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Source: *Waterbirds: The International Journal of Waterbird Biology*, 1999, Vol. 22, No. 3 (1999), pp. 411-416

Published by: Waterbird Society

Stable URL: https://www.jstor.org/stable/1522117

Long-term Movement Patterns for Seven Species of Wading Birds

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Abstract.—We obtained banding and recovery records from 1914 through 1994 for seven species of wading birds from the Bird Banding Laboratory, United States Geological Survey, Patuxent Wildlife Research Center. We analyzed these data to evaluate differences in dispersal distance and frequency of dispersal movement among species. All records were from birds banded as juveniles and recovered at least five months later between March and July, which is the breeding season in most regions of North America. Focusing on recoveries during the breeding season reduced the chance that movements were related to migration rather than dispersal. When an individual was banded and recovered in the same ten-minute block of latitude and longitude, a movement distance of zero km was recorded. The frequency of zero-distance records provides an indication of breeding site fidelity for each species at a spatial resolution of ten minutes. Our results showed that mean dispersal distance was greatest for the Little Blue Heron (*Egretta caerulea*; 1148 km) followed by Glossy Ibis (*Plegadis falcinellus*; 1142 km), Tricolored Heron (*Egretta tricolor*; 1019 km), Great Egret (*Casmerodius albus*; 909 km), Snowy Egret (*Egretta thula*; 837 km), Great Blue Heron (*Ardea herodias*; 758 km), and White Ibis (*Eudocimus albus*; 545 km). Species which dispersed large distances also exhibited fewer zero-distance records, indicating greater movement frequency. The White Ibis has been classified as a nomad, at one end of a continuum defined by low breeding site-fidelity and several life history traits associated with unpredictable foraging habitat. We found that White Ibises were indeed recovered at new locations the majority (76%) of the time but that the other six species of wading birds we examined were even more likely to move to different sites during subsequent breeding seasons. Movement distance and site fidelity will both likely affect whether a response to habitat restoration is due to immigration or local reproduction. Although an increase in total birds using a restored habitat may be an indication of increased habitat quality, caution should be used in inferring population changes without understanding reproduction, mortality, and movement of individuals using restored habitats.

Received 20 July 1999, accepted 8 September 1999.

Key words.—Biological indicators, Ciconiiform, ecosystem restoration, dispersal, movements, nomadism, philopatry, South Florida, wading birds.

Waterbirds 22(3): 411-416, 1999

Despite their widespread use as biological indicators (Custer and Osborn 1977; Temple and Wiens 1989; Kushlan 1993), bird species are not equal in their ability to reflect local conditions. Foraging patterns of wading birds indicate that some species integrate information about habitat quality and prey availability over large areas on a daily basis (Kushlan 1986), whereas others forage much closer to their roost (Smith 1995; Strong *et al.* 1997). The same pattern is evident in population responses over longer time scales. For example, Fleury and Sherry (1995) suggested that several species of wading birds in Louisiana have increased over two decades in response to increased food abundance from crayfish aquaculture, while species that do not rely as heavily on crayfish did not respond.

Geographic shifts in the breeding populations of wading birds between states and regions also have been attributed to changes in habitat conditions (Shanholtzer *et al.* 1970; Grant 1971; Byrd 1978; Ogden *et al.* 1978; Ogden *et al.* 1980; Frederick *et al.* 1996). Ciconiiforms are stimulated to nest by habitat quality, especially the availability of food (Ogden *et al.* 1980; Kushlan 1986; Frederick 1995); therefore, changes in habitat quality can influence breeding site choice by wading birds. Changes in habitat conditions may be negative, such as drainage of wetlands or declining prey populations; or positive, such as habitat restoration. The ability of birds to locate new habitats when these changes occur is dependent on their mobility.

