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EXPANSION OF WILLOW IN THE BLUE CYPRESS MARSH CONSERVATION AREA, UPPER ST. JOHNS RIVER BASIN

by

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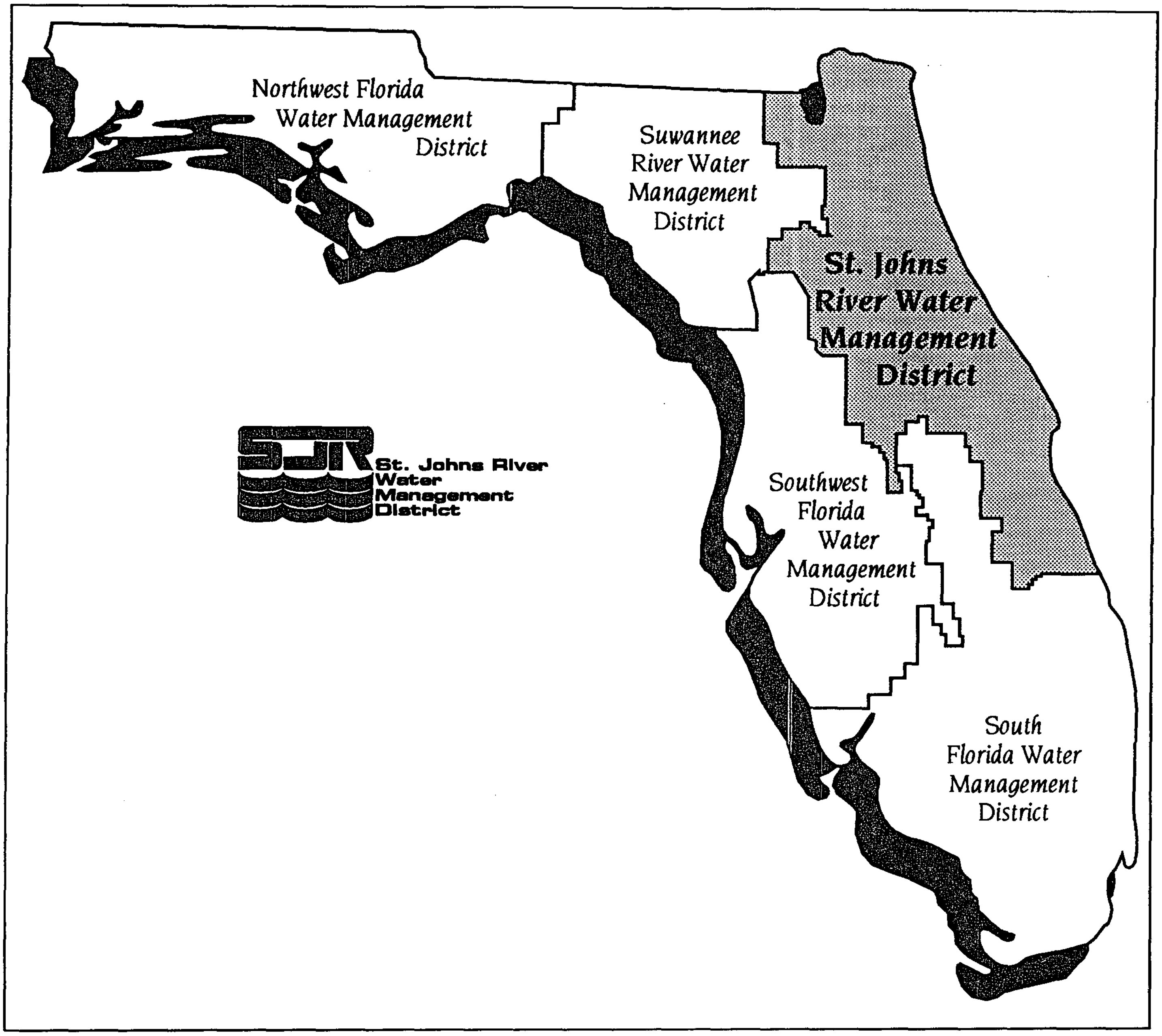

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Expansion of Willow in the Blue Cypress Marsh Conservation Area, Upper St. Johns River Basin

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ABSTRACT

Expansion of coastal plain willow (*Salix caroliniana* Michaux) was investigated in a relatively unimpacted, 8,400-acre study area in the Upper St. Johns River Basin in east-central Florida. Two remote-sensing approaches using color infrared aerial photographs were used to quantify the pattern and the rate of spread of willow. In the first approach, maps were created from 1971, 1981, 1989, and 1993 aerial photographs. These maps showed that dense willow increased by 305 acres, from 11.2% to 14.8% of the total study area, from 1971 to 1981 and by an additional 172 acres from 1981 to 1993. Most of the increase appeared to have been along the southern and eastern boundaries of the study area. A second approach, photoplot sampling, was developed to measure the rate of expansion of willow at lower densities. Estimations of willow cover were made stereoscopically from 150 two-acre plots from the 1981 and 1993 photographs. Cover was rated in cover classes: 0, 1, 2, 3, and 4, representing 0%, 1%–25%, 26%–50%, 51%–75%, and 76%–100% cover, respectively. Over the entire study site, the median cover class of willow increased from class 1 to class 2. Cover classes 2, 3, and 4 increased in frequency from 15.3% to 24.7%, from 8.7% to 16.7%, and from 12.7% to 22% of all plots, respectively. Cover classes 0 and 1 declined in frequency from 19.3% to 4.7% and from 44% to 32%, respectively. This approach showed that expansion of willow, particularly in the less dense cover classes, had occurred throughout the study area. Mapping and photoplot sampling gave complementary information on willow expansion. Mapping worked well to show increases in the area of dense willow. Photoplot sampling allowed increases in the extent of lower cover classes of willow to be described.

