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Citizen Monitoring of Aquatic Bird Populations Using a Florida Lake

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ABSTRACT

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Five years of monthly bird counts on a 2.32 km^2 lake in north central Florida were used to examine the ability of a citizen volunteer to monitor aquatic bird populations. When compared to published aquatic bird data, collected by professional biologists, the citizen volunteer was able to accurately assess bird abundance and species richness. The monthly counts over a five-year period were also used to examine seasonal patterns in aquatic bird use. We highly recommend the development of citizen based aquatic bird monitoring programs for the assessment of reportedly declining aquatic bird populations. This would be especially useful if entire states programs could be developed to monitor regional as well as temporal trends in aquatic bird populations.

Key Words: water quality, bird species richness, lake area, bird abundance.

Florida supports a rich and diverse population of aquatic birds, which increases dramatically in the winter as migratory populations move south (Hoyer and Canfield 1990). Nesting populations of many species have reportedly declined over the past few decades (Kushlan et al. 1984; Ogden 1994). This decline has been attributed, in part, to the loss of wetland habitat. From 1950 to the mid-1970s, there was a tremendous loss of palustrine emergent wetlands (freshwater marshes, wet prairies, and the everglades), accounting for 74% of the total wetland loss in the state (Hefner 1986).

Aquatic bird studies in Florida generally are conducted in marsh systems, with only a few studies examining aquatic bird populations using lake systems (Jenni 1969; Johnson and Montalbano 1984; Hoyer and Canfield 1994). With the reported loss of wetland habitat in Florida, the importance of Florida's lake systems to aquatic bird populations may be increasing and warrant more study (Edelson and Collopy 1990).

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Florida has more than 7,700 lakes that range in size from 0.4 ha to over 180,000 ha (Shafer et al. 1986). It would be difficult for any state agency or university to acquire the resources needed to monitor aquatic bird populations, with professional biologists, on a large percentage of these lake systems (e.g., 1,000 lakes). It would be even more difficult if the aquatic bird monitoring was needed monthly over several years to examine temporal trends and migratory patterns. Similar statements can be made about water quality monitoring. However, citizen volunteers have successfully and economically monitored water chemistry on over 1050 lakes in Florida, with many lakes sampled monthly for over five years (Florida LAKEWATCH 2000). Thus, the objective of this study is to evaluate the ability of citizen volunteers to monitor aquatic bird populations in Florida lakes, as a possible way to acquire much needed information on the aquatic bird populations in Florida. Using five years of monthly bird counts from one Florida lake, this paper will evaluate the ability of citizen volunteers to document species richness, bird abundance, and temporal trends in aquatic bird populations.

Methods and Materials

Study Lake

Lake Alto is located in north central Florida (Alachua County) and has a surface area of 2.32 km^2 (Fig. 1). The lake is located in the Upper Santa Fe Flatwoods Lake Region (Griffith et al. 1997), in a geology dominated by deeply weathered clayey sand and granular sand of the Hawthorn Formation (Brooks 1981). Lake Alto is relatively undeveloped, with a 100 m buffer of terrestrial land around the lake dominated by a mosaic of wetland mixed forest (50%), mixed wetland hardwoods (30%), shrub-brush land (10%) and residential (10%) (Florida LAKEWATCH unpubl. data).

Lake Alto has been in the Florida LAKEWATCH program (a citizen based water quality monitoring program) since 1987. The long-term average total phosphorus, total nitrogen, and chlorophyll concentrations for 139 monthly samples are 15 $\mu g \cdot L^{-1}$, 560 $\mu g \cdot L^{-1}$, and 10 $\mu g \cdot L^{-1}$, respectively (Florida LAKEWATCH 2000). Secchi depth averaged 1.8 m during this same time period. These values suggest that Lake Alto is a eutrophic lake following the criteria of Forsberg and Ryding (1980). Lake Alto is also a softwater (alkalinity=1.5 mg $\cdot L^{-1}$ as $CaCO_3$), acidic (pH=5.9) lake with moderate true color of 44 Pt-Co units.

