DISTRIBUTION AND ABUNDANCE OF MARSHES, MANGROVES AND SUBMERGED AQUATIC VEGETATION IN TIDAL WATERS OF THE MYAKKA RIVER SARASOTA COUNTY, FLORIDA

Final report to
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by the
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PREFACE

Tidal rivers are among the least studied aquatic ecosystems in Florida and throughout the world. In this state and country, palustrine (riverine) ecology has developed into a mature science but such knowledge usually extends from a river's headwaters downstream only as far as its hydrology and chemistry are "uncomplicated" by the effects of tides. Likewise, estuarine ecology enjoys a broad theoretical and comparative foundation and nearly every large estuary in the nation has been the subject of site- and process-specific research. Many estuaries also have management programs. In practice, however, the majority of estuarine research and management has traditionally stopped at the mouths of rivers, leaving a literal gap in our knowledge of, and ability to manage, entire basins, rivers, and estuaries. Tidal rivers are appealing environments for both river and estuary scientists because each has the opportunity to examine factors controlling their respective systems. Estuarine scientists particularly benefit because the typical two or three dimensional complexity of open estuaries is usually reduced to only two or even one dimension of variability. We do know that tidal rivers are essential to the overall productivity of estuaries because the rivers are often the primary sources of carbon and other nutrients, nursery-ground for juvenile invertebrates and fishes, and habitat for rare, threatened and endangered species. We do not know enough about tidal rivers to formulate the general principles of limnology or oceanography, much less of resource management. As this report illustrates, there is still much work left to do in the field of basic description and characterization.

Acknowledgements

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INTRODUCTION

Objectives

This project was conducted to provide background information on the composition, distribution and phenology of wetland plant communities within the fresh to marine salinity gradient, downstream of the T. Mabry Carlton (Ringling-MacArthur) Reserve. This background information will provide valuable insight to long- and short-term vegetational changes caused by both natural and man-induced alterations to the streamflow of the Myakka River, and guide future monitoring efforts.

Two separate tasks were completed within the scope of this project. In TASK 1, the wetland vascular plant communities of the Myakka River were mapped according to a classification scheme based on dominant plant species, developed to resolve mixed communities within the salinity gradient from freshwater to marine conditions. TASK 2 identified wetland emergent species composition on a bi-monthly basis from October 1987 to August 1988 at the east and west banks of 30 transects along the salinity gradient of the River (total of 60 sites). Species composition and distribution data were compared to data gathered in previous studies and from Task 1 mapping, along the same transect locations. This task was experimental and intended to test the feasibility of repetitive transect surveys (instead of the groundtruthing of aerial photographs) as features of routine monitoring.

Project History

This project is the third phase in a series of investigations concerning the ecology of the tidal Myakka River. Phases 1 and 2 were wet and dry season reconnaissances, respectively. The last task of Phase 2 involved and independent peer review of progress to date (Browder, 1987), which review agreed with the decision that data were needed on the distribution and abundance of tidal wetlands downstream of the Reserve. Phase 3 wetland studies were expanded by Sarasota County when the opportunity arose to inventory shorelines, and the results of the extra surveys were reported in Estevez et al. (1990). This report describes the results of the original scope of work for wetland studies. Phase 4 of the project involved the calibration and verification of a one-dimensional hydrologic model of the tidal river, the results of which are reported in Siler and Blanchard (1990) and Siler, Hayward and Blanchard (1990).

Definition of the Study Area

For both tasks, tidal wetlands along the Myakka River from the Interstate 75 bridge crossing, downstream to the Sarasota-Charlotte County line were studied. The study area included Deer Prairie Creek upstream to the salinity barrier and a portion of Big Slough and the tidal Myakkahatchee Creek (Figure 1).

PREVIOUS INVESTIGATIONS

In 1985, Wharton reported the results of an effort to "naturalize" the Myakka River landscape using General Land Office Survey (GLOS) records from the 1840s. This work was conducted for Mote Marine Laboratory as part of the ongoing downstream impact studies sponsored by Sarasota County. Wharton stated, "historic evidence discloses no major changes have occurred in the overall configuration of the river corridor. Its major features...remain today as they appeared in presettlement times", although evidence of meandering and island changes were noted. Interpreting GLOS records and other historic reports, he places the transition from fresh to salt or brackish at or within a mile above river mile 10.1, or between Deer Prairie Creek and Big Slough (GLOS records), to river mile 13.0 (other historic sources). He also noted post-settlement, upstream migration of mangroves from about river-mile 6.4 to 11.0. Additional historic notes are provided by McCarthy and Dame (1983).

Descriptions of the modern flora of the Myakka Corridor have been given by the Soil Conservation Service (1959), Miller (1979), the National Wetland Inventory (1979), Harris, Haddad, Steidinger and Huff (1983), Hussey (1985), the Florida Department of Environmental Regulation (1988)The Florida Department of Natural Resources (Hunter Services, Inc., 1990), Clewell, Beaman, and Winchester (1990), and Estevez, Palmer, Evans and Blanchard (1990). The Soil Conservation Service (SCS) actually described soils of Sarasota County, based on aerial photography and ground-truthing performed in the 1940s and 1950s. SCS maps depict sandy alluvial soils along the river below the Park, downstream to the Big Bend area (river-mile 15.5) where that soil type pinches out and is replaced by a widening band (downstream) of tidal marsh soil.

lower Myakka River but do serve to describe overall wetland and seagrass conditions in the area upstream and immediately adjacent to the river mouth.

As part of the MML wet-season characterization of the tidal Myakka River, Hussey (1985) used transects to depict wetland composition along the salinity gradient downstream of the T. Mabry Carlton Reserve. Seventy-two species were identified. Black needle rush was the most common species, followed by cabbage palm, Brazilian pepper, and wax myrtle. Distribution of the 20 most common species bore no relation to salinity although the distribution of twelve salinity-sensitive species followed a pattern consistent with effects of salt penetration. Eight physiographic shoreline types were found along the tidal river. Forested freshwater shorelines occurred upstream of river-mile 15. Tidal freshwater marsh was very rare and all occurred on the east bank between river-miles 16.9-19.8. Brackish marshes contained mixtures of salt marsh and freshwater species; these were found between river-miles 6.7-16.6 (east bank) and 9.4-12.7 (west bank). The influence of tributaries was noted in localized mixtures of freshwater species in salt marsh or mangrove forest in the river, near the mouth of each tributary. Admixture was particularly high at the mouth of Deer Prairie Creek. Overall, Hussey recognized river miles 6.0-13.0 as floristically transitional between the estuarine/marine and riverine plant communities. The presence of only one patch of sawgrass was noted and compared to its abundance in other tidal rivers.

Clewell et al. (1990) reported on a botanical survey between the Park and Snook Haven, performed as part of an ongoing Myakka River basin study. The river flora was found to be depauperate (147 species) relative to northern and southern coastal rivers. Four vegetation types were recognized, hydric hammocks, mesic evergreen hammocks, marshes, and sloughs. Hydric hammocks contained live oak, cabbage palm, laurel oak, sweetgum, American elm, loblolly pine, red maple, ironwood, water oak and red cedar. Mesic evergreen hammocks contained live oak and cabbage palm with a saw palmetto undergrowth and few epiphytes. Sloughs were numerous in the upriver half of their study area. Most shoreline marshes were small and occupied low flats or sand bars near sloughs. Shoreline marshes downstream of river-mile 25 were small to large, contained more species, and were more numerous than marshes upstream of that point. Six shoreline species were found along the lower river that are characteristic of tidal influence and another 6 were common upstream but absent downstream.

For the river reach in Sarasota County, Miller (1979) recognized 8 plant associations in three groups: river-independent, man-disturbed, and river-related. The latter group contained low upriver (near the Park), low downriver (tidal), and oak-cabbage palm hammock associations. The low upriver associations, generally small in extent, include popash heads, mixed meadows of buttonbush, popash, and water locust, and willow points. The low downriver associations include brackish marshes and mangroves, first appearing "just south of Snook Haven", and are dominated by rush, cordgrass, leather fern, and cattail. Miller stated that mangroves first appear about a mile north of the U.S. 41 bridge. Oak-cabbage palm hammocks are numerous downstream of Myakka City, all the way to tidal waters. Upstream of Myakka City, the river canopy is dominated by maples, bays and popash.

The National Wetland Inventory project photo-interpreted high altitude photographs (1:80,000) using a structural classification system described by Cowardin et al. (1979). The photography was performed in 1972. Wetlands are hierarchically defined and mapped into 5 ecological systems and numerous subsystems, classes, and subclasses. Almost all of the tidal wetlands downstream of U.S. Highway 41 were classified "Estuarine Intertidal" and constitute marshes or mangrove forests. Only 3 small wetland patches bearing the palustrine forest or palustrine marsh labels appear downstream of the Highway, on the Myakka River quadrangle. Upstream of the Highway, to Rambler's Rest Resort, estuarine marshes dominate. From the Resort upstream to Big Bend, wetlands are a mixture of palustrine forests and emergent marshes. Upstream of Big Bend, the National Wetland Inventory reported palustrine forests that are comprised of "broad-leaved evergreens" (cabbage palms) and the first occurrences (heading upriver) of open water tributaries bearing the "Riverine Lower Perennial" label are mapped.

Harris et al. (1983) reported on fishery habitat distribution, abundance and trends since 1945 for the Charlotte Harbor area, including the "El Jobean" topographic quadrangle that includes the tidal Myakka River upstream to the Charlotte-Sarasota County line. In 1982, this area contained 4,321 acres of mangrove, 1,528 acres of salt marsh, and 894 acres of seagrass beds. Since 1945, mangroves increased in area by 26%, while salt marsh and seagrass decreased by 13% and 45%, respectively. Harris et al. attributed salt marsh losses to urbanization and noted that mangrove increases coincided with a 631 acre decrease (-83%) in unvegetated tidal flats. Because the El Jobean map includes part of the Peace River and upper Charlotte Harbor, data from this study cannot be applied directly to the

Hunter Services, Inc. (1990) provided descriptions of major plant communities and maps of the river reach designated as a Florida Wild and Scenic River, including extensive "saltwater marsh" downstream of Rambler's Rest Resort (river-mile 15) and patches of "freshwater swamp" between Rambler's Rest and the mouth of Deer Prairie Creek (river-mile 13). A patch of sawgrass (*Cladium jamaicense*) was mapped in marshes across the stream from Deer Prairie Creek, apparently the same occurrence of the species mapped by Hussey (1985). Upriver patches of freshwater swamp were mapped near Snook Haven Fish Camp and downstream of Laurel Road.

Estevez et al. (1990) inventoried shorelines of the tidal river in Sarasota and Charlotte Counties, for Sarasota County, using shoreline lengths to classify the condition of the river banks. There are eight miles of shoreline per river mile in the tidal reach because of the extensive edges associated with marshes, islands and tributaries. Hardened shores comprise 12.4% of the total. By length, exotic species are present along more than one-third of tidal river shorelines, with brazilian pepper constituting 93% of the exotic cover, by species.

To recapitulate, the Myakka River corridor has been relatively well described in terms of major plant communities, from State Road 64 in Manatee County downstream to Charlotte Harbor. Below the Park, a hydric hammock with numerous sloughs grades into mesic evergreen hammocks with few sloughs. Downstream of river-mile 25 shoreline marshes become more numerous, larger, and species-rich than upstream, and these are basically freshwater marshes with some bulrush. More species with tidal freshwater marsh affinities occur downstream of river-mile 20. Tidal freshwater marsh is rare and mostly occurs between river-miles 16 (Big Bend) and 14. Tidal marshes occur at and below river-mile 14 (near Rambler's Rest Resort) and extend downriver to the Sarasota-Charlotte County line (west bank) and El Jobean (east bank). Mangroves penetrate upriver from Charlotte Harbor to a point about one mile upstream of U.S. 41. Marine wetlands near the mouths of tributaries contain fresh and brackish-water species, such as sawgrass, which occurs near the mouth of Deer Prairie Creek. Submersed aquatic vegetation is highly zoned in the river downstream of Border Road, with zonal breaks at Snook Haven, Rambler's Rest, and the vicinity of El Jobean. Finally, cypress does not appear to occur naturally anywhere along the river corridor.

Submersed aquatic vegetation (SAV) in the tidal river has been mapped by the National Wetland Inventory, although the only intertidal or subtidal aquatic beds of estuarine or marine character reported for the El Jobean quadrangle were downstream of Cattle Dock Point. Harris et al. (1983) mapped 1945 and 1982 seagrasses in the same area, as mentioned above. The first attempt to map SAV within the tidal river was reported by Hussey (1986), in a dry season characterization performed by Mote Marine Laboratory for Sarasota County. The survey was made during a relatively wet 1986 spring season following a 2 year drought that ended abruptly with a hurricane in 1985. Four SAV zones were recognized within the tidal river. From Snook Haven upstream, dwarf arrowhead (*Saqittaria subulata*) was the dominant species and this reach was defined as "freshwater". Between Snook Haven and Rambler's Rest Resort the dominant species was tape grass (*Vallisneria neotropicalis*) and this reach was designated "low salinity". The tidal river between Rambler's Rest and the El Jobean bridge was dominated by widgeon grass (*Ruppia maritima*) and was defined as "brackish". Shoal grass (*Halodule wrightii*) was dominant in Charlotte Harbor and extended upstream to a point about 1.5 miles above the El Jobean bridge; this "marine" reach therefore overlapped with the brackish reach in the lower part of Myakka Bay. Tributaries often contained species less tolerant of salt than the prevailing conditions at the confluence of the stream and river, as in the case of *Vallisneria* in Deer Prairie Creek.

METHODS

TASK 1--WETLANDS MAPPING

Other Vegetation Classification Systems

In order to develop a wetlands classification system suitable to the needs and scale of the present project, several existing classification systems were evaluated. These included the U.S. Fish and Wildlife Service Wetlands Classification, Sarasota County's system as described in *Apoxsee*, and the Florida Land Cover and Classification System. Each of these was developed to encompass areas much larger and diverse than needed for the present project. As much as possible, the system developed for the present project was designed to be compatible with other systems while still providing the detail necessary to accomplish the task of characterizing the gradation of wetlands in the tidal Myakka River from predominantly freshwater to predominantly estuarine environments.

A brief description of each of the classification systems follows, with an assessment of how each would apply to the Myakka wetland corridor. A description and evaluation of the method developed for this study then follows.

U.S. Fish and Wildlife Service--This structural system was developed to assess and compare habitats throughout the United States. The structure of this classification is hierarchical, progressing from systems and subsystems, at the most general levels, to classes,- subclasses, and dominance types. Figure 2 illustrates the classification structure to the class level. Figure 3 illustrates an application of the classification system to the Myakka River.

The U.S. Fish and Wildlife Service classification system enables comparison of structurally similar systems that may or may not be composed of the same plant species. The main advantage of the system is that comparisons can be made across large geographic areas, and it is applicable throughout the United States. However, the classification is somewhat tedious and difficult to apply to the plant communities of the Myakka River. Assigning some of the species to a class or subclass can be arbitrary, as in the case of mangroves which could be classified as either:

-Class: Scrub-Shrub Wetland, Subclass: Broad-leaved Evergreen, or
-Class: Forested Wetland, Subclass: Broad-leaved Evergreen.

In many cases, mangroves could be either "scrub-shrub wetlands" or "forested wetlands" within the same mapping unit, and the classification depends on the judgment of the mapping, interpreters and field personnel. In addition, the system does not distinguish species of mangroves, which was one of the objectives in the present study.

