Morbidity and mortality of urban wildlife in the midwestern United States

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Abstract

The Ohio Wildlife Center has served the central Ohio community; accepting injured, orphaned, diseased, and displaced wildlife for the past 18 years. These wild animals stand in a sentinel position as biological indicators of environmental conditions in urban and suburban areas. Most causes of morbidity and mortality can be termed "unnatural" and directly related to human activities and dominant influence. The traumatic injuries of wildlife range from vehicular strikes, window collisions, cat and dog predation to malicious gun shot. Diseases include: outbreaks of house finch conjunctivitis, trichomoniasis, and salmonellosis which occurs at backyard bird feeders. Density-dependent parasitic diseases include sarcoptic mange of red foxes and notoedric mange of gray squirrels. Several other problems not easily classified include: monofilament line injuries, tar, oil, fly paper contact, and pesticide toxicities. A review of the commonly recognized diseases and maladies of urban wildlife is presented.

INTRODUCTION

Wildlife species taking advantage of urban and suburban areas of North America include a diverse group of animals. These species that exploit resources in a human-dominated landscape have not only survived, but many have reached population levels not found in typical natural areas. Raccoons (*Procyon lotor*), Eastern gray squirrels (*Scuirus carolinensis*) and Eastern fox squirrels (*S. niger*) are common residents of urban communities in the United States and can benefit from human presence. Flyger (1974) commented that it is incorrect to think that gray squirrels have adapted to urban environments, but rather have taken advantage of the superior habitat created by human presence. Other species have also benefited from their close association with humans, including Eastern cottontail rabbits (*Sylvilagus floridanus*), Virginia opossums (*Didelphis marsupialis*), Eastern screech owls *(Otus asio*) and even peregrine falcons (*Falco peregrinus*) in recent years.

In association with human environments, however, wildlife species also experience excess stress compared to more naturally occurring populations. Busy city streets create an almost impenetrable barrier to wildlife crossing. Plate glass windows in residential homes, office buildings and large high-rises become enormous obstacles in migratory pathways for many avian species. Even avian residents of many urban areas become window casualties as a result of everyday collisions.

Direct human disturbance can also negatively impact urban wildlife. Children playing in yards and urban pets, cats and dogs, adversely affect wildlife by disturbing young in nests or preying on vulnerable species. Lawn herbicides and pesticides are regularly applied to many green areas to promote a weed-free monoculture of neatly grown grass. These few examples help illustrate some of the potential hazards confronting wildlife.

Though none of the wildlife hazards discussed are completely restricted to urban wildlife, they are common issues facing wildlife in Ohio and adjacent

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states. The causes of wildlife morbidity and mortality are representative of cases presented by the public to The Ohio Wildlife Center (OWC) in Columbus, Ohio. Columbus is a large metropolitan area with a human population exceeding 1 million. The Ohio Wildlife Center is a non-profit wildlife rehabilitation facility with an organization of volunteers founded in 1984 to promote awareness and appreciation of Ohio's native wildlife through education and rehabilitation programs. The Ohio Wildlife Center offers biological and humane solutions to human-wildlife conflicts, advocating exclusion and prevention versus harming, trapping, and relocating. The center is frequently called upon to provide mitigative solutions to hazards encountered by native wildlife as well as medical and surgical treatments. Over 3,500 individuals are received at the center each year and through rehabilitative measures, OWC strives to give wildlife a second chance of surviving human-imposed problems.

URBAN WILDLIFE DISEASES

Backyard Feeder Diseases

In 1996, the U. S. Fish and Wildlife Service (USFWS) reported 60 million people, 16 years and older, spent over $29 billion on trips and equipment in the pursuit of wildlife watching (Caudill and Laughland 1998). Backyard bird feeding is an increasingly popular form of this type of recreation. While providing occupants of residential buildings an opportunity to closely observe birds, bird feeding offers granivorous species a readily available food source. The concentrating of birds at feeders, however, increases the likelihood of contact with other birds or fecal droppings resulting in an increased opportunity for disease transmission. There are 3 diseases commonly associated with artificial feeding at feeders: salmonellosis, mycoplasma conjunctivitis and trichomoniasis.

Salmonellosis is a bacterial disease caused by more than 2,200 serotypes of the genus *Salmonella*. Bird mortality from salmonellosis was reported from 18 states to the National Wildlife Health Laboratory (U. S. Geological Service) from January 1998 - March 1998. In 16 of these 18 (89%) states, salmonella was the confirmed cause of death (Quist 1998). The occurrence of salmonellosis at bird feeders is typical in winter months when cold and inclement weather predisposes birds to disease. House sparrows (*Passer domesticus*) are commonly infected (Wobeser 1967) as are pine siskins (*Carduelis pinus*), American goldfinches (*Carduelis tristis*), brown-headed cowbirds (*Molothrus ater*), and Northern cardinals (*Cardinalis cardinalis*). Several other flocking species, including dark-eyed juncos (*Junco hyemalis*), and evening grosbeaks (*Coccothraustes vespertinus*) have also had salmonella-related mortality.

