Reassessment

A Closer Look at "Critical Assessment of Claims Regarding Managment of Feral Cats by Trap-Neuter-Return"

In late 2009, *Conservation Biology* published the essay "Critical Assessment of Claims Regarding Management of Feral Cats by Trap-Neuter-Return" by Travis Longcore, Catherine Rich, and Lauren M. Sullivan. The paper was immediately embraced by groups opposing Trap-Neuter-Return (TNR), quickly appearing on various Web sites, including, for example, that of the American Bird Conservancy. Careful scrutiny of the author's claims, however, reveals glaring omissions, blatant misrepresentations, and obvious bias.

The authors of the paper are hardly disinterested parties. The Urban Wildlands Group—for which Longcore serves as Science Director, and Rich as Executive Officer—was the lead petitioner in a case (LASC BS115483) aimed at ending city-funded/promoted TNR in Los Angeles [1]. There's nothing inherently wrong with scientists shaping public policy—indeed, the scientific community is too often under-represented or left out entirely. But it's absolutely essential that they not be given a "pass" simply because of their degrees, titles, or professional associations. Sound policy making requires that their assertions, like those of any other stakeholder, must stand up to rigorous review.

What follows, then, is a brief[a] review of "Critical Assessment," focusing primarily on the authors' claims regarding the impact (both direct and indirect) of free-roaming cats on wildlife, and the efficacy of TNR as an approach to managing feral cats.

a Lengthy excerpts are included throughout for two reasons: (1) Too often, TNR opponents interested more in "selling" their claims than supporting them with rigorous science oversimplify the complex issues at the heart of the debate; the resulting sound bites, however, do little to move the discussion forward; and, (2) Readers who may not have easy access to the publications cited will be able to get a sense of the larger context.

1. PREDATION BY CATS

Longcore et al. cite several research studies in their attempt to show a causal relationship between predation by cats—or, in some cases, even their mere *presence*—and declining bird populations. Most predation studies, however—including several of those the authors endorse—don't hold up well under close examination. More troublesome, though, as far as the authors' central argument is concerned, is the fact that predation—even at significant rates—does not necessarily lead to population-level impacts. Indeed, it's been shown that birds killed by cats are often unhealthy relative to those killed due to non-predatory events (e.g., window collisions), though Longcore et al. make no mention of this critical distinction.

Much of the research designed to estimate the number of birds killed by cats, including most of that cited by Longcore et al., is deeply flawed—case studies in "proofiness," to borrow a term from Charles Seife's 2010 book. Proofiness, writes Seife, is "the art of using bogus mathematical arguments to prove something that you know in your heart is true—even when it's not" [2].

Among the numerous factors that contribute to erroneous estimates are unfounded assumptions regarding the proportion of cats that actually hunt, the number of cats allowed outdoors and their hunting behavior, cat densities across various habitats, and so forth. Often, this is on top of inflated predation levels, the result of researchers incorrectly using a simple average—or, *arithmetic mean*—to describe sample distributions that are highly skewed. Researcher David Barratt found that "median numbers of prey estimated or observed to be caught per year are approximately half the mean values, and are a better representation of the average predation by house cats based on these data" [3]. Analysis of one large, well-documented study [4] suggests less dramatic, but significant, differences: medians approximately 62 percent (for mammals) to 73 percent (for birds) of corresponding means. Analysis

* Adapted from a series of posts on the blog Vox Felina; revised December 2010. Contact author: peter@voxfelina.com

of another often-cited study [5] reveals a median approximately 65 percent of the mean (for all prey returned). Researchers using the mean instead of the median are, in other words, probably overestimating predation estimates by 40–100 percent,[b] as shown in Figure 1.

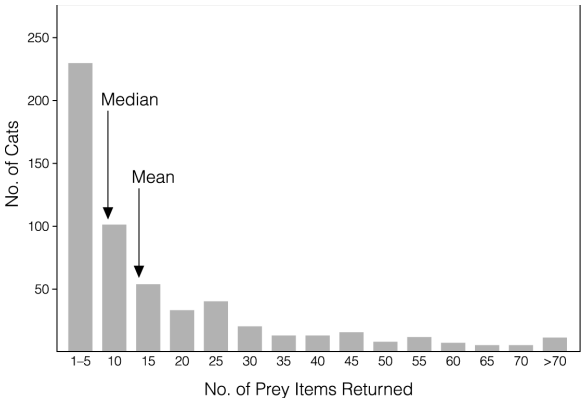

Figure 1. Using the arithmetic mean to describe distributions of prey killed/returned substantially overestimate predation levels. Medians, which can be 50–75 percent of means, better represent "average" levels of predation. (Adapted from Woods et al. [4])

But it's not uncommon for researchers to multiply one inflated figure by another—multiplying the average number of prey items caught by the average number of outdoor cats per household (which also happens to be a highly skewed distribution), for example. The resulting estimates may well be *two or three times* greater than actual predation levels—and that's assuming the rest of the study is sound, which is rarely the case. Then, of course, there are the risks inherent in estimating population numbers and characteristics based on small sample sizes, and extrapolating from one habitat or region to another—both common practices. (Of greater concern, though, is the suggestion—and it's typically nothing more than that: a suggestion, without so much as a hint of supporting evidence—that predation levels can be linked directly to population declines. This topic is addressed in detail below.)

Longcore et al., for their part, scarcely acknowledge these shortcomings, choosing instead to present as evidence figures known to be, at best, highly speculative; more often than not, though, they are misleading, deceptive, or just plain wrong. In doing so, the authors give far greater importance to this work than is warranted, not only within the context of their own essay, but also in the larger body of literature. This is simply irresponsible (and here, *Conservation Biology* is implicated as well[c]).

The question of how many birds are killed by cats has, in recent years, became central to the "cat debate." In fact, the question is, in addition to being largely unanswerable, also largely misguided (as discussed below). Nevertheless, the authors summarize some of the best-known studies on the subject, suggesting that the results associated with this work are accurate, meaningful, and relevant.

English Village Study

Among the work cited by Longcore et al. is a yearlong survey in Bedfordshire, England, conducted between August 1981 and July 1982 [5], now often referred to simply as the "English Village Study." As Longcore et al, note, "Churcher and Lawton concluded that cats were responsible for 30 percent of the mortality of House Sparrows in an English village" [7].

The relationship between cat predation and bird populations is highly complex, though, and our understanding quite limited. It doesn't help matters that results of small, isolated studies are often extrapolated from rural to urban environments, one region to another, islands to continents, and so forth. In 1995, Churcher himself cautioned against making such leaps. "I'd be very wary about extrapolating our results even for the rest of Britain, let alone America" [8], he told *Catnip*, a newsletter published by the Cummings School of Veterinary Medicine at Tufts University.

Actually, Churcher went much further, suggesting that the observed predation was compensatory rather than additive: "I don't really go along with the idea of cats being a threat to wildlife. If the cats weren't there, something else would be killing the sparrows or otherwise preventing them from breeding" [8].

Gary Patronek's comments on the English Village Study emphasize the importance of context. "When the birds were counted," writes Patronek, former Di-

b The two key factors determining the extent of this error are (1) the distribution's skewness, and (2) the proportion of cats returning no prey (when this figure is relatively low, the mean is pushed higher; when high, the mean is pulled closer to zero).

c Gary Meffe, editor at the time, declined to publish a letter critical of "Critical Assessment" (upon which "Reassessment" is based), arguing that the topic of TNR, while not "unimport¬ant to conservation… is a fairly narrow and specialized topic." Meffe continued: "Publication of the Longcore et al. paper was nibbling at the margins to begin with, but I and the reviewers felt that it had enough relevance and interest for us to publish it. I am reluctant to further engage the topic in the journal in great detail…" (Personal communication). Nevertheless, less than six months later, the journal published a lengthy comment "applaud[ing] the recent essay by Longcore et al. in raising the awareness about trap-neuter-return (TNR) to the conservation community" [6].

rector of the Center for Animals and Public Policy at the Cummings School, and one of the founders of the Hoarding of Animals Research Consortium, "they represented the postwinter population prior to hatching of spring chicks. By the year's end, the actual sparrow population in the village numbered in the thousands, and the 130 birds caught represented about 5 percent of that number" [9].

