Reassessment of the Vegetation of the Nonquitt Salt Marsh

1999

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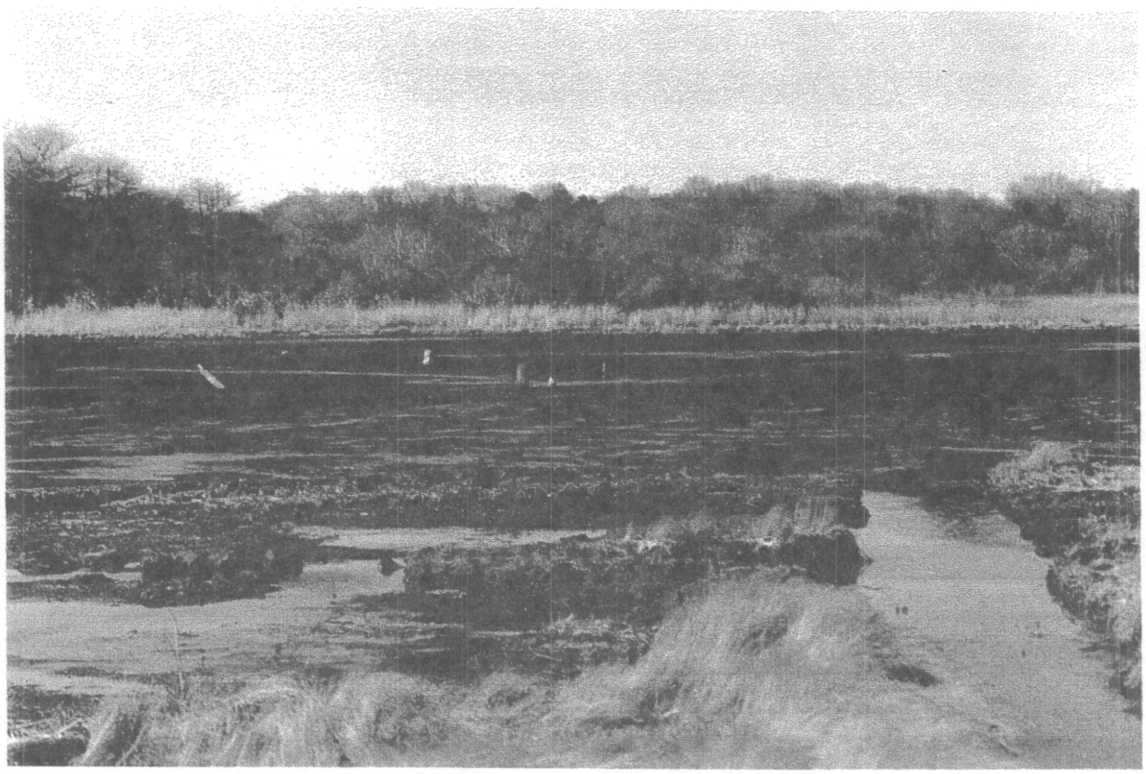

Report Submitted to the
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INTRODUCTION

The goals of the present study were to reestablish line transects set out in the Nonquitt salt marsh 1981 in order to assess the biological condition of the marsh after a period of fifteen years. By comparing current data with historical records on the percent cover by vegetation along established transect lines has enabled us to estimate further die-back or regrowth of marsh grasses as an indicator of the current health of the marsh.

In 1981, the Nonquitt Conservation Committee, through Mr. Peter Bator of the Nonquitt Association, contracted Jim Sears and Henry Parker to do a preliminary study and analysis of the condition of the Nonquitt salt marsh. In their 1981 report Sears and Parker reported that by 1980 61% of the vegetation of previously vegetated salt marsh had died at a uniform elevation around the marsh. The loss of vegetation, principally saltwater cord grass, *Spartina alterniflora,* and saltmarsh hay, *S. patens* , was attributed to tidal restriction that reduced the exchange of seawater between the marsh and adjacent Buzzards Bay (Sears and Parker, 1981). This tidal restriction was caused by three factors: a small culvert pipe; a shallow, rip-raped open channel; and an obstruction to free water flow below the bridge. Tidal exchange was further restricted by intermittent blockages in the culvert pipe due to the influx of sediment and vegetation from Buzzards Bay. Several periods of major blockages were documented. No tidal exchange occurred during the entire winter of 1980-81 due to complete blockage from a large coastal storm, and the marsh was flooded with fresh water during a 3-4 month period up to the shrub border.

Saltmarsh grasses require normal tidal cycles of draining and filling the marsh to maintain healthy stands. Marsh grasses are also unable to withstand long periods of submersion that are often attended by anaerobic conditions, especially when these conditions occur in early spring just as new growth is initiated. The die-back of grasses eventually left barren areas of peat. The exposed peat was then subject to erosion, further degrading the marsh.

Wave-driven sand and gravel filled the culvert pipe through openings that were created to aid in maintaining tidal flow and maintenance of the culvert pipe when it became clogged. Removable caps were designed and installed (Figures 11 and 12) to keep out sand and gravel, but still allowed access to the interior to clear blockages.

In summary of the first report by Sears and Parker (1981) marsh grass die-back was attributed to tidal restriction and intermittent complete tidal blockage; water logging of sediments; increased salt concentrations intolerable to plant growth; possible use of herbicides/fungicides on surrounding land; and diking by sediments along mosquito ditches. It was recommended that a hydrologic study be done on water circulation and tidal exchange and to remove all obstructions to tidal exchange. A new bridge was installed in the mid 1990's, removing one of the tidal restrictions by providing a deeper and wider opening (Figure 16)

In the summer of 1981 Sears and Parker established transects to quantitatively assess further die-back or regrowth. Follow-up analyses of the marsh grass along the five line transects established in 1981 and four more in 1982 (Sears and Parker, 1982, 1983 and 1984) indicated that by 1984: a) no further major blockages of the culvert pipe for more than a few day's duration had occurred; b) marsh grasses were regrowing slowly from the edges of existing grasses at most transects; c) little or no new marsh grasses occurred on barren peat by seedlings, though an annual *Salicornia* which is tolerant of high salinity peat did seed-in some areas; d) erosion had begun to occur on barren peat by 1983 and 1984; and e) transplanting of plugs of marsh grasses was not successful either because the plugs were pulled up by geese or other birds and/or sediment conditions were not suitable due to water logging, salt buildup or other conditions adverse to growth of transplants. Most new growth of marsh grass was directly adjacent to existing vegetation, and further die-back was considered arrested as of June, 1981. The Lloyd Center for Environmental Studies confirmed most of what was in Sears and Parker's reports (Lloyd Center Reports, 1989 and 1994) and added data on tidal regimes before and after the new bridge was installed. They also documented further erosion of exposed peat.

METHODS

At the request of the Dartmouth Natural Resources Trust, the organization overseeing the Nonquitt marsh, line transects that had been established in 1981 by Sears and Parker (1981,1982) were reestablished by us and Sarah French Storer on February 12 and March 26, 1999. After the 15 intervening years from the last analysis of the transects in 1984 by Sears, we were able to relocate transects 1-4 with exact accuracy because we found the original stakes. Exact locations of transects 8-9 could only be estimated because the stakes were gone. Photographs and slides from the previous studies also aided us in determining the position of these original transects. Transects 5, 6 and 7 had been established on nearly barren peat in 1982. Because these areas are now completely barren of vegetation and eroded, it was not necessary to reestablish transect lines to make new estimates. Sediments near them were also very soft and made it impossible to reach, but we could see that they were eroded and barren of any vegetation in 1999 (Figures 5-7, 20 and 21).

As in the 1981 study, one-quarter meter^2 quadrats were placed every two meters along the transect line to estimate the percent cover by total vegetation and the portion of each quadrat covered by *S. alterniflora*. Data were then calculated for percent cover by *S. alterniflora*.

Tabulated and graphed data for transects 1-9 are given in Tables and Graphs of corresponding transect numbers. There was total loss of vegetation along transects 5-7, but previous data are presented for these transects in Tables and Graphs 5-7. Photographs from 1981, and/or 1982, 1984 and 1999 of transects 1-9 are given in Figures 1-9. Additional photographs taken in March, 1999 are given in Figures 10-17 and 20-21. Aerial views taken in 1981 of the Nonquitt marsh are reproduced in Figures 18 and 19.

RESULTS

The total vegetation and percent of the total vegetation occupied by *S. alterniflora* is represented in Tables and Graphs 1-10. Refer to a copy of the original map of the Nonquitt marsh drawn by Sears and Parker in 1981 in Figure 22 for transect locations.

<u>Transect #1.</u> This transect, twenty-two meters in length (eleven quadrats), is in a healthy region of the marsh near the open entrance channel. There has been an increase in percent cover by both marsh grasses since 1981 so that most of the quadrats are at least 75% vegetated and many are up to 100% vegetated (Graph and Table 1). Total vegetation cover along this transect increased by 65% between 1981 (37%) and 1999 (94%). Of the total vegetation cover in 1999, 45% was *S. alterniflora* in contrast to 29% in 1981. The remainder of the vegetation consisted mainly of *S. patens*. The area does not seem to have suffered further die-back in any of its quadrats.

<u>Transect 2:</u> The transect is thirty meters long comprising fifteen quadrats. There was a gradual increase of total vegetation cover between 1981 and 1983 and again in 1999 (Table and Graph 2). There was a slight decline in total vegetation 1984. Total vegetation along this transect more than doubled between 1981 (15%) and 1999 (33%). A portion of the percent cover increase in total vegetation was due to an outward extension from existing vegetation over previously barren peat in quadrats 11 and 12. Vegetation found on the bayward end (quadrats 1 and 2) of the transect in 1982 and 1983 had completely lost their vegetative cover by 1999. The percent *S. alterniflora* decreased slightly along this transect due to the loss in quadrats 1 and 2 and an expansion of *S. patens* in the shoreward quadrats. Except for quadrats 1 and 2 further die-back has not occurred along this transect, and an outward expansion of existing vegetation has occurred over a previously barren area.

Transect 3: This transect, thirty-two meters (sixteen quadrats) in length, was originally established in a mostly healthy area in the marsh in 1981 (Table and Graph 3). Total vegetation cover steadily increased from 1981 - 1984 and again by 1999 so that marsh grasses dominate the entire transect line. *S. patens* increased at both ends of the transect while *S. alterniflora* decreased due to replacement by *S. patens*. Overall percent cover by vegetation increased by 193% between 1981 (31%) and 1999 (91%).

Transect 4: Transect 4 extends for thirty-two meters with sixteen quadrats. This transect has shown a gradual increase in total vegetation cover from 1981 to 1983, but in 1984, and again by 1999, the total vegetation decreased (Table and Graph 4). Despite these declines, total vegetation cover increased 79% between 1981 (24% cover)and 1999 (43% cover). *S. alterniflora* experienced the same trend along this transect. The data show that the small amounts of vegetation that had begun to colonize the outer quadrats of the transect near the bay between 1981 and 1984 had disappeared by 1999 . The overall increase of vegetation occurred in quadrats previously supporting stands of the two dominant marsh grasses.

Transect 5: In 1981, this thirty-two meter (sixteen quadrats) transect had been established near the center of the marsh in an area of barren peat that had undergone nearly 100% marsh grass die-back. Several shoots of *S. alterniflora* that had begun to recolonize the barren peat in 1981 were completely gone by 1983. The percent vegetation decreased from 2% in 1981 to 0% by 1999, a 100% loss (Table and Graph 5). The transect remains barren in 1999 and the peat has become severely eroded. Figures 5, 17, 20 and 21 show erosion of exposed peat that had been vegetated prior to 1981.

Transect 6: Transect 6 was a bayward extension of transect 4 that extended thirty meters (fifteen quadrats) to the west. Sparsely vegetated in 1983 (16%), it had become completely devoid of vegetation by 1999 (Table and Graph 6). As occurred at transect 5, the peat along transect 6 had become severely eroded by 1991. Refer to Figure 6 to see eroded peat close by transect 6 in 1999 in contrast to earlier conditions in 1983 and 1984.

Transect 7: Transect 7, established in 1983, is a thirty meter (fifteen quadrats) line located near transect 5. Vegetation which was sparsely scattered along this transect in 1983 (51% cover) was completely gone by 1999 (Table and Graph 7). The peat in this area has become extensively eroded in 1999. Peat erosion already had begun when the photographs was made in 1984 (Figure 7).

Transect 8: We were unable to re-establish the exact location of this transect line originally established in 1983 due to the absence of stakes and visual cues. The thirty meter transect was established as near as possible to the previous line. This transect runs along a marsh edge which has a sinusoidal line due to the eroding embankment. This transect had decreased 32% in total vegetation cover from 1983 (42%) to 1999 (26%) (Table and Graph 8). It appears that vegetation along at least part of the edge of the bay had disappeared by 1999 in an area that has become subject to extensive erosion (Figure 8).

Transect 9: The percent cover along this thirty meter transect remained unchanged in 1999 from 1983 (Table and Graph 9). The percent of *S. alterniflora* decreased in 1999, but there was a concomitant expansion of *S. patens* and *Phragmites*. This transect is in healthy condition except for the invasion of *Phragmites*. This invasive reed had begun to grow along the edges of the open marsh channel by 1981, and it has expanded its area of cover in subsequent years, especially on the dredge spoils deposited along the edges of the channel. By 1999 *Phragmites* has extended onto the high marsh where it is invading stands of *S. patens* (Figure 9).

