

# Conservation Strategy for Migratory Species

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Migratory animals derive a blessing and a curse from their itinerant habits. They benefit from their ability to exploit resources cyclically in places unsuitable for continuous use. But this same facility can lock them into a dependency on a specific sequence of sites, a linked chain of areas essential for completing their annual cycles. The successful functioning of the system as a whole rests on the continued functioning of each link in the chain. Migration thus complicates and compounds the efforts required for conservation of a species.

Shorebirds (Aves: Charadrii), which include species of plovers, sandpipers, and curlews, illustrate well the problems involved in the conservation of international migrant species. Most shorebird species in the Western Hemisphere are highly migratory, with the majority breeding in the Arctic and spending nonbreeding periods in temperate and tropical regions (Pitelka 1979; Morrison 1984). Of the 49 shorebird species that breed in North America, 40 migrate to wintering sites in the temperate and tropical regions of Central and South America; 31 species fly annually between the Arctic and South America, with most birds making a round-trip migration of more than 12,000 km, and with many exceeding 25,000 km (Fig. 1). (To avoid confusion, "winter" and "wintering" will denote the period of nonbreeding residency—that is, the months of north temperate winter—even though shorebirds migrating far into South America encounter a summer season.)

Major migration corridors pass along the Pacific and Atlantic coasts, through South America, and also through the western Gulf of Mexico and the Great Plains of North America (Fig. 2). Some species restrict their movements to single corridors, especially on the Pacific coast, while others use two or more. Several major migration flyways exist in South America. Species migrating between the northern and southern hemispheres

often follow an elliptical route, with their southward path in autumn east of their northward route in spring. In general, species breeding farther north migrate to more southerly nonbreeding sites.

The duration of each of the three phases of a shorebird's annual cycle—breeding, migration, and nonbreeding residency—varies considerably among populations. Typically, nesting dates are later farther north, and the season is shorter. Populations that winter farther south normally have migrations of greater duration, and they spend less time at wintering sites. For these, the northbound and southbound migrations together may span up to seven months, with compensatory reductions in the time they spend at the wintering sites. This

does not necessarily imply, however, that the birds drift leisurely on migration; many make a series of long uninterrupted flights between stopover areas, where they temporarily reside while accumulating energy reserves for the next stage of the journey (Fig. 3).

Four aspects of the natural history of shorebirds raise concern for

their conservation: the fragile characteristics of their life histories, their concentration into small migration and wintering sites, the precise timing and energy requirements in migration, and their competition with man. In this article, we will outline each of these problems in turn, and we will then describe an ongoing international effort to develop a comprehensive conservation program for these birds.

## Life history characteristics

Shorebirds have low reproductive rates. Their clutch sizes are small, usually limited to four eggs, with larger clutch sizes found rarely if ever (Winkler and Walters 1983). The breeding season of shorebirds is short; for many species, particularly long-distance migrants breeding in the Arctic, summer is too short to permit more than one breeding attempt each season. Moreover, because of natural environmental factors such as intense predation on nests and disruptive weather during incubation and the rearing of chicks, there is considerable risk for many adults that their one breeding effort in a given summer will fail.

As might be expected from these low reproductive rates, survivorship among adult shorebirds tends to be high, between 70% and 95% per year, even for many

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*Shorebirds illustrate  
the need for  
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in conservation programs*

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Figure 1. Ruddy turnstones (*Arenaria interpres*) and red knots (*Calidris canutus*) taking flight from Delaware Bay, where they have as much as doubled their weight in preparation for the last stage of their migration from wintering sites in South America to their Arctic breeding grounds. The ability to store fat reserves at such stopover sites is critical to migratory species: nearly all the energy reserves these birds have built up will be depleted in the two-to-three days of continuous flying to the breeding grounds. (All photographs by J. P. Myers/VIREO.)

small species (Evans and Pienkowski 1984). As a result, shorebird populations are sensitive to factors that decrease survivorship away from the breeding ground (Goss-Custard 1977, 1979). This sensitivity was demonstrated convincingly in North America before the turn of the century when massive hunting at migration and wintering sites led to widespread population declines (Wetmore 1926; Banks 1979). Hunting was stopped by international treaty (Senner and Howe 1984); as a result, population levels of all but one species, the Eskimo curlew (*Numenius borealis*), rose gradually.

