CHAPTER 13. FLOODPLAIN WILDLIFE

by

Donna Curtis

St. Johns River Water Management District
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FLOODPLAIN WILDLIFE WORKING GROUP

Name (Organization)	**Role**
Donna Curtis (SJRWMD)	Author
Ed Lowe (SJRWMD), Ph.D.	Reviewer
Larry Battoe (SJRWMD), Ph. D.	Reviewer
Erich Marzolf (SJRWMD), Ph.D.	Reviewer

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ACRONYMS, ABBREVIATIONS, AND CONVERSION FACTORS

AQ	Aquatic
CFR	Code of Federal Regulation
CS	Cypress swamp
DM	Deep marsh
FAC	Facultative
FACW	Facultative wet
FW	Freshwater
FWC	Florida Fish and Wildlife Conservation Commission
HH	Hydric hammock
HS	Hardwood swamp
L	Listed species
NA	No analysis
NRCS	Natural Resources Conservation Service
OBL	Obligate
OW	Open freshwater
RN	Rookery nesting
SJRWMD	St. Johns River Water Management District
SM	Shallow marsh
SS	Shrub swamp
SSC	Species of special concern
SW	Estuarine
TS	Transitional shrub
UPL	Upland
USFWS	United States Fish and Wildlife Service
USGS	United State Geological Survey
WP	Wet prairie
WSIS	Water Supply Impact Study

1 ABSTRACT

The Floodplain Wildlife Working Group evaluated the potential effects of water withdrawals on the river's wildlife fauna. Wildlife responses to hydrologic conditions in the floodplain are qualified using information from the scientific literature and results from the Water Supply Impact Study working groups for wetland vegetation, benthic macroinvertebrates, and fish. Results from the working groups for water withdrawal model scenarios of 155 mgd or greater support the need for supplemental water sources within the St. Johns River basin. No direct effects are anticipated for the distributions and abundances of floodplain wildlife in cases where water supply scenarios are 77.5 mgd and include water discharges from the Upper St. Johns River Basin Project.

2 INTRODUCTION

2.1 FLOODPLAIN WILDLIFE EVALUATION

The St. Johns River Water Management District (SJRWMD) Water Supply Impact Study (WSIS) joins the wildlife evaluation to the results of several working groups. Evaluations by the working groups for Wetland Vegetation (see Chapter 10), Benthic Macroinvertebrates (see Chapter 11), and Fish (see Chapter 12) collectively applied seven water withdrawal scenarios (Table 2–1), including the Full2030PN for a specific analysis by the Benthic Macroinvertebrate Working Group. Using the analyses, the floodplain wildlife evaluation qualifies wildlife responses to predicted changes in hydrology, wetland habitats, and floodplain production of benthic macroinvertebrates and fish for specific river segments (Figure 2-1).

Table 2–1. Water withdrawal scenarios used in the floodplain wildlife evaluation.*

Scenario Name	Withdrawal Rate (mgd)	Land Use	Upper Basin Projects	Sea Level Rise
FwOr1995NN	262	1995	No	No
FwOR2030PS	262	2030	Yes	Yes
Full1995NN	155	1995	No	No
Full1995PN	155	1995	Yes	No
Half1995PN	77.5	1995	Yes	No
Full2030PN	155	2030	Yes	No
Half2030PS	77.5	2030	Yes	Yes
Full2030PS	155	2030	Yes	Yes

*See Chapter 6. (River Hydrodynamics Results) for a discussion of the scenarios.

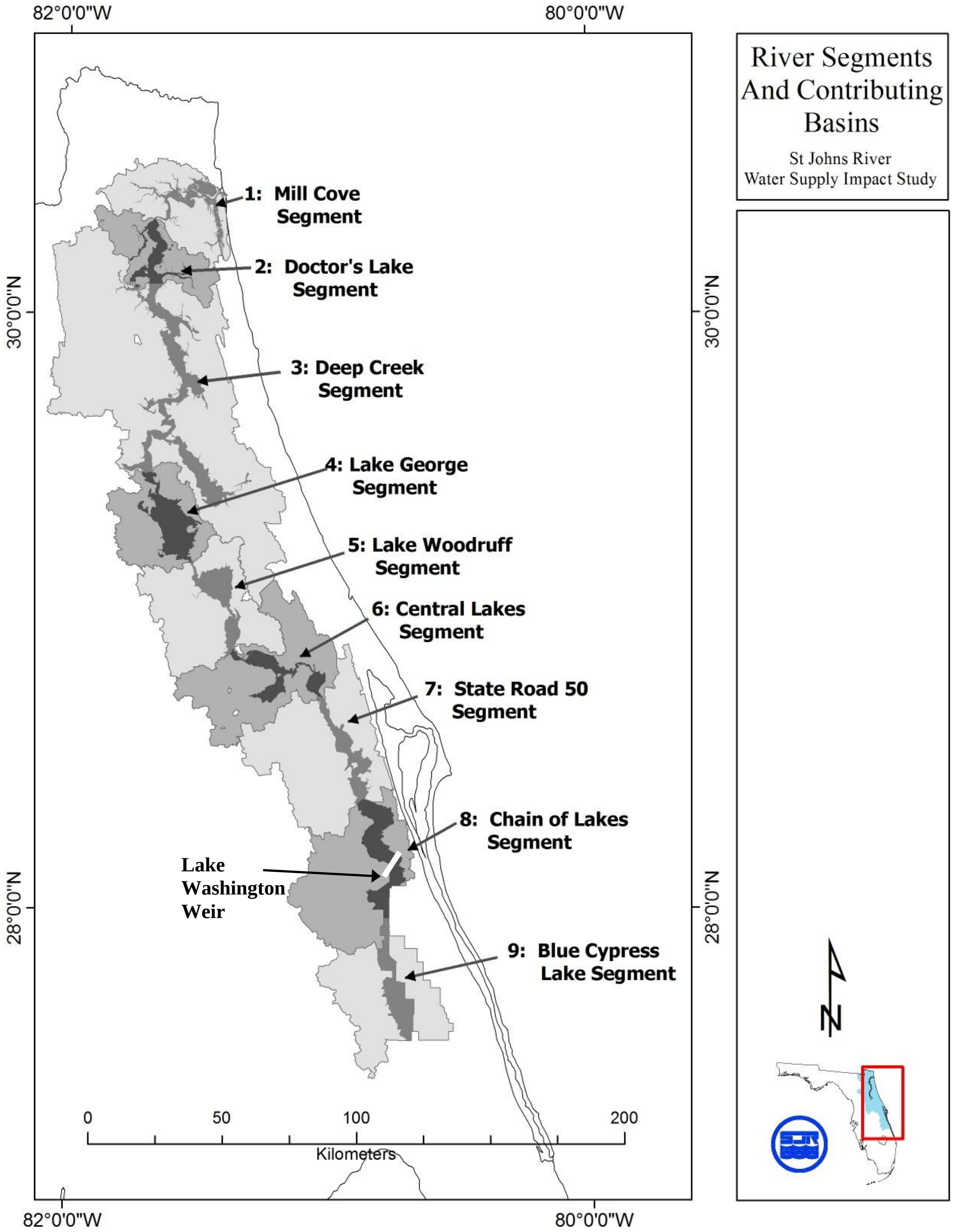


Figure 2–1. River segments of the St. Johns River.*

*Map indicates the river and associated wetland areas (shaded in dark grays) and drainage basins (shaded in light grays)

2.2 CONCEPTUAL MODEL FOR THE FLOODPLAIN WILDLIFE EVALUATION

Hydrologic regimes largely determine the biodiversity of wetland systems (Richter et al. 1996). Hydrology is a strong determinant for floodplain productivity with respect to prey availability and abundance (Vannote et al. 1980; DeAngelis et al. 1997; Poff et al. 1997; Poff and Zimmerman 2010). The conceptual model for the floodplain wildlife evaluation (Figure 2–2) assumes a hydrologically driven system where water depth, duration, seasonal pattern, and flow-related salinity determine wildlife species composition and faunal distribution.

The conceptual model begins with the integration of the hydrologic and hydrodynamic modeling process (see chapters 3 through 6) as analyzed and interpreted by the Wetland Vegetation (see Chapter 10), Benthic Macroinvertebrates (see Chapter 11), and Fish (see Chapter 12) working groups. Chain of causation is represented by the five major hydrologic drivers or attributes that affect floodplain wildlife: water depth, annual inundation rate (or hydroperiod), hydropattern (including return intervals), recession rate, and salinity. Predictive variables are qualitative only. With few exceptions, supporting information was taken from the literature and input data from the working groups.

