

IMPACTS OF FREE-RANGING DOMESTIC CATS (*FELIS CATUS*) ON BIRDS IN THE UNITED STATES: A REVIEW OF RECENT RESEARCH WITH CONSERVATION AND MANAGEMENT RECOMMENDATIONS

NICO DAUPHINÉ¹ AND ROBERT J. COOPER

Warnell School of Forestry and Natural Resources, University of Georgia, Athens, Georgia 30602, USA

Abstract. American birds face an estimated 117 to 157 million exotic predators in the form of free-ranging domestic cats (*Felis catus*), which are estimated to kill at least one billion birds every year in the United States. Cats have contributed to declines and extinctions of birds worldwide and are one of the most important drivers of global bird extinctions. In this paper, we review recent scientific research on the impacts of free-ranging cats on birds, with an emphasis on threats to migratory landbirds in the United States. Studies have shown that cats pose threats to many bird populations, including priority species for conservation, through their predation of adult, nestling, and juvenile birds. Cats also have impacts on birds through competition with native predators such as raptors, and through the harboring and transmission of zoonotic and other diseases to birds and other wildlife. In addition to direct mortality, cats may also cause stress responses in birds due to predation risk that may result in bird population declines. A substantial increase in public outreach is urgently needed to educate citizens about the conservation and welfare problems caused and faced by outdoor cats. Effective cat and wildlife management in this context will also require strengthening and enforcing policies and laws that control outdoor cats, many of which are already in place.

Key Words: anthropogenic mortality, birds, *Felis catus*, feral cats, invasive species, predation, trap-neuter-release.

IMPACTOS DE LOS GATOS DOMÉSTICOS SUR LAS AVES EN LOS ESTADOS UNIDOS

Resumen. Las aves Americanas enfrentan un estimado de 117 a 157 millones de depredadores exóticos en la forma de gatos domésticos (*Felis catus*) en condición de libertad, los cuales probablemente matan anualmente al menos, mil millones de aves cada año en Estados Unidos. Los gatos han contribuido a la declinación y extinción de las aves a nivel mundial, y pueden ser la mayor causa de la extinción global de las aves luego de la destrucción de hábitat. En este artículo, yo reviso la reciente investigación científica sobre el impacto que los gatos en condición de libertad causan a las poblaciones de aves en los Estados Unidos, con énfasis en su amenaza a las aves migratorias. Estudios han demostrado que los gatos constituyen una amenaza importante para muchas poblaciones de aves, incluyendo aquellas especies cuya conservación es prioritaria, a través de la depredación de adultos, las nidadas y los juveniles, compitiendo también con depredadores nativos, tales como las aves de presa. En adicción a la mortalidad directa causada, los gatos causan reducciones en la fecundidad y supervivencia en las aves expuestas al riesgo de depredación, las mismas que potencialmente y substancialmente dañan y reducen las poblaciones. Acciones efectivas para la conservación de las aves requerirá del fortalecimiento y aplicación de leyes que prohíben los gatos en condición de libertad, muchas de las cuales ya han sido promulgadas, así como también una mejora sustancial en la educación y que este esfuerzo por enfrentar los problemas que son causados por los gatos llegue al público en general, y producir métodos para controlar las poblaciones y movimientos de los gatos en condición de libertad.

INTRODUCTION

Many North American bird species have been declining during the past several decades, some of them precipitously (Terborgh 1989,

Stutchbury 2007). Habitat loss is considered to be a primary cause of many of these declines, and other major anthropogenic causes of bird mortality include collisions with human-made structures (such as buildings and windows,

¹Present address: Zoological Society of London, Regent's Park, London NW1 4RY, United Kingdom.
E-mail: nico.dauphine@zsl.org

power lines, and vehicles), predation by domestic cats (*Felis catus*), and pesticides (Erickson et al. 2005). While scientific estimates vary widely depending on the methods of calculation used, even the most conservative estimates place domestic cat predation among the most important anthropogenic causes of bird mortality in the United States (Gill 1995, Erickson et al. 2005).

The number of domestic cats in the United States has tripled during the last 40 years (Lepczyk 2008). The continued conversion of natural areas to development means that the importance of human-dominated landscapes as wildlife habitat is increasing; this, combined with the large and growing number of cats raises concerns about interactions of domestic cats and wildlife in urban, rural, and suburban areas (Calver et al. 2007). Due to a combination of their opportunistic predatory behavior and their occurrence in numbers exponentially higher than native predators, cats can wipe out bird populations from otherwise suitable habitat (Crooks and Soulé 1999, Nogales et al. 2004, Balogh and Marra 2008); in such contexts, cat predation may supersede habitat loss as a primary threat to birds' survival.

Unfortunately, many members of the American public remain unaware of the serious conservation and welfare implications of letting pet cats roam and of feeding stray and feral cats. The goal of this paper is therefore to provide a brief review of our current state of knowledge of the cumulative effects, including population level effects, of outdoor domestic cats in the United States, based on the best available science. In addition, we review and provide management recommendations based on this information for use by policymakers, landowners, land managers, animal conservation and welfare advocates, and private citizens.

PEOPLE AND CATS: A BRIEF HISTORY FOCUSED ON THE UNITED STATES

Domestic cats have been associated with humans for thousands of years and have accompanied humans to nearly every part of the world (Brickner 2003). All domestic cats carry genetic signatures matching wild cats (*Felis sylvestris*) from the Middle East, but are now considered a separate species; they appear to have been domesticated on several occasions 8000-10,000 years ago with the beginning of agricultural settlement in the region (O'Brien and Johnson 2007). They were introduced throughout Europe during the Roman Empire, and more recently introduced around the world by European colonists (Dickman 1996, Coleman et al. 1997).

Approximately 600 million domestic cats exist in the world today, one of the only feline species not considered threatened or endangered by conservation organizations (O'Brien and Johnson 2007). Because they form a domestic species distinct from their wild ancestral species, domestic cats are considered to be an exotic, or non-native, species in all environments in which they occur. Because of their ability to overwhelm existing native species and natural ecosystem processes in environments in which they have been introduced, domestic cats are moreover classified as invasive species. Invasive species, particularly predators, together with habitat destruction, have been a major cause of declines and extinctions of native species throughout the world for the past few centuries (Clavero and García-Berthou 2005). An analysis of the International Union for the Conservation of Nature (IUCN) database has shown that predation alone and in concert with other contributing factors is responsible for more than 80% of all documented vertebrate extinctions (Sax and Gaines 2008). Due largely to impacts resulting from its predation on other species, the domestic cat is listed by the IUCN as one of the "100 of the world's worst invasive alien species" (ISSG 2008). It should be emphasized that the invasive species label applies exclusively to outdoor cats, rather than pet cats kept indoors or otherwise kept under control by their owners.

The United States hosts between a quarter and a third of the global domestic cat population and by far the largest number of cats of any single nation, with an estimated total 148-188 million domestic cats. An estimated 88 million of these are pet cats (APPA 2008), of which approximately 65%, or 57 million, are free-ranging outdoor cats for at least some portion of the day (Winter 2004). In addition to this, there are an estimated 60-100 million stray and feral (unsocialized) cats (Jessup 2004), nearly all of which range freely outdoors. There is therefore an estimated total of 117-157 million free-ranging cats in the United States.

