ungulate species, that even minor, seemingly sorts of disturbances cause increased heart and increased energy expenditures." For additailed information and summary tables on the impacts of recreation on ungulates, birds, animals, see Stetsinger and White (2009).

Medium-sized animals

to recreation-related food sources similar of black bears occurs among many mediumals. Raccoons and skunks are common of many frontcountry campgrounds, partic- at night. Skunks in Great Smoky Mountain Park have become so numerous and habitu- humans that they are common visitors during hours, usually meandering through camp- Local populations in these recreation areas rapidly, leading to population densities at wildlife disease epidemics can be a serious

and wolves show more avoidance toward rec- This is more true of wolves (Whittington 2005) than of red foxes, as the latter have been to increase activity on and near snowmobile snowshoe trails. This behavior may be a result of walking on the compacted snow or the presence cottontail rabbits, snowshoe hares, and other prey that commonly use compacted snow trails. have been extensively studied in Isle Royale Park, Michigan, because movement of the is confined to the island and visitor use is heavy. (1977) found that wolf use of Isle Royale trails after visitors arrive in the spring. Selection and rendezvous sites indicates pronounced avoid- humans. Management suggestions include visitation, enlarging backcountry campsites than establishing new campgrounds, disallow- further trail development, and the assessment of winter visitor use. Today, the Isle Royale population is in great danger from biological inbreeding and low genetic diversity), with reduced to only eight wolves in 2012– No new pups were recorded in 2012.

The impacts of snowmobiles on medium-sized ani- are inconclusive. Snowshoe hares were observed snowmobile trails, but red foxes were more and in such trails (Neumann and Merriam Schmid (1971) also observed that red foxes and deer were commonly seen following snowmobile trails. Apparently, the animals penetrate the snow less in the tracks of snowmobiles and find it easier to travel in the tracks. Penetrometer readings and measurements of animal penetration in snow off trails indicate an increase of about 85% (Neumann and Merriam 1972).

The indirect impact on predator species such as foxes, wolves, coyotes, bobcats, owls, hawks, and eagles of lowering the population of small animals in snowmobile use areas is a concern that has not been investigated. Snowmobile activity can have a detrimental effect on the numbers of small mammals surviving under compacted snow cover.

Easier and accelerated harvesting of animals because of increasing access to remote areas by snowmobiles is a concern for resource managers. The overharvesting of beavers, wolverines, and other furbearers has been suggested but not conclusively documented (Usher 1972; Squires et al. 2007). There is also little evidence that the snowmobile is likely to lead to significantly increased hunting pressure on big game. This is not to say that the incidence of illegal hunting and harassment by snowmobiles is not a concern, but rather that the overharvesting of animals as a result of snowmobiles has little support.

The popularity of river recreation has presented new levels of impact on many water-based species. Floating on whitewater and backcountry rivers has increased rapidly in the US, increasing the incidence of human interaction with waterfowl, eagles, osprey, and similar species. On canoeing rivers and lakes where overnight camping is common, the impact on loon populations is a concern. Increasing use of loon nesting islands for camping by canoeists appears to be the primary cause of decrease in loon productivity in the Boundary Waters Canoe Area, Minnesota. Osprey in Minnesota were also observed to build nests farther from lake and river shores, presumably because of increased watercraft activity.

Flushing distance of bald eagles when exposed to actual and simulated walkers, joggers, anglers, bicyclists, and vehicles was conducted on the Boise River in Idaho, USA (Spahr 1990) The highest frequency of eagle flushing was associated with walkers (46%), followed by anglers (34%), bicyclists (15%), joggers (13%), and vehicles (6%). However, bicyclists caused eagles to flush at the greatest distance (mean = 148 m, 486 ft), followed by vehicles (107 m), walkers (87 m), anglers (64 m), and joggers (50 m). Eagles were most likely to flush when recreationists approached slowly

or stopped to observe them, and were less alarmed when bicyclists or vehicles passed quickly at constant speeds. Similar findings have been reported by other authors, who attribute the difference in flushing frequency between walkers and bikers/vehicles to either the shorter time of disturbance and/or the additional time an eagle has to "decide" to fly.

