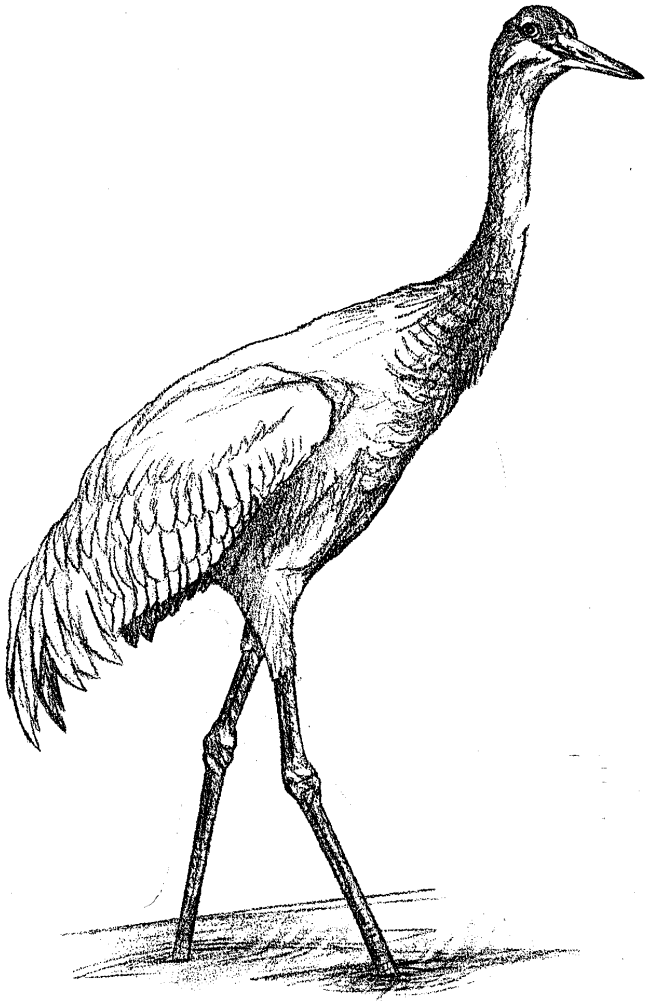
POTENTIAL EFFECTS OF HUMAN RECREATION, URBAN DEVELOPMENT, AND RELATED ACTIVITIES ON BIRDS AND MAMMALS IN THE ANCHORAGE AREA: AN ANNOTATED BIBLIOGRAPHY



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

May 16, 2003

Revised and updated

"Do you want to stop and look at the snow geese?" "No, they're just a bunch of white birds in the mud."

~conversation between two bikers on the Tony Knowles Coastal Trail, April 25, 2003.

The impetus for this bibliography was a proposal to construct a heavily used, multi-purpose trail in or near the Anchorage Coastal Wildlife Refuge. During the planning process for the South Extension of the Tony Knowles Coastal Trail, the planning team decided to use existing scientific studies on wildlife disturbance, rather than conducting an expensive, long-term study of potentially affected species in Anchorage. This is a selective, annotated bibliography of 351 scientific articles and books documenting impacts of human recreation, urban development, and related activities on wildlife.

The focus of the bibliography was to gather information relevant to wildlife in the Anchorage area. I have included studies if the species (or a related species) is found in the Anchorage area. The relevant species are included in Appendix 1. For most of the species not normally found in the Anchorage area, I've taken a stab at listing a related species that is found in or near Anchorage. I did not include many studies on disturbance of colonial waterbirds (Carney and Sydeman 1999, Nisbet 2000) or other species not represented in the Anchorage area. In some of the annotations, I've added one or more editorial comments in parentheses.

The scientific literature on recreational disturbance, habitat fragmentation, and other urban development-related topics has increased exponentially in the last three decades. Boyle and Samson (1985) compiled 536 references concerning effects of nonconsumptive outdoor recreation on terrestrial wildlife species of North America. Much of that literature was unpublished or published in journals, reports, or conference proceedings with no peer review. Much of the literature was anecdotal. At best the studies reported statistically significant associations between recreational activities and impacts.

Since then many studies have been conducted and published in peer-reviewed journals or books. In the last decade, many researchers have advocated for more rigorous field experiments to determine causal relationships (Gutzwiller 1991, Gill et al. 1996, Sutherland 1998). This bibliography includes studies published in 62 scientific journals, most of which accept only peer-reviewed articles. In addition, a few books, conference proceedings, and other sources are included. The exponential increase in published studies on these topics is illustrated by the number of titles I've included from recent decades: 10 (before 1970), 37 (1970-79), 79 (1980-89), 152 (1990-99), and 73 (2000-03). At least 30 of the studies used experimental designs and most of the remainder were correlational studies. There are very few anecdotal or purely observational studies included. This bibliography is not comprehensive because the literature base is already large and expanding rapidly.

Although the initial focus of the bibliography was to document trail-related impacts, it soon became clear that the project and its potential impacts were larger than that. People don't stay on trails, and they often don't leash their dogs. Wildlife impacts are likely to extend some distance from the trail. Many studies have found that the unpredictable behavior of pedestrians is very stressful to many wildlife species. People on foot are typically more likely to disturb wildlife than vehicles, boats, planes, or even helicopters. Studies that documented the effects of boats on wildlife are instructive because it is the unpredictable motion in many cases that is at the root of the problem. Even the effects of hunting can be boiled down to the essence of human disturbance. A birdwatcher can be as disruptive as a person with a gun.

Similarly, some species, e.g., bighorn sheep and bobcats, won't be found along the South Extension of the Coastal Trail. Yet they are likely to respond to human disturbance in much the same way as a moose or a lynx.

There are still many gaps in our understanding of how recreational activities, urban development, and related activities affect wildlife. Showing that a population decline is correlated with a human activity doesn't prove that the activity caused the decline. Correlational studies cannot prove cause and effect. However, the wide variety of activities that have been statistically correlated with population impacts in a wide variety of species leads one to believe that the impacts are real. Many review articles and books have found negative effects reported most commonly (Boyle and Samson 1985, Hammitt and Cole 1987, Knight and Gutzwiller 1995, Liddle 1997, Marzluff et al. 1998, Oliff et al. 1999, Joslin et al. 1999, Trombulak and Frissell 1999). While we should not set impossibly high environmental standards for development and recreational activities, the burden of proof for developments in or near a wildlife refuge belongs to the person or organization that proposes to change the status quo.

Acknowledgements. Lance Trasky and his staff in the Division of Habitat and Restoration, Alaska Department of Fish and Game, set the standard for fish and wildlife protection in Alaska. Without Celia Rozen and other staff of ARLIS, this bibliography would still be a 98-pound weakling. Lisa, Erin, and Meg graciously granted me hundreds of "off-duty" hours when we should have been on the Coastal Trail.

LOONS

Lehtonen, L. 1970. Zur Biologie des Prachttauchers, *Gavia a. arctica* (L.). Ann. Zool. Fennica 7:250-60. *[cited in Titus and VanDruff (1981)]*

Crows and humans (with dogs) caused 77% of the egg losses of arctic loons studied in central Finland.

Titus, J. R., and L. W. VanDruff. 1981. Response of the common loon to recreational pressure in the Boundary Waters Canoe Area, northeastern Minnesota. Wildlife Monographs 79:1-59.

Human use of the area may be somewhat compatible with loons, particularly if shoreline development and motorcraft use are curtailed. Recreational impact was measured indirectly, and the actual number of visitors or disturbances was not known for any nests. Most measures of breeding success showed little or no effect of heavy recreational use on loon productivity. In fact, while human recreational used increased, the size of the adult breeding population during the past 25 years has not declined. Nevertheless, significant negative results were noted in a portion of the data. A significantly greater hatch/egg laid was observed on smaller (usually remote) lakes; and consistently, although not significantly, greater success in brood rearing was also noted. Loons on lakes where motors were not allowed were more successful at hatching eggs and producing broods than those on lakes where motors were permitted. Comparison of nests near areas of high and low human use showed that loon pairs that experienced fewer human contacts produced significantly more surviving young. Less visible nests produced significantly more successfully hatched eggs than more visible nests. Mean flushing distances for pairs in areas of high and low use were 41.6 and 23.1 meters, respectively, although these distances were not statistically significant, perhaps due to low sample sizes. The main period of loon nest establishment occurred during the peak of early recreational use. Early recreational impacts on the larger lakes with many loon pairs may have also precipitated increased territorial encounters. Birds disturbed too much in their primary nesting area may have switched to secondary sites in “fringe areas” of the territory for nesting, areas to which they were less attracted and in which the conditions were suboptimal or where territorial encounters were more frequent. Researchers caution that the findings of this study should not be applied to loon populations on lakes with other types of use patterns or a higher magnitude of human impacts.

SANDHILL CRANES

Bettinger, K. A., and R. Milner. 2000. Sandhill crane (*Grus canadensis*). In E. M. Larsen and N. Nordstrom, eds. Management recommendations for Washington’s priority species, Vol. IV: Birds. Washington Department of Fish and Wildlife. Available http://www.wa.gov/wdfw/hab/phs/vol4/sndhlcrn.htm

The sandhill crane is a state endangered species. They are in jeopardy of extinction in Washington because of their limited distribution, low numbers, poor breeding success and colt survival, and loss of shallow marshes or wet meadows for feeding and nesting. A large percentage of their wintering habitat is privately owned and subject to potential alteration. Management recommendations include: sandhill cranes should not be disturbed during their breeding season (March – September), vehicle and foot traffic should be avoided within 400 meters of nesting areas during the breeding period (March – September), construction and road building should be avoided within 800 meters of feeding

areas, construction of new roads should be avoided within 500 meters of night roosts, and hunting near roosts should be avoided or restricted from 4 hours after sunrise until 2 hours before sunset.

Burger, J., and M. Gochfeld. 2001. Effect of human presence on foraging behavior of sandhill cranes (*Grus canadensis*) in Nebraska. Bird Behavior 14:81-87.

Foraging cranes during spring migration are disturbed by people and vehicles. On the Platte River, disturbance from people on foot is minimized by controlling human access to several locations, supervision by naturalists, and by entering and leaving blinds when the cranes have left the sites. Visitors can watch cranes from vehicles; however, they are told not to leave the vehicles in the presence of cranes. Nevertheless, some people ignored the warnings, leaving their vehicles to observe flocks or even deliberately flushing the birds to see them fly. It's well known that cranes are readily disturbed by people on foot. Although cranes routinely ignored or merely glanced at vehicles passing by, cranes were also disturbed by vehicles that stopped. When no cars were nearby, about 85% of cranes in a nearby flock were feeding and fewer than 10% were dancing (courtship behavior, but also indicative of low-level disturbance) or vigilant. Cranes over 300 meters (measured to the nearest crane; the flock center was farther away) from the stopped car rarely flushed, although some interrupted feeding to watch. At distances from 70-300 meters the percentage of cranes that became vigilant or flew showed great variation, although at less than 200 meters the majority flew or became vigilant. At distances of 70 meters or less, most birds stopped feeding and flew, or walked away slowly. Disturbance by people in vehicles was also indicated by the largest crane aggregations being over 1 kilometer (0.6 mile) from the nearest road. Cranes are not hunted in Nebraska, but the researchers speculated that hunting in other states and provinces is probably a strong selective pressure against habituating to humans. Because cranes in Nebraska spent 21.6% of the day resting, they could tolerate some feeding disturbance by resting less and feeding more; however, flying also depletes energy reserves, and there is a ceiling in the amount of feeding time available to an individual bird.

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.

Folk, M. J., and T. C. Tacha. 1990. Sandhill crane roost site characteristics in the North Platte River valley. Journal of Wildlife Management 54:480-486.

There was no difference in distance to nearest occupied farm building or wetland size among semipermanent wetlands where cranes did or did not roost. Distance to nearest paved road differed between wetlands used or not used by roosting cranes, but this was confounded with differences in wetland characteristics (water depth, mud depth, and wetland width).

Gee, G. F., and S. Russman. 1996. Reproductive physiology. Pp. 123-136 *in* Ellis, D. H., G. F. Gee, and C. M. Mirande, eds. Cranes: their biology, husbandry, and conservation. Department of the Interior, National Biological Service, Washington, D.C., and the International Crane Foundation, Baraboo, Wisconsin.

Captive cranes appear to be especially susceptible to stress from physical and behavioral disturbance, unfamiliar territories, and disease. Although mature cranes normally reproduce annually, they may experience one or more years of reduced productivity apparently due to stress. Stress interferes with reproduction in cranes by reducing egg production or terminating the reproductive effort.

Littlefield, C. D. 1986. Autumn sandhill crane habitat use in southeast Oregon. Wilson Bulletin 98:131-137.

Cranes seemed less tolerant to human disturbance on Malheur National Wildlife Refuge than reported elsewhere. One roost was within 100 meters of a well-traveled highway, with no vegetative screen. Another roost was within 0.8 mile of a human residence, but visibility was restricted by dense bulrushes. However, other roost sites on the refuge were isolated from human activity.

Lovvorn, J. R., and C. M. Kirkpatrick. 1981. Roosting behavior and habitat of migrant greater sandhill cranes. Journal of Wildlife Management 45:842-857.

The 2 main roosting requirements of sandhill cranes in eastern states are water <20 centimeters deep (depending on bottom firmness) and freedom from human disturbance. Roosting cranes avoid human disturbance by maximizing their distance and visual isolation from human activity. Minimum distances from human activity averaged 140 meters for roosts surrounded by woods and 380 meters for roosts visible from roads. To eliminate virtually all direct disturbance to roosting cranes, hunting or other potentially disruptive activities should not be allowed earlier than 4 hours after sunrise or later than 2 hours before sunset.

Mirande, C. M., G. F. Gee, A. Burke, and P. Whitlock. 1996. Egg and semen production. Pp. 45-57 *in* Ellis, D. H., G. F. Gee, and C. M. Mirande, eds. Cranes: their biology, husbandry, and conservation. Department of the Interior, National Biological Service, Washington, D.C., and the International Crane Foundation, Baraboo, Wisconsin.

Captive cranes maintained on public display produce significantly fewer eggs. Caretaker activity and public viewing should leave sections of the pen undisturbed. Reproduction greatly increased when caretakers began providing food and water from the exterior, public-viewing area. The pairs selected nest sites in the undisturbed areas of the pens.

Norling, B. S., S. H. Anderson, and W. A. Hubert. 1992. Roost sites used by sandhill crane staging along the Platte River, Nebraska. Great Basin Naturalist 52:253-261. *[cited in Trombulak and Frissell (2000)]*

Relative to habitat availability, cranes avoided nesting near paved and gravel public roads. They did not avoid private roads with low-traffic volume.

Ohsako, Y. 1994. Analysis of crane population change, habitat selection, and human disturbance. Pp. 107-113 *in* Higuchi, H., and J. Minton, eds. The future of cranes and wetlands: proceedings of the international symposium. Wild Bird Society of Japan, Tokyo, Japan. *[cited in Ellis, D. H., G. F. Gee, and C. M. Mirande, eds. Cranes: their biology, husbandry, and conservation. Department of the Interior, National Biological Service, Washington, D.C., and the International Crane Foundation, Baraboo, Wisconsin.]*

Sauey, R. T. 1987. Disturbance factors affecting Siberian cranes at Keoladeo National Park, India. Pp. 151-170 *in* G. W. Archibald and R. F. Pasquier. Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin.

Daily activities of wintering cranes were frequently disturbed by a variety of factors. Of the 5 most common sources of disturbance, humans were the most important, accounting for 42% of the disturbance incidents and 46% of the cranes' total response time to all disturbances. All wetlands in the park were within easy viewing distance from roads and dikes. As many as 10,000 domestic animals grazed daily in the sanctuary. These were principally water buffalo, cattle, and swine. Cranes seldom flew away from buffalo, unless the buffalo ran toward them or were accompanied by humans. Most human activity was confined to a single road through the sanctuary. Cranes responded to local villagers and tourists similarly. The usual stimulus for flight, however, seemed to differ. Villagers most often caused cranes to take flight when they entered the water, usually with their livestock. Tourists most often caused flight by stopping on the dikes to watch the cranes, sometimes remaining for several minutes in full view of the nervous birds. Cranes in such situations seemed to fly more because of the lengthy interruption in their activities rather than because they were unduly frightened. Without strict control over human access to the park, it is inevitable that the area will lose its function as a sanctuary, and its cranes as well.

Sugden, L. G., R. G. Clark, E. J. Woodsworth, and H. Greenwood. 1988. Use of cereal fields by foraging sandhill cranes in Saskatchewan. Journal of Applied Ecology 25:111-124.

The effect of hunting was examined by comparing the total number of cranes seen on morning counts during 3 consecutive days preceding the hunting season with morning counts during the first 3 days of the season. There were 7 sets of counts for comparison. Flocks disturbed by hunters probably spent more time flying, particularly during morning counts. Overall the effect of hunting was not strong and was evident for 1-2 days. The influence of roads on crane distribution was investigated by plotting the position of flock centers relative to field halves and quarters. In all cases, cranes occurred more frequently on the most distant quarter.

Swengel, S. R., and J. W. Carpenter. 1996. General husbandry. Pp. 31-43 *in* Ellis, D. H., G. F. Gee, and C. M. Mirande, eds. Cranes: their biology, husbandry, and conservation. Department of the Interior, National Biological Service, Washington, D.C., and the International Crane Foundation, Baraboo, Wisconsin.

Human disturbances are stressful to cranes in captivity. Most activities that are not directly related to breeding are best conducted in the non-breeding season when cranes are less susceptible to disturbance.

Swengel, S. R., G. W. Archibald, D. H. Ellis, and D. G. Smith. 1996. Behavior management. Pp. 105-122 *in* Ellis, D. H., G. F. Gee, and C. M. Mirande, eds. Cranes: their biology, husbandry, and conservation. Department of the Interior, National Biological Service, Washington, D.C., and the International Crane Foundation, Baraboo, Wisconsin.

Blinds set up near captive cranes allow longer-term observations of relatively undisturbed (by humans) behavior. Because some cranes remain disturbed by observers in nearby blinds, it is crucial to locate blinds with care and use one-way glass if necessary to enable the observer to be invisible to the crane. All cranes can become more sensitive to disturbance when incubating and raising chicks. Because captive cranes (even normally aggressive individuals) become very shy when molting, minimize human contact during this time. Many captive cranes will not breed when on display. Crane pairs are healthier and breed better when disturbance is minimized. Stress can be reduced by taming captive cranes. The process involves conditioning birds to human activity through providing treats (favorite foods), avoiding direct eye contact, and announcing your approach by calling when still far away.

Végvári, Z., and J. Tar. 2002. Autumn roost site selection by the common crane *Grus grus* in the Hortobágy National Park, Hungary, between 1995-2000. Ornis Fennica 79:101-110.

This park supports more than 60,000 cranes for 2 months during migration. Human movements in the park were limited to 20 minor concrete and dirt roads. The public was not allowed to access roost sites between 2 p.m. and 8 a.m. to minimize disturbance of roosting cranes. Roost sites most preferred by cranes had the following characteristics: (1) large and relatively far from human settlements and roads with suitable conditions created by legal protection, (2) relatively deep (up to 40 centimeters), and (3) close to feeding areas.

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.

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.

Maringuy, J., J. Bety, G. Gauthier, and J.-F. Giroux. 2002. Are body condition and reproductive effort of laying greater snow geese affected by the spring hunt? Condor 104:156-161.

The spring hunts occurred during the period of nutrient storage during spring migration. Snow geese were captured and radio-collared on their arctic molting grounds in late summer, relocated the following spring on their staging grounds in southern Quebec (where the hunt occurred) and then relocated again on the breeding grounds. The following indices of body condition of nesting snow geese were considered: whole body mass, dry breast muscles (an index of protein), and abdominal

fat (a reliable index of total body fat). All indices of body condition and clutch size were significantly lower in years with a spring hunt (1999 and 2000) than in years without (1989 and 1990), and laying dates were delayed 2-7 days. The average potential clutch size in years with a spring hunt was considerably reduced (by almost 1.5 eggs, a 29% reduction) compared to years without a hunt. Most birds that did not reach the breeding grounds or were not found nesting had survived, as 81% (n = 42) of those birds were subsequently detected on the fall staging area in 1997-1998, and 66% (n = 35) in 1999. Researchers suggest that poor body condition upon arrival in the arctic was a major reason for the reduced breeding effort, late nesting, and reduced clutch size after the spring hunts. Birds arriving with reduced fat and protein reserves would have to feed more on or near the breeding grounds in order to acquire the nutrients needed to produce eggs. This would have delayed the onset of laying, and thus reduced the average clutch size. For many geese, body condition may have been so poor than they were unsuccessful at reaching the nesting area or simply skipped breeding. Detection in fall of most radio-marked birds than were not found nesting confirmed that they were still alive. Increased disturbance caused by hunters was the most likely factor explaining the low pre-migratory body condition of geese in years with a spring hunt. *[Spring hunts are generally prohibited in the United States.]*

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

Fox, A. D., and J. Madsen. 1997. Behavioural and distributional effects of hunting disturbance on waterbirds in Europe: implications for refuge design. Journal of Applied Ecology 34:1-13.

Authors compare results of their work and other research on effects of hunting on geese and ducks in Europe. They recommend refuges, at a minimum, should have a diameter of three times the escape flight distance of the most sensitive species present. Escape flight distances observed for several species ranged from 200-500 meters.

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.

Madsen, J. 1985. Impact of disturbance on field utilization of pink-footed geese in West Jutland, Denmark. Biological Conservation 33:53-63.

The distance at which goose flocks take flight was estimated using a vehicle as a standard stimulus. In both autumn and spring, flight distances was correlated with flock size. In general, flocks above 400-600 individuals have a flight distance of 500 meters in autumn and 300-400 meters in spring.

The increased wariness is likely related to harassment during the fall hunting season. Roads with a traffic volume of 20-50 vehicles per day had a serious depressing effect on goose use up to 500 meters from the road.

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.

Percival, S. M., Y. Halpin, and D. C. Houston. 1997. Managing the distribution of barnacle geese on Islay, Scotland, through deliberate human disturbance. Biological Conservation 82:273-277.

Seven to eight people in four teams approached feeding geese on a wintering area until the geese took flight. Gas-guns and plastic tapes were used to further discourage geese from feeding there. In addition to this disturbance, geese could be hunted by local landowners. The intensive scaring reduced the number of geese using an area by about 50%, mainly by moving them to neighboring refuges. Geese in scaring zones were less likely to remain faithful to their preferred feeding areas; however, a core of geese remained despite the scaring activity. There were no major differences in distances moved by disturbed and undisturbed geese. The subsequent breeding success of geese that remained in the scaring zone was higher than that of geese that preferred or were hazed into refuge areas. Researchers concluded that an intensive scaring scheme can only work in the long-term if there are sufficient feeding areas elsewhere for the birds to move to, and the high number of geese already present in the refuges meant that it was a more attractive option for many geese to remain in the scaring zone.

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 disturbance on staging brent geese: a progress report. Wader Study Group Bulletin 68:29-34.

An area of 265 hectares, mostly *Puccinellia* salt marsh, was heavily used by tourists, up to 200 people simultaneously during a day in spring. Human-related disturbances were observed more often than natural or unidentified disturbances. Tourists and small planes were the most important causes of disturbance, in that order. The percentage of birds in a flock taking flight after a disturbance varied according to stimulus, averaging between 40 and 88%. The highest percentage was caused by helicopters and small planes, which also caused the longest time in flight and time taken to resume feeding. Overall, reactions lasted between one and two minutes. A walking person caused fewer members of a flock to take flight than a plane or car, however, the reaction time was intermediate. The impact of disturbance is related to its frequency and stimuli. Intensity of the disturbance was measured by the percent of the flock taking flight and duration of interrupted feeding. The mean disturbance level recorded (about 2 disturbances/hour) was considered high compared to other areas. During the early morning and later afternoon, when visitor numbers were low, geese used nearly the whole salt marsh. Under high disturbance pressure (>30 visitors/265 hectares [approx. 1 visitor/22 acres]), the geese left the area and flew to an adjacent, undisturbed saltmarsh. Thus, possibly large parts of the food stocks are not optimally utilized.

Stock, M., and F. Hofeditz. 1997. Compensatory limits: energy budgets of Brent Geese, *Branta b. bernicla*, the influence of human disturbance. Journal für Ornithologie 138:387-411.

The influence of human disturbances on the energy budget of brent geese during spring migration was investigated in 2 salt marshes in Germany. Human disturbance caused a significant change in the net energy intake on an hourly basis. Daily metabolizable energy/hour increased in 1 marsh and decreased in the other with increasing frequency of disturbance. At the same time the daily energy expenditure increased significantly in both areas. As a consequence, the net daily energy intake was reduced on days with a high disturbance frequency by 8.7% and 27.5% in the 2 marshes. Birds compensated for the lost feeding time and the higher energetic costs of disturbance-related flights by a change in activity pattern and by increasing their food consumption rate.

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

Ahlund, M., and F. Gotmark. 1989. Gull predation on eider ducklings *Somateria mollissima*: effects of human disturbance. Biological Conservation 48:115-127.

Researchers experimentally compared the effects of boats on eider duckling predation in Sweden. Two observers monitored undisturbed broods then disturbed broods with a small boat run at 6-9 knots. Gulls, primarily herring gulls, paid little attention to ducklings on land or in undisturbed broods in the water. The mean rate of total predation attempts as well as successful attacks was >200 times higher on disturbed than undisturbed broods.

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.

Bolduc, F., and M. Guillemette. 2003. Human disturbance and nesting success of common eiders: interaction between visitors and gulls. Biological Conservation 110:77-83.

Common eider colonies are often disturbed by human visitors. Researchers used 3 experimental treatments and 6 eider colonies over 3 years to test the effects of human visits on eider nesting success. Changes in frequency of visits (once every 3 days vs. once every 15 days) had little impact on nesting success. In contrast, timing of visits had a major influence, as high-frequency visits starting early in the incubation period had significantly higher nesting success than high-frequency visits starting late. Most nest failures occurred after the first visit in all treatments, although the impact

of the first visit was lowest when visits started late in incubation. Between 26 and 33% of nests failed following the first visit during early incubation, but only 11% of nests failed after a first visit during late incubation. There are 2 principal causes for bird nest failure: nest desertion and predation. The main consequence of the visits was that disturbance produced good opportunities for egg predators to find unattended nests, rather than nest desertion by eiders.

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.

Evans, D. M., and K. R. Day. 2001. Does shooting disturbance affect diving ducks wintering on large shallow lakes? A case study on Lough Neagh, Northern Ireland. Biological Conservation 98:315-323.

Hunting is the dominant recreational activity and represents the most important source of human disturbance for wintering waterfowl on the lake. The lake has 125 km of shoreline and a mean depth of about 9 meters. Hunters shoot from blinds on or near the shore. The distributions of wintering pochard, tufted duck, and scaup were affected by shooting disturbance. But because they predominantly roosted during the day, when hunters were active, at distances >500 meters from the shore and were not observed to forage in near-shore areas at night, any energetic impacts of shore-

based shooting disturbance are likely to be small. Goldeneyes predominantly fed during the day, but did not shift distribution in response to shooting disturbance, confirming the lack of effect.

Evans, D. M., and K. R. Day. 2002. Hunting disturbance on a large shallow lake: the effectiveness of waterfowl refuges. Ibis 144:2-8.

Same study as above. A small number of refuges have been provided to limit the effects of shooting disturbance on the wintering duck populations. Duck use of one refuge during one winter was compared with use of a non-refuge site the following winter. Significantly more birds were observed in the refuge during the shooting season than the closed season. However, there was little difference or trend in the number of birds observed in the hunt area at low shooting rates (<10 shots/hour) and the highest shooting rates (about 20 shots/hour), with the exception of 1 count. Significantly more birds were observed on weekends compared to weekdays in the hunt area when the shooting season closed, possibly due to disturbance other than shooting (e.g., fishing) during the week.

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.

George, J. L., C. E. Braun, R. A. Ryder, and E. Decker. 1991. Responses of waterbirds to experimental disturbances. Pp. 52-59 *in* Issues and Technology in the Management of Impacted Wildlife. Proceedings of a National Symposium, Snowmass Resort, Colorado.

Declines in species diversity followed disturbances in all trials despite varying responses among species. Redheads and mallards flew from the area (or hid in bulrushes) and did not return to pre-disturbance activity during the hour following the disturbance. Gadwalls did return to pre-disturbance activity within an hour; however, they may not have been the same individuals.

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.

Havera, S. P., L. R. Boens, M. M. George, R. T. Shealy. 1992. Human disturbance of waterfowl on Keokuk Pool, Mississippi River. Wildlife Society Bulletin 20:290-298.

Hundreds of thousands of ducks are observed during peak counts of autumn migration; fewer in spring. Due to the size of the study area (30 kilometers long and 2-4 kilometers wide), most human disturbance is from boats. In autumn, during the waterfowl hunting season, boating associated with fishing, hunting, and other recreational activities resulted in more birds taking flight/disturbance than barge activities. During spring, boating activities associated with fishing and barges affected a higher number of birds/disturbance. Birds also flew farther when disturbed by boating activities associated with fishing, hunting, and other recreational boats than when disturbed by barges. Waterfowl were more sensitive to disturbance in autumn and spring as measured by average flushing distance (183 vs. 137 meters), time in flight (including birds that flew out of sight) (60 vs. 45 seconds), and flight distance (>3.2 vs. 1.6 kilometers). Boating activity closer than approximately 450 meters causes diving ducks to take flight. A minimum buffer zone of 450 meters should protect flocks of diving ducks from boating activity.

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.

Kahl, R. 1991. Boating disturbance of canvasbacks during migration at Lake Poygan, Wisconsin. Wildlife Society Bulletin 19:242-248.

Most disturbances to canvasbacks resulted from sport fishing boats in spring and hunting boats in autumn. Even in autumn, fishing boats caused 32-33% of all disturbances. More canvasbacks took flight from each boating disturbance in spring than autumn. The energetic cost of boating disturbances averaged 14-24 kcals per day for flight plus incremental feeding activity to compensate for this flight. Maximum daily energy costs of flight for an individual responding to all disturbances would have been 46 to 60 kcals. These energetic costs represent minimum estimates. Spring disturbance may have a greater impact than autumn disturbance because migrating ducks must acquire nutrient reserves for egg laying and food resources in spring may be less abundant and of lower nutritional quality. Flight distance from boats indicated that refuges should be at least 1.5-2.0 kilometers across and should encompass as much of a feeding area as possible.

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., 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.

Knapton, R. W., S. A. Petrie, and G. Herring. 2000. Human disturbance of diving ducks on Long Point Bay, Lake Erie. Wildlife Society Bulletin 28:923-930.

The most frequently disturbed species were scaup and canvasbacks. The disturbance rate (number of disturbances/observation hour) was greater in spring (3.2/hour) than in fall (0.7/hour); however, more birds were disturbed in fall because the birds were in larger flocks. Birds flushed at similar distances in spring (189 meters) and fall (174 meters). Commercial fishing boats were the most common cause of waterfowl disturbance during spring; hunting boats were the most common cause in fall. Fall migrating waterfowl are not constrained by the need to acquire reserves for reproduction, and they do not need to arrive promptly on wintering areas; thus, foraging opportunities are less limited by human disturbance in fall.

Livezey, B. C. 1980. Effects of selected observer-related factors on fates of duck nests. Wildlife Society Bulletin 8:123-128.

Data from 667 duck nests (622 were blue-winged teal nests) in Wisconsin were used to test the effects that researchers had on the outcome of nesting. Some nest abandonment probably resulted from human disturbance and was most frequent during egg-laying and when more than 1 person approached the nest. Abandonment more than doubled if more than 1 person visited nests. Predators (primarily skunks and raccoons) destroyed 82% of the nests. Crows and gulls were uncommon during the study. Nest predation was not related to time spent at nests by observers or number of persons that approached the nest.