GLOBAL IMPACTS OF CAT PREDATION ON BIRD POPULATIONS

Studies from around the world show that domestic cats kill large numbers of wildlife, including a wide range of bird species (Dickman 1996, Lepczyk et al. 2004, Calver et al. 2007; Fig. 1). In a global review of IUCN-listed Critically Endangered bird species, Butchart et al. (2006) found that exotic predators, especially feral cats and rats, were among the most important threats to these species and, likewise, that invasive predator control



FIGURE 1. Cat-killed Eastern Towhee (*Pipilo erythrophthalmus*), a PIF-designated species of regional conservation concern, Athens, GA, January 2008.

was an important management action taken to prevent many extinctions. Historically, cats have been specifically implicated in at least 33 bird extinctions, making them one of the most important causes of bird extinctions worldwide (Nogales et al. 2004).

Oceanic islands have provided the most obvious showcase for the negative ecological impacts of cats (Nogales et al. 2004). Global extinctions caused in whole or in part by cats include those of the Stephen's Island Wren (*Xenicus lyalli*) in New Zealand and the Guadalupe Storm Petrel (*Oceanodroma macrodactyla*) and the Socorro Island Dove (*Zenaida graysoni*) in Mexico (Nogales et al. 2004). The case of the Stephen's Island Wren is notable in that this species was never observed alive in the wild with certainty before its extinction, and that most or all of the museum specimens were collected by a single cat (Dickman 1996, Fuller 2001). Cats have also caused a number of regional extinctions, reducing the ranges and associated genetic variation of bird species. Extirpations caused partly or wholly by cats include those of Cassin's Auklet (*Ptychoramphus aleuticus*) from the Coronado Islands, Mexico, and the Common Diving Petrel (*Pelecanoides urinatrix*) from Marion Island, South Africa (Nogales et al. 2004). Finally, cats have caused substantial declines in bird populations, including the Sooty Tern (*Sterna fuscata*) on Ascension Island (UK), and the Black-vented Shearwater (*Puffinus opisthomelas*) and Socorro Mockingbird (*Mimodes graysoni*) on Socorro Island, Mexico, the latter of which is currently listed as Critically Endangered by the IUCN (Nogales et al. 2004).

Courchamp et al. (1999) modeled interactions of invasive mammals (feral cats and rabbits) and native birds on islands. They found that the presence of exotic prey (rabbits) served to maintain extremely high populations of cats while breeding birds were absent. This superabundance of cats then decimated native seabird colonies during their annual breeding season, a phenomenon the authors termed *hyperpredation*. The human provisioning of food to cats can likewise enable hyperpredation, where cats continue to kill prey even when populations of that species are low, enabling them to eradicate prey species (Woods et al. 2003).

The frequent extinctions of island birds due to cat predation highlight the increasing vulnerability of birds confined to "islands" of fragmented habitat, especially when such habitat may be surrounded by housing developments featuring multiple anthropogenic threats. Both oceanic islands and habitat fragments in urban and suburban areas are surrounded by an inhospitable matrix, but in urban and suburban areas this matrix may moreover act as a source of subsidized exotic predators in the form of cats (Walter 2004, Longcore et al. 2009). While continental avifaunas, unlike many of their insular counterparts, have evolved alongside native predators, the continuous predation pressure exerted by exotic predators in exponentially high densities can and has resulted in numerous local extinctions of continental land birds (Crooks and Soulé 1999, Hawkins et al. 2004, Winter 2004).

CASE STUDIES OF CAT PREDATION ON BIRDS IN THE UNITED STATES

While populations of wild predators are controlled by prey availability, predation, competition, and disease, free-ranging cat populations are bolstered by human-provided supplemental food and protected by the human removal of higher predators in the environments in which they live and by vaccinations from several diseases. A number of peer-reviewed quantitative studies of the impacts of free-ranging cat predation on native birds in the United States suggest that cat predation on birds may be unsustainable, drives ecological sinks, and may cause local extinctions. Studies include analyses of the impacts of free-ranging pet cats as well as stray and feral cats fed by people on public land, using methods including radio telemetry, surveys of cats' prey returns to owners, fecal and stomach content analyses, and point and transect surveys of birds and mammals.

Crooks and Soulé (1999) conducted research on the relationships between apex predators, mid-sized predators, or mesopredators, and native breeding birds in a landscape fragmented by development in coastal southern California. They termed the population explosions of smaller predators, including cats, in response to the removal of higher predators (in this case, coyotes), *mesopredator release*. They found that a typical 20 hectare forest fragment contained 35 hunting pet cats, compared with one or two pairs of similar-sized native predators. These cats collectively killed at least 525 birds per year in a system where the population sizes of some birds did not exceed 10 individuals. Coyote presence had a negative effect on domestic cat abundance, and a correspondingly positive effect on bird diversity. The authors concluded that the level of cat predation on birds appeared to be unsustainable, and reported at least 75 local bird extinctions in these fragments over the past century.

Recent research by Balogh and Marra (2008) on the Gray Catbird (*Dumetella carolinensis*) in the suburban greater Washington DC metropolitan area found that predation caused 79% of catbird nestling and post-fledging mortality and that cats were the main fledgling predator. Cats turned areas calculated to be sources using the typical estimate of the total number of young fledged from the nest into sinks when also accounting for the survival of fledglings into overall estimates of recruitment. Their findings suggest that suburban areas may act as ecological sinks for breeding birds because they provide habitat cues that stimulate settlement and breeding in areas with negative population

growth, which appears to be driven largely by domestic cats.

Hawkins et al. (2004) conducted a study of native birds and small mammals in a public park on California's central coast, comparing one area where outdoor cats were being fed by people with a similar area where no cats were detected. They found nearly double the number of birds in the no-cat area compared with the cat-feeding area, and that two native bird species, California Quail (*Callipepla californica*) and California Thrasher (*Toxostoma redivivum*) were entirely absent in the cat-feeding area. In addition, the number of exotic rodents was nine times higher in the cat-feeding area. The authors suggest that cat predation pressure may be greater on native than exotic rodents and that providing food for free-ranging cats may facilitate the spread of exotic rodents into new areas. Finally, the authors suggest that cats in such systems act as keystone modifiers, causing substantial long-term changes in the structure and composition of the biota of the environment in which they occur.

In Hawaii, Smith et al. (2002) compared Wedge-tailed Shearwater (*Puffinus pacificus*) breeding colonies located where predators were absent with those located near areas where outdoor cats were being fed by people on public land. They found that predation had a devastating impact on shearwaters, and that cats attracted to supplemental food were likely the primary predators. The closer the birds were to the cat feeding area, the more likely they were to be killed. The shearwater colony located closest to the cat feeding area exhibited total reproductive failure, and almost all the adult shearwaters at this site were apparently killed by cats. They concluded that bird breeding colonies near cat feeding areas were ecological sinks.

CUMULATIVE IMPACTS OF CATS ON MIGRATORY LANDBIRDS IN THE UNITED STATES

The most commonly quoted estimate of cat-caused bird mortality in the United States in recent years has been "hundreds of millions of birds," as cited in position statements on the management of free-ranging cats by many national professional scientific and conservation organizations. Traditionally, published estimates of bird mortality due to cats in the United States have only accounted for minimum bird mortality caused by pet cats, rather than all cats, including stray and feral cats (Fig. 2). However, if we accept the range estimated above of 117-157 million outdoor cats in the United States, then each of these cats killing a



FIGURE 2. Feral cat at an illegal cat colony in McAllen, TX, February 2008.

single bird per year would result in “hundreds of millions” of cat-killed birds, whereas we know from published studies that the average minimum number of birds per year killed by many cats may exceed fifty times this number.

