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EFFECTS OF HABITAT LOSS ON SHOREBIRDS DURING THE NON-BREEDING SEASON: CURRENT KNOWLEDGE AND SUGGESTIONS FOR ACTION

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Resumen. – Efecto de la pérdida de hábitat en las aves playeras durante la época no-reproductiva: conocimiento actual y sugerencias sobre cómo proceder. – Muchas de las aves playeras son especies migratorias Neárticas-Neotropicales que migran de sus áreas norteñas de reproducción a áreas de invernada en Centro y Sudamérica. Las aves playeras difier

strated for European shorebird population parameters. In contrast, little is known about the population or behavioral ecology of the wintering shorebirds south of the United States. We briefly review of the state of knowledge of the effects of habitat loss on shorebirds during the non-breeding season in the Neotropics, illustrated with several examples, to highlight the many unanswered questions. It is crucial to gain better understanding of population limiting factors in this region because shorebird populations are influenced by habitat alterations across the non-breeding range. The relative importance of non-breeding vs breeding season density-dependence remains to be assessed for most species. *Accepted 15 December 2007.*

Key words: Habitat loss, migratory shorebirds, Neotropics, non-breeding season, research needs.

INTRODUCTION

Migratory shorebirds, as a group, are of particular conservation concern, owing to their long migrations, low reproductive rate, and dependence on a wide variety of wetland habitats for which extensive losses have occurred (Myers *et al.* 1987, Bildstein *et al.* 1991). Shorebirds worldwide have suffered alarming recent declines. Forty-eight per cent of 200 populations with known trends are in decline, whereas only 16% are increasing (International Wader Study Group 2003). Migration monitoring suggests that declines are also occurring in shorebirds that breed in North America (Howe *et al.* 1989, Morrison *et al.* 2001, Bart *et al.* 2007). There is little information to explain proximate cause(s) of these population declines (Thomas *et al.* 2007), but habitat loss is one likely factor (Zöckler *et al.* 2003). The principal habitats used by most kinds of shorebird during migration and winter seasons are coastal and interior wetlands. Therefore, these declines are of particular conservation concern because the reliance of shorebirds on wetland ecosystems suggests that they may be important indicators of wetland health on a global scale (CHASM 2004).

Although not well enumerated, there is no doubt that the cumulative loss of wetlands worldwide has been enormous during the last two centuries. In the United States, for example, it is estimated that more than 50% of the wetlands that existed in the 1700s' are now gone (Harrington 2003). In the Western Hemisphere little effort has been made outside Canada and United States to document wetland loss on a systematic basis. Further, little is known about the population or behavioral ecology of migratory shorebirds south of the United States, and the effect of habitat loss on population sizes. Population dynamics of migratory shorebirds can be influenced by events that occur during the non-breeding, migration and breeding periods, and population regulation can occur by a combination of mechanisms operating in one or more of these seasons (Piersma & Baker 2000). In this paper, we present a brief overview of the state of knowledge of the effects of habitat loss on migratory shorebirds during the non-breeding season in the Neotropics, illustrated with several examples, to highlight the many unanswered questions.

HABITAT LOSS – A BEHAVIORAL AND POPULATION ECOLOGICAL FRAMEWORK

Many human activities, such as agricultural intensification, industrial development, landclaim, resource harvesting, and salt production, affect or destroy the habitats used by shorebird populations. Their coastal habitats may also be particularly vulnerable to sea level rise caused by climate change. Human disturbance is equivalent to habitat loss or degradation because shorebirds may avoid or underuse areas (Gill & Sutherland 2000). As consequences of habitat loss or human disturbance,

food abundance, habitat or time available for feeding may decrease. To understand the effect of habitat loss on migratory shorebirds, we need to think about habitat quality and individual variability. Habitats used by shorebirds vary in quality as a function of food abundance, predation danger and competition. Individuals typically vary considerably in how they exploit food resources, and in their susceptibility to predation and interference competition (Durell 2000, Ydenberg *et al.* 2002). Habitat quality depends on both benefits and costs, and the best habitat choice for any individual thus involves condition- or state-dependent tradeoffs that balance metabolic requirements, safety priorities, and social status or dominance. Such individual variations have important implications for the effect the population consequences of habitat loss or change. If habitat loss or change occurs, some segments of the population will be affected more than others, particularly first-year birds (Goss-Custard & Sutherland 1997, Goss-Custard 2003).