Not only do feeder birds become diseased, but peridomestic species such as rock doves (*Columbia livia*), mallard ducks (*Anas platyrhynchos*), and ring-billed gulls (*Larus delawarensis*) become infected with salmonella from sewage treatment plants, city waste landfills and animal processing plants (Mitchell and Ridgwell 1971; Fenlon 1981; and Stroud and Friend 1987). Hawks and owls can then become infected after consuming diseased prey.

Salmonella is shed from the bird's intestine into the environment contaminating the ground, feeder, food or water source. Birds demonstrate salmonellosis ranging from an inapparent carrier state to acute death. Clinical disease usually, however, follows a gradual progression from general puffiness and anorexia, to greenish, blood-tinged, watery diarrhea. The weakened bird can demonstrate weight loss with huddling and crowding near feeder areas. House sparrows with visibly swollen, matted eyelids, and birds with thickened necrotic crops have been diagnosed with salmonellosis.

A diagnosis of salmonellosis should always be regarded as a public health risk. Domestic cats are known to prey on sick and moribund backyard species and can subsequently become infected. Cats taken into homes can expose humans to this pathogenic bacterium. Appropriate precautions should be taken with cats to prevent contact with infected birds (Stroud and Friend 1987).

Mycoplasma Conjunctivitis. Beginning in February 1994, house finches (*Carpodacus mexicanus*) in Washington, D.C. were being reported at backyard feeders as having swollen eyelids (Luttrell et al. 1996). From this locus, what was soon to be known as house finch conjunctivitis spread throughout the eastern United States (Ley et al. 1996). Within two years, this disease spread to include the entire eastern range of the house finch and a new strain of *Mycoplasma gallisepticum* (related to, but distinctly different from the domestic poultry strain) was later identified as the etiologic agent (Ley et al. 1996; Dhondt et al. 1998). This newly emerging strain of *Mycoplasma* causes primarily, conjunctivitis, and less commonly, rhinitis and tracheitis in house finches and occasionally occurs in other species such as American goldfinches and blue jays (*Cyanocitta cristata*) (Fischer et al.1997).

Clinically, infected finches have one or both eyes swollen with a mucopurulent occular and nasal discharge. At times, eyelids may be completely matted together. Infected birds demonstrate a propensity to remain around feeders, becoming generally debilitated, losing weight, and eventually dying. Clinical disease can arise in 2 to 6 weeks post exposure or the bird may remain a carrier contributing to this chronic endemic disease in house finches (Luttrell et al. 1998).

Trichomoniasis. One of the most prevalent and important diseases affecting rock doves and mourning doves (*Zenaida macroura*) is caused by a one-celled protozoal parasite, *Trichomonas gallinae*. *Trichomonas* is a common parasite of the upper digestive tract, usually occupying the crop, with extension into the oropharynx in more advanced cases. Varying degrees of virulence occur with strains of *Trichomonas*. Some are well tolerated by the host while other strains produce invasive disease of the trachea, lungs, and liver resulting in avian mortality. Rock doves serve as the primary hosts for *Trichomonas* but numerous species of doves and pigeons can also be susceptible (Stabler 1954). Many other non-columiform species such as America robins (*Turdus migratorius*) have also become infected. Hawks and owls can also acquire infections by preying on these diseased birds.

In addition, *Trichomonas* has a direct life cycle. It can be transmitted from parents to nestlings by regurgitation of crop milk, or acquired through a common contaminated water or food source. Trichomonads are known to survive in water for at least 30 minutes and varying periods of time on wet grain (Kocan and Herman 1971).

Clinically, trichomoniasis appears as caseous white plaques in the mouth and can lead to obstruction of the posterior oropharynx and esophagus. In individuals still able to feed, crop stasis results in crop distention. Seeds retained in the crop for a long period of time become moldy, creating pressure necrosis and rupturing the crop. These birds present with foul-smelling seeds dropping out of the neck region. In terminal cases, severe emaciation, anorexia, weight loss, dehydration and respiratory difficulty precede death.

Diseases associated with backyard feeding stations are largely the result of poor maintenance and sanitation. To minimize disease transmission and feeder die-offs, feeders should be cleaned and disinfected on a regular basis using a dilute solution of household bleach (1:30). Good quality seeds, stored in a cool dry place, should be offered in feeders off the ground. Surrounding areas of the feeding station should be maintained free of spilled seed and droppings. Bird baths need to be emptied and cleaned on a weekly basis. If birds are noted to be dying near feeding stations, feeding should be temporarily suspended to disperse birds or the feeder can be cleaned and rotated to another site. Avoid large concentrations of birds at feeders to help minimize transmission of disease (Nettles 1992).