A number of peer-reviewed publications on cat predation of birds and other animals report information provided by cat owners on cats’ prey returns. These demonstrate various minimum averages of pet cat predation rates on birds in the United States, including kill rates of 4, 15, 52, and 54 birds per year, depending on location and degree of urbanization (Mitchell and Beck 1992, Crooks and Soulé 1999, Fiore and Sullivan 2002, Lepczyk et al. 2004). While such studies provide direct physical evidence of mortality caused by cats, they invariably underestimate the actual mortality caused by cats, because cats frequently either discard or consume prey rather than present it to their owners. In Illinois, George (1974) found that only about half of animals killed by cats were provided to their owners, and in upstate New York, Kays and DeWan (2004) found that observed cat predation rates were 3.3 times higher than predation rates measured through prey returns to owners. Thus, predation rates measured through prey returns may represent one half to less than one third of what pet cats actually kill, and some cats do not return any prey to their owners (Fiore and Sullivan 2000).

Given the large numbers of cats and considering the numbers of avian prey returned to owners, a minimum of one billion birds killed

by cats annually in the United States is a conservative estimate, and the actual number is probably much higher. Stallcup (1991) and Gill (1995) estimated bird mortality caused by pet cats alone at over one billion birds per year. While reaching consensus on a precise estimate of the number of birds killed annually by cats presents a noteworthy challenge, as noted in The Wildlife Society’s position statement on feral and free-ranging cats (TWS 2006): “Extensive popular debate over exact numbers or types of prey taken is not productive. The number of cats is undeniably large. Even if conservative estimates of prey taken are considered, the number of prey animals killed is immense.”

Debate about exact numbers or types of prey taken by cats generally centers around the question of whether cat predation has demonstrable population level impacts with respect to other sources of mortality. Species that are range-restricted or endangered are more likely to show population level impacts than are other species. However, populations of many more common species may also be negatively affected by free-ranging cats, and many birds previously considered to be common are declining at alarming rates (NAS 2007). In addition, while biologists often study populations, the value of birds and other wildlife is not restricted to population level phenomena. As Longcore et al. (2009), pointed out: “it is philosophically inappropriate for population level impacts to be the only criteria by which the effects of cats are judged... We

see no justification for valuing birds and other wildlife only as populations, while valuing cats as individuals."

DISTINCTIONS BETWEEN CATS AND NATIVE PREDATORS

Predators in nature tend to be rare with respect to prey populations. Wild predators are dependent on their prey, and will naturally decline with a declining prey base. Cat predation of birds is unlike that by any native predator, perhaps most importantly because outdoor cats are maintained in numbers far above natural carrying capacity. There are also a number of other important ways in which cats are distinct from native predators that may compound their negative effects on bird and other wildlife populations (Coleman et al. 1997, Brickner 2003).

Where humans have reduced or eliminated populations of top-level predators such as wolves (*Canis lupus*, *Canis rufus*) and coyotes (*Canis latrans*), in many parts of the United States, the survival and movements of free-ranging cats and other mesopredators are not kept in check by the predation they would be exposed to in a wild ecosystem (Crooks and Soulé 1999). Unlike native mesopredators such as raccoons (*Procyon lotor*) and skunks (*Mephitis mephitis*, *Spilogale* sp.), domestic cats are opportunistic predators and cats typically kill prey regardless of whether or not they will consume it. Experimental evidence has shown a lack of connection between hunger and hunting in cats (Adamec 1976), such that well-fed cats may be no less likely to kill. While native mesopredators are predominantly nocturnal, cats may be active during the day as well as at night, such that small wildlife may be exposed to cat predation. Domestic cats are also less motivated than wild predators to hide from people, such that they may hunt in the open in human-dominated environments. Finally, while native mesopredators may depredate eggs or nestlings of birds, no native mammalian predator typically stalks and kills adult birds, as cats do.

In addition to having direct impacts on prey, cats compete with avian predators, such as American Kestrels (*Falco sparverius*), Northern Harriers (*Circus cyaneus*), and Red-tailed Hawks (*Buteo jamaicensis*) (George 1974, Mosher 1989, Lepczyk et al. 2004). George (1974) estimated that cats killed 5.5 million rodents and other vertebrates in a 26 000 square mile area in Illinois, effectively depleting the prey base for wintering raptors and other native predators. In a study

in Maryland of Cooper's Hawks (*Accipiter cooperii*) that depended heavily on eastern chipmunks (*Tamias striatus*) to feed nestlings, Mosher (1989) found that these raptors altered their diet to prey more on songbirds in an area where chipmunks were eradicated by cats. The resulting increase in hunting time and difficulty for Cooper's Hawks was associated with a decrease in nestling survival.

While vaccinations may protect them from several diseases, domestic cats act as reservoirs and vectors for many diseases and parasites that jeopardize wildlife, including federally endangered and threatened birds and mammals (Work et al. 2000, Danner et al. 2007, Miller et al. 2007). Examples include the infection of the American mountain lion (*Puma concolor*) with feline leukemia (Jessup et al. 1993, Brickner 2003) and the infection of the federally endangered Florida panther (*Puma concolor coryi*) with feline panleukopenia, or feline parvovirus, an immune deficiency disease (Roelke et al. 1993, Brickner 2003).

Cats play an integral role in the life cycle of the parasite *Toxoplasmosis gondii* that has caused fatal infections of the federally endangered Hawaiian Crow (*Corvus hawaiiensis*) (now likely extinct in the wild) and federally threatened Southern sea otter (*Enhydra lutris*) (Work et al. 2000, Miller et al. 2007). *T. gondii* is known to have infected more than 50 bird species worldwide and at least a dozen in the United States, including American Kestrel (*Falco sparverius*), Red-shouldered Hawk (*Buteo jamaicensis*), Great Horned Owl (*Bubo virginianus*), Nene (*Branta sandvicensis*), and Red-bellied Woodpecker (*Melanerpes carolinus*) (Dubey 2002, Work et al. 2002, Gerhold and Yabsley 2007). A zoonotic parasite spread through cat feces that also infects humans, *T. gondii*'s symptoms include confusion, poor coordination, seizures, and eye infections that can lead to blindness; infection by the parasite can cause brain damage and death.

Finally, predators affect prey populations not only by killing individual prey but by altering prey behaviors, including foraging and breeding patterns and habitat use. Using a model combining cat predation on birds with the sub-lethal effect of stress caused by cat density on bird fecundity, Beckerman et al. (2007) showed that these sub-lethal effects of cats may be substantial for urban songbirds, potentially leading to population-level declines. The authors suggest that cat densities per se, which may be extremely high in urban areas, may detrimentally affect avian productivity to the extent that low predation rates simply reflect low numbers of remaining prey.

EFFECTIVE AND INEFFECTIVE CAT MANAGEMENT STRATEGIES FOR ANIMAL CONSERVATION AND WELFARE

The management of domestic companion animals, including cats, is typically locally regulated at the city and/or county level in the United States. Traditional animal control strategies for unclaimed companion animals typically include sheltering, adoption, rescue, and lethal control in the form of euthanasia. In general, animal control law enforcement effort has tended to be greater for dogs than for cats, in part for public health and socioeconomic reasons. Thus, while free-ranging dog populations have been effectively controlled by the enforcement of existing policies, the numbers of cats have not been effectively controlled, and large numbers of free-ranging cats now live in parks and other public and private lands in the United States. Often these cats are fed by people and/or find reliable food sources in waste disposal areas. Abundant food resources tend to increase cat survival and fecundity and reduce ranges and movement, thus increasing cat densities and carrying capacity, and associated negative impacts on local wildlife (Schmidt et al. 2007). Subsidized populations of free-roaming cats may also serve as source populations for surrounding areas (Schmidt et al. 2007).