4.5.3 Small animals

Because the niche and microhabits of small animals are small, the habitat of these species is susceptible to destruction during the improvement and alteration of recreation sites. Clearing of both terrestrial and aquatic vegetation eliminates herbs, shrubs, and trees, which serve as sources of food and shelter for birds and small mammals. At the same time, human food sources attract rodents and certain species of small mammals and birds. Surveys of the riparian zone of the Colorado River showed abnormally high and unhealthy populations of rock squirrels, resulting from feeding by hikers. Lizard populations, which utilize driftwood for shelter and foraging, were reduced through the reduction of driftwood, used for campfires.

The effects of campgrounds on rodents are alteration of the feeding behavior and an increase in the population density of opportunistic feeders such as wood rats and deer mice. Backcountry overnight shelters along the 3200-km-long (2000 miles) Appalachian Trail receive heavy visitation at night by mice, requiring proper storage of backpacker food. The same is true for food storage during daylight hours, because of chipmunks and ground squirrels. Similar results have been found for campgrounds in Canyonlands, Arches, and Yosemite National Parks.

The influence of recreation on birds has already been discussed to some extent. Human intrusion can affect bird behavior, distribution, habitat use, reproduction, and survival (Knight and Gutzwiller 1995). Habitat loss and fragmentation are the major factors affecting bird populations at landscape scales, but humans activity is a primary stressor of bird populations at local scales (Schlesinger, Manley, and Holyoak 2008). Birdwatching, photography, research, and various forms of recreation can cause an increase in harassment and risk of nest predation of songbirds. Birdwatching is one of the most popular forms of nonconsumptive, wildlife recreation. However, balancing wildlife viewing with wildlife impacts is a growing concern. Of five different recreationist-user groups a wildlife refuge in Florida, photographers were the most disruptive, as they were most likely to stop, leave their vehicles, and approach wildlife (Klein 1993). In subalpine forests of the Rocky Mountains, Gutzwiller, Riffell, and Anderson (2002) found that low-impact, repeated human intrusion (by a single hiker) into an area increased the number of gray jays, and thus also probably increased levels of nest predation on other bird species. High-use recreation areas, such as campgrounds and picnic areas, often have higher levels of nest predators as well, drawn by food and garbage left behind by visitors (Delap and Knight 2004). Brewer's blackbird, the brown-headed cowbird, and robins were significantly more abundant in campgrounds of Yosemite National Park, but Oregon juncos were less abundant than in surrounding areas (Garton, Hall, and Foin 1977).

The most dramatic impact on small mammals is caused by off-road vehicles, particularly snowmobiles. The compaction of snow by snowmobiles causes a reduction or destruction of the subnivean space, resulting in a mechanical barrier to the movement of small animals. The tunnels of these animals are collapsed and the feeding area greatly reduced. The compaction also reduces the insulating qualities of the snow, causing stress and death to small mammals through reduced temperatures (Schmid 1971). Schmid (1971) further documents the effects by stating:

> Experimental manipulation of a snowfield has shown that the winter mortality of small mammals is markedly increased under snowmobile compaction. We recovered none of 21 marked animals from the experimental plot, whereas 8 to 18 marked specimens were captured at least once on an adjacent control plot (p. 37).

Pikas, a small mammal of rock-fields at high elevations in the Rocky Mountains, are currently under review for protection under the Endangered Species Act due to concerns over climate change, the primary threat to their persistence (Wolf, Nowicki, and Siegel 2007). In addition, recreation use of high-elevation environments continues to increase and the alpine meadows used by both hikers and foraging pikas are fragile environments. Hikers trample vegetation, and human presence can disrupt foraging of pikas, as has been shown for marmots (Mainini, Neuhaus, and Ingold 1993). Foraging opportunities for pikas are already becoming limited due to climate change and their