TOMOKA RIVER and SPRUCE CREEK
Riparian Habitat Protection Zone

By

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P.O. Box 1439
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Under contract No. 94K353

October 31, 1995

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INTRODUCTION

Background

To address concerns over increased urbanization and its effect on the protection and maintenance of water quality and habitat for aquatic and wetland dependent wildlife species, the St. John's River Water Management District requested that The Center For Wetlands research current knowledge concerning Riparian Habitat Protection Zones (RHPZ) and their applicability to the Tomoka River and Spruce Creek, in Volusia County, Florida.

Past development within these watersheds has led to loss of habitat and fragmentation of remaining wildlands, decreases in diversity, and reductions in overall habitat quality. These changes have often occurred within upland communities very near or adjacent to the Tomoka and Spruce Creek stream channels or bordering riparian wetlands. Both the Tomoka and Spruce Creek rivers exhibit some undisturbed stretches along their water courses, intermingled with development. Yet, because of increasing urban growth pressures within the region, continued development, loss of habitat, and decline of aquatic resources may be expected. Data collected by the Volusia-Flagler Sierra Club (1989a, 1989b) in support of Outstanding Florida Water designations for the Tomoka River and Spruce Creek, point to two rivers with fair to good water quality and relatively intact faunal populations. Data developed in the course of this study show increasing development pressure, which can only mean further declines in habitat value and water quality.

Scope and Intent

The overall goal of this project was to assess the suitability of the Riparian Habitat Protection Zone (RHPZ) findings in Brown. et.al (1990b) to the Tomoka River and Spruce Creek watersheds in Volusia County, Florida. The project was originally organized into two tasks: (1) an updated literature review of the most current literature concerning RHPZ's and their application to the Tomoka and Spruce Creek rivers, and (2) an updated listing of aquatic and wetland dependent wildlife utilization of RHPZ's, most importantly, wildlife species within the Tomoka and Spruce Creek watersheds. In addition to the two tasks of literature review we have added a third task of evaluation and synthesis of existing conditions and regulations within the Tomoka River and Spruce Creek systems. This third task seemed appropriate since we believed that to make recommendations concerning the need and applicability of RHPZ's it was necessary to analyze existing conditions and future development pressures. To accomplish the third task, we reviewed current wetlands and buffer zone regulations, present and future land use, and existing land cover within each of the basins.

Organization of the Report

This report is organized to review the current literature concerning RHPZ's for aquatic and wetland dependent species protection, provide lists of supplemental species utilization, and make suggestions concerning the need and applicability of RHPZ's for water and wildlife protection in the Tomoka and Spruce Creek systems.

The first section of the report reviews the current literature concerning RHPZ's. First the section begins with a brief explanation of what RHPZ's are and explains the rational driving the need for RHPZ's and how they help solve problems created by developmental pressures. Finally, the current literature on RHPZ's is reviewed.

An updated species list of wildlife utilizing RHPZ's, especially those characteristic of the Tomoka River and Spruce Creek is given in the second section of the report. In addition to the wildlife lists, this second section includes a description of the ecological and hydrological resources of each of the watersheds, describing the resources of the Tomoka and Spruce Creek.

The final section of the report includes a review of land use regulations and Comprehensive Plan policies that relate to buffer zones or RHPZ's in each of three municipalities and two counties that have jurisdiction over parts of each of the river systems. In addition, current and future land use are evaluated, and land use and land cover were studied as they relate to the need for RHPZ's. The section ends with a discussion of the biotic and abiotic conditions of the watersheds, development pressures that exist as a result of present and future urban growth, and recommendations for RHPZ's that reflect existing conditions, future pressures, and resource needs.

Numerous maps were developed for the Tomoka River and Spruce Creek using Arc/Info software and coverages provided by the St. Johns River Water Management District's GIS section. These maps are included at the end of the report as fold out illustrations. The coverages of each of the watersheds were used to evaluate the land use and land cover in the areas immediately adjacent to the riparian zones of each of the rivers, and thus spatially evaluate the need for RHPZ's. Volusia County's future land use map was digitized and used to develop insight into where future conflicts between development and environmental protection might arise and thus where RHPZ's might be of particular importance.

Acknowledgements

Funding for this project were provided by the St. Johns River Water Management District. Ms. Carla Palmer, was project manager for the District. We wish to acknowledge the valuable contribution of the GIS section of the District by providing land use and land cover, and other coverages for the study areas. The Volusia County Growth Management Department, especially Ron Paradise, provided valuable dialog on the Volusia County Comprehensive Plan. The Volusia-Flagler Group of the Sierra Club compiled much data for the Tomoka River and Spruce Creek in their petitions for designation of the Tomoka and Spruce Creek as Outstanding Florida Waters. We have relied on their data for much of the descriptions of resources within the watersheds.

TASK 1: REVIEW OF RHPZ'S AND THEIR APPLICATION TO TOMOKA RIVER AND SPRUCE CREEK

Riparian Habitat Protection Zones

Lands immediately adjacent to and upland of wetlands are transition zones between wetlands and uplands. They are zones that are wetland at times and upland at times, exhibiting characteristics of each and vegetated by species that are found in each. They are important to both the wetland and the upland as seed reservoirs, as habitat for aquatic and wetland-dependent wildlife species, as refuges to wildlife species during high-water events, and as buffers to the extreme environmental conditions that result from sharp vegetated edges. When development activities occur in transition zones wetland-dependent wildlife species that are frequent users of these areas are excluded, silt laden surface waters are generated and cannot be filtered, and groundwater may be diverted or drained.

Recently, much attention has been given to the concept of vegetative buffers for wetland communities. In an earlier discussion of buffers, Jordan and Shisler (1986) posed several questions regarding buffers that should be researched. They conclude..."until the data are collected and the answers found, we are probably unreasonable to expect developers to adhere to buffer regulations." Their questions were:

1. How does the structure of a buffer (both vegetation type and buffer width) affect its ability to reduce disturbance to the wetland?
2. What use is being made of existing buffers by wildlife and what is the minimum buffer width necessary to maintain levels of use?
3. How do differing land uses and levels of development affect the feasibility of buffer zones?
4. What are the implications of topography and soil conditions [*on buffer effectiveness*]?
5. Are hardwood swamps, salt marshes, and freshwater marshes all equally amenable to protection by buffers?
6. Can large wetland systems be protected as readily by buffers as small, isolated systems?

Many of these questions have been addressed in recent research in Central Florida (Brown and Schaefer 1987, Brown et. al 1990a, and Brown et.al. 1990b). As a means of protecting the values and functions of wetlands, vegetative buffers have been proposed for the Wekiva (Brown and Schaefer 1987) and the Econ Rivers (Brown et.al. 1990b) and the wetlands of the East Central Florida Regional Planning Council (Brown et.al. 1990a). Numerous local initiatives have resulted from these studies.

We have attempted to review the recent literature (since 1990) to answer the questions posed by Jordan and Shisler (1986), paying particular attention to aquatic and wetland dependent wildlife. In addition we have paid particular attention to scientifically determined buffers and scientific studies that have established acceptable buffer widths. Castelle et.al (1994) reviewed wetland and stream buffer requirements finding that buffer size requirements have typically been established by political acceptability and not scientific merit. Their review was of the scientific functions of buffers, and they concluded that the need for buffers was real and that buffer widths were dependent on site specific conditions. In their search for buffer requirements, they found widths ranging from 3 meters to 200 meters, depending on conditions and functions required of the buffer. They suggested that a buffer of at least 15 meters was necessary to protect wetlands and water courses under most conditions.

Riparian Buffers and Water Quality

Probably one of the most studied functions of riparian buffers is their water quality improvement function, that is their ability to reduce nonpoint-source pollution. While sediments have been studied, and buffers shown to be effective in their trapping and removal, probably the most studied aspect is their nutrient removal function. Haycock and Pinay (1993) in Great Britain found removal efficiencies of 99% for nitrate in surficial groundwaters moving toward streams. They found that forested riparian buffers were better than planted grass buffers, and they postulated that above ground biomass of forested systems contributed more carbon to the soil microbial biomass that is engaged in NO_3 reduction.

Gilliam (1994) studied riparian buffers in the North Carolina Coastal Plain and reviewed the literature related to their water quality improvement functions. He concluded that numerous researchers have measured greater than 90% reductions in sediment and nitrate concentrations in water flowing through riparian buffers, but that riparian buffers were less effective for P removal, retaining only as much as 50% of the surface water P entering them. Measuring water quality improvement of riparian vegetated buffer strips in central Illinois, Osborne and Kovacic (1993) found that both forested and grass buffers were effective in removing nitrate nitrogen up to 90% in shallow groundwater. On an annual basis the forested buffer was more effective in reducing the concentrations than was the grass, but was less efficient at retaining total and dissolved phosphorus.

Riparian Buffers and Wildlife

There are few systematic studies of wildlife uses of riparian buffer zones. However, Triquett et.al (1990) studied song bird uses of riparian buffer strips in silvicultural landscapes concluding that buffer strips were necessary from continued survival of some species. On logged sites where a buffer strip of mature trees of 15 meters (50 feet) in width was maintained higher richness and diversity of birds were supported than on clear cut sites.

In a study of two watersheds in central Pennsylvania, an undisturbed reference one and a partially disturbed agricultural and residential one, Croonquist and Brooks (1993) found significant differences in bird usage and supported populations related to buffer widths along riparian corridors. Bird species richness and abundance generally decreased with distance from the stream in disturbed watersheds, but remained relatively constant through the reference watershed. While an impoverished bird community can exist in the vicinity of the riparian band immediately adjacent to the water with less than 10 meters (30 feet) of natural vegetation, sensitive species will not occur unless an undisturbed corridor of greater than 25 meters (82 feet) in width on each bank is present.

The habitat needs of aquatic and wetland dependent wildlife species are related to requirements for feeding, breeding, or nesting areas, and on sufficient solitude to carry out these life functions. The State of Washington, Department of Wildlife, Habitat Management Division (1992) has evaluated habitat needs for aquatic and wetland dependent species and determined that buffer dimensions need be 200 to 300 feet upland of the wetland edge. They concluded:

> To retain wetland dependent wildlife in important wildlife areas, buffers need retain plant structure for a minimum of 200-300 feet beyond the wetland. This is especially the case where open water is a component of the wetland or where the wetland has heavy use by migratory birds or provides feeding for heron. the size needed would depend upon disturbance from adjacent land use and resources involved.

Effects of Land Uses And Intensity of Development on Riparian Buffer Zones

Natural vegetated buffer zones of 91.4 meters (300 feet) were recommended by Nieswand et al (1990) for water supply reservoirs based on the need to protect these systems from nonpoint-source water pollution that results from increasing development. Taking this study further, Whipple, Jr. (1993) proposed a strategy to design a narrower buffer system that precluded development only along the reservoir itself, and a wider zone behind (up slope) the front buffer having special controls over nonpoint-source pollution imposed as a condition of development. The extent of the up slope buffer was determined by pollutant travel time in streams using the rational that as travel time increases, there is more in stream treatment of pollutants. To illustrate the methodology Whipple used an equation derived for pool and riffle flows and an acceptable travel time of 5 hours. His calculated up slope buffer width as 0.5 km from the reservoir edge, and extended as much as 4 km up tributaries to the reservoir. Calling this zone a "special control zone," he proposed that the controls on development would be required not only within the zone as mapped, but on developments delivering runoff by closed sewers through, or into the special control zone, since storm sewers do not reduce pollution to the same extent as runoff in natural channels.

That intensity of activity should have an impact on buffer size requirements makes intuitive sense, but little research has been conducted to verify this assumption. In earlier work, Shisler et al. (1987) analyzed 100 sites in coastal New Jersey, to determine the effect of human disturbance on wetlands. They found that the adjacent land use type accounted for much of the variation found in the level of human disturbance. Human disturbance within wetlands was highest adjacent to dense residential, commercial and industrial uses, and disturbance was inversely proportional to buffer width.

Topography, Soil Conditions, And Buffer Effectiveness

Several researches have argued that generic riparian buffer widths for dealing with sediment control are inappropriate, suggesting that they are over simplifications of complex processes. Factors that effect the efficiency of riparian buffers in reducing sediments are micro and macro topographic relief, density of vegetation, type of vegetation, litter characteristics, soil characteristics, incoming sediment type, subsurface drainage, and slope, as well as the temporal distribution of contributed sediment loads (Osborne and Kovacic, 1993). Indeed, earlier research on sediment trapping effectiveness of vegetated riparian buffers showed widths necessary for sediment removal of from 9 to 45 meters, where one of the main factors effecting width was topographic slope (Karr and Schlosser, 1977; and Gough, 1988).

Buffer Requirements of Different Wetland Types and Sizes

It seems plausible that different sized wetlands will have different resiliency to impacts from development activities in adjacent areas. Small wetlands, or thin bands of riparian habitat adjacent to a stream channel should be less resilient to developmental impacts. Smaller size should translate into lower "buffering capacity," that is, lower ability to absorb impacts and buffer their negative effects. Yet we have not found any literature, or scientific studies that have addressed these points.

For a riparian habitat protection zone to be effective, it should be sensitive to differences in wetland type, and spatial distances. For instance, wetlands have differing functions; and a RHPZ that addresses functional protection would vary its size depending on wetland types. In like manner, wetland size should affect RHPZ requirements. Small wetlands with lower buffering capacity, or thin riparian habitat adjacent to stream channels should have different buffer requirements than large wetlands or broad riparian habitats. It might be appropriate to tailor riparian habitat protection zone widths to the terrain, wetland type, and size of wetland. However, there are no detailed studies in the literature that would confirm these suppositions, nor research underway that can add to our body of knowledge concerning structure and function of riparian habitats of different types and sizes, and the impacts of development upon them. Without this work, all wetlands are treated the same and the tendency is for regulations to gloss over the differences in function and size by selecting a standard buffer width that is easy to apply.