Although much research is underway to find nonlethal animal control methods, at present such methods remain limited in their effectiveness (Warburton and Norton 2009). Nevertheless, lethal control methods are increasingly the targets of negative campaigns by many animal rights and welfare groups and special interest groups, often with disastrous results for the conservation of native wildlife (Perry and Perry 2008). In the case of free-ranging cats, a number of special interest groups and several national animal welfare groups now oppose the use of euthanasia to control their populations, and instead promote feeding and sterilization programs often branded as “trap-neuter-release” or “trap-neuter-return” (TNR).

In TNR programs, colonies of free-ranging cats are fed regularly at fixed locations (feeding stations) and are the subjects of attempts, usually by volunteers, to trap, sterilize, and re-release them. TNR advocates typically claim that traditional lethal control methods are not effective, and that TNR is “the only proven and effective method” for controlling feral cat population growth or reducing feral cat populations. However, evidence for TNR program effectiveness at reducing cat populations remains largely anecdotal (Nutter 2006) and data collected from TNR efforts typically fail to

meet standards necessary for its evaluation as a method of population control (Centonze and Levy 2002, Winter 2004). Meanwhile, a growing body of evidence suggests that TNR is not effective in reducing numbers of free-ranging cats under prevailing conditions (Barrow 2004, Longcore et al. 2009).

Andersen et al. (2004) used mathematical models to compare the effectiveness of removal versus sterilization in reducing numbers of free-roaming cats. They reported effective cat population control through removal of at least 50% of the population or annual neutering of more than 75% of the population. They noted that: “TNR programs are not likely to convert increasing cat populations into declining populations or even stable populations until the neutering rate is quite high.” Under prevailing conditions, where immigration of new cats attracted to feeding stations is frequent, such high rates of sterilization may never be attained.

In practice, TNR programs often sustain large and even increasing numbers of free-ranging cats, in part due to frequent immigration by more cats. In a study of TNR in Florida, Levy et al. (2003) found that: “free-roaming cats do not appear to have sufficient territorial activity to prevent new arrivals from permanently joining colonies.” Foley et al. (2005) assessed long-term TNR programs in California and Florida, and concluded that they did not approach the necessary sterilization levels to reduce cat populations. They concluded: “Our analysis indicated that population-level effects were minimal... [and] indicated ongoing population growth.”

In a study of TNR in North Carolina, Nutter (2006) concluded that TNR “will not lead to long-term reduction in the numbers of cats because colonies can re-establish due to immigration.” Immigration is bolstered by the increased abandonment of unwanted cats in areas where public feeding takes place (Castillo and Clarke 2003). Many cats thus remain unsterilized and feeding improves cats’ prospects for survival and breeding (Roberto 1995).

TNR advocates frequently cite various peer-reviewed scientific studies as support for TNR’s effectiveness in reducing cat populations in campaigns to convince the public and policymakers to legalize and/or fund TNR (Longcore et al. 2009). Some of these studies describe TNR programs that were not designed for the purpose of cat population reduction in the first place. For example, Zaunbrecher and Smith (1993) described a TNR program in Louisiana designed “to address the feral cat problem by stabilizing... rather than reducing the number of cats in the population.” Likewise, in a paper describing a TNR program on a university campus in Texas,

Hughes and Slater (2002) wrote: "It cannot be stated definitively that the total number of cats on campus decreased because the program was not designed to determine this."

In a study that is frequently cited to support the claim that TNR reduces populations of cats, Centonze and Levy (2002) surveyed 101 people feeding free-ranging cats in Florida, and used anecdotal recollections of cat feeders to report a total surveyed cat population of 920 "before TNR" and 678 "after TNR." However, the reported total number of cats (920) minus reported deaths (151), disappearances (149), and adoptions (238), plus births (498) and immigrations (103) equals 983 at the conclusion of the study, not 678 (Winter 2004). The authors wrote: "the fact that the numbers do not add up is attributable to fluctuations in colony members and the fact that these numbers were estimates based on the recollections of individual caretakers. These numbers should not be interpreted as precise data based on accurate record-keeping."

Quantitative evidence to date suggests that TNR generally does not reduce free-ranging cat populations in a reasonable period of time, almost never results in the elimination of feral cat colonies, generally results in perpetual colony maintenance, and may even result in increasing cat populations (Barrows 2004, Winter 2004)—one TNR program in Hawaii grew from about 100 to over 1000 cats and resulted in the temporary closure of a daycare center due to cat-related public health concerns (Jessup 2004). Natoli et al. (2006) reported mixed results of surveys of long-term TNR programs for more than 10,000 cats in Italy; in 55 colonies numbers of cats decreased, while in 48 colonies numbers of cats increased or remained stable. The authors concluded that: "all these efforts without an effective education of people to control the reproduction of house cats (as a prevention for abandonment) are a waste of money, time, and energy."

As it stands now, traditional animal control methods, including removing unclaimed, stray, and feral animals from the environment, remain the most effective way to control populations of free-ranging domestic animals, including cats. Castillo and Clarke (2003) reported that TNR "is not an effective means to control the population of unwanted cats and confirms that the establishment of cat colonies on public lands encourages illegal dumping and creates an attractive nuisance." TNR is frequently counterproductive, and the large numbers of free-ranging cats subsidized by TNR programs can alter basic ecological processes, cause declines in biodiversity, and threaten endangered, sensitive, and protected native species (Hawkins et al. 2004, Jessup 2004).

Many veterinary and animal rights and welfare professionals also object to TNR as inhumane, because it facilitates pet abandonment and exposes domestic animals to neglect, abuse, and death by trauma. Jessup (2004) wrote that TNR: "actually appears to undermine its stated goal of protecting the welfare of cats and fails to educate people as to their legal and moral responsibilities." Storts (2003) wrote: "Most TNR programs are poorly run and disorganized... It is impossible to provide ongoing maintenance and surveillance of thousands of cats, and the attempt to employ herd health management principles while enjoying the human-animal bond has proven ineffective and irresponsible." Chagrin (2008) wrote: "While the idea may sound appealing, in reality TNR programs sanction the abandonment of cats... The 'humane community' sends the public a clear message when it endorses TNR programs—that cats can survive and thrive living outdoors behind dumpsters and in barns. It's not only the wrong message—it's absolutely untrue."

Population considerations aside, TNR is moreover clearly not humane to the billions of wild animals that are annually attacked, killed, mauled, injured, and orphaned by cats. Animal intake from many wildlife rehabilitation centers shows that cat predation (including injured and orphaned animals) is the single largest reason for their admission (Jessup 2004, Sallinger 2008). Sallinger (2007) reported that cats accounted for nearly 40% of animal intake at Portland Audubon's Wildlife Care Center, "the number one cause of injury by a wide margin." Due to the trauma and infection associated with cat attacks, most cat attack victims do not survive (Fiore and Sullivan 2000, Sallinger 2007), and typically die of massive internal hemorrhaging and soft tissue damage from crushing. Animals not immediately killed by cats are "maimed, mauled, dismembered, ripped apart, and gutted while still alive" (Jessup 2004).

