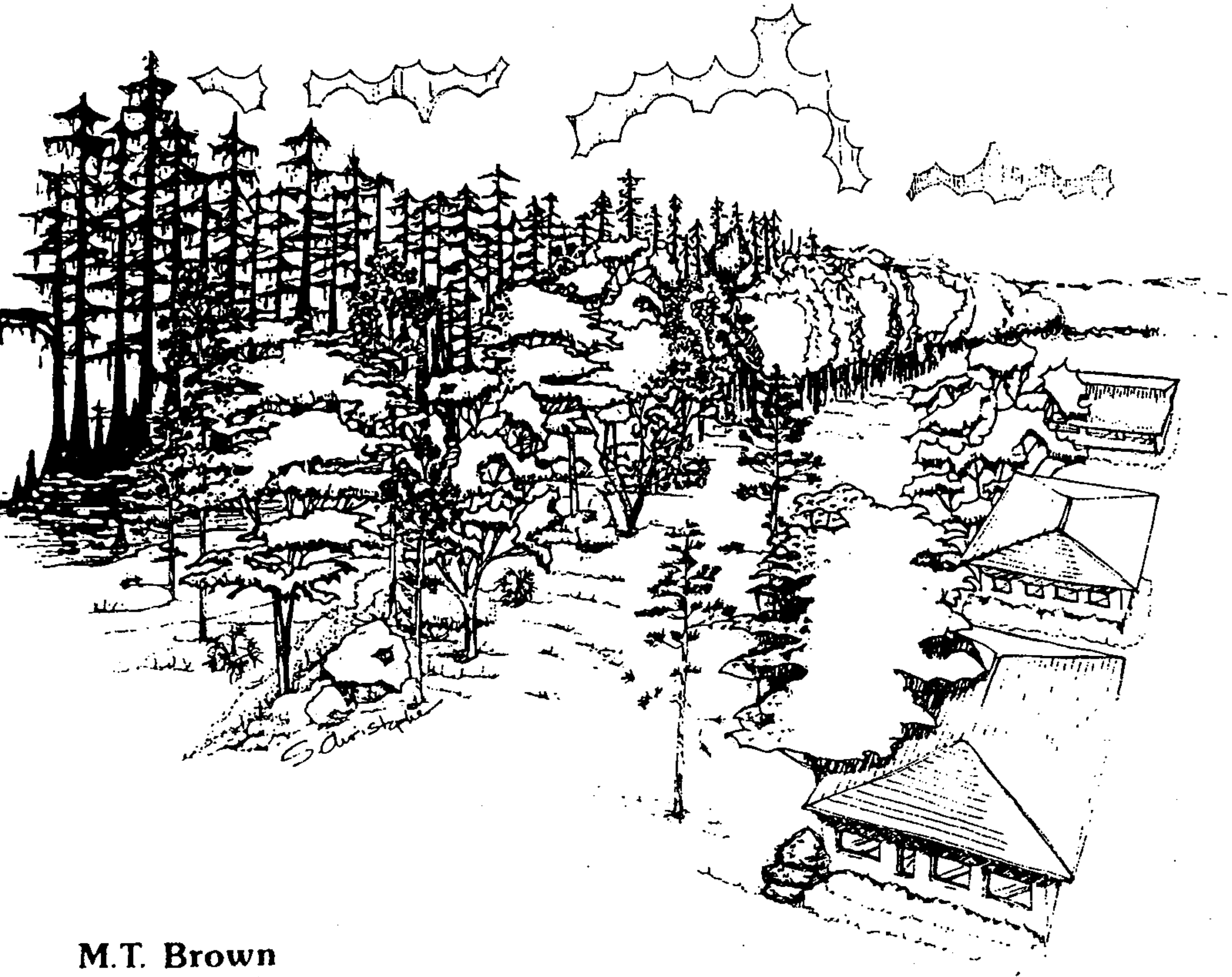
Buffer Zones for Water, Wetlands and Wildlife in East Central Florida



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BUFFER ZONES
FOR WATER, WETLANDS, AND WILDLIFE IN EAST CENTRAL FLORIDA

prepared for the
East Central Florida Regional Planning Council

by

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PREFACE

Developing a methodology for determining buffer requirements for water, wetlands, and wildlife is a complex undertaking when one considers the complexities of the landscape and the various activities associated with urbanization. Our tasks from the outset of this project and a previous project (Brown and Schaefer, 1987) were to simplify the complexity of the world, while retaining some measure of reality, and to develop meaningful and realistic recommendations for wetland buffers based on those simplifications. To those ends, we have identified three goals for determining buffer widths: (1) minimization of impacts from groundwater drawdown, (2) protection against sedimentation and turbidity, and (3) protection of habitat needs of wetland-dependent wildlife. To further simplify the world, we have classified the landscape into six landscape associations, a classification of land types that is based on ecosystems, hydrology, and landscape position. The classification scheme minimizes some of the complexity of the real-world landscape and makes application of buffer standards less arduous. In all, the goal was to develop a rational methodology that was not overly complicated and yet was defensible on scientific grounds.

Early discussions regarding the purpose of this study were centered on developing a methodology for determination of buffers for regionally significant wetlands[1] within the area of the East Central Florida Regional Planning Council (ECFRPC). Later discussions refined the purpose to include not only a methodology, but also generalized buffers for the region that could be applied at the regional level--in essence, some basic, minimum buffer requirements as presumptive minimum standards. Still later discussions added the need to develop a step-by-step procedure so that buffers might be calculated by all landowners within the region with a minimum of training and data required.

As the focus of the program shifted, the intended use of this document shifted. In the beginning, it was considered a report to the ECFRPC so that the Planning Council might develop buffer standards for regionally significant wetlands. As the program changed, the report included recommendations for generalized buffers based on the developed methodology, and finally, the report became a public document that gives step-by-step procedures for the determination of buffer requirements for all wetlands within the ECFRPC. To the extent that it was possible, we have tried to accommodate these shifting purposes. However, the changing focus has added significantly to the length and complexity of the report; to the extent that it now requires some minor explanation of its organization.

In Section I, Table 1-1 summarizes our recommendations for generalized, minimum buffer requirements that may be used as presumptive minimum standards applied regionwide. These recommendations are organized by landscape associations. Appendix A gives descriptions and maps of the associations within the ECFRPC. Use these descriptions and maps to determine where the differing standards apply.

In Section II, a discussion of the rationale and the methodology used to calculate buffer widths and detailed buffer recommendations are given. Use this section to develop regionwide minimum standards.

Section III contains step-by-step procedures and required data for the determination of buffer requirements. This section is included for the purpose of determining more refined buffer requirements than those provided in Table 1-1 or Section II should individual site conditions warrant. Background and derivations of the formulae in Section III are given in Appendices A, B, C, D, and E.

In summary, we suggest that the ECFRPC adopt a regulatory framework that uses the minimum presumptive standards for buffer requirements given in Section II but, that also allows for site-by-site determination of buffer requirements should site conditions warrant a more detailed evaluation.

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[1] Regionally significant wetlands are defined by the ECFRPC as generally, wetlands greater than 5 acres (see Section 1).

ACKNOWLEDGEMENTS

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BUFFER ZONES
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SECTION I: Recommended Buffer Requirements

Introduction

This report builds upon previous work in the development of a methodology for the determination of buffer zones for water, wetlands, and wildlife (Brown and Schaefer, 1987). This report also further develops and refines the methods of earlier work, recommends standards and criteria, suggests minimum buffer requirements, and proposes site-specific measurements that could be used to determine buffers on a site-by-site basis. The criteria for the determination of buffer zones were designed to address the concerns identified in Policy 43.8 (as amended on 5-18-88) of the East Central Florida Comprehensive Regional Policy Plan (ECFCRPP):

> In order to protect the quality and quantity of surface waters and provide habitat for semi-aquatic or water-dependent terrestrial species of wildlife, buffer zones should be established landward of regionally significant wetlands...

Regionally significant wetlands include:

> those wetlands which are Florida Department of Environmental Regulation jurisdictional as defined by s. 17-4.002, F.A.C; isolated wetlands five acres or more in area; and wetlands which provide significant habitat for species which are listed as endangered, threatened or species of special concern by the Florida Game and Fresh Water Fish Commission or Florida Department of Agriculture and Consumer Services, or which are assigned State Element Ranks of S1 or S2 by the Florida Natural Areas Inventory (ECFCRPP, page 150).

Policy 43.8 further states that:

> the landward extent of buffer zones around wetlands shall be determined based on scientific evaluation of site specific conditions, including the nature of the existing soils, vegetation, topography, hydrology, water quality, wildlife diversity and the resource protection status of receiving waters.

The purpose of setting aside buffer zones between a wetland and a developed upland area is to protect the integrity of the wetland's water supply, its water quality, and associated wetland-dependent wildlife. A buffer can be thought of as a zone of transition between two different land uses that separates and protects one from the other. Based on consideration of our previous work in this area (Brown and Schaefer, 1987), three goals have been identified that can be used to determine buffer sizes for wetland protection: minimization of groundwater drawdown in wetlands, minimization of sediment transport into wetlands, and protection of wildlife habitat. This report provides estimates of buffer sizes necessary to achieve these goals in the area comprised of the six counties in the ECFRPC's area (Brevard, Lake, Orange, Osceola, Seminole, and Volusia; see Figure 1-1). Also included are detailed descriptions of the methodologies and step-by-step procedures for calculating buffer requirements are given so that buffer sizes may be calculated on a site-by-site basis if desired.

Buffer Widths and Landscape Associations

To achieve some measure of sensitivity to the varying conditions found throughout the east central Florida landscape, the region was classified into several landscape associations that could be used to determine minimum buffer requirements. A landscape association is an assemblage of ecological communities having distinct topographic, geologic, and hydrologic conditions and landscape position. Six landscape associations were identified in the region:

1) Pine flatwoods/isolated wetlands
2) Pine flatwoods/flowing water wetlands
3) Pine flatwoods/hammocks/hardwood swamps
4) Sandhill communities/isolated or flowing-water wetlands
5) Pine flatwoods/salt marshes
6) Coastal hammocks w/salt marshes

A description of each association, maps of associations by county of the ECFRPC, and soils information that is important for evaluation of site-specific buffer determinations are given in Appendix A.

Soil properties, groundwater hydrology, topography, and wildlife characteristics of each landscape association were evaluated to determine generalized buffer requirements. The physical conditions and wildlife characteristics that are typical of each association overlap to a large degree, and therefore, when average conditions are used to determine buffer requirements for each association, there are few differences. Table 1-1 gives the minimum and maximum buffer requirements to minimize groundwater drawdown and sedimentation and to protect wetland-dependent wildlife for each of the landscape associations in the east central Florida region. To determine the appropriate buffer to meet each of the three goals, turn to the appropriate part of Section II.

Average conditions found for soils and hydrology are very similar for all associations except sandhills. Topography differs from one association to the next and in fact, differences in topography are the main variable controlling groundwater buffers. Therefore, differences in buffer widths for drawdown protection in Table 1-1 are mostly related to differences in topography. The landscape associations offer a convenient means of summarizing the data because they simplify much of the complexity of the landscape. Instead of dealing with 10-20 types of ecological communities and innumerable combinations of each, the associations offer a classification scheme with six components.

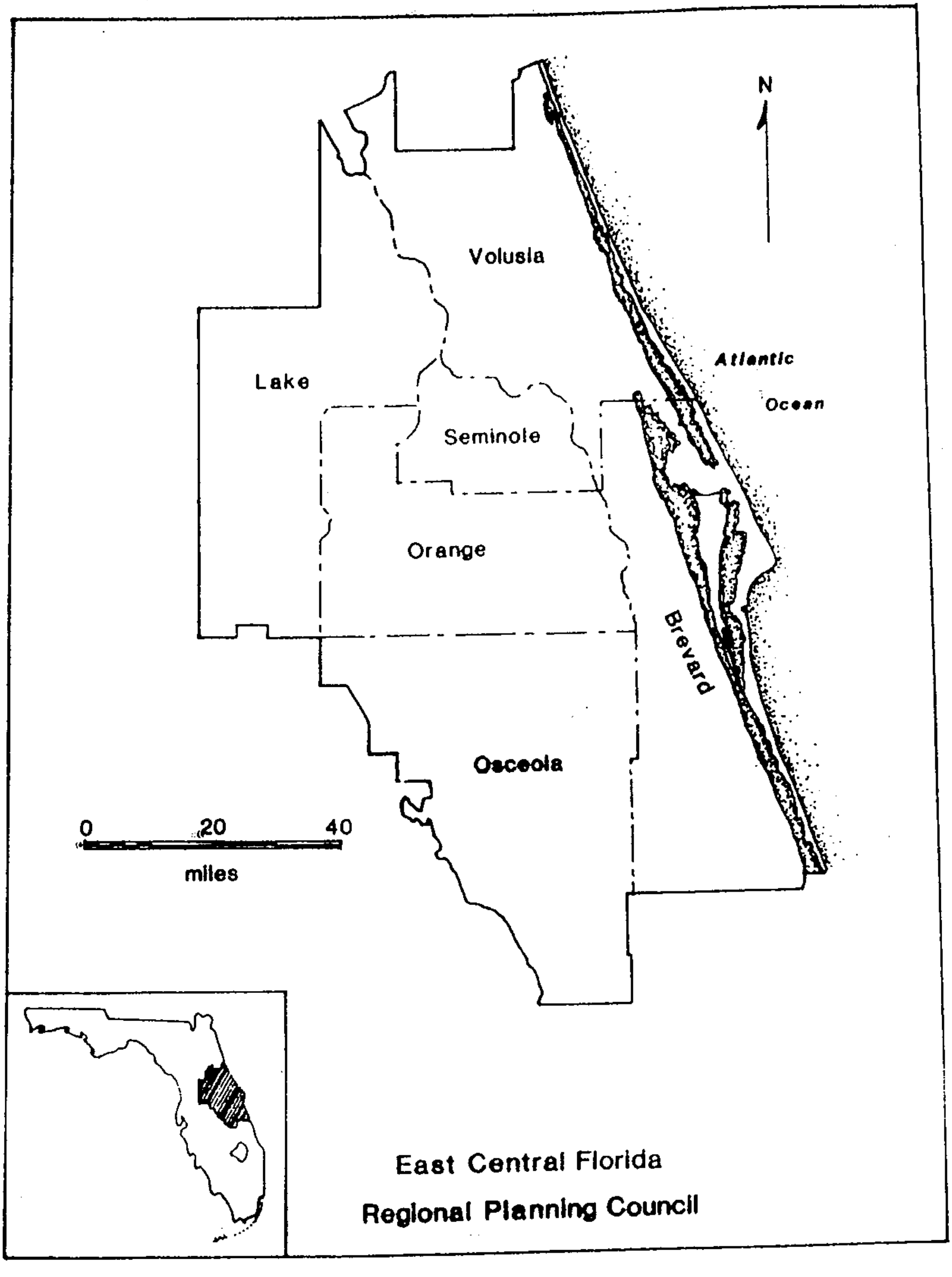

Figure 1-1. Map showing the counties of the East Central Florida Regional Planning Council.

Table 1-1. Minimum and maximum recommended buffer widths in feet for landscape associations of the east central Florida region for protection of water quality and quantity and wetland-dependent wildlife habitat.

Landscape Association	Minimize Groundwater Drawdown[2] Min. (feet)	Max.	Control Sedimentation[3] Min. (feet)	Max.	Protect Wildlife Habitat[4] Min. (feet)	Max.
1. Flatwoods/ isolated wetlands	100	550	75	375	322	550
2. Flatwoods/ flowing-water wetlands	100	550	75	375	322	550
3. Flatwoods/ hammocks/hardwood swamps	50	250	75	375	N/A	550
4. Sandhills/ wetlands	20	250	75	375	322	732
5. Flatwoods/ salt marshes	100	550	75	375	322	N/A
6. Coastal hammocks/ salt marshes	100	550	75	375	322	N/A

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[2] Buffer width depends on the extent of groundwater drawdown and slope of the groundwater table. The buffer widths were calculated using 1-foot and 5-foot drawdowns at the source of drawdown, a zero-inch allowable drawdown at the wetland edge, and a circular wetland of 5 acres (radius of 263 ft). Recommended buffers for 2-and 3-foot drawdowns are given in Table 2-1. The following slopes were assumed for the groundwater table: landscape association (LA)#1 = 1%; LA#2 = 1-2%; LA#3 = 2%; LA#4 = 2-4%; LA#5 = 1%, and LA#6 = 1%.

[3] Minimum widths are based on the settling velocity of sand; maximum widths are based on the settling velocity of silt. The buffer width for sand is measured from the upland/wetland boundary while the buffer for silt is measured from edge of open water through wetland to the upland (i.e., buffers for silt include the wetland).

[4] The minimum width is based on minimum habitat requirements of species associated with marsh ecosystems; the maximum width is based on minimum habitat requirements for wetland-dependent wildlife species associated with the various forested wetland ecosystems.

It is important to recognize the following qualifiers when using the suggested buffer widths in Table 1-1:

1. The buffer widths given are estimates of buffer requirements using average conditions for each landscape association. Detailed site-specific data could be gathered and more refined buffer widths determined on a site-by-site basis.
2. The data used to calculate the buffer widths and the values of other parameters in this report are derived from maps, literature, and other general sources. They are not derived from field investigations.
3. Wildlife buffers begin at the waterward edge of the forested wetland or upland habitat that is adjacent to the aquatic system. Marsh buffers are measured landward from the landward edge of the marsh vegetation. A minimum 50-foot-upland strip should also be included in each buffer for semi-aquatic reptile nesting and overwintering.
4. Buffer sizes set out in this report will not ensure the maintenance of minimum viable populations of wildlife species.

Recommended Buffer Widths

The suggested minimum and maximum buffer widths given in Table 1-1 are for illustrative purposes. Tables in Section II give recommended buffers that can be used to set presumptive regulatory standards for the region. In addition, it is recommended that the Council consider including a provision in any buffer rule that would give permit applicants the option of collecting site-specific data and determining buffer widths using the methods described in Section III of this report.

Section II describes in some detail the rationale behind the recommended buffer widths; however, some explanation here may help to minimize confusion. The original objective of this project was to develop a single recommended buffer width for each landscape association, but soon it became apparent that a single number contained too many hidden assumptions and minimized too much of the important variability in the landscape. Thus, recommended buffer widths are based on physical attributes of the site. To determine which buffer width applies to a site requires some knowledge of the site and its intended use and the following procedure:

1. Determine the landscape association the site occupies (use Appendix A maps).
2. Determine the extent of groundwater drawdown planned and slope of groundwater table (average terrain slope may suffice).
   *READ REQUIRED DRAWDOWN BUFFER WIDTH FROM TABLE 2-1; Section II.
3. Determine soil type and USDA soil class from soils map.
   *READ REQUIRED SEDIMENTATION BUFFER WIDTH FROM TABLE 2-2; Section II.
4. Determine vegetative cover of each wetland on the site.
   *READ REQUIRED WILDLIFE HABITAT BUFFER WIDTH FROM TABLE 2-5; Section II.
5. The widest of the three buffers should be used.

This method provides a relatively simple yet reasonable means of tailoring the buffer width to the most important site conditions and anticipated site engineering. The recommended widths are conservative (that is, buffer widths given in this report are the maximum widths necessary to achieve each goal). As a result, many development applicants may opt to collect site-specific data and apply the methods given in Section III to determine buffer requirements.

A much simpler approach, but one that is not recommended, is the adoption of a single presumptive buffer width of, say, 200 or 500 feet. However a single presumptive buffer would probably increase the use of Section III methods, defeating the attractiveness of a single numeric buffer width.

Saltwater and Freshwater Wetlands

Saltwater wetlands differ significantly from freshwater wetlands in species composition because of interactions of landscape position and the driving energies of tides and waves. Nevertheless, the relationship to groundwater, potential sedimentation, and wildlife of freshwater and saltwater wetlands are similar. Therefore, strategies for determining buffers for the interface of upland and saltwater wetlands are the same as those employed for inland freshwater wetlands. The following rationale may help to explain the reason for treating saltwater and freshwater wetlands similarly for the purposes of determining buffer requirements.

A lens of fresh groundwater that is particularly sensitive to changes in flow direction exists at the interface between uplands and saltwater wetlands. As long as a positive freshwater head in the uplands is maintained, salty groundwater movement toward the upland is minimized. However, increased drainage or pumpage in upland areas adjacent to saltwater wetlands causes rapid movement of saltwaters toward the upland. Thus, groundwater drawdown in uplands adjacent to saltwater wetlands is of primary concern.

Sedimentation and turbidity are of equal concern in saltwater and freshwater systems. No differences between saltwater wetlands and their counterparts farther inland were discerned related to potential impacts from for sedimentation or responses to turbidity. Sedimentation in saltwater wetlands as in freshwater wetlands acts to fill the wetland, suffocating vegetation and raising ground surface elevation. Turbidity in the water column reduces light penetration and can significantly reduce primary production in saltwater as well as in freshwater. As a result the same relationships used in freshwater wetlands have been applied to the saltwater wetlands.

Finally, while there is some knowledge concerning differences in wildlife utilization of saltwater and freshwater wetlands, data related to their precise habitat requirements of wildlife using saltwater wetlands are insufficient to distinguish between them for the purpose of setting buffer widths. Thus, with the exception of turtle nesting requirements, the wildlife habitat requirements developed for freshwater wetlands have been applied to saltwater systems.

SECTION II: Rationale for Buffer Determination

This section provides a rationale for each of the buffer goals (minimize groundwater drawdown, control sediment and turbidity, and protect wildlife habitat). Each subsection presents a brief rationale, explains the methodology, and gives recommended buffer widths. Appendices to this volume contain further explanatory information, formulae, and data that may be used to evaluate buffer requirements on a site-by-site basis using the procedures in Section III.

Recommended buffer widths are based on a synthesis of all pertinent information that must be considered when developing a regulatory framework, not the least of which are: (1) a rational limit to what can be reasonably expected of a buffer, (2) detection limits of the equipment that might be used to measure parameters and impacts, (3) the limits of knowledge and understanding concerning negative impacts of anthropogenic activities on wetland structure and function, and (4) the variability of nature. Often, when developing a framework for regulating natural resources, some suggested standards may seem arbitrary on the surface, e.g., trapping 95% of sediments in a buffer instead of 100% or requiring 50 feet of sandy soil around wetlands for nesting of certain wildlife species. They are arbitrary in the sense that 94% may be just as acceptable a sediment deposition rate as 95%, or 51 feet an acceptable wildlife nesting zone. Some parameter values have been rounded off so that they can be easily identified and remembered. The real issue is that detection limits and marginal return factors suggest that measuring a parameter beyond the suggested limits is probably not feasible given a reasonable amount of time and money. Furthermore, not enough is known about some parameters (the nesting habits of most wildlife species, for example) to predict the exact requirements for upland nesting zones. To expect greater precision is unwarranted and unreasonable.

Recommendations for various coefficients and constants used to determine buffer requirements are based on analysis of the conditions and parameters found in the region and best judgment related to what is reasonable, what is understood about wetland structure and function, what is known about the detection limits of current measurement techniques, marginal returns on investments of time and energy, and what is known about the variability of nature.

Groundwater Drawdown

The interplay of surface water in wetlands with groundwater in surrounding uplands is not at all simple. To understand how lowered groundwater levels in surrounding lands will affect surface water levels in adjacent wetlands, a significant amount of detailed data on the structure and composition of the soils immediately under and in the immediate vicinity of the wetland is required. In addition, data on surface water levels within the wetland, groundwater levels in adjacent uplands, and rainfall need to be collected for at least one year. As a result of these data requirements, the use of less data-intensive methods and generalized parameters is attractive and may lead to acceptable results given the limits of precision dictated by the methods and initial generalizations.

The diagram in Figure 2-1 illustrates the effect of drainage structures (ditches, drainage tiles, etc.) on groundwater levels in the vicinity of a wetland. The degree to which groundwater levels are lowered depends on characteristics of intervening soils,the depth of the drainage structure, and the capacity for outfall from the structure to some lower elevation. In some cases outfall is by a gravity connection to some structure or water body of lower elevation. In others, pumps are used to remove water to maintain lowered water table elevations.

The suggested buffer widths for the minimization of groundwater drawdown effects on wetland hydroperiod given in this report are based on a generalized model that requires a minimum of data collection. Under some circumstances, individual projects and conditions at particular sites may warrant a more detailed examination of drawdown effects. Under these circumstances, more complex hydrological models and detailed data may result in the determination of different buffer requirements. The use of other models should be encouraged when warranted by site conditions, but only if they are valid representations of site conditions and are driven by sufficient, reliably obtained data.

The Function of Groundwater Drawdown Buffers

The purpose of minimizing groundwater drawdown is to maintain an acceptable wetland hydroperiod after development. Lowered groundwater tables in areas surrounding wetland communities can decrease surface water depth and shorten periods of standing water within wetlands. Since the greatest single driving force determining wetland community organization is hydrology, actions that alter hydrology have direct effects on the integrity of wetland communities. Lowered water levels and shortened hydroperiods cause a shift in community structure toward species characteristic of drier conditions. The maintenance of hydroperiod is probably the single most critical variable in maintaining viable wetland communities.

Characteristic hydroperiods of wetland communities depend on the community type. Some wetland types have water depths of 3 feet or more and remain inundated for most of the year. Others have water depths of 1 foot or less and are inundated for relatively short periods of time during the year. Depths and periods of inundation within any given wetland determine its species composition. Species adapted to one hydrologic regime are often not well-adapted to a different one. Complete loss of water has obvious impacts on wetland community organization and may be caused by groundwater manipulations in adjacent uplands that lower water tables enough to "drain" wetlands.

Because water levels in wetlands are not static, predicting the impact of lowered water levels and shorter periods of inundation on the community organization of a wetland ecosystem is not an easy task. To illustrate the complexity of the problem, a model of wetland hydrology was developed that, when simulated on computer, generates curves that represent water levels within a typical wetland.

Figure 2-2 is a diagram of a simulation model of wetland hydrology that shows inflows of water from rainfall and runoff; surface water storage in the wetland; losses of water from evaporation, transpiration, and surface water outflows; and the interaction between surface water and groundwater. Figure 2-3 displays simulation results for a series of years are given where the different curves represent different rainfall patterns.

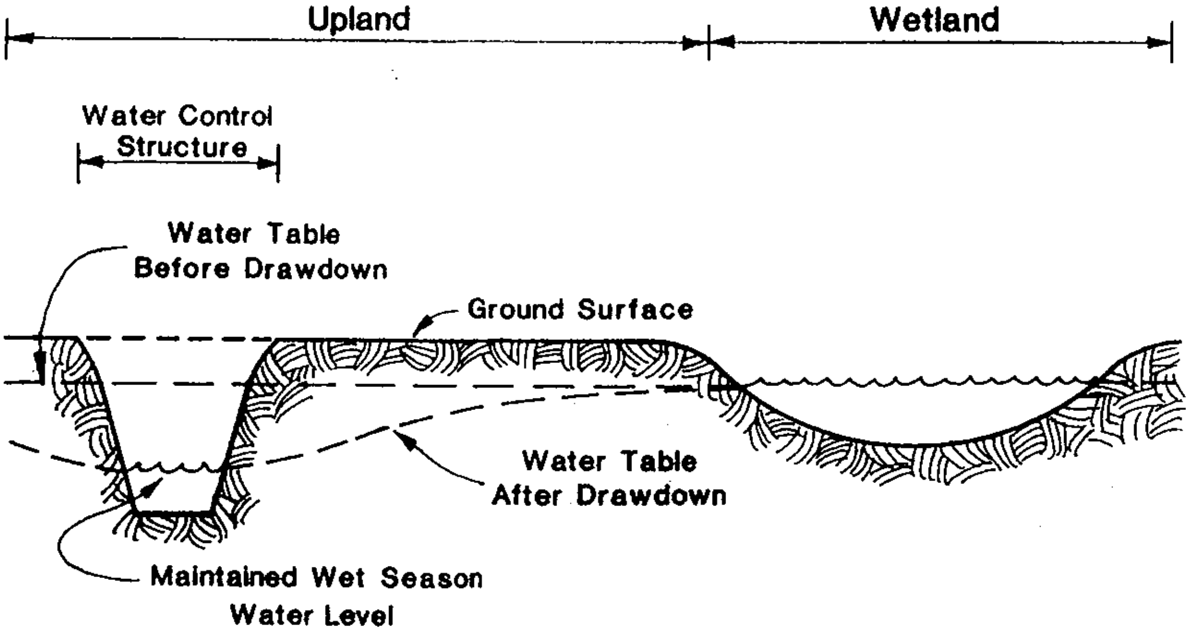

Figure 2-1. Diagram illustrating the effect of a water control structure on groundwater table. With increasing distance between the control structure and the wetland, negative impacts and wetland hydrology may be minimized.

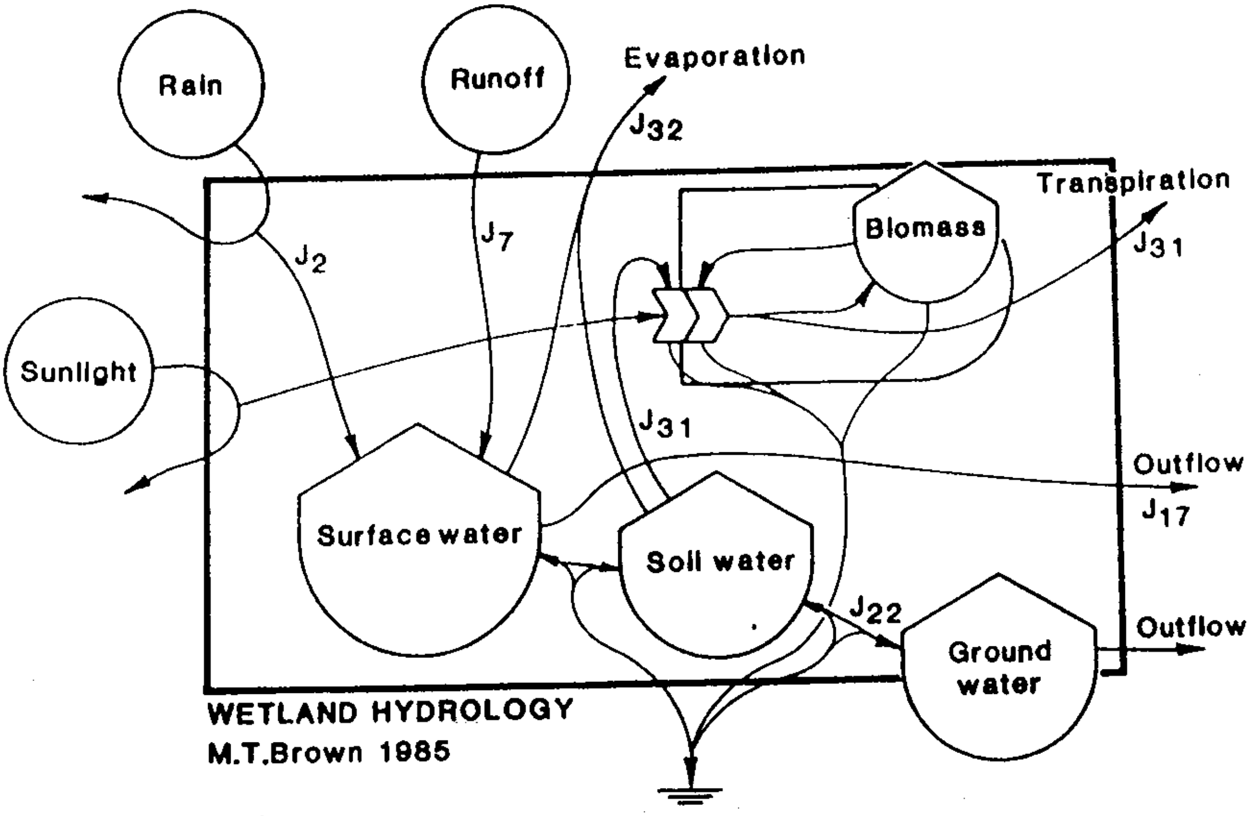

Figure 2-2. Diagram of computer simulation model of wetland hydrology.

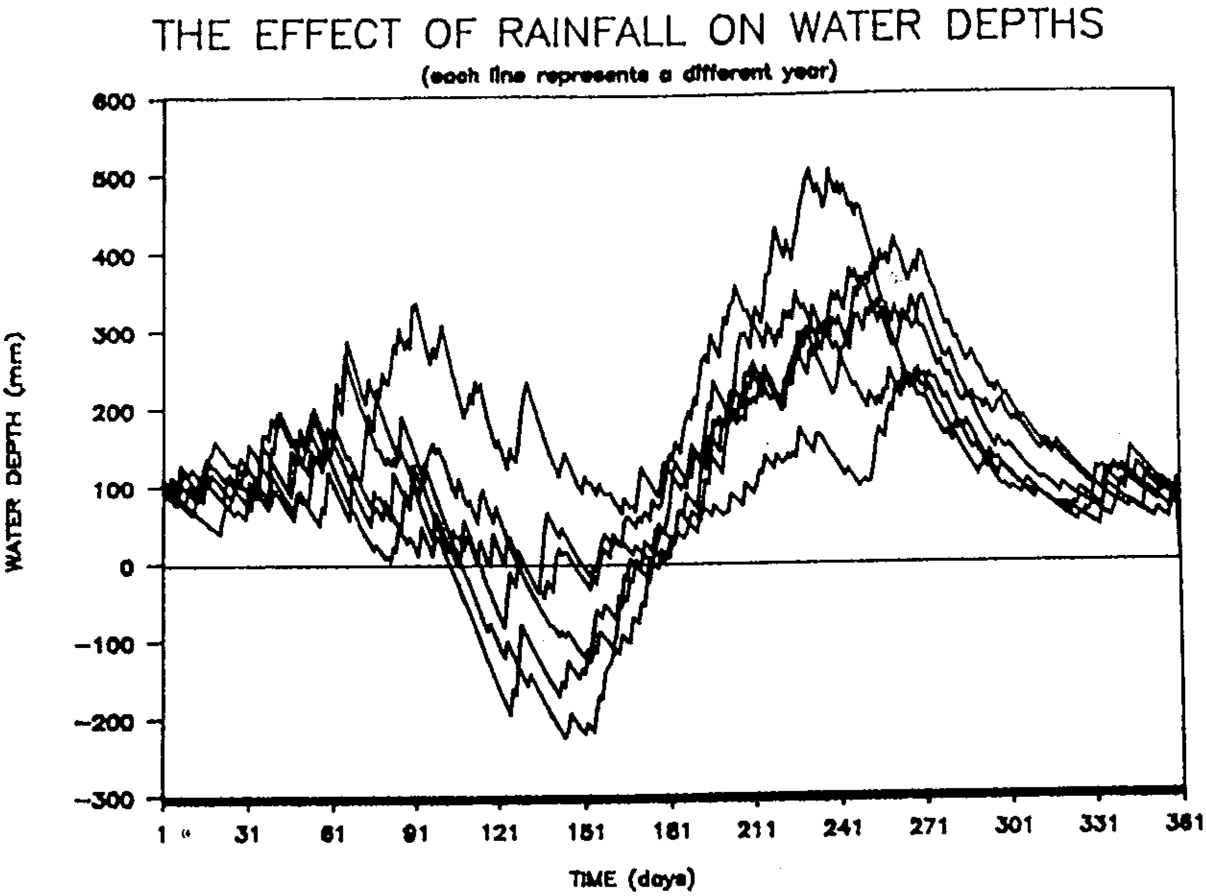

Figure 2-3. Simulation results of the wetland hydrology model in Figure 2-2 showing the variation in surface water levels within a wetland typical of central Florida. The variation from year to year is due to differences in yearly rainfall simulating wet and drought years.

The simulation shows how water levels vary depending on how much rain falls during the year. The variation in rainfall is a key factor in determining characteristic hydroperiod, since it illustrates the transient nature of wetland hydrology. What may be a characteristic hydroperiod during one year is not necessarily characteristic the next. Thus, the problem of predicting the impact on community structure of a drawdown of several inches or even 1 foot is compounded by the fact that water levels are not static and vary from year to year and within each year.

The simulation results in Figure 2-4 show the effects of lowered groundwater levels in the landscape surrounding a wetland community. Rainfall is held constant for each simulation, and groundwater levels are decreased in increments of 1 foot. The top curve shows the normal condition. Each succeeding curve results from an additional 1 foot of groundwater drawdown in the surrounding landscape. Each succeeding drawdown lowers water levels within the wetland and shortens the length of time that the wetland is inundated. The largest difference between succeeding curves is between the normal condition and 1-foot drawdown; the second biggest difference is between the 1- and 2-foot drawdown. Thereafter, additional lowering of the groundwater table does not have as great an effect as the initial 1 or 2 feet, since water levels within the wetland are now maintained for very short periods immediately after rainfall events. Comparison of these curves with the normal fluctuations of water levels that result in yearly variation in rainfall suggest that a 1-foot drawdown in the surrounding landscape is sufficient to cause a marked lowering of water levels within the wetland and that drawdowns of less than 1 foot are probably not discernable from the normal variation.

The effects of drainage structures on groundwater elevations diminish with distance from the structure. In other words, structures farther away from a wetland will have smaller impacts on water table elevations than structures in closer proximity. Thus, it is possible to determine how far a drainage structure must be from a wetland so that drawdown in the wetland is minimized.

Buffer Requirements to Minimize Impacts from Groundwater Drawdown

Appendix B is a report by Dr. Wendy D. Graham of the Department of Agricultural Engineering, University of Florida, which describes a procedure for determining the distance required between a ditch or other water control structure that lowers groundwater levels and the edge of a wetland so as to minimize the drop in water levels in the wetland. The complexities of groundwater hydrology have made it necessary to make several assumptions that limit the applicability of this method. In particular, a continuous horizontal impervious layer must exist beneath the wetland/upland system, and the depth from the soil surface to the top of the impervious layer must be known. As a result of these assumptions, the model has limited applicability in areas where there is no impervious lower boundary to the surficial aquifer or where the layer is extremely deep. Impermeable layers are frequently absent in sandhill landscapes. Under these conditions the model cannot be used; however, when these conditions prevail, groundwater levels are usually not close to the surface and thus, groundwater drawdown is not of concern. Where an impervious layer is known to exist, the model may be used to determine buffer widths.