In 1998, Lake Alto had a moderate amount of aquatic vegetation with a percent area covered with aquatic vegetation of 30% and a percent volume occupied with aquatic plants of 5% (Florida LAKEWATCH 2000). Approximately 30 species of aquatic plants were identified in the lake with an average emergent, floating leaved and submersed plant biomass of 7.8, 2.6 and 0.8 kg·wet·wt·m^{-2}, respectively.

Bird Counts

Bird counts for this study were conducted following the methods of Hoyer and Canfield (1990; 1994). Aquatic birds for this study were considered those birds that were observed using any type of aquatic habitats. Some bird species counted in this study (e.g., black vulture, turkey, vulture, and cattle egret) are generally not considered aquatic birds but because they were counted over or in direct proximity of Lake Alto they were included as aquatic birds. The counts were conducted between 9:00 am and 12:00 noon once a month from January, 1995 to December, 1999. The birds were counted by a citizen volunteer who also collects water samples for the Florida LAKEWATCH program. The observer motored slowly around the perimeter of the lake in a small boat and birds were identified to species except gulls, terns, and crows. Care was taken to avoid counting birds twice if they flushed ahead of the boat.

Statistical Analyses

Relations of bird abundance versus chlorophyll concentrations and species richness versus lake surface area have been recorded using data from over 40 Florida lakes (Hoyer and Canfield 1990; 1994). Lake Alto's annual average chlorophyll data (Florida LAKEWATCH 2000) and annual average aquatic bird abundance (birds $\cdot km^2$) was plotted on the aquatic bird abundance versus chlorophyll relation published by Hoyer and Canfield (1990) to determine if the citizen volunteer's counts put Lake Alto into the range expected for other eutrophic Florida lakes. Aquatic bird species richness for Lake Alto was defined as the total number of aquatic bird species seen throughout the study period. This value was also plotted with Lake Alto surface area on the aquatic bird species versus lake surface area relation published by Hoyer and Canfield (1994) to determine if the citizen volunteer observed the number of aquatic bird species expected for a Florida lake with a surface area of 2.32 km^2.

Monthly bird counts for a period of 5 years allowed the creation of two cumulative species list by

