2.7	5	1.6%
	Eupatorium leucolepsis	13	8	33	1	4	2.8	5	1.5%
	Juncus articulatus	43	25	22	2	3	2.7	5	1.5%
	Aster spp.	4	3	33.0	0.2	4	3.5	4	1.5%
	Juncus nodosus	26	15	22	1	3	5.3	4	1.4%
	Juncus spp.	18	10	22	1	3	5.5	4	1.3%
	Teucrium canadense	3	2	33.0	0.1	4	0.5	4	1.3%
	Eupatorium pilosum	4	2	33.0	0.2	4	no sample	4	1.3%
	Stachys tennifolia	15	9	22	1	3	2.9	3	1.2%
	Leersia oryzoides	12	7	22.0	0.5	3	3.4	3	1.1%
	Scirpus acutus	1	1	11.0	0.1	1	1.9	2	0.5%
	Impatiens capensis	0.4	0.3	11.00	0.02	1	0.5	1	0.4%
	Salix spp.	0.4	0.3	11.00	0.02	1	0.3	1	0.4%
	Scutellaria galericulata	0.4	0.3	11.00	0.02	1	0.07	1	0.4%
	Eupatorium perfoliatum	0.4	0.3	11.00	0.02	1	0.1	1	0.4%
Totals		2576.0					736.8		

Table 4 con't. Composition of the coastal plant community at Vanderbilt Park in 1995.

Water Level	Scientific Name	stems/m² Mean	± (S.E.)	Frequency %	Relative Density %	Relative Frequency %	Biomass grams dry wt/m^{-2}	Importance Value (RD+RF+RB)	% of Total IV
1-10cm	*Scirpus americanus*	123	123	50	62	25	161.6	124	41.4%
	Typha angustifolia	29	28	67	15	33	268.9	110	36.7%
	Eleocharis erythropoda	42	42	17	21	8	0.7	30	9.9%
	Carex viridula	2	2	17	1	8	0.3	9	3.1%
	Sagittaria latifolia	1	1	17	1	8	0.5	9	3.0%
	Lythrum salicaria	1	1	17.0	0.3	8	1.8	9	3.0%
	Eupatorium leucolepsis	1	1	17.0	0.3	8	0.1	9	2.9%
Totals		199.3					433.9		
11-25cm	*Typha angustifolia*	32	8	56	13	29	216.5	100	33.5%
	Scirpus americanus	85	31	42	34	21	79.0	76	25.5%
	Sagittaria latifolia	46	20	35	18	18	32.3	45	15.1%
	Eleocharis smallii	52	36	10	21	5	14.0	30	9.9%
	Nymphaea odorata	3	1	15	1	7	5.2	10	3.3%
	Scirpus acutus	7	7	4	3	2	10.0	8	2.5%
	Eleocharis obtusa	11	10	4	4	2	0.3	7	2.2%
	Lythrum salicaria	3	3	4	1	2	9.1	6	2.0%
	Eleocharis erythropoda	8	8	4	3	2	0.1	5	1.7%
	Eupatorium leucolepis	0.4	0.4	6.0	0.2	3	0.08	3	1.1%
	Carex viridula	0.3	0.3	4.0	0.1	2	0.05	2	0.8%
	Unknown seedlings	2	2	2	1	1	no sample	2	0.6%
	Eupatorium pilosum	1	1	2.0	0.4	1	no sample	1	0.5%
	Juncus spp.	1	1	2.0	0.3	1	0.3	1	0.5%
	Eupatorium perfoliatum	1	1	2.0	0.3	1	0.2	1	0.5%
	Acer rubrum	0.1	0.1	2.00	0.03	1	no sample	1	0.4%
Totals		251.9					367.1		

Table 4 con't. **Composition of the coastal plant community at Vanderbilt Park in 1995.**

Water Level	Scientific Name	stems/m^2 Mean	± (S.E.)	Frequency %	Relative Density %	Relative Frequency %	Biomass grams dry wt/m^{-2}	Importance Value (RD+RF+RB)	% of Total IV
26-40cm	*Sagittaria latifolia*	79	27	43	66	37	79.4	135	45.1%
	Typha angustifolia	7	3	19	6	16	95.5	62	20.6%
	Scirpus americanus	20	18	19	17	16	32.5	46	15.3%
	Nymphaea odorata	9	3	30	7	25	22.8	42	14.1%
	Scirpus acutus	4	3	6	3	5	5.7	10	3.4%
	Sparganium eurycarpum	1	1	2	1	2	3.8	4	1.4%
Totals		**120.2**					**239.7**		
41-55cm	*Scirpus americanus*	66	26	51	70	46	121.4	166	55.3%
	Nymphaea odorata	16	7	33	17	30	55.4	70	23.2%
	Typha angustifolia	3	2	7	3	6	51.2	30	9.9%
	Sagittaria latifolia	7	7	4	7	4	10.9	16	5.2%
	Scirpus acutus	2	1	9	2	8	3.8	11	3.8%
	Eleocharis smallii	2	2	7	2	6	0.4	8	2.6%
Totals		**94.2**					**243.1**		
56-70cm	*Scirpus americanus*	58	12	76	49	63	142.7	255	59.7%
	Typha angustifolia	4	3	12	4	10	65.8	80	18.6%
	Scirpus acutus	8	4	17	7	14	31.2	52	12.2%
	Nymphaea odorata	4	3	8	3	6	16.9	27	6.2%
	Eleocharis smallii	4	2	8	4	6	4.1	14	3.3%
Totals		**78.5**					**260.7**		
71-85cm	*Scirpus americanus*	31	14	53	89	84	83.3	259	86.2%
	Eleocharis smallii	3	3	7	9	11	3.3	23	7.5%
	Typha angustifolia	1	1	3	3	5	10.5	19	6.3%
Totals		**35.0**					**97.1**		

in 1995 at Cotter Road and from 534 stems/m^{-2} in 1994 to 2576 stems/m^{-2} in 1995 at the Vanderbilt Park site (Tables 1-4, Figures 4 and 5).