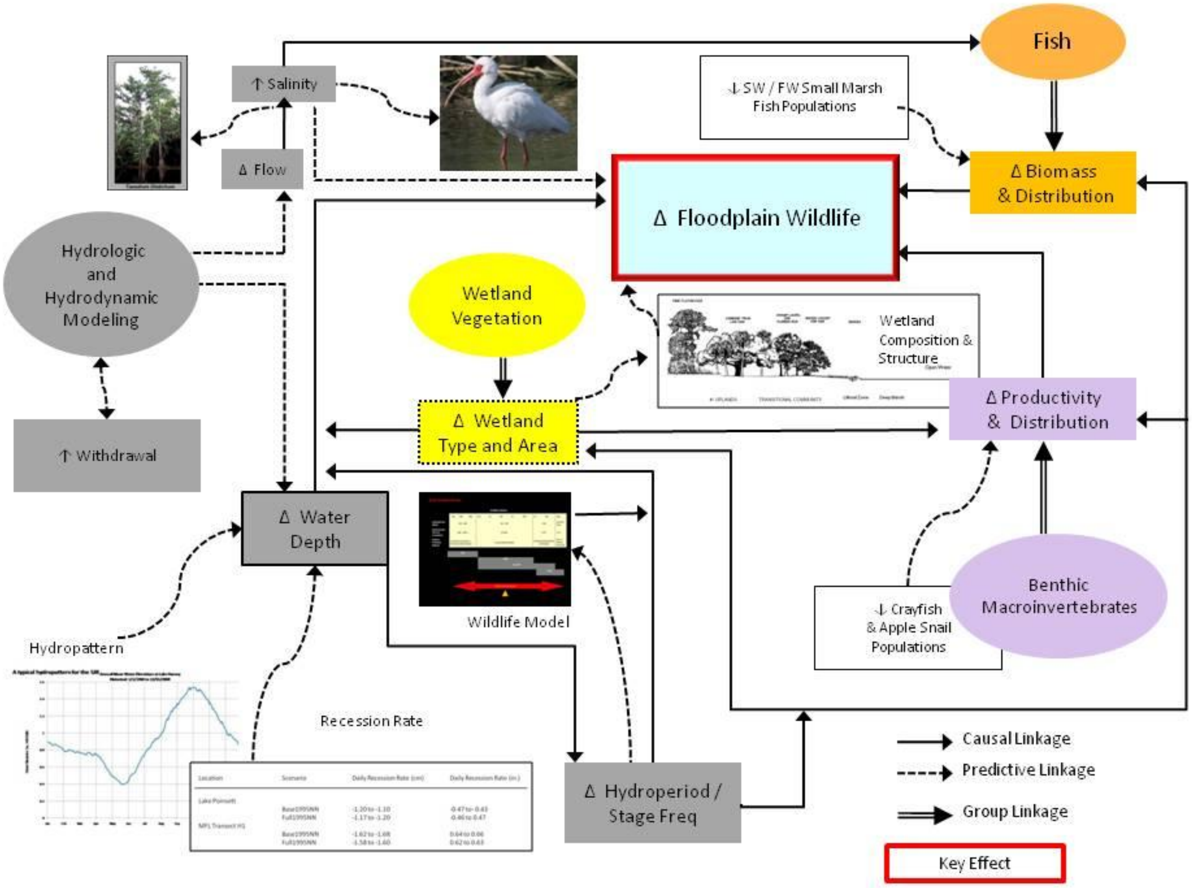


Figure 2–2. Conceptual model for the floodplain wildlife evaluation.

3 METHODS

3.1 WILDLIFE INVENTORY METHODS

The Floodplain Wildlife working group compiled a species list for the St. Johns River by examining range maps from a variety of sources including AmphibiaWeb, Florida Museum of Natural History, Savannah River Ecology Laboratory, University of Florida Wildlife Extension, USGS Amphibian Research and Monitoring Initiative, NatureServe Explorer, Florida Statewide Environmental Sensitivity Index Maps, Cornell Lab of Ornithology Birds of North America, and Florida Breeding Bird Atlas. Databases and websites were accessed multiple times from 2009 to 2011.

3.2 HYDROLOGIC WILDLIFE MODEL

The Floodplain Wildlife working group prepared a qualitative model for this study to arrange wildlife distributions along a simplified hydrologic gradient. The hydrologic wildlife model (Figure 3–1) applies approximated inundation rates for eleven plant communities that function as wildlife habitats: estuarine environments including saltwater marshes, estuaries, lagoons, sand flats, jetties, and coastal shorelines (SW), open freshwater (OW), deep or floating marsh (DM), shallow marsh (SM), shrub swamp (SS), hardwood swamp (HS), cypress swamp (CS), wet prairie (WP), transitional shrub (TS), hydric hammock (HH), and, upland (UPL). The model is supported by tabulated information for each wildlife species (see Results and Discussion).

We used information and data compiled by Vince et al. (1989) and Mace (2006, 2007a, 2007b, 2009) for the ranges of annual inundation rates shown in Figure 3–1. An annual inundation rate equals the expected annual days of flooding divided by 365; the value is converted to a percentage (%) for the model.

Each plant community and inundation range relates to one of four riverine hydrologic regimes from the National Wetlands Inventory (Cowardin et al. 1979): (1) semipermanently to permanently flooded (includes the tidal regimes irregularly flooded, regularly flooded, irregularly exposed, and subtidal); (2) seasonally flooded; (3) temporarily flooded or ponded; and, (4) dry to infrequently flooded.

Using the wetland qualifiers from Cowardin et al. (1979) and wetland plant species for Florida (Chapter 62-340, F.A.C.), each wildlife species was given a hydrologic type code: obligate (OBL); facultative wet (FACW); facultative (FAC) (Table 3–1 and Table 3–2). The aquatic (AQ) type was added to correspond to deepwater habitats that lack hydric soils.

Aquatic and a number of obligate wildlife species use the semipermanently to permanently flooded habitats that correspond to the lowest topographic elevations and the longest inundated conditions in the floodplain. Semipermanently and permanently flooded habitats in the floodplain have an annual inundation $\geq$ 85% (Mace (2006, 2007a, 2007b, 2009). They may include areas where water depth is > 2 m (6.6 ft) below the low water line (Cowardin et al. 1979). Floodplain aquatic wildlife are adapted to open water, and the waterward extent of littoral zones, or deep and floating marshes.

Obligate wetland wildlife, and some facultative wet species, use seasonally flooded wetlands that occur at higher elevations compared to the semipermanently and permanently flooded habitats. Standing water from inundation typically occurs 180 days on average, or an annual inundation rate of 50%. Inundation rates vary within the seasonally flooded zone depending on the wetland community and its position in the landscape. Habitats include shallow marsh, shrub swamp, mixed hardwood swamp, cypress swamp, and wet prairie.

Facultative wet and facultative wildlife, including some upland species, use the temporarily flooded or ponded wildlife habitats that have shorter inundation rates than the seasonally flooded wetlands. At slightly higher elevations, the hydric hammocks and transitional shrub wetlands occur where hydroperiods are typically 6 weeks or less annually. Annual inundation rates for hydric hammocks along the river are < 17% (Vince et al. 1989; Mace 2006, 2007a, 2007b, 2009). Transitional shrub wetlands, which are often vegetated by flood-sensitive *Baccharis* spp., are inundated from 5% to 17 % of the time (Mace 2006, 2009).

Facultative species, including upland wildlife, use infrequently flooded habitats. These are ecotonal areas where the lower elevations of upland communities, such as pine flatwoods and mesic oak hammocks, intergrade with wetlands (Figure 3–1). These areas may experience infrequent flooding for several days in the year, or a <1% inundation rate.

<table>
<tr><th rowspan="2"></th><th colspan="11">Wildlife Habitats</th></tr>
<tr><th>SW</th><th>OW</th><th>DM</th><th>SM</th><th>SS</th><th>HS</th><th>CS</th><th>WP</th><th>TS</th><th>HH</th><th>UPL</th></tr>
<tr><td>Approximate inundation rates</td><td colspan="3">>85% to 100%</td><td colspan="5">17% to 85%</td><td colspan="2">< 17%</td><td>< 1%</td></tr>
<tr><td>Habitat hydrologic regimes</td><td colspan="3">Semipermanently to permanently flooded</td><td colspan="5">Seasonally flooded</td><td colspan="2">Temporarily flooded or ponded</td><td>Dry to intermittently flooded</td></tr>
<tr><td rowspan="2">Wildlife hydrologic types</td><td colspan="3">AQ</td><td colspan="5">OBL</td><td colspan="3">FAC</td></tr>
<tr><td colspan="3"></td><td colspan="7">FACW</td><td></td></tr>
</table>

Figure 3–1. Hydrologic wildlife model for the St. Johns River floodplain showing eleven habitats organized into four inundation rate ranges, associated hydrologic regimes, and four wildlife hydrologic types.*

* Wildlife Habitats: SW = estuarine environments including saltwater marshes, estuaries, lagoons, sand flats, jetties, and coastal shorelines; OW = open freshwater; DM = deep or floating marsh; SM = shallow marsh; SS = shrub swamp; HS = hardwood swamp; CS = cypress swamp; WP = wet prairie; TS = transitional shrub; HH = hydric hammock; UPL = upland. Wildlife hydrologic types: AQ = aquatic; OBL = obligate; FACW = facultative wet; FAC = facultative

Table 3–1. Sources for hydrologic types assigned to wildlife species.

Hydrologic Wildlife Type	Source
Aquatic	Wildlife that use open water habitats ≥ 2 m, a limit based on Cowardin et al. (1979). Aquatic habitats do not fit the wetlands definition in Chapter 62-340, F.A.C., because they lack hydric soils.
Obligate	Wetland indicator designations for plants in the Florida Administrative Code (Chapter 62-340, F.A.C)
Facultative wet	Wetland indicator designations for plants in the Florida Administrative Code (Chapter 62-340, F.A.C)
Facultative	Wetland indicator designations for plants in the Florida Administrative Code (Chapter 62-340, F.A.C)

Table 3–2. Example species for hydrologic wildlife types with habitat flooding regime, annual hydroperiod, and annual inundation.

