0075668

From: GOLDER, Walker
To: Patrick Field
Cc: 'Mike_Murray@nps.gov'
Subject: Waterbird-Shorebird Literature
Date: 10/30/2008 01:29 PM
Attachments: Waterbird-Shorebird Literature.doc

Pat,
I've attached a partial listing of publications related to waterbirds, shorebirds, and beaches. These are publications that I found relevant to issues at Cape Hatteras National Seashore.

Best regards,
Walker

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Waterbird and Shorebird Literature
(partial listing)
This is not meant to be and should not be considered a complete literature review

Anders, F. J. and S. Leatherman. 1987. Effects of off-road vehicles on coastal foredunes at Fire Island, New York, USA. Environmental Management 11: 45-52.

The effects of off-road vehicles (ORVs) on the dune system of Fire Island National Seashore, New York, USA, were examined through a detailed, two-year field study. The experimental approach was adopted in order to evaluate the environmental effects of ORVs in this zone. Adjacent control and impact sites were established in two locations. Vehicle impacts were applied at the equivalent rate of one vehicle pass per week. Monitoring of foredune vegetation through sequential quadrat surveys and construction of sea-ward limit maps showed a significant loss of vegetation resulting from ORV impacting. Loss of vegetation resulted in an alteration of the natural foredune profile, which could increase dune erosion during storm wave attack.

Anders' F. J. and S. P. Leatherman 1987. Environmental Management 11: 183-189.

A three-year investigation was undertaken to examine the effects of off-road vehicles (ORVs) on the beach at Fire Island, New York. Within the National Seashore over 45,000 vehicle trips per year are concentrated in the zone seaward of the dune toe. The experimental approach was adopted in order to assess the environmental effects of ORVs. Specially developed instrumentation was used to measure the direct displacement of sand by vehicles traversing the beach. Direct displacement data were reduced graphically and analyzed by stepwise linear regression. The results of 89 field experiments (788 cases) showed that slope, sand compaction, and number of vehicle passes in the same track were the principal factors controlling the measured net seaward displacement of sand. The data suggest that ORV use levels within the National Seashore could be contributing to the overall erosion rate by delivering large quantities of sand to the swash zone (max. of 119,300 m^3/yr). However, with proper management downslope movement of sand could be reduced by an order of magnitude. While vehicular passage over the open beach displaces sand seaward, it is not known if such activity actually increases the amount of erosion, measured as net loss to the beach face.

Anderson, D. W. and J. O. Keith. 1980. The human influences of seabird nesting success: conservation implications. Biological Conservation 18:65–80.

Based on studies of brown pelicans *Pelecanus occidentalis californicus* and Heermann's gulls *Larus heermanni*, disturbances by recreationists, educational groups, local fishermen and scientists alike can be seriously disruptive and damaging to breeding seabirds in the Gulf of California and off the west coast of Baja California. Similar instances have been identified throughout the world—the problem is not difficult to document, but it is difficult to eliminate. The increasing human-seabird contacts on islands in the Gulf of California and along the west coast of Baja California raise serious questions and immediate concern about the continued preservation of nesting colonies of marine birds in those areas. Conservation measures must consider the extreme sensitivity of many seabirds to the inter- and intraspecific behavioural imbalances created by human disturbances. In some cases, total exclusion of humans may be required; in others, limited access might be possible under closely managed conditions at certain times of the year. A symbiotic relationship between seabird conservation, legitimate research and tourism should be the desired goal.

Anderson, S. H. 1995. Recreational disturbance and wildlife populations. p. 157-168, *in* R. L. Knight and K. J. Gutzwiller eds. Wildlife and Recreationists. Island Press, Washington, D. C.

Dramatic changes in recreation have occurred during the past century (see Chapter 1). With more leisure time and more people living in cities, many have turned to fishing and wildlife activities. In 1993, the National Survey of Fishing, Hunting, and Wildlife Associated Recreation reported results from Americans surveyed about their wildlife related activity conducted in 1991. About 109 million people 16 years and older enjoyed some form of wildlife-related recreation including hunting, fishing, and nonconsumptive use (U.S. Fish and Wildlife Service 1993). People have an impact habitat and all that depends on it, no matter what the activity. In Great Britain, for example, people involved in wildlife-related activities affect wildlife by destroying food, increasing pollution, and changing the environment in a variety of ways (Liddle and Scorgie 1980).

When trails and campsites are developed, habitat can be drastically altered. Discarded human food wastes provide different sources of food for animals, affecting their population structure. As people intrude into an area, the effects on animals can include altered behavior, increased stress, or changes in productivity and diet. The populations can change in size and distribution, and the species composition and interactions of whole communities can change (Knight and Cole 1991).

When suitable habitat is diminished, populations may decline. For example, rock climbing may make nest sited used by birds for years unsuitable. In the long term, if extensive habitat alteration occurs for animals that have a limited distribution, the population of a particular species may experience substantial declines.
In this chapter I will examine specific impacts on wildlife populations such as hunting, wildlife viewing, habitat encroachment, and stress. Then I will consider ways to maintain wildlife populations and allow outdoor recreational activities as well. Management options and research needs will also be addressed.

Atkinson, P. W., A. J. Baker , K. A. Bennett , N. A. Clark, J. A. Clark , K. B. Cole , A. Dekinga , A. Dey , S. Gillings , P. M. Gonzalez , K. Kalasz , C. D. T. Minton , J. Newton , L. J. Niles , T.Piersma , R. A. Robinson and H. P. Sitters. 2007. Rates of mass gain and energy deposition in red knot on their final spring staging site is both time- and condition-dependent. Journal of Applied Ecology 44: 885-895.

1. Millions of shorebirds migrate each year through a small number of highly productive staging areas where they often conflict with fisheries interests. Delaware Bay, USA, is a major shorebird stopover site where, in spring, many thousands of shorebirds undergo rapid mass gain by feeding on the eggs of commercially harvested horseshoe crabs *Limulus polyphemus.*
2. Environmental factors may cause deviations from the best migration schedule. We used within-year mass gain data from red knot *Calidris canutus* caught in Delaware Bay between 1998 and 2005 to determine the degree of flexibility individuals have to vary migration speed.
3. Mass gain by birds below 133 g was shown to comprise 15·3% fat (39 kJ g^{-1}), the remainder being lean mass (6 kJ g^{-1}). Above this critical level, fat comprised 83·9% of mass deposition. The rates of energy deposition (kJ d^{-1}) were therefore fundamentally different between the two states but were among the highest ever recorded among vertebrates (5–7 × basic metabolic rate).
4. A total of 36–62% of the variation in observed rates of energy deposition between 1998 and 2002 was explained by a year factor, date and mass at initial capture and interaction terms, such that light-weight birds at the end of May had rates of mass gain or energy deposition two to three times higher than birds of similar mass in mid-May, indicating that birds were attempting to achieve a certain mass by a certain date. In 2003 and 2005, this relationship broke down as a result of lower densities of eggs.
5. Synthesis and application. The maintenance of high densities of crab eggs required for high rates of mass gain in red knot requires severe cuts in, or the complete cessation of, the crab harvest, reduced human and raptor-related disturbance as well as management of beaches to provide sufficient crab-spawning habitat. These findings are widely applicable to other systems where harvesting activities come into conflict with migrating animals and show that certain sections of the population, in this case the long-distance migrants from South America, will be impacted more than short-distance migrants whose physiology may give them access to alternative food resources.

Avery, A. L., T. Penn, E. Savage, and H. Hollis. 2004. Piping Plover monitoring and management summer 2004 report and 2005 plans for beach nesting shorebirds. USFWS, Chincoteague National Wildlife Refuge, VA.

An estimated 98 pairs of breeding piping plover (*Charadrius melodus*) nested on Chincoteague National Wildlife Refuge in 2004. Three additional pairs of piping plovers were not monitored on Metompkin and Cedar Islands. The population has fluctuated over the past ten years from a low of 44 pairs in 1994 to a high of 98 pairs in 2004. Nesting activity was documented on all traditional nesting sites of the refuge. A total of 224 plover chicks fledged (minimum of 25 days old) on Chincoteague NWR resulting in a productivity ratio of 2.29 fledglings per nesting pair for the refuge.

Bart, J., S. Brown, B. Harrington & R.I.G. Morrison. 2007. Survey trends of North American shorebirds: population declines or shifting distributions? *J. Avian Biol.* 38: 73–82.

We analyzed data from two surveys of fall migrating shorebirds in central and eastern North America to estimate annual trends in means per survey and to determine whether trends indicate a change in population size or might have been caused by other factors. The analysis showed a broad decline in means per survey in Atlantic Canada and the northeastern United States (North Atlantic region). For example, 9 of 9 significant trends in this region were <1 ($P=0.004$), and the mean, annual rate of change among 30 species was 0.9783, a decline of −2.17% per year ($P<0.001$).

Trends in the midwestern United States (Midwest region) showed no clear pattern. The mean among 29 species was 1.0090 (P=0.35). Only 4 of the trends were significant. Several hypotheses were evaluated to identify causes of the declining means per survey in the North Atlantic region. The most likely hypothesis appears to be a decline in the breeding populations that supply migrants to the North Atlantic region, but a change in movements, for example passing through the region more quickly in recent years, cannot be excluded as an explanation. Further surveys of arctic breeding areas coupled with analysis of long-term survey data from western North America would be helpful in determining whether the declines found in this analysis are also occurring in other areas.

Baudains, T. P. and P. Llyod, 2007. Habituation and habitat changes can moderate the impacts of human disturbance on shorebird breeding performance. Animal Conservation 10: 400-407.

Disturbance by humans is widely expected to reduce the reproductive fitness of nesting birds if disturbance reduces nest attentiveness, and unattended eggs experience increased risk of predation or exposure to potentially lethal temperature extremes. Yet, relatively few studies have examined the physiological or behavioural mechanisms whereby disturbance influences reproductive fitness, or the extent to which the costs of disturbance may be reduced through habituation. We compared the behavioural responses, egg temperatures and reproductive success of shore-nesting white-fronted plovers Charadrius marginatus to disturbance at two breeding sites experiencing low versus high human recreational activity, respectively. Daytime nest attentiveness decreased with increasing experimental disturbance at both sites, but this relationship differed between sites; for any given level of disturbance, incubating birds at the more disturbed site had greater nest attentiveness. They achieved this through habituation, allowing a closer human approach before leaving the nest, and returning to the nest faster after a disturbance event. Despite lower average daytime nest attentiveness at the more disturbed site, incubation temperatures did not differ significantly between sites. Nest mortality, mostly by natural mammalian and corvid predators, was significantly lower at the site experiencing high recreational activity. However, chick mortality was significantly greater at the more disturbed site, most likely because of predation by domestic dogs. Chick mortality may have been increased by the habitation of chicks, whose escape responses were much reduced at the more disturbed site. Nonetheless, annual fecundity was substantially higher at the more disturbed site, showing that the overall reproductive fitness of wild birds is not always compromised by human disturbance and urbanization.

Beale, C. M. and P. Monaghan. 2004. Human disturbance: people as predation-free predators? Journal of Applied Ecology 41: 335-343.

Human disturbance has been associated with declines in breeding success in numerous species and is of general concern to conservationists. However, the current framework for predicting and minimizing disturbance effects is weak and there is considerable uncertainty about why animals are disturbed by people in the first place. We developed a behavioural model of perceived predation risk as a framework for understanding the effects of disturbance on cliff-nesting birds. This encompassed the concept that the effects of disturbance should increase with increasing numbers of visitors, and decrease with distance from the nest, an insight ignored in current conservation practice. The predictions of this model were tested using field data on nesting success in two species of seabird, kittiwake Rissa tridactyla and guillemot Uria aalge. Statistical models of nesting success in both species suggested that perceived predation risk is a good predictor of the effects of disturbance. Synthesis and applications. Our findings suggest that fixed set-back distances and buffer zones are likely to be inappropriate conservation measures in situations where the numbers of visitors to wildlife areas fluctuates spatially and temporally, as is generally the case. In managing access to wildlife areas there is a need to ensure that larger parties of visitors are kept further away from the nesting areas of vulnerable species or that set-back distances are determined for the largest party likely to visit the site.

Blumstein, D.T. (2003). Flight-initiation distance in birds is dependent on intruder starting distance. Journal of Wildlife Management 67: 852–857.

The distance at which animals move away from approaching threats (often quantified as flight-initiation distance [FID], or flush distance) has been used by behavioral ecologists to understand the economics of antipredator behavior. Wildlife managers often use FID when seeking to develop set-back distances to reduce human impacts on wildlife. Economic models of escape behavior predict that escape decisions will be dynamic and will be influenced by both the costs and benefits of remaining. In contrast, wildlife managers often aim to generate a single set-back distance for each species. While a number of factors are acknowledged to influence FID, the starting distance between the observer and the animal is typically ignored in FID studies. For 64 of 68 species of Australian birds, I found a significant positive relationship between starting distance and FID. This demonstrates that, as predicted by economic models, species generally assess risk dynamically and flush at a greater distance as starting distances increase. My finding is consistent with the idea that animals accrue an attentional cost for continued monitoring of an approaching predator. Researchers or managers aiming to quantify human impact using FID should use starting distance as a covariate.

Blumstein, D. T., L. L. Anthony, R. Harcourt, and G. Ross. 2003. Testing a key assumption of wildlife buffer zones: is flight initiation distance a species-specific trait? Biological Conservation 110:97–100.

The distance at which animals flee an approaching predator is known as the 'flight initiation distance' (FID). Wildlife managers use FID to develop buffer zones to reduce human impacts on wildlife. Many variables have been demonstrated to influence FID leading one to question whether it can be viewed as a species-specific trait. We tested this critical assumption for developing buffer zones by experimentally approaching eight species of shorebirds found at six sites around Botany Bay, 15 km south of Sydney, Australia. Botany Bay encompasses a range of human impacted areas, from urban developments with high levels of human presence, through to National Parks and wildlife protection areas where human presence is significantly lower. We found that both species and site influenced the distance birds flew away from an approaching human. Importantly, however, there was no significant statistical interaction between site and species demonstrating that 'flighty' species were consistently flighty while more tolerant species were consistently tolerant. Taken together, these results suggest that FID can therefore be viewed as a species-specific trait for these shorebirds. The great variability in FID suggests that wildlife managers should be somewhat conservative in developing buffer zones, but they can use previously published FID data for a given species as guidelines for setting buffer zones.

Blumstein, D. T., E. Fernandez-Juricic, P. A. Zollner, and S. C. Garity. 2005. Interspecific variation in avian responses to human disturbance. Journal of Applied Ecology 42: 943–953.

Increasing urbanization and recreational activities around and within biodiversity hotspots require an understanding of how to reduce the impacts of human disturbance on more than a single species; however, we lack a general framework to study multiple species. One approach is to expand on knowledge about the theory of anti-predator behaviour to understand and predict how different species might respond to humans. We reviewed the literature and found that only 21% of studies that used a behavioural approach to study human disturbance focused on multiple species. These studies identified a number of potential predictive variables. We developed a simulation model that investigates interspecific variation in different parameters of disturbance with variation in human visitation. We found that fitness-related responses, such as the quantity of food consumed by a species, are relatively sensitive to the distance at which animals detect humans, the frequency of disturbance by humans and the interaction of these factors, but are less sensitive to other characteristics. We examined avian alert distance (the distance animals first orientated to an approaching threat, a proxy for detection distance) across 150 species, controlling for phylogenetic effects. We found that larger species had greater alert distances than smaller species, which could increase local spatial and temporal limitations on suitable habitat with increasing human visitation. Synthesis and applications. Our results suggest that body size could be a potential predictor of responses to human disturbance across species, and could be used by managers to make conservation decisions regarding levels of human visitation to a protected site. We suggest that three things are essential to develop predictive models of how different species will respond to human disturbance. First, multiple indicators of disturbance should be studied to select those with lower intraspecific variation for a given study system. Secondly, the species-specific nature of responses should be identified. Thirdly, life history, natural history and other correlates with these species-specific responses must be assessed.

Boellstorff, D. E. D. W. Anderson, H. M. Ohlendorf and E. J. O'Neill. 1988. Reproductive effects of nest-marking studies in an American White Pelican colony. Colonial Waterbirds 11:215-219.

In 1981 and 1982 we studied the reproductive success of American White Pelicans in the Klamath Basin of northern California. We observed that reproductive success at one colony (Lower Klamath) became reduced in 1981 when we entered that colony to collect eggs for chemical analysis and to mark nests for an assessment of nesting success. Those pelicans produced only 0.5 Y/N (young per nest attempt) contrasted to pelicans nesting at an undisturbed colony that produced about 1.2 Y/N. No colonies were entered in 1982 and both produced about 1.1 Y/N. We concluded that our activities (similar to those of many researchers) reduced the success of that one disturbed colony. We suggest that the sample-egg technique should not be used in American White Pelican colonies, in-colony activities should be very limited, and researchers in bird colonies should attempt more often to assess the effects of their own activities.

Boersma, P.D., Parrish, J.K., 1998. Threats to seabirds: research, education, and societal approaches to conservation. In: Marzluff, J.M., Sallabanks, R. (Eds.), Avian Conservation: Research and Management. Island Press, Washington, DC , pp. 237–259.

Many bird species throughout the world are in decline or are suffering from unmistakable signs of ill-health. Such problems often indicate more serious and widespread environmental problems, making avian research a critical component of the overall protection of biodiversity.Avian Conservationpresents the findings and insights of leading

avian conservationists from around the world including Frances C. James, Ian Newton, Richard L. Hutto, John T. Rotenberry, P. Dee Boersma, David F. DeSante, Robert C. Fleischer and many others. Contributors review current research and identify information gaps that need to be filled if conservation measures are to be effectively carried out. They highlight the peril many species are experiencing, showcase important projects, and present the advice of practicing managers.The book features a blend of methodological, empirical, and applied chapters that introduce new ideas and strategies to working managers, and suggest how to most effectively implement research results. Sections consider techniques for conserving and monitoring birds approaches for conserving endangered and sensitive species research needs in forested landscapes conservation in nonforested and urban landscapes global variation in conservation needs relevance of conservation to land manager. Each section is preceded by a brief introduction that provides a valuable overview of the issue being considered. Throughout, contributors emphasize three themes: that an expanding human population has caused widespread changes in bird habitats; that research must be shifted from short-term, correlative studies of bird abundance to long-term, experimental studies that measure avian population viability; and that a closer relationship needs to be developed between researchers and managers. Conservation biologists, managers, and students interested in the conservation of birds will find the book an important guide and resource.

Boettcher, R., T. Penn, R.R. Cross, K. T. Terwilliger, and R. A. Beck. 2007. An Overview of the Status and Distribution of Piping Plovers in Virginia. Waterbirds 30: 138-151.

From 1986-2005, Virginia supported between 6% and 13% of the federally threatened Atlantic Coast Piping Plover (*Charadrius melodus*) breeding population with an annual average of 111 nesting pairs (SD ± 25.0, range = 84-192 pairs). The statewide population remained relatively static from 1986-2003 ($\bar{x}$ = 104.4 pairs, SD ± 12.0, range = 84-127 pairs). In 2004, the population increased to 152 pairs and in the following year grew to 192 pairs. Over 95% of the state's Piping Plover breeding activity occurred on the barrier islands. From 1986-1997, five pairs or less were observed at Craney Island, a dredge material deposition site in Portsmouth and at Grandview Nature Preserve, a high-use recreation area located in the City of Hampton. Predators and human disturbance likely account for the present-day absence of nesting pairs from both inland sites. From 1990-2002, annual productivity studies revealed an annual average of 1.14 fledged young per pair (SD ± 0.4, range = 0.59-1.65). The 2003 breeding season marked the first time Piping Plover productivity approached two fledged young per pair, which was followed by another increase in 2004 when productivity rose to over two fledged young per pair. The virtual doubling of Virginia's breeding population observed in 2005 along with the recent increase in breeding success represents an important contribution to the overall security of the Atlantic Coast Piping Plover population. We attribute the vitality of Virginia's Piping Plover population to the combined effects of predator management, public education and outreach, and the unique conservation status of the barrier islands that affords plovers a level of protection not found elsewhere within the Atlantic coast breeding range.

Botton, M. L., R. E. Loveland, and T. R. Jacobsen. 1994. Site selection by migratory shorebirds in Delaware Bay, and its relationship to beach characteristics and abundance of horseshoe crab (*Limulus polyphemus*) eggs. The Auk 111(3): 605- 616.

The distribution of migratory shorebirds within Delaware Bay, New Jersey, was examined relative to prey abundance and the physical characteristics of the intertidal beaches. Red Knots (*Calidris canutus*), Sanderlings (C. alba), Ruddy Turnstones (*Arenaria interpres*), and "peeps" comprised nearly 100% of the shorebirds on seven study beaches from mid-May to early June in both 1990 and 1991. The most abundant food item on these beaches was horseshoe crab (*Limulus polyphemus*) eggs, and there were few other available macroinvertebrates. Beaches preferred by shorebirds had higher numbers of crab eggs; the density of eggs in some surface (0-5 cm) sediments exceeded 1 05/m2 . In general, both horseshoe crab eggs and shorebirds increased along the bay shore from Higbee's Beach (near Cape May Point) to Moore's B each, 32 km up-bay. However, shorebirds were widely distributed within the bay, possibly because eggs were sufficiently abundant on most beaches to support foraging by at least four birds per meter of shoreline. Shorebirds aggregated near shoreline discontinuities, such as salt-marsh creeks and jetties that acted as concentrating mechanisms for passively drifting eggs. Sediment grain size and heterogeneity were probably not a primary determinant of shorebird distribution within Delaware Bay. Intertidal sand flats were not extensively used by foraging shorebirds, but the potential importance of nearby saltmarshes as foraging sites requires further investigation.
1993.

Bowles, A. E. 1995. Responses of wildlife to noise. pp. 109-156. In: Knight, R. L. and K. J. Gutzwiller. (eds.) Wildlife and Recreationists: Coexistence through Management and Research. Island Press: Washington, D.C.

Outdoor recreation has historically been viewed as an environmentally benign activity. Yet with growing numbers of recreationists visiting public lands, and with a greater understanding of the role of public land in safeguarding

biodiversity, it is becoming apparent that the effects of recreation on both the environment and wildlife are chronic and pervasive. Wildlife and Recreationists defines and clarifies the issues surrounding the conflict between outdoor recreation and the health and well-being of wildlife and ecosystems. The book is a valuable synthesis of what is known concerning wildlife and recreation. More important, it addresses both research needs and management options to minimize conflicts.

Boyle, S. A. and F. B. Samson. 1985. Effects of non-consumptive recreation on wildlife: a review. Wildlife Society Bulletin 13:110-116.

Interest and participation in nonconsumptive outdoor recreation have increased rapidly during the past 20 years (U.S. Dep. Inter. 1982, Diamond et al. 1983). Recreational demands and the nature and behavior of participants have been reviewed elsewhere (Potter et al. 1973, More 1979, U.S. Dep. Inter. 1979, 1982). Approximately 145 million Americans (72% of the U.S. population) engaged in nonconsumptive outdoor recreation in 1980 (Diamond et al. 1983), and substantial increases in numbers of participants are expected in the next 2 decades (U.S. Dep. Inter. 1979). By some analyses, nonconsumptive recreational values of wildlife may outweigh direct consumptive values (Shaw and King 1980, Lyons 1982). Governmental agencies are interested in developing a sound basis for management of nonconsumptive outdoor recreation (Diamond et al. 1983). Agency planners and managers must not only assess and provide for recreational demands, but also assess effects of recreational activities on natural resources, including wildlife and wildlife habitat. This paper evaluates available information on the effects of nonconsumptive outdoor recreation on wildlife in order to bring attention to, and provide a better understanding of, the relationship between recreationists and wildlife.

Burgeoning numbers of nonconsumptive outdoor recreationists are creating increasing impacts on wildlife and wildlife habitat, but proper management is hampered by the complexity of cause-and-effect relationships and the incompleteness of existing knowledge. Recreationists can affect wildlife through habitat alteration, disturbance, or direct mortality. Mechanized forms of recreation present the most serious potential impacts, but even the most casual intrusion by a person on foot may significantly affect vulnerable populations. Individuals, populations, and species vary in their sensitivity to disturbance; and researchers have begun to identify some mechanisms of human-wildlife interactions. Wildlife conservationists are challenged to identify recreational impacts on wildlife, establish priorities for management, and implement schemes to con- serve wildlife resources while providing for increasing use-demands of recreationists.

Brodhead, J. M. and P. J. Godfrey. 1977. Off road vehicle impact in Cape Cod National Seashore: disruption and recovery of dune vegetation. International Journal of Biometeorology 21: 299-306

An on-going investigation of the rates of vegetation breakdown and natural recovery under controlled conditions has been established at Cape Cod National Seashore, Massachusetts, U.S.A. In this study, the effects of controlled impacts on a variety of coastal habitats were measured in terms of above and below ground biomass. Dune sites, ranging from unstabilized to moderately stabilized, were driven on at varying levels of intensity and along different exposures relative to slope and prevailing wind direction. Preliminary evidence suggests that a single summer season of driving (300–700 passes) on a confined track through dense stands of*Ammophila vreviligulata*, *Arctostaphylos uva-ursi*, and*Deschampsia flexuosa*, can completely destroy the above-ground portions but leave adequate underground roots and thizomes for a small amount of vegetative regrowth after cessation of impact in the late summer and fall. Large differences in wind speed at ground level have been noted in driving tracks with different alignments relative to wind direction. Deflation rates may be excessive in tracks devoid of above ground cover and aligned parallel to strong prevailing winter winds.

Brown, S., C. Hickey, B. Gill, L. Gorman, C. Gratto-Trevor, S. Haig, B. Harrington, C. Hunter, G. Morrison, G. Page, P. Sanzenbacher, S. Skagen, N. Warnock. 2000. National Shorebird Conservation Assessment: Shorebird Conservation Status, Conservation Units, Population Estimates, Population Targets, and Species Prioritization. Manomet Center for Conservation Sciences. http://www.Manomet.org/USSCP/files.htm

This document presents the information collected by the U.S. Shorebird Conservation Plan technical working groups that addressed the current status of shorebirds in North America, established preliminary population estimates, and set

preliminary population targets that should be achieved to meet the overall plan goal of ensuring stable, self-sustaining populations of all shorebirds that occur in the U.S.

The first section provides the results of the shorebird conservation status assessment, which brings together existing information about the conservation status and threats facing each shorebird species. Conservation activities to address these issues often requires consideration of distinct populations of birds. The second section of the report describes the subspecies of shorebirds that occur in the U.S., and discusses which subspecies or distinct populations must be considered separately to adequately protect shorebirds. One major effort conducted as part of the planning process for the United States and Canada was to develop estimates of the current size of shorebird populations, and to assess the information available for making such estimates. The methodology for making estimates of current population sizes for each species is described in section three. Planning for self-sustaining populations requires the setting of population goals that can help guide conservation actions on the ground. The methodology for setting tentative population targets for shorebirds, and the first approximation of targets for each species, is presented in section four. Carrying out conservation strategies often requires the prioritization of activities, and a system was developed to set national and regional shorebird species priorities. This system and the resulting priorities are presented in section five, including the species priorities, and the assessment of the importance of each area of the country to each species that was used in the prioritization process.

Each of these efforts is a significant part of the work done as part of the Shorebird Conservation Plan. In many cases, specific individuals took responsibility for sections of this report, and they are listed at the beginning of each section. In addition, the entire Research and Monitoring Working group, and the Regional Working Group leaders, reviewed and commented on the various parts of the document, and their assistance was critical to completion of the many tasks involved in completing this overall assessment. Taken together, these reports provide much of the technical information on which the U.S. Shorebird Conservation Plan was based, and support the rationale behind the major aspects of the plan.

1) Shorebird Conservation Status Assessment

Susan Haig, Leah Gorman, and Peter Sanzenbacher

As part of the U.S. Shorebird Conservation Plan and as a contribution to development of the Canadian Shorebird Plan, we collected information to assess the conservation status of the 50 shorebird species that breed in northern North America (U.S. and Canada). The overall goal of both the U.S. and Canadian Shorebird Plans is to ensure that stable and self-sustaining shorebird populations are distributed across their ranges in northern North America. In addition, the plans strive to ensure demographic and genetic stability for each species so that populations will persist far beyond the next century. Achieving this goal will result from mitigating the anthropogenic factors that currently threaten most shorebird species.

The baseline information from which these goals were determined was obtained through coordination and collection of species-specific information from 36 shorebird biologists from the U.S. and Canada. The results of this information were summarized in a matrix presenting many different variables describing the status of knowledge about each shorebird species (Appendix 1). Based on this matrix, the report below includes the following: 1) the assumptions all assessments were based on; 2) some background information derived from data provided by the species experts as well as our review of the shorebird literature; 3) conclusions and recommendations. The species experts reviewed the first draft of population estimates and provided tentative population targets. Both have been revised by the working group and are now presented separately in Sections 3 and 4.

Assumptions

1. We considered shorebirds that breed in the U.S. and Canada. Some of these species also breed in Mexico and the Caribbean. However, we did not consider shorebird species that breed in Mexico and the Caribbean but not in the U.S. or Canada.
2. Species conservation assessments were based on consideration of threats to the species while they are in the United States and Canada, as well as threats encountered in other regions throughout various stages of the annual cycle. The other regions in the New World primarily included Mexico, the Caribbean, Central America, and South America; in the Old World they include Europe and the Australasian region.
3. Population estimates were based on the North American breeding population estimates for each species, not global population estimates.
4. This conservation assessment was conducted on a continental scale. Certain species may face significant threats to persistence at a local or regional level. Thus, priorities and objectives stated here should complement regional and local priorities, not supercede them.
5. All of these assessments are considered to be first approximations, and will be revised in future updates of the Shorebird Plan to reflect additional information as available.
6. Use of the term significant does not necessarily imply a statistical assessment.

Background Information

A. Northern North American Shorebird Diversity: There are 50 shorebird species breeding in the U.S. and Canada; 27 of these species also breed outside of North America to varying degrees.

B. Northern North American Shorebird Population Estimate: The current northern North American breeding population estimate for all 50 breeding species is approximately 27,800,000 individuals (see section 3).

C. Relative Abundance: the 50 shorebird species have the following distribution of northern North American population estimates:
Species with ≤ 10,000 individuals: 8
Species with ≤ 100,000 individuals: 8 + 12 = 20
Species with ≤ 1,000,000 individuals: 8 + 12 + 24 = 44
Species with > 1,000,000 individuals: 6
Species under 10,000 individuals include:
Piping Plover
Wandering Tattler
Wilson's Plover
Bristle-thighed Curlew
Mountain Plover
Eskimo Curlew (possibly extinct)
American Oystercatcher
Black Oystercatcher
Species between 10,000 and 25,000 individuals include:
Snowy Plover
Solitary Sandpiper
Long-billed Curlew
Pacific Golden-Plover
Buff-breasted Sandpiper
Purple Sandpiper

D. Species-Specific Censuses: Only 10/50 (20%) species have had a significant census undertaken--most were censused during winter or migration and counts were not repeated regularly. Piping Plovers are the only species where annual, species-wide censusing takes place (with an in-depth winter and breeding census every five years). Thus, overall, we have very limited information on which to base population estimates.

E. Population Declines: In addition to market hunting which caused large declines in many shorebird populations at the turn of the century, reviews of current information by species experts suggested that there had been a significant population decline since the 1950's in many shorebird species and subspecies. Appendix 4 includes detailed information about the status of the 73 shorebird taxa (species and subspecies) addressed by the plan. Of these, 28 show evidence of significant decline, and there is insufficient information to estimate the status of 12. Thus, almost half of all North American shorebirds are thought to have suffered a significant post-market hunting decline.

F. Breeding Range Decline:
24% (12/50) of species have undergone a significant decline in breeding range.
46% (23/50) have not undergone a significant breeding range decline.
There was not sufficient information to evaluate 15 species.
Species undergoing a breeding range decline include the following:
Snowy Plover
American Oystercatcher
Eskimo Curlew
Piping Plover
Black Oystercatcher
Long-billed Curlew
Mountain Plover
Lesser Yellowlegs
Marbled Godwit
Wilson's Plover
Upland Sandpiper
Red Phalarope
** All but Red Phalaropes, Lesser Yellowlegs, and Eskimo Curlews breed in the lower 48 states.

G. Threats: In 62% (31/50) of cases, experts indicated threats to the species persistence were *global*, rather than just *local* phenomena. 34% (17/50) of species had local threats to their continued persistence. Experts felt there was not enough information to evaluate the 2 remaining species (Red-necked Phalarope, Bar-tailed Godwit).
Significant threats during breeding were reported in 54% (27/50) of species.
Significant threats during migration were reported in 72% (36/50) of species.
Significant threats during winter were reported in 80% (40/50) species.

H. Need for Population Increases: The short-term goal of the shorebird plan for species that have declined is to halt declines and at least maintain current population
sizes. In addition, species experts called for a significant population increase in many species (see Appendix 4).

I. Specific Challenges for Species that Aggregate: Species that aggregate face different threats than species that are widely dispersed. Many kinds of shorebirds have a tendency to aggregate during various phases of the annual cycle, leaving large proportions or all of a species vulnerable to local environmental risks or catastrophic disturbance. Therefore, identifying these species is an important aspect of setting conservation priorities. There were 8 species in which the majority or all of the species occurred at one site during the annual cycle.

These sites and species need particular attention:
American Avocet
Semipalmated Sandpiper
Bristle-thighed Curlew
Buff-breasted Sandpiper
Surfbird
Wilson's Phalarope
Red Knot
Red-necked Phalarope

During various phases of the annual cycle,
30% (15/50) of species were highly aggregated during breeding.
72% (36/50) of species were highly aggregated during migration.
82% (41/50) of species were highly aggregated during winter.

Likewise, the degree of patchiness in a species distribution can play a role in assessing their vulnerability to local or global threats.
62% (31/50) of species were widely distributed throughout their range.
32% (16/50) of species were patchily distributed throughout their range.
6% (3/50) of species had isolated breeding populations: Whimbrel, Hudsonian Godwit, and Marbled Godwit.

J. Conservation Status Listings: The following species are listed under the Endangered Species Act (U.S. Fish and Wildlife Service) or by the Committee on the Status of Endangered Species in Canada (Canadian Wildlife Service). Piping Plovers are listed as endangered in the U.S. Great Lakes, threatened elsewhere in the U.S. COSEWIC lists them as endangered throughout Canada. Snowy Plovers are listed as threatened on the U.S. Pacific Coast and are under consideration for listing in the Southeast U.S. Mountain Plovers are endangered in Canada, and under review as Threatened in the U.S. Eskimo Curlews are listed as endangered/extinct by the IUCN, endangered in Canada and in the U.S. They are further protected under CITES. Long-billed Curlews are listed as vulnerable in Canada.

The Conservation Assessment Matrix presented in Appendix 1 also lists important conservation factors for each species. These include: whether the population estimate is less than 10,000, or less than 25,000 individuals; whether there has been a decline in the breeding range of the species; whether there has been a significant recent population decline; whether the species is highly aggregated at some point in the annual cycle; whether the species is highly isolated; and whether the species is listed as threatened or endangered. This information is intended to assist in the development of specific conservation strategies for species and groups of species within regional shorebird groups and by other organizations.

<u>Conclusions</u>
1. The information available is not adequate to assess with confidence the status of most, if not all, northern North American shorebirds.
2. The limited information that is available suggests that overall, northern North American breeding shorebird numbers need to increase substantially.
3. Development of adequate monitoring and research programs should be a high priority of both the U.S. and Canadian shorebird plans so that shorebird status issues can be properly addressed.

Brown, S., C. Hickey, B. Harrington, and R. Gill, Eds. 2001. The U. S. Shorebird Conservation Plan, 2nd ed. Manomet Center for Conservation Sciences, Manomet, MA.

The U.S. Shorebird Conservation Plan is a partnership involving organizations throughout the United States committed to the conservation of shorebirds. This document summarizes all of the major technical reports and recommendations produced by the various working groups that participated in developing the Plan. The organizations and individuals working on the Plan have developed conservation goals for each region of the country, identified critical habitat conservation needs and key research needs, and proposed education and outreach programs to increase awareness of shorebirds and the threats they face. The shorebird partnership created during the development of the Plan will remain active and will work to improve and implement the Plan's recommendations. Natural landscapes in the United States have been altered significantly, and the wetlands, shoreline habitats, and grasslands used by shorebirds have been particularly disturbed. For many shorebird species, existing information is insufficient to determine how these alterations have affected populations. Many shorebird species face significant threats from habitat loss, human disturbance, and from different forms of habitat degradation such as pollution, prey resource depletion, and increasing threats from predators. Despite ongoing conservation efforts, many shorebird populations are declining, in some cases at alarming rates. Because development pressure will continue, critical conservation actions must be identified, integrated management practices must be developed, and ongoing changes in habitat configuration, quality, and availability must be controlled. Focused conservation action is needed now to protect and restore necessary habitats and address other threats to prevent additional shorebird species from becoming threatened or endangered.

The Plan has three major goals at different scales. At a regional scale, the goal of the Plan is to ensure that adequate quantity and quality of habitat is identified and maintained to support the different shorebirds that breed in, winter in, and migrate through each region. At a national scale, the goal is to stabilize populations of all shorebird species known or suspected of being in decline due to limiting factors occurring within the U.S., while ensuring that common species are also protected from future threats. At a hemispheric scale, the goal is to restore and maintain the populations of all shorebird species in the Western Hemisphere through cooperative international efforts.

The Plan was developed by a wide array of state and federal agencies, non-governmental conservation organizations, and individual researchers throughout the country. Major partners include all 50 States, the U.S. Fish and Wildlife Service, the North American Waterfowl and Wetlands Office, most of the Joint Ventures established through the North American Waterfowl Management Plan, the Bureau of Land Management, the U.S. Geological Survey, the USDA Forest Service, the International Association of Fish and Wildlife Agencies, The Nature Conservancy, National Audubon Society, Ducks Unlimited, the Canadian Wildlife Service, the Western Hemisphere Shorebird Reserve Network, Point Reyes Bird Observatory, and many other regional organizations. Manomet Center for Conservation Sciences initiated the project, obtained the funding to develop the Plan, and hired the coordinators who oversaw all aspects of the project to date as well as publication of these reports.

Three major working groups were formed at a national level. The research and monitoring group developed scientifically sound approaches for tracking populations of shorebirds, identified the critical research questions that must be answered to guide conservation efforts, and determined funding requirements to meet these needs. The habitat management group worked with the regional groups to assemble specific regional habitat management goals into a national program. The education and outreach group focused on development of materials for schools and public education programs to help build awareness of shorebirds and the risks facing them throughout the country, and identified areas where increased funding for education and outreach are needed. Eleven regional groups were formed during the development of the Plan. The major focus of these groups was to determine what habitats need to be protected and managed to meet the requirements of the shorebirds in each region. Each group set its own regional goals and objectives, and collected information about ongoing management efforts and how they can be improved. In addition, the regional groups provided input to the development of the research and monitoring programs, and helped identify education and outreach needs.

The loss of wetland habitat in the U.S. has motivated federal, state, and private agencies to increase conservation and management of wetlands to preserve the public values of these critical habitats. Wetland management and restoration have developed rapidly in recent years, and the North American Waterfowl Management Plan has stimulated significant increases in funding for wetland conservation activities. There is growing recognition among land managers of the opportunity to integrate management practices beneficial to shorebirds and other waterbirds into current management practices focused predominantly on game species. This changing orientation reflects the rapidly growing number of people who engage in bird watching, wildlife photography, and eco-tourism in addition to traditional activities such as fishing and hunting. This growing constituency brings substantial economic benefits to wetlands and waterfowl areas, and has broadened public support for wetland conservation. We need management practices to focus on entire landscapes, but this requires an unprecedented level of coordination among multiple partners. No single conservation initiative can be effective alone. Wetland conservation for wildlife across entire landscapes requires the

coordination of multiple efforts. The Shorebird Conservation Plan represents a significant contribution to the development of landscape-level wildlife conservation, and can contribute significantly to these larger goals as part of a broad partnership for wetland conservation.

The Shorebird Plan is designed to complement the existing landscape-scale conservation efforts of the North American Waterfowl Management Plan, Partners in Flight, and the North American Colonial Waterbird Conservation Plan. Each of these initiatives addresses different groups of birds, but all share many common conservation challenges. One major task is to integrate these efforts to ensure coordinated delivery of bird conservation on the ground in the form of specific habitat management, restoration, and protection programs. The newly developing North American Bird Conservation Initiative addresses conservation needs for all birds in North America, and the Shorebird Plan partnership will work closely with this initiative toward common goals. Each partner organization involved in the Shorebird Plan will take on implementation roles suited to its focus and skills. The U.S. Shorebird Plan Council, which includes representatives of all partners in the Plan, will coordinate implementation. Major implementation partnerships are being set up with interested Joint Ventures organized under the North American Waterfowl Management Plan and with Partners in Flight. International coordination is also underway between the U.S. Shorebird Plan and the Canadian Shorebird Conservation Plan, which share responsibility for many of the same species at different points in their annual cycles. These partnerships will work to ensure that all of the recommendations provided in this document and the accompanying technical reports are addressed, and to ensure that stable and self-sustaining shorebird populations are maintained into the distant future.

Buckley, P. A., and F. G. Buckley. 1976. Guidelines for the protection and management of colonially nesting waterbirds. North Atlantic Regional Office, National Park Service, Boston, Massachusetts.

Disturbance to colonial nesters

Kinds of disturbance: aircraft, sonic boom, off-road vehicles, pedestrians, pets, bird banders, nature photographers, scientists, vandals, egging, poaching, mosquito control, dredging activities.

Effects of disturbance: Reduced fertility, fecundity or viability; nest material stolen by those individuals or species settling first following disturbance; “aggressive neglect” of egg and young leading to hatching failure or death; eggs falling or being kicked out of the nest, eggs being broken or chicks becoming lost; chick or egg mortality; nest desertion; colony abandonment; some species or individuals may fail to relay or may move abruptly to new colonies; severe changes in individual or social behavior; species undergo extreme changes in habitat use and colony siting; pathological predation appears, or normal predation increases abnormally; populations decline; species’ ranges contract.

Protective measures against disturbance:

Interpretative and Educational: lectures and tours, leaflets, exhibits, signs, off-road vehicle stickers, press releases.

Restrictions of movements: seasonal or areal closure to off-road vehicles (close off entire areas to all ORVs, reduce to the bare minimum all official ORV traffic, restrict essential ORVs to carefully marked tracks, do not allow ORVS to stop or discharge passengers within 1000’ of active colonies; forbid foot traffic within 1000’ of active colonies; pets must remain under physical control of ORV occupants or owners and not allowed within 1000’ of colonies, trail bikes, ATVs, and other self propelled devices should be banned from areas with active colonies, forbid ORV driving on dunes, prohibit night use by visitors anywhere near colony); seasonal or areal closure to pedestrians (1000’ buffer), signs and posting.

Buehler, D. M and A. J. Baker. 2005. Population divergence times and historical demography in red knots and dunlins. Condor 107: 497-513.

We employed Bayesian coalescent modeling of samples of mitochondrial control region sequences in two species of shorebird, Red Knots (*Calidris canutus*) and Dunlins (*Calidris alpina*) to estimate evolutionary effective population size, population divergence times, and time to most recent common ancestor of genes in the samples. The gene trees for the two species contrast sharply: knot haplotypes were connected in a shallow, star phylogeny whereas Dunlin haplotypes were related in a deeper bifurcating genealogy. Divergence times of populations representing all six subspecies of knots are estimated to have occurred within the last 20 000 (95% CI: 5600–58 000) years, and evolutionary effective population sizes of females are small (N_{ef} = 2000–14 000). We hypothesized that breeding knots were restricted to unglaciated regions of Eurasia during the last glacial maximum, and gradually expanded eastwards into Alaska, the high Canadian Arctic and Greenland as the ice melted. Population divergence times in Dunlins are much older (58 000–194 000 ybp) and effective population size has historically been higher in major lineages (N_{ef} = 12 000–44 000). We conclude that Dunlin populations were not severely reduced in size in the last 200 000 years, and major lineages have differentiated under restricted gene flow for a much longer time than knots.

Knots present a snapshot of genetic evolution in the last 20 000 years, whereas Dunlins display patterns of genetic evolution over an order of magnitude longer time frame.

Burger, J. 1981. The effect of human activity on birds at a coastal bay. Biological Conservation 21:231–241.

I examined the direct and indirect effects of human activity on birds at a coastal bay refuge along the Atlantic Coast. Over the year, human activity varied at different sample sites on the refuge, but people were present on part of the refuge every day, although activity was concentrated on designated paths around a freshwater pond and at a fishing pier. On the refuge (exclusive of the ponds) people were present at the sample sites 17% of the time, birds were present 42% of the time when people were present, but birds were present 72% of the time when people were absent. Human activities, such as jogging or grass mowing, which involved rapud movement or close proximity to roosting birds, usually caused them to flush. Slow-walking bird watchers and clammers did not usually cause birds to flush. Gulls and terns were least affected as they usually relanded where they had been, ducks usually flushed and flew to the centre of the pond, and herons, egrets and shorebirds were most disturbed and flushed to distant marshes. These results suggest that if management objectives include providing roosting areas for migrating shorebirds then some areas must be protected from close and fast-moving human activities.

Burger, J. 1981. Effects of human disturbance on colonial species, particularly gulls. Colonial Waterbirds 4: 28-36.

Colonial birds are particularly vulnerable to human disturbance because of the large concentrations of birds nesting in close proximity. Vulnerability varies de- pending on species, nest location, and the type of disturbance (see Manuwal 1978). Nearness to human activities is one key factor, as the potential for disturbance is much greater regardless of a species' intrinsic vulnerability. Mere distance is not sufficient to assess the potential for disturbance because the surrounding habitat affects human (or predator) access. Birds nesting a half mile from a town on an island surrounded by deep, rough waters are surely less vulnerable than those surrounded by solid ground. Similarly, nest- ing habitat is crucial: nests on cliffs are less accessible than are nests on flat ground, nests in trees are less accessible than are ground nests, and burrows are less accessible than are surface-areas. Ground-nesting species such as gulls, terns, and some herons, egrets, ibises, and cormorants are thus particularly vulnerable to human disturbance because they are accessible and often nest in close proximity to human activities. The types of human activity that affect colonial bird populations are varied, ranging from overall destruction to direct intervention such as entering colonies, collecting eggs, and killing adults, eggs, or chicks. The response of colonial birds to human activities varies markedly, but no species can withstand the direct effects of killing adults, eggs, or chicks for sustained periods of time. Assessing the effects of human disturbance on nesting colonial birds is a difficult task because the observer can never completely remove himself. The problem is further complicated by the de- creased accuracy of success measurements with fewer egg or chick censuses. Observation of reproductive success from afar is usually impossible in the egg stage, and is complicated in the chick phase by the presence of vegetation and rocky or uneven terrain. Reproductive success can be lowered either directly by causing desertion of nests, eggs or young, by adults, or indirectly by causing thermal stress, predation, and cannibalism. In this paper I discuss the direct and indirect ways human activities affect colonial birds, particularly Larids, and I report on some of the sub-lethal effects of human disturbance including behaviors contributing to the lowered reproductive success. I present results on the behavioral responses of gulls, terns, and skimmers to human disturbance including decreased egg and chick attendance, shifts in the mate incubating, movements and entanglements of chicks, higher brood sizes, and greater aggressive interactions.

Burger, J. 1982. The role of reproductive success in colony-site selection and abandonment in Black Skimmers (*Rynchops niger*). Auk 99: 109-115.

I examined colony-site tenacity and reproductive success in 19 colonies of Black Skimmers (Rynchops niger) for 5 yr in New Jersey. Frequent colony-site shifts occurred, and only two sites were occupied in all 5 yr. Although in one year fledging success was nearly zero due to flood tides, in most years tides destroyed less than 25% of the colonies, while predators destroyed up to 50% of the colonies. Skimmers usually abandoned unsuccessful sites and continued to nest in successful sites. Colony abandonment was greater in colonies subjected to predation pressures than in those subjected to flooding. I suggest that this difference related to the high predictability of future low reproductive success when a colony was destroyed by predators (high probability of future loss) as compared to floods (low predictability). Received 26 January 1981, accepted 6 July 1981.

Burger, J. 1982. An overview of proximate factors affecting reproductive success in colonial birds: concluding remarks and summary of panel discussion. Colonial Waterbirds 5: 58-65.

Reproductive success is often used as a measure of an animal's fitness (Lack 1954, Fisher 1958, Hamilton 1964, Williams 1966). Presumably an animal's overall fitness is the sum of its reproductive success during its lifetime. Although it is easy to define reproductive success as the number of young produced per year, success is difficult to measure because biologists do not always have complete data on the fate of every individual. Furthermore, one could argue about the definition of an end point: has a young bird been "produced" when it reaches two months of age, two years of age or reproductive age? Biologists interested in measures of reproductive success calculate it on the basis of young reaching some pre- scribed number of days. For birds, this age is usually equal to or less than fledging age, mainly because it is difficult or impossible to find older juveniles.

It is always risky to compare reproductive success figures that have been derived from different sampling procedures (see Erwin, 1982). For example, checking nests once a week is less precise than checking nests daily. By checking only once a week, one often cannot determine why an egg or chick died. The cost of daily censusing, however, may be decreased re- productive success caused by increased disturbance (Gillett et al. 1975, Robert & Ralph, Conover &k Miller 1979, Ellison & Cleary 1978, Gochfeld 1981). Perhaps the critical factor is defining reproductive success sufficiently clearly so that other re- searchers can compare their results with your results. Methodological problems not withstanding, it is important to determine reproductive success in order to understand the breeding biology and behavior of species, as well as to assess and manage populations.

As Darwin (1871) first noted, animals produce more offspring than can survive. The factors that lower the survival of off- spring are many and varied, and can be categorized as ultimate and proximate causative factors. Proximate factors are those that influence reproductive success in any given year, whereas ultimate factors shape the evolution of reproductive behavior. Any given factor (such as predator pressures) can act as a proximate cause of lowered reproductive success, and an ultimate cause of the evolution of particular behavior patterns (such as antipredator behavior). Natural selection operates on individuals, not populations. But the summation of the effects of natural selection on individuals constitutes reproductive success for populations, or colonies. Only by comparing re- productive success figures over many years for many colonies of different species cal we begin to understand how proximate factors affect reproductive success. The behavior of colonial birds has been shaped by the proximate factors that increase or de- crease reproductive success. As Morris (pers. comm.) suggests, long term studies that allow identification of proximate factors controlling reproductive success are of value as they suggest what the ultimate factors may be.

