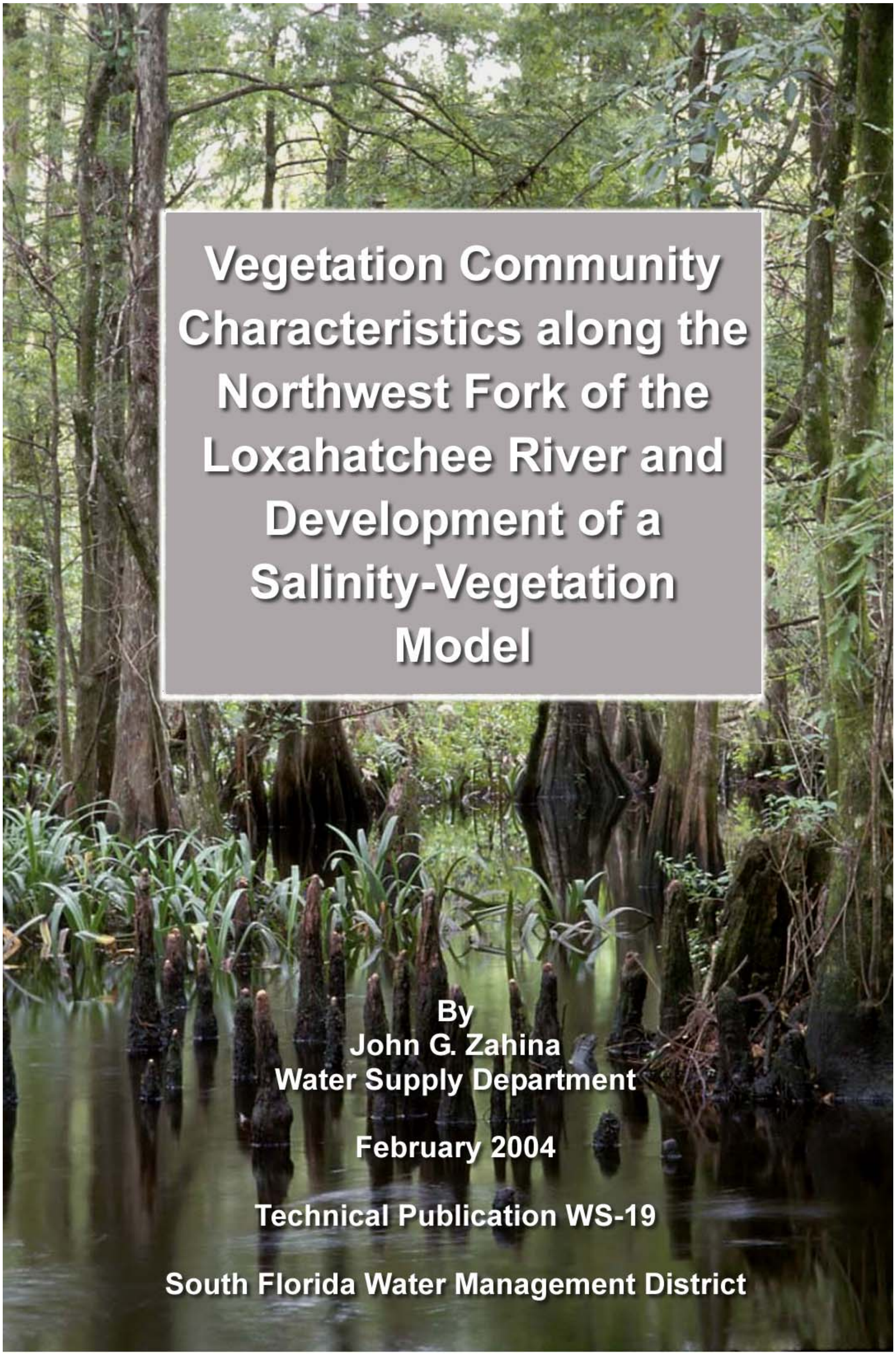

Vegetation Community Characteristics along the Northwest Fork of the Loxahatchee River and Development of a Salinity-Vegetation Model

By
John G. Zahina
Water Supply Department

February 2004

Technical Publication WS-19

South Florida Water Management District

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

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EXECUTIVE SUMMARY

The purpose of this report is to document the methods and results from vegetation studies conducted by South Florida Water Management District (SFWMD or District) staff along the Northwest Fork of the Loxahatchee River (Northwest Fork) and the development of a salinity-vegetation (SAVELOX) model derived from these studies. A section containing basic information concerning movement of salt water within the Northwest Fork and the dominant species found within the river floodplain is included. This background information is essential to understand the system and rationale supporting development of the SAVELOX model.

SFWMD staff conducted vegetation surveys at floodplain sites from 2000-2002. Two different methods were used in these surveys; a semiquantitative survey was conducted first at more than twenty locations in order to gain an understanding of the distribution of species across this system and to discern the locations of fresh water, transitional and salt-tolerant floodplain communities. More intensive, quantitative surveys focused on studying vegetation changes along this gradient with particular emphasis on documenting physical differences of dominant species and community structure.

Because long-term salinity monitoring data is not available for all vegetation sites surveyed along the Northwest Fork, a hydrodynamic salinity model was used to generate a "historic" 30-year salinity time series (1971–2001). This model was calibrated and verified using existing salinity-freshwater flow relationships derived from field studies. The long-term salinity time series at each vegetation site was used to calculate the *Ds/Db* ratio, which is a means to integrate salinity exposure duration, magnitude and recovery time between salinity events into a single numerical factor. This ratio was related to quantitative vegetation survey data to examine relationships between salinity conditions and stress to freshwater vegetation.

A model was developed from relationships between field data and long-term salinity conditions. The SAVELOX model uses an empirical approach to extrapolate vegetation parameter response given a set of long-term salinity conditions. A comparison of model output with field data indicates that it provides a reasonable estimate of the status of the vegetation community at a site. The predicted values calculated by the SAVELOX model are useful to examine salinity-vegetation relationships and to compare potential changes in the distribution of freshwater habitat along the Northwest Fork associated with different flow scenarios. This model can be a useful tool for evaluating hydrological modeling alternatives relative to restoration efforts.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS I

EXECUTIVE SUMMARY III

INTRODUCTION 1

BACKGROUND INFORMATION 3

DESCRIPTION OF THE LOXAHATCHEE RIVER 3
CHARACTERISTICS OF SALINITY MOVEMENT IN THE NORTHWEST FORK 5
LOXAHATCHEE RIVER HYDRODYNAMIC MODEL 8
Model Description 8
Modeling Assumptions 9
FLOODPLAIN SWAMP FLORISTICS 10
Ecological Characteristics of the Floodplain Swamp Forest 9
Bald Cypress 11
Other Freshwater Swamp Species 12
Red Mangrove 13
SALINITY-VEGETATION RELATIONSHIPS ALONG THE NORTHWEST FORK 15
FLOODPLAIN VEGETATION STUDIES 17
General Land Office Survey of Township & Range Plats 17
United States Geological Survey Topographic Map of the Jupiter Area 17
Alexander & Crook 18
Floodplain Transect Study along the Northwest Fork- Various Authors 19
U.S. Department of the Interior Environmental Impact Statement 21

METHODS 22

DEVELOPMENT OF A LONG TERM SALINITY TIME SERIES 23
FIELD VEGETATION SURVEYS 25
Semiquantitative Vegetation Survey 25
Quantitative Vegetation Survey 26
STATISTICAL ANALYSIS OF FIELD DATA 29
SALINITY-VEGETATION RELATIONSHIPS AND DEVELOPMENT OF A MODEL 30

RESULTS 35

DEVELOPMENT OF A LONG TERM SALINITY TIME SERIES 36
VEGETATION SURVEY RESULTS 36
Semiquantitative Vegetation Survey 36
Quantitative Vegetation Survey 43
LOXAHATCHEE SALINITY-VEGETATION (SAVELOX) MODEL VERIFICATION AND RESULTS 51

DISCUSSION 55

RECENT VEGETATION CHANGES ALONG THE NORTHWEST FORK 55
APPLICATION AND INTERPRETATION OF SAVELOX OUTPUT 57

CONCLUSIONS 61

RECOMMENDATIONS.. 63

REFERENCES.. 65

APPENDIX A: CSCE/EWRI & ICECM Conference Preceedings…………..…....A-1

APPENDIX B: General Land Office 1855 Survey Notes…………………………...B-1

APPENDIX C: Field Studies Vegetation Data……………………………..…..……C-1

APPENDIX D: SAVELOX Model Verification…………………………………..D-1

INTRODUCTION

Floodplain vegetation along downstream segments of the Northwest Fork of the Loxahatchee River (Northwest Fork) (**Figure 1**) has changed over the past century from freshwater swamp dominated by bald cypress (*Taxodium distichum*) to salt-tolerant red mangrove (*Rhizophora mangle*) swamp. Protection and restoration of freshwater vegetation along the Northwest Fork requires an understanding of the relationship between the floodplain swamp plant community composition and exposure to salinity. In addition, characterization of succession processes between freshwater and salt-tolerant species can aid in developing management guidelines and strategies to support restoration goals. To begin the process of understanding and documenting these relationships, field vegetation surveys were conducted along the Northwest Fork and correlated with a long-term salinity time series for survey sites.

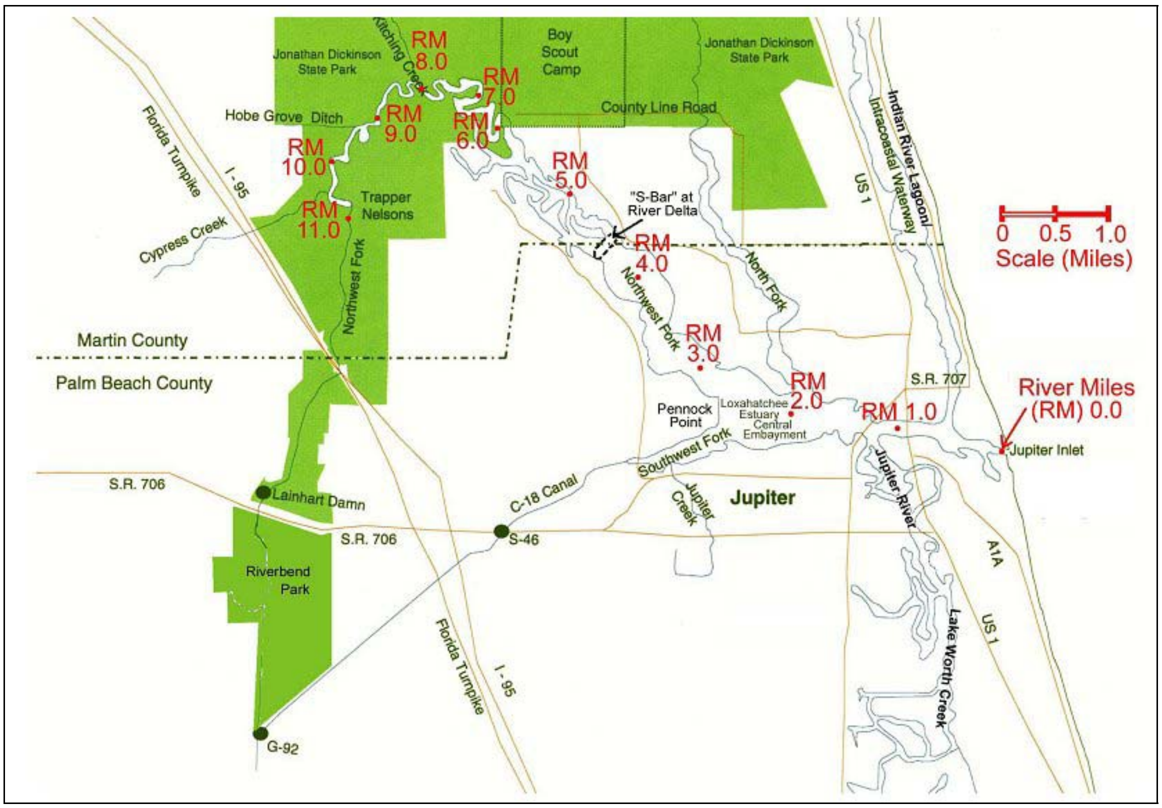


Figure 1. Location of the Loxahatchee River in Southeastern Florida; Shaded Areas Indicate Publicly-owned Lands.

Because long-term salinity sampling data were not available for all vegetation sites surveyed, a hydrodynamic/salinity model was used to simulate salinity conditions at several upstream river sites for a 30-year period of record. Using these model results, the correlation between long-term salinity conditions and vegetation community characteristics were examined. Formulas were then developed to describe relationships between measured vegetation parameters and a calculated salinity ratio that encompasses the magnitude, duration and time between salinity events. Use of a single ratio allowed simplification of several factors involved in characterizing the salinity history at a site. These formulas became the foundation of a salinity-vegetation model to predict floodplain swamp plant community composition based on a long-term salinity history. The model uses an empirical approach to extrapolate vegetation parameter response given a set of long-term salinity conditions. The SAlinity-VEgetation model for the Northwest Fork of the LOXahatchee River (SAVELOX Model) could be useful to predict the freshwater conditions needed to protect the freshwater riverine swamp at different segments along the river and to provide insight to changes caused by exposure to different salinity conditions.

This document describes the process used to conduct vegetation surveys and to develop the SAVELOX model for the Northwest Fork of the Loxahatchee River. The **Background Information** section provides a general description of the river, including salinity movement dynamics, development of the hydrodynamic model for the Loxahatchee River and local floristics. Readers are provided fundamental information about the dynamics of the Northwest Fork of the Loxahatchee River, upon which the salinity-vegetation model was developed. The **Discussion** section includes a discourse of study results relative to the ecological management of the river along with the application and interpretation of the SAVELOX model output.

BACKGROUND INFORMATION

This section presents background information that supports the development of the salinity-vegetation model. It includes a general description of the Loxahatchee River, a presentation of salinity movement dynamics through the Northwest Fork and a description of local floristics. The discussion of salinity movement within the river includes a description of the hydrodynamic model used to generate a long-term salinity time series, as well as a depiction of how salinity data is analyzed in terms relatable to the vegetation community. The discussion of local floristics provides a general description of major species found within the river floodplain and previous vegetation studies that have been conducted.

Description of the Loxahatchee River

The Northwest Fork of the Loxahatchee River is a natural river channel that originates in the Loxahatchee Slough. The C-18 Canal receives discharges from the Slough, and runoff and groundwater inflow from adjacent uplands. Downstream from the Slough, the Northwest Fork receives additional input from three major tributaries-Cypress Creek, Hobe Grove Ditch and Kitching Creek (**Figure 1**). Much of the watershed remains in a natural (undeveloped) state or in low-density agriculture use so that the quality of water runoff from most areas is good. Large tracts are protected in parks or preserves, and various private interests and government entities are purchasing additional land for preservation.

The Northwest Fork is a shallow river. Average depths generally range from 3 to 6 feet. Depths in upstream sections are less than 10 feet and maximum depths range from 10 to 16 feet upstream near Cypress Creek (Chiu 1975). The Northwest Fork is a narrow, sinuous, free-flowing stream between River Bend Park and the Trapper Nelson Site in Jonathan Dickinson State Park (**Figure 1**). In this segment, a dense canopy of freshwater floodplain swamp species overhangs the river channel. Dominant species include bald cypress (*Taxodium distichum*), pop ash (*Fraxinus caroliniana*), swamp hickory (*Carya aquatica*), and red maple (*Acer rubrum*). Downstream of the Trapper Nelson Site the river widens and there is no longer a closed canopy of vegetation due to the increased width of the river channel (USDOI 1983, 1985). Because of natural conditions, such as shading from the overhanging forest canopy, darkly-stained water color, the sandy bottom substrate and periodic rapid currents, submerged freshwater vegetation is lacking in most upstream sections of the Northwest Fork.

The floodplain width gradually increases from upstream to downstream segments, ranging from approximately 400 feet upstream of the I-95/Florida Turnpike corridor to 700 feet in sections near and downstream of Kitching Creek. The floodplain is generally of low relief with a rapid increase in elevation at the floodplain-upland ecotone. The degree of floodplain inundation is related to river flow (SFWMD 2002, Appendix N). Average floodplain elevations decrease from 9.9 feet to 2.3 feet NGVD between Lainhart Dam near Riverbend Park/State Road 710 to the Trapper Nelson site (SFWMD 2002,

Appendix N). Downstream of Trapper Nelson's site, the elevation drop is less pronounced; average floodplain elevation near Kitching Creek is 1.6 feet NGVD.

The extent of freshwater habitats along the Northwest Fork has decreased in the past century due to construction of the Intracoastal Waterway, permanent opening of the Jupiter Inlet, dredging of downstream segments of the Loxahatchee River, lowering of the local freshwater table and diversion of fresh water from the Northwest Fork. Most of these projects were carried out before 1970. All of these projects had a potential to allow further upstream encroachment of salt water during the daily tidal cycles and extended dry periods (Hu 2002, 2003), see **Appendix A**.

The primary source of freshwater inflow to the Northwest Fork is the G-92 structure. This structure was enlarged and new operational criteria were developed in the late 1970s. Previous to the reconstruction and operation of the G-92, only a limited amount of flow was provided to the Northwest Fork with the majority of storm water being diverted through the C-18 Canal to the Southwest Fork of the Loxahatchee River (**Figure 1**). The period before the reconstruction and revised operational plan for the G-92 coincides with the period of the most change from freshwater to saltwater conditions within the Northwest Fork. **Figure 2** shows the increased flows to the Northwest Fork resulting from changes to the G-92 structure beginning in the 1980's. Even larger increases in flows during the 1990's are the result of a series of above-average rainfall years.

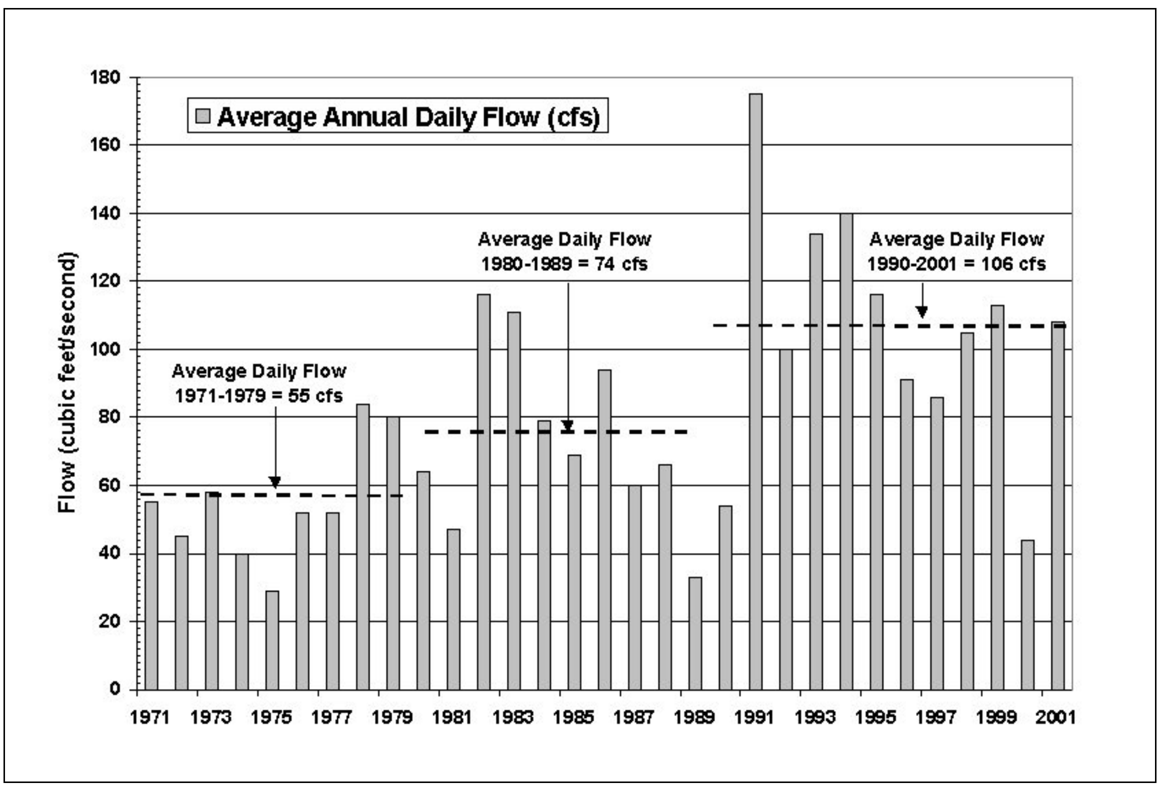


Figure 2. Average Annual Daily Flows (cfs) Recorded at the Lainhart Dam (1971–2001).

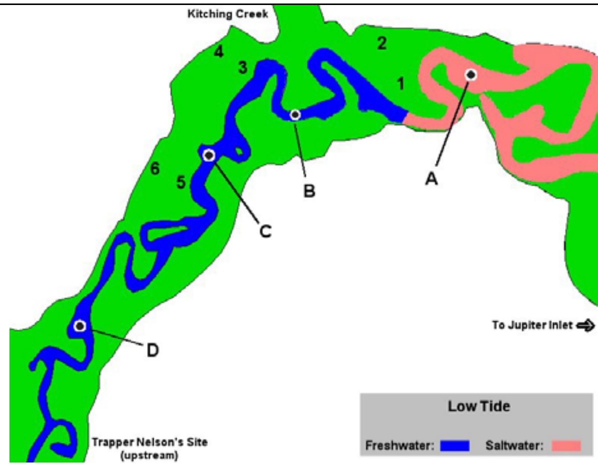
Flows in the Northwest Fork exhibit two types of cyclic variability- seasonal and tidal. Within the river segment upstream of Trapper Nelson's site, the dominant flow regime is highly seasonal; freshwater flows from headwaters relate to the timing and distribution of annual rainfall patterns. Because of the large distance from the Jupiter Inlet (more than 10 miles), tidal waters can reach these upstream areas only during extended dry periods when freshwater flows are negligible.

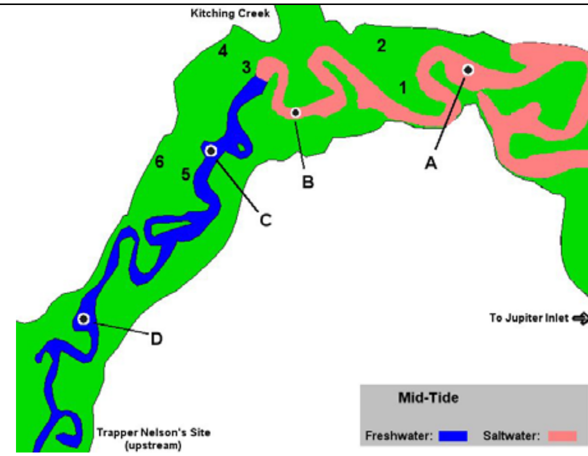
Characteristics of Salinity Movement in the Northwest Fork

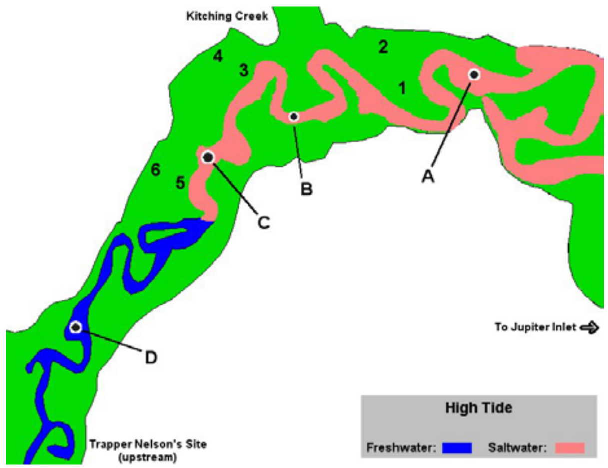
Saltwater intrusion into the Northwest Fork occurs as a result of tidal flux through the Jupiter Inlet. The primary factors dampening salinity inflows include the physical resistance of the flow corridor and freshwater counter-flows from upstream sources. Since tidal forces are cyclic and predictable and the physical characteristics of the flow corridor are fixed, the primary variable influencing the magnitude of salinity intrusion is freshwater flow. The cyclic nature of tidal flux (high tide-mid tide-low tide) allows only a fixed amount of time that the force of tidal flows can overcome physical resistance by the channel and freshwater flow. The stronger the tidal flow and weaker the freshwater flow, the further upstream the saltwater front can penetrate before regressing during mid and low tide periods. Other factors that can influence salinity concentrations in estuaries include circulation patterns and wind mixing, but in the relatively narrow channel of the Loxahatchee River these may not be significant.

Because of the cyclic nature of saltwater intrusion into the Northwest Fork, the salinity concentration profile at a site can vary according to proximity to the Jupiter Inlet. For example, under constant moderate freshwater flow conditions, a spot in the river channel located in the lower part of the Northwest Fork may have salinity concentrations that would oscillate between euryhaline and mesohaline conditions twice daily (**Figure 3**). However, another point in the river channel near Kitching Creek (**Figure 3**) may oscillate between freshwater and oligohaline conditions twice daily. In upstream locations, such as near Trapper Nelson's site, there would be constant freshwater conditions throughout the day. The locations of these respective salinity concentration regimes would migrate upstream or downstream in response to changes in freshwater flows, which are influenced primarily by annual rainfall patterns. The daily and seasonal oscillation between freshwater and saltwater conditions makes correlation of salinity conditions at a site and plant community response more complex.

In addition to the upstream migration of salt water, there is a "horizontal" movement of salt water into the floodplain (**Figure 3**). The movement of salt water from the river channel into the floodplain is influenced by physical resistance to overland flow and by freshwater flow magnitude (surface water and ground water), which is unidirectional from the higher-elevation upland-floodplain ecotone to the lower-elevation river channel. The extent of penetration of salt water into the floodplain is limited temporally by the cyclic nature of tidal flux (high tide-mid tide-low tide). The salinity concentration at a floodplain site is a function of distance from the inlet, distance from the river channel and magnitude of freshwater flows (surface and groundwater) from surrounding uplands.







Site	Low Tide	Mid Tide	High Tide
A	SALTWATER	SALTWATER	SALTWATER
B	FRESHWATER	SALTWATER	SALTWATER
C	FRESHWATER	FRESHWATER	SALTWATER
D	FRESHWATER	FRESHWATER	FRESHWATER
1	SALTWATER	SALTWATER	SALTWATER
2	FRESHWATER	SALTWATER	SALTWATER
3	FRESHWATER	SALTWATER	SALTWATER
4	FRESHWATER	FRESHWATER	SALTWATER
5	FRESHWATER	FRESHWATER	SALTWATER
6	FRESHWATER	FRESHWATER	FRESHWATER

Figure 3. Hypothetical Freshwater–Saltwater Characteristics in the Northwest Fork of the Loxahatchee River during a Tide Cycle.

The relationship between tidal stage and the movement of salt water upstream (**Figure 3**) has important implications for the vegetation community within the floodplain. The vegetation growing along the river embankment at *Site A* would experience constant exposure to salt water, however the concentration would oscillate between oligohaline to polyhaline conditions once every twelve hours with the tidal cycle. *Site B* experiences salt water for most of the tidal cycle with short periods of fresh water during low tide. In contrast, *Site C* is dominated by freshwater conditions with short periods of saltwater intrusion twice a day. During periods of fresh water, salt may be washed from the site before returning on the next tide inflow. The freshwater flow between salinity events may flush out residual salt and there may not be sufficient duration of salinity exposure to allow salt to penetrate the soil substrate. *Site D* vegetation does not experience saltwater conditions throughout the tidal cycle. Based upon this distribution of saltwater concentration, both temporally and spatially, one would expect the plant communities' responses along the river embankment to vary by site.

Using the simplified model of salinity movement presented in **Figure 3**, surface water salinity within the floodplain (adjacent to the river channel) would also be expected to vary throughout the day. Because of the essentially saltwater regime at *Site A*, *Site 1* in the floodplain adjacent to the river would be dominated by saltwater conditions. However, *Site 2* is located close to the edge of the floodplain where groundwater flows may provide sufficient hydrostatic head to maintain a mostly freshwater condition at low tide, but tide inflows between mid and high tides may overflow the soil surface. The floodplain at *Site 5* may experience short-term elevated salinity levels during high tide; however *Site 6* would most likely remain freshwater since there may not be sufficient force or time to penetrate this part of the floodplain before tidal regression begins. Using this understanding of the distribution of saltwater concentration, both temporally and spatially, one would expect the plant community's response within the floodplain to vary both by proximity to the river channel and by distance from the Jupiter Inlet. Additional factors that may influence salinity distribution in the floodplain include ponding of saltwater in low lying areas and surface water depths.

The transient salinity concentrations at *Sites B*, *C* and *2-5* throughout the day (two oscillations between freshwater and saltwater conditions) makes it difficult to relate field observations of vegetation community characteristics with laboratory studies of salinity tolerance. Generally in laboratory studies, a constant salinity concentration is administered to a treatment group through time. It would be expected that intermittent salinity exposure and continuous salinity exposure would not yield the same biological response.

The simplified model of salinity movement presented in **Figure 3** represents conditions expected for a constant freshwater flow from upstream sources. In reality, freshwater flows through the Northwest Fork vary with rainfall in the basin. Also, inputs from tributaries can vary due to local rainfall patterns and water management practices. However, given the very seasonal nature of rainfall within the watershed, it is generally true that during the rainy season (May through October) there is a downstream shift in the freshwater-saltwater regime shown in **Figure 3**. Conversely, during the dry season or extended drought conditions, the freshwater-salinity regime would shift upstream.

Damage to vegetation can result from two different types of salinity exposure: acute and chronic. Calculations of average salinity concentrations and ranges can provide an estimate of the degree of exposure that a vegetation community has experienced over time. These values, however, do not give an accurate representation of the amount of salinity applied to a community. To provide a more reliable characterization of salinity exposure experienced at a site, the magnitude of a salinity event, the duration of a particular salinity event and the amount of time that elapsed between events (recovery period) are needed.

Loxahatchee River Hydrodynamic Model

A hydrodynamic/salinity model was developed to study the influence of freshwater input on salinity conditions in the Loxahatchee River and downstream estuary. The model was also used to predict salinity concentrations at various points in the river and downstream estuary with respect to freshwater inflow rates and tidal fluctuations. The following model description is from SFWMD (2002) and Hu (2002, 2003) (see **Appendix A**).

Model Description

The computer programs used in the development of Loxahatchee River Hydrodynamics/ Salinity Model were RMA-2 and RMA-4, developed by the U.S. Army Corps of Engineers (USACE 1996). RMA-2 is a two-dimensional, depth-averaged, finite-element, hydrodynamic numerical model. It computes water surface elevations and horizontal velocity components for sub critical, free-surface flow in two dimensional flow fields. RMA-2 computes a finite element solution of the Reynolds form of the Navier-Stokes equations for turbulent flows. Friction is calculated with the Manning's or Chezy equation, and eddy viscosity coefficients are used to define turbulence characteristics. Both steady and unsteady state (dynamic) problems can be analyzed. The program has been applied to calculate: (a) water levels and flow distribution around islands; (b) flow at bridges having one or more relief openings; (c) flow in contracting and expanding reaches; (d) flow into and out of off-channel hydropower plants; (e) flow at river junctions; (f) flow into and out of pumping plant channels; (g) circulation and transport in water bodies with wetlands; and (h) general water levels and flow patterns in rivers, reservoirs and estuaries. The water quality model, RMA-4, is designed to simulate the depth-average advection-diffusion process in an aquatic environment. The model is used for investigating the physical processes of migration and mixing of a soluble substance in reservoirs, rivers, bays, estuaries and coastal zones. The model is useful to evaluate the basic processes and to define the effectiveness of remedial measures. For complex geometries, the model utilizes the depth-averaged hydrodynamics from RMA-2. The formulation of RMA-4 is limited to one-dimensional (cross-sectionally averaged) and two-dimensional (depth-averaged) situations in which the concentration is fairly well mixed in the vertical direction. It will not provide accurate concentrations for stratified situations in which the constituent concentration influences the density of the fluid. The preliminary results indicated that the model was able to predict the salinity fluctuation driven by the tide cycle and the influence of freshwater input on the salinity regime in the river.

Modeling Assumptions

Due to a lack of data, various assumptions concerning freshwater inflow were made. Measured flow data was not available after 1991 for Cypress Creek or Hobe Grove Ditch. Therefore, discharges from these tributaries were calculated as a constant fraction of discharge at Lainhart Dam. The percent of total river flow contributed by the Lainhart Dam was estimated in the model as 44 percent. This compares with USGS field measurements, which showed that Lainhart Dam provided about 45 percent of the flow during the 1980–81 drought dry season, 46 percent during the 1980–81 drought wet season, 40 percent during the 1989–90 drought dry season, and 56 percent during the 1989–90 drought wet season. Based on these data, the flow ratio of 44 percent used in the model was determined to be a reasonable estimate of the flow contributed by Lainhart Dam, relative to the other tributaries, during dry periods when the saltwater intrusion concerns are strongest.

Another important model assumption was a constant input from ground water of 40 cubic feet per second (cfs). This estimate was derived from a review of field data obtained from a USGS report (Russell and McPherson 1984) and measured flow/salinity data collected from a dry period in May 1999. From these data it was estimated that each of the four tributaries provide about 10 cfs of groundwater flow to the river during dry periods. The District recognizes that more groundwater flow data would be desirable to confirm the estimate used in the model, but the 40 cfs value currently represents "best available data." The model was calibrated and verified against field data that were collected from January to June of 1999. A comparison of hydrodynamic model output with other shorter-term salinity studies on the Northwest Fork is shown in **Figure 4** (see **Appendix A** for a discussion of these studies). Provisional continuously-sampled salinity data collected since December 2002 indicate that the model output closely matches measured field data. Currently, field studies are underway to collect groundwater and flow data from tributaries for model refinement.

Floodplain Swamp Floristics

Ecological Characteristics of the Floodplain Swamp Forest

Freshwater swamp forest is ecologically valuable for many reasons. Cypress swamps are known to provide habitat to a great diversity of invertebrates (Brightman 1984; McMahan & Davis 1984). McMahan & Davis (1984) found that microarthropod diversity in cypress swamps is large in comparison with that of most other ecosystems. Harris & Vickers (1984) studied vertebrate faunal communities in cypress domes and found that reptile and amphibian species dominate the cypress fauna during the summer and birds dominate the winter vertebrate fauna (year-round residents plus large numbers of northern migrants). They concluded that both the abundance of broad-leaved evergreen plants (e.g., dahoon holly) that bear fruit and the swamp's ability to support active arthropod populations throughout the winter are the probable explanations for this high abundance of birds. In addition, they note that mammals use cypress swamps for refuge sites and many wading birds use them as rookery and roosting sites. Other vertebrates that inhabit cypress swamps include salamanders, frogs, toads, turtles, anoles, glass lizards, skinks, snakes, opossum, shrew, raccoon, river otters, bobcat, squirrels, deer, rabbits, rats and mice. Birds found in cypress swamps include kestrel, herons, ibis, yellow-billed cuckoo, owls, woodpeckers, flycatchers, blue jay, wrens, catbird, gnatcatcher, vireos, warblers, cardinal and sparrows (Harris & Vickers 1984).

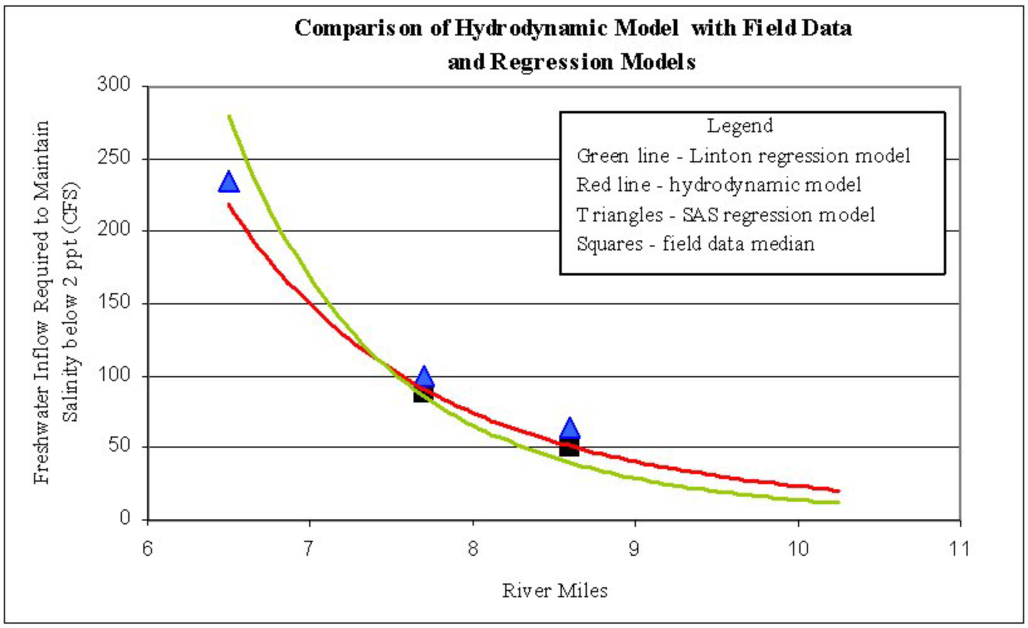


Figure 4. Comparison of Hydrodynamic Model Results with other Salinity Regression Models for the Northwest Fork of the Loxahatchee (see **Appendix A** for a Comparison of Salinity Field Studies).

In closed-canopy forests, little light reaches the forest floor, which suppresses seed germination (photodormancy), reduces growth of seedlings and saplings (photomorphogenic effects and reduction in photosynthesis) and exerts competitive pressure against shade-intolerant species (Salisbury & Ross 1992). The canopy also regulates the microclimate of the forest, controlling humidity, light quality, rainfall distribution and other physical parameters that can have profound influences on plant growth. A listing of species found on the forest floor of cypress swamps reveals an array of shade-tolerant herbs, ferns, shrubs and a few swamp hardwoods (Duever et al. 1984; Ewel 1990; Mitch & Gosselink 2000; Roberts & Woodbury in review). Shade-intolerant species generally persist only in areas of the forest that have a gap in the canopy (e.g., from a tree fall) or along the canopy edge.

Bald Cypress

Bald cypress is the most common wetland tree in Florida and is usually the dominant species in swamps with fluctuating water levels (Ewel 1990). It is a deciduous conifer, losing its needles by the end of November and leafing out again in March. Bald cypress seeds cannot germinate when soils are permanently flooded and although seedlings grow best in saturated but unflooded soils (Dickson & Broyer 1972), they grow too slowly to survive competition with faster growing hardwoods. Seedlings do not survive extended periods of submergence (Demaree 1932; Conner et al. 1986), making successful regeneration of a cypress swamp virtually dependent on regular water level fluctuations. When mature, however, bald cypress is among the most flood-tolerant of all tree species in Florida (e.g., Harms et al. 1980).

Bald cypress forests in Florida can reach formidable heights and ages, and are typically the dominant tree species in seasonally flooded swamps (Ewel 1990). In fact, bald cypress are among the tallest and longest-lived trees native to Florida, some having been reported to almost 165 feet tall and hundreds of years old. Bald cypress are generally sun loving plants. The shade tolerance of bald cypress has not been measured, however seeds often germinate in heavily shaded places but usually do not survive or develop into large trees (Conner et al. 1986; Conner 1988). Although mature bald cypress produce abundant amounts of seeds each year, a mature forest will typically contain few saplings. Recruitment generally occurs only when a large gap opens in the canopy. This species grows slowly in partial shade but best growth occurs with full light (Fowells 1965; Wilhite & Toliver 2000).

Cypress swamps are typically restricted to freshwater areas and a transition zone to another wetland type is usually found along salinity gradients where rivers discharge to an estuary (e.g., Loxahatchee River transition to mangroves, Suwannee River transition to Spartina marsh). Cypress swamps are defined as freshwater wetlands in essentially all literature related to distribution of this community (Good et al. 1978; Godfrey & Wooten 1981; Wunderlin 1982, 1998; Gunderson 1984; Myers & Ewel 1990; Mitsch & Gosselink 2000). Salinity tolerance in bald cypress is not well understood and a review of the scientific literature on the subject reveals scant studies relevant to south Florida that can directly address the issue. Bald cypress is generally considered to be salt-sensitive (Brown & Montz 1986; Pezeshki et al. 1986, 1987), but there is evidence of substantial intraspecific variation in salt tolerance. Pezeshki et al. (1990) and Yanosky et al. (1995) reported that individuals or mature stands of bald cypress have been found at sites exposed to substantial salinity stress where other bald cypress trees have died. Other authors have demonstrated significant intraspecific variability in salt tolerance of bald cypress seedlings (Allen 1994; Allen et al. 1994, 1997; Pezeshki et al. 1995) from areas subject to salinity stress. Results from these studies indicate that in southern Louisiana, which is an extensive coastal wetland system that is impacted by saltwater intrusion from sinking deltas and tropical storm events, some bald cypress have been able to develop some salt tolerance through a prolonged process of natural selection. However, application of results from these studies of coastal Louisiana bald cypress to south Florida populations is difficult. In a general sense, these studies have demonstrated that the salinity concentration needed to induce acute toxicity in coastal Louisiana bald cypress seedlings depends on the seed source and the salinity history of that area. However, a more defined and specific interpretation and application of these findings to south Florida populations would not be appropriate without studies from local seed sources for verification. Furthermore, chronic (long-term) toxicity is not addressed, nor is the effect of salinity on mature cypress trees.

Other Freshwater Swamp Species

Other woody species of the floodplain swamp include cabbage palm (*Sabal palmetto*), dahoon holly (*Ilex cassine*), laurel oak (*Quercus laurifolia*), pond apple (*Annona glabra*), pop ash (*Fraxinus caroliniana*), swamp bay (*Persea palustris*), red maple (*Acer rubrum*), Virginia willow (*Itea virginica*) and water hickory (*Carya aquatica*). These species are significant components of the forest structure in terms of both size and numbers.

Cabbage palm and pond apple are evergreen trees of subtropical origin. Cabbage palm has a fibrous trunk, which can grow into the canopy. Pond apple is typically a sub-canopy species, sometimes stout in stature with a buttressed trunk, which attains heights of more than 20 feet. Both species are abundant along stream and river banks, freshwater ponds, strands and deep slough swamps (Tobe et al. 1998). Seeds of both species are food sources for wildlife, which are an important dispersal mechanism. Pond apple seeds can also be distributed by flowing water. Salinity tolerances for these species have not been established, but they can be found in freshwater tidal wetlands that may experience periodic mild salinity stress.

Laurel oak, pop ash, red maple and water hickory are also significant components of the swamp forest. All of these species are large-stature deciduous or semi-deciduous canopy trees that can reach heights of 40 to 50 feet or more. Unlike laurel oak and red maple, pop ash is typically shorter, multi-trunked and somewhat more crooked in growth. All of these species are typically found throughout central and north Florida in swamps, floodplains, wooded sloughs and pond margins (Tobe et al. 1998). Seeds of laurel oak are eaten and disbursed by wildlife. Seeds of pop ash and red maple are primarily wind disbursed, but are often carried through the floodplain by surface water movement. Salinity tolerance for these species is not reported in the literature, but they are not usually found in coastal wetlands that experience occasional salinity stress. Along the Northwest Fork, water hickory is not found downstream of Trapper Nelson's site.

Dahoon holly and swamp bay are large shrubs to medium-sized evergreen trees (to 30 feet or more) that are typically found in a wide variety of wetland communities, such as stream banks, cypress swamps, wet flatwoods and margins of sloughs (Tobe et al. 1998). Both of these species produce leathery leaves and berries that are used and dispersed by wildlife. Salinity tolerance for these species is not reported in the literature, but they are not usually found in coastal wetlands that experience occasional salinity stress.

Virginia willow is a very common understory shrub that may grow up to 10 feet tall. It is common in cypress and floodplain swamps throughout Florida (Tobe et al. 1998). Growth habit can be spindly and young plants can be overlooked during winter dormancy when they lose their leaves. Salinity tolerance for this species is not reported in the literature, but they are not usually found in coastal wetlands that experience occasional salinity stress.

Red Mangrove

Red mangrove's (*Rhizophora mangle*) most distinctive characteristic is the complex network of "prop roots" that arise from the trunk and "drop roots" from branches. These prop roots only shallowly (a few centimeters) penetrate the soil below the tree. Flowering and fruiting occurs predominantly in spring and summer in Florida (Odum and McIvor 1990). Red mangrove canopies are extremely efficient interceptors of light (Golley et al. 1962), with approximately 95 percent of available light being intercepted within the first four meters of the (mature) canopy, where 90 percent of the leaf biomass is found. Typically red mangrove forests lack an understory (Odum et al. 1982; Janzen 1985; Corlett 1986; Lugo 1986), the result of limiting conditions (shading, salt stress, etc.) (Janzen 1985; Lugo 1986). Propagules of red mangroves have been found to have an obligate dispersal time (period during dispersal for germination to be completed) of approximately forty days (Rabinowitz 1978). However, viable red mangrove propagules have been found floating for more than twelve months (Davis 1940). Root establishment has been estimated at fifteen days (Rabinowitz 1978) in a suitable substrate.

Red mangrove is a tropical species that has only a limited extension into the subtropics. The chief restriction is cold; Rhizophora is killed by frost and cannot survive extended periods of near-freezing temperatures (Tomlinson 1986; Twilley 1998). The exact limits of the latitudinal range of Rhizophora are not precise because populations may be killed in exceptional winters but are subsequently restored by seedlings brought some distance via ocean currents, as occurs in central Florida (Mitsch & Gosselink 2000). In 1962, during the late 1970s and early 1980s a series of short-term severe cold weather events into Florida caused widespread, but uneven, mortality of all mangrove species as far south as West Palm Beach on the Atlantic coast (Odum & McIvor 1990). Generally, mangroves do not occur in regions where the annual average temperature is much below 19°C (66°F) (Waisel 1972). Fluctuations in temperature of more than 10°C (18°F) over short periods of time and below freezing for more than a few hours can cause severe damage (Odum & McIvor 1990). Red mangroves reportedly survived temperatures as low as 2° C to 4° C for 24 hours. Chapman (1976) suggested that three to four nights of light frost are sufficient to kill even the hardiest of mangrove species. Lugo & Patterson-Zucca (1977) hypothesized that soil salinity stress could modify frost stress on mangroves. Low temperature stress leads to damage to tree architecture, causing decreased tree height, leaf area index, leaf size and an increase in tree density (branching). To further complicate recovery following a frost event, reserve buds in red mangrove are known to last no more than three years, so the tree has no capability for sprouting from older wood (Tomlinson 1986).

In Florida, red mangrove attains forest stature (to 75 feet or more) in the relatively frost-free southernmost part of the peninsula in Everglades National Park. The National Wetlands Inventory in 1982 (from Lewis et al. 1985) estimated that 90 percent of mangroves in Florida were restricted to the four southern counties (Lee, Collier, Monroe and Miami-Dade). North of Broward County, red mangrove is often limited in height by frosts that sweep through the region. Red mangrove can be found only as discrete populations or scattered individuals north of Cape Canaveral (Odum & McIvor 1990; Mitsch & Gosselink 2000). In Jonathan Dickinson State Park (**Figure 1**), red mangrove forest height has been restricted and has suffered significant stunting by occasional frost events. A severe frost event in Martin County in early 1980's severely impacted mangroves along the Northwest Fork and restoration of the mangrove canopy took several years (Dick Roberts, Jonathan Dickinson State Park Biologist, personal communication). Severe weather records from Florida, including frost events for south Florida, were reviewed by Hagemeyer & Carney (National Weather Service) and can be found on the Internet: NOAA's National Weather Service Southern Region web site: http://www.srh.noaa.gov/mlb/history/html. Their information indicates that frosts/freezes occur as far south as West Palm Beach approximately every 4–5 years on average. A severe freeze, similar to the one that caused significant damage to the red mangrove community along the Loxahatchee River in the early 1980's, occurred at least five times from 1900–1980's.

Red mangrove swamps are typically restricted to brackish and saltwater areas, and a transition zone to another (freshwater) wetland type is usually found along salinity gradients where rivers discharge to an estuary (e.g., Loxahatchee River transition to bald cypress, Florida Bay mangroves transition to sawgrass marsh in Shark River Slough). Red mangrove swamps are defined as brackish and saltwater wetlands in essentially all literature related to distribution of this community (Godfrey & Wooten 1981; Wunderlin 1982, 1998; Gunderson 1984; Tomlinson 1986; Odum & McIvor 1990; Mitsch & Gosselink 2000). Red mangroves are facultative halophytes, meaning salt water is not required for good growth (Bowman 1917; Egler 1948).

Red mangroves can be successfully propagated in fresh water both in the laboratory and by the nursery industry (Teas 1979); however the red mangrove does not appear to establish communities in natural freshwater systems (Davis 1940; Simberloff 1983; Odum & McIvor 1990; Mitsch & Gosselink 2000). Scattered individuals of red mangroves have been reported from tidal freshwater marsh areas of Everglades National Park, having been carried there as propagules during severe hurricanes in the 1960's. However, despite these introductions of red mangroves into freshwater marshes, they tend to persist without successful reproduction, development of a community or expansion. Several authors note that there has not been found self-sustaining (healthy or reproductive) red mangrove communities surviving in fresh waters, presumably due to their inability to compete with freshwater vegetation (Davis 1940; Simberloff 1983; Tomlinson 1986; Odum & McIvor 1990; Mitsch & Gosselink 2000). One study conducted by Florida International University for the SFWMD in the C-111/Taylor Slough Basin (SFWMD 1996) compared changes in vegetation communities associated with more recent hydrological alterations to freshwater flows along an estuary-freshwater wetland ecotone in southern Florida. This study looked at present day vegetation communities and associated salinity conditions and compared them to earlier surveys conducted by Egler (1952) and Tabb et al. (1968). Between 1940 and 1994, there was an inland migration of salt-tolerant mangrove communities, which replaced freshwater sawgrass communities. This correlated to a time of reduced freshwater flows to this area as a result of construction of several water management/water control projects (e.g., C-111 Canal). The report found "extensive mangrove encroachment" and documented an "advancing wave of replacement of *Cladium jamaicense* (sawgrass)-dominated marsh by low *Rhizophora mangle* (red mangrove) swamp, …(which) signifies an extension of marine and brackish water conditions into formerly freshwater wetlands." The extent of encroachment of red mangroves into freshwater communities was associated with elevated soil salinity concentrations and did not occur in earlier decades when mangrove propagules were likely driven into coastal freshwater marshes by hurricanes.

Salinity-Vegetation Relationships along the Northwest Fork

Recent changes in the historic distribution of freshwater floodplain swamp along the Northwest Fork of the Loxahatchee River have been well-documented. The mechanisms related to this change are not entirely understood, but there is a strong relationship between bald cypress tree die off and increasing levels of salinity within the river (Rodis 1973; Alexander and Crook 1975). To understand the effects of elevated salinity on freshwater floodplain swamp vegetation, two salinity thresholds need to be considered: acute and chronic.

The acute threshold is the salinity level where plants are injured or killed after one or a few exposure events. This may occur during a severe drought or from a surge of seawater pushed upstream during a storm. Under such conditions, areas that are primarily freshwater systems become inundated with salt water. As the magnitude of salinity and duration of exposure increases, the potential for injury or death to freshwater species increases. Effects are often visible within a short time from exposure (i.e., weeks to months).

The chronic threshold is the salinity level where freshwater species are injured or killed after long-term exposure. Unlike the transient drought or storm surge event, this threshold is characterized by continuous or repeated exposure to low-level saline conditions. This exposure has the effect of crippling vital biological functions of the individual, which can lead to developmental deformities, slowed growth rates, reduced canopy or leaf area, increased parasitism and perhaps eventual death. Freshwater species suffering from salt stress are less disease resistant, less competitive ecologically and less capable of producing viable offspring that are capable of regenerating the forest. Effects are usually only visible after a long period of exposure (i.e., months to years). The chronic threshold level is expected to be lower than the acute threshold level. Furthermore, differences in responses between life stages (e.g., mature trees and seedlings) may be significant, with seedlings and saplings usually being more sensitive than established adults.

A primary consideration for protection of the riverine swamp community is the provision of sufficient freshwater conditions and prevention of saltwater intrusion upstream. As more water flows through the river, the saltwater interface is pushed further downstream towards the ocean. Another important consideration is the effect of groundwater discharges and seeps to the river floodplain. Groundwater levels in areas adjacent to the floodplain also influence the inland extent of saltwater intrusion. Typically, the depth at which saltwater intrusion occurs is directly related to the elevation of ground water as shown in **Figure 5.**

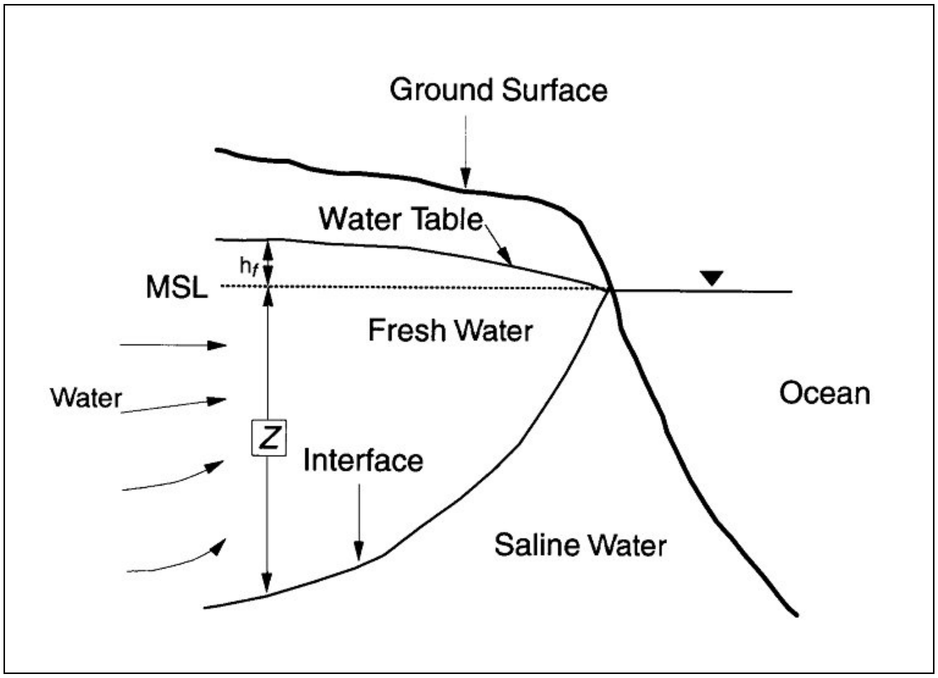


Figure 5. Relationship between Water Table Elevation (h_f) and the Depth below Ground at which Saltwater Intrusion Occurs (Z); as Ground Water Levels Increase, the Depth at which Intrusion Occurs also Increases.

Plant physiology, especially relative to root development, is an important factor that determines the response of a species to salinity. The depth and extent of root systems, and proximity to the edge of the floodplain both influence the potential for impact from elevated saline conditions. Mangroves typically develop shallow networks of roots near the soil surface so these species are more influenced by surface water conditions. Bald cypress and the floodplain hardwoods are more deeply rooted and would be more influenced by subsurface water quality. Established, mature trees near the floodplain-upland ecotone are less affected by river salinity variations, since groundwater seepage from the uplands can maintain a head of freshwater against the saltwater influx, while those near the river channel are more likely to be damaged by periods of increased salinity.

Floodplain Vegetation Studies

A review of the available literature resources was conducted in order to obtain previous field studies along the Northwest Fork. The purpose was to construct a generalized understanding of the pre-settlement and current vegetation of the area. In addition, more recent (past several decades) field studies that focused on the freshwater-saltwater transitional zone are important to document changes that have occurred in the area of greatest interest to river management and restoration efforts.

General Land Office Survey of Township & Range Plats (1855)

Historically, downstream segments of the Loxahatchee River were dominated by freshwater vegetation. The 1855 General Land Office (GLO) Township Plats & Field Survey Notes (GLO 1855) (see **Appendix B)** from the Loxahatchee River (Township 40 S, Range 42 E) contains a single notation of mangroves near the confluence of the North, Northwest and Southwest Forks (the Central Embayment). A description of shoreline vegetation up to the mouth of Kitching Creek is not available. Floodplain swamp vegetation along the northwest side of the confluence of Kitching Creek with the Northwest Fork is described as a swamp containing (red) maple, bay and (pop) ash. Floodplain swamp upstream of Kitching Creek is described as containing bald cypress, cabbage palms, wax myrtle, pop ash and bay.

The distribution of red mangrove downstream of Kitching Creek is not clear from the survey field notes; either they were absent or there was no record made of river shoreline vegetation. Field note descriptions close to the river's embankment downstream of Kitching Creek describe pines, saw palmetto, myrtle and cabbage palms. However, it is clear that mangroves were known to the survey crew, and when appropriate, they were identified in field notes. This survey was conducted before any large-scale alteration of the landscape had occurred, so these field notes offer a glimpse of the pre-drainage and pre-development condition of the local vegetation. Although mangroves were found along the shoreline in the Central Embayment in 1855, they did not appear to have become abundant enough to warrant mention in field notes upstream of that site, even where more detailed notes of species were made.

United States Geological Survey Topographic Map of the Jupiter Area (1949)

A United States Geological Survey (USGS) Rood Quadrangle/Topographic Map of the Jupiter Area (**Figure 6**) indicates that by the early 1940's, mangroves were established in the floodplain just upstream of the mouth of Kitching Creek. The topographic map was published in 1949, but a description on the map indicated that the source data were 1942 and 1945 aerial photography. Comparing this USGS map with the 1855 GLO Field Notes indicates that red mangrove had moved into this upstream area after 1855. Interestingly, the dates of the base aerial photography used to produce this topographic map were from approximately the same period when the first dredging of the estuary occurred (late 1930's through early 1940's), and *before* the permanent stabilization of the Jupiter Inlet (1947) and construction of the C-18 Canal (1957-1958).

Both inlet stabilization and C-18 construction dramatically altered the Loxahatchee estuary by deepening the water body, providing an efficient opening for tidal exchange and effectively diverting freshwater flow away from the NW Fork. Because changes in the extent of saltwater communities occurred before these two major events, it would be unreasonable to correlate the migration of mangroves to this upstream location (8.4 miles upstream from the Jupiter Inlet) with these events. However, a major alteration to the local landscape that may have been responsible for altering river hydrology occurred at the turn of the 20th Century when the Intracoastal Waterway was dredged. The red mangrove community is currently found 9.2 miles upstream of the Jupiter Inlet.

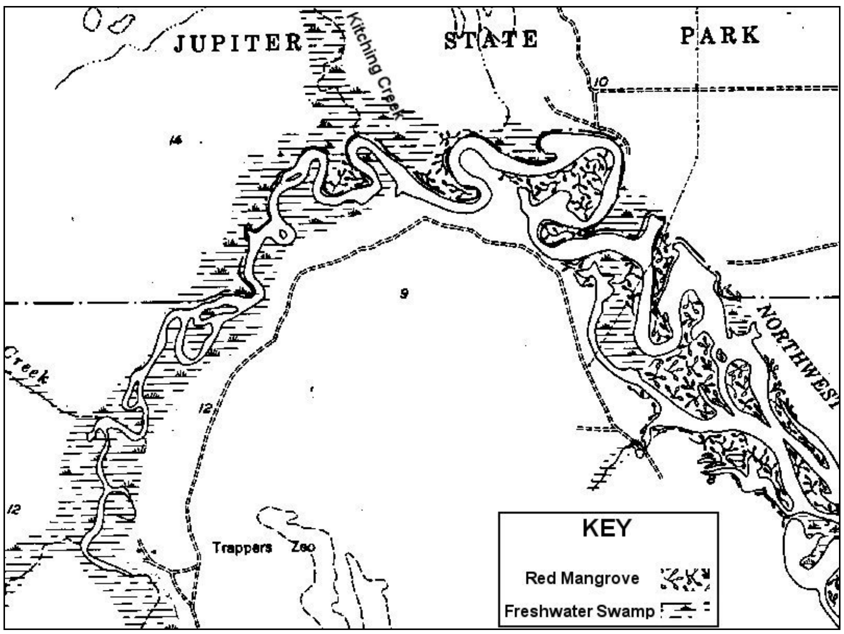


Figure 6. 1949 Map of the Loxahatchee River Area (Source: 1949 USGS Quadrangle Topographic Map; based on 1942 and 1945 Aerial Photography).

Another notable characteristic is the distribution of freshwater wetland and mangrove within the floodplain itself. In transitional areas, freshwater wetland in the floodplain tends to occupy the areas closer to the upland-floodplain ecotone, whereas mangrove tends to be restricted to areas adjacent to the river channel. This observation is consistent with the dispersal mechanism of mangroves (propagules carried into upstream areas under low flow and storm conditions via the river channel) and the dynamics of saltwater movement upstream during tidal cycles.

Alexander & Crook (1975)

Alexander and Crook produced a comprehensive study of the major changes in vegetation that have occurred in South Florida from the 1940's through the early 1970's. This study utilized aerial photographs and ground truthing to examine plant communities along the Northwest Fork of the Loxahatchee River and Kitching Creek. Plant species lists were compiled for sites on the Northwest Fork and Kitching Creek. Areas of living and dead cypress canopy with a mangrove understory were noted in 1970. They concluded that since 1940, prairie and swamp hardwoods had been displaced by pineland and mangrove communities due to a lowering of the groundwater table and invasion of salt water between 6 and 8 miles upstream from the Jupiter Inlet. They were able to identify areas of active logging in the aerial photographs, which could explain the loss of mature trees within portions of the watershed. Also, they mentioned the impact of fire, hurricanes and heavy frost on the major plant communities. At a location 6.5 miles upstream from the Jupiter Inlet, they collected freshwater marsh peat at a depth of 24 inches below the surface. Based on this information, they further concluded that there was no evidence that bald cypress forest had extended much further downstream than this sampling location. Wanless (written communication, 1982) suggested that sites approximately 6 miles upstream from the Jupiter Inlet have experienced brackish conditions for at least the last 4,500 years. Finally, Alexander and Crook (1975) predicted that the mangrove invasion would accelerate, if anthropogenic activities in the upper floodplain of the river further reduced the freshwater head.

Floodplain Transect Study along the Northwest Fork- Various Authors (1984-2002)

A survey of floodplain vegetation along the Northwest Fork was conducted progressively by Worth & Roberts in 1984 (unpublished data), Ward & Roberts (unpublished document, 1996) and then revisited by SFWMD Staff in 2002 (unpublished data). In 1984, Worth and Roberts established six transects perpendicular to the river channel across the floodplain (Ward & Roberts, unpublished document, 1996). These transects stretched along an elevation gradient from the floodplain-upland ecotone to the river channel embankment. Four of the transects were located upstream of the Trapper Nelson site, one was in Cypress Creek just upstream of the confluence with the Northwest Fork, and one was located in the floodplain north of the "Ornamental Gardens" site (**Figure 7**). *Transects #1* through *#4* lie upstream of Trapper Nelson's site where the swamp forest forms a dense canopy over the river and is essentially intact, being too far upstream (and too high in elevation relative to the tide) to have been impacted by salinity intrusion. The Cypress Creek transect (*#5*) is upstream from the Northwest Fork and has not been exposed to chronic salinity. *Transect #6* runs north from the Ornamental Gardens site, a location which has been dominated by red mangrove at least since 1984 (**Figure 7**). Field data from the initial 1984 vegetation surveys along these transects has not been acquired and (to date) has not been published.