There is a dearth of scientific analysis on the buffer requirements of differing wetland types and sizes in the literature. In our earlier work in Central Florida (Brown et al 1990a), we recommended buffer widths between 20 and 550 feet for wetlands of differing types. We developed methods for calculating buffer widths based on three aspects of wetlands: water quality, water quantity, and wildlife habitat. Using proposed development intensities and impacts, and soils, slope, and groundwater for a particular site, the methodology could be used to calculate buffer widths in a variety of circumstances based on the potential for groundwater draw down, and sediment transport. The range of buffer widths for protection against groundwater drawdown were from 20 feet to 550 feet, depending on site conditions and the intended development groundwater elevations. The range of buffer widths necessary for sedimentation control were from 75 to 375 feet, depending on particle size, slope, and vegetation of the buffer.

In addition, extensive evaluations of habitat requirements of aquatic and wetland dependent wildlife were compiled for 6 landscape associations. In landscapes typical of the Tomoka River and Spruce Creek, recommended buffer widths aquatic and wetland wildlife protection were between 322 and 550 feet for freshwater riverine systems and 322 feet for salt water (salt marsh) systems.

TASK 2: AQUATIC AND WETLAND RESOURCES OF THE TOMOKA RIVER AND SPRUCE CREEK

General Description of Tomoka River and Spruce Creek

The following discussion is based on reports by the Volusia-Flagler Group of the Sierra Club (VFSC 1989a,b), U.S. Geological Survey reports (Rutledge 1985, Simonds et al. 1980), and analysis of land cover maps provided by the St. Johns Water Management District.

Contained almost entirely within Volusia County, Florida, the watersheds of the Tomoka River (150 mi^2) and Spruce Creek (94 mi^2) drain into the Halifax "River". Figure 1 shows the drainage areas of both rivers and their locations within Volusia County and relationships to metropolitan areas. The drainage basins of both streams have been artificially increased, by drainage works that have connected previously isolated wetland areas. Lower reaches of both rivers are located in the geomorphic region known as the Silver Bluff Terrace, while upper portions of the basins originate in the Pamlico Terrace. The Atlantic Coastal Ridge forms the eastern divides of both basins, although artificial channels have created connections between the coastal towns and the northward flowing portions of both streams. The western boundary of both watersheds is formed primarily by the Rima Ridge. Both the northern boundary of the Tomoka River basin and the southern boundary of Spruce Creek basin are indeterminate, due to the flat, swampy topography of these areas.

Tomoka River

The Tomoka River is located in the northeastern portion of the county and runs parallel to the coast for more than half its distance before turning northeast and emptying into the Halifax River. The natural channel of the Tomoka River rises near the intersection of Interstate Highways 4 and 95, flows north for approximately 9 miles, then northeast approximately 7 miles to its confluence with the Halifax River estuary. The river is tidally influenced for up to 10 miles upstream from the Halifax River, making it important manatee habitat. Natural tributaries are the Little Tomoka River, Groover Branch, and Priest Branch--all of which have been modified to improve drainage--and Misners Branch and Thompsons Creek. Several drainage canals now drain into the river; Strickland Creek, Tiger Bay Canal, Thayer Canal, and the Lamoureaux canal which increase the total size of the drainage basin to its current size of 95,437 acres.

Topography of the drainage basin is generally flat contributing to poorly defined watershed boundaries. The basin is bound on its south western edge by the Rima Ridge at a height of 40-45 feet above mean sea level (msl). On the southeastern portion of the basin is the Atlantic Coast Ridge at an elevation of 30-35 msl. The river flows in the area between these two moderate ridges called the Pamlico Terrace. Two of the canals; Thayer and Tiger Bay, were constructed through such ridges to drain isolated wetlands. The same is true for the Lamoureaux Canal in the northern portion of the watershed whose topography is even more poorly defined.

The slope of the river is generally flat, however significant variation does occur from approximately 1 foot per mile near I-95 to 5 feet per mile north of 11th street. The flat and sandy nature of the watershed gives it a characteristically slow flow rate and slow response times to storm events. This flat slope also allows for the Tomoka River to be tidily influence up to 10 miles inland of the Halifax. The Tomoka River receives little surface runoff during most of the year. Most of the river flow is contributed via subsurface flow. Only during the rainy season from late July to October when water tables are typically at the surface does any appreciable amount of surface runoff occur. An obvious exception to this would be areas that have been urbanized and have a significant percentage of impervious surface area.

Lower reaches of the Tomoka River are characterized by extensive areas of salt marsh along its margin and coastal hardwood forest in the uplands immediately adjacent.. The remainder of the floodplain upstream from approximately river mile 3 consists of forested hardwood hammock, and various adjoining vegetative communities. From U.S. Highway 1 to I-95, sawgrass and other herbaceous communities are interspersed throughout the channelway and floodplain, bordered by live oak/sand pine communities. From I-95 to around 11th Street, live oak predominates in the adjoining uplands, while scrub oak/sand pine dominate in this zone further upstream.

Tiger Bay Canal joins the large Tiger Bay swamp to the southwest portion of the basin. This area is mainly forested wetland and marsh, with adjoining areas of upland forest, agriculture, and pine plantations. The western portion of the basin, between U.S. Highway 92 and the Little Tomoka River, is primarily pine plantations and the extensive Bennet Swamp forested wetland. The latter is connected to the drainage basin by Thayer Canal. The area north of the Little Tomoka and the lower (northern) Tomoka rivers is a more heterogeneous mix of natural forest, agriculture, and urban land. Much of the eastern basin is highly developed.

Spruce Creek

The Spruce Creek drainage basin (approx. 71,347 acres) is located in the southeast portion of Volusia county immediately south of the Tomoka watershed. Of the two drainage basins Spruce Creek has the largest percent of area that is urbanized. The southern half of the watershed is drained by the Samsula Canal. This canal and its network of contributing canals flow north joining the creek south of where it makes a wide sweeping turn to the east a which point it becomes tidily influenced. Spruce creek is joined at Strickland Bay with Turnbull Creek, a major tributary from the south.

The topography of the spruce creek drainage basin is relatively flat. The highest elevation of the creek at its headwaters is 27 feet above mean sea level (msl). The western boundary is formed by the Atlantic Coast Sand Ridge and is bound on the east by the Rima Ridge. The creek eventually flows through a section of the Rima Ridge as it turns to the east. Slope of the creek averages about 1.4 feet per mile, typical of many of Florida's streams and rivers. Due to the low topography of the area, stream flow is tidily influenced approximately 10 miles upstream from Strickland Bay. A combination of the creek's low relief and small watershed translates into a relatively small volume of runoff and discharge, but discharge can vary greatly with seasonal differences in rainfall and isolated storm events. Base flow is as small as 1.0 cubic feet per second (cfs) and can peak at 500 cfs. Velocities have similar variability from about 0.1 to 3.0 feet per second (fps).

The natural channel of Spruce Creek rises around State Road 40A, and flows north then east to Strickland Bay in the Halifax River. The natural channel has been significantly extended to the south by the Samsula canal, which provides substantial drainage of the southern, headwaters area of the basin. This area is comprised of extensive forested wetlands and large areas of pine plantations. The middle portion of the basin has extensive areas of agricultural and urban uses adjoining the creek, with interspersed forest, pasture, and pine plantations along the western side. The eastern parts of the basin, along the coastal ridge and the Halifax River, are heavily urbanized, including the areas adjoining Turnbull Creek. The channelway of Spruce Creek, from Strickland Bay upstream to I-95, is characterized by extensive areas of herbaceous marsh, dominated by salt marsh with fringing needle rush. Live oak hammocks adjoin these areas landward. Further upstream, swamp hammock communities dominate the floodplains of the creek, similar to those found along the Tomoka River. Upper reaches of the 18 mile long Spruce Creek have been designated a Florida Canoe Trail.

Ecological Resources of Tomoka River and Spruce Creek

Numerous plant communities exist along the length of the Tomoka River and Spruce Creek (see Maps #1 and #2). Plant communities are the biotic result of differing sets of physical parameters such as soil type, soil moisture, and burn frequency. Generally soil moisture regimes of the landscape for both of the drainage basins can be subdivided into Xeric, Mesic, and Hydric classifications based on the persisting soil moisture. These in turn can been subdivided into different community types that are defined by dominate vegetation. Excellent descriptions of dominant plant communities of Tomoka River and Spruce Creek, including lists of dominant species can be found in two volumes by the Volusia-Flagler Group of the Sierra Club petitioning for designation of the Tomoka and Spruce Creek as Outstanding Florida Waters (Volusia-Flagler Sierra Group 1989a, 1989b).

Xeric areas are found in association with sandy soils and are adapted to dry conditions which persist for most of the year with the possible exception of the rainy season. The Xeric communities described by the Volusia-Flagler Sierra Group (1989a, 1989b) that are of importance to the two river systems are as follows: (1) Maritime systems, which have **Coastal Scrub Communities**, and (2) Sand Hill/Sand Ridge areas bordering the rivers which have **Pine/Xeric Oak, Sand Pine/Scrub Oak, Xeric Oak, Live Oak/Scrub**, and **Live Oak/Sand Pine** communities. Areas of xeric communities are found in the lower reaches of the Tomoka River between I-95 and US 1, occurring immediately adjacent and upland of the riparian zone of swamp hardwoods. There appears to be an area of Live Oak/Scrub Oak bordering the Spruce Creek riparian swamp hammock in the vicinity of Airport Road. An area of Sand Pine/Scrub oak exists along the northern shore of Spruce Creek bordering the riparian marsh community about 3/4 of a mile east of I-95.

Mesic communities are those areas that have water tables below the soil surface but are less well drained than the Xeric communities. Mesic conditions are caused by topographical location and water retention capabilities of the soil. They are often located as a transition area between Xeric uplands and wetlands, and often result in fire exclusion. Mesic communities described by the Volusia-Flagler Sierra Group (1989a, 1989b) that are of importance to the two streams include: **Live Oak Community, Live Oak/Slash Pine**, and **Pinelands (or Pine flatwoods)** communities.

Pine Flatwoods are dominated by slash pine which is adapted to live under dry conditions as well as areas that may experience extended wet periods during the rainy season. The pine flatwoods are an upland system that can be found growing almost to the banks of Spruce Creek just east of the rail road tracks that cross Strickland Bay. Extensive areas of pinelands (or former pinelands that are now in silvicultural uses) are found throughout the headwaters of the Tomoka River, and in the mid-reaches of the Spruce Creek surrounding I-95. For the most part, in these middle reaches the pinelands are not adjacent to riparian wetlands but are found landward of bordering mesic hardwoods such as the Live Oak community, or Live Oak /Slash Pine Community.

The mesic hammocks (Live Oak community, or Live Oak /Slash Pine Community) form an important continuum with the riparian wetlands of the two rivers. Much of the lands immediately adjacent to the riparian wetlands that remain undeveloped in the mid and lower reaches of both rivers, are dominated by mesic hammocks.

Along the lower extremes of the mesic hammocks where elevation is low and soil moisture is high, but where soils are never inundated, hydric hammocks occur. Soils are saturated for much of the year and the diversity of vegetation is very high. These hammocks may form a relatively narrow band between mesic uplands and riparian wetlands or they may by quite wide where sand hill soils may contribute seepage to maintain high ground water tables.

Wetland areas within the drainage basins of the Tomoka River and Spruce Creek are highly variable. There are depressional marshes and swamps communities such as; **Wet Prairies, Inland Ponds, Bay Swamps, Cypress Swamps,** and **Mixed Wetland Hardwoods.** Other community types are only found along the floodplain of the rivers such as; **Freshwater Marsh, Salt Marsh, Mangroves,** and **Bottomland Hardwood Swamps.** The following floodplain communities are those that have been identified along the banks of the two waterways.

Bottomland Hardwood Swamp Communities are found along the water ways of both systems inland from areas influenced by salt water. They are situated along the banks in what are permanently or semi-permanently saturated soil conditions. At times where topographic relief is higher, the hardwood swamp communities may be relatively narrow in expanse, in other areas where topography is relatively flat, the riparian hardwood swamps may form a wide band bordering the rivers, as much as 1/4 mile across.

Marsh wetlands dominate the channelways of both rivers in their lower reaches. **Needlerush marsh communities** are found within the brackish water interface between the fresh water flowing to the coast and the tide water flowing in from the Halifax River. **Sawgrass communities** are found in both watersheds and are located along the upland edge of saltmarsh communities where the water is relatively fresh. The **salt marsh community** is found along the lower, saline influenced portions of both Spruce Creek and the Tomoka River. Mangroves can be found in the Halifax River and bordering the lowest portions of both rivers.

The mangroves are relatively small here as a result of killing winter freezes that often naturally prune trees back. Spartina often co-dominates during periods when the trees are reestablishing.

Hydrological Resources of the Tomoka River and Spruce Creek

Tomoka River

The quality of water in the Tomoka River was considered fair to good from the upper reaches of the river to its outflow into the Halifax River by the Volusia-Flagler Sierra Club (1989b). All of the tributaries and channels were also characterized as having fair water quality conditions and no contributing stream or channel was identified as causing a notable decrease in the over all quality of water in the Tomoka River. Nonpoint pollutant sources comprised the bulk of inputs to the Tomoka, with agricultural sources dominating the western portions of the river and urban sources dominating the eastern portions. There was one point source, Volusia County's Tomoka Farms Road Landfill that discharged into the headwaters of the Tomoka, but only during extreme rainfall events.

