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PURPOSE

The purpose of *USGA Turfgrass and Environmental Research Online* is to effectively communicate the results of research projects funded under USGA's Turfgrass and Environmental Research Program to all who can benefit from such knowledge. Since 1983, the USGA has funded more than 290 projects at a cost of $25 million. The private, non-profit research program provides funding opportunities to university faculty interested in working on environmental and turf management problems affecting golf courses. The outstanding playing conditions of today's golf courses are a direct result of ***using science to benefit golf***.

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Habitat Value of Golf Course Wetlands to Waterbirds

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SUMMARY

University of Florida researchers conducted a two-year study (2001 and 2002) in southwest Florida to determine the habitat value of golf course ponds to waterbirds. Their findings include:

- A total of 42 species were observed on 183 golf course ponds in southwest Florida during a 2-year study conducted by the University of Florida.
- The majority of birds (46%) observed during surveys used the ponds as foraging habitat. The least commonly observed behavior during the study was nesting (<1%).
- The extent to which waterbirds used golf course ponds in this study was primarily related to pond size, ability of the birds to access prey, and habitat features that influenced security and foraging success.
- In general, larger ponds (defined by the surface area or perimeter of the ponds) attracted more waterbirds. However, some species, such as wading birds that are unable to access prey in open water areas, selected ponds based on the size of their littoral zones rather than overall size.
- A wide range of other habitat variables were selected by the waterbirds. In order to provide habitat for the greatest number of waterbird species, golf course ponds could be managed as a wetland complex whereby different ponds or sections of ponds are enhanced or modified for different species.
- Some types of habitat modifications could benefit waterbirds, as well as provide management options for the golf course. For example, low-lying wet areas that are often difficult to maintain may be ideal areas to increase the littoral zone for wading birds.

Urbanization, roads, and other human-induced changes to natural areas continue to alter and degrade wetlands nationwide. As natural wetlands decline in availability and quality, alternative habitats such as created wetlands may become increasingly important to wetland-dependent wildlife. Wetland-dependent birds, often referred to as waterbirds, seem well suited to use created wetlands when appropriate habitat is available.

In urban and suburban areas, golf course ponds have excellent potential to provide valuable habitat in areas that otherwise lack suitable habitat for waterbirds. Almost anyone who has spent time on a golf course has noticed a variety of birds such as ducks, geese, herons, and the little peeps running along pond shorelines. It seems clear that many species of waterbirds use golf course ponds. What is unclear, however, is what characteristics of the golf course ponds are important for waterbird species.

We conducted a two-year study (2001 and 2002) in southwest Florida to determine the habitat value of golf course ponds to waterbirds. Our objectives were to identify the diversity and abundance of waterbirds using golf course ponds and to evaluate the effects of numerous habitat variables on waterbird use. Habitat and hydrological variables were quantified at each pond to determine the relationship between these components

Increasing littoral zones can improve the habitat value of golf course ponds for wading birds such as this Great Egret (*Ardea albus*) shown above.