Determination of a buffer width that will protect wetland hydrology is based on the model described in Appendix B. A model was sought that would simply and accurately represent the relationships between water levels within wetlands and groundwater levels in the surrounding landscape. The simplifying assumptions in the model have reduced requirements for detailed data to a minimum. The main data needed are: the depth to the

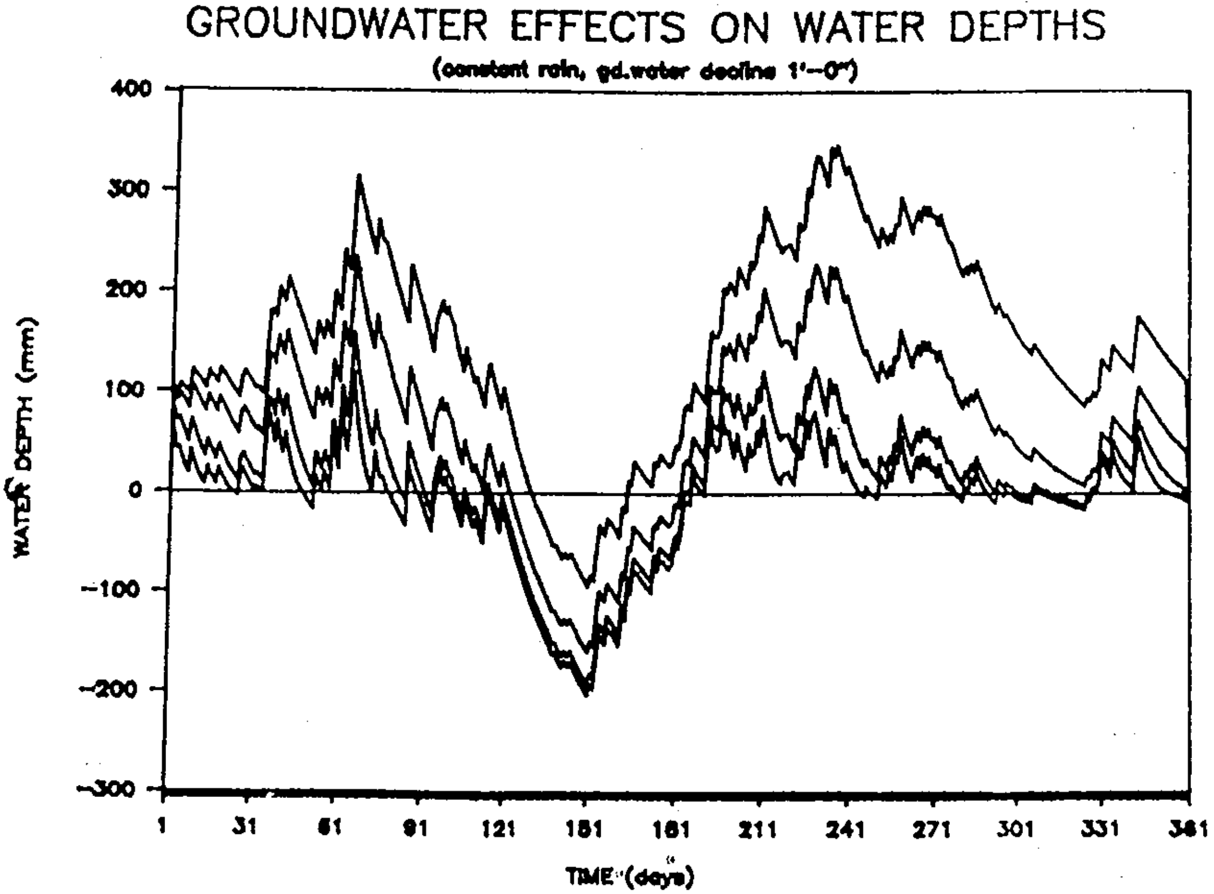

Figure 2-4. Simulation results of the groundwater hydrology model showing the effect on surface water levels within the wetland of increased groundwater drawdowns on the surrounding landscape. Each curve represents a different groundwater level drawdown. The top curve is the normal condition; the next curve down represents a drawdown of 1 foot; the curve below that represents a 2-foot drawdown; and so on.

impermeable, lower boundary of the surficial aquifer, the size of the wetland (radius), the wet season elevation of water in the center of the wetland, the pre-construction wet-season slope of the surficial aquifer (assume the ground surface slope), and the amount of drawdown at the water control structure. Figures 2-5 and 2-6 show a series of curves for a circular wetland of 5 acres (263 feet in radius) that were generated using the model in Appendix B for various surficial-aquifer slopes. In the most general sense, as demonstrated by the graphs, required buffer widths are quite sensitive to slope. Sensitivity of the model to depth to the lower limit of the aquifer depends on the size of the wetland in question. A sensitivity analysis of the model showed that for wetlands smaller than 5 acres, depth to impermeable layer was somewhat significant, but it had little influence on solutions for larger wetlands. Similarly, when all other model variables are held constant, varying the size of the wetland had no effect on buffer width except for wetlands smaller than 5 acres (263-foot radius).

The curves given in Figure 2-5 show drawdown effects in all landscape associations, for varying degrees of slope of the surficial aquifer for a 1-foot (top graph) and 2-foot (bottom graph) drawdown at the surface water control structure. The horizontal axis shows required distance from wetland edge[5], and the vertical axis represents drawdown at the wetland edge. The buffer required to ensure no drawdown at the wetland edge varies from 200 feet (for a 2-foot drawdown at the structure and 1% slope) to approximately 20 feet (for a 1-foot drawdown at the structure and 10% slope). Figure 2-6 illustrates the consequences of drawdowns of 3 and 5 feet. The shape of the curve is the same, but the magnitude of drawdown at the wetland edge is greater, and the required buffer width to minimize drawdown at the wetland edge is greater. In this case, to ensure zero drawdown at the wetland edge, a buffer width of approximately 550 feet is required for a drawdown of 5 feet in areas with groundwater slopes of 1%. The minimum buffer required for a 3-foot drawdown is 30 feet in areas with surficial aquifer slopes of 10%.

Changes in water levels will affect fringing areas of a wetland, altering hydrologic conditions in the transition zone between upland, and wetland. While those impacts are always potentially present, they are of greater importance in wetlands of smaller size, since with larger size, the effects of groundwater drawdown are somewhat mitigated by the hydrologic storage within the wetland. Thus, smaller wetlands require buffers of greater dimension. Small wetlands have lower capacity to ameliorate the effects of lowered groundwaters in the surrounding landscape. Buffer widths for wetlands smaller than 5 acres will be greater than those given in Table 2-1. The 5-acre limit used in this report was chosen since wetlands of less than 5 acres generally are not considered of regional significance by the ECFRPC.

The buffer recommendations given in Table 2-1 are based on typical slopes assumed for each landscape association. However, where greater resolution is warranted because of site specific conditions, the methodology explained in Section III of this document may be used to calculate required buffer widths.

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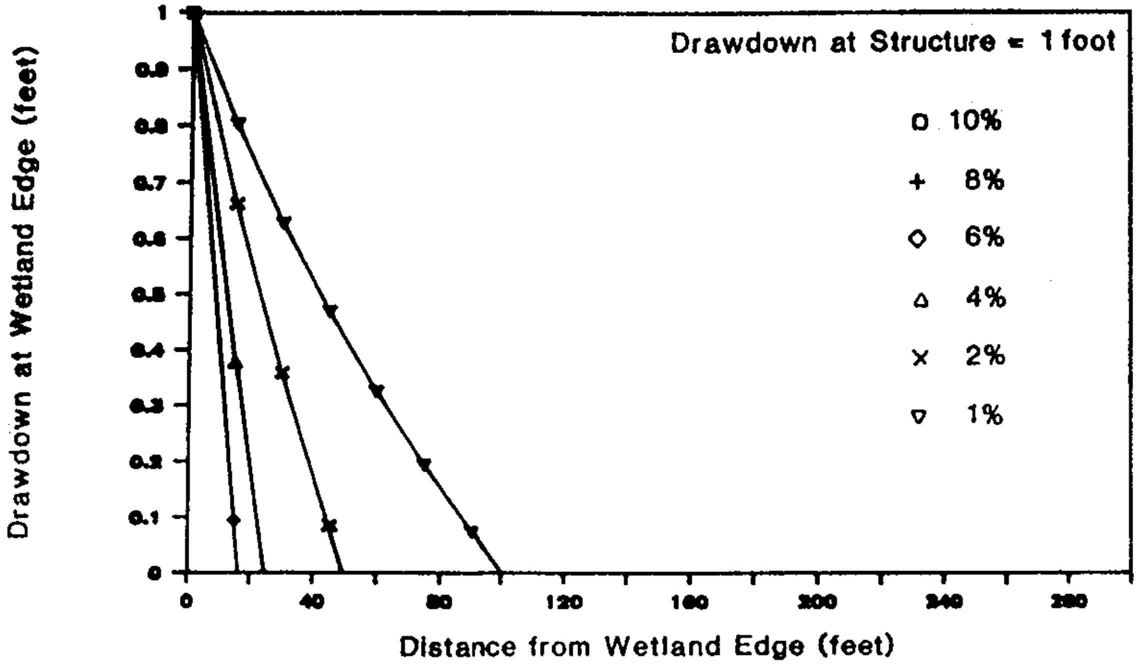
[5] The wetland edge can be determined using any of several methods for demarcating the boundary between uplands and wetlands. The best methods are those developed by the Florida Department of Environmental Regulation, the Army U.S. Corps of Engineers, and the St. Johns River Water Management District. Under most circumstances, all determinations are quite similar. We suggest, for consistency, that the methodology employed by the St. Johns River Water Management District be used to establish the wetland edge when determining buffer requirements in the east central Florida region.

EFFECT OF GROUNDWATER SLOPE ON DRAWDOWN



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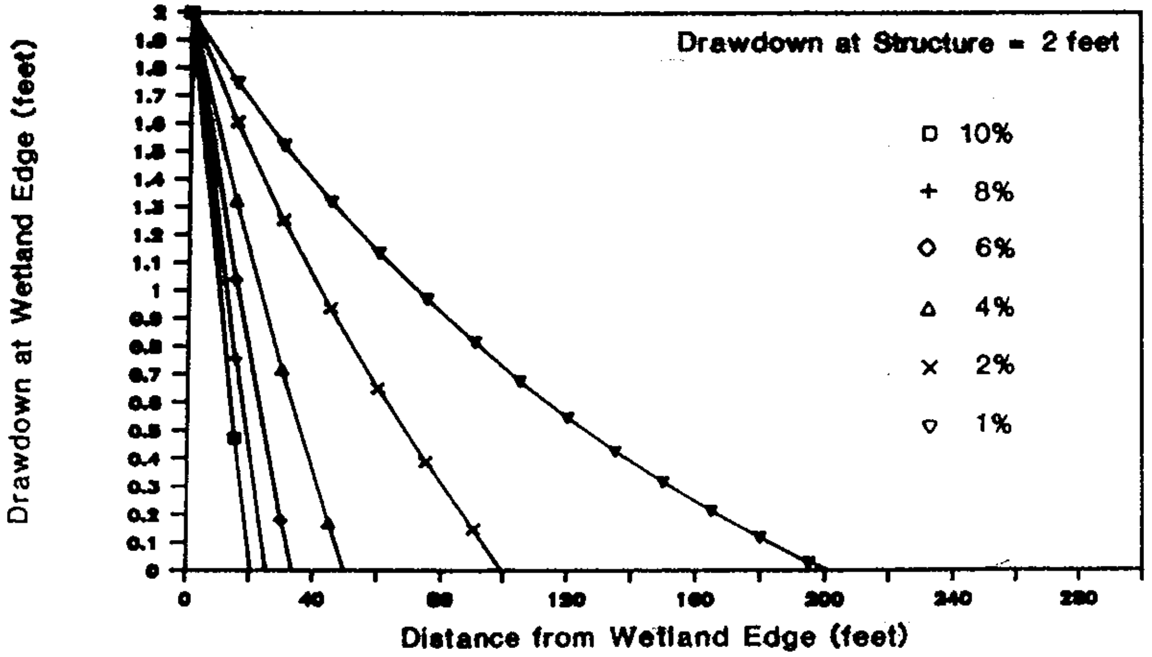

Figure 2-5. Graphs of drawdown versus distance from wetland edge for 1-foot drawdown (top) and 2-foot drawdown (bottom). Each line in the graphs illustrate a different slope of the groundwater table. The appropriate buffer distance from wetland edge for differing water table slopes is read as the intersection of graph lines with the horizontal axis.

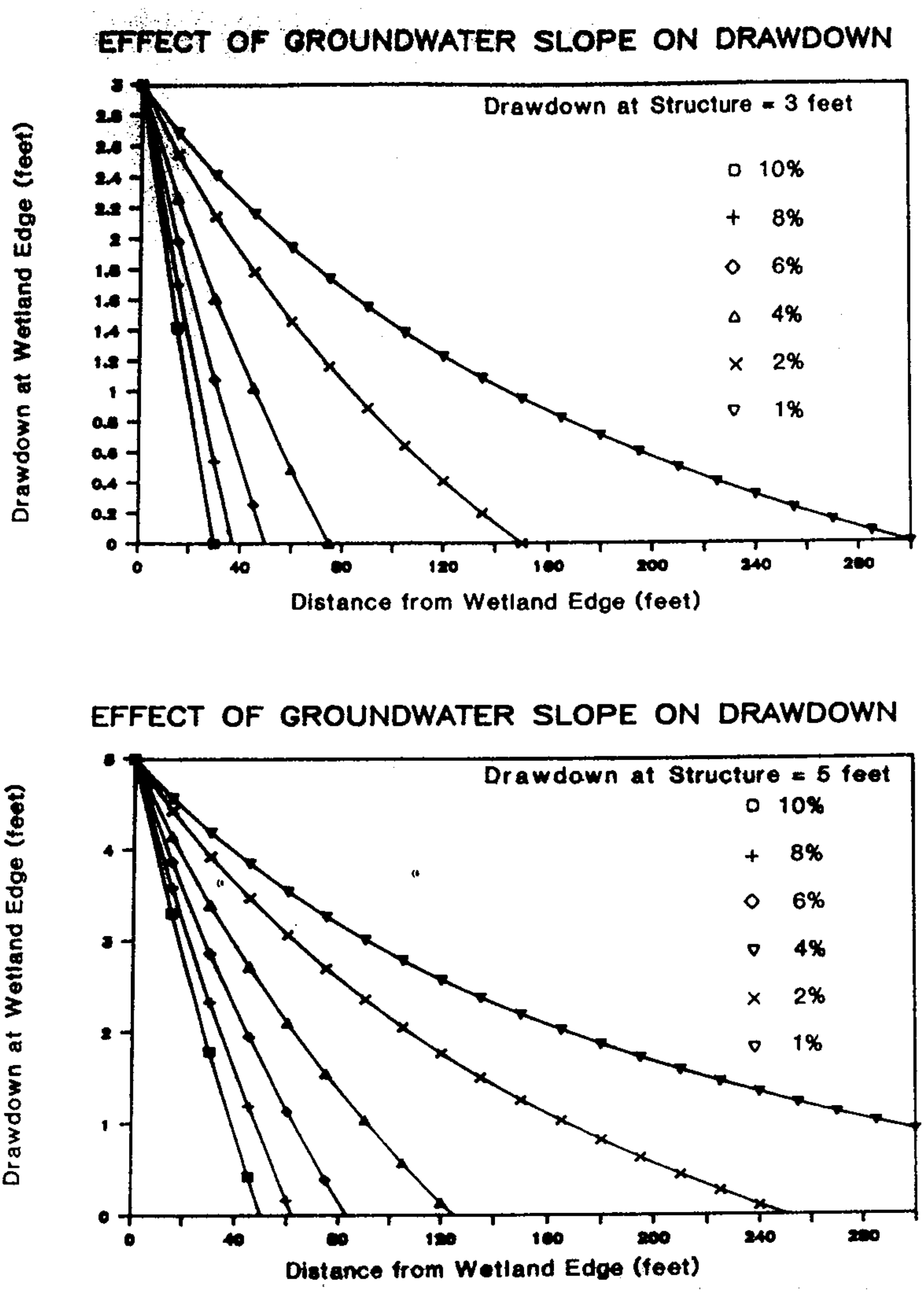

Figure 2-6. Graphs of drawndown versus distance from wetland edge for 3-foot drawdown (top) and 5-foot drawdown (bottom). Each line in the graphs illustrates a different slope of the groundwater table. The appropriate buffer distance from the wetland edge for differing water table slopes is read as the intersection of graph lines with the horizontal axis.

Table 2-1. Recommended wetland buffers to minimize water table drawdown for landscape associations of the east central Florida planning region.

Landscape Association #	Slope[1] (%)	Drawdown at structure[2] 1 ft.	2 ft.	3 ft.	5 ft.
1 Flatwoods w/isolated wetlands	1	100	200	300	550
2 Flatwoods w/flowing-water wetlands	1	100	200	300	550
	2	50	100	150	250
3 Flatwoods and/or hammocks w/hardwood swamps	2	50	100	150	250
4 Sandhill communities w/isolated or flowing-water wetlands	2	50	100	150	250
	4	25	50	75	125
	6	20	35	50	85
5 Flatwoods w/salt marshes	1	100	200	300	550
6 Coastal hammocks w/salt marshes	1	100	200	300	550

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[1] The slopes given are estimates of the slope of the surficial aquifer characteristic of each association based on averages of topographic relief of the various associations. Where more than one slope is given, variation of topographic relief within associations was sufficient to require listing several slopes.

[2] At the present time, the St. Johns River Water Management District allows a maximum 5-foot, groundwater drawdown at any one point within project boundaries and an overall average drawdown of 3 feet.

Sediment and Turbidity Control

A naturally vegetated buffer zone can catch and retain sediment carried by overland flow from construction sites and developed landscapes. Vegetated buffers are far more effective than sediment screens or hay bales, which are vulnerable to accidental breaching by heavy equipment and to blowouts from the brief but intense rainstorms characteristic of the region. If adequate stormwater control systems are installed and if buffer zones between wetlands and construction sites are incorporated into such systems, buffer zones for sediment and turbidity control are needed only temporarily, (i.e., between the time the land is cleared and the time it is revegetated and detention ponds or other runoff control systems are put in place). Buffers for sediment protection are assumed to be unimportant after construction is complete if the developed lands immediately adjacent to the wetland in question have an adequately designed and maintained stormwater control system and if the lands used for sediment buffers are incorporated into the system.

The Function of Sediment and Turbidity Control Buffers

A sediment buffer is necessary to ensure that sediment eroded from surrounding uplands and deposited in a wetland does not act to fill the area, thereby creating an upland from deposited material where there once was a wetland. Additionally, a turbidity buffer is required where surface waters may be degraded by turbidity associated with very fine-grained silt or clay particles. A distinction is drawn between sediment control and turbidity control since the effects and required buffers are quite different. The term "sediment," is defined in this report to mean relatively large-grained sand material (0.05 - 2.0 mm diameter) that because of its size will settle in relatively short distances. Because of their small size, silt particles (0.002 - 0.05 mm in diameter) have greater mobility, require long settling times and distances, and pose significant threats to water clarity. As a result of these differences, silt turbidity control buffers are different from sediment control buffer requirements.

Buffers for sediment control are necessary whenever upland erosion and subsequent deposition of eroded materials in a wetland is possible. Under most circumstances, eroded sediment is large-grained and will settle out in a relatively short distance. As a result, the required buffers are small.

Buffers for turbidity control are necessary whenever downstream water clarity may be degraded by suspended silt that may result from erosion of adjacent upland locations. Since silt is small-grained and does not settle out in short distances, the required buffers are of relatively large widths under most circumstances.

The important differences that must be addressed in determining buffer requirements are in the pathways of interaction and the threats that each pose. Sediment can fill a wetland, thereby compromising its function; but sedimentation can be easily avoided by using upland buffers as sediment traps. On the other hand, silt creates turbidity which reduces water transparency and, thus, interferes with photosynthesis of submerged vegetation and phytoplankton in the water column. Turbidity is of great concern in lakes and streams and it is a very difficult problem to remedy. In vegetated wetlands turbidity is of little concern since there is only minor photosynthesis from submerged vegetation or phytoplankton in the water column.

Buffers to protect water bodies against turbidity are not required if the adjacent wetland is isolated (i.e., not connected to a body of open water) and is 100% vegetated with emergent or loating vegetation. For wetlands connected to lakes, rivers, streams, or other water bodies, the buffer width for turbidity should be measured from the water edge and should include the wetland. In other words, wetlands are good filters of fine-grained silts and buffers necessary for water-quality purposes should include the wetland's filtering action. Because Florida soils have low percentages of silts and clays, and because disturbances that cause erosion are typically temporary (e.g., construction), it is highly unlikely that including a wetland in a turbidity buffer will result in damage to the wetland from excessive siltation.

Buffer Requirements to Minimize Impacts From Sediment and Turbidity

The graph in Figure 2-7 shows the relationship between percentages of various kinds of sediment trapped by a buffer and the length of the buffer. The curves were derived from a methodology that first determines the expected volume of runoff (using TR-55 [SCS, 1986]) and then calculates the length of the vegetated strip required to settle out sediments of varying sizes. The methodology is explained in Section III.

The efficiency of a buffer is directly proportional to the size and specific gravity of the particles eroded from upland areas and carried by the flowing water (all other things being equal). In general the smaller the material being carried, the farther it will travel before water velocity is sufficiently reduced to cause it to settle out. Under most circumstances in central Florida, particles carried by surface runoff are sands and aggregates of sand particles of varying sizes and, to a lesser extent, silt particles. Under rare conditions eroded material may contain significant amounts of clay particles. Clay particles are the smallest in size (< 0.002 mm diameter); primary silt particles are next smallest (0.002 - 0.05 mm diameter); then fine sand (0.05 - 0.25 mm diameter); and finally medium to coarse sands (0.25 - 2.0 mm diameter). The smaller the particles, the farther they travel and the greater their potential for causing sedimentation of wetlands and turbidity of downstream waters.

Determination of the buffer requirement is related to the type of wetland and/or receiving waters that are downslope and the particle size that is characteristic of the soils subject to erosion. Appropriate distances between the waterward edge of the wetland and the upland edge of the buffer can be read from Figure 2-7 and are summarized in Table 2-2. Where well washed medium to coarse-grained sands are characteristic of the soil material, the buffer width should be approximately 75 feet to allow for deposition of nearly 100% of the material within the buffer. For soils having higher proportions of fine sands, the buffer width should be 200 feet to allow for deposition of 100% of the material. In soils where larger quantities of silts are expected and where there are downstream water bodies that would suffer from increases in turbidity, the buffer width should be 500 feet (measured from water edge and including the wetland) to deposit approximately 95% of silt material. Where there is the potential for suspension of clay particles in runoff waters that may adversely affect streams and lakes, additional measures for protection against turbidity (such as settling or holding ponds, filter fabric barriers, or sand filtration systems) should be employed during construction, since the required width of a vegetated buffer under these circumstances makes them impractical.

The use of a 95% deposition rate for silts is based on the marginal rates of return from further increases in buffer widths related to percent of sediment deposited. While it may be desirable to trap 100% of silt leaving a construction site prior to its entry into a watercourse, the practicality of doing so is questionable. Because of the exponential nature of the curves in Figure 2-7, the buffer required to trap 100% of the silt leaving a site would be approximately 700 feet wide. Buffers greater than 500 feet wide, have significant declines in their

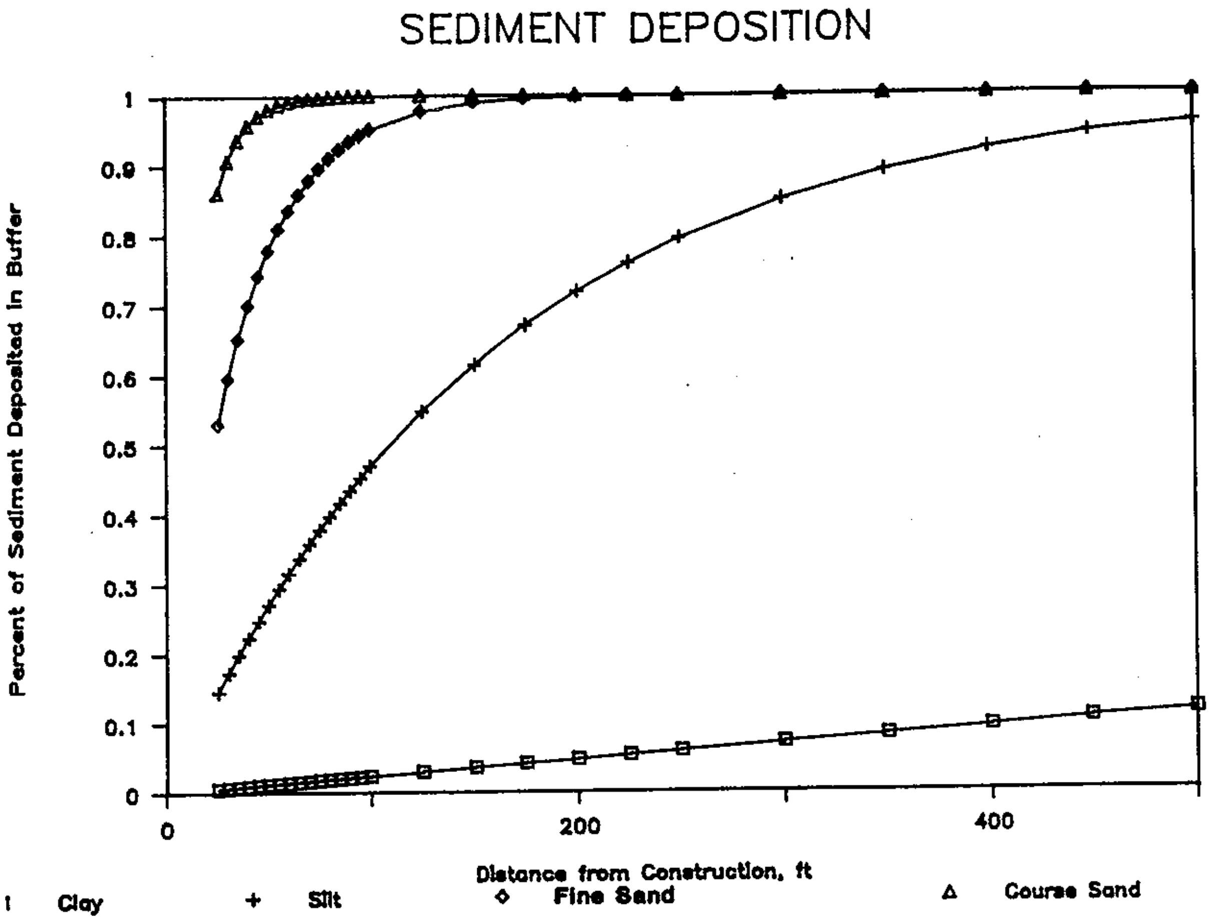

Figure 2-7. Graphs of percent sediment deposition versus distance. Each line illustrates the buffer widths necessary to deposit sediments of differing sizes to minimize sedimentation in wetlands.

Table 2-2. **Recommended wetland buffers to minimize sedimentation in wetlands and to control turbidity in adjacent open waters.**

USDA Soil Type	Buffer requirements
Clay	Sedimentation and turbidity control cannot be met with buffer requirements alone.
Silt	450 feet measured from open water/wetland boundary through the wetland to the upland.
Fine sand	200 feet from wetland/upland boundary.
Coarse sand	75 feet from the wetland/upland boundary.

marginal effect, especially when compared to the amount of material that remains after 95% has been deposited. Thus, widths greater than 500 feet were deemed impractical.

The curves in Figure 2-7 are based on soil conditions, rainfall, and antecedent conditions that are typical of the region and to the conditions that would be expected during construction. That is, the soil hydrologic group is D, the soils are newly graded, and the rainfall event is a 5-year storm of 6.5 inches in a 24-hour period. Thus, the recommended buffer widths are based on more or less average expected conditions, except for soil hydrologic group. The characteristics of soil hydrologic group D (since this is the dominant soil group in the region) have been used to calculate the runoff which drives potential erosion and subsequent sedimentation. Computed runoffs and the resulting buffer widths will be smaller for soils of hydrologic groups A, B, or C.

Wetland Wildlife Habitat Buffers

The major topics discussed in this section include: The intended purpose of wetland wildlife habitat buffers; wetland habitat quality and quantity; adverse impacts of animal and human activities; impacts of noise; recommended wetland wildlife habitat buffers; and limitations of wetland wildlife habitat buffers.

The Intended Purpose of Wetland Wildlife Habitat Buffers

The specific charge of the wildlife component of this study was to develop a methodology for determining the upland boundaries of these proposed wetland buffers that would "provide habitat for semi-aquatic or water-dependent terrestrial species of wildlife." One interpretation of the intent of such buffers, as broadly defined in Policy 43.8 of the ECFCRPP, is to maintain the biological integrity of regionally significant wetlands by protecting sufficient habitat to ensure that all wildlife species currently using these resources will be perpetuated. At the opposite end of the spectrum of logical translations would be one that identified the role of these buffers as that of providing satisfactory protection from human-related activities to the extent that only a token remnant of the original wildlife community would continue to use these wetlands.

One application of these buffer determination procedures is to assist in DRI reviews by the ECFRPC staff. Because the amount of habitat area needed to maintain a full complement of wildlife species currently utilizing a wetland may exceed the size of an entire proposed development project, a conservative interpretation of the habitat provision mentioned in Policy 43.8 is desired. The use of buffers is just one of several methods proposed by the ECFRPC to be used in the achievement of the following Regional Goal.

> "Provide for the protection, enhancement and management of the region's environmentally sensitive and/or significant ecosystems in order to maintain their ecological, economic, aesthetic and recreational values." (ECFCRPP, page 147)

Isolated ephemeral wetlands (wetlands that periodically do not hold any standing water) are included in this analysis of wetland wildlife habitat buffers. Sufficient evidence now are available to suggest that ephemeral wetlands support very distinct wildlife communities from permanent wetlands. For example, oak toads, chorus frogs, little grass frogs, and several other frog and toad species are found almost exclusively in isolated, ephemeral wetlands that do not contain fish and other predators (Table 2-3).

Wetland Habitat Quality

Food, cover, and water are life-sustaining elements for all wildlife species. If every requirement for an animal is available in a particular area, the area is considered to be good quality habitat for that species; if one or more of a species' requirements are not available, the area is not suitable.

Some habitats are more suitable (of greater quality) than others and produce greater densities of wildlife than those of poorer quality. Much of the variability observed in numbers of species and numbers of individuals between populations in similar or different habitat types results from differences in available food, cover, water, and other requirements (Black and Thomas, 1978). Habitats with a high suitability (abundant food, cover, and readily available water resources) have a greater potential to support more individuals per area. The number of individuals within a population for which a particular area is able to supply all energetic and physiological requirements over a long period of time, barring no major perturbations, is called carrying capacity (Smith, 1974). Numbers of species and numbers of individuals within species often fluctuate due to a variety of causes including diseases, catastrophic events, predation, and competition. However the carrying capacity potential of an area remains relatively unchanged. Therefore, the extent of a buffer required to perpetuate populations is highly dependent on the long-term quality of the habitat in question.

By far, the most common cause of wildlife population reduction is natural landscape alteration through agriculture, silviculture, or construction activities. Altering or changing natural conditions to which species are adapted often harms native wildlife communities by destroying key conditions that make a given habitat suitable. An obvious example is the removal of snags (dead trees) that provide essential nesting structures, food sources, and perches for many birds, mammals, reptiles, and amphibians. A common misconception is that no harm is done because there are plenty of other undeveloped areas containing the same requirements. On the contrary, other areas that have the necessary elements for a particular species are probably already occupied at a saturation level, leaving no room for individuals that are ousted by development occurring elsewhere. Therefore, the most effective method of protecting wetland wildlife resources would be to preserve areas in their most natural conditions.

Brown and Schaefer (1987) suggested some minimum standards for an area to be considered suitable for a full spectrum of wildlife along the Wekiva River. This ideal approach is the method used by the Habitat Evaluation Procedure that currently is being developed and validated (U.S. Fish and Wildlife Service, 1980). However, due to the severe paucity of habitat requirement data for Florida species, selection of evaluation (indicator) species and further application of this strategy would not be defensible at this time.

Table 2-3. Occurrence and ephemeral wetland dependence of amphibians in east central Florida landscape associations.

Flatwoods/isolated wetlands

Frogs and Toads

Oak Toad*
Ornate Chorus Frog*
Little Grass Frog*
Pinewoods Treefrog*
Squirrel Treefrog*
Eastern Narrowmouth Toad*

Green Treefrog
Southern Cricket Frog
Bullfrog
Pig Frog
River Frog
Southern Leopard Frog

Amphibian Predators

Southern Dusky Salamander
Dwarf Salamander
Eastern Lesser Siren
Greater Siren

Flatwoods/flowing water wetlands

Frogs and Toads

Green Treefrog
Southern Cricket Frog
Bullfrog
Pig Frog
River Frog
Southern Leopard Frog

Amphibian Predators

Southern Dusky Salamander
Dwarf Salamander
Eastern Lesser Siren
Greater Siren
Dwarf Siren

Flatwoods/mesic hammock/hydric hammock/hardwood swamp

Frogs and Toads

Little Grass Frog*
Pinewoods Treefrog*
Squirrel Treefrog*

Green Treefrog
Southern Cricket Frog
Bullfrog
Pig Frog
Southern Leopard Frog

Amphibian Predators

Striped Newt*

Dwarf Salamander
Slimy Salamander
Eastern Lesser Siren
Greater Siren
Two-toed Amphiuma
Peninsula Newt
Southern Dusky Salamander

Table 2-3. Continued.

Flatwoods/mesic hammock/hydric hammock/hardwood swamp

Frogs and Toads

- River Frog
- Southern Toad
- Southern Spring Peeper

Amphibian Predators

- Dwarf Siren

Sandhill/isolated wetlands

Frogs and Toads

- Oak Toad*
- Gopher Frog*
- Barking Treefrog*
- Pinewoods Treefrog*
- Squirrel Treefrog*
- Eastern Narrowmouth Toad*
- Eastern Spadefoot Toad*

- Bullfrog
- Pig Frog
- River Frog
- Southern Toad

Amphibian Predators

- Striped Newt*

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* Principal or exclusive breeding habitat is ephemeral, isolated wetlands (Heyer et al., 1975; Wilbur, 1980; Woodward, 1983; Morin, 1983; Caldwell, 1987; Moler and Franz, 1987; Ashton and Ashton, 1988).

Until an accurate and easily applied method to specifically quantify habitat suitability is developed, the following qualitative assessment of habitat quality can be easily determined on each proposed development site.

1. High Quality: If an area is still in a relatively natural state, and large enough to provide requirements for at least one pair of most species associated with the habitat type occupying the area, it is suitable for those species.
2. Medium Quality: If an area has been cleared for agricultural or silvicultural purposes but no permanent structures such as roads and buildings have been constructed, it still has some current wildlife value and a potential for increased future wildlife habitat values. Because these areas can be converted easily back into native habitat, they should not be excluded from any buffer areas.
3. Low Quality: If an area has been cleared and developed with roads, buildings, and other permanent structures, its suitability for wildlife dependent on the original natural habitat type would be minimal.

Wetland Habitat Quantity

Every animal requires a certain amount of space to carry out life functions such as feeding, courtship, and nesting. The quantity of habitat needed is highly variable even within species. Differences are associated with many factors including: sex and age, time of year, availability and distribution of food and cover, and social structures. In general, larger species tend to require greater quantities of habitat. Also, species with more unpredictable and unevenly distributed food resources require more space to satisfy their nutritional needs.

The spatial arrangement of an adequate supply of the proper food, cover, and water habitat components for a given individual will determine how much area it needs to survive. For example, a semi-aquatic turtle that depends on the availability of sandy upland soils for nesting and overwintering would have larger area needs if the closest upland was 600 feet from the river than if it was only 50 feet away.

The importance of stream and river-associated habitats as wildlife corridors has received much attention. However, to effectively function as an area through which animals will travel and gain access to larger connected habitat areas, the corridor must be of sufficient size and quality to provide essential requirements for animals to be attracted to it. Cursorial (non-flying) animals are especially unlikely to disperse across unsuitable terrain (Frankel and Soule, 1981).

Brown and Schaefer (1987) presented spatial requirement information for many wetland-dependent species found along the Wekiva River. Since then we have greatly expanded this data base and have adopted a more exact strategy to determine habitat quantity requirements.

The Use of Wildlife Guilds in Determining Habitat Quantity.

Habitat is the place occupied by a specific population within a community of populations (Smith, 1974), and often can be characterized by a dominant plant form or some physical characteristic (Ricklefs, 1973). Each species requires a particular habitat or a combination of habitat types (ecological communities) to supply the space, food, cover, and other requirements for survival. Thus wildlife species are products of their habitats.

The specific habitat types found within the six major landscape associations identified in this study were reviewed earlier in this report. More detailed ecological descriptions of the non-coastal vegetation communities can be found in Brown and Schaefer (1987).

To assess the value of wetland buffers or any other conservation/management scheme, it is important to understand the wildlife communities that may be potentially benefitted or adversely impacted. A guilding technique has been used to describe semi-aquatic and wetland-dependent wildlife communities that utilize various habitat types in east central Florida.

The first step in this method involved developing wildlife species lists (Appendix C) based on checklists published by the Florida Game and Fresh Water Fish Commission; the Florida Breeding Bird Atlas Guide to Breeding Ranges, Seasons, and Habitats; the Rare and Endangered Biota of Florida series; several other references; and personal knowledge. All vertebrate, semi-aquatic and wetland-dependent species known to breed in east central Florida are listed by taxonomic class. The majority, but not all migrant species that are found in this region during non-breeding seasons also are included. Of the 706 species identified by the Florida Game and Fresh Water Fish Commission to occur in the state, 166 or 24% are listed. The largest taxonomic grouping was birds (95) and the smallest was mammals (11).

The next step determined which habitat types were utilized by these species. These species were further divided into appropriate feeding and breeding zones (guilds) within each habitat type. The guilding technique for describing and evaluating impacts on wildlife communities was first proposed by Root (1967). He defined a guild as a group of species that exploit the same class of environmental resources in a similar way. Guilding is a functional as opposed to a taxonomic classification of species.

To identify appropriate guilds, a common approach used in other guilding studies was followed (Short and Burnham, 1982; Verner, 1984). Feeding sources and breeding requirements were selected as the basis for organizing wildlife information. Both axes of the matrix were partitioned by physical strata, because of the importance of strata in describing the form and function of ecological communities (Appendix D). Seven strata were selected to describe utilization of food resources in habitats. One additional guild, "breeds elsewhere," was added to the breeding requirements.

Appropriate feeding and breeding strata used by each species were compiled and then species were assigned to these guilds within each habitat type (Appendix D). Four wetland habitats (salt marshes, fresh water marshes, cypress swamps, and hardwood swamps) and three upland habitats (hammocks, flatwoods, and sandhills) were identified as those utilized by the species in Appendix C. Species that use more than one habitat were placed in all relevant habitat matrices. However, each species was not represented more than once within each habitat type.

From these data, a simple two-dimensional species-habitat matrix was developed with feeding resources along the y-axis and physical features of the habitat required for breeding along the x-axis. This matrix resulted in a possible 56 (7 x 8) feeding and breeding combinations for each habitat type. The number of species utilizing each feeding/breeding guild block is shown in Appendix E. The number in the center of each block signifies the number of different species in that guild as indicated in Appendix D. The number in the upper-right corner of a block indicates the number of listed (endangered, threatened, special concern) species in the guild (See Appendix C).

