Technical Memorandum No. 13

ENVIRONMENTAL WATER MANAGEMENT PLAN FOR THE BLUE CYPRESS WATER MANAGEMENT AREA; UPPER ST. JOHNS RIVER BASIN PROJECT

by

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EXECUTIVE SUMMARY

This document outlines the surface water management plan for the Blue Cypress Water Management Area (BCWMA) that has been implemented to 1) protect endangered snail kites (*Rostrhamus sociablis plumbeus*) which may be nesting or foraging in the BCWMA and, 2) maintain the wetland habitat in the area in its existing condition. This plan only affects non-flood control discharges and does not alter nor impact design flood control discharge schedules.

To derive non-flood control discharge schedules for the BCWMA, a target hydrologic regime for the area was developed to describe long-term surface water conditions. This target hydrologic regime represents optimal water level conditions because it balances prolonged flooding, which is optimal for kites and their exclusive prey, the apple snail (*Pomacea paludosa)*, against periodic drying events, which are essential to maintaining the existing marsh vegetation mosaic. The target hydrologic regime is presented as a suite of hydrologic criteria which numerically address the individual attributes of mean water level, maximum water level, frequency, intensity and duration of annual drydown, seasonality of annual water level fluctuation and water level recession rate. Criteria were developed and refined through cooperative efforts involving the St. Johns River Water Management District, the University of Florida, the Florida Game and Fresh Water Fish Commission, the U. S. Fish and Wildlife Service and the U. S. Army Corps of Engineers.

Hydrologic modeling was used to determine a discharge schedule that would best create water conditions described by the hydrologic criteria. No single discharge schedule modeled caused all criteria to be met simultaneously. Therefore, an inter-agency agreement was reached to accept a discharge schedule which would cause slightly prolonged flooding over one which would create more frequent drydowns. The following discharge was agreed upon to regulate non-flood control discharges from the BCWMA: *When water levels in the St. Johns Water Management Area (SJWMA) reach 19.7 ft NGVD, 300 cfs will be discharged from the BCWMA through Structure S-96D until 1) water levels in the SJWMA reach or exceed 21.0 ft NGVD, or 2) water levels in the BCWMA reach or fall below 23.2 ft NGVD*.

The discharge schedule presented above restored many of the temporal and spatial aspects of the natural hydrologic cycle to the BCWMA. Approximately 70% of the area (5,000 acres) will experience hydrologic conditions specified by the criteria. Approximately 1,700 acres of the BCWMA may be subject to flooding of sufficient duration to adversely impact some vegetation communities. A biological monitoring program is needed to ensure habitat changes that may occur in the BCWMA as a result of the implementation of this water management plan are detected in a timely manner. If changes are considered to be undesirable (potentially capable of adversely affecting kites, apple snails, or the viability of the habitat), the hydrologic criteria and the discharge schedule will be modified.

Consumptive use of water from the BCWMA is an anthropogenic impact which could adversely impact snail kites. The Water Management District will use rule-making authority given it in Chapter 373 F.S. (e.g., Reservation of Water and/or setting Minimum Flows and Levels) to ensure

that permitted use of water from the BCWMA will not cause the hydrologic criteria presented in this plan to be violated. Every attempt is being made to develop water management strategies which will both protect kites and allow consumptive use needs to be met.

Water quality is as important as water quantity in maintaining the habitat in the BCWMA. Acceptable water quality standards for waters discharged into the BCWMA have yet to be determined. When water quality criteria are established, the St. Johns River Water Management District will initiate rule-making activities as necessary, utilizing the authority given it in Chapter 373 F. S. regarding discharges into the BCWMA for the purposes of protecting wildlife which utilize the area from adverse impacts caused by changes in water quality. Additional measures which could protect water quality include blocking some canals and flow-ways which provide direct access of nutrient enriched water to the marsh.

Acknowledgments

This water management plan was developed through cooperative efforts between the St. Johns River Water Management District, the University of Florida, the Florida Game and Fresh Water Fish Commission, the U. S. Fish and Wildlife Service and the U. S. Army Corps of Engineers. In particular, appreciation is expressed to Rob Bennetts, Brian Toland, Bill Hoeft, Dave Ferrell. Donna Curtis, Karen Warr and Madeline Northcutt of the SJRWMD reviewed this manuscript and provided many helpful comments and suggestions.

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1.0 Introduction

The Blue Cypress Water Management Area (BCWMA) is a part of a large federal flood control project currently under construction within the headwater region of the St. Johns River. The entire flood control project is known as the Upper St. Johns River Basin Project (USJRBP). The BCWMA was built to temporarily retain flood waters from agricultural lands, to segregate farm discharges from the more pristine project areas, and when possible, to provide water for farm irrigation. Original water management plans for the BCWMA did not focus on environmental enhancement or preservation. These plans had to be modified however, when the BCWMA began providing significant nesting and foraging habitat for the endangered Everglades snail kite (Toland 1991, Toland 1993, Bennetts *et al.* 1995).

Snail kites are protected by the Endangered Species Act, therefore management activities within the BCWMA must address species protection. The purpose of this paper is to describe a surface water management plan for the BCWMA that has been developed to protect snail kites and their habitat over the long-term, while still meeting initial USJRBP goals. This plan will be included as part of the U. S. Army Corps of Engineers Upper St. Johns River Basin Water Control Plan which will regulate the operation of project structures.

2. 0 Project Area

The BCWMA consists of approximately 10,000 acres located north of State Road 60 and east of Blue Cypress Lake in Indian River County, Florida (Figure 1). The BCWMA is bisected by State Road 512 into two hydrologically connected areas, BCWMA-East (5,200 acres) and BCWMA-West (4,600 acres).

2.1 Water Control Structures

Four gated culverts (S-251) connect the BCWMA at State Road 512 (Figure 1). S-251, which has a discharge capacity of 400 cfs, will be operated to control water levels in BCWMA-East to prevent overdrainage, and to prevent reverse flows from BCWMA-West to BCWMA-East (USACOE 1991). The BCWMA will receive agricultural discharges from the St. Johns Water Control District via the C-52 floodway, and from areas east of BCWMA-East. Water will be discharged from the BCWMA into the SJWMA primarily via the C-65 flow-way and Structure S-96D. The maximum discharge capacity of S-96D is 1,000 cfs. An additional 600 cfs can also be released from the C-65 flow-way into the SJWMA through Structure S-3 which is adjacent to S-96-D. Under the Corps of Engineers design conditions, maximum discharges through S-96D will occur when water levels in the BCWMA-West equal or exceed 25.5 ft NGVD during the dry season, and 24.5 ft NGVD during the wet season (Figure 2). When water levels are below this regulation schedule (Zone B; Figure 2), stages can be manipulated for environmental or water supply purposes.

Figure 1. Map of the Blue Cypress Water Management Area

2.2 Vegetation Communities

The BCWMA-West is comprised of the Ansin West and the Lake Miami Ranch properties (Figure 1). Ansin West contains a mosaic of freshwater marsh plant communities dominated mainly by sawgrass and maidencane (*Panicum hemitomon*), and interspersed with bald cypress (*Taxodium distichum*) tree islands. Lake Miami Ranch had been drained and farmed prior to project construction. Because of soil subsidence, this area is now a deep-water habitat.