Proximate factors that can affect reproductive success include human disturbance, toxic chemicals, predators, inclement weather, social factors, physiological factors, and food-related problems. The effects of human disturbance include direct killing of eggs, chicks and adults, as well as disruption of behavior and desertion of nests (see above, Manuwal 1978, Gochfeld 1981, Burger 1981a). Human disturbance can be caused by investigators as well as by other people coming into the colonies for recreation (bird-banding, photography, picnics) or other activities (i.e., dredging or mosquito control). Presumably human disturbance is a more important cause of lowered reproductive success at coastal and inland colonies that it is at colonies on off- shore islands and rocky cliffs. Another man- related factor reducing reproductive success is toxic chemicals (see Manuwal 1978). Al- though DDT and dieldrin contaminant problems were greater a few years ago these substances still present problems for some species (K. King, pers. comm., see Gochfeld 1975, Ohlendorf et al. 1978). Furthermore, toxic metals such as lead, zinc, and cadmium, whose effects are only now being investigated in some depth (see Finley & Stendall 1978, Blus et al. 1978, Firmreite 1979, Hoffman &8 Curnon 1979) may be important factors in reproduction. When considering such substances it is important to examine sub-lethal effects in addition to lethal and interaction effects. Sub-lethal effects such as behavioral changes are difficult to document or measure, but they may be important.

Predation pressures have shaped the evolution of nesting patterns of all birds. Solitary species rely on cryptic coloration, or being widely spaced, and on careful placement of nests and eggs, while colonial species rely on selection of safe sites for colonies, camouflaging coloration of eggs and young (Patterson 1965, Tinbergen et al. 1967, Lack 1968), early warning of predators (Burger 198 lb) and antipredator behavior such as mobbing (Cullen 1960, Kruuk 1964, Patterson 1965, Montevecchi 1977). In general, ground predators such as mammals, reptiles, and invertebrates more often affect species that nest on the main- land or close to the ground. Some mammalian predators such as raccoons can climb trees to eat heron eggs (Pratt, pers. comm.), but the majority of species prey on eggs and chicks that nest close to the ground. Avian predators such as crows (Corvus) and gulls (Larus) primarily prey upon the eggs and young of coastal nesters, rather than forage in colonies that are far offshore.

Food constraints affect reproductive success by causing starvation of chicks, or increased predation due to decreased parental care when parents are forced to spend more time foraging (Lack 1968, Harris 1969, Emlen & Demong 1975, Ashmole 1971). In several tropical species food shortages are the primary cause of differences in reproductive success (see Lack 1968, Ashmole 1963, 1971, Burger 1981b). In temperate regions the reproductive success of species such as Wood Storks (*Mycteria americana*) is influenced primarily by the availability of food (J. Ogden, pers. comm.).

Weather-related factors can lower reproductive success for most species of birds. Important weather-related events that cause problems for birds are of two types: every- day changes in temperature and precipitation that cause the death of eggs or young, and catastrophic events such as storms, high winds, and flood tides. Extremes in temperatures can cause death of embryos and chicks when they are exposed, even for short periods of time (Austin 1933, Power 1964, Harris & Plumb 1965, Nisbet 1975,' Hand et al. 1981). Furthermore, some species such as Black Skimmers (Rynchops niger) seem unable to adequately brood young during heavy rains, resulting in deaths due to exposure (M. Gochfeld, pers. comm.). Flood tides can destroy entire colonies, resulting in no reproduction for that year (Beer 1966, Montevecchi 1978, Burger & Lesser 1978, 1979, Burger 1980a, Burger 8c Shisler 1980, Buckly & Buckley, 1982).

Overall, humans, predators, food constraints and weather-related events seem to be the primary factors lowering reproductive success in colonial birds. Differences in reproductive success, however, have been found to vary with social factors such as brood size (sibling competition), group or colony size, and breeding density. Compe- tition between unequal sized siblings may result in the death of some offspring or in all members of the brood being under-weight (D. Mock, pers. comm.), Reproductive success often is higher in large colonies compared to small colonies, for a variety of reasons (Darling 1938, Burger 1979a, Gochfeld 1979, 1980).

The relationship between reproductive success and density is not clear. In colonies where heterospecific predators are the primary cause of reproductive losses, dense nesting areas fare better than do sparse areas as antipredator behaviors deter predators (Tinbergen 1963, Kruuk 1964, Patter- son 1965, Andersson 1976). However, in colonies where cannibalism is the most important cause of egg and chick deaths, birds nesting in dense areas often suffer the highest reproductive losses (Parsons 1971, 1975, Hunt 8c Hunt 1975, 1976). In general, authors have assumed that birds with the largest territories have the highest reproductive success (Verner 1977, Hunt & Hunt 1976). However, few field data support this hypothesis.

Physiological factors such as age and hormone levels are also correlated with re- productive success. In general, older birds have higher reproductive success than do younger birds (Coulson 1966, Mills 1973, Fisher 1975, Brooke 1978, Finney 8c Cooke 1978, Blus & Keahey 1978, Ryder 1980, Haymes 8c Blokpoel 1980).

Although all the factors discussed above affect reproductive success in some species, the specific influence of these factors on all groups is not the same. The remainder of this paper summarizes a discussion (held during the Colonial Waterbird Group meeting at Corpus Christi, Texas) of the affects of the aforementioned factors on reproductive success in several groups of colonial birds (see Table 1).

Cormorants seem particularly vulnerable to human disturbance (Kury & Gochfeld 1975, Ellison & Cleary, R. D. Slack Table 1). Adults leave the eggs and young unprotected when disturbed, leaving them vulnerable to gull predation (Kury & Gochfeld 1975), and rendering it difficult for young forced to abandon nests to success- fully return and climb back into tree nests (Slack, pers. comm.). Olivaceous Cormorants (Phalacrocorax olivaceus) are particularly vulnerable to storms and inclement weather, often resulting in the loss of entire nests (Slack, pers. comm.). For alcids, variations in the availability of food (Capelin Ammodytes) is one of the most important factors affecting reproductive success (Lock, pers. comm.). Ac- cording to Lock, heavy ice floes in some years cause food problems for alcids, and hole nesters sometimes have their burrows flooded (Table 1). Although Herring Gulls (L. argentatus) have increased near alcid colonies, they do not seem to be a limiting factor affecting reproductive success in these colonies (Lock, pers. comm.).

Many species of gulls are expanding their breeding range and increasing in numbers although this does not apply to the smaller gulls (Burger 1979b). Causes of low reproductive success are human disturbance (Burger 1981a), flood and storm tides (Burger 1980 a, b), cannibalism (Parsons 1971, Hunt g& Hunt 1975, 1976), predation (Krunk 1964, Patterson 1965, Tinbergen et al. 1967), and competition for nest sites (Burger 1979b). Smaller gulls often cannot compete with larger species of gulls for nest sites and are forced to nest in suboptimal areas (Burger 1979b). Factors such as density and colony size also influence reproductive success: large colonies are more successful (Darling 1938, Burger 1979a). Similarly, older birds generally pro- duce more young than do younger birds (see Ryder 1980 for review).

Tern colonies vary from very dense aggregations of Royal Terns (Sterna maxima (Buckley &c Buckley 1972, Veen 1977), to widely dispersed nests of Peruvian (Sterna lorata) and Damara (S. balaenarum) Terns (Gochfeld, pers. comm., Frost & Shaughnessy 1976). Adverse effects vary depending on the species, the habitat (see papers by Buckley & Buckley 1982, Severinghaus 1982, and McNicholl 1982) and its accessi- bility, and the colony structure. Avian predators such as crows and gulls nesting in proximity to tern colonies are sometimes important predators. Various raptors may specialize on terns, and Short-eared Owls (Asio flammeus, Gochfeld, pers. comm.) and Great-horned Owls (Bubo virginianus, Nisbet 1975) may take a substantial toll of adults and young. Night-herons also are important predators in certain colonies (Hun- ter and Morris 1976). Mammalian predators are mainly human commensals such as dogs, cats, and rats. Occasionally extensive mustelid or fox predation on gull and tern colonies occurs (Patton &c

Southern 1978, Burger 8c Lesser 1979, Nisbet, pers. comm.). Human disturbance may have more important indirect than direct consequences, by interfering with incubation and brooding, exposing eggs and chicks to tempera- ture extremes. Prolonged periods of rain and fog interfere with feeding, and chicks hatching during such periods often fare badly. Nests of many species of terns are exposed to flooding.

Black Skimmers nest in clusters of few to many pairs, usually among terns. Skimmers may benefit by the antipredator aggression of the terns, although interspecific aggression may result in death of some skimmer chicks (Erwin 1979, Burger 1981c). In general, skimmer adults are much less vulnerable to predation than are the terns among which they nest. Skimmer chicks probably suffer similar predation although on certain substrates they may be less conspicuous, hence less vulnerable than are tern chicks. Disturbance greatly increases movements of young skimmers (Gochfeld 1981), and leads to a substantial mortality of young birds. During prolonged rain- storms skimmers may brood very young chicks, but chicks more than 1 week old are apparently not brooded, and may experience high mortality, as occurred during the July 4-6 rainstorm of 1978 when virtually all young skimmers in New Jersey and New York perished (M. Gochfeld, pers. comm.). Salt-marsh nesting skimmers are frequently subject to washouts. Both terns and skimmers show a propensity for be- coming entangled in various artifacts such as kite string, plastic 6-pack rings, and monofilament line which is often en- countered along the shore. Thus far, oiling is not a major concern for terns and skim- mers, although the potential for oil spills near breeding colonies is increasing because of offshore drilling (M. Gochfeld, pers. comm.) and increased supertanker traffic (H. Kale, pers. comm.).

The reproductive behaviors of tropical seabirds such as boobies (Sula), frigatebirds (Fregata), tropicbirds (Phaethon) and noddies (Anous) are influenced by food supplies, both in terms of reproductive success and the frequency of breeding (Nelson 1970). They simply do not breed until the food conditions are favorable (R. Clapp pers. comm.). Predators include mammals such as cats, dogs, pigs, rats; Monitor Lizards; avian predators such as Ruddy Turnstones (Arenaria interpres) and Bristle-thighed Curlews (Numenius tahitiensis), which puncture eggs; and land and hermit crabs (R. Clapp, pers. comm.). Goats and humans change habitat making it unfavorable for nesting. Humans cause problems directly by keeping parents off eggs and young chicks (making them vulnerable to heat stress) and by providing monofilament line in which they become tangled.

The major reason for nesting failures in the Wood Stork is low food resources (small fish in freshwater wetlands) due to droughts or unseasonably high water levels (J. Ogden, pers. comm., Table 1). Conversely, the maximum production of young (clutch size, number of pairs nesting, number of young produced per pair) occurs when feeding conditions are optimum. Al- though, late winter storms frequently cause adults to abandon active nests, abandon- ment may be related to loss of feeding sites (with the change in water levels) rather than to the direct effects of cold or rain (J. Ogden pers. comm.). For Wood Storks, predators seem to be relatively unimportant, and perhaps only become a problem in colonies that are already stressed for other reasons.

For ibises in Texas (Plegadis chihi) human disturbance is minimal when scientists are careful to minimize exposure of the eggs and young to heat stress, and because non-scientists usually stay out of the colonies (K. King pers. comm.). Avian and mammalian predation is minimal, al- though fire ants and ticks can be serious predators in some years for ibises as well as other ground-nesting species (King et al. 1977). Heat stress is a problem only if humans keep adults off eggs and chicks. However, flood tides, heavy rains, and hurricanes provide some of the most important proximate causes of lowered reproductive success. Although larger colonies are more stable than are smaller colonies (King, pers. comm.), the effect of colony and group size on reproductive success is unclear for ibises. DDE and dieldrin levels in the tissues of ibises resulted in direct mortality and lowered reproductive success in past years, and DDE-induced egg- shell thinning is still apparent (King et al. 1980).

For herons nesting in northeastern North America, storms and heavy rains are the primary causes of lowered reproductive -success (W. E. Davis, pers. comm.). Other causes of reproductive failures include human disturbance, low food supplies, avian predators, and habitat destruction (Table 1). Competition for nest sites may be severe whenever there are large numbers of Cattle Egrets (Bubulcus ibis, Burger 1978, Dusi 1978, Werschkul 1978), although this problem is largely confined to southern areas of North America. Pesticide load food unavailability, and avian and mammalian predation also contributes to lowered reproductive success in ardeids (H. Pratt pers. comm., Table 1).

It is apparent from the above discussion that factors affecting reproductive success vary both within and among species. The primary proximate causes of lowered reproductive success that affect most species are human effects, predation, weather, and lack of food. Lack of food seems to be an important factor affecting reproductive success in Wood Storks, alcids, southern herons, and tropical seabirds. Indeed, the timing of breeding, and whether these species breed, depends upon food resources. For other species weather-related events are the most important cause of lowered re- productive success: herons in the northeast (storms), terns in Texas (hurricanes), alcids (storms and ice floes) and marsh-nesting terns, gulls, and skimmers (flood tides). For many species the effects of these factors are additive. When birds are forced off their nests by storms, floods, or people, predators (such as gulls, crows, raccoons, rats) often come in and eat eggs and young. Factors such as colony size, group size, and parental age are clearly related to reproductive success,

but they are not the causes of lowered success. The agents of egg and chick loss in colonial birds appear to be inclement weather, predators, and food shortages.

Over evolutionary time, these causes of lowered reproductive success have shaped the behavior and ecology of colonial birds, resulting in a wide range of temporal and spatial nesting patterns. Some species respond to food shortages by not nesting at all (some tropical seabirds), by reducing brood size (herons, egrets, ibises, gulls), or by abandoning nests (Wood Storks). Adaptations to inclement weather involve changing nest locations (gulls, terns, skimmers), renesting after failure (terns, skimmers), and nesting in areas with sufficient cover (gulls, alcids).

This symposium illustrates the need for more information on the specific effects of proximate factors, and the adaptations of colonial birds to these factors.

Burger, J. 1984. Colony stability in Least Terns. Condor 86:61-67.

I examined colony site tenacity, turnover rates, and causes of reproductive failure in Least Terns (*Sterna antillarum*) nesting in coastal New Jersey from 1976 through 1982. During this period Least Terns used 44 colony sites, although only 17-29 (mean = 22) sites were used in any one year. Population levels ranged from 942 to 2,469 birds (mean = 1,817, SD = +/-513). The number of breeding terns increased significantly during the study period. Annual turnover rates varied from 0.16 to 0.30 (mean = 0.22, SD = +/-0.05), and were intermediate to low compared to those for other coastal-nesting terns, gulls (Larus spp.), and Black Skimmers (*Rynchops niger*). Reproductive success for the Least Tern colonies in New Jersey averaged 0.48 young per pair (SD = +/-0.22). The causes of reproductive failure were similar among colonies, except that colonies with over80 birds suffered higher losses due to predators than colonies with fewer than 80birds. I suggest that the large, mainland colonies are more vulnerable to predators because they are more stable (making their presence known to predators) and predators have easy access. Human disturbance accounted for over half of the reproductive failures of Least Tern colonies. The low turnover rate and high loss to human activity suggest that reproductive success can be improved by increased protection.

Burger J. (ed.) 1984. Abiotic Factors Affecting Migrant Shorebirds. Plenum Press, New York, pp. 1–73.

Burger, J. 1986. The effect of human activity of shorebirds in two coastal bays in Northeastern United States. Environmental Conservation 13: 123-130.

The effect of human disturbance on migrant birds is a conservation issue of international importance, as is determining if disruption has long-term population effects. Disruptions can occur during migration, wintering, breeding and foraging. Thousands of shorebirds migrate through Delaware Bay (Atlantic Coast of North America) in a four-week period each spring; this is the largest concentration of shorebirds in the continental USA. Ecotourists come to see them, creating the potential for disruption. Data available on shorebird/human interactions at a migratory stopover over a 20-year period were used to describe the interactions of shorebirds and people from 1982–2002 and examine trends in human disruptions and shorebird behaviour during this time. The rate of disruptions caused by people increased during the 1980s, declined slightly by the early 1990s, and declined sharply by 2002. The decline in human activity along the beach was directly related to the conservation efforts of the New Jersey Endangered and Nongame Species Program, New Jersey Audubon, and others interested in preserving the shorebirds. In the 1980s, birdwatchers concentrated on the beaches on which it was easy to walk and which had the highest shorebird counts, because there were no restrictions on human behaviour. During this time, the average disturbance duration was over 10 min, regardless of the type of intruder, and shorebirds were often disrupted for over 40 min hr^{-1}. Even though the number of disruptions declined over the study period, the percentage of shorebirds that flew away (and did not return within 10 min) did not change during the 1980s, and increased in 2002. The average time that shorebirds were disrupted per hour by people declined during this period (mainly because there were fewer people on the beaches). The Endangered and Nongame Species Program placed signs on shorebird foraging beaches, restricted access, built viewing platforms to contain ecotourists, and eventually patrolled key beaches and issued summonses for infractions. These activities were so effective that only one bird watcher disturbed the birds in 2002. Education was also vital to encouraging local residents not to walk or fish along these beaches during the spring migratory stopover, and to keep their dogs on a leash. These data support the importance of actions on the part of state agencies and conservation organizations to limit disruptions to foraging shorebirds during critical migratory stopovers, a problem faced by shorebirds in many temperate regions of the world.

Burger, J. 1987. Physical and Social determinants of nest-site selection in Piping Plover in New Jersey. Condor. 89: 811-818.

I examined nest-site selection and reproductive success in Piping Plover (*Charadrius melodus*) over a 4-year period on four nesting beaches in New Jersey. Nest site characteristics varied among the four nesting locations with respect to distance to dunes, water, nearest Least Tern (*Sterna antillarum*) nest, and percent shell cover. Compared with random

points, Piping Plover nests were closer to dunes and vegetation, farther from water, closer to tern nests, farther from other Piping Plover nests, in spots with more shell cover. Reproductive success varied among colonies and years, but was generally higher at Brigantine than the other sites. Causes of nest failure included predation, human destruction, abandonment, and flooding. Plovers derived antipredator benefits from nesting near terns, andplover nesting in tern colonies often had higher success than those nesting outside of tern colonies.

Burger, J. 1988. Effects of demolition and beach clean-up operations on birds on a coastal mudflat in New Jersey. Estuarine, Coastal and Shelf Science. 27: 95-108.

Coastal lands are increasingly exposed to disturbances from demolition, beach clean-up, and construction for development. Although data exist concerning the effects of investigators on breeding populations, little information is available for migrant populations. I investigated the effects of demolition and beach clean-up on resident and migrant birds on a coastal mudflat in New Jersey. A year's censusing before work initiation was used to determine when demolition and clean-up would affect the least number of birds. Work activity on and along the beach was from 15 October to 15 November 1985. The overall population size was lower in 1985 compared to the same period in 1984, although the drop in numbers was not due solely to human disturbance. Human work activity influenced avian distribution along the mudflat: birds moved farther along the beach and out onto the mudflat when activity began, and moved back onto the mudflat when activity ceased. For gulls, foraging efficiency was lowered when work began and did not return to previous levels until 60–90 min after work began. Gulls that moved farther out on the mudflat had significantly lower foraging efficiencies than did those that remained close to the beach. Efforts to mitigate the adverse effects on birds by restricting human activity to a 100 m stretch of beach at any one time succeeded in significantly reducing adverse effects and in allowing birds some space to rest and feed.

Burger, J. 1989. Least tern populations in coastal New Jersey: monitoring and management of a regionally-endangered species. Journal of Coastal Research 5:801-811.

Least tern *Sterna antillarum* is endangered in New Jersey and New York and is being considered for the U. S. Federal List as threatened along the Atlantic Coast. Like many coastal, ground-nesting species, it has suffered habitat losses, increased predation, and increased human disturbance with increased human population. This paper presents an overview of ten years of monitoring and managing of least terns in New Jersey under the auspices of the Endangered and Non-Game Species Program of New Jersey. The program involves monitoring population levels and reproductive success, protecting colonies from people and predators, manipulating vegetation and habitat, and actively attracting least terns with decoys. In successive years a trend has indicated increased population levels, and reproductive success, and decreased and then increased number of colonies. During this time, monitoring and managing efforts have increased, suggesting that they are effective in very slowly restoring population levels.

Burger J. 1991. Foraging behavior and the effect of human disturbance on the Piping Plover *Charadrius melodus*. Journal of Coastal Research 7: 39–51.

Foraging behavior of Piping Plover (*Charadrius melodus*) was studied using a focal animal approach from 1985-1986. Time devoted to foraging decreased as vigilance (time devoted to being alert) increased. Variations in vigilance were explained by beach, reproductive stage, brood size, time of day, and number of people nearby. Overall, Piping Plovers foraged from 46-79 sec., were alert for 14-57 sec., and displayed or ran from people for 1-8 sec. in the 2 min. samples. Plovers at sites less disturbed by people (Little Beach, Holgate) generally devoted more time to foraging and less time to vigilance than birds at the other sites. Time devoted to foraging was generally higher in May, lower in June, and increased again in July. Plovers that were incubating or caring for chicks spent less time foraging than those that had lost their chicks. Chicks spent less time foraging and more time being alert, running, and crouching than did their parents foraging during the same time periods.

Burger, J. 1994. The effect of human disturbance on foraging behavior and habitat use in piping plover (*Charadrius melodus*). Estuaries. 17(3): 695-701.

Piping plovers breed in coastal areas where they experience intense competition with man. I studied habitat use (using transects) and foraging behavior (using focal animals) at three habitats on each of three nesting beaches over a 2-yr period (1988-1989) in New Jersey, USA, to understand how plovers use space. Piping plovers forage along the tidal oceanfront, in the dunes, and in backbays, and their relative use of these habitats partially depends on the presence of people. Within each habitat the plovers select sites that contain fewer people than the habitat as a whole. The time devoted to vigilance (when they are not searching for food) is directly related to the number of people near them, and to the overall human use of that habitat. Thus, in habitats with few people the plovers can spend 90% of their foraging time actively searching for prey and feeding, whereas on beaches with many people they may spend less than 50% of their foraging time in direct feeding behaviors. A diversity of habitats allows the birds to move between habitats to

minimize interactions with people and maximize the time devoted to foraging. The results suggest that it is critical to maintain high habitat diversity in coastal environments to help mitigate competition with people.

Burger, J. 1994. Nocturnal foraging behavior of breeding piping plovers (*Charadrius melodus*) in New Jersey. Auk 111: 579-587.

The nocturnal foraging behavior of breeding Piping Plovers (*Charadrius melodus*) was studied in New Jersey using a focal-animal approach in 1989 and 1990. More than 30% of the variation in the number of plovers foraging at night was explained by stage of the breeding cycle, tidal stage, and year. The greatest numbers of adult plovers fed in the intertidal zone during the prenesting and fledgling stages of the breeding cycle. Piping Plovers were more likely to be observed feeding during late ebb and early flood tides, than other times. Time devoted to feeding per 2-min sample was similar at each study site but differed significantly during the tidal stages. Pecking rate was higher during late ebb and early flood tides than late flood and early ebb tides. Time devoted to being alert varied depending on stage of the breeding cycle. Prenesting plovers and individuals with fledglings fed longer and were alert less per 2-min sample than plovers engaged in incubation or brood rearing. The nocturnal peck rate of Piping Plovers was considerably lower than daytime levels. Plovers foraging at night had significantly lower peck rates when disturbed. Abundance of intertidal polychaetes varied according to tidal stage and, where present, they constituted the main food of the plovers. We suggest that nocturnal foraging is a natural behavior pattern in Piping Plovers although it may vary in intensity. Future management should include the assessment of nighttime recreational use of beaches where Piping Plovers breed. Received 31 July 1992, accepted 25 November 1992.

Burger, J. 1995. Beach recreation and nesting birds. Pages 281-295 in Wildlife and recreators: coexistence through management and research (R.L. Knoght and K.J. Gutzwiller, Eds.). Island Press, Washington, D.C.

Burger J. 1998. Effects of motorboats and personal watercraft on flight behavior over a colony of Common Terns. Condor. 100:528–534.

Abstract. I examined the flight behavior of Common Terns (*Sterna hirundo*) over a nesting colony in Barnegat Bay, New Jersey in 1997. I used the number of birds flying over the colony to test the hypothesis that there were no differences in flight behavior as a function of presence and type of craft (motor boat, personal watercraft). For the overall model, 66% of the variation in the number of terns flying over the colony was explained by breeding period, type of craft, speed, route (established channel or elsewhere), the inter- action of route and speed, and time of day. However, for the early stage of the reproductive cycle, type of craft, speed, and route explained 95% of the variation. Boats that raced elicited the strongest response, as did boats that were outside of the established channel. Boats traveling closer to the nesting colonies elicited stronger responses than those that remained in the channel. Personal watercrafts elicited stronger responses than motor boats. These data suggest that personal watercraft should be managed to reduce disturbance to colonial-nesting species, by eliminating them within 100 m of nesting colonies and restricting speed near such colonies.

Burger, J. and M. Gochfeld. 1991. Reproductive vulnerability: parental attendance around hatching in Roseate (*Sterna dougallii*) and Common (*S. hirundo*) Terns. Condor 93: 125-129.

Abstract. Presence of one or both members of a pair at the nest site during the incubation and early chick stage reduces reproductive losses due to predation and weather stresses. We monitored the presence of pair members by the temporary removal of one member of several pairs of Roseate (*Sterna dougallii*) and Common (*Sterna hirundo*) Terns at nests at Cedar Beach, New York, to determine if vulnerability varies by reproductive stage, to compare species differences that might partially account for declines in Roseate Tern populations, and to examine their response to trapping. There were significant differences between species in the time to return to the nest following an initial disturbance, and Roseate Terns that were trapped and released took longer to return to the nest and resume incubating than did Common Terns. The nests of Roseate Terns were vulnerable (neither adult in attendance) for longer time than were the nests of Common Terns.

Burger, J. and M. Gochfeld. 1991. The Common Tern: Its Breeding Biology and Social Behavior. Columbia University Press, New York. 413 pp.

Burger, J., and M. Gochfeld. 1991. Human activity influence and diurnal and nocturnal foraging of Sanderlings (*Calidris alba*). Condor 93:259–265.

We studied the foraging behavior of Sanderlings (*Calidris alba*) in the winter of 1986, 1988 and 1990 in Florida to determine whether the presence of people influenced foraging behavior, and whether foraging behavior varied as a function of time of day. We used a focal animal sampling approach. For all three years, the models explaining the greatest variation in seconds per minute devoted to feeding included the number of people within100 m of foraging Sanderlings. Although the number of people within l0 m of foraging Sanderlings during the day did not increase from 1986 to 1990, the number of people within100 m rose dramatically, and foraging time per minute decreased. Sanderlings continued to feed through dusk into night and the time devoted to foraging and to aggression was greater at night, while the time devoted to avoiding people was less at night than during daylight or dusk.

Burger, J. and M. Gochfeld. 1994. Predation and effects of humans on island-nesting seabirds. Pp. 39-67 *in* Seabirds on Islands: threats, case studies and action plans. (D. N. Nettleship, J. Burger and M. Gochfeld, eds.). BirdLife International, BirdLife Conservation Series No. 1. Cambridge, U.K.

Burger, J. and M. Gochfield. 1998. Effects of ecotourists on bird behaviour at Loxahatchee National Wildlife Refuge, Florida. Environmental Conservation 25:13-21.

Increasingly, natural areas are exposed to people who come to view, study or photograph wildlife. In order to develop appropriate management plans for both avian and human use of natural environments it is essential to understand how people affect foraging birds. The foraging behaviour of five species of water-birds at Loxahatchee (Arthur B. Marshall National Wildlife Refuge), part of the Everglades, in Southern Florida was observed, between 1992 and 1994, from a dike that received many visitors. Species examined included common gallinule (*Gallinula chloropus*), sora rail (*Porzana carolina*), glossy ibis (*Plegadis falcinellus*), little blue heron (*Egretta caerulea*) and Louisiana heron (*E. tricolor*). These birds were observed before people were near, while people were present, and following the departure of people. Variation in feeding behaviour was largely explained by whether people were present, the number of people present, and the amount of noise made by the people. For all species, time devoted to feeding and number of strikes or pecks decreased while people were present. The percentage of time spent foraging and the number of strikes decreased as the noise made by people increased. Birds that were closer to the path flew away from people more often than birds that were further away. Birds usually swam or flew away from the path while people were present.

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Burger J., and M. Gochfeld. 1990. Nest site selection in Least Terns (*Sterna antillarum*) in New Jersey and New York. Colonial Waterbirds 13: 31-40.

East Coast Least Terns (*Sterna antillarum*) generally nest in relatively barren, homogeneous habitats of broad sandy beaches on barrier islands or on spoil deposition sites. We studied Least Terns at several New York (N=4) and New Jersey colonies. About 300 pairs of Least Terns nested along 2 km of beach on Brigantine Beach, NJ in 1983. The New York colonies contained from 20-300 pairs estimated from single visits in 1971, 1974 and 1977. At most sites choice of nest sites differed from random with respect to position on the beach, elevation and slope, shell cover, vegetation cover, and distance to vegetation. Terns preferred to nest in the middle third of the beach, on areas with shell cover, and on ridges and slopes. On sparsely vegetated beaches, nests were closer to vegetation than were the random points; on heavily vegetated areas, nests were further from vegetation than were the random points. At Brigantine, fox and cats entered the colony from the dunes and preyed heavily on nests closest to the dunes. Terns nesting during the peak of the nesting season fledged the most young and suffered the fewest losses to predators. At Brigantine, distur- bance was less at the ends of the colony, resulting in higher reproductive success in these sections. In the Long Island colonies beach vehicles, humans, and cats were the main causes of egg and clutch mortality.

Burger, J., C. Jeitner, K. Clark, and L. J. Niles. 2004. The effect of human activities on migrant shorebirds: successful adaptive management. Environmental Conservation 31: 283–288.

The effect of human disturbance on migrant birds is a conservation issue of international importance, as is determining if disruption has long-term population effects. Disruptions can occur during migration, wintering, breeding and foraging. Thousands of shorebirds migrate through Delaware Bay (Atlantic Coast of North America) in a four-week period each spring; this is the largest concentration of shorebirds in the continental USA. Ecotourists come to see them, creating the potential for disruption. Data available on shorebird/human interactions at a migratory stopover over a 20-year period were used to describe the interactions of shorebirds and people from 1982–2002 and examine trends in human disruptions and shorebird behaviour during this time. The rate of disruptions caused by people increased during the 1980s, declined slightly by the early 1990s, and declined sharply by 2002. The decline in human activity along the beach was directly related to the conservation efforts of the New Jersey Endangered and Nongame Species Program, New Jersey Audubon, and others interested in preserving the shorebirds. In the 1980s, birdwatchers concentrated on the beaches on which it was easy to walk and which had the highest shorebird counts, because there were no restrictions on human behaviour. During this time, the average disturbance duration was over 10 min, regardless of the type of intruder, and shorebirds were often disrupted for over 40 min hr^{-1}. Even though the number of disruptions declined over the study period, the percentage of shorebirds that flew away (and did not return within 10 min) did not change during the 1980s, and increased in 2002. The average time that shorebirds were disrupted per hour by people declined during this period (mainly because there were fewer people on the beaches). The Endangered and Nongame Species Program placed signs on shorebird foraging beaches, restricted access, built viewing platforms to contain ecotourists, and eventually patrolled key beaches and issued summonses for infractions. These activities were so effective that only one bird watcher disturbed the birds in 2002. Education was also vital to encouraging local residents not to walk or fish along these beaches during the spring migratory stopover, and to keep their dogs on a leash. These data support the importance of actions on the part of state agencies and conservation organizations to limit disruptions to foraging shorebirds during critical migratory stopovers, a problem faced by shorebirds in many temperate regions of the world.

Burger, J., M. Gochfeld, and L. J. Niles. 1995. Ecotourism and birds in coastal New Jersey: contrasting responses of birds, tourists, and managers. Environmental Conservation 22:56–65.

The impact of tourism in a largely urbanized US State, New Jersey, is discussed, together with the factors affecting avian vulnerability to ecotourists, and indeed to human disturbances in general. Case studies examine different avian situations (migrants, breeding birds and solitary versus colonial species) and tourism types (solitary birders, small groups, and large masses of birders). It is concluded that bird-watchers and birds can co-exist amicably, but only when careful consideration is given to controlling the duration and closeness of the encounters. Birds will adapt and habituate to the presence of people, but there is a distance beyond which closer interactions will cause disturbance or disruption, and may lower reproductive success, decrease foraging efficiency, or force birds to abandon suitable habitats. In many places paths or boardwalks can be used to direct the flow of bird watchers, in others some of the habitat may need to be closed during a sensitive part of the year, with particularly sensitive areas fenced to prevent human access.

Burger, J., L. Niles and K.E. Clark. 1997. Importance of beach, mudflat and marsh habitats to migrant shorebirds on Delaware Bay. Biological Conservation 79: 283- 292.

Shorebirds migrate over long distances from breeding to wintering grounds, stopping at a few bays and estuaries to refuel. Most information on migration of shorebirds concentrates on population dynamics and foraging behavior on intertidal habitats. We studied the behavior of shorebirds on mudflats, beaches and marshes on Delaware Bay to understand how they use different habitats. Dense flocks of shorebirds concentrated on a tidal mudflat, but shorebirds used all the habitats, including several marshes. The overall percent of shorebirds feeding ranged from 34% (open beach), and 59–63% (tidal and non-tidal marshes), to 80% (tidal mudflat). Variations in the percentage of shorebirds engaged in feeding, resting and other behaviors depended on location, date, time, tide and species. A higher percentage of shorebirds fed during the middle of migration, in early to mid-morning, and during low and rising tides than at other times. Some shorebirds fed on the marshes and mudflats during all tidal states, but none fed on beaches at high tide (beaches were too narrow). Within each habitat, the highest percentage of shorebirds engaged in foraging during low tide (marshes) or rising tides (mudflats and beaches). Using the percentage of shorebirds engaged in foraging as an indication of foraging value for each habitat type within the landscape, we concluded that a mosaic of habitat types ranging from mudflats to high marshes is essential to sustain the high populations of shorebirds that use Delaware Bay during spring migration.

Burger, J., I. C. T. Nisbet, C. Safina and M. Gochfeld. 1996. Temporal patterns of reproductive success in the endangered Roseate Tern (*Sterna dougallii*) nesting on Long Island, New York, and Bird Island, Massachusetts. Auk 113: 131-142.

Roseate Terns (*Sterna dougallii*) nest in few colonies in the northeastern United States, and the population is listed as endangered. We compare reproductive success from 1987 through 1990 at Cedar Beach, Long Island, and in 1980 and 1987 through 1990 at Bird Island, Massachusetts, to examine yearly and seasonal differences. Productivity was highest for terns breeding in the first six days of the egg-laying period and decreased thereafter. Clutch size, hatching success, and productivity declined significantly during the season, with some variations in pattern among years and between colony sites. Pairs initiating nests after 22 June fledged almost no young. Patterns of reproductive success were more irregular at the smaller colony (Cedar Beach) than the larger colony. Reproductive success was related to age of adults; young birds (two to three years old) had lower clutch sizes, had lower reproductive success, and laid later than older birds. The effective reproductive population of the colony included primarily birds that bred in the early and peak periods; thus, monitoring reproductive success only from early or peak nests overestimates overall reproductive success. Selection against even earlier breeding in this species may be due to lower food resources early in the season and higher predation rates on early nests. Received 20 April 1994, accepted 2 July 1994.

Burger, J., M. A. Howe, D. C. Hahn, and J. Chase. 1977. Effects of tide cycle on habitat selection and habitat partitioning by migrating shorebirds. Auk 94: 743-758.

We studied assemblages of feeding shorebirds in three intertidal habitats on the coast of New Jersey during August to document how species segregate spatially both among and within habitats and to determine the effects of tidal cycles on these patterns. The habitats were a sandy beach facing the ocean proper (outer beach), a sandy beach on the mainland side of a barrier island (inner beach), and a small mudflat adjacent to a *Spartina alterniflora* salt marsh. We were able to identify several microhabitats on the outer beach and mudflat. Most species fed in more than one habitat, but only two, *Charadrius semipalmatus* and *Calidris canutus*, used all three habitats regularly. Within habitats, most species exhibited strong preferences for the wettest areas, but we found differences among species in degrees of preference. The least amount of partitioning occurred on the inner beach, where birds crowded into a small zone near the water's edge and had frequent agonistic encounters suggesting intense competition. Shorebird feeding activity was partly a function of tide time: each habitat had a characteristic temporal pattern of use by shorebirds related to tide time rather than diel time; within habitats, we found species-characteristic feeding activity rhythms that were also a function of tide time. Feeding by most species peaked during the first 2 hours after low tide on the outer beach and mudflat. The results are discussed in terms of feeding strategies and interspecific competition.

Burger, J., S. A. Carlucci, C. W. Jeitner, and L Niles· 2007. Habitat Choice, Disturbance, and Management of Foraging Shorebirds and Gulls at a Migratory Stopover. Journal of Coastal research 23: 1159-1166.

Habitat choice and interactions of foraging shorebirds and gulls were studied at a migratory stopover in Delaware Bay, New Jersey. Foraging, vigilance, aggressive behavior, and habitat choice of shorebirds were affected by the presence of gulls. There were significant differences in the time each species devoted to actively feeding; knots spent significantly less time foraging than did the other species. Birds congregated in the habitats where their foraging rates were the highest. When turnstones and laughing gulls fed in larger conspecific flocks, they had higher foraging times. Red knots were most aggressive toward laughing gulls, turnstones were most aggressive toward herring gulls, sanderlings were most aggressive toward turnstones, and semipalmated sandpipers were most aggressive toward knots.

There were significant differences in habitat use: 1) Gulls and turnstones were more abundant along the tide line, 2) turnstones were more abundant on the upper beach, 3) semipalmated sandpipers and turnstones were more abundant on sandbars, 4) only gulls fed on the beach mud, and 5) laughing gulls and semipalmated sandpipers were more common along creeks than were the other species.

Within 5 minutes of a human disturbance, gulls returned to predisturbance levels, while the shorebirds did not. Shorebirds responded most strongly to the presence of dogs than to other disturbances and did not return to beaches following a disturbance by a dog. These observations suggest that there may be some competition for foraging space among foraging species, especially between the shorebirds and the larger gulls, that human disturbance affects shorebirds more strongly than gulls, and that shorebirds and gulls use the habitats differently. The data can be used to manage human disturbance and to protect habitats where the shorebirds have the highest foraging rates, but the least exposure to gulls.

Burger, J., K. Parsons, D. Wartenberg, C. Safina, J. O'Connor, and M. Gochfeld. 1994. Biomonitoring Using Least Terns and Black Skimmers in the northeastern United States. Journal of Coastal Research, 10: 39-47

Population sizes and reproductive success in colonies of least terns (*Sterna antillarum*) and black skimmers (*Rynchops niger*) were examined from Massachusetts to Cape May, New Jersey, to determine the utility of these species for monitoring population trends and environmental quality. Although some colonial species have been monitored for reproductive success, most schemes monitor only numbers of breeding birds or are more restricted geographically. For least terns in 1991, reproductive success was significantly lower on Long Island and higher in New Jersey. These differences persisted when compared with reference data from the previous 13-15 years for several of the same colonies that were relatively uncontaminated. There were no geographical differences in reproductive success in 1991 for black skimmers, although western Long Island productivity was below normal. The differences in reproductive success coupled with stable population numbers suggest that southern New Jersey may be providing excess young least terns and black skimmers that move into parts of New York with low reproductive success. Monitoring population numbers alone may not be adequately sensitive for management. Monitoring of productivity though more labor intensive allows the early identification of problem regions and temporal trends. Regional monitoring of reproductive success may be essential to determining the relative importance of protecting specific colonies, and for the early recognition of human impacts.

Burton, N.H.K. 2007. Landscape approaches to studying the effects of disturbance on waterbirds. Ibis 149: 95–101.

The internationally important populations of waterbirds that winter in the United Kingdom can face intense pressure from human disturbance as a result of the high urbanization found around many protected coastal or inland wetland sites. Here, I describe and evaluate an approach that has been used to investigate the spatial effects of human disturbance on waterbirds. Rather than directly investigating behavioural responses to individual disturbance events, the presence of features in the landscape associated with disturbance is instead used as a surrogate, with the essential aim being to demonstrate that bird numbers or densities are depressed or their behaviour altered in proximity to areas used by humans. This paper first describes case studies that demonstrate the limitations of the basic inference (i.e. that disturbance influences patterns of waterbird distribution or behaviour) and then how investigations might be strengthened. For conclusions to be sound, it is particularly important that other factors, such as food supply, that might also explain the spatial patterns observed are considered or other corroborative evidence presented. The approach is thus least applicable in the most heterogeneous environments where many factors, perhaps spatially autocorrelated, may explain variation in distribution or behaviour. However, greatest confidence in the validity of conclusions may be gained where studies are able to show (ideally by experimental manipulation) that species' distributions or behaviour vary temporally in line with the levels of human use of the features examined. Although its aim and scope are thus limited, the use of a landscape approach, provided that it takes into account other factors affecting spatial variation in bird abundance or behaviour, can provide a preliminary assessment of species avoidance of key sources of disturbance that may offer a framework for more detailed investigation.

Burton, N. H. K., M. J. S. Armitage, A. J. Musgrove, and M. M. Rehfisch. 2002. Impacts of man-made landscape features on numbers of estuarine waterbirds at low tide. Environmental Management 30: 857-864.

The potential impact of human disturbance on wintering waterbirds using intertidal mudflats was considered by relating their numbers to the presence of nearby footpaths, roads, railroads, and towns. Data were obtained for six English estuaries from the Wetland Bird Survey Low Tide Count scheme. Counts were undertaken monthly from November to February, and data were available for an average of 2.8 years per estuary for the period 1992–1993 to 1999–2000. Count sections and the positions of man-made landscape features were mapped using a GIS. Generalized linear models tested whether bird numbers varied according to the estuary, month, area, whether or not the section bordered water, and the proportion of each section within a specified distance of each landscape feature. In addition, the proximity of sections to the nearest footpath access point was considered. Numbers of six of nine species, northern shelduck (*Tadorna tadorna*), red knot (*Calidris canutus*), dunlin (*Calidris alpina*), black-tailed godwit (*Limosa limosa*), Eurasian curlew (*Numenius arquata*) and common redshank (*Tringa totanus*), were significantly lower where a footpath was close to a count section, while those of brant (*Branta bernicla*) were greater. Northern shelduck, black-bellied plover (*Pluvialis squatarola*), dunlin, and black-tailed godwit numbers were reduced close to railroads and those of common ringed plover (*Charadrius hiaticula*), black-bellied plover, and Eurasian curlew close to roads. Common ringed plover numbers were greater close to towns. The relative distances to which species were affected by footpaths corresponded to published information concerning their flight distances in response to human disturbance. The study provided

evidence that sustained disturbance associated with footpaths, roads, and railroads reduced local habitat quality for waterbirds and the carrying capacity of estuaries.

Burton, N. H. K., M. M. Rehfisch, and N. A. Clark. 2002. Impacts of disturbance from construction work on the densities and feeding behavior of waterbirds using the intertidal mudflats of Cardiff Bay, U.K. Environmental Management 30:865–871.

The impact of disturbance from construction work around Cardiff Bay, south Wales, on the densities and feeding behavior of seven waterbird species was studied over an 11-year period. Construction of a barrage across the mouth of the bay has subsequently resulted in its impoundment; other major works included the construction of a bridge carrying a divided highway. Construction work disturbance significantly reduced the densities of five species—green-winged teal (*Anas crecca*), Eurasian oystercatcher (*Haematopus ostralegus*), dunlin (*Calidris alpina*), Eurasian curlew (*Numenius arquata*), and common redshank (*Tringa totanus*)—on adjacent intertidal mudflats, and thus the overall carrying capacity of the bay. Construction work also reduced the feeding activity of Eurasian oystercatcher, dunlin, and common redshank on these mudflats. The possible impact of the loss of birds from these mudflats upon the populations that the bay supported is discussed. Evidence from other local studies suggests that the displacement of common redshank from these mudflats did not contribute to a decline in this species.

Burton, N.H.K., Evans, P.R., Robinson, M.A., 1996. Effects on shorebird numbers of disturbance, the loss of a roost site and its replacement by an artificial island at Hartlepool, Cleveland. Biological Conservation 77, 193–201.

Hartlepool West Harbour contains nationally important high water roosts for wintering shorebirds, including purple sandpipers *Calidris maritima*, turnstones *Arenaria interpres* and knots *Calidris canutus*. Redevelopment of the site, starting in summer 1991, replaced the dilapidated stone pier used formerly as the main roost site with a new pier and an island built specially for the birds. Maximum numbers of turnstone, oystercatcher *Haematopus ostralegus* and knot using the harbour have declined in the two winters since the development. Local changes in feeding numbers and national winter population trends of turnstone, oystercatcher and knot do not explain the size of the declines seen in their roosting numbers at West Harbour. An increase in disturbance, particularly from people and boats — a result of increased access and the creation of a marina — are probable causes. Purple sandpiper numbers at the West Harbour roost are falling due to a local population decline, perhaps associated with emigration from the area between winters. Despite these overall declines in the use of West Harbour, the island now forms the main roost site in the harbour for all species. Features of the design and construction of the island which may affect its attractiveness to shorebirds are discussed.

Cairns, W. E. 1982. Biology and breeding behavior of breeding Piping Plovers. Wilson Bulletin 94: 531-545.

The Piping Plover (*Charudrius melodus*) is an endemic species of central and eastern North America which breeds discontinuously throughout its range in suitable sand beach habitat. Apart from early accounts such as those by Bent (1929) and Wilcox (1939), a single study by Wilcox (1959) provides most of the breeding information known for the species. An assessment of the numerical status of the population in eastern North America is contained in Cairns and McLaren (1980). The present study was undertaken to obtain baseline information on the Piping Plover in Nova Scotia. Emphasis was placed on detailing the biology and behavior associated with the nesting cycle, and on examining the relationship between nesting success and the multiple use of beaches.

Calvert, A. M., D. L. Amirault, F. Shaffer, R. Elliot, A. Hanson, J. McKnight, and P. D. Taylor. 2006. Population assessment of an endangered shorebird: the Piping Plover (*Charadrius melodus melodus*) in eastern Canada. Avian Conservation and Ecology - Écologie et conservation des oiseaux **1**(3): 4. [online] URL: http://www.ace-eco.org/vol1/iss3/art4/

Small, at-risk populations are those for which accurate demographic information is most crucial to conservation and recovery, but also where data collection is constrained by logistical challenges and small sample sizes. Migratory animals in particular may experience a wide range of threats to survival and reproduction throughout each annual cycle, and identification of life stages most critical to persistence may be especially difficult for these populations. The endangered eastern Canadian breeding population of Piping Plover (*Charadrius melodus melodus*) was estimated at only 444 adults in 2005, and extensive effort has been invested in conservation activities, reproductive monitoring, and marking of individual birds, providing a comprehensive data set on population dynamics since 1998. We used these

data to build a matrix projection model for two Piping Plover population segments that nest in eastern Canada in order to estimate both deterministic and stochastic rates of population growth (λ_d and λ_s, respectively). Annual population censuses suggested moderate growth in abundance between 1998–2003, but vital rate estimates indicated that this temporary growth may be replaced by declines in the long term, both in southern Nova Scotia ($\lambda_d = 1.0043$, $\lambda_s = 0.9263$) and in the Gulf of St. Lawrence ($\lambda_d = 0.9651$, $\lambda_s = 0.8214$). Nonetheless, confidence intervals on λ estimates were relatively wide, highlighting remaining uncertainty in future population trajectories. Differences in projected growth between regions appear to be driven by low estimated juvenile post-fledging survival in the Gulf, but threats to juveniles of both population segments following departure from nesting beaches remain unidentified. Similarly, λ in both population segments was particularly sensitive to changes in adult survival as expected for most migratory birds, but very little is understood about the threats to Piping Plover survival during migration and overwintering. Consequently, we suggest that future recovery efforts for these and other vulnerable migrants should quantify and manage the largely unknown sources of both adult and juvenile mortality during non-breeding seasons while maintaining current levels of nesting habitat protection.

Cameron, S. and D. Allen. 2004. American Oystercatcher breeding distribution and population estimate in North Carolina. North Carolina Wildlife Resources, Raleigh, North Carolina, USA.

Cameron, S. E., D. H. Allen, M. M. Lyons, J. R. Cordes, and S. B. Maddock. 2005. Compilation and assessment of Piping Plover wintering and migratory staging area data in North Carolina. Proceedings of the Symposium on the Wintering Ecology and Conservation of Piping Plovers. 5pp.

The coast of North Carolina provides important habitat for both migrating and wintering Piping Plovers (*Charadrius melodus*). All three geographic populations of this species are known to use the North Carolina coastline during the non-breeding season. Migrating and wintering Piping Plovers face a number of threats in the state including habitat loss and degradation due to development, chronic human disturbance and beach and inlet stabilization projects. In the past, surveys for non-breeding Piping Plovers were conducted primarily in an opportunistic fashion and not compiled in one location. In 2001, the North Carolina Wildlife Resources Commission created an Access database for non-breeding Piping Plover observations and compiled sightings in an effort to help identify some of the most important areas for non-breeding Piping Plovers. In recent years, systematic surveys conducted on Cape Hatteras and Cape Lookout National Seashores and at various locations in the state in association with beach stabilization projects coupled with the increase in sightings reported and the compilation of coast-wide data, have lead to an increase in our knowledge about nonbreeding Piping Plovers in North Carolina. In addition, it has aided in the review of projects that have the potential to negatively impact Piping Plovers and in management efforts for nonbreeding plovers. Much is still to be learned about non-breeding Piping Plovers in the state and the impacts of the aforementioned threats. Additional systematic surveys are needed in other areas along the coast such as difficult to reach shoals and more frequent surveys are required along sites of known importance to further our understanding of migrating and wintering Piping Plovers in the state.

Cape Cod National Seashore. 1993. Piping Plover nest found trampled by pedestrian.. News release. Cape Cod national Seashore, South Wellfleet, Massachusetts. 2 pp.

Cardoni, D. A., M. Favero, and J. P. Issach. 2008. Recreational activities affecting the habitat use by birds in Pampa's wetlands, Argentina: Implications for waterbird conservation. Biological Conservation 141: 797-806.