INTRODUCTION

The Upper St. Johns River Basin in east-central Florida, an area formerly dominated by extensive wetlands, has been greatly impacted by agricultural development and drainage alteration. The original marsh area has been reduced to less than half of its original extent, and the integrity of the remaining marsh area has been impacted by roads, canals, and levees (Lowe et al. 1984). Among the consequences of these changes have been the introduction of high levels of nutrients, alteration of hydrology, and spread of exotic, as well as native, invasive species.

The Blue Cypress Marsh Conservation Area is one of the least-altered areas in the Upper St. Johns River Basin. However, a comparison of recent and historic aerial photographs (1943 and subsequent dates) indicates that the vegetation in this area is changing. Among the changes has been an increase in coastal plain willow (*Salix caroliniana* Michaux). The expansion of willow may be undesirable if it leads to landscape-scale decreases in community or species diversity.

The objective of this study was to determine the extent, rate, and pattern of willow expansion in the southern part of the Blue Cypress Marsh Conservation Area, where change appears to have been most extensive. The causes and consequences of willow expansion should be the focus of future investigations. This expansion needs to be better understood before management decisions are made to reduce willow coverage.

THE COASTAL PLAIN WILLOW

Salix caroliniana, the coastal plain willow (Figure 1), is one of four willow species native to the St. Johns River Water Management District. It occurs throughout the coastal plain of the southeastern United States, as well as in Cuba (Sargent 1965). It occurs throughout all of Florida except in the western panhandle (Little 1978). The

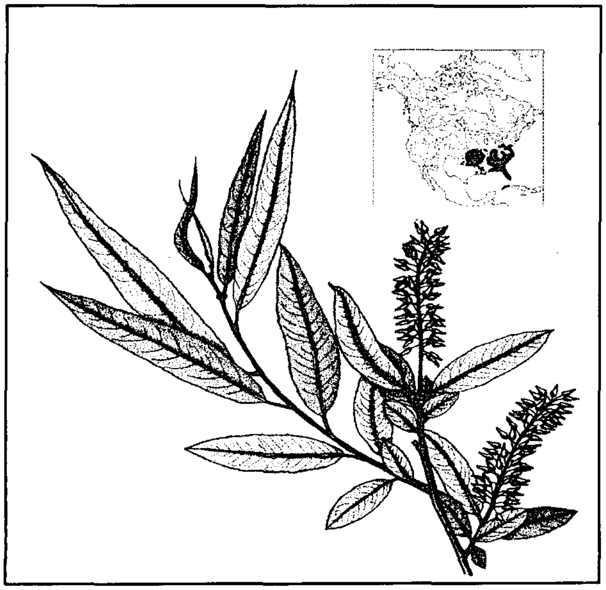

Figure 1. *Salis caroliniana*, the coastal plain willow (from Argus 1986)

other three species are less common in the District. *Salix floridana*, the Florida willow, is a rare, typically shrub-sized endemic. *S. humilis*, the upland willow, is a small to medium-sized shrub that is rare in Florida but common in the southern piedmont and mountains. *S. nigra*, the black willow, occurs throughout the eastern United States, including the Florida panhandle, but within the District it occurs only in the most northern counties, where it intergrades with *S. caroliniana* (Argus 1986). Of the four species, only the black willow has been extensively studied; therefore, the black willow was used, where more species-specific data were absent, as a source of life history information for the closely related coastal plain willow.

The coastal plain willow may grow as a multi-stemmed shrub or as a small tree up to 30 feet tall and 1 foot in diameter (Brockman 1979). The shrub form is most common in open situations, where there is little competition for light. Crowding, with the attendant struggle for light, induces a taller, typically tree-like growth form. The coastal plain willow occurs over a wide range of saturated or flooded soil types along lakeshores and stream banks and in swamps, marshes, and other wet situations.

The coastal plain willow is dioecious (i.e., male and female flowers are borne on different individuals) and insect pollinated, although wind pollination may also occur (Argus 1986). In east-central Florida, flowering typically occurs in early March but may occur as early as December or as late as May. Flowering is quickly followed by seed production (Tomlinson 1980). The age at which coastal plain willows begin to produce seeds has not been documented, but it appears to be before the plant is 10 years old. Willow produce numerous minute seeds (18,300 seeds per gram, Brinkman 1974) that are capable of being carried great distances by wind action on the attached long, silky hairs. The seeds also are readily dispersed by water.

The reproduction biology of *S. nigra* has been extensively studied. In *S. nigra*, initial germination rates are high; seed longevity is limited and is greatly reduced by only a few days of drying (Burns and Honkala 1990). Germination occurs within 12 to 24 hours under natural conditions, although moist seed may remain viable at low temperatures for up to a month (Young and Young 1992). For good germination and establishment to occur, the seedbed must be consistently moist, sunlit, and free from competition (Burns and Honkala 1990). *Salix caroliniana*, which is closely related, requires similar seedbed conditions.

During the first year, black willow can grow to a height of four feet (Burns and Honkala 1990); coastal plain willow probably grow equally rapidly. Incremental growth for the coastal plain willow is not well documented, but samples taken in the Blue Cypress Marsh Conservation Area included a tree estimated to be 13 years old with a basal diameter of approximately 4.5 inches (Appendix A).

Although individual plants may develop multiple stems following fire or mechanical pruning (Craighead 1971; Hofstetter 1984; Robertson 1953; Miller et al., in press), vegetative reproduction appears generally to be of minor importance. Neither rhizomes nor root shoots are produced, although ground layering and rooting of fallen branches may occasionally occur (Argus 1986).

The coastal plain willow is not a long-lived tree. Trees approximately 50 years old were noted in the Ocklawaha River Basin, but were very unsound. Natural mortality appears to be high in

Florida. In south Florida, Craighead (1971) documented heavy infestations of a stem borer, *Prianoxyatus robiniae*, which contributed substantially to the mortality of mature trees. *Paranthrene dolli* (Lepidoptera, Sesiidae) is also considered a serious wood-boring pest of willow (Engelhardt 1946). Numerous insects feed on the foliage but seem generally to cause little serious damage. In mature stands, there are often many dead or dying trees, and regeneration may be poor owing to the absence of an appropriate seedbed. Under these conditions, invasion by red maple or other hardwood species is common.