DISCUSSION AND CONCLUSIONS

The results of this study show that some areas of the Nonquitt salt marsh are still suffering marsh grass die-back, while others support regrowth of the dominant grasses *Spartina alterniflora* and *S. patens.* The expanded cover by *Phragmites* (reed) and *Typha* (cat tail) indicate increased freshwater influence and less tidal exchange. This invasion of the southern and western areas of the salt marsh by freshwater species was also noted in the Lloyd Center studies. The marsh grasses in the majority of the transects in the eastern part of the marsh are healthy and have full coverage of *Spartina* spp. At least some regrowth of marsh grasses has occurred in these areas by vegetative tillering from existing high marsh vegetation.

Most of the die-back of marsh grasses and subsequent peat erosion have occurred in the central and western regions of the marsh where tidal exchange is minimal and where wind driven water motion is greatest. Isolated islands of peat and grasses surrounded by lower areas of barren peat have suffered further die-back and erosion as seen in transects 2 and 4. In these areas, marsh grasses have died since the original studies were done in 1980 and have further exposed surrounding peat to erosion. Areas of peat previously barren of grasses have become severely eroded since Sears and Parker's original observations. This erosion of peat is the most striking difference in viewing the marsh in 1999 when contrasted to 1981-1984.

The existing fringing grasses of the high marsh do not appear noticeably different from Sears' last observations in 1984 when compared with those in 1999. Our current quantitative data along transects 1-9 support this view. Extensive marsh degradation seems to have occurred primarily in the areas of the marsh that had become denuded by 1981, and the small island stands of vegetation throughout those areas. Extensive erosion has occurred in these areas between 1981 and 1999.

When Sears and Parker did their initial study in 1980 (Sears and Parker, 1981) they were not certain exactly when the marsh had lost 61% of its grass cover. It now seems that their estimate that most of the die-back had occurred in the late 1970's was correct. There was little erosion of the marsh peat when they made their first observations in 1980, whereas now much of the barren peat had become severely eroded by 1994 when the Lloyd Center made their study of the marsh, and even more so in 1999 based on our observations. This suggests that the intact peat of 1980 had not been exposed to erosional forces for more than a few years' time. As pointed out in the Lloyd Center's Nonquitt Marsh report of 1994 where they too noted the extensive erosion, these eroded areas of the marsh may now be too low in elevation to support marsh grass recolonization. We agree with this conclusion. There may be additional conditions of eroded areas, e.g., water logged sediments and high salinity that are currently unfavorable to marsh grass colonization. Transplant experiments by Sears and Parker in 1982 demonstrated the unsuitability of marsh peat for grass colonization in their attempts to plug grasses in otherwise barren areas of the marsh.

Tidal restrictions still exist in the channel connecting the marsh to Buzzards Bay. The 30" diameter culvert severely restricts tidal exchange, as does the shallowness of the open part of the channel that has rip-rap on the bottom and along the sides. It may be that over the years the large granite blocks at the bottom of that open channel have been lifted from ice causing further obstruction to tidal exchange. This granite "shelf" may not have been present when the blocks were initially layed. Even with careful maintenance to remove accumulated sand and gravel there, the granite blocks lining the bottom of the channel prevent total drainage of the marsh during low tides. To bring a natural tidal exchange to the marsh both of these obstructions will have to be removed or replaced.

If both the culvert and the "shelf" are completely removed, there will be more tidal exchange, but there will likely also be more influx of sediments and detritus, seaweed etc., from Buzzards Bay into the marsh. These obstructions need to be removed or modified, but advice from an experienced hydrological engineer should be sought cost/benefits of either completely removing the culvert pipe or replacing it with one of larger diameter. Whichever way is chosen, the granite rip rap should also be removed. If the culvert pipe s replaced with one of larger diameter , it may be wise to extend it beyond the low tide line where seaweeds tend to accumulate and with its end suspended off the bottom. In any case more water entering the marsh channels and bays twill create greater current that may help to keep the channel open. The optimum size of an natural opening to a marsh is determined by the amount of water entering and leaving, i.e., the tidal prism. The optimum opening size could be fairly easily determined by a competent hydrologic engineer. With that information in hand, the culvert and channel could be reconstructed to an optimum size. This is the kind of data that Sears and Parker originally suggested was needed in the conclusions to their 1984 report (Sears and Parker , 1984, pp. 7-10). Whether or not the channel is best left natural, or rip-rapped, will need further consideration by the engineers.

With the surface 5-10 cms of peat eroded over much of the barren part of the marsh, this area virtually has become new 'bay' of the marsh. With a larger bay, there will be more water, and with more water there will be a greater current to keep the channel open as long as existing obstructions are removed. It may be many years before there is much regrowth of salt marsh grasses, especially on barren, eroded peat. To prevent further degradation and habitat change tidal exchange must be increased to bring salt water to the upper reaches of the marsh. Improved water circulation and exchange may not bring back the barren areas peat any time soon, but they will help hold the *Phragmites* and *Typha* at bay and will reduce invasion of the marsh by other freshwater species.

In conclusion it seems that there are several benefits to removing and/or replacing the culvert pipe, and removing at least the bottom of the rip-rap in the open channel, and no apparent negative effects. Maybe the time has come act.

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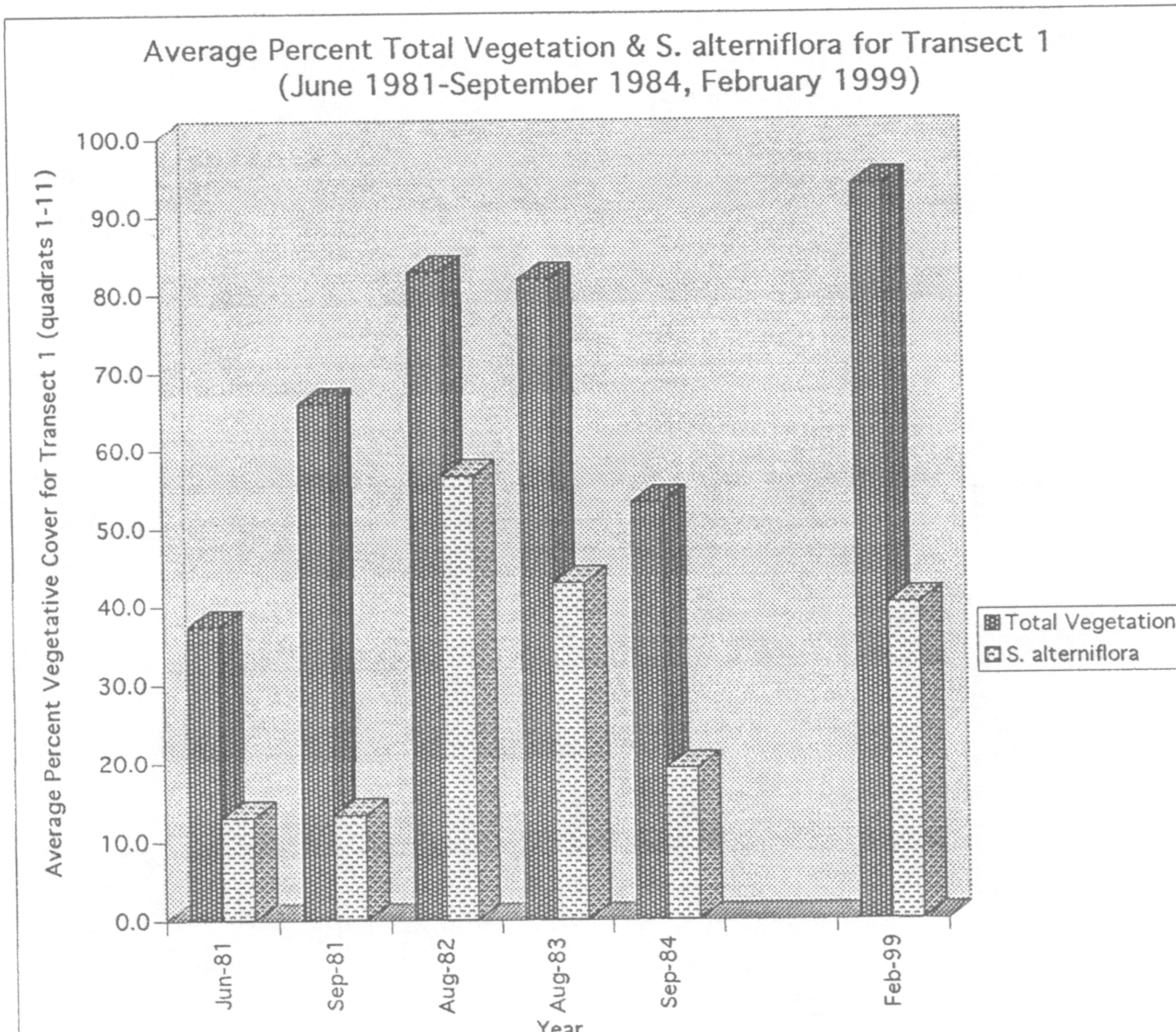
Table 1: Transect #1

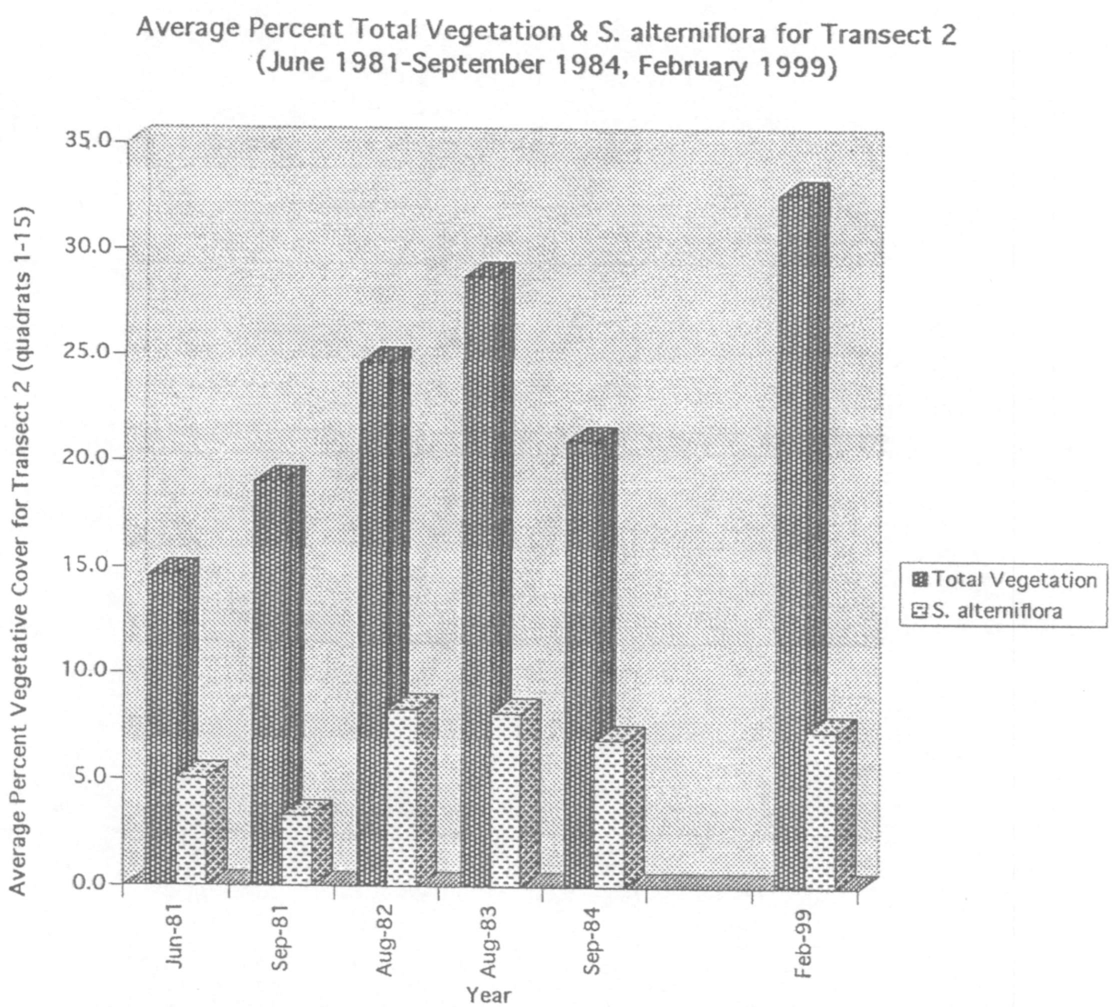
Quadrat	Total % Veg. Jun-81	Sep-81	Aug-82	Aug-83	Sep-84	Feb-99	% quadrat occupied by S. alt. Jun-81	Sep-81	Aug-82	Aug-83	Sep-84	Feb-99
1	75	80	100	100	90	100	50.2	20	50	50	9	5
2	25	75	75	80	0	100	0.3	0.75	7.5	20	0	5
3	35	75	75	50	0	95	0	0.75	7.5	15	0	47.5
4	10	50	60	70	0	98	3.7	6	6	28	0	49
5	5	60	90	80	95	100	0	0	1.8	24	95	50
6	10	40	80	80	75	95	0.6	0	24	32	45	85.5
7	1	15	50	50	75	80	1	15	30	37	60	80
8	10	40	80	90	80	75	3.2	36	48	45	2.5	75
9	70	100	100	100	50	100	49.7	45	80	80	0	0
10	80	90	100	100	20	100	24.8	18	352	50	0	0
11	90	100	100	100	100	90	9	5	15	90	0	45
Mean %	37.4	65.9	82.7	81.8	53.2	93.9	13.0	13.3	56.5	42.8	19.2	40.2



Graph 1: The mean percent cover along one-quarter meter^2 quadrats of Transect 1 by total vegetation or *S. alterniflora* during 1981-1984 and 1999. The vegetative cover increased by a factor of two from 1981-1999 with most regrowth by marsh grasses, *S. alterniflora* (shown) and *S. patens* (not shown).