Water quality problems in the Tomoka consisted of two parameters: low dissolved oxygen (DO) and relatively moderate phosphorous concentrations. The Tomoka River is one of Florida's many black water rivers. As with most blank water rivers the Tomoka has high concentrations of dissolved organic matter and tanins that color water and result in low (DO) levels.

Dissolved oxygen concentrations (according to 1985 FDER data as reported by the Volusia-Flagler Sierra Club [1989b]) appeared to be about 3 to 4 mg/l throughout the length of the Tomoka, with a slight tendency for higher DO's at its confluence with the Halafax River. The dark water color, and narrowness of the headwaters, as well as the wetland source of much of the surface water in the river, are most likely the causes for these low DO concentrations.

Phosphorus concentrations in the Tomoka overall are appear to be within normal ranges for rivers draining pine flatwoods and relic dunes of the coastal plain. In 1985 total phosphorus concentrations in the river ranged from about 0.03 to 0.11 mg/l, with highest concentrations at it confluence with the Halifax and successively lower concentrations as one moves toward the headwaters.

Overall the water quality in the Tomoka River when discussed by the Volusia-Flagler Sierra Club (1989b) was fair to excellent depending on its characterization by chemistry or biological parameters. Water quality was fair at most locations when chemical parameters were used to judge condition, and good to excellent when biological parameters were used.

Spruce Creek

Numerous sampling stations under a variety of sampling efforts spanning 10 years have been established along the Spruce Creek system. Water quality in Spruce Creek is generally good. There are no direct point source discharges along the creek that might lead to serious water quality degradation. Threats to water quality exist in the form of urban development and agricultural uses within the watershed giving rise to non point source surface discharge. Much of the new development in Port Orange and other areas of development within the basin are required to maintain storm water retention facilities which in addition to lowering peak discharges during storm events, reduce sediment loads and to a lesser extent some of the other pollutants that accompany urban storm runoff. This, however, is not the case for the agricultural and pasture land in the southern portion of the watershed.

The dissolved oxygen (DO) values for the creek were generally below the 5 mg/l standard set by the state for Class III waters. This is most likely due to naturally occurring conditions not anthropogenic causes. The Spruce Creek is a black water system (water color in Spruce Creek was measured to be between 250 and 500 units). Black water is the result of organic compounds leeching from decaying organic matter that has accumulated in uplands and wetlands boarding the creek and that is carried into the river via ground waters. Black water rivers often have lower dissolved oxygen concentrations as a result of low light penetration and high biochemical oxygen demand (BOD). Waters flowing from wetland ecosystems are often low in dissolved oxygen as a result of decomposition within wetlands.

Nitrogen and Phosphorous were measured in the Spruce Creek but were not excessively high. Concentrations were high enough to cause algae growth and potential problems, however, it was assumed that low light conditions (resulting from the narrow river channel and dark water) significantly reduced algae growth. Phosphorus levels were extremely variable and were generally higher toward the coast. The highest levels of nitrogen were found in the Samsula Canal which receives water from upland pastures.

Coliform bacterial measured during the sampling periods exhibited unusually high numbers in the big bend area of the creek up into the Samsula Canal but decreased in the most remote sample stations in the canal. The types of bacteria found were of animal origin presumably from pastures and not from urban sewage. Bacterial counts dropped dramatically upon entering the larger, brackish waters of Turnbull and Strickland Bay.

The following summary of water quality for Spruce Creek was given by the Volusia-Flagler Sierra Club (1989b):

> As a whole, the present water quality in the Spruce Creek watershed may be generally characterized as having moderate to low biodegradable organic content, high color, very low dissolved oxygen, moderate to high nitrogen and phosphorus levels, and very high bacteriological counts. It is difficult to firmly establish whether the overall poor quality is relative mainly to man-made situations or to natural factors....Although they [land areas within the basin] cannot be considered to all be in their original natural state, the direct influence of man should be very minor. Under these conditions, it is entirely possible that the undesirable water quality results primarily from natural factors...

Wildlife Resources of the Tomoka River and Spruce Creek

Wildlife resources of the Tomoka River and Spruce Creek are given in Tables 1 through 4. The data in Tables 1 and 2 were taken from Volusia-Flagler Sierra Club (1989a and 1989b). A total of 59 species of fish, 17 crustaceans, 12 mollusks, 8 worms, 9 reptiles, 6 amphibians, 9 mammals, and 40 birds were found within the Tomoka and Spruce creek systems by the Volusia-Flagler Sierra Club. Habitat needs of the various species of land animals are given in Table 1 and widths of land needed by each species (assuming the presence of a river edge) are given in the last column. These data were summarized from Brown et al (1990a)

Table 3 lists rare and endangered faunal species that may occur within the Tomoka River and Spruce Creek watersheds. The listed status is given in the third column and whether they occur within the watersheds is indicated with a star in the fourth column, under the heading "Occ". Habitat needs of each species are given in the fifth column. Table 4 lists rare and endangered plant species that may occur within the Tomoka River and Spruce Creek watersheds. Data for Tables 3 and 4 were taken from Florida Natural Areas Inventory (1995).

TASK 3: RELEVANT REGULATIONS, POLICIES, AND LAND USE OF THE TOMOKA RIVER AND SPRUCE CREEK

Regulatory Framework and Existing Buffers

There are five local governmental entities (2 counties, and 3 municipalities) that have some jurisdiction over portions of both the Tomoka and Spruce Creeks. The Tomoka has portions of its watershed in southern Flagler county, as well as large portions of the river in unincorporated Volusia County. In its mid-reach, the Tomoka River flows through lands recently annexed by the city of Daytona Beach. Nearer the confluence with the Halifax River, the Tomoka flows through the city of Ormond Beach. Spruce Creek originates in unincorporated Volusia County and flows through the City of Daytona Beach and Port Orange.

The following are policies, regulations, and development guidelines of the various governmental entities that have some jurisdiction over the rivers.

Volusia County

Land Use Regulations

The 1990 Volusia County Comprehensive Plan, and updates there after, provide for several important policies and criteria that affect land use and urban development within the Tomoka River and Spruce Creek. The Comprehensive Plan provides for: (1) a Natural Resource Management Area, an overlay district that limits development; (2) Environmental Systems Corridors, areas where development shall be limited to conservation, silviculture using Best Management Practices and large residential lots with limits on clearing; (3) Forestry zones, (4) Low Impact Urban areas, lands within NRMA's that are determined to be suitable for development, and (5) Conservation areas. Each of these districts or zoning classifications affect the need for buffers, since wetlands and water courses are protected within each category to greater or lessor degrees.

Natural Resource Management Areas are set aside for the maintenance of ecologically sensitive areas. It is the intention of this land use category to maintain large tracts of land as part of a landscape system with continuous and interactive parts. Areas designated as NRMA include; the central pine flatwood and cypress swamp area, Turnbull Basin (from Highway 442 south), the headwaters of Tomoka River and Spruce Creek, immediate drainage basins of the Tomoka Basin, Mosquito Lagoon/Indian River and Strickland Bay, and the St. Johns River flood plain. Three special use areas have been designated as compatible with NRMA's, these include: Environmental Systems Corridors, Forestry, and Low Impact Urban.

Environmental Systems Corridors are important ecological corridors containing sensitive or rare habitats. Some land development is allowed under this classification. The principal uses and structures permitted are; apiaries, aquatic preserves, aviaries, utility services, excavations covered by section 817.00 or article III of the Land Development Code, fire stations, fishing, hunting, wildlife management, hobby breeders, musical events, pasture, public schools, public parks and recreation areas, public water supply wells, silviculture, single family and manufactured dwellings on a minimum of 25 acres with vegetation clearance not exceeding 20% and principle or accessory building not exceeding 10% of the total area.

Forestry resources or silviculture is seen as a multiple land use activity. It provides not only for economic activity but recreational, wildlife, reduction of storm water runoff, and ground water recharge also. Silviculture is exempt from buffer requirements. Instead, it is suggested that silvicultural operations adhere to practices outlined in the Silviculture Best Management Practices Manual (Florida Department of Agriculture and Consumer Services, 1979). The manual provides for a 35 foot permanent stream side management zone (SMZ) and a secondary upland buffer. This secondary SMZ is highly discretionary and is based on a site sensitivity index. Site sensitivity is a function of soil erode-ability and percent slope. The secondary boundary is not required to be maintained in its natural condition. Clear cutting is allowed for nonsensitive sites while selective cutting is allowed in other more sensitive areas. Buffer zones for silviculture are designed solely for water quality and no consideration is given for the maintenance of wildlife. Once established some activities are discouraged within the secondary zone such as mechanical preparation, fertilization, herbicide and pesticide use, and use as a log gathering and loading area. Residential use may also be allowed in Forestry areas. Density of dwelling should not exceed one unit per 20 acres but development of smaller lot sizes at a density of 1 unit per 5 acres may be permitted if consistent with the intent of the NRMA.

Low Impact Urban are lands within the NRMA which are determined to be suitable for urban type development, and are adjacent to existing urban development, may be designated as a Low Impact Urban Zone category. Any land use considered to be urban may be permitted within this zone, but shall comply with standards consistent with the provisions of the NRMA. The standards shall include, at minimum: a requirement to be serviced by central utilities, designation of at least 50% of lands as open space preservation as provided for in Land Development Code to preserve upland habitat sited in an ecologically strategic manner (e.g. adjacent to wetlands); and clustering of residential dwelling units. The gross residential density for such areas shall not exceed 1 dwelling per unit acre but net density may exceed that to facilitate clustering of dwellings.

For the most part, areas designated as Conservation on the Future Land Use Map are areas in public ownership. As a result, there is little need for wetlands buffering within lands that are designated as conservation. Development at densities that may adversely affect riparian wildlife, water quality or quantity are highly unlikely.

Buffer Zone Requirements

Natural Buffer Zones or setbacks are required landward of wetlands occurring in unincorporated Volusia County. Within NRMA's the buffer zone has a minimum width of 50 feet from the wetland/upland edge, and could be more depending on site specific conditions. Determination of buffer widths greater than 50 feet use the following criteria: soil erode-ability; cover and type of vegetation, slope, water table depths, water quality, wildlife, and protective status of the receiving waters. In practice, for the majority of situations, the minimum 50 feet buffer zone is used. Natural buffer zones shall consist of intact natural vegetative species in the overstory, shrub and understory layer. Activities within the natural buffer zone are limited to those which are shown to be consistent with the intended use of the zone while providing for reasonable access to water bodies

Wetlands which are hydrologically connected to a surface water body, and not located within the NRMA, require a natural buffer zone of 25 feet.

Flagler County

Flagler County is located to the north of Volusia County. A small portion of the Tomoka River watershed extends into the south east corner of the county. The county is typically rural with more that half of its approximately 11,000 residents living in unincorporated areas.

Land Use Regulations

Lands within Flagler County that are within the Tomoka watershed are classified as General Rural, Agricultural Pursuits and Timberlands. As the name implies these lands are designated as appropriate locations for agricultural activities and forestry operations. Allowable housing densities within this land use designation are 1 unit to 5 acres (under special application) and 1 unit per 20 acres (general provision for all lands in this classification)

Buffer Zone Requirements

Flagler County's definition for a buffers is as follows: upland areas adjacent to wetlands which are necessary to protect the wetland and wetland dependant species from the detrimental impacts of development or alteration. The buffer shall include canopy, understory and groundcover which consists of preserved existing vegetation or planted native species where there is no existing vegetation.

The buffer zone requirements are similar to those found in unincorporated areas outside of NRMA's in Volusia County. Flagler County requires a buffer of no less than 25 feet adjacent to and surrounding all wetlands. The buffer may coincide with the setback on a lot under the Zoning article in effect in Flagler County or may coincide with wildlife corridors designated tn Flagler County's Comprehensive Plan.

Silvicultural operations near wetlands whether connected to surface water bodies or isolated are to be managed according to the Best Management Practices(BMP) as described in the Silviculture Best Management Practices Manual, published by the Florida Department of Agriculture and consumer Services, Division of Forestry.

City of Port Orange

Port Orange boarders the Spruce Creek for approximately 2 miles. It is located on both sides of I - 95 and to the north and south of the creek. The heaviest development occurs in the north east portion of the city limits and consists mainly of planned communities and downtown shopping districts. Scattered low density housing and two small planned communities occur on either side of I - 95 in the north western quadrant of the city. Much of the development on the north side of the creek occurs immediately adjacent the creek itself. There is little development along the southern boundary of the creek.

As of the 1993 Port Orange Land Development Code, wetland buffer zones of not less than 25 feet are required for all areas adjacent to and surrounding wetlands. An additional 10 foot upland buffer is required in which no structure shall be allowed, and a 20 foot buffer must be maintained from the back edge of any single family or duplex units. Construction within the buffer such as the creation of trails, decks, or catwalks cannot significantly impact the area. Allowable maintenance activities and vegetation types are regulated by the same guidelines put fourth by the county.

Ormond Beach

Ormond Beach city limits cover 3 miles of the river between US 1 and I - 95 and extend from I - 95 to the west on the north side of the Little Tomoka River. The land area lying between the two interstates is heavily developed with residential uses on the south side of the river, while the north side has lower development densities. The Ormond Beach Municipal Airport is located along the north side of the River. Another area of heavy residential development is clustered along the Groover Branch tributary.

The 1994 Ormond Beach Land Development Code, Article XII - Resource Protection, calls for the preservation of all natural vegetation occurring adjacent to surface water bodies and the protection of riparian areas from developmental practices. The surface waters and marine life habitat portion of the rules requires a setback of a minimum of 120 feet from the mean high water mark or 50 feet from the upland/wetland interface line, whichever is greater for the Tomoka and Little Tomoka Rivers. Setbacks of a minimum of 60 feet from the high water mark or 50 feet from the upland/wetland interface is required for the mosquito control ditches; Strickland, Dodson's, Thompson's Creek, Misner's and Groover's Branches. Any reductions in the wetland/upland setback area will be required to conform to the following criteria:

(a) The proposed development shall be connected to a central water and sewer system.

