

Role of parks, forest and recreation sites in urban wildlife

Urban parks can constitute invaluable habitats for species that otherwise could be lost from the urban ecosystem. Habitat patches such as urban parks with little or no connectivity suffer from a range of deleterious effects yet they are often the only occurrences of urban nature. A conservation strategy in metropolitan areas must use a wide variety of tools, and well-managed small reserves can be very valuable for conservation in the urban matrix. They can act as corridors and stepping stones to improve connectivity for some species, and at the same time be crucial habitat patches for others. It is important to improve the connectivity between habitat patches to foster the movement of animals between fragments and to provide a greater range of opportunities for residents to experience nature in the city. These park-reserves must be created with both the local and landscape scales in mind as part of an overall strategy that includes reserves with different conservation roles, of different sizes, and with different habitats and uses. Flexibility, creativity and multipurpose are fundamental concepts in urban conservation.

Positive aspects

There are a number of positive impacts that park users and managers may have on wildlife. Two groups of positive impacts are identified, the first pertaining to the provision and protection of natural habitat, and the second to increased food supplies. Habitat creation, augmentation, restoration, and conservation

Urban environments may actually provide a greater diversity of opportunities for some species than wildland areas. For example, in their study of raptors, Mannan and Boal (2004) report that urban areas may offer increased prey (such as pigeons, rabbits and rats), alternative nesting sites, and greater stability of resources such as nesting materials. Other animals including skunks, raccoons, and coyotes may also prosper from increased habitat diversity found in urban areas.

Such incidental opportunities may be supplemented through habitat creation and restoration in urban areas. The increase of native plant species, and even some ornamental species found in gardens, may be accompanied by an increase in insectivorous birds (Sears and Anderson 1991). Allowing ruderal areas to go undisturbed and enter a succession process is another avenue toward restoration, often resulting in an increase in total species diversity, and a reduction in non-native species diversity (McKinney 2002). Other approaches include conserving habitat swaths by fencing off areas for protection, and performing exotic plant weeding and revegetation.

One of the most effective (and, in the long run, inexpensive) habitat conservation strategies is to preserve as much remnant native habitat as possible. Urban parks and other developed areas that retain pre-development vegetation can sustain native birds, mammals, and plants at levels of species richness that increase with the area of the native habitat patches. Planners and developers must also pay attention to the greater matrix in which the native habitat remnants are embedded: if the land surrounding the remnants is highly disturbed, the native habitats suffer from more and more intense edge effects than if the surrounding land is at a low level of development (McKinney 2002). Environmental engineering projects such as sustainable drainage systems can provide good urban wildlife habitat, especially if built in conjunction with appropriate landscaping and native vegetation. Ponds, wetlands, and swales provide habitat for waterbirds, amphibians, and invertebrates as they manage runoff (Wright 2003). In general, urban open space, unpaved areas, and green cover not only provide habitat for wildlife, but also absorb stormwater runoff, take up pollutants such as ozone, particulates, and carbondioxide from the air,

moderate wind, and reduce urban heat island effects and hence energy demands (Nowak et al. 2000; Luley 1998). Open space and green cover are, essentially, a part of the city's infrastructure.

Increased food supply

The feeding of wildlife by park users may have short-term benefits including enhanced reproductive success (Orams 2002). Despain et al. (1986) found that grizzly bears in Yellowstone National Park that exploited human food waste averaged larger body sizes, higher reproductive rates, and larger litter sizes prior to the closure of park garbage dumps. According to Brittingham (1991), the use of bird feeders has a positive impact on bird populations and there is little evidence to suggest that birds become dependent on feeders. Fedriani et al. (2001) found that coyote densities in the Santa Monica Mountains were highest in the most developed portions of the mountains, and that anthropogenic food sources such as trash, fruit, and pets may constitute up to 25% of the coyotes' diets in these areas. Similar trends were noted for skunks and raccoons by Hoffman and Gottschang (1977) and Riley et al. (1998), who found that these animals prospered around anthropogenic food sources. Prange et al. (2004) found that raccoons in an urban and a suburban open space had smaller and more stable home ranges than raccoons in a rural open space, due to abundant and fairly reliable anthropogenic food sources. Consequently, urban and suburban raccoons lived at higher densities, and experienced increased survival, higher annual recruitment, and higher site fidelity than their rural counterparts.