Another difficulty in using this system for the present study is separating species into Estuarine and Riverine subsystems. There is no *a priori* mechanism for identifying salinity gradients or classifying ubiquitous species. For instance, a species must be identified as either estuarine or riverine, but not both, which can be the case in tidal rivers. Additionally, this system does not distinguish between cattails and bullrush, which have different salinity tolerances.

Sarasota County Apoxsee--Apoxsee (1980, 1990) is the comprehensive land use plan adopted by the Sarasota County Board of County Commissioners. The chapter on the environment provides a descriptive definition and identification system for county habitats. Four major categories apply to the Myakka River system : "Estuarine Edges", "Brackish Bays", "Original Waterways", and "Contiguous Wetlands". These are further defined as follows:

Estuarine Edges-- In this classification, two habitats (mangrove swamps and tidal marshes) are described based on species presence and value of the system.

Brackish Bays--Three habitats (seagrass beds, oyster beds and bay waters) are described based on species presence and value of the system.

Original Waterways-- In this category, the Myakka River is identified as a unique habitat that closely resembles its original waterway condition. The value of the Myakka River is described but no information on wetland plant species or community types is provided.

Contiguous wetlands-- Swamps, marshes and sloughs are identified as specific habitats and described based on species presence and value of the system.

The main difficulties with using the Apoxsee classification system for the present study is that: 1) the classifications are too general and 2) many of the habitats encountered in the Myakka River could easily be classified under more than one category. For instance, there is no provision for classifying the numerous *Acrostichum* spp. (fern) marshes located along the river and this species could easily be considered as "Estuarine Edges", "Original Waterways", or "Contiguous Wetlands". Additionally, with the Sarasota County Apoxsee system, the term "tidal marsh" is too vague to identify salinity effects and changes.

Florida Land Cover and Classification System --This classification was developed to provide a statewide methodology for interpreting and mapping aerial photography and other remotely sensed images (such as Landsat MultiSpectral Scanner data and Landsat Thematic Mapper data). It is arranged in hierarchical levels with each level containing land information of increasing specificity.

The Florida Land Cover and Classification System is perhaps the most complete system for Florida that is based on alpha taxonomy. However, three aspects make it difficult to apply to the needs of this study: 1) the identification of some species was lacking (i.e. Acrostichum spp.), 2) the quantitative estimate of cover is subjectively based on field personnel interpretation and is somewhat arbitrary (as in a case requiring discrimination of 66% cover), and 3) the system divides species between freshwater and saltwater thus making it difficult (or at least somewhat inaccurate) to classify those species with wide ranging salinity tolerances. During reconnaissance, the system was also found difficult to apply to the numerous situations along the River where mixed communities were present and no single species dominated more than 66% of the cover.

A Myakka River Classification System

Field data showed numerous instances where mixed communities were present, particularly in the brackish areas of the river. In these cases, both "freshwater" and "saltwater" species occurred in approximately equal numbers making it difficult to apply any of the classification systems discussed. Since a specific goal of the study is to characterize the gradation of wetlands from predominantly freshwater to predominantly estuarine environments, a classification system using 12 mapping units was developed as follows:

- Open water (for digital closure)
- Red mangrove (Rhizophora mangle) only
- Other mangroves (including mangroves mixed with red mangrove)
- Black needle rush (Juncus roemerianus)
- Leather Fern (Acrostichum spp.)
- Bullrush (Scirpus validus)
- Cattails (Typha spp.)
- Mixed species without cattails and without mangroves
- Mixed species with cattails and without mangroves
- Mixed species with mangroves and without cattails
- Mixed species with mangroves and with cattails
- Other (predominantly uniform stands of other species)

Since it was desirable to characterize the estuarine/freshwater overlap zone as clearly as possible while keeping the number of various "mixed" categories to a minimum, the above four mixed categories were chosen.

Mangroves and cattails were chosen as key indicator species because, when compared to all of the predominant species occurring in the mixed communities, these two species had the least degree of overlap. Cattails are predominantly freshwater species with a minimum of saltwater tolerance (Bear and Zedler, 1987) and mangroves are predominantly estuarine plant species that are quickly outcompeted in freshwater systems (Odum, McIvor and Smith, 1982).

Juncus, bullrush and leather ferns were the other plant species commonly occurring in the Mixed Communities but each of these was found to be wider-ranging along the salinity gradient that was measured during reconnaissance, than either cattails or mangroves. An "Other" category was necessary for the few instances where a single species dominated but, overall, it was not an important single component of the system. Plants occurring in the "Other" category included: Crinum americanum; Cladium jamaicensis; Spartina bakeri and Spartina spp.; Ludwigia peruviana; and Distichlis spicata.

This system accomplishes the specific goal of characterizing the gradation of Myakka River's habitats from predominantly freshwater riverine wetlands to predominantly estuarine wetlands. It is based on dominant species so it can be compared to the other classification schemes, if needed. For instance, if it were desirable to apply the information in this study to another study using a different system it could be accomplished as follows. Red mangroves could be labeled "Estuarine Edges" under the Apoxsee system, labeled "612 Mangrove Swamps" under the Florida Land Use and Cover Classification System or identified as "System: Estuarine, Subsystem: Intertidal, Class: Forested Wetland" (or in some cases, possibly Scrub-Shrub Wetland), "Subclass: Broad-leaved Evergreen, Dominance Type: Red mangrove (Rhizophora mangle)" under the U.S. Fish and Wildlife classification system.

Task 1 Materials and Methods

Black and white 1986 Sarasota County aerial photographs (scale of 1 inch = 200 feet) were obtained from the County Engineering Department. These were taken into the field in December 1987 for verification of plant species. Most wetlands were inspected from the top of a ladder lashed into a 16 foot jon boat. Areas that could not be reached by boat because of low tides were visited on foot. Areas that were not accessible by either method were inspected from a Sarasota County mosquito control helicopter on March 14, 1988, so that all sites were 100% field surveyed.

A second set of aerials were marked by hand using the classification system described earlier. These were digitized on a CADD system by Cadventures, Inc. into three editions depicting combinations of wetland types. CADVentures, Inc. also provided a separate color version of the maps, including shoreline data from Estevez et al. (1990) as a separate product for Sarasota County. Acreage figures reported in this report for each classification unit were provided by CADVenture, Inc., but wetland area data per river mile were calculated manually using a standard grid system. CADVentures, Inc. is presently using digital methods to refine the area per river mile measurements.

TASK 2--BIMONTHLY VEGETATION SURVEY OF THE MYAKKA RIVER

Purpose of Study

The purposes of this task were: 1) to identify seasonal changes occurring within the plant communities along the salt and tide influenced portion of the Myakka River, 2) identify distribution of herbaceous ground cover species in wetlands along the salinity gradient, and 3) to compare current species assemblages with data gathered in earlier studies at the same transects. The task was conducted to determine whether any of these methods were useful as a rapid-survey technique for long-term monitoring, instead of the more complicated and expensive ground-truthing of aerial photographs.

Materials and Methods

Thirty stations established in an earlier study (Estevez, 1985) were chosen for this study to enable comparison of current conditions to the earlier data collected immediately after the drought of 1984 and 1985 Figure 4). Transects deployed at each station were staked in November 1987 and wetland transects were surveyed every-other month to determine the presence of vascular plant species. Note were made on flowering, fruiting, seed-set and senescence. Surveys were made in October and December of 1987 and in February, April, June, and August of 1988. Appendix I provides a sample tally sheet used during sampling.

Sampling commenced on each transect at the shoreline location of the stake and was continued 16 feet (4.6 meters) in each direction along the shoreline and 30 feet (9.1 meters) normal to the shoreline or until upland vegetation was reached, whichever occurred first. Due to the nature of Station #5 West Bank and Station #8 East Bank, a more intensive sampling regime was followed. Notes were made on the identity and reproductive condition of each vascular plant species. Specimens of unknown plants were returned to the Laboratory for identification.

Additionally, submerged aquatic vegetation occurring within 16 feet (4.6 meters) perpendicular to the transect stake and along the shoreline were noted for incidence and vigor according to the point scale shown in Table 2. (A sample data sheet used at each station during sampling is shown in Appendix II). Estimates of vigor were made visually and, where transparency was poor or no submerged vegetation was apparent, the substratum was also sampled by hand or rake. A minimum of three drags along the shore was conducted in these instances. An underwater viewer was also used to assist observation. As in the earlier study (Estevez, 1986), emphasis was placed upon vascular species and attached macroalgal species.

RESULTS

General Wetland Distribution and Abundance

It is helpful to put the study area (tidal river in Sarasota County) in the context of the entire tidal reach. The mouth of the river at Cattle Dock Point is an estuarine beach with mangroves and tropical hammock. Across the river, on Hog Island, mangroves fringe the shoreline and the island interior is a mosaic of herbaceous marshes. Tippecanoe Bay is vegetated by a fringing forest of mangroves, within which freeze damage may be extensive, particularly on the El Jobean side. Myakka Bay has more mangroves on the east and north side than on the south and west side, and mangroves are intermixed with small marshes in and near tributaries to the river.

In Sarasota County, beginning at the county line and proceeding upriver, there are approximately 1,634 acres of tidal wetlands. This estimate includes mangrove forests, marshes, and tributary wetlands but does not include floodplain forest (mesic evergreen hammocks) that may be inundated by occasional tides. Tidal flooding is not extensive in hammocks, even in those which occur as islands surrounded by marsh or open water. Along much of the tidal river, floodplain forest is separated from open water by low levees of natural (storm) origin.

Nearing Big Bend from down-river, tidal wetlands become small and discontinuous patches of brackish and fresh marsh growing in creek mouths, along stretches of collapsed bank, and in oxbows such as Lost Lake, across the river from Snook Haven. Upstream of Snook Haven, floodplain forest dominates the river bank and the influence of tidal action diminishes.

General Wetland Structure

Wetland widths were determined by Siler et al. (1990) for the purpose of calibrating a hydrodynamic river model. Total forest or marsh width at a given river mile (sum of both banks) in the first 15 river miles ranges from nearly zero to 7000 feet. Myakka Bay has little wetland fringe and the increasing width of wetland downstream is primarily mangrove, although most of the lower river is open-water. Upstream of Myakka Bay, wetlands are mostly salt marsh and most of the river is wetland instead of open water. Marsh width increases steadily to a maximum at river mile segment 9.0-10.0. Above this reach, marsh width declines rapidly except for a short expansion between Deer Prairie Creek and Rambler's Rest Resort.

Siler et al. (1990) also determined wetland elevation using photogrammetric data provided by the Southwest Florida Water Management District (Venice Office). Contours and spot-elevations were available on a 0.1 foot basis for fringing and island wetlands. River wetlands in Sarasota County range in mean elevation from -1.1 to -0.7 ft. below the National Geodetic Vertical Datum, with wetlands downstream of U.S. 41 generally situated higher than upstream wetlands.

The areal abundance of wetlands decreases steadily in an upriver direction. Figure 5 illustrates the change in tidal wetland area along the river, for segments of about 1.0 kilometer. The tidal river has 5 wetland conditions, with respect to areal coverage.

(1) From the county line to about U.S. 41, wetlands average 40 acres or more per segment.
(2) From U.S. 41 to near Rambler's Rest Resort, wetlands range from 20 to 40 acres per segment.

(3) The next reach, from Rambler's Rest to Big Bend, is an area where wetland acreage decreases rapidly, to about 10 acres per segment.
(4) Upstream of Big Bend, wetland area averages less than 5 acres per segment, and
(5) Upstream of Snook Haven Fish Camp wetlands comprise less than an acre per segment.

Antecedent Salinity Conditions

Salinity structure of the tidal Myakka river was determined during monthly low-tide surveys made as part of another study by Mote Marine Laboratory, of larval and juvenile fishes (Estevez, Tinsky and Blanchard, in preparation). Because the sensitivity of vegetation to salt varies with respect to the persistence of certain salinities, low-tide data have been compiled for antecedent periods of 24 and 12 months, the immediately preceding dry season, and immediately preceding 3 months (Figure 6).

During the antecedent 24 months the 10 part per thousand (ppt) isohaline was located in Charlotte County waters; the 5 ppt isohaline was about one river mile upstream from the county line, and the 1 ppt isohaline was located between Rambler's Rest Resort and Big Bend. The calendar year 1987 was wetter than 1986, so both the 10 and 5 ppt isohalines were located in Charlotte County and the 1 ppt isohaline was situated near U.S. 41. The dry season (April-June) salinity structure was similar to the average for 1987 as a whole, and the 3 months prior to the survey (October-December) were intermediate.

For low tide salinity, overall, the mean 1 ppt isohaline ranged from U.S. 41 upstream to near Big Bend. Because tidal excursions may transport the salt wedge a mile or so, depending on discharge, the high tide location of the salt wedge may be taken as ranging from Deer Prairie Creek to near Snook Haven.

Distribution and Abundance of Major Wetland Species

Beginning at the Charlotte-Sarasota County line, mangroves are the most conspicuous wetlands near the head of Myakka Bay. Mangroves are more extensive and taller (to 12 meters) near Cattle Dock Point but near the county line the trees are rarely taller than 6 to 7 meters. Mangroves attain this height upriver to near U.S. 41, although freeze damage will reduce canopy height depending on the severity and repetition of freezes.

The trees grow as a fringe around marsh islands in the river, without ever reaching an overwash forest aspect (Lugo and Snedaker, 1974). Likewise, the trees grow along the bank and are wider in creek mouths, but never acquire a fringe, basin, or riverine forest aspect. In Charlotte County, however, fringe and basin forest forms do occur, especially along the shores of Tippecanoe Bay. There is a total of approximately 53.5 acres of mangroves (as pure stands) in the project area. Another 31.1 acres occur where mangroves are mixed together with various marsh species, so mangroves cover about 84.6 acres, or five percent of the tidal wetlands in the project area.

Red mangroves are more common along island edges and creek-banks but nowhere form large monospecific stands (Figure 7). Among pure stands of red mangrove which do occur in Sarasota County, the largest tend to be down river, especially between Tarpon Point and the county line. As a map unit, there are only 22 acres of pure red mangrove in the project area.

The usual upriver limit to red mangrove is set as an island 0.6 miles upstream of the mouth of Deer Prairie Creek (Figure 8). This occurrence is a shrub that is taller than 2 meters after mild winters, or shorter after freezes. It flowers and successfully drops propagules into the surrounding marsh and river. Actually, mangroves, including red mangrove, occur farther upriver as newly rooted recruits growing at and behind marsh edges. For example, we discovered one established red mangrove sapling, by size and branching at least two years rooted, as far upriver as river mile 14.9 (or 0.7 miles upriver of Rambler's Rest Resort). It occurred on the north/east shore at the upper end of a small embayment, under dense canopy. This plant was monitored for two years, including one winter, before it was apparently destroyed by grazing cattle.

Black and white mangroves, and buttonwood, are much more abundant in Charlotte than Sarasota County, and decrease in occurrence and size upriver. The largest stands of these species grow on islands from the county line upstream to Big Slough. Black mangroves tend to grow toward the interior of large stands, and are separated from open water by fringes of white mangrove or salt marsh, most commonly black needle rush.

Juncus roemerianus is the most common wetland species in the tidal river. It occurs in broad marshes near the county line, as islands and mainlaind fringe upriver to U.S. 41, and as broad mainland fringes upriver of U.S. 41 to Rambler's Rest Resort. Upstream of Rambler's Rest, Juncus occurs as "pocket marsh", lining small bights. As monospecific marsh it covers 732 acres, or about 38% of all wetland in the study area. All of it collected together would nearly cover upper Myakka Lake.