The coastal plain willow, like other willow species, is thin-barked and very sensitive to fire. Resprouting following a burn, however, may be extensive, especially if water levels were high enough during the fire to protect a portion of the trunk (Miller et al., in press). Hot fires reaching ground level in an unflooded marsh or burning into the peat, on the other hand, may be fatal (S.J. Miller and G.B. Hall, St. Johns River Water Management District, pers. com. 1996). In contrast, Craighead (1971), in part, attributes the rapid increase of willow in the Shark River Slough and other portions of the Everglades to fire. The removal of shade and the exposure of litter-free, moist soil apparently allowed willows to become established in the slough from windblown seeds.

METHODS

The study covered an area of approximately 8,400 acres in the southern portion of the Blue Cypress Marsh Conservation Area (Figure 2). This area contains a mosaic of plant community types, including sawgrass marsh dominated by sawgrass (*Cladium jamaicense*), slough dominated by white water lily (*Nymphaea odorata*), wet prairie dominated by maidencane (*Panicum hemitomon*), and shrub swamp dominated by coastal plain willow (*Salix caroliniana*).

Two remote-sensing approaches were used to study the pattern and rate of spread of willow in this area. In both approaches, color infrared aerial photographs were the primary source of data. Map creation and analysis were performed using ARC/INFO geographic information system software (ESRI 1996).

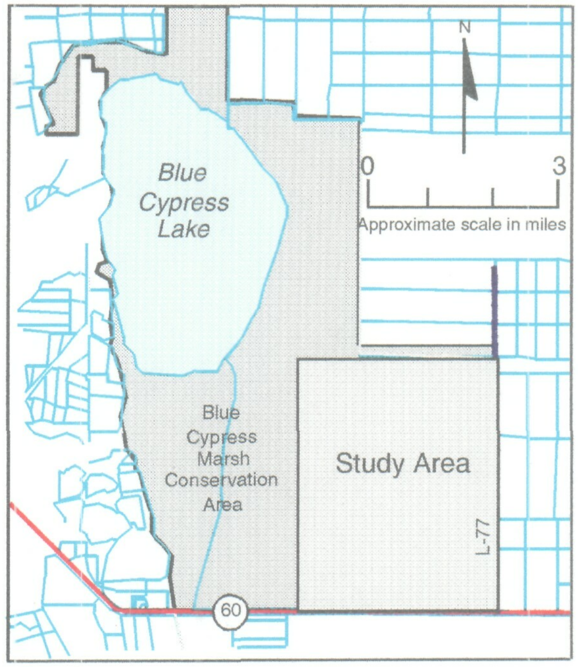

Figure 2. Willow expansion study area in the Blue Cypress Marsh Conservation Area

In the first study approach, maps were created from aerial photographs taken on four dates: November 9, 1971; March 20, 1981; April 8, 1989; and September 23, 1993. Willows were in a fully leafed-out condition in the March and April photographs, whereas in the fall photographs some leaf fall had occurred. The scale of the 1971 photographs was 1:60,000; that of the 1989 photographs was 1:24,000. Both the 1981 and 1993 photographs were at a scale of 1:12,000. Willows in these images appeared in cover patterns ranging from solid, dense stands of mature trees to dispersed saplings, with all intergradations between. In order to map the general pattern of increase, only those areas containing dense growth of willow (defined as ≥ 50% cover) with definite boundaries separating them from adjacent vegetation types were delineated. All other areas were classified either as shallow marsh, hardwood swamp, or upland. All of the maps were compared in detail and patterned (templated) on the 1993 interpretation to ensure that differences in the maps would represent real changes in willow density and not differences in interpretation. To further reduce variability, a single interpreter performed all delineations.

A second approach was developed to measure the rate of expansion of willow over a range of densities that could not be delineated using standard photointerpretation techniques. The 1981 and 1993 photographs were used in the second approach. A Universal Transverse Mercator-referenced grid of 2-acre plots (photoplots) was generated for the entire study area. This grid was plotted as an overlay on the 1993 vegetation map produced using the first approach. The grid was then divided into three strata, based on the visually observed pattern of willow cover (Figure 3). The first stratum contained dense willow cover; this stratum extended along SR 60 and Levee-77 (L-77) (Figure 2). The second stratum, which extended 1,000–3,000 feet into the study area, showed moderate willow cover, as a whole. The third, located far into the study area, had only sparse willow cover.

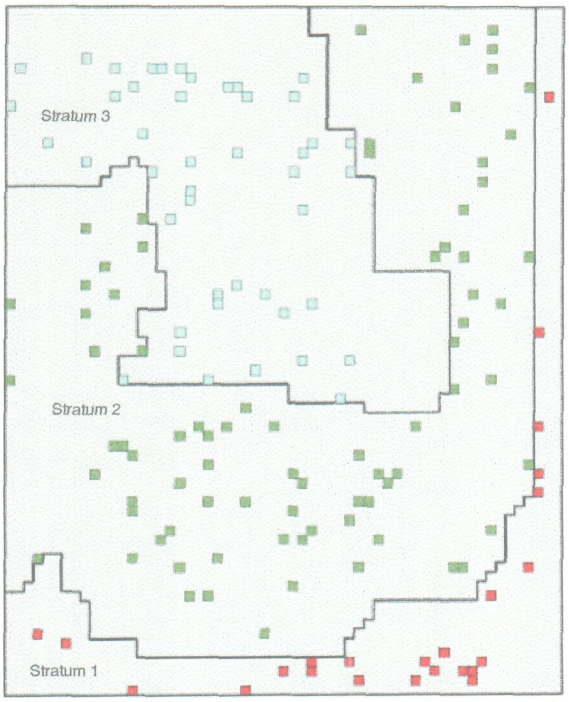

Figure 3. Willow sample blocks in the Blue Cypress Marsh study area

Within each stratum, a number of plots proportionate to stratum size were chosen randomly and examined under high stereoscopic magnification. Features on the 1993 vegetation map were used to align the grid to the photographs to be sampled. A total of 150 photoplots, representing 300 acres (3.6% of the total study area), was sampled for 1981, and the same plots were sampled for 1993. Willow cover was determined in five classes: 0, 1, 2, 3, and 4, representing 0%, 1%–25%, 26%–50%, 51%–75%, and 76%–100% cover, respectively. The results of photoplot sampling were examined statistically using a Wilcoxon matched-pair test (Sokal and Rohlf 1969). The null hypothesis to be tested was that the median of the differences between paired 1981 and 1993 samples would be zero, that is, that there was, overall, no change in willow cover.