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.

Madsen, J. 1998. Experimental refuges for migratory waterfowl in Danish wetlands. I. Baseline assessment of the disturbance effects of recreational activities. Journal of Applied Ecology 35:386-397.

Effects of fishing, sailing, windsurfing, and different types of waterfowl hunting on autumn-staging waterfowl, including mute swan, wigeon, and coot, were examined at a coastal wetland. Shooting from mobile punts was the most disturbing human activity, followed by shooting from stationary punts. Fishing, windsurfing, and sailing were not important sources of disturbance at observed levels. Windsurfing elicited the longest escape flight distances, but since the activity was infrequent during autumn, this was not regarded as critical. The wigeon was the most sensitive to human disturbance, probably because it was the primary quarry. Few hunter pursued coots and the swans were protected. *[The author appeared to be focused on direct disturbance (i.e., hunting) and failed to address what appeared to be avoidance of moving boats. Wigeons and swans (and to a lesser extent coots) appeared to associate with, or near, extensive eelgrass beds. Stationary and mobile shooting punts were concentrated in the same areas as wigeons and swans. Motorboats and windsurfers appeared to avoid the eelgrass bed and either avoided the birds or the birds avoided these mobile watercraft. Where mobile shooting punts and fishing boats overlapped portions of eelgrass beds, wigeons and swans appeared to be less abundant.]*

Mathers, R. G., S. Watson, R. Stone, and W. I. Montgomery. 2000. A study of the impact of human disturbance on wigeon *Anas penelope* and brent geese *Branta bernicla hrota* on an Irish sea loch. Wildfowl 51:67-81.

Researchers collected 196 discrete disturbance events involving brent and 101 incidents involving wigeon during a 3-year period. Brent are more tolerant of human activity (mostly pedestrians walking along the beach) than wigeon. Wigeon reacted at greater distances, were more likely to fly greater distances and less likely to return to their former activity at this site. Herbivorous waterfowl feeing in the intertidal zone (e.g., wigeon) are especially susceptible to disturbance because of (1) the relatively low nutritional quality of the food and (2) the restricted access to their feeding resource depends on the tide. Most (75%) of human activity causing a reaction were within 250 meters of brent, while 65%

of cases were within 250 meters of wigeon. Brent were significantly less likely to fly >500 meters compared to wigeon. Brent were significantly more likely to resume their previous activity (86%) than wigeon (63%). Walkers had a greater than expected effect at distances <250 meters, while highly mobile activities (e.g., horse riding, wind surfing) had a greater than expected effect at >250 meters. Larger flocks were more likely to react at longer distances than small flocks. The lower tolerance by wigeon may be due to hunting, while the brent are protected in the loch. Whereas brent seemed to habituate to or tolerate human activity, wigeon were never recorded in close proximity to any source of regular disturbance stimulus. The site of highest disturbance almost never holds wigeon. There are several refuges where hunting is not allowed; however, other forms of human disturbance are still present. The researchers recommend a 250-meter buffer and refuges must be large enough to encompass an escape flight distance; thus ensuring that even if disturbed, birds will not normally have to leave the site. As most escape flight distances were >500 meters for wigeon, refuges should be at least 1 kilometer in size. Highly mobile activities must be prohibited from areas important for waterfowl.

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.

Mikola, J., M. Miettinen, E. Lehikoinen, and K. Lehtila. 1994. The effects of disturbance caused by boating on survival and behavior of velvet scoter *Melanitta fusca* ducklings. Biological Conservation 67:119-124.

Scoter broods were observed in Finland. During 308 hours of observation of 84 broods, 113 boats passed the broods. Each brood was exposed to disturbance by boats on average 8.5 times a day in 1990 and 3.5 times a day in 1991. Disturbance lengthened the swimming distances of ducklings and reduced the time used for feeding. Broods disturbed more frequently than average were smaller than those disturbed less frequently. The common predators were gulls. The frequency of gull attacks was 3.5 times higher in disturbed than in undisturbed situations.

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 that were not disturbed, 17% were lost to predation. In an area with 781 nests that 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 Bulletin 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.

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 Bulletin 68:47-52.

Hunting and other recreational activity can have a cumulative effect on waterfowl. A decline in the wigeon population was attributed to hunting from punts during late autumn/early winter, when most wigeon were present. However, numbers of wigeon, bar-tailed godwits, and redshank were substantially lower in parts of the nature reserve where hunting was prohibited when bait-digging took place. Bait-digging involved presence of people scattered over large parts of the refuge during the low-water period. Populations of these species—as well as shelduck, teal, mallard, and eider—increased substantially the year following prohibition of bait-digging. Only 8 punts are permitted and most have two hunters. Punt-gunning involves a loud bang and lots of smoke. After each discharge there is an extended period (30-40 minutes) where the hunters wade around the boat to retrieve ducks, which may cause as much as, or on occasion, more disturbance than the shot itself. Normal shotguns are also used by hunters, although it appears that much of this hunting occurs at night. The combination of punt-gunning and bait-digging appears to have a cumulative or synergistic effect in reducing the number of wigeon. The authors speculated that wigeon can tolerate high levels of continuous disturbance from punt-gunning provided there are adequate undisturbed refuge areas available.

Zehnter, H.-C., and M. Abs. 1994. Cyclists and pedestrians trigger diurnal activity-rhythm of wintering tufted ducks (*Aythya fuligula*). Journal für Ornithologie 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. 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.

The number of terns flying over a colony was used as an index of boating disturbance in New Jersey. During the early stage of nesting, the type of craft, speed, and route explained 95% of the variation. Boats that raced elicited the strongest response, as did boats that were outside of the established channel. Boats traveling closer to the nesting colonies elicited stronger responses than those that remained in the channel. Personal watercrafts elicited stronger responses than motorboats.

Motorboats normally followed maritime law and passed slowly through the appropriate channel, and only the personal watercrafts raced. Common tern colonies with the lowest reproductive success were those that were exposed to personal watercrafts. Personal watercraft should be restricted to reduce disturbance to colonial nesting species by restricting speed near nesting colonies and prohibiting use within 100 meters.

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.

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

Recreational disturbance is now perceived to be one of the major threats facing the United Kingdom's shorebird and waterfowl populations. The potential impact of human disturbance on wintering

waterbirds using intertidal mudflats of 6 estuaries was compared to the presence of nearby footpaths, roads, railroads, and towns. The majority of counts were undertaken on weekends when the use of footpaths was likely to have been at its greatest. Numbers of 6 of 9 species (northern shelduck, red knot, dunlin, black-tailed godwit, Eurasian curlew, and common redshank) were significantly lower where a footpath was close to a count section. In contrast, numbers of only 4 and 3 species were reduced close to railroads and roads, respectively. The relative distances to which species were affected by footpaths corresponded to published information concerning their flight distances in response to human disturbance. Dunlin numbers were most greatly reduced if a large proportion of the count section was within 25 meters of a footpath, those of common redshank and black-tailed godwit if sections were within 50 meters, while those of Eurasian curlew were reduced on sections within 200 meters. Brant may be more tolerant to disturbance than other waterfowl. Brant numbers fell in proximity to access points, but in contrast to other species, were otherwise greater within 25 meters of footpaths. Sustained disturbance associated with footpaths, roads, and railroads reduced local habitat quality for waterbirds and the carrying capacity of estuaries. New routes should avoid areas that hold high waterbird densities. Roads may only have to be placed 25 meters from the high tide mark to avoid disturbing birds feeding at low tide, but more room would allow the creation of high tide refuges. Railroads and footpaths, in contrast, may have to be placed 200 meters from intertidal areas to avoid disturbance to every species.

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.

Fahey, K. A., and C. D. Woodhouse. 1995. 1995 snowy plover linear restriction monitoring project: Vandenberg Air Force Base. Report prepared for Natural Resources, Vandenberg Air Force Base. *[cited in Lafferty (2001)]*

Forty percent of the people using the beach and 70% of unleashed pets disturbed plovers. Human activity disturbed plovers at distances up to 80 meters. Thirty percent of beach users entered posted closed areas where plovers breed and roost. Leashed pets were about half as likely to disturb snow

plovers as unleashed pets. Posting and a moderate enforcement presence (15% of daylight hours) brought compliance with the leash law to 30%.

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 that 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.

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

Humans walking on four beaches elicited a significantly higher level of response from adult plovers than potential predators or non-predatory species. Beaches with "excessive disturbance" had 5-50 pedestrians and 3-20 vehicles/day. Adults usually flushed from the nest at distances of <40 meters from approaching humans. However, great variation existed and reaction distances as far as 210 meters were observed. The behavior of plover chicks began to change when humans were 160 meters distant. Pedestrians significantly reduced the incidence of chicks feeding or brooding and the pecking rate during feeding, and increased the incidence of chicks being vigilant. Adults and chicks were indifferent to approaching vehicles. Thus, pedestrians caused chicks to shift tactics from feeding and energy conservation to vigilance and cryptic predator avoidance. Given sufficient disturbance, chick energy reserves would be depleted, making them more susceptible to inclement weather and predators. Disturbance reduced fledging success. Researchers concluded that human disturbance may be an important component of the species' population decline throughout the range.

Gill, J. A., K. Norris, and W. J. Sutherland. 2001. The effects of disturbance on habitat use by black-tailed godwits *Limosa limosa*. Journal of Applied Ecology 38:846-856.

There are 2 components to the problem of disturbance: whether human presence causes animals to avoid areas that they would otherwise use, and whether this in turn affects mortality, reproductive success or population size. *[It isn't as simple as this, because animals don't have to avoid an area to affect mortality, reproductive success or population size.]* In a previous study the researchers showed that black-tailed godwits were the major cause of overwinter depletion of available prey in the study areas. Levels of human activity were measured on weekdays when weather conditions were good

and within 3 hours of low tide. Effect on the birds was measured by whether the birds moved or took flight and how long the disturbance lasted. This study included 6 estuaries with some of the highest levels of recreational use in Britain, and the 2 sites with the highest levels of human activity in winter were marinas and footpaths. For the footpath survey, 3 types of sites were selected in each estuary: those with high levels of human activity (>20 people/hour), those with low levels of human activity (<10 people/hour), and sites with no footpaths. The distribution of godwits at 3 levels of analysis (patches, large mudflats, estuaries) was strongly related to available bivalve (food) density. There was not a significant relationship between numbers of godwits and human activity. Distance from the nearest road or footpath did not affect overwinter depletion of available bivalves. Black-tailed godwits are not hunted in wintering sites in Britain or breeding grounds in Iceland; this may be one reason for the lack of a detectable response to human presence. *[Researchers did not measure energy depletion of flying and stress or overwinter survival rates of godwits.]*

Gill, J. A., W. J. Sutherland, and K. Norris. 1998. The consequences of human disturbance for estuarine birds. RSPB Conservation Review 12:67-72. *[cited in Burton et al. (2002)]*

Estuaries with frequently used footpaths held lower densities of waterbirds and, in particular, black-tailed godwits, than those with no or only infrequently used paths.

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 Bulletin 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. By the time most people arrive on the receding tide, most birds had moved to their muddy low water feeding areas where they were little disturbed. Bait-digging and dog-walking were common there throughout the year, and in summer boaters and wind-surfers visited sandy islands. People generally avoided the mudflats used by the majority of shorebirds and, by mid-winter when birds are most hard-pressed for food, few people visited the estuary. Oystercatchers and smaller numbers of other shorebirds feeding on mussel beds were sensitive to human disturbance. Disturbance could be intense at mussel beds; however, disturbance levels varied greatly, depending on access. As the number of people increased, most birds spent less time feeding and did so at a lower rate. Presence of three people (there are seldom more) reduced the average proportion of birds feeding from approximately 85% to 65%; that is, the average bird fed for 20-25% less of the time. Severe disturbance occurred if several casual shell-fishers along with dog-walkers or birdwatchers roamed over the mussel beds at the same time, and the birds tended to leave the area. Two of the smallest

mussel beds were seldom used by birds in daylight because people occurred there almost continuously. If present in sufficient numbers, people can prevent birds using otherwise suitable feeding habitat. However, when disturbance does occur, birds compensated by moving elsewhere or by feeding at a greater rate during undisturbed periods, including night. Researchers concluded there was no evidence that levels of human disturbance significantly affected the feeding, and thus numbers, of overwintering shorebirds in this estuary.

Hatch, D. A. 1996. Western snowy plover (a federally threatened species) wintering populations and interaction with human activity on Ocean Beach, San Francisco, Golden Gate National Recreation Area, 1988 through 1996. Report. Golden Gate National Recreation Area, National Park Service, San Francisco, California. *[cited in Lafferty (2001)]*

With education and posting, but without enforcement, 10% of owners leashed their pets at Ocean Beach, San Francisco. Full-time enforcement brought compliance to near 100%, mostly because pet owners moved their activity to adjacent beaches lacking enforcement.

Kålås, J. A., P. Fiske, and S. A. Sæther. 1995. The effect of mating probability on risk taking: an experimental study in lekking great snipe. The American Naturalist 146:59-71.

Male snipe that return to the lek rapidly after being flushed gain additional mating advantage because fewer competing males are present. Researchers in Norway flushed great snipe males from leks once each night and compared their hiding times to their temporary expected mating probabilities. Snipe were flushed by walking rapidly toward the lek for about 15 seconds. Hiding times during the peak breeding season averaged about 1-3 minutes per flush; later in the breeding season hiding times were about 4-11 minutes per flush. Habituation was not observed.

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, including black-bellied plover, red knot, sanderling, dunlin, and bar-tailed godwit. Increasing disturbance attributed to walkers, dogs, and horse riders 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.

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

Interactions between birds, people, and dogs on a Santa Barbara beach often caused birds to move or fly away, particularly when people were within 20 meters. On this stretch of beach each bird, on average, was disturbed dozens of times/day. During the 2-10 minute observation period, 10% of people disturbed an average of 10 birds each (of which about 70% flew). Joggers, which were less abundant than walkers, disturbed twice as many birds/person. Bikers were less likely to disturb birds than walkers or joggers; however, birds disturbed by bikers were more likely to fly. On average, there were 11 dogs to every 100 people, or about 2 dogs/kilometer. During the same short observation period, 39% of dogs disturbed 22 birds each (of which 75% flew). Leashing reduced both the probability that a dog disturbed birds and the number of birds/disturbance; however, only 7% were leashed. The leash law was posted at the beach entrance, but the law was not enforced. Birds were less reactive to humans (but not dogs) when beach activity was low. When disturbed birds moved, they did not often move out of the sector where they were disturbed, making the effect of disturbance difficult to detect at this scale. This is consistent with other research; however, other research has measured effects of recreational disturbance on shorebird abundance in larger areas or among beaches. Disturbance rates could be minimized by concentrating human activity away from preferred shorebird habitat. This could include the strategic distribution of parking lots and access points. Where birds and humans overlap, reducing the frequency of high-impact activity, such as unleashed pets, could also substantially reduce disturbance. Changing human behavior is likely to be a challenge, requiring sustained efforts of education, notification, and enforcement.

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

Plover avoidance behavior (moving or flying) was 16 times higher at a public beach than at protected beaches in southern California. Wintering plovers reacted to disturbance at half the distance (about 40 meters) as has been reported for breeding snowy plovers (about 80 meters). Humans, dogs, crows and other birds were the main sources of disturbance on the public beach, and each snowy plover was disturbed, on average, once every 27 weekend minutes and once every 43 weekday minutes. Dogs off leash were a disproportionate source of disturbance. Only 21% of dogs were leashed even though posted regulations required leashing. Plovers were more likely to fly from dogs, horses, and crows than from humans and other shorebirds. A smaller proportion of joggers (6%) disturbed plovers than did walkers (19%). Over short time scales, plovers did not acclimate to or successfully find refuge from disturbances. Feeding rates declined with increased human activity. A model found that prohibiting dogs and a 30-meter buffer zone surrounding a 400-meter stretch of beach provided the most protection for plovers for the least amount of impact to beach recreation. Snowy plovers are less frequently disturbed than most other shorebirds because (1) snowy plovers are relatively hesitant to move or fly from a person or dog and (2) snowy plovers roost in the dry sand away from most foot traffic.

Lord, A., J. R. Waas, and J. Innes. 1997. Effects of human activity on the behavior of northern New Zealand dotterel *Charadrius obscurur aquilonius* chicks. Biological Conservation 82:15-20.

Chicks belonging to 6 pairs of adults were observed. During “disturbed” days, visitors to the refuge walked freely in the intertidal zone; however, the nesting area on the sandy beach is fenced. People frequently passed within 3-5 meters of the chicks and were almost always unaware of their presence. “Undisturbed” observations were obtained by cutting off human access to the refuge for three 3-day periods. When people were present, chicks spent less of their time in the intertidal zone, where they feed, and more in the sandy beach zone, and in general spent less time feeding when people were present.

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

Dotterels usually lay their eggs on open sandy beaches. Researchers experimentally approached 15 nests by walking, running, or with a leashed dog. Nesting pairs were sampled at sites subjected to either high or low levels of human activity. High activity levels were 7-30 visitors/hour (7 nests). Low activity levels were 0-3 visitors/hour (8 nests). Leading a dog caused the greatest disruption of incubation, while responses to walking and running approaches did not differ significantly. The mean flush distances in response to walking and running versus walking with a dog were 64 meters and 94 meters, respectively. The mean times off the nest for walking and running versus walking with a dog were 208 and 288 seconds. There was evidence of habituation or greater tolerance on busy beaches. Birds nesting on beaches with high levels of human activity responded with shorter flush distances when approached by a walker, but beach usage level did not significantly affect responses for the other treatments. Beach usage level was not significantly related to the amount of time spent off the nest in response to any approach. However, during the approach with a dog, there was a trend for incubation to be disrupted for longer period at beaches with fewer visitors. The researchers speculated that dotterels would respond even more intensely to an unrestrained dog. They recommended that dogs be banned within 100 meters of dotterel nesting sites, and human access should be prevented within 50 meters on busy beaches and 70 meters on remote beaches.

Milsom, T. P., D. C. Ennis, D. J. Haskell, S. D. Langton, and H. V. McKay. 1998. Design of grassland feeding areas for waders during winter: the relative importance of sward, landscape factors, and human disturbance. Biological Conservation 84:119-129.

Researchers examined the relative importance of ground habitats, landscape variables, and sources of human disturbance to the suitability of permanent grass fields as winter feeding habitats for golden plovers, curlews, and other waders and brent geese. In general, larger fields are used more frequently and by the greatest number of birds, and fields enclosed by tall hedges, trees or other barriers are less attractive. The attractiveness of fields to waders and brent geese will be enhanced if they are situated away from sources of frequent human 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.

Paving a 4-kilometer section of the trail appears to have resulted in a two-fold increase in the number of visitors. Following paving, 3.8% of walkers strayed from the path, compared to over 30% before paving. Thus, despite the increased pressure along the route, the overall level of recreational disturbance to the surrounding moorlands has fallen dramatically. The number of people using the trail ranged from 95-518 per day (mean = 311). This includes many people who were counted twice due to a round trip. About 1 dog was observed for every 21 walkers, and 57.5% of the dogs were off leash. The proportion of dogs kept on a leash has increased in the last decade (from 33.6% to 42.4%), possibly as a result of publicity of the previous research; however, a significantly greater proportion of the dogs off leashes were running over 25 meters from their owners compared to a decade earlier (from 8.6% to 14%).

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 semipalmated 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.

Robinson, J. A., and M. S. Pollitt. 2002. Sources and extent of human disturbance to waterbirds in the UK: an analysis of Wetland Bird Survey data, 1995/96 to 1998/99. Bird Study 49:205-211.

Human activities and perceived disturbance were routinely recorded during national bird surveys. Bird counters were not asked to indicate the species or number of birds disturbed by human activities, nor were they asked to quantify the level of the activity present at the site. However, they recorded

disturbance levels in 4 categories. During this period, about 100,000 counts were conducted and over 83% of the counters completed the disturbance section. Of these, 68% indicated that there had been no disturbance on their site, 26% moderate disturbance (birds moving in response to a stimulus), 5% high levels of disturbance (birds temporarily flying in response to a stimulus), and 1% very high levels of disturbance (birds continually moving around in response to a stimulus). Disturbance was most frequently recorded at coastal and estuarine sites, and high and very high levels of disturbance occurred more frequently at mineral extraction pits and coastal and estuarine sites than in other habitat types. Almost 37% of counters observed at least 1 human activity at the count site. Walkers and dogs were by far the most frequently observed at inland and coastal sites. During the 4 years of the study, hunting declined whereas numbers of walkers increased. Walkers and anglers were the most frequently observed activities in summer. Shooting occurred most frequently in fall and winter, during the open hunting season. Ultralight flying, jet-skiing, and shooting caused the greatest disturbance relative to their occurrence. However, these activities were observed infrequently (e.g., shooting at 1-2% of sites) compared to walking (35-40% of sites), dogs, and angling. Comparatively, walkers, horse riders, shooters, vehicles, wind-surfers, and aircraft were far more likely than other recreational activities to disturb birds at coastal sites. Because recreational disturbance events are generally more frequent on weekends and at high tides (in coastal areas), the counts were likely to have been conducted during periods of highest disturbance.

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.

Rusticali, R., F. Scarton, and R. Valle. 1999. Habitat selection and hatching success of Eurasian oystercatchers in relation to nesting yellow-legged gulls and human presence. Waterbirds 22:367-375.

This study compared bird use of small, offshore islets in northeastern Italy. Eurasian oystercatchers nest primarily on sand islets, just above high tide, in lagoons, deltas, and estuaries, and feed on adjacent tidal flats. Islands subject to heavy human disturbance, including those linked to the mainland, hosted far fewer oystercatchers, and no gulls at all, than those not linked. Human disturbance was second to gull predation in causing a significant loss of eggs. Although clutch size on disturbed islands was similar to that on undisturbed islands (3.5 vs. 3.41), the number of eggs hatched per clutch was far lower (0.5 vs. 2.46).

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; whereas cattle, cars, dogs, or people with predictable movement patterns (e.g., farmers) are less disturbing. Cyclists that remain on paths are one of the least likely sources of disturbance. 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. Species of shorebirds, ducks, and geese tend to flush in response to walking people at different distances, ranging from 47-339 meters. When roosts are approached by walking people, golden plovers are fairly tolerant (mean flushing distance >40 meters [130 feet]), but curlews and redshanks tend to take flight at >90 meters [300 feet]. Walking people within 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 there. Some birds change their behavior at distances that 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. Flight distances are time and location dependent. For example, curlews roosting in cultivated grassland areas with a certain amount of human activity could be approached to approximately 100 meters, whereas on the salt marshes on the same island the flight distance was 200 meters. 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.

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

Response to disturbance is often measured as the distance over which animals respond to disturbance or the time to return after human activity has ceased. At low tide, oystercatchers were disturbed experimentally at an estuary in England by a person walking across a mussel bed until all birds took flight ("bed-wide disturbance"). Typically, oystercatchers would land nearby, but in late winter many returned immediately. In another set of experiments, a person walked to the edge of a mussel bed and after 30 minutes recorded distances to the nearest, apparently unaffected groups of birds ("local disturbance"). Oystercatchers approached more closely later in winter. Their behavioral response to disturbance was less when they were having more difficulty surviving, measured by the number of birds feeding before the disturbance; hence, their starvation risk of avoiding disturbance is greater. The results of this study have implications for studies that assume that a larger behavioral response means that a species is more vulnerable to disturbance. The opposite may be true.

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

Urbanization and coastal development has dramatically reduced the beach habitat available for foraging shorebirds worldwide. The number and activity of people on two California beaches significantly reduced the amount of time sanderlings spent foraging. The number of people, type of human activity, free-running dogs, and estimated distance of humans from the sanderling had significant effects on estimated distance and number of times the sanderling moved and the response of the sanderling to the approaching human. The average minimum approach distance for all activities combined was 14 meters, and 96% of sanderlings responded to humans when people were 30 meters or closer. Although the sample size was low, the most significant negative factor was the presence of free-running dogs. Human impact on foraging shorebirds can be minimized on beaches by (1) maintaining a minimum distance of 30 meters from areas where shorebirds concentrate and (2) strictly enforcing leash laws.

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

Researchers conducted 2 experiments to quantify effects of human disturbance on foraging and parental care in European oystercatchers. These birds breed on the salt marsh and feed on the mudflat. Most of the study area was closed to visitors during the breeding season. Chicks were 2-3 weeks old. In the first experiment (4 pairs), 2 observers each followed a member of the focal pair for 2 hours before and 1 hour after the daily feeding period (low tide) when the birds were in the feeding territory until they were outside the territory, where they would then normally continue foraging. During the hours of disturbance, the incubation time was significantly reduced on the disturbance day, compared with the control days, and foraging time lost during the disturbance period was not compensated for later in the tidal cycle. Reduced incubation time may slow fetal development and probably increased vulnerability to predation. In the second experiment (6 pairs), the observers varied the distance between themselves and the edge of the marsh where the chicks were for 2 hours before and 2 hours after low tide. Responses were measured at 100, 200, and 300 meters from the marsh edge. The distance of observers from the salt marsh (and the hiding chicks) did not affect the amount of food eaten by the adults; however, with increasing the level of disturbance by decreasing distance between observers and chicks, the chicks were fed at a lower rate. There is no evidence that compensation occurred, at least within the time frame of the experiments. Chick survival is

related to chick growth. Both experiments demonstrated that human disturbance of foraging reduced the amount of parental care and thus presumably reproductive success.

Verboven, N., B. J. Ens, and S. Dechesne. 2001. Effect of investigator disturbance on nest attendance and egg predation in Eurasian oystercatcher. Auk 118:503-508.

Eurasian oystercatchers breeding on a salt marsh in the Netherlands lose many eggs to predators, mainly herring and mew gulls. When researchers were in the study area, oystercatchers spent more time at greater distances from their nests. Researchers experimentally determined whether their presence resulted in more eggs being lost to predators. Two experimental areas were visited by 1 observer at high (3 times/day) and at low (once every other day) frequency for a week, then switched, for a total of 8 weeks. Egg losses resulting from the 2 treatments were not significantly different.

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.

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

The model predicted the impact of human disturbance on oystercatchers on their wintering grounds in an estuary in Great Britain. For the same overall area disturbed, numerous small disturbances would be more damaging than fewer, larger disturbances. A person walking across a preferred feeding area (e.g., mussel bed) was considered a major disturber. A person walking around or near a mussel bed was considered a minor disturber. When the time and energy costs arising from disturbance were included, disturbance could be more damaging than permanent habitat loss. The model predicted the consequences of several restrictions to human use of the shorebird habitat. The most effective restriction was to ban disturbance during the second half of the winter, because the birds could compensate for disturbance early in winter when feeding conditions were good and energy requirements low. The model suggested that even if oystercatchers on the estuary habituated to unpredictable disturbance or modified their response to it during cold weather, they would be unable entirely to compensate for the costs of disturbance.

GULLS AND TERNS

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

Authors reviewed 64 published investigations reporting effects of human disturbance. They cited recommendations for minimizing visitor disturbance, including buffer zones of 100-400 meters for common terns and 100 meters for least and royal terns.

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

Researchers compared spatial and temporal variation in the composition and abundance of 19 species of marine birds subjected to human recreational activity on a 1.5 kilometer stretch of rocky coast. The most common species were kelp gull, olivaceous cormorant, and dark-bellied cincloides, but 3 migratory species—whimbrel, ruddy turnstone, and surfbird—became locally abundant during summer and fall. The highest mean number of people observed along the study area during bird surveys (56) was recorded in summer and the lowest (5) in winter. The number of people per observation point was negatively correlated with the maximum number of birds observed at the same location. Further evidence of human effects on the spatial and temporal distribution of shorebirds and seabirds was the persistently higher number of birds recorded on observation points located inside a small marine reserve (about 200 meters of the shoreline) and the increase in the number of birds inside the reserve on weekends, when more people visit the coast. Human interference appeared to be stronger and more evident for birds roosting on the beach zone than for birds actively foraging on the intertidal zone.

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

Common, least, and royal terns in Virginia and North Carolina flushed at average distances of 142, 64, and 106 meters, respectively, when humans approached the colony directly.

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

Human disturbance of colonies of nesting herring gulls was studied in Maine. Disturbance was measured subjectively on the basis of the number of old fireplaces, beer cans, and picnic groups observed. Hatching success was inversely related to the disturbance of colonies by picnickers, which apparently caused the adults to leave their eggs exposed to sufficient solar radiation to addle the eggs. During the 2-year study, hatching success at disturbed colonies (19-25%) was half that at undisturbed colonies (43-54%). After the eggs hatched, there was no significant difference between disturbed and undisturbed colonies in chick-raising success.

Morrison, B. 1996. Effects of human disturbance on the breeding success of Arctic Terns (*Sterna paradisaea*) and on the behaviour of Arctic and Common Terns (*Sterna hirunda*) during the 1995 breeding season at Machias Seal Island, N.B. B.S. Thesis. University of New Brunswick, N.B. *[cited in Nisbet (2000)]*

Investigator intrusions, including intensive nest studies, had no effects on breeding success of arctic or common terns.

Nisbet, I. C. T. 2000. Disturbance, habituation, and management of waterbird colonies. Waterbirds 23:312-332.

Author critiques Carney and Sydeman (1999), adding another 64 reports of the effects of human disturbance. He challenges the mind-set that the effects of disturbance are always adverse and believes published studies and reviews overstate the significance of human disturbance, especially investigator activity. He proposes definitions for human disturbance, habituation, and tolerance and classifies types of disturbance and effects. He does not believe physiological effects (e.g., increased heart rate), flushing, nest desertion, abandonment of the colony by some or all pairs, or reductions in hatching success should be classified definitively as adverse unless it can be shown that they result in reductions in survival or reproductive success because pairs may re-lay eggs, relocate to another breeding area, or compensate by increased survival of other chicks. Only reduction in breeding success, deaths of individual adults, and reduction in local, regional, or total populations should be classified definitively as adverse. Nisbet concludes that, with modest precautions, most or all species of terns can be studied—in some cases intensively and intrusively—without significant adverse effects. He chastises researchers for publishing studies without rigorous scientific proof (e.g., longitudinal measurements, controlled repetition, hypothesis testing) of adverse impacts. However, Nisbet also relies heavily on decades of anecdotal evidence and personal experience. He agrees that in eastern North America breeding terns tend to concentrate at sites where human disturbance is least and where disturbance is limited by protection and management. He agrees that predation and human disturbance tend to co-occur, partly because many of the predators are human commensals. He agrees that actual effects of human disturbance on terns are probably occurring but are under-reported in the scientific literature. He agrees that demonstrating causal relationships between human disturbance and adverse effects on colonial waterbirds, especially for uncontrolled visitors, is inherently difficult. In 30 years of research at the same colony, common terns have learned to tolerate researchers and have also become tolerant of other visitors. He believes that high tolerance is a "natural" state for many seabirds; low tolerance is an acquired response to human predation in the past. There are 2 ways to minimize adverse effects of human disturbance: 1) prohibit all human access, including research, or 2) actively promote habituation so that the birds learn to tolerate human presence and breed successfully in spite of constant human activity. Both require active management, including frequent (although not necessarily daily) presence of wardens or monitors. Nisbet recommends the second strategy, where wardens and monitors must disturb the colonies frequently, regularly, and predictably to facilitate habituation. Nisbet admits that all of these recommendations must be tempered in cases where colonies are subject to predation by diurnal avian predators such as gulls or crows. *[Although Nisbet's ideas have merit, it is obvious that humans*

cannot actively manage every waterbird colony subject to any human disturbance. Some colonies will be lost, some will continue to function with low levels of disturbance, some will be studied or designated as educational or recreational sites, and some will be protected by prohibiting human access.]

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

Common terns flushed at an average distance of 80 meters in Florida.

Shealer, D. A., and J. A. Haverland. 2000. Effects of investigator disturbance on the reproductive behavior and success of black terns. Waterbirds 23:15-23.