Negative Aspects Unfortunately there is a much larger array of negative human impacts on wildlife. Knight and Cole (1995b) note that humans affect wildlife in four possible ways — disturbance, habitat modification, exploitation, and pollution. Disturbance may be either unintentional (accidentally scaring a nesting bird) or intentional (deliberately frightening a deer to get a good photograph). Habitat modification typically results from vegetation clearing or damage, the introduction of invasive plant species, or the release of predators or competitors. Knight and Cole state that exploitation results in the death of the animal as a direct result of human interaction, including hunting, trapping or collection. Pollution may occur in a variety of forms including noise pollution, light pollution, visual intrusion, and air, water and soil contamination through activities such as pesticide application, dumping of trash, or contaminants from storm water runoff. Many of the impacts we discuss below fall neatly into Knight and Cole's (1995b) framework. In addition to these effects, the urban setting of park spaces may pose other threats to wildlife. Mannan and Boal (2004) cite several hazards that the urban matrix poses to raptors, including electrocution from overhead powerlines, poisoning from insecticides or rodenticides, collision with vehicles, and collision with glass windows. Klem (1991) has documented that bird collisions with glass windows of buildings cause millions of avian deaths in the United States each year. Disease is also a hazard, and may be due to transmission resulting from high concentrations of wildlife around food sources, or to ingesting prey such as pigeons that may have a range of avian diseases not found in wildland species.

Disturbance and destruction in habitat fragments

Perhaps the greatest impact of people on wildlife in urban areas is habitat loss (Tigas et al. 2002). This is especially the case in southern California which is not only a global biodiversity hotspot, but where urban development has destroyed hundreds of thousands of acres of unique habitat (Rideout 1993; Soulé 1991). The conservancies, in a sense, seek to inject habitat fragments into the urban matrix, which carries many of the same implications for wildlife as exurban fragmentation. Generally speaking, populations in habitat fragments are exposed to a heightened degree of edge effects like noise and exotic predators, due to the higher perimeter-to-surface area ratio that characterizes habitat fragments. Habitat destruction has many faces, with trampling of vegetation by recreationists and introduction of invasive species including weeds, insects and exotic animals (Wolch et al. 1995) being most relevant to urban parks and open space. Recreation in habitat fragments can lead to serious ecological disturbance including soil compaction, reduced infiltration, increased erosion, and changes in soil moisture, temperature, and fertility with concomitant changes in soil flora and fauna. Impediment of interactions between soil, microbiota, and vegetation caused by soil compaction can result in a decrease in primary productivity (Cole and Landres 1995). The alteration or destruction of park habitat by users may also foster increased bird predation. This may occur due to vegetation trampling by recreationists or their pets or through the removal of cover during trail construction, which also increases edge effects such as weed invasion (Miller and Hobbs 2000). Miller and Hobbs found that the establishment of greenway trails increased nest predation by birds, mice, raccoons, red foxes, and squirrels. Knight and Cole (1995b) cite evidence of avian and mammalian predators following human scent trails to bird nests, and Gutzwiller (1995) has noted that recreationists disrupt species interdependencies and alter the composition of guilds. He asserts that recreational activities alter species richness, abundance and composition. Species that are able to survive and even prosper in the mosaic of urban habitat fragments are opportunistic and highly adaptable. These characteristics oftentimes bring adaptive species into conflict with urban residents. Habitat fragmentation forces animals such as coyotes and bobcats to search for food amidst trash or to include domestic animals in their diet. Though adaptable, these species are often less able to coexist with humans than are "less-threatening" species like raccoons (Riley et al. 2003). Individuals located in habitat fragments are also more prone to disturbance and may shift their foraging behaviors to nocturnal patterns. Habitat fragmentation also brings animals into more frequent contact with vehicles and with toxins, such as rodenticides (Riley et al. 2003).

Release of exotic species

Next to habitat fragmentation and degradation, the biological invasion of alien species of flora and fauna currently constitutes the most serious threat to urban biodiversity in the United States. The over 50,000 alien species in the United States cause upward of \$138 billion of damage to agricultural and industrial infrastructure, and disturb the intricate processes of both urban and wildland ecosystems (Pimentel et al. 1992). Introduced species have serious environmental and ecological impacts. Recreation causes disturbances that favor the establishment of exotic flora, which has implications for the dietary and shelter needs of native species. For instance, differences between resident bird populations in native and exotic Canadian grasslands were attributable to differences in habitat structure and food supply (Cole and Landres 1995). Invasive plants encounter few predators in new environments and may subsequently gain dominance over native plants that serve as a significant source of food to native herbivores.