Spatial aspects of the data were explored using the GRID module of ARC/INFO. The GRID module was used to create, analyze, and display cell-based or raster format data (grids). Grids were produced from the photoplot sampling results for 1981 and 1993 and used to create surface models representing willow densities (as smoothed, continuous surfaces) on the two dates. The 1981 surface values were then subtracted from the 1993 surface values to obtain a difference surface showing those areas in which willow cover had increased between the two dates. In addition, grids were created from the map coverages previously produced by conventional interpretation of 1981 and 1993 photographs. Grid creation allowed comparisons to be made between conventional mapping and photoplot sampling results.

The 1993 photoplot cover estimates made stereoscopically were verified in the field on March 16, 1994, at which time 11 plots were visited and on-the-ground assessments were made. Cover classes 0, 1, 2, 3, and 4 were represented by 1, 5, 2, 2, and 1 samples, respectively. Also at that time, a small number of woody vegetation samples were collected. The samples were collected to investigate the feasibility of using tree ring analysis to assess the relative growth rates of woody plants in relation to distance from disturbance or potential sources of nutrients (Appendix A).

RESULTS

Extent of Change

Conventional Mapping. The four maps produced for the period 1971–93, using the first, or conventional, mapping approach, show that the largest increase in willow cover (305 acres) occurred from 1971 to 1981 (Figure 4; Table 1).

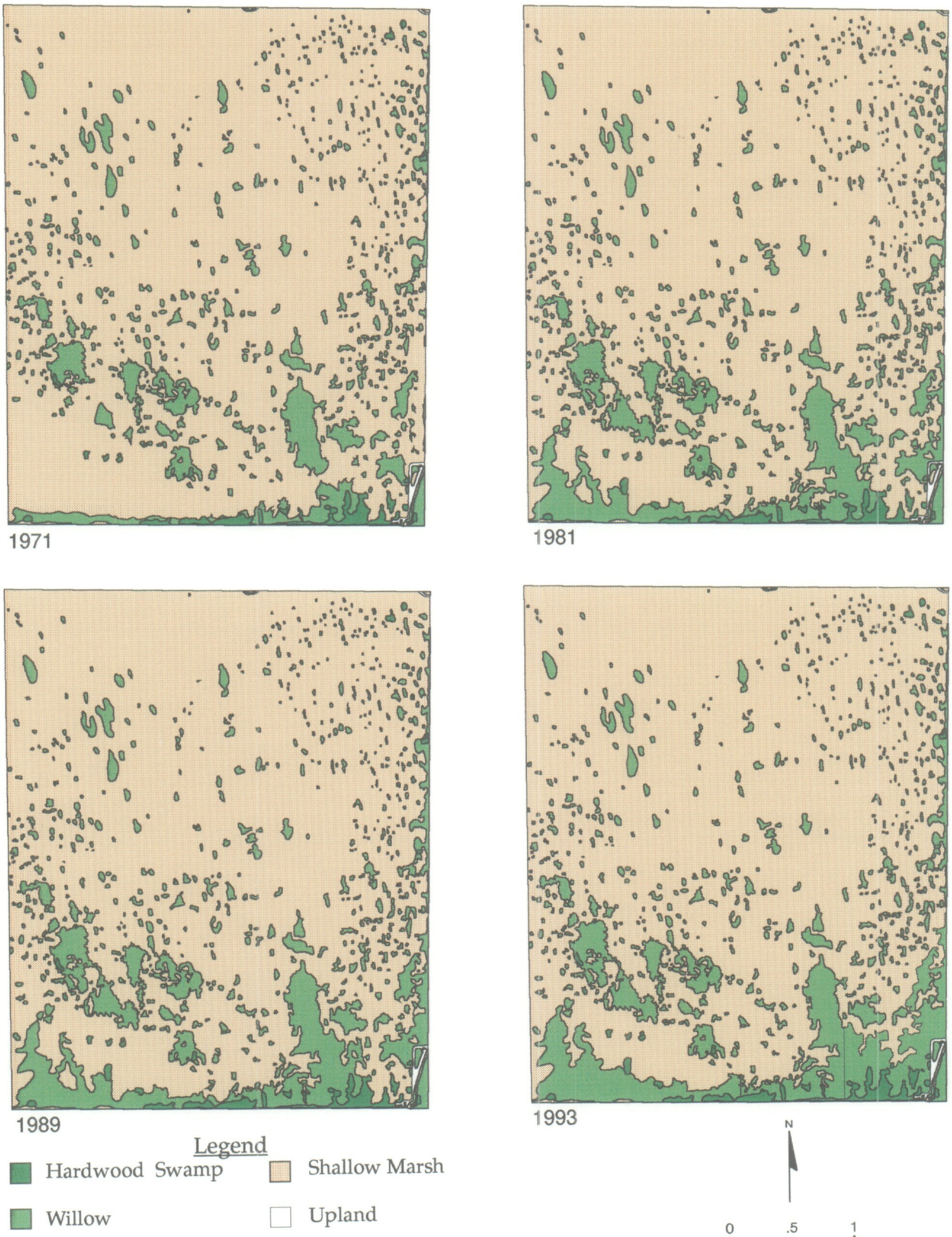

Figure 4. Change in extent of willow documented by conventional mapping methods 1971–93