Researchers experimentally compared 4 levels of disturbance on terns breeding at a relatively undisturbed site: high (nest site visited every 4 days and both adults trapped or attempted to trap), moderate (same, except only 1 adult trapped), low (same, except no adults were trapped), and minimal (nest not visited between clutch completion and hatching, about 20 days). They found no differences in either hatching success or fledging success among the treatments. None of the 23 adults trapped on nests permanently deserted its clutch. The only detectable adverse effect was that adults trapped early in the incubation period took longer to return to the nest site than those trapped later. Intense study of black terns can be conducted without detrimental impacts on reproductive success.

GROUSE

Olsson, G. E., T. Willebrand, and A. A. Smith. 1996. The effects of hunting on willow grouse *Lagopus lagopus* movements. Wildlife Biology 2:11-15.

Researchers used radio telemetry to monitor movements of willow grouse (similar to ptarmigan) in a heavily hunted area compared to movements in areas where hunting was prohibited. The following fall, 6 grouse were deliberately flushed once every other day for about 3 weeks (mean flushes was 7.8) to compare with hunted grouse. No significant differences were found. Willow grouse did not move out of the hunted area and seasonal migration was not induced by deliberate human disturbance during the fall and winter hunting season.

Räty, M. 1979. Effect of highway traffic on tetraonid densities. Ornis Fennica 56:169-170. *[cited in Reijnen et al. (1997)]*

Grouse species in woodlands were disturbed up to a distance of 500 meters near relatively quiet highways, and the density of the grouse population in the disturbed zone was reduced by 50% or more.

RAPTORS

Anderson, D. E., O. J. Ringstad, and W. R. Mytton. 1990. Home-range changes in raptors exposed to increased human activity levels in Southeastern Colorado. Wildlife Society Bulletin 18:134-142.

During a 3-week period, approximately 2,700 personnel and 1,000 vehicles used an area of approximately 600 km^2 for military training. Training activity included helicopter overflights, simulation of heavy weapons firing, military traffic and maneuvers, and camps of generally <3-5 days and several hundred personnel. Red-tailed, Swainson's, and ferruginous hawks and golden eagles in the experimental group shifted the center of their home range and activity areas, increased the size of the area they used, and made extra-home range movements more frequently than raptors in the control group.

Anthony, R. G., and F. B. Isaacs. 1989. Characteristics of bald eagle nest sites in Oregon. Journal of Wildlife Management 53:148-159.

Human activities and man-made structures within 1.6 kilometers of nest trees were used as an indication of potential human disturbance. Each type of human activity was scored based on the potential for disturbing nesting bald eagles. A second score was assigned based on distance of the activity or structure from the nest tree, and the ratings were combined. Bald eagles appeared to select forest stands for nesting that were dense and had high basal areas, and where logging activities and other human activities were limited. Human activities appear to have influenced the selection of alternative nests within breeding territories. Recently used nests were farther away from recreational facilities and paved, gravel, and logging roads than old nests. Bald eagles prefer to nest near water but have moved farther away from water because of human disturbance. Maintenance of high tree density and moderate canopy closure are important for visual buffers to human disturbance and protection from nest and nest-tree blowdown. USFWS buffers of 100 meters (primary zone) and 200 meters (secondary zone) from the nest tree are inadequate. Human activities within 800 meters of nests should be restricted from January 1 to August 31, and clearcut logging, road building, hiking trails, and boat launch facilities should not be allowed within 400 meters of nests.

Boal, C. W., and R. W. Mannan. 1999. Comparative breeding ecology of Cooper's hawks in urban and exurban areas of southeastern Arizona. Journal of Wildlife Management 63:77-84.

Cooper's hawks are similar to northern goshawks. Urban pairs nested earlier and had larger clutches than those in undeveloped, natural areas. Nestling mortality was greater among urban nests (50.3% vs. 4.9%). The primary cause of death among urban nestlings was trichomoniasis. An overall failure rate was greater among urban nests (52.6% vs. 20.5%). Urban bird feeding has been implicated in the spread of trichomoniasis. The greatest cause of mortality among free-ranging Cooper's hawks in the urban area was collisions (69.8%), primarily with windows. Cooper's hawks are occasionally aggressive when defending their nests from perceived threats, which may lead to fear and persecution by city residents.

Brown, B. T., and L. E. Stevens. 1997. Winter bald eagle distribution is inversely correlated with human activity along the Colorado River, Arizona. Journal of Raptor Research 31:7-10.

Helicopter surveys found 22 times more eagles in river reaches with low human use compared to river reaches with moderate to high human use. Although some bald eagles have apparently habituated to human activity according to some studies, there was no evidence of habituation in this area. Researchers recommend managing some areas as refugia where bald eagles are not excluded or influenced by human activity.

Buehler, D. A., T. J. Mersmann, J. D. Fraser, and J. K. D. Seegar. 1991. Effects of human activity on bald eagle distribution on the northern Chesapeake Bay. Journal of Wildlife Management 55:282-290.

Bald eagle distribution along the shoreline was compared to indices of human activity and development. A shoreline segment was classified as used by humans if pedestrians or boats were observed within 500 meters of that segment on any survey. Developed segments were those with at least 1 building within 500 meters. Eagle use of pedestrian-used segment was lower than expected when pedestrian activity was greatest. Few eagles used shoreline segments with boats or pedestrians nearby. Only 55 of 1,117 locations of radio-tagged eagles (4.9%) occurred in the developed land-cover type (≥4 buildings per 4 hectares); although 18.2% of potential bald eagle habitat was developed. Eagle use of the shoreline was inversely related to building density and directly related to the development set-back distance. Eagles were seldom observed within 500 meters of human activity. No eagles were observed in the Baltimore area, apparently because of the intense development of 70% of the shoreline. Shoreline segments with at least 1 building per hectare were almost never used. Eagle flushing distances were estimated by approaching perched eagles by boat (>3 km/hr) from a distance ≥500 meters and perpendicular to the shoreline). Summer and winter flush distances averaged 176 and 265 meters, respectively. Bald eagles do not appear to be adapting to human presence in Chesapeake Bay.

Delaney, D. K., T. G. Grubb, P. Beier, L. L. Pater, and M. H. Reiser. 1999. Effects of helicopter noise on Mexican spotted owls. Journal of Wildlife Management 63:60-76.

Nesting owls were experimentally disturbed using helicopters or chainsaws. Owls exhibited alert responses (i.e., head movements) when helicopters were an average of 403 meters away. No spotted owls flushed out of the nest box when the disturbance was >105 meters away. Chain saws were more disturbing than helicopters at comparable distances. At ≤60 meters during the non-nesting season, response to chain saws (72%) was greater than response to helicopters (20%). Spotted owls returned to pre-disturbance behavior within 10-15 minutes after a stimulus event. Spotted owls tend to be less affected by nearby, nonthreatening human activity than most other raptor species; however, it is possible that human presence increased the stimulus of the chain saw noise. Short duration, single pass, single aircraft overflights had little effect on spotted owls.

Dykstra, C. R., J. L. Hays, F. B. Daniel, and M. M. Simon. 2000. Nest site selection and productivity of suburban red-shouldered hawks in southern Ohio. Condor 102:401-407.

Red-shouldered hawks nests in suburban habitat were very similar to rural nests in site selection and productivity.

Estes, W. A., and R. W. Mannan. 2003. Feeding behavior of Cooper's hawks at urban and rural nests in southeastern Arizona. Condor 105:107-116.

Eighteen nests were monitored in Tucson and 18 nests in rural areas. Urban hawks delivered approximately twice as much prey biomass per nestling per hour to nests than rural hawks. Prey appeared to be more abundant and available to urban hawks than rural hawks. Diet composition also differed. Doves comprised 57% of urban prey deliveries, but only 4% of rural prey deliveries, and may explain the high rate of nestling mortality from trichomoniasis, an avian disease often associated with doves, at urban nests (infection rates of 85% urban, 9% rural). Overall, urban and rural hawks delivered at least 12 and 27 different species of prey to nests, respectively.

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.

Fraser, J. D., L. D. Frenzel, and J. E. Mathisen. 1985. The impact of human activities on breeding bald eagles in north-central Minnesota. Journal of Wildlife Management 49:585-592.

Researchers found no evidence that, under current management policies, human activities have an important impact on bald eagle reproductive success on the Chippewa National Forest. However, level of human activities along roads and trails within 1.5 kilometers of unsuccessful nests was determined up to a week after a nest failed, not during nesting, and there were other confounding factors. Nests built on developed shoreline were significantly farther from the water (80-1,200 meters) than nests built on undeveloped shoreline (10-400 meters), and nests were farther from clusters of occupied houses than expected. Eagles avoided human settlements when building new nests, although researchers acknowledged individual eagles differ in response to disturbance and the same eagles may respond differently at different times. Breeding eagles flushed at 57-991 meters (mean = 476 meters) at the approach of a pedestrian. Rather than habituating to repeated intrusions, eagles flushed at increasing distances with additional disturbances. Results suggested that, if buffer zones remain inviolate, restriction of human activities with 500 meters of nests will prevent disturbance in populations similar to the study population. If occasional violations of the buffer zones are expected, as might be the case in populated regions, a large zone may be desirable to ensure against disturbing sensitized birds.

Grubb, T. G., and R. M. King. 1991. Assessing human disturbance of breeding bald eagles with classification tree models. Journal of Wildlife Management 55:500-511.

Volunteers recorded human activity in the vicinity of 13 eagle nests in Arizona during >51,000 hours of observation over a 3-year period. Bald eagles were more often flushed from perches than nests and were most easily disturbed when foraging. Pedestrians were the most disturbing human activity, ranking highest in response frequency (79% at ≤543 meters) and duration (median = 8 minutes). At <72 meters any human activity, regardless of type or characteristics, caused a very high response. Hikers and anglers had the same median duration, but the comparatively louder and more mobile hikers elicited twice the response duration. Aircraft was the most common activity, yet it consistently showed the lowest levels of response. The median distance for awareness, as indicated by alert or restless behavior, was 300 meters; however, a better estimate of threshold for response is 630 meters, the distance within which 75% of the alert observations were observed. The response frequency and critical distance (75% at ≤445 meters) for vehicles was comparable to pedestrians; however, most vehicles were off-road, frequently noisy, and rarely consistent in pattern. Researchers suggested a minimum, generic, primary zone of approximately 600 meters around breeding eagles. Beyond this distance response frequency was generally below 30%. A 1,200-meter secondary buffer zone would accommodate most of the distant responses from vehicle, noise, and aircraft disturbance. Typically, the researchers recommend, no human activity should be permitted at any time within a

primary protection zone. Implications of the model include managing for low numbers per event and visual buffering at ≤215 meters and for short duration, quiet activities at >216 meters. All else being equal, pedestrian activity should be given first priority for management.

Holmes, T. L., R. L. Knight, L. Stegall, and G. R. Craig. 1993. Responses of wintering grassland raptors to human disturbance. Wildlife Society Bulletin 21:461-468.

The effects of walkers and cars on raptors were experimentally tested in Colorado. A walk disturbance consisted of one person approaching a perched raptor along the center of the road. A vehicle disturbance consisted of a vehicle approaching a perched raptor at a constant speed of 70 km/hour. Kestrels, merlins, rough-legged hawks, and golden eagles were more likely to flush when approached by a human on foot than an automobile. Although flush distance did not vary with disturbance type for kestrels, merlins, and prairie falcons, it was greater during walk disturbances for rough-legged hawks and golden eagles and greater during vehicle disturbances for ferruginous hawks. Overall, 97% of raptors approached on foot flushed with a mean flush distance of 118 meters, whereas 38% of raptors approached by car flushed with a mean flush distance of 75 meters. Small species rarely flushed at distances >125 meters, whereas large species often flew when disturbances were >200 meters away.

Jaksic, F. M., E. F. Pavez, J. E. Jimenez, and J. C. Torres-Mura. 1995. The conservation status of raptors in the metropolitan region, Chile. Journal of Raptor Research 35:151-158.

Of 24 raptors found in a metropolitan area with 5.5 million people in an area of 15,800 square kilometers, 4 species have increased over the last 30 years, 7 have decreased, and 11 remained at the same levels. All of the species that are decreasing are doing so because of habitat deterioration brought about by human activities including the clearing of native vegetation for agricultural and urban development. The four species, including the kestrel, that are increasing have been benefited by the same processes that affect the remaining species. They are thriving in the new habitats created by humans, apparently because of increases in commensal species such as introduced mice and naturalized birds, which serve as new prey. They also tend to be small birds, and tolerant of human activities.

Jones, Z. F., and C. E. Bock. 2002. Conservation of grassland birds in an urbanizing landscape: a historical perspective. Condor 104:643-651.

A central question in conservation biology is whether particular sorts of reserve design and management can compensate for habitat lost to such things as urban growth. The goal of this study was to estimate what proportion and which species of grassland birds have been sustained by protection of open spaces in an urbanizing landscape (Boulder, Colorado). Conservation of many shortgrass prairie birds may be possible only on large uninterrupted expanses of grasslands relatively far from urban centers. Although northern harriers are considered a tallgrass species, its population has declined since the early 1900s, due perhaps to loss of wetland breeding habitat. The apparent long-term stability of ferruginous hawks around Boulder may be due to 2 opposing forces. They have undoubtedly lost preferred habitat due to development and a tendency to avoid urban edges; however, their primary prey, prairie dogs, are almost certainly more common now than 100 years ago, when livestock grazing provoked widespread prairie dog control efforts. Savannah sparrows have increased substantially due to an apparent shift from montane meadows to tallgrass prairies and hayfields; however, they also avoid urban edges.

Knight, R. L., D. P. Anderson, and N. V. Marr. 1991. Responses of an avian scavenging guild to anglers. Biological Conservation 56:195-205.

Refer to Songbirds.

Knight, R. L., and J. Y. Kawashima. 1993. Responses of raven and red-tailed hawk populations to linear rights-of-way. Journal of Wildlife Management 57:266-271.

Refer to Songbirds.

Knight, R. L., and S. K. Knight. 1984. Responses of wintering bald eagles to boating activity. Journal of Wildlife Management 48:999-1004.

Responses of eagles to experimental approach by canoes were measured on two rivers in Washington. The Skagit River receives heavy winter boating activity from anglers and others. An estimated 160 boats carried 1,200-1,300 people during the study period specifically to view eagles. The Nooksack River study area received little winter boating use. Eagles perched in trees along the Skagit flew in response much less often than along the Nooksack. The lack of flushing response from a large percentage of eagles on the Skagit may result from selection of perch sites farther from the river. Eagles perched in trees flew at a mean distance of 168 and 150 meters on the Skagit and Nooksack, respectively. Eagles standing or feeding on the ground flew at greater distances than perched eagles. Eagles on the ground flew at a mean distance of 233 and 267 meters on the Skagit and Nooksack, respectively. Eagles in groups on the ground flew at greater distances than solitary eagles on the ground or perched in trees and eagles in groups perched in trees. As winter progressed, perched eagles along both rivers showed a decreasing tendency to flush, indicating they may have habituated to boating activities. However, the low numbers of boats on the Nooksack suggested an alternative explanation. The Skagit had high levels of boating activity but low levels of food, whereas the Nooksack had low levels of boating activity but higher levels of food. Eagles may have been less likely to fly due to a decreased food supply. An activity restriction zone of at least 450 meters would be required to protect 99% of the feeding eagles on both rivers from disturbance by a single canoe.

Knight, R. L., and S. K. Skagen. 1988. Effects of recreational disturbance on birds of prey: a review. National Wildlife Federation Scientific & Technical Series 11:355-359.

Recreational disturbance can alter normal raptor activity patterns by (1) altering the distribution of raptors, (2) disrupting nest attentiveness patterns, (3) causing abandonment of breeding territories, (4) reducing productivity, and (5) affecting foraging behavior. Recreational disturbance of raptors 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. Under this second option two general strategies can be followed: spatial or temporal restrictions of recreational disturbances.

Mathisen, J. E. 1968. Effects of human disturbance on nesting bald eagles. Journal of Wildlife Management 32:1-6.

Human activity at levels existing in the Chippewa National Forest in Minnesota is not an important source of disturbance and has no measurable effect on nesting success or nest occupancy. Most human activity around nest sites occurred during the latter part of the nesting season after the young were about half grown and parents are least likely to abandon nestlings. The frequency and duration of disturbances were not measured, and infrequent observations of the nests from the ground were not entirely reliable methods.

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.

Plumpton, D. L., and D. E. Anderson. 1998. Anthropogenic effects on winter behavior of ferruginous hawks. Journal of Wildlife Management 62:340-346.

Ferruginous hawks appear to modify their behavior in fragmented, largely human-altered habitats, provided some foraging habitats with adequate populations of suitable prey species are present. Ferruginous hawks benefit by clumps of mature deciduous trees in suburban areas because they are used as roost sites and day perches. Likewise, the hawks used fences and utility poles as perches. The primary anthropogenic influence that impoverishes habitats is extirpation of prairie dogs or reductions in colonies to a size or level of isolation within human-altered landscapes than makes habitat unsuitable to ferruginous hawks.

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. 1980. Management strategies for wintering bald eagles in the Pacific Northwest. Pp. 49-67 *in* R. L. Knight, G. T. Allen, M. V. Stalmaster, and C. W. Servheen, eds. Proceedings of the Washington Bald Eagle Symposium. The Nature Conservancy, Seattle. *[cited in Knight and Knight (1984)]*

Recommended restricting land activities 250 meters from eagles perched in shoreline trees in order to protect 99% of the eagles. The buffer could be shortened to 75-100 meters if at least 50 meters of this zone contained dense, shielding vegetation.

Stalmaster, M. V., and J. R. Newman. 1978. Behavioral responses of wintering bald eagles to human activity. Journal of Wildlife Management 42:506-513.

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.

Stalmaster, M. V., and J. L. Kaiser. 1998. Effects of recreational activity on wintering bald eagles. Wildlife Monographs 137:1-46.

Winter use of the Skagit River Bald Eagle Natural Area in Washington was high for both eagles (peak 264 birds/day) and recreationists (peak 115 events/day), and human-eagle interactions were common. Number of eagles was negatively correlated with daily number of recreational events, and feeding activity declined exponentially with increased recreational activity. Based on flushing responses and distances, foot traffic was more disturbing to eagles than fishing boats or eagle-viewing boats. Mean flushing distances of perched eagles was 201 meters, and they flew an average distance of 710 meters from foot traffic. Eagles feeding on the ground were less tolerant than eagles perching in trees. Flights from the ground tended to be shorter than flights from perches; however, these eagles were often flushed again by the same or successive events, and then they flew longer distances. Strong winds increased the likelihood of flushing. Eagles resumed feeding relatively rapidly after the initial disturbances of the day, but after 20 recreational events, eagles were slow to resume eating and, after 40 events, feeding was uncommon. Eagles required nearly 4 hours to resume feeding after disturbance by foot traffic compared to 36 minutes after boat traffic. Abnormally high feeding activity after weekends indicates that some eagles adapted by delaying food intake until weekdays. A model predicted that feeding was reduced 35% because of recreational use. Flushing responses declined over the winter season but flushing distances were unchanged. This suggests a long-term redistribution of intolerant eagles from the eagle refuge, habituation to non-threatening activities, increased tolerance due to hunger, or a combination of these factors. There were situations in which birds were unable to adapt due to high levels of disturbance on most weekends, presence of humans walking on gravel bars, and any close encounters (<300 meters) between humans and eagles feeding on the ground, especially in the morning. A reduction in numbers implies that intolerant eagles were displaced to habitat of lesser quality than the eagle refuge. The consequences of disrupted feeding depend on the availability of alternative foraging areas within, or outside, of the refuge. A concentration area in the refuge had extremely high eagle densities and the frequency of fighting for food increased exponentially as group size increased, thereby lowering feeding efficiency of individuals. Another consequence of feeding disruptions includes the delay in consumption of salmon carcasses. Such delays increase the time for salmon to be eaten by scavengers that are more tolerant of humans, reducing the amount of food available to eagles. Human disturbance likely is reducing the quality of winter habitat and adversely affecting the carrying capacity of the river. Researchers recommended prohibiting recreational activity during the first 5 hours of daylight within 400 meters of eagles to minimize disturbance of feeding behavior and restricting foot traffic, among other things.

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 of breeding and nonbreeding bald eagles to recreational boating (nonmotorized). Flush response rate of nonbreeding eagles decreased as perch height and 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 a geographic location. Flush distance of nonbreeding eagles increased as perch height and distance from the river's edge increased and as the season progressed. Breeding adults were much less likely to flush than nonbreeding adults, and flushed at lesser distances (88 vs. 113 meters). Flush distance increased as the distance the disturbance was first visible increased; therefore, average flush distances may be higher in more open areas. Both flush response and flush distance of breeders and nonbreeders were highest in areas with the lowest levels of human activity. Researchers believed eagles did not habituate to humans,

but relocated to more secluded areas. One strategy used to establish buffer zone width is to determine the distance within which 95% of the eagles that are approached flush. For breeding and nonbreeding eagles in the Gulkana Basin these distances were 200 and 230 meters, respectively.

Steidl, R. J., and R. G. Anthony. 2000. Experimental effects of human activity on breeding bald eagles. Ecological Applications 10:258-268.

Researchers experimentally disturbed 20 eagle nests in Alaska during 50 continuous 48-hour observation bouts. Activity budgets of breeding eagles changed considerably when humans were camped for 24 hours at a distance of 100 meters from nests compared to when they were camped 500 meters (control) from nests. With humans near nests, adult eagles decreased the time they preened (by –53% compared to control), slept (-56%), maintained nests (-50%), fed themselves and nestlings (-30%). They also decreased the amount of prey adults consumed (-26%) and fed to their nestlings (-29%). Differences in observed impacts did not differ markedly between nests located in areas with relatively high and low levels of human activity. Throughout 24-hour visits, eagle responses to nearby humans diminished, suggesting that eagles habituated by the disturbance, although frequent vocalizations indicated continued agitation. Adults at nests visited on more than one occasion responded similarly to those visited only once. These changes in behavior suggest that frequent human activities near nests could adversely affect nestling survival, and therefore reproductive success. Golden eagles responses were similar to those observed for bald eagles. Vulnerability of eagles to human activities depends in part on the phase of their nesting cycle, breeding eagles are likely most vulnerable during egg-laying, incubation, and early brood rearing, when adults are tied most closely to nests.

Swarthout, E. C. H., and R. J. Steidl. 2001. Flush responses of Mexican spotted owls to recreationists. Journal of Wildlife Management 65:312-317.

Researchers experimentally assessed factors that influenced flush responses, flush distances, distances of avoidance flights, and behavioral changes of spotted owls in response to a single hiker who approached roosting owls. Increased perch height decreased the likelihood that adults and juveniles would flush; having flushed previously the same day increased the likelihood of adults flushing on subsequent approaches. A 55-meter buffer zone around roosting sites would eliminate virtually all behavioral responses of owls to hikers. A less conservative 12-meter buffer zone would eliminate 95% of juvenile and 80% of adult flush responses.

Swarthout, E. C. H., and R. J. Steidl. 2003. Experimental effects of hiking on breeding Mexican spotted owls. Conservation Biology 17:307-315.

Owls in Utah were experimentally disturbed by 1 person hiking past the nest once every 15 minutes (i.e., simulating 48 hikers/day). Although the overall changes to owl activity budgets were relatively small, hikers caused declines in several activities that could adversely affect reproductive success. During control treatments, the observer was the only human near nests. When hikers were present in the canyons, female owls decreased maintenance behaviors (including self-preening, preening nestlings, allopreening, and maintaining their nest) during midday by 30% and prey handling by 57% during all time periods (morning, midday, and evening) combined. Females in nests highest above hiking trails showed the strongest responses, suggesting that greater visibility may expose these owls to disturbance from hikers for a longer period of time. Because the observer was present at the "undisturbed" control treatment, hikers walking past unmonitored nests would likely have an even greater affect on owl behavior. Thus, the observed effects can be interpreted as the minimum response of owls to hikers. Cumulative effects of high levels of short-duration recreational hiking near nests may be detrimental to Mexican spotted owls.

Wasser, S. K., K. Bevis, G. King, and E. Hanson. 1997. Noninvasive physiological measures of disturbance in the northern spotted owl. Conservation Biology 11:1019-1022.

Two studies of captive spotted owls established the reliability of fecal corticosterone measures as an index of stress. Subsequently, fecal samples were collected from 16 owl pairs and 2 territorial single owls in the wild. Fecal corticosterone levels were significantly higher in adult male versus female owls in the wild, and in males with home ranges centered within 0.41 kilometer of a major logging road versus other territorial males.

White, C. M., and T. L. Thurow. 1985. Reproduction of ferruginous hawks exposed to controlled disturbance. Condor 87:14-22.

To simulate the effects of low-level human activity on nesting ferruginous hawks in Idaho, researchers disturbed 24 of 62 nests by approaching them once each day, either on foot or in a vehicle. Another treatment involved shooting a .22-caliber rifle about every 20 meters as the observers approached the nest; however, they could not separate the effect of the noise from the presence of the observers. None of the disturbance treatments produced significantly different effects on the birds, but their effects were significantly different from the nests that were not disturbed. Therefore, all disturbed nests were compared to undisturbed nests. Only 52% of territories containing disturbed nests were occupied the year after disturbance. In contrast, 93% of the territories containing undisturbed nests were occupied the following year. Undisturbed nests fledged, on average, 1 young more than successful disturbed nests or twice as many young if all disturbed nests are considered. The hawks differed slightly in response to treatments, but none increased tolerance over time. In fact, most became sensitized to the disturbances, flushing at increasing distances until just before their eggs hatched. Eight of the 9 nests that failed as a result of the disturbances were also not used the following year, a significant reduction. When a pair deserted a territory, the birds did not simply move to an adjacent site the following year. Therefore, if the pair from the deserted territory bred in the year following desertion, they would have had to move completely out of the area. Researchers observed that a buffer zone suitable to minimize the effect of brief human disturbance around ferruginous hawk nests is 250 meters. Adults will not flush 90% of the time if human activity is at greater distances (at 120 meters adults flushed 60% of the time). However, in years when prey are scarce, the buffer zone may need to be considerably larger.

SONGBIRDS

Askins, R. A. 1994. Open corridors in a heavily forested landscape: impact on shrubland and forest-interior birds. Wildlife Society Bulletin 22:339-347.

A literature review and commentary by a specialist in habitat fragmentation. Studies in eastern North America show that >25 species of forest songbirds tend to be more abundant in large forests than in small, isolated patches of forests. Most of these “area sensitive” species are neotropical migrants. Like forest fragmentation found in agricultural or suburban landscapes, logging and road building in state and national forests breaks the continuity of the forest canopy. Fragmentation of continuous forest into patches can reduce the abundance and diversity of Neotropical migrants even in fairly heavily forested landscapes. Instead of creating the crisscross pattern of open corridor found in many forests, it would be better to consolidate new roads, railroads, and utility corridors into a single open corridor.

Bart, J. 1977. Impact of human visitation on avian nesting success. The Living Bird 16:187-192.

This study used data gathered by hundreds of observers during many years across North America to evaluate whether human visits affect predation of nests. Reproductive success of 30,000 nests of 5 species (e.g., American robin, red-winged blackbird) was compiled. The total nest mortality rate, or loss of the entire clutch or brood, was higher on the first day after a visit than on subsequent days during the laying, incubation, and nestling periods. The high mortality rate immediately after a nest was visited by a human was assumed to be due to predators observing the nest disturbance or following the person to the nest.

Blair, R. B. 1996. Land use and avian species diversity along an urban gradient. Ecological Applications 6:506-519.

This researcher examined the distribution and abundance of bird species by censusing bird populations at 6 nearby sites in California. The urban gradient ranged from relatively undisturbed to highly developed and included a biological preserve, recreational area, golf course, residential neighborhood, office park, and business district. These sites were all former oak woodlands, believed to be similar to one another before development. None was completely undisturbed; the preserve had been used for cattle grazing and recreation until 2 decades before, but was now closed to public access. The recreation area was heavily grazed until a decade before and during the study was open space used by joggers, dog-walkers, hikers, and equestrians. Pedestrians, bicyclists and cars were counted 1 day as an index of human activity. The predevelopment species (assumed to be those found at the most undisturbed site) dropped out gradually as the sites became more urban. Seven species were “urban avoiders,” with maximum densities in the preserve, including dark-eyed junco and Steller’s jay. Thirty species were “suburban adaptable,” including violet-green swallow, mallard, robin, and starling. Three species were “urban exploiters,” including rock dove and house sparrow. The number of species and species diversity peaked in the open space recreational area and golf course. Bird density peaked at the golf course and residential area. Bird biomass peaked in the business district due to the abundance of rock doves. Moderate levels of development apparently increase the number of species, density, and diversity, but closer examination reveals that the increase results from the addition of widely distributed species at the expense of native species.

Bezzel, E. 1985. Birdlife in intensively used rural and urban environments. Ornis Fennica 62:90-95.

A review of human-related impacts on birds in central Europe. Nonpasserine land birds show the strongest decrease. Intensively used rural and urban areas have very low species numbers and very high numbers of the most abundant species. Tourism, outdoor sports, and other holiday activities are at present one of the most urgent problems of nature conservation. The only means of preserving a diverse array of birds in intensively used areas is to maintain a network of sparingly used, natural or seminatural reserves.

Clergeau, P., J. Jokimaki, and J.-P. L. Savard. 2001. Are urban bird communities influenced by the bird diversity of adjacent landscapes? Journal of Ecology 38:1122-1134.

Researchers compared relationships between the bird species richness and community composition between rural areas surrounding towns, suburbs, and town centers. The type of surrounding rural landscape, number of inhabitants, and town diameter did not affect bird species richness within towns. Bird species richness was similar between the cities of a given biogeographical area. However, highly urban areas tended to have similar bird species richness independent of their geographical location.

Neither bird species richness nor community similarity changed in relation to the distance of a city park from the surrounding rural landscape. At regional and local scales, urban bird communities are independent of the bird diversity of adjacent landscapes and local features are more important than surrounding landscapes in determining bird species richness.

Cooke, A. S. 1980. Observations on how close certain passerine species will tolerate an approaching human in rural and suburban areas. Biological Conservation 18:85-88.

The researcher approached birds at a normal walking pace. Mean flush distances were measured for 17 species on at least 10 occasions in either area. For 7 species, mean flush distances were significantly lower in the suburban area. Only 3 species, including 2 tits (similar to chickadees), were not significantly more approachable in the suburban area. Species tended to be significantly more approachable in suburban areas than in rural areas. Small birds allowed a closer approach than larger species.

Fernandez-Juricic, E. 2000. Local and regional effects of pedestrians on forest birds in a fragmented landscape. Condor 102:247-255.

The researcher assessed the effects of pedestrians on forest bird species within 3 large (18-110 hectares) and between 30 (0.4-110 hectares) other parks in Madrid. Within the parks, increasing numbers of pedestrians reduced species richness and overall abundance of individuals. Abundance of foraging individuals and breeding densities of 4 ground-feeding species, including magpies and blackbirds (similar to American robins), diminished when pedestrians walked near sampling plots. Between parks, after controlling for fragment size effects, pedestrian rate was negatively related to species richness for 25 recorded species. Only 1 species, blue tit, was not affected by human disturbance. The researcher concluded it is worth considering how human presence could disrupt bird patch-selection and fragment occupation in other habitats, particularly those which are of conservation value. Because of the interest of people in visiting wildlife refuges, human disturbance effects turn out to be particularly relevant in highly endangered habitats (namely wetlands) and outdoor recreational areas (national parks, reserves, etc.) that harbor threatened species. Wildlife managers are encouraged to carefully evaluate whether visitor presence could disrupt bird behavior and breeding densities, and then seek short and long term solutions, such as restrictions of overall visitor levels, re-distribution of disturbance loads, setting buffer zones for visitors, seasonal limitation of tourism, and restricting access to areas with high diversity value.