The frequency and distance that birds move, which will likely affect their response to changing habitat conditions, have not been examined. Birds move during dispersal and migration. Migration movements are regular, extensive, seasonal movements between breeding and wintering regions (Koford *et al.* 1994). Dispersal is movement of an individual away from the place of birth or centers of population density (Koford *et al.* 1994). Our intent was to focus on dispersal movements of wading birds, because migratory species that exhibit high breeding site fidelity may move large distances but still return to previous breeding sites, regardless of habitat conditions elsewhere. We were interested in examining whether wading birds were likely to disperse from their natal colony to a different breeding location, thereby exhibiting low site fidelity.

Dispersal patterns (i.e., movement frequency and distance) influence a species' ability to locate available habitat. Species that move often will be more prone to discovering new sources of food. For example, White Ibises change colony locations frequently, forming new colonies where food abundance is extremely high (Frederick and Ogden 1997). Species that move short distances are affected more by local changes in habitat quality (Warkentin and Hernandez 1996) than species that move greater distances. In the context of habitat restoration, information on dispersal patterns may be critical for matching the spatial scale of a restoration project to the potential response of candidate indicator species. This information would be particularly useful for distinguishing among conflicting population responses of different indicator species to restoration projects.

Two major ecosystem restoration projects, the Everglades and Kissimmee River, are currently underway in southern Florida. Both of these projects require evaluation of selected biological responses to gauge the progress of ecosystem restoration. Wading bird population responses have been recommended as measures of restoration success for both the Everglades (Science Subgroup 1997) and the Kissimmee River (Weller 1995) restoration projects. Our objective was to compare the distance, frequency, and geographic region of dispersal among seven wading bird species to evaluate their usefulness as indicators of restoration success.

METHODS

We obtained banding and recovery records from the Bird Banding Laboratory, United States Geological Survey, Patuxent Wildlife Research Center (BBL) to compare large-scale movement patterns among seven species of wading birds. Although banding data are biased for some purposes (Mikuska *et al.* 1998), banding data can be used to evaluate long-term movement patterns for a wide range of species at the scale of entire continents (e.g. Rydzewski 1956; Frederick *et al.* 1996; Mikuska *et al.* 1998). We examined 3,297 individual encounter or recovery records from 1914 through 1994. Encounter records indicate re-sighting of a live individual, while recovery records typically mean the bird was found dead. Here, we use the term recovery to represent both types of data, although most birds were recovered dead. To ensure that each individual had the opportunity to undergo natal dispersal, we included only records from birds at least five months old when recovered. To separate dispersal from migration movements, we used only those individuals that were recovered during the months of March through July. Because the majority of wading birds were banded at the nest site as nestlings or fledglings (87%) and were recovered dead (77%), these records reflect at least a minimum distance moved by an individual over its entire lifetime.

Data taken from each recovery record included recovery location, date banded, date recovered, banding location, and band number. Coordinates for Mexican recoveries were not available prior to 1989; therefore, we estimated the locations for those records as the center of their respective Mexican state. All recoveries were recorded to the closest ten-minute block of latitude and longitude, which is the finest resolution available for BBL banding data.

We included 557 records for seven species of wading birds: Great Blue Heron (*Ardea herodias*; N = 216), Great Egret (*Casmerodius albus*; N = 84), Little Blue Heron (*Egretta caerulea*; N = 63), Tricolored Heron (*Egretta tricolor*; N = 24), Snowy Egret (*Egretta thula*; N = 111), Glossy Ibis (*Plegadis falcinellus*; N = 34), and White Ibis (*Eudocimus albus*; N = 25). We used the GeoCurve object in ArcView® 3.1 to calculate the "great circle distance" between banding and recovery sites of individuals. The "great circle distance" differs from "straight-line distance" by accounting for the curvature of the earth in the calculation of distance between two points. Mean, maximum, minimum, and standard error of dispersal distance were calculated for each species. Ninety-three individuals were recovered in the same ten-minute block of latitude and longitude where they were banded. We represented those dispersal distances as zero km and considered their frequency as an indication of breeding site fidelity (Rydzewski 1956) at a spatial resolution of ten minutes.

