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**THE AVIFAUNA OF CONSTRUCTED TREATMENT
WETLANDS IN SOUTH FLORIDA USED FOR
EVERGLADES RESTORATION**

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Constructed treatment wetlands invariably create wildlife habitat (Kadlec and Knight 1996, U.S. Environmental Protection Agency 1999, Knight et al. 2001). Habitat improvement can be dramatic, especially when these systems are built on degraded areas such as farm fields (Hickman 1994). The South Florida Water Management District (SF-WMD) and the U.S. Army Corps of Engineers have built a complex of large treatment wetlands, known as Stormwater Treatment Areas (STAs), on reclaimed farmland in south Florida as part of a multi-billion dollar effort by State and Federal governments to protect and restore the Everglades (Chimney and Goforth 2001, Sklar et al. 2005, SFWMD 2006). Current plans call for the STAs to encompass more than 17,000 ha. These wetlands were designed to treat and reduce high phosphorus concentrations in stormwater runoff from the Everglades Agricultural Area (EAA) before this water enters the northern portion of the remaining Everglades, the Water Conservation Areas (WCAs) (Fig. 1). The STAs have attracted a high abundance and diversity of wildlife species, including many birds. This paper presents a checklist of the avifauna found in two of the STAs and compares STA bird community composition and species richness with regional and other treatment wetlands.

METHODS

Birds in two STAs were surveyed: STA-1West (STA-1W) in Palm Beach County (2,699 ha, 26°39' N, 80°25' W) and STA-5 in Hendry County (1,663 ha, 26°26' N, 80°54' W). Both STAs are located within the EAA and are part of a regional landscape dominated by wetlands (Fig. 1). The STAs were built on relict Everglades marshland that had been drained and farmed for decades. Portions of STA-1W were flooded in 1989 and first opened for public birding in 2005; STA-5 was flooded in 1999 and opened for public birding in 2004. Each STA has a perimeter earthen levee that impounds water and various control structures (pump stations, interior levees, culverts, etc.) to manage flow through the system. The STAs are kept inundated except when inflow is restricted during ex-