CONCLUSIONS AND RECOMMENDATIONS

Free-ranging domestic cats are collectively one of the largest sources of bird mortality in the United States and present a special problem to conservation and control programs because their ecological impacts are often overlooked due to their status as popular companion animals. Declining bird populations are facing burgeoning numbers of subsidized exotic predators in dwindling habitat, and conservation action is clearly warranted. The management of feral and free-ranging cats, and particularly the conflicts between stated and actual outcomes of TNR, provides an exceptional conservation challenge

with far-reaching implications for wildlife, the environment, and public health.

Due the enormous environmental impacts of feral cat management, it must be treated as an environmental as well as an animal welfare problem, and municipal decisions regarding cat management should receive formal environmental assessment (Longcore et al. 2009). Many environmentalists and biologists, however, are not aware of the extent and growth of TNR and its consequences (Longcore et al. 2009). With some notable exceptions, the attention thus far devoted to the rapidly increasing numbers of free-ranging, stray, and feral cats on American landscapes has been dominated by single species focused special interest groups that often fail to understand or appreciate the wider management implications of their actions.

Unfortunately, neither the lack of quantitative evidence that TNR significantly reduces cat populations nor the adverse animal welfare impacts has dissuaded many TNR advocates. In fact, the TNR movement is increasingly well-organized, well-funded, and politically influential. One of the largest groups advocating TNR nationally, Alley Cat Allies, took in more than \$4.5 million in 2008 and spent \$3.8 million of this on public education and outreach, in part to promote a nationwide campaign for feral cat colonies by aggressively marketing them to legislators and the public. In the words of one biologist: "This movement has a huge network. Environmentalists don't know yet what they're up against" (Roberto 1995).

Soulé (1990) noted: "Conflicts between animal rights groups and management agencies are increasing in frequency and cost – the cost is being borne by endangered species and ecosystems as well as by the public that pays for expensive rescue operations and time consuming court battles. The minimization of such conflicts will require both public education and courageous leadership." Minimizing such conflicts will also require an examination of why and how they occur, and an appreciation of the differing motivations that cause them.

There is an unfortunate discrepancy between the motivations of TNR groups to save and rescue individual animals on the one hand and the serious negative animal welfare, conservation, and environmental health impacts of maintaining large numbers of free-ranging cats on the other hand. As Hutchins (2008) wrote, this perspective "is not a good foundation for the future of life on our planet and does not recognize the interrelationships that exist among various species in functioning ecosystems."

The most important motivations of TNR participants in one study included "love of

cats," "opportunity to nurture," and "increased self-esteem" (Zasloff and Hart 1998). Because their motivations lie elsewhere, many of these people do not keep records and may not be genuinely interested in cat population control (Jessup 2004). The actual commitment of many TNR advocates to cat population control may thus range from questionable to entirely lacking. To the contrary, some leading TNR advocates seek to promote the acceptance of feral cats as "protected wildlife" (Longcore et al. 2009).

Jessup (2004) asked: "How is the person who must save 25 to 30 cats in their home different from the person who sees themselves as the savior of 25 to 30 cats in a park?" In many cases, the characteristics and behavior of people involved in TNR are suggestive of the psychiatric disorders described in problematic animal hoarding (Frost 2000). When presented with alternatives to TNR, such as enclosed sanctuaries, no-kill shelters, and traditional animal control, many such people can be "fiercely protective, retaliatory, and uncooperative" (Storts 2003), and will subject public officials and other citizens opposing TNR to harassment and threats (Barrows 2004, Hatley 2004).

In an increasingly urbanizing world, most Americans today are familiar with cats and dogs but have little knowledge of wildlife, and many people look to pets for the companionship traditionally provided by family members (Roberto 1995). Many animal rescue, welfare, and rights groups are motivated by the desire to reduce the tragically high numbers of companion animals euthanized in animal shelters. This is an important goal, and there are many ways to achieve it. It should not, however, be pursued at the expense of wildlife already suffering from multiple anthropogenic threats.

Public education is a crucial part of the solution. While many cat owners feed and enjoy birds and repeatedly express dismay over birds killed by their cats, they fail to take the crucial step of preventing these kinds of events from occurring (Sallinger 2007). Many cat owners will be more motivated to keep their cats away from wildlife if they understand the negative impacts of cats on wildlife (Fiore and Sullivan 2000). Individuals can be part of the solution by keeping their cats indoors and converting outdoor pet cats to living indoors whenever possible. Outdoor enclosures can be provided to let cats enjoy the outdoors without exposing them to interactions with wildlife, and this in turn reduces the risk of trauma to cats and cat owners by outdoor cats' deaths due to cars, higher predators such as coyotes, and injuries due to fights with other cats.

For broad-scale public education to be effective, many more environmentalists and conservation scientists must become more informed, involved, and vocal about this problem than they have been until now. Dozens of science-based national and regional wildlife, conservation, and veterinary organizations have position statements promoting the humane control of free-ranging cats and opposing feral cat colonies to protect birds and other wildlife, including the American Association of Wildlife Veterinarians, the American Ornithologists' Union, the American Society of Mammalogists, the National Audubon Society, and the National Wildlife Federation. To our knowledge, however, the American Bird Conservancy (ABC) is the only such national organization that has significantly invested in public education, by maintaining its Cats Indoors! campaign for more than a decade. The extent of this problem demands many more significant contributions and efforts from a broad coalition of groups and agencies in order to successfully reach a larger proportion of the public. As it is, TNR is being legalized and funded in a growing number of cities and counties in the United States, in part because numerous false claims are made by TNR advocates in the popular media and these claims are often not refuted (Longcore et al. 2009). Many policymakers and members of the public, lacking other information, believe them and act accordingly.

Animal shelters can make the many reasons to keep cats indoors part of their educational message, and can implement policies to adopt cats only to owners who will keep cats indoors. They can also seek subsidies to provide low-cost or free spaying and neutering of pet cats. Wildlife rehabilitation centers and veterinarians can contribute by informing visitors of the extent of the impacts of cat predation on wildlife. Public awareness campaigns should be creative and engaging, providing people with opportunities to better appreciate nature and wildlife and to better understand the impacts of free-ranging domestic cats on birds as well as small mammals, herpetofauna, and endangered species.

Education alone, however, is not enough. While many people already voluntarily keep their cats indoors, many more people control their dogs due to greater enforcement of animal control laws with regard to dogs. Pet ownership laws already in place need to be enforced with cats as well as dogs, and cities and counties can be proactive by instituting and enforcing additional regulatory measures that require cat owners to assume more responsibility for their cats (Hatley 2003, 2004). Examples include requiring

cat owners to register and license their pets and instituting mandatory spaying and neutering. Local jurisdictions can set up and enforce heavy fines for failure to spay or neuter cats, allowing cats to roam, abandonment of cats, and feeding in public places. A number of cities and counties around the country have already done so (Roberto 1995, Winter 2004).

Birds and other wildlife and their right to exist are protected by the Migratory Bird Treaty Act (MBTA), Endangered Species Act (ESA), and other federal, state, and local laws (Hatley 2003, Barrows 2004, Hatley 2004, Jessup 2004). These laws need to be better enforced, as do laws and ordinances that prohibit feeding cats and other animals in public parks. If they are not already in place, cities, counties and park authorities can adopt feral animal policies; feral animal removal should become a permanent, regular feature of wildlife management. Deadlines can be established for voluntary removal of cat colonies, followed by mandatory humane removal (Castillo and Clarke 2003).