Canine Distemper Virus

Canine distemper virus (CDV) is a Morbillivirus classically producing systemic neurological disease in domestic dogs (Greene 1990). Since the 1950s, it has increasingly been recognized in a wide range of terrestrial carnivores. It is now generally known to infect all members of families *Canidae, Mustelidae,* and *Procyonidae* (Budd 1981). In urban environments, CDV has produced epizootic disease in raccoons, gray foxes (*Urocyon cinereoargenteus*) and red foxes (*Vulpes fulva*). In a New York study of post-mortem carnivores submitted for necropsy, CDV was diagnosed in 60.5% of 416 specimens (Monson and Stone 1976). Similarly, Robinson (1957) reported 24 of 32 (75%) raccoons examined in Indiana were found to have CDV. Canine distemper virus has been responsible for large numbers of sick and morbid raccoons found in Columbus, Ohio. In 21 raccoons found sick in public places in Columbus and presented to OWC in the last 16 months (October 1997-February 1999), 18 (86%) have been diagnosed with advanced neurologic disease caused by CDV. Most of these raccoons have been found in the winter months spanning December - March.

The disease is propagated by contact of recently infected or diseased individuals with susceptible raccoons in areas where they concentrate (i.e. backyard feeding stations). Diseased raccoons shed virus from the respiratory tract by aerosol droplets, through oral, nasal, or ocular discharges, and urine.

Symptoms of the clinical disease include behavioral abnormalities such as circling, confusion, staggering gait, and being found exposed during the daytime. Red and gray foxes with distemper can display respiratory difficulty, lethargy, emaciation, paralysis, terminal convulsions, and coma (Budd 1981). Raccoons frequently have purulent ocular and nasal discharges often sealing the eyes shut. Oral and nasal mucosal membranes may be ulcerated with multifocal hemorrhages. Some individuals may even self-mutilate leading to dermal ulcerations of the head, face and extremities. Lesions of the foot pad lead to chronically thickened pads. Terminal raccoons have neurological disease including chorea, seizures and coma. Raccoons may lose their fear of humans and wander up to people who may view this as aggression. Several raccoons have even wandered into garages and have been unable to exit. Considering the predominate clinical signs of CDV are manifested as a neurologic disease, differential diagnosis of rabies should always be taken into account when handling CDV-diseased raccoons.

Canine distemper is an important infectious disease impacting carnivore populations, especially raccoons. The degree of mortality depends heavily on the density and susceptibility of local raccoon populations. Canine distemper's continued presence as an endemic disease in Columbus, Ohio is indicative of dense urban populations of raccoons.

Parasitic Diseases

Notoedric mange of gray squirrels and sarcoptic mange of red foxes are 2 highly contagious parasitic diseases of wild mammals. They are transmitted by direct animal contact or indirect contact with dens, nests or scratching posts. They can be a population-limiting factor especially when species are stressed by environmental conditions such as food scarcity or high population density (Pryor 1956). Both diseases are caused by a dermal-inhabiting mite which leads to hair loss, and when unchecked predisposes animals to high levels of morbidity and mortality.

Notoedric Mange. Multiple gray squirrels from localized urban populations in central Ohio have presented with varying degrees of alopecia (hairloss). *Notoedres doughlasi* has been identified on numerous occasions to produce hair loss, which usually begins in shoulder regions and in mild cases, may be confined in these regions. Alopecia involves only 5-20% of the body and the infected areas beginning to regrow new hair are considered mild (Carlson, Roher and Nielsen 1982). In progressive diseases, head and neck regions often become infested, with severe cases involving more than 60-70% of the body surface. The skin in affected areas is grossly thickened, crusty yellow to cream colored with cracks and fissures (Carlson, Roher and Nielsen 1982).

Sarcoptic Mange. Sarcoptic mange is found in a wide variety of hosts including most wild carnivores. The agent *Sarcoptes scabiei* is considered 1 species of mange, and is indistinguishable from different host species. However, it does show a considerable degree of host specificity. When interspecies transmission does occur, only transient self-limiting infections usually result. Red foxes experience one of the most aggressive and lethal forms of sarcoptic mange where the skin is known to undergo marked ten-fold increase in thickness with thousands of mites found residing (Georgi and Georgi 1990). Exposure to as few as 2 dozen mites in a den site has been known to cause clinical disease in its inhabitants (Sweatman 1971). The infestation usually begins on the limbs, ischiac protuberances, tail and ear tips. Most foxes are highly pruritic, gnawing and scratching affected areas. Severe cases usually involve the whole body with scaling, crusting and extensive hair loss. Many foxes, especially juveniles lose condition, experiencing weight loss and inability to catch prey causing them to exploit food sources associated with humans.

