Chapter 5

Effects of Urbanization and Recreation on Songbirds

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Introduction

The world's population has grown to over 5 billion people and shows no sign of slowing (Horiuchi 1992). Our increasing population and natural resource use is the fundamental reason that much of the natural world is in crisis (Mangel et al. 1996). In the United States, the greatest recent increases in human population are in the Western states. Nevada leads in population growth, followed by Arizona; New Mexico ranks ninth (U.S. Department of Commerce). As a result, human impacts on western bird communities, which are already severe (Jehl and Johnson 1994), will probably increase.

The human population in the ponderosa pine forests of Arizona and New Mexico, although currently low, is on the rise due to tourism and retirement industries (Raish et al. this volume). Computers have enabled many people to conduct business remotely. Work-at-home individuals are choosing ponderosa pine forest towns because of their small size, safety, cleanliness, scenic beauty, and friendly inhabitants (J. Burding, Flagstaff Chamber of Commerce, personal communication). Moreover, cool temperatures and scenic beauty attract large numbers of recreationists to the forests, especially during the summer months when desert dwellers want to escape extreme temperatures. The importance of ponderosa pine forests as recreation sites (Raish et al. this volume) indicates that the potential impacts of humans on the forest will probably be greater than resident population censuses might suggest.

Human pressures on ponderosa pine forests will continue to increase (Boyle and Samson 1985; Anderson 1995; Flather and Cordel 1995; Raish et al. this volume). The potential effects of these increases on songbirds in ponderosa pine forests are not well studied, but many results are predictable if human use of the forests can be quantified (Foin et al. 1977). This chapter discusses how urbanization and recreation in Southwestern ponderosa pine forests might influence songbirds and comments on the research necessary to provide an assessment of future affects. Other important human impacts on ponderosa pine forest birds, including fire suppression, logging, and grazing, are discussed in Chapters 2, 6, and 7 of this publication.

Effects of Urbanization and Recreation on Songbirds

There have been few studies documenting the effects of urbanization and recreation on songbirds and only 2 that test the affects on Southwestern ponderosa pine forests (Aitchison 1977; Yarnell 1993). However, a general study review is useful because many affects are consistent over large geographic areas (Rosenberg et al. 1987) and are predictable given knowledge of local avian natural history (Foin et al. 1977).

In this chapter, the words "urban" and "urbanization" reference towns and their associated affects. Concentrated human presence is the key feature that distinguishes urbanization from other forms of disturbance.

Urbanization

Urbanization directly influences songbird populations and communities by changing ecosystem processes, habitat, and/or food supply. Urbanization indirectly influences songbirds by affecting their predators, competitors, or disease organisms. Individual birds may adjust their behavior in response to human factors in urban environments. In forested North America, urbanized habitats typically support larger (measured by biomass) and richer (more species) but less even in relative abundance avian communities because they are dominated by a few, abundant species (Pitelka 1942; Emlen 1974; DeGraff and Wentworth 1981; Rosenberg et al. 1987; Mills et al. 1989). Urbanization also favors some species but selects against others so that the composition of urban avian communities differs from those in native environments (Beissinger and Osbome 1982; Rosenberg et al. 1987; Mills et al. 1989; Blair 1996). While many studies have documented these findings, none have specifically measured the effects of urbanization on avian demography. Many urban populations may be sink (area of population decline) populations (Pulliam 1988) that attract many recruits but produce few (Blair 1996). Marzluff and Balda (1992) suggested that this was the case for pinyon jays in Flagstaff, Arizona during the 1980s, and this is probably also true for many flycatchers, Steller's jays, wrens, thrushes, warblers, tanagers, grosbeaks, and sparrows.

Changes in Ecosystem Processes

The affects likely to have the greatest impact on ponderosa pine forest birds are changes in the basic functioning of the ponderosa pine ecosystem; specifically, reduction in natural processes such as fire, altered nutrient cycling, and disrupted water cycling. These changes are accentuated by urbanization and can lead to long-term forest degradation.

Existence of buildings has prompted intense efforts to suppress fire near urban areas, which disrupts the natural fire regime that has evolved with ponderosa pine forest birds. Detailed discussion of the effects of fire suppression on forest structure and function and forest avifauna are in Chapters 1 and 6, respectively.

The energy and building requirements of humans disrupts the natural nutrient cycling of ponderosa pine forests. Forests are thinned to reduce the fire threat and some dead woody material is removed for fuelwood. Loss of snags leads to reductions in insectivores, which can lead to a reduction in forest health (Hall et al. this volume). The combination of fire suppression, logging, and fuel wood harvest has created a new, unbalanced nutrient cycle where nutrients in living trees are removed from the forest as wood products and nutrients in dead debris are removed as firewood. The most important effect of urbanization on nutrient cycling is probably a lengthening of cycles. Fire suppression around urban areas has eliminated the primary mechanism of nutrient cycling in ponderosa pine forests. The lack of fire causes living and dead biomass to accumulate much faster than it degrades and recycles (Covington and Moore 1994). Prescriptions to reduce the Future fire threat, such as thinning (Edminster and Olsen 1996), are then used rather than prescribed burning. As a result, the urban pine forest, although accumulating nutrients and energy, typically exports them rather than recycles them. This nutrient and energy loss may steadily degrade forest growth with long-lasting affect on forest birds.

Water is an important, often limiting, resource in ponderosa pine forests. Permeable, volcanic soils hold little water above ground and permanent streams, lakes, and ponds are rare. Runoff patterns are affected by urbanization as native soils are replaced by impermeable concrete and surrounding forest substrates are compacted by vehicular and foot traffic. Urban centers have tremendous water requirements that affect water distribution and cycling in surrounding forests. Water tables are lowered as aquifers are used at greater than replacement rates (Thorn et al. 1993; Haneberg and Friesen 1995). As forest health declines, springs and seeps important to wildlife may dry up causing bird reductions or redistributions. Songbirds that are able to tolerate human activity will become increasingly dependent on urban areas for water.

Habitat Changes

Vegetation in moderately urban environments is typically more fragmented, includes less coverage at mid- and upper levels, and has more ground level coverage than in natural environments (Beissinger and Osborne 1982; Blair 1996). Not only are patches of vegetation isolated in urban environments, they also rarely include the full complement of species found in natural forests (Beissinger and Osborne 1982). Native plant species are often removed from urban environments and replaced by exotic ornamentals (Beissinger and Osborne 1982; Rosenberg et al. 1987). Even moderately urban environments contain few standing or downed dead trees to provide nest and foraging sites for cavity nesters and timber drillers. Extreme urbanization leads to decreases in vegetation at all levels as man-made structures replace vegetation (Blair 1996). In heavily urbanized areas, forest structure may be modified well beyond the city boundaries (Kamada and Nakagoshi 1993).