Although Longcore et al. cite Churcher and Lawton's now-classic work as evidence of the damage cats can do, they make no mention of Churcher's later comments, or the distinction between compensatory and additive predation—just one of many instances of their tendency to cherry pick from the literature only the bits and pieces that fit neatly into their argument.

"Our estimates … do not equate to an assessment of the impact of cats on wildlife populations."

—Woods et al.

Great Britain

Longcore et al. also cite a more recent UK study, this one "with a larger sample size and geographic area that included England, Scotland, and Wales. From a survey of cat owners that documented prey returned by 696 cats, Woods et al. [4] estimated that the 9 million cats in Britain kill at least… 25–29 million birds… each summer" [6]. But Woods et al. go to some lengths to emphasize the limitations of their study, conceding, for example, that they "may have focused on predatory cats" [4]. Indeed, the authors are quite clear about how their work should—and should *not*—be interpreted: "Our estimates of the total numbers of animals brought home by cats throughout Britain should be treated with requisite caution and these figures do not equate to an assessment of the impact of cats on wildlife populations" [4].

But Longcore et al. ignore the researcher's recommendation, and instead cite their study (along with another one [10] that has nothing to do with population impacts) as "evidence indicat[ing] that cats can play an important role in fluctuations of bird populations" [7].

Wisconsin Study

The most problematic of the bird studies cited by Longcore et al., though, is the infamous "Wisconsin Study" (actually a series of four related articles, the first of which [11] was published in 1989). "In North America," write the authors, "Coleman and Temple [12] developed estimates of cat densities in Wisconsin and associated mortality of 8–217 million birds per year" [7]. More than any other work, the Wisconsin Study has been used to vilify free-roaming cats in general, and TNR in particular—a remarkable accomplishment considering the authors never actually had their predation study published. What Longcore et al. refer to as "estimates" were, in the words of Coleman and Temple, "our best guesses at low, intermediate and high estimates of the number of birds killed annually by rural cats in Wisconsin" [12].[d] These guesses—little more than back-of-envelope calculations—are plagued by several fundamental errors, including:

- Coleman and Temple's "estimate that 23 percent of [cats'] diet consists of birds" [12] is well above the 7–10.5 percent figure suggested by Fitzgerald [14, but see 15 for detailed explanation], one of the world's foremost experts on the subject. In fact, the authors suggest that their study corroborates Fitzgerald's work, making the error all the more egregious.
- The authors assume that all cats hunt; in fact, no study has shown this to be the case. Australian researchers have suggested that only 36–56 percent of cats are hunters [16, 17]. In a pair of related studies, Baker et al. found first that "the majority of cats (51–74 percent) failed to return any prey" [18], and later, "an average of 64 percent of the cats surveyed failed to return any prey" [19]. The prey totals reported by Woods et al. [4] are considerably lower, at 27.3 percent, but nevertheless confirm the error in one of Coleman and Temple's key assumptions.[e]
- The annual predation rates upon which Coleman and Temple base their intermediate and high estimates are flimsy at best. Their intermediate rate

d For a more complete critique, see Goldstein, O'Keefe, and Bickel [13].

e While it's true that cats are unlikely to return home with all they prey they catch, it's equally true that they will bring home items they didn't kill.

was based on a study that involved exactly *four* "urban" cats and *one* rural cat [20]. And, though the authors cite three sources [21, 22, and 23] (the most recent of which was published 40 years earlier) for their high estimate of "at least one kill per cat per day, resulting in over 365 kills per cat per year" [24], *not one of the three mentions any annual predation estimate whatsoever.*

- Finally, Coleman and Temple's figures for cat density were, suggests Merritt Clifton of *Animal People*, an independent newspaper dedicated to animal protection issues, "grossly inflated" [25].

Now 14 years old, the Wisconsin Study has achieved mythical status. Regardless of their dubious origins, its staggering estimates have, time and again, proved too tempting for people looking for a connection between free-roaming cats and declining bird populations. James Tantillo, a Lecturer in the Department of Natural Resources at Cornell University's College of Agriculture and Life Sciences, is right on the money when he refers to Coleman and Temple's guesstimate as an example of a "'mutant statistic' whose origins and genesis have been greatly lost to the people who cite it" [26].

"Those figures... aren't actual data; that was just our projection to show how bad it might be."

— Stanley Temple

Among those who cite it are, of course, Longcore et al. But they fail to mention that Stanley Temple himself admitted the figures he and Coleman developed "aren't actual data." In a 1994 interview with *The Sonoma County Independent*, Temple was asked about their work (apparently referenced in a fact sheet published by the National Audubon Society). Temple—described in the story as "exasperated when asked again to rehash his findings"—told reporter Jeff Elliot, "The media has had a field day with this since we started. Those figures were from our proposal. They aren't actual data; that was just our projection to show how bad it might be" [27].

More than the media, however, it's been the wildlife conservationists and bird advocates who've had a field day with the Wisconsin Study. For example:

- The American Bird Conservancy (ABC) refers to the study in its brochure *Domestic Cat Predation on Birds and Other Wildlife*. But ABC goes one step further, pointing out that Coleman and Temple's estimate was for rural cats, and that "suburban and urban cats add to that toll" [28]. ABC also includes a reference to the Wisconsin Study in its 2010 book, *The American Bird Conservancy Guide to Bird Conservation* [29].
- The U.S. Fish and Wildlife Service cites the study's "intermediate" estimate of 39 million birds in its *Migratory Bird Mortality Fact Sheet* [30].
- A 2009 article in *Audubon* magazine suggests "cats were annually knocking off somewhere in the neighborhood of 8 million birds just in rural Wisconsin" [31]. To the magazine's credit, they used Coleman and Temple's low estimate (a surprise given the overall tone of the article). Still, *none* of the numbers from the Wisconsin Study are scientifically sound (indeed, one can make a strong argument that very little of the work constitutes actual *research*).

For Longcore et al. to cite the Wisconsin Study without even a mention of its numerous flaws, or the public admission by one of its authors that their estimates "aren't actual data," casts serious doubt on their entire paper. Either the authors didn't know about all the holes in Coleman and Temple's work, or they knew and pressed on, ignoring the facts. Neither approach makes for good science, of course.

Estimating the number of birds killed by cats is difficult enough; demonstrating that their predation is the cause of declining bird populations is an even greater challenge. Nevertheless, Longcore et al. suggest the evidence is both plentiful and persuasive. According to the authors, "Comparative field studies and population measurements illustrate the adverse effects of feral and free roaming cats on birds and other wildlife" [7]. But a careful review of these studies reveals a more complex, less direct relationship between cats and wildlife—not to mention a number of the fundamental flaws described previously.

San Diego Canyon Country

"In canyons in San Diego," write Longcore et al., referring to a two-year study by Crooks and Soulé [32], "native bird diversity declined significantly with density of domestic cats" [7]. But the authors, in their effort to draw a straight line between declining bird populations and the number of cats in the area, omit several critical points.