Sarcoptic mange is thought to be present in populations at low levels under most conditions, but red fox sarcoptic mange has been reported as an epizootic, involving large numbers of foxes (Trainer and Hale 1969). Epizootics are thought to have population limiting consequences with this parasite historically being advocated as a biological control, when state issued bounties to control red fox populations were still in effect (Trainer and Hale 1969).

TOXICOSES OF URBAN WILDLIFE

Pesticides

Organophosphates (OPs) and carbamates, cholinesterase-inhibiting pesticides, have widespread distribution in urban and suburban areas of the United States as lawn insecticides, herbicides, acaracides, nematocides, helminthicides and fungicides (Fairbrother 1996). They are usually applied to lawns by spraying or broadcastings of granules where non-target birds and mammals are certain to be exposed (Fairbrother 1996). Examples of OPs include disulfoton, dichlovos, parathion, malathion, ronnel, diazinon, sevin and chlorpyrifos. Diazinon and chlorpyifos are 2 OPs implicated in the intoxication of wild birds. Carbofuran is a carbamate product specifically responsible for avian toxicoses and has restricted use due to its high toxicity potential (Stone and Okoniewski 1988, Porter 1994).

Early clinical disease is difficult to recognize in wild birds. It may appear simply as restlessness or irritability. In most cases of toxicoses, clinical disease will progress to hypersalivation, diarrhea and respiratory difficulty with open-mouthed breathing. Advanced signs include muscle fasciculation, ataxia, depression, miosis, spastic nictitans, and opisthotonus. Death usually results from central nervous system depression, respiratory failure, or drowning in waterfowl. Acute signs of intoxication may be evident as early as minutes in highly toxic cases of ingestion or 1 - 12 hours following inhalation or cutaneous absorption (Fairbrother 1996). Spontaneous recovery in 48 hours can follow low level exposure (Porter 1994).

Diagnosis of acute OP or carbamate toxicoses can be presumptive based on history of exposure, e.g. a large die-off of Brandt geese (*Branta bernicla*) on a New York golf course after diazon was applied to the grass (Stone and Crandall 1985); or in central Ohio, two incidents of waterfowl exposure involving mallard ducks and Canada geese (*Branta canadensis*) following the application of 100% powdered diazinon on crushed limestone as a grubicide to lawns around ornamental ponds in apartment complexes. As a result, mallard ducks were subsequently found dead in the water and along banks of the ponds, and Canada geese were found dead at the water's edge. A resident flock of Canada geese was found hypersalivating, open mouthed breathing, stuporous and uncoordinated. A presumptive diagnosis could be made based on this history alone. A definitive diagnosis would require the demonstra-

tion of the pesticide in the stomach contents or depressed acetylcholinesterase levels in the brain or blood.

Lead Poisoning

Lead poisoning has been recognized as an important cause of mortality in waterfowl for more than 100 years (Pain 1996). Bellrose estimated (1959) that lead poisoning kills 2-3% of the North American waterfowl population. This figure represents up to 2 million lead-associated deaths annually. Today, legislation in the United States restricts the use of lead shot for sport hunting in aquatic systems, but decades of littering with lead shot continues to be a source of poisoning and mortality. Aquatic feeding species are also exposed to lead in the form of lead fishing weights. Mute swans (*Cygnus olor*), trumpter swans (*C. buccinator*), tundra swans (*C. columbianus*), and common loons (*Gavia immer*) have been documented as having experienced lead toxicity from ingested lead sinkers (Pokras and Chafel 1992; Locke and Thomas 1996). Birds of prey can also be secondarily poisoned after consuming hunter-shot, crippled waterfowl or game.

Once the highly toxic lead is ingested, it is degraded by mechanical grinding of the ventriculus (gizzard) and adsorbed from the small intestine into the blood stream where it is distributed to soft tissue, primarily the liver and kidneys, and bone. Generally, disease is manifested as a slowly progressive toxicity in Canada geese, taking 10-72 days before anemia may result from lead's inhibition of enzymes necessary for the synthesis of heme (Pain 1996). Lethargy, depression, weakness, vomiting, green fluid diarrhea, ataxia, convulsions and coma are common clinical signs. Gastrointestinal stasis often results in crop impactions with sand or plant fiber. Neurologically, birds may be unable to stand and in severe cases unable to even hold up their heads. Chronically, lead exerts a general immunosuppressive effect, predisposing birds to opportunistic pathogens. Lead toxicity can be acutely fatal when large amounts of lead are ingested before any signs of clinical disease are noted (Locke and Thomas 1996).

Lead poisoning can be diagnosed by measuring concentrations in the blood and/or liver. Blood lead levels of more than 0.5ppm are suggestive of lead toxicity when combined with clinical signs. Radiographic evidence of a radio-dense metallic object in the ventriculus is highly correlated with lead toxicity, though the lack of evidence does not entirely rule out lead poisoning or toxicity (Brown 1991). Birds and mammals demonstrating lead shot in soft tissue or skeletal muscle upon radiologic examination are not normally subject to lead poisoning.