(b) The proposed development shall not adversely impact the hydroperiod and other functioning values of the adjacent wetland as determined by review of a Wetland Management Plan.

(c) The proposed development shall provide one-to-one mitigation for reductions in the setback requirements stated in paragraph b above, by enhancing the functioning values of the on-site upland and wetland buffer areas.

The management and maintenance of setback requirements or buffer zones has similar restriction as the county. Indigenous vegetation is to be left undisturbed except for the removal of exotic species or dead debris that may pose some public threat. Some selective clearing may be done to provide access way to water bodies. Selective thinning of the underbrush may occur provided the area does not exceed 20% of the wetland site or 30 feet whichever is less. Any development in the setback area is required to replant disturbed areas. Restoration plans must be submitted to the Park's Director for approval. Wetlands are differentially protected within the city of Ormond Beach. Wetlands are subdivided into four different Classes which have there own different set of standards. The only wetland type of interest to this report is their Class 1 wetlands. Class I wetlands include hydrologically connected riparian flood plain bottom land hardwood hammocks; salt marshes; freshwater marshes; connected bay, gum swamps or other swamp hardwoods. Upland buffer zones of not less than 50 feet or greater than 100 feet are required landward of the upland/wetland interface and activities shall be limited to those described in the setback management requirements described above.

Daytona Beach

Daytona Beach is located on the central east coast of the county. Development occurs at high densities on the land area immediately adjacent to the coast. Daytona Beach has recently incorporated a large area of undeveloped land to it's west, which extends past I - 95 to 11th Street and overlaps the Tomoka River by 3.5 to 3.75 miles.

Daytona Beach has similar buffer requirements to those of Volusia County's non-NRMA wetlands. The city requires a minimum buffer zone of 25 feet for all wetlands. Performance and maintenance standards vary little from those of Volusia County.

Summary of Buffer Zone Requirements

Maps #3 and #4 summarize the buffer zone requirements of the various governmental jurisdictions for both the Tomoka and Spruce creeks. Most of the lower reaches of the Tomoka River have a 50 feet buffer zone requirements, while mid-reaches of the river require a 25 feet buffer. The opposite is true in the Spruce Creek basin. A 25 feet buffer is required in the lower reaches , while the upper reaches are dominated by a 50 feet buffer zone. The following table summarizes buffer zone requirements by governmental jurisdiction:

Buffer Zone Requirements

Governmental Unit	Buffer Zone Requirement
Volusia County	
Wetlands Within NRMA's	50 feet minimum from upland/wetland edge
Wetlands Outside NRMA's	25 feet from upland/wetland edge
Outstanding Waters	50 feet minimum from upland/wetland edge
Flagler County	
All Wetlands	25 feet from upland/wetland edge
Port Orange	
All Wetlands	25 feet from upland/wetland edge
Ormond Beach	
Tomoka and Little Tomoka	50 feet from upland/wetland edge or 120 feet from mean high water line, whichever is greater
Tributaries to Tomoka	50 feet from upland/wetland edge or 60 feet from mean high water line, whichever is greater
Daytona Beach	
All Wetlands	25 feet from upland/wetland edge

Current Land Use in the Tomoka River Watershed

Current land use/land cover for the Tomoka River basin (1992) was obtained from the St. Johns River Water Management District are is given in Map #1. For convenience of analysis and presentation, the watershed was divided into 5 subsections: Tomoka River estuary, Lower Tomoka River, Upper Tomoka River, Little Tomoka River, and Groover Branch (see Figure 2). Land use immediately upland of the river floodplain wetland system (called interface zone) was analyzed using GIS technology.

The relative areas of land use/land cover of the interface zone are given as pie diagrams for the sub-basins in Figure 3 and for the Tomoka River, as a whole, in Figure 4 . Land use and land cover categories were summarized into three classes: natural, agricultural and urban lands. For the purposes of this summary, pine forest plantations were included in the natural lands category. Pine forest plantations accounted for about 2% of the natural lands category.

Each of the various sub-basins had differing percentages of the interface zone in each of the land uses categories; reflecting development trends in the county. Tomoka River estuary had only about 22% of the interface zone in urban land uses and about 78% in natural cover. The lower Tomoka had about 44% of the interface zone in urban uses and about 54% in natural cover. Agriculture accounted for only 1.4% of the interface zone in the lower Tomoka sub-basin. The upper Tomoka sub-basin had nearly 73% of the interface zone in natural cover, about 22% in agricultural uses, and about 5% in urban uses.

The two main tributaries to the Tomoka River had very different land cover in the interface zone. Groover Branch interface zone was dominated by 64% urban land uses, 20% natural cover and about 16% agricultural uses. The Little Tomoka River was more equal in its distribution of land cover, having about 40% agricultural uses and about 30% each in urban and natural cover.

In summary, the Tomoka River had nearly 77% of the land immediately adjacent to its floodplain wetlands system in a natural cover. About 23% of the interface zone was in urban uses, while less than 1% was in agricultural uses. The bulk of the interface zone that was in natural cover was in the upper Tomoka River sub-basin; while that dominated by urban uses was in the lower Tomoka and Groover Branch sub-basins.

A relatively large section of the middle Tomoka River west of I-95 and north of highway 92 was recently annexed into the City of Daytona Beach. Presumably development plans are underway, although the most recent Volusia County Future Land Use Map designated the area as Planned Development. The majority of the interface zone in this portion of the River is dominated by natural cover.

Current Land Use in the Spruce Creek Watershed

As in the Tomoka River Basin, the Spruce Creek was divided into 4 sub-basins for ease of presentation: Lower Spruce Creek, Spruce Creek Channel, Spruce Creek Slough, and Turnbull Creek (see Figure 5). A map of land use/land cover for the basins is given as Map #2. Levels of development within the interface zone varied between sub-basins (see Figures 6 and 7). About 70% of the interface zone of lower Spruce Creek was in natural cover while 30% was in urban uses (most of which was along the northern rivers edge. Here, the river channel is dominated by salt marsh and is relatively close to uplands.

In the mid reaches of the Spruce Creek (Spruce Creek Channel) nearly 50% of the interface zone was dominated by urban uses, stretching along both sides of the river. About 32% of the interface zone was in natural cover, and about 19% was in agricultural uses. In the upper reaches (Spruce Creek Slough) the creek's interface zone was dominated by agricultural uses (almost 82%). In this region, natural cover in the interface zone was about 15% of total, and urban uses were only about 3%. Turnbull Creek's interface zone was over 64% urban and about 35% natural cover. Agricultural uses accounted for less than 1% of the total interface zone.

In summary, the interface zone of Spruce Creek had greater proportion of urban uses than did the Tomoka River (Figure 7). Overall, 47% of the interface zone of the Creek was in urban uses, 43.3% was in natural cover, and 9.6% was in agricultural uses. The largest contiguous area of natural cover in the interface zone was along the southern edge of the Creek surrounding I-95 and eastward to Turnbull Creek.

Existing Cover and Future Land Use

Maps #5 and #6 overlay 1992 land use land cover with future land use provided by the Volusia County Planning and Zoning Department for the Tomoka River and Spruce Creek basins. The Tomoka River basin is given in Map #5. Most of the lower reaches of the Tomoka east of I-95 are depicted as "City". This area corresponds, relatively, to the Tomoka River Estuary section and portions of the Lower Tomoka River section (Figure 2). The river corridor of Grover Branch is designated "conservation". Much of the mid-reaches of the Tomoka are designated as "Conservation" surrounded by "Low Impact Urban" . The upper reaches of the Tomoka are dominated by "City" (north of US 92 and west of I-95), with the area between US 92 and I-4 designated as "Activity Center". The river corridor in this area appears to be designated as "Conservation" and extends south of I-4.

Future land use of the Spruce Creek basin is given in Map #6. The vast majority of river corridor in the mid and upper reaches of the Spruce Creek is designated "Conservation" surrounded by "Agricultural Resource" in the upper reaches, and mid reaches surrounded by "Rural" and "Urban Low Intensity". Upper portions of the lower reaches of the Spruce Creek, on both sides of I-95 are designated as "City", while the lower estuary portion is surrounded by the designation "Conservation".

In all, the areas of most serious conflict, or areas where an RHPZ may be warranted within both basins are as follows:

1. Lower reaches of the Tomoka River (remaining natural land cover adjacent to the Floodplain)
2. Upper reaches of the Tomoka (especially those areas surrounded by the activity center between US 92 and I-4, and extending southward)
3. The upper portion of the lower reach of Spruce Creek (remaining natural land cover along the southern shore line of the creek)
4. The mid reaches of the Spruce creek surrounded by "Rural" and "Urban Low Intensity" uses
5. The upper reaches of the Spruce Creek surrounded by "Agricultural Resource"

Buffer Recommendations for Tomoka River and Spruce Creek

It appears that much of the interface zone on both the Spruce Creek and Tomoka River was in urban uses (47% and 23% respectively) in 1992. There were some areas along the northern shore of the Lower Tomoka River in the vicinity of the Ormond Airport and along the eastern shore around and south of the confluence of the Little Tomoka, Groover Branch and the Tomoka River that remained in natural cover. Most of the interface zone of the Upper Tomoka was in natural cover. Little natural cover remained along Groover Branch (20%), while the Little Tomoka had about 70% of its interface zone dominated by agricultural and urban uses. The only areas along the Spruce Creek that remained in natural cover were along the southern shore of the Creek extending west of I-95 about 1 mile, and east of I-95 about 2 miles. In addition, a small section (about 1/3 mile) along the northern shore of the Creek, just upstream from the confluence with Turnbull Creek remained in natural cover.

A RHPZ may be appropriate for those areas on both rivers that remain undeveloped, as a means of protecting aquatic and wetland dependent wildlife. Since significant portions of the zone that would be designated RHPZ, have been developed, it is imperative that the remaining areas be considered for protection. A zone that measures 550 feet from the waters's edge toward the upland, and including at least 50 feet of upland has been determined adequate for aquatic and wetland dependent wildlife in previous studies (Brown et al 1990a and 1990b). In areas where the floodplain is dominated by marsh vegetation, the RHPZ should measure 322 feet from the landward edge of the marsh. In areas where there is no discernable channel, and/or the tree canopy is continuous across the river channel, the RHPZ should be measured as 550 feet straddling the river.

Maps #7 through #12 show an RHPZ for each of the five sections of the Tomoka as well as land use/land cover in 1992. Map #7 shows a 550 feet RHPZ straddling the floodplain of Grover Branch and surrounding a large wetland complex west of the floodplain. Since much of the Tomoka River Estuary area is dominated by salt marsh, the RHPZ in Map 8 is 322 feet from the Marsh edge. Some areas were already developed along the rivers edge, but there remained undeveloped portions just east of US 1, near the airport. Map #9 shows a 550 feet RHPZ along the relatively undeveloped Little Tomoka. The confluence of Grover Branch, the Little Tomoka and the Upper portions of the Tomoka is shown in Map #10. Portions of the northern banks of the Tomoka were undeveloped and are shown with a 550 feet RHPZ on each side of the river channel. The Little Tomoka and Tomoka river, where canopy closure was complete, are shown with a 550 feet RHPZ straddling the channel. Maps #11 and #12 show the upper reach of the Tomoka river with a 550 feet RHPZ straddling the river channel. In 1992 this area was relatively undeveloped, but as indicated on the future land use map, the area between US 92 and I-4 could become relatively intensely developed as an Activity Center. While the river is designated as "Conservation" the extent of the buffer beyond the river floodplain forest (if at all) is not known. The recommended width is 550 feet straddling the river channel.

The mapped RHPZ for Spruce Creek is shown in Maps #13 through #15. The lower reaches of Spruce Creek and Turnbull Creek are dominated by salt marsh. Most of the landward edge of Turnbull Creek (Maps #13 and #14) was developed in 1992. On the upper portion of the lower reach of the Spruce creek, the southern bank of the river was not developed in 1992. A RHPZ of 322 feet from the marsh edge is recommended. Much of the area of the headwaters of Spruce Creek were developed adjacent to the river floodplain in 1992. Some areas adjacent to the flood plain, indicated as upland forest on the land use/land cover maps remained undeveloped. The RHPZ is shown as 550 feet straddling the river channel.

Tables 5 and 6 summarize the areas of land use and land cover within the recommended RHPZ for the Tomoka River and Spruce Creek. In Table 5 areas within the recommended RHPZ for the Tomoka River are summarized. Total area within the Tomoka RHPZ is about 5000 acres. Land cover categories having the greatest extent within the RHPZ were Forested Wetlands (1516 acres), salt marsh (1244 acres) and Upland Forest (1169 acres). Upland Forests (1169 acres), Rangeland (88 acres), and Agricultural (54 acres) represented about 25% of the total area within the recommended RHPZ. Wetlands, and water areas (about 3233 acres) made up about 64% of the total recommended RHPZ, leaving about 437 acres, or 8.6%, of the recommended RHPZ in urban uses.

Table 6 gives the areas of different land uses and land covers within the proposed Spruce Creek RHPZ. Total area within the RHPZ is about 4000 acres. Urban uses within the proposed zone totaled about 860 acres or about 21% of the RHPZ. Upland forests (791 acres) and rangeland (96 acres) covered approximately 22% of the proposed Spruce Creek RHPZ. Wetlands (1362 acres) and water (837 acres) represented about 55% of the total RHPZ.