(Vitousek and D'Antonio 1997). The inadvertent or intentional release of non-native fauna into parks can result in the establishment of populations of feral species. Parrots, cats, reptiles can all take their toll on native species through trophic level disturbance and habitat destruction. Alien fauna represent a new component to a native assemblage of southern California species, whether predator, prey, and/or competitor, resulting in disruption to the species composition of an emerging park ecosystem. Non-natives may enter into direct competition for resources with native species and outcompete their native counterparts. Other species in higher trophic levels feel the repercussions of this relationship as a native prey species disappears; and lower trophic levels may lose a natural predator or grazer (Cole and Landres 1995). For instance, in southern California, Garrett et al. (1997) recorded the exploitation of tree seeds, flowers, and fruits by different species of naturalized parrots. They found that several species of parakeets and Amazon parrots include acorns from native oak species in their diets, and that six parakeet and parrots species consume native sycamore seeds. Garrett et al. predict that some of the naturalized species may enter into substantial competitive relationships with native bird species for food resources in the future. A well-known example of invasive species disturbance to a park ecosystem is the explosion of the cane toad population in Australia. Introduced from Central and South America in 1935 as a biological control mechanism against beetle pests infesting sugarcane fields, the venomous cane toad became a major pest itself, heavily impacting the region's ecology. The recent arrival of cane toads in Kakadu National Park is linked to a decline in native park predators. With no natural predators of the cane toad in Australia, there is currently no far-reaching means of population control available (AGDEH 2004).

Substitute feeding

Orams (2002) has catalogued a wide range of issues associated with human feeding of wildlife. Substitute feeding can create wildlife dependencies on park visitors. Animals may alter their foraging behaviors in favor of easier food sources such as trash left by visitors or food provided directly by park users. This can create problems with artificially high population levels, and the risk of population crashes if food sources are suddenly removed as a result of declining park visitation (Orams 2002). Consumption of human waste food may impair the health of individual animals, and also negatively impact their natural foraging or predatory behavior (Grace 1976). Populations that become too reliant on human handouts may quit their natural roles in a forest or park ecosystem, whether they be pollinators, seed dispersers, or predators (Knight and Temple 1995a). Some individuals dependent upon substitute feeding may damage property in search of unnatural food sources (Peine 2001). Other problems include habituation to human contact, intra and inter-species aggression, and animal injury and disease (Orams 2002; Burns and Howard 2003). A dependency upon handouts can result in the relocation or culling of "problem" animals or populations that become too aggressive or too large (Conover 1999; Schullery 1980). Urban areas also create ideal conditions for rabbits, rats, squirrels, seagulls, crows and other highly adaptable species. This makes them attractive to opportunistic predators such as coyotes and bobcats, potentially bringing them into conflict with urban residents and recreationists (Tigas et al. 2002). Opportunistic species such as crows and raccoons that are attracted to garbage left behind by recreationists may prey upon native species to supplement their diets. When compared to the estimated cumulative \$97 billion in damages derived from invasive species during the 85 year period from 1906–1991, the \$138 billion annual estimate illustrates the staggering impact of the rapidly growing exotic animal trade, increased demand for agricultural production, and the globalization of the world economic market and airfields (Belant 1997).

Behavioral changes in wildlife

Wildlife respond to human presence in three ways: attraction, avoidance, and habituation (Knight and Temple 1995a). Attraction behavior results from positive experiences with humans, and avoidance behavior from negative experiences. Habituation means that wildlife simply become accustomed to the presence of humans, through neither positive nor negative experiences with them (Knight and Temple 1995a). Vaske et al. (1995) note that animal responses to human intrusion or disturbance are not uniform even within species, and are multifaceted. Behavioral changes may be short term or long term, occur at the individual level or at the population level (Knight and Cole 1995b), and, importantly, may carry over into individual or species-level ecologies. Factors to be taken into consideration include the type of park use, frequency of park use, and behavior of park users (Vaske et al. 1995). Different wildlife species have different tolerance levels — some are detrimentally affected by small impacts whereas others, particularly opportunistic species such as crows, squirrels, seagulls, skunks, raccoons and foxes (Rosatte et al. 1991), may profit from increased human interactions. Outcomes will depend on the time and place of interactions, issues of seasonality such as breeding cycles, and the duration, intensity and predictability of interactions. Outcomes will also be a function of the type of animal involved, the health of the animal, body size, behavioral adaptability, group size, age and sex (Knight and Cole 1995a). Species attracted to human-disturbed landscapes include but are not limited to crows, coyotes, foxes, skunks, raccoons, opossums, pigeons, sparrows, and Norway rats. McKinney (2002) distinguishes between urban adapters, species adapted to forest edges and open spaces but able to exploit anthropogenic resources; and urban exploiters, species extremely or completely dependent upon anthropogenic resources. These species are often implicated as antagonists in “nuisance” situations, as they infringe upon “human” spaces. Though these animals benefit from urban food sources and shelters, their constant presence in or near to urban areas means that individuals are more at risk of being trapped and euthanized by animal control personnel, and of being injured or killed in vehicle collisions. Further, dependence on anthropogenic resources makes these species vulnerable to population fluctuations, if for some reason their food source is terminated (Orams 2002). However, populations of urban exploiters are generally quite resilient. Various wildlife species, when harassed by recreationists, undergo significant changes in habitat use, nesting behavior, and territoriality as part of their avoidance behavior (Knight and Temple 1995a). Human disturbance can cause temporary avoidance behaviors including nest abandonment and food habit changes. Longer-term changes can include the abandonment of preferred foraging grounds and changes in food sources.