The increasing popularity of outdoor recreational activities in recent years has resulted in elevated human disturbance of waterbird communities. Anthropogenic disturbance is defined as any human activity that constitutes a stimulus sufficient to disrupt normal activities and/or distribution of animals relative to the situation in the absence of that activity. The goals of this study were (1) to quantify changes in habitat use by waterbirds caused by the proximity of people's activities to the shoreline, in Los Padres Lagoon Reserve (Argentina), (2) to evaluate differential responses of waterbird groups caused by this human disturbance, and (3) to propose management guidelines to improve waterbird conservation in Pampas lagoon. We performed bird surveys monthly in areas with high levels of disturbance (HD areas) and with no or low levels of disturbance (LD areas) via recreational activities during days with (weekends) and without (weekdays) presence of people close to the lagoon. We recorded 34 bird species using the lagoon. The bird richness and abundance in HD areas was higher in days without recreational activities, conversely, in LD areas we found no differences in these parameters between days. Waders were found to be the group most vulnerable to disturbance, since these birds were only recorded in HD areas in days without human activity. Podicipedidae, as a group were less affected by recreational activities. We detected changes in the waterbird assembles and structure in relation to the presence of people on the shoreline. Our results in this study suggest direct effects of recreational

activities on the habitat use of waterbirds. The buffer area defined by the current Reserve management strategy is working properly, and the impact of recreational activities on transitional area has only instantaneous effects on waterbirds because they return to that area in absence of disturbance. However, it should be considered that we only estimated the response to short-term effects of these activities on the waterbird community. Further studies should assess long-term effects.

Carlson, L. H., and P. J. Godfrey. 1989. Human impact management in a coastal recreation and natural area. Biological Conservation **49**:141-156.

A scientifically based management plan was developed for a recreation and natural area to allow high visitation while preserving the environment. A private organization managing the R.T. Crane Jr Memorial Reservation, and members of a public university, cooperated to examine human impacts, and develop and implement management strategies. Basic scientific research methods, including vegetation surveying and vegetation mapping, were combined with proven management techniques, such as constructing elevated boardwalks, fencing sensitive areas, and educating visitors. A resurvey of study sites two years after implementation of the plan confirmed the success of this project and suggested that a similar approach could be used in other contexts.

Carney, K. M., and W. J. Sydeman. 1999. A review of human disturbance effects on nesting colonial waterbirds. Waterbirds 22:68–79.

We reviewed 64 published investigations concerning effects of human disturbance on nesting colonial waterbirds. We summarized and reviewed articles, based on taxonomy, examining investigator, ecotourist, recreator, watercraft, and aircraft activity effects on physiology, reproductive behavior, reproductive success, and population trends of waterbirds. Though most studies found significant negative effects, taking careful measures minimized impact on some species. Guidelines for minimizing investigator and visitor disturbance are outlined. Little practical information for visitor management is available. Increasing pressure from the ecotourism industry to visit waterbird colonies makes research that develops scientifically-defensible tourism policies imperative.

Clark, K.E. and L. Niles. (2000). "U.S. Shorebird Conservation Plan: Northern Atlantic Regional Shorebird Plan," Version 1, U.S. Fish and Wildlife Service. Online at: *http://www.fws.gov/shorebirdplan/ RegionalShorebird/RegionalPlans.htm* (accessed 16 May 2006).

The North Atlantic planning region is one of the most heavily populated areas in the U.S. Many wetland habitats have been affected by development, causing wetlands loss, pollution, and increased human access leading to disturbance. The Atlantic coast beaches and bays, however still have high quality habitats that have become more essential to shorebirds than ever before. The region is critical to the survival of hemispheric populations of some species (e.g., Red Knots, Piping Plovers, Whimbrels), which would be decimated by continued habitat degradation or catastrophic chemical or petroleum spills.

The North Atlantic region has a number of inherent strengths supporting effective shorebird protection:
1) a huge constituency with reasonably good access to shorebird viewing opportunities: 2) large portions of habitat in public ownership (averaging 60%-95% in most states); and 3) strong state land use regulations that affect actions on private land.

The potent threats in the region are almost the flip side of the strengths. Large human population centers create a substantial threat from development and disturbance, and cause a significant potential for resource conflicts. Further, the northeast Atlantic Coast is always under the threat of catastrophic oil spills and consequent damage to shorebird habitat or shorebirds themselves. The major weaknesses in existing protection center on inadequate funding for management and surveys, thus leading to an insufficient database on population, distribution, and habitats.

Combining these strengths, weaknesses and threats, our group developed a number of opportunities that may be unique to the North Atlantic region: First, strong state agencies create the potential for creative intra- and interstate shorebird projects; second, the large human population and easy access to important shorebird sites create a significant opportunity for improving recreational use of shorebirds with small increases in funding for developing access; and third, strong agency interest exists for developing interspecies management and protection.

The group considered the regional strengths and threats, and suggested the following high priority project:
1. Begin region-wide coastal surveys conducted by individual state agencies and coordinated by the USFWS throughout the region.

2. Work on-site at known important areas to reduce disturbance, identify and protect critical food resources, and control predation.
3. Significantly improve impoundment management, also coordinated throughout the region.
4. Create a strong emphasis on volunteer banding and wardening, as methods to increase awareness.
5. Develop coordinated state and federal satellite habitat mapping, delineating all important shorebird habitats.
6. Establish a number of "all bird" Joint Venture projects.
7. Improve spill prevention and emergency response.

Clark, K. E., L. Niles, and J. Burger. 1993. Abundance and distribution of migrant shorebirds in Delaware Bay. Condor 95: 694-705.

Northbound migrant shorebirds (Charadridae and Scolopacidae) were surveyed weekly by air on Delaware Bay beaches on the Atlantic coast of North America in May-June 1986 through 1992. The single day peak count occurred between 26-30 May when an average of more than 216,000 birds was counted. The most abundant species were Semipalmated Sandpiper (*Calidris pusilla*), Ruddy Turnstone (*Arenaria interpres*), Red Knot (*Calidris canutus*) and Sanderling (*Calidris alba*). Our surveys documented high hemispheric counts for each of these species, and established Delaware Bay as the most important spring stopover in the eastern U.S. for these shorebirds. Counts of Sanderlings and Semipalmated Sandpipers declined significantly over the seven years; no trends for other species were detected. Differences among species in distribution along bay beaches were attributable partly to habitat factors. We suggest that a thorough understanding of shorebird abundance and habitat use in Delaware Bay is necessary to develop a conservation strategy for regulatory protection and conservation of migrant shorebirds using this area. Key words: Shorebirds; migration; Delaware Bay; habitat; stopover; conservation.

Cohen, J. B., E. H. Wunker, and J. D. Fraser. 2008. Substrate and Vegetation Selection by Nesting Piping Plovers. Wilson Journal of Ornithology 120: 404–407.

We studied substrate composition and vegetation cover at Piping Plover (*Charadrius melodus*) nests and paired random plots on New York beaches that had been widened by renourishment (deposition of dredged sand). Most nests (59.4%, $n = 32$) were in unvegetated plots, mean ± SE vegetative cover around nests was 7.5 ± 1.7%, and all plovers nested in <47% cover. Most nests (59.4%) were on pure sand and mean coarse grain cover (pebble and cobble-sized objects) on nest plots was 9.1 ± 2.6%. Nest plots were more likely to be vegetated than paired random plots. Coarse substrate also was of high relative importance in distinguishing nests and random plots. Beach management projects can reduce sparse vegetation and coarse substrate, which may affect Piping Plover nest site selection.

Cohen, J. B. 2005. Factors limiting Piping Plover nesting pair density and reproductive output on Long Island, New York. Ph.D. Dissertation, VA Polytechnic Institute and State University. Pp. 251.

Storm-created nesting habitat and low wave energy moist sediment habitat (MOSH), such as intertidal sandflats, have long been considered important to the recovery of the piping plover (*Charadrius melodus*), a federally threatened shorebird. Beach renourishment is a common practice on the U.S. Atlantic Coast for the protection of human property from storms, but it also prevents normal MOSH formation. We examined factors limiting piping plover nesting pair density and reproductive output on Atlantic Barrier Islands, 2001- 2004, including one site that had been breached by a storm in 1992, and subsequently repaired and renourished by the U.S. Army Corps of Engineers.
We also investigated the short-term impact of beach renourishment at these sites. Number of pairs at a site increased with beach area. Pair density increased with MOSH availability at the site level. Home range size increased as the distance from plover nests to MOSH increased. Home range size was smaller for plovers with higher foraging rates in the territory-establishment period, but this effect was most likely independent of distance to MOSH. Reproductive output was not apparently related to availability of MOSH to adults or broods, and was limited by predation. Habitat widths, prey abundance, and brood habitat selection changed at two of our sites after renourishment. However, similar changes occurred in reference areas. Other research shows that in addition to long-term loss of storm-created features, beach stabilization can lead to loss of habitat and low reproductive success due to human development and an increased presence of introduced predators. Management for recovery of this species should thus include permitting natural storm-mediated habitat creation to occur where feasible. However, since we found no direct negative short-term impact of renourishment on prey or habitat availability, habitat restoration via renourishment of eroded beaches could be a viable strategy for plover recovery, if negative indirect short and long-term effects are mitigated. Restoration projects should include restoration or creation of MOSH adjacent to nesting habitat, because MOSH attracts a high density of pairs and to offset long-term loss of storm-created habitat. Human disturbance and predation must also be controlled at restoration sites.

Cohen, 2005. Management and protection protocols for the threatened Piping Plover (*Charadrius melodus*) on Cape Hatteras National Seashore, North Carolina. USGS Patuxent Wildlife Research Center.

1. The breeding population of the piping plover (*Charadrius melodus*), a federally-threatened shorebird, at Cape Hatteras National Seashore (CAHA) declined from 15 pairs/yr to 3 pairs/yr from 1989-2004. A population of this size may face immediate risk of extirpation from several sources. At several former breeding sites at CAHA, there have been no nesting pairs in recent years.

2. Only one plover chick has survived to fledging at CAHA, 2001-2004. While survival of eggs has often been moderate to high since 1989, survival of chicks has generally been low. Reproductive rate improved in 2005, with 6 chicks fledging from 2 pairs in conjunction with more actively managed closures in brood-rearing areas.

3. Inclement weather, predation, and recreational disturbance may negatively impact reproductive success of piping plovers at CAHA. Recreational disturbance and habitat loss caused by ORVs may discourage pairs from attempting to nest.

4. To recover the breeding plover population at CAHA, it will be necessary to create disturbance-free areas containing high-quality nesting and foraging habitat from the territory-establishment phase to the brood-rearing phase of the breeding cycle. We provide three management options to reduce risk of disturbance and mortality. They entail full closure of the seashore to recreation, closure of historical breeding sites to ORVs, or restriction of recreation to an oceanside corridor.

5. To reduce the risk of egg and chick mortality, we recommend continued efforts to trap and remove mammalian predators from all aforementioned sites and the continued use of predator exclosures around nests. We further recommend intensive monitoring and surveillance of protected areas to determine the extent and timing of threats to nests and broods, including nest overwash, predation, and disturbance or vandalism by humans.

6. Even if reproductive success improves under our recommendations, however, a population of this size will take several years to recover in the absence of immigrants from other sites, and there may not be a noticeable increase in population size in the short term. We recommend using an Adaptive Management approach, combining research, monitoring and management to assess the effectiveness of management actions in achieving our goals to recovery this threatened species at Cape Hatteras.

7. The size of nonbreeding flocks, their habitat use, their site tenacity, and sources of disturbance and mortality are not known with high precision. We recommend monitoring standards and research to address this problem, while at the same time restricting recreation adjacent to important migration and wintering sites to afford nonbreeding birds increased protection.

Cohen, J. B., J. D. Fraser and D. H. Catlin. 2006. Survival and site fidelity of Piping Plovers on Long Island, New York. Journal of Field Ornithology 77: 409–417.

The threatened Atlantic Coast population of Piping Plovers (*Charadrius melodus*) has not increased in recent years and remains 332 pairs short of the recovery goal of 2000 pairs. Habitat loss to development is a major threat to the population, and there has been interest in restoring nesting and foraging habitat. However, the demographic response of coastal Piping Plovers to either habitat loss or creation has not been documented. We estimated survival rates and site fidelity of a declining Piping Plover population on Long Island, New York, from 2001 to 2005 on a beach subject to human development and recreation. The mean annual adult survival was 0.703 ± 0.032 (SE) and was similar among years. Site fidelity during the period of territory establishment averaged 0.827 ± 0.069 (SE). Given this high site fidelity, ensuring the survival of adults is important for maintaining local populations. Although the 2002-2004 average was high, site fidelity was apparently lower in 2003 than in 2002. This decrease in site fidelity may have been related to several years of habitat loss and increasing predation of nests or chicks, as reported in a partly concurrent long-term study at our site. The species-level effect of local dispersal due to anthropogenic habitat loss depends on the fitness of dispersers, and is currently unknown for Piping Plovers.

Cole, D. N., and P. B. Landres. 1995. Indirect effects of recreation on wildlife. p. 183-202, IN: R. L. Knight and K. J. Gutzwiller eds. Wildlife and Recreationists. Island Press, Washington, D. C.

Most of this book focuses on direct impacts to wildlife that result from contact with people. The purpose of our chapter is to provide a broad overview of the indirect influences that recreation has on wildlife. Recreational activities can change the habitat of an animal. This, in turn, affects behavior, survival, reproduction, and distribution of individuals. Although more difficult to isolate and study, these indirect impacts may be as serious and long-lasting as direct impacts for many species.

Cole D. N., and R. L. Knight. 1991. Wildlife preservation and recreational use: conflicting goals of wildland management. Transactions of the North American Wildlife and Natural Resources Conference **56**:233-237.

Coleman, R.A., N.A. Salmon and S. J. Hawkins. 2003. Sub-dispersive human disturbance of foraging oystercatchers *Haematopus ostralegus*. Ardea 53: 263–268.

Disturbance of foraging shorebirds is a known impact of human use of shorelines. Most previous work examined disturbances which caused dispersal of foraging or roosting animals, and used an uncontrolled correlative approach. In a preliminary study using experimental methods, we show that feeding birds when disturbed, but not dispersed, can show behavioural modifications and suffer reduced foraging success.

Collazo, J. A., J. R. Walters, and J. F. Parnell. Undated. Factors affecting reproduction and migration of waterbirds on the North Carolina barrier islands. Final report to the National Park Service – Cape Hatteras and Cape Lookout Seashores . NC State University, Raleigh, North Carolina.

Colwell, M.A., Dafunsky, T., Fox-Fernandez, N.W., Roth, J.E. & Conklin, J.R. (2003) Variation in shorebird use of diurnal, high-tide roosts: how consistently are roosts used? *Waterbirds*, **26**, 484–493.

In coastal environs during the non-breeding season, many shorebirds (suborder Charadrii) congregate at roosts, long considered to be traditional sites where flocks of individuals coalesce when high tides inundate feeding areas. Humboldt Bay, California was surveyed (9.5 months at roughly 10-d intervals) to assess temporal variation in incidence (proportion of 28 surveys birds used a roost), proportional abundance, concentrations, and repeatability (of seasonal average proportional abundances) of shorebird use of diurnal, high-tide roosts. Two hundred and forty roosting locations were identified and observations were made of 30 species. Fourteen species accounted for over 99% of observations. Shorebirds occurred at most roosts infrequently (<20% of surveys) and only 4% of roosts had roosting birds present on more than 80% of occasions. Abundant species occurred at more roosts (20-141 roosts per species) compared with less common species. Even at the most-used roosts, abundances at the species level varied greatly. Repeatability of roost use among seasons was high. At Humboldt Bay, roost use formed a continuum from ephemeral locations used by a few birds to sites used consistently by large numbers of individuals

Colwell, M. A. and K. D. Sundeen. 2000. Shorebird distributions on ocean beaches of northern California. Journal of Field Ornithology 71: 1-15.

Use of coastal beaches by nonbreeding shorebirds along the Pacific coast of North America is poorly understood because survey efforts have targeted large bays and wetlands where birds concentrate. Consequently, we studied coastal shorebird distributions and community composition by conducting monthly surveys at 40, 0.5-km linear plots along sandy beaches of coastal northern California from January through April 1996. We recorded 12 species, whose ranked abundances were consistent between winter (January–February) and spring (March–April). However, five of the six commonest species were more abundant in winter than spring. Among beaches, we detected a mean of 2.6 ± 2.3 (SD; range: 0–9) species and 12.0 ± 14.1 (range: 0–62) individuals. Number of species correlated positively with total shorebird abundance. Most species' abundances varied greatly among sites; nine taxa had aggregated spatial distributions, one species was hyper-dispersed, and two species were randomly distributed among beaches. Species composition of the shorebird community was highly nested, partly because abundant species were more widespread in their occurrence than less-numerous taxa. More species and individuals occurred at sites near Humboldt Bay, probably because high tides forced birds off their principal feeding areas within the bay to adjacent beaches. Variation in shorebird use of beaches suggests that some areas are more important to wintering and migrating shorebirds than other locations. Although current levels of human activity in coastal northern California do not appear to influence distributions of nonbreeding shorebirds, we suggest that monitoring and management plans be considered to minimize potential negative impacts of recreational activities, which are certain to increase with human population size and recreational use of beaches.

Corbat, Carol A. and Peter W. Bergstrom. 2000. Wilson's Plover (*Charadrius wilsonia*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/516

Corbat, C. A., and P. W. Bergstrom. 2000. Wilson's Plover (*Charadrius wilsonia*). *In* The Birds of North America, No. 516 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Cornelius, C., S. A. Navarrete and P. A. Marquet. 2001. Effects of human activity on the structure of coastal marine bird assemblages in central Chile. Conservation Biology 15: 1396–1404.

In comparison with the effects of the collection of marine intertidal organisms by humans, the effects of human recreational activities on assemblages of marine birds have received scarce attention. We evaluated whether in central Chile the spatial and temporal variation in the composition and abundance of the avian assemblage is affected by the presence of humans on the coast. We studied a 1. 5-km stretch of rocky coast, in the center of which is a small marine reserve where no fishing or recreational activities take place. At 15 observation points, we conducted 12 monthly surveys of birds that roost in the supralittoral zone, between the high-tide mark and the terrestrial vegetation, and/or that forage in the intertidal zone. In addition, within the reserve we conducted daily bird surveys over 2 years to evaluate whether abundance or composition changed according to the activity of people outside the reserve. We recorded 19 species of coastal marine birds. Eleven species used the supralittoral zone only for roosting (roosting assemblage), whereas the others foraged on intertidal organisms and roosted in the supralittoral zone (foraging assemblage). Although the largest negative effect of human activity on bird abundance occurred in summer, the period of greatest recreation intensity, the presence of humans negatively affected birds year round, changing both the spatial and temporal distribution of birds along the shore. Bird abundance was higher at observation points inside the marine reserve, although the pattern was stronger for birds roosting on the supralittoral zone than for birds actively foraging in the intertidal zone. Similarly, the number of birds recorded during weekends inside the reserve was higher than during week days. Our results illustrate the important role played by this marine reserve, which offers marine birds safe roosting sites without human interference. Larger marine reserves than the one we studied are needed because the dynamics of birds inside the reserve were strongly influenced by human activities in immediately adjacent areas. Our results emphasize the need to consider human recreational activities along the coast when establishing conservation programs because harvesting refugia or "no-take' zones will not provide protection to coastal bird assemblages unless human access is restricted.

Cox, J. H., H. F. Percival, S. V. Colwell. 1994. Impact of vehicular traffic on beach habitat and wildlife at Cape San Blas, Florida. Technical Report 50, Florida Coop Fish and Wild1ife Research Unit.

Culik, B., D. Adelung and A. J. Woakes. 1990. The effect of disturbance on the heart rate and behaviour of Adelie Penguins (*Pygoscelis adeliae*) during the breeding season. Pages 177-182 in Antarctic ecosystems: Ecological change and conservation (K. R. Kerry and G. Hempel. Eds.). Springer Verlag, Berlin, Germany.

Cuthbert, F.J., Wires, L.R. and K. Timmerman. 2003. Status Assessment and Conservation Recommendations for the Common Tern (*Sterna hirundo*) in the Great Lakes Region. U.S. Department of the Interior, Fish and Wildlife Service, Ft. Snelling, MN.

During the past several decades, a number of studies have reported significant declines in local populations of the Common Tern *(Sterna hirundo)* in the Great Lakes region. Concern for Great Lakes Common Terns is further supported by special listing status for this species in 6 of 9 states bordering the Great Lakes. Additionally, the Great Lakes population of the Common Tern is a U.S. Fish and Wildlife Service (USFWS) nongame bird species of management concern. The USFWS contracted the authors of this document to: evaluate the current status of the Great Lakes population in 1995, summarize Common Tern life history, determine major threats to Common Terns in the Great Lakes region and summarize management/protection efforts and priorities for this species. For this report, the boundaries of the Great Lakes population are assumed to be all islands and mainland shoreline of U.S. and Canadian portions of Lake Superior, Lake Michigan, the St. Marys River, Lake Huron, Lake St. Clair, the St. Clair River, the Detroit River, Lake Erie, Niagara River, Lake Ontario and the St. Lawrence River downstream to Cornwall, Ontario. Based on band recovery data and recommendations from state and provincial biologists we also include population estimates and biology from inland colony sites in Minnesota, Wisconsin, New York and Vermont.

The only binational censuses conducted to date (1989/90; 1997/98) estimated approximately 10,000 and 7,500 pairs of Common Terns within 1 km of Great Lakes shoreline. Adjusting this estimate to include adjacent inland sites indicates a regional population of about 8,500-11,000 pairs at the beginning of 21st century. When examined on a state or provincial basis, there is very strong evidence that Common Terns have experienced significant population declines between the time first estimates were made (1927-1960) and the present (1997). Using this historical perspective, only one state (Vermont) has recorded a population increase. Three populations in states with historically small numbers

(<50 pairs) (Illinois, Indiana, Pennsylvania) are essentially extirpated. The remaining populations in 5 states (Minnesota, Wisconsin, Michigan, Ohio, New York) and 1 province (Ontario) all experienced significant declines during the 1900's.

Common Terns are affected by a diversity of threats in the Great Lakes region. The most serious problems include destruction and modification of habitat and predation. Habitat loss is caused by competition with Ring-billed Gulls (*Larus delawarensis*) for nest habitat and annual variation in amount of available habitat based on fluctuating Great Lakes water levels. Predation causes mortality of eggs, chicks and adults and results in significantly lowered reproductive success at some colony sites. Other important threats include human disturbance and contaminants.

Threats impacting terns have resulted in extensive knowledge and tested methodology to enhance colony productivity and protection in the Great Lakes. These include habitat management (e.g. habitat restoration, enhancement, creation, and acquisition), predator control, eliminating or minimizing competition for nest sites, and prevention of human disturbance.

Long term survival of the Common Tern in the Great Lakes region requires monitoring, research, intensive local management, communication and conservation. The following are region-wide research and management priorities: (1) a reliable, periodic, coordinated international census , (2) identification of a network of important breeding sites, (3) identification of important colonies in need of special attention, (4) communication with state and provincial governments regarding the importance of consistent and coordinated monitoring and management, (5) standardized methods for collecting and reporting population trend data, (6) collation of extensive information on methodology for enhancing Common Tern survival and reproductive success, (7) analysis of North American band recoveries to ascertain biological population boundaries and facilitate management coordination, (8) recognition of the important role contaminants may play in the long term survival of this species and (9) the need for information on the biology and distribution of Great Lakes Common Terns during migration and winter. Preparation of this status assessment was initiated in 1995 and a draft report was completed in 1996. Shortly after its preparation, several related research efforts were undertaken by report authors (e.g. 1997 international census, an analysis of North American band recoveries, and prioritization of Common Tern breeding sites for conservation). The original report was delayed to incorporate results of these newer efforts into the final status assessment for this species. It is important to note that with the exception of the newer studies, most of the original information collected for the draft report is based on data collected in 1995.

Davidson, N.C., & Rothwell, P.I. 1993. Human disturbance to waterfowl on estuaries: conservation and coastal management implications o f current knowledge. In: Disturbance to waterfowl on estuaries. N. Davidson & P. Rothwell, Eds. Wader Study Group Bull. 68: 97-106.

Davis, M. B. 1999. Reproductive success, status and viability of the American Oystercatcher (*Haematopus palliatus*). Unpublished M.S. Thesis, North Carolina State University, Raleigh, North Carolina.

Davis, M. B., T. R. Simons, M. J. Groom, J. L. Weaver and J. R. Cordes. 2001. The breeding status of the American Oystercatcher on the east coast of North America and breeding success in North Carolina. Waterbirds 24: 195-202

We studied American Oystercatchers (*Haematopus palliatus*) by examining reproductive success and the factors affecting it at one location, and by examining the status and trends of breeding population numbers from Florida to Nova Scotia on the east coast of North America. We conducted our field research on Cape Lookout National Seashore, Carteret County, North Carolina from 1997 to 1999, and we documented larger scale breeding population trends by contacting state biologists and reviewing the literature and historical accounts. Presence of eggs and young were checked two to five times per week (by observing from a distance), and efforts were made to determine the reasons for loss of the nest contents. We monitored a total of 245 nests and found low productivity. At least one egg in 32 (13%) nests hatched and one or more chicks fledged from 12 broods. Overall, 14 chicks successfully fledged (nine from North Core Banks and five from South Core Banks) during the three years of the study. Of the 213 clutches that did not hatch, 163 (76%) failed because of predation, and 46 (22%) because of overwash or severe weather. Our minimum estimate for the number of oystercatchers breeding along the entire Atlantic coast and the Gulf coast of Florida is 1,624 pairs. North of Virginia, numbers appear to be stable or slowly increasing and the species has expanded as far north as Cape Sable Island in Nova Scotia. From Virginia south, breeding numbers show a decline in recent years. The number of oystercatchers breeding on barrier islands in Virginia has decreased by more than 50% in the last 20 years. Given their relatively small numbers and inherently low productivity, American Oystercatchers are at risk in rapidly changing coastal ecosystems.

Dias, M. P., J. P. Grandadeiro, M. Lecoq, C. D. Santos, and J. M. Palmeirim. 2006. Distance to high-tide roosts constrains the use of foraging areas by dunlins: Implications for the management of estuarine wetlands. Biological Conservation 131: 446-452.

Shorebirds are declining all around the world, mostly due to deterioration of the estuarine habitats used in winter and migration. Estuaries cover small areas, so it is essential to guarantee that shorebirds can access all the tidal flats where they usually feed at low-tide.

Studying use of space by dunlins (*Calidris alpina*) in the Tagus estuary (Portugal), we noted that lack of suitably located high-tide roosts can limit the access of shorebirds to feeding habitats. Density of dunlins on foraging areas declined significantly with distance to the nearest roost, and fewer than 20% individuals foraged more than 5 km from two roosts where they were dye-marked.

So to permit full access to feeding areas it is important to maintain a network of suitably located high-tide roosts. We developed a GIS modeling methodology to evaluate the adequacy of existing roost networks, and to estimate the consequences of losing or creating new roosts. The methodology requires maps with the location of roosts and foraging habitats, and knowledge of the distances that birds are willing to fly to reach foraging areas. It quantifies the proportion of foraging areas close to the existing roosts and the average distance that birds have to fly to reach potential feeding sites.

Applying this methodology to the Tagus estuary we concluded that lack of roosts probably explains why the intertidal flats in the north-west of the estuary are underused by shorebirds. A modeling exercise suggested that this gap could be eliminated by creating a roost in an old drained wetland area. We also modeled the impact of the loss of two roosts that are currently threatened. Without them almost half of the available feeding areas will be too far from roosts to be efficiently used by dunlins, and possibly by other shorebirds.

Dinsmore, S. J., A. A. Collazo, and J. R. Walters. 1998. Seasonal numbers and distribution of shorebirds on North Carolina's Outer Banks. Wilson Bulletin, 110:171-181.

We documented the seasonal abundance, distribution, and relative importance of outer beach habitats to shorebirds on the Outer Banks of North Carolina. The Outer Banks span 228 km and attract millions of tourists every year, underscoring the need for baseline data for conservation. Twenty-one species were recorded during the study. The most abundant were Sanderling (Culidn's alba), Red Knot (Calidris canutus), and Willet (Catoptrophorus semipalmatus). As an assemblage, shorebirds were most abundant in May and August. Peak numbers for each species were recorded between April-May and July September. The greatest numbers were recorded on North Beach and the lowest on South Beach (1992) and Bodie Island (1993). Shorebird abundance was greater during fall (68 birds/km) than in spring (50 birds/km). Patterns of abundance of the eight most abundant species were examined in detail. Black-bellied Plovers (Pluvialis squatarola), Willets, Whimbrels (Numenius phaeopus), Ruddy Turnstones (Arenaria interpres) and Sanderlings were most abundant on North Beach. North Core Banks harbored the highest numbers of Piping Plovers (Charudrius melodus), American Oystercatchers (Haematopus palliatus), and Red Knots. American Oystercatchers and Whimbrels were significantly more abundant during spring than fall, whereas Willet and Sanderlings were more abundant during fall. The Outer Banks emerged as an important staging area for the Atlantic populations of Piping Plovers, Whimbrels, and Sanderlings when compared to 7 other areas along the eastern U.S. coast. The importance of the area to Sanderlings was reaffirmed by return rates of 58%, most (69989%) returning to the beach stretch where they were banded. The area gains special significance because it also supports a nesting population of Piping Plovers. Our findings confirm that the Outer Banks of North Carolina provide a critical link in the migratory path of several shorebird species. Habitat loss or alteration could adversely affect the Atlantic Flyway population of several species (e.g., Sanderlings) as well as the threatened Piping Plover.

Dodd, S.L. & Colwell, M.A. (1998) Environmental correlates of diurnal and nocturnal foraging patterns of nonbreeding shorebirds. *Wilson Bulletin*, **110**, 182–189.

Knowledge of abiotic factors influencing the foraging ecology of nonbreeding shorebirds (Charadriiformes: Charadrii) is based on research conducted almost exclusively during the day. Consequently, we examined the relative contributions of environmental variables to diurnal and nocturnal foraging patterns (presence/absence) of nonbreeding shorebirds at Humboldt Bay, California, USA from January 1992 to January 1993. The influence of environmental variables on foraging patterns differed between day and night. Most notably, the diurnal presence of birds increased with: (1) shorter daylength [Black-bellied Plover (Pluviais squatarola), dowitchers (Limnodromus spp.), and small sandpipers (Calidris mauri and C. minutilla)]; and (2) shorter durations of mud flat exposure [American Avocet

(Recurvirostra americana), Marbled Godwit (Limosa fedoa), and Dunlin (Calidris alpina)]. By contrast, the nocturnal presence of most species increased during the fall [Marbled Godwit, dowitchers, Black-bellied Plover, Semipalmated Plover (Charadrius semipalmatus), and Dunlin] and on nights with a visible moon [Marbled Godwit, Willet (Catoptrophorus semipalmatus), dowitchers, Semipalmated Plover, and Dunlin]. Our results suggest that interspecific variation in diurnal and nocturnal feeding patterns of shorebirds is associated mostly with variation in tidal, seasonal, and moonlight conditions. Furthermore, our findings suggest that nocturnal foraging by most shorebird species at a northern temperate, intertidal site did not increase during periods of short daylength.

Donaldson, G.M., C. Hyslop, R. I. G. Morrison, H. L. Dickson, and I. Davidson., eds. (2000). "Canadian Shorebird Conservation Plan," Canadian Wildlife Service, Ottawa, Ontario.

Canada's national biodiversity strategy calls on government and other stakeholders to attack the causes of biodiversity loss at their source and prevent further endangerment of species. Certainly there is cause for concern for Canadian shorebird species. Fully two-thirds of Canada's shorebird populations show downward trends according to survey data. No single cause accounts for these declines; clearly the situation warrants concern. Canada has a unique responsibility with respect to shorebirds. For many species, more than half of their breeding range occurs in Canada.

Opportunity exists to cooperate with ongoing conservation initiatives such as the Western Hemisphere Shorebird Reserve Network (WHSRN), U.S. Shorebird Conservation Plan, Partners in Flight, Wings Over Water, North American Bird Conservation Initiative, North American Waterfowl Management Plan, and others. The plan's vision is for healthy populations of shorebirds to be distributed across their range and diversity of habitats in Canada and throughout their global range. The plan thus recognizes the need to collaborate internationally as well as regionally and locally.

The Canadian Shorebird Conservation Plan has five goals designed to fulfill the needs for research, monitoring, and evaluation as well as conservation, communication, and international linkages.

Those goals are:
1. Sustain the distribution, diversity, and abundance of shorebird populations within Canada and restore populations of declining, threatened, and endangered species;
2. Secure and enhance sufficient high-quality habitat to support healthy populations of shorebirds throughout their ranges in Canada;
3. Ensure that information on shorebird conservation needs and practices is widely available to decision makers, land managers, and the public;
4. Ensure that coordinated shorebird conservation efforts are in place, on the ground, throughout the range of Canadian shorebird species;
5. Ensure that shorebird conservation efforts are guided by common principles throughout the Western Hemisphere.

The implementation of strategies aimed at achieving these goals will be overseen by a national working group made up of partners committed to shorebird conservation. A science support team will ensure that actions are based on sound science and will address information gaps.

The migratory nature of shorebirds
The spectacular migrations of shorebirds are one of the greatest biological wonders of the world.

In the Americas, some species, such as the Red Knot *Calidris canutus*, migrate from one end of the hemisphere to the other, moving from breeding grounds in the Canadian Arctic to wintering grounds as far away as Tierra del Fuego at the southern tip of South America. A few populations breeding in the northeastern Canadian Arctic migrate to European wintering grounds, while some species of shorebirds in Alaska and some parts of the western Arctic migrate to wintering sites throughout the Pacific as far south as Australia.
Conserving these intercontinental migration systems, through preservation of the hemispheric mosaic of habitats and landscapes on which the birds depend, presents a tremendous conservation challenge at local, national, and international levels.

Shorebird species
While all shorebirds share the characteristic of being dependent on wetlands at some stage of their life cycles, they do in fact comprise a highly varied group. In Canada, 75 species have been recorded.
Of those 75 species, 47 species breed or occur regularly within our borders (Appendix 1). Taxonomically, these shorebirds are part of the Order Charadriiformes (shorebirds and seabirds) and include members in four shorebird Families:
• Charadriidae (Plovers): 7 species
• Haematopodidae (Oystercatchers): 2 species

• Recurvirostridae: (Avocets and Stilts): 2 species
• Scolopacidae: 36 species - includes Scolopacinae (Sandpipers and allies, 33 species) and Phalaropodinae (phalaropes, 3 species).

Declining populations
Today it is becoming more apparent that pressures from the increasing human use of land and resources are threatening shorebirds and their migration systems and that conservation measures are urgently needed.

Growing evidence gathered over the past 10–20 years indicates that many shorebird populations are in decline (Morrison et al. 2001a) .

Morrison et al. (2001) assessed population trends for 35 species of shorebirds across Canada, based on available data from a number of survey programs. Overall, of the 35 species of shorebirds covered by the analyses (Appendix 2), 28 (80%) were negative: this includes 17 species with statistically significant declines somewhere in their range, 2 showed persistent negative trends. Only one species showed a significant positive trend in part of its range. Many declines appear to be ongoing and widespread. Species such as the Semipalmated Sandpiper have shown significant declines in almost all major analyses that have been conducted. Short-billed Dowitchers, a boreal breeding species, have also shown persistent declines in eastern North America. Other species for which negative trends were suspected, such as the Red Knot, have now been shown to have statistically significant declines. Arctic breeding species such as the Sanderling and Ruddy Turnstone are also showing declining numbers. A major conservation concern exists for the Red-necked Phalarope, which has essentially disappeared from staging areas where it was once extremely numerous in the Bay of Fundy.

Declines have been noted for species using coastal sites and interior habitats, but seem to be most pronounced in the central and eastern areas of North America. No single cause has been found for these declines: a number of different factors are likely affecting shorebird populations such as wetland drainage, pollution, habitat loss and disturbance on the nesting grounds. Different species may be affected by a variety of factors, depending on their life history characteristics and migratory pathways. It is clear, however, that unless these trends are stopped or reversed, shorebirds are at risk.

Dowling, B. & Weston, M. (1999). Managing a breeding population of the hooded plover Thinornis rubricollis in a high use recreational environment. Bird. Conserv. Int. 9, 255–270.

Drake, K.R., J.E. Thompson, K.L. Drake, and C. Zonick. 2001. Movements, habitat use, and survival of nonbreeding Piping Plovers. Condor 103: 259–267.

We studied movements, habitat use, and survival rates of 49 radio-marked Piping Plovers (*Charadrius melodus*) overwintering along the southern Laguna Madre of Texas during 1997–1998. Plovers exhibited strong site fidelity to nonbreeding areas throughout fall, winter, and spring. Mean home-range size of plovers (based on 95% of locations) was 12.6 km^2 with a mean core area (50% of locations) of 2.9 km^2. Seasonal home-range size and core areas differed only between fall and winter; home-range and core areas were smaller in fall than winter. Mean linear distance moved was 3.3 km; fall movements were smaller than those made in winter and spring. Habitat use varied seasonally: plovers used algal flats more during fall and spring than during winter; plovers used exposed sand flats more often during winter than in fall and spring. We recorded no mortality of radio-marked birds. High rates of survival and strong site fidelity throughout the nonbreeding period suggest that this period of the annual cycle may not contribute to the declining population size for Piping Plovers wintering in this region. However, because Piping Plovers spend most of the annual cycle on nonbreeding areas, they are likely to be negatively affected by loss of those sites, emphasizing the importance of conserving nonbreeding areas for this threatened and endangered species.

Elias, S.P., J. D. Fraser, P. A. Buckley. 2000. Piping plover brood foraging ecology on New York barrier islands. Journal of Wildlife Management 64: 346-354.

Effective management of piping plover (Charadrius melodus) populations requires knowledge of the habitats that foster successful reproduction. We studied piping plover chick foraging ecology and survival on the central barrier islands of Long Island, New York, 1992 and 1993. Within the 90-km study area, all 1-km beach segments with ephemeral pools or bay tidal flats were used for nesting and brood rearing, whereas <50% of beach segments without these habitats were used. On beach segments with ephemeral pools, broods preferred ephemeral pools to ocean intertidal zone, wrack, backshore, open vegetation, and interdune habitat. Indices of terrestrial arthropod abundance and foraging rates were greater in ephemeral pools than in other habitats. In 1992, chick survival was higher on beach segments with ephemeral pools than on segments without ephemeral pools. On beach segments with bay tidal flats, broods preferred bay tidal flats and wrack to ocean intertidal zone, backshore, and open vegetation habitats. Foraging rates in bay tidal flats were

similar to those in ephemeral pools and greater than in open vegetation, wrack, and backshore habitats. On beach segments without ephemeral pools and bay tidal flats, broods preferred wrack to all other habitats, and open vegetation was second most preferred. To assist in the recovery of the piping plover, land-use planners should avoid beach management practices (e.g., beach filling, dune building, renourishment) that typically inhibit natural renewal of ephemeral pools, bay tidal flats, and open vegetation habitats.

Elias-Gerken, S.P. 1994. Piping plover habitat suitability on central Long Island, New York barrier islands. M.S. Thesis. Virginia Polytechnic Institute and State University, Blacksburg, Virginia. 48 pp.

Elliott-Smith, Elise and Susan M. Haig. 2004. Piping Plover (Charadrius melodus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/002

Ellison, L. N. and L. Cleary. 1978. Effects of human disturbance on breeding of Double-crested Cormorants. Auk 95: 510-517.

In 1975 and 1976, studies of the Double-crested Cormorant were conducted in the St. Lawrence Estuary to assess the influence of investigators visiting colonies during the breeding season. Frequent visits caused nest abandonment, gull predation, and discouraged late-nesting birds from settling in disturbed experimental colonies. Late clutch commencement was more prevalent in the relatively undisturbed controls. Birds were less susceptible to disturbance in the second year of study, but for some reason other than habituation. Received 10 March 1977, accepted 19 October 1977.

Elphick, Chris S. and T. Lee Tibbitts. 1998. Greater Yellowlegs (*Tringa melanoleuca*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/355

Erwin, R.M. 1996. Dependence of waterbirds and shorebirds on shallow-water habitats in the Mid-Atlantic coastal region: An ecological profile and management: Recommendations. Estuaries 19(2A): 213-219.

Waterbirds (waterfowl, colonially nesting wading and seabirds, ospreys [*Pandion haliaetus*], and bald eagles [*Haliaeetus leucocephalus*]) and shorebirds (sandpipers, plovers, and relatives) may constitute a large fraction of the toplevel carnivore trophic component in many shallow-water areas of the mid-Atlantic region. The large biomass of many species (>1 kg body mass for the two raptors and some waterfowl) and enormous populations (e.g.,>1 million shorebirds in late May in parts of Delaware Bay) reveal the importance of waterbirds as consumers and as linkages in nutrient flux in many shallow-water habitats. Salt and brackish marsh shallow-water habitats, including marsh pannes and tidal pools and creeks as well as constructed impoundments, are used intensively during most months of the year; in fall and winter, mostly by dabbling ducks, in spring and summer by migrant shorebirds and breeding colonial wading birds and seabirds. In adjacent estuaries, the intertidal flats and littoral zones of shallow embayments are heavily used by shorebirds, raptors, and colonial waterbirds in the May to September periods, with use by duck and geese heaviest from October to March. With the regional degradation of estuarine habitats and population declines of many species of waterbirds in the past 20 yr, some management recommedations relevant to shallow waters include: better protection, enhancement, and creation of small bay islands (small and isolated to preclude most mammalian predators) for nesting and brooding birds, especially colonial species; establishment of sanctuaries from human disturbance (e.g., boating, hunting) both in open water (waterfowl) and on land; better allocation of sandy dredged materials to augment islands or stabilize eroding islands; improvement in water management of existing impoundments to ensure good feeding, resting, and nesting opportunities for all the waterbirds; support for policies to preclude point and nonpoint source runoff of chemicals and nutrients to enable submerged aquatic vegetation to recover in many coastal bays; and improvement in environmental education concerning disturbance to wildlife for boaters and recreationists using the coastal zone.

Erwin, R. M. 1980. Breeding habitat use by colonially nesting waterbirds in two mid-Atlantic U.S. regions under different regimes of human disturbance. Biological Conservation 18: 39–51.

More than 80% of the beach-nesting seabirds (common tern, least tern, black skimmer, and herring gull) in coastal Virginia nest on natural barrier island beaches, while in New Jersey the vast majority nest on dredge deposition material or natural marsh islands. This contrast probably results from the differences in human disturbance in the two regions. Although 75% of all oceanfront in New Jersey allows unrestricted recreation, about 85% of the Virginia beaches are ‘protected’ under the ownership of several conservation agencies. Attendant with changes in habitat

utilisation in New Jersey, competitive interactions have apparently intensified with herring gulls usurping tern and laughing gull nest sites. Other implications are discussed.

Erwin, R. M. 1989. Responses to human intruders by birds nesting colonies: experimental results and management guidelines. Colonial Waterbirds 12:104–108.

Colonies of nesting wading birds and seabirds were studied at coastal sites in Virginia and North Carolina to determine distances at which birds flushed in response to human intrusion. Mixed colonies of Common Terns-Black Skimmers responded at the greatest distances, with respective means of 142 and 130 m; mixed wading bird species were more reluctant to flush (30-50 m average). The disturbance distances measured in this study are much greater than the 50 m guideline suggested in a 1976 National Park Service report. The author recommends distances of 100 m for Least and Royal Terns and wading birds and 200 m for Common Terns and Skimmers for sign-posting of established colonies. Greater distances will be necessary as a buffer before birds become established at a site.

Erwin, R. M., D. H. Allen, and D. Jenkins. 2003. Created verses natural coastal islands: Atlantic waterbird populations, habitat choices, and management implications. Estuaries 26: 949-955.

Nesting colonial waterbirds along the Atlantic Coast of the United States face a number of landscape-level threats including human disturbance, mammalian predator expansion, and habitat alteration. There have been changes from 1977 to the mid-1990s in use of nesting habitats and populations of a number of seabird species of concern in the region, including black skimmers *Rynchops niger* Linnaeaus, common terns *Sterna hirundo* Linnaeaus, gull-billed terns *Sterna nilotica* Linnaeaus, least terns *Sterna antillarum* Lesson, royal terns *Sterna maxima* Boddaert, and sandwich terns *Sterna sandvicensis* Cabot. These species form colonies primarily on the following habitat types: large, sandy barrier or shoal islands, natural estuarine or bay islands (mostly marsh) man-made islands of dredged deposition materials (from navigation channels), and the mainland. Significant changes in the use of the dredged material islands have occurred for these species in New Jersey and North Carolina, but not in Virginia. Population declines and changes in bird habitat use appear to be at least partially associated with the conditions and management of the existing dredged material islands, coastal policy changes associated with creating new dredged material islands, and competing demands for sand for beach augmentation by coastal communities. As these and other coastal habitats become less suitable for colonial waterbirds, other man-made sites, such as, bridges and buildings have become increasingly more important. In regions with intense recreational demands, coastal wildlife managers need to take a more aggressive role in managing natural and man-made habitats areas and as stakeholders in the decision-making process involving dredged materials and beach sand allocation.

Erwin, R. M., G. M. Haramis, D. G. Krementz and S. L. Funderburk. 1993. Resource protection for waterbirds in Chesapeake Bay. Environmental Management 17: 613-619.

Many living resources in the Chesapeake Bay estuary have deteriorated over the past 50 years. As a result, many governmental committees, task forces, and management plans have been established. Most of the recommendations for implementing a bay cleanup focus on reducing sediments and nutrient flow into the watershed. We emphasize that habitat requirements other than water quality are necessary for the recovery of much of the bay's avian wildlife, and we use a waterbird example as illustration. Some of these needs are: (1) protection of fast-eroding islands, or creation of new ones by dredge deposition to improve nesting habitat for American black ducks*(Anas rubripes)*, great blue herons*(Ardea herodias)*, and other associated wading birds; (2) conservation of remaining brackish marshes, especially near riparian areas, for feeding black ducks, wading birds, and wood ducks*(Aix sponsa)*; (3) establishment of sanctuaries in open-water, littoral zones to protect feeding and/or roosting areas for diving ducks such as canvasbacks*(Aythya valisineria)* and redheads*(Aythya americana)*, and for bald eagles*(Haliaeetus leucocephalus)*; and (4) limitation of disturbance by boaters around nesting islands and open-water feeding areas. Land (or water) protection measures for waterbirds need to include units at several different spatial scales, ranging from “points” (e.g., a colony site) to large-area resources (e.g., a marsh or tributary for feeding). Planning to conserve large areas of both land and water can be achieved following a biosphere reserve model. Existing interagency committees in the Chesapeake Bay Program could be more effective in developing such a model for wildlife and fisheries resources.

Erwin, R. M., J. D. Nichols, T. B. Eyler, D. B. Stotts, and B. R. Truitt. 1998b. Modeling colony-site dynamics: A case study of gull-billed terns (*Sterna nilotica*) in coastal Virginia. Auk 115: 970-978.

We developed a Markov process model for colony-site dynamics of Gull-billed Terns (Sterna nilotica). From 1993 through 1996, we monitored breeding numbers of Gull-billed Terns and their frequent colony associates, Common

Terns (Sterna hirundo) and Black Skimmers (Rynchops niger), at colony sites along 80 km of the barrier island region of coastal Virginia. We also monitored flooding events and renesting. We developed the model for colony survival, extinction, and recolonization at potential colony sites over the four-year period. We then used data on annual site occupation by Gull-billed Terns to estimate model parameters and tested for differences between nesting substrates (barrier island vs. shellpile). Results revealed a dynamic system but provided no evidence that the dynamics were Markovian, i.e. the probability that a site was occupied in one year was not influenced by whether it had been occupied in the previous year. Nor did colony-level reproductive success the previous season seem to affect the probability of site occupancy. Site survival and recolonization rates were similar, and the estimated overall annual probability of a site being occupied was 0.59. Of the 25 sites that were used during the four-year period, 16 were used in one or two years only, and only three were used in all four years. Flooding and renesting were frequent in both habitat types in all years. The frequent flooding of nests on shellpiles argues for more effective management; augmentation with shell and sand to increase elevations as little as 20 cm could have reduced flooding at a number of sites. The low colony-site fidelity that we observed suggests that an effective management approach would be to provide a large number of sand and/or shellpile sites for use by nesting terns. Sites not used in one year may still be used in subsequent years.

Erwin, R. M., and D. C. Smith. 1985. Habitat comparisons and productivity in nesting common terns on the mid-Atlantic coast. Colonial Waterbirds 8: 155-165.

Nesting Common Terns (*Sterna hirundo*) were studied at a number of barrier beaches and small islands of tidal salt marsh in New Jersey and the Eastern Shore of Maryland-Virginia from 1980 through 1982. Data were collected on clutch sizes, nest spacing, and nesting success. The principal null hypothesis tested was that no difference in reproductive success exists between beach and marsh habitats. Nests were monitored from egg-laying in mid-May until mid-July when young fledged. Clutch sizes varied among colonies and across years but no systematic effect of year, habitat, or colony size on mean clutch size per colony was detected. Analyses of nest productivity (estimated using both the Mayfield method and using a colony average) failed to reveal significant effects of habitat or colony size but showed a strong year effect. Storm tide flooding and egg chick disappearance (presumably predation by Herring Gulls *Larus argentatus* and Laughing Gulls *L. atricilla* nesting nearby) accounted for most nest failures. Losses due to both these mortality factors were unpredictable from year to year. Nest spacing in salt marsh colonies was much closer than it was on barrier beaches. In mixed- species colonies with Black Skimmers (*Rynchops niger*), distances between tern and skimmer nests were also much smaller in marsh colonies than they were on beaches. The limited amount of wrack (windrows of dead, matted vegetation) preferred by marsh-nesting terns probably explains these spacing differences. Several lines of evidence suggest that terns prefer beaches to marshes for nesting, however, the uncertainty of predation and flooding may often obscure any intrinsic differences in habitat quality. Long-term field studies are essential for testing hypotheses related to differential fitness of individuals among habitats.

Erwin, R. M. 1996. Dependence of waterbirds and shorebirds on shallow-water habitats in the Mid-Atlantic coastal region: An ecological profile and management recommendations. Estuaries and Coasts 19: 213-219.