Urbanization in ponderosa pine forests produces most of the vegetation effects previously noted. Native shrub and oak understories are usually replaced by lawns and ornamental shrubs. The ponderosa pine canopy is fragmented by houses and roads, but this forest type is not typified by a closed canopy. Even with fragmentation, the actual density of trees in and around urban centers is probably much greater than during presettlement times because of smaller average tree size and fire suppression (Morgan 1994). Snags and downed woody debris are found at low densities in urban ponderosa pine forests because of safety, fire, and aesthetic concerns. Exotic junipers and Colorado pinyon pine trees, commonly planted in urban yards, supply food for wintering Townsend's solitaires, western bluebirds, American robins, and jays. However, exotic plant communities disproportionately favor a few bird species at the expense of preserving the entire native avifauna. Despite these changes, towns in ponderosa pine are less likely to modify natural habitat than other urban centers (eastern United States, West Coast, desert Southwest) because they are modestly sized and have housing developments that are often widely dispersed to enjoy the natural scenic beauty. Where heavily urbanized areas do occur, opportunities for ground foragers are greatly reduced.

Direct habitat modification by urbanization in ponderosa pine forests will likely: 1) benefit ground-gleaning and probing birds that are tolerant of human activity (American robin, European starling, Brewer's blackbird, and American crow); 2) benefit species that nest in man-made structures or ornamental vegetation (rock dove, house sparrow, European starling, house wren, purple martin, barn swallow, house finch, and eastern kingbird); 3) reduce shrub and canopy nesters and foragers (warblers, vireos, tanagers, grosbeaks, wrens, creepers, chickadees, and nuthatches); and 4) reduce burn specialists, cavity nesters, and bark drillers (olive-sided flycatcher, swallows, woodpeckers, chickadees, nuthatches, creepers,

and bluebirds). These effects have been noted on similar species in other environments (Beissinger and Osborne 1982; Rosenberg et al. 1987; Mills et al. 1989; Blair 1996). Yarnell's (1993) study of annual trends in birds counted on Flagstaff's National Audubon Society's Christmas Bird Count suggests that urban obligates and grassland species have increased around Flagstaff from 1967 to 1991.

Food Changes

Urban centers provide food to birds directly at feeders and indirectly at areas of waste treatment, collection, and transfer. Seed eaters and nectivores (hummingbirds, jays, woodpeckers, chickadees, nuthatches, juncos, sparrows, finches, and grosbeaks) benefit from feeders. Scavenging omnivores (gulls, jays, crows, and ravens, blackbirds, and European starlings) benefit from spilled waste (Robbins et al. 1986; Boarman 1993; Marzluff et al. 1994).

Food resources are also affected indirectly by changes in vegetation as previously discussed. In particular, exotic plants have fewer insects than native plants and urban lawns are rich and consistent feeding grounds (Rosenberg et al. 1987). These changes favor ground foragers and granivores while selecting against shrub and mid-canopy foliage gleaners as previously mentioned.

Predator Changes

Introduced predators (cats, dogs) are more abundant in urban areas than in native forests and may have substantial affects on the avifauna (Churcher and Lawton 1987). Other avian predators (sharp-shinned hawk, northern pygmy owl, merlin, and Cooper's hawk) may increase in urban areas and concentrate their activities at feeders where prey are abundant. Human predators can also seriously deplete local songbirds, sometimes just for sport. An example of this occurred in Flagstaff when a teenager shooting pinyon jays during one breeding season caused most of the nest failure and mortality experienced by the flock that year (Marzluff and Balda 1992). Large predators are usually eliminated from areas of human habitation. If northern goshawks in urban ponderosa pine forests are also reduced, songbird populations may increase. Coyotes (*Canis latrans*) and mountain lions (Felis concolor) have increased in and around urban areas recently. These predators may benefit many songbirds by reducing mammalian nest predators, especially cats (Quinn 1992).

Perhaps even more important than the increasing mortality experienced by free-flying birds, urbanization reduces nesting productivity by escalating the number of predators that destroy bird nests. Nest predation is probably the most important limiting factor on songbirds (Martin 1993a, b), even outweighing winter mortality for migratory species (Bohninggaeseet al. 1993). Nest predators, often more abundant in urban areas than native habitats, have increased dramatically in the Western United States during the last century (Robbins et al. 1986; Boarman 1993; Marzluff et al. 1994). As predator density increases so does the predation rate (Andren 1992; Marzluff et al. 1995).

Important nest predators in ponderosa pine include domestic cats, striped skunks (Mephitus *mephitus*), rock squirrels (Citellus variegatus), Abert squirrels (Sciurus aberti), gopher snakes (Pituophis melanoleucus), Steller's jays, American crows, and common ravens (Marzluff and Balda 1992). Surveys of jays, crows, and ravens conducted at several locations in and adjacent to Southwest ponderosa pine each winter since about 1960, suggest that ravens are more abundant and increasing quicker at urban than at rural sites (figure 1; Yarnell 1993). Moreover, the greatest densities of ravens in rural areas are at sites near urban areas. Figure 1b shows that Mormon Lake, which is 25 km from Flagstaff, has the highest density of ravens of the rural sites studied. American crows are also more typically abundant at urban than rural sites (figure 2). Crows in Flagstaff continued to increase in 1996 (R. Balda, personal communication). However, Prescott, Arizona has yet to be colonized by crows and rural areas near urban centers (Sandia Mountains, New Mexico; Mormon Lake, Arizona) are occasionally visited by many crows. Steller's jays vary greatly in abundance from year to year at rural and urban sites without a consistent tendency to be more abundant in urban sites (figure 3). Other jays, such as scrub and Mexican, may actually respond positively to urbanization (Marzluff et al. 1994). These lower-elevation species are invading ponderosa pine towns most notably Payson, Prescott, and Flagstaff, Arizona (Yarnell 1993). Counts during the breeding season at rural sites (none are available for urban sites) suggest that crows, ravens, and Steller's jays are common, and that typically urban nest predators, such as crows, can be abundant in rural sites (figure 4).

