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Pick One: Outdoor Cats or Conservation

THE FIGHT OVER MANAGING AN INVASIVE PREDATOR

By Nico Dauphiné, Ph.D., and Robert J. Cooper, Ph.D.



Credit: Joel Holzman

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Credit: Clark Jones

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Stocked with food, water, and shelter, a cat feeding station in Athens, Georgia provides the comforts of home for homeless felines. Though built by well-meaning cat lovers, such stations attract feral and stray cats that will prey upon native wildlife and potentially spread disease. n March 2, 2010, in Athens, Georgia, a longbrewing fight reached City Hall. Legislators had gathered to vote on an ordinance that would legalize a trap-neuter-release (TNR) program to manage the county's overpopulation of feral cats. After years of arguments—from scientists opposing TNR and feral cat advocates endorsing it—the vote was cast: 9-1 in favor of the ordinance, with an additional 7-3 vote establishing a \$10,000 annual budget to support the TNR program. It was a resounding defeat for science—and for wildlife conservation.

How could this happen in a progressive community like Athens, Georgia, home to one of the nation's finest university programs in wildlife science? The answer is a complex mix of money, politics, intense emotions, and deeply divergent perspectives on animal welfare. This victory for TNR—and many others like it across the nation—marks in part the failure of scientists to effectively convey the threat that outdoor cats pose to native wildlife and habitats. If we're going to win the battle to save wildlife from cats, then we'll need to be smarter about how we communicate the science.

When Pets Become Predators

Domestic cats (*Felis catus*) are the descendents of wild cats (*Felis silvestris*) native to the Middle East. Now among the most common pets in the United

States, cats account for a multi-million-dollar outlay for food and care. Clearly pet cats enrich millions of human lives. The problem comes when those cats leave the confines of home and roam freely outdoors or become stray or feral, with dire consequences for wildlife, biodiversity, and human and animal health.

Now the most abundant carnivore in North America, cats are recognized by the International Union for the Conservation of Nature as one of the "world's worst" invasive species (IUCN 2008). The number of outdoor pet cats, strays, and feral cats in the U.S. alone now totals approximately 117 to 157 million (Dauphiné and Cooper 2009). Local densities can be extremely high, reaching up to 1,580 cats per square kilometer in urban areas (Sims *et al.* 2008). Instinctive predators, those cats will kill—hungry or not. A review of studies demonstrates the point:

- Cats are the most significant invasive species affecting birds, with documented impacts on 254 threatened, near threatened, and extinct bird species worldwide (Butchart 2008).
- Cat predation is among the most significant anthropogenic causes of bird mortality in the U.S., responsible for an estimated annual death toll of at least one billion birds (Gill 1995, Dauphiné and Cooper 2009).



- Nearly one-third of the more than 800 species of birds in the U.S. are endangered, threatened, or in significant decline (NABCI 2009), while the number of pet cats has tripled over the same period (Lepczyk *et al.* 2010). This means that increasing numbers of cats are preying on decreasing numbers of birds.
- Cats may kill more than twice as many mammals as birds. A survey in Great Britain found that mammals made up about 69 percent of cats' prey, birds about 24

Credit: Steve Holzman





As born hunters with a taste for the great outdoors, cats will range widely to prey on a variety of wildlife species including birds. rodents. lizards. and rabbits (clockwise from top left). By some estimates, outdoor cats in the U.S. on average kill more than a million birds a day and about twice as many small mammals and other creatures. an unsustainable toll.

percent, and amphibians and reptiles 5 percent (Woods *et al.* 2003).

In combination with habitat loss, cat predation has contributed to wildlife declines and extinctions worldwide, including the global extinctions of dozens of bird species (Dickman 1996, Brickner 2003, Nogales *et al.* 2004). These include the Socorro dove (*Zenaida graysoni*), now extinct in the wild, and the Guadalupe storm-petrel (*Oceanodroma macrodactyla*), a formerly abundant species that has not been recorded since 1912 (BirdLife International 2011).

Island-dwelling species are particularly vulnerable. A survey of 124 oceanic islands showed that cats had negatively impacted at least 174 endangered vertebrate species, 71 percent of which were bird species (Ringler *et al.* 2010). Likewise, cat predation may contribute to declines and extirpations of continental bird populations confined to habitat "islands" such as parks or open spaces in developed landscapes. Cats are often the dominant predators in these highly fragmented systems, where human food subsidies allow cats to reach densities that can be exponentially higher than all native carnivores combined.

In the fragmented landscapes of coastal southern California, for example, researchers studied how cats and other predators affected breeding birds in remnant patches of scrub habitat. They found that approximately 35 cats patrolled a typical 20-hectare habitat fragment, killing an estimated 525 birds per year (Crooks and Soulé 1999). The authors concluded that this predation was possibly associated with some of the 75 or more documented local extinctions of birds. Interestingly, the researchers also found that the presence of coyotes (*Canis latrans*) correlated with fewer cats and greater bird diversity. They believe this was due both to coyotes' killing cats and the tendency of cat owners to keep their pets indoors in areas with coyotes.

Recent studies of urban areas also raise alarms. Scientists studying gray catbird (*Dumetella carolinensis*) populations in suburban Washington, D.C., found that in areas with high densities of outdoor pet cats, predation caused 79 percent of catbird nestling and juvenile post-fledging mortality, and that cats appeared to be the main fledgling predators (Balogh *et al.* 2011). In Florida, researchers studying the nest success of northern mockingbirds (*Mimus polyglottos*) found that cats accounted for more than 70 percent of predation events on mockingbird eggs and nestlings in urban areas (Stracey and Robinson 2010). And scientists in Dunedin, New Zealand, used models based on empirical data to suggest that cat predation in urban areas drives bird population sinks (van Heezik *et al.* 2010).



Where is the outrage over such slaughter? "There was a massive public outcry when people witnessed the effects of the recent Deepwater Horizon oil spill on birds in the Gulf of Mexico," says Steve Holzman, a U.S. Fish and Wildlife Service (FWS) biologist who helped with disaster response. "Yet cats across the U.S. kill more than one million birds in a single day, which is far more than all of the birds killed in the worst oil spill in U.S. history." Even so, much of the public remains silent on cat predation, and most people do not appear to be aware of the significant problems cats pose to wildlife.

The Fallacies of TNR

We believe that public complacency is rooted in the close relationship between cats and humans, a status that often gives cats priority consideration over wildlife and makes control strategies highly controversial. Recent victories for TNR suggest as much.

On the surface, TNR may sound reasonable, even logical. Practitioners trap feral cats, neuter them, and re-release them, often into clusters called colonies that receive food, water, and shelter from private groups or municipalities. TNR cats often receive a clipped ear as a sign that they've been neutered. In theory, if sterilization rates are high, the cat population should eventually decline because the sterilized animals cannot reproduce. Advocates claim that this approach is a humane alternative to euthanizing unadoptable feral cats and, as we saw in the case of Athens, these arguments can be effective at convincing local municipalities to adopt TNR.

Advocates of TNR have gained tremendous political strength in the U.S. in recent years. With millions of dollars in donor funding, they are influencing legislation and the policies of major animal-oriented nonprofit organizations (Longcore *et al.* 2009). The TNR approach has been legally adopted in at least 10 large metropolitan areas in the U.S., from Miami to Chicago to San Diego. In addition, unknown numbers of unofficial or illegal TNR programs appear to be proliferating as well.

Though TNR may seem reasonable, numerous studies have shown that it usually fails to reduce cat populations due to ongoing cat immigration

Incompatible Neighbors in the Florida Keys

By Pamela Jo Hatley, J.D.

The Ocean Reef Club is a gated community on 2,000 acres at the northern tip of Key Largo, Florida. It is also home to ORCAT, one of the oldest and most well-funded trap-neuter-release (TNR) cat colonies in the United States. Ocean Reef citizens founded the colony in 1993 to curb a severe overpopulation of feral cats, then estimated at about 2,000 animals (ORCAT). Today, the population is down to about 350 cats. ORCAT supporters consider the program a success, but conservationists see it quite differently.

Immediately adjacent to Ocean Reef is the last remaining habitat for two endangered rodent species: the Key Largo woodrat (*Neotoma floridana smalli*) and Key Largo cotton mouse (*Peromyscus gossypinus allapaticola*). They live within the Dagny Johnson Key Largo Hammocks Botanical State Park and Crocodile Lake National Wildlife Refuge, together comprising more than 8,000 acres.

Populations of both rodent species have been in steep decline for years. By 2003, the Key Largo woodrat population had plummeted to fewer than 100 individuals in the wild (McCleery 2003). Numerous factors have sped the decline, including development, disease, and predation by raccoons, rats, and cats. Feral cats were responsible for 77 percent of mortality of woodrats in a recent re-introduction effort (FWS 2011).

Concerned about cat predation on endangered species, the Florida Fish and Wildlife Conservation Commission (FWC) in May 2003 adopted a "Policy on Feral and Free-Ranging Cats," supporting "elimination of TNR colonies and similar managed cat colonies wherever they potentially and significantly impact local wildlife populations." Likewise, in January 2011 the U.S. Fish and Wildlife Service issued a draft predator-management plan for the Florida Keys National Wildlife Refuges Complex, noting that "TNR practices are prohibited on National Wildlife Refuges, and violate the Endangered Species Act (ESA) and the Migratory Bird Treaty Act (MBTA) because they may result in the direct harm of protected species" (USFWS 2011).