Fernandez-Juricic, E. 2001. Avian spatial segregation at edges and interiors of urban parks in Madrid, Spain. Biodiversity and Conservation 10:1303-1316.

This researcher compared the number of species, density of guilds, and density of individual species varied between the edge and interior of urban parks and analyzed patterns in relation to car and pedestrian traffic. He found 25 avian species in 5 guilds. Species included rock dove, blackbird, magpie, crossbill, treecreeper, and several tits (similar to chickadees) and woodpeckers. Car and pedestrian traffic was significantly higher in edge than in interior areas of the parks. Mean species richness was lower in edge than in interior areas. Densities of all guilds, except the house sparrow/rock dove guild, were significantly higher in interior areas in both years (except the tree foraging/tree nesting guild which was higher but not significantly in 1 year). All species foraging in trees and off the ground, and nesting in trees and in tree cavities, except house sparrows and rock doves, had lower numbers and breeding densities at edges relative to interior areas. Of the 10 individual species considered, only house sparrows and rock doves were more abundant in edges in each park in both years. Magpies and blackbirds were significantly more abundant in interiors in both years, while most other individual species were significantly more abundant (or higher but not

significantly) in interiors in one or both years. To conserve native birds in increasingly urbanized landscapes, the author recommended that urban parks reach a minimum area between 15 and 20 hectares and that the effects of car and pedestrian traffic be reduced by buffer zones.

Fernandez-Juricic, E. 2000. Density-dependent habitat selection of corridors in a fragmented landscape. Ibis 143:278-287.

The vegetation structure of wooded streets is less complex, and wooded streets are presumably less suitable, than parks for some breeding birds in urban areas. As park suitability decreased with rising population densities, wooded streets became a profitable alternative in terms of foraging, breeding, or moving between parks for 5 of 6 bird species, including black-billed magpies. However, the relationship varied both between and within species in different years. Such differences could have been caused by variable rates of human disturbance, renewal of resources, and predation risks in wooded streets; thus, the relationship is not clear.

Fernandez-Juricic, E., and J. L. Telleria. 2000. Effects of human disturbance on spatial and temporal feeding patterns of Blackbird *Turdus merula* in urban parks in Madrid, Spain. Bird Study 47:13-21.

Researchers studied how human presence in 3 urban parks affected blackbird densities by changing feeding behavior patterns. Pedestrians were the main source of flushing responses, followed by magpies (nest predators), and dogs with people. The mean flush distances from humans was 10 meters. The number of pedestrians was positively correlated with blackbird distance to pathways and negatively correlated with increase in the number of pedestrians during the day. Blackbird density was negatively related to the number of visitors per park. This disturbance ultimately modified spatial and temporal patterns of habitat selection and blackbird abundance. Methods for limiting visitor effects within urban parks may include restricting certain public activities with high levels of pedestrians and noise (particularly during the breeding season), designing special areas for specific purposes (e.g., walking, sports), setting buffer zones for visitors, determining the appropriate level of visitor presence in sensitive areas (e.g., where birds are nesting), curtailing the use (e.g., dog walking) of certain patches with high numbers of sensitive species, and promoting the value of urban wildlife and public awareness through education).

Fernandez-Juricic, E., M. D. Jimenez, and E. Lucas. 2002. Factors affecting intra- and inter-specific variations in the difference between alert distances and flight distances for birds in forested habitats. Canadian Journal of Zoology 80:1212-1220.

Studies of escape from predators and humans have usually focused on fleeing. The difference between alert and flight can be considered a “buffer distance.” Researchers measured buffer distances for humans approaching 4 species of ground-foraging birds living in forested parks in Madrid. Buffer distances increased with group size. Buffer distances decreased with shrub and coniferous cover, probably because of increased visual obstruction, and increased tree height, probably because of the increased security provided by taller trees. Larger species (black-billed magpies and wood pigeons) showed greater buffer distances, landed farther away and in higher trees, and flew higher, probably because they need to ensure a certain margin on security from predators. Alternatively, the increased buffer distances of large species may be related to the increasing energy expenditure of flight.

Forman, R. T. T., B. Reineking, and A. M. Hersperger. 2002. Road traffic and nearby grassland bird patterns in a suburbanizing landscape. Environmental Management 29:782-800.

A light traffic volume of 3,000-8,000 vehicles/day (local collector street) had no significant effect on grassland bird distribution. For moderate traffic of 8,000-15,000 (through street), there was no effect on bird presence although regular breeding was reduced for 400 meters from a road. For heavier traffic of 15,000-30,000 (two-lane highway), both bird presence and breeding were decreased for 700 meters. For a heavy traffic volume of ≥30,000 vehicles/day (multilane highway), bird presence and breeding were reduced for 1,200 meters from a road.

Friesen, L. E., P. F. J. Eagles, and R. J. MacKay. 1995. Effects of residential development on forest-dwelling neotropical migrant songbirds. Conservation Biology 9:1408-1414.

Forest size has been identified as a key determinant of avian community structure; many forest-dwelling neotropical migrants decline in number or become locally extinct when forest are subdivided. Diversity and abundance of neotropical migrants was measured in 72 woodlots in Ontario, Canada, and found to fit the predicted pattern. However, neotropical migrants consistently decreased in diversity and abundance as the level of adjacent development increased, regardless of forest size. The effects of development were striking: 4-hectare woodlots without any nearby houses had on average a richer, more abundant neotropical community than did 25-hectare urban woodlots. High development sites (≥25 houses) had less than half the average diversity and one-third to one-half the average abundance of neotropical migrants of forest patches with no adjacent houses. Development and forest size did not appear to affect diversity or abundance of short-distance migrants or permanent resident birds. Neotropical migrant species showed varying sensitivities to development pressures. The most dramatic response to adjacent houses came from the wood thrush, which was common at no-development and low-development sites (1-3 houses) but practically disappeared from high-development forests. Researchers suggested several causes for declines in diversity and abundance, including predation by cats and gray squirrels (subsidized in part by bird feeders).

Gutzwiller, K. J., R. T. Wiedenmann, K. L. Clements, and S. H. Anderson. 1994. Effects of human intrusion on song occurrence and singling consistency in subalpine birds. Auk 111:28-37.

Because song is essential in territory defense, mate acquisition, and in other reproductive activities, levels of intrusion that alter normal singing behavior have the potential to lower the reproductive fitness of males that are sensitive to this form of disturbance. Some subalpine species of birds respond to human intrusion by reducing singing activity. One person visiting a breeding territory for 1-2 hours/week reduced singing of some species during a single breeding season; however, the intrusions did not consistently influence song occurrence for any single species every year of the three-year study.

Hickman, S. 1990. Evidence of edge species attraction to nature trails within deciduous forest. Natural Areas Journal 10:3-5.

Repulsion from or attraction to nature trails by forest-breeding birds was determined by comparing the average distance of individual species' territories from trails vs. control transects in a forested area without trails. Trails altered bird community composition. Edge species, such as blue jays and American robins, were more abundant on sites with trails than on sites without trails. The researcher noted the vulnerability of forest-interior birds to nest predators like the blue jay and hypothesized that reproductive success of forest interior species may be indirectly decreased by nature trails.

Jones, Z. F., and C. E. Bock. 2002. Conservation of grassland birds in an urbanizing landscape: a historical perspective. Condor 104:643-651.

Refer to Raptors

Kenny, S. P., and R. L. Knight. 1992. Flight distances of black-billed magpies in different regimes of human density and persecution. Condor 94:545-547.

Researchers approached foraging magpies at a normal walking pace at 3 residential neighborhoods/city parks, 4 rural parks, and 4 other rural areas. Magpies were not shot at in the neighborhoods and parks; however, they were actively persecuted in the third category. Human density affected flushing response as magpies in rural parks flushed at greater distances than magpies in town (mean distances were 29 and 9 meters, respectively). Magpies in rural, persecuted areas flew at greater distances than those in state parks (mean distances were 65 and 29 meters, respectively).

Knight, R. L. 1984. Responses of nesting ravens to people in areas of different human densities. Condor 86:345-346.

The level of human densities and the frequency and nature of human activities in the nesting area affect responses of ravens towards human intruders. In Washington, ravens nesting in an area of moderate human density and high persecution (i.e., farmland) were more timid and showed stronger avoidance behavior and lower nest defense than ravens in an area of low human density and low persecution (i.e., rangeland). Farmland had more dwellings and roads than rangeland.

Knight, R. L., D. P. Anderson, and N. V. Marr. 1991. Responses of an avian scavenging guild to anglers. Biological Conservation 56:195-205.

Whereas scavengers might be present in an area and appear to be unaffected by human activity, a closer inspection is necessary to discern if they are able to feed normally. Although the presence of anglers did not affect the presence of eagles in trees, eagles and ravens were more likely to be on the ground (feeding) when anglers were absent. Crow numbers were also greater when anglers were absent; however, crows were more frequently than expected on gravel bars when anglers were present. When anglers were present, there were fewer ravens and crows and, for all three species, there were fewer individuals feeding. When anglers were present, eagles and ravens shifted their foraging time from early morning to late afternoon. Crows, however, continued to forage throughout the day, thereby depleting the food at the expense of eagles and ravens. Crows were able to feed in the presence of humans because they showed lower flushing responses, shorter flushing distances, and quicker return times. There is not reason to believe that other recreational activities (e.g., hiking, picnicking) would not have a similar impact.

Knight, R. L., and R. E. Fitzner. 1985. Human disturbance and nest site placement in black-billed magpies. Journal of Field Ornithology 56:153-157.

Nest sites were disturbed experimentally by visiting and looking into each active nest once during the incubation period and twice during the nestling period during April and May. During the following nesting season, magpies attempted to minimize the risk of human disturbance by placing nests higher above the ground. However, nests were not built higher in willows, presumably because of a scarcity of higher alternative or suitable nest sites (primarily multiple limbs intersecting the trunk). In a study site with few trees, where the magpies nested in bushes, the number of nests declined the following year by 1/3, presumably due to magpies abandoning the site.

Knight, R. L., D. J. Grout, and S. A. Temple. 1987. Nest-defense behavior of the American crow in urban and rural areas. Condor 89:175-177.

Crows have colonized urban areas where they are generally protected from widespread persecution as a pest and from hunting. Nest-defense behavior of a persecuted rural crow population was compared to that of an adjacent, protected urban crow population in Wisconsin. Nesting crows in the urban area did not call or fly off as researchers approached their nests whereas rural crows always did. Urban crows almost never called when researchers stood at the base of their nest trees whereas rural crows frequently did so. Rural crows showed less aggressive nest-defense behavior than urban crows. Crows can minimize energy expenditures and disruptions of their activity patterns by habituating to human presence; however, they do not do so when persecuted or hunted.

Knight, R. L., H. A. L. Knight, and R. J. Camp. 1993. Raven populations and land-use patterns in the Mojave Desert, California. Wildlife Society Bulletin 21:469-471.

Ravens are more abundant in urban-suburban areas and irrigated farmlands than desert rangeland because of the greater abundance, availability, and dependability of food sources. In addition to landfills and other sources of garbage, high road traffic and densities provide a source of plentiful carrion. These areas also provide plentiful water and abundant potential nest sites.

Knight, R. L., H. A. L. Knight, and R. J. Camp. 1995. Common ravens and number and type of linear rights-of-way. Biological Conservation 74:65-67.

Other studies have reported increased numbers of ravens along paved roads compared with unpaved roads or areas away from roads, presumably due to more carrion from greater numbers and higher speeds of vehicles. This study did not find more ravens along roads, perhaps because increased traffic volume and speeds on roads don't necessarily increase levels of road-killed carrion. However, raven numbers are correlated with multiple linear rights-of-way, probably due to increased nesting and perching sites, in combination with additional food (anthropogenic and carrion) and grit.

Lenington, S. 1979. Predators and Blackbirds: the "uncertainty principle" in field biology. Auk 96:190-192.

In addition to data from this study, data from 10 other marshes and 5 upland sites where red-winged blackbirds were studied for 2 or more consecutive years were compared. In 10 of the 11 marshes the proportion of successful nests was lower in the second year of the study than in the first. The average decline in the proportion of successful nests was 22.9%. Four marshes were studied for 3 or more consecutive years, and the trend continued, although the increase in predation was not as large as that observed between the first and second year of the study. The impact of human activity on predation seems to be less for upland than marsh habitats. In 3 of 5 upland study sites, the proportion of successful nests was slightly lower in the second year than the first. On the remaining 2 upland sites, however, the trend was reversed and a larger proportion of successful nests was found during the second year than in the first.

Major, R. M. 1990. The effect of human observers on the intensity of nest predation. Ibis 132:608-612.

White-fronted chats nest close to the ground and inhabit saltmarshes in Australia. Ten matched pairs of previously used nests were placed in bushes and an additional 10 matched pairs were left in their original positions. Three finch eggs were placed in each of the 40 nests. One member of each pair was visited daily for 14 days; the other nest was visited only at the end of the 14-day experiment. An additional 20 occupied nests were visited daily for comparison. There was no difference in predation between the occupied and transplanted nests. Daily visits significantly increased nest predation: 9 of

20 visited nests were preyed upon, compared with only 2 of 20 unvisited nests. Of course, even "unvisited" nests were approached by a researcher when initially placed. The most likely nest predators were ravens.

Mancke, R G., and T. A. Gayes. 2000. Breeding bird density in woodlots: effects of depth and buildings at the edges. Ecological Applications 10:598-611.

In Pennsylvania, in addition to the adverse effects of forest fragmentation, densities of 21 of 36 bird species were affected by buildings near the woodlots: 10 species increased and 11 decreased (e.g., downy woodpecker). Researches concluded that certain species can persist only in the absence of nearby buildings. They speculated that one reason may be the enhanced densities near buildings of nest-robbing bird species and abundance of other nest predators such as squirrels, house cats, and dogs that may also correlate with buildings. Some bird species may be outcompeted by species that prefer buildings.

Miller, J. R., and N. T. Hobbs. 2000. Recreational trails, human activity, and nest predation in lowland riparian areas. Landscape and Urban Planning 50:227-236.

In landscapes dominated by human settlement, remnants of semi-natural vegetation are set aside as parks or greenways under the assumption that these areas simultaneously provide recreational opportunities and conserve biological diversity. Researchers used artificial nests to test this hypothesis in Boulder County, Colorado. The 2 trails were "heavily used," averaging 16 and 22 people/hour. Bird predation on nests was greater near recreational trails, and mammals preyed more on nests away from trails. This was largely because magpies and jays were attracted to trails, whereas many mammal predators avoided trails. The most frequent mammal predators on eggs were deer mice and squirrels. Researchers speculated that human or dog scent could have caused some mammals to avoid the trails, or an increase in coyotes using the trails may have reduced the number of deer mice. The researchers recommended ways to minimize adverse impacts near established trails. Trails should be located on one side of the stream and human activity restricted to a well-defined corridor, by using fences, for example. It is critical that dogs be kept from ranging freely. Signs that explain why restrictions are necessary will foster greater cooperation.

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

Researchers compared the influence of recreational trails on species composition and nest predation for breeding bird communities in forest and mixed-grass prairie ecosystems in Colorado. The study area was large, about 11,000 hectares, and visitor use was heavy, almost 3.5 million/year. Bird species composition was altered adjacent to trails in both ecosystems. Generalist species, such as American robins, were more abundant near trails, whereas specialist species were less common. Within the grassland ecosystem, birds were less likely to nest near trails. Within both ecosystems, nest predation was greater near trails. For the majority of species found in reduced numbers near trails, the zone of influence of trails appeared to be about 75 meters; however, Townsend's solitaires exhibited reduced numbers as far as 100 meters from trails. Trail effects were presumably due to habitat edges attracting avian and mammalian nest predators as well as recreational disturbance. Management of natural areas must entail not only proper trail placement, but also recreationist management. Consolidation of trails to certain areas (e.g., edge of forests and grasslands) will reduce the fragmentation of large blocks of habitat, maintaining less-disturbed areas for species sensitive to fragmentation. Natural areas personnel can inform recreationists of how their activities affect wildlife and how they can modify their activities by remaining on trails and keeping pets leashed to minimize impacts.

Miller, S. G., R. L. Knight, and C. K. Miller. 2001. Wildlife responses to pedestrians and dogs. Wildlife Society Bulletin 29:124-132.

Researchers measured responses of 2 species of grassland songbirds (vesper sparrow, western meadowlark), 1 species of forest songbird (American robin), and mule deer exposed to a pedestrian, a pedestrian accompanied by a dog on a leash, and a dog ahead of a pedestrian on and off recreational trails. The loose dog walked approximately 20 meters in front of the observer and did not attempt to chase birds. For all species, area of influence (measured perpendicular to the trail or line of movement), flush distance, distance moved and alert distance (for mule deer) was greater when activities occurred off-trail versus on-trail. The grassland birds were least responsive to the dog off leash, either because they didn't consider it a threat or they may have held position until the last moment, attempting to remain undetected. Mean flush distances for the vesper sparrow for on-trail and off-trail disturbances were 9-10 meters and 11-17 meters, respectively. Mean flush distances for the western meadowlark for on-trail and off-trail disturbances were 19-31 meters and 34-38 meters, respectively. Mean flush distances for the American robin for on-trail and off-trail disturbances were 10 meters and 14-16 meters, respectively. Mule deer exhibited a greater area of influence, alert and flush distances, and distance moved for a dog on a leash versus a pedestrian without a dog. Because recreational activities occurring on-trail were frequent and spatially predictable, animals had likely habituated to activities in these locations. Researchers did not stop and view the subjects for extended periods or attempt to move toward them. However, on-trail activities are still an important source of disturbance that may displace wildlife and reduce fitness in local populations. Even though the dog-alone treatment resulted in the smallest area of influence for grassland birds, area of influence will increase if recreationists allow their dogs to roam away from a trail. Prohibiting dogs, requiring leashes, or restricting use to trails will aid in minimizing disturbance, Managers can also restrict the number and spatial arrangement of trails so that sensitive areas or habitats are avoided.

Reijnen, R., R. Foppen, and G. Veenbaas. 1997. Disturbance by traffic of breeding birds: evaluation of the effect and considerations in planning and managing road corridors. Biodiversity and Conservation 6:567-581.

Dense road traffic can cause an important loss of numbers of species. This paper reviews the effects of traffic on birds in woodland and grassland habitats in the Netherlands. Thirty-three of 45 species from 22 taxonomic groups found in woodlands (primarily songbirds) and 7 of 12 species from 7 taxonomic groups found in grasslands (primarily waterfowl and shorebirds) were affected by traffic. The maximum size of the disturbed zone adjacent to main roads with heavy traffic that have a reduced density, for all species of breeding birds combined, is 190 and 560 meters for 10,000 and 50,000 vehicles/day (respectively) in grassland habitat and 125 and 365 meters for 10,000 and 50,000 vehicles/day (respectively) in woodland habitat. The presence of a road *per se* and roadkills are not very important in affecting bird densities. In woodlands and open landscapes, noise appears to be the most critical factor in reducing population densities close to roads. Although visibility of vehicles in an open landscape may contribute to the disturbance effect, even roads bordered by hedgerows affect breeding bird densities. In some instances, population densities and low reproductive success are correlated with disturbance to communication (e.g., territorial song, warning calls) but the main factor may be stress. For grassland birds, including black-tailed godwits, there is strong evidence that disturbance by traffic has a significant impact, an estimated reduction of 16%, on the size of breeding populations in the west Netherlands. For roads where traffic noise is expected to be high, researchers recommended maintaining a buffer of 1,000 meters between the road and important breeding areas.

Restani, M., J. M. Marzluff, and R. E. Yates. 2001. Effects of anthropogenic food sources on movements, survivorship, and sociality of common ravens in the arctic. Condor 103:399-404.

Three hundred eighty-three ravens were captured at or near a landfill in Greenland and banded. Thirty-nine ravens were recovered. Ravens survived an average 494 days and moved an average distance of 151 kilometers between banding and recovery. Ravens wintering near the majority of human settlements along coastal Greenland suffered severe negative consequences. Most recovered ravens had been shot (86%), which was similar to shooting mortality reported in Iceland (87%). Shooting removed an estimated 35% of the raven population based on banding in Greenland, which appeared to reduce the local breeding population.

Rich, A. C., D. S. Dobkin, and L. J. Niles. 1994. Defining forest fragmentation by corridor width: the influence of narrow forest-dividing corridors on forest-nesting birds in southern New Jersey. Conservation Biology 8:1109-1121.

Ubiquitous, narrow, forest-dividing corridors influence the relative abundance and community composition of forest-dwelling birds. Three width classes of corridors were studied, including unpaved roads (8 meters wide), paved roads (16 meters wide), and powerlines (23 meters wide). Forest-interior species of neotropical migrants had significantly reduced relative abundances along 16- and 23-meter-wide corridors, compared with 8-meter corridors. However, corridors as narrow as 8 meters produce forest fragmentation effects in part by attracting nest predators to corridors and adjacent forest interiors. Researchers suggest that these widespread corridors may be inconspicuous but important contributors to declines of forest-interior nesting species.

Riffell, 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.

Researchers experimentally assessed whether or not temporally cumulative impacts occurred in Wyoming bird communities as a result of repeated intrusions by solitary hikers. The intrusions lasted 1-2 hours each week during 10 consecutive weeks during breeding season for a 5-year period. Relative richness and mean relative abundance declined for several species; however, there were no cumulative or yearly declines in seasonal richness, mean richness, or in mean total abundance.

Robertson, R. J., and N. J. Flood. 1980. Effects of recreation use of shorelines on breeding bird populations. Canadian Field-Naturalist 94:131-138.

Shorelines of 6 lakes in Ontario were studied. The lakes were located in a popular recreation area, with use of shorelines varying from light to heavy. Disturbance was rated based on density of cottages, proximity of roads, and amount of boat traffic adjacent to the shoreline. Disturbance scores ranged from 1-11 with increasingly heavy use (areas scoring 1-2 were considered undisturbed). In addition, intensity of human activity was established near nests by noting the presence and number of picnic tables, camp sites, and/or cottages within 25 meters of the nest. These scores ranged from 1-8 (nest sites scoring 1-3 were considered undisturbed). In general, species common in urban areas, such as American robins, were found more frequently and in greater abundance in disturbed areas. Common loons nesting in undisturbed areas appeared to have had higher success (4 of 6 nests fledged young) than those nesting in disturbed locations (2 of 7 nests fledged young), although the sample size was too small to test for significance. A larger percentage of the total number of eastern kingbird (which commonly nested less than 3 meters high at the water's edge) eggs hatched in undisturbed than in disturbed locations (73.8% vs. 53.6%). Nests in undisturbed areas produced

significantly more fledglings as a proportion of the total number of eggs laid than did nests in disturbed areas (50% vs. 25%). Researchers believed the level of disturbance in this study was low compared to areas with more intensive recreational development and human use.

Ruiz, G., M. Rosenmann, F. F. Novoa, and P. Sabat. 2002. Hematological parameters and stress index in rufous-collared sparrows dwelling in urban environments. Condor 104:162-166.

Rufous-collared sparrows inhabit rural and urban areas in Chile; however, rural sparrows were 19% heavier. Researchers compared body weight with 2 indices of acute and chronic stress (glycemia and leukocyte counts in the blood). Urban-dwelling sparrows revealed both acute and chronic stress characteristics. Wild rural sparrows kept in captivity developed acute and chronic stress characteristics and lower weight similar to urban-dwelling sparrows. Researchers hypothesized that fragmentation of the urban habitat and the aggressive behavior of house sparrows were the main factors explaining the chronic stress characteristics of urban-dwelling rufous-collared sparrows. They did not investigate other potential sources of stress, including direct human disturbance.

Skagen, S. K., R. L. Knight, and G. H. Orians. 1991. Human disturbance of an avian scavenging guild. Ecological Applications 1:215-225.

Scavenging on dead salmon by bald eagles, American crows, and glaucous-winged gulls in Washington varied in time and space with the presence of human activity at experimental feeding stations. At undisturbed locations, eagles preferred to feed >100 meters from vegetative cover, whereas gulls fed <50 meters from cover. At disturbed locations, eagles rarely fed, and feeding activity by gulls increased. Birds were experimentally disturbed by the approach of 1 observer on foot. The first bird in a group to fly in response to an approaching human did so at a significantly greater distance for eagles (338 meters) than crows (202 meters) or gulls (90 meters). The same trend held for the last bird in the group to fly. After a disturbance, eagles seldom returned to feed that day. Gulls returned to salmon carcasses with 7.3 minutes and crows within 15.5 minutes. Eagles fed at a site more on days of no disturbance than days when feeding was interrupted. In contrast, disturbance appeared to enhance feeding opportunities for gulls. The total amount of salmon consumed by crows, gulls, and eagles at the feeding stations did not differ between disturbed days and undisturbed days, but the relative amounts consumed did vary. Eagles ate only 5.7% of the salmon consumed on disturbed days in contrast to 55.3% on undisturbed days. Gulls accounted for nearly 72.1% of the daily salmon consumption when disturbed and only 16% when undisturbed. Consumption by crows did not vary significantly in response to disturbance. Researchers predicted that in areas of frequent human disturbance, densities of gulls and crows would increase in response to greater availability of partly consumed salmon carcasses abandoned by eagles. They cited a survey of 381 anglers and eagle viewers in Washington wherein only 5% considered their activity a frequent disturbance to eagles (Stalmaster 1989).

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).

Verbeek, N. A. M. 1982. Egg predation by northwestern crows: its association with human and bald eagle activity. Auk 99:347-352.

Crows took 1,167 cormorant eggs, an estimated 22% of all eggs in first clutches at a study area in British Columbia. When bald eagles were present, more cormorant eggs were taken by crows than on days when eagles were absent. More eagles were present on weekends than on weekdays, presumably because the local eagle population was kept inadvertently on the move by people seeking recreation on the water.

Vierling, K. T. 2000. Source and sink habitats of red-winged blackbirds in a rural/suburban landscape. Ecological Applications 10:1211-1218.

The researcher monitored 591 red-winged blackbird nests near Boulder, Colorado, in breeding habitats that were either natural (wetlands, tallgrass prairie) or anthropogenic (hayfields, roadside ditches). Sources of blackbird productivity occurred only in natural habitats and source sites had fewer buildings nearby than did sinks. Anthropogenic habitats consistently functioned as sinks throughout the three-year study. High quality patches had relatively few houses or buildings within 200 meters of the edge of the patches. Suburban area appeared to function as a regional sink, possibly because human activity attracts high densities of human commensal predators such as corvids that depredate red-winged blackbird nests.

Ward, C., and B. S. Low. 1997. Predictors of vigilance for American crows foraging in an urban environment. Wilson Bulletin 109:481-489.

Foraging crows were observed during the breeding season in Michigan. Human disturbance was classified as high if moderate to high levels of human activity, including pedestrian traffic and voices, was within 200-400 meters and low at low levels of human activity, including 1 or 2 pedestrian sightings within 200-400 meters during the 5-minute observation period. Crows were more vigilant in areas of high human disturbance than in areas of low human disturbance. Percent time vigilant averaged 21.2% in high disturbance areas and 9.5% in low disturbance areas. Crows that scanned less devoted more time to feeding.

SMALL MAMMALS

Andreassen, H. P., and R. A. Ims. 1998. The effects of experimental habitat destruction and patch isolation on space use and fitness parameters in female root vole *Microtus oeconomus*. Journal of Animal Ecology 67:941-952.

Researchers tested whether experimentally induced destruction and fragmentation of habitat and varying degrees of patch isolation affected space use and fitness of root voles in Norway. Seven unfragmented 30 x 95-meter patch of habitat was fragmented into 6 strips with interpatch distances of

1.5, 3, 7.5, 15, and 22.5 meters. After treatment the patches resembled the 4 control patches, which were previously fragmented. Home ranges were larger in the unfragmented, predestruction populations compared to the permanently fragmented control populations. However, the basic spatio-social organization of reproductive females was resistant to habitat destruction. There were no effects of habitat destruction on female fitness parameters. There was less between-patch movements when interpatch distances were large than when they were small. Predation by avian predators, the main cause of mortality, was highest in fragments with long interpatch distances, probably because long-distance movements between fragments increased the predation risk. The farther a female had to relocate her home range because of habitat destruction, the higher was the predation risk. Natural habitats of root voles, river banks and sedge bogs, are frequently disturbed by floods, and root voles may be adapted to colonizing empty habitats during breeding season.

Andreassen, H. P., R. A. Ims, and O. K. Steinset. 1996. Discontinuous habitat corridors: effects on male root vole movements. Journal of Applied Ecology 33:555-560.

Movements of male voles were tested experimentally in a 300-meter corridor (1 meter wide) consisting of tall grass and clover surrounded by mowed vegetation. Half of the corridor had no gaps (control) and the other half was manipulated by cutting gaps every 10 meters. After each series of 14 trials with 28 voles, the gap size was increased until 5 gap sizes were tested, from 0.25 to 4 meters. Movements were monitored by radio telemetry. Male voles did not respond to gaps until the gap size became 4 meters. The critical gap size, between 2 and 4 meters, decreased the movement rates significantly.

Bakowski, C., and M. Kozakiewicz. 1988. The effect of forest roads on bank vole and yellow-necked mouse populations. Acta Theriologica 33:345-353.

This was a short-term experiment using a 5-meter-wide gravel road (averaging 3 vehicles/hour) through a forest. A total of 276 individual small mammals were captured 1,627 times; however, only the bank voles (226) were subjected to detailed analysis. The number of voles moving between adjacent traps on either side of the road was significantly greater than the number moving between adjacent traps straddling the road. Only 1 vole crossed the road on its own. In another experiment, 40 voles were captured on one side of the road, but released a little over 40 meters from the other side of the road. Within a week 83% returned. Thus, voles were capable of crossing the road, but road crossing was infrequent unless the vole was displaced.

Bolger, D. T., A. C. Alberts, R. M. Sauvajot, P. Potenza, C. McCalvin, D. Tran, S. Mazzoni, and M. E. Soulé. 1997. Response of rodents to habitat fragmentation in coastal southern California. Ecological Applications 7:552-563.

The distribution of native rodents in 25 urban habitat fragments (1-80 hectares) was assessed by live-trapping. Over half of the fragments (13 of 25) did not support populations of native rodents, and it was assumed that local extinctions had occurred in a time span of 20-80 years.. Fragments supported fewer species than equivalently sized plots in large expanses of unfragmented habitat, and fragments that were isolated for a longer period of time supported fewer species. Fragments under 25 hectares that have been isolated for at least 30 years support very few populations of native rodents. Habitat attrition and degradation which resulted from trampling of vegetation, trail formation, intentional clearing of vegetation for fire breaks, increased fire frequency, and the introduction of invasive plant species may reduce rodent fitness. Fragmentation in urban areas may also increase predation risk from domestic cats and other exotic or native predators. Management of small parcels of natural habitat for the purpose of conservation must include protection against this type of

degradation through prevention, monitoring, and restoration. Corridors also must be protected from disturbance.

Collins, R. J., and G. W. Barrett. 1997. Effects of habitat fragmentation on meadow vole (*Microtus pennsylvanicus*) population dynamics in experiment landscape patches. Landscape Ecology 12:63-76.

Researchers studied the effects of habitat fragmentation on vole population dynamics in Ohio during a 5-month period in summer and fall. Eight small mammal enclosures were used: 4 contained a 12.6 x 12.6-meter "nonfragmented" patch and 4 contained 4 6.3 x 6.3-meter fragmented patches. All patches were surrounded by mowed, less suitable habitat. Six pairs of adult voles were released in each enclosure. Thirty-six adult females were radiocollared. Due to reproduction, a total of 366 voles were captured 2,379 times in the patches and surrounding low-quality habitat. Greater densities of female voles were found during October in the fragmented patches compared to the "nonfragmented" patches. Significantly more subadult and juvenile males were found in the low-quality habitat vs. the patch of the "nonfragmented" treatment compared to the fragmented treatment. Meadow voles are reported to be edge tolerant and, perhaps, less vulnerable to extrinsic effects of habitat fragmentation than some other species. Very small patches doe not always have deleterious effects on vole populations. *[However, even the large patches of this experiment could be considered small fragments relative to other experiments, such as La Polla and Barrett (1993)].*

Delin, A. E., and H. Andrén. 1999. Effects of habitat fragmentation on Eurasian red squirrel (*Sciurus vulgaris*) in a forest landscape. Landscape Ecology 14:67-72.

