EFFECTS OF RECREATIONAL TRAILS AND RELATED HUMAN ACTIVITIES ON BIRDS: AN ANNOTATED BIBLIOGRAPHY

Rick Sinnott
Division of Wildlife Conservation
Alaska Department of Fish and Game
Anchorage, Alaska

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Introduction

This is a selective bibliography of 74 scientific reports documenting adverse impacts of recreational trails, human recreation, and associated activities on birds. The primary focus is on wetland birds found in southcentral Alaska (or closely related species); however, studies on some forest and grassland species are included.

There have been no studies to document human disturbance of birds along the existing coastal trail. The following abstracts suggest that enhancing access of humans and their pets is likely to have significant adverse effects on bird populations in the Anchorage Coastal Wildlife Refuge.

Almost any human activity has a potential for disrupting birds at some time of the year. Some studies have documented adverse impacts of hunting in autumn; however, the most sensitive seasons for birds are generally spring (when birds are mating, gathering nutrients for egg-laying, and nesting) and summer (when birds are nesting, raising their young, and molting). Ground-nesting birds in general, and wetland nesters in particular, are sensitive to human disturbance. The most disturbing human activities are fast or unpredictable movements and loud or unexpected noises. Pedestrians are often more disturbing than vehicles. Children and dogs are unpredictable, and therefore highly disruptive. Even birdwatching can be a problem at high levels or with sensitive or unusual species. Experience with other trails has shown that human use will not be confined to the coastal trail; people and pets will use the trail to access adjacent wetlands. With hundreds or thousands of people using the trail daily in all seasons, wildlife use of the refuge would be significantly altered.

Bird species that could be affected by additional disturbance from a coastal trail through the refuge include sandhill crane; tundra and trumpeter swans; snow, white-fronted, and Canada geese; common nesting ducks (mallard, northern shoveler, American wigeon, green-winged teal, scaups); shorebirds; terns; and bald eagles and northern harriers. This bibliography is limited to these and closely related species. Some species, e.g. snow goose and tundra swan, are only numerous during spring migration.

There is also indirect evidence that human activity associated with the bike trail would affect birds. Westchester Lagoon has a bike trail along the east, north, and west sides. There are no nesting ducks, geese, gulls, or shorebirds on those shores. However, on the two, tiny islands in the lake there were several goose nests, about 15 scaup and mallard nests, 1 grebe nest, and almost 130 mew gull nests in 1997. The only difference is the islands are more difficult for dogs and people to reach.

The effects of human disturbance have been likened to loss of habitat, although in some cases the impact is reversible. In addition to human disturbance, a paved coastal trail in the marsh would eliminate and alter wetland habitats used by wildlife. With a base approximately 30 feet wide, a paved trail would have much the same effect as building a two-lane highway through the refuge. For each mile of trail in the refuge, approximately 3 acres of marsh would be eliminated by fill material. The fill material would form a dike that would affect freshwater drainage and tidal influx.

Relatively unexplored field...conflict between recreational use and bird conservation...most research has been conducted in last two decades.

Many other studies have documented adverse impacts of recreational use on bird species that are not closely related to those found in southcentral Alaska. Many of these studies are cited in the following references.

LOONS

Jung, R. E. 1991. Effects of human activities and lake characteristics on the behavior and breeding success of common loons. Passenger Pigeon 53:207-218.

Lakes with loons in upper Michigan were more likely to have islands and hummocks and were less likely to have Canada geese. The number of boats on the lake, lake access, boats/time, and lakeshore development (number of homes and campgrounds divided by lake area) were not related to loon presence or status. However, more boats were found on larger lakes, and successful loons on large lakes appeared to locate nests further from areas of human activity than do unsuccessful loons on smaller lakes. Also, the study was initiated when loon chicks were 2 weeks old, i.e., after the point at which adult loons are presumably most sensitive to human disturbance.

SANDHILL CRANES

Dwyer, N. C., and G. W. Tanner. 1992. Nesting success in Florida sandhill cranes. Wilson Bulletin 104:22-31.

Researchers visited crane nests every 2-10 days on foot and spent less than 5 minutes at each nest. Nests were approached noisily to avoid surprising incubating birds, which can crack eggs when they flush quickly. Cranes flushed when approaching human was 3-75 meters [10-250 feet] from nest and remained off the nest for 15 minutes to at least 3 hours. Causes of nest failure included predation, flooding, abandonment, and egg infertility and addling. Nesting cranes seemed to habituate to some forms of human disturbance and were tolerant of occasional helicopter flyovers. Even so, human visits and development-induced alterations of surface water drainage were implicated in 24% of the nest failures. The 3 nests that failed due to abandonment were associated with approach and handling of the eggs. Some additional egg predation, cracking, and addling losses may also be attributable to human visits. Some cranes continued to nest within 500 meters [1,650 feet] of citrus harvesting, cattle ranching, farming, and human residences; with 200-300 meters [660-990 feet] of large trucks on an interstate highway; and within 400 meters [1,320 feet] of a sand mine. Recommendations include: (1) agencies should prohibit construction of impermeable surfaces near wetlands used by nesting cranes to reduce chances of flooding, (2) require the increased use of culverts in roads that pass through wetland areas, and (3) require buffer zones adjacent to nest marshes to minimize human disturbance and increase potential brood rearing habitat.

Norling, B. S., S. H. Anderson, and W. A. Hubert. 1992. Roost sites used by sandhill cranes staging along the Platte River, Nebraska. Great Basin Naturalist 52:253-261.

Flock locations and random points were identified on infrared aerial photos along a 36-km [... mile) study area. Distances were measured from the edge of each flock and individual random point to the nearest human disturbance feature, e.g., paved roads, gravel roads, private roads, urban dwelling, single dwellings, railroads, commercial development, highways, and bridges. In general, the greatest disturbance potentials were attributed to roads (paved and gravel), bridges, and single dwellings where irregular, but considerable human activity might occur. Cranes avoided sites closer than 500 meters [1,650 feet] from the nearest paved road and 400 meters [1,320 feet] from the nearest gravel road, but used sites as close as 301-400 meters

[990-1,320 feet]. Gravel pits, private roads, railroads, and power lines had infrequent disturbances and did not seem to affect roost site selections.

Safina, C. 1993. Population trends, habitat utilization, and outlook for the future of the sandhill crane in North America: a review and synthesis. Bird Populations 1:1-27.

Wetland preservation and enhancement are the most important issues in sandhill crane conservation. Cited many other studies and concluded the intolerance of cranes to disturbance is often commented on, and there are several reports of rapid departure of cranes on the opening day of waterfowl hunting. However, sandhill cranes have generally increased despite some controlled hunting. Thus, sport hunting seems unlikely to pose an imminent problem if well monitored.

SWANS

Hansen, H. A., P. E. K. Shepherd, J. G. King, and W. A. Troyer. 1971. The trumpeter swan in Alaska. Wildlife Monograph 26. The Wildlife Society, Washington, D.C. 83 pp.

Cygnet mortality was significantly higher on the Copper River Delta, compared to 2 other study areas in Alaska that were subjected to less human disturbance. The delta study area was accessible for its entire length by a 20-mile public road, several tidal sloughs facilitated boat travel, and the delta was visited by people engaged in commercial and sport fishing, casual driving, photography, hiking, picnicking, hunting, target shooting and other recreational activities. A forced and rapid movement of cygnets from one body of water to another less secure, induced by human intrusion, appeared to be the greatest factor leading to high mortality rates. Researchers concluded that human disturbance should be kept to a minimum during the brood season.

Henson, P., and T. A. Grant. 1991. The effects of human disturbance on trumpeter swan breeding behavior. Wildlife Society Bulletin 19:248-257.

Six nests were studied in 1988 and 4 nests in 1989 on the Copper River Delta, Alaska. Birds were often alerted by aircraft overflights, but the response was of short duration and caused no detectable changes in incubation constancy or cygnet behavior. Swan behavior was not seriously affected by vehicle traffic on the highway as long as vehicles did not stop. Mean distance from nests to the road was 230 meters [760 feet]. Pedestrians, including researchers, elicited the greatest response from incubating and brood-rearing swans. Incubating females usually left nests at the first sign of human presence, and the males would also stay away, leaving eggs vulnerable to predation. Undisturbed swans always covered eggs with nesting material prior to recessing, whereas disturbed females failed to do so on 26 of 28 occasions. Where wildlife viewing areas are desired, such sites should be located >300 meters [990 feet] from a trumpeter swan nest, and be hidden in vegetation or designed to minimize noise and visibility of users.

U.S. Fish and Wildlife Service. 1987. Migratory nongame birds of management concern in the United States: the 1987 list. Office of Migratory Bird Management, Washington, D.C. 27 pp. + app.

From a list of major threats to listed species, human disturbance was viewed as the second greatest threat, being mentioned in 20% of the references and identified as a problem for 13

species. Species most harmed by human disturbance are the marsh-wading birds, birds of prey, marine shore birds, and species associated with coastal and freshwater wetlands and beaches. Species most often mentioned as suffering from human disturbance were common loons and trumpeter swans.

SNOW GEESE

Belanger, L., and J. Bedard. 1989. Responses of staging greater snow geese to human disturbance. Journal of Wildlife Management 53:713-719.