Waterbirds (waterfowl, colonially nesting wading and seabirds, ospreys [*Pandion haliaetus*], and bald eagles [*Haliaeetus leucocephalus*]) and shorebirds (sandpipers, plovers, and relatives) may constitute a large fraction of the toplevel carnivore trophic component in many shallow-water areas of the mid-Atlantic region. The large biomass of many species (>1 kg body mass for the two raptors and some waterfowl) and enormous populations (e.g.,>1 million shorebirds in late May in parts of Delaware Bay) reveal the importance of waterbirds as consumers and as linkages in nutrient flux in many shallow-water habitats. Salt and brackish marsh shallow-water habitats, including marsh pannes and tidal pools and creeks as well as constructed impoundments, are used intensively during most months of the year; in fall and winter, mostly by dabbling ducks, in spring and summer by migrant shorebirds and breeding colonial wading birds and seabirds. In adjacent estuaries, the intertidal flats and littoral zones of shallow embayments are heavily used by shorebirds, raptors, and colonial waterbirds in the May to September periods, with use by duck and geese heaviest from October to March. With the regional degradation of estuarine habitats and population declines of many species of waterbirds in the past 20 yr, some management recommedations relevant to shallow waters include: better protection, enhancement, and creation of small bay islands (small and isolated to preclude most mammalian predators) for nesting and brooding birds, especially colonial species; establishment of sanctuaries from human disturbance (e.g., boating, hunting) both in open water (waterfowl) and on land; better allocation of sandy dredged materials to augment islands or stabilize eroding islands; improvement in water management of existing impoundments to ensure good feeding, resting, and nesting opportunities for all the waterbirds; support for policies to preclude point and nonpoint source runoff of chemicals and nutrients to enable submerged aquatic vegetation to recover in many coastal bays; and improvement in environmental education concerning disturbance to wildlife for boaters and recreationists using the coastal zone.

Erwin, R. M. 2005. Monitoring and protection protocols for colonially nesting waterbirds at Cape Hatteras National Seashore, North Carolina. USGS Patuxent Wildlife Research Center.

The Outer Banks region of North Carolina supports a large number of colonial waterbird species that depend upon its extensive sounds and the near-ocean waters for feeding, and relatively undisturbed islands (or portions thereof) for nesting (for example, see Parnell and Soots 1979 for one of the pioneering atlas projects on waterbirds in North Carolina). Many species of waterbirds are in jeopardy in the State, however (Parnell et al. 1977). Reasons for this are many: predation increases by mammals, competition with, and predation by, large gulls, especially herring gulls, *Larus argentatu*s, human development, beach stabilization, and recreational disturbances on the outer beaches (especially Cape Hatteras National Seashore [hereafter, CAHA] and villages north, as well as extreme southern North Carolina in the Wilmington region), and perhaps mortality on the wintering grounds (Parnell et al. 1977, 1995, Erwin 1994).

The colonially nesting species of most concern for CAHA include: gull-billed terns, *Sterna nilotica*, common terns, *S. hirundo*, least terns, *S. antillarum*, and black skimmers, *Rynchops niger*. Gull-billed terns are considered to be "Threatened" in North Carolina, while the other three are "Species of special concern" both to the North Carolina Wildlife Resources Commission (fide D. H. Allen, NCWRC) and to the National Park Service (S. Harrison, NPS, unpublished report). Numbers of most breeding birds within North Carolina have declined over the past 20-30 years for all of these species. During the period 1977 to 2004, Gull-billed terns declined from approximately 268 to only 99 pairs, common terns from 2760 to only 570 pairs, and black skimmers from 976 to 623 pairs; however, least terns increased from 1925 to 2408 pairs in the same period (NCWRC database, fide D. Allen).

At CAHA, recent nesting by these species has been rather limited relative to population levels from the 1970s (Table 1). The USGS Patuxent Wildlife Research Center developed this protocol, based on the best available scientific information, to guide management, monitoring and research activity at CAHA that would result in the protection and recovery of each species. These protocols do not attempt to balance the need for protection of these species with other activities that occur at CAHA, nor was NPS management policy considered in detail. A draft of the protocols was sent to species experts for scientific review; the final draft of protocols were reviewed by NPS personnel to ensure that description of recent management at CAHA was accurately represented and that the approach was consistent with our work agreement.

Erwin, R. M. 1977. Black skimmer breeding ecology and behavior. Auk 94: 709-717.

Black Skimmers arrive in their breeding colonies at approximately the same time as most of the terns, usually in late April or early May. They are commonly found in dense colonies on open sandy beaches in association with other seabirds, most frequently Common Terns in Virginia. The usual clutch size is large for a seabird (X = 3.6), with 4-egg clutches being most common. Incubation begins with the first egg laid. Hatching success was high (nearly 80%) in the colonies studied, but fledgling success was low in both 1973 (0.40 young per pair) and 1974 (0.37 young per pair). Probably food acts to limit production as 10 of the 11 surviving fledglings were the first hatched in the brood. Survival of 2nd, 3rd, and 4th hatchlings drops off precipitiously. Adult skimmers are sexually dimorphic, the male being approximately 1/4 larger than the female. Both parents incubate and share parental duties until fledging. The growth characteristics of the Black Skimmer appear to follow the logistic model developed by Ricklefs. Only after the midpoint of the fledging period (about 11 days) do male chicks begin to grow more rapidly than females. Male chicks fledged at an average of 295.2 g while females fledged at 264.4 g. Adults captured a fish approximately every 5 minutes. Most foraging was done at low tide in marsh habitats. No pulse of high-fishing activity at dawn and dusk was noted as has been reported in the literature. Birds foraged alone in most cases, except when the immatures begin fishing. Apparently learning occurs at this time. Each young was fed on the average of 0.43 fish/hour during the day; the low rate may largely explain the low fledging success in 1973-1974. The extent of nocturnal feeding requires investiga- tion. The diet consists of 100% fish, with silversides and killifishes predominating.-

Erwin, R. M., J. Galli, and J. Burger. 1981. Colony site dynamics and habitat use in Atlantic Coast seabirds. Auk 98: 550-561.

Seabird colony sizes and movements were documented in the DelMarVa coastal region in 1976-1977 and in New Jersey in 1978-1979. Most colonies were found on marsh and dredge deposition islands and on barrier island beaches. For the traditionally beach-nesting Herring Gull, Common Tern, and Black Skimmer, larger, more stable colonies were found on barrier beaches than on marsh islands. In marsh habitats, rates of colony-site change of marsh nesting Forster's Tern and Laughing Gulls were similar to those of the former beach nesters. Several adaptations have evolved in marsh specialists to cope with a high risk of reproductive failure due to flooding, but both Herring Gulls and Common Terns also appear to be very adaptable in nesting under various habitat conditions. New colonies and those abandoned between years may be pioneering attempts by younger or inexperienced birds, because they are often smaller than persistent colonies, although patterns differ among areas and habitats. Colony-site dynamics are complex and result from many selective factors including competition, predation, physical changes in site structure, and flooding. The invasion of Herring Gulls into marshes along the mid-Atlantic coast has had an impact on new colony-

site choice by associated seabirds. Calculating colony-site turnover rates allows for comparisons among species, habitats, and regions and may give useful insights into habitat quality and change and alternative nesting strategies. Received 10 November 1980, accepted 20 February 1981.

Erwin, R. M., B. R. Truitt, and J. E. Jimenez. 2001. Ground-nesting waterbirds and mammalian carnivores in the Virginia barrier island region: running out of options. Journal of Coastal Research 17: 292-296.

We examined changing patterns of distribution of two large mammalian predators, the raccoon (*Procyon lotor*) and red fox (*Vulpes vulpes*), and beach-nesting terns and Black Skimmers (*Rynchops niger*) along ca. 80 km of the Virginia barrier island landscape between the periods 1975-1977 and 1998. Based on evidence from trapping, scent stations, den observations and sightings of the two predators, there has been a marked increase in their island ranges. In 1975-77, only 6 of the 11 surveyed barrier islands definitely harbored at least one of the two mammals, but by 1998, 11 of 14 islands showed evidence of one or both during the spring and summer. Concurrently, annual beach-nesting bird surveys have been conducted since the mid 1970s during June. From 1977 to 1998, the number of colonies of terns [Common (*Sterna hirundo*), Gull-billed (*S. nilotica*), Least (*S. antillarum*), Royal (*S. maxima*), and Sandwich (*S. sandvicensis*)] and Black Skimmers declined from 23 colonies on 11 barrier islands to 13 colonies on 10 islands. In addition, the populations decreased dramatically for all species except the marginal Sandwich Tern and Least Tern. This pattern suggests that mammalian predation may be a major factor in colony site selection or success, although we have no data on success at most locations. The only consistently large colony over the years has been the Royal Tern colony on Fisherman Island, one of the few with no resident large mammals. Because these declining waterbirds appear to be running out of options for safe colony sites in coastal Virginia, we discuss the prospects of conducting limited predator removals on certain islands. In addition, considerations of strict management and enforcement of protection at critical manmade colony sites that now attract large numbers of certain species, are timely. Lastly, where dredged material disposal projects are planned, providing nesting sites for these colonial species and roosting sites for migrant birds may be appropriate.

Eyler, T. B., R. M. Erwin, D. B. Stotts, and J. S. Hatfield. 1999. Aspects of hatching success and chick survival in gull-billed terns in coastal Virginia. Waterbirds 22: 54-59.

Because of a long-term population decline in Gull-billed Terns (Sterna nilotica) nesting along the coast of Virginia, we began a three-year study in 1994 to monitor hatching success and survival of Gull-billed Tern chicks at several Virginia colony sites. Colonies were located on either small, storm-deposited shellpiles along marsh fringes or large, sand-shell overwash fans of barrier islands. Nests were monitored one to three times a week for hatching success, and enclosures were installed around selected nests to monitor chick survival from hatching to about two weeks of age. Hatching success was lower in marsh colonies than island colonies, and was lower in 1995 than in 1994 and 1996, primarily because of flooding. The average brood size of nests where at least one chick hatched was 1.99 chicks. Survival rates of chicks to 14 days depended on hatch order and year but not brood size (one vs. two or more) or time of season. First-hatched chicks had higher survival rates than second-hatched and third-hatched chicks (0.661 compared to 0.442 and 0.357, respectively). The year effect was significant only for first-hatched chicks, with lower survival in 1994 (0.50) than in 1995 (0.765) or 1996 (0.758). Overall, productivity was low (0.53 chick per nest) compared to estimates for colonies in Denmark and was attributable to nest flooding by spring and storm-driven high tides and chick predation, mostly by Great Horned Owls (*Bubo virginianus*).

Fernández-Juricic, E., Jimenez, M. D. and E. Lucas. 2001. Alert distance as an alternative measure of bird tolerance to human disturbance: implications for park design. Environmental Conservation 28:263-269.

Animal tolerance to human approaches may be used to establish buffers for wildlife that can minimize the probability that animals will be disturbed by human activity. Alert distance (the distance between an animal and an approaching human at which point the animal begins to exhibit alert behaviours to the human) has been proposed as an indicator of tolerance mainly for waterbirds; however, little is known about its utility for other bird species. The factors that influenced alert distances of four bird species to pedestrian approaches in five large wooded fragments in the city of Madrid (Spain) were analysed. Location of human activity affected only *Passer domesticus* alert distances, which increased in the proximity of pathways. Habitat structure modified alert distances of all the species (*Passer domesticus*, *Turdus merula*, *Columba palumbus*, and *Pica pica*), increasing bird tolerance with greater availability of escape cover (shrub and coniferous cover, and shrub height). Alert distances varied among species, with large species being less tolerant of human disturbance than small ones. Alert distance appears to be a more conservative indicator of tolerance than flight distances, because it includes a buffer zone (the difference between alert and flight distance) in which birds may adapt their reaction to the behaviour of visitors. Alert distance may be used in the determination of minimum

approaching areas, allowing people to enjoy their visit to parks, and birds to use patches for foraging and breeding without being displaced.

Finney, S. K., J. W. Pearce-Higginsand and D. W.Yalden. 2005. The effect of recreational disturbance on an upland breeding bird, the Golden Plover *Pluvialis apricaria*. Biological Conservation 121: 53–63.

The use of the countryside for recreation has increased dramatically in recent years. This has led to concern amongst conservationists about the effects increased human disturbance may have on important wild animal populations. In the UK, recent legislation has widened the level of access to upland habitats, which support internationally important breeding bird populations. Determining the extent to which recreational disturbance affects upland breeding birds is therefore a conservation priority. We used data collected over 13 years to investigate the impact of recreational disturbance on the distribution and reproductive performance of golden plovers breeding in close proximity to the Pennine Way, an intensively used long-distance footpath. Importantly, the Pennine Way was resurfaced in 1994 to prevent further erosion of the surrounding vegetation. We were therefore able to examine if the response of golden plovers to recreational disturbance was influenced by changes in the intensity and extent of human activity resulting from the resurfacing work. Before the Pennine Way was resurfaced, golden plovers avoided areas within 200 m of the footpath during the chick-rearing period. At this time over 30% of people strayed from the footpath and the movement of people across the moorland was therefore widespread and unpredictable. Following resurfacing, over 96% of walkers remained on the Pennine Way, which significantly reduced the impact of recreational disturbance on golden plover distribution; golden plovers only avoided areas within 50 m of the footpath at this time. Despite the clear behavioural responses of golden plovers to the presence of visitors, there was no detectable impact of disturbance on reproductive performance. In many countries, a conflict arises between the use of the countryside for recreational purposes and the protection of habitats or species of high conservation value. However, this study suggests that the implementation of simple measures to influence visitor behaviour can dramatically reduce the impact of recreational disturbance on wild animal populations.

Fitzpatrick S. and Bouchez B. 1998. Effects of recreational disturbance on the foraging behaviour of waders on a rocky beach. Bird Study 45: 157–171.

Oystercatcher *Haematopus ostralegus*, Curlew *Numenius arquata* and Redshank *Tringa totanus* reacted in a variety of ways to human disturbance. They delayed arrival and departed earlier when disturbed. Vigilance (scan rates) increased with the vigour of human activity and the birds were more vigilant in the higher shore zones, but there was no corresponding decrease in food searching (peck rates). Prey capture rates of Oystercatcher and Curlew apparently increased with moderately close human disturbance. Undisturbed birds may not have been foraging at maximum rates and rested periodically during the low tide period. Characteristic avoidance behaviour elicited by disturbance differed between the species; Curlew and Redshank typically stopped feeding and, if they left, flew away, whereas Oystercatcher walked away. This difference may be related to plumage crypsis. Flight distances of all species were very low. Habituation may be an important response to regular but benign disturbance, reducing the disturbance-induced decrease in feeding time to a level which may be compensated for, at least in summer, within the normal low-tide foraging period.

Flemming, S. P., R. D. Chiasson, P.C. Smith, P. J. Austin-Smith and R. P. Bancroft. 1988. Piping Plover status in Nova Scotia related to its reproductive and behavioral responses to human disturbance. Journal of Field Ornithology 59: 321-330.

Piping Plover (*Charadrius melodus*) censuses and behavioral observations w ere made in Nova Scotia t o assess the species status a nd its responses to human disturbance. The population declined from 1983 (66-71 pairs) to 1987 (48-54 pairs) at a rate of 3.3- 5.8 pairs/yr. Increased disturbance resulted i n fewer chicks surviving to age 17 d. Disturbed chicks exhibited decreased feeding and brooding, and increased sitting and vigilance. W hen feeding d id occur, it was at a reduced r ate. By altering chick behavior, disturbance may have caused increased chick mortality and subsequently contributed to the declining n umbers in Nova Scotia. Human disturbance may be an important component of the species population decline throughout its range.

Fraser, J. D., S. E. Keane, and P. A. Buckley. 2005. Prenesting use of intertidal habitats by Piping Plovers on South Monomoy Island, Massachusetts. Journal of Wildlife Management 69: 1731-1736.

On barrier islands, piping plovers commonly select nest sites adjacent to bay-side intertidal flats, pools, or other moist substrates that are protected from ocean waves (Patterson et al. 1991, Elias et al. 2000, Keane 2002). During the fledging period, these areas often support more terrestrial arthropods than adjacent ocean beaches (Loegering and Fraser 1995, Elias et al. 2000). Plover chicks in these areas typically forage at higher rates, and they often have higher

survival rates than chicks foraging exclusively on back- shore and ocean intertidal areas (Loegering and Fraser 1995, Elias et al. 2000). In some places, however, piping plovers nest near protected moist substrates even though physical barriers prevent broods from reaching them (Patterson et al. 1991, Loegering and Fraser 1995, Keane 2002). This suggests that nesting near protected moist substrates is adaptive for adults even if their hatchlings cannot forage there until they fledge.

One possible value of selecting nest sites near protected moist substrates is that these areas may provide a reliable food supply for adults prior to nesting. Protected sandflats, mudflats, and algal flats (sandflats with dense Lyngbya spp.) are frequently used by piping plovers wintering in southeast Atlantic and Gulf Coast sites (Johnson and Baldassarre 1988, Nicholls and Baldassarre 1990, Drake et al. 2001). Marine organisms such as polychaetes, mollusks, and crustaceans are common prey in these zones (Bent 1929, Johnson and Baldassarre 1988, Nicholls 1989). In contrast, during the brood rearing period, piping plovers may consume a higher proportion of terrestrial invertebrates including dipterans and coleopterans (Shaffer and Laporte 1994). When piping plovers arrive on northern beaches in mid-March (Keane 2002) these terrestrial invertebrates are relatively scarce (L. M. Houghton, Virginia Tech, unpublished data). Thus, the marine organisms obtained on intertidal flats may be particularly important at this time. Nesting near inter- tidal flats may allow piping plovers to minimize time and energy expended while traveling to feeding areas. This may allow them to spend more time and energy on maintenance, survival, courtship, territorial defense, and egg production.

Intertidal flats and ponds appear to be diminishing resources. They are created when ocean storm waves move across (overwash) barrier islands scouring sand from some areas and depositing it in others (Leatherman 1982) but the frequency of overwashes has been reduced by coastal engineering (Dean 1999). It is important, therefore, to understand the full range of ecological values these zones provide so that the impacts of coastal engineering and habitat management can be accurately evaluated.

We studied plover foraging ecology before nesting on South Monomoy Island, Massachusetts, in 1999 and 2000, to test the hypothesis that intertidal flats and ponds are key piping plover foraging habitats in the weeks prior to nesting. We compared use and availability of different substrates and the foraging rates of plovers within each.

Management Implications.-The tidal flats and ponds selected by piping plovers were created during storm-caused overwash or other erosional processes (Leatherman 1982). Beach management efforts aimed at protecting human property reduce the number and extent of these overwashes (Dean 1999) and therefore reduce the extent of key intertidal foraging habitats. Piping plover management can be improved by increasing the number and size of bayside intertidal flats either by allowing their formation by natural processes or by active sediment management.

Frid, A., and L. M. Dill. 2002. Human-caused disturbance stimuli as a form of predation risk. Conservation Ecology 16. ,http://www. ecologyandsociety.org/vol6/iss1/. Accessed 2003 Oct 10.

A growing number of studies quantify the impact of nonlethal human disturbance on the behavior and reproductive success of animals. Although many are well designed and analytically sophisticated, most lack a theoretical framework for making predictions and for understanding why particular responses occur. Behavioral ecologists have recently begun to fill this theoretical vacuum by applying economic models of antipredator behavior to disturbance studies. In this emerging paradigm, predation and nonlethal disturbance stimuli create similar trade-offs between avoiding perceived risk and other fitness-enhancing activities, such as feeding, parental care, or mating. A vast literature supports the hypothesis that antipredator behavior has a cost to other activities, and that this trade-off is optimized when investment in antipredator behavior tracks short-term changes in predation risk. Prey have evolved antipredator responses to generalized threatening stimuli, such as loud noises and rapidly approaching objects. Thus, when encountering disturbance stimuli ranging from the dramatic, low-flying helicopter to the quiet wildlife photographer, animal responses are likely to follow the same economic principles used by prey encountering predators. Some authors have argued that, similar to predation risk, disturbance stimuli can indirectly affect fitness and population dynamics via the energetic and lost opportunity costs of risk avoidance. We elaborate on this argument by discussing why, from an evolutionary perspective, disturbance stimuli should be analogous to predation risk. We then consider disturbance effects on the behavior of individuals—vigilance, fleeing, habitat selection, mating displays, and parental investment—as well as indirect effects on populations and communities. A wider application of predation risk theory to disturbance studies should increase the generality of predictions and make mitigation more effective without over-regulating human activities.

Gabrielson , G. W. and E. N. Smith. 1995. Physiological responses of wildlife to disturbance. Pages 95-107 *in* R. L. Knight and K. J. Gutzwiller, ed. Wildlife and Recreationists: coexistence through management and research. Island Press, Washington, D. C. 372pp.

Outdoor recreation has historically been viewed as an environmentally benign activity. Yet with growing numbers of recreationists visiting public lands, and with a greater understanding of the role of public land in safeguarding biodiversity, it is becoming apparent that the effects of recreation on both the environment and wildlife are chronic and pervasive. Wildlife and Recreationists defines and clarifies the issues surrounding the conflict between outdoor recreation and the health and well-being of wildlife and ecosystems. The book is a valuable synthesis of what is known concerning wildlife and recreation. More important, it addresses both research needs and management options to minimize conflicts.

Gill, J. A., W., Sutherland and A. R. Watkinson. 1996. A method to quantify the effects of human disturbance on animal populations. Journal of Applied Ecology 33:786-792.

Human disturbance of wildlife is widely considered to be a serious conservation problem. However, despite many qualitative studies, little attempt has been made to assess whether human presence limits the number of animals that sites can support. This can be quantified by incorporating measures both of human presence and of resource distribution into analyses of population distribution. The effects of disturbance can then be measured from any reduction in resource use at disturbed sites, which in turn indicates any reduction in the number of animals supported. Shorebirds are often considered highly susceptible to disturbance because of their very obvious flight responses to humans and because they use areas that are generally subject to high levels of human recreational use.
This study addressed the effect of human presence on the distribution of black-tailed godwits Limosa limosa islandica on coastal areas in eastern England. We identified the prey types selected by godwits and related their depletion to different levels and types of human disturbance at a range of spatial scales.
Three methods of analysis are described: simple regressions of the effect of human activity on the number of godwits supported; multiple regression analyses of the effect of human presence and prey density on godwit numbers; and analyses of the effect of human presence on prey density at the end of the season. The latter method assumes that godwits are responsible for the majority of resource depletion. None of the analyses showed any effect of human presence on the number of godwits supported by the food supply at any of the spatial scales examined.
Many species may appear to avoid human presence but this may not reduce the number of animals supported in an area. Assessing the influence of disturbance on the relationship between animal distribution and resource distribution provides a means of assessing whether numbers are constrained by disturbance.

Gill, J. A., K. Norris and W. J. Sutherland. 2001. Why behavioral responses may not reflect the population consequences of human disturbance. Biological Conservation 97: 265–268.

The effect of human disturbance on animals is frequently measured in terms of changes in behaviour in response to human presence. The magnitude of these changes in behaviour is then often used as a measure of the relative susceptibility of species to disturbance; for example species which show strong avoidance of human presence are often considered to be in greater need of protection from disturbance than those which do not. In this paper we discuss whether such changes in behaviour are likely to be good measures of the relative susceptibility of species, and suggest that their use may result in confusion when determining conservation priorities.

Gochfeld, M. 1983. Colony site selection by Least Terns: Physical attributes of sites. Colonial Waterbirds 6: 205-213.

Abstract.-I examined physical characteristics of sites occupied by Least Tern (*Sterna antillarum*) colonies on Long Island, New York, in comparison to sites without colonies. Contrary to historical records most Least Terns were found on broad sand flats or small rounded areas (knobs) adjacent to inlets, rather than close to the high tide line on long stretches of beach. This habitat shift is related to overall changes in habitat availability. Humans have usurped most beaches with extensive recreational use, off-road vehicle traffic, and construction. Conversely, man -modified sites suitable for nesting have been created by deposition of dredged soil. In 1976, 98% of Least Tern colonies were on sites that had been graded excellent or good quality in 1975. Although only 48% were on sites more or less free from human disturbance, there was nonetheless a statistically significant preference for sites either remote from human use areas or with little evidence of off-road vehicular traffic. Although social factors and previous experience are of importance in influencing where a Least Tern will nest in a given year, it is possible to predict the Suitability of sites for Least Terns based on estimates of physical Quality (e.g., size, shape, slope, substrate, vegetation), and Availability (freedom from human disturbance). Semiquantitative estimates of Quality and Availability were used to produce a composite Suitability score. Least Terns nested on 67% of the highly suitable, but only 17% of the poorly suited sites. Because of the shortage of suitable undisturbed nesting sites, Least Terns now occupy sites that are suitable in every respect except for a high prevalence of off-road vehicle tracks or other disturbance.

Gochfeld, M. and J. Burger. 1994. Black Skimmer (*Rynchops niger*). *In* The Birds of North America, No. 108 (A. Poole and F. Gill, Eds.). Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union.

Godfrey, P., S. Leatherman, and P. Buckley. 1978. Impact of offroad vehicles on coastal ecosystems. Pages 581-600 *in* Proceedings of the Symposium on Technical, Environmental, Socio-economic and Regulatory Aspects of Coastal Zone Planning and Management 1978. San Francisco, CA.

Goldin, M. R. 1993. Effects of human disturbance and off-road vehicles on piping Plover reproductive success and behavior at Breezy Point, Gateway National Recreation Area, New York. MS Thesis. University of Massachusetts, Amherst, Massachusetts. 128 pp.

Goldin, M. R. and J. V. Regosin. 1998. Chick behavior, habitat use, and reproductive success of piping plovers at Goosewing Beach, Rhode Island. Journal of Field Ornithology 69: 228-234.

Abstract.--We studied Piping Plovers (*Charadrius melodus*) at Goosewing B each, Rhode Island during 1993 and 1994. Broods with access to salt-pond mudflat habitat experienced higher fledging success (3 .0 fledglings/brood) than broods limited to ocean beachfront habitat (1.4 fledglings/brood). This difference may be attributed to greater survivorship among chicks with access to mudflat habitat. Broods using pond shore mudflat habitat spent less time responding to human disturbance (1.6%) than chicks u sing ocean beach front habitat (17.0%). The difference in time spent feeding between pond shore (77.5%) and ocean beachfront (51.2%) habitats approached statistical significance S. alt pond water levels w ere artificially manipulated t o increase availability o f mudflat habitat f or plover chicks, though the effect of such manipulation on Piping Plover reproductive success remains unclear.

Goss-Custard, J.D., 2003. Fitness, demographic rates and managing the coast for shorebird populations. Wader Study Group Bulletin 100, 183–191. Goss-Custard, J.D., Durell, S.E.A. le

Goss-Custard, J.D., P. Triplet, F. Sueur, A.D. West. 2006. Critical thresholds of disturbance by people and raptors in foraging wading birds. Biological Conservation 127: 88-97.

Intertidal areas support during the non-breeding season many wading birds Charadrii that may often take flight in response to the presence of people or of birds of prey on their intertidal feeding and roosting grounds. Disturbance can cause birds to spend energy flying away and to lose feeding time while relocating to different feeding areas, where the increased bird densities may intensify competition from interference and, if of sufficient duration, from prey depletion. Until now, there has been no method for establishing how frequently birds can be put to flight before their fitness is reduced. We show how individual-based behavioural models can establish critical thresholds for the frequency with which wading birds can be disturbed before they die of starvation. It uses oystercatchers *Haematopus ostralegus* in the baie de Somme, France where birds were put to flight by disturbance up to 1.73 times/daylight hour. Modelling shows that the birds can be disturbed up to 1.0–1.5 times/h before their fitness is reduced in winters with good feeding conditions (abundant cockles *Cerastoderma edule* and mild weather) but only up to 0.2–0.5 times/h when feeding conditions are poor (scarce cockles and severe winter weather). Individual-based behavioural models enable critical disturbance thresholds to be established for the first time.

Goss-Custard, J.D., and N. Verboven. 1993. Disturbance and feeding shorebirds on the Exe estuary. Wader Study Group Bull. 68: 59-66.

The effects of disturbance on shorebirds wintering on the Exe estuary are reviewed. The local level of disturbance varies according to access and habitat type. Most people occur in sandy areas where, at low water, only a minority of the birds of most species feed. By the time most people arrive on the receding tide, most birds have moved to their muddy low water feeding areas where they are little disturbed. Disturbance can be intense on the third major habitat, the mussel beds, where the most numerous shorebird is the Oystercatcher. However, disturbance levels vary greatly between mussel beds, according to access. Few Oystercatchers feed on two small intensively disturbed beds. Disturbance is also common on two large beds near Cockwood and Exmouth and can reduce the rate at which the most vulnerable Oystercatchers feed by as much as 33-50%. However the overall effect is much lower because so much feeding occurs when people are not present (on neap tides; at night; on the receding and advancing tides). The birds also adapt to disturbance by habituating to the presence of stationary people, by moving to other less disturbed mussel beds, or by rescheduling their feeding routine during the tidal cycle The increasing levels of disturbance over the last 10-15 years may have caused some redistnbution of birds between beds, with many birds leaving t he most intensively disturbed areas at Cockwood. Yet numbers have increased considerably on the beds at Exmouth which are also frequently disturbed. However here is no evidence that the total number of Oystercatchers on the mussel beds over

the whole estuary have been reduced by the rising levels of disturbance, their numbers have increased in line with the rise in the whole British wintering population over the same period.

Gratto-Trevor, Cheri L. 2000. Marbled Godwit (Limosa fedoa), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/492

Gratto-Trevor, Cheri L. 1992. Semipalmated Sandpiper (Calidris pusilla), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/006

Gutzwiller, K. J. 1995. Recreational disturbance and wildlife communities. p. 169-181, IN: R. L. Knight and K. J. Gutzwiller eds. Wildlife and Recreationists. Island Press, Washington, D. C.

Outdoor recreation has been recognized as an important factor that can reduce biosphere sustainability (Lubchenco et al. 1991, Fig. 4; 1993, Box 1). Indeed, recreational activities, including many that seem innocuous, can alter vertebrate behaviour, reproduction, distributions, and habitats (see review by Boyle and Samson 1985). Recreational disturbance is quickly becoming a dominant structuring force in many wildlife communities, and projections indicate that the frequency and geographic extent of such disturbance will continue to increase in natural landscapes in the years ahead (see Chapter 1; Purdy et al. 1987; Holecek 1993).

Our understanding of how recreational activities influence communities is just developing. Until recently, investigators have focused primarily on how recreationists influence wildlife at the levels of individuals, family groups, and populations. Only a few studies to date have addressed issues important for understanding the effects of recreationists on community structure and dynamics. Accordingly, many of community-level questions remain unanswered. Until the influences of recreationists on wildlife, at the community level, are better understood, efforts to achieve and sustain the coexistence of recreationists and intact wildlife communities will not be successful. My objectives here are to: (1) describe what is presently known about the influences of recreationists on wildlife communities; (2) suggest management strategies by which recreationists and wildlife communities can coexist; (3) identify major voids in our knowledge about recreational impacts on wildlife communities; and (4) recommend research approaches that will help fill these gaps.

Haig, S. M., C. L. Ferland, F. J. Cuthbert, J. Dingledine, J. P. Goossen, A. Hecht, and N. McPhillips. 2005. A complete species census and evidence for regional declines in Piping Plovers. Journal of Wildlife Management 69: 160-173.

Complete population estimates for widely distributed species are rarely possible. However, for the third time in 10 years, an International Piping Plover (*Charadrius melodus*) Breeding and Winter Census was conducted throughout the species range in 2001. Nearly 1,400 participants from 32 U.S. states and Puerto Rico; 9 Canadian provinces; St. Pierre and Miquelon, France; Cuba; and the Bahamas visited 2,244 sites covering 11,836 km of shoreline habitat. During the winter census, 2,389 piping plovers were observed at 33.5% of potentially occupied sites (n = 352). Of these, 56.8% had ≤ 10 birds present. The breeding census recorded 5,945 adults at 777 of 1,892 sites surveyed. More than 80% of sites with piping plovers present had ≤ 10 birds. Results indicated an 8.4% increase from 1991 but only a 0.2% increase since 1996. Regional trends suggest that since 1991, number of breeding birds increased on the Atlantic Coast by 78% (2,920 birds; 12.4% increase since 1996) and by 80% in the Great Lakes (72 birds; 50% increase since 1996). However, plovers declined 15% (2,953 birds; 10% decline since 1996) in Prairie Canada/U.S. northern Great Plains. Subregional trends since 1991 reflect a 32.4% decline in Prairie Canada (972 birds; 42.4% decline since 1996), a 2.5% decline in the U.S. northern Great Plains (1,981 birds; 24% increase since 1996), 5.5% decline in eastern Canada (481 birds; 14% increase since 1996), although a 66.2% increase on the U.S. Atlantic Coast (2,430 birds; 12% since 1996). While numbers were down in much of the U.S. northern Great Plains since 1996, an increase (460%, 1,048 birds; 67.7% increase since 1991) was detected on the Missouri River. Results from 3 complete species census efforts provide essential data for conservation planning and assessment and illustrate the utility of global censuses for species of concern.

Haig, S. M., and E. Elliott-Smith. 2004. Piping Plover. *The Birds of North America Online*. (A. Poole, Ed.) Ithaca: Cornell Laboratory of Ornithology; Retrieved from The Birds of North American Online database: http://bna.birds.cornell.edu/BNA/account/Piping_Plover/.

Haig, S. M. and L. W. Oring. 1985. The distribution and status of the piping plover throughout the annual cycle. Journal of Field Ornithology 56: 334-345.

The distribution and status of Piping Plovers was defined via coordination of researchers and agencies throughout the species annual range. While there is no doubt variation among censusers and/or single census data points can be quite limiting, until now there has been little baseline information that allows for assessment of population stability at the species level. Continued search for birds in prairie breeding areas, on migration, and during winter will clarify trends initially observed.

Haig, S.M. and L.W. Oring. 1988a. Distribution and dispersal in the Piping Plover. Auk 105: 630–638.

Individually marked Piping Plovers (*Charadrius melodus*) were studied from 1981-1987 in Manitoba and Minnesota relative to dispersal patterns of age and sex classes. Unlike monogamous passerines, males returned to former breeding sites only slightly more often than females. Dispersal distances did not differ between the sexes. Across North America, 24-69% of adults exhibited breeding-site fidelity, a variability equivalent to that among species of migratory shorebirds. Distribution of Piping Plover habitat across the species range accounts for some of this variability: birds used local sites if they were available, rather than disperse long distances. Similar to most migratory shorebirds, few (1.6-23%) Piping Plover chicks returned to natal sites to breed. No difference was found in return patterns between first-year males and females, nor in distances either sex dispersed from natal sites. First-year birds were found in the vicinity of their natal sites when habitat was available. During winter, birds from the Northern Great Plains and Great Lakes were seen primarily in mixed population flocks on the Gulf of Mexico. Piping Plovers from Atlantic coast breeding areas wintered further south on the Atlantic. Received 27 November 1987, accepted 19 April 1988.

Haig, S. M. and L. W. Oring. 1988. Mate, site, and territory fidelity in Piping Plovers. Auk 105: 268-277.

Breeding-site fidelity, territory retention, and mate fidelity were examined in a color-banded population of monogamous Piping Plovers (*Charadrius melodus*) breeding at five focal sites in southern Manitoba from 1981 to 1986. Frequent nest destruction by predators and storms provided numerous opportunities for birds to change mates and territories during and among breeding seasons. Between years approximately 70% of surviving adults were site faithful. Males did not return significantly more often than females, and both sexes returned regardless of previous reproductive success. Although former mates were present in subsequent years, 30 of 37 birds changed mates. Birds that changed mates from the previous year and whose mates were present in subsequent years had experienced poorer hatching success the previous season than those that retained mates. Birds that retained mates did not improve their reproductive success over the previous year.After nest destruction during the breeding season, most adults kept mates (34/52 pairs) but changed territories. Birds changed territories significantly more often, and moved significantly farther, following nest destruction by storm than following predation. Birds that retained mates during the breeding season fledged more chicks than those that changed. Received 5 June 1987, accepted 19 November 1987.

Haig, S. M. and J.H. Plissner. 1993. Distribution and abundance of piping plovers: Results and implications of the 1991 International census. Condor 95: 145-156.

Assessing status and recovery of the endangered Piping Plover (*Charadrius melodus*) requires knowledge of the species' current distribution and abundance throughout the annual cycle. To address this issue, over 1,000 biologists and volunteers from 10 nations collaborated in the 1991 International Piping Plover Census. Approximately 2,099 sites were censused yielding the highest number of breeding (5,482 adults) and wintering (3,451 birds) Piping Plovers ever recorded. Most winter birds occurred in Texas (55%) and along other United States Gulf Coast sites (93%). Among winter birds, 51% used ocean beaches, 43% used sand or algal flats in protected bays, and 6% used areas where protected bays met ocean beaches. Breeding birds were widely distributed in small populations in the Northern Great Plains/Prairie (63.2%) and on the Atlantic Coast (36%). Few birds (N = 39) remain on the Great Lakes. Habitat use among breeding birds varied considerably across the species range. While most Atlantic (93.9%) and Great Lakes (100%) birds used sandy beaches, 59.6% of Northern Great Plains/Prairie birds used shorelines around small alkaline lakes, 18.2% used large reservoir beaches, 19.9% used river islands and adjacent sand pits, 2% used beaches on large lakes, and 0.4% used industrial pond shorelines. Change in status from previous censuses was difficult to determine. New populations were found in Montana, Colorado, and Saskatchewan, Canada; however, the distribution gap between Atlantic and Northern Great Plains/Prairie Piping Plover distribution grows as numbers decline in Minnesota; Manitoba, Canada; and the Great Lakes. Repeated inter- national censuses every five years and a better assessment of reproductive success in local populations will help determine future population trends for the species.

Hand. J.L. 1980. Human disturbance in Western Gull *Larus accidentalis livens* colonies and possible amplification by intraspecific predation. Biological Conservation 18: 59-63.

Indirect evidence is presented that human disturbances are having a profound effect on reproductive efforts of *Larus occidentalis livens* at several colonies in the Gulf of California. Breeding adults that lose their eggs or chicks apparently practise conspecific predation whether or not humans are present, thus increasing effects of human intrusions. These combined effects could lead to a severe decline in numbers or even pose a threat to the survival of this endemic population, if human disturbance is widespread. Attempts to assess breeding success throughout the Gulf seem warranted and, if necessary, some action to regulate human contact may be essential.

Harrington, Brian A. 2001. Red Knot (Calidris canutus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/563

Harrington, B. A., J. M. Hagan, and L. E. Leddy. 1988. Site fidelity and survival differences between two groups of New World red knots *Calidris canutus*. Auk 105: 439-445.

During the boreal winter, New World Red Knots (*Calidris canutus rufa*) principally occupy two areas widely separated in latitude. The larger group of approximately 100,000 birds is distributed along the Patagonian Atlantic coast, the smaller group of about 10,000 along Florida's Gulf coast. Resightings of banded individuals showed no interchange between these groups. The annual survival rate of knots marked in Florida is twice that of marked knots that winter in Patagonia. During northward migration Florida knots were sighted significantly less often at a major New Jersey stopover site than knots marked in Argentina. Whether this segregation is maintained during the breeding season is unknown. Wing and culmen lengths did not differ between the groups. The higher survival of individuals from the smaller Florida group, which presumably migrates a much shorter distance than the Argentina birds, runs counter to current evolutionary theories on the benefits of migration.

Harrington, B.A., & Drilling, N. 1996. Investigations of effects of disturbance to migratory shorebirds at migration stopover sites on the U.S. Atlantic Coast. Contract report to U.S. Fish & Wildlife Service, Region V, Nongame Program. 87pp.

Harrington, B. A. 2003. Shorebird management during the non-breeding season – an overview of needs, opportunities, and management concepts. Wader Study Group Bull. 100: 59-66.

In the United States, as in most other parts of the world, vast areas of wetlands have been lost and many shorebird species are in decline. I highlight opportunities to manage the wetlands that remain for shorebirds. In the US, many of these are already wildlife management areas. In marine wetlands, probably the greatest problem is chronic human disturbance and I suggest ways in which this might be mitigated. For nonmarine wetlands, I suggest a range of management prescriptions. The most important of these are those designed to increase the availability of invertebrate food supplies, such as managing water levels and increasing organic inputs.

Haysmith, L. and J. D. Hunt. 1995. Nature tourism: impacts and management. Pages 203-219 *in* R. L. Knight and K. J. Gutzwiller, ed. Wildlife and Recreationists: coexistence through management and research. Island Press, Washington, D. C. 372pp.

Outdoor recreation has historically been viewed as an environmentally benign activity. Yet with growing numbers of recreationists visiting public lands, and with a greater understanding of the role of public land in safeguarding biodiversity, it is becoming apparent that the effects of recreation on both the environment and wildlife are chronic and pervasive. Wildlife and Recreationists defines and clarifies the issues surrounding the conflict between outdoor recreation and the health and well-being of wildlife and ecosystems. The book is a valuable synthesis of what is known concerning wildlife and recreation. More important, it addresses both research needs and management options to minimize conflicts.

Hecker, S. 2008. The Piping Plover as an Umbrella Species for the Barrier Beach Ecosystem. Pages 59-74 *in* Saving Biological Diversity Balancing Protection of Endangered Species and Ecosystems, Robert A. Askins, Glenn D. Dreyer, Gerald R. Visgilio and Diana M. Whitelaw (eds.). Springer Science.

Conservation of federally threatened Piping Plovers (*Charadrius melodus*) on the Atlantic Coast has contributed greatly to the overall conservation of the barrier beach ecosystem. From the northernmost nesting pairs in maritime Canada to

the southernmost wintering individuals in the Caribbean islands, biologists deploy above average resources and effort to locate, map, and conserve this species and its habitats. Efforts to protect Piping Plovers benefit other beach-nesting birds, migrating and wintering shorebirds, threatened and endangered species, and barrier beach fauna and flora. Over the past twenty or more years of targeted Piping Plover conservation efforts, both the target species and its associates have increased dramatically at key sites throughout its range. The history of Piping Plover and barrier beach conservation in Massachusetts and the management techniques developed there serve as a model for the National Audubon Society's Coastal Bird Conservation Program as it promotes and develops similar conservation measures for beach-nesting birds and barrier beach habitats throughout North America.

Helmers, D. L. 1992. Shorebird Management Manual. Western Hemisphere Shorebird Reserve Network, Manomet, Massachusetts.

Hernández, D. 2005. Conservation and Foraging Dynamics of Migratory Shorebirds. Unpublished Ph.D Dissertation. Rutgers University, New Brunswick, New Jersey. 176 pp.

Holmes, Richard T. and Frank A. Pitelka. 1998. Pectoral Sandpiper (*Calidris melanotos*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/348

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Hoopes E.M. 1993. Relationships between human recreation and piping plover foraging ecology and chick survival. MS Thesis, University of Massachusetts, Amherst, Massachusetts, 106 pp.

Hoopes, E.M. 1994. Breeding ecology of piping plovers nesting at Cape Cod National Seashore - 1994. National Park Service, South Wellfleet, Massachusetts. 34 pp.

Piping Plovers were monitored at 9 study beaches by the National Park Service at Cape Cod National Seashore. Observations of plovers began in early April and continued through August. Egg-laying began the third week of April and peak nesting occurred in mid-June. This year, 72 pairs of plovers were observed at the 9 beaches. This represents an increase of 12 (20%) pairs from 1993. Twenty-six and 46 pairs of plovers were observed in the South and North Districts, respectively. Hatching success was 67% (range 43% - 78%). Fledging success was 79% (range 53%-100%). Productivity was 2.5 fledged chicks/pair (Range 1.6 fledged chicks/pair to 3.5 fledged chicks/pair). Thirty-eight percent of all nests initiated (n=105) failed to hatch at least one egg. Overwash was the leading cause of failure, accounting for 48% (n=19) of all nests lost. Predator exclosures were installed around 76% (n=80) of all nests. Eighty percent (n=64) of exclosed nests successfully hatched. In contrast, 9% (n=2) of unexclosed nests successfully hatched. Berm habitat was used as nesting habitat by plovers 43% of the time. This year, 22 pairs of plovers nested in the off-road vehicle (ORV) corridor. AS these nests hatched, affected sections of the ORV corridor were closed. Maximum closures occurred in late June and July, when the majority (70%) of the Race Point North and South (90%) beaches were closed for approximately 1.5 months and 1 month, respectively. By 8 August, the entire ORV corridor was opened, 9 days earlier than in 1993.

Hoopes, E.M. 1995. Piping plover nest distribution with respect to concrete walkways at the Breezy Point Cooperative, New York, 199 1-1994. Report for the U.S. Fish and Wildlife Service, Sudbury, Massachusetts. 6 pp.

Hoopes, E.M., C.R. Griffin, and SM. Melvin. 1989. Atlantic Coast Piping Plover winter distribution survey. Unpublished report to the U.S. Fish and Wildlife Service, Newton Corner, Massachusetts. 6pp.

Hoopes, E.M., C.R. Griffin, and SM. Melvin. 1991. Relationships between human recreation and piping plover foraging ecology and chick survival. Unpublished report. University of Massachusetts, Amherst, Massachusetts. 77 pp.

We examined piping plover (*Charadrius melodus*) foraging ecology and activity budgets at six sites, four on Outer Cape Cod and two in Bristol County, MA, during two field seasons (1988-1989). Study emphasis was placed on assessing the relationships between human disturbance and plover foraging ecology and

chick survival Adult plovers and chicks spent a majority (70% and 75% respectively) of their time in feeding and maintenance activities. Feeding and maintenance activities occurred in all habitats but feeding occurred most frequently in intertidal, wrack, and mudflat habitats while maintenance behaviors occurred most often in berm, overwash, and dune habitats. Overall, plovers spent <10% of their time responding to human disturbance. Chicks spent 15% of their time responding to human-related disturbances. Average foraging rates were 5.4 and 3.8 attempts/min (1988 and 1989, respectively) and ranged from 1.2-7.2 attempts/min. Mean foraging rates varied between habitats and were highest in mudflat (7.2/min.), intertidal (5.1/min.), and wracj 3.8/min.). Infauna invertebrate and surface-flying insect abundances were highest in mudflat, intertidal, and wrack habitats. Over 95% of all plover observations were in areas where there were < 10 people within 100m of birds. Pedestrians accounted for 86% of all human-related disturbances to plovers. Pet, off-road vehicle (ORV), and kite disturbances accounted for the remaining 14% of human-related disturbances (7%, 5%, and 2%, respectively). Pedestrians elicited and response from plovers at the shortest distance (mean = 23 m) while kites elicited a response the longest distances (mean = 85 m). Pets and ORV's elicited responses by plovers at similar distances (mean = 46 m and 40 m, respectively). Greatest numbers of human disturbances to plovers were observed on weekend days. Kites within 100m of focal birds caused plovers to stop feeding 100% of the time, while ORV's, pets, and pedestrians within 50 m of focal birds caused plovers to stop feeding 77%, 52%, and 31% of he time, respectively. Disturbance rates varied between beaches and ranged from 1.5 to 4.6 disturbances/h. Plover chicks moved significantly ($P < 0.001$) faster and farther during undisturbed states than they did during disturbed states. There was no correlation between human disturbance rates and plover productivity. Those beaches with highest disturbance rates also had relatively high plover productivity. We attributed 4 of 61 (< 7%) chick deaths to direct human-related mortality (3 house cat, 1 ORV).

Hosier, P. E., M. Kochhar, and V. Thayer. 1981. Off-Road vehicle and pedestrian track effects on the Sea-approach of hatchling Loggerhead Turtles. Environmental Conservation. 8: 158-161.

Information concerning the role of substrate topography on the ability of turtles to reach their destination is especially important for the endangered Loggerhead Turtles (*Carretta caretta caretta*) as off-road vehicle (ORV) and pedestrian beach visitations increase each year. By observing newly-hatched Loggerhead Turtles which were released to the intertidal beach, the authors determined the effect of ORV and pedestrian tracks on the behaviour and rate of sea-approach of these turtles. As tracks or footprints in the sand may have local microtopographic relief of as much as 10-15 cm amplitude, especially in coarse-grained sands, these features may serve as a significant impediment to the movement of hatchling turtles to the sea. Two study-sites were selected: Fort Fisher Beach, and Cape Lookout Beach, North Carolina. ORV, pedestrian, and tricycle tracks interfere with the ability of hatchling Loggerhead Turtles to reach the ocean. The extended period of travel required to negotiate suitable paths to the surf, together with the tendency to invert, may increase the susceptibility of Loggerhead Turtles to stress and predation during transit to the ocean when hatching on ORV-impacted or heavily-used bathing beaches.

Hosier, P. E. and T. E. Eaton. 1980. The impact of vehicles on dune and grassland vegetation on a southeastern North Carolina barrier beach. Journal of Applied Ecology 17:173-182.

(1) Two barrier beaches in southeastern North Carolina were compared with respect to vegetation patterns and soil compaction. One had been widely used by off-road vehicles and te other had not.
(2) The vegetation cover and the number of species present on both dunes and grassland were fewer on the area that had been subjected to vehicular traffic. It is suggested that the reduction in vegetation cover may increase the intensity of oceanic overwash at this site.
(3) The soil was more compact where vehicular traffic had been most intense. It is suggested that this compaction may increase the area of salt flats in the impacted area.

Houghton, L. M. 2005. Piping Plover population dynamics and effects of beach management practices on piping plovers at West Hampton Dunes and Westhampton Beach, New York. PhD. Dissertation, Virginia Polytechnic Institute and State University, Blacksburg, VA. 162pp.

In the early 1990's, a series of habitat changes caused by storms and subsequent beach management by the U.S. Army Corps of Engineers (USACE, The Corps) provided a unique opportunity to study piping plover population dynamics in

a changing environment. In this study, 1993-2004, we attempt to determine the factors that limit or influence the abundance and distribution of piping plovers in West Hampton Dunes (WHD), Long Island, NY, a renourished, highly developed, and high human disturbance area.

The piping plover population on Westhampton Island increased after the hurricane of 1938, and declined thereafter. The decline co-occurred with beach development and vegetative succession. After storms in the winter of 1992-1993 breached the island at West Hampton Dunes, piping plovers re-colonized the area. The New York District USACE filled the breach in 1993, and renourished the beach in 1996 and 2000-2001. USACE renourished parts of the groinfield in Westhampton Beach in 1997.

Each spring and summer, we monitored plovers intensively at WHD and part of the adjacent town of Westhampton Beach (The Reference Area) 1993-2004. We located nests and estimated reproductive and nest and chick survival rates. We monitored plover management efforts and determined causes of nest loss when possible. We monitored piping plover behaviors and obtained an index to plover food supply. We estimated area of plover habitats and defined areas unsuitable for piping plover nesting. We also obtained indices to human and predator presence on the beach.

The WHD piping plover population increased from 0 pairs in 1992 to 39 in 2000 then decreased to 18 pairs in 2004. This decline was closely associated with changes in potential nesting habitat which increased from 22.4 ha in 1992 to 50.1 ha in 2000 then declined to 31.1 ha in 2004. The primary process regulating the WHD population appears to be density dependent immigration and emigration. No other vital rates (clutch size, renest rate, fertility, egg survival, nest survival, chick survival, brood survival, chicks fledged/pair) were correlated with density. The higher equilibrium density at WHD (~1 pair/ha) than at The Reference Area (~0.4 pair/ha) appeared to be a function of the large bay intertidal flats at WHD.