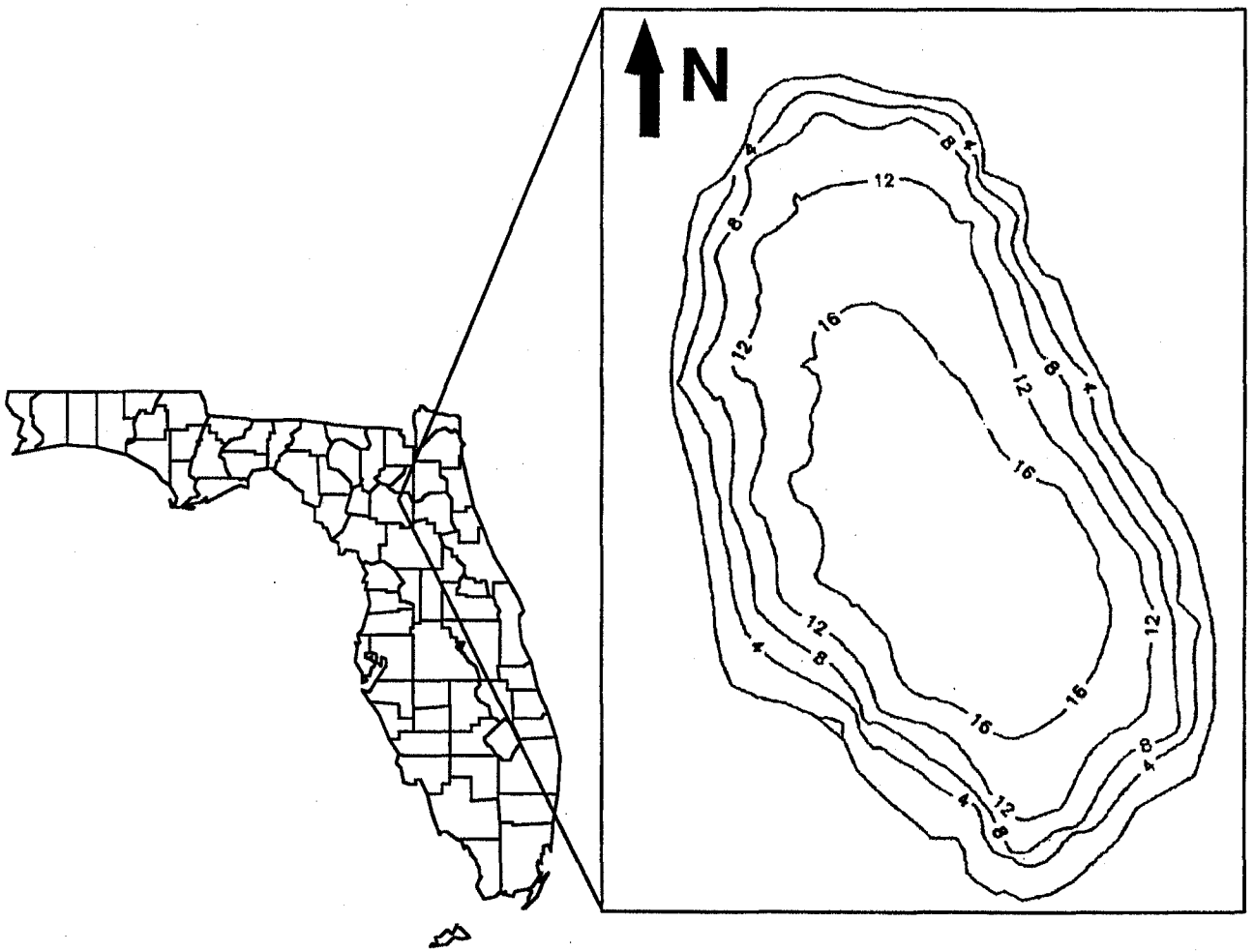

Figure 1.–Location in Florida and bathymetric map of Lake Alto. Contours are in feet.

sampling event relations to determine how many monthly counts are needed to observe the maximum number of aquatic bird species on a given lake. These data also allow us to average individual bird species counts by month to examine seasonal patterns for individual bird species using a Florida lake.

Results and Discussion

Lake Alto had a total species richness of 33 aquatic bird species from 1995 through 1999 (Table 1). Of the 33 species 17 were counted at least once in every year (e.g., great blue heron *Ardea herodias*) and eight were counted in only one year (e.g., common loon *Gavia immer*). These data suggest that some birds commonly use a Florida lake system while others are only occasional visitors. This is similar to the findings of Hoyer and Canfield (1994) who observed fifty aquatic bird species in their survey of 46 Florida lakes with some species occurring on only one lake throughout the study.

Annual average total bird abundance on Lake Alto ranged from 14.54 birds $\cdot km^{-2}$ in 1998 to 26.93 bird $\cdot km^{-2}$ in 1997 (Table 1) and the five-year total average bird abundance was 19.77 birds $\cdot km^{-2}$. It is interesting to note that the year with the lowest bird abundance (1998) is also the year of tremendous rains covering north central Florida where lake Alto is located. Potentially, the rain could have created extensive wet areas allowing aquatic bird to disperse into newly created habitat and decreasing the need to use Lake Alto. On the opposite side, the highest average bird count was collected in 1997 with 26.93 birds $\cdot km^{-2}$ and this was the driest year in the data set. It is possible that normally wet areas had dried up in 1997 making Lake Alto an attractive refuge for aquatic birds during dry weather. Over the five year study, the three most abundant bird species using Lake Alto were turkey vulture *Cathartes aura* (8.63 birds $\cdot km^{-2}$), black vulture *Coragyps atratus* (3.03 birds $\cdot km^{-2}$), and cattle egret

Bubulcus ibis (1.18 birds · km^{-2}). The least abundant bird species, all with only one bird being counted in five years, were the common loon *Gavia immer*, horned grebe *Podiceps auritus*, and northern harrier *Circus cyaneus*.