The likelihood of recapturing an individual at its banding site is a function of both the site fidelity of the bird and the length of time that banding was conducted at that site. To separate potential confounding effects of banding period from site fidelity, we excluded zero-distance records from statistical analyses of dispersal distances. We conducted an analysis of variance for unbalanced data using the General Linear Models procedure in SAS (SAS Institute 1988) to test for differences in movement distance among species. If the overall model was significant, we performed pairwise comparisons on the least square means using a critical level of 0.05.

RESULTS

White Ibises had the highest percentage of zero-distance records, followed by Great Egrets, Snowy Egrets, and Great Blue Herons (Table 1). Tricolored Herons and Glossy Ibises had nearly identical percentages of zero-distance records, and Little Blue Herons had the fewest zero-distance records of all seven wading bird species. Great Blue Herons showed the greatest maximum dispersal distance (4,584 km) between banding site and recovery site and Tricolored Herons (2,328 km) exhibited the lowest maximum dispersal distance (Table 2).

Mean dispersal distances differed significantly among species (P = 0.02). Pairwise comparisons indicated that mean dispersal distance for Great Blue Herons and White Ibises were significantly lower than those of Glossy Ibises and Little Blue Herons, but not significantly different from each other nor any other species. Little Blue Herons (1148 km) and Glossy Ibises (1,142 km) exhibited the greatest average dispersal distances, followed by Tricolored Herons (1,019 km), Great Egrets (909 km), Snowy Egrets (837 km), Great Blue Herons (758 km), and White Ibises (545 km) (Table 2).

Maps generated from banding and breeding-season recovery locations (Fig. 1) illustrate that all seven species moved primarily north and south, with little exchange between eastern and western populations. Species with ranges that are not limited to the east coast (i.e., Great Blue Heron, Great Egret, Snowy Egret, Little Blue Heron, and Tricolored Heron) had several north-south corridors distributed across the United States. Snowy Egrets, Great Egrets, Great Blue Herons, and Little Blue Herons were recovered in Central America and the Caribbean. Birds that were banded in the northern United States, especially Great Blue Herons, were recovered in the southern United States as well as the Caribbean Islands, Central America and South America. Great Blue Herons and Snowy Egrets banded in the western and central United States were not commonly recovered outside of the United States. In contrast, Glossy Ibises were recovered almost exclusively in the Caribbean Islands. White Ibises were recovered both in the Caribbean Islands and South America.

DISCUSSION

The term "nomadic" is defined as roaming about from place to place aimlessly or without a fixed pattern of movement (Merriam-Webster 1961), which for wading birds would indicate low breeding-site fidelity. White Ibis are reported to have low breeding-site fidelity and therefore have been classified as a nomad (Kushlan and Bildstein 1992; Frederick *et al.* 1996; Frederick and Ogden 1997). This species is thought to represent one end of a continuum defined by weak philopatry and several other life history traits associated with unpredictable location of foraging habitat among years (Frederick and Ogden 1997). We found that White Ibises were indeed recovered at new locations the majority of the time. However, our results are noteworthy because the other six species of wading birds we examined were even more likely to move to different sites during subsequent breeding seasons. Also,

Table 1. Total records and zero-distance records for seven wading bird species.

Species	Total Records	Zero-Distance Records	Percent Zero-Distance Records
White Ibis	25	6	24.0
Great Egret	84	20	23.8
Snowy Egret	111	20	18.0
Great Blue Heron	216	35	16.2
Tricolored Heron	24	3	12.5
Glossy Ibis	34	4	11.8
Little Blue Heron	63	5	7.9

Table 2. Maximum and mean distance (km) recorded between banding and recovery locations for seven species of wading birds. Mean distances of species with the same letter are not significantly different (P > 0.05). Minimum distance for each species = 0 km.