The increasing number of nest predators, especially ravens, in urban ponderosa pine forests reduces productivity of native songbirds. Nearly half of all pinyon jay nests in Flagstaff failed from predation in the 1980s. This was a significant increase over predation in the 1970s and was closely correlated with increasing raven populations in the city (Marzluff and Balda 1992). Reduced jay productivity led to a decrease in population size and an increased reliance on immigration to sustain the Flagstaff population. Thus, the population functioned as a sink population during the 1980s although it was probably a source (area of population increase) population in the 1970s. Perhaps other open-nesting songbirds suffer similar fates in urban environments.

Disease

Disease rarely regulates temperate bird populations. Urban populations are probably more susceptible to disease than those in native forests because artificial feeders concentrate birds and increase the incidence of disease spread. Moreover, some urban species, such as rock doves and

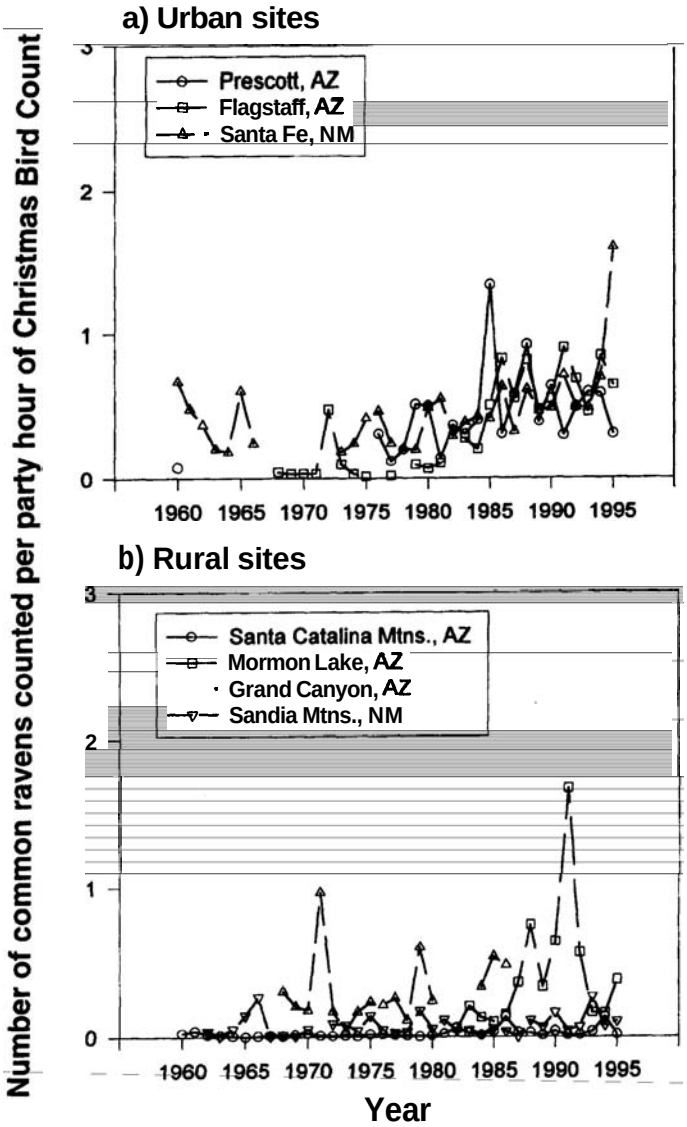

Figure 1. Number of common ravens counted during winter surveys in Southwestern ponderosa pine areas. Birds were counted each winter at the same location as part of the National Audubon Society's Christmas Bird Count. Counts were standardized by observers, which varies annually, by dividing the total number of birds counted by total observation time (party hours). All sites in Arizona and New Mexico that had relatively complete counts from 1960 through 1995 were used. Sites inside the city limits of urban centers are plotted in the top panel and those outside city limits are plotted in the bottom panel.

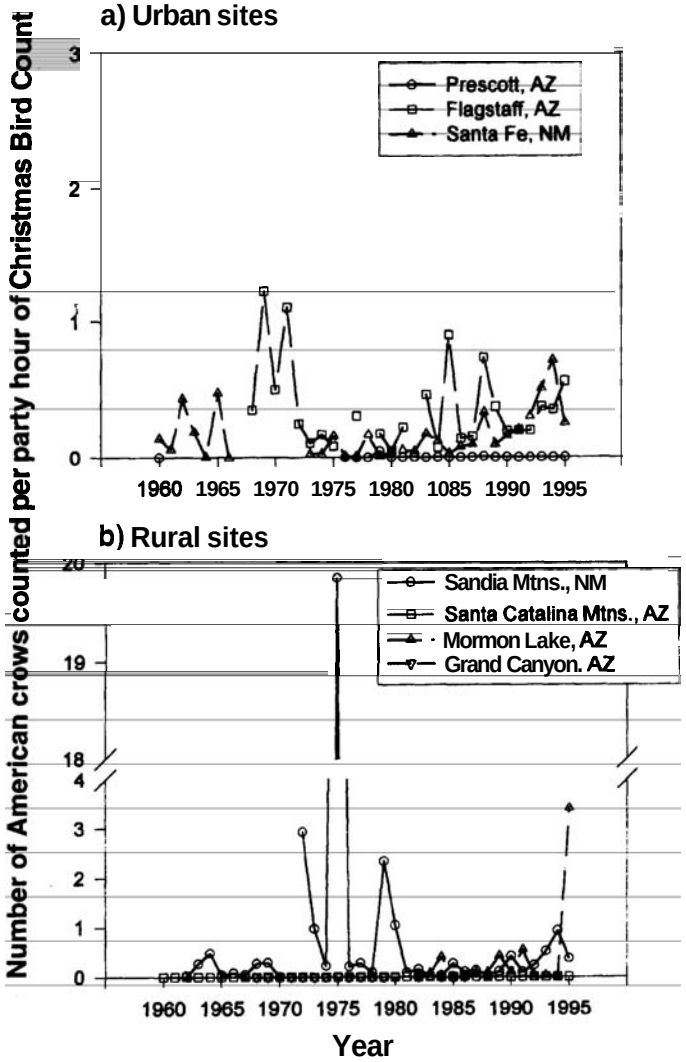

Figure 2. Number of American crows counted at urban and rural sites during the annual National Audubon Society's Christmas Bird Counts. Counts were standardized by observers, which varies annually, by dividing the total number of birds counted by total observation time (party hours). All sites in Arizona and New Mexico that had relatively complete counts from 1960 through 1995 were used. Sites inside the city limits of urban centers are plotted in the top panel and those outside city limits are plotted in the bottom panel.

blackbirds, may be reservoirs for disease (Garner 1978). Rock doves, more common in urban ponderosa pine forests than in natural forests (figure 5; Yarnell 1993), are known to carry diseases such as *Trichornonas.* This protozoan may survive in urban settings better than in rural areas because of the large rock dove population. In addition, when environmental conditions, such as warm springs, favor *Trichornonas* growth, it is quickly transmitted at communal feeding sites. During the spring of 1996 in Flagstaff, *Trichomonas* growth and transmission resulted in the death of several evening grosbeaks and pine siskins (Bill Watt, Arizona Department of Fish and Game, personal communication). Seed eaters and nectivores are most susceptible to such diseases because they frequent urban feeders.

