SPATIAL DISTRIBUTION OF WATERBIRDS IN A RECENTLY MOWED SECTION OF TROPICAL MARSH

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Abstract: The Palo Verde marsh is undergoing a restoration program that involves mowing overgrown vegetation, mainly *Typha* and *Thalia*. It is unclear how marsh bird species will respond spatially to these newly opened areas. Because some marsh birds may require dense vegetative cover for feeding or protection, we hypothesized that in a large area of open water, bird density would vary spatially, with many species remaining near edges with denser vegetation. We collected abundance data and monitored habitat use by focal individuals in a recently mowed area in the marsh and found that 11 of 14 species had higher densities within 10 m of the edge than in the central, more open habitat. Three of the five species for which focal individuals were monitored spent more time foraging in the edge habitat. These results suggest that large open areas may not be optimal habitat for several species of water birds, though further mechanistic studies are needed to understand the patterns we observed.

Key words: egret, gallinule, heron, limpkin, Palo Verde marsh, restoration, waterbirds, wetlands

INTRODUCTION

The Palo Verde marsh, located along the Tempisque River in Palo Verde National Park, is one of the most extensive areas of wetland in northwestern Costa Rica and provides important habitat for a variety of waterbird species. Since the late 1970's, the historically open-water marsh has become choked by cattails (*Typha* sp.), which have created a homogeneous habitat limiting bird diversity and abundance (Holmes, pers. comm.). In 2003, OTS and partners began a restoration program to reopen some cattail-dominated sections of the marsh (E. Gonzalez, pers. comm.). An early study suggested that the newly created open-water space increased the abundance of some waterbird species (e.g., black-bellied whistling-duck, *Dendrocygna autumnalis;* Licona et al. 2003).

Other marsh birds, however, may require some amount of dense vegetation (e.g., *Thalia, Typha*) as cover from predators, foraging substrate, or nesting sites. Thus, large areas lacking vegetative cover, such as those created by restoration activities, could be detrimental to such species. These adverse effects could be manifest on a variety of scales, from daily foraging behavior—the scale we examined—to reproductive success. To test the hypothesis that marsh species favor areas with nearby cover, we quantified bird abundance in a recently mowed sector of the Palo Verde marsh. We predicted that marsh birds would be more abundant in edge areas (i.e., closer to cover), than in more open habitat.

METHODS

Our study location was Laguna de Palo Verde, Palo Verde National Park, Costa Rica. On 13 January 2004, marsh vegetation (mainly dense *Thalia* stands) just west of the OTS station's observation tower was mowed by a tractor (Appendix 2). This created 28,000 m^2 of open water with patches of floating, uprooted vegetation, bordered by dense, 2 m high *Thalia* and *Typha* on all sides. The edge between the open area and uncut vegetation was abrupt. We defined any point within the mowed area < 10 m from the cut edge as "edge" habitat and any point > 10 m as "open" habitat. We believed that 10 m was an appropriate distance for our purposes because any bird within this range would be able to reach cover quickly. Also,

greater proximity to the edge might reduce visibility of marsh birds to potential predators.

On 14 - 15 January, MK conducted three surveys per morning (ca. 0745 - 0815, 0830 - 0900, 0915 - 0945) during which he counted all individuals of each bird species that were foraging or sitting within the mowed area. The location of each individual was categorized as edge or open habitat. All abundance data were weighted according to the total area of each spatial category, producing a per hectare measure of density of individuals. We did not record flying individuals or species such as snail kite (*Rostrhamus sociabilis*) and red-winged blackbird (*Agelaius phoeniceus*) that were not continuously utilizing the area at the level of the water or floating vegetation. We analyzed density data with a full factorial two-way ANOVA, with habitat and species as main effects. For each individual species, we also used a chi-square test to evaluate whether birds occurred in edge vs. open habitat more or less often than expected based on the relative area of the two habitats; for this we used the average of the six counts (which guarded against inflating our observations with repeat measurements of the same individuals).