There were a total of 36 quadrats sampled in the strand community (18/year), 42 quadrats sampled within the 1-30 cm depth, 70 quadrats sampled within the 31-60 cm water depth and a total of 33 quadrats sampled within the 61-90 cm water depth (Figure 4). Major changes in stem density and species richness occurred in the strand and 0-30 cm depth zones, but few changes occurred at depths greater than 30 cm (Tables 1-4, Figures 4 and 6).

Table 5. Lake levels (m above sea level) for Saginaw Bay in 1994 and 1995 from the NOAA station at Essexville, Michigan.

Daily	**June**	**July**	**August**	**Daily**	**June**	**July**	**August**
Mean	176.76	176.81	176.82	**Mean**	176.66	176.61	176.65
Max.	177.63	177.11	177.19	**Max.**	177.16	176.95	176.92
Min.	176.55	176.44	176.27	**Min.**	176.47	176.32	176.35

	1994	**1995**
Annual Mean	**176.68**	**176.53**

Stem density was also compared from site to site for 1994 and 1995 using distance from shore to open water (Figure 5a and 5b) instead of water depth. Total stem density decreased significantly from the strand (0 m) to 50 m and continued to decrease out to open water in both years. Total stem density increased in the strand and 50 m communities from 1994 to 1995 but few changes were documented at 100 m or greater distances from shore from 1994 to 1995 (Figures 5a and 5b). Thus, major changes occurred primarily in areas subjected to dryness during this study.