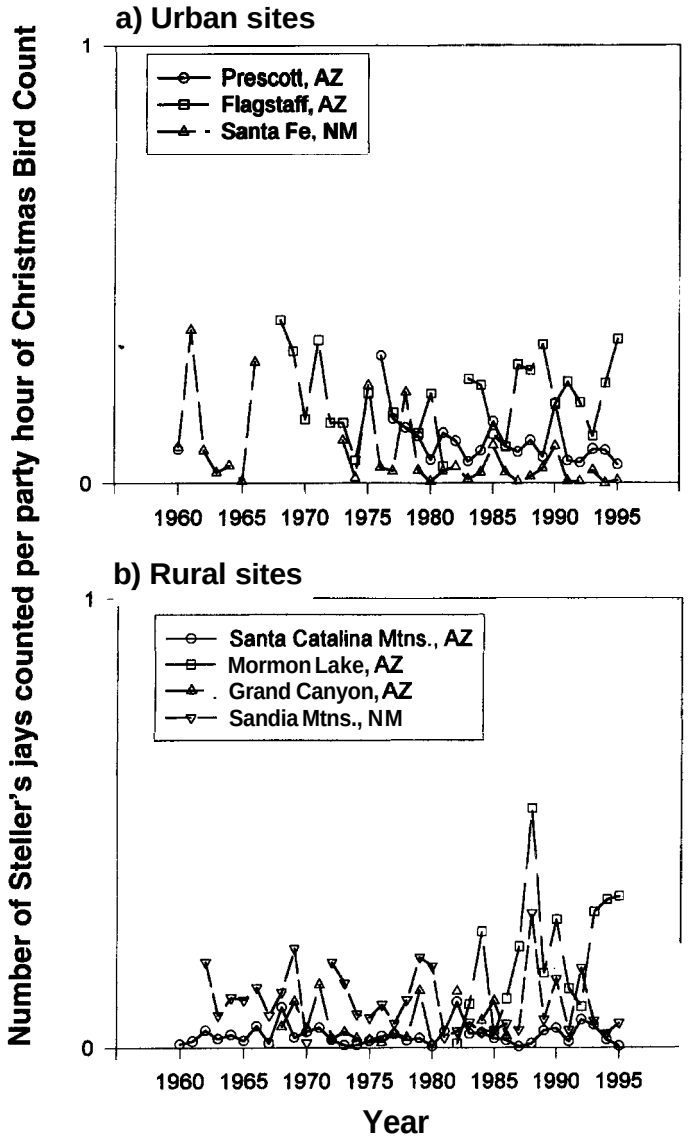

*Figure 3. Number of **Steller's** jays counted at urban and rural sites during the annual National Audubon Society's Christmas Bird Counts. Counts were standardized by observers, which varies annually, by dividing the total number of birds counted by total observation time (party hours). All sites in Arizona and New Mexico that had relatively complete counts from 1960 through 1995 were used. Sites inside the city limits of urban centers are plotted in the top panel and those outside city limits are plotted in the bottom panel.*

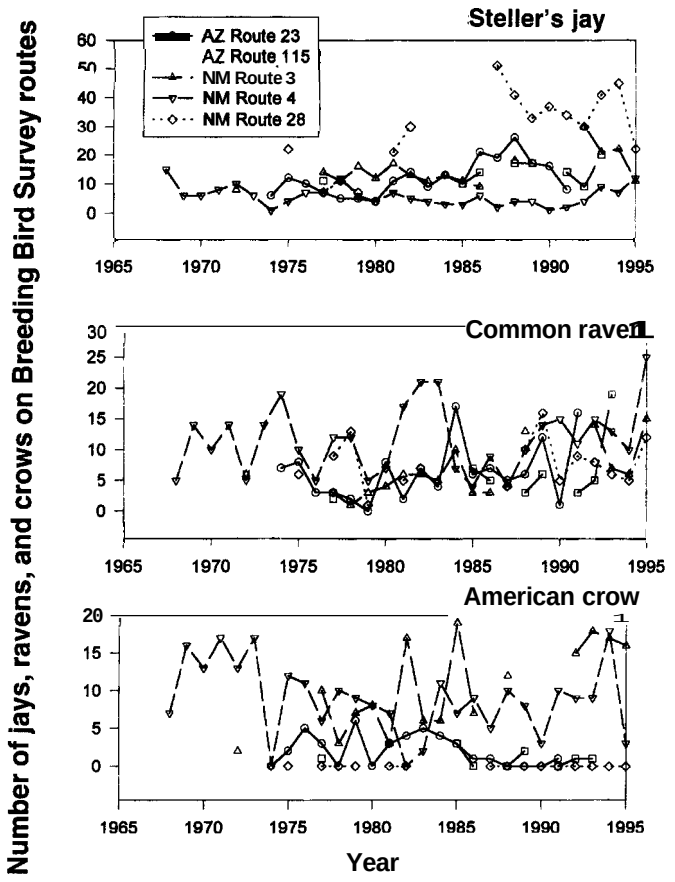

Figure 4. Number of nest predators counted during breeding season surveys in ponderosa pine forests of New Mexico and Arizona. These counts are part of the National Biological Service's Breeding Bird Survey program that began in 1966. Birds are counted along a 49.5 mile route that is driven by an observer once per year. The observer counts birds while stopping for 3 minutes at each of 50 locations spaced at 0.5 mile intervals along the route. All routes with fairly complete data in New Mexico and Arizona were in rural locations.