On the same mornings, LE and BW monitored focal individuals of five species (glossy ibis, great egret, limpkin, little blue heron, northern jacana). They observed each individual for 10 min (n = 8 for all species except limpkin, n = 5), recording total time spent in edge and open habitat. Focal individuals were selected randomly from a pool of all birds within the mowed area. These data provided time-budget measures of habitat use for a subset of species to complement our abundance measures. The proportion of time spent by each bird in edge habitat was evaluated with a t-test against the null hypothesis of 0.255 based upon the proportional area.

RESULTS

We recorded 19 species of birds foraging or sitting within the newly opened area of marsh (Appendix 1). Common gallinule, great blue heron, least bittern, roseate spoonbill, and white ibis were rare (< 5 sightings) and excluded from the analyses. For the remaining 14 species (Fig. 1), the two-way ANOVA revealed signifi-

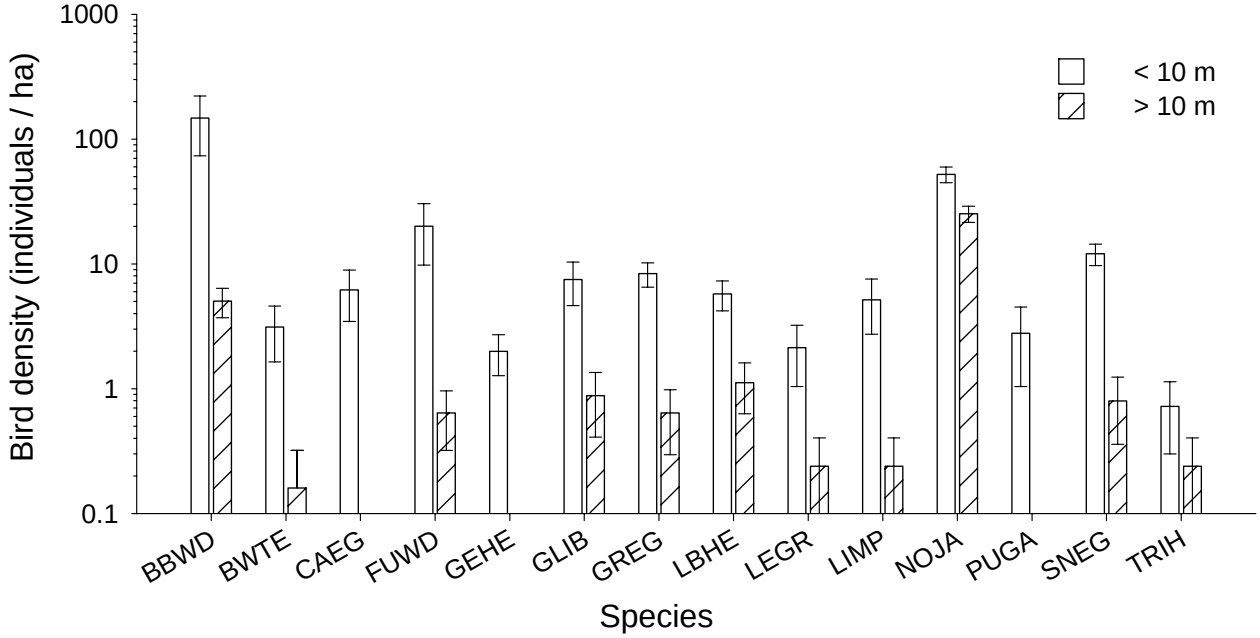


Figure 1. Comparison of the density of individuals (mean ± SE; n = 6 censuses; note log scale) of each species recorded in edge and open habitat. Codes, latin names, and total count numbers for each species are in Appendix 2.

cant effects of both species ($F_{13,14}$ = 11.76, P < 0.0001) and habitat ($F_{1,14}$ = 62.82, P < 0.0001), but not the species-habitat interaction ($F_{13,14}$ = 0.79, P = 0.68). In the chi square analysis, 11 of 14 species showed significantly higher density of individuals in the edge zone than in the open habitat, while the other four species showed no significant difference in density between edge and open areas (Table 1).