Habitat Flooding Regime	Annual Hydroperiod	Annual Inundation	Examples
Aquatic			
semipermanently to permanently flooded wetlands	310 to 365 days	≥ 85% to 100 %	Florida softshell (*Apalone ferox*), double-crested cormorant (*Phalacrocorax auritus*), anhinga (*Anhinga anhinga*), brown pelican (*Pelecanus occidentalis*), lesser scaup (*Aythya affinis)*, Florida manatee (*Trichechus manatus latirostris*)
Obligate			
seasonally flooded wetlands	60 to 310 days	17% to < 85 %	Southern leopard frog (*Lithobates sphenocephala sphenocephala*), hylid tree frogs (e.g., *Hyla cinerea*), two-toed amphiuma (*Amphiuma means*), American alligator (*Alligator mississippiensis*), mud turtles (*Kinosternon* spp., *Sternotherus* spp.), small herons (e.g., *Egretta* spp.), wood stork (*Mycteria americana*), Florida sandhill crane (*Grus canadensis pratensis*), limpkin (*Aramus guarauna*), sandpipers (*Calidris* spp.), northern river otter (*Lontra canadensis*), Florida round-tailed muskrat (*Neofiber alleni*)
Faculative and Faculative Wet			
infrequently to temporarily flooded wetlands	< 60 days	< 17%	Eastern narrow-mouthed toad (*Gastrophryne carolinensis*), southern toad (*Bufo terrestris*), barn owl (*Tyto alba*)

3.3 WILDLIFE LITERATURE REVIEW

We reviewed the scientific literature to gather information about the wildlife that occur in the St. Johns River. Search topics included information about habitats, food, and hydrologic requirements. Literature sources included scientific journals, government reports and related contractor reports, field notes, academic theses and dissertations, and information from non-profit conservation and biodiversity organizations, government agencies, and academic institutions. Hundreds of sources were collected for a bibliographic database, but only those applicable to the text and the appendices are cited.

Because the river occurs in the southeastern United States, the literature review focused on biological surveys in the region, particularly where wildlife studies evaluated hydrologic effects. With a few exceptions, the study locations ranged from the wetlands of south and central Florida to the Carolinas and Louisiana because wetlands in these locations have wildlife species in common with the St. Johns River floodplain.

3.4 WORKING GROUP INPUT

The conceptual model (see Figure 2–2) shows input relationships from the Wetland Vegetation (see Chapter 10), Benthic Macroinvertebrates (see Chapter 11), and Fish (see Chapter 12) working groups. Input was selected from the working groups representing those attributes with potentially moderate to major effects on wildlife (see Results and Discussion). The Plankton (see Chapter 8) and Submersed Aquatic Vegetation (see Chapter 9) working groups indicated that no deterioration was expected with respect to their results from the water withdrawal scenarios.

4 RESULTS AND DISCUSSION

4.1 WILDLIFE INVENTORY

We provide the results of the wildlife inventory including an overview of floodplain fauna (Appendix 13.A), a species list (Appendix 13.B), and a list of species with conservation and protection status (Appendix 13.C). We estimated a total array of over 280 wildlife species for the floodplain. Aprroximately seven percent of the array represents protected species. Five percent of the total consists of wildlife species that are declining in Florida. Less than 10 percent consist of wildlife species restricted to the estuary, or to floodplain habitats in a few freshwater segments.

4.2 WILDLIFE HYDROLOGIC MODEL

Supporting tables for the wildlife hydrologic model provide information on wildlife distributions by river segment, habitat use, and hydrologic type (Appendix 13.D).

4.3 WILDLIFE LITERATURE REVIEW

The literature review relates specific aquatic and wetland obligate floodplain wildlife species to hydrology (Appendix 13.E). We focused on the aquatic and obligate wetland wildlife for the WSIS evaluation and literature review since their habitats are most vulnerable to surface withdrawals (see Chapter 10. Wetlands).

4.4 WORKING GROUP INPUT AND KEY EFFECTS ON WILDLIFE

We applied the working group input for Wetland Vegetation (see Chapter 10), Benthic Macroinvertebrates (see Chapter 11), and Fish (see Chapter 12) for the Floodplain Wildlife evaluation as depicted in Table 4–1.

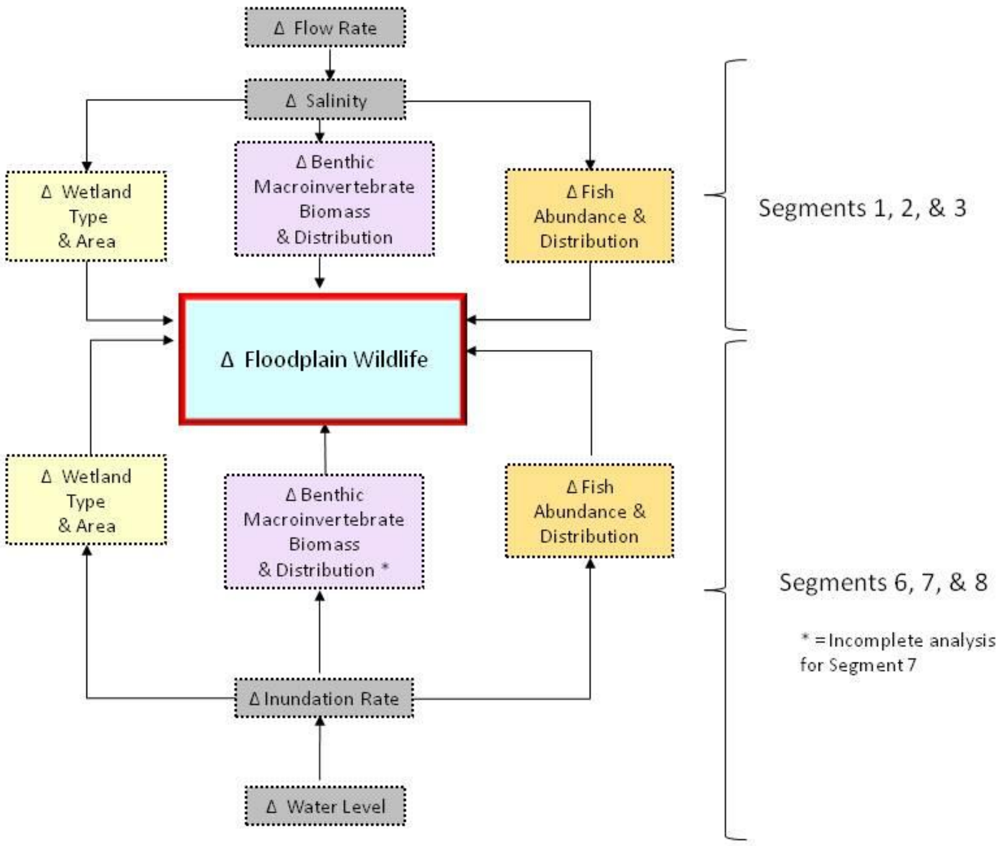


Figure 4–1. Floodplain Wildlife Working Group analysis for six segments of the St. Johns River.

Working group input is summarized in Table 4–1 for the WSIS scenarios. Five scenarios have the potential for at least *Moderate* effects: FwOR1995NN, FwOR2030PS, Full1995NN, Full1995PN, Half1995PN. We include a list of working group attributes following Table 4–1 to indicate the distribution of effects.

Table 4–1. WSIS model scenarios and the working group attributes with *Moderate* and *Major* effects.* **

River Segment	**FwOR 1995NN**	**FwOR 2030PS**	**Full1995 NN**	**Full1995 PN**	**Half1995 PN**	**Half2030 PS**	**Full2030 PS**
1		q r s t u v	q r s t u v	q r s t u v	q r s t u v	▨	▨
2	▨	l n q r s t u v	b d l n q r s t u v	b d l n q r s t u v	l n q r s t u v	▨	▨
3	e	l s t u v	l s t u v	l s t u v	l s t u v	▨	▨
4		▨	▨	▨	▨	▨	▨
5		▨	▨	▨	▨	▨	▨
6		▨	p	p	▨	▨	▨
7		▨	b e f g p	b p	▨	▨	▨
8		▨	b e f g p	b p	▨	▨	▨

*Effects" Yellow = Moderate effects; Rose = Major effects; Gray = Minor or Negligible effects; Blank = Not applicable

**Attributes

Wetland Vegetation

a. Change to upper and lower wetland boundaries
b. Boundaries between wetland types
c. Wetland hydrologic seasonality
d. Boundaries between freshwater and saltwater communities

Benthic Macroinvertebrates

e. FW Benthic Community 1995
f. FW Benthic Populations 1995
g. FW Target Taxa Populations 1995
h. FW Benthic Community 2030
i. FW Benthic Populations 2030
j. FW Target Taxa Populations 2030

Fish

k. Entrainment / Impingement
l. Open Water Riverine Large Fishes
m. Open Water Small Forage Fishes
n. Large Sunfishes
o. Marsh and Floodplain Large Fishes
p. Littoral Zone, Marsh, and Floodplain Small Fishes
q. Open-water Small Estuarine Fishes
r. Estuarine Marsh Fishes
s. Estuarine Benthic Fishes
t. Sciaenid Fishes
u. Estuarine Invertebrates
v. Marine Fishes

We used Table 4–2 to relate overall *Moderate* or *Major* effects of water supply scenarios on sensitive floodplain wildlife. We used floodplain wildlife attributes organized by aquatic and obligate wetland species for the freshwater and estuarine segments of the river. We assigned uncertainty scores for evaluated attributes, but omitted the characteristic scores of strength, persistence, and diversity because of the qualitative character of the wildlife analysis.

Reduction effects are shown in Table 4–3 for two scenarios with *Negligible* overall effects: Half2030PS or Full2030PS. Projected conditions improve under these scenarios when withdrawals are reduced to 77.5 mgd or 155 mgd because of added runoff from expected land use conditions and operation of the completed Upper St. Johns River Basin Project.

For Table 4–2 and Table 4–3 we used uncertainty scores ranked as *Very High* for the estuarine segments 1, 2, and 3. The uncertainty scores are based on the variability related to fish pseudospecies responses combined with those of estuarine invertebrates. We used *High* uncertainty scores for the freshwater segments 6, 7, and 8. The uncertainty scores are based on a general understanding of wildlife responses to wetland habitat losses and reductions of benthic macroinvertebrates and fish.

Only negligible or minor effects were projected for segments 4 and 5 under all the mentioned scenarios. These segments are indicated with NA (not applicable) for Table 4-2 and Table 4-3.