Table 2: Transect #2

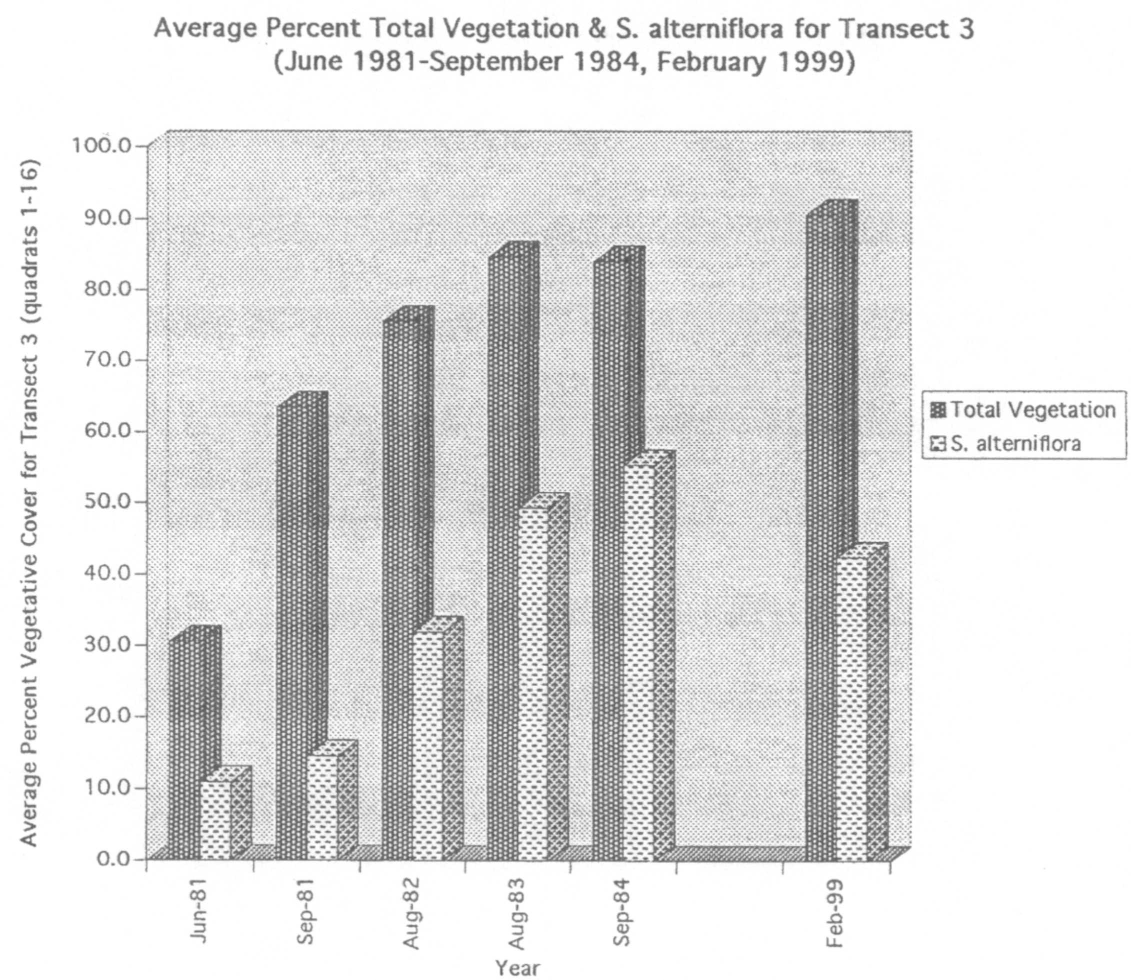
Quadrat	Total % Veg. Jun-81	Sep-81	Aug-82	Aug-83	Sep-84	Feb-99	% quadrat occupied by S. alt. Jun-81	Sep-81	Aug-82	Aug-83	Sep-84	Feb-99
1	30	75	90	80	60	0	24.9	0	54	76	48	0
2	5	30	30	50	10	0	0	0	0	0	0	0
3	0	0	0	10	5	0	0	0	0	0	0	0
4	0	0	0	1	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	90	0	0	0	0	0	90
12	0	0	0	0	0	100	0	0	0	0	0	20
13	5	0	50	90	50	100	0	0	0.5	36	50	0
14	80	80	100	100	100	100	50	40	50	5	5	0
15	100	100	100	100	90	100	1	10	20	5	0	0
Mean %	14.7	19.0	24.7	28.7	21.0	32.7	5.1	3.3	8.3	8.1	6.9	7.3



Graph 2: The graph shows gradual increase of total vegetative cover (except in 1984) for 1981-1984 and again by 1999. While the total vegetation increased, vegetation on the bay end of the transect declined. Shoreward quadrats saw an increase in *S. patens* accounting for most of the increase in total vegetation.

Table 3: Transect #3

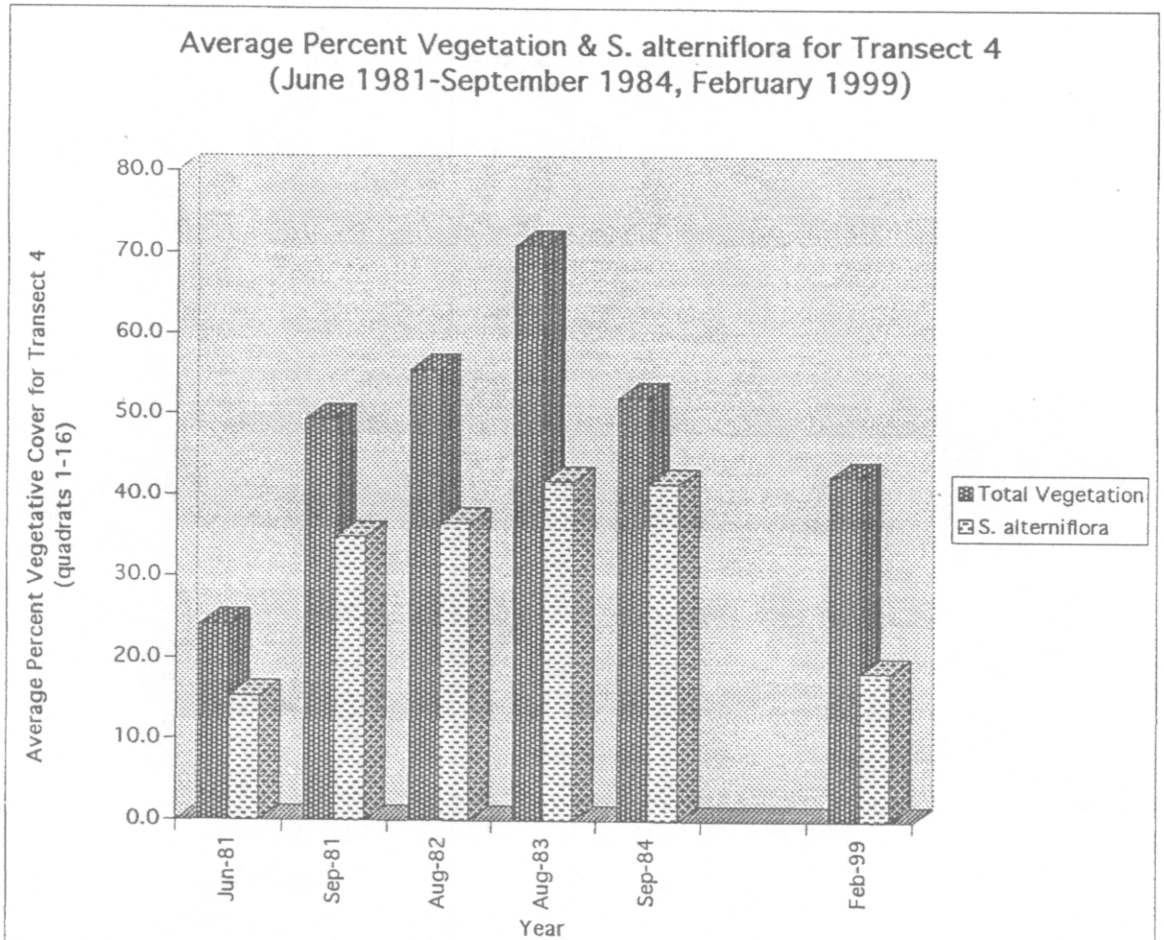
Quadrat	Total % Veg. Jun-81	Sep-81	Aug-82	Aug-83	Sep-84	Feb-99	% quadrat occupied by *S.alt.* Jun-81	Sep-81	Aug-82	Aug-83	Sep-84	Feb-99
1	5	30	20	10	50	80	0	0	0	0.5	50	40
2	35	75	85	90	80	50	15.1	37.5	68	81	32	0
3	35	80	90	100	85	100	4.9	28	54	80	34	0
4	35	80	90	100	100	100	4.9	12	45	80	20	0
5	20	90	60	80	85	60	0	0.9	36	72	64	54
6	5	40	75	80	60	100	0	0.4	7.5	32	60	100
7	5	40	65	95	75	100	0	0.4	3.3	18	75	100
8	10	40	60	80	90	100	0	0.4	0	20	90	100
9	50	100	40	90	80	100	0	0	0	18	80	100
10	5	40	80	85	85	100	0	0	16	34	85	100
11	30	75	75	90	90	100	15	26.3	52.5	54	45	60
12	70	60	100	90	75	60	60.2	39	95	85	30	0
13	5	40	75	80	90	100	0	2	37.5	80	90	0
14	10	40	95	95	100	100	9.5	6	57	90	92	20
15	75	85	100	90	100	100	65.3	80.8	40	45	40	5
16	95	100	100	100	100	100	0	0	0	0	0	0
Mean %	30.6	63.4	75.6	84.7	84.1	90.6	10.9	14.6	32.0	49.3	55.4	42.4



Graph 3: This graph shows a steady increase in total vegetation along Transect #3. By 1999, the total vegetation increased over previous years by growth of *S. patens,* at the expense of *S. alterniflora.*