The BCWMA-East is an oligotrophic marsh supporting herbaceous emergent vegetation such as sawgrass, maidencane, pickerelweed (*Pontedaria lanceolata*), and spikerush (*Eleocharis elongata*); it is also interspersed with tree islands. In BCWMA-East, ground elevations

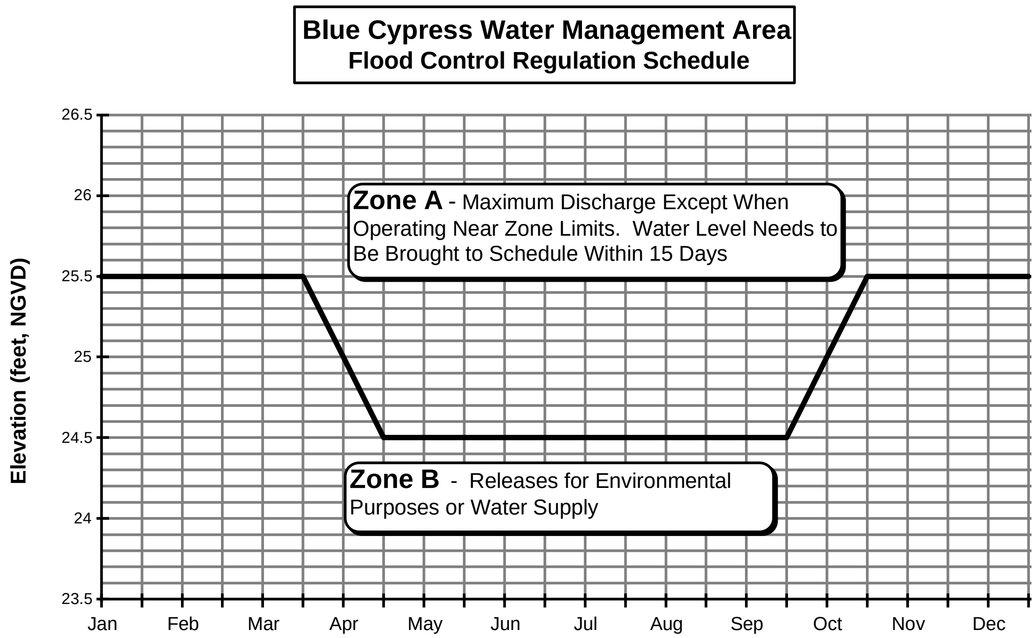

Figure 2. Flood control regulation schedule for the BCWMA.

gradually rise from west to east. The eastern third of BCWMA-East (Jewish Federation) contains large tree islands consisting of slash pine (*Pinus elliottii*), cabbage palm (*Sabal palmetto*), red maple (*Acer rubrum*), red bay (*Persea palustris*), black tupelo (*Nyssa sylvatica*), and live oak (*Quercus virginiana*) (Toland 1991). Throughout the western two-thirds of the BCWMA-East, tree islands are dominated by bald cypress, willow (*Salix caroliniana*), wax myrtle (*Myrica cerifera*), dahoon holly (*Ilex cassine*), and pond apple (*Annona glabra*) (Toland 1991).

2.3 Topography

The majority of marsh acreage in the BCWMA, excluding Lake Miami Ranch, lies between 22.0 and 23.5 ft NGVD (Table 1). In Lake Miami Ranch, the majority of acreage (approx. 2,200 acres) lies between 20.0 and 22.5 ft NGVD. An area which was important to snail kite nesting efforts in 1992 and 1993 is the Jewish Federation, which constitutes the easternmost acreage of BCWMA-East (Toland 1993). The majority of acreage in the Jewish Federation lies between 22.5 ft and 23.5 ft NGVD (Table 1).

3.0 History of Snail Kites in the Upper St. Johns River Basin

Snail kites are found within the United States only in south and central Florida and their survival is entirely dependent upon on the extensive network of wetland habitats found throughout this region (Bennetts and Kitchens 1993). Historically, snail kites were reported as being common residents of the Upper St. Johns River marshes (Nicholson 1926; Howell 1932; Townsend 1927). However, from the 1970's through the early 1980's, the number of kites observed within the upper

Table 1. Stage-area relationships (in acres) for the BCWMA. This table does not include Lake Miami Ranch which has an area of 2,850 acres lying below the 22.0 ft contour.

Elevation (ft NGVD)	Ansin West	Ansin East	Jewish Federation	Total	% of Total Acreage
22.0	8.1	64.8	12.2	85.1	1.2%
22.5	459.1	1572.0	151.3	2182.4	30.9%
23.0	1451.7	3429.4	463.6	5344.9	75.7%
23.5	1605.3	3806.6	850.9	6262.8	88.7%
24.0	1662.5	4029.8	896.8	6589.1	93.3%
24.5	1720.1	4113.5	928.9	6762.5	95.8%
25.0	1776.4	4194.5	951.7	6922.6	98.0%
25.5		4279.0	970.2	7025.7	99.5%
26.0			1007.1	7062.5	100.0%

basin steadily declined. This decline was attributed to loss of wetlands, erratic basin water levels, and the runoff of agricultural contaminants (Sykes 1983).

The number of snail kites reported in the upper basin began increasing in 1988 when 30 birds and 7 nests were reported (Rogers 1988). The number of kites reported increased over the next several years (Figure 3), with the majority of sightings occurring within the BCWMA (Toland 1993). With increased numbers of kites, there was also increased nesting. From 1990 to 1993, 114 kites were successfully fledged in the area.

Snail kite nesting in the BCWMA occurred in a variety of vegetation types with willow, cabbage palms, cypress, cattail, sawgrass, and wax myrtle being most commonly used (Toland 1993; Bennetts *et al*. 1995). The use of different substrates probably reflects yearly differences in the location of nesting activity, which in turn is influenced primarily by water depth (Bennetts *et al.* 1995). The occurrence of suitable nesting substrates could be an important factor regulating reproductive efforts in the BCWMA if long-term hydrologic conditions result in the loss of the more stable substrates such as willow (Bennetts *et al.* 1995).