Table 4–2. Floodplain wildlife divided into four attributes across eight river segments and conditions based on five scenarios having *Moderate* or *Major* effects: FwOR1995NN, FwOR2030PS, Full1995NN, Full1995PN, and Half1995PN.*

Freshwater Wildlife			Estuarine Wildlife	
River Segment	**Δ FW Aquatic Species**	**Δ FW Obligate Wetland Species**	**Δ SW Aquatic Species**	**Δ SW Obligate Wetland Species**
1	NA	NA	*****	*****
2	*****	*****	*****	*****
3	NA	*****	NA	NA
4	NA	NA	NA	NA
5	NA	NA	NA	NA
6	NA	****	NA	NA
7	****	****	NA	NA
8	****	****	NA	NA

*FW = Freshwater; SW = Estuarine; NA = Not applicable

Overall Effects	
Negligible	Negligible— no appreciable change in any ecosystem component
Minor	Minor—ephemeral and weak; no significant change in any ecosystem component
Moderate	Moderate— ephemeral or weak, or limited to minor species; no significant change in natural resource values
Major	Major—persistent and strong, but not highly diverse; significant change in natural resource values
Extreme	Extreme— persistent, strong, and highly diverse; significant change in natural resource values

Uncertainty Scores	
***** Very high	Weak qualitative evidence with no predictive model, weak supporting evidence and weak understanding of the mechanism
**** High	Weak quantitative evidence or moderate qualitative evidence with no predictive model, but has either supporting evidence or an understanding of the mechanism
*** Medium	Moderate quantitative evidence or strong qualitative evidence with a strong predictive model, or both strong supporting evidence and a good understanding of the mechanism
** Low	Strong quantitative evidence with a strong predictive model, and either strong supporting evidence or a good understanding of the mechanism
*Very low	Very strong quantitative evidence with a strong predictive model, strong supporting evidence, and a good understanding of the mechanism

Table 4–3. Floodplain wildlife divided into four attributes across eight river segments and conditions based on two scenarios with *Negligible* overall effects: Half2030PS or Full2030PS.*

	Freshwater Wildlife		**Estuarine Wildlife**	
River Segment	**Δ FW Aquatic Species**	**Δ FW Obligate Wetland Species**	**Δ SW Aquatic Species**	**Δ SW Obligate Wetland Species**
1	NA	NA	*****	*****
2	*****	*****	*****	*****
3	NA	*****	NA	NA
4	NA	NA	NA	NA
5	NA	NA	NA	NA
6	NA	****	NA	NA
7	****	****	NA	NA
8	****	****	NA	NA

*FW = Freshwater; SW = Estuarine; NA = Not applicable, this segment was not analyzed in the floodplain wildlife evaluation.

Overall Effects	
Negligible	Negligible—no appreciable change in any ecosystem component
Minor	Minor—ephemeral and weak; no significant change in any ecosystem component
Moderate	Moderate— ephemeral or weak, or limited to minor species; no significant change in natural resource values
Major	Major— persistent and strong, but not highly diverse; significant change in natural resource values
Extreme	Extreme— persistent, strong, and highly diverse; significant change in natural resource values

Uncertainty Scores	
***** Very high	Weak qualitative evidence with no predictive model, weak supporting evidence and weak understanding of the mechanism
**** High	Weak quantitative evidence or moderate qualitative evidence with no predictive model, but has either supporting evidence or an understanding of the mechanism
*** Medium	Moderate quantitative evidence or strong qualitative evidence with a strong predictive model, or both strong supporting evidence and a good understanding of the mechanism
** Low	Strong quantitative evidence with a strong predictive model, and either strong supporting evidence or a good understanding of the mechanism
*Very low	Very strong quantitative evidence with a strong predictive model, strong supporting evidence, and a good understanding of the mechanism

Segments 1, 2, and 3

For Segment 1, we estimated *Minor* overall effects with *Very High* uncertainty for the estuarine aquatic and obliglate wetland wildlife (Table 4–2). We based the scores on the Fish Working Group discussion (see Chapter 12. Fish), which concluded *Moderate*–rated flow effects for six estuarine attributes including estuarine invertebrates (Table 4–1; see attributes *q, r, s, t, u, v*) and scenarios FwOR2030PS, Full1995NN, Full1995PN, and Half1995PN. From that discussion, we concluded that the ichthyofaunal distribution changes described for the pseudospecies and their actual relationship to local wildlife are equivocal or indeterminate. The Fish Working Group described increases and reductions of certain pseudospecies. We concluded that overall fish and estuarine invertebrate biomass may not be greatly affected for the floodplain wildlife in this segment.

For Segment 2 (extending from the Fuller Warren Bridge in Jacksonville to the Flemming Island area), we estimated *Moderate* overall effects with *High Uncertainty* scores to the freshwater and estuarine wildlife attributes for scenarios FwOR2030PS, Full1995NN, Full1995PN, and Half1995PN (Table 4–1). We based the effects on salinity-related changes to wetland cover (Table 4–1; see attributes *b* and *d*) and fish and estuarine invertebrate abundances (Table 4–1; see attributes *l, n, q, r, s, t, u, v*). Foraging success by endangered wood storks in Segment 2 may decline based on reductions in centrarchid sunfish (Table 4–1 and Table 4–2; see Chapter 12. Fish).

For Segment 3 (from Fleming Island to Buffalo Bluff), we estimated *Moderate* overall effects with *Very High* uncertainty for freshwater and estuarine wildlife attributes under scenarios FwOR1995NN, FwOR2030PS, Full1995NN, Full1995PN, and Half1995PN (Table 4–1). We based the effects on changes to freshwater benthic macroinvertebrate communities (Table 4–1 see benthic macroinvertebrate attribute *e*) and fish and estuarine invertebrate abundances (Table 4–1; see fish attributes *l, s, t, u, v*).

For segments 1, 2, and 3 we rated the overall effects to wildlife as *Negligible* based on the collective results for wetland vegetation, benthic macroinvertebrates, and fish under the Full2030PS and the Half2030PS scenarios (Table 4–3).

Any changes in fish and estuarine macroinvertebrate biomass have the potential to have at least minor effects on the coastal wildlife in the estuarine reaches of the St. Johns River although actual changes may not be evident without long-term monitoring. Wildlife examples (listed species are indicated with an [*L]), include: common loon *(Gavia immer*), pied-billed grebe *(Podilymbus podiceps*), hooded merganser *(Lophodytes cucullatus*), American white pelican *(Pelecanus erythrorhynchos*), brown pelican [*L], double-crested cormorant, black-crowned night-heron *(Nycticorax nycticorax*), yellow-crowned night heron *(Nyctanassa violacea*), great blue heron *(Aredea herodias*), great egret (*Ardea alba*), anhinga, white ibis [*L] (*Eudocimus albus*), reddish egret [*L] (*Egretta rufescens*), black skimmer [*L] (*Rynchops niger*), osprey (*Pandion haliaetus*), northern river otter, and bottlenose dolphin (*Tursiops truncates*).

Salinity-related losses of hardwood swamps and bald cypress are expected where they occur in the three segments. A study by Mortl et al. (2006) observed salinity-related mortality of bald cypress stands in the floodplain of the Loxahatchee River in south Florida. Krauss et al. (2009) reported an observed sensitivity threshold of about 2.0 ppt (range = 0.1 to 3.4 ppt) for tidal and nontidal bald cypress wetlands in Louisiana, South Carolina, and Georgia.

Loss of bald cypress (*Taxodium distichum*) trees, which represent an important floristic feature in the forested wetlands that occur along the shorelines of the St. Johns River, would mean reductions in cover, denning, roosting, and nesting habitats for certain wildlife. Under the Full2030PS scenario, the recovery of wetland habitats is not likely in the event of sea level rise, but direct effects from water withdrawals are not expected. Examples of wildlife that occur in riparian bald cypress swamps, including declining [*D] species, are southern dusky salamander [*D] (*Desmognathus auriculatus*), striped mud turtle (*Kinosternon baurii*), eastern mud snake (*Farancia abacura abacura*), black swamp snake (*Seminatrix pygaea*), double-crested cormorant, anhinga, little blue heron [*L] (*Egretta caerulea*), bald eagle (*Haliaeetus leucocephalis*), osprey, American swallow-tailed kite (*Elanoides forficatus*), Acadian flycatcher (*Empidonax virescens*), northern parula warbler (*Parula americana*), and Rafinesque's big-eared bat *(Corynorhinus rafinesquii*).

Segments 6, 7 and 8

For the floodplain in Segment 6 at Lake Monroe, we estimated *Moderate* overall effects with *High Uncertainty* scores for freshwater aquatic and obligate wetland wildlife (Table 4–2). Direct effects may occur to wildlife piscivores based on expected reductions in small marsh fish biomass (Table 4–1; see fish attribute *p*). Results are for the Full1995NN and Full1995PN scenarios. Reduced effects are possible under the Full2030PS and Half2030PS scenarios (Table 4–3).

For segments 7 and 8 (extending from Lake Harney south to the chain-of-lakes area including Lake Poinsett), we estimated *Moderate* overall effects with *High Uncertainty* scores for freshwater obligate wetland wildlife (Table 4–2). Results are for the Full1995NN and Full1995PN scenarios. Reduced effects are possible under the Full2030PS and the Half2030PS scenarios (Table 4–3).