Arctic-nesting geese may be vulnerable to disturbance during spring. Disturbance could affect their ability to store fat reserves necessary for migration and breeding. Hence, human disturbance may reduce the value of a staging area for geese. When disturbance exceeded 2/hour, it produced a 50% drop in the mean number of geese present in the sanctuary the next day. Low-level aircraft flights over goose sanctuaries should be strictly regulated.

Belanger, L., and J. Bedard. 1990. Energetic cost of man-induced disturbance to staging snow geese. Journal of Wildlife Management 54:36-41.

More than 2 disturbances/hour may cause an energy deficit that no behavioral compensatory mechanism (e.g., night feeding) can counterbalance. A primary goal for managers should be to reduce human disturbance, particularly aircraft overflights. Sanctuary should be large enough (e.g., >200 hectares [500 acres]) so that geese can fly away but promptly return to the foraging site and resume feeding.

Cooch, F. G. 1958. The breeding biology and management of the blue goose (*Chen caerulescens*). Ph.D. thesis, Cornell Univ., Ithaca, NY. 235 pp.

Reaction of nesting snow geese toward humans is variable, but seems density dependent. If researchers approached nests daily from the same direction, geese moved away at no more than 6 meters [20 feet]. If approached from different routes, geese moved away at 46 meters [150 feet].

Davis, R. A., and A. N. Wiseley. 1974. Normal behaviour of snow geese on the Yukon-Alaska North Slope and the effects of aircraft-induced disturbance on this behaviour, September 1973. *In* Gunn, W. W. H., W. J. Richardson, R. E. Schweinsburg, and T. D. Wright, eds. Studies on Snow Geese and Waterfowl in the Northwest Territories, Yukon Territory and Alaska, 1974. Canadian Arctic Gas Study Ltd., Biological Report Series 27.

An average seasonal disturbance rate of 0.5 events/hour was estimated to cause a reduction of 20.4% in the energy reserves of staging snow geese.

Prevett, J. P., and C. D. MacInnes. 1980. Family and other social groups in snow geese. Wildlife Monograph 71. The Wildlife Society, Washington, D.C. 46 pp.

When feeding or loafing snow geese were frightened suddenly, entire flocks took off in near unison without normal preflight coordination of families. Social groups were frequently dispersed in the disorder. Flocks mixed while circling before landing again. Sources of profound disturbances were eagles on the wing, aircraft, and nearby human activity. The

observations were from protected areas; however, geese that flew outside the refuge were subjected to hunting.

OTHER GEESE

Hanson, W. C., and L. L. Eberhardt. 1971. A Columbia River Canada goose population, 1950-1970. Wildlife Monograph 28. The Wildlife Society, Washington, D.C. 61 pp.

On islands open to public use, the greatest damage was from harassment caused by picnics, beach parties, photographing nests, and other human activities.

Mickelson, P. G. 1975. Breeding biology of cackling [Canada] geese and associated species on the Yukon-Kuskokwim Delta, Alaska. Wildlife Monograph 45. The Wildlife Society, Washington, D.C. 35 pp.

Human activity near brood-rearing areas adversely affected broods. Parent geese often deserted their young temporarily, leaving them susceptible to predation by glaucous gulls. Checking nests of geese several times prior to hatching resulted in twice the normal loss of eggs to predators, and boating increased predation on young birds. Human activity must be restricted on waterfowl nesting and brooding areas.

Owen, M. 1972. Movements and feeding ecology of white-fronted geese at the New Grounds, Slimbridge. Journal of Applied Ecology 9:385-398.

Greater white-fronted geese preferred fields isolated from disturbance while overwintering. The profoundest disturbances are directional and usually arise from human activity. Low-flying aircraft and hunters have a marked effect. Noise is not as disturbing as sightings of moving objects.

Owen, M. 1972. Some factors affecting food intake and selection in white-fronted geese. Journal of Animal Ecology 41:79-92.

Greater white-fronted geese are less wary after the hunting season. Wariness of a flock of foraging geese may depend on traditional disturbance and novel disturbances.

Riddington, R., M. Hassall, S. J. Lane, P. A. Turner, and R. Walters. 1996. The impact of disturbance on the behaviour and energy budgets of Brent Geese *Branta b. bernicla*. Bird Study 43:269-279.

Geese were observed from November to March on saltmarsh and grass pastures in England. A disturbance event was defined as 75% or more of the birds in a flock suddenly becoming alert, shortly followed by all or part of the flock taking flight. The most frequent source of disturbance was pedestrians, followed by aircraft, then unknown factors. Pedestrians included mostly walkers, birdwatchers, bait-diggers, or waterfowl hunters. Flight duration in response to aircraft and gunshots was much higher than that in response to other sources; response was lowest to nonhuman sources (birds and mammals, except dogs). On average, a higher percentage of the flock responded to aircraft and vehicles. Observers were usually more than 100 meters [330 feet] from the geese; at this distance they recorded no increase in vigilant behavior. The total sum of goose flight time attributed to disturbance--which accounts for magnitude and frequency of events and the number of geese affected--shows pedestrians, aircraft, and "unknowns" as

high-impact causal factors, followed to a lesser extent by gunshots. Because geese were already feeding at or close to the maximum possible rate during the day, the consequences of such increased energy demand may be critical. The main impact of disturbance is not that it reduces food intake, but that it increases the amount of time spent in flight, which is extremely expensive in terms of energetic cost. They found no evidence that brant habituate to disturbance. On goose refuges, human access should be restricted to clearly defined routes, well away from grazing areas. A single, large refuge may be more effective than 2 separate, smaller sites.

Stock, M. 1993. Studies on the effects of disturbances on staging brent geese: a progress report. Wader Study Group Bull. 68:29-34.

Behavioral responses and distribution of spring-staging brant were studied in a saltmarsh used by thousands of brant and up to 200 people simultaneously. Human-related disturbances were observed more often than natural or unidentified disturbances, with tourist activities ranking first and small airplane overflights second. Intensity of the disturbance was measured by the percent of the flock taking flight and duration of interrupted feeding. Helicopters and small planes caused the most severe reactions, with over 80% of the flock flushing and mean disturbance periods over 100 seconds. Humans flushed an average of about 50% of the geese in a flock and mean disturbance periods were about 80 seconds. Under high disturbance pressure (>30 visitors/265 hectares [approx. 1 visitor per 22 acres), the brant left the area and flew to an adjacent, undisturbed saltmarsh.

Ward, D. H., and R. A. Stehn. 1989. Response of brant and other geese to aircraft disturbance at Izembek Lagoon, Alaska. U.S. Fish and Wildlife Service, Alaska Fish and Wildlife Research Center. Final report to the Minerals Management Service, Anchorage, Alaska. 193 pp.

Brants, Canada geese, and emperor geese were disturbed by human activities. Of all disturbances, bald eagles and boats elicited the greatest responses from brants. Canada geese and emperor geese responded most to bald eagles and persons on foot. Brants and emperor geese were more responsive to aircraft than Canada geese. Noise rather than visual cues triggered responses. Ten daily disturbances reduced body weight by 4% from the expected departure weight.

DUCKS

Balat, F. 1969. Influence of repeated disturbance on the breeding success in the mallard, *Anas platyrhynchos* Linn. Zoologicke Listy 18:247-252.

Researchers regularly visited ninety-eight mallard nests in willows. Anglers also used study area. After first flush, mallards became much more sensitive to approaching humans. Flushed mallards did not return to nests for several days. Sixty percent of the hens abandoned eggs or hatching young. Where incubating hens were not disturbed, few abandoned nests.

Bell, D. V., and L. W. Austin. 1985. The game-fishing season and its effects on overwintering wildfowl. Biological Conservation 33:65-80.

At a large reservoir in Great Britain, anglers and wintering ducks are attracted to limited areas. Green-winged teals, Eurasian wigeons, mallards, and common pochards were driven from usual feeding or roosting sites and departed the reservoir prematurely.

Bergman, R. D. 1973. Use of southern boreal lakes by postbreeding canvasbacks and redheads. Journal of Wildlife Management 37:160-170.

Compared summer and fall use of a lake with negligible human disturbance and one with boaters and anglers. Human disturbance of summer-molting ducks may impair their selection of lakes during the flightless stage.

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.

Studied the short-term effects of construction activities on an expansive mudflat. Developers were committed to using environmentally sound procedures, including limiting construction schedules and procedures to minimize disturbance. Many ducks moved 100-200 meters [330-660 feet] out from the beach when workers arrived. Gull numbers decreased when workers arrived and increased when they left. The gulls that remained usually moved 25-50 meters [80-165 feet] directly offshore. The foraging efficiency of gulls decreased significantly when beach clean-up work commenced, and fewer gulls foraged. Gulls habituated enough to feed as efficiently as prior to the disturbance 60-90 minutes after work initiation. It is extremely critical to limit these human activities to small sections of the beach and limited time periods to allow birds to continue foraging.

Campredon, P. 1981. Wintering of the wigeon in the Camargue region of wintering grounds and their activities. Alauda 49:161-193. [in French, with English abstract]

Eurasian wigeons were disturbed by natural predators, people, and planes. A greater percentage of a flock was disturbed by hunters, anglers, and planes than by other sources. Ducks were very sensitive to anglers who went in the water. Human disturbances seriously curtailed feeding.

Cooke, A. S. 1974. The effects of fishing on waterfowl at Graftham Water. Cambridge Bird Club Report 48:40-46.