Competition

Availability of nest sites helps determine the population density of cavity-nesting birds in ponderosa pine forests (Brawn and Balda 1988). Cavity nest sites are usually at a premium in urban sites because of snag removal. The increased abundance of European starlings at urban sites (Johnston and Garrett 1994) suggests that the limited number of urban cavity nest sites may be difficult for native birds to obtain. Starlings commonly outcompete native birds for cavities (Feare 1984), which affects native cavity-nester populations in urban forests. Even the best public intentions can exacerbate this problem; nest boxes for native birds often support breeding starlings and house sparrows. House wrens may also use these boxes and prey on eggs and nestlings of other species.

Behavioral Adjustment to Urbanization

Individuals may adjust their behavior in response to features of urban environments. Such adjustments may enhance a species' ability to persist in the urban environment and may have ramifications beyond the urban setting.

The best documented behavior changes in urban environments involve nesting. Birds breeding in urban environments often nest earlier than those in rural environments because of supplemental food (Balda and Bateman 1972). This may be detrimental in ponderosa pine forests where late spring snow storms often destroy early nests (Marzluff and Balda 1992). Songbirds that are repeatedly disturbed at their nest may increase their aggressiveness (Knight and Temple 1986). Persecution by humans may select for reduced aggressiveness (Knight et al. 1989). Species that live closely with humans, such as American crows, may become accustom to human presence in urban areas (Knight et al. 1987). Increased nest predation in urban areas may cause some birds to change nest placement to minimize losses (Knight and Fitzner 1985; Marzluff 1988).

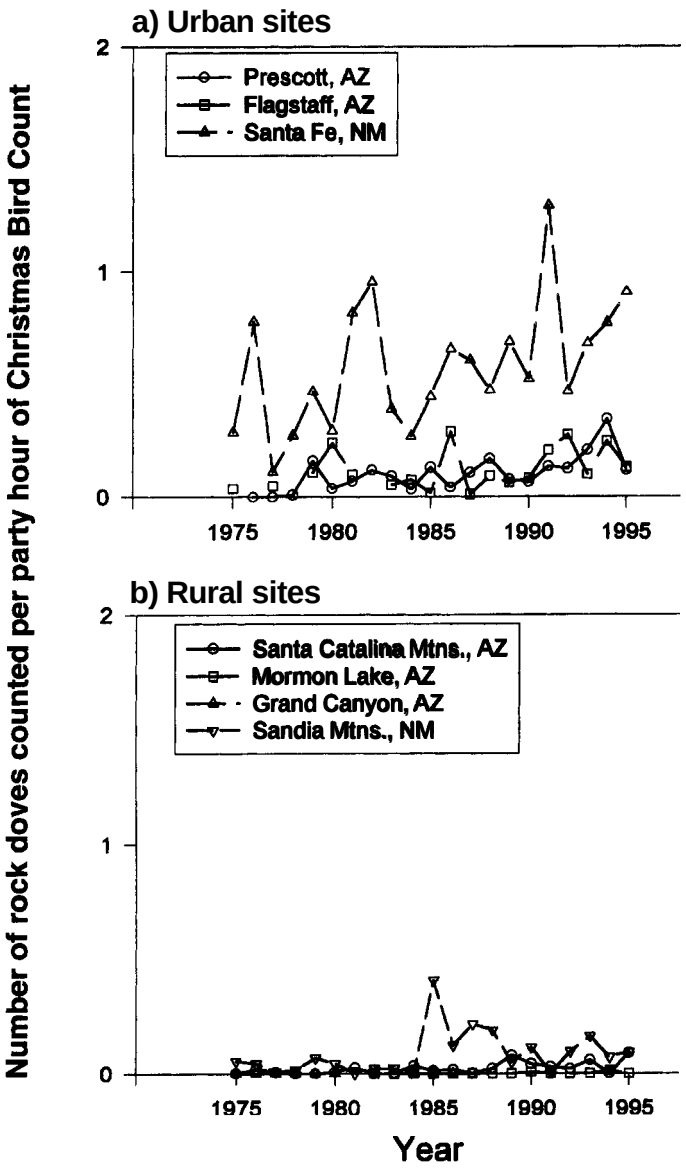

Figure 5. Number of rock doves counted at urban and rural sites during the annual National Audubon Society's Christmas Bird Counts. Counts were standardized by observers, which varies annually, by dividing the total number of birds counted by total observation time (party hours). All sites in Arizona and New Mexico that had relatively complete counts from 1960 through 1995 were used. Sites inside the city limits of urban centers are plotted in the top panel and those outside city limits are plotted in the bottom panel.

Foraging behavior also may be modified in urban environments. Species that use human food sources may reduce their use of natural foods and change their temporal and spatial foraging behavior to include provisioning sites. Reduced reliance on natural foods may interrupt seed dispersal and pollination far beyond the urban center. Clark's nutcrackers, for example, are important dispersal agents for whitebark pine in Colorado. Nutcracker reliance on human handouts in Rocky Mountain National Park may have decreased the dispersal of whitebark pine in the region (Tomback and Taylor 1986). This may also occur with pinyon pine, which depends on jays, crows, and ravens, especially the pinyon jay, for dispersal (Marzluff and Balda 1992). However, pinyon jays in Flagstaff that regularly visited feeders, abandoned them in the fall when pinyon pine seeds were ripe. They cached seeds from the lower elevation pinyon pine forest in the ponderosa forest. Many of the pinyon seeds germinated and became established trees. Pinyon pine is now encroaching into ponderosa pine habitat because of the actions of this bird. Ironically, the pinyon jay may only survive in ponderosa pine forests because of urbanization and supplemental food provided at bird feeders.

Recreation

Recreation can affect wildlife through harvest, habitat modification, predation, and disturbance (Knight and Cole 1995b). Habitat modification and disturbance are most relevant for songbirds because their affects on behavior may modify vigor, productivity, or survival of individuals. Individual demographics and behavior may affect abundance, distribution, and population viability (Anderson 1995; Knight and Cole 1995b). Populations may influence community organization and interactions among community members (Gutzwiller 1995). The general effect of and impacts on specific types of recreation in ponderosa pine forests are discussed in this section.