The most common nest predators, cats (WHD = 13% of known predated nests), American Crows (17% of known predated nests) and foxes (37% of known predated nests), are newcomers to piping plover habitats. Thus, plovers may be especially vulnerable to them. Predator removal from the study area appeared to improve nest success and chick survival (R2 = 0.79). Predator exclosures at nests reduced nest loss (WHD = 34% exclosed nests lost vs. 43% of unexclosed nests lost, though in one year, one or more foxes learned to exploit plovers in exclosures (22% of all exclosed nests were predated by foxes in 1995).

This study highlights the long suspected piping plover paradox: increasing beach width can temporarily raise the carrying capacity of an area, but preventing overwash can reduce or eliminate the natural formation of the bay side foraging flats that increase piping plover density, and sometimes, survival. Moreover, beach stabilization allows human development of the habitat which also reduces the carrying capacity of the environment for piping plovers, increases human/plover interactions, and attracts potential predators.

Howe, M., J. Bart, S. Brown, C. Elphick, R. Gill, B. Harrington, C. Hickey, G. Morrison, S. Skagen, and N. Warnock, eds. 2000. A Comprehensive Monitoring Program for North American Shorebirds. Manomet Center for Conservation Sciences. http://www.Manomet.org/USSCP/files.htm

Anthropogenic changes to the biosphere, including widespread degradation and losses of habitats and ecosystems, are causing rapid and profound changes to bird and other wildlife populations throughout the world. Such changes have led to increasing risks and rates of extinction. As a consequence, information on how bird populations are changing is becoming increasingly important to wildlife conservationists and managers. Early detection of population change is crucial for setting wildlife planning and management priorities. For example, information on population size, population vulnerability, and population change has been central to international conservation strategies such as the Ramsar Convention, the Western Hemisphere (Bonn) Convention, and the Western Hemisphere Shorebird Reserve Network. Measuring population size or change is also crucial for evaluating the effectiveness of population management programs implemented by wildlife agencies both locally and regionally.

Although the concept of determining population size is simple, practical difficulties can be enormous and costly to overcome. In the United States, $4 billion will be spent in year 2000 to census the human population, possibly one of the most easily counted of all vertebrates. By contrast, the portion of the FY 2000 budget of the U.S. Department of the Interior allotted for tracking populations of all migratory birds (> 600 species) is less than $5 million (.0125% of the human census figure). This falls far short of the amount required to provide adequate, science-based information about bird populations and population change to wildlife managers

The gap between current ability and need is especially noteworthy for shorebirds. There are 72 species, subspecies, or distinct populations of shorebirds in North America. Even though most of these have received less conservation

attention than such groups as waterfowl, colonial waterbirds, or songbirds, recent independent evaluation of data collected for other purposes in the eastern United States and Canada during the 1970s and early 1980s showed that16 of 26 species surveyed are apparently declining, some at rates exceeding 5% per year (Howe et al., 1989). Except for one increasing species, populations of the other 9 species were statistically unchanged over the time period analyzed. In most cases causes of shorebird population declines are poorly known. For some species, the declines may be part of natural population cycles. For others the changes may reflect deterioration of conditions on the nesting grounds, at migration stopover locations, in wintering zones, or combinations of these. Determining which of these scenarios is correct and what management actions, if any, are warranted will be possible only after implementing a comprehensive monitoring plan such as that described here.

Howe, M. A., P H. Geissler, and B. A. Harrington. 1989. Population trends of North American shorebirds based on the International Shorebird Survey. Biological Conservation. 49: 185-199.

Shorebirds *Charadrii* are prime candidates for population decline because of their dependence on wetlands that are being lost at a rapid pace. Thirty-six of the 49 species of shorebirds that breed in North America spend most of the year in Latin America. Because populations of most species breed and winter at remote sites, it may be most feasible to monitor their numbers at migration stopovers. In this study, we used statistical trend analysis methods, developed for the North America Breeding Bird Survey, to analyze data on shorebird populations during southbound migration in the United States. Survey data were collected by volunteers in the International Shorebird Survey (ISS). The analyses indicate that whimbrels *Numenius phaeopus*, short-billed dowitchers *Limnodromus griseus*, and sanderlings *Calidris alba* have undergone statistically significant declines. Methodological concerns over both the ISS and the trend analysis procedures are discussed in detail and biological interpretations of the results are suggested.

Hunter, W. C., L. Peoples, and J. Collazo. 2000. South Atlantic coastal plain partners in flight bird conservation plan. Retrieved from http://www.blm.gov/wildlife/plan/pl_03_10.pdf

Hunter, W. C., J. Collazo, B. Noffsinger, B. Winn, D. Allen, B. Harrington, M. Epstein, and J. Saliva. 2005. Southeastern Coastal Plains-Caribbean Region Shorebird Plan: Version 1.0 (Revised October 3, 2005). http://www.acjv.org/documents/shorebird_plan_se_car.pdf

This report articulates what is needed in the Southeastern Coastal Plains and Caribbean Region to advance shorebird conservation. A separate Caribbean Shorebird Plan is under development and will be based in part on principles outlined in this plan. We identify priority species, outline potential and present threats to shorebirds and their habitats, report gaps in knowledge relevant to shorebird conservation, and make recommendations for addressing identified problems. This document should serve as a template for a regional strategic management plan, with step-down objectives, local allocations and priority needs outlined.

The Southeastern Coastal Plains and Caribbean region is important for breeding shorebirds as well as for supporting transient species during both northbound and southbound movements. Breeding species of highest regional priority include American Oystercatcher (*Haematopus palliatus*), Snowy Plover (*Charadrius alexandrinus*), Wilson's Plover (*Charadrius wilsonia*), and Piping Plover (*Charadrius melodus*). Shorebirds in the planning region face potential impacts primarily from: (1) chronic human-caused disturbance to roosting, nesting birds and possibly to foraging birds too, (2) oil spills, (3) transfer of water rights that may directly or indirectly affect shorebird food base in some systems by reducing freshwater input into important estuarine habitats, (4) recent but sharp increase of harvesting pressure on horseshoe crab populations leading to decreasing food resources for northbound migrating shorebirds, (5) barrier beach stabilization that may affect foraging and nesting habitat, (6) contaminants (*e.g.*, from agricultural runoff, dredged materials, water treatment areas), and (7) inadequate management capability on public lands, where high quality habitats should be more dependably available. The well-documented loss of wetland habitats in this region during the last 200 years undoubtedly affects shorebirds. Our strategies to best address these issues are outlined below and in the following sections.

Three general habitat goals for our region are: (1) to provide optimal breeding habitat to maintain and increase populations of priority species, (2) to provide high quality managed habitat to support requirements of species migrating through or spending winter in the region, and (3) to restrain human disturbance to tolerable levels for shorebirds throughout the year.

In our region, the challenge for directly providing habitat for migrating shorebirds can be partly met by public land managers fostering appropriate management, including disturbance management along with more traditional habitat management –particularly of impounded wetlands. At present 4.8 million shorebirds are estimated to occur within the region during peak migration periods and about 2.4 million shorebirds are estimated to use inland and managed wetland habitats. Presently, about 50,000 acres of publicly managed wetlands are potentially available, with about 30,500 acres

on National Wildlife Refuges alone. Because shorebirds generally live on a broad geographic scale, interagency, collaborative management needs to better target shorebirds throughout the region, starting with 4800 acres in the year 2000, which equates to less than 10% of shorebirds estimated to use inland and managed habitats.

The plan calls for increasing habitat availability to 18,500 acres by 2002, which equates to about 25% of all shorebirds using inland and managed habitats. Monitoring peak times of passage and species composition will follow International Shorebird Survey protocols along the Atlantic Coast portion of this region (from Virginia to Florida). Data will be entered unto a website to keep track of managed habitat availability and identify needs for adjustments while migration is underway. If monitoring and research shows that more managed wetland habitat is needed, upwards to 50% of all shorebirds using inland and managed habitats, then the plan calls for providing 37,000 acres by 2005. In addition for shorebirds feeding primarily within coastal habitats, retaining important washover habitat along beaches (i.e., minimize or avoid beach "restoration") after major storms is becoming an increasingly important issue.

Meeting habitat objectives for nesting shorebirds will depend more upon actions taken on lands managed cooperatively through public/private partnerships, especially along beach fronts, dredge spoil and oyster rake sites, and other near-shore habitats. Presently, this plan calls for the region to support a minimum 1000 pairs of American Oystercatchers, 300 pairs of Snowy Plovers, 1500 pairs of Wilson's Plovers, and 55 pairs of Piping Plovers (*i.e.*, status quo) and to attempt to at least double these numbers during the next 50 years. These numbers will be subject to better information such as appropriate population viability analyses, establishing more specific objectives targeting higher reproduction (in terms of numbers of fledged young per successful nest), and a better understanding of present nesting habitat capacity versus potential. Monitoring and assessment of management efforts should become a high priority for evaluating the success of nesting habitat protection measures.

Setting management objectives for roosting habitat should focus on areas where known concentrations of shorebirds occur and should concentrate on controlling sources of chronic human disturbance.

In all aspects of shorebird conservation, research and education/outreach must play important roles in both refining specific objectives and for gaining both

Hunter, W. C., W. Golder, S. Melvin, and J. Wheeler. 2006. Southeast United States regional waterbird conservation plan. Retrieved from http://www.fws.gov/birds/waterbirds/SoutheastUS/.

Isaksson, D., J. Wallander and M. Larsson. 2007. Managing predation on ground-nesting birds: The effectiveness of nest exclosures. Biological Conservation 136: 136-142.

Ground-nesting birds have declined world-wide, probably partly due to high nest predation. A non-lethal method for decreasing predation uses protective cages at nests. Tests have mainly looked at the effect of such nest exclosures on hatching success and adult predation, but several additional aspects need to be explored for a comprehensive evaluation of this conservation technique. Here, we test the effect of nest exclosures in two common European shorebirds: northern lapwing (*Vanellus vanellus*) and redshank (*Tringa totanus*), measuring hatching success, incubation length, hatching synchrony, hatchability, partial clutch loss, chick condition, and adult predation. In both species, protected nests had higher hatching success than unprotected nests. Taking into account incubation time, nest abandonment, hatchability and partial clutch loss, protected nests still hatched more young than unprotected controls. In lapwings, but not in redshanks, protected nests were incubated longer, but this did not impair the condition of lapwing chicks. Protected redshanks suffered increased predation on incubating adults, which often sit on the nest until a predator is close by. Our results emphasize the need for caution in the use of nest exclosures, particularly in redshanks and other species with similar incubation behaviour. Exclosures can, however, be a useful management tool in shorebirds that leave their nest early, when an approaching predator is still far away.

Ikuta, L. A. and D. T. Blumstein. 2003. Do fences protect birds from human disturbances? Biological Conservation 112: 447-452.

Outdoor recreation and ecotourism are becoming increasingly popular, but such human activities are not entirely benign to birds. One way to manage wildlife habitats is to restrict public access with a fence or some similar barrier, under the assumption that this provides wildlife with a refuge from human activities. We tested this assumption by measuring the responses of 10 species of birds at a site containing a fence with a relatively large number of visitors on only one side. We compared these responses to those at a less-visited, control site. Responses were measured by quantifying flight initiation distance (FID), the distance birds would allow a human to approach before fleeing. Overall, we found birds on the protected side of the fence responded similarly to birds at the low visitation control site, and significantly differently from birds at the high visitation site. Our results suggest that by reducing the number of

humans and providing areas of refuge within highly visited habitats, protective barriers allow birds to behave as they would in an undisturbed environment.

Ingle, C., Y. Leung, C. Monz, and H, Bauman. 2003. Monitoring visitor impacts in coastal Nationkal Parks: A review of techniques. In *Protecting Our Diverse Heritage: The Role of Parks, Protected Areas, and Cultural Sites.* (Proceedings of the George Wright Society/National Park Service Joint Conference, April 14–18, 2003, San Diego, California.) D. Harmon, B.M. Kilgore, and G.E. Vietzke, eds. Hancock, Mich.: The George Wright Society, 228–233.

Coastal areas, particularly sandy coasts and barrier islands, are prime destinations for outdoor recreation activities, yet the same zones possess diverse, dynamic, and, often, sensitive ecosystems (Beatley et al. 2002). There are 295 barrier islands, totaling 2,700 miles of barrier length in the 18 eastern U.S. states alone (Leatherman 1988). Visitor use and impacts are an important and growing concern in national parks located in these sensitive zones. Activities such as the use of off-road vehicles (ORVs), walking on the beach or dunes, and feeding wildlife can trample vegetation, accelerate soil erosion, reduce sand dune height, and change wildlife behavior.

The utility of visitor impact monitoring as an effective tool for managing visitation in coastal parks has been recognized (Marion et al. 2001). As part of the National Park Service (NPS) Vital Signs Program, we initiated a research project to develop visitor impact indicators and monitoring protocols for seven park units within the NPS Northeast and Barrier Network. One of the project objectives was to conduct a thorough review of the scientific literature, with the scope set to sandy coasts and barrier islands. This paper highlights results of this literature review.We identified relevant publications in our personal databases and also conducted thorough searches in reference databases through the university libraries. A substantial number of references were identified, but only a small portion is applicable to sandy coasts and barrier islands. Several studies were conducted in the park units included in this project (such as Patterson et al. 1991; Steiner and Leatherman 1981).

Jehl, Jr., Joseph R., Joanna Klima and Ross E. Harris. 2001. Short-billed Dowitcher (Limnodromus griseus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/564

Johnson, C. M. and G. A. Baldassarre. 1988. Aspects of the wintering ecology of Piping Plovers in coastal Alabama. Wilson Bulletin 100: 214-223.

Piping plovers (*Charadrius melodus*) wintering on the Alabama coast were studied from September-October through April 1984-85 and 1985-86. Time spent foraging dominated diurnal activities during all months (x super(-) = 76%) and was highest in December (90%). Tidal height was correlated negatively with foraging time and appeared to be the most important factor influencing activities. Time spent resting and preening was related inversely to foraging, and combined time spent in agonistic, territorial, alert, and locomoting activities was < 5% during all months.

Jones, L. K. 1997. Piping plover habitat selection, home range, and reproductive success at Cape Cod National Seashore, Massachusetts. MSc. Thesis, University of Massachusetts Amherst. 96 pp.

Kirby, J. S., C. Clee and V. Seager. 1993. Impact and extent of recreational disturbance to wader roosts on the Dee estuary: some preliminary results. Wader Study Group Bulletin 68: 53–58.

During the 1986/87 to 1990/91 period, 3-5 voluntary wardens patrolled the West Kirby beach on 339 occasion si n an attempt t o reduce t he level of disturbance to roosting waders. Whilst doing so, the types and frequency o f potential disturbances details o f actual disturbances and the numbers of each wader species using the beach have been recorded. Walkers and dogs were the main sources of disturbance, the potential for disturbance having increased and diversified during the period. Potential disturbance rates were significantly greater on weekend visits. Dogs and walkers were responsible for most of the actual disturbances recorded, though there was no evidence that the frequency of actual disturbances had increased. Most types of disturbances resulted in waders leaving the West Kirby beach on occasions, and Grey Plover, Knot, Dunlin and Bar-tailed Godwit most commonly left the estuary altogether when disturbed. The majonty of wader species have increased at West Kirby during the period despite the potential for disturbance having increased. This may be due to a successful program of intervention and education by the voluntary wardens.

Klein, M. L, S. R. Humphrey and F. Percival. 1995. Effects of ecotourism on distribution of waterbirds in a wildlife refuge. Conservation Biology 9: 1454-1465.

Humans visiting natural areas often disturb wildlife, possibly displacing animals from desirable habitat. To hold ecotourism at acceptable levels refuge managers need to know which species are likely to be affected and which response occurs at different levels of disturbance. Displacement of waterbirds at J. N. "Ding" Darling National Wildlife Refuge, Florida (U.S.A.), by specific human activities was demonstrated experimentally by Klein in 1993. We assessed the extent of this effect of ecotourism on the distribution of 38 species of waterbirds by surveying birds in plots of known distance from a dike along which wildlife tours occurred. Most resident species were less sensitive to disturbance than were migrants. Migrant ducks were most sensitive when they first arrived, mid-October to mid-December, usually remaining more than 80 m from the drive, even at low levels of human visitation. Herons, egrets. Brown Pelicans (*Pelecanus occidentalis*), and Anhingas (*Anhinga anhinga*) were most likely to remain close to areas of high human activity. Shorebirds were displaced at intermediate distance and visitation levels. Mottled Ducks (*Anas fulvigula*) and several of the ardeids seemed to include two groups differing in behavior, one habituated to humans and one sensitive to disturbance. Public education and changes in management practices are needed to reduce disturbance. Guided tours and low-disturbance zones where people stay in their cars could reduce the negative effects of tourists, especially in the fall when migrants arrive. The number of human visitors may have to be reduced or the wildlife drive closed on certain days during the tourist season.

Knight, R. L., and D. N. Cole. 1991. Effects of recreational activity on wildlife in wildlands. Transactions North American Wildlife and Natural Resource Conference **56**:238-247.

Knight, R. L., and D. N. Cole. 1995. Factors that influence wildlife responses to recreationists. p. 71-79, IN: R. L. Knight and K. J. Gutzwiller eds. Wildlife and Recreationists. Island Press, Washington, D. C.

A number of factors influence the nature and severity of recreational impacts on wildlife. Some activities may have serious consequences, while others have little or no effect. It is critical that these factors be understood and managed to mitigate recreational impacts. Impacts are the result of interactions between recreational disturbances and animals. Therefore, the two broad categories of factors we discuss in this chapter are: (1) characteristics of the recreational disturbance, and (2) characteristics of the affected animals.

Knight, R. L. and D. N. Cole. 1995. Wildlife responses to recreationists. Pages 71-79 *in* R. L. Knight and K. J. Gutzwiller, ed. Wildlife and Recreationists: coexistence through management and research. Island Press, Washington, D. C. 372pp.

Outdoor recreation has historically been viewed as an environmentally benign activity. Yet with growing numbers of recreationists visiting public lands, and with a greater understanding of the role of public land in safeguarding biodiversity, it is becoming apparent that the effects of recreation on both the environment and wildlife are chronic and pervasive. Wildlife and Recreationists defines and clarifies the issues surrounding the conflict between outdoor recreation and the health and well-being of wildlife and ecosystems. The book is a valuable synthesis of what is known concerning wildlife and recreation. More important, it addresses both research needs and management options to minimize conflicts.

Knight, R. L. and K.J. Gutzwiller (Eds.). 1995. Wildlife and recreationists: coexistence through management and research. Island Press. Washington DC and Covelo CA.

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Knight, R.L., D.P. Anderson, and N.V. Marr. 1991. Responses of an Avian Scavenging Guild to Anglers. Biological Conservation 56:195-205.

We experimentally examined the responses of an avian scavenging guild (bald eagles *Haliaetus leucocephalus*, common ravens *Corvus corax*, and American crows *Corvus brachyrhynchos*) to anglers in Washington, USA. We hypothesized that anglers did not influence the numbers, behavior, and diurnal distribution of avian scavengers. We rejected our null hypothesis as there were differences in both numbers, behavior and diurnal distribution of scavengers present at sites during fishing days when compared with nonfishing days. The presence/absence of scavengers was

independent of presence/absence of anglers. When scavengers were present, however, anglers influenced either the total number present, the number perched in trees, or the number on the ground. Finally, anglers altered the diurnal patterns of each species.

Knight, R. L. and S. A. Temple. 1995. Origin of wildlife responses to recreationists. Pages 81-91 *in* R. L. Knight and K. J. Gutzwiller, ed. Wildlife and Recreationists: coexistence through management and research. Island Press, Washington, D. C. 372pp.

Knight, R. L., and S. A. Temple. 1995. Wildlife and recreationists: Coexistence through management. p. 327-333, IN: R. L. Knight and K. J. Gutzwiller eds.. Wildlife and Recreationists. Island Press, Washington, D. C.

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Kotliar, N.B. and J. Burger. 1984. The use of decoys to attract Least Terns to abandoned colony sites in New Jersey. Colonial Waterbirds 7: 134-138.

The number of Least Tern colony sites in New Jersey has declined in recent years. Decoys were used at two recently abandoned Least Tern colony sites in New Jersey to encourage nesting. The sites were chosen because of their apparent suitability as colony sites and the relative ease of protecting them from human disturbance and predators. Least Terns were observed flying over and landing at both sites, although nesting occurred at only one site. The effect of decoys was statistically significant at the colony site used for nesting. At this site, 44.5% of the landings occurred in the plot containing decoys and only 10.6% of the landings were in the control plot. Nesting was initiated among the decoys. These results indicate that decoys can be used to attract Least Terns to abandoned colony sites and may be useful for managing Least Terns and other colonial nesting birds.

Kress, S. W. and C. S. Hall. 2002. Tern Management Handbook: Coastal Northeastern United States and Atlantic Canada. U.S. Fish and Wildlife Service, Hadley, MA

This handbook provides historic background, a review of factors limiting populations, biology and techniques for managing and monitoring the tern species nesting from Long Island, New York to Newfoundland and the north shore of the Gulf of St. Lawrence. The handbook also identifies research needs and includes maps showing the location of tern populations within the United States. The handbook focuses on coastal populations of Common, Arctic, Roseate and Least Terns. It also provides information about less common southern species, including Forster's and Gull-billed Terns, Black Skimmers that edge into the southern boundaries of the region, and Caspian Terns which nest in Newfoundland.

The primary audiences for this book are professional wildlife managers employed by government and non-government conservation organizations, and private landowners and volunteers that work in conjunction with public and private parks and refuges. This handbook is intended to provide specific management techniques to help achieve the goals set forth in several previous planning approaches—most notably the "Atlantic Region Management Plan for Marine Terns" (Canadian Wildlife Service, 1992), "The Gulf of Maine Tern Management Plan" of the Maine Department of Inland Fisheries and Wildlife (Drury and Melvin, 1989), and the "Roseate Tern Recovery Plan Northeastern Population - First Update (U.S. Fish and Wildlife Service, 1998). This document will also help managers implement the goals of the forthcoming "North American Waterbird Conservation Plan."

This handbook builds on existing management reviews for the region, including: *Guidelines for Protection and Management of Colonially Nesting Waterbirds* (Buckley and Buckley, 1976); *Mass. Tern and Piping Plover Handbook: a Manual for Stewards* (Blodget and Melvin, 1996); *The Long Island Piping Plover and Tern Protection Program: a Manual for Plover/Tern Stewards and Volunteers* (Dougherty and Motivans, undated) and *Management Brief for Jones Beach Island East* (Zadi, undated). This document includes information previously scattered throughout local handbooks, island reports and the collective memory of many field researchers and managers.

A comprehensive handbook and assessment is necessary because terns are suffering in many ways from the impact of increasing human population. Terns are vulnerable to a long list of human-imposed threats. The list includes loss of coastal habitat to development, over-exploitation of fisheries, pollution of coastal waters with heavy metals, pesticides, industrial chemicals and oil, disturbance of beach-nesting colonies by off-road vehicles and disruption of island-nesting colonies by an increasingly mobile boating public. Tern populations also suffer when soil erosion shrinks nesting habitat, and from the effects of predators and competitors such as Great Horned Owls, Great Black-backed Gulls, Herring Gulls, red foxes, raccoons and rats, all of which benefit from human-caused changes in food and habitat. Threats to terns and other coastal nesting birds are becoming increasingly severe as human populations increase and concentrate along coastlines. In 1997, coastal areas throughout the United States were home to an average of 277 people/square mile, which is three times the national average of 91 people/square mile (Bookman *et al*., 1999). The Northeastern United States contains 1/3 of the U.S. coastal population, with 18 of the 25 most densely populated counties in the entire U.S. In 1988, coastal counties from Maine to Virginia were home to 3 million people, about 16% of the U.S. population. The Northeast population is projected to increase by 10% over the next two decades, to almost 43 million by 2010 (Culliton *et al*., undated).

If terns are to maintain viable populations in Northeastern North America, their management will require careful planning at both a regional and international level. This is necessary because of their highly mobile nature and to avoid concentrating the birds at a few locations where they become vulnerable to local catastrophes (e.g. pollution, predation and exhaustion of food supplies). Throughout most of the region covered by this plan, terns have already become "wards of the state," dependent on human action because human enterprise has placed them at risk.

The once vast populations that were free to move from site to site in response to erosion, deposition, predators and storms, are now crowded onto just a few nesting places. Within the region defined by this report (excluding Newfoundland), presently 75% of Common Terns nest at just 13 sites, 94% of Arctic Terns nest at 4 and 95% of Roseate Terns nest at 5 locations. When forced to nest on islands near the mainland or on beaches close to human development, terns usually become vulnerable to mammals and a variety of avian predators, such as crows, Great Horned Owls and Black-crowned Night-herons, leading to chronic low productivity. Without secure nesting places, it is only a matter of time before local populations dwindle, colonies become extinct and huge gaps appear within previously contiguous populations.

Fortunately, terns are very responsive to management and will locate where they find favorable conditions. This characteristic predisposes terns to active management where managers manipulate vegetation and control predation to create "permanent" colonies that rely on intensive management methods. This will likely be necessary far into the foreseeable future. While this approach has proved effective on the short term, the increased risk to terns from disease, predation and pollution are obvious threats that loom over these concentrated colonies. However, restoration of historic tern nesting islands also helps other seabirds such as eiders, alcids and storm-petrels which benefit from the aggressive behavior of terns that drive off gulls and corvids (Anderson and Devlin 1999, Kress 1997).

Many questions remain concerning the long-term management of terns. Who will do the monitoring? Who will coordinate methods and exert quality control? Who will manage the data and archive it for ready access? And most importantly, who will pay for tern management well into the foreseeable future?

State and municipal agencies usually have little funding to support tern conservation, which often leaves terns dependent on public support through non-government conservation organizations such as the National Audubon Society and The Nature Conservancy. When these groups work with government agencies, strong and effective partnerships can result. The effectiveness of these groups usually depends upon public support. For this reason, the future well being of terns and other coastal waterbirds depends on building a large constituency of caring people, and a higher place on the priority lists of agencies that have the mandate for their protection.

It is vital for the public to understand that these elegant birds are indicators of the health of our increasingly crowded coasts, and that many other seabirds benefit where solid tern conservation is in place. For these reasons, public education is an important component of tern conservation. Ultimately, public choices will determine economic priorities and this will determine how many seabird colonies we can effectively manage.

Kress, S.W. 1983. The use of decoys, sound recordings, and gull control for re-establishing a tern colony in Maine. Colonial Waterbirds 6: 185-196.

To re-establish breeding Arctic Terns, (*Sterna paradisaea*) on Eastern Egg Rock (Knox Co., Maine), breeding populations of Great Black-backed Gulls (*Larus marinus*) and Herring Gulls (*L. argentatus*) were eliminated and social attractants (Arctic Tern decoys and sound recordings of nonaggressive tern vocalizations) were used to attract terns to this former nesting site. Herring Gull populations were significantly reduced after the first summer of control efforts and Great Black-backed Gulls were significantly reduced after three summers of control by poisoning, shooting, egg

and chick destruction and human disturbance. Common Eider (*Somateria mollissima*) and Black Guillemot (*Cepphus gry*lle) populations have remained constant despite nine years of gull control and human occupation on the island. In the first year of using decoys and sound recordings, tern sightings nearly doubled in frequency and in the third year of using these attractants, Arctic Terns and Common Terns (*Sterna hirundo*) nested in the immediate vicinity of the decoys and playback speaker. Roseate Terns (*S. dougallii*) joined the colony in 1981. By 1982 Eastern Egg Rock supported the largest Common Tern colony in Maine. The relative importance of gull control, decoys, and sound recordings cannot be deter- mined from this study, however, the re-establishment of breeding terms on Eastern Egg Rock demonstrates that tern populations may be restored through an integrated program of gull control and social attractants. These techniques offer opportunities for re-establishing terns on historic, remote locations where they are safer from the increased predation, flooding, and human disturbance often characteristic of sites adjacent to mainlands.

Krogh, M. G. and S. H. Schweitzer. 1999. Least Terns nesting on natural and artificial habitats in Georgia, USA. Waterbirds 22: 290-296.

Although increasing numbers of Least Terns (*Sterna antillarum*) are nesting on artificial substrates such as dredged-material and roofs, it is not known if these colonies are successfully fledging young. Aspects of Least Tern nesting ecology were studied in 1996 and 1997 along Georgia's coast. Numbers of nests, eggs, chicks, and fledglings at beach, dredged-material, and roof colonies were surveyed using walk-through counts from late April to mid-July. Numbers of nests ranged from 6 to 929 and they did not differ between years or among habitat types. Percent hatching success ranged from 0 to 53.4% and did not differ between years or among habitat types when the data were compared among colonies. High within-habitat type variability due to catastrophic colony failures masked differences in hatching success among habitat types. Causes of mortality included tidal flooding and human disturbance on beaches; extreme temperatures, predation by raccoons, dogs, cats, birds, and fire ants on dredged-material islands; and extreme temperatures, flooding, avian predation, and falling off roofs on buildings. More than 70% of Least Terns in Georgia are nesting with -30% hatching success on flat, gravel-covered roofs. These roofs could provide better refugia and nesting habitat if they continued to be gravel-covered rather than vinyl-covered, if drains were screened, and if -30 cm parapets were constructed around the perimeter.

Kushlan, J. A. 1983. Special species and ecosystem preserves: colonial waterbirds in U. S. National Parks. Environmental Management 7: 201-207.

An important aspect of developing a philosophical foundation for management of reserves using an ecosystem approach is the exploration of the relationship of ecosystem management strategies to the need for conservation of species of special concern Colonial water birds are species that may deserve special consideration They occur in over 25 US national parks, but in no case do the parks have a monopoly on the total protection or management of these birds As an agency responsible for such populations, the National Park Service engages in activities such as inventory, monitoring, research, and management, using an ecosystem management philosophy Most parks contain only segments of natural ecosystems, and management actions, even those undertaken from an ecosystem perspective, may not be in the best interest of an individual species Management strategies for widely ranging special species require a regional perspective, including plans that take into consideration the differing objectives of the agencies responsible for such species A matrix of the different management strategies in various areas may provide a suitable, perhaps the best, method for protecting special species In practice, any one strategy, such as management of remnant ecosystem patches or intensive single-species management, may not be successful alone

Kushlan, J. A., M. J. Steinkamp, K. C. Parsons, J. Capp, M. A. Cruz, M. Coulter, I. Davidson, L. Dickson, N. Edelson, R. Elliot, R. M. Erwin, S. Hatch, S. Kress, R. Milko, Miller S., K. Mills, R. Paul, R. Phillips, J. e. Saliva, B. Sydeman, J. Trapp, J. Wheeler, and K. Wohl. 2002. Waterbird Conservation for the Americas: The North American Waterbird Conservation Plan, Version 1. Waterbird Conservation for the Americas, Washington, D. C. 78 pp.

The North American Waterbird Conservation Plan (the Plan) is the product of an independent partnership of individuals and institutions having interest and responsibility for conservation of waterbirds and their habitats in the Americas. This partnership— Waterbird Conservation for the Americas—was created to support a vision in which the distribution, diversity, and abundance of populations and habitats of breeding, migratory, and nonbreeding waterbirds are sustained or restored throughout the lands and waters of North America, Central America, and the Caribbean. The Plan provides a continental-scale framework for the conservation and management of 210 species of waterbirds, including seabirds, coastal waterbirds, wading birds, and marsh birds utilizing aquatic habitats in 29 nations throughout North America, central America, the islands and pelagic waters of the Caribbean Sea and western Atlantic, the US-associated Pacific Islands and the pelagic waters of the Pacific. Birds as familiar as herons, loons, pelicans, and gulls, as well as the lesser known albatrosses, petrels, auks, and rails are among the species considered in the Plan. These birds' dependence on aquatic habitats such as wooded swamps, stream corridors, salt marshes, barrier islands,

continental shelf waters and open pelagic waters make them especially vulnerable to the myriad threats facing water and wetland resources globally. In addition, the congregatory behavior of many waterbirds increases population risks by concentrating populations in limited areas.

The conservation of waterbirds faces significant challenges. Eighty percent of the species considered in the Plan are colonial nesters—congregating at breeding sites in numbers ranging from many to hundreds of thousands of birds. Of this group, the Plan finds that one-third are considered to be at risk of serious population loss. Eleven species of pelagic seabirds are highly imperiled, and 36 species of pelagic and coastal seabirds as well as seven species of wading birds are of high conservation concern. Although non-colonial waterbirds remain to be assessed quantitatively, many of these populations are also clearly at risk. Waterbird populations are subject to numerous threats, many of which are habitat-based and affect all aquatic birds and other aquatic resources. The threats that the Plan identifies as requiring remedial action include destruction of inland and coastal wetlands, introduced predators and invasive species, pollutants, mortality from fisheries and other human industries, disturbance, and conflicts arising from abundant species.

Additional information on population sizes and trends is needed to improve the assessment of conservation risk, as well as allow a detailed assessment of the relative importance of specific areas to the various species and the effectiveness of waterbird management prescriptions. More precise information on spatial habitat needs is also needed; presently, there is little information on habitat use outside of the breeding season for many species, particularly during migration. Critical to the effective management of waterbird populations and habitats will be increasing knowledge, through monitoring and research, broadly disseminating this information, and encouraging conservation action by policy makers, wildlife managers, and the public.

The Plan identifies strategies and opportunities for achieving its vision. It documents a dynamic process for species status assessment to inform setting of conservation priorities at a regional scale, and has identified many of the key issues requiring conservation action. The Plan has involved the scientific community, especially through partnership with ornithological societies, in identifying information needs It proposes the development of a continental monitoring partnership including standardized methodology, bias-assessment, and internet-accessible database systems to support status and trend evaluation.

The Plan promotes habitat and site-based conservation actions throughout the Americas, especially via the Important Bird Areas programs and similar efforts. Regional waterbird conservation working groups will step down the continental-level aspects of the Plan to the regional and local levels. At all scales, the Plan advocates integration of waterbird conservation with other bird conservation initiatives when appropriate, in order to efficiently provide the best management options for local wildlife and habitat managers.

An evolving Waterbird Conservation Council will facilitate implementation of the Plan, assess its effectiveness, and plan the future course of waterbird conservation. Finally, the Plan details resources and infrastructure needed to more fully accomplish waterbird conservation. Rather than establishing new structures, implementation of the Plan will be entrusted to governmental and nongovernmental entities, especially national governments state governments, habitat Joint Ventures and other partnerships, and conservation-oriented nongovernmental organizations.

Kuss, F. R., A. R. Graefe, and J. J. Vaske. 1990. Visitor impact management: A review of research. National Parks and Conservation Association, Washington, D. C.

Lafferty, K. D. 2001. Birds at a southern California beach: seasonality, habitat use and disturbance by human activity. Biodiversity and Conservation 10:1949–1962.

Use of a Santa Barbara beach by people and birds varied in both time and space. There were 100 birds, 18 people and 2 dogs per kilometer. Bird density varied primarily with the season and tide while human activity varied most between weekend and weekday. Bird distributions along the beach were determined mainly by habitat type (particularly a lagoon and exposed rocky intertidal areas). For crows and western gulls, there was some evidence that access to urban refuse increased abundance. Interactions between birds and people often caused birds to move or fly away, particularly when people were within 20 m. During a short observation period, 10% of humans and 39% of dogs disturbed birds. More than 70% of birds flew when disturbed. Bird species varied in the frequency that they were disturbed, partially because a few bird species foraged on the upper beach where contact with people was less frequent. Most disturbances occurred low on the beach. Although disturbances caused birds to move away from humans, most displacement was short enough that variation in human activity did not alter large-scale patterns of beach use by the birds. Birds were less reactive to humans (but not dogs) when beach activity was low.

Lafferty, K. D.. 2001. Disturbance to wintering western snowy plovers. *Biological Conservation 101:315-325*

In order to better understand the nature of disturbances to wintering snowy plovers, I observed snowy plovers and activities that might disturb them at a beach near Devereux Slough in Santa Barbara, California, USA. Disturbance (activity that caused plovers to move or fly) to wintering populations of threatened western snowy plovers was 16 times higher at a public beach than at protected beaches. Wintering plovers reacted to disturbance at half the distance (~40 m) as has been reported for breeding snowy plovers (~80 m). Humans, dogs, crows and other birds were the main sources of disturbance on the public beach, and each snowy plover was disturbed, on average, once every 27 weekend min and once every 43 weekday min. Dogs off leash were a disproportionate source of disturbance. Plovers were more likely to fly from dogs, horses and crows than from humans and other shorebirds. Plovers were less abundant near trail heads. Over short time scales, plovers did not acclimate to or successfully find refuge from disturbance. Feeding rates declined with increased human activity. I used data from these observations to parameterize a model that predicted rates of disturbance given various management actions. The model found that prohibiting dogs and a 30 m buffer zone surrounding a 400 m stretch of beach provided the most protection for plovers for the least amount of impact to beach recreation.

Laferty, K. D., D. Goodman, and C. P. Sandoval. 2006. Restoration of breeding by Snowy Plovers following protection from disturbance. Biodiversity and Conservation 15: 2217-2230.

Promoting recreation and preserving wildlife are often dual missions for land managers, yet recreation may impact wildlife. Because individual disturbances are seemingly inconsequential, it is difficult to convince the public that there is a conservation value to restricting recreation to reduce disturbance. We studied threatened western snowy plovers (*Charadrius alexandrinus nivosus*) at a public beach (Sands Beach, Coal Oil Point Reserve) in Santa Barbara, California (USA) before and during a period when a barrier directed foot traffic away from a section of upper beach where snowy plovers roost. The barrier reduced disturbance rates by more than half. Snowy plovers increased in abundance (throughout the season) and their distribution contracted to within the protected area. Snowy plovers that were outside the protected area in the morning moved inside as people began using the beach. Experiments with quail eggs indicated an 8% daily risk of nest trampling outside the protected area. Before protection, plovers did not breed at Coal Oil Point. During protection, snowy plovers bred in increasing numbers each year and had high success at fledging young. These results demonstrate how recreational disturbance can degrade habitat for shorebirds and that protecting quality habitat may have large benefits for wildlife and small impacts to recreation.

Larson, R. A. 1995. Balancing wildlife viewing with wildlife impacts: A case study. Pages 257-270 *in* R. L. Knight and K. J. Gutzwiller, ed. Wildlife and Recreationists: coexistence through management and research. Island Press, Washington, D. C. 372pp.

Outdoor recreation has historically been viewed as an environmentally benign activity. Yet with growing numbers of recreationists visiting public lands, and with a greater understanding of the role of public land in safeguarding biodiversity, it is becoming apparent that the effects of recreation on both the environment and wildlife are chronic and pervasive. Wildlife and Recreationists defines and clarifies the issues surrounding the conflict between outdoor recreation and the health and well-being of wildlife and ecosystems. The book is a valuable synthesis of what is known concerning wildlife and recreation. More important, it addresses both research needs and management options to minimize conflicts.

Larson, MA | Ryan, MR | Murphy, RK. 2003. Assessing recovery feasibility for piping plovers using optimization and simulation. Wildlife Society Bulletin Vol. 31: 1105-1116. 2003.

Optimization and simulation modeling can be used to account for demographic and economic factors simultaneously in a comprehensive analysis of endangered-species population recovery. This is a powerful approach that is broadly applicable but underutilized in conservation biology. We applied the approach to a population recovery analysis of threatened and endangered piping plovers (Charadrius melodus) in the Great Plains of North America. Predator exclusion increases the reproductive success of piping plovers, but the most cost-efficient strategy of applying predator exclusion and the number of protected breeding pairs necessary to prevent further population declines were unknown. We developed a linear programming model to define strategies that would either maximize fledging rates or minimize financial costs by allocating plover pairs to 1 of 6 types of protection. We evaluated the optimal strategies using a stochastic population simulation model. The minimum cost to achieve a 20% chance of stabilizing simulated

populations was approximately $1-11 million over 50 years. Increasing reproductive success to 1.24 fledglings/pair at minimal cost in any given area required fencing 85% of pairs at managed sites but cost 23% less than the current approach. Maximum fledging rates resulted in >20% of simulated populations reaching recovery goals in 30-50 years at cumulative costs of <$16 million. Protecting plover pairs within 50 km of natural resource agency field offices was sufficient to increase simulated populations to established recovery goals. A range-wide management plan needs to be developed and implemented to foster the involvement and cooperation among managers that will be necessary for recovery efforts to be successful. We also discuss how our approach can be applied to a variety of wildlife management issues.

Larson, M. A., M. R. Ryan, and B. G. Root 2000. PIPING PLOVER SURVIVAL IN THE GREAT PLAINS: AN UPDATED ANALYSIS. Journal of Field Ornithology 71: 721-729.

Population viability analyses for Piping Plovers (*Charadrius melodus*) are highly sensitive to survival estimates, especially those of adults. Thus, the discrepancy between the previous adult survival estimate for the Great Plains Piping Plover population (0.664, SE = 0.057) and estimates from other regions and closely related species prompted us to re-examine banding data for Great Plains plovers. We used published data plus three additional years of band resightings, data from banded juveniles, and a new modeling approach to estimate local annual survival rates of adults and immatures for a breeding site in central North Dakota in 1984–1994. Mean adult survival was 0.737 (SE = 0.092), and the temporal variance was 0.040–0.045. Immature survival was 0.318 (SE = 0.075), but true immature survival is probably higher, mostly due to unknown but likely high dispersal rates. Based on our revised survival estimate for adult Piping Plovers and projections from published plover population models, it is likely that the feasibility of recovering the Great Plains population is greater than previously thought.

Le Fer, D., J. D. Fraser, and C. D. Kruse. 2007. Piping Plover chick foraging, growth, and survival in the Great Plains. Journal of Wildlife Management 72: 682-687.

We tested the hypothesis that piping plover (*Charadrius melodus*) habitat quality and chick survival on the Missouri River, USA, were lower on a cold-water reservoir and downstream from a hypolimnetic (cold-water) release dam with diel water fluctuations (Garrison Dam) than downstream from an epilimnetic dam (Gavins Point Dam). Plovers in adjacent alkali wetlands provided an index to the maximum reproductive potential in the region. Chicks gained weight more rapidly in the alkali wetlands than on epilimnetic and hypolimnetic river reaches. Invertebrate numbers and biomass were higher in the wetlands and epilimnetic reach, but chick survival was lower on the epilimnetic reach. Thus, piping plovers adapted to a variety of prey densities, and other factors, likely predation, reduced survival rates in the epilimnetic reach. Temporal and spatial variability in site quality indices suggests the need for a regional management strategy with different strategies at each site. Managers can minimize effects of local fluctuations in resource abundance and predators by ensuring protection of or creating geographically dispersed habitat.

Leseberg, A. P. A. R. Hockey, and D. Loewenthal. 2000. Human disturbance and the chick-rearing ability of African Black Oystercatchers (Haematopus moquini): a geographical perspective. Biological Conservation 96: 379-385.

African black oystercatchers (*Haematopus moquini*) breed on the open coast of the southwestern Afrotropics at the height of the summer tourist season. They are thus vulnerable to effects of human disturbance, including destruction of nests by people and vehicles and predation of eggs and chicks by domestic dogs. Because they forage exclusively intertidally, disturbance may further result in adults having insufficient time to satisfy both their own energy demands and those of their young. To test whether vulnerability to this form of disturbance varies regionally, in response to regional variation in foraging conditions, foraging times of adult oystercatchers were recorded on rocky shores at four sites around the South African coast that experience little or no human pressures. At the same time, a measure of prey abundance was obtained at each site for the dominant prey types — mussels and prosobranch limpets. Time spent foraging per day increased on a west–east axis. This pattern could not be explained from simple measures of food abundance, but does parallel a west–east decrease in intertidal primary productivity and hence in the biomass of grazing invertebrates, such as limpets, as well as a west–east decrease in oystercatcher density. A simple time-energy model was constructed to estimate the additional foraging time that adults would need to meet the energy demands of chick-rearing. At south coast sites, where adult intake rates are relatively low, they regularly experience difficulties in rearing two chicks under undisturbed conditions, and their ability to rear even a single chick could be compromised by fairly low levels of human disturbance. Both tourism and coastal development are growing rapidly in South Africa, and tourist activity on the south coast is greater than on the west coast. Oystercatchers have many attributes favouring their use as bio-indicators of coastal disturbance, but high adult survivorship makes census data alone a poor predictor of future population trends.

Loegering, J. P. and J. D. Fraser. 1995. Factors affecting piping plover chick survival in different brood-rearing habitats. Journal of Wildlife Management 59: 646-655.

The decline of piping plover (*Charadrius melodus*) populations and subsequent listing as a threatened species has been attributed, in part, to low chick survival. During 1988-90, we observed piping plover chicks daily to evaluate hypotheses of differential food resources, predation, and disturbance explaining differences in chick survival in 3 habitats on Assateague Island National Seashore (AINS), Maryland. Chicks reared on the bay beach and island interior had higher daily survival rates (0.97, 0.99 vs. 0.87; $P < 0.001$), higher foraging rates (13.3, 10.8 vs. 5.9 attempts/min; $P < 0.001$), and spent more time foraging (76, 80 vs. 37%, $P < 0.004$) than chicks reared on the ocean beach. Terrestrial arthropod abundance on the bay beach and island interior was greater than on the ocean beach in 5 of 6 cases ($P < 0.01$). Amphipods, however, were more abundant on ocean beaches than in bay and island interior habitats each year ($P \leq 0.03$). Chicks 4-5 days old that were reared on the bay beach or island interior habitats were heavier than those reared on the ocean beach (8.5, 7.8 vs. 6.5 g; $P < 0.01$). Overall disturbance rates did not differ among habitats (behavioral observations; $P = 0.29$). The number of predator trails did not differ among the 3 habitats ($P = 0.2$). Red fox (Vulpes vulpes) trails were more numerous in the island interior and ocean beach ($P < 0.001$), ghost crab (Ocypode quadrata) burrows were more numerous on ocean beach ($P < 0.001$), and gull (Larus spp.) and raccoon (Procyon lotor) trails were more numerous on bay beach ($P < 0.001$ and $P = 0.001$, respectively). Piping plover chicks moved from ocean beach nest sites to the bay beach and island interior along ephemeral, vegetation-free paths created during winter storms by waves surging across the island. These paths should be maintained to enable piping plover chicks to move to the island interior and bay habitats where chick survival is greatest. Preserving access to high quality brood-rearing habitat will ensure reproductive rates that will sustain the local population and contribute to the species' recovery.

Lord, A., J. R. Waas, J. Innes, and M. J. Whittingham. 2001. Effects of human approaches to nests of northern New Zealand dotterels. Biological Conservation 98: 233-240.

The northern New Zealand dotterel *Charadrius obscurus aquilonius* is an endangered shorebird, and it is thought that human disturbance may decrease its nesting success. We made three types of approach to nests (walking, running or leading a dog). We measured the flush distance, length of time parents spent off the nest and distraction display intensity. Leading a dog caused the greatest disruption of incubation, while responses to walking and running approaches did not differ significantly. Distraction display intensity appeared to be unrelated to approach type. There was evidence of habituation to humans on busy beaches. Our results provide the first experimental evidence that shorebirds perceive dogs as posing more of a threat than humans on foot, and that their subsequent avoidance response is greater. We recommend that human activity, particularly the walking of dogs, should be limited near nesting sites. Further study on causes of nest failure is required.

Lord, A., Waas, J.R., Innes, J., 1997. Effects of human activity on the behaviour of Northern New Zealand dotterel *Charadrius obscurus aquilonius* chicks. Biological Conservation 82, 15–20.

Human disturbance is one of the factors that may contribute to low breeding success in the endangered New Zealand dotterel *Charadrius obscurus aquilonius*. This study examined how foraging and related behaviours of northern New Zealand dotterel chicks were affected by human presence. Chicks were observed both in the presence, and in the controlled absence, of people. Results showed that, when people were present, chicks spent less of their feeding time in the littoral zone, and more in the supralittoral zone, and in general spent less time feeding when people were present. These data suggest that the littoral zone may be more desirable for foraging than is the supralittoral zone, and that high levels of human disturbance may infer energetic constraints on New Zealand dotterel chicks. Fledging success of chicks may be enhanced if human access to feeding areas adjacent to breeding sites is reduced during the chick-rearing phase of the breeding season.

Lowther, Peter E., Hector D. Douglas, Iii and Cheri L. Gratto-Trevor. 2001. Willet (*Catoptrophorus semipalmatus*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/579

Luckenbach, R. A. and R. B. Bury. 1983. Effects of off-road vehicles on the biota of the Algodones dunes, Imperial County, California. Journal of Applied Ecology 20: 265-286.

(1) The Algodones Dunes, the largest dune complex in California, contains many unique species. This dune system also receives the greatest use by off-road vehicles (ORVs).
(2) Studies of paired plots (unused v. ORV-used) and animal tracks along sand sweeps clearly demonstrate that ORV activities in the Algodones Dunes significantly reduced the biota.

(3) There were marked declines in herbaceous and perennial plants, arthropods, lizards and mammals in ORV-used areas compared with nearby controls. All sand-adopted species, including several plants considered rare or threatened species, were greatly reduced in habitats where ORVs operate.
(4) The biota was negatively affected even by relatively low levels of ORV activities. Areas heavily used by ORVs had virtually no native plants not wildlife.

Macwhirter, Bruce, Peter Austin-Smith, Jr. and Donald Kroodsma. 2002. Sanderling (*Calidris alba*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/653

Manfredo, M. J. 1989. Human dimensions of wildlife management. Wildlife Society Bulletin **17**:447-449.

Manuwal, D. A. 1978. Effects of man on marine birds: a review. Pages 140-160 *in* Wildlife and people: the proceedings of the John S. Wright Forestry Conference. Department of Forestry and Natural Resources and the Cooperative Extension Service, Purdue University, IN.

Macwhirter, Bruce, Peter Austin-Smith, Jr. and Donald Kroodsma. 2002. Sanderling (Calidris alba), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/653

Mathews, G. V. T. 1982. The control of recreational disturbance. Pages 325-330 in D. A. Scott, editor. Managing wetlands and their birds, a manual of wetland and waterfowl management. Proceedings 3rd Tech. Meeting on Western Palearctic Migratory Bird Management, Bioogische Station Rieselfelder Münster, Federal Republic of Germany, 12-15 Oct. 1982.

Maxson, SJ. 2000. Interspecific Interactions of Breeding Piping Plovers: Conservation Implications. Waterbirds 23: 270-276.