## Concentration into small areas

Although shorebird populations disperse widely on the breeding ground, where they occupy suitable patches of habitat spread over vast expanses of arctic and subarctic tundra and wetland, their habitats in migration and on

the wintering ground are much more restricted—small patches of coastal wetland, intertidal mudflats, remnants of grasslands and marshes, and narrow strips of beach and rocky shore (Fig. 4). This disparity between the expansive breeding grounds and the much smaller sites used in migration and during winter leads to enormous concentrations of shorebirds in very small areas (Myers 1983). Often a large proportion of a given population may be found at only a few sites (Morrison 1984).

Breeding and wintering grounds are separated by ecological barriers—vast expanses without suitable foraging sites. This underlies the bottleneck pattern of shorebird migration illustrated in Figure 3. It also emphasizes the critical importance of stopover areas, where the birds accumulate fat reserves essential for making the next long-distance, nonstop flight. Four systems of estuary and bay in North America each support more than 1 million shorebirds during migration: Copper River Delta, Alaska; Grays Harbor, Washington;

Delaware Bay (pictured in Fig. 5); and the Bay of Fundy, between New Brunswick and Nova Scotia (Senner and Howe 1984). Each of these sites may support more than 80% of the breeding population of one or more species of shorebirds.

Studies of the availability of food and habitats indicate that the birds have no alternative to gathering at these limited sites (Senner and Howe 1984). Geographic factors often dictate that few, if any, suitable alternatives exist. For example, the Copper River Delta in Alaska is the only extensive geographic formation of its type along the southeastern Alaskan coastline; no other choices lie along this portion of the Pacific coast for birds requiring extensive intertidal mudflats for foraging. Comparable examples in South America are Lagoa do Peixe in Brazil and Paracas Peninsula in Peru.

Even where alternative wetlands exist, the special characteristics of a particular site may render it uniquely able to support the energy requirements of large numbers of birds con-