- Longcore et al. fail to mention the density of *people* here—the study site was a "moderately sized fragment [approximately 49 acres] bordered by 100 residences" [32]. Obviously, the development of the area had a significant impact on the wildlife there—which Crooks and Soulé point out repeatedly in their paper.
- The cats included in the study were all pets; it's not clear how their hunting behavior compares to feral cats in general, or managed TNR colonies in particular. Clifton suggests that, in fact, "feral cats appear to hunt no more, and perhaps less, than free-roaming pet cats. This is because, like other wild predators, they hunt not for sport but for food, and hunting more prey than they can eat is a pointless waste of energy" [25].
- According to the researchers, 77 percent of cat owners allowed their cats outdoors—nearly *twice* the rate reported from a national telephone survey conducted around the same time. According to American Pet Products Association (APPA) 1998 National Pet Owners Survey, 56 percent of cats were indoor-only during the daytime, and 68 percent were kept in at night [33]. Rates for 2008 (the most recent data available) are 64 percent and 69 percent, respectively [33].[f] Other surveys have yielded similar results, and also indicate that, of those cats that are allowed outdoors, approximately half were outside for three hours or less each day [34, 35]. The sample of cats used for Crooks and Soulé's study, then, is hardly representative in terms of hunting *opportunity*—an obvious prerequisite for hunting *success*.
- Although Crooks and Soulé suggest their predation figures "are probably underestimates" [32], they actually appear to be excessive. To begin with, they seem (not enough detail is provided in their paper to be certain) to have used a simple average, thereby overestimating actual predation levels (as described previously). In addition, the authors asked residents to estimate annual levels of prey returned home by their cats (in contrast to some studies in which actual prey items are recorded and/or collected). Barratt found that such guesswork exaggerates hunting success: "predicted rates of predation greater than about ten prey per year generally over-estimated predation observed" [3]. At the levels reported by Crooks and Soulé—an average of 56 prey items per year—predicted rates were often twice actual predation rates. Taken together, these two factors alone suggest that actual predation levels might be just a *third* of those suggested by Crooks and Soulé.
- Finally, it's not clear how sites such as this one, which the authors describe as, "undeveloped steep-sided canyons… habitat islands in an urban sea," correspond to other, more common environments. Combined with the high levels of outdoor access for pet cats in the area, the site may well be something of a worst-case scenario—in no way representative of TNR colony sites.

"Predicted rates of predation greater than about ten prey per year generally over-estimated predation observed."

—David Barratt

Alameda County Parks

Longcore et al. describe Cole Hawkins' 1998 PhD dissertation work [36] as a "comparative study," in which it was shown "a site with a colony of feral cats had significantly fewer resident birds, fewer migrant birds, and fewer breeding birds than a control site without cats" [7]. "Ground-foraging species," the authors continue, "notably California Quail and California Thrashers were present at the control site but never observed at the site with cats. Native rodent density was drastically reduced at the site with cats,

f Crooks and Soulé report an average of 1.7 cats/owner, significantly less than the APPA's 2008 figure of 2.45 cats/owner. In terms of overall impact, however, the corresponding reduction in predation doesn't come close to offsetting their overestimations elsewhere.

whereas exotic house mice were more common" [7]. In fact, Hawkins' research methods and analysis are so problematic that the suggestion of a causal relationship between the presence of cats and the absence of birds (or presence of house mice) is highly inappropriate (actually, Hawkins scarcely investigates predation at all).

- Hawkins describes the "cat" and "no-cat" areas as being similar enough that a valid comparison is appropriate, but a closer look at the study suggests otherwise. Indeed, the habitat along the 2.2 km (1.4 miles) transects from which bird counts were conducted varied considerably between the two areas. Compared to the no-cat area, the cat area had 31 percent less chaparral, 183 percent more trees, 52 percent less grass, and 240 percent more "modified" habitat (it's not clear what Hawkins means by "modified"—perhaps habitat that reflects significant human impact). Furthermore, much of the cat area bordered the park's lake and marina, not far from a number of picnic sites (see detailed explanation below).

- Hawkins notes that there were more people in the cat area (often twice as many as were observed at the no-cat area), but dismisses the possibility that their presence may have influenced—directly or indirectly—the numbers of birds and rodents he observed there.

- In addition, pesticides may have played a role in the study's findings. According to a 2002 report (the earliest available online) from the East Bay Regional Park District, "The focus of Lake Chabot's weed control efforts are vegetation reduction within the two-acre overflow parking lot, picnic sites and firebreaks around park buildings, corp. yard, service yard, and the Lake Chabot classroom" [37]. And it's clear from an article summarizing Hawkins' dissertation that the cat area *did* include picnic sites ("…over half of the cat scat in this study was collected under and around picnic tables" [38]). Hawkins' fieldwork was done years earlier, in 1995 and 1996, but if there was any pesticide use during the study period, it may have affected the results—especially if the chemicals were distributed differently across the two areas (which seems likely, given the 2002 report).

- "The preference of ground feeding birds for the no-cat treatment was striking," writes Hawkins. "For example, California quail were seen almost daily in the no-cat area, whereas they were never seen in the cat area." What's more striking, though, is the fact that five of the nine ground-feeding species mentioned in the study showed *no preference for either area*—a point Hawkins downplays, and Longcore et al. ignore entirely. If, as Hawkins suggests, "the differences observed in this study were the results of the cat's [sic] predatory behavior,"[g] then how to explain their remarkably selective hunting practices? "Domestic cats (both house and feral ones) are," as Fitzgerald and Turner point out, "best described as generalist resident predators, exploiting a wide range of prey, and able to switch readily from one prey to another" [39].

- Finally, it's not clear how Hawkins' research constitutes much of a comparative study at all. He chose two sites: one where cats were being fed, and another (approximately two miles away) where cats were not being fed. But Hawkins leaves far too many questions unanswered. For example: What was the cat area like prior to the cats being fed there? Hawkins merely assumes the populations of birds and rodents would have been identical to those found at the no-cat site. What effect did the feeding have? What if the cats were present but had to fend for themselves—what impact would that have on the study? Similarly, were the cats sterilized? Simply put, Hawkins didn't know enough about what was going on at the two sites to conclude, as he does, that his findings can be linked directly and specifically to the cats. Or, more broadly, that "it is not prudent to manage for wildlife and allow cat feeding in the same parks" [36].

Urban Cat Density (Bristol, UK)

Longcore et al. refer to a 2002–2004 study by Baker, Bentely, Ansell, and Harris [18] in which the researchers "calculated that the predation rates by cats on three bird species in an urban area is high relative to annual productivity," suggesting, ultimately, "that the area under study may be a habitat sink" [7]. *Dispersal sinks* or *habitat sinks*, are patches of low-quality habitat unable to sustain a population of a particular species were it not for immigration from higher quality habitat patches—called *sources*—nearby. So, what Baker et al. are suggesting is that predation by area cats may be extensive enough to deplete populations of certain bird species such that at least some of the birds observed at the study site were immigrants from nearby habitat. Their conclusion, though, depends on rather inflated predation rates, as outlined below.

g It should be noted that Hawkins tempered this assertion in his 1999 article [37] summarizing the work: "The differences observed in this study *may have been* due to the cats' predatory behavior" (italics mine).

- The method Baker et al. use for calculating predation rates invariably leads to exaggerated figures. To begin with, they make the all-too-frequent mistake of using a simple average as a statistic to describe a highly skewed distribution, which typically overestimates the average number of prey killed by each cat (though in this case, the very large proportion of cats—51 to 74 percent—that returned no prey may very well offset this effect). More troublesome is the fact that the authors then multiply the average by 3.3, a factor meant to correct for prey not returned home. This multiplier comes from a study [40] plagued by very small sample sizes and its own dubious mathematics.[h] Nevertheless, Baker et al. defend the study: "to the best of our knowledge, this is the only study that has managed to quantify this parameter" [18].

- Also, Longcore et al. fail to mention that Baker et al. concede an important point: "collectively, despite [cats] occurring at very high densities, the summed effects on prey populations appeared unlikely to affect population size for the majority of prey species" [18]. And those "summed effects" were, as described above, greatly overstated.

- In addition, a subsequent study (also conducted in Bristol) involving two of the authors, suggests that much of the predation observed was compensatory rather than additive. That is, many of these birds would have, for one reason or another, died anyhow, whether the cats were present or not. Specifically, the authors found that "birds killed by cats in this study had significantly lower fat and pectoral muscle mass scores than those killed by collisions" [19]. Baker at al. are cautious about these findings, suggesting, "the distinction between compensatory and additive mortality does… become increasingly redundant as the number of birds killed in a given area increases: where large numbers of prey are killed, predators would probably be killing a combination of individuals with poor and good long-term survival chances." But once again, their estimates of birds killed by cats are inflated, first by using the simple average, and then by including the "correction factor" of 3.3, as described above—all of which raises doubts about any level of "redundancy."