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Species	Total abundance	Average density (no./ha)	Occurrence (# of ponds) 2001	2002
Diving Birds				
Double-crested cormorant (*Phalacrocorax auritus*)	3,078	6.564	105	107
Anhinga (*Anhinga anhinga*)	943	2.011	111	119
Pied-billed grebe (*Podilymbus podiceps*)	247	0.527	38	7
Hooded merganser (*Lophodytes cucllatus*)	240	0.512	9	3
Lesser scaup (*Aythya affinis*)	78	0.166	N/A	25
Ring-necked duck (*Aythya collaris*)	1	0.002	N/A	1
Ruddy duck (*Oxyura jamaicensis*)	1	0.002	N/A	1
Open Water Waders				
Little blue heron (*Egretta caerulea*)	677	1.444	100	21
Great egret (*Ardea albus*)	533	1.137	107	79
Snowy egret (*Egretta thula*)	530	1.130	74	79
Tricolored heron (*Egretta tricolor*)	420	0.896	73	108
Great blue heron (*Ardea herodias*)	340	0.725	85	2
Glossy ibis (*Plegadis falcinellus*)	249	0.531	24	68
White ibis (*Eudocimus albus*)	208	0.444	31	78
Wood stork (*Mycteria americana*)	76	0.162	18	29
Sandhill crane (*Grus canadensis*)	7	0.015	2	14
Dense Vegetation Waders				
Green heron (*Butorides virescens)*	96	0.205	21	1
Black-crowned night-heron (*Nycticorax nycticorax*)	22	0.047	4	35
American bittern (*Botaurus lentiginosus*)	1	0.002	N/A	4
Dipping and Dabbling Foragers				
Common moorhen (*Gallinula chloropus*)	511	1.090	17	2
Mottled duck (*Anas fulvigula*)	475	1.013	58	8
Blue-winged teal (*Anas discors*)	130	0.277	16	28
American coot (*Fulica americana*)	48	0.102	2	1
Wood duck (*Aix sponsa*)	2	0.004	N/A	70
Hybrid (mottled duck and mallard)	1	0.002	N/A	1
Moist-soil Foragers				
Killdeer (*Charadrius vociferous*)	497	1.060	99	2
Unidentified shorebird	362	0.772	22	2
Greater/lesser yellowlegs (*Tringa melanoleuca/flavipes*)	288	0.614	58	0
Ring-billed gull (*Larus delawarensis*)	162	0.345	19	10
Common snipe (*Gallinago gallinago*)	35	0.075	12	60
Laughing gull (*Larus atricilla*)	8	0.017	N/A	3
Willet (*Catoptrophorus semipalmatus*)	7	0.015	4	9
Black-bellied plover (*Pluvialis squatarola*)	3	0.006	N/A	36
Black-necked stilt (*Himantopus mexicanus*)	4	0.009	N/A	1
Bonaparte's gull (*Larus philadelphia*)	1	0.002	1	45
Aerial Piscivores				
Bald eagle (*Haliaeetus leucocephalus*)	4	0.009	N/A	4
Belted kingfisher (*Ceryle alcyon*)	157	0.335	33	67
Brown pelican (*Pelecanus occidentalis*)	2	0.004	2	0
Forster's tern (*Sterna forsteri*)	7	0.030	2	2
Least tern (*Sterna antillarum*)	2	0.004	N/A	1
Osprey (*Pandion haliaetus*)	16	0.034	N/A	10
Royal tern (*Sterna maxima*)	5	0.021	2	1
STUDY TOTAL	**10,474**	**22.337**		

Table 1. Waterbird species observed during surveys of 183 golf course ponds in southwest Florida during 2001 and 2002. Total abundance, average density (average abundance/total hectares for all golf course ponds), and number of ponds where species were observed in 2001 and 2002 are listed. Species are ranked by numbers observed within each guild classification.

Foraging Guild	General Description	Species
Diving Birds	Forage in a variety of water depths, but were generally observed in open water	Grebes, cormorants, anhingas, mergansers, scaup, ruddy and ring-necked ducks
Open Water Waders	Forage in shallow water with low density vegetation	Herons, egrets, ibises, storks, cranes
Dense Vegetation Waders	Forage in shallow water surrounded by dense vegetation	Night and green herons, bitterns
Dipping/Dabbling Foragers	Forage by surface dipping or dabbling in shallow water	Mottled ducks, blue-wing teal, moorhens, coots
Moist-soil Foragers	Forage in muddy or moist-soil areas along the shoreline	Sandpipers, yellowlegs, stilts, willets, killdeer, snipes, gulls
Aerial Piscivores	Generally use perches to search for prey and then dive from a height to capture prey	Terns, kingfishers, eagles, osprey, pelicans

Table 2. Foraging guilds with general description of foraging techniques used for classification and representative species for each guild.

and waterbird abundance and species richness. Hydrological variables included trophic status, as an indicator or food availability, and available shallow water (<40 cm) habitat around each pond's perimeter. Habitat features included shoreline and littoral zone vegetation type and cover, and adjacent landscape features (e.g., golf course, residential housing, construction, etc.).

Methodology

Study species

All species studied in this project were waterbirds and are defined, for the purposes of this study, as any water-dependent bird species (14). Members from the following orders of birds were surveyed: Ciconiiformes (wading birds), Gruiformes (short-legged and other wading birds), Pelecaniformes (diving birds), Anseriformes (waterfowl), Podicipediformes (grebes), Coraciiformes (kingfishers), and Charadriformes (shorebirds). Birds from these orders represent a variety of bird sizes, morphology, foraging techniques, and major substrate used for foraging (e.g., bare mudflat vs. open water). Because the degradation of wetland habitat has affected nearly all species of wetland-dependent birds, it is important to consider more than one species when determining the functionality of created ponds on golf courses for waterbirds. Therefore, all waterbird species observed in the ponds or within 5 meters of pond edges were included during surveys (Table 1).

Terrestrial Categories	Aquatic Categories	Surrounding Landscape Categories
Short Herbaceous (<1m high)	Submerged/floating aquatics	Herbaceous (non-manicured)
Tall Herbaceous (>1m high)	Short Herbaceous (<1m high)	Shrub/tree
Shrub	Tall Herbaceous (>1m high)	Housing/residential lawn
Tree	Man-made structures	Golf course/ manicured grass
Mixed shrub/tree		Construction activity
Man-made structures		Bulldozed/cleared area for future construction
Manicured grass		

Table 3. Vegetation and landscape categories used to characterize aquatic and terrestrial vegetation along shorelines of golf course ponds and immediate surrounding areas.