4.0 Zone B Water Management Issues and Strategies

Managing wetlands to protect snail kite nesting habitat entails establishing a hydrologic regime which maintains a balance between prolonged hydroperiods, which are optimal for apple snail (*Pomacea paludosa*) populations (Kushlan 1975; Turner 1994), and periodic drydowns, which are essential to maintaining woody shrubs (Bennetts *et al.* 1988; Toland 1991). Although additional information on the specific inundation frequencies of suitable kite foraging habitat are needed, available information suggests that to optimize nesting habitat, drydowns to a central marsh elevation should occur at least every three to four years and the marsh should not dry out

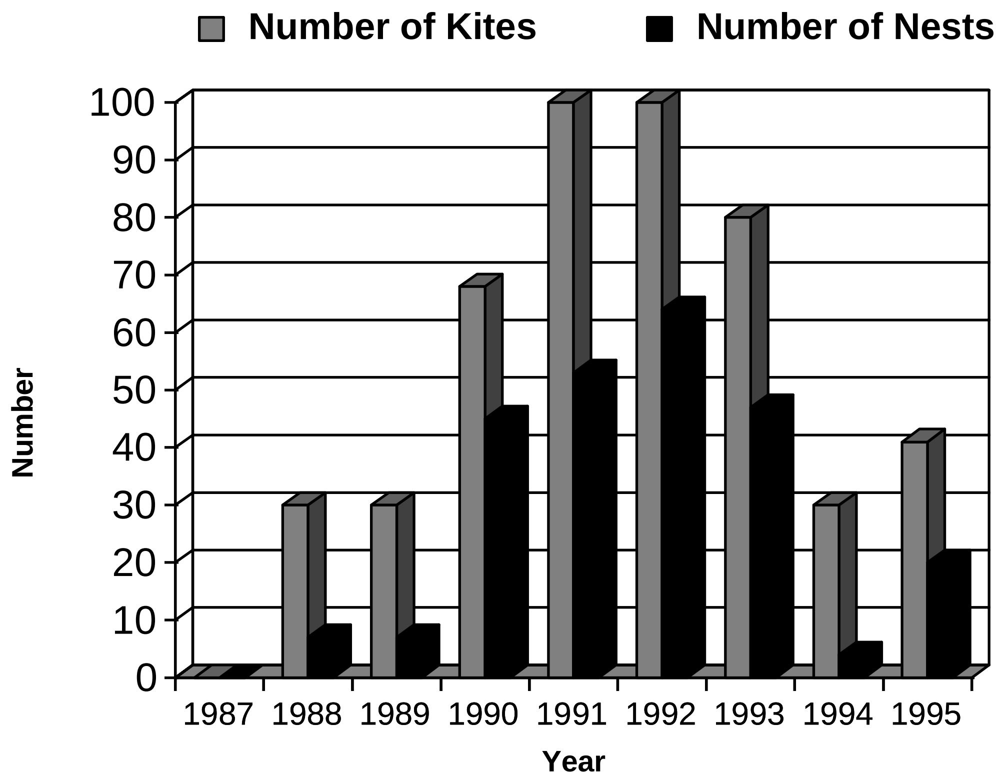

Figure 3. Number of kites censused in the BCWMA during the statewide mid-winter count and the number of nests observed in the BCWMA during the nesting season, 1987-1995**..**

more frequently than once every 1.6 to 1.7 years (Bennetts *et al.* 1988). To maximize nesting success it has been suggested that water depths of at least 1.5 ft should be maintained under nest sites during the breeding season (January to July) (Sykes 1987; Toland 1991). Optimal foraging habitats for snail kites may have longer hydroperiods than optimal nesting habitats although these habitats are not considered to be exclusive of each other. (R. Bennetts pers. comm.).

Implementing an intensive water management strategy designed solely to optimize hydrologic conditions for snail kites has never been attempted on any spatial scale. Intuitively it seems that managing water levels for kites would involve creating prolonged hydroperiods to benefit apple snails (Beissinger 1983; Beissinger 1988; Turner 1994). However, there is compelling evidence that this strategy will not work over the long-term. Prolonged hydroperiods in some areas of the Water Conservation Areas in South Florida apparently provided preferred habitat for only a few years; kites then abandoned such areas in favor of adjacent sites that had experienced more recent drydowns (U. S. Fish and Wildlife Service 1986; Bennetts *et al.* 1994). Exact mechanisms causing these population shifts are not well understood but are probably related to changes in habitat and/or apple snail availability (Bennetts *et al*. 1994).

Preliminary data currently being collected on the dispersal patterns of snail kites strongly suggest that protecting snail kite populations will require the development of a region-wide perspective to water management (Bennetts and Kitchens 1993). Radio telemetry data has revealed that kites regularly move throughout southern Florida to take advantage of local hydrologic conditions (Bennetts and Kitchens 1993). These movements, which are an adaptation needed to survive in a highly fluctuating environment, underscore the importance of maintaining a number suitable habitats throughout the species range (Takekawa and Beissinger 1989; Bennetts and Kitchens 1993). Because maintaining the integrity of individual marsh habitats is dependent upon periodic drydowns, it must be accepted that all habitats, including the BCWMA cannot be optimal for kites at all times.

4.1 Environmental Hydrologic Criteria for the BCWMA

Hydrologic criteria were developed for the BCWMA to meet two main objectives: 1) optimize habitat for snail kites and, 2) maintain the existing wetland habitat in its current state. These criteria were formulated to mimic most of the spatial and temporal attributes of a natural hydrologic regime, but yet maintain a minimum water level. The desired hydrologic regime is presented as a suite of hydrologic criteria which numerically address the individual attributes of mean water level, maximum water level, frequency, intensity and duration of annual drydown, seasonality of annual water level fluctuation and water level recession rate. Criteria have been refined through cooperative efforts involving the District, the Game and Fresh Water Fish Commission, the U. S. Fish and Wildlife Service, the University of Florida, and the Corps of Engineers. Criteria were developed taking into consideration the topography of the area and the known distribution of marsh vegetation communities along elevational gradients. They were further refined following numerous field trips to the area by involved agency staff.

4.1.1 Minimum Water Level

Although periodic drydowns are needed to maintain the existing marsh habitat, our knowledge about the necessary intensity and duration of these events is incomplete. A concern is that drydowns which are too extreme could cause a collapse of the apple snail population. Apple snail populations usually remain low for at least two years following an extreme drying event (U.S. Fish and Wildlife Service 1986; R. Bennetts pers. comm.). Extreme drydowns which occur with a greater return frequency than once every two years have the potential to prevent apple snail populations from reaching abundance levels which will support snail kites.

Based on documented kite use of the BCWMA, analysis of stage-area curves, and on-site visits by agency staff, 23.0 ft NGVD was established through interagency agreement as a lower critical limit for water level management. Approximately 76% of the acreage in the BCWMA, excluding Lake Miami Ranch, lies at or below this elevation (Table 1). Water levels should only rarely fall below 23.0 ft NGVD. This will ensure that the BCWMA experiences extended hydroperiods while still allowing flexibilty for experiencing drying events at the higher ground elevations. As more information on the relationships between hydrology and apple snail population dynamics is obtained, the lower critical limit of 23.0 ft NGVD may or may not have to be adjusted.

4.1.2 Criteria

The individual environmental hydrologic criteria and the basis for their selection as ecologically important components of the natural hydrology are:

- ***Mean Water Elevation*** ***The long term (30yr) average water elevation should be no less than 24.0 ft NGVD.***

A mean water level elevation criterion of 24.0 ft was established to provide extensive acreage of shallow, frequently inundated marsh. Water levels at 24.0 ft will inundate approximately 4,800 acres of the BCWMA to depths between 1.5 and 2.0 ft.