Summary

The concept of RHPZ's was an outgrowth of the realization that no system is isolated from its environment. Just as single species wildlife management has been discredited by wildlife management experts, it is obvious that protection of water resources requires a whole systems approach. Aquatic and wetland dependent wildlife and water quality cannot be adequately protected if only a river and its floodplain are considered. But more importantly, RHPZ's should be looked upon as assets, instead of development potential that must to be forgone to protect some environmental amenity. Once fully developed, much of the Florida urban landscape will be without greenways. Instead of greenways, the urban landscape will be a patchwork of streets, private lawns, and parking lots. Where will nature reside in such an urban scene? Where do humans recreate, walk, or ride bikes?

Much of the proposed RHPZ is developed, however, this is no reason to suppose that efforts to protect undeveloped stretches from further urban encroachment should not be attempted. Often there is concern that buffer zones or RHPZ's infringe on property rights or that they are excessive in the land that they take from developable portions of property. To accomplish resource protection and at the same time not excessively hinder development should be the goal of efforts to integrate RHPZ's into the development pattern. This may be achieved by providing development credits, or transfer of development rights from RHPZ areas. Mitigation credits might be given for purchase and rehabilitation of areas that have already been developed or used for agriculture. Transfer of mitigation requirements might be coordinated so that financial resources are focused on RHPZ's the community feels are important, and community funds for recreation and conservation land purchases might be used to add to these funds. RHPZ's then become an "urban asset". They are greenways that wind through developed lands which can accommodate human walking and biking traffic away from motorized vehicles and in the tranquility of nature. They provide an alternative to the streets as a means of getting from one end of the city to another. They add to the quality of life of everyone; and in the process, help to protect aquatic and wetland dependent species and water quality of our surface water bodies.

Maps of the proposed RHPZ show numerous areas where the RHPZ is coincident with urbanized lands or lands in agricultural uses. By all rights, greater protection of aquatic and wetland dependent species could have been afforded had RHPZ's been developed prior to development of these areas. A long term vision of the Tomoka River and Spruce Creek might include the reclamation of these developed lands to natural ecological communities. It is possible to retro-fit urbanized areas, not immediately, but over the long term as land uses change or housing becomes senescent. The waterward edge of urbanized areas can be purchased and returned to forested communities. Cleared and landscaped areas can be allowed to succeed to natural communities. To some extent, agricultural lands can be managed to include the RHPZ concept. The edges of wetlands are often marginally productive for agricultural purposes and if given tax incentives are given, these lands might be allowed to revegetate.

In all, it seems like a "win-win" situation when communities implement RHPZ's. Environmental systems that are given added protection, benefit, and just as importantly, human dominated systems benefit, as more greenspace is incorporated into urban lands. A network of greenways through cities has been shown to be one of the most significant amenities that enhances property values and quality of life. RHPZ's should be thought of as an opportunity, instead of a constraint to development.

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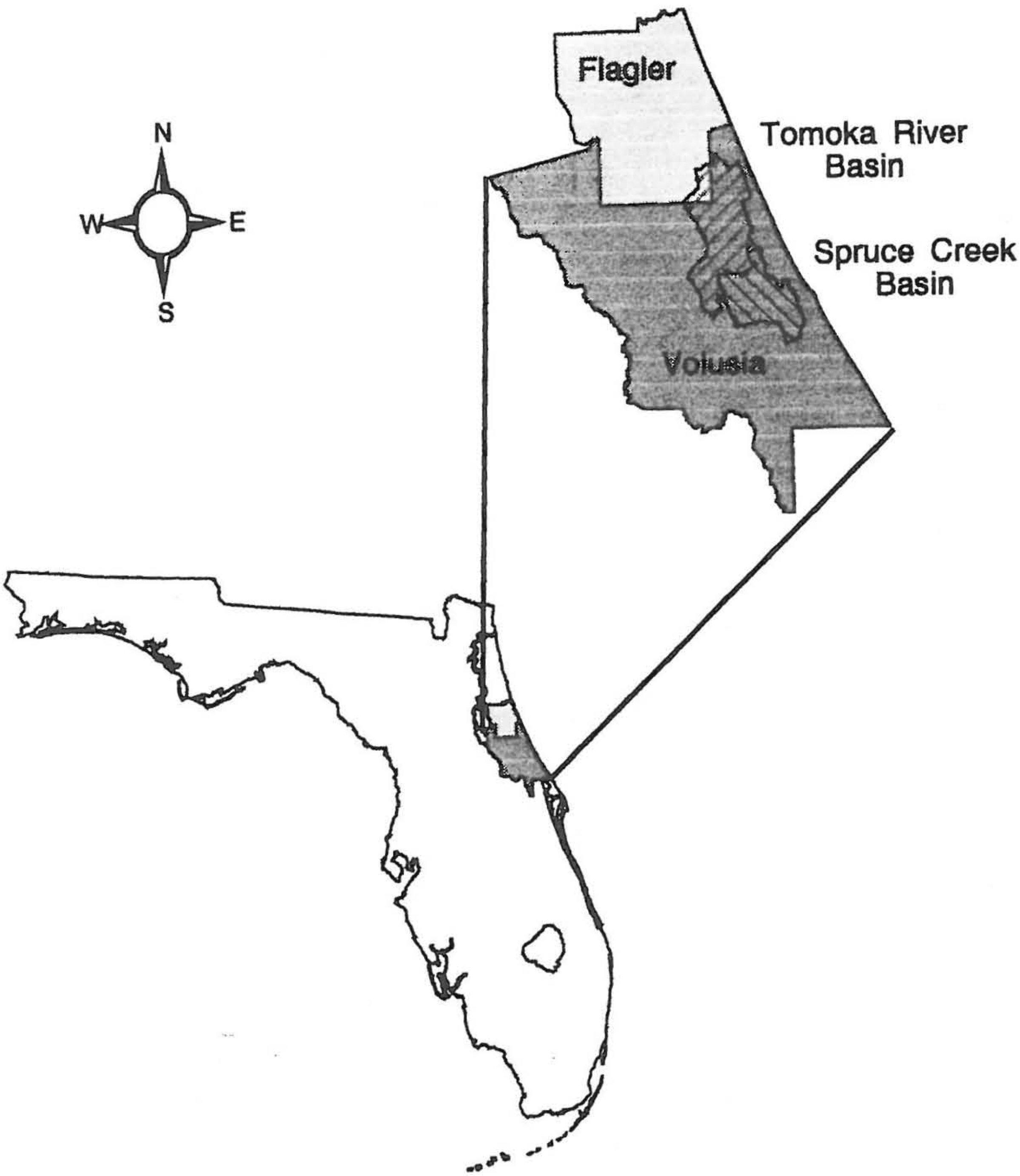

Figure 1. Map showing the drainage basins of the Tomoka River and Spruce Creek in Volusia County, Florida

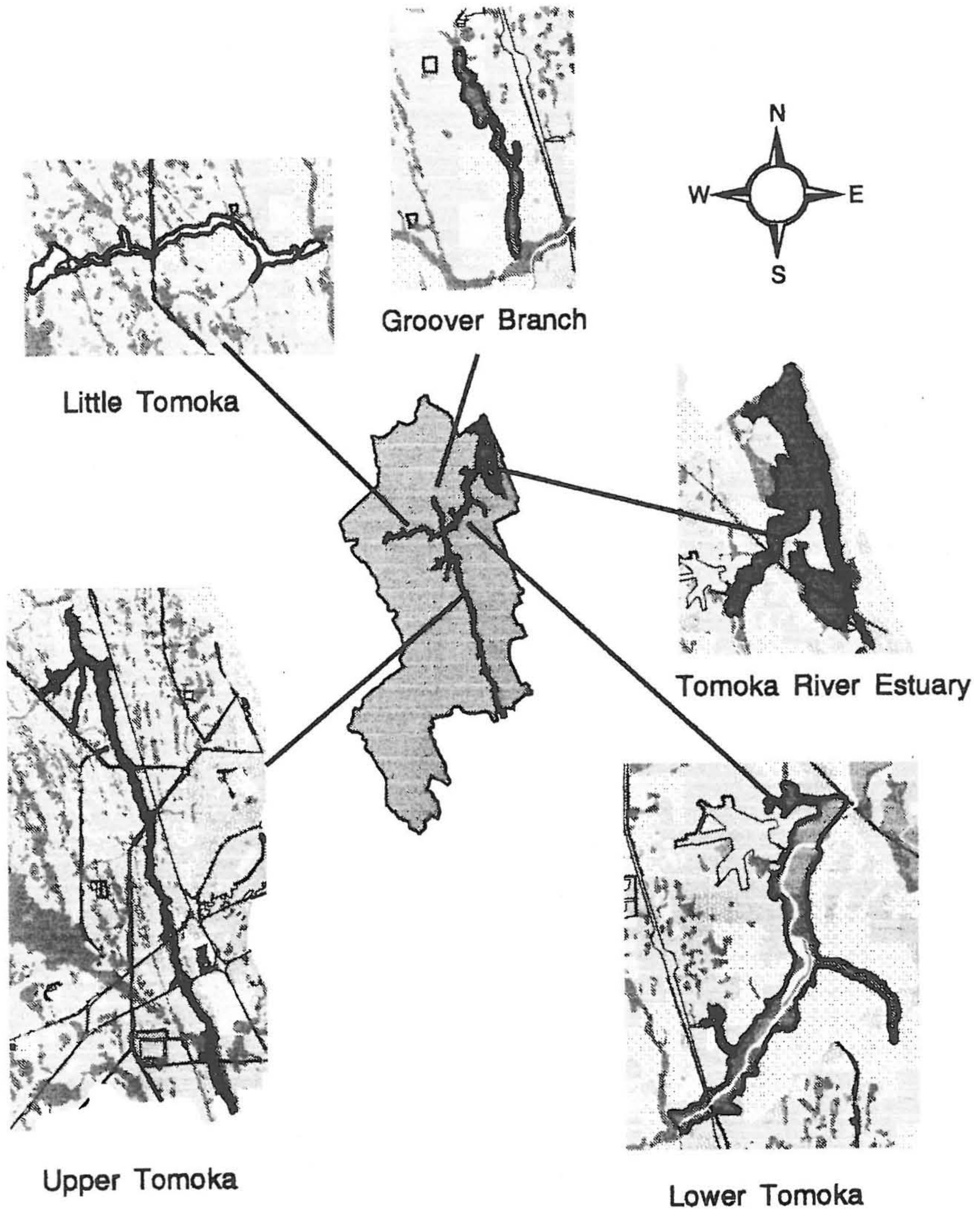

Figure 2. Map of the Tomoka River watershed showing the five sub-basins used for detailed analysis of land use / land cover within the wetland/upland "interface zone".

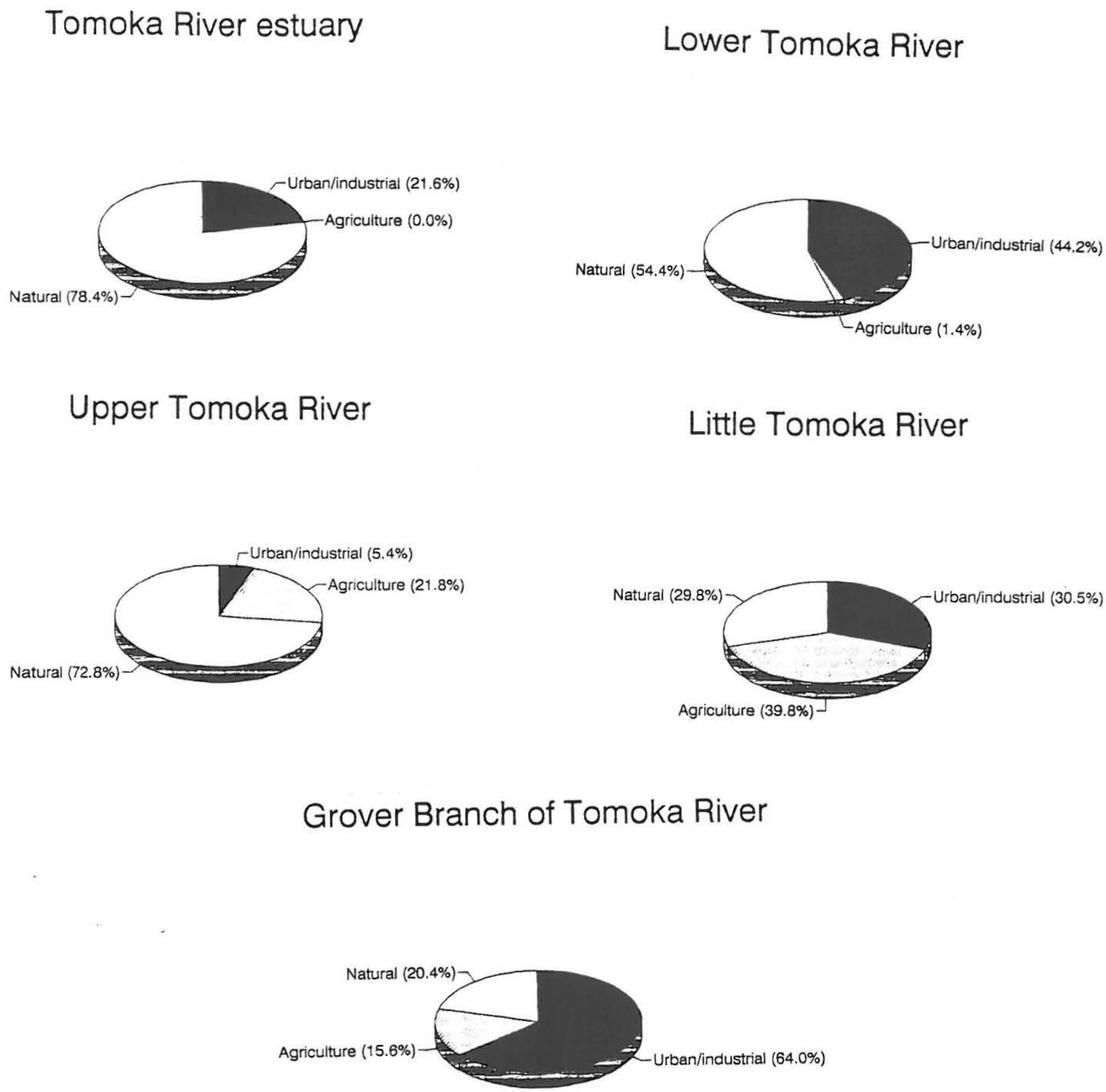

Figure 3. Percent of the "interface zone" between uplands and wetlands occupied by urban, agricultural, and natural cover of sub-basins of the Tomoka River.