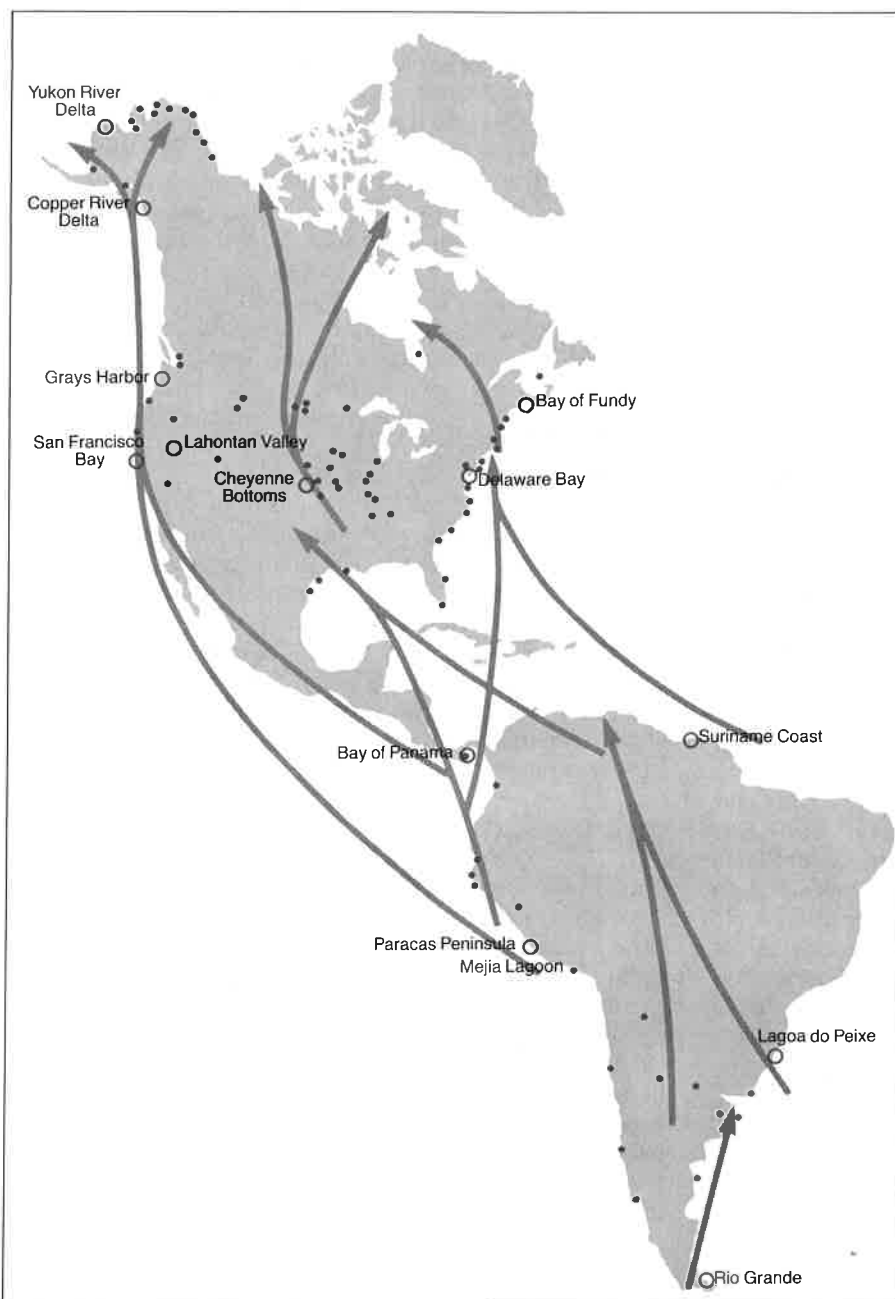


Figure 2. The principal northbound and southbound migration corridors of migratory shorebirds are shown schematically (here and on the facing page) superimposed on maps of the Western Hemisphere Shorebird Reserve Network. The network, established by an international consortium of public and private organizations, currently consists of more than 90 sites divided into two categories: hemispheric reserves (circles), defined by an international panel of biologists as supporting either more than 250,000 birds or at least 30% of a species' population moving along a migration corridor, and regional reserves (dots), defined as supporting more than 20,000 birds or 5% of a migrating population.

centrated at a migration stopover. Delaware Bay illustrates this point well (Myers 1986). The eggs of the horseshoe crab *Limulus polyphemus*, extraordinarily numerous on the sandy inner shores of the bay, provide the major food resource for shorebirds stopping there in late May. Delaware Bay harbors the highest number of *Limulus* along the east coast of the United States. Moreover, the peak of *Limulus* egg-laying in the bay occurs just at the time when shorebirds must depart for arctic breeding grounds. A convergence of two schedules, crab egg-laying and shorebird nesting, thus has brought shorebirds to Delaware Bay for many years (Wilson 1813). Because of such constraints, major sites are used year after year, by populations over generations as well as by individuals within their lifetimes (see, for example, Bainbridge and Minton 1978; Myers 1984).

Detailed ecological studies of shorebird populations during the nonbreeding season and during migration indicate that shorebirds fully use the resources available to them (e.g., Goss-Custard 1977, 1979; Schneider and Harrington 1981). For example, Evans and his colleagues (1979) estimate that shorebirds wintering in an estuary in England capture over 90% of the prey available within a given winter. The implication, although one almost impossible to test directly, is that birds displaced by the destruction or degradation of their habitats fare poorly because they are forced to sites that are already exploited near their capacity (Goss-Custard 1979). If the destruction occurs in prime areas, where more birds are located because of better resources, then the damage is much more severe in that more birds will be displaced to much poorer areas.