Squirrel density was measured during 4 years in 46 forest stands in Sweden. Fragment size and degree of isolation had no significant effect on squirrel density. The effect of habitat fragmentation in this study seemed to be only pure habitat loss; i.e., halving the proportion of preferred habitat in the landscape should result in a halving of the red squirrel population. The landscape appeared to be functionally continuous for the squirrels, although the preferred habitat was divided into fragments. The most likely explanation for the absence of a fragmentation effect found by other studies on squirrels is a combination of shorter distances and less hostile surroundings in this study area. They found no habitat fragments more than 600 meters from another fragment of preferred habitat, well within the maximum daily movement of male and female squirrels found in an earlier study.

Dickman, C. R. 1987. Habitat fragmentation and vertebrate species richness in an urban environment. Journal of Applied Ecology 24:337-351.

Twenty species of terrestrial mammals were found in patches of semi-natural and disturbed vegetation in Oxford, England. The patches were delimited by roads, walls, or other artificial barriers and ranged from 0.16 to 20 hectares. Woodland was the only habitat in which all species of mammals were recorded. More species occurred in semi-natural habitats such as woodland, long grass, and scrub than in intensively cultivated patches. The number of species within patches decreased with increasing percentage of paths and other barren ground and with proximity to buildings. More species of mammals were retained in 2 small patches than in 1 large patch with the same total area.

Dickman, C. R., and C. P. Doncaster. 1989. The ecology of small mammals in urban habitats. II. Demography and dispersal. Journal of Animal Ecology 58:119-127.

Demographic parameters were compared in 2 species of rodents in 3 human-disturbed and 3 undisturbed habitat patches in Oxford, Britain. The disturbed patches were English-style gardens,

with 10-25% of the patch under continuous human management. The patches varied from 0.2 to 1.31 hectares. Population densities of wood mice and bank voles, and survival and residency of wood mice, were greater in undisturbed than in disturbed patches. The mean annual population density of both species was 3 times higher in the undisturbed as in the disturbed patches. Low population densities in the disturbed patches were probably caused by human modification of the vegetation and by predation from domestic cats, rather than lack of food.

Douglass, R. J. 1977. Effects of a winter road on small mammals. Journal of Applied Ecology 14:827-834.

Winter roads were constructed in the northern boreal forest of Canada by removing trees and forming a surface of ice and compacted snow. Little soil or surface vegetation was removed. This increased frequency of grasses and sedges and decreased litter, mosses, lichens, and shrubs. The vegetation on the road was similar to that found in dry meadows. The combined population density of meadow, northern red-backed, and yellow-cheeked voles on the winter road was 53% as large as in the adjacent, undisturbed forest. Meadow voles made up a higher percentage of the population on the road than it did in most undisturbed areas. Daytime activity of northern red-backed voles was significantly reduced on the winter road.

Gerlach, G., and K. Musolf. 2000. Fragmentation of landscape as a cause for genetic subdivision in bank voles. Conservation Biology 14:1066-1074.

Voles were live-trapped and marked at 4 sites in Germany to study the barrier effects of roadways on population genetics. Three different roadways—a country road (10 meters wide, 5,300 vehicles/day), a railroad (6 meters wide, 62 trains/day), and a 4-lane highway (50 meters wide, 28,680 vehicles/day)—were compared with 3 sites in a forested control area with no road. Low proportions of voles were observed crossing the country road and the control area. No voles were observed crossing the railroad or the highway. Based on genetic analysis, there was a barrier effect caused by limited migration across the highway, but not the country road or railroad. The highway was 25 years old. Thus, not only long-term, natural barriers but also much more recent highways have an important effect on gene flow and the genetic substructuring of populations which should be considered in future environmental impact assessments.

Kozakiewicz, M. 1993. Habitat isolation and ecological barriers—the effect on small mammal populations and communities. Acta Theriologica 38:1-30.

Reviews literature. Increased mobility of individuals seems to be the best strategy for survival in heterogeneous landscapes. Highly mobile individuals seem to have better chances to find in a proper time spatially scattered patches of habitats, establish temporal residence, survive, and breed successfully there. Roads were not effective barriers for stopping recolonization of empty habitats, they also were not effective barriers to gene flow, but they did inhibit movements of individual bank voles and white-footed mice.

Kozel, R. M., and E. D. Fleharty. 1979. Movements of rodents across roads. Southwestern Naturalist 24:239-248.

Three hundred fourteen small rodents were live-trapped in grids on both sides of Kansas roads: a 2-lane paved road, 4-lane paved highway, a 7.5-meter gravel road, and a 9.1-meter limestone road. Sample sizes of 5 species were small; however 5 of 66 thirteen-lined ground squirrels and 1 of 134 deer mice crossed the gravel and limestone roads. No rodents crossed the paved roads. Small

rodents were more likely to cross the road when moved to the other side. Road inhibit movement of some small rodents, but don't appear to block all movement.

La Polla, V. N., and G. W. Barrett. 1993. Effects of corridor width and presence on the population dynamics of the meadow vole (*Microtus pennsylvanicus*). Landscape Ecology 8:25-37.

A small-scale, replicated experiment consisting of 3 sets of unmowed patches, surrounded by tilled ground. In each set were 2 unmowed patches separated by 10-meter-wide mowed strips. Control treatments (pairs of unmowed patches unconnected by corridors) supported significantly lower vole densities than pairs of unmowed patches interconnected with 1-meter or 5-meter-wide corridors. No significant difference was found in vole densities between treatments with narrow or wide corridors.

Mader, H.-J. 1984. Animal habitat isolation by roads and agricultural fields. Biological Conservation 29:81-96.

Bank voles and yellow-necked mice were captured and marked on both sides of a 2-lane, paved highway (6 meters wide, 250 vehicles/hour) in West Germany. None of the 121 marked and 35 recaptured animals crossed the road. In another experiment, 40 mice were marked and released on site and 14 mice were released on the other side of a 4- to 5-meter-wide, paved road (20 vehicles/hour). None of the 40 mice released on site crossed the road; however, 2 of the translocated mice returned to the original side by crossing the road—one of them 3 times. Even a narrow forest road (3 meters wide, 2 vehicles/hour) not open to public traffic seemed to be a barrier to mice and voles. Thirty-four movements were recorded to and from the road while only 2 mice crossed the road. On a control area with no road, 28 mice crossed a 16-meter-wide center strip (representing an imaginary road with shoulders) while only 19 movements were observed to and from the center strip. Mice and voles may avoid road crossings due to differences in physical conditions, habitat, human disturbance, and risk from vehicles or predators.

Mainini, B., P. Neuhaus, and P. Ingold. 1993. Behaviour of marmots *Marmota marmota* under the influence of different hiking activities. Biological Conservation 64:161-164.

A series of experiments by 2 observers simulated five types of hikers: walking on a marked trail, cross-country, across marmot burrows, with a dog on a short leash, and with a dog on a 10-meter leash (to simulate a free-roaming dog). The study area in the Swiss Alps had a dense network of hiking trails used, in good weather, by many visitors; thus marmots were familiar with humans and dogs. Marmots fled at the greatest distance when approached by hikers with a dog (>100 meters), compared to about 60 meters from cross-country hikers and hikers walking over burrows and about 40 meters from hikers on trails. Marmots seldom took refuge in burrows from hikers on trails; they were most likely to take refuge from hikers walking over burrows and a "free-roaming" dog. After taking refuge from a cross-country hiker all marmots emerged within 10 minutes. It took much longer for the marmots to emerge after a trail hiker with a dog on a short leash. Half of the marmots remained in their burrows for over 30 minutes in response to a "free-roaming" dog. Marmots in less heavily used areas have stronger reactions to human disturbance. Thus, marmots can adapt to human disturbance, but adaptation may be limited by hiked leaving the trail or accompanied by dogs.

Merriam, G., M. Kozakiewicz, E. Tsuchiya, and K. Hawley. 1989. Barriers as boundaries for metapopulations and demes of *Peromyscus leucopus* in farm landscapes. Landscape Ecology 2:227-235.

On 4 study areas in Canada, white-footed mice seldom crossed a narrow, gravel road varying in width from 3.3 to 6.4 meters. The traffic intensity was very low on all 4 roads (1-2 vehicles/hour). During the 5-week study, 115 mice were caught 395 times. In only 3 cases was the maximum movement distance longer after the first day. Only 9 mice (7.9%) crossed the road (1 twice). In another measure of movement, percentages of feces containing the bait from the opposite side of the road were also very low (1-5%). Trap mortality was higher for mice crossing roads (5 of 9; 55%) than for captures not associated with crossings (17 of 106; 16%).
There was no relationship between width of road or traffic volume and numbers of mice crossing. These roads were not effective barriers for stopping recolonization of empty habitat.

Meserve, P. L. 1971. Population ecology of the prairie vole, *Microtus ochrogaster*, in the western mixed prairie of Nebraska. American Midland Naturalist 86:417-433.

There was no evidence that prairie voles moved across a 3-meter gravel road.

Neuhaus, P., and B. Mainini. 1998. Reactions and adjustment of adult and young alpine marmots *Marmota marmota* to intense hiking activities. Wildlife Biology 4:119-123.

Researchers experimentally compared marmot reactions to hikers in remote areas (average of less than 30 hikers/day) and heavily used areas (about 800 hikers on an average day). Adult marmots in heavily used areas allowed researchers to approach more closely before they reacted and fled than marmots in remote areas (median distances.about 210 meters and about 65 meters, respectively). In remote areas, marmots were less likely to reappear within 30 minutes than in heavily used areas. In both areas the flight distance was much shorter for juveniles than adults. Juvenile marmots reacted more intensely in September than in May and they exhibited a much higher increase in flight distance in remote areas.

Oxley, D. J., M. B. Fenton, and G. R. Carmody. 1974. The effects of roads on populations of small mammals. Journal of Applied Ecology 11:51-59.

The width of the cleared strip influenced crossings of 2 and 4-lane roads in Ontario. Traffic and road surface (paved vs. gravel) did not appear to inhibit crossing. Small forest mammals, such as deer mice and tree squirrels, were reluctant to venture onto road surfaces where the distance between forest edges exceeded 20 meters. Species used to living in open areas, like meadow voles, were less reluctant to cross roads. Road mortality increased with increasing road improvement for medium-sized mammals and was highest when traffic density was high and young were emerging. A 4-lane divided highway may be as effective a barrier to the dispersal of small forest mammals as a body of fresh water twice as wide.

Sauvajot, R. M., M. Buechner, D. A. Kamradt, and C. M. Schonewald. 1998. Patterns of human disturbance and response by small mammals and birds in chaparral near urban development. Urban Ecosystems 2:279-297.

Disturbance patterns were evaluated in a 6,700-hectare study area in California. The area was extensively altered from past human activities such as clearing, fires, refuse dumping, and vegetation trampling and by 22 kilometers of roads and 136 kilometers of trails. Human-altered habitat was not associated with development *per se*, but was significantly associated with proximity to roads. Disturbance dropped off steadily to 600 meters from the road edge and remained fairly constant beyond this distance threshold. Trails were also more frequent near urban development and roads. Thirteen native rodent and 15 resident bird species were censused in 27 sites across undeveloped open space in the study area. The effects of human development on small mammals was substantial.

Mammal richness and abundance were reduced in more disturbed sites, while disturbance-associated mammals were more abundant in these sites. Resident bird species were much less affected by human disturbances. It is possible than the bird species studied were in fact resistant to habitat disturbance effects. In this study area, habitat alteration from human activities, which can penetrate deep into remaining open space, appears to be a primary conservation concern, more so than proximity to urban environments. Because human habitat alteration can be significant in natural areas near development and disturbance patterns can affect wildlife distribution, management efforts should focus on reducing habitat disturbance by humans in remaining habitats.

Swihart, R. K., and N. A. Slade. 1984. Road crossing in *Sigmodon hispidus* and *Microtus ochrogaster*. Journal of Mammalogy 65:357-360.

Previous studies of road crossing by small mammals were conducted over a relatively short time period, with wider roads and more traffic. This was a 9-year experiment with a lightly used road (10-20 vehicles/day). During the first 4 years the road was less than 3 meters wide and consisted of 2 dirt strips across the meadow; the last 5 years the road was widened to 3.6 meters and gravel was spread. A total of 828 cotton rats and 741 prairie voles was captured 2,636 and 5,961 times, respectively. Only 47 cotton rats and 23 voles were known to have crossed the road during the 9-year study. Both species appeared to avoid the road. For voles, 150 of 163 (92%) individuals captured adjacent to the road subsequently moved away rather than across the road, whereas the road repulsed 159 of 195 (81.5%) cotton rats caught adjacent to it. Of those that crossed the road, 32 cotton rats (68%) and 18 voles (78%) crossed only once. Thus, animals apparently did not incorporate the road into their home ranges. Even at the densest vole population (135/hectare), the relative cost of crossing the road was too great to increase the frequency of road crossing. Increasing the width and altering the road surface did not increase the inhibitory effect for voles or cotton rats.

Wilkins, K. T. 1982. Highways as barriers to rodent dispersal. Southwestern Naturalist 27:459-460.

Ten species of small rodents were live-trapped on both sides of an interstate highway and a 12-meter-wide 2-lane highway in Texas. A total of 1,968 rodents were marked. Individuals of only 3 species were recorded crossing the roads: 86 of 1,532 (5.6%) hispid cotton rats, 5 of 272 (1.8%) pygmy mouse, and 1 of 99 (1%) fulvous harvest mouse. [*Sample sizes were too small for other species*.] Although crossings were infrequent, roads do not inhibit dispersal of some rodent species.

CANIDS, CATS AND WEASELS

Beier, P. 1993. Determining minimum habitat areas and habitat corridors for cougars. Conservation Biology 7:94-108.

Population dynamics of cougars were modeled to predict the minimum areas and levels of immigration needed to avoid population extinction caused by demographic and environmental stochasticity. In the absence of immigration, a habitat area of 1,000-2,200 square kilometers (depending on the demographics of a particular population) is needed to support a cougar population with a 98% or more probability of persistence for 100 years; these minimum areas would support about 15-20 adult cougars. If a wildlife movement corridor is available to allow immigration of up to 3 males and 1 female per decade, an area as small as 600-1,600 square kilometers can support a cougar population without significant extinction risk in 100 years. Higher levels of immigration would allow even smaller areas to support cougars.

Chapman, R. C. 1979. Human disturbance at wolf dens—a management problem. National Park Service Transactions and Proceedings Series 5:323-328.

Based on detailed observations at 4 dens and a comprehensive literature review, in most cases the mere presence of humans has been sufficient to disturb wolves at dens and rendezvous sites. However, pup mortality has not been reported to occur as a result of human disturbance. In all reported cases, wolves have not been known to detect other animals or humans by vision or by scent beyond 1.6 kilometers. However, wolves have been known to howl and/or bark at humans encountered as far as 2.4 kilometers from pups. In forested areas, observers cause little or no disturbance while remaining within 0.4 kilometer of den sites. It would be unlikely for wolves to be disturbed if human activity is excluded within a 2.4-kilometer radius of active dens in tundra areas, less in forested areas. In southcentral Alaska (Denali National Park and Preserve) closed areas should be established from April 1-August 1, unless circumstances dictate otherwise. Known rendezvous sites should remain closed for as long as pups are there, generally no longer than October 1.

Clevenger, A. P., B. Chruszcz, and K. Gunson. 2001. Drainage culverts as habitat linkages and factors affecting passage by mammals. Journal of Ecology 38:1340-1349.

Although not designed for animal passage, drainage culverts are ubiquitous and may offer a safe passage for small and medium-sized mammals across roads that may otherwise be a barrier to movement. In Banff National Park, Alberta, species responded to different attributes of roads and culverts. Traffic volume, noise levels, and road width ranked high as significant factors affecting species' use of culverts. Short-tailed weasels and deer mice used the culverts for passage most frequently; shrews and voles also used culverts substantially more often than expected based on adjacent transects. Noise level was the most significant culvert attribute inhibiting snowshoe hare movement, whereas traffic volume was the most significant attribute inhibiting coyote, marten, and red squirrel movement. For marten and red squirrels the relationship was positive; the higher the traffic volume, the greater the use of culverts. However, short-tailed weasel, marten, snowshoe hare, and red squirrel passage was negatively correlated with noise levels, suggesting that traffic-related disturbances may cause some species to reduce their activity near the highway or avoid the area altogether. To improve the permeability of roads for small and medium-sized mammals, culverts should be placed at more frequent intervals (150-300 meters). Also, if a road does not have large wildlife crossing structures, a mixed size class of culverts should be provided to accommodate the greatest variety of species; for example, large culverts (1–1.5 meter diameter) will facilitate passage of coyotes.

Creel, S., J. E. Fox, A. Hardy, J. Sands, B. Garrott, and R. O. Peterson. 2002. Snowmobile activity and glucocorticoid stress responses in wolves and elk. Conservation Biology 16:809-814.

Glucocorticoids are secreted in response to physiological or behavioral stress. Chronically elevated levels may result in reproductive suppression, ulcers, muscle wasting, and immune suppression. Fecal samples were collected from elk in Yellowstone National Park and from wolves in Yellowstone, Voyageurs, and Isle Royale national parks. Snowmobile activity was tallied at Yellowstone. Snowmobile numbers at Voyageurs came from trail counters (index rather than total count). Only 1 snowmobile was present at Isle Royale. Snowmobiles provoked a stronger physiological stress response in elk than wheeled vehicles, and stress responses paralleled changes in the number of snowmobiles. Wolves had higher glucocorticoid levels in Voyageurs than in Isle Royale. Within Voyageurs, a 37% decline in the annual index of snowmobile use (23,922 vs. 15,011 visitors) was

accompanied by a 37% decline in mean glucocorticoid levels. Mean glucocorticoid levels in Yellowstone wolves were intermediate, as predicted by the intermediate level of snowmobile use. Despite these stress responses, there was no evidence that current levels of snowmobile activity are affecting the population dynamics of either species in these locations in the short-term.

Crooks, K. R. 2002. Relative sensitivities of mammalian carnivores to habitat fragmentation. Conservation Biology 16:488-502.

The distribution and abundance of 9 native and 2 exotic carnivore species in southern California varies in response to habitat fragmentation in urbanized areas. Fragment size and isolation were the 2 strongest landscape variables. Six species (e.g., mountain lion, bobcat, coyote, and long-tailed weasel), were sensitive to fragmentation, generally disappearing as habitat patches became smaller and more isolated. Two species (e.g., raccoon) tolerated fragmentation, with little or no effect on their distribution and abundance. Fragmentation increased the distribution and abundance of 3 species (i.e., gray fox, domestic cat, opossum—the latter 2 are exotics). Body size of the carnivore, in conjunction with other ecological characteristics, partially accounts for the difference in responses. A single, large reserve is more likely to support populations of coyotes, bobcats, and mountain lions than groups of smaller areas of the same total size. Coyotes persist in developed areas and are generally considered to be tolerant; nevertheless, coyote occupancy, residency, and relative abundance declined with fragment area and isolation, to the point of local extinctions of coyote populations in the smallest, most isolated urban remnants. Compared to the other species, bobcats were intermediate in their sensitivity to fragmentation, and mountain lions were extremely vulnerable.

Dumond, M., M.-A. Villard, and E. Tremblay. 2000. Does coyote diet vary seasonally between a protected and an unprotected forest landscape? Ecoscience 8:301-310.

Researchers analyzed scat contents to compare seasonal variations in annual coyote diet in a national park and an adjacent populated area (<7 inhabitants/square kilometer), mostly concentrated in a few villages of 250-2000 residents. The level of human disturbance was estimated from the proportion of the area disturbed by human activities plus a 500-meter buffer. Roads and a 100-meter buffer on each side were also considered disturbed areas. Outside the park, some coyotes are trapped and coyotes are frequently persecuted by aggressive yelling, chasing with vehicle, and shooting. Scats contained significantly more snowshoe hare and moose (probably from carcasses remaining after the hunting season) remains in the unprotected area and diet diversity was higher in the protected area during winter. Although snowshoe hare densities were higher in the protected area, forest edges associated with human development increases vulnerability of snowshoe hares to coyote predation during winter, favoring coyote populations in unprotected areas. However, during summer, human persecution seems to reduce the daylight activity of coyotes and limits their use of open habitats, limiting the diversity of their diet.

Feriani, J. M., T. K. Fuller, and R. M. Sauvajot. 2001. Does availability of anthropogenic food enhance densities of omnivorous animals? An example with coyotes in southern California. Ecography 14:325-331.

Researcher compared 3 neighboring areas under contrasting human pressures. In the most human-influenced area (24% residential and a large landfill) anthropogenic foods (trash, livestock, domestic fruit) comprised seasonally between 14-25% of total items in coyote diets, whereas in the least human-influenced area (2% residential development) anthropogenic foods only comprised seasonally between 0-3% of items. Coyote density was significantly higher in the most human-influenced area.

Ferreras, P., J. J. Aldama, J. F. Beltrán, and M. Delibes. 1992. Rates and causes of mortality in a fragmented population of Iberian lynx *Felis pardina* Temmink, 1824. Biological Conservation 61:197-202.

Human activities were the main cause of lynx mortality in the mainly fully protected area. The second most important cause of mortality was road traffic (16.7%). The main cause of mortality was illegal trapping supposedly targeting foxes and rabbits (41.7%).

Grinder, M. I., and P. R. Krausman. 2001. Home range, habitat use, and nocturnal activity of coyotes in an urban environment. Journal of Wildlife Management 65:887-898.

Researchers determined home range, habitat use, and nocturnal activity for 16 coyotes in Tucson, Arizona, using radio collars. Home ranges encompassed more park and residential areas in a higher proportion than were available; however, they used habitat patch types within the home ranges in proportion to their availability, except during the dispersal season when coyotes selected natural areas and washes and avoided park and residential areas. Coyotes in urban areas appear to be able to fulfill their daily requirements by shifting activity to times when humans are least active, by using areas where they can avoid humans and by concentrating their time in parks, residential areas, and natural sites. Coyotes may benefit from some level of alteration to the natural environment, even if to do so they must change their activity patterns. There is probably a threshold of alteration above which coyotes can no longer benefit.

Lovallo, M. J., and E. M. Anderson. 1996. Bobcat movements and home ranges relative to roads in Wisconsin. Wildlife Society Bulletin 24:71-76.

Selection or avoidance of particular road types appeared related to vehicle traffic levels and habitat composition of buffer zones (100 meters on each side) around roads. Nineteen radiocollared bobcats crossed paved roads less frequently than expected, while secondary highways, unpaved roads, and trails were crossed in proportion to their occurrence. Mean counts of vehicular traffic were 7.5 axles/hour for paved roads, 3.7 for secondary highways, 4.7 for unpaved roads, and 0.1 for trails. Trails received the least vehicle use and buffer zones around trails contained more preferred habitat than buffers around other road types.

McClennen, N., R. R. Wigglesworth, S. H. Anderson, and D. G. Wachob. 2001. The effect of suburban and agricultural development on the activity patterns of coyotes (*Canis latrans*). American Midland Naturalist 146:27-36.

Coyotes in an undeveloped/national park area were significantly more active during daylight than those in an adjacent suburban/agricultural area. Thus, coyotes in suburban/agricultural areas reduced activity during the day and increased activity during the night due to human activity, including vehicles, shooting, trapping, and competition with domestic dogs.

Mech, L. D., S. H. Fritts, G. L. Radde, and W. J. Paul. 1988. Wolf distribution and road density in Minnesota. Wildlife Society Bulletin 16:85-87.

Distribution of wolves was mapped based on the authors' experience. The area currently occupied by wolves had road densities of 0.36 km/km^2. Road density in the primary range vs. peripheral and disjunct range was 0.29 and 0.54 km/km^2, respectively. In the part of the primary range that was devoid of wolves the road density was >0.83 km/km^2. The primary threat of high road densities was not the road itself, but the accessibility that allows humans to deliberately, accidentally, or incidentally

kill wolves. Road densities may also be associated with different types of land use, which may affect wolf security.

Mech, L. D. 1989. Wolf population survival in an area of high road density. American Midland Naturalist 121:383-389.

Wolves will gradually occupy areas of relatively greater road density (>0.58 km/km^2, but <1.0 km/km^2), if a large region of low road density serves as a wolf population source and the population has protected status.

Merrill, S. B. 2000. Road densities and gray wolf, *Canis lupus*, habitat suitability: an exception. Canadian Field Naturalist 114:312-313.

Several studies have suggested that gray wolf populations are jeopardized at road densities >0.58 km/km^2. In one example in central Minnesota, wolves are breeding successfully in a small area (214 km) with a road density of 1.42 km/km^2. The area is a National Guard training site with light traffic in winter, but thousands of vehicles/month from April through September. Speeds are limited to 40 km/hour. Public access is limited, so wolves are less vulnerable to mortality from hunters than elsewhere in Minnesota. Many wolves dispersing from this area are hit by cars or illegally shot or trapped. Thus, road density is an index of high-speed vehicles and human attitudes, and there are situations when road density alone is not an accurate index of wolf habitat suitability.

Mladenoff, D. J., T. A. Sickley, R. G. Haight, and A. P. Wydeven. 1995. A regional landscape analysis and prediction of favorable gray wolf habitat in the northern Great Lakes region. Conservation Biology 9:279-294.

Wolf numbers are increasing in this region, with wolves selecting heavily those areas that are most remote from human influence, as defined largely by low road density. Road density is an index; wolves do not avoid roads but the humans using roads and road-accessible areas. Few portions of any pack territory are located in areas of road density >0.45 km/km^2, and no portion of any pack area is located in an area of road density >1.0 km/km^2. Overall land cover patches within pack territories are less complex than patches in nonpack areas, which may also indicate wolves are selecting areas with lower human presence and less landscape fragmentation.

Mladenoff, D. J., T. A. Sickley, and A. P. Wydevens. 1999. Predicting gray wolf landscape recolonization logistic regression models vs. new field data. Ecological Applications 9:37-44.

The relationship between wolf use of the landscape and road density is a robust predictor of suitable wolf habitat, particularly in a region where suitable areas are fragmented and a large source population of wolves is not immediately available. Existing pack territories are usually within areas of road densities <0.45 km/km^2. Dispersing wolves can be expected to occur well outside blocks of suitable habitat.

Nielsen, C. K., and A. Woolf. 2002. Survival of unexploited bobcats in southern Illinois. Journal of Wildlife Management 66:833-838.

Annual and seasonal mortality rates were estimated based on 75 radiocollared bobcats in Illinois, where bobcats are protected from harvest. Nineteen mortalities occurred during the 5-year study: 10 (52%) were hit by vehicles, 3 (16%) were unknown, 2 (11%) were hit by trains, 3 (16%) were accidentally trapped, and 1 (5%) was natural. Human mortalities were the primary cause of mortality,

resulting in 15 of 19 (79%) diagnosed deaths. Researchers believed the relatively high road density (1.4 km/km^2) was responsible for the high mortality rate. Although current human influence was not severely limiting bobcat populations in southern Illinois, researchers predicted that continued human expansion into rural areas may adversely affect bobcats.

Palma, L, P. Beja, and M. Rodrigues. 1999. The use of sighting data to analyze Iberian lynx habitat and distribution. Journal of Applied Ecology 36:812-824.

Researchers studied lynx distribution patterns in remote mountainous habitat in Portugal. Sighting probabilities declined with road density and the amount of developed land, suggesting that lynx are very susceptible to human interference. Indices of human presence were never associated positively with lynx sightings, suggesting that observation patterns were not influence by the spatial distribution of potential observers.

Philcox, C. K., A. L. Grogan, and D. W. MacDonald. 1999. Patterns of otter *Lutra lutra* road mortality in Britain. Journal of Applied Ecology 36:748-762.

Records of otter road kills (673 between 1971 and 1996) were compiled and analyzed. A 100-meter-wide zone adjacent to watercourses or the coast accounted for 67% of all kills. The optimal approach for river crossings is the use of wide-span bridges which permit the retention of the river bank under the bridge, enabling otters to cross beneath roads in times of high flows. Where bridges are impractical, oversized culverts incorporating ledges above the high water-level may achieve similar results.

Quinn, T. 1997. Coyote (*Canis latrans*) habitat selection in urban areas of western Washington via analysis of routine movements. Northwest Science 71:289-297.

Six radiocollared coyotes were followed in Seattle, Washington. Analysis of movement data suggested that coyotes preferred relatively undisturbed habitats in urban environments despite the fact that the amount of those habitat types was quite variable among home ranges and in some cases made up a small proportion of the home range. Movement data also suggested that coyotes remained in close proximity (within 1 hour travel time) of preferred forest and shrub habitat types. Sparsely mixed vegetation in dense residential housing developments, major metropolitan areas, or industrial areas may facilitate coyote travel at night became relatively unsuitable by day. Coyotes traveled relatively long distances at night but tended to restrict movement length during the day, presumably to avoid contact with humans. Despite the fact that night movements were longer and less constrained by habitat type than day movements, urban coyotes still preferred relatively vegetated habitats at night.

Riley, S. P. D. 1999. Spatial organization, food habits and disease ecology of bobcats (*Lynx rufus*) and gray foxes (*Urocyon cinereoargenteus*) in national park areas in urban and rural Marin County, California. Ph.D. dissertation. University of California, Davis. *[cited in Riley et al. (2003)]*

In Golden Gate National Recreation Area in northern California, female bobcats appear more sensitive to urbanization because they maintain home ranges only in the interior of the park, whereas males range out to the park edge.

Riley, S. P. D., R. M. Sauvajot, T. K. Fuller, E. C. York, D. A. Kamradt, C. Bromley, and R. A. Wayne. 2003. Effects of urbanization and habitat fragmentation on bobcats and coyotes in southern California. Conservation Biology 17:566-576.

Based on home ranges of 35 bobcats and 40 coyotes, both species occupied predominantly natural areas. Bobcats were more sensitive to urbanization than omnivorous canids. Adult female bobcats had low levels of urban association, significantly lower than coyotes, adult male bobcats, and young female bobcats. However, home range size was positively correlated with urban associations for both species, suggesting human-dominated areas were less suitable than natural areas. Bobcats and coyotes were more likely to use developed areas at night than during the day, presumably avoiding human activity. Vehicles, other carnivores, and toxins were the principal causes of death for bobcats and coyotes. However, mortality rates from human-related causes were not related to urban association. For bobcats, preserving open space of sufficient quantity and quality for adult females is necessary for population viability.

Rodriguez, A., F. Crema, and M. Delibes. 1997. Factors affecting crossing of red foxes and wildcats through non-wildlife passages across a high-speed railway. Ecography 20:287-294.

Researchers used a layer of sand to record passage of foxes and wildcats (a large, wild relative of domestic cats) through unpaved, rural paths under a railway in Spain. The railway had side fences 2 meters high that apparently did not completely preclude movement of foxes and wildcats. The study stretch (25 kilometers) contained 42 passages (underpasses 1.2-3.5 meters wide and overpasses) and railway traffic was less than 10 trains/day, limited to daylight hours. Foxes and wildcats preferred using passages located in habitats with cover and low level of human disturbance. The presence of cover by the passage entrance was the only passage feature which was significantly associated with high crossing rates in both species. Passage design and dimensions had little effect on passage rates; however, this lack of effect may change with increased human use. At average use levels by humans (<1 crossing/passage-day) did not affect fox and wildcat crossing rates; however, in a subsample of passages, both species infrequently used passages near permanent sources of "intense" human traffic [the level was undefined].