Many species/habitat relationships can be derived from these matrices. Only some of the major interpretations are pointed out here. Flatwoods support the most species (110) and salt marshes the least (60).

The ground feeding and ground breeding zones in most habitats are utilized by more species than other zones. Water column zones are most heavily utilized in both salt and fresh water marshes. Tree canopies are more heavily utilized as breeding zones than feeding zones.

All habitats supported at least 6 listed species. Flatwoods lead this category with 12. A major feeding strata for listed species in all habitats is the water column zone.

Several semi-aquatic and wetland-dependent species must have access to upland or transitional habitat regardless of the landward extent of the wetlands. Many examples can be seen in the Appendix E matrices. Of the 90 semi-aquatic and wetland-dependent species found in the sandhills (the most xeric of all habitats), 45 (50%) depend on non-aquatic areas for feeding and 77 (86%) for breeding. Not as obvious are those species that make seasonal shifts in their feeding requirements. Amphibian species associated with ephemeral wetlands in these habitats usually have larger home ranges during the adult stage to increase the probability of finding suitable breeding areas. Some may travel several miles between breeding ponds (Franz et al., 1988). However, frogs and toads living in permanent water bodies will not receive the same benefits from migrating far away from their dependable water source. Elimination of these adjacent habitats could extirpate numerous species from ephemeral wetland systems.

Trees are not as important in marshes as in other habitats, although, members of the heron family need this strata for breeding. Much of the food energy produced in salt marshes is utilized by species that do not breed in these systems.

If allowances are made for the large proportion of salt marsh species that breed elsewhere, the species distribution pattern between the two marshes are similar. Some of the most important guilds in these systems are the ground surface breeding zone combinations with the ground and water column feeding zones, and the tree canopy breeding and water column feeding guild. The majority of the ground breeders in the fresh water marsh are amphibians and reptiles, while ground breeding birds become more important in the salt marsh. Birds from the heron family make up all of the tree nesting and water column feeding species. Both marshes support relatively large numbers of listed species: 8 in the fresh water system and 11 in the salt marsh.

The next step in the analysis of habitat quantity involved assigning spatial requirement values to each species and then compiling these values for each habitat (Appendix F). Spatial data were obtained from references listed in Appendix C. Several spatial requirement data types including the following were used: distance from humans tolerated before taking flight, home range diameter, nest location landward from the waterward extent of the forest, maximum distance found from closest water source, maximum distance from closest water to nest, and distance between captures of the same individual. If spatial requirement data were not found for a species, values were assigned from species that are closely related, similar-sized, found in comparable habitats, and categorized in corresponding guilds.

Because analysis of the guild matrices in Appendix E suggested that trees were not used as much by species in marsh systems as those in forested systems, the spatial requirements of these two groups were compared. A nonparimetric Wilcoxon Scores 2-sample statistical test run with SAS PC showed that spatial requirements of species in marsh habitats are less than that of species in forested habitats (Table 2-4; $P = 0.001$). The mean and median values for salt marshes are about half that of any other habitat.

In all habitats, the median value is only about one-third of the mean (Table 2-4). In other words, the majority of species in each habitat have relatively low spatial requirement values, but a few species also have extremely large habitat area needs. By illustrating these habitat quantity or spatial values, we can show where

Table 2-4. Mean spatial requirements for semi-aquatic and wetland-dependent wildlife species in various habitats.

Habitat Type	Number of Species	Mean Spatial Requirement (ft)	Standard Deviation	Median
Salt Marshes	60	544.4	1,464.6	180
Fresh Water Marshes	87	1,005.3	1,715.4	300
Cypress Swamps	91	1,302.6	2,503.1	350
Hardwood Swamps	86	1,309.6	2,538.2	350
Hammocks	103	1,451.7	2,603.9	370
Flatwoods	110	1,479.3	2,597.3	387.5
Sandhills	90	1,774.1	2,848.4	614.5

the increase in the percent of species per spatial requirement unit slows down in each habitat. The salt marsh curve begins to level off at approximately 300 feet whereas the curves for the other habitats don't level off until about 500 feet (Figures 2-8, 2-9, 2-10, 2-11, 2-12, 2-13, 2-14).

Habitat Quantity Summary. We used a guilding technique to describe semi-aquatic and wetland-dependent wildlife communities that occur in east Central Florida and to determine the quantity of habitat needed to protect the ecological integrity of the significant wetlands in this area. Spatial requirements of species in marshes are generally less than that of species in forested habitats. Although trees are used less in marsh systems, they provide important breeding areas for several listed species. As a group, sandhill species have the greatest spatial needs. Spatial requirements for all species considered in this study are presented in Appendix F.

Adverse Impacts of Animal and Human Activities in Altered Habitats

The negative impacts of induced edges in a forested system and of the noise and domestic animal problems associated with development adjacent to natural habitat areas have been reported by Brown and Schaefer (1987). Some of the major points will be highlighted here.

Induced edges created by human manipulation of natural vegetation (especially forested areas) encourages non-forest-dwelling species to penetrate into the forest and prey on and compete with forest adapted species. Whitcome et al. (1976) provided evidence that, in areas along forest edges avian brood parasites (brown-headed cowbirds), nest predators (small mammals, grackles, jays, and crows), and non-native nest hole competitors (e.g., starlings) are usually abundant. Gates and Gysel (1978) found that a field-forest edge attracts a variety of open-nesting birds, but such an edge functions as an "ecological trap." Birds nesting near the edge had smaller clutches and were more subject to higher rates of predation and cowbird parasitism than those nesting in either adjoining habitats. This abnormally high predation rate is related to the artificially high densities of many opportunistic animals near forest edges and in disturbed habitats including suburbs; (Wilcove et al., 1986). Every forest tract has a "core area" that is relatively immune to deleterious edge effects and is always far smaller than the total area of the forest (Temple, 1986). Relatively round forest tracts with small edge-to-interior ratios would thus be more secure, whereas thin, elongated forests (such as those along unbuffered riparian strips) may have very little or no core area and would be highly vulnerable to negative edge effects.

Direct impacts of human activities on wildlife is a newly evolving science. Hiking and camping affect wildlife through trampling of habitat (Liddle, 1975), disturbance of animals (Ward et al., 1973; Aune, 1981) and less directly through discarded food or other items (Foin et al., 1977). Klein (1989) documented effects of visitor use on avian species at Ding Darling Refuge, Florida. A majority of the species that she classified as most sensitive to humans (reacted negatively to human presence) occur in east central Florida. These include: pied-billed grebe, white ibis, willet, sanderling, dunlin, and blue-winged teal. The average minimum distance from humans tolerated by these species was 260 feet (Appendix F).

There are several accounts of disturbances affecting waterbirds. Some duck species and the great crested grebe did not winter in one reservoir since it was opened to sailboats, even though these species were observed elsewhere in the vicinity (Batten, 1977). Rodgers and Burger (1981) reported that human activities in waterbird colonies may delay nesting for some pairs, eliminate late-nesting pairs, or cause late-nesting pairs to shift to other less suitable nesting sites. Wintering eagles were more disturbed by infrequent activities than by regular activities (Stalmaster and Newman, 1978). Tremblay and Ellison (1979) reported that visits to black-crowned night heron colonies just before or during laying provoked abandonment of newly constructed nests and either predation of eggs or abandonment of eggs followed by predation. This study also concluded that herons did not nest in areas where human interference occurred. Ellison and Cleary (1978) found similar results with double-crested cormorants.

Human disturbance or even occupancy also may be preventing listed species from using otherwise useful habitat areas. For example, bald eagles on the northern Chesapeake Bay tended to avoid developed shoreline areas during daytime and selected areas that on average were over 1,500 feet from houses than were randomly selected points ($P < 0.001$; D. Buehler, J. Fraser, and J. Chase, unpub. data).

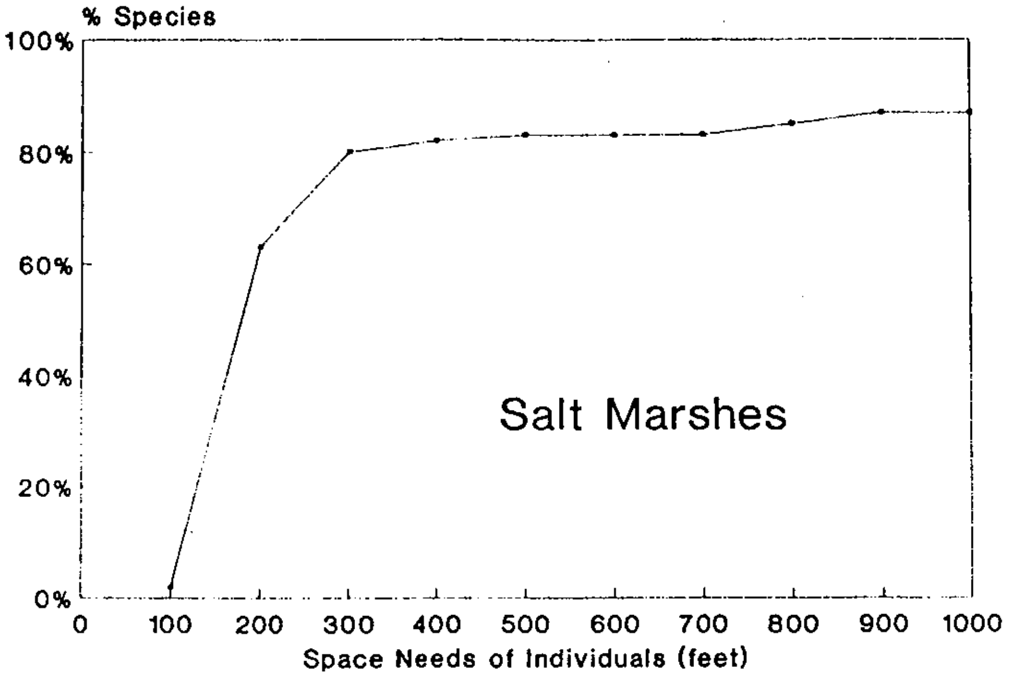

Figure 2-8. Percentages of semi-aquatic and wetland-dependent wildlife species that occur in salt marshes and have individual space needs equal to or less than the respective 100-foot intervals. Calculations were not made beyond 1,000 feet.

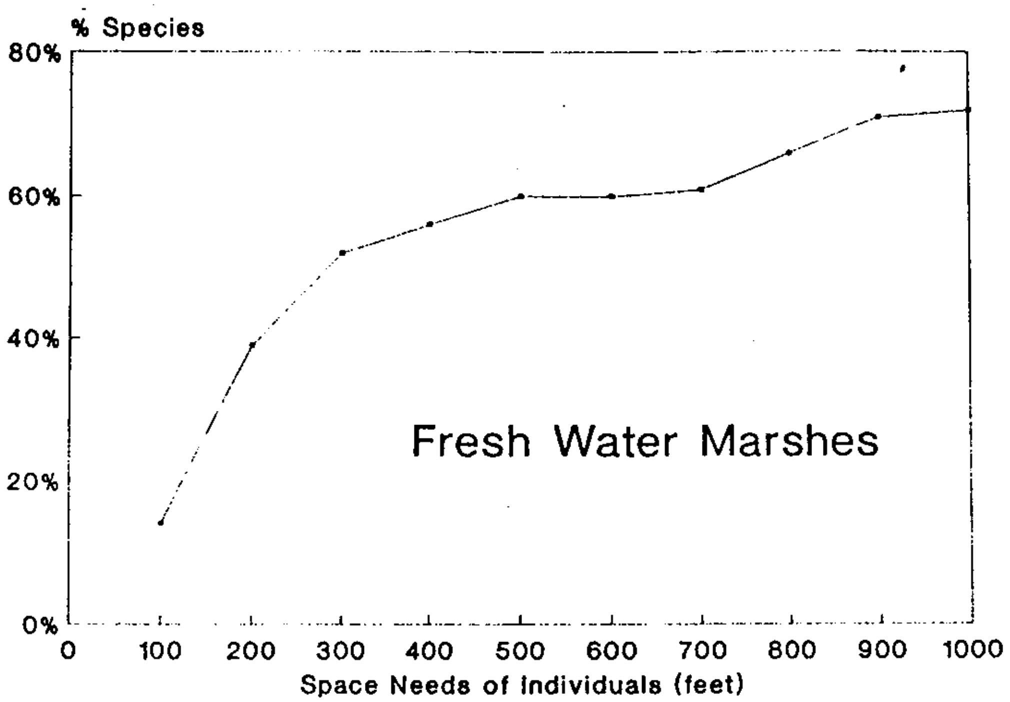

Figure 2-9. Percentages of semi-aquatic and wetland-dependent wildlife species that occur in freshwater marshes and have individual space needs equal to or less than the respective 100-foot intervals. Calculations were not made beyond 1,000 feet.

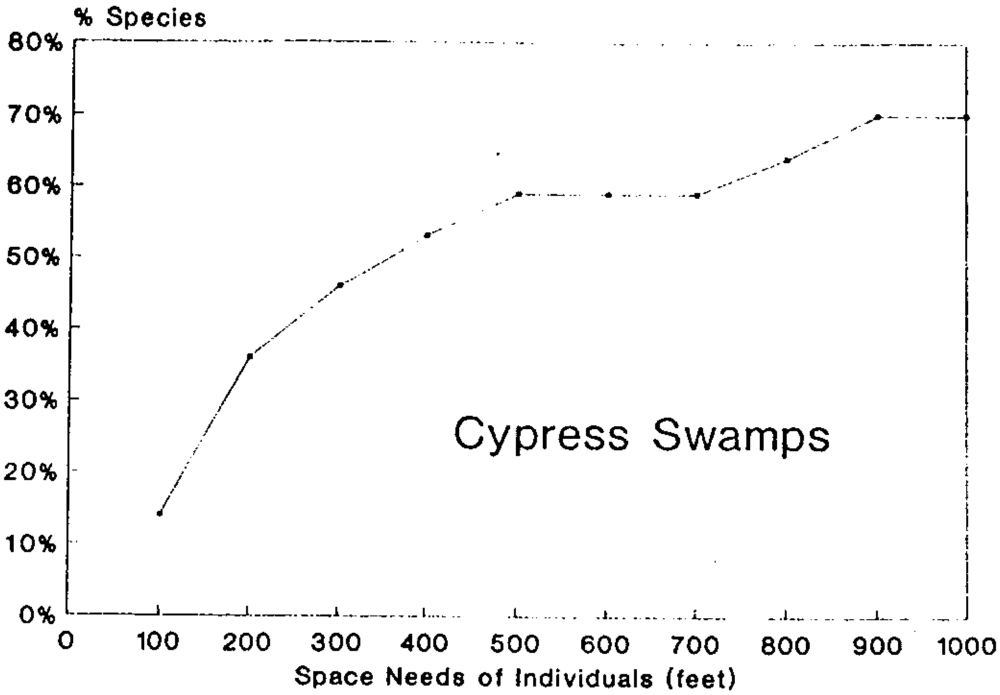

Figure 2-10. Percentages of semi-aquatic and wetland-dependent wildlife species that occur in cypress swamps and have individual space needs equal to or less than the respective 100-foot intervals. Calculations were not made beyond 1,000 feet.

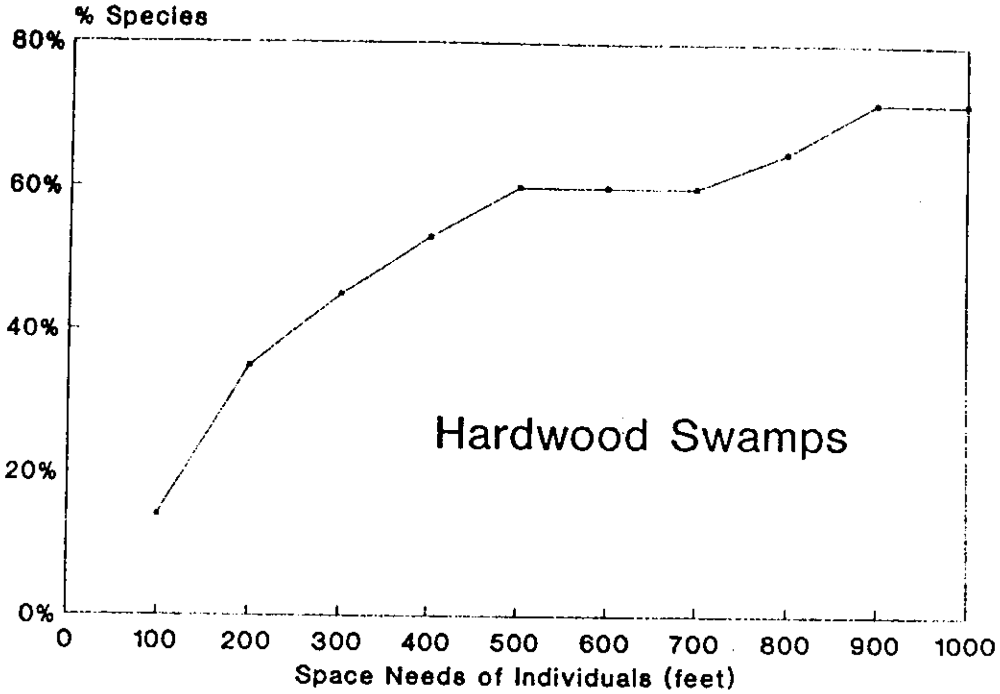

Figure 2-11. Percentages of semi-aquatic and wetland-dependent wildlife species that occur in hardwood swamps and have individual space needs equal to or less than the respective 100-foot intervals. Calculations were not made beyond 1,000 feet.

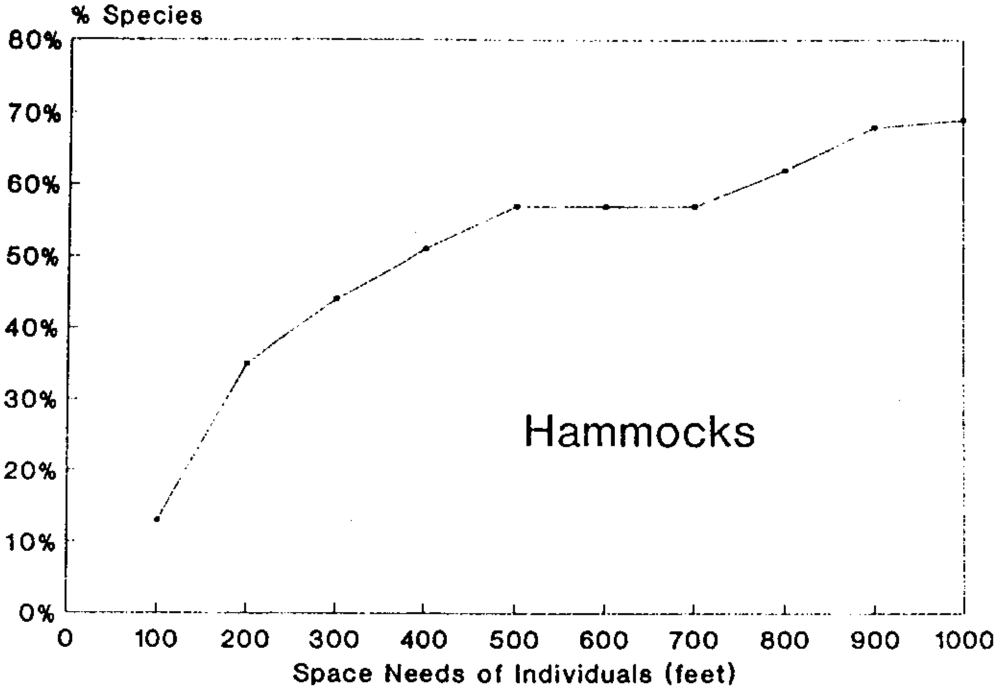

Figure 2-12. Percentages of semi-aquatic and wetland-dependent wildlife species that occur in hammocks and have individual space needs equal to or less than the respective 100-foot intervals. Calculations were not made beyond 1,000 feet.

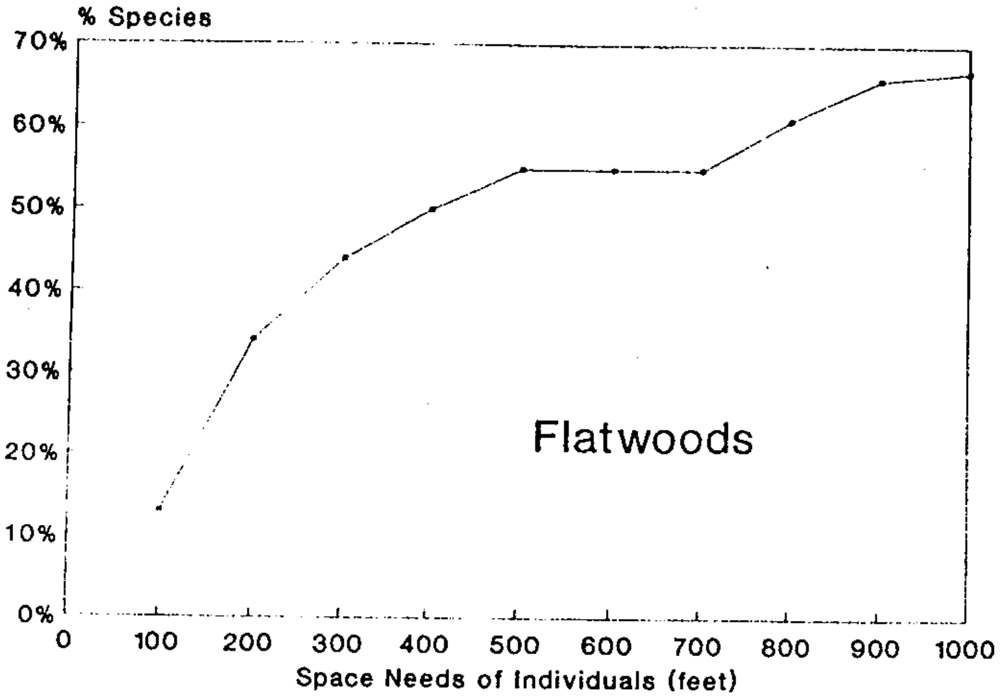

Figure 2-13. Percentages of semi-aquatic and wetland-dependent wildlife species that occur in flatwoods and have individual space needs equal to or less than the respective 100-foot intervals. Calculations were not made beyond 1,000 feet.

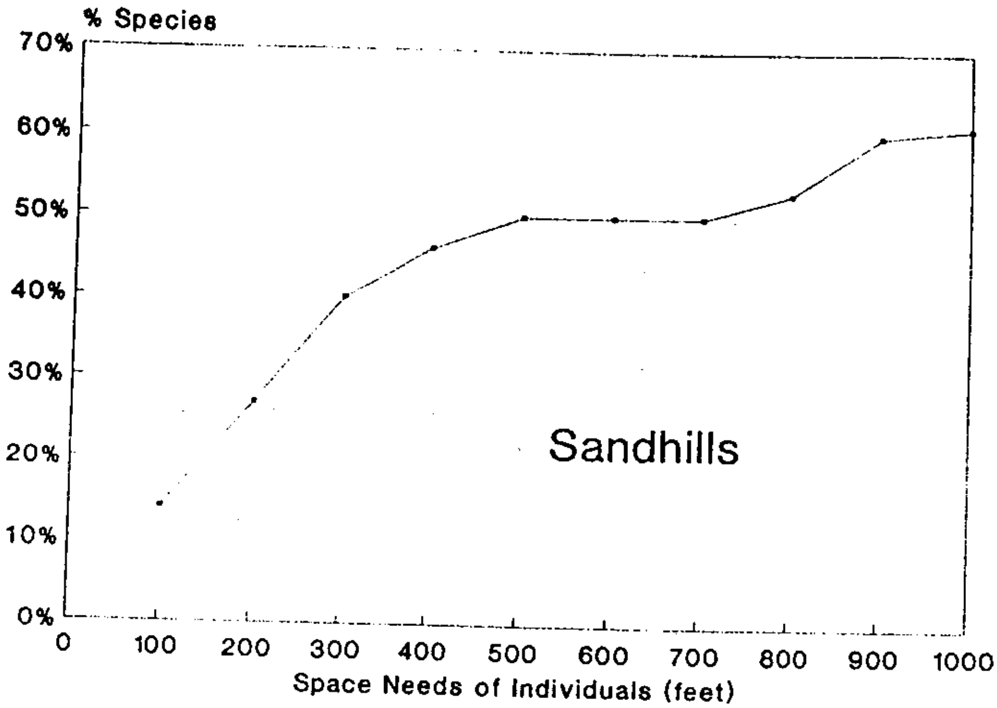

Figure 2-14. Percentages of semi-aquatic and wetland-dependent wildlife species that occur in sandhills and have individual space needs equal to or less than the respective 100-foot intervals. Calculations were not made beyond 1,000 feet.

Predation and harassment of wildlife by free-ranging domestic cats and dogs are other detrimental effects of development adjacent to significant wildlife habitat areas. Several authors have documented the occurrence to wildlife prey in the diets of free-ranging cats and dogs and the effects of their predatory behavior on individual wildlife animals and populations (Errington, 1936; Korschgen, 1957; Smith, 1966; Gilbert, 1971; Jackson, 1971; Gill, 1975). Local extinctions of the Anastasia beach mouse along Florida's coast (Stephen R. Humphery, pers. comm., 1989); a dove on a South Pacific island (Jehl and Parkes, 1983); and diving petrels, broad-billed prions, yellow-crowned parakeet, robin, fern-bird, brown creeper, Stewart Island snipe and banded rail in New Zealand (Fitzgerald and Veitch, 1985) have been attributed to cat predation. Churcher and Lawton (1989) concluded from their study that domestic cats kill at least twenty million birds a year in Britain. Cats and dogs can be especially devastating on ground feeding and ground breeding species. These guilds in Appendix E represent the majority of semi-aquatic and wetland-dependent wildlife species in east central Florida.

Edge effects thoroughly described by Brown and Schaefer (1987) have been shown to negatively impact wildlife species within at least 300 feet of forest boundaries. Studies of nature reserve boundaries have provided data that support the need for zones of decreasing land use toward the boundary of reserves (Unesco, 1974; Dasmann, 1988; Schonewald-Cox, 1988). The core of these areas must be protected from cats, dogs, human activities, noise, predators, exotic competitors, parasitism and other detrimental effects of development.

Impacts of Noise

Brown and Schaefer (1987) presented some general arguments suggesting that certain sound levels were detrimental to wildlife and offered a formula for determining vegetation buffers width necessary to adequately reduce noise. In this report, a more complete synthesis of noise impacts on wildlife is provided as well as some state-of-the-art information related to noise abatement.

Sound is a physical phenomenon and defined as an oscillation in pressure of a medium measured in decibels (dB); (American National Standards Institute, 1971). Sometimes, sound is noise which is defined as unwanted or undesirable sound (U.S. Environmental Protection Agency, 1978). This annoyance factor of sound negatively impacts all hearing animals. Along with air and water contaminants, noise has been recognized as a serious pollutant.

The physiological impacts of noise on people is well documented. Short-term exposure to very high sound levels (120 to 130 dB) and long-term exposure to lower levels (80 dB) can cause temporary or permanent changes in human ability to hear (Carelstam, 1972), and increased blood pressure, elevated rates of heartbeat and respiration, muscle tension, hormone release, cardiovascular disorders and increased susceptibility to disease (Alexandre and Barde, 1981). Long-term exposure above 55 dB interferes with activity and causes annoyance for people in outdoor settings (U.S. Environmental Protection Agency, 1974). However, the physiological and behavioral impacts on wildlife are little known.

Noise associated with construction, operation, and maintenance of developments can cause harmful impacts on wildlife. Animals that rely on their hearing for courtship and mating behavior, prey location, predator detection, homing, etc., will be more threatened by increased noise than will species that utilize other sensory modalities. However, due to the complex interrelationships that exist among all the organisms in an ecosystem, direct interference with one species will indirectly affect many others.

Unfortunately, few data are available that demonstrate the effects of noise on wildlife . Much of what is found in the literature lacks specific information concerning sound intensity, spectrum, and duration of exposure. There have been no systematic studies with experimental designs that show definite relationships between specific noise disturbances for various species and different sound levels. Brandt and Brown (1988) conducted an extensive literature search on this topic and found that most of our current knowledge of sound impacts on wildlife are based on observations of animal reactions to aircraft overflights and laboratory studies. Because such little research emphasis has been given to this topic, it is not surprising that results are inconclusive and sometimes contradictory.

The following studies have reported negative impacts of noise on wildlife.

- Gulls near Kennedy Airport in New York flew into the air when SSTs passed overhead (average sound level = 108.2 dB; Burger, 1981a).
- Eagles responded to gunshots by flushing from their roosts (Edwards 1969 in Stalmaster and Newman, 1978).
- Gulls destroyed eggs when white pelicans flushed from their nests in response to sonic booms (Graham, 1969 in Memphis State University, 1971).
- Airboats evoked severe flushing and panic flights in a colony of wading birds and these responses did not subside until the boats either left the colony vicinity or were turned off (Black et al., 1984).
- Speeding motorboats caused osprey to flush and kick eggs out of their nests (Ames and Mesereau, 1964).
- Titus and VanDruff (1981) reported that loon hatching and rearing successes were greater in areas where motorboats did not occur.
- Manci et al. (1988) reported that sound pressure levels above 90 dB are likely to cause adverse effects in mammals.
- Caged wild rats and mice exposed to sounds from 60 to 140 dB decreased nesting near the sound source and even died at the highest intensities (Spock et al., 1967 in Memphis State University, 1971).
- Exposure to dune buggy noise (95 dB): 1) reduced hearing acuity in the desert kangaroo rat to levels below that required for adequate detection of predatory snakes; 2) caused spadefoot toads to emerge from their burrows during suboptimal conditions; 3) reduced hearing acuity in the Mojave fringe-toed lizard (Bondello and Brattstrom, 1979).
- Sound producing stimuli also have been reported to be successful animal damage control techniques for nuisance rodents, bats, rabbits, deer and birds (Diehl, 1969; Crummet, 1970; Hill, 1970; Messersmith, 1970).
- Although there were individual differences, noise was more disruptive than any other visitor-action besides approach on foot for brown pelicans, anhingas, double-crested cormorants, tricolored herons, and white ibis at the Ding Darling Refuge (Klein, 1989).

Several accounts have described situations when wildlife apparently were not affected by various noise sources.

- Snail kites near an airport in Colombia showed no difference in distribution or breeding success from kites that nested elsewhere (Snyder et al., 1978 in Manci et al., 1988).
- Gulls nesting at Jamaica Bay Refuge near Kennedy Airport in New York did not usually respond to subsonic aircraft (average sound of 91.8 dB; Burger, 1981b).
- Grubb (1978) found no observable response to low-flying aircraft generating up to 88 dB at ground level in a heron rookery in St. Paul.
- Gyrfalcons did not respond to helicopters at 600 meters above the ground (Platt, 1977 in Ellis, 1981).
- No impact was detected from a study of military overflights on a wading bird colony (55 dB to 100 dB; Black et al., 1984).
- Great blue herons seemed to become habituated to repeated exposure to boats passing by their rookery (Vos et al., 1985).
- Sea otters were not "repelled" by loud sounds (120 dB) projected underwater (Davis et al., 1987).
- Deer were not disturbed while grazing near a Texas heliport (Fletcher, 1971 in Luz and Smith, 1976).

Few studies have attempted to separate the effects of sound from the effects of the activity causing the sound. Eagles were more tolerant of sounds from concealed sources than they were of sounds from sources within view (Stalmaster and Newman, 1978). Birds in California's Channel Islands were more sensitive to visual stimuli and to combined visual and auditory stimuli than they were to sound stimuli alone (Cooper and Jehl, 1980). Gyrfalcons temporarily left their nests in response to helicopters flying at 160 meters above ground, but did not respond to helicopters that were not visible (Platt, 1977 in Ellis, 1981).

Some studies have shown disturbance impacts on other types of wildlife. No gyrfalcons nested in the test area in the year following exposure to helicopters (Platt, 1977 in Ellis, 1981). Of 40 bird species studied, 43% were less numerous than normal within 2.5 km of an Alaska exploratory oil well (Connors and Risebrough, 1979 in Hanley et al., 1981). Van der Zande et al. (1980) found that breeding densities of three grassland bird species were significantly reduced within 500 meters of quiet rural roads and 1,600 meters of busy highways in the Netherlands.

While general understanding and consequences of noise impacts on wildlife are not very specific, a few conclusions are obvious. Short-term exposure to loud sounds can cause physiological changes in animals just as it does in humans. Chronic lower level sounds (55 dB) are annoying to humans and also probably make an area relatively less desireable to wildlife. Some, but not all, species can adapt to some sounds. Human activity also disturbs wildlife and can have similar effects such as nest abandonment. Noise and human activity will negatively impact semi-aquatic and wetland-dependent wildlife from the landward side as well as the water side if the water is used for recreational purposes.

Recommended Wetland Wildlife Habitat Buffers

To be effective at providing habitat so that significant wetlands can protect their ecological values, buffers should be delineated and maintained in such a way so that they protect: the quality of the wetland habitat; the quantity of habitat that will provide sufficient space for species; and the wildlife in these buffers from adverse impacts of adjacent land-uses.

Protecting Wetland Habitat Quality. The best approach to maintaining and protecting wetland habitat quality is to leave it in as natural a state as possible. Wetlands and any adjacent upland buffer areas should not be used as recreational areas. The information we have presented regarding human disturbance impacts on wildlife at Ding Darling Refuge and other recreational areas indicates that human use of an area is most often incompatible with wildlife protection goals. Construction of nature trails and boardwalks only encourage further human encroachment into wetlands that are the focus of protection.

All areas in and adjacent to significant wetlands that have been cleared for agricultural or silvicultural purposes within a designated buffer area should be converted back into native habitat. These land-use practices also should be banned from buffer areas. The wetland wildlife habitat buffers are relatively narrow strips meant to serve the purpose of shielding wetlands from adjacent adverse land-use impacts. Silvicultural and agricultural activities will alter the natural habitat and create obstacles to dispersing wildlife using these buffer corridors and reduce the overall quality of the wetland habitat.

Protecting Wetland Habitat Quantity. Based on a limited amount of data, Brown and Schaefer (1987) recommended a wetland wildlife habitat buffer zone consisting of the diameter of a one-acre circle (236 feet) plus a 300-foot negative impact zone of suitable habitat situated landward from the waterward edge of the forest canopy. A 50-foot buffer landward from the wetlands jurisdictional line also was recommended to allow species such as semi-aquatic turtles access to uplands to nest and/or overwinter. Suggestions for protecting wetland habitat quantity are presented next for each major habitat type within the six landscape associations in east Central Florida.

Although hammocks, flatwoods, and sandhills are not "wetland" habitats, there are many situations in the landscape where wetlands do not occur as transitional areas between aquatic and upland systems. In these cases, semi-aquatic and water-dependent wildlife species associated with the aquatic system still use the adjacent terrestrial areas which need to be protected if the aquatic system is to maintain its ecological function.

Indicator species were used to determine the extent of buffers that would be most effective in accomplishing the goal of protecting wetland habitats and also that would be feasible to administer.

Indicator species were selected for each habitat type based on the following criteria.

- the spatial requirement for the indicator species as listed in Appendix F must fall within the following lower and upper limits:
    - lower limit: median spatial value for the habitat (at least 50% of the spatial requirements of all species in the habitat must be satisfied).

    - upper limit: 1,000 feet (to reduce the probability that properties adjacent to significant wetlands would be totally undevelopable).
- the indicator species must represent one of the important guilds in the habitat.
- the indicator species' needs must overlap with those of listed species in the same habitat.
- the indicator species must be characteristic of the habitat (i.e., found at most locations where the habitat type occurs).

Once the indicator species was selected for a given habitat, the spatial requirement of that species as recorded in Appendix F was designated as the recommended buffer. The theory behind this process is that if the needs of species that satisfy these criteria are addressed, then many other species also will receive similar protection. Validation of this method does not require that the indicator species be present on each specific site within an identified habitat. Indicator species only reflect the space needs of individuals within species that are adapted to a particular habitat type.

The extent of the wildlife buffers recommended in this section include portions of wetlands if they occur between the aquatic and upland systems. The waterward buffer line should start at the interface between the aquatic and the wetland or upland habitat. If the wetland is narrower than the recommended buffer, then the buffer will extend landward into the upland. If the wetland is wider, then an upland buffer of 50 feet should be maintained in all situations to conserve nesting and over-wintering habitat for semi-aquatic reptiles. Buffers along flowing water wetlands also provide travel corridors for wildlife and connectivity of habitat systems.

The snowy egret was chosen as the indicator species for both marsh systems (Table 2-5). It typically nests in trees or tall shrubs from 5 to 30 feet above the ground or water on the periphery of marshes. Like other egrets, the snowy feeds on fish and other aquatic organisms in the water column. The snowy egret is listed as a Species of Special Concern. It uses both saltwater and freshwater marshes and also represents guilds within these two systems that contain several listed species. The spatial requirements of this species were determined by combining the results of two separate studies. Maxwell and Kale (1977) reported that the snowy egret tended to nest about 82 feet landward from the waterward edge of the tree canopy adjacent to aquatic systems. Klein (1989) found that the minimum distance from humans tolerated by snowy egrets was 240 feet. A 322-foot buffer in salt marshes will provide enough habitat for individuals in about 81% of the total wetland species in this habitat. The same buffer applied to fresh water marshes will be sufficient for only about 53% of the species.

All herons are highly susceptible to disturbance and nest abandonment during the early stages of incubation. Because these heronries are highly visible from the waterward perspective (looking back toward the trees along the marsh edge), some protection should be given to these breeding areas by restricting access to these wetlands from February through July.

The indicator species for the cypress and hardwood swamps is the Prothonotary Warbler. It is the only cavity-nesting warbler in Florida. Prothonotary warblers usually nest in old woodpecker holes from 5 to 30 feet above water or ground. Like other warblers, it feeds on insects. It belongs to the tree canopy breeding guild which contains five listed species, the majority in these habitat types. The spatial requirements for this species (Appendix F) were obtained from a study being supervised by Dr. Schaefer in Alachua County. Preliminary results of a current study (Schaefer, personal communication) show that the warbler was not found in natural riparian vegetation strips up to 450 feet wide in developed areas but was recorded in similar habitats within the 6000-acre, rural San Felasco Hammock State Park. Because this study did not examine a large continuum of

Table 2-5. **Wetland wildlife habitat buffers for various habitats based on spatial requirements of indicator species (see Appendix F.).**

Habitats (Landscape Associations)	Indicator Species	Median Spatial Requirement in Habitat	Habitat Quality	Wildlife Buffer*
Salt Marshes (5,6)	Snowy Egret	180 feet	High - Med. Low**	322 feet < 322 feet
Freshwater Marshes (1,2,4)	Snowy Egret	300 feet	High - Med. Low	322 feet < 322 feet
Cypress Swamps (1,2,3)	Prothonotary Warbler	350 feet	High - Med. Low	550 feet < 550 feet
Hardwood Swamps (2,3)	Prothonotary Warbler	350 feet	High - Med. Low	550 feet < 550 feet
Hammocks (3,6)	Prothonotary Warbler	370 feet	High - Med. Low	550 feet < 550 feet
Flatwoods (1,2,3,5)	Prothonotary Warbler	387.5 feet	High - Med. Low	550 feet < 550 feet
Sandhills (4)	Eastern Hognose Snake	614.5 feet	High - Med. Low	732 feet < 732 feet

* Measured from the waterward edge of the forested wetland or upland habitat that is adjacent to the aquatic system. Marsh buffers are measured landward from the landward edge of marsh vegetation. A 50-foot upland strip for semi-aquatic reptile nesting and over-wintering should be included in each buffer.