In 1993–1994, Ward & Roberts revisited the floodplain transects originally established by Worth & Roberts a decade earlier (Ward & Roberts unpublished document, 1996). Results from that survey are available and provide a characterization of the vegetation community from that time. However, since four of the five transects were located in areas that are not influenced by saltwater intrusion, they are not useful for studying salinity-vegetation relationships. The remaining transect (near the Ornamental Gardens site) was already dominated by red mangrove by 1984, so this site was not useful for monitoring vegetation changes associated with salinity intrusion. In addition to vegetation surveys, a one-time sampling of soil water chemistry was conducted. Unfortunately, no additional sampling has been conducted since then and there has been no continuous or periodic soil or surface water sampling conducted at these sites.

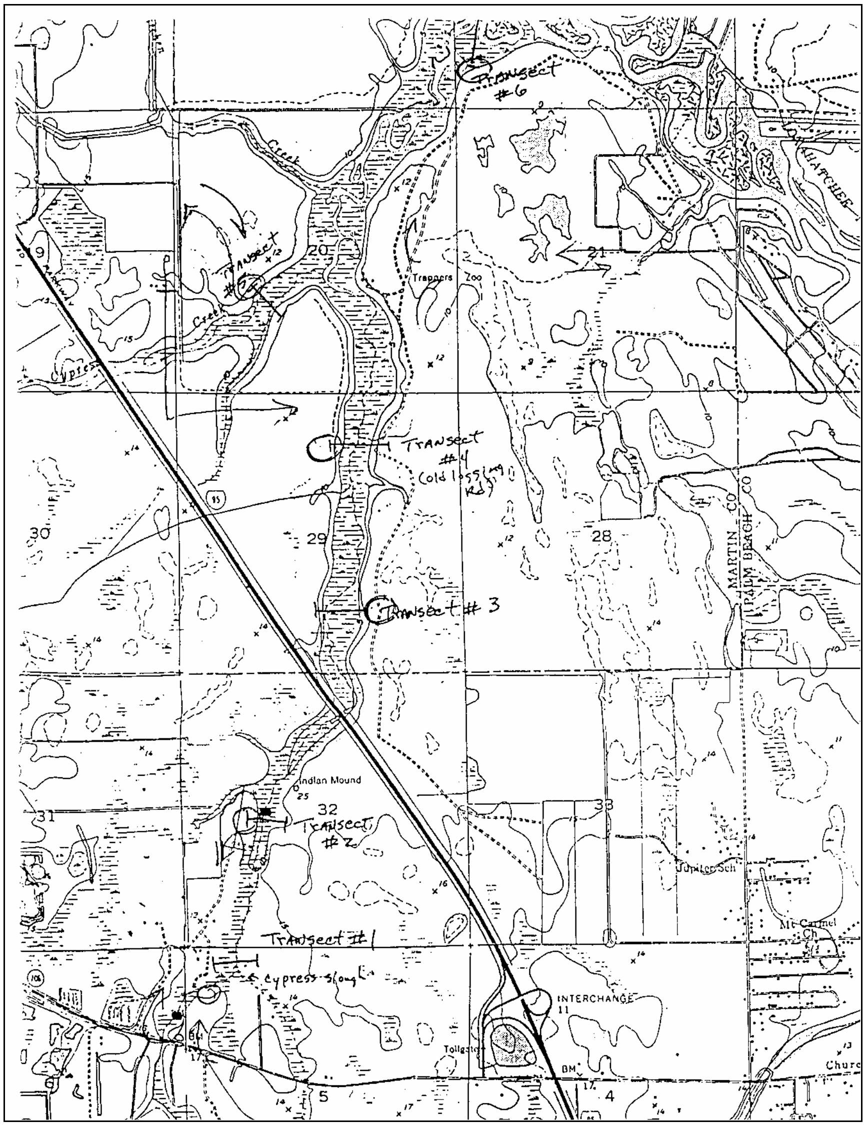


Figure 7. Vegetation Survey Transects Studied by Worth & Roberts and Ward & Roberts (1996); Map from Ward & Roberts Unpublished Document-1996.

In 2002, SFWMD staff revisited some of the original transect sites with Roberts in order to collect soil samples for chemical analysis (SFWMD 2002, Appendix G) and to conduct vegetation surveys. *Transect #4*, located just upstream of the Trapper Nelson site, was resurveyed using the same method as Worth & Roberts (1984, unpublished data) and Ward & Roberts (unpublished document, 1996). These data are useful to monitor vegetation community changes through time, but other applications are limited. The lack of (long term or periodic) environmental, water quality or soil chemistry data for the site precluded the ability to relate observed changes to measured factors. In addition, if a change were detected in the community structure, it would not be possible to determine if it was due to natural variation in forest composition, environmental perturbation or human activities. Because of the displacement of the original vegetation by non-native species along some portions of transects surveyed by Ward & Roberts (unpublished document-1996), the ability to attribute changes in growth parameters of native vegetation to hydrological or water chemistry factors is confounded. As a result of the impact by non-native species and the fact that none of these transects were located in the transitional zone (between wholly fresh water and wholly salt water), efforts to continue vegetation surveys along these transects were discontinued by this project.

U.S. Dept. of the Interior Environmental Impact Statement (1982, 1985)

The Loxahatchee River Wild and Scenic River Study Environmental Impact Statement (EIS) (1985 Final Version and July 1982 Draft Version) includes a narrative description of vegetation changes along the Northwest Fork. Locations along the river have been standardized by the use of the term "river mile". A river mile (RM) location indicates the distance upstream from the Jupiter Inlet, the terminus of the Loxahatchee River, as well as the source of salinity. Please note that the RM locations provided in the EIS are different from those currently used by the SFWMD; the RM locations from the EIS presented in this document have been converted to SFWMD's standard. A generalized vegetation map was included in the EIS (**Figure 8**).

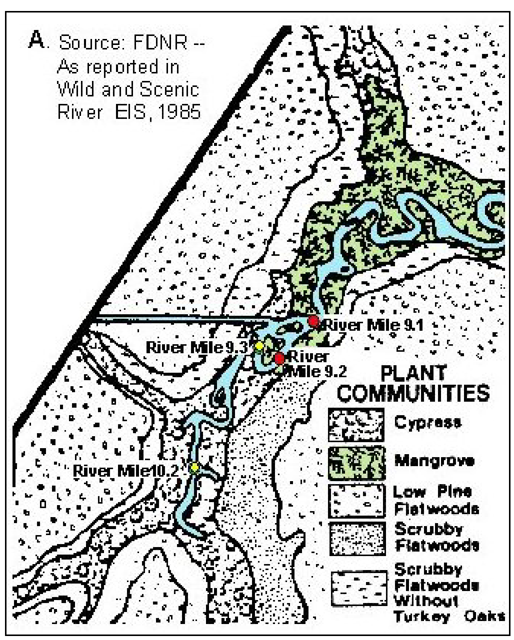


Figure 8. Mid-1980's Vegetation Map of the Northwest Fork of the Loxahatchee River (from USDOI 1985).

A general description of the river segment upstream of Trapper Nelson's site indicates that the historic vegetation community at this part of the river was virtually intact. Downstream of Trapper Nelson's site the character of the river changed dramatically. The EIS document states that the river widens and there is no longer a closed forest canopy overhead. The description continues to say, "the first mangroves begin to appear in this reach of the river. Cypress trees close to Trapper Nelson's appear to be stressed, presumably by salt water. Further downstream, mangroves dominate the river's edge and most of the cypress trees are dead." This description clearly indicates that there were stressed bald cypress trees near Trapper Nelson's site. A photograph taken at (SFWMD) RM 10.1 shows that most bald cypress trees appear stressed (as described by the photo caption) and numerous red mangroves are present along the embankment. In the EIS document section detailing the vegetation changes along the river corridor, the text indicates that the cypress-river swamp ended at approximately (SFWMD) RM 9.5. Here there is mention of towering dead bald cypress trees amid dense mangroves along that section of the river. Furthermore, a photograph taken at (SFWMD) RM 9.5 is provided that clearly indicates a shoreline of red mangrove, dead mature bald cypress, as well as bald cypress saplings.

METHODS

In this section the methods used to collect supporting data for development of the SAVELOX model are presented. This includes generating a long-term salinity time series using the hydrodynamic salinity model for the Loxahatchee River, field studies to collect adequate vegetation data of the appropriate type and analysis used to determine salinity-vegetation relationships.

Development of a Long Term Salinity Time Series

Long-term, continuous salinity records (e.g., 30 years of data) were not available for the river. The record of salinity measurements is sporadic. Samples have been collected occasionally, and sometimes intensively, over the last 25 years in conjunction with special studies (e.g., Birnhak 1974; Russell and McPherson 1984; Law Environmental 1991). Since 1992, the Loxahatchee River Environmental Control District (LRECD) has monitored salinity (and other parameters) at 29 stations in the watershed twice each month in conjunction with routine water quality monitoring efforts. In addition, the LRECD has established continuous salinity recording stations at various locations and times in the river.

Because changes in floodplain community structure have occurred gradually over decades, a method to generate an estimated time series of "historical" salinity was developed as a means to relate salinity and vegetation community changes through time. A long-term (30 year) daily salinity time series was estimated using current (1994–2000) flow/salinity relationships developed for the Northwest Fork and long-term (30 year) historical flows from Lainhart Dam using the RMA-2/RMA-4 hydrodynamic salinity model (USACE 1996). The model was developed specifically for the Loxahatchee River using methods described in Hu (2002, 2003) (see **Appendix A**).

A 30-year period of record (POR) of mean daily salinity, which extended from April 1971 through January 2001, was simulated for each of seven sites (**Table 1**). The simulated salinity value from the hydrodynamic model is based on a daily average of the water column salinity at a point along the river. Salinity within the river channel at a site is not homogeneous, but rather is stratified so that when the "average" salinity is 1 part per thousand (ppt), river bottom salinity may be 2–3 ppt, while river surface salinity may be near 0 ppt. Model output will read as 1 ppt average salinity for that location, so selection of a 1 ppt threshold will encompass the range of salinity from freshwater at the surface to more saline water that can cause potential impacts to freshwater organisms (2-3 ppt) at the river bottom. A model output value of 1 ppt can be interpreted as the predicted point where salinity from the estuary (i.e., above background levels) has reached a particular river location.

Table 1. Sites along the Northwest Fork of the Loxahatchee River where Long-Term Mean Daily Salinity Time Series were Simulated.

Site Name	Site Location
Vegetation Site 7C	River Mile 7.8
Vegetation Site 8B	River Mile 8.4
Vegetation Site V6	River Mile 8.6
Vegetation Site 8D	River Mile 8.9
Vegetation Site 9B	River Mile 9.2
Vegetation Site 9C	River Mile 9.7
Vegetation Site 10B	River Mile 10.2

From the salinity time series, descriptive statistics (mean, standard deviation, median, mode and maximum daily salinity concentrations) were calculated for each site. Other analyses included calculation of the percent of time that salinity was equal to or above a particular threshold value (1 ppt, 2 ppt, 3 ppt, 4 ppt), and the mean salinity event duration and the mean time between salinity events (i.e., salinity event analysis).

A salinity event analysis grouped the simulated salinity data from a site into periods when salinity equaled or exceeded a particular threshold value. For example, at a threshold of 2 ppt or greater, a salinity event was defined as the number of continuous days that the simulated salinity time series was at or above this value. The mean number of days (duration) of each salinity event (*Ds*) and the mean number of days between events (*Db*) at each site (**Table 1**) were derived for the POR. Salinity conditions at a site were expressed in terms of *Ds* and *Db* for a minimum threshold value in order to relate it to vegetation community characteristics. In terms of potential effects of salinity exposure on freshwater vegetation, the magnitude (concentration) and duration of exposure to salinity is related to the extent of damage to the freshwater community caused by that exposure (Pezeshki et al. 1986, 1987, 1990, 1995; Conner & Askew 1992; Allen 1994; Allen et al. 1994, 1997). The time between salinity events is also important to allow recovery from the last damaging salinity event.

For this analysis, a unique ratio of the salinity event duration and time between events (*Ds/Db*) was created as the preferred metric to relate to vegetation community parameters. The advantage of this approach is that a single numeric value can be used to express the salinity characteristics at a specific site, which reduced the number of factors in the analysis. The use of average, median or mode salinity concentration at a site fails to take into account the variable nature of salinity experienced by vegetation along the Northwest Fork. Event duration and time between events can be expressed in any time scale (days, weeks, months), however in our application we have used days as the standard unit of measure for this ratio. A *Ds/Db* ratio of 1 indicates that half of the time average daily salinity at a site is at or above the selected threshold. *Ds/Db* ratio values that are increasingly larger than 1 indicate more predominantly saltwater conditions at a site. This ratio decreases consistently as one travels upstream from the Jupiter Inlet and becomes zero as constant freshwater conditions are observed. For this reason, the *Ds/Db* ratio was used as a general index of salinity at a given location along the river.

Field Vegetation Surveys

Surveys of the floodplain swamp vegetation (vascular macrophytes) along the Northwest Fork of the Loxahatchee River (Northwest Fork) were conducted to characterize species and community changes that occur along the salinity gradient upstream from the Jupiter Inlet and Central Embayment. These surveys provided both community-based (i.e., canopy structure, community composition) and species-based (i.e., abundance, number of individuals, height, trunk diameter, age class) information which were useful for gauging the "health" of the freshwater community and to measure biological change along the salinity gradient. Two methods of vegetation surveys were used; a semiquantitative method provided a more generalized view of the local community and a quantitative method gave more detailed information about selected species at a site.

Semiquantitative Vegetation Survey

A semiquantitative vegetation survey method, suitable for statistical analysis, was used to examine community-wide changes along the Northwest Fork of the Loxahatchee River. This method was used primarily because it: 1) could be completed rapidly, allowing more sites to be surveyed in the time available; 2) was not labor intensive; 3) provided a reliable and generalized perspective of the distribution of species; 4) and was comprehensive in scope. Sixteen sites (labeled 5B through 10C) were surveyed in November 2000 and seven additional verification sites (labeled V1 through V7) were surveyed in December 2001 (**Figure 9**). Ten additional sites were surveyed along Kitching Creek during the 2000 survey. The Kitching Creek sites are useful to compare with the Northwest Fork sites because both have had a similar history of salinity intrusion.

Site locations were not randomly dispersed along the river corridor, but instead were based on the following criteria to eliminate some unevenly distributed factors that could influence plant community distribution:

- Vegetation survey sites were located more than 100 feet from a river bend or oxbow to reduce potential effects of shifting currents, riverbank dynamics and river flow energy on vegetation community composition.

- Vegetation survey sites were located at or near the center of the river's floodplain and at least 100 feet away from the floodplain-upland transitional zone to reduce the possible influence of freshwater seeps on vegetation community composition.

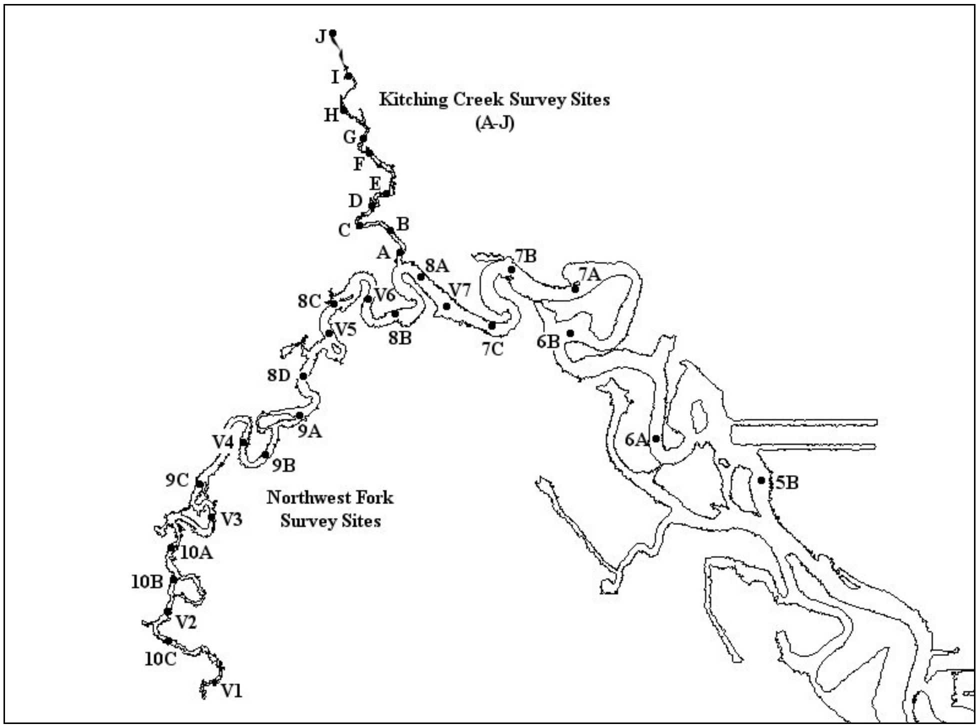


Figure 9. Location of Semiquantitative Vegetation Survey Sites along the Northwest Fork of the Loxahatchee River and Kitching Creek.

Vegetation was examined within an area of approximately 400 feet (122 meters) by 50 feet (7.5 meters) along each river bank at a site. All vascular plant (macrophyte) species present were identified and an estimated abundance index for floodplain species (excluding aquatic and epiphytic species) was recorded. An abundance index was determined from a dichotomous key that categorized a species' abundance or cover into classes (**Figure 10**). This method follows a modified version of the Braun-Blanquet cover-abundance scale (Braun-Blanquet 1932, 1965; Mueller-Dombois & Ellenberg 1974; Bonham 1989). This information was used to investigate general vegetation trends along the river that may be associated with different salinity conditions. The information was also used to indicate "key" species of interest, which were more intensively sampled by quantitative survey methods.

Quantitative Vegetation Survey

A quantitative vegetation survey was conducted along the Northwest Fork of the Loxahatchee River in January 2002. Nine sites that were previously surveyed by the semiquantitative method (see previous section) were re-surveyed (**Figure 11**). Due to time constraints, site V3 was only partially surveyed, so data collected there was limited. These sites allowed for comparison of these results with those of the semiquantitative method and for relating quantitative vegetation parameter data to the long-term salinity time series. At each sampling site, two strip quadrats (belt transects) were established, one along each opposite shoreline. Each strip quadrat was 100 feet (30 meters) by 25 feet (7.5 meters), covering a combined area of 5000 square feet (465 square meters). The selected area of each strip quadrat was larger than that typically used to estimate density in tree communities (Bonham 1989).

Description of Species Population Density	**Abundance Index**
1a. Species not present	0
1b. Species present.	
2a. Two or less individuals; rare	1
2b. More than two individuals.	
3a. Highly abundant or dense population (>75% cover), a dominant component of the plant community	4
3b. Species not a dominant component of the plant community.	
4a. Sparse; widespread and of low density or restricted to localized populations	2
4b. Common; widespread and of moderate density but not a dominant component of the plant community (<50% cover)	3

Figure 10. Abundance Index Key used in the Semiquantitative Vegetation Surveys.

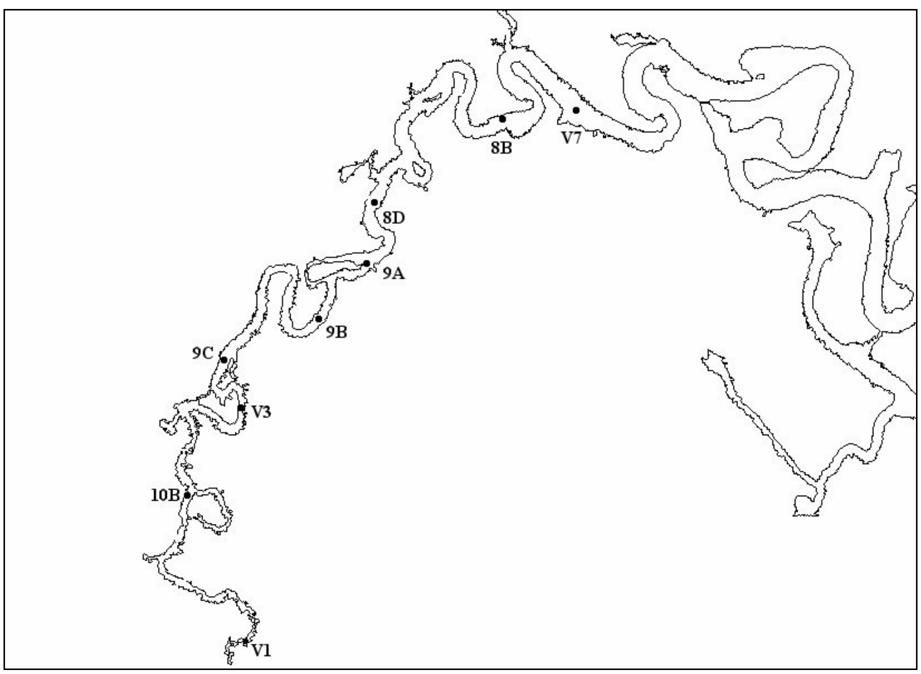


Figure 11. Location of Quantitative Vegetation Survey Sites along the Northwest Fork of the Loxahatchee River.

At each of the nine sites, parameters listed in **Table 2** were measured and recorded for different age classes of "key" species within a sampling plot. Age classes were defined as adults (mature), saplings (juvenile taller than breast height but shorter than canopy height), seedlings (juveniles shorter than breast height) and stump sprouts (damaged adults that were resprouting from a trunk). Tree height was estimated using a hypsometer method (BSA 1967; Bonham 1989); the estimator was located at a fixed distance from the tree and used the hypsometer tree scale to estimate the tree height.

Table 2. Measured Parameters* for Key Species.

	Adults	**Saplings**	**Seedlings**	**Stump Sprouts**
Number of Individuals	X	X	X	X
Canopy Diameter	X	X		X
Tree Height	X	X		X
Trunk Circumference (used to calculate DBH)	X	X		X (cumulative)

DBH= trunk diameter at breast height

*A discussion of the methods and importance of these parameters in forest studies can be found in Mueller-Dombois & Ellenberg 1974, Bonham 1989

Mean tree canopy diameter (average of shortest and longest) and trunk circumference at breast height were measured with a tape measure. Tree canopy diameter was used to calculate tree cover area as:

$$\text{Cover} = [(\text{canopy diameter})/2)^2]\pi$$

Tree canopy cover could, in some cases, exceed 100 percent of the survey area because multiple strata of leaf cover at different heights above the forest floor are possible within the forest structure. The cumulative tree canopy cover for tree height classes was used to examine vertical distribution of the canopy cover and its changes associated with salinity conditions. The tree diameter at breast height (DBH) was calculated from the measured trunk circumference as follows:

$$\text{DBH} = (\text{tree circumference at breast height})/\ \pi$$

Due to time limitations, difficulty in accessing sites and uncertainty in defining functionally individual plants, counts of red mangrove were not conducted at sites where it was the dominant vegetation species. Instead, an estimate of the number of adults (i.e., 200) was used, based on the average canopy cover (25 square feet) of measured adults at other sites and plot size (5000 square feet total/ 25 square feet per adult =200 adults).

"Key" species were defined by results of the semiquantitative survey and a corresponding literature review to represent different salinity tolerances. They also have physiological characteristics that play important functional roles in the forest ecology and that make them useful as indicators of long-term salinity conditions. The criteria for selection of key species are as follows:

1. Species that are significant components of the local riverine swamp community in terms of abundance and physical forest structure. This criterion was intended to exclude minor (rare) species and to avoid variation due to uneven distribution of populations.

2. Terrestrial species that are rooted in the soil. This excludes aquatics, which may reflect only short-term (transient) salinity conditions.

3. Species that are relatively long lived (generally woody or tree species) are more reliable indicators of long-term conditions. Herbaceous species were excluded as they typically have shorter life spans (less than several years).

4. Species that have different functional roles in the freshwater swamp. A decline in one or more of these functional roles can have ecological consequences, such as impacts to wildlife.

5. Species that are abundant producers of differing seed types that are readily dispersed throughout the area. This helps to ensure that an observed decline in seedling or sapling numbers is not related to species-specific dispersal characteristics.

6. Species that represent a range of saltwater tolerance and sensitivities. This characteristic will help to document the range of salinity conditions and changes along the Northwest Fork.

Information gathered from the semiquantitative vegetation survey indicated that ten species would fit the criteria described above. These species are listed in **Table 3** along with their relative salinity tolerances obtained from a review of the available literature.

Statistical Analysis of Field Data

Data from the vegetation surveys were examined for trends by calculating descriptive statistics (mean, standard deviation, median and mode). Regression analysis (including determination of significance) was used to correlate salinity with distance from the Jupiter Inlet, measured vegetation parameters and species richness. All analyses were conducted using the SAS Statistical program package.

Table 3. Key Species Identified along the Northwest Fork of the Loxahatchee River.

Species	**Saltwater Tolerance**
Bald cypress (*Taxodium distichum*)	Freshwater to slight salt tolerance[a]
Cabbage palm (*Sabal palmetto*)	Freshwater to slight salt tolerance[b]
Laurel oak (*Quercus laurifolia*)	Freshwater[c]
Virginia willow (*Itea virginica*)	Freshwater[c]
Dahoon holly (*Ilex cassine*)	Freshwater[c]
Pop ash (*Fraxinus caroliniana*)	Freshwater[c]
Pond apple (*Annona glabra*)	Freshwater[c]
Swamp bay (*Persea palustris*)	Freshwater[c]
Red mangrove (*Rhizophora mangle*)	Salt tolerant[c]
Red maple (*Acer rubrum*)	Freshwater[c]

[a]Pezeshki et al. 1986, 1987, 1990, 1995; Conner 1992; Javanshir & Ewel 1993; Allen 1994; Allen et al. 1994, 1997

[b]Cabbage palm is generally associated with freshwater and coastal habitats, Johnson & Barbour 1990.

[c]Tobe, et al. 1998, which is primarily a plant identification manual that gives generalized habitat descriptions of where species are naturally found rather than specific salinity tolerance of the species listed in the table; this reference is provided since studies of salinity tolerances for these species have not been found in the literature

Salinity-Vegetation Relationships and Development of a Model

Salinity-vegetation relationships were examined using vegetation survey data and estimated long-term salinity conditions for specific sites along the Northwest Fork. The change in values of a vegetation parameter along the salinity gradient often produced a graphic that can best be described by **Figure 12**. At one end of the gradient the parameter (*Segment 1*) is at a fixed maximum value, except for natural variation around a mean. At the other end of the gradient (*Segment 3*), the parameter is at a minimum value (usually zero value or absent from the site). Between *Segments 1* and *3*, the decline in the parameter's value is usually incremental (*Segment 2* in **Figure 12**). Because the rate of decline in *Segment 2* is typically consistent, the values along this slope can usually be described by a linear equation.

Where sufficient numerical data were available for measured vegetation parameters and estimated long-term salinity conditions, formulas were developed to describe these relationships and a deterministic regression model was used to predict (extrapolate) vegetation community parameter values based on salinity. The model formulas were based on the correlation between measured vegetation parameters (i.e., abundance, canopy cover, etc.) and the salinity ratio *Ds/Db* at those sites where both computed salinity and vegetation survey data existed.

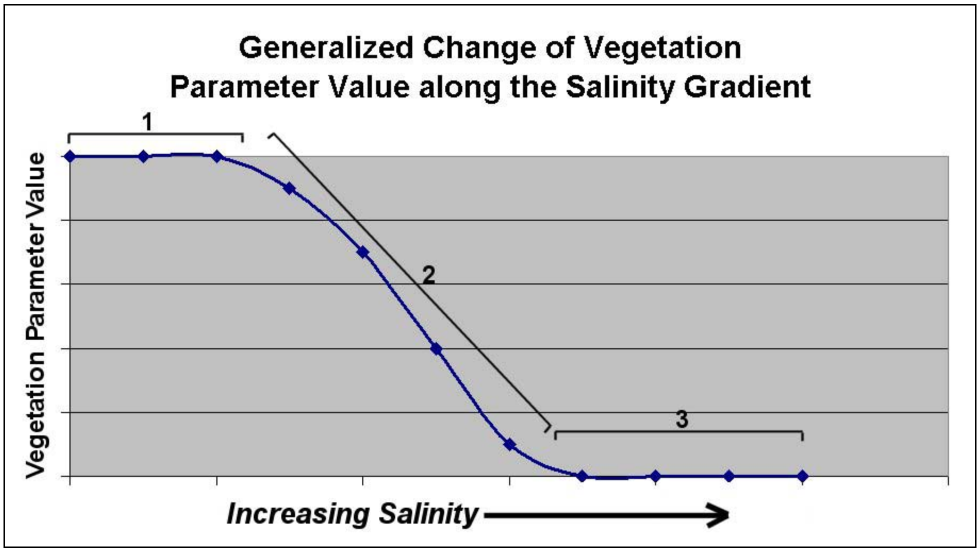


Figure 12. Generalized Pattern of Change in a Freshwater Species Vegetation Parameter Value along the Salinity Gradient of the Northwest Fork.

The SAVELOX Model was developed in an MS Excel workbook. Formulas describing the relationship between salinity and selected vegetation parameter values were derived for the species listed in **Table 4**. The species included in the model were limited to those with sufficient data to allow reliable statistical analysis and whose distribution was correlated with the salinity gradient. Calculations of predicted vegetation parameter values associated with an input freshwater-salinity regime are carried out on a separate spreadsheet for each species and the results are displayed in a linked user-input spreadsheet. A flow chart outlining the general model process is shown in **Figure 13**.

Table 4. Vegetation Parameters and Species Included in the SAVELOX Model.

	Abundance Index	Number of Adults[1]	Canopy Cover[1]
Bald cypress	X	X	X
Cabbage palm	X		
Dahoon holly	X	X	X
Pond apple	X	X	X
Pop ash	X	X	X
Red mangrove	X	X	X
Red maple	X	X	X
Virginia willow	X	X	

[1]Expected within a strip quadrat covering an area of 5000 ft^2 (465 m^2)

User input consisted of a salinity event duration (*Ds*) and duration of time between events (*Db*) at a specified salinity threshold (e.g., 2 ppt), which is used to calculate a predicted vegetation parameter value. Output is displayed in tabular and graphical formats. An additional input field for "River Mile" was added to display the current vegetation parameter values for select species at a specified location along the Northwest Fork.

Verification of these relationships and their ability to accurately predict intermediate values were conducted by comparing predicted values with those from verification sites that were not used in formula development**. Table 5** shows the sites used to derive model formulas and the sites used for model verification.

In general terms, flows in the Northwest Fork can be grouped into three distinct periods– each of which is approximately a decade in length (**Figure 2**). The period from 1971 through 1981 is characterized by a series of below-average rainfall and corresponding low flows. During the period from 1981 though 1991, rainfall was closer to average and improvements to the G-92 allowed enhanced freshwater deliveries to the Northwest Fork. Between 1991 and 2001, the combination of above-average rainfall and operational improvements led to a significant increase in freshwater flows to the Northwest Fork. With increased flows is a reduction in saltwater intrusion and likely associated changes to floodplain vegetation. SAVELOX model output was used to examine the potential shift in vegetation associated with each of these periods. Input consisted of a *Ds/Db* ratio, which was calculated for each of the three decades from the long-term salinity time series.

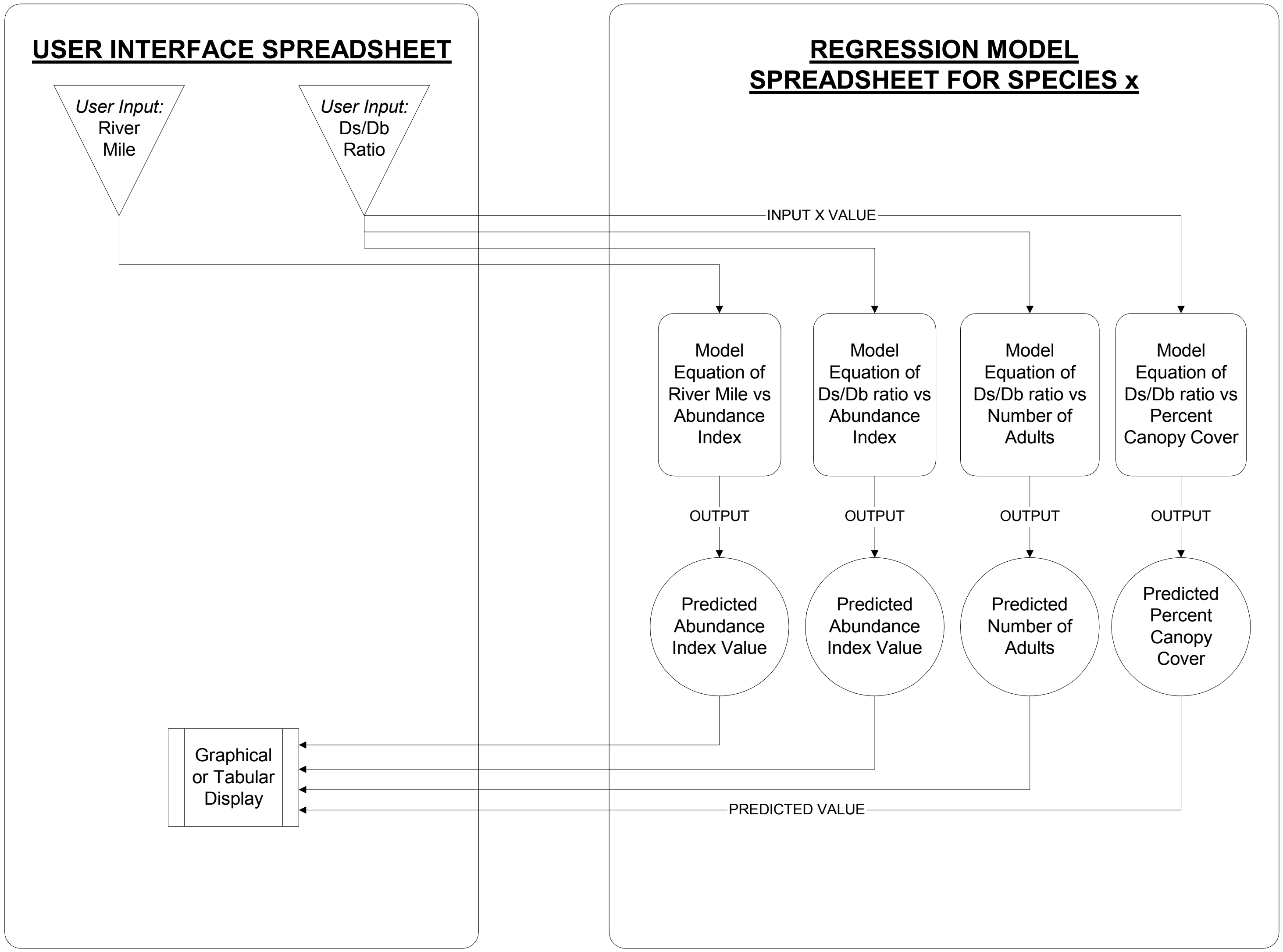


Figure 13. Flow Chart of SAVELOX Model Structure.

Table 5. Loxahatchee River Sites Used to Derive Model Formulas.

Site Name (River Mile)	**Data Types**			**Application**		
	Semiquantitative Vegetation Data	**Quantitative Vegetation Data**	**Estimated Salinity**	**Vegetation Trends**	**Salinity-Vegetation Relationships**	**Model Verification**
Site 5-B (RM 5.6)	X			X		
Site 6-A (RM 6.2)	X			X		
Site 6-B (RM 6.8)	X			X		
Site 7-A (RM 7.3)	X			X		
Site 7-B (RM 7.5)	X			X		
Site 7-C (RM 7.75) WQ Station 64	X	X	X	X	X	
Site V-7 (RM 8.0)	X	X				X
Site 8-A (RM 8.1)	X			X		
Site 8-B (RM 8.4)	X			X	X	
Site V-6 (RM 8.6) WQ Station #65	X		X			X
Site 8-C (RM 8.7)	X			X		
Site V-5 (RM 8.8)	X					X
Site 8-D (RM 8.9)	X	X	X	X	X	
Site 9-A (RM 9.1)	X	X		X		
Site 9-B (RM 9.2)	X	X	X	X	X	

Table 5. (Continued) Loxahatchee River Sites Used to Derive Model Formulas.

Site Name (River Mile)	Data Types			Application		
	Semiquantitative Vegetation Data	Quantitative Vegetation Data	Estimated Salinity	Vegetation Trends	Salinity-Vegetation Relationships	Model Verification
Site V-4 (RM 9.35) WQ Station 66	X					X
Site 9-C (RM 9.7)	X	X	X	X	X	
Site V-3 (RM 9.9)	X	X*				X
Site 10-A (RM 10.1)	X			X		
Site 10-B (RM 10.2)	X	X	X	X	X	
Site V-2 (RM 10.3)	X					X
Site 10-C (RM 10.4)	X			X		
Site V-1 (RM 10.5)	X	X	X			X

* data set incomplete and not used in analysis

RESULTS

Development of a Long Term Salinity Time Series

In 2002, the South Florida Water Management District (SFWMD) established a minimum freshwater flow for the Northwest Fork of the Loxahatchee River (SFWMD 2002). As part of that effort, a hydrodynamic salinity model was developed for the Loxahatchee River and Estuary (Hu 2002, 2003) (see **Appendix A**). Using this model and historical flow data for Lainhart Dam and other tributaries that drain into the Northwest Fork, the mean daily salinity concentrations at seven sites (**Table 1**) along the Northwest Fork were estimated. An example of model output for two stations, RM 10.2 and RM 9.2, are shown in **Figure 14**. The summary statistics from the result of this model output are shown in **Table 6**.

In order to express long-term salinity conditions at a site in terms of influence on the vegetation community, salinity was expressed as the mean event duration (*Ds*) and time between events (*Db*). **Table 7** shows the duration of salinity concentrations at or above several selected threshold values for the modeled period of record. **Table 8** shows the mean duration of salinity events and the mean time between salinity events at or above the selected threshold values for the modeled period of record. The salinity event ratio *Ds/Db* (1 ppt threshold) showed a highly significant ($p < 0.0001$) negative correlation ($r^2=0.997$) with distance from the Jupiter Inlet (**Figure 15**). As one moves upstream, the *Ds/Db* ratio approaches zero as fewer salinity events occur. In contrast, the *Ds/Db* ratio exceeds one and rapidly increases downstream as the magnitude and duration of each salinity event increases, and the time between salinity events decreases. Use of the *Ds/Db* ratio afforded a closer "fit" to salinity conditions than would have been provided by the use of standard descriptive statistics (compare **Tables 6 and 8**). The influence of salt water on vegetation at a fixed site in a tidally-influenced system is more complex than examination of average or maximum values for a period of record.

Vegetation Survey Results

Semiquantitative Vegetation Survey

A semi-quantitative survey was conducted in November of 2000 and December of 2001 to examine community-based vegetation changes along the Northwest Fork of the Loxahatchee River. Field data from these surveys are presented in **Appendix C**.

A total of 76 species were recorded at vegetation survey sites. Species that showed consistent trends associated with distance from the Jupiter Inlet were noted for further study by the quantitative survey method. Species that showed patchy or inconsistent distribution, or were found at low abundance were not included in further analysis.

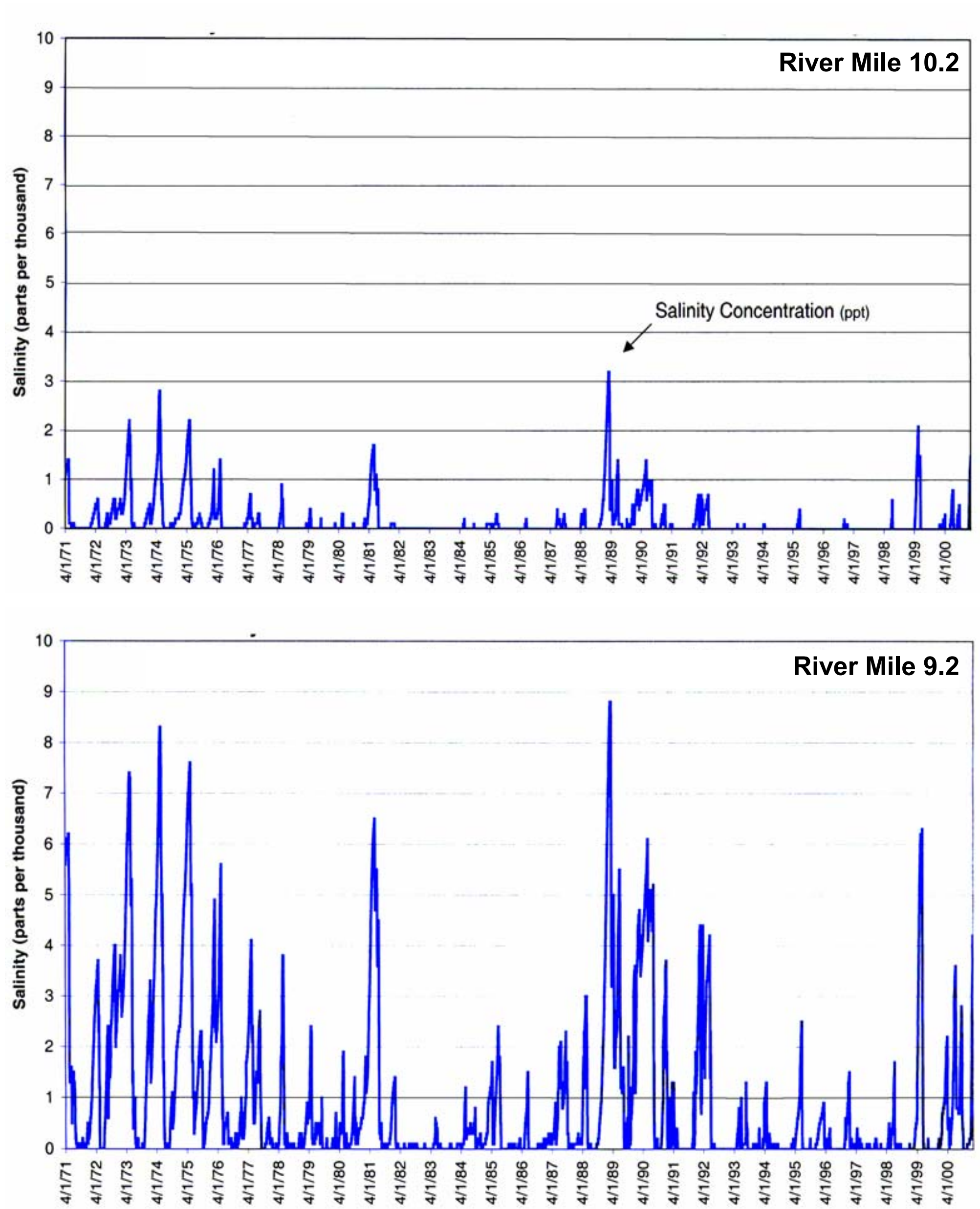


Figure 14. Simulated Salinity Time Series Generated from the Hydrodynamic/Salinity Model Developed for the Loxahatchee River Showing the Estimated Mean Daily Salinity at River Miles 10.2 and 9.2, Northwest Fork of the Loxahatchee River.

Table 6. Summary Statistics of the Estimated Mean Daily Salinity Concentrations for the 30 Year Period of Record.

Site Name	River Mile	Daily Salinity			
		Mean ± St. Deviation	Median	Mode	Maximum
7-C	7.8	6 ± 5	5	0	21
8-B	8.4	4 ± 4	2	0	18
WQ Sta. #65	8.6	3 ± 3	1	0	16
8-D	8.9	2 ± 3	1	0	14
9-B	9.2	1 ± 2	0	0	9
9-C	9.7	0 ± 1	0	0	6
10-B	10.2	0 ± 0	0	0	3

Table 7. Duration of Estimated Mean Daily Salinity Concentrations from the 30 Year Period of Record for Several Selected Threshold Values at Sites along the Northwest Fork.

Site	River Mile	Number of Days (Percent of Time) at or above Threshold			
		≥ 1 ppt	≥ 2 ppt	≥ 3 ppt	≥ 4 ppt
7C (#64)	7.8	9252 (84.9%)	7913 (72.6%)	6689 (61.4%)	5831 (53.5%)
8B	8.4	7038 (64.6%)	5496 (50.4%)	4613 (42.3%)	3873 (35.5%)
WQ #65	8.6	5870 (53.9%)	4562 (41.9%)	3666 (33.6%)	3013 (27.6%)
8D	8.9	4525 (41.5%)	3297 (30.3%)	2497 (22.9%)	1959 (18.0%)
9B	9.2	3071 (28.2%)	1953 (17.9%)	1297 (11.9%)	834 (7.7%)
9C	9.7	1870 (17.2%)	906 (8.3%)	418 (3.8%)	161 (1.5%)
10B	10.2	568 (5.2%)	113 (1.0%)	14 (0.1%)	0 (0.0%)

Table 8. Mean Salinity Event Duration (days) and Time between Events (days) Based on Estimated Mean Daily Salinity along the Northwest Fork of the Loxahatchee River.

Site	**River Mile**	**Mean Duration (*Ds*) and Time Between (*Db*) Salinity Events**							
		≥ 1 ppt		**≥ 2 ppt**		**≥ 3 ppt**		**≥ 4 ppt**	
		Ds	***Db***	***Ds***	***Db***	***Ds***	***Db***	***Ds***	***Db***
7C (#64)	7.8	157	14	76	20	50	26	44	33
8B	8.4	83	23	49	39	52	62	48	77
WQ #65	8.6	67	30	68	70	58	85	56	111
8D	8.9	54	52	47	90	46	130	37	144
9B	9.2	55	143	46	207	45	344	41	504
9C	9.7	38	189	40	455	34	874	20	1800
10B	10.2	31	576	22	2157	13	10899	-	-

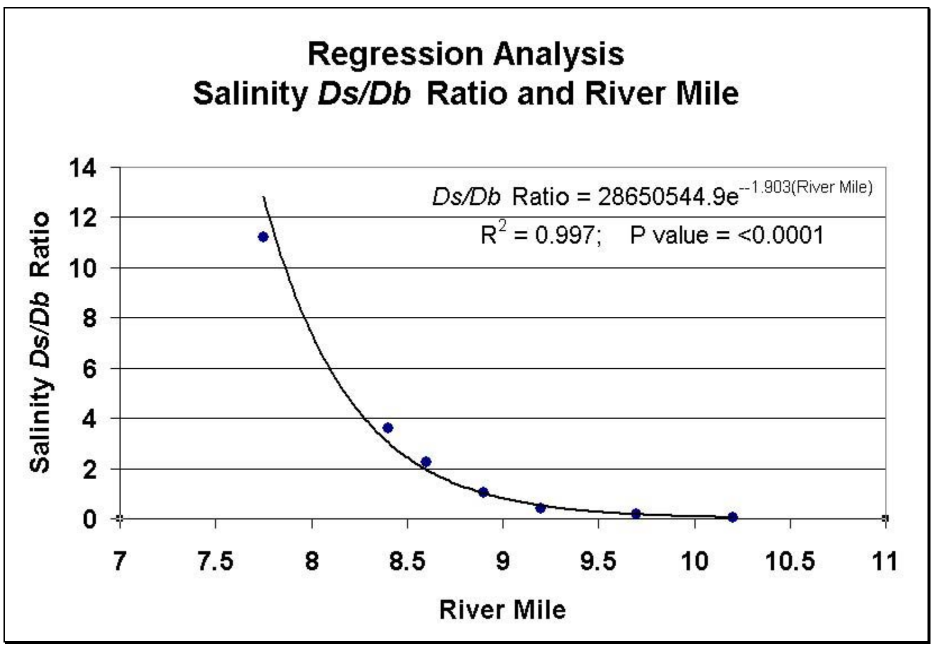


Figure 15. Correlation between Salinity Event Ratio *Ds/Db* (>1 ppt) and River Mile.

Species Richness at Survey Sites

Results from the November 2000 semiquantitative vegetation survey are shown in **Figure 16**. The second (2001) semiquantitative vegetation survey, which examined sites intermediate to those studied in 2000, indicated a higher total number of species. Statistical analysis revealed a strong relationship between the distance from the Jupiter Inlet (the source of salinity to the Northwest Fork) and the number of species observed at survey sites, as well as the abundance of dominant floodplain swamp species. The differences in number of observed species could be accounted for by differences in weather patterns. The previous growing season (1999–2000) represented a drought period, whereas 2001 was a normal rainfall year that had relatively warm weather until December. A summary of the regression analysis for the semiquantitative survey is shown in **Table 9**. These data indicate that a) observed vegetation trends were consistent in both the 2000 and 2001 surveys; b) the number of species increased as a function of distance from the inlet; c) the trend was consistent in both the Northwest Fork and Kitching Creek; and d) the number of species was correlated with salinity.

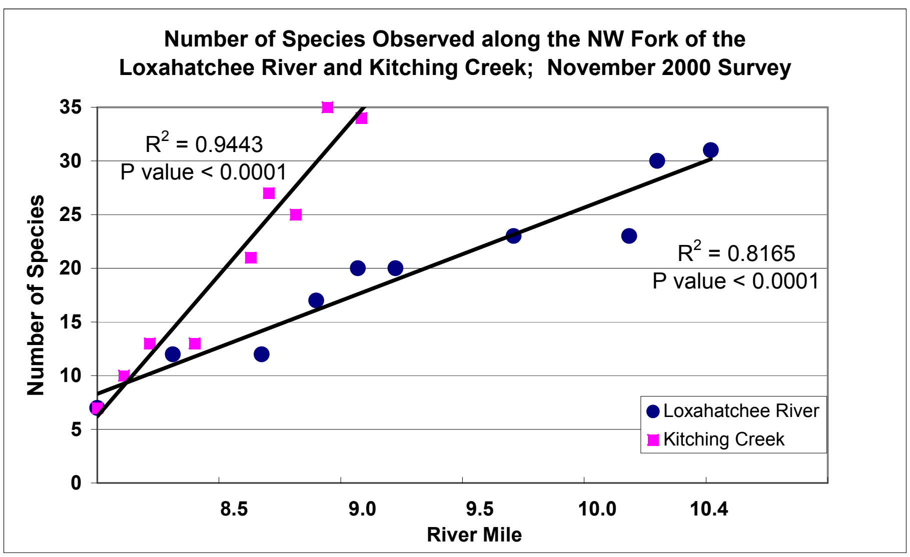


Figure 16a. Number of Observed Vascular Plant Species along the Northwest Fork of the Loxahatchee River and Kitching Creek (November 2000 Semiquantitative Vegetation Survey).

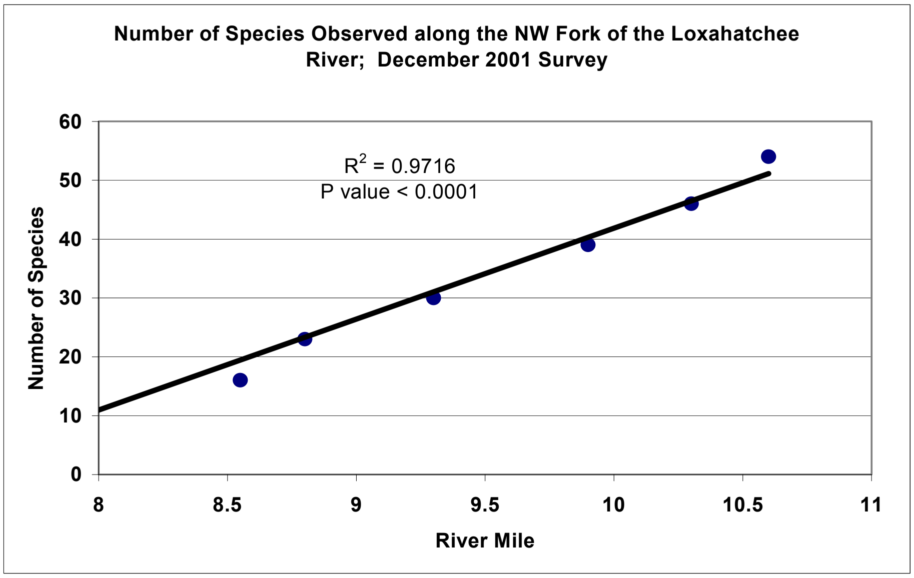


Figure 16b. Number of Observed Vascular Plant Species along the Northwest Fork of the Loxahatchee River (December 2001 Semiquantitative Vegetation Survey).

Table 9. Regression Analysis of Semiquantitative Vegetation Survey Data; *Ds/Db* Ratio Based upon $\geq$1 ppt Salinity Threshold.

	r^2	P value
2000 Number of Species per Site vs. River Mile	0.8165	<0.0001*
2001 Number of Species per Site vs. River Mile	0.9716	<0.0001*
Total (2000 & 2001) No. spp/site vs. River Mile	0.7146	<0.0001*
2000 Number of Species per Site vs. *Ds/Db* Ratio	0.6479	0.0002*
2001 Number of Species per Site vs. *Ds/Db* Ratio	0.8025	0.0064*
Total (2000 & 2001) No. spp/site vs. *Ds/Db* Ratio	0.6145	<0.0001*

*statistically significant ($p \leq 0.05$)

Species Abundance along the Northwest Fork

The abundance of freshwater swamp trees, which form the basis of the upstream floodplain forest structure, declined with increasing salinity conditions (**Table 10**). Tree species associated with mixed freshwater swamps (bald cypress, dahoon holly, pop ash and red maple) all declined in abundance as salinity conditions (expressed by the estimated *Ds/Db* salinity ratio) increased (**Table 11**). Virginia willow, a woody shrub found in freshwater swamps, also exhibited the same decline. In contrast, red mangrove dominated more saline habitats (higher *Ds/Db* ratio indicates more saline habitat), but rapidly declined in abundance and was absent in most freshwater areas (**Table 10**).

Table 10. Selected results of a Semiquantitative Vegetation Survey along the Northwest Fork (November 2000/December 2001); Units are Abundance Index*.

Station Name	7A	7B	7C	V7	8A	8B	V6	8C	V5	8D	9A	9B	V4	9C	V3	10A	10B	V2	10C	V1
River mile	7.3	7.5	7.8	7.95	8.1	8.4	8.55	8.7	8.8	8.9	9.1	9.2	9.3	9.7	9.9	10.1	10.2	10.3	10.4	10.6
Bald cypress	0	0	1	1	1	2	1	2	2	3.5	3	3	2	4	4	4	4	4	4	4
Cabbage palm	2.5	3	3.5	2	4	3	2	3.5	3.5	3.5	4	3	3	3	3	3	3	2.5	2	3
Dahoon holly	0	0	0	0	0	0	0	0	0	1	1	1	1	1	2	2	2	3.5	3	2
Pond apple	0	0	0	1	0	0	0	3	2	3	3	3	1	3	3.5	3.5	3	3	3.5	3.5
Pop ash	0	0	0	0	0	0	0	0	0	0	0	1	0	2	2	2	2	2	2	2.5
Red mangrove	4	4	4	4	4	4	4	4	4	4	4	4	3	2.5	2	0	0	1	0	0
Red maple	0	0	0	0	0	0	0	0	0	1	1	1	0	2	1	3	3	3	3.5	3.5
Swamp bay	0	0	0	0	0	0	0	0	0	0	0	0	1.5	0	0	0	1.5	1	0	1.5
Virginia willow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2.5	2	3.5

* Abundance Index (**Figure 10**)
4 = Highly abundant or dense population (>75% cover), a dominant component of the plant community; 3 = Common, widespread and of moderate density but not a dominant component of the plant community; 2 = Sparse, widespread and of low density or restricted to localized populations; 1 = Two or less individuals, rare; 0 = Species not present.

Table 11. Abundance Index of Selected Species and Estimated Salinity Conditions Expressed as Salinity Ratio *Ds/Db.*

	Salinity Ratio *Ds/Db* at a Threshold of $\geq$1 ppt						
	0.05	**0.20**	**0.38**	**1.04**	**2.23**	**3.61**	**11.21**
River Mile	***10.2***	***9.7***	***9.2***	***8.9***	***8.6***	***8.4***	***7.8***
Bald cypress	4	4	3	3.5	2	2	1
Cabbage palm	3	3	3	3.5	3.5	3	3.5
Dahoon holly	2	1	1	1	0	0	0
Pond apple	3	3	3	3	3	0	0
Pop ash	2	2	1	0	0	0	0
Red mangrove	0	2.5	4	4	4	4	4
Red maple	3	2	1	1	0	0	0
Virginia willow	2	0	0	0	0	0	0

Quantitative Vegetation Survey

Field data from the quantitative vegetation surveys are presented in **Appendix C** and summarized below. Analysis of the vegetation data revealed a strong relationship between salinity (expressed as *Ds/Db ratio*) and measured vegetation parameters at survey sites. Results indicate that pond apple, pop ash, red maple and Virginia willow were highly correlated with salinity condition, indicating a high potential for use as indicator species. Bald cypress was less correlated, indicating that it may be less sensitive to salinity than the other species examined (**Table 3**).

Number of Individuals at Survey Sites

Downstream of RM 9.1 most of the woody freshwater swamp species were not present at survey sites (**Table 12**). At RM 9.2 only three freshwater swamp species were present, while all freshwater species are present upstream.

The most highly correlated relationships between salinity and number of adults were found with bald cypress, red maple and pop ash (**Table 13**). Correlation of red mangrove to salinity was poor in this analysis, most likely due to the nature of the estimated data used. However, a review of changes in abundance relative to salinity (**Table 10**) shows a strong relationship between the abundance of this species and salinity.

Table 12. Total Number of adults and Saplings of Selected Species Recorded During the January 2002 Quantitative Vegetation Survey.

Station Name	***V1***	***10B***	***9C***	***9B***	***9A***	***8C***	***8B***	***V7***
River mile	***10.6***	***10.2***	***9.7***	***9.2***	***9.1***	***8.7***	***8.4***	***7.95***
Bald cypress	22	58	33	4	4	4	3	0
Cabbage palm	19	31	43	33	13	11	47	46
Dahoon holly	1	20	5	2	0	0	0	0
Pond apple	17	52	42	13	24	0	0	0
Pop ash	39	40	35	2	1	0	0	0
Red mangrove	0	1	18	200*	200*	180*	200*	200*
Red maple	22	16	10	0	0	0	0	0
Swamp bay	4	7	6	0	0	0	0	0
Virginia willow	123	47	35	0	1	0	0	0

* Due to the large number of red mangrove trees present at sites V7 – 9B, values were estimated.

Tree Height of Adults at Survey Sites

Tree height showed a similar trend to that indicated by the numbers of adults and saplings. Downstream from RM 10.6 there is reduced tree height in freshwater swamp species, suggesting that downstream communities have been physiologically stressed by periodic exposure to increased salinity levels (**Figure 17**). There appears to be a decrease in the mean tree height for some species between RM 10.6 and 10.2.

Table 13. Results from a Regression Analysis Comparing Number of Adults to Salinity; *Ds/Db* Ratio Based upon ≥1 ppt Salinity Threshold.

	r^2	P value
Bald cypress No. Adults vs. *Ds/Db* Ratio	0.8206	0.0004*
Pond apple No. Adults vs. *Ds/Db* Ratio	0.6805	0.0025*
Pop ash No. Adults vs. *Ds/Db* Ratio	0.9022	<0.0001*
Red mangrove No. Adults vs. *Ds/Db* Ratio	0.2706	0.1511
Red maple No. Adults vs. *Ds/Db* Ratio	0.8684	0.0002*
Virginia willow No. Adults vs. *Ds/Db* Ratio	0.7847	0.0017*

*statistically significant ($p \leq 0.05$)

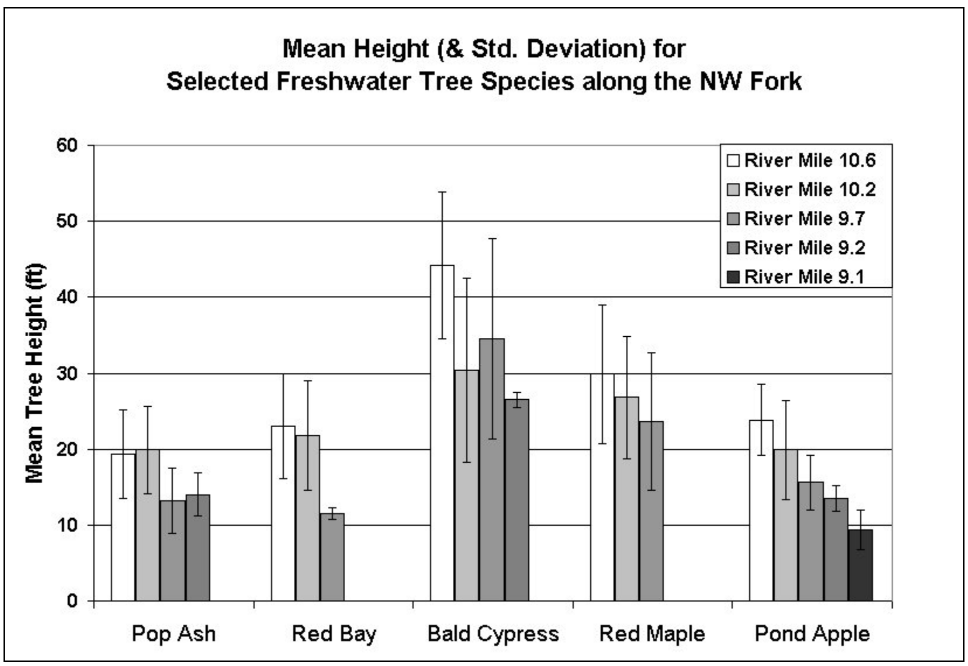


Figure 17. Mean Tree Height (ft) of Adults at Vegetation Survey Sites (January 2002, **Figure 11**); Note that All Species Shown are Absent Downstream of River Mile 9.1.

Results of the regression analysis between height of adults and salinity (**Table 14**) shows that there was a decline in the height of adults of bald cypress, pond apple, pop ash and swamp bay that is highly correlated with salinity exposure. Several freshwater tree and woody species were not included in this analysis. Cabbage palm and red mangrove height did not vary along the gradient. The height of Virginia willows were not measured as it tends to be a woody shrub in the understory. Numbers of adults of dahoon holly were insufficient to provide a reliable statistic.

Tree Diameter at Survey Sites

Trunk diameter (DBH) showed a similar trend as other vegetation parameters. Downstream from RM 10.6 there is a reduction of trunk diameter, suggesting that communities downstream have been physiologically stressed due to periodic exposure to increased salinity levels (**Figure 18**).

Table 14. Results of a Regression Analysis that Related Height of Adult Plants with Salinity; *Ds/Db* Ratio Based upon $\geq$1 ppt Salinity Threshold.

	r^2	P value
Bald cypress Height of Adults vs. *Ds/Db* Ratio	0.7292	0.0002*
Pond apple Height of Adults vs. *Ds/Db* Ratio	0.9728	< 0.0001*
Pop ash Height of Adults vs. *Ds/Db* Ratio	0.954	< 0.0001*
Swamp bay Height of Adults vs. *Ds/Db* Ratio	0.9423	< 0.0001*
Red maple Height of Adults vs. *Ds/Db* Ratio	0.9163	< 0.0001*

*statistically significant ($p \leq 0.05$).