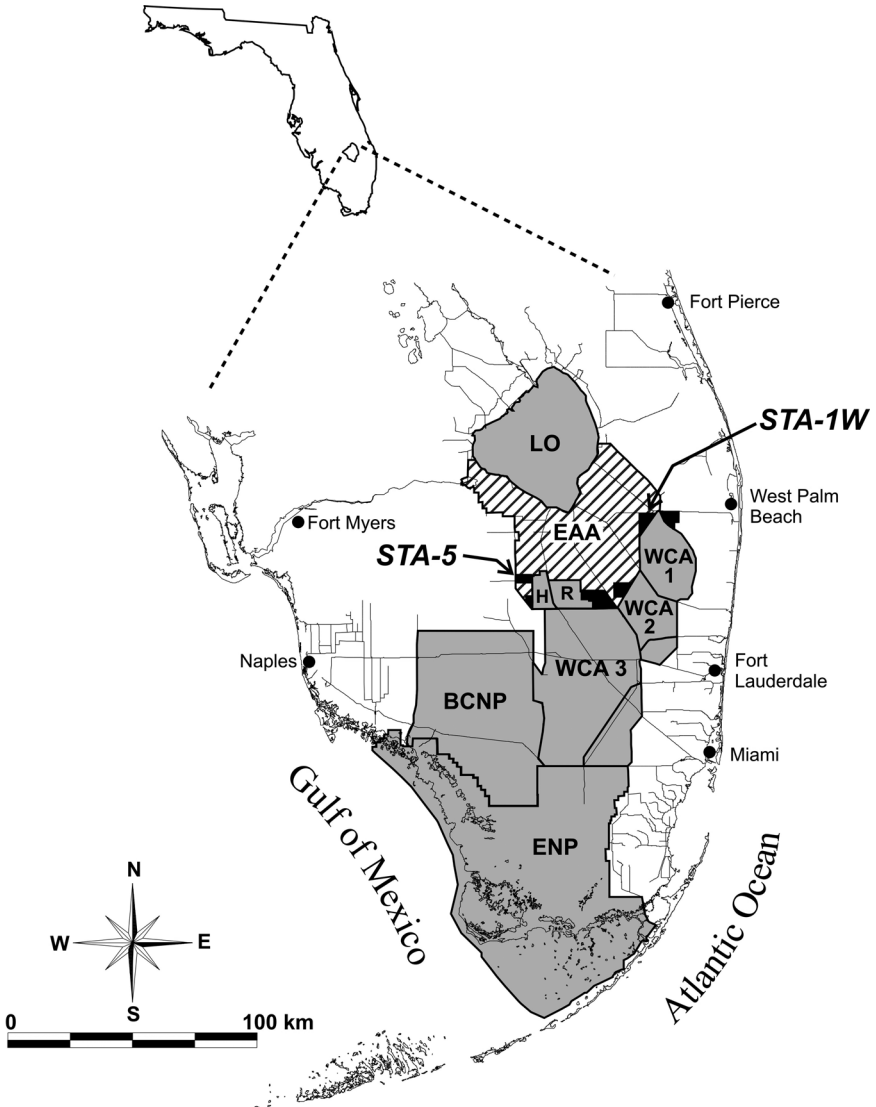


Figure 1. Location of Stormwater Treatment Areas 1-West and 5 (STA-1W and STA-5) in relation to the Everglades Agricultural Area, the other STAs (black areas), Lake Okeechobee, and major wetland management units (gray areas) in south Florida. More than 40% of the landscape in this region is classified as freshwater habitat. BCNP = Big Cypress National Preserve; EAA = Everglades Agricultural Area; ENP = Everglades National Park; H = Holey Land Wildlife Management Area; LO = Lake Okeechobee; R = Rotenberger Wildlife Management Area; WCA = Water Conservation Areas 1, 2, and 3. Water Conservation Area 1 also is designated as the Arthur R. Marshall Loxahatchee National Wildlife Refuge.

treme droughts or when treatment cells are taken off-line for maintenance. The target depth in these systems is ~0.5 m, but can exceed 1 m after large rain events when the STAs are treating runoff. Water depth in these systems can fluctuate rapidly in response to management activities. Flooded areas in the STAs developed into a mosaic of habitat types that included open-water areas intermixed with stands of *Typha* spp., other emergent marsh species (e.g., arrowhead [*Sagittaria* spp.], spikerush [*Eleocharis* spp.] and pickerelweed [*Pontederia cordata*]), submersed vegetation (e.g., coontail [*Ceratophyllum demersum*], southern naiad [*Najas guadalupensis*] and hydrilla [*Hydrilla verticillata*]) and floating species (e.g., water hyacinth [*Eichhornia crassipes*], water lettuce [*Pistia stratiotes*] and duckweed [*Lemna* spp.]). The STA levees, access roads and adjacent lands were upland areas that include grassed, old-field, and woodland habitats.

A master bird list was compiled for each STA by combining species identifications made by one of us (DEG) on 84 occasions in STA-1W from May 1995 to November 1997 (primarily winter and spring), by amateur ornithologists from local Audubon Society chapters in both STAs during fall, winter and spring (12 trips to STA-1W from September 2005 to March 2006; 15 trips to STA-5 from February 2004 to March 2006) and other incidental sightings. The accuracy of identifications made by citizen volunteers can be comparable to data collected by professional biologists (Hoyer et al. 2001). We did not estimate individual species densities from our survey data, but did ascertain the more abundant bird groups. Birds seen on at least 50% of all trips to each STA from 2004 to 2006 were designated as "frequent" species. The nomenclature, classification and sequence of each species followed American Ornithologists' Union (2006); habitat preferences are from American Ornithologists' Union (1998). The protective status of birds was based on Florida Fish and Wildlife Conservation Commission (2004). Breeding status and seasonality of birds in south Florida was based on distribution maps and descriptions provided in Robertson and Kushlan (1974), Robertson and Woolfenden (1992), Ridgely et al. (2003) and U.S. Fish & Wildlife Service (2006). Wetland bird species richness in the STAs, the Arthur R. Marshall Loxahatchee National Wildlife Refuge (LNWR; see Fig. 1) and a subset of treatment wetlands (Knight et al. 1993, USEPA 1999) was fit to wetland surface area as a power function: $S = cA^z$, where S is species richness, A is surface area, c is a constant and z is the slope of the regression (Gotelli 2001).