Sunde, P., S. O. Stener, and T. Kvam. 1998. Tolerance to humans of resting lynxes *Lynx lynx* in a hunted population. Wildlife Biology 4:177-183.

Tolerance to human presence was studied in Norway using telemetry. Resting lynx avoided forested land within 200 meters of the nearest road or house. The closest distances observed from resting lynx to houses and roads were 60 and 40 meters, respectively. The researchers did not believe this avoidance behavior was strong and lynx did not avoid human facilities at night indicating it was probably the presence of people rather than the presence of the road or house that influenced lynx behavior during the day. One or 2 researchers experimentally approached resting 9 different lynx on 24 occasions. The median tolerance distance of resting lynx to humans was 50 meters (range 8-250 meters). Resting lynx tolerated people at closer ranges when the vegetation cover was dense and in more mature forests. The median movement distance of lynx after displacement was 300 meters, but ranged from 0 (the lynx withdrew 50 meters and returned when the intruders left) to 2,500 meters independent of habitat characteristics. Lynx appear to tolerate humans at high densities as long as sufficient forest habitats are present with undisturbed refuges in mature forest and dense vegetation.

Thiel, R. P. 1985. Relationship between road densities and wolf habitat suitability in Wisconsin. American Midland Naturalist 113:404-407.

The increase in road densities in wolf habitat led to the extinction of wolves in Wisconsin. Wolves failed to survive when road densities throughout their range exceeded 0.93 mile/miles^2. This relationship may only apply to the study period (1926-1960), when negative public attitudes,

supported by government bounties, were at a higher level, and potential for immigration from Minnesota's wolf population was low. However, during the subsequent 2 decades, wolves from Minnesota successfully colonized only a few areas where road densities were less than the critical threshold.

Thiel, R. P., S. Merrill, and L. D. Mech. 1998. Tolerance of denning wolves, *Canis lupus*, to human disturbance. Canadian Field-Naturalist 112:340-342.

Some wolves in several states have demonstrated extreme tolerance to human presence, including vehicles, military camps and activity, and explosives, at distances less than 0.5 kilometer from den and rendezvous sites. These wolves indicate an ability to habituate to human activity in the absence of hunting.

Thurber, J. M., R. O. Peterson, T. D. Drummer, and S. A. Thomasma. 1994. Gray wolf response to refuge boundaries and roads in Alaska. Wildlife Society Bulletin 22:61-68.

Sixty-four wolves were radio-collared and monitored in and near the Kenai National Wildlife Refuge. On the eastern boundary of the refuge, bordering national forest, there was no detectable difference in wolf use inside or outside the refuge. On the western boundary, adjacent to private, developed land, there was greater use within the refuge, with 48 of 50 distance categories exhibiting greater use than the corresponding distance category outside the refuge. Wolf location patterns indicated avoidance of the oilfield access roads, which received a substantial amount of worker traffic and were open for public use all year (however, locations were primarily recorded in winter, when human activity in wolf habitats was at a seasonal minimum). Wolf use of lands adjacent to the well-traveled state highway indicated no clear avoidance. Wolves were attracted to a gated pipeline access road and secondary gravel roads with limited human use.

Tigas, L. A., D. H. Van Vuren, and R. M. Sauvajot. 2002. Behavioral responses of bobcats and coyotes to habitat fragmentation and corridors in an urban environment. Biological Conservation 108:299-306.

Eleven bobcats and 13 coyotes were radiocollared and monitored for over a year near Los Angeles. Both species were less active during the day in fragmented habitat than in unfragmented habitat, suggesting some behavioral avoidance of human activities. Home ranges of over half of the bobcats (especially females) were entirely within habitat fragments. Bobcats were within a single fragment in 72% of all observations and were farther than 100 meters from development in 50% of observations. In contrast, coyotes appeared to be relatively tolerant of human development. Coyotes appeared more willing to cross roads than bobcats. Both species tended to cross over roads rather than use culverts. Both species used corridors between habitat fragments as habitat and, less often, for travel. Both species also crossed development to move between fragments, but seemed to prefer corridors when available.

van der Zee, F. F., J. Wiertz, C. J. F. Ter Braak, R. C. van Apeldoorn, and J. Vink. 1992. Landscape change as a possible cause of the badger *Meles meles* L. decline in The Netherlands. Biological Conservation 61:17-22.

Between 1960 and 1980 the number of used badger setts decreased by more than 30%. Road density, and associated human disturbance and road kills, appeared to be the only significant variable accounting for the decline.

Van Dyke, F. G., R. H. Brocke, H. G. Shaw, B. B. Ackerman, T. P. Hemker, and F. G. Lindzey. 1986. Reactions of mountain lions to logging and human activity. Journal of Wildlife Management 50:95-102.

Locations of radiocollared mountain lions in Arizona and Utah were compared to disturbed areas, where the sight or sound of humans, machines, or man-made structures were perceptible (to researchers) ≤500 meters from the estimated location of the lion. Near human disturbance, lion activity peaks shifted from ≤2 hours of sunrise and sunset to after sunset. Established resident lions and young lions that ultimately became residents in the study area selected home areas with road densities lower than average, no recent timber sales, and few or no sites of human residence. All disturbances examined appeared to have at least potential adverse impacts on mountain lions, especially dispersing juveniles. This suggests 2 possible implications about the impact of human disturbance on mountain lions. First, areas that experience permanent or repeated habitat alteration are reduced in quality to the lion population, even if human residence, presence, or activity is temporary. Second, areas where there is continuing, concentrated human presence or residence are essentially lost to the lion population, even if there is little impact on the habitat itself.

Woodroffe, R., and J. R. Ginsberg. 1998. Edge effects and the extinction of populations inside protected areas. Science 280:2126-2128.

Refer to Bear citations.

BEARS

Chi, D. K., and B. K. Gilbert. 1999. Habitat security for Alaskan black bears at key foraging sites: are there thresholds for human disturbance? Ursus 11:225-238.

Closely monitored wildlife-viewing activities affect bears fishing at Anan Creek. Although fish were accessible from 2 sites, some bears never used the lower falls (10-40 meters from an observation deck) and were displaced from fishing upon encountering people at the upper falls (closed to research and the public). At the lower falls, the duration of visits by tolerant bears decreased as visitors on the observation deck increased. These results are a conservative estimate of human disturbance to bears at Anan Creek. Bears intolerant of people may have completely abandoned the area as the popularity of this site increased. Large numbers of visitors on the observation deck (>15) affected maximum fishing time of habituated bears. Placing restrictions on group size and providing education on appropriate viewing etiquette (e.g., no loud talking, minimize movement) could reduce disturbance.

Elgmork, K. 1978. Human impact on a brown bear population (*Ursus arctos* L.). Biological Conservation 13:81-103.

The effect of human disturbance and activities on a small, remnant brown bear population in Norway was studied for a 25-year period. The distribution and density of bear observations by the public were evaluated for reliability (27% of the reports were rejected). Areas within 2 kilometers (1.2 miles) of cabin concentrations (>5 cabins <500 meters apart) were considered influence zones. Associated human activities, compounded by secondary traffic on many forest roads and the large numbers of people hiking from the roads, represented a considerable disturbance to bears. As the number of people increased, the number of bear observations decreased. Although care should be taken in interpreting correlations of this type, it is extremely difficult to find any reasonable factor that would independently influence bear use other than the construction and use of forest roads.

Goodrich, J. M., and J. Berger. 1994. Winter recreation and hibernating black bears *Ursus americanus*. Biological Conservation 67:105-110.

Denning black bears were studied at 2 sites in Nevada. The Sierra study site was between Lake Tahoe and Reno and included several ski resorts with associated human activities. The Sweetwater study site had little human disturbance in winter. Black bears from the Sierra site entered dens a month earlier and were more selective in their choice of dens than bears in the Sweetwater site. Bears in both study areas abandoned dens and cubs in response to investigator disturbance, and all but one bear remained active after abandonment. Since the quiet approach of investigators sometimes causes abandonment of dens and cubs, skiing and other recreational activities could have the same or more heightened effects.

Gunther, K. A. 1990. Visitor impact on grizzly bear activity in Pelican Valley, Yellowstone National Park. International Conference of Bear Research and Management 8:73-78.

Human use affected bear use of open meadow habitats in the park. Combined overnight and day use averaged 84 people/day during the peak season (July-August), prior to implementation of human-use restrictions. During the 5 years of the study, backcountry use averaged 2 people/day during closed periods, 12 people/day during restricted (day-use-only periods), and 21 people/day during the open periods. Compliance with the area closure and day-use-only regulations was 99% and 83%, respectively. Signs posted at the trailhead recommended hiking parties of 4 or more people and strongly recommended against hiking alone. Despite these warnings, 83% of the parties entering the valley had group sizes of less than 4 people and 20% of the hikers hiked alone. Bears made significantly more frequent use of areas farther than 500 meters from tree cover during the closed and restricted periods than during the open periods. The difference between the closed and restricted periods was not significant. The average flight distance of grizzly bears to tree cover following disturbance by visitors was 422 meters. Restricting use of the valley to time periods when grizzlies were least active (0900- 1900 hours) appeared to successfully prevent human-caused displacement of bears from productive open habitats and at the same time allowed for recreational use of the area. It also increased human safety by reducing the chance of bear-human encounters. Not all bears observed during the study were displaced by recreational activity. Several bears were habituated to people and tolerated people at close distances in exchange for habitat during diurnal periods. Although habituation may increase the efficiency of bear habitat use in some instances by reducing displacement and minimizing the frequency of energy-demanding responses, it often results in the bear being removed from the population due to concern for human safety. Researchers cautioned that impact of recreational activity on grizzly bears may not be as pronounced in areas where security cover is more readily accessible.

Hood, G. A., and K. L. Parker. 2001. Impact of human activities on grizzly bear habitat in Jasper National Park. Wildlife Society Bulletin 29:624-638.

Researchers compared levels of human activity (hiking, camping, picknicking, vehicles, and motorized boats) on habitat suitability for grizzly bears. All trails in the study area experienced days of no human use, and all but 1 trail averaged <200 people/day from April through October. Similarly, all campgrounds experienced days of no use and seasonal averages were all <6 people/day. “Habitat effectiveness” values ranged from 0 to 1, with 0 indicating the habitat is effectively unavailable to grizzly bears because of the high level of human use and 1 indicating that 100% of the habitat is available (with no human use) to bears. A threshold habitat effectiveness value adopted for Jasper National Park is >0.8 (80%). Habitat effectiveness values in all 3 bear management units in the study area during July and August were less than the >80% threshold value. Disturbance was the most

important variable. When human activities increased in areas of high habitat suitability for grizzly bears, habitat effectiveness values decreased.

Jope, K. L. 1985. Implications of grizzly bear habituation to hikers. Wildlife Society Bulletin 13:32-37.

Hikers were surveyed about bear encounters in Glacier National Park, Montana. Bears >150 meters from a hiker generally did not respond to the encounter; however, bears responded overtly when ≤150 meters. Grizzly bear habituation to hikers reduces the rate of fear-induced full-charges in heavy-use areas. Characteristics of hikers that may contribute to habituation include (1) a consistent context for encounters with hikers, such as on trails during the daytime; (2) frequent, irregularly spaced encounters; (3) an easily recognizable stimulus, such as hikers with bear bells or hikers on heavily used trails; and (4) innocuous behavior by hikers.

Kasworm, W. F., and T. L. Manley. 1990. Road and trail influences on grizzly bears and black bears in northwest Montana. International Conference of Bear Research and Management 8:79-84.

Radio locations of 3 adult grizzly bears (317 locations) and 26 adult black bears (1,647 locations) were analyzed. Grizzly bears used habitat up to 914 meters from open roads less than expected based on availability during spring and fall. Black bears used habitat up to 274 meters from open roads less than expected during spring and used habitat less than 914 meters from roads less than expected during fall. Grizzly bears used habitat less than 122 meters from trails less than expected during spring and fall. Black bears used habitat less than 122 meters from trails less than expected during spring and used habitat less than 305 meters from trails less than expected during fall. Grizzly bears avoided high quality habitat near roads and trails, which may reduce opportunity for individuals to obtain food and increase intraspecific competition. Conversely, the tolerance of black bears to human disturbance may allow that species to exploit habitat in the relative absence of grizzly bears.

Keay, J. A., and J. W. Van Wagtendonk. 1983. Effect of Yosemite backcountry use levels on incidents with black bears. International Conference of Bear Research and Management 5:307-311.

Park Service staff documented 1,038 black bear incidents that involved property damage or personal injury in backcountry areas in 1976-1979. There was a definite correlation between visitor density and bear incidents. In order to reduce bear incidents to an acceptable level, managers of backcountry areas must address the level and nature of visitor use. This may be accomplished by increased public information and education efforts. However, a reduction in visitor density, both on an annual and per-night basis, may also be necessary and would contribute to reducing both bear-human interactions and food availability.

Linnell, J. D. C., J. E. Swenson, R. Andersen, and B. Barnes. 2000. How vulnerable are denning bears to disturbance? Wildlife Society Bulletin 28:400-413.

The authors reviewed the literature on den-site selection, denning physiology, and responses to disturbance for brown, black and polar bears. Denning bears seemed to tolerate most human activities (roads, habitation, industrial activity) that occurred more than 1 km from the den. Activity closer than 1 km and especially within 200 m caused variable responses. Some bears tolerate disturbance even inside the den, but bears will abandon dens in response to activity within this zone, especially early in the denning period. Loss of a single denning area following human disturbance will not always lead to deleterious effects, if alternative denning areas are available within the home

range. Winter activity should be minimized in suitable or traditional denning areas. Activity should avoid known bear dens by at least 1 km.

Mace, R. D., and J. S. Waller. 1996. Grizzly bear distribution and human conflicts in Jewel Basin Hiking Area, Swan Mountains, Montana. Wildlife Society Bulletin 24:461-467.

Most grizzly bears surviving in multiple-use and other highly impacted areas in western Montana have become negatively conditioned to humans. An average of 90 people/day used the study area during June-August. During each season for seven years, bears were significantly farther away from areas frequented by humans than from other areas. Most recreational activity in the study area was confined to well-defined, historical hiking trails and campsites; however, use was unpredictable because of low numbers of recreationists. Grizzly bears were hunted in surrounding areas for the first four years of the study, and this probably contributed to their avoidance of humans in the study area.

Martinka, C. J. 1982. Rationale and options for management in grizzly bear sanctuaries. Transactions of the North American Wildlife and Natural Resources Conference 47:470-475.

Based on interactions between grizzly bears and visitors in Glacier National Park, Montana, confrontations that resulted in injury or death to people are directly related to the number of people in bear habitat. Visitor distribution management can reduce future confrontations and bear removals in parks. Rerouting trails to avoid important bear habitats is one possible technique, as well as restricting local activity on existing trails to time periods when grizzlies were least likely to be present.

McLellan, B. N., and D. M. Shackleton. 1989. Immediate reactions of grizzly bears to human activities. Wildlife Society Bulletin 17:269-274.

Researchers analyzed 165 interactions between people and 29 radio-collared bears in Montana and British Columbia, Canada. In open habitats, bears responded more strongly when >150 meters from people on foot than when closer. Researchers believed this was related to density of human use. Bears were encountered more frequently at close distances near roads and residences where their responses were more moderate than those of bears encountered in remote areas. In cover, stimulus distance had no effect on bears' level of reaction. Bears in areas of low human use fled from a person on foot in every encounter (n=10), and in 7 of these they ran >1 km or out of the immediate drainage. In areas of high human use, bears fled in 10 of 16 cases (63%). High human-use areas such as roads should be constructed away from open areas to reduce disturbance. Areas with known seasonal concentrations of bears could be closed to hikers to protect both bears and people.

Nadeau, M. S. 1987. Habitats, trail and campground situations associated with human-grizzly confrontations in Glacier National Park, Montana. M. S. thesis. University of Montana, Missoula. 91pp.

Reimchen, T. E. 1998. Diurnal and nocturnal behavior of black bears, *Ursus americanus*, on bear trails. Canadian Field-Naturalist 112:698-699.

The researcher monitored black bear movements in a riparian habitat in British Columbia during daylight and also during darkness, using light-enhancing night-viewing goggles. During daylight, bears regularly moved off the trails on first visual detection of his presence (>20 meters). However, during darkness, bears maintained high fidelity to these trails even during close approaches (1 meter) suggesting these trails act as nocturnal sensory corridors.

Swenson, J. E., F. Sandegren, S. Brunberg, and P. Wabakken. 1997. Winter den abandonment by brown bears *Ursus arctos*: causes and consequences. Wildlife Biology 3:35-38.

Researchers monitored den use of 68 radio-marked bears in Norway during 194 bear-winters. Rate of den abandonment for all bears combined was 9%. Researchers visited all 18 dens after abandonment. Evidence of human activity was found at 12 (67%) of the dens. Human tracks may have been obliterated by snow or wind at remaining 6 dens. One bear returned to the same den; movements to new dens varied from 100 meters to 30 kilometers (mean 5.1 kilometers). Den abandonment had a negative effect on reproductive success. Of 5 pregnant females that moved prior to giving birth, 3 (60%) lost at least 1 cub in or near the second den, whereas only 6% of those that did not move lost a cub in or near their dens. Researchers recommended that an area around known active bear dens be avoided by humans. Limited data suggested the distance should be over 100 meters, perhaps up to 1 kilometer.

Tietje, W. D., and R. L. Ruff. 1980. Denning behavior of black bears in boreal forest of Alberta. Journal of Wildlife Management 44:858-870.

Den sites were approached to document bear behavior. About 6% were subsequently abandoned. The tendency to abandon dens was greatest during den construction and decreased thereafter. Black bears that changed dens had a greater weight loss (25%) than those that did not (16%). No overwinter or early spring mortality was noted in disturbed bears, and reproductive performance of females appeared normal. However, den abandonment at any period may deplete fat reserves below a critical threshold and, in turn, inhibit cub production.

White, D., Jr., K. C. Kendall, and H. D. Picton. 1999. Potential energetic effects of mountain climbers on foraging grizzly bears. Wildlife Society Bulletin 27:146-151.

Grizzly bears foraging at sites with alpine aggregations of army cutworm moths were sensitive to disturbance from climbers. On 7 separate occasions at 3 different moth aggregations, they observed 11 bears stop feeding and either leave the moth aggregation or temporarily discontinue feeding until the climbers left the area. Of the 9 bears we observed displaced from a moth aggregation due to climber presence, none returned to the site that same day. Human disturbance had an energetic cost to the bears. When bears detected climbers, they subsequently spent 53% less time foraging on moths, 52% more time moving within the foraging area, and 23% more time behaving aggressively, compared to when they were not disturbed. To reduce both climber interruption of bear foraging and the potential for aggressive bear-human encounters, researchers recommended routing climbers around moth feeding sites used by bears or limiting access to these sites during bear-use periods.

Wilker, G. A., and V. G. Barnes. 1998. Responses of brown bears to human activities at O'Malley River, Kodiak Island, Alaska. Ursus 10:557-561.

Encounters between people and bears resulted in strong responses (walking or running until out of sight) from bears more frequently (37%) during years of general public use than in years of structured bear viewing (6%). Bears ran or walked away from photographers more often (30%) than from people who were just watching (15%). Bears reacted strongly in all encounters where people were walking or using deterrence methods (shouting, waving arms). Fixed-wing aircraft flying at <100 meters were often disruptive to bears, but the incidence of strong response declined sharply at 100-200 meters and was negligible at >200 meters. The researchers suggested that higher levels of low or neutral response by bears to encounters with guided bear viewing groups was the result of consistent and predictable patterns of human activity. Guided groups traveled to and from the viewing platform at

approximately the same time each day, used a trail that did not interfere with bears using the river, and stayed on the platform during the time they were at the river. Activities such as walking, aggressive behavior to alert or scare bears, and stalking with cameras were particularly disruptive to bears.

Yost, A. C., and R. G. Wright. 2001. Moose, caribou, and grizzly bear distribution in relation to road traffic in Denali National Park, Alaska. Arctic 54:41-48.

Grizzly bear and caribou distributions indicated no pattern of traffic avoidance. Moose sightings were lower than expected within 300 meters of the road; however, this may have been influenced by the spatial pattern of preferred forage.

Woodroffe, R., and J. R. Ginsberg. 1998. Edge effects and the extinction of populations inside protected areas. Science 280:2126-2128.

Theory predicts that small populations may be driven to extinction by random fluctuations in demography and loss of genetic diversity through drift. However, population size is a poor predictor of extinction in large carnivores inhabiting protected areas. Conflict with people on reserve borders is the major cause of mortality in such populations, so that the border areas are populations sinks. The species most likely to disappear from small reserves are those that range widely—and are therefore most exposed to threats on reserve borders—irrespective of population size. Critical reserve sizes (i.e., the area for which the logistic model predicts a 50% probability of population persistence) for brown bears, black bears, and wolves are 3,981, 36, and 766 km^2, respectively

UNGULATES

Andersen, R., J. D. C. Linnell, and R. Langvatn. 1996. Short term behavioural and physiological response of moose *Alces alces* to military disturbance in Norway. Biological Conservation 77:169-176.

Four moose, fitted with hear-rate transmitters, were subjected to specific stimuli in controlled disturbance trials, and 12 radio-collared moose were followed for 3-week-long periods before, during, and after military maneuvers. In total, 6,000 people, several hundred all-terrain vehicles, tanks, and several dozen helicopters and jets were involved. The entire area was subjected to repeated low-level jet and helicopter overflights. Nine types of stimuli were considered, including a cross-country skier, a person on foot, a platoon of soldiers (approximately 30?) on foot, a tracked all-terrain vehicle, a snowmobile, a four-wheeler, a helicopter, a fighter jet, and cannon fire. In total, 40 trials were carried out, 19 human (the first 3 types of stimuli) and 21 mechanical (the last 6 types of stimuli). Trails were ended when the moose fled. Approaches by single people or groups on foot tended to elicit flight response at much greater distances than mechanical stimuli. There was no significant difference between human and mechanical stimuli in the distance covered during flight. The distance from the stimuli when the moose began to flee was significant, however, with human disturbances eliciting flight at much greater distances (211 vs. 116 meters) than mechanical disturbances. Home range size tended to increase during and decrease after disturbances. Moose that were slightly displaced may have needed more than a week to return to their normal area. Even the noise of F-16 jets flying at heights of 150 meters was not able to elicit any heart rate or activity response from a moose, while skiers and walkers flushed moose at 200-400 yards. Although flight distances were similar for both human and mechanical categories of disturbance, it was extreme stimuli (e.g., snowmobiles being driven to within 5 meters and helicopters flying at 50 meters or below) that caused

flights in excess of 1 kilometer (0.6 mile), comparable to flights produced by solitary pedestrians. Greater fear of humans than vehicles may be due to hunting and the familiarity of moose to all-terrain, timber-cutting vehicles in this area. The researchers concluded that effects of the military maneuvers should not differ from comparable civilian harassment.

Bangs, E. E., T. N. Bailey, and M. F. Portner. 1989. Survival rates of adult female moose on the Kenai Peninsula, Alaska. Journal of Wildlife Management 53:557-563.

Survival and cause-specific mortality rates were determined for 51 radio-collared adult female moose during a 6-year period. Collisions with vehicles were the primary cause of death (0.04/year). Snow cover was incomplete most winters and rarely exceeded 25 centimeters; therefore, the vehicle collision rate is probably higher in years with deep snow. Mortalities from vehicle collisions occurred at nearly twice the rate reported to authorities. There was no apparent relationship between kilometers of road/moose home range and road-kill mortality. The dominant factor influencing moose-vehicle collisions appeared to be the presence of a highway within a home range.

Behrend, D. F., and R. A. Lubeck. 1968. Summer flight behavior of white-tailed deer in two Adirondack forests. Journal of Wildlife Management 32:615-618.

The influence of hunting on flight behavior and sightability of deer was compared in a hunted and unhunted population. The mean flight distance for antlered deer (except spikehorns) on the hunted area; was significantly longer than for antlered deer on the unhunted area (57.9 vs. 29.5 yards), and for antlerless deer on both areas (37.6 and 33.8 yards). Response of deer to vehicles was less pronounced in both areas than to people on foot.

Bullock, D. J., F. J. Kerridge, A. Hanlon, and R. W. Arnold. 1993. Short-term responses of deer to recreational disturbances in two deer parks. Journal of Zoology 230:327-332.

Deer parks offer an opportunity for people to observe free-ranging deer, and their educational and amenity value is high. However, high visitor pressure may alter routine activities of deer such that feeding is reduced or deer are harassed by dogs. Fallow and red deer were observed for 30-minute periods in 2 deer parks in England between June and August. About 11% of 1 park was in sanctuaries where public access was prohibited. About 1.3 million people visit the park annually. The other park had no sanctuaries. Deer densities were similar. Dogs were allowed in both parks. Unleashed dogs were prohibited in 1 park but the law was difficult to enforce. All people, dogs, vehicles, cyclists and other potential disturbances within 50 meters from a deer under observation were recorded, giving an encounter rate. Encounter rates with dogs were low (0-1.4/30 minutes) in the sanctuary area, and dogs typically caused few withdrawals. Higher rates of dog encounters (1.5-2.8/30 min) in non-sanctuary areas of the same park invariably caused withdrawals. In the other park, dog encounter rates (0.1-0.9/30 min) were also low for deer, and most encounters resulted in withdrawals, however, some deer approached small dogs. Encounter rate alone did not adequately quantify disturbance to deer. Percentage of encounters that caused a withdrawal was a more useful indicator of disturbance. Using this measure, fallow deer and female red deer in non-sanctuary areas were particularly responsive to disturbance, with percentage of withdrawals negatively correlated with encounter rate. In other situations (e.g., all deer in sanctuary areas and male red deer in non-sanctuary areas), encounter rates may have been high (e.g., up to about 40 people/30 min), but percentage withdrawals were low. There was some evidence that both red and fallow deer may become habituated and less responsive to disturbance in parks as a result of frequent encounters with people.

Cassirer, E. F., D. J. Freddy, and E. D. Ables. 1992. Elk responses to disturbance by cross-country skiers in Yellowstone National Park. Wildlife Society Bulletin 20:375-381.

Radio-collared female elk were intentionally disturbed by groups of people walking or skiing directly into their location in three study areas. Elk in two areas were exposed to few skiers (<10 visits/winter) outside of the study; however, the elk at Mammoth Hot Springs frequently encountered people year-round because it was the administrative and tourist area. The median distance at which elk started to move when skiers approached was 400 meters, except at Mammoth (15 meters). The median distance moved (1,675 meters) depended on distance to the nearest ridge and wind speed. In 78% of the disturbances outside of Mammoth, the elk left the drainage. Although responses of elk at Mammoth were nearly always less than those at the other study areas, they increased 3-fold when elk were disturbed outside the developed area where people were present 24 hours each day. Flight distances at Mammoth were greater outside the developed area, but distances moved were not. Individual elk differed significantly in their responses to disturbance. Elk at Mammoth have habituated to predictable human activity, but responses increased substantially when elk encountered people in unusual locations. Displacement was usually temporary, and elk returned after people left the area. Each elk was disturbed 3-18 times during the winter by researchers. However, this tendency may decline with repeated disturbances. Energy expended moving away from skiers represented approximately 5.5% of an estimated average daily energy expenditure. Energy cost of movement would increase exponentially with increasing snow depths and would be most critical when accompanied by severe winter weather, reduced forage availability, or when elk are in poor condition. The amount of winter range used by skiers and the number of days involved seemed to be more important than skier numbers. Therefore, when skiing is located on elk winter range, skiers should be concentrated into as small an area as possible.

Colescott, J. H., and M. P. Gillingham. 1998. Reaction of moose (*Alces alces*) to snowmobile traffic in the Greys River Valley, Wyoming. Alces 34:329-338.

Moose bedding within 300 meters and feeding within 150 meters of passing snowmachines altered their behavior in response to the disturbance. This response was more pronounced when moose where within 150 meters of the disturbance. The frequency of snowmobile traffic did not seemingly affect the average percent of moose active, or the number of moose present in the study areas. Moose appeared to move away from the active snowmobile trail as the day progressed. Consequently, snowmobile traffic, although it did not appear to alter moose activity significantly, did influence the behavior of moose positioned within 300 meters of a trail and did displace moose to less favorable habitats. The time of day when snowmobilers arrive appears important. The effects of snowmobiles on moose behavior would be reduced if snowmobile activities were restricted to 10 a.m. to 4 p.m. This coincides with the resting period of moose and would therefore offset the time lost foraging to time spent hiding. In addition, snowmobilers should avoid the willow-riparian areas to avoid disturbing moose. If snowmobilers stop to observe a moose, they should remain on, or next to, their machines, thereby reducing the negative response of moose typically displayed to a person walking, snowshoeing, or skiing.

Dorrance, M. J., P. J. Savage, and D. E. Huff. 1975. Effects of snowmobiles on white-tailed deer. Journal of Wildlife Management 39:563-569.

Response of radio-collared deer to snowmobile traffic was monitored in a state park in Minnesota with approximately 192 kilometers (119 miles) of established, well-groomed trails with snowmobiles restricted to these trails. Daily numbers of snowmobiles registered at park headquarters were used as an index to snowmobile traffic. Daily numbers averaged 10 on weekdays and 195 on weekends. Number of deer along a 10-kilometer (6 mile) segment was used as an index to deer activity on areas

immediately adjacent to snowmobile traffic. The park was a wintering area for large numbers of deer. Deer responded to relatively low intensities of snowmobile traffic, and response increased with the duration of the disturbance. Deer became more visible adjacent to trails less than 24 hours after periods of heavy traffic. Results suggested that deer do habituate to snowmobile traffic on established trails; however, the researchers hypothesized that deer that are hunted annually would not become as habituated as those in the park, where hunting had not been allowed for several years. Researchers recommended routing trails away from areas where deer concentrate in winter and avoiding use of a particular trail on consecutive days.

Eckstein, R. G., T. F. O'Brien, O. J. Rongstad, and J. G. Bollinger. 1979. Snowmobile effects on movements of white-tailed deer: a case-study. Environmental Conservation 6:45-51.

A 19-kilometer (approximately 12-mile) snowmobile system was established to experimentally test responses of radio-collared deer to snowmobiles and cross-country skiers. The first winter, snowmobiles were operated on the trail system 3 days/week and other days served as controls. The second year, the experiment was designed to better measure the reaction of individual deer by using radios to direct the snowmobiles to circle the deer for 15-30 minutes on the trail system. A group of 20 cross-country skiers also employed this technique. Both winters were mild, and deer were never tightly concentrated. Intensive snowmobiling caused a significant increase in deer activity during a normally inactive period of the day. It was common for the lead snowmobiles to see 20-25 deer during the first run, but to see no more than 6-7 deer on subsequent runs. However, displacement by snowmobiles was not considered a serious disturbance because activity patterns and habitat uses were not altered. During the first winter, snowmobiles had little effect on the overall winter movements of 5 radio-collared deer. Conversely, in 8 of 11 encounters, deer moved at least 23 meters (25 yards; the minimum detectable movement) away from the trail in response to cross-country skiers. Deer remained close to noisy heavy equipment and chainsaws, but moved away from people approaching silently on foot. In this area, deer used snowmobile trails when convenient, but did not seem to prefer them over their own trails. Snowmobile trail networks and cross-country ski trails should be designed to by-pass traditional, heavily used deer yards. Sections of trails which pass through areas with large concentrations of deer should be closed when critical winter conditions develop.

Enggist-Dűblin, P., and P. Ingold. 2003. Modeling the impact of different forms of wildlife harassment, exemplified by a quantitative comparison of the effects of hikers and paragliders on feeding and space use of chamois *Rupicapra rupricapra*. Wildlife Biology 9:37-45.