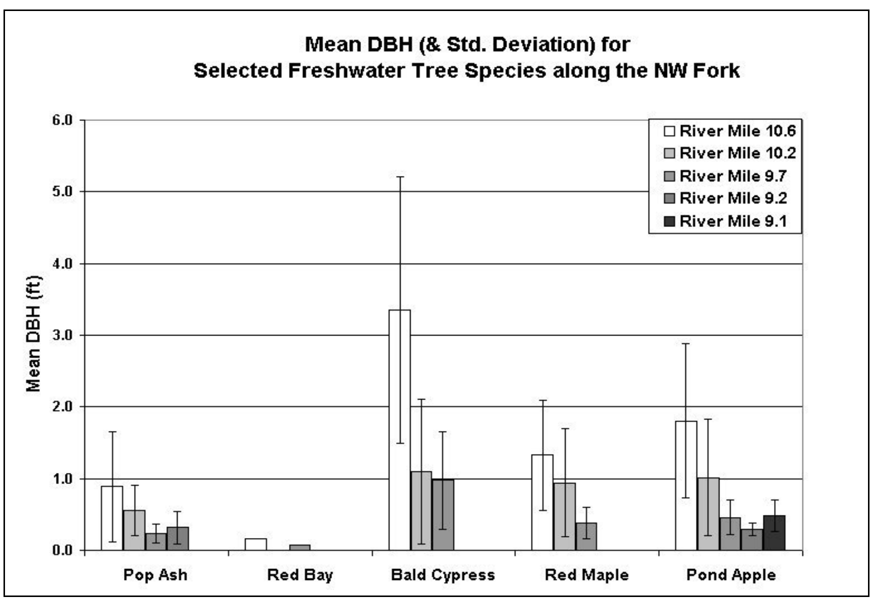


Figure 18. Mean Diameter at Breast Height (ft) of Adults at Vegetation Survey Sites (January 2002, **Figure 11**); Note that All Species Shown are Absent Downstream of River Mile 9.1.

Regression analysis (**Table 15**) shows that there was a decline in the trunk diameter of adults of freshwater swamp species that is correlated with salinity exposure. Correlation r^2 values for bald cypress and pond apple were lower than for other tree species examined. This may be related to variability in buttressing in bald cypress, which has been shown to be related to the magnitude of flooding at the site (Varnell 1998); however this mechanism has not been studied in pond apple. Cabbage palm, dahoon holly, swamp bay, red mangrove and Virginia willow were not included in this analysis. Stem diameter does not change in cabbage palm because it is a monocot without bark cambium for diameter growth; measurement of this parameter would be inappropriate. The unique growth form of red mangrove (large biomass investment in prop roots, spreading rather than erect growth habit) did not make comparison of the stem diameter of this species with other "typical" tree growth forms possible. Virginia willow stem diameter was not measured because it is a woody shrub species and not an erect tree. Numbers of adults of dahoon holly were insufficient to provide a reliable statistic and swamp bay showed no trend relative to salinity for this statistic and was not included for this reason.

Table 15. Results of a Regression Analysis that Related Stem Diameter of Adult Plants with Salinity; *Ds/Db* Ratio Based upon $\geq$1 ppt Salinity Threshold.

	r^2	P value
Bald cypress Stem Diameter of Adults vs. *Ds/Db* Ratio	0.7108	0.0141*
Pond apple Stem Diameter of Adults vs. *Ds/Db* Ratio	0.7978	< 0.0017*
Pop ash Stem Diameter of Adults vs. *Ds/Db* Ratio	0.827	< 0.0009*
Red maple Stem Diameter of Adults vs. *Ds/Db* Ratio	0.9872	< 0.0001*

*statistically significant ($p \leq 0.05$).

Canopy Diameter at Survey Sites

Downstream from RM 10.6 there is a trend of reduced canopy diameter suggesting that downstream communities have been physiologically stressed due to periodic exposure to increased salinity levels (**Figure 19**). The apparent decrease in the mean canopy diameter between RM 10.6 and 10.2 may be attributed to a change in the forest due to a wider river channel (at RM 10.2) downstream of Trapper Nelson's site. The forest canopy completely covers the narrower river channel at RM 10.6, but not at RM 10.2.

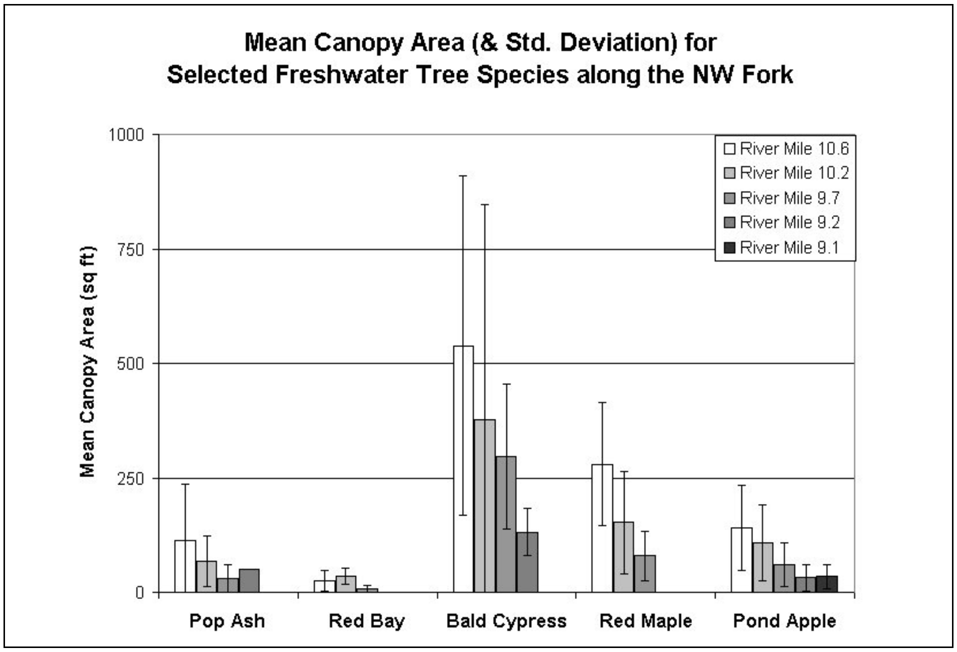


Figure 19. Mean Canopy Diameter (ft) of Adults at Vegetation Survey Sites (January 2002, **Figure 11**); Note that All Species Shown are Absent Downstream of River Mile 9.1.

Regression analysis (**Table 16**) shows a decline in the canopy diameter of adults of freshwater swamp species correlated with increasing salinity exposure. Correlation r^2 values for bald cypress were lower than for other tree species examined. This may be related to variability in the canopy diameter between trees; bald cypress is the tallest tree found in the floodplain swamp and the canopy diameter may be lower when an individual forms part of the lower canopy, but can expand unconstrained once it reaches above the canopy. Several tree and woody species were not included in this analysis. Canopy diameter does not change in cabbage palm because of its morphology. Red mangrove canopy was estimated and not included for this reason. Virginia willow, a woody shrub, does not contribute to the forest canopy and canopy measurements were not made. Dahoon holly and swamp bay were of insufficient numbers and densities to be included in this statistic (i.e., represent only small percentages of the forest canopy).

Table 16. Results of a Regression Analysis that Related Canopy Diameter of Adult Plants with Salinity; *Ds/Db* Ratio Based upon $\geq$1 ppt Salinity Threshold.

	r^2	P value
Bald cypress Canopy Diameter of Adults vs. *Ds/Db* Ratio	0.6695	0.0004*
Pond apple Canopy Diameter of Adults vs. *Ds/Db* Ratio	0.9487	< 0.0001*
Pop ash Canopy Diameter of Adults vs. *Ds/Db* Ratio	0.9145	< 0.0001*
Red maple Canopy Diameter of Adults vs. *Ds/Db* Ratio	0.9438	< 0.0001*

*statistically significant ($p \leq 0.05$).

To examine canopy density and height changes between sites, canopy area and height of each tree were used. All canopy data for trees at a site (**Table 3**) were sorted into incremental (5 feet) height classes between 0 and 60 feet. The canopy area for an individual tree, which was calculated from the estimated canopy diameter, was summed for each height class. This analysis indicated changes in the forest structure by RM 9.7 and striking changes by RM 9.2 (**Figure 20**). The forest at RM 10.6 and 10.2 appears as a complex structure with a high canopy (between 35–60 feet, dominated by bald cypress and swamp hardwoods) and a secondary canopy (between 15–25 feet, dominated by mixed hardwoods, bald cypress and pond apple). Some shrubby species are found below the secondary canopy, at or less than 10 feet. The forest structure at RM 9.7 shows a decrease in the area of the high canopy strata. At RM 9.2 the high canopy has been virtually eliminated and replaced by a low canopy (red mangrove dominated) approximately 15 feet above the ground surface. These changes in forest structure can have profound effects on microclimate, ecological function and species composition (both flora and fauna) of the swamp forest.

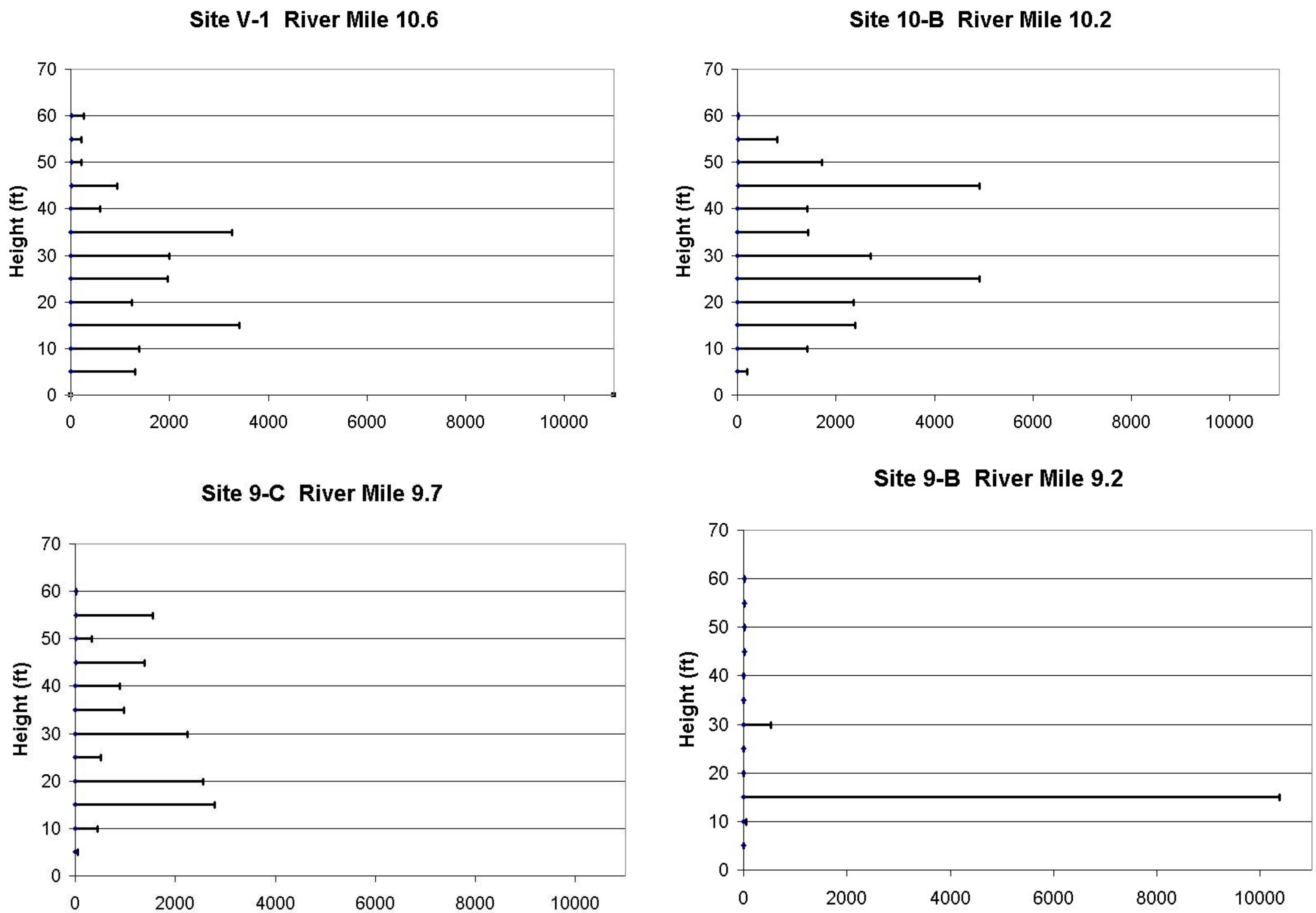


Figure 20. Total Forest Canopy Area within Height Classes for four sites along the Northwest Fork of the Loxahatchee River. Values are Canopy Area (ft^2).

Analysis of Age Classes and Forest Reproduction

The number of immature (seedlings and saplings) individuals recorded at vegetation sites are shown in (**Table 17**). The presence of seedlings and saplings in upstream sites indicates that conditions there support the reproduction and development of the forest. From RM 9.2 and downstream, the freshwater floodplain forest is not reproducing.

Table 17. Number of Saplings and Seedlings Present at Vegetation Survey Sites, Northwest Fork of the Loxahatchee River (January 2002).

Station name	**V1**	**10B**	**9C**	**9B**	**9A**	**8C**	**8B**	**V7**
River mile	**10.6**	**10.2**	**9.7**	**9.2**	**9.1**	**8.7**	**8.4**	**7.95**
Number of Seedlings/Saplings Present								
Bald cypress	1/0	24/7	5/0	0/0	4/0	0/0	0/0	0/0
Cabbage palm	0/0	1/0	0/0	0/0	0/0	0/0	0/0	0/0
Dahoon holly	0/0	7/0	1/0	0/0	0/0	0/0	0/0	0/0
Pond apple	0/1	0/10	1/3	0/0	1/0	0/0	0/0	0/0
Pop ash	6/13	5/3	3/0	0/0	1/0	0/0	0/0	0/0
Swamp bay	1/1	3/11	4/0	0/0	0/0	0/0	0/0	0/0
Red maple	1/44	5/38	0/0	0/0	0/0	0/0	0/0	0/0
Red mangrove	0/0	0/0	2/27	NC	NC	NC	NC	NC
Virginia willow	63/NA	20/NA	9/NA	0/NA	1/NA	0/NA	0/NA	0/NA

NA = data not available, this type of data not collected.
NC = data not available, transect inaccessible.

A comparison of the ratios or distribution of ages can be useful to detect changes in the forest structure between sites. **Table 18** shows the ratios of the number of adults (adults plus stump sprouts, which are damaged adults) to the number of saplings at each site. Since Virginia willow is a woody shrub, an age class definition for "sapling" is not appropriate, so the ratio of adults to seedlings is presented. In a mature canopied forest, the number of adults relative to saplings is expected to be high, since most seedlings never survive to adulthood due to competition and shading from the existing, stable community. In a community impacted by salinity intrusion, reproduction would decline as a result of stress to adults and saplings, leading to less viable seed production. At such sites, one would expect to observe a decline in the number of adults due to mortality and a lack of saplings to replace them. The results of the age class analysis presented in **Tables 17** and **18** indicate that the freshwater floodplain community at RM 10.6 has very few saplings relative to the number of adults. Conversely, the community at RM 9.2 is damaged (evidenced by the reduced number of adults as compared to RM 10.6) and not reproducing. Interestingly, red mangrove are not reproducing upstream of RM 9.7.

Table 18. Ratio of the Number of Adults to the Number of Saplings* from Vegetation Survey Sites.

Station Name	***V1***	***10B***	***9C***	***9B***
River Mile	***10.6***	***10.2***	***9.7***	***9.2***
Bald cypress	21:0	34:24	28:5	4:0
Dahoon holly	1:0	13:7	4:1	2:0
Pond apple	17:0	52:0	41:1	11:0
Pop ash	33:6	35:5	32:3	1:0
Swamp bay	3:1	4:3	2:4	0:0
Red mangrove	0:0	1:0	16:2	N/A
Red maple	21:1	11:5	10:0	0:0
Virginia willow*	123:63	47:20	35:9	0:0

*saplings of this species are not defined for Virginia willow since it is a shrub; values given indicate adults:seedling ratio.

Loxahatchee Salinity-Vegetation (SAVELOX) Model Verification and Results

The SAVELOX model output compared very well with field data from sites along the Northwest Fork. Examples of the ability of the Model to predict vegetation parameters for bald cypress are shown in **Figure 21**. A complete set of figures and model output values for all species can be found in **Appendix D**. These results indicate that the SAVELOX model provides a reasonable estimate of vegetation parameter values for the floodplain swamp community along the Northwest Fork. Since several vegetation parameters (abundance index, number of adults and canopy cover) are highly correlated with long-term salinity conditions, the model may also be useful to predict the expected parameter values resulting from a defined long-term salinity condition.

The SAVELOX model was used to examine three differing periods of flow to the Northwest Fork. The period from 1971 through 1981 is characterized by a series of below-average rainfall and corresponding low flows (see **Figure 2** and **Figure 14**). The period from 1981 though 1991 had rainfall near average and improvements to the G-92 allowed enhanced freshwater deliveries to the Northwest Fork. Between 1991 and 2001, the combination of above-average rainfall and operational improvements led to a significant increase in freshwater flows to the Northwest Fork. The results of this analysis are presented in **Figure 22** and charts of the current vegetation community composition from the 2000–2001 field surveys are shown for comparison. This analysis shows little change expected in the vegetation communities at River Mile 8.7 and 10.2 throughout the three decade time series. However, at River Mile 9.2 and 9.7, where there is a transition zone, a potential for recovery of the freshwater swamp community during the last decade (1991–2001) is indicated. Results of field studies indicates that there are no seedlings or saplings of freshwater species present at River Mile 9.2 (**Tables 17 & 18**), indicating that the freshwater swamp is not recovering in that area. However, at

River Mile 9.7, there are indications that the freshwater swamp is reproductive and perhaps recovering (**Tables 17 & 18**). It is probable that when recovery occurs, it does so from upstream to downstream direction.

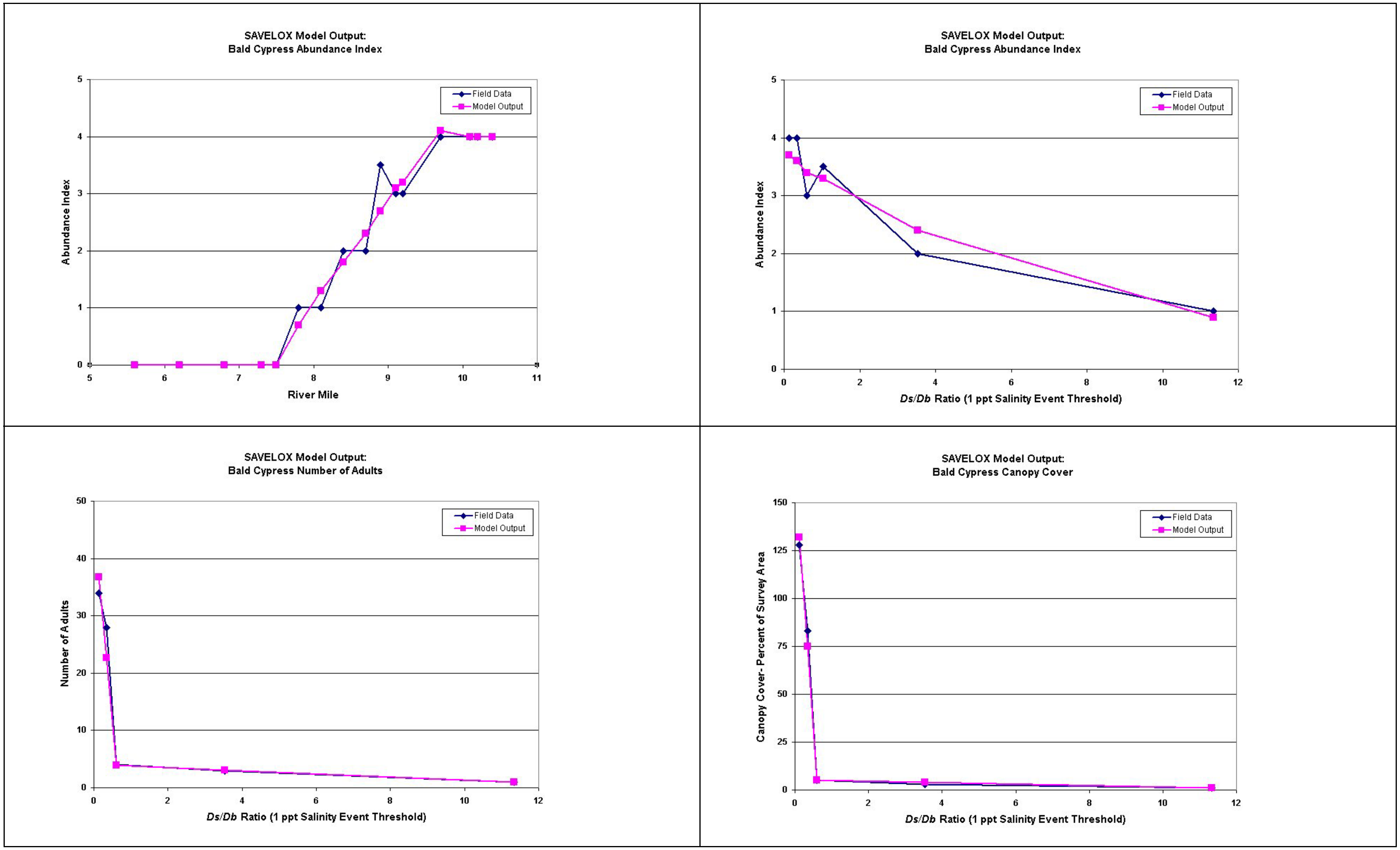


Figure 21. A Comparison of SAVELOX Model Output and Field Data for Bald Cypress.

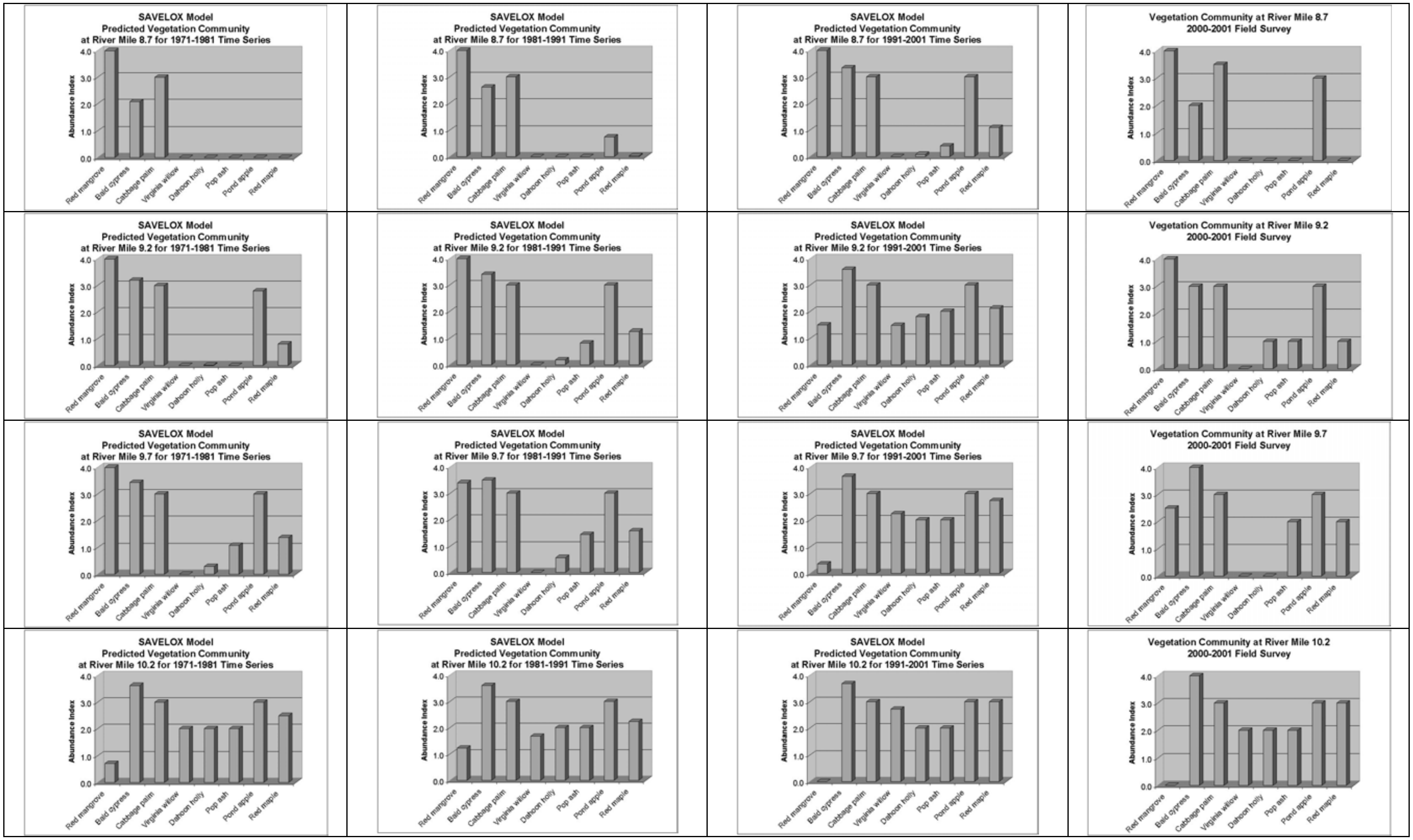


Figure 22. SAVELOX Model Output for Three Decades and Vegetation Survey Results (see **Figure 10** for Abundance Index).

DISCUSSION

Recent Vegetation Changes along the Northwest Fork

The effects of salinity stress on freshwater swamp forest species have been studied by a number of authors (Brown & Montz 1986; Pezeshki et al. 1986, 1987, 1990, 1995; Conner & Askew 1992; Javanshir & Ewel 1993; Allen 1994; Allen et al. 1994, 1997; Yanosky et al. 1995). Salinity is known to be toxic to freshwater vegetation; however, the concentrations and exposure duration that lead to either acute or chronic stress in a particular species are not well documented. Laboratory studies typically focus on seedling response to a continuously applied treatment of a fixed salinity concentration, which is likely to be very different from the response of mature trees experiencing intermittent exposure along the Loxahatchee River. In this study, we have utilized long-term modeled salinity time series to understand the effects of intermittent and chronic low-level exposure on freshwater floodplain species. Our results show a decrease in measured vegetation parameters (tree height, trunk diameter, canopy diameter, species richness and species abundance) that is associated with intermittent exposure to salinity events over longer periods of time than most field and laboratory studies have been conducted.

According to the vegetation descriptions in the Environmental Impact Statement for the Northwest Fork (USDOI 1983, 1985), as well as photographs presented in that document, stressed bald cypress and red mangrove once extended further upstream than observed in our vegetation studies from 2000–2002. Vegetation descriptions within the EIS, as well as descriptions of vegetation along this segment of the river by state biologists (David Crewz, personal communication), indicate red mangrove once were found upstream to Trapper Nelson's site (approximately RM 10.5). At the time of the EIS survey, stressed bald cypress and established red mangroves along the shoreline were found at and downstream of (SFWMD) RM 10.1. In the more recent vegetation surveys (2000–2002, **Table 10**), the red mangrove community first appears at RM 9.9 (with the exception of a single individual that was noted at RM 10.3). The EIS survey also states that the cypress-river swamp ended at approximately (SFWMD) RM 9.5. The more recent vegetation surveys (2000–2002, **Table 10**) indicate that this transition zone is located at RM 9.2. These data suggest that a recovery of the freshwater floodplain swamp has occurred within this zone and that red mangrove has receded downstream approximately 0.3 miles.

Further evidence for recovery of salinity-damaged freshwater communities in the area upstream of RM 9.2 is provided by the age class distribution of freshwater floodplain trees from the quantitative vegetation survey. The results of the age class analysis (**Table 18**) indicate a "healthy site" at RM 10.6 where numbers of adults are high and numbers of saplings are low. In a mature canopied forest, the ratio of adults to saplings is expected to be high, because most seedlings never survive to adulthood due to competition and shading from the existing community. Only when a light gap opens in the canopy will saplings or seedlings grow up to the canopy and become established over the long term. In a damaged forest community or one in decline, such as by salinity intrusion events, it is expected that the number of adults and the reproductive capacity of those adults would decline. In addition, few, if any, saplings would be found due to reproductive failure and seedling stress. Sites that are in a state of recovery would be expected to have the ratio of adults to saplings show a higher number of saplings (relative to the "healthy" site.

The age class ratios at RM 9.7 indicate a state of "recovery"; at this site, the ratios of number of adults and saplings are equal to or greater than the ratios found at RM 10.6 for most freshwater swamp species (bald cypress, dahoon holly, pond apple, pop ash and swamp bay) (**Table 18**). The age class ratios at RM 9.7 indicate a reproductively successful community, in contrast to the ratios found at RM 9.2. These observations suggest that the stressed freshwater swamp forest upstream of RM 9.7 is recovering, most likely due to increased freshwater flows provided over the past two decades (**Figure 2**).

Several authors have studied vegetation along salinity-freshwater gradients (e.g., Hicks & Burns 1975, Odum et al. 1984). A graphical representation of generalized vegetation changes found along estuarine salinity zones is shown in **Figure 23**. This same type of vegetation gradient occurs along the Northwest Fork, with the exception that red mangroves dominate the floodplain swamp along oligohaline to polyhaline zones. Red mangrove plays a dominant role in the saltwater-influenced floodplain due to the subtropical climate (red mangrove is a tropical species) and its dominance over other lower-stature vegetation types (e.g., Spartina or needle rush). However, red mangrove's distribution in more freshwater systems is limited.

A review of data from the 2000–2002 vegetation surveys (compare **Figure 20** with **Table 10**) indicates that red mangrove has not become established in areas where the freshwater swamp is intact. The pattern of red mangrove invasion follows the pattern of salinity intrusion and stress to freshwater vegetation. There is a clear gradient in mangrove abundance from downstream to upstream and from river channel to floodplain-upland ecotone– a gradient that would not be expected if red mangrove were able to compete equally with freshwater vegetation. Red mangrove is not found growing as an understory plant in established freshwater floodplain swamp along the Northwest Fork, although natural disturbances over the past century must have moved propagules into freshwater floodplain areas.

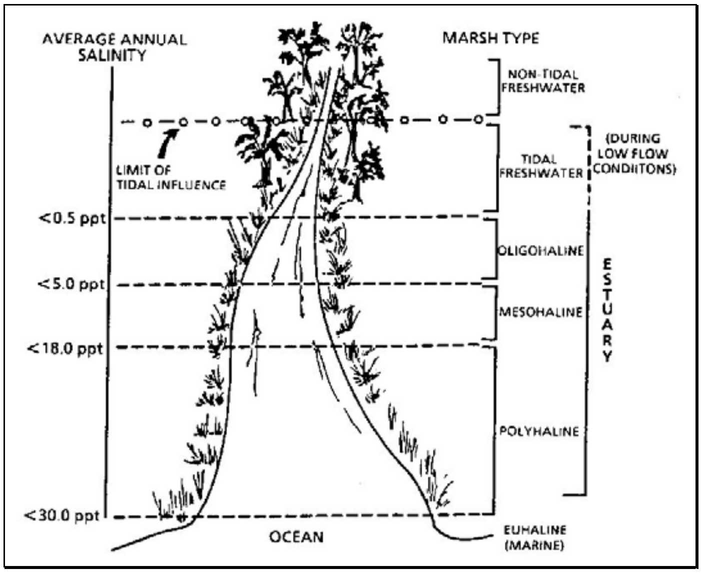


Figure 23. Generalized Estuary Zones and Related Salinity Characteristics (From Odum et al., 1984).

The evidence for recovery of the freshwater floodplain swamp upstream of RM 9.2 is consistent with historical freshwater flow patterns. Most likely, damage to this site occurred up through the 1970's until the improved flows were delivered over the past two decades (**Figure 2**). One primary principle of restoration along the Northwest Fork is the concept that if appropriate freshwater conditions are provided to a site where the freshwater swamp has been damaged by salinity, then through time it will revert back to the original (freshwater) forest type. The primary mechanisms involved in the change from bald cypress-dominated floodplain swamp to red mangrove-dominated floodplain swamp include salinity tolerance, competitive dominance, climatic characteristics and seed dispersal/success. **Table 19** shows the characteristics of bald cypress and red mangrove that can provide the framework for a conceptual freshwater-saltwater floodplain vegetation model for the Northwest Fork.

Application and Interpretation of SAVELOX Output

The SAVELOX model was constructed from data trends that follow the decline of a freshwater community and expansion of a saltwater community relative to a salinity gradient. If no change at a mangrove-dominated site occurred, it was assumed that the salinity conditions were sufficiently high to prevent "recovery" of the freshwater floodplain swamp over the past three decades. Application of the model for predicting the current floodplain swamp community along the Northwest Fork is reasonable based upon the verification data (**Appendix D**). However, the model was also constrained by the data upon which it was built. These constraints include:

- This model is specific to the Northwest Fork of the Loxahatchee River only. It may have application to the tributaries to the Northwest Fork (e.g., Kitching Creek), but reliable long-term salinity and flow data for them is lacking.

- The model is constructed on survey data from River Miles 5.6 to 10.4 and application beyond these locations is outside the model domain.

- The model is constructed on long-term (30 year period of record) data and trends.

- Appropriate definition of the salinity value (e.g., daily mean as modeled), as outlined in earlier sections of this document.

- There is an assumption that the freshwater-salinity regime is the primary driving force that shaped the floodplain swamp community composition over the past decades; this assumption arises from the observed gradual change from freshwater-associated species in the floodplain to saltwater-tolerant species over the past century.

- The model addresses community-level (floodplain swamp species composition and relative abundance) and species-level (abundance, number of adults, canopy area) responses.

Table 19. Summary of Major Characteristics of Bald Cypress and Red Mangrove.

	Bald Cypress	**Red Mangrove**
Salinity Tolerance	Obligate freshwater species, low-level salinity tolerance in some Gulf Coast populations	Facultative saltwater species
Competition- Light	Saplings found as understory in canopied forest	Saplings not found as understory in canopied forest
Forest Structure	Dominant high canopy (>60 feet)	Low canopy in Loxahatchee River (≤12 feet)
Frost Tolerance	Tolerant, dormant during frost season	Intolerant, low stature in Loxahatchee due to periodic frost damage
Frost Recovery	No recovery time required	Multi-year following severe freezes
Seed Life Span	Long, multi-year	Short, 1 year or less
Seed Origin	Water disbursed, Abundant upstream sources	Water disbursed, Abundant downstream sources
Seed Distribution	Seeds moves from upstream to downstream with flow	Seeds moved downstream with flow, upstream movement rare

Output from the SAVELOX Model can be used to understand both species-specific changes, as well as community changes, that are associated with a change in freshwater-salinity regime. Species-specific information can be helpful in determining if "stress" is occurring. For example, the loss or absence of Virginia willow can be used to indicate stress. Other examples of community level changes include a decline in the forest canopy structure, which can have profound effects on the local environment.

Application of the SAVELOX Model for predicting future (long-term) vegetation parameter values for select species may be appropriate and useful as a resource management tool. The rationale for this application is as follows:

- Since all of the lands surrounding the area of the Northwest Fork in the SAVELOX Model domain are publicly owned, no change in land use are expected.

- Succession of plant communities between types is well documented, often shaped by a dominant force. Some examples include shifts between upland and wetland habitats, recovery after logging and effects of burning frequency. Most (low-fire frequency) climax communities are dominant because of the establishment of a closed canopy, which excludes shade-intolerant seedlings and species (red mangrove is a shade-intolerant species) (Janzen 1985; Lugo 1986).

- Significant potential exists for the movement of freshwater swamp seeds from upstream sources to repopulate areas where adults are no longer producing seeds or have been extirpated (see Gunderson 1984 for a discussion on the regeneration of bald cypress in the Corkscrew Swamp after logging and burning).

- Currently under dry conditions, low- and no-flow events are common. During these periods, propagules and seeds of saltwater species can be carried via tidal flux into upstream areas and encourage the establishment of saltwater-tolerant species. Establishment of a minimum flow and level for the Northwest Fork (2003) will cause a continuous net positive (downstream) flow and retard dispersal of saltwater species into upstream areas. In addition, continuous freshwater flow will provide an enhanced vehicle for freshwater vegetation seeds to be carried into areas now dominated by saltwater species.

- Provided that a suitable freshwater-dominated regime is established at a saltwater-impacted site, regression of lower-stature red mangrove to high canopy freshwater species is likely to occur, resulting from domination of high freshwater swamp canopy over low canopy forest types (**Figure 20**) (Spurr 1964, Salisbury & Ross 1992, Perry 1994, Bazzaz 1996). The re-establishment of dominant freshwater tree species is favored by the influence of three mechanisms: 1) encroachment of freshwater species from upstream to downstream areas- via the same mechanism that led to the establishment of mangroves upstream; 2) encroachment of freshwater species from the floodplain-upland ecotone toward the river bank, where remnant freshwater vegetation still persist in many areas; and 3) red mangrove is at the edge of its climatic range, and as such frosts in this area have been demonstrated to severely impact mangroves for up to several growing seasons.

The predicted values calculated by the SAVELOX Model for a vegetation parameter are useful as an indicator of potential change in the upstream-downstream distribution of that parameter resulting from a change in the freshwater-salinity regime. In addition, if the SAVELOX model was applied to a time series from a hydrological or hydrodynamic model, a chart of the results for a parameter for each time step could be generated. This graph of SAVELOX values would provide a sense of direction (decreased abundance, increased abundance, or no change) through time, indicating a community trajectory for a given salinity condition assuming there have been no other disturbances (e.g. hurricanes) or alterations (wetland drainage) that might affect the distribution of these species.

CONCLUSIONS

Results from vegetation surveys along the Northwest Fork of the Loxahatchee River documented a gradient of species composition, richness and abundance along the salinity gradient. Changes in forest structure (canopy height and complexity) were evident as the floodplain community changed from freshwater swamp in upstream segments (above River Mile 9.7) to red mangrove swamp downstream of River Mile 9.2. Many of these changes are highly correlated to salinity conditions, specifically the magnitude, duration and frequency of salinity events. Information from these field studies provide a basis for: 1) determining the location of stressed and healthy communities along the Northwest Fork; 2) identifying which plant species are most sensitive to salinity; and 3) identifying species that may be useful as indicators of salinity conditions.

A model constructed from these relationships was useful for predicting vegetation parameter values at field sites and may have application in predicting future trends, providing appropriate input data are available and model constraints are recognized. Applications of the model include: 1) determination of the current vegetation parameter values at a site along the Northwest Fork; 2) use as a performance measure to gauge the effects of a proposed future freshwater-salinity regime; and 3) the determination of the freshwater-salinity regime required to sustain certain floodplain species and communities.

RECOMMENDATIONS

The SAVELOX model is based upon a 2-D hydrodynamic salinity model which is currently being updated. Three salinity monitoring stations were installed by the SFWMD in the NW Fork in order to continuously measure salinity in the upper and lower water column. These data are being compiled and compared with output from the 2-D model and will also provide the basis for development of a 3-D hydrodynamic salinity model. Once the 3-D salinity model is operational and calibrated, a re-run of the "historic" salinity time series is recommended to re-calculate the Ds/Db ratios used in the SAVELOX model. If necessary, the SAVELOX model can be updated to incorporate these improved data sets.

Additional studies have been recommended in order to verify the salinity-vegetation relationships observed in field studies and to link salinity change with shifts in freshwater floodplain forest composition. These studies would aim to directly measure vegetation response resulting from salinity exposure both in the field and in a controlled setting. The response of seedlings, saplings and adults should be included to in order to determine relative sensitivities. This information can be useful in determining potential inequality of salinity impacts and determining sentinel species or life stages for use in monitoring. In addition, periodic monitoring of the vegetation community between River Miles 9 and 10 is needed to determine if restoration/recovery is occurring as predicted by SAVELOX.

REFERENCES

Alexander, T.R. and A.G. Crook. 1975. Recent and Long-Term Vegetation Changes and Patterns in South Florida. Part II. South Florida Ecological Study, National Technical Information Service, PB-264-462.

Allen, James A. 1994. Intraspecific variation in the response of bald cypress (Taxodium distichum) seedlings to salinity. PhD. Dissertation. Louisiana State University, Baton Rouge, Louisiana, USA.

Allen, James A., J. L. Chambers, and D. McKinney. 1994. Intraspecific variation in the response of Taxodium distichum seedlings to salinity. Forest Ecology and Management 70:203-214.

Allen, James A., J. L. Chambers, and S.R. Pezeshki. 1997. Effects of salinity on baldcypress seedlings: physiological responses and their relation to salinity tolerance. Wetlands 17(2):310-320.

Bazzaz, Fakhri. 1996. Plants in changing environments: linking physiology, population, and community ecology. Press Syndicate of the University of Cambridge, Cambridge, UK, 320 pp.

Birnhak, B.I. 1974 An examination of the influence of freshwater canal discharges on salinity in selected southeastern Florida estuaries. Report No. DI-SFEP-74-19. Department of the Interior, South Florida Environmental Project. Atlanta, GA.

Bonham, Charles D. 1989. Measurements for terrestrial vegetation. John Wiley & Sons, Inc, New York, 338 pp.

Bowman, H.H.M. 1917. Ecology and physiology of red mangroves. Proc. Am. Philos. Soc. 56:589-672.

Boy Scouts of America. 1967. Fieldbook for boy scouts, explorers, scouters, educators, outdoorsmen. McGraw-Hill, New York, pp 399.

Braun-Blanquet, J. 1932. Plant sociology. (Translated by G.D. fuller and H.S. Conard), McGraw-Hill, New York, 439 pp.

Braun-Blanquet, J. 1965. Plant sociology. (Translated, revised, and edited by C.D. Fuller and H.S. Conard), Hafner, London, 439 pp.

Brightman, Richard S. 1984. Benthic macroinvertebrate response to secondarily treated wastewater in North-Central Florida cypress domes. IN: (K.C. Ewel & H.T. Odum, eds.) Cypress Swamps. University Presses of Florida, Gainesville, FL, pp.186-196

Brown, C.L. and G.N. Montz. 1986. Baldcypress: the tree unique, the wood eternal. Claitor's Publishing Division, Baton Rouge, LA, USA.

Chapman, V.J. 1976. Mangrove vegetation. J. Cramer, Vaduz, Germany. 447 p.

Chiu, T.Y. 1975. Evaluation of Salt Intrusion in Loxahatchee River, Florida. Coastal and Oceanographic Engineering Laboratory, University of Florida. Gainesville, FL. UFL/COEL – 75/013.

Conner, William H. 1988. Natural and artificial regeneration of baldcypress [Taxodium distichum (L.) Rich.] in the Barataria and Lake Verret basins of Louisiana. PhD. Dissertation, Louisiana State University, Baton Rouge. 4 p.

Conner, William H., J.R. Toliver, and F.H. Sklar. 1986. Natural regeneration of baldcypress [Taxodium distichum (L.) Rich.] in a Louisiana swamp. Forest Ecology and Management 14:305-317.

Conner, William H. and G.R. Askew. 1992. Response of bald cypress and loblolly pine seedlings to short-term saltwater flooding. Wetlands 12(3):230-233.

Corlett, R.T. 1986. The mangrove understory: some additional observations. J. Trop. Ecol. 2:93-94.

Crewz, David, personal communication. Florida Department of Natural Resources Interoffice Memorandum to George Henderson, RE: Loxahatchee River Saltwater Intrusion, February 5, 1982.

Davis, J.H., Jr. 1940. The ecology and geologic role of mangroves in Florida. Pap. Tortugas Lab. 32:304-412. Carnegie Inst. Wash. Publ. No. 517.

Demaree, D. 1932. Submerging experiments with Taxodium. Ecology 13:258-262.

Dickson, R.E. and T.C. Broyer. 1972. Effects of aeration, water supply, and nitrogen source on growth and development of tupelo gum and bald cypress. Ecology 53:626-634.

Duever, Michael J., John E. Carlson, and Lawrence A. Riopelle. 1984. Corkscrew Swamp: a virgin cypress strand. IN: (K.C. Ewel & H.T. Odum, eds.) Cypress Swamps. University Presses of Florida, Gainesville, FL, pp.334-348.

Egler, F.E. 1948. The dispersal and establishment of the red mangrove Rhizophora in Florida. Caribbean Forestry 9:299-310.

Egler, F.E. 1952. Southeast saline Everglades vegetation, Florida, and its management. Veg. Acta. Geobot. 3:213-265.

Ewel, Katherine C. 1990. Swamps. IN: (R.L. Myers and J.J. Ewel eds.) Ecosystems of Florida. University of Central Florida Press, Orlando, pp281-323.

Fowells, H.A. 1965. Silvics of forest trees of the United States. Agriculture Handbook 271. U.S. Dept. of Agric., For. Serv., Washington, D.C., 762 pp.

General Land Office. 1855. Surveyor field notes from the 1855 survey of the Jupiter/Loxahatchee River area are available from the website: http://www.labins.org/.

Godfrey, Robert K. and J.W. Wooten. 1981. Aquatic and wetland plants of southeastern United States: Dicotyledons. Univ. of Georgia Press, Athens, GA.

Golley, F.B., H.T. Odum, and R.F. Wilson. 1962. The structure and metabolism of a Puerto Rican red mangrove forest in May. Ecology 43:1-9.

Good, R.E., D.F. Whigham, and R.L. Simpson. 1978. Freshwater wetlands: ecological processes and management potential. Academic Press, New York. 378p.

Gunderson, Lance H. 1984. Regeneration of cypress in logged and burned strands at Corkscrew Swamp Sanctuary, Florida. IN: (K.C. Ewel & H.T. Odum, eds.) Cypress Swamps. University Presses of Florida, Gainesville, FL, pp.349-357.

Harms, W.R., H.T. Schreuder, D.D. Hook, C.L. Brown, and F.W. Shropshire. 1980. The effects of flooding on the swamp forest in Lake Ocklawaha, Florida. Ecology 61:1412-1421.

Harris, Larry D. and Charles R. Vickers. 1984. Some faunal community characteristics of cypress ponds and the changes induced by perturbations. IN: (K.C. Ewel & H.T. Odum, eds.) Cypress Swamps. University Presses of Florida, Gainesville, FL, pp. 171-185.

Hicks, D.B. and L.A. Burns. 1975. Mangrove metabolic response to alterations of natural freshwater drainage to southwestern Florida estuaries. IN: (G. Walsh, S. Snedaker and H. Teas, eds.) Proceedings of the International Symposium on the Biology and Management of Mangroves, pp. 238-255.

Hu, Gordon. 2002. The effects of freshwater inflow, inlet conveyance and sea level rise on the salinity regime in the Loxahatchee Estuary. Proceedings from the CSCE/EWRI of the American Society of Engineers Environmental Engineering Conference, Niagara, NY. (See Appendix A of this document)

Hu, Gordon. 2003. Modeling study of saltwater intrusion in Loxahatchee River, Florida. Proceedings from the 8th International Conference on Estuarine and Coastal Modeling, Monterey, California, November 3-5, 2003. (See Appendix A of this document)

Javanshir, K. and K. Ewel. 1993. Salt resistance of bald cypress. p.285-291. IN: (H. Leith and A. Al Masoom, eds.) Towards the Rational Use of High Salinity Tolerant Plants. Vol. 2: Agriculture and Forestry Under Marginal Soil Water Conditions. Tasks for Vegetation Science 28. Kluwer Academic Publishers, Boston, MA, USA.

Johnson, Ann F. and Michael G. Barbour. 1990. Dunes and maritime forests. IN: (R.L. Myers and J.J. Ewel eds.) Ecosystems of Florida. University of Central Florida Press, Orlando, pp281-323.

Janzen, D.H. 1985. Mangroves: where's the understory? J. Trop. Ecol. 1:89-92.

Law Environmental, Inc. 1991. West Loxahatchee River management plan. Submitted to the Jupiter Inlet River District, Jupiter FL.

Lewis, R.R., III, R.G. Gilmore, Jr., D.W. Crewz, and W.E. Odum. 1985. Mangrove habitat and fishery resources of Florida. IN: (W.Seaman, Jr. ed.) Florida Aquatic Habitat and Fishery Resources, pp. 281-336. Florida Chap. Am. Fish. Soc., Kissimmee, FL.

Lugo, Ariel E. 1986. Mangrove understory: an expensive luxury. J. Trop. Ecol. 2:287-288.

Lugo, A.E. and C. Patterson-Zucca. 1977. The impact of low temperature stress on mangrove structure and growth. J. Trop. Ecol 18:149-161.

McMahan, Elizabeth A. and Lloyd R. Davis, Jr. 1984. Density and diversity of microarthropods in manipulated and undisturbed cypress domes. IN: (K.C. Ewel & H.T. Odum, eds.) Cypress Swamps. University Presses of Florida, Gainesville, FL, pp.197-209.

Mitch, William J. and J.G. Gosselink. 2000. Wetlands. John Wiley & Sons, Inc., New York. Third Edition.

Mueller-Dombois, Dieter, and Heinz Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley & Sons, Inc, New York, 547 pp.

Myers, Ronald L. and J.J. Ewel. 1990. Ecosystems of Florida. University Presses of Florida, Gainesville, FL.

Odum, William E. & C.C. McIvor. 1990. Mangroves; IN: (Ronald L. Myers and John J. Ewel) Ecosystems of Florida, University of Central Florida Press, Orlando.

Odum, W.E., C.C. McIvor and T.J. Smith III. 1982. The ecology of mangroves of South Florida: a community profile. FWS/OBS-81/24, Office of Biological Services, U.S. Fish and Wildlife Service, Washington D.C., 144 pp.

Odum, W.E., T.J. Smith III, J.K Hoover and C.C. McIvor. 1984. The ecology of tidal freshwater marshes of the United States East Coast: a community profile. FWS/OBS-83/17, Office of Biological Services, U.S. Fish and Wildlife Service, Washington D.C., 177 pp.

Perry, David A. 1994. Forest ecosystems. Johns Hopkins University Press, Baltimore, 649 pp.

Pezeshki, S.R., R.D. DeLaune, and W.H. Patrick, Jr. 1986. Gas exchange characteristics of baldcypress (Taxodium distichum): evaluation of responses to leaf aging, flooding, and salinity. Canadian Journal of Forest Research 16:1394-1397.

Pezeshki, S.R., R.D. Delaune, and W.H. Patrick, Jr. 1990. Flooding and saltwater intrusion: potential effects on survival and productivity of wetland forests along the U.S. Gulf Coast. Forest Ecology and Management 33/34:287-301.

Pezeshki, S.R., R.D. Delaune, and H.S. Choi, Jr. 1995. Gas exchange and growth of baldcypress seedings from selected U.S. Gulf Coast populations: responses to elevated salinities. Canadian Journal of Forest Research 25:1409-1415.

Pezeshki, S.R., R.D. Delaune, and W.H. Patrick, Jr. 1987. Response of baldcypress (Taxodium distichum) to increases in flooding salinity in Louisiana's Mississippi River deltic plain. Wetlands 7(1):1-10.

Pickett, S.T.A. and P.S. White. 1985. Natural disturbance and patch dynamics: an introduction. IN: (S.T.A. Pickett and P.S. White, eds.) The Ecology of Natural Disturbances and Patch Dynamics. Academic Press, New York, pp. 3-13.

Rabinowitz, D. 1978. Dispersal properties of mangrove propagules. Biotropica 10:47-57.

Roberts, Richard and Roy Woodbury. A plant list for Jonathan Dickinson State Park. Florida Scientist, in review.

Rodis, H G. 1973. Encroaching salt water in northeast Palm Beach County, Florida. U.S. Geological Survey with Palm Beach County Board of Commissioners, Tallahassee, FL. Map series; no. 59.

Russel, G.M. and B.F. McPherson. 1984. Freshwater runoff and salinity distribution in the Loxahatchee Estuary, Southeastern Florida, 1980-1982. U.S. Geological Survey, Water Resources Investigations Report 83-4244.

Salisbury, Frank B. and C.W. Ross. 1992. Plant Physiology. Wadsworth Publishing Company, Belmont, California, fourth edition, 682 pp.

Simberloff, D.S. 1983. Mangroves. IN: (D.H. Janzen, ed.) Costa Rican Natural History. Univ. of Chicago Press, Chicago, IL, pp. 273-276.

Spurr, Stephen H. 1964. Forest ecology. The Ronald Press Company, New York, 352 pp.

South Florida Water Management District. 1996. Vegetation analysis in the C-111/Taylor Slough Basin. Final report for contract #C-4244. South Florida Water Management District, West Palm Beach, FL.

South Florida Water Management District. 2002. Technical Documentation to Support Development of Minimum Flows and Levels for the Northwest Fork of the Loxahatchee River. Final Draft, November 2002. Water Supply Department, Water Resources Management, SFWMD, West Palm Beach, FL. Document is available from the website: http://www.sfwmd.gov/org/wsd/mfl/loxmfl/docs.html.

Tabb, D.C., T.R. Alexander, T.M. Thomas, and N. Maynard. 1968. The physical, biological, and geological character of the area south of the C-111 Canal in extreme southeastern Everglades National Park. Submitted to the National Park Service, Miami, FL.

Teas, H. 1979. Silviculture with saline water. IN: (A. Hollaender, ed.) The Biosaline Concept. Plenum, New York, pp.117-161.

Tobe, John D., K. Craddock Burks, R.W. Cantrell, M.A. Garland, M.E. Sweeley, D.W. Hall, P. Wallace, G. Anglin, G. Nelson, J.R. Cooper, D. Bickner, K. Gilbert, N. Aymond, K. Greenwood, and N. Raymond. 1998. Florida Wetland Plants: An Identification Manual. Rose Printing Company, Tallahassee, FL.

Tomlinson, Philip B. 1986. The botany of mangroves. Cambridge Univ. Press, London.

Twilley, R.R. 1998. Mangrove wetlands. IN: (M.G. Messina & W.H. Conners, eds.) Southern Forested Wetlands: Ecology and Management. Lewis Publishers, Boca Raton, FL, pp.445-473.

United States Army Corps of Engineers. 1996. User's guide to RMA2 Version 4.3. US Army Corps of Engineers, Waterways Experiment Station, Hydraulic Laboratory.

United States Department of Interior, National Park Service. 1982. Loxahatchee River: Draft Wild and Scenic River/Draft Environmental Impact Statement, U.S. Department of Interior/National Park Service, Atlanta, GA.

United States Department of Interior, National Park Service. 1984. Final Wild and Scenic River Study, Environmental Impact Statement, Loxahatchee River Florida. U.S. Department of Interior/National Park Service, Atlanta, Ga. July 1984.

Varnell, Lyle M. The relationship between inundation history and baldcypress stem form in a Virginia floodplain swamp. Wetlands 18(2):176-183.

Waisel, Y. 1972. Biology of halophytes. Academic Press, New York.

Ward, T.H. and R.E. Roberts. 1996. Vegetation Analysis of the Loxahatchee River Corridor, Florida Department of Environmental Protection. Florida Department of Environmental Protection/Jonathan Dickinson State Park, Hobe Sound, FL (unpublished).

Wilhite, L.P. and J.R. Toliver. 2000. Baldcypress. North Carolina Dept. of Agriculture, Forest Service, Southeastern Forest Experiment Station, Asheville. A literature summary of Taxodium distichum published at http://willow.ncfes.umn.edu/silvic.

Wunderlin, Richard P. 1982. Guide to the vascular plants of central Florida. Univ. Presses of Florida, Gainesville, FL.

Wunderlin, Richard P. 1998. Guide to the vascular plants of Florida. Univ. Presses of Florida, Gainesville, FL.

Yanosky T.M., C.R. Hupp, and C.T. Hackney. 1995. Chloride concentrations in growth rings of Taxodium distichum in a saltwater-intruded estuary. Ecological Applications 5:785-792.

APPENDIX A

THE EFFECTS OF FRESHWATER INFLOW, INLET CONVEYANCE AND SEA LEVEL RISE ON THE SALINITY REGIME IN THE LOXAHATCHEE ESTUARY

From Hu 2002, Proceedings from the CSCE/EWRI of the American Society of Civil Engineers Conference, Niagara, NY

MODELING STUDY OF SALTWATER INTRUSION IN LOXAHATCHEE RIVER, FLORIDA

From Hu 2003, Proceedings from the 8th International Conference on Estuarine and Coastal Modeling, Monterey, California, November 3-5, 2003

THE EFFECTS OF FRESHWATER INFLOW, INLET CONVEYANCE AND SEA LEVEL RISE ON THE SALINITY REGIME IN THE LOXAHATCHEE ESTUARY

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ABSTRACT

The upstream migration of salt water into the historic freshwater reaches of the Loxahatchee River is the likely cause of the altered floodplain cypress forest community along the Northwest Fork and some of its tributaries. Mangroves are replacing cypress forest and areas of mixed swamp hardwoods have reacted to different degrees to the saltwater stress. A hydrodynamic/salinity model was developed to study the influence of freshwater input, tidal inlet deepening and sea level rise on the salinity regime in the estuary.

Field data analysis and model simulations indicate that the salinity condition in the estuary is sensitive to the amount of freshwater input from the watershed. During dry seasons the salt front advances into areas that were historically freshwater habitats.

Historic evidence indicates that the Loxahatchee estuary was periodically closed and opened to the sea. Due to the active long shore sediment transport, the tidal inlet was probably characterized by shifting sandbars through which ran a narrow and unstable channel. Inlet dredging in the past several decades has increased the hydraulic conveyance of the inlet and the tidal influence into the estuary.

The sea level record from a site in south Florida indicates that the sea level has been rising at a rate of approximately 2.3-mm per year. The rise of sea level in the past century has probably raised the mean tide level by about 23 centimeters. If the sea level rise continues as predicted, it is foreseeable that the salt front will move further upstream along with the sea level rise.

Field data analysis and the preliminary model output led us to believe that the advance of seawater up the estuary is the combined effect of watershed hydrological changes, inlet deepening and sea level rise.

Keywords: estuary; freshwater inflow; sea level rise; salinity; saltwater intrusion

INTRODUCTION

The Loxahatchee River estuary empties into the Atlantic Ocean at Jupiter Inlet in southeastern Florida. The estuarine system is comprised of three forks: the Southwest Fork, North Fork, and Northwest Fork (**Figure A-1**). Estuarine conditions extend from Jupiter Inlet to about 5 river miles up the Southwest Fork, 6 river miles up the North Fork, and 10 river miles up the Northwest Fork. Four tributaries; Loxahatchee River, Cypress Creek, Hobe Grove Ditch, and Kitching Creek discharge to the Northwest Fork. Canal 18 (C-18), built in 1957 – 1958, is the major tributary to the Southwest Fork. The North Fork has several small unnamed tributaries. Rainfall in the area is seasonal, 5 inches per month is common during the wet season from May through October. Amounts near 2.5 inches per month generally occur during the dry season from November to April (Russell and Goodwin, 1987).

The upstream migration of salt water into the historic freshwater reaches of the Loxahatchee River is the likely cause of the altered floodplain cypress forest community along the Northwest Fork and some of its tributaries. A hydrodynamic/salinity model was developed to study the influence of freshwater input on the salinity conditions in the river and estuary. The hydrodynamic model was calibrated against National Ocean Service (NOS) data for a three-month period from December 1996 to February 1997. The tidal output was then verified against NOS data for a four-month period from January 1999 to April 1999. The salinity model was calibrated and verified against field data that were collected from January to June of 1999. The model was applied to scenarios with varying amounts of freshwater inflow. Both the field data and model simulation indicated that there is a strong correlation between freshwater inflow and the salinity regime in the estuary. Based on model output and field data analysis, a relationship was developed to predict salinity at various points in the estuary with respect to freshwater inflow rates and tidal fluctuations. The model was also used to provide a preliminary assessment of the impacts that inlet deepening and sea level rise have had on the salinity regime in the estuary.

METHODS

The software used in the development of the Loxahatchee River Hydrodynamics/Salinity Model were computer programs RMA-2 and RMA-4, which were developed by Resource Management Associates (RMA) and the Army Corps of Engineers (USACE, 1996). The model mesh was formed from a total of 4736 topographic data points derived from survey data. The XY coordinates and elevation of the 4736 points provide the geometry of the model. **Figure A-1** shows the finite element model mesh that was developed for this modeling study. The available bathymetric data does not cover the upstream portion of the Northwest Fork. The model mesh in **Figure A-1** used average depths, which were reported by a previous study, for that portion of the river (Russell and Goodwin, 1987). The model mesh will be updated when the bathymetric data for the upper Northwest Fork are collected.

Freshwater inflow data were available from three flow gages. The gage on the upper Northwest Fork at Lainhart Dam controls about forty to fifty percent of total freshwater input to the Northwest Fork. The other two gages are located on the North Fork, and on the Southwest Fork at flow control structure S-46 (**Figure A-1**). The freshwater input from Cypress Creek, Hobe Grove and Kitching Creek was estimated based on a previous study by

USGS (Russell and McPherson, 1983). Based on flow data from these tributaries and Lainhart Dam, the report established ratios between discharge from each tributary and the discharge at Lainhart Dam. These ratios were used to estimate the discharge from these tributaries.

The hydrodynamic model was calibrated against NOS data for a three-month period from December 1996 to February 1997. The tidal output was verified against NOS data for a four-month period from January 1999 to April 1999. **Figure A-2** is the comparison of model output and NOS predicted tide at the station Boy Scout Dock on the Northwest Fork (**Figure A-1**). This station is the most upstream (inland) station that is listed in the NOS Tide Table. Model output was also verified against data from other NOS sites at the Middle and Lower Estuary and at the Jupiter Inlet.

Calibration of the salinity model was based on flow and salinity records from January 1 to April 30, 1999. The period includes a typical transition from wet season to dry season. While the flow record at Lainhart Dam shows a decreasing freshwater inflow to the estuary, the salinity records indicate that the salinity increased significantly, even at the upstream portion of the estuary. **Figures A-3** and **A-4** are comparisons between model output and the field records at Station 64 (River Mile 7.7) and Station 65 (River Mile 8.6).

Model verification was based on the field records of the subsequent two months - May and June 1999. Starting in May, the freshwater inflow increased and salinity level dropped accordingly. Model output was depicted with two different colors in **Figure A-4**. The first portion shows the results of the model calibration. The second portion shows results of the model verification. **Figure A-5** is the verification results at Station 66 (River Mile 9.4).

While the model output followed the overall trend of salinity changes, it did not track all the short term variations that were observed in the field. Field data indicates that salinity in the upper estuary is extremely sensitive to the amount of freshwater input. Since approximately fifty to sixty percent of the freshwater input was estimated based on a set of fixed ratios, the amount of total freshwater input apparently did not accurately reflect the short term variations of flow discharge from tributaries. Such inaccuracy would in turn cause error in salinity prediction. On the other hand, over longer periods these ratios seem to have produced a relatively accurate estimate of the overall amount of freshwater input to the estuary. As a result, the model was able to follow the overall trend of salinity changes indicated by the field data. New flow stations are currently being deployed on major tributaries. The model will be re-calibrated when a more complete data set becomes available.