Waterfowl rapidly redistributed when the permitted fishing season ended in autumn. Mallard, teal, pochard, and tufted duck had previously been restricted to a portion of the nature reserve where fishing and sailing was prohibited.

Coulter, M. W., and W. R. Miller. 1968. Nesting biology of black ducks and mallards in northern New England. Bulletin 68-2, Vermont Fish and Game Department, Montpelier. 73 pp.

Human activity on islands is detrimental to waterfowl production. The presence of people discourages nesting. Potential for predation of eggs and ducklings increases.

Cronan, J. M., Jr. 1957. Food and feeding habits of the scaups in Connecticut waters. Auk 74:459-468.

Lesser scaups foraged less near human activity, particularly hunting in fall and angling or boating in fall and spring.

Esler, D., and J. B. Grand. 1993. Factors influencing depredation of artificial duck nests. Journal of Wildlife Management 57:244-248.

Frequency of human visits is an important determinant in nest depredation. Nest depredation was not significantly increased by 1-4 visits by researchers throughout the nest period, but was significantly increased by daily visits.

Figley, W. K., and L. W. Vandruff. 1982. The ecology of urban mallards. Wildlife Monograph 81. The Wildlife Society, Washington, D.C. 40 pp.

During January-March, many mallards were wary of humans and often flew up 60 meters [200 feet] in advance of an approaching boat. Increased wariness during winter may be due to an increased number of wild migrant ducks. One of 7 factors contributing to severe brood losses in summer was the capturing and scattering of broods by people. Cats and dogs killed ducklings.

Fog, M. 1982. Reduced human activity and breeding eiders *Somateria mollissima* at Hov Ron, Denmark. Pp. 331-332 *in* D. A. Scott, ed. Managing wetlands and their birds: a manual of wetland and waterfowl management. International Waterfowl Research Bureau, Slimbridge, Glos., England.

Prior to 1955, admittance to a 2-acre island in Denmark was unrestricted, and many people went there to fish and hunt. Since 1957, human visits have been curtailed during the breeding season (March to mid-August). The island remains open to hunters and other visitors outside the breeding season. Eiders began to breed on the island in the late 1950s and increased rapidly. The number of nests exceeded 1,000 in the last 2 years of the study (1980 and 1981). On a similar island nearby, which remained open to the public throughout the breeding season, there were only 2 eider nests in 1967, when 260 nests were found on Hov Ron.

Fox, A. D., D. V. Bell, and G. P. Mudge. 1993. A preliminary study of the effects of disturbance on feeding wigeon grazing on eel-grass Sister. Wader Study Group Bull. 68:67-71.

Wigeon feeding on eelgrass was limited by tides to four periods, each about two hours in duration, in every 24 hours. In situations where foraging opportunity is already highly restricted by natural environmental factors (e.g., tides), additional disruption by human disturbance is likely to have considerable energetic consequences for the birds and could lead to the abandonment of the site. Wigeon populations have shown dramatic declines in situations where human disturbance has been implicated.

Götmark, F. 1992. The effects of investigator disturbance on nesting birds. Current Ornithology 9:63-104.

In 22 of 29 studies of nesting success, investigator disturbance increased intra- and inter-specific predation on eggs and young. The primary predators were gulls and corvids. The activities of field researchers are comparable to those of wildlife watchers and photographers in that each group approaches wildlife closely, repeatedly, and sometimes for extended periods.

Heitmeyer, M. E. 1985. Wintering strategies of female mallards related to dynamics of lowland hardwood wetlands in the Upper Mississippi Delta. Ph.D. thesis, Univ. Missouri, Columbia. 376 pp.

Wintering mallards changed their habitat use, daily time budgets, and food habits in response to human-related disturbance, mainly hunting, but also vehicular and foot traffic. Refuge areas were especially important during hunting seasons, as evidenced by concentrations of mallards on certain areas. Effects of disturbance by hunters are not entirely known. Disturbance seems most detrimental to mallards in late winter and spring.

Heusmann, H. W., and R. G. Burrell. 1974. Park mallards. Pp. 77-86 *in* A symposium on wildlife in an urbanizing environment. 27-29 November 1973, Springfield, Mass. Mass. Cooperative Extension Service, Amherst.

Most destruction of nests and broods in urban areas may be from human disturbance.

Hirons, G., and G. Thomas. 1993. Disturbance on estuaries: RSPB nature reserve experience. Wader Study Group Bull. 68:72-78.

Cited unpublished reports by Gomes (1981, 1982) that hunting redistributed wildfowl, particularly mallards and teal, but that there was little or no effect on distribution of protected ducks, shorebirds, or gulls. Other research confirmed that the creation of sanctuaries resulted in increases of greylag geese, wigeon, and mallards. Anecdotal observations suggested boating, angling, water-skiing, wind-surfing, shellfish collecting, bait-digging, dog-walking, jet-skiing, ultralights, canoeing, and birdwatching may also disturb birds substantially on the nature reserves. [Hunting was conducted in winter months, which may have affected bird responses.]

Jahn, L. R., and R. A. Hunt. 1964. Duck and coot ecology and management in Wisconsin. Wisconsin Conservation Department Technical Bulletin 33, Madison. 164 pp.

Activities of shore residents, anglers, and boaters seem to discourage breeding waterfowl from using otherwise adequate habitat.

Keller, V. E. 1991. Effects of human disturbance on eider ducklings Somateria mollissima in an estuarine habitat in Scotland. Biological Conservation 58:213-228.

Effects of on-shore anglers, walkers, dogs, cars, windsurfers, and rowboats on ducklings were measured in a small estuary with extensive mudflat habitat. Most disturbances were caused by shore-based activities. At low tide, 70% of disturbances were caused by dogs with or without people, while people without dogs accounted for 9%. At low and high tides, people and dogs caused more disturbances than expected from their frequencies of occurrence. Boats were responsible for fewer disturbances than expected, while windsurfers were responsible for more than expected only when they could approach broods at high tide. Broods were disturbed by dogs for significantly longer periods than by walkers or anglers and at about twice the distance. Human disturbance lasted 20-35 minutes, depending on tide level. Frequent disturbance, resulting in a reduction in the time spent feeding, could reduce energy intake. Disturbance during roosting increases energy expenditure. Predation of ducklings by gulls was 4 times higher after human disturbance than before the disturbance.

Klein, M. L. 1993. Waterbird behavioral responses to human disturbances. Wildlife Society Bulletin 21:31-39.

This study included experimental disturbances of 31 species and observations of refuge visitors. As intensity of disturbance increased, avoidance response by the birds tended to increase. Photographers were more likely to approach birds than any other group types except fitness. Even slow approach by photographers disrupted waterbirds. Photographers disturbed waterbirds (18%) more often than wildlife viewers (9%) and anglers (0%). One of five observed fitness visitors (20%) disturbed wildlife; however, the sample size was too small to allow an inference to be drawn. Out-of-vehicle activity was more disruptive than vehicular traffic. Groups that spoke with refuge staff were less likely to disturb wildlife than any other groups, except anglers.

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

Researchers assessed effects of wildlife viewers on the distribution of 38 waterbird species in a wildlife refuge in Florida. Waterbird distribution was measured from 2 dikes along which wildlife tours occurred. On one dike, visitors were primarily in slow-moving vehicles (most parties got out of their cars at least once [96% of visitor groups] or more than once [82%]) and on the other, less-frequently used dike visitors were on foot. Migrant ducks were the most sensitive group, especially when they first arrived, usually remaining more than 80 meters [264 feet] from the drive, even at low levels of human visitation. Northern pintails and blue-winged teal continued to avoid humans throughout the winter, whereas the sensitivity of other ducks to humans decreased during the winter. Nevertheless, more than 80% of American wigeons and more than 50% of northern shovelers remained more than 60 meters [200 feet] from the road. Distribution of green-winged teal, greater yellowlegs, lesser yellowlegs, red knots, and short-billed dowitchers was also skewed away from the road. The approach of humans on foot seemed to be the most disruptive action of visitors. If waterbirds currently using the refuge rely on off-refuge habitat when they are flushed by visitors, the future value of the refuge to waterbirds will diminish when off-refuge habitats are converted to human uses. When public viewing exceeds the tolerance of the animals for which the refuge was established, human activity must be reduced.

Lin, Jen-chu. 1995. Reactions of summering waterfowl to three types of human disturbance at Lee Metcalf National Wildlife Refuge. M. S. thesis. University of Montana. 38 pp.

Mallards and blue-wing teal are more sensitive to disturbance by walking or bicycling than from automobiles. Among these activities, the mean distance that ducks responded to human disturbance and the proportion of ducks that responded to the disturbance was: walking (44 meters [145 feet], 57% responded); bicycling (38 meters [125 feet], 44% responded); and driving (36 meters [119 feet], 17% responded). An important observation not captured in these data is that ducks that did not attempt to escape before the researcher reached the nearest point on the shoreline (thus were recorded as "no escape response") flushed when the researcher stopped walking, bicycling, or driving.

Madsen, J. 1993. Experimental wildlife reserves in Denmark: a summary of results. Wader Study Group Bull. 68:23-28.