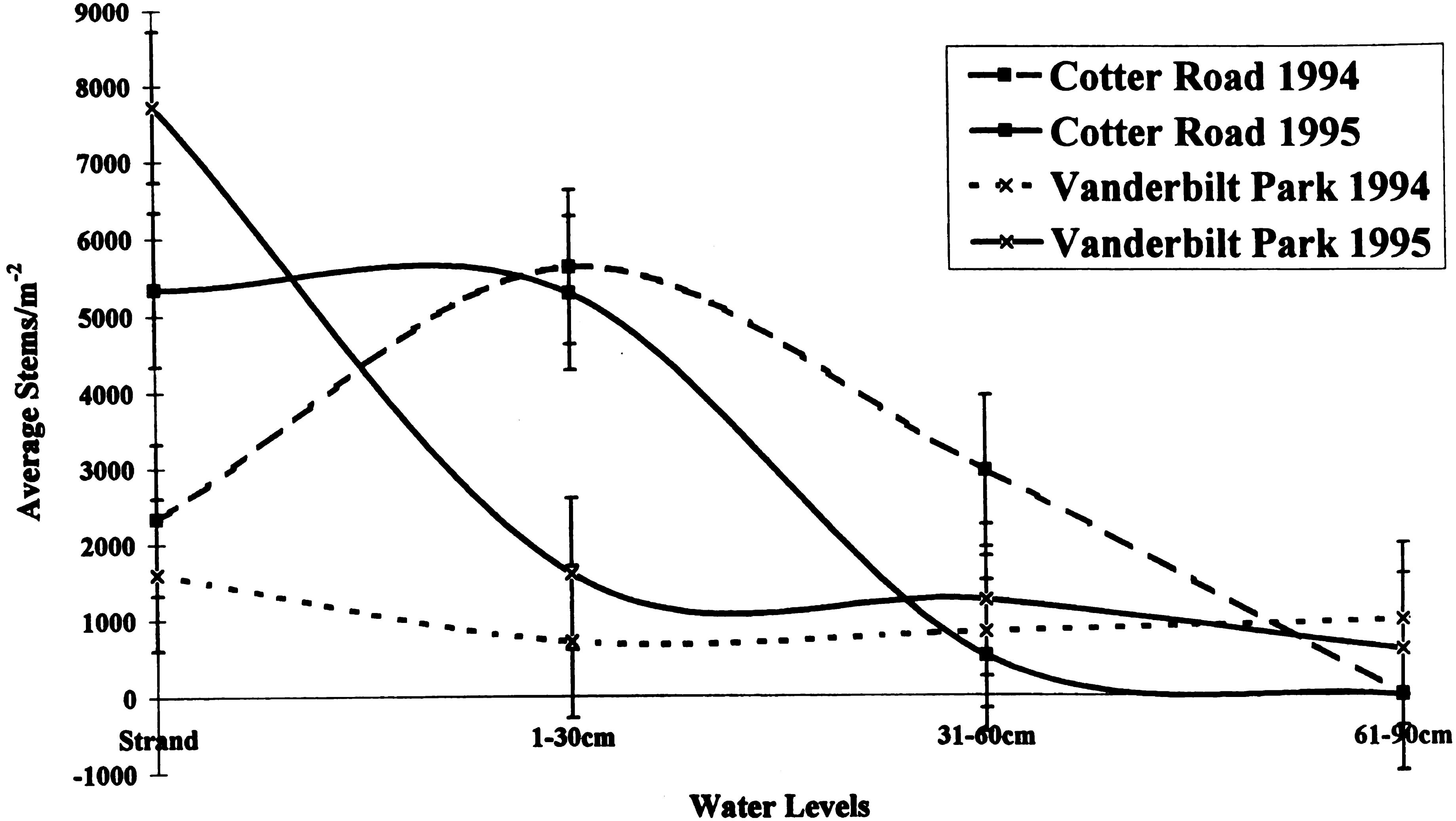


Figure 4. Mean stem density (x-stems/m^{-2}) along a water level gradient for all points sampled for every transect for both sites in 1994 and 1995.

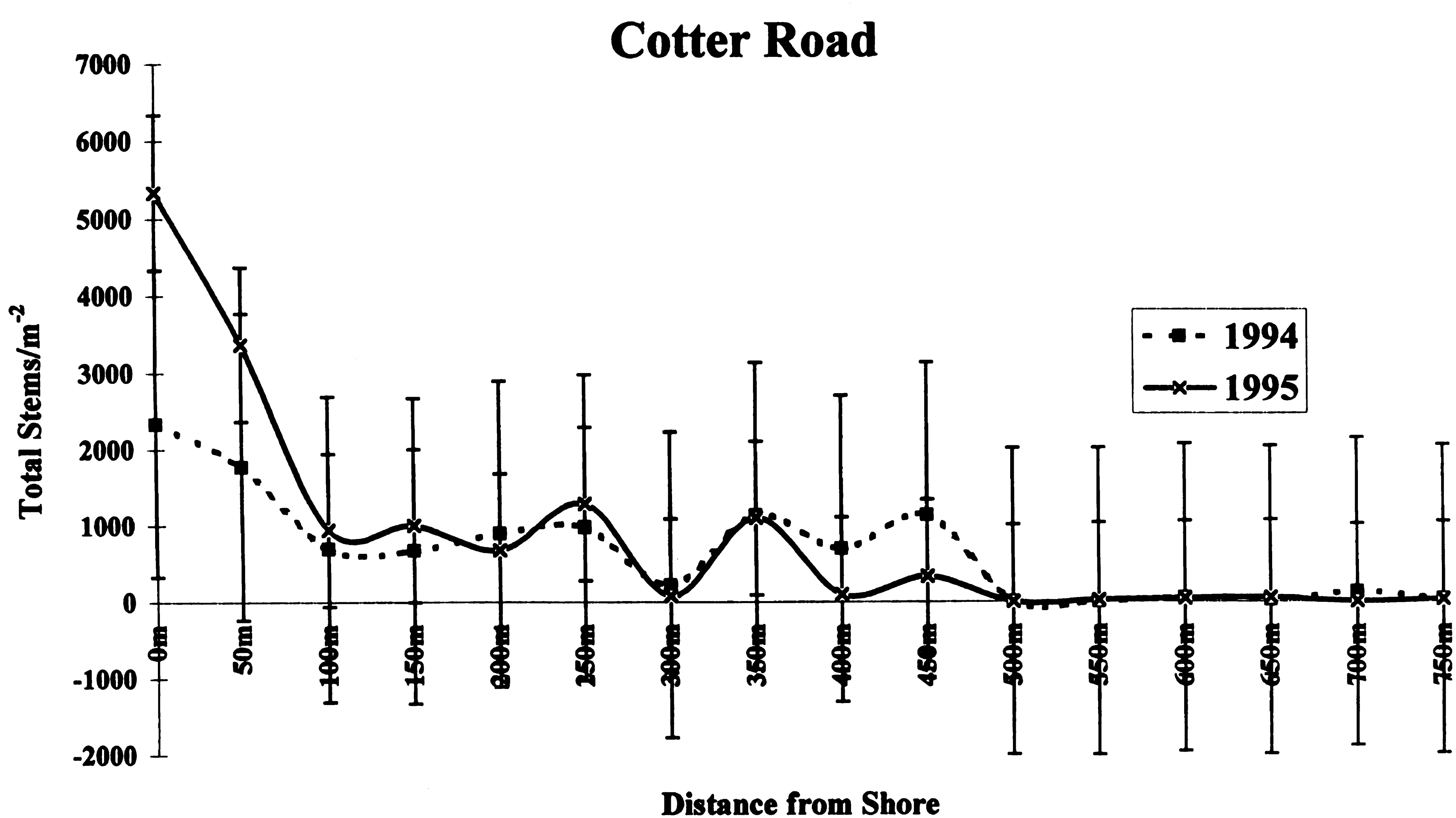


Figure 5a. Stem density is shown using stems/m^{-2} and comparing 1994 to 1995 using distance from shore for the Cotter Road site.