** In situations where the habitat area adjacent to the wetland is already developed, the buffer should be as wide as possible up to the wildlife buffer width for high - medium habitat quality areas.

riparian widths, a minimum forest habitat width was not determined. Nevertheless, a sensitivity to development has been demonstrated. Based on this information, a conservative estimate of the amount of habitat needed to protect one breeding pair would be a 550-foot wide forest strip. Buffers of 550 feet would address the spatial needs for individuals in about 60% of all species in these habitats.

The eastern hognose snake is a good indicator species of the sandhills. It feeds almost exclusively on toads that it finds buried in sandy soil. Like more than half of the wildlife found in this habitat, the hognose obtains all of its resources from the ground surface. Unlike the other habitats, a greater percentage of listed species also are highly dependent on this stratum. The spatial requirements for this species were determined from a study that recorded an average distance between captures of the same individual as 732 feet. A 732-foot buffer in sandhill wetlands will provide adequate space for individuals in more than 50% of the species in this habitat.

Protecting Wetland Habitats from Adverse Animal and Human Activities. One serious consideration in the forested habitats is the large proportion of species that are utilizing the ground zone for feeding and breeding. These species are the most susceptible to cat and dog predation and influences of vegetation trampling and other human-related activities. If the buffer is to be effective at protecting habitat for most of the species under consideration, much can be accomplished by addressing the needs of species in these guilds. Restricting human use of these buffers and encouraging enforcement of domestic animal leash laws are highly recommended.

Four listed species use the forest ground zone either for breeding or feeding and another six use the tree canopy for breeding. Adequate protection of these forested areas adjacent to significant wetlands will help to ensure their continued existence in an environment that already has caused them to be in jeopardy of extinction.

Protecting Wetland Wildlife from Noise Impacts. Wildlife in significant wetlands can be protected from sound disturbances generated in adjacent areas through the use of sound ordinances, barriers, educational programs, and buffers. This report focuses on the latter.

Three factors will determine the amount of buffer necessary to abate noise to an acceptable level: threshold level established for noise in habitat areas adjacent to development; sound level at the source; and amount of sound attenuated from the source to the habitat occupied by species that need protection.

In response to a Congressional directive initiated by the Noise Control Act of 1972, the Environmental Protection Agency identified a range of yearly sound levels sufficient to protect public health and welfare from the effects of environmental noise in different areas (U.S. Environmental Protection Agency, 1978). A maximum sound level of 55 dB was determined for "outdoors in residential areas and farms and other outdoor areas where people spend widely varying amounts of time and other places in which quiet is a basis for use."

The continuous traffic noise at distances of greater than a mile or two from any reasonably busy road is about 45 dB (Harrison, 1974). This is commonly accepted as a reasonable noise level for sleeping areas in the suburbs of cities (Myles et al., 1971).

Dailey and Redman (1975) reported the following background noise levels in a wilderness area:

- 35 dB under low wind conditions (3 to 5 miles/hour) in forested areas.
- 45 dB three feet from the bank of a steam with small rapids.
- 30 dB under low wind conditions (3 to 5 miles/hour) in an open meadow.

Harrison (1974) recommended that 15 dB below prevailing background noise was required to muffle human-caused sounds in wilderness areas. For example, in a forested area with a background noise level of 35 dB, a level of 20 dB must be achieved before any other noise is effectively masked by the sound of the stream.

Tables 2-6 and 2-7 also can be used to establish a threshold noise level for properties adjacent to significant wetlands. Based on this information, efforts should be made to minimize any noise that would exceed the sound level recommended by the Federal Highway Administration for areas where serenity and quiet are of extraordinary significance (57 dB; Table 2-7) and that a maximum threshold and not an average daily sound level should be used..

There are many human-produced sounds in developed areas. Some of these are shown in Table 2-8. Loud and sudden intrusive noises such as chain saws, motorcycles, and rifles from the landward side and motorboats from the water will have the most severe impacts on semi-aquatic and wetland-dependent wildlife.

Several factors affect how far a sound will travel outdoors: distance, rain, frequency of the sound, fog, snow, wind, temperature, atmospheric turbulence, molecular absorption, and ground surface features including vegetation (Dailey and Redman, 1975). All of these factors except distance have extremely variable and, for the most part, minimal impacts on sound. As noise spreads out from its source, its sound pressure level will decrease as the distance from the source increases. This decreasing loudness or attenuation of a noise is at a rate of 6 dB for each doubling of distance from the source. This phenomenon is known as "spherical spreading" (Beranek, 1960). For example, a noise measured at 100 dB at 50 feet from the source will be 94 dB at 100 feet, 88 dB at 200 feet, 82 dB at 400 feet, etc. as a result of spherical spreading (assuming no other attenuation). This relationship can be shown by the following equation:

$$L_X = L_o - 20 \log_{10} (D_x/D_o)$$

where: L_x is the decibel level of the source to be calculated at a desired distance

L_o is the decibel level of the source at a given distance

D_x is the distance from the source for which L_x is to be calculated

D_o is the given distance at L_o is measured

When D_x, the distance from the source, is unknown, the following equation would apply:

$$D_x = D_o \times 10^{(L_o - L_x/20)}$$

Vegetation in some situations may help to attenuate noise, but estimates of the magnitude of attenuation by forests vary from -1.5 dB (actually increasing the level) per 100 feet (Harrison, 1974) to as much as 10 dB per 100 feet of forest depth (Myles et al., 1971) and 15 dB per 100 feet (Robinette, 1972). The Federal Highway Administration (1979) reported that the amount of sound attenuated by any forest does not exceed 10 dB regardless of the forest width. Robinette (1972) reported that a tree belt would attenuate highway traffic noise from about 90 dB to almost 60 dB within 450 feet (15 dB per 100 feet). Noise attenuation over dense brush such as a marsh is almost negligible and over water is negative (increases the level; Harrison, 1974). Therefore, motorboat sound will not be attenuated at all until it reaches the shore. This probably eliminates otherwise suitable nesting habitats for many of the listed herons. These birds prefer to nest along the waterward edge of a forest canopy.

The buffers recommended in this report to satisfy space needs of wildlife will not be sufficient to minimize loud and sudden noises that may be detrimental to wildlife in these significant wetlands.

Table 2-6. **Examples of average outdoor day/night sound levels measured at various locations (EPA 1978).**

Outdoor location	Decibels (dB)
Apartment next to freeway	87
3/4 mile from major airport	86
Downtown construction activity	79
Urban high density apartment	78
Urban row housing on major avenue	68
Old urban residential area	59
Wooded residential	51
Agricultural crop land	44
Rural residential	39
Wilderness ambient	35

Table 2-7. Federal Highway Administration abatement criterion guidelines for traffic noise impact assessment with respect to recommended average sound levels for various land uses (FHWA 1982 in Greiner, Inc., 1988).

Description of Activity Category	Decibels (dB)
Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.	57
Picnic areas, recreation areas, playground, active sports areas, parks, residences, motels, hotels, schools, churches, libraries, and hospitals.	67
Developed lands, properties or activities not included above.	72

Table 2-8. **Examples of development-related noise levels produced by various sources.**

Noise Source	Decibels (dB)	Reference
Residual	40	EPA, 1971
Dog barking	50	EPA, 1971
Cars on nearby blvd.	55	EPA, 1971
Airplane overflight	65	EPA, 1971
Local cars	65	EPA, 1971
Buses	82	EPA, 1972
Trucks	85	EPA, 1972
Home shop tools	85	EPA, 1972
Lawn mowers	87	EPA, 1972
Motorcycles	95	EPA, 1972
Motor boat (45hp)	95	EPA, 1972
Chain saw	100	EPA, 1972
Two-man saw	55*	Harrison, 1974
Man shouting loudly	67*	Harrison, 1974
Pickup truck	73*	Harrison, 1974
Chopping wood	75*	Harrison, 1974
Rock drill	75*	Harrison, 1974
Pick and shovel	76*	Harrison, 1974
350-cc motorcycle	80*	Harrison, 1974
Chain saw	93*	Harrison, 1974
Small portable welder	95*	Harrison, 1974
.22 caliber pistol	107*	Harrison, 1974
30-06 rifle	130*	Harrison, 1974

Table 2-8. Continued.

Noise Source	Decibels (dB)	Reference
Four-person conversation	48**	Dailey and Redman, 1975
Guitar	52**	Dailey and Redman, 1975
Four people singing	60**	Dailey and Redman, 1975
Chopping wood	64**	Dailey and Redman, 1975
Pounding tent stakes	66**	Dailey and Redman, 1975
Clattering pans	66**	Dailey and Redman, 1975
Harmonica	72**	Dailey and Redman, 1975
125-cc trail bike	74**	Dailey and Redman, 1975
Safety whistle	76**	Dailey and Redman, 1975
Yelling	78**	Dailey and Redman, 1975
30-06 rifle	136**	Dailey and Redman, 1975

* dB levels at 100 feet

** dB levels at 50 feet

The effectiveness of vegetation noise buffers depends on many factors including plant shape, foliage thickness, and height of vegetation. As a result of the unpredictability of determining noise attenuation, a specific noise buffer is not recommended, but the following is suggested to properly address adverse impacts of noise on wetland wildlife:

- to educate the public about the impacts of noise on wildlife in regionally significant wetlands,
- to adopt a noise threshold level for significant wetlands,
- to require a noise attenuation assessment on a site by site basis between proposed development sites and adjacent significant wetlands,
- to consider the use of physical noise barriers or dense plantings such as those used by highway departments, and
- to consider adopting sound ordinances wherever necessary.

Limitations of Wetland Wildlife Buffers

Just discussed are the confines of buffers in reducing loud disturbing noises. Buffers also have other limitations. Buffers recommended in this report will address spatial needs of individuals in only half of the semi-aquatic and wetland-dependent wildlife species in east central Florida. They will also help to reduce some of the adverse impacts of animal and human activities in adjacent areas. These buffers are an important part but not a complete conservation plan that will achieve Regional Goal 43, to protect the ecological values of significant ecosystems.

The most serious problem confronting Florida's wildlife is fragmentation of natural habitat areas into small, isolated parcels that are not large enough to sustain viable populations. Growth management decisions must focus on maintaining the biological integrity of systems by designing areas that will perpetuate functional communities and not merely token remnants.

In order to develop a conservation strategy that addresses the need to ensure continued perpetuation of all currently existing wildlife populations within a large geographic area, minimum viable or minimum functional population considerations must be made. A minimum viable population is the lowest number of individuals that can ensure the capability of the population to persist through time dealing successfully with agents of extinction (Shaffer, 1981). Put in more specific terms, a minimum viable population can be defined as the smallest population that will give a 99% probability of surviving at least 1,000 years (Shaffer, 1981). Too small a population is subject to extirpation due to the accumulation of detrimental genetic make-up through inbreeding (Ralls and Ballou, 1983).

It is important to note that the process of extirpation for longer-lived species may take several decades. Therefore, the impacts of some ineffective land-use decisions will not be realized for several generations.

Reed et al. (1986) recommended an effective population size of more than 50 for short-term survival of species and 500 for long-term population and species survival. Frankel (1983) warned that populations as large as 300 individuals may be needed to provide for minimum levels of persistence for populations confronted with consistently harsh conditions over 200 years. Land managers and planners should of course aim above the minimum levels whenever possible because the consequences of falling below are extreme and these population models have not been substantially validated.

Once the minimum viable population size is determined then the minimum area required to support that population can be calculated by extrapolating the home range size of the average individual. In landscapes with isolated wetland habitats, area requirements should be satisfied in large contiguous blocks. In flowing water wetlands that are situated between two larger habitat islands, area requirements may be satisfied merely by providing the appropriate link or wildlife corridor.

The buffers recommended in this report pertain to the protection of wetland habitats to the extent that they will merely satisfy requirements of some individuals. However, this does not mean that the needs of far-ranging individuals and of populations should be ignored. Local comprehensive planning efforts must effectively design systems that will provide large minimum area requirements such as 300,000 acres for black bears and 60,000 acres for indigo snakes. These goals probably cannot be achieved within one county's jurisdiction. Therefore, cooperative approaches are necessary to assure the perpetuation of populations of semi-aquatic and water-dependent wildlife species in east central Florida.

SECTION III: Calculating Site-Specific Buffers

This section provides the methods for determining buffer requirements for a specific site. For each case, it gives a brief rationale, explains the method, and lists data requirements and sources. It is important to note that the methods for calculating buffer requirements for protection against groundwater drawdown and control of sediment and turbidity are designed to be as simple as possible so that a minimum of data is required.

In most cases, the required buffer width is measured from the boundary between the wetland the upland. For convenience, the methodology employed by the St. Johns River Water Management District for determining wetland/upland boundaries should be used to establish the wetland edge since many of the wetlands for which a buffer is applicable will have been surveyed by SJRWMD personnel.

Groundwater Drawdown

The impact of lowered groundwater level in lands surrounding wetlands alters the length of time of wetland inundation (hydroperiod) and the depths of inundation. Both hydroperiod and depth of inundation affect the species composition of vegetation and wildlife and, ultimately the "health" of the entire ecosystem. The following are consequences of drainage of wetlands: (1) drained wetlands are more prone to damaging fires, (2) their organic substrates (peat or muck) oxidize away when exposed to air, (3) wetland trees easily topple when exposed roots die, and (4) drained wetlands are more prone to invasion by exotic vegetation and upland species. The protection of wetland function and structure is probably best accomplished by protecting hydroperiod and depth of inundation.

There are numerous approaches to determining the drawdown of surficial aquifers from open ditches, sub-surface drains, or other drainage structures. Some are more complex than others, and, while they may yield very detailed information about hydraulic effects of drainage structures, their use requires significant amounts of time and energy. The most appropriate method in this context is the simplest one that provides the necessary information and has sufficient rigor that its results merit confidence.

Two methods are discussed here and are considered appropriate for the calculation of site- specific wetland drawdown buffers. The first was developed by Dr. Wendy Graham of the University of Florida Department of Agricultural Engineering (see Appendix B) and the second by the Southwest Florida Water Management District, Resource Regulation Department (Miller and Weber, 1989). The two methods are applicable for different conditions and require different input data. The SWFWMD method assumes a horizontal groundwater flow having a small surficial aquifer slope $[(dh/dx)^2 << 1.0]$. While this condition can be met in many flatwoods situations, slopes can often exceed 5% in other landscapes. The "Graham method" assumes a surficial aquifer sloped toward the wetland <u>or</u> a horizontal surficial aquifer. Under horizontal surficial aquifer conditions, both methods yield similar results.

Calculating Wetland Drawdown Buffer: Method 1

Use this method when the surficial aquifer slopes toward the wetland or when the slope of the surficial aquifer is nearly horizontal.

Figure 3-1 illustrates the impact of a drainage structure on the surficial aquifer near a wetland. The magnitude of the impact is related to the drawdown in the drainage canal or structure and is the difference between pre-development and post-development levels. The equation that may be used to determine the magnitude of drawdown and thus the effective width of a buffer is as follows:

$$S(x) = \frac{h_{lc}^2 - h_o^2}{L_c} x + h_o^2 \;\; ^{1/2} - \frac{(h_{lc} - s_{lc})^2 - h_o^2}{L_c} x + h_o^2 \;\; ^{1/2} \qquad (3.1)$$

where:

h_o = height of the surficial aquifer at the center of the wetland in wet season (feet)

h_{lc} = height of the surficial aquifer at the proposed canal location before development in wet season (feet)

L_c = distance between the center of the wetland system and the center of the canal

s_{lc} = surficial aquifer table drawdown at the drainage structure

The formula requires that an impervious layer exists below the surficial aquifer, and all heights are measured relative to this layer. In larger wetlands (equal to or greater than 5 acres), the drawdown formula is not sensitive to the depth of the impervious layer. Therefore, for the purposes of this calculation, a convenient depth may be assumed, and field measurement is not required.

The required data are:

a) distance from center of wetland to wetland edge,
b) the slope of the surficial aquifer, and
c) drawdown at the drainage structure.

Distance from the center of the wetland to the wetland edge can be measured from aerial photographs or measured in the field.

Slope can be determined through field measurement by measuring the difference in elevation of groundwater in excavated soil pits at two or more locations along a line perpendicular to the wetland edge. In most flatwood situations, the slope can be assumed to be equivalent to the slope of the ground surface.

Drawdown at the drainage structure is usually given by engineering requirements of the site.

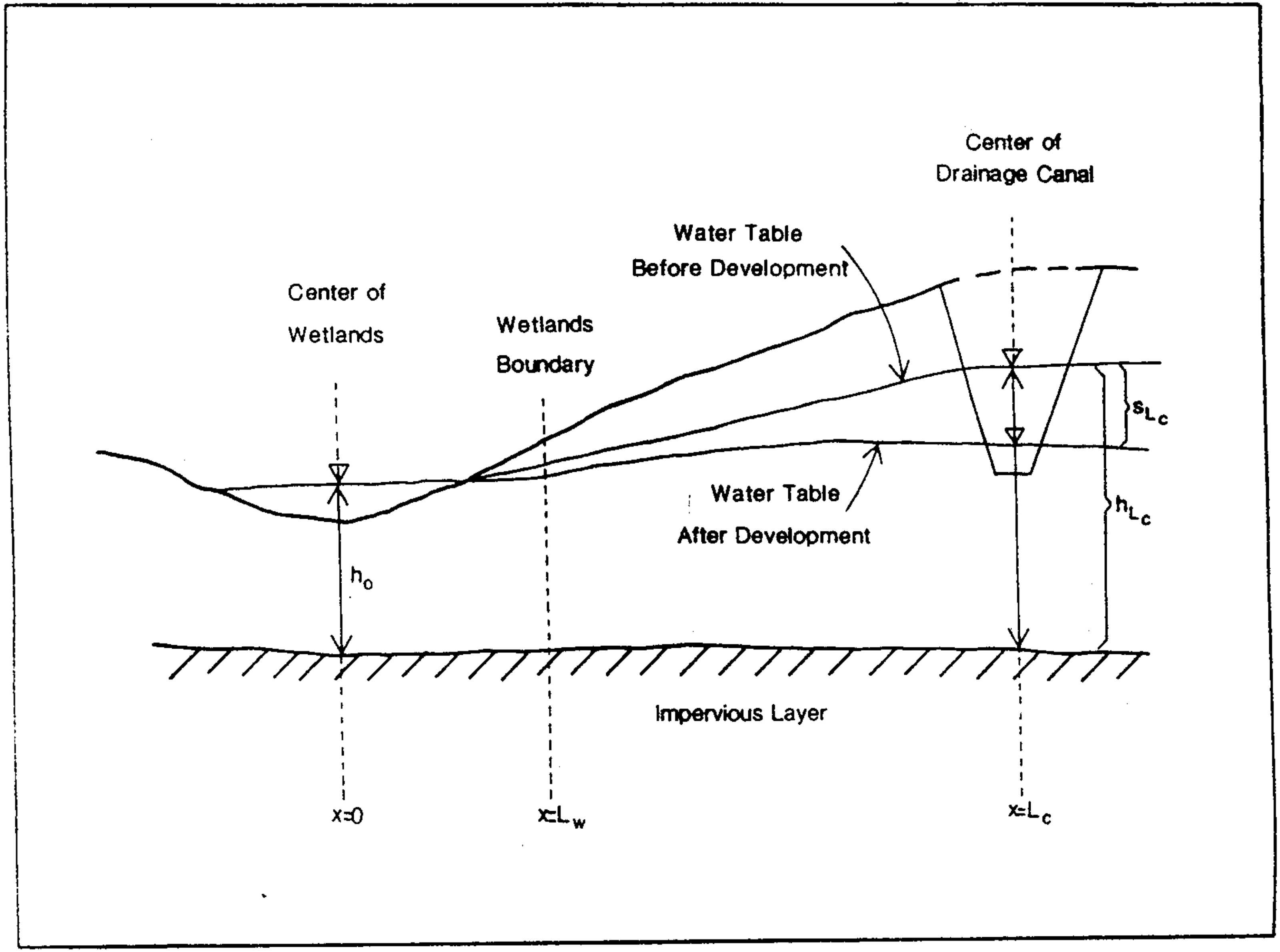

Figure 3-1. Diagram illustrating the effects of groundwater drawdown on wetland water levels in areas of sloped groundwater tables. Letters refer to variables in Equation 3.1.

Because equation 3.1 depends on the predevelopment level of the surficial aquifer, it cannot be rewritten to calculate buffer width directly. The only way to find the required buffer distance is to substitute various buffer distances in the equation until the drawdown at the wetland edge approaches zero.

Calculating Wetland Drawdown Buffer: Method 2.

Referring to Figure 3-2, the required buffer distance can be calculated for flatwoods situations where the surficial aquifer is nearly level and flow is horizontal using a two-dimensional analytical equation that is used to estimate the spacing of soil drains. Called the Hooghoudt equation, this steady state equation is based on the Dupuit-Forchheimer assumption and on Darcy's law. For the derivation and explanation of assumptions, see Miller and Weber, 1989. The derived equation applicable to the determination of required wetland buffers is as follows:

$$d = \frac{[K(M)^2 + 2AM]}{q}^{1/2} \qquad (3.2)$$

where:

K = average hydraulic conductivity above the impermeable layer (in/hr.). For practical purposes, hydraulic conductivity is equal to permeability.

M = vertical distance of surficial aquifer above maintained water level in drainage structure at wetland edge (assume wet season water level at the ground surface). (feet)

A = depth to impermeable layer below bottom of drainage structure. (feet)

q = drainage coefficient, rate of water removal and uniform replenishment, or effective rainfall (in/hr). Calculate as difference between yearly rainfall and evapotranspiration.

d = setback distance for drainage structures to prevent drawdown of existing seasonal high surficial aquifer level in the wetland.

The required data include:

Hydraulic Conductivity - The USDA-SCS county soil surveys give permeabilities by soil type, and these are summarized in Appendix A for soils within the Region. For practical purposes hydraulic conductivity can be assumed to equal permeability. Where multi-layer soils exist, use a weighted mean of the given permeabilities and soil strata depths.

Normal Wet Season High Water Table (NWSHWT) - assume that wet season high surficial aquifer level intersects the ground surface at the wetland edge.

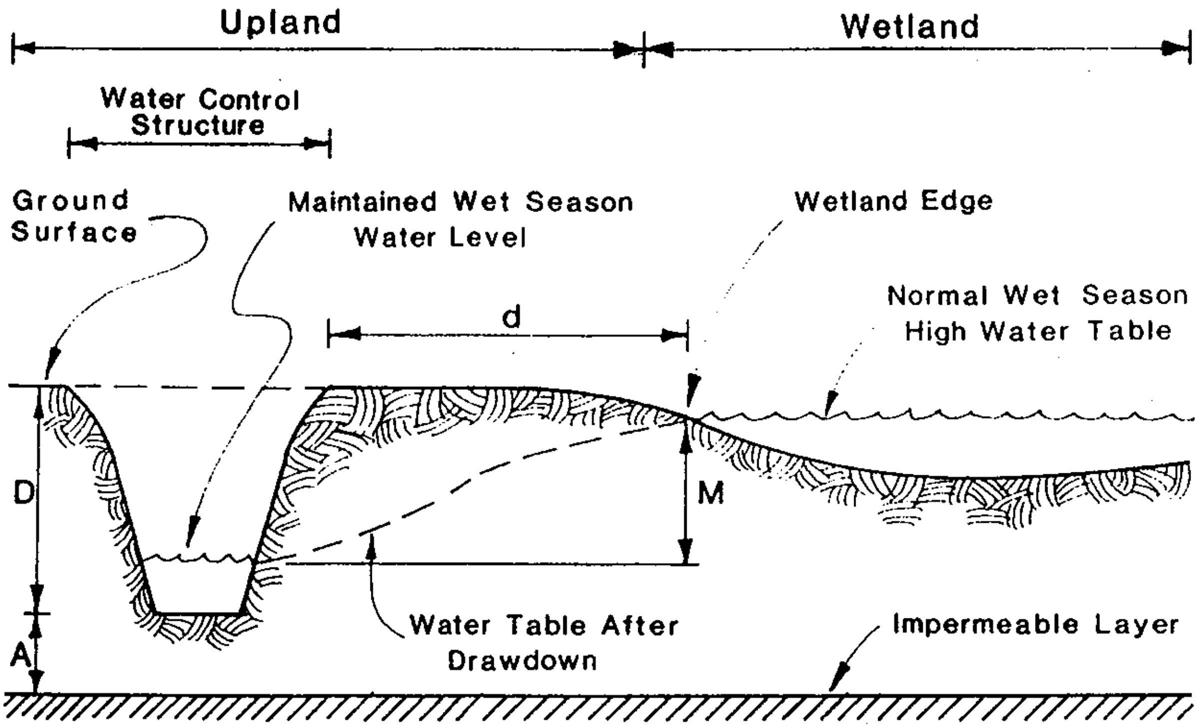

Figure 3-2. Diagram illustrating the effects of groundwater drawdown on wetland water levels in areas having nearly horizontal groundwater tables. Letters refer to variables in Equation 3.2.

Depth to water level (D) after drawdown - Depth below the ground surface to the maintained wet season water level in the drainage structure.

Vertical distance (M) - The difference between NWSHWT and the maintained water level in the drainage structure (D).

Depth to impermeable layer (A) - In the absence of geotechnical information showing a layer having hydraulic conductivity of less than one tenth of the overlaying material, depth (A) may be assumed to equal 0.5 depth (D). If no impermeable layer is encountered in test borings to a depth equal to depth (D) below the drainage structure bottom, then depth (A) may cautiously be assumed to equal depth (D).

Drainage coefficient (q) - Annual net effective rainfall is estimated by subtracting yearly evapotranspiration (ET) from annual rainfall. In central Florida rainfall averages approximately 54 inches per year and ET is estimated to be about 87% of rainfall or about 47 inches. Net effective rainfall, then, is equal to 7 inches/yr or 0.0007991 in/hr.

Sediment and Turbidity Control

Sediment deposition in wetland ecosystems results in significant impacts to wetland structure and function. Accumulations of sediment tend to fill the wetland, displacing vegetation and altering water storage capacity. Increased turbidity caused by silts and clays washing from disturbed lands are less a problem in wetland ecosystems but represent a serious impact to aquatic systems. Thus, sedimentation in wetlands should be avoided and release of turbid waters to aquatic environments controlled.

To minimize the potential for wetland sedimentation, upland buffers of undisturbed natural vegetation can act to slow the velocity of sediment-laden runoff waters, causing deposition of sediments prior to release to the wetland. Buffers of upland and wetland combined can act as filters and silt traps to minimize negative impacts of silt on aquatic ecosystems. The following methods can be used to determine the buffer required to minimize sediment impacts on wetlands and turbidity impacts on aquatic systems.

Calculating Sediment and Turbidity Control Buffers

Calculating sediment buffer widths involves ascertaining the soil type of the area immediately adjacent to the wetland, the soil hydrologic group, and USDA soil classification. Runoff volume is estimated using methods described in SCS TR-55 and buffer width is calculated using equations explained below. The procedure is as follows:

1. Determine soil type of the site from USDA-SCS county soils survey.

2. From SCS soils survey or from Table A-1 in Appendix A, obtain soil hydrologic group and USDA soil type.
3. Using procedures described in SCS TR-55 "Urban Hydrology for Small Watersheds," calculate peak discharge from one acre of newly graded soil of the appropriate hydrologic group. The size is set at 300 feet along the slope and 145.2 feet wide. This length is important since channelized flow may occur on longer slopes (SCS, 1986).
4. Calculate the first-order reaction coefficient for deposition using the following formula (Foster, 1982):

$$\alpha = \frac{0.5\ V_s}{q} \qquad (3.3)$$

where:

V_s = fall velocity (feet/sec). Use the following fall velocities (adapted from Flanagan et al., 1986), depending on USDA soil type (from Table A-1):

Clay soils = 0.000010 ft/sec
Loamy soils and mucks = 0.000263 ft/sec
Fine sands = 0.001093 ft/sec
Sands = 0.002500 ft/sec

q = peak discharge of surface runoff per unit width per unit time ($ft^3/sec\ .\ ft^{-1}$) (from TR-55)

5. Calculate the length of the buffer strip required using the following equation adapted from Foster (1982):

$$L = \ln \frac{(1 - SD)}{\alpha} \qquad (3.4)$$

6. If the soil type is fine or coarse sand, the required buffer is measured from the boundary between the wetland and the upland. Wetland edge is determined using methods adopted by the St. Johns River Water Management District.[11]
7. If the soil type is silt or clay and there is a body of open water adjacent to the wetland, the required buffer is determined using the larger of either of the following measures:
   a) measured as that required for fine sand in step 6 above, or
   b) measured from the edge of open water toward the upland including any adjacent wetlands.

Wetland Wildlife Habitat Buffers

Landscape alterations associated with development and other human-related activities adversely affect wildlife resources and their habitats. Some of specific problems include fragmenting habitats into small parcels not adequate to retain the ecological balance and function of the original system and disturbing wildlife by activities and noises that prevent them from using critical nesting and feeding areas.

The intended purpose of the recommended wetland wildlife habitat buffers is to provide habitat for semi-aquatic and wetland-dependent wildlife and to protect the ecological values of significant wetlands. In order to most effectively achieve this purpose buffers should adhere to certain quality and quantity standards, and should address potential domestic animal and human-related disturbances (including noise).

Calculating Wetland Wildlife Habitat Buffers

The procedure for calculating wetland wildlife habitat buffers is as follows:

1. Determine the habitat type of the particular regionally significant wetland that is on or waterward from the proposed development site (see Appendix G). For landscape situations where there is no vegetated wetland transitional area (e.g., marsh or swamp), the habitat determination should be made for the upland habitat (e.g., flatwoods, hammock, sandhill) that is adjacent to the aquatic system.
2. Determine the quality of the habitat.
   High - The area is still in a relatively natural state.
   Medium - The area has been cleared for agricultural or silvicultural purposes but no permanent structures such as roads and buildings have been constructed.
   Low - The area has been cleared and developed with roads, buildings, and other permanent structures.
3. Select the buffer width found in Table 3-1 for the previously determined habitat type and quality.
4. Note that the wildlife buffers can include wetland as well as upland habitats. The wetland wildlife habitat buffer should begin at the waterward edge of the forested wetland or upland habitat that is adjacent to the aquatic system. A minimum 50-foot upland strip for semi-aquatic reptile nesting and overwintering also should be included in each buffer (i.e., if the marsh or swamp wetland is wider than the recommended buffer, a 50-foot-wide upland buffer strip should be added to the landward edge of the wetland).
5. If no trees are adjacent to the marsh (e.g., open flatwoods) a 322-foot buffer is needed to prevent disturbance from human activities (minimum distance from humans tolerated, see Appendix F).
6. Marsh areas frequently occur along flowing water systems (e.g., rivers). These marshes do not function as separate habitats unless they are large enough to support most wildlife species associated with marsh communities. For separate buffer considerations, these marshes must be at least 5 acres in size and vegetation must extend waterward from the waterward edge of the adjacent upland or forested wetland community for at least 50 feet.

Table 3-1. **Recommended wetland wildlife buffer widths for various habitats of high, medium and low quality.**

Habitat	Quality	Buffer Width
Salt and Freshwater Marshes	High	322 feet
	Medium	322 feet and revegetate buffer into natural habitat
	Low	as wide as possible up to 322 feet
Cypress and Hardwood Swamps, Hammocks, and Flatwoods	High	550 feet
	Medium	550 feet and revegetate buffer into natural habitat
	Low	as wide as possible up to 550 feet
Sandhills	High	732 feet
	Medium	732 feet and revegetate buffer into natural habitat
	Low	as wide as possible up to 732 feet

Calculating Noise Attenuation Requirements

The procedure for calculating noise attenuation requirements is as follows:

1. Obtain information on the local noise threshold policies for significant wetlands (assuming that such policies will be forthcoming).
2. Assess the maximum (not average) current or potential (if site is proposed for development) noise level for the site.
3. Assess the amount of noise attenuated under proposed conditions following development from the site to the waterward edge of the wetland (or upland if no wetland is present). Measurements of sound attenuated through vegetated areas should be conducted during the winter when most deciduous foliage is absent. There are several standardized methods for assessing noise levels (U.S. Department of Transportation, 1981; U.S. Department of Housing and Urban Development, 1984). The former reference includes information relating to the instrumentation, equipment operation, personnel, measurement procedure, and computation procedure for a noise measuring project.
4. Determine the width of a vegetated buffer or some other attenuation means (e.g., barriers) that would be necessary to reduce the maximum expected sound level to the acceptable threshold.

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GLOSSARY

BIOTA - The animal and plant life of a particular region considered as a total ecological entity.

BUFFER - A zone of transition between two different land uses that separates and protects one from another. In this report, the word "buffer" refers to the zone between a wetland and a developed or developable area.

CARRYING CAPACITY - The size of a population that an environment or habitat can support indefinitely.

COMMUNITY, ECOLOGICAL - A natural assemblage of plants and animals that live in the same environment, are mutually sustaining and interdependent, and are constantly fixing, utilizing, and dissipating energy.

COMMUNITY, WILDLIFE - All of the populations of different species of animals that live in the same environment.

CURSORIAL - Adapted to or specialized for running as opposed to flying, crawling, etc.

DIVERSITY, BIOLOGICAL - The composition of a particular environment or habitat as it relates to the plant and animal species present and their relative abundance.

DRAWDOWN - The lowering of the upper surface of a water table.

EQUILIBRIUM NUMBER - The number of species supportable in a given area over the long term.

EXTIRPATION - Extinction of a species from a particular area (not its entire range) where it formerly occurred.

GENETIC VIABILITY - The probability of survival from egg to adult.

GROUNDWATER - Water below ground level in completely saturated soil. Not confined (under pressure), the source of which is rainfall, and the elevation of which rises and falls.

HABITAT, WILDLIFE - The area or type of environment in which an organism or biological population normally lives or occurs.

HYDRAULIC CONDUCTIVITY (K) - The coefficient which quantifies the resistance of a porous medium (i.e., saturated soil) to fluid flow. This coefficient depends on properties of the fluid and the medium and has units of length per time. In the United States, K is often expressed as the flow in gallons per day through an area of one square foot under a gradient of one foot per foot at 60° F.

HYDRIC - Characterized by, relating to, or requiring an abundance of moisture. Compare mesic and xeric.

HYDROPERIOD - The length of time during which there is standing water in a wetland.

INSULARITY - Of or relating to the extent that a specific habitat area is surrounded by dissimilar landuses that in an ecological sense isolates it from natural animal and plant dispersion mechanisms.

INTEGRITY, BIOLOGICAL - All of the plants and animals that are characteristic of an area and all of the processes that result from interactions between these species and their environment.

LANDSCAPE ASSOCIATION - An assemblage of ecological communities with similar topography and geology which are hydrologically connected.

LANDSCAPE DYNAMICS - The areal and functional relationships between different parts of the landscape, e.g., the distribution, sizes, and topographic and hydrologic connections among ecosystems in a landscape association.

LIFE REQUISITES - Those components of a habitat that an organism needs to survive.

MESIC - Midway between very wet and very dry.

MODEL, COMPUTER SIMULATION - A representation of any kind of system (such as an ecosystem, a set of wildlife populations, or a landscape association) written in a computer language that shows changes over time and responses to different sets of conditions.

OVERSTORY - The layer of foliage (leaves and branches) formed by the largest trees in a forested area.

PHREATIC AQUIFER - An unconfined saturated permeable geologic unit which is capable of transmitting a significant amount of water under typical conditions.

POPULATION, MINIMUM VIABLE - The smallest number of individuals that will give 99% probability of the species surviving in a particular area for at least 1,000 years.

RIPARIAN - Of or relating to living or located on the bank of a flowing watercourse (as a river or stream) and also an isolated water source such as a pond or lake.

SAND, PRIMARY - Unweathered soil particles between .05 and 2.0 mm in diameter.

SEED SCARIFICATION - Processes required to prepare seeds for germination.

SEEPAGE, GROUNDWATER - Slow, vertical or horizontal movement of groundwater in the soil.

SEMI-AQUATIC - Adapted for living near water and needing water to survive but living in water all of the time such as fish.

SILTS, PRIMARY - Unweathered soil particles between .002 and .05 mm in diameter.

SILVICULTURE - Activities of man involving regeneration, tending, and harvesting a forest.

SPECIES RICHNESS - The number of different species in an area.

STEADY-STATE SYSTEM - A system in which short-term effects have been damped out over time and which therefore does not vary over time.

SUCCESSION, VEGETATIONAL - The process of change in the types of plants occupying an area as plants mature, are replaced, and otherwise respond to the environment.

SURFICIAL AQUIFER - Water below ground level in completely saturated soil. Not confined (under pressure), the source of which is rainfall, and the elevation of which rises and falls.

TAXA - Plural of taxon.

TAXON - A group of organisms constituting one of the categories in taxonomic classification of living organisms such as class, order, family, genus, species.

TERRITORY, BREEDING - An area usually including the nesting or denning site and possibly a variable foraging range that is preempted by an individual male animal and defended against the intrusion of rival individuals.

TURBIDITY - The concentration in water of suspended solids (such as silts, clays, and small particles of organic matter).

UNDERSTORY - The foliage lying beneath the tallest trees consisting mainly of seedling trees, small trees, shrubs, and herbaceous plants.

VEGETATION AREAS, TRANSITIONAL - Areas that contain plants that are characteristic of identifiable adjacent plant communities.

VERTEBRATE - Of or relating to the taxonomic subphylum "vertebrata" that compromises bilaterally symmetrical animals with a segmented spinal column or in primitive forms with a persistent notochord, a tubular dorsal nervous system divisible into brain and spinal cord, an anterior head bearing a mouth and the major sense organs, an internal articulated skeleton of bone and cartilage, respiration by gills or lungs, and not more than two pairs of limbs which may be modified as grasping, walking, swimming or flying organs in different members of the division, and that includes the mammals, birds, reptiles, amphibians, fishes, elasmobranchs, and cyclostomes and sometimes the lancelets.