Habitat Modification

Habitat modification indirectly affects wildlife and can have long-lasting effects. Recreationists modify habitat primarily by trampling vegetation and harvesting fire wood. Trampling from hiking, camping, fishing, and nature study compacts soil, decreases its porosity, and increases erosion (Cole and Landres 1995). This, along with

vegetation crushing, reduces seed germination, seedling establishment, plant growth, and reproduction. Trails may be used by predators and parasites, such as cowbirds, to gain access to forest interiors. Plant species composition often changes in recreation sites as disturbance favors very small or very large species, low growing species, species with tough leaves, and annuals with rapid growth and copious seed production (Cole and Landres 1995). Aboveground vegetation, dead wood, and brush piles are reduced. Plant species diversity is reduced under extreme disturbance but may increase with low to moderate recreation levels (Cole and Landres 1995; Blair 1996). Recreationists may increase the spread of exotic plants by acting as dispersal agents. Habitat contiguity and horizontal and vertical diversity is reduced by recreation. Habitat changes will generally cause the greatest reduction in bird species that rely on shrub and ground cover (juncos, thrushes, warblers, sparrows, vireos, and wrens) and those that depend on standing dead and downed woody debris (woodpeckers, secondary cavity nesters).

Human Disturbance

Disturbance from recreation on wildlife depends on the recreationist and the animals (Knight and Cole 1995a). The predictability, frequency, magnitude, timing, and location of recreation are important to songbirds. Birds may habituate to predictable disturbances such as walking, driving, or camping in consistent locations. This may reduce the recreation disturbance, but it can also be detrimental if habituated birds later approach humans and are persecuted (Snyder and Snyder 1974). The potential influence of disturbance increases with its frequency and intensity. Increases in visitor use of a park in the Netherlands was correlated with reductions in songbird density (van der Zande and Vos 1984). Most songbirds use ponderosa pine forests only during the breeding season, so the timing of recreation has important implications. Effects may be especially pronounced during the early part of the nesting cycle when nest construction and incubation occur (Gotmark 1992). Disturbance during the winter may be important to permanent residents, especially when cold temperatures and deep snow increase energetic requirements and decrease foraging efficiency.

Ponderosa pine songbirds are less affected by recreation than many animals because of their life history traits. The degree of ecological specialization, body size, and sociality of animals may influence their responses to recreation (Knight and Cole 1995a). Specialized birds that require specific foods or habitats (hummingbirds, cavity nesters, pinyon jays, Clark's nutcrackers, and crossbills) are more vulnerable to disturbance because they have less ability to respond to environmental changes (Croonquist and Brooks 1991). The variable temperature, precipitation regime, and seed crops characteristic of ponderosa pine forests (Marzluff and Balda 1992), has favored birds' abilities to exploit alternative resources when necessary. Thus, even specialists in ponderosa pine forests may be more resilient to change than species in less variable climates. This is especially relevant for permanent residents that may adjust better to recreational disturbance than migrants. Large animals are more affected by disturbance than small ones possibly because of historical persecution and energetics (Knight and Cole 1995a). This suggests that most songbirds will tolerate recreational disturbance better than larger birds or mammals. Animals that feed in social groups may respond quicker to disturbance than solitary ones because of increased vigilance and the past experiences of other individuals (Knight and Cole 1995a). Therefore, although songbirds in general may tolerate disturbance from recreation, social species in ponderosa pine forests (pygmy nuthatch, pinyon jay, red crossbill, evening grosbeak, pine siskin) may be less tolerant than solitary species.

The influence of recreation on individuals and populations can affect communities by altering competitive, symbiotic, and predator-prey relationships (Gutzwiller 1995). If interacting species differ in their tolerance of humans, then recreation may affect some participants more than others and unbalance the relationship. Scavenging birds include tolerant crows and wary ravens and raptors. In one study, disturbance by fisherman favored crows because eagles and ravens quickly flushed when humans approached allowing crows to obtain more meat from salmon carcasses (Knight et al. 1991; Skagen et al. 1991). A similar effect could occur in ponderosa pine forests where eagles are flushed by nature viewers from big game carcasses during the winter. Recreationists may upset predator-prey relationships by disturbing nesting birds and advertising nest locations to predators (Gutzwiller 1995). Predators may be more tolerant of human activity than nesting birds or may actually cue in on human activity to locate nests (Gotmark 1992).

Effects of Recreation in Ponderosa Pine Forests

Motorized travel and scenery viewing — Although motorized travel and scenery viewing are the most popular forms of recreation in Southwestern ponderosa pine forests (Raish et al. this volume), they probably have minor, indirect affects on songbirds. Forest fragmentation by unimproved roads is unlikely to significantly affect songbird movements because the nonforested areas around such roads are small and ponderosa pine forests do not naturally have closed canopies. Paved, heavily-traveled roads may constrain movement by relatively sedentary songbirds, such as winter wrens, and affect their selection of breeding habitat (S. J. Hejl, personal communication). Roads may decrease songbird productivity because increased road-kills and litter may subsidize nest predators and provide them with foraging corridors into the forest interior (Knight et al. 1995). People stopping at scenic overlooks also may subsidize jays, crows, and ravens

and perhaps disrupt nearby breeding songbirds. Seed-eating songbirds (finches, sparrows, juncos) may benefit from roads that concentrate rain water run-off and increase annual plant productivity along roadsides. However, such benefits may be countered by increases in cowbirds that may also use annual plant seeds.

Camping — Camping, one of the most common forms of recreation in Southwestern ponderosa pine forests (Raish et al. this volume), is perhaps the most destructive recreational pursuit (Jim 1989). Most responses by songbirds to camping are indirect reactions to human intrusion; songbirds respond directly to habitat change and food supplementation (Foin et al. 1977). Although these responses are usually concentrated in relatively small areas, how far they extend beyond the campground is poorly understood. Vegetation in newly established campsites usually changes within a year as it is trampled and soil becomes compacted (Cole and Landres 1995; Marion and Cole 1996). Cover declines, especially in ground and shrub layers, and erosion increases. Dead and downed wood is quickly scavenged for fires or removed for safety (Foin et al. 1977; Cole and Landres 1995). Plant species diversity and horizontal and vertical structural diversity decline.