- ***Frequency of Inundation*** ***The long term frequency of inundation for the 24.0 ft NGVD contour should be at least 75%.***

A frequency of inundation criterion was needed in conjunction with mean depth criteria to insure that strongly skewed or bimodal depth frequency distributions do not occur. An inundation frequency of 75% was chosen to ensure a prolonged hydrology for this elevation (R. Bennetts pers. comm.).

- ***Maximum Water Elevations*** ***Water elevations should not exceed 26.0 ft NGVD for more than 30 continuous days more frequently than 1 year out of 10.***

Water levels at or above 26.0 ft NGVD, which occurred for an extended interval during 1991, were observed to severely stress many upland tree species in the eastern half of the BCWMA (B. Barnett; B. Toland pers. comm.). Many of these trees were used by snail kites for nesting. In addition, water levels above 26.0 ft will violate flood control constraints established for the BCWMA.

- ***Minimum Range of Annual Drydowns***

Fluctuations in water level are critical to establishing and maintaining both spatial and temporal aspects of habitat heterogeneity in marsh ecosystems. Water level fluctuations and their duration affect physical and chemical properties of wetlands such as nutrient availability, degree of substrate anoxia, sediment properties and pH (Mitsch and Gosselink 1986). These in turn directly impact the biotic components of the wetlands, such as plant species composition, diversity, and productivity. Slight alterations in the hydrologic regimes of wetlands can cause massive changes in plant community dynamics. In addition, reproductive strategies of many wetland animals are dependent upon water fluctuation cycles.

1. The 23.0 ft NGVD elevation should be exposed for at least one day not more frequently than once every 2.5 years but not less frequently than once every 4.5 years.

This criterion was established to prevent more extreme drydowns from occurring too frequently but yet ensuring that occasionally drydowns to this level will occur. At a water elevation of 23.0 ft, approximately 1,700 acres in the BCWMA (excluding Lake Miami Ranch) will be dry. Approximately 3,162 acres will have water depths of 6 inches or less and 2,180 acres will have depths greater than 6 inches. This is expected to provide enough refugia to ensure adequate survival of apple snail populations through the dry season. The return frequency of 2.5 years and 4.5 years corresponds to the lower and upper limits of the optimal drydown intervals for maintaining snail kite nesting habitats (Bennetts *et al.* 1988).

2. The 23.0 ft NGVD elevation should be exposed for 30 continuous days at least once every 5 to 7 years.

This criterion will allow for occasional drydowns to 23.0 ft NGVD to occur for a sufficient duration to rejuvenate the exposed marsh habitat. Drydown durations of 30 days correspond to the estimated minimum exposure interval needed to allow for seed germination of many species of herbaceous vegetation such as sawgrass (Alexander 1971; Gerritsen and Greening 1989).

3. The 22.5 ft NGVD elevation should be exposed for 30 continuous days once every 7 to 10 years.

This criterion will allow for infrequent exposure of the majority of acreage in the BCWMA. This drydown will expose the majority of sawgrass and deep marsh habitat.

4. The 22.5 ft NGVD elevation should not be exposed for 60 continuous days more frequently than once every 10 years.

This criterion will prevent more extensive drydowns from occurring for excessive durations.

5. The 22.0 ft NGVD elevation should be exposed for 30 continuous days once every 10 to 15 years.

This drydown will allow for complete exposure of the BCWMA at infrequent intervals.

- ***<u>Timing of Fluctuations</u> Timing of annual fluctuations should be such that minimum levels occur between April 1 and June 30 in more than 50% of the years and maximum levels occur between September 1 and November 31 in more than 50% of the years.***

Temporal aspects of water level fluctuations are as important as the magnitude of the fluctuations themselves. This criterion re-establishes the natural wet-dry season cycle.

- ***<u>Water Level Recession Rates</u> Recession rates when stages are above 24.5 ft are unregulated. When water levels are at or below 24.5 ft, recession rates should not exceed 1.2 feet during any 30 day period or exceed 0.5 feet during any 7 day period.***

Water level recession rates can have a dramatic impact on wetland animal communities. This criterion was derived from historical stage data for the Blue Cypress Marsh Conservation Area.

These hydrologic criteria should not be viewed as specific goals for active water management, but instead, should be viewed as constraints which form the boundaries of an acceptable long-term hydrologic regime. Long-term hydrologic statistics for the BCWMA should fall within these boundaries while still maintaining the stochastic variability of a natural hydrologic regime. The Water Management District will utilize, as necessary, the authority given to it under Chapter 373 F. S. (e.g. Reservation of Water and/or setting Minimum Flows and Levels) to ensure that any permitted use of water from the BCWMA will not cause these hydrologic criteria to be violated.

4.2 Zone B Regulation Schedules for the BCWMA

Zone B discharge schedules for Structure S-96D (Figure 2) were developed to meet the environmental hydrologic criteria for the BCWMA. Historic rainfall data and consumptive use assumptions for the SJWMA were incorporated into the Upper Basin hydrologic model (Suphunorranop and Tai 1982) to produce simulated daily water levels for the BCWMA under a variety of project conditions. A total of 16 separate model simulations were conducted to refine a water management schedule which would best meet the hydrologic criteria. Under these hydrologic simulations, S-251 remained open and water levels were equalized between BCWMA-East and BCWMA-West.

The model simulations which best met the overall hydrologic criteria were created from the following water management schedule:

When water levels in the SJWMA reach 19.7 ft NGVD, 300 cfs is discharged from the BCWMA through S-96D until such time that 1) water levels in the SJWMA reach or exceed 21.0 ft NGVD, or 2) water levels in the BCWMA reach or fall below 23.2 ft NGVD.

Water releases from the BCWMA were initiated based on water levels in the SJWMA in order to maintain natural stochastic variability in the hydrologic regime. Maintaining a regulation schedule based on water levels in the BCWMA alone would tend to stabilize water levels between allowable seasonal highs and lows.

4.3 Simulated Hydrology for the BCWMA

The discharge schedule presented above will restore many of the temporal and spatial aspects of the natural hydrologic cycle to the BCWMA (Table 2). Approximately 70% of the area (5,000 acres) will experience hydrologic conditions specified by the criteria. Approximately 1,700 acres of the BCWMA lying below the 22.5 ft contour may be subject to flooding of sufficient duration to adversely impact some vegetation communities.

Table 2. Environmental hydrologic criteria-related performance summary for the BCWMA.