WATER-DEPENDENT - Of or relating to the need for water as a necessary habitat component for survival.

WATER TABLE - Water below ground level in completely saturated soil. Not confined (under pressure), the source of which is rainfall, and the elevation of which rises and falls.

WETLAND - Lands transitional between terrestrial and aquatic ecosystems where the water table is usually at or near the surface.

WETLANDS, EPHEMERAL - Areas temporarily or seasonally supporting wetland conditions.

WETLANDS, JURISDICTIONAL - Wetlands that can be legally regulated by government.

XERIC - Of or relating to an extremely low amount of moisture available for the support of plant life.

APPENDIX A:

Landscape Associations of East Central Florida

Appendix A: Landscape Associations of East Central Florida

The number of associations used for delineating buffer zones must be small enough to minimize methodological complexity and large enough to represent ecological and hydrological factors accurately. Based on analysis of vegetation and land use maps of the St. Johns River Water Management District,[1] six landscape associations were identified in the East Central Florida region: (1) pine flatwoods/isolated wetlands, (2) pine flatwoods/flowing water wetlands, (3) pine flatwoods/hammock/hardwood swamps, (4) sandhills/isolated and or flowing-water wetlands, (5) pine flatwoods/salt marshes, and (6) coastal hammock/salt marshes. Landscape associations selected for buffer-zone delineation were designed to reflect differences in the three goals of the buffer determination procedure--minimization of groundwater drawdown, sediment and turbidity control, and protection of wildlife habitat. The critical factors distinguishing these groups for purposes of calculationg buffer widths are the differences in drainage and in topography.

Following are descriptions of the components of the six landscape associations. Figures A-1 through A-6 are maps of landscape associations in each of the six counties of the region. Table A-1 lists typical soil series of the components of the associations and some of the soil characteristics used in calculating buffer widths.

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[1] Maps prepared by the Center for Wetlands under joint contractual agreement with the Jacksonville Area Planning Board and the St. Johns River Water Management District, 1973.

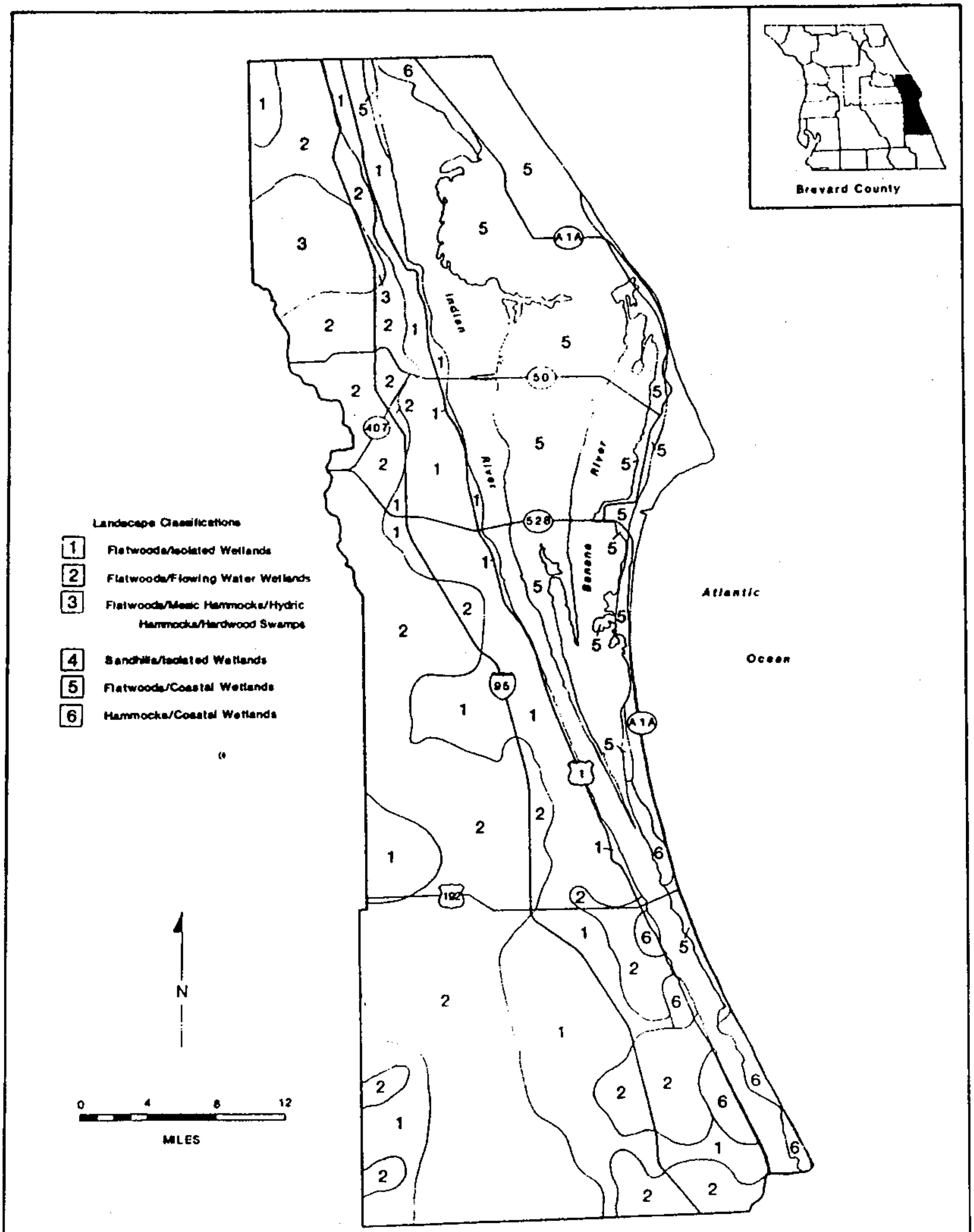

Figure A-1. Landscape associations in Brevard County, Florida.

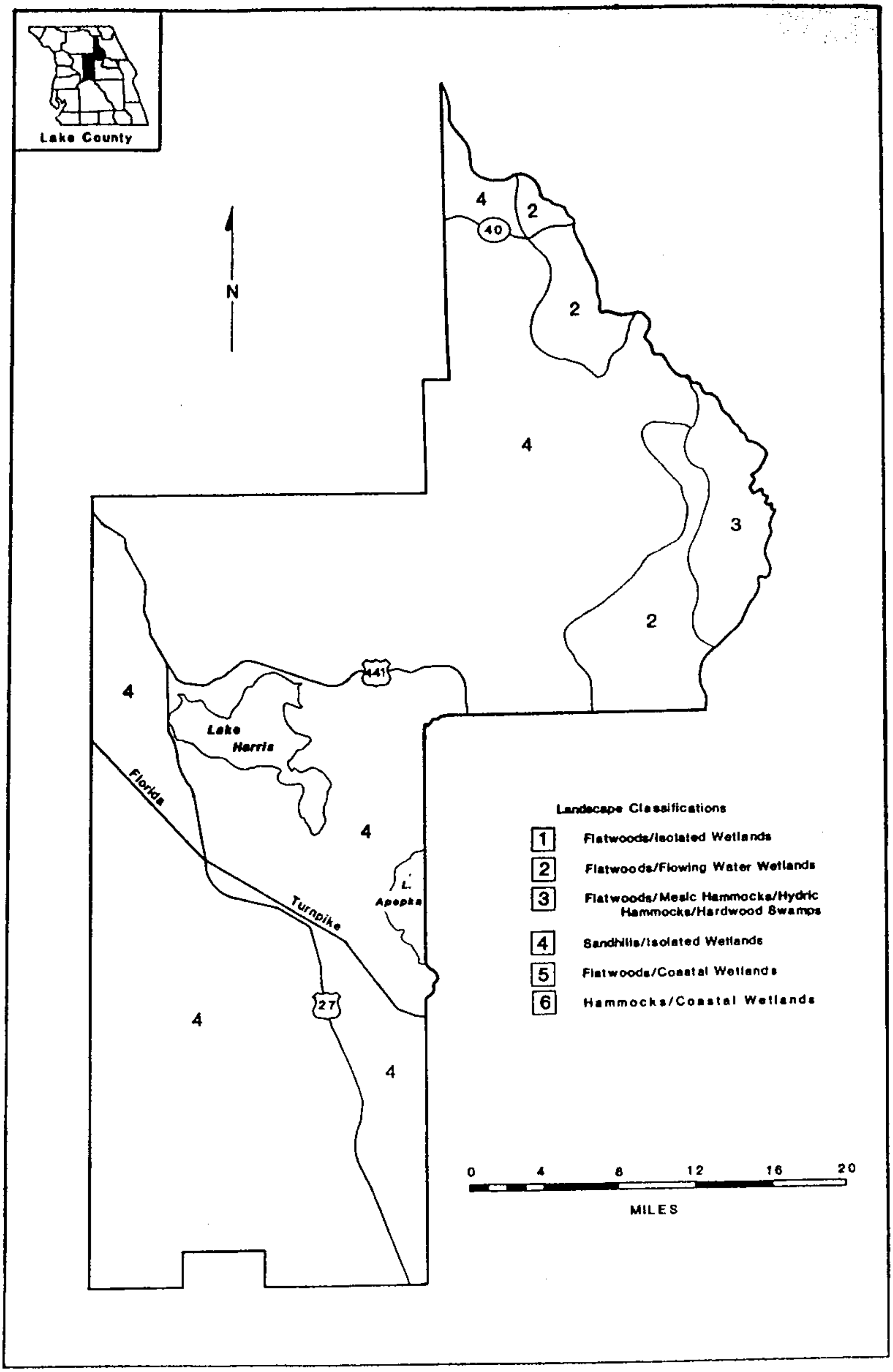

Figure A-2. Landscape associations in Lake County, Florida.

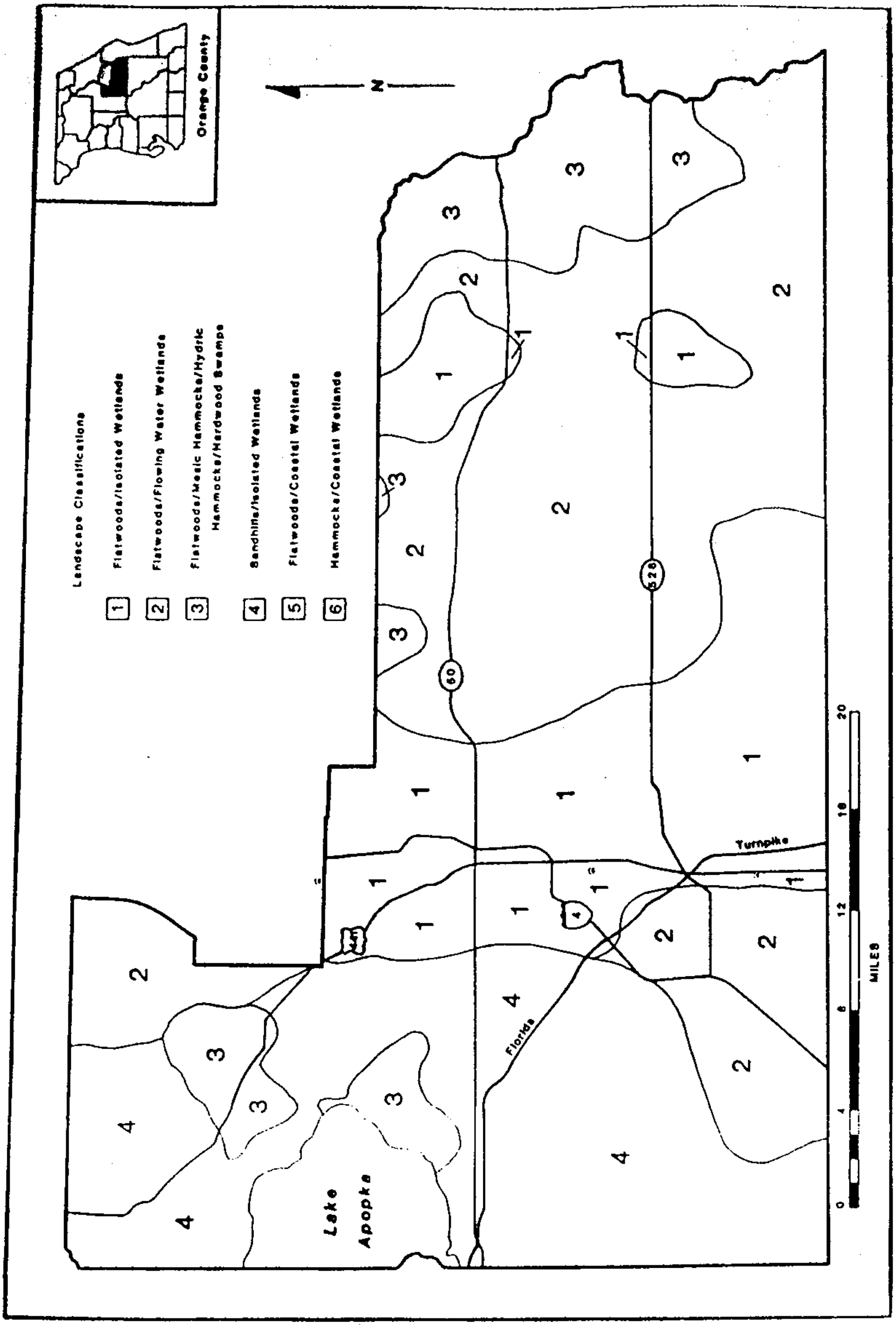

Figure A-3. Landscape associations in Orange County, Florida.

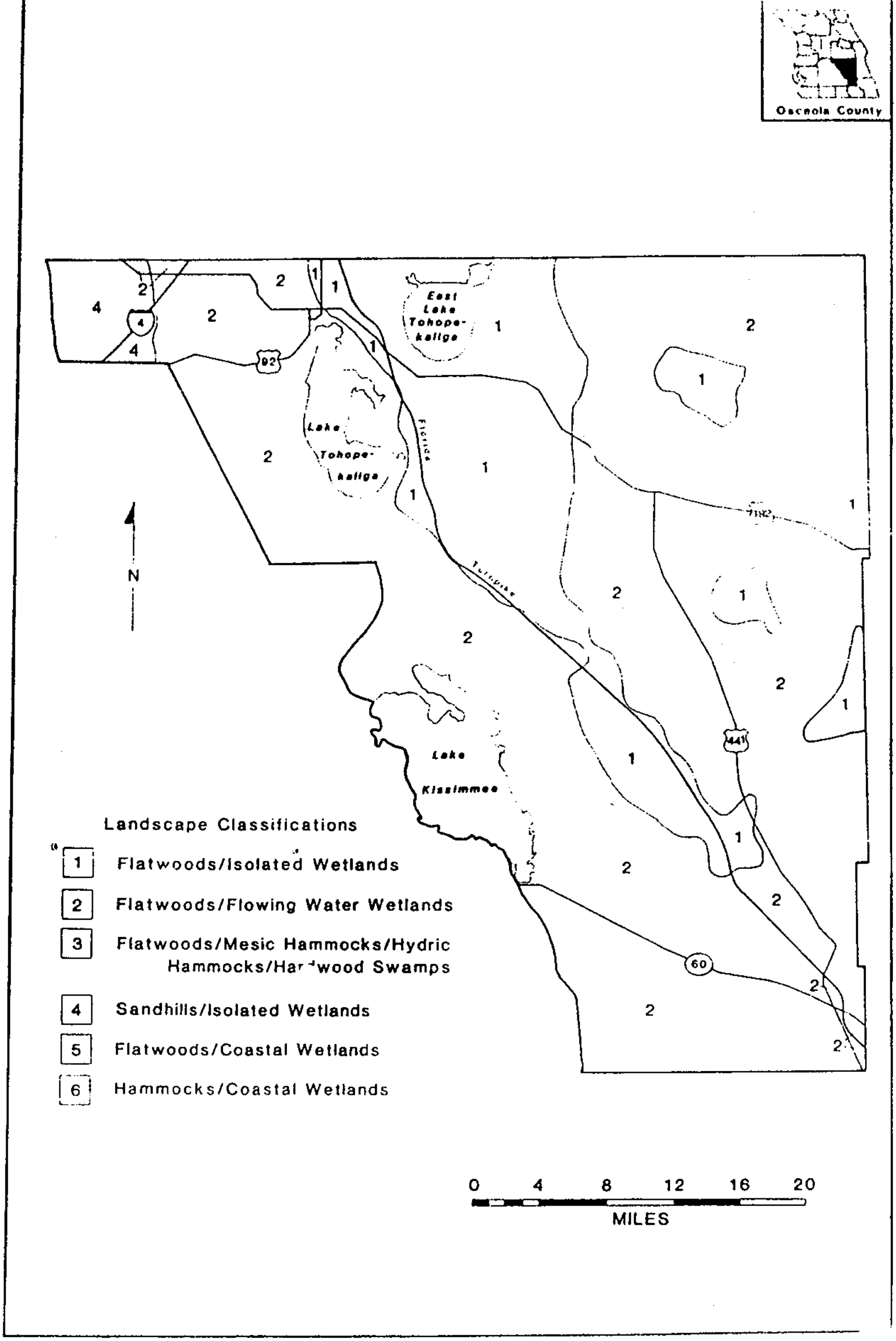

Figure A-4. Landscape associations in Osceola County, Florida

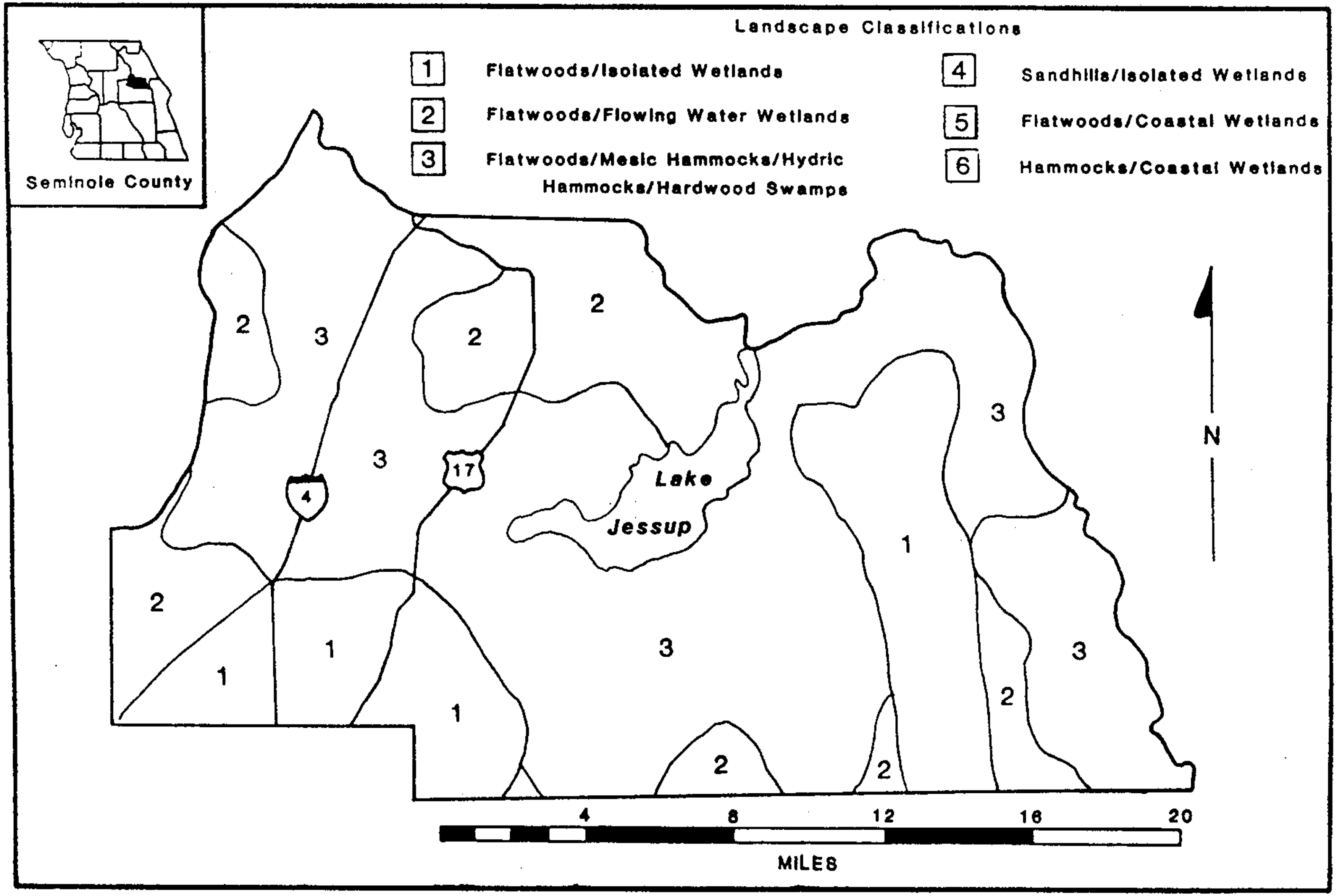

Figure A-5. Landscape associations in Seminole County, Florida.

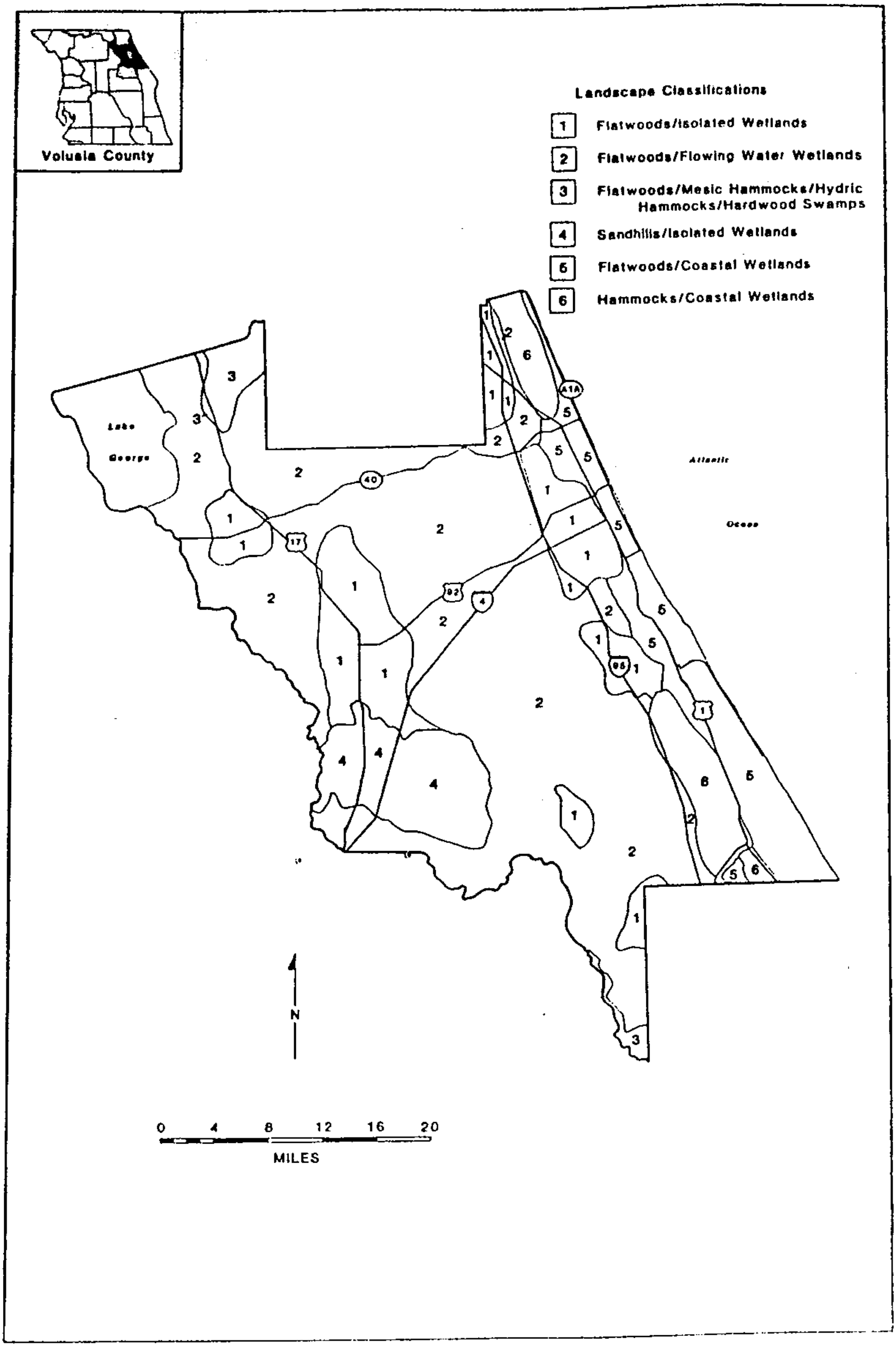

Figure A-6. Landscape associations in Volusia County, Florida.

Landscape Association 1. Pine flatwoods/isolated wetlands

Pine flatwoods are so named because of the flat topography on which this association is typically found. The lack of gradient results in frequent flooding during the summer rainy season (Brown, 1980). Many of the grassy scrub areas shown on the 1973 maps were probably once pine flatwoods that have been converted to grassy scrub by tree harvest, increased drainage, and/or greater fire frequency (Brown, 1980).

Interspersed throughout the flatwoods are topographically low areas, which are occupied by patches of wetlands of various types. These include cypress domes, bayheads, and wet prairie (Brown and Schaefer, 1987), as well as shallow and deep freshwater marshes (Brown, 1980).

Cypress domes are dominated by pond cypress (Taxodium distichum var. nutans). Dominant tree species in bayheads include redbay (Persea borbonia), sweetbay (Magnolia virginiana), loblolly bay (Gordonia lasianthus), blackgum (Nyssa sylvatica var. biflora), red maple (Acer rubrum), pond pine (Pinus serotina), and slash pine (Pinus elliottii). Typical wet prairie plants include St. John's wort (Hypericum fasciculatum), primrose willow (Ludwigia spp.)., elderberry (Sambucus simpsonii), panicum grasses (Panicum spp.), soft rush (Juncus effusus), spike rush (Eleocharis cellulosa), and pickerelweed (Pontederia cordata).

Deepwater marshes are usually dominated by free-floating plants such as water hyacinth (Eichhornia crasspipes) and water lettuce (Pistia stratiodes) or rooted aquatic plants such as water lily (Nymphaea odorata) and spatterdock (Nuphar luteum). Shallow marshes may be dominated by one of the following species: pickerelweed, sawgrass (Cladium jamaicense), arrowhead (Sagittaria spp.), fire flag (Thalia geniculata), cattail (Typha spp.), spike rush, bulrush (Scirpa spp.), or maidencane (Panicum hemitomon); some marshes contain patches or mixtures of some or all of these species (Brown and Starnes, 1983).

Landscape Association 2. Flatwoods/flowing water wetlands

The soils in this category are poorly drained and have higher percentages of clay and organic matter than do those of the flatwoods/isolated wetland association, and the topography is more variable. Flowing water wetlands include both bald cypress (Taxodium distichum) and hardwood forests growing along sloughs and rivers. Common hardwood species include red maple (Acer rubrum), water tupelo (Nyssa aquatica), swamp black gum (Nyssa sylvatica var. biflora), sweet gum (Liquidambar styraciflua), pop ash (Fraximus caroliniana), Florida elm (Ulmus floridana), and cabbage palm (Sabal palmetto) (Brown, 1980).

The seasonal flooding that is characteristic of flowing water wetlands provides the nutrients needed for plant growth. Water levels fluctuate about 2.5 feet in an average year, but the range may be as large as 5 feet (Brown and Starnes 1983). Flooding is also important for seed distribution, seed scarification, and elimination of upland plant species (Brandt and Ewel, 1989).

For a description of flatwoods, see Landscape Association 1 above.

Landscape Association 3. Pine flatwoods/hammocks/hardwood swamps

Poorly drained to moderately well-drained, sandy soils and level to sloping topography characterize this landscape association. Between flatwoods and mesic hammock in relatively higher zones and hardwood swamp or marsh in lower zones are hydric hammocks, which also occur on the banks of spring runs such as the Wekiva River.

Mesic hammocks are the most diverse of the upland communities in the East Central Florida region and may contain between 8 and 35 tree species. Overstory species in mesic hammock include southern magnolia (Magnolia grandiflora), laurel oak, red bay (Persea borbonia), pignut (Carya glabra), American holly (Ilex opaca), water oak (Q. nigra), black cherry (Prunus serotina), and live oak (Quercus virginiana). The canopy is so dense that little sunlight reaches the forest floor. Soils are moderately well drained to somewhat poorly drained. Rainfall is the major water source for mesic hammocks, although seepage and runoff may provide water to some stands (Brown, 1980).

Soils in hydric hammocks are generally shallow and sandy, and limestone (either in bedrock or in nodules in the soil) is always present (Vince et al., 1989). Hardpans (weakly cemented Bh horizons) do not occur in hydric hammocks, but clay layers that support surficial water tables occur in some hammocks (Vince et al., 1989).

High water tables are characteristic; hydric hammock soils are saturated most of the year (Brown and Schaefer, 1987). Sources of water to hydric hammocks include groundwater seepage, rainfall, stream overflows, and aquifer discharge (Vince et al., 1989); groundwater seepage from uplands is the major source of water for the hydric hammocks bordering the Wekiva River. The relative contribution of rainfall, overland flow, and aquifer discharge are probably greater in other hydric hammocks elsewhere in the East Central Florida region.

Hydric hammocks have the most diverse flora of any wetland in East Central Florida. Species include popash (Fraxinus caroliniana), live oak (Quercus virginiana), laurel oak (Quercus laurifolia), water oak, Southern magnolia, red bay, sweetbay, tulip poplar (Liriodendron tulipifera), red maple, red cedar (Juniperus silicicola), cabbage palm, slash pine, and blue beech (Carpinus caroliniana) (Brown and Starnes, 1983).

Hardwood swamps are characterized by seasonal flooding of the flowing waters along which they are found. Species composition depends upon the flow rate, water quality, and turbidity of the adjacent waterway. The most common species are red maple (Acer rubrum), water tupelo (Nyssa aquatica), swamp black gum (Nyssa sylvatica var. biflora), sweet gum (Liquidambar styraciflua), bald cypress (Taxodium distichum), pop ash (Fraxinus caroliniana), Florida elm (Ulmus floridana), and cabbage palm (Sabal palmetto) (Brown, 1980). Soils associated with this community are nearly level, very poorly drained, and dark in color. They are either organic or have coarse- to medium-textured surfaces underlain by finer textured material (Brown and Starnes, 1983).

For a description of flatwoods, see Landscape Association 1 above.

Landscape Association 4. Sandhills/isolated or flowing-water wetlands

Relative to the other three landscape classes in the East Central Florida region, the sandhills/wetlands complex has the greatest topographic relief and the greatest degree of soil drainage. We use the term "sandhills" to include both pine sandhill and sand pine scrub communities.

Sandhill soils are well-drained, deep sands. The top of the surficial water table is often 6 feet or more below the soil surface.

Typical plants of pine sandhills are longleaf pine (Pinus palustris), turkey oak (Quercus laevis), and wiregrass (Aristida stricta); sand pine scrub is characterized by sand pine (Pinus clausa), Chapman oak (Quercus chapmanii), myrtle oak (Quercus myrtifolia), dwarf live oak (Quercus minima), and rosemary (Ceratiola ericoides). In sand pine scrubs, the understory is sparse and interspersed with patches of bare sand. The dominant overstory species is sand pine (Pinus clausa) (Brown, 1980).

Wetlands associated with sandhills include both isolated wetlands (see landscape association 1) and, particularly along parts of the Wekiva River, flowing-water wetlands (see landscape association 2).

Landscape Association 5. Pine flatwoods/salt marshes

Salt marshes, which are characterized by grasses, sedges, and rushes, is generally found on the east side of the Atlantic coastal strand and along coastal waterways such as the Indian River.

Salt marsh soils are nearly level and are covered with salt water or brackish water during daily high tides. They are very poorly drained, mucky or sandy clay loams. Salt marsh vegetation is often zoned in accordance with the average salinity and depth of flooding to which the zones are exposed. Black needlerush (Juncus roemerianus) and seashore saltgrass (Distichlis spicata) are tolerant of variable conditions and are found throughout the marsh. Smooth cordgrass (Spartina alterniflora) is found in regularly flooded areas and is often the dominant East Coast salt marsh plant; marshhay cordgrass (Spartina patens), marsh elder (Iva imbricata), saltwort (Batis maritima), and sea oxeye (Borrichia spp.) are typical of higher areas that are less frequently flooded (Soil Conservation Service, 1987).

See landscape association 1 for a description of flatwoods.

Landscape Association 6. Coastal hammocks/salt marshes

Coastal hammocks are found inland of Atlantic beaches and along bays, sounds, and coastal waterways. They are topographically variable but for the most part along the wetland/upland interface they are level to very slightly sloping. Soils are deep and sandy; drainage is generally very poor in lower areas to moderate in higher areas.

Trees and shrubs, which are often stunted from wind, include cabbage palm, sand live oak (Quercus virginiana var. maritima), live oak, marsh elder, saw palmetto, and Spanish bayonet (Yucca aloifolia); in the southerly portion of the region is also found coconut palm (Cocos nucifera), the exotic Australian pine (Casurina equisetifolia), sea grape (Coccoloba uvifera), and coco plum (Chysobalanus icaco). Grasses and herbs include sea purslane (Sesuvium portulacastrum), blanket flower (Gaillardia pulchella), several grasses of the genus Panicum, and wild grape (Vitis spp.) (Soil Conservation Service, 1987).

See landscape association 5 for a description of salt marshes.

Table A-1. Soils typical of ecological associations of the Wekiva River Basin

LANDSCAPE ASSOCIATION COMPONENT Ecological Type Soil Series (Hydrol. Group) *USDA Soil Type* Depth from surface (in)	Permeability (in/hr)	Erosion Factor (tons/acre/ unit rainfall)	High Water Table depth (ft) months
FLATWOODS			
South Florida flatwoods			
Adamsville (C) *Sand*			
0-4	6.0-20	.10	2.0-3.5 Jun-Nov
4-80	6.0-20	.10	
EauGallie (D) *Fine sand*			
0-18	6.0-20	.10	0-1.0 Jun-Oct
18-30	0.6-6.0	.15	
30-45	6.0-20	.10	
45-54	0.06-2.0	.20	
54-80	0.6-6.0	.15	
Immokalee (D) *Fine sand*			
0-4	6.0-20	.10	0-1.0 Jun-Nov
4-42	6.0-20	.10	
42-52	0.6-2.0	.15	
52-80	6.0-20	.10	
Malabar (D) *Fine sand*			
0-18	6.0-20	.10	0-1.0 Jun-Nov
18-30	6.0-20	.10	
30-42	6.0-20	.10	
42-58	<0.2	.24	
58-80	2.0-20	.15	
Myakka (D) *Fine sand*			
0-28	6.0-20	.10	0-1.0 Jun-Nov
28-45	6.0-20	.10	
45-80	0.6-6.0	.15	
Ona (D) *Fine sand*			
0-6	6.0-20	.10	0-1.0 Jun-Nov
6-15	0.6-2.0	.15	
15-80	6.0-20	.10	
Pineda (D) *Fine sand*			
0-37	6.0-20	.10	0-1.0 Jun-Nov
37-80	<0.2	.24	
Pompano (D) *Fine sand*	6.0-20	.10	0-1.0 Jun-Nov
St. Johns (D) *Sand*			
0-12	6.0-20	.10	0-1.0 Jun-Apr
12-24	6.0-20	.10	
24-44	0.2-2.0	.15	
44-80	6.0-20	.10	

Table A-1. **Continued.**

LANDSCAPE ASSOCIATION COMPONENT Ecological Type Soil Series (Hydrol. Group) *USDA Soil Type* Depth from surface (in)	Permeability (in/hr)	Erosion Factor (tons/acre/ unit rainfall)	High Water Table depth (ft) months
Smyrna (D) *Fine sand* continued.			
0-17	6.0-20	.10	0-1.0 Jul-Oct
17-27	0.6-6.0	.15	
27-80	6.0-20	.10	
Wabasso (D) *Sand*			
0-18	6.0-20	.10	0-1.0 Jun-Oct
18-21	0.6-2.0	.15	
21-70	<0.2	.24	
70-80	6.0-20	.10	
ISOLATED WETLANDS			
Cypress swamp			
Basinger, depressional (D) *Fine sand*			
0-6	>20	.10	+2-1.0 Jun-Feb
6-25	>20	.10	
25-35	>20	.10	
35-80	>20	.10	
Chobee (frequently flooded) (D) *Sandy loam*			
0-7	2.0-6.0	.15	0-1.0 Jun-Feb
7-50	<0.2	.32	
50-80	0.2-6.0	.20	
Delray (D) *Loamy fine sand*			
0-12	6.0-20	.10	0-1.0 Jun-Mar
12-50	6.0-20	.10	
50-80	0.6-6.0	.24	
Felda, depressional (D) *Sand*			
0-4	6.0-20	.10	+2-1.0 Jun-Dec
4-28	6.0-20	.10	
28-36	0.6-6.0	.24	
36-80	6.0-20	.17	
Floridana (frequently flooded) (D) *Fine sand*			
0-17	6.0-20	.10	0-1.0 Jun-Feb
17-28	6.0-20	.10	
28-80	<0.2	.24	
Nittaw (frequently flooded) (D) *Muck*			
0-4	6.0-20	-	0-1.0 Jun-Nov
4-9	6.0-20	.10	
9-80	0.06-0.2	.32	

Table A-1. Continued.

LANDSCAPE ASSOCIATION COMPONENT Ecological Type Soil Series (Hydrol. Group) *USDA Soil Type* Depth from surface (in)	Permeability (in/hr)	Erosion Factor (tons/acre/ unit rainfall)	High Water Table depth (ft) months
Samsula (D) *Muck*			
0-26	6.0-20		+2-1.0 Jan-Dec
26-80	6.0-20	.17	
Freshwater Marsh and Ponds			
Basinger, depressional (D) *Fine sand*			
0-6	>20	.10	+2-1.0 Jun-Feb
6-25	>20	.10	
25-35	>20	.10	
35-80	>20	.10	
Brighton (D) *Muck*	6.0-20	.10	+1-1.0 Jan-Dec
Canova (D) *Peat*			
0-10	6.0-20	.10	+2-0 Jan-Dec
10-27	6.0-20	.10	
27-30	0.6-6.0	.28	
30-38	0.6-2.0	.28	
38-80	0.6-6.0	.28	
Chobee (D) *Sandy loam*			
0-7	2.0-6.0	.15	0-1.0 Jun-Feb
7-50	<0.2	.32	
50-80	0.2-6.0	.20	
Delray (D) *Loamy fine sand*			
0-12	6.0-20	.10	0-1.0 Jun-Mar
12-50	6.0-20	.10	
50-80	0.6-6.0	.24	
EauGallie (D) *Fine sand*			
0-18	6.0-20	.10	0-1.0 Jun-Oct
18-30	0.6-6.0	.15	
30-45	6.0-20	.10	
45-54	0.06-2.0	.20	
54-80	0.6-6.0	.15	
Emeralda (D) *Fine sand*			
0-7	6.0-20	.10	0-1.0 Jun-Feb
7-12	6.0-20	.15	
12-41	<0.2	.24	
41-80	<0.2	.24	
Felda, depressional (D) *Sand*			
0-4	6.0-20	.10	+2-1.0 Jun-Dec
4-28	6.0-20	.10	
28-36	0.6-6.0	.24	
36-80	6.0-20	.17	

Table A-1. Continued.