Table 1. Vegetation acreages (percentage of total area), 1971–93

Community	1971	1981	1989	1993
Hardwood swamp	98.8 (1.2)	104.2 (1.2)	104.2 (1.2)	105.5 (1.3)
Willow	940.3 (11.2)	1,245.7 (14.8)	1,287.5 (15.3)	1,417.3 (16.8)
Shallow marsh	7,372.7 (87.5)	7,061.9 (83.8)	7,020.1 (83.3)	6,889.0 (81.8)
Upland	14.6 (0.2)	14.6 (0.2)	14.6 (0.2)	14.6 (0.2)

Areas of dense willow cover (≥ 50%) increased from 11.2% to 14.8% of the total study area during this 10-year period. From 1981 to 1993, willow increased by an additional 172 acres.

Photoplot Sampling. Over the entire study site from 1981 to 1993, photoplot sampling showed increases in cover classes 2, 3, and 4 (Figure 5; Table B1). Plots rated as cover class 2 increased in frequency from 15.3% to 24.7% of all plots; class 3, from 8.7% to 16.7%; and class 4, from 12.7% to 22%. Complementary changes occurred in cover classes 0 and 1, which declined in frequency from 19.3% to 4.7% and from 44% to 32%, respectively. The median cover class of willow increased from class 1 to class 2 between 1981 and 1993. The Wilcoxon matched-pair test indicated that changes in willow cover between 1981 and 1993 were statistically significant both overall and for each stratum ($p < 0.05$) (Table 2)

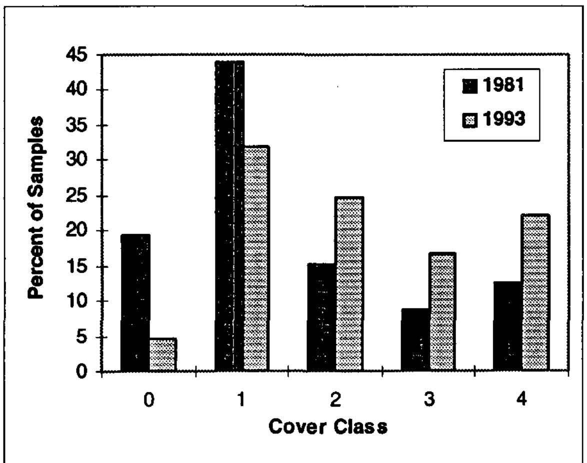

Figure 5. Change in frequency of willow cover classes, 1981–93 (all strata)

The results varied by stratum. In stratum 1, a large proportion of plots occurred in the higher density classes both in 1981 and 1993 (Table B2). However, the only increase occurred in cover class 4, which increased in frequency from 50% to 87.5% (Figure 6). By 1993, no plots in stratum 1 remained in classes 0, 1, or 2. Between 1981 and 1993, the median cover class of willow in stratum 1 increased from class 3 to class 4.

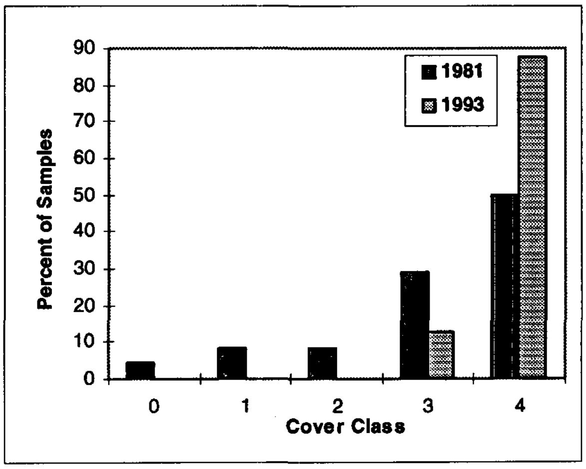

Figure 6. Change in frequency of willow cover classes, 1981–93 (stratum 1)

For stratum 2, the greatest increase occurred in class 3, which increased in frequency from 6.2% to 18.5% of all plots, although there were also increases in classes 2 and 4 (Figure 7; Table B3). Classes 0 and 1 both declined. In stratum 2, the median cover class increased from class 1 to class 2.

Stratum 3 showed the greatest increase in class 2 (15.6% to 31.1%), although class 3 showed nearly as large an increase (Figure 8; Table B4).

Table 2. Wilcoxon signed-rank, two-sample paired test

Stratum	Sample Pairs	Non-Zero-Difference Pairs	p Value	Result
All strata	150	95	2.65e-17	Significant ($p < 0.05$)
Stratum 1	24	12	0.001	Significant ($p < 0.05$)
Stratum 2	81	49	1.15e-09	Significant ($p < 0.05$)
Stratum 3	45	34	3.82e-07	Significant ($p < 0.05$)

Null hypothesis: The median of the paired differences is 0.

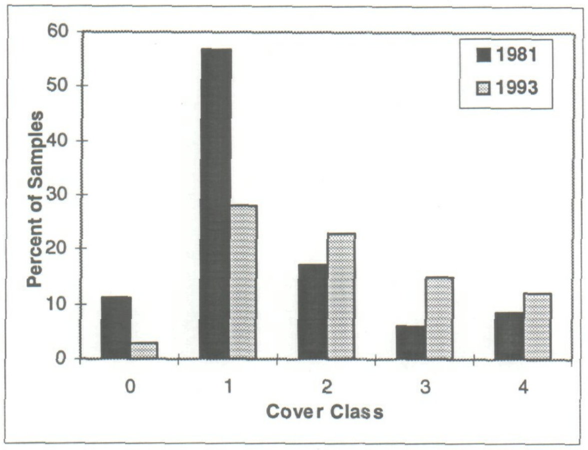

Figure 7. Change in frequency of willow cover classes, 1981–93 (stratum 2)