Researchers developed a mathematical model to calculate additive effects of interrupted feeding and flight distances on chamois caused by human disturbance. In the study area, hikers were more numerous than paragliders. However, hikers rarely left trails because the slopes were steep and rocky. Hikers were observed on 26 of 27 days, and hiker-hours ranged from a few to 400 per day (median = 126.7). The maximum losses in feeding time and area were less than 1.8% and 0.2%, respectively. At lower frequencies of hikers the losses increase much faster than at higher frequencies, until additional hikers only had a marginal effect on the increase in losses. Paragliders flew over the area on 6 of 27 days, and paraglider-hours were never more than 1 per day (median = 0.17). The losses in both feeding time and area were between 2.2 and 26.5%, increasing steeply with the number of paraglider-hours. Much of the difference between hikers and paragliders resulted from the dramatic difference in reaction time: 5 minutes to hikers versus 150 minutes to paragliders. As long as hikers stay on trails, their effects will quickly approach an asymptote, and additional hikers will only have minor effects. The maximum loss in feeding time and area will then depend on the density

of the network of trails in an area. Such 'trails' do not exist for paragliders; therefore, each additional paraglider contributed to an increase in losses.

Ferguson, M. A., and L. B. Keith. 1982. Influence of Nordic skiing on distribution of moose and elk in Elk Island National Park, Alberta. Canadian Field-Naturalist 96:69-78.

Cross-country skiing influenced the general over-winter distribution of moose but not of elk. Both species, however, tended to move away from areas near heavily used trails during the ski season (January-March). The ski trail system was established in 1973-74 and the number of skiers increased to 18,000 in 1977-78, then declined to an estimated 10,000 in 1978-79, the year of the study. A traditional over-winter shift was accentuated after ski trails were built in areas from which moose normally moved. During October-March, there were far fewer moose near heavily used than near lightly used trails (utilization was about 60% less based on pellet-group counts). During the January-March ski season, densities were notably lower near heavily used trails and where trails passed through open terrain. Day-to-day movements away from trails occurred after the onset of skiing, but such displacement did not increase with the passage of additional skiers. Trails were presumably used for classic skiing only, averaging 31 centimeters wide, and were probably awkward for moose to walk on.

Freddy, D. J., W. M. Bronaugh, and M. C. Fowler. 1986. Responses of mule deer to disturbance by persons afoot and snowmobiles. Wildlife Society Bulletin 14:63-68.

Mule deer were disturbed more by people on foot than by snowmobiles. Radio-collared deer were disturbed by 1 or 2 researchers walking (usually on snowshoes) or riding snowmobiles at 16-24 km/hr while the interaction was monitored from several blinds. Deer moved away at greater distances from people than from snowmobiles. Responses intensified as people on foot and snowmobiles moved closer. Deer activities were interrupted more by people on foot than by snowmobiles. Deer spent more time abstaining from foraging and moving away from people than snowmobiles. Deer moved greater horizontal distances when initially fleeing from people (mean =191 meters) than snowmobiles (mean = 133 meters). The distance at which deer movement was provoked tended to increase from the initial to third trials suggesting deer became more responsive (over several days). Estimates of energy expended by deer per trial ranged from 0.2-5% of their daily metabolizable energy. However, at this level the disturbances did not markedly affect mortality or prevent adult females from producing fawns. Minimizing all levels of response by deer would require people on foot and snowmobiles to remain >334 meters and >470 meters from deer, respectively.

Grover, K. E., and M. J. Thompson. 1986. Factors influencing spring feeding site selection by elk in the Elkhorn Mountains, Montana. Journal of Wildlife Management 50:466-470.

Elk foraging rate was estimated by recording the number of rough fescue, Idaho fescue, and bluebunch wheatgrass plants combined that were grazed in 48 sample plots. Elk in this area fed primarily on these bunchgrass communities in the spring. Elk selected feeding sites that were previously grazed by cattle and supported relatively high densities of bunchgrass plants. Elk made the greatest use of these sites when they were located near cover and away from visible roads. Only improved dirt roads commonly used by the public were used in the analysis; unimproved dirt roads that generally were unused during spring were not considered.

Grund, M. D., J. B. McAninch, and E. P. Wiggers. 2002. Seasonal movements and habitat use of female white-tailed deer associated with an urban park. Journal of Wildlife Management 66:123-130.

The study area encompassed 2,971 hectares in a suburb of Minneapolis. The park was 15% of the study area. It was an island of preserved land surrounded by residential neighborhoods and commercial properties and was extensively used for nonconsumptive recreational purposes. Deer avoided using areas where human activity was high and preferred secluded areas found on the park or conservation areas near the park during birthing and early summer.

Kuck, L., G. L. Hompland, and E. H. Merrill. 1985. Elk calf response to simulated mine disturbance in southeast Idaho. Journal of Wildlife Management 49:751-757.

Calves are generally considered to be more vulnerable to disturbance than adult elk. Cow-calf pairs were radio-collared and experimentally harassed. Two people approached calves until visual contact, noise, or radio signals indicated that the calf had run from the observers. Elk cow-calf pairs were sensitive to human disturbance. Disturbed calves consistently moved farther, made greater elevational changes, and used larger areas than undisturbed calves. Human-harassed calves moved 2 times farther than control animals. Effects were greater in response to direct human approaches than to mine-noise simulation. Disturbed cow-calf pairs used less desirable habitat. Initially, following disturbance, cow-calf pairs tended to return to the calf-rearing area several days after being disturbed. Eventual abandonment of the calf-rearing area resulted in withdrawal from presumably favorable areas to more marginal habitats. This did not result in abandonment of calves, and survival rates between disturbed and control groups were not different.

MacArthur, R. A., V. Geist, and R. H. Johnston. 1982. Cardiac and behavioral responses of mountain sheep to human disturbance. Journal of Wildlife Management 46:351-358.

Heart rate is a sensitive indicator of arousal, the first stage of an alarm reaction to stress. Five wild bighorn sheep were telemonitored in a sanctuary in Alberta. Sheep were regularly exposed to human activities along a road. During peak periods of recreational use, sheep may encounter 25-30 vehicles/hour. Three experiments were conducted. Sheep reacted more to approach by a person from over a ridge away from the road and from the road with a leashed dog than from a person approaching from the road. Only 19 of 215 passes of sheep by vehicles evoked heart rate responses, and most responses occurred when vehicles passed within 25 meters of the sheep. Only 2 of the 215 vehicle passes resulted in withdrawal by the sheep. No heart rate responses were associated with helicopter or fixed-wing aircraft at distances exceeding 400 meters from sheep. The findings suggest that heart rate usually recovered to pre-disturbance levels before, or shortly after maintenance activity was resumed. Thus, as long as the animal is engaged in maintenance behavior, its physiological response to a potential stressor is likely minimal. Researchers recommend that on sheep range used heavily for recreation, disturbance to sheep may be minimized by restricting human activities to roads and established trail systems. The presence of dogs on sheep range should be discouraged.

MacArthur, R. A., R. H. Johnston, and V. Geist. 1979. Factors influencing heart rate in free-ranging bighorn sheep: a physiological approach to the study of wildlife harassment. Canadian Journal of Zoology 57:2010-2021.

The heart rates and behavior of 3 unrestrained female bighorn sheep were monitored in Alberta, Canada. Within the sanctuary, sheep were frequently exposed to humans and traffic on a graveled road used heavily for recreation. The ewes were approached to within 20-50 meters by a person walking with or without a leashed dog. Sheep were approached from a parked vehicle on the road or from a ridge or hillside above the band. On 4 occasions a trained hunting dog was permitted to run past the sheep at a distance of 20-100 meters. Free-ranging dogs and coyotes elicited maximum heart rate and withdrawal responses in the 3 ewes. The reaction to a dog was significantly reduced when the dog was on a leash. The absence of hunting combined with frequent exposure to human

activities had undoubtedly resulted in some habituation to people. Thus, in most trials involving approach by a human with or without a leashed dog, heart rate responses were not detected until the person was within 50 meters of the ewe. Vehicular traffic (cars, trucks, motorbikes) on the road elicited heart rate responses in only 14.3% of observed passes, and then only when the vehicle was within 200 meters of the subject. A low-flying Bell-206 helicopter failed to elicit heart rate responses in ewes 500-1,500 meters away. However, a single pass by a helicopter directly over 1 ewe at a height of 150-200 meters resulted in a dramatic 3.5-fold rise in heart rate. Most (78.1%) heart rate responses to disturbing stimuli preceded or occurred in the absence of overt behavioral reactions. Though immediate and often dramatic, heart rate responses to transient stimuli usually terminated rapidly, implying that brief disturbances are not particularly costly in terms of energy expended. Nevertheless, the 20% rise in the mean heart rate of ewes during the continued presence (1-10 minutes) of a human within 50 meters indicates that the cumulative effects of these peaks may be energetically significant.

Miller, S. G., R. L. Knight, and C. K. Miller. 2001. Wildlife responses to pedestrians and dogs. Wildlife Society Bulletin 29:124-132.

Refer to Songbirds citations.

Morgantini, L. E., and R. J. Hudson. 1979. Human disturbance and habitat selection in elk. Pp. 132-139 *in* M. S. Boyce and L. D. Hayden-Wing, eds. North American elk: ecology, behavior and management. University of Wyoming.

Activity, movements, and behavior of elk were observed in Alberta, Canada. Habitat selection appeared to be strongly related to time of day and proximity to roads. With darkness, the elk moved closer to the main road, making better use of the potentially available habitat. This elk population was subjected to heavy hunting pressure. During the hunting period, elk increased distance from the road, then gradually shifted back toward the road when hunting ceased. Human harassment associated with hunting also appeared to reverse the winter migratory movement of elk from alpine areas to the valley floor.

Morrison, J. R., W. J. de Vergie, A. W. Alldredge, A. E. Byrne, and W. W. Andree. 1995. The effects of ski area expansion on elk. Wildlife Society Bulletin 23:481-489.

Two populations of elk (each with 200-300 animals) responded to ski area development in Colorado. Elk numbers in the first post-development year was 4% of the pre-development population in the 3-5% of the area (Vail) that was most developed with roads, timber removal, and chairlifts. Human activities in this area were limited to a group of 1-5 people every 1-2 weeks, because much of the area was closed to humans during periods of concentrated elk use. Recreational use consisted of hiking, mountain biking, and motorcycling and was concentrated on a trail. In another area (Beaver Creek) there was little physical disturbance, but human activity was the primary disturbance. Although not the sole source of activity, human use of a recreational cabin provided an index of activity. Up to 30 people used the cabin on 1/3 to 2/3 of the summer nights during the 5-year study and people often used the area for horse rides and picnics. After development, elk use at the Beaver Creek study site was lowest when human activity was highest. Four years after development at Vail the number of elk had rebounded to 30% of the pre-development population. Thus, elk have partially habituated to development. Since habituation may level off in later years, complete recovery should not be assumed. Researchers recommended that when managers wish to reduce effects of recreational development on elk, they should minimize human activities during periods of concentrated elk use.

Papouchis, C. M., F. J. Singer, and W. S. Sloan. 2001. Responses of desert bighorn sheep to increasing human recreation. Journal of Wildlife Management 65:573-582.

Human recreation has been implicated in the decline of several populations of desert bighorn sheep. Researchers compared behavioral responses, distances moved, and duration of responses of sheep to recreational activity in a low- and high-use area in a national park in Utah. Hikers caused the most severe responses in desert bighorn sheep (animals fled in 61% of encounters), followed by vehicles (17% fled), and mountain bikers (6% fled), apparently because hikers were more likely to be in unpredictable locations and often directly approached sheep. Seven radiocollared sheep whose home ranges were bisected by roads were located more often outside than within the road corridor. Overall, there was an avoidance of the road corridor by most other sheep in the high-use area where all individuals, on average, were found 39% farther from roads (490 meters vs. 354 meters) than in the low-use area. This avoidance of the road corridor by some animals represented 15% less use of potential suitable habitat in the high-use area over the low-use area. Researchers recommended hikers be confined to designated trails during spring lambing (when ewes were more sensitive to humans) and the autumn rut (when rams were more sensitive to humans).

Pedevillano, C., and R. G. Wright. 1987. The influence of visitors on mountain goat activities in Glacier National Park, Montana. Biological Conservation 39:1-11.

An off-highway visitor parking lot and a viewing platform provided a partially screened view of a mineral lick 150 meters away. The mean number of vehicles per day entering the viewing area was 186 and 212 during 2 years. There were approximately 4.3 visitors/vehicle. These visitors did not appear to have an adverse effect on mountain goat use of the lick. However, traffic on the highway and visitors standing above the underpasses influenced goats crossing under the highway. More visitors on the highway increased the time it took goats to make a successful crossing. Eventually all goats crossed successfully. Goats ran back from the crossing in 24% of the attempts after the underpasses were constructed, compared to 44% when they had to cross the road surface.

Phillips, G. E., and A. W. Alldredge. 2000. Reproductive success of elk following disturbance by humans during calving season. Journal of Wildlife Management 64:521-530.

Researchers evaluated effects of human disturbance on radio-collared female elk in a controlled experiment in Colorado. Data were collected during 1 pretreatment (control) year and 2 treatment years. Observers attempted to approach treatment elk twice weekly throughout a 3-4 week period of peak calving until the elk were seen or heard running away, while control elk did not receive this treatment. The average number of displacements/cow were 5.4 and 8.3 during the 2 years of the study. The rationale was that a small number of people targeting a specific sample of animals (using telemetry equipment) could create an effect equal to a greater number of recreationists hiking through the area. However, most of the treatments occurred away from recreational trails and off-trail recreation during calving season appeared to be minimal. Therefore, large numbers of recreationists, traveling randomly and covering long distances, would be necessary to produce levels of disturbance similar to our treatment effort. On the other hand, the spatial segregation of elk in relation to human recreational trails suggested that female elk were avoiding areas of human activity during the calving season. After treatments, calf/cow proportions for the control area remained stable, but those for the treatment area declined each year. Reproductive success was correlated with the average number of disturbances/elk/year. The estimated annual population growth in both study areas was 7% without experimental disturbance, given that existing human activities cause some unknown level of disturbance during the calving season. With an average of 10 disturbances/cow above ambient levels, the model predicted no population growth and averaging more than 10 disturbances/cow

caused the population to decline. Researchers recommended maintaining disturbance-free areas for elk during the calving season.

Richens, V. B., and G. R. Lavigne. 1978. Response of white-tailed deer to snowmobiles and snowmobile trails in Maine. Canadian Field-Naturalist 92:334-344.

Disturbance of deer by snowmobiles did not cause them to abandon preferred bedding and feeding areas along a 17-kilometer (10.5-mile) snowmobile trail system. Deer consistently bedded near snowmobile trails and fed along them even when the trails were used for snowmobiling several times a day. There were no heavily used snowmobile trails. Sinking depth of deer on snowmobile trails was significantly less than off trails. Deer encountered on snowmobile trails usually ran away immediately whereas deer met near a trail sometimes ran toward the observers to gain access to the trail for escape. Snowmobiling at high speeds frightened deer more easily than at low speeds (16 km/h [about 10 miles/hr] or less), but stopping to view deer invariably resulted in their flight. The reaction of deer to a person walking differed markedly from their reaction to a person on a snowmobile. A significantly greater number of deer ran than stayed under all snow, weather, habitat, and temporal conditions. Researchers believed deer management could be enhanced by use of snowmobiles to facilitate movement between feeding areas and to induce deer to move to unexploited areas in their winter range.

Rost, G. R., and J. A. Bailey. 1979. Distribution of mule deer and elk in relation to roads. Journal of Wildlife Management 43:634-641.

The distribution and density of fecal pellet groups was compared to roads in Colorado. Assuming pellet-group densities are valid measures of habitat use by deer and elk on winter range, deer and elk avoided roads, particularly areas within 200 meters of a road. Deer also avoided dirt roads used only by 4-wheel drive vehicles, trail bikes, and hikers.

Schneider, R. R., and S. Wasel. 2000. The effect of human settlement on the density of moose in northern Alberta. Journal of Wildlife Management 64:513-520.

While access is generally assumed to have a negative influence on moose, researchers found that at the regional scale the density of moose was positively associated with the density of roads, despite substantial hunting pressure near roads. Human settlement results in a substantial direct loss of habitat through conversion to cropland and pasture, but the fragmented nature of these losses may increase the overall carrying capacity for moose. This is because habitat fragmentation results in a large quantity of edge habitat comprised of the early stages of seral succession that constitutes high-quality moose forage. Another mechanism by which human settlement may lead to an increased density of moose is through decreased mortality. Even with high levels of recreational hunting, mortality is directed at adult bulls and has little population impact as long as all of the cows are impregnated. Predation by wolves and bears is lower in settled areas, and these predators are not focused on adult bulls. The authors agreed that roads could have a negative influence on moose in local areas, in the immediate vicinity of a road.

Schultz, R. D., and J. A. Bailey. 1978. Responses of national park elk to human activity. Journal of Wildlife Management 42:91-100.

Elk use of open areas, bugling, and timing of movements were compared to an index of human activity (traffic counter) in Colorado. Traffic volume had a small effect, but no trends were statistically significant. Elk viewing from parking areas and roads did not appear to significantly affect elk movements. Elk which experience little or no hunting are disturbed little by normal on-road visitor

activities. However, people approaching animals off roads usually caused elk to leave open areas. People seldom left the roads to observe or photograph elk because park regulations prohibited it. Elk were more apt to walk than to trot from an approaching vehicle than from an observer approaching on foot. Elk trotted away from a person approaching on foot proportionately more times when flight distances were less than 120 meters. Elk were frequently seen feeding at dawn, dusk, and at night in the park's residential areas; however, they seldom stayed during the daylight hours.

Schnidrig-Petrig, R., and P. Ingold. 2001. Effects of paragliding on alpine chamois *Rupicapra rupricapra rupricapra*. Wildlife Biology 7:285-294.

The affects of paragliding on female chamois were studied in 4 areas, ranging from heavy paragliding activity (30-200 take-offs per day since 1985) to none, in the Swiss Alps. Female chamois showed strong reactions in all study areas, becoming alert at distances of up to 1,280 meters and taking flight at distances of up to 900 meters. Chamois took flight in 47 of 54 cases. In all areas with regular paragliding, chamois moved away from the air traffic and eventually disappeared into the forest, and did so with increasing flying activity. In an area with only sporadic paragliding, chamois sought refuge within the forest for up to 4 hours after single fly-overs.

Sibbald, A. M., R. J. Hooper, I. J. Gordon, and S. Cumming. 2001. Using GPS to study the effect of human disturbance on the behaviour of red deer stags on a Highland estate in Scotland. Pp. 39-43 in Conference: Tracking Animals With GPS, The Macaulay Land Use Research Institute, Aberdeen < UK. 12-13 March 2001.
[http://www.mluri.sari.ac.uk/gps/prog.htm]

Recreational activity caused stags to move away from a well-established vehicle track and popular walking route. Automatic, infrared counters recorded people on the route. The number of people was normally highest in summer and lowest in winter, with around twice as many people per day on weekends as during the week in summer. Distribution of stags with radio-collars was compared on Sundays (mean = 192 visitors) and Wednesdays (mean = 53 visitors) in May and June. The mean distance of all collared stags from the track was higher on Sundays (about 330 meters) than Wednesdays (about 240 meters). The mean distance of stags from the track was positively correlated with the number of people counted each day. The mean distance moved by stags during a 24-hour period was about the same on Sundays and Wednesdays in May (about 5 miles), but much greater on Sundays in the other 3 months (July, October, November). The difference was greatest in July, when stags moved an average of about 7 miles on Sundays and about 3-4 miles on Wednesdays. The stags were used to seeing people on the trail. Nevertheless, due to the distribution of vegetation in the glen, disturbance could affect their diet in early summer. The most nutritional vegetation was almost all within 300 meters of the track, and stags spent little time feeding there on Sundays. They did not appear to make up for this by spending more time feeding there the following night, when the track was quiet.

Sopuck, L. G., and D. J. Vernam. 1986. Distribution and movements of moose (*Alces alces*) in relation to the Trans-Alaska Oil Pipeline. Arctic 39:138-144.

Researcher used snowmobiles to determine the number and location of moose trails encountering the right-of-way along a 67-kilometer stretch of pipeline in Alaska. Along elevated portions of the pipeline, moose used pipe heights less than 1.5 meters significantly less than expected and heights of 2.4-2.7 meters significantly more than expected. All other categories were used in proportion to availability; although heights less than 2.1 meters tended to be underused. Because snow can reduce the effective height of elevated structures, crossing success may be reduced and deflections may increase at minimally acceptable heights during periods of heavy snow cover.

Tidhar, D. 2000. Short-term responses of wild red deer *Cervus elaphus* stags to intense recreational disturbance. M. S. thesis, University of Aberdeen, UK. [cited in Sibbald et al. (2001)]

This was an observational study related to a GPS collar study in the same area (Sibbald et al. 2001). Stags only showed significant changes in behavior when walkers on a trail came within 100 meters. Stags reacted most strongly to walkers or cyclists who were accompanied by dogs and to walkers who wandered off the track. Walkers who left the trail were the most likely to provoke a change in behavior.

Witmer, G. W., and D. S. deCalesta. 1985. Effect of forest roads on habitat use by Roosevelt elk. Northwest Science 59:122-125.

Locations of 6 radiocollared female elk were monitored for 1 year in Oregon. Significantly fewer elk observations were noted in a 500-meter zone adjacent to paved roads and a 125-meter zone adjacent to spur roads with vehicular traffic, but elk did not avoid spur roads without traffic. Effect of roads on elk use of habitat may be mitigated by road closures.

Yalden, D. W. 1990. Recreational disturbance of large mammals in the Peak District. Journal of Zoology (London) 221:293-298.

Red deer were introduced to this area in about 1939. The land was privately owned, however, the number of hikers began to increase in about 1972. Coinciding with the increased recreational use during 1972-1977, deer were seen less regularly and in smaller numbers. The land became public in 1980 and recreational use intensified. In the late 1980s, an average of 51 people/km^2 (about 132 people/mi^2) were counted on surveys, with 1 dog accompanying every 33 people and 50% of the dogs off leash. Since then, deer have nearly abandoned the area, except for occasional use in early winter as they disperse after the rut.

Yarmoloy, C., M. Bayer, and V. Geist. 1988. Behavior responses and reproduction of mule deer, *Odocoileus hemionus*, does following experimental harassment with an all-terrain vehicle. Canadian Field-Naturalist 102:425-429.

Five mule deer does were captured from an unhunted population and radiocollared in Alberta, Canada. They were habituated to an all-terrain vehicle which traveled the same trail for 12 weeks. Three of the females were then followed by the ATV for 9 minutes per day for 15 days in October, causing the deer to run and hide repeatedly. October was chosen for experimental harassment because that was the month during which does are expected to fatten just prior to mating. Researchers expected to impose stress to simulate disruption of normal patterns of feeding and resting, and thereby affect body condition and possibly reproduction. The harassed does, but not the other 2 does, shifted feeding into darkness, used cover more frequently, left their home ranges more often, and increased flight distance from the ATV. In the following year the 3 harassed does collectively raised 1 fawn, having had normal reproduction the year before and the year after. Neither the unmarked does in the study area nor the 2 radiocollared control does suffered decreases in reproduction during the study.

DOGS AND CATS

Baker, P. J., R. J. Ansell, P. A. A. Dodds, C. E. Webber, and S. Harris. 2003. Factors affecting the distribution on small mammals in an urban area. Mammal Review 33:95-100.

Wood mouse abundance in residential gardens (average density was 81 mice/hectare) in Bristol, England, was negatively related to the abundance of cats and the distance to the nearest patch of natural or seminatural vegetation greater than 0.25 hectare.

Barratt, D. G. 1997. Home range size, habitat utilization and movement patterns of suburban and farm cats *Felis catus*. Ecography 20:271-280.

Ten house cats and 7 farm cats were radio-collared and followed for over 9 months in Australia. Four of the suburban house cats moved 390-900 meters into habitat adjoining the residential area. Movements further than 100-200 meters beyond the suburb edge were always made at night.

Barratt, D. G. 1997. Predation by house cats, *Felis catus* (L.), in Canberra, Australia. I. Prey composition and preference. Wildlife Research 24:263-277.

Prey deposited at cat owners' homes were recorded for 12 months. Reliable records were compiled for 138 cats and 1,961 prey items. Small mammals were the preferred prey: 64% were introduced mammals, mostly mice and rats, and 27% were birds, mostly house sparrows. Predation on mammals was greatest in the evening (6 p.m. to midnight), and predation on birds was greatest in the morning (6 a.m. to noon). In relatively undisturbed environments adjoining new residential developments, predation by house cats may have a substantial impact on locally abundant, patchily distributed populations of native fauna, particularly mammals.

Barratt, D. G. 1998. Predation by house cats, *Felis catus* (L.), in Canberra, Australia. II. Factors affecting the amount of prey caught and estimates of the impact on wildlife. Wildlife Research 25:475-487.

Same study as above. The mean number of prey caught per cat who was known to bring home prey was 10.2/year, about half that estimated by the owners prior to the study. There is an enormous variation in the number of prey caught annually, from none to possibly hundreds. These figures underestimate the number of prey caught because not all prey are observed by cat owners. The average amount of prey caught by house cats is significantly less, possibly an order of magnitude less, than that needed by cats with no domestic food supplement. Neither belling cats nor the number of supplemental meals provided per day have a significant influence on the amount of prey caught. More prey were caught by cats living close to rural/grassland and forest/woodland habitats than by those living in inner suburban areas, and the average amount of prey caught by cats in outer suburban areas was significantly greater than the average for all cats.

Bekoff, M. and C. A. Meaney. 1997. Interactions among dogs, people, and the environment in Boulder, Colorado: a case study. Anthrozoös 10:23-31.

Approximately 800 different dogs were observed for about a total of 150 hours. Off-leash dogs generally traveled less than 2-5 meters off trail for fewer than 1-2 minutes. The general impression of observers was that when dogs went far off trail, they were lured off by the people who were responsible for them (e.g., people threw sticks or called them). It is also notable that only 2 "earnest chases" of wildlife (1 deer and 1 squirrel) were observed in which it was unambiguously concluded that it was the dog who initiated and maintained the chase. Dogs also only rarely entered bodies of water. Trail users completed 450 questionnaires [response rate was unreported]; of those completing

the survey, non-dog owners (53%) outnumbered dog owners (47%). Respondents reported seeing other people disturb wildlife (92%) significantly more often than dogs (50%).

Causey, M. K., and C. A. Cude. 1980. Feral dog and white-tailed deer interactions in Alabama. Journal of Wildlife Management 44:481-484.

Radio-collars facilitated gathering observations on 94 feral dogs in 14 packs. No direct food or shelter was provided to these dogs, and most appeared to have some type of hound ancestry. Feral dogs regularly chased white-tailed deer. During the 30-month study period, feral dogs were observed killing small rodents and cottontail rabbits; however, observations of packs after 7 chases found no evidence the dogs caught or killed a deer. Researchers concluded that feral dogs in this area are not efficient predators of adult deer. However, researchers observed 1 pack feeding on a freshly killed fawn and cautioned that their study methods did not enable them to determine the incidence of feral dog predation on young fawns. [compare with Lowry and McArthur (1978)]

Churcher, J. B., and J. H. Lawton. 1987. Predation by domestic cats in an English village. Journal of Zoology (London). 212:439-455.

Prey items brought home by approximately 70 house cats were identified during a 1-year period. A total of 1,090 prey items averaged about 14/cat/year. Most of the prey were caught in summer. Voles were the most frequent prey (21%), followed by wood mice (17%), house sparrows (16%), and shrews (16%). Based on the estimated number of house sparrows in the village, cat predation accounted for at least 30% of the annual mortality.

Crooks, K. R., and M. E. Soulé. 1999. Mesopredator release and avifauna extinctions in a fragmented system. Nature 400:563-566.

Mammalian carnivores are particularly vulnerable to extinction in fragmented landscapes, and their disappearance may lead to increased numbers of smaller carnivores that are principle predators of birds and other small vertebrates. The relationships between coyotes, mid-sized predators (including domestic cats), and birds were studied in San Diego, California. Participants collected prey items brought home by cats. Seventy-seven percent of cat owners let their cats outdoors, and 84% of outdoor cats brought home kills. On average, each outdoor cat that hunted brought home 24 rodents, 15 birds, and 17 lizards annually. On average, approximately 35 hunting, outdoor cats surrounded a moderately sized fragment (~20 hectares) bordered by 100 residences. From this, researchers estimated cats surrounding moderately sized fragments brought home 840 rodents, 525 birds, and 595 lizards each year. Researchers thought this level of predation was unsustainable. In comparison, each fragment may support only 1 or 2 pairs of native predators, such as foxes or coyotes. Coyotes kill domestic cats: 21% of the coyote scats contained cat remains, and 25% of radio-collared cats were killed by coyotes. The presence of coyotes also had an indirect effect on cat predation because 46% of cat owners restricted their cat's outdoor activity when they believed coyotes in the neighborhood. In small habitat fragments where coyotes were absent, there was an increase in mid-sized predators such as cats, raccoons, and opossums, and a drastic decline in diversity, and in some cases elimination, of scrub-breeding birds. However, in larger fragments, where coyotes were still present, the scrub-breeding birds were also present. The disappearance of a dominant carnivore results in elevated numbers and activity of mesopredators that exert strong predation pressure on native prey species.

Denny, R. N. 1974. The impact of uncontrolled dogs on wildlife and livestock. Transactions of the North American Wildlife and Natural Resources Conference 39:257-291.

A questionnaire was sent to each of the state and territorial departments of agriculture and to the wildlife conservation or natural resource agencies. Thirty-one (86%) of 36 returned questionnaires indicated that they considered uncontrolled dogs as a problem. Damage to wildlife was listed as the first-ranking problem. Over 20 thousand deer were reported killed in 32 states, based on adjusted estimates from known kills and on opinion estimates. Author acknowledges other research which suggests that the effects of dogs on deer are overestimated. [compare with Lowry and McArthur (1978)]

Fromont, E., M. Artois, and D. Pontier. 1998. Epidemiology of feline leukemia virus (FeLV) and structure of domestic cat populations. Journal of Wildlife Management 62:978-988.

In carnivores, several viruses may cross the species barrier between domestic and wild species. Evidence suggests that feline leukemia virus may be a threat to wildcats. Although the history of association of FeLV predates the domestication of cats, small isolated populations can stay free of disease for relatively long periods. Wildcat populations are spatially fragmented and have a lower density than populations of domestic cat (<1 individual/km2). The infection of wildcats may be due to frequent contacts with domestic cats.

George, W. G. 1974. Domestic cats as predators and factors in winter shortages of raptor prey. Wilson Bulletin 86:384-396.

Three cats in a rural setting in Illinois were observed hunting on 1,387 days, or about 8,500 daylight and 7,300 crepuscular-nocturnal hours. Prey items were identified and weighed, and then the cats were allowed to eat them. The cats were also fed daily in the house. An estimated 50% of the cats' captures were observed, and the estimate of total kills was adjusted to account for this. Young cottontail rabbits constituted the leading prey by volume (40%). Prairie voles were the prey most frequently captured, composing more than 41% of all captured vertebrates.

Hawkins, C.C. 1998. Impact of a subsidized exotic predator on native biota: effect of house cats (*Felis catus*) on California birds and rodents. PhD. Dissertation. Texas A&M University, College Station, Texas. 66 pp. [cited in http://www.abcbirds.org]

A 2-year study compared the effect of cat predation in 2 grassland parks. One park had no cats; the other park had over 20 cats that were fed daily. Almost twice as many birds were observed in the park without cats. Two ground-nesting species (California thrasher and California quail) were never seen in the park with cats. Over 85% of native deer mice and harvest mice were trapped in the no-cat area, compared to 79% of the house mice, an exotic pest. Cats at artificially high densities, sustained by supplemental feeding, reduce abundance of native rodent and bird populations, change the rodent species composition, and may facilitate the expansion of the house mouse into new areas.