Human activities observed included pedestrians, swimmers, intense fishing using traps and nets, sailing in deep water, windsurfing, and hunting from punts and shore. The most numerous species were mute and whooper swans, Canada and greylag geese, wigeon and mallards. Results were mixed. When dinghies, shooting punts, or windsurfers approached a flock, the birds abandoned feeding and moved to an undisturbed area where they rested before resuming feeding. Mobile shooting punts caused the longest feeding disruptions. However, shooting from a stationary punt was less disturbing than being approached by a fishing dinghy, and wigeon flushed at 400-600 meters [1,320-2,000 feet] from windsurfers compared to 20-200 meters [66-660 feet] from mobile shooting punts. Shooting from mobile punts was much more disturbing to wigeon than from stationary punts. Pedestrians in marshes and on beaches were an important disturbance factor in August, before the hunting season. Experimental hunting closures in portions of the area resulted in increases in 11 of 16 species under observation, although most of the Canada geese and mallards remained outside the experimental sanctuaries, but in areas undisturbed by the motorized and mobile punts. Researchers concluded that these species tolerated shooting from stationary punts, and that their numbers were kept down due to the combined effect of shooting from motorized and mobile punts.

Madsen, J. 1994. Impacts of disturbance on migratory waterfowl. Ibis 137:S67-S74.

Researchers manipulated areas closed to waterfowl hunting in two coastal wetland staging areas in Denmark. Study areas were shallow fiords with adjoining salt marsh and reed swamp. Swans, geese and dabbling ducks (primarily European wigeon, green-winged teal, mallard, northern pintail, and northern shoveler) are the dominant waterfowl. During autumn, the areas are used mainly for waterfowl hunting and fishing, and more extensively for walking, sailing, and windsurfing. Waterfowl hunters use punts and motorized boats. Baseline studies indicated that waterfowl hunting was the only critically disturbing activity during autumn. However, researchers did not explain why waterfowl appeared to avoid offshore waters within 500 meters [1,650 feet] of shorelines even when hunting was prohibited (presumably because of other human activities). When portions of the fiords were closed to hunting, the number of hunted ducks and geese in the closed areas increased 4 to 20-fold and the number of protected birds (swans, some geese, and shorebirds) increased 2 to 5-fold. Hunted species of waterfowl prolonged their stays by up to several months compared with the baseline periods, and this was the reason for increased numbers, rather than larger populations. The increase in numbers of the protected species, e.g. swans, can be explained by an increase in population size due to a series of mild winters. It is still too early to judge whether food resources can support more birds; however, in both areas heavy grazing on submerged vegetation has been observed and in one area eelgrass is now almost fully depleted in the refuge area by early winter.

Matthews, G. V. T. 1982. The control of recreational disturbance. Pp. 325-330 *in* Managing wetlands and their birds: a manual of wetland and waterfowl management. International Waterfowl Research Bureau, Slimbridge, Glos., England.

Activities that cause disturbance to waterfowl, in order of decreasing disturbance, include: (1) those involving rapid movement and loud noise (power boating), (2) those involving movement but little noise (sailing, wind surfing, rowing, canoeing), (3) those involving little movement or noise (swimming), and (4) those carried out largely from the banks (fishing, birdwatching). Boats must be kept at least 300 meters [990 feet] from a waterfowl area. The disturbance effect of hunting can be serious if shooting is widespread and continuous.

Morgan, N. C. 1972. Problems of the conservation of freshwater ecosystems. Pp. 135-154 *in* R. W. Edwards and D. J. Garrod, eds. Conservation and productivity of natural waters. Symposia of the Zoological Society of London 29.

Water-based recreation--such as fishing, birdwatching, swimming, canoeing, and picnicking--is incompatible with nesting waterfowl. In a control area with 84 duck nests which were not disturbed, 17% were lost to predation. In an area with 781 nests which were disturbed by 1-2 visits per week, 41% were lost to predation. Wildlife reserves should prohibit boats, fishing from banks, and picnicking.

Owen, M. 1993. The UK shooting disturbance project. Wader Study Group Bull. 68:35-46.

Raises questions about the impact of hunting on game and nongame birds. Counting droppings in shooting and non-shooting areas of a marsh found no apparent effect of hunting on intensity of use by wigeon. Hunting on this marsh was "very well controlled"; i.e., there was no night shooting and most of the wigeons' feeding occurs at night. [This paper highlights the difficulty of comparing effects of hunting between North America and other continents. Much of the waterfowl hunting in Europe occurs in winter, a critical period for waterfowl and shorebird populations, whereas North American waterfowl hunting is in fall. Europeans in some areas hunt from motorized boats or use punt guns; both practices are illegal in North America.]

Reichholf, J. 1970. The influence of disturbance by anglers on duck reproduction in backwaters of the Lower River Inn. Die Vogelwelt 91:68-72.

An 85% decrease in breeding ducks in 8 years was attributed to disturbance from an increasing number of anglers at two 2.5-acre ponds in Germany. Numbers of northern shovelers, green-winged teals, mallards, common pochards, and tufted ducks decreased from 26 pairs with 134 ducklings in 1961 to 4 pairs with 19 ducklings in 1969.

Townshend, D. J., and D. A. O'Connor. 1993. Some effects of disturbance to waterfowl from bait-digging and wildfowling at Lindisfarne National Nature Reserve, north-east England. Wader Study Group Bull. 68:47-52.

The most disturbing recreational activity in this nature reserve is punt-gunning. Mounted on boats, punt guns are up to 3 meters [10 feet] long, with a maximum bore of 45 mm [1.8 inches]. They discharge over 2,500 pellets of the most favored shot size. On firing, not all the birds hit are killed outright, so the hunters leap into the water to recover injured birds, which can take 30-40 minutes. The authors believed the recovery efforts after the shot caused as much as or occasionally more disturbance than the shot itself. Normal shotguns are also used by hunters, although it appears that much of this hunting occurs at night. Numbers of wigeons, bar-tailed godwits, and redshanks are substantially lower when bait-diggers are scattered over large parts of the bay during low tide. In years when bait-digging was prohibited, numbers of wigeons, teal, mallards, and eiders increased substantially. The combination of punt-gunning and bait-digging appears to have a cumulative or synergistic effect in reducing the number of wigeon. The authors believed wigeon are able to tolerate high levels of continuous disturbance from punt-gunning in late autumn and early winter provided that there are adequate undisturbed refuge areas available. [This is comparable to the refuge provided for Canada geese and dabbling ducks in Anchorage-area lakes and Potter Marsh when hunting is allowed in the remainder of the Anchorage Coastal Wildlife Refuge.]

Zehnter, H.-C., and M. Abs. 1994. Cyclists and pedestrians trigger diurnal activity-rhythm of wintering tufted ducks (*Aythya fuligula*). J. Orn. 135:81-93.

Wintering tufted ducks changed activity patterns and distribution in relation to cyclists and pedestrians on the shore of a 20-acre pond in Germany. Ducks moved to the far side of the pond and shifted from diving and swimming to resting and preening as human activity increased. Researchers believed resting permitted more vigilance than feeding.

SHOREBIRDS AND GULLS

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

Waterbirds were censused during a one-year period (1977-78) in a coastal wildlife refuge adjacent to New York City. The refuge included coastal waters, freshwater ponds, salt marshes, extensive mudflats, and miles of shoreline. Migratory and wintering waterbirds included gulls (primarily herring gulls and common terns), waterfowl (primarily brant, Canada geese, mallards, wigeon, and greater scaup), and shorebirds (primarily long-billed and short-billed dowitchers, dunlin, black-bellied plover, and small sandpipers). Human use of the refuge, in descending frequency, included walking, worm-digging, horseback riding, and jogging. Walkers and joggers always disturbed nearby birds; however, birds did not fly from people digging worms or riding horses at a distance greater than 15 meters [50 feet]. Rapid movement elicits a response in that joggers flushed birds even though the joggers remained on a path. The slow-moving pace of birdwatchers or other naturalists was less threatening. Human presence may be affecting birds even when some birds are present and seemingly undisturbed; birds were less often found when people were present, suggesting that the more sensitive species or individuals had already been displaced. Among the migratory and wintering birds, gulls and terns were least disturbed, ducks responded by relocating to a nearby pond or bay, and shorebirds flushed and flew to distant marsh areas. When shorebirds are using a particular area, human activity should be restricted to a distance from their loafing areas. Some activities, such as jogging, always caused birds to flush, suggesting that these activities must be eliminated if the primary management objective is to provide suitable roosting locations for migratory shorebirds.

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

Shorebirds were censused along two beaches in New Jersey from April-October 1982. Eight of the 27 species present accounted for 95% of the shorebirds: semipalmated sandpiper, ruddy turnstone, sanderling, long-billed dowitcher, short-billed dowitcher, red knot, dunlin, and greater yellowlegs. People used the beaches for walking, jogging, clamming, walking dogs, and fishing. Most study sites had only 5-275 disturbances during the whole study. The average disturbance duration was about 7 minutes, and at the most disturbed site shorebirds were exposed to human activity for an average of about 19 minutes (or 31%) of every hour. People walking accounted for most of the disturbances, although jogging, fishing, and clam-digging were also important. People can walk slowly past, while joggers, dogs, and children usually move rapidly. Whereas joggers usually run in a straight line, children and dogs commonly run up and down the beach in a zigzag fashion. Anglers are present for long periods of time and remain relatively still. At a minimum, only 30% of the shorebirds remained undisturbed on a beach when there is human activity. When the number of disturbances increased, more birds flew and fewer remained. Qualitatively, shorebirds were affected most by children and joggers, and least by anglers,

sunbathers, and some people walking. Dogs were a problem in areas with the highest concentrations of shorebirds. Overall, shorebirds remained on the beaches when disturbed in April, September, and October, but flew away from May through August. Thus, they are most disturbed during the peak spring (May) and autumn (August) migrations.