Table 4: Transect #4

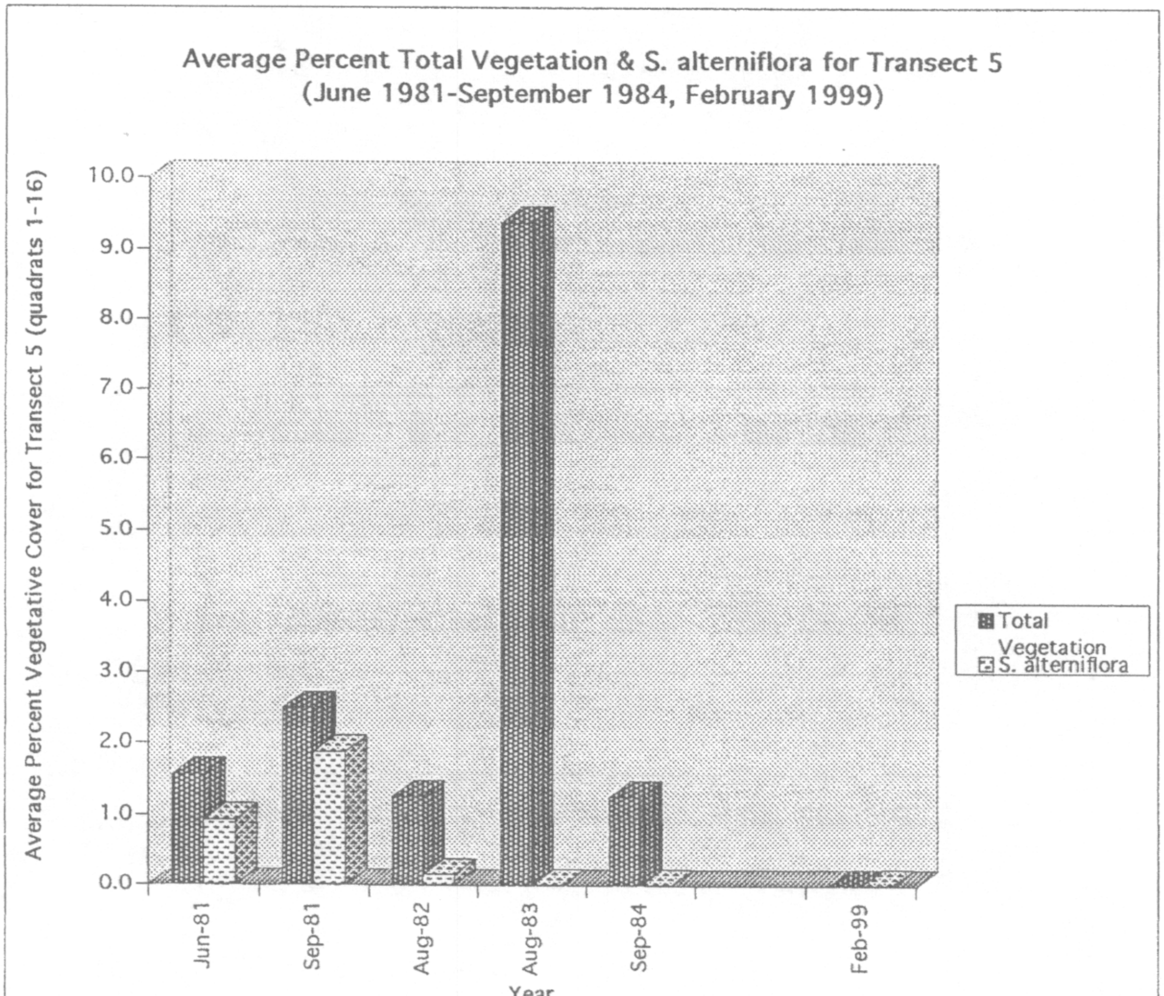
Quadrat	Total % Veg. Jun-81	Sep-81	Aug-82	Aug-83	Sep-84	Feb-99	% quadrat occupied by *S.alterniflora* Jun-81	Sep-81	Aug-82	Aug-83	Sep-84	Feb-99
1	5	80	80	90	90	0	1.5	24	24	18	22	0
2	5	20	45	40	0	0	0	0	0	0	0	0
3	5	25	30	80	5	0	0	0.3	0	4	2.5	0
4	5	35	10	40	10	0	4.7	31.5	9.9	2	5	0
5	5	5	5	5	15	0	0	0	2	5	13	0
6	5	30	5	20	5	0	4.9	27	0	0	2.5	0
7	5	50	5	20	5	0	4.5	49.5	4.5	18	5	0
8	0	0	5	70	40	0	0	0	5	42	40	0
9	5	15	50	80	80	0	4.7	15	45	80	80	0
10	25	70	95	100	95	90	25	66.5	95	100	95	100
11	50	85	90	100	95	90	49.5	80.7	90	100	95	100
12	50	80	90	100	100	100	49.5	76	90	100	90	50
13	20	20	80	90	100	100	19.8	20	80	90	100	2
14	50	85	100	100	100	100	49.5	85	100	90	100	40
15	60	90	100	100	95	100	30	72	40	20	15	0
16	90	100	100	100	0	100	0	10	0	0	0	0
Mean %	24.1	49.4	55.6	70.9	52.2	42.5	15.2	34.8	36.6	41.8	41.6	18.3



Graph 4: This graph shows a steady increase in total vegetation until August 1983 where growth decreases. The *S. alterniflora* also follows the same trend. The vegetated areas of the transect are still dominated by high marsh *S. patens*, but the quadrats near the water's edge had lost most if not all of their vegetation, thus causing a decrease in overall transect vegetation. This transect lies along areas experiencing further dieback.

Table 5. Transect #5

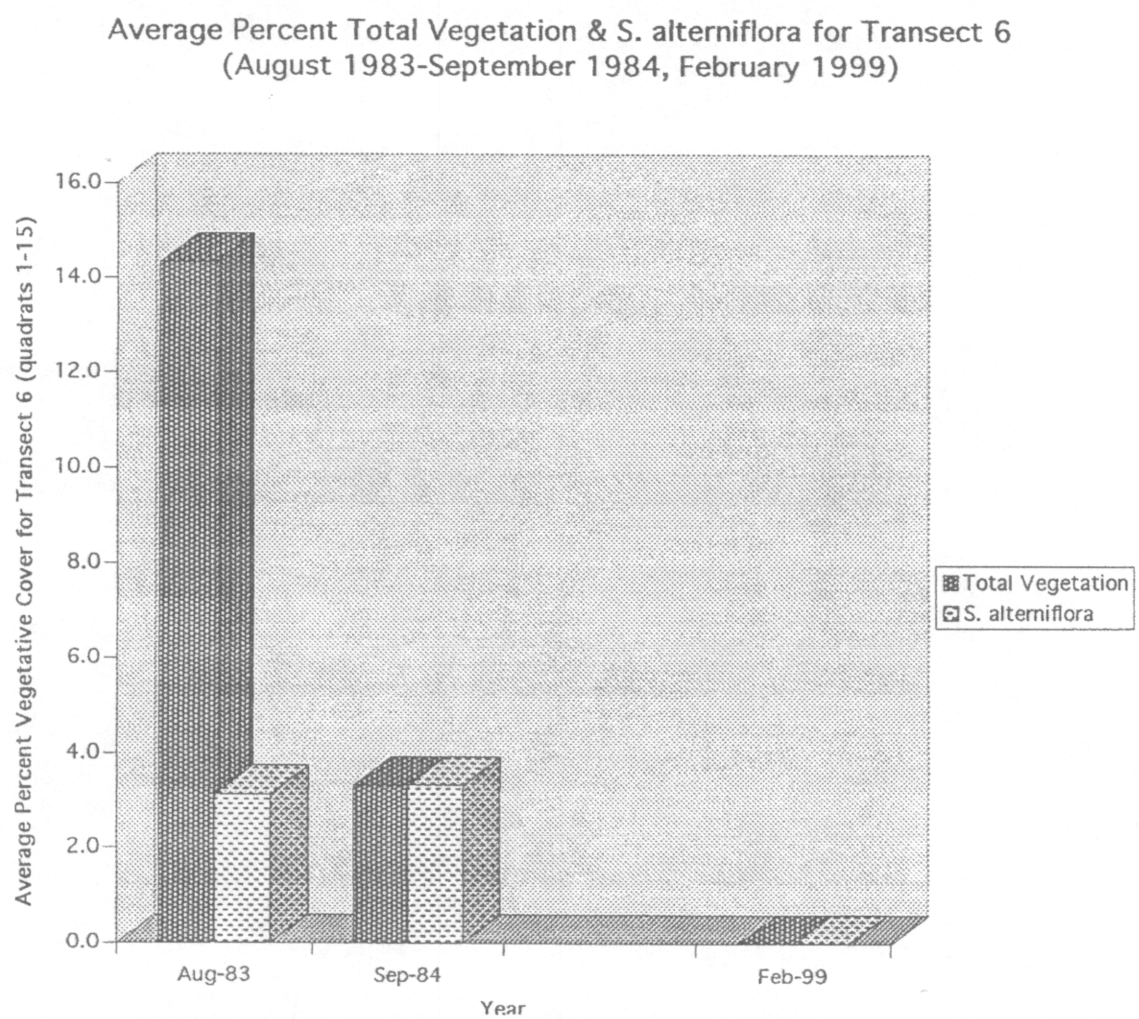
Quadrat	Total % Vegetation Jun-81	Sep-81	Aug-82	Aug-83	Sep-84	Feb-99	% quadrat occupied by *S. alterniflora* Jun-81	Sep-81	Aug-82	Aug-83	Sep-84	Feb-99
1	0	0	5	5	0	0	0	0	0	0	0	0
2	0	0	1	5	0	0	0	0	0	0	0	0
3	5	5	1	40	10	0	0	0	0	0	0	0
4	0	0	0	30	5	0	0	0	0	0	0	0
5	10	30	10	5	0	0	10	30	2.5	0	0	0
6	0	0	0	25	5	0	0	0	0	0	0	0
7	0	0	0	10	0	0	0	0	0	0	0	0
8	5	0	0	0	0	0	4.9	0	0	0	0	0
9	5	0	1	5	0	0	0	0	0	0	0	0
10	0	0	1	5	0	0	0	0	0	0	0	0
11	0	5	0	15	0	0	0	0	0	0	0	0
12	0	0	1	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	5	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0
Mean %	1.6	2.5	1.3	9.4	1.3	0.0	0.9	1.9	0.2	0.0	0.0	0.0



Graph 5: Only a few sprigs of *S. alterniflora* occurred originally along this transect during 1981-1984. The rest of the vegetation was represented by *Salicornia*. By 1999, all the vegetation was absent and the area has had severe erosion to the peat surface.

Table 6. Transect #6

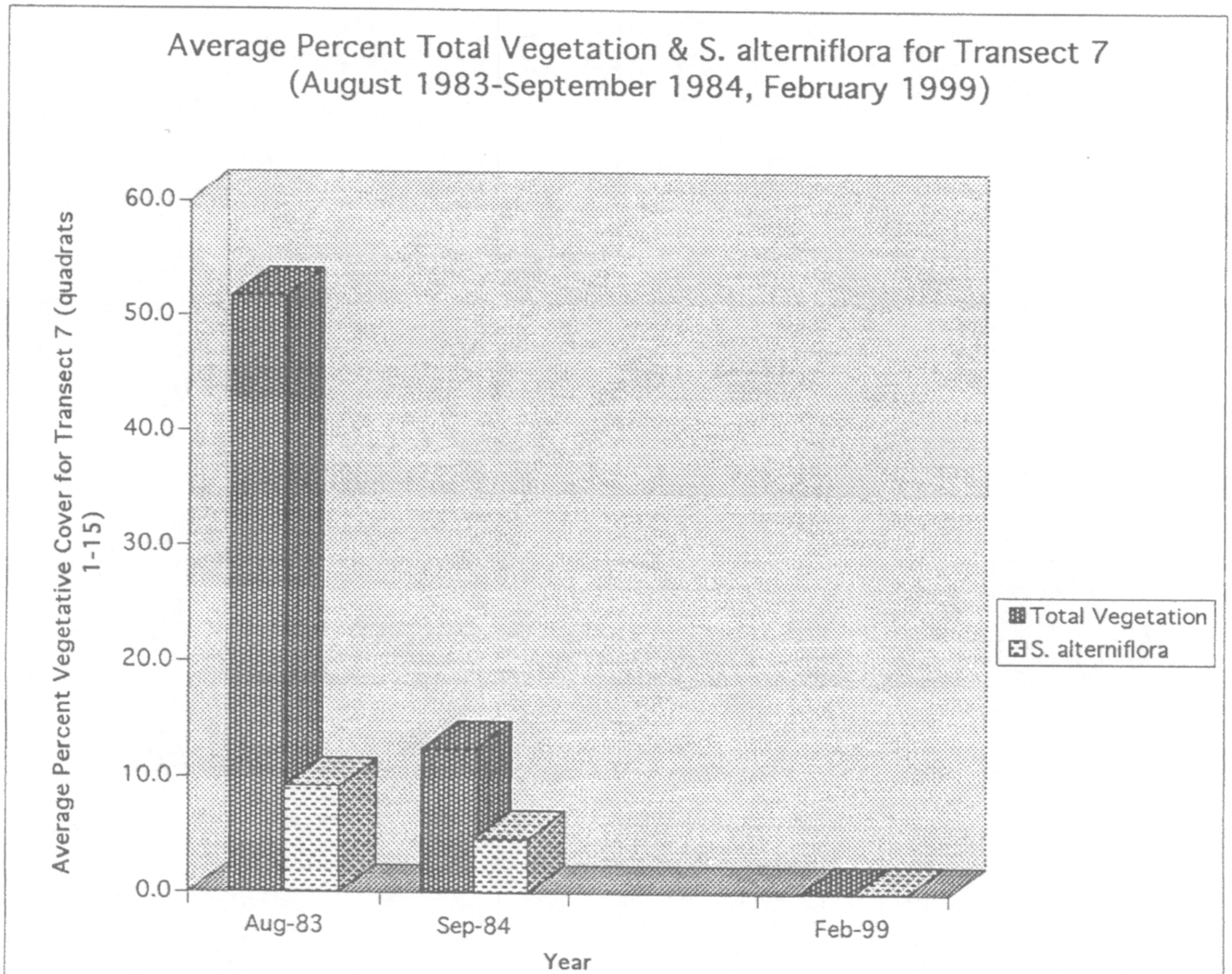
	Total % Vegetation			% Quadrat occupied by *S. alterniflora*		
Quadrat:	Aug-83	Sep-84	Feb-99	Aug-83	Sep-84	Feb-99
1	30	5	0	15	5	0
2	40	5	0	20	5	0
3	40	20	0	12	20	0
4	25	20	0	0	20	0
5	5	0	0	0	0	0
6	5	0	0	0	0	0
7	10	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	5	0	0	0	0	0
12	15	0	0	0	0	0
13	5	0	0	0	0	0
14	10	0	0	0	0	0
15	25	0	0	0	0	0
Mean %	14.3	3.3	0.0	3.1	3.3	0.0



Graph 6: The area around Transect 6 is heavily eroded in 1999. The vegetation along the transect was sparse in 1983 and 1984 and was dominated by *Salicornia* in those years with only a few clumps of *S. alterniflora*. All of the vegetation had disappeared in 1999 accompanied by considerable erosion in this area.