Criteria	Criteria	Simulated From 1942-1989 Data	Criteria Met?
Mean Water Level	24.0 ft	24.4	Yes
Freq. of Inundation	24.0 ft = 75%	73.5%	Nearly
Maximum Water Elevation 30 Day	More than 1/10 Years Not To Exceed: 26.0 ft	Never Occurred	Yes
Range of Annual Drydowns		Occurred :	
1 Day	Down to 23.0 ft Once Every 2.5 to 4.5 Years.	Once Every 2.8 Years	Yes
30 Day (Continuous)	Down to 23.0 ft At Least Once Every 7 Years.	Once Every 3.1 Years	Yes
30 Day (Continuous)	Down to 22.5 ft At Least Once Every 10 Years.	Once Every 23.5 Years	No
30 Day (Continuous)	Down to 22.0 ft At Least Once Every 15 Years.	Never Occurred	No
60 Day (Continuous)	Should Not Go Down To 22.5 More Frequently Than Once Every 10 Years.	Once Every 47 Years	Yes
Timing of Fluctuation	During > 50% of Years Occurred Between	Occurred in:	
One-Day Yearly Min.	Apr. 1 - June 30	77.0% of Years	Yes
One-Day Yearly Max.	Sept. 1 - Nov. 31	60.0% of Years	Yes
Recession Rates	> Than 95% of Time	Met Greater than:	
7 Day	< 0.5 ft	99% of time	Yes
30 Day	<1.2 ft	96% of time	Yes

- ***Mean Water Elevation* - Criterion Met**

The simulated mean water elevation under this plan is 24.42 ft NGVD (Table 2; Figure 4). This exceeds the criterion value by over 0.4 ft. The average annual water level fluctuation is 2.72 ft. Under this plan water levels never fell below 22.0 ft NGVD.

- ***Frequency of Inundation* - Criterion Nearly Met**

The frequency of inundation of the 24.0 ft NGVD elevation is 73.5%. This is slightly under the criteria value of 75% (Table 2; Figure 5).

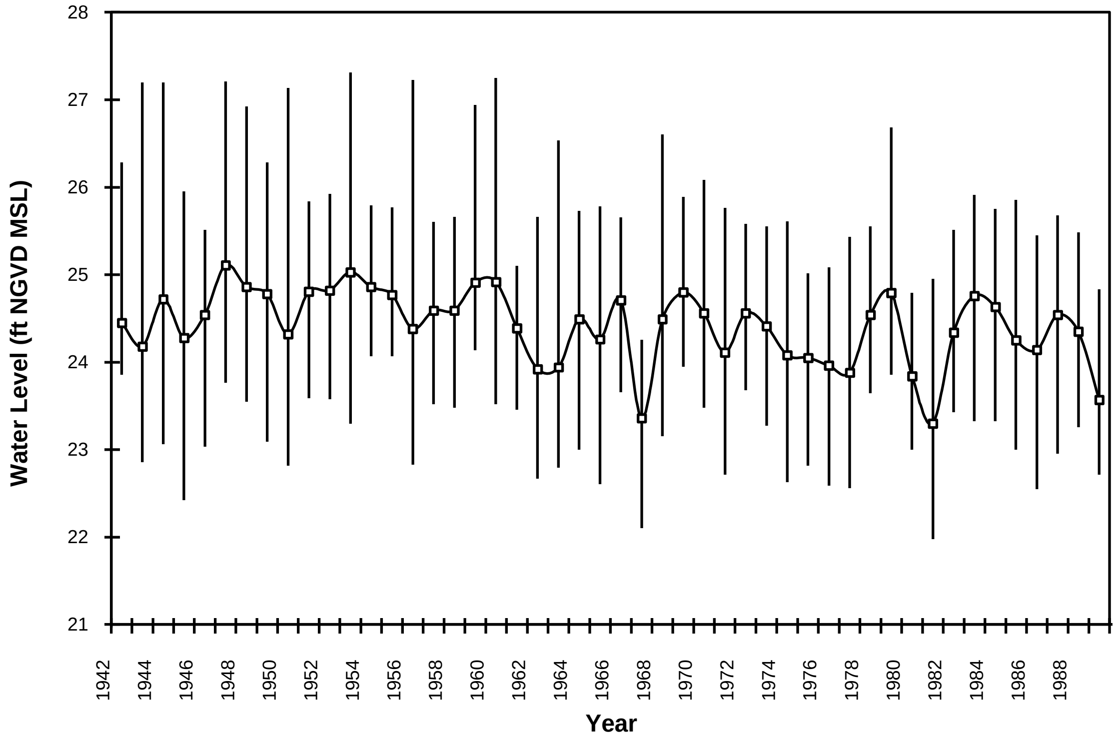

Figure 4**.** Simulated yearly mean stages for the BCWMA. Boxes represent mean values and vertical bars represent annual range of fluctuation. The mean level for all years was 24.42 ft and the average annual fluctuation was 2.72 ft.

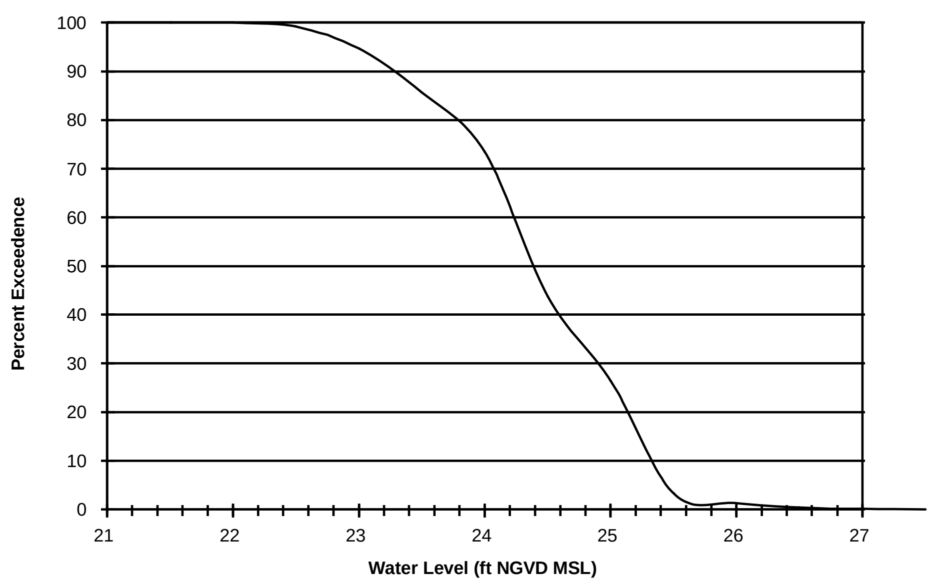

Figure 5. Simulated inundation frequencies for the BCWMA. Based on simulated data for the period 1942 to 1989.

♦ ***Maximum Water Levels* - Criterion Met**

The maximum water level criterion was not exceeded (Table 2; Figure 6). The highest 30-day continuous water level was 25.71 ft NGVD. Water levels exceeded 26.0 ft NGVD for 14 continuous days in only 5 of the 47 simulated years (11%).

♦ ***Minimum Range of Annual Drydowns* - Not All Criteria Met**

1. One-Day 23.0 ft NGVD Water Level - Criterion Met

The one-day low water elevation of 23.0 ft NGVD was reached once every 2.8 years (Figure 4; Table 3).

2. 30-Day 23.0 ft NGVD Water Level - Criterion Met

The 23.0 ft NGVD contour was exposed for 30 continuous days once every 3.1 years (Table 3).

3. 30-Day 22.5 ft NGVD Water Level - Criterion Met

The 22.5 ft contour was exposed for 30 continuous days once every 23.5 years (Table 3).

4. 60-Day 22.5 ft NGVD Water Level - Criterion Met

The 22.5 ft NGVD contour was exposed for 60 continuous days only once every 47 years (Table 3).