Foraging guild classification

Species were categorized into 6 foraging guilds, defined by their major foraging techniques, food types, and substrates listed for each species in Ehrlich et al. (4) and Degraaf et al. (3), as well as personal observations of foraging birds on golf course ponds (Table 2). Foraging guilds were used in the analysis of waterbird site selection because there were normally too few observations to conduct separate analyses for each species. Foraging guilds also provide a useful approach for evaluating the influence of habitat changes on community dynamics (3) and allow for the development of management recommendations to benefit groups of birds rather than individual species.

Golf course selection

Twelve golf courses were surveyed during this study, nine owned by Bonita Bay Group and three by Watermark Communities Incorporated. All golf courses were located in Lee or Collier County in southwest Florida. Golf courses were selected to provide a diversity of study sites within the study area without previous knowledge of the quality or nature of habitat associated with ponds on those golf courses. A total of 183 golf course ponds from these 12 courses were monitored during the study. Study ponds included only those water bodies that occurred primarily within golf course property boundaries.

Waterbird surveys

Annual surveys were conducted during January through April, 2001 and 2002. Each pond was surveyed 8 times each field season by the same observer between sunrise and noon and as close to sunset as golf course closing schedules would allow. These periods were chosen because most active foraging by wading birds occurs near dawn and dusk (8). Surveys were conducted from a golf cart and birds were identified from a distance with binoculars to avoid disturbance. The

Shoreline vegetation is important for many foraging and nesting birds, as well as for birds seeking shelter and protective cover.

amount of time spent at each pond varied according to pond size and vegetation, with larger or more densely vegetated ponds requiring greater amounts of time for surveys. This study focused on birds that were actively using golf course ponds, therefore only waterbirds observed in the water or within 5 meters of the water's edge were recorded. Birds that flew over ponds, but were not obviously foraging or did not stop at the pond were not included in the analyses.

Pond surface area and perimeter

The surface area of each pond was obtained from golf course superintendents or the blueprints for each course. The primary analysis included surface area of individual ponds, but the responses of waterbirds to total surface area of all ponds at each course were also examined. Pond perimeters were measured with a standard 3-ft diameter measuring wheel because perimeter size may be an important factor for birds that feed along the shore (e.g., shorebirds) or near the water's edge (e.g., wading birds). This variable was included in the primary analysis and was also used to calculate the percent vegetation coverage and effective foraging area at each pond.

Shoreline vegetation and adjacent landscape features

Shoreline vegetation is important for many foraging and nesting birds, as well as for birds seeking shelter and protective cover (14). During

Behavior	Proportion
	(%)
Foraging/associated movements	45.9
Stationary/resting	34.8
Moving but not foraging	7.6
Preening	5.4
Wing drying	3.9
Flushed	2.1
Nesting activities	0.3

Table 4. Proportion (%) of birds engaged in various behaviors recorded during surveys of golf course ponds in southwest Florida in 2001 and 2002.

this study, shoreline vegetation was delineated by the pond's waterline because the centers of the ponds were generally too deep to allow growth of vegetation other than purely aquatic plants. Percent cover of shoreline and aquatic vegetation was visually estimated in three, 1-m^2 quadrats placed along 5-meter transects at 30-meter intervals. Transects ran parallel to the waterline and quadrats were placed perpendicular to the waterline, with quadrats for shoreline vegetation extending 1 meter landward, and quadrats for aquatic vegetation extending 1 meter into the pond.

Percent cover class (2) was used to quantify visual estimates of vegetative cover, which was classified into 7 terrestrial and 4 aquatic categories (Table 3). Cover classes were converted to median percent cover values (2) and used in conjunction with perimeter calculations to determine the percent coverage of each of the terrestrial and aquatic vegetation categories at each pond. This data was used to determine the influence of different types and densities of vegetation on site selection by waterbirds.

Measurements of the landscape features adjacent to the ponds were taken simultaneously with the shoreline vegetation measurements (i.e., at the same 30-meter intervals). The transect used to quantify shoreline vegetation was moved 1 meter away from the waterline (so as not to overlap with previous habitat measurements) and extended landward a distance of 10 meters to form a 5- x 10-meter plot. Percent cover class (2) was used to quantify visual estimates of percent cover for 6 habitat categories (Table 3), which also included non-vegetation categories to more fully characterize the areas adjacent to ponds.