Table 7: Transect #7

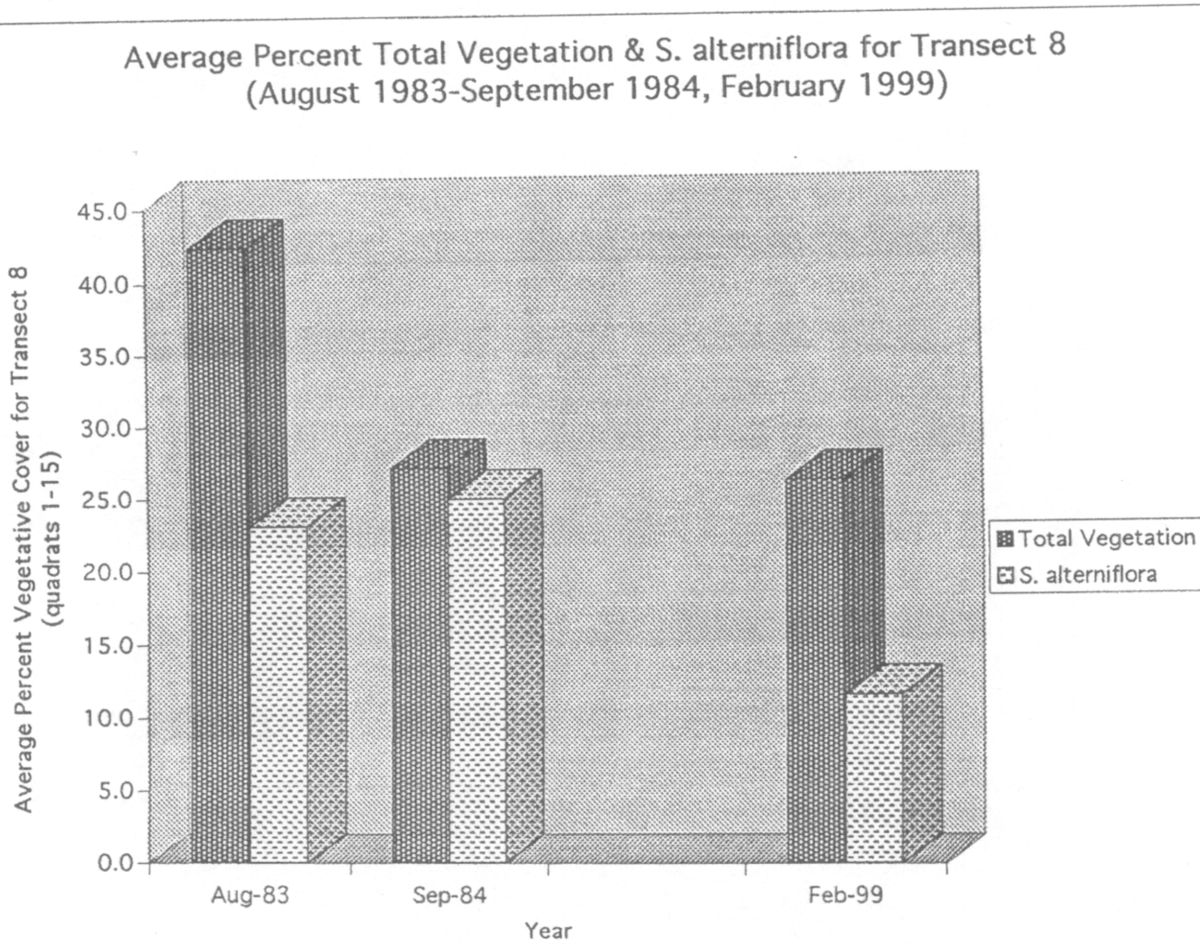
Quadrat:	Total % Vegetation Aug-83	Sep-84	Feb-99	% Quadrat occupied by *S. alterniflora* Aug-83	Sep-84	Feb-99
1	5	0	0	0	0	0
2	40	5	0	0	0	0
3	40	5	0	0	0	0
4	50	10	0	0	0	0
5	30	0	0	0.9	0	0
6	50	30	0	0	15	0
7	75	5	0	0	0	0
8	20	5	0	0	0	0
9	80	10	0	0	5	0
10	40	30	0	4	15	0
11	75	5	0	56.3	5	0
12	80	40	0	0	0	0
13	80	5	0	0	0	0
14	80	30	0	76	30	0
15	30	5	0	0	0	0
Mean %	51.7	12.3	0.0	9.1	4.7	0.0



Graph 7: In 1983 the vegetation present was mostly the annual *Salicornia*, with *Spartina* accounting for about 5% of the vegetation along the transect. All of thevegetation had disappeared as of 1999 accompanied by considerable erosion along the old transect line.

Table 8: Transect #8

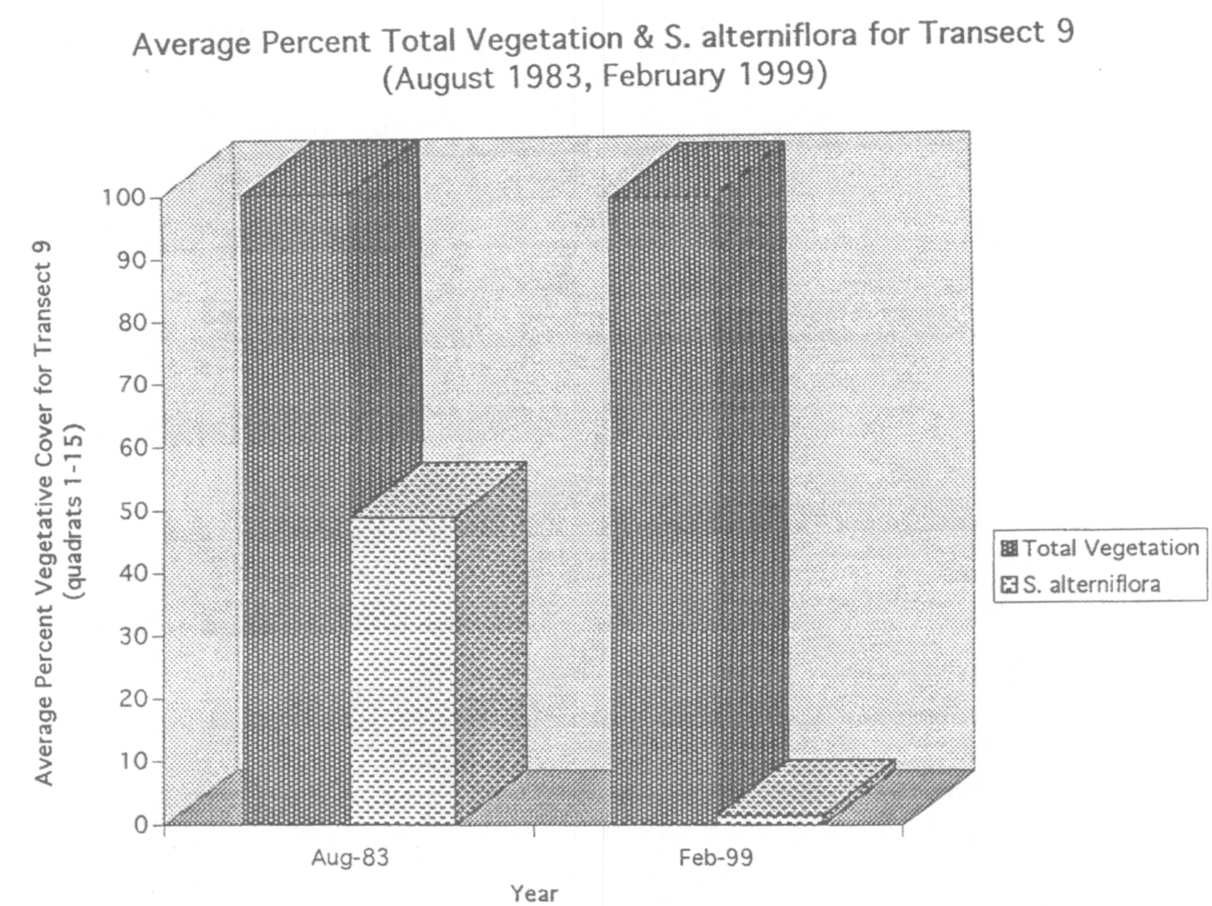
	Total % Vegetation			% Quadrat occupied by *S. alt.*		
Quadrat:	Aug-83	Sep-84	Feb-99	Aug-83	Sep-84	Feb-99
1	0	0	0	0	0	0
2	70	35	0	3.5	15	0
3	60	15	0	0	7.5	0
4	60	5	0	0	0	0
5	50	5	0	0	5	0
6	50	0	0	0	0	0
7	0	0	0	0	0	0
8	30	5	0	28.5	5	0
9	30	50	0	28.5	50	0
10	5	20	0	5	20	0
11	0	5	0	0	5	0
12	5	0	95	5	0	95
13	75	85	95	75	85	76
14	100	90	100	100	90	0.01
15	100	90	100	100	90	0.01
Mean %	42.3	27.0	26.0	23.0	24.8	11.4



Graph 8: In 1983 and 1984 1/4 to 1/3 of the transect was vegetated by about equal portions of marsh grasses and annual *Salicornia* . By 1999, grasses along the marsh edges had died back and the peat had eroded. The entire vegetation at the bay end of the transect had died, and the peat had eroded there as well. The marsh showed extensive dieback in the area by 1999.

Table 9: Transect #9

Quadrat:	Total % Vegetation Aug-83	Total % Vegetation Feb-99	% quadrat occupied by S. alterniflora Aug-83	% quadrat occupied by S. alterniflora Feb-99
1	100	100	0	0
2	100	100	0	0
3	100	100	0	0
4	100	100	0	0
5	100	100	100	10
6	100	90	0	9
7	100	95	10	4.75
8	100	100	100	0
9	100	100	100	0
10	100	100	100	0
11	100	100	100	0
12	100	100	100	0
13	100	100	90	0
14	100	100	30	0
15	100	100	0	0
Mean %:	100	99	48.7	1.6



Graph 9: Percent total vegetation remained unchanged in 1999 from 1983, but *S. alterniflora* was replaced by high marsh *S. patens* and *Phragmites*. The vegetation is in a healthy condition except for the invasion of *Phragmites*.

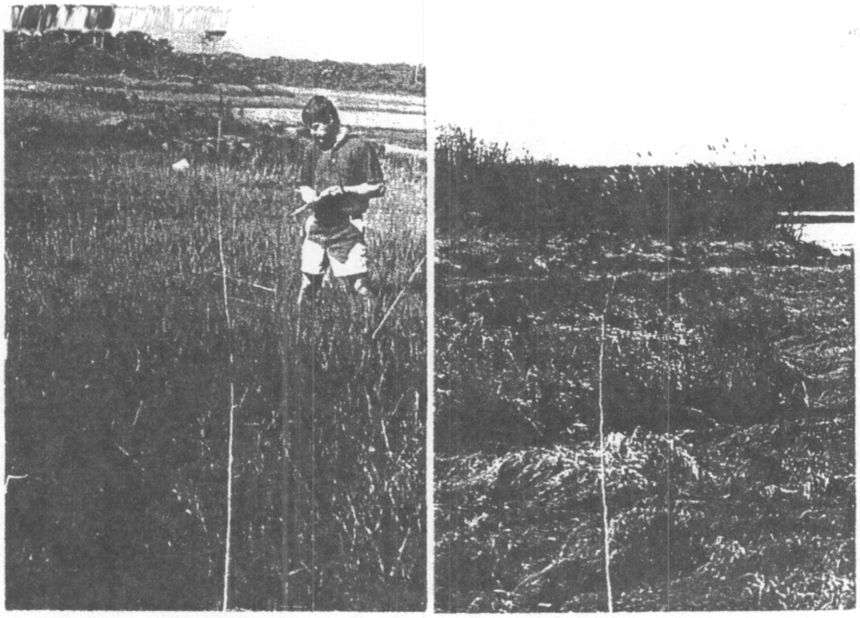


Figure 1: Transect #1 in summer, 1981 (left) and early spring (right) 1999. This part of the salt marsh has nearly 100% cover by the marsh grasses *Spartina alterniflora* and *Spartina patens* .