- Given the publication date of the second Baker et al. paper, it's possible that Longcore et al. had no opportunity to read it prior to submitting their own. However, they must have known about an earlier, similar study by Møller and Erritzøe in which the average spleen mass of birds killed by cats was compared to that of birds killed in collisions with windows. The authors found that "small passerine birds falling prey to cats had spleens that were significantly smaller than those of conspecifics that died for other reasons," concluding that the birds killed by cats "often have a poor health status" [41]. In other words, the birds killed by cats were among the population least likely to survive anyhow.

Clearly, the issue is more complex—not to mention contentious—than Longcore et al. suggest. Many researchers have disputed the kinds of broad, overreaching claims the authors make about the impact of cats on wildlife. Consider, for example, the following:

- Biologist C.J. Mead, reviewing the deaths of "ringed" (banded) birds reported by the British public, suggests that cats may be responsible for 6.2–31.3 percent of bird deaths. "Overall," writes Mead, "it is clear that cat predation is a significant cause of death for most of the species examined." Nevertheless, Mead concludes that "there is no clear evidence of cats threatening to harm the overall population level of any particular species… Indeed, cats have been kept as pets for many years and hundreds of generations of birds breeding in suburban and rural areas have had to contend with their predatory intentions" [42].

- Mike Fitzgerald and Dennis Turner come to essentially the same conclusion: "We consider that we do not have enough information yet to attempt to estimate on average how many birds a cat kills each year. And there are few, if any studies apart from island ones that actually demonstrate that cats have reduced bird populations" [39].

- Clifton makes a compelling argument that the

h This ratio of 3.3 hinges on the hunting behaviors of just 24 cats—12 that returned prey home, and another 12 (11 pets and 1 feral) that were observed hunting for a total of 181 hours (anywhere from 4.8–46.5 hours per cat). It's interesting to note that the cat observed the most (46.5 hours) was only a year old—by far the youngest of the 12 observed, and likely the most active hunter (though detailed hunting tallies are not provided; nor are ages of the pet cats involved in the study). This factor alone could have had a significant influence on the outcome of the study. But the key to Kays and DeWan's calculation is the average time spent outdoors—typically a highly skewed distribution (see, for example, [29] and [34]), though the authors' data suggests a bimodal distribution (another case in which using the mean is inappropriate). In any event, by using a simple average (8.35 hours/day), Kays and DeWan overestimate potential predation levels, perhaps significantly.

population of feral cats in the U.S. is much smaller than is often reported (e.g., Jessup's [43] unattributed 60–100 million figure, which was later inflated by Dauphine and Cooper [44]), and may very well be on the decline [45]. In 2003, Clifton suggested that "the winter feral cat population may now be as low as 13 million and the summer peak is probably no more than 24 million" [25]. If so, the implications for wildlife predation (and other environmental impacts) are obviously significant.

Mesopredator Release

Some researchers have suggested that, in some habitats, the presence of cats may actually serve to protect threatened bird species [46, 47, and 48], as the cats tend to keep populations of rats in check. Removing only the cats would likely result in a spike in rat numbers, thereby increasing the overall threat to birds. The phenomenon is known as *mesopredator release*. "In the absence of large, dominant predators," suggest Soulé et al., "smaller omnivores and predators undergo population explosions, sometimes becoming four to 10 times more abundant than normal" [49].

In 1991, Fitzgerald et al. warned that the eradication of cats from Raoul Island (New Zealand) would likely trigger such a process, and therefore "bring little benefit to bird populations" [46]. "If cats were eradicated," argued the authors, "the Norway rat population on Raoul Island is likely to remain at least as high as it is now, and the rats on their own might kill sufficient sooty terns in the colonies at Denham Bay and on the south coast of Hutchison Bluff to reduce the size of the colonies further" [46].

Between 2002 and 2004, the New Zealand Department of Conservation undertook what's been described as "the world's largest multi-species eradication project to date," on the 11.3-square-mile island, killing off the populations of Norway and Pacific rats "via aerial drops of poisoned bait for rats… with follow-up ground hunting with dogs and guns for cats" [50]. Following the successful "removal" of rats and cats, an effort estimated to cost NZ$1 million [51], red-crowned parakeets have recolonized Raoul Island [50].

Nevertheless, mathematical modeling of the mesopredator release phenomenon illustrates the complexities involved in eradication efforts, even on small islands. "Although in some cases, the control of cat [sic] has been proved to be effective in restoring some endangered ecosystems," argue Fan et al., "such strategies are not universally applicable. In some cases, it may cause a disastrous impact to managed or natural ecosystems" [48].

Macquarie Island, located roughly halfway between New Zealand and Antarctica, offers a well-documented example of such a disastrous impact. In 2000, cats were eradicated from this United Nations Educational, Scientific and Cultural Organization World Heritage Site in order to protect seabird populations. The resulting rebound in rabbit and rodent numbers, however, has had its own disastrous impact. "In response, Federal and State governments in Australia have committed AU$24 million for an integrated rabbit, rat and mouse eradication programme" [52].

Some researchers have suggested that the risk of mesopredator release is not limited to actual islands, but may also exist in "habitat islands," discontinuous patches of habitat typically the result of human disruption [32, 49]. Given the extent to which conservation efforts backfired on Macquarie Island—less than 50 square miles in size—one can only imagine the consequences and cost of similar attempts aimed at addressing thousands of habitat islands across the continental U.S.

"What I find inconsistent… is how indictment of cats has been pursued almost in spite of the evidence."

— Gary Patronek

Indictment of Cats

Given the scope of their essay, perhaps it's understandable that Longcore et al. were unable to cover each aspect of this rather broad topic in a more comprehensive manner. Nevertheless, the amount of research into cat predation and wildlife impacts—a critical piece of the puzzle, to be sure—that was omitted, glossed over, and/or misrepresented suggests a clear agenda. And the various studies cited by Longcore et al.—presumably, the best evidence available—are less than convincing. Close scrutiny reveals a range of issues (as outlined above) that challenge the sweeping statements made by the authors.

But there's something even more troubling with

their argument: they're attempting to answer the wrong question. As Patronek puts it so eloquently: "If the real objection to managed colonies is that it is unethical to put cats in a situation where they could potentially kill any wild creature, then the ethical issue should be debated on its own merits without burdening the discussion with highly speculative numerical estimates for either wildlife mortality or cat predation" [53].

"Whittling down guesses or extrapolations from limited observations by a factor of 10 or even 100," Patronek continues, "does not make these estimates any more credible, and the fact that they are the best available data is not sufficient to justify their use when the consequence may be extermination for cats… What I find inconsistent in an otherwise scientific debate about biodiversity is how indictment of cats has been pursued almost in spite of the evidence, and without regard to the differential effects of cats in carefully selected, managed colonies, versus that of free-roaming pets, owned farm cats, or truly feral animals. Assessment of well-being for any species is an imprecise and contentious process at best. Additional research is clearly needed concerning the welfare of these cats" [53].

2. OTHER IMPACTS

In addition to their numerous claims about the direct impact of cats on wildlife—primarily through predation—Longcore et al. argue that free-roaming cats have indirect impacts as well. The authors suggest, for example, that by competing with raptors for prey, cats may be affecting the populations of these birds. And that a parasite linked to domestic cats is responsible for the deaths of otters, seals, and sea lions off the coast of California. In fact, both claims misrepresent the very research Longcore et al. cite in their paper as supporting evidence.

Cat predation on mammals," write Longcore et al., referring to a often-cited study by William G. George [54], is "cause for concern because of direct impacts to native species and competition with native predators" [7]. But, competition for prey is one thing; having an impact on the population of competitors is something else altogether.

Over four years, from January 1, 1968 through December 31, 1971, George monitored and recorded with meticulous care the various small mammals his three cats killed on his "fallow farmland" [54] property in rural Cobden, Illinois. "As predators on rodents," writes George, "cats inevitably compete for prey with many of our declining raptors, and therein *may* lie a serious problem" [54, emphasis mine].