RESULTS

A total of 139 bird species representing 39 families was observed in the STAs; 100 species in 31 families occurred in STA-1W, whereas STA-5 had 118 species in 38 families (Table 1). Combined, the two STAs had 20 of the 21 families identified by Kadlec and Knight (1996) as common in North American treatment wetlands. Wading birds (Ciconiiformes, 15 species), shorebirds (Charadriiformes, 31 species), gallinules and coots (Gruiformes, 7 species) and ducks (Anseriformes, 16 species) were often numerically abundant in the STAs as were perching birds (Passeriformes, 39 species) on occasion. Twenty-eight of the 35 frequently observed species belonged to these aforementioned groups. Sixteen species are State and/or Federally listed as Endangered, Threatened or a Species of Special Concern. Seventy-two species are classified as residents and are known to breed in south Florida. Six frequent species (Osprey [*Pandion haliaetus*], Roseate Spoonbill [*Platylea ajaja*], Snowy Egret [*Egretta thula*], Tricolored Heron [*Egretta*

Table 1. Checklist of birds observed in Stormwater Treatment Areas 1-West and 5 (STA-1W and STA-5) including seasonality, breeding and protective status and habitat preference. + = species present, * = frequently observed species listed on at least 50% of all surveys in that STA. Status key: E = endangered (Federal), e = endangered (State), s = species of special concern (State), T = threatened (Federal), t = threatened (State), R = breeding resident, R_e = exotic resident, S = uncommon straggler (non-breeding), M = transient migrant (non-breeding), V = seasonal visitor (non-breeding). Habitat preference key: A = aquatic, U = upland.

Order		STA-	STA-	Status	Habitat
Family	Species Name	1W	5		
Anseriformes					
Anatidae	Ducks, Geese, & Swans				
	<i>Dendrocygna autumnalis</i>	+	*	V	A
	<i>Dendrocygna bicolor</i>	+	*	R	A
	<i>Anser albifrons</i>	+		V	A
	<i>Aix sponsa</i>		+	R	A
	<i>Anas americana</i>		+	V	A
	<i>Anas platyrhyncho</i>		+	V	A
	<i>Anas fulvigula</i>	+	*	R	A
	<i>Anas discors</i>	*	*	V	A
	<i>Anas cyanoptera</i>		+	V	A
	<i>Anas clypeata</i>	+	+	V	A
	<i>Anas acuta</i>	+	+	V	A
	<i>Anas crecca</i>		+	V	A
	<i>Aythya collaris</i>	+	*	V	A
	<i>Aythya affinis</i>		+	V	A
	<i>Lophodytes cucullatus</i>	+		V	A
	<i>Oxyura jamaicensis</i>		+	V	A
Podicipediformes					
Podicipedidae	Grebes				
	<i>Podilymbus podiceps</i>	+	+	R	A
Pelecaniformes					
Pelecanidae	Pelicans				
	<i>Pelecanus erythrorhynchos</i>	+	+	V	A
	<i>Pelecanus occidentalis</i>	+	+	R,s	A
Phalacrocoracidae	Cormorants				
	<i>Phalacrocorax auritus</i>	*	*	R	A
Anhingidae	Darters				
	<i>Anhinga anhinga</i>	*	*	R	A
Ciconiiformes					
Ardeidae	Herons, Bitterns, & Allies				
	<i>Botaurus lentiginosus</i>	+	+	V	A
	<i>Ixobrychus exilis</i>	+	+	R	A
	<i>Ardea herodias</i>	*	*	R	A
	<i>Ardea alba</i>	*	*	R	A

Table 1. (Continued) Checklist of birds observed in Stormwater Treatment Areas 1-West and 5 (STA-1W and STA-5) including seasonality, breeding and protective status and habitat preference. + = species present, * = frequently observed species listed on at least 50% of all surveys in that STA. Status key: E = endangered (Federal), e = endangered (State), s = species of special concern (State), T = threatened (Federal), t = threatened (State), R = breeding resident, R_e = exotic resident, S = uncommon straggler (non-breeding), M = transient migrant (non-breeding), V = seasonal visitor (non-breeding). Habitat preference key: A = aquatic, U = upland.