River segments 7 and 8, particularly Lake Poinsett in Segment 8, represent the floodplain areas that are potentially the most sensitive for freshwater wetland obligate species under the Full1995NN and Full1995PN scenarios. Reduced inundation on floodplain wetlands in these segments, particularly where inundation rates or exceedences are normally $\geq$ 50%, present the greatest potential for habitat impairment compared to changes in ponded depth, hydropattern, and recession rate (see Appendix 13.E). We base this comment on input from the working groups (Table 4–1; see wetland attribute *b*, benthic macroinvertebrate attributes *e*, *f*, and g, and fish attribute *p*). Drier conditions and exposed substrates are expected to cause changes to wetland cover types (see Chapter 10. Wetland Vegetation) and reductions of benthic macroinvertebrates (see Chapter 11. Benthic Macroinvertebrates) and small marsh fish (see Chapter 12. Fish). Conditions under the Full1995NN and the Full1995PN scenarios have the potential to affect the habitats and forage base of aquatic and obligate wetland wildlife in segments 7 and 8.

The 50% exceedence appears to be an important benchmark with respect to aquatic and obligate wetland floodplain wildlife. For example, the two-toed amphiuma and the greater siren, both aquatic intermediary predators and prey species (Schalk et al. 2010), persist in not only littoral zones and deep marshes, respectively, but also shallow marshes having at least a 50% inundation rate (Snodgrass et al. 1999). For comparison, a 55% inundation rate is a typical for the marshes at Lake Poinsett in Segment 8 (P. Kinser, SJRWMD, pers. comm., 2011). This information leads us to believe that habitats are potentially available at Lake Poinsett for these two salamander species. Additional evidence for the importance of the 50% inundation rate is from Sincock et al. (1957), who worked in wetlands of the Kissimmee River Valley. They reported that most of the herbaceous waterfowl foods present in their study occurred within the 50% to 100% annual inundation range.

Affected wildlife under the Full1995NN and the Full1995PN scenarios include listed [*L] species, such as wood stork, Florida sandhill crane, little blue heron, snowy egret *(Egretta thula*), tricolored heron (*Egretta tricolor*), white ibis, and limpkin. Drier conditions may result in a favorable response by facultative and facultative wet wildlife, such as cattle egrets (*Bubulcus isbis*) and red-winged blackbirds (*Agelaius phoeniceus*) (see Appendix 13.D for wildlife occurrences and habitat requirements).

The Wetland Vegetation Working Group (see Chapter 10. Wetland Vegetation) reported a possible expansion of sand cordgrass (*Spartina bakeri*)-dominated wet prairie and upper wet prairie habitats under the Full1995NN and Full1995PN scenarios. Monocultures of sand cordgrass (Figure 4–2) represent habitats that are suitable for marsh rabbit (*Sylvilagus palustris*), Wilson’s snipe (*Gallinago delicate*), marsh wren (*Cistothorus* spp.), and the rarely observed black rail (*Laterallus jamaicense*). Replacement of shallow marshes, such as those around Lake Poinsett (Figure 4–2), could potentially reduce wildlife diversity (Sincock 1958) although the isolated pools embedded within wet prairies may support good wildlife values (Toth et al. 1998). The Florida mottled duck (*Anas fulvigula*) is an example of an obligate wetland species that will nest in sand cordgrass prairies, but this declining endemic prefers shallow marshes with emergent vegetation (Johnson et al. 1991).

Figure 4–2. Wet prairie with sand cordgrass (*Spartina bakeri*) at Lake Poinsett.*
*Photo by J. Mace, February 2005

Figure 4–3. Marsh and open water mosaic at Lake Poinsett.*
*Photo by J. Mace, August 2005

Overall, marsh birds and waterfowl benefit with at least a 50% cover of emergent vegetation and open water (Weller and Spatcher 1965; Post and Seals 2000). Optimal nesting habitats for female alligators consist of emergent vegetation interspersed by 20% to 40% open water (Newsom et al. 1987).

A drier marsh condition may mean changes in habitat structure that can reduce wildlife values due to increases in taller herbaceous vegetation or shrubs. Some vertical structure is important as long as woody competition and shading do not reduce native marsh vegetation (Kahl 1964; Frederick et al. 1996; Toth et al. 1998; Mooij et al. 2007). Mated Florida sandhill cranes, for example, may avoid nesting in marshes where the shrub cover obstructs the horizon, blocking the birds' view of predators. Additionally, shrub invasion and low water levels could potentially exclude the Florida round-tailed muskrat, which prefers marshes of low herbaceous species such as maidencane (*Panicum hemitomon*) and pickerelweed (*Pontederia lanceolata*) (Birkenholz 1963). Drier conditions in the upper St. Johns River floodplain may require more prescribed fires to maintain the open marshes recommended by Hoffman (1996).

Kushlan et al. (1985) and Hoffman et al. (1994) concluded that herbaceous vegetation height is a limiting factor for wading birds. They observed that small herons, white ibis, and large waders (i.e., great egret, great blue heron, and wood stork) are similar in their avoidance of marshes with tall herbaceous vegetation. White ibis, for example, prefer open marshes of short vegetation stands interspersed by water (Kushlan 1974). Tall, dense emergent vegetation does provide cover for American bittern (*Botarus lentiginosus*) and least bittern (*Ixobrychus exilis*) (Kushlan et al. 1985). Preferred habitat structure for wading birds is shown in Table 4–4.

Table 4–4. Habitat structure for foraging by wading birds.*

Wading Bird Species	**Wetland/Aquatic Birds**		**Terrestrial Birds**	
	Plant Cover Height			
	Short	**Tall**	**Short**	**Tall**
American bittern (*Botarus lentiginousus*)		░		
Least bittern (*Ixobrychus exilis*)		░		
Great blue heron (*Ardea herodias*)	░	▨		
Great egret (*Ardea alba)*	░	▨		
Snowy egret (*Egretta thula*)	░			
Little blue heron (*Egretta caerulea*)	░			
Tricolor heron (*Egretta tricolor*)	░			
Cattle egret (*Bubulcus ibis*)			░	
Green heron (*Butorides virescens*)		░		
Black-crowned Night-heron (*Nycticorax nycticorax*)	░			
Yellow-crowned Night-heron (*Nyctanassa violacea*)	░			
White ibis (*Eudocimus albus*)	░		▨	
Glossy ibis (*Plegadis falcinellus*)	░		▨	
Roseate spoonbill (*Platalea ajaja*)	░			
Wood stork (*Mycteria americana*)	░			

*Adapted from Kushlan et al. (1985); shaded cells = preferred habitats; hatched cells = secondary habitats

Vegetation height and density greatly reduce the success rates by which Florida snail kites (*Rostrhamus sociabilis plumbeaus*) can capture apple snails (*Pomacea paludosa*). Florida snail kites avoid marshes of tall dense vegetation, such as cattails or sawgrass. Sykes (1987) and Bennetts et al. (2006) report that less than 10% of apple snail capture attempts by Florida snail kites are successful in marshes with dense vegetation.

Moderate overall effects to benthic macroinvertebrates relate to potential exposure of shorelines and floodplain habitats under the Full1995NN and Full1995PN scenarios, with slight increases of critical events for target taxa explained by the Benthic Macroinvertebrate Working Group (Table 4–1; see benthic macroinvertebrate attributes *e*, *f*, *g*). Reductions in annual invertebrate productivity for segment 7 and 8 under the Full1995PN scenario, including Lake Poinsett, could have potential effects on the invertivorous wildlife of the area (Table 4–2; see Chapter 11. Benthic Macroinvertebrates). Reductions could potentially affect a large array of invertivores where suitable habitats occur, including amphibians, alligator hatchlings, white ibis, limpkin, Florida sandhill crane, pied-billed grebe, ducks including Florida mottled duck hatchlings (Rorabuagh and Swank 1983), Florida green water snake *(Nerodia floridana*), black swamp snake, crayfish snakes (*Regina* spp.), least tern (*Sternula antillarum*), bittern, *Egretta* herons and other wading birds, moorhen (*Gallinula chloropus*), and purple gallinule *(Porphyrio martinica*), rails (Rallidae), plovers (Charadriidae), and sandpipers (Scolopacidae). Conditions for wildlife invertivores are more favorable under the Full2030PS scenario (Table 4–3).

The 90-day annual drying limit for adult apple snails from Darby et al. (2008) was compared to the 4.3-year return interval reported by Beissinger (1995) for Florida snail kites (see Chapter 11. Benthic Macroinvertebrates). The return interval represents the recovery time needed for apple snails to grow to a size that is suitable for exploitation by Florida snail kite adults that have chicks or juveniles to feed. Toland (1994) observed that nesting snail kites preferred large apple snails that averaged 3.8 cm (1.5 in.) in length by 4.1 cm (1.6 in.) in diameter. Kushlan (1975) reports that, on average, long hydroperiod marshes with fluctuating water levels produce larger apple snails than dry marshes and impounded wetlands. The lag time for apple snail growth is also noted by other researchers (Sykes 1987; Comiskey et al. 1998b; USFWS 1999).

The Full1995PN scenario and Full2030PN scenario (substituted for the Full2030PS in Table 4-2) just meet the 4.3-year return interval reported by Beissinger (1995) (Figure 4–4). The Base1995NN baseline and the Full1995NN scenarios indicate marsh-drying events that occur too frequently for Florida snail kite habitat when compared to Beissinger (1995). Considering the baseline condition, Lake Poinsett marshes may not represent suitable snail kite foraging habitat, but could potentially improve with the water contributions represented by the Full2030PN scenario (Figure 4–4). In addition to suitable return intervals for drying, the water depth range for the marshes must support apple snail populations (Hanning 1978).