I recorded interspecific agonistic interactions (n = 578) and opportunities for interactions (n = 1,550) of Piping Plovers (*Charadrius melodus*) during incubation and brood-rearing periods at Lake of the Woods, Minnesota to determine whether interactions (chases, balanced agonistic encounters, fights) were potentially detrimental to Piping Plover reproductive success. Piping Plovers interacted with 16 species, but five (Common Tern [*Sterna hirundo*], Ring-billed Gull [*Larus delawarensis*], Spotted Sandpiper [*Actitis macularia*], Semipalmated Sandpiper [*Calidris pusilla*], Killdeer [*Charadrius vociferus*]) accounted for 88.6% of male and 92.7% of female interactions. Interaction opportunities and interactions peaked during the brood-rearing period. Several species (Common Tern, Franklin's Gull [L. pipixcan], Spotted Sandpiper, Semipalmated Sandpiper) posed a low risk of direct negative effects on reproduction, ignoring Piping Plover chicks when they were in close proximity. Piping Plovers responded intensely to three potential predators (Ring-billed Gull, American Crow [*Corvus brachyrhynchos*], Common Grackle [*Quiscalus quiscula*]). Killdeers had the highest interaction indexes and under certain circumstances posed a threat of physical harm to Piping Plover adults and chicks. This method of quantifying interactions could be used at other Piping Plover breeding sites to help identify problem species and facilitate development of site-specific management strategies to reduce detrimental aggressive interactions.

McCollough, M. A. 2000. Piping Plover Assessment. Maine Department of inland fisheries and wildlife. 42pp.

Limiting Factors
Habitat availability, human disturbance, direct mortality caused by humans and their pets, and predation are the most important factors limiting the abundance and distribution of breeding piping plovers in Maine. Sandy beaches and low, sloping dunes suitable for nesting are uncommon in Maine, and often have been so altered by construction and stabilization activities that they are unacceptable to plovers.

Many sections of beaches in Maine that are physically suitable for breeding plovers are functionally unavailable to the birds because of human recreational activities and predators. Disturbance may cause plovers to leave the nest, exposing eggs to the summer sun or predation. Excessive disturbance eventually may cause abandonment. Foot or vehicular traffic on beaches can crush eggs or young, or prevent young from feeding.

At sites where piping plovers do nest in Maine, predation on eggs or chicks by red fox (*Vulpes vulpes*) , striped skunk (*Mephitis mephitis*) , raccoon (*Procyon lotor*), American crow (*Corvus brachyrynchos*), and gulls (*Larus spp*.) may seriously limit reproductive success in some years. Free-roaming dogs and cats that chase adults and chicks, kill chicks, and eat eggs are a serious problem at several sites.

SUMMARY AND CONCLUSIONS

Piping plovers are rare in Maine, and have probably always been uncommon because of limited sandy beach and dune habitat. Because this species is so habitat restricted in Maine, intensive management is expected to result in only moderate increases in population abundance and distribution.

Much of Maine's piping plover habitat has become physically or functionally unavailable to the birds because of habitat alteration and disturbance. Estimated physical and functional carrying capacity of existing habitat in Maine is 40-70 pairs. The population can be expected to be maintained at carrying capacity only if current management actions are continued or intensified and further habitat is not lost. High levels of productivity and/or ingress of individuals from elsewhere along the Atlantic Coast will likely be necessary to prevent the extirpation of this small breeding population. It is unlikely that Maine's piping plover populations can be recovered sufficiently to warrant state de-listing, although recent population increases and productivity are contributing to the recovery of the Atlantic Coast population and federal recovery objectives.

McGowan C. P. 2004. Factors affecting nesting success of American Oystercatchers (*Haematopus palliatus*) in North Carolina. M.S. Thesis, North Carolina State University, Raleigh, NC.

McGowan, C. P. and T. R. Simons. 2006. Effects of human recreation on the incubation behavior of American Oystercatchers. Wilson Journal of Ornithology, 118:485-493.

Human recreational disturbance and its effects on wildlife demographics and behavior is an increasingly important area of research. We monitored the nesting success of American Oystercatchers (*Haematopus palliatus*) in coastal North Carolina in 2002 and 2003. We also used video monitoring at nests to measure the response of incubating birds to human recreation. We counted the number of trips per hour made by adult birds to and from the nest, and we calculated the percent time that adults spent incubating. We asked whether human recreational activities (truck, all-terrain vehicle [ATV], and pedestrian traffic) were correlated with parental behavioral patterns. Eleven *a priori* models of nest survival and behavioral covariates were evaluated using Akaike's Information Criterion (AIC) to see whether incubation behavior influenced nest survival. Factors associated with birds leaving their nests (n _ 548) included ATV traffic (25%), truck traffic (17%), pedestrian traffic (4%), aggression with neighboring oystercatchers or paired birds exchanging incubation duties (26%), airplane traffic (1%) and unknown factors (29%). ATV traffic was positively associated with the rate of trips to and away from the nest (_1 _ 0.749, P _ 0.001) and negatively correlated with percent time spent incubating (_1 _ _0.037, P _ 0.025). Other forms of human recreation apparently had little effect on incubation behaviors. Nest survival models incorporating the frequency of trips by adults to and from the nest, and the percentage of time adults spent incubating, were somewhat supported in the AIC analyses. A low frequency of trips to and from the nest and, counter to expectations, low percent time spent incubating were associated with higher daily nest survival rates. These data suggest that changes in incubation behavior might be one mechanism by which human recreation affects the reproductive success of American Oystercatchers.

McGowan, C. P. 2004. Factors affecting nesting success of American Oystercatchers (*Haemaptopus palliatus*) in North Carolina. MS Thesis. North Carolina State University, Raleigh, North Carolina, USA.

McGowan, C. P., T. R. Simon, W. Golder, and J. Cordes. 2005. A comparison of American Oystercatcher reproductive success on barrier beach and river island habitats in coastal North Carolina. Waterbirds 28:150-155.

American Oystercatcher (*Haematopus palliates*) numbers along the east coast of the United States are declining in some areas and expanding in others. Researchers have suggested that movement from traditional barrier beach habitats to novel inland habitats and coastal marshes may explain some of these changes, but few studies have documented oystercatcher reproductive success in non-traditional habitats. This study compares the reproductive success of the American Oystercatcher on three river islands in the lower Cape Fear River of North Carolina with that of birds nesting on barrier island beach habitat of Cape Lookout National Seashore. There were 17.6 times more oystercatcher breeding pairs per kilometer on the river island habitat than barrier beach habitat. The Mayfield estimate of daily nest content survival was 0.97 (S.E. ± 0.0039) on river islands, significantly higher than 0.92 (S.E. ± 0.0059) on barrier islands. The primary identifiable cause of nest failure on the river islands was flooding while the main cause of nest failure on the

barrier islands was mammalian predation. Fledging success was equally low at both study sites. Only 0.19 chicks fledged per pair in 2002, and 0.21 chicks fledged per pair in 2003 on the river islands and 0.14 chicks fledged per pair in 2002 and 0.20 chicks fledged per pair in 2003 on the barrier islands. Many questions are still unanswered and more research is needed to fully understand the causes of chick mortality and the functional significance of non-traditional nesting habitats for the American Oystercatcher in the eastern United States.

McCrary M.D. and Pierson M.O. 2000. Influence of human activity on shorebird beach use in Ventura County, California. In: Brown D.R., Mitchell K.L. and Chang H.W. (ed.), Fifth California Islands Symposium, OCS Study, MMS 99–0038. Santa Barbara, CA, pp. 424–427.

McLean, E. F. 1993. Human impacts on beach use by wintering and migrating birds in lower Chesapeake Bay. Unpublished M. A. Thesis. College of William and Mary, Williamsburg, VA. 48 pp.

Medeiros, R., J. A. Ramos, V. H. Paiva, A. Almeida, P. Pedro, and S. Antunes. 2007. Signage reduces the impact of human disturbance on little tern nesting success in Portugal . Biological Conservation 135: 99-106.

This study evaluated the influence of human disturbance in nesting success of little tern (*Sterna albifrons*) and its interaction with the intrinsic seasonal variation in the birds' breeding biology. During 2003–2005 we studied little tern nesting ecology in southern Portugal in two different types of habitat: their natural habitat (sandy beaches) and a man-made habitat (salinas). In both habitat types, annual variations were found in the distribution of nest initiation over the breeding season and in the size of the clutches. The percentage of nests producing hatched chicks varied between 26.7% and 66.4% in different years and habitats. The main causes of hatching failure varied between years and habitats, but predation, flooding and human activities were very common. No consistent differences in breeding parameters or nesting success were found between habitats. On sandy beaches, the effect of protective measures (warning signs and wardening) on nesting success, together with differences between years and within each breeding season, were assessed using a logistic regression model. The presence/absence of protective measures was the most important predictor of nesting success, with birds being up to 34 times more likely to succeed with protective measures. Seasonal declines were found for clutch size and egg volume, and season was also an important predictor of nesting success, with nests more likely to succeed earlier in the season. Hence, earlier breeders will be those that benefit more from protective measures, suggesting that conservation efforts for little tern can be maximised if concentrated earlier in the season.

Melvin, S. M., A. Hecht, and C. R. Griffin. 1994. Piping Plover mortalities caused by off-road vehicles on Atlantic Coast beaches. Wildlife Society Bulletin 22: 409-414.

Management Implications: Incidents summarized in this paper demonstrate that ORV use, even at levels <5-10 vehicle passes per day, is a threat to unfledged piping plover chicks and adults during brood-rearing periods. Both the U. S. Endangered Species Act and state laws in Maine, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Maryland, Virginia, and North Carolina prohibit killing, harming, or harassing piping plovers (U.S. Fish and Wildlife Service 1985; Griffin and French 1992; C. R. Griffin and T. W. French, Univ. Mass, Amherst and Mass. Div. Fish. And Wildl., unpubl. Data). Fencing of nesting areas, while allowing vehicles to pass just above the wrack line, has effectively prevented direct mortality of plover eggs in many locations. However, to avoid violation of both federal and state endangered species statutes, we recommend banning recreational vehicles and all but essential administrative and service vehicles on sections of beaches where unfledged piping plover chicks are present. Where administrative or service vehicles are essential, drivers should be accompanied by a monitor with up-to-date information on locations of unfledged chicks and should drive slowly and cautiously. Although mortality may be reduced when monitors guide vehicles or when open ATV's are used by biologists and law enforcement personnel, these methods do not insure that chicks are not run over. We recommend that monitoring, research, and law enforcement patrols be conducted on foot whenever possible.

Closure to ORV's should begin > 1 day before hatching for nests for which hatch date can be predicted (i.e., nests found before clutch completion, assuming average incubation of 27-28 days from clutch completion to beginning of hatching [Wilcox 1959, Cairns 1982, MacIvor 1990.]). If hatching date cannot be predicted, closure should begin on the earliest recorded hatching date for piping plovers in that area. Alternatively, nests should be monitored twice/daily, in early morning and late afternoon, so that hatching

can be detected and vehicle closues implemented immediately. Nests should be monitored from a distance with spotting scopes or binoculars to minimize disturbance (MacIvor et al. 1990).

Daily or more frequent monitoring of broods to determine their locations and activity patterns will help managers determine which beach areas should remain closed and if alternative access points or travel corridors may be used to route vehicles away from broods. To minimize chicks killed by ORV's, beaches should remain closed until all plover chicks are able to fly (30-35 days old; Wilcox 1959, Cairns 1982, MacIvor 1990).

Melvin, S. M., C. R. Griffin, and L. H. MacIvor. 1991. Recovery strategies for piping plovers in managed coastal landscapes. Coastal Management 19: 21-34.

Piping plovers that nest and winter along the US Atlantic coast are threatened by cumulative impacts of habitat loss and alteration, human disturbance, and predation. Coastal stabilization activities may degrade plover habitat by altering natural processes of dune and beach erosion and accretion. Dredging and beach nourishment projects may be beneficial or detrimental to plovers, depending on timing and location. Management strategies to reduce disturbance and mortality caused by beachgoers and off-road vehicles include fencing of nesting and brood-rearing areas, partial or complete beach closures to pedestrians or vehicles during the breeding season, restrictions on pets, and public education. Beaches where piping plovers nest are owned and managed by a variety of federal and state agencies , county and municipal governments, private conservation organizations, and individuals. Wildlife biologists must work with coastal managers to implement multiple-use management strategies that include protection for piping plovers and their habitats.

Meyers, J. M. 2005. Management, monitoring, and protection protocols for American Oystercatchers at Cape Hatteras National Seashore, North Carolina. USGS Patuxent Wildlife Research Center.

The Outer Banks region of North Carolina supports approximately 90 breeding pairs of American Oystercatchers (Simon et al. 2004), along 160 km of beach, of an estimated 327 pairs surveyed in the state (Cameron and Allen 2004). Since the 1990s, this population has sustained declines in breeding pairs at Cape Hatteras National Seashore (CAHA), e.g., on Hatteras Island nesting pairs declined from 24 to 15 from 1999 to 2004 (Simon et al. 2004). Reproductive success for CAHA has been very low (<0.1 fledged per breeding pair) and sporadic depending on years and locations; however, some signs of successful reproduction have been noted at Cape Lookout National Seashore (just south of Cape Hatteras) on North Core and Middle Core Banks in 2004 (Simon et al. 2004). On Cape Hatteras, overall trends indicate that American Oystercatcher nesting attempts could decline to a scattered few per island per year (<5) in less than a decade.

Threats to nesting oystercatchers on CAHA are numerous and inter-related, but more than 51% of nest losses are from undetermined causes, which does not allow managers to correct the problem (Simons et al. 2004). Major causes of known nest failures (<49% of nesting attempts) are mammalian predation (60%), overwash (25%), avian predation (5%), abandonment (5%, possibly another cause), and humans (3%), vehicles (<2%), andghost crabs (<2%) (Simon et al. 2004). Sabine (2005) found strong associations with significantly reduced oystercatcher reproductive success/high predation and high levels of human disturbances on Cumberland Island National Seashore. Others have found reduced foraging for European oystercatchers in areas disturbed by humans (Verhulst et al. 2001). In other counties similar relationships have been found (to quote Sabine, 2005): "Human activities reduced reproductive success and influenced geographical distribution of African Black Oystercatchers (*H. moquini*) in South Africa (Jeffery 1987, Leseberg et al. 2000). Human disturbance and use of coastal areas have been implicated as primary causes of the extinction of the Canarian Black Oystercatcher (*H. meadewaldoi*) (Hockey 1987)."

The USGS Patuxent Wildlife Research Center developed this protocol, based on the best available scientific information, to guide management, monitoring and research activity at CAHA that would result in the protection and recovery of each species. These protocols do not attempt to balance the need for protection of these species with other activities that occur at CAHA, nor was NPS management policy considered in detail. A draft of the protocols was sent to species experts for scientific review; the final draft of protocols were reviewed by NPS personnel to ensure that description of recent management at CAHA was accurately represented and that the approach was consistent with our work agreement.

Mizrahi, D.S. 2002. Shorebird Distribution along New Jersey's Southern Atlantic Coast: Temporal Patterns and Effects of Human Disturbance. Final report, U.S. Fish and Wildlife Service.

Molina, K. C. and R. M. Erwin. 2006. Distribution and conservation status of the Gull-billed Tern (*Gelochelidon nilotica*) in North America. Waterbirds 29: 271-295.

The Gull-billed Tern (*Gelochelidon nilotica*) has until recently received little conservation and management attention within North America despite a relatively low overall population size and significant declines in parts of the breeding range. This lack of attention may stem in part from the wide distribution of the species, encompassing parts of six continents, and from its tendency to nest in relatively small, scattered and often ephemeral colonies. Populations of North American subspecies are alarmingly small. The current population of the eastern subspecies *aranea* in the U.S. is unlikely to exceed 3,600 pairs, with over 60% of these birds occurring in Texas. The Texas population has remained generally stable, but declines of populations in Maryland (where probably extirpated), Virginia, North Carolina, Florida, and possibly Georgia give cause for concern for this subspecies. For the western subspecies *vanrossemi*, as few as 250 pairs nest at only two locations in the U.S., both in California. When populations in western Mexico are considered, the entire *vanrossemi* population numbers only 600-800 pairs. Currently the Gull-billed Tern is listed as "endangered" or "threatened" in four states, and is considered to be of management concern in five others. The breeding range of the species has contracted and shifted slightly from its known historic range in the middle Atlantic states, but otherwise occupies its historic range in the United States and has expanded slightly to coastal southern California. Some range contraction in Mexico (e.g., in Sonora) may have occurred. In eastern Mexico, historical information is almost non-existent and knowledge of current distribution and abundance is incomplete. Main threats to populations in North America include loss of natural nesting islands through beach erosion or perturbations to estuarine functions, development or modification of upland habitats near breeding areas that may be important for foraging, and disturbances to colonies by humans and feral or human-subsidized predators. This species often nests on man-made substrates suggesting it could be responsive to management of breeding sites. Key research needs include more frequent and refined population monitoring, a better understanding of demographics, metapopulation dynamics and factors limiting populations as well as refinement of subspecies' breeding distributions and wintering ranges.

Monz, C. A., E. A. Young and Y. Leung. 2004. Monitoring the impacts of visitors to shorebird populations in the NPS coastal and barrier island network areas. Proceedings of the 2004 Northeastern Recreation Research Symposium. P. 373-377.

The impacts of recreationists on wildlife are a growing concern in protected natural areas around the world. In the NE Coastal and Barrier Island Network areas managed by the National Park Service (NPS), the effect of ever increasing visitor numbers on beach nesting shorebirds such as the piping plover is an ongoing management concern. Currently, these NPS areas conduct counts of shorebird species and numbers, but do not monitor other important trends such as visitor-wildlife interactions. The purpose of this study was to evaluate established procedures for the assessing the type and frequency of human disturbance to shorebirds and to determine the applicability of these procedures to monitoring trends of impact in the Coastal Network. Based on a literature review of disturbance studies, and a preliminary field assessment, the monitoring variables of pre and post disturbance behavior, visitor activity type and

Morris, R. D., H. Blokpoel and G. D. Tessier. 1992. Management efforts for the conservation of common tern *Sterna hirundo* colonies in the Great Lakes: Two case histories. Biological Conservation 60: 7-14.

Numbers of common tern *Sterna hirundo* colony sites have declined throughout the lower Great Lakes since the early 1970s. For the past 10-13 years, we have developed and tested management procedures to maintain numbers of breeding pairs. At an insular colony site near Port Colborne on Lake Erie, management procedures included protection from human disturbance, substrate rehabilitation, prevention of nesting on tern substrate by ring-billed gulls *Larus delawarensis* and control of egg/chick predation by ring-billed and herring *L. argentatus* gulls. At the Eastern Headland in Lake Ontario, management efforts included vegetation control, monofilament lines to prevent nesting by gulls, control of human disturbance, and construction of new nesting habitat. Success in maintaining numbers of breeding pairs was high at Port Colborne but poor at the Eastern Headland. We discuss probable reasons for the differences in success at the two colonies.

Morrison, R.I.G, B.J. McCaffery, R.E. Gill, S.K. Skagen, S.L. Jones, G.W. Page, C.L. Gratto-Trevor, and B.A. Andres. 2006. Population estimates of North American shorebirds. Wader Study Group Bull. 111: 67-85.

This paper provides updates on population estimates for 52 species of shorebirds, involving 75 taxa, occurring in North America. New information resulting in a changed estimate is available for 39 of the 75 taxa (52%), involving 24 increases and 15 decreases. The preponderance of increased estimates is likely the result of improved estimates rather than actual increases in numbers. Many shorebird species/taxa are

considered to be declining: current information on trends indicates negative trends outnumbered increasing trends by 42 to 2, with unknown or stable trends for 31 taxa.

Morrison, R. I. G., R. Gill, B. Harrington, S. Skagen, G. W. Page, C. L. Gratto-Trevor and S. M. Haig. 2001. Estimates of Shorebird Populations in North America. Occasional paper No. 104, Canadian Wildlife Service, Ottawa, Ontario. 64 pp.

Morrison, R.I.G., R.E. Gill, B.A. Harrington, S. Skagen, G.W. Page, C.L. Gratto-Trevor & S.M. Haig. 2000. Population estimates of Nearctic shorebirds. *Waterbirds* 23: 337–354.

Morrison, R.I.G., Y. Aubry, R.W. Butler, G.W. Beyersbergen, C. Downes, G.M. Donaldson, C.L. Gratto-Trevor, P.W. Hicklin, V.H. Johnston & R.K. Ross. 2001a. Declines in North American shorebird populations. *Wader Study Group Bull.* 94: 34–38.

Morse, J. A., A. N. Powell, and M. D. Tetreau. 2006. Productivity of Black Oystercatchers: Effects of recreational disturbance in a National Park. Condor 108: 623-633.

National parks in Alaska are generally assumed to be high-quality, undisturbed wildlife habitats. However, these parks attract recreational users, whose presence may reduce the suitability of key habitats for nesting shorebirds. In Kenai Fjords National Park, Black Oystercatchers (*Haematopus bachmani*) often breed on gravel beaches that are also popular campsites. In this study, we examined the effects of recreational activities in coastal Alaska on reproductive performance of Black Oystercatchers. We monitored survival of nests and chicks on 35 to 39 breeding territories annually during four breeding seasons (2001–2004). Most recreational disturbance on these territories occurred after the peak hatching date of first clutches. Annual productivity was low (average of 0.35 chicks per pair), but was not strongly affected by recreational disturbance. Daily survival of nests varied annually and declined over the season. Our results suggest that nest survival was lower during periods of extreme high tides. Daily survival rate of broods increased over the season and was higher on island than mainland territories, likely due to differences in predator communities. Territory occupancy rate and site fidelity were high; 95% of color-banded oystercatchers returned to the same breeding territory in the subsequent year. We conclude that Black Oystercatchers are resilient to low levels of recreational disturbance. However, in light of projected increases in recreation, we suggest managers move campsites away from the traditional nest sites identified in this study to minimize future disturbances.

Morton, J. M. 1996. Effects of human disturbance on the behavior and energetics of nonbreeding sanderlings. Dissertation. Virginia Polytechnic and State University, Blacksburg, VA.

Myers, J.P. et al. 1987. Conservation strategy for migratory species. American Scientist 75: 19-26.

Nebel, Silke and John M. Cooper. 2008. Least Sandpiper (*Calidris minutilla*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/115

Nester, L. R. 2006. Effects of off-road vehicles on the nesting activity of loggerhead sea turtles in North Carolina. MSc. Thesis, University of Florida. 81pp.

Loggerheads sea turtles face many anthropogenic nesting threats, including beach armoring, beach nourishment, artificial lighting, commercial fishing, beach vehicular driving, and pollution. Most potential threats have been thoroughly evaluated, but there remains a dearth of information about the effects of beach vehicular driving on nest success. Several factors were evaluated to determine the effect of driving off-road vehicles (ORVs) on nesting activity. To compare driven and non-driven beaches, data on beach slope, sand compaction, beach width, sand color, sand grain size, moisture content, incubation temperature, and pedestrian activity were collected during the 2005 nesting season at Cape Lookout National Seashore, Cape Hatteras National Seashore and Pea Island Wildlife Refuge, North Carolina, USA. Data collected in the 2000 to 2005 nesting seasons were assessed to determine differences in incubation period and the percentages of false crawls between ORV and non-ORV beaches.

ORV use was found to be a significant factor in determining nesting laying. False crawls were more likely to occur on ORV beaches. The light intensities for 300-500 nm were found to be a significant factor in determining the occurrence of a nest or false crawl. A T-test for light intensities for 300-500 nm found greater light intensity on non- ORV beaches.

Incubation period was estimated to be an average of 2 days longer for ORV beaches. This is estimated to cause a decline of 20% in production of female loggerhead turtles at these locations. None of the beach and sand characteristics accounted for this difference. More nests were relocated on ORV beaches than non-ORV beaches. However, nests on non-ORV beaches were subject to higher rates of inundation by the sea. Emergence success of hatchlings in Cape Hatteras was reduced by more than half by overwash and approached zero with washout.

The greater occurrences of false crawls on ORV beaches may cause the nesting turtle to expend additional energy. This energy could be put into egg production or growth. Cape Hatteras and Cape Lookout need to further evaluate this effect and take action to mitigate it. ORV use could be stopped completely, permitted, mileage reduced, discontinued during nesting season, or prohibited during nighttime hours. The habitat quality of non-ORV beaches was inferior to the beaches designated for ORV use. The issues of overwash, washout, and light intensity should be considered when selecting an area for ORV use or as a nest relocation site. Areas with high historic nesting percentages and low incidence of overwash and washout ought to be designated as non- ORV. The possible skewed sex ratios present a risk for a recovering population. ORV use should be discontinued in order to correct sex ratio.

Nettleship, David N. 2000. Ruddy Turnstone (Arenaria interpres), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/537

Nicholls, J.L. 1989. Distribution and other ecological aspects of piping plovers wintering along the Atlantic and Gulf Coasts. M.S. thesis, Auburn University; Auburn, Alabama.

Nicholls, J.L., and G.A. Baldassarre. 1990a. Winter distribution of piping plovers along the Atlantic and Gulf Coasts of the United States. Wilson Bulletin 102(3):400-412.

We conducted winter surveys of Piping Plovers (*Charadrius melodus*) along the Atlantic Coast (December 1986-March 1987) and Gulf Coast (December 1987-March 1988) of the United States to identify specific wintering sites. A total of 222 Piping Plovers was observed on the Atlantic Coast (about 14% of the entire Atlantic Coast breeding population) and 1508 on the Gulf Coast (about 56% of the entire Great Lakes/Northern Great Plains breeding population). Highest Atlantic Coast estimates occurred in Georgia (N = 105; 47.5%), whereas the most plovers on the Gulf Coast occurred in Texas (N = 834; 55.3%). The survey included 1422 km of barrier beach on the Atlantic Coast (69% of the coast) and 1283 km on the Gulf Coast (50% of the coast). The greatest potential for locating more plovers in the United States is in South Carolina and Louisiana. However, a large percentage of the North American breeding population (particularly on the Atlantic Coast) probably winters outside the United States, thus future surveys should explore the Caribbean and Mexico. Received 28 April 1989, accepted 21 Nov. 1989.

Nicholls, J.L., and G.A. Baldassarre. 1990b. Habitat associations of piping plovers wintering in the United States. Wilson Bulletin 102(4):581-590.

During winter distribution surveys of Piping Plovers (*Charadrius melodus*) on the Atlantic Coast (1986-1987) and Gulf Coast (1987-1988) of the United States we examined factors affecting habitat use and documented associations with other species of shorebirds. Stepwise and discriminant analyses generated models that correctly classified Piping Plover presence 75% of the time for the Atlantic Coast and 65% of the time along the Gulf Coast. The presence of large inlets and passes and mudflats on the Atlantic Coast and beach width, number of small inlets, and beach area on the Gulf Coast appeared as important habitat features affecting presence of Piping Plovers. Both models suggest that habitat heterogeneity (including key feeding sites) may be more important than specific habitat features in affecting winter use of a site by Piping Plovers, however, models only explained 22-28% of the variability in habitat use. Received 24 July 1989, accepted 10 Feb. 1990.

Niles, L. J., H. P. Sitters, A. D. Dey, P. W. Atkinson, A. J. Barker, K. A. Bennett, K. E. Clark, N. A. Clark, C. Espoz, P. M. Gonzalez, B. A. Harrington, D. E. Hernandez, K. S. Kalasz, R. Matus, C. D. T. Minton, R. I. G. Morrison, M. K. Peck, and I. L. Serrano. 2007. Status of the Red Knot (Calaidris canutus rufa) in the western hemisphere. Report to USFWS, Ecological Services, Region 5, Pleasantville, NJ, USA. 287 pp.

The population of the *rufa* subspecies of the red knot *Calidris canutus*, which breeds in the central Canadian arctic and mainly winters in Tierra del Fuego, has declined dramatically over the past twenty years. Previously estimated at 100,000-150,000, the population now numbers 18,000-33,000 (18,000 if just the Tierra del Fuego birds are *rufa*, more if the knots of uncertain subspecific status that winter in northern Brazil (7,500) or Florida (7,000) are also *rufa*).

Counts show that the main Tierra del Fuego wintering population dropped from 67,546 in 1985 to 51,255 in 2000, 29,271 in 2002, 31,568 in 2004, but only 17,653 in 2005 and 17,211 in 2006.

Demographic studies covering 1994-2002, showed that the population decline over that period was related to a drop in annual adult survival from 85% during 1994-1998 to 56% during 1999-2001. Population models showed that if adult survival remained low, *rufa* would go extinct within about ten years. After 2002, the population held up in 2003-2004, but plunged again by nearly 50% in 2005 increasing the likelihood of extinction within the next decade.

Despite intensive studies, the reasons for the population decline and reduced adult survival are imperfectly known.

During northward migration, most *rufa* stopover in Delaware Bay where they feed mainly on the eggs of horseshoe crabs (*Limulus polyphemus*) and lay down fat and protein reserves both to fuel the 3,000 kilometer flight to the arctic breeding grounds and ensure their survival after they arrive at a time when food availability is often low.

The crucial importance of Delaware Bay is demonstrated by studies that show that lower weight knots in Delaware Bay have lower survival than heavier birds and that over 1998-2002 the proportion of birds there at the end of May that weighed more than the estimated departure mass of 180 grams declined by over 60%. This might be the result of the progressive failure of the food supply in Delaware Bay and/or a trend for birds to arrive there later and/or in poorer condition. In years when red knots experience both reduced food availability and there are late arrivals, the result may be an exacerbation of the effects of each of these deleterious factors.

The main identified threat to the *rufa* population is the reduced availability of horseshoe crabs eggs in Delaware Bay arising from elevated harvest of adult crabs for bait in the conch and eel fishing industries. Since 1990, there has been a substantial decline in the crab population. Although significant uncertainty regarding the extent of the decline of the horseshoe crab population remains, there is general agreement that horseshoe crab stocks have declined to a level where increased management of the fishery is necessary and appropriate. The decline in crabs has led to a decrease in the density of eggs available to shorebirds. Because of their delayed maturity, demographic models indicate that even if further exploitation of crabs ceases immediately, it will be some years before the horseshoe crab population recovers to its former level.

Although there is clear evidence, as in 2003 and 2005, that the reduced availability of eggs is already having an impact in some years on the knots ability to gain mass in Delaware Bay, it is likely that there are other threats to *rufa* and that these are the cause of some birds arriving in the Bay late and/or in poor condition. It is not known what these are, but they could be related to Bahia Lomas, the main wintering site in Tierra del Fuego (because the largest reduction in recent years has occurred there and because northwards migration from Bahia Lomas along the Atlantic coast of Argentina has taken place 1-2 weeks later since year 2000).

If it is proved that there are factors that lead knots to arrive late in Delaware Bay and/or in poor condition, this does not diminish the importance of the Delaware Bay food resource. If anything, it is increased because it is of critical importance in enabling the birds to recover quickly and reach the breeding grounds on time and in good reproductive condition.

Actions already being taken to improve feeding conditions for red knots and other shorebirds in Delaware Bay include beach closures to prevent disturbance and exclosures to reduce competition from gulls. However, although these measures help, they are no substitute for a recovered horseshoe crab population. Actions to conserve horseshoe crabs have included reduced harvest quotas, more efficient use of crabs as bait, closure of the harvest in certain seasons and places and the designation of a sanctuary off the mouth of Delaware Bay. The latest information is that the crab population may have stabilized, but there is no evidence of recovery.

Another red knot subspecies, *roselaari*, breeds in Alaska and is presumed to include those knots that winter on the Pacific coast of the U.S. and Mexico. There are two other red knot wintering populations of uncertain subspecific status: one in the southeast of the United States (mainly Florida) of about 7,000 and one on the north coast of Brazil of about 7,500. These populations have not been the subject of regular systematic surveys, but it is not thought that either has suffered the same catastrophic decline as the *rufa* that winter in Tierra del Fuego. Substantial proportions of both pass through Delaware Bay during northward migration, but banding shows that these are distinct populations without interchange with the Tierra del Fuego birds. Moreover genetic studies show that there has been no exchange of genes between the SE United States and the Tierra del Fuego birds for at least 1,200 years.

Some progress has been made towards understanding why the Tierra del Fuego population has suffered a major decline, but the northern wintering birds have apparently remained more stable. It appears that physiological constraints mean that the southern birds, which mostly make a long, non-stop flight to Delaware Bay from at least Northern Brazil, are more reliant on soft, easily-digested horseshoe crab eggs in Delaware Bay than the northern winterers, many of which feed on blue mussel (*Mytilus edulis*) spat or surf clams (*Donax variablis*) on the Atlantic coast of New Jersey. There is also evidence from Patagonia that, for a reason that remains obscure, northward migration of Tierra del Fuego birds has become 1-2 weeks later since year 2000 and this has probably led to more red knots arriving late in Delaware Bay. Late arriving birds have been shown to have the ability to make up lost time by increasing their mass at a higher rate than usual provided there are sufficient food resources. However, late-arriving red knots failed to do this in 2003 and 2005 when egg availability was low.

Although *rufa* knots are spread thinly across a large area of the Canadian arctic during the breeding season, for the rest of the year they occur mainly in large flocks at a limited number of key coastal wintering and staging sites.

This review describes each of these sites and the threats the birds face ranging from oil pollution to disturbance and reclamation for development.
Overall the goal of conservation activities throughout the flyway should be to increase the *rufa* population to at least the figure of 25 years ago of 100,000-150,000 by 2015. Given the uncertain genetic relationships between the three main wintering populations there should also be a target for each. The following are suggested:

1. Tierra del Fuego wintering population to 70,000-80,000 birds
2. Brazilian wintering population to 20,000-25,000
3. Florida wintering Population to 20,000-25,000
4. Other sites 15,000-20,000

The means whereby such population increases might be achieved include:

1) Recovery and maintenance of Delaware Bay horseshoe crab egg densities to levels sufficient to sustain stopover populations of all shorebirds including 100,000 red knots.
2) Control impact of disturbance at all stopovers and wintering areas, particularly in high-importance, high-disturbance areas like Delaware Bay and the west coast of Florida.
3) By 2008, develop a system for the yearly determination of population demographic status based on counts, capture data, and resightings of banded individuals.
4) By 2008, determine the genetic and breeding status of the three main wintering populations (Tierra del Fuego, Maranhão, and Florida).
5) By 2008, identify all important breeding locations in Canada and recommend protection needs and designations for the most important sites.
6) By 2009, complete site assessments and management plans for all important wintering areas and stopovers in the Flyway.
7) By 2009, delineate and propose protection measures for key habitats within the main wintering areas of Maranhão, Tierra del Fuego, and Florida, and develop management plans to guide protection.
8) By 2009, determine key southbound and northbound stopovers that account for at least 80% of stopover areas supporting at least 100 red knots, and develop coast-wide surveillance of birds as they migrate.
9) By 2011, create a hemisphere-wide system of protected areas for each significant wintering, stopover, and breeding area.

Also crucial to *rufa*'s recovery is adequate funding to support the conservation actions and research needed. Despite the fact that much of the research, survey, monitoring and conservation work has been carried out by volunteers and has been supported financially by state, federal government and non-government agencies, present funding levels are inadequate to sustain the work required.

Nisbet, I. C. T. 1977. Noise and disturbance. Pages 671-673 *in* Coastal ecosystem management (J. R. Clark, Ed.). John Wiley & Sons, New York.

Nisbet, I.C.T. 1979. Conservation of marine birds of northern North America – A summary. Pages 305-315 *in* Conservation of Marine Birds of Northern North America. U.S. Fish and Wildl. Serv. Wildl. Res. Rep. 11. Seattle, WA.

Nisbet, I. C. T. 1995. Marine birds of the eastern United States: Status and Conservation. Prepared for Stichting Greenpeace Council, Amsterdam, The Netherlands. 84 pp.

Nisbet, I, C. T. 2000. Disturbance, habituation, and management of waterbird colonies. Waterbirds 23: 312–322.

Nisbet, I. C. T. 2002. Common Tern (*Sterna hirundo*). *In* The Birds of North America, No. 618 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Nisbet, Ian C. 2002. Common Tern (*Sterna hirundo*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/618

Noel, B. L. and C. R. Chandler. 2008. Spatial Distribution and Site Fidelity of Non-breeding Piping Plovers on the Georgia Coast. Waterbirds 31: 241-251.

The Piping Plover (*Charadrius melodus*) is a federally listed species with three distinct breeding populations, including Great Plains (threatened), Great Lakes (endangered), and Atlantic Coast (threatened), all of which winter along the Atlantic and Gulf coasts of the United States. The spatial distribution and site fidelity of wintering Piping Plovers was investigated on Little St. Simons Island (LSSI), Georgia, from 2003-2006, with emphasis on the conservation significance of this site for the endangered Great Lakes population. Of the individually recognizable color-banded plovers observed on LSSI during 2003-2004 (N = 39), 31% (N = 12) were observed the following year; 69% (N = 9) of plovers that wintered in 2003-2004 returned to winter in 2004-2005. Although good winter survival in 2003-2004 was estimated, survival estimates dramatically declined in 2004-2005. Even with low survival estimates for 2004-2005, 44% of these wintering individuals returned to winter in 2005-2006. Wintering plovers on LSSI were site faithful to particular sections of beaches and occupied small home-ranges. These data on site fidelity and home-range suggest that relatively small areas on LSSI may be of disproportionate importance to wintering Piping Plovers. Critical habitat designations should take account of this within-island variation, and modest detection rates suggest plover numbers could be underestimated by single-visit surveys throughout their winter range.

Nol, E. 1989. Food supply and reproductive performance of the American Oystercatcher in Virginia. Condor 91: 429-435.

The relationship between food supply and reproductive performance was determined in a 3-year study of the American Oystercatcher, *Haematopus palliatus*, in Virginia. Clutch size, clutch-initiation dates, interclutch intervals, fledging success, distance to food, and quality and density of food were examined for 41 territories. Food supply varied more among territories than did clutch size, clutch-initiation dates, or interclutch intervals. Annual and interannual fledging success was extremely variable. Although no measure of food supply contributed significantly to variation in clutch size, the size of nearby feeding areas was positively correlated with average egg size and fledging success and was negatively correlated with the date of first clutch initiation. Earlier laying females had greater fledging success. Of the measures of food supply only the size of the nearby feeding area contributed significantly to variation in fledging success. Growth rates and rates of provisioning young were similar among broods of different sizes. In general, the match between food supply and reproductive performance was poor. As predation was the major cause of chick losses, I suggest that better territories for oystercatchers are those that allow parents to watch for predators of the young, and forage at the same time.

Nol, E., A. J. Baker and M. D. Cadman. 1984. Clutch initiation dates, clutch size, and egg size of the American Oystercatcher in Virginia. Auk 101: 855-867.

The timing of egg laying, clutch size, and egg size of the American Oystercatcher (*Haematopus palliatus*) were studied over six consecutive breeding seasons in Virginia. Synchrony of laying dates occurred in each of five localities of the study area in at least one year. Mean clutch size was 2.8 eggs (mode = 3) in first clutches and 2.4 eggs (mode = 2) in replacement clutches. Individual females laid replacement clutches of the same size and laid eggs of similar average volume in all years. A change in mate had little effect on the date on which females initiated their first clutches in successive years. The average egg size in a clutch was correlated with the size of the laying female. Egg-size ordering occurred within clutches, the first-laid egg being smaller than the second egg and about equal in volume to the third. We propose that the second egg is largest because it has the highest probability of hatching, and the resulting sibling hierarchy reduces the frequency of sibling competition. Received 19 October 1983, accepted 19 April 1984.

Nol, Erica and Michele S. Blanken. 1999. Semipalmated Plover (Charadrius semipalmatus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/444

Nol, E. and R. C. Humphrey. 1994. American Oystercatcher (*Haematopus palliatus*). *In* The Birds of North America, No. 82 (A. Poole and F. Gill, Eds.). Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union.

Nol, Erica and R. C. Humphrey. 1994. American Oystercatcher (*Haematopus palliatus*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/082

Nol, E., Truitt, B, Allen, D., Winn, B., & Murphy, T . 2000. A survey of wintering American Oystercatchers from Georgia to Virginia, U.S.A., 1999. Wader Study Group Bull. 93: 46-50.

Using a variety of survey techniques were attempted to estimate the size of the wintering population of American Oystercatchers *Haematopus palliatus palliatus* along the Atlantic coast of eastern United States. Highest counts were from South Carolina with over 3,000 wintering birds; numbers approached 2 ,000 birds in coastal Virginia. Counts of less than 6 00 were from Georgia and North Carolina. Ninety percent o f oystercatchers were roosting on wind produced shell mounds a long s alt Marsh channels. T he remaining birds occurred in singles or pairs a long barrier island beach fronts. Average roosts size was 106 birds (range 18-390). Surveys were most efficient two hours from high tide when all birds were roosting. Wintering f locks in all states south of South Carolina probably consist primarily of breeding birds from those states whereas Virginia and North Carolina have both breeding And wintering birds. All roosting birds used edges of tidal creeks and (primarily) commercial oyster Beds f or foraging. The total population size for this region is estimated a t 7,700 birds. The total Central And North American population is estimated to consist of 9,000 birds.

Noel, B. L., C. R. Chandler, and B. Winn. 2007. Seasonal abundance of nonbreeding Piping Plovers on a Georgia barrier island. Journal of Field Ornithology 78: 420-427.

ABSTRACT. Although breeding populations of Piping Plovers are well studied, their winter distribution is less clear. We studied the seasonal abundance of nonbreeding Piping Plovers (*Charadrius melodus*) during the winters of 2003–2004 and 2004–2005 on Little St. Simons Island (LSSI), Georgia. Our objectives were to determine the relative abundance of individuals from three breeding populations at LSSI, and identify possible differences among populations in arrival time, winter movements, or departure time. We observed up to 100 Piping Plovers during peak migration, and approximately 40 plovers wintered at LSSI. From July 2004 to May 2005, approximately 20% of the Great Lakes breeding population used LSSI. Plovers were not present at LSSI during June. All breeding populations of Piping Plovers had similar patterns of temporal occurrence on LSSI, suggesting no need for population-specific management plans at this site. Our results suggest that LSSI is among the most important wintering sites on the Atlantic coast for Piping Plovers, especially for individuals from the endangered Great Lakes population.

Nordstrom, K. F., R. Lampe, and L. M. Vandemark. Reestablishing Naturally Functioning Dunes on Developed Coasts. Environmental Management 25: 37-51.

Common beach management practices reduce the ecological values of coastal dunes. Mechanical beach cleaning eliminates incipient dunes, habitat for nesting birds, seed sources for pioneer dune colonizers and food for fauna, and artificially small, stabilized foredunes reduce the variability in microenvironments necessary for biodiversity. Recent initiatives for reducing coastal hazards, protecting nesting birds, and encouraging nature-based tourism provide incentive for the development of a restoration program for beaches and dunes that is compatible with human use. Suggested changes in management practice include restricting or rerouting pedestrian traffic, altering beach-cleaning procedures, using symbolic fences to allow for aeolian transport while preventing trampling of dunes, and eliminating or severely restricting exotic species. Landforms will be more natural in function and appearance but will be more dynamic, smaller and in a different position from those in natural areas. Research needs are specified for ecological, geomorphological, and attitudinal studies to support and inform restoration planning.

Novick J. S. 1996. An analysis of human recreation impacts on the reproductive success of American Oystercatchers (*Haematopus palliatus*): Cape Lookout National Seashore, North Carolina. Unpublished M.S. Thesis, Duke University, Durham, North Carolina.

Nudds, R.L., Bryant, D.M., 2000. The energetic cost of short flight in birds. Journal of Experimental Biology 203, 1561–1572.

Many small birds perform short flights, for which take-offs, ascents and descents form a large component of the total flight time and which are characterised by low airspeeds. Using the doubly-labelled water technique, zebra finches *Taeniopygia guttata* engaging in repeated short flights were found to expend 13.65 kJ more than 'non-flying' controls, which equated to a flight expenditure of 27.8 times their basal metabolic rate. This is over three times the predicted flight expenditure derived from existing aerodynamic models. These data were used to determine a coefficient (0.11) for converting the mechanical power derived from aerodynamic models into metabolic power. An equation is presented, based on body mass, which can be used to predict the costs of short flights in ecological and behavioural studies of birds.

Olson, C.R., Vleck, C.M. & Vleck, D. (2006). Periodic cooling of bird eggs reduces embryonic growth efficiency. Physiological and Biochemical Zoology 79, 927–936.

For many bird embryos, periodic cooling occurs when the incubating adult leaves the nest to forage, but the effects of periodic cooling on embryo growth, yolk use, and metabolism are poorly known. To address this question, we conducted incubation experiments on eggs of zebra finches (*Taeniopygia guttata*) that were frequently cooled and then rewarmed or were allowed to develop at a constant temperature. After 12 d of incubation, embryo mass and yolk reserves were less in eggs that experienced periodic cooling than in controls incubated constantly at 37.5 degrees Celsius. Embryos that regularly cooled to 20 degrees Celsius had higher mass-specific metabolic rates than embryos incubated constantly at 37.5 degrees Celsius. Periodic cooling delayed development and increased metabolic costs, reducing the efficiency with which egg nutrients were converted into embryo tissue. Avian embryos can tolerate periodic cooling, possibly by adjusting their physiology to variable thermal conditions, but at a cost to growth efficiency as well as rate of development. This reduction in embryo growth efficiency adds a new dimension to the fitness consequences of variation in adult nest attentiveness.

Parnell, J.F. et al. 1997. Changes in nesting populations of colonial waterbirds in coastal North Carolina 1900-1995. Colonial Waterbirds 20: 458-469.

In the early 1900s, 13 species of gulls, terns, herons and egrets nested in the coastal zone of North Carolina. Four of these, Least Tern, Gull-billed Tern, Snowy Egret and Great Egret were uncommon or rare. By the time the first coast wide censuses of all species were completed in the 1970s, 23 species were nesting, and populations of most appeared relatively stable or were increasing. No species is known to have been extirpated from the state. Prior to the initiation of dredging in the coastal sounds, all colonies of gulls and terns were on natural beaches or islands while most heronries were in coastal swamps. By the 1970s, most nesting sites for gulls, terns and waders were in the estuarine zone and nearly 50 percent of all sites were on man-made or man-modified substrate. In the early 1900s, the Audubon Society of North Carolina provided the first protection for these birds, and the first sites were protected by wardens. By 1995, about 65 percent of all sites were protected by private, state or federal agencies. The outlook is guardedly optimistic. Maintenance of sites by the deposition of dredged material may decline as costs of dredging coastal channels and competition for dredged material escalates. Management agencies, however, are showing strong interest in the welfare of these species, and the level of effort directed toward protection and management is increasing.

Parnell, J. F., W. W. Golder, and T. Henson. 1995. 1993 Atlas of colonial waterbirds of North Carolina estuaries. NC Sea Grant Publication, UNC-SG-95-02, Raleigh, North Carolina.

Parnell, J. F. and M. A. Shields. 1990. Management of North Carolina's colonial waterbirds. UNC Sea Grant Publication UNC-SG-90-03, Raleigh, North Carolina.

Parnell, J. F. and D. A. McCrimmon. 1984. 1983 supplement to Atlas of colonial waterbirds of North Carolina estuaries. UNC Sea Grant Publication, UNC-SG-84-07, Raleigh, North Carolina

Parnell, J. F., and R. F. Soots, Jr. 1979. Atlas of colonial waterbirds of North Carolina estuaries. UNC Sea Grant Publication, UNC-SG-78-10, Raleigh, North Carolina

Parnell, J. F., D. G. Ainley, H. Blokpoel, B. Cain, T. W. Custer, J. L. Dusi, S. Kress, J. A. Kushlan, W. E. Southern, L. E. Stenzel, and B. C. Thompson. 1988. Colonial waterbird management in North America. Colonial Waterbirds 11(2): 129-169.

Colonial waterbirds are an important natural resource highly valued by many people in Canada and the United States. The habit of nesting often in large groups makes these birds especially susceptible to problems, such as human disturbance, predation, severe weather events, and competition for nesting habitat. They, like all birds, also face threats from habitat degradation, loss and contamination of their environments, and changes in food webs. Management strategies to deal with these problems include habitat preservation and restoration, the elimination of toxic chemicals from the environment, reduction of predation, competition, and disturbance at nesting sites, reintroduction of species to nesting sites from which they have been eliminated, and fisheries management from a multispecies ecosystem perspective. Techniques are discussed and examples provided. A few colonial waterbird species have increased greatly in numbers and now pose problems for other bird species or are in conflict with people.

Parnell, J. F., R. M. Erwin, and K. C. Molina. 1995. Gull-billed Tern (*Sterna nilotica*). *In* The Birds of North America, No. 140 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia and The American Ornithologists' Union, Washington, D.C.

Parnell, J. F., R. M. Erwin and K. C. Molina. 1995. Gull-billed Tern (Sterna nilotica), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/140

Patterson, M. E., J. D. Fraser, and J. W. Roggenbuck. 1991. Factors affecting piping plover productivity on Assateague Island. Journal of Wildlife Management 55: 525-531.

We studies piping plovers (*Charadrius melodus*) on Assateague Island (Md., Va.) in 1986-87 to estimate population size and to identify factors affecting productivity. Fledging rates (0.19-1.11 chicks/pair) appeared to be lower than the level necessary to maintain a stable population. Fifty-four percent of the nests were unsuccessful. Predators accounted for most (91%) of the known causes of nest losses. Only 1 nest (2.2% of losses with known cause) was lost due to direct human destruction, and we found no evidence that suggested recreational disturbance was a factor affecting productivity. Mean chick fledging success was 69% for broods foraging at a bay flats or tidal pool and 19% for broods foraging on ocean beach ($P < 0.05$).

Patterson, M.E., J.D. Fraser, and J.W. Roggenbuck. 1990. Piping plover ecology, management, and research needs. Virginia Journal of Science 41(4A):419-426.

The Atlantic coast piping plover (*Charadrius melodus*) population was listed as threatened under the Endangered Species Act in January 1986 due to declining populations. Part of the decline is attributed to habitat loss from beach development and dune reclamation. Where plovers continue to nest, productivity is often low. Nest predation appears to be the most immediate threat to piping plovers in many areas. Although unrestricted recreational activity may be highly detrimental, nesting plovers can apparently habituate to some degree of human activity on beaches. Factors affecting chick mortality are not fully understood. We believe that foraging habitats have a major influence on the distribution and reproductive success of piping plovers on barrier islands. However, these hypotheses need to be tested.

Paulson, Dennis R. 1995. Black-bellied Plover (*Pluvialis squatarola*). The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/186

Pearson, T. G., C. S. Brimley, and H. H. Brimley. 1942. Birds of North Carolina. Bynum Printing Co., New York.