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.

Refer to Duck citations.

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

Foraging behavior and habitat use was compared in three areas with different management schemes. Plovers devoted more time to feeding when there were fewer people within 100 meters [330 feet]. Thus, in an area closed to the public during the nesting season, the plovers devoted similar amounts of time feeding on the beach, dunes, and backbay. In an area where people primarily use the backbay and were forbidden to go in the dunes and beach by the presence of fences, signs, and park personnel, the plovers foraged primarily in the dunes and the ocean. In an area where the backbay is used extensively by fishermen during the day and night, the dunes are used by picnickers, and only the beach is fenced and posted, the plovers spent the most time foraging in the ocean and, secondarily, in the backbay.

Burger, J. 1995. Beach recreation and nesting birds. Pp. 281-295 in R. L. Knight and K. J. Gutzwiller, eds. Wildlife and recreationists: coexistence through management and research. Island Press, Washington, D.C.

Ongoing research during the nesting season on New Jersey beaches and coastal marshes indicates that foraging piping plovers devote more time to vigilance as numbers of people increase within 100 meters [330 feet].

Burger, J. 1998. Effects of motorboats and personal watercraft on flight behavior over a colony of common terns. Condor 100:528-534.

There has been a great increase in the number of use of personal watercraft, such as jet skis and wave runners. Tern colonies that had the lowest reproductive success were those that were exposed to personal watercraft, that PWCs sometimes ran up on the edge of nesting islands and over nests, and that in most colonies the entire breeding population flushed when a PWC came near the island. Terns responded significantly more to PWCs than to motor boats. Other factors that affected flight behavior (and subsequent reproductive success) were distance from the colony, whether the boat was in an established channel, and the speed of the craft. PWCs should not be allowed closer than 100 meters [330 feet] from nesting islands, speeds should be restricted, and regulations must be strictly enforced thoughout the nesting season.

Burger, J., and A. Galli. 1987. Factors affecting distribution of gulls (*Larus* spp.) on two New Jersey coastal bays. Environmental Conservation 14:59-65.

Unlike shorebirds in the same study (see Burger 1986), gulls showed some habituation to the presence of people. Nonetheless, in May and June only 30-40% of the gulls remained on the beach, foraging when people were present. Thus, most gulls were disturbed from their foraging

by people. In June the gulls are breeding in nearby salt marshes and have restricted time for feeding as they spend half of their time incubating eggs.

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

Sanderlings wintering on beaches in Florida were studied for three years. The greatest variation in the time devoted to feeding included the number of people within 100 meters [330 feet] of foraging birds. Although the number of people within 10 meters [33 feet] of foraging sanderlings did not increase from 1986 to 1990, the number of people within 100 meters rose dramatically, and foraging time per minute decreased.

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.

Migrant shorebirds and gulls were censused on beach, salt marsh, and mudflat habitats from 2-6 times each month from 1984-1989. During much of the study, birdwatchers were the only people who frequented the beach. During each year, shorebirds and gulls were noted closer to the path when there were no birdwatchers than when there were. The mean distance of shorebirds from the path each year ranged from 71-136 meters [234-449 feet] with birdwatchers and 19-45 meters [63-149 feet] without birdwatchers. The mean distance of gulls from the path each year ranged from 63-124 meters [208-409 feet] with birdwatchers and 24-42 meters [79-139 feet] without birdwatchers. Shorebirds and gulls are influenced by people even when they seem not to be, and when to the birdwatcher the birds appear to be behaving normally. Many birdwatchers habitually approach birds as closely as possible, until they exceed the birds' approach distance and the birds move away. Birdwatchers can impact birds at all times of the year. Interactions can interrupt incubation; scare parents and chicks from nests; disturb foraging birds; separate parents and young while foraging; force foraging birds to abandon suitable and optimal sites; disturb the prey base for hawks; and encourage breeding, roosting or foraging birds to avoid beaches, forests, or open fields which they traditionally used. The researchers suggested that it is important to keep some mudflat areas in wildlife refuges free from birdwatchers.

Clark, K., and L. Niles. 1986. Use of three Delaware Bay beaches by migrant shorebirds. Report to New Jersey Department of Environmental Protection (Endangered and Non-game Species Program), Trenton, New Jersey. 41 pp.

Shorebird use was significantly affected by the presence of people in 1985. Bird numbers were almost double on surveys when people were not present compared with when they were present.

Davidson, N. C., and P. I. Rothwell. 1993. Human disturbance to waterfowl on estuaries: conservation and coastal management implications of current knowledge. Wader Study Group Bull. 68:97-105.

A summary of research on the effects of human disturbance on waterfowl and shorebirds during winter and spring and fall migration. Of the 3 seasons, birds are particularly vulnerable to disturbance during winter and spring migration because of the difficulty in finding enough food to meet high energy demands. The summer molt is also a stressful period, although food supplies are typically abundant then. Some species (e.g., brant, bar-tailed godwit, redshank, and curlew)

are more "nervous" than others (e.g., oystercatcher, turnstone, and dunlin). Several studies have found that the most widespread and long-lasting disturbance often comes from aircraft, and that the slower the aircraft the worse the disturbance. On tidal flats, moving people and animals (especially dogs) generally create worse disturbance than sedentary people. On many British estuaries many different types of recreational activity take place, so the potential for synergistic effects and impacts is considerable. Activities that occur throughout the year can carry a high risk of causing disturbance; however, waterbirds are generally most vulnerable in the season when most recreational activities take place and intensity of use is greatest.

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

Observations of a 1-kilometer [0.6-mile] stretch of sandy beach strewn with boulders. Human activity was categorized as "sitting" (people and dogs stationary), "walking" (slow movement), and "fast" (running, jogging, bicycling). The mean number of people present was usually over five; however, most stayed above the high-tide line. Observers estimated an average of three or four disturbances per hour. Oystercatchers, curlews, and redshanks arrived significantly later than expected (relative to low water) and oystercatchers and redshanks departed significantly sooner when there were people on the beach. Disturbance level was measured by time spent scanning (i.e., not eating). For all three species, scan rate was greatest in the upper shore (nearest people) and least in the low shore, and increased with faster human activities. Presence and location (upper vs. lower beach) of dogs had no effect on the scan rate. Despite increased vigilance, the rate at which all three species appeared to probe for food was hardly affected by location or type of disturbance. Disturbance reduced potential feeding time by influencing arrival and departure times and during individual encounters. Most disturbed birds which remained on the beach resumed feeding within 1-2 minutes. However, on days when many people were on the low shore zone, continuous disturbances of 20-25 minutes were recorded. Despite no noticeable change in vigilance when dogs were present, dogs did affect the birds by chasing them. A reduction of feeding time by only 3 minutes per hour would represent 5% of the total low-tide time available on this beach; however, it is possible that short-term effects of disturbance could be compensated for by reducing time spent resting or preening.

Gillett, W. H., J. F. Hayward Jr., and J. F. Stout. 1975. Effects of human activity of egg and chick mortality in a glaucous-winged gull colony. Condor 77:492-495.

Mortality was greater in plots disturbed two or three times each day than in undisturbed control plots.

Godfrey, P. J., J. M. B. Brodhead, J. DiMaio, J. M. Gilligan, D. Reynolds, B. G. Blodget, and N. R. Wheeler. 1975. The ecological effects of off-road vehicles in Cape Cod National Seashore, Massachusetts (Phase II). Univ. Mass., Amherst, National Park Service Cooperative Research Unit Report 18. 133 pp.

Experimental results and observations from several studies of off-road vehicle impacts, including effects on least terns and other shorebirds. Nesting terns tolerated a passing vehicle much more readily than pedestrians. People on foot pose a greater threat to nesting terns than people in vehicles.

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

Human activities in this estuary included dog-walking, casual and commercial shell-fishing, birdwatching, and walking. Walkers were more attracted to sandflats than mudflats or mussel beds. Bait-digging and dog-walking are common there throughout the year, and in summer boaters and wind-surfers visit sandy islands. People generally avoid the mudflats used by the majority of shorebirds and, by mid-winter when birds are most hard-pressed for food, few people visit the estuary. Oystercatchers and smaller numbers of other shorebirds feeding on mussel beds are sensitive to human disturbance. As the number of people increases, most birds spend less time feeding and do so at a lower rate. Presence of three people (there are seldom more) reduces the average proportion of birds feeding from approximately 85% to 65%; that is, the average bird feeds for 20-25% less of the time. Severe disturbance occurs if several casual shell-fishers along with dog-walkers or birdwatchers roam over the mussel beds at the same time, and the birds tend to leave the area. Two of the smallest mussel beds are seldom used by birds in daylight because people occur there almost continuously. If present in sufficient numbers, people can prevent birds using otherwise suitable feeding habitat. However, the researchers concluded there is no evidence that current levels of human disturbance significantly affect the feeding, and thus numbers, of overwintering shorebirds in this estuary.

Hunt, G. L. 1972. Influence of food distribution and human disturbance on the reproductive success of herring gulls. Ecology 53:1051-1061.

When nesting herring gulls were disturbed regularly by picnickers on an island off the coast of Maine, their hatching success was only 22%, compared to 49% in undisturbed colonies. The cause of death was attributed to predation and hypothermia.