The upriver limit of Juncus marsh occurs near river mile 14.7, or 0.5 miles upstream of Rambler's Rest Resort (Figure 9). This pocket marsh grows on the western bank of the river, three bends downstream of Big Bend. From this point through Big Bend, other pocket marshes are smaller in area and vegetated by tidal freshwater species. Thus, the upriver penetration of Juncus into potential marsh habitat appears to be more complete than the penetration of mangroves into potential forest habitat. Individual specimens of Juncus may be found farther upriver toward Snook Haven Fish Camp but none is organized into marsh systems.

In general, Juncus marshes appear to be dissected more by distributaries and braided channels as one proceeds upriver.

Scirpus validus, or bulrush, is an evanescent species in the tidal Myakka River, occurring farther downstream during periods of high river discharge (low salinity) and retreating upriver during drier periods. Following the drought of 1984-85, bulrush downstream of U.S. 41 was highly reduced in area and vigor. In many places where it was known to occur, only dead tissue could be found above-ground.

Based upon the results of this survey, Scirpus covered 19.8 acres, or about one percent of total wetland area. It was found growing as marsh fringe and also in larger patches within the interior of upriver marshes, especially upriver of Rambler's Rest Resort. Patches of bulrush were found from the county line upstream to Snook Haven Fish Camp. Clewell et al. (1990) found it farther upriver, beginning at their station 35 (transect 4-1 of their survey). Reasons for the disjunct distribution (e.g., lack of bulrush between their station 35 and Snook Haven) are not apparent and may be an artifact of point-sampling.

Geographically, Big Slough and the tidal Myakkahatchee Creek contained the highest number of neighboring patches (Figure 10), and the river near the mouth of Deer Prairie Creek contained the second highest collection of bulrush patches. On the other hand, the largest contiguous bulrush marshes occur along meanders immediately downriver of Big Bend.

Some of the areas that contained bulrush prior to the drought have apparently converted to cattail (Typha). Cattail is known to have a mild tolerance to brackish water and it has gained a foot-hold on downriver flats once occupied by bulrush. Bulrush on the wood stork rookery near Big Slough, and other bulrush between Warm Mineral Springs and Deer Prairie Creek, are sites of recent cattail invasion.

In pure stands, cattail amounts to 7.4 acres in the study area but it is highly intermixed with other rarer wetland species, so taken together cattails occupy all or part of about 12.1 acres. Cattail is most common in tributaries and in the river between Deer Prairie Creek and Big Bend, although it continues upriver to the limit of the study area near the I-75 bridge and beyond (Clewell et al., 1990).

Leather fern does not occur extensively as it does in other tidal rivers (such as the Caloosahatchee) but it is present throughout the study area. It grows mostly as individual plants or patches of plants along or just within marsh shorelines. It often grows on accumulations of marsh wrack or levees of low relief. It occurs upriver as far as the upstream side of the hair-pin turn at Snook Haven[1], but only as individual plants.

Wetland Plant Associations

About 47 acres, or 2 percent, of the tidal wetlands in the study area occur as mixtures of two or more species. As mentioned in Methods, these were divided into four categories according to the presence or absence of cattails and mangroves. Obviously, a mixed marsh lacking both was comprised of "other" species (*Crinum americanum*; *Cladium jamaicensis*; *Spartina bakeri* and *Spartina* spp.; *Ludwigia peruviana*; and *Distichlis spicata*). One with cattails but without mangroves reflected lower salinity conditions than one without cattails but with mangroves. Thus, categories of "other" and "mixed without cattails or mangroves" indicated wetlands of a tidal, freshwater nature.

[1] Although this range can be extended to just above the I-75 bridge, based on a single sighting by Clewell et al., 1990.

There were only about 12.5 acres of wetland that could be identified as tidal freshwater on the basis of their species composition. Slightly more than 80% of it occurred upstream of U.S. 41 and the largest contiguous patches of tidal freshwater wetland were found upstream of Deer Prairie Creek, to near Snook Haven Fish Camp (Figure 11). The distribution of tidal freshwater wetland so identified extends downstream farther than the main-stem location of the salt-wedge because of local influences of Big Slough and minor drainages. Likewise, all wetland upstream of the salt-wedge's main-stem location may be considered tidal, freshwater in estuarine position and function. The reason such marshes are mostly Juncus instead of other species is that recurring periods of extended drought tend to limit the development of tidal, freshwater plant communities.

SAV Distribution

Distributions of submerged aquatic vegetation were determined during bimonthly transect visits rather than by the once-only photo-interpretation of aerial photographs, because the ground-truthing was a rapid survey method for emergent wetlands and aerial photography typically understates the distribution and abundance of SAV in highly colored tidal rivers. Results of SAV mapping are described here irrespective of season, except as noted.

Halodule wrightii was not present in the study area during the survey period but occurs farther downstream, from the river mouth to just downstream of the county line, as described by Hussey (1986). The first submerged aquatic species encountered upstream of the county line was Ruppia maritima (widgeon grass). Based upon a year of bimonthly surveys, widgeon grass was found along a 6.8 mile reach from river mile 7.1 upriver to river mile 13.9, or approximately the county line to Rambler's Rest Resort (Figure 12). It was not found at stations 17-19 or 30, however.

Ruppia is an opportunistic colonizer of available substratum and exhibits seasonal variability in its presence or luxuriance depending on salinity. During the period of this study it was present at downstream stations on each bimonthly visit except August, and at the upstream end of its range was present only in June. Between these river extremes, widgeon grass was variably present in the winter and spring, mostly as a narrow fringing bed located in the low intertidal zone.

Tape grass (Vallisneria neotropicalis) covered a 6.7 mile reach of the tidal river, distributed almost as widely as Ruppia. Tape grass was located farther upstream than widgeon grass, between river miles 10.2 and 16.9, or approximately from Warm Mineral Springs upriver to a point near Snook Haven (Figure 13). Over the survey year, tape grass was found at every station between these extremes, and also in Deer Prairie Creek.

Whereas *Ruppia* is tolerant of low salinity, *Vallisneria* tends to be limited in its downstream distribution by brackish water. Despite this sensitivity, tape grass was found during each visit near its down-river limit --a condition which may be the local effect of discharges from Deer Prairie Creek and Warm Mineral Springs. Another difference noted between the two species was the tendency of tape grass to grow along shorelines, like widgeon grass, but also to grow as dense, contiguous beds on sand bars and on shallow, level bottoms within the river. This growth-form was best developed near Rambler's Rest Resort, in the vicinity of day beacons. Propeller cuts were seen across these beds.

Dwarf arrowhead (*Sagittaria subulata*) occurs farther upstream in the tidal river than tape grass. Its range begins between Warm Mineral Springs and U.S. 41 and it was found at 11 of 19 stations, to the upriver limit of the surveys --Interstate 75 (Figure 14). Clewell et al. (1990) reported this species near the entrance of Curry Creek but at no stations farther upriver toward the Park. *Sagittaria* resembles Ruppia in habitat preference, growing as a narrow intertidal band, especially along undercut banks.

Some SAV species were observed rarely, such as *Hydrilla* and *Utricularia*, but the only other species that covered a significant river reach (4.8 miles) was *Ceratophyllum demersum*, or coontail. Coontail is a highly variable, entirely submersed plant without roots, and may grow so densely in Florida waters as to be regarded a weed. It occurs in the tidal river within the range of tape grass, from river mile 11.8 to 16.6, or from Deer Prairie Creek to a point upstream of Big Bend (Figure 15). Within this reach it was absent at more stations than it was present and no seasonality was apparent.

Taken as a group, submerged aquatic vegetation occurred at every station from the county line upriver to Station 5, just below Interstate 75, except that none was ever seen at Station 30 (Tarpon Point). As mentioned previously, *Halodule wrightii* grows in the Charlotte County reach of the river so SAV habitat may be taken as all shallows within the entire tidal river downstream of the Interstate 75 bridge, with particular species composition depending upon recent salinity patterns. The river reach between Deer Prairie Creek and Rambler's Rest Resort contained the highest SAV species diversity.

Floristics

A total of 55 vascular wetland species from 29 plant families were identified during the year (Table 3). An additional four drift species (non-rooted vascular plants) were not included in the analysis but occurred throughout the study area: Lemna spp.; Salvinia caroliniana; Pistia stratioles; and Eichornia crassipes.

Species varied considerably in apparent salinity tolerance, ranging from occurrence in only freshwater locations (Spartina bakeri, Panicum hemitomon, Eleocharis baldwinii, Aster caroliniensis, Mikania scandens) to occurrence in only saline influenced areas (Rhizophora mangle, Laguncularia racemosa, Avicennia qerminans). A number of euryhaline species occurred throughout most of the study area (Acrostichum, Crinum americanum, Hydrocotyle umbellata, Micranthemum glomeratum) while Juncus roemerianus, Vallisneria neotropicalis and Ruppia maritima occur up to nearly freshwater areas.

A few species (Bacopa spp., Micranthemum gloemeratum and Hydrocotyle umbellata) occurred throughout most of the study area but were somewhat ephemeral, appearing during drier seasons and apparently washed away during floods. Salinity may play a role in their occurrence although several plants of each species were found growing in washed up seaweed wrack at some of the downstream, high salinity stations.

Wetland species richness increased significantly with river mile distance, upstream (Figure 16). Species number is lowest near Tarpon Point but upstream from there the trend in richness is upward, with an average doubling in species number in 9 to 10 river miles. This trend can also be described as an increase of one vascular plant species per river mile, on the average. Based on the frequency-distribution of species numbers, the tidal river can be divided into overlapping low (<10 species), moderate (11-20 species) and high (>20 species) diversity zones. The low diversity reach corresponds with the mangrove-vegetated part of the river. The high diversity reach begins in the tidal freshwater wetlands near Big Bend and continues upriver, and the river between Tarpon Point and the Interstate is moderately diverse.

Species richness also varied through time (Table 4). At six of 9 selected stations, there were more wetland species in August 1988 than in August 1985. The increase in species richness at most compared stations is due in part to high waters in 1985, but also due to the inhibiting effects of high salinity that persisted in the tidal river for 18 months of antecedent drought. In general, the current study followed a year of relatively heavy fresh water influence and more species with fresh water affinities were therefore represented.

It is noteworthy that species richness at each station was significantly greater (by factors of 2 to 3 times) on an annual basis than for a single survey period. The previous study was conducted only once whereas bimonthly sampling for this study was able to detect herbaceous annuals and cryptic species.

On the other hand, mean species richness per station did not display seasonality (Table 5). The facts that total species richness increased in an upriver direction and also over a period of 3 years suggested that a trend would also exist in mean species richness per station, but the finding otherwise leads us to conclude that each river reach contains a base-line number of perennial species and ecological space for annual species that occupy sites opportunistically. This interpretation applies not only for all stations, but also for the "high diversity" stations in upriver areas (Table 5).

For all main-stem survey sites, mean species richness per station tended downward from 8.7 species in October 1987 to 5.8 in August 1988, whereas the same index tended upward in the high diversity stations, from 10.0 to 13.3 species per station, from October 1987 to June 1988, respectively. August 1988 had a down-turn to 6.9 species per station in the high diversity area that tracked a similar year-end down-turn for all stations. This result implies that there was no one season that best represented river-wide wetland species richness.

36 Month Changes in Species Ranges

Hussey (1985) identified 72 plant species in her shoreline survey from Cattle Dock Point to Border Road. Many of these species occurred exclusively in Charlotte County or were part of terrestrial plant communities along the river in both counties. Other species were rare occurrences, and some had distributional end-points outside of the river reach between the Charlotte County line and the Interstate 75 bridge. Taking these constraints into consideration, meaningful comparisons between August 1985 and August 1988 can only be made as follows:

Upstream limit only: Juncus and Rhizophora

Downstream limit only: Crinum, Typha and Hypericum

Both limits: Acrostichum, Scirpus and Spartina bakeri

These species fell into separate classes of change. Rhizophora and Typha exhibited no change insofar as the common limits between the two periods were known. Three species, Juncus, Hypericum and Spartina bakeri, contracted in range between surveys. Crinum expanded its range with a 1.6 mile down-river extension. Finally, two species shifted their ranges: Acrostichum shifted approximately a mile upriver and Scirpus shifted about 2 miles down-river, with a concomitant expansion of 0.5 miles.

Range changes occurred among indicators of all three salinity conditions without consistency. The river freshened after the drought characterized by Hussey (1985) and we expected more evidence for reduced salinity among indicator species' ranges. Typha did not change although Scirpus moved down-river, but Acrostichum moved up-river. Crinum expanded in range as would be expected but Hypericum and Spartina bakeri contracted in range.

These patterns were only confused more when 1985 ranges were compared to the combined ranges during the 1987-88 study period. High water conditions mentioned earlier are not believed to explain the results because these indicators are common, tall emergent species, and for the same reason taxonomic skill is not in question. Stations were relocated with accuracy through the use of common field crews and project notes, so ranges are accepted as reported.

Total species richness per station changed as expected with relaxation of drought conditions (Table 4) but the absence of seasonality (Table 5) or coherent changes in the ranges of dominant species (Table 6) indicate that rarer species, especially herbaceous ground-covers and annuals, play an important role in depicting wetland response to salinity. These results also point to spatial and temporal averaging within tidal river wetlands, on the order of miles and years, respectively. We conclude that wetland monitoring may have a noise-to-signal ratio that is too large for periods of short duration but that a continuing trend in wetland composition or distribution could denote significant salinity-related impacts.

DISCUSSION

The correspondence of wetland features to salinity and other structural gradients in the tidal Myakka River is most apparent at large scales of analysis. The width of mangrove forests and tidal marshes decreases in proportion to salinity, eventually pinching out near Big Bend. Mangroves dominate the lower river, salt marshes occupy a wide central reach, and tidal freshwater marshes are compactly situated upstream of the salt marshes. Most of the tidal freshwater marsh (mapped in this project as "other" or "mixed without cattails or mangroves") occurs in tributaries and immediately downstream of big Bend. Wetland species richness also increased in proportion to the relative amount of freshwater, so that on average, one new species is added with each upriver mile. The river reach from near Big Bend to the Interstate had the highest diversity, usually averaging 10 or more species per station. Finally, species richness was seen to increase during the three years following a major drought. Over the large time scale of a year (relative to a bimonthly survey frequency) many more plant species were encountered.

Pattern and trend in wetland features are more difficult to discern at smaller scale. Geographically, range limits of several salinity indicator species varied incoherently with respect to salinity between and within years. Overlap was generally large between plant communities and individual species, including submerged aquatic plants. Even the range of red mangrove, for which the upriver limit is generally regarded as rigid, was shown to be more widespread because rooted propagules were found miles upriver from the last conspicuous plants. Temporally, mean species richness per station drifted within a broad range (+/- fifty percent of means) and did not tend meaningfully, even for the species-rich "high diversity" reach of the river.

The correspondence of many wetland features with a strong salinity gradient illustrates the large role that salinity plays in organizing the tidal river. On the one hand, it is necessary to recognize the co-occurrence with salinity of other physical factors that also affect wetlands, namely elevation, bathymetry, current speed, tidal range, and sediment type. It is not yet possible to decompose wetland features according to the relative influence of each, and in this sense, river salinity is taken instead as a register of their affects. All, including salinity, are ultimately the consequence of river discharge.

On the other hand, a number of processes operate to smooth the individual and combined effects of these structuring forces. One paramount factor is the variability of river discharge. Such variability generates an averaging force and induces lag effects with respect to salinity, current speed, sediment type, etc. These integrating and lagging influences then are translated to the wetland ecosystem which contains its own response characteristics. The net effect is that physical and chemical controls are manifest in biological features with greater clarity at large scale, than small.