"I am not suggesting a cause-and-effect relationship exists between the historical increase of cats and the historical decrease of raptors," George warned, "however, cats, which are as efficient in their way as guns and DDT, accompany and add another dimension to man's encroachment into wildlife areas" [54].

By ignoring George's cautionary tone, Longcore et al. imply such a cause-and-effect relationship, thereby overstating any "cause for concern." And they only make matters worse by failing to follow up on his 40-year-old study.

How have these raptors fared since George first sounded the alarm? It's easy to imagine the worst. Certainly there are factors other than cats that would likely contribute to their decline—habitat fragmentation and destruction, for instance. Such environmental impacts have the potential to affect the birds themselves, clearly, but also their prey. However, research into the population trends of Red-tailed Hawks, Northern Harriers, and American Kestrels—three raptors identified specifically by George—suggests that George's concerns, while understandable, were largely unfounded.

BBS Routes and Data

Only one North American Breeding Bird Survey (BBS) route runs into Union County, Illinois, where George's property was located. Unfortunately, count data for BBS Route 34080 go back only to 1993. However, data for neighboring routes are available from the time of George's study through 2006. Surveys along two nearby routes in southern Illinois (34059 and 34061) began in 1970; surveys of two others, along the eastern edge of Missouri (52001 and 52007), date back to 1967 [55].[i]

No BBS count data from the routes in question are available for Northern Harriers, suggesting that perhaps this species was, for one reason or another, simply not included in the area's surveys. Data sets for other birds—the Red-shouldered Hawk, for example—exist despite frequent counts of zero (in the case of the Red-shouldered Hawk, just one bird was recorded along the four routes from 1967 through 2006).

BBS data for Red-tailed Hawks indicate a rather dramatic population increase for the two southwestern Illinois routes, and slight increases for the same period across the two eastern Missouri routes. Populations of American Kestrels, along the same routes and for the same period, remained mostly stable.

i Refer to North American Breeding Bird Survey Web site for detailed information.

If the area's cats are out-competing the raptors for prey, there's no evidence in the BBS count data.

Of course, isolating the relationship between the population of a predator and that of its preferred prey species is incredibly difficult; there are simply too many additional—often interdependent—factors that must be considered. Zooming out for a big-picture view of population dynamics across the U.S. only blurs such relationships, thereby complicating any subsequent analysis. Yet even such a blurred view challenges the impacts implied by Longcore et al.

George claimed (unfortunately, without referring to a specific source, and without specifying whether he was referring only to owned/pet cats) that there were 31 million cats in the U.S. at the time of his study [54]. Today, according to the APPA 2009–2010 National Pet Owners Survey, there are 93.6 million [33]. Direct comparisons over this 40-year time frame are difficult for a number of reasons (e.g., lack of reliable data, the increasing proportion of indoor-only cats in recent years [33, 34, 35, and 56], etc.). But if it's true that cats are having an negative impact on raptor populations—and there are now *three times as many of them*[j] (not accounting for feral cats)—one might reasonably expect find these birds in dire straights by now.

Conservation Reports

Located in east-central Pennsylvania, Hawk Mountain Sanctuary is, according to its Web site, "the world's first refuge for birds of prey." Among the many resources the sanctuary provides online are its Conservation Status Reports, which suggest that the outlook for Northern Harriers and Red-tailed Hawks is mostly good. "The Northern Harrier is considered secure in most of North America, but it is a species of concern regionally in many of the [Bird Conservation Regions] west of the Mississippi River" [57].

The Red-tailed Hawk, too, "is considered secure throughout most of its range in North America" [58]. "Migration counts have declined in eastern North America since 1995, but concurrent increases in [Breeding Bird Surveys] and [Christmas Bird Counts] suggest that these migration trends may be the result of changes in migration geography or behavior. Elsewhere in North America, population monitoring generally indicates increasing or stable populations of this common raptor" [58].

American Kestrels, on the other hand, seem to be in trouble: "Overall, the data suggest substantial declines in populations… across much of North America, and consequently strong cause for conservation concern" [59]. The factors affecting these declines are unknown and, the report notes, "warrant further investigation." However, some patterns have been observed—"factors exerting negative influences on populations are strongest along the Atlantic coast," for example. Also: "More recent declines in western North America… appear to have occurred in concert with a prolonged drought" [59].

The Cornell Lab of Ornithology's Web site paints a rather different picture, noting that the population of American Kestrels "increased greatly with historical deforestation of North America. No significant trend across North America, but some local increases and decreases" [60].

Like the BBS data from southern Illinois and eastern Missouri, the Conservation Status Reports for these raptors reveal population trends perhaps best described as "mixed." Nowhere is there any indication that declining numbers (in those cases where they are declining) can be linked to the success of competing predators, including cats. For George, of course, the idea was nothing more than a hypothesis anyhow. But rather than put it to the test, Longcore et al. have instead tried to elevate its status through nothing more than repetition.

"Three of the Type X-infected carnivores were wild felids … but no domestic cats were Type X-positive."

— Miller et al.

In recent years, *Toxoplasma gondii* has been linked to the illness and death of marine life, primarily sea otters [61], prompting investigation into the possible role of free-roaming (both owned and feral) cats [62, 63]. It's generally thought that oocysts (the mature, infective form of the parasite) are transferred from soil contaminated with infected feces to coastal waterways by way of freshwater run-off [63]. But

j The increasing tendency of American's to keep their cats inside obviously reduces this ratio, but to what degree is unclear (surveys regarding indoor/outdoor habits seem to be a recent phenomenon).

there is compelling evidence by Miller et al. to suggest that domestic cats may not be the culprits they've been made out to be: "Three of the Type X-infected carnivores were wild felids (two mountain lions and a bobcat), *but no domestic cats were Type X-positive*" [63, emphasis mine].

"Examination of larger samples of wild and domestic felids will help clarify these initial findings. If Type X strains are detected more commonly from wild felids in subsequent studies, this could suggest that these animals are more important land-based sources of *T. gondii* for marine wildlife than are domestic cats" [63].

As the authors note, "subsequent studies" are in order. For one thing, their sample size was quite small: three bobcats, 26 mountain lions, and seven domestic cats (although the authors suggest at one point that only five domestic cats were included). However, a recently published study from Germany seems to corroborate the authors' findings. Herrmann et al. analyzed 18,259 fecal samples (all from pet cats) for *T. gondii* and found no Type X strain [64].[k]

Still, the implications of this work are significant. An earlier study, this one of southern sea otters from coastal California, conducted between 1998 and 2004, found that 36 of 50 otters were infected with the Type X strain of *T. gondii*, one of at least four known strains [65]. In other words, 72 percent of the otters were infected with a strain of *T. gondii* that has yet to be traced to domestic cats.

But when Longcore et al. refer to these findings, they dissemble to such an extent that readers are likely to come away missing the point entirely: "The large quantity of waste from feral and free-roaming cats containing Toxoplasma oocysts [62, 66] and the correlation between freshwater runoff and toxoplasmosis in marine mammals [67] has led researchers to suspect domestic cats as the source of the infections, although further research is needed to determine the relative importance of native versus exotic felids as sources of this parasite [63]" [7].

While technically correct, Longcore et al. gloss over the fact that, based on the very study they cite, "the relative importance of native versus exotic felids as sources of this parasite" might be something like *two-and-a-half-to-one*.

But Longcore et al. go further: "Felids, including feral and free-roaming cats, shed Toxoplasma oocysts that infect southern sea otters [65, 67], Pacific harbor seals, and California sea lions" [7]. In fact, Conrad et al. examined just *one* harbor seal and *one* sea lion—and in both cases, found the Type X strain of *T. gondii* [65]. Which, when combined with the results from Miller et al. [63], suggests wild felids as the more likely source, rather than domestic cats. These two studies not only contradict the specific claims made by Longcore et al., but also challenge commonly-held beliefs—reinforced by the authors—about non-native/invasive species (e.g., domestic cats) being inherently problematic while native species are inherently benign.

k It's interesting to note, too, that only 0.25 percent of the samples tested positive for *T. gondii*.