The model applications included eleven simulations at various levels of freshwater input to develop flow versus salinity relationship. The estuarine salinity regime is the result of a dynamic process that involves mainly tides and freshwater inflow. Salinity fluctuates constantly in response to changes in tides and freshwater inflow. Even if the freshwater inflow is constant, there is a significant variation in salinity within each tidal cycle. The variation in range between spring and neap tides is another major factor that affects the salinity. A 28-day tidal cycle with two spring tides and two neap tides was chosen for all the flow scenario simulations. The model predicts salinity for each of the over 3000 nodes at 30-minute intervals. The model output was filtered to select high tide and low tide salinity. The 56 high tide salinity values and 56 low tide salinity values were averaged to find the mean high tide salinity and the mean low tide salinity for the 28-day period.

RESULTS

The Influence of Freshwater Input on the Salinity Regime in the Estuary

The results of eleven model simulations at various levels of freshwater input are condensed into two color plates (**Figures A-6** and **A-7**). The curves in **Figure A-6** and **A-7** represent the flow versus salinity relationship at 7 sites in the Northwest Fork. On the horizontal axis of these charts, the amount of freshwater input was represented by the flow rate at the Lainhart Dam. The corresponding salinity for the given flow can be read from the vertical axis. Salinity given by **Figure A-6** is mean high tide salinity. **Figure A-7** gives mean low tide salinity. Combined, these two charts can be used to predict high tide and low tide salinity values in the Northwest Fork for a given freshwater discharge.

The model output is consistent with the results of field measurements and indicates a correlation between salinity in the estuary and freshwater inflow rate. The correlation appears to be the strongest in the upper Northwest Fork. When freshwater discharge at the Lainhart Dam decreases to approximately 35 cubic feet per second (cfs), salinity in a large portion of the Northwest Fork will exceed two parts per thousand (ppt). Both the field data and model results indicate that a change of freshwater input as small as 10 cfs can cause detectable salinity changes in this area.

To facilitate management decisions, maps of 2-ppt salinity lines were prepared based on model output (**Figure A-8** and **A-9**). **Figure A-8** shows the spatial positions of 2-ppt salinity lines with various freshwater inflow rates at high tide. **Figure A-9** shows the locations of 2-ppt lines at low tide.

The difference between spring and neap tides is also a significant factor. To present the 2-ppt lines under an average tide condition, the results in **Figure A-8** and **A-9** were created based on a tide range of 2.48 ft at Jupiter Inlet. The mean tidal range at the inlet is 2.46 ft, according to NOS data. Therefore the results presented on the maps represent an "average tidal condition." The 2-ppt lines shown in these maps will be at about the middle point between the position of the salt front at spring tides and at the neap tides.

The Influence of Inlet Conveyance and Sea Level Rise on the Salinity Regime

Inlet Configuration

Historic evidence indicates that the Loxahatchee estuary was periodically closed and opened to the sea (McPherson, Sabanskas and Long, 1982). Due to active, long-shore sediment transport, the Jupiter Inlet was probably characterized by shifting sandbars through which ran a narrow and unstable channel. When James Henshall visited the area in the early 1880s, he observed the "Jupiter River flowing eastward, and over Jupiter Bar into the sea." He also described the difficulty of sailing through the inlet, which was "quite narrow" and had "an angle in its channel at the worst possible place" (Henshall, 1884). An aerial photo of the inlet from 1940s shows extensive flood shoals (sandbars that were formed by sands pushed into the inlet by tides), which would have limited the hydraulic conveyance of the inlet and the tidal range in the estuary. Under natural conditions with active sedimentation, the hydraulic conveyance of the inlet would be smaller than the conveyance under dredged conditions.

Sea Level Rise

Extensive analyses of tidal records indicates that global sea level has risen at a rate of approximately 2 mm per year for at least the last century or so (Douglas, 1991; 1992). Based on this estimate, the sea level around 1900 was about eight inches lower than the present level. A lower sea level means that a smaller range of tidal influence existed in the estuary.

Sea level rise was even more rapid prior to 1900. Approximately 15,000 years ago, the shore of the Atlantic Ocean was several miles east and more than 300 feet lower than its present location and altitude at Jupiter Inlet. From about 15,000 to 6,000 years ago, sea level rose at a rate of more than 3 feet per century. Tidal waters began to flood the estuary embayment. Prior to this time, the embayment was probably a flood plain or freshwater marsh (McPherson, Sabanskas and Long, 1982).

The rise of sea level has likely increased the range of tidal influence in the Loxahatchee River. If the sea level rise continues as predicted, it is foreseeable that the tide influence will move further upstream along with the sea level rise.

The Effects of Inlet Deepening and Sea Level Rise

The hydrodynamic/salinity model was applied as part of a preliminary investigation, to estimate the impacts of inlet dredging and sea level rise. This section outlines the preliminary results of six model simulations that have been completed. Freshwater input was kept constant through all six model simulations. Sea level and inlet depth were changed so that their effects on the position of saltwater wedge could be examined. **Table A-1** lists boundary conditions of the model simulations. Inlet depth was reduced from the current condition to average depths of 6, 4, and 2 feet subsequently. The current average depth of the inlet is approximately 8 - 10 feet. While the first four simulations were all at current sea level, simulation 5 was at the1900 sea level, which was 8 inches lower. Simulation 6 used the boundary condition of Simulation 1, except that sea level was one foot higher. The purpose of this simulation was to estimate the possible effects of future sea level rise.

Table A-1. Boundary Conditions of Model Simulations

Boundary Condition	Simulation 1	Simulation 2	Simulation 3	Simulation 4	Simulation 5	Simulation 6
Sea level	Present MSL	Present MSL	Present MSL	Present MSL	1900 MSL	Present MSL + 1 ft
Discharge at Lainhart Dam	65 cfs	65 cfs	65 cfs	65 cfs	65 cfs	65 cfs
Total freshwater input to Northwest Fork	188 cfs	188 cfs	188 cfs	188 cfs	188 cfs	188 cfs
Freshwater input to North Fork	4 cfs	4 cfs	4 cfs	4 cfs	4 cfs	4 cfs
Freshwater input to South Fork	5 cfs	5 cfs	5 cfs	5 cfs	5 cfs	5 cfs
Inlet condition	1999 condition*	Average depth 6 feet	Average depth 4 feet	Average depth 2 feet	Average depth 2 feet	1999 condition*

To compare the range of tidal influence at various inlet depths, the location of 2 ppt salinity lines of model simulations 1 through 4 were plotted in **Figure A-10**. The model output indicates that a shallower inlet would reduce the tidal influence on the river. For example, when the inlet depth is reduced to 4 feet by sedimentation, the 2 ppt line would move approximately 1 mile downstream from its present location under existing inlet condition. Therefore, dredging of the inlet in the past several decades has probably helped move the salt wedge upstream.

The two green lines in **Figure A-11** show the predicted locations of 2 ppt salinity lines at the estimated 1900 sea level (8 inches lower than current sea level) and a predicted future sea level (12 inches higher than current sea level). Comparing the results of Simulations 4 (current sea level with 2' inlet depth, Line D) and 5 (1900 sea level, Line E), the sea level rise itself in the past century would have moved the salt wedge upstream nearly 0.5 miles. The green line at the upstream end (Line F) is the predicted position of 2 ppt salinity line with an one foot sea level rise. If the inlet depth and freshwater inflow remain unchanged, the effect of sea level rise will therefore push saltwater further upstream from its present location (Line A).

DISCUSSION

Both field data analysis and the model output indicate a strong correlation between the amount of freshwater input and the estuarine salinity regime. The upstream portion of the Northwest Fork is especially sensitive to changes in freshwater input. **Table A-2** is based on the flow ~ salinity relationship presented in **Figure A-6**. The table shows the flow rate of freshwater input that is required to maintain salinity below 2-ppt at various locations in the Northwest Fork.

Table A-2. Freshwater Inflow Required to Maintain High Tide Salinity Below 2ppt at Seven Locations in the Northwest Fork

River Mile	Station #	Freshwater discharge into Northwest Fork above Kitching Creek (cfs)	Estimated discharge at Lainhart Dam(cfs)
6.5	#63	424	187
7.7	#64	202	89
8.6	#65	123	54
9.4	#66	64	28

The position of the salt wedge is the balance point between ocean tides and freshwater flow from the watershed. While a reduction in freshwater flow could cause saltwater intrusion, the modeling results illustrated that deepening of the inlet and rising sea level would also push the salt wedge further upstream. The preliminary modeling results indicate sea level rise and inlet dredging have significant impacts on the salinity regime in the Loxahatchee Estuary.

Based on the model simulations that had a shallower inlet and lower sea level, **Table A-3** lists the amount of freshwater that would be required under present conditions to maintain the 2 ppt line at locations that correspond to the 2ppt locations that occurred under the three historic scenarios.

The analysis outlined above indicates that sea level rise and inlet dredging have significant impacts on the salinity regime in the Loxahatchee Estuary. Due to the changes in sea level and inlet configuration, the amount of freshwater required to prevent salt water intrusion has increased if the management goal is to provide historic salinity condition in the river and estuary.

Table A-3. Increased freshwater demand to prevent saltwater intrusion

Present and historic conditions	**2 ppt line river mile**	**Required freshwater under historic condition (cfs)**		**Required freshwater under present condition (cfs)**	
		Freshwater discharge at Lainhart Dam	**Freshwater input to NWF**	**Freshwater discharge at Lainhart Dam**	**Freshwater input to NWF**
A-Present condition	8.25			65	188
B-Inlet average depth 6 ft	7.7	65	188	85	246
C-Inlet average depth 4 ft	7.4	65	188	100	289
D-Inlet depth 4 ft, 1900 MSL	7.0	65	188	120	347

Inlet sedimentation is a very dynamic process. The modeling effort outlined in this document is just the first step of a preliminary investigation. More efforts are necessary to acquire historic bathymetry and sea level data and improve the accuracy of freshwater inflow data.

REFERENCES

Douglas, B. C., 1991. *Global sea level rise*, J. Geophys. Res., 96(C4), 6981-6992, 1991.

Douglas, B. C., 1992. *Global sea level acceleration*, J. Geophys. Res., 97(C8), 12,699-12,706, 1992.

Henshall, J. A., 1884. *Camping and Cruising in Florida*. Robert Clarke & Co., Cincinnati, 1884.

McPherson, B.F., Sabanskas, M., & Long, W., 1982. Physical, Hydrological, and Biological Characteristics of the Loxahatchee River Estuary, Florida. USGS Water-Resources Investigations, Open file report, 82-350.

Russell, G.M., McPherson, B.F., 1983. Freshwater Runoff and Salinity Distribution in the Loxahatchee River Estuary, Southeastern Florida. USGS Water-Resources Investigations Report, 83-4244.

Russell, G.M., Goodwin, C.R., 1987. Simulation of Tidal Flow and Circulation Patterns in the Loxahatchee River Estuary, Southeastern Florida. USGS, Water-Resources Investigations Report 87-4201. Tallahassee, Florida, 1987.

USACE, 1996. Users' Guide to RMA2 Version 4.3. US Army Corps of Engineers, Waterways Experiment Station, Hydraulic Laboratory.

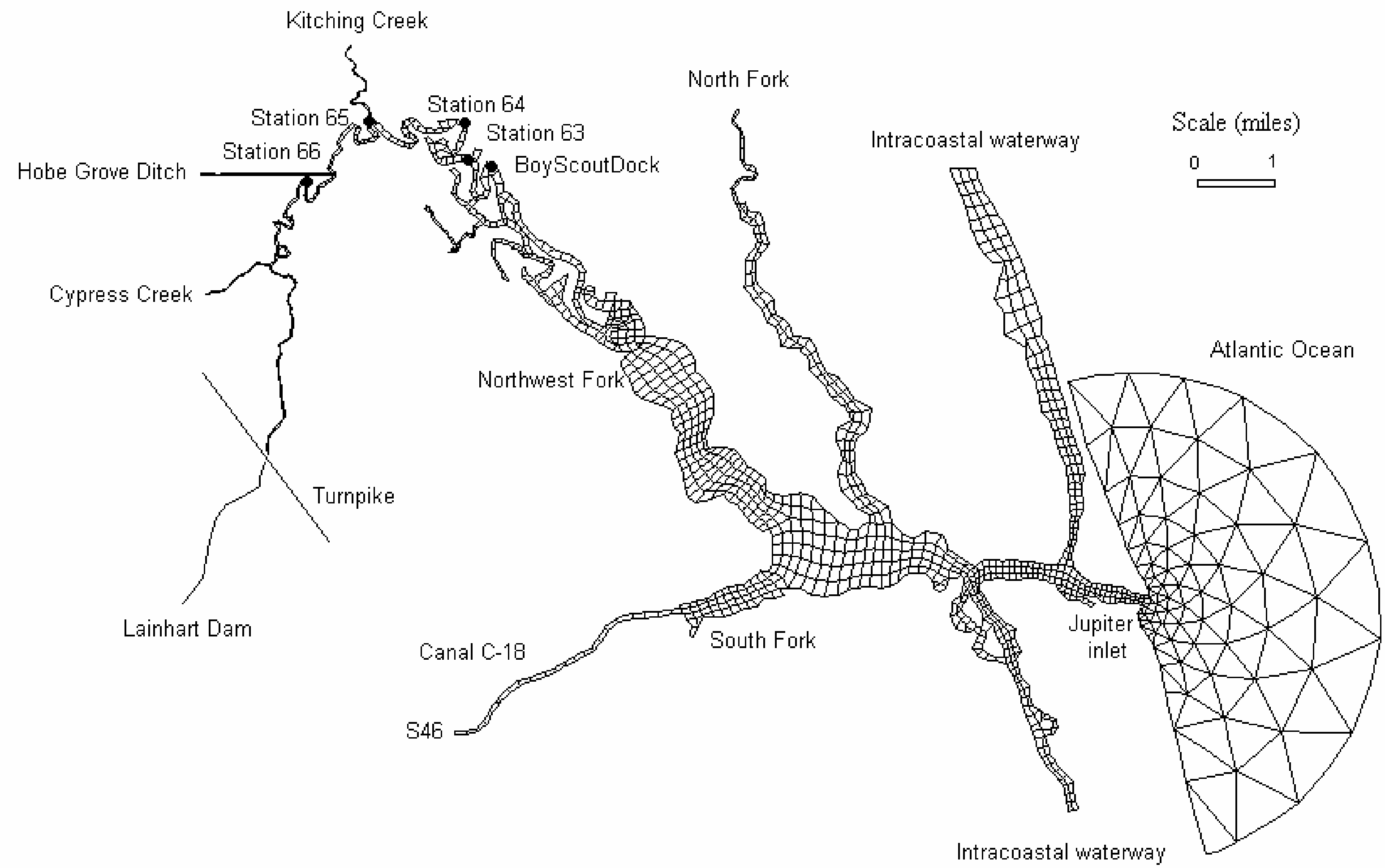

Figure A-1. Finite Element Mesh of Loxahatchee Estuary Salinity Model.

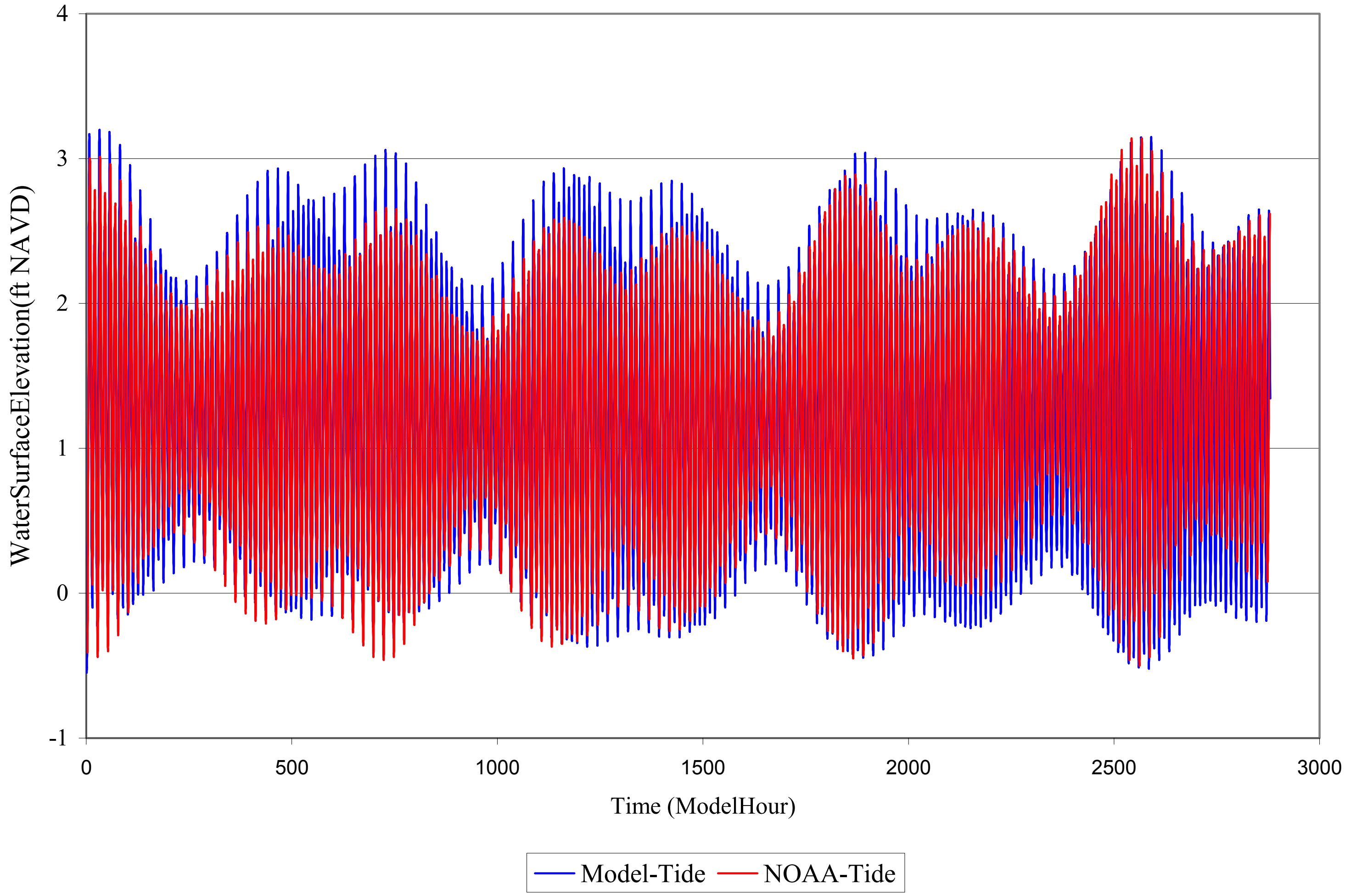

Figure A-2. Model Output vs. NOS Data: Tides at BoyScoutDock, January 1 - April 30, 1999.

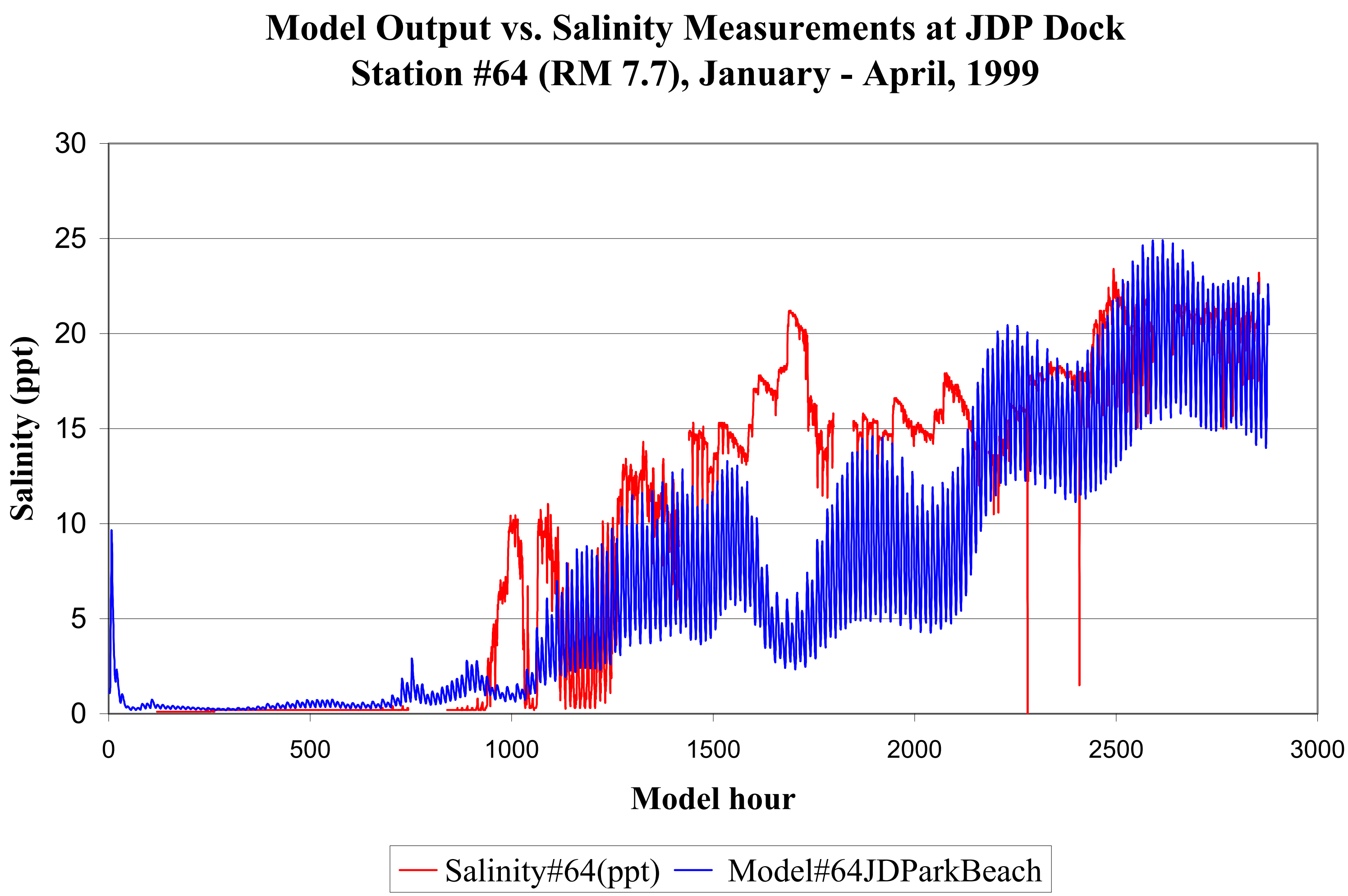

Figure A-3. Comparison of Model Output and Field Record at Station 64 (RM 7.7).

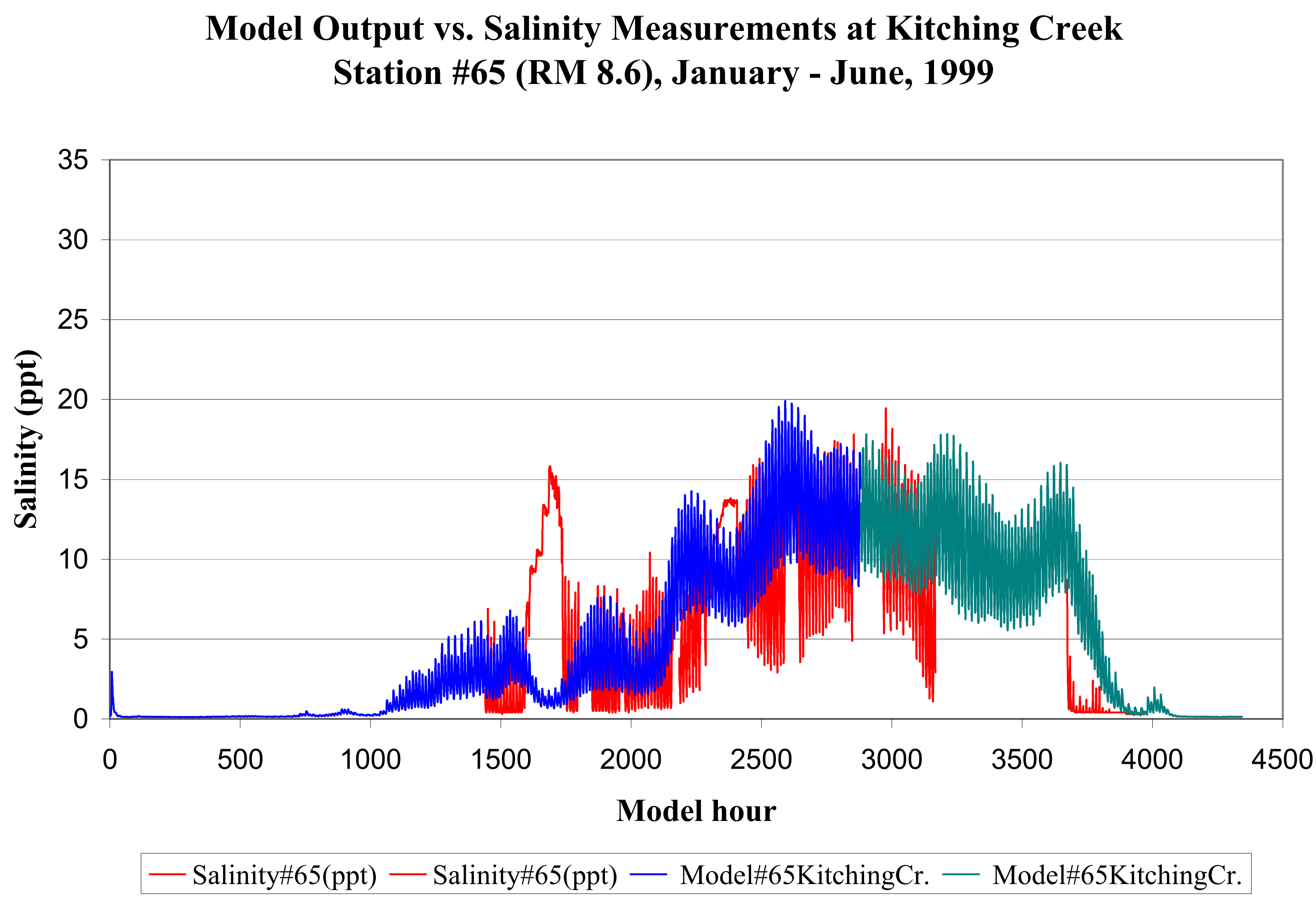

Figure A-4. Comparison of Model Output and Field Record at Station 65 (RM 8.6).

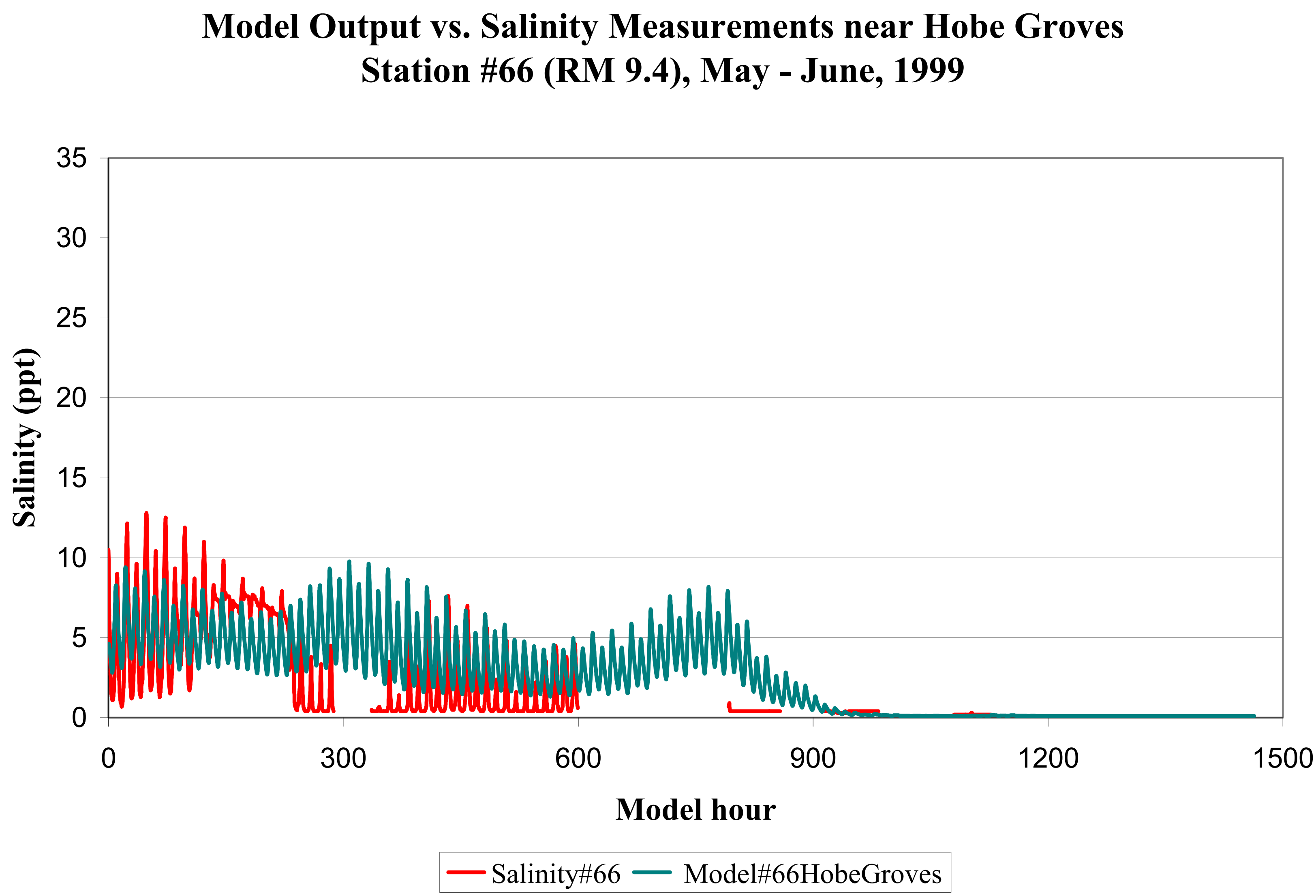

Figure A-5. Comparison of Model Output and Field Record at Station 66 (RM 9.4).

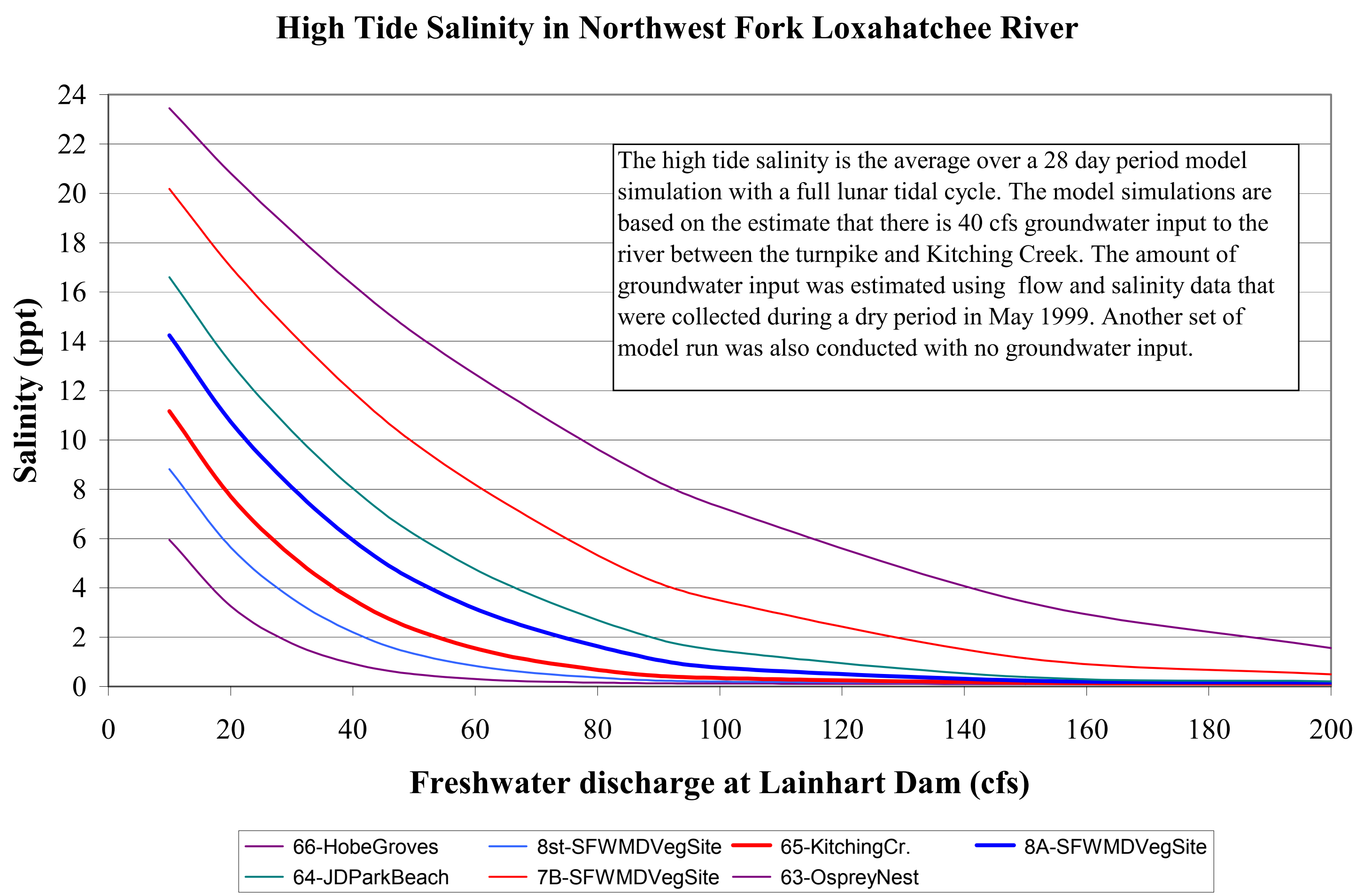

Figure A-6. The Relationship between High Tide Salinity and the Amount of Freshwater Inflow.

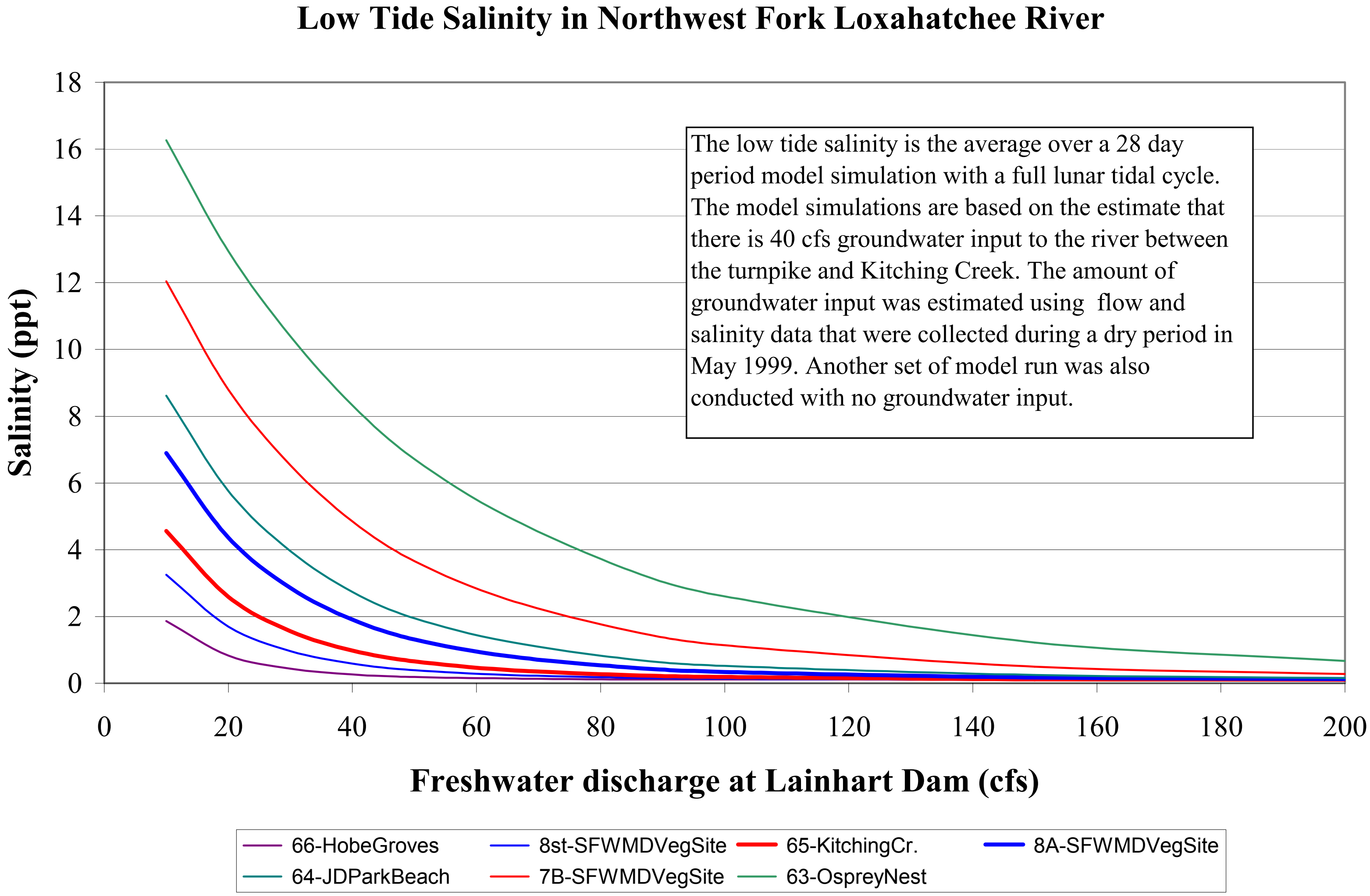

Figure A-7. The Relationship between Low Tide Salinity and the Amount of Freshwater Inflow.

Figure A-8. 2-ppt Salinity Line Position at High Tide; 2-ppt Lines are Labeled with Discharge at Lainhart Dam.

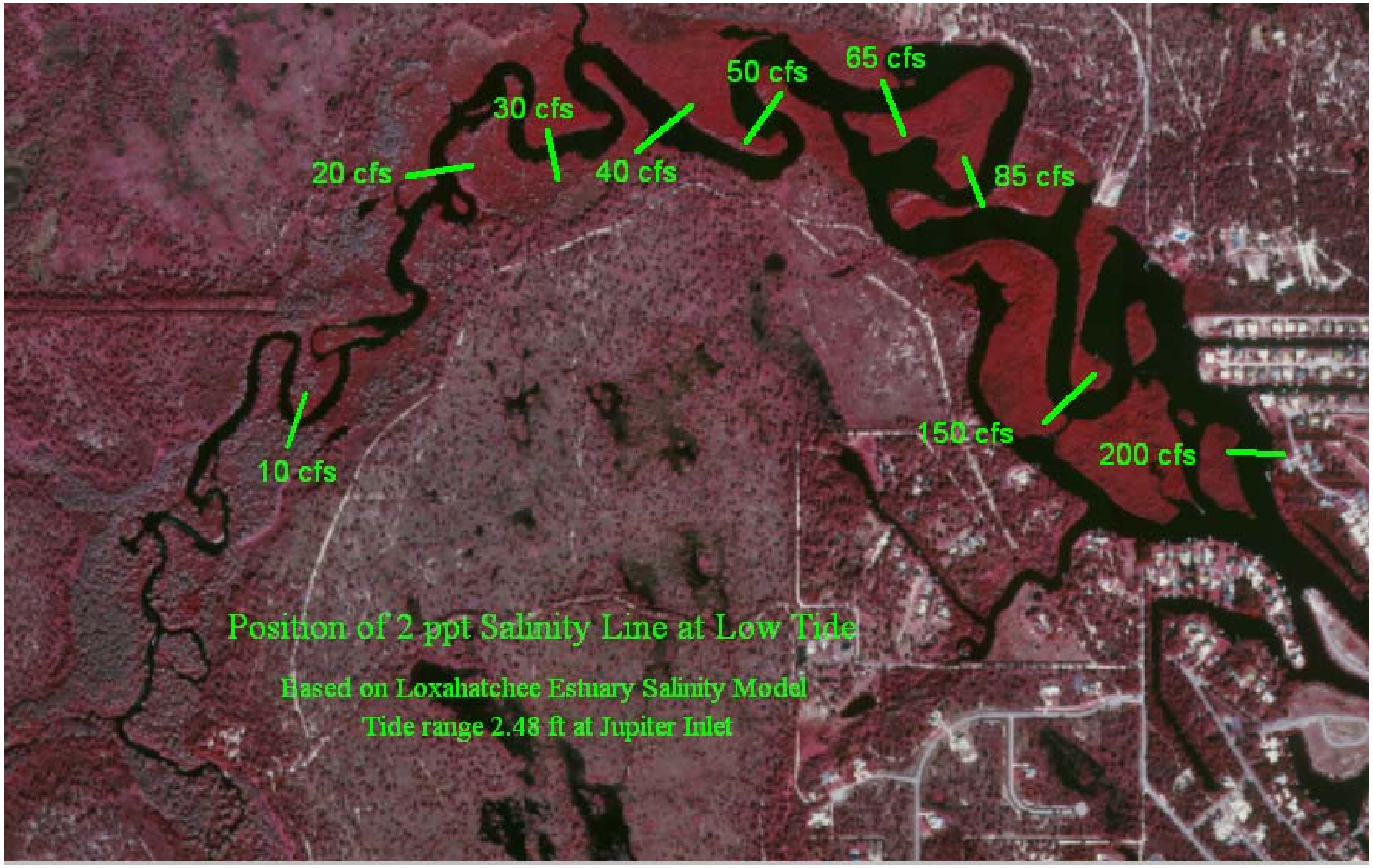

Figure A-9. 2-ppt Salinity Line Position at Low Tide. 2-ppt Lines are Labeled with Discharge at Lainhart Dam.

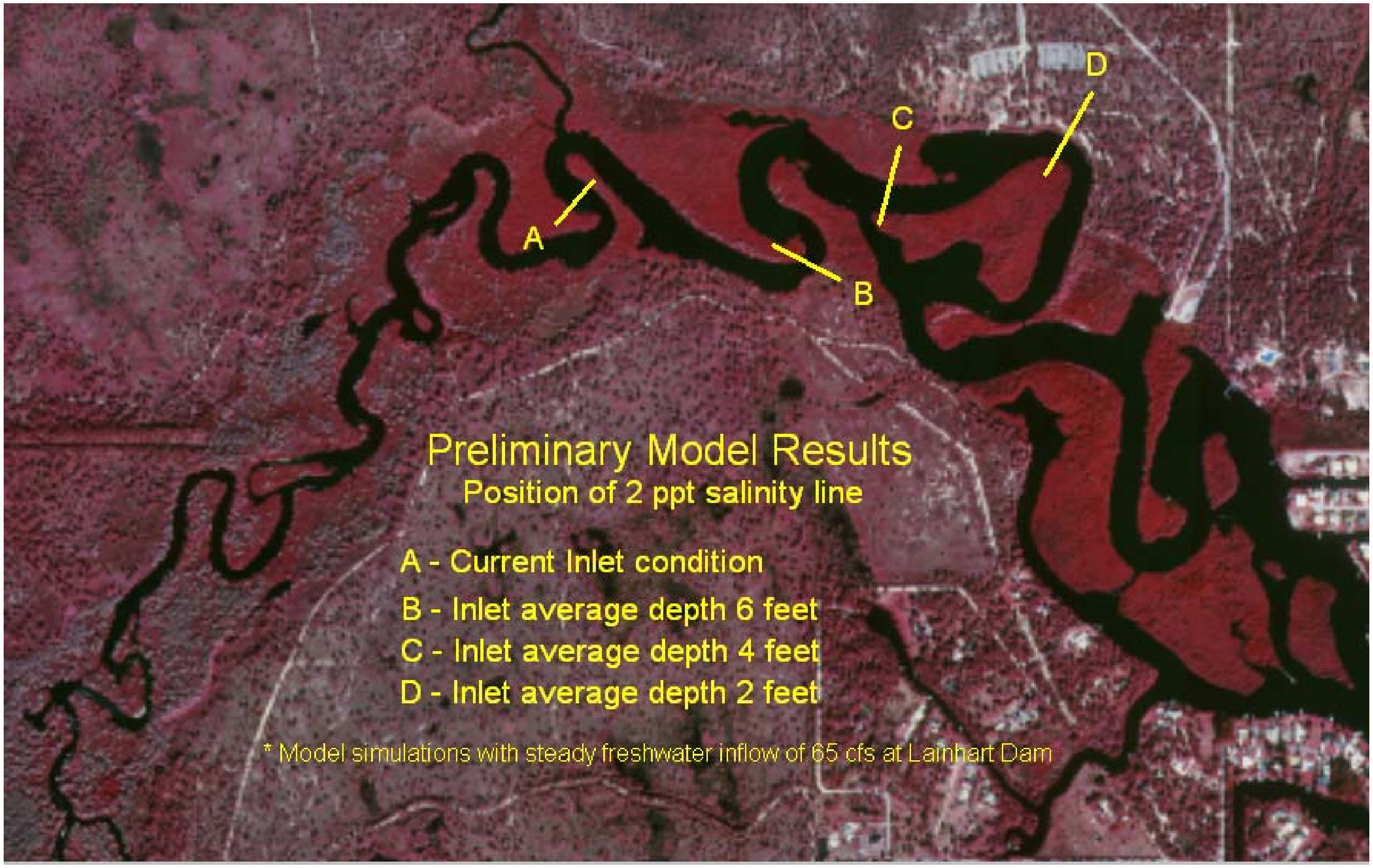

Figure A-10. 2-ppt Salinity Line Position at Various Inlet Depths. 2-ppt Lines are Labeled with Depth at Jupiter Inlet.

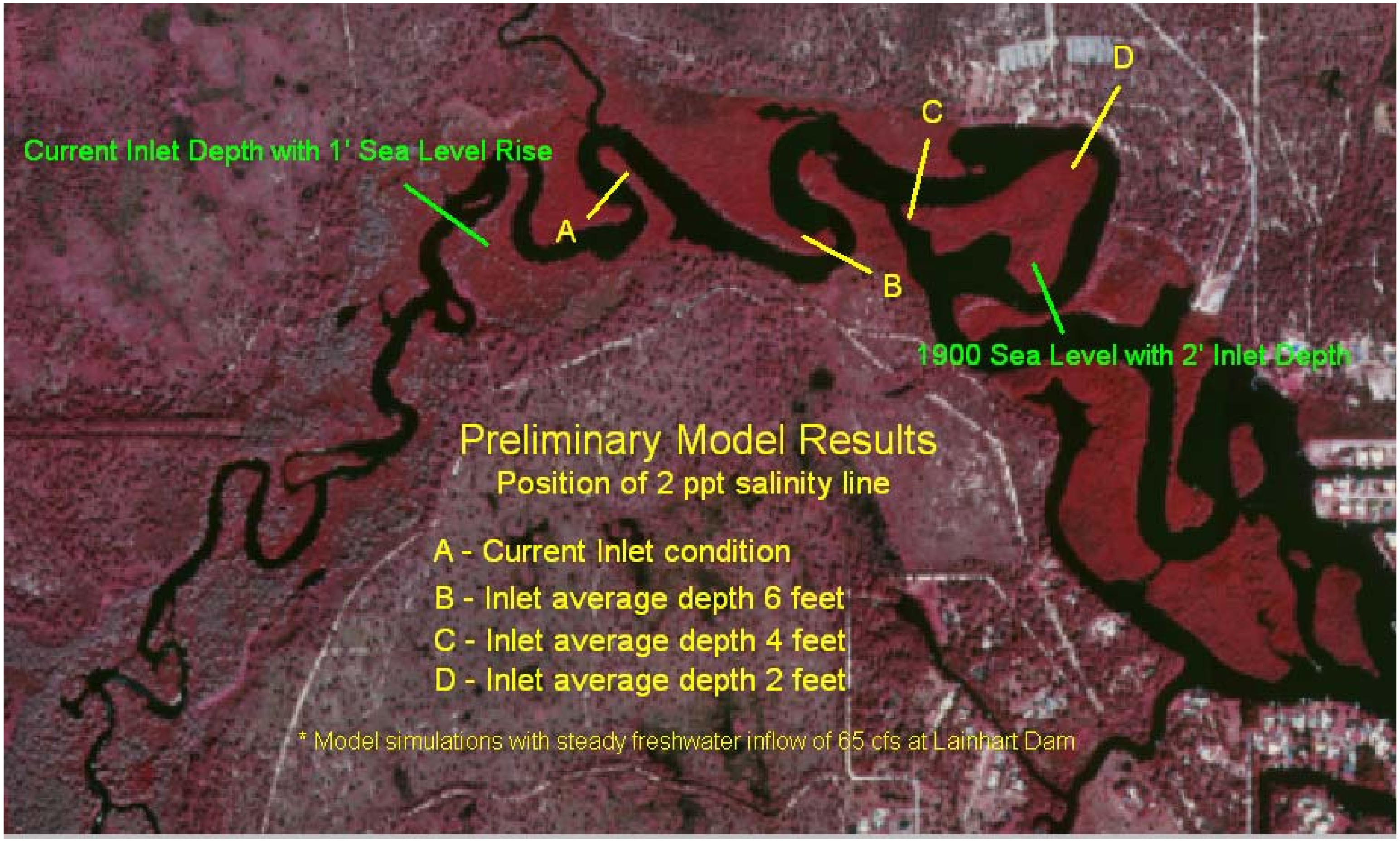

Figure A-11. 2-ppt Salinity Line Position at Various Inlet Depths and Sea Level. 2-ppt Lines are Labeled with Depth at Jupiter Inlet and Sea Level.

MODELING STUDY OF SALTWATER INTRUSION IN LOXAHATCHEE RIVER, FLORIDA

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ABSTRACT

The upstream advance of saltwater into the historic freshwater reaches of the Loxahatchee River has altered the floodplain cypress forest community along the river and some of its tributaries. A hydrodynamic/salinity model was developed to study the influence of freshwater input, tidal inlet deepening and sea level rise on the salinity regime in the estuary (Hu, 2002). The model was recently updated with new bathymetric data. The updated model was tested against the tide and salinity data that had been collected in 2003. The model output and field data were examined and compared to assess the performance of the two-dimensional depth averaged model for the intended application.

INTRODUCTION

The Loxahatchee River estuary empties into the Atlantic Ocean at Jupiter Inlet in southeastern Florida. The estuarine system is comprised of three forks: the Southwest Fork, North Fork, and Northwest Fork (**Figure A-12**). Estuarine conditions extend from the Jupiter Inlet to about 5 river miles up the Southwest Fork, 6 river miles up the North Fork, and 10 river miles up the Northwest Fork. Four major tributaries: the upper Northwest Fork of Loxahatchee River, Cypress Creek, Hobe Grove Ditch, and Kitching Creek discharge to the Northwest Fork. Canal 18 (C-18), built in 1957 – 1958, is the major tributary to the Southwest Fork. The North Fork has several small unnamed tributaries. Rainfall in the area is seasonal, 5 inches per month is common during the wet season from May through October. Amounts near 2.5 inches per month generally occur during the dry season from November to April (Russell and Goodwin, 1987).

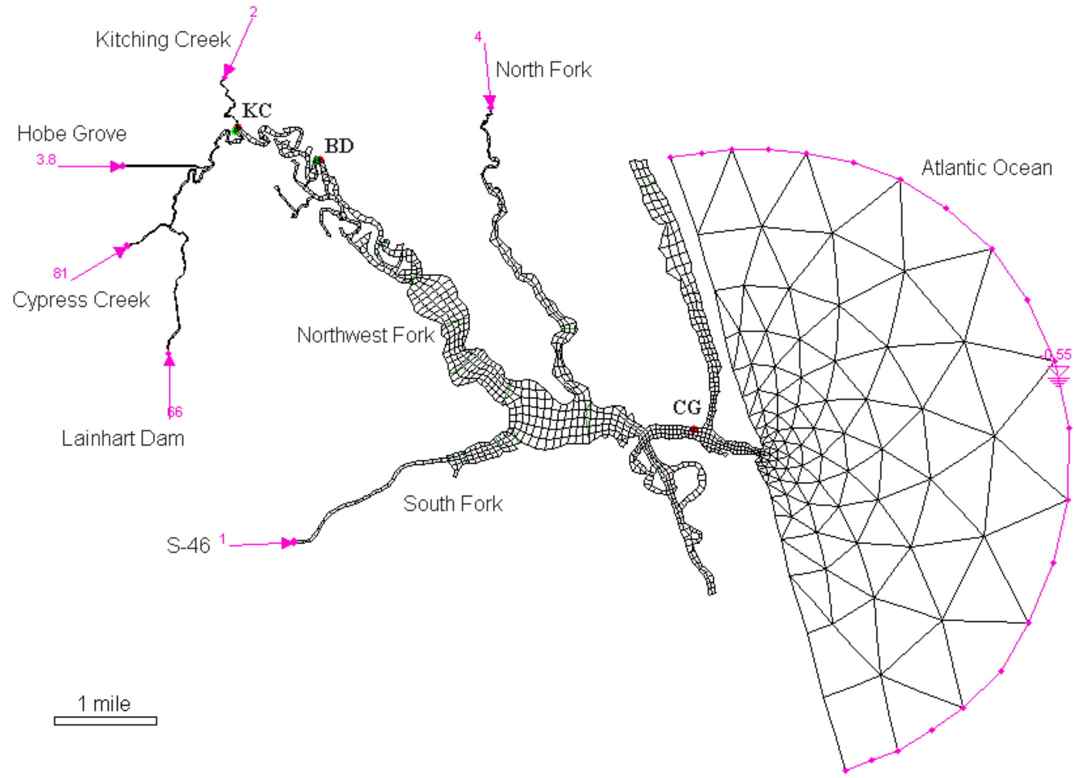


Figure A-12. Model Domain and Finite Element Mesh.

The upstream migration of salt water into the historic freshwater reaches of the Loxahatchee River is the likely cause of the altered floodplain cypress forest community along the Northwest Fork and some of its tributaries (McPherson, Sabanskas, & Long, 1982). A hydrodynamic/salinity model was developed to study the influence of freshwater input on the salinity conditions in the river and estuary. The model was applied to scenarios with varying amounts of freshwater inflow. Both the field data and model simulation indicated that there is a strong correlation between freshwater inflow and the salinity regime in the estuary. Based on model output and field data analysis, a relationship was developed to predict salinity at various points in the estuary with respect to freshwater inflow rates and tidal fluctuations. The model also provided a preliminary assessment of the impacts that inlet deepening and sea level rise have had on the salinity regime in the estuary (Hu, 2002).

In parallel with the preliminary model setup, a data collection program was implemented. A bathymetric survey was conducted in Northwest Fork and North Fork in early 2003. Two flow gauges were established on Cypress Creek and Hobe Grove Ditch in November, 2002. Combined with flow gauges that were previously established at the Lainhart Dam on the upper Northwest Fork and Kitching Creek, the four gauges monitor a majority of freshwater input to the Northwest Fork which has been the focus of the salinity study. Four tide and salinity stations have been deployed in the estuary since November 2002. For current velocity measurements, two bottom mount ADCP units have been deployed at various locations through out the estuary since June, 2003. The estuary model was updated recently using the new bathymetry and freshwater inflow data. The updated model was tested against tide, salinity and velocity data collected in the period from May to August, 2003. This paper outlines the results of the three-month model simulation.

MODEL DESCRIPTION

The Loxahatchee River Hydrodynamics/Salinity Model was setup using two computer programs: RMA-2 and RMA-4 (USACE, 1996). RMA-2 is a two dimensional depth averaged finite element hydrodynamic numerical model. It computes water surface elevations and horizontal velocity components for subcritical, free-surface flow in two dimensional flow fields. RMA-2 computes a finite element solution of the Reynolds form of the Navier-Stokes equations for turbulent flows. Friction is calculated with the Manning's or Chezy equation, and eddy viscosity coefficients are used to define turbulence characteristics. The water quality model, RMA4, is designed to simulate the depth-average advection-diffusion process in an aquatic environment. In this application, RMA-4 was used for salinity simulation only. The finite element mesh was recently updated with new bathymetric data. The current model mesh includes a total of 4956 nodes with elevations derived from survey data. **Figure A-12** shows the model mesh with 1075 quadrilateral elements and 231 triangular elements. Arrows in the figure indicate the locations where flow boundary conditions are applied. The model mesh was extended three miles offshore into the Atlantic Ocean in order to obtain a relatively stable salinity boundary condition. Tide and salinity data collected from three stations were used in the initial model testing. The locations of the three stations are marked in the mesh map as CG – Coastguard Station, BD – Boy Scout Dock Station and KC – Kitching Creek Station.

Figure A-13 shows the combined freshwater inflow from four major tributaries to the Northwest Fork for the period from May 1 to August 12, 2003. Daily averaged flow rates in terms of cubic feet per second from flow gauges on upper Northwest Fork at Lainhart Dam, Cypress Creek, Hobe Grove and Kitching Creek were used for the calculation. Discharge from S-46 into South Fork was based on measurements at the discharge structure for the model simulation period.

The water surface elevation on the ocean side was based on tidal data from the Coastguard Station near the Jupiter Inlet. Tidal data was collected at 15-minute intervals. The model time step was set at 30 minutes in this application. **Figure A-14** is a comparison of tidal data from the Coastguard station with the RMA-2 model output. For RMA-4 applications, a constant salinity of 35.5 ppt was applied on the ocean boundary.

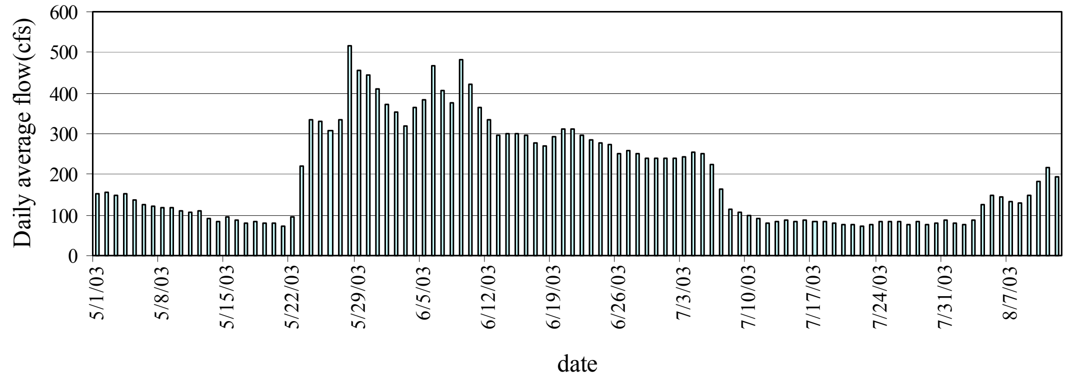


Figure A-13. Freshwater Inflow from Major Tributaries to the Northwest Fork.

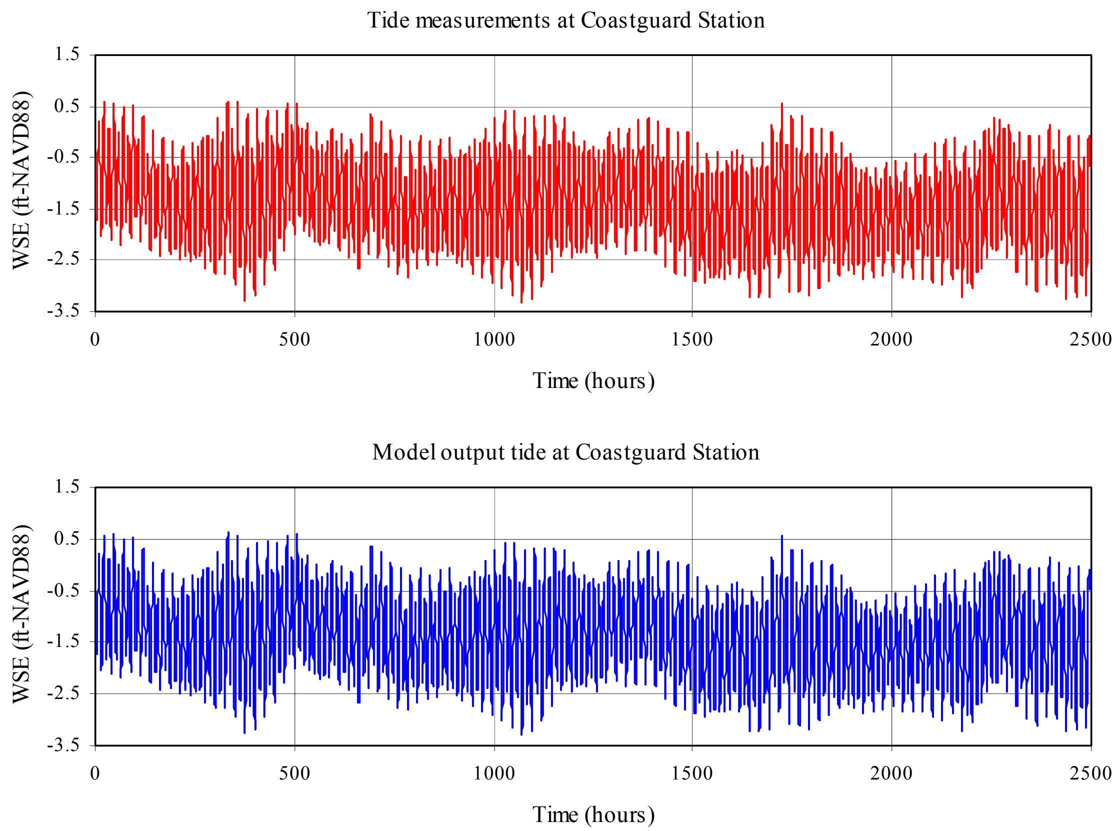


Figure A-14. Tide at the Coastguard Dock Station – Field Data and Model Output.

RESULTS AND DISCUSSION

Field data and model output of tides at Boy Scout Dock and Kitching Creek are plotted in **Figure A-15** for comparison. The two stations are approximately two river miles apart and there is no major tributary in between. Both field data and model output indicate that the tidal regimes at these two sites are similar in terms of range. Flow velocity measurements were taken at these two sites in late June and July of 2003 (see **Figure A-16**). The instruments were bottom mount ADCP units with transducers at approximately two and a half feet over the bed surface. Since the water depth in the area is only about 6 to 10 feet deep, the records provided by these instruments are in fact the flow velocity of the faster moving upper layer in the water column. This is probably one of the reasons that the depth averaged velocity from RMA-2 is lower then the ADCP measurements.

In order to speed up model execution for long-term simulations, the Northwest Fork is represented in the current model mesh with a single row of elements. Therefore the elevation variation of bed surface in the lateral direction was not resolved in detail by the current model mesh. The flow velocity produced by the model should probably be considered mean velocity over a cross section. On the other hand, the up-looking ADCP units can only cover a small portion of the river channel depending on the spread angle of acoustic signal and the water depth. This is another possible reason that the model flow velocity is smaller than ADCP measurements. Future plans include a higher resolution model mesh to model scenarios that involve hydraulic structures on the Northwest Fork.