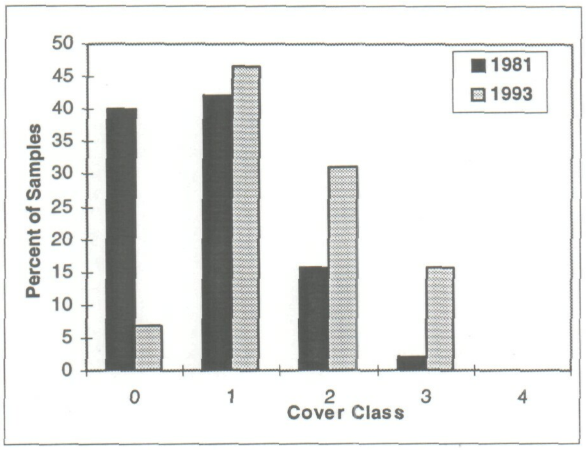

Figure 8. Change in frequency of willow cover classes, 1981–93 (stratum 3)

Increases also occurred in classes 1 and 2. No plots in this stratum were rated in class 4 in either 1981 or 1993. In spite of these changes, the median cover in stratum 3 remained in class 1.

Rate of Increase

The yearly rate of willow expansion shown by conventional mapping differed among the time periods. In the first 10 years, 1971 to 1981, willow expanded, on average, by 30.5 acres per year (3.24% rate of increase per year). Between 1981 and 1989, the average increase was 5.2 acres per year (0.42% rate of increase per year), and between 1989 and 1993 the average increase was 32.5 acres per year (2.52% rate of increase per year).

Photoplot data were obtained for only a single time interval, 1981 to 1993. Over that interval, photoplot samples in combined cover classes 3 and 4, which most closely match the dense willow documented by conventional mapping, increased from 32 to 58 of the 150 plots sampled (6.8% rate of increase per year) (Table B1). This rate of increase may be compared with an increase of 14.3 acres per year (1.15% rate of increase per year) detected over this same interval by mapping.

Spatial Pattern

Both conventional mapping and photoplot sampling yielded information on the spatial patterns of willow occurrence and change. Mapping showed that the greatest increases occurred along the southern edge of the study area, near SR 60 (Figures 2 and 4). Additional increases occurred adjacent to the southern end of L-77. With increasing distance into the study area, fewer changes in willow density were observed. In the northern half of the study area, no changes were observed over the entire time period from 1971 to 1993.

The pattern of expansion suggested by photoplot sampling and analysis using the GRID module of ARC/INFO was more complex and spread throughout the study area (Figures 9 and

Figure 9. Willow density surface, 1981. *Darker tones represent greater willow density.*

10). The subtraction of the density surfaces shows areas that had increases in willow cover between 1971 and 1993 (Figure 11). The spatial pattern of change illustrated by this method is somewhat different from that shown by conventional mapping. Not only does the zone of change along L-77 show up, but additional changes in willow cover throughout the study area are revealed. In addition, the analysis using the GRID module showed that, in areas mapped by conventional methods as dense willow, the number of samples rated as cover class 4 (dense willow) increased from 56.4% to 77.8% (Figure 12; Table B5). The incidence of all other cover classes decreased. In areas mapped by conventional methods as marsh, the numbers of sample cells in classes 2, 3, and 4 increased substantially, whereas the number of cells in the lower cover classes decreased (Figure 13; Table B6).

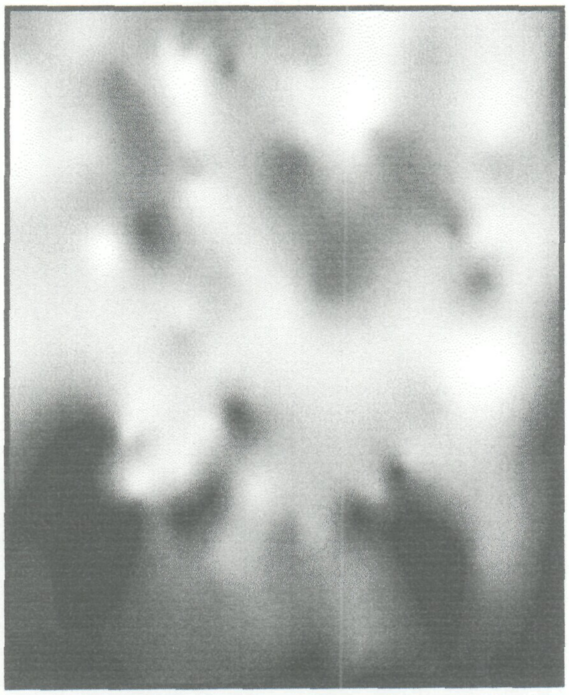

Figure 10. Willow density surface, 1993. *Darker tones represent greater willow density.*

Figure 11. Difference between 1981 and 1993 willow density surfaces. *Darker tones represent greater increases.*