Three of the five species for which we obtained focal sample data spent significantly more time foraging in the edge versus the open area than would be predicted by available area in each category (great egret, t = 13.90, df = 7, P < 0.0001; little blue heron, t = 4.96, df = 7, P = 0.0008; limpkin, t = 2.50, df = 4, P = 0.03; Fig. 2).

Table 1. Chi-square comparisons of bird abundance in edge vs. open habitats in the Palo Verde marsh. Species in bold had significantly more individuals in edge habitat than expected under the null hypothesis that abundance is proportional to area (df = 1 for all species). See Appendix 1 for full species names.

Species	X^2	P
BBWD	**318.76**	**< 0.001**
BWTE	**7.21**	**< 0.01**
CAEG	**8.70**	**< 0.005**
FUWD	**44.9**	**< 0.001**
GEHE	3.07	< 0.10
GLIB	**13.30**	**< 0.001**
GREG	**12.00**	**< 0.001**
LBHE	**5.07**	**< 0.05**
LEGR	2.29	< 0.25
LIMP	**6.56**	**< 0.025**
NOJA	**15.35**	**< 0.001**
PUGA	**5.01**	**< 0.05**
SNEG	**19.10**	**< 0.001**
TRIH	0.67	< 0.50

The other two species did not show a significant difference in time spent between the two habitats (glossy ibis, t = 1.40, df = 7, P = 0.10; jacana, t = 1.44, df = 7, P = 0.10).

Discussion

Our results showed that marsh birds were generally more abundant and spent more time near edges than in open areas. Mechanisms for the observed patterns include foraging habitat preferences and the need for nearby cover from predation, probably from raptors (e.g., peregrine falcons, *Falco peregrinus*), but the relative importance of these may vary among species. The foraging of least grebes, which are open water divers, should not be affected by the edge; furthermore, this species' diving ability reduces the need for vegetation as predation cover. The three duck species (black-bellied whistling-duck, fulvous whistling-duck, blue-winged teal), in contrast, used the mowed area for resting rather than foraging, so their use of

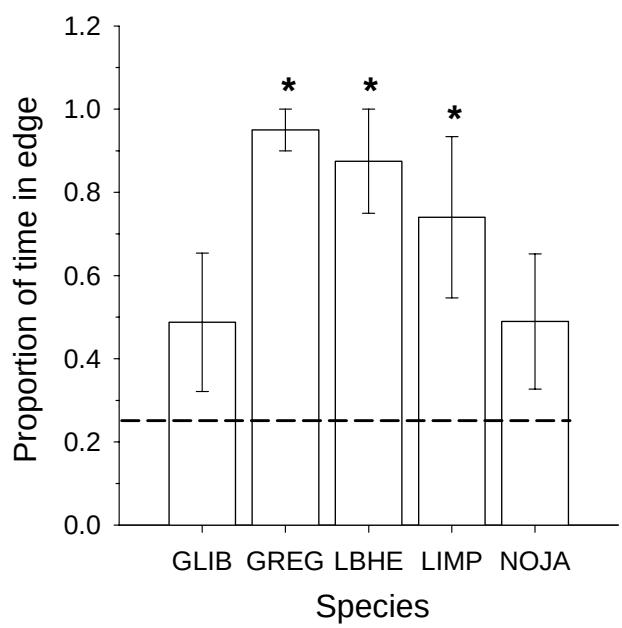


Figure 2. Proportion of time spent < 10 m from the edge (mean ± SE). Stars indicate a significant difference from the expected value based on proportionate area of edge habitat (0.255, represented by dashed line).

the edge habitat is probably related to reducing vulnerability to predators.