Species	Min	Max	Mean ± SE	Significance	N
Little Blue Heron	15.31	4114.55	1148.32 ± 163.46	b	58
Glossy Ibis	23.62	2603.48	1141.56 ± 159.28	b	30
Tricolored Heron	57.57	2327.60	1019.24 ± 190.03	a,b	21
Great Egret	16.45	3124.91	909.38 ± 113.73	a,b	64
Snowy Egret	18.50	2828.57	836.81 ± 96.30	a,b	91
Great Blue Heron	12.18	4584.25	757.91 ± 71.77	a	181
White Ibis	18.48	2478.60	545.40 ± 91.57	a	25

when birds moved, White Ibises moved the shortest average distance of the seven species we examined. A host of life history traits have been associated with nomadism in the White Ibis, which has led to the suggestion that conservation strategies for White Ibis should differ fundamentally from those of more sedentary species (Frederick *et al.* 1996). Although several life history characteristics differ between White Ibis and other wading bird species, it is unclear whether a dichotomy for conservation strategies is justified based on the degree of nomadism.

The distribution of breeding populations of White Ibises has exhibited large-scale shifts in recent years (Frederick *et al.* 1996). Our results suggest the majority of movements among breeding seasons for all seven species was along a north and south corridor that corresponds with seasonal migration routes. This pattern suggests that wading birds can locate and take advantage of newly-available habitat along their migration route and remain there to breed (e.g., Rydzewski 1956). Neither Wood Storks (Stangel *et al.* 1990) nor White Ibises (Stangel *et al.* 1991) show significant genetic subdivision among individuals, as would be expected if birds returned to breeding sites regardless of habitat conditions encountered along migration routes.

The ability of wading birds to locate and utilize newly-available resources is dependent on the scale at which each individual species chooses habitat. Dispersal distance is one measure of that scale. Holling (1992) proposed a hierarchical habitat-selection model that was greatly influenced by the degree of movement exhibited by individual species. The two factors comprising movement patterns of wading birds in this study (i.e., frequency and distance) were related: species that dispersed great distances also moved often. Little Blue Herons and Glossy Ibises moved more frequently and greater distances between banding and recovery locations than did Great Blue Herons and White Ibises, although all seven species had low breeding site fidelity and moved an average of more than 500 km.

Frequent movements indicate low breeding site fidelity, which may provide an increased likelihood of locating habitats that vary in quality across time. Andersson (1980) suggests that low breeding site fidelity may be an adaptation to cyclic abundance of food sources, such as fluctuations in prey availability resulting from wet-dry cycles in seasonal wetlands (Kushlan 1976a). Birds that disperse great distances have more opportunity to locate habitats that vary in quality across space, such as a regionally high food availability due to the aquaculture industry (Fleury and Sherry 1995).

The large average dispersal distance and low site fidelity for the seven species examined in this study support the notion that wading birds are capable of locating resources at a landscape scale (Frederick *et al.* 1996) and therefore responding to habitat restoration projects by increasing local abundance through immigration and reproduction. Species that move frequently or over great distances should respond to habitat restoration through reproduction at the local level and through immigration from other regions. An increase in abundance due to improved habitat conditions for species that move shorter