3. EFFICACY OF TNR

Longcore et al. criticize TNR programs for their use of adoptions, reliance on volunteers, measures of success, and struggle against "prevailing conditions." For the Urban Wildlands Group, it seems, there is simply no such thing as a successful TNR program. By their standards, though, virtually every conservation effort—wildlife or environmental—should be considered a failure. And when it comes to alternatives to TNR, the authors are dead silent.

Although Longcore et al. suggest that there is a need for additional research into the effectiveness and impact (environmental and otherwise) of TNR, it's not clear that any future studies would address their objections or satisfy their apparent standards.

Adoptions

To begin with, the authors challenge the efficacy of TNR, noting, for example, that where TNR has proved effective at reducing the size of colonies, success has been "derive[d] in part from intensive efforts to remove cats for adoption as part of the TNR program" [7]. This, it seems, would appeal to Longcore and the Urban Wildlands Group. After all, adoptions lead to fewer free-roaming cats. How a successful adoption program might lessen the efficacy of TNR is unclear; indeed, such efforts are integral to any TNR program. For Longcore et al., however, it's as if adoptions constitute some sort of cheating.

Cats that remain with their colonies are, as part of a TNR program, sterilized (actually, those that are adopted out are also typically spayed/neutered). It is the *combination* of sterilization *and* adoption that makes for a successful TNR effort. Adoption alone will not work because the remaining unsterilized cats will continue to reproduce, quickly replacing cats removed for adoption. Moreover, volunteers are unlikely to participate in such a poorly conceived management scheme (this is even more likely to be the case with trap-and-kill efforts).

Referring to a population modeling study by Andersen, Martin, and Roemer [68], Longcore et al. concede: "If adoption is sufficiently high, it may offset immigration to colonies and even reach the 50 percent removal threshold necessary for population decline" [7]. But that 50 percent removal threshold is based on their being *no sterilization whatsoever*. As sterilization is increased, fewer cats need to be removed in order to achieve an eventual reduction in the overall population.

The "primary objective," write Andersen et al., "was to compare the efficacy of TNR programs versus euthanasia [i.e., trap-and-kill] programs as methods of cat population management" [68]. In other words, sterilization-only (with no removal of any kind, either for adoption or for extermination) vs. trap-and-kill-only[1] (with no sterilization). The authors never even consider adoption programs, which, they note "are similar in effect to euthanasia because these cats are permanently removed from the free-roaming cat population" [68]. Nor do they consider emigration between cat colonies, though they point out that "a substantial number of owned cats are reported to be adopted strays" [68]. (Indeed: in 2003, Clifton suggested that "up to a third of all pet cats now appear to be recruited from the feral population" [25].)

Researchers vs. Volunteers

Longcore et al. complain that "examples of dramatic population declines at TNR sites are from programs in limited geographic areas that were implemented with participation of the researchers themselves," suggesting, too, that "programs implemented by researchers are likely to be much more thorough than programs implemented exclusively by volunteers" [7]. But what's wrong with TNR programs being limited to a particular geographical area, especially if they yield dramatic population declines? Their tight focus is a key to the success of such programs, not a drawback.

In addition, Longcore et al. offer nothing to support their assertion that TNR programs run by researchers are more effective at reducing feral cat populations than those run by volunteers. Those involving researchers are, by their very nature, more likely to be documented in scientific publications—but such reporting suggests nothing one way or the other about their performance relative to volunteer-only programs. Indeed, the authors refer only obliquely to cases in which TNR has proved ineffective, citing the 2004 paper by Jessup [69]. (Jessup, for his part, offers little to support his own sweeping claim that, "in most locations where TNR has been tried, it fails to substantially or quickly reduce cat numbers and almost never eliminates feral cat populations" [69].) Even if these examples *do* represent "failed" TNR efforts (and it's not at all clear that this is the case) they don't speak to the efficacy of TNR as a management approach—any more than a handful of failed conservation efforts can be used to portray wildlife conservation, in general, as wrong-headed.

TNR programs are, especially during the early stages, labor-intensive. It's not difficult to see, then, why having an large team of volunteers—all of whom are motivated and committed to the cause—can produce results equal or superior to a small number of highly-trained researchers. Advanced degrees are, in the end, no substitute for "boots on the ground." But this is hardly news to anybody involved in wildlife conservation efforts. Indeed, this is the very premise of "citizen science" programs. Breeding Bird Surveys, for example, "annually engage tens of thousands of participants," and these efforts are now beginning to leverage the power of the Internet via Web-based programs such as eBird [70].

Anecdotes of Success

Longcore et al. criticize supporters of TNR for their "anecdotes of success" and "assertions of colony declines often… supported only by reference to Web sites" [7]. By calling the data "anecdotal," the authors dismiss it out of hand—but offer nothing in the way of alternative, more acceptable measures of success.

In general, caretakers of feral colonies—as providers of food, water, shelter, and, often, healthcare—know their cats quite well. Yet, Longcore et al. suggest that their reports are not to be trusted. Again, it's not clear how TNR programs are any different from citizen science programs in this regard. Bird counts rely on the ability of "amateurs" to quickly locate, identify, and record—often under less-than-ideal circumstances—individual birds, distinguishing one species from a number of others in the area. The whole process hinges upon "anecdotes."

Prevailing Conditions

Citing a 2006 study from Rome, Longcore et al. focus not on TNR's rather remarkable success, but on its greatest challenge: "Ten years of TNR in Rome showed a 16–32 percent decrease in population size across 103 colonies but concluded that TNR was 'a waste of time, energy, and money' if abandonment of owned cats could not be stopped" [71]. It must be recognized that TNR is part of a larger mission—ex-

1 The specific language used by TNR opponents (Longcore et al. included) is no small matter. Referring to the killing of healthy cats as euthanasia suggests that this practice is, in fact, a humane option. Interestingly, Longcore et al. refer repeatedly in their paper to cats killing birds and mammals; they never, however, refer to humans killing cats.

pressed via the burgeoning no-kill movement [72]—that includes adoptions, sterilization of owned cats, shelter reform [73], and so forth.

Any TNR program contends with the unfortunate (and illegal) dumping of cats. Nevertheless, it's difficult to imagine that the presence or absence of a nearby TNR program would affect a person's decision to abandon his/her pet cat(s). (If any studies had demonstrated such a connection, Longcore et al. would surely have cited them.) On the other hand, cats dumped near a managed colony are far more likely to be adopted and/or sterilized—thereby mitigating their potential impact on the overall population of unowned cats (as well any impacts to wildlife and the environment).

Longcore et al. also overlook the value of population stabilization. Julie Levy, Maddie's Professor of Shelter Medicine in the University of Florida's College of Veterinary Medicine, argues that "Wildlife benefits when populations of cats that are trending rapidly upwards are at least stabilized" [74].

In any case, what animal welfare or wildlife/environmental conservation work isn't "a waste of time, energy, and money" when considered in the harsh light of what the authors call "prevailing conditions"? The same could be said, for instance, about efforts to save songbirds faced with the elimination and fragmentation of habitat, increased levels of pollution, collisions with buildings, power lines, and wind turbines; endangered and threatened species are, *by definition*, the victims of prevailing conditions. The fact that such efforts are uphill battles may say something about their underlying moral imperative—but very little about their efficacy.

"Nearly seven centuries of killing cats doubled the fecundity of the species."

— Merritt Clifton

TNR in Context

Many proponents of TNR will acknowledge that the practice is not appropriate for all environments [15, 25, and 53]. Patronek, for example, suggests that "the release of cats into an environment where they would impact endangered or threatened species, or even into wildlife preserves or refuges, is inexcusable" [53]. The key issue in such cases in not mere *proximity*, of course, but whether any endangered or threatened species in the area in question are actually vulnerable to predation by cats.