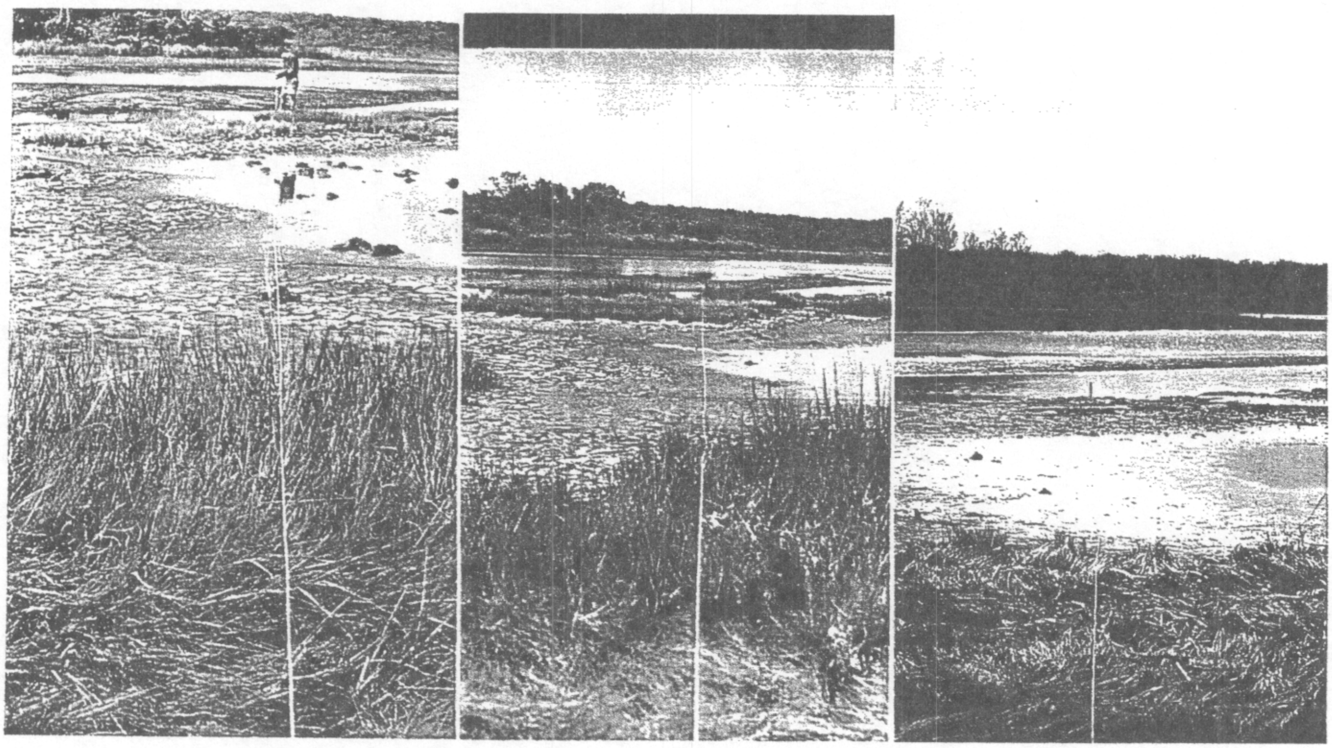


Figure 2: View southward along Transect #2 in 1982 (left), 1983 (center) and 1999 (right). By 1999 marsh grasses had extended outward by about four meters toward the pond, but no new vegetation had colonized the central, wet, barren area. Marginal colonization occurred by vegetative tillering, not by seed. The area at the distant end of the transect that supported vegetation in 1982 and 1983 (left) had completely lost its vegetation cover and had become severely eroded by 1999 (right).

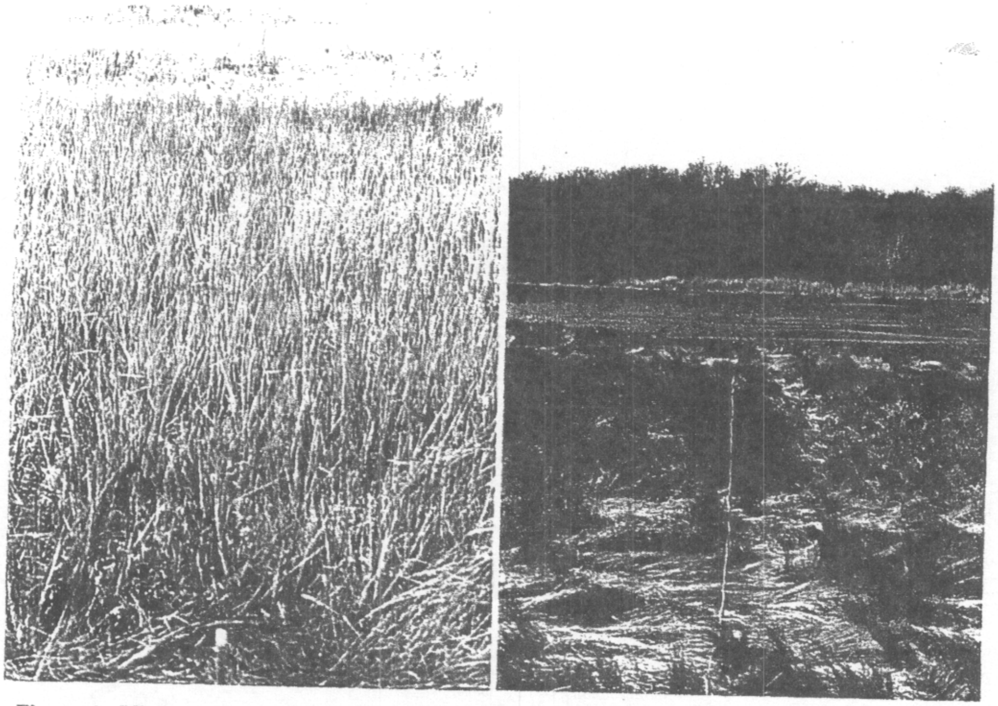


Figure 3: View along Transect #3 in summer, 1983 (left) and fall, 1999 (right). Total vegetation dominated by the marsh grasses *S. alterniflora* and *S. patens* increased between 1981 and 1999. This remains a healthy area of the high marsh.

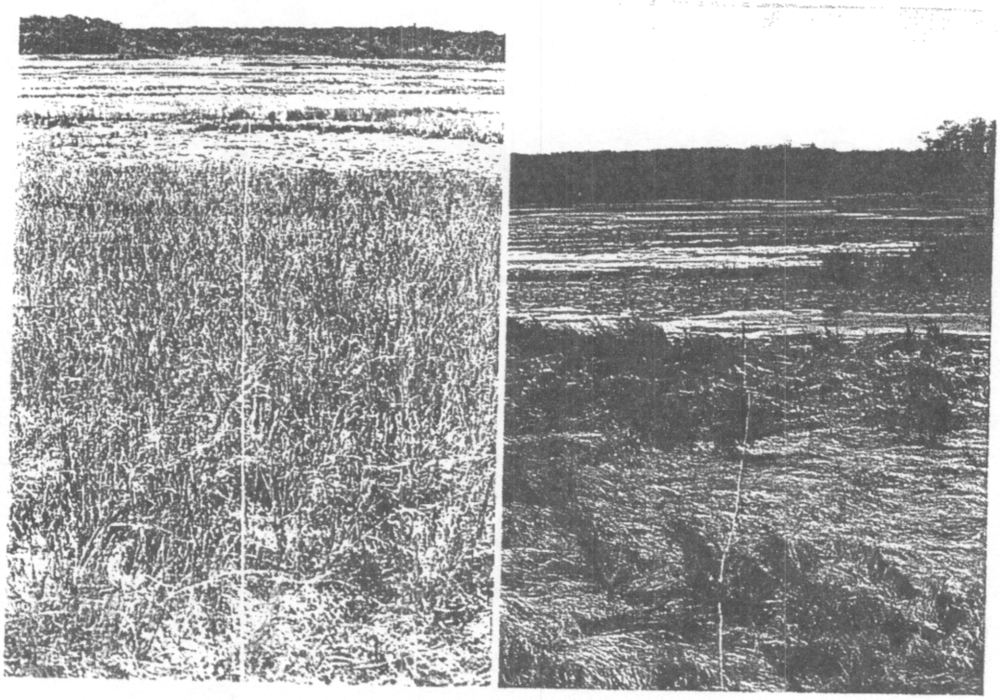


Figure 4: Looking west over Transect #4 in summer, 1984 (left) and early spring, 1999 (right). Vegetation at the far end of the transect that was present in 1983 had completely died back and the peat eroded by 1999. At the shoreward end of the transect (base of photo) marsh grasses had increased to nearly 100% cover from a previous 60-70% cover prior to 1984.

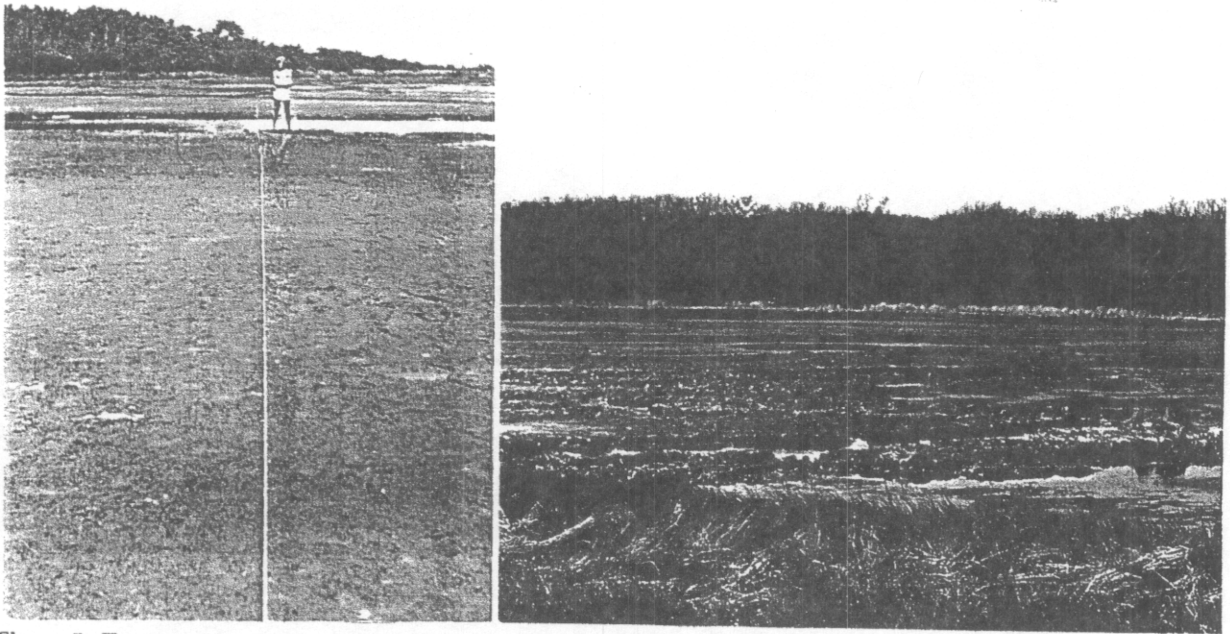


Figure 5: Transect #5 was established in 1981 in an area of barren marsh peat that had suffered nearly 100% die-back prior to 1981. Several shoots of *S. alterniflora* present in 1981 had completely disappeared by 1983. The photograph on the right shows a nearby area where marsh peat had become severely eroded by 1999. Similar conditions as shown on the photo on the right occurred at Transect #5. The peat in the area of Transect # 5 was too soft and eroded to allow walking on for a photo to be taken.

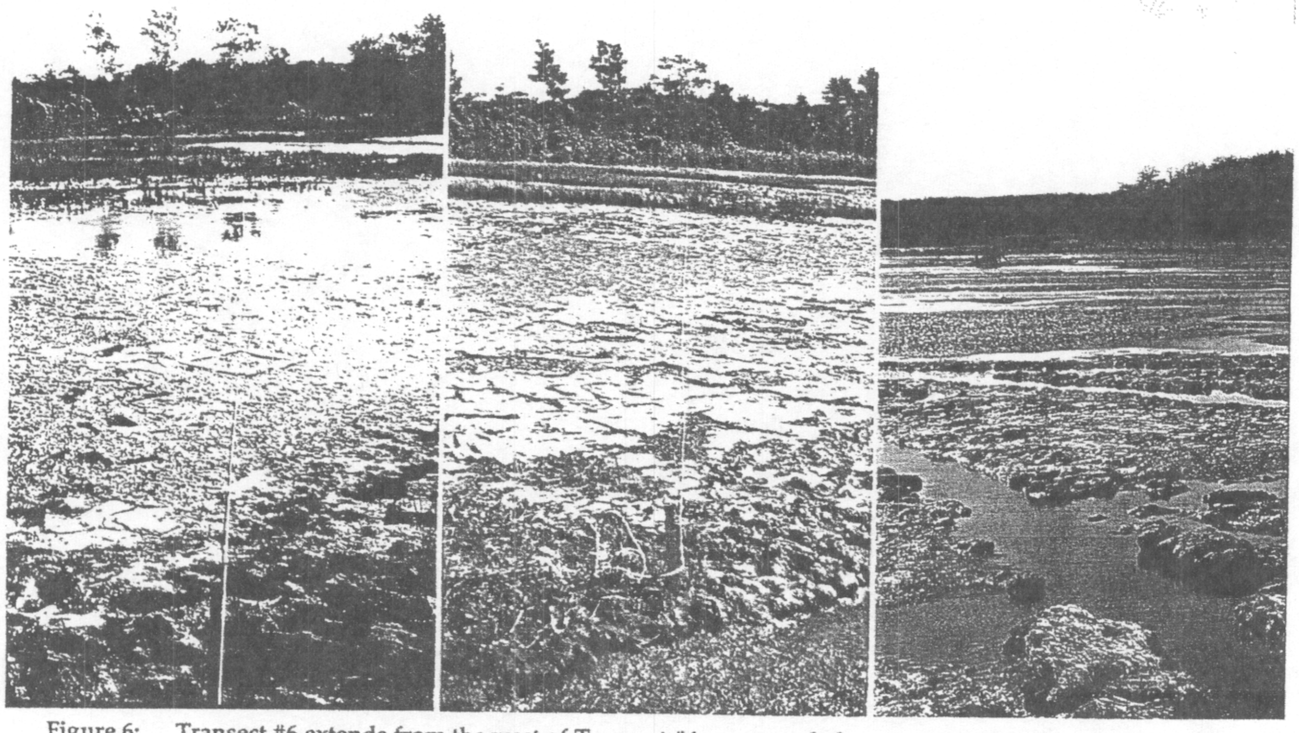


Figure 6: . Transect #6 extends from the west of Transect #4 over mostly barren peat to a creek to the west (left). As seen in 1983 (left), 1984 (center) and the general area in 1999 (right) the grasses on the east end (top) had completely disappeared by 1999 and the peat over the entire transect had further eroded and did not support any grasses in 1999.