In this and the preceding set of wetland studies made by Mote Marine Laboratory, a number of provisional "zones" were recognized for discrete parameters. Hussey (1985) defined shoreline types for the entire tidal river, using terrestrial species as well as wetlands. That report divided wetlands into mangroves, salt marsh, brackish marsh, fresh water marsh, and fresh water forest. Estevez et al . (1990) divided the river according to shoreline hardening and the extent to which exotic species had invaded wetlands. Here, we recognize a number of plant associations and map each with respect to river location and salinity. We have also divided the river according to wetland width and also by the ranges of wetland and submerged aquatic species. Lastly, zones of species richness have been recognized.

These efforts have demonstrated that (1) the very strong gradient in salinity along the tidal river is associated with strong gradients in wetland structure; (2) tributaries and the river near their mouths are affected by local inputs of fresh water; (3) although every part of the river is transitional in some respect, the reach upstream of U.S. 41 is distinguished by many significant wetland transitions; (4) the tidal freshwater wetlands of the river coincide with the reach upstream of U.S. 41 on a functional basis and coincide with the reach between Ramblers' Rest Resort and Big Bend on a structural (floristic) basis; and (5) there only about 2.5 square miles of wetland in the tidal river, with tidal freshwater marsh constituting a precariously small amount thereof.

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[2] Eg., the river is often fresh water downstream to that point.

The Big Bend area of the river has been mentioned many times in this report. The Big Bend is part of the most downstream meander system in the Myakka River and, as described earlier, has already been recognized as a transitional area with respect to river soils (Soil Conservation Service, 1959) and structural wetland types (National Wetland Inventory (1979). The soil survey depicts the Big Bend area as the transition from "sandy alluvial" to "tidal marsh" soils and the same area is the only place on the river where the National Wetland Inventory mapped contiguous patches of "palustrine-emergent-narrow leaved persistent-semipermanent tidal"wetlands. The wetland classification refers to tidal freshwater marsh.

Sandy alluvium was a miscellaneous soil type in 1959, composed of mixed alluvium [sediment deposited by flowing water], made mostly of sand and some clay. Its characteristics change with each flooding as a result of scouring and deposition, and its drainage is variable. Tidal marsh soil occupies level wet positions slightly above sea level, and commonly occurs in narrow strips adjacent to tidal swamp and along streams. It is covered or affected by salt or brackish water, during high tide. Tidal marsh soil contains a large amount of organic material and is very poorly drained (Soil Conservation Service, 1959). Sandy alluvium extends down-river from the Park and pinches out just below Big Bend, at a point where tidal marsh soil begins and then extends farther down-river (Figure 17).

Figure 6 depicts low tide, surface salinity at Big Bend for 1987 and 1988. The mean salinity for that period was 1.03 ppt (+/- 2.19), in a range of 0.02 to 9.60 ppt. Data provided by Susan Lowrey (Sarasota County Office of Environmental Monitoring) for surface salinity at high tide during 1989 were used to calculate a mean of 1.42 ppt (+/- 3.38) in a range of 0.1 to 11.1 ppt. From these results it may be said that Big Bend salinity ranged from fresh water to about 10 ppt and averaged less than 1.5 ppt, irrespective of tide. It was near this location that past mapping efforts reported the transition of soils and presence of tidal fresh water marsh, and this is the same reach identified in this report as the terminus of tidal marsh and zone of most tidal fresh water marsh.

Physical factors responsible for soil, salinity and wetland characteristics near Big Bend may operate in a similar fashion within other tidal rivers on the coastal plain, at least on the west coast of peninsular Florida. A transition from sandy alluvial to tidal marsh soil occurs in the Braden, Manatee, Little Manatee, and Alafia Rivers, and in Double Branch

Creek in upper Old Tampa Bay. Tidal stage effects occur at each point of transition. With assistance from Michael S. Flannery (Southwest Florida Water Management District) we have established that the mean, high tide, surface salinity of a sampling site in the Little Manatee River, near the point of soil transition, was 1.41 ppt (+/- 2.05), in a range of 0.7 to 8.18 ppt (N=36). The mean for the Little Manatee River was not significantly different ($p<0.05$) than the mean salinity of the Myakka River at Big Bend, under comparable tides.

The general applicability of this discovery is being tested and, if bourne valid by studies in other local rivers, means that tides, discharge, bathymetry, storm-effects, and other physical and chemical factors combine to create a tangible marker (eg., soils) of their integrated effects, which is in turn meaningfully correlated with long-term salinity and wetland features in the river. The immediate value of this possibility is the guidance it provides for long-term monitoring. In a broader application, it may also be useful in restoring rivers affected by impoundments, diversions, or flood control projects.

Implications for Altered Discharges and Salinity

At issue is the possible effect upon wetlands of a change in discharge associated with the development of water resources on the T. Mabry Carlton Reserve. Such development has the potential to alter the amount, location and quality of river discharge. Specific development plans have not yet been developed, so the general effect of simple flow reduction is evaluated here because activities on the Reserve may reduce runoff and diversion of river water has also been considered.

Long-term meteorological trends notwithstanding, discharge has been increased by development in the basin and by diking of the Tatum Sawgrass area (Hammett et al., 1978). During the same period, the Blackburn Canal (to Curry Creek) has diverted an estimated 10 percent of peak flow to the Gulf of Mexico and in-stream impoundments in the river and tributaries have had an unknown but probably subtractive effect. If these changes mitigate one another the discharge (and salinity) history of the river may be similar to natural conditions or at least not a history of wetter conditions.

Depending upon the specific manner in which discharge is reduced, and also upon tides and river geometry, salt will penetrate farther upriver. Based on studies in other Florida rivers, the effect will be non-linear. In other words, a given upstream movement of the salt wedge will not necessarily correspond to similar upstream movements of other isohalines (lines of equal salinity). To simplify this analysis we assume the shift in river salinity will be linear.

It is evident from Figure 5 that tidal wetland area decreases with upriver position, eventually pinching out among tidal fresh water marshes near Big Bend. If the average salinity conditions at Ramblers' Rest Resort were shifted less than 2.0 miles upstream, the largest main-stem association of tidal fresh water marshes would be eliminated. Tidal fresh water marsh could not migrate upriver because of habitat limitations (eg., lack of suitable soils) at least until floodplain forest deteriorated to the point that its sediments were redistributed by storms (Begin, 1990; DeLaune et al., 1987).

Salt marsh will grow in reaches where tidal fresh water marsh have been displaced, although the potential for cattail and brazilian pepper invasion is high. The predominantly freshwater species, Typha latifolia, now occurs between Deer Prairie Creek and Big Bend but continues upriver to the Interstate. Near Deer Prairie Creek it already tolerates average low tide salinity as high as 3.0 ppt. In other areas, it has been reported that Typha spp. occur in higher salinity areas (and can become a problem) following alterations in stream flow. Laboratory experiments have shown that older, rhizome-bearing plants are salt tolerant although seeds and seedlings are extremely salt sensitive (Beare and Zedler, 1987).

Along the Myakka River (particularly the downriver portions), cattails primarily occurred along the mouths of the numerous creeklets, due to the input of sediments, fresh water and nutrients. It has been well-documented that cattails proliferate and become a nuisance in nutrient-enriched conditions (Linde et al., 1976). Currently the watershed of the Myakka River is relatively pristine and cattails are not extensive (only 12.1 acres). However, alterations to streamflow, changes in salinity or increased nutrient inputs could change this balance over a much larger river area because cattail is so opportunistic (Bellis and Gaither, 1985; Davis et al., 1985).

Mangrove will continue invading upriver areas but permanent colonization of salt marsh will probably be constrained by low temperatures. Other constraints on the expansion of mangrove range include net downstream export during summer months and depredations of wood-boring animals. One borer, the isopod Sphaeroma terebrans, is already distributed throughout the river in mangroves and Blanchard (1986) reported the first known instance of its occurrence in black needle rush, cattail, bulrush and leather fern between Big Slough and Deer Prairie Creek. Juvenile borers were also seen to this point but not beyond. Sphaeroma reproduction and increased attack occurs in salinity greater than 4.0 to 8.0 ppt (John, 1968), and flow reductions that move the 4.0 ppt isohaline from its present location (between the county line and Tarpon Point on low tides: Figure 5) may accelerate borer damage to tidal marshes as well as mangroves, with unknown consequences to wetland succession and ecosystem function.

In the final analysis, it will be necessary to evaluate the discharge and salinity effects of specific hydrologic changes proposed for the Carlton Reserve. This will be possible using a hydrodynamic model of the Myakka River produced by Siler et al., (1990), with certain improvements planned for 1991. Input from Sarasota County will be needed on proposed changes to river discharge at the upstream and downstream ends of the Reserve, and also proposed changes in the discharge of Deer Prairie Creek. Once the change in salinity has been quantified, reach-specific impacts to wetlands can be evaluated.

Sea Level Rise

Sea level has been rising at a rate of approximately 2.2 mm per year along the Florida west coast (Hicks, 1978), or about one foot since the General Land Office Survey of the Myakka River area in the 1840s. This rise may be responsible in part for the 4.3 mile migration upstream of mangroves reported by Wharton (1985). If the useful life of water development projects on the Myakka River is only 50 years, sea level may be expected to rise another 4 inches at current, measured rates. A four inch rise in mean sea level is within the range of sediment accumulation by coastal wetlands, assuming sediment supplies are not disrupted (Hatton et al., 1983). However, it is not yet possible to forecast the effects on river salinity of a four inch sea level rise, except to state that salt will penetrate farther upriver than present. In this respect, sea level rise mimics the effect of flow reduction, and flow reduction will aggravate the effects of rising sea level.

Because of global warming (National Research Council, 1983) sea level is expected to rise at greater rates than historically measured. Recent projections converge on a rate of about 10 mm per year, or slightly more than three feet per century. The time-step of this change is not well known as of 1990, but an average rate of sea level rise near 10 mm per year is very close to the maximum measured rates of wetland sedimentation (Orson et al., 1985). Unless sediment sources were augmented, there is a very real possibility that accelerated sea level rise will cause tidal wetlands to drown in place (Titus, 1988), converting to open water.

In the Myakka River, accelerated sea level rise would translate into a widespread loss of tidal wetlands as far upstream as Big Bend. Furthermore, salinity intrusion into the river and coastal aquifer will be severe. During periods of low flow, a characteristic of the Myakka River (Hughes, 1981), salt could extend as far upriver as Rocky Ford on a recurring basis. Such a major intrusion of salt would have profound effects upon the floodplain forest (Clewell et al., 1990; DeLaune et al., 1987) and all of these effects would be compounded if discharge was significantly reduced by impoundments or diversions.

Monitoring

Several recommendations for long-term monitoring of the tidal Myakka River may be made on the basis of this study.

1. First and foremost, a permanent salinity (conductivity) recorder should be installed near Ramblers' Rest Resort to monitor variations in surface and bottom salinity, because the river reach upstream of the Resort, to Big Bend, harbors tidal freshwater marshes.

2. Ground-truthing of aerial photography should be performed for the entire tidal river downstream of the Reserve, on a recurring five year basis. This frequency will permit identification of permanent and significant trends.

3. Site-intensive field monitoring should be limited to the river reach between U.S. 41 and Big Bend, using the transect methods described here plus general surveys. Emphasis should be placed on the distribution and abundance of (a) mangroves (b) submerged aquatic vegetation, and (c) brazilian pepper, cattails, and other problem species.

4. The areal location and size of major beds of submerged aquatic vegetation should be mapped into the GIS data-base for the tidal Myakka River.

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Table 1. River-mile locations of wetland stations (#) and major river features.

Feature	Location
Cattle Dock Point	0.0
El Jobean bridge	2.6
#36	7.1
Charlotte-Sarasota County line	7.5
#35	7.7
#34	8.2
#32	8.8
#30	9.3
Big Slough	9.3
#29	10.2
#28	10.2
#27	10.6
Warm Mineral Springs	10.7
#26	10.8
#25	11.1
U.S. 41 bridge	11.3
#24	11.8
Deer Prairie Creek	12.1
#21	12.2
#20	12.7
#19	13.0
#18	13.4

Table 1, continued. River-mile locations of wetland stations (#) and major river features.

#17	13.7
#16	13.9
#15	14.2
Rambler's Rest Resort	14.2
#14	14.4
#13	14.8
#12	15.1
#11	15.6
#10	16.2
Big Bend	16.2
#9	16.6
#8	16.9
Snook Haven campground	17.8
#7	17.9
#6	18.1
#5	18.8
Interstate 75	19.6
Border Road (Blackburn Bridge)	21.1
Power lines	22.8
Downs' Dam	28.6
Deep Hole	32.0
Park gaging station	35.8

Table 2. Point system used in evaluating incidence and vigor of submerged aquatic vegetation.

Incidence

Condition	Point Score
Absent	0
Sparse	1
Occasional	2
Patchy	3
Mostly Continuous	4
Continuous	5

Vigor

Condition	Point Score
Old (Poor)	1
New Shoots/Blades	2
Moderate	3
Healthy	4
Luxuriant	5

Table 3. Master list of wetland plant species and species with wetland affinities, in the tidal Myakka River, Sarasota County, Florida.

Acrostichum sp.
Alternanthera philoxeroides
Amaranthus floridanus
Aster caroliniensis
Avicennia germinans

Baccharis halimifolia
Bacopa caroliniana
Bacopa monnieri

Ceratophyllum demersum
Ceratopteris pteridoides
Chara
Cladium jamaicensis
Conocarpus erectus
Coreopsis sp.
Crinum americanum

Dichromena sp.
Distichlis spicata

Eleocharis baldwinii
Eleocharis cellulosa

Hydrilla verticillata
Hydrocotyle umbellata
Hygrophila polysperma?
Hypericum fasciculatum

Iris sp.
Iva frutescens

Juncus effusus
Juncus roemerianus

Table 3, continued. Master list of wetland plant species and species with wetland affinities, in the tidal Myakka River, Sarasota County, Florida.

Laguncularia racemosa
Ludwigia repens
Ludwigia peruviana

Micranthemum glomeratum
Mikania scandens

Osmunda regalis

Panicum spp.
Panicum hemitomon
Paspalum sp.
Polygonum punctatum
Pontederia lanceolata
Proserpinaca pectinata

Rhizophora mangle
Rhyncospora tracyi
Ruppia maritima

Sagittaria graminea
Sagittaria lancifolia
Sagittaria latifolia
Sagittaria subulata
Samolus ebracteatus
Scirpus validus
Spartina alterniflora
Spartina bakeri
Spartina patens

Typha latifolia

Utricularia sp.

Vallisneria neotropicalis
Vigna luteola

Table 4. Comparison of species richness at selected stations, adapted from Hussey, 1985 (1) and this study (2).

Zone of Low Diversity

Station	River Mile	Species Number 9-85[1]	8-88[2]	87-88[2]
34	8.2	3	4	8
28	10.2	5	4	8
21	12.2	2	3	7

Zone of Moderate Diversity

Station	River Mile	Species Number 9-85[1]	8-88[2]	87-88[2]
16	13.9	6	5	12
10	16.2	4	7	17
6	18.1	3	6	15

Zone of High Diversity

Station	River Mile	Species Number 9-85[1]	8-88[2]	87-88[2]
11	15.6	9	5	22
8	16.9	2	8	25
5	18.8	4	7	26

Table 5. Mean species richness (number of species) per station for all main-stem stations and for "high diversity" stations (Nos. 5 through 11).

All Main-Stem Stations

	10-87	12-87	2-88	4-88	6-88	8-88
Mean	8.7	8.2	7.9	7.3	7.7	5.8
S.D.	3.6	2.7	4.0	2.8	4.2	2.1

High Diversity Stations

	10-87	12-87	2-88	4-88	6-88	8-88
Mean	10.0	11.0	11.3	10.0	13.3	6.9
S.D.	4.7	2.3	4.5	3.1	3.4	1.1

Table 6. Comparison of range limits for selected wetland species, adapted from Hussey (1985) and this study. Dates of comparison are August 1985 and August 1988.