Pearson, T. G., C. S. Brimley, and H. H. Brimley. 1919. Birds of North Carolina. Edwards and Broughton Printing Co., Raleigh, NC.

Peters, K. A., and D. L. Otis. 2005. Using the risk-disturbance hypothesis to assess the relative effects of human disturbance and predation risk on foraging American oystercatchers. Condor 107: 715–724.

The risk-disturbance hypothesis asserts that animals perceive human disturbance similar to nonlethal predation stimuli, and exhibit comparable responses in the form of optimization tradeoffs. However, few studies have examined how natural predation risk factors interact with human-disturbance stimuli to elicit such responses. We observed American Oystercatcher (*Haematopus palliatus*) vigilance behavior from September–December 2002 on the Cape Romain National Wildlife Refuge, South Carolina. A set of models was constructed based on 340 focal-animal samples and models revealed relationships between vigilance behavior, predator density, and boat activity. Oystercatchers increased vigilance in response to aerial predators, particularly late in the season when predator species composition was dominated by Northern Harriers (*Circus cyaneus*). At a broader temporal scale, oystercatchers exhibited the highest vigilance rates during simultaneous peaks in boating disturbance and Osprey (*Pandion haliaetus*) activity. Due to this temporal overlap of stimuli, it is difficult to interpret what may have been driving the observed increased in vigilance. Foraging rates appeared to be primarily driven by habitat and tidal stage indicating that time lost to vigilance did not

effectively reduce intake. Taken together, these findings provide some support for the risk-disturbance hypothesis, underscore the sensitivity of disturbance studies to temporal scale, and draw attention to the potential confounding effects of natural predation risk.

Peters, K. A. and D. Otis. 2006. Wading Bird Response to Recreational Boat Traffic: Does Flushing Translate into Avoidance? Wildlife Society Bulletin 34(5):1383 -1391.

It generally is assumed that direct flushing responses to disturbance may affect overwintering bird fitness by altering site use. However, little is actually known about the relationship between the flushing response and resulting patterns of habitat use on a local scale. We examined the association between flushing and local site use among 6 wading bird species in tidal creeks on the Cape Romain National Wildlife Refuge, South Carolina, USA, which is frequently used for recreational activities. Experimental, cumulative boat intrusion caused approximately one-half of individuals of all species except snowy egrets (*Egretta thula*) to immediately abandon a tidal creek. However, species counts across the refuge tended to be driven primarily by Julian date, tidal stage, and creek width; only 2 species, yellow-crowned night heron (*Nyctanassa violacea*) and great egret (*Ardea herodias*), appeared to avoid high-traffic creeks. Overall, patterns of response varied among species, and there was no clear relationship between flushing and site use. Flush rates, thus, may not adequately reflect species sensitivity to human disturbance and should only be used as a management guide in conjunction with other indices such as spatial distribution.

Peters, K. A., and D. L. Otis. 2005. Shorebird roost-site selection at two temporal scales: is human disturbance a factor? Journal of Applied Ecology 44: 196-209.

Roost-site selection in shorebirds is governed by ambient factors, including environmental conditions and human disturbance. Determination of the extent to which these factors affect roost use and the associated implications for shorebird habitat protection is important for conservation strategies and informed management of human recreational use of these habitats. Shorebird conservation as a whole is a high priority world-wide because a large proportion of shorebird species is in decline. However, little is understood about the consistency of roost use by different species, what conditions affect species-specific roost-site selection, and at what spatial and temporal scales conditions influence selection. We studied high-tide roost-site selection by eight species of non-breeding shorebirds on a critically important stopover and wintering refuge. We calculated spatial and temporal variability in roost use for each species based on counts and consistency of incidence. We then examined roost-site selection in relation to structural, environmental and human disturbance factors, and how this varied across spatial and temporal scales. Most roosts were used less than 50% of the time, although larger roosts were used more consistently. This varied among species, with red knot *Calidris canutus* tending to concentrate at a few roosts and American oystercatcher *Haematopus palliatus*, dowitcher Limnodromus griseus and *Limnodromus scolopaceus* and ruddy turnstone *Arenaria interpres* more diffusely distributed among roosts. At an annual scale, the principal factors affecting shorebird presence at roosts were roost length (size), local region, substrate and aspect. The extent and direction of these effects varied among species. Among years, red knots avoided roosts that had high average boat activity within 1000 m, but disturbance did not appear to be a factor for other species. Daily roost use was influenced primarily by wind speed and the ability of roosts to provide shelter from the wind. Only dowitchers appeared to track daily disturbance, avoiding prospective roosts when boat activity within 100 m was high. Synthesis and applications. Our findings emphasize the need to consider species-specific differences in temporal- and spatial-scale effects of roost-site selection factors, including human disturbance, when employing conservation measures for shorebirds. We suggest that conservation management should aim to provide a wide range of potential roosts (both natural and artificial) that could be used under different wind conditions and that are within reasonable travelling distance of preferred feeding areas. Roost use is often highly variable, and monitoring efforts must take this into account before making inferences about changes in use or selection of roost sites.

Pfister, C., B. A. Harrington, and M. Lavine. 1992. The impact of human disturbance on shorebirds at a migration staging area. Biological Conservation 60: 115-126.

Human disturbance was investigated as a factor that might limit the capacity of a staging area to support migrating shorebirds. Long-term census data were used to test the hypothesis that human disturbance at an important coastal migration staging area has a negative impact on shorebird movement patterns because of (1) displacement of shorebirds from preferred resting areas within the study area; and (2) abandonment of the study area. Results revealed that four of seven species showed one or more types of movement in response to disturbance. The impact of disturbance was greater on species using the heavily distributed front side of the beach. The abundance of impacted species may be reduced by 50% at high disturbance levels. Abundance of front-beach species, such as red knot *Calidris canutus* and short-billed dowitcher *Limnodromus griseus*, declined between 1972 and 1989 more than back-beach species, such as black-bellied plover *Pluvialis squatarola* and semipalmated plover *Charadrius semipalmatus*; red knot and short-billed dowitcher declined more at Plymouth Beach than at two comparable, but less disturbed, coastal staging areas and more than the overall eastern North American population. Disturbance is implicated as a potential factor in long-term

declines in shorebird abundance at Plymouth Beach. The impacts of disturbance could be reduced or perhaps eliminated by closing one or more small portions of the front beach as refuge resting areas during migration.

Pienkowski, M. W. 1992. The impact of tourism on coastal breeding waders in western and southern Europe: an overview. Wader Study Group Bull. 68: 92-96.

This brief overview is an amended and updated version of a discussion paper that originally appeared as Pienkowski (1984). Since much of its contents remain relevant, and since it was of restricted circulation in its original form, it is reproduced in this volume. The paper summarizes the various ways in which human recreational presence on coasts during the summer can affect breeding waders, lists possible protection measures, and outlines topics where further work is needed. In its original form the paper was intended to stimulate workshop discussion of the issues; many of its questions remain largely unanswered.

Piersma, T. and A. J. Baker. 2000. Life history characteristics and the conservation of migratory shorebirds. p. 105-124. *In* Gosling, L. M. and W. J. Sutherland [eds.], *Behaviour and Conservation*. Cambridge University Press. Cambridge.

Pfister, C., B. A. Harrington, and M. Lavine. 1992. The impact of human disturbance on shorebirds at a migration staging area. Biological Conservation 60:115–126.

Human disturbance was investigated as a factor that might limit the capacity of a staging area to support migrating shorebirds (Charadriiformes). Long-term census data were used to test the hypothesis that human disturbance at an important coastal migration staging area has a negative impact on shorebird movement patterns because of (1) displacement of shorebirds from preferred resting areas within the study area; and (2) abandonment of the study area. Results revealed that four of seven species showed one or more types of movement in response to disturbance. The impact of disturbance was greater on species using the heavily distributed front side of the beach. The abundance of impacted species may be reduced by 50% at high disturbance levels. Disturbance is implicated as a potential factor in long-term declines in shorebird abundance at Plymouth Beach. The impacts on disturbance could be reduced or perhaps eliminated by closing one or more small portions of the front beach as refuge resting areas during migration.

Placyk, J. S., Jr., and B. A. Harrington. 2004. Prey abundance and habitat use by migratory shorebirds at coastal stopover sites in Connecticut. Journal of Field Ornithology 75: 223-231.

Stopover areas are vital for the successful migration of many species of shorebirds, as they, in part, allow individuals to deposit large quantities of fat needed to fuel their northward and southward journeys. While much research has focused on bird migration, few studies closely examine the environmental characteristics of specific stopover areas. For our study, we conducted prey availability surveys and documented shorebird habitat use during northward summer migration for three historically important stopover areas along the Connecticut Long Island Sound coastline in 2000. Coastal Connecticut provides important habitat not only for shorebirds migrating from northern Canada to South America, but also for resident breeding shorebirds (e.g., oystercatchers, plovers, and sandpipers). Our prey availability surveys indicate that all three stopover sites were characterized by some combination of polychaete worms, crustaceans, and mollusks. Polychaete worms of the family Neredidae were the most common prey item at two of the three sites. In addition, the site frequented by the greatest densities of shorebirds also had the greatest density of nereid worms and the greatest diversity of invertebrates. In terms of habitat use, our results indicate that foraging densities tended to be highest on intertidal habitats that were sheltered from coastal wave action and where densities of benthic (burrowing) and epifaunal (surface-dwelling) prey tended to be high. However, some shorebird species, including one breeding resident, the American Oystercatcher (*Haematopus palliatus*) and one migrant, the Ruddy Turnstone (*Arenaria interpres*), both of special management concern, favored foraging on beach-front habitats. In contrast to foraging habitat preferences, shorebirds roosting at high tidal phases showed strong preferences for beach habitats fronting the Long Island Sound. The use of beach-front habitats for both foraging and roosting poses a challenging situation for beach managers.

Plissner, J. H. and S. M. Haig. 2000. Status of a broadly distributed endangered species: results and implications of the second International Piping Plover Census. Canadian Journal of Zoology 78: 128-139.

Methods for monitoring progress toward recovery goals are highly variable and may be problematic for endangered species that are mobile and widely distributed. Recovery objectives for Piping Plovers (*Charadrius melodus*) include attainment of minimum population sizes within specified recovery units, as determined by two U.S. and two Canadian recovery teams. To assess progress toward these goals, complete surveys of the species' winter and breeding ranges in

Canada, the United States, Mexico, the Bahamas, and the Greater Antilles are conducted every 5 years. In 1996, 1200 biologists and volunteers participated in the second International Piping Plover Census, tallying 2515 wintering birds and 5913 adults (2668 breeding pairs) during the breeding census. Winter numbers were 27% lower than those of the first international census conducted in 1991, with substantially fewer wintering birds along the Gulf of Mexico and an overall increase in numbers along the Atlantic Coast. Large numbers of wintering plovers remain undetected. In 1996, the total number of breeding adults was 7.7% higher than in 1991. Regionally, breeding numbers were 31% higher along the Atlantic Coast and 20% higher in the small Great Lakes population, but declined by 5% in the U.S. Great Plains and the Canadian Prairie. Target recovery numbers were met only for Saskatchewan but were approached in Alberta and New England. The results suggest that Piping Plover distribution and habitat use in the U.S. Great Plains/Canadian Prairie region may shift dramatically with water conditions.

Plissner, J. H. and S. M. Haig. 2000. Viability of piping plover *Charadrius melodus* metapopulations. Biological Conservation 92: 163-173.

The metapopulation viability analysis package, VORTEX , was used to examine viability and recovery objectives for piping plovers *Charadrius melodus*, an endangered shorebird that breeds in three distinct regions of North America. Baseline models indicate that while Atlantic Coast populations, under current management practices, are at little risk of near-term extinction, Great Plains and Great Lakes populations require 36% higher mean fecundity for a significant probability of persisting for the next 100 years. Metapopulation structure (i.e. the delineation of populations within the metapopulation) and interpopulation dispersal rates had varying effects on model results; however, spatially-structured metapopulations exhibited lower viability than that reported for single-population models. The models were most sensitive to variation in survivorship; hence, additional mortality data will improve their accuracy. With this information, such models become useful tools in identifying successful management objectives; and sensitivity analyses, even in the absence of some data, may indicate which options are likely to be most effective. Metapopulation viability models are best suited for developing conservation strategies for achieving recovery objectives based on maintaining an externally derived, target population size and structure.

Prange, S., S. D. Gehrt and E. P. Wiggers. 2003. Demographic factors contributing to high raccoon densities in urban landscapes. Journal of Wildlife Management 67: 324-333.

We simultaneously studied raccoon (Procyon lotor) populations inhabiting urban, suburban, and rural open areas in northeastern Illinois, USA, to examine the effects of urbanization on raccoon demographics. We predicted that raccoon density was higher in urbanized than rural landscapes because of increased survival and reproduction rates and greater site fidelity in urbanized areas. Density estimates for both the urban and suburban sites were greater ($P < 0.001$) than for the rural site during all seasons. Density estimates for the urban and suburban sites were similar ($0.177 \leq P < 0.603$) during 4 of seasons. Percentages of porous females were similar among sites. However, higher proportions of juveniles to adult females captured at the urbanized sites may indicate larger litter sizes. Adult female survival was highest at the urban site during the first 2 years, but dropped due to an unknown disease during the final year. Urban raccoons experienced the fewest mortality sources, whereas rural raccoons experienced the most. Disease was the greatest mortality factor at the urban site, while vehicle-related mortalities dominated at the suburban and rural sites. The high ratio of marked to unmarked raccoons captured may indicate greater site fidelity at urbanized sites. Our data suggest that multiple factors, including increased survival, higher annual recruitment, and increased site fidelity, are jointly responsible for high-density raccoon populations in urbanized areas. Direct management of raccoon numbers in urbanized areas likely will require continuous control measures, because raccoons are capable of quickly repopulating an area after the resident population has been reduced. The most effective control measure may be the reduction of anthropogenic food sources that support raccoons at high densities.

Preissler, H. K., A. A. Ager and M. J. Wisdom. 2006. Statistical methods for analyzing responses of wildlife to human disturbance. Journal of Applied Ecology 43: 164–172.

Off-road recreation is increasing rapidly in many areas of the world, and effects on wildlife can be highly detrimental. Consequently, we have developed methods for studying wildlife responses to off-road recreation with the use of new technologies that allow frequent and accurate monitoring of human–wildlife interactions. To illustrate these methods, we studied the response of Rocky Mountain elk Cervus elaphus L. to all-terrain vehicles (ATVs), one of the most prominent forms of summer recreation in North America. We studied elk because the species is not only of keen economic and social interest across North America and Europe but also exemplifies species that can be sensitive to human disturbance.

The study was part of a controlled landscape experiment where global positioning system (GPS)-equipped recreationists traversed an established 32-km route inside a 1453-ha elk-proof enclosure. Elk locations before and during the human disturbances were monitored using an automated telemetry system. The unique data set and study objectives led to our development of statistical methods for analysing the response of wildlife to human disturbance. We developed a statistical method, referred to as a probabilistic flight response, which accounted for daily circadian rhythms in movement behaviour of elk, and related the probability of flight to distance to the disturbance and a number of environmental covariates. We also present methods for estimating spatially and temporally explicit movement vectors as a way of detecting and visualizing landscape-level movement patterns.

Using these methods, we observed that elk appeared to respond at relatively long distances (> 1000 m) to ATVs, and that the estimated probability of flight appeared to be higher when elk were closer to the ATV routes, even when the distance to an ATV was large.

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Synthesis and applications. Our study quantifies the response of wildlife to human disturbance at a resolution well beyond previous work, and provides methods to improve our understanding of wildlife–human interactions related to management of wildlife and recreation. These methods may be used for any study involving accurate, frequent monitoring of animals and humans with the use of GPS or similar technologies now commonly available.

Quan, R. C., X. Wen, and X. Yang. 2002. Effects of human activities on migratory waterbirds at Lashihai Lake, China. Biological Conservation 108:273–279.

Surveys on migratory waterbirds and their habitats at Lashihai Lake, China, were conducted from October 1999 to April 2000. Five fixed points, representing different degrees of habitat disturbance and quality, were selected around the lake. We used counts (n=30) to compare diversity and abundance of waterbirds at each point and evaluate the effects of habitat disturbance. The distribution of waterbirds was affected by disturbance, with more than one-third of the total species and nearly half of the total individuals occurring at the least disturbed point. Species richness was weakly and abundance was strongly correlated to habitat disturbance, but not to habitat quality. Habitat destruction and use of canoes were prominent at the lake. Naxi ethnic fishermen (n=37) were interviewed. They caught 570 waterbirds between October 1999 and March 2000 in fishing nets. An estimation of the total number of waterbirds been trapped on the lake is 6164. Diving species were most susceptible. Conservation measures that should implement immediately include the cessation of habitat destruction, better plan for the development of tourism, a reduction in the number of canoes and zoning of the non-fishing area.

Rappole J. H. 1981. Management possibilities for beach-nesting shorebirds in Georgia. Pages 114-126 *in* Proceedings of Nongame and Endangered Wildlife Symposium. Technical Bulletin WL15 (R. R. Odom and J. W. Guthrie, Eds.), Georgia Department of Natural Resources, Athens.

Recher, H. F. 1966. Some aspects of the ecology of migrant shorebirds. Ecology 47: 393-407.

During migration, shorebirds from dense multispecific aggregations within relatively uniform and limited marine littoral habitats. The amount of available feeding space in the habitats frequented fluctuates widely with the daily ad seasonal changes in the tidal rhythm. Shorebird species broadly overlap in their periods of peak abundance, inter- and intrahabitat distributions, and in the food organisms preyed upon. However, the totality of species differences and the transient character of migratory assemblages apparently minimizes interspecific interactions that might result in competitive exclusion. The staggering of peak population densities and differences in distribution is most pronounced among morphologically similar species. The number of individuals and species that occur in an area is apparently determined by the amount of available feeding space and the physical diversity of the habitat. Food appears to be generally abundant relative to the requirements of the birds in all habitats studied. The environmental conditions encountered during migration and the interactions with other individuals have evidently been important factors in the evolution of morphological and behavioral differences among shorebird species. Individuals must be as able to survive during the nonbreeding season as they are during the breeding season.

Reese, J. G. 1977. Reproductive success of Ospreys in central Chesapeake Bay. Auk 94: 202-221.

Osprey nest success and factors influencing nest success were studied by frequent annual visits to active nests in a defined area. Of the eggs found in the 1970's, 52% failed to hatch. Eggs disappearing between nest visits and those found damaged (cracked, punctured, etc.) or addled made up 90% of the failures. Shells from failed eggs averaged 11% thinner than eggs collected prior to 1947. The additive effect of increasing human disturbance to Ospreys incubating

eggs with shells thinned by environmental contaminants is responsible for the high egg attrition resulting in poor nest success. Constructing artificial nest platforms aids nest success by retaining nesting pairs at established sites where potential for success is greater than if the Ospreys are forced to use an alternate site. Terrestrial nests are 14% less successful than nests on offshore structures. Brood size (1.9) and population productivity (1.08) are among the best in the country, but below brood sizes of Ospreys prior to 1947 and estimated production requirements for population stability.

Roberts G., P. R. Evans. 1993. Responses of foraging Sanderlings to human approaches. Behaviour. 126:29–43.

Sanderlings *Calidris alba* were put to flight by walking towards them as they foraged at the water's edge on a sandy beach. Studies of the responses of birds to disturbances have concentrated on the relationship between group size and the distance from the cause of the disturbance at which members of the group take flight (the flight reaction distance). The study of responses to disturbance is extended to consider the frequencies with which birds took flight; their flight directions (whether towards the approacher and then in behind or whether ahead of the approacher); and the distances to which they flew. The nearest birds to the approacher tolerated approaches to well within the range at which the approacher should have been visible. When the nearest birds flew, the likelihood of other birds flying decreased as the distance by which they were further away from the approacher than the nearest birds increased. Birds further away were more likely to fly when more birds flew from nearer to the approacher. The nearest birds tended to fly in behind the approacher while those further away from the approacher flew further ahead. The findings suggested that the birds were acting so as to maximise their foraging time by minimising both the number of flights they made and the distance of each flight, subject to not tolerating close approaches.

Rodgers, J. A., Jr., and H. T. Smith. 1995. Set-back distances to protect nesting bird colonies from human disturbance in Florida. Conservation Biology 9:89-99.

Breeding colonial waterbirds are particularly susceptible to human disturbance because of their high-density nesting habits. Identified detriments to reproductive success include egg and nestling mortality, nest evacuation, reduced nestling body mass and slower growth, premature fledging, and modified adult behaviors. Fifteen species of colonial waterbirds nesting at 17 colonies in north and central Florida were exposed to three different human disturbance mechanisms (HDMs) in order to determine recommended set-back (RS) distances for protecting these mixed-species nesting assemblages. Both intraspecific and interspecific variation were observed in flushing response distances to the same human disturbance mechanisms. In general, colonial waterbirds exhibited greater average flush distances in reaction to a walking approach than to approaching motor boats. Recommended set-back distances were estimated using a formula based on the mean plus 1.6495 standard deviations of the observed flushing distances plus 40 meters [X = exp (X + 1.6495X + 40)]. In general, a recommended set-back distance of about 100 meters for wading bird colonies and 180 meters for mixed tern/skimmer colonies should be adequate to effectively buffer the sites we studies from human disturbance caused by approach of pedestrians and motor boats. We recommend follow-up studies to test our model at other breeding colonies.

Rodgers, J. A. Jr., and H. T. Smith. 1997. Buffer zone distances to protect foraging and loafing waterbirds from human disturbance in Florida. Wildlife Society Bulletin 25(1):139-145.

Sixteen species of waterbirds (Pelecaniformes, Ciconiiformes, Charadriiformes) in north and central Florida were exposed to 4 types of human disturbances (walking, all-terrain vehicle, automobile, boat) to determine buffer zones that minimize flushing of foraging or loafing birds. Both intraspecific and interspecific variation were observed in flushing distance plus 40 m (buffer distance = exp [$\mu + 1.6495\sigma$] + 40). A buffer of about 100 m should minimize disturbance to most species of waterbirds we studied in Florida. We recommend follow-up studies to test our buffer distances for to other species and disturbance situations.

Rodgers, J. A., and S. T. Schwikert. 2002. Buffer-zone distances to protect foraging and loafing waterbirds from disturbance by personal watercraft and outboard-powered boats. Conservation Biology 16: 216–224.

Outdoor recreation and ecotourism can have negative effects on wildlife species, so it is important to determine buffer zones within which activities near critical wildlife areas are limited. We exposed 23 species of waterbirds (Pelecaniformes, Ciconiiformes, Falconiformes, Charadriiformes) to the direct approach of a personal watercraft (PWC) and an outboard-powered boat to determine their flush distances. We used 11 sites with a mixture of low, moderate, and high amounts of human activity along the east and west coasts of Florida during September–November 1998 and April–June 1999. We detected considerable variation in flush distances among individuals within the same species and among species in response to both types of vessels. Average flush distances for the PWC ranged from 19.5 m (Least Tern [Sterna antillarum]) to 49.5 m (Osprey [Pandion haliaetus]), whereas average flush distances for the

outboard-powered boat ranged from 23.4 m (Forster's Tern [S. forsteri]) to 57.9 m (Osprey). Larger species generally exhibited greater average flush distances for both types of watercraft. A comparison of the flush distances elicited by each watercraft indicated that only the Great Blue Heron (Ardea herodias) exhibited significantly larger flush distances (t test, $p < 0.01$) in response to the approach of the PWC than in response to the outboard, whereas four species (Anhinga [Anhinga anhinga], Little Blue Heron [Egretta caerulea], Willet [Catoptrophorus semipalmatus], and Osprey) exhibited significantly larger flush distances (t test, $p < 0.05$) in response to the approach of the outboard-powered boat than in response to the PWC. Eleven species (68.8%) showed no significant difference (t test, $p > 0.05$) in their flush distances in response to the fast-moving PWC and the outboard-powered boat. Our data suggest that a single buffer-zone distance can be developed for both PWC and outboard-powered vessels. Buffer zones of 180 m for wading birds, 140 m for terns and gulls, 100 m for plovers and sandpipers, and 150 m for ospreys would minimize their disturbance at foraging and loafing sites in Florida.

Rodgers, J. A. and S. T. Schwikert. 2003. Buffer zone distances to protect foraging and loafing waterbirds from disturbance by airboats in Florida. Waterbirds 26: 437-443.

Outdoor recreation and ecotourism can have negative effects on wildlife species, so it is important to determine buffer zones within which activities near critical wildlife areas are limited. We exposed 23 species of waterbirds (Pelecaniformes, Ciconiiformes, Falconiformes, Charadriiformes) to the direct approach of a personal watercraft (PWC) and an outboard-powered boat to determine their flush distances. We used 11 sites with a mixture of low, moderate, and high amounts of human activity along the east and west coasts of Florida during September–November 1998 and April–June 1999. We detected considerable variation in flush distances among individuals within the same species and among species in response to both types of vessels. Average flush distances for the PWC ranged from 19.5 m (Least Tern [Sterna antillarum]) to 49.5 m (Osprey [Pandion haliaetus]), whereas average flush distances for the outboard-powered boat ranged from 23.4 m (Forster's Tern [S. forsteri]) to 57.9 m (Osprey). Larger species generally exhibited greater average flush distances for both types of watercraft. A comparison of the flush distances elicited by each watercraft indicated that only the Great Blue Heron (Ardea herodias) exhibited significantly larger flush distances (t test, $p < 0.01$) in response to the approach of the PWC than in response to the outboard, whereas four species (Anhinga [Anhinga anhinga], Little Blue Heron [Egretta caerulea], Willet [Catoptrophorus semipalmatus], and Osprey) exhibited significantly larger flush distances (t test, $p < 0.05$) in response to the approach of the outboard-powered boat than in response to the PWC. Eleven species (68.8%) showed no significant difference (t test, $p > 0.05$) in their flush distances in response to the fast-moving PWC and the outboard-powered boat. Our data suggest that a single buffer-zone distance can be developed for both PWC and outboard-powered vessels. Buffer zones of 180 m for wading birds, 140 m for terns and gulls, 100 m for plovers and sandpipers, and 150 m for ospreys would minimize their disturbance at foraging and loafing sites in Florida.

Rogers, D. I., P. F. Bailey, T. Piersma, J. A. Van Gils, and K. G. Rogers. 2006. High-tide habitat choice: insights from modelling roost selection by shorebirds around a tropical bay. Animal Behaviour 72: 563-575.

High tides force shorebirds from intertidal feeding areas to sites known as roosts. We investigated the roost selection of great knots, *Calidris tenuirostris*, and red knots, *Calidris canutus*, on a tropical coastline in northwestern Australia, assessing several roost attributes and recording the frequency of use of each site through automatic radiotelemetry. To model roost choice we used two approaches: (1) conditional logistic regression models that assumed roost selection to be a trade-off based on a probabilistic assessment of several environmental characteristics; and (2) bounds-based models that assumed that birds selected the nearest roost site to their feeding grounds, provided that threshold values for certain environmental characteristics were met. Bounds-based models were more effective, and we suggest that they offer a closer approach to real roost choice mechanisms. By day, roost choice was affected by distance from the feeding area and microclimate; birds selected nearby roosts where they could stand on cool, wet substrates. Different roost selection criteria were used at night when birds chose safer, but more distant, roosts. Models that assumed that roost choice was influenced by recent experience of roost sites performed better than models that assumed constant assessment of roost quality. This effect was significant only at night, suggesting that memory was used more when information on roost quality was limited. Evidence that roost availability may influence selection of foraging areas is also presented. Our results suggest that shorebirds select roosts by using simple mechanisms, making roost choice models a potentially valuable tool in conservation planning.

Rogers, D., C. Hassell, and J. Lewis. 2006. Shorebird disturbance on the beaches of Roebuck Bay, 2005-2006: Conservation implications and recommendations. A report by Broome Bird Observatory for the WA Department of Conservation and Land Management, NHT and the Shorebird Conservation Project/WWF Australia. 40pp.

Rogers, D.I., T. Piersma and C.J. Hassell. 2006b. Roost Availability May Constrain Shorebird Distribution: Exploring the Energetic Costs of Roosting and Disturbance Around a Tropical Bay. *Biological Conservation*. 133: 225-235.

High tides force shorebirds from their intertidal feeding areas to refuges known as roosts. This paper explores the energetic costs of roost disturbance of great knot (*Calidris tenuirostris*) and red knot (*C. canutus*) at Roebuck Bay, North-western Australia, assessing disturbance levels at different roost sites through direct observation and automatic radio-telemetry, and applying physiological equations and predictive roost choice models to estimate energetic costs of disturbance through a complete tidal cycle. The study area had a variety of roosts, but use of each was constrained by conditions of tide and time. The roost most suitable for shorebirds on daytime high tides of intermediate height experienced high levels of disturbance from both natural sources (birds of prey) and humans. Flight costs caused by disturbance at this site exceeded the costs of flying to and roosting at the nearest alternative roost, 25 km away. However, shorebirds did not roost at the alternate site, possibly because of the risk of heat stress in a prolonged flight in tropical conditions. Increases in disturbance levels at just one of the roost sites of Roebuck Bay would increase energetic costs substantially, and could easily reach the point at which feeding areas accessed from this roost cannot be used without incurring a net energy deficit. Roost availability can therefore limit access to feeding areas and hence limit population size. Adequate provision and management of roost sites is accordingly an important consideration in conservation of sites used by coastal shorebirds.

Rogers, D. I. 2003. High-tide roost choice by coastal waders. Wader Study Group Bulletin 100: 73–79

Ruhlen, T. D., S. Abbott, L. E. Stenzel, and G. W. Page. 2003. Evidence that human disturbance reduces Snowy Plover chick survival. Journal of Field Ornithology. 74:300-304.

Disturbance from human recreation may impact vulnerable life stages of beach-nesting plovers (*Charadrius* spp.). Although human recreation may decrease hatching success of Snowy Plovers (*C. alexandrinus*), we are unaware of any studies indicating an impact on chick survival. We tested whether the rate of chick loss in a breeding population of Snowy Plovers was lower on weekdays than on weekends and holidays, when beach visitation increases in most coastal areas. We used data collected on chick survival and the timing of chick loss in 1999 and 2000 at Point Reyes National Seashore, California. Observed weekend and holiday chick loss was 72% greater than expected in 1999 and 69% greater than expected in 2000. This suggests that increased human recreation on Point Reyes beaches over weekends and holidays negatively affected Snowy Plover chick survival.

Sabine, J. B., III. 2005. Effects of human activity and predation on breeding American Oystercatchers. MS Thesis, The University of Georgia, Athens, Georgia, USA.

The United States population of American Oystercatchers (*Haematopus palliatus*) is of special concern. Biologists attribute low numbers and reduced reproductive success to excessive predation and human disturbance; however, researchers have not documented nest predators positively and the mechanism by which human presence reduces reproductive success is not well understood. During the 2003 and 2004 breeding seasons, I video-monitored American Oystercatcher nests (n = 32) to document causes of nest failure and observed oystercatcher behavioral responses to human activity at Cumberland Island National Seashore. Hatching and fledging success were 45% and 33%, respectively. Predation was the primary cause of nest failure (44% of nests). Pedestrian activity reduced reproductive behavior during incubation. Vehicular activity reduced foraging behavior during brood rearing. Presence of boats did not affect behavior. Oystercatchers were fairly intolerant of pedestrian activity ≤137 m of nests during incubation. During brood rearing, oystercatchers reacted to pedestrian activity ≥137 m of chicks.

Sabine, J. B., III., J. M. Meyers, C. T. Moore, and S. H. Schweitzer. 2008. Effects of human activity on behavior of breeding American Oystercatchers, Cumberland Island National Seashore, Georgia, USA. Waterbirds 31: 70-82.

Increased human use of coastal areas threatens the United States population of American Oystercatchers (*Haematopus palliatus*), a species of special concern. Biologists often attribute its low numbers and reproductive success to human disturbance, but the mechanism by which human presence reduces reproductive success is not well understood. During the 2003 and 2004 breeding seasons, 32 nesting attempts of American Oystercatchers were studied on Cumberland Island National Seashore (CINS). Behavior was examined with and without human activity in the area to determine how human activity affected behavior. The oystercatchers' behavioral responses (proportion time) were analyzed with and without human or intraspecific disturbances using mixed models regression analysis. Proportions of time human activities were present (≤300 m from oystercatchers) during observations averaged 0.14 (N = 32, 95% CI = 0.08-0.20). During incubation, pedestrian activity near (≤137 m) oystercatchers reduced the frequency of occurrence of

reproductive behavior, but pedestrian activity far (138-300 m) from oystercatchers had no effect. Vehicular and boat activities (≤300 m) had minimal effects on behavior during incubation. During brood rearing, an effect of pedestrian activity near oystercatchers was not evident; however, pedestrian activity far from oystercatchers increased the frequency of reproductive behavior. Vehicular and boat activity had no effects on behavior during brood rearing. Of 32 nesting attempts, two failed (<10%) because of human disturbance and were located in areas of greater human activity (south end). Managers on CINS should minimize pedestrian activity near nests (≤137 m) during incubation. During brood rearing, protection from pedestrian activity should be increased, when possible, to >137 m and vehicular activity should be minimized at current levels or less.

Sabine, J.B., S.H. Schweitzer & J.M. Meyers. 2006. Nest fate and productivity of American oystercatchers, Cumberland Island national seashore, Georgia. *Waterbirds* 29(3): 308–314.

The American Oystercatcher (*Haematopus palliatus*) is listed as a species of high priority by the U.S. Shorebird Conservation Plan and is state-listed as rare in Georgia; however, biologists have not focused on identifying the causes of egg and hatchling losses. In 2003 and 2004, continuous video monitoring was used to document reproductive success of American Oystercatchers and identify causes of nest failure at Cumberland Island National Seashore, Georgia. The modified Mayfield method and program CONTRAST were used to determine and compare survival of eggs and nestlings. Eleven pairs made 32 nest attempts during two seasons. Nine attempts were successful, fledging 15 chicks. Daily survival of clutches was 0.973 (95% CI = 0.960-0.987) for 2003, 0.985 (95% CI = 0.974-0.995) for 2004, and 0.979 (95% CI = 0.970-0.987) for combined years. Daily survival was greater on the North End, than on the South End of the island (χ^2_1 = 7.211, P = 0.007). Eighteen of 20 nest failures during the egg stage and one of eight chick losses were documented. Egg predators included raccoon (*Procyon lotor*, N = 9), bobcat (*Lynx rufus*, N = 3), and American Crow (*Corvus brachyrhynchos*, N = 1). A ghost crab (*Ocypode quadata*) preyed on one chick. Other causes of nest failure were tidal overwash (N = 1), horse trampling (N = 1), abandonment (N = 2), and human destruction (N = 1). The North End of the island has one of the highest reproductive rates reported along the Atlantic coast. Predator control may be an effective means of increasing reproductive success on the South End of the island.

Safina, C. and J. Burger. 1983. Effects of human disturbance on reproductive success in the Black Skimmer. Condor 85:164–171.

We subjected Black Skimmers (Rynchops niger), nesting in six subcolonies within a tern colony, to either daily or weekly nest checks in order to study the effects of human activity on reproduction. Many prelaying adults left subcolonies that were disturbed daily and settled in relatively undisturbed subcolonies; some pairs in these areas deserted nests early in incubation. Nest density ,late nesting, hatching success, and fledging success were inversely correlated with disturbance. In consequence of disturbance, a few chicks ate younger conspecifics. Low fences placed around groups of nests depressed fledging in areas disturbed weekly, but enhanced it in subcolonies disturbed daily.

Saino, N., M. Romano, R. P. Ferrari, R. Martinelli, A. P. Møller. 2005. Stressed mothers lay eggs with high corticosterone levels which produce low-quality offspring. Journal of Experimental Zoology Part A Comparative Experimental Biology 303A: 998-1006.

Organisms frequently encounter stressful ecological conditions. In vertebrates, a major mechanism of physiological response to stress is mediated by the hypothalamic-pituitary-adrenal axis and results in increased secretion of glucocorticosteroids, which can have adverse consequences on diverse phenotypic traits affecting fitness. Maternal stress may thus have carry-over effects on progeny if it influences pre-natal offspring environment in terms of glucocorticosteroid concentration, although this hypothesis has never been tested in any species under field conditions. We manipulated stress experienced by female barn swallows *Hirundo rustica*, by exposing them to a predator during laying and measured egg corticosterone concentration. Stressed females laid eggs with greater corticosterone concentration than controls exposed to a herbivore. In another experiment, we injected physiological doses of corticosterone in the egg albumen and compared the phenotype of offspring originating from these eggs with their control siblings originating from either sham-inoculated or unmanipulated eggs and reared in the same nest. Eggs injected with corticosterone had lower hatchability and produced fledglings with smaller body size and slower plumage development than did control eggs. Nestling body size in our study population predicts long-term survival. Thus, maternal stress impaired offspring phenotype and viability by increasing transmission of glucocorticosteroids to the eggs. This study identifies a novel mechanism mediating early maternal effects whereby maternal stress affects offspring quality. These results are relevant to biological conservation because they disclose a mechanism that can link environmental conditions to population productivity and viability.

Schlacher, T. A. and L. M.C. Thompson. 2008. Physical Impacts Caused by Off-Road Vehicles to Sandy Beaches: Spatial Quantification of Car Tracks on an Australian Barrier Island Journal of Coastal Research 24: 234–242

Beach traffic can substantially modify the physical environment on sandy beaches. Vehicle impacts on beaches were quantified on North Stradbroke Island, a barrier island on the east coast of Australia where large volumes of recreational off-road vehicle (ORV) traffic are concentrated on two beaches (Flinders Beach and Main Beach). The distribution, density, and depth of vehicle ruts on these beaches were quantified during the peak holiday period around late December and early January 2005–06. The density of tyre tracks per meter of beach face ranged from 2.69 to 6.35 on Flinders Beach and from 2.38 to 8.06 on Main Beach, and substantial areas (54–61%) of each beach were covered withy tyre tracks up to a maximum of 90% in some areas. ORVs corrugated the sand as deep as 28 cm (mean depth: 5.86 ± 4.72 cm), with the deepest rutting occurring between the foredunes and the drift line. On a volume basis, vehicles disrupted 5.8% (Main Beach) and 9.4% (Flinders Beach) of the available faunal habitat matrix (top 30 cm of the sand) in a single day. Traffic density was higher on the lower shore, but ruts were significantly deeper in the soft sand of the upper shore. Thus, half of all sand displaced by vehicles on Flinders Beach originated from the upper shore, although this section represents only 36% of beach width. Similarly, the narrow (13% of beach width) upper shore on Main Beach contributed 55% of the total volume of sand dislodged by ORVs. Beach traffic overlapped to a large extent with the distribution of the invertebrate infauna, and vehicles routinely disturbed the drift line and the base of the foredunes. This study emphasizes the need to develop multifaceted management strategies for recreational ORV use on beaches that balance ecological requirements with sociocultural and economic demands.

Schlacher, T. A., L. M. C. Thompson and Simon J. Walker 2008. Mortalities caused by off-road vehicles (ORVs) to a key member of sandy beach assemblages, the surf clam Donax deltoids. Hydrobiologia 610: 345-350

Sandy beaches are prime recreational areas, but human use of beaches is not without ecological consequences. Driving of off-road vehicles on beaches for recreational pursuits is perhaps the physically most severe form of direct anthropogenic disturbance on sandy shores. Potential management and conservation interventions lack, however, data on how sensitive beach species are to vehicle impacts. We therefore experimentally quantified the link between beach traffic and lethal damages caused by vehicles to sandy shore invertebrates, using surf clams (*Donax deltoides*) as the biological response variable. Although clams had some tolerance against vehicles at low traffic volumes (5 vehicle passes), more than half of them were killed at higher traffic volumes (75 passes) in situations where cars traversed soft sand and turned across the beach face. Overall, both traffic volume and driver behaviour (i.e. straight vs. turning vehicle tracks) determined the incidence of direct crushing of clams under vehicles. Our data demonstrate that recreational use of ORVs is a source of mortality for beach invertebrates, but equally caution against extrapolating impact data from hard-shelled clams to potentially more sensitive soft-bodied species. Robust management interventions that seek to mitigate ecological damage from beach traffic will therefore require information on the functional relationship between the form, intensity and frequency of human disturbance and the biological responses for entire faunal assemblages on sandy shores.

Schneider, D. C., and B. A. Harrington. 1981. Timing of shorebird migration in relation to prey depletion. Auk 98:801-811. Senner, S., and M. A. Howe. 1984. Conservation of Nearctic shorebirds. Pages 379421 in Shorebirds: Breeding behavior and populations (J. Burger and B. L. Olla, Eds.). Plenum Press, New York.

Schulte, S., S. Brown, and the American Oystercatcher Working Group. 2006. Version 1.0. American Oystercatcher Conservation plan for the United States Atlantic and Gulf Coasts. Retrieved from http://www.ncsu.edu/project/grsmgis/AMOY/Research.htm.

The American Oystercatcher, *Haematopus palliatus*, a large shorebird, is classified as a Species of High Concern on the Eastern and Gulf coasts of the United States because of its small overall population (11,000 individuals), widespread habitat loss, and the threats it faces both during the breeding and non-breeding seasons. The species occurs only in the coastal zone in areas that support intertidal shellfish beds. While other populations, including distinct subspecies, of American oystercatchers occur elsewhere, the present plan address only the population on the East and Gulf coasts. Future revisions to this plan will incorporate populations throughout the entirety of the species's range, including the Caribbean, Central and South America.

The major threats to the species's health are

- Loss of habitat from coastal development
- Disturbance, from human recreational activities, at all stages of the birds' annual cycle
- Elevated predation from predators associated with human activities
- Contamination of their primary food sources by non-point pollution and/or oil spills
- Effects of global climate change, especially predicted raising of sea-level

Conservation activities recommended to address these threats include

- Identification and protection of existing habitat
- Creation of new habitat through carefully designed use of dredge-spoil materials
- Management of existing protected areas to reduce predation and disturbance
- Control of predator populations, especially in the nesting season

Because American Oystercatchers share habitat with other coastal specialist birds, conservation efforts for Oystercatchers will benefit these other species, and *vice-versa*.

Considerable research is needed to refine knowledge of the population dynamics and limiting factors that affect American Oystercatchers, and specific recommendations are provided in this document. Suggestions are also made for methods to evaluate the effect of conservation actions.

Schulz, R. and M. Stock. 1993. Kentish Plovers and tourists: competitors on sandy coasts. Wader Study Group Bull. 68: 83-91.

The effects of human-related disturbances in a breeding colony of Kentish plovers were investigated. Nest searches revealed a maximum of nearly 200 nests in the foreland of St Peter in Schleswig-Holstein . The breeding colony thus accounts for 10% of the entire north-west European breeding population and contains nearly5 0% of the German population. Large parts of the potential breeding habitat could not be colonized because they were occupied by tourists sun-bathing and resting in the primary dunes. Furthermore the birds showed r educed hatching success. Nest failures from various causes amounted to 52.1% on average. A strong relationship between the disturbance intensity and the rate of clutch losses was found. Habitat characteristics such as vegetation cover and the vegetation structure around the nests, expressed as the view obstruction, can reduce these losses. Possible disturbance-related and disturbance-independent reasons for nest failures are discussed.

Shepherd, P. C. F. and J. S. Boates. 1999. Effects of a commercial baitworm harvest on Semipalmated Sandpipers and their prey in the Bay of Fundy Hemispheric Shorebird Reserve. Conservation Biology 13: 347–356.

The conservation of key stopover sites for migratory wading birds is important because there are so few and because in some cases they support entire populations. In Minas Basin in the Bay of Fundy, over 500,000 Semipalmated Sandpipers (Calidris pusilla) on southward migration feed on the abundant amphipod Corophium volutator. When a baitworm harvesting industry began there in 1985 (focused on bloodworms [Glycera dibranchiata]), concerns were raised about the potential effects of this activity on the foraging behavior of Semipalmated Sandpipers and on the density and age structure of their principal prey, C. volutator. Core sampling for invertebrates and paired focal sandpiper observations were undertaken in disturbed (dug) and undisturbed sediment. Semipalmated Sandpiper foraging efficiency decreased by 68.5% in dug sediment, corresponding to observed reductions in prey density. The decreased foraging efficiency may also have been related to reductions in prey availability due to the obstruction of visual and tactile prey cues caused by turning and loosening of the surface sediment. The overall density (adult and juvenile) of C. volutator decreased by 38.8% in dug sediment in the first year of baitworm harvesting, due to direct mortality and lower juvenile recruitment. Juvenile C. volutator were particularly susceptible to disturbance (55% decrease in dug sediment); because they overwinter to become the next year's potential breeders, this decrease can be expected to compound with each subsequent year of harvesting. All the significant, negative effects of baitworm harvesting on Semipalmated Sandpiper foraging behavior and on the density and age structure of their principal prey, C. volutator, were realized after only one season of digging. Semipalmated Sandpipers foraging in harvested areas may take longer to deposit the fat required for migration, thereby delaying their arrival on the wintering grounds or forcing them to depart without sufficient fat loads.

Sidle, J.G., K. Mayne, and E.N. McPhillips. 1991. Protecting the piping plover under section 7 of the Endangered Species Act. Environmental Management 15(3):349- 356.

Section 7(a)(2) of the Endangered Species Act directs federal agencies to ensure that their actions do not jeopardize the continued existence of endangered and threatened species. The US Fish and Wildlife Service (USFWS) issues jeopardy or nonjeopardy biological opinions on proposed federal actions that affect endangered and threatened species. We summarize several biological opinions issued by the USFWS to protect the threatened piping plover (*Charadrius melodus*). These opinions address federal actions involving hundreds of piping plovers on the Missouri River system and a few piping plover pairs on short stretches of Atlantic coast beach. Some of these opinions are decisive, but most allow the proposed action to proceed conditional upon a lengthy set of reasonable and prudent alternatives to protect the piping plover. These conditions may prove difficult to track and will add to the workload of the USFWS.

Simons, T. R., S. Schulte, J. Cordes, M. Lyons, and W. Golder. 2004. American Oystercatcher (*Haematopus paliatus*) research and monitoring in North Carolina. Annual report, North Carolina Cooperative Fish and Wildlife Research Unit, Department of Zoology, North Carolina State University, Raleigh, North Carolina, USA.

Simons, T. R., S. Schulte, J. Cordes, M. Lyons, and W. Golder. 2006. American Oystercatcher (*Haematopus palliatus*) research and monitoring in North Carolina : 2006 Annual report. North Carolina Cooperative Fish and Wildlife Research Unit, Department of Zoology, North Carolina State University, Raleigh, North Carolina, USA.

Skagen, S.K. 2006. Migration stopovers and the conservation of Arctic-breeding Calidridine sandpipers. *Auk* 123(2): 313–322.

LONG-DISTANCE MIGRATION, one of the most physically demanding events in the animal kingdom, is well developed in many species of Charadriidae and Scolopacidae. Some shorebirds renowned for their extraordinary long-distance migrations, notably American Golden-Plover (*Pluvialis dominica*), Red Knot (*Calidris cainitiis rufa*), and White-rumped Sandpiper (*C. fuscicollis*), travel as many as 15,000 km between southern South American wintering grounds and Canadian Arctic breeding areas. Migration strategies of shorebirds vary in many aspects. There are remarkable accounts of shorebirds, such as northbound Red Knots, that stage in a few key sites for 2-3 weeks and lay on extensive body stores, then fly nonstop for distances of ≤2,500 km (Harrington 2001, Piersma et al. 2005). Less well known are the examples of populations that refuel only briefly at stopover sites, disperse broadly on the landscape, and fly shorter distances between sites (Skagen 1997, Haig et al. 1998, Warnock et al. 1998). This latter pattern applies to many long-distance migrant shorebirds that cross the interior plains of North America during spring and fall migrations. For them, interior wetland complexes provide critical refueling resources along the direct routes between summering and wintering grounds (Skagen et al. 1999). In this issue of The Auk, Krapu et al. (2006) describe patterns and implications of fat deposition by Semipalmated Sandpipers (*C. pusilla*), White-rumped Sandpipers, and Baird's Sandpipers (*C. bairdii*) refueling during northward migration across the prairies of mid-continental North America.

Skagen, S., J. Bart, B. Andres, S. Brown, G. Donaldson, B. Harrington, V. Johnston, S.L. Jones & R.I.G. Morrison. 2003. Monitoring the shorebirds of North America: towards a unified approach. *Wader Study Group Bull.* 100: 102–104.

The Program for Regional and International Shorebird Monitoring (PRISM) has recently developed a single blueprint for monitoring shorebirds in Canada and the United States in response to needs identified by recent Shorebird conservation plans. The goals of PRISM are to: (1) estimate the size of breeding populations of 74 shorebird taxa in North America;(2) describe the distribution, abundance, and habitat relationships for these taxa; (3) monitor trends in shorebird population size; (4) monitor shorebird numbers at stopover locations, and; (5) assist local managers in meeting their shorebird conservation goals. The initial focus has been on developing methods to estimate trends in population size. A three-part approach for estimating trends includes: (1) breeding surveys in arctic, boreal, and temperate regions, (2) migration surveys, and (3) wintering surveys.

Skagen, S. K., S. Brown, and R. Johnson. 2005. Implications of different shorebird migration strategies for habitat conservation. Pages 680–683 in Bird Conservation Implementation and Integration in the Americas: Proceedings of the Third International Partners in Flight Conference, vol. 2 (C. J. Ralph and T. D. Rich, Eds.). U.S. Department of Agriculture, Forest Service, General Technical Report PSW-GTR-191.

Shorebird migration strategies vary by species, migration distance and route, time of year, and resources at staging and stopover sites. The Western Hemisphere Shorebird Reserve Network has been highly successful in the identification, designation, and protection of important migration habitats for many species that stage in traditional areas. Recently, conservation efforts also focus on species and populations that disperse broadly on the landscape and that exhibit opportunistic use of available habitat in highly dynamic wetland systems. This unpredictability makes the conservation of wetland stopover habitats in the interior of North America highly challenging. We present an approach to identifying landscapes and wetlands critical to en route migrants in extensive ephemeral wetland systems.

Skagen, S.K., D.A. Granfors & C.P. Melcher. 2008. On determining the significance of ephemeral continental wetlands to North American migratory shorebirds. *Auk* 125.