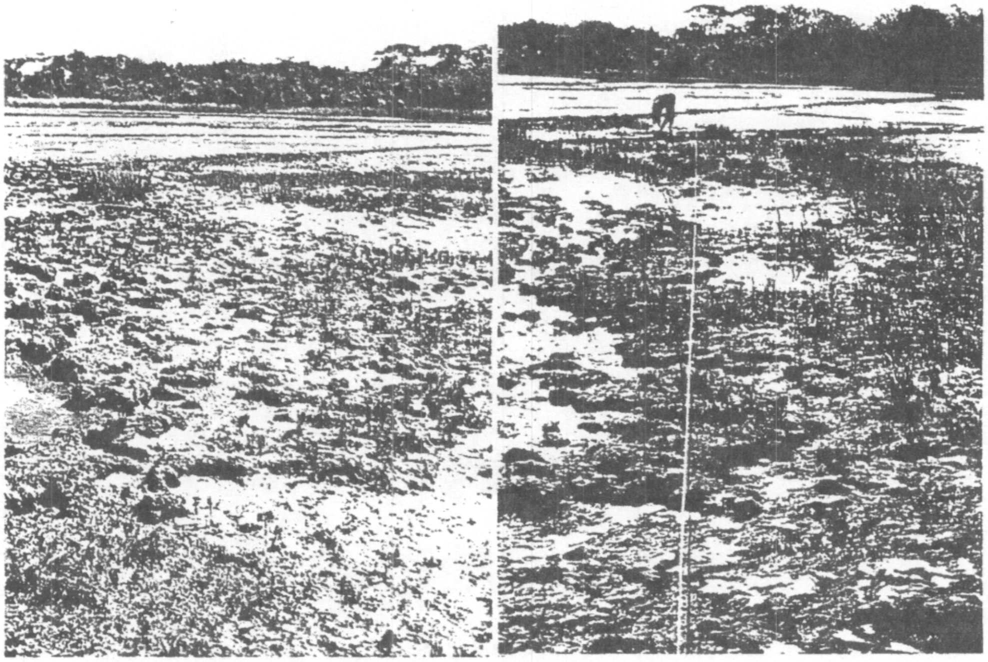


Figure 7: Established in 1983 on a nearly barren area of marsh peat previously vegetated, the area was colonized mostly by *Salicornia* in 1983 and 1984, but by 1999, as in Transect #6, all vegetation was gone and further erosion of peat had occurred.

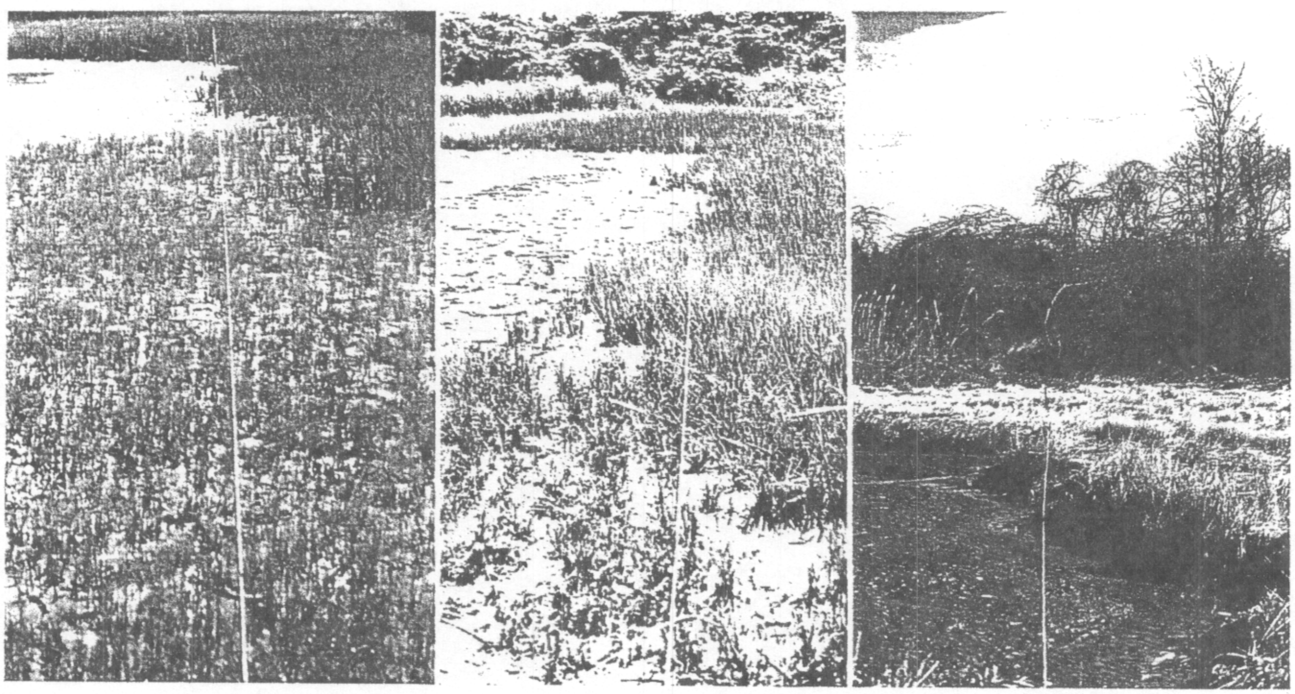


Figure 8: We were unable to replicate the exact position of Transect #8 established in 1982 because the stakes had been lost, but a close approximation of the lines shown in 1982 (left) and 1983 (center) was made. The grasses and peat banks and the grasses and *Salicornia* at the bay end of the transect had receded by 1999, but the upland marsh grasses persist in dense populations.

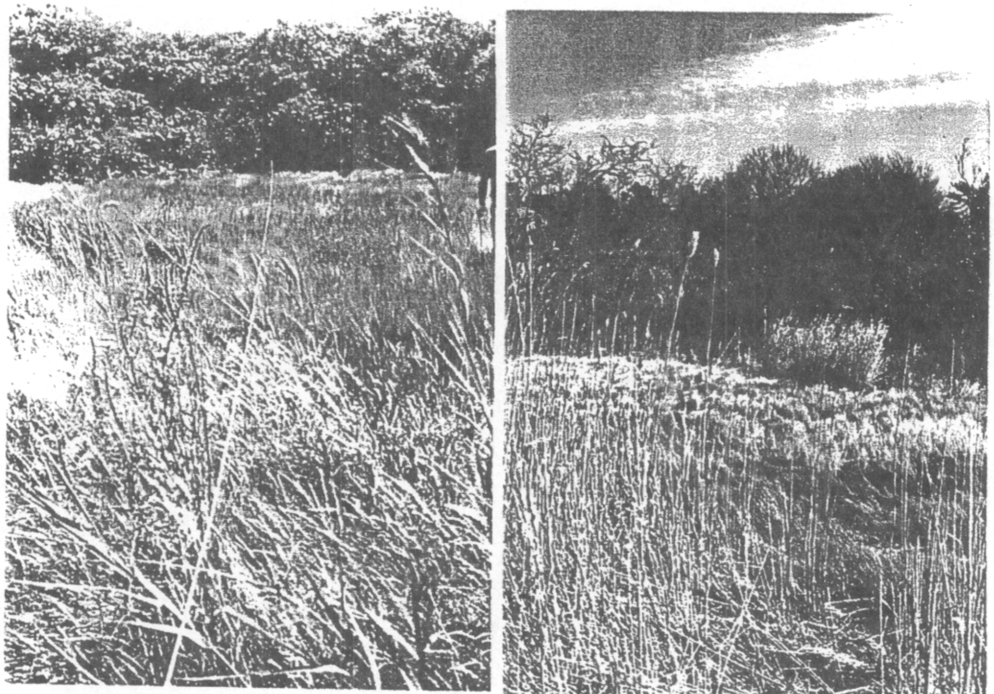


Figure 9: Transect #9 has remained densely vegetated (100% in 1983 and in 1999), but *S. patens* has replaced *S. alterniflora* and the tall invasive grass, *Phragmites,* had expanded along the channel bank from 1983 to 1999.

Figure 10: The culvert pipe that runs from the open channel to the bay is currently the major restriction to tidal exchange. This restriction will have to be rectified before there is much hope of the marsh becoming re vegetated with it's natural saltmarsh grasses.

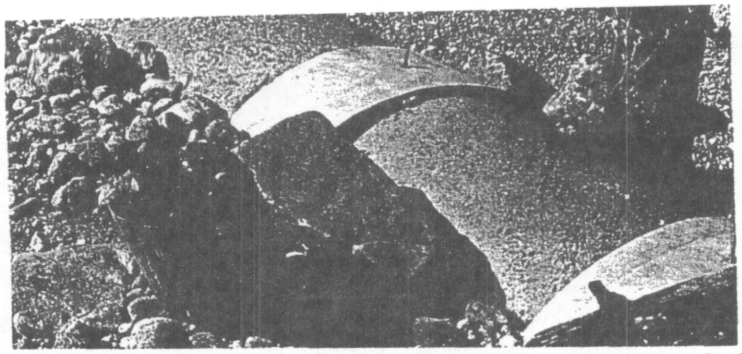


Figure 11: Because storms often filled the culvert pipe with gravel when the clean-out holes were open, removable caps were installed by Sears and Parker in 1981. They allowed access to the interior of the pipe when it became blocked. These caps apparently still function after eighteen years.

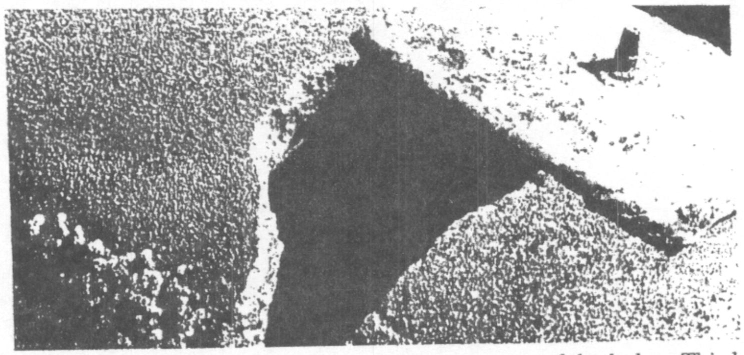


Figure 12: A sample cap only partly covering one of the holes. This hole is a source of sediment.

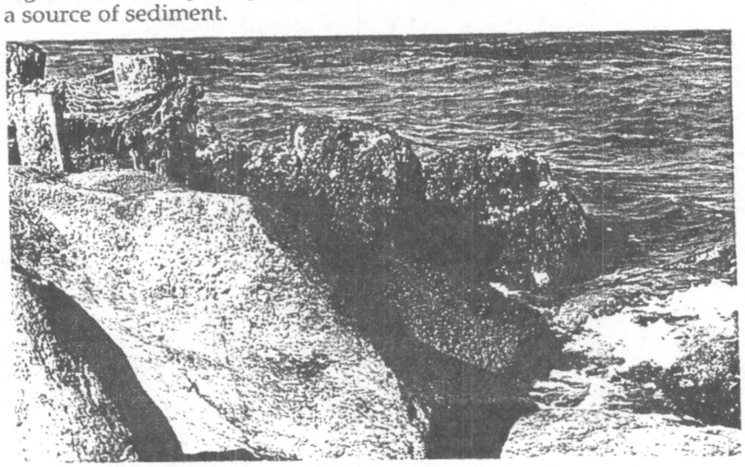
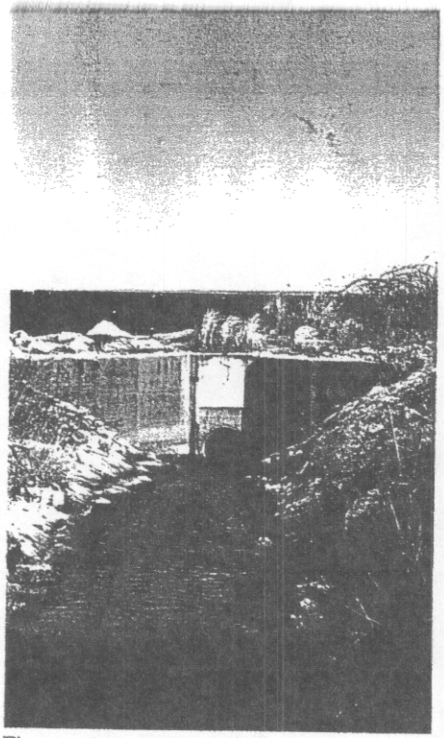
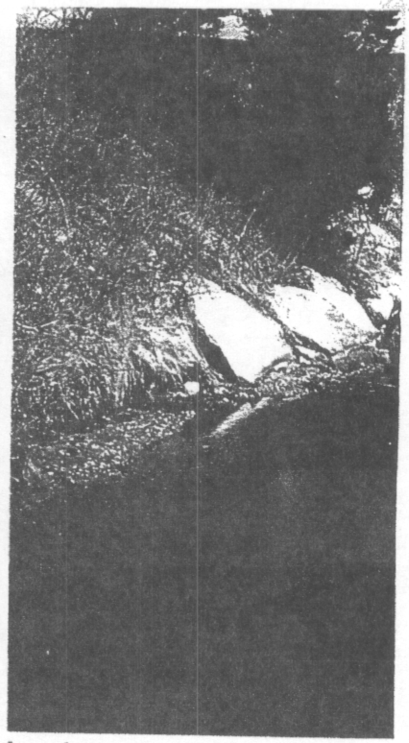


Figure 13: End of the culvert that drains into the bay. The culvert is located at such a point along the beach that seaweeds and eelgrass accumulate and enter the pipe, eventually being carried into the marsh.