Order		STA-	STA-	Status	Habitat
Family	Species Name	1W	5		
	<i>Egretta thula</i>	*	+	R,s	A
	<i>Egretta caerulea</i>	*	+	R,s	A
	<i>Egretta tricolor</i>	*	*	R,s	A
	<i>Bubulcus ibis</i>	*	*	R	A/U
	<i>Butorides virescens</i>	+	*	R	A
	<i>Nycticorax nycticorax</i>	+	+	R	A
	<i>Nyctanassa violacea</i>		+	R	A
Threskiornithidae	Ibises & Spoonbills				
	<i>Eudocimus albus</i>	*	+	R,s	A
	<i>Plegadis falcinellus</i>	*	*	R	A
	<i>Platalea ajaja</i>	*	+	R,s	A
Ciconiidae	Storks				
	<i>Mycteria americana</i>	*	+	R,E,e	A
Cathartidae	New World Vultures				
	<i>Coragyps atratus</i>	+	*	R	U
	<i>Cathartes aura</i>	+	*	R	U
Phoenicopteriformes					
Phoenicopteridae	Flamingos				
	<i>Phoenicopus ruber</i>		+	S	A
Falconiformes					
Accipitridae	Hawks, Kites, Eagles, & Allies				
	<i>Pandion haliaetus</i>	*	+	R,s	A
	<i>Elanoides forficatus</i>		+	R	U
	<i>Rostrhamus sociabilis</i>	+		R,E,e	A
	<i>Haliaeetus leucocephalus</i>	*	+	R,T,t	A
	<i>Circus cyaneus</i>	+	+	V	A/U
	<i>Accipiter striatus</i>		+	V	U
	<i>Accipiter cooperii</i>	+	+	V	U
	<i>Buteo lineatus</i>	+	+	R	A/U
	<i>Buteo jamaicensis</i>		*	R	U
Falconidae	Caracaras & Falcons				
	<i>Caracara cheriway</i>		+	R,T,t	U
	<i>Falco sparverius</i>	+	+	R,T	U
	<i>Falco columbarius</i>		+	V	A/U
	<i>Falco peregrinus</i>	+	+	R,e	A/U

Table 1. (Continued) Checklist of birds observed in Stormwater Treatment Areas 1-West and 5 (STA-1W and STA-5) including seasonality, breeding and protective status and habitat preference. + = species present, * = frequently observed species listed on at least 50% of all surveys in that STA. Status key: E = endangered (Federal), e = endangered (State), s = species of special concern (State), T = threatened (Federal), t = threatened (State), R = breeding resident, R_e = exotic resident, S = uncommon straggler (non-breeding), M = transient migrant (non-breeding), V = seasonal visitor (non-breeding). Habitat preference key: A = aquatic, U = upland.