Fish reductions are important to the listed wildlife piscivores occurring in segments 7 and 8 (Table 4–5). The Fish Working Group (see Chapter 12. Fish) reported small changes at Lake Poinsett for the Full1995NN and Full1995PN scenarios. They expected declines of about 5% in small prey fish abundances on the floodplain downstream of Lake Poinsett to the MFL transects TOSO 528 (at the Tosohatchee State Reserve) and H1 in segment 7 (Table 4–6) . The Fish Working Group reported potential effects for 18 species of small marsh fish: mosquitofish (*Gambusia holbrooki*), rainwater killifish (*Lucania parva*), bluefin killifish (*L. goodie*), least killifish (*Heterandria formosa*), sailfin molly (*Poecilia latipinna*), flagfish (*Jordanella floridae*), sheepshead minnow (*Cyprinodon variegates*), golden topminnow (*Fundulus chrysotus*), marsh killifish (*F. confluentus*) bluespotted sunfish (*Enneacanthus gloriosus*), banded sunfish (*E. obesus*), dollar sunfish (*Lepomis marginatus*), Everglades pygmy sunfish (*Elassoma evergladei*), clown goby (*Microgobius gulosus*), naked goby (*Gobiosoma bosc*), speckled madtom (*Noturus leptacanthus*), tadpole madtom (*N. gyrinus*), and swamp darter (*Etheostoma fusiform*). The working group expected more favorable conditions under the Half2030PS and the Full2030PS scenarios with potential exceptions posed by the Impingement/Entrainment attribute (Table 4–3; see Chapter 12. Fish).

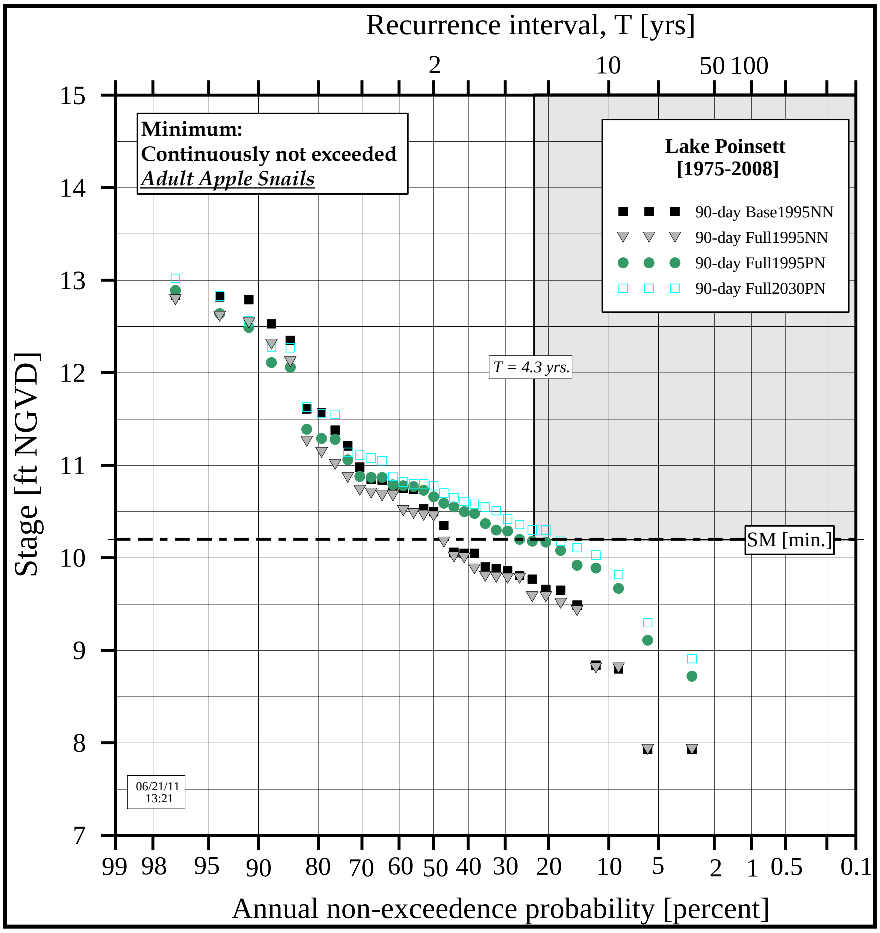


Figure 4–4. Apple snail drought recovery—a frequency evaluation of 90-day annual drying events at Lake Poinsett using a 4.3-yr return interval (*T*).*
*Analysis by P. Robison, P.E., SJRWMD, 2011; SM [min] = shallow marsh minimum elevation

Table 4–5. Listed wildlife species of the St. Johns River floodplain that prey on small marsh fish.*

Species	Age Class	Status
Alligator (*Alligator mississippiensis*)	Juveniles	SSC
Wood stork (*Mycteria americana*)	Adults	Endangered
Least tern (*Sternula antillarum*)	Adults	Threatened
Little blue heron (*Egretta caerulea*)	Adults	SSC
Snowy egret (*Egretta thula*)	Adults	SSC
Tricolored heron (*Egretta tricolor*)	Adults	SSC
White ibis (*Eudocimus albus*)	Adults	SSC
Roseate spoonbill (*Platalea ajaja*)	Adults	SSC

*SSC = Species of special concern

Table 4–6. Summary of modeled changes to small marsh fish abundance on the St. Johns River floodplain.*

Scenario	Comparison Scenario	Location	Densities of Small Marsh Fish Assemblages
Full1995NN	Base1995NN	Lake Poinsett at MFL County Line transect	-11%
		Downstream of Lake Poinsett at MFL transect H1	-9%
		Downstream of Lake Monroe at MFL Transect Lake Woodruff	-0.2%
		Downstream of Lake Monroe at MFL Transect Pine Island	-10%
Base1995PN	Base1995NN	Upstream of Lake Monroe at MFL County Line transect and MFL H1 transect	3% to 7%
		Lake Monroe and downstream	No change
Full1995PN	Base1995PN	Lake Poinsett	Small changes
		Downstream of Lake Poinsett at MFL Transect TOSO 528 and MFL Transect H1	-5%
Full1995PS	Base1995NN	Downstream of Lake Monroe at Lake Woodruff	60%
Full2030PS	Base1995NN	Downstream of Lake Monroe at Lake Woodruff	60%

*modified from Chapter 12. Fish

Fish consumption studies indicate the importance of small marsh fish to wading birds. Bancroft et al. (1990) observed that individual *Egretta* herons in the Everglades consumed about 200 fish daily. Kahl (1964) estimated that a family of wood storks with 2.25 nestlings reared to the fledgling stage, needs 201 kg (443 lbs) of live fish for one breeding season, a period of about three months.

In one Everglades study, Kushlan et al. (1985) found that the great egret, snowy egret, little blue heron, and wood stork all have diets of mostly small marsh fish. An exception is the mostly invertivorous white ibis. Important prey fish genera for these wading birds belong to the killifish (Cyprinodontidae, Fundulidae) and livebearer (Poeciliidae) families. Wood storks in the study ate mostly killifish (Table 4–7).

In his study on wood storks, Kahl (1964) makes the case for not only a pulsed hydrologic regime related to hydropattern, but also for total wetted area as influential to prey fish productivity. Ogden et al. (1976) also stated that marsh hydroperiods and drying intervals must be long enough for small marsh fish to grow to a suitable prey size. Wood stork predation may be selective and dependent on size class and prey species. Wading bird selection by individual fish size is described by Ogden et al. (1976) and Gawlik et al. (2004).

Table 4–7. Percent composition of fish diets for five wading bird species.*

Wading Bird	Gar	Suckers	Bullheads	Killifish	Livebearers	Sunfish	Sleepers	Other
Great egret	< 2	< 2	< 2	26	47	13		8
Snowy egret		< 2		28	50	< 2		< 2
Little blue heron				12	49	2	< 2	< 2
White ibis				< 2	2			16
Wood stork	< 2			75	13	9		

*Adapted from Kushlan et al. (1985); blue cells = most abundant

Ogden et al. (1976) describes 27 fish species in wood stork diets. Most of the biomass (72%) in their study consists of several small marsh fish species that also occur in the St. Johns River floodplain: sailfin mollie, flagfish, killifish, and several species of sunfish. Wood storks may have a preference for centrarchid sunfish, even if these prey occur in low densities. Mosquitofish, which often occur in high densities at the top of the water column, may not be consumed sufficiently to guarantee persistence and successful nesting by wood storks (Ogden et al. 1976). Ogden et al. (1976) described wood stork predation on flagfish to be more dependent on fish density than size, a condition of shallow water depths.

Although white ibis are mostly dependent on freshwater crayfish and consumption of small fish is usually low, prey switching does occur (Kushlan 1979a, 1979b, 1980, 1986; Hingtgen et al. 1985; Bildstein et al. 1990). Foraging on small prey fish is an adaptive behavior by nesting adult white ibis at a time when high caloric consumption and expenditure is required (Kushlan 1979b; Kushlan 1980). Kushlan (1979b) found that large numbers of small marsh fish provide more food calories than invertebrates for white ibis. One adult white ibis needs 165 kcal d^{-1} (Kushlan 1974b), or about 21% of its body weight in food (Kushlan 1977).

4.5 FLOODPLAIN WILDLIFE RESPONSES TO DRYING WETLANDS

A biodiversity model was modified from Holling (1973) to provide a conceptualization of wildlife persistence with respect to hydrologic changes (Figure 4–5). Holling (1973) suggests that, "… if we are dealing with a system profoundly affected by changes external to it, and continually confronted by the unexpected, the constancy of [the system's] behavior becomes less important than the persistence of its relationships." The model demonstrates that wildlife populations are not static, but fluctuate depending on environmental conditions.

The spiral represents a domain of attraction or exclusion represented by the oval dashed line (Holling 1973). The inward-pointing arrows denote the presence of suitable conditions for the wildlife species array that we associate with the St. Johns River, where prevailing conditions include sufficient food, cover, hydrology, and water quality. Counter to the domain of attraction, however, are the natural and anthropogenic pressures that can exclude species, particularly some habitat specialists. Exclusions (outward-pointing arrows) occur when selective pressures exceed the adaptive strategies or tolerances of a species to persist, thus pushing a species out of the domain of attraction (Figure 4–5).