LANDSCAPE ASSOCIATION COMPONENT
Ecological Type

Soil Series (Hydrol. Group) *USDA Soil Type* Depth from surface (in)	Permeability (in/hr)	Erosion Factor (tons/acre/ unit rainfall)	High Water Table depth (ft) months
Floridana (D) *Fine sand*			
0-17	6.0-20	.10	0-1.0 Jun-Feb
17-28	6.0-20	.10	
28-80	<0.2	.24	
Gator (D) *Muck*			
0-28	6.0-20	-	+2-1.0 Jun-Dec
28-80	2.0-6.0	.17	
Holopaw (D) *Fine sand*			
0-50	6.0-20	.10	0-1.0 Jun-Feb
50-80	0.6-2.0	.24	
Hontoon (D) *Muck*	6.0-20	-	+2-1.0 Jan-Dec
Immokalee (D) *Fine sand*			
0-4	6.0-20	.10	0-1.0 Jun-Nov
4-42	6.0-20	.10	
42-52	0.6-2.0	.15	
52-80	6.0-20	.10	
Malabar (D) *Fine sand*			
0-18	6.0-20	.10	0-1.0 Jun-Nov
18-30	6.0-20	.10	
30-42	6.0-20	.10	
42-58	<0.2	.24	
58-80	2.0-20	.15	
Manatee (D) *Loamy fine sand*			
0-10	2.0-6.0	.10	0-1.0 Jun-Feb
10-52	0.6-2.0	.24	
52-80	0.6-2.0	.24	
Myakka (D) *Fine sand*			
0-28	6.0-20	.10	0-1.0 Jun-Nov
28-45	6.0-20	.10	
45-80	0.6-6.0	.15	
Nittaw (D) *Muck*			
0-4	6.0-20	-	0-1.0 Jun-Nov
4-9	6.0-20	.10	
9-80	0.06-0.2	.32	
Okeelanta (D) *Muck*			
0-25	6.0-20	-	+1-0 Jun-Jan
25-80	6.0-20	.15	
Pineda (D) *Fine sand*			
0-37	6.0-20	.10	0-1.0 Jun-Nov
37-80	<0.2	.24	

Table A-1. Continued.

LANDSCAPE ASSOCIATION COMPONENT Ecological Type Soil Series (Hydrol. Group) *USDA Soil Type* Depth from surface (in)	Permeability (in/hr)	Erosion Factor (tons/acre/ unit rainfall)	High Water Table depth (ft) months
Pompano (D) *Fine sand*	6.0-20	.10	0-1.0 Jun -Nov
St. Johns (D) *Sand*			
0-12	6.0-20	.10	0-1.0 Jun-Apr
12-24	6.0-20	.10	
24-44	0.2-2.0	.15	
44-80	6.0-20	.10	
Samsula (D) *Muck*			
0-26	6.0-20	-	+2-1.0 Jan-Dec
26-80	6.0-20	.17	
Sanibel (D) *Muck*			
0-14	6.0-20	.10	+1-1.0 Jun-Feb
14-80	6.0-20	.10	
Terra Ceia (D) *Muck*	6.0-20	-	+1-1.0 Jan-Dec
Wabasso (D) *Sand*			
0-18	6.0-20	.10	0-1.0 Jun-Oct
18-21	0.6-2.0	.15	
21-70	<0.2	.24	
70-80	6.0-20	.10	
Wauberg (D) *Fine sand*			
0-8	>6.0	.15	0-1.0 Jun-Dec
8-28	>6.0	.15	
28-60	<0.2	.28	
60-80	<0.2	.24	
FLOWING WATER WETLANDS (see also Cypress swamps, above)			
Swamp hardwoods			
Basinger, depressional (D) *Fine sand*			
0-6	>20	.10	+2-1.0 Jun-Feb
6-25	>20	.10	
25-35	>20	.10	
35-80	>20	.10	
Chobee (D) *Sandy loam*			
0-7	2.0-6.0	.15	0-1.0 Jun-Feb
7-50	<0.2	.32	
50-80	0.2-6.0	.20	
Emeralda (D) *Fine sand*			
0-7	6.0-20	.10	0-1.0 Jun-Feb
7-12	6.0-20	.15	
12-41	<0.2	.24	
41-80	<0.2	.24	

Table A-1. Continued.

<u>LANDSCAPE ASSOCIATION COMPONENT</u> <u>Ecological Type</u> Soil Series (Hydrol. Group) *USDA Soil Type* Depth from surface (in)	Permeability (in/hr)	Erosion Factor (tons/acre/ unit rainfall)	High Water Table depth (ft) months
Floridana (D) *Fine sand*			
0-17	6.0-20	.10	0-1.0 Jun-Feb
17-28	6.0-20	.10	
28-80	<0.2	.24	
Gator (D) *Muck*			
0-28	6.0-20	-	+2-1.0 Jun-Dec
28-80	2.0-6.0	.17	
Hontoon (D) *Muck*	6.0-20	-	+2-1.0 Jan-Dec
Manatee (D) *Loamy fine sand*			
0-10	2.0-6.0	.10	0-1.0 Jun-Feb
10-52	0.6-2.0	.24	
52-80	0.6-2.0	.24	
Nittaw (D) *Muck*			
0-4	6.0-20	-	0-1.0 Jun-Nov
4-9	6.0-20	.10	
9-80	0.06-0.2	.32	
Okeelanta (D) *Muck*			
0-25	6.0-20	-	+1-0 Jun-Jan
25-80	6.0-20	.15	
Pompano (D) *Fine sand*	6.0-20	.10	0-1.0 Jun-Nov
Samsula (D) *Muck*			
0-26	6.0-20	-	+2-1.0 Jan-Dec
26-80	6.0-20	.17	
Terra Ceia (D) *Muck*	6.0-20	-	+1-1.0 Jan-Dec
<u>Slough</u>			
Basinger (D) *Fine sand*			
0-6	>20	.10	+2-1.0 Jun-Feb
6-25	>20	.10	
25-35	>20	.10	
35-80	>20	.10	
Felda (D) *Sand*			
0-4	6.0-20	.10	+2-1.0 Jun-Dec
4-28	6.0-20	.10	
28-36	0.6-6.0	.24	
36-80	6.0-20	.17	
Holopaw (D) *Fine sand*			
0-50	6.0-20	.10	0-1.0 Jun-Feb
50-80	0.6-2.0	.24	

Table A-1. **Continued.**

LANDSCAPE ASSOCIATION COMPONENT Ecological Type Soil Series (Hydrol. Group) *USDA Soil Type* Depth from surface (in)	Permeability (in/hr)	Erosion Factor (tons/acre/ unit rainfall)	High Water Table depth (ft) months
Malabar (D) *Fine sand*			
0-18	6.0-20	.10	0-1.0 Jun-Nov
18-30	6.0-20	.10	
30-42	6.0-20	.10	
42-58	<0.2	.24	
58-80	2.0-20	.15	
Pineda (D) *Fine sand*			
0-37	6.0-20	.10	0-1.0 Jun-Nov
37-80	<0.2	.24	
Wabasso (D) *Sand*			
0-18	6.0-20	.10	0-1.0 Jun-Oct
18-21	0.6-2.0	.15	
21-70	<0.2	.24	
70-80	6.0-20	.10	
Cabbage palm flatwoods			
Pinellas (D) *Fine sand*			
0-18	6.0-20	.10	0-1.0 Jun-Nov
18-34	6.0-20	.17	
34-46	0.6-2.0	.24	
46-80	6.0-20	.10	
MESIC HAMMOCK/HYDRIC HAMMOCK/HARDWOOD SWAMP (see also Swamp hardwoods, above)			
Wetland Hardwood Hammocks			
Felda (occasionally flooded) (D) *Sand*			
0-22	6.0-20	.10	0-1.0 Jul-Mar
22-42	0.6-6.0	.24	
42-80	6.0-20	.10	
Holopaw (D) *Fine sand*			
0-50	6.0-20	.10	0-1.0 Jun-Feb
50-80	0.6-2.0	.24	
Pompano (D) *Fine sand*	6.0-20	.10	0-1.0 Jun-Nov
Wabasso (D) *Sand*			
0-18	6.0-20	.10	0-1.0 Jun-Oct
18-21	0.6-2.0	.15	
21-70	<0.2	.24	
70-80	6.0-20	.10	

Table A-1. Continued.

LANDSCAPE ASSOCIATION COMPONENT Ecological Type Soil Series (Hydrol. Group) *USDA Soil Type* Depth from surface (in)	Permeability (in/hr)	Erosion Factor (tons/acre/ unit rainfall)	High Water Table depth (ft) months
Oak hammock			
Adamsville (C) *Sand*			
0-4	6.0-20	.10	2.0-3.5 Jun-Nov
4-80	6.0-20	.10	
Tavares (A) *Fine sand*			
0-6	>6.0	.10	3.5-6.0 Jun-Dec
6-80	>6.0	.10	
SANDHILL			
Sand Pine Scrub			
Archbold (A) *Fine sand*	>20	.10	3.5-6.0 Jun-Nov
Astatula (A) *Fine sand*			
0-3	>20	.10	>6.0
3-80	>20	.10	
Pomello (C) *Fine sand*			
0-40 in.	>20	.10	2.0-3.5 Jul-Nov
40-55 in.	2.0-6.0		
55-80 in.	6.0-20		
St. Lucie (A) *Fine sand*	>20	.10	>6.0
Longleaf pine/turkey oak hills			
Apopka (A) *Fine sand*			
0-65	6.0-20	.10	>6.0
65-80	0.6-2.0	.24	
Astatula (A) *Fine sand*			
0-3	>20	.10	>6.0
3-80	>20	.10	
Candler (A) *Sand*			
3-5	6.0-20	.10	>6.0
5-74	6.0-20	.10	
74-80	6.0-20	.10	
Lake (A) *Fine sand*	>6.0	.10	>6.0
Orlando (A) *Fine sand*			
0-19	6.0-20	.10	4.0-6.0 Jun-Dec
19-80	6.0-20	.10	
Tavares (A) *Fine sand*			
0-6	>6.0	.10	3.5-6.0 Jun-Dec
6-80	>6.0	.10	

Table A-1. Continued.

LANDSCAPE ASSOCIATION COMPONENT Ecological Type Soil Series (Hydrol. Group) *USDA Soil Type* Depth from surface (in)	Permeability (in/hr)	Erosion Factor (tons/acre/ unit rainfall)	High Water Table depth (ft) months
SALT MARSH			
Turnbull (D) *Muck*			
14-0	6.0-20	-	+2-1.0
0-36	<0.06	-	Tidally flooded
36-80	6.0-20	-	year-round
Turnbull variant (C) *Sand*			
0-50	6.0-20	.17	1.0-3.0
50-55	0.6-2.0	.17	Tidally flooded
55-60	0.06-0.2	.32	year-round
COASTAL HAMMOCK			
Astatula (A) *Fine sand*			
0-3	>20	.10	>6.0
3-80	>20	.10	
Canaveral (C) *Sand*			
0-9	>20	.15	1.0-3.0 Jun-Nov
9-80	>20	.15	
Daytona (B) *Sand*			
0-36	>20	.17	3.5-5.0 Jul-Nov
36-47	2.0-6.0	.20	
47-80	>20	.17	
Palm Beach (A) *Sand*			
0-80	>20	.15	>6.0
Paola (A) *Fine sand*			
0-30	>20	.15	>6.0
30-80	>20	.15	

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Soil Conservation Service. 1987. 26 Ecological Communities of Florida (revised). Florida Chpater, Soil and Water Conservation Society of America, Gainesville, Florida. Four landscape associations, which share some of the same soil series as mapped by the U.S. Soil Conservation Service.

APPENDIX B:

Wetlands Buffer Determination for Water Quantity Conservation

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Appendix B: Wetlands Buffer Determination for Water Quantity Conservation

The depth to the groundwater table immediately upland of the wetland line is an important indicator of groundwater interaction with nearby wetlands. When the water table is near the ground surface in the upland region and slopes toward the wetland, the wetland area is fed by discharging groundwaters. Excavations such as drainage canals in these uplands may intercept groundwater flows and have the potential to decrease the quantity of groundwater reaching the downslope wetland (Wang and Overman, 1981). If the wetland is perched above the main zone of saturation, it can serve to recharge the aquifer. Drainage canals in the uplands surrounding these wetlands may cause the wetland to drain in the direction of the excavation. Where either of these conditions is present, a buffer zone may be warranted to ensure that proposed drainage canals do not significantly diminish the quantity of water entering the wetland.

Figure 1 illustrates the impact of a drainage canal on the surficial aquifer near a wetland. The construction of drainage canals lowers the water table throughout the wetland/upland region, thereby diverting recharge waters away from the wetland. The magnitude of the dewatering impact is related to the drawdown in the drainage canal, the distance between the canal and the wetland, the average hydraulic conductivity of the surficial aquifer, the average depth of the surficial aquifer, and the prior water table geometry. The steady-state drawdown effects of a proposed drainage canal can be estimated analytically if the surficial aquifer is modeled as a homogeneous one-dimensional system. The ordinary differential equation governing this simplified system can be written (Bear, 1972):

$$\frac{\partial}{\partial x} Kh \frac{\partial h}{\partial x} = 0 \tag{1.1}$$

$$h = h_o \text{ at } x = 0 \tag{1.2}$$

$$h = h_{Lc} \text{ at } x = L_c \tag{1.3}$$

where

K = average saturated hydraulic conductivity of the aquifer,

h = hydraulic head (height of the water table above the impervious bottom layer),

h_o = height of the water table at the center of the wetland ($x = 0$),

h_{Lc} = height of the water table at the proposed canal location before development ($x = L_c$),

L_c = distance between the center of the wetland system and the center of the canal, and

x = horizontal distance measured from the center of the wetland system

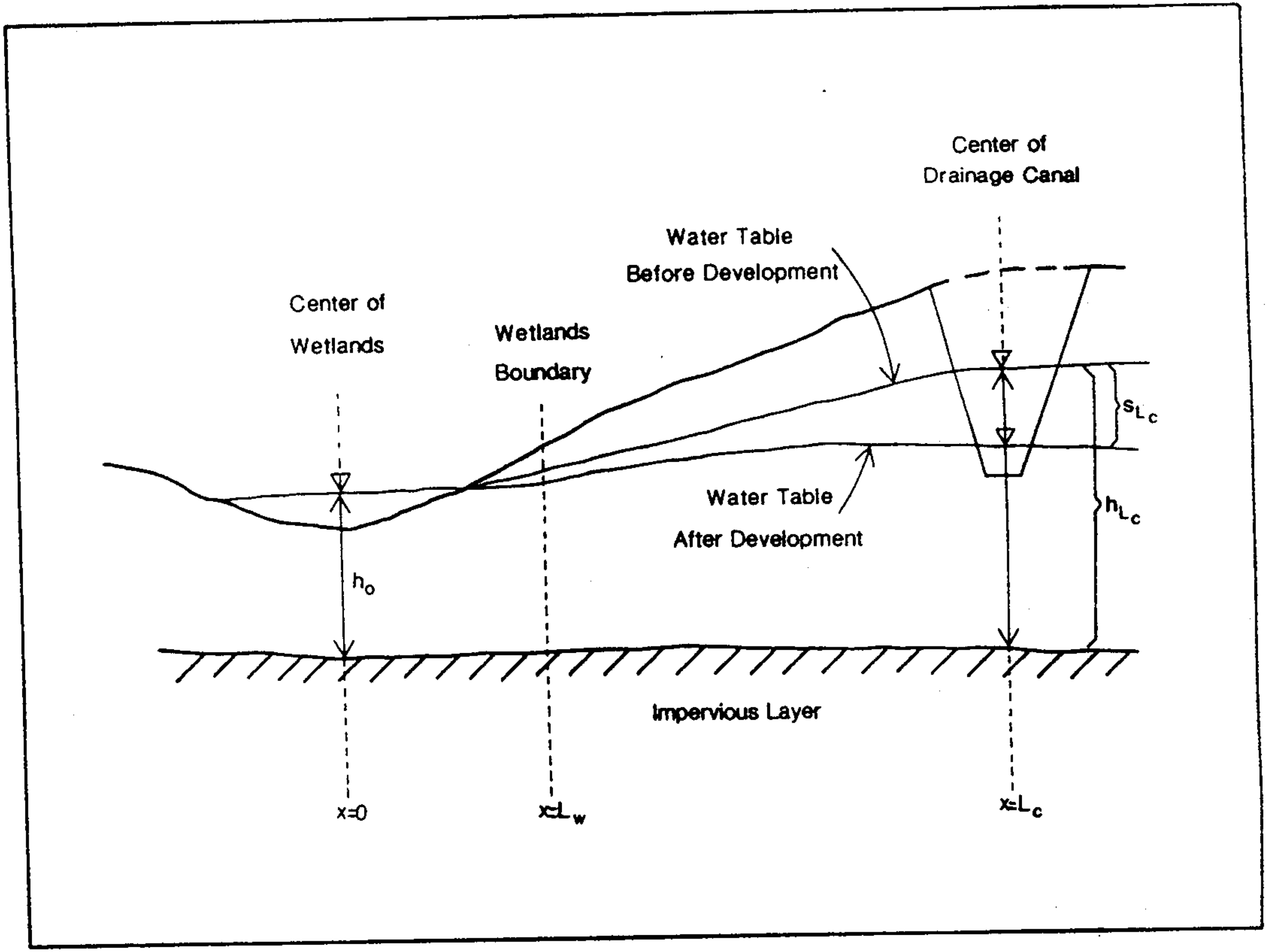

Figure B-1. The impact of a drainage canal on the surficial aquifer near a wetland.

The solution to equation (1.1) gives the water table height at any distance (x) from the center of the wetland system $[h_b(x)]$. The solution also gives the subsurface recharge to (or discharge from) the wetland (Q_b). Solution techniques for this type of equation may be found in any elementary ordinary differential equations textbook (e.g., Ross, 1974). The solution to equation 1 may be written:

$$[h_b(x)]^2 = \frac{h_{Lc}^2 - h_o^2}{L_c} x + h_o^2 \tag{2.1}$$

$$Q_b = - \frac{K}{2} \frac{h_{Lc}^2 - h_o^2}{L_c} \tag{2.2}$$

where the subscript "b" indicates the condition before development.

After canal development the boundary conditions on the governing system of equations change to the following:

$$\frac{\partial}{\partial x} Kh \frac{\partial h}{\partial x} = 0 \tag{3.1}$$

$$h = h_o \text{ at } x = 0 \tag{3.2}$$

$$h = h_{Lc} - s_{Lc} \text{ at } x = L_c \tag{3.3}$$

where

s_{Lc} = water table drawdown at the drainage canal.

The water table height (h_a) and subsurface recharge after canal development (Q_a) can be expressed:

$$[h_a(x)]^2 = \frac{(h_{Lc} - s_{Lc})^2 - h_o^2}{L_c} x + h_o^2 \tag{4.1}$$

$$Q_a = - \frac{K}{2} \frac{(h_{Lc} - s_{Lc})^2 - h_o^2}{L_c} \tag{4.2}$$

where the subscript "a" indicates the condition after development.

The drawdown between the canal and the wetland due to development can thus be written:

$$s(x) = h_b(x) - h_a(x)$$

$$= \frac{h_{Lc}^2 - h_o^2}{L_c} x + h_o^2 \quad ^{1/2} \quad - \quad \frac{(h_{Lc} - s_{Lc})^2 - h_o^2}{L_c} x + h_o^2 \quad ^{1/2} \tag{5}$$

The percent flow lost from the wetland may also be calculated:

$$\% \, Q_{loss} = 1 - \frac{Q_a}{Q_b} * 100 = 1 - \frac{(h_{Lc} - s_{Lc})^2 - h_o^2}{h_{Lc}^2 - h_o^2} * 100 \tag{6}$$

Use of equations 1 through 6 implies the following assumptions:

1. The system can be described as a homogeneous steady-state phreatic aquifer.
2. The Dupuit approximation applies. This assumes that the slope of the phreatic surface is small and therefore the groundwater flow is approximately horizontal.
3. A continuous horizontal impervious layer exists beneath the wetland/upland system.
4. The wetland and drainage canal are parallel and of infinite extent.
5. There is no significant recharge to the aquifer between the drainage canal and the wetland system.
6. The height of the water table at the center of the wetland remains constant after development (i.e., drainage water is diverted back to the head of the wetland).

Given these assumptions, equations 5 and 6 may be used to estimate the drawdown at the wetland boundary and the flow lost from the wetland due to a proposed canal located at a known distance ($x = L_c$). However, since these equations depend on the prior head elevation at the proposed canal location [$h_{Lc}(L_c)$], a simple expression cannot be written to calculate directly the required buffer distance (L_c) which achieves the desired wetlands boundary drawdown $s(L_w)$. Therefore, to determine an appropriate buffer distance, the drawdown at the wetland boundary must be calculated for a series of proposed buffer distances. Then a graph can be constructed of drawdown versus buffer distance, and the buffer distance that achieves the desired drawdown can be selected. Example 1 illustrates this procedure.

<u>Example 1</u>. Assume that the following hydrogeologic conditions exist:

Height of water table above impermeable layer at wetland center (h_o)	10.0 ft
Distance from wetland center to wetland boundary (L_w)	50.0 ft
Prior head elevation at the wetland boundary ($h_b(_{Lw})$)	10.4 ft
Proposed drawdown at drainage canal [$s_{(Lc)}(L_c)$]	3.0 ft
Average saturated hydraulic conductivity (K)	1.0 ft/day

Further assume that the prior head elevation above the impermeable layer has been measured at the following proposed canal locations:

x	$h_b(x)$
200 ft	11.5 ft
400 ft	12.8 ft
600 ft	13.9 ft
800 ft	15.0 ft
1000 ft	16.0 ft

For a design drawdown at the drainage canal (S_{Lc}) of 3 ft, the resulting drawdown at the wetland boundary and the percent flow loss from the wetland for this series of proposed canal locations are:

L_c	$h_b(L_w)$	$h_a(L_w)$	$s(L_w)$	Q_b^*	Q_a^*	$\%Q_{loss}$
(ft)	(ft)		(ft)	(ft)	(ft^2/day)	(ft^2/day)
200	10.4	9.65	0.75	-0.08	0.07	187.5
400	10.4	9.98	0.42	-0.08	0.005	106.3
600	10.4	10.08	0.32	-0.08	0.016	80.0
800	10.4	10.14	0.25	-0.08	-0.028	65.0
1000	10.4	10.17	0.23	-0.08	-0.035	56.3

*Negative flows indicate flow toward the wetland from the upland. Positive flows indicate flow away from the wetland toward the upland.

Figure 2 shows a graph of drawdown at the wetlands boundary versus buffer distance for the sample problem. This curve indicates that a buffer distance of approximately 350 feet is required to limit the drawdown at the wetlands boundary to .5 feet. Figure 3 shows the percent flow lost from the wetland versus buffer distance for the sample problem. This graph indicates that canals located within approximately 400 feet of the wetland center will induce flows from the wetland to the canal. Canals located farther than 400 feet from the wetland will reduce recharge to the wetland but will not reverse the natural flow direction.

Tradeoff curves like those shown in Figures 2 and 3 could provide planners with information on the relative benefits of alternative buffer distances and, therefore, should be a valuable aid in the process of determining buffer widths. To determine buffer width guidelines for a particular wetlands landscape classification, a series of such curves could be constructed using data that typify each system. When calculating the buffer distance needed for a specific site, however, it is highly recommended that wetland boundaries, hydraulic conductivity, water table elevation, and depth to impermeable layer be measured at the site.

Obviously, a real-world wetland system will not be perfectly described by the assumptions listed above. The steady-state assumption implies that the transient (or seasonal) drawdown effects of ditching are not as great a concern as the magnitude of the maximum drawdown. Therefore, average high water table conditions should be used in the analysis to ensure minimal wet-season effects. An approximate continuous impervious layer should exist between the wetland/upland system for this method to be applicable. The assumption that the wetland and the upland are hydrologically connected in this relatively simple manner considerably reduces the model's complexity and the data input requirements.

The assumption that the drainage canal and the wetland are parallel and of infinite extent is necessary to maintain the one-dimensional nature of the model. In essence, this assumption presumes that the water table equipotentials parallel the wetland boundary and that all drawdown effects are produced by activities directly up-gradient of the wetland edge. Perhaps the most limiting assumption of the analysis is that the height of the water table at the center of the wetland remains constant after development. For this to hold, the total quantity of water entering the wetland must remain relatively constant. If the wetland is fed primarily by upland groundwater, the drainage water collected from upland canals must be diverted back to the head of the wetland for this assumption to hold. If the water table at the center of the wetland is lowered after development, this model will underpredict the drainage effect.

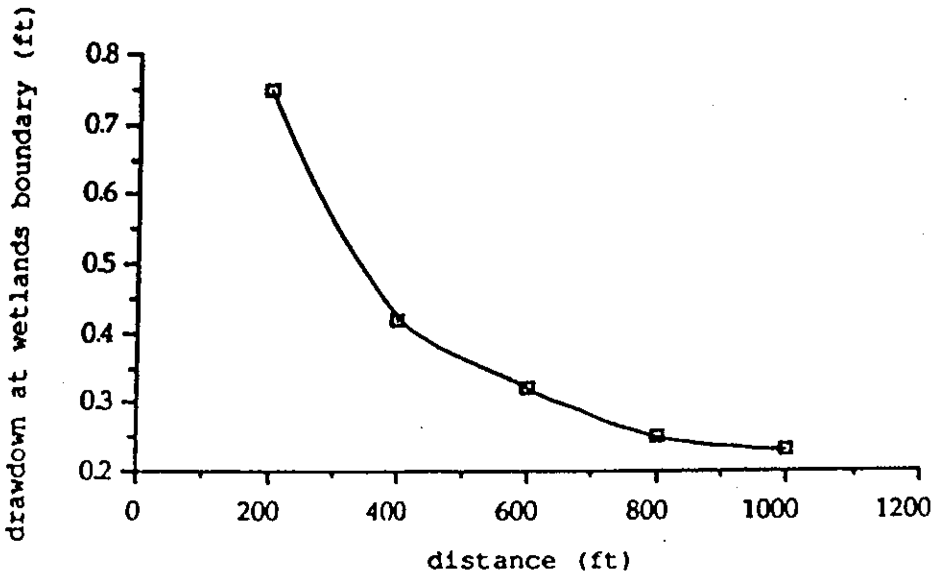

Figure 2: Drawdown at Welands Boundary versus Buffer Distance

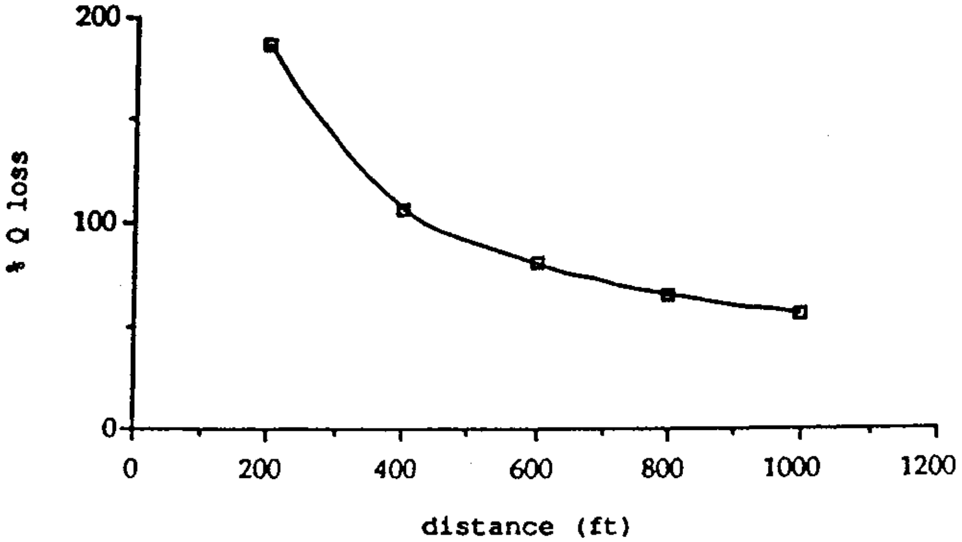

Figure 3: Percent Flow Loss versus Buffer Distance

The extent to which these assumptions are satisfied indicates the reliability of predictions based on such a simplified model. If field conditions indicate that many of the above assumptions are not applicable to a particular wetland, a more detailed multi-dimensional numerical groundwater flow model may be required to predict accurately the drawdown effects of ditching.

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APPENDIX C:

Semi-aquatic and wetland-dependent wildlife species that occur in East Central Florida organized by taxonomic classes.

Reference lists of the main sources used to determine species' requirements follow each table.

References for Table C-1: Amphibians

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Table C-1. Semi-aquatic and wetland dependent wildlife species of East Central Florida: **AMPHIBIANS**

Species	Scientific Name	References
Toad Family		
A 1. Oak toad	(*Bufo quercicus*)	Wright, 1949
A 2. Southern toad	(*Bufo terrestris*)	Wright, 1949
Treefrog Family		
A 3. Southern cricket frog	(*Acris gryllus*)	Burt, 1938; Wright, 1949; Mecham, 1964
A 4. Green treefrog	(*Hyla cineria*)	Burt, 1938; Garton and Brandon, 1975
A 5. Spring peeper	(*Hyla crucifer*)	Delzell, 1958
A 6. Pinewoods treefrog	(*Hyla femoralis*)	Martof et al., 1980
A 7. Barking treefrog	(*Hyla gratiosa*)	Martof et al., 1980
A 8. Squirrel treefrog	(*Hyla squirella*)	Goin and Goin, 1957
A 9. Little grass frog	(*Limnaoedus ocularis*)	Ashton and Ashton, 1988
A10. Ornate chorus frog	(*Pseudacris ornata*)	Martof et al., 1980
Narrowmouth Toad Family		
A11. Eastern narrowmouth toad	(*Gastrophryne carolinensis*)	Ashton and Ashton, 1988
Spadefoot Toad Family		
A12. Eastern spadefoot toad	(*Saphiopus holbrookii holbrookii*)	Green and Pauley, 1987; Moler, 1988
True Frogs		
A13. Gopher frog+	(*Rana areolata*)	Wright, 1949
A14. Bullfrog	(*Rana catesbeiana*)	Bury and Wheland, 1984
A15. Pig frog	(*Rana grylio*)	Burt, 1938; Martof et al., 1980; Lamb, 1986
A16. River frog	(*Rana heckscheri*)	Martof et al., 1980
A17. Southern leopard frog	(*Rana utricularia*)	McCoy, 1978
Lungless Salamander Family		
A18. Southern dusky salamander	(*Desmognathus auriculatus*)	Mohr, 1935
A19. Dwarf salamander	(*Eurycea quadridigitata*)	Martof et al., 1980
Newt Family		
A20. Striped newt	(*Notophthalmus perstriatus*)	Carr and Goin, 1955

+ Endangered, threatened, or special concern species

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Table C-2. Semi-aquatic and wetland dependent wildlife species of East Central Florida: **REPTILES**

Species	Scientific Name	References
Alligator Family		
R 1. American alligator+	(Alligator mississipiensis)	Joanen and McNease, 1970, 1972; Metzen, 1977
Snapping Turtle Family		
R 2. Common snapping turtle	(Chelydra serpentina)	Loncke and Obbard, 1977; Obbard and Brooks, 1980, 1981; Graves and Anderson, 1987
Box and Water Turtle Family		
R 3. Chicken turtle	(Deirochelys reticularia)	Ernst and Barbour, 1972
R 4. Diamondback terrapine	(Malaclemys terrapine)	Ashton and Ashton, 1985
R 5. Florida cooter	(Pseudemys floridana)	Martof et al., 1980
R 6. Florida redbelly turtle	(Pseudemys nelsoni)	Martof et al., 1980
R 7. Florida box turtle	(Terrapene carolina bauri)	Ashton and Ashton, 1985
R 8. Slider turtle	(Trachemys scripta)	Cagle, 1950; Moll and Legler, 1971; Morreale and Gibbons, 1986
Mud and Musk Turtle Family		
R 9. Striped mud turtle	(Kinosternon baurii)	Ernst and Barbour, 1972; Ernst et al., 1972
R10. Florida mud turtle	(Kinosternon subrubrum steindachneri)	Ernst and Barbour, 1972
R11. Stinkpot turtle	(Sternotherus ordoratus)	Ernst and Barbour, 1972
Softshell Turtle Family		
R12. Florida softshell turtle	(Apalone ferox)	Ernst and Barbour, 1972
Iguanidae Family		
R13. Green anole	(Anolis carolinensis)	Burt, 1939
Skink Family		
R14. Broadhead skink	(Eumeces laticeps)	Ashton and Ashton, 1985
Colubrid Family		
R15. Florida scarlet snake	(Cemophora coccinea coccinea)	Palmer, 1970
R16. Southern black racer	(Coluber constrictor priapus)	Ashton and Ashton, 1985
R17. Southern ringneck snake	(Diadophis punctatus punctatus)	Ashton and Ashton, 1985
R18. Yellow rat snake	(Elaphe obsoleta quadrivittata)	Ashton and Ashton, 1985
R19. Eastern Indigo snake+	(Drymarchon corais couperi)	Allen and Neill, 1952; Lawler, 1976; Moler, 1985
R20. Eastern mud snake	(Farancia abacura abacura)	Mount, 1975; Trutnau, 1979
R21. Rainbow snake	(Farancia crytrogramma)	Mount, 1975; Martof et al., 1980

Table C-2. Continued.

Species	Scientific Name	References
R22. Eastern hognose snake	(Heterodon platyrhinos)	Platt, 1969; Moler, 1988
R23. Eastern kingsnake	(Lampropeltis getulus getulus)	Ashton and Ashton, 1985
R24. Scarlet kingsnake	(Lampropeltis triangulum elapsoides)	Macartney et al., 1988
R25. Atlantic salt marsh snake+	(Nerodia fasciata taeniata)	Ashton and Ashton, 1985
R26. Green water snake	(Nerodia cyclopion)	Trutnau, 1979; Macartney et al., 1988
R27. Florida banded water snake	(Nerodia fasciata pictiventris)	Trutnau, 1979
R28. Brown water snake	(Nerodia taxispilota)	Trutnau, 1979
R29. Rough green snake	(Opheodrys aestivus)	Macartney et al., 1988
R30. Striped crayfish snake	(Regina alleni)	Godley, 1980
R31. Glossy crayfish snake	(Regina rigida)	Ashton and Ashton, 1985
R32. North Florida swamp snake	(Seminatrix pygaea pygaea)	Dowling, 1950
R33. Florida brown snake+	(Storeria dekayi victa)	Macartney et al., 1988
R34. Redbelly snake	(Storeria occipitomaculata)	Ashton and Ashton, 1985
R35. Peninsula ribbon snake	(Thamnophis sauritus sackenii)	Macartney et al., 1988
R36. Eastern garter snake	(Thamnophis sirtalis sirtalis)	Macartney et al., 1988
Viper Family		
R37. Cottonmouth	(Agkistrodon piscivorus)	Allen and Neill, 1950; Mount, 1975; Macartney et al., 1988
R38. Timber rattlesnake	(Crotalus horridus)	Ashton and Ashton, 1985
R39. Dusky pigmy rattlesnake	(Sistrurus miliarius barbouri)	Ashton and Ashton, 1985

+ Endangered, threatened, or special concern species

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Table C-3. Semi-aquatic and wetland dependent wildlife species of East Central Florida: **BIRDS**

Species	Scientific Name	References
Grebe Family		
B 1. Pied-billed grebe*	(Podilymbus podiceps)	Pough, 1951
Pelican Family		
B 2. Brown pelican*+	(Pelecanus occidentalis)	Harrison, 1975
Cormorant Family		
B 3. Double-crested cormorant	(Phalacrocorax auritus)	Siegel-Causey and Hunt, Jr., 1986
Anhinga Family		
B 4. Anhinga*	(Anhinga anhinga)	Allen, 1961; Hamel et al., 1982
Waterfowl Family		
B 5. Wood duck*	(Aix sponsa)	Johnsgard, 1975
B 6. American widgeon	(Anas americana)	Girard, 1941; Keith, 1961; Johnsgard, 1975; Potter et al., 1980
B 7. Northern shoveler	(Anas clypeata)	Palmer, 1976
B 8. Green-winged teal	(Anas carolinensis)	Palmer, 1976
B 9. Blue-winged teal*	(Anas discors)	Bennett, 1938
B10. Mottled duck*	(Anas fulvigula)	Johnsgard, 1975
B11. Mallard*	(Anas platyrhynchos)	Mulhern et al., 1985
B12. Ring-necked duck	(Anthya collaris)	Mendall, 1958
B13. Hooded merganser*	(Lophodytes cucullatus)	Hamel et al., 1982
Kite, Hawk and Eagle Family		
B14. Short-tailed hawk*	(Buteo brachyurus)	Hamel et al., 1982
B15. Red-shouldered hawk*	(Buteo lineatus)	Portnoy and Dodge, 1979; Hamel et al., 1982
B16. Northern harrier*	(Circus cyaneus)	Hamel et al., 1982
B17. Swallow-tailed kite*	(Elanoides forficatus)	Hamel et al., 1982
B18. Bald eagle*+	(Haliaeetus leucocephalus)	U.S. Fish and Wildlife Service, 1984; Jaffee, 1980; Anthony and Isascs, 1981; Peterson, 1986
B19. Snail kite*+	(Rostrhamus sociabilis)	Hamel et al., 1982
Osprey Family		
B20. Osprey*	(Pandion haliaetus)	Austin-Smith and Rhodenize, 1983

Table C-3. Continued.