Effective foraging area

At each 30-meter interval used to measure shoreline vegetation, the effective foraging area within the littoral zone was quantified to determine its influence on site selection of golf course ponds, particularly by wading birds (e.g., herons and egrets). This variable was determined by measuring the lateral surface distance from the waterline to a depth of 40 cm using a pole calibrated in 10-cm intervals. This depth represents the maximum in which wading birds effectively forage (12). Measurements were averaged and multiplied by pond perimeter to determine the effective foraging area available to wading birds at each pond. The number of measurements varied according to pond perimeter.

Pond productivity measurements

Four water-chemistry parameters were measured to determine the trophic status (i.e., biological productivity) of golf course ponds: water clarity and total chlorophyll a, phosphorus, and nitrogen. Due to time and cost constraints, chlorophyll a, phosphorus, and nitrogen were measured at 4 randomly selected ponds at each golf course. All water samples were gathered according to protocol developed by the LAKEWATCH Team at the University of Florida (10).

Water clarity was measured at all golf course ponds during May 2001 and March 2002 with an 8-inch diameter Secchi disk. Secchi disk measurements were used in conjunction with chlorophyll a measurements to establish a correlation model that enabled estimates of biological productivity from Secchi disk measurements alone, thereby providing at least one measurement of productivity in all of the golf course ponds surveyed.

Predictor variable [b]	Guild [a]					
	DB	OWW	DVW	DDF	MSF	AP
Surface area	+					
Perimeter			+		+	+
Effective foraging area		+		+		
Year					-	+
Submerged and floating aquatics			+			
Aquatic herbaceous vegetation < 1 m high	+					
Aquatic herbaceous vegetation > 1 m high		+[c]				
Shoreline herbaceous vegetation < 1 m high				+		
Shoreline herbaceous vegetation > 1 m high					-	
Shoreline trees		+[c]				
Shoreline trees and shrubs	+		+	+		
Shoreline man-made structures				-		
Shoreline manicured grass				+	-	
Surrounding herbaceous vegetation	-			-		
Surrounding trees and shrubs					-	
Surrounding residential lawns		+				
Surrounding golf course turf		+				
Surrounding areas under construction			-			
Surrounding areas cleared for construction			-	-		

[a]Guild abbreviations: DB = Diving Birds, OWW = Open Water Waders, DVW = Dense Vegetation Waders, DDF = Dipping and Dabbling Foragers, MSF = Moist-soil Foragers, AP = Aerial Piscivore.

[b]Predictor variables include effective foraging area, perimeter, surface area, year, 4 aquatic vegetation categories, 7 terrestrial vegetation categories, 6 adjacent landscape categories, and estimated chlorophyll a. + and - indicate positive or negative significant correlations ($P < 0.05$).

[c]Variables selected separately by each of two competing models. Chi-square values were not significant when both variables were included in a single model.

Table 5. Variables that proved to positively (+) or negatively (-) affect the presence of waterbird foraging guilds at surveyed golf course ponds in Southwest Florida in 2001 and 2002.

Statistical analysis

All analyses for this study were done in the SAS statistical program (13). Foraging guilds were used as the response variable because there were generally not enough observations for each of the 42 species to perform separate analyses for each species. A generalized linear model with logistic regression was used to model the probability of observing a member from a particular foraging guild as a function of the features of a pond (shoreline vegetation, surface area, perimeter, etc.). The presence or absence of species from each guild was used as the binomial (0=absent, 1=present) response variable. Predictor variables included survey year, pond surface area, pond perimeter, effective foraging area, pond productivity, and percent cover of aquatic and terrestrial shoreline vegetation and adjacent landscape features.

Results

Waterbird observations

During January-April 2001 and 2002, 10,474 waterbirds were observed during surveys of 183 man-made ponds on 12 golf courses. We

The Diving Birds guild (species group) was the most commonly recorded group. The two most abundant species from this guild were double-crested cormorants (*Phalacrocorax auritus*) and anhingas (*Anhinga anhinga*) (shown above).

observed 42 species of waterbirds (30 in 2001 and 40 in 2002; Table 1) over both years. The most common behaviors of all birds observed were associated with foraging and the least common with nesting activities (Table 4). Approximately 46% of all waterbirds observed used golf course ponds as foraging habitat. The remaining 54% may also have used the golf courses as foraging habitat, but were engaged in other activities (resting, preening, etc.) during surveys.

The Diving Birds guild was the most commonly recorded (n = 4,588). Anhingas (in 2001) and double-crested cormorants (in 2002) were also observed on more study ponds than any other species (Table 1). The second most frequently observed guild was Open Water Waders (n = 3,040), with little blue herons (*Egretta caerulea*) most abundant over the 2-year study period. The Dense Vegetation Wader guild was observed least frequently (n = 119).