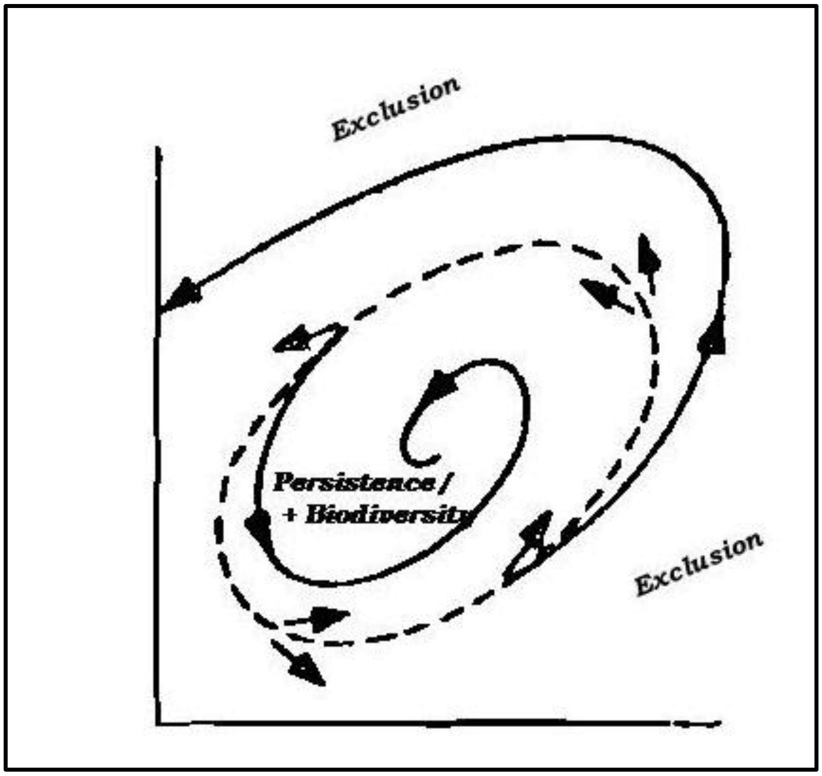
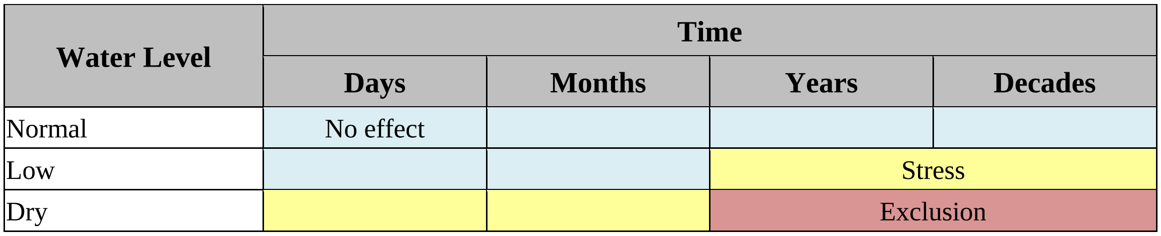


Figure 4–5. A model of species persistence and change.*
* Modified from C. S. Holling (1973)

The timing, magnitude, and combined residual effects of environmental stressors affect extinction or exclusion events. An altered ecosystem becomes a domain of attraction for other species as resource niches change. Complete species extinctions may not occur; instead there may be reductions in species richness and abundance or changes in species composition. In addition, biological productivity of organisms in the lower trophic levels may be affected, such as the abundance and diversity of benthic macroinvertebrate and fish communities. Predator-prey relationships may change affecting wildlife.

Recognizing the adaptive resilience that most species have for drying events, a general model is shown for water withdrawal effects on wildlife (Table 4-6). Floodplain wildlife species like wading birds are adapted to seasonal water levels. Long droughts, such as those related to La Niña weather patterns, can stress wildlife by limiting habitat and food resources. Prolonged drying that is beyond the adaptive abilities of wildlife can eliminate populations from the system. Re-introduction then becomes a matter of the metapopulation dynamics of an area, and the existence of functional wildlife corridors that allow individuals from peripheral habitats to recolonize a wetland location.



Water Level	Time			
	Days	Months	Years	Decades
Normal	No effect			
Low			Stress	
Dry			Exclusion	

Figure 4–6. Example of general effects to floodplain wildlife resulting from dewatering events.*
*Blue = No effect; Yellow = Stress; Rose = Exclusion

The Florida snail kite is an example of a species that is sensitive to drying marshes in segments 7 and 8, as in the case of the Full1995NN and Full1995PN scenarios. The endangered raptor is potentially excluded from upper St. Johns River marshes in these segments if inundation rates and return intervals are inadequate to maintain sufficient quantities of large-sized apple snails.

5 SUMMARY AND CONCLUSIONS

A list of wildlife species was compiled for 11 floodplain habitats that occur along the St. Johns River floodplain (see appendices). From a cross-sectional perspective, the habitats included the natural communities that extend from open water to the wetland-upland ecotones that border the river. Each faunal species was categorized by a hydrologic preference. A literature review summarized the hydrologic constraints of water depth, inundation, recession rate, hydropatterns, and to a limited extent, flow-related salinity.

We evaluated the water withdrawal scenario input from the working groups for Wetland Vegetation (see Chapter 10), Benthic Macroinvertebrates (see Chapter 11), and Fish (see Chapter 12), and related the strongest scenario effects to the wildlife resources of the St. Johns River ecosystem. We concluded:

Segment 1

- Minor effects with very high uncertainty for estuarine floodplain wildlife under the FwOR2030PS, Full1995NN, Full1995PN, and Half1995PN scenarios based on the expectation of flow and salinity-related replacement of fish and estuarine macroinvertebrate pseudospecies including open-water small estuarine fishes, estuarine marsh fishes, estuarine benthic fishes, sciaenid fishes, estuarine invertebrates, and marine fishes

Segment 2

- Moderate effects to wildlife with very high uncertainty for the FwOR2030PS and Half1995PN scenarios based on flow and salinity- related changes to open water riverine large fishes, large sunfishes, open-water small estuarine fishes, estuarine marsh fishes, estuarine benthic fishes, sciaenid fishes, estuarine invertebrates, and marine fishes
- Similar effects and uncertainty are assumed for the same fish attributes under the Full1995NN and Full1995PN scenarios with the addition of wetland changes; i.e.,

boundaries between wetland types and boundaries between freshwater and saltwater communities

Segment 3

- Moderate effects to wildlife with very high uncertainty for the FwOR1995NN scenario based on flow and salinity-related reductions of freshwater benthic communities under the 1995 land use condition
- Moderate effects to wildlife with very high uncertainty for the FwOR2030PS, Full1995NN, Full1995PN, and Half1995PN scenarios based on reductions of open water riverine large fishes, estuarine benthic fishes, sciaenid fishes, estuarine invertebrates, and marine fishes

Segment 6

- Moderate effects to wildlife with high uncertainty for the Full1995NN and Full1995PN scenarios based on inundation-related changes that may cause a reduction of littoral zone, marsh, and floodplain small fishes at Lake Monroe

Segments 7 and 8

- Moderate effects to wildlife with high uncertainty for the Full1995NN scenario based on expected inundation-related change to wetland boundaries between wetland types, benthic macroinvertebrate reduction of freshwater communities, populations, and target taxa populations (1995 land use), and reduction of littoral zone, marsh, and floodplain small fishes
- Moderate effects to wildlife with high uncertainty for the Full1995PN scenario based on expected inundation-related change to wetland boundaries between wetland types and reduction of littoral zone, marsh, and floodplain small fishes
- Conditions under the Full2030PN scenario at Lake Poinsett may provide beneficial return intervals related to marsh drying events that support apple snail growth for nesting Florida snail kites.

Segments 4 and 5 were not evaluated based on the expection of no effects from the three working groups.

We expect improved conditions under the Half2030PS or Full2030PS scenarios with negligible effects for floodplain wildlife for segments 1, 2, 3, 6, 7, and 8. We project *High* uncertainty levels for these scenarios.

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7 LITERATURE CITED

Bancroft, G. T., S. D. Jewell, and A. M. Strong. 1990. Foraging and nesting ecology of herons in the lower Everglades relative to water conditions. Final report # 202-M86-0254-R. South Florida Water Management District, West Palm Beach.

Beissinger, S. R. 1995. Modeling extinction in periodic environments: Everglades water levels and snail kite population viability. Ecol. App. 5(3):618-631.

Bennetts, R. E., P. C. Darby, and L. B. Karunaratne. 2006. Foraging patch selection by snail kites in response to vegetation structure and prey abundance and availability. Waterbirds 29(1):88-94.

Bildstein, K. L., W. Post, J. Johnston, and P. Frederick. 1990. Freshwater wetlands, rainfall, and the breeding ecology of white ibises in coastal South Carolina. Wilson Bull. 102(1):84-98.

Birkenholz, D. E. 1963. A study of the life history and ecology of the round-tailed muskrat (Neofiber alleni) in northern Florida. Ecol. Monogr 33:255-280.

Comiskey, J., J. Curnutt, L. Gross, and M. Huston. 1998a. Wading bird foraging conditions index: basic model description. University of Tennessee, Knoxville.

Comiskey, J., J. Curnutt, and L. Gross. 1998b. Snail Kite: Breeding Potential Index (BPI). ATLSS Snail Kite Index Model: Basic Model Description. The Institute for Environmental Modeling, Knoxville, Tennessee.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRow. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. and Jamestown, North Dakota.

Darby, P. C., R. E. Bennetts, et al. (2008). "Dry down impacts on apple snail (*Pomacea paludosa*) demography: implications for wetland water management." Wetlands 28(1): 204-214.