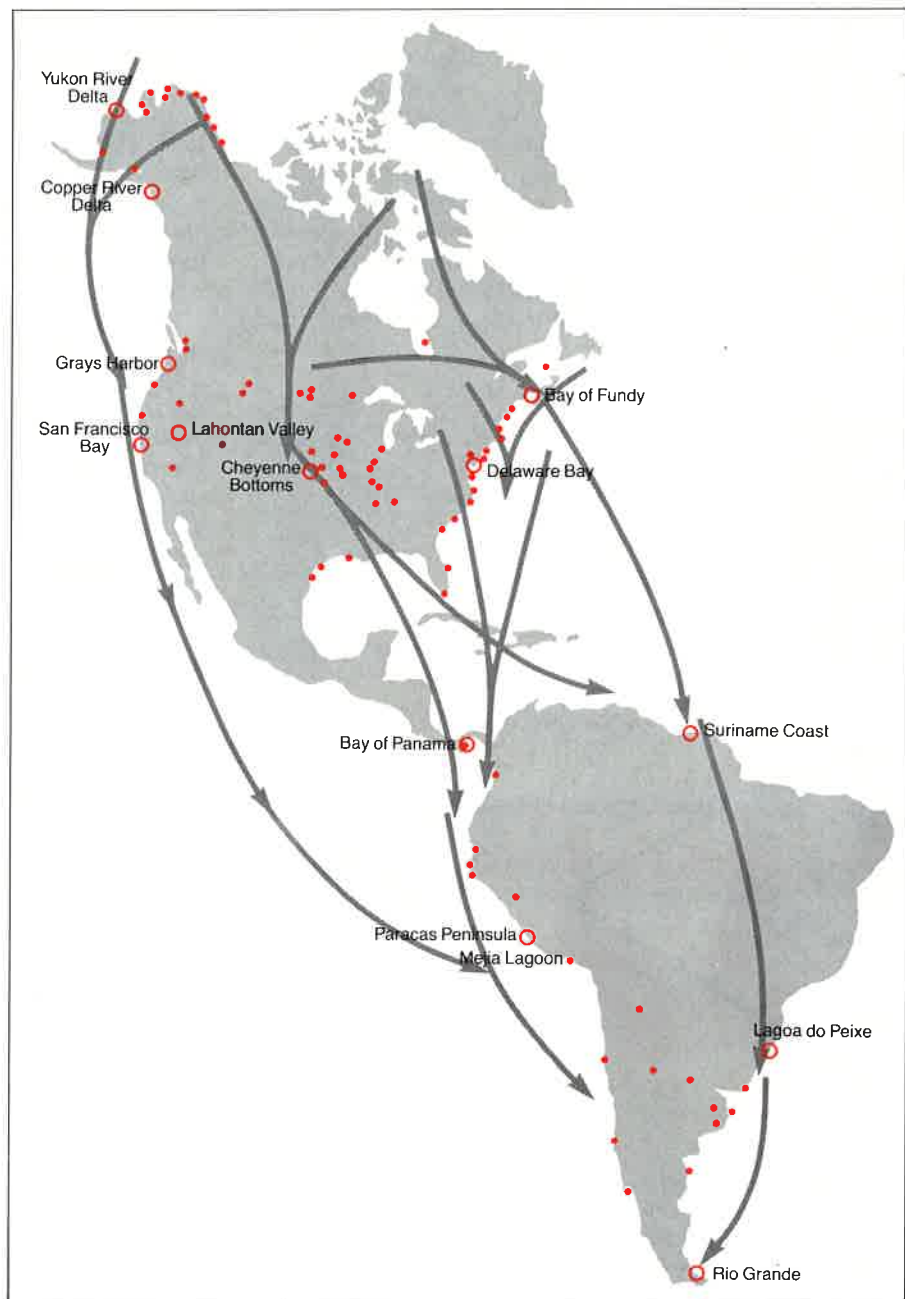
The concentrations of shorebirds during winter and migration are of heightened significance because they break the normal link between the abundance of a species and its immunity to extinction. Typically, large populations are thought to be immune to extinction by virtue of the vanishingly small probability that all members of a population will fail to replace themselves in the same period (Diamond 1984). If  $P_i$  is the probability per unit time that an individual (or breeding unit) will die, then  $P_i^N$  is the probability of extinction of a population as a function of its population size  $N$ .

This argument, however, assumes that members all die independently of one another. Concentrations on wintering grounds and staging sites remove that independence and lower the effective  $N$  toward the number of sites  $S$  used during a given part of the annual

cycle. How closely  $N$  approaches  $S$  depends on the spatial scale of the disturbance relative to the site, that is, on the degree of independence within the site. The extreme would occur when a single disturbance destroyed a single site through which an entire population funneled and on which the birds were completely dependent. In several shorebird species migration brings together more than 80% of the flyway populations (Senner and Howe 1984).

## Energy requirements and timing in migration

The tempo of migration among shorebirds compounds their critical dependence on environmental conditions at staging sites. Two distinct factors dictate this tempo. First, the seasonal availability of resources imposes severe time constraints. Because the arctic breeding season



is short, northbound birds must reach the nesting ground as soon as the snow has melted; early arrival and rapid nesting increases their reproductive success (Hildén 1979). However, a countervailing time constraint is that the seasonal supply of resources along the migration

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pathways does not allow movement to within striking distance of the breeding grounds until late spring. The timing of southbound migration is constrained as well because the abundance of prey at stopovers gradually decreases as the season progresses (Schneider and Harrington 1981). The early bird indeed gets the worm.