5. 30-Day 22.0 ft NGVD Water Level - Criterion Not Met

The 22.0 ft contour was never exposed (Table 3).

♦ ***Timing of Fluctuation* - Criteria Met**

Criteria were met under this simulation. Annual high water levels occurred between September 1 and November 31 in 60% of the years while annual lows occurred between April 1 and June 30 in 77% of the years (Table 2).

♦ ***Stage Recession Rates* - Criteria Met**

Recession rate criteria were met under this management plan (Table 2). Over 98% of the time during any 7-day period, water levels receded 6 inches or less. Over 99.5% of the time water levels during any 7-day period fell less than 9 inches. Over 99% of the time, water levels fell less than 1.2 ft during any 30-day period.

Table 3. Simulated yearly return frequencies of 1,7,14, 30, 60, and 120 continuous-day drydown intervals for the BCWMA. This table was created from simulated water level data over the period 1942 to 1989. As an example, during this 47 year period water levels were below the 23.0 ft elevation for 60 continuous days every 9.4 years. However, water levels were below 23.0 ft for 30 continuous days on the average of once every 3.1 years.

	Interval (No. of Days)					
Elevation	1	7	14	30	60	120
22.00	0	0	0	0	0	0
22.25	23.5	23.5	47.0	47.0	0	0
22.50	15.7	23.5	23.5	23.5	47.0	0
22.75	4.3	5.2	6.7	11.8	23.5	0
23.00	2.8	2.9	2.9	**3.1**	**9.4**	47.0
23.25	2.0	2.0	2.2	2.6	2.9	15.7
23.50	1.5	1.8	1.9	2.1	2.5	9.4
23.75	1.2	1.2	1.5	1.9	2.2	5.2
24.00	1.1	1.1	1.1	1.3	1.9	3.4
24.25	1.0	1.0	1.1	1.2	1.5	2.2
24.50	1.0	1.0	1.0	1.0	1.2	1.7
24.75	1.0	1.0	1.0	1.0	1.1	1.4
25.00	1.0	1.0	1.0	1.0	1.0	1.2
25.25	1.0	1.0	1.0	1.0	1.0	1.0

5.0 Ecological Assessment of the Simulated Hydrologic Regime

This water management plan is designed to restore many of the spatial and temporal attributes of the natural hydrologic cycle. This reflects an ecosystem-based approach to management which should help maintain the habitat and protect endangered species. A similar approach is being taken in the Everglades where restoration and preservation efforts are focusing on restoring the natural hydrologic cycle and preventing further compartmentalization of the remaining system (Holling *et al.* 1994; Davis and Ogden 1994). Where this plan differs from a total ecosystem-based approach is that minimum water levels will be maintained to protect kites. The impacts of the hydrology created by this plan on kites, apple snails and the habitat needs to be rigorously evaluated.

Under this plan over 6,200 acres in the BCWMA which lie at ground elevations less than 23.5 ft NGVD (89% of the total area), will be subjected to inundation frequencies exceeding 85% (Figure 5). The range of inundation frequencies considered optimal for snail kite habitat is 85% to 100% (R. Bennetts pers. comm.). At a water elevation of 23.0 ft NGVD, approximately 5,300 acres of the BCWMA will be inundated and 1,700 acres will be dry. Drydowns to the 23.0 ft NGVD elevation will occur for one day once every 2.8 years and for 30 days once every 3.1 years (Table 3). These return frequencies are within the optimal range of the habitat suitability model presented by Bennetts *et al.* 1988. Bennetts *et. al* (1988) derived this interval from comparisons of documented kite use of several different areas to the return drydown frequencies of those areas.

5.1 Vegetation

Ground elevations below 23.0 ft NGVD (approximately 1,700 acres) will be subjected to inundation frequencies exceeding 95% (Figure 5). Although prolonged hydroperiods are known to benefit apple snail populations, long hydroperiods could also slowly change the habitat at lower elevations by causing shifts in the vegetation community (Worth 1983; Urban *et al.* 1993). These shifts include a loss of more woody species, a decrease in sawgrass, an increase in cattails and a gradual shift to more slough-like communities. To evaluate the potential impacts of this proposed hydrologic schedule the distributions of plant communities along various contour intervals were calculated (Tables 4 and 5). Data were tabulated separately for BCWMA-East and BCWMA-West; BCWMA-East data does not include the Jewish Federation.

Seventy-two percent of the sawgrass communities in BCWMA-West and 87% of the sawgrass community in BCWMA-East lie below the 23.0 ft NGVD contour (95% inundation frequency; Tables 4 and 5; Figure 5). Inundation frequencies exceeding 95% may be sufficient to cause a shift from sawgrass to more slough like plant communities or cattail. Lowe (1986) reported that sawgrass was not found in areas of the Blue Cypress Marsh where inundation frequencies exceeded 85%. Sawgrass reached peak abundance in areas of the St. Johns River Valley that were inundated 30% to 40% of the time (Sincock 1958). Zaffke (1983) reported sawgrass was found within the inundation frequency range of 15% to 94%. In the Loxahatchee National Wildlife Refuge sawgrass occupied elevations which experienced inundation frequencies from 5% to 65% (U.S. Dept. of Interior 1972). Gunderson (1990) reported that sawgrass occurred at sites in Everglades National Park which were inundated an average of 198 (53%) to 317 (87%) days per year . Sawgrass was not recorded at the wettest site which was inundated an average of 337 days (92%) per year. Prolonged hydroperiods were found to be conducive to cattail replacement of sawgrass in Water Conservation Area 2A (Urban *et al*. 1993). Periodic drydowns appeared to at least temporarily reduce cattail densities in areas where encroachment occurred.

Prolonged inundation frequencies may also cause shifts in *Panicum* dominated communities. Approximately 82% of this community in BCWMA-East lies below the 23.0 ft NGVD contour (Table 4). Extensive wet prairie communities generally in occur in areas where periodic drying occurs (Worth 1983) although optimum inundation frequencies documented for this community range from 40% to 90% (Sincock 1958; U.S. Dept. of Interior 1972; Zaffke 1983; Lowe 1986). Drying events are apparently critical for germination of many species found in this community (Worth 1983). Without occasional drying, wet prairie communities will probably shift toward more slough-like (*Nymphaea*) and open water conditions.

Plant community shifts in the BCWMA could impact apple snails and their availability to kites by reducing emergent vegetation substrate. Apple snails must surface periodically to breathe and lay eggs. This is accomplished by climbing plant stems. Studies conducted in the BCWMA-East indicate that apple snail clutch densities were greatest along the edge of sawgrass strands and in mixed shallow marshes (Turner 1994). No clutches were observed in

Table 4. Percent of vegetation communities in BCWMA-East which will be exposed at a given water elevation. Results are based on 497 data points. Analysis does not include the Jewish Federation.