DeAngelis, D. L., W. F. Loftus, J. C. Trexler, and R. E. Ulanowicz. 1997. Modeling fish dynamics and effects of stress in a hydrologically pulsed ecosystem. J. Aquatic Ecosystem Stress and Recovery 6:1-13.

Frederick, P. C., K. L. Bildstein, B. Fleury, and J. Ogden. 1996. Conservation of large, nomadic populations of white ibises (*Eudocimus albus*) in the United States. Conservation Biology 10(1):203-216.

Frederick, P. C., and J. C. Ogden. 2001. Pulsed breeding of long-legged wading birds and the importance of infrequent severe drought conditions in the Florida Everglades.Wetlands 21(4):484-491.

Gawlik, D. E., G. Herring, B. Botson, R. Harris, and B. Garrett. 2004. Wading bird prey concentrations in the Everglades. South Florida Wading Bird Report. 10:30-32.

Hanning, G. W. 1978. Aspects or reproduction in *Pomacea paludosa* (Mesogastropoda: Pilidae). M. S. Thesis. Department of Biological Sciences. Florida State University. Tallahassee.

Hingtgen, T., R. Mulholland, and R. W. Repenning. 1985. Habitat suitability index models: white ibis. U. S. Fish and Wildlife Service, Washington, D. C.

Hoffman, W. 1996. Survey of wading bird utilization of the upper St. Johns River. SJ97-SP2. St. Johns River Water Management District, Palatka, Florida.

Hoffman, W., G. T. Bancroft, and R. J. Sawicki. 1994. Foraging habitat of wading birds in the water conservation areas of the Everglades. Pages Pp. 585-614 in S. M. Davis, and J. C. Ogden, editors. Everglades: The Ecosystem and its Restoration. St. Lucie Press, Delray Beach, Florida.

Holling, C.S. 1973. Resilience and stability of ecological systems. Ann. Rev. Ecol. and Syst. 4:1-23.

Johnson, F. A., F. Montalbano, III, J. D. Truitt, and D. R. Eggeman. 1991. Distribution, abundance, and habitat use by mottled ducks in Florida. J. Wildl. Manage. 55(3):476-482.

Kahl, P. M., Jr. 1964. Food ecology of the wood stork (*Mycteria americana*) in Florida. Ecological Monographs 34(2):97-117.

Krauss, K. W., J. A. Duberstein, T. W. Doyle, W. H. Conner, R. H. Day, L. W. Inabinette, and J. L. Whitbeck. 2009. Site condition, structure, and growth of bald cypress along tidal/non-tidal salinity gradients. Wetlands 29(2):505-519.

Kushlan, J. A. 1974. The ecology of the white ibis in southern Florida, a regional study. Ph.D. dissertation. University of Miami, Coral Gables, Florida.

_________. 1975. Population changes in the apple snail, *Pomacea paludosa*, in the southern Everglades. The Nautilus 89(1):21-23.

_________. 1977. Population energetics of the American white ibis. The Auk 94: 114-122.

_________. 1979a. Prey choice by tactile-foraging wading birds. Proc. Colonial Waterbird Group 3:133-142.

_________. 1979b. Feeding ecology and prey selection in the white ibis. Condor 81:376-389.

_________. 1980. Feeding ecology and prey selection in the white ibis. Condor 81:376-389.

_________. 1986. Responses of wading birds to seasonally fluctuating water levels: strategies and their limits. Colonial Waterbirds 9(2):155-162.

Kushlan, J. A., G. Morales, and P. C. Frohring. 1985. Foraging niche relations of wading birds in tropical wet savannahs. Neotropical Ornithology Ornithological Monographs No. 36:663-682.

Mace, J. W. 2006. Minimum levels determination: St. Johns River at State Road 44 near DeLand, Volusia County. SJ2006-5. St. Johns River Water Management District, Palatka, Florida.

_______. 2007a. Minimum levels determination: Lake Monroe in Volusia and Seminole counties, Florida. SJ2007-2. St. Johns River Water Management District, Palatka, Florida.

_______ . 2007b. Minimum levels determination: St. Johns River at State Road 50 Orange and Brevard counties, Florida. Technical Publication SJ2007-1. St. Johns River Water Management District Palatka, Florida.

_______. 2009. Minimum levels determination: Lake Poinsett in Brevard, Orange, and Osceola counties (draft report). St. Johns River Water Management District, Palatka, Florida.

Mooij, W. M., J. Martin, W. M. Kitchens, and D. L. DeAngelis. 2007. Exploring the temporal effects of seasonal water availability on the Snail Kite of Florida. Pages 155-173 *in* J. A. Bissonette, and I. Storch, editors. Temporal Dimensions of Landscape Ecology: Wildlife Responses to Variable Resources. Springer Science + Business Media, LLC, New York, New York.

Mortl, A. E., R. Munoz-Carpena, and Y. C. Li. 2006. Hydroperiod and soil water salinity in the bald cypress floodplains of the Loxahatchee river. Pages 395-402 in D. Amatya, editor. Hydrology and Management of Forested Wetlands, Proceedings of the International Conference, New Bern, North Carolina.

Newsom, J. D., T. Joanen, and R. J. Howard. 1987. Habitat suitability index models: American alligator. U. S. Fish and Wildlife Service, Washington, D. C.

Ogden, J. C., J. A. Kushlan, and J. T. Tilmant. 1976. Prey selectivity by the wood stork. The Condor 78:324-330.

Poff, N. L., D. Allan, M. B. Bain, J. R. Karr, K. L. Prestegaard, B. D. Richter, R. E. Sparks, and J. C. Stromberg. 1997. The natural flow regime. BioScience 47(11):769-784.

Poff, N. L., and J. K. H. Zimmerman. 2010. Ecological responses to altered flow regimes: A literature review to inform the science and management of environmental flows. Freshwater Biology **55**:194-205.

Post, W., and C. A. Seals. 2000. Breeding biology of the common moorhen in an impounded cattail marsh. J. Field Ornith. 71(3):437-442.

Richter, B. D., J. V. Baumgartner, J. Powell, and D. P. Braun. 1996. A method for assessing hydrologic alteration within ecosystems. Conservation Biology 10(4):1163-1174.

Rorabaugh, J. C. and P. J. Swank (1983). Habitat suitability index models: Mottled duck. Washington, D. C., U. S. Fish and Wildlife Service. FWS/OBS-82/10.52.

Schalk, C. M., T. M. Luhring, and B. A. Crawford. 2010. Summer microhabitat use of the Greater Siren (*Siren lacertina*) and Two-toed Amphiuma (*Amphiuma means*) in an isolated wetland. Amphibia-Reptilia **31**:251-256.

Sincock, J. L., J. A. Powell, R. K. Hyde, and H. E. Wallace. 1957. The relationship of the wintering waterfowl populations of the Kissimmee River Valley to the hydrology, topography, distribution of the vegetation and the proposed hydrological regulations. Florida Game and Fresh Water Fish Commission, Tallahassee.

Sincock, J. L. 1958. Waterfowl ecology in the St. Johns River Valley as related to proposed conservation area changes in the hydrology from Lake Harney to Ft. Pierce, Fl. Tallahassee, Florida Game and Fresh Water Fish Commission**:** 224.

Snodgrass, J.W., J.W. Ackerman, A.L. Bryan Jr. and J. Burger. 1999. Influence of hydroperiod, isolation, and heterospecifics on the distribution of aquatic salamanders (*Siren* and *Amphiuma*) among depression wetlands. Copeia 1999:107–113.

Sykes, P. W., Jr. 1979. 1987. The feeding habits of the snail kite in Florida, USA. Colonial Waterbirds 10(1):84-92.

Toland, B. R. 1994. Snail kite ecology and status reports of other species of regional concern in the Upper St. Johns River marshes: 1990-1993 Final Report. St. Johns River Water Management District, Palatka, Florida.

Toth, L. A., S. L. Melvin, D. A. Arrington, and J. Chamberlain. 1998. Hydrologic manipulations of the channelized Kissimmee River: Implications for restoration. BioScience 48(9):757-764.

Turner, R. L. 1994. The effects of hydrology on the population dynamics of the Florida apple snail (Pomacea paludosa). St. Johns River Water Management District, Palatka, Florida.

U.S. Fish and Wildlife Service (USFWS). 1999. Everglades Snail Kite (*Rostrhamus sociabilis plumbeus*). Pages 4-291 - 294-324. U. S. Fish and Wildlife Service, Vero Beach, Florida.

Vannote, R. L., G. W. Minshall, K. W. Cummins, J. R. Sedell, and C. E. Cushing. 1980. The River Continuum Concept. Can. J. Fish. Aquatic Sci. 37:130-137.

Vince, S. W., S. R. Humphrey, and R. W. Simons. 1989. The ecology of hydric hammocks: A community profile. US Fish and Wildlife Service Biol Rep 85(7.26).

Weller, M. W., and C. S. Spatcher. 1965. Role of habitat in the distribution and abundance of marsh birds. Special Report No. 43. Iowa State University, Ames.

8 APPENDICES

APPENDIX 13.A. WILDLIFE OF THE ST. JOHNS RIVER FLOODPLAIN

APPENDIX 13.B. TAXONOMIC WILDLIFE LIST

APPENDIX 13.C. WILDLIFE SPECIES OF CONSERVATION CONCERN FOR THE ST. JOHNS RIVER FLOODPLAIN

APPENDIX 13.D. SUPPORTING INFORMATION AND GLOSSARY FOR THE HYDROLOGIC WILDLIFE MODEL

APPENDIX 13.E. WILDLIFE SPECIES AND THEIR HYDROLOGIC REQUIREMENTS

APPENDIX 13.F. WATERFOWL POPULATION SUMMARY