Figure A-17 compares model output of depth-averaged salinity with salinity measurements from instruments at a fixed elevation. While these two quantities are not exactly the same physically, the comparison reveals both the limitations and capabilities of a depth averaged model such as RMA-2 and RMA-4.

The salinity record for Boy Scout Dock was at 15 to 20 ppt around the middle of the simulation for a seven day period. This sudden salinity increase does not seem to be related or supported by data from other field records. High salinity between 15 and 20 ppt at this site usually occurs when freshwater inflow is below 100 cfs. The flow gauges actually recorded 300 cfs for that period. The salinity record from the adjacent Kitching Creek station is also inconsistent with this salinity increase in the Boy Scout Dock station record. Previous studies indicated that 20ppt at Boy Scout Dock station would have bought up salinity at Kitching Creek station to 5 ppt or above (Russell & McPherson, 1983). The station at Kitching Creek did not record such an increase for that period (See **Figure A-17**).

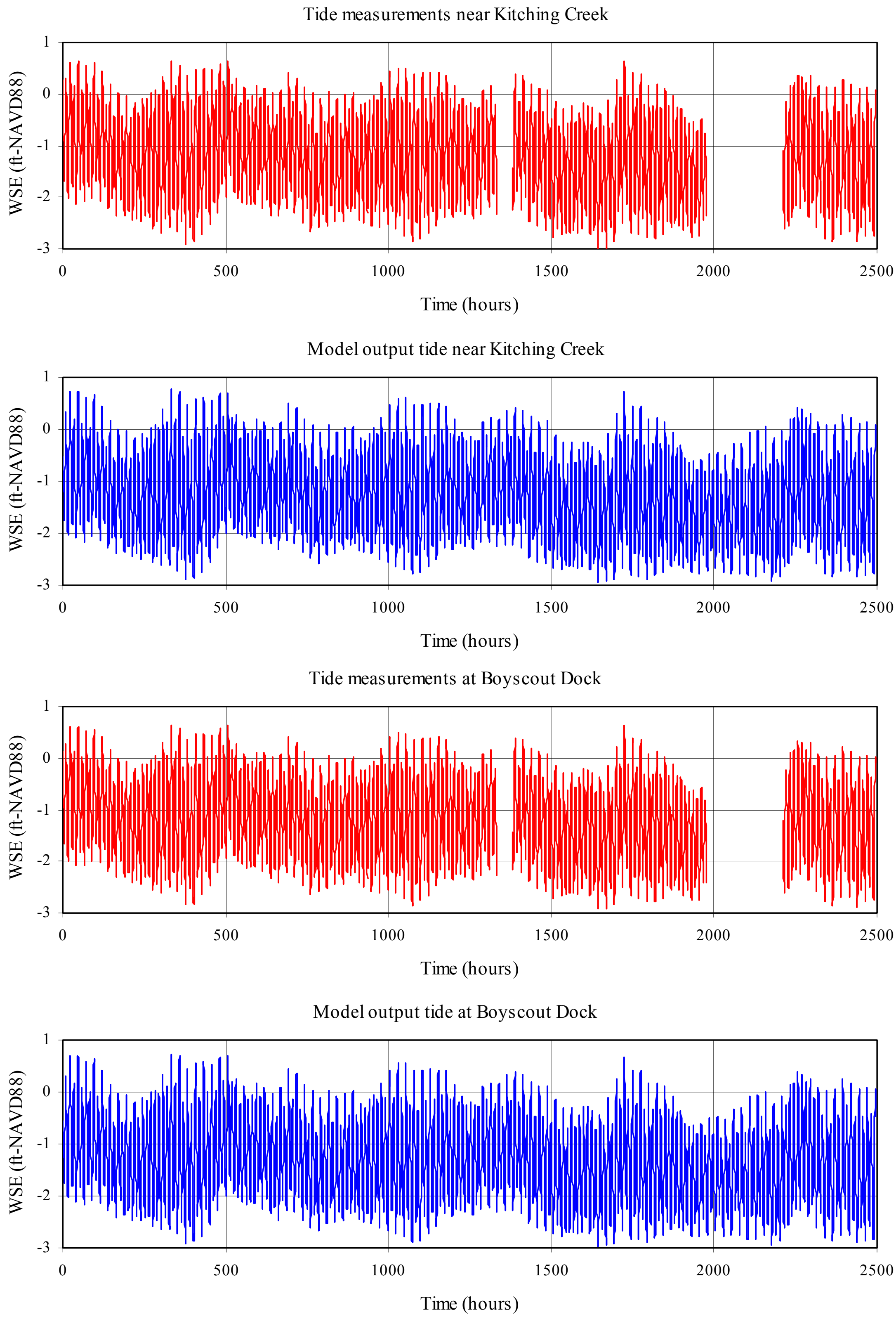


Figure A-15. Tide at BD and KC stations – Field Data and Model Output.

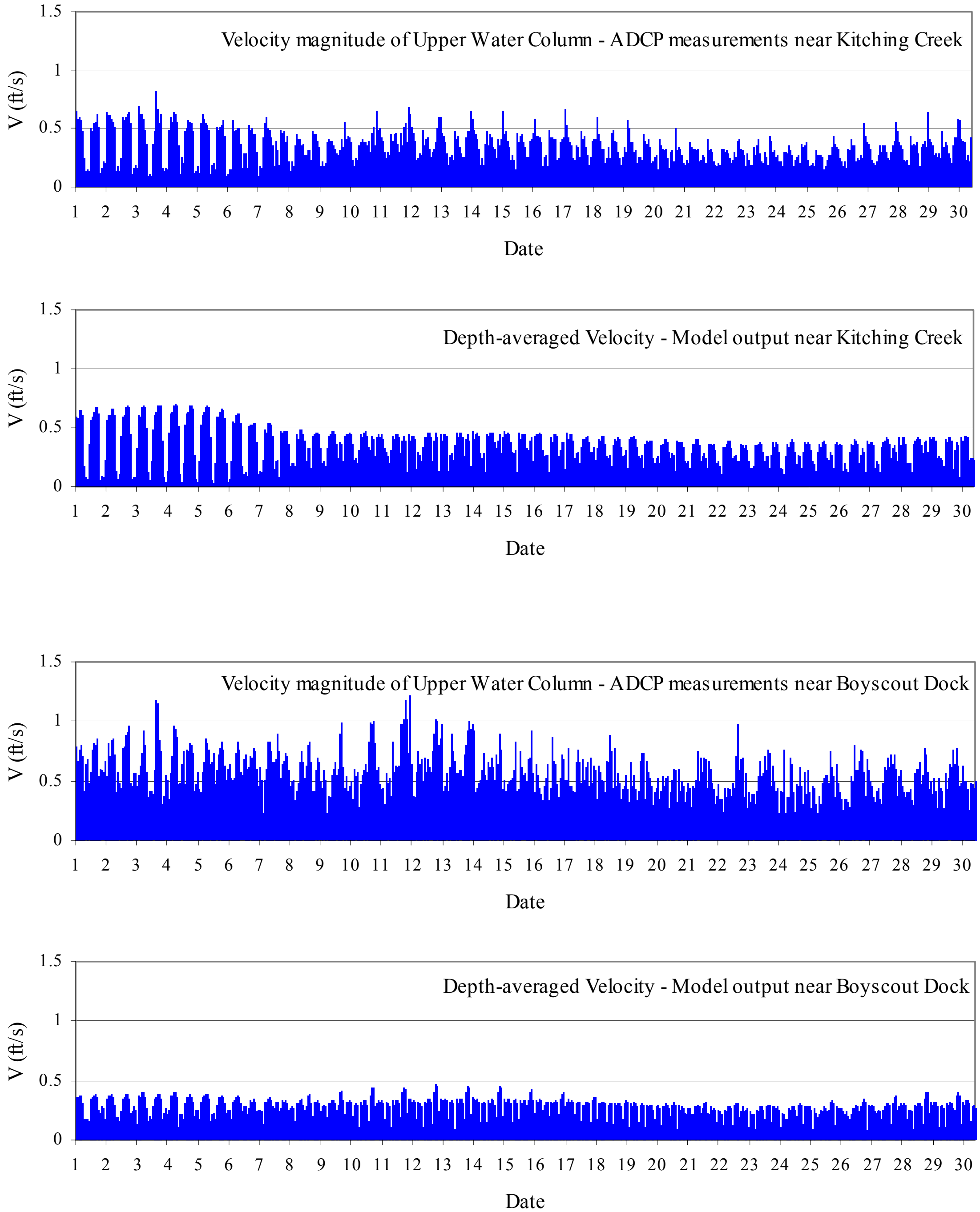
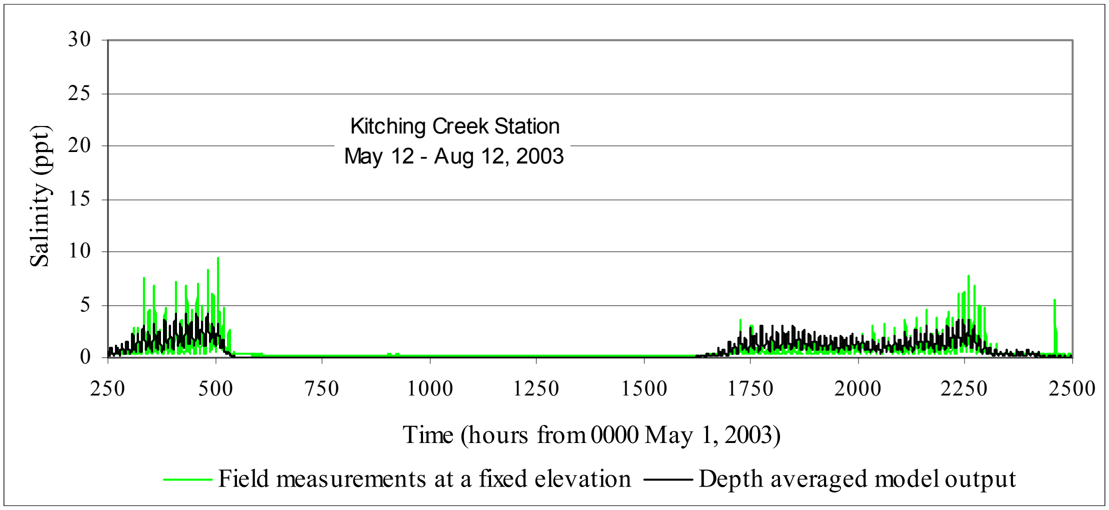
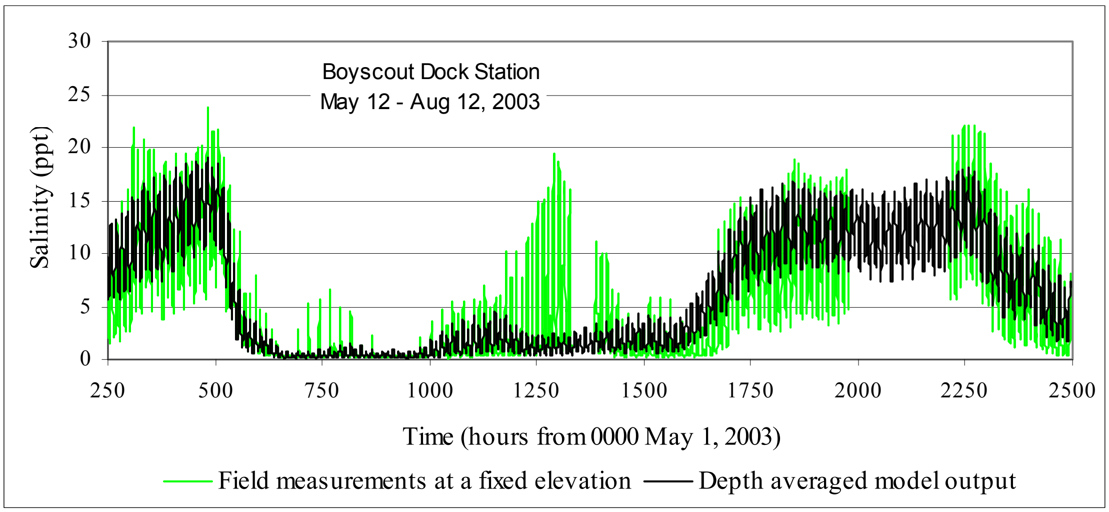


Figure A-16. Flow Velocity Magnitude – ADCP Measurements of Upper Water Column Flow Velocity and Model Output of Depth Averaged Velocity.





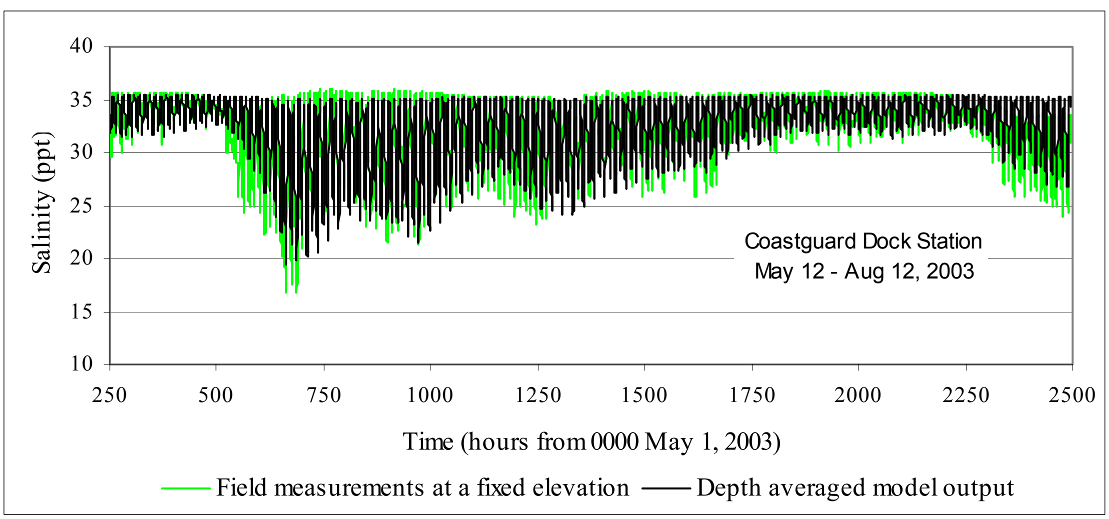


Figure A-17. Model Output of Depth Averaged Salinity and Field Measurements at Fixed Elevations in the Water Column.

Both RMA-2 and RMA-4 are two dimensional depth averaged models. The models do not simulate the formation of a saltwater wedge and salinity stratification. When the system is less stratified, such as the condition near the inlet at the coastguard station, the model output salinity tracks field data rather closely. On the other hand when the system is stratified in certain areas the model output for that area tends to give a smaller salinity variation between high tide and low tide, which is the most evident in this simulation at the Boy Scout Dock station.

The RMA-4 output is depth averaged salinity, which is different from salinity read by a transducer at a fixed elevation. The conductivity transducers were installed at elevations that would remain below the water surface at low tide. Since the range between higher high and lower low water is close to 4 feet and the over all water depth is only about 6 feet to 10 feet, the conductivity transducers would be situated in the lower water column during high tide. This situation would make the instrument take measurements in the surface layer at low tide and in a bottom layer at high tide. If the system is well mixed (no stratification), there should be no difference between depth averaged salinity and salinity at a fixed elevation. On the other hand, when the system is stratified, the daily variation range recorded by the instruments would be wider than the daily variation range of the depth averaged salinity.

The intended application of the model is to predict daily mean salinity for a number of locations in the estuary. It is interesting to observe how a depth averaged model would perform for such applications. **Figure A-18** compares daily mean salinity from the model simulation with field data. For the three months period, the difference between the model output and field record is less than 1 ppt for most cases except for the seven day period at the Boy Scout Dock station where a further assessment on the field data is pending.

An objective of this preliminary modeling study is to assess the possibility of establishing a relationship between the amount of freshwater inflow from major tributaries and salinity at various locations in the estuary. **Figure A-19** shows plots of freshwater inflow versus daily average salinity at the Boy Scout Dock station. The first chart in the figure was based on model output salinity. The second chart was based on measured salinity. There are certainly driving forces other than freshwater inflow that affects salinity. Therefore the salinity record shows a wide range of variation for the same freshwater input. On the other hand, the chart does show a clear trend, which indicates that freshwater inflow affect salinity at this site significantly. The range of salinity variation in the model output was narrower since the model in its current form is driven by tide and freshwater inflow only. The scattering of model data points is mostly due to the variation of tidal conditions. Another factor of salinity variation from a single freshwater ~ salinity relationship was the transition of the system from one salinity regime to another in response to the changes in the freshwater input.

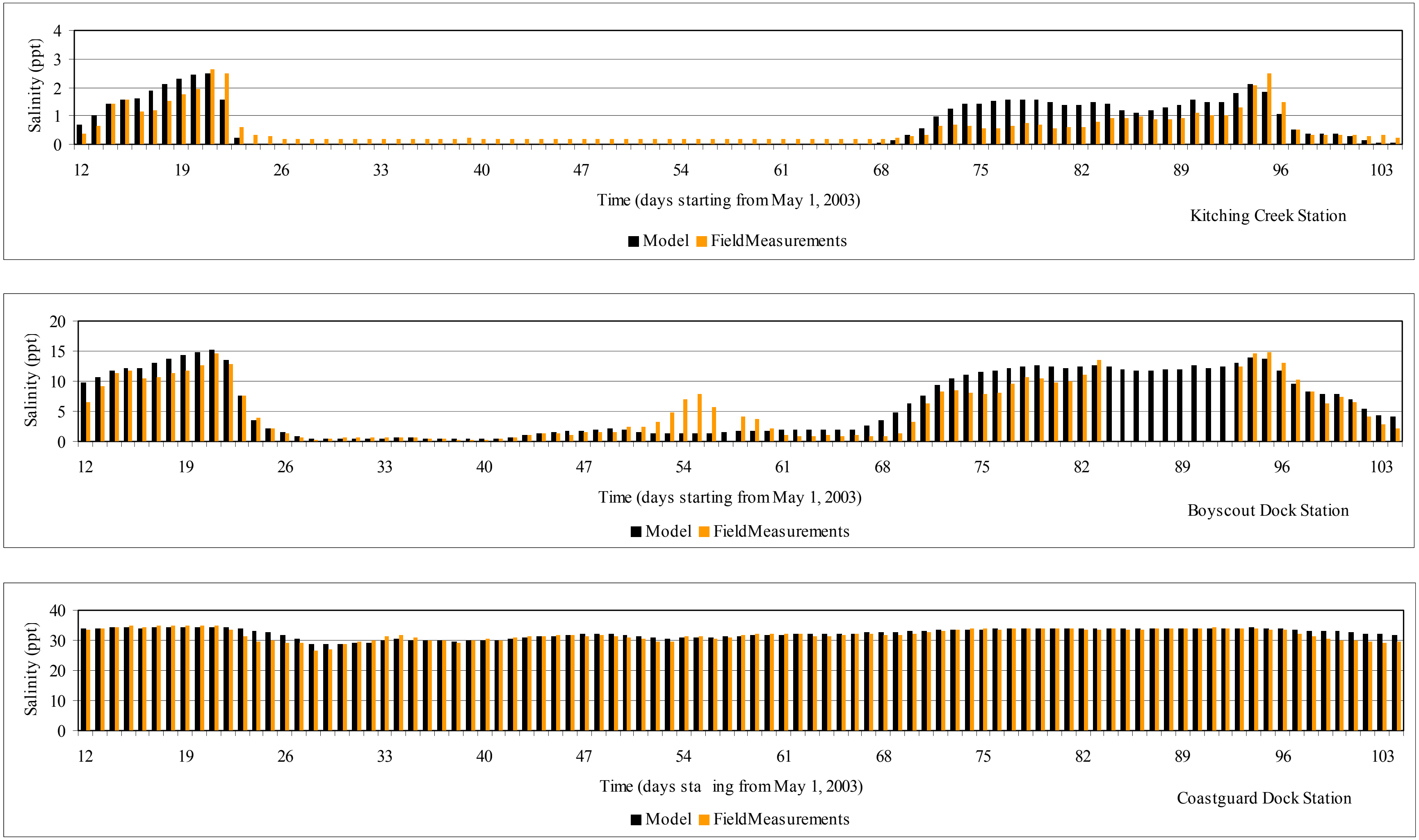
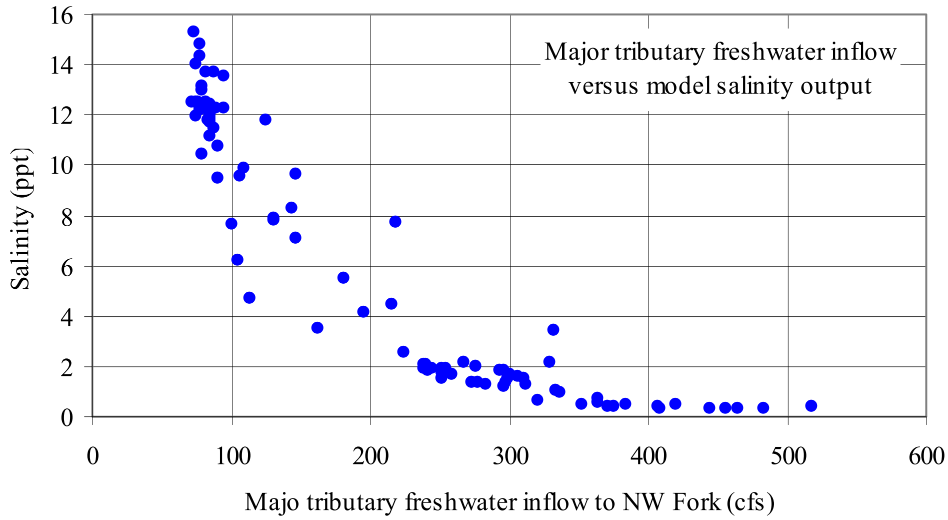


Figure A-18. Daily Average Salinity Based on Model Output and Field Measurements.



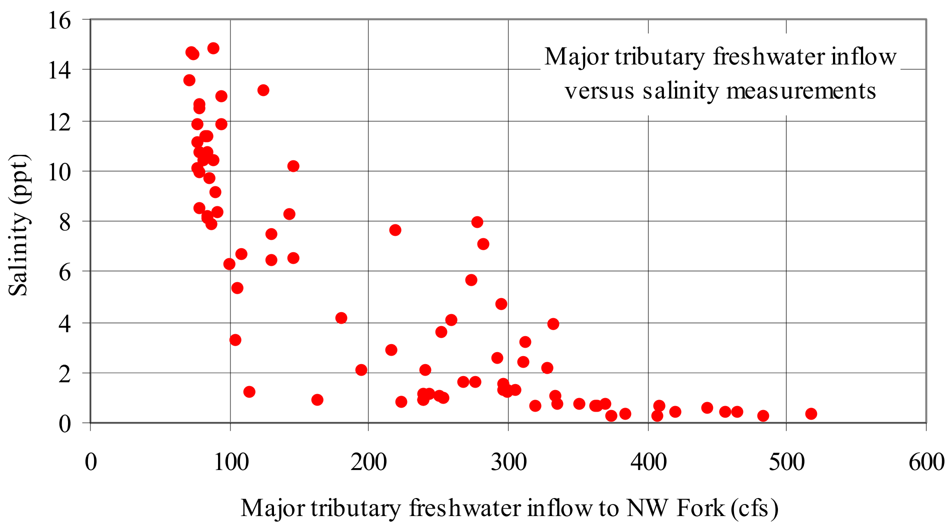
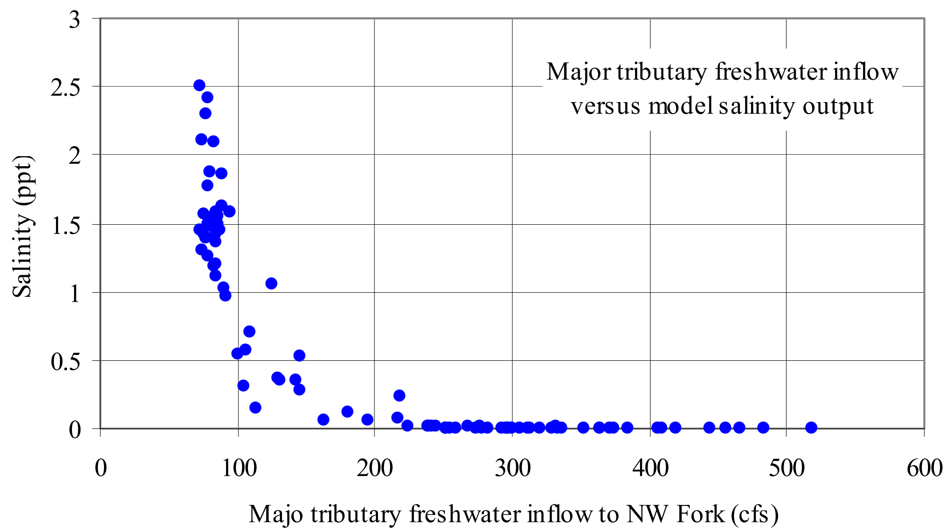


Figure A-19. Freshwater Inflow versus Daily Average Salinity at Boy Scout Dock Station.

Data points based on field measurements are more scattered, which is an indication that there are other factors at working. For example, there is freshwater inflow to the system such as overland flow and discharge from small tributaries that bypass the four flow gauges. Given the intensive rainfall in summer, the significance of direct rainfall on the estuary also needs to be assessed. Wind is another factor that needs to be considered in the next phase of the model improvements.

Similar freshwater flow versus salinity plots are shown in **Figure A-20** for the Kitching Creek station. The relationship based on model output resembles more closely the relationship based on the field data. The data points are also less scattered comparing to the Boy Scout Dock station plots. Kitching Creek station is two miles upstream from the Boy Scout Dock station. Apparently freshwater inflow is a more dominating factor near the head of the estuary. Therefore the freshwater inflow and salinity appears more closely correlated at the upstream station. The minimum salinity that the Kitching Creek station recorded was 0.2 ppt which suggests that the RMA-4 model should probably have applied a salinity of 0.2 ppt instead of 0 ppt to the tributary inflow model boundaries.



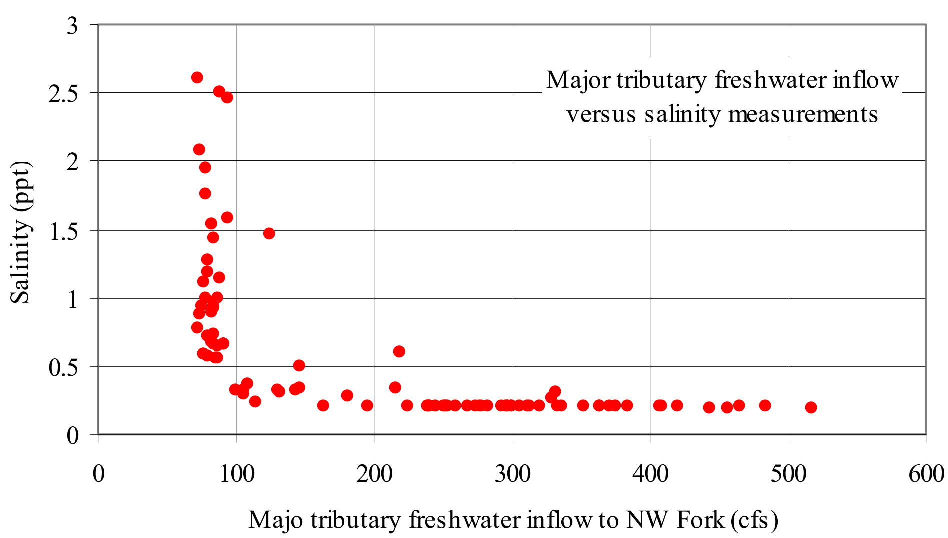


Figure A-20. Freshwater Inflow versus Daily Average Salinity at Kitching Creek Station.

Due to insufficient freshwater inflow data, the previous modeling study and statistical analysis estimated total freshwater inflow to the Northwest Fork using flow records at the Lainhart Dam. The estimation was based on a percentage established by USGS and South Florida Water Management District field measurements in 1980s and 1990s (SFWMD, 2002). Over the three month model simulation period in 2003, freshwater from Lainhart Dam was about 30 – 70% of the total from all four freshwater flow gauges. Average percentage for the three month period was 52%. The freshwater inflow versus salinity relationships shown in **Figures A-19** and **A-20** are consistent with the previous modeling study and statistical analysis.

CONCLUSIONS

The current model does not include driving forces such as wind, precipitation/evaporation and the exchange between the river and the groundwater which can be significant in the upper river reaches during dry season. While sensitivity analysis will be conducted to assess the significance of these factors the current model, which was only driven by major tributary freshwater input and ocean tide, was able to predict the tide regime rather accurately and predict the trend of salinity changes over the three month simulation that include both low and high freshwater input to the estuary. This seems to indicate that the amount of freshwater inflow to the estuary and tide are the two most dominant factors that affect the salinity regime in the estuary.

The depth averaged model does not simulate salinity stratification in the system. It appears that this will probably hinder the capability for the model to predict the full range of salinity variation between high and low water. On the other hand, the daily mean salinity from the model output follows the field record rather closely.

The model was able to predict the overall tide and salinity regime over the three month period that includes both low and high freshwater input to the system. For applications where an accurate description of flow field (spatial distribution of flow velocity) is required in the upper estuary such as Northwest Fork, the model mesh needs to increase its resolution to describe the river channel geometry in greater detail. For simulations of high flow scenarios, floodplain should also be included in the model mesh.

Both model output and field data were examined to assess the possibility of establishing a relationship between salinity and freshwater inflow. While both data plots for the two stations on the Northwest Fork show a clear pattern of freshwater influence, it appears that fresh water is a more dominating factor at the upstream station. The relationships drawn from both the field data and model simulation over the three month period in 2003 (shown in **Figures A-19** and **A-20**) are consistent with the results of previous modeling study and statistical analysis.

REFERENCES

Hu, G. (2002). "The Effects of Freshwater Inflow, Inlet Conveyance and Sea Level Rise on the Salinity Regime in the Loxahatchee Estuary." Proceedings of *2002 Environmental Engineering Conference, Environmental & Water Resources Institute, American Society of Civil Engineers-Canadian Society of Civil Engineers*, Niagara Falls, Ontario, Canada, July 21-24, 2002.

McPherson, B.F., Sabanskas, M., & Long, W. (1982). "Physical, Hydrological, and Biological Characteristics of the Loxahatchee River Estuary, Florida." USGS Water-Resources Investigations, Open file report, 82-350.

Russell, G.M., McPherson, B.F. (1983). Freshwater Runoff and Salinity Distribution in the Loxahatchee River Estuary, Southeastern Florida. USGS Water-Resources Investigations Report, 83-4244.

Russell, G.M., Goodwin, C.R. (1987). Simulation of Tidal Flow and Circulation Patterns in the Loxahatchee River Estuary, Southeastern Florida. USGS, Water-Resources Investigations Report 87-4201. Tallahassee, Florida, 1987.

SFWMD (2002). Technical Documentation to Support Development of Minimum Flows and Levels for the Northwest Fork of the Loxahatchee River. South Florida Water Management District, Water Supply Department, November, 2002.

USACE, (1996). Users' Guide to RMA2 Version 4.3. US Army Corps of Engineers, Waterways Experiment Station, Hydraulic Laboratory.

APPENDIX B

GENERAL LAND OFFICE'S 1855 SURVEY NOTES

OF THE LOXAHATCHEE RIVER AREA;

TOWNSHIP 40 SOUTH, RANGE 42 EAST

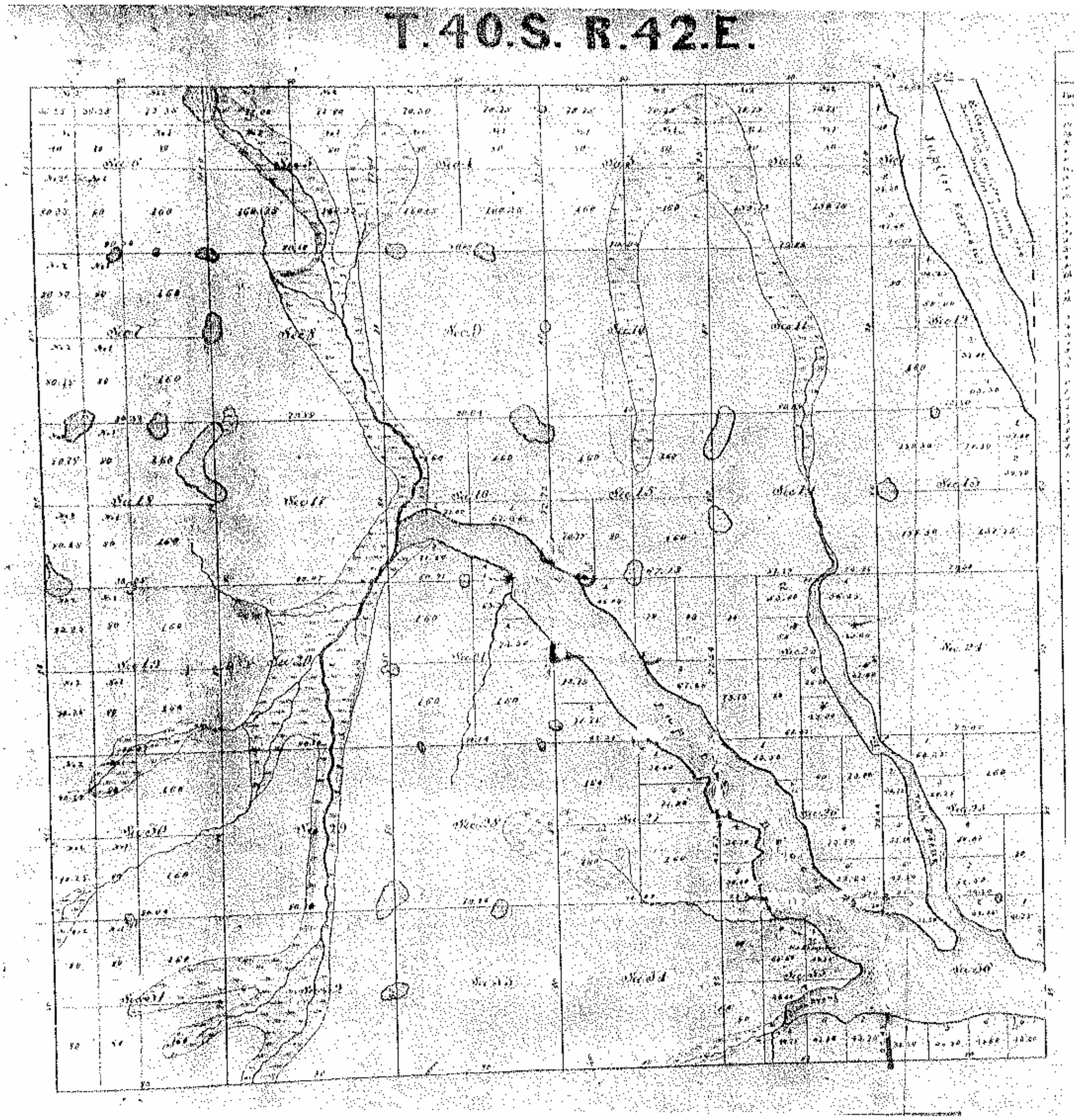


Figure B-1. Map of the Loxahatchee River Area from the 1855 General Land Office Survey Field Notes.

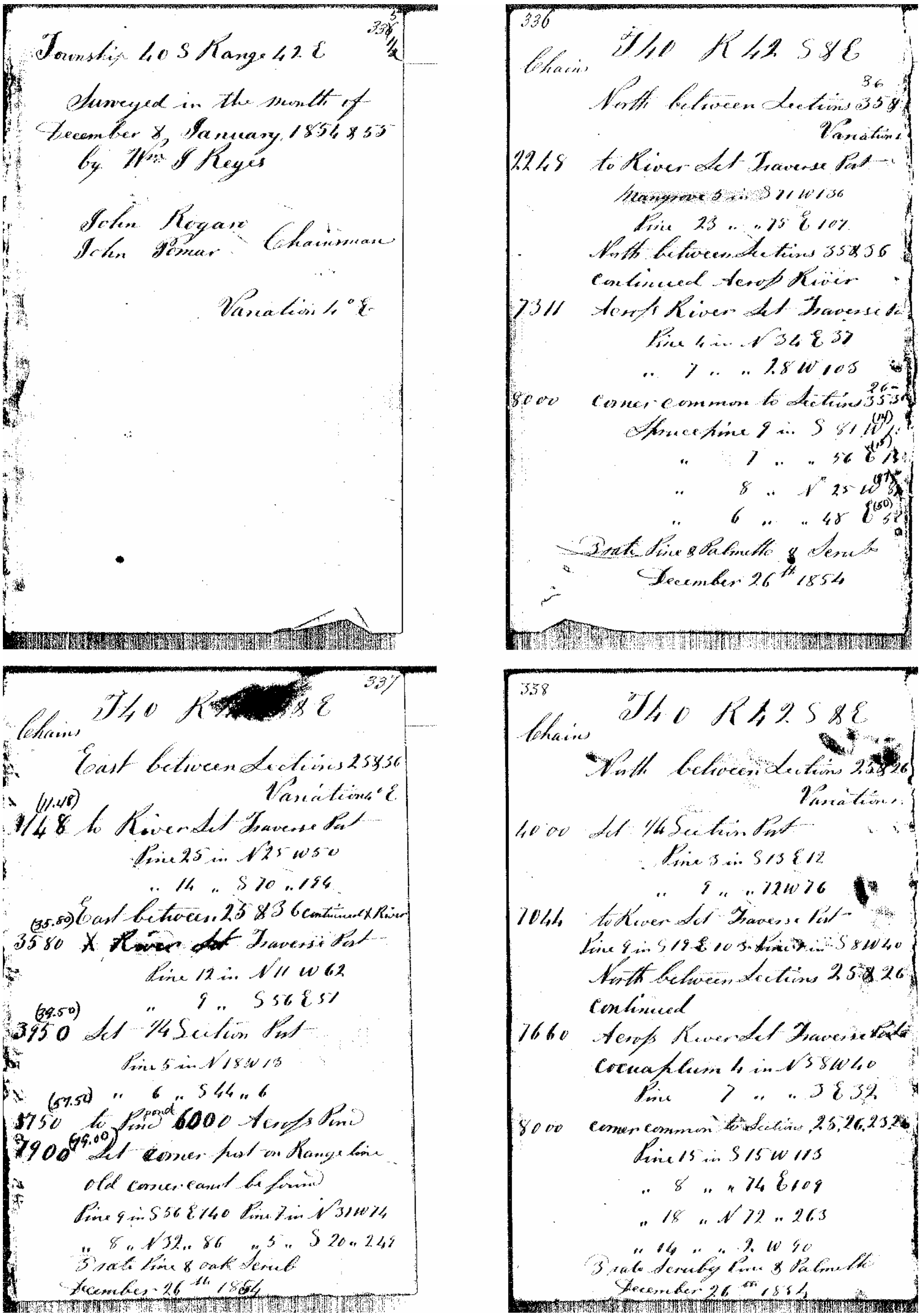
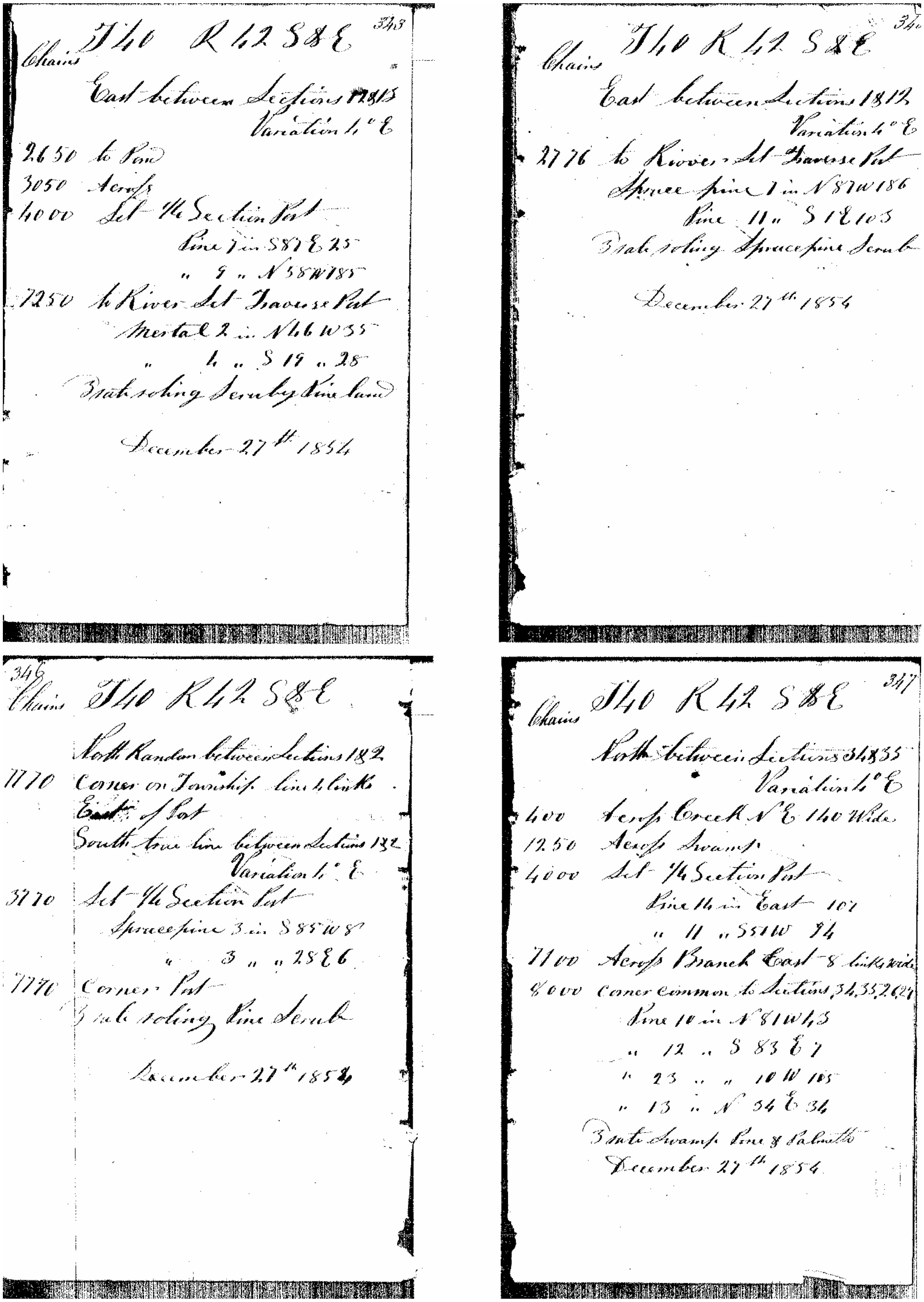


Figure B-2. Field Notes from the 1855 General Land Office Survey of the Loxahatchee River Area.



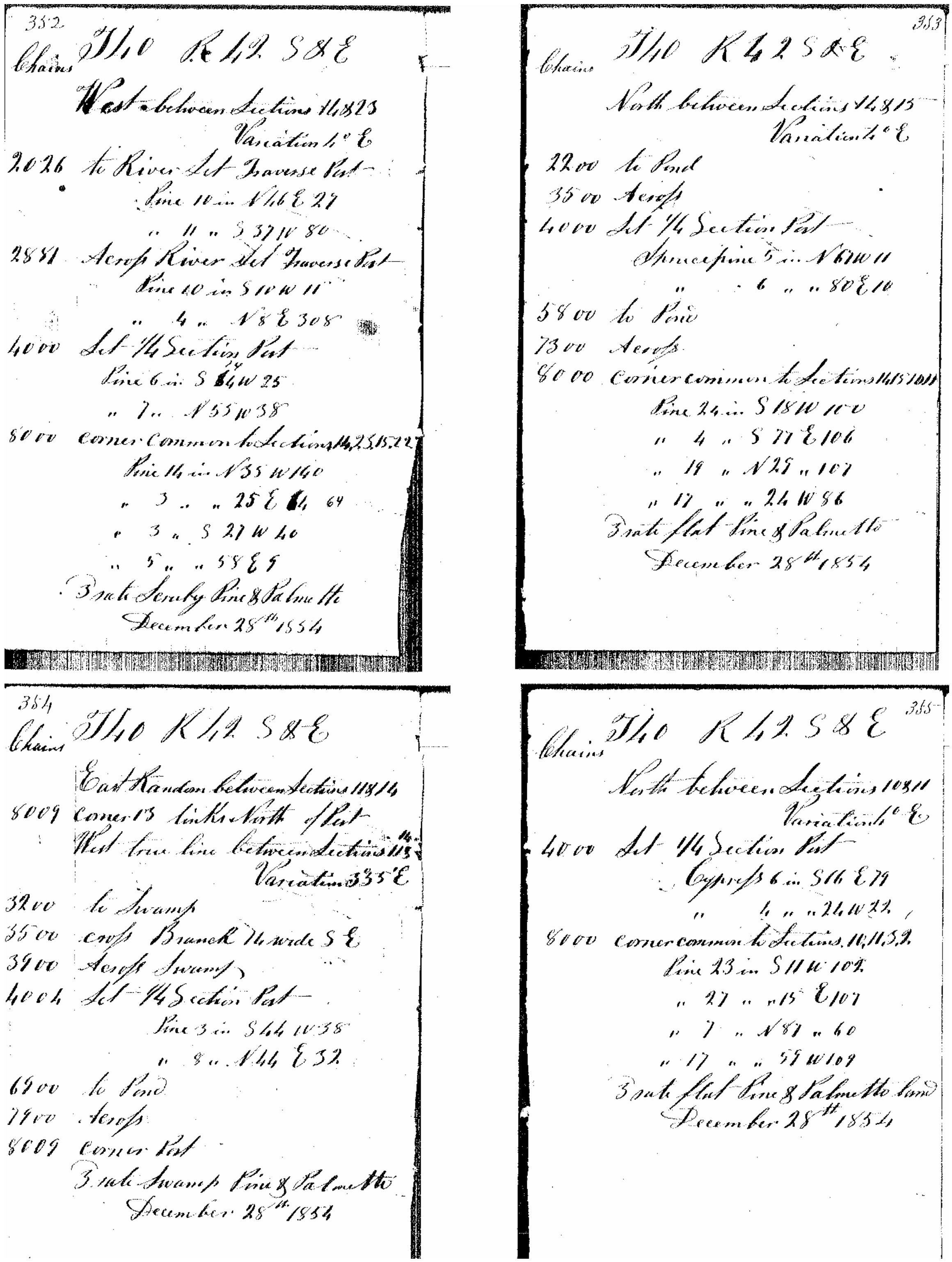
343
Chains T40 R42 S&E
East between Sections 18&13
Variation 4° E
26 50 to Pond
30 50 Across
40 00 Set 1/4 Section Post
Pine 7 in S 87 E 25
" 9 " N 58 W 185
72 50 to River Set Traverse Post
Mastic 2 in N 46 W 55
" 4 " S 19 " 28
3rd rate rolling Scruby Pine land
December 27th 1854

344
Chains T40 R42 S&E
East between Sections 18&12
Variation 4° E
27 76 to River Set Traverse Post
Spruce pine 7 in N 87 W 186
Pine 11 " S 1 E 103
3rd rate rolling Spruce pine Scrub
December 27th 1854

346
Chains T40 R42 S&E
North Random between Sections 1&2
77 70 Corner on Township line 4 links East of Post
South true line between Sections 1&2
Variation 4° E
37 70 Set 1/4 Section Post
Spruce pine 3 in S 85 W 8
" 3 " " 28 E 6
77 70 Corner Post
3rd rate rolling Pine Scrub
December 27th 1854

347
Chains T40 R42 S&E
North between Sections 34&35
Variation 4° E
4 00 Across Creek N E 140 Wide
12 50 Across Swamp
40 00 Set 1/4 Section Post
Pine 14 in East 107
" 11 " S 51 W 74
71 00 Across Branch East 8 links wide
80 00 Corner common to Sections 34, 35, 2 & 1
Pine 10 in N 81 W 43
" 12 " S 83 E 7
" 23 " " 10 W 105
" 13 " N 54 E 34
3rd rate Swamp Pine & Palmetto
December 27th 1854

Figure B-3. Field Notes from the 1855 General Land Office Survey of the Loxahatchee River Area.



352
Chains T40 R42 S8E
West between Sections 14 & 23
Variation 4° E
2026 to River Set Traverse Post
Pine 10 in N 46 E 27
" 11 " S 37 W 80
2881 Across River Set Traverse Post
Pine 10 in S 10 W 11
" 4 " N 8 E 308
4000 Set 1/4 Section Post
Pine 6 in S 24 W 25
" 7 " N 55 W 38
8000 Corner Common to Sections 14, 23, 15, 22
Pine 14 in N 35 W 140
" 3 " " 25 E 14 64
" 3 " S 27 W 40
" 5 " " 58 E 9
3 rate Scruby Pine & Palmetto
December 28th 1854

353
Chains T40 R42 S8E
North between Sections 14 & 15
Variation 4° E
2200 to Pond
3500 Across
4000 Set 1/4 Section Post
Spruce pine 5 in N 67 W 11
" 6 " " 80 E 10
5800 to Pond
7300 Across
8000 Corner common to Sections 14, 15, 10, 11
Pine 24 in S 18 W 100
" 4 " S 71 E 106
" 19 " N 25 " 107
" 17 " " 24 W 86
3 rate flat Pine & Palmetto
December 28th 1854

354
Chains T40 R42 S8E
East Random between Sections 11 & 14
8009 Corner 13 links North of Post
West true line between Sections 11 & 14
Variation 3 35' E
3200 to Swamp
3500 cross Branch 14 wide S E
3900 Across Swamp
4004 Set 1/4 Section Post
Pine 3 in S 44 W 38
" 8 " N 44 E 32
6900 to Pond
7900 Across
8009 Corner Post
3 rate Swamp Pine & Palmetto
December 28th 1854

355
Chains T40 R42 S8E
North between Sections 10 & 11
Variation 4° E
4000 Set 1/4 Section Post
Cypress 6 in S 16 E 79
" 4 " " 24 W 22
8000 Corner common to Sections 10, 11, 3, 2
Pine 23 in S 11 W 102
" 27 " " 15 E 107
" 7 " N 81 " 60
" 17 " " 59 W 109
3 rate flat Pine & Palmetto land
December 28th 1854

Figure B-4. Field Notes from the 1855 General Land Office Survey of the Loxahatchee River Area.

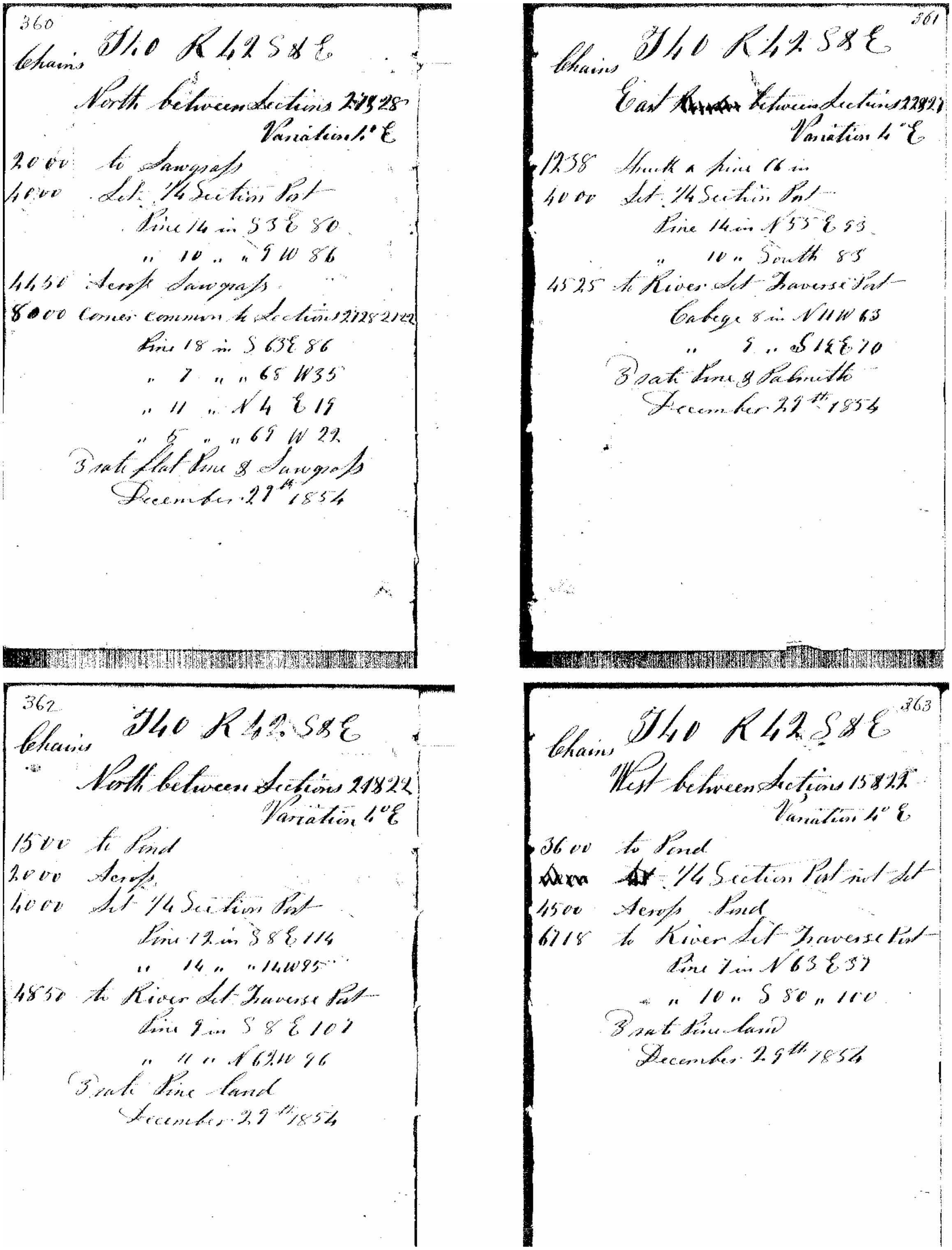


Figure B-5. Field Notes from the 1855 General Land Office Survey of the Loxahatchee River Area.

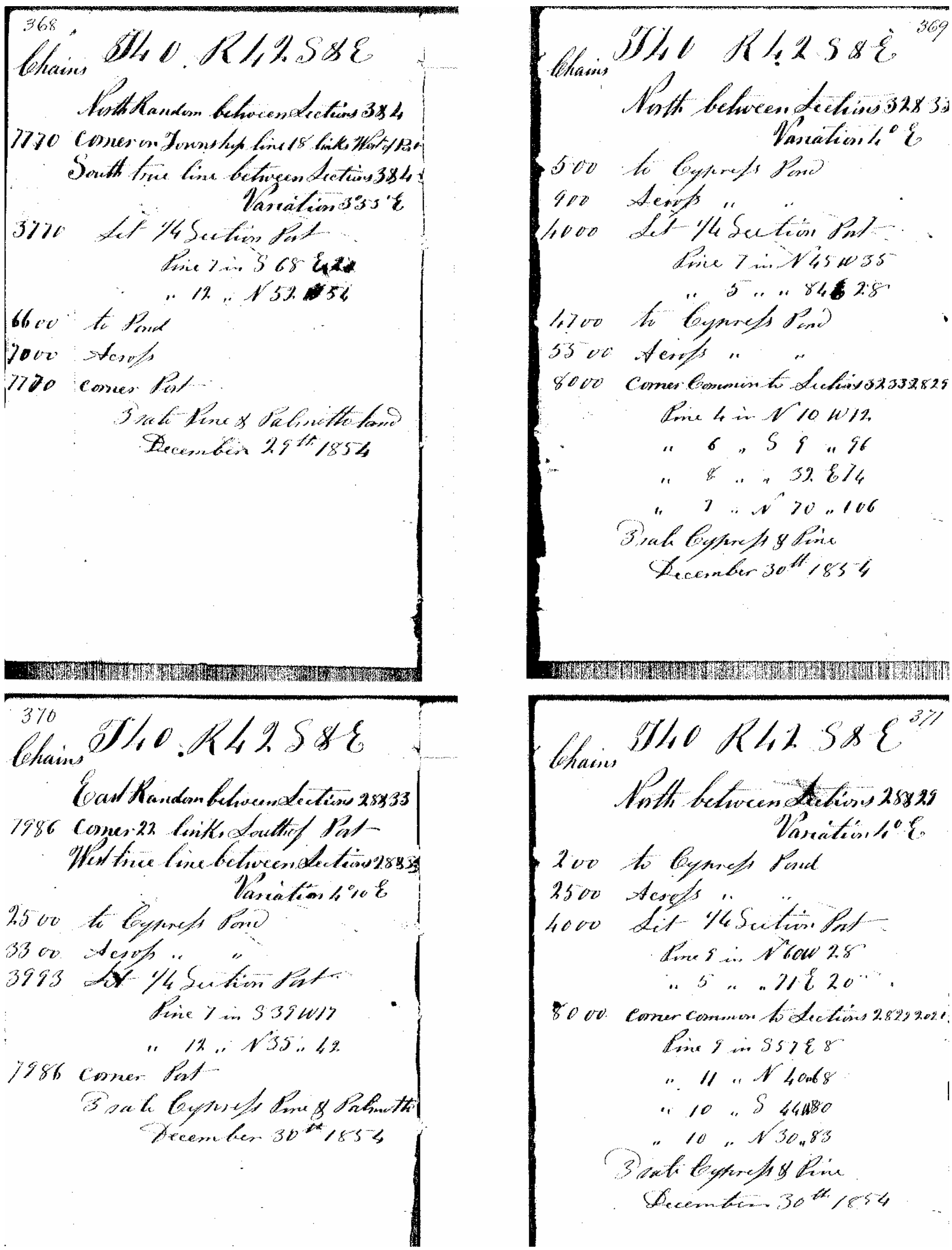
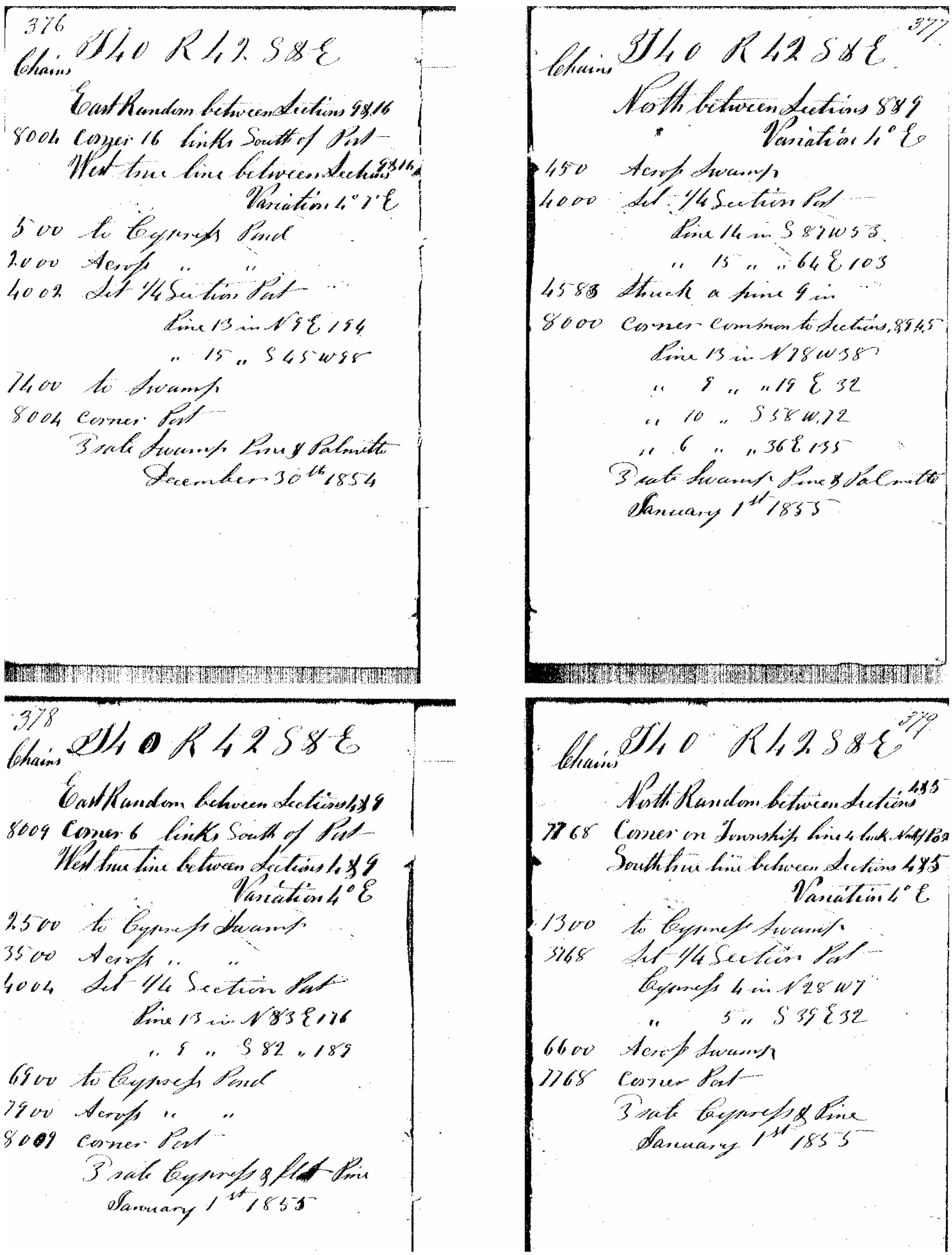


Figure B-6. Field Notes from the 1855 General Land Office Survey of the Loxahatchee River Area.