It is hard to imagine how one could argue that free-roaming nonnative predators should be kept in a colony near the last remaining habitat of endangered rodents. Yet cat advocates have argued just that. When the FWC scheduled a hearing on its feral-cat policy in 2003, cat advocates protested so adamantly that the FWC sponsored a series of meetings seeking collaboration and consensus. The agency opened the meetings to the public and invited certain stakeholders who represented cat advocacy organizations, veterinary professionals, wildlife professionals, and conservationists.

I participated in several of those meetings because of my interest in wildlife and property law. At a meeting hosted by the Ocean Reef Resort in June 2004, I learned that the ORCAT colony then had about 500 free-ranging cats, several paid employees, and an



from surrounding areas. More important, TNR encourages the notion that cats should be allowed outdoors, where they prey on native wildlife at will. All wildlife professionals who are concerned about this issue can better make a case against TNR by pointing to the facts:

Fact: TNR does not typically reduce feral cat populations. One colony in Florida, for example, grew from 920 to 983 cats over a nine-month period—an increase of nearly 7 percent (Centoze and Levy 2002, Winter 2004). Many empirical studies of TNR demonstrate that food provisions attract cat immigration, often of cats deliberately abandoned by owners near feeding areas (Hughes and Slater 2002, Castillo and Clarke 2003, Levy *et al.* 2003). These factors, along with births to unsterilized cats, tend to offset population declines due to sterilization or deaths from accidents or disease (Foley *et al.* 2005, Nutter 2006, Schmidt *et al.* 2009).

Fact: Many cats in TNR colonies are not sterilized. A 12-year study of TNR efforts in California and six-year study of TNR in Florida indicated ongoing cat popula-

tion growth. They estimated that 71 to 94 percent of cats would need to be sterilized in order to reduce cat population growth, and noted that actual sterilization rates were much lower than that (Foley *et al.* 2005).

Fact: TNR does not reduce predation pressure on native wildlife. One might assume that sterilized cats would have small home ranges since they have no biological need to search for mates. However, a study of 14 sterilized and 13 intact radio-collared cats on Catalina Island, California, found no significant difference in the size of their home ranges (Guttilla and Stapp 2010).

Fact: Many TNR programs exist to perpetuate, not eliminate, feral cat colonies, and many provide feeding and neutering services without charting population changes over time. A description of a three-year study of a TNR program in Louisiana stated that the program was designed to stabilize a resident population of stray and feral cats "for an indefinite period" (Zaunbrecher and Smith 1993). In a two-year study of TNR in Texas, organizers stated that their primary goal was simply to neuter as many cats as possible,

annual operating budget of some \$100,000. I then visited Key Largo woodrat habitat in the nearby Dagny Johnson park, where I observed that only a chain link fence separated woodrat habitat from the ORCAT property. In some areas there was no fence at all, giving feral cats direct access to hunt in that critical habitat.

ORCAT proponents insist that their cats are not contributing to a decline in the woodrat population. However, I spoke with ORCAT employees who acknowledged that they were unable to trap and neuter all cats in the colony, and that unwanted cats were regularly dumped at the site. Clearly, then, it is impossible to track the comings and goings of all colony cats, let alone determine what they might prey upon at night.

Park and FWC employees believe that cats are a factor in the decline of endangered woodrats and, according to the U.S. Geological Survey, the Key Largo woodrat is so "threatened by development and predation by feral cats and other predators" that captive-breeding programs may be the only way to save the rodents (USGS). To that end, federal agencies are engaged in captive breeding programs for Key Largo woodrats, and private groups such as Disney's Animal Kingdom are also breeding and conducting genetic studies on the species in an effort to save it from extinction (Alligood *et al.* 2010). Costly efforts to save this endangered species seem unlikely to succeed, however, if cat colonies and resulting predation continue.

Allowing cats to roam in natural areas has been compared to "releas-

ing a serial murderer in a maternity ward" (Pittman 2003). Equally strong rhetoric flies from supporters of cat colonies, no matter the cost to native wildlife. I believe the facts speak for themselves. It is essential to acknowledge that free-roaming cats are a significant contributing factor in pushing certain wildlife populations toward extinction. To deny this is unrealistic. To do nothing about it is irresponsible.



Credit: Clay Degayne

The highly endangered Key Largo woodrat now lives only in Key Largo, where the presence of a TNR colony threatens the rodent's survival.

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rather than quantify how cat populations responded to these efforts (Hughes and Slater 2002).

By perpetuating and concentrating feral cat populations, TNR programs can seriously amplify impacts on wildlife. Researchers in Hawaii studied wedge-tailed shearwater (*Puffinus pacificus*) breeding colonies located at increasing distances from a cat-feeding area. The closer the birds were to the cat-feeding area, the more likely they were to be killed, and birds closest to the cat-feeding area were completely wiped out (Smith *et al.* 2002).

Likewise, in a study of native birds and rodents in the East Bay Regional Park District on California's central coast, researchers compared an area where people were feeding outdoor cats with a nearby no-cat area (Hawkins *et al.* 2004). They found nearly double the number of birds in the no-cat area compared with the cat-feeding area. Two native bird species—the California quail (*Callipepla californica*) and California thrasher (*Toxostoma redivivum*)—were totally absent from the cat-feeding area. In addition, they found that the number of exotic rodents was nine times higher in the cat-feeding area, suggesting that cat predation pressure may be greater on native than exotic rodents. Provisioning food for cats may therefore facilitate the spread of exotic rodents into new areas.

Follow the Money: The Economics of TNR Advocacy

By Nico Dauphiné, Ph.D.

The promotion of TNR is big business, with such large amounts of money in play that conservation scientists opposing TNR can't begin to compete. Best Friends Animal Society, one of the largest organizations promoting TNR, took in over \$40 million in revenue in 2009 (BFAS). The group spent more than \$11 million on cat advocacy campaigns that year, including their "Focus on Felines" program, which promoted TNR and paid for 80,000 tons of dry cat food to feed feral cats. In 2010, the pro-TNR group Alley Cat Allies reported taking in more than \$5 million and spending \$3.3 million on public outreach, largely to promote TNR and its legalization nationwide through its "Every Kitty, Every City" campaign (ACA).

Donations range from small contributions of individual cat lovers to large donations and grants supporting TNR initiatives. In some cases, conservation groups accept funding to join in efforts promoting TNR. The New Jersey Audubon Society, for example, had previously rejected TNR but began supporting it in 2005, acknowledging funding from the Frankenberg and Dodge Foundations for collaboration with TNR groups (NJAS).

Pet industry giants such as PetSmart and PetCo also fund activities to promote TNR, and presumably profit from the huge amounts of cat food purchased by TNR practitioners. The global market for pet products-of which pet food represents about 80 percent-is valued at over \$50 billion and has been growing at roughly 4 percent per year (Combelles 2004, De Silva and Turchini 2008).

PetSmart recently funded a study that Best Friends commissioned from a for-profit consultancy group to produce a "Feral Fiscal Impact Calculator," intended to help TNR advocates convince municipalities that they will save money by adopting TNR in place of traditional animal control (AVMA 2010). Cash-strapped legislators may buy that argument. However, as veterinarian David Jessup notes, "If you attach even a few dollars in value to the wildlife killed, and consider the costs of trying to recover sensitive species, environmental cleanup, and human health impacts associated with outdoor feral cats, any hypothetical savings disappear" (Nolen 2010).

What of the value of lost wildlife? One group of researchers from Cornell University has estimated the economic value of birds killed by cats. At the time of their study a decade ago, they estimated that 71 million outdoor cats killed approximately 568 million birds per year in the U.S. (Pimentel *et al.* 2000, 2005). Based on estimates that bird watchers spent 40 cents per bird observed, hunters spent \$216 per bird shot, and biologists spent \$800 per bird in captive breeding programs (Tinney 1981, USFWS 1988), the researchers estimated the economic value of a single bird as roughly \$30. That would equate to a loss of about \$17 billion per year from cat predation of birds.

There are large, as-yet unquantified costs associated with nuisance wildlife control of raccoons, skunks, opossums, and other animals drawn to cat feeding stations. Additional costs involve the rehabilitation of wildlife injured by cats, the primary cause of injury to incoming wildlife reported by some wildlife hospitals (Jessup 2004, Sallinger 2008). Cat-carried pathogens that affect public health, including rabies, may also lead to potentially enormous costs borne by citizens and taxpayers.

Ultimately, the science suggests that cat removal is cheaper and more effective than TNR for managing large numbers of feral cats (Loyd and DeVore 2010). However, the cost of removal is controversy–and that's a price that many cities and legislators appear unwilling to pay.