Order	Family	Species Name	Common Name	STA-1W	STA-5	Status	Habitat
	Gruiformes						
	Rallidae		Rails, Gallinules, & Coots				
		<i>Rallus elegans</i>	King Rail	+		R	A
		<i>Porzana carolina</i>	Sora	+	+	V	A
		<i>Porphyrio martinica</i>	Purple Gallinule	+	+	R	A
		<i>Porphyrio porphyrio</i>	Purple Swampphen	+	+	R _e	A
		<i>Gallinula chloropus</i>	Common Moorhen	*	*	R	A
		<i>Fulica americana</i>	American Coot	*	*	R	A
	Aramidae		Limpkin				
		<i>Aramus guarauna</i>	Limpkin	+	+	R,s	A
	Charadriiformes						
	Charadriidae		Plovers				
		<i>Pluvialis squatarola</i>	Black-bellied Plover	+	+	V	A
		<i>Pluvialis dominica</i>	American Golden-Plover		+	M	A/U
		<i>Charadrius semipalmatus</i>	Semipalmated Plover	+		V	A
		<i>Charadrius vociferus</i>	Killdeer	*	*	R	A/U
	Recurvirostridae		Stilts & Avocets				
		<i>Himantopus mexicanus</i>	Black-necked Stilt	*	*	R	A
		<i>Recurvirostra americana</i>	American Avocet	+	+	V	A
	Scolopacidae		Sandpipers & Allies				
		<i>Tringa solitaria</i>	Solitary Sandpiper	+		M	A
		<i>Tringa melanoleuca</i>	Greater Yellowlegs	+	*	V	A
		<i>Tringa flavipes</i>	Lesser Yellowlegs	*	+	V	A
		<i>Tringa semipalmata</i>	Willet	+	+	R	A
		<i>Arenaria interpres</i>	Ruddy Turnstone	+		V	A
		<i>Calidris alba</i>	Sanderling	+		V	A
		<i>Calidris mauri</i>	Western Sandpiper	+		V	A
		<i>Calidris minutilla</i>	Least Sandpiper	*	*	V	A
		<i>Calidris melanotos</i>	Pectoral Sandpiper	+	+	M	A
		<i>Calidris alpina</i>	Dunlin	+	+	V	A
		<i>Calidris himantopus</i>	Stilt Sandpiper	+	+	V	A
		<i>Philomachus pugnax</i>	Ruff		+	V	A
		<i>Limnodromus griseus</i>	Short-billed Dowitcher	+	+	V	A
		<i>Limnodromus scolopaceus</i>	Long-billed Dowitcher	+	+	V	A
		<i>Gallinago delicata</i>	Wilson's Snipe	+	+	V	A
	Laridae		Skuas, Gulls, Terns, & Skimmers				
		<i>Larus atricilla</i>	Laughing Gull	+		R	A

Table 1. (Continued) Checklist of birds observed in Stormwater Treatment Areas 1-West and 5 (STA-1W and STA-5) including seasonality, breeding and protective status and habitat preference. + = species present, * = frequently observed species listed on at least 50% of all surveys in that STA. Status key: E = endangered (Federal), e = endangered (State), s = species of special concern (State), T = threatened (Federal), t = threatened (State), R = breeding resident, R_e = exotic resident, S = uncommon straggler (non-breeding), M = transient migrant (non-breeding), V = seasonal visitor (non-breeding). Habitat preference key: A = aquatic, U = upland.

Order						
Family			STA-	STA-	Status	Habitat
	Species Name	Common Name	1W	5		
	<i>Larus delawarensis</i>	Ring-billed Gull	+	+	V	A
	<i>Larus argentatus</i>	Herring Gull		+	V	A
	<i>Larus fuscus</i>	Lesser Black-backed Gull		+	V	A
	<i>Sterna antillarum</i>	Least Tern	+		R,t	A
	<i>Gelochelidon nilotica</i>	Gull-billed Tern	+		R	A
	<i>Hydroprogne caspia</i>	Caspian Tern	*	+	V	A
	<i>Sterna forsteri</i>	Forster's Tern	+		V	A
	<i>Thalasseus maximus</i>	Royal Tern	+		R	A
	<i>Rynchops niger</i>	Black Skimmer	+	+	R,s	A
Columbiformes						
	Columbidae	Pigeons & Doves				
	<i>Columba livia</i>	Rock Pigeon	+	+	R _e	U
	<i>Streptopelia decaocto</i>	Eurasian Collared-Dove		+	R _e	U
	<i>Zenaida asiatica</i>	White-winged Dove	+		R	U
	<i>Zenaida macroura</i>	Mourning Dove	+	+	R	U
	<i>Columbina passerina</i>	Common Ground-Dove	+	+	R	U
Cuculiformes						
	Cuculidae	Cuckoos, Roadrunners, & Anis				
	<i>Crotophaga ani</i>	Smooth-billed Ani	+		R	A/U
Strigiformes						
	Strigidae	Typical Owls				
	<i>Strix varia</i>	Barred Owl		+	R	A/U
Caprimulgiformes						
	Caprimulgidae	Goatsuckers				
	<i>Chordeiles minor</i>	Common Nighthawk		+	R	U
Coraciiformes						
	Alcedinidae	Kingfishers				
	<i>Ceryle alcyon</i>	Belted Kingfisher	+	+	R	A
Piciformes						
	Picidae	Woodpeckers & Allies				
	<i>Melanerpes carolinus</i>	Red-bellied Woodpecker	+	+	R	U
Passeriformes						
	Tyrannidae	Tyrant flycatchers				
	<i>Sayornis phoebe</i>	Eastern Phoebe		+	V	U
	<i>Myiarchus crinitus</i>	Great Crested Flycatcher		+	R	U