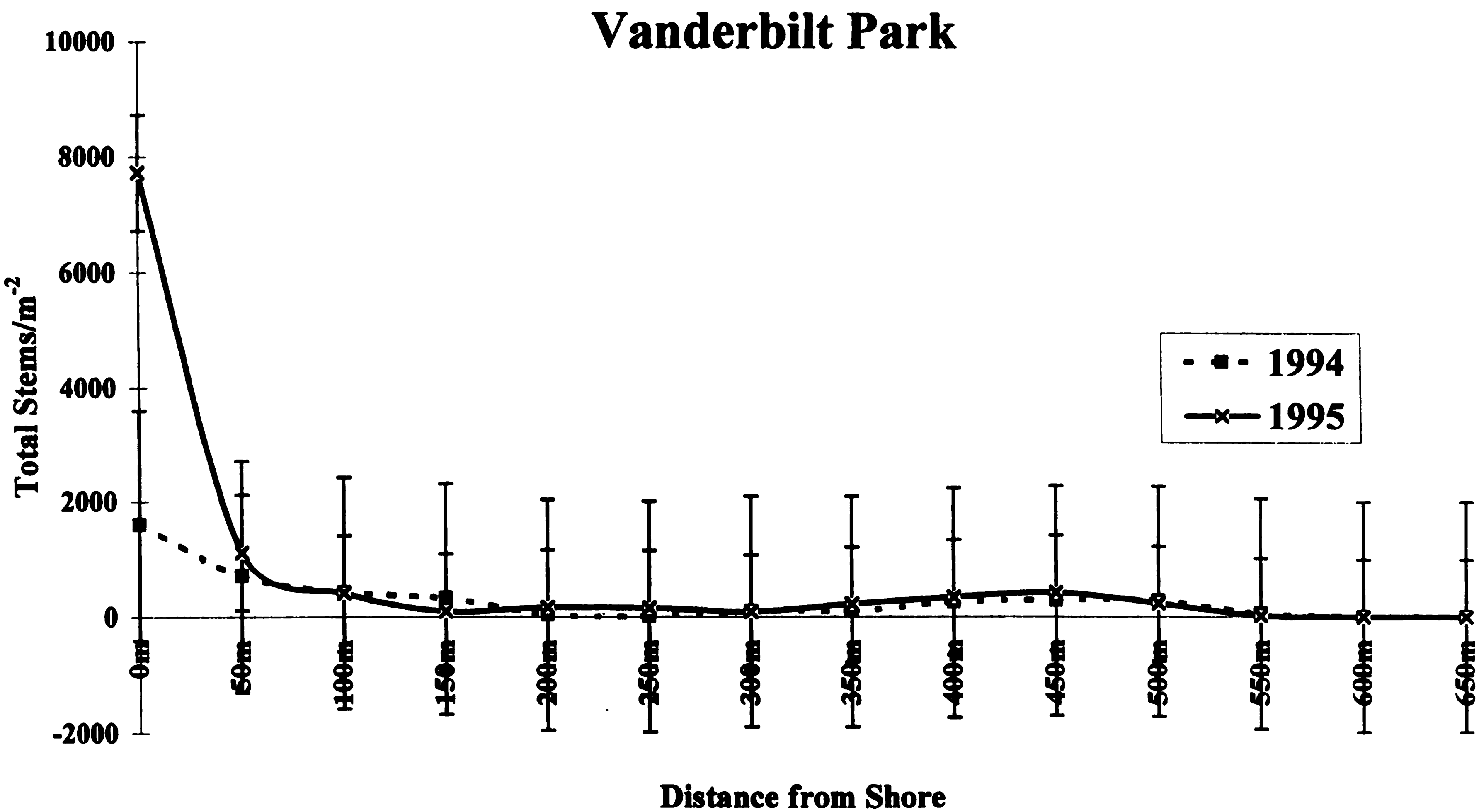


Figure 5b. Stem density is shown using stems/m^{-2} and comparing 1994 to 1995 using distance from shore for the Vanderbilt Park site.

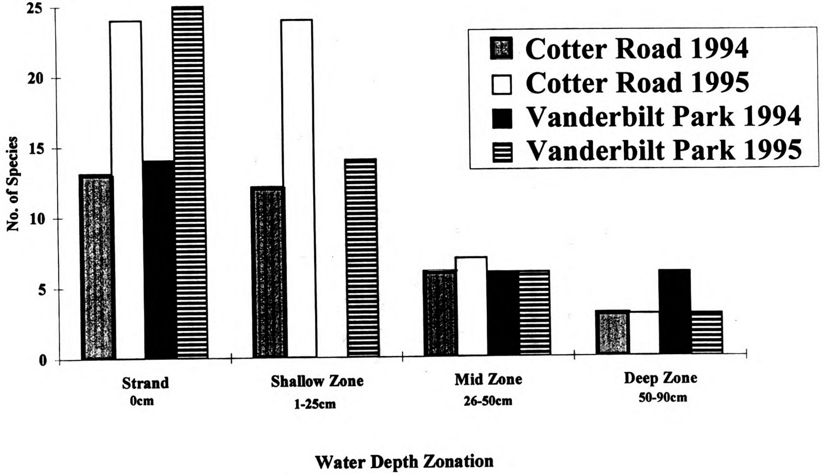


Figure 6. Plant species richness for both sites in 1994 and 1995.

Characterizing the Strand Community

Plant species occurred in greater numbers and richness along the strand community in 1995 with conditions dry enough to stimulate germination (Tables 2 and 4). Since the lake level had dropped 15 cm from 1994 to 1995, the strand was less exposed to standing water over long periods of time in 1995 so the drier conditions allowed for a wet meadow type plant community to begin to develop. The plant species with the highest importance values at the Cotter Road site in 1994 included *Lythrum salicaria*, *Calamagrostis canadensis*, *Scirpus americanus*, *Carex* spp., *Eleocharis* spp., *Juncus* spp. and various grasses.