Nevertheless, Patronek's larger point is an important one: "I do not believe that this is being advocated by cat protectors who see urban, managed colonies as an imperfect but still preferable alternative to the euthanasia of healthy animals. Abandoned pet cats whose own habitat has been reduced to colonies, and the wild species endangered by clear-cutting or beachfront development, are casualties of the same callous disregard for the lives of animals. I see little justification for shifting the role of cats to that of scapegoat" [53].

And what about the efficacy of TNR's alternative, trap-and-kill? Longcore et al. provide nothing whatsoever to suggest that "traditional" feral cat management has been effective (given the subject and tone of their paper, though, one might reasonably expect such a baseline, against which TNR would presumably compare poorly). On the other hand, there is plenty of evidence to suggest that it has been—and continues to be—a monumental failure. "The effect on the feral cat population," writes Clifton, "replicates natural predation: the most frequent victims are the very young, the old, the disabled, and the ill. The healthiest animals usually escape to breed up to the carrying capacity of the habitat, if they can" [25]. And, as Mark Kumpf, president of the National Animal Control Association President from 2007 to 2008, put it in an interview with Animal Sheltering magazine, "the traditional methods that many communities use… are not necessarily the ones that communities are looking for today" [75]. Kumpf describes traditional approaches to feral cat management (i.e., trap-and-kill) as "bailing the ocean with a thimble" [75].

Clifton also argues that such strategies have, in fact, had another—unintended and profoundly counterproductive—consequence as well: "Responding to the intensified mortality, *felis catus* now bears an average litter of four. Nearly seven centuries of killing cats doubled the fecundity of the species" [25].

4. CONTINUING THE CAT DEBATE

"Critical Assessment" is an unapologetic call to action: "Scientists and conservationists have an important role to play by conducting research on feral cats and providing credible scientific information to resource managers, funding agencies, foundations,

and policy makers about the adverse ecological consequences of condoning the indefinite maintenance of feral cat colonies through adoption of TNR as a preferred management scheme" [7].

Longcore et al. have certainly attracted the attention of TNR opponents. But when it comes to "providing credible scientific information," they have fallen far short.

In his comprehensive article, "Free-roaming and Feral Cats—Their Impact on Wildlife and Human Beings," Patronek laments the fact that "the debate about free-roaming cats is often framed as pro-cat and anti-wildlife, or vice-versa. This attitude polarizes groups and individuals who otherwise have common concerns about animals and the environment, and is a barrier to developing effective public policy" [9]. This, unfortunately, is precisely how the Urban Wildlands Group framed their essay. Worse, however, is the fact that its publication in a highly regarded scientific journal—giving it currency within the scientific community and beyond—further impedes chances for an honest discussion.

There are legitimate issues to be debated regarding the efficacy, environmental impact, and morality of TNR, but such debate continues to be hindered (if not derailed entirely) by those—including Longcore et al.—who misrepresent the scientific research on the subject. Given all that's at stake, none of us can afford to indulge in such irresponsible behavior.

LITERATURE CITED

1. Yoshino, K. (2010, January 17). A catfight over neutering program. *Los Angeles Times*.
2. Seife, C., *Proofiness: The Dark Arts of Mathematical Deception*. 2010: Viking Adult.
3. Barratt, D.G., "Predation by house cats, *Felis catus* (L.), in Canberra, Australia. II. Factors affecting the amount of prey caught and estimates of the impact on wildlife." *Wildlife Research*. 1998. 25(5): p. 475–487.
4. Woods, M., McDonald, R.A., and Harris, S., "Predation of wildlife by domestic cats Felis catus in Great Britain." *Mammal Review*. 2003. 33(2): p. 174–188.
5. Churcher, P.B. and Lawton, J.H., "Predation by domestic cats in an English village." *Journal of Zoology*. 1987. 212(3): p. 439–455.
6. Lepczyk, C.A., et al., "What Conservation Biologists Can Do to Counter Trap-Neuter-Return: Response to Longcore et al." *Conservation Biology*. 2010. 24(2): p. 627–629.
7. Longcore, T., Rich, C., and Sullivan, L.M., "Critical Assessment of Claims Regarding Management of Feral Cats by Trap-Neuter-Return." *Conservation Biology*. 2009. 23(4): p. 887–894.
8. n.a., *What the Cat Dragged In*, in *Catnip*. 1995, Tufts University School of Veterinary Medicine: Boston, MA. p. 4–6.
9. Patronek, G.J., "Free-roaming and feral cats—their impact on wildlife and human beings." *Journal of the American Veterinary Medical Association*. 1998. 212(2): p. 218–226.
10. Lepczyk, C.A., Mertig, A.G., and Liu, J., "Landowners and cat predation across rural-to-urban landscapes." *Biological Conservation*. 2003. 115(2): p. 191–201.
11. Coleman, J.S. and Temple, S.A., *Effects of Free-Ranging Cats on Wildlife: A Progress Report*, in *Fourth Eastern Wildlife Damaage Control Conference*. 1989: University of Nebraska—Lincoln. p. 8–12.
12. Coleman, J.S. and Temple, S.A., *On the Prowl*, in *Wisconsin Natural Resources*. 1996, Wisconsin Department of Natural Resources: Madison, WI. p. 4–8.
13. Goldstein, L.D., O'Keefe, C.L., and Bickel, H.L. *Addressing "The Wisconsin Study"*. 2003.
14. Fitzgerald, B.M., *Diet of domestic cats and their impact on prey populations*, in *The Domestic cat: The biology of its behaviour*, D.C. Turner and P.P.G. Bateson, Editors. 1988, Cambridge University Press: Cambridge; New York. p. 123–147.
15. Berkeley, E.P., *TNR Past present and future: A history of the trap-neuter-return movement*. 2004, Bethesda, MD: Alley Cat Allies.
16. Perry, G. *Cats—perceptions and misconceptions: Two recent studies about cats and how people see them*. in *Urban Animal Management Conference*. 1999.
17. Millwood, J. and Heaton, T. *The metropolitan domestic cat*. in *Urban Animal Management Conference*. 1994.
18. Baker, P.J., et al., "Impact of predation by domestic cats *Felis catus* in an urban area." *Mammal Review*. 2005. 35(3/4): p. 302–312.
19. Baker, P.J., et al., "Cats about town: is predation by free-ranging pet cats *Felis catus* likely to affect urban bird populations?" *Ibis*. 2008. 150: p. 86–99.
20. Mitchell, J.C. and Beck, R.A., "Free-Ranging Domestic Cat Predation on Native Vertebrates in Rural and Urban Virginia." *Virginia Journal of Science*. 1992. 43(1B): p. 197–207.
21. Errington, P.L., "Notes on Food Habits of Southwestern Wisconsin House Cats." *Journal of Mammalogy*. 1936. 17(1): p. 64–65.
22. Parmalee, P.W., "Food Habits of the Feral House Cat in East-Central Texas." *The Journal of Wildlife Management*. 1953. 17(3): p. 375–376.
23. Eberhard, T., "Food Habits of Pennsylvania House

Cats." *The Journal of Wildlife Management*. 1954. 18(2): p. 284–286.