Table 1. (Continued) Checklist of birds observed in Stormwater Treatment Areas 1-West and 5 (STA-1W and STA-5) including seasonality, breeding and protective status and habitat preference. + = species present, * = frequently observed species listed on at least 50% of all surveys in that STA. Status key: E = endangered (Federal), e = endangered (State), s = species of special concern (State), T = threatened (Federal), t = threatened (State), R = breeding resident, R_e = exotic resident, S = uncommon straggler (non-breeding), M = transient migrant (non-breeding), V = seasonal visitor (non-breeding). Habitat preference key: A = aquatic, U = upland.

Order	Family	Species Name	Common Name	STA-1W	STA-5	Status	Habitat
	Laniidae		Shrikes				
		<i>Lanius ludovicianus</i>	Loggerhead Shrike	+	+	R	U
	Vireonidae		Vireos				
		<i>Vireo griseus</i>	White-eyed Vireo		+	R	U
	Corvidae		Crows & Jays				
		<i>Cyanocitta cristata</i>	Blue Jay	+	+	R	U
		<i>Corvus brachyrhynchos</i>	American Crow		+	R	U
		<i>Corvus ossifragus</i>	Fish Crow	+	+	R	A
	Hirundinidae		Swallows				
		<i>Progne subis</i>	Purple Martin	+	+	R	U
		<i>Tachycineta bicolor</i>	Tree Swallow	+	*	V	U
		<i>Stelgidopteryx serripennis</i>	Northern Rough-winged Swallow	+	+	V	U
		<i>Petrochelidon pyrrhonota</i>	Cliff Swallow		+	M	A
		<i>Hirundo rustica</i>	Barn Swallow		+	M	A/U
	Troglodytidae		Wrens				
		<i>Troglodytes aedon</i>	House Wren		+	V	U
	Sylviidae		Old World Warblers				
		<i>Poliophtila caerulea</i>	Blue-gray Gnatcatcher	+	+	R	U
	Turdidae		Thrushes				
		<i>Sialia sialis</i>	Eastern Bluebird		+	R	U
		<i>Turdus migratorius</i>	American Robin		+	V	U
	Mimidae		Mockingbirds & Thrashers				
		<i>Dumetella carolinensis</i>	Gray Catbird		+	V	U
		<i>Mimus polyglottos</i>	Northern Mockingbird	+	+	R	U
	Sturnidae		Starlings				
		<i>Sturnus vulgaris</i>	European Starling	+	+	R _e	U
	Parulidae		Wood-Warblers				
		<i>Parula americana</i>	Northern Parula		+	R	A/U
		<i>Dendroica petechia</i>	Yellow Warbler		+	R	U
		<i>Dendroica coronata</i>	Yellow-rumped Warbler	+	+	V	U
		<i>Dendroica discolor</i>	Prairie Warbler	+		R	U
		<i>Dendroica palmarum</i>	Palm Warbler	*	+	V	U
		<i>Minotilta varia</i>	Black-and-white Warbler		+	V	U
		<i>Seiurus noveboracensis</i>	Northern Waterthrush	+		M	A
		<i>Geothlypis trichas</i>	Common Yellowthroat	+	+	R	A
	Emberizidae		Emberizids				
		<i>Pipilo erythrophthalmus</i>	Eastern Towhee	+		R	U

Table 1. (Continued) Checklist of birds observed in Stormwater Treatment Areas 1-West and 5 (STA-1W and STA-5) including seasonality, breeding and protective status and habitat preference. + = species present, * = frequently observed species listed on at least 50% of all surveys in that STA. Status key: E = endangered (Federal), e = endangered (State), s = species of special concern (State), T = threatened (Federal), t = threatened (State), R = breeding resident, R_e = exotic resident, S = uncommon straggler (non-breeding), M = transient migrant (non-breeding), V = seasonal visitor (non-breeding). Habitat preference key: A = aquatic, U = upland.