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 Bull. 68:53-58.

An estuarine beach in Wales is a traditionally important roost for several shorebird species also found in Anchorage, including black-bellied plover, red knot, sanderling, dunlin, and bar-tailed godwit. Increasing disturbance attributed to walkers, dogs, and horseriders resulted in dramatic declines in roosting shorebirds (up to 99% of bar-tailed godwits). Recently, a minimum of 3, and up to 5, voluntary "wardens" have attempted to intercept and talk to people who were about to disturb the birds. At extreme high tides, when the shorebirds are most concentrated, the wardens ask walkers to use pathways out of sight of roosting birds. Wardens have found dogs (27-72% of total disturbances per year) and walkers (20-34% of total disturbances per year) caused the majority of the disturbances in all 5 years of the study. Birdwatchers, windsurfers, and cyclists also disturbed shorebirds, and the incidence of the latter two disturbance types was increasing, despite the efforts of the wardens. Reactions varied according to species; black-bellied plovers, red knots, dunlins, and bar-tailed godwits were most likely to leave the estuary altogether after a disturbance.

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

Refer to Duck citations.

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.

Long-term census data showed human disturbance has a negative impact on shorebirds because they are displaced from or abandon preferred resting areas. Study areas were sandy beaches surrounded by tide flats in Plymouth Bay, Massachusetts. Shorebird species affected included red knot, short-billed dowitcher, sanderling, and semi-palmated sandpiper. Off-road vehicles were counted on the beaches as an index of disturbance, although researchers noted the most serious disturbance was probably caused by pedestrians and unleashed dogs. The negative relationship between abundance of short-billed dowitcher and sanderling and disturbance occurs at disturbance levels of less than 50 vehicles--at most 10 vehicles per linear kilometer [16 vehicles/mile] of beach.

Pienkowski, M. W. 1993. The impact of tourism on coastal breeding waders in western and southern Europe: an overview. Wader Study Group Bull. 68:92-96.

Provided examples of recreational activities that have reduced breeding range, density, and productivity of shorebirds. Most of the remaining breeding population of ringed plovers in southern and eastern England are now restricted to areas such as nature reserves that are protected from human disturbance. Presence of tourists has reduced nesting densities of oystercatchers, Kentish plovers, curlews, and redshanks in northern areas of The Netherlands. The only simple correlates of nesting success by ringed plovers at a nature reserve in northeast England were distance from public access and frequency of visits by tourists. Tourists affect breeding shorebirds by erosion and trampling of beach and saltmarsh habitats; disturbing feeding, incubating, and brood-rearing birds; egg-collecting and trampling of eggs and young; introducing dogs into breeding areas; attracting predators with picnic waste or deliberate feeding; and increasing predation by forcing incubating birds off nests or scattering broods. Possible protective measures include prohibiting vehicles and dogs in breeding areas, excluding the public from small areas of colonial breeding and large areas of dispersed breeding, and redirecting public access to less sensitive areas.

Purdy, K. G., G. R. Goff, D. J. Decker, G. A. Pomerantz, and N. A. Connelly. 1987. A guide to managing human activity on National Wildlife Refuges. Human Dimensions Research Unit, Department of Natural Resources, Cornell Univ., Ithaca, New York; U.S. Fish and Wildlife Service, Fort Collins, Colo. 57 pp.

Managers of 16 refuges reported various disturbances of 20 wildlife species, including shorebirds and waterfowl. Exploring on foot was involved in 48% of 148 observed human disturbances, and shorebirds were the most easily disturbed group. In half of the refuges, reduced use of refuges resulted from hiking, bicycling, jogging, sunbathing, and swimming. Reduced use of preferred habitats resulted from exploring on foot in 18% and from hunting in 17% of the refuges surveyed.

Robert, H. C., and C. J. Ralph. 1975. Effects of human disturbance on the breeding success of gulls. Condor 77:495-499.

Intensity of human disturbance had a proportional effect on the mortality of eggs and small chicks of the western gull. Weekly disturbance only caused 8% loss, compared to 18-28% losses when the gulls were disturbed three times a day.

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 25:139-145.

Sixteen species of waterbirds were exposed to 4 types of disturbance (walking, all-terrain vehicle, automobile, boat) to determine flushing distances of foraging or loafing birds. Study sites were chosen randomly, but included many areas (primarily coastal and lake shorelines) that had moderate to high human activity (compared with Alaskan wetlands). Most species were not related to Anchorage birds; however, semipalmated plover and western sandpiper were observed. Both intraspecific and interspecific variation were observed in flushing-response distances to the same type of disturbance; other literature suggested a regional difference in a species response as well. Researchers recommended a buffer of 100 meters [330 feet] to minimize disturbance of most species of foraging and loafing waterbirds they studied.

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

Sunbathers and other relatively sedentary tourists displaced nesting plovers from preferred breeding habitats in sparsely vegetated sand dunes. Most successful nests were found in remote areas away from the main human activities and walking routes. People walking along a nearby beach were less intrusive, presumably because most followed the high-tide line, avoiding breeding areas. Increasing numbers of visitors resulted in more unsuccessful nests. Clutch losses were lowest (10%) in areas with little disturbance, but increased steadily up to 36% in heavily disturbed areas.

Scott, F. E. 1989. Human disturbance of wading birds on the Ythan estuary. Unpubl. B.Sc. thesis, Department of Zoology, Univ. Aberdeen. 42 pp. [abstract in Wader Study Group Bull. 68:81-82]

Dog-walkers were the most frequent cause of disturbance. Over half the walkers were accompanied by dogs. Most fishing took place during low tide, as did most bait-digging, but walkers visited at all tide stages. Several species kept a considerable distance from anglers: 35-50 meters [115-165 feet] for oystercatchers, redshanks, and curlews, compared with 20-25 meters [66-83 feet] from bait-diggers. This may be related to the greater activity of anglers in casting lines. Numbers of oystercatcher and redshanks declined sharply during disturbance from walking or bait-digging, with numbers not returning to previous levels for 20-25 minutes. Firing a single shot from a gun seemed to have little effect on either species, as numbers of birds present 5 minutes after the shot were similar to those beforehand.

Smit, C. J., 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 Bull. 68:6-19.

A summary of Dutch research from reports not normally accessible to English-speaking scientists. Shorebirds are particularly disturbed by small aircraft and pedestrians; cattle, cars, dogs, or people with predictable movement patterns (e.g., farmers) are less disturbing. Flight distance is influenced by human behavior. One person generally disturbs less than a group, running dogs are very disturbing, bait-diggers are tolerated at shorter distances than walkers. Some shorebird species are more sensitive to disturbance than others. The presence of just one person on a tidal flat can create a large area in which birds stop feeding or fly off, ranging from about 5 hectares [12 acres] for gulls and 13 hectares [32 acres] for dunlins up to 50 hectares [124 acres] for curlews. When roosts are approached by walking people, golden plovers are fairly tolerant (mean flushing distance >40 meters [130 feet]), but curlews and redshanks (related to yellowlegs) tend to take flight at >90 meters [300 feet]. Walking people

with 250 meters [825 feet] flushed 57% of roosting oystercatcher flocks and 76% of roosting curlew flocks. Hunting increases flight distances. Brant take flight at 210 meters [700 feet] in September, before the hunting season, but the mean flight distance increased to 370 meters [1,220 feet] by the end of October, after hunting began. Curlews show extreme wariness in Denmark, with mean flight distances of 500 meters [1,650 feet], probably because they are hunted. Some birds change their behavior at distances which are on average 30% greater than those at which they take flight. Brant that flushed at a mean distance of 105 meters [350 feet] exhibited alert or alarm behavior at a mean distance of 205 meters [680 feet]. Small planes can be more disturbing than jets and even helicopters, and ultralights are also very disturbing. Although many species or individual birds can habituate to predictable disturbances, some species do not. Recreational activities can have cumulative or synergistic effects that lead to disturbance levels far exceeding the effects of each activity alone.

Yalden, D. W. 1992. The influence of recreational disturbance on common sandpipers *Actitis hypoleucos* breeding by an upland reservoir in England. Biological Conservation 61:41-49.

Common sandpipers disturbed by anglers and other visitors take flight about 29% more often than undisturbed sandpipers. Mean flight distance from an approaching human is 27 meters [90 feet], but they react with alarm at 75 meters [250 feet] when guarding chicks. The sandpipers avoided using the preferred beaches due to human disturbance, reducing the size of the breeding population. Breeding success of the remaining birds was unaffected.

Yalden, D. W., and P. E. Yalden. 1989. The sensitivity of breeding golden plovers *Pluvialis apricaria* to human intruders. Bird Study 36:49-55.

Golden plovers give alarm calls when humans approach within about 187 meters [617 feet]. Their sensitivity at such distances suggests that there may be an extensive zone around well-used footpaths which they would be reluctant to occupy for breeding. Researchers recommended avoiding paths spaced more closely than 400 meters [1,320 feet] and avoiding siting major paths along narrow strips of otherwise suitable habitat.

Yalden, P. E., and D. W. Yalden. 1990. Recreational disturbance of breeding golden plovers *Pluvialis apricaria*. Biological Conservation 51:243-262.