Figures 14a and 14b: Channel leading to the culvert pipe (a). The photo is taken from the small bridge under which the channel flows. Note the accumulation of sand and gravel along the bottom and banks of the channel (b). Both sediments and underlying granite as well as the culvert pipe are restrictions to free exchange of seawater between the marsh and bay. Diligence in keeping this channel dredged open sand and gravel has not resulted in significant flow or increased health of the marsh vegetation. The channel needs to be deepened and the opening to the sea made larger, either by removing the pipe altogether or installing a larger diameter pipe that is set deeper into the channel.

Figure 15: Large stands of *Phragmites spp.* dominate this area. This stand is near Transect 9. *Phragmites* indicates a lack of tidal exchange and/or freshwater runoff. It does not develop where salt water has free exchange between marsh and bay.

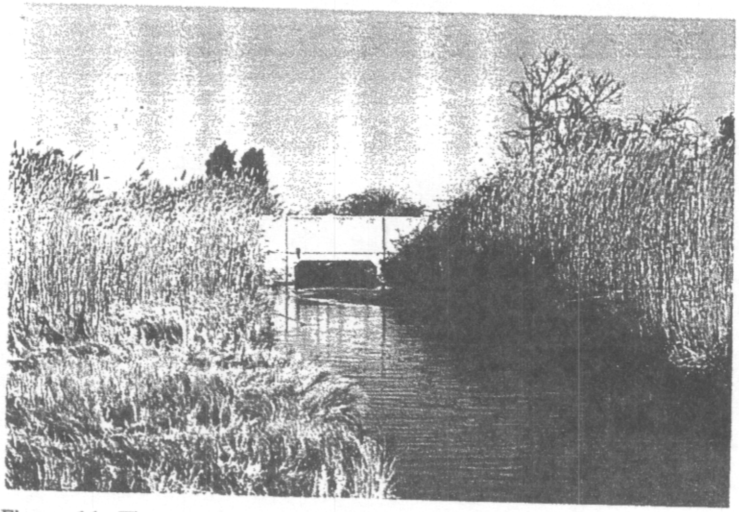


Figure 16: The new bridge allows for much more tidal exchange than the previous structure. Now it is the channel on the east side of the bridge and the culvert to the bay that restricts tidal exchange. *Phragmites* has begun to grow here by 1981 on the spoils from the channel, but has spread to almost the entire length of the channel.

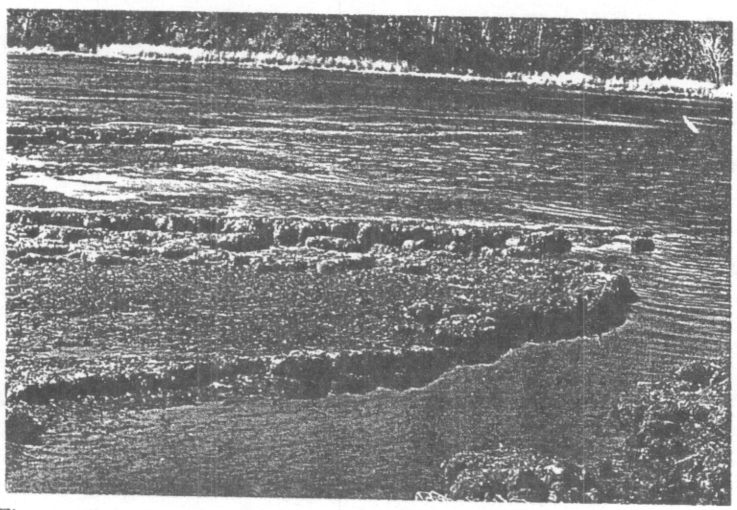
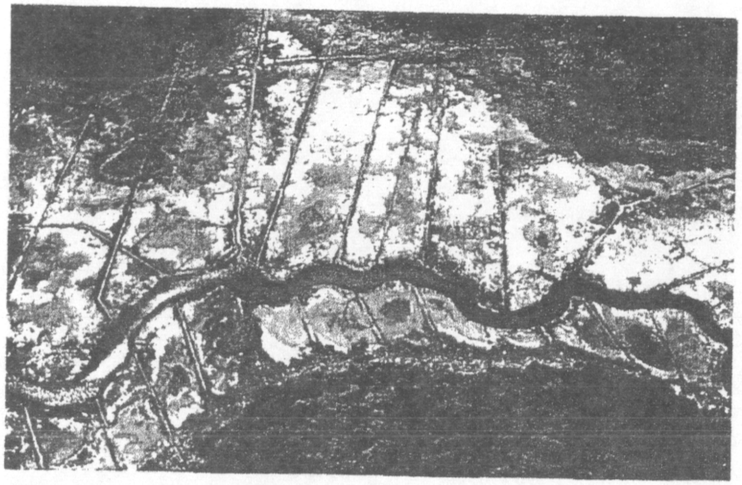
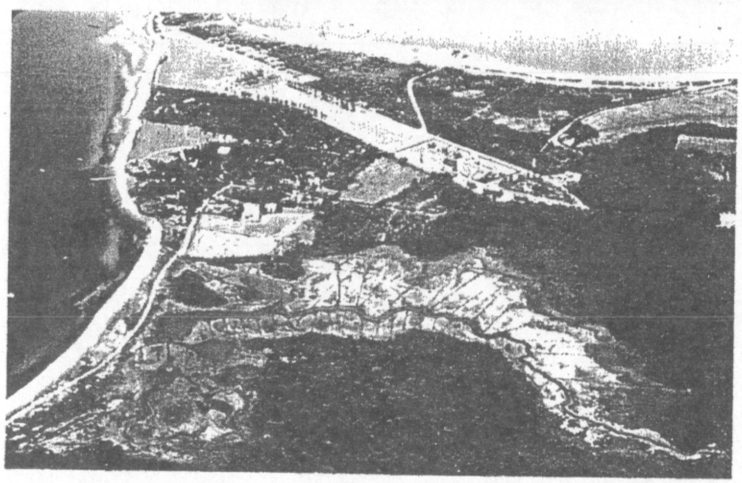
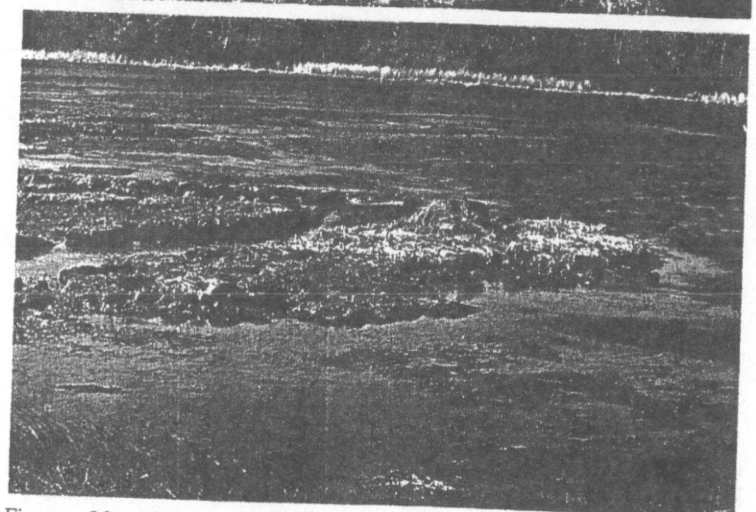


Figure 17: The marsh was still draining at the time of the photo. Some of the standing water is in channels, but most is in areas of the marsh peat that have become eroded over the past eighteen years.





Figures 18 and 19 Aerial views of the Nonquitt salt marsh in 1981. At that time 60% of the marsh vegetation had died, exposing the peat to erosion. Straight lines are ditched dug by a machine earlier to help control mosquito populations. When healthy, all of the entire marsh except for the creeks would have been covered by the marsh grasses *Spartina patens* and *Spartina alterniflora* . The reddish-brown areas are populations of the annual *Salicornia europeae.*



Figures 20 and 21: Over much of the eastern end of the marsh, and probably beyond, it appears that 4-6" of peat have eroded from the marsh surface, leaving depressions for standing water. These areas will not become vegetated until unrestricted tidal flow is improved and even then, it may be years before grasses grow over these areas from existing beds.

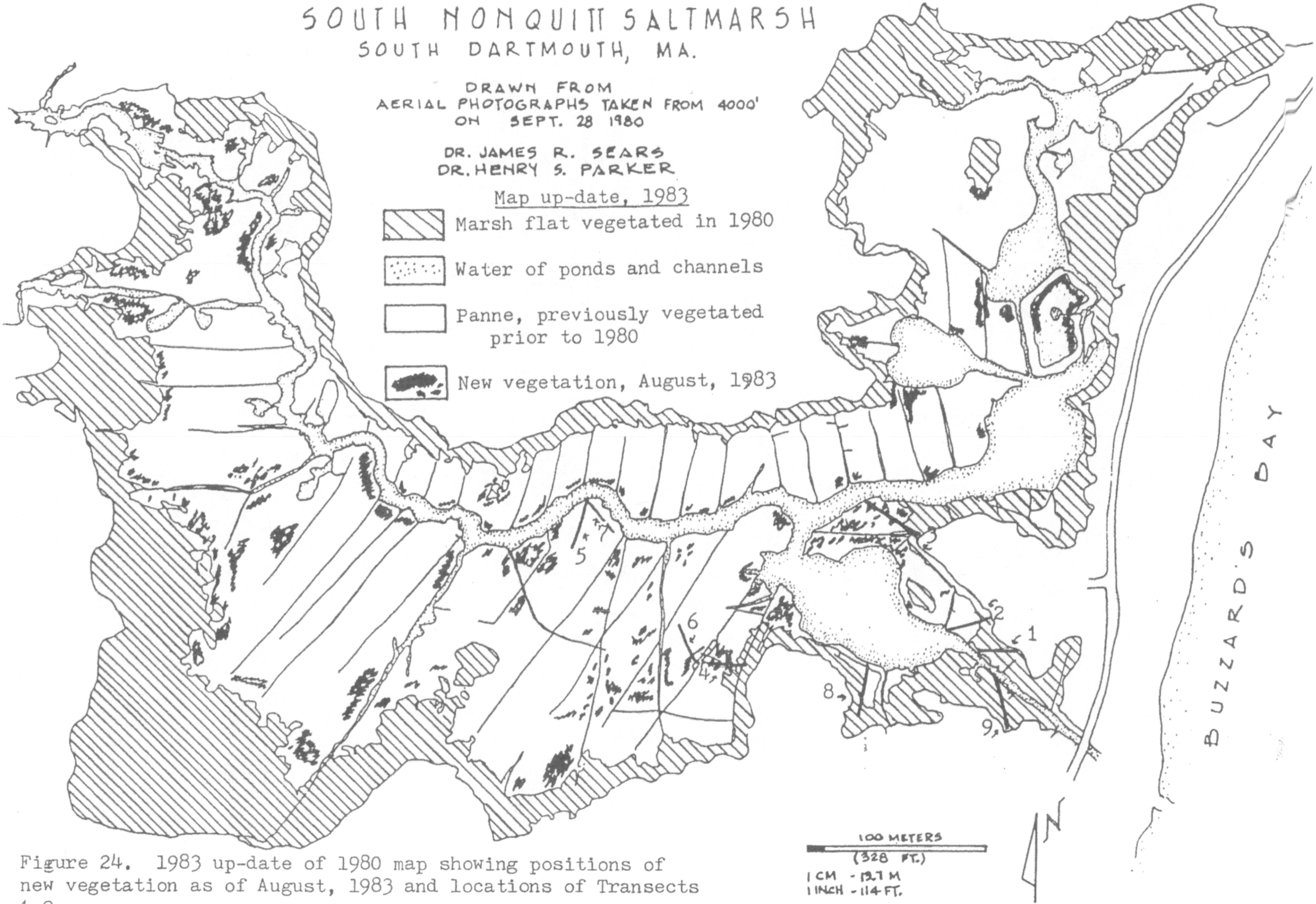


Figure 24. 1983 up-date of 1980 map showing positions of new vegetation as of August, 1983 and locations of Transects 1-9.