Problems Beyond Predation

Wildlife professionals who oppose TNR and hope to convince pet owners to keep their cats indoors would do well to focus not just on wildlife predation, but also to call attention to the other problems associated with outdoor cats. "I look at the problem as a box with four sides: cat welfare, environment, public health, and public nuisance," says David Blumig, a New Jersey animal control officer with 30 years of experience dealing with outdoor cats. "You've got to address as many sides as you can."

Cat Welfare. Many feral cats live short, brutal lives, with annual mortality rates as high as 80 percent. The American Veterinary Medical Association has estimated the average lifespan of feral cats at two years as compared with 10 for owned cats (Jessup 2004). Feral cats suffer considerably higher rates of injury and disease than their owned counterparts, and are more likely to succumb to vehicle trauma, predation, disease, and severe weather (Jessup 2004).

Environment. Owned and feral cats make significant contributions to fecal pollution of the environment and to bacterial loading of streams and coastal waters (Young and Thackston 1999, Mallin *et al.* 2000, Dabritz *et al.* 2006). In a study of cats in three communities on the central coast of California, researchers found evidence of substantial fecal contamination, with 44 percent of owned cats defecating outside more than 75 percent of the time, and 36 percent of owned cats defecating exclusively outside. Owned and feral cats in these communities of about 12,000 households contributed an estimated 106 tons of feces to the environment each year—in an area of less than 30 square kilometers (Dabritz *et al.* 2006).

Public and Wildlife Health. The substantial amount of feline feces in human-dominated environments raises concerns about disease transmission (see articles on pages 58 and 62). Federally endangered Florida panthers (Puma concolor coryi) have been known to contract feline panleukopenia, or feline parvovirus, an immune deficiency disease (Roelke *et al.* 1993, Brickner 2003). Passed through cat feces, the protozoan parasite Toxoplasmosis gondii is known to have infected more than 50 bird species worldwide and at least a dozen in the U.S., including the federally endangered Hawaiian crow (Corvus hawaiiensis) (Dubey 2002, Work et al. 2002, Gerhold and Yabsley 2007, Miller et al. 2007). Now the most common domestic animal carrier of rabies, cats also can spread pathogens such as Campylobacter, Salmonella spp., roundworms





The Outdoor Life for Cats. In this gruesome gallery of images (top to bottom), one cat lies dead with a broken leg, one lies dying in a coat of maggots, and another suffers as ticks and ear mites plague its face. These are some of the 150 cats that New Jersey animal-control officer David Blumig was called upon to retrieve last year. Blumig typically takes cats to a shelter for treatment. Those that can't be adopted are euthanized, a far better fate than being left to suffer the hazards of life outdoors.



(or ascarids such as *Toxocara cati*), hookworms (*Ancylostoma* spp.), and protozoan parasites such as *Cryptosporidium* spp. and *Giardia* spp. (Dabritz *et al.* 2006). Many of these pathogens potentially threaten humans as well as wildlife (Work *et al.* 2000, Danner *et al.* 2007, Miller *et al.* 2007).



Fresh from the hunt, an outdoor cat grips an ovenbird, a neotropical migratory songbird species that migrates between North and South America. Whether a resident species or a long-distance migrant, any bird within reach of a free-roaming cat may be at risk of predation— a form of mortality that humans could easily prevent by keeping cats indoors.

Nuisance Factor. As feral cat populations increase, some members of the public begin to see the animals as an attractive nuisance that encourages illegal dumping of unwanted animals (Castillo and Clarke 2003). These cats and their owned counterparts become vulnerable to abuse by members of the public fed up with strays roaming their property or stalking their backyard bird feeders. Indeed, the animal rights group People for the Ethical Treatment of Animals (PETA) opposes TNR on the grounds that it involves cruelty to both cats and wildlife.

Contention Trumps Conservation

Given such evidence of the harm caused by and done to outdoor cats, it's discouraging that advocates continue to present TNR to municipalities as a viable management approach. Public meetings to discuss TNR can become quite explosive, given the passions and substantial funding of the pro-TNR lobby. When the Florida Fish and Wildlife Conservation Commission unanimously passed a policy designed to discourage feral cat colonies that threaten birds and small mammals, angry protesters accused the commissioners of being "murderers" and "cat killers" (Jacobson 2003).

On a national scale, pro-TNR groups are increasingly influencing policy and legislation. For example, the feral cat advocacy group Alley Cat Allies and other organizations have conducted national campaigns to pressure FWS to accept cat colonies in places such as Cape May, New Jersey, and San Nicolas Island, California, even though such colonies would pose a direct predation threat to federally threatened and endangered species. The Humane Society of the United States and other pro-TNR groups successfully blocked a federal bill (HR 767) that would have provided funding for the removal of harmful invasive species from national wildlife refuges on the grounds that feral cats could have been targeted in these efforts to protect wildlife on public land.

For conservationists concerned about birds and other wildlife, such relentless devotion to protecting outdoor cats can be disconcerting, even dangerous. Cat advocates "make no compromises and take no prisoners," says New Jersey's David Blumig, who has received numerous death threats for his opposition to TNR. He's not alone. At the annual meeting of the American Ornithologists' Union in 2008, several scientists at a round table on cat predation reported the same experience. Such intense passions can force political leaders to bow to the pressure of TNR advocacy groups. Yet in Blumig's own New Jersey township, TNR remains illegal—an indication, perhaps, of the power of one individual who effectively communicates the facts about feral cats and says "no" to TNR.

More of us in the wildlife profession need to stand up and add our voices to the cause. We need strong leadership coupled with proactive policies and well-enforced laws that recognize cats as invasive species, impose fines on owners who refuse to control their pets, require mandatory sterilization of pets, prohibit feral cat colonies and feeding stations especially on public land, and acknowledge the legitimate role of euthanasia when necessary. Such measures will go a long way towards protecting the native wildlife we cherish so much.

This article has been reviewed by subject-matter experts.



For a full bibliography and additional information about feral cat management, go to *www.wildlife.org.*

Cats as Carriers of Disease

THE POTENTIAL TO SPREAD A HOST OF DISEASES TO HUMANS AND WILDLIFE

By Rick Gerhold, DVM, Ph.D.



Credit: Kevin Keel

Rick Gerhold, DVM, Ph.D., is a postdoctoral associate at the Center for Wildlife Health, Department of Forestry, Wildlife, and Fisheries at the University of Tennessee. day at the beach was anything but soothing for several Miami beachgoers last summer and fall. Along Miami Beach, at least seven people developed unsightly rashes caused by hookworms crawling under their skin. People affected in the outbreak contracted the parasites from the feces of feral cats that use beach pathways and dunes as litter boxes (Smiley 2010). With seven confirmed and eight suspected cases of hookworm dermatitis, Miami-Dade public health officials responded to the outbreak by combing the beach to remove cat feces and educating beachgoers about how to avoid cat feces and treat hookworm infections.

This recent case is just one illustration of the potential for outdoor cats to transmit disease to humans. Through feces, fleas, bites, or scratches, cats can pass a variety of parasitic, bacterial, and viral illnesses including rabies, toxoplasmosis, typhus, and plague. With the number of feral cats at epic proportions, the need for cat control programs is increasingly a matter of public health.

Historically, animal control programs have been paramount in minimizing zoonotic risk in the



Pellets of dry food scattered for cats attract a raccoon to a feeding site in the Florida Keys. The top vector for rabies in the wild, raccoons can pass the virus to outdoor cats, which are increasingly the source of human exposure to this dangerous disease.

United States. A rabies control program that began in the 1950s required mandatory rabies vaccination in dogs and launched programs aimed at removing stray and feral dogs to minimize human contact with potentially rabid animals. These efforts significantly reduced the incidence of human rabies in the U.S. Today, however, reports of domestic cat-associated rabies exposure and other zoonotic diseases are warranting increased attention and concern.

Cat Rabies on the Rise

Since 1988, rabies has been detected more frequently in cats than in dogs in the U.S. (Rupprecht 2002). By 2008, the number of rabies cases in cats was approximately four times the number of cases in dogs (Blanton *et al.* 2009). Although rabies infection is detected most frequently in wildlife such as raccoons, multiple recent studies show that human exposure to rabies is increasingly associated with domestic cats, primarily because people are more likely to come in contact with cats than wildlife (Cole and Atkins 2007, Roseveare *et al.* 2009, Eidson and Bingman 2010). A few examples illustrate the trend:

- From 2002 to 2006 in Georgia, 70 cats tested positive for rabies, and the virus was detected more frequently in cats than any other domestic animal (Cole and Atkins 2007). Moreover, from 2004 to 2006, 17 percent of all confirmed human rabies exposures in Georgia were due to cat bites, whereas domestic dogs comprised 5 percent of all confirmed human rabies cases in Georgia during the same time period.
- An investigation of rabies exposure in domestic animals in South Carolina showed that stray cats were disproportionately associated with potential human rabies exposure and were the species most frequently reported rabid among domestic animals exposed to rabies (Roseveare *et al.* 2009).
- Similarly, in New York from 1993 to 2010, cats were most frequently associated with human rabies exposure incidents (32.8 percent) and post-exposure prophylaxis (PEP) treatments (31.8 percent) (Eidson and Bingman 2010).