The second factor dictating the tempo of migration is the enormous energy required. Northbound shorebirds migrate in a rapidly repeating sequence of intensive feeding to accumulate lipids and of long-distance flight. During the feeding phase, each bird nearly doubles its weight, laying on lipid reserves that then provide the energy to power flight (Davidson 1984). Nonstop flights from eastern North America to northern South America cover 4,000 km and last 40 to 60 hours or longer (Stoddard et al. 1983). Most of the energy stores are

depleted during flight, so that the ability to accumulate a small additional reserve may be crucial if poor weather is encountered along the way or if feeding conditions are poor after arrival. These small reserves may be essential for breeding.

Although some populations migrate in only one step, most require two or more cycles of feeding and flight and therefore require adequate food at each staging area for intensive feeding. Few locations along the migration pathways can provide enough food at the right time to support the requirements of migratory shorebirds (Senner 1979; Morrison 1984). The fact that these sites must function in precise sequence both in time and in space means that functional alternatives to current staging areas are unlikely.

### Competition with man

Many of the sites needed by shorebirds in winter and in migration are highly prized by man. Throughout the Western Hemisphere, human development of wetlands, beaches, estuaries, and grasslands has steadily diminished the size and number of suitable habitats available to migratory shorebirds (Senner and Howe 1984; Tiner 1984). The rate at which coastal wetlands are lost is directly related to the density of the human population (Gosselink and Baumann 1980). Throughout the United States the combined total of coastal and interior wetlands that have been lost may exceed 40% nationally (Horwitz 1978).

Within particular regions the extent of the loss is much higher. By 1938 mosquito-control programs in tidelands from Maine to Virginia had affected 90% of the wetlands existing prior to 1885 (Bourne and Cottam 1950). The system of barrier islands along the coasts of New Jersey and Delaware has been given over largely to densely populated beach resorts, and comparable habitats along the coasts of Texas and Florida are following a similar path. Over two-thirds of coastal wetlands that existed in California in 1900 have now been developed (Speth 1979). Dredging and filling activities at Grays Harbor, Washington, threaten critical sites within the estuary. Tidal power projects represent another emerging threat. In Canada, various existing or proposed developments could have profound effects on regional tidal patterns with unpredictable consequences for a number of major migration stopovers (Morrison 1984).

Although comprehensive data from South America on the destruction of wetland and grassland habitats are not available, it is nonetheless clear that similar trends prevail there. The increased spread of agriculture into marginal croplands such as coastal saline wetlands and grasslands portends a continuation of the process (Fig. 6). Moreover, the use of pesticides and herbicides follows the spread of agriculture, with unknown consequences for shorebird reproduction.

Although human activities in shorebird habitats usually entail a gradual and largely irreversible reduction of available habitat, short-term risks also exist, especially where shorebird staging sites are near centers of chemical and petroleum transport. For example, the Copper River Delta lies immediately south of Valdez, Alaska, the southern terminus of the Alaska oil pipeline. Delaware Bay receives tankers en route to Philadelphia and Wil-