Waterbird site selection

Pond size, defined as the surface area or perimeter, was identified as a positive significant predictor of bird presence for 4 of the 6 foraging guilds. The size of the effective foraging area (littoral zone) was a better predictor of bird presence than pond size for the 2 remaining guilds (Open Water Waders and Dipping and Dabbling Foragers). Other habitat variables selected in the models varied among foraging guilds (Table 5).

When the 'golf course' variable was included in logistic regression models many other predictor variables were no longer significant. The major objective of this study was to determine the influence of pond characteristics on bird use. Therefore, the 'golf course' variable was dropped from the primary analyses so that the influence of other variables could be determined. Nevertheless, the dominant influence of this variable suggests that the golf course as a unit may have a significant effect on waterbird site selection.

Differences among golf courses may be due to variables that were not easily captured by analyses, but may have included differences in human use, management practices, or location of the courses relative to other resources that were not quantified during this study (e.g., distance to nesting colonies). However, we did analyze the influence of the total pond surface area on each golf course (versus the surface area of individual ponds) on waterbird use. A generalized linear model resulted in a significant relationship, indicating that the total pond surface area explains some of the variation in average bird abundance among golf courses.

Discussion

Several major factors appeared to influence waterbird use of golf course ponds at the landscape and individual pond scale. At the landscape scale, individual golf courses varied in waterbird use. One important difference among courses was the total pond surface area available at each golf course. Golf courses with more total pond surface area had more birds on average. Greater pond surface area (in the form of larger or more numerous ponds within the same golf course) may provide advantages such as reduction of effort required by the birds when moving among ponds to find food.

Observed differences in bird presence among golf courses may also be related to the course location relative to other landscape features important to waterbirds, such as natural wetlands, flooded pastures, and roosting or nesting areas. Once a golf course has been selected, birds may then select from available ponds within the course based on more specific pond features such as pond size or vegetation structure and density.

At the individual pond scale, pond size (defined either by the surface area or perimeter) influenced waterbird use by 4 of the 6 foraging guilds (Table 5). Larger ponds may be able to provide more foraging opportunities and habitat types to support a greater diversity of waterbirds. This relationship has been reported for birds in other freshwater habitats (1, 6, 7, 11). However, the availability of food, the most crucial feature for determining foraging habitat suitability for waterbirds, includes not only density but accessibility of suitable prey (5, 9). Many waterbirds are unable to access prey in open water areas. For example, wading birds and shorebirds are typically confined to water depths no greater than their leg length. Indeed, the effective foraging area was a better predictor of pond use by the majority of wading birds (Open Water Waders) than either surface area or perimeter.

Analysis of waterbird site preference for other pond features resulted in a wide range of habitat variables selected by each foraging guild (Table 5). However, several similarities exist among the selected variables. For example, trees and shrubs provide roosting and resting habitat for several foraging guilds. Short vegetation in the littoral zone and along the shoreline of the ponds was selected by several foraging guilds probably because it allows for increased predator detection while foraging. Ponds with man-made structures such as walls and ledges around the perimeter were avoided by one foraging guild (Dipping and Dabbling Foragers) probably because they impeded movement into and out of the water.

Conclusion

The large number of species of waterbirds observed during this study indicates that golf course ponds are used by many different types of waterbirds, principally as foraging habitat (46%). The extent to which waterbirds used golf course ponds in this study was primarily related to pond size, ability of the birds to access prey, and habitat features that influenced security and foraging success. The low densities of birds (<2 birds/hectare for most species), also suggest there is ample opportunity to increase the value of golf course ponds to waterbirds.

The wide range of habitat variables selected by each foraging guild indicates that providing a diversity of habitat features among ponds within a golf course would provide the greatest benefits to the largest number of species. To accomplish this goal, ponds could be managed as a wetland complex, whereby different ponds or sections of ponds are enhanced or modified to meet guild-specific needs. For example, creating areas along ponds that have dense shrub cover would benefit dense-vegetation waders, trees can provide roosting sites, and the creation of shallow foraging areas will benefit wading birds and numerous other species. Not only would this type of management strategy benefit waterbirds, but could also provide greater management options for the golf course.

Maintenance problems associated with wet areas along edges of ponds may be ideal for modifications to benefit waterbirds while simultaneously reducing management costs and maintenance challenges. Consequently, opportunities likely exist on many golf course ponds to improve habitat for waterbirds, while providing financial savings and generating positive public relations for practices that provide benefits to wildlife.

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