Tomoka River Basin

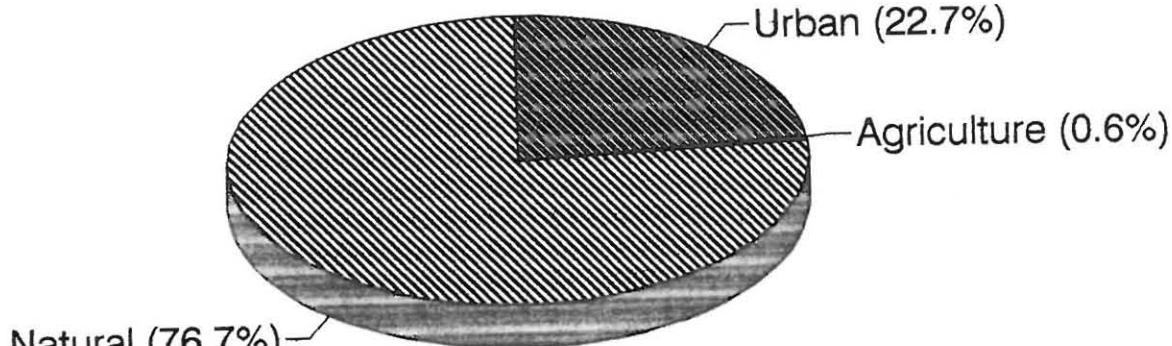

Figure 4. Percent of the "interface zone" between uplands and wetlands occupied by urban, agricultural, and natural cover for the Tomoka River

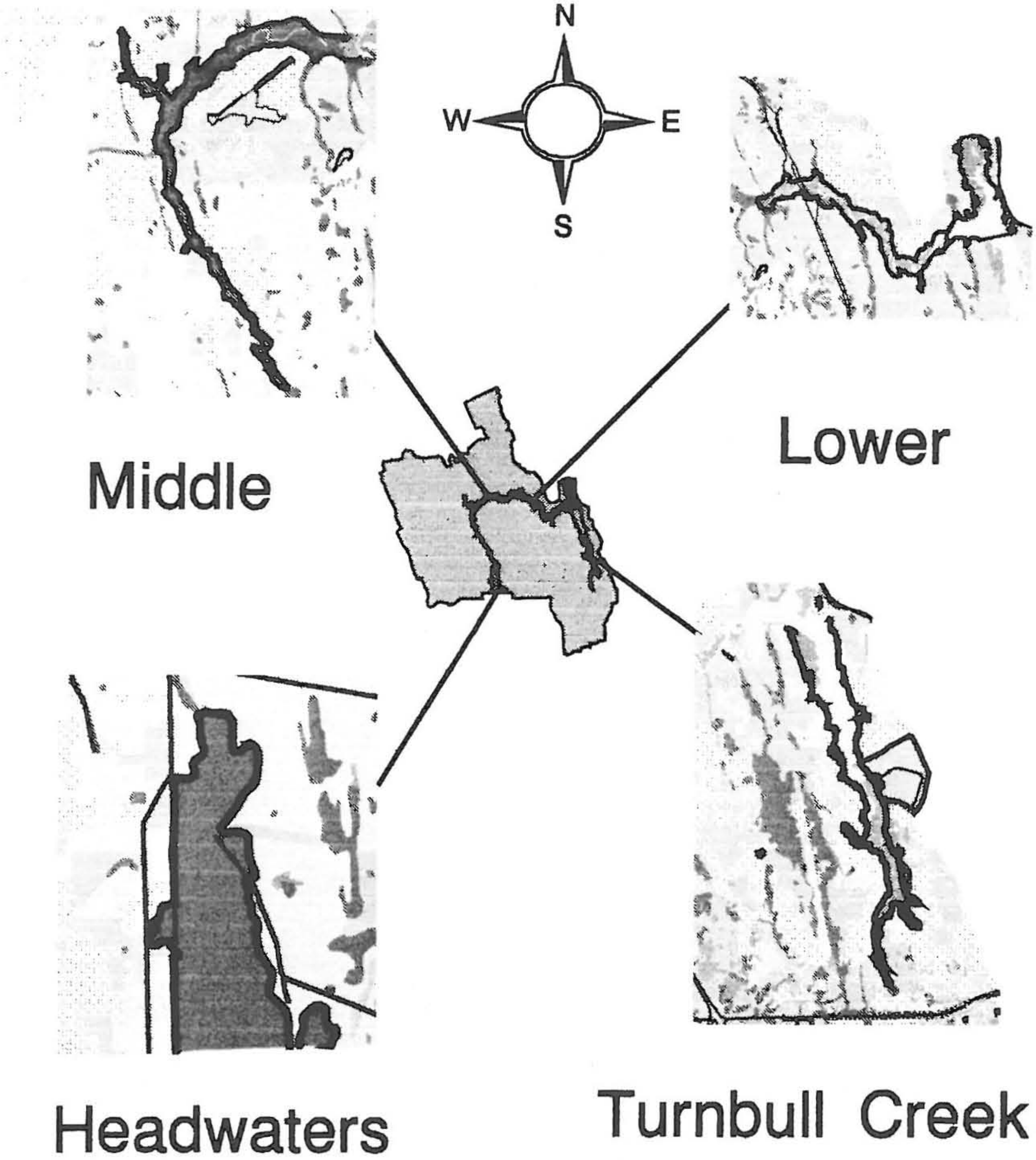

Figure 5. Map of the Spruce Creek watershed showing the four sub-basins used for detailed analysis of land use / land cover within the wetland/upland "interface zone".

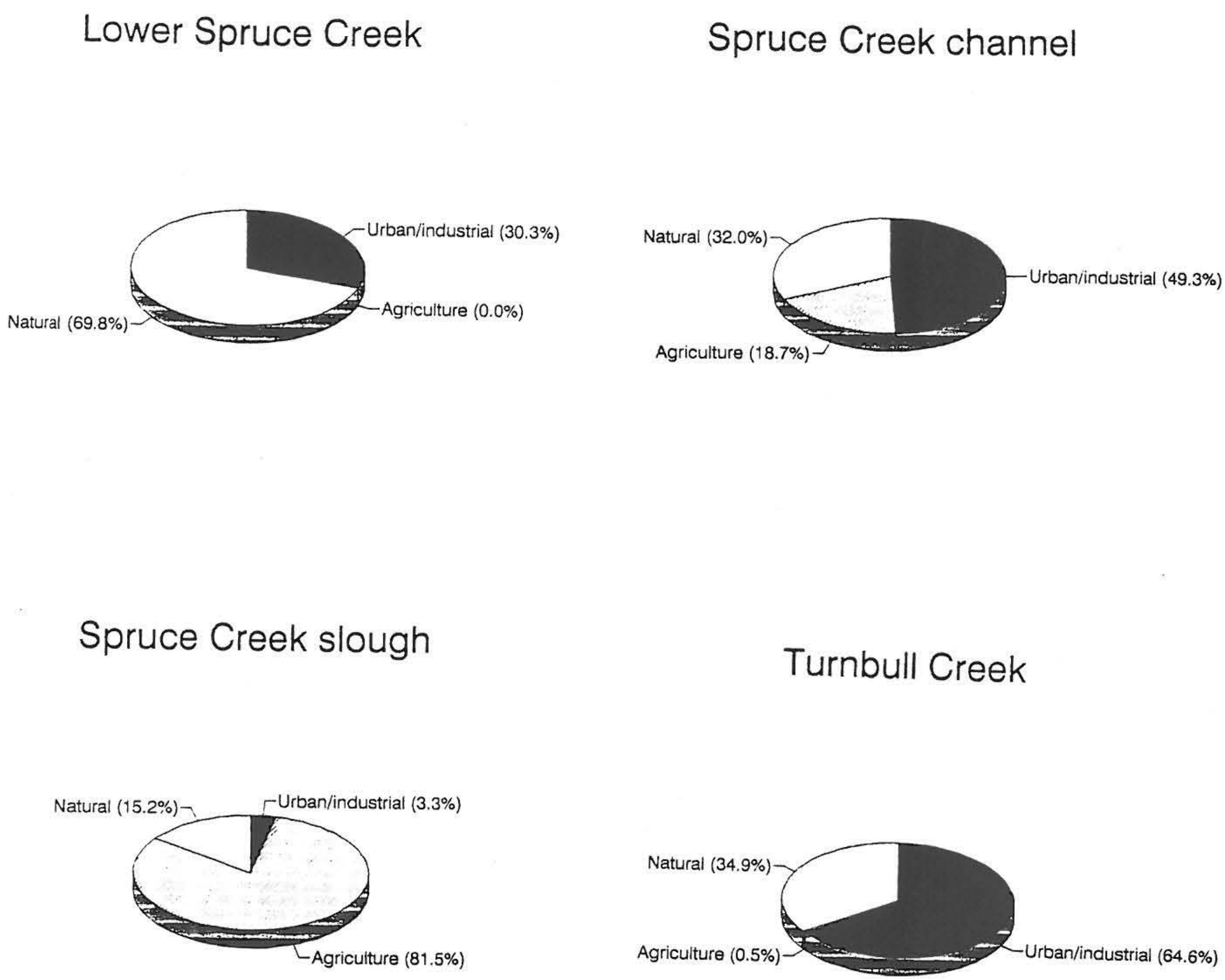

Figure 6. Percent of the "interface zone" between uplands and wetlands occupied by urban, agricultural, and natural cover of sub-basins of the Spruce Creek.

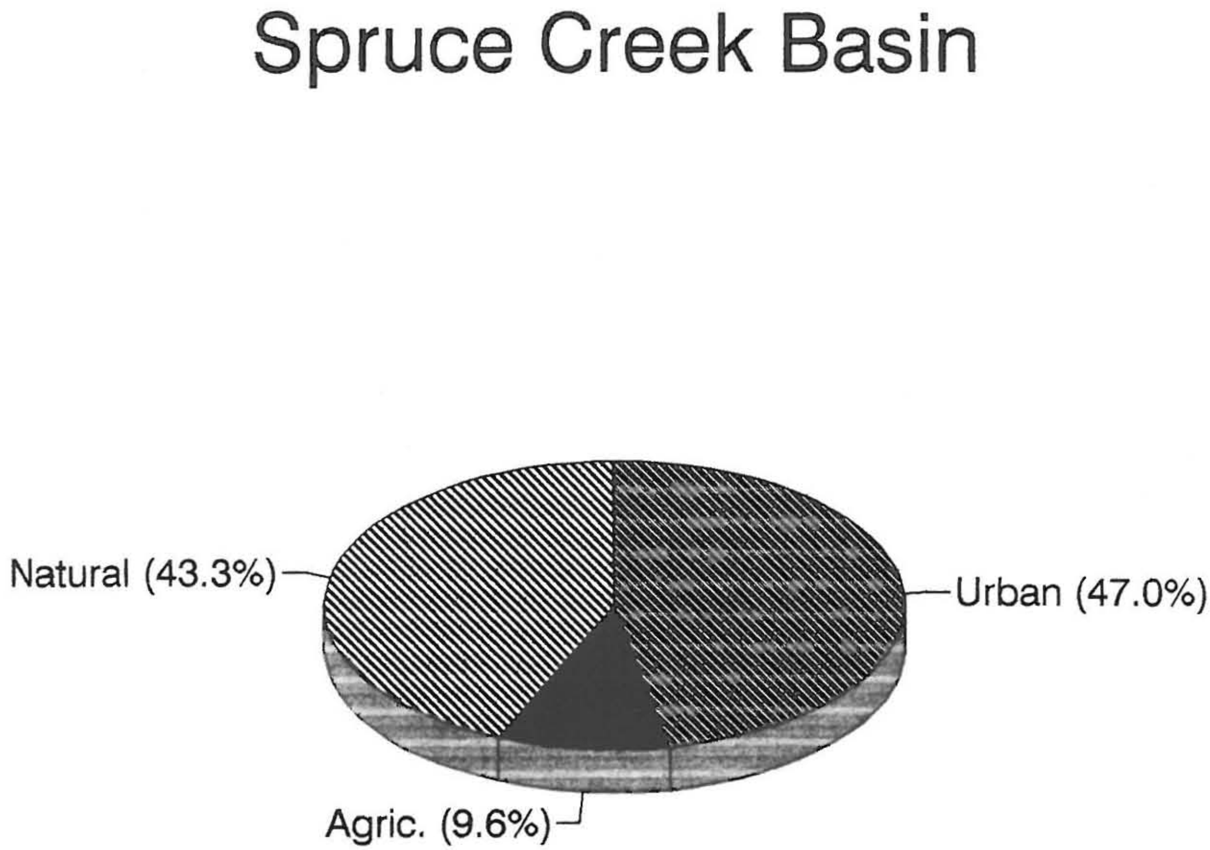

Figure 7. Percent of the "interface zone" between uplands and wetlands occupied by urban, agricultural, and natural cover for the Spruce Creek