ORPHAN URBAN WILDLIFE

Annually, wildlife rehabilitation centers across North America experience a surgence of phone calls in spring concerning what the general public calls an "orphan." The Ohio Wildlife Center routinely receives more than 4,000 phone calls monthly from individuals who have encountered an "orphaned" wild infant. From 1995 - 1998 > 6,660 orphan wild infants were brought to OWC, 37.2 % of which had been intentionally disturbed by the public. Several misconceptions about wildlife often lead to unnecessary human intervention or disturbance. For example, handling wildlife expounds upon the myth that infant animals will be immediately abandoned by their parents once touched by humans. While it is true wild infants should not be handled more than is absolutely necessary, casual handling of a baby will not result in parental abandonment. Wildlife display a high degree of fidelity to their offspring, sometimes to the extreme of aggressive defense.

Certain species, such as Eastern cottontail rabbits and white-tailed deer (*Odocoileus virginianus*), have a different strategy of distant parental attention. This method keeps adults distant so as not to attract attention to the concealed rabbit nest, or the cryptic coloration of a young fawn during daylight hours. Often the public views infrequent nest visitation of Eastern cottontails as nest abandonment or neglect when the nest, in fact, is being properly attended by the mother. If nests in groomed yards are uncovered by mowing or other activities, the majority of infants can be successfully re-nested by placement in the same area, covering the nest with natural vegetation, and keeping domestic pets restrained.

Secondly, there is the misconception that human rearing of wild infants is an acceptable alternative to each species raising its own offspring. Humans make very inadequate surrogate parents for wild infants in spite of their ability to properly nourish them. There is far more parental investment in young than merely feeding. Species recognition, sibling interaction and rivalry, and learning wild food sources are only a few of the critical skills necessary for successful survival. Artificial hand rearing should only be attempted when every possible attempt to return the wild infant to its proper parents has been exhausted.

In the process of hand rearing, wild infants often become habituated to the presence of humans and domestic pets. These young lose their natural protective survival skills, one of which is aversive fear of humans. Birds are known to experience a process termed imprinting, where during a specific critical time period they fix their species recognition and future social and courtship behaviors on the largest object in their immediate area. The critical

period is a short, precise period of time characteristic for each species. Hand raised birds in their first 10 days of life must be provided a conspecific adult to recognize or they will become behavioral cripples (Beaver 1984). If humans improperly hand rear nestling predatory birds, these human imprinted fledglings can become a threat to human safety. Additionally, male white-tailed deer raised in the presence of humans have been known to seek human sparring partners during the fall rutting season, leading to human fatalities.

Thirdly, the wildlife "rescuer" mistakenly perceives the "cute little fuzzy animal" as an acceptable long-term pet. It should be noted that all native wildlife in the United States is protected either by state or federal laws, and it is therefore illegal to take, possess or transport them. Native mammals are protected by state divisions of wildlife or conservation departments. Birds are protected by federal law under the Federal Migratory Bird Treaty Act of 1918. All endangered species are afforded protection by the Endangered Species Act of 1973.

CAT PREDATION

A consistent cause of admission to rehabilitation centers across the United States is domestic animal predation. Each year rehabilitators report cat predation as the most common reason for animal admission, accounting for almost 20% of cases (Frink et al. 1994). The American Veterinary Medical Association in 1996 estimated approximately 59.1 million people owned cats in the United States excluding stray or feral cats. From studies performed by the American Bird Conservancy, only 35% of cat owners keep their cats indoors exclusively, leaving nearly 38.4 million owned cats (excluding stray or feral cats) free to prey on native wildlife. In a now classic study of urban cats in England, Churcher and Lawton (1987) studied the prey of 77 pet cats. Extrapolating from this study, they estimate that 5 million pet cats in England are responsible for killing 70 million native wild animals each year. Sixty-four percent of 1,100 prey items gathered from 77 cats consisted of mammals, the majority of which were mice, voles, and shrews. The remaining prey included birds, most commonly house sparrows, song thrushes (*Turdus philomelus*), blackbirds (*Turdus merula*) and European robins (*Erithacus rebecula*). In Wisconsin, a 4-year study calculated free roaming rural cats killed 19 million birds annually (Coleman and Temple 1995). In the continental United States, cats are thought to kill 100 million birds annually (American Bird Conservancy 1997).

In urban environments, loss and fragmentation of wildlife habitat resulting from development and road construction have forced native wildlife into habitat islands, and has effectively provided cats with more convenient access to wildlife. Cats also have a dependable food source, which gives them an advantage over native predators. Consequently, local populations of cats can exist at far greater densities than natural predators. Cats also have superior reproductive ability, having up to 3 litters per year yielding 4-6 kittens per litter.