Order		STA-1W	STA-5	Status	Habitat
Family	Species Name	Common Name			
	<i>Spizella pusilla</i>	Field Sparrow		+	V U
	<i>Passerculus sandwichensis</i>	Savannah Sparrow	+	+	V A
	<i>Melospiza georgiana</i>	Swamp Sparrow	+		V A/U
Cardinalidae		Cardinal, Saltators, & Allies			
	<i>Cardinalis cardinalis</i>	Northern Cardinal	+		R U
	<i>Passerina ciris</i>	Painted Bunting		+	V U
Icteridae		Blackbirds			
	<i>Agelaius phoeniceus</i>	Red-winged Blackbird	*	*	R A
	<i>Sturnella magna</i>	Eastern Meadowlark	+	+	R U
	<i>Quiscalus quiscula</i>	Common Grackle		+	R A/U
	<i>Quiscalus major</i>	Boat-tailed Grackle	*	*	R A/U
	<i>Molothrus ater</i>	Brown-headed Cowbird		+	V U
Passeridae		Old World Sparrows			
	<i>Passer domesticus</i>	House Sparrow		+	R _e U

tricolor], White Ibis [*Eudocimus albus*], and Wood Stork [*Mycteria americana*] are both State/Federally listed and breed in the region. The STAs were used by many migratory species, often in great numbers, during the spring and fall (e.g., American White Pelican [*Pelecanus erythrorhynchos*], Black-bellied Whistling-Duck [*Dendrocygna autumnalis*], Blue-winged Teal [*Anas discors*], Lesser Yellowlegs [*Tringa flavipes*] and Black-necked Stilt [*Himantopus mexicanus*]). Sixty-nine percent of STA bird species preferred aquatic habitats or shared an affinity for both aquatic and upland areas. However, all pigeons and doves, and many of the raptors and perching birds are considered upland species.

DISCUSSION

Bird diversity and abundance in wetlands is influenced by a number of variables such as wetland surface area (Reaves and Croteau-Hartman 1994), water depth (Breininger and Smith 1990, Twedt et al. 1998, Bancroft et al. 2002), composition of the vegetation community (Johnson and Montalbano 1984, Bancroft et al. 2002), prey availability

(Gawlik 2002) and trophic status (Hoyer and Canfield 1994, Crozier and Gawlik 2002). High quality upland habitat immediately adjacent to wetlands also attracts a number of species that may be only facultative wetland inhabitants (Kent 1994, Knight et al. 2001). The STAs shared 91% of their avifauna with the LNWR (USFWS 2006), but only 78% with the EAA (Pearlstone et al. 2005). The EAA notably had fewer co-occurring species of perching birds and ducks, which may be related to its limited shrub habitat and type of wetlands (largely restricted to rice fields, flooded fallow fields and drainage canals). Differences in surface area accounted for slightly more than one-half of the variance in bird species richness among wetlands ($r^2 = 0.59$, $p < 0.01$) (Fig. 2). The unexplained variance can be attributed to the other species-habitat relationships noted above (Rafe et al. 1985) or factors such as differences in sampling methods among investigators.