Total bird abundance among lakes generally increases with an increase in chlorophyll concentrations (Nilsson and Nilsson 1978; Murphy et al. 1984). In Fig. 2 we plotted the annual average total bird abundance and corresponding annual average chlorophyll value, for each year of Lake Alto counts, on the bird abundance versus chlorophyll data published by Hoyer and Canfield (1994). The bird abundance values fall within the range of 46 other Florida lakes but below the

Table 1.–Annual mean bird abundance, by species, for 33 aquatic bird species counted on Lake Alto, Florida between 1995 and 1999.

		Yearly Average Bird Abundance (Birds · km^{-2})				
Common Name	Scientific Name	1995	1996	1997	1998	1999
American coot	Fulica americana	0.000	0.036	0.000	0.000	0.000
Anhinga	Anhinga anhinga	0.287	0.970	0.682	0.430	0.826
Bald eagle	*Haliaeetus leucocephalus*	0.036	0.072	0.036	0.108	0.036
Belted kingfisher	*Ceryle alcyon*	0.108	0.466	0.323	0.143	0.251
Black vulture	*Coragyps atratus*	0.718	3.770	7.255	1.759	1.653
Black-crowned night-heron	*Nycticorax nycticorax*	0.036	0.000	0.000	0.000	0.000
Cattle egret	*Bubulcus ibis*	5.173	0.251	0.036	0.000	0.431
Common loon	*Gavia immer*	0.000	0.000	0.108	0.000	0.000
Crows	(Corvidae[1])	0.681	1.221	0.860	0.609	0.968
Double-crested cormorant	*Phalacrocorax auritus*	2.838	1.365	0.036	0.000	3.951
Great blue heron	*Ardea herodias*	0.251	0.394	0.072	0.466	0.645
Great egret	*Casmerodius albus*	0.467	0.681	0.826	0.753	0.645
Green heron	*Butorides striatus*	0.323	0.179	0.215	0.179	0.179
Gulls	(Laridae: Larinae[2])	0.179	0.000	0.000	0.036	0.000
Horned grebe	*Podiceps auritus*	0.000	0.000	0.036	0.000	0.000
Lesser scaup	*Aythya affinis*	0.000	0.000	0.108	0.000	0.000
Little blue heron	*Egretta caerulea*	0.036	0.000	0.000	0.072	0.000
Northern harrier	*Circus cyaneus*	0.000	0.000	0.108	0.000	0.000
Osprey	*Pandion haliaetus*	0.323	0.538	0.358	0.789	0.646
Pied-billed grebe	*Podilymbus podiceps*	0.143	0.251	0.108	0.000	0.215
Purple martin	*Progne subis*	0.108	0.036	0.179	0.215	0.359
Red-shouldered hawk	*Buteo lineatus*	0.287	0.143	0.143	0.179	0.143
Red-tailed hawk	*Buteo jamaicensis*	0.036	0.072	0.000	0.072	0.108
Red-winged blackbird	*Agelaius phoeniceus*	0.108	0.575	0.000	0.072	0.000
Ring-necked duck	*Aythya collaris*	0.000	0.000	0.143	0.000	0.000
Ruddy duck	*Oxyura jamaicensis*	0.000	0.000	0.000	0.000	0.036
Snowy egret	*Egretta thula*	0.000	0.036	0.000	0.036	0.000
Terns	(Laridae: Sterninae[2])	0.179	0.072	0.072	0.036	0.036
Tricolored heron	*Egretta tricolor*	0.036	0.000	0.000	0.000	0.000
Turkey vulture	*Cathartes aura*	6.250	7.722	14.260	7.327	7.615
White ibis	*Eudocimus albus*	0.000	0.000	0.610	0.683	0.000
Wood duck	*Aix sponsa*	0.036	0.359	0.358	0.323	0.682
Wood stork	*Mycteria americana*	0.036	0.036	0.000	0.252	0.036
	Yearly Totals (Birds · km^{-2})	18.7	19.2	26.9	14.5	19.5