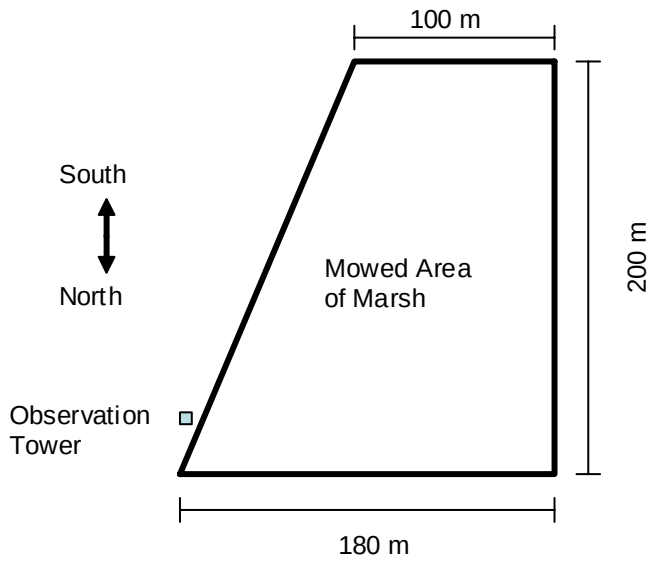
Eight out of the ten wading species (three egret species, little blue heron, ibis, jacana, limpkin, gallinule) showed significantly higher densities in edge habitat; the other two (green heron, little blue heron) showed a similar trend. Individuals of these species are generally solitary foragers, so they might benefit from nearby vegetation as a refuge from predators. Alternatively, the edge may simply have provided better foraging sites for wading birds, even though qualitative characteristics such as water depth and density of floating vegetation did not differ between the edge and open habitats.

Because of the unique, recently disturbed nature of our unreplicated study site, management implications of our results are presently unclear. Nevertheless, we suggest caution in aggressively pursuing large-scale mowing activities throughout the marsh, because our data suggest that some bird species favor edge habitat, and some may in fact be more abundant within the densely vegetated portions of the marsh. Further studies should examine whether the distributional pattern we observed holds for all large open areas of the marsh, as well as explore potential mechanisms for this pattern on a species by species basis. Also, long-term census data in mowed and unmowed areas would be useful in determining the effects of restoration activities on the overall abundance of marsh birds.

LITERATURE CITED

Licona, M. M., I. Biedron and R. M. Ermentrout. 2003. Effects of wetland habitat restoration on the species diversity and abundance of tropical avifuana. Dartmouth Studies in Tropical Ecology, p. 42 -7.

Appendix 1. Shape and dimensions of the census plot. Surveys were conducted from the observation tower.



Appendix 2. Codes, common names, and Latin names of marsh bird species recorded during the census periods, with mean and maximum count (in parentheses) of six censuses.

Symbol	Common name	Latin name	Census mean (max)
BBWD	Black-bellied whistling duck	*Dendrocygna autumnalis*	130.3 (260)
BWTE	Blue-winged teal	*Anas discors*	3.2 (7)
CAEG	Cattle egret	*Bubulcus ibis*	2.8 (7)
COGA	Common gallinule	*Gallinula chloropus*	0.2 (1)
FUWD	Fulvous whistling duck	*Dendrocygna bicolor*	18.0 (54)
GBHE	Great blue heron	*Ardea herodias*	0.3 (2)
GEHE	Green heron	*Butorides striatus*	1.0 (3)
GLIB	Glossy ibis	*Plegadis falcinellus*	8.5 (16)
GREG	Great egret	*Casmerodius albus*	7.0 (12)
LEBI	Least bittern	*Ixobrychus exilis*	0.2 (1)
LBHE	Little blue heron	*Egretta caerulea*	6.3 (8)
LEGR	Least grebe	*Tachybaptus dominicus*	1.8 (4)
LIMP	Limpkin	*Aramus guarauna*	3.3 (13)
NOJA	Northern jacana	*Jacana spinosa*	91.3 (113)
PUGA	Purple gallinule	*Porphyrula martinica*	1.5 (6)
ROSP	Roseate spoonbill	*Ajaia ajaja*	0.7 (2)
SNEG	Snowy egret	*Egretta thula*	9.2 (13)
TRIH	Tri-colored heron	*Egretta tricolor*	1.2 (2)
WHIB	White ibis	*Eudocimus albus*	0.2 (1)