Cat management is a complex problem, and "there is no single, simple solution to the epidemic of unwanted, abandoned pets. However, education, subsidized neutering, closing down backyard breeders, and escalating fines for leash law violations are steps in the right direction. Responsibility and compassion go hand in hand" (Wagner 2008). Brickner (2003), Castillo and Clarke (2003), Coleman et al. (1997), Hatley (2003, 2004), Sallinger (2007), TWS (2006), and Winter (2004, 2006) provide many additional constructive recommendations for individuals, organizations, and local governments to mitigate the impacts of domestic cats on wildlife and effectively manage free-ranging cats.

Public discussion on this subject at the 4th International Partners in Flight Conference session "Anthropogenic causes of bird mortality" generated a wide range of ideas and approaches to this problem. These were summarized in the final needs assessment generated following the conference and linked to the Partners in Flight (PIF) website (PIF 2008). Ideas and recommendations on conservation actions and research related to impacts of domestic cats on birds are reprinted here, with some minor editorial changes, and include the following:

- Develop a White Paper by PIF regarding cumulative effects, including population level effects, from all anthropogenic sources of mortality based on the best currently available science, recognizing for some sources of mortality that data gaps/voids are huge;

- Develop links from PIF pages to existing sites, such as websites of the ABC Cats Indoors! campaign and American Association of Wildlife Veterinarians, and to position statements from a dozen professional organizations on the issue of cat predation at: <http://www.tnrrealitycheck.com/positions.asp>;
- Consider developing a PIF message regarding free-ranging cat predation;
- Develop PowerPoint presentations and fact sheets and provide public access in the form of website downloads as a way to distribute this information, and for use in presentations to schools and in other venues;
- Consider cat predation as an International Migratory Bird Day theme;
- Help ABC promote their Cats Indoors! program through PIF educational outlets;
- Is there a need to develop more products or different audiences? Develop task force or interest group to assess current outreach products and their intended audiences;
- Develop a plan to direct messages to certain groups—bird educators, law enforcement agents, animal control agencies, humane societies, pet products companies. PetSmart and PETCO support TNR programs, but also sell wild bird products such as bird seed. Pressure these companies to either stop their support of TNR, or stop selling bird seed;
- Work specifically with pet industry companies to deliver clear messages regarding proper pet care and not in any way supporting feral cat colonies. This will be challenging because they sell products (e.g. pet/cat doors and radio collars for cats) that encourage the public not to be responsible or delude the owners regarding safety;
- Develop public service announcements, possibly from the U.S. Fish and Wildlife Service (USFWS), regarding free-ranging cats and feral cat colonies
- Support, enact, develop, and enforce leash laws and spay and neuter programs for cats. Work to eliminate feral cat colonies;
- Make sure that USFWS law enforcement, and State wildlife law enforcement officials know about egregious violations, especially of cat colonies in or near endangered and threatened species critical habitat, Important Bird Areas (IBAs), breeding bird concentration areas, etc.;
- Look for additional alliances to address issues of anthropogenic causes of mortality, such as: pet food industries, animal control agencies, humane societies, city and county governments, state and federal agencies, non-profit organizations, professional and conservation organizations, and academia;
- Graduate students should consider acting as liaisons to communicate issues to schools, conservation organizations, and other networking groups;
- Although ABC seems poised to make more of their national campaign for Cats Indoors!, they need others to take up the charge, because ABC cannot do this alone. Approach ABC to determine whether or not they might be able to amplify their efforts by finding new partners if they had additional resources devoted to this issue;
- Volunteer to humanely trap and remove cats where no public service to do so is available, in accordance with the wishes of property owners and managers and relevant laws. Some businesses or institutions (e.g. campuses) might be eager to humanely remove feral cats from their premises, but may lack appropriate information or resources to do so;
- Can the MBTA and ESA be enforced more effectively? Ask USFWS law enforcement and state wildlife enforcement agents if there is a potential role to play at scales broader than individual violations—such as roles for communities, cities, counties, etc.;
- Encourage a more accurate assessment of mortality from different anthropogenic sources, and use this assessment to prepare a relative scale of attrition attributable to each anthropogenic source of avian mortality;
- Cumulative effects analyses should be done for some species of concern, incorporating into models the estimates of current rates of annual mortality from various anthropogenic sources;
- Conduct additional studies on the impacts of cats on migratory birds. Areas with many cat colonies and few or no studies of their impacts should be a priority, such as Texas, New Jersey, New York, California, Florida, and Hawaii. Consider using modified BACI designs (Green 1979, Underwood 1994)—before and after cat removal, and in areas with and without cats *sensu* Hawkins et al. 2004.

If each conservation group and/or individual connected with or inspired by the PIF mission would consider tackling at least one aspect of mitigating the impacts of domestic cats on birds and other wildlife in the United States, including any of those mentioned above, we will come a long way. With this particular problem, constructive engagement and strategic alliances are especially critical for successful education and conservation efforts, such as between scientists, veterinarians, public health officials, conservation groups, animal rights and welfare groups, and animal control and care agencies. In the words of George Schaller: "To understand nature is not enough. Scientists also have a moral obligation to help save what they study" (Bennett 2001). We may not prevail at every opportunity, but if we don't make the attempt, we will lose them all.

ACKNOWLEDGMENTS

ND thanks Mike Green and Al Manville for the invitation to present a talk based on research for this paper at the 4th International Partners in Flight Conference session "Anthropogenic causes of bird mortality," and for their detailed summary of discussion points raised at that session and included here. We thank the Warnell School of Forestry and Natural Resources at the University of Georgia for travel support to attend that conference, and ND thanks the Graduate School at the University of Georgia for supporting her studies during the time this review was conducted. We thank the presenters at the 126th Meeting of the American Ornithologists' Union symposium "Free-ranging cats and bird conservation," for providing a rich array of information and approaches to this problem: they are: Chris Lepczyk, Brad Keitt, Pete Marra, Pamela Hatley, and Bob Sallinger. For helpful information, advice, ideas, and discussion in researching this subject, we are grateful to: Paul Barrows, Sandy Cederbaum, Teresa Chagrin, Christy Champagne, Linda Cherkassky, Mark Cherry, Mike Conroy, the Cooper Lab, Ellen Corrie, the Dauphiné family, Rick Gerhold, Cole Hawkins, Sonia Hernandez-Divers, Steve Holzman, Dave Jessup, Carol Lambert, Kerrie Anne Loyd, DeeAnne Meliopoulos, Mike Mengak, Joe Meyers, Daphna Nachminovitch, Ellen Paul, Patrick Rives, Tim Rose, Bob Sargent, Jim Sterba, Ildiko Szabo, Stan Temple, Billi Wagner, Tammy Watkins, and Tom Will. Oscar Beingolea kindly provided the Spanish translation of the abstract. Finally, we are very grateful to J. M. Baird, Jessica Hardesty, Steve Hess, Travis Longcore, Catherine Rich, Terry Rich, and Darin Schroeder for many constructive comments on earlier drafts of this manuscript.