(1) Listed as family
(2) Listed as subfamily

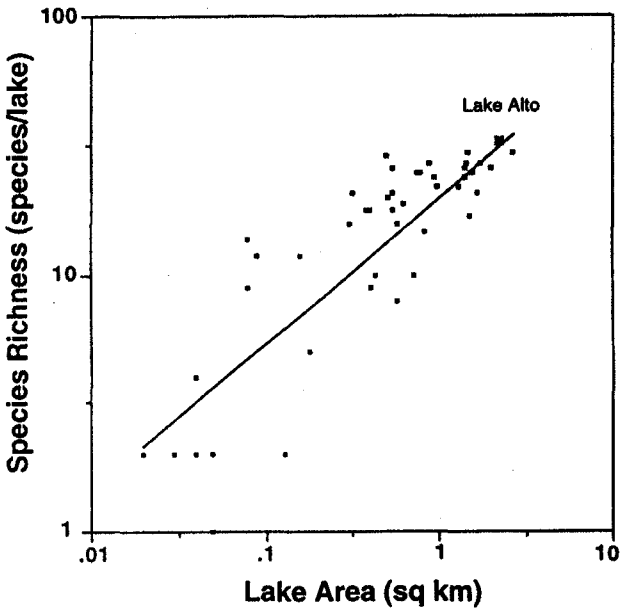

Figure 2.–Lake Alto's yearly average chlorophyll concentration and aquatic bird abundance from 1995 through 1999 (indicated with an x) plotted on the relation between average annual bird abundance (birds/km^2) and total chlorophyll ($\mu g \cdot L^{-1}$) for 46 Florida lakes (Hoyer and Canfield 1994).

average bird per unit of chlorophyll among all lakes. A possible explanation for this could be that the average values from Hoyer and Canfield (1994) are from three counts during the year while this study was the average of 12 counts per year. These data do suggest, however, that citizen volunteers can estimate aquatic bird abundance values that fall within the range of those estimated by professional biologists.

Determining total species richness of any flora or fauna is difficult because most times the number of species encountered is dependent on the number of sampling events conducted and the size of the area sampled (Elliott 1977). Because the area of Lake Alto remained relatively constant over the period of this study it is important to determine the number of sampling events needed before no additional bird species were encountered. Thus, we plotted a cumulative aquatic bird species count versus number of monthly counts to determine how many monthly counts are needed before no more additional species are added to the total species richness for Lake Alto (Fig. 3). The number of aquatic bird species counted increased rapidly in the first few months but did not reach a maximum until the lake had been surveyed for 36 months. An additional 24 monthly counts did not reveal any new species so we feel comfortable that 33 is an accurate assessment of the total species richness for Lake Alto (Table 1). There is, however, always the chance that another rare species could be observed at Lake Alto.

As mentioned above, species richness of many types of flora and fauna are related to area sampled (Flessa and Sepkoshi 1978; Connor and McCoy 1979), including aquatic bird species richness and lake area (Hoyer and Canfield 1994). In Fig. 4, we plotted total bird species richness and lake area for Lake Alto on the relation between bird species richness and lake area reported by Hoyer and Canfield (1994). The Lake Alto data fall directly on the best fit linear regression line for the relation. These data again suggest that citizen volunteers can accurately count aquatic birds using lakes and that they can accurately determine total bird species richness.

With limited temporal data (three counts in one year) Hoyer and Canfield (1990) showed some seasonal patterns in the abundance of individual bird