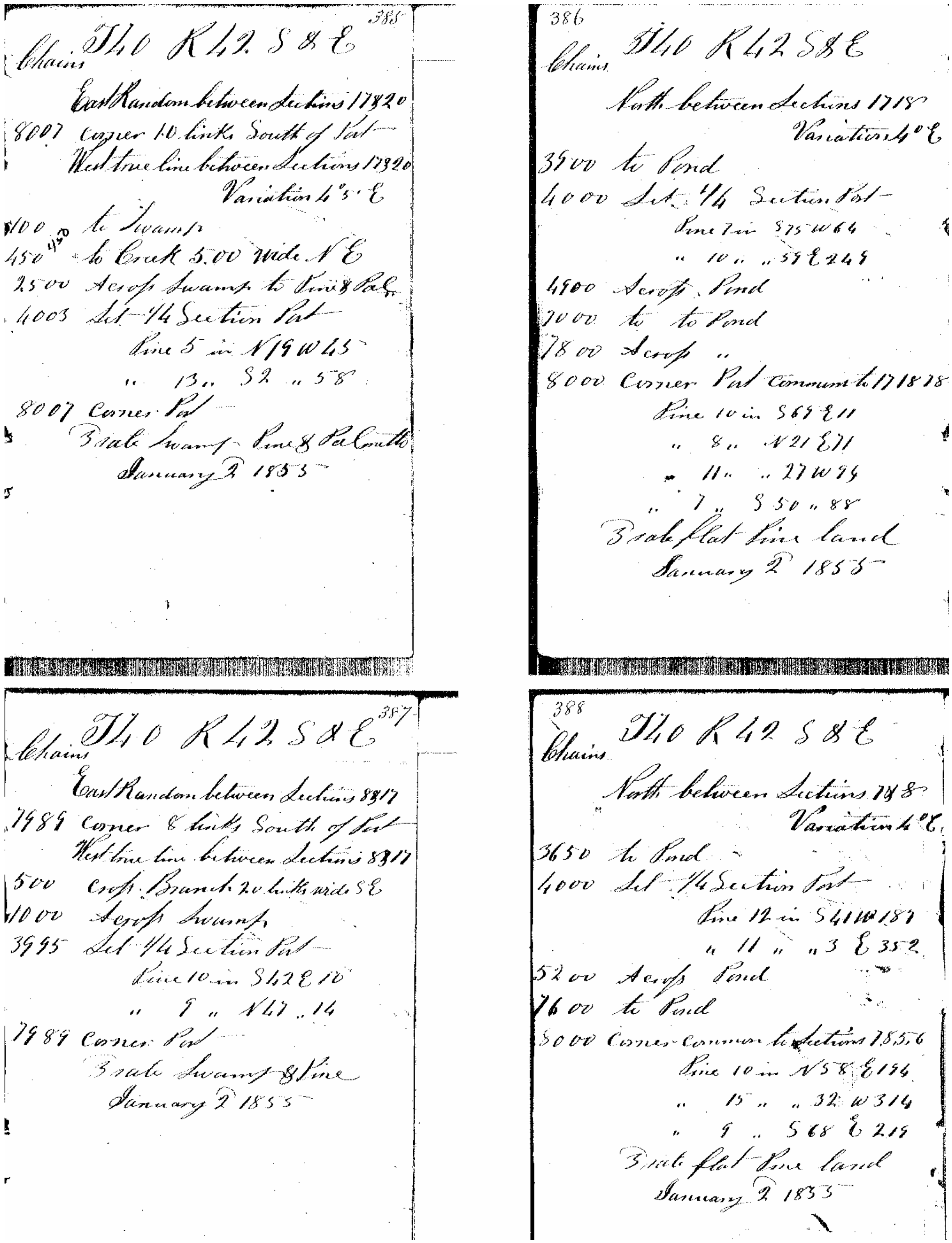
376
Chains T40 R42 S8E
East Random between Sections 9 & 16
80 04 Corner 16 links South of Post
West true line between Sections 9 & 16
Variation 4° 7' E
5 00 to Cypress Pond
20 00 Across " "
40 02 Set 1/4 Section Post
Pine 13 in N 9 E 154
" 15 " S 45 W 98
74 00 to Swamp
80 04 Corner Post
3 rate Swamp Pine & Palmetto
December 30th 1854

Chains T40 R42 S8E 377
North between Sections 8 & 9
Variation 4° E
4 50 Across Swamp
40 00 Set 1/4 Section Post
Pine 14 in S 87 W 53
" 15 " " 64 E 103
45 88 Struck a pine 9 in
80 00 Corner common to Sections 8, 9, 4, 5
Pine 13 in N 78 W 38
" 9 " " 19 E 32
" 10 " S 58 W 72
" 6 " " 36 E 135
3 rate Swamp Pine & Palmetto
January 1st 1855

378
Chains T40 R42 S8E
East Random between Sections 4 & 9
80 09 Corner 6 links South of Post
West true line between Sections 4 & 9
Variation 4° E
25 00 to Cypress Swamp
35 00 Across " "
40 04 Set 1/4 Section Post
Pine 13 in N 83 E 176
" 9 " S 82 " 189
69 00 to Cypress Pond
79 00 Across " "
80 09 Corner Post
3 rate Cypress & flat Pine
January 1st 1855

Chains T40 R42 S8E 379
North Random between Sections 4 & 5
77 68 Corner on Township line 4 links North of Post
South true line between Sections 4 & 5
Variation 4° E
13 00 to Cypress Swamp
38 68 Set 1/4 Section Post
Cypress 4 in N 28 W 7
" 5 " S 39 E 32
66 00 Across Swamp
77 68 Corner Post
3 rate Cypress & Pine
January 1st 1855

Figure B-7. Field Notes from the 1855 General Land Office Survey of the Loxahatchee River Area.



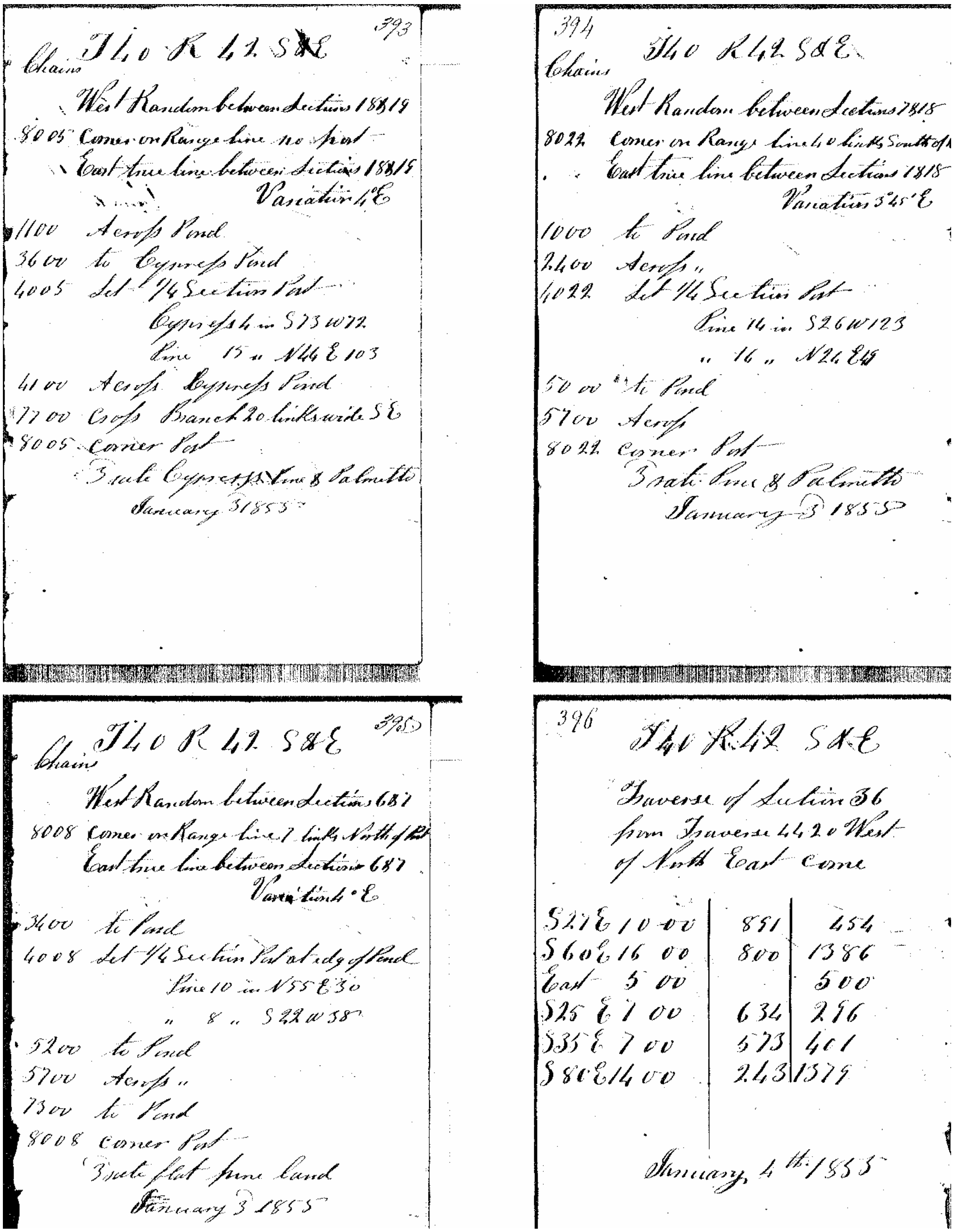
385
Chains T40 R42 S 8 E
East Random between Sections 17 & 20
8007 Corner 10 links South of Post
West true line between Sections 17 & 20
Variation 4° 5' E
1100 to Swamp
450 to Creek 5.00 wide N E
2500 Across Swamp to Pine & Palm
4003 Set 1/4 Section Post
Pine 5 in N 19 W 45
" 13 " S 2 " 58
8007 Corner Post
Grade Swamp Pine & Palmetto
January 2 1855

386
Chains T40 R42 S 8 E
North between Sections 17 & 18
Variation 4° E
3500 to Pond
4000 Set 1/4 Section Post
Pine 7 in S 75 W 64
" 10 " " 59 E 249
4900 Across Pond
7000 to Pond
7800 Across "
8000 Corner Post common to 17 18 7 8
Pine 10 in S 69 E 11
" 8 " N 21 E 71
" 11 " " 27 W 99
" 7 " S 50 " 88
Grade flat Pine land
January 2 1855

387
Chains T40 R42 S 8 E
East Random between Sections 8 & 17
7989 Corner 8 links South of Post
West true line between Sections 8 & 17
500 Cross Branch 20 links wide S E
1000 Across Swamp
3995 Set 1/4 Section Post
Pine 10 in S 42 E 10
" 9 " N 47 " 14
7989 Corner Post
Grade Swamp & Pine
January 2 1855

388
Chains T40 R42 S 8 E
North between Sections 7 & 8
Variation 4° E
3650 to Pond
4000 Set 1/4 Section Post
Pine 12 in S 41 W 187
" 11 " " 3 E 352
5200 Across Pond
7600 to Pond
8000 Corner Common to Sections 7 8 5 6
Pine 10 in N 58 E 196
" 15 " " 32 W 314
" 9 " S 68 E 219
Grade flat Pine land
January 2 1855

Figure B-8. Field Notes from the 1855 General Land Office Survey of the Loxahatchee River Area.



393

Chains T 40 R 42 S & E

West Random between Sections 18 & 19

80 05 Corner on Range line no post

East true line between Sections 18 & 19

Variation 4° E

11 00 Across Pond

36 00 to Cypress Pond

40 05 Set 1/4 Section Post

Cypress 14 in S 73 W 72

Pine 15 " N 46 E 103

41 00 Across Cypress Pond

77 00 Cross Branch 20 links wide S E

80 05 Corner Post

Scrub Cypress Pine & Palmetto

January 3 1855

394

Chains T 40 R 42 S & E

West Random between Sections 7 & 18

80 22 Corner on Range line 40 links South of P

East true line between Sections 7 & 18

Variation 3°45' E

10 00 to Pond

24 00 Across "

40 22 Set 1/4 Section Post

Pine 14 in S 26 W 123

" 16 " N 24 E 49

50 00 to Pond

57 00 Across

80 22 Corner Post

Scrub Pine & Palmetto

January 3 1855

395

Chains T 40 R 42 S & E

West Random between Sections 6 & 7

80 08 Corner on Range line 7 links North of Post

East true line between Sections 6 & 7

Variation 4° E

34 00 to Pond

40 08 Set 1/4 Section Post at edge of Pond

Pine 10 in N 55 E 30

" 8 " S 22 W 38

52 00 to Pond

57 00 Across "

73 00 to Pond

80 08 Corner Post

Scrub flat pine land

January 3 1855

396

T 40 R 42 S & E

Traverse of Section 36

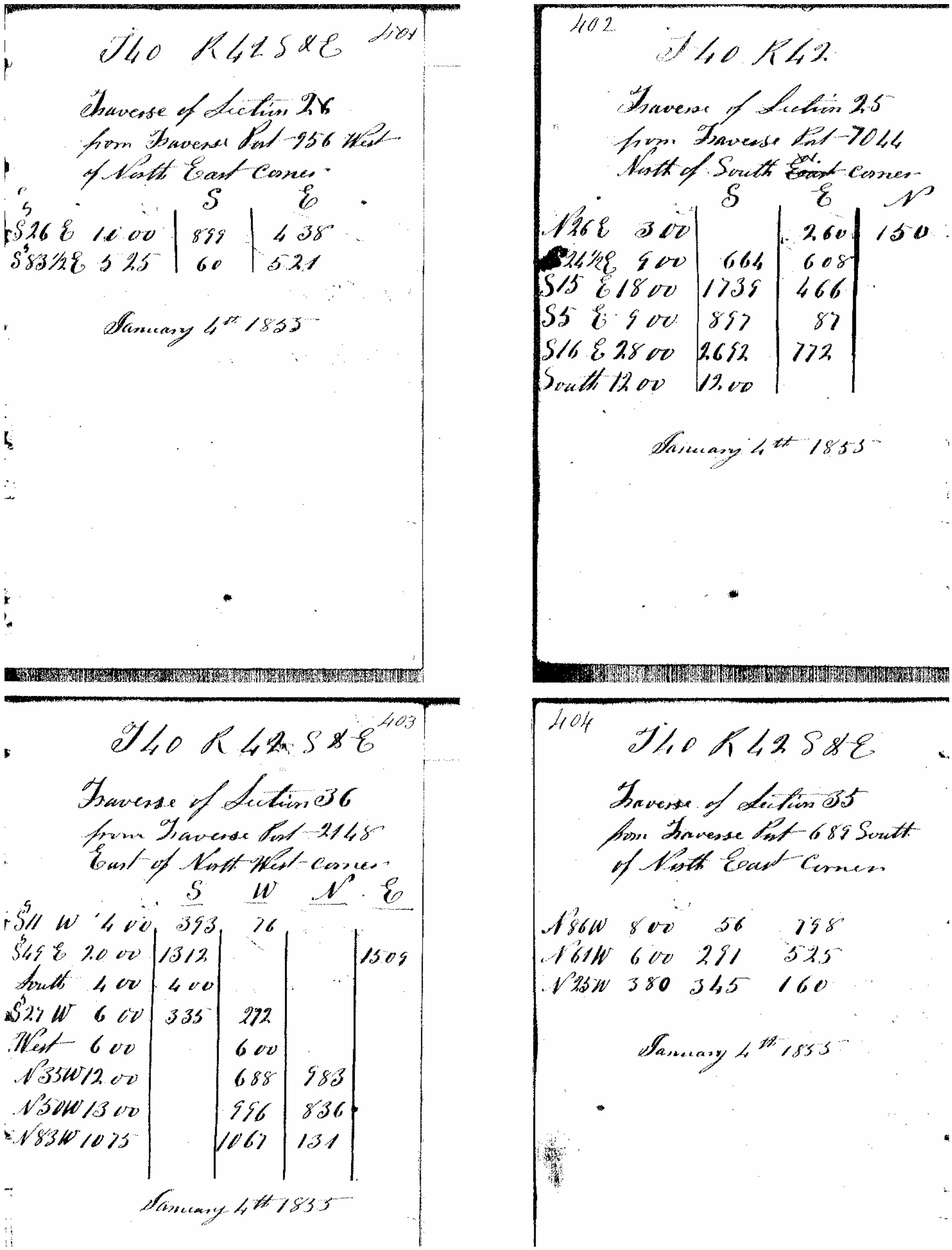
from Traverse 44 20 West

of North East Corner

S 27 E	10 00	891	454
S 60 E	16 00	800	1386
East	5 00		500
S 25 E	7 00	634	296
S 35 E	7 00	573	401
S 80 E	14 00	243	1379

January 4th 1855

Figure B-9. Field Notes from the 1855 General Land Office Survey of the Loxahatchee River Area.



401

T40 R41 S&E

Traverse of Section 26
from Traverse Post 956 West
of North East Corner

	S	E
S26 E 10.00	899	438
S83½E 5.25	60	521

January 4th 1855

402

T40 R42

Traverse of Section 25
from Traverse Post 7044
North of South ~~East~~ West Corner

	S	E	N
N26E 3.00		2.60	1.50
S24½E 9.00	664	608	
S15 E 18.00	1739	466	
S5 E 9.00	897	87	
S16 E 28.00	2692	772	
South 12.00	12.00		

January 4th 1855

403

T40 R42 S&E

Traverse of Section 36
from Traverse Post 2148
East of North West Corner

	S	W	N	E
S11 W 4.00	393	76		
S49 E 20.00	1312			1509
South 4.00	4.00			
S27 W 6.00	335	272		
West 6.00		6.00		
N33W 12.00		688	983	
N50W 13.00		996	836	
N83W 10.75		1067	131	

January 4th 1855

404

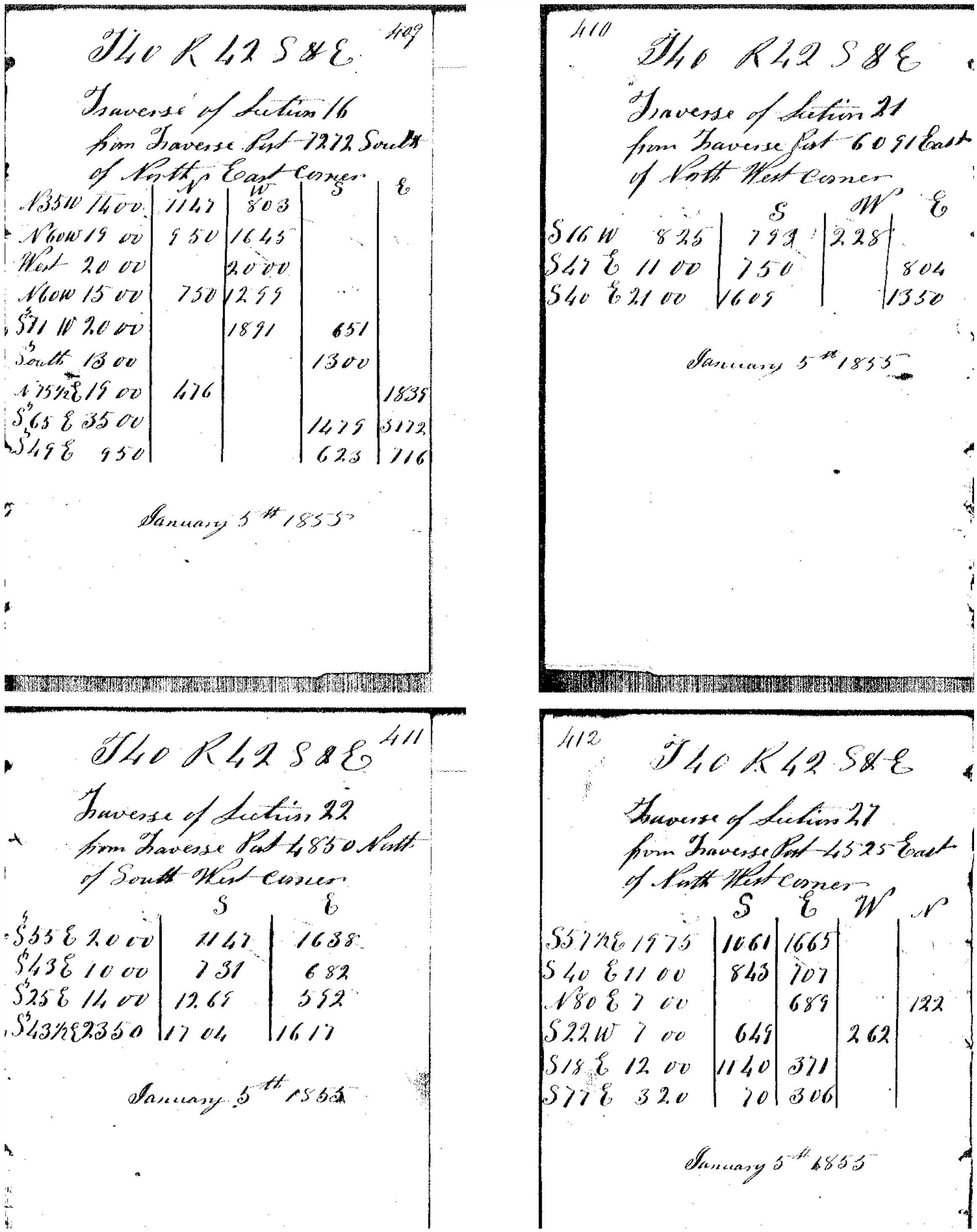
T40 R42 S&E

Traverse of Section 35
from Traverse Post 689 South
of North East Corner

N86W 8.00	56	798
N61W 6.00	291	525
N25W 3.80	345	160

January 4th 1855

Figure B-10. Field Notes from the 1855 General Land Office Survey of the Loxahatchee River Area.



T40 R42 S & E 409

Traverse of Section 16
from Traverse Post 7272 South
of North East Corner

	N	W	S	E
N35W 14 00	1147	803		
N60W 19 00	950	1645		
West 20 00		2000		
N60W 15 00	750	1299		
S71 W 20 00		1891	651	
South 13 00			1300	
N75½E 19 00	476			1835
S65 E 35 00			1479	3172
S49 E 9 50			623	716

January 5th 1855

410 T40 R42 S & E

Traverse of Section 21
from Traverse Post 6091 East
of North West Corner

	S	W	E
S16 W 8 25	793	228	
S47 E 11 00	750		804
S40 E 21 00	1609		1350

January 5th 1855

T40 R42 S & E 411

Traverse of Section 22
from Traverse Post 4850 North
of South West Corner

	S	E
S55 E 20 00	1147	1638
S43 E 10 00	731	682
S25 E 14 00	1269	592
S43½E 23 50	1704	1617

January 5th 1855

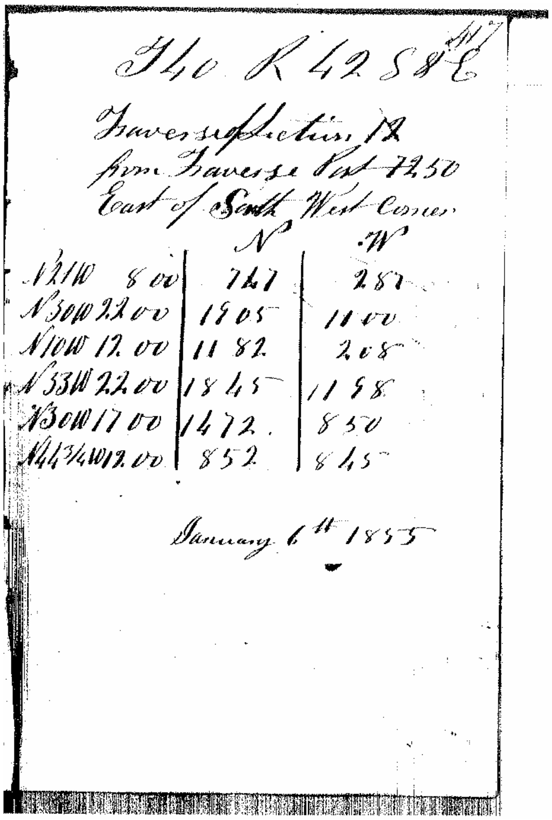
412 T40 R42 S & E

Traverse of Section 27
from Traverse Post 4525 East
of North West Corner

	S	E	W	N
S57½E 19 75	1061	1665		
S40 E 11 00	843	707		
N80 E 7 00		689		122
S22 W 7 00	649		262	
S18 E 12 00	1140	371		
S77 E 3 20	70	306		

January 5th 1855

Figure B-11. Field Notes from the 1855 General Land Office Survey of the Loxahatchee River Area.



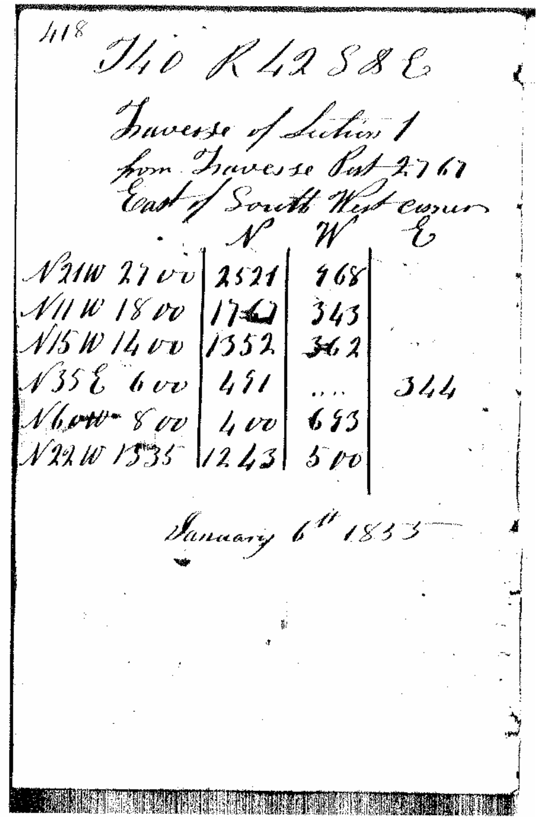
417

T40 R42 S8E

Traverse of Section 12
from Traverse Post 72.50
East of South West Corner

	N	W
N21W 8 00	747	287
N30W 22 00	1905	1100
N10W 12 00	1182	208
N33W 22 00	1845	1198
N30W 17 00	1472	850
N44 3/4 W 12 00	852	845

January 6th 1855



418

T40 R42 S8E

Traverse of Section 1
from Traverse Post 27.67
East of South West Corner

	N	W	E
N21W 27 00	2521	968	
N11W 18 00	17[illegible]	343	
N15W 14 00	1352	362	
N35E 6 00	491	....	344
N6 [illegible]W 8 00	400	693	
N22W 13 35	1243	500	

January 6th 1855

Figure B-12. Field Notes from the 1855 General Land Office Survey of the Loxahatchee River Area.

APPENDIX C

FIELD STUDIES VEGETATION DATA

Field Data from the Vegetation Surveys along the NW Fork of the Loxahatchee River and Kitching Creek

<u>Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site V-1</u>

(river mile 10.6, surveyed 1/15/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Acer rubrum	Red maple	1.3	11	24	1				west
Acer rubrum	Red maple	1.3	23		1				west
Acer rubrum	Red maple	1.9	19			1			west
Acer rubrum	Red maple						2		west
Acer rubrum	Red maple	1.6		16	1				west
Acer rubrum	Red maple						12		west
Acer rubrum	Red maple	2.5		24	1				west
Acer rubrum	Red maple	1.3		24	1				west
Acer rubrum	Red maple						24		west
Acer rubrum	Red maple	3.8	19	24				1	west
Acer rubrum	Red maple	1.3	8	16	1				west
Acer rubrum	Red maple	1.6	8	20	1				west
Acer rubrum	Red maple	1.3	8	16	1				west
Acer rubrum	Red maple	1.3	8	16	1				west
Annona glabra	Pond apple		60	0.5				1	west
Annona glabra	Pond apple	1.0		18	1				west
Annona glabra	Pond apple	0.2	19	10				1	west
Annona glabra	Pond apple	3.8		16	1				west
Annona glabra	Pond apple	2.5	32	10	1				west
Annona glabra	Pond apple	1.9	32	20	1				west
Annona glabra	Pond apple	2.2	32	8	1				west
Annona glabra	Pond apple	2.9	32	16	1				west
Annona glabra	Pond apple	0.3	13	12	1				west
Fraxinus caroliniana	Pop ash	2.5	40			1			west
Fraxinus caroliniana	Pop ash						9		west
Fraxinus caroliniana	Pop ash	0.3	19			1			west

Quantitative Vegetation Survey of NW Fork Loxahatchee River: Site V-1 (continued)

(river mile 10.6, surveyed 1/15/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Fraxinus caroliniana	Pop ash	1.6	22	12				1	west
Fraxinus caroliniana	Pop ash						2		west
Fraxinus caroliniana	Pop ash	1.3	15	20	1				west
Fraxinus caroliniana	Pop ash	1.9	13	8				1	west
Fraxinus caroliniana	Pop ash	0.3	10	6	1				west
Fraxinus caroliniana	Pop ash	0.2	6	6	1				west
Fraxinus caroliniana	Pop ash	1.3	6	16	1				west
Fraxinus caroliniana	Pop ash	1.0	13	16	1				west
Fraxinus caroliniana	Pop ash	2.2		16	1				west
Fraxinus caroliniana	Pop ash	0.6	4	12	1				west
Fraxinus caroliniana	Pop ash	1.3	20	24				1	west
Fraxinus caroliniana	Pop ash	1.0	14	16				1	west
Fraxinus caroliniana	Pop ash	1.0	7	16	1				west
Fraxinus caroliniana	Pop ash	1.9	5	20	1				west
Fraxinus caroliniana	Pop ash	1.0	5	8	1				west
Fraxinus caroliniana	Pop ash	0.6	28	8	1				west
Fraxinus caroliniana	Pop ash	0.3	26	6	1				west
Fraxinus caroliniana	Pop ash	0.6		6	1				west
Fraxinus caroliniana	Pop ash	0.2	21	6	1				west
Fraxinus caroliniana	Pop ash	0.2	32	6	1				west
Fraxinus caroliniana	Pop ash	0.3	26	8	1				west
Fraxinus caroliniana	Pop ash	0.3		6	1				west
Fraxinus caroliniana	Pop ash	0.1				1			west
Fraxinus caroliniana	Pop ash	0.1	26	6		1			west
Fraxinus caroliniana	Pop ash	0.6	35	8	1				west
Fraxinus caroliniana	Pop ash	0.2		6	1				west
Itea virginica	Virginia willow		8		1				west
Itea virginica	Virginia willow		12		1				west
Itea virginica	Virginia willow						1		west

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site V-1 (continued)

(river mile 10.6, surveyed 1/15/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Itea virginica	Virginia willow						8		west
Itea virginica	Virginia willow		24						west
Itea virginica	Virginia willow		15						west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow						2		west
Itea virginica	Virginia willow						1		west
Itea virginica	Virginia willow		42		1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow		36		1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow		19		1				west
Itea virginica	Virginia willow		32		1				west
Itea virginica	Virginia willow		23		1				west
Itea virginica	Virginia willow				3				west
Itea virginica	Virginia willow	0.0			1				west
Itea virginica	Virginia willow						1		west
Itea virginica	Virginia willow						1		west
Itea virginica	Virginia willow						13		west
Itea virginica	Virginia willow		16		1				west
Itea virginica	Virginia willow		12		1				west
Itea virginica	Virginia willow		11		1				west
Itea virginica	Virginia willow		35		1				west
Itea virginica	Virginia willow		45		1				west
Itea virginica	Virginia willow		11		1				west
Itea virginica	Virginia willow		10		1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow		15		1				west

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site V-1 (continued)

(river mile 10.6, surveyed 1/15/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Itea virginica	Virginia willow		28		4				west
Itea virginica	Virginia willow		40		6				west
Persea borbonia	Red bay	0.1					1		west
Taxodium distichum	Bald cypress	5.1	3	24	1				west
Taxodium distichum	Bald cypress	1.3	3	22	1				west
Taxodium distichum	Bald cypress	1.3	27	16	1				west
Taxodium distichum	Bald cypress	2.5	40	20	1				west
Taxodium distichum	Bald cypress	0.3	24	8		1			west
Taxodium distichum	Bald cypress	3.8	30	32	1				west
Taxodium distichum	Bald cypress	1.6	16	16	1				west
Taxodium distichum	Bald cypress	7.6	22	36	1				west
Acer rubrum	Red maple	0.6	25	16	1				east
Acer rubrum	Red maple						6		east
Acer rubrum	Red maple	1.1		24	1				east
Acer rubrum	Red maple	0.6	60	18	1				east
Acer rubrum	Red maple	0.6	32	6				1	east
Acer rubrum	Red maple	1.6	18	20	1				east
Acer rubrum	Red maple	1.3	22	16	1				east
Acer rubrum	Red maple	1.3		24	1				east
Acer rubrum	Red maple	0.6	15	16	1				east
Acer rubrum	Red maple	1.9	35	20	1				east
Acer rubrum	Red maple	0.6	38	16	1				east
Acer rubrum	Red maple	0.3		8	1				east
Annona glabra	Pond apple	0.3	30	6	1				east
Annona glabra	Pond apple	2.2	18	10	1				east
Annona glabra	Pond apple	2.2	4	12				1	east
Annona glabra	Pond apple	1.6		20	1				east
Annona glabra	Pond apple						1		east
Annona glabra	Pond apple	3.2	55	16	1				east

Quantitative Vegetation Survey of NW Fork Loxahatchee River: Site V-1 (continued)
(river mile 10.6, surveyed 1/15/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Annona glabra	Pond apple	2.5	26	12	1				east
Annona glabra	Pond apple	1.0	15	14	1				east
Annona glabra	Pond apple	1.0	30	12	1				east
Carya aquatica	Water hickory	0.6	45	28	1				east
Fraxinus caroliniana	Pop ash	0.2	28	6	1				east
Fraxinus caroliniana	Pop ash	3.8	28	16	1				east
Fraxinus caroliniana	Pop ash	0.6		6				1	east
Fraxinus caroliniana	Pop ash	0.6		4				1	east
Fraxinus caroliniana	Pop ash	0.6		4		1			east
Fraxinus caroliniana	Pop ash	0.6		8				1	east
Fraxinus caroliniana	Pop ash	0.3	38	8	1				east
Fraxinus caroliniana	Pop ash	0.3	36	4	1				east
Fraxinus caroliniana	Pop ash	1.3	15	8				1	east
Fraxinus caroliniana	Pop ash	0.2		6		1			east
Fraxinus caroliniana	Pop ash	1.3	12	24	1				east
Fraxinus caroliniana	Pop ash	0.5	27	6	1				east
Fraxinus caroliniana	Pop ash						2		east
Ilex cassine	Dahoon	0.6	50	16	1				east
Itea virginica	Virginia willow				1				east
Itea virginica	Virginia willow		40		1				east
Itea virginica	Virginia willow						1		east
Itea virginica	Virginia willow						1		east
Itea virginica	Virginia willow		18		1				east
Itea virginica	Virginia willow		18		1				east
Itea virginica	Virginia willow		18		1				east
Itea virginica	Virginia willow		18		1				east
Itea virginica	Virginia willow				7				east
Itea virginica	Virginia willow						6		east
Itea virginica	Virginia willow		12		4				east

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site V-1 (continued)

(river mile 10.6, surveyed 1/15/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Itea virginica	Virginia willow						3		east
Itea virginica	Virginia willow		23		4				east
Itea virginica	Virginia willow		23		6				east
Itea virginica	Virginia willow		17		5				east
Itea virginica	Virginia willow		25		5				east
Itea virginica	Virginia willow				7				east
Itea virginica	Virginia willow				6				east
Itea virginica	Virginia willow	0.3	12		1				east
Itea virginica	Virginia willow				6				east
Itea virginica	Virginia willow						4		east
Itea virginica	Virginia willow		25		3				east
Itea virginica	Virginia willow						8		east
Itea virginica	Virginia willow				3				east
Itea virginica	Virginia willow				1				east
Itea virginica	Virginia willow		32		4				east
Itea virginica	Virginia willow		25		6				east
Itea virginica	Virginia willow		10		3				east
Itea virginica	Virginia willow						1		east
Itea virginica	Virginia willow						6		east
Itea virginica	Virginia willow		40		5				east
Itea virginica	Virginia willow						6		east
Itea virginica	Virginia willow		22		6				east
Persea borbonia	Red bay	0.2		8				1	east
Persea borbonia	Red bay	0.2		4				1	east
Persea borbonia	Red bay	0.2	36	4	1				east
Persea borbonia	Red bay	0.1				1			east
Sabal palmetto	Cabbage palm		55		1				east
Sabal palmetto	Cabbage palm				1				east
Sabal palmetto	Cabbage palm		20		1				east

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site V-1 (continued)

(river mile 10.6, surveyed 1/15/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Sabal palmetto	Cabbage palm		18		1				east
Sabal palmetto	Cabbage palm		25		1				east
Sabal palmetto	Cabbage palm		22		1				east
Sabal palmetto	Cabbage palm		18		1				east
Sabal palmetto	Cabbage palm		22		1				east
Sabal palmetto	Cabbage palm		7		1				east
Sabal palmetto	Cabbage palm		55		1				east
Sabal palmetto	Cabbage palm				1				east
Sabal palmetto	Cabbage palm		40		1				east
Sabal palmetto	Cabbage palm		38		1				east
Sabal palmetto	Cabbage palm		22		1				east
Sabal palmetto	Cabbage palm				1				east
Sabal palmetto	Cabbage palm				1				east
Sabal palmetto	Cabbage palm				1				east
Sabal palmetto	Cabbage palm		50		1				east
Sabal palmetto	Cabbage palm		28		1				east
Taxodium distichum	Bald cypress	4.8		24	1				east
Taxodium distichum	Bald cypress	2.5	12	24	1				east
Taxodium distichum	Bald cypress	1.9	45	20	1				east
Taxodium distichum	Bald cypress	3.2		32	1				east
Taxodium distichum	Bald cypress	1.3		16	1				east
Taxodium distichum	Bald cypress	3.8	30	20	1				east
Taxodium distichum	Bald cypress	1.3	12	8	1				east
Taxodium distichum	Bald cypress	3.8		32	1				east
Taxodium distichum	Bald cypress	7.6	32	40	1				east
Taxodium distichum	Bald cypress	2.2	17	10	1				east
Taxodium distichum	Bald cypress	4.5	33	28	1				east
Taxodium distichum	Bald cypress	3.2		20	1				east
Taxodium distichum	Bald cypress	3.8	35	20	1				east
Taxodium distichum	Bald cypress	3.2	15	36	1				east

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site 10-B

(lat –80.164987106/lon 26.978938944; river mile 10.2, surveyed 1/17/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Acer rubrum	Red maple	1.0	35	16	1				west
Acer rubrum	Red maple						1		west
Acer rubrum	Red maple	0.2	20	6		1			west
Acer rubrum	Red maple						3		west
Acer rubrum	Red maple	0.6	35	14	1				west
Acer rubrum	Red maple						7		west
Acer rubrum	Red maple						8		west
Acer rubrum	Red maple	0.3	18	6		1			west
Acer rubrum	Red maple	0.2	8	4		1			west
Acer rubrum	Red maple						17		west
Acer rubrum	Red maple	1.3	33	20	1				west
Acer rubrum	Red maple	0.2	8	2		1			west
Acer rubrum	Red maple	0.8	28	8	1				west
Annona glabra	Pond apple	0.2	13	6	1				west
Annona glabra	Pond apple	0.1	12	3	1				west
Annona glabra	Pond apple	1.3	14	6	1				west
Annona glabra	Pond apple	0.6	21	8	1				west
Annona glabra	Pond apple	1.0	25	8	1				west
Annona glabra	Pond apple	0.1	23						west
Annona glabra	Pond apple		8						west
Annona glabra	Pond apple	1.0		10	1				west
Annona glabra	Pond apple	0.6	23	16	1				west
Annona glabra	Pond apple	0.3	10	8	1				west
Annona glabra	Pond apple	0.3	8	4	1				west
Annona glabra	Pond apple						2		west
Annona glabra	Pond apple						1		west
Annona glabra	Pond apple						1		west
Annona glabra	Pond apple						1		west
Annona glabra	Pond apple	1.0	20	10	1				west

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site 10-B (continued)
(lat –80.164987106/lon 26.978938944; river mile 10.2, surveyed 1/17/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Annona glabra	Pond apple	0.8	14	6	1				west
Annona glabra	Pond apple	1.3	24	12	1				west
Annona glabra	Pond apple	1.3	25	16	1				west
Annona glabra	Pond apple	1.3	25	14	1				west
Annona glabra	Pond apple						1		west
Annona glabra	Pond apple	1.3	24	10	1				west
Annona glabra	Pond apple	1.3	33	12	1				west
Annona glabra	Pond apple	0.3	30	14	1				west
Annona glabra	Pond apple	1.0	25	8	1				west
Annona glabra	Pond apple	1.0	25	8	1				west
Annona glabra	Pond apple	0.6	25	10	1				west
Annona glabra	Pond apple	0.3	20	6	1				west
Annona glabra	Pond apple	0.6	15	16	1				west
Annona glabra	Pond apple	0.3	15	4	1				west
Annona glabra	Pond apple	0.5	11	8	1				west
Annona glabra	Pond apple	1.0	15	12	1				west
Annona glabra	Pond apple	1.3	15	20	1				west
Annona glabra	Pond apple	0.8	23					1	west
Fraxinus caroliniana	Pop ash	1.0	30	10	1				west
Fraxinus caroliniana	Pop ash						1		west
Fraxinus caroliniana	Pop ash	0.6	23	10	1				west
Fraxinus caroliniana	Pop ash	0.5	23	6	1				west
Fraxinus caroliniana	Pop ash	1.0	28	12	1				west
Fraxinus caroliniana	Pop ash	0.1	20	6	1				west
Fraxinus caroliniana	Pop ash	0.1	20	6	1				west
Fraxinus caroliniana	Pop ash	0.3	14	8	1				west
Fraxinus caroliniana	Pop ash	0.3	28	6	1				west
Fraxinus caroliniana	Pop ash	0.6	18	10	1				west
Fraxinus caroliniana	Pop ash	0.2	7	4		1			west

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site 10-B (continued)

(lat –80.164987106/lon 26.978938944; river mile 10.2, surveyed 1/17/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Fraxinus caroliniana	Pop ash	0.2	10	2		1			west
Fraxinus caroliniana	Pop ash	0.5	28	14	1				west
Fraxinus caroliniana	Pop ash	1.0	24	12	1				west
Fraxinus caroliniana	Pop ash	0.5	13	4	1				west
Fraxinus caroliniana	Pop ash	0.2	10	4	1				west
Ilex cassine	Dahoon		10	4		1			west
Ilex cassine	Dahoon	0.2	32	4	1				west
Ilex cassine	Dahoon	0.2	32	6	1				west
Ilex cassine	Dahoon	0.2	33	4	1				west
Ilex cassine	Dahoon	0.6	21	8				1	west
Ilex cassine	Dahoon	0.2	11	4		1			west
Ilex cassine	Dahoon	0.3	12	6	1				west
Ilex cassine	Dahoon	0.2	6	6		1			west
Ilex cassine	Dahoon	0.3	22	6		1			west
Ilex cassine	Dahoon	0.3	25	4	1				west
Ilex cassine	Dahoon	0.3	18	4	1				west
Ilex cassine	Dahoon	0.1	5.5	2		1			west
Ilex cassine	Dahoon	0.2	18	6	1				west
Ilex cassine	Dahoon	0.1	9	2		1			west
Ilex cassine	Dahoon	0.3	13	8	1				west
Ilex cassine	Dahoon	0.5	18	6					west
Ilex cassine	Dahoon	0.6	13	8	1				west
Ilex cassine	Dahoon	0.1	8	4		1			west
Ilex cassine	Dahoon	0.3	20	12	1				west
Itea virginica	Virginia willow						1		west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				2				west

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site 10-B (continued)

(lat –80.164987106/lon 26.978938944; river mile 10.2, surveyed 1/17/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Itea virginica	Virginia willow				2				west
Itea virginica	Virginia willow						1		west
Itea virginica	Virginia willow						2		west
Itea virginica	Virginia willow						1		west
Itea virginica	Virginia willow						1		west
Itea virginica	Virginia willow				3				west
Persea borbonia	Red bay	0.2	17	4		1			west
Persea borbonia	Red bay	0.3	28	8	1				west
Persea borbonia	Red bay						1		west
Persea borbonia	Red bay						2		west
Persea borbonia	Red bay						5		west
Persea borbonia	Red bay	0.1	12	4		1			west
Persea borbonia	Red bay	0.3	28	8	1				west
Persea borbonia	Red bay	0.2	26	6		1			west
Persea borbonia	Red bay	0.3	16	4	1				west
Persea borbonia	Red bay						1		west
Persea borbonia	Red bay						2		west
Quercus laurifolia	Laurel oak						1		west
Sabal palmetto	Cabbage palm		28		1				west
Sabal palmetto	Cabbage palm		35		1				west
Sabal palmetto	Cabbage palm		28		1				west
Sabal palmetto	Cabbage palm		50		1				west
Sabal palmetto	Cabbage palm		45		1				west
Sabal palmetto	Cabbage palm		32		1				west
Sabal palmetto	Cabbage palm		45		1				west
Sabal palmetto	Cabbage palm		45		1				west
Sabal palmetto	Cabbage palm		17		1				west
Sabal palmetto	Cabbage palm		17		1				west
Sabal palmetto	Cabbage palm		45		1				west

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site 10-B (continued)

(lat –80.164987106/lon 26.978938944; river mile 10.2, surveyed 1/17/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Sabal palmetto	Cabbage palm		45		1				west
Sabal palmetto	Cabbage palm		45		1				west
Sabal palmetto	Cabbage palm		32		1				west
Sabal palmetto	Cabbage palm		35		1				west
Taxodium distichum	Bald cypress	1.0	38	16	1				west
Taxodium distichum	Bald cypress	1.0	45	24	1				west
Taxodium distichum	Bald cypress	3.2	55	32	1				west
Taxodium distichum	Bald cypress	0.2	10	12		1			west
Taxodium distichum	Bald cypress	0.2	18	14		1			west
Taxodium distichum	Bald cypress						6		west
Taxodium distichum	Bald cypress	2.5	6	30	1				west
Taxodium distichum	Bald cypress	2.5	45	32	1				west
Taxodium distichum	Bald cypress						1		west
Taxodium distichum	Bald cypress	1.3	50	24	1				west
Taxodium distichum	Bald cypress	0.1	7	6		1			west
Taxodium distichum	Bald cypress	0.3	22	8	1				west
Taxodium distichum	Bald cypress	1.3	35	18	1				west
Taxodium distichum	Bald cypress	4.5	45	56	1				west
Acer rubrum	Red maple						2		east
Acer rubrum	Red maple	1.0	20	16	1				east
Acer rubrum	Red maple	0.3	33	10	1				east
Acer rubrum	Red maple	0.1	6	2		1			east
Acer rubrum	Red maple	1.0	18	22	1				east
Acer rubrum	Red maple	2.9	30	12	1				east
Acer rubrum	Red maple	0.3	23	6	1				east
Acer rubrum	Red maple	0.3	30	10	1				east
Acer rubrum	Red maple		10	10	1				east
Annona glabra	Pond apple	0.5	14	12	1				east
Annona glabra	Pond apple	1.0	22	10	1				east

<u>Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site 10-B (continued)</u>
(lat –80.164987106/lon 26.978938944; river mile 10.2, surveyed 1/17/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Annona glabra	Pond apple	1.0	21	10	1				east
Annona glabra	Pond apple	1.0	22	12	1				east
Annona glabra	Pond apple	0.3	22	14	1				east
Annona glabra	Pond apple						1		east
Annona glabra	Pond apple						3		east
Annona glabra	Pond apple	1.0	20	8	1				east
Annona glabra	Pond apple	0.5	23	8	1				east
Annona glabra	Pond apple	1.0	28	12	1				east
Annona glabra	Pond apple	0.3	22	6	1				east
Annona glabra	Pond apple	0.3	18	4	1				east
Annona glabra	Pond apple	1.0	15	12	1				east
Annona glabra	Pond apple	3.2	22	20	1				east
Annona glabra	Pond apple	1.0	20	18	1				east
Annona glabra	Pond apple	2.9	25	18	1				east
Annona glabra	Pond apple	3.2	24	14	1				east
Annona glabra	Pond apple	3.2	24	18	1				east
Annona glabra	Pond apple	2.9	38	18	1				east
Annona glabra	Pond apple	2.5	25	10	1				east
Annona glabra	Pond apple	0.5	13	12	1				east
Annona glabra	Pond apple	0.6	13	4	1				east
Annona glabra	Pond apple	1.0	24	12	1				east
Annona glabra	Pond apple	1.9	5	16	1				east
Annona glabra	Pond apple	0.6	14	6	1				east
Annona glabra	Pond apple	0.5	10	12	1				east
Fraxinus caroliniana	Pop ash	1.0	22	14	1				east
Fraxinus caroliniana	Pop ash	1.0	22	14	1				east
Fraxinus caroliniana	Pop ash	0.3	15	6		1			east
Fraxinus caroliniana	Pop ash	1.0	24	16	1				east
Fraxinus caroliniana	Pop ash	1.6	21	16	1				east

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site 10-B (continued)

(lat –80.164987106/lon 26.978938944; river mile 10.2, surveyed 1/17/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Fraxinus caroliniana	Pop ash	0.6	25	14	1				east
Fraxinus caroliniana	Pop ash	0.6	20	6	1				east
Fraxinus caroliniana	Pop ash	0.1	7			1			east
Fraxinus caroliniana	Pop ash	1.0	13	8				1	east
Fraxinus caroliniana	Pop ash	0.8	13	8	1				east
Fraxinus caroliniana	Pop ash	0.8	15	12	1				east
Fraxinus caroliniana	Pop ash	0.1	10	4				1	east
Fraxinus caroliniana	Pop ash	0.8	18	6	1				east
Fraxinus caroliniana	Pop ash	0.1	18	4				1	east
Fraxinus caroliniana	Pop ash	0.6	15	6	1				east
Fraxinus caroliniana	Pop ash	0.6	16	8	1				east
Fraxinus caroliniana	Pop ash						1		east
Fraxinus caroliniana	Pop ash	0.2	22	6	1				east
Fraxinus caroliniana	Pop ash	0.2	15	10	1				east
Fraxinus caroliniana	Pop ash	0.2	22	4	1				east
Fraxinus caroliniana	Pop ash	0.3	25	10	1				east
Fraxinus caroliniana	Pop ash	0.6	30	8	1				east
Fraxinus caroliniana	Pop ash	0.3	18	6	1				east
Fraxinus caroliniana	Pop ash	0.2	10	6	1				east
Fraxinus caroliniana	Pop ash	0.2	18	8		1			east
Fraxinus caroliniana	Pop ash	0.3	24	6	1				east
Fraxinus caroliniana	Pop ash						1		east
Fraxinus caroliniana	Red bay	0.3	15	6	1				east
Ilex cassine	Dahoon	0.3	13	6	1				east
Ilex cassine	Dahoon	0.1	15	6	1				east
Itea virginica	Virginia willow						2		east
Itea virginica	Virginia willow						2		east
Itea virginica	Virginia willow				2				east
Itea virginica	Virginia willow						1		east

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site 10-B (continued)
(lat –80.164987106/lon 26.978938944; river mile 10.2, surveyed 1/17/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Itea virginica	Virginia willow				1				east
Itea virginica	Virginia willow				1				east
Itea virginica	Virginia willow				1				east
Itea virginica	Virginia willow				3				east
Itea virginica	Virginia willow				3				east
Itea virginica	Virginia willow				3				east
Itea virginica	Virginia willow						2		east
Itea virginica	Virginia willow				2				east
Itea virginica	Virginia willow						3		east
Itea virginica	Virginia willow				2				east
Itea virginica	Virginia willow				1				east
Itea virginica	Virginia willow						2		east
Itea virginica	Virginia willow				2				east
Itea virginica	Virginia willow				4				east
Itea virginica	Virginia willow				1				east
Itea virginica	Virginia willow				1				east
Itea virginica	Virginia willow				3				east
Itea virginica	Virginia willow				1				east
Itea virginica	Virginia willow						2		east
Itea virginica	Virginia willow				3				east
Itea virginica	Virginia willow				1				east
Rhizophora mangle	Red mangrove		12	14	1				east
Sabal palmetto	Cabbage palm		30		1				east
Sabal palmetto	Cabbage palm		10		1				east
Sabal palmetto	Cabbage palm		25		1				east
Sabal palmetto	Cabbage palm		45						east
Sabal palmetto	Cabbage palm		30		1				east
Sabal palmetto	Cabbage palm		25		1				east
Sabal palmetto	Cabbage palm		15		1				east

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site 10-B (continued)

(lat –80.164987106/lon 26.978938944; river mile 10.2, surveyed 1/17/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Sabal palmetto	Cabbage palm		20		1				east
Sabal palmetto	Cabbage palm		21		1				east
Sabal palmetto	Cabbage palm		20		2				east
Sabal palmetto	Cabbage palm		42		1				east
Sabal palmetto	Cabbage palm		35		1				east
Sabal palmetto	Cabbage palm		18		1				east
Sabal palmetto	Cabbage palm		19		1				east
Sabal palmetto	Cabbage palm		6			1			east
Taxodium distichum	Bald cypress	1.6	38	32	1				east
Taxodium distichum	Bald cypress	0.6	21	18	1				east
Taxodium distichum	Bald cypress	1.9	45	22	1				east
Taxodium distichum	Bald cypress	1.3	30	22	1				east
Taxodium distichum	Bald cypress	1.0	28	20	1				east
Taxodium distichum	Bald cypress	1.3	45	32	1				east
Taxodium distichum	Bald cypress	0.1	13	8		1			east
Taxodium distichum	Bald cypress	0.2	13	8		1			east
Taxodium distichum	Bald cypress	0.2	14	12		1			east
Taxodium distichum	Bald cypress	0.1	11	4		1			east
Taxodium distichum	Bald cypress	0.2	14	10		1			east
Taxodium distichum	Bald cypress	0.1	7	6		1			east
Taxodium distichum	Bald cypress	0.3	18	12	1				east
Taxodium distichum	Bald cypress	0.4	21	10	1				east
Taxodium distichum	Bald cypress	0.5	30	16	1				east
Taxodium distichum	Bald cypress	0.5	28	16	1				east
Taxodium distichum	Bald cypress	0.2	18	8		1			east
Taxodium distichum	Bald cypress	0.1	12	4		1			east
Taxodium distichum	Bald cypress	0.3	20	16	1				east
Taxodium distichum	Bald cypress	0.6	29	20	1				east
Taxodium distichum	Bald cypress	0.6	40	14	1				east

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site 10-B (continued)
(lat –80.164987106/lon 26.978938944; river mile 10.2, surveyed 1/17/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Taxodium distichum	Bald cypress	2.9	50	40	1				east
Taxodium distichum	Bald cypress	0.5	18	12	1				east
Taxodium distichum	Bald cypress	0.2	15	6		1			east
Taxodium distichum	Bald cypress	0.6	22	12	1				east
Taxodium distichum	Bald cypress	0.5	20	10	1				east
Taxodium distichum	Bald cypress	0.3	23	12	1				east
Taxodium distichum	Bald cypress	0.2	20	6		1			east
Taxodium distichum	Bald cypress	0.5	21	10	1				east
Taxodium distichum	Bald cypress	0.1	10	6		1			east
Taxodium distichum	Bald cypress	0.6	26	14	1				east
Taxodium distichum	Bald cypress	0.2	22	8		1			east
Taxodium distichum	Bald cypress	0.1	9	6	1				east
Taxodium distichum	Bald cypress	0.1	12	6		1			east
Taxodium distichum	Bald cypress	0.2	14	6		1			east
Taxodium distichum	Bald cypress	0.1	8	4		1			east
Taxodium distichum	Bald cypress	0.2	22	8	1				east
Taxodium distichum	Bald cypress	0.1	9	4		1			east
Taxodium distichum	Bald cypress	0.1	7	4		1			east
Taxodium distichum	Bald cypress	0.5	30	10	1				east
Taxodium distichum	Bald cypress	0.2	18	6		1			east
Taxodium distichum	Bald cypress	0.2	15	4		1			east
Taxodium distichum	Bald cypress	0.5	25	10	1				east
Taxodium distichum	Bald cypress	0.2	13	8		1			east
Taxodium distichum	Bald cypress	0.1	8	8		1			east
Taxodium distichum	Bald cypress	1.9	35	18	1				east

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site V-3

(river mile 9.9, surveyed 1/16/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Annona glabra	Pond apple	1.9	15	16	1				west
Annona glabra	Pond apple	1.3	15	14	1				west
Annona glabra	Pond apple	1.0	15	12	1				west
Annona glabra	Pond apple	1.0	15	12	1				west
Annona glabra	Pond apple	1.0	15	16	1				west
Annona glabra	Pond apple	0.1	13	16	1				west
Annona glabra	Pond apple	1.6	14	8	1				west
Annona glabra	Pond apple	0.6	15	8	1				west
Annona glabra	Pond apple	1.3	15	8	1				west
Annona glabra	Pond apple	0.3	15	4	1				west
Annona glabra	Pond apple	0.6	15	6	1				west
Annona glabra	Pond apple	1.0	15	12	1				west
Annona glabra	Pond apple	0.6	15	6	1				west
Annona glabra	Pond apple	0.8	15	8	1				west
Annona glabra	Pond apple	0.8	15	8	1				west
Annona glabra	Pond apple	0.3	15	6	1				west
Annona glabra	Pond apple	0.6	15	6	1				west
Annona glabra	Pond apple	0.3	15	4	1				west
Annona glabra	Pond apple	0.3	15	6	1				west
Annona glabra	Pond apple	0.8	15	6	1				west
Annona glabra	Pond apple	0.3	15	4	1				west
Annona glabra	Pond apple	0.5	15	4	1				west
Annona glabra	Pond apple	0.3	15	4	1				west
Annona glabra	Pond apple	1.9	15	8	1				west
Annona glabra	Pond apple	1.0	15	5	1				west
Annona glabra	Pond apple	0.3	15	6	1				west
Annona glabra	Pond apple	1.3	15	10	1				west
Annona glabra	Pond apple	0.8	15	4	1				west
Annona glabra	Pond apple	1.0	15	8	1				west

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site V-3 (continued)
(river mile 9.9, surveyed 1/16/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Annona glabra	Pond apple	1.3	15	6	1				west
Annona glabra	Pond apple	2.2	12	8	1				west
Annona glabra	Pond apple	0.5	13	6	1				west
Annona glabra	Pond apple	1.0	15	12	1				west
Annona glabra	Pond apple	1.0	15	8	1				west
Annona glabra	Pond apple	0.8	15	8	1				west
Annona glabra	Pond apple	0.8	15	4	1				west
Annona glabra	Pond apple	1.6	15	10	1				west
Annona glabra	Pond apple	1.4	15	8	1				west
Annona glabra	Pond apple	1.8	15	12	1				west
Annona glabra	Pond apple	1.0	15	12	1				west
Annona glabra	Pond apple	0.6		8	1				west
Annona glabra	Pond apple	1.0	15	8	1				west
Annona glabra	Pond apple	0.8	15	6	1				west
Annona glabra	Pond apple	2.5	15	10	1				west
Annona glabra	Pond apple	1.9	15	12	1				west
Annona glabra	Pond apple	1.3	15	10	1				west
Annona glabra	Pond apple	1.3		12	1				west
Annona glabra	Pond apple	1.0	15	8	1				west
Annona glabra	Pond apple	0.5	15	6	1				west
Annona glabra	Pond apple	0.5	15	6	1				west
Annona glabra	Pond apple	2.2	15	14	1				west
Annona glabra	Pond apple	1.3	15	8	1				west
Annona glabra	Pond apple	0.2	15	4	1				west
Annona glabra	Pond apple	1.0	14	10	1				west
Annona glabra	Pond apple	0.1	14	8	1				west
Annona glabra	Pond apple	0.3	15	4	1				west
Annona glabra	Pond apple	1.0		8	1				west
Annona glabra	Pond apple	0.5	14	8	1				west

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site V-3 (continued)
(river mile 9.9, surveyed 1/16/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Annona glabra	Pond apple	0.3	10	6	1				west
Annona glabra	Pond apple	0.6	15	12	1				west
Annona glabra	Pond apple	0.3	15	6	1				west
Annona glabra	Pond apple	0.3	15	6	1				west
Annona glabra	Pond apple	0.3	14	2	1				west
Annona glabra	Pond apple	1.0	15	8	1				west
Annona glabra	Pond apple	0.3		8	1				west
Annona glabra	Pond apple	1.3	15	14	1				west
Annona glabra	Pond apple	1.4	15	14	1				west
Annona glabra	Pond apple	0.6	12	14	1				west
Annona glabra	Pond apple	1.3	15	14	1				west
Annona glabra	Pond apple	0.6	15	10	1				west
Annona glabra	Pond apple	0.3	15	4	1				west
Annona glabra	Pond apple	1.3	15	10	1				west
Annona glabra	Pond apple	1.3	15	10	1				west
Annona glabra	Pond apple	1.3	15	16	1				west
Annona glabra	Pond apple	0.5	15	12	1				west
Annona glabra	Pond apple	0.3	15	6	1				west
Annona glabra	Pond apple	1.6	15	14	1				west
Fraxinus caroliniana	Pop ash	0.5	12	20	1				west
Fraxinus caroliniana	Pop ash	0.6	15	14	1				west
Fraxinus caroliniana	Pop ash	0.5	8	4				1	west
Fraxinus caroliniana	Pop ash	0.6	14			1			west
Fraxinus caroliniana	Pop ash	0.1	13		1				west
Fraxinus caroliniana	Pop ash	0.1	13		1				west
Fraxinus caroliniana	Pop ash	0.1	13		1				west
Fraxinus caroliniana	Pop ash	0.1	8		1				west
Fraxinus caroliniana	Pop ash	0.5	15	6	1				west
Fraxinus caroliniana	Pop ash	0.1	10	2		1			west

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site V-3 (continued)

(river mile 9.9, surveyed 1/16/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Fraxinus caroliniana	Pop ash	0.3	13	4	1				west
Fraxinus caroliniana	Pop ash	1.3	15	16	1				west
Fraxinus caroliniana	Pop ash	0.2	15	6	1				west
Fraxinus caroliniana	Pop ash	0.6	16	8	1				west
Ilex cassine	Dahoon	0.2	13			1			west
Itea virginica	Virginia willow						1		west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Rhizophora mangle	Red mangrove	0.1	11	4	1				west
Rhizophora mangle	Red mangrove		14	10	1				west
Rhizophora mangle	Red mangrove		15	14	1				west
Rhizophora mangle	Red mangrove						1		west
Rhizophora mangle	Red mangrove						1		west
Rhizophora mangle	Red mangrove		15	10	1				west
Rhizophora mangle	Red mangrove		15	12	1				west
Rhizophora mangle	Red mangrove						1		west
Rhizophora mangle	Red mangrove		15	4	1				west
Rhizophora mangle	Red mangrove		15	4	1				west
Rhizophora mangle	Red mangrove		6			1			west
Rhizophora mangle	Red mangrove		10			1			west
Rhizophora mangle	Red mangrove		10			1			west
Rhizophora mangle	Red mangrove		9			1			west
Rhizophora mangle	Red mangrove		15		1				west
Rhizophora mangle	Red mangrove		15	14	1				west
Rhizophora mangle	Red mangrove		15	14	1				west
Rhizophora mangle	Red mangrove		15	14	1				west
Rhizophora mangle	Red mangrove		15	14	1				west
Rhizophora mangle	Red mangrove		15	14	1				west

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site V-3 (continued)