Conservation challenges enhance the need for quantitative information on dispersed bird populations in extensive landscapes, for techniques to monitor populations and assess environmental effects, and for conservation strategies at appropriate temporal and spatial scales. By estimating population sizes of shorebirds in the U.S. portion of the prairie pothole landscape in central North America, where most migrating shorebirds exhibit a highly dispersed spatial pattern, we determined that the region may play a vital role in the conservation of shorebirds. During northward and southward migration, 7.3 million shorebirds (95% CI: 4.3–10.3 million) and 3.9 million shorebirds (95% CI: 1.7–6.0 million) stopped to rest and refuel in the study area; inclusion of locally breeding species increases the estimates by 0.1 million and 0.07 million shorebirds, respectively. Seven species of calidridine sandpipers, including Semipalmated Sandpipers (*Calidris pusilla*), White-rumped Sandpipers (*C. fuscicollis*), and Stilt Sandpipers (*C. himantopus*), constituted 50% of northbound migrants in our study area. We present an approach to population estimation and monitoring, based on stratified random selection of townships as sample units, that is well suited to 11 migratory shorebird species. For extensive and dynamic wetland systems, we strongly caution against a monitoring program based solely on repeated counts of known stopover sites with historically high numbers of shorebirds. We recommend refinements in methodology to address sample-size requirements and potential sources of bias so that our approach may form the basis of a rigorous migration monitoring program in this and other prairie wetland regions.

Skagen, S. K., C. P. Melcher, and E. Muths. 2001. The interplay of habitat change, human disturbance and species interactions in a waterbird colony. American Midland Naturalist 145:18–28.

Potential responses to human disturbance at breeding colonies of waterbirds include reproductive failure, population declines and displacement from activity areas. Several additional factors, including species interactions and environmental change, can either mask or intensify the effects of human activity. This study highlights the importance of considering these factors in concert with breeding biology when assessing the impacts of human disturbance on wildlife. We studied the effects of a Wildlife Viewing Area (WVA) at Chatfield State Recreation Area, Colorado, on a nesting colony of great blue herons (*Ardea herodias*) and double-crested cormorants (*Phalacrocorax auritus*). We stratified the colony's nest trees into near, middle and far areas relative to distances from the WVA and compared the distribution of nests, nesting and fledging success and breeding chronology among areas 2 y before and 2 y after construction of the WVA. We also evaluated whether adult nest attendance patterns and chick behavior differed relative to distance from the WVA. The number of active heron nests and nest success of herons declined during the study, but evidence that these declines were due solely to human disturbance is equivocal. These changes were most likely due to the interplay of habitat changes (loss of 14 of 31 original nest trees by windfall), acquisition of heron nests by cormorants and human disturbance. We found no evidence that cormorants were adversely affected by the WVA in distribution of nests, nesting and fledging success, breeding chronology, adult nest attendance or chick behaviors. Habitat changes and adverse weather contributed to nesting failures of cormorants

Skagen, S.K., P.B. Sharpe & R.G. Waltermire. 1999. *Biogeographical profiles of shorebird migration in midcontinental North America.* U.S. Geological Survey Biological Science Report 2000–0003, Fort Collins, Colorado. *http://www.fort.usgs.gov/shorebirds* (accessed 10 May 2006).

Skeel, Margaret A. and Elizabeth P. Mallory. 1996. Whimbrel (Numenius phaeopus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/219

Soulliere, G. J., B. A. Potter, D. J. Holm, D. A. Granfors, M. J. Monfils, S. J. Lewis, and W. E. Thogmartin. 2007. Upper Mississippi River and Great Lakes Region Joint Venture Waterbird Habitat Conservation Strategy. U.S. Fish and Wildlife Service, Fort Snelling, MN. 68pp.

Bird habitat conservation is typically implemented at local scales, but avian ecologists have recognized the need to integrate continental migratory bird priorities into local habitat recommendations. In this strategy we attempt to “step-

down" continental waterbird conservation priorities to the Joint Venture (JV) region and to smaller scales within the region, providing wildlife managers guidance in designing landscapes with greater value to birds. We estimated what, where, when, and how much habitat is needed to increase and sustain populations of priority waterbird species at target levels. The strategy goal is to *"Establish efficient habitat conservation to maintain or increase carrying capacity for populations of priority waterbird species consistent with continental and JV regional goals."*
Population estimates and objectives are continually being refined for waterbirds, and we recognize population estimates used in this strategy may soon be dated. Nonetheless, science-based recommendations were developed to efficiently and effectively increase landscape carrying capacity through waterbird habitat protection, restoration, and enhancement. In addition, this document was developed to complement JV habitat conservation strategies for waterfowl, shorebirds, and landbirds.

In order to scientifically link population and habitat objectives for this diverse bird group, several "JV focal species" were selected for habitat planning and monitoring. Each JV focal species represents a primary cover type used during the breeding season. We assumed habitat actions designed for JV focal species would accommodate populations of other breeding waterbirds within designated guilds. Migration requirements were not assessed due to lack of information; migration habitat planning will be addressed in future iterations of this strategy.
Regional waterbird population and habitat trends, in concert with population estimates and an assessment of limiting factors, provide a biological planning foundation. Planning steps included characterizing and assessing the landscape for JV focal species, modeling population response, identifying conservation opportunities, and developing an initial landscape design with capacity expected to sustain current waterbird populations plus eliminate population deficits. Much of the technical information, including habitat models and decision support maps, appears in JV focal species accounts (Appendix A). Sections on monitoring and research needs, adaptive management, and program coordination are also provided.

Our intent in this JV Waterbird Habitat Conservation Strategy is to establish explicit regional goals for waterbird habitat conservation and identify and use available survey data and new technological tools to efficiently achieve those goals. Lack of population and ecological information for many species was a significant planning challenge. However, we establish a scientific process for habitat objective-setting plus identify assumptions and research needs to improve subsequent iterations of the strategy. This plan is a "living document" that will be refined periodically as knowledge of regional waterbird conservation improves and new spatial data becomes available and can be incorporated.

Smit, C., and G. J. M Visser. 1993. Effects of disturbance on shorebirds: a summary of existing knowledge from the Dutch Wadden Sea and Delta area. Wader Study Group Bulletin 68, 6–19.

The extent to which shorebirds are disturbed by various activities is discussed, with reference to studies carried out on the Wadden Sea and Delta area. The effects of leisure activities on foraging and roosting birds are discussed. The effects of small airplanes, jets and helicopters are also considered, as are the effects of disturbance on food intake and behaviour of territorial birds. Frequent disturbance may force waders to abandon traditional high-tide roosts. The implication of disturbance on energy are not yet clear but indicate that the effects can be larger than would appear from the studies described.

Staine, K. J. and J. Burger. 1994. Nocturnal foraging behavior of breeding piping plovers (*Charadrius melodus*) in New Jersey. Auk 111: 579-587.

The nocturnal foraging behavior of breeding Piping Plovers (*Charadrius melodus*) was studied in New Jersey using a focal-animal approach in 1989 and 1990. More than 30% of the variation in the number of plovers foraging at night was explained by stage of the breeding cycle, tidal stage, and year. The greatest numbers of adult plovers fed in the intertidal zone during the prenesting and fledgling stages of the breeding cycle. Piping Plovers were more likely to be observed feeding during late ebb and early flood tides, than other times. Time devoted to feeding per 2-min sample was similar at each study site but differed significantly during the tidal stages. Pecking rate was higher during late ebb and early flood tides than late flood and early ebb tides. Time devoted to being alert varied depending on stage of the breeding cycle. Prenesting plovers and individuals with fledglings fed longer and were alert less per 2-min sample than plovers engaged in incubation or brood rearing. The nocturnal peck rate of Piping Plovers was considerably lower than daytime levels. Plovers foraging at night had significantly lower peck rates when disturbed. Abundance of intertidal polychaetes varied according to tidal stage and, where present, they constituted the main food of the plovers. We suggest that nocturnal foraging is a natural behavior pattern in Piping Plovers although it may vary in intensity. Future management should include the assessment of nighttime recreational use of beaches where Piping Plovers breed.
Received 31 July 1992, accepted 25 November 1992.

Stillman, R. A., and J. D. Goss-Custard. 2002. Seasonal changes in the response of oystercatchers *Haematopus ostralegus* to human disturbance. Journal of Avian Biology 33:358–365.

The response of foraging animals to human disturbance can be considered as a trade-off between the increased perceived predation risk of tolerating disturbance and the increased starvation risk of not feeding and avoiding disturbance. We show how the response of overwintering oystercatchers *Haematopus ostralegus* to disturbance is related to their starvation risk of avoiding disturbance. As winter progresses, oystercatcher energy requirements increase and their feeding conditions deteriorate. To survive they spend longer feeding and so have less spare time in which to compensate for disturbance. Later in winter, birds approach a disturbance source more closely and return more quickly after a disturbance. Their behavioural response to disturbance is less when they are having more difficulty surviving and hence their starvation risk of avoiding disturbance is greater. These results have implications for studies which assume that a larger behavioural response means that a species is more vulnerable to disturbance. The opposite may be true. To more fully understand the impact of disturbance, studies should measure both behavioural responses and the ease with which animals are meeting their requirements. Conservation effort should be directed towards species which need to spend a high proportion of their time feeding, but still have a large response to disturbance.

Stillman, R. A., A. D. West, R. W. G. Caldow and S. E. A. Le V. Dit Durell. 2007. Predicting the effect of disturbance on coastal birds. Ibis 149: 73–81.

Assessments of whether disturbance is having a deleterious effect on populations have often measured behavioural responses to disturbance and assumed that populations with a larger behavioural response are more susceptible to disturbance. However, there is no guarantee that the behavioural response to disturbance is related to the population consequence, measured in terms of decreased reproduction or increased mortality. Individual-based models, consisting of fitness-maximizing individuals, are one means of linking the behavioural responses to disturbance to population consequences. This paper reviews how individual-based models have been used to predict the effect of disturbance on populations of shorebirds and wildfowl at several European sites, and shows how these models could be improved in the future by incorporating a range of alternative responses to disturbance.

Stolen, E. D. 2003. The effects of vehicle passage on foraging behavior of wading birds. Waterbirds 26:429–436.

Protected lands contain a large proportion of existing critical habitat for many wading bird species, but human activities in these areas have the potential to adversely effect these species. The effects of passing vehicles on the foraging behavior of wading birds was studied using observational and experimental methods at the Merritt Island National Wildlife Refuge near Titusville, Florida. Foraging wading birds were more likely to be disturbed when vehicles slowed or stopped adjacent to them, than when vehicles continued driving by. In an area with a high rate of human visitation, some individual wading birds responded more strongly to passing vehicles than did others, suggesting that some were habituated to disturbance. Experimental disturbance by a vehicle caused a significant depression in the foraging rates of the Snowy Egret (*Egretta thula*) and the Great Egret (*Ardea alba*) and non-significant reductions in foraging rates in the Tricolored Heron (*E. tricolor*). Nineteen percent of the birds flushed following disturbance. The proximity of the disturbance vehicle influenced the probability of flushing in a species-specific manner with the Tricolored Heron being the most sensitive, the Great Egret intermediate, and the Snowy Egret the least sensitive. Recommendations to managers include concentrating ecotourism in certain areas and educating ecotourists about the effects of their behavior on wading birds.

Strauss E. 1990. Reproductive success, life history patterns, and behavioral variation in a population of piping plovers subjected to human disturbance (1982–1989). PhD, Tufts University, Medford, Massachusetts, 143 pp.

The behavioral ecology of a small population of federally threatened and state endangered Piping Plovers (*Charadrius melodus*) were studied on Cape Cod, Massachusetts from 1982-1989. The population was subject to variable degrees of human disturbance on their breeding grounds that ranged from occasional pedestrian activity to intensive off-road motor vehicle traffic. The birds were observed throughout the breeding season (March-September) and both adults and juveniles were color banded.

Reproductive success (measured as fledglings/pair/year) was higher for plovers nesting in low disturbance regions (1.12) than in areas of high human disturbance (.47). Hatching success did not vary significantly between areas but the probability of a chick fledging was higher in areas of low human disturbance (54%) verses 23%). Predation rates and nest site desertion were higher for plovers breeding in areas of high

human disturbance. The use of predator exclosures increased hatching success from 15% to 95% and was a deterrent to egg depredation from red foxes (*Vulpes vulpes*).

Piping Plovers consistently chose nesting habitats that were associated with either the eroded sections of dunes called blowouts or the newly forming sandspits adjacent to the harbor mouth. Plovers avoided nesting on the mature, steep slope of the foredunes. Reproductive success was higher for plovers that nested in blowouts compared to those birds that nested on sandspits. The current practice of revegetating and plugging up blowouts in order to stabilize the foredunes reduced plover nesting habitat by 40%.

Plover reproductive success was severely limited by low fledging rates of juvenile plovers in areas of high human disturbance. The precocial plover chicks spent less time feeding (50% verses 91%) and spent more time running (33% verses 2 %), fighting with conspecifics (4% verses 0.1%), and standing alert (9% verses 0.1%) when pedestrians or moving vehicles were closer than 100m when they were undisturbed. In addition, plover chicks spent less time out on the feeding flats (8% verses 97%) and more time up in the grass (68% verses 0.1%) during periods of human disturbance. Future viability and recovery of the piping plover appears to be severely constrained by the lack of undisturbed and predator free nesting and chick rearing habitat.

Taylor, E. C., R. E. Green, and J. Perrins. 2007. Stone-curlews *Burhinus oedicnemus* and recreational disturbance: developing a management tool for access. Ibis 149: 37-44.

Stone-curlews *Burhinus oedicnemus* have a vulnerable population status in the UK after a large population decline and range contraction since the 1930s. Much Stone-curlew breeding habitat is open-access land designated under the Countryside and Rights of Way Act 2000. In order to guide the conservation and habitat management for this species whilst allowing recreational access, a tool known as the Stone-Curlew Access Response Evaluator (SCARE) has been developed. SCARE offers a method to assess the effects of scenarios for future changes in disturbance type, routes and frequency and will be valuable in making informed decisions about the management of public access to Stone-curlew breeding sites and the deployment of habitat creation measures.

Thomas, G. H., R. B. Lanctot, and T. Szekely. 2006. Can intrinsic factors explain population declines in North American breeding shorebirds? A comparative analysis. Animal Conservation 9: 252-258.

Many shorebirds that breed in North America are declining. These trends reflect global patterns in shorebird populations. Here we ask what factors make some shorebird species more prone to decline than others. Specifically, we test the influence of migratory behaviour (route and distance), biogeography (population size and range), life history (body size, clutch size) and sexual selection (social mating system and testis size) on population trends in North American breeding shorebirds. Using phylogenetic comparative methods, we show that species that migrate across continental North America are more prone to decline than species that do not. Our finding that continental migrants are associated with population decline indicates that intrinsic factors may play an important role in predisposing a species to decline. Previous studies within the class Aves have failed to identify migration route as a correlate of decline or extinction risk. Two other intrinsic factors (oceanic migrants and threats on the non-breeding grounds) were also important in our overall models, although neither was significant alone. The moderate explanatory power of our variables indicates that other factors are also important for explaining shorebird declines. We suggest that contemporary threats, most notably habitat loss and degradation at migratory stopover sites, are likely to be important.

Thomas, K., R. G. Kvitek, and C. Bretz. 2003. Effects of human activity on the foraging behavior of Sanderlings *Calidris alba*. Biological Conservation 109:67–71.

Urbanization and coastal development has dramatically reduced the beach habitat available for foraging shorebirds worldwide. This study tested the general hypothesis that recreational use of shorebird foraging areas adversely affects the foraging behavior of sanderlings *Calidris alba*. Observations conducted on two central California beaches from January through May and September through December of 1999 showed that number and activity of people significantly reduced the amount of time sanderlings spent foraging. Although the sample size was low, the most significant negative factor was the presence of free running dogs on the beach. The experimentally determined minimal approach distance did not vary significantly with the type of human activities tested. Based on these results, policy recommendations for minimizing the impact of human beach activities on foraging shorebirds include: (1) people maintain a minimum distance of 30 m from areas where shorebirds concentrate and (2) strict enforcement of leash laws.

Thompson, Bruce C., Jerome A. Jackson, Joannna Burger, Laura A. Hill, Eileen M. Kirsch and Jonathan L. Atwood. 1997. Least Tern (Sterna antillarum), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/290

Thomsen, S. K. 2006. A GIS-based analysis of human disturbance on piping plover abundance, distribution and productivity on the barrier islands of Long Island, New York. Division III Project, Hampshire College, NY 29pp.

Impacts from coastal recreation activities were cited as a primary reason for listing the Atlantic Coast population of the piping plover (*Charadrius melodus*) as threatened under the Endangered Species Act in 1986. To assess the impact of these threats, I conducted a geographic information system (GIS) analysis of the spatial distribution and productivity of piping plover nests in relation to proxy indicators of human disturbance on the barrier islands of Long Island, New York. Specifically, I investigated whether off-road vehicle (ORV) access and proximity to parking lots, roads and residential areas affected plover productivity. I also compared nests and random points at a range of spatial scales and used binary logistic regression to look for relationships between the proxy indicators of disturbance and the presence or absence of plover nests. Results of the logistic regression analysis indicated that for each additional kilometer of road within a 500m radius, the likelihood of the presence of a plover nest decreased by up to 53%, controlling for other variables in the model. Compared to random points, nests tended to be closer to parking lots but they also tended to have less area of parking within 250m, indicating that plovers respond to human disturbance at different spatial scales. Only about 6-11% of plover nests were located on sections of beach with unrestricted ORV access during the plover breeding season. Higher productivity appeared to be only slightly correlated with increasing distance from parking lots, roads, and residential areas and no difference in mean productivity was observed among the levels of ORV access. Therefore, the greatest impact from human disturbance may be to reduce the carrying capacity of the beach.

Thompson, B. C., J. A. Jackson, J. Burger, L. A. Hill, E. M. Kirsch, and J. L. Atwood. 1997. Least Tern (*Sterna antillarum*). *In* The Birds of North America, No. 290 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.

Thompson, Bruce C., Jerome A. Jackson, Joannna Burger, Laura A. Hill, Eileen M. Kirsch and Jonathan L. Atwood. 1997. Least Tern (Sterna antillarum), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/290

Tibbitts, T. Lee and William Moskoff. 1999. Lesser Yellowlegs (Tringa flavipes), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/427

Traut, A. H., J. M. McCann, and D. F. Brinker. 2006. Breeding Status and Distribution of American Oystercatchers in Maryland. Waterbirds 29: 302-307.

The Atlantic coast population of the American Oystercatcher (*Haematopus palliates*) has seen mixed success in its recovery from historic lows at the turn of the 20th century. During the mid-1980s, breeding numbers in Maryland were estimated at 50-75 pairs based on incidental observations and the results of the state's first breeding bird atlas project. With growing national and regional concern for the species and a need for current information on its status in Maryland, the state's first comprehensive survey of nesting oystercatchers was conducted during the 2003 breeding season. Both hatching success and fledging success were relatively high, with some breeding birds nesting in areas where they were not previously found in the state. Most oystercatchers nested on salt marsh islands, as opposed to the extensive barrier island found along Maryland's coast. Although a similar number of birds nested in the Chesapeake Bay and Coastal Bays, nest success was significantly greater in the Chesapeake Bay. Landscape type proved to be the only variable that was significantly associated with statewide nest success, though it did not explain the differences in success between Chesapeake Bay and Coastal Bay birds. Several existing and potential threats require consideration in future studies and management of this species.

Tremblay, J. and L. N. Ellison. 1979. Effects of human disturbance on breeding of Black-crowned Night Herons. Auk 96: 364-369.

Visits to Black-crowned Night Heron (Nycticorax nycticorax) colonies just before or during laying provoked abandonment of newly constructed nests and either predation of eggs or abandonment of eggs followed by predation. Investigator disturbance caused mortality of young in some situations. Frequent disturbance also discouraged the settlement of late-nesting night herons, late clutches being more likely in colonies visited only twice than in colonies visited 10-15 times. Clutch size and fledging success of successful early nests were the same in frequently and infrequently disturbed colonies. Received 1 September 1978, accepted 13 February 1979.

Truitt, B.R. and B. Brown. 2000. Stopover Biology of Red Knots - Virginia Barrier Islands. Report to the U.S. Fish and Wildlife Service, 5 Pp.

Trulio, L. 2005. Understanding the Effects of Public Access and Recreation on Wildlife and their Habitats in the Restoration Project Area. San Jose State University.

The scientific synthesis addresses potential impacts of public access and recreation on the South Bay Salt Pond Restoration Project and discusses methods for minimizing those impacts. An important objective of the Project is to provide high-quality recreation and public access compatible with wildlife (Objective 3). This will include trails, overlooks, and other structures to facilitate access. US Fish and Wildlife Service (FWS) and the California Department of Fish and Game (DFG) own the restoration sites, and, as a result, only certain types of public access and recreation can be accommodated, consistent with state and federal regulations. This literature review focuses specifically on what effects public access and recreation allowed by the Project could have on the species and ecological communities central to achieving the Project Objectives, especially Objective 1.

Public access is one of the three primary objectives of the Restoration Project because recreation in natural and semi-natural areas is extremely popular. Many studies have documented the rise in eco-tourism and the popularity of national parks from the 1970s into the 1990s (US Department of the Interior 2003). While the numbers of anglers, hunters and wildlife viewers fell in 1996 from their high in 1991, spending on these activities increased (US Department of the Interior 2003). The 2001 report of National Survey of Fishing, Hunting, and Wildlife-Associated Recreation shows that by 2001 the popularity of these activities had increased from 1996 levels (US Department of the Interior 2003). In California, public survey polls conducted in 1987 showed that outdoor recreation was important to 44% of Californians.

This percentage increased to 62% in 1997 (California Department of Parks and Recreation 2002). Participation in all trail activities increased significantly in the last 15 years; bicycling doubled and hiking increased by 50% from 1987 to 1992 (California Department of Parks and Recreation 2002). California's population is expected to grow from its current level of 34 million to 45 million by 2020, further fueling the demand for recreational opportunities. California Department of Parks and Recreation (2002) reports that popular recreational activities of significance to the Restoration Project include recreational walking, driving for pleasure, trail hiking, general nature and wildlife study, bicycling on paved surfaces, visiting historic sites, attending outdoor cultural events, and picnicking at developed sites. Recreational trends show growing interest in nature study and wildlife viewing, especially among two growing demographic groups, Hispanics and seniors, and a general continued interest inmotorized recreation, such as "all terrain vehicles" (ATVs) and personal watercraft. However, two traditional recreational uses, hunting and fishing, continue to decline in popularity. The FWS lands in the Restoration Project are now part of the National Wildlife Refuge System. While the primary mission of the Refuge system is wildlife protection, the National
Wildlife Refuge Improvement Act of 1997 also states that refuges should provide compatible wildlife-dependent recreation. Six general categories of activities allowed in Refuges include: hunting, fishing, wildlife viewing, photography, environmental education, and interpretation (DeLong 2002). In the San Francisco Bay area, wildlife viewing and outdoor exercise are facilitated by trails, especially the system of near-Bay trails provided by the Bay Trail Project.

Many near-Bay trails are located on levees and allow non-motorized access, especially walking, running, biking, roller-blading, bird-watching, photography and dog-walking. Because an extensive levee system defines the ponds in the Project area, levee-top trails and public overlooks will be a significant part of the public access component of the South Bay Salt Pond Restoration Project. In addition to non-motorized access trails, vehicle trails and kayak-focused water trails may also be included. Other recreational activities likely to be supported in the Restoration Project area are waterfowl hunting, fishing, watercraft launching sites and associated motorized and non-motorized watercraft use.

The FWS and DFG are dedicated to providing high-quality recreational opportunities as part of the Restoration Project. However, the potential for conflict exists between the goals of restoring and managing habitat for wildlife (Objective 1) and providing public access (Objective 3) (Stolen 2003, Delong 2002). It is well-known that human disturbance can have a range of impacts on individuals, species, communities and ecological functions. Fox and Madsen (1997) note

that, “societies with strong urban-based cultures put major recreational pressures on wetlands, creating the need to balance conflicting demands of recreation and species conservation”. This statement is certainly an accurate description of the San Francisco Bay area. Since the restoration project has a number of ecosystem and species-related objectives (Objectives 1A, 1B and 1C), this review will focus on potential impacts of public access on these species and their habitats. Species of greatest concern to the Project are **birds**, including the California clapper rail (*Rallus longirostris obsoletus*), California least tern (*Sterna antillarum brownii*), snowy plover (*Charadrius alexandrinus*), and migratory and resident waterbirds; **mammals**, including salt marsh harvest mice (*Reithrodontomys raviventris*) and harbor seals (*Phoca vitulina richardsi*); **aquatic life**, especially native fish and the native oyster (*Ostrea lurida*); and **vegetation**, especially rare plants and vegetation communities in low, mid-, and high marsh regions and upland transitional zones.

U.S. Fish and Wildlife Service. 2003. Recovery Plan for the Great Lakes Piping Plover *(Charadrius melodus*). Ft. Snelling, Minnesota. viii + 141 pp.

Current Status : The Great Lakes population of piping plovers was listed as endangered under provisions of the U.S. Endangered Species Act on January 10, 1986. Critical habitat was designated on the Great Lakes breeding grounds on May 7, 2001 and for all populations of piping plovers on the wintering grounds on July 10, 2001. The Great Lakes population had declined from a historic size of several hundred breeding pairs to 17 at the time of listing. From 1986-2002, the population fluctuated between 12 and 51 breeding pairs, with breeding areas remaining largely confined to Michigan. The restricted breeding range of this population creates a gap in the distribution of piping plovers across North America, with the Great Lakes population isolated from the two other breeding populations (Atlantic and Northern Great Plains). The current size of the Great Lakes population makes it extremely vulnerable to chance demographic and environmental events that could extirpate the species from the Great Lakes region.

Habitat Requirements and Limiting Factors : In the Great Lakes region, piping plovers breed and raise young mainly on sparsely vegetated beaches, cobble pans, and sand spits of glacially formed sand dune ecosystems along the Great Lakes shoreline. Wintering grounds range from North Carolina to Florida and along the Florida Gulf Coast to Texas, Mexico, and the Caribbean Islands. On the wintering grounds, piping plovers forage and roost along barrier and mainland beaches, sand, mud, and algal flats, washover passes, salt marshes, and coastal lagoons. Threats to populations and habitat are similar on the breeding and wintering ranges. Habitat destruction and degradation are pervasive and have reduced physically suitable habitat. Human disturbance and predators further reduce breeding and wintering habitat quality and affect survival. Contaminants, as well as genetic and geographic consequences of small population size, pose additional threats to piping plover survival and reproduction.

Recovery Objective: To restore and maintain a viable population (95% or greater chance of persisting 100 years) to the Great Lakes region and remove the Great Lakes population from the list of Threatened and Endangered Species by 2020.

Recovery Strategy: To increase average fecundity, protect essential breeding and wintering habitat, increase genetic diversity to levels needed to maintain population persistence, increase public education and outreach, and establish and maintain funding mechanisms and partnerships for long-term protection and management.

Recovery Criteria:
Reclassification from endangered to threatened when:
1. the population has increased to at least 150 pairs (300 individuals), for at least 5 consecutive years, with at least 100 breeding pairs (200 individuals) in Michigan and 50 breeding pairs (100 individuals) distributed among sites in other Great Lakes states,
2. five-year average fecundity is within the range of 1.5-2.0 fledglings per pair, per year, across the breeding distribution, and ten-year population projections indicate the population is stable or continuing to grow above the recovery goal,
3. ensure protection and long-term maintenance of essential breeding and wintering habitat, sufficient in quantity, quality, and distribution to support the recovery goal of 150 pairs (300 individuals), and
4. genetic diversity within the population is deemed adequate for population persistence and can be maintained over the long-term. Delisting when the above criteria are met, plus:
5. agreements and funding mechanisms are in place for long-term protection and management activities in essential breeding and wintering habitat.

Actions Needed:
1. Protect the Great Lakes piping plover breeding population and manage breeding habitat to maximize survival and fecundity,
2. Protect wintering piping plovers and manage habitat to promote survival and recruitment,
3. Identify and protect migration habitat outside of wintering range,
4. Conduct scientific research to facilitate recovery efforts,

5. Develop and implement public education and outreach,
6. Develop partnerships and additional funding mechanisms,
7. Develop emergency methods to prevent extirpation, and
8. Review progress toward recovery and revise recovery tasks as appropriate.

U.S. Fish and Wildlife Service [FWS]. 1998. 1997 status update: U.S. Atlantic Coast piping plover population. Sudbury, Massachusetts.

U.S. Fish and Wildlife Service. 1996. Piping Plover *(Charadrius melodus)*, Atlantic Coast Population, Revised Recovery Plan. Hadley, Massachusetts. 258 pp.

CURRENT STATUS: The Atlantic Coast piping plover *(Charadrius melodus)* population breeds on coastal beaches from Newfoundland to North Carolina (and occasionally in South Carolina) and winters along the Atlantic Coast from North Carolina south, along the Gulf Coast, and in the Caribbean. Since being listed as Threatened in 1986, the population has increased from approximately 800 pairs to almost 1350p~ in 1995; however, most of the apparent increase between 1986 and 1989 is attributable to increased survey effort in two States, and the population increase between 1989 and 1995 has been very unevenly distributed. Since 1989, the New England subpopulation has increased 346 pairs, while the New York-New Jersey and the Southern (DEMD- VA-NC) subpopulations gained 62 and 18p~ respectively, and the Atlantic Canada subpopulation Declined by 34 pairs. Substantially higher productivity rates have also been observed in New England than elsewhere in the population's range. Recovery of the Atlantic Coast piping plover population is occurring in the context of an extremely intensive protection effort now being implemented on an annual basis. Pressure on Atlantic Coast beach habitat from development and human disturbance is pervasive and unrelenting, and the species is sparsely distributed.

HABITAT REQUIREMENTSAND LIMITING FACTORS**:** Piping plovers nest above the high tide line on coastal beaches, sandflats at the ends of sandspits and barrier islands, gently sloping foredunes, blowout areas behind primary dunes, sparsely vegetated dunes, and washover areas cut into or between dunes. Feeding areas include intertidal portions of ocean beaches, washover areas, mudflats, sandflats, wrack lines, and shorelines of coastal ponds, lagoons, or salt marshes. Wintering plovers on the Atlantic Coast are generally found at accreting ends of barrier islands, along sandy peninsulas, and near coastal inlets. Loss and degradation of habitat due to development and shoreline stabilization have been major contributors to the species' decline. Disturbance by humans and pets often reduces the functional suitability of habitat and causes direct and indirect mortality of eggs and chicks. Predation has also been identified as a major factor limiting piping plover reproductive success at many Atlantic Coast sites, and substantial evidence shows that human activities are affecting types, numbers, and activity patterns ofpredators, thereby exacerbating natural predation.

RECOVERY OBJECTIVE: The primary objective of the revised recovery program is to remove the Atlantic Coast piping plover population from the List of Endangered and Threatened Wildlife and Plants by: (1) achieving well-distributed increases in numbers and productivity of breeding pairs, and (2) providing for long-term protection of breeding and wintering plovers and their habitat.

RECOVERY CRITERIA: Delisting of the Atlantic Coast piping plover population may be considered when the following criteria have been met:
1. Increase and maintain for five years a total of2,000 breeding pairs, distributed among four recovery units as follows: Atlantic Canada, 400 pairs; New England, 625 pairs; New York-New Jersey, 575 pairs; Southern (DE-MD-VA-NC),400 pairs.
2. Verify the adequacy of a 2,000-pair population of piping plovers to maintain heterozygosity and allelic diversity over the long tern.
3. Achieve five-year average productivity of 1.5 fledged chicks per pair in each of the four recovery units described in criterion 1, based on data from sites that collectively support at least 90% of the recovery unit's population.
4. Institute long-term agreements to assure protection and management sufficient to maintain the population targets and average productivity in each recovery unit.
5. Ensure long-term maintenance of wintering habitat, sufficient in quantity, quality, and distribution to maintain survival rates for a 2,000-pair population.

ACTIONS NEEDED:
1. Manage breeding piping plovers and habitat to maximize survival and productivity.
2. Monitor and manage wintering and migration areas to maximize survival and recruitment into the breeding population.
3. Undertake scientific investigations that will facilitate recovery efforts.
4. Develop and implement public information and education programs.

5. Review progress towards recovery annually and revise recovery efforts as appropriate.
In furtherance of action 1, appendices to this plan include: (a) guidelines for managing recreational activities in piping plover breeding habitat to avoid direct mortality, harassment, and/or harm (Appendix G); and (b) guidelines for preparation and evaluation of permit applications for incidental take of piping plovers (Appendix H).

U.S. Fish and Wildlife Service [FWS]. 1988. Great Lakes and Northern Great Plains Piping Plover Recovery Plan. U.S. Fish and Wildlife Service; Twin Cities, Minnesota.

U.S. Shorebird Conservation Plan April 10, 2000: revised September 30, 2002. Retrieved from http://www.fws.gov/shorebirdplan/RegionalShorebird/RegionalPlans.htm.

Van Der Merwe, D. 1991. Effects of off-road vehicles on the macrofauna of a sandy beach. South African Journal of Science 87: 210-213.

Effects of off-road vehicles on four intertidal macrofaunal species, the gastropod *Bullia rhodostoma* , the bivalves *Donax serra* and *Donax sordidus* , the benthic mysid *Gastrosaccus psammodytes* , and the supralittoral isopod, *Tylos capensis* , were investigated on an exposed sandy beach. Intertidal species, with the exception of *G. psammodytes* , showed a high tolerance for vehicular traffic. The apparent vulnerability of *G. psammodytes* might have been a consequence of the experimental procedures used. The supralittoral species *T. capensis* was highly susceptible to vehicle impacting, the amount of damage sustained increasing as a function of the number of vehicle passes. This is caused by deep tracks ploughed by vehicles in the less compact and above the drift time.

Vaske, J.J., D. J. Decker, and M.J. Manfredo. 1995. Human Dimensions for Wildlife Management: An integrated framework for coexistence. Pages 71-79 *in* R. L. Knight and K. J. Gutzwiller, ed. Wildlife and Recreationists: coexistence through management and research. Island Press, Washington, D. C. 372pp.

Verhulst, S., K. Oosterbeek,, and B. J. Ens. 2001. Experimental evidence for effects of human disturbance on foraging and parental care in oystercatchers. Biological Conservation 101, 375–380.

We carried out two experiments to quantify effects of human disturbance on foraging and parental care in European oystercatchers (*Haematopus ostralegus*). In experiment 1, pairs incubating a clutch were disturbed on their feeding territory on the mudflat. Disturbance significantly reduced the proportion of time that the clutch was incubated, but also the proportion of time that the pair spent on the mud flat. In experiment 2, foraging oystercatcher pairs with chicks were disturbed by two observers at different distances from the edge of the salt marsh where the chicks resided. Total food collected was independent of disturbance, but a smaller proportion of the food collected was allocated to the chicks with increasing disturbance level. Both experiments demonstrate that human disturbance of foraging in breeding oystercatchers reduced the amount of parental care, and thus presumably reproductive success.

Warnock, N., and M. A. Bishop. 1998. Spring stopover ecology of migrant Western Sandpipers. Condor 100:456–467.

We describe stopover ecology for 132 migrant radiomarked Western Sandpipers (Calidris mauri) relocated repeatedly along the Pacific Flyway of North America. Eighty-eight percent of radiomarked birds were detected at 1-5 sites north of their banding sites, at distances ranging from 240-4,000 km away. We compare length of stay and physical indices of Western Sandpipers banded at coastal sites (San Francisco Bay, California and Grays Harbor, Washington), and an interior, western Great Basin site (Honey Lake, California). Western Sandpipers radiomarked at the interior site had significantly shorter length of stays than birds radiomarked at coastal sites, and they had significantly lower fat scores. The ephemeral nature of Great Basin stopover sites and an increased risk of predation may explain some of this variation. Fat and body condition indexes explained little of the observed variation in length of stay of Western Sandpipers at banding and other stopover sites. Length of stay of birds radiomarked at Grays Harbor were significantly longer compared to birds radiomarked to the south that also stopped at Grays Harbor, suggesting a potential capture effect on length of stay of birds at banding sites. Mean length of stays at seven sites other than banding sites ranged from 1.1-3.3 days and were not significantly affected by sex of bird, year of study, or banding location. Length of stay of male Western Sandpipers at the Copper River Delta, Alaska became significantly shorter later in the migration period, but not for females. Coastal sites along the Pacific Flyway from San Francisco to the breeding grounds generally function as stopovers for Western Sandpipers instead of staging areas.

Warnock, Nils D. and Robert E. Gill. 1996. Dunlin (Calidris alpina), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/203

Watson, J. J., G. I. H. Kerley, and A. McLachhlan. 1996. Human activity and potential impacts on dune breeding birds in the Alexandria coastal Dunefield. Landscape and Urban Planning 34: 315-322.

Human use of coasts has increased considerably with increasing demand for recreational experiences, increased availability of off-road vehicles (ORVs) and population increase. Besides impacts on dune morphology and flora, humans and ORVs also affect the fauna. The Alexandria Dunefield in Algoa Bay comprises a 50 km sandy beach backed by a 2.1 km wide strip of dunefield. The dunefield is largely conserved, but access to the beach is allowed under permit, and the beach is heavily utilised by fishermen and recreational ORV drivers. The area is also important for dune breeding birds. Beach and dune use by fishermen and other users was quantified by recording their position relative to the high water mark and along a 20 km stretch of beach, and through analysis of access permits and angling competition data. An increase in vehicle use in the area was observed. An indication of human perception of the area was obtained by questionnaires. Eighty percent of human activity was concentrated in 50% of the study site where the highest concentration of dune breeding birds nest. Sixty percent of the vehicles recorded, were on or above the high water mark (in the dunes). Of the beach-users interviewed, 74% suggested that only registered vehicles should be allowed on the beach. Most (80%) anglers had no problem determining the position of the high water mark. There is an overlap in area and seasonal use between beach-users and breeding birds. With specific areas along the beach being heavily impacted and vehicles utilising the area above the high water mark the potential for impact on the fauna and flora of these areas is high. There is a need to educate beach users as to the vulnerability of dune systems and to develop appropriate management guidelines to minimise the impacts of beach users on the dune fauna.

Wearing, S., Neil, J., 1999. Ecotourism: Impacts, Potentials and Possibilities. Reed Educational and Professional Publishing Ltd, Oxford.

Weber, T.P. and A. I. Houston. 1997. Flight costs, flight range and the stopover ecology of migrating birds. Journal of Animal Ecology 66: 297-306.

Flight range equations are a central component in the analysis of avian migration strategies. These equations relate the distance that can be covered to the fuel load that the birds carry. Models of stopover decisions deal with the question of how birds should react to variations in fuel deposition rates. Time-minimization models generally predict an increasing relationship between departure fuel load and fuel deposition rate. We show that quantitative details of predictions derived from optimality models depend critically on the flight range equation that is used. We use two classes of flight range equations: one class is based on theoretical assumptions of aerodynamics; the other is based on empirical measurements of metabolism during flight. Most empirically derived equations can be written as Y(x) = c[1-(1 + x) super(- zeta)], where 0 < zeta < 1, and c is a constant that includes morphological traits and lean body mass. Patterns of site use and departure loads in environments with discrete stopover sites depend in significant ways on flight costs. Flight range estimates that are based on empirically derived, multivariate equations are sensitive to errors in the estimates of exponents of the equations. Varying some exponents within their confidence limits can alter flight ranges by an order of magnitude.

Wemmer, L. C., U. Ozesmi, and F. J. Cuthbert. 2001. A habitat-based population model for the Great Lakes population of the piping plover (*Charadrius melodus*). Biological Conservation 99: 169-181.

We created a stochastic habitat-based population model to compare the relative effectiveness of potential conservation strategies to increase the endangered Great Lakes population of piping plovers. Initial model parameters were based on an extensive 14-year dataset obtained by annual studies of breeding pairs in Michigan and 6 years of observations of color-marked individuals. Cumulative persistence probability curves and population trends were compared for scenarios with all possible combinations of the following: (1) empirical, medium and high site specific probabilities of reproductive success and (2) empirical, medium and high numbers of available breeding territories. Sites were also categorized according to land ownership to determine if long-term preservation of publicly owned lands is sufficient for population recovery under any of the scenarios. Only scenarios in which both reproduction and habitat availability were

high and all ownership classes were included resulted in a model population that persisted for 100 years and was likely to reach the US Fish and Wildlife Service current population recovery goal (100 breeding pairs) for Michigan. The model was most sensitive to survival rates of adults and more sensitive to changes in reproductive parameters than to number of breeding sites or territories. Model results suggest that intensive measures to increase productivity alone are not sufficient for population recovery; increases in nesting densities or total number of available territories are also likely necessary. Given uncertainties about nesting densities possible at specific breeding sites, preservation of presently unoccupied habitat throughout the Great Lakes region and management of this habitat to encourage breeding by plovers are recommended. Use of techniques to augment the breeding population in conjunction with protection of habitat and reproduction may be warranted.

West, A. D., Goss-Custard, J. D., Stillman, R. A., Caldow, R. W. G., Durell, S. E. A le V. dit, McGrorty, S., 2002. Predicting the impacts of disturbance on wintering waders using a behaviour based individuals model. Biological Conservation 106, 319–328.

To assess the long-term effects of human disturbance on birds, ways of predicting its impacts on individual fitness and population size must be found. In this paper we use a behaviour-based model to predict the impact of human disturbance on oystercatchers (*Haematopus ostralegus*) on their intertidal feeding grounds in the Exe estuary in winter. The model predicted that, for the same overall area disturbed, numerous small disturbances would be more damaging than fewer, larger disturbances. When the time and energy costs arising from disturbance were included, disturbance could be more damaging than permanent habitat loss. Preventing disturbance during late winter, when feeding conditions were harder, practically eliminated its predicted population consequences. Although disturbance can cause increased mortality, it was not predicted to do so at the levels currently occurring in the Exe estuary.

West, A. D. and R. W. G. Caldow. 2006. The development and use of individuals-based models to predict the effects of habitat loss and disturbance on waders and waterfowl. Ibis 148: 158-168.

Current commitments to increase renewable energy generation have led to concern about the possible effects of such developments on shorebirds and waterfowl. To assess the future impact of industrial developments – of changes in the intensity or type of activity on an estuary – or to evaluate the cost effectiveness of proposed mitigating measures, ecologists must be able to predict accurately to new environmental conditions. The difficulty with predicting to new circumstances is often that there is no way of knowing whether the empirical relationships upon which models are based will hold under the new conditions, and so predictions are of uncertain accuracy. Individuals-based models of shorebirds feeding on estuaries have been developed in an attempt to overcome this problem. These models follow the behavioural responses of individual animals to changes in the environment and predict variables such as population mortality rate from the fates of all individuals. Birds in these models use optimal decision rules to determine their behaviour, which means that model birds are likely to respond to environmental changes in the same way as real ones would and are therefore expected to provide a reliable means of predicting how animal populations will be influenced by environmental change. We describe previous approaches to predicting the effects of development in estuaries using two estuarine barrage schemes as examples. We then describe the development of individuals-based models to overcome the limitations of these approaches and discuss examples of how the models have already been used to predict the consequences of habitat loss and disturbance. Finally, we describe two current applications that demonstrate how individuals-based models are being used to predict the effects of barrages and offshore wind farm developments on waterbirds. We believe that individuals-based modelling has the potential to play an important role in future investigations of the impacts of a wide range of renewable energy developments.

Weston, M. A. and M. A. Elgar. 2007. Responses of Incubating Hooded Plovers (*Thinornis rubricollis*) to Disturbance. Journal of Coastal Research 23: 569-576.

Hooded Plovers (*Thinornis rubricollis*) and recreationists co-occur on the ocean beaches of southern Australia, and it has been suggested that disturbance of the breeding birds by humans constitutes a conservation problem. This study examines whether humans disturb incubating Hooded Plovers and places that disturbance in context with naturally occurring disturbances. Incubating Hooded Plovers encountered and responded to a variety of human and natural stimuli. The most common response involved leaving the nest for a period of time (an “absence”), and humans were responsible for 33.1% of time spent off nests. The response rates of incubating birds varied with the type of stimulus, with higher than expected response rates to two species of potentially predatory birds. About 17% of encounters with potential causes of disturbance occurred while birds were already responding to other disturbance, and this prolonged the return to the nest. Absences from the nest that were not apparently caused by disturbance were shorter and less frequent than those caused by external disturbance stimuli. Nest habitat influenced the response to encounters with humans, and on average foredune nests suffered the greatest decrease in attendance per encounter. This study has

confirmed that human disturbance is more frequent than natural disturbances, and that humans decrease nest attendance substantially and more than any other source of disturbance.

Wilke, A. L., D. F. Brinker, B. D. Watts, A. H. Traut, R. Boettcher, J. M. McCann, B. R. Truitt, and P. P. Denmon. American Oystercatchers in Maryland and Virginia, USA: Status and Distribution. Waterbirds 30: 152-162.

The conservation status of the American Oystercatcher (*Haematopus palliatus palliatus*) along the Chesapeake Bay, coastal bays, and barrier island shorelines of Maryland and Virginia has been investigated in detail in recent years. The region supports approximately 700 breeding pairs with more than 80% occurring on the east coast of the Delmarva Peninsula and less than 20% occurring along the shorelines of the Chesapeake Bay. The number of breeding pairs in Maryland appears to have been stable or to have increased slightly during the past 20 years. The overall trend of the breeding population in Virginia is less clear, but recent evidence suggests that numbers on the barrier islands are increasing after more than two decades of a declining trend. The coastal bays and barrier islands typically support between 1,500 and 2,000 wintering birds with most occurring on the east coast of the Virginia portion of the Delmarva Peninsula. The shorelines of both states together play an important role in supporting core breeding and wintering populations of the American Oystercatcher in the eastern United States. Throughout the region, oystercatchers are facing threats common to all coastal waterbird and shorebird species such as predation and overwash events. The threat of habitat loss to development, however, is not as alarming as in other areas of the species's breeding range due to a significant amount of habitat being in protective conservation ownership or being unfit for development and recreation purposes. Habitat loss attributed to sea level rise, barrier island dynamics, and the indirect effects of development, such as pollution and contaminants, may play more important roles in the stability of breeding and wintering habitat for the American Oystercatcher in Maryland and Virginia.

Williams, A. J., V. L. Ward, and L. G. Underhill. 2004. Waders respond quickly and positively to the banning of off-road vehicles from beaches in South Africa. Wader Study Group Bull. 104: 79-81.

Off-road vehicles (ORVs) were first identified as a threat to breeding shorebirds along the South African coastline in the mid-1970s. The use of ORVs on South Africa's beaches was banned from 21 December 2001. The impact of this ban on five species which breed on the coastline, two waders, two terns and a cormorant, was evaluated at two localities, one on the west coast of the Western Cape and one on the south coast, in the first breeding season following the ban. The changes were measured as increases in numbers of birds, increases in numbers of breeding pairs, and/or increased breeding productivity. Each of the five species re acted positively to the ban. The results provide a strong case for continuing t he ban on ORVs from driving on South African beaches.

Wilson, W. Herbert. 1994. Western Sandpiper (*Calidris mauri*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/090

Wolcott, T. G., and D. Wolcott. 1984. Impact of off-road vehicles on macroinvertebrates of a mid-Atlantic beach. Biological Conservation 29: 217-240.

Potential and actual impacts of off-road vehicle (ORV) use on beach macroinvertebrates were examined on the Cape Lookout National Seashore (North Carolina). Mole crabs *Emerita talpoida* and coquinas *Donax variabilis* were not damaged. Ghost crabs *Ocypode quadrata* were completely protected by burrows as shallow as 5 cm, and therefore were not subject to injury during the day, but they could be killed in large numbers by vehicles while feeding on the foreshore at night. Ghost crab populations on the Seashore were large (10 000 km^{-1} of beach) and a small proportion of the population would be killed by a single vehicle pass. Nevertheless, predicted population mortalities calculated from observed kills of ghost crabs per vehicle-km ranged from 14–98% for 100 vehicle passes. Currently vehicle use on this beach is light and essentially none occurs on the foreshore after dark. Little impact on beach macroinvertebrates would be expected from this usage pattern. Actual impact on ghost crab populations, assessed by burrow censuses, was negligible. No differences were detected between heavy-use and light-use sites in total population size, average crab size or population change through the heaviest traffic season. However, increases in traffic to levels seen on other beaches, especially night driving, would probably have devastating effects on ghost crab populations. In heavily used areas, banning of ORVs from the foreshore between dusk and dawn may be required to protect this species.

Yasue, M. 2005. The effects of human presence, flock size and prey density on shorebird foraging rates. Journal of Ethology 23: 199–204.

Animals may alter their foraging behaviour in the presence of humans because they perceive humans as potential predators. In this study I determined whether people caused shorebirds to reduce feeding rates at a stopover site in coastal British Columbia, Canada. I controlled for prey density and flock size because these variables may influence both the foraging rates as well as the effect of human disturbance on feeding efficiency. Semipalmated plovers decreased feeding rates when there were more people on the beach (multiple regression: $F_{1,15}$=5.86, b=0.59, P=0.029, R^2=37.6%). For least sandpipers, the effect of human densities on feeding rates depended on flock size ($F_{1,21}$=5.97, P=0.023) and amphipod availability ($F_{1,21}$=4.98, P=0.037). This study demonstrated the importance of measuring subtle behavioural changes in foraging rates along with key ecological variables in order to assess the true impact of human disturbance on migratory shorebirds.

Yasue, M. 2006Environmental factors and spatial scale influence shorebirds' responses to human disturbance. Biological Conservation 128: 47-54.

The extent of a shorebird's response to a human disturbance depends on the associated energetic or predation risk costs. These costs are influenced by a suite of environmental variables, operating at several temporal and spatial scales. Here, I measured prey availability, distance to forest cover, cloud cover, and wind speed, in addition to human and shorebird densities to examine how human presence affected habitat choice, relative to these environmental variables, at Pachena Beach, British Columbia. In a standardised experiment, I also approached feeding flocks to determine if environmental factors influenced the time take for shorebirds to resume feeding. Binary logistic models suggested that people did not displace shorebirds. Instead, shorebirds were preferentially selecting areas further from forest cover that may have had lower predation risk. The time taken for shorebirds to resume feeding after a human disturbance was greater in the morning and in areas of low prey availability. This suggests that shorebirds respond more to a disturbance when the foraging cost is lower indicating that behavioural responses may not necessarily reflect the potential fitness costs of human disturbance.

Zonick, C. A. 2000. The winter ecology of Piping Plovers (Charadrius melodus) along the Texas guf coast. PhD Dissertation, University of Missouri, Columbia. 168pp.

Zonick, C. A. 1997. The use of Texas barrier island washover pass habitat by Piping Plovers and other coastal waterbirds. Report to Texas Parks and Wildlife Dept. and U. S. Fish and Wildlife Service.