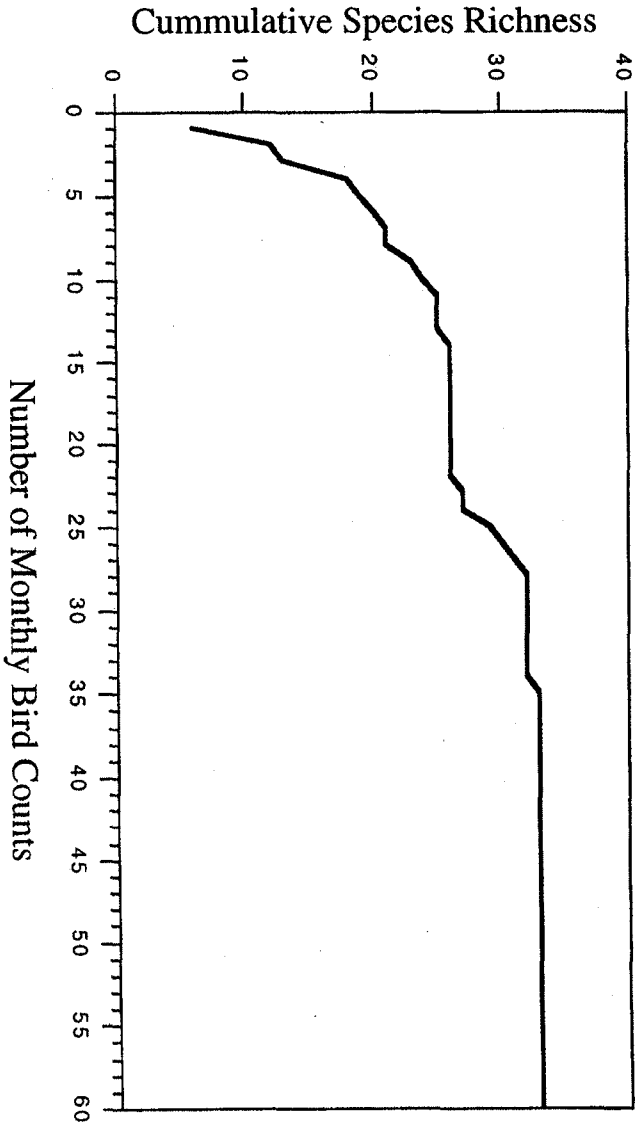

Figure 3.–Cumulative aquatic bird species richness plotted by 60 consecutive monthly (1995-1999) bird counts for Lake Alto, Florida.

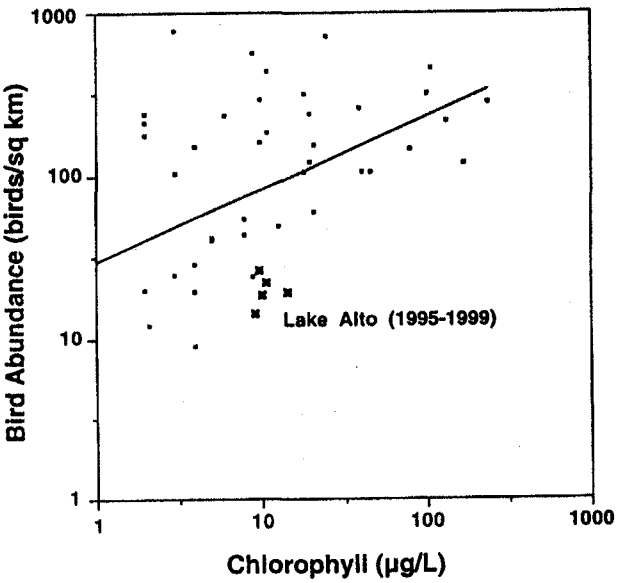

Figure 4.–Lake Alto's total aquatic bird species richness and lake area (indicated with an x) plotted on the relation between aquatic bird species richness (birds species/lake) and lakes surface area (km^2) for 46 Florida lakes (Hoyer and Canfield 1994).

species using 33 Florida lakes. They showed that total bird abundance is higher during winter months then the rest of the year. This is also true for Lake Alto with total bird abundance ranging about 25 to 54 bird $\cdot km^{-2}$ from November through February and about 6 to 21 bird $\cdot km^{-2}$ for the remainder of the year (Table 2). While total bird counts show high bird abundance during winter months, examining individual bird species shows some other interesting patterns.

With limited monthly data Hoyer and Canfield (1990) divided individual bird species into the following groups based on the percentage of lakes an individual bird species occurred on during winter, spring and summer periods; 1) resident-migrants, 2) winter-migrants, and 3) spring-migrants and 4) summer-users. Examining the seasonal trends for individual species using Lake Alto data shows that many species fit into these groups but some do not (Table 2). It is possible with only three monthly counts in one year that Hoyer and Canfield (1990) may have placed some species into groups that may not describe the true seasonal pattern of those species. For example, Hoyer and Canfield (1990) suggested that the red-shouldered hawk was a winter-migrant but the data from Lake Alto indicate red-shouldered hawk was observed in all but two months (January and August, Table 2) suggesting it is probably a resident-migrant.