Rabies virus is transmitted via saliva from one host to another primarily from bites. The virus replicates in neurons and disseminates through the nervous system. Later in the infection, the virus can be found in highly innervated organs including the cornea, skin, and salivary glands (Iwasaki 1991). If left untreated, rabies leads to inflammation and destruction of brain tissue and an almost certain and difficult death. Fortunately, prophylactic treatment is highly effective-but costly: A course of treatment runs \$5,000 to \$8,000 per individual, with costs often borne by public health agencies (Recuanco et al. 2007). Today, cat exposures to rabies account for approximately one-third of all PEP treatments in the U.S. In addition to the cost of PEP, skin infections due to numerous bacteria (including Pasteurella multocida, Staphylococcus spp., and Streptococcus spp.) are often associated with cat bite wounds and often require antibiotic treatment and possible hospitalization (Talan et al. 1999).

Cats maintained in trap-neuter-release (TNR) colonies—supported in many places across the nation—may receive vaccinations against rabies. However, this does not decrease the need for PEP treatments because it is impossible to know when and how feral cats may have been exposed, and difficult to determine their vaccination status or to confine them for observation (Jessup and Stone 2010). Furthermore, one study found 22 reported rabies cases in cats that had been vaccinated, including in two cats classified as currently vaccinated, indicating that vaccine failures can occur (Murray *et al.* 2009).

Wild mesocarnivores such as raccoons, skunks, and foxes—the wildlife species most frequently infected with rabies in the U.S. (Rupprecht *et al.* 2001)—are often attracted to the abundant food at cat colony feeding stations. These outdoor feeding stations may therefore increase the concentrations of wildlife and the interface between humans, mesocarnivores, and cats, leading to an even greater public health threat due to rabies and other disease agents associated with wild animals.

For example, some raccoons harbor raccoon roundworm (*Baylisascaris procyonis*), an intestinal nematode parasite that has caused morbidity and death in humans, especially children (Kazacos 2001). Infections occur after exposure to contaminated raccoon feces followed by accidental ingestion of the microscopic roundworm eggs from the feces. The geographical distribution of *B. procyonis* is expand-



Credit: City of Miami Beach

A satellite map of part of Miami Beach shows GPS data points indicating cat fecal matter (green dots) located near cat feeding stations (red dots). City leaders commissioned the map to pinpoint cat-use areas after beachgoers began contracting hookworm parasites from cat feces in the sand. Unsightly lesions typical of hookworm dermatitis (below) covered the leg of a patient who developed symptoms after a Florida vacation.



Courtesy of Scott C. Sherman





Josh Cook, a veterinary student at the

University of Georgia in Athens, scoops beach sand near a local lake as part of a research project to test for the presence of parasites passed through cat feces. After sampling public-use areas such as playgrounds and beaches, Cook and co-researcher Jessica Murdock will assess implications for human and wildlife health. Credit: Jessica Murdock

ing from its historical range of the midwestern, western, and northeastern U.S. (Kazacos 2001) to multiple states in the southeastern U. S., Canada, Europe, and Japan (Kazacos 2001, Blizzard *et al.* 2010, Yabsley *et al.* 2010). The discovery of *B. procyonis* in raccoons near urban areas in Georgia (Blizzard *et al.* 2010) is of particular concern given that feral cat colonies are likely to be found in urban settings.

Tainted by Toxoplasmosis

Domestic and wild felids are the definitive hosts for several zoonotic parasites, including the protozoan *Toxoplasma gondii* and the ascarid *Toxocara cati*. One study found that the seroprevalence of *T. gondii* is higher in feral cats than in pet cats, with the lowest prevalence in cats kept indoors (Nutter *et al.* **2004**). Because *T. gondii* oocysts are extremely environmentally resistant (Long 1990, Kazacos 2001), infections can occur months or even years after excretion of the parasite. For this reason, cat fecescontaminated playgrounds, garden soil, sandboxes, and other outdoor recreational areas may serve as a source of infection for humans (Lee *et al.* 2010).

Contact with infective *T. gondii* oocysts in cat feces is found to be a primary risk factor for toxoplasmosis in humans, who become infected primarily by ingestion of sporulated oocysts from contaminated soil or water or by ingesting tissue cysts in undercooked or raw meat (Elmore *et al.* 2010). Outbreaks of toxoplasmosis in communities are often associated with contaminated water sources. Since tissue cysts can't survive outside their hosts, and cats are the only definitive host that sheds oocysts, these types of outbreaks have to be cat-feces associated. Consider the following health implications:

- *Toxocara cati* infections have been associated with visceral and ocular larval migration and can result in permanent ocular damage in humans (Holland and Smith 2006, Lee *et al.* 2010).
- *Toxoplasma* infections can cause neurological impairment and can lead to abortions and birth defects such as hydrocephalus in humans (Dubey and Odening 2001).
- Toxoplasmosis is a dangerous disease for individuals receiving immunosuppressive therapy and is a major cause of systemic infection and death for immunosuppressed patients (Elmore *et al.* 2010).
- Increased risk of schizophrenia, autism spectrum disorders, and other neuro-inflammatory diseases has been associated with *T. gondii* infection (Torrey and Yolken 2003, Prandota *et al.* 2010).
- Toxoplasmosis is a major issue for wildlife and has been documented in multiple wild avian and mammalian species, especially marine mammals and Australian marsupials (Dubey and Odening 2001, Dubey 2002, De Thoisy *et al.* 2003).
- Toxoplasmosis is a significant cause of abortion in domestic animals including sheep and goats.

Worms, Fleas, and Other Ills

Humans can become infected by several species of cat-borne hookworms including *Uncinaria stenocephala*, *Ancylostoma tubaeforme*, *A. braziliense*, and *A. ceylanicum* (Bowman *et al.* 2010). Deposited in feces, hookworm eggs hatch and their infectious filariform larvae can then penetrate the skin of animals or human hosts. Infective larvae can cause skin lesions known as cutaneous larva migrans (CLM) and less frequently pneumonitis and muscle and ocular infections. Occasionally, *A. ceylanicum* can develop into an adult hookworm in humans and cause abdominal discomfort (Prociv 1998).

The problem is widespread. Several human cases of feline hookworm infections have been reported from soil under houses or on beaches where cats defecate. In Florida alone, one study found that approximately 75 percent of feral cats were positive for *A. tubaeforme* and 33 percent were positive for *A. braziliense* (Anderson *et al.* 2003). In 2006, 22 people were diagnosed with CLM at a Miami-Dade County children's camp. Although feral cats were found in the vicinity of the camp, the source of the infection was not determined (CDC MMWR 2006).

Ectoparasites of domestic cats, especially the cat flea (*Ctenocephalides felis*), are also efficient transmit-



ters of zoonotic diseases. Three major flea-associated diseases of cats in the U.S. include cat-scratch disease (CSD), flea-borne typhus, and plague (McElroy et al. 2010). CSD, or bartonellosis, is caused by the gram-negative bacterium Bartonella henselae. Though cats are the primary source of the bacteria, they are silent carriers and thus appear healthy. Fleas acquire *B. henselae* from the blood of an infected cat. Infection then passes to an animal or human when B. henselae-contaminated flea feces comes into contact with an open wound from a cat scratch or bite. Prevalence of *B. henselae* in cats ranges from 15 to 93 percent (Nutter et al. 2004, Case et al. 2006, Lappin et al. 2006) and feral cats have a significantly higher seroprevalence than pet cats (Nutter et al. 2004). Symptoms in humans with CSD include fever, headaches, weakness, joint pain, and lymph node enlargement. Chronic CSD cases have manifestations similar to Lyme disease and can be very debilitating for infected people. In addition, the disease is one of the most frequent diagnoses of benign lymphadenopathy in children and young adults (McElroy et al. 2010). Atypical complications including encephalitis, retinitis, and endocarditis occur in 5 to 15 percent of CSD-infected humans (Chomel et al. 2004).

In addition to CSD, cat fleas vector rickettsial diseases including murine typhus (Rickettsia typhi) and the closely related zoonotic disease agent Rickettsia felis, both of which are potential human health threats wherever cat, rat, or flea populations are dense (Case et al. 2006). As is the case with CSD, cats are inapparent carriers of R. typhi. Outbreaks and potential outbreaks have been associated with feral cat colonies (Kliks 2003). Other reported cases of murine typhus in the U.S. have occurred in central and south-central Texas and the Los Angeles area (Adams et al. 1970, Sorvillo et al. 1993). In Los Angeles, 90 percent of collected cats were seropositive for R. typhi antibodies, whereas no seropositive cats were found in control areas where no human infections were reported (Sorvillo et al. 1993). Flea suppression may help protect public health, but failure to control feral cat populations could lead to future outbreaks.

Joining the list of cat-related ills, human bacterial diseases including tularemia, caused by *Francisella tularensis*, and plague, caused by *Yersinia pestis*, are associated with direct contact with cats or cat fleas (Liles and Burger 1993, Gage *et al.* 2000, McElory *et al.* 2010). Approximately 8 percent of plague cases in the U.S. are associated with transmission by cats; cases of plague associated with cate exposure are reported year-round, while flea-

associated cases are generally restricted to warmer months (Gage *et al.* 2000). Both tularemia and plague can cause various disease symptoms such as painful lymph node enlargement, fever, and chills, and can potentially lead to fatal respiratory disease. It is suggested that in addition to harboring infected fleas, cats preying on infected rodents can contain the bacterial agents of tularemia and plague in their mouths and potentially transmit the bacteria to humans via bites or scratches (Elliot *et al.* 1985).