Human disturbance can result in physiological repercussions for many animals, such as elevated heart rates. Longer physiological changes include altered energy budgets because of increased energy expenditure for escape or decreased energy intake due to foraging interruptions; this can result in decreased reproductive capacity (Knight and Cole 1995b). Other animals react to frightening situations with a passive defense response or freezing mechanism. A variety of behavioral and physiological effects can occur, including decreased heart rates, body temperature, and oxygen consumption.

Disturbance of breeding or roosting birds Another impact of park users on wildlife is associated with the disturbance of nesting or roosting birdlife. Hiking, backpacking, cross-country skiing and other non-motorized recreational uses primarily affect reproductive success through the

redistribution of avian populations. Avian populations are also displaced by rock climbers, who use ledges that serve as ideal nest sites (Knight and Cole 1995b). Fernández-Juricic et al. (2004) recently found that birds are less prone to disturbance if recreationists remain on designated trails, and that birds roosting higher in the tree canopy are less prone to disturbance than ground foraging or low canopy birds.

Wildlife viewing, a seemingly unobtrusive category of recreational use, can significantly affect avian populations. Wildlife viewers often target populations during breeding time. Disturbance also significantly affects breeding avian populations by altering nest selection and flight patterns. Reproductive success is reduced when avian species are forced to seek new habitat (Burger 1995). When an intolerable level of disturbance forces species out of their familiar habitat they must survive and reproduce with unknown amounts of food, shelter and access to other vital natural resources. Moreover, reduction in environmental complexity and the depletion of habitat can reduce the abundance of avian populations

Vehicle collisions

Roadways constitute significant barriers to migration, dispersal, foraging, and genetic exchange for wildlife species, and many animals that attempt to surmount these barriers fall victim to motor vehicle collisions (Aresco 2005). Ruediger (2004) has recently cited evidence that a high percentage of large predators such as cougars and wolves are killed by vehicle collision each year in the United States. Knight and Cole (1995b) cite examples of declining wolf populations in national parks due to motorists intentionally or unintentionally running over wolves. Birds are also vulnerable to collision (Mannan and Boal 2004) though more frequently with aircraft than with automobiles (Conover 2002; HaySmith and Hunt 1995). Reporting on research on seagulls in urban environments, Belant (1997) noted that gulls comprised 30% of bird collisions with aircraft in the United States and are estimated to cause \$40 million in annual aircraft damage costs. Conover (2002) reports that over 8,000 collisions between birds and civilian aircraft occur each year in the United States.

Disease

Another area where park users may impact non-human species is through the spread of diseases. Once again, this may be a direct or indirect result of users' actions. Disease may be spread through a variety of vectors including pet droppings, contact between pets and wildlife, fungus spread on footwear or automobile tires of park users, or through the release of exotic species. Another source of disease transmission may occur when animals gather in high densities at sites of opportunistic feeding such as trash cans or bird feeders (Brittingham 1991). Riley et al. (1998) have noted that in urban parks the density of animals such as raccoons greatly exceeds densities in wildlands, as parks contain a ready supply of food and den sites and provide opportunities for foraging in park-adjacent neighborhoods. Moreover, urban parks offer wildlife a refuge from hunting and vehicle traffic, often resulting in higher densities of animals, which may render animals more prone to epizootic transmission and mortality.

Pollution

Human activity has unleashed a variety of negative environmental effects on parklands. Some, like global warming and air and water pollution, are far more widespread than the park environments they affect; but others, like trash, noise pollution, and light pollution, are localized problems.

Poisoning of wildlife and their environments may result from pollutants released into the air, water, and soil. For instance, rats exposed to ambient particulate matter, a specific air pollutant

that includes soot, smoke and dirt derived from cars and factories, demonstrate cardiac arrhythmia (Su et al. 2004). Chronopoulos et al. (1997) studied the concentrations of lead and cadmium — two metals that are toxic to plants and animals — in soils and plants at urban parks in Athens, Greece. In urban environments, car fumes and tire wear are the main sources of lead and cadmium, respectively. The authors found the highest concentrations of cadmium and lead in soil and plants situated at the periphery of the parks. Noise and light pollution also represent serious threats to urban park and open space populations. Noise pollution oftentimes forces animals to alter their foraging, nesting and reproductive behaviors. Radle (1998) suggests that there is a broad consensus that noise can affect wildlife physiology and behavior, and that chronic noise stress can have negative effects on animals' energy budgets, reproductive success, and long-term survival