In 1995, the plant species at Cotter Road included the same species as were found in 1994 but the species of plants counted and identified nearly doubled with several species of *Carex*, *Juncus*, and *Eleocharis* germinating in large numbers as well as a few woody plant species and herbaceous wetland perennial wildflowers (Tables 1 and 2). The plant species with the highest importance values at the Vanderbilt Park site in 1994 included *Scirpus americanus*, *Juncus* spp., *Lythrum salicaria*,, *Typha angustifolia* and various grasses. In 1995, the plant species at Vanderbilt Park included the same species as found in 1994, but the species of plants counted and identified nearly doubled and included additional species of *Carex*, *Juncus*, and *Eleocharis* as well as herbaceous wetland perennial wildflowers (Tables 3 and 4). Woody plant species were counted at Vanderbilt Park in 1994 and 1995.

Plant biomass within the strand community was calculated in 1994 and 1995 based on weights of individual plant species. The larger the individual plant, the more it

weighed. However, the relative biomass of each species within the strand community from site to site and year to year did not change significantly (Tables 1-4).

Plant Community Description/Water Level Zonation

Importance values were calculated for each plant species at every depth range (Tables 1-4). The plant species with the highest importance values for both sites in 1994 and in 1995 were *Scirpus americanus*, *Lythrum salicaria*, *Typha angustifolia*, *Sagittaria latifolia*, *Scirpus acutus* and *Eleocharis pauciflora* (Tables 1-4). *Scirpus americanus* was ranked the highest in importance at almost every sample point in 1994 and 1995 (Tables 1-4). *Lythrum salicaria* was ranked the highest at the strand at Cotter Road for both years (Tables 1,2).

The dominant assemblages using the top three species and their importance values was broken into four categories: strand, shallow, mid and deep based on water depth from strand to open water (Table 6). *Lythrum salicaria* and *Scirpus americanus* were co-dominants in the strand community at each site during both years (Table 6). *Eleocharis spp.* was dominant at both sites in 1995. *Calamagrostis canadensis* was dominant only at Cotter Road, and *Juncus spp.* was dominant at Vanderbilt. None of these species, except for *Scirpus americanus,* were among the top three dominants in shallow, mid or deep water habitats (Table 6).

Scirpus americanus, *Eleocharis smallii*, *E. erythropoda*, *Typha angustifolia*, and *Sagitaria latifolia* were co-dominants in the shallow zone (Table 6). The mid zone dominant species were *S. americanus*, *T. angustifolia*, *S. latifolia*, *E. smallii* and

Nymphaea odorata. The dominant species in the deep zone were *S. americanus*, *S. acutus*, *T. angustifolia* and *E. smallii.*

Table 6. Dominant assemblages using the top three species with the highest importance values for the four water level zones for each year.

	Cotter '94	Cotter '95	Vanderbilt '94	Vanderbilt '95
Strand	*L. salicaria*	*L. salicaria*	*S. americanus*	*S. americanus*
	C. canadensis	*E. erythropoda*	*Juncus spp.*	*L. salicaria*
	S. americanus	*C. canadensis*	*L. Salicaria*	*T. angustifolia*
Shallow	*S. americanus*	*S. americanus*	no sample taken	*S. americanus*
	E. smallii	*E. erythropoda*	no sample taken	*T. angustifolia*
	T. angustifolia	*S. latifolia*	no sample taken	*S. latifolia*
Mid	*S. americanus*	*S. americanus*	*S. americanus*	*S. americanus*
	T. angustifolia	*T. angustifolia*	*S. latifolia*	*N. odorata*
	S. latifolia	*S. latifolia*	*E. smallii*	*T. angustifolia*
Deep	*S. acutus*	*T. angustifolia*	*S. americanus*	*S. americanus*
	T. angustifolia	*S. acutus*	*T. angustifolia*	*E. smallii*
	S. americanus	*S. americanus*	*E. smallii*	*T. angustifolia*

Zonation patterns in wetlands tend to be sharp and have abrupt boundaries that call attention to vegetation change and the uniqueness of each zone (Mitsch and Gosselink, 1993). This concept of zonation for this study has been applied to water level gradients and vegetation patchiness. In the shallow zone at Cotter road, *S. americanus* formed a monoculture with some open pockets of *S. latifolia, E. smallii* and *T. angustifola* in the more open water areas. Patchiness was observed along each transect for both sites from the mid zone to open water. *T. angustifola* and *Nymphaea odorata* formed monocultures with minor species interspersed, while *S. americanus*, *S. latifolia* and *E. smallii* were usually found together.

Species Area Curves

Species area curves for both years and sites were similar within the strand community showing an increase in cumulative number of species as the number of quadrats sampled increased until the fifth and sixth quadrats (sampling area of 1.5 m). There was little increase in cumulative number of species after six quadrats had been sampled (Figures 7a). In 1995, the water levels decreased and more plants germinated along the drier, exposed shore so the asymptote was higher for the strand community in 1995 than in 1994. Also, more plants were identified to species level in 1995 compared to 1994 which could partially account for the greater cumulative number of species in 1995 (Tables 2 and 4, Figure 7a). There was also a direct relationship between distance and depth. As distance increased from shore to open water, water depth increased gradually to 80-90 cm at the outer edge of the emergent zone.