The Case for Control

Cats may be implicated in other diseases not historically associated with felines, including H5N1 avian influenza, as evidenced by natural and experimental infection of domestic cats (Kuiken *et al.* 2004, Songserm *et al.* 2006). Experimentally infected cats excreted the virus and transmitted it to H5N1-free cats, demonstrating horizontal transmission and suggesting that cats can be involved in epidemiology and transmission of the virus (Kuiken *et al.* 2004).

Native predators such as cougars (*Felis concolor*) and other wild felids can contract disease by eating infected domestic cats. Cases of feline leukemia virus (FeLV) transmitted from domestic cats to wild felids have been reported in California and Florida (Jessup *et al.* 1993, Cunningham 2008). Because FeLV is a retrovirus that causes immunosuppression of hosts, infected wild felids have a greater susceptibility to opportunistic disease agents. In one case, genetic analysis of the FeLV virus associated with the deaths of five Florida panthers showed that the virus envelope sequence was nearly identical, indicating that the source of the infection was likely a single domestic cat (Brown *et al.* 2008).

Clearly the existence of millions of feral, stray, and outdoor domestic cats poses a significant health risk for humans, pets, livestock, and wildlife. Wildlife professionals who have difficulty convincing the cat-loving public to control populations of feral cats might have better luck by emphasizing the health consequences of cat-borne diseases. One look at a leg infected with hookworms might be enough to do the trick.

This article has been reviewed by subject-matter experts.



For a full bibliography and additional information about cats and disease, go to *www.wildlife.org.*

The Trickle-Down Effect

HOW TOXOPLASMOSIS FROM CATS CAN KILL SEA OTTERS

By David A. Jessup, DVM, MPVM, and Melissa A. Miller, DVM, Ph.D.



Courtesy of David A. Jessup

David A. Jessup, DVM, MPVM, Dipl. ACZM, CWB, recently retired as Senior Wildlife Veterinarian of the Marine Wildlife Veterinary Care and Research Center in California and is now Executive Manager of the Wildlife Disease Association.



Credit: Francesca Batac

Melissa A. Miller, DVM, Ph.D., is a Senior Wildlife Veterinarian at the Marine Wildlife Veterinary Care and Research Center in California.

alifornia has passed a state law that advises pet owners on the proper disposal • of used cat litter. Though the law drew a few laughs, its intent is dead serious. The state recognizes that threatened southern sea otters (Enhydra lutris nereis) are dying from the Toxoplasma gondii parasite, which originates in cat feces, washes into the ocean, and contaminates the otters' prey. To help protect water quality and the threatened sea otter population, California's Assembly Bill 2485 asks cat owners not to "flush cat litter in toilets or dispose of it outdoors in gutters or storm drains." Though responsible pet owners may comply, the law alone can't stop the most significant source of the problem: thousands of pet, stray, and feral cats defecating outdoors.

By some estimates, up to 70 percent of adult southern sea otters may be infected with *T. gondii* (Miller *et al.* 2002a), a protozoan parasite that can lead to systemic disease, neurologic impairment, and death. In some years, *T. gondii* and related parasites kill or contribute to the death of sea otters, and the parasites have been linked to significant otter mortality events. The southern sea otter population can ill-afford such an assault. Found only along the California coast, this federally listed threatened species now numbers fewer than 3,000 individuals. Despite more than 70 years of state and federal legal protection, the population has failed to significantly increase its numbers or reclaim large expanses of its historical range.

Although fecundity appears to be normal, mortality is extremely high, with approximately 10 percent of the population found dead each year. A high proportion—40 to 64 percent—of necropsied southern sea otters have died as a result of exposure to pathogens and toxins (Thomas and Cole 1996, Kreuder *et al.* 2003). Though there are no simple explanations, evidence suggests that high mortality and failure of population recovery are associated with various forms of environmental degradation and exposure to chemical and biological pollutants flowing from land to sea.

A Parasite's Deadly Path

Sea otters are near-shore feeders, often foraging within sight of land and near river mouths and bays that efficiently concentrate and retain plumes of surface-water runoff (Estes 1997, Jessup *et al.* 2004 and 2007, Miller *et al.* 2010a). The otters often selectively feed on marine and estuarine invertebrates such as clams and mussels (Tinker *et al.* 2008), which are highly efficient bioaccumulators of toxins and organisms flushed into the ocean. One of the more significant biological pollutants that accumulates in bivalves are protozoan parasites like *T. gondii.*

First reported in sea otters in 1996, *T. gondii* infections rapidly became a major focus of sea otter disease research (Thomas *et al.* 1996, Fayer *et al.* 2004, Miller *et al.* 2002a, 2002b, 2004, and 2008, Johnson *et al.* 2009, Massie *et al.* 2010). This was due in part to a high level of public interest and to potential human health implications. While its importance to otter population recovery may be debated, there is little doubt that the sea otter-*T. gondii* connection is one of the clearest examples ever documented of ocean pollution by terrestrial-origin pathogens.

The unique life cycle of *Toxoplasma gondii* is highly complex (see diagram). Only domestic and wild felids—including domestic cats, bobcats (Lynx rufus), and mountain lions (Felis concolor)-are known to serve as definitive hosts that support the sexual phase of the parasite's life cycle. T. *qondii* initially reproduces in the lining of cats' intestines; cats then shed the parasite's highly infective oocysts in their feces. The feline host is able to pass 100 million oocysts in its feces over 10 to 14 days (Conrad et al. 2005), and these oocysts may remain viable for months or even years under optimal conditions. By ingesting food or water contaminated with oocysts, essentially any warm blooded mammal can become infected. Invertebrates, like clams and mussels, may act as paratenic hosts (which simply store the oocysts) for weeks or months. However, a more common and efficient means of transmission occurs when cats or other carnivores ingest an infected inter-





mediate host (such as a rodent or bird) and its tissue-cyst stage parasites (Conrad *et al.* 2005).

The majority of marine mammal infections by *T*. *gondii* are thought to result from oocyst ingestion, primarily because sea otters and most other marine mammals rarely, if ever, consume recognized intermediate hosts for *T. gondii* such as rodents and birds (Thomas *et al.* 1996, Conrad *et al.* 2005). The high level of otter infection suggests that environmental contamination by oocysts is extensive where definitive hosts (cats) are present. Additional factors such as enhanced parasite infectivity or pathogenicity, novel host-parasite interactions, and multiple-species protozoan parasite infections could also influence susceptibility in marine mammals to disease caused by *T. gondii* (Jessup *et al.* 2007, Miller *et al.* 2010b).

Ingestion of even a single sporulated oocyst can cause infection in sea otters or other animals (Conrad *et al.* 2005). Once ingested, the parasites leave the intestinal tract and spread systemically. This may cause serious disease immediately, but more commonly the effects are delayed. As host immunity is generated, a "resting stage" is produced that resides within tissue cysts in the cytoplasm of host cells. Tissue cysts persist for months to years, leading to chronic, perhaps lifelong infection. When host immunity wanes later in life due to other infections, intoxications, or pregnancy, the parasite can reactivate, leading to severe clinical disease that destroys portions of the brain, heart, and other vital organs. This parasite recrudescence may be an important reason for the development of clinical toxoplasmosis in *T. gondii*-infected marine animals, including sea otters (Miller *et al.* 2008, 2010b).

The Science Points to Cats

Based on proximity and sheer numbers, outdoor pet and feral domestic cats may be the most important source of *T. gondii* oocysts in near-shore marine waters. Mountain lions and bobcats rarely dwell near the ocean or in areas of high human population density, where sea otter infections are more common. One study of an area around three small towns near the California coast found that domestic cats could deposit up to 106.4 tons of feces per year, or approximately 97 oocysts per square meter of soil (Dabritz *et al.* 2007). Area rainfall can wash some of that contaminated soil into the ocean. In addition, cat feces from private yards or city gutters can wash into storm drains that flush into the sea. The use of

Insidious Cycle

The protozoan parasite Toxoplasma gondii reproduces in the intestines of cats and other felids, the definitive hosts for the parasite. Cat feces carry the parasite's infective oocysts into the environment, where they can be ingested by intermediate hosts (such as birds or rodents), that may then infect predators. When washed into marine environments. the oocysts can be absorbed into filterfeeders such as clams and mussels, which, if ingested, can infect sea otters and other marine mammals.

Gredit. Sara D. Willer







Credit: Liz vanvvor

A sea otter swims near a pile of animal feces (likely a dog's) on the shore of Monterey Bay in California. The shot symbolizes a serious threat: When cats defecate near water, feces-borne parasites that cause toxoplasmosis can wash into the Bay and infect endangered sea otters, a risk to the species' survival.