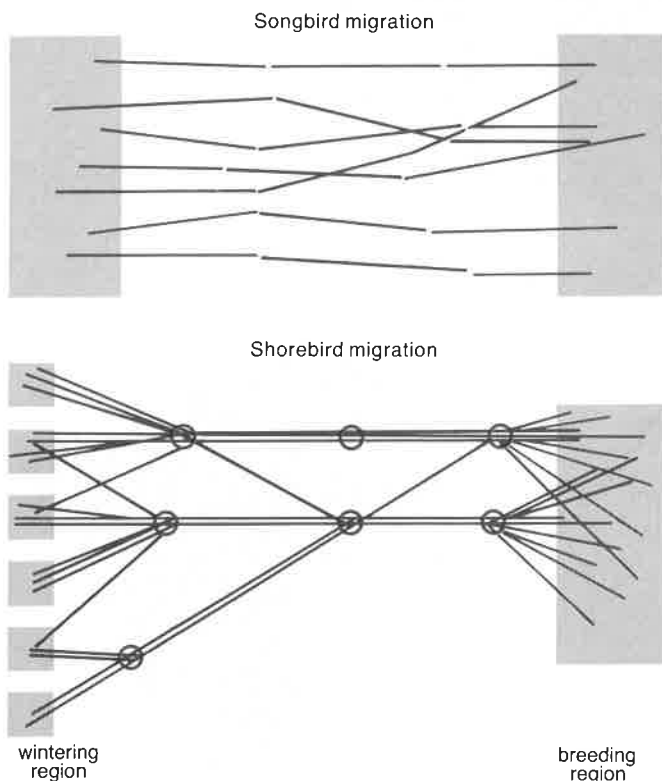


Figure 3. Shorebirds migrate along narrow corridors between the few key staging areas, such as Delaware Bay (Fig. 5), that can support large proportions of given species' populations. Songbirds, in contrast, migrate from wintering to breeding sites across a broad front following many paths.

mington, important petrochemical processing centers. The coast of southern Argentina, the main wintering site for red knots (*Calidris canutus*) and Hudsonian godwits (*Limosa haemastica*), serves as a major oil-tanker route as well.

## A conservation strategy

Although it is understood that these four characteristics of the natural history of shorebirds place them at risk, despite the current abundance of many species, how imminent the actual danger is remains poorly known. Ongoing research sponsored by the International Shorebird Survey and the United States Fish and Wildlife Service suggests that over the last 15 years several species have suffered major declines exceeding 70% cumulatively (Howe and Harrington 1986). These are among the largest declines of common North American bird species reported during the twentieth century.

The large-scale alteration of the environment in one of the major staging sites is likely to have profound and long-lasting effects on entire populations. More commonly, the gradual loss of habitats caused by the cumulative encroachment of agriculture, construction, and recreational activities will have only incremental consequences. Yet ultimately these gradual losses may pass a threshold beyond which damage could be rapid and severe (Morrison 1984). This possibility seems especially plausible in the major migratory staging sites and in a few wintering habitats that have been nearly eliminated; an example is the saline short-grass lowlands of coastal Buenos Aires Province, Argentina, the winter habitat of the buff-breasted sandpiper (*Tryngites subruficollis*). In contrast to long-term, irreversible changes, short-term disruptions such as major spills of toxic chemicals or petrochemicals at major staging sites could induce immediate and catastrophic effects.

Any comprehensive plan for the conservation of shorebirds must take their natural history into account and recognize that isolated efforts at single sites will not suffice. For migratory shorebirds the probability of successfully completing an annual cycle is the combined

product of the probabilities for completing each component of the cycle, and a low probability of success in one component jeopardizes the entire annual cycle. Therefore, the overall effectiveness of efforts to protect populations of migrant shorebirds depends on the level of effort in the region of highest vulnerability, not necessarily in the region where the popular concern is greatest. The result is that even extraordinary efforts in one area can be vitiated by the absence of effort in another.

Yet the same qualities that make migrant shorebirds so vulnerable and that challenge traditional practices for their conservation—particularly the fact that they congregate at a few, traditional sites—facilitate an alternative and feasible strategy for shorebird conservation in the Western Hemisphere. An informal consortium of conservation organizations, both governmental and private, is now collaborating to organize a network of

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reserves spread across the hemisphere. The network is composed of sites linked by the movement of individual birds and identified by research as critical to shorebird migrations. The network forms, in essence, an international reserve defined by the migrants rather than by geography.

The initial impetus for the network came independently from the World Wildlife Fund in the United States and from the Canadian Wildlife Service. In 1984 the World Wildlife Fund-US and the Academy of Natural Sciences forged a link with New Jersey's Division of Fish, Game, and Wildlife that resulted the following year in the states of New Jersey and Delaware jointly declaring the lower estuary of the Delaware Bay to be a reserve