Recently animal protection groups have advocated a trap-test-vaccinate-alter-and-release (TTVAR) program as an alternative to euthanasia for controlling feral cat colonies. Cats are trapped and given a thorough health examination. When deemed healthy, they are vaccinated, surgically sterilized and released. Most of these colonies have humans who regularly provide food (Patronek 1998). This has allowed feral cat populations to exist at levels above normal, placing a greater pressure on resident native species. In formal written statements, the Association of Wildlife Veterinarians and the National Association of State Public Health Veterinarians have publicly opposed TTVAR programs.

The American Bird Conservancy in cooperation with the Humane Society of the United States, and the American Humane Association are sponsoring a campaign called "Cats Indoors! The Campaign for Safer Birds and Cats." Their efforts are to educate the general public about the problem of cat predation on native wildlife, and the quality of life of cats left outside to roam. They have published a variety of resource publications, bibliographies, and informational leaflets to help dispel misconceptions people have about cats and wildlife. The American Bird Conservancy through extensive telephone interviews, has studied attitudes concerning cats and wildlife with an increasingly greater concern for wild animals being noted. This offers hope for the future management of cats whose owners plan to keep their next feline pet, exclusively indoors.

STRUCTURES AND URBAN WILDLIFE

Avian Collision Injuries

Towers. Significant morbidity and mortality has been attributed to collisions of nocturnal migratory birds with tall communications towers. Television, radio, microwave and cell phone towers; ceilometers, nuclear cooling towers, utility wires and high rise buildings have been documented with levels of collision mortality on a regular basis. Tall towers have proportionally greater mortality associated with them. Currently an estimated 75,000 towers above 70 m in height in the United States are regis-

tered with the Federal Aviation Administration. Since 1990 and the advent of the cell phone, there are an estimated 5,000 new towers annually. Although there is a high number of isolated incidence reports, there are few long-term studies. The Tall Timbers Research Station in Leon County, Northern Florida, monitored a 307.8 m television tower from 1955-1980 and documented 43,386 avian mortalities comprising 190 species (Crawford 1981). A study from 1957-1994 in Eau Claire, Wisconsin, identified 121,560 avian mortalities comprising 112 species during spring and fall migratory seasons (Kemper 1996).

Two separate mechanisms have been identified as causing bird mortalities at towers. One condition involves birds flying in poor visibility weather conditions and not recognizing the tower before colliding with it (Avery et al. 1976). Rapid-flighted birds such as the Anseriformes and Charadiiformes are two groups susceptible to blind collisions at non-lighted towers in daylight or nocturnal hours, usually with prevalent fog or inclement conditions. A second mechanism of avian mortality at towers involves tall-lighted structures, low cloud ceiling or foggy conditions and light refracting off water particles producing a lighted area around the tower (Avery et al. 1976). Nocturnal songbird migrants use both celestial orientation and landmass cues for directed migration. When cloud cover blocks celestial orientation, birds are forced to fly at lower altitudes (Avery, Springer and Cassel 1976). At lower altitudes, birds lose broad landscape cues. When flying within range of a tower and seeing light emanating from around the tower, they are attracted to the light and become disoriented, completely losing their directional movement (Cochran and Graber 1958). Birds then stay in the lighted area and fly in roughly a circular pattern around and through the tower structure colliding with the tower, guy wires, or even each other (Graber 1968, Verheijen 1981, Larkin and Frase 1988). This is thought to be the predominate method of avian tower collision mortality. These same positive phototactic mechanisms may be responsible for the toll on nocturnal migrants colliding with high rise glass buildings in large metropolitan areas.

Glass Buildings. Glass and glass exterior buildings have also been documented as sources of avian mortality in North America. Studies suggest birds do not appear to recognize glass panels as lethal obstacles and consequently strike windows head first. More than 225 species are recorded in the literature as having become causalities of window strikes (Klem 1991). Unlike tower strikes, there seems to be no season, time or weather condition affecting glass strikes (Klem 1990b). Strikes can occur at any window but large window panes >2 m^2 in area near ground level or those above 3 m pose the greatest threat (Klem 1991). Whenever birds congregate near glass, window strikes increase, e.g. bird feeders and other attractants placed in front of windows for viewing purposes increase the likelihood of window strikes. Approximately 17% of window strikes from feeders are caused by panic flights (Dunn 1993). An acceptable proposed alternative is to place feeders within 0.3 m of the glass, thus limiting momentum of the strike and consequently mortality (Klem 1991).

An extensive study of window strikes identified approximately a 50% mortality rate. Those recovering may do so almost immediately, appearing only mildly stunned. Others may take minutes to hours before recovering and flying off. Birds which die, often demonstrate intracranial hemorrhage. Ruptured cranial vessels and progressive bleeding increases intracranial pressure on the brain resulting in death. Beaks and mandibular fractures suggest birds strike the windows first with their heads (Klem 1990a).