In 1994 samples were taken every 50 m and in 1995, samples were taken every 20 m so the sampling area increased in 1995 (Figure 7b and 7c). Although the number of quadrats sampled increased from 1994 to 1995, there is a resemblance in the shape of curve from year to year although the cumulative number of species sampled was greater within the 20-60 m sampling distance (Figure 7b). The increase in the cumulative number of species from quadrat twenty to twenty-one within the 80-120 m distance can be attributed to a shallow sand bar point along the transect where the water level decreased to 11 cm (Figure 7c). Other than that increase, the cumulative number of species for the 80-120 m distance was predictable given the relationship between distance and depth (Figure 7c).

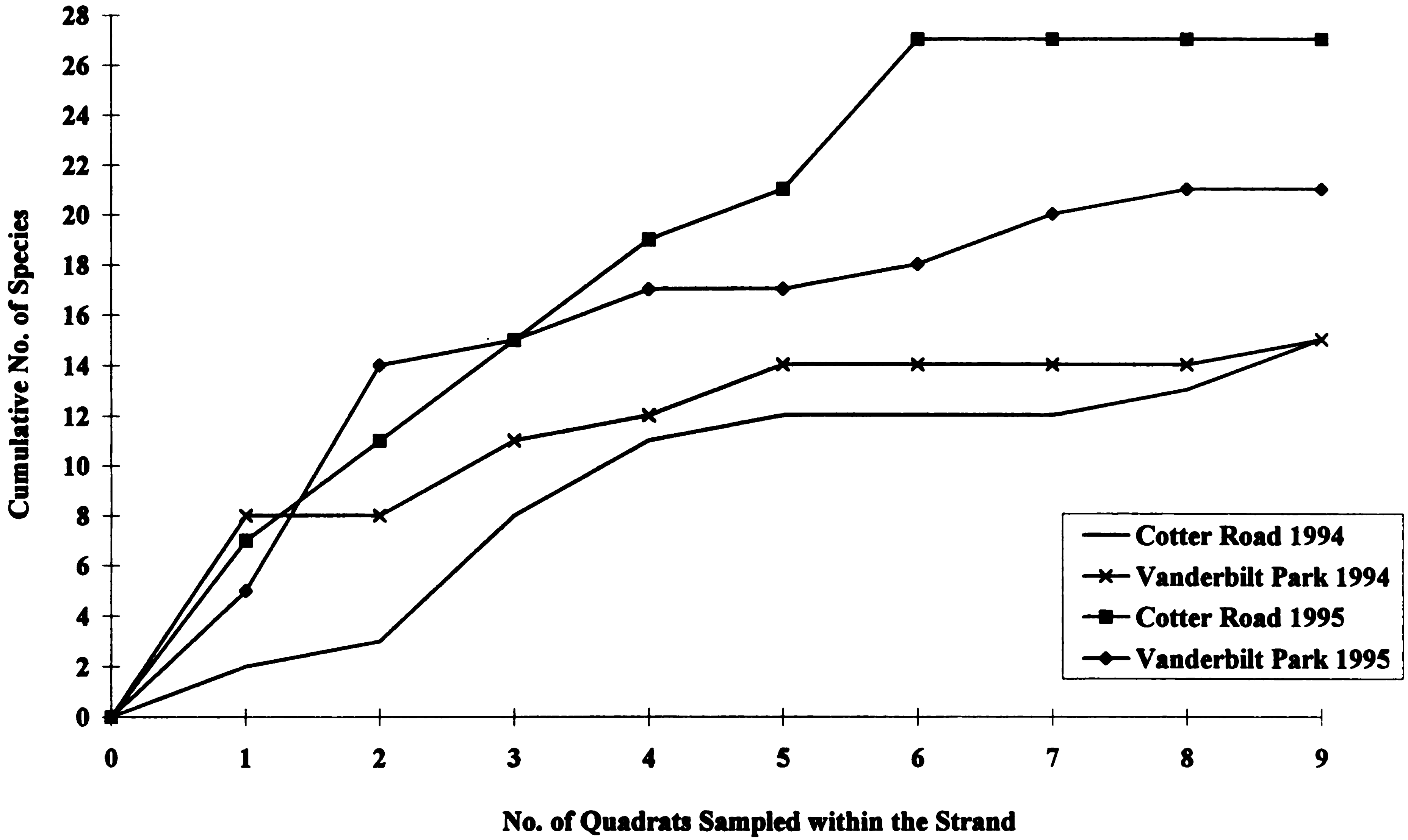


Figure 7a. Species area curve comparing the cumulative number of species for both sites in 1994 and 1995 within the Strand community.