Ground			Vegetation	Community		
Elevation	Cattail	Deep Marsh	Sawgrass	Panicum	Willow	Mixed Trees
21.00	100	100	100	100	100	100
21.25	100	100	100	100	100	100
21.50	100	98	100	100	98	100
21.75	100	94	100	100	98	100
22.00	86	62	94	94	95	99
22.25	86	49	87	81	90	99
22.50	62	25	52	59	67	93
22.75	33	13	30	42	55	89
23.00	14	7	13	18	36	76
23.25	5	3	4	8	17	64
23.50	0	1	3	1	5	50
23.75	0	0	0	0	5	38
24.00	0	0	0	0	0	24
24.25	0	0	0	0	0	14
24.50	0	0	0	0	0	10
24.75	0	0	0	0	0	4
25.00	0	0	0	0	0	3
25.25	0	0	0	0	0	1
25.50	0	0	0	0	0	0

Table 5. Percent of vegetation communities in BCWMA-West which will be exposed at a given water elevation. Results are based on 322 data points.

Ground		Vegetation	Community		
Elevation	Cattail	Deep Marsh	Sawgrass	Cypress	Willow
21.00	100	100	100	100	100
21.25	100	100	100	100	100
21.50	100	100	100	100	100
21.75	100	99	100	100	100
22.00	100	91	100	100	100
22.25	100	74	99	100	100
22.50	92	31	86	100	100
22.75	77	16	67	82	84
23.00	31	1	28	65	63
23.25	0	0	8	41	11
23.50	0	0	2	24	5
23.75	0	0	1	12	0
24.00	0	0	0	6	0

slough communities which are dominated primarily by white water lily (*Nymphaea odorata*). This information suggests that vegetation shifts to more slough-open water conditions could potentially cause a decrease in clutch production. In addition, conversion of sawgrass to cattail could negatively influence snails and /or their availability to kites by changing bottom substrate composition, altering dissolved oxygen dynamics and reducing availability of foraging habitats (Worth 1983; Bennetts *et al.* 1994).

Approximately 76% of the mixed tree community in the BCWMA-East will experience inundation frequencies exceeding 73% (Tables 4 and 5). In addition, over 90% of the community will experience inundation frequencies which exceed 40%. Many woody species will not be able to survive these conditions, especially those trees which occupy ground elevations below 23.0 ft NGVD. The loss of some of the woody terrestrial vegetation which has been used by kites for nesting in the past few years (Toland 1991; 1993) is expected. However, this loss is not expected to adversely impact overall kite nesting efforts or nesting success because of the abundance of other suitable nesting substrates within or in close proximity to the BCWMA (R. Bennetts pers comm.).

5.2 Wood Storks

During the past few years wood storks (*Mycteria americana*) foraged in the BCWMA in late summer or fall, when water levels in some areas receded to depths of 6 inches or less (Toland 1993). During these years drydowns usually occurred in the fall instead of late spring, because water levels were held as high as possible during the snail kite nesting season. Flocks of as many as 150 wood storks were observed in the BCWMA. Wood stork nesting success is extremely dependent on spring drydowns to concentrate forage fishes (Kushlan *et al.* 1975). The simulated hydrology of the BCWMA under this plan indicates that the natural spatial and temporal aspects of water level fluctuations will be re-established. Average annual 30-day drydowns to 23.54 ft NGVD will result in large acreage's of the BCWMA being shallowly flooded each year. This should create optimal foraging conditions for storks as well as a number of other wading bird species.

Wood storks used the BCWMA for nesting only in the spring of 1992. Seven nesting pairs used a cypress dome in Ansin-West (Toland 1993) and successfully fledged 3 young. These birds may have been a satellite colony of a major wood stork colony found at Pelican Island National Wildlife Refuge (Toland 1993). Nesting was initiated in April when water levels in Ansin-West were approximately 23.5 ft NGVD. Water levels in Ansin-West declined to approximately 22.5 ft NGVD on June 3 but had risen to greater than 24.0 ft NGVD by June 15. At this time water levels in Ansin-East were being regulated separately from Ansin-West and for the most part were about one foot higher in Ansin-East. Drydowns from 23.5 to 23.0 ft will occur regularly during the late dry season under this plan. This should benefit wood stork nesting efforts.

5.3 Bald Eagles

One pair of bald eagles (*Haliaeetus leucocephalus*) has successfully maintained a nest site in the Jewish Federation since 1990 and fledged at least three young (Toland 1993). The original nest tree, a slash pine, was reportedly killed by high water conditions in 1991. The nest was subsequently lost in 1993 when high winds broke off the top of the tree. The nest was rebuilt in another pine in the same approximate area as the original nest later in 1993. The ground elevation occupied by this new tree is unknown. High water levels could potentially adversely impact this tree, however; there are an abundance of other nest sites available in the area.

6.0 Water Quality Issues

Water quality is as important as water quantity in maintaining the habitat in the BCWMA. Controlling nutrients is essential to preventing extreme cattail and hyacinth proliferation. Acceptable water quality criteria (both concentrations and total loading) for agricultural waters discharged into the BCWMA have yet to be developed. When water quality criteria are established, The St. Johns River Water Management District will initiate rule-making activities as necessary to ensure that any permitted discharge of water into the BCWMA will not cause these criteria to be violated. Additional measures which may be enacted to protect water quality over the short-term include blocking some canals and flow-ways which allow for direct access of nutrient enriched water to the marsh.

7.0 Ecological Monitoring

It has become apparent that managing water levels in the BCWMA for snail kites while trying to maintain the integrity of the existing habitat requires "a fined-tuned balancing act for which we have very coarse information" (R. Bennetts pers. comm.). Some biologists involved with establishing the hydrologic criteria feel strongly that hydroperiods which are too long will ultimately degrade the habitat, while others feel that drydowns which occur too frequently or are too extensive, will have the same impact.

Ensuring that the environmental objectives established for this area are met will require implementation of an intensive biologic, hydrologic and water quality monitoring program. Biological monitoring is needed to ensure that any habitat changes which may occur are detected in a timely manner. If biological changes are considered to be undesirable, the hydrologic criteria may have to be modified. A decision tree which can be used to implement changes in the hydrologic criteria has been formulated and is presented in the Draft Environmental Water Management Plan for the Upper St. Johns River Basin Project (Miller *et al.* 1993).

The decision tree process can also be used to implement emergency water management actions. For example, if severe drought conditions exist in other major kite habitats, water levels in the BCWMA may be held high to provide refugia. This scenario occurred in 1991 when severe drought conditions in Lake Okeechobee and Water Conservation Area 3A forced kites from these areas. During that year the BCWMA supported nearly 140 birds.

The biological monitoring program for the BCWMA is currently in the development stage. Until this plan is complete, the SJRWMD is monitoring water quality and hydrology. Vegetation is being monitored by aerial photography whereas snail kites are being monitored by the statewide snail kite project under contract to the SJRWMD.

8.0 Literature Cited

Alexander, T. R. 1971. Sawgrass biology related to the future of the Everglades ecosystem. *Proc. Soil and Crop Soc. of Fla.* 31:72-74.

Bennetts, R. E., M. W. Collopy, and S. R. Beissinger. 1988. *Nesting ecology of snail kites in Water Conservation 3A*., Department of Wildlife and Range Science, University of Florida, Gainesville, Florida Cooperative Fish and Wildlife Research Unit Technical Report Number 31.