• *T. gondii* oocyst uptake by marine bivalves has been demonstrated both experimentally (Lindsay *et al.* 2001, Arkush *et al.* 2003) and under natural conditions (Miller *et al.* 2008).

flushable cat litter may in-

crease the loading of sewage effluent with *T. gondii* oo-

cysts. These oocysts are not

killed by traditional sewage

treatment-one impetus for

California's law discourag-

ing pet owners from flushing

litter and requiring warning

labels on litter sold in stores.

Researchers increasingly recognize the importance

of terrestrial runoff in the

dissemination of T. gondii

oocysts to humans and marine

mammals (Bowie et al. 1997,

Aramini et al. 1999, Miller

et al. 2002b, 2008). Among

recent studies that highlight

Oocysts can contaminate

water or be taken up by

fish (Massie *et al.* 2010)

et al. 2001, Arkush et al.

2003, Miller et al. 2008).

and invertebrates (Lindsay

the problem:

- Once ingested by invertebrates, *T. gondii* oocysts may remain infectious for at least 14 days (Arkush *et al.* 2003).
- Marine snails, clams, and fat innkeeper worms also appear to be prey items with a high risk of infecting otters with protozoan parasites like *T. gondii* (Johnson *et al.* 2009).
- Oocysts can sporulate in seawater and remain infectious for at least six months (Lindsay *et al.* 2003).

Additional studies in central California have identified high-risk areas for *T. gondii* exposure and disease in sea otters, including the Monterey and Morro Bay areas (Miller *et al.* 2002b, Kreuder *et al.* 2003 and 2005, Johnson *et al.* 2009). Characteristics shared by these high-risk areas include proximity to more dense human (and cat) populations and to high-outflow creeks, streams, and rivers or to large enclosed bays with limited tidal exchange (Miller *et al.* 2002a and 2002b, Johnson *et al.* 2009). It is worth noting that populations of northern sea otters (*Enhydra lutris kenyoni*) in Alaska, which have considerably higher rates of population growth, have far lower evidence of exposure to *T. gondii*, presumably because of minimal human population centers, sparse distribution of feline definitive hosts of *T. gondii*, and harsh winter weather, which limits the overwinter survival of feral domestic felids and leads to hard freezes that may kill oocysts.

Ecological Dominoes

The health and stability of near-shore marine ecosystems are dependent on the health and stability of populations of keystone species that help structure their habitat. For the kelp forest communities off California's coast, the primary keystone species is the sea otter. Diseases and other causes of mortality that inhibit normal population recovery may therefore threaten the health of the entire ecosystem.

If the cat-related threat to California's sea otters and coastal ecosystem isn't enough to cause public concern about T. gondii infection, then perhaps the associated human health implications will raise the alarm. The evidence is mounting that *T. gondii* can cause a variety of human health problems, notably fetal brain developmental abnormalities and fulminant systemic and neurologic disease in immune-compromised people (see article on page 58). Its presence in marine invertebrates constitutes a risk for human communities that harvest or eat uncooked shellfish. In addition, researchers have recently linked T. gondii exposure to a number of neuro-inflammatory diseases, including but not limited to autism spectrum disorders, Alzheimer's, and Parkinson's disease (Miman et al. 2010, Pandota 2010, Gulinello et al. 2010).

The scope of this ecological and public health threat clearly extends far beyond a simple headline that "a parasite in cat feces kills endangered sea otters." It's fair to say, however, that sea otters, other marine mammals, near-shore marine ecosystems, and the health of humans enjoying California's ocean would be better served if cat fecal contamination could be significantly reduced in the outdoor environment.

This article has been reviewed by subject-matter experts.



To see a full bibliography and additional resources about toxoplasmosis in marine environments, go to *www.wildlife.org*.

By Land and by Sea

THE WIDESPREAD THREAT OF FERAL CATS ON HAWAIIAN WILDLIFE

By Steven C. Hess, Ph.D.



Steven C. Hess, Ph.D., is a Research Wildlife Biologist with the U.S. Geological Survey Pacific Island Ecosystems Research Center in Hawaii. High on the slopes of Hawaii's Mauna Loa volcano, National Park Service biologists recently discovered the mangled remains of three band-rumped storm-petrels (*Oceanodroma castro*), Hawaii's rarest seabird. Discovered at the end of the nesting season in the fall of 2010, the birds had been depredated by feral cats. Band-rumped storm-petrels are a candidate endangered species, but because of their extreme rarity, little is known about them (Slotterback 2002). Often, the only time these small nocturnal birds are seen ashore is after they have been killed by feral cats, the predominant predator in the harsh alpine environment of the storm-petrel's nesting grounds.

This recent case is just one of many that point to the severe impact that non-native domestic cats are having on Hawaiian wildlife. Although there are no hard numbers on cat populations, clearly many thousands of cats dwell on each of the Hawaiian Islands, ranging across all habitat types—from the ocean to alpine zones, from rainforests to deserts.

The first domestic cats (*Felis catus*) did not arrive in the Hawaiian Islands until Europeans "found"



The dismembered bits of endangered palila chicks mark the visit of a feral cat. Palila are endemic passerines that live in dry subalpine woodlands of Mauna Kea, where feral cats depredate about 11 percent of palila nests each year.

the remote archipelago in 1778. Never having seen domestic cats, native Hawaiian people must have been fascinated by the tame predatory mammals that served as mousers on ocean-voyaging ships (Tomich 1986). Cats were taken from the ships and quickly escaped into the wild, where there was no other similarly sized competitor. Feral cats ultimately became the most widespread *de facto* apex predator throughout Hawaii.

The first known written record of "wild cats" came from the remote wilderness of Kilauea on the Island of Hawaii (Brackenridge 1841). They soon became famously abundant in Honolulu, where Mark Twain described seeing "companies of cats, regiments of cats, armies of cats ..." (Twain 1872). The effects of these armies on native wildlife soon became apparent. In 1903, English naturalist R.C.L. Perkins wrote: "On Lanai, in walking up a single ravine, I counted the remains of no less than twenty-two native birds killed by cats." Many of the bird species Perkins observed on Lanai are now extinct, as is more than half of Hawaii's native avifauna. Although cats are not solely responsible for these extinctions, they nonetheless have played a significant role and continue to decimate Hawaii's remaining endemic wildlife, not only by direct predation, but also by carrying lethal pathogens.

A Mounting Toll on Rare Species

In the dry subalpine woodlands of Mauna Kea, 11 percent of the nests of endangered palila (Loxioides bailleui) are now depredated each year by feral cats (Hess *et al.* 2004). That percentage may not seem extreme, but the toll extends. Adult females are also killed on their nests, likely explaining the skewed sex ratio in this forest bird, which is not adapted to mammalian predation. Moreover, the nestling development period for the typical two-chick brood is 25 days, nearly twice the length of continental species (Banko et al. 2002). This leaves nestlings vulnerable to predation for nearly a month. The compounded effects of cat predation may be one of the most easily managed threats to the continued existence of palila, which are currently in a precipitous eight-year population

decline largely related to habitat loss and drought (Leonard *et al.* 2008, USGS unpublished data).

The endangered Hawaiian petrel (*Pterodroma sandwichensis*) faces similar threats. Extirpated from remote alpine nesting grounds on Mauna Kea, Hawaiian petrels now exist only in small colonies on Mauna Loa and other islands, where these seabirds are vulnerable to depredation by cats (Simons and Hodges 1998). The loss of an adult petrel can be particularly devastating to local populations because of the species' delayed maturity. Individuals must attain five to six years of age before breeding. They hatch out single squabs, which must be fed for as long as 90 days. Petrels locate their nests in burrows below barren lava, unprotected and exposed to the vagaries of cats while adult petrels forage far off the coasts of Alaska and Canada (Adams 2007).

Predation by cats on these two endangered bird species has been well documented with remote camera images and videography. Researchers have also used telemetry to study the home ranges and activity patterns of cats—and the results are ominous. A study of radio-collared cats on Mauna Kea shows that males can range up to eight square miles, rivaling the largest home range of cats anywhere in the world (Hess and Banko 2006). Most of these long-range wanderings occur at night, when birds are settled on their nests and therefore more vulnerable to predation.

The Unseen Threat of Disease

Less conspicuous but potentially as harmful as direct predation are the effects of cat-borne toxoplasmosis on a host of native wildlife. Fatal toxoplasmosis has occurred in the endangered nene or Hawaiian goose (Branta sandvicensis), the critically endangered Hawaiian crow (Corvus hawaiiensis), and the red-footed booby (Sula sula) (Work et al. 2000, 2002). Cat feces that wash into the ocean may also cause fatal toxoplasmosis in marine mammals (see article on page 62). Toxoplasmosis has caused the death of at least one endangered Hawaiian monk seal (Monachus schauinslandi) on the coast of Kauai (Honnold et al. 2005), and research shows that T. gondii oocysts can sporulate in seawater and infect seal and dolphin species (Lindsay et al. 2003).

It is impossible to know the extent of cat-related infection and mortality in marine mammals around the vast waters of the Hawaiian Islands, or even in the terrestrial wildlife on Hawaii's relatively small land area. Yet the National Park Service, U.S.