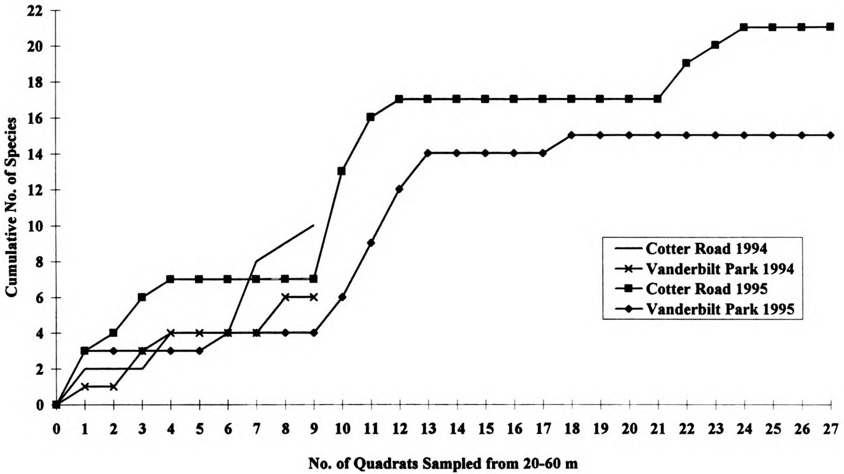


Figure 7b. Species area curve comparing the cumulative number of species for both sites in 1994 and 1995 from 20 m to 60 m using distance from shore. Samples were taken every 50 m in 1994 and every 20 meters in 1995.

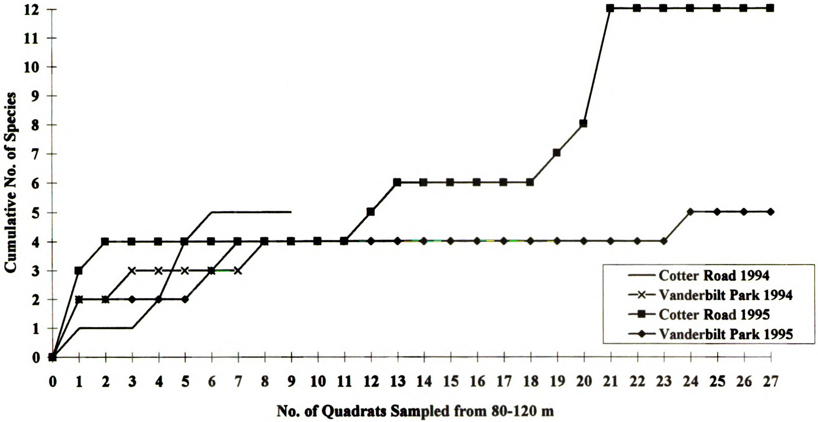


Figure 7c. Species area curve comparing the cumulative number of species for both sites in 1994 and 1995 from 80 m to 120 m using distance from shore. Samples were taken every 50 m in 1994 and every 20 meters in 1995.

DISCUSSION

Plant Diversity

The development of a plant community is characterized by many factors and conditions and include the seedbank viability and other propagules within the site, appropriate environmental conditions for germination and growth, and the replacement by plants of the same or different species as site conditions change in response to abiotic and biotic factors (Mitsch and Gosselink, 1993). This concept of succession dates back as early as 1917 when Gleason developed the hypothesis that individual species respond individualistically to changes along environmental gradients as an explanation for the distribution of plant species. From there, the continuum concept was developed (Whittaker, 1967) implying that the distribution of individual plant species directly responds to its environments, resulting in a continuum of overlapping species niches along environmental gradients.

The emergent marsh community of the wetland fringe of Saginaw Bay changes along a depth gradient from the shoreline to the outer edge of the wetland. The highest diversity is at the shoreline in the strand community which is subject to alternate wetting and drying as lake levels rise and fall over short (seiche and storm surges) and long (seasonal and year to year) time periods. The diverse ecotonal community of the strand is comprised of a diverse mix of annuals and perennials with high stem density, and it is replaced by a community of perennials with fewer species present and with lower stem density as water depth increases until the emergent plant community is reduced to a few sparse, scattered stems of 1-3 species at the outer edge of the marsh. Minc (1996) described the general changes that occur along this gradient and divided the marsh into plant community zones that are projected to migrate shoreward or lakeward as lake levels rise or fall. Such general descriptions tend to mask the heterogeneity in the plant communities that exists within each plant community zone.

I documented changes that occurred over a depth gradient that extended for 600-800 m from the shoreline to the outer edge of the emergent zone at two sites from 1994 to 1995 when water level decreased by 15-20 cm. Over this short period of modest lake level changes, the plant communities did not migrate up or down slope as predicted. Instead, stem density and species richness increased dramatically for the strand and shallow water zones, perhaps from underground seed sources and/or from new shoots produced vegetatively, while plant communities that existed at depths of 25 cm or more in 1994 did not change much in 1995.

Effects of Wave Energy

Comparisons can be made between the Vanderbilt Park and Cotter Road sites with respect to wave energy and substrate. Keddy (1982), suggested that waves may affect shoreline plants directly by uprooting seedlings or indirectly by eroding fine sediments. Furthermore, exposure may be an important ecological factor affecting the within lake distribution of shoreline plants (Keddy, 1982). Keddy also believed that one of the most likely causes of variation in lakeshore vegetation aside from water depth is exposure to wave activity. Keddy hypothesized that this wave activity could have direct effects on plants by transporting seeds, uprooting seedlings and damaging mature plants. I observed this phenomenon at Vanderbilt Park in 1994 during large storm surges where

the vegetation was damaged and the tips or flowers were ripped off from the strong wave action.