	River mile translation in location of	
	Upstream limit	Downstream limit
Saltwater		
Juncus	-0.4	NA
Rhizophora	-0-	NA
Transitional		
Acrostichum	+0.9	+1.1
Scirpus	-1.7	-2.3
Typha	NA	-0-
Freshwater		
Crinum	NA	-1.6
Hypericum	NA	+1.3
S. bakeri	-0.4	+1.4

NA: not applicable
A positive (+) change is upstream.

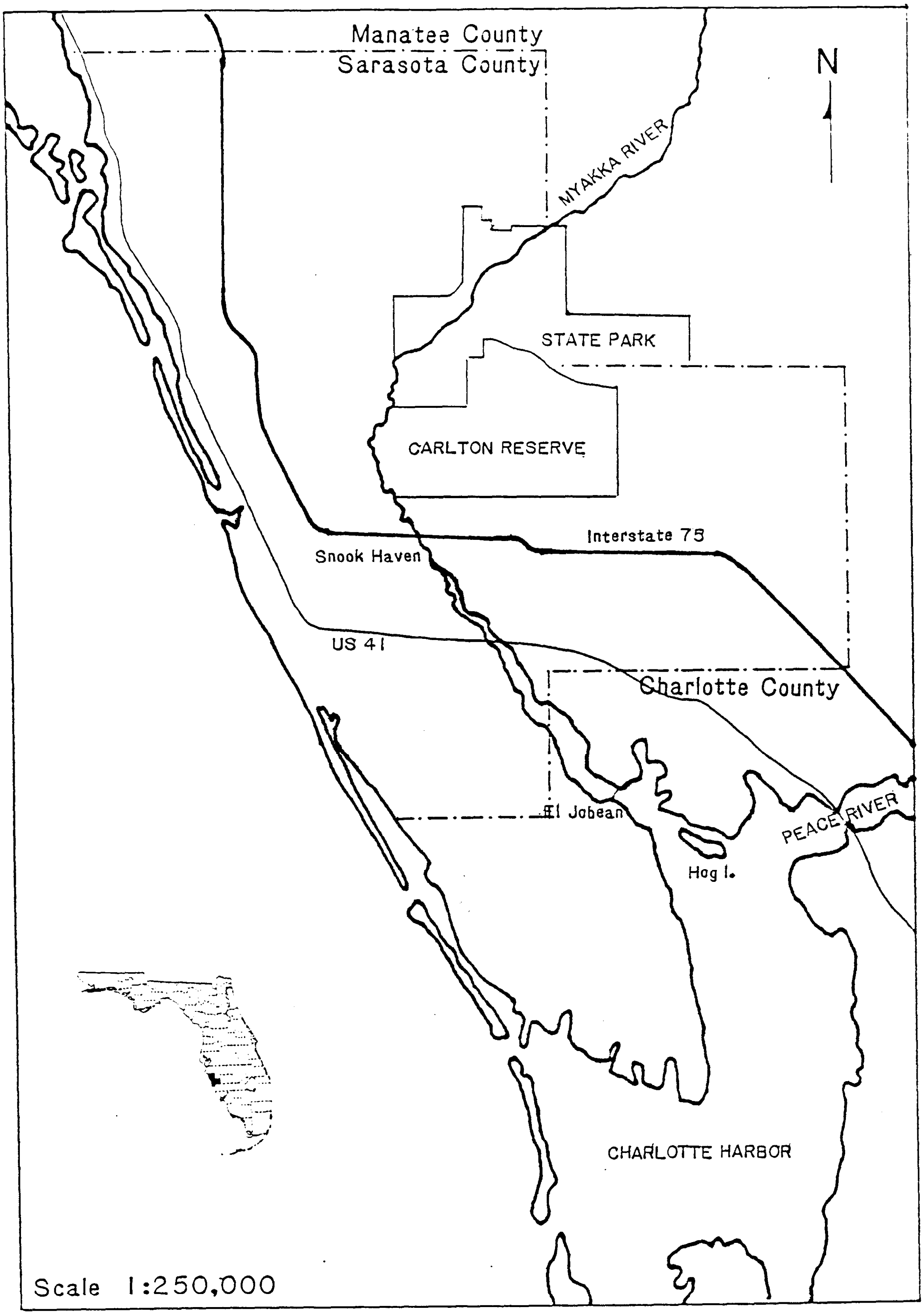

Figure 1. Location of the tidal Myakka River. The study area falls between Interstate 75 and the Sarasota-Charlotte County line.

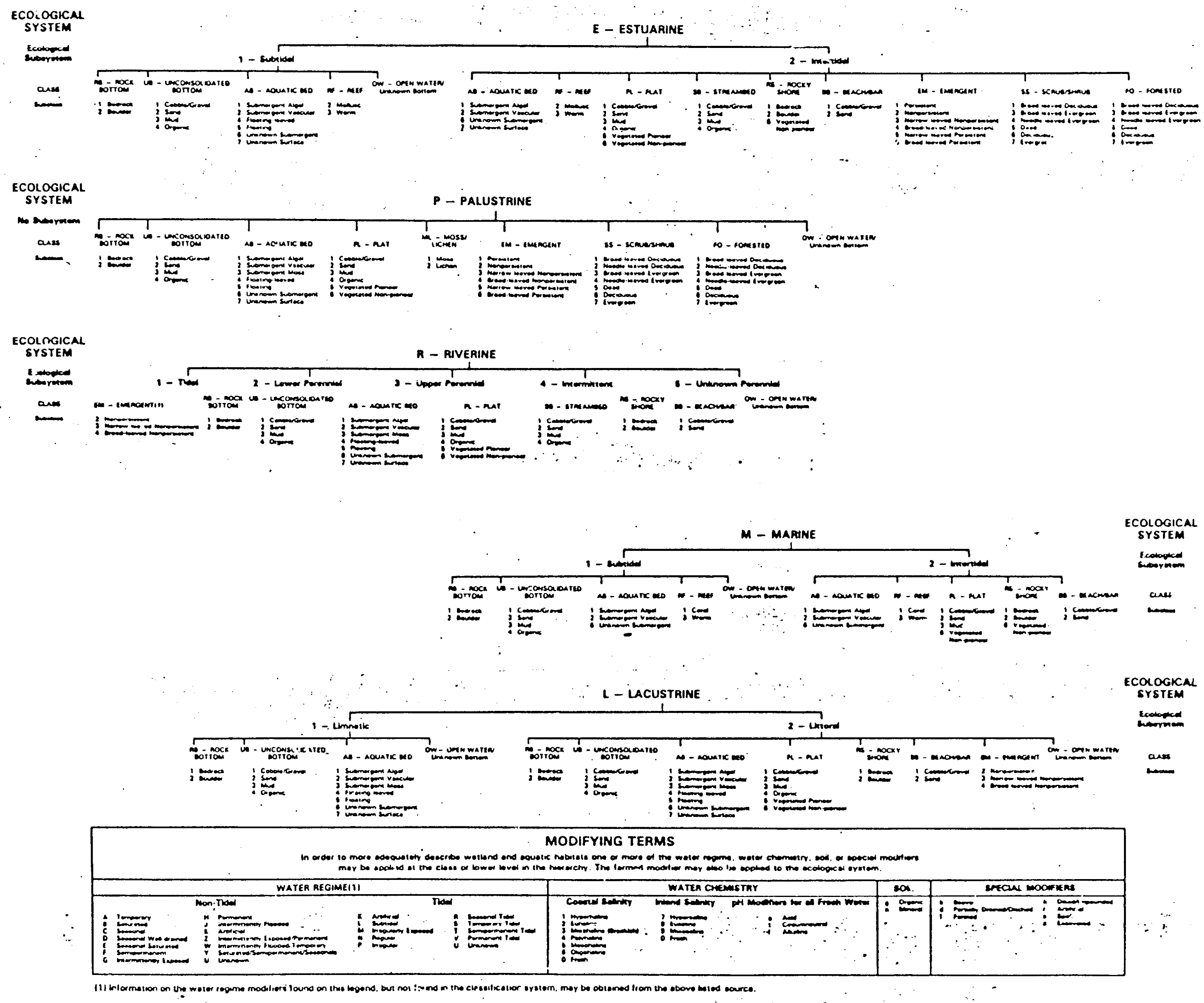

Figure 2. National Wetland Inventory Classification System.

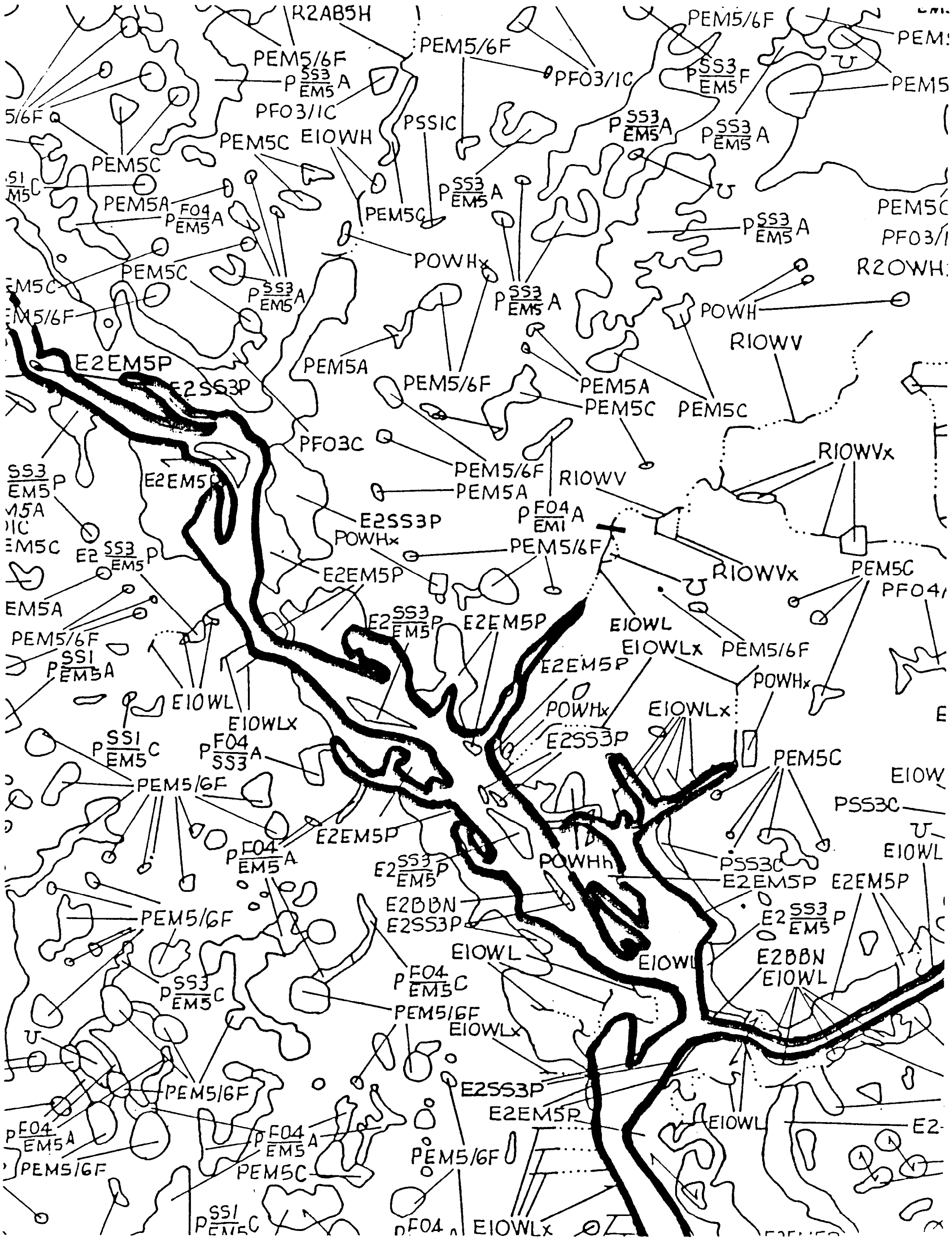

Figure 3. Myakka River example of the National Wetland Inventory. The tributary at lower right is Big Slough.

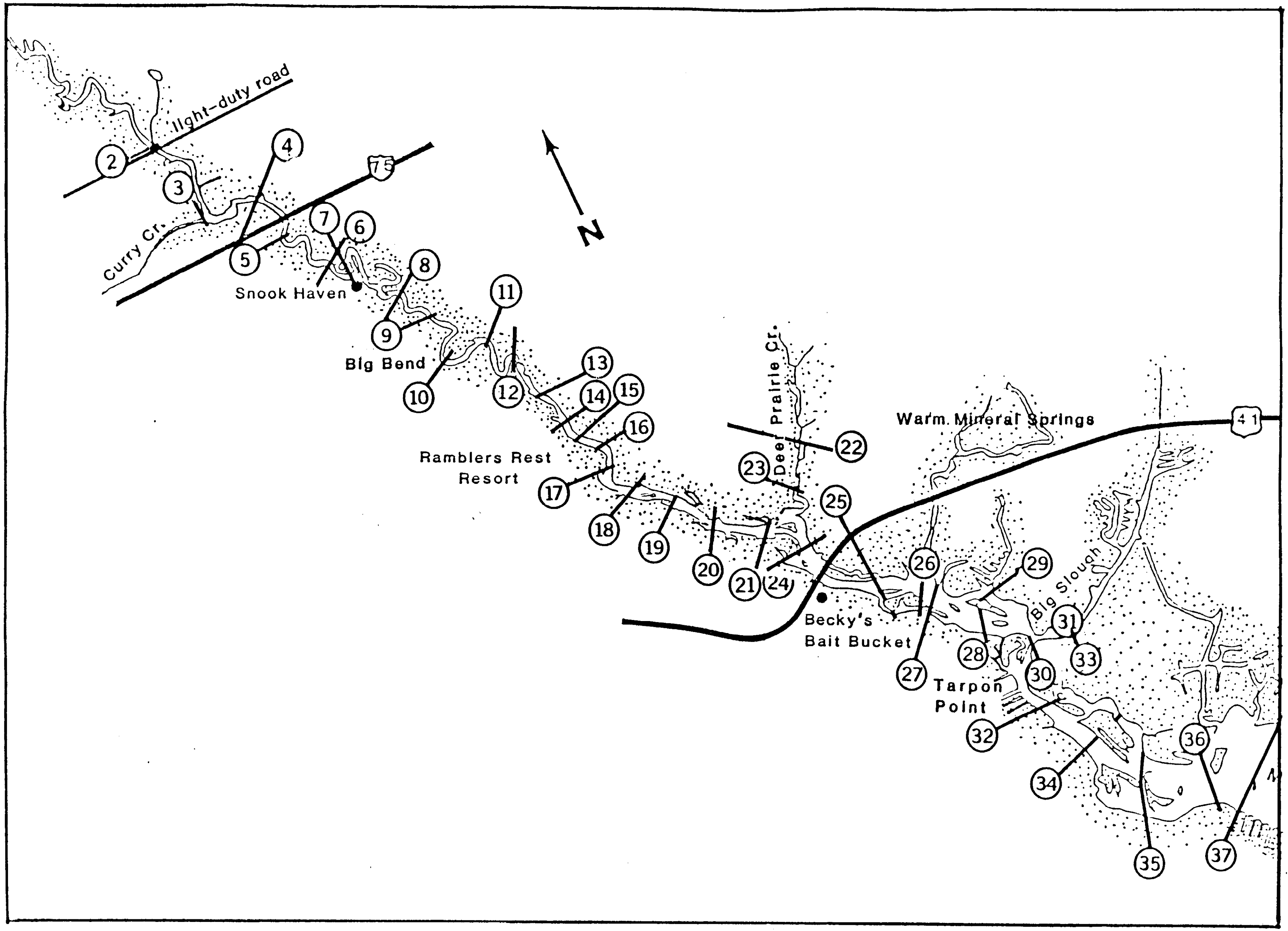

Figure 4. Wetland survey station locations.