LITERATURE CITED

- ADAMEC, R. E. 1976. The interaction of hunger and preying in the domestic cat (*Felis catus*): an adaptive hierarchy? *Behavioral Biology* 18:263-272.
- ANDERSEN, M. C., B. J. MARTIN, AND G. W. ROEMER. 2004. Use of matrix population models to estimate the efficacy of euthanasia versus trap-neuter-return for management of free-roaming cats. *Journal of the American Veterinary Medical Association* 225:1871-1876.
- APPA. 2008. APPA National Pet Owner's Survey 2007-2008. American Pet Products Association, Inc., Greenwich, CT.
- BALOGH, A., AND P. MARRA. 2008. Of cats and catbirds: juvenile post-fledgling survival of Gray Catbirds in a suburban world (abstract). 126th Stated Meeting of the American Ornithologists' Union, Portland, OR.
- BARROWS, P. L. 2004. Professional, ethical, and legal dilemmas of trap-neuter-release. *Journal of the American Veterinary Medical Association* 225:1365-1369.
- BECKERMAN, A. P., M. BOOTS AND K. J. GASTON. 2007. Urban bird declines and the fear of cats. *Animal Conservation* 10:320-325.
- BENNETT, E. 2001. Timber certification: where is the voice of the biologist? *Conservation Biology* 14:921-923.
- BRICKNER, I. 2003. The impact of domestic cat (*Felis catus*) on wildlife welfare and conservation: a literature review with a situation summary from Israel. Tel Aviv University report. [Online.] Available at: <<http://www.tau.ac.il/lifesci/zoology/members/yom-tov/inbal/cats.pdf>> (29 March 2009).
- BUTCHART, S. H. M., A. J. SATTERSFIELD, AND N. J. COLLAR. 2006. How many bird extinctions have we prevented? *Oryx* 40:266-278.
- CALVER, M., S. THOMAS, S. BRADLEY, H. MCCUTCHEON. 2007. Reducing the rate of predation on wildlife by pet cats: The efficacy and practicability of collar-mounted pounce protectors. *Biological Conservation* 137:341-348.
- CASTILLO, D., AND A. L. CLARKE. 2003. Trap/neuter/release methods ineffective in controlling domestic cat "colonies" on public lands. *Natural Areas Journal* 23:247-253.
- CENTONZE, L. A., AND J. K. LEVY. 2002. Characteristics of free-roaming cats and their caretakers. *Journal of the American Veterinary Medical Association* 220:1627-1633.
- CHAGRIN, T. L. 2008. Cats are back (Letter). *Flagpole*. [Online.] Available at: <<http://flagpole.com/Weekly/Letters/CatsAreBack.17Dec08>> (31 March 2009).

- CLAVERO, M., AND GARCÍA-BERTHO, E. 2005. Invasive species are a leading cause of animal extinctions. *Trends in Ecology and Evolution* 20:110.
- COLEMAN, J. S., S. A. TEMPLE, AND S. R. CRAVEN. 1997. Cats and wildlife: A conservation dilemma. University of Wisconsin Cooperative Extension Publications. [Online.] Available at: <<http://wildlife.wisc.edu/extension/catfly3.htm>> (29 March 2009).
- COURCHAMP, F., M. LANGLAIS, AND G. SUGIHARA. 1999. Control of rabbits to protect island birds from cat predation. *Biological Conservation* 89:219–225.
- CROOKS, K. R., AND M. E. SOULÉ. 1999. Mesopredator release and avifaunal extinctions in a fragmented system. *Nature* 400:563–566.
- DANNER, R. M., D. M. GOLTZ, S. M. HESS, AND P. C. BANKO. 2007. Evidence of feline immunodeficiency virus, feline leukemia virus, and *Toxoplasma gondii* in feral cats on Mauna Kea, Hawaii. *Journal of Wildlife Diseases* 43:315–318.
- DICKMAN, C. R. 1996. Overview of the impacts of feral cats on Australian native fauna. Report to the Australian Nature Conservation Agency, Canberra, and Institute of Wildlife Research, Sydney, Australia.
- DUBEY, J. P. 2002. A review of toxoplasmosis in wild birds. *Veterinary Parasitology* 106:121–153.
- ERICKSON, W. P., G. D. JOHNSON, AND D. P. YOUNG, JR. 2005. A summary and comparison of bird mortality from anthropogenic causes with an emphasis on collisions. USDA Forest Service General Technical Report PSW-GTR-191:1029–1042.
- FIGLIORE, C., AND K. B. SULLIVAN. 2000. Domestic cat (*Felis catus*) predation of birds in an urban environment. M. S. Thesis. Wichita State University, Wichita, KS. [Online.] Available at: <http://www.geocities.com/the_src0/Article.html> (29 March 2009).
- FROST, R. 2000. People who hoard animals. *Psychiatric Times* 17(4). [Online.] Available at: <<http://www.psychiatristimes.com/display/article/10168/54031?pageNumber=2&verify=0>> (29 March 2009).
- FULLER, E. 2001. Extinct birds. Cornell University Press. Ithaca, NY.
- GEORGE, W. G. 1974. Domestic cats as predators and factors in winter shortages of raptor prey. *Wilson Bulletin* 86:384–396.
- GERHOLD, R. W., AND M. J. YABSLEY. 2007. *Toxoplasmosis* in a Red-bellied Woodpecker (*Melanerpes carolinus*). *Avian Diseases* 51:992–994.
- GILL, F. 1995. Ornithology, 2nd ed. W.H. Freeman. New York, NY.
- GREEN, R. H. 1979. Sampling design and statistical methods for environmental biologists. Wiley Interscience. Chichester, UK.
- HATLEY, P. J. 2003. Feral cat colonies in Florida: The fur and feathers are flying. University of Florida Conservation Clinic report to the U. S. Fish and Wildlife Service. [Online.] Available at: <<http://www.law.ufl.edu/conservation/pdf/feralcat.pdf>> (29 March 2009).
- HATLEY, P. J. 2004. Will feral cats silence spring in your town? [Online.] Available at: <<http://www.pamelajohatley.com/Articles/ABA.pdf>> (29 March 2009).
- HAWKINS, C. C., W. E. GRANT, AND M. T. LONGNECKER. 2004. Effect of house cats, being fed in parks, on California birds and rodents, pp. 164–170. In W. W. Shaw, L. K. Harris, and L. Vandruuff [eds.], Proceedings of the 4th International Urban Wildlife Symposium. School of Natural Resources, College of Agriculture and Life Science, University of Arizona, Tucson, AZ. [Online.] Available at: <<http://cals.arizona.edu/pubs/adjunct/snr0704/snr07042l.pdf>> (29 March 2009).
- HUGHES, K. L., AND M. R. SLATER. 2002. Implementation of a feral cat management program on a university campus. *Journal of Applied Animal Welfare Science* 5:15–28.
- HUTCHINS, M. 2008. Animal rights and conservation (letter). *Conservation Biology* 22:815–816.
- ISSG. 2008. Invasive Species Specialist Group Global Invasive Species Database. [Online.] Available at: <<http://www.issg.org>> (20 September 2008).
- JESSUP, D. A. 2004. The welfare of feral cats and wildlife. *Journal of the American Veterinary Medical Association* 225:1377–1383.
- KAYS, R. W., AND A. A. DEWAN. 2004. Ecological impact of inside/outside house cats around a suburban nature preserve. *Animal Conservation* 7:273–283.
- LEPCZYK, C. A., A. G. MERTIG, AND J. LIU. 2004. Landowners and cat predation across rural-to-urban landscapes. *Biological Conservation* 115:191–201.
- LEPCZYK, C. A. 2008. An overview of the natural history, human dimension, and management of outdoor cats (abstract). 126th Stated Meeting of the American Ornithologists' Union. Portland, OR.
- LONGCORE, T., C. RICH, AND L. M. SULLIVAN. 2009. Critical assessment of claims regarding management of feral cats by trap-neuter-return. *Conservation Biology* 23:887–894.
- MILLER, M. A., M. E. GRIGG, W. A. MILLER, H. A. DABRITZ, E. R. JAMES, A. C. MELLI, A. E. PACKHAM, D. JESSUP, AND P. A. CONRAD.