Table 1. Habitat needs of faunal species found in Tomoka River and Spruce Creek Watersheds

Common Name	Scientific Name	Tomoka River	Spruce Creek	Habitats XS	FW	HH	CS	SH	M&R	EW	Width of land needed (ft) *
Reptiles											
Green Turtle	Cheolonia mydas	X									
Alligator	Alligator mississippiensis	X	X			n	fn	fn	fn		50
Florida Mud Turtle	Kinosternon subrubrum	X	X	n	n	n	f	f	f		1350
Florida Softshell Turtle	Trionyx fevox	X	X	n	n	n	f	f			1350
Banded Water Snake	Neridia fasciata	X	X								50
Green Anole	Anolis carolinensis	X	X	fn	fn	fn	f	f			51; 78
Indigo Snake	Drymarchon corais	X	X	fn	fn	fn		f			4654
Cottonmouth Water Moccasin	Agkistrodon piscivorus	X	X		n	n	f	f	f		50
Florida Cooter	Pseudemys floridan	X		n	n	n	f	f	f		1350
Amphibians											
Dusky Salamander	Desmongatus auriculatus	X			f	f	fn	fn	fn		93; 177-591
Mud Salamander	Plethinitida montanus	X	X			f		fn			93; 177-591
Southern Toad	Bufo terrestris	X	X	f	f	f	fn	fn	fn	n	180
Green Treefrog	Hyla ocularis	X	X		f	f	fn	fn	n	n	180
Bullfrog	Rana catesbeina	X	X				fn	fn	fn		350
Cricket Frog	Acris gryllus	X					fn	fn	fn	n	180
Mammals											
Manatee	Trichechus manatus	X	X								
River Otter	Lutra candensis	X	X				fn	fn	fn		100
Opossum	Didelphis virginiana	X	X	fn	fn	fn	fn	fn	fn		60
Racoon	Procyon lotor	X	X	fn	fn	fn	fn	fn	f		60
Marsh Rabbit	Sylvilagus palustris	X	X						fn		700
Florida Panther	Felis Concolor		X								
Cottontail Rabbit	Sylvilagus floridanus	X			fn	fn					527
Water Rat	Neofiber alleni	X									
Bottlenosed Dolphin	Tursiops truncatus	X									

Table 1. Habitat needs of faunal species found in Tomoka River and Spruce Creek Watersheds

Common Name	Scientific Name	Tomoka River	Spruce Creek	Habitats XS	FW	HH	CS	SH	M&R	EW	Width of land needed (ft) *
Birds											
White Pelican	Pelecanus erythrorhynchos	X	X								
Brown Pelican	Pelecanus occidentalis	X	X								
Little Blue Heron	Florida caerulea	X	X		n	n	fn	fn	fn	f	180; 39-63
Double Crested Cormorant	Phalacrocorax auritus	X	X				fn	fn	fn		50; 30-132
White Ibis	Eudocimus albus	X	X		n	n	fn	fn	fn	f	240; 38-120
American Egret	Casmerodius albus	X	X		n	n	fn	fn	fn	f	60; 45-84
Cattle Egret	Bubulcus ibis	X	X	f	fn	fn	n	n	n	f	60; 33-63
Belted Kingfisher	Megaceryle alcyon	X	X	n	n	n	f		f		60
Roseate Spoonbill	Ajaia ajaja	X	X								
Marsh Hawk	Circus cyaneus	X	X								
Fish Crow	Corvus ossifragus	X	X		fn	fn			f		60
Snowy Egret	Leucophoyx thula	X	X		n	n	fn	fn	fn	f	240; 123-165
Osprey	Pandion haliaetus	X	X		n	n	n	n	f		60
Great Blue Heron	Ardea herodias	X	X		n	n	fn	fn	fn	f	60; 48-144
Black Vulture	Coragyps atratus	X	X	fn	fn	fn					500
Red Shouldered Hawk	Buteo lineatus	X	X		f	f	fn	fn			1177-2346;2640-2978
American Coot	Fulica americana	X	X						fn		50
Herring Gull	Larus argentatus	X	X								
Bonapartes Gull	Larus philadelphis	X	X								
Common Tern	Sterna hirundo	X	X								
Barred Owl	Strix varia	X	X		fn	fn	fn	fn			3455-7153
Chuck-Will's-Widow	Caprimulgus carolinensis	X	X	fn	fn	fn					166
Screech Owl	Otus asio	X	X	fn	fn	fn	fn	fn			3455-7153
Pileated Woodpecker	Ceophloeus pileatus	X	X	f	f	f	fn	fn			3098-5763; 2419
Red-Cockaded Woodpecker	Picoides borealis	X	X	fn	fn	f					3960
Purple Martin	Progne subis	X	X	n	n	n	fn	fn	f		50
Redwing Blackbird	Agelaius phoenicens	X	X						fn		50
Common Grackle	Quiscalus quiscula	X	X		fn	fn					60
Boattailed Grackle	Quiscalus major	X	X		fn			fn			60

Table 1. Habitat needs of faunal species found in Tomoka River and Spruce Creek Watersheds

Common Name	Scientific Name	Tomoka River	Spruce Creek	Habitats XS	FW	HH	CS	SH	M&R	EW	Width of land needed (ft) *
Bald Eagle	Haliaetus leucocephalus	X	X	n	n	n	n	n	f		1500
Savannah Sparrow	Passerculus sandwichensis	X	X								
Swamp Sparrow	Melospiza georgiana	X									
Wood Duck	Aix sponsa	X			n	n	fn	fn	f	f	300
Carolina Wren	Thryothorus ludovicianus	X			fn	fn	fn	fn			60
Loggerhead Shrike	Lanius ludovicianus	X		fn	fn						
Purple Gallinule	Porphyrula martinica	X							fn		50
Limpkin	Aramus guarana	X					fn	fn	fn		180; 39-165
American Kestrel	Falco spaverius	X		fn	fn						
Wood Stork	Mycteria americana	X			n	n	fn	fn	f		1500
Louisiana Heron	Egretta tricolor	X			n	n	fn	fn	fn	f	240; 75-141

LEGEND
XS = Scrub or Sandhill
FW= Flatwoods
HH = Hardwood Hammock
CS = Cypress Swamp
SH = Swamp Hardwood
M&R = Freshwater Marsh and Rivers
EW = Emphemeral Wetland
f = use habitat to obtain food resources
n = use habitat for nesting/breeding

* Width needed is the width of land needed in feet by one individual of the species

Table 2. Fish and marine species found in Tomoka River and Spruce Creek watersheds

Common Name	Scientific Name	Tomoka River	Spruce Creek
Fish			
Tidewater Silversides	Menidia beryllina	X	X
Bay Anchovy	Anchoa mitchilli		X
Striped Anchovy	Anchoa hepsetus		X
Bluegill	Lepomis macrochirus	X	X
Silver Jenny	Eucinostomus gula		X
Redear Sunfish	Lepomis microlophus	X	X
Moharra	Eucinostomus argenteus	X	X
Florida Gar	Lepisiosteus platyrhincus	X	X
Largemouth Bass	Micropterus salmoides	X	X
Gizzard Shad	Dorosoma cepedianum	X	X
White Mullett	Mugil curema	X	X
Striped Mullet	Mugil cephalus	X	X
Sheepshead	Archosargus probatocephalus	X	X
Spotted Sea Trout	Cynoscion nebulosus	X	X
Snook	Centropomus undecimalis	X	X
Jack Crevale	Caranx hippos	X	X
Sea Catfish	Arius felis	X	X
Mangrove Snapper	Lutjanus griseus	X	X
Croaker	Micropogon undulatus	X	X
Silver Jenny	Eucinostomus argenteus	X	
Bullhead Catfish	Ictalurus nebulosus	X	X
Channel Catfish	Ictalurus punctatus	X	
Flagfish	Jordanella floridae	X	
Needlefish	Stringylura marina	X	X
Mosquitofish	Gambusia affinis	X	X
Sheepshead Minnow	Cyprinodon variegatus	X	X
Pinfish	Lagodon rhomboides	X	X
Darter Goby	Gobionellus boleosoma	X	X
Channel Bass	Sciaenops ocellata	X	X
Worm Eel	Ahlia egmontis	X	X
Golden Topminnow	Fundulus chrysotus	X	
Starhead Topminnow	Fundulus notti	X	X
Spot	Leiostomus xanthurus	X	X
Flier	Centrarchus macropterus	X	
Freshwater Goby	Cobionellus schufeldti	X	
Southern Flounder	Paralichtys lethostigma		X
Left Eyed Flounder	Citharichtys arenaceus		X
Fringed Flounder	Etropus crossotus		X
Sailfin Molly	Poecilia latipinna	X	X

Table 2. Fish and marine species found in Tomoka River and Spruce Creek watersheds

Common Name	Scientific Name	Tomoka River	Spruce Creek
Mimmichog	Fundulus hereroclitus	X	X
Bull Shark	Carcharhinus leucas		X
Southern Stingray	Dasyatis americana	X	X
Tarpon	Megalops atlanticus	X	X
Hog Choker	Trinectes maculatus	X	X
Silver Perch	Bairdella chrysura	X	X
Black Drum	Pogonias cromis	X	X
Sail Catfish	Bagre marinus	X	X
Lookdown	Selene vomer		X
Bonnethead Shark	Sphyrna tiburo		X
Pigfish	Orthopristis chrysopterus		X
Leather Jack	Oligoplites saurus		X
Lemon Shark	Negaprion brevirostris		X
Barracuda	Sphyraena barracuda		X
Menhaden	Brevoortia tyrannus	X	X
Striped Killifish	Fundulus confluentus	X	X
Gulf Killifish	Fundulus grandis	X	
Least Killifish	Heterandria formosa	X	
Rainwater Killifish	Lucania parva	X	
Ladyfish	Elops saurus	X	X
Crustaceas			
Blue Crab	Callinectes sapidus	X	X
Ornate Crab	Callinectes ornatus	X	X
White Shrimp	Peneus setiferus	X	X
Brown Shrimp	Peneus azetecus	X	X
Stone Crab	Menippe mercenaria		X
Mud Crab	Panopeus herbstii	X	X
Grass Shrimp	Palaemonetes intermedius	X	X
Prawn	Macrobrachium sp.	X	X
Fiddler Crab	Uca minax	X	X
Saltmarsh Crab	Sesarma reticulata	X	X
Isopods	Aegathoa spp.	X	X
Horseshoe Crab	Pagurus annulipes	X	X
Snapping Shrimp	Alphaeus heterochaelis	X	X
Hermit Crab	Pagurus annulipes	X	X
Amphipods	Gammaropsis sp.	X	X
Crayfish	Cambarus sp.	X	X
Tanaids	Tanaeidae	X	X

Table 2. Fish and marine species found in Tomoka River and Spruce Creek watersheds

Common Name	Scientific Name	Tomoka River	Spruce Creek
Molluscs			
Quahog Clams	Mercenaria campechiensis		X
Periwinkle Snail	Littorina angulifera		X
Coffee Bean Snail	Melampus olivaceous	X	X
Mud Snails	Nassarius spp.	X	X
Oysters	Ostraea virginica	X	X
Barnacles	Balanus balanoides	X	X
Ribbed Mussels	Midiolus demissus	X	X
Hooked Mussels	Brachiodontes recurvus	X	X
Blue Mussels	Mytilus edulis	X	X
Oyster Drill	Urosalpinx cinerea	X	X
Freshwater Marsh Clams	Corbicula manilensis	X	X
Bubble Shells	Bulla occidentalis	X	X
Worms			
Round Worms	Oligochaeta	X	
Tube Worms	Serpula sp.	X	X
Mud Worms	Onuphidae	X	X
Polychaete Worms	1. Pectinaris sp.	X	X
	2. Neanthes sp.	X	X
	3. Capitella capitata		X
	4. Streblospio sp.	X	X
Feather Worms	Euchone elegans		X
Coelenterates			
Comb Jellies	Ctenophora	X	
White Jellyfish	Arelia surita	X	
Many-Mouth Sea Jelly	Stomolophus meleagris	X	

Table 3. Faunal species that may occur in Tomoka River and Spruce Creek watersheds (after Florida Natural Areas Inventory, 1994)