Wave activity also may indirectly have effects on erosion and deposition of sediments, nutrients and organic matter. I observed a difference in substrate between Cotter Road and Vanderbilt Park. At Cotter Road, the substrate was very sandy and firm with only small areas of organic deposits near the shore. At Vanderbilt Park, the substrate was very high in organic matter in protected areas shoreward of and in *Typha angustifolia* stands and it was very difficult to walk the transects in these areas. The loose substrate was up to 60cm deep in places with high organic matter and detritus. In areas lakeward of the cattail stands, the substrate was also sandy and firm.

Site Geographical Location

The geographical location of the two sites may be important in determining substrate, patchiness and density and diversity along the shore. Cotter Road is located on the southwest shore of Saginaw Bay. The prevailing winds coming from the west tend to blow along the shore from west to east into the southeast shore at Vanderbilt Park. Thus, Vanderbilt Park is in a much more exposed location than the Cotter Road site. I observed a large amount of detritus along the shore at Vanderbilt Park compared to Cotter Road. Most of the detritus was deposited along the strand and further inland by storm surges (personal observation). Cotter Road had a stable plant community along the shore and the shallow zone consisting mainly of a dense stand of *S. americanus*. Vanderbilt park had less individual species within the shallow zone and tended to have more open water areas within the patchy vegetation. Exposure to waves affects plant establishment, growth, survival and dispersal directly as well as indirectly (Jupp and Spence, 1977; Keddy, 1982; Spence, 1982; Chambers, 1987). This may explain the absence of a large dense and stable shallow zone at Vanderbilt Park as compared to Cotter Road.

Wetland Conservation

Characterizing the plant community in Saginaw Bay is an essential component to the relevance of the environmental conservation for the site. Without a stable plant community, the entire wetland system is affected as evidenced by the effects of the storm surges in 1994 (Whitt, 1996). The coastal plant community acts as a buffer and protects the shoreline from long term erosion and instability. The importance of the coastal plant community is well documented as a staging, feeding and breeding area for waterfowl and other forms of aquatic life.

Plans for successful wetland restoration for Great Lakes coastal wetlands need to be based on knowledge of how these coastal plant communities respond to water level changes and exposure to wave action and storm surges. The data collected for this thesis represent an essential first step in gaining the understanding of plant community dynamics in relation to water level changes and should be invaluable for restoration planning in the future.

LITERATURE CITED

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APPENDIX

Appendix 1. Plant species of the Saginaw Bay study areas at Cotter Road and Vanderbilt Park.

Scientific Name	Common Name	status
Acer rubrum	red maple	FAC
Aster spp.	aster	OBL-FACW
Calamagrostis canadensis	blue-joint	OBL
Carex lasiocarpa	wooly-fruit sedge	OBL
Carex spp.	sedge	OBL-FACW
Carex viridula	little green sedge	OBL
Cirsium muticum	swamp thistle	OBL
Cladium mariscoides	smooth sawgrass	OBL
Convolulus arvense	field bindweed	NI
Cornus stolonifera	red-osier dogwood	FACW
Eleocharis calva	spikerush	OBL
Eleocharis erythropoda	bald spikerush	OBL
Eleocharis obtusa	blunt spikerush	OBL
Eleocharis pauciflora	few-flower spikerush	OBL
Eleocharis smallii	small's spikerush	OBL
Equisetum spp.	horsetail	NI
Eupatorium leucolepsis	white-braced thorough	NI
Eupatorium perfoliatum	common boneset	FACW+
Eupatorium pilosum	hairy thoroughwort	FACW+
Impatiens capensis	touch-me-not	FACW
Juncus articulatus	jointed rush	OBL
Juncus balticus	baltic rush	OBL
Juncus effusus	soft rush	OBL
Juncus nodosus	knotted rush	OBL
Leersia oryzoides	rice cutgrass	OBL
Lobelia nuttallii	nutall's lobelia	NI
Lycopus americanus	american bugleweed	OBL
Lysimachia quadriflora	prairie loosestrife	OBL
Lythrum salicaria	purple loosestrife	OBL
Mentha arvensis	field mint	FACW
Nymphaea odorata	white water-lily	OBL
Panicum longifolium	panic grass	OBL
Potentilla anserina	silverweed	FACW+
Sagittaria latifolia	arrowhead	OBL
Salix spp.	willow	OBL-FACW
Scirpus acutus	hardstem bulrush	OBL
Scirpus americanus	three-square bulrush	OBL
Scirpus atrovirens	green bulrush	OBL

Appendix 1. Con't.

Scientific Name	Common Name	status
Scutellaria galericulata	marsh skullcap	OBL
Solidago spp.	goldenrod	OBL-FACW
Sparganium eurycarpum	giant burreed	OBL
Spartina pectinata	prairie cord grass	FACW+
Stachys tennifolia	smooth hedgenettle	OBL
Teucrium canadense	american germander	FACW-
Typha angustifolia	narrow-leaf cattail	OBL
unknown seedlings		

Obligate Wetland	**Occurs w/est. 99% probability in wetlands**
Facultative Wetland	**Occurs w/est. 67%-99% probability in wetlands**
Facultative	**Occurs w/est. 34%-66% equal probability in wetlands and nonwetlands**
Facultative Upland	**67%-99% probability in nonwetlands, 1%-33% in wetlands**
Obligate Upland	**occurs >99% in nonwetlands in this region**
No Indicator	**currently no indicator status**