For resident populations, the simplest starting assumption is that populations will decrease in proportion to amounts of habitat lost or degraded. However, to predict the population consequences of habitat loss, we also need to understand the role of density-dependence (Goss-Custard & Sutherland 1997, Goss-Custard 2003). In our case, how will populations be affected if more shorebirds attempt to occupy less space during the non-breeding season? It is likely that body condition and rates of survival of shorebirds will decline due to changes in competition for food and/or intensity of predation at fewer sites. Whether shorebirds starve or emigrate may not be of immediate concern for a particular site, but could have an important effect on that site in the long term (Goss-Custard 2003). Local population size would be expected to decline by an amount that depends on the availability of alternative non-breeding sites, and also of density-dependent interactions on the breeding grounds (see below). Migratory species require a more complex conceptual framework for predicting the consequences of habitat loss (Goss-Custard *et al.* 1995, Sutherland 1998). Because density-dependent processes operate with different relationships at b

during the non-breeding season is meager and dispersed. As a starting point, however, for the most at-risk shorebird species, most non-breeding sites and areas of substantial importance have been identified (WHSRN 2007). Although there is an assessment of how much habitat has been lost in some countries (e.g., Fuente de León & Carrera 2005), there is no analysis of its effects on shorebird populations beyond a local scale. While annual adult survivorship has been estimated for some species (Sandercock 2003), there is no partitioning of these values into breeding season, migration season, and non-breeding season mortality rates (cf. Sillett & Holmes 2002), which would identify stages with the highest daily risk of mortality. There is information for some species on differential habitat distribution by sex, age, and size, either latitudinally (Myers 1981, Nebel *et al.* 2002, O'Hara *et al.* 2006, Nebel 2006) or among habitats on a local scale (Fernández & Lank 2006), and we know of intraspecific differences in energetic costs and life-history strategies with respect to migration distances (Myers *et al.* 1985, Castro *et al.* 1992, O'Hara *et al.* 2005), but the population implications of these patterns have not been worked out. There are several published studies on the feeding and intertidal food resources of migratory shorebird species from sites in Brazil (Kober & Bairlein

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standing the factors that have affected shorebird populations and as a first step towards predicting the effect of habitat change upon them during the non-breeding season. Adult survival is a critical variable in determining population dynamics of migratory shorebirds (Hitchcock & Gratto-Trevor 1997), and this magnifies the importance of the quality of the limited non-breeding habitat in the winter and migration sites on which birds rely (Piersma & Baker 2000). Banding (marking) programs are essential to estimate survivorship, and the color banding of individuals also allows more detailed observation of behavior including habitat use and foraging ecology. Also, we must understand the functional links between the seasonal habitats of migratory shorebirds (Webster *et al* 2002). Coupled with banding shorebirds, the use of stable isotopes and genetic information may provide a powerful tool for estimating population-specific demographic parameters and increase our understanding of their migration systems.

Behavior-based modeling. Recently, individual-based models have been developed in an attempt to predict how migratory bird populations will be affected by environmental change, such as habitat loss, disturbance, and climate change (Pettifor *et al.* 2005, West & Caldow 2006). These models follow the behavioral responses of individual animals to changes in the environment and predict variables such as population mortality rates from the fates of all individuals. Birds in these models use optimal decision rules to determine their behavior, thus model birds should respond to environmental changes in the same way as real ones would. The most important advantage of this approach is provides a means of predicting how animal populations will be influenced by environmental changes outside the ranges of those we have already observed. Although individual-based models are often complex and take a long time to develop, they have already proved useful in a range of issues and locations in Europe (e.g., Durell *et al.* 2005, Pettifor *et al.* 2005, West & Caldow 2006).

Finally, to safeguard migratory shorebird populations, we have to protect the interconnected chains of wetlands they rely on from further deterioration and disappearance (Myers *et al.* 1987, Piersma & Baker 2000). Invariably, to develop a thorough understanding of the functioning of a wetland ecosystem in which shorebirds represent a key component, requires a huge investment