2007. *Toxoplasma gondii* and *Sarcocystis neurona* infections of pacific coastal sea otters in California, USA: evidence for land-sea transfer of biological pathogens. *Journal of Eukaryotic Microbiology* 54:48S-49S.
- MITCHELL, J. C., AND R. A. BECK. 1992. Free-ranging domestic cat predation on native vertebrates in rural and urban Virginia. *Virginia Journal of Science* 43:197-206.
- MOSHER, J. 1989. Status reports: Accipiters, pp. 47-52. In B. A. Gion Pendleton [ed.], *Proceedings of the Northeast Raptor Management Symposium and Workshop*. National Wildlife Federation Scientific and Technical Series 13. Washington D.C.
- NAS (NATIONAL AUDUBON SOCIETY) 2007, June 15. Disappearing common birds send environmental wake-up call. *ScienceDaily*. [Online.] Available at: <<http://www.sciencedaily.com/releases/2007/06/070614173737.htm>> (13 October 2008).
- NOGALES, M., A. MARTÍN, B. R. TERSHY, C. J. DONLAN, D. VEITCH, N. PUERTA, B. WOOD, AND J. ALONSO. 2004. A review of feral cat eradication on islands. *Conservation Biology* 18:310-319.
- NUTTER, F. B. 2005. Evaluation of a trap-neuter-return management program for feral cat colonies: population dynamics, home ranges, and potentially zoonotic diseases. PhD dissertation, North Carolina State University. Raleigh, NC.
- O'BRIEN, S. J., AND W. E. JOHNSON. 2007. The evolution of cats. *Scientific American*. 297:68-75.
- PERRY, D., AND G. PERRY. 2008. Improving interactions between animal rights groups and conservation biologists. *Conservation Biology* 22:27-35.
- PETA. 2009. People for the Ethical Treatment of Animals factsheet. [Online.] Available at: <<http://www.peta.org/campaigns/feralcats.asp>> (31 March 2009).
- PIF. 2008. Partners in Flight needs assessment: results from the 4th International Partners in Flight conference. [Online.] Available at: <<http://www.pwrc.usgs.gov/pif/events/mcallen/PIF%20Bird%20Conservation%20Needs%20Assessment.pdf>> (31 March 2009).
- ROBERTO, P. 1995. Whose right to live? The cat rescue movement versus wildlife defenders. *California Coast and Ocean*. 11:31-40. [Online.] Available at: <http://www.dfg.ca.gov/wildlife/nongame/nuis_exo/dom_cat/cat.html> (Accessed 3/31/09).
- ROELKE, M. E., J. S. MARTENSON, AND S. J. O'BRIEN. 1993. The consequences of demographic reduction and genetic depletion in the endangered Florida Panther. *Current Biology* 3:340-350.
- SALLINGER, B. 2007. Cats and wildlife. Audubon Society of Portland "Living with Urban Wildlife" brochure. [Online.] Available at: <<http://www.audubonportland.org/backyardwildlife/brochures>> (13 October 2008).
- SALLINGER, B. 2008. An unorthodox campaign to reduce cat predation on native birds in the Portland metropolitan area (abstract). 126th Stated Meeting of the American Ornithologists' Union. Portland, OR.
- SAX, D. F., AND S. D. GAINES. 2008. Species invasions and extinction: the future of native biodiversity on islands. *Proceedings of the National Academy of Sciences USA* 105 (Supplement 1):11490-11497.
- SCHMIDT, P. M., R. R. LOPEZ, AND B. A. COLLIER. 2007. Survival, fecundity, and movements of free-roaming cats. *Journal of Wildlife Management* 71:915-919.
- SMITH, D. G., J. T. POLHEMUS, AND E. A. VANDERWERF. 2002. Comparison of managed and unmanaged Wedge-tailed Shearwater colonies on O'ahu: Effects of predation. *Pacific Science* 56:451-57.
- SOULÉ, M. E. 1990. The onslaught of alien species, and other challenges in the coming decades. *Conservation Biology* 4:233-239.
- STALLCUP, R. 1991. A reversible catastrophe. *Observer* 91 (Spring/Summer): 8-9.
- STORTS, C. M. 2003. Discussion on TNR programs continue (letter). *Journal of the American Veterinary Medical Association* 222:711-712.
- STUTCHBURY, B. 2007. Silence of the songbirds: how we are losing the world's songbirds and what we can do to save them. Walker & Co. New York, NY.
- TERBORGH, J. 1989. *Where have all the birds gone?* Princeton University Press. Princeton, NJ.
- TWS (THE WILDLIFE SOCIETY). 2006. Final TWS position statement: feral and free-ranging domestic cats. [Online.] Available at: <<http://joomla.wildlife.org/documents/positionstatements/28-Feral%20&%20Free%20Ranging%20Cats.pdf>> (29 March 2009).
- UNDERWOOD, A. J. 1994. On beyond BACI: Sampling designs that might reliably detect environmental disturbances. *Ecological Applications* 4:3-15.
- WALTER, H. S. 2004. The mismeasure of islands: Implications for biogeographical theory and the conservation of nature. *Journal of Biogeography* 31:177-197.
- WAGNER, B. 2008. There is no single solution to helping feral cats (letter). *Roosevelt Examiner*. [Online.] Available at: <<http://examiner.gmnews.com/news/2008/0731/letters/014.html>> (31 March 2009).

- WARBURTON, B., AND B. G. NORTON. 2009. Towards a knowledge-based ethic for lethal control of nuisance wildlife. *Journal of Wildlife Management* 71:158–164.
- WINTER, L. 2004. Trap-neuter-release programs: the reality and the impacts. *Journal of the American Veterinary Medical Association* 225:1369–1376.
- WINTER, L. 2006. Impacts of feral and free-ranging cats on bird species of conservation concern: a five state review of New York, New Jersey, Florida, California, and Hawaii. American Bird Conservancy. [Online.] Available at: <<http://www.abcbirds.org/newsandreports/NFWF.pdf>> (31 March 2009).
- WOODS, M., R. A. McDONALD, AND S. HARRIS. 2003. Predation of wildlife by domestic cats *Felis catus* in Great Britain. *Mammal Review* 33:174–188.
- WORK, T. M., J. G. MASSEY, B. A. RIDEOUT, C. H. GARDINER, D. B. LEDIG, O. C. H. KWOK, AND J. P. DUBEY. 2000. Fatal toxoplasmosis in free-ranging endangered ‘Alala from Hawaii. *Journal of Wildlife Diseases* 36:205–212.
- WORK, T. M., J. G. MASSEY, D. S. LINDSAY, AND J. P. DUBEY. 2002. Toxoplasmosis in three species of native and introduced Hawaiian birds. *Journal of Parasitology* 88:1040–1042.
- ZASLOFF, R. L., AND L. A. HART. 1998. Attitudes and care practices of cat caretakers in Hawaii. *Anthrozoos* 11:242–248.
- ZAUNBRECHER, K. L., AND R. E. SMITH. 1993. Neutering of feral cats as an alternative to eradication programs. *Journal of the American Veterinary Medical Association* 203:449–452.