Window collision mortality is widespread across North America. It is likely to increase as development progresses into unobstructed wildlife habitat. Estimates of bird loss range from 3.5 million (Banks 1979) to 97-976 million (Klem 1990b). Questionnaires sent out by the Cornell Laboratory of Ornithology to participants in Project Feederwatch suggest avian mortality ranging from 0.65 -7.7 birds per dwelling annually (Dunn 1993); this data corresponds to the 97 million losses suggested by Klem (1990b). Therefore, window strikes and glass become substantial mortality factors and may represent a serious threat especially to threatened and endangered birds.

Abuse, Entrapments and Entanglements

Abuse. Humans directly impact wildlife through ignorance, disregard, or even hatred. This type of human impact is due to the general ignorance of urban wildlife needs, natural history and biology; some regard even the presence of a wild animal in their yard as a threat and have an irrational fear resulting from this narrow perspective. The public often takes matters into their own hands, and use commercial traps to trap urban backyard animals and then translocate them to more rural areas. Ohio rabies laws require a trapped raccoon, skunk (*Mephitis mephitis*) or opossum either to be held for 65 days or euthanized.

Aside from nuisance complaints, individuals also persecute and harm urban wildlife as a result of intentional abuse or unethical treatment. Ducks and geese have presented to OWC with gunshot wounds and arrows imbedded in their bodies. In one case, gray squirrels were found dead in a backyard of a wildlife advocate who fed neighboring wildlife.

Upon admission, 3 of these 7 squirrels were radiographed, each having multiple pellets in the head and neck regions. A neighbor admitted to shooting and killing these gray squirrels because they were a nuisance. On several occasions, backyard wildlife have also been intentionally poisoned. Five gray squirrels bled to death around a feeder after consuming rat poisoning. Allegedly, a neighbor did not share the same affection for squirrels as the resident who pursued the cause of deaths. Purposeful poisoning with the pesticide, diazinon, is often difficult to prove, but was investigated and documented in New Jersey (Monson and Stone 1976).

Entrapments. Wildlife can become entrapped in various structures such as entrances to residential buildings via structural deficiencies in the attic, basement or screened porches. For example, screech owls and European starlings (*Sturnus vulgaris*) are known to have either entered the chimney of homes or become intoxicated from the fumes emitted from the flues and fallen into the chimney needing assistance to be freed. It is common to observe entrapments of wild birds in warehouses and garden stores where large doors are left open during daylight hours. The flight abilities of the individuals make capture and release difficult. In these cases, mist nets can be used to capture building entrapped or injured birds. Wildlife also can become entrapped in liquid tars, oils, sticky flypaper and rodent traps. These heavy adhesive materials stick to hair and feathers tenaciously, eliciting severe stress responses, and compromising the animal's ability to thermoregulate.

Urban nesting mallard ducks attract public attention as they hatch and the female tries to lead the ducklings to water. Human intervention of chasing mallards to offer help often results in ducklings hopping down storm drains. Sometimes ducklings even get entrapped in half empty swimming pools, and the ducklings are unable to negotiate the slick, perpendicular pool walls. Trying to rescue them, especially in cold weather, can lead to highly stressed, water- logged ducklings needing aggressive supportive medical therapy and hand rearing.

Fences can also cause wildlife species distress and compromise. By constructing fences at property lines, movement along urban wildlife corridors is impeded, thus making them more vulnerable to urban predators. Aside from acting as a barrier effect, fences can also cause physical harm to wildlife. In panic retreats, Eastern cottontail rabbits can become entrapped in fences, and owls have even been known to fly into fences producing head injury, fractures, or degloving injuries.

Entanglements. Bird morbidity and mortality can also be attributed to inanimate objects, such as litter discarded by humans. Monofilament fishing line is particularly treacherous and recognized as a common problem in aquatic species such as ducks and geese, but line can also be a problem for passerine species such as American robins and Eastern bluebirds (*Sialia sialis*). The thin transparent line gets entangled around the distal legs and feet where it tightens with time in response to swelling. Vascular entanglement leads to necrosis of the distal limb and eventual amputation. Canada geese, however, have demonstrated a remarkable degree of resistance to distal limb necrosis, even with line embedded in the bone. Occasionally, line caught on a bird's body will become wrapped around a stationary object, such as a branch, thus leaving the bird to a hanging death. Two sport fishing-related wildlife hazards are fishing hooks and artificial baits. These littered objects often get affixed to the mouth or beak of aquatic species leading to compromised foraging ability and often death. Improper disposal of plastic packaging material can also be an environmental hazard for wildlife. For example, plastic tree netting has entangled black rat snakes and has become embedded through the scales into muscle during their struggle to free themselves.