(river mile 9.9, surveyed 1/16/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Rhizophora mangle	Red mangrove		10			1			west
Rhizophora mangle	Red mangrove						1		west
Rhizophora mangle	Red mangrove						1		west
Rhizophora mangle	Red mangrove						1		west
Rhizophora mangle	Red mangrove						1		west
Rhizophora mangle	Red mangrove		14	10	1				west
Rhizophora mangle	Red mangrove		17	14	1				west
Rhizophora mangle	Red mangrove		15	8	1				west
Rhizophora mangle	Red mangrove		16	8	1				west
Rhizophora mangle	Red mangrove		15	16	1				west
Rhizophora mangle	Red mangrove						4		west
Rhizophora mangle	Red mangrove						10		west
Rhizophora mangle	Red mangrove			6	1				west
Rhizophora mangle	Red mangrove		15	10	1				west
Rhizophora mangle	Red mangrove		15	12	1				west
Rhizophora mangle	Red mangrove		15	16	1				west
Rhizophora mangle	Red mangrove		15	8	1				west
Rhizophora mangle	Red mangrove		14	14	1				west
Rhizophora mangle	Red mangrove		14	14	1				west
Rhizophora mangle	Red mangrove		14	12	1				west
Rhizophora mangle	Red mangrove		13	12	1				west
Rhizophora mangle	Red mangrove		11	8	1				west
Rhizophora mangle	Red mangrove		15	14	1				west
Rhizophora mangle	Red mangrove		15	8	1				west
Rhizophora mangle	Red mangrove		15	12	1				west
Rhizophora mangle	Red mangrove		15	10	1				west
Rhizophora mangle	Red mangrove		15	8	1				west
Rhizophora mangle	Red mangrove		15	8	1				west
Rhizophora mangle	Red mangrove		10	4		1			west

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site V-3 (continued)

(river mile 9.9, surveyed 1/16/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Rhizophora mangle	Red mangrove		10	4		1			west
Rhizophora mangle	Red mangrove		12	8	1				west
Rhizophora mangle	Red mangrove		10	8	1				west
Rhizophora mangle	Red mangrove		15	12	1				west
Sabal palmetto	Cabbage palm		12		1				west
Taxodium distichum	Bald cypress	0.6	30	24	1				west
Taxodium distichum	Bald cypress	1.6	35	28	1				west
Taxodium distichum	Bald cypress	3.5	45	40	1				west

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site 9-C

(lat –80.163800034/lon 26.982719318; river mile 9.7, surveyed 1/17/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Acer rubrum	Red maple	0.3	20	8	1				west
Acer rubrum	Red maple	0.1	15	2	1				west
Acer rubrum	Red maple	0.2	17	12	1				west
Acer rubrum	Red maple	0.3	22	4	1				west
Acer rubrum	Red maple	0.3	18	4	1				west
Acer rubrum	Red maple	0.5	42	12	1				west
Acer rubrum	Red maple	0.5	32	12	1				west
Acer rubrum	Red maple	0.6	22	12	1				west
Acer rubrum	Red maple	0.8	33	14	1				west
Annona glabra	Pond apple	0.3	17	6	1				west
Annona glabra	Pond apple	0.3	15	12	1				west
Annona glabra	Pond apple	0.1	16	4	1				west
Annona glabra	Pond apple	0.3	14	6	1				west
Annona glabra	Pond apple	0.3	14	6	1				west
Annona glabra	Pond apple	0.3	13	6	1				west
Annona glabra	Pond apple						1		west
Annona glabra	Pond apple	0.3	14	6				1	west
Annona glabra	Pond apple	0.6	15	6	1				west
Annona glabra	Pond apple	1.0	15	8	1				west
Annona glabra	Pond apple	0.6	18	8	1				west
Annona glabra	Pond apple	0.6	18	8	1				west
Annona glabra	Pond apple	0.6	18	8	1				west
Annona glabra	Pond apple	0.6	18	8	1				west
Annona glabra	Pond apple	0.6	18	14	1				west
Annona glabra	Pond apple	0.3	12	4	1				west
Annona glabra	Pond apple	0.6	18	8	1				west
Annona glabra	Pond apple	0.6	12	12	1				west
Annona glabra	Pond apple	0.6	16	12	1				west
Annona glabra	Pond apple	1.0	12	12	1				west

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site 9-C (continued)
(lat –80.163800034/lon 26.982719318; river mile 9.7, surveyed 1/17/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Annona glabra	Pond apple	0.6	14	12	1				west
Annona glabra	Pond apple	0.6	14	14	1				west
Annona glabra	Pond apple	0.6	15	16	1				west
Annona glabra	Pond apple	0.6	15	8	1				west
Annona glabra	Pond apple	0.6	18	12	1				west
Annona glabra	Pond apple	0.6	18	4	1				west
Annona glabra	Pond apple	1.0	18	12	1				west
Annona glabra	Pond apple	0.6	15	12	1				west
Annona glabra	Pond apple	0.3	14	8	1				west
Annona glabra	Pond apple	0.3	15	8	1				west
Annona glabra	Pond apple	0.3	15	6	1				west
Annona glabra	Pond apple	0.3	18	6	1				west
Annona glabra	Pond apple	0.3	14	4	1				west
Annona glabra	Pond apple	0.5	15	12	1				west
Annona glabra	Pond apple	0.3	15	6	1				west
Annona glabra	Pond apple	0.3	15	6	1				west
Fraxinus caroliniana	Pop ash	0.2	17	4	1				west
Fraxinus caroliniana	Pop ash	0.3	12	4	1				west
Fraxinus caroliniana	Pop ash	0.3	7	4	1				west
Fraxinus caroliniana	Pop ash	0.2	10	4	1				west
Fraxinus caroliniana	Pop ash	0.1	6	2		1			west
Fraxinus caroliniana	Pop ash	0.1	16	4		1			west
Fraxinus caroliniana	Pop ash	0.1	14	2	1				west
Fraxinus caroliniana	Pop ash	0.2	12	2	1				west
Fraxinus caroliniana	Pop ash	0.2	12	2	1				west
Fraxinus caroliniana	Pop ash	0.3	13	6	1				west
Fraxinus caroliniana	Pop ash	0.3	20	8	1				west
Fraxinus caroliniana	Pop ash	0.3	18	6	1				west
Fraxinus caroliniana	Pop ash	0.5	15	8	1				west

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site 9-C (continued)

(lat –80.163800034/lon 26.982719318; river mile 9.7, surveyed 1/17/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Fraxinus caroliniana	Pop ash	0.3	13	6	1				west
Fraxinus caroliniana	Pop ash	0.2	13	4	1				west
Fraxinus caroliniana	Pop ash	0.2	9	4	1				west
Fraxinus caroliniana	Pop ash	0.3	14	8	1				west
Fraxinus caroliniana	Pop ash	0.1	7	2	1				west
Fraxinus caroliniana	Pop ash	0.1	13	2	1				west
Fraxinus caroliniana	Pop ash	0.5	12	8	1				west
Fraxinus caroliniana	Pop ash	0.2	12	8	1				west
Ilex cassine	Dahoon	0.2	23	4	1				west
Ilex cassine	Dahoon	0.1	10	4		1			west
Ilex cassine	Dahoon	0.0	4	2	1				west
Ilex cassine	Dahoon	0.1	16	6	1				west
Ilex cassine	Dahoon	0.3	13	8	1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow						1		west

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site 9-C (continued)

(lat –80.163800034/lon 26.982719318; river mile 9.7, surveyed 1/17/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Itea virginica	Virginia willow						1		west
Itea virginica	Virginia willow						1		west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow				1				west
Persea borbonia	Red bay	0.1	5	2	1	1			west
Persea borbonia	Red bay	0.0	6	2		1			west
Persea borbonia	Red bay	0.0	7	2		1			west
Persea borbonia	Red bay	0.0	7	2		1			west
Persea borbonia	Red bay	0.1	11	4	1				west
Persea borbonia	Red bay						1		west
Persea borbonia	Red bay	0.1	12	2	1				west
Rhizophora mangle	Red mangrove		10	8	1				west
Sabal palmetto	Cabbage palm		18		1				west
Sabal palmetto	Cabbage palm		13		1				west
Sabal palmetto	Cabbage palm		30		1				west
Sabal palmetto	Cabbage palm		15		1				west
Sabal palmetto	Cabbage palm		8		1				west
Sabal palmetto	Cabbage palm								west
Sabal palmetto	Cabbage palm		9		1				west
Sabal palmetto	Cabbage palm		22		1				west
Sabal palmetto	Cabbage palm		20		1				west
Sabal palmetto	Cabbage palm		30		1				west

Quantitative Vegetativon Survey of the NW Fork Loxahatchee River: Site 9-C (continued)

(lat –80.163800034/lon 26.982719318; river mile 9.7, surveyed 1/17/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Sabal palmetto	Cabbage palm		25		1				west
Sabal palmetto	Cabbage palm		10		1				west
Sabal palmetto	Cabbage palm		21		1				west
Sabal palmetto	Cabbage palm		40		1				west
Taxodium distichum	Bald cypress	1.9	55	24	1				west
Taxodium distichum	Bald cypress	1.0	55	20	1				west
Taxodium distichum	Bald cypress	1.3	50	20	1				west
Taxodium distichum	Bald cypress	0.6	45	14	1				west
Taxodium distichum	Bald cypress	1.0	55	20	1				west
Taxodium distichum	Bald cypress	1.3	55	24	1				west
Taxodium distichum	Bald cypress	1.3	45	24	1				west
Taxodium distichum	Bald cypress	0.3	30	12	1				west
Taxodium distichum	Bald cypress	0.1	30	24	1				west
Taxodium distichum	Bald cypress	1.0	45	20	1				west
Taxodium distichum	Bald cypress	0.8	30	16	1				west
Taxodium distichum	Bald cypress	1.3	35	22	1				west
Taxodium distichum	Bald cypress	1.3	38	20	1				west
Taxodium distichum	Bald cypress	1.9	40	24	1				west
Taxodium distichum	Bald cypress	1.0	25	20	1				west
Acer rubrum	Red maple	0.1	15	12	1				east
Annona glabra	Pond apple	0.2	18	8	1				east
Annona glabra	Pond apple	0.1	7	3		1			east
Annona glabra	Pond apple	0.2	30	6	1				east
Annona glabra	Pond apple						1		east
Annona glabra	Pond apple						1		east
Annona glabra	Pond apple	0.1	6	2	1				east
Annona glabra	Pond apple	0.1	11	2	1				east
Annona glabra	Pond apple	0.1	12	6	1				east
Annona glabra	Pond apple	0.1	23	8	1				east

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site 9-C (continued)

(lat –80.163800034/lon 26.982719318; river mile 9.7, surveyed 1/17/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Fraxinus caroliniana	Pop ash	0.6	20	12	1				east
Fraxinus caroliniana	Pop ash	0.2	20	6	1				east
Fraxinus caroliniana	Pop ash	0.1	15	5	1				east
Fraxinus caroliniana	Pop ash	0.3	18	8	1				east
Fraxinus caroliniana	Pop ash	0.1	15	2	1				east
Fraxinus caroliniana	Pop ash	0.1	13	4	1				east
Fraxinus caroliniana	Pop ash	0.1	6	2				1	east
Fraxinus caroliniana	Pop ash	0.2	10	4				1	east
Fraxinus caroliniana	Pop ash	0.2	6	2				1	east
Fraxinus caroliniana	Pop ash	0.3	13	6	1				east
Fraxinus caroliniana	Pop ash	0.1	5	4	1				east
Fraxinus caroliniana	Pop ash	0.3	19	12	1				east
Fraxinus caroliniana	Pop ash	0.3	20	12	1				east
Fraxinus caroliniana	Pop ash	0.1	13	12		1			east
Ilex cassine	Dahoon	0.1	6	2	1				east
Itea virginica	Virginia willow				1				east
Itea virginica	Virginia willow				1				east
Itea virginica	Virginia willow						1		east
Itea virginica	Virginia willow				1				east
Itea virginica	Virginia willow				1				east
Itea virginica	Virginia willow				1				east
Itea virginica	Virginia willow				1				east
Itea virginica	Virginia willow				1				east
Itea virginica	Virginia willow				1				east
Itea virginica	Virginia willow						1		east
Itea virginica	Virginia willow						1		east
Itea virginica	Virginia willow						1		east
Itea virginica	Virginia willow						1		east
Itea virginica	Virginia willow				1				east

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site 9-C (continued)

(lat –80.163800034/lon 26.982719318; river mile 9.7, surveyed 1/17/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Itea virginica	Virginia willow				1				east
Itea virginica	Virginia willow				1				east
Itea virginica	Virginia willow				1				east
Itea virginica	Virginia willow						1		east
Itea virginica	Virginia willow				1				east
Rhizophora mangle	Red mangrove		1	4		1			east
Rhizophora mangle	Red mangrove						1		east
Rhizophora mangle	Red mangrove						1		east
Rhizophora mangle	Red mangrove		12	4	1				east
Rhizophora mangle	Red mangrove		7	6	1				east
Rhizophora mangle	Red mangrove		4	2		1			east
Rhizophora mangle	Red mangrove		18	8	1				east
Rhizophora mangle	Red mangrove		5	4	1				east
Rhizophora mangle	Red mangrove		7	4	1				east
Rhizophora mangle	Red mangrove		15	8	1				east
Rhizophora mangle	Red mangrove		7	4	1				east
Rhizophora mangle	Red mangrove		8	4	1				east
Rhizophora mangle	Red mangrove		7	4	1				east
Rhizophora mangle	Red mangrove						1		east
Rhizophora mangle	Red mangrove						1		east
Rhizophora mangle	Red mangrove						1		east
Rhizophora mangle	Red mangrove						1		east
Rhizophora mangle	Red mangrove						1		east
Rhizophora mangle	Red mangrove						1		east
Rhizophora mangle	Red mangrove						1		east
Rhizophora mangle	Red mangrove						1		east
Rhizophora mangle	Red mangrove						1		east
Rhizophora mangle	Red mangrove						1		east
Rhizophora mangle	Red mangrove		10	8	1				east

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site 9-C (continued)

(lat –80.163800034/lon 26.982719318; river mile 9.7, surveyed 1/17/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Rhizophora mangle	Red mangrove		12	4	1				east
Rhizophora mangle	Red mangrove						1		east
Rhizophora mangle	Red mangrove		14	8	1				east
Rhizophora mangle	Red mangrove		7	6	1				east
Rhizophora mangle	Red mangrove		7	6	1				east
Rhizophora mangle	Red mangrove		6	8	1				east
Rhizophora mangle	Red mangrove						1		east
Rhizophora mangle	Red mangrove						1		east
Rhizophora mangle	Red mangrove						1		east
Rhizophora mangle	Red mangrove						1		east
Rhizophora mangle	Red mangrove						1		east
Rhizophora mangle	Red mangrove						1		east
Rhizophora mangle	Red mangrove						1		east
Rhizophora mangle	Red mangrove						1		east
Rhizophora mangle	Red mangrove						1		east
Rhizophora mangle	Red mangrove						1		east
Rhizophora mangle	Red mangrove						1		east
Rhizophora mangle	Red mangrove						1		east
Rhizophora mangle	Red mangrove						1		east
Rhizophora mangle	Red mangrove						1		east
Sabal palmetto	Cabbage palm		21		1				east
Sabal palmetto	Cabbage palm		30		1				east
Sabal palmetto	Cabbage palm		25		1				east
Sabal palmetto	Cabbage palm		25		1				east
Sabal palmetto	Cabbage palm		18		1				east
Sabal palmetto	Cabbage palm		40		1				east
Sabal palmetto	Cabbage palm		45		1				east
Sabal palmetto	Cabbage palm		20		1				east
Sabal palmetto	Cabbage palm		40		1				east

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site 9-C (continued)

(lat –80.163800034/lon 26.982719318; river mile 9.7, surveyed 1/17/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Sabal palmetto	Cabbage palm		40		1				east
Sabal palmetto	Cabbage palm		10		1				east
Sabal palmetto	Cabbage palm		12		1				east
Sabal palmetto	Cabbage palm		19		1				east
Sabal palmetto	Cabbage palm		35		1				east
Sabal palmetto	Cabbage palm		35		1				east
Sabal palmetto	Cabbage palm		40		1				east
Sabal palmetto	Cabbage palm		25		1				east
Sabal palmetto	Cabbage palm		12		1				east
Sabal palmetto	Cabbage palm		5		1				east
Sabal palmetto	Cabbage palm		30		1				east
Sabal palmetto	Cabbage palm		15		1				east
Sabal palmetto	Cabbage palm		15		1				east
Sabal palmetto	Cabbage palm		30		1				east
Sabal palmetto	Cabbage palm		40		1				east
Sabal palmetto	Cabbage palm		21		1				east
Sabal palmetto	Cabbage palm		22		1				east
Sabal palmetto	Cabbage palm		35		1				east
Sabal palmetto	Cabbage palm		40		1				east
Sabal palmetto	Cabbage palm		28		1				east
Taxodium distichum	Bald cypress	0.6	40	12	1				east
Taxodium distichum	Bald cypress	0.5	28	10	1				east
Taxodium distichum	Bald cypress	0.2	15	10	1				east
Taxodium distichum	Bald cypress	0.2	18	12	1				east
Taxodium distichum	Bald cypress	0.5	28	13	1				east
Taxodium distichum	Bald cypress	0.5	18	12	1				east
Taxodium distichum	Bald cypress	0.2	15	10		1			east
Taxodium distichum	Bald cypress	0.6	18	20	1				east
Taxodium distichum	Bald cypress	1.3	35	20	1				east

<u>Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site 9-C (continued)</u>
(lat –80.163800034/lon 26.982719318; river mile 9.7, surveyed 1/17/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Taxodium distichum	Bald cypress	1.3	45	24	1				east
Taxodium distichum	Bald cypress	1.0	14	16	1				east
Taxodium distichum	Bald cypress	1.0	30	28	1				east
Taxodium distichum	Bald cypress	0.2	15	10		1			east
Taxodium distichum	Bald cypress	0.3	16	14	1				east
Taxodium distichum	Bald cypress	0.3	20	16		1			east
Taxodium distichum	Bald cypress	0.1	10	10		1			east
Taxodium distichum	Bald cypress	0.1	14	10		1			east
Taxodium distichum	Bald cypress	3.5	28	28	1				east

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site 9-B

(lat –80.160870447/lon 26.983861002; river mile 9.2, surveyed 1/15/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Rhizophora mangle	Red mangrove		14	200*	100*				west
Sabal palmetto	Cabbage palm		22		1				west
Sabal palmetto	Cabbage palm		24		1				west
Sabal palmetto	Cabbage palm		32		1				west
Sabal palmetto	Cabbage palm		18		1				west
Sabal palmetto	Cabbage palm		15		1				west
Sabal palmetto	Cabbage palm		15		1				west
Sabal palmetto	Cabbage palm		10		1				west
Sabal palmetto	Cabbage palm		12		1				west
Sabal palmetto	Cabbage palm		14		1				west
Sabal palmetto	Cabbage palm		8		1				west
Sabal palmetto	Cabbage palm		8		1				west
Sabal palmetto	Cabbage palm		12		1				west
Taxodium distichum	Bald cypress		26	10	1				west
Taxodium distichum	Bald cypress		26	15	1				west
Taxodium distichum	Bald cypress		26	15	1				west
Annona glabra	Pond apple		13	8				1	east
Annona glabra	Pond apple		15					1	east
Annona glabra	Pond apple	0.3	14	6	1				east
Annona glabra	Pond apple	0.3	14	6	1				east
Annona glabra	Pond apple	0.3	14	6	1				east
Annona glabra	Pond apple	0.3	14	6	1				east
Annona glabra	Pond apple	0.3	14	6	1				east
Annona glabra	Pond apple	0.3	14	6	1				east
Annona glabra	Pond apple	0.3	14	12	1				east
Annona glabra	Pond apple	0.3	14	3	1				east
Annona glabra	Pond apple	0.3	14	3	1				east
Annona glabra	Pond apple	0.3	14	3	1				east

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site 9-B (continued)

(lat –80.160870447/lon 26.983861002; river mile 9.2, surveyed 1/15/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Annona glabra	Pond apple	0.0	8	8	1				east
Fraxinus caroliniana	Pop ash	0.2	16		1				east
Fraxinus caroliniana	Pop ash	0.5	12	8				1	east
Ilex cassine	Dahoon		14	3	1				east
Ilex cassine	Dahoon	0.2	12	4	1				east
Rhizophora mangle	Red mangrove		14	200*	100*				east
Sabal palmetto	Cabbage palm		22		1				east
Sabal palmetto	Cabbage palm		20		1				east
Sabal palmetto	Cabbage palm		14		1				east
Sabal palmetto	Cabbage palm		6		1				east
Sabal palmetto	Cabbage palm		19		1				east
Sabal palmetto	Cabbage palm		14		1				east
Sabal palmetto	Cabbage palm		16		1				east
Sabal palmetto	Cabbage palm		24		1				east
Sabal palmetto	Cabbage palm		22		1				east
Sabal palmetto	Cabbage palm		20		1				east
Sabal palmetto	Cabbage palm		16		1				east
Sabal palmetto	Cabbage palm		20		1				east
Sabal palmetto	Cabbage palm		22		1				east
Sabal palmetto	Cabbage palm		26		1				east
Sabal palmetto	Cabbage palm		22		1				east
Sabal palmetto	Cabbage palm		22		1				east
Sabal palmetto	Cabbage palm		16		1				east
Sabal palmetto	Cabbage palm		26		1				east
Sabal palmetto	Cabbage palm		24		1				east
Sabal palmetto	Cabbage palm		30		1				east
Sabal palmetto	Cabbage palm		25		1				east
Taxodium distichum	Bald cypress		28	11	1				east

*indicates estimated value

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site 9-A

(lat –80.159358557/lon 26.985374135; river mile 9.1, surveyed 1/16/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Annona glabra	Pond apple	1.0	10	10	1				west
Annona glabra	Pond apple	0.5	10	5				1	west
Annona glabra	Pond apple	0.6	10	5				1	west
Annona glabra	Pond apple	0.6	10	5				1	west
Annona glabra	Pond apple	0.3	8	6	1				west
Annona glabra	Pond apple	0.5	10	5				1	west
Annona glabra	Pond apple	0.3	8	3				1	west
Annona glabra	Pond apple	0.3	12	7				1	west
Annona glabra	Pond apple	0.5	10	6				1	west
Annona glabra	Pond apple	0.5	12	10	1				west
Annona glabra	Pond apple	0.3	4	4	1				west
Annona glabra	Pond apple	0.3	11	3				1	west
Annona glabra	Pond apple	0.3	12	3	1				west
Fraxinus caroliniana	Pop ash	0.3	11	2		1			west
Itea virginica	Virginia willow				1				west
Itea virginica	Virginia willow						1		west
Rhizophora mangle	Red mangrove		9	200*	100*				west
Sabal palmetto	Cabbage palm		18		1				west
Sabal palmetto	Cabbage palm		13		1				west
Sabal palmetto	Cabbage palm		18		1				west
Sabal palmetto	Cabbage palm		16		1				west
Sabal palmetto	Cabbage palm		22		1				west
Sabal palmetto	Cabbage palm		15		1				west
Sabal palmetto	Cabbage palm		12		1				west
Sabal palmetto	Cabbage palm		15		1				west
Sabal palmetto	Cabbage palm		16		1				west
Sabal palmetto	Cabbage palm		16		1				west
Sabal palmetto	Cabbage palm		16		1				west
Sabal palmetto	Cabbage palm		4.5		1				west

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site 9-A (continued)

(lat –80.159358557/lon 26.985374135; river mile 9.1, surveyed 1/16/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Sabal palmetto	Cabbage palm		4		1				west
Annona glabra	Pond apple		11	8					east
Annona glabra	Pond apple	0.5	15	7				1	east
Annona glabra	Pond apple	0.6	12	10	1				east
Annona glabra	Pond apple	1.0	12	10	1				east
Annona glabra	Pond apple		5	3	1				east
Annona glabra	Pond apple	0.2	6	1		1			east
Annona glabra	Pond apple	0.2	6	1	1				east
Annona glabra	Pond apple	0.5	8	7	1				east
Annona glabra	Pond apple	0.6	9	6	1				east
Annona glabra	Pond apple	0.3	9	8	1				east
Annona glabra	Pond apple	0.5	6	8	1				east
Annona glabra	Pond apple	0.8	7	8	1				east
Rhizophora mangle	Red mangrove			200*	100*				east
Taxodium distichum	Bald cypress	0.3	15	4		1			east
Taxodium distichum	Bald cypress	0.3	14	4		1			east
Taxodium distichum	Bald cypress	0.3	14	4		1			east
Taxodium distichum	Bald cypress	0.3	14	4		1			east

*indicates estimated value

Quantitative Vegetation Survey of the NW Fork Loxahatchee River: Site 8-C

(lat –80.157838347/lon 26.989749400; river mile 8.7, surveyed 1/16/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Sabal palmetto	Cabbage palm		10		1				w
Sabal palmetto	Cabbage palm		10		1				w
Sabal palmetto	Cabbage palm		8		1				w
Sabal palmetto	Cabbage palm		8		1				w
Sabal palmetto	Cabbage palm		11		1				w
Sabal palmetto	Cabbage palm		13		1				w
Rhizophora mangle	Red mangrove		9	200*	100*				w
Taxodium distichum	Bald cypress	1.0	14	16	1				e
Taxodium distichum	Bald cypress		13	8	1				e
Taxodium distichum	Bald cypress		17	18	1				e
Taxodium distichum	Bald cypress	1.0	24	9	1				e
Sabal palmetto	Cabbage palm		13		1				e
Sabal palmetto	Cabbage palm		12		1				e
Sabal palmetto	Cabbage palm		12		1				e
Sabal palmetto	Cabbage palm		17		1				e
Sabal palmetto	Cabbage palm		8		1				e
Rhizophora mangle	Red mangrove		9	160*	80*				e

*indicates estimated value

Quantitative Vegetative Survey of NW Fork Loxahatchee River: Site 8-B

(lat –80.155118577/lon 26.989388511; river mile 8.4, surveyed 1/14/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Rhizophora mangle	Red mangrove		8	200*	100*				north
Sabal palmetto	Cabbage palm		18		1				north
Sabal palmetto	Cabbage palm		17		1				north
Sabal palmetto	Cabbage palm		9		1				north
Sabal palmetto	Cabbage palm		18		1				north
Sabal palmetto	Cabbage palm		12		1				north
Sabal palmetto	Cabbage palm		17		1				north
Sabal palmetto	Cabbage palm		20		1				north
Rhizophora mangle	Red mangrove		8	200*	100*				south
Sabal palmetto	Cabbage palm		17		1				south
Sabal palmetto	Cabbage palm		17		1				south
Sabal palmetto	Cabbage palm		17		1				south
Sabal palmetto	Cabbage palm		17		1				south
Sabal palmetto	Cabbage palm		16		1				south
Sabal palmetto	Cabbage palm		16		1				south
Sabal palmetto	Cabbage palm		16		1				south
Sabal palmetto	Cabbage palm		18		1				south
Sabal palmetto	Cabbage palm		18		1				south
Sabal palmetto	Cabbage palm		18		1				south
Sabal palmetto	Cabbage palm		15		1				south
Sabal palmetto	Cabbage palm		10		1				south
Sabal palmetto	Cabbage palm		20		1				south
Sabal palmetto	Cabbage palm		20		1				south
Sabal palmetto	Cabbage palm		18		1				south
Sabal palmetto	Cabbage palm		19		1				south
Sabal palmetto	Cabbage palm		19		1				south
Sabal palmetto	Cabbage palm		19		1				south
Sabal palmetto	Cabbage palm		19		1				south
Sabal palmetto	Cabbage palm		17		1				south

Quantitative Vegetative Survey of the NW Fork Loxahatchee River: Site 8-B (continued)
(lat –80.155118577/lon 26.989388511; river mile 8.4, surveyed 1/14/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Sabal palmetto	Cabbage palm		17		1				south
Sabal palmetto	Cabbage palm		17		1				south
Sabal palmetto	Cabbage palm		30		1				south
Sabal palmetto	Cabbage palm		25		1				south
Sabal palmetto	Cabbage palm		20		1				south
Sabal palmetto	Cabbage palm		20		1				south
Sabal palmetto	Cabbage palm		18		1				south
Sabal palmetto	Cabbage palm		18		1				south
Sabal palmetto	Cabbage palm		15		1				south
Sabal palmetto	Cabbage palm		22		1				south
Sabal palmetto	Cabbage palm		22		1				south
Sabal palmetto	Cabbage palm		22		1				south
Sabal palmetto	Cabbage palm		22		1				south
Sabal palmetto	Cabbage palm		25		1				south
Sabal palmetto	Cabbage palm		25		1				south
Sabal palmetto	Cabbage palm		25		1				south
Sabal palmetto	Cabbage palm		25		1				south
Sabal palmetto	Cabbage palm		25		1				south
Sabal palmetto	Cabbage palm		25		1				south
Sabal palmetto	Cabbage palm		25		1				south
Taxodium distichum	Bald cypress		25	12	1				south
Taxodium distichum	Bald cypress		25	12	1				south
Taxodium distichum	Bald cypress		25	12	1				south

*indicates estimated value

Quantitative Vegetative Survey of the NW Fork Loxahatchee River: Site V-7

(river mile 7.95, surveyed 1/14/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Rhizophora mangle	Red mangrove		7	200*	100*				north
Sabal palmetto	Cabbage palm		20		1				north
Sabal palmetto	Cabbage palm		8		1				north
Sabal palmetto	Cabbage palm		12		1				north
Sabal palmetto	Cabbage palm		18		1				north
Sabal palmetto	Cabbage palm		13		1				north
Sabal palmetto	Cabbage palm		13		1				north
Sabal palmetto	Cabbage palm		10		1				north
Sabal palmetto	Cabbage palm		20		1				north
Sabal palmetto	Cabbage palm		22		1				north
Sabal palmetto	Cabbage palm		16		1				north
Sabal palmetto	Cabbage palm		10		1				north
Sabal palmetto	Cabbage palm		23		1				north
Sabal palmetto	Cabbage palm		10		1				north
Sabal palmetto	Cabbage palm		13		1				north
Sabal palmetto	Cabbage palm		11		1				north
Sabal palmetto	Cabbage palm		15		1				north
Sabal palmetto	Cabbage palm		17		1				north
Sabal palmetto	Cabbage palm		15		1				north
Sabal palmetto	Cabbage palm		25		1				north
Sabal palmetto	Cabbage palm		17		1				north
Sabal palmetto	Cabbage palm		20		1				north
Sabal palmetto	Cabbage palm		8		1				north
Sabal palmetto	Cabbage palm		22		1				north
Sabal palmetto	Cabbage palm		10		1				north
Sabal palmetto	Cabbage palm		12		1				north
Sabal palmetto	Cabbage palm		16		1				north
Sabal palmetto	Cabbage palm		15		1				north
Rhizophora mangle	Red mangrove		8	200*	100*				south

Quantitative Vegetative Survey of the NW Fork Loxahatchee River: Site V-7 (continued)
(river mile 7.95, surveyed 1/14/02)

Scientific Name	Common Name	DBH (ft)	Height (ft)	Canopy diameter (ft)	No. of Adults	No. of Saplings	No. of Seedlings	No. of Stump sprouts	Bank
Sabal palmetto	Cabbage palm		15		1				south
Sabal palmetto	Cabbage palm		15		1				south
Sabal palmetto	Cabbage palm		15		1				south
Sabal palmetto	Cabbage palm		17		1				south
Sabal palmetto	Cabbage palm		12		1				south
Sabal palmetto	Cabbage palm		12		1				south
Sabal palmetto	Cabbage palm		16		1				south
Sabal palmetto	Cabbage palm		15		1				south
Sabal palmetto	Cabbage palm		17		1				south
Sabal palmetto	Cabbage palm		16		1				south
Sabal palmetto	Cabbage palm		10		1				south
Sabal palmetto	Cabbage palm		10		1				south
Sabal palmetto	Cabbage palm		18		1				south
Sabal palmetto	Cabbage palm		17		1				south
Sabal palmetto	Cabbage palm		12		1				south
Sabal palmetto	Cabbage palm		15		1				south
Sabal palmetto	Cabbage palm		17		1				south
Sabal palmetto	Cabbage palm		20		1				south
Sabal palmetto	Cabbage palm		18		1				south

*indicates estimated value

Semiquantitative Vegetation Survey of NW Fork Loxahatchee River

Site V-1 (river mile 10.6, surveyed 12/12/01)

Scientific Name	Common Name	Abundance Index
Acer rubrum	Red maple	3.5
Acrostichum sp.	Leather fern	3.5
Annona glabra	Pond apple	3
Aster caroliniana	Carolina aster	2.5
Baccaris sp.	Saltbush	2
Blechnum serrulatum	Swamp fern	1
Boehmeria cylindrica	False nettle	1
Carya aquatica	Water hickory	2
Crinum americanum	String lily	2.5
Ficus aurea	Golden fig	2
Fraxinus caroliniana	Pop ash	2
Hydrocotyl sp.	Water pennywort	present
Hyptis sp.		1
Ilex cassine	Dahoon	2
Ipomoea alba	Moon flower	2
Ipomoea sp.	Morning glory	1
Itea virginica	Virginia willow	3.5
Limnophila sp.		present
Ludwigia peruviana	Water primrose	1
Ludwigia repens	Creeping primrose willow	present
Lygodium microphylum	Japanese climbing fern	1
Mikania scandens	Climbing hempvine	2
Myrica cerifera	Wax myrtle	1
Nephrolepis sp.	Wild Boston fern	present
Osmunda regalis	Royal fern	1
Persea borbonia	Red bay	1.5
Phlebodium aureum	Golden polypody	present
Pleopeltis polypodioides	Resurrection fern	present
Poaceae spp.		1
Polygonum sp.	Swamp smartweed	present
Pontederia cordata	Pickerelweed	1
Quercus laurifolia	Laurel oak	2
Sabal palmetto	Cabbage palm	1.5
Salix caroliniana	Swamp willow	1
Sarcostemma clausum	White vine	2
Schinus terebinthifolius	Brazilian pepper	2
Smilax sp.	Greenbriar	1
Syzygium cumini	Java plum	3
Taxodium distichum	Baldcypress	4
Tillandsia balbisiana		present
Tillandsia fasciculata	Stiff-leafed wild pine	present
Tillandsia recurvata	Ball moss	present
Tillandsia setaceae		present
Tillandsia usneoides	Spanish moss	present
Toxicodendron radicans	Poison ivy	2
Vitits munsoniana	Wild grape	1

Semiquantitative Vegetation Survey of the NW Fork Loxahatchee River

Site 10-C (lat –80.165192015/lon 26.976525692; river mile 10.4, surveyed 11/14/00)

Scientific Name	Common Name	Abundance Index
Acer rubrum	Red maple	3.5
Acrostichum sp.	Leather fern	3.5
Annona glabra	Pond apple	3.5
Aster caroliniana	Carolina aster	3
Baccaris sp.	Saltbush	2
Bacopa monnieri	Water hyssop	present
Crinum americanum	String lily	2
Fraxinus caroliniana	Pop ash	2
Ilex cassine	Dahoon	3
Itea virginica	Virginia willow	2
Limnophila sp.		present
Ludwigia peruviana	Water primrose	2
Ludwigia repens	Creeping primrose willow	present
Lygodium microphylum	Japanese climbing fern	2.5
Mikania scandens	Climbing hempvine	2
Pandanus sp.		2
Phlebodium aureum	Golden polypody	present
Pleopeltis polypodioides	Resurrection fern	present
Polygonum sp.	Swamp smartweed	present
Quercus laurifolia	Laurel oak	2
Sabal palmetto	Cabbage palm	2
Salix caroliniana	Swamp willow	2
Sarcostemma clausum	White vine	2
Schinus terebinthifolius	Brazilian pepper	1
Syzygium cumini	Java plum	2
Taxodium distichum	Baldcypress	4
Tillandsia balbisiana		present
Tillandsia fasciculata	Stiff-leafed wild pine	present
Tillandsia recurvata	Ball moss	present
Tillandsia usneoides	Spanish moss	present
Toxicodendron radicans	Poison ivy	2

Semiquantitative Vegetation Survey of the NW Fork Loxahatchee River

Site V-3 (river mile 10.3, surveyed 12/12/01)

Scientific Name	Common Name	Abundance Index
Acer rubrum	Red maple	3
Acrostichum sp.	Leather fern	3.5
Annona glabra	Pond apple	3
Aster caroliniana	Carolina aster	3
Baccaris sp.	Saltbush	2
Blechnum serrulatum	Swamp fern	2
Carya aquatica	Water hickory	2
Crinum americanum	String lily	2
Fraxinus caroliniana	Pop ash	2
Hydrocotyl sp.	Water pennywort	present
Ilex cassine	Dahoon	3.5
Ipomoea alba	Moon flower	1
Itea virginica	Virginia willow	2.5
Ludwigia peruviana	Water primrose	2
Ludwigia repens	Creeping primrose willow	present
Lygodium microphylum	Japanese climbing fern	2
Mikania scandens	Climbing hempvine	2
Myrica cerifera	Wax myrtle	2
Osmunda regalis	Royal fern	2
Persea borbonia	Red bay	1
Phlebodium aureum	Golden polypody	present
Pleopeltis polypodioides	Resurrection fern	present
Poaceae spp.		1
Quercus laurifolia	Laurel oak	2
Rhizophora mangle	Red mangrove	1
Sabal palmetto	Cabbage palm	2.5
Salix caroliniana	Swamp willow	2
Sarcostemma clausum	White vine	2.5
Schinus terebinthifolius	Brazilian pepper	2
Smilax sp.	Greenbriar	2
Syzygium cumini	Java plum	2.5
Taxodium distichum	Baldcypress	4
Tillandsia balbisiana	Air plant	present
Tillandsia fasciculata	Stiff-leafed wild pine	present
Tillandsia recurvata	Ball moss	present
Tillandsia setaceae		present
Tillandsia usneoides	Spanish moss	present
Toxicodendron radicans	Poison ivy	2.5
Vitits munsoniana	Wild grape	1

Semiquantitative Vegetation Survey of the NW Fork Loxahatchee River

Site 10-B (lat –80.164987106/lon26.978938944; river mile 10.2, surveyed 11/14/00)

Scientific Name	Common Name	Abundance Index
Acer rubrum	Red maple	3
Acrostichum sp.	Leather fern	3
Annona glabra	Pond apple	3
Aster caroliniana	Carolina aster	2
Blechnum serrulatum	Swamp fern	2
Carya aquatica	Water hickory	2
Crinum americanum	String lily	2.5
Ficus aurea	Golden fig	1
Fraxinus caroliniana	Pop ash	2
Ilex cassine	Dahoon	2
Ipomoea alba	Moon flower	present
Itea virginica	Virginia willow	2
Limnophila sp.		present
Ludwigia peruviana	Water primrose	2
Lygodium microphylum	Japanese climbing fern	2
Mikania scandens	Climbing hempvine	2
Myrica cerifera	Wax myrtle	1
Osmunda regalis	Royal fern	2
Phlebodium aureum	Golden polypody	present
Pleopeltis polypodioides	Resurrection fern	present
Sabal palmetto	Cabbage palm	3
Salix caroliniana	Swamp willow	2
Sarcostemma clausum	White vine	3
Smilax sp.	Greenbriar	1
Syzygium cumini	Java plum	2
Taxodium distichum	Baldcypress	4
Tillandsia fasciculata	Stiff-leafed wild pine	present
Tillandsia recurvata	Ball moss	present
Tillandsia usneoides	Spanish moss	present
Toxicodendron radicans	Poison ivy	2

Semiquantitative Vegetation Survey of the NW Fork Loxahatchee River

Site 10-A (lat –80.165062424/lon 26.980186754; river mile 10.1, surveyed 11/14/00)

Scientific Name	Common Name	Abundance Index
Acer rubrum	Red maple	3
Acrostichum sp.	Leather fern	3.5
Annona glabra	Pond apple	3.5
Aster caroliniana	Carolina aster	3
Crinum americanum	String lily	2.5
Fraxinus caroliniana	Pop ash	2
Ilex cassine	Dahoon	2
Itea virginica	Virginia willow	2
Limnophila sp.		present
Ludwigia peruviana	Water primrose	2
Mikania scandens	Climbing hempvine	2
Myrica cerifera	Wax myrtle	3
Osmunda regalis	Royal fern	2.5
Phlebodium aureum	Golden polypody	present
Pleopeltis polypodioides	Resurrection fern	present
Sabal palmetto	Cabbage palm	3
Salix caroliniana	Swamp willow	3
Sarcostemma clausum	White vine	3
Taxodium distichum	Baldcypress	4
Tillandsia fasciculata	Stiff-leafed wild pine	present
Tillandsia recurvata	Ball moss	present
Tillandsia usneoides	Spanish moss	present
Toxicodendron radicans	Poison ivy	3

Semiquantitative Vegetation Survey of the NW Fork Loxahatchee River

Site V-3 (river mile 9.9, surveyed 12/12/01)

Scientific Name	Common Name	Abundance Index
Acer rubrum	Red maple	1
Acrostichum sp.	Leather fern	3.5
Annona glabra	Pond apple	3.5
Aster caroliniana	Carolina aster	2
Baccaris sp.	Saltbush	1
Blechnum serrulatum	Swamp fern	2
Crinum americanum	String lily	2
Dalbergia ecastaphyllum	Coin vine	1
Fraxinus caroliniana	Pop ash	2
Ilex cassine	Dahoon	2
Ipomoea alba	Moon flower	1
Ipomoea sp.	Morning glory	1
Ludwigia peruviana	Water primrose	2.5
Lygodium microphylum	Japanese climbing fern	2
Mikania scandens	Climbing hempvine	2
Myrica cerifera	Wax myrtle	2
Nephrolepis sp.	Wild Boston fern	present
Osmunda regalis	Royal fern	2
Phlebodium aureum	Golden polypody	present
Pleopeltis polypodioides	Resurrection fern	present
Poaceae spp.		1
Quercus laurifolia	Laurel oak	1.5
Rhabdadenia biflora	Rubber vine	2
Rhizophora mangle	Red mangrove	2
Sabal palmetto	Cabbage palm	3
Sagittaria lancifolia	Lance-leaf arrowhead	1
Salix caroliniana	Swamp willow	2
Sarcostemma clausum	White vine	2
Schinus terebinthifolius	Brazilian pepper	2
Smilax sp.	Greenbriar	2
Syzygium cumini	Java plum	1
Taxodium distichum	Baldcypress	4
Tillandsia balbisiana	Air plant	present
Tillandsia fasciculata	Stiff-leafed wild pine	present
Tillandsia recurvata	Ball moss	present
Tillandsia setaceae		present
Tillandsia usneoides	Spanish moss	present
Toxicodendron radicans	Poison ivy	2

Semiquantitative Vegetation Survey of NW Fork Loxahatchee River

Site 9-C (lat –80.163800034/lon 26.982719318; river mile 9.7, surveyed 11/14/00)

Scientific Name	Common Name	Abundance Index
Acer rubrum	Red maple	2
Acrostichum sp.	Leather fern	3
Annona glabra	Pond apple	3
Aster caroliniana	Carolina aster	3
Baccaris sp.	Saltbush	2
Crinum americanum	String lily	1
Dalbergia ecastaphyllum	Coin vine	2
Fraxinus caroliniana	Pop ash	2
Ludwigia peruviana	Water primrose	1.5
Mikania scandens	Climbing hempvine	1.5
Myrica cerifera	Wax myrtle	2
Phlebodium aureum	Golden polypody	present
Polygonum sp.	Swamp smartweed	1
Rhizophora mangle	Red mangrove	2.5
Sabal palmetto	Cabbage palm	3
Sarcostemma clausum	White vine	2
Schinus terebinthifolius	Brazilian pepper	1
Syzygium cumini	Java plum	1
Taxodium distichum	Baldcypress	4
Tillandsia fasciculata	Stiff-leafed wild pine	present
Tillandsia recurvata	Ball moss	present
Tillandsia usneoides	Spanish moss	present
Toxicodendron radicans	Poison ivy	2

Semiquantitative Vegetation Survey of the NW Fork Loxahatchee River

Site V-4 (river mile 9.3, surveyed 12/12/01)

Scientific Name	Common Name	Abundance Index
Acrostichum sp.	Leather fern	2
Annona glabra	Pond apple	1
Aster caroliniana	Carolina aster	2.5
Baccaris sp.	Saltbush	2
Blechnum serrulatum	Swamp fern	2
Carya aquatica	Water hickory	1
Dalbergia ecastaphyllum	Coin vine	2
Ilex cassine	Dahoon	1
Lygodium microphylum	Japanese climbing fern	2
Mikania scandens	Climbing hempvine	2
Myrica cerifera	Wax myrtle	2
Nephrolepis sp.	Wild Boston fern	present
Osmunda regalis	Royal fern	2
Persea borbonia	Red bay	1.5
Phlebodium aureum	Golden polypody	present
Quercus laurifolia	Laurel oak	2
Rhabdadenia biflora	Rubber vine	1
Rhizophora mangle	Red mangrove	3
Sabal palmetto	Cabbage palm	3
Sarcostemma clausum	White vine	2
Schinus terebinthifolius	Brazilian pepper	2
Smilax sp.	Greenbriar	1
Taxodium distichum	Baldcypress	2
Tillandsia balbisiana	Air plant	present
Tillandsia fasciculata	Stiff-leafed wild pine	present
Tillandsia recurvata	Ball moss	present
Tillandsia setaceae		present
Tillandsia usneoides	Spanish moss	present
Toxicodendron radicans	Poison ivy	2

Semiquantitative Vegetation Survey of NW Fork Loxahatchee River

Site 9-B (lat –80.160870447/lon 26.983861002; river mile 9.2, surveyed 11/14/00)

Scientific Name	Common Name	Abundance Index
Acer rubrum	Red maple	1
Acrostichum sp.	Leather fern	3
Annona glabra	Pond apple	3
Aster caroliniana	Carolina aster	3
Baccaris sp.	Saltbush	2
Chrysobalanus icaco	Coco plum	1
Dalbergia ecastaphyllum	Coin vine	1
Eugenia uniflora	Surinam cherry	1
Fraxinus caroliniana	Pop ash	1
Ilex cassine	Dahoon	1
Myrica cerifera	Wax myrtle	1
Phlebodium aureum	Golden polypody	present
Rhizophora mangle	Red mangrove	4
Roystonea regia	Royal palm	1
Sabal palmetto	Cabbage palm	3
Sarcostemma clausum	White vine	2
Schinus terebinthifolius	Brazilian pepper	2
Syzygium cumini	Java plum	1
Taxodium distichum	Baldcypress	3
Toxicodendron radicans	Poison ivy	1

Semiquantitative Vegetation Survey of the NW Fork Loxahatchee River

Site 9-A (lat –80.159358557/lon 26.985374195; river mile 9.1, surveyed 11/14/00)

Scientific Name	Common Name	Abundance Index
Acer rubrum	Red maple	1
Acrostichum sp.	Leather fern	3
Annona glabra	Pond apple	3
Aster caroliniana	Carolina aster	3
Baccaris sp.	Saltbush	2
Dalbergia ecastaphyllum	Coin vine	2
Ilex cassine	Dahoon	1
Phlebodium aureum	Golden polypody	present
Rhabdadenia biflora	Rubber vine	2
Rhizophora mangle	Red mangrove	4
Sabal palmetto	Cabbage palm	4
Salix caroliniana	Swamp willow	2
Sarcostemma clausum	White vine	2.5
Schinus terebinthifolius	Brazilian pepper	2
Taxodium distichum	Baldcypress	3
Toxicodendron radicans	Poison ivy	1.5
Typha domingensis	Cattail	2
Tillandsia fasciculata	Stiff-leafed wild pine	present
Tillandsia recurvata	Ball moss	present
Tillandsia usneoides	Spanish moss	present

Semiquantitative Vegetation Survey of the NW Fork Loxahatchee River

Site 8-D (river mile 8.9, surveyed 11/14/00)

Scientific Name	Common Name	Abundance Index
Acer rubrum	Red maple	1
Acrostichum sp.	Leather fern	3
Annona glabra	Pond apple	3
Aster caroliniana	Carolina aster	3
Baccaris sp.	Saltbush	1.5
Dalbergia ecastaphyllum	Coin vine	1
Ilex cassine	Dahoon	1
Rhabdadenia biflora	Rubber vine	2
Rhizophora mangle	Red mangrove	4
Roystonea regia	Royal palm	1
Sabal palmetto	Cabbage palm	3.5
Sarcostemma clausum	White vine	1
Schinus terebinthifolius	Brazilian pepper	1.5
Taxodium distichum	Baldcypress	3.5
Tillandsia fasciculata	Stiff-leafed wild pine	present
Tillandsia recurvata	Ball moss	present
Tillandsia usneoides	Spanish moss	present

Semiquantitative Vegetation Survey of the NW Fork Loxahatchee River

Site V-5 (river mile 8.8, surveyed 12/12/01)

Scientific Name	Common Name	Abundance Index
Acrostichum sp.	Leather fern	1.5
Annona glabra	Pond apple	2
Aster caroliniana	Carolina aster	2.5
Bacopa monnieri	Water hyssop	1
Crinum americanum	String lily	1
Dalbergia ecastaphyllum	Coin vine	2.5
Laguncularia racemosa	White mangrove	1.5
Ludwigia peruviana	Water primrose	1
Mikania scandens	Climbing hempvine	1
Myrica cerifera	Wax myrtle	2
Osmunda regalis	Royal fern	2
Poaceae spp.		1
Rhabdadenia biflora	Rubber vine	2
Rhizophora mangle	Red mangrove	4
Roystonea regia	Royal palm	1
Sabal palmetto	Cabbage palm	3.5
Salix caroliniana	Swamp willow	1
Sarcostemma clausum	White vine	2
Schinus terebinthifolius	Brazilian pepper	2
Syzygium cumini	Java plum	1
Taxodium distichum	Baldcypress	2
Tillandsia usneoides	Spanish moss	present
Toxicodendron radicans	Poison ivy	2

Semiquantitative Vegetation Survey of the NW Fork Loxahatchee River

Site 8-C (lat –80.157838347/lon 26.989749400; river mile 8.7, surveyed 11/14/00)

Scientific Name	Common Name	Abundance Index
Acrostichum sp.	Leather fern	3
Annona glabra	Pond apple	3
Aster caroliniana	Carolina aster	2
Baccaris sp.	Saltbush	1
Laguncularia racemosa	White mangrove	1
Rhizophora mangle	Red mangrove	4
Sabal palmetto	Cabbage palm	3.5
Schinus terebinthifolius	Brazilian pepper	1
Taxodium distichum	Baldcypress	2
Tillandsia fasciculata	Stiff-leafed wild pine	present
Tillandsia recurvata	Ball moss	present
Tillandsia usneoides	Spanish moss	present

Semiquantitative Vegetation Survey of the NW Fork Loxahatchee River

Site V-6 (river mile 8.55, surveyed 12/12/01)

Scientific Name	Common Name	Abundance Index
Acrostichum sp.	Leather fern	2
Aster caroliniana	Carolina aster	2.5
Baccaris sp.	Saltbush	1
Dalbergia ecastaphyllum	Coin vine	2.5
Mikania scandens	Climbing hempvine	2
Phlebodium aureum	Golden polypody	present
Rhabdadenia biflora	Rubber vine	2.5
Rhizophora mangle	Red mangrove	4
Sabal palmetto	Cabbage palm	3
Schinus terebinthifolius	Brazilian pepper	2
Taxodium distichum	Baldcypress	1
Tillandsia balbisiana		present
Tillandsia fasciculata	Stiff-leafed wild pine	present
Tillandsia recurvata	Ball moss	present
Tillandsia setaceae		present
Tillandsia usneoides	Spanish moss	present

Semiquantitative Vegetation Survey of the NW Fork Loxahatchee River

Site 8-B (lat –80.155118577/lon 26.989388511; river mile 8.4, surveyed 11/14/00)

Scientific Name	Common Name	Abundance Index
Acrostichum sp.	Leather fern	3
Aster caroliniana	Carolina aster	3
Laguncularia racemosa	White mangrove	1
Rhabdadenia biflora	Rubber vine	3
Rhizophora mangle	Red mangrove	4
Sabal palmetto	Cabbage palm	3
Sarcostemma clausum	White vine	1
Schinus terebinthifolius	Brazilian pepper	1
Taxodium distichum	Baldcypress	2
Tillandsia fasciculata	Stiff-leafed wild pine	present
Tillandsia recurvata	Ball moss	present
Tillandsia usneoides	Spanish moss	present

Semiquantitative Vegetation Survey of the NW Fork Loxahatchee River

Site 8-A (lat –80.153982377/lon 26.990833609; river mile 8.1, surveyed 11/14/00)

Scientific Name	Common Name	Abundance Index
Aster caroliniana	Carolina aster	1
Baccaris sp.	Saltbush	1
Phragmites australis	Giant reed	1.5
Rhabdadenia biflora	Rubber vine	2
Rhizophora mangle	Red mangrove	4
Sabal palmetto	Cabbage palm	4
Taxodium distichum	Baldcypress	1

Semiquantitative Vegetation Survey of NW Fork Loxahatchee River

Site V-7 (river mile 7.95, surveyed 12/12/01)

Scientific Name	Common Name	Abundance Index
Acrostichum sp.	Leather fern	1
Annona glabra	Pond apple	1
Aster caroliniana	Carolina aster	1
Crinum americanum	String lily	1
Dalbergia ecastaphyllum	Coin vine	1
Laguncularia racemosa	White mangrove	2
Rhabdadenia biflora	Rubber vine	3
Rhizophora mangle	Red mangrove	4
Sabal palmetto	Cabbage palm	3
Schinus terebinthifolius	Brazilian pepper	2
Taxodium distichum	Baldcypress	1
Tillandsia recurvata	Ball moss	present
Tillandsia usneoides	Spanish moss	present

Semiquantitative Vegetation Survey of the NW Fork Loxahatchee River

Site 7-C (lat –80.150862762/lon 26.988849080; river mile 7.8, surveyed 11/14/00)

Scientific Name	Common Name	Abundance Index
Acrostichum sp.	Leather fern	2
Aster caroliniana	Carolina aster	2
Baccaris sp.	Saltbush	2
Blechnum serrulatum	Swamp fern	1
Chrysobalanus icaco	Coco plum	1
Crinum americanum	String lily	1
Dalbergia ecastaphyllum	Coin vine	3
Lygodium microphylum	Japanese climbing fern	2
Myrica cerifera	Wax myrtle	2
Rhabdadenia biflora	Rubber vine	3
Rhizophora mangle	Red mangrove	4
Sabal palmetto	Cabbage palm	3.5
Schinus terebinthifolius	Brazilian pepper	2
Taxodium distichum	Baldcypress	1
Toxicodendron radicans	Poison ivy	1

Semiquantitative Vegetation Survey of the NW Fork Loxahatchee River

Site 7-B (-80.149975096/lon 26.99106662; river mile 7.5, surveyed 11/14/00)

Scientific Name	Common Name	Abundance Index
Acrostichum sp.	Leather fern	3
Rhizophora mangle	Red mangrove	4
Sabal palmetto	Cabbage palm	3

Semiquantitative Vegetation Survey of the NW Fork Loxahatchee River

Site 6-B (lat –80.147410631/lon 26.988542914; river mile 6.8, surveyed 11/14/00)

Scientific Name	Common Name	Abundance Index
Acrostichum sp.	Leather fern	1
Dalbergia ecastaphyllum	Coin vine	1
Juncus roemerianus	Black needlerush	2
Laguncularia racemosa	White mangrove	3
Myrica cerifera	Wax myrtle	1
Phragmites australis	Giant reed	1
Rhizophora mangle	Red mangrove	4
Sabal palmetto	Cabbage palm	2.5
Schinus terebinthifolius	Brazilian pepper	2

Semiquantitative Vegetation Survey of the NW Fork Loxahatchee River

Site 6-A (lat –80.143669519/lon 26.984342169; river mile 6.2, surveyed 11/14/00)

Scientific Name	Common Name	Abundance Index
Casuarina sp.	Australian pine	1
Dalbergia ecastaphyllum	Coin vine	1
Rhabdadenia biflora	Rubber vine	3
Rhizophora mangle	Red mangrove	4
Sabal palmetto	Cabbage palm	1.5
Schinus terebinthifolius	Brazilian pepper	1

Semiquantitative Vegetation Survey of the NW Fork Loxahatchee River

Site 5-B (lat –80.139039353/lon 26.982712901; river mile 5.6, surveyed 11/14/00)

Scientific Name	Common Name	Abundance Index
Dalbergia ecastaphyllum	Coin vine	3
Rhizophora mangle	Red mangrove	4
Schinus terebinthifolius	Brazilian pepper	2

Semiquantitative Vegetative Survey of Kitching Creek

Site A (lat -80.154898869/lon 26.991771447; surveyed 11/14/00)

Scientific Name	Common Name	Abundance Index
Acrostichum sp.	Leather fern	2
Annona glabra	Pond apple	2
Baccaris sp.	Saltbush	2
Dalbergia ecastaphyllum	Coin vine	2
Rhizophora mangle	Red mangrove	4
Sabal palmetto	Cabbage palm	4
Taxodium distichum	Baldcypress	2
Tillandsia fasciculata	Stiff-leafed wild pine	present
Tillandsia recurvata	Ball moss	present
Tillandsia usneoides	Spanish moss	present

Semiquantitative Vegetative Survey of Kitching Creek

Site B (lat -80.155330876/lon 26.992670262; surveyed 11/14/00)

Scientific Name	Common Name	Abundance Index
Annona glabra	Pond apple	2
Aster caroliniana	Carolina aster	2
Baccaris sp.	Saltbush	1
Bacopa monnieri	Water hyssop	present
Laguncularia racemosa	White mangrove	1
Rhabdadenia biflora	Rubber vine	2
Rhizophora mangle	Red mangrove	4
Sabal palmetto	Cabbage palm	4
Schinus terebinthifolius	Brazilian pepper	1
Taxodium distichum	Baldcypress	2
Tillandsia fasciculata	Stiff-leafed wild pine	present
Tillandsia recurvata	Ball moss	present
Tillandsia usneoides	Spanish moss	present

Semiquantitative Vegetative Survey of Kitching Creek

Site C (lat -80.156664449/lon 26.992851025; surveyed 11/14/00)

Scientific Name	Common Name	Abundance Index
Acrostichum sp.	Leather fern	3
Annona glabra	Pond apple	3
Aster caroliniana	Carolina aster	2
Bacopa monnieri	Water hyssop	present
Blechnum serrulatum	Swamp fern	2.5
Dalbergia ecastaphyllum	Coin vine	2
Laguncularia racemosa	White mangrove	2
Mikania scandens	Climbing hempvine	2
Quercus laurifolia	Laurel oak	2
Rhabdadenia biflora	Rubber vine	1.5
Rhizophora mangle	Red mangrove	3
Sabal palmetto	Cabbage palm	3
Sarcostemma clausum	White vine	1
Taxodium distichum	Baldcypress	2.5
Tillandsia fasciculata	Stiff-leafed wild pine	present
Tillandsia recurvata	Ball moss	present
Tillandsia usneoides	Spanish moss	present
Vitits munsoniana	Wild grape	1

Semiquantitative Vegetative Survey of Kitching Creek

Site D (lat -80.156095466/lon 26.993647772; surveyed 11/14/00)

Scientific Name	Common Name	Abundance Index
Acrostichum sp.	Leather fern	3
Annona glabra	Pond apple	2.5
Aster caroliniana	Carolina aster	1
Baccaris sp.	Saltbush	1
Bacopa monnieri	Water hyssop	present
Rhizophora mangle	Red mangrove	3
Sabal palmetto	Cabbage palm	3
Schinus terebinthifolius	Brazilian pepper	2
Taxodium distichum	Baldcypress	3
Tillandsia fasciculata	Stiff-leafed wild pine	present
Tillandsia recurvata	Ball moss	present
Tillandsia usneoides	Spanish moss	present
Typha domingensis	Cattail	3

Semiquantitative Vegetative Survey of Kitching Creek

Site E (lat -80.155459331/lon 26.994103015; surveyed 11/14/00)

Scientific Name	**Common Name**	**Abundance Index**
Acrostichum sp.	Leather fern	3
Andropogon sp.	Broomsedge	2.5
Annona glabra	Pond apple	3
Aster caroliniana	Carolina aster	2
Baccaris sp.	Saltbush	2
Bacopa monnieri	Water hyssop	present
Blechnum serrulatum	Swamp fern	2.5
Crinum americanum	String lily	2
Eupatorium sp.	Dog fennel	2
Laguncularia racemosa	White mangrove	2
Myrica cerifera	Wax myrtle	2
Nephrolepis sp.	Wild Boston fern	2
Phlebodium aureum	Golden polypody	1
Poaceae spp.		1.5
Rhizophora mangle	Red mangrove	2
Sabal palmetto	Cabbage palm	3.5
Schinus terebinthifolius	Brazilian pepper	2.5
Smilax sp.	Greenbriar	2
Taxodium distichum	Baldcypress	3
Tillandsia fasciculata	Stiff-leafed wild pine	present
Tillandsia recurvata	Ball moss	present
Tillandsia usneoides	Spanish moss	present

Semiquantitative Vegetative Survey of Kitching Creek

Site F (lat-80.156193578/lon 26.995723248; surveyed 11/14/00)

Scientific Name	Common Name	Abundance Index
Acer rubrum	Red maple	2
Acrostichum sp.	Leather fern	3
Annona glabra	Pond apple	3
Aster caroliniana	Carolina aster	3
Bacopa monnieri	Water hyssop	present
Blechnum serrulatum	Swamp fern	2
Crinum americanum	String lily	3
Ipomoea sp.	Morning glory	3
Lygodium microphylum	Japanese climbing fern	2
Mikania scandens	Climbing hempvine	2
Myrica cerifera	Wax myrtle	2
Pontederia cordata	Pickerelweed	2
Quercus laurifolia	Laurel oak	2
Rhabdadenia biflora	Rubber vine	1.5
Rhizophora mangle	Red mangrove	3
Rhynchospora sp.	Beakrush	2
Sabal palmetto	Cabbage palm	3
Taxodium distichum	Baldcypress	4
Tillandsia fasciculata	Stiff-leafed wild pine	present
Tillandsia recurvata	Ball moss	present
Tillandsia usneoides	Spanish moss	present

Semiquantitative Vegetative Survey of Kitching Creek

Site G (surveyed 11/28/00)

Scientific Name	Common Name	Abundance Index
Acer rubrum	Red maple	2
Acrostichum sp.	Leather fern	3
Annona glabra	Pond apple	4
Aster caroliniana	Carolina aster	3
Baccaris sp.	Saltbush	1
Bacopa monnieri	Water hyssop	3
Cephalanthus occidentalis	Buttonbush	1
Crinum americanum	String lily	3
Fraxinus caroliniana	Pop ash	3
Laguncularia racemosa	White mangrove	2
Mikania scandens	Climbing hempvine	3
Myrica cerifera	Wax myrtle	2
Nephrolepis sp.	Wild Boston fern	2
Osmunda regalis	Royal fern	1
Phlebodium aureum	Golden polypody	2
Pontederia cordata	Pickerelweed	2
Rhizophora mangle	Red mangrove	2.5
Rhynchospora sp.	Beakrush	1
Sabal palmetto	Cabbage palm	3
Sarcostemma clausum	White vine	3
Schinus terebinthifolius	Brazilian pepper	3
Taxodium distichum	Baldcypress	3.5
Tillandsia balbisiana	Air plant	present
Tillandsia fasciculata	Stiff-leafed wild pine	present
Tillandsia recurvata	Ball moss	present
Tillandsia usneoides	Spanish moss	present
Typha domingensis	Cattail	3

Semiquantitative Vegetative Survey of Kitching Creek

Site H (surveyed 11/28/00)

Scientific Name	Common Name	Abundance Index
Acer rubrum	Red maple	3
Acrostichum sp.	Leather fern	4
Annona glabra	Pond apple	4
Aster caroliniana	Carolina aster	3
Baccaris sp.	Saltbush	2.5
Cephalanthus occidentalis	Buttonbush	2
Crinum americanum	String lily	3
Fraxinus caroliniana	Pop ash	2
Laguncularia racemosa	White mangrove	2
Ludwigia peruviana	Water primrose	2
Ludwigia repens	Creeping primrose willow	2
Mikania scandens	Climbing hempvine	3
Polygonum sp.	Swamp smartweed	2.5
Pontederia cordata	Pickerelweed	2
Rhizophora mangle	Red mangrove	1
Sabal palmetto	Cabbage palm	1
Sarcostemma clausum	White vine	2
Saururus cernuus	Lizard's tail	3
Schinus terebinthifolius	Brazilian pepper	2
Taxodium distichum	Baldcypress	3
Tillandsia balbisiana	Air plant	present
Tillandsia fasciculata	Stiff-leafed wild pine	present
Tillandsia recurvata	Ball moss	present
Tillandsia usneoides	Spanish moss	present
Typha domingensis	Cattail	2

Semiquantitative Vegetative Survey of Kitching Creek

Site I (surveyed 11/28/00)

Scientific Name	Common Name	Abundance Index
Acer rubrum	Red maple	2
Acrostichum sp.	Leather fern	3
Annona glabra	Pond apple	4
Aster caroliniana	Carolina aster	2
Baccaris sp.	Saltbush	2
Bacopa monnieri	Water hyssop	2
Blechnum serrulatum	Swamp fern	3
Boehmeria cylindrica	False nettle	1
Crinum americanum	String lily	3.5
Fraxinus caroliniana	Pop ash	2
Hypericum sp.		1.5
Hyptis sp.		2
Ilex cassine	Dahoon	1
Laguncularia racemosa	White mangrove	1
Ludwigia repens	Creeping primrose willow	present
Mikania scandens	Climbing hempvine	3
Osmunda regalis	Royal fern	3
Phlebodium aureum	Golden polypody	present
Poaceae sp.		1
Polygonum sp.	Swamp smartweed	present
Pontederia cordata	Pickerelweed	2
Rapanea punctata	Myrsine	1
Rhizophora mangle	Red mangrove	1
Rhynchospora sp.	Beakrush	2
Sabal palmetto	Cabbage palm	2
Sarcostemma clausum	White vine	2
Saururus cernuus	Lizard's tail	2.5
Schinus terebinthifolius	Brazilian pepper	2
Taxodium distichum	Baldcypress	3
Tillandsia balbisiana	Air plant	present
Tillandsia fasciculata	Stiff-leafed wild pine	present
Tillandsia recurvata	Ball moss	present
Tillandsia setaceae	Air plant	present
Tillandsia usneoides	Spanish moss	present
Vitits munsoniana	Wild grape	1

Semiquantitative Vegetative Survey of Kitching Creek

Site J (surveyed 11/28/00)

Scientific Name	Common Name	Abundance Index
Acer rubrum	Red maple	3
Acrostichum sp.	Leather fern	3
Annona glabra	Pond apple	3
Apios americana	American groundnut	1
Ardisia escallonioides	Marl berry	2
Baccaris sp.	Saltbush	2
Blechnum serrulatum	Swamp fern	3.5
Boehmeria cylindrica	False nettle	2
Crinum americanum	String lily	1
Fraxinus caroliniana	Pop ash	3
Hydrocotyl sp.	Water pennywort	1.5
Hyptis sp.		2
Itea virginica	Virginia willow	3
Ludwigia repens	Creeping primrose willow	present
Lygodium microphylum	Japanese climbing fern	3
Mikania scandens	Climbing hempvine	2.5
Osmunda regalis	Royal fern	3
Panicum spp.		2.5
Pleopeltis polypodioides	Resurrection fern	present
Polygonum sp.	Swamp smartweed	present
Rhabdadenia biflora	Rubber vine	1
Sabal palmetto	Cabbage palm	3
Saururus cernuus	Lizard's tail	2
Schinus terebinthifolius	Brazilian pepper	2
Taxodium distichum	Baldcypress	3.5
Tillandsia balbisiana	Air plant	present
Tillandsia fasciculata	Stiff-leafed wild pine	present
Tillandsia recurvata	Ball moss	present
Tillandsia setaceae	Air plant	present
Tillandsia usneoides	Spanish moss	present
Toxicodendron radicans	Poison ivy	2
Vigna luteola	Cow pea	2
Vitits munsoniana	Wild grape	2
Woodwardia sp.	Chain fern	2

APPENDIX D

SAVELOX MODEL VERIFICATION;

MEASURED AND PREDICTED VALUES

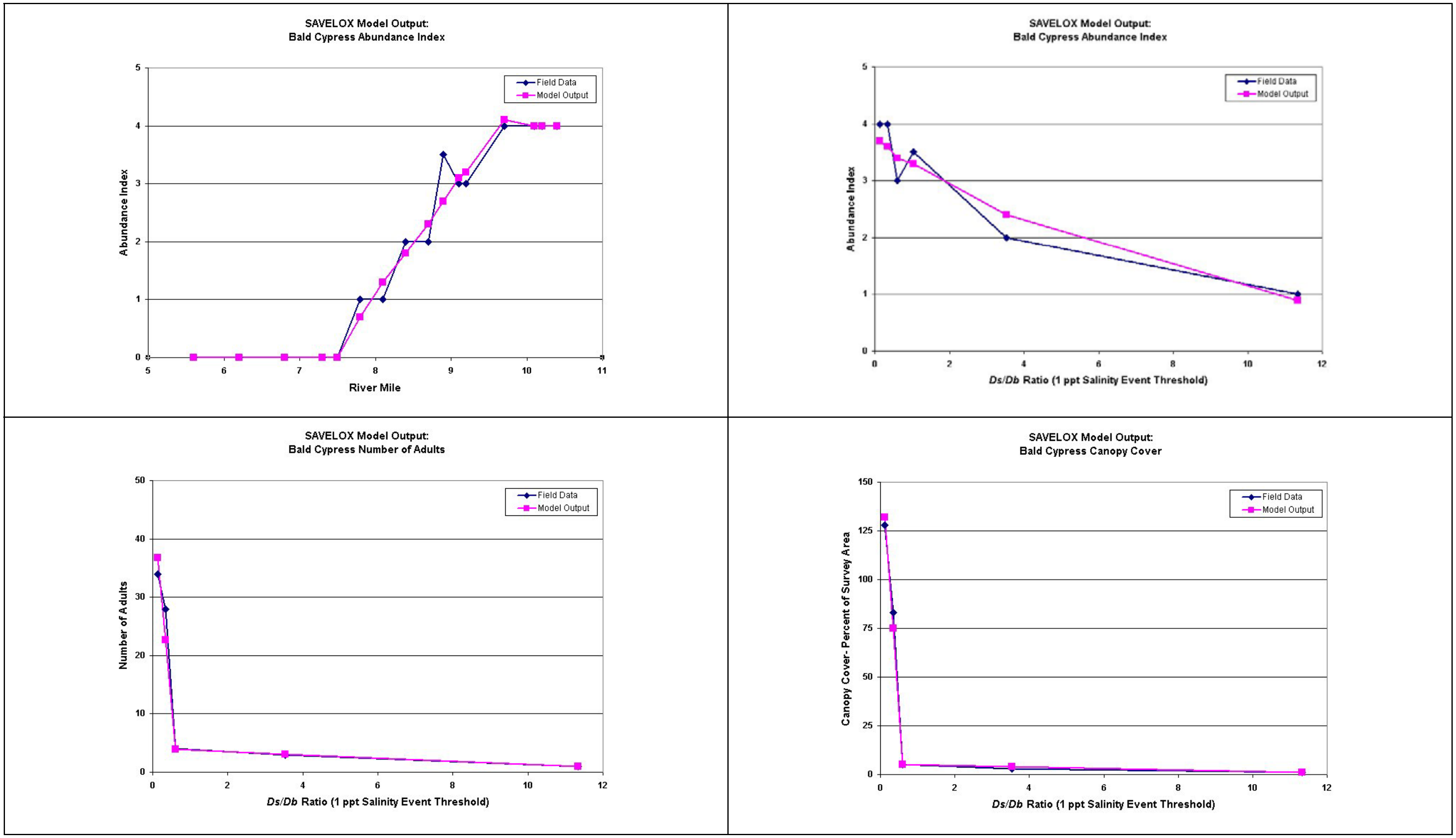


Figure D-1. Comparison of Field Data with Model Output for Bald Cypress.