Bennetts, R. E. and H. Maier. 1992. *1991 mid-winter snail kite survey*. Department of Wildlife and Range Science, University of Florida, Gainesville, Florida Cooperative Fish and Wildlife Research Unit Unpublished Report.

Bennetts, R. E., and W. M. Kitchens. 1993. *Estimation and Environmental Correlates of Survival and Dispersal of Snail kites in Florida.* 1993 Annual Progress Report to the U. S. Dept. of the Interior. Florida Cooperative Fish and Wildlife Research Unit, Gainesville, Fla.

Bennetts, R. E., M. W. Collopy and J. A. Rodgers Jr. 1994. The snail kite in the Florida Everglades: a food specialist in a changing environment. in *Everglades: The Ecosystem and Its Restoration,* S. M. Davis and J. C. Ogden (Eds.) St. Lucie Press, Delray Beach, Fla.

Bennetts, R. E., M. J. Steinkamp, and W. M. Kitchens. 1995. *Numbers, distribution, and success of nesting snail kites in the Blue Cypress Water Management and Conservation areas.* Final report prepared for the St. Johns River Water Management District, Palatka, Fla. 20 pp.

Beissinger, S. R. 1983. *Nest failure and demography of the snail kite: effects of Everglades water management.* Annual Report to the U. S. Fish and Wildlife Service. Atlanta, Ga. 22p.

Beissinger, S. R. 1988. The snail kite. in *Handbook of North American Birds,* R. S. Palmer (Ed.) Yale University Press, New Haven Conn., pp. 148-165.

Davis, S. M., and J. C. Ogden 1994. Toward ecosystem restoration. in *Everglades: The Ecosystem and Its Restoration,* S. M. Davis and J. C. Ogden (Eds.) St. Lucie Press, Delray Beach, Fla.

Gerritson, J., and H. S. Greening. 1989. Marsh seed banks of the Okefenokee Swamp: effects of hydrologic regime and nutrients. *Ecology* 70(3):750-763.

Gunderson, L. H. 1990. Historical hydropatterns in wetland communities of Everglades National Park. in R. R. Sharitz and J. W. Gibbons (Eds.) *Freshwater Wetlands and Wildlife* Department of Energy Symposium Series No. 61, Savannah River Ecology Laboratory, Savannah, S.C.

Holling, C.S., L. H. Gunderson and C. J. Walters 1994. The structure and dynamics of the Everglades System: guidelines for ecosystem restoration. in *Everglades: The Ecosystem and Its Restoration,* S. M. Davis and J. C. Ogden (Eds.) St. Lucie Press, Delray Beach, Fla.

Howell, A. H. 1932. *Florida bird life.* Coward-Mcann Inc. 579 pp.

Kushlan, J. A. 1975. Population changes of the apple snail, Pomacea paludosa, in the southern Everglades. *Nautilus* 89:21-23.

Kushlan, J. A., J. C. Ogden and L. A. Higer. 1975. *Relation of water level and food availability to wood stork reproduction in the southern Everglades, Florida*. U.S. Geological Survey Open File Report 75-434. Tallahassee, Fla.

Lowe, E. 1986. The relationship between hydrology and vegetational pattern within the floodplain marsh of a subtropical, Florida lake. *Florida Scientist* 49(4):213-233.

Miller, S. J., M. A. Lee, A. K. Borah and E. F. Lowe 1993 *Draft environmental water management plan for the Upper St. Johns River Basin Project* St. Johns River Water Management District Draft Technical Publication. Palatka, Fla.

Mitsch, W. J. and J. G. Gosselink. 1986. *Wetlands*. Van Nostrand Reinhold Co. New York N.Y.

Nicholson, D. J. 1926. Nesting habits of the Everglades kite in Florida. *Auk.* 43:62-67.

Rogers, J. A. Jr. 1988. *Threatened and endangered bird research*. Annual Performance Report No. E-1-12-II-H-1-7520. Florida Game and Fresh Water Fish Commission, Tallahassee, Fla. 11pp

Sincock, J. L. 1958. *Waterfowl ecology in the St. Johns River Valley as related to the proposed conservation areas and changes in the hydrology from Lake Harney to Ft. Pierce, Florida.* Florida Game and Fresh Water Fish Commission Final Project Report W-19-R. Tallahassee, Fla.

Suphunvorranop, T., and C. T. Tai. 1982. *Upper St. Johns Hydrologic Model Users Manual*. St. Johns River Water Management District Technical Publication 82-4. Palatka, Fla.

Sykes, P. W. 1983. Snail kite use of the freshwater marshes of South Florida. *Florida Field Naturalist* 11:73-88.

Sykes, P. W. 1987. Snail kite nesting ecology in Florida. 1987. *Florida Field Naturalist* 15(3):57-84.

Takekawa, J. E., and S. R. Beissinger. 1989. Cyclic drought, dispersal, and the conservation of the snail kite in Florida: lessons in critical habitat. *Conservation Biology* 3(3):302-311.

Toland, B. 1991. *Snail Kite ecology in the Upper St. Johns River basin*. Florida Game and Fresh Water Fish Commission, Annual Performance Report, Vero Beach, Fla.

Toland, B. 1993. *Snail Kite ecology and status reports of other species of regional concern in the Upper St. Johns River marshes*. Florida Game and Fresh Water Fish Commission, 1990-1993 Final Performance Report to the St. Johns River Water Management District, Palatka, Fla.

Townsend, C. W. 1927. Notes on the courtship of the lesser scaup, Everglade kite, crow, and boat-tailed grackles. *Auk.* 44:549-554.

Turner, R. L. 1994. *The effects of hydrology on the population dynamics of the apple snail (Pomacea paludosa)*. St. Johns River Water Management District Technical Publication SJ94-SP3, Palatka, Fla.

Urban, N. H., S. M. Davis, and N. G. Aumen. 1993. Fluctuations in sawgrass and cattail densities in Everglades Water Conservation Area 2A under varying nutrient, hydrologic and fire regimes. *Aquatic Botany* 46:203-223.

U. S. Army Corps of Engineers. 1991. *Preliminary water control manual central and southern Florida project for flood control and other purposes*. Department of the Army Jacksonville District, Jacksonville, Fla.

U. S. Department of the Interior. 1972. *A preliminary investigation of the effects of water levels on vegetative communities of Loxahatchee National Wildlife Refuge, Florida.* U.S. Dept. of the Interior Bureau of Sport Fisheries and Wildlife Report, Washington, D. C.

U. S. Fish and Wildlife Service. 1986. *Florida snail kite recovery plan (Rostrahamus sociablis plumbeus)* revised recovery plan. U. S. Fish and Wildlife Service, Atlanta, Ga.

Worth, D. 1983. *Preliminary responses to marsh dewatering and reduction in water regulation schedule in Water Conservation Area - 2A.* South Florida Water Management District Tech. Pub. 83-6, West Palm Beach, Fla.

Zaffke, M. 1983. *Plant community of Water Conservation Area 3A; baseline documentation prior to the operation of S-339 and S-340.* South Florida Water Management District Tech. Mem., West Palm Beach, Fla.