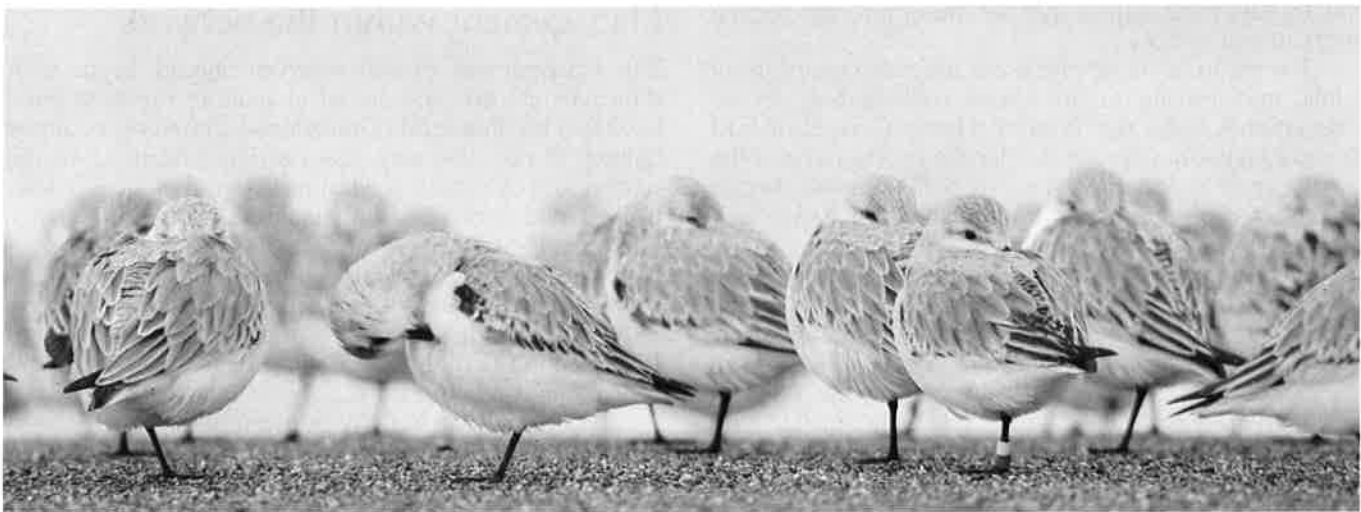


Figure 4. The life history of shorebirds, such as these sanderlings (*Calidris alba*) roosting at their wintering grounds on the California coast, combines low reproductive rates with compensatingly high rates of survival. This combination of traits renders these species vulnerable to unnatural sources of mortality, especially during migration and wintering, when their populations are concentrated.



Figure 5. Delaware Bay, designated a hemispheric reserve in the Western Hemisphere Shorebird Reserve Network, is a staging area for over a million shorebirds migrating between South America and the Arctic. Because of an enormous abundance of horseshoe crabs, on whose eggs the birds feed, the bay is one of the few sites in North America that can accommodate the large populations which concentrate during critical migration stopovers; as much as 60% of the migrating populations of ruddy turnstones and 80% of red knots may congregate at Delaware Bay at one time, making its preservation critical to these species.

for shorebird conservation. In 1985 the International Association of Fish and Wildlife Agencies (IAFWA) pledged to collaborate with the World Wildlife Fund in organizing the membership of the IAFWA—the federal, state, and provincial game agencies of Canada, the United States, and Mexico—to identify and designate lands under their control that are important sites for the international system.

The result of these efforts is a unique consortium of public and private organizations collaborating on an international scale, the Western Hemisphere Shorebird Reserve Network (WHSRN). Under the sponsorship of the IAFWA, an international panel of biologists has begun drafting recommendations for the network's structure, composition, and function.

Over 90 sites have been identified to date, divided between hemispheric and regional sites. Each hemispheric site harbors more than 250,000 birds or at least 30% of the flyway population of a species. These form the central core of shorebird migration in the Western Hemisphere. Regional sites play relatively smaller roles but serve as important habitats to shorebirds within a given geographical region; each has more than 20,000 birds or 5% of the flyway populations. The list is growing rapidly and is being refined as new data are obtained.

To date, 23 state and provincial wildlife agencies, the United States Fish and Wildlife Service, the Canadi-

an Wildlife Service, and the Peruvian national forestry and wildlife agency have committed relevant lands under their administration to the reserve network, as have the United States Nature Conservancy and the National Audubon Society.

## Management within the network

The management of the reserves should begin with directives at each site aimed at making the area more habitable for shorebird populations—aimed especially at halting, if not reversing, the outright shrinking of the habitat and at restoring what has been damaged. Clearly, this goal benefits all inhabitants of protected sites—local or migratory, plant or animal—and the network of reserves thereby contributes generally to efforts to preserve wetlands. Goals aimed more specifically at shorebirds should include the reduction of contamination and the creation of zones free of disturbance near important roosting and feeding sites.