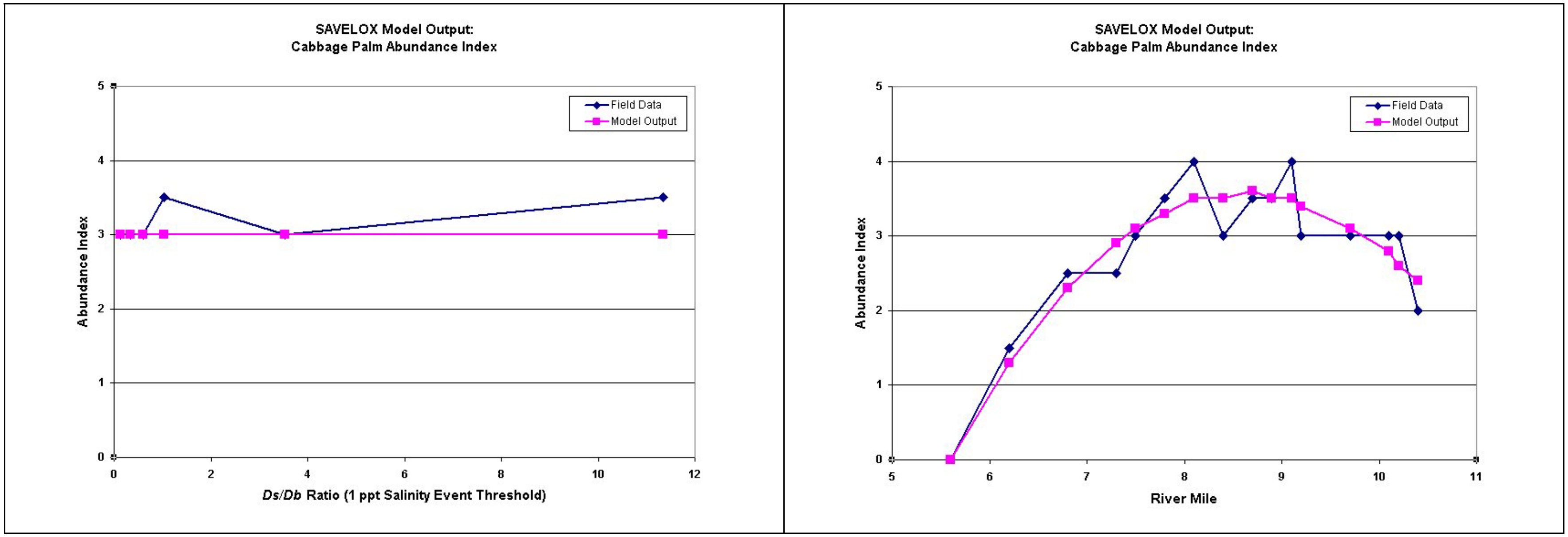


Figure D-2. Comparison of Field Data with Model Output for Cabbage Palm.

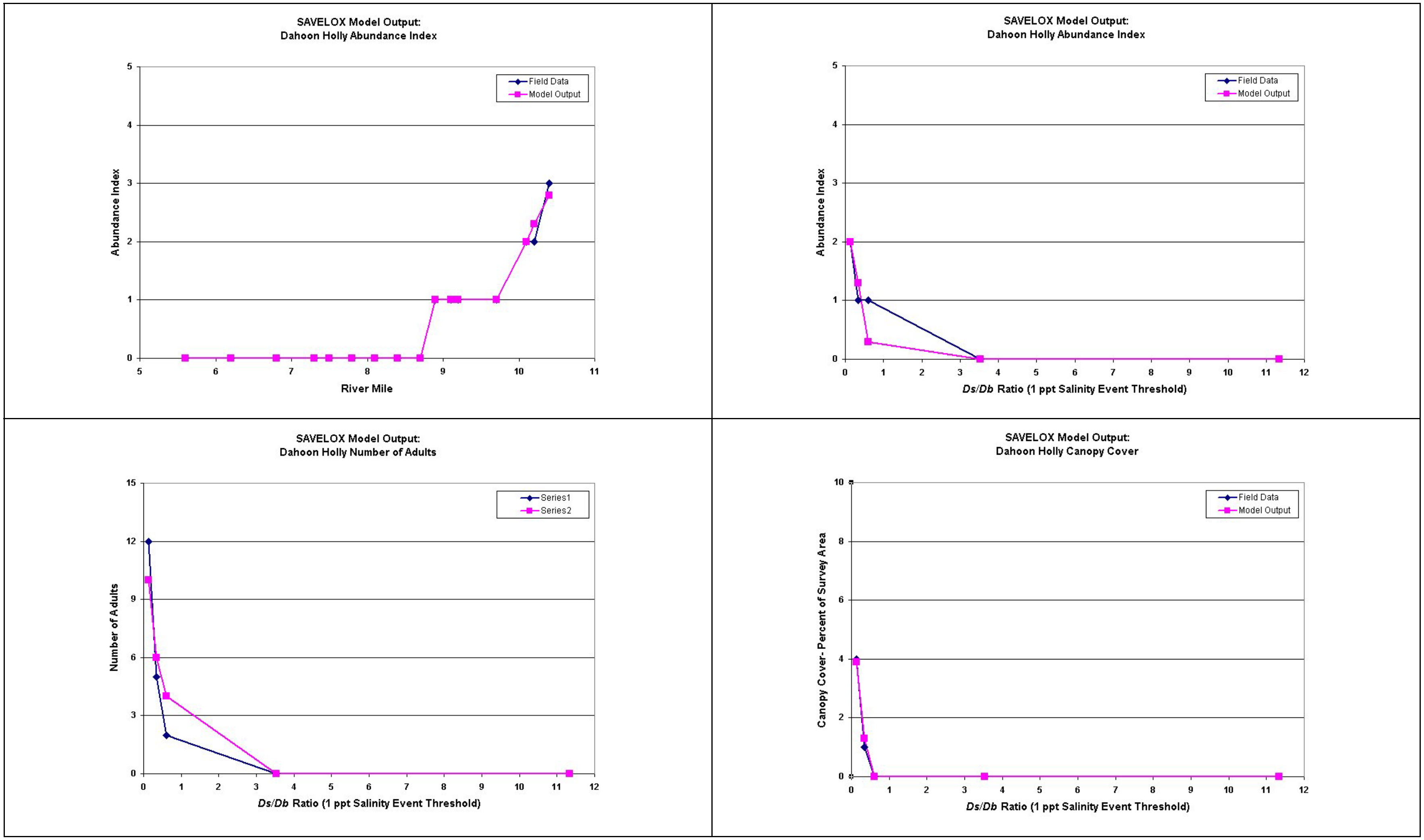


Figure D-3. Comparison of Field Data with Model Output for Dahoon Holly.

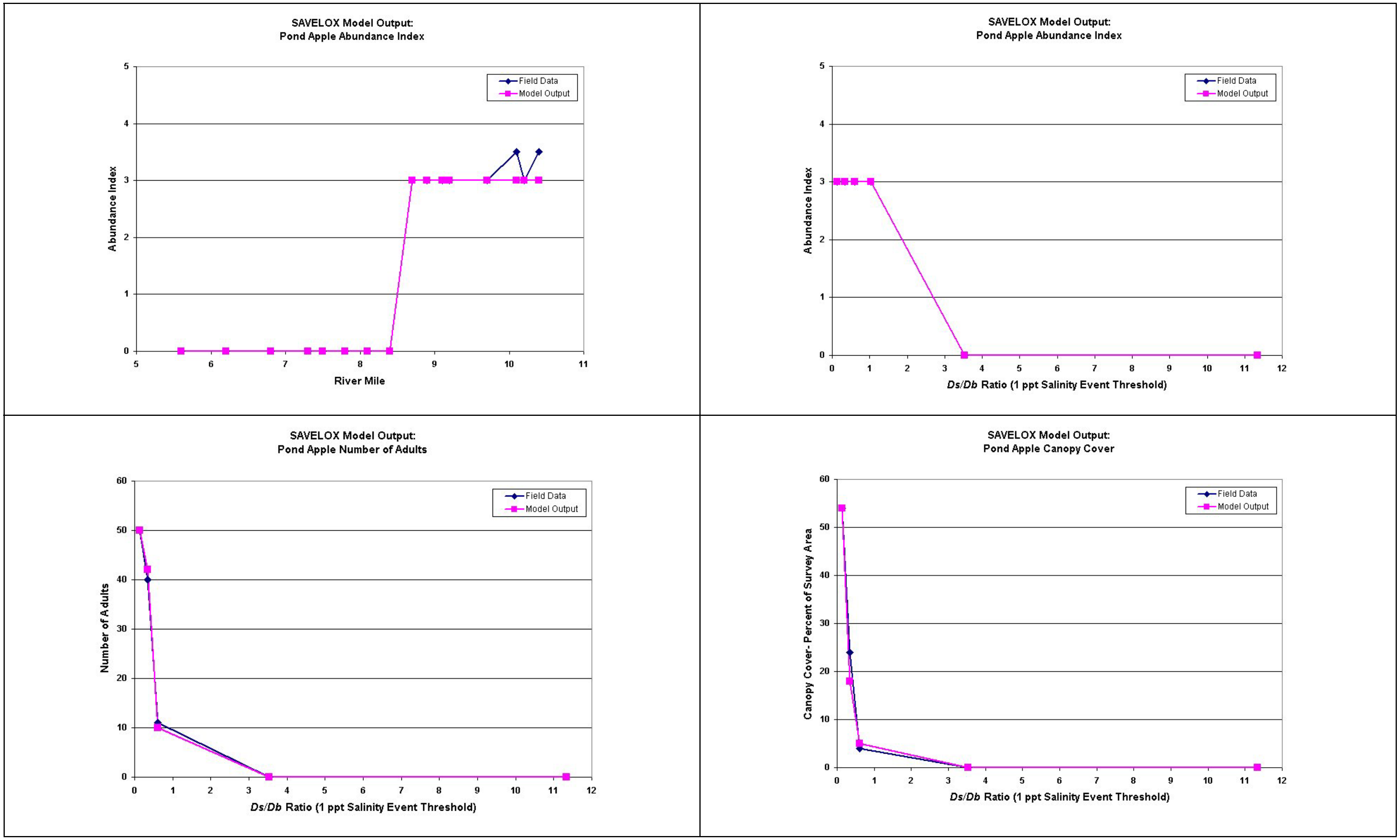


Figure D-4. Comparison of Field Data with Model Output for Pond Apple.

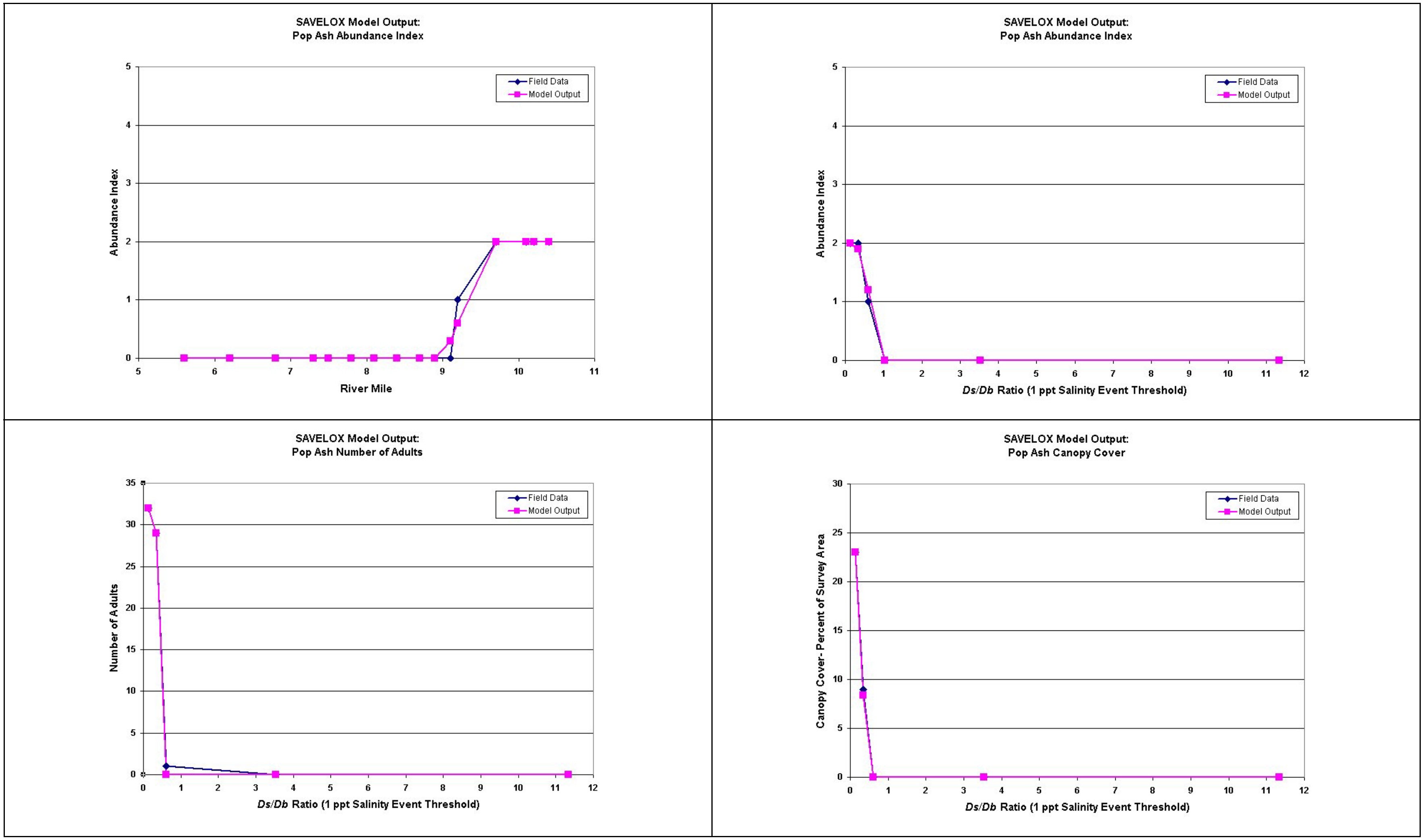


Figure D-5. Comparison of Field Data with Model Output for Pop Ash.

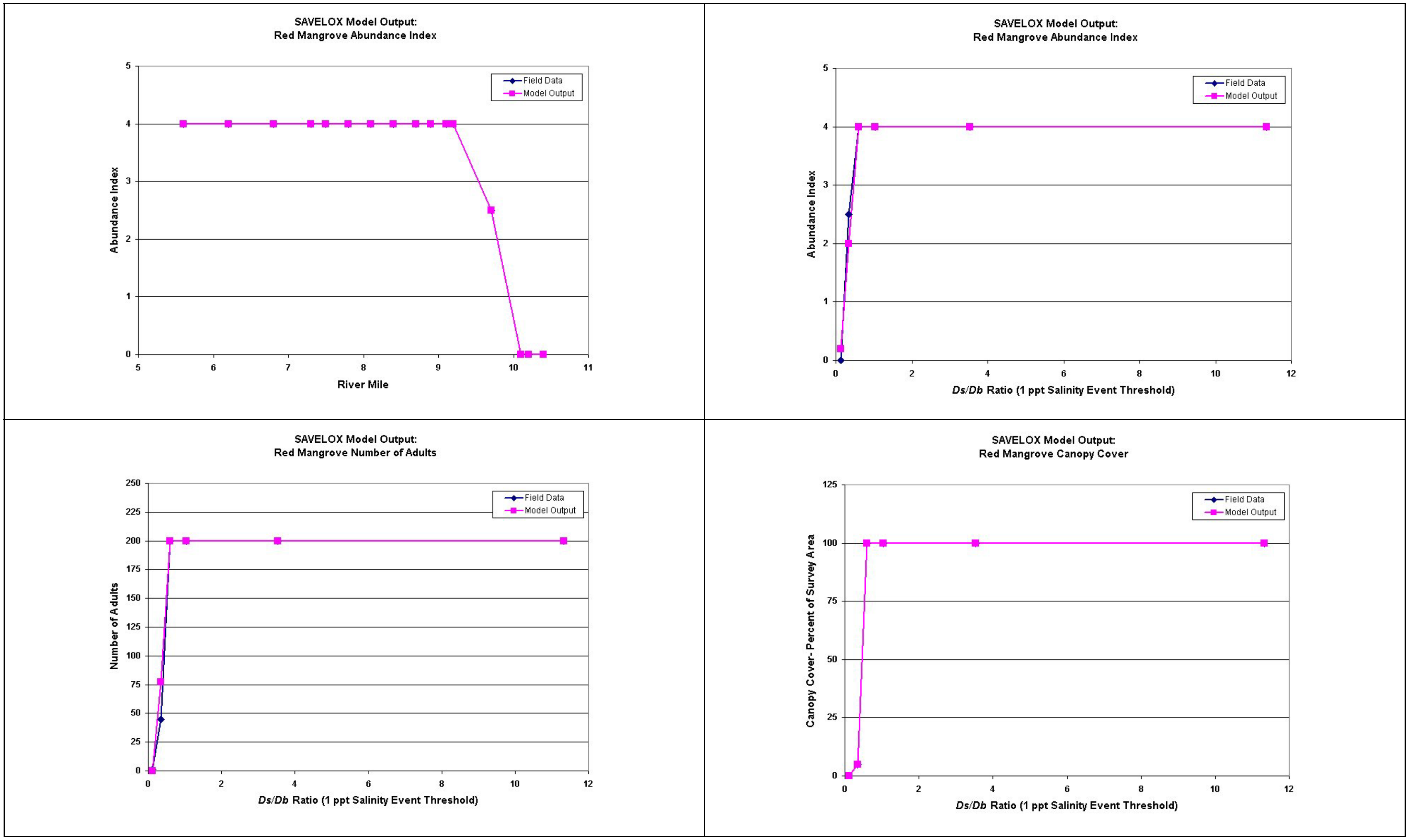


Figure D-6. Comparison of Field Data with Model Output for Red Mangrove.

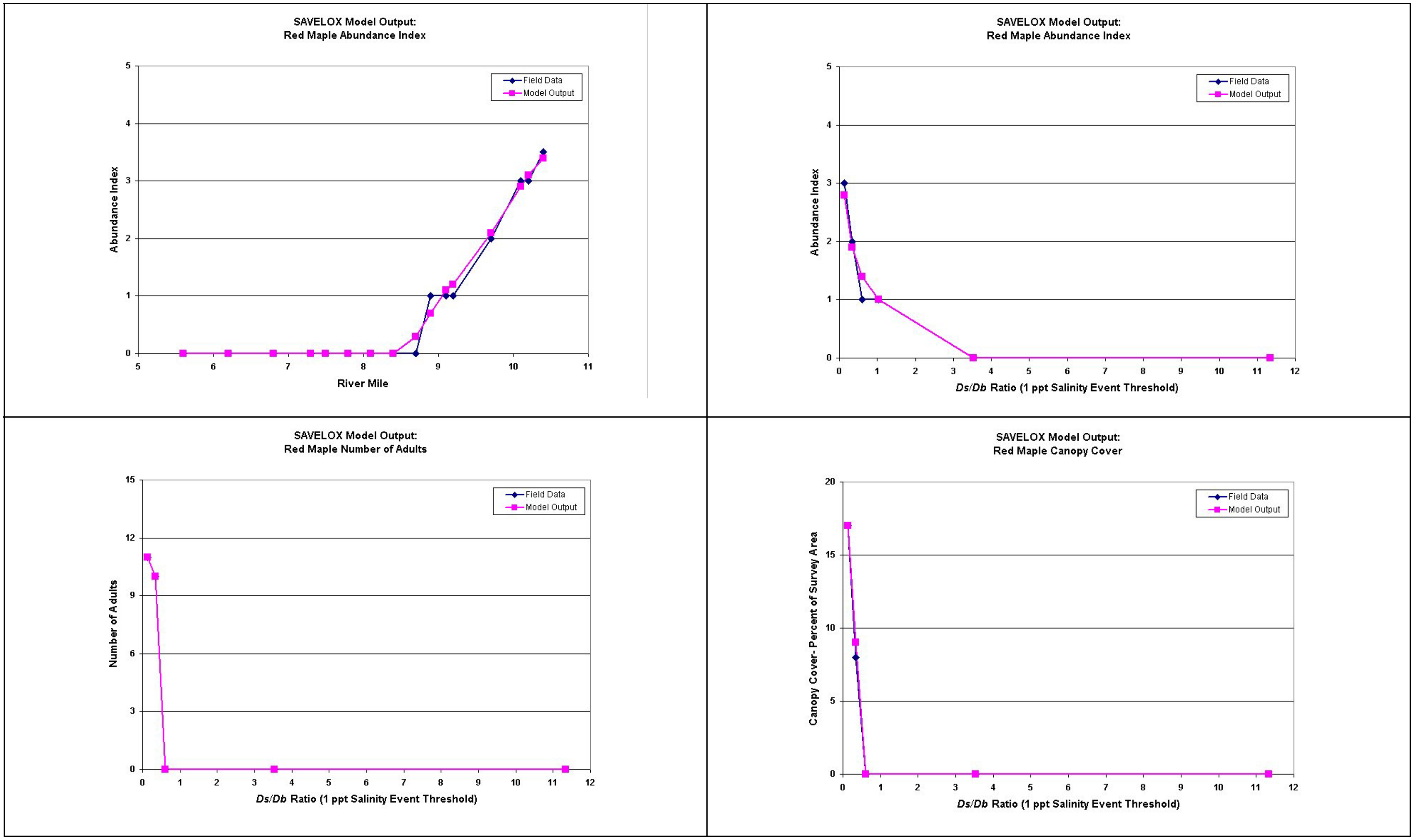


Figure D-7. Comparison of Field Data with Model Output for Red Maple.

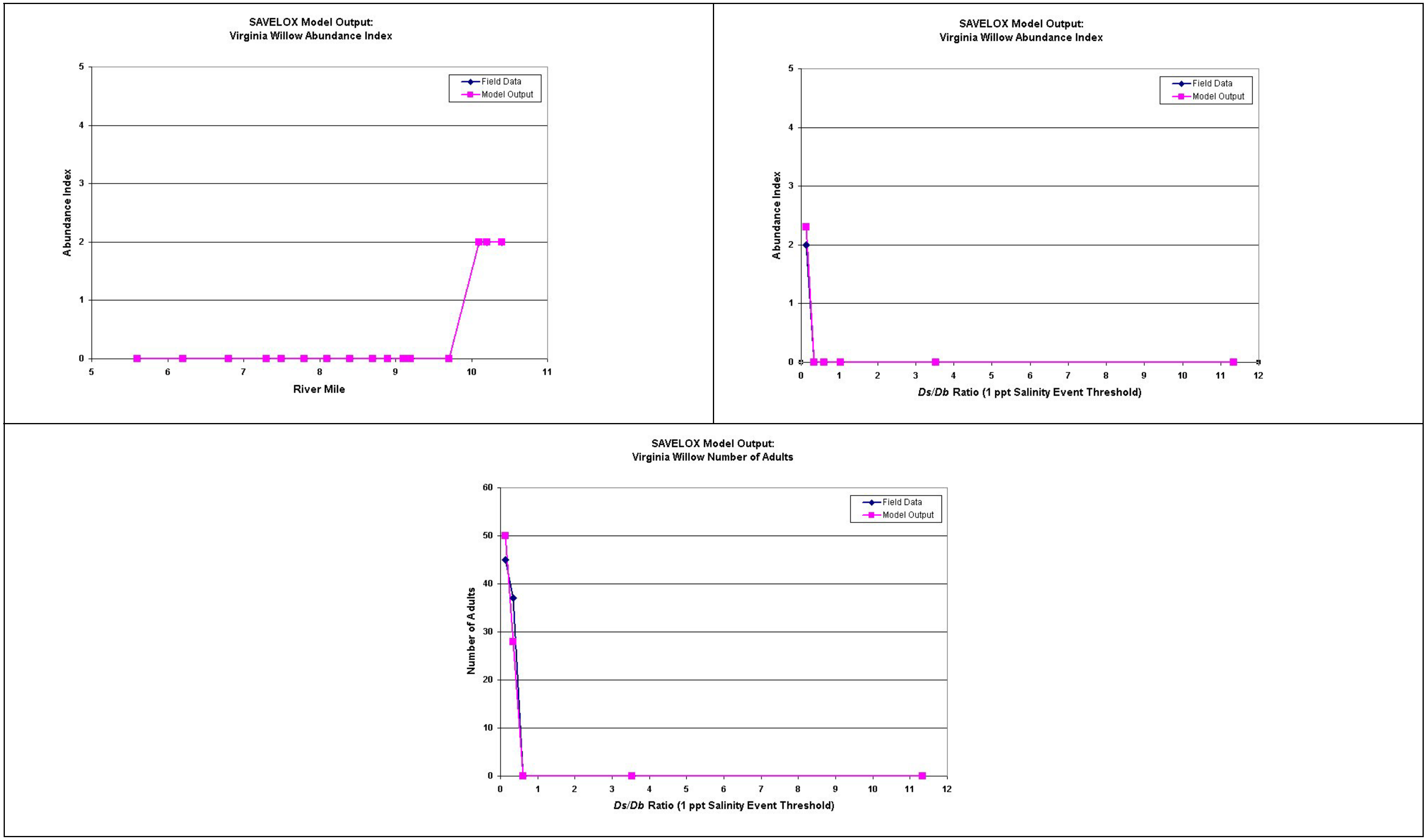


Figure D-8. Comparison of Field Data with Model Output for Virginia Willow.

Table D-1. Formulas used in the SAVELOX Model to Predict "Current" (2002) Abundance Index Values at a Specified River Mile; "y" is the Predicted Value, "x" is the Input Value for River Mile.

Species	**General Model Formula**
Bald Cypress	$y = 1.7857x - 13.19$, WHERE $\{y_{min} = 0, y_{max} = 4\}$
Cabbage Palm	IF ($x < 6.2$ THEN $y = 0$) OR IF ($x > 10.4$ THEN $y = 2$) OR IF ($x \geq 6.2$ AND $x \leq 10.4$ THEN $y = -0.3762x^2 + 6.4929x - 24.45$)
Dahoon Holly	$y = 2.6923x - 25.192$, WHERE $\{y_{min} = 0, y_{max} = 3\}$
Pond Apple	IF $x \geq 8.6$ THEN $y = 3$ OR IF $x < 8.6$ THEN $y = 0$
Pop Ash	$y = 2.9032x - 26.097$, WHERE $\{y_{min} = 0, y_{max} = 2\}$
Red Mangrove	$y = -3.6111x^2 + 65.25x - 290.66$, WHERE $\{y_{min} = 0, y_{max} = 4\}$
Red Maple	$y = 1.8115x - 15.422$, WHERE $\{y_{min} = 0, y_{max} = 3.5\}$
Virginia Willow	$y = 5x - 48.5$, WHERE $\{y_{min} = 0, y_{max} = 2\}$

Table D-2. Formulas used in the SAVELOX Model to Predict (Long-Term) Abundance Index Values for a Specified Freshwater-Salinity Regime (expressed as Ds/Db ratio for a Salinity Event Threshold Value); "y" is the Predicted Value, "z" is the Input Value *Ds/Db*.

Species	**General Model Formula Threshold of $\geq$1 ppt**	**General Model Formula Threshold of $\geq$2 ppt**	**General Model Formula Threshold of $\geq$3 ppt**
Bald Cypress	$y = 3.7081(2.71828^{-0.1206z})$	$y = 3.8113*(2.71828^{-0.3699z})$	$y = 3.9408*(2.71828^{-0.714z})$
Cabbage Palm	IF $z \leq 11$ THEN $y = 3$ OR IF $z > 11$ THEN $y = 0$	IF $z \leq 3.76$ THEN $y = 3$ OR IF $z > 3.76$ THEN $y = 0$	IF $z \leq 1.95$ THEN $y = 3$ OR IF $z > 1.95$ THEN $y = 0$
Dahoon Holly	$y = 7.458(2.71828^{-5.1065z})$, WHERE $\{y_{min} = 0, y_{max} = 3\}$	$y = 8.9733(2.71828^{-14.291z})$, WHERE $\{y_{min} = 0, y_{max} = 3\}$	$y = 5.6543(2.71828^{-20.74z})$, WHERE $\{y_{min} = 0, y_{max} = 3\}$
Pond Apple	$y = -1.2055z + 4.2479$, WHERE $\{y_{min} = 0, y_{max} = 3\}$	$y = -4.119z + 5.172$, WHERE $\{y_{min} = 0, y_{max} = 3\}$	$y = -6.0519z + 5.1289$, WHERE $\{y_{min} = 0, y_{max} = 3\}$
Pop Ash	$y = -2.8386z + 2.8757$, WHERE $\{y_{min} = 0, y_{max} = 2\}$	$y = -4.9716z + 2.563$, WHERE $\{y_{min} = 0, y_{max} = 2\}$	$y = -6.6845z + 2.283$, WHERE $\{y_{min} = 0, y_{max} = 2\}$
Red Mangrove	$y = 8.3179z - 0.8021$, WHERE $\{y_{min} = 0, y_{max} = 4\}$	$y = 14.96z - 0.0165$, WHERE $\{y_{min} = 0, y_{max} = 4\}$	$y = 24.304z + 0.3003$, WHERE $\{y_{min} = 0, y_{max} = 4\}$
Red Maple	$y = -0.8926(L_n z) + 0.9775$, WHERE $\{y_{min} = 0, y_{max} = 3\}$	$y = -0.7296(L_n z) + 0.3035$, WHERE $\{y_{min} = 0, y_{max} = 3\}$	$y = -0.5937(L_n z) + 0.109$, WHERE $\{y_{min} = 0, y_{max} = 3\}$
Virginia Willow	$y = -5.4208z + 3$, WHERE $\{y_{min} = 0, y_{max} = 2\}$	$y = -14.962z + 3$, WHERE $\{y_{min} = 0, y_{max} = 2\}$	$y = -32.386z + 3$, WHERE $\{y_{min} = 0, y_{max} = 2\}$

[1]Expected within a strip quadrat of 200 ft (60 m) by 25 ft (7.5 m), covering an area of 5000 ft^2 (465 m^2)

Table D-3. Formulas used in the SAVELOX Model to Predict Number of Adults*; "y" is the Predicted Value, "z" is the Input Value *Ds/Db*.

Species	**General Model Formula Threshold of $\geq$1 ppt**	**General Model Formula Threshold of $\geq$2 ppt**	**General Model Formula Threshold of $\geq$3 ppt**
Bald Cypress	IF ($z \leq 0.6$ THEN $y = -63.585z + 44.694$) OR IF ($z > 0.6$ THEN $y = -0.27478z + 4.082$)	IF ($z \leq 0.28365$ THEN $y = -117.27z + 39.114$) OR IF ($z > 0.28365$ THEN $y = -0.8513z + 4.1693$)	IF ($z \leq 0.16246$ THEN $y = -197.78z + 37.188$) OR IF ($z > 0.16246$ THEN $y = -1.6937z + 4.3362$)
Cabbage Palm	N/A	N/A	N/A
Dahoon Holly	$y = -3.3902(L_n z) + 2.7146$, WHERE $\{y_{min} = 0, y_{max} = 12\}$	$y = -3.0352(L_n z) - 0.4669$, WHERE $\{y_{min} = 0, y_{max} = 12\}$	$y = -2.5196(L_n z) - 1.4411$, WHERE $\{y_{min} = 0, y_{max} = 12\}$
Pond Apple	$y = 286.39(2.71828^{-5.5247z})$, WHERE $\{y_{min} = 0, y_{max} = 50\}$	$y = 557.89(2.71828^{-15.974z})$, WHERE $\{y_{min} = 0, y_{max} = 50\}$	$y = 259.98(2.71828^{-22.781z})$, WHERE $\{y_{min} = 0, y_{max} = 50\}$
Pop Ash	$y = -109.86z + 67.03$, WHERE $\{y_{min} = 0, y_{max} = 32\}$	$y = -184.88z + 53.443$, WHERE $\{y_{min} = 0, y_{max} = 32\}$	$y = -277.49z + 46.082$ WHERE $\{y_{min} = 0, y_{max} = 32\}$
Red Mangrove	$y = 421.39z - 68.397$ WHERE $\{y_{min} = 0, y_{max} = 200\}$	$y = 776.21z - 31.276$ WHERE $\{y_{min} = 0, y_{max} = 200\}$	$y = 1306.8z - 18.356$ WHERE $\{y_{min} = 0, y_{max} = 200\}$
Red Maple	$y = -39.237z + 23.582$, WHERE $\{y_{min} = 0, y_{max} = 11\}$	$y = -66.03z + 18.73$, WHERE $\{y_{min} = 0, y_{max} = 11\}$	$y = -99.103z + 16.101$, WHERE $\{y_{min} = 0, y_{max} = 11\}$
Virginia Willow	$y = -95.472z + 61.408$, WHERE $\{y_{min}=0, y_{max} = 2\}$	$y = -176.3z + 53.062$, WHERE $\{y_{min} = 0, y_{max} = 2\}$	$y = -297.88z + 50.209$, WHERE $\{y_{min} = 0, y_{max} = 2\}$

*Expected within a strip quadrat of 200 ft (60 m) by 25 ft (7.5 m), covering an area of 5000 ft^2 (465 m^2)

Table D-4. Formulas used in the SAVELOX Model to Predict Percent Canopy Cover*; "y" is the Predicted Value, "z" is the Input Value *Ds/Db*.

Species	**General Model Formula Threshold of $\geq$1 ppt**	**General Model Formula Threshold of $\geq$2 ppt**	**General Model Formula Threshold of $\geq$3 ppt**
Bald Cypress	IF ($z \leq 0.6$ THEN $y = -258.78z + 164.36$) OR IF ($z > 0.6$ THEN $y = -0.3486z + 4.7962$)	IF ($z \leq 0.28365$ THEN $y = -472.69z + 140.98$) OR IF ($z > 0.28365$ THEN $y = -1.0822z + 4.9101$)	IF ($z \leq 0.16246$ THEN $y = -786.09z + 132.37$) OR IF ($z > 0.16246$ THEN $y = -2.2014z + 5.1701$)
Cabbage Palm	N/A	N/A	N/A
Dahoon Holly	$y = -2.5775(L_nz) - 1.4787$, WHERE $\{y_{min} = 0, y_{max} = 4\}$	$y = -1.5821(L_nz) - 2.0791$, WHERE $\{y_{min} = 0, y_{max} = 4\}$	$y = -1.2498(L_nz) - 2.3589$, WHERE $\{y_{min} = 0, y_{max} = 4\}$
Pond Apple	$y = 113.67(2.71828^{-5.2662z})$, WHERE $\{y_{min} = 0, y_{max} = 54\}$	$y = -187.5z + 54.696$, WHERE $\{y_{min} = 0, y_{max} = 54\}$	$y = -305.32z + 50.78$, WHERE $\{y_{min} = 0, y_{max} = 54\}$
Pop Ash	$y = -14.481(L_nz) - 6.9289$, WHERE $\{y_{min} = 0, y_{max} = 23\}$	$y = -8.7732(L_nz) -10.105$, WHERE $\{y_{min} = 0, y_{max} = 23\}$	$y = -6.9316(L_nz) -11.66$, WHERE $\{y_{min} = 0, y_{max} = 23\}$
Red Mangrove	$y = 372.75z - 124.03$ WHERE $\{y_{min} = 0, y_{max} = 100\}$	$y = 627.28z - 77.932$ WHERE $\{y_{min} = 0, y_{max} = 100\}$	$y = 941.48z - 52.957$ WHERE $\{y_{min} = 0, y_{max} = 100\}$
Red Maple	$y = -35.504z + 21.005$, WHERE $\{y_{min} = 0, y_{max} = 17\}$	$y = -64.226z + 17.706$, WHERE $\{y_{min} = 0, y_{max} = 17\}$	$y = -105.27z + 16.417$, WHERE $\{y_{min} = 0, y_{max} = 17\}$
Virginia Willow	N/A	N/A	N/A

*Expected within a strip quadrat of 200 ft (60 m) by 25 ft (7.5 m), covering an area of 5000 ft^2 (465 m^2)

Table D-5. Comparison of Field Data from Verification Sites and SAVELOX Model Output for Bald Cypress.

Site Name	5B	6A	6B	7A	7B	7C	8A	8B	8C	8D	9A	9B	9C	10A	10B	10C	V-1	V-2	V-3	V-4	V-5	V-6	V-7
River Mile	5.6	6.2	6.8	7.3	7.5	7.8	8.1	8.4	8.7	8.9	9.1	9.2	9.7	10.1	10.2	10.4	10.6	10.3	9.9	9.3	8.8	8.55	7.95
Abundance Index (Semiquantitative Survey)																							
Field Data	0	0	0	0	0	1	1	2	2	3.5	3	3	4	4	4	4	4	4	4	2	2	1	1
Model Output	0	0	0	0	0	0.7	1.3	1.8	2.3	2.7	3.1	3.2	4.1	4	4	4	4	4	4	3.5	2.5	2	1
Bald Cypress Abundance Index Related to Salinity; ≥1 ppt threshold																							
Field Data						1		2		3.5		3	4		4		4		4				1
Model Output						1		2		3.3		3	4		4		3.7		3.8				1
Bald Cypress Abundance Index Related to Salinity; ≥2 ppt threshold																							
Field Data						1		2		3.5		3	4		4		4		4				1
Model Output						1		2		3.7		3.7	4		4		3.8		3.6				1
Bald Cypress Abundance Index Related to Salinity; ≥3 ppt threshold																							
Field Data						1		2		3.5		3	4		4		4		4				1
Model Output						1		2		3.1		3.5	4		4		3.9		3.8				1
Mature Bald Cypress No. Adults per site Related to Salinity; ≥1 ppt threshold																							
Field Data						1		3				4	28		34		21						0
Model Output						1		3				4	23		37		37						1
Mature Bald Cypress No. Adults per site Related to Salinity; ≥2 ppt threshold																							
Field Data						1		3				4	28		34		21						0
Model Output						1		3				4	24		37		37						1
Mature Bald Cypress No. Adults per site Related to Salinity; ≥3 ppt threshold																							
Field Data						1		3				4	28		34		21						0
Model Output						1		3				4	25		36								
Mature Bald Cypress Canopy (percent of plot area) Related to Salinity; ≥1 ppt threshold																							
Field Data						1		3				5	83		128		104						0
Model Output						1		4				5	75		132		132						1
Mature Bald Cypress Canopy (percent of plot area) Related to Salinity; ≥2 ppt threshold																							
Field Data						1		3				5	83		128		104						0
Model Output						1		4				5	78		131		131						1
Mature Bald Cypress Canopy (percent of plot area) Related to Salinity; ≥3 ppt threshold																							
Field Data						1		3				5	83		128		104						0
Model Output						1		3				5	84		127								

Table D-6. Comparison of Field Data from Verification Sites and SAVELOX Model Output for Cabbage Palm.

Site Name	5B	6A	6B	7A	7B	7C	8A	8B	8C	8D	9A	9B	9C	10A	10B	10C	V-1	V-2	V-3	V-4	V-5	V-6	V-7
River Mile	5.6	6.2	6.8	7.3	7.5	7.8	8.1	8.4	8.7	8.9	9.1	9.2	9.7	10.1	10.2	10.4	10.6	10.3	9.9	9.3	8.8	8.55	7.95
Abundance Index (Semiquantitative Survey)																							
Field Data	0	1.5	2.5	2.5	3	3.5	4	3	3.5	3.5	4	3	3	3	3	2	1.5	2.5	3	3	3.5	3	3
Model Output	0	1.3	2.3	2.9	3.1	3.3	3.5	3.5	3.6	3.5	3.5	3.4	3.1	2.8	2.6	2.4	2	2.5	3	3.5	3.5	3.5	3.5
Cabbage Palm Abundance Index Related to Salinity; >1 ppt threshold																							
Field Data						3.5		3		3.5		3	3		3		1.5		3				3
Model Output						3		3		3		3	3		3		3		3				3
Cabbage Palm Abundance Index Related to Salinity; >2 ppt threshold																							
Field Data						3.5		3		3.5		3	3		3		1.5		3				3
Model Output						3		3		3		3	3		3		3		3				3
Cabbage Palm Abundance Index Related to Salinity; >3 ppt threshold																							
Field Data						3.5		3		3.5		3	3		3		1.5		3				3
Model Output						3		3		3		3	3		3		3		3				3

Table D-7. Comparison of Field Data from Verification Sites and SAVELOX Model Output for Red Mangrove.

Site Name	5B	6A	6B	7A	7B	7C	8A	8B	8C	8D	9A	9B	9C	10A	10B	10C	V-1	V-2	V-3	V-4	V-5	V-6	V-7
River Mile	5.6	6.2	6.8	7.3	7.5	7.8	8.1	8.4	8.7	8.9	9.1	9.2	9.7	10.1	10.2	10.4	10.6	10.3	9.9	9.3	8.8	8.55	7.95
Abundance Index (Semiquantitative Survey)																							
Field Data	4	4	4	4	4	4	4	4	4	4	4	4	2.5	0	0	0	0	1	2	3	4	4	4
Model Output	4	4	4	4	4	4	4	4	4	4	4	4	2.5	0	0	0	0	0	1.5	4	4	4	4
Red Mangrove Abundance Index Related to Salinity; >1 ppt threshold																							
Field Data						4		4		4		4	2.5		0		0		2				4
Model Output						4		4		4		4	2		0		0		1.7				4
Red Mangrove Abundance Index Related to Salinity; >2 ppt threshold																							
Field Data						4		4		4		4	2.5		0		0		2				4
Model Output						4		4		4		4	2		0		0		1.8				4
Red Mangrove Abundance Index Related to Salinity; >3 ppt threshold																							
Field Data						4		4		4		4	2.5		0		0		2				4
Model Output						4		4		4		4	2		0.5		0		1.5				4
Mature Red Mangrove No. Adults per site Related to Salinity; >1 ppt threshold																							
Field Data						200		200		200		200	45		1		0						200
Model Output						200		200		200		200	77		0		0						200
Mature Red Mangrove No. Adults per site Related to Salinity; >2 ppt threshold																							
Field Data						200		200		200		200	45		1		0						200
Model Output						200		200		200		200	71		0		0						200
Mature Red Mangrove No. Adults Related per site to Salinity; >3 ppt threshold																							
Field Data						200		200		200		200	45		1		0						200
Model Output						200		200		200		200	62		0								
																	0						200
Mature Red Mangrove Canopy (percent of plot area) Related to Salinity; >1 ppt threshold																							
Field Data						100		100		100		100	5		0		0						100
Model Output						100		100		100		100	5		0		0						100
Mature Red Mangrove Canopy (percent of plot area) Related to Salinity; >2 ppt threshold																							
Field Data						100		100		100		100	5		0		0						100
Model Output						100		100		100		100	5		0		0						100
Mature Red Mangrove Canopy (percent of plot area) Related to Salinity; >3 ppt threshold																							
Field Data						100		100		100		100	5		0		0						100
Model Output						100		100		100		100	5		0		0						100

Table D-8. Comparison of Field Data from Verification Sites and SAVELOX Model Output for Laurel Oak.

Site Name	5B	6A	6B	7A	7B	7C	8A	8B	8C	8D	9A	9B	9C	10A	10B	10C	V-1	V-2	V-3	V-4	V-5	V-6	V-7
River Mile	5.6	6.2	6.8	7.3	7.5	7.8	8.1	8.4	8.7	8.9	9.1	9.2	9.7	10.1	10.2	10.4	10.6	10.3	9.9	9.3	8.8	8.55	7.95
Abundance Index (Semiquantitative Survey)																							
Field Data	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	1.5	2	0	0	0
Model Output	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	1	0	0	0	0	0

Table D-9. Comparison of Field Data from Verification Sites and SAVELOX Model Output for Virginia Willow.

Site Name	5B	6A	6B	7A	7B	7C	8A	8B	8C	8D	9A	9B	9C	10A	10B	10C	V-1	V-2	V-3	V-4	V-5	V-6	V-7
River Mile	5.6	6.2	6.8	7.3	7.5	7.8	8.1	8.4	8.7	8.9	9.1	9.2	9.7	10.1	10.2	10.4	10.6	10.3	9.9	9.3	8.8	8.55	7.95
Abundance Index (Semiquantitative Survey)																							
Field Data	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	3.5	2.5	0	0	0	0	0
Model Output	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	1	0	0	0	0
Virginia Willow Abundance Index Related to Salinity; >1 ppt threshold																							
Field Data						0		0		0		0	0		2		3.5		0				0
Model Output						0		0		0		0	0		2.3		3		1.4				0
Virginia Willow Abundance Index Related to Salinity; >2 ppt threshold																							
Field Data						0		0		0		0	0		2		3.5		0				0
Model Output						0		0		0		0	0		2.7		3		1.2				0
Virginia Willow Abundance Index Related to Salinity; >3 ppt threshold																							
Field Data						0		0		0		0	0		2		3.5		0				0
Model Output						0		0		0		0	0		2.8		3		1.4				0
Mature Virginia Willow No. Adults per site Related to Salinity; >1 ppt threshold																							
Field Data						0		0				0	37		45		123						0
Model Output						0		0				0	28		50		61						0
Mature Virginia Willow No. Adults per site Related to Salinity; >2 ppt threshold																							
Field Data						0		0				0	37		45		123						0
Model Output						0		0				0	30		49		53						0
Mature Virginia Willow No. Adults per site Related to Salinity; >3 ppt threshold																							
Field Data						0		0				0	37		45		123						0
Model Output						0		0				0	32		48		50						0

Table D-10. Comparison of Field Data from Verification Sites and SAVELOX Model Output for Dahoon.

Site Name	5B	6A	6B	7A	7B	7C	8A	8B	8C	8D	9A	9B	9C	10A	10B	10C	V-1	V-2	V-3	V-4	V-5	V-6	V-7
River Mile	5.6	6.2	6.8	7.3	7.5	7.8	8.1	8.4	8.7	8.9	9.1	9.2	9.7	10.1	10.2	10.4	10.6	10.3	9.9	9.3	8.8	8.55	7.95
Abundance Index (Semiquantitative Survey)																							
Field Data	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2	3	2	3.5	2	1	0	0	0
Model Output	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2.3	2.8	3	3	1.5	1	0	0	0
Dahoon Abundance Index Related to Salinity; >1 ppt threshold																							
Field Data						0		0				1	1		2		2		2				0
Model Output						0		0				0.3	1.3		2								
Dahoon Abundance Index Related to Salinity; >2 ppt threshold																							
Field Data						0		0				1	1		2		2		2				0
Model Output						0		0				0.3	1.4		2								
Dahoon Abundance Index Related to Salinity; >3 ppt threshold																							
Field Data						0		0				1	1		2		2		2				0
Model Output						0		0				0.2	1.6		2								
Mature Dahoon No. Adults per site Related to Salinity; >1 ppt threshold																							
Field Data						0		0				2	5		12		0						0
Model Output						0		0				4	6		10								
Mature Dahoon No. Adults per site Related to Salinity; >2 ppt threshold																							
Field Data						0		0				2	5		12		0						0
Model Output						0		0				3	6		11								
Mature Dahoon No. Adults per site Related to Salinity; >3 ppt threshold																							
Field Data						0		0				2	5		12		0						0
Model Output						0		0				3	6		11								
Mature Dahoon Canopy (percent of plot area) Related to Salinity; >1 ppt threshold																							
Field Data						0		0				0	1		4		0						0
Model Output						0		0				0	1.3		3.9								
Mature Dahoon Canopy (percent of plot area) Related to Salinity; >2 ppt threshold																							
Field Data						0		0				0	1		4		0						0
Model Output						0		0				0	1.1		4								
Mature Dahoon Canopy (percent of plot area) Related to Salinity; >3 ppt threshold																							
Field Data						0		0				0	1		4		0						0
Model Output						0		0				0	1.1		4								

Table D-11. Comparison of Field Data from Verification Sites and SAVELOX Model Output for Pop Ash.

Site Name	5B	6A	6B	7A	7B	7C	8A	8B	8C	8D	9A	9B	9C	10A	10B	10C	V-1	V-2	V-3	V-4	V-5	V-6	V-7
River Mile	5.6	6.2	6.8	7.3	7.5	7.8	8.1	8.4	8.7	8.9	9.1	9.2	9.7	10.1	10.2	10.4	10.6	10.3	9.9	9.3	8.8	8.55	7.95
Abundance Index (Semiquantitative Survey)																							
Field Data	0	0	0	0	0	0	0	0	0	0	0	1	2	2	2	2	2	2	2	0	0	0	0
Model Output	0	0	0	0	0	0	0	0	0	0	0.3	0.6	2	2	2	2	2	2	2	1	0	0	0
Pop Ash Abundance Index Related to Salinity; >1 ppt threshold																							
Field Data						0		0		0		1	2		2								
Model Output						0		0		0		1.2	1.9		2								
Pop Ash Abundance Index Related to Salinity; >2 ppt threshold																							
Field Data						0		0		0		1	2		2								
Model Output						0		0		0		1.2	1.9		2								
Pop Ash Abundance Index Related to Salinity; >3 ppt threshold																							
Field Data						0		0		0		1	2		2								
Model Output						0		0		0		1	2		2								
Mature Pop Ash No. Adults per site Related to Salinity; >1 ppt threshold																							
Field Data						0		0				1	29		32								
Model Output						0		0				0	29		32								
Mature Pop Ash No. Adults per site Related to Salinity; >2 ppt threshold																							
Field Data						0		0				1	29		32								
Model Output						0		0				1	32		32								
Mature Pop Ash No. Adults per site Related to Salinity; >3 ppt threshold																							
Field Data						0		0				1	29		32								
Model Output						0		0				1	32		32								
Mature Pop Ash Canopy (percent of plot area) Related to Salinity; >1 ppt threshold																							
Field Data						0		0				0	9		23								
Model Output						0		0				0	8.4		23								
Mature Pop Ash Canopy (percent of plot area) Related to Salinity; >2 ppt threshold																							
Field Data						0		0				0	9		23								
Model Output						0		0				0.9	8		23								
Mature Pop Ash Canopy (percent of plot area) Related to Salinity; >3 ppt threshold																							
Field Data						0		0				0	9		23								
Model Output						0		0				1	8		23								

Table D-12. Comparison of Field Data from Verification Sites and SAVELOX Model Output for Pond Apple.

Site Name	5B	6A	6B	7A	7B	7C	8A	8B	8C	8D	9A	9B	9C	10A	10B	10C	V-1	V-2	V-3	V-4	V-5	V-6	V-7
River Mile	5.6	6.2	6.8	7.3	7.5	7.8	8.1	8.4	8.7	8.9	9.1	9.2	9.7	10.1	10.2	10.4	10.6	10.3	9.9	9.3	8.8	8.55	7.95
Abundance Index (Semiquantitative Survey)																							
Field Data	0	0	0	0	0	0	0	0	3	3	3	3	3	3.5	3	3.5	3	3	3.5	1	2	0	1
Model Output	0	0	0	0	0	0	0	0	3	3	3	3	3	3	3	3	3	3	3	3	3	0	0
Pond Apple Abundance Index Related to Salinity; >1 ppt threshold																							
Field Data						0		0		3		3	3		3								
Model Output						0		0		3		3	3		3								
Pond Apple Abundance Index Related to Salinity; >2 ppt threshold																							
Field Data						0		0		3		3	3		3								
Model Output						0		0		3		3	3		3								
Pond Apple Abundance Index Related to Salinity; >3 ppt threshold																							
Field Data						0		0		3		3	3		3								
Model Output						0		0		3		3	3		3								
Mature Pond Apple No. Adults per site Related to Salinity; >1 ppt threshold																							
Field Data						0		0				11	40		50								
Model Output						0		0				10	42		50								
Mature Pond Apple No. Adults per site Related to Salinity; >2 ppt threshold																							
Field Data						0		0				11	40		50								
Model Output						0		0				6	50		50								
Mature Pond Apple No. Adults per site Related to Salinity; >3 ppt threshold																							
Field Data						0		0				11	40		50								
Model Output						0		0				6	50		50								
Mature Pond Apple Canopy (percent of plot area) Related to Salinity; >1 ppt threshold																							
Field Data						0		0				4	24		54								
Model Output						0		0				5	18		54								
Mature Pond Apple Canopy (percent of plot area) Related to Salinity; >2 ppt threshold																							
Field Data						0		0				4	24		54								
Model Output						0		0				2	30		51								
Mature Pond Apple Canopy (percent of plot area) Related to Salinity; >3 ppt threshold																							
Field Data						0		0				4	24		54								
Model Output						0		0				1	32		49								

Table D-13. Comparison of Field Data from Verification Sites and SAVELOX Model Output for Red Maple.

Site Name	5B	6A	6B	7A	7B	7C	8A	8B	8C	8D	9A	9B	9C	10A	10B	10C	V-1	V-2	V-3	V-4	V-5	V-6	V-7
River Mile	5.6	6.2	6.8	7.3	7.5	7.8	8.1	8.4	8.7	8.9	9.1	9.2	9.7	10.1	10.2	10.4	10.6	10.3	9.9	9.3	8.8	8.55	7.95
Abundance Index (Semiquantitative Survey)																							
Field Data	0	0	0	0	0	0	0	0	0	1	1	1	2	3	3	3.5	3.5	3	1	0	0	0	0
Model Output	0	0	0	0	0	0	0	0	0.3	0.7	1.1	1.2	2.1	2.9	3.1	3.4	3.5	3	2.5	1.5	0.5	0	0
Red Maple Abundance Index Related to Salinity; >1 ppt threshold																							
Field Data						0		0		1		1	2		3								
Model Output						0		0		1		1.4	1.9		2.8								
Red Maple Abundance Index Related to Salinity; >2 ppt threshold																							
Field Data						0		0		1		1	2		3								
Model Output						0		0		0.8		1.2	1.8		3								
Red Maple Abundance Index Related to Salinity; >3 ppt threshold																							
Field Data						0		0		1		1	2		3								
Model Output						0		0.2		0.7		1.2	1.8		3								
Mature Red Maple No. Adults per site Related to Salinity; >1 ppt threshold																							
Field Data						0		0				0	10		11								
Model Output						0		0				0	10		11								
Mature Red Maple No. Adults per site Related to Salinity; >2 ppt threshold																							
Field Data						0		0				0	10		11								
Model Output						0		0				0	10		11								
Mature Red Maple No. Adults per site Related to Salinity; >3 ppt threshold																							
Field Data						0		0				0	10		11								
Model Output						0		0				0	10		11								
Mature Red Maple Canopy (percent of plot area) Related to Salinity; >1 ppt threshold																							
Field Data						0		0				0	8		17								
Model Output						0		0				0	9		17								
Mature Red Maple Canopy (percent of plot area) Related to Salinity; >2 ppt threshold																							
Field Data						0		0				0	8		17								
Model Output						0		0				0	9		16								
Mature Red Maple Canopy (percent of plot area) Related to Salinity; >3 ppt threshold																							
Field Data						0		0				0	8		17								
Model Output						0		0				0	10		16								