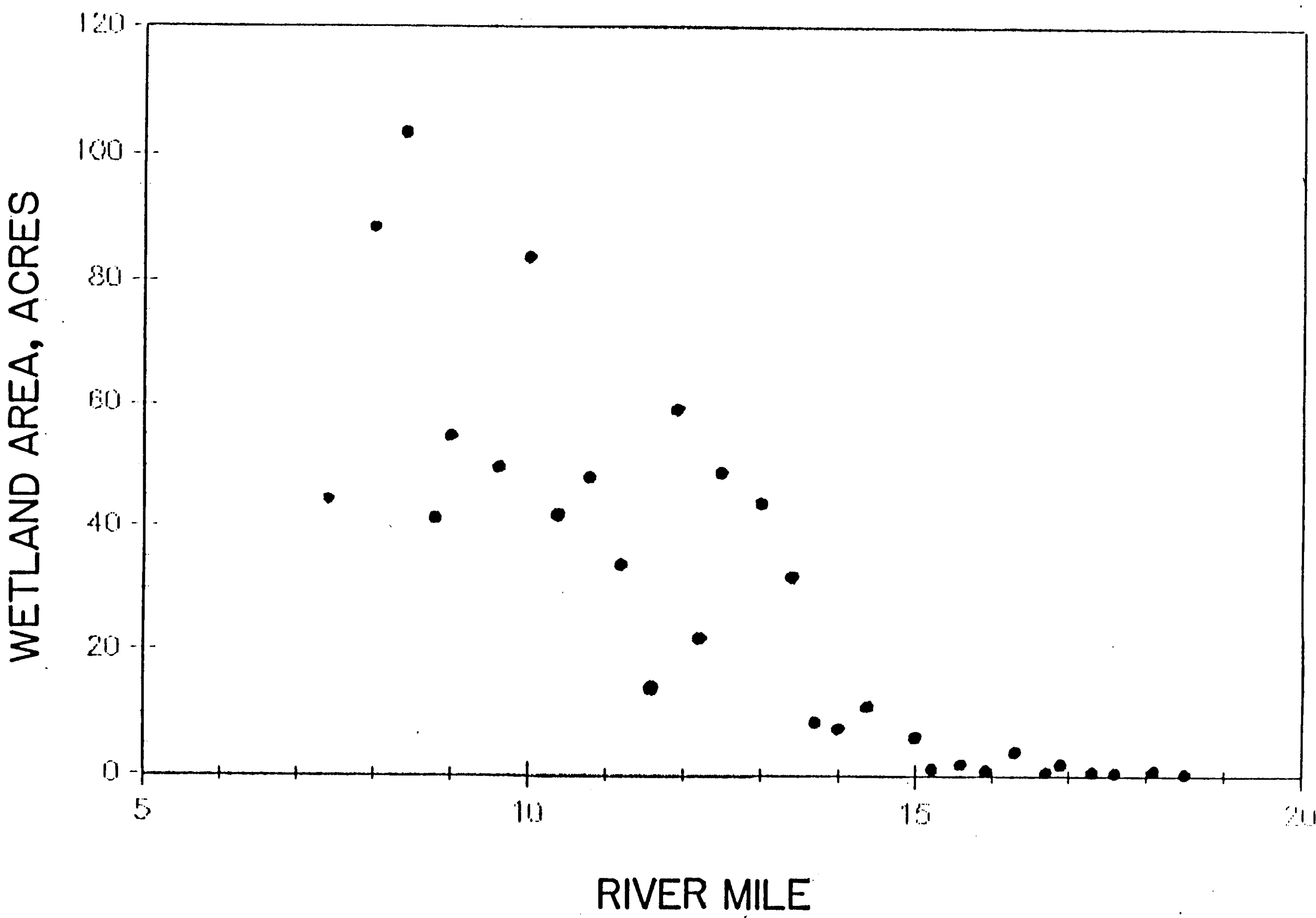

Figure 5. Wetland area, in acres, in relation to river mile.

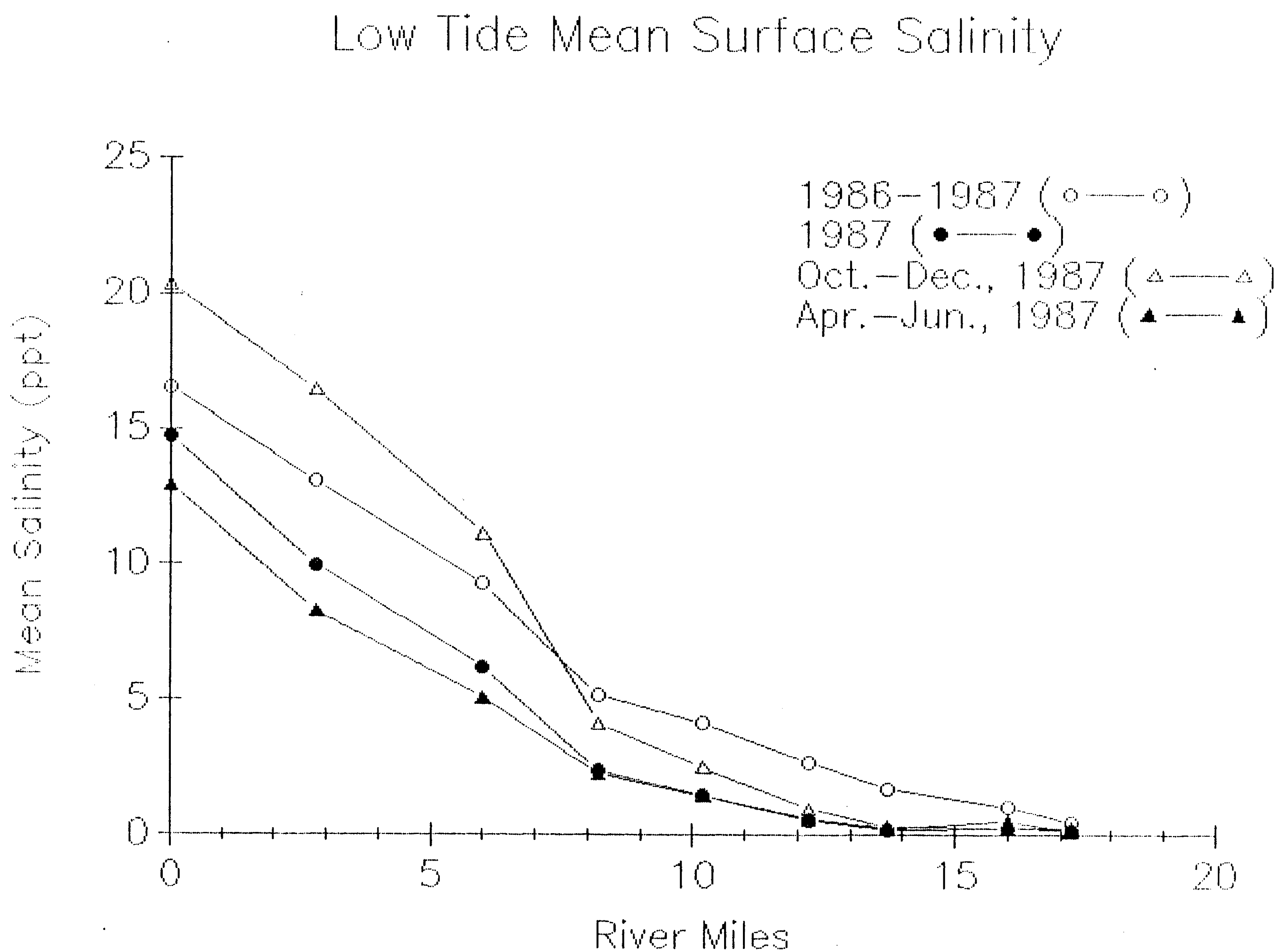

Figure 6. Salinity data, in parts per thousand, for 1986 and 1987.

Figure 7. Example of red mangrove cover in the tidal Myakka River. Medium stippling marks red mangrove and dark areas mark red and other mangroves.

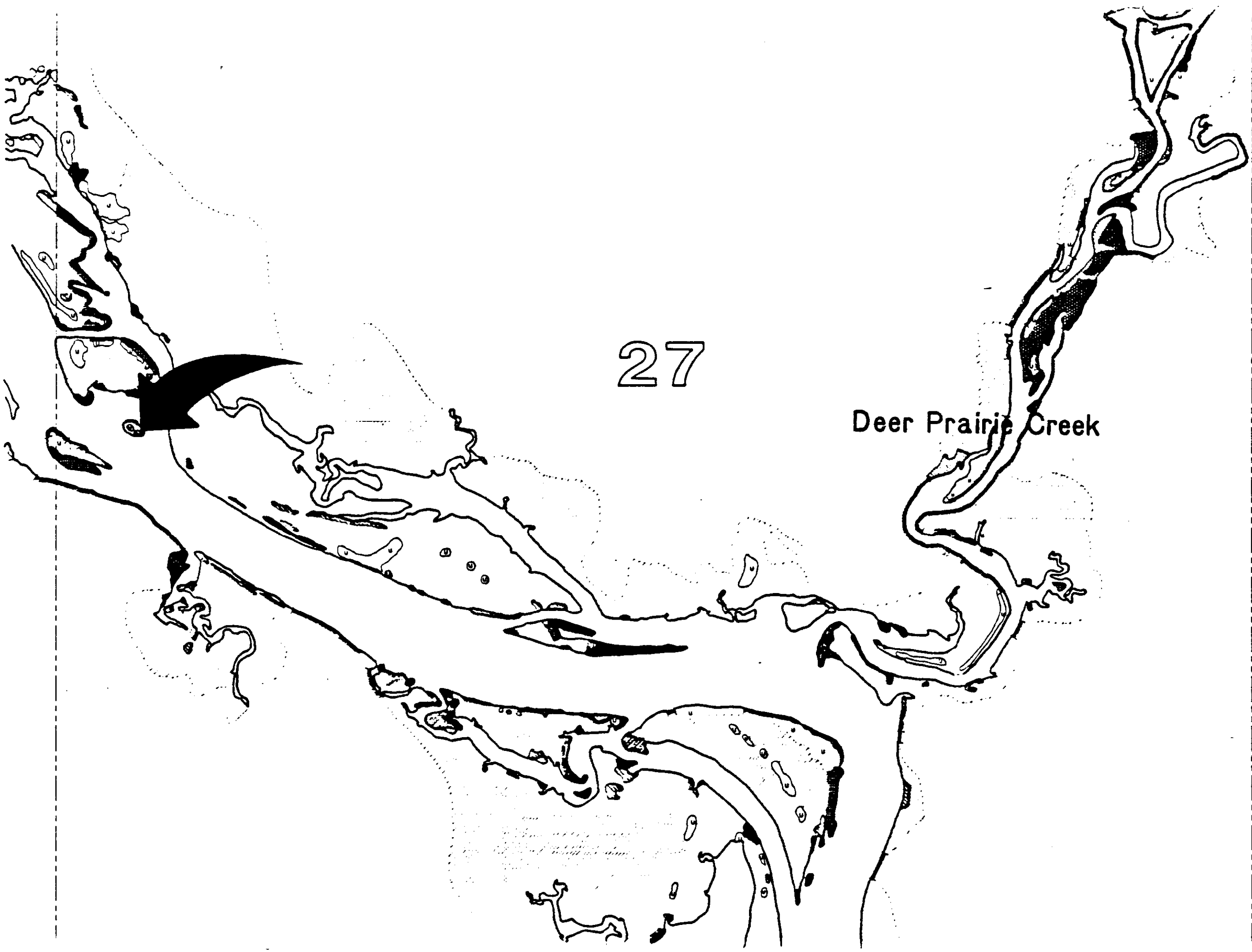

Figure 8. Location of most-upstream red mangrove in the tidal Myakka River.

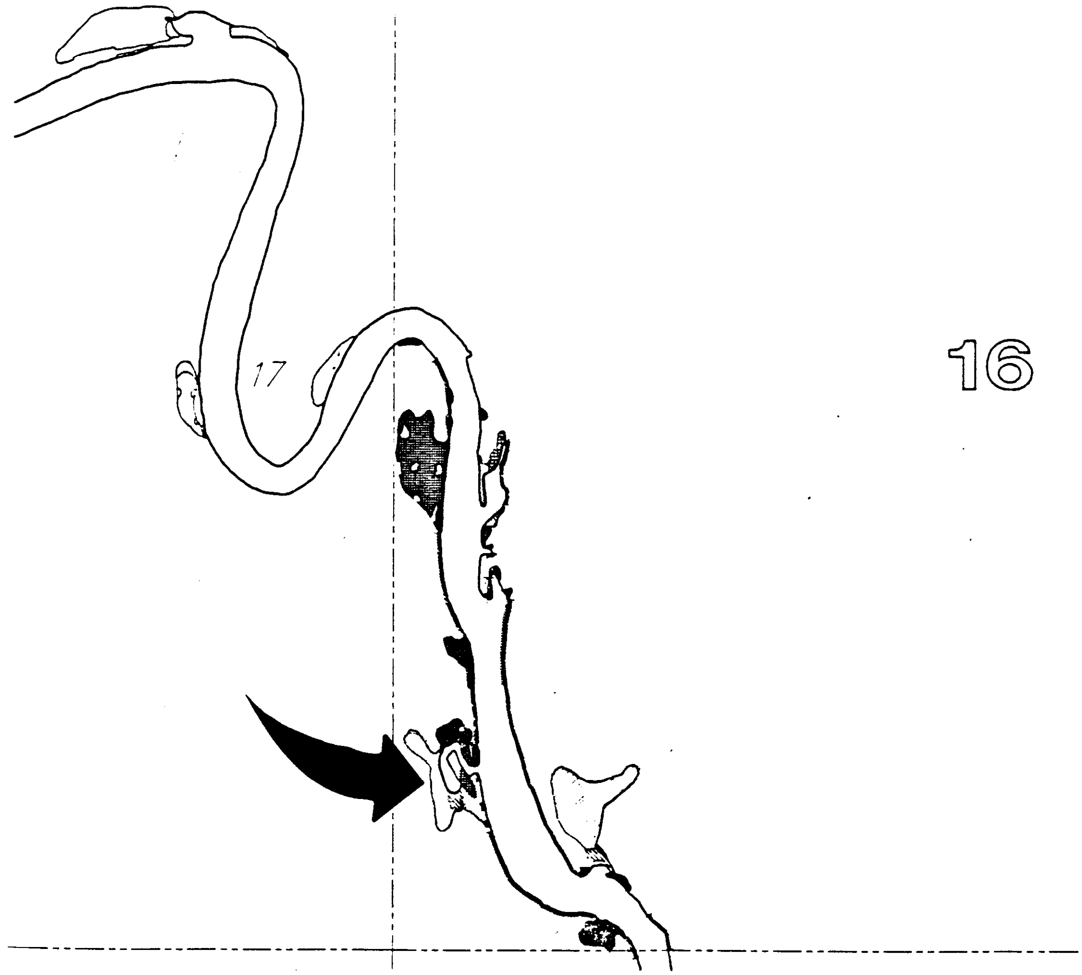

Figure 9. Location of most-upstream black needle rush in the tidal Myakka River. This site is between Ramblers' Rest Resort (downstream) and Big Bend (upstream).