Geological Survey, and other federal and state agencies working in Hawaii are so concerned about the potential disease and predation impacts of feral cats that they are beginning to install predator-proof fences and are considering the removal of cats from smaller islands. Such steps may be the last best

This article has been reviewed by subject-matter experts.

hope for the rare native birds of Hawaii.

To see a full bibliography and additional resources about feral cats in Hawaii, go to *www.wildlife.org.* Credit: Dan Goltz

A researcher attaches a transmitter to an anesthetized feral cat (top) that will later be tracked (above) as part of a movement and home range study on Mauna Kea. The study found that the mean home range for feral cats at the site was the second largest reported in the literature. The home range for one male cat was 2.050 hectares, and 610 hectares for a female.

An Issue with All-Too-Human Dimensions

IT'S PEOPLE, NOT SCIENCE, AT THE HEART OF THE CAT DEBATE

By Christopher A. Lepczyk, Ph.D., Yolanda van Heezik, Ph.D., and Robert J. Cooper, Ph.D.



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at Manoa.

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The debate over outdoor cats is often over-simplified as one between people who love cats and those who don't, the latter typically assumed to include wildlife biologists, conservationists, and ornithologists. In reality, most scientists and



Harsh language on a hand-written sign reflects the extreme frustration of a New Jersey resident angered at finding an unattended litter of kittens at the back of an office complex. When outdoor cats become over-abundant they can be perceived as a public nuisance, generating concern about disease, predation, and property damage.

wildlife managers do not hate cats—many fondly care for pet cats themselves. Rather, they hate what free-roaming cats do to other species and the environment. Thus the debate is predominately about whether cats should be allowed to run wild across the landscape and, if not, how to effectively and humanely manage them. It's much more about human views and perceptions than science—a classic case where understanding the human dimensions of an issue is the key to mitigating the problem.

A Complicated Bond

Our attitudes towards cats are complex and diverse, the product of a relationship that is thousands of years old. Cats are heroes (killers of vermin, companions) and villains (carriers of disease, predators of wildlife). They're enigmatic, attractive, and amusing. Addressing the problem of cats therefore requires an understanding of the cultural, psychological, and socio-economic drivers that shape peoples' attitudes and motivations. Unfortunately, little research to date addresses these issues.

The complexities of the cat problem also serve to focus our attention on wider issues relevant to urban conservation management. We need to understand whether people are even aware of the cumulative impact that their actions-choosing to let cats outdoors-can have on wildlife populations. Do they understand the struggles of urban species to survive where the odds are stacked against them? How much value do people place on natural diversity in their environment, and are they conscious of their own views on what is natural and what is not? Have they thought about how what they see as their right to let cats roam freely stacks up against the rights of other animals to survive? These are difficult questions that give rise to difficult decisions, but all people should be exposed to these issues as part of their formal education.

The cat problem exemplifies the disconnect between humans and nature. Addressing the problem therefore requires that wildlife biologists collaborate with

OF FREE-ROAMING CATS

social scientists and psychologists, and exert their influence politically. Some jurisdictions in Australia have had success with this approach, where a combination of legislation and public education has led to acceptance of strict control measures, such as indoor confinement of pet cats. In many countries, however, the right to allow cats to roam outdoors is largely unquestioned and unchallenged. Furthermore, when it comes to exerting influence, cat advocates clearly have the edge.

In Athens, Georgia, for example, county commissioners were bombarded with information for months before voting last year to legalize TNR (trap-neuter-release) for cat management. Wildlife professionals who opposed TNR used scientific literature to make their points, but so did TNR advocates. In some cases, both sides even cited the same articles as supporting their positions! The commissioners were understandably confused and frustrated (Meyers 2010). It was also obvious that TNR advocates had been lobbying the commissioners (some of whom fed feral cats themselves) long before anti-TNR conservation scientists entered the debate. In the end, the professional opinion of wildlife biologists counted no more than that of any other citizen, a major reason for the defeat. The lesson is this: Scientists and others who hope to convince leaders to favor wildlife conservation over free-roaming cats should be prepared for a long and intense confrontation with zealous, committed, and well-funded cat advocates.

Combating Polarization

Because both sides of the cat debate are fairly entrenched, it is unrealistic to think that all stakeholders are going to settle on a single unified approach to address the cat problem. However, there are ways to move forward (Lepczyk *et al.* **2010**). One approach is exemplified in Hawaii, where we've become part of a large coalition of stakeholders working together with the shared goal of reducing and eventually removing feral cats from the landscape.

Our diverse group includes individuals from the Humane Society of the United States, the Hawaiian Humane Society, the U.S. Fish and Wildlife Service, the National Park Service, Hawaii's Department of Land and Natural Resources, and the University of Hawaii. Our team also regularly interacts with other groups around the nation such as regional



Audubon Societies and the American Bird Conservancy. Several stakeholders in the group have differing views, such as on whether or not euthanasia or culling is appropriate, or whether people should feed feral cats. However, the coalition has agreed to certain broad actions, such as first addressing feral cat colony issues in locations with critical habitat for endangered species, and acknowledging the need to address the social and legal aspects of responsible pet ownership. Overall, the notably positive aspect of this group is that a shared goal exists of ultimately removing cats from the landscape. This common purpose enables us to collaborate on solutions and keep moving forward.

Working groups such as this are essential given that the issues related to outdoor cats are so diverse and emotional. Activists on both sides of the issue too often present polarized viewpoints that only obscure the truth and exaggerate the divide. In Wisconsin in 2005, for example, cat advocates protested angrily when free-roaming cats were legally reclassified as a non-native species (Lepczyk 2005). Likewise, the views published on many proferal-cat websites are often vitriolic and demonize opponents, which can simply inflame scientists and wildlife managers. And though TNR advocates often claim that public opinion favors TNR over the lethal control of feral cats, there is little evidence to support this claim; in fact, the vast majority of the public is generally apathetic or ignorant of the

Credit: Pawtrait Persians

Fit for pampered felines, outdoor enclosures such as this in New Zealand-complete with fans, lighting, climbing structures, litter boxes, and snug cat housesallow doting pet owners to give cats fresh air without allowing them to roam freely. Such containment could help solve the split between cat lovers and conservationists.

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issues regarding free-roaming cats (Ash and Adams 2003). Without concerted effort to work on the problem in a professional, collaborative manner that acknowledges all the differing viewpoints, the debate is likely to become more divided and negative, resulting in lawsuits rather than solutions.

Because the debate over free-roaming cats is much more about conflicts in human values and emotions than science, we must use a multi-pronged approach to making progress. This requires focusing on three main means to move forward: legal or policy changes, incentives, and increased education (including extension). For these approaches to be most effective, they will require collaborative partnerships such as the one in Hawaii. Considering the rapid rise in the numbers of pet cats (Lepczyk *et al.* 2010), which is likely mirrored by increases in feral cats, it is critical to increase all of these efforts. According to McGill University ornithologist David Bird, changing attitudes towards feral cats is likely to take 50 years, so it's high time we got started.

A New Zealand Perspective

By Yolanda van Heezik

In New Zealand, there are no regulations to limit the free-ranging behavior of cats or the number of cats that people can own. I find this extraordinary in a nation that directs enormous conservation efforts towards control of other introduced predators. New Zealanders are generally very pragmatic, even enthusiastic, about controlling mustelids, rats, or brushtail possums to protect native biodiversity. Yet domestic cats have remained under the radar, despite nationwide media coverage of cats preying on native wildlife.

Part of the problem is that the "cat issue" is seen more as a question of public nuisance or cat welfare than of wildlife conservation. That was clear when I approached my own city council to outline the impacts of cat predation and discuss mitigation measures such as 24-hour cat confinement and designated no-cat zones. The response was incredulity. Confinement of cats is considered unnatural and cruel.

Most publically acceptable mitigation measures to reduce cat predation serve only as sops for our conscience and prove ineffective or baseless. For example, some guidelines suggest keeping a cat well-fed, yet there is no evidence that this curtails predation. Some suggest keeping cats indoors at night, though that doesn't protect diurnal species such as birds and reptiles. Registering and microchipping cats can distinguish between pets and strays, yet that's irrelevant in terms of predation. Collar-mounted bells, bibs, and sonic devices can reduce catch rates but don't eliminate the problem.

Cat-free zones around areas of conservation concern are equally well-meaning but probably ineffective. When we investigated how large such zones would need to be to effectively exclude cats, we found that cats expand their home ranges to fill available space, covering tens of hectares in rural areas (Metsers *et al.* 2010). Clearly 24-houra-day confinement of cats inside homes or backyard enclosures is the only truly effective measure to stop cats from catching wildlife.

A fundamental problem behind calls for such cat regulation is the lack of studies conclusively showing that urban pet cats are responsible for wildlife declines. Many studies show that cats collectively kill large numbers of prey, and that cats exist in high densities of between 200 to 1,580 per square kilometre in urban areas. However, it's unclear to what extent declines in wildlife can be attributed to cats versus other human-related modifications to urban landscapes. Such data are difficult to obtain because it is not feasible to manipulate cat ownership for study purposes, and research around new sub-divisions with cat regulations are likely to be hampered by difficulties of replication and habitat matching.