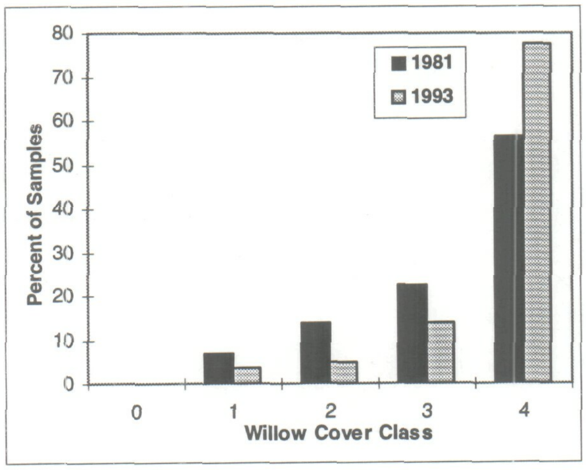

Figure 12. Photoplot samples in areas mapped as dense willow

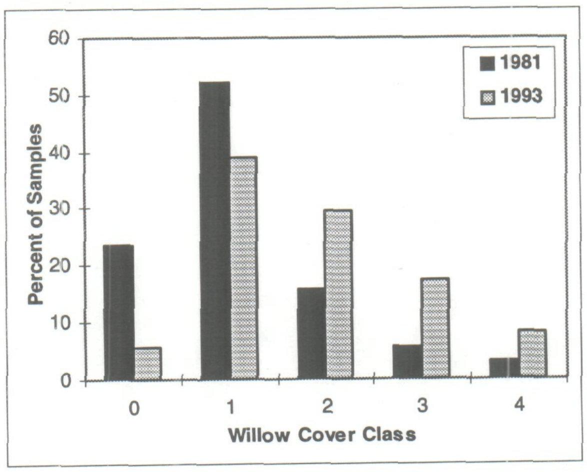

Figure 13. Photoplot samples in areas mapped as marsh

Field Checking

Of the 11 photoplots that were ground-truthed, 10 had been correctly categorized. In the single instance of error, buttonbush (*Cephalanthus occidentalis*) occurred at a density of about 25% and was tall enough to be mistaken for willow.

DISCUSSION AND CONCLUSIONS

Comparison of Methods

Mapping and photoplot sampling gave different results on the extent, rate, and pattern of willow expansion (Figure 14). Each method contributed to our understanding of these processes. Conventional mapping allowed mature, dense stands (≥ 50% cover) to be recognized and quantified for the entire study area but could not be used to quantify immature or mixed species stands. The supplemental use of photoplots, however, allowed these visible, but difficult to map, willow densities and patterns to be assessed.

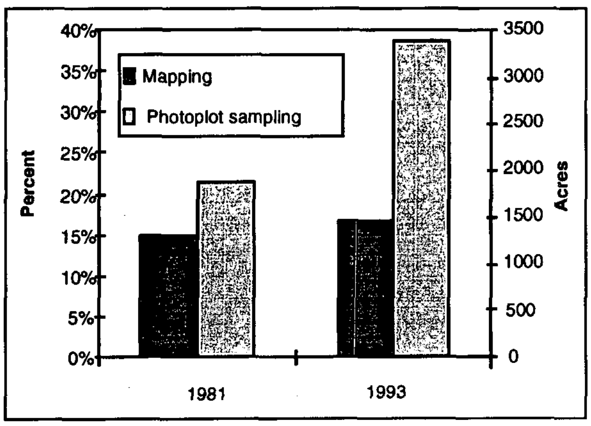

Figure 14. Comparison of mapping and photoplot sampling results, 1981–93 (cover classes 3 and 4)

Conventional mapping was used to accurately delimit areas of high willow density along the southern and eastern boundaries of the study area and also was successfully employed to detect small, dense willow heads throughout the study area. Changes over time in the extent of these well-defined willow concentrations were also well documented. However, mapping was insufficient at detecting less-dense willow classes or more subtle changes. For example, increases in willow density in stratum 3 were not detected and the increases in density within willow stands in stratum 1 were not quantified.

Photoplot sampling allowed low densities of willow to be detected and more subtle changes to be observed. With the use of the GRID module, information was obtained on the pattern of willow in low-density classes and on changes in these patterns. Photoplot sampling also enabled densities and changes in density of willow to be assessed. On the other hand, the spatial resolution of the results was poor. Fine-scale patterns were either missed or exaggerated. Although the stratified random design allowed statistical tests to be performed, systematic sampling would have been more efficient for discerning patterns. The two methods are complementary and should be used together for documenting the density, pattern, and spread of willow.

Expansion of Willow

An examination of the results of this study in the context of the life history requirements of willow suggests that willow expansion into new areas of the marsh occurs neither at a steady rate nor by a single mechanism. Expansion may occur both by enhanced seedling establishment and by increased survival and growth. Seedling establishment may increase following drought, fire, or physical disturbances (such as airboat damage or alligator activity), all of which create a favorable seedbed environment and reduce shade. These processes may be particularly effective in the spring when innumerable fresh seed have been released by previously established willows. For example, extended spring drawdown of slough areas may allow willows to become established in these normally flooded communities.

Forces affecting willow survival and growth include fire, water level, nutrient availability, and competition. The effects of fire are likely to be complex; depending upon the circumstances, fire may either suppress or promote willow growth. Fires occurring while the marsh is flooded will generally favor sawgrass or maidencane and suppress willow. Under dry conditions, willow seedling establishment may be enhanced by hot, springtime fires that kill competing vegetation at a time when willow seed is abundant and viable.

Although low water levels are necessary for willow seedling establishment, subsequent increase in levels may promote growth by reducing competition from other invasive species. On the other hand, prolonged high water levels may negatively impact healthy, mature willows.

Increased availability of nutrients is also very likely to be a major factor in willow expansion. The differences in the rates of change found by mapping and the spatial patterns found by both mapping and photoplot sampling support this hypothesis. The high rates of change found between 1971 and 1981 corresponded to the period when extensive improvements were made to SR 60. The second period of rapid expansion, 1989 to 1993, corresponded to the period during which L-78 and L-77 were constructed (1989–92). The areas where the disturbances occurred are adjacent to the areas of greatest willow density and of most rapid increase in willow. The disturbances may have increased nutrient availability by disturbing substrate and may have produced conditions more favorable to seed germination by altering marsh hydrology and exposing soil for seed colonization. The observed invasion of other weedy species, such as cattails, pennywort, hydrilla, and waterhyacinth, in areas near these disturbances is also compatible with this hypothesis.

The role of competition in the marsh remains poorly understood. Competition for both light and nutrients may be important throughout the life cycle of willow. Although willow and sawgrass are commonly found together, the decline of sawgrass may in some instances be a precondition for further willow establishment or for release of suppressed willows.