HIGHWAY AND ROAD EFFECTS ON WILDLIFE

In urban and suburban areas, housing, commercial and other intensely compacted land usage has lead to an extensive network of roads, which ultimately have a dramatic impact on wildlife. It is estimated in the United States that 1.5 million animals are killed each day on roadways (Gregory 1975). Aside from direct mortality, roads directly remove critical habitat and have been estimated to cover approximately 2% of the existing area of the lower 48 states in the U.S. (Forman and Hersperger 1996). Especially in urban and dense population areas, roads occupy a significant percentage of total available habitats. Roads also dissect more natural habitat and signify habitat loss in the process of urban sprawl. By dissecting habitat, roads limit animal movement by serving as a barrier (Forman and Hersperger 1996). Conspicuous presence of road kills and causalities along roads is a testimony of this issue. A less easily observable effect of roads on wildlife is an avoidance factor. For some sensitive species, specific distance must be established from a roadway. This phenomena can result in isolated subpopulations which are more vulnerable to local population genetics and other fluctuations that may cause local extinction (Forman and Hersperger 1996).

Wildlife losses on highways are known to be related to both the conditions and location of the road, and the biology and ecology of local wildlife. The type and density of the habitat cover adjoining the road has a directly proportional effect on the rate of wildlife loss. In most studies of rights-of-way (ROWs), the most numerous vertebrate species present were also the most likely to be road-killed (Oxley and Fenton 1976). Highway losses are also directly related to the habits and movements of the particular species (McClure 1951). For example, when wildlife selectively use the roads or adjacent ROWs for foraging, acquisition of salt or grit by birds, thermoregulation of reptiles and amphibians, or as migration corridors, they are more likely to experience loss (Oxley and Fenton 1976). Vehicular speed is another variable directly proportional to wildlife loss where animals are more sensitive to strikes at higher speeds (Hodson 1962). There is also an age composition factor relating to young inexperienced wildlife being more susceptible to vehicular strikes than adults (McClure 1951). July represents the peak month in the United States during which the most wildlife road mortality occurs (Case 1978). This month corresponds to the time when the young wildlife of the year are starting to disperse from family groups or beginning to wander from natal nest areas.

Vehicular strikes ranks only behind orphan and cat predation as a leading cause of presentation to wildlife centers. From 1995-1998, OWC has admitted 6,179 mammals of which 8.12% were hit or traumatized on the road, and therefore assumed to be hit by cars. Eastern gray squirrel, Eastern cottontail rabbit, and Virginia opossum make up the vast majority of mammalian vehicle cases. These 3 species also rank as the most common mammals found in roadside mortality studies throughout the Eastern United States (Evenden 1971, MacNamara 1962). Urban waterfowl species were proportionally reported struck by cars more frequently than smaller passerine species, with approximately 22% of mallard ducks and 21% Canada geese hit. Mourning doves and American robins are smaller avian species most commonly hit by vehicles. Of all groups presented for being victims of vehicular strikes, predatory birds admitted to OWC were proportionally struck by vehicles more frequently: both the American kestrel (*Falco sparverius*) and Eastern screech owl have greater than 50% chance of being presented for an automobile strike. In Pennsylvania, the cause of death of 82 of 113 (72.6%) screech owls was identified as automobile-related (Sutton 1927). Sixty-two percent of American kestrels presented to OWC from 1995-1998 were similar strikes. This extremely high rate of strikes could possible relate to their dependence on highway corridors as hunting areas often using roadside utility poles and wires as stationary perches.

CONCLUSION

Uncontrollable human population growth, cities, roads and urban sprawl are rapidly replacing natural habitat, local vegetation, and native wildlife. Wildlife species must adapt to change if their populations are to remain viable. Gray squirrels and raccoons are successfully coexisting in urban and suburban environments and continue to prosper from human food sources. Similarly, many avian species now benefit from backyard feeding stations and increased public interest in wildlife-based outdoor recreation and conservation.

Although public interest in wildlife issues appears to be increasing, wildlife species and habitats are threatened now more than ever before. Despite sympathy and concern, humans continue to present challenges and stresses to wildlife through competition for resources.

Wildlife rehabilitation, addressing morbidity and mortality of urban wildlife, is being recognized as a mitigative approach to easing human influence and impact. Rehabilitators, such as those at OWC and other facilities throughout the United States, strive to educate the public on the value of native wildlife species and promote an understanding of coexistence. Additionally, rehabilitators are in a sentinel position to recognize environmental hazards. By accepting native wildlife cases and definitively diagnosing their maladies, rehabilitators can alert the public and governmental agencies on the environmental issues facing urban wildlife. Until society acknowledges and respects wildlife, rehabilitators must continue to raise awareness of the plight of wildlife and urban environments.

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