With five years of monthly data on Lake Alto we examined seasonal trends for the aquatic bird species that use the lake. Using three of the same group titles as Hoyer and Canfield (1990) and adding one called visitor, we divided the seasonal patterns into four groups (Table 2); 1) resident-migrants, 2) summer-users, and 3) winter-migrants and 4) visitor. A resident-migrant is a species that was counted in almost every month but tended to have higher count during winter months. A good example of a resident-migrant is the great blue heron (Fig. 5a). A summer-user is a species that is usually not counted in the winter months but is counted in increasing and then decreasing numbers throughout the summer. A good example of a summer user is the green heron (Fig. 5b). A winter-migrant is a species that is rarely counted in the summer months but is counted in increasing and then decreasing numbers throughout the winter. A good example of a winter-migrant is a pied-billed grebe (Fig. 5c). A visitor is a species that is only counted in low numbers and usually in only one or two months.

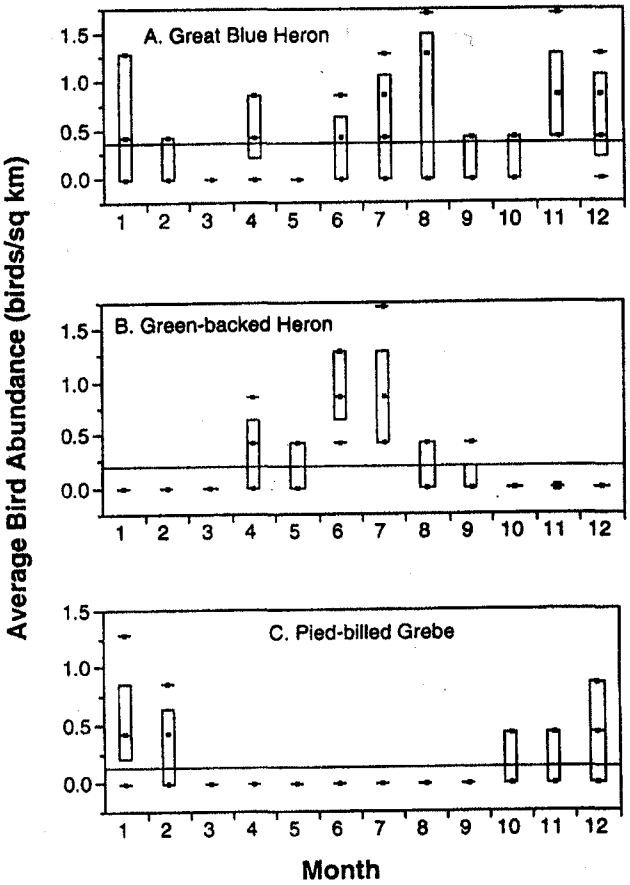

Figure 5.–Examples of three seasonal patterns in aquatic bird species abundance using Lake Alto, Florida. A) Resident-migrant (e.g., Great blue heron), B) Summer-user (e.g., Green-backed heron), and C) Winter-migrant (e.g., Pied-billed grebe). Bird abundance of each species was averaged by month for the five years of counts and plotted. The line represents the grand mean of all values. The quantile boxes show the median value as a line across the middle of the box and the 10^{th} and the 90^{th} quantiles are the lines above and below the box.

Table 2.–Monthly bird abundance, by group and species, for 33 aquatic bird species counted on Lake Alto, Florida between 1995 and 1999.