Hubbs, E. L. 1951. Food habits of feral house cats in the Sacramento Valley. California Fish and Game 37:177-189.

Many of these cats were free-ranging, and not necessarily feral. Stomach contents of 219 cats, shot in every month of a single year, contained the following prey items, by number and volume: house mice (216, 24.1%), voles and other native rodents (115, 23.8%), pheasants (33, 10.8%), cottontail rabbits (27, 10.5%), and ducks (10, 3.2%). All of the ducks were taken in spring and all 8 hens were assumed to have been killed on their nests.

Kosiński, Z. 2001. Effects of urbanization on nest site selection and nesting success of the greenfinch *Carduelis chloris* in Krotoszyn, Poland. Ornis Fennica 78:175-183.

Populations of some birds reach distinctly higher densities in urban areas than in more natural sites. Some studies have found urban areas have few natural predators; however, nest predation in urban areas is often higher than in natural areas. Nest success of greenfinches was measured in three urban habitats, ranging from highly developed to suburban/rural. Nest success was higher in nests located higher in trees. Avian nest predators were not implicated. Mammals, most probably cats, affected nest success in lower nests. Some birds, like greenfinches, can exploit urban areas where nest predation is limited to cats.

Liberg, O. 1984. Food habits and prey impact by feral and house-based domestic cats in a rural area in southern Sweden. Journal of Mammalogy 65:424-432.

The cat population fluctuated between 84 and 121 during the study, and 80-85% were house-based. Based on scat contents, wild rabbits were the most important prey (about 60% of weight of all prey annually), followed by small rodents. In a period of high rabbit abundance, cat predation accounted for 4% of annual production of rabbits and about 20% of annual production of field voles and wood mice. From May-September a large proportion of the rabbits eaten were juveniles and subadults. The average house-based cat consumed about 66 grams of prey per day (equivalent to 2-3 voles or 1.5 small songbirds per day). Starlings were the most common bird in scats (46% of bird remains); most of the starlings in scats were juveniles. Cats ate 3 short-tailed weasels. The average annual consumption of field voles by the entire cat population was about 30,000 individuals. About 3,200 rabbits were taken annually, primarily in summer. Cat predation alone was not limiting any of their prey; however, competition with native predators such as weasels, owls, and hawks may affect populations of these species.

Lowry, D. A., and K. L. McArthur. 1978. Domestic dogs as predators on deer. Wildlife Society Bulletin 6:38-39.

Details of 39 reported incidents of dogs chasing deer in Idaho resulted in the deaths of 12 white-tailed and mule deer. In 8 of the incidents the dogs killed the deer, 3 crippled deer were subsequently shot, and 1 deer drowned. Communities and residences were interspersed throughout the deer winter range, and harassment by dogs has increased as homes are built in areas where deer formerly had little disturbance. Dogs have an advantage over deer when running over crusted snow. Most studies of dogs chasing deer have been in areas with little or no snow and have used trained hunting dogs. Results of these studies should not be applied to feral or free-ranging dogs, whose hunting behavior is quite different.

Parmalee, P. W. 1953. Food habits of the feral house cat in east-central Texas. Journal of Wildlife Management 17:375-376.

Stomach contents of 31 cats collected during an 18-month period included mostly cotton rats, followed by other small rodents and cottontail rabbits. Only 2 birds were found.

Pearre, S., Jr., and R. Maass. 1998. Trends in the prey size-based trophic niches of feral and house cats *Felis catus* L. Mammal Review 28:125-139.

Researchers compared 36 studies of cat predation from around the world, including many not translated into English. The principle prey in most areas was mammals (rodents and rabbits), with bird prey secondary. Not including islands, mammals outnumbered birds among prey of cats by a mean of about 6:1. Rabbit prey was largely juveniles.

Progulske, D. R., and T. S. Baskett. 1958. Mobility of Missouri deer and their harassment by dogs. Journal of Wildlife Management 22:184-192.

Using radio-collars, researchers documented 194 incidents of white-tailed deer harassed by dogs in Missouri during a 4-year study period. In this area, only hounds appeared to have the ability to remain on the deer's trail for long periods. Dogs forced some deer long distances, including out of home ranges. However, no mortalities were observed. *[compare with Lowry and McArthur (1978)]*

Ruxton, G. D., S. Thomas, and J. W. Wright. 2002. Bells reduce predation of wildlife by domestic cats (*Felis catus*). Journal of Zoology (London) 256:81-83.

Two previous studies concluded that bells had no effect on predation, and 1 previous study concluded that cats wearing bells killed more wildlife than cats without bells. These were correlation studies, and results may have been confounded by unknown factors. In this study, 21 cat owners in Great Britain recorded dead prey items brought home by 41 cats during an 8-week period. These cats had previously brought home dead prey and had worn collars without bells. During the experiment, cats either wore a bell for 4 weeks, followed by 4 weeks without a bell; had no bell for 4 weeks, followed by 4 weeks with a bell; or alternated weeks of bell wearing. The total number of prey delivered by cats during periods with bells on were 82 mammals, 26 birds, and 10 amphibians. For the periods without bells these totals were 167 mammals, 48 birds, and 11 amphibians. Thus, bell wearing reduced the number of mammals and birds brought home by cats by about 50%; although bells didn't affect the relative numbers of mammals and birds delivered.

Scott, M. D., and K. Causey. 1973. Ecology of feral dogs in Alabama. Journal of Wildlife Management 37:253-265.

Three feral packs and 2 solitary feral dogs (12 total) were studied. All but 1 were mongrels, predominantly of collie and hound ancestries. To verify predation on deer and livestock, 30 different locations visited more than once by feral packs, and others visited only once, were thoroughly searched. One site had remains of a dead domestic calf; however, the researchers assumed the calf could have died naturally. These observations and several other incidents of calves approaching dog packs or livestock approaching dog dens without being chased suggested that dogs did not appear to be significant predators on deer or livestock in this area. Feral and free-ranging dogs also did not limit population growth in 2 introduced deer herds. Of 5 scats examined, 3 contained rabbit remains. *[compare with Lowry and McArthur (1978)]*

Sweeney, J. R., R. L. Marchinton, and J. M. Sweeney. 1971. Responses of radio-monitored white-tailed deer chased by hunting dogs. Journal of Wildlife Management 35:707-716.

Researchers documented 65 experimental chases of 6 radio-collared deer by hounds. The dogs were hunting hounds specifically trained to chase deer. Chases average 33 minutes in duration and 2.4 miles in distance. Deer in high populations were more difficult to chase for extended periods than those in low populations, because the hounds switched to the trail of other deer. In every case, the deer escaped and all deer appeared to be in good physical condition throughout the study. *[compare with Lowry and McArthur (1978)]*

Warner, R. E. 1985. Demography and movements of free-ranging domestic cats in rural Illinois. Journal of Wildlife Management 49:340-346.

Types of prey items deposited near buildings by over 200 domestic cats were monitored for 2 years. Cats were fed daily at all residences. Cats deposited prey in the following proportions at 51

farmsteads: house mice and rats (77%), small birds (43%), cottontail rabbits (13%), and voles and field mice (12%). Hunting by cats is not related to hunger; therefore, analysis of scats and stomach contents may not truly represent the numbers and types of prey taken. Although researchers did not attempt to quantify numbers of animals captured, hunting was universal for free-ranging house cats and the killing of rodents, rabbits, and passerines was common. Summer ranges of 11 cats with radio-collars averaged 155 hectares (383 acres). Cats are attracted to linear or edge habitats. About 44% of the radiolocations were in some form of linear or edge habitat, such as roadsides, field edges, or waterways.

Woods, M., R. A. McDonald, and S. Harris. 1998. Predation of wildlife by domestic cats in Great Britain. The Mammal Society. 22 pp.
http://www.abdn.ac.uk/mammal/cat_predation.htm

Domestic and feral cats are a major predator of wild animals in Great Britain. Kill and capture records of 964 cats from 618 households were collected and analyzed. More than 14,000 prey items were documented during a 5-month period in summer 1997. The mean number of catches or kills per cat was 16.7, or an annual average of 40 captures or kills per cat [however, didn't compensate for potentially lower capture rates in winter]. This does not include the animals that cats killed and ate away from home. Mammals comprised 69% and birds 24% of the prey items. The number of birds brought home per cat was significantly lower in households that provided food for birds, but no significant effect of providing food was observed for mammals. The numbers of mammals brought home was significantly lower if the cat wore a bell or if the cat was kept indoors at night, but no similar effect was observed for birds.

MISCELLANEOUS

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

The authors compiled 536 references concerning effects of nonconsumptive outdoor recreation on wildlife. References were restricted to terrestrial vertebrates of North America and included technical and semi-technical articles, books, agency publications, private organization reports, theses, dissertations, and federal aid reports. Negative effects were reported most commonly for most activity types and all major taxonomic groups. Few references reported positive effects. Much of the existing information on recreational effects on wildlife consists of casual observations or reported incidents of disturbance or mortality, with quantitative assessments of long-term ecological effects. Recent, well-designed investigations, in which hypotheses were evaluated, were beginning to reveal the complexities of recreationist-wildlife interactions. Typically, recreation management involves restrictions on human-related influences on the environment. Methods of limiting effects of recreationists on wildlife include location and design of facilities, designation of local viewing or special-use areas, and establishment of larger refuges in which certain activities may be prohibited or regulated.

Clevenger, A. P., B. Chruszcz, and K. E. Gunson. 2003. Spatial patterns and factors influencing small vertebrate fauna road-kill aggregations. Biological Conservation 109:15-26.

Small mammal and bird road-kill indices were consistently higher on a low-volume parkway than on the high-speed, high-volume Trans-Canada highway. Road kills were less likely to occur on raised

sections of road. Road kills tended to occur close to vegetative cover and far from wildlife passages or culverts.

Findlay, C. S., and J. Bourdages. 1999. Response time of wetland biodiversity to road construction on adjacent lands. Conservation Biology 14:86-94.

Density of paved roads tripled on lands adjacent to wetlands in southeastern Ontario during the past half century. Historical changes in road densities had negative effects for vascular plants, birds, and herptiles. These results have at least 3 important implications. First, short-term environmental assessments of road construction on measures of wetland biodiversity are likely to substantially underestimate the real effects. Second, the negative effects of historical road densities were detected on adjacent lands up to 1 or 2 kilometers from the wetland. Third, even if no new roads are constructed, wetland biodiversity will likely continue to decline in lagged response to historical increases in road densities. The full effects of road construction on wetland biodiversity may be undetectable in some taxa for decades.

Findley, C. S., and J. Houlahan. 1997. Anthropogenic correlates of species richness in southeastern Ontario wetlands. Conservation Biology 11:1000-1009.

Researchers examined the relationship between the richness of 4 different taxonomic groups (birds, mammals, herptiles, and plants) in 30 wetlands and anthropogenic factors, including road construction. The species richness of all taxa except mammals was negatively correlated with the density of paved roads on lands up to 2 kilometers from the wetland. Both herptile and mammal species richness showed a strong positive correlation with the proportion of forest cover on lands with 2 kilometers. Road construction and forest removal on adjacent lands pose significant risks to wetland biodiversity. These results suggest that most existing wetland policies, which focus almost exclusively on activities within the wetland itself and/or a narrow buffer zone around the wetland perimeter, are unlikely to provide adequate protection for wetland biodiversity.

Forman, R. T. T., and R. D. Deblinger. 2000. The ecological road-effect zone of a Massachusetts (U.S.A.) suburban highway. Conservation Biology 14:36-46.

The road-effect zone is a broad area where significant ecological impacts associated with roads occur. Several key ecological factors were measured: (1) altered streams and wetland drainage, (2) road salt reaching surface water bodies, (3) habitat invasion by exotic species, and animal habitat and movement patterns of (4) large mammals such as moose and white-tailed deer, (5) forest and grassland birds, and (6) amphibians. The effects of all factors extended >100 meters from the road, and moose corridors and road avoidance by grassland birds extended outwards >1 kilometer. The road-effect zone averaged approximately 600 meters in width and is asymmetric. Busy roads and nature reserves should be well separated.

Frid, A., and L. Dill. 2002. Human-caused disturbance stimuli as a form of predation risk. Conservation Ecology 6(1):11. *[online]*

From an evolutionary perspective, disturbance stimuli should be analogous to predation risk. Similar to predation risk, disturbance stimuli can indirectly affect fitness and population dynamics via the energetic and lost opportunity costs of risk avoidance. This also explains why habituation to disturbance stimuli, although it generally occurs to some extent, often is partial. The risk-disturbance hypothesis predicts that long-term and intense disturbance stimuli can cause population declines via reduced body condition and consequent reductions in reproductive success, particularly during

periods of high environmental stress. Reduced body condition caused by high disturbance levels could also contribute to increased predation rates.

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

Gutzwiller, K. J. 1991. Assessing recreational impacts on wildlife: the value and design of experiments. Transactions of the North American Wildlife and Natural Resources Conference 56:248-255.

Wildlife scientists have used 2 types of studies to assess recreational impacts: observational and experimental. Observational studies are advantageous when logistical difficulties and resource constraints cannot be overcome to conduct experiments. Sometimes observational studies are the only realistic way to obtain data. They can also be convenient and inexpensive. However, establishing a correlation does not determine cause and effect. The objectives of this paper were (1) to emphasize the practical and scientific value of field experiments in recreational impact assessment, and (2) to offer advice about how such experiments should be designed to maximize their interpretability.

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.

Haskell, D. G. 1999. Effects of forest roads on macroinvertebrate soil fauna of the southern Appalachian Mountains. Conservation Biology 14:57-63.

Roads significantly depressed the abundance and the richness of the macroinvertebrate soil fauna up to 100 and 15 meters into the forest from the edges of unpaved, low-traffic roads, respectively. Even relatively narrow roads through forests can produce marked edge effects that may have negative consequences for the function and diversity of the forest ecosystem.

Joslin, G., and H. Youmans, coordinators. 1999. Effects of recreation on Rocky Mountain wildlife: a review for Montana. Committee on Effects of Recreation on Wildlife, Montana Chapter of The Wildlife Society. 307 pp.

This bibliography summarizes the results of hundreds of scientific studies on the effects of recreation on wildlife and offers guidelines for avoiding or minimizing impacts.

Knight, R. L., and K. J. Gutzwiller, eds. 1995. Wildlife and recreationists: coexistence through management and research. Island Press, Washington, D.C.

This bibliography summarizes the results of hundreds of scientific studies on the effects of recreation on wildlife and offers guidelines for avoiding or minimizing impacts.

Liddle, M. 1997. Recreation ecology: the ecological impact of outdoor recreation and ecotourism. Chapman & Hall, New York.

This bibliography summarizes the results of hundreds of scientific studies on the effects of recreation on plants and wildlife and offers guidelines for avoiding or minimizing impacts.

Marzluff, J. M., F. R. Gehlbach, and D. A Manuwal. 1998. Urban environments: influences on avifauna and challenges for the avian conservationist. Pp. 283-299 in Avian Conservation: Research and Management. Island Press.

Comprehensive summary of the effects of urbanization on bird populations.

Olliff, T., K. Legg, and B. Kaeding. 1999. Effects of winter recreation on wildlife of the Greater Yellowstone area: a literature review and assessment. Yellowstone National Park, U. S. Park Service. 162 pp. + appendix (141 pp.)
[http://www.nps.gov/yell/publications/pdfs/wildlifewinter]

This bibliography summarizes the results of hundreds of scientific studies on the effects of winter recreation on wildlife and offers guidelines for avoiding or minimizing impacts.

Parks, S. A., and A. H. Harcourt. 2002. Reserve size, local human density, and mammalian extinctions in U. S. protected areas. Conservation Biology 16:800-808.

A greater proportion of the original large mammal species present in national parks have gone extinct and have become extinct at a greater rate in parks surrounded by relatively high human densities. Thus, (1) processes occurring outside of a reserve's boundary may unexpectedly strongly affect species within the reserve, (2) small [or narrow] reserves might suffer the double jeopardy of not only their size but also their situation in especially adverse surrounds, and (3) small reserves might suffer more intense edge effects and be more isolated than large reserves.

Pomerantz, G. A., D. A. Decker, G. R. Goff, and K. G. Purdy. 1988. Assessing impact of recreation on wildlife: a classification scheme. Wildlife Society Bulletin 16:58-62.

Researchers developed a classification scheme for recreational impacts on wildlife and sent a questionnaire to refuge managers in northeastern states. Managers identified 12 visitor activities that had negative impacts on species of special concern on their refuges. Two activities, exploring on foot and driving on beaches, accounted for >60% of the impacts. Lowered productivity was cited in 41% of reported impacts on the species of interest. Direct mortality was cited in 12% of impacts. Hunting accounted for about 30% of all impacts described in which direct mortality was a result, whereas exploring on foot with pets and driving on beaches accounted for 18 and 47%, respectively, of impacts involving direct mortality. Exploring on foot impacted nearly all groups of species identified.

San Francisco Bay Conservation and Development Commission. 2001. Public access and wildlife compatibility survey. Appendix E in Public Access and Wildlife Compatibility. Staff report. San Francisco, California.

A survey was mailed to 362 land managers from coastal and Great Lake states in the United States. Participants managed local, state and federal reserves, parks, refuges, open spaces, recreational areas, and wildlife management areas. Response rate was 43%. The recreational activity most commonly reported to have an immediate effect on wildlife was unleashed dogs, followed by walking/jogging. The most commonly reported long-term effect on wildlife was from humans feeding

wildlife, followed by fishing. The most commonly employed design and management strategies were education, activity type and user behavior restrictions, area closures or separation features (e.g., fences), and wildlife management and monitoring, in that order. The vast majority of respondents believed that their design and management strategies were at least somewhat effective in avoiding or reducing impacts on wildlife from human activities. Vegetative buffers were the design feature most often cited as effective at avoiding or reducing recreational impacts. After vegetative buffers, bridges, boardwalks, viewing platforms, and fencing were mentioned. Linear dead-end trails potentially encouraged renegade trails as visitors are enticed to wander past the end of the road. Most respondents (108/157) indicated that there are areas within their sites where trail development is prohibited. The most common reason indicated for prohibiting trails was for habitat and species protection. Activity types most often restricted were boats, jet skis, motorized vehicles, bicycles, pets, and skating/boarding, in that order. Pet restrictions were the most often employed restriction on user behavior, as well. Most respondents required dogs to be leashed, but a large minority prohibited pets. The most often employed enforcement strategies were signs, staff patrols, and law enforcement, in that order.

Skagen, S. K., T. R. Stanley, and M. B. Dillon. 1999. Do mammalian nest predators follow human scent trails in the shortgrass prairie? Wilson Bulletin 111:415-420.

Based on experiments with artificial ground nests, there was no evidence that human scent influenced egg predation rates, nor that mammalian predators followed human trails between nests in this study area, where vegetation trampling was minimal and avian predators were rare.

Sutherland, W. J. 1998. The effect of local change in habitat quality on populations of migratory species. Journal of Applied Ecology 35:418-421.

One of the major issues about proposals that will result in habitat deterioration is: will any displaced individuals simply move elsewhere (as developers often argue) or is each site already full so that the total population will decline by the number of individuals affected by the local habitat deterioration (as conservationists often argue). This paper suggests a model for resolving the issue. The author cites several examples of declines in local populations due to local habitat changes. Using the model to predict declines in the entire population requires an estimate of the strength of density dependence, the increase in per capita mortality caused by the addition of a further (displaced) individual, and the decrease in per capita breeding output caused by an extra (displaced) individual. It would be useful to have more estimates of declines in local populations due to local habitat changes and more estimates of density dependence.

Trails and Wildlife Taskforce, Colorado State Parks, and Hellmund Associates. 1998. Planning trails with wildlife in mind: a handbook for trail planners. Colorado State Parks, Denver. 51 pp.

An introduction to wildlife concerns and trail impacts for planners. Presents key concepts and guidelines on trails and their zones of influence, avoiding large natural areas, landscape patterns, habitat quality, wetlands, how wildlife and plants respond to trails, and trail design and management.

Trombulak, S. C., and C. A. Frissell. 1999. Review of ecological effects on roads on terrestrial and aquatic communities. Conservation Biology 14:18-30.

Reviews scientific studies finding the following effects of roads on terrestrial and aquatic ecosystems: (1) increased mortality from road construction, (2) increased mortality from collision with vehicles, (3) modification of animal behavior, (4) alteration of the physical environment, (5) alteration of the

chemical environment, (6) spread of exotic species and (7) increased alteration and use of habitats by humans. Due to multiple effects, it is unlikely that the consequences of roads will ever be completely mitigated or remediated. Thus, it is critical to retain remaining roadless or near-roadless portions of the landscape in their natural state.

von der Ohe, C. G., and C. Servheen. 2003. Measuring stress in mammals using fecal glucocorticoids: opportunities and challenges. Wildlife Society Bulletin 30:1215-1225.

Measurement of fecal glucocorticoids is a new and non-invasive approach to studying stress in free-ranging animals and is being applied to an increasing number of species. Researchers argue that adaptation and sensitization, sex, reproductive events, diet, prehibernatory preparations, inter-species differences, and assay methods are potential sources of difficulty in interpreting data when adapting this approach to studies of stress in wildlife.

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.

Appendix 1: Scientific Names and Related Species[1]

Common name	Scientific name	Related species in Anchorage[2]
Loons		
Arctic loon	*Gavia arctica*	Pacific loon
Pacific loon	*Gavia pacifica*	
Common loon	*Gavia immer*	
Swans		
Mute swan	*Cygnus olor*	Trumpeter swan
Whooper swan	*Cygnus cygnus*	Trumpeter swan
Trumpeter swan	*Cygnus buccinator*	
Geese		
Greater white-fronted goose	*Anser albifrons*	
Greylag goose	*Anser anser*	Greater white-fronted goose
Pink-footed goose	*Anser brachyrhynchus*	Greater white-fronted goose
Snow goose	*Chen caerulescens*	
Canada goose	*Branta canadensis*	
Barnacle goose	*Branta leucopsis*	Canada goose
Brent goose (or brant)	*Branta bernicla*	Canada goose
Emperor goose	*Philacte canagica*	Canada goose
Ducks		
Green-winged teal	*Anas crecca*	
Blue-winged teal	*Anas discors*	
American black duck	*Anas rubripes*	Mallard
Mallard	*Anas platyrhynchos*	
Northern pintail	*Anas acuta*	
Northern shoveler	*Anas clypeata*	
Gadwall	*Anas strepera*	
Wigeon (or Eurasian wigeon)	*Anas penelope*	American wigeon
American wigeon	*Anas americana*	
Shelduck	*Tadorna tadorna*	Mallard
Common pochard	*Aythya ferina*	Greater scaup
Canvasback	*Aythya valisineria*	
Redhead	*Aythya valisineria*	
Tufted duck	*Aythya fuligula*	
Greater scaup	*Aythya marila*	
Lesser scaup	*Aythya affinis*	
Velvet scoter	*Melanitta fusca*	Greater scaup
Eider (or common eider)	*Somateria mollissima*	Greater scaup
Common goldeneye	*Bucephala clangula*	
Raptors		
Bald eagle	*Haliaeetus leucocephalus*	
Golden eagle	*Aquila chrysaetos*	
Northern harrier	*Circus cyaneus*	
Marsh harrier	*Circus aeruginosus*	Northern harrier
Cooper's hawk	*Accipiter cooperii*	Northern goshawk (*A. gentilis*)
Red-tailed hawk	*Buteo jamaicensis*	
Red-shouldered hawk	*Buteo lineatus*	Red-tailed hawk
Swainson's hawk[3]	*Buteo swainsoni*	Red-tailed hawk
Ferruginous hawk	*Buteo regalis*	Red-tailed hawk

Rough-legged hawk	*Buteo lagopus*	
American kestrel	*Falco sparverius*	
Merlin	*Falco columbarius*	
Prairie falcon	*Falco mexicanus*	Peregrine falcon (*F. peregrinus*)
Spotted owl	*Strix occidentalis*	
Grouse		
Willow grouse (or ptarmigan)	*Lagopus lagopus*	
Cranes		
Sandhill crane	*Grus canadensis*	
Common crane	*Grus grus*	Sandhill crane
Siberian crane	*Grus leucogeranus*	Sandhill crane
Shorebirds		
Black-bellied plover	*Pluvialis squatarola*	
Golden plover	*Pluvialis apricaria*	Lesser golden plover (*P. dominica*)
Semipalmated plover	*Charadrius semipalmatus*	
Piping plover	*Charadrius melodus*	Semipalmated plover
Snowy (or Kentish) plover	*Charadrius alexandrinus*	Semipalmated plover
Ringed plover	*Charadrius hiaticula*	Semipalmated plover
New Zealand dotterel	*Charadrius obscurur*	Semipalmated plover
Oystercatcher	*Haematopus ostralegus*	
Greater yellowlegs	*Tringa melanoleuca*	
Lesser yellowlegs	*Tringa flavipes*	
Redshank	*Tringa tetanus*	Lesser yellowlegs
Common sandpiper	*Actitis hypoleucos*	Spotted sandpiper (*T. macularia*)
Whimbrel	*Numenius phaeopus*	
Curlew (or Eurasian curlew)	*Numenius arquata*	Whimbrel
Black-tailed godwit	*Limosa limosa*	Hudsonian godwit (*L. haemastica*)
Bar-tailed godwit	*Limosa lapponica*	
Turnstone (or ruddy turnstone)	*Arenaria interpres*	
Surfbird	*Aphriza virgata*	
Red knot	*Calidris canutus*	
Sanderling	*Calidris alba*	
Semipalmated sandpiper	*Calidris pusilla*	
Western sandpiper	*Calidris mauri*	
Dunlin	*Calidris alpina*	
Short-billed dowitcher	*Limnodromus griseus*	
Long-billed dowitcher	*Limnodromus scolopaceus*	
Great snipe	*Gallinago media*	Common snipe (G. gallinago)
Gulls and Terns		
Western gull	*Larus occidentalis*	Glaucous-winged gull
Glaucous gull	*Larus hyperboreus*	Glaucous-winged bull
Glaucous-winged gull	*Larus glaucescens*	
Herring gull	*Larus argentatus*	
Yellow-legged gull	*Larus michahellis*	Herring gull
Black tern	*Chlidonias niger*	Arctic tern
Common tern	*Sterna hirundo*	Arctic tern
Arctic tern	*Sterna paradisaea*	
Least tern	*Sterna antillarum*	Arctic tern
Royal tern	*Sterna maxima*	Arctic tern
Pigeons		
Rock dove	*Columba livia*	

Wood pigeon	*Columba palumbus*	Rock dove
Woodpeckers		
Downy woodpecker	*Picoides pubescens*	
Songbirds		
Olive-sided flycatcher	*Contopus borealis*	
Eastern kingbird	*Tyrannus tyrannus*	Olive-sided flycatcher
Violet-green swallow	*Tachycineta thalassina*	
Steller's jay	*Cyanocitta stelleri*	
Blue jay	*Cyanocitta cristata*	Steller's jay
Black-billed magpie	*Pica pica*	
Northwestern crow	*Corvus caurinus*	Common raven
American crow	*Corvus brachyrhynchos*	Common raven
Common raven	*Corvus corax*	
Blue tit	*Parus caeruleus*	Black-capped chickadee (*P. atricapillus*)
Treecreeper	*Certhia familiaris*	Brown creeper (*C. americana*)
American robin	*Turdus migratorius*	
Blackbird	*Turdus merula*	American robin
Townsend's solitaire	*Myadestes townsendi*	
Starling	*Sturnus vulgaris*	
Savannah sparrow	*Passerculus sandwichensis*	
Vesper sparrow	*Pooecetes gramineus*	Savannah sparrow
House sparrow	*Passer domesticus*	
Red-winged blackbird	*Agelaius phoeniceus*	
Rufous-collared sparrow	*Zonotrichia capensis*	White-crowned sparrow (*Z. leucophrys*)
Dark-eyed junco	*Junco hyemalis*	
Western meadowlark	*Sturnella neglecta*	Passerine
Crossbill (or red crossbill)	*Loxia curvirostra*	
White-fronted chat	*Epthianura albifrons*	Passerine
Greenfinch	*Carduelis chloris*	Common redpoll (*Acanthis flammea*)
Shrews, Rodents and Hares		
Shrews	*Sorex* spp.	
Voles	Arvicolinae	
Meadow vole	*Microtus pennsylvanicus*	
Yellow-checked vole	*Microtus xanthognathus*	Meadow vole
Field vole	*Microtus agrestis*	Meadow vole
Prairie vole	*Microtus ochrogaster*	Meadow vole
Root vole (tundra vole)	*Microtus oeconomus*	Meadow vole
Hispid cotton rat	*Sigmodon hispidus*	Meadow vole
Northern red-backed vole	*Clethrionomys rutilus*	
Bank vole	*Clethrionomys glareolus*	Northern red-backed vole
Harvest mouse	*Reithrodontomys* spp.	Northern red-backed vole
Fulvous harvest mouse	*Reithrodontomys fulvescens*	Northern red-backed vole
Wood mouse	*Apodemus sylvaticus*	Northern red-backed vole
Yellow-necked mouse	*Apodemus flavicollis*	Northern red-backed vole
Deer mouse	*Peromyscus maniculatus*	Northern red-backed vole
White-footed mouse	*Peromyscus leucopus*	Northern red-backed vole
Pygmy mouse	*Baiomys taylori*	Northern red-backed vole
House mouse	*Mus domesticus*	
Red squirrel	*Tamiasciurus hudsonicus*	
Eurasian red squirrel	*Sciurus vulgaris*	Red squirrel
Marmot	*Marmota marmota*	Hoary marmot (*M. caligata*)

Thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*	Arctic ground squirrel (*S. parryii*)
Snowshoe hare	*Lepus americanus*	
Cottontail rabbit	*Sylvilagus floridanus*	Snowshoe hare
European rabbit	*Oryctolagus cuniculus*	Snowshoe hare
Canids		
Gray fox	*Urocyon cinereoargenteus*	Red fox
Red fox	*Vulpes vulpes*	
Coyote	*Canis latrans*	
Gray wolf	*Canis lupus*	
Cats		
Lynx	*Lynx lynx*	
Iberian lynx	*Lynx pardinus*	Lynx
Bobcat	*Felis rufus*	Lynx
Mountain lion (cougar)	*Felis concolor*	Lynx
Wildcat	*Felis sylvestris*	Lynx
Domestic cat	*Felis catus*	
Weasels		
American marten	*Martes americana*	
Short-tailed weasel	*Martes erminea*	
Long-tailed weasel	*Mustela frenata*	Short-tailed weasel
Otter	*Lontra lutra*	River otter (*L. canadensis*)
Badger	*Meles meles*	Wolverine (*Gulo gulo*)
Bears		
Black bear	*Ursus americanus*	
Grizzly (or brown) bear	*Ursus arctos*	
Polar bear	*Ursus maritimus*	Grizzly bear
Moose, Elk, Deer		
Moose	*Alces alces*	
Elk	*Cervus canadensis*	Moose
Red deer	*Cervus elaphus*	Moose
Fallow deer	*Dama dama*	Moose
Mule deer	*Odocoileus hemionus*	Moose
White-tailed deer	*Odocoileus virginianus*	Moose
Caribou	*Rangifer tarandus*	Moose
Bighorn sheep	*Ovis canadensis*	Dall's sheep (*O. dalli*)
Mountain goat	*Oreamnos americanus*	
Chamois	*Rupicapra rupricapra*	Mountain goat

[1] Related species is a species from the same genus or family (with a few exceptions) that is found in the Anchorage area.

[2] Includes common to rare residents and migrants, as defined by R. L. Scher (1993. Birds of Anchorage and eastern Cook Inlet. Okiotak 20(4):insert.).

[3] Species is casual or accidental in the Anchorage area.