Bird communities change in response to habitat changes. Bird species richness and density increases, but evenness of abundance generally declines as campgrounds become dominated by a few widespread, permanent, generalist residents (Foin et al. 1977; Boyle and Samson 1985; Guth 1978). Density and diversity declined at one Arizona campground immediately after it was opened to the public for the summer season (Aitchison 1977). Brewer's blackbirds, mountain chickadees, Steller's jays, American crows, and common ravens will probably increase at campgrounds in ponderosa pine forests, as they have elsewhere in the West (Foin et al. 1977; Marzluff et al. 1995). However, Aitchison (1977) noted a severe decline in Steller's jays after an Arizona campground was opened, primarily because many nests were destroyed by removal of trees and slash. Dark-eyed juncos, American robins, hermit thrushes, warblers, vireos, wrens, and deep forest species will decline as ground, shrub, and mid-canopy cover is removed and isolated (Aitchison 1977; Foin et al. 1977; Guth 1978; Blakesley and Reese 1988). Cavity nesters, bark drillers, and other birds that forage on downed woody debris will decline. Productivity of open-nesting birds will decline as nest predators and parasites (brown-headed cowbirds) increase in response to food supplementation (Clevenger and Workman 1977; Rothstein 1994; Marzluff et al. 1995).

Pack animals have the potential to disrupt ponderosa pine forest bird communities. Spilled feed, feces, and litter attracts and supports brown-headed cowbirds that parasitize native songbirds reducing their productivity (Rothstein 1994). Establishment of pack stations or corrals in remote ponderosa pine locations could pave the way for these parasites into areas with minimal human disturbance. Warblers, vireos, and flycatchers are most susceptible to cowbird parasitism (Rothstein 1994). Although it is unlikely that parasitism alone would cause significant declines in such species, it could contribute to declines in conjunction with habitat destruction, nest predation, and disruption of ecosystem functioning (Rothstein 1994).

Hiking, Nature Study, and Wildlife Photography — These nonconsumptive recreational pursuits are usually thought inconsequential to wildlife. However, their recent surge in popularity (Boyle and Samson 1985; Raish et al. this volume) has prompted evaluation of their impacts (Boyle and Samson 1985; Riffell et al. 1996). These activities can affect songbirds as humans intrude into their territories to observe nests or unique behavioral activities. Nature study and photography may be of special concern because they tend to repeatedly disturb rare and unusual species (Boyle and Samson 1985).

Repeated intrusions in songbird territories during the breeding season can decrease singing (Gutzwiller et al. 1994), increase or decrease nest defense (Knight and Temple 1986; Keller 1989), and increase predation (Gotmark 1992). These changes may reduce the productivity of individuals and influence community composition (Riffell et al. 1996). In fact, intrusion involving 8 to 37 people/ha/day was correlated with declining songbird (warblers, wrens, thrushes) density in the Netherlands (van der Zande and Vos 1984; van der Zande et al. 1984). More dispersed intrusions (1 person for 1 to 2 hrs/ha/week), even if repeated for up to 5 breeding seasons, did not cause widespread impacts to the birds living in mixed-conifer forests in Wyoming (Riffell et al. 1996). Such widespread recreation may influence songbirds as community diversity and density of common species declined in some years. Nearly all songbirds in Southwestern ponderosa pine forests were included in this study, but no affects on individual species were noted. Therefore, although common species may be affected by disturbance in a given year, the effects of hiking, nature study, and photography are unlikely to be cumulative in ponderosa pine forests except where visitor densities are high such as in Grand Canyon National Park and large recreation areas.

Resorts and Recreation Residences — The number of resorts, established camps, and recreational residences in Southwestern national forests has fluctuated and recently declined (Raish et al. this volume). However, the effects of the substantial number of resorts and residences that remain are similar to the impacts from urbanization, camping, and hiking. The most important results of these developments are habitat loss and fragmentation, supplementing nest predators, habitat structure simplification, snag removal, and increased intrusion into surrounding forests by residents. Birds near resorts often have breeding disrupted (Lehtonen 1973; Vermeer 1973; Robertson

and Flood 1980). Avian diversity decreases and density increases as common, widespread species dominate these areas (Robertson and Flood 1980).

Winter Sports and Mechanized Off-road Travel — Snowmobiling and off-road vehicles, which are increasing in popularity across the United States (Boyle and Samson 1985), have great potential to destroy vegetation, alter habitat, and increase wildlife harassment (Berry 1980; Boyle and Samson 1985; Cole and Landres 1995). These forms of recreation are less common in ponderosa pine forests than in higher or lower elevation areas and do not appear to significantly affect songbirds in Southwestern ponderosa pine forests.

More important to ponderosa pine forests is ski-area development in adjacent, higher elevations. There is an increased abundance of scavengers that prey on nests at such developments (Watson 1979). More importantly, ski-area development often increases urbanization in ponderosa pine towns. Flagstaff, Showlow, Pinetop, Ruidoso, and Taos are all expanding (Raish et al. this volume), partly because of increased recreation at nearby ski areas.

Cumulative Effects of Urbanization and Recreation

Table 1 qualitatively assesses the variety of the potential effects of urbanization and recreation on songbirds in the ponderosa pine forest. This assessment summarizes the affects discussed in this chapter and are hypotheses rather than known influences; many potential affects are unknown and many may depend on context.

The following assumptions were made based on studies conducted elsewhere and species natural history: 1) disease negatively affects seed eaters and nectarivores that frequent urban feeders; 2) nest predation negatively influences open nesters, especially those in urban areas; 3) competition with European starlings negatively affects urban cavity nesters; 4) habitat for species that nest in ornamental vegetation or man-made structures improves with urbanization, but habitat for natural cavity, canopy, shrub, and ground nesters is degraded by urbanization; 5) urbanization provides increased food for species using feeders, lawns, and those able to scavenge refuse; 6) road construction favors scavengers and small seed eaters; 7) campgrounds are associated with reduced ground and shrub coverage, increased nest predation, and supplemental food; 8) hiking, nature study, and photography have minor, negative affects on open-nesting species that are relatively intolerant of humans; and 9) resorts and recreation residences favor scavengers and birds able to exploit lawns and feeders.

Few species benefit from urbanization and recreation. Large jays, crows, and ravens, human commensals (purple martin, brown-headed cowbird, house sparrow, house wren, barn swallow, rock dove), and widespread generalists (European starling, Brewer's blackbird) will probably increase in ponderosa pine forests as human populations continue to increase. Several other species (hummingbirds, jays and nutcrackers, chickadees, nuthatches, American robin, grosbeaks, juncos, small finches, and chipping sparrow) that exploit some aspect of human activity (primarily food supplements) should remain stable with increasing human populations. The remaining species require habitat features that humans disrupt most severely. These species (flycatchers, swallows, brown creeper, wrens, bluebirds, Townsend's solitaire, hermit thrush, vireos, warblers, tanagers, song sparrow, and red crossbill) will probably decline in areas of high human use and perhaps throughout the ponderosa pine forest if human activities continue to increase.