Species	Scientific Name	References
Falcon Family		
B21. Peregrine falcon+	(Falco peregrinus)	Bent, 1961; Kale, 1978
Turkey Family		
B22. Wild turkey*	(Meleagris gallopavo)	Hamel et al., 1982
Heron and Bittern Family		
B23. Great blue heron*	(Ardea herodias)	Hancock and Kushlan, 1984
B24. American bittern*	(Botaurus lentiginosus)	Hamel et al., 1982
B25. Cattle egret*	(Bubulcus ibis)	Maxwell and Kale, 1977
B26. Green-backed heron*	(Butorides striatus)	Hancock and Kushlan, 1984
B27. Great egret*	(Casmerodius albus)	Graber et al., 1978; AOU Checklist, 1983
B28. Little blue heron*+	(Egretta caerulea)	Hancock and Kushlan, 1984
B29. Snowy egret*+	(Egretta thula)	Maxwell and Kale, 1977, Hancock and Kushlan, 1984
B30. Tricolored heron*+	(Egretta tricolor)	Maxwell and Kale, 1977; Hancock and Kushlan, 1984 "
B31. Least bittern*	(Ixobrychus exilis)	Hamel et al., 1982
B32. Black-crowned night heron*	(Nycticorax nycticorax)	Beaver, 1980
B33. Yellow-crowned night heron*	(Nycticorax violacea)	Palmer, 1976
Wood Ibis Family		
B34. Wood stork*+	(Mycteria americana)	Kale, 1978
Ibis and Spoonbill Family		
B35. White ibis*	(Eudocimus albus)	Kushlan, 1976; Hamel et al., 1982
Crane Family		
B36. Sandhill crane*+	(Grus canadensis)	Ambruster, 1987
Limpkin Family		
B37. Limpkin*+	(Aramus guarauna)	Hamel et al., 1982

Table C-3. Continued.

Species	Scientific Name	References
Rail, Gallinule, and Coot Family		
B38. American coot*	(Fulica americana)	Hamel et al., 1982
B39. Common moorhen*	(Gallinula chloropus)	Hamel et al., 1982
B40. Black rail*	(Laterallus jamaicensis)	Hamel et al., 1982
B41. Purple gallinule*	(Porphyrula martinica)	Meanley, 1963
B42. Clapper rail*	(Rallus longirostris)	Lewis and Garrison, 1983
B43. King rail*	(Rallus elegans)	Meanley and Wetherbee, 1962
Oystercatcher Family		
B44. American oystercatcher*+	(Haematopus palliatus)	Levings et al., 1986
Stilt Family		
B45. Black-necked stilt*	(Himantopus mexicanus)	Potter et al., 1980
Plover Family		
B46. Killdeer*	(Charadrius vociferus)	Harrison, 1975
B47. Wilson's plover*	(Charadrius wilsonia)	Harrison, 1975
Sandpiper Family		
B48. Spotted sandpiper	(Actitis macularia)	Potter et al., 1980
B49. Sanderling	(Calidris alba)	Hall, 1960; Parmelee, 1970
B50. Western sandpiper	(Calidris mauri)	Potter et al., 1980
B51. Least sandpiper	(Calidris minutilla)	Potter et al., 1980
B52. Willet*	(Catoptrophorus semipalmatus)	Ryan and Renken, 1987
B53. Dunlin	(Erolia alpina)	Potter et al., 1980
B54. Short-billed dowitcher	(Limnodromus griseus)	Hall, 1960
B55. Long-billed dowitcher	(Limnodromus scolopaceus)	Potter et al., 1980
B56. Lesser yellowlegs	(Tringa flavipes)	Hall, 1960; McElroy, 1974
B57. Greater yellowlegs	(Tringa melanoleuca)	Hall, 1960; McElroy, 1974
Woodcock and Snipe Family		
B58. Common snipe	(Gallinago gallinago)	Potter et al., 1980
B59. American woodcock	(Scolopax minor)	Sheldon, 1967
Gull and Tern Family		
B60. Laughing gull*	(Larus atricilla)	Burger and Shisler, 1980
B61. Ring-billed gull	(Larus delawarensis)	Collins, 1959
B62. Least tern*+	(Sterna antillarum)	McElroy, 1974
B63. Fosters tern	(Sterna forsteri)	Collins, 1959
B64. Gull-billed tern	(Sterna nilotica)	Collins, 1959; Potter et al., 1980
B65. Royal tern*	(Thalasseus maximus)	Buckley and Buckley, 1977

Table C-3. Continued.

Species	Scientific Name	References
Skimmer Family		
B66. Black skimmer*	(Rynchops niger)	McElroy, 1974
Cuckoo Family		
B67. Yellow-billed cuckoo*	(Coccyzus americanus)	Smith unpub.
Owl Family		
B68. Barred owl*	(Strix varia)	Smith unpub.
Hummingbird Family		
B69. Ruby-throated hummingbird*	(Archilochus colubris)	Harrison, 1975
Kingfisher Family		
B70. Belted kingfisher*	(Ceryle alcyon)	Cornwell, 1963; Potter et al., 1980
Woodpecker Family		
B71. Ivory-billed woodpecker+	(Campephilus principalis)	Tanner, 1942; Potter et al., 1980
B72. Pileated woodpecker*	(Dryocopus pileatus)	Hamel et al., 1982
B73. Downy woodpecker*	(Picoides pubescens)	Schroeder, 1982a
Flycatcher Family		
B74. Eastern wood pewee*	(Contopus virens)	Harrison, 1975
B75. Acadian flycatcher*	(Empidonax virescens)	Smith unpub.
Swallow Family		
B76. Tree swallow	(Tachycineta bicolor)	McElroy, 1974
Crow Family		
B77. Fish crow*	(Corvus ossifragus)	Hamel et al., 1982
Wren Family		
B78. Marsh wren*	(Cistothorus palustris)	Bent, 1948; Gutzwiller and Anderson, 1987
B79. Sedge wren	(Cistothorus platensis)	Hamel et al., 1982
Thrush Family		
B80. Wood thrush	(Hylocichla mustelina)	Brackbill, 1943; Hamel et al., 1982

Table C-3. Continued.

Species	Scientific Name	References
Pipit Family		
B81. Water pipit	(Anthus spinoletta)	Hamel et al., 1982
Wood Warbler Family		
B82. Yellow-throated warbler*	(Dendroica dominica)	Hamel et al., 1982
B83. Pine warbler*	(Dendroica pinus)	Robbins, 1979; Schroeder, 1982b
B84. Common yellow throat*	(Geothlypis trichas)	Stewart, 1953
B85. Swainson's warbler	(Limnothlypis swainsonii)	Hamel et al., 1982
B86. Northern parula*	(Parula americana)	Tassone, 1981
B87. Prothonotary warbler*	(Protonotaria citrea)	Smith unpub
B88. Louisiana waterthrush	(Sciurus motacilla)	Tassone, 1981
B89. Northern waterthrush	(Sciurus noveboracensis)	Hamel et al., 1982
B90. Hooded warbler*	(Wilsonia citrina)	Smith unpub.
Blackbird Family		
B91. Red-winged blackbird*	(Agelaius phoeniceus)	Case and Hewitt, 1963; Orians, 1973, 1980
B92. Rusty blackbird	(Euphagus carolinus)	Orians 1980
Sparrow Family		
B93. LeConte's sparrow	(Ammodramus leconteii)	Potter et al., 1980
B94. Seaside sparrow*	(Ammospiza maritima)	Post, 1974; Harrison, 1975
B95. Swamp sparrow	(Melospiza georgiana)	Hamel et al., 1982

* Breeds in East Central Florida

\+ Endangered, threatened, or special concern species

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Table C-4. Semi-aquatic and wetland dependent wildlife species of East Central Florida: **MAMMALS**

Species	Scientific Name	References
Shrew Family		
M 1. Southeastern shrew	(Sorex longirostris)	Layne, 1978
Twilight Bat Family		
M 2. Eastern pipistrele	(Myotis subflavus)	Southall, 1988
Rabbit Family		
M 3. Marsh rabbit	(Sylviagus palustris)	Collins, 1959
Squirrel Family		
M 4. Gray squirrel	(Sciurus carolinensis)	Flyger, 1960; Doebel, 1967; Cordes and Barkalow, 1972; Allen, 1987
New World Mice, Rats, and Voles		
M 5. Round-tailed muskrat	(Neofiber alleni)	Layne, 1978
M 6. Marsh rice rat	(Oryzomys palustris)	Southall, 1988
Bear Family		
M 7. Black bear	(Ursus americanus)	Taylor, 1971; U.S. Forest Service, 1975; Garshelis, 1978; Landers et al., 1978; Smith, 1985; Rogers and Allen, 1987
Raccoon Family		
M 8. Raccoon	(Procyon lotor)	Johnson, 1970
Weasels and Skunks		
M 9. River otter	(Lutra canadensis)	Melquist and Hornocker, 1983; Chandler, 1988
M10. Mink	(Mustela vison)	Mitchell, 1961; Gerell, 1974; Melquist et al., 1981; Allen, 1986
Cat Family		
M11. Bobcat	(Felis rufus)	Hall and Newsom, 1976; Miller and Speake, 1979; Miller, 1980; Buie, 1980; Boyle and Fendley, 1987

+ Endangered, threatened or special concern species

References for Table C-4: Mammals

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APPENDIX D:

Feeding and breeding zones (guilds) used by semi-aquatic, and wetland-dependent wildlife species in various wetlands and habitat types adjacent to significant wetlands in East Central Florida.

Table D-1. Wildlife species charateristic of **SALT MARSHES.**

GUILDS Feeding Zone	Breeding Zone	Species*
Shrubs or grasses	Shrubs or grasses	B78, B91, B94
Shrubs or grasses	Breeds elsewhere	B21, B76, B79, B92, B93, B95
Ground surface	Ground surface	B16, B60, M6
Ground surface	Tree bole	M8
Ground surface	Breeds elsewhere	B61, B77
Water surface	Ground surface	R1, B66
Water surface	Shrubs or grasses	B38, B40, B42, B43
Water surface	Breeds elsewhere	B6, B8, B9, B10
Water column	Ground surface	R4, R6, R25, B45, B62, B65
Water column	Shrubs or grasses	B2
Water column	Tree canopy	B20, B23, B26, B27, B28, B29, B30, B32, B33
Water column	Breeds elsewhere	B3, B18, B63, B64
Water bottom	Ground surface	R10, B44, B46, B47, B52
Water bottom	Breeds elsewhere	B48, B49, B50, B51, B53, B54, B55, B56, B57, B58

* See Appendix C for species names. A = Amphibian, R = Reptile, B = Bird, M = Mammal

Table D-2. Wildlife species charateristic of **FRESHWATER MARSHES.**

Feeding Zone	GUILDS Breeding Zone	Species*
Tree canopy	Tree canopy	M2
Tree bole	Water surface	A7
Shrubs or grasses	Shrubs or grasses	B78, B79, B84, B91, B93, B94
Shrubs or grasses	Breeds elsewhere	B21, B76, B95
Ground surface	Water column	A3
Ground surface	Water surface	A2, A4, A15, A16, A17, A19
Ground surface	Ground surface	R16, R18, R20, R36, R39, B16, B36, M3
Ground surface	Breeds elsewhere	B15, B58, B77, M8
Water surface	Ground surface	R1, R37, B9, B10, B11, M5
Water surface	Shrubs or grasses	B38, B39, B41, B43
Water surface	Tree bole	B5
Water surface	Breeds elsewhere	B6, B7, B8, B81
Water column	Ground surface	A18, R2, R3, R4, R5, R6, R8, R9, R12, R26, R27, R28, R32, B45, B70, M9, M10
Water column	Shrubs or grasses	B1, B4, B19, B24, B31, B38, B39
Water column	Tree bole	B13
Water column	Tree canopy	B23, B26, B27, B28, B29, B32, B33, B35, B37
Water column	Breeds elsewhere	B12, B18, B20, B34
Water bottom	Ground surface	R10, R11, R30, B46, B47

* See Appendix C for species names. A = Amphibian, R = Reptile, B = Bird, M = Mammal

Table D-3. Wildlife species charateristic of **CYPRESS SWAMPS**.

GUILDS Feeding Zone	Breeding Zone	Species*
Tree canopy	Tree bole	B87
Tree canopy	Tree canopy	B17, B67, B74, B75, B82, B86, M2
Tree canopy	Breeds elsewhere	B85
Tree bole	Water surface	A5
Tree bole	Ground surface	R13, R29
Tree bole	Tree bole	B72, B73
Shrubs or grasses	Ground surface	R35
Shrubs or grasses	Shrubs or grasses	B84, B90
Shrubs or grasses	Tree canopy	B69
Shrubs or grasses	Breeds elsewhere	B92, B95
Ground surface	Water bottom	A8
Ground surface	Water column	A3, A9, A10, A20
Ground surface	Water surface	A1, A4, A11, A13, A14, A16, A17, A19
Ground surface	Ground surface	R15, R17, R18, R20, R23, R36, R38, R39, M1, M6, M7
Ground surface	Tree bole	B68, M8
Ground surface	Tree canopy	B14, B15, B25, B77
Ground surface	Breeds elsewhere	B80, B88, B89
Water surface	Ground surface	R1, R37
Water surface	Tree bole	B5
Water surface	Breeds elsewhere	B6, B7, B8
Water column	Ground surface	A18, R2, R3, R4, R5, R6, R8, R9, R12, R26, R27, R28, R31, R32, M9, M10
Water column	Shrubs or grasses	B4
Water column	Tree canopy	B18, B20, B23, B26, B27, B28, B29, B32, B33, B34, B35, B37
Water bottom	Ground surface	R10, R11, R30

* See Appendix C for species names. A = Amphibian, R = Reptile, B = Bird, M = Mammal

Table D-4. Wildlife species characteristic of **HARDWOOD SWAMPS.**

GUILDS Feeding Zone	 Breeding Zone	Species*
Tree canopy	Tree bole	B87
Tree canopy	Tree canopy	B17, B67, B74, B75, B82, B86, M2
Tree canopy	Breeds elsewhere	B85
Tree bole	Water surface	A5, A6, A7
Tree bole	Ground surface	R13
Tree bole	Tree bole	B72, B73
Shrubs or grasses	Ground surface	R35
Shrubs or grasses	Shrubs or grasses	B84, B90
Shrubs or grasses	Tree canopy	B69
Shrubs or grasses	Breeds elsewhere	B92, B95
Ground surface	Water bottom	A8
Ground surface	Water column	A3, A10
Ground surface	Water surface	A2, A11, A14, A15, A16, A17, A19
Ground surface	Ground surface	R14, R15, R18, R20, R23, R33, M1, M7
Ground surface	Tree bole	B68, M8
Ground surface	Tree canopy	B14, B15, B25, B77
Ground surface	Breeds elsewhere	B80, B88, B89
Water surface	Ground surface	R1, R37
Water surface	Tree bole	B5
Water surface	Breeds elsewhere	B6, B7, B8
Water column	Ground surface	A18, R2, R3, R4, R5, R6, R8, R9, R12, R26, R27, R28, R31, R32, M9, M10
Water column	Shrubs or grasses	B4
Water column	Tree canopy	B18, B20, B23, B26, B27, B28, B29, B32, B33, B34, B35, B37
Water bottom	Ground surface	R10, R11, R30

* See Appendix C for species names. A = Amphibian, R = Reptile, B = Bird, M = Mammal

Table D-5. Wildlife species characteristic of **HAMMOCKS.**

GUILDS Feeding Zone	Breeding Zone	Species*
Tree canopy	Tree bole	B87
Tree canopy	Tree canopy	B17, B67, B74, B75, B82, B86, M2, M4
Tree canopy	Breeds elsewhere	B85
Tree bole	Water surface	A5, A6
Tree bole	Ground surface	R13, R29
Tree bole	Tree bole	B71, B72, B73
Shrubs or grasses	Ground surface	R35
Shrubs or grasses	Shrubs or grasses	B84, B90
Shrubs or grasses	Tree canopy	B69
Ground surface	Water bottom	A8
Ground surface	Water column	A3, A9, A10, A20
Ground surface	Water surface	A2, A4, A11, A14, A15, A16, A17, A19
Ground surface	Ground surface	R7, R14, R16, R17, R18, R19, R20, R21, R22, R23, R24, R33, R34, R36, R38, B22, M1, M7, M11
Ground surface	Tree bole	B68, M8
Ground surface	Tree canopy	B14, B15, B25, B77
Ground surface	Breeds elsewhere	B59, B80, B88, B89
Water surface	Ground surface	R1, R37, B9, B10, B11
Water surface	Tree bole	B5, B13
Water column	Ground surface	A18, R2, R3, R4, R5, R6, R8, R9, R12, R26, R27, R28, R31, R32, B12, B70, M9, M10
Water column	Shrubs or grasses	B1, B4
Water column	Tree canopy	B23, B26, B27, B28, B29, B32, B33, B34, B35, B37
Water bottom	Ground surface	R10, R11, R30

* See Appendix C for species names. A = Amphibian, R = Reptile, B = Bird, M = Mammal

Table D-6. Wildlife species characteristics of **FLATWOODS.**

GUILDS Feeding Zone	 Breeding Zone	 Species*
Tree canopy	Tree bole	B87
Tree canopy	Tree canopy	B17, B67, B74, B75, B82, B83, B86, M2
Tree canopy	Breeds elsewhere	B85
Tree bole	Water surface	A6
Tree bole	Ground surface	R13, R29
Tree bole	Tree bole	B71, B72, B73
Shrubs or grasses	Ground surface	R35
Shrubs or grasses	Shrubs or grasses	B84, B90
Shrubs or grasses	Tree canopy	B69
Shrubs or grasses	Breeds elsewhere	B21
Ground surface	Water bottom	A8
Ground surface	Water column	A3, A9, A10, A20
Ground surface	Water surface	A1, A2, A4, A11, A13, A14, A15, A16, A17, A19
Ground surface	Ground surface	R7, R14, R15, R16, R17, R18, R19, R20, R21, R22, R23, R24, R33, R34, R36, R39, B16, B22, B36, M1, M7, M11
Ground surface	Tree bole	B68, M8
Ground surface	Tree canopy	B14, B15, B25, B77
Ground surface	Breeds elsewhere	B59, B80, B88, B89
Water surface	Ground surface	R1, R37, B9, B10, B11
Water surface	Tree bole	B5, B13
Water column	Ground surface	A18, R2, R3, R4, R5, R6, R8, R9, R12, R26, R27, R28, R31, R32, B12, B70, M9, M10
Water column	Shrubs or grasses	B1, B4
Water column	Tree canopy	B18, B20, B23, B26, B27, B28, B29, B32, B33, B34, B35, B37
Water bottom	Ground surface	R10, R11, R30

* See Appendix C for species names. A = Amphibian, R = Reptile, B = Bird, M = Mammal

Table D-7. Wildlife species characteristic of **SANDHILLS.**

GUILDS		
Feeding Zone	Breeding Zone	Species*
Tree canopy	Tree canopy	B82, B83, B86, M2, M4
Tree bole	Water surface	A6, A7
Tree bole	Ground surface	R13, R29
Tree bole	Tree bole	B72, B73
Shrubs or grasses	Ground surface	R35
Shrubs or grasses	Shrubs or grasses	B84
Ground surface	Water bottom	A8
Ground surface	Water column	A12, A20
Ground surface	Water surface	A1, A2, A4, A11, A13, A14, A15, A16
Ground surface	Ground surface	R7, R15, R16, R17, R18, R19, R20, R21, R22, R24, R33, R34, R36, R39, B22, M7, M11
Ground surface	Tree bole	M8
Ground surface	Tree canopy	B14, B25, B77
Water surface	Ground surface	R1, R37, B9, B10, B11
Water surface	Tree bole	B5, B13
Water surface	Breeds elsewhere	B6, B7, B8
Water column	Ground surface	R2, R3, R4, R5, R6, R8, R9, R12, R26, R27, R28, R31, R32, B70, M9, M10
Water column	Shrubs or grasses	B1, B4
Water column	Tree canopy	B18, B20, B23, B26, B27, B28, B29, B32, B33, B34, B35, B37
Water column	Breeds elsewhere	B3, B12
Water bottom	Ground surface	R10, R11, R30, B46

* See Appendix C for species names. A = Amphibian, R = Reptile, B = Bird, M = Mammal

APPENDIX E:

Combined feeding and breeding guild matrices for semi-aquatic and wetland-dependent wildlife species that occur in various habitat types in East Central Florida. The number in the center of a block signifies the number of different species in that guild (see Appendix E). The number in the upper-right corner of a block indicates the number of listed (endangered, threatened, special concern) species in the guild (see Appendix D).

SALT MARSHES

Feeding Zone

	Water bottom	Water column	Water surface	Ground surface	Shrubs/ grasses	Tree bole	Tree canopy	Breeds elsewhere	Totals
Tree canopy									0
Tree bole									0
Shrubs or grasses					3			6^{1}	9^{1}
Ground surface				3		1		2	6
Water surface				2	4			4^{1}	10^{1}
Water column				6^{2}	1^{1}		9^{4}	4^{1}	20^{8}
Water bottom				5^{1}				10	15^{1}
Totals	0	0	0	16^{3}	8^{1}	1	9^{4}	26^{3}	60^{11}

Breeding Zone

Figure E-1. Guild matrix with feeding and breeding zones for semi-aquatic and wetland-dependent wildlife species that occur in salt marshes in East Central Florida. The number of species using each feeding/breeding guild (center of square) and the number of listed (endangered, threatened, special concern) species in the guild (upper-right corner) is shown.

FRESH WATER MARSHES

Feeding Zone	Water bottom	Water column	Water surface	Ground surface	Shrubs/ grasses	Tree bole	Tree canopy	Breeds elsewhere	Totals
Tree canopy							1		1
Tree bole			1						1
Shrubs or grasses					6			3	9
Ground surface		1	6	1 8				4	1 19
Water surface				1 6	3	1		4	1 14
Water column				17	1 7	1	3 9	2 4	6 38
Water bottom				5					5
Totals	0	1	7	2 36	1 16	2	3 10	2 15	8 87

Breeding Zone

Figure E-2. Guild matrix with feeding and breeding zones for semi-aquatic and wetland-dependent wildlife species that occur in fresh water marshes in East Central Florida. The number of species using each feeding/breeding guild (center of square) and the number of listed (endangered, threatened, special concern) species in the guild (upper-right corner) is shown.

CYPRESS SWAMPS

Feeding Zone	Water bottom	Water column	Water surface	Ground surface	Shrubs/ grasses	Tree bole	Tree canopy	Breeds elsewhere	Totals
Tree canopy						1	7	1	9
Tree bole			1	2		2			5
Shrubs or grasses				1	2		1	2	6
Ground surface	1	4	8	11		2	4	3	1 33
Water surface				1 2		1		3	1 6
Water column				16	1		5 12		5 29
Water bottom				3					3
Totals	1	4	1 9	1 35	3	6	5 24	9	7 91

Breeding Zone

Figure E-3. Guild matrix with feeding and breeding zones for semi-aquatic and wetland-dependent wildlife species that occur in cypress swamps in East Central Florida. The number of species using each feeding/breeding guild (center of square) and the number of listed (endangered, threatened, special concern) species in the guild (upper-right corner) is shown.

HARDWOOD SWAMPS

Feeding Zone

	Water bottom	Water column	Water surface	Ground surface	Shrubs/ grasses	Tree bole	Tree canopy	Breeds elsewhere	Totals
Tree canopy						1	7	1	9
Tree bole			3	1		2			6
Shrubs or grasses				1	2		1	2	6
Ground surface	1	2	7	1 8		2	4	3	1 27
Water surface				2		1		3	6
Water column				16	1		5 12		5 29
Water bottom				3					3
Totals	1	2	10	1 31	3	6	5 22	9	6 86

Breeding Zone

Figure E-4. Guild matrix with feeding and breeding zones for semi-aquatic and wetland-dependent wildlife species that occur in hardwood swamps in East Central Florida. The number of species using each feeding/breeding guild (center of square) and the number of listed (endangered, threatened, special concern) species in the guild (upper-right corner) is shown.

HAMMOCKS

Feeding Zone

	Water bottom	Water column	Water surface	Ground surface	Shrubs/ grasses	Tree bole	Tree canopy	Breeds elsewhere	Totals
Tree canopy						1	8	1	10
Tree bole			2	2		1 3			1 7
Shrubs or grasses				1	2		1		4
Ground surface	1	4	8	2 19		2	4	4	2 42
Water surface				1 5		2			1 7
Water column				18	2		4 10		4 30
Water bottom				3					3
Totals	1	4	10	3 48	4	1 8	4 23	5	8 103

Breeding Zone

Figure E-5. Guild matrix with feeding and breeding zones for semi-aquatic and wetland-dependent wildlife species that occur in hammocks in East Central Florida. The number of species using each feeding/breeding guild (center of square) and the number of listed (endangered, threatened, special concern) species in the guild (upper-right corner) is shown.

FLATWOODS

Feeding Zone	Water bottom	Water column	Water surface	Ground surface	Shrubs/ grasses	Tree bole	Tree canopy	Breeds elsewhere	Totals
Tree canopy						1	8	1	10
Tree bole			1	2		1 3			1 6
Shrubs or grasses				1	2		1	1 1	1 5
Ground surface	1	4	1 10	3 22		2	4	4	4 47
Water surface				1 5		2			1 7
Water column				18	2		5 12		5 32
Water bottom				3					3
Totals	1	4	1 11	4 51	4	1 8	5 25	1 6	12 110

Breeding Zone

Figure E-6. Guild matrix with feeding and breeding zones for semi-aquatic and wetland-dependent wildlife species that occur in flatwoods in East Central Florida. The number of species using each feeding/breeding guild (center of square) and the number of listed (endangered, threatened, special concern) species in the guild (upper-right corner) is shown.

SANDHILLS

Feeding Zone

	Water bottom	Water column	Water surface	Ground surface	Shrubs/ grasses	Tree bole	Tree canopy	Breeds elsewhere	Totals
Tree canopy							5		5
Tree bole			2	2		2			6
Shrubs or grasses				1	1				2
Ground surface	1	2	1 8	2 17		1	3		3 32
Water surface				1 5		2		3	1 10
Water column				16	2		5 11	2	5 31
Water bottom				4					4
Totals	1	2	1 10	3 45	3	5	5 19	5	9 90

Breeding Zone

Figure E-7. Guild matrix with feeding and breeding zones for semi-aquatic and wetland-dependent wildlife species that occur in sandhills in East Central Florida. The number of species using each feeding/breeding guild (center of square) and the number of listed (endangered, threatened, special concern) species in the guild (upper-right corner) is shown.

APPENDIX F:

Spatial requirements reported for semi-aquatic and wetland-dependent wildlife species in various wetlands and habitat types adjacent to wetlands in East Central Florida.

Table F-1. Semi-aquatic and wetland dependent wildlife species of East Central Florida: **SALT MARSHES**

Species Code*		Spatial Requirement (feet)
B 2	20	very tolerant of humans while feeding
B 3	20	very tolerant of humans while feeding
B20	20	very tolerant of humans near nest site
M 6**	30	same as M 5
B23**	60	same as B27 (fairly tolerant of humans)
B26**	60	same as B27 (fairly tolerant of humans)
B47**	60	same as B27 (fairly tolerant of humans)
B48**	60	same as B27 (fairly tolerant of humans)
B76**	60	same as B27 (fairly tolerant of humans)
B60**	60	same as B27 (fairly tolerant of humans)
B61**	60	same as B27 (fairly tolerant of humans)
B77**	60	same as B27 (fairly tolerant of humans)
B30	64	nest location landward from the waterward extent of forest
B27	84	nest location landward from the waterward extent of forest (24) + minimum distance from humans tolerated (60)
B10	120	minimum distance from humans tolerated
B38	120	minimum distance from humans tolerated
B91	165	home range diameter
B92**	165	same as B91
B32**	180	same as B28 (minimum distance tolerated)
B33**	180	same as B28 (minimum distance tolerated)
B46	180	minimum distance from humans tolerated
B44**	180	same as B46
B45**	180	same as B46
B54**	180	same as B46
B55**	180	same as B46
B56**	180	same as B46
B57**	180	same as B46
B58**	180	same as B46
B62**	180	same as B46
B63**	180	same as B46
B64**	180	same as B46
B65**	180	same as B46
B66**	180	same as B46
B78	196	home range diameter
B79**	196	same as B78
B93**	196	same as B78
B94**	196	same as B78
B95**	196	same as B78
B52	240	minimum distance from humans tolerated
B49	240	minimum distance from humans tolerated

Table F-1. Continued.

Species Code*	Spatial Requirement (feet)	
B50	240	minimum distance from humans tolerated
B51	240	minimum distance from humans tolerated
B28	243	nest location landward from the waterward extent of forest (64) + minimum distance from humans tolerated (180)
B 9	300	minimum distance from humans tolerated
B 6	300	minimum distance from humans tolerated
B 8**	300	same as B 6
B21**	300	same B 6 (winter migrant, not tolerant of humans)
B53	300	minimum distance from humans tolerated
B29	322	nest location landward from the waterward extent of forest (82) + minimum distance from humans tolerated (240)
R 4**	497	same as R 2
B16**	795	same as B15
R25**	884	same as R26
R 6**	1,350	same as R 9
R10**	1,350	same as R 9
B18	1,500	secondary restrictive activity zone around eagle nests
B42	1,800	home range diameter
B40**	1,800	same as B42
B43**	1,800	same as B42
M 8	1,851	1/2 of home range diameter (entire home range includes the marsh as well as the adjacent flatwood or hammock forest)
R 1	11,045	home range diameter

*See Appendix C for species names. A = Amphibian, R = Reptile, B = Bird, M = Mammal

**Because no spatial requirement data were found for these species, the numbers used here represent spatial requirements for species that are closely related, similar-sized, found in comparable habitats, and categorized in corresponding guilds.

Table F-2. Semi-aquatic and wetland dependent wildlife species of East Central Florida: **FRESHWATER MARSHES**

Species Code*	Spatial Requirement (feet)	
B 4	20	very tolerant of humans while feeding
B20	20	very tolerant of humans near nest site
M 5	30	home range diameter
B26**	60	same as B27 (fairly tolerant of humans)
B23**	60	same as B27 (fairly tolerant of humans)
M 2**	60	same as B27 (fairly tolerant of humans)
B70**	60	same as B27 (fairly tolerant of humans)
B76**	60	same as B27 (fairly tolerant of humans)
B77**	60	same as B27 (fairly tolerant of humans)
B47**	60	same as B27 (fairly tolerant of humans)
B27	84	nest location landward from the waterward extent of forest (24) + minimum distance from humans tolerated (60)
B37**	84	same as B27
B 5**	120	same as B10
B11**	120	same as B10 (minimum distance tolerated)
B38	120	minimum distance from humans tolerated
B84	135	home range diameter
B10	150	nest location landward from the waterward extent of forest (30) + minimum distance from humans tolerated (120)
B91	165	home range diameter
A 4	180	maximum distance found from closest water
A 3**	180	same as A 4
A18**	180	same as A 4
A19**	180	same as A 4
B24**	180	same as B28 (minimum distance tolerated)
B31**	180	same as B28 (minimum distance tolerated)
B32**	180	same as B28 (minimum distance tolerated)
B33**	180	same as B28 (minimum distance tolerated)
B46	180	minimum distance from humans tolerated
B45**	180	same as B46
B58**	180	same as B46
B81**	180	same as B67
B78	196	home range diameter
B79**	196	same as B78
B93**	196	same as B78
B94**	196	same as B78
B95**	196	same as B78
R37	202	1/2 of home range diameter (entire home range includes the marsh as well as the adjacent forest)
B 1	240	minimum distance from humans tolerated
B35	240	minimum distance from humans tolerated

Table F-2. Continued.

Species Code*	Spatial Requirement (feet)	
B28	243	nest location landward from the waterward extent of forest (63) + minimum distance from humans tolerated (180)
B 6	300	minimum distance from humans tolerated
B 7	300	minimum distance from humans tolerated
B 8**	300	same as B 6
B12**	300	same as B 6
B13**	300	same as B 6
B21**	300	same B 6 (winter migrant, not tolerant of humans)
M10	300	maximum distance of den from closest water
B29	322	nest location landward from the waterward extent of forest (82) + minimum distance from humans tolerated (240)
A15**	350	same as A14
A16**	350	same as A14
A17**	350	same as A14
R 2	497	home range diameter
R 4**	497	same as R 2
R12**	497	same as R 2
R36	698	1/2 of home range diameter (entire home range includes the marsh as well as the adjacent forest)
M 3	700	maximum distance found from shore
B15	795	home range diameter
B16**	795	same as B15
B19**	795	same as B15
R26	884	home range diameter
R27**	884	same as R26
R28**	884	same as R26
R30**	884	same as R26
R32**	884	same as R26
B 9	960	nest location landward from the waterward extent of forest (660) + minimum distance from humans tolerated (300)
R 9	1,350	maximum distance from closest water to winter hibernation site
R 3**	1,350	same as R 9
R 5**	1,350	same as R 9
R 6**	1,350	same as R 9
R10**	1,350	same as R 9
R11**	1,350	same as R 9
R20**	1,395	same as R36

Table F-2. Continued.

Species Code*	Spatial Requirement (feet)	
B18	1,500	secondary restrictive activity zone around eagle nests
B34**	1,500	same as B18
B36**	1,500	same as B18
R16**	1,664	same as R24
R18**	1,664	same as R24
R39**	1,664	same as R24
B39**	1,800	same as B42
B41**	1,800	same as B42
B43**	1,800	same as B42
M 8	3,702	home range diameter
A 7**	4,000	same as A 5
R 8	5,280	maximum distance from closest water to nest
R 7**	5,280	same as R 8
A 2**	6,336	same as A13
M 9	6,600	home range diameter
R 1	11,045	home range diameter

*See Appendix C for species names. A = Amphibian, R = Reptile, B = Bird, M = Mammal

**Because no spatial requirement data were found for these species, the numbers used here represent spatial requirements for species that are closely related, similar-sized, found in comparable habitats, and categorized in corresponding guilds.

Table F-3. Semi-aquatic and wetland dependent wildlife species of East Central Florida: **CYPRESS SWAMPS**

Species Code*	Spatial Requirement (feet)	
B25	14	nest location landward from the waterward extent of forest
B 4	20	very tolerant of humans while feeding
B20	20	very tolerant of humans near nest site
M 6**	30	same as M 5
R29	51	home range diameter
R13**	51	same as R29
M 2**	60	same as B27 (fairly tolerant of humans)
B23**	60	same as B27 (minimum distance tolerated)
B26**	60	same as B27 (fairly tolerant of humans)
B69**	60	same as B27 (fairly tolerant of humans)
B77**	60	same as B27 (fairly tolerant of humans)
B27	84	nest location landward from the waterward extent of forest (24) + minimum distance from humans tolerated (60)
B37**	84	same as B27
B 5**	120	same as B10
B84	135	home range diameter
B92**	165	same as B91
A 4	180	maximum distance found from closest water
A 8**	180	same as A 4
A 3**	180	same as A 4
A 9**	180	same as A 4
A10**	180	same as A 4
A18**	180	same as A 4
A19**	180	same as A 4
A20**	180	same as A 4
B67	180	minimum forest habitat width
B80**	180	same as B67
B68	180	minimum forest habitat width
B75	180	minimum forest habitat width
B74**	180	same as B75
B88	180	minimum forest habitat width
B89**	180	same as B88
B32**	180	same as B28 (minimum distance tolerated)
B33**	180	same as B28 (minimum distance tolerated)
B95**	196	same as B78
B86	210	minimum forest habitat width
B82**	210	same as B86
B85**	210	same as B86
B35	240	minimum distance from humans tolerated
B28	243	nest location landward from the waterward extent of forest (63) + minimum distance from humans tolerated (180)

Table F-3. Continued.

Species Code*		Spatial Requirement (feet)
M10	300	maximum distance of den from closest water
B 6	300	minimum distance from humans tolerated
B 7	300	minimum distance from humans tolerated
B 8**	300	same as B 6
B29	322	nest location landward from the waterward extent of forest (82) + minimum distance from humans tolerated (240)
R35	331	home range diameter
A14	350	maximum distance found from permanent water
A16**	350	same as A14
A17**	350	same as A14
M 1**	370	same as M 4
R37	405	home range diameter
B87	> 450	minimum forest habitat width
B90	> 450	minimum forest habitat width
R 2	497	home range diameter
R 4**	497	same as R 2
R12**	497	same as R 2
B73	740	home range diameter
B15	795	home range diameter
B17**	795	same as B15
B14**	795	same as B15
R26	884	home range diameter
R27**	884	same as R26
R28**	884	same as R26
R30**	884	same as R26
R31**	884	same as R26
R32**	884	same as R26
R 9	1,350	maximum distance from closest water to winter hibernation site
R 3**	1,350	same as R 9
R 5**	1,350	same as R 9
R 6**	1,350	same as R 9
R10**	1,350	same as R 9
R11**	1,350	same as R 9
R36	1,395	home range diameter
R20**	1,395	same as R36
B18	1,500	secondary restrictive activity zone around eagle nests
B34**	1,500	same as B18
R15**	1,664	same as R24
R17**	1,664	same as R24

Table F-3. Continued.

Species Code*	Spatial Requirement (feet)	
R18**	1,664	same as R24
R23**	1,664	same as R24
R39**	1,664	same as R24
R38	2,756	home range diameter
M 8	3,702	home range diameter
A 5	4,000	maximum distance found from breeding pond
B72	4,221	home range diameter
R 8	5,280	maximum distance from closest water to nest
A13	6,336	distance between captures of same individual
A 1**	6,336	same as A13
A11**	6,336	same as A13
M 9	6,600	home range diameter
R 1	11,045	home range diameter
M 7	17,287	home range diameter

*See Appendix C for species names. A = Amphibian, R = Reptile, B = Bird, M = Mammal

**Because no spatial requirement data were found for these species, the numbers used here represent spatial requirements for species that are closely related, similar-sized, found in comparable habitats, and categorized in corresponding guilds.

Table F-4. Semi-aquatic and wetland dependent wildlife species of East Central Florida:
HARDWOOD SWAMPS

Species Code*	Spatial Requirement (feet)	
B25	14	nest location landward from the waterward extent of forest
B 4	20	very tolerant of humans while feeding
B20	20	very tolerant of humans near nest site
R13**	51	same as R29
R14**	51	same as R29
M 2**	60	same as B27 (fairly tolerant of humans)
B23**	60	same as B27 (fairly tolerant of humans)
B26**	60	same as B27 (fairly tolerant of humans)
B69**	60	same as B27 (fairly tolerant of humans)
B77**	60	same as B27 (fairly tolerant of humans)
B27	84	nest location landward from the waterward extent of forest (24) + minimum distance from humans tolerated (60)
B37**	84	same as B27
B 5**	120	same as B10
R33	128	distance between captures of same individual
B84	135	home range diameter
B92**	165	same as B91
A 8**	180	same as A 4
A 3**	180	same as A 4
A10**	180	same as A 4
A18**	180	same as A 4
A19**	180	same as A 4
B67	180	minimum forest habitat width
B80**	180	same as B67
B68	180	minimum forest habitat width
B75	180	minimum forest habitat width
B74**	180	same as B75
B88	180	minimum forest habitat width
B89**	180	same as B88
B32**	180	same as B28 (minimum distance tolerated)
B33**	180	same as B28 (minimum distance tolerated)
B95**	196	same as B78
B86	210	minimum forest habitat width
B82**	210	same as B86
B85**	210	same as B86
B35	240	minimum distance from humans tolerated
B28	243	nest location landward from the waterward extent of forest (63) + minimum distance from humans tolerated (180)
M10	300	maximum distance of den from closest water
B 6	300	minimum distance from humans tolerated
B 7	300	minimum distance from humans tolerated
B 8**	300	same as B 6

Table F-4. Continued.