Group	Common Name	Monthly Average Bird Abundance (Birds · km^{-2})											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Resident/Migrant	Anhinga	1.21	1.55	1.03	0.00	0.00	0.09	0.17	0.26	0.43	0.52	0.95	1.47
Resident/Migrant	Belted kingfisher	0.34	0.26	0.00	0.09	0.00	0.00	0.09	0.17	0.43	0.60	0.43	0.69
Resident/Migrant	Black vulture	10.69	5.69	1.64	3.45	0.34	0.86	0.43	0.34	0.00	0.52	7.76	4.66
Resident/Migrant	Crows	0.69	1.03	1.12	0.86	0.69	0.34	1.90	1.98	0.43	0.77	0.26	0.34
Resident/Migrant	Double-crested cormorant	3.19	0.09	0.09	6.81	0.09	0.00	0.00	0.00	0.00	0.17	0.09	9.14
Resident/Migrant	Great blue heron	0.60	0.17	0.00	0.52	0.00	0.26	0.52	0.60	0.17	0.17	0.77	0.60
Resident/Migrant	Red-shouldered hawk	0.00	0.26	0.60	0.26	0.26	0.26	0.09	0.00	0.09	0.09	0.09	0.17
Resident/Migrant	Turkey vulture	35.08	15.09	11.55	5.17	0.26	0.52	0.34	0.17	0.52	0.00	19.05	15.9
Resident/Migrant	Wood duck	0.86	0.00	0.69	0.26	0.17	0.34	0.17	0.09	0.34	0.52	0.78	0.00
Summer User	Cattle egret	0.00	0.00	0.00	0.09	4.31	6.64	2.24	0.78	0.09	0.00	0.00	0.00
Summer User	Great egret	0.26	0.26	0.17	0.69	0.60	1.03	1.55	1.38	0.60	0.43	0.43	0.69
Summer User	Green heron	0.00	0.00	0.00	0.34	0.17	0.95	0.77	0.26	0.09	0.00	0.00	0.00
Summer User	Osprey	0.00	0.34	1.12	1.20	1.12	1.12	0.52	0.52	0.26	0.17	0.00	0.00
Summer User	Purple martin	0.00	0.00	0.00	0.09	0.09	0.43	1.38	0.00	0.00	0.17	0.00	0.00
Winter Migrant	Bald eagle	0.09	0.17	0.09	0.09	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Winter Migrant	Pied-billed grebe	0.52	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.26	0.43
Winter Migrant	Red-tailed hawk	0.09	0.17	0.09	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Winter Migrant	Terns	0.09	0.09	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.60
Visitor	American coot	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00
Visitor	Black-crowned night-heron	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Visitor	Common loon	0.17	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Visitor	Gulls	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.26
Visitor	Horned grebe	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Visitor	Lesser scaup	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Visitor	Little blue heron	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.09	0.00	0.09
Visitor	Northern harrier	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Visitor	Red-winged blackbird	0.00	0.00	0.00	0.26	0.00	0.17	0.00	0.00	0.00	0.00	1.38	0.00
Visitor	Ring-necked duck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.00
Visitor	Ruddy duck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Visitor	Snowy egret	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Visitor	Tricolored heron	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00
Visitor	White ibis	0.00	0.00	1.21	0.00	0.00	1.90	0.00	0.00	0.00	0.00	0.00	0.00
Visitor	Wood stork	0.00	0.00	0.00	0.09	0.00	0.09	0.00	0.00	0.00	0.09	0.00	0.60
	Monthly Totals (Birds · km^{-2})	54.13	25.68	19.47	20.93	8.27	14.99	10.25	6.54	3.53	4.99	32.49	35.9

These group titles may hold true for Lake Alto but not all other Florida lakes. We suggest additional monthly counts from a variety of Florida lakes be examined before these group titles be used extensively.

Conclusions

Five years of monthly bird counts on a 2.32 km^2 lake in north central Florida were used to examine the ability of a citizen volunteer to monitor aquatic bird populations. When compared to published aquatic bird data, collected by professional biologists, the citizen volunteer was able to accurately assess bird abundance and species richness. The monthly counts over a five-year period were also used to better define seasonal patterns in aquatic bird use. We highly recommend the development of citizen based aquatic bird monitoring programs for the assessment of reportedly declining aquatic bird populations. This would be especially useful if entire states programs could be developed to monitor regional as well as temporal trends in aquatic bird populations.

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