Research Needs

Future research should investigate the potential effects of urbanization and outdoor recreation in ponderosa pine forests. None of the studies reviewed in this chapter directly assessed urbanization and recreation in Southwestern ponderosa pine forests. Nearly every relationship hypothesized in table 1 should be tested with designed experiments. Studies of urbanization are especially important because affects on birds are significant and human populations are expanding rapidly in ponderosa pine forests. In addition, even though many forms of recreation may have minor affects on birds, recreation is widespread and increasing in popularity throughout the ponderosa pine forest.

Investigations should be rigorous, carefully designed experiments to establish causal relationships between human activity and songbird population viability (Gutzwiller 1995; Knight and Cole 1995b). Experiments should address the direct and indirect effects of humans on songbirds and identify short-term, behavioral and long-term affects on inclusive fitness. Demonstration of human impacts on avian fitness is crucial to understand how people affect bird populations (Van Horne 1983; Vickery et al. 1992). Experiments must be designed to consider natural factors, such as weather and food availability, and should test the interaction of natural factors with recreation and urbanization on bird populations. An adaptive management approach should be used where managers implement ideas in a controlled, experimental way and researchers test specific management hypotheses.

Critical evaluation of human influence requires long-term monitoring of abundance, distribution, and fitness

of uniquely-marked songbirds. Rather than focusing on a single species, researchers should monitor all members of the avian community simultaneously, perhaps conducting detailed fitness measurements on representatives of those species most likely to be affected by human activities. Species, such as American crows, common ravens, European starlings, and house wrens that appear to benefit from human activities, should be carefully monitored because they can affect songbirds that may not decline from direct human actions.

Some of the most important research questions concerning urbanization impacts are: 1) How do bird communi-

Table 1. Hypothesized changes in songbird abundance in response to urbanization and recreation in Southwestern ponderosa pine forests. Species groups are listed if all members are expected to respond in similar ways; otherwise individual species are listed.

	Urbanization						Recreation		
Species	Disease	Predation	Competition	Habitat	Food	Roads	Camp/ Picnic	Hike/ Study/Photo	Resort/ Residence
Hummingbirds	—	—			++				+
Woodpeckers			——	——	+		——		—
Olive—sided flycatcher		——		——					
Western kingbird		——		+	+				+
Other flycatchers		——		—			——	—	
Purple martin[a]			——	++					+
Barn swallow				++					+
Other swallows				—				—	
American crow	—			++	++	+	++		++
Common raven				++	++	++	++		++
Pinyon jay	—	——		—	++		—	—	
Clark's nutcracker				—	+		+		+
Steller's jay	—	——		—	++		+	—	+
Chickadees	—		——	—	++		+		+
Nuthatches	—		——	—	++		—		+
Brown creeper				——			——	—	
House wren			—	++	+				+
Other wrens		—	—	——			——	—	
Bluebirds			——	——			——	—	—
Townsend's solitaire		—		—			—		
Hermit thrush		—		—			——	—	
American robin		——		+	++	—	——	+	
Vireos		—		—			—	—	
Ground nesting warblers		—		——		—	—	—	
Shrub nesting warblers		—		——		—	—	—	
Canopy nesting warblers		—		—		—	—	—	
Tanagers		—		—		—	—	—	
Grosbeaks	—	—		—	+	—	—	+	
Song sparrow		—		——	+	—	—	—	
House sparrow	—	—		++	++	++		+	
Chipping sparrow		—		—	+		—	—	+
Juncos		—	—		—	+	+	—	—
Blackbirds/cowbirds	—	——		+	++		++	—	+
European starling	—			++	++		++		+
Red crossbill		—		—		+	—	—	
Other finches	—	—		+	++	+	—	—	+

[a] Natural purple martin nesting sites are reduced with snag removal, but this may be overcompensated for by martin houses placed near urban residences.

+Affects that may moderately increase a species' abundance or productivity.

++ Affects that may strongly increase a species' abundance or productivity.

— Affects that may moderately decrease a species' abundance or productivity.

—— Affects that may strongly decrease a species' abundance or productivity.

Blank, no affect suspected.

ties change with increasing urbanization? Standardized surveys should be expanded to include urban areas and similar rural controls so that changes through time can be assessed. Specific comparisons of bird abundance and productivity in towns of various size and through time would help answer this question. 2) How does a particular type and level of urban development affect birds? Comparisons of bird abundance and productivity among different intensities of urbanization have not been done in ponderosa pine forests. In particular, the effects of dispersed housing in the forest, which is growing rapidly, should be studied. 3) What types of urban developments are most compatible with native songbirds? Research about the benefits of landscaping with native plants, using alternative energy sources, and educating homeowners would help identify long-term adjustments that government could encourage to minimize human impacts on the ponderosa pine avifauna. 4) Do nest predators disproportionately decrease productivity in urban areas relative to rural areas? If so, how does this affect various types of birds (open nesters versus cavity nesters, ground versus canopy nesters, social versus solitary species, etc.)?5) How do birds respond to the urban/rural interface? How far from urban centers do the effects of urbanization extend into the surrounding forest? How important is the impact from house cats and other subsidized predators at varying distances from urban sources? Detailed studies of radio tagged predators are needed.

Some of the more important research questions about recreation impacts are: **1)** What motivates people to pursue various recreational activities? This information will better quantify the behavior of people in the forest and improve estimation of the amount and projected increase in the activity. 2) How do various forms of recreation synergistically affect songbirds? Many forms of recreation occur at the same place and at the same or different times, yet we know nothing about how they combine to influence songbirds (Gutzwiller 1995). Comparisons of bird abundance and productivity across areas with increasing multiple recreation use could address this question. **3)** What influence does Grand Canyon National Park, which attracts millions of visitors for a variety of recreational pursuits, have on songbirds? This question could be addressed in a broad study comparing bird abundance and productivity in and around recreation areas of various size in ponderosa pine forests. 4) How long should camps be closed to reduce subsidized predator populations? How much recovery is needed in camps before sensitive ground foragers or cavity nesters return? Assuming that camping affects songbirds as hypothesized, research should be conducted to determine how various degrees of camp closure would reduce affects. 5) How can campsites be made more beneficial to forest birds and less attractive to human commensals? Research is needed to determine how to effectively reduce food supplementation at campgrounds and pack stations, and how to determine if actions, such as increasing habitat diversity or erecting nest boxes, would benefit shrub, canopy, and cavity nesters.

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