Species Code*		Spatial Requirement (feet)
B29	322	nest location landward from the waterward extent of forest (82) + minimum distance from humans tolerated (240)
R35	331	home range diameter
A14	350	maximum distance found from permanent water
A15**	350	same as A14
A16**	350	same as A14
A17**	350	same as A14
M 1**	370	same as M 4
R37	405	home range diameter
B87	> 450	minimum forest habitat width
B90	> 450	minimum forest habitat width
R 2	497	home range diameter
R 4**	497	same as R 2
R12**	497	same as R 2
B73	740	home range diameter
B15	795	home range diameter
B17**	795	same as B15
B14**	795	same as B15
R26	884	home range diameter
R27**	884	same as R26
R28**	884	same as R26
R30**	884	same as R26
R31**	884	same as R26
R32**	884	same as R26
R 9	1,350	maximum distance from closest water to winter hibernation site
R 3**	1,350	same as R 9
R 5**	1,350	same as R 9
R 6**	1,350	same as R 9
R10**	1,350	same as R 9
R11**	1,350	same as R 9
R20**	1,395	same as R36
B18	1,500	secondary restrictive activity zone around eagle nests
B34**	1,500	same as B18
R15**	1,664	same as R24
R18**	1,664	same as R24
R23**	1,664	same as R24
M 8	3,702	home range diameter
A 5	4,000	maximum distance found from breeding pond
A 6**	4,000	same as A 5
A 7**	4,000	same as A 5

Table F-4. Continued.

Species Code*	Spatial Requirement (feet)	
B72	4,221	home range diameter
R 8	5,280	maximum distance from closest water to nest
A 2**	6,336	same as A13
A11**	6,336	same as A13
M 9	6,600	home range diameter
R 1	11,045	home range diameter
M 7	17,287	home range diameter

*See Appendix C for species names. A = Amphibian, R = Reptile, B = Bird, M = Mammal

**Because no spatial requirement data were found for these species, the numbers used here represent spatial requirements for species that are closely related, similar-sized, found in comparable habitats, and categorized in corresponding guilds.

Table F-5. Semi-aquatic and wetland dependent wildlife species of East Central Florida: **HAMMOCKS**

Species Code*		Spatial Requirement (feet)
B25	14	nest location landward from the waterward extent of forest
B 4	20	very tolerant of humans while feeding
R29	51	home range diameter
R13**	51	same as R29
R14**	51	same as R29
M 2**	60	same as B27 (fairly tolerant of humans)
B23**	60	same as B27 (minimum distance tolerated)
B26**	60	same as B27 (fairly tolerant of humans)
B69**	60	same as B27 (fairly tolerant of humans)
B70**	60	same as B27 (fairly tolerant of humans)
B77**	60	same as B27 (fairly tolerant of humans)
B27	84	nest location landward from the waterward extent of forest (24) + minimum distance from humans tolerated (60)
B37**	84	same as B27
B 5**	120	same as B10
B11**	120	same as B10
R33	128	distance between captures of same individual
R34**	128	same as R33
B84	135	home range diameter
B10	150	nest location landward from the waterward extent of the forest (30) + minimum distance from humans tolerated (120)
A 4	180	maximum distance found from closest water
A 8**	180	same as A 4
A 3**	180	same as A 4
A 9**	180	same as A 4
A10**	180	same as A 4
A18**	180	same as A 4
A19**	180	same as A 4
A20**	180	same as A 4
B67	180	minimum forest habitat width
B80**	180	same as B67
B68	180	minimum forest habitat width
B75	180	minimum forest habitat width
B74**	180	same as B75
B88	180	minimum forest habitat width
B89**	180	same as B88
B32**	180	same as B28 (minimum distance tolerated)
B33**	180	same as B28 (minimum distance tolerated)
B59**	180	same as B46
B86	210	minimum forest habitat width
B82**	210	same as B86

Table F-5. Continued.

Species Code*		Spatial Requirement (feet)
B85**	210	same as B86
B 1	240	minimum distance from humans tolerated
B35	240	minimum distance from humans tolerated
B28	243	nest location landward from the waterward extent of forest (63) + minimum distance from humans tolerated (180)
M10	300	maximum distance of den from closest water
B12**	300	same as B 6
B13**	300	same as B 6
B29	322	nest location landward from the waterward extent of forest (82) + minimum distance from humans tolerated (240)
R35	331	home range diameter
A14	350	maximum distance found from permanent water
A15**	350	same as A14
A16**	350	same as A14
A17**	350	same as A14
M 4	370	home range diameter
M 1**	370	same as M 4
R37	405	home range diameter
B87	> 450	minimum forest habitat width
B90	> 450	minimum forest habitat width
R 2	497	home range diameter
R 4**	497	same as R 2
R12**	497	same as R 2
R22	732	distance between captures of same individual
B73	740	home range diameter
B15	795	home range diameter
B17**	795	same as B15
B14**	795	same as B15
R26	884	home range diameter
R27**	884	same as R26
R28**	884	same as R26
R30**	884	same as R26
R31**	884	same as R26
R32**	884	same as R26
B 9	960	nest location landward from the waterward extent of the forest (660) + minimum distance from humans tolerated (300)
R 9	1,350	maximum distance from closest water to winter hibernation site
R 3**	1,350	same as R 9
R 5**	1,350	same as R 9

Table F-5. Continued.

Species Code*	Spatial Requirement (feet)	
R 6**	1,350	same as R 9
R10**	1,350	same as R 9
R11**	1,350	same as R 9
R36	1,395	home range diameter
R20**	1,395	same as R36
R21**	1,395	same as R36
B34**	1,500	same as B18
R24	1,664	home range diameter
R17**	1,664	same as R24
R18**	1,664	same as R24
R23**	1,664	same as R24
R16**	1,664	same as R24
R38	2,756	home range diameter
M 8	3,702	home range diameter
A 5	4,000	maximum distance found from breeding pond
A 6**	4,000	same as A 5
B72	4,221	home range diameter
B71	4,352	home range diameter
R19	4,654	home range diameter
R 8	5,280	maximum distance from closest water to nest
R 7**	5,280	same as R 8
M11	5,912	home range diameter
A 2**	6,336	same as A13
A11**	6,336	same as A13
M 9	6,600	home range diameter
B22	10,472	home range diameter
R 1	11,045	home range diameter
M 7	17,287	home range diameter

*See Appendix C for species names. A = Amphibian, R = Reptile, B = Bird, M = Mammal

**Because no spatial requirement data were found for these species, the numbers used here represent spatial requirements for species that are closely related, similar-sized, found in comparable habitats, and categorized in corresponding guilds.

Table F-6. Semi-aquatic and wetland dependent wildlife species of East Central Florida: **FLATWOODS**

Species Code*	Spatial Requirement (feet)	
B25	14	nest location landward from the waterward extent of forest
B 4	20	very tolerant of humans while feeding
B20	20	very tolerant of humans near nest site
R29	51	home range diameter
R13**	51	same as R29
R14**	51	same as R29
M 2**	60	same as B27 (fairly tolerant of humans)
B23**	60	same as B27 (minimum distance tolerated)
B26**	60	same as B27 (fairly tolerant of humans)
B69**	60	same as B27 (fairly tolerant of humans)
B70**	60	same as B27 (fairly tolerant of humans)
B77**	60	same as B27 (fairly tolerant of humans)
B27	84	nest location landward from the waterward extent of forest (24) + minimum distance from humans tolerated (60)
B37**	84	same as B27
B 5**	120	same as B10
B11**	120	same as B10
R33	128	distance between captures of same individual
R34**	128	same as R33
B84	135	home range diameter
B10	150	nest location landward from the waterward extent of the forest (30) + minimum distance from humans tolerated (120)
A 4	180	maximum distance found from closest water
A 8**	180	same as A 4
A 3**	180	same as A 4
A 9**	180	same as A 4
A10**	180	same as A 4
A18**	180	same as A 4
A19**	180	same as A 4
A20**	180	same as A 4
B67	180	minimum forest habitat width
B80**	180	same as B67
B68	180	minimum forest habitat width
B75	180	minimum forest habitat width
B74**	180	same as B75
B88	180	minimum forest habitat width
B89**	180	same as B88
B32**	180	same as B28 (minimum distance tolerated)
B33**	180	same as B28 (minimum distance tolerated)
B59**	180	same as B46
B86	210	minimum forest habitat width

Table F-6. Continued.

Species Code*		Spatial Requirement (feet)
B82**	210	same as B86
B83**	210	same as B86
B85**	210	same as B86
B 1	240	minimum distance from humans tolerated
B35	240	minimum distance from humans tolerated
B28	243	nest location landward from the waterward extent of forest (63) + minimum distance from humans tolerated (180)
M10	300	maximum distance of den from closest water
B12**	300	same as B 6
B13**	300	same as B 6
B21**	300	same B 6 (winter migrant, not tolerant of humans)
B29	322	nest location landward from the waterward extent of forest (82) + minimum distance from humans tolerated (240)
R35	331	home range diameter
A14	350	maximum distance found from permanent water
A15**	350	same as A14
A16**	350	same as A14
A17**	350	same as A14
M 1**	370	same as M 4
R37	405	home range diameter
B87	> 450	minimum forest habitat width
B90	> 450	minimum forest habitat width
R 2	497	home range diameter
R 4**	497	same as R 2
R12**	497	same as R 2
R22	732	distance between captures of same individual
B73	740	home range diameter
B15	795	home range diameter
B16**	795	same as B15
B17**	795	same as B15
B14**	795	same as B15
R26	884	home range diameter
R27**	884	same as R26
R28**	884	same as R26
R30**	884	same as R26
R31**	884	same as R26
R32**	884	same as R26
B 9	960	nest location landward from the waterward extent of the forest (660) + minimum distance from humans tolerated (300)

Table F-6. Continued.

Species Code*	Spatial Requirement (feet)	
R 9	1,350	maximum distance from closest water to winter hibernation site
R 3**	1,350	same as R 9
R 5**	1,350	same as R 9
R 6**	1,350	same as R 9
R10**	1,350	same as R 9
R11**	1,350	same as R 9
R36	1,395	home range diameter
R20**	1,395	same as R36
R21**	1,395	same as R36
B18	1,500	secondary restrictive activity zone around eagle nests
B34**	1,500	same as B18
B36**	1,500	same as B18
R24	1,664	home range diameter
R15**	1,664	same as R24
R16**	1,664	same as R24
R17**	1,664	same as R24
R18**	1,664	same as R24
R23**	1,664	same as R24
R39**	1,664	same as R24
M 8	3,702	home range diameter
A 6**	4,000	same as A 5
B72	4,221	home range diameter
B71	4,352	home range diameter
R19	4,654	home range diameter
R 8	5,280	maximum distance from closest water to nest
R 7**	5,280	same as R 8
M11	5,912	home range diameter
A13	6,336	distance between captures of same individual
A 1**	6,336	same as A13
A 2**	6,336	same as A13
A11**	6,336	same as A13
M 9	6,600	home range diameter
B22	10,472	home range diameter
R 1	11,045	home range diameter
M 7	17,287	home range diameter

*See Appendix C for species names. A = Amphibian, R = Reptile, B = Bird, M = Mammal

**Because no spatial requirement data were found for these species, the numbers used here represent spatial requirements for species that are closely related, similar-sized, found in comparable habitats, and categorized in corresponding guilds.

Table F-7. Semi-aquatic and wetland dependent wildlife species of East Central Florida: SANDHILLS

Species Code*	Spatial Requirement (feet)	
B25	14	nest location landward from the waterward extent of forest
B 3	20	very tolerant of humans while feeding
B 4	20	very tolerant of humans while feeding
B20	20	very tolerant of humans near nest site
R29	51	home range diameter
R13**	51	same as R29
M 2**	60	same as B27 (fairly tolerant of humans)
B23**	60	same as B27 (minimum distance tolerated)
B26**	60	same as B27 (fairly tolerant of humans)
B70**	60	same as B27 (fairly tolerant of humans)
B77**	60	same as B27 (fairly tolerant of humans)
B27	84	nest location landward from the waterward extent of forest (24) + minimum distance from humans tolerated (60)
B37**	84	same as B27
B 5**	120	same as B10
B11**	120	same as B10
R33	128	distance between captures of same individual
R34**	128	same as R33
B84	135	home range diameter
B10	150	nest location landward from the waterward extent of the forest (30) + minimum distance from humans tolerated (120)
A 4	180	maximum distance found from closest water
A 8**	180	same as A 4
A20**	180	same as A 4
B46	180	minimum distance from humans tolerated
B32**	180	same as B28 (minimum distance tolerated)
B33**	180	same as B28 (minimum distance tolerated)
B86	210	minimum forest habitat width
B82**	210	same as B86
B83**	210	same as B86
B 1	240	minimum distance from humans tolerated
B35	240	minimum distance from humans tolerated
B28	243	nest location landward from the waterward extent of forest (63) + minimum distance from humans tolerated (180)
M10	300	maximum distance of den from closest water
B 6	300	minimum distance from humans tolerated
B 7	300	minimum distance from humans tolerated
B 8**	300	same as B 6
B12**	300	same as B 6
B13**	300	same as B 6

Table F-7. Continued.

Species Code*	Spatial Requirement (feet)	
B29	322	nest location landward from the waterward extent of forest (82) + minimum distance from humans tolerated (240)
R35	331	home range diameter
A14	350	maximum distance found from permanent water
A15**	350	same as A14
A16**	350	same as A14
R37	405	home range diameter
R 2	497	home range diameter
R 4**	497	same as R 2
R12**	497	same as R 2
R22	732	distance between captures of same individual
B73	740	home range diameter
B14**	795	same as B15
R26	884	home range diameter
R27**	884	same as R26
R28**	884	same as R26
R30**	884	same as R26
R31**	884	same as R26
R32**	884	same as R26
B 9	960	nest location landward from the waterward extent of the forest (660) + minimum distance from humans tolerated (300)
R 9	1,350	maximum distance from closest water to winter hibernation site
R 3**	1,350	same as R 9
R 5**	1,350	same as R 9
R 6**	1,350	same as R 9
R10**	1,350	same as R 9
R11**	1,350	same as R 9
R36	1,395	home range diameter
R20**	1,395	same as R36
R21**	1,395	same as R36
B18	1,500	secondary restrictive activity zone around eagle nests
B34**	1,500	same as B18
R24	1,664	home range diameter
R17**	1,664	same as R24
R18**	1,664	same as R24
R15**	1,664	same as R24
R16**	1,664	same as R24
R39**	1,664	same as R24
M 8	3,702	home range diameter

Table F-7. Continued.

Species Code*	Spatial Requirement (feet)	
A 6**	4,000	same as A 5
A 7**	4,000	same as A 5
B72	4,221	home range diameter
R19	4,654	home range diameter
R 8	5,280	maximum distance from closest water to nest
R 7**	5,280	same as R 8
M11	5,912	home range diameter
A13	6,336	distance between captures of same individual
A 1**	6,336	same as A13
A 2**	6,336	same as A13
A11**	6,336	same as A13
A12**	6,336	same as A13
M 9	6,600	home range diameter
B22	10,472	home range diameter
R 1	11,045	home range diameter
M 7	17,287	home range diameter

*See Appendix C for species names. A = Amphibian, R = Reptile, B = Bird, M = Mammal

**Because no spatial requirement data were found for these species, the numbers used here represent spatial requirements for species that are closely related, similar-sized, found in comparable habitats, and categorized in corresponding guilds.

Table F-8. Semi-aquatic and wetland dependent wildlife species of East Central Florida: SPATIAL REQUIREMENTS OF ALL SPECIES ARRANGED BY TAXA

Species Code*	Spatial Requirement (feet)	
A 1**	6,336	same as A13
A 2**	6,336	same as A13
A 3**	180	same as A 4
A 4	180	maximum distance found from closest water
A 5	4,000	maximum distance found from breeding pond
A 6**	4,000	same as A 5
A 7**	4,000	same as A 5
A 8**	180	same as A 4
A 9**	180	same as A 4
A10**	180	same as A 4
A11**	6,336	same as A13
A12**	6,336	same as A13
A13	6,336	distance between captures of same individual
A14	350	maximum distance found from permanent water
A15**	350	same as A14
A16**	350	same as A14
A17**	350	same as A14
A18**	180	same as A 4
A19**	180	same as A 4
A20**	180	same as A 4
R 1	11,045	home range diameter
R 2	497	home range diameter
R 3**	1,350	same as R 9
R 4**	497	same as R 2
R 5**	1,350	same as R 9
R 6**	1,350	same as R 9
R 7**	5,280	same as R 8
R 8	5,280	maximum distance from closest water to nest
R 9	1,350	maximum distance from closest water to winter hibernation site
R10**	1,350	same as R 9
R11**	1,350	same as R 9
R12**	497	same as R 2
R13**	51	same as R29
R14**	51	same as R29
R15**	1,664	same as R24
R16**	1,664	same as R24
R17**	1,664	same as R24
R18**	1,664	same as R24

Table F-8. Continued.

Species Code*	Spatial Requirement (feet)	
R19	4,654	home range diameter
R20**	1,395	same as R36
R21**	1,395	same as R36
R22	732	distance between captures of same individual
R23**	1,664	same as R24
R24	1,664	home range diameter
R25**	884	same as R26
R26	884	home range diameter
R27**	884	same as R26
R28**	884	same as R26
R29	51	home range diameter
R30**	884	same as R26
R31**	884	same as R26
R32**	884	same as R26
R33	128	distance between captures of same individual
R34**	128	same as R33
R35	331	home range diameter
R36	1,395	home range diameter
R36	698	1/2 of home range diameter (entire home range includes the marsh as well as the adjacent forest)
R37	202	1/2 of home range diameter (entire home range includes the marsh as well as the adjacent forest)
R37	405	home range diameter
R38	2,756	home range diameter
R39**	1,664	same as R24
B 1	240	minimum distance from humans tolerated
B 2	20	very tolerant of humans while feeding
B 3	20	very tolerant of humans while feeding
B 4	20	very tolerant of humans while feeding
B 5**	120	same as B10
B 6	300	minimum distance from humans tolerated
B 7	300	minimum distance from humans tolerated
B 8**	300	same as B 6
B 9	960	nest location landward from the waterward extent of the forest (660) + minimum distance from humans tolerated (300)
B 9	300	minimum distance from humans tolerated
B10	120	minimum distance from humans tolerated
B10	150	nest location landward from the waterward extent of the forest (30) + minimum distance from humans tolerated (120)
B11**	120	same as B10

Table F-8. Continued.

Species Code*		Spatial Requirement (feet)
B12**	300	same as B 6
B13**	300	same as B 6
B14**	795	same as B15
B15	795	home range diameter
B16**	795	same as B15
B17**	795	same as B15
B18	1,500	secondary restrictive activity zone around eagle nests
B19**	795	same as B15
B20	20	very tolerant of humans near nest site
B21**	300	same B 6 (winter migrant, not tolerant of humans)
B22	10,472	home range diameter
B23**	60	same as B27 (fairly tolerant of humans)
B24**	180	same as B28 (minimum distance tolerated)
B25	14	nest location landward from the waterward extent of the forest
B26**	60	same as B27 (fairly tolerant of humans)
B27	84	nest location landward from the waterward extent of the forest (24) + minimum distance from humans tolerated (60)
B28	243	nest location landward from the waterward extent of the forest (63) + minimum distance from humans tolerated (180)
B29	322	nest location landward from the waterward extent of the forest (82) + minimum distance from humans tolerated (240)
B30	64	nest location landward from the waterward extent of the forest
B31**	180	same as B28 (minimum distance tolerated)
B32**	180	same as B28 (minimum distance tolerated)
B33**	180	same as B28 (minimum distance tolerated)
B34**	1,500	same as B18
B35	240	minimum distance from humans tolerated
B36**	1,500	same as B18
B37**	84	same as B27
B38	120	minimum distance from humans tolerated
B39**	1,800	same as B42
B40**	1,800	same as B42
B41**	1,800	same as B42
B42	1,800	home range diameter
B43**	1,800	same as B42
B44**	180	same as B46
B45**	180	same as B46
B46	180	minimum distance from humans tolerated
B47**	60	same as B27 (fairly tolerant of humans)
B48**	60	same as B27 (fairly tolerant of humans)
B49	240	minimum distance from humans tolerated

Table F-8. Continued.

Species Code*	Spatial Requirement (feet)	
B50	240	minimum distance from humans tolerated
B51	240	minimum distance from humans tolerated
B52	240	minimum distance from humans tolerated
B53	300	minimum distance from humans tolerated
B54**	180	same as B46
B55**	180	same as B46
B56**	180	same as B46
B57**	180	same as B46
B58**	180	same as B46
B59**	180	same as B46
B60**	60	same as B27 (fairly tolerant of humans)
B61**	60	same as B27 (fairly tolerant of humans)
B62**	180	same as B46
B63**	180	same as B46
B64**	180	same as B46
B65**	180	same as B46
B66**	180	same as B46
B67	180	minimum forest habitat width
B68	180	minimum forest habitat width
B69**	60	same as B27 (fairly tolerant of humans)
B70**	60	same as B27 (fairly tolerant of humans)
B71	4,352	home range diameter
B72	4,221	home range diameter
B73	740	home range diameter
B74**	80	same as B75
B75	180	minimum forest habitat width
B76**	60	same as B27 (fairly tolerant of humans)
B77**	60	same as B27 (fairly tolerant of humans)
B78	196	home range diameter
B79**	196	same as B78
B80**	180	same as B67
B81**	180	same as B67
B82**	210	same as B86
B83**	210	same as B86
B84	135	home range diameter
B85**	210	same as B86
B86	210	minimum forest habitat width
B87	> 450	minimum forest habitat width
B88	180	minimum forest habitat width

Table F-8. Continued.

Species Code*	Spatial Requirement (feet)	
B89**	180	same as B88
B90	> 450	minimum forest habitat width
B91	165	home range diameter
B92**	165	same as B91
B93**	196	same as B78
B94**	196	same as B78
B95**	196	same as B78
M 1**	370	same as M 4
M 2**	60	same as B27 (fairly tolerant of humans)
M 3	700	maximum distance found from shore
M 4	370	home range diameter
M 5	30	home range diameter
M 6**	30	same as M 5
M 7	17,287	home range diameter
M 8	3,702	home range diameter
M 8	1,851	1/2 home range diameter (entire home range includes the marsh as well as the adjacent flatwood or hammock forest)
M 9	6,600	home range diameter
M10	300	maximum distance of den from closest water
M11	5,912	home range diameter

*See Appendix C for species names. A = Amphibian, R = Reptile, B = Bird, M = Mammal

**Because no spatial requirement data were found for these species, the numbers used here represent spatial requirements for species that are closely related, similar-sized, found in comparable habitats, and categorized in corresponding guilds.

Table F-9. Semi-aquatic and Wetland dependent Wildlife species of East Central Florida: **SPATIAL REQUIREMENTS OF ALL SPECIES ARRANGED IN ASCENDING ORDER**

Species Code*	Spatial Requirement (feet)	
B25	14	nest location landward from the waterward extent of the forest
B 2	20	very tolerant of humans while feeding
B 3	20	very tolerant of humans while feeding
B 4	20	very tolerant of humans while feeding
B20	20	very tolerant of humans while feeding
M 5	30	home range diameter
M 6**	30	same as M 5
R29	51	home range diameter
R13**	51	same as R29
R14**	51	same as R29
B23**	60	same as B27 (fairly tolerant of humans)
B26**	60	same as B27 (fairly tolerant of humans)
B47**	60	same as B27 (fairly tolerant of humans)
B48**	60	same as B27 (fairly tolerant of humans)
B60**	60	same as B27 (fairly tolerant of humans)
B61**	60	same as B27 (fairly tolerant of humans)
B69**	60	same as B27 (fairly tolerant of humans)
B70**	60	same as B27 (fairly tolerant of humans)
B76**	60	same as B27 (fairly tolerant of humans)
B77**	60	same as B27 (fairly tolerant of humans)
M 2**	60	same as B27 (fairly tolerant of humans)
B30	64	nest location landward from the waterward extent of the forest
B27	84	nest location landward from the waterward extent of forest (24) + minimum distance from humans tolerated (60)
B37**	84	same as B27
R33	128	distance between captures of same individual
B10	120	minimum distance from humans tolerated
B11**	120	same as B10
B38	120	minimum distance from humans tolerated
B5**	120	same as B10
R33	128	distance between captures of same individual
R34**	128	same as R33
B84	135	home range diameter
B10	150	nest location landward from the waterward extent of forest (30) + minimum distance from humans tolerated (120)
B91	165	home range diameter
B92**	165	same as B91
B46	180	minimum distance from humans tolerated
B44**	180	same as B46
B45**	180	same as B46
B54**	180	same as B46

Table F-9. Continued.

Species Code*		Spatial Requirement (feet)
B55**	180	same as B46
B56**	180	same as B46
B57**	180	same as B46
B58**	180	same as B46
B59**	180	same as B46
B62**	180	same as B46
B63**	180	same as B46
B64**	180	same as B46
B65**	180	same as B46
B66**	180	same as B46
A 4	180	maximum distance found from closest water
A 3**	180	same as A 4
A 8**	180	same as A 4
A 9**	180	same as A 4
A10**	180	same as A 4
A18**	180	same as A 4
A19**	180	same as A 4
A20**	180	same as A 4
B24**	180	same as B28 (minimum distance tolerated)
B31**	180	same as B28 (minimum distance tolerated)
B32**	180	same as B28 (minimum distance tolerated)
B33**	180	same as B28 (minimum distance tolerated)
B68	180	minimum forest habitat width
B67	180	minimum forest habitat width
B80**	180	same as B67
B81**	180	same as B67
B75	180	minimum forest habitat width
B74**	180	same as B75
B88	180	minimum forest habitat width
B89**	180	same as B88
B78	196	home range diameter
B79**	196	same as B78
B93**	196	same as B78
B94**	196	same as B78
B95**	196	same as B78
R37	202	1/2 of home range diameter (entire home range includes the marsh as well as the adjacent forest)
B86	210	minimum forest habitat width
B82**	210	same as B86
B83**	210	same as B86

Table F-9. Continued.

Species Code*	Spatial Requirement (feet)	
B85**	210	same as B86
B49	240	minimum distance from humans tolerated
B50	240	minimum distance from humans tolerated
B51	240	minimum distance from humans tolerated
B52	240	minimum distance from humans tolerated
B35	240	minimum distance from humans tolerated
B 1	240	minimum distance from humans tolerated
B28	243	nest location landward from the waterward extent of forest (63) + minimum distance from humans tolerated (180)
B 9	300	minimum distance from humans tolerated
B 6	300	minimum distance from humans tolerated
B 7	300	minimum distance from humans tolerated
B 8**	300	same as B 6
B12**	300	same as B 6
B13**	300	same as B 6
B21**	300	same as B 6 (winter migrant, not tolerant of humans)
B53	300	minimum distance from humans tolerated
M10	300	maximum distance of den from closest water
B29	322	nest location landward from the waterward extent of forest (82) + minimum distance from humans tolerated (240)
R35	331	home range diameter
A14	350	maximum distance found from permanent water
A15**	350	same as A14
A16**	350	same as A14
A17**	350	same as A14
M 4	370	home range diameter
M 1**	370	same as M 4
R37	405	home range diameter
B87	> 450	minimum forest habitat width
B90	> 450	minimum forest habitat width
R 2	497	home range diameter
R 4**	497	same as R 2
R12**	497	same as R 2
R36	698	1/2 of home range diameter (entire home range includes the marsh as well as the adjacent forest)
M 3	700	maximum distance found from shore
R22	732	distance between captures of same individual
B73	740	home range diameter
B15	795	home range diameter
B14**	795	same as B15
B16**	795	same as B15

Table F-9. Continued.

Species Code*		Spatial Requirement (feet)
B17**	795	same as B15
B19**	795	same as B15
R26	884	home range diameter
R25**	884	same as R26
R27**	884	same as R26
R28**	884	same as R26
R30**	884	same as R26
R31**	884	same as R26
R32**	884	same as R26
B 9	960	nest location landward from the waterward extent of forest (660) + minimum distance from humans tolerated (300)
R 9	1,350	maximum distance from closest water to winter hibernation site
R3**	1,350	same as R 9
R 5**	1,350	same as R 9
R 6**	1,350	same as R 9
R10**	1,350	same as R 9
R11**	1,350	same as R 9
R36	1,395	home range diameter
R20**	1,395	same as R36
R21**	1,395	same as R36
B18	1,500	secondary restrictive activity zone around eagle nests
B34**	1,500	same as B18
B36**	1,500	same as B18
R24	1,664	home range diameter
R15**	1,664	same as R24
R16**	1,664	same as R24
R17**	1,664	same as R24
R18**	1,664	same as R24
R23**	1,664	same as R24
R39**	1,664	same as R24
B42	1,800	home range diameter
B39**	1,800	same as B42
B40**	1,800	same as B42
B41**	1,800	same as B42
B43**	1,800	same as B42
M 8	1,851	1/2 home range diameter (entire home range includes the marsh as well as the adjacent flatwood or hammock forest)

Table F-9. Continued.

Species Code*	Spatial Requirement (feet)	
R38	2,756	home range diameter
M 8	3,702	home range diameter
A 5	4,000	maximum distance found from breeding pond
A 6**	4,000	same as A 5
A 7**	4,000	same as A 5
B72	4,221	home range diameter
B71	4,352	home range diameter
R19	4,654	home range diameter
R 8	5,280	maximum distance from closest water to nest
R 7**	5,280	same as R 8
M11	5,912	home range diameter
A13	6,336	distance between captures of same individual
A 1**	6,336	same as A13
A 2**	6,336	same as A13
A11**	6,336	same as A13
A12**	6,336	same as A13
M 9	6,600	home range diameter
B22	10,472	home range diameter
R 1	11,045	home range diameter
M 7	17,287	home range diameter

*See Appendix C for species names. A = Amphibian, R = Reptile, B = Bird, M = Mammal

**Because no spatial requirement data were found for these species, the numbers used here represent spatial requirements for species that are closely related, similar-sized, found in comparable habitats, and categorized in corresponding guilds.

APPENDIX G:

Habitat descriptions. (SCS, 1989)

SALT MARSHES

This habitat occurs along the Atlantic coast and inland along tidal rivers. It appears as an open expanse of grasses, sedges, and rushes. Vegetation often occurs in distinct zones within the salt marsh complex as a result of water levels from tidal action and salinity concentrations in water and soils. Some species have a wide tolerance range and may be found throughout the grass marsh. Plants in this group are black needlerush and seashore saltgrass. Smooth cordgrass is usually dominant in this system and more indicative of low, regularly flooded marsh, while the high marsh supports salt myrtle, marshhay cordgrass, marshelder, saltwort and sea oxeye. Plants that characterize this habitat are:

HERBACEOUS PLANTS AND VINES - Sea blite (*Suaeda linearis*), Sea pursland (*Sesuvium portulacastrum*).

GRASSES AND GRASSLIKE PLANTS - Big cordgrass (*Spartina cynosuroides*), Marshhay cordgrass (*Spartina patens*), Olney bulrush (*Scripus americanus*), Seashore dropseed (*Scorobolus virginicus*), Seashore paspalum (*Pasalum vaginatum*), Seashore saltgrass (*Distichlis spicata*), Shoregrass (*Monanthochole littoralis*), Smooth cordgrass (*Spartina alterniflora*).

FRESHWATER MARSHES

This habitat appears as an open expanse of grasses, sedges, and rushes, and other herbaceous plants in areas where the soil is usually saturated or covered with surface water for two or more months during the year. Plants that characterize this habitat are:

GRASSES AND GRASSLIKE PLANTS - Beak rushes (Rhynchospora spp.), Blue maidencane (Amphicarpum muhlenbergianum), Bottlebush threeawn (Aristida spiciformis), Bulrushes (Scirpus spp.)Caric sedges (Carex spp.), Clubhead cutgrass (Leersia hexandra), Common reed (Phragmites spp.), Flat sedge (Cyperus spp.), Maidencane (Panicum hemitomon), Rush (Juncus spp.), Sawgrass (Cladium jamaicense), Spike rushes (Eleocharis spp.), Umbrella grass (Fuirena spp.), Wild millet (Echinocloa spp.).

HERBACEOUS PLANTS - Arrowhead (Saggitaris spp.), Blue flag (Iris hexagona savannarum), Cattail (Typha spp.), Fire flag (Thalia geniculata), Pickerelweed (Pontederia cordata) and (Pontederia lanceolata), Smartweed, (Polygonum spp.), Pennywort (Hydrocotle spp.).

SHRUBS - St. Johns wort (Hypericum spp.), Primrose willow (Ludwigia lanceolata), Smartweed (Polygonum spp.), Pennywort (Hydrocotle spp.).

CYPRESS SWAMPS

This habitat occurs along rivers, lake margins, and interspersed throughout other communities such as flatwoods. Bald cypress, along lakes and stream margins, is dominant and often is the only plant found in large numbers. Pond cypress occurs in cypress heads or domes which are usually found in flatwoods. Plants that characterize this habitat are:

TREES - Bald cypress (Taxodium distichum), Blackgum (Nyssa sylvatica), Coastal plain willow (Salix caroliniana), Pond cypress (Taxodium distichum var. nutans), Red maple (Acer rubrum).

SHRUBS - Common buttonbush (Cephalanthus occidentalis), Southern waxmyrtle (Myrica cerifera).

HERBACEOUS PLANTS AND VINES - Cinnamon fern (Osmunda cinnamomea), Fall-flowering ixia (Nemastylis floridana), Laurel greenbriar (Smilax laurifolia) Pickerel weed (Pontederia cordata), Royal fern (Osmunda regalis).

GRASSES AND GRASSLIKE PLANTS - Maidencane (Panicum hemitomon), Narrowleaf sawgrass (Cladium mariscoides).

HARDWOOD SWAMPS

This habitat occurs along rivers and in basins which are either submerged or saturated part of the year. Bayhead swamps are included here. The vegetation is primarily deciduous hardwood trees. Many areas may have originally been dominated by cypress, but when the large cypress were cut out, the hardwoods became dominant. Plants that characterize this habitat are:

TREES - Blackgum (Nyssa sylvatica), Red maple (Acer rubrum), Sweetbay (Magnolia virginiana), Water ash (Fraxinus carolinensis).

SHRUBS - Buttonbush (Cephalanthus occidentalis), Dahoon holly (Ilex cassine).

HERBACEOUS PLANTS AND VINES - Cinnamon fern (Osmunda cinnamomea), Lizard's tail (Suarurus cernuus), Royal fern (Osmunda regalis), Wild pine (Tillandsia fasiculata).

HAMMOCKS

This habitat complex includes xeric, mesic, and hydric hammocks. They occur in a variety of site conditions from strongly sloping, dry, sandy sites to level, poorly drained sites with high water tables. This habitat supports a luxurious growth of vegetation with a diversity of species. Plants that characterize this habitat are:

TREES - Black cherry (Prunus serotina), Flowering dogwood (Cronus florida), Pignut hickory (Carya palustris), Cabbage palm (Sabal palmetto), Hawthorns (Craetaegus spp.), Laurel oak (Quercus laurifolia), Live oak (Quercus virginiana), Red bay (Persea borbonia), Red maple (Acer rubrum), Sweetbay (Magnolia virginiana), Sweetgum (Liquidambar styraciflua), Water oak (Quercus nigra), Magnolia (Magnolia grandiflora).

SHRUBS - American beautyberry (Callicarpa americana), Arrowwood (Viburnum dentatum), Sparkleberry (Vaccinium arboreum), Waxmyrtle (Myrica cerifera), Sawpalmetto (Serenoa repens).

HERBACEOUS PLANTS AND VINES - Cat greenbriar (Smilax glauca), Common greenbriar (Smilax rotundifolia), Crossvine (Bignonia capreolata), Partridge berry (Mitchella repens), Partirdge pea (Cassia spp.), Virginia creeper (Parthenocissus quinquefolia), Wild grape (Vitis spp.), Blackberry (Rubus spp.).

GRASSES AND GRASSLIKE PLANTS - Low panicum (Panicum spp.), Switchgrass (Panicum virgatum), Eastern gamagrass (Tripsacum dactyloides), Maidencane (Panicum hemitomon).

FLATWOODS

This habitat occurs on nearly level land. Water movement is very gradual. During the rainy season, this water may be on or near the soil surface. At other times, the soil can be fairly dry. The natural vegetation of this habitat is typically scattered pine trees and occasionally cabbage palms with an understory of sawpalmetto and grasses. The plants that characterize this habitat are:

TREES - Live oak (Quercus virginiana), Slash pine (Pinus elliottii), Cabbage palm (Sabal palmetto).

SHRUBS - Sawpalmetto (Serenoa repens), waxmyrtle (Myrica cerifera), Ground blueberry (Vacinnium myrsinites), Gallberry (Ilex glabra), Shining sumac (Rhus copallina).

HERBACEOUS PLANTS AND VINES - Creeping beggarweed (Desmodium incanum), Deer tongue (Trilisa ordoratissima), Gay feather (Liatris gracillis).

GRASSES AND GRASSLIKE PLANTS - Chalky bluestem (Andropogon capillipes), creeping bluestem (Schizachyrium stoloniferum), Lopsided indiangrass (Sorghastrum secundum), Low panicum (Panicum spp.).

SANDHILLS

This habitat includes the sand scrub and longleaf pine-turkey oak ecological communities. Sandhills occur on rolling land with strong slopes. Water movement is rapid through the sandy soil. Plants that characterize this habitat are:

TREES - Bluejack oak (*Quercus incana*), Chapman oak (*Quercus chapmannii*), sand live oak (*Quercus virginiana* var.), Sand pine (*Pinus clausa*), Longleaf pine (*Pinus palustris*), Turkey oak (*Quercus laevis*).

SHRUBS - Dwarf huckleberry (*Gaylussacia dumosa*), Gopher apple (*Chrysobalanus oblongifolius*) Prickly pear (*Opuntia* spp.).

HERBACEOUS PLANTS AND VINES - Grassleaf goldenaster (*Heterotheca graminifolia*), Deermoss (*Cladonia* spp.), Aster (*Aster* spp.), Blazing star (*Liatris tenuifolia*), Butterfly pea (*Centrosema virginianum*), Elephant's foot (*Elephantopus* spp.), Partridge pea (*Cassia* spp.), Pineland beggarweed (*Desmodium strictum*), Sandhill milkweed (*Asclepias humistrata*), Wild indigo (*Baptista* spp.).

GRASSES AND GRASSLIKE PLANTS - Yellow indiangrass (*Sorphastrum nutans*), Low panicum (*Panicum* spp.), Pinewoods dropseed (*Sporobolus junceus*).

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