Common Name	Scientific Name	Status	Occ	Habitat
Fishes				
Shortnose Sturgeon	Acipenser brevirostrum	S1		
Mountain Mullet	Agonostomus monticola	S3	*	stream, marine, estuarine
Snail Bullhead	Ameirus brunneus	S3		alluvial stream, blackwater stream
Sea lamprey	Petromyzon marinus			blackwater stream, marine, estuarine
Amphibians				
Striped newt	Notophthalmus perstriatus			Ephemeral wetlands, lakes
Ephemeral wetlands, lakes	Rana areolata			Ephemeral wetlands, lakes
Reptiles				
American Alligator	Alligator mississippiensis	S4	*	Various aquatic and hydric habitats
Loggerhead	Caretta caretta	S3		Coastal, various marine and estuarine habitats
Green Turtle	Chelonia mydas	S2		Coastal, various marine and estuarine habitats
Spotted turtle	Clemmys guttata			Mesic flatwoods, various hydric habitats
Leatherback Turtle	Dermochelys coriacea	S2	*	Coastal, various marine and estuarine habitats
Eastern Indigo Snake	Drymarchon corais couperi	S3		Various hydric, mesic, and xeric habitats
Gopher tortoise	Gopherus polyphemus	S3	*	Sandhill, scrub, flatwoods, xeric hammock, coastal
Atlantic ridley	Lepidochelys kempii			Various marine and estuarine habitats
Atlantic salt marsh snake	Nerodia clarkii taeniata	S1	*	Marine and estuarine tidal marsh
Florida pine snake	Pituophis melanoleucus mugitus	S3	*	Sandhill, scrubby flatwoods, xeric hammock, ruderal
Birds				
Cooper's hawk	Accipiter cooperii			Various terrestrial and palustrine habitats
Bachman's sparrow	Aimophila aestivalis			Various terrestrial habitats, ruderal
Roseate spoonbill	Ajaia ajaia			Various aquatic and hydric habitats
Florida scrub jay	Aphelocoma coerulescens coerulescens	S3	*	Scrub, scrubby flatwoods
Limpkin	Aramus guarauna	S3		Various aquatic and hydric habitats
Short-tailed hawk	Buteo brachyurus			Various terrestrial, palustrine, and estuarine habitats
Great egret	Casmerodius albus	S4	*	Various terrestrial, hydric, and aquatic habitats
Piping plover	Charadrius melodus	S2	*	Beaches and beach dunes
Florida prairie warbler	Dendroica discolor paludicola			Maritime hammock, marine and estuarine tidal swamp
Little blue heron	Egretta caerulea	S4		Various hydric and aquatic habitats
Snowy egret	Egretta thula	S4	*	Various hydric and aquatic habitats

Table 3. Faunal species that may occur in Tomoka River and Spruce Creek watersheds (after Florida Natural Areas Inventory, 1994)

Common Name	Scientific Name	Status	Occ	Habitat
Tricolored heron	Egretta tricolor	S4	*	Various hydric and aquatic habitats
Black-shouldered kite	Elanus caeruleus			Various terrestrial and palustrine habitats, ruderal
White ibis	Eudocimus albus	S4	*	Various hydric and aquatic habitats
Merlin	Falco columbarius			Various terrestrial, palustrine, and estuarine habitats
Peregrine falcon	Falco peregrinus			Various terrestrial, palustrine, lacustrine and estuarine
Southeastern american kestrel	Falco sparverius paulus	S3?		Various terrestrial, palustrine, and estuarine habitats
Florida sandhill crane	Grus canadensis pratensis	S2S3		Dry prairie, ruderal, marsh, lake
Bald eagle	Haliaeetus leucocephalus	S2S3	*	Various aquatic and hydric habitats
Black rail	Laterallus jamaicensis	S3?		Marsh
Wood stork	Mycteria americana	S2		Various palustrine, lacustrine and estuarine habitats
Yellow-crowned night-heron	Nyctanassa violacea			Various palustrine, riverine and estuarine habitats
Black-crowned night-heron	Nycticorax nycticorax	S3?	*	Various aquatic and hydric habitats
Osprey	Pandion haliaetus	S3S4		Various terrestrial, aquatic and hydric habitats
Brown pelican	Pelecanus occidentalis	S3	*	Various marine and estuarine habitats
Red-cockaded woodpecker	Picoides borealis	S2		Sandhill, scrubby flatwoods, mesic flatwoods
Hairy woodpecker	Picoides villosus			Various terrestrial and palustrine habitats
Glossy ibis	Plegadis falcinellus			Various palustrine, lacustrine and estuarine habitats
Crested caracara	Polyborus plancus			Dry prairie, ruderal, wet prairie, wet flatwoods
Black skimmer	Rynchops niger			Beach dune, ruderal, various marine and estuarine habitats
Least tern	Sterna antillarum	S3	*	Beach dune, ruderal, various aquatic habitats
Caspian tern	Sterna caspia			Beach dune, ruderal, various aquatic habitats
Royal tern	Sterna maxima			Beach dune, ruderal, various aquatic habitats
Sandwich tern	Sterna sanvicensis			Beach dune, ruderal, various marine and estuarine habitats
Black-whiskered vireo	Vireo altiloquus			Maritime and rockland hammock, tidal swamp
Mammals				
Southeastern weasel	Mustela frenata olivacea			Various terrestrial and palustrine habitats
Florida long-tailed weasel	Mustela frenata peninsulae	S3?		Various terrestrial and palustrine habitats
Round-tailed muskrat	Neofiber alleni			Marsh, lake
Pallid beach mouse	Peromyscus polionotus decoloratus			Coastal strand, beach dune
Southeastern beach mouse	Peromyscus polionotus niveiventris			Beach dune, coastal strand, scrub
Southeastern big-eared bat	Plecotus rafinesquii			Various terrestrial and palustrine habitats
Florida mouse	Podomys floridanus			Scrub, sandhill, scrubby flatwoods
Sherman's fox squirrel	Sciurus niger shermani			Sanhill, mesic and scrubby flatwoods, depressional swamp
Southeastern shrew	Sorex longirostris longirostris			Floodplain forest, floodplain swamp

Table 3. Faunal species that may occur in Tomoka River and Spruce Creek watersheds (after Florida Natural Areas Inventory, 1994)

Common Name	Scientific Name	Status	Occ	Habitat
Manatee	Trichechus manatus	S2?	*	Various riverine, marine and estuarine habitats
Florida black bear	Ursus americanus floridanus	S2	*	Various terrestrial and palustrine habitats
Invertebrates				
Blue spring aphaostracon	Aphaostracon asthenes	S1		
Enterprise spring snail	Cincinnatia monroensis	S1		
Blue spring snail	Cincinnatia parva	S1		

Notes:

S1 = Critically imperiled statewide of extreme rarity or because of extreme vulnerability to extinction due to natural or human caused factor

S2 = Imperiled statewide because of rarity or because of vulnerability to extinction due to natural or human caused factor

S3 = Either very rare and local throughout its range or found locally in restricted range or vulnerable to extinction

S4 = Apparently secure statewide; but may be rare in parts of range

* known occurance in Tomoka River and/or Spruce Creek

Table 4. Plant species that may occur in Tomoka River and Spruce Creek watersheds (after Florida Natural Areas Inventory, 1994)

Common Name	Scientific Name	Status	Occ	Habitat	Comments
Golden leather fern	Acrostichum aureum	S3			
Brittle maidenhair fern	Adiantum tenerum			Upland hardwood forest, spring-run stream banks	
Balsam torchwood	Amyris balsamifera	S2		Coastal	
Curtiss' milkweed	Asclepias curtissii	S3			
Auricled spleenwort	Asplenium auritum			Slough, hydric hammock	
Bird's nest spleenwort	Asplenium serratum			Strand and dome swamp	
Ashe's savory	Calamintha ashei			Scrub	disturbed areas
Curtiss' sandgrass	Calamovilfa curtissii	S2	*	Flatwoods, wet prairie, depressional marsh	
Sand butterfly pea	Centrosema arenicola			Sandhill, scrubby flatwoods	ruderal
Simpson's prickly-apple	Cereus gracilis var simpsonii	S2			
Sand-dune spurge	Chamaesyce cumulicola	S2	*	Coastal; in openings	
Piedmont jointgrass	Coelorachis tuberculosa			Sandhill upland lake margins	
Large-flowered rosemary	Conradina grandiflora	S3	*	Scrub, coastal strand	disturbed areas
Rugel's pawpaw	Deeringothamnus rugelii	S1	*	Mesic flatwoods	
Coastal vervain	Glandularia maritima	S2		Beach dune, coastal strand	ruderal
Tampa vervain	Glandularia tampensis	S1		Mesic flatwoods, hydric hammock	edges & clearings
Hartwrightia	Hartwrightia floridana			Flatwoods, depressional swamps	clearings
Lake-side sunflower	Helianthus carnosus			Seepage slope, wet flatwoods	
Scrub holly	Ilex opaca var arenicola	S3	*	Scrub	
Star anise	Illicium parviflorum	S1		Bottomland forest, hydric hammock, bay swamp	
	Lantana depressa var floridana	S2	*	Coastal, pine rockland, marl prairie	
Nodding pinweed	Lechea cernua	S3		Scrub	openings & disturbed areas
Pine pinweed	Lechea divaricata			Scrub, scrubby flatwoods	
Southern red lily	Lilium catesbaei	S3	*	Flatwoods, wet prairie, seepage slope	
Florida spiny-pod	Matelea floridana			Upland mixed forest, upland hardwood forest	
Godfrey's sandwort	Minuartia godfreyi			Seepage slope	ruderal
Pigmy-pipes	Monotropsis reynoldsiae			Upland hardwood forest	
Piedmont water-milfoil	Myriophyllum laxum			Floodplain or dome swamp, lake, blackwater stream	
Fall-flowering ixia	Nemastylis floridana	S2	*	Flatwoods, wet prairie, depressional swamp	clearings
Florida bear-grass	Nolina atopocarpa	S3		Mesic flatwoods	grassy areas
Hand fern	Ophioglossum palmatum	S2		Hydric hammock	
Yellow hibiscus	Pavonia spinifex	S2S3	*	Upland hardwood forest, shell mound, hydric hammock	on limestone
Spoon-flower	Peltandra sagittifolia			Freshwater hydric habitats	
Terrestrial peperomia	Peperomia humilis			Upland hardwood forest, swamps	

Table 4. Plant species that may occur in Tomoka River and Spruce Creek watersheds (after Florida Natural Areas Inventory, 1994)

Common Name	Scientific Name	Status	Occ	Habitat	Comments
Scrub bay	Persea humilis	S3	*	Scrub, sandhill	
Slender-leaved dragon-head	Physostegia leptophylla			Hydric habitats	
Brown-haired snoutbean	Rhynchosia cinerea			Pine rocklands, dune, scrub, sandhill, mesic flatwoods	roadsides, fields
Chaffseed	Schwalbea americana			Scrub, sandhill, mesic flatwoods, wet prairie	
Rain lily	Zephyranthes simpsonii			Dome swamp, wet flatwoods	ditches, wet pastures

Notes:

S1 = Critically imperiled statewide of extreme rarity or because of extreme vulnerability to extinction due to natural or human caused factor

S2 = Imperiled statewide because of rarity or because of vulnerability to extinction due to natural or human caused factor

S3 = Either very rare and local throughout its range or found locally in restricted range or vulnerable to extinction

S4 = Apparently secure statewide; but may be rare in parts of range

* known occurance in Tomoka River and/or Spruce Creek

Table 5. Land Use / Land Cover Within TOMOKA RIVER recommended RHPZ (Acres)

Land Use Type	Groover Branch	Tomoka River Estuary	Little Tomoka	Confluence	Tomoka River Headwaters	Rivers End	Basin Total** (acres)	(Percent of total)
Urban								
Residential	13.8	137.0	8.4	157.6	0.0	0.0	316.9	6.3%
Commercial	0.0	20.1	0.0	2.3	0.8	0.0	23.1	0.5%
Transportation	9.1	63.3	2.2	5.3	13.3	4.0	97.2	1.9%
Recreational	2.0	11.2	27.6	0.0	0.0	0.0	38.8	0.8%
Subtotal	24.9	231.6	38.2	165.2	14.1	4.0	476.0	9.5%
Agricultural								
Agriculture	47.4	0.0	0.0	4.1	1.9	0.0	53.8	1.1%
Rangeland	0.0	82.7	1.3	1.6	2.4	0.0	88.0	1.8%
Subtotal	47.4	82.7	1.3	5.7	4.3	0.0	141.8	2.8%
Natural Cover								
Upland Forests	258.2	494.3	209.3	150.0	43.3	14.0	1169.2	23.3%
Forested Wetlands	40.7	443.7	196.0	461.8	276.2	97.4	1516.6	30.2%
Salt Marsh	0.0	1244.7	0.0	0.0	0.0	0.0	1244.7	24.8%
Freshwater Marsh	25.4	12.0	2.8	7.5	0.9	0.0	4.9	0.1%
Non-forested Wetlands	15.9	19.6	0.5	11.4	2.3	0.0	49.7	1.0%
Open Water	4.6	318.4	10.9	84.7	0.0	0.0	418.5	8.3%
Subtotal	344.8	2532.7	419.5	103.6	322.7	111.4	4403.6	87.7%
Total	417.1	2847.0	459.0	274.5	341.1	115.4	5021.4	100%

** Basin total is based on data for the entire basin and may not equal sum of columns due to overlap between map coverages

Table 6. Land Use / Land Cover Within SPRUCE CREEK recommended RHPZ (Acres)

Land Use Type	Spruce Creek Estuary	Trunbull Bay	Spruce Creek Headwaters	Basin Total** (acres)	Basin Total** (Percent of total)
Urban					
Residential	430.5	490.9	166.7	772.0	19.0%
Commercial	4.6	4.0	0.0	8.6	0.2%
Transportation	32.3	32.4	20.0	78.8	1.9%
Recreational	2.0	51.0	6.5	54.4	1.3%
Subtotal	469.4	578.3	193.2	913.8	22.5%
Agricultural					
Agriculture	0.0	12.5	50.4	62.9	1.5%
Rangeland	50.0	77.4	11.5	95.8	2.4%
Subtotal	50.0	89.9	61.9	158.7	3.9%
Natural Cover					
Upland Forests	545.8	363.3	129.6	790.8	19.5%
Forested Wetlands	60.0	45.9	354.3	441.1	10.9%
Salt Marsh	581.3	368.4	2.7	749.9	18.5%
Freshwater Marsh	6.7	8.7	65.3	79.8	2.0%
Non-forested Wetlands	75.7	23.2	10.6	91.8	2.3%
Open Water	743.7	476.3	37.5	837.5	20.6%
Subtotal	2013.2	1285.8	600.0	2990.9	73.6%
Total	2532.6	1954.0	855.1	4063.4	100%

** Basin total is based on data for the entire basin and may not equal sum of columns due to overlap between map coverages