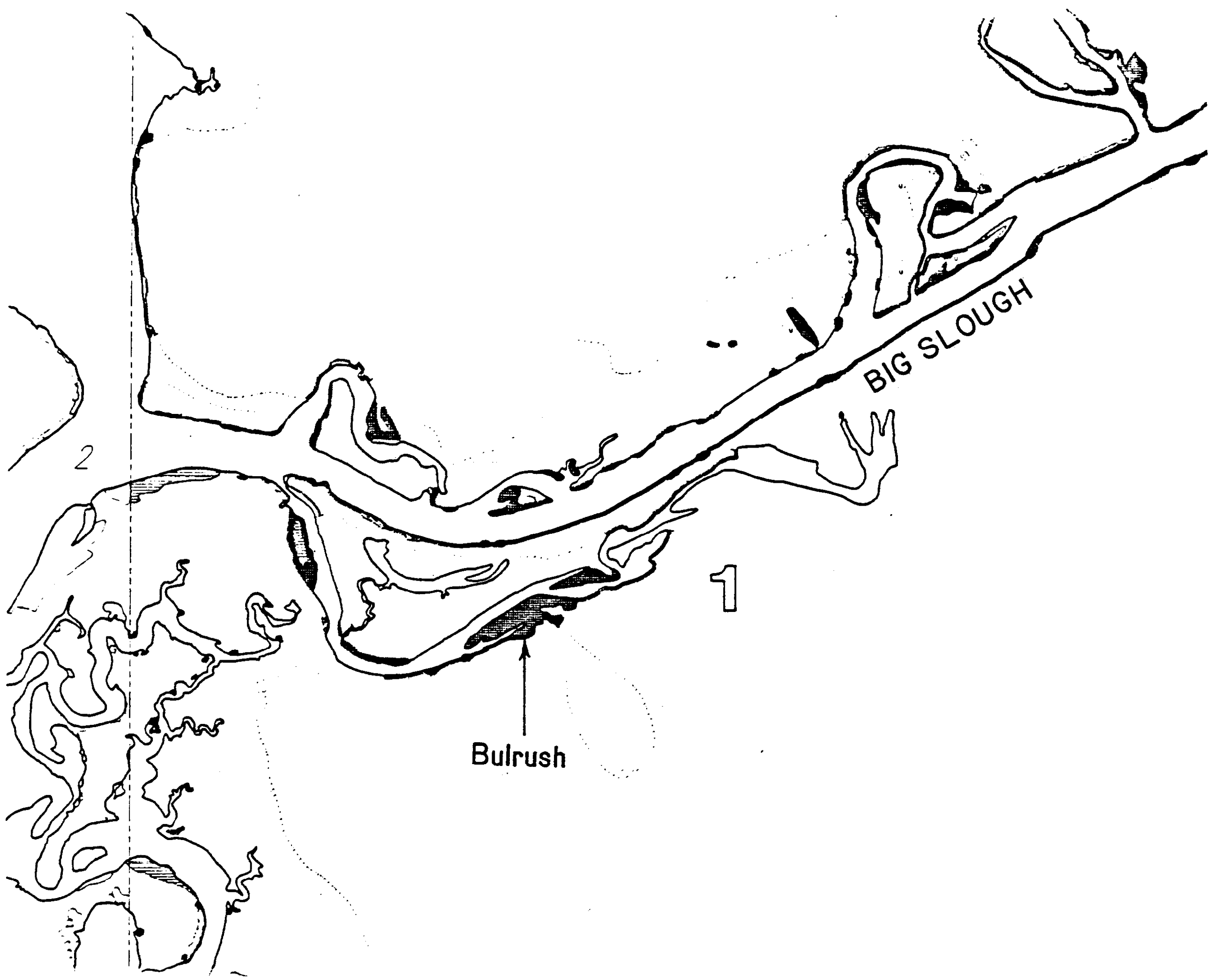

Figure 10. Example of bulrush cover in Big Slough.

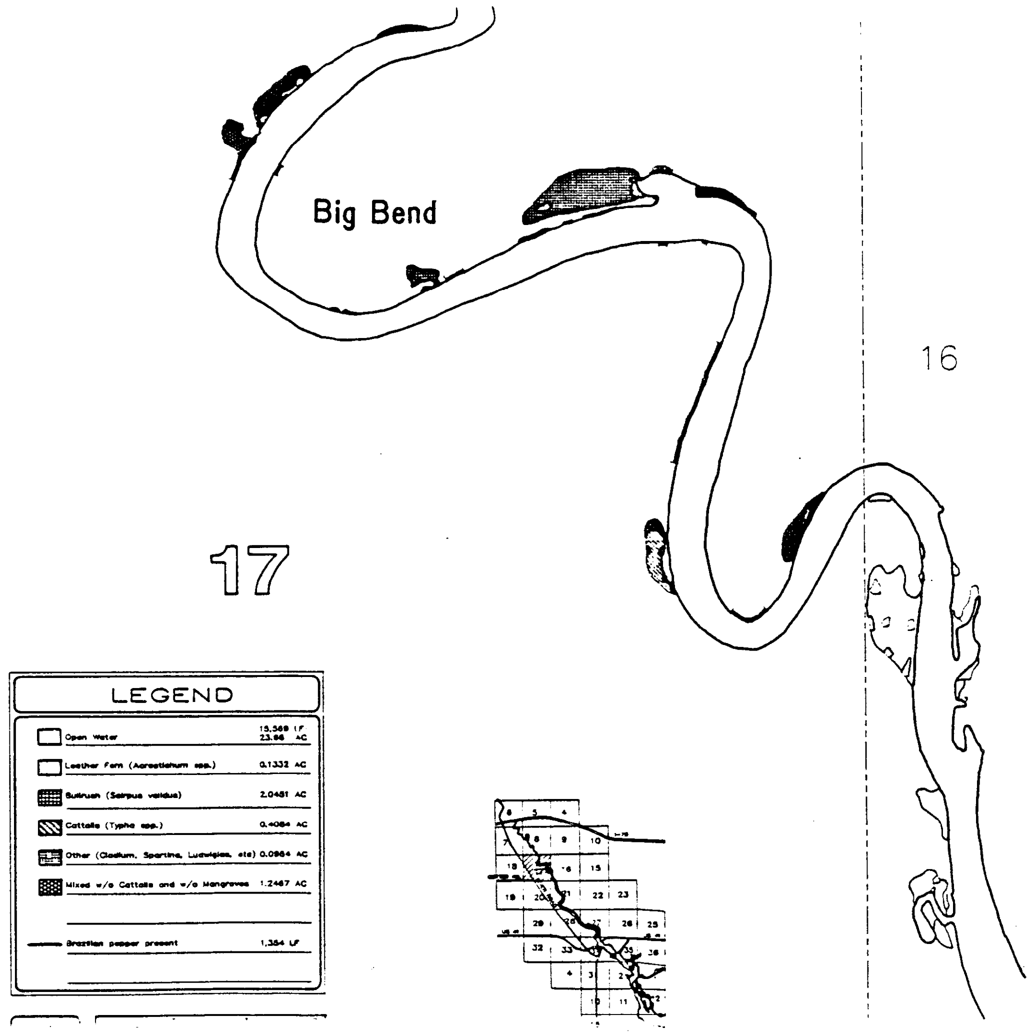

Figure 11. Example of tidal freshwater wetland ("Other" and "Mixed without cattails or mangroves") in the tidal Myakka River.

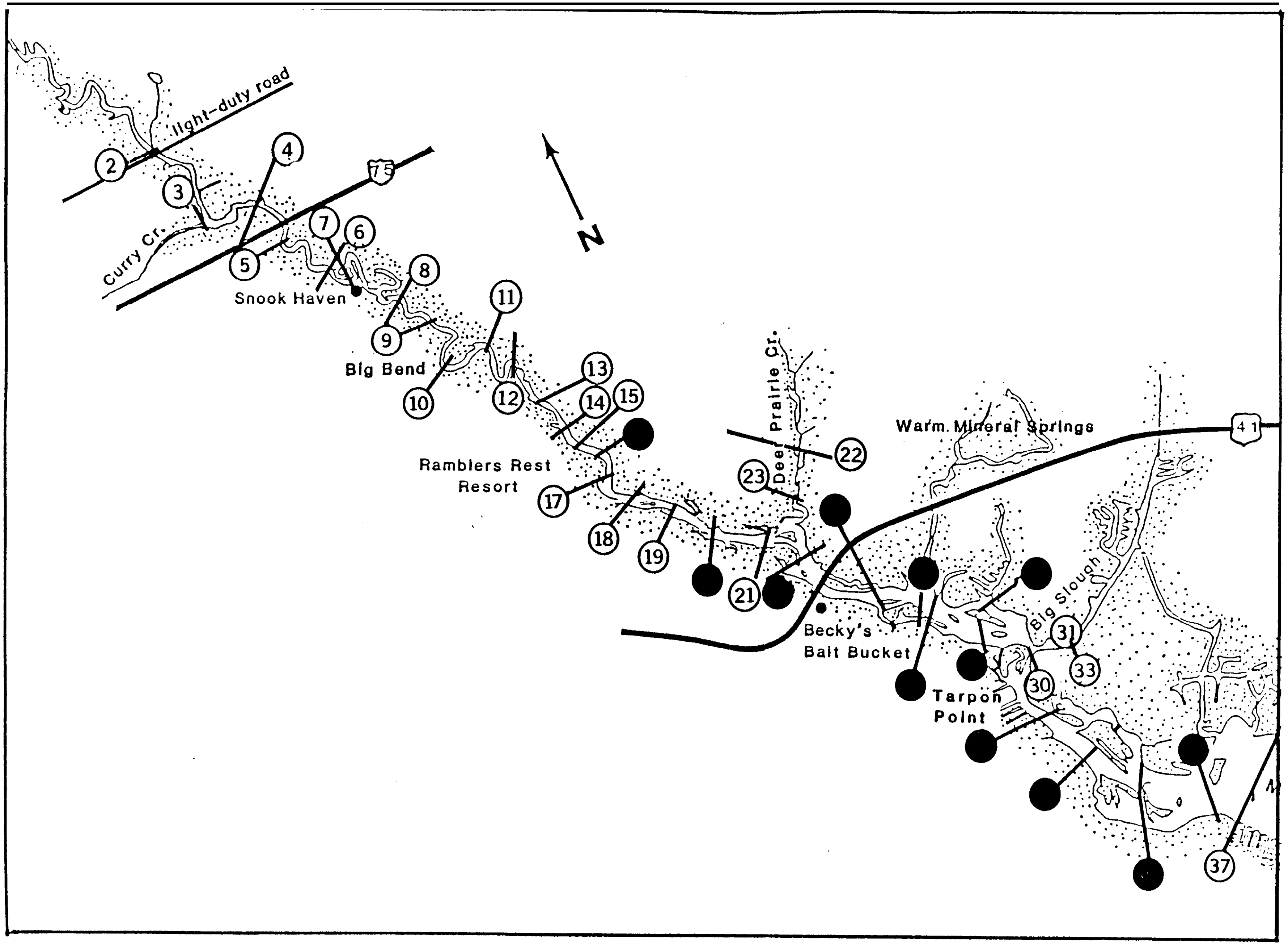

Figure 12. Distribution of widgeon grass in the tidal Myakka River, October 1987 to August 1988. Data from both banks were combined.

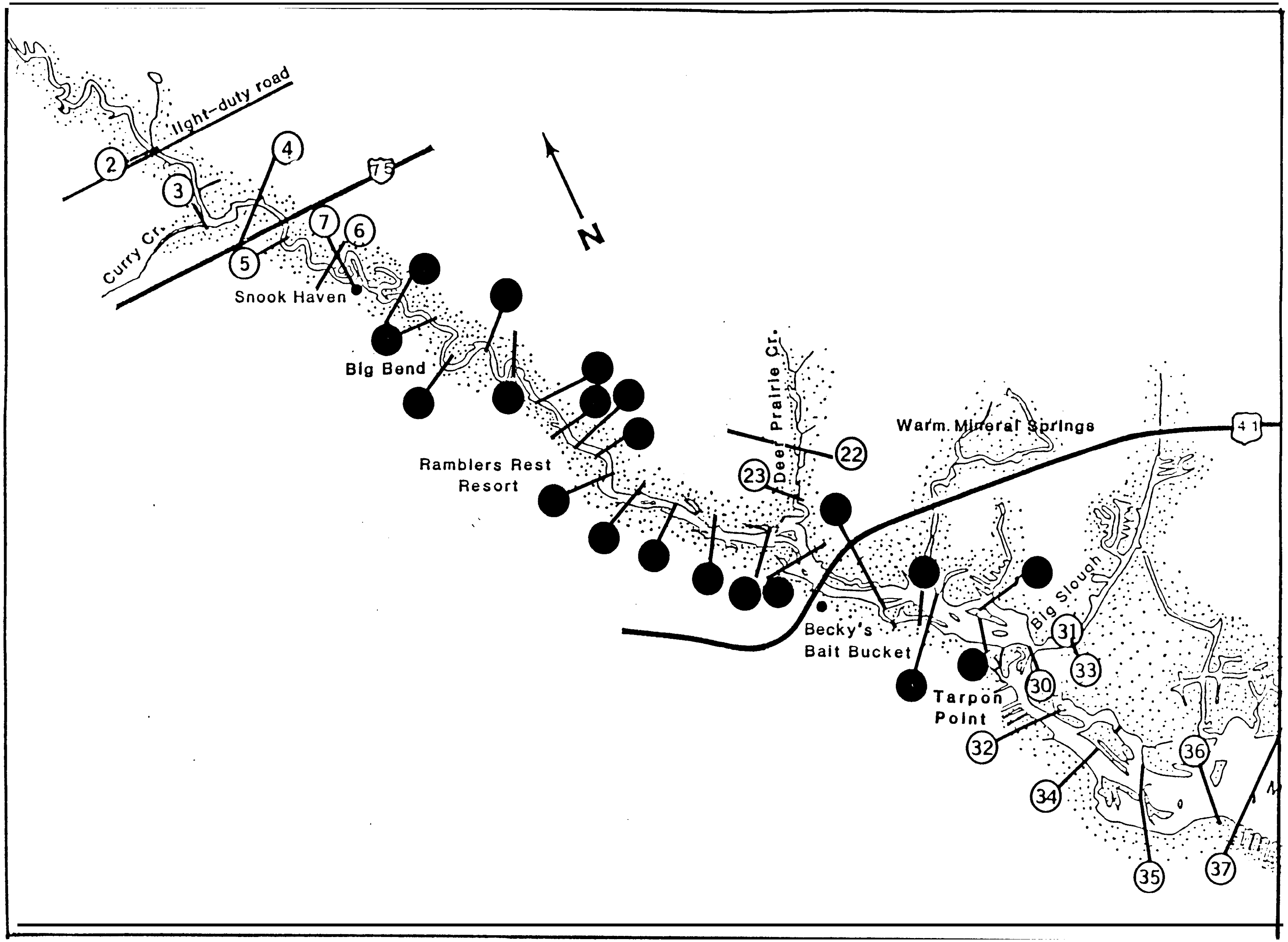

Figure 13. Distribution of tape grass in the tidal Myakka River, October 1987 to August 1988. Data from both banks were combined.