Although the short-term threat to the health of the marsh may be debated, there is broad consensus that when extended over the long term these changes become a matter of environmental concern. When willow exceeds 50% cover, sawgrass declines. The decline results in a loss of the fuel necessary for prescribed or natural fires. Without fire, more expensive methods of chemical or mechanical control are required for control of willow (S.R. Miller, pers. com.). Large-scale replacement of open herbaceous marsh by willow and eventually by other woody species would decrease habitat diversity. This change could lead to a decrease in the value of the marsh as a habitat for wildlife and to a loss of biodiversity. To address this environmental concern, further research efforts are needed to determine the cause of the expansion of willow. Additional efforts would include studies on the effects of fire, hydrological alterations, and nutrient enrichment. In addition, the biodiversity and habitat value of willow swamp and of other habitats in the Upper St. Johns River Basin need further investigation.

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APPENDIX A

Growth Ring Analysis

A small number of woody vegetation samples, including three willows, one wax myrtle (*Myrica cerifera*), and one buttonbush (*Cephalanthus occidentalis*), were collected from the study area. These samples were then cross-sectioned to investigate the feasibility of using tree ring analysis to assess the relative growth rates of woody plants in relation to distance from a disturbance or potential sources of nutrients.

From the woody vegetation samples, each species showed well-defined growth rings. The wax myrtle collected in stratum 3 was about 26 years old, indicating that a fire sufficiently hot to scar or kill had not occurred at that location in the study area since at least 1968. The buttonbush collected in stratum 2 was 26 years old and showed a clear fire scar at about 18 years of age (1986). Three willows showed varying size and incremental growth. The first, collected in stratum 3, was 1.75 inches in diameter, was estimated to be 10 years old, and had an average incremental growth of 0.175 inches per year. A second willow was collected from stratum 2. It was 1.5 inches in diameter, was estimated to be 10 years old, and showed an average incremental growth of 0.15 inches per year. The third willow was collected from the southeast corner of the study area near the levee, had a diameter of 4.5 inches, was estimated to be 13 years old, and showed an average incremental growth of 0.35 inches per year. None of the willows showed evidence of fire damage. Estimation of ages for the first two willows was hampered by the presence of numerous false rings. Although the results are inconclusive owing to the sparsity of data, the results do demonstrate the feasibility of using tree ring analysis as a means of investigating marsh processes from a historical perspective.

APPENDIX B

Changes in Frequency of Willow Cover Classes, 1981–93, Based on Photoplot Sampling

Table B1. Change in frequency of willow cover classes, 1981–93, all strata

Class	1981		1993		Change in Count	Change in Percent	Percent Change
	Count	Percent	Count	Percent			
0	29	19.3	7	4.7	-22	-14.6	-75.9
1	66	44.0	48	32.0	-18	-12.0	-27.3
2	23	15.3	37	24.7	14	9.4	60.9
3	13	8.7	25	16.7	12	8.0	92.3
4	19	12.7	33	22.0	14	9.3	73.7
Totals	150	100	150	100.1	0	0.1	

Table B2. Change in frequency of willow cover classes, 1981–93, stratum 1

Class	1981 Count	Percent	1993 Count	Percent	Change in Count	Change in Percent	Percent Change
0	1	4.2	0	0	-1	-4.2	-100.0
1	2	8.3	0	0	-2	-8.3	-100.0
2	2	8.3	0	0	-2	-8.3	-100.0
3	7	29.2	3	12.5	-4	-16.7	-57.1
4	12	50.0	21	87.5	9	37.5	75.0
Totals	24	100	24	100	0	0	

Table B3. Change in frequency of willow cover classes, 1981–93, stratum 2

Class	1981		1993		Change in Count	Change in Percent	Percent Change
	Count	Percent	Count	Percent			
0	9	11.1	3	3.7	-6	-7.4	-66.7
1	46	56.8	28	34.6	-18	-22.2	-39.1
2	14	17.3	23	28.4	9	11.1	64.3
3	5	6.2	15	18.5	10	12.3	200.0
4	7	8.6	12	14.8	5	6.2	71.4
Totals	81	100	81	100	0	0	

Table B4. Change in frequency of willow cover classes, 1981–93, stratum 3

Class	1981		1993		Change in Count	Change in Percent	Percent Change
	Count	Percent	Count	Percent			
0	18	40.0	3	6.7	-15	-33.3	-83.3
1	19	42.2	21	46.7	2	4.5	10.5
2	7	15.6	14	31.1	7	15.5	100.0
3	1	2.2	7	15.6	6	13.4	600.0
4	0	0	0	0	0	0	0
Totals	45	100	45	100.1	0	0.1	

Table B5. Change in frequency of willow cover classes in areas mapped as dense willow, 1981–93

Class	1981		1993		Change in Count	Change in Percent	Percent Change
	Count	Percent	Count	Percent			
0	17	0.2	0	0	-17	-0.2	-100.0
1	476	6.9	265	3.5	-211	-3.4	-44.3
2	962	13.9	366	4.8	-596	-9.1	-62.0
3	1,566	22.6	1,068	14.0	-498	-8.6	-31.8
4	3,908	56.4	5,933	77.7	2,025	21.3	51.8
Totals	6,929	100	7,632	100	703	0	

Table B6. Change in frequency of willow cover classes in areas mapped as marsh, 1981–93

Class	1981		1993		Change in Count	Change in Percent	Percent Change
	Count	Percent	Count	Percent			
0	7,407	23.5	1,792	5.8	-5,615	-17.7	-75.8
1	16,420	52.2	12,023	39.0	-4,397	-13.2	-26.8
2	4,926	15.6	9,106	29.6	4,180	14.0	84.9
3	1,762	5.6	5,332	17.3	3,570	11.7	202.6
4	956	3.0	2,515	8.1	1,559	5.1	163.1
Totals	31,471	99.9	30,768	99.8	-703	-0.1	

*The large counts in Tables B5 and B6 reflect subdivision of the original 2-acre photoplot samples into much smaller cells (0.008 acres) for GRID analysis.