Not all human activity is incompatible with shorebird conservation. An extreme example is that individuals of some species thrive on the rich invertebrate fauna of sludge farms. Other species use agricultural fields during certain stages of crop development, taking invertebrates and even, in a few cases, rice. These examples, however, represent short-term adaptations by individ-

uals and tell little about consequences to entire populations.

To identify human activities compatible with the conservation of shorebirds would require an assessment of the needs of the shorebird populations at each reserve in the network. Particular attention should be paid to different forms of agriculture in marginal grasslands that are used by species such as buff-breasted sandpipers and to irrigation and drainage practices in coastal wetlands; these habitats are most at risk. It may be possible to compensate for the loss of some sites by the creation of new ones.

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More ambitious, coordinated management steps could involve the seasonal control of water levels in nontidal habitats to avoid, for example, either too much or too little water, both of which effectively prevent most shorebirds from foraging. A gradually receding water line provides the range of microhabitats (from 10 cm of water down to damp substrate) used by most species. The gradual shift in the water line also means that new areas become available for foraging, thereby creating, in effect, a renewing resource. Water levels, both in their actual amount and in their direction of change, can be manipulated to favor shorebird foraging, and this could be carried out at each reserve in the network in an annual pattern designed to match the timing of population movements

Timing is critical in the management of each site. Some human activities that are otherwise incompatible with the conservation of migrating birds might prove acceptable if they occurred when the birds were absent and if their effects have dissipated before the birds' return. This would allow compromises with some competing uses, such as with certain types of agriculture.

### The ideal and the feasible

Ideally, each element in the reserve network would be a conservation unit under legal protection from environmental threats. Each would be formally recognized and would be managed under the jurisdiction of an appropriate local government or wildlife agency to conserve shorebirds. However, full-scale implementation of this ideal faces formidable obstacles. For one, formal international coordination at the governmental level is difficult to initiate and more difficult to sustain. Even more telling is that shorebirds compete with humans for critical habitat; the economic and social justifications for developing many sites often seem undeniable.

Efforts that are less comprehensive than the ideal of full-scale implementation based on intergovernmental accords can still be beneficial. The minimum level of implementation would be a network of sites nominated for inclusion on the basis of research, yet without any



Figure 6. The greatest threat to migratory shorebirds is that the key wintering and migration sites in which the birds concentrate and on which they depend are under growing pressure to be developed for use by man. Shown here, for example, is a site in coastal Peru, Mejía Lagoon, which was a critical wintering area before it was drained by pumps to clear a marsh for agricultural development.

legal protection or formal coordination. Even this minimal approach enhances the conservation of migratory species by formally recognizing the concept of a network and by explicitly designating a series of sites for inclusion. Potentially deleterious actions within a particular site could then receive immediate international attention rather than allowing sites to deteriorate under local scrutiny. Thus, even at this level, participating sites would benefit by recognition.

This recognition is pivotal to the system of reserves no matter what its level of implementation. Inclusion within a network gains each local site additional local political stature even if it is without formal legal protection, and inclusion is especially helpful where legal protection exists in letter but not in fact. For existing parks and reserves that lack effective enforcement of conservation regulations, the additional visibility that could come through being recognized as a part of the international network might tip the balance.

A compromise lies between the ideal and the minimal. Many sites known to be important are already under environmental protection in such forms as wildlife refuges, parks, and private holdings by conservation groups. Other sites are under consideration for protection, and still more are potential candidates. The reserve network can encompass a mixture of formal and informal components. Those with full legal protection form the central core. The others will remain on the list as adjuncts, benefiting by association with the network, and perhaps joining in full in the future.

Can conservation challenges faced by other migratory species be met with similar networks? Perhaps, depending on the species' life history, migratory patterns, and the nature of the challenge. Species that, like shorebirds, pass through geographic bottlenecks in their migrations lend themselves readily to a network approach. Several birds of prey, large wading birds, some cetaceans, and large terrestrial mammals fit this pattern. Conversely, setting up networks for species that have diffuse migratory pathways, as do many songbirds, would pose practical problems because of the difficulty in establishing discrete lists of critical sites. In cases such as these, reserves might be established on the basis of a mixture of international biological criteria and local conservation priorities, much as the regional reserves in the WHSRN.

For virtually all migratory animals traversing international boundaries, conservation efforts require international collaboration. Benjamin Franklin's revolutionary admonishment, "We must all hang together, or assuredly we shall all hang separately," bears special relevance in this context.

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