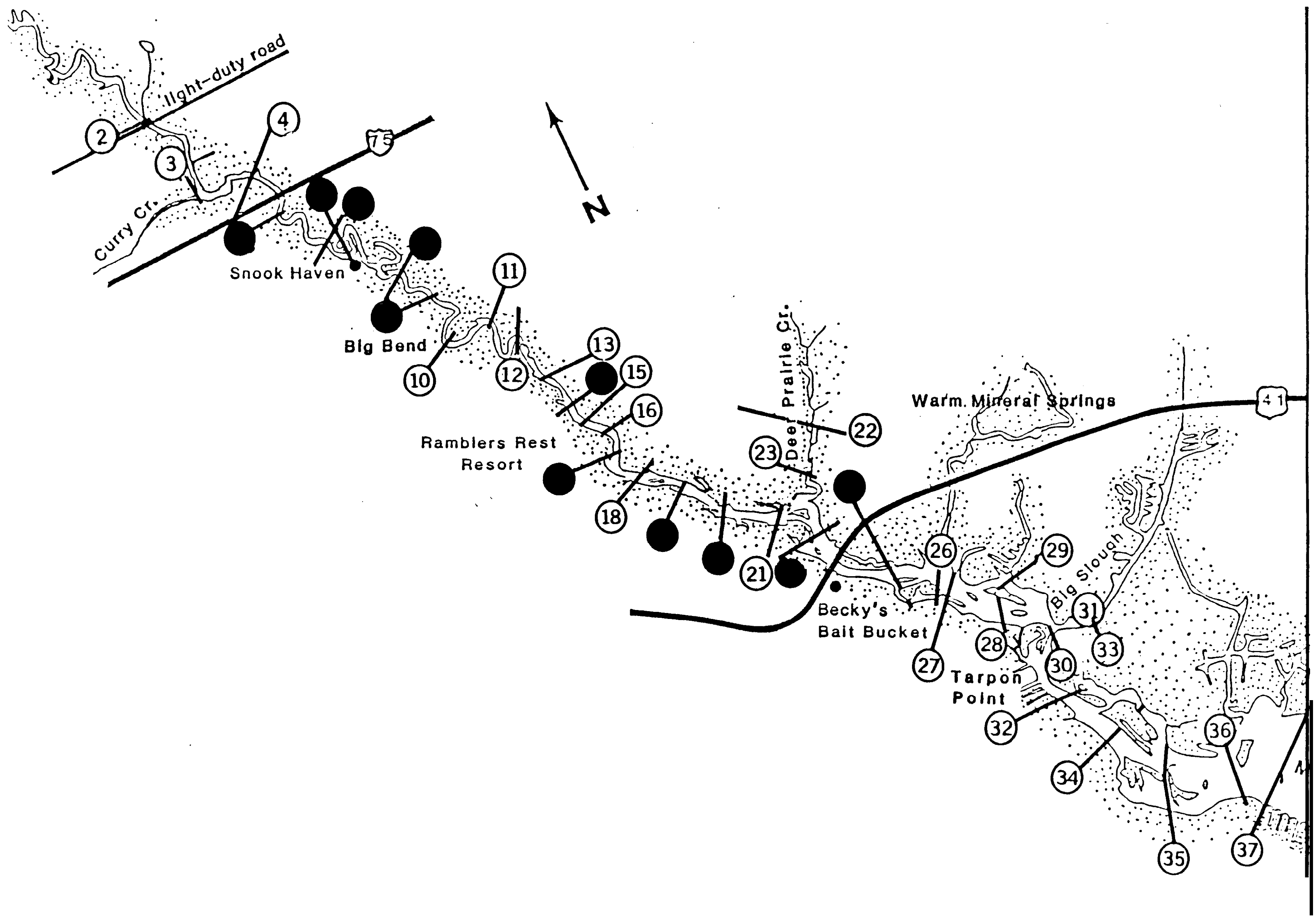

Figure 14. Distribution of dwarf arrowhead in the tidal Myakka River, October 1987 to August 1988. Data from both banks were combined.

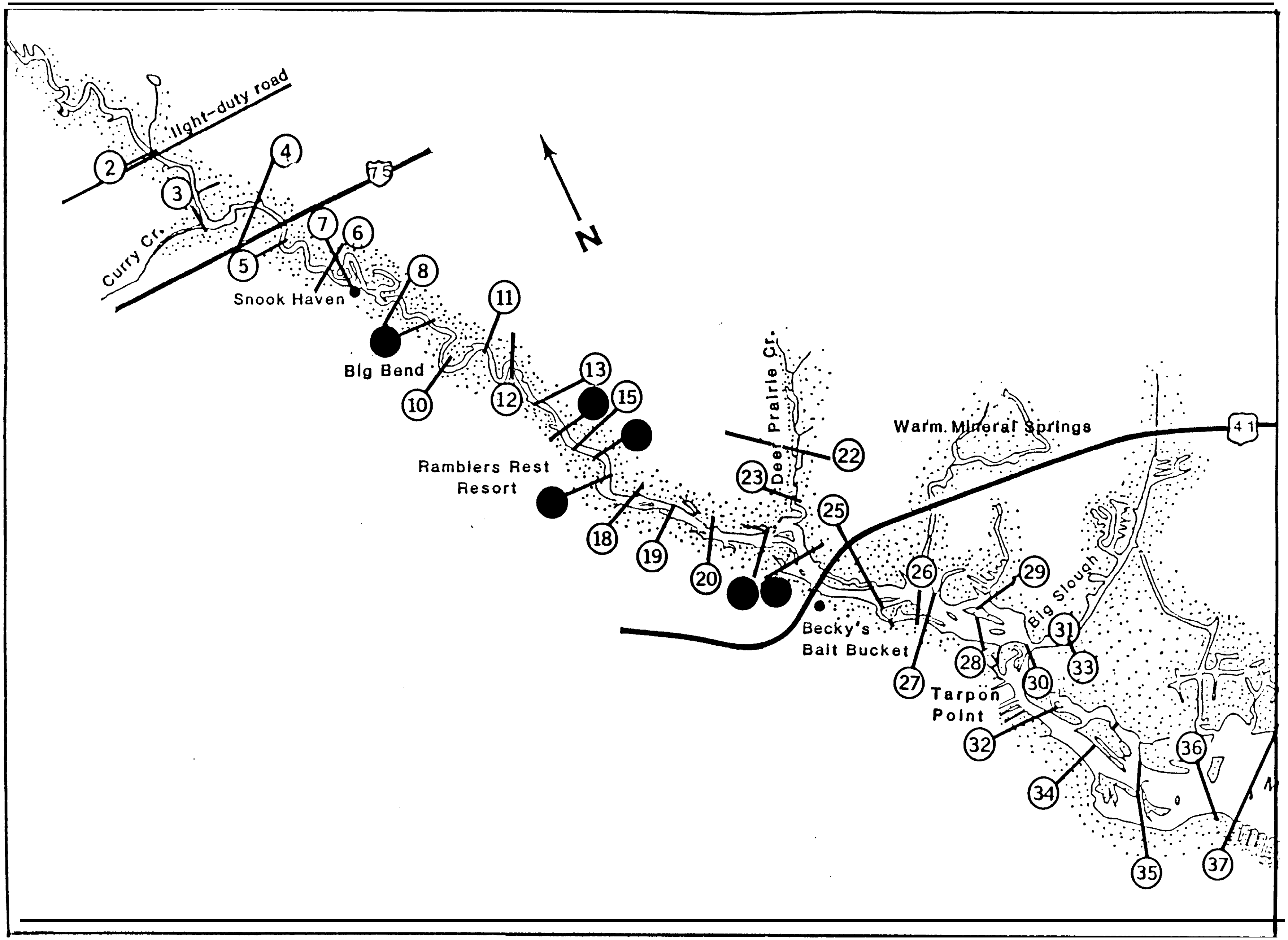

Figure 15. Distribution of coontail in the tidal Myakka River, October 1987 to August 1988. Data from both banks were combined.

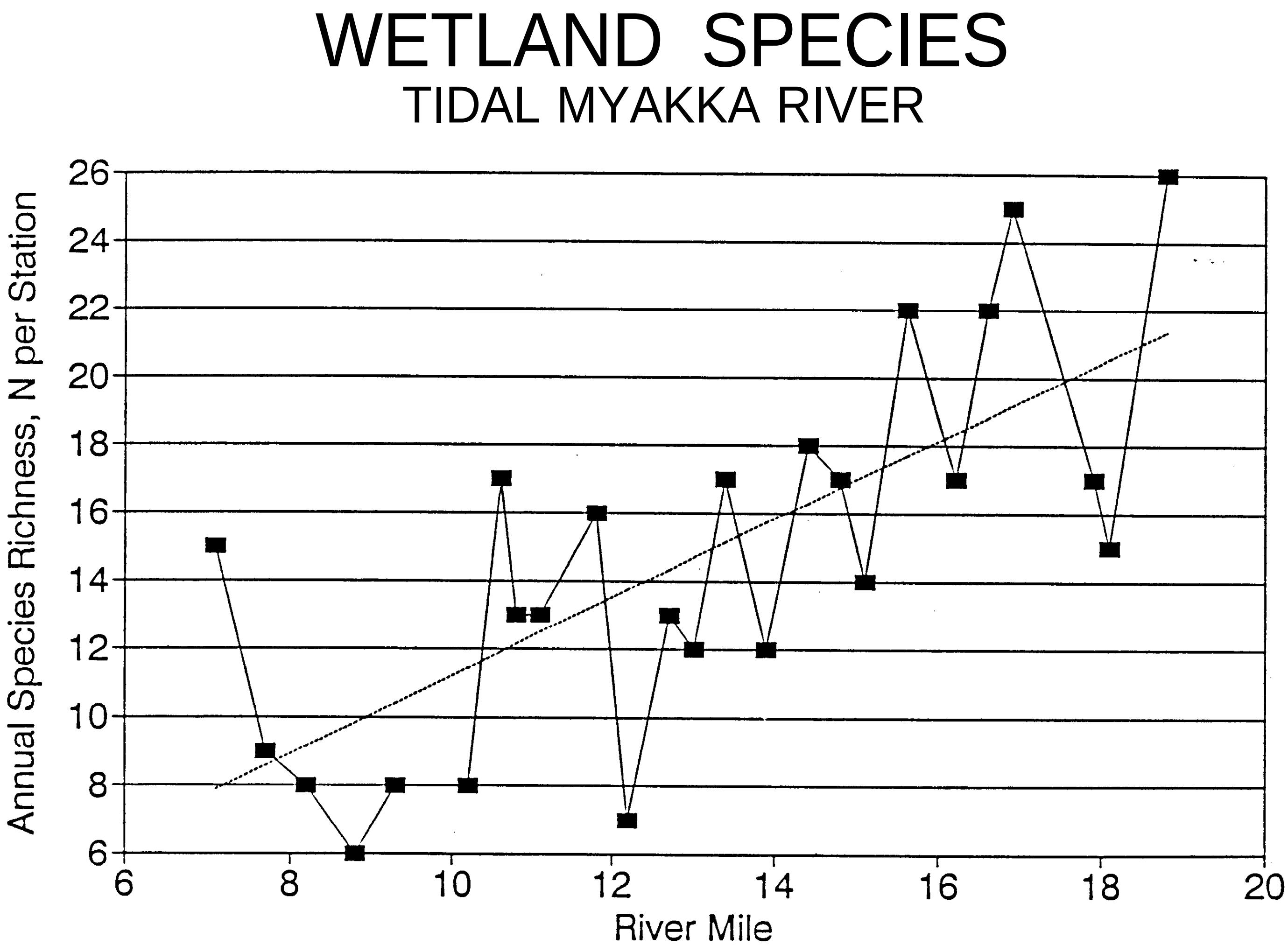

Figure 16. Wetland species richness as a function of river mile. The dotted line is a least-squares fit, highly significant at $p < .01$.

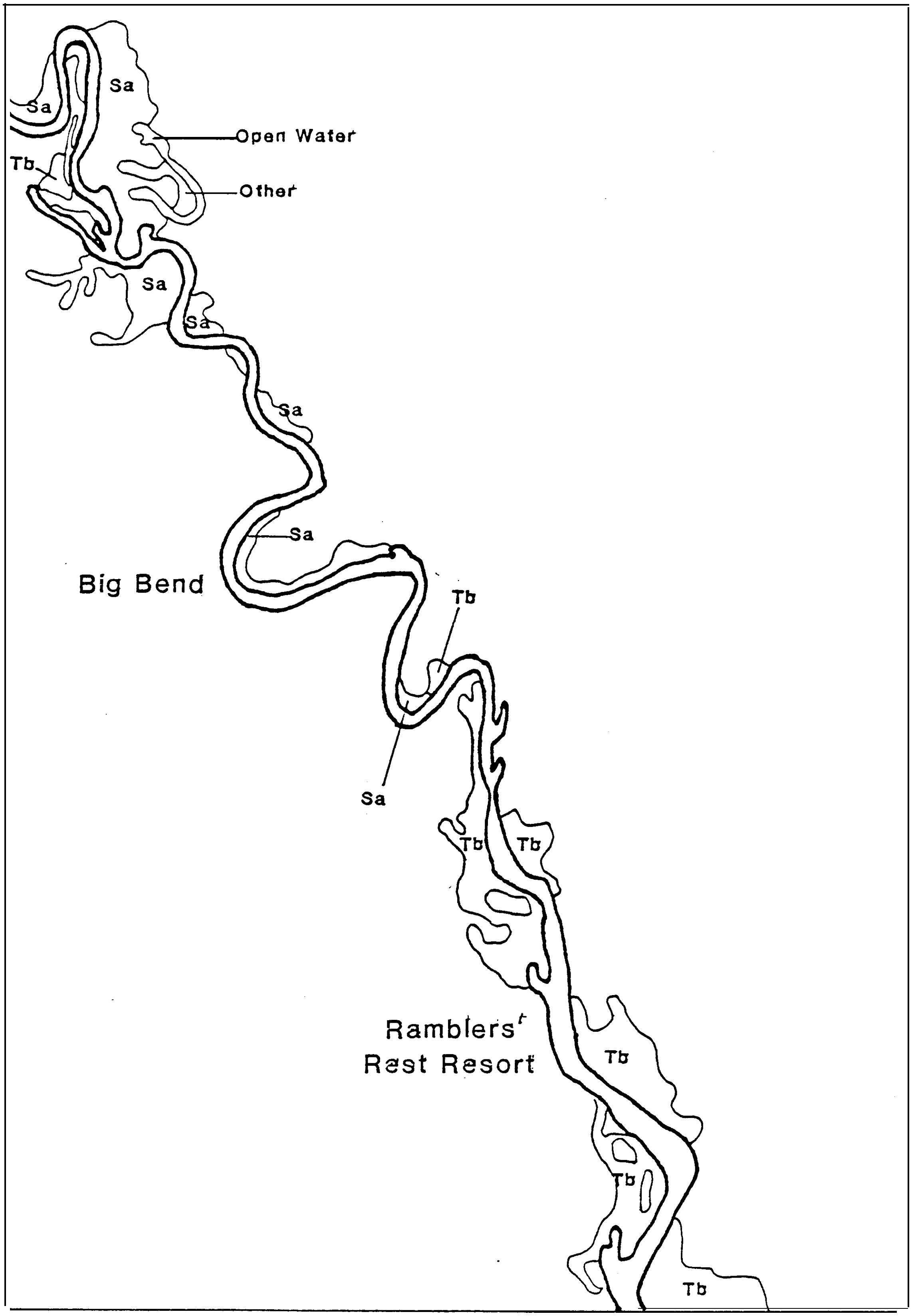

Figure 17. Soils near Big Bend. The arrow marks a transition between sandy alluvium (Sa) and tidal marsh (Tb) soil types (SCS, 1959).