A detailed study of the effects of hikers and their dogs on plovers during the breeding season. Before incubation the birds were sensitive to the presence of people within about 200 meters [660 feet] and flushed more often. During incubation hikers reduced the amount of time the birds would have remained on the nest by about 2%. Plovers flushed more readily in response to dogs that people and took much longer to resume incubation when people were around. After hatching, plovers spent 11% of observation time reacting to people, increasing energy expenditure by 15%. Chicks were also affected because they could not be fed or brooded while the adults were reacting to human intruders. The study area was visited by up to 8,000 people during the birds' breeding season, people did not restrict themselves to footpaths, they were accompanied by an estimated 1 dog per 25 people, and over 60% of the dogs were not on leads.

RAPTORS

Fernandez, C., and P. Azkona. 1993. Human disturbance affects parental care of marsh harriers and nutritional status of nestlings. Journal of Wildlife Management 57:602-608.

A 21-hectare [53-acre] lake, bordered by about 4.2 hectares [10.5 acres] of reeds and bulrushes, in Spain is visited by 5-10 humans/day during the week and 50-100/day on weekends. Most visitors are fishermen. Nests nearest to the paths were most often disturbed. When human disturbances caused harriers to leave the nest they took 1-89 minutes to return. Human disturbance caused a reduction in parental care, characterized by decreases in incubation time, protection of the chicks, time spent in the territory, and quantity of food delivered. Although this reduced the physiological condition of nestlings, survival was not affected in the short term. Further study is needed to determine the long term effects of reduced physiological condition of nestlings on survival probability.

Fletcher, R. J., S. T. McKinney, and C. E. Bock. 1999. Effects of recreational trails on wintering diurnal raptors along riparian corridors in a Colorado grassland. Journal of Raptor Research 33:233-239.

Three study sites with recreational trails were compared to three sites with no trails. Species richness, abundance of all raptors, and abundance of bald eagles were greater in sites without trails. Perching distances from riparian corridors were greater in sites with trails. Raptors perched along riparian corridors more frequently in sites without trails.

Niles, L. J., and K. E. Clark. 1989. Prey management for migrating raptors. Pp. 154-161 *in* Proc. Northeast Raptor Management Symposium and Workshop. National Wildlife Federation, Washington, D.C.

Researchers compared use of fields having restricted human access with those having unrestricted use. Several raptor species, including northern harriers, used closed areas in significantly greater concentrations than unprotected (and consequently frequented by humans, primarily birdwatchers) fields. Kestrels and red-tailed hawks were not affected. Even the restricted fields were not completely free from people. In the closed areas, the total number of raptors decreased as the number of people and the time they were present increased, although the difference was insignificant because of the low number of people.

Richardson, C. T., and C. K. Miller. 1997. Recommendations for protecting raptors from human disturbance: a review. Wildlife Society Bulletin 25:634-638.

After reviewing scientific literature, authors recommended buffer-zone distances from nests of 11 North American raptor species. Harriers were not included; however, with the exception of the American kestrel, the recommended buffer-zone distances ranged from 500-1,000 meters [1,650-3,300 feet].

Stalmaster, M. V., and J. R. Newman. 1978. Behavioral responses of wintering bald eagles to human activity. Journal of Wildlife Management 42:506513.

Wintering bald eagles were studied in Washington for 2 years. Tolerance was determined by measuring flight distances of eagles from simulated human disturbances. Eagles were displaced to areas of lower human activity. Older birds were more sensitive to disturbances. Flight distances were greatest in open habitat. Disturbances in "high activity" study areas were beyond the tolerance limits of most wintering eagles. "High activity" included human activity

frequently within sight of eagles during high recreational use. In winter, feeding birds were most sensitive to human interference. Wintering eagles can habituate to routine human activities; they are most disturbed if activities do not regularly occur there.

Steidl, R. J., and R. G. Anthony. 1996. Responses of bald eagles to human activity during the summer in interior Alaska. Ecological Applications 6:482-491.

Researchers measured flush response rate and flush distance to recreational, non-motorized boats. Responses depended on context. Flush response rate of nonbreeding eagles decreased as perch height and its distance from the river's edge increased, increased as the season progressed and as eagle group size increased, was lower for juveniles (20%) than other age classes (49-65%), and varied with the existing level of human activity. In contrast to response rate, flush distance was strongly associated with age and was greatest for adults. Breeding adults were much less likely to flush than nonbreeding adults, and flushed at lesser distances. Contrary to expectations, flush distances in this remote area were well below those reported in areas with more human activity. Buffer zones (e.g., the distance within which 95% of the eagles that are approached flush) have been used to protect eagle populations. In this study these distances were 200 and 220 meters [660 and 726 feet] for breeding and nonbreeding eagles, respectively. Along narrow wilderness rivers, recreational disturbance should be avoided by limiting the number of users seasonally, rather than with buffer zones.

van der Zande, A. N., and T. J. Verstrael. 1985. Impacts of outdoor recreation upon nest-site choice and breeding success of the kestrel. Ardea 73:90-99.

Breeding success was monitored at about 160 nest boxes during a 5-year period. Recreation appeared to cause kestrels to avoid areas and lowered breeding success with unrestricted human access and areas approximately 50 meters [165 feet] from sources of disturbance. Recreational impact was greatest in years with low food supply and is especially important during the settlement and incubating stage of the breeding cycle.

SONGBIRDS

Camp, R. J., and R. J. Knight. 1998. Rock climbing and cliff bird communities at Joshua Tree National Park, California. Wildlife Society Bulletin 26:892-898.

Bird composition and behavior and human disturbance were compared at 18 cliff sites (6 with no evidence of climbing, 6 with moderate evidence, and 6 with evidence of intensive use). There were no differences in numbers of bird species among the 3 categories. However, species with broad ecological niches (e.g., American robin) or invasive species (e.g., European starling) were observed only at climbed cliffs. The popular cliffs were nearer parking lots and campgrounds than the unclimbed cliffs; thus, the greater likelihood of observing invasive species may have been due to human activities other than climbing. At unclimbed cliffs, birds were more frequently observed adjacent to cliff faces and more likely to be perched than at climbed cliffs. Common ravens were 1 of the 2 most commonly observed species at unclimbed cliffs.

Gutzwiller, K. J., and S. H. Anderson. 1999. Spatial extent of human-intrusion effects on subalpine bird distribution. Condor 101:378-389.

Simulated recreational intrusions (1 person for 1-2 hours or 5 hours per week for 10 consecutive weeks) displaced mountain chickadees, American robins, and hermit thrushes during a few

years of the study. However, human intrusions had only minimal effects on distribution of these subalpine species. In human-dominated areas, mountain chickadees and American robins are relatively easy to approach and do not seem to be hampered by people. Frequent encounters with people may enable these species to learn to tolerate or habituate to intrusions.

Gutzwiller, K. J., K. L. Clements, H. A. Marcum, C. A. Wilkins, and S. H. Anderson. 1998. Vertical distributions of breeding-season birds: is human intrusion influential? Wilson Bulletin 110:497-503.

Low intensity human disturbance (1 person for 1-2 hours per week for 10 consecutive weeks) did not appreciably affect the vertical distribution of mountain chickadees, ruby-crowned kinglets, yellow-rumped warblers, and dark-eyed juncos in subalpine vegetation. These species can tolerate low levels of recreational intrusion.

Gutzwiller, K. J., E. A. Kroese, S. H. Anderson, and C. A. Wilkins. 1997. Does human intrusion alter the seasonal timing of avian song during breeding periods? Auk 114:55-65.

Because singing is important in territory defense and mate attraction, human disturbance that alters singing behavior may influence a bird's reproductive performance. Simulated recreational intrusions (1 person for 1-2 hours or 5 hours per week for 10 consecutive weeks) during breeding season did not significantly affect seasonal timing of singing activity in most instances for ruby-crowned kinglets, yellow-rumped warblers, and dark-eyed juncos. However, researchers cautioned that their findings were conservative because--depending on the ecological context, spatial scale, frequency and duration of intrusion, and prior experiences with humans--responses are context-specific and often appear to be inconsistent.

Gutzwiller, K. J., H. A. Marcum, H. B. Harvey, J. D. Roth, and S. H. Anderson. 1998. Bird tolerance to human intrusion in Wyoming montane forests. Condor 100:519-527.

A field experiment measured responses of five bird species—gray jay, mountain chickadee, American robin, yellow-rumped warbler, and dark-eyed junco—encountered frequently by recreationists. Researchers hiking in the study area approached birds directly and steadily until they flushed, then timed how long the bird remained visible within 10 meters [30 feet] of its initial flush point (detectability period). Species with brighter or more contrasting colors and those active closer to the ground during the breeding season were less tolerant of human approach. These songbirds were also less tolerant of human approach when fewer members of their species were nearby. Vegetation situated between the researcher and a bird did not influence tolerance in this study; although the authors noted that it has for other species.

Hickman, S. 1990. Evidence of edge species' attraction to nature trails within deciduous forest. Natural Areas Journal 10:3-5. [cited in Miller et al. (1998)]

Nature trails altered bird community composition. Habitat edge species, such as American robins, were more abundant on sites with trails than on sites without trails. Avian nest predators were attracted to narrow, open corridors and this could result in greater rates of nest predation.

Miller, S. G., R. L. Knight, and C. K. Miller. 1998. Influence of recreational trails on breeding bird communities. Ecological Applications 8:162-169.