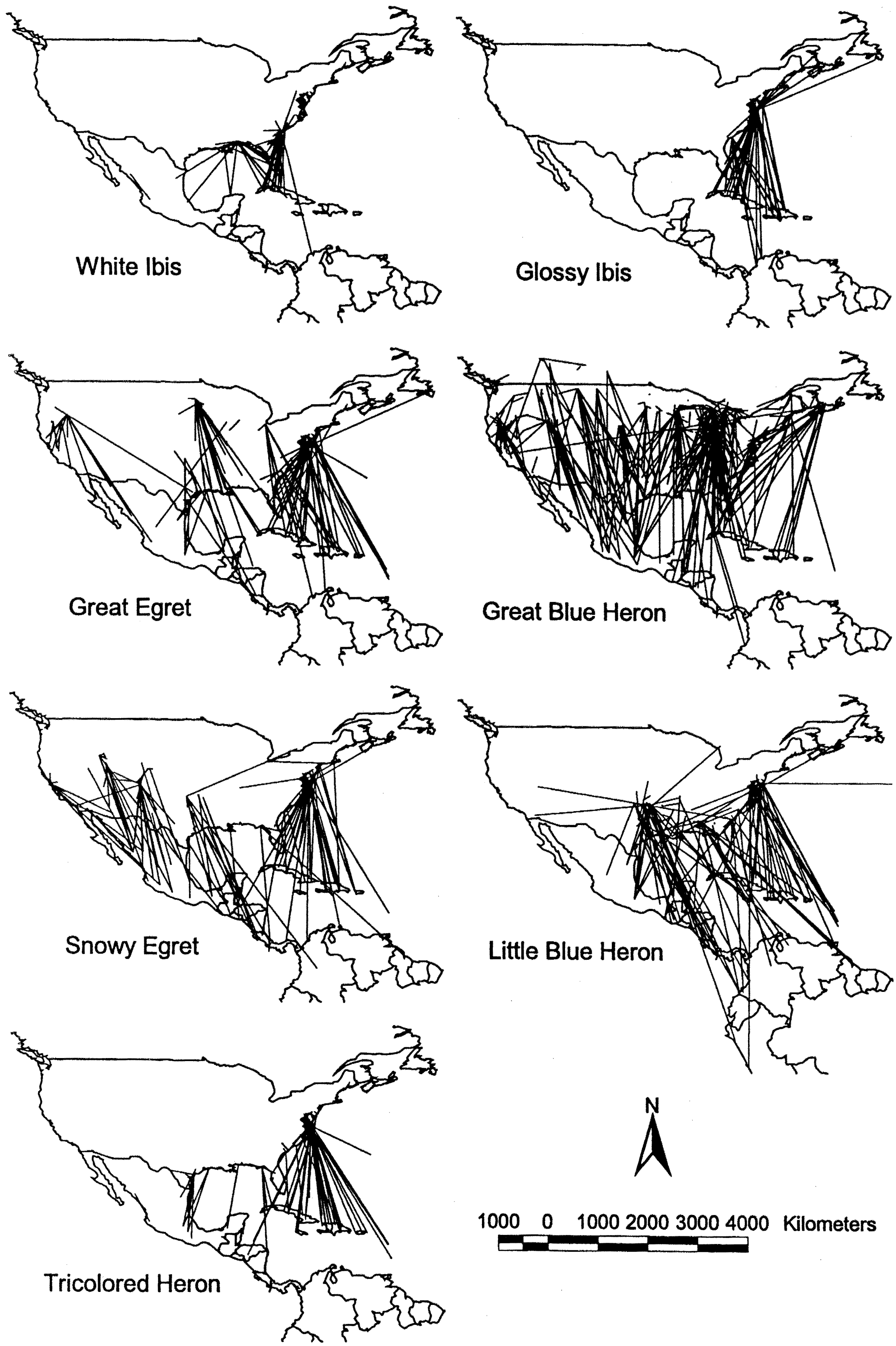

Figure 1. Banding and recovery locations of White Ibises, Glossy Ibises, Great Egrets, Great Blue Herons, Snowy Egrets, Little Blue Herons, and Tricolored Herons.

distances, or move less frequently, would likely be based only on local reproduction (Gawlik *et al.* 1998) and would occur more slowly than for more mobile species. The abundance of birds, regardless of reproductive status, is a good measure for evaluating the success of restoration proj-ects, because it is presumably linked to the condition of the habitat (Weller 1995). However, because the abundance of birds may be a function of highly mobile individuals redistributing over the landscape, increased abundance may not necessarily indicate a population increase. To make inferences on the effects of restoration projects on wading bird populations, it is necessary to quantify reproduction, mortality, and movements of individuals using restored habitats.

ACKNOWLEDGMENTS

We are grateful to everyone who provided banding or recovery data to the Bird Banding Lab, and to the BBL for sharing these data. We also thank John Ogden, Lou Toth, Tom Fontaine, Fred Sklar, Doug Shaw, Brad Jones, Heinz Hafner, and an anonymous reviewer for comments on earlier drafts of this manuscript.

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