24. Coleman, J.S. and Temple, S.A., *How Many Birds Do Cats Kill?*, in *Wildlife Control Technology*. 1995. p. 44.
25. Clifton, M. (June 2003) Where cats belong—and where they don't. *Animal People*.
26. Tantillo, J.A., *Killing Cats and Killing Birds: Philosophical issues pertaining to feral cats*, in *Consultations in Feline Internal Medicine Volume 5*, J.R. August, Editor. 2006, Elsevier Saunders: St. Louis, MO. p. 701–708.
27. Elliott, J. (1994, March 3–16). The Accused. *The Sonoma County Independent*, pp. 1, 10.
28. ABC, *Domestic Cat Predation on Birds and Other Wildlife*. n.d., American Bird Conservancy: The Plains, VA.
29. Lebbin, D.J., Parr, M.J., and Fenwick, G.H., *The American Bird Conservancy Guide to Bird Conservation*. 2010, London: University of Chicago Press.
30. n.a., *Migratory Bird Mortality*. 2002, U.S. Fish and Wildlife Service: Arlington, VA.
31. Williams, T., *Felines Fatale*, in *Audubon*. 2009, National Audubon Society: New York, NY.
32. Crooks, K.R. and Soulé, M.E., "Mesopredator release and avifaunal extinctions in a fragmented system." *Nature*. 1999. 400(6744): p. 563–566.
33. APPA, *2009–2010 APPA National Pet Owners Survey*. 2009, American Pet Products Association: Greenwich, CT.
34. Clancy, E.A., Moore, A.S., and Bertone, E.R., "Evaluation of cat and owner characteristics and their relationships to outdoor access of owned cats." *Journal of the American Veterinary Medical Association*. 2003. 222(11): p. 1541–1545.
35. Lord, L.K., "Attitudes toward and perceptions of free-roaming cats among individuals living in Ohio." *Journal of the American Veterinary Medical Association*. 2008. 232(8): p. 1159–1167.
36. Hawkins, C.C., *Impact of a subsidized exotic predator on native biota: Effect of house cats* (Felis catus) *on California birds and rodents*. 1998, Texas A&M University.
37. Brownfield, N.T., *2002 Annual Analysis of Pesticide Use East Bay Regional Park District*. 2003, East Bay Regional Park District.
38. Hawkins, C.C., Grant, W.E., and Longnecker, M.T., "Effect of Subsidized House Cats on California Birds and Rodents." *Transactions of the Western Section of the Wildlife Society*. 1999. 35: p. 29–33.
39. Fitzgerald, B.M. and Turner, D.C., *Hunting Behaviour of domestic cats and their impact on prey populations*, in *The Domestic Cat: The biology of its behaviour*, D.C. Turner and P.P.G. Bateson, Editors. 2000, Cambridge University Press: Cambridge, U.K.; New York. p. 151–175.
40. Kays, R.W. and DeWan, A.A., "Ecological impact of inside/outside house cats around a suburban nature preserve." *Animal Conservation*. 2004. 7(3): p. 273–283.
41. Møller, A.P. and Erritzøe, J., "Predation against birds with low immunocompetence." *Oecologia*. 2000. 122(4): p. 500–504.
42. Mead, C.J., "Ringed birds killed by cats." *Mammal Review*. 1982. 12(4): p. 183–186.
43. Jessup, D.A., et al., "Sea otters in a dirty ocean." *Journal of the American Veterinary Medical Association*. 2007. 231(11): p. 1648–1652.
44. Dauphine, N. and Cooper, R.J., *Impacts of Free-ranging Domestic Cats* (Felis catus) *on birds in the United States: A review of recent research with conservation and management recommendations*, in *Fourth International Partners in Flight Conference: Tundra to Tropics*. 2009. p. 205–219.
45. Clifton, M. (November 2003) Roadkills of cats fall 90% in 10 years—are feral cats on their way out? *Animal People*.
46. Fitzgerald, B.M., Karl, B.J., and Veitch, C.R., "The diet of feral cat (*Felis catus*) on Raoul Island, Kermadec group." *New Zealand Journal of Ecology*. 1991. 15(2): p. 123–129.
47. Courchamp, F., Langlais, M., and Sugihara, G., "Cats protecting birds: modelling the mesopredator release effect." Journal of Animal Ecology. 1999. 68(2): p. 282–292.
48. Fan, M., Kuang, Y., and Feng, Z., "Cats protecting birds revisited." *Bulletin of Mathematical Biology*. 2005. 67(5): p. 1081–1106.
49. Soulé, M.E., et al., "Reconstructed Dynamics of Rapid Extinctions of Chaparral-Requiring Birds in Urban Habitat Islands." *Conservation Biology*. 1988. 2(1): p. 75–92.
50. Ortiz-Catedral, L., et al., "Recolonization of Raoul Island by Kermadec red-crowned parakeets (*Cyanoramphus novaezelandiae cyanurus*) after eradication of invasive predators, Kermadec Islands archipelago, New Zealand." *Conservation Evidence*. 2009. 6: p. 26–30.
51. Welham, K. (2003, January 25). No evidence of rats and cats. *The Christchurch Press*, p. 2.
52. Bergstrom, D.M., et al., "Indirect effects of invasive species removal devastate World Heritage Island." *Journal of Applied Ecology*. 2009. 46(1): p. 73–81.
53. Patronek, G.J., "Letter to Editor." *Journal of the American Veterinary Medical Association*. 1996. 209(10): p. 1686–1687.
54. George, W., "Domestic cats as predators and factors in winter shortages of raptor prey." *The Wilson Bulletin*. 1974. 86(4): p. 384–396.

55. Sauer, J.R., Hines, J.E., and Fallon., J. (2008) *The North American Breeding Bird Survey, Results and Analysis 1966–2007. Version 5.15.2008.*

56. ABC, *Human Attitudes and Behavior Regarding Cats*. 1997, American Bird Conservancy: Washington, DC.

57. n.a., *Conservation Status Report: Northern Harrier*. 2007, Hawk Mountain Sanctuary: Kempton, PA.

58. n.a., *Conservation Status Report: Red-tailed Hawk*. 2007, Hawk Mountain Sanctuary: Kempton, PA.

59. n.a., *Conservation Status Report: American Kestrel*. 2007, Hawk Mountain Sanctuary: Kempton, PA.

60. n.a. *American Kestrel: Life History*. The Cornell Lab of Ornithology.

61. Jones, J.L. and Dubey, J.P., "Waterborne toxoplasmosis - Recent developments." *Experimental Parasitology*. 124(1): p. 10–25.

62. Dabritz, H.A., et al., "Outdoor fecal deposition by free-roaming cats and attitudes of cat owners and nonowners toward stray pets, wildlife, and water pollution." *Journal of the American Veterinary Medical Association*. 2006. 229(1): p. 74–81.

63. Miller, M.A., et al., "Type X Toxoplasma gondii in a wild mussel and terrestrial carnivores from coastal California: New linkages between terrestrial mammals, runoff and toxoplasmosis of sea otters." *International Journal for Parasitology*. 2008. 38(11): p. 1319–1328.

64. Herrmann, D.C., et al., "Atypical Toxoplasma gondii genotypes identified in oocysts shed by cats in Germany." *International Journal for Parasitology*. 2010. 40(3): p. 285–292.

65. Conrad, P.A., et al., "Transmission of Toxoplasma: Clues from the study of sea otters as sentinels of Toxoplasma gondii flow into the marine environment." *International Journal for Parasitology*. 2005. 35(11-12): p. 1155–1168.

66. Dabritz, H.A., et al., "Detection of Toxoplasma gondii-like oocysts in cat feces and estimates of the environmental oocyst burden." *Journal of the American Veterinary Medical Association*. 2007. 231(11): p. 1676–1684.

67. Miller, M.A., et al., "Coastal freshwater runoff is a risk factor for Toxoplasma gondii infection of southern sea otters (Enhydra lutris nereis)." *International Journal for Parasitology*. 2002. 32(8): p. 997–1006.

68. Andersen, M.C., Martin, B.J., and Roemer, G.W., "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*. 2004. 225(12): p. 1871–1876.

69. Jessup, D.A., "The welfare of feral cats and wildlife." *Journal of the American Veterinary Medical Association*. 2004. 225(9): p. 1377–1383.

70. Sullivan, B.L., et al., "eBird: A citizen-based bird observation network in the biological sciences." *Biological Conservation*. 2009. 142(10): p. 2282–2292.

71. Natoli, E., et al., "Management of feral domestic cats in the urban environment of Rome (Italy)." *Preventive Veterinary Medicine*. 2006. 77(3-4): p. 180–185.

72. Winograd, N.J., *Redemption: The myth of pet overpopulation and the no kill revolution in America*. 2007: Almaden Books.

73. Winograd, N.J., *Irreconcilable Differences: The Battle for the Heart and Soul of America's Animal Shelters*. 2009.

74. Levy, J.K., Personal communication, 2010.

75. Hettinger, J., *Taking a Broader View of Cats in the Community*, in *Animal Sheltering*. 2008. p. 8–9.