If a precautionary approach is adopted in the absence of solid evidence, some understanding of public attitudes towards cats and control measures is necessary. My impression is that cat owners in New Zealand are unaware of the cumulative impacts of cat predation, so owners will be reluctant to accept that their pets should be regulated. In addition, many people don't perceive urban areas as a home for wildlife. Unless we can foster a greater awareness and appreciation of urban wildlife, the bottom line for most people will be preference for their feline friends over native species.



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The Cat Conundrum

By Colin Gillin, DVM



Credit: Peregrine Wolff

Colin Gillin, DVM, is President of the American Association of Wildlife Veterinarians.

Yve had my share of cats; even was owned by a few. Nearly 25 years ago I lived with a demure calico. An indoor-outdoor cat, she once brought home a prairie dog that was nearly half her size, a gift from a nearby burrowing owl colony in Cheyenne, Wyoming. The conquering of this hefty rodent showed what pernicious predators cats can be—and started my curiosity about the effects of pet, stray, and feral cats on wildlife.

More recently, a feral cat took up residence under the deck of my home in the heavily wooded, rural foothills of western Oregon. I assume it had been abandoned by an owner. Almost right away I began to notice the effects of this new predator on native woodland wildlife. The first victims were garter snakes, whose sole job (in my opinion) is to keep the never-ending population of slugs under control. Finding half-eaten, headless serpents lying about the deck, I realized that the predator-prey balance in my vard would shift unless I did something about the cat. I captured it with a live trap and, as a veterinarian, I was able to apply humane chemical euthanasia. However, this is generally not an option for the millions of people who may face a similar situationand have varied opinions on how to deal with it.

I'm well aware that conservation means different things to different people. From a biological perspective, it might be defined as "to preserve or protect species, their habitats, and ecosystems from extinction." For others, it might mean "to prevent any loss" including that of a non-native predator. The person who may have released an unwanted cat into my rural neighborhood might have assumed that the cat would live as one with nature, in conservation harmony, as if in a Disney movie. Yet its life came at the expense of the resource and caused conservation "disharmony" with the native snakes, rodents, and birds that it killed to survive.

Statistics about cat numbers vary widely, but all are mind-boggling. By some estimates, 60 to 100 million stray or feral cats live in the U.S. alone, and an additional 60 million or more pet cats are allowed outdoors to roam free (Dauphiné 2010, Jessup 2004). Those numbers equate to a lot of carnage. Programs to control free-roaming cats range from education to trap-neuter-release (TNR) to total removal. Many well-meaning communities have bought into the TNR concept only to find out that it is expensive and fails to effectively decrease feral cat populations. TNR cat colonies often increase in size, in part because many of these populations are not closed, so sterilization of all individuals is nearly impossible. More important, when feral cats are left on the landscape, sterilized or not, they will prey on native wildlife and degrade food supplies, water, and other resources.

The ecosystems where cats are placed evolved with a suite of appropriate endemic wild species, each filling their respective niches and using their available resources for survival. Artificially adding a highly adaptive, invasive species that's capable of successfully exploiting those resources changes the dynamics of the ecosystem. Competition for limited prey, population declines through predation, direct and indirect effects on habitat, and introduced diseases carried by cats to other animals and humans are just a few of the negative consequences of feral cat introductions.

Cats are just one in a long list of invasive species that have triumphed over natives. Goats, rats, brown tree snakes, nutria, and myriad invasive plants have all made a go of it in various locations. But cats offer a classic case of why prevention is far preferable to control. Getting "Pandora" back in the box is extremely difficult, particularly given that not everyone agrees there is a problem.

The Tricky Politics of Pets

The debate over how to acceptably manage one of the most-owned pet species quickly shifts from statistics to politics to emotional arguments. Cat owners or supporters of TNR may not realize the impact of feral cats on wildlife and landscapes, creating a disconnect in philosophy and communication. These folks are *not* anti-wildlife, and may in fact bird watch, visit national parks, and support conservation groups. However, the extent of their support for TNR means that we haven't done our job of communicating the perils of allowing feral cats to negatively

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Why the Move to WSB?

As much as I like The Wildlife Professional (TWP), I couldn't help but wonder why the leadership of The Wildlife Society doesn't use it more to gauge member thoughts on such topics as reinstating the Wildlife Society Bulletin (WSB). I recall a few articles explaining how WSB differed from The Journal of Wildlife Management (JWM), but I was never clear on the difference. I thought covering research in JWM and policy and news in TWP made great sense. Now that we are going back to WSB as a third periodical, I'd appreciate an article in TWP to explain the demand and the expected difference among the three publications. I am not deriding the decision, but I would have liked to read an article explaining the perceived gap in coverage when I learned that WSB would be back, rather than a short decree. Keeping the membership informed is

more than just providing bulleted notes of what measures have been passed by the Council; it should explain some background on issues, the pros and cons, and why a path was chosen.

Brian Scheick, Certified Wildlife Biologist Bear Research Program, Fish and Wildlife Research Institute, Florida Fish and Wildlife Conservation Commission Deltona, FL

Correction

In the Field Notes department of the Winter 2010 issue of TWP, we left off the name of a contributor to the item "Aerial Surveys of Prairie Chicken Leks." In addition to Jon McRoberts, Jennifer Timmer should have been listed as a co-submitter of the Field Note. She provided information for the write-up and participated in the research described. We regret the omission.

Leadership Letter

(continued from page 10)

affect the public's wildlife resources. This impact is only amplified when including the armies of pet cats allowed outdoors.

Conservation must involve practices and policies that sustain biodiversity and protect healthy ecosystems. TNR and feral cat colonies do neither. The risks from feral cats to humans and other wildlife are well documented in the literature, including zoonotic transfer of toxoplasmosis and rabies, both with proven lethal consequences. Allowing feral cats to thrive outdoors is clearly not an option for sustaining conservation.

Finding solutions to controlling invasive species like feral cats, however, will involve dialogue among all stakeholders and effective communication with all members of the public, particularly cat owners. The welfare of free-ranging cats must be a part of this equation, similar to the welfare of wildlife. If removal and euthanasia of unadoptable feral cats is not acceptable to TNR proponents, then they need to offer the conservation community a logical, science-based proposal that will solve the problem of this invasive species and its effect on wildlife and the environment.

On the conservation side, The Wildlife Society recently initiated efforts to develop a coalition of federal and state partners and non-governmental organizations to share information and develop a consensus position on feral-cat policy. This effort is a monumental step toward combating an invasive species on the landscape. Participating in this effort, the Wildlife Disease Association and American Association of Wildlife Veterinarians add depth to the discussion by providing perspectives on wildlife disease issues and environmental health.

As with all contentious issues—particularly those involving domestic or wild animals—saying that a problem doesn't exist does not make it go away. By working in coalition with natural resource professionals as well as cat advocates, we may not come to consensus, but we can likely find common ground.



Crimes Against Nature?

This Spring 2011 issue of The Wildlife Professional launches our fifth year of publication with a bang of controversy-and irony. It features a package of articles about the impacts of free-roaming cats on native wildlife, and also describes the extraordinary efforts that wildlife biologists are making to save wetland habitats, often to benefit bird species. Readers will learn that outdoor cats in the



Credit: Ruxandra Giur

United States kill more than one million birds every day on average, and about twice as many other small creatures. At the same time that cat numbers are on the rise, nearly one-third of the bird species in the U.S. are endangered, threatened, or in decline. So, while we humans devote time and money to restore habitat for birds, we're letting cats outside to kill them. Ironic indeed.

Cats aren't the only culprits in bird declines, of course. The usual litany of human development, habitat loss, disease, and pollution all take a serious toll on birds and other wildlife. But by allowing cats to roam freely, humans are pushing some species toward the tipping point.

Free-roaming pet, stray, and feral cats now number roughly 120 million in the U.S. alone. These nonnative predators are instinctive hunters that prey on native wildlife wherever it's found, from urban parks and backyard bird feeders to "protected" wildlife refuges and island ecosystems. Numerous scientific studies show that cats are causing wildlife declines, yet the science doesn't seem to make a dent in human behavior.

Why do people let cats outdoors, and why do increasing numbers support outdoor trap-neuter-release (TNR) cat colonies, where cats are free to prey on area wildlife and spread disease? The answer, of course, lies in human hearts. Beloved as pets, cats melt hearts and win champions, who go to great lengths (and expense) to support TNR and the "rights" of cats to live outside. But what about the welfare of native wildlife?

Well-meaning cat owners may believe that their pets can't possibly impact the balance of nature. Yet the articles in this issue should inspire all of us to do the math and face the truth: Cat predation has devastating consequences for wildlife. And though the cats are innocent creatures doing what comes naturally, people who allow cats outdoors are effectively complicit in crimes against nature, defying the Endangered Species Act and the Migratory Bird Treaty Act.

The Wildlife Society takes a strong stand on this issue, which will undoubtedly draw fire from cat advocates. Part of the role of this magazine, however, is to air controversial issues and offer sciencebased information that can inform debate. Perhaps a rational scientific look at the impacts of outdoor cats will bring reason to the table-and give birds and other small animals a shot at survival.

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