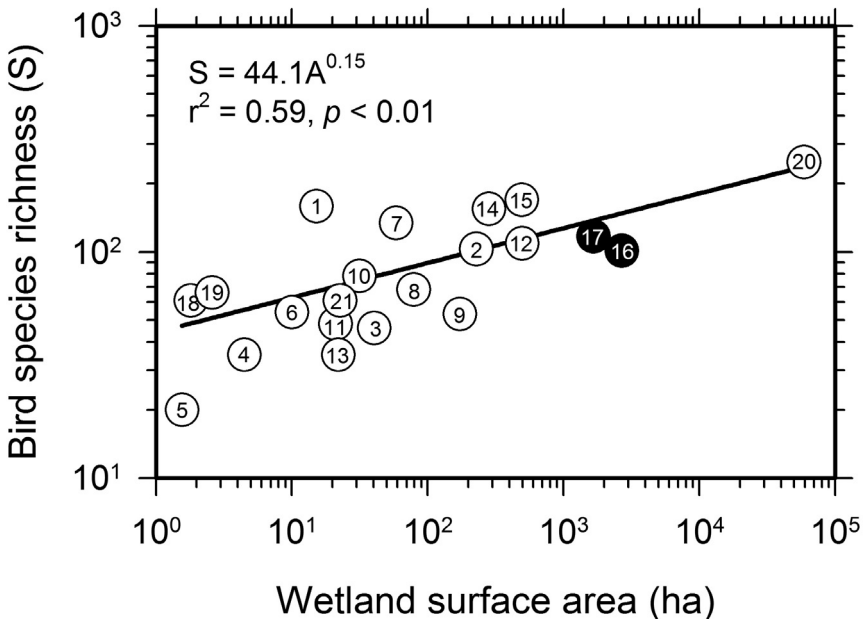


Figure 2. Species-area curve for wetland bird communities. Symbol key: 1 = Arcata (CA), 2 = Bear Bay (SC), 3 = Biwabik (MN), 4 = Collins (MS), 5 = Cypress Domes (FL), 6 = Des Plaines (IL), 7 = Hayward (CA), 8 = Houghton Lake (MI), 9 = Incline Village (NV), 10 = Lake Buena Vista (FL), 11 = Lake Coral (FL), 12 = Lakeland (FL), 13 = Ocean Springs (MS), 14 = Orlando Easterly (FL), 15 = Show Low (AZ), 16 = STA-1W (FL), 17 = STA-5 (FL), 18 = Tres Rios Cobble (AZ), 19 = Tres Rios Hayfield (AZ), 20 = LNWR (FL), 21 = West Jackson County (MS). Data sources: 1-9, 12, 15, 18, 19, & 21 (USEPA 1999); 10 (Kent and Langston 2000); 11 (Knight et al. 1985); 13 (Kadlec and Knight 1996); 14 (M. Sees pers. comm.); 16 & 17 (this paper); 20 (USFWS 2006). All systems except LNWR are treatment wetlands.

The bird assemblage in the STAs was not static. The periodic influx of large numbers of birds of a single species or group of species into the STAs generally occurred under one of two circumstances. The first was associated with large numbers of migrating birds moving into the area that found the STAs suitable habitat. Seasonal migrants accounted for the high concentrations of Tree Swallows, Blue-winged Teal and other waterfowl. The STAs at normal operating depth (~0.5 to 1.0 m) afforded birds with moderate to deep-water marsh habitat. The sharp increases in bird abundance during the fall and spring was somewhat predictable, but varied in magnitude from year to year, probably because of external factors such as annual recruitment and habitat suitability of the surrounding landscape.

The second circumstance that produced dramatic increases in bird abundance occurred when water depth in the STAs decreased during recessions. In this case, the habitat changed quickly and local birds attracted to shallow water (e.g., wading- and shorebirds) moved in to exploit it. An example of this situation occurred in March 1996 when water levels in portions of STA-1W rapidly fell from depths that approached 1 m to 0.2 m or less. A group of over 1000 herons, egrets, ibis and Wood Storks, many of which had been feeding in the surrounding area, quickly moved in and began feeding in the drying marsh. Although we did not continue observations, we suspect that as soon as water levels increased to normal, most of the wading birds would have returned to their previous feeding areas. A similar managed drawdown in winter 2005 of a substantial portion of STA-1W that contained little emergent vegetation attracted a great number of shorebirds. The influx of birds into the STAs in response to falling water levels has occurred on other occasions; these events were driven by management activities and therefore were unpredictable from the bird's perspective or occurred during prolonged regional droughts. The proximate factor for the increase in bird density was likely a sharp increase in food availability (Gawlik 2002) because prey was suddenly more vulnerable to being captured. This situation differed from seasonal migrations in that the increase in bird abundance was from a redistribution of local birds rather than a regional influx of migrants and it was caused by a short-term change in the habitat (i.e., water depth) rather than from long-term processes that structure vegetation, such as trophic status.

The two situations that cause high bird abundance in the STAs are not mutually exclusive and it is possible that a decrease in water depth that coincides with seasonal bird migration could result in very high bird density and diversity. Such a convergence of events contributed to the high diversity of shorebirds in STA-1W. Although the STAs are operated as treatment systems to reduce nutrients in stormwater runoff, bird use of these areas is extensive and dependent on variable wetland conditions, much like in natural wetlands.

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