Research was conducted in parks in Boulder, Colorado, encompassing about 11,000 hectares [24,000 acres], that are visited almost 3.5 million times per year. Recreational activities include hiking, wildlife viewing, exercising pets, jogging, mountain biking, and horseback riding. Composition and abundance of birds were altered adjacent to trails in both grassland and forest ecosystems. Some species (e.g., western wood-pewee) did not occur, or occurred in lower densities, near trails than at greater distances from trails, whereas some species, mainly generalists (e.g., American robin), were more abundant near trails. For most species found in reduced numbers near trails, the zone of influence appeared to be about 75 meters [250 feet]; however, some species were more sensitive to recreational disturbance. Nests near trails in both forest and grassland had higher levels of predation, likely due, in part, to black-billed magpies, which were more abundant near trails. Researchers cautioned that recreational trails not situated in urban areas with heavy use may not exert similar effects on bird communities. They concluded that natural area management must consider not only proper trail placement, but also recreationists themselves. Trails should be consolidated in certain areas (e.g., edges of forests and open areas) to reduce fragmentation of large blocks of habitat and maintain less-disturbed areas for sensitive species. Recreationists should be individually informed how their activities affect wildlife and how they can modify their behavior (e.g., remain on trails and keep pets leashed) to minimize impacts.

Riffel, S. K., K. J. Gutzwiller, and S. H. Anderson. 1996. Does repeated human intrusion cause cumulative declines in avian richness and abundance? Ecological Applications 6:492-505.

Simulated recreational intrusions (1 person for 1-2 hours per week for 10 consecutive weeks) altered the relative richness and mean relative abundance of the most common species in some years. However, when all species were considered, richness and abundance were not influenced. Cumulative declines may not have developed despite yearly impacts for several reasons. Any individual bird displaced each year by intrusions may have been replaced by different resident or migrant birds. Intruded sites were surrounded by undisturbed habitat with many potential replacements. Many songbird species have average lifespans of 2-3 years, so each year richness and abundance may have been restored by naïve individuals. Finally, the intrusions were relatively benign in that birds were not pursued or killed, nests were not destroyed, habitats were not altered, and the intrusion only lasted 1-2 hours each week. Thus some individuals may have habituated or learned to tolerate the intrusions.

van der Zande, A. N., J. C. Berkhuizen, H. C. van Latesteijn, W. J. ter Keurs, and A. J. Poppelaars. 1984. Impact of outdoor recreation on the density of a number of breeding bird species in woods adjacent to urban residential areas. Biological Conservation 30:1-39.

To reduce recreation-related displacement of wildlife, recreational activities should be concentrated in busy, heavily altered sites and not permitted to expand into previously undisturbed or only mildly impacted areas.

van der Zande, A. N., and P. Vos. 1984. Impact of a semi-experimental increase in recreation intensity on the densities of birds in groves and hedges on a lake shore in The Netherlands. Biological Conservation 30:237-259.

Abundance of 11 of 12 avian species was lower in areas where recreation intensity (cyclists, walkers, moped riders, boaters) was high. Lower abundances were associated with recreation

intensities that ranged from 3-15 people per acre (maximum number of visitors present simultaneously).

SYNTHESES AND RELATED ARTICLES

Hammitt, W. E., and D. N. Cole. 1987. Wildland recreation: ecology and management. John Wiley and Sons, New York.

Species that are sensitive to the presence of people may be displaced permanently; therefore, displacement may be more detrimental to wildlife than harassment or recreation-induced habitat changes. Recreationists typically reduce environmental structure and complexity, and although some species may increase numerically under these conditions, typically species diversity and richness decline.

Hill, D., D. Hockin, D. Price, G. Tucker, R. Morris, and J. Treweek. Bird disturbance: improving the quality and utility of disturbance research. Journal of Applied Ecology 34:275-288.

Results of several dozen studies are reviewed. Continuous or frequent, high-intensity activities (e.g., regular shooting or people getting in and out of vehicles) cause more disturbance than continuous low-intensity disturbances (e.g., water pumps). Birds appear to habituate to continual noises so long as there is no large amplitude "startling" component. Vehicles and vehicle movements are tolerated much better than people at the source of disturbance. Most water-based recreation generates "medium-intensity continuous" or "high-intensity infrequent" disturbance. The former may cause a site to become unattractive to the most susceptible species, while the latter might result in displacement of birds for short periods. Larger bird species, those higher up the food chain, or those which feed in flocks in the open tend to be more vulnerable to disturbance than small birds living in structurally complex or "closed" habitats such as woodlands. In estimating the severity and likely impact of disturbance to birds, the following factors should be considered: (1) intensity of disturbance, (2) duration and frequency, (3) proximity of source, (4) seasonal variation in sensitivity of affected species, (5) presence of people associated with source, (6) whether birds move away, but return after disturbance ceases, (7) whether regional numbers are affected, (8) whether there are alternative habitats available nearby, and (9) whether rare, scarce or especially shy species are affected. There is an urgent need for common criteria that can be used to evaluate the importance of disturbance impacts.

Hudson, P. 1983. Red grouse production and management in relation to tourism. Pp. 45-54 in K. Hearn, ed. Moorlands: Wildlife Conservation, Amenity and Recreation. Recreational Ecology Research Group Report 8. [cited in Pearce-Higgins and Yalden (1997)]

A dog out of control disturbed seven times more red grouse than one under control.

Knight, R. L., and S. K. Skagen. 1988. Effects of recreational disturbance on birds of prey: a review. Pages 355-359 *in* R. L. Glinski et al., eds. Proceedings of the Southwest Raptor Management Symposium and Workshop. Univ. of Arizona, Tucson. National Wildlife Federation, Washington, D.C.

Results of several dozen studies are reviewed. Recreational disturbance can alter normal raptor activity patterns by (1) altering the distribution of raptors, (2) disrupting nest attentiveness, (3) causing abandonment of breeding territories, (4) reducing productivity, and (5) affecting foraging behavior. Disturbance can be mitigated by either completely denying human access to important raptor habitat or by devising management plans which allow humans and raptors to coexist, i.e., spatial or temporal restrictions on recreational disturbance.

Pearce-Higgins, J. W., and D. W. Yalden. 1997. The effect of resurfacing the Pennine Way on recreational use of blanket bog in the Peak District National Park, England. Biological Conservation 82:337-343.

Among the most widespread and chronic causes of recreational disturbance are walkers and hikers. A 4-kilometer section of the Pennine Way, an intensively used trail through moorland, was paved with flagstones to encourage hikers to remain on the path and thus reduce the incidence of trampling and disturbance to the blanket bog. During the study, the number of hikers ranged from 95-518 per day, with a mean of 311 (people making a round-trip were counted twice). The number of visitors on the paved trail increased significantly compared to unpaved sections of the same trail, presumably because it facilitated walking. Although other studies have shown considerable variation in the effectiveness of footpaths in channeling walkers through sensitive areas, much of the variation may be a result of the quality of the footpath surface. This study concluded that additional use was concentrated on the path, rather than the surrounding bog. However, of 280 dogs observed in 1986 and 278 dogs in 1996 (about 1 dog to every 21 walkers), most were off leash and 9% and 14%, respectively, seemed to be out of control, despite public notices during the 1990s urging dog owners to keep their pets on leashes. Three independent studies in the same area during the past decade documented similar ratios of dogs to walkers, 20 to 31 walkers for each dog.

Ward, D. 1990. Recreation on inland lowland waterbodies: does it affect birds? RSPB Conservation Review 4:62-68.

Reviewed about 2 dozen articles, many from obscure sources in Great Britain. Compared average distances at which waterbirds flushed or moved away from an approaching person: wigeon (230 and 115 meters [759 and 380 feet]), gadwall (181 meters [597 feet]), teal (86 meters [284 feet]), shoveler (126 meters [416 feet]), mallard (207 and 127 meters [683 and 419 feet]), tufted duck (107 and 131 meters [353 and 432 feet]), goldeneye (280 and 168 meters [924 and 554 feet]). Flocks and family groups are more sensitive than individual birds. Tolerance distance also varies depending on the position of the birds and the source of disturbance, with birds on land reacting earlier to land-based disturbance and birds on the water to water-based disturbance. Where observations take place on a site already exposed to recreational disturbance, the birds present may be those species or individuals which have the greatest degree of tolerance. Other individuals or species may have been displaced entirely before studies commenced. The relative overall effects of various activities were ranked, based on the total number of wintering species per month and declines associated with each activity. Nationally, coarse fishing was most disturbing. However, this is because coarse fishing is widespread, takes place in winter when large numbers of wintering waterfowl are present, and participants are on or close to the water for long periods. The main effect of the anglers was their physical presence. Other recreational activities—sailing, windsurfing, power boats and waterskiing, and birdwatching—also caused significant declines in waterbirds, at least temporarily and in local areas. Disturbance can be modified in a number of ways, principally habitat modification, zoning, and constraints on season or time of activity. Construction of islands, spits, bays and appropriate planting and management of vegetation will allow people

and birds to be segregated. The most damage effects of recreation can be mitigated by establishing or restoring closed seasons and temporary restrictions at the most critical times of the year, for example when birds are nesting or molting. Segregating birds and recreation onto separate waterbodies is perhaps the best option where multiple sites are available. Disturbance from land-based recreation can be reduced by encouraging people to use certain areas. This may involve the provision of fishing stations, hides for birdwatching, signposted paths, physical barriers